## CACTVS Tcl Scripting Introduction

## Script Interpreter Programs

The standard distribution of the toolkit contains a number of standard application scripts, and two general-purpose interpreters for the execution of custom scripts.

## Start scripts

When the setup program is executed, a number of start scripts named cs?? are generated. The prefix $c s$ is the abbreviation for $\underline{C} A C T v s^{\underline{S}}$ System, and the final two or three letters are a short mnemonic form of the application, such as $b r$ for structure browser, or $t b$ for table builder. Most of these start scripts execute a predefined script, but two of them are general-purpose interpreters which can be fed with any script.

On Unix, these start scripts are short shell scripts which set up a number of environment variables and then start one of two general-purpose chemistry interpreters. One of these is tclcactvs, the other tkcactus. The only difference in functionality is that the latter includes the Tk platform-independent GUI toolkit. In principle, it is also possible to start with a plain tclcactvs, and then load Tk as a toolkit at run-time.

On MS Windows, the cs?? files are short-cuts which start tclcactvs or tkcactvs with the application script file directly. On Windows, path information is extracted from the registry, so no environment set-up is required.

This is a sample start script for the generic GUI-less script interpreter csts:

```
#! /bin/sh
TK_LIBRARY=/usr/local/lib/cactvs/tk8.2
TCL_LIBRARY=/usr/local/lib/cactvs/tcl8.2
TKX_LIBRARY=/usr/local/lib/cactvs/tkx8.2
TCLX_LIBRARY=/usr/local/lib/cactvs/tclx8.2
BLT_LIBRARY=/usr/local/lib/cactvs/blt2.4
TIX_LIBRARY=/usr/local/lib/cactvs/tix4.1
OS="Linux2.4"
DATADIR=/usr/local/lib/cactvs
PATH=$DATADIR:$PATH
LD_LIBRARY_PATH=/usr/local/lib/cactvs/lib:$LD_LIBRARY_PATH
LD_LIBRARYN32_PATH=/usr/local/lib/cactvs/lib:$LD_LIBRARYN32_PATH
export LD_LIBRARY_PATH LD_LIBRARYN32_PATH TKX_LIBRARY TCLX_LIBRARY
export TK_LIBRARY TCL_LIBRARY BLT_LIBRARY TIX_LIBRARY OS DATADIR
PGM=/usr/local/lib/cactvs/lib/tclcactvs
exec $PGM -b -d "$@"
```

The generic multi-platform version of this script which is part of the development distributions looks slightly more difficult, but does essentially the same. That script version determines the operating system version at runtime by analysing uname command output, and compensates for incompatibilities between SuSE and RedHat C++ runtime library naming conventions. The uname output analysis in the generic version looks complicated because it distinguishes between Linux on I386 and Alpha processor architectures, which are not trivial to keep apart from its messages.

If the environment variables are already set up appropriately, the start scripts are not needed and the central program tclcactvs and tkcactvs may be started directly.

## Environment variables

The following environment variables are used by the Cactvs system:

- blt_library Path to the BLT runtime script library. Usually, it is a subdirectory of the \$DATADIR directory. BLT is an extension module for the TK toolkit. All standard GUI applications included with the toolkit use this package, for example for the drag\&drop functionality. This variable is only used by Tk-enabled interpreter versions. BLT is not compiled into the tkcactvs application, but loaded as a package on demand.
- DATADIR The variable stores the path to the directory which contains the Cactvs script libraries and other directories with critical runtime information. In standard customer installations, this is the base library installation directory, for example /usr/local/lib/cactvs.
- LD_LIBRARY_PATH This variable is not used by the toolkit directly, but nevertheless very important because the toolkit is very modular, and many programs such as tkcactvs depend on a dozen or more dynamic libraries. The standard start-up scripts will prefix the library path with the location of the runtime libraries. On IRIX systems, the variable LD_LIBRARYN32_PATH is also important. The toolkit libraries and executables are compiled in n32 format on all IRIX releases which support this linker format.

The operating system. This variable will actually be re-exported by the initialization routine if it is not set. This variable is used as a path component in various Cactvs extension modules search paths in multi-platform installations. Setting this variable is optional, since it will be automatically generated if necessary. The syntax of this variable is the basic OS name as reported by the uname command, followed by its version, followed by the processor class if it is not the standard class. Examples of valid values are SunOS5.10-64 (not Solaris something), and Linux2.6. On Windows, the generic OS name is WIN32.

- Path This is the standard search path for executables. The start scripts will prefix the path with the directory where the executable programs of the toolkit are stored. Indirectly, this variable is used whenever an external executable is started by a script, or directly by the core toolkit code. The latter happens for example when I/O to or from pipes is performed, or when reading compressed structure files. An up-to-date gzip program should be installed on the system in a location contained in the РАтн in order to enable input of structure files in standard compression formats.
- TCL_LIBRARY Path to the Tcl runtime script library. Usually, it is a subdirectory of the \$DATADIR directory.
- TCLX_LIBRARY

Path to the TclX runtime script library. Usually, it is a subdirectory of the \$DATADIR directory. The TclX Tcl extension module is a compiled-in component of all Tcl-enabled toolkit versions. It is essential because it for example provides the functions for the encoding and decoding of object handles.

- TIX_LIBRARY Path to the Tix runtime script library. Usually, it is a subdirectory of the \$DATADIR directory. Tix is another extension for the Tk GUI toolkit. It is used by some of the GUI application scripts, such as the structure browser csbr. However, not all GUI applications rely on this extension module. This variable is only used by $\mathbf{T k}$-enabled interpreter versions, and only of the Tix package has been loaded. Tix is not compiled into the tkcactvs application, but loaded as a package on demand.
- TK_LIBRARY Path to the Tk runtime script library. Usually, it is a subdirectory of the \$DATADIR directory. This variable is only used by $\mathbf{T k}$-enabled interpreter versions.


## Stand-alone applications

The compilation environment of the toolkit supports the compilation of stand-alone executables. In these executables, the application script, all runtime libraries, script libraries, extra property definitions and toolkit extension modules are collected and linked into a big static executable. In addition, the dynamic extension capabilities of the toolkit are disabled in these programs, so that they will never attempt to load additional functionality from modules or description files.

These stand-alone applications do not access any environment variables, and the only installation procedure required is to move them into a standard binary directory, such as /usr/local/bin.

From a user standpoint, stand-alone executables and application scripts started via a start script and backed by a full toolkit installation are supposed to be indistinguishable. The only notable difference is the behaviour in case unknown data is encountered, where the toolkit version will go through its procedure of automatic extension look-up and loading, while the stand-alone versions will not. Given a suitable set of additional property definition and extension modules compiled into the stand-alone versions, these programs have no need not have to refer to automatic loading of extra modules and their behaviour is indeed identical to the script version.

## Encrypted scripts

It is possible to distributed confidential scripts and open scripts in the same environment. The script interpreters contain a compiled-in and usually customer-specific key which can be used to run encrypted scripts.

Encrypted scripts can be generated from a standard readable Tcl or Tk script by performing an RC4 encoding:

```
rc4 the_key <plain_script.tcl >enc_script.rc4
```

The encrypted script may be run on interpreters which have the same key by setting the $-x$ option:
tclcactvs -x -f enc_script.rc4
Keys may also be set by providing a digitally signed license.dat file as part of a distribution. This file overrides the standard license settings, including the decryption key.

## CACTVS as generic Tcl extension module

The standard Cactvs script interpreters contain the Tcl scripting language interface as a compiled-in component.

However, it is also possible to compile the Сactvs toolkit libraries without the main $\mathrm{Tcl} / \mathrm{Tk}$ libraries, but still with Tcl scripting support. The basic toolkit library may then be loaded into any program which uses a Tcl interpreter as a Tcl module, similar to the way Cactvs uses the Tix and BLT extension modules. After loading, the Tcl extensions provided by Cactvs are available in the host application as additional commands. Since Cactvs does not know anything about the internal data structures of the host application, there will be no built-in mechanisms for direct interfacing with the host application data structures. However, data exchange on the Tcl level (such as passing a SMILES string which was generated by CACTvs commands) into a host application command is possible and useful.

Examples:
package require Cactvs
load /the/path/libcactvs.so
This are two methods to load the Cactvs library into a host application. The first example requires a suitable set-up of the host application pkgIndex.tcl file which contains the path information to the shared libraries of available extension modules. The second example is a direct load. In both cases, the environment variables which can influence the operation of the toolkit must have been set-up properly, especially the DATADIR variable.

In both cases, Tclx must be available as a module for the host application, or compiled into it. The Tcl scripting capabilities of Cactvs depend on this extension. When the Cactvs subsystem is initialized, an attempt will be made to load the Tclx package. If it was compiled in, or loaded into the host application before the Cactvs module as accessed, this will automatically succeed. Otherwise, the Tcl library will try to locate this package via its current package path. The best method to ensure that it is found is therefore to enter the load data for the Tclx package into the host application pkgIndex.tcl file if the host application does not already contain it as a compiled-in component.

This approach works with a number of different applications, starting with a plain Tclx interpreter (usually named $t c l$ as executable file), via the Tcl Web browser plug-in to large packages such as the VMD visualization and modelling suite.

## Toolkit libraries without Tcl scripting language support

Versions of the Cactvs toolkit are available which do not contain Tcl scripting language support. Since the core library and the scripting language environment are implemented as clearly separate layers, the removal of the scripting language layer (and potentially its replacement by other language bindings) is relatively painless.

A toolkit library without scripting language support must be programmed by calling C functions. The most important C functions for interfacing are described in a separate library programming document.

Examples for this kind of libraries are DLLs or shared object libraries based on the Cactvs toolkit which provide reduced, specialized functionality, for example for structure depiction or substructure searching. Generally, these libraries include all functionality, such as property definitions and modules, as compiled-in components and do not require any environment set-up or loading of additional modules.

## Interpreter program options

Both the standard script interpreter tclcactvs and the GUI-enabled variant tkcactvs understand a number of options which can be used to modify the script execution.

For tclcactvs, these are:

| - -! | Enable structure security. If this flag is set, structure and reaction information will not be sent over the Internet for computations which invoke external Web services. For academic distributions, this flag is off by default. Commercial packages have it enabled bz default. |
| :---: | :---: |
| - -b | Remove all compiled-in paths from the search paths for extension modules which are dependent on the build environment. |
| - -ccmd | Execute the specified command and exit immediately afterwards. |
| - -Csecs | Set a CPU time execution limit. By default, no such limit is enforced. |
| - -d | Allow the loading of dynamic extensions. By default, only dynamic extension loading from trusted locations, such as the installation directory, are allowed. With this option, additional privately configurable locations which are not in the trusted path will be checked if an extension cannot be found in a standard location. |
| - -D | Similar to option $-d$, but with this option the additional non-trusted private locations will be searched before those in the standard path. |
| - -e | Run scripts with command tracing. Equivalent to executing cmdtrace on as first script command. |
| - -fscriptfile | Execute the script file. When the script finishes, the program exits. By default, if neither the $-f,-c$, or $-u$ options are set, an interactive command line interpreter is started. |
| - -Fscriptfile | Secondary script file sent to the interpreter of the language not executing the primary script (i.e. this would be a Python script if the primary script is TcL. and vice versa). |
| - -h | Print short option help text and exit. |
| - -i0/1/2 | Control Internet access. Level 0 disables all automatic Internet look-up. Level one allows this in computational modules and file I/O modules, but this is further subject to the settings of the host control variables and the structure security flag. Level two enables Internet look-up also for property definitions and modules from Internet sources listed in the search paths.The default level is one. If the level is zero, all Internet host control variables will also be reset to NULL, so that even increasing the look-up level value in a script will not directly re-enable Internet look-ups without also re-initializing the host variables. |
| - -I | If set, enable readline support on interactive shells. This option is not supported on Windows. | supported on Windows.

- -1file
- -kmode
- -Kflags
- -Lurn
- -n
- -pportno
- -Mlimit
- -N
- -0
- -pport
- -P
-     - $q$
- -r
- -R
- -spropertylist

Specify a $\log$ file for capturing property computation $\log$ output. By default, property logs are written to the standard error channel. Note that this file will not capture trace output. Logging and tracing use different file handles.

Specifiy KNIME interface mode.
Set KNIME interface flags. This can be a combination of the words none, streamimport and streamexport.

Define local URN namespace.
If the script fails, suppress error backtrace and just silently exit with an error code.

If the program is running as a server, listen to the specified port instead of port 16520 , the default.

Specify the maximum amount of memory to be used. The argument is an integer, optionally with a ' K ' or ' M ' suffix to indicate kilobytes or megabytes, respectively. By default, no memory limit is enforced.

If the program is running as a compute server, do not fork() the program for the processing of the request. Instead, further requests are blocked until the current request has been finished.

Use pre-resolved object pointers in Tcl value objects. This option can speed up scripts with lots of minor object references by up to $20 \%$, but it will have subtle effects on the re-use of object handle names etc. In general, it is a safe option and most scripts will work without any change under this execution model. However, implicit assumptions about object naming schemes valid for standard scripts may no longer be guaranteed, and there is a risk of breaking code which is not cleanly written.

Set RPC server port. Only ports beyond 1023 (the reserved space) are allowed.

If set, the main interpreter is forced to be a Python interpreter. By default the main interpreter type is defined by the suffix of the primary script, or the name of the executable if no script is processed.

Quick start-up without the loading of any extension modules.
Allow the processing of RPC requests, in addition to script execution or the interactive command line.

Configure for the exclusive processing of RPC requests. Do not attempt to run a script or to start with a command line.

Configure to act as a compute server for the properties in the list (comma-separated). Only base property names following the CaCTvs nomenclature are allowed, no subfields or original names. This option alone will not yet make the interpreter running as a server. It will only

```
- -Sid Set the RPC service ID. This is an expert debugging feature.
- -tvalue Activate subsystem traces. The option value is an unsigned integer.
    Every set bit in this number activates the tracing of a different
    subsystem, which are linked to a different bit position. The subsystems
    are listed below. Trace output is written to the stderr channel on Unix,
    and uses the atlitrace functions on Windows.
- -T Disabled all computation or query time-out and signal processing. This
    is primarily useful when debugging the interpreter with a debugger and
    source code access.
- -uurl Execute a script which is downloaded from a URL. Currently, the toolkit
understands HTTP, FTP, Gopher and FILE URLs.
- -Uusername Run the program and script as the named user and in its primary group.
    This will only work if the program is started as root, and only on Unix.
- -V
    Print interpreter version information and exit.
    Set the RPC program version. This is an expert debugging feature.
    Change the working directory of the program to the specified directory
    before any scripts are executed.
- -x Assume script file is encrypted and use compiled-in key to decode it
    transparently in memory when it is executed.
```

These options can be used both with the standard start script csts as with the raw tclcactvs application. To distinguish between standard interpreter options and application options, the option separator -- can be used. Everything after this separator is passed as application options.

Example:
csts -q -f myscript.tcl -- -q myscript.dat
If called like this, the first $-q$ will be consumed and used as an interpreter option, as is the $-f$ specification, while the second $-q$ parameter is passed to the script environment. For the script, the program arguments, which are stored in the standard global Tcl list variable argv, seem to consist of only two list elements with values "- $q$ " and "myscript.dat", which are read from the argument list after the separator.

The arguments of options which require additional information, such as a file name, may be specified with or without a white space separator between the option character and the argument. Multiple option characters without arguments may be merged, for example as
csts -qfmyscript.tcl -- -q myscript.dat
which is completely equivalent to the sample line above.
The tkcactvs program options a little bit more limited:

| - -console | Start a console window for controlling the main interpreter in a separate window. On Windows, this happens automatically if the program is started without a script. On Unix, the program displays a command line prompt in the start shell if not run with a script via the $-f$ or $-u$ options. |
| :---: | :---: |
| - -crypt | Corresponds to option -x of tclcactvs interpreter. |
| - -dynload | Corresponds to option - $d$ of tclcactvs interpreter. |
| - -file file | Corresponds to option $-f$ of tclcactvs interpreter. |
| - -internet | Corresponds to option -i of tclcactvs interpreter. |
| - -quick | Corresponds to option -q of tclcactvs interpreter. |
| - -namespace $n s$ | Corresponds to option -L of tclcactvs interpreter. |
| - -nobuildpath | Corresponds to option -b of tclcactus interpreter. |
| - -norpe | The inverse of option $-r$ of tclcactvs interpreter. |
| - -trace bits | Corresponds to option - $t$ of tclcactvs interpreter. |
| - -slave | Install a fully chemistry-enabled slave interpreter of the main interpreter. This is required for the editing of property computation scripts in the property editor cspe. |
| - -url url | Corresponds to option $-u$ of tclcactus interpreter. |
| - -wrapper name | Pass the name of a wrapper program which was used to invoke the interpreter. |

In this application, the standard Tk argument parsing routines are used. Therefore, it is possible to abbreviate the full option name to the shortest unique part. For example, using $-f$ is equivalent to the full option name -file. This application also understands the -- option list separator.

## Codes for traceable subsystems

These are the codes for traceable subsystems. Multiple subsystems can be traced in parallel by summing up the codes and using this number for the -t (tclcactvs) or -trace (tkcactvs) program options:

| - $(1 \ll 0)$ | RPC communication |
| :--- | :--- |
| - $(1 \ll 1)$ | General property calculation |
| - $(1 \ll 2)$ | System initialization |
| - $(1 \ll 3)$ | Binary I/O of native Cactvs formats |
| - $(1 \ll 4)$ | Filter processing |
| - $(1 \ll 5)$ | Database operations |
| - $(1 \ll 6)$ | File I/O |
| - $(1 \ll 7)$ | Stereochemistry |
| - $(1 \ll 8)$ | Aromaticity resolution |
| - $(1 \ll 9)$ | Object deletion |

- $(1 \ll 10) \quad$ Connectivity generation from 3D coordinates
- $(1 \ll 11) \quad$ Client/server based property computation
- $(1 \ll 12) \quad$ Basic ring system analysis
- $(1 \ll 13)$ Radical resolver
- $(1 \ll 14) \quad$ Path walking
- $(1 \ll 15) \quad$ Charge resolver
- $(1 \ll 16) \quad$ Substructure matching
- $(1 \ll 17)$ Table operations
- $(1 \ll 18) \quad 2 \mathrm{D}$ layout coordinate generation
- $(1 \ll 19) \quad$ File query operations
- $(1 \ll 20)$ Tree walking
- $(1 \ll 21) \quad$ Native Cactvs structure/reaction database queries
- $(1 \ll 22)$ Extended ring sets
- $(1 \ll 23)$ 3D substructure match operations
- $(1 \ll 24) \quad$ Hydrogen addition and removal
- $(1 \ll 25)$ Structure hash code computation
- $(1 \ll 26)$ Timing and time-outs
- $(1 \ll 27) \quad$ SMILES/SMARTS decoder
- $(1 \ll 28)$ Temporary debugging
- $(1 \ll 29)$ Dynamic extension module loading
- $(1 \ll 30) \quad$ Query parsing and execution
- $(1 \ll 31) \quad$ Reaction processing


## Registry entries on Windows

When the toolkit is installed on Windows, the registry entries listed in the table are set in HEKY_LOCAL_MACHINE. $\{\operatorname{app}\}$ is a place holder for the application installation directory. These registry settings associate the file suffixes.$t c l$ with tclcactvs.exe and.$t k$ with tkcactvs.exe. Stand-alone applications and special-purpose DLL libraries do not create registry entries, nor do they depend on them.

| Path | Name | Value |
| :---: | :---: | :---: |
| Software\Xemistry |  |  |
| Software\Xemistry\CACTVS | basedir | \{app \} |
| Software\Xemistry\CACTVS | blt_library | \{app\} ${ }_{\text {blt }}$. 0 |
| Software\Xemistry\CACTVS | datadir | \{app \} |
| Software\Xemistry\CACTVS | tcl_library | \{app\} \tcl8.6 |
| Software\Xemistry\CACTVS | tclx_library | \{app\} $\backslash$ tclx 8.4 |
| Software\Xemistry\CACTVS | tix_library | \{app\}\tix8.4 |


| Software\Xemistry\CACTVS | tk_library | \{app \} \tk8.6 |
| :---: | :---: | :---: |
| SoftwarelCLASSES\.tcl |  | tclFile |
| Software\CLASSES $\backslash$. tk |  | tkFile |
| SoftwarelCLASSES\tclfile |  |  |
| Software\CLASSES\tclfile\DefaultIcon |  |  |
| SoftwarelCLASSES\tclfile\Shell |  |  |
| SoftwarelCLASSES\tclfile\Shell\Open |  |  |
| Software\CLASSES\tclfile\Shell\Open\Command |  |  |
| Software\CLASSES\tkfile |  |  |
| Software\CLASSES\tkfile\Defaulticon |  |  |
| Software\CLASSES\tkfile\Shell |  |  |
| SoftwarelCLASSES\tkfilelShell\Open |  |  |
| Software\CLASSES\tkfile\Shell\Open\Command |  | " $\{$ app\} \lib\tkcactvs.exe" -f \%1-- \%s |

## Standard Tcl and Tk Packages

Cactvs uses in its script interpreters and application scripts a number of auxiliary Tcl and Tk packages, which are also part of the standard distributions. In addition, any other Tcl or Tk package from third parties may be loaded into a Cactvs interpreter by the native Tcl mechanism (load and package commands).

This is the list of currently used packages:

| Package | Description | Use in tclcactvs | Use in tkcactvs |
| :--- | :--- | :--- | :--- |
| Gd 2.0 | Tk extension - pixel <br> image generation module | Loadable as package | Used by csimg sample <br> application. This Gd <br> package is significantly <br> extended compared to the <br> standard Gd package. |
| Gdbm 1.10 | GDBM file support <br> module | Loadable as package | Loadable as package |
| Itcl 3.4 | Object-oriented Tcl <br> extension | Compiled-in | Compiled-in |
| Itk 3.4 | Object-oriented Tk <br> extension | Loadable as package | Compiled-in |
| Ldap1.0 | Tcl module - <br> communication with <br> LDAP servers | Loadable as package | Loadable as package |
| Tc | TokroCABINET file <br> support module | Loadable as package | Loadable as package |


| Tcl 8.6.1 | Core Tcl scripting <br> language interpreter | Compiled-in | Compiled-in |
| :--- | :--- | :--- | :--- |
| TclBlt3.0 | Tcl extension - various <br> additional functions | Loadable as package | Automatically loaded as <br> package by standard <br> start-up script |
| TclReadline 2.1.0 | Interactive readline <br> command line support | Loadable package, <br> automatically loaded <br> when Tcl interpreter is <br> started with -I option | Loadable package |
| TclX 8.4 | Tcl extension, provides <br> object handle <br> functionality | Compiled-in | Compiled-in |
| Thread 2.7.0 | Tcl thread package | Compiled-in in some <br> interpreter versions, <br> loadable module in others. <br> Automatically loaded <br> when commands such as <br> dataset addthread <br> are executed. | Compiled-in in some <br> interpreter versions, <br> loadable module in others |
| Tix 8.4 | Tk extension - various <br> additional widgets | Loadable as package | Loaded by some <br> application scripts as <br> package |
| Tk 8.6.1 | Core Tk GUI toolkit <br> package | Loadable as package | Compiled-in |
| TkBlt3.0 | Tk extension - various <br> additional widgets, drag <br> \& drop | Loadable as package | Automatically loaded as <br> package by standard <br> start-up script |
| Tk extension - table <br> widget | Loadable as package | Used by QSAR table <br> application csqt, loaded as <br> package |  |

## Major Object Commands

Most of the toolkit functionality is linked to a small collection of objects, providing means to manipulate data and structure of these objects. The core set of objects are called major objects. Major objects may carry property data, and they may control minor objects, which cannot exist without a controlling major object. A major object is addressed in the scripting language environment by its handle.

The Cactvs toolkit currently supports the following major chemistry objects in its standard edition:

$$
\begin{array}{ll}
\text { - ens } & \text { molecular ensembles } \\
\text { - reaction } & \begin{array}{l}
\text { reactions, consisting of reagent and product ensembles, and optionally also } \\
\text { solvents, catalysts, etc. }
\end{array} \\
\text { - molfile } & \text { chemical structure files of any type, not just MDL Molfiles }
\end{array}
$$

- table data tables, optionally associated with ensembles or reactions
- dataset dataset usually consisting of of ensembles or reactions, but can also hold networks and tables
- network universal graph object with nodes and connections for the modelling of complex data relationships

Each object class is associated with a Tcl command which implements the scriptable functionality the object class supports. The name of the command is the same as the object class it represents. The general structure of these commands is
objecttype subcommand objecthandle ?args?
When they are created, major objects are automatically assigned an object handle, which is a short identifier string. The identifier starts with the name of the object class, followed by a number.

Example: ens0 is an ensemble handle.
When an object is destroyed, its handle becomes invalid, and their use will result in an error. However, object handles will be reused in an unpredictable fashion if new objects are created.

Example:

```
set ehandle [ens create CCC]
```

ens delete \$ehandle
will first create an ensemble object from a SMILES string, and then delete it, showing the generic command syntax for major object commands.

## Minor Object Commands

Major objects may contain minor objects. Minor objects are also chemistry objects, but they do not have their own handle. They do not exist outside the context of a major object.

Minor objects are usually identified by a combination of their major object handles and a numeric label. For each minor object class, a default label property exists. Its name is the standard object class property prefix, followed by _LABEL.

Examples:
A_LABEL, M_LABEL, G_LABEL, V_LABEL
Standard minor objects are:

- atom - subobject of ensembles
- bond - subobject of ensembles
- connection - subobject of networks
- group - subobject of ensembles (arbitrary collection of atoms, also recursively including other groups)
- mol - subobject of ensembles
- $\mathbf{p i}$ - subobject of ensembles ( $\pi$ system)
- ring - subobject of ensembles
- ringsystem - subobject of ensembles
- sigma - subobject of ensembles ( $\sigma$ bond system)
- surface - subobject of ensembles (surface elements, optionally related to atom)
- vertex - subobject of networks

Each minor object has a command which is associated with it. The name of the command is the same as the object class.

Examples for these commands:

```
atom get $ehandle 1 A_ELEMENT
bond atoms $ehandle 2
```

Not all subobject classes may be present at all times for any major object. For example, if no ring information was ever used during the history of an ensemble, the ring subobject list will not have been initialized. Whenever a property which is associated with a given type of subobject is requested, the system will check if the subobject class has been set up for the controlling major object and attempt to set it up.

Example:

```
ens get $ehandle R_SIZE
```

may automatically invoke the determination of ring systems if they have not yet been set up. For some subobject classes, for which no computational procedure exists (such as group), the initialization will set up an empty list. Automatic non-void set-up routines exist for rings, ringsystems, molecules, bonds, $\pi$ systems and $\sigma$ systems. In the case of bonds, an attempt will be made to reconstruct a bonding scheme from atomic 3D coordinates, if these are available.

Subobjects may be individually created and discarded. For some cases, such as groups, atoms, or bands, this makes sense. For rings, molecules, etc. this is likely to interfere with the system operations.

Subobject manipulations will have effects on the status of other subobject sets on the same major object. For example, the deletion of a ring atom will remove all groups where the atom was a member, and totally destroy all ring and ringsystem information.Introduction to Properties

Data on chemical objects is stored as property data. Every data item is associated with a property description. Property descriptions may be built-in, loaded from standard installation locations, (depending on the set-up) loaded from Internet sources and databases, or generated ad-hoc by scripting language commands.

CACTvs does not distinguish between built-in property descriptions or those from any other source. It has no fixed data structure for chemical objects, such as a standard set of properties it maintains. For the system, it does not matter if at any given time element information on atoms is stored as a periodic system number, an element symbol, or both. Any property data may be requested at any time. The system will try to find a way to compute the requested data from what is already known about the system by looking at the property definitions and associated computational methods.

Every property is associated with a specific object class - major or minor. Data for this property can only be attached to objects matching that class. The object class a property is related to can be decoded from its initial character. These are the prefixes for the most common object classes:

```
- A_ atoms (of ensembles)
- B_ bonds (of ensembles)
- C_ connections (of networks)
- D_ datasets
- E_ ensembles
- F_ structure files
- G_ groups (of ensembles)
- M_ molecules (of ensembles)
- N_ networks
- o_ surface elements (of ensembles, mnemonic: German Oberfläche means surface)
- P_ }\pi\mathrm{ systems (of ensembles)
- R_ rings (of ensembles)
- S_ \sigma systems (of ensembles)
- T_ tables
- V_ vertices (of networks)
- X_ reactions
- Y_ ringsystems (of ensembles)
- Z_ table cell data (internal use only)
```

Examples:
A_LABEL Atom property
X_IDENT Reaction property

Property data on minor objects is always maintained and updated as a block.
Example:
Either all atoms in an ensemble have valid property data for A_SYMBOL, or none has.

## Property Validity

Property data attach to an object will remain valid once it has been set until either

- The major object is destroyed
- It is explicitly deleted, overwritten, or re-computed
- The major object undergoes a modification which renders the data invalid Example: Atom deletion will delete molecule weight data. This applies also to major objects: Many dataset properties will probably become invalidated when an ensemble is removed from a dataset.
- The values of another property at the same major object change and that property has been listed as input data for the property considered.
Example: If the molecular weight m_WEIGHT changes, the ensemble weight E_WEIGHT is invalidated, since the E_WEIGHT property definition declares it is dependent on M_WEIGHT (all it does in its computation routine is to sum up M_WEIGHT for all molecules).

The behaviour of property data with respect to object or data modifications is part of their property definition record. They may be completely oblivious to any such change, or very sensitive.

Hydrogen addition and removal with the standard commands is treated somewhat different from normal atom and bond manipulation. Since it is assumed that the hydrogen removal is only done for export purposes, to prepare the data for software which still uses the concept of implicit hydrogen atoms, most properties, except those which were explicitly declared to be sensitive also to this operation, will remain valid.

The library was designed to err on the side of caution with respect to the validity of data. Maintaining a consistent data set under all circumstances is a high priority. In case an structure modification operation would result in loss of data which should not happen, it is possible to lock existing property data, or even all data on a specific subobject type on a major object. If locking is active, none of the normal data consistency checks apply to the locked data.

In some cases, locking is inevitable because changing of property data can have cascading irrevocable effects. For example, changing data in the property A_SEARCHINFO will invalidate the element symbols in A_SYMBOL, because some pseudo atoms have specific symbol representations. Invalidating A_SYMBOL however will invalidate A_ELEMENT, and now all atom element information has been lost. In such cases, an essential property such as A_ELEMENT should be requested and then locked until the potentially cascading operation has been completed. For normal structure operations the built-in consistency manager is a clear benefit, not a nuisance.

## Property Naming

Property names in the Cactvs system follow a logical scheme.

- The first character is a prefix, which identifies the object class instances of property data are attached to.
Example: E_NAME is an ensemble property.
- The prefix is separated by an underscore from the remainder of the name.
- The following sequence of letters, digits and underscores is the body of the name. Only upper-case letters are allowed, and the underscore is the only acceptable punctuation character.
- If the body of the property name is enclosed by a pair of asterisks, this is a synthetic property. Synthetic properties are automatically generated under certain circumstances when data needs to be captured, but no descriptor record for the property can be found. This happens for example when reading SD-files with data fields which do not correspond to standard Сactvs properties. A synthetic property has only minimal set of information. In most cases, not even the data type can be established reliably, so the data is stored in neutral form as strings.
Example: E_*SDFIELD1* is a synthetic property.
- The next section which may be present is a pound/hash character, followed by a number. This number is a property ID. Property IDs are a tool to avoid naming collisions. Property IDs may not be generated by normal users defining their own properties. Rather, the idea is to establish a central repository where properties are registered and assigned an unique ID. This ID can be used to break collisions between properties with the same name.
Example: E_IDENT\#1 identifies the built-in system property E_IDENT and no other property of the same name.
- If the name of the property is followed by a percent character, this is a backup property. Some property definitions contain flags which instruct the system to make a backup of the property before it is changed. An example for such a a property are atom labels (A_LABEL). When two ensembles are merged, which often implies atom renumbering of the atoms of the second ensemble in order to avoid collisions, the old labels of the second ensembles are saved in property A_LABEL\%. Backup properties are identical in all respects to the original property, but they are by definition not computable, even if their originator property is.
- If the name of a property is followed by a slash and a number, this is multiple-instance property data. The Cactvs system allows the storage of multiple sets of data of the same property on any major object. The first instance of a property data may be identified by the suffix /1 (as in E_NAME/1), but this is optional (a plain E_NAME selects precisely the same instance). The number suffixes may be freely allocated. It is not required to have a sequence without holes.
Example: E_IRSPECTRUM/3 selects the third IR spectrum.
- Some types of properties may be indexed. A property subfield is selected by attaching a bracketed index identifier.
Examples: E_IRSPECTRUM (INSTRUMENT), E_SCREEN(0)
An index may either be the internal field index, beginning with 0 , or, if the fields have been named, the field name. Field names must be specified in lower-case. All vector types and compound types are indexible, but indexing capabilities are also provided by pseudo-vectors (float pairs, etc.), string (word indexing), bit sets (bit indexing), blobs (single byte access) and other data types.
- Starting with release 3.358, compound and compound vector properties which have fields that are properties themselves may be accessed in a dot notation. Examples:

```
vertex get $nh $v V ONTOLOGY TERM
vertex get $nh $v V_ONTOLOGY_TERM(synonyms)
vertex get $nh $v V_ONTOLOGY_TERM(synonyms.size)
vertex get $nh $v V ONTOLOGY TERM(synonyms.7)
vertex get $nh $v V_ONTOLOGY_TERM(synonyms.7.text)
vertex get $nh $v V_ONTOLOGY_TERM(synonyms.7.dbxrefs.0.db)
```

Individual field elements of compound vectors may be accessed by a element.field notation. This syntax can be used as part of a longer access chain, as shown above. Currently, the maximum number of dot addressing elements that can be used in this syntax is five, the same as shown in the last example.

- Do not use the colon character with a numeric identifier in a property name, such as E_NAME: 2. This feature is reserved for future selection between multiple computation functions associated with a single property definition and not yet officially supported.

All these property name elements may be combined, in the order listed.

## Example:

E_*SOMEDATA*/3(5) will select the sixth word (index begins with 0 , synthetic properties are strings) from the third instance of the data associated with property $\mathrm{E}_{-}$*SOMEDATA*.

Various schemes exists which associate additional names with a property.
All property definitions have an attribute "original name", which may be set to any string. In output operations, Сactvs will generally use this name, if it is set, in preference to the internal system property name. The original name is also used for property identification in input operations. If the name of a data field in an input file matches an original name of a property description, the field data is stored as data of the type and name identified by the matched descriptor record. In many contexts (but not all) an original name may be used as a completely equivalent substitute to the system name when referring to properties and property data. Note however, because there is no control on the used character set, original names cannot be used for indexing, multiple-instance data and other operations which require the parsing of the name into subfields.

## Example:

```
prop set E_IDENT origname Company_ID
```

sets the original name of the built-in standard property E_IDENT to "Company_ID". If an SD file is read afterwards which contains a data field "Company_ID", its data will be stored as property data E_IDENT on the read ensemble.

Properties may also be aliased. A property alias is a redirection mechanism which tells the system that, whenever a specific property name is used, it is substituted by another name. This mechanism allows the convenient mapping of multiple property names as they might be occurring during a processing sequence onto a common internal property. Redirections may happen in multiple steps.

Example:
prop alias E_IDENT E_NAME
If this alias is set up, E_IDENT will only be another name for E_NAME, hiding the original definition of E_IDENT completely. The alias name however does not need to be an existing property name. It may be any name which follows the property naming syntax. Aliases may be layered, i.e. an alias may refer to another alias instead of an original property name, but the alias structure will contain a reference to the original property and not to any intermediate alias name because aliases to the property name are resolved when the command is executed.

Aliases can be removed with a command like
prop unalias E_IDENT
where the arguments are one or more alias names, not the original property names the aliases are referring to (E_NAME in this example).

Some property value types do not allow the full range of field indexing for setting. Currently, the predefined set of fields in property value types P_URL (such as hostname, port, protocol, etc.) and ${ }^{\text {P_DATE (such as year, hour, weekday) may only the read, but not set individually. }}$

## Object Identification

The standard methods for identifying objects have already been presented:

- Major objects are identified by their handle Example: ens get ens0 E_NAME
- Minor objects are identified by a combination of a major object handle and an object label Example: atom get ens0 1 A_ELEMENT

However, the scripting language provides a number of additional methods for minor object identification:

- Identification via backup labels. If a percent character is appended to the label, the label is interpreted as referring to the backup label property. If backup label property data does not exist, an error results.
Example: atom get ens0 1\% A_ELEMENT
- Identification via object list index. Prefixing a number if the pound/hash character implies that the object is the nth object in the object list. The first list element has index 0 . Example: atom get ens0 \#0 A_ELEMENT
- Identification via property value comparison. Any property of the same object class association type as the decoded object may be used in an equality comparison operation. The label argument must be a list consisting of the property used for the comparison and the property value. Note that in case a property value occurs more than once, only the first minor object with the property value is found. The comparison value must be provided in a format which can be decoded to the data type of the comparison property.
Example: atom get ens0 \{A LABEL 1\} A_ELEMENT
- Bond, and only these, may also be identified by a list of the atoms participating in them. Example: bond get ens0 \{1 2\} B_ORDER gets the bond order of the bond between atoms 1 and 2. If no such bond exists, an error results.

The property definitions of the minor object label properties (A_LABEL, B_LABEL, etc.) guarantee that these properties remain valid under almost all circumstances. In case there should be no valid minor object labelling at any time, a default labelling numbering the objects in their list in sequential order, starting with 1 , is generated.

Operations which potentially will result in a label renumbering, for example the merging of ensembles, will save the values prior to renumbering as backup properties (A_LABEL\%, etc.). These backup properties can be used to access data in the new ensemble via saved labels from the old un-merged ensemble.

Whenever labels are generated or minor objects are combined, the system will take care that the primary minor object label values are without collisions.

## Filters

Filters are objects which operate on chemical objects, but are not chemical objects themselves. They are often used to select specific objects from larger object collections, for example atoms with specific properties from the atom set of an ensemble.

Using filters for this kind of selection operation is efficient. Filters have significantly less computational overhead than script commands which retrieve property data and compare it to some values.

The Cactvs system provides a convenient set of built-in filters. Additional filters can be created on the fly, or existing filters be modified, by the filter command.

Filters are referred to by their name. By convention, filter names are simple, self-explanatory lower case strings. However, this is not enforced - filter names may contain blanks and use arbitrary characters.

If a name of a filter is used which is not yet loaded into the system, the toolkit will attempt to find a filter definition file in the filter search path. A filter definition file is an ASCII file which contains keyword/values pairs describing the internal set-up of the filter. The file name is the name of the filter, with a suffix .fil. Filter definition files are usually created by using a filter definition manager, or by generating them by a script and dumping the filter to a file by a script command. If a filter name cannot be resolved, an error is raised.

In its simplest form, a filter consists of a property name, a comparison value, and a comparison operator. For example, the statement

```
filter create carbon property A_ELEMENT value1 6 operator eq
```

defines a simple filter which will check whether the object data for property A_ELEMENT is equal to six. This filter, when applied to a set of atoms, will only let carbon atoms pass. If data of the filter property is not yet present on the filtered objects, it will be computed, it this action is not explicitly prohibited by the filter definition. If the computation fails, the command using the filter will fail.

One of the most interesting features of filters, but also a source of complexity, is their ability to operate on objects whose class does not correspond to the object class the filter property is attached to.

Example:
ens bonds \$ehandle carbon
The application of the carbon filter defined above to the set of bonds in an ensemble is completely legal. Generally, when there is a mismatch between the filtered object type and the property object type, an expansion step is inserted, replacing the original object by a list of objects of the class of the filter property the original object is contained in or participating in. In this case, every bond is internally represented by the (usually 2 ) atoms in the bond, and the property values of these atoms will be compared against the filter value.

Since now more than two comparison take place, the question is what will happen if these comparisons yield different results, for example in the case of a bond between a nitrogen atom and
a carbon atom. In the default case, whenever an object replacement occurs, the filter will let the original object pass when any single replacement object passes the filter conditions. In the example case, a carbon-hetero bond would pass. However, using special filter configuration options, it is possible to write a filter which will only carbon-carbon bonds pass if such a feature is required.

Filter object expansion is supported for all classes of structure and reaction objects.
More examples:

```
reaction ens $xhandle product
```

Get the product ensemble from a reaction.
mol atoms \$ehandle \$label 6ring
Get the labels of those atoms in the indicated molecule which are members of one or more six-membered rings.

Property descriptions may contain filters as part of their property description record. Filters on properties are used to specify a subset of objects the property is defined for - for example, classical atoms only (no superatoms, 3D points in space, etc.), or atoms with valid 3D coordinates.

## Filter Sets and Filter Modifiers

Many commands on chemical objects, especially those performing data retrieval operations, support an optional parameter called a filter set. In some cases, this parameter may be augmented by another parameter following the filter set called the filter modifier.

A filter set defines a set of conditions the requested object must meet in order to have their data returned. The filter modifier changes the kind of data which is returned and may impose additional restrictions on the selected objects.

## Filter Sets

A filter set is a list of filter names. Optionally, the first element of the list may be an integer number. An empty list is equivalent to not providing any filter list at all. Since filter names may contain white space, it is a good idea to quote the names.

By default, the filter list operates in an and mode. All conditions must be met to allow further processing for the request on the object. If the first argument in a filter list is a number, this number indicates the number of filters which let the object pass. Using 1 for this number is equivalent to an or mode. Setting it to 0 effectively disables filtering.

Examples:

```
atom neighbors $ehandle $label carbon
```

atom neighbours \$ehandle \$label carbon
retrieves the labels of all carbon atoms which are bonded to the atom.
ens get \$ehandle A_FORMAL_CHARGE \{1 oxygen nitrogen\}
retrieves the formal charges of all oxygen or nitrogen atoms in the ensemble.
Filters in filter sets may be individually inverted by prefixing their name with an exclamation mark.

## Example:

```
ring get $ehandle $r A_LABEL {!carbon doublebond}
```

will find those labels of the atoms in the ring which are not carbon atoms but do participate in a double bond.

## Simple Filter Lists

In some contexts, not all of the functionality of filter sets is available. Instead, only a simple list of filter names, optionally negated by a prefixed !, is understood. Selecting the number of filters that must match is not possible. All listed filters must let the filtered object pass.

Simple filter lists do not occur in contexts which allow the use of filter modifiers.
Simple filter lists will be gradually phase out and replaced by more powerful filter sets. This change is compatible because filter sets provide an exact superset of the functionality of filter lists.

## Filter Modifiers

A filter modifier is another list, which may be specified as an optional additional parameter after a filter set in some contexts. This list may contain of an arbitrary combination of the keywords count, bool (or boolean), include and exclude. The include and exclude keywords must be followed, as a second list element, by a list of minor object labels.

The count modifier will change the behaviour of the command to return only an object count, not the labels or data of the objects which pass the filter.

Example:

```
ens atoms $ehandle carbon count
```

will return the number of carbon atoms in the ensemble. The bool modifier is similar to count, but will simply return 1 if any object passes the filter set and 0 if not.

The include and exclude lists define a list of objects which are eligible or not eligible for processing. If they are not set, all objects on the major object are processing candidates. An include list specifies objects which will be subjected to the filter test. An exclude list will remove objects identified by the labels therein, but will not block unreserved objects. If both an exclude and include list are specified, only the objects listed in the include list and not the exclude list are processed.

Example;

```
set alist [atom neighbors $ehandle $l1]
atom neighbors $ehandle $l2 {carbon multibond} [list count include $alist]
```

will return the number of neighbors of the atom with the label in $\$ 12$ which are carbon atoms with a multiple bond and are also neighbors of the atom with the label stored in variable \$11.

All objects support a filter subcommand to check whether it passes a simple filter list.
Example:
atom filter \$ehandle \$label [list carbon !aroatom]
will return 0 if the filter set stops the atom, 1 if it lets it passes - which means that it is a non-aromatic carbon atom.

## Obtaining object cross references

The Tcl scripting language environment provides an extensive group of commands to obtain the object identifiers of object which are related to the original object. The relationship may be that of a major object managing minor objects, or an intersection of minor object lists.

Examples:

```
ens atoms $ehandle
bond atoms $ehandle 1
mol rings $ehandle 1
vertex connections $nhandle 1
```

The first command will retrieve the labels of all atoms from the managing major object. The second command gets the labels of the atoms forming the bond. The third example retrieves the labels of all rings which are in the first molecule in the ensemble ${ }^{1}$. The final example shows that these cross referencing mechanisms are not limited to structure data - they are also available in networks, which manage vertices and connections as minor objects.

Within the major object groups of ensemble-related data and network-related data, the full matrix of cross-referencing possibilities is implemented. However, one cannot combine object identifiers from those two realms, i.e. ens vertices \$ehandle is not supported and does not make sense since the result list would always be empty.

Self-references are supported, and are actually useful, because of the possibility to identify a minor object not just by its label.

## Examples:

bond bond \$ehandle [list 1 2]
atom atom \$ehandle \#3
Above examples return the bond label of a bond identified by the labels of the bond atoms, and the atom label of the third atom in the atom list of the ensemble.

Self-references for group objects are a special case, because groups are recursive. A group can contain another group. For this reason, the command
group group \$ehandle 1
will, as the other similarly named commands do, return the group label, while with a plural groups as in
group groups \$ehandle 1
reports the labels of all groups which are contained in group 1, or an empty list if the group only consists of atoms. Because of the variability of the objects which form a group, the statement
group atoms \$ehandle 1 count

1. As a special complication, it is possible to have rings which are not just part of a single molecule, if the bond types which are used for ring detection and separation of atoms into molecules are not identical. The default bond sets are identical, but since the sets may be changed, data analysis and computation routines must not assume that this complication cannot occur.
does not return the correct size of the group, if the group contains other groups. In order to access all objects in a group regardless of the object class, groups have a special objects subcommand, which returns nested lists consisting of the object class name and the minor object label.

Two restrictions on cross referencing major objects exist. First, there are no commands to obtain the label of the controlling major object from a minor object. A command such as atom ens ens0 1 would be really useless, since the controlling major object handle is already needed to address the minor object. Second, hopping from a minor object to a major object which is not the controlling major object is also currently not implemented. Attempts to obtain the reaction handle from an atom participating in a reaction via a statement like atom reaction \$ehandle 1 will currently fail.

It is however possible to obtain major object handles from related major objects via cross referencing. The commands
reaction ens \$xhandle
ens reaction \$ehandle
queue ens \$dhandle
dataset ens \$thandle
and others of this type are all implemented. If a major object is not a part of a referred major object class, such as in case of an ensemble which is not a component of a reaction, these commands will return an empty list. Otherwise, the related major object handles (not the labels, as in cross references to minor objects) will be returned.

From a syntactical perspective, plural forms of the names of retrieved object identifiers must be used if the statement can possibly return more than one result element, and singular forms if only one element can be returned, or alternatively a single element or an empty list. The plural of ens is defined to be ens, the plural of ringsys is ringsys, and the plural of vertex is vertices.

An ensemble can only be a member of a single reaction and/or a single dataset. A reaction can only be a member of a single dataset, but contain multiple ensembles (but the plural does not differ here). Any minor object can only be controlled by a single major object. Rings can (under specific circumstances) be a member of more than one molecule, so the correct form is "ring mols". An atom however can only be a part of a single molecule ${ }^{2}$, so the official form is "atom mol". Bonds of more exotic types which are not used for separating atoms into molecules may span molecules, so it is "bond mols".

For historical reasons, not all of these syntactic singular/plural rules are strictly enforced. However, code written today should adhere to the syntactic rules because backwards compatibility is not guaranteed indefinitely. It is dangerous to write scripts in a way that they expect a single returned identifier when the returned data could possibly be a list of identifiers with more than one element. The distinction between singular and plural forms helps to shape awareness of this issue.

Atoms and bonds provide an additional neighbors subcommand which can be used to obtain information on neighbour objects separated by one or more bonds (spheres) from the requestor object.

The labels returned by minor object cross reference commands correspond to the $x_{-}$LABEL properties ${ }^{3}$, where $x$ is the property attachment class prefix of the object class. In principle, the code examples
2. It is however possible that certain pseudo atoms are not part of any molecule.

```
ens atoms $ehandle
ens get $ehandle A_LABEL
```

are performing the same operation. The direct cross referencing command is somewhat more efficient.

Besides being shorter and more efficient, the direct cross referencing commands provide extended capabilities for filtering the result set. The standard property retrieval commands only support the use of a filter set, while the cross referencing commands support an additional filter modifier parameter.

## Example:

ens atoms \$ehandle carbon count
returns directly the number of carbon atoms in the ensemble. The equivalent expression

```
llength [ens get $ehandle A_LABEL carbon]
```

is significantly slower, because of the property decoding overhead and the required construction of an internal Tcl value list, which is immediately discarded after its length has been determined. Still, this is much better than

```
set cnt 0
foreach a [ens atoms $ehandle] {
    if {[atom get $ehandle $a A_SYMBOL]=="'C"} {
        incr cnt
    }
}
```

In some cases, it is useful to know the position of an object in the object list of the controlling major object. All minor objects provide an index subcommand, which returns this information. The first position is index 0 .

Example:
atom index \$ehandle 99
The index position is not necessarily the same as the label minus one. Labels may be changed by many commands, directly or indirectly, and they do not need to form any uninterrupted sequence. The only requirement is that within a minor object set under a controlling major object, no two minor objects of the same class have the same label. On the other hand, a minor object label does not change if the object is moved around in its object list.

## Computing data for chemical objects

Obtaining data from chemical objects for analysis or export is one of the most important operations of the toolkit.

Generally, the toolkit relies an a lazy computation approach. Date is usually generated only when a specific data item is requested. At this moment, the toolkit will look at what data is already available and the computation function which is associated with the requested property data. If the requested
3. The label property associated with a minor object class is actually configurable, but it is very strongly recommended not to tamper with it.
data is already present, the toolkit library will simple return it. If it is not yet present, it will call the computation function, which will itself request input data, which is either directly returned, or generated in a recursive fashion. When the uppermost computation function returns, either the data has been generated, or the whole process has failed and an error is generated. As a side effect, additional data required by the computational functions will often be generated and attached to chemistry objects involved in the computation. ${ }^{4}$

As long as no events take place which invalidate the data, it remains attached to the chemistry object. The property consistency mechanism used to keep all information in a consistent state and the events which can lead to a discard of previously attached data is described in a separate section of this manual.

In no case the programmer ever has to specify a sequence of explicit function calls to gather data or to prepare input data for high-level functions. These issues are handled in a completely automatic fashion by the underlying toolkit library.

The concept of a computation function is actually rather broad. These are the standard mechanisms used for computation:

- Built-In functions. For the most common properties, the computation functions are built into the core library. Examples are conversion function from element symbol A_SYMBOL to period system number A_ELEMENT and reverse, computing the free electrons A_FREE_ELECTRONS from the number of shell electrons and the bonds an atom is participating in, or getting the molecular weight M_WEIGHT by summing up the atomic weights and isotope labelling information on all atoms in a molecule - potentially automatically initiating the grouping of atoms into molecules at this moment if molecule information was not yet present for the ensemble. Built-in functions are written in C.
- Dynamically loaded functions. Computation functions, together with the descriptions of properties they are serving, may (and frequently are) be kept outside the core library. When the computation function needs to be invoked, a shared object or DLL is located using its name in the property description record and the object search path. If the object could be found, and found in a place which passes security constraints, it is loaded and performs the computation just as a built-in function. Dynamically loaded functions are usually written in C, but may also be written in $\mathrm{C}++$ if the main application was linked with a suitable set of run-time libraries. The build environment of the Cactvs toolkit contains mechanisms to include modules which are usually shipped as separate modules and property description files into a library. This method, in combination with the capability to compile an application script into a $n$ executable, is used to build stand-alone applications which, even though they use properties, computation functions and other extensions outside the core library, do not require a full toolkit installation for these modules and are completely self-contained.

[^0]- Script functions. The computation functions of property descriptions do not need to be written in compiled code. It is possible, and often a very convenient rapid development approach, to code computation functions in Tcl. These functions become an integral part of the property description record and are stored directly in the file containing the description. This, no additional look-up for locating the script code is required. Script functions are executed in a so-called slave interpreter. Every script function set associated with a property is executed in its own slave environment. In this environment, the computation scripts may freely create variables etc. without fear of stepping onto data of the main interpreter running the application script. Slave interpreters may be further restricted in their capabilities, for example by disabling file I/O and Internet capabilities, in order to allow the execution of code from not completely trusted sources in a sandbox environment.
- Distributed computation. The computation of any property computation function, regardless whether it is a built-in function, a dynamically loaded object, or a script function, may be offloaded to another toolkit process. In order to use this feature, the second toolkit process is started with flags instructing it to listen to an RPC port for computation requests. The property definitions used by the primary process are changed in such a way that the offloaded functions are linked to a specific host name and port where the computation server is listening. If a request for a distributed computation arrives, the first interpreter will send a packet of credentials and the required information (which is usually not the full amount of data the requesting process has on the chemical object involved) to the computation server. Depending on the set-up, the second computation server will either directly respond with the result, or try to call the requestor process later after the computation is finished in an asynchronous manner. A mechanism to report results at a time when the requesting process is no longer active using a dedicated mailbox drop is also available. RPC-based property computation is currently not supported on Windows.
- Legacy programs. Such programs are easily integrated into the Cactvs computation scheme by a script wrapper function. The wrapper function receives the handle of the requesting object as input parameter, extracts the data needed by the legacy program, writes an input file for that program, runs it, extracts the result data and attaches it to the chemical object. Because property interpreters are isolated from the rest of the system and from other such interpreters, they may keep state, for example maintaining an open pipe pair to the external program. By this method, restarting the program for every computation request can often be avoided and efficiency be maintained.
- Another method to integrate legacy applications is the use of an alternative representation adapter. Alternative representation adapters are a special class of modules which copy CaCTvs structure data directly into a foreign data structure, calls functions, and extracts information from the updated foreign data structure. To use this feature, the external program must be available as a link library, which is linked to the alternative representation module to build a shared object or a DLL. In case the external library performs multiple functions, interfacing to its functions can be streamlined and automatized by the use of a common adapter module.
- A special class of pseudo-computational properties are those which are configured to automatically set the instance data values to the default values of the property when a computation is requested, without actually invoking any function.
- Property computation requests via the SOAP protocol are currently under development.


## Retrieving chemical object data

Accessing chemical object data is a very common task when writing Cactvs scripts. The scripting language interface provides a common set of access commands which are supported for all chemical objects, both major and minor.

The following access (sub)commands are available:

- get Get the property data in a Tcl-parseable format. If the data is already present, return it directly. If it is not available, attempt to compute it. If computation fails, return an error. If the property definition specifies enumerated value, and the internal property value corresponds to a symbolic enumeration value, the value is returned as string. Properties of data type date will be returned in ISO format (YYYY-MM-DD HH:MM:SS) in readable format.
- dget Get the property data in a Tcl-parseable format. If the data is already present, return it directly. If it is not available, attempt to compute it. If computation failed, initialize the property data to the default value and return these values.
- local Get the property data in a Tcl-parseable format, and always re-compute it, just as in the new subcommand described below. However, if the computation function supports this, and property data is already present, the re-computation is performed only for the single data item identified by the object descriptor, so that only one property value is updated. For example, a few selected property computation functions support the update of data for single atoms, not just the full atom set in an ensemble, which is the default. If the property computation function does not support local updates, the standard re-computation on the full minor object set is performed. The local command is only supported for minor objects, because it is always equivalent to new for major objects, which are by definition the only object in their property data object set.
- nget Get the property data in numerical form in a Tcl-parseable format. If the data is already present, return it directly. If it is not available, attempt to compute it. If computation fails, return an error. Enumerations are ignored, and properties of data type date return the value as seconds since 1970. This number is suitable for use with the Tcl clock format command.
- new Get the property data in a Tcl-parseable format. Always re-compute it. It computation fails, return an error. Note that the re-computation only discards the requested property, but not any more low-level data present which will be used in the computation. For example, for a new request for the ensemble molecular weight E_WEIGHT, only E_WEIGHT property data will be re-computed, but not the underlying $M_{-W E I G H T}$ property data which is used to get the ensemble weight. In order to restart the computation using the atomic weights, M_WEIGHT needs to be explicitly discarded.
- show Get the property data in a Tcl-parseable format. Do not attempt to compute it. If the data is not already valid, raise an error.
- sqlget Same as get, but will return the data formatted with SQL syntax.
- sqldget Same as dget, but will return the data formatted with SQL syntax.
- sq1new Same as new, but will return the data formatted with SQL syntax.
- sqlshow Same as show, but will return the data formatted with SQL syntax.

If the descriptor record of a requested numerical property contains enumeration information, and the numerical property value within the range of the enumerated set, symbolic names of the stored numeric values are returned and not the internal numerical value.

## Example:

bond get [ens create CC] [list 1 2] B_TYPE
will return the bond type name normal, not the integer value 2 which is internally used. In some cases, numerical values are preferable. The nget data retrieval command variation will always return the raw numerical data:

```
bond nget [ens create CC] [list 1 2] B_TYPE
```

This command will simply return " 2 ". There is no corresponding sqlnget command variant, because the SQL formatting will always use the numerical values.

Only a small fraction of property computation functions support local updates for single minor objects. Whether the computation function associated with a property supports this functionality or not can be checked with the following code snippet:

```
set does_local [lcontain [prop get $prop flags] localupdate]
```

Examples for functions which do support this feature are the built-in functions associated with the properties A_LABEL_STEREO, A_MAP_STEREO, B_LABEL_STEREO, B_MAP_STEREO and B_FLAGS.

## Data retrieval commands

The access commands for major objects will need the object handle and the property name as identifier, while access command for minor object use the standard combination of major object handle and minor object label.

Examples:

```
ens get $ehandle E NAME
atom show $ehandle $label A_SYMBOL
```

The retrieval of property data via an object which is not in the same class as the one the property data is associated with is fully supported and in many cases an elegant solution for a variety of problems. The rules for property access via non-matching object classes are the same as for cross-referencing objects.

Examples:

```
ens get $ehandle A_SYMBOL
bond get $ehandle $label A_SYMBOL
mol get $ehandle $label R_SIZE
```

These statements will retrieve the element symbols of all atoms in the ensemble, the symbols of the atoms participating in the bond, and the sizes of all rings which are contained in the molecule.

Retrieving lists of property data items is generally more efficient than individual requests. So, instead of writing a loop like

```
foreach a [ens atoms $ehandle] {
    set sym [atom get $ehandle $a A_SYMBOL]
}
this loop is preferable:
foreach sym [ens get $ehandle A_SYMBOL] {
    ...
}
```

In cases where both the label and the symbol is needed, it is worthwhile to remember that the Tcl foreach loop instruction supports the walking of multiple lists in parallel:

```
foreach a [ens atoms $ehandle] sym [ens get $ehandle A_SYMBOL] {
}
```

Identical to the mechanisms used in object cross referencing, the returned objects may be filtered by a filter set. However, unlike object cross referencing, the data retrieval statements do not support the second optional filter modifier argument.

Examples:

```
set msizelist [ens get $ehandle M_NATOMS heterocycle]
set rsizelist [mol get $ehandle $mlabel R_SIZE heterocycle]
```

The first example will return the number of atoms in all molecules which contain one or more heterocycles. The second statement yields a list of the size of all heterocyclic rings in the selected molecule.

It is possible to retrieve more than one property by a single command. In this case, a nested list is returned.

Example:

```
ens get [ens create C] [list A_SYMBOL A_NEIGHBORS]
{C H H H H} {\begin{array}{lllllll}{4}&{1}&{1}&{1}&{1}\end{array}}
```

Above statement will return a list which has two sublists: The first sublist contains the element symbols, and the second list contains the number of neighbors of that atom.

It is even possible to mix the association classes of retrieved properties:

```
atom get [ens create C] [list A_SYMBOL B_ORDER]
```

C $\left\{\begin{array}{llll}1 & 1 & 1 & 1\end{array}\right\}$

The returned nested list contains a single element symbol for the selected atom in the first sublist, and the bond orders of all bonds the atom is participating in is returned in the second sublist.

## Setting of property computation parameters

As a final parameter after the optional filter list, it is possible to specify a list of name/value pairs for the computation of the requested property. If the data is already present, the specified computation parameters are checked against the saved computation parameters which were used for computing the existing parameters. If any discrepancy is fund, the property data is re-computed with
the new parameters. Only specified parameters are checked - parameters which are not mentioned in the requested parameter list and which are present in the saved parameter set will not trigger a re-computation. Implicitly, the parameters which are used in the computation request are also set as default for future computations inside the property definition data structure.

Example:
ens get \$ehandle E_GIF \{\} [list height 200 width 200]
This line will always return an image with height 200 and width 200. If an image of a different size is attached as E_GIF property data to the ensemble, it will be discarded. This command will not change the current global parameter setting of property E_GIF. Parameters not listed in the parameter list will be taken from the global settings of $E_{-} G I F$, but any parameter which is set locally in this statement will be active only for the execution of the command.

Note the use of an empty filter set as fifth word in this example. This empty parameter is required to skip the filter set parameter argument position. An empty filter set is equivalent to omitting the filter set altogether.

The parameters which are recognized depend on the property. Names of parameters which are not used by the computation routine for the requested property are ignored. The names of parameters recognized by a property, as well as its current settings, can be obtained by calling

```
prop get E_GIF parameters
prop get E_GIF defaultparams
```

Both commands return a name/value list of parameter names and values, which can be stored in a Tcl array via an array set command. The first version returns the current parameter setting, while the second returns the default setting. Individual values can be obtained via commands like
prop getparam E_GIF width
prop getparam E_GIF height
Property computation parameters can also be set directly on the property definition structure, via commands like

```
prop setparam E GIF height 200 width 200
```

The setparam subcommand of the prop command allows the manipulation of individual parameter values, just like the getparam subcommand is used for extracting specific parameter values. Using the get or set commands on the parameter attribute, which is only one of a large number of attributes which form a property definition, will retrieve or set the complete parameter list in one step.

The prop set and prop setparam commands change the parameter values of a property globally within the current program. The changes remain active until the program is terminated, or until they are overwritten by additional commands, or a reloading of the property definition. They will not change the parameter settings persistently - when a new interpreter is started, it will use the original parameter settings. The only way of changing property parameters permanently is by editing the corresponding property definition files.

Resetting parameters to the default value is easily done via statements like

```
prop set E_GIF parameters [prop get E_GIF defaultparams]
```


## Property metadata

The toolkit remembers the parameters property data was computed with, and numerous other information about the history and origin of data. Some parts of this meta information may also be edited or augmented by script commands.

All commands to work with metadata are used with major objects only. This makes sense since properties are always computed or otherwise set up for all minor objects of a major object in a concerted action.

The generic command to access property metadata is the metadata subcommand for major objects:

```
ens metadata $ehandle E_GIF
ens metadata $ehandle E_GIF comments
ens metadata $ehandle E_GIF comments "this is a beautiful picture"
```

Note that this will work with all major object types, such as tables, reactions, or networks, if you use the corresponding object command and object handle. The first example will return a list of keyword/value pairs of all metadata. It can be stored in a Tcl array variable by means of a array set command:
array set gifparams [ens metadata \$ehandle E_GIF]
The second example will selectively return the value of the comments field in the metadata record. The third line shows how to set a metadata field.

The standard fields for property metadata are:

$$
\left.\begin{array}{ll}
\text { - parameters } & \begin{array}{l}
\text { The parameter set used for computation, as a list of keyword/value } \\
\text { pairs. }
\end{array} \\
\text { - info } & \begin{array}{l}
\text { Information about events which happened during computation as a } \\
\text { string. }
\end{array} \\
\text { - flags } & \text { Free-text comments as a string. } \\
& \begin{array}{l}
\text { A standard set of flags indicating status. Usually, this field is none, } \\
\text { but it can be a list of the values unreliable (applicability of } \\
\text { computational method questionable, but not a hard error), remote } \\
\text { (computation underway on remote server), async (remote } \\
\text { computation in asynchronous mode), interpolated (data is not in } \\
\text { original grid, but was interpolated from other data points not on the } \\
\text { grid), reagent (applies to reagent side of a reaction), product (applies } \\
\text { to product side of a reaction) and unoptimized (basic data was }
\end{array} \\
\text { successfully computed, but successive optimization/smoothing steps } \\
\text { failed). }
\end{array} \quad \begin{array}{l}
\text { This is not the property base unit (which can be obtained via a prop } \\
\text { get } \$ p \text { unit statement), but rather the unit for grid points of } \\
\text { multi-dimensional properties. This field is not available for non-grid } \\
\text { data. As an example, the base unit of a property might be fractions of }
\end{array}\right]
$$

- xrange, yrange... The low and high limits of the coordinates for grid data on each axis, in the units defined above. Not available for non-grid data. This parameter is a pair of floating-point numbers, or empty strings if the low/high bounding data is unknown. The coordinate axis names are $\mathrm{x}, \mathrm{y}, \mathrm{z}, \mathrm{w}, \mathrm{u}, \mathrm{v}, \mathrm{a}, \mathrm{b}, \mathrm{c}, \mathrm{d}, \mathrm{e}, \mathrm{f}, \mathrm{g}, \mathrm{h}$ in this order. Only the coordinates up to the declared number of dimensions are output.

The dimension count and coordinate ranges cannot be changed.
Additional parameter keywords in the parameters metadata field may be conveniently set on existing property data with the setparam command:

```
ens setparam $ehandle E GIF mimetype "image/gif"
```

This command will also overwrite existing keywords in the parameter set. This is a convenience function - it could be replaced by first getting the full parameter list, manipulating it, and writing it back as a whole.

There is also a corresponding getparam command:

```
ens getparam $ehandle E_GIF width
ens getparam $ehandle E_GIF format
```

The first line of code will selectively return the value of the width parameter which was used during the computation of the E_GIF property and which reflects the image width ${ }^{5}$. The second example line of code will report the image format, which can actually be gif, png or various Windows bitmap types. Note that every property has its own parameter set, which can be obtained via a prop get $\$ p$ parameters statement. These examples are not directly transferable to other properties.

The native Сactvs file formats store and thus preserve property metadata. Unfortunately, none of the standard structure exchange formats provide similar functionality, so this information is lost when importing or exporting structures and other data objects in non-native formats.

The metadata command may be abbreviated to meta. The deprecated alias propenv is also still supported.

## Indexed access to property data

As it has been explained in the chapter on property naming, many properties allow indexed access to subfields of the property. The precise meaning of indexed access depends on the data type of the property in question. Some examples:
ens get \$ehandle E_FILE(name)
The first example line demonstrates the subfield access to a compound property. E_FILE is a property which is automatically added by the structure file input routine. If contains the name of the file the structure was read from, the record number before and after reading the data ${ }^{6}$, the line number of the beginning of the read file section, and the file format name. The file name is stored

[^1]in the field named name of the E_FILE compound data structure, and may be accessed directly by specifying its name. If the full property data without indexing is returned, a list of all the data fields is returned. The name of the field is set in the property definition record for e_file. Alternatively, its numerical index, which is 0 , could have been used. Using the symbolic name is generally preferable, since it makes the code more readable and the name will not change if fields are added or removed from a later version of the property definition.

```
ens set $ehandle E_NAME "a b c"
ens show $ehandle E_NAME(1)
```

The second indexing example shows the use of a numeric index on a string property. This example will return the second word (the index positions begin with 0 ), which is "b".

Finally, the statement
ens get \$ehandle A_XY(x)
will only return the X -coordinates of the 2D display coordinates of the compound.

## Property computation requests without data retrieval

In some cases, a script is not interested in accessing the data items, but just wants to make sure that certain property data is present. This can be achieved by the need subcommand:
ens need \$ehandle A_LABEL_STEREO
This command will not return the actual data values, but start a computation if the data is not yet present. If the computation fails, an error is raised. It is possible to use a property name list instead of a single property name.

Optionally, a processing flag list and a computation parameter list may be specified as well:

```
ens need $ehandle E GIF recalc {width 200 height 200 bgcolor white}
```

The mode flags argument may be empty, or any combination of the flags recalc (force recalculation), reload (force reloading of computation module if it is an external module), default (no computation, just set to default, but preserve if already present), reset (make sure that property is attached, and reset to the default value), ifcomputable (compute if possible, otherwise set to default), defaultonerror (if computation raises error, reset to default but ignore error), plus a couple of undocumented specialist options mainly intended for debugging.

## Checking data presence and applicability

The valid subcommand is available for major objects to check whether a property is valid for that object.

Example:
ens valid \$ehandle A_ISOTOPE
ens valid \$ehandle E_NAME
expr \{! [catch \{ens show \$ehandle E_NAME\}]\}
the first two code lines will return 1 if the properties A_ISOTOPE or E_NAME are part of the data attached to the ensemble, 0 otherwise. Note that this query always operates on the controlling major object. This is due to the fact that either all minor objects under a major object have a valid property value, or none has, so that an individual check on a minor object does not make sense. The third code
line performs the same operation as the second one in a convoluted way - the show subcommand will raise an error if it is used on non-existing data.

However, having a valid property as part of the major object data does not necessarily mean that the property is defined for an individual object. It may well be that, for example because an atom is of an exotic pseudo-atom type, some property data for such pseudo atoms has no meaning. Usually, the property value for these objects will be the default value of the property, or be set to a magic number, but this is not reliable. The simplest way to check whether a property is actually meaningful for an object is to use the defined subcommand.

## Example:

```
atom defined $ehandle $label A_XYZ
```

will return 1 or 0 , depending on whether the concept of 3D coordinates is defined for that class of atom, or not. Limitations to the applicability constraints of properties are implemented as a filter set which is part of the property definition. An empty filter set does not impose any applicability constraints.

Currently, the property management mechanism do not support explicit nuLL values on chemistry objects. Table element data is an exception - tables already support the notion of unset data on rows, columns and cells, but not in table-global property data. This feature will be added in generic form in the near future.

## Setting property data

The scripting language interface provides three subcommands for setting data on chemical objects. These subcommands are available for all major and minor chemical objects.

- set Create new property data information. If the data is already present, it is overwritten.
- append Append property data information. If the data is not yet present, it will be computed and the new value appended to the computed data.
- fill Essentially the same as the set subcommand, but the value list may be shorter. The missing elements are initialized to the default value of the property.

The precise meaning of "appending" data depends on the data type of the property values which are manipulated. The following rules apply:

- For vector data types, the new data is appended by adding elements to the vector.
- For string data, the new data is appended by concatenating it to the current value.
- For numerical data, both integer and floating point types including hashcodes, which are 64 -bit unsigned integers, the new value is numerically added to the old value.
- For bit sets, the bits in the new data are bit-ored to the existing value.
- For tree-type data (data and query trees), the new value is linked as a new child of the topmost tree node. If the old tree did not have any nodes, the new data becomes the tree.
- For other data types, append is treated as set and will just replace the old value.

The rules are applied in this order, meaning that for example float vector data will be extended by adding new vector elements, not by adding the two vectors. Other behaviours can easily be enforced by requesting the data item with a get command, manipulating it by any method, and then overwriting it with a normal set command.

Examples:
ens set \$ehandle E_NAME "New "
ens append \$ehandle E_NAME "lead"
After these two commands, the ensemble name will be "New lead".
It is possible to set or append to indexed fields of property data selectively without changing the rest of the data.

Example:
ens set \$ehandle E_NMRSPECTRUM(instrument) "Bruker PaceMkrStopper 2003 Ultra"
More than a single property can be set in one command. After the object has been identified, an arbitrary number of property and data pairs may be used as arguments.

Example:
atom set \$ehandle \$label A_COLOR red A_FLAGS boxed
The associated property class of the modified property does not have to correspond to the class of the manipulated object. If there is a discrepancy, the same object replacement algorithm as in object cross referencing and object data retrieval is invoked. If the set or append methods are used, the number of values passed in must correspond to the number of objects after substitution. In case of the fill method, superfluous data items are ignored, and missing data items substituted by the property default value.

Example:
bond set \$ehandle \$label A_COLOR [list red red]
This command sets the colour of the two atoms which form the bond (assuming it is a standard bond with two atoms) to red. Using more than two colour data items, or less, will result in an error.

## Property data consistency manager issues

The toolkit has an automatic mechanism to keep the overall property data set in a consistent state. Property definitions contain information about underlying, more basic properties the values depend on. When property data is changed, all other properties which rely on the changed value will be purged. The process is recursive, and all properties whose data was invalidated in the first generation will be submitted to another round of dependency checking. Changes on core data such as the element number will result in the loss of most ensemble information.

In some cases, this mechanism can overshoot. A common example is setting of A_SEARCHINFO atomic query data. Example:
atom set \$ehandle \$label A_SEARCHINFO(ringcount) [expr ~1]
This line sets the match condition that the atom must be a member of one or more rings. However, the molecular ensemble will afterwards most likely become almost unusable. The reason is that A_SYMBOL, the atomic symbol, depends on A_SEARCHINFO, because special symbols such as ? for an
any atom, or $L$ for an element list are produced when A_SYMBOL is computed from basic information, which includes the properties A_TYPE, A_ELEMENT, and A_SEARCHINFO. Now, when A_SYMBOL is invalidated, A_ELEMENT is also in the next round of dependency checking, because A_ELEMENT is computed from A_SYMBOL when it is not present. Thus, we end up with neither A_ELEMENT nor A_SYMBOL and have lost all element information and there is no way to re-compute the information. The next time element information is needed, an error message about possible infinite recursion will be generated, because the toolkit is caught in a loop trying to get A_ELEMENT from A_SYMBOL, and A_SYMBOL again from A_ELEMENT.

The way to prevent this from happening is to lock the element information:

```
ens lock [ens need $ehandle A_ELEMENT] A_ELEMENT
atom set $ehandle $label A_SEARCHINFO(ringcount) [expr ~1]
ens unlock $ehandle A_ELEMENT
```

The first line makes sure that A_ELEMENT is present, and then locks it, making it insensitive to the normal dependency checks. After setting the query data, the element information is unlocked again and put back under the control of the data manager.

Fortunately, in most cases the property data consistency manager does not interfere in unexpected ways and setting property data is straightforward.

## Object Attributes

Not all data attached to chemical objects is stored as property data. Internal state information of the objects are accessible as attributes, not as property data.

An attribute can be distinguished from a property by the name. Object attributes are always simple, lower case, single words. These cannot be confused with property names in Cactvs nomenclature, since these are always written in uppercase. Attributes cannot be indexed. In case of a collision with an alternative property name (such as a data field name from an SD file, etc.), the object attribute has precedence in the identification process. The attribute set for each object class, which is directly linked to the object data structure, is fixed and cannot be changed without recompilation. There are no definition records or other meta-level description mechanisms for attributes.

The number of attributes associated with a chemical object is highly dependent on its object class. Structure file objects have dozens of attributes, but usually no or very few properties. Ensemble objects typically store a rich set of property data, but have only very few attributes. Most minor objects possess no attributes at all, since their state is generally managed by their major object and they cannot exist without it.

The object attribute access commands are the same as for object properties. All retrieval commands for attributes return the attribute value in Tcl format, without any mechanisms to change the formatting. Most attributes only support a simple set operation. The only exception are bit sets, which also provide an append method to allow the addition of specific attribute bits. Attributes may only be queried and manipulated directly on the current object. Implicit or explicit cross-referencing to other objects is not supported. Many attributes are read-only, but not necessarily constant. In some cases, changing the value of an object attribute will result in major internal reorganization, which can have far-reaching side effects.

A few selected object attributes are saved and restored if native Cactvs storage formats are used, but not all. For example, the ensemble modification count attribute is not saved. It is reset to zero when an ensemble is created, and is already incremented during the initial input process, regardless of the file format read. Traditional chemical information exchange formats will not preserve any object attributes.

Examples:

```
set fmt [molfile get $fhandle format]
molfile set $fhandle format sdf eoltype unix
molfile append $fhandle readflags noimplicith
ens get $ehandle modcount
```


## Atoms and Bonds

The Cactvs library has a very broad view of what atoms and bonds are or could be. Scripts should be written to be prepared to cope with unexpected atom and bond types.

The atom and bond types are declared by values of the properties $A_{-} T Y P E$ and $B_{-} T Y P E$. These are essential properties and should never be deleted. Both properties are encoded as bit positions on a 32-bit integer. All acceptable values of the type properties are powers of two. A type declaration has only a single bit set, but in other contexts multiple bits may be set to form a mask of acceptable or unacceptable types. In principle, it is possible to declare new atom and bond types at runtime.

The type property only defines the general class of the atom or bond. For example, an atom with A_TYPE normal will be fully defined only by additional data in properties A_ELEMENT and/or A_SYMBOL, possibly A_ISOTOPE, A_FORMAL_CHARGE and/or A_FREE_ELECTRONS plus bonding information, and so forth.

## Atom types

These types of atoms are supported in the standard toolkit distribution:

- normal (1) A standard atom with an element number. This is what is usually considered an atom. It is the only type of atom where electron counting is performed for bonds.
- search (2) A search specification, such as an any atom, or a list of possible elements. The query data is stored in property A_SEARCHINFO.
- epair (4) An electron pair. This type of pseudo atom is usually generated as result of reading certain modelling software files. The Cactvs toolkit does not natively encode electron pairs as pseudo atoms.
- 3dpoint (8) A point in 3D space without a nucleus. Examples are grid points with property data such as NMR shielding, or a point in space used as reference in 3D substructure searching.
- super (16) A superatom, which is a placeholder for a larger group of atoms. Known superatoms may be expanded.
- delocanchor (32) A 2D or 3D point related to a delocalized $\pi$ system. An example where this is used are charge symbols placed in the vicinity and connected to a $\pi$ system with a delocalized charge for depiction purposes.
- polymer (64) A generic polymer, for example a bead in solid phase synthesis. The standard depiction methods in the toolkit allow the display of these pseudo-atoms as a bead.
- annotation (128) A generic placeholder for non-structural annotations to a 2D or 3D depiction, such as comments, arrows, etc.
- open (256) A generic placeholder for an open valence. These are generated by reading certain data sources - Cactvs does not encode open valences by itself as pseudo atoms, but as atom attributes.
- enzyme (512) A generic placeholder for an enzyme or peptide. This type has been used for the modelling of metabolic pathways.

From this list, only the types normal, search, 3dpoint, super and polymer are routinely encountered. Some of the more exotic types were introduced only for specific projects and should not be considered fully supported in all contexts.

## Bond types

This is the list of standard bond types:

- $\operatorname{link}(1)$ A neutral indication for a relationship between the involved atoms.
- normal (2) A standard valence bond. This is the most common type of bond. The electrons needed for the bond are automatically subtracted from the A_free_electrons count of the involved atoms (if these atoms are normal atoms) when the bond is formed. Likewise, the standard commands for bond manipulation will update the atom electron counts when changing the bond order B_ORDER, or cutting the bond.
- hydrogen (4) A hydrogen bond (not a bond to a hydrogen atom - these are encoded as normal VB bonds).
- dative (8) A dative bond. This bond type is treated slightly differently from the more common complex bond type. For example, it is not contained in the set of bonds which are used to define molecules.
- 3center (16) A three-centre bond, as they are for example found in boranes. Note that this bond contains three atoms!
- angle (32) A pseudo-bond used to encode bond angle information. This bond contains three atoms. The middle atom is the atom for which the angle to the other two atoms is computed. It it not required that normal bonds between the first and middle, or the middle and third atom exist, so this construct can be used to measure the angle of any atom triangle.
- torsion (64) This pseudo bond is very similar to the angle pseudo bond. It is used to store torsion angle (the angle between the plane formed by the first three atoms and the plane formed by the last three atoms) information. This bond contains four atoms. It is not required that there are any normal bonds between the atoms which form this pseudo bond.
- rgroup (128) This bond links one or more alternative R-groups to a core fragment. It is for example used in substructure searching where different substituent groups are possible. The first atom in the bond is part of the core fragment, all other atoms are the link atoms of alternative fragments.
- nobond (256) This bond type is used in substructure searches. It declares a bond which must not be present in a matched structure.
- deloc (512) This uncommon pseudo bond type is used for the encoding of delocalized systems. It is generated by reading data from certain data sources like the SpecInfo database which use this bond type for the encoding of delocalized charge or tautomer systems. This bond type, which was introduced for a specific project, is not fully supported in all contexts and should be avoided.
- complex (1024) A generic complex bond. It is the preferred method to encode metal complexes. In most respects, it behaves like a normal VB bond, but electrons for bonding are not counted or consumed. The standard Cactvs display modules will depict these bonds as dotted lines, without a need for setting this attribute bit in B_FLAGS explicitly.

The most common bond types are normal and complex. The file I/O routines of the toolkit contain routines to convert almost any compound into a reasonable representation with a mixture of normal and complex bonds.

## Bond class sets

The sets of bonds which are used to sort atoms into molecules, and to find rings in ensembles, are configurable as a bit mask, for example via the global control array elements ::cactvs (molbond) and ::cactvs (ringbond). The standard set of molecule-defining bonds consists of normal, 3center and complex. This is also the standard set of ring bonds. Note that these bond sets are indeed independent - under the right circumstances, it is possible to have rings which span multiple molecules.

Another important bond set is the set of persistent bonds, which may be modified via the control variable : :cactvs (persistbond). This set contains by default the bond types normal, nobond, 3 center, rgroup and complex. Only bonds of these types survive any modification of the bond list. Pseudo bonds such as torsions and angles will automatically disappear whenever the bond list is edited.

## Aromatic bonds

There is no aromatic bond type in the Cactvs toolkit. Internally, aromatic systems are managed as a Kekulé structure with single and double bonds. However, Сactvs is of course aware of bond aromaticity. This information is encoded as additional properties B_ISAROMATIC (a boolean flag)
and B_ARORING_COUNT (integer, number of aromatic rings the bond is a member of). The toolkit contains a aromatic system resolver, which will automatically generate a Kekulé form from data sources which encode aromatic bonds explicitly as such. The original aromaticity information is preserved as B_ISAROMATIC property data. In the other hand, aromaticity will be detected if the properties are not yet present, so simply using B_ISAROMATIC data in any context will implicitly trigger a ring system and aromaticity analysis if this has not yet been done.

One common problem encountered upon reading data from MDL Molfiles is a misinterpretation in the proper encoding of aromatic bond information in these files. The MDL bond type 4 is, according to the official MDL documentation, a query bond type, and properly read as such by the toolkit. A normal single bond will be generated, and an addition an attribute flag in B_SEARCHINFO is set to make sure that this bond will only match an aromatic bond in a substructure match. However, no Kekulé structure is generated, and such structures appear to have all single bonds. Structure data in Molfiles with aromatic bonds should be written in Kekulé form by conforming programs generating the output. In case aromatic bonds were nevertheless mistakenly output as type 4, the resolver must be invoked explicitly:

```
set fh [molfile open sloppy.sdf r aroresolver 1]
set eh [molfile read $fh]
```

The aromaticity detector of Састvs generally works well, but does not in all cases have an identical opinion as other structure processing toolkits on the question whether a given system is aromatic or not. As an example, the Daylight toolkit has a broader idea on what aromatic systems are than Cactvs. For Cactvs, rings with exocyclic keto groups cannot be aromatic because the $\pi$ system is not cyclic, but for Daylight apparently every ring where all member atoms participate in $\pi$ systems is automatically considered aromatic. For substructure matching, a special mode has been implemented to allow to compensate for this difference in the perception of aromaticity, but in other contexts developers need to be aware of potential differences.

## Query bonds

While there is an explicit atom type search, no explicit query bond type exists, with the exception of the special case of the nobond bond. A bond always has a primary type, which usually is a standard single VB bond, or a link bond in case problems with electron counting need to be avoided. Bond query information in then stored in property B_SEARCHINFO. Fields in that property will, for example, allow overriding of the actual bond order in the substructure by a list of acceptable bond orders and bond types in the matched structure. If no such attribute is set, the actual bond order must match the bond order in the structure, with special consideration given to aromatic systems where bond orders are not compared directly.

## Bond set-up

Under most circumstances, bonds will be present when an ensemble is generated, and they remain present as minor object set throughout the lifetime of the ensemble.

However, this is not an absolute requirement. The minor object group of bonds may be absent from an ensemble, just like rings or molecule, and the toolkit has a built-in mechanism to set up bonds as a minor object group whenever they are needed.

If bonds are required but not present, an attempt will be made to generate them by an analysis of atomic 3D coordinates. The degree of success for this automatic 3D structure analysis varies. I is beneficial to have structures with a full set of hydrogen atoms.

Whenever files which do not contain bonding information are read (such as .xyz files, or some PDB files), the bond generation algorithm is automatically invoked.

Because of the possibility to use pseudo bonds such as torsional angles or bond angles, the bond set of a structure may change even without any structural modifications. Applications should always filter the bond sets they are working on by the bond and atoms types (properties B_TYPE and A_TYPE).

## Ensemble Minor Objects

Besides atoms and bonds, which form the backbone of an ensemble, ensembles may control an open set of additional minor objects. In principle this set is designed to be extensible, but currently no scripting language interface to minor object class extensions exists.

When an ensemble is input, directly as an ensemble or indirectly as a part of a larger structure such as a reaction, dataset, or as attached property data, in almost all cases the standard minor object sets of atoms and bonds is set up.

## Automatic initialization

Other object classes are usually not initialized. However, these object sets are set up whenever property data for that object class is requested, either directly or indirectly by some recursive computation function. For example, atoms are often not sorted into molecules. The first time a molecular property is accessed, for example by requesting M_WEIGHT, or executing an ens mols command which implicitly uses M_LABEL, the toolkit will perform assign the atoms to molecules, and set up molecule minor objects, one for each molecule found. These molecule objects then act as anchors for the attachment of molecule properties, such as M_LABEL or M_WEIGHT.

The same system is used for rings, ring systems, $\pi$ systems, $\sigma$ systems, etc. Not all minor object types have set-up functions which actually generate objects. For example, the set-up functions for groups will initialize the group control structure, but not actually generate any default set of groups because there is no standard procedure to generate an initial set of groups.

## Loss of minor object sets

In contrast to atoms and bonds, which are very stable with regard to structural modifications and are rarely completely discarded, this is generally not true for other minor object sets. For example, molecule, ring and ringsystem information is completely discarded whenever a bond is made or broken, without any deep analysis whether this operation results in an actual change of molecule or ring information. Rings, ringsystems and molecules are regenerated in a lazy fashion whenever their presence is required the next time. Some specialized operations which are technically speaking atom and bond changes will however preserve additional information - for example, hydrogen addition via hadd commands will not destroy ring information because these commands will never change the ring set.

Not all minor object types are completely destroyed as a result of atom and bond changes. For example, groups are more robust - when an atom is deleted which is a member of a group, that group
(and potentially other groups which contain the group as elements) is deleted, but not the complete set of groups. The behaviour of a minor object class depends on the class-specific handler function.

## Locking of minor object sets

It is possible to lock minor object groups, and thus make them insensitive to structural changes. In case a minor object whose list is locked stores object references, and a referenced object is deleted, the minor object containing the object is deleted instead of the full minor object list. This is a recursive procedure. Under certain conditions, this will work as expected. For example, it is simple and convenient to lock the ring information if the programmer knows for certain that all structure manipulations which are performed during the lock will not change the ring set for the structure. If however an atom is deleted which is a ring member, the rings containing the deleted atom are themselves deleted, resulting in an incomplete set of rings. Since the set of rings is still considered to be set up, rediscovery of the ring set will not automatically happen and must be initiated manually - and this requires that the developer is aware of what happened. For this reason, locking of minor object sets should not be considered a routine procedure.

## Properties set as result of automatic minor object set-up

The discovery process of minor object sets will set a number of properties on these objects, and potentially on other types minor objects of the controlling major objects. In all cases, the label property for the identification of the minor object is initialized.

All label properties, when initially set, number the objects controlled by the major object in a sequence starting with one. After that, the object label is never automatically changed as long as the object is in existence. Very few exceptions exist, such as the merging of ensembles and similar operations, where minor object labels may be shifted with a constant offset in order to avoid collisions. Because the object label is the primary access key to the object within the scripting language environment, extra care should be taken to avoid collisions when setting them directly.

Object label properties are configured to create automatic back-ups when they are changed. The previous label set is preserved under the original name with a \% character suffix, for example A_LABEL\%.

This is the list of properties set when a minor object list is set up:

```
- Bonds B_LABEL (bond label), B_TYPE (bond type), B_ORDER (bond order)
- Molecules m_LABEL (molecule label), E_NMOLECULES (molecule count),
    A_MOL_NUMBER (atom molecule index plus 1, 0 for atoms outside
    molecule }\mp@subsup{}{}{7}\mathrm{ )
- Rings R_LABEL (ring label), R_TYPE (ring class)
- Ringsystems Y_LABEL (ring system label), R_SYSTEM (ring system label)
- }\pi\mathrm{ Systems P_LABEL ( }\pi\mathrm{ system label), P_CLASS ( }\pi\mathrm{ system class)
- \sigma Systems S_LABEL (\sigma system label)
```

7. Warning: A_MOL_NUMBER is not guaranteed to correspond to the molecule label M_LABEL. Use property A_MOL_LABEL for this purpose.
```
- Groups G_LABEL (group label)
- Vertices V_LABEL (vertex label)
- Connections C_LABEL (connection label)
```


## Molecules and Rings

Molecules, rings and ring systems are standard minor object classes which are automatically maintained by the toolkit. Set-up of these object classes is fully automatic. There are no mechanisms ${ }^{8}$ for manually generating object instances for these classes.

## Controlling the detection of molecules, rings and bonds

The automatic set-up of molecules and rings can be controlled in a number of fashions. Important mechanisms are:

- molecule bond types
- ring bond types
- ring set

A bit mask of bond types which are used to find atoms which are linked to a common molecule, which can be configured at the scripting language level in the cactvs (molbond) control array element.

A similar bit mask of bond types which define rings in the ensemble. It can be configured at the scripting language level via the cactvs (ringbond) control array element.

The toolkit can be configured to find different kinds of ring sets. The ring set used for automatic ring detection can be changed by means of the cactvs (ringset) control array element. The most useful values for this field are 0 (SSSR), 1 (extended SSSR) and 3 (full set). The default is the extended SSSR set. The definition of the extended SSSR is that it contains the SSSR rings, plus all rings with a sequence of three consecutive ring atoms which are not contained in any SSSR ring. For example, under this definition cubane will have 6 four-membered rings ( 5 in the SSSR), anthracene 3 six-membered rings and two 10 -membered rings, but no 14-membered outer ring (in the SSSR, anthracene has only three six-membered rings), and norbornane two five-membered rings and one six-membered ring (two five-membered rings in the SSSR).

The determination of ring systems do not directly rely on bonding information. Rather, any rings from the current ring set which contain at least two common atoms are considered to the part of the same ring system. Spiro ring pairs are not in the same ring system, if no other link than connecting one spiro atom exists.
8. There still is a method to create a ring system manually, but this is deprecated functionality.

## Ring sets

The choice of the ring set will influence a number of other property values, for example all ring membership counts. In case of metal complexes, the choice of the ring bond types will also have a pronounced effect on the rings detected in the structures. The class of a ring can be queried via the R_TYPE property, which is automatically set during the ring detection process.

## Example:

foreach r [ens rings \$ehandle !envelope] \{ \}
This code fragment will do something with the rings, but filter out all envelope rings. An envelope ring is a ring which can be constructed by the union of smaller rings. In naphthalene, all rings except the six-membered rings are envelope rings. In norbornane, the six-membered base ring is not an envelope, because it does not contain the bridge atom present the five-membered rings and is thus not a union. The envelope filter is a built-in filter which checks the value of property $\mathrm{R}_{\mathrm{Z}}$ TYPE to be envelope (and not esssr, or sssr).

The ESSSR ring set has the advantage that it is much more stable with respect to atom numbering than the $\mathrm{SSSR}^{9}$. This is for example important in substructure searching with ring membership counts or checks on ring types. For example, a check whether an atom is a member of a heterocycle can easily fail for cage compounds if the heterocycle was by chance assigned to be one of the implicit rings, such as the sixth four-membered ring in cubane which is not in the SSSR.

A number of functionalities which rely on ring information were programmed to use only rings of the ESSSR and ignore extra rings which might be present because of a larger ring set was computed. Whether a function or property restricts itself to the use of ESSSR rings, or uses all rings it finds, is documented for the specific functions.

## Effects of setting different bond and ring bond type masks

Because the bond types used for the detection of rings and molecules are independent, it is possible to have rings which span more than one molecule, or molecules which contain partial rings. When an ensemble is split into molecules to form individual ensembles, partial minor object structures are lost.

Certain atom types (undefined, 3dpoint values in property A_TYPE) are not considered to be part of any molecule, regardless of the bonding situation. These pseudo atoms will have 0 as A_MOL_NUMBER or A_MOL_LABEL property values.

## Molecule manipulations

Molecules support an extended set of commands compared to other minor objects. Most of these reflect the fact that molecules are central to organizing chemistry data and exist as isolatable physical entities.

When molecules are addressed, it generally means that the group of atoms which form the molecule are processed. Information which is encapsulated within the molecule (such atom, bond and ring data) is preserved where possible. Any objects which cross the molecule boundaries (such as rings or bonds which are not covered by the bond types used to define a molecule) will be lost.
9. But is it not guaranteed to be completely independent of atom numbering! For practical purposes, this is however usually no an issue, in stark contrast to working with traditional SSSR ring sets.

Examples:

```
mol dup $ehandle 1
mol delete $ehandle 2
```

The first example will duplicate the molecule with label 1 . The molecule forms a new ensemble. Data of the duplicated molecule is preserved where possible, so atom, bond and ring labels will be the same as in the original molecule. Objects which are not restricted to the original molecule, such as molecule-crossing bonds and rings, or groups which contain atoms from different molecules, are not duplicated. Other minor objects of the ensemble, such as other molecules, atoms and bonds outside the deleted molecule, groups which did not contain any atoms of the deleted molecule, etc. are preserved.

The second line of sample code deletes a molecule with label 2 from an ensemble. Here, all minor objects restricted to the molecule, such as atoms or bonds, are also deleted, as well as all minor objects which refer to deleted atoms, for example bonds, rings and groups which partially or fully overlap the atoms of the deleted molecule.

Object duplication will trigger a dup property invalidation event in the new ensemble. Properties such as unique IDs may be defined to not survive duplication even if there are no structural changes in the objects they are linked to. Deleting a molecule, or merging ensembles, will trigger a merge invalidation event. Again, properties may be set up to react to this event.

There are no similar functions for rings or ring systems. These are intended to be managed completely by the system. Groups do have deletion commands - but in that case, the deletion operation applies only to the group object. No atoms contained in the group are deleted if the group is removed.

## Groups

Groups are a generic mechanism to manage groups of atoms and/or bonds. In contrast to other minor object of ensembles they are intended to be managed by the application. There are fewer automatisms for maintaining groups and group data than, for example, molecules and rings.

The basic objects which forms a group are atoms and possibly also bonds. However, in addition to atoms, groups may contain other groups. This nesting can be of arbitrary depth, but no cyclic graphs must be produced.

## Automatic group set-up

There is an automatic set-up mechanism for groups, but this function will simply initialize an empty group set.

Example:
ens groups [ens create CC]
will report an empty list.

## Creation and modification of simple groups

Groups can be created, changed and deleted with a standard set of commands:
set glabel [group create \$ehandle \{1 2\}]

```
group add $ehandle $glabel 3
puts [group get $ehandle $glabel G_SIZE]
group remove $ehandle $glabel 1
group delete $ehandle $glabel
```

This short sequence of commands show the most important methods to set up, modify and delete groups. The first line creates a group which contains the atoms of the ensemble with the labels 1 and 3. The commands returns the group label of the new group. The next line then adds atom 3 to the group. This kind of operation does not change the group label. The standard property data request for group property G_SIZE reports 3. Individual atoms may be removed from a group, and groups may be deleted, as shown in the final two lines of sample code.

Atoms may be a member of any number of groups, and they may be listed more than once within a group.

## Groups and substructure matching

In an alternative way of defining groups, they may also be generated as a side effect of a successful substructure match command.

Example:

```
set st [ens create {C[N+](=O)[O-]}]
set ss [ens create {N(=O)=O} smarts]
match ss -creategroup 1 $ss $st
```

This example will set up a group with the atoms of the matched nitro group on the structure. The substructure match routine is smart enough to recognize the equivalence of the two nitro group forms. Using appropriate match options, it is possible to mark all instances of a substructure by generating a group for every match.

Every successful match will add more groups, so in case a structure is used for multiple matches and the accumulation of groups is not desired, they should be removed all prior to matching:

```
group delete $st all
```


## Recursive groups

Groups may contain other groups, In case a group is deleted which is contained in another group, the containing group is also deleted. Recursive groups may be set up and modified by script commands, just as normal groups:

```
set glabel1 [group create $ehandle {1 2}]
set glabel2 [group create $ehandle [list [list "group" $glabel1] 3 4]
puts [group atoms $ehandle $glabel2]
puts [group objects $ehandle $glabel2]
group delete $ehandle $glabel1
puts [ens groups $ehandle]
```

This sample code first creates a basic group with atoms 1 and 2. Then, a second group is created which contains the basic group, and atoms 3 and 4 . The distinction between atoms and groups as member objects is made by prefixing the group label by the object class identifier group. If no object
class identifier is used, the object label is assumed to describe an atom. It is also possible to explicitly prefix atom labels by an atom object class identifier. The newly created recursive group is assigned a label, just as a standard group. The atom list of the recursive group will only list atoms 3 and 4. For a full member object listing, the objects command is available. In this case, it will report

```
{group 1} {atom 3} {atom 4}
```

The format is a fully qualified object list, which could be used in a group create statement. Deleting the simple group which is included in the recursive group will also destroy the recursive group, as demonstrated by the final statement which returns an empty list.

In case all atoms which are a member in a recursive group are needed, directly or indirectly as part of an included group, a simple recursive function can be used:

```
proc all_groupatoms {ehandle glabel} {
    set alist [group atoms $ehandle $glabel]
    foreach glabel [group groups $ehandle $glabel] {
        set alist [concat $alist [all_groupatoms $ehandle $glabel]]
    }
    return $alist
}
```


## Recursive groups and 3D searching

Recursive groups were originally introduced for the implementation of 3D structure searching. In 3D structure searching, coordinates of structure features which need to be matched are often defined in a dependent fashion. For example, the centroid of a matched ring should be within a certain distance to another atom.

In the toolkit, this is modelled by using groups and recursive groups as part of the substructure to represent these relationships. For example, the distance constraint is encoded as a substructure group containing an atom and the centroid group, which contains the atoms of the ring. When a match is checked, coordinates of matched structure fragments are accessed by the substructure groups. The distance can only be computed after the centroid coordinates have been established, and these can only be obtained if the ring substructure atoms where matched onto structure atoms with defined coordinates.

These group hierarchies are set up automatically when, for example, an ISIS 3D query file is read. But since the mechanism is general, it is also possible to configure it manually.

Example:

```
set ss [ens create clcccccl.N smarts]
set centgroup [group create $ss {11 2 2 3 4 5 6}]]
set distgroup [group create $ss [list [list "group" $centgroup] 7]
group set $ss $centgroup G_CONSTRAINT centroid
group set $ss $distgroup G_CONSTRAINT [list distance [list 3.0 4.5]]
```

This substructure can now be used for 3D matching and will only match those 3D structures where the distance between the centroid of the phenyl ring and the nitrogen atom is between 3 and 4 Angstroms. The extraction of coordinate information and the checking of the 3D constraints is automatically handled within the substructure match routine.

## Traps and Pitfalls

There are two cross-referencing commands which are very similar, but perform clearly distinct operations:

```
group group $ehandle $gspec
```

will return the group label from an alternative group specification, such as an index or a property value look-up. This is the same mechanism as in the atom atom or bond bond commands.
group groups \$ehandle \$gspec
The only typographical difference is the plural s in groups (vs. group). This command lists all groups with a a member of the group, which is always a different result since a group cannot contain itself.

## String Representations of Structure Data

The Cactvs toolkit supports several methods of encoding and decoding structure and reaction information as strings.

## SMILES

Cactvs supports Smiles nearly completely. The only unsupported feature is the encoding of higher-order stereochemistry (square planer, pentagonal bipyramid, octaeder). After the SMILES structure code part, separated by whitespace, an optional name may be added. This information is stored in property E_NAME after decoding. SMILES strings may be stored and generated as property E_SMILES.

The toolkit contains an implementation of the original version of the Unique Smiles algorithm. However, the published version is no longer identical to what Daylight is actually using in its software. It is possible to generate Unique Smiles from an ensemble with this toolkit, but it does not match the results of Daylight software for almost any non-trivial structure. For structure comparison, we strongly recommend the use of the native Cactvs structure hash codes instead of Unique SMILES strings.

The e_SMILES property has the following computation parameters which influence the style of the result string:

- usearo (default 0 )
- useisotope (default 1 )
- usemapping (default 1 )

If set, aromatic atoms will be output in lower case, and double bonds in aromatic systems will not be output explicitly as a Kekulé system. The default output style is as a Kekulé system with fully specified bond orders and element symbols starting with an uppercase letter.

If set, atomic isotope information (property A_ISOTOPE) will be encoded in the smiles string if it is available. If this flag is not set, isotope labelling information will be ignored even if it is present.

If set, atom mapping information (property A_MAPPING) will be encoded in the smiles string if it is available. If this flag is not set, atom mapping information will be ignored even if it is present.

- usesmarts (default 0) Encode as SMARTS, with explicit hydrogen counts at all atoms, and \#1 notation for hydrogen atoms which are not encoded as hydrogen counts of core atoms.
- usestereo (default 1) If set, atom and bond stereochemistry (properties A_LABEL_STEREO and B_LABEL_STEREO) will be encoded in the smiles string. An attempt will be made to compute B_LABEL_STEREO if it is not present, but not for A_LABEL_STEREO. If the computation fails, no error is generated and stereochemistry is not output. If this flag is not set, stereochemistry will be ignored if it is present.
- usesuperatom (default 0) If set, super atoms will be included in the smiles string with their symbol. This can result in illegal smiles strings. If the flag is not set, super atoms in the ensemble are ignored.
- unique (default 0) If set, the result string will be Unique smiles according to the original publication.

Example:

```
set ehandle [ens create clccccc1]; ens new $ehandle E_SMILES {} {usearo 0}
```

This sample code will first decode an ensemble from a Smiles string. The original smiles string is stored as property E_SMILES. The next statement re-computes the SMILES string, but with the computation parameter usearo set to 0 . The result is " $C 1=C C=C C=C 1$ ".

## SMARTS

Cactvs supports nearly the full SMARTS feature set, including Recursive SMARTS. The only exception is again high-order stereochemistry.

## Reaction SMILES

Reaction SMILES is fully supported. The optional middle part of a reaction specification will be decoded as a reaction ensemble with property E_REACTION_ROLE set to agent. Reaction SMILES strings may be stored and generated as property X_SMILES. Optional atom mapping labels in Reaction Smiles expressions cannot be negative numbers. Atom mapping labels will be deposited and read from property A_MAPPING.

Example:

```
set xhandle [reaction create {[CH2:1]=[CH2:2]>[Pt]>[CH3:1][CH3:2]}]
set xmiles [reaction new $xhandle X_SMILES]
```

The first sample line creates a reaction with three ensembles. By looking at property E_REACTION_ROLE they can be identified via their roles of reagent, product, and agent. The ensembles are really always listed in the reaction in that order when they are added by the Reaction Smiles decoder, but this is not a sequence which should be relied upon for general reaction processing. The second line re-computes the Reaction SmIles string, which in this case is completely identical to the input string.

## SMIRKS

The toolkit supports the use of SMIRKS for the description of reaction transforms. The advanced version is supported - i.e. the creation and deletion of atoms within a transform is supported.

However, stereochemistry change, both on atoms and bonds, is not yet possible. The only atom attribute change which is already fully supported are changes in formal charge. The creation, deletion and change of bonds within a transform is completely implemented.

Example:

```
set ehandle [ens create C=C]
set thandle [reaction create {[C:1]=[C:2]>>[C:1]-[C:2]} smirks]
ens transform $ehandle $thandle
```


## SMILES and SMARTS extensions

A number of useful backward-compatible extensions were introduced into the Smiles and Smarts decoders:

## Attribute ranges

At all places where an attribute count is expected, a range may be specified instead. Ranges are enclosed by curly braces. They may be open on either or both sides, with an implicit lower limit of 0 and upper limit of 31 .

Example:

```
ens create {[C;H2,H3,H4]} smarts
ens create {[C;H{2-4}]} smarts
ens create {[C;H{2-}]} smarts
```

The first example is standard SMARTs. The other lines show how to use ranges for more compact and readable encoding.

## Implicit superatoms

If an atom cannot be decoded as an element symbol, or, in a SMARTS context, as a SMARTS expression, a superatom will be created. This feature is an option of the decoder and not active in all contexts. The superatom symbol will be stored in property A_SUPERATOMSTRING.

Example:

```
ens create {[BOc]}
```


## Explicit superatoms

Atom symbols starting with a tilde character $\sim$ in a bracketed atom expression are decoded as superatoms. The superatom symbol (a_Superatomstring) does not include the tilde. The superatom symbol may consist of digits and letters, plus the underscore and minus characters. The superatom may possess additional attributes or be a port of an SMARTS expression, but these must be separated by explicit logical expression operators, such as ',' or ';' because the usual rules of tokenization are not used in order to determine the end of the superatom symbol.

## Example:

```
ens create {[~\textrm{COOH}}}
```


## Special atoms

The following special atom types are introduced:
HA Generic hydrogen acceptor. This checks property A_hydrogen_bonding
hD Generic hydrogen donor. This checks property A_hydrogen_bonding. $^{\text {a }}$
D Deuterium. This checks A_TYPE, A_element and A_ISotope.
T Tritium. This checks A_TYPE, A_element and A_Isotope.

## Attributes

The following extra query attributes and attribute extensions are recognized:

## a

If used without a count, it corresponds to the standard smiles meaning of aromatic. In this toolkit, this attribute can optionally take a count which is interpreted as the number of aromatic rings the atom is a member of.

Example:

```
ens create {[C;a{2-}]} smarts
```

This defines a carbon atom which is a member in two or more aromatic rings, for example the two centre atoms of naphthalene. The checked property is A_ARORING_COUNT in the extended case, A_ISAROMATIC in the standard case.
e
Number of $\pi$-electrons in a ring the atom is member of. The checked property is
R_N_PI_ELECTRONS.
Example:

```
ens create {[S;e6]} smarts
```


## X

If used with a count, it is the standard smiles neighbour count. If used without a count, it defines a hetero (no carbon, no hydrogen) atom.

Examples:

```
ens create {[X]} smarts
ens create {[X2]} smarts
```

The first example will match any hetero atom. The second example matches any atom which has exactly two neighbors. In the standard case, the checked property is a_neighbors. In the extension case, an expression involving A_TYPE and A_ELEMENT is generated.
$\mathbf{x}$

Number of hetero-atom substituents on an atom.
Example:
ens create $\left\{\left[C ; x_{2}\right]\right\}$ smarts
This will match a carbon atom which has two hetero neighbors. The checked property is
A_HETERO_SUBSTITUENT_COUNT.

## Special bond types

A bond described solely by an exclamation mark is interpreted as a bond which must not be present in a substructure match (the decoded B_TYPE property value is set to nobond).

Example:

```
ens create {C!C} smarts
```

is a (disconnected) substructure where the two substructure atoms must not be matched on adjacent structure atoms, but

```
ens create {C!-C} smarts
```

is a substructure where the carbon atoms are linked by a bond which is not a single bond.

## Non-overlapping recursive SMARTS fragments

By default, the substructure which is part of a Recursive SMARTS definition has no knowledge which part of the structure was already matched by the basic part of the substructure, and it is free to match on any atom in the substructure, even if it is already covered by another substructure atom in the hierarchy above.

This toolkit allows the exclusion of the part of the substructure which was already matched. This feature can be activated by using a double $\$ \$$ as initiator of a recursive SMARTS specification instead of a single \$.

Example:

```
set ssl [ens create {CN[$(CN),$(CO)]} smarts]
set ss2 [ens create {CN[$$(CN),$$(CO)]} smarts]
match ss $ss1 CNC
match ss $ss2 CNC
```

The first SMARTS structure is a classical Recursive SMARTS definition. The second one uses the same fragments but the extended syntax to prevent the recursive fragments to match on any structure part which was already matched. On the simple sample compound dimethylamine, the first match succeeds with the C-N fragment, because the carbon fragment atom matches on the second carbon atom, and the nitrogen fragment atom matches onto the central nitrogen atom, without any knowledge that this atom was already matched by the nitrogen atom in the base fragment. The same match with the extended syntax fails, because the nitrogen fragment atom cannot be matched - the central nitrogen atom in the structure is not allowed, because it is already covered by the base fragment.

## Exclusion atoms

Negated recursive fragments are often not very useful, because they tend to be matched on unexpected structure parts.
Example:

```
set ss [ens create {C[!$(Cl)]} smarts]
match ss $ss CCl amap
```

This match attempt will actually succeed, because the substructure atom which should be not chlorine is matched onto one of the hydrogen atoms in the structure. The atom match map in variable amap will contain the list " $\{11\}\{23\}$ ", showing that the first atom of the substructure was matched on the first atom of the structure (carbon on carbon), and atom 2 (the not chlorine atom) on atom 3 (one of the hydrogen atoms).

For atoms and fragments which should not match in any way, the CACTvs toolkit implements the concept of exclusion atoms and fragments. Exclusion atoms are specified by the attribute ${ }^{\wedge}$. Exclusion fragments are substructure fragments which consist only of exclusion atoms.

```
Example:
set ss [ens create {C[^Cl]} smarts]
match ss $ss CCl
```

This match attempt will not succeed. Matches with exclusion atoms will fail whenever these atoms can be matched in some way. For this purpose, all exclusion atoms which are linked together by bonds are treated as a joint fragment.
Example:

```
set ss [ens create {C[^O][^C]} smarts]
match ss $ss COC
match ss $ss CO
```

Here, the first match attempt will fail, because the carbon atom contains an OC substituent, which is prohibited by the sequence of exclusion atoms. The second attempt will however succeed, because there is no way to match the whole group of exclusion atoms.

Groups of exclusion atoms are processed after all non-exclusion atoms have been processed, and at that moment they are treated as substructure extensions where each branch must be assigned a location - only that a failure to find such a location is considered a success.

Example:

```
set ss [ens create {[^^C]O[^C]} smarts]
match ss $ss COC
match sS $ss COO
match ss $ss CO
```

The first match attempt will fail, because all independent exclusion groups could be assigned matches. The second and third examples will match, because it is not possible to assign both
non-carbon exclusion branches independent locations since there is only one carbon, and overlaps of exclusion fragments are not allowed.

In case of ambiguities in the string syntax, the standard interpretation has precedence. So , $[\mathrm{Se}]$ is a standard selenium atom, and [ $\mathrm{S} ; \mathrm{e}$ ] a sulphur atom which is a member of a ring with one $\pi$ electron. The only exception is the pseudo atom HA - conceivably, that atom could be interpreted as an aliphatic atom with one hydrogen neighbour.

## SMILES and SMARTS traps and pitfalls

SMILES and SMARTS are easy to use and powerful and play a prominent role in typical script applications developed with the Сaстvs toolkit. However, there are some problems which appear to be encountered frequently. The following section describes some common errors and correct solutions which address these problems.

## SMILES/SMARTS decoder mode

The decoder mode influences the interpretation of the structure string. Example:

```
ens create clccccc1 hadd
ens create clccccc1 nohadd
ens create clcccccl smarts
```

These three decoder statements produce three clearly different internal structure representations. The first (which is the default which is also used if no decoder mode is explicitly set) produces a benzene molecule complete with hydrogen, with alternating single and double bonds in a Kekulé structure. When used as a substructure, this structure will not match arbitrary phenyl rings, except benzene, because the hydrogen atoms are part of the structure and need to be matched too.

The second line is similar, but no hydrogens are added, so only six carbon atoms are generated. This structure will match phenyl rings - but in the default match mode, where aromatic bonds match both single and double bonds, will also match a hexane or hexene ring.

Only the last sample line is a complete SMARTS decoding - here, the match attribute aromatic is set as an atom flag on all the carbon atoms, because the atom symbols are specified in lower case. Since these carbon atoms, if used as a substructure, will only match aromatic structure atoms, this substructure specification will not match hexane or hexene.

## Hydrogens

CACTvs generally wants to work with structures where all hydrogen atoms are defined. Property computations will often report misleading results if these routines are called with hydrogen-depleted structures. Therefore, hydrogen atoms in SMILES are expanded when a structure is created from the string. This is not the case in SMARTS decoding, and additionally, the H attribute in SMARTS is a hydrogen count, while in SMILES it specified a hydrogen atom. The alternative notation via the element number must be used in case explicit hydrogen atoms should be generated from SMARTS string. Note that explicit hydrogens such as in [NH2] or [\#1] are always expanded, even if the nohadd decoder mode is used. In order to get rid of these atoms, an ens hstrip command can be executed.
(1) ens create $\{[\mathrm{NH} 2]\}$
(2) ens create $\{[H][N][H]\}$
(3) ens create $\{[\mathrm{N} ; \mathrm{H} 2]\}$ smarts
(4) ens create $\{[\mathrm{NH} 2]\}$ smarts
(5) ens create $\{[H][N][H]\}$ smarts
(6) ens create [[\#1][N][\#1]\} smarts

The first line decodes into a nitrogen atom with two hydrogen atoms attached. Since the number of hydrogens is explicitly specified on all atoms, the selection of the hadd (default) or nohadd decoder modes (but not smarts, see examples below) does not make any difference. In both modes, the second line decodes to exactly the same structure, the only difference being the order of the atoms in the atom list.

Line three is where things begin to become interesting. This line will decode into an ensemble with a nitrogen atom with the additional query constraint of needing to have exactly two hydrogen neighbors. If the structures defined in line one or two are used for substructure matching, they will match ammonia $\left(\mathrm{NH}_{3}\right)$, mapping the two substructure hydrogen atoms onto two of the structure hydrogen atoms and leaving the last structure hydrogen atom unmatched. The substructure generated in line three will not match, because the nitrogen atom in that structure must possess exactly two hydrogen neighbors.

Line four demonstrates a Cactvs SMARTS decoder extension. In original SMARTS, this encoding is completely equivalent to that of the previous line, but Сactvs introduces a subtle difference. If an element symbol is directly followed by a hydrogen count, without any logical operators, or other query attributes between these atom definition components, the hydrogen atoms are instantiated. This substructure string will expand into three atoms - one nitrogen and two hydrogens. The nitrogen atom will still bear the constraint that in substructure matching it must possess exactly two hydrogen neighbors. However, this substructure is able to provide explicit substructure/structure atom correspondence information for the hydrogen atoms, which can be useful.

SMARTS encodings as shown in line five are usually written unintentionally. This string defines a substructure of three atoms - a nitrogen atom and two any atoms, which both must possess exactly one hydrogen neighbour. H is the hydrogen count attribute in SMARTS, not a hydrogen atom. If no element is specified as part of the atom definition, it is translated into an any match atom which then used to attach additional constraints. Syntactically this encoding is absolutely correct, and the query will work as defined in the SMARTS standard, but the results may be unexpected, since [H] does not encode a hydrogen atom. Line six implements correctly what may originally have been intended by the construct in line five: Two explicit hydrogen atoms, and a nitrogen atom as a simple SMARTS substructure without additional attributes, as in line one or two.

## Serialized major object strings

Major objects, such as ensembles, reactions, networks, tables and datasets, may be packed into a string. This string captures the full state of the object (including, by default, all subobjects). If no filtering operations are used to restrict the type of data which is packed into the string, it is a lossless method of encoding the object state. Technically, this string is a base-64 encoded, zlib-compressed, serialized object, using XDR encoding for platform-neutral storage of byte-order dependent data.

After removing the encoding and compression layers, these strings are very similar, but not identical, to the native Cactvs binary file formats for I/O of these objects.

Since the base64-encoded packed string is guaranteed not to contain any non-printable or problematic (quotation, etc.) characters, these strings can be conveniently sent by mail, stored in database columns, etc. Packed object strings are portable and platform-independent.

Only major objects may be packed into packed formats.
Example:
set packstring [ens pack [ens create CCC]]
set newens [ens unpack \$packstring]
Packed object strings are significantly larger than, for example, a molecule representation as a SMILES string. However, this string will preserve all attached ensemble and minor object data, such as 2D and 3D coordinates and other properties, which cannot be done with SMILES, SLN or other simple string encodings.

## SMILES and SMARTS files

Both SMILES and SMARTS, including the reaction versions, can be saved to and read from structure files. This is a built-in file format. The SMILES/SMARTS format is automatically detected, including whether it contains reactions or structures. It is not possible to read Reaction SMILES files in ensemble or molecule input mode, and vice versa. During the format analysis procedure, the read mode is set appropriately and should not be changed.

In the simplest case, SMILES/SMARTS files are simply text files which contain a SMILES/SMARTS string on each line. After the actual structure code, a name field (property E_NAME) may follow separated by whitespace.

Files are by default read with the addition of implicit hydrogens, just as it is the default when decoding a SMILES string with an ens create statement. This is independent of the explicit hydrogen addition or removal set as a file attribute. The file-wide hydrogen processing is applied to every ensemble read from the file handle regardless of the file format. The implicit hydrogen addition when reading SMILES files is the result of a flag set on the decoder which is invoked as part of the record input process, long before the postprocessing operations. In case this addition of implicit hydrogen is not desired, for example when reading substructures from file, it can be disabled by the statement
molfile append \$fhandle flags noimplicith
Besides structure data lines, SMILES files may contain the following types of additional lines without raising an error:

## Empty lines

These are silently ignored

## Comment lines

These are lines starting with an '\#' character. They are ignored.

## File property lines

These are lines beginning with the magic character sequence ' $\# \mathrm{~F}$ ' and containing a property name and a property value. When a line like

```
#F content New lead series
```

is read, a property $\mathrm{F}_{-} * C O N T E N T *$ is attached to the file object (or $\mathrm{F}_{-}$CONTENT, in case that property is defined) and set its value to the trimmed remainder of the line ("New lead series" in this case). This data can be retrieved with a

```
molfile get $fhandle F_*CONTENT*
```

command. When the file is opened, all file properties which occur before the first structure line or ensemble property line are immediately available without reading any records. Later file property data becomes available as soon as the line has been read as a result of normal structure input.

## Ensemble property lines

Similar to file property lines, these are lines which begin with the magic characters ' $\# \mathrm{E}$ '. All ensemble properties which are found before the actual structure line is read are attached to the ensemble as regular property data, analogous to the processing of file properties. If a set of lines like

```
#E E_IDENT PharmaconX123
CCO
#E E_IDENT PharmaconX124
CCS
```

is encountered, the property e_IDENT (here specified in Cactvs nomenclature, and since this is a defined property, no name standardization takes place) is attached to both records. The first read command will retrieve ethanol (CCO) with E_ident set to PhramaconX123, and the second input operation fetches CCS and sets its E_IDENT to PharmaconX124.

## Folded lines

In an attempt to counter a common problem in e-mailed smiles files, the input routine will attempt to detect the folding of long lines in the original file into two shorter lines by a mail tool or another processing application. If a structure could not be successfully decoded from a single line, an attempt is made to join the next line to the first line and decode that the joined line. This is not foolproof, but often works as a reasonable makeshift auto-correction mechanism. Only a single line will be merged. If the file is even more broken, its problems should be fixed at the source.

## Indented lines

The indentation level (number of whitespace characters) of Smiles and Smarts data lines is read into property E_LEVEL. Thus, a file structure like

```
CC[Cl,Br,I]generic
CCClchlorinated
CCBrbrominated
CCIiodated
```

can be conveniently used to store hierarchies. The first line will be read with e_level set to 0 , and the other lines (assuming a tab character is used) with e_Level set to 1 . If e_ Level is set for an ensemble when it is written to a smiles file, indentation will automatically be added. If this property is not present, no indentation is used.

## Structure names

Everything to the right of the first word of the data lines (which is decoded as the Smiles string proper) is read as structure name and stored in property E_NAME. Example:
CCC propane
If this line is read, the structure is decoded, and its name (property E_NAME) is set to propane. The name part will be trimmed on both sides, but not split. Any whitespace after the beginning of the name part and not reachable by an uninterrupted sequence of whitespace characters from the end of the line will be preserved. Example:

```
CCC propane 74-98-6
```

Here, the name will be set to "propane 74-98-6". Further processing of the name will have to be performed by explicit script commands. Note that indexing of string words can be very helpful for this task, as in
ens set \$ehandle E_CAS [ens get \$ehandle E_NAME(1)]

## Other structure string representations

The toolkit supports the work with a number of additional string representations:

## Hex-encoded SMILES

In standard structure decoding contexts (such as in an ens create command, but not while reading files), an attempt is made to interpret a string not just as a SMILES string or a serialized object string, but also as a hex-encoded SMILES string if the first two methods fail. Hex-encoded SMILES is used in a number of Daylight tools.

Example:

```
ens create [encode -hex CCC]
```


## PubChem Compound IDs (CIDs)

A simple integer is interpreted to represent a PubChem compound ID. The structure is looked up on the interpet.

Example:
ens create 1

## Cactvs Minimols

A Cactvs Minimol is an extremely compact representation of a structure with all attributes which are usually of relevance for structure searching. In contrast to serialized object strings, this format does not encode arbitrary data, but only a fixed set. Compared to SMILES and similar formats, the information density is much higher, and decoding much faster because for standard
structure matching o proeprties need to be computed. Minimols can be computed as property E_MINIMOL, and decoded direclty in ens create statements.

Example:

```
set mm [ens get [ens create CCC] E_MINIMOL]
set eh [ens create $mm]
```


## CAS Numbers

Cactvs recognizes CAS numbers and will attempt to decode them by means of a PubChem lookup.

Example:

```
set cas [ens get [ens create CC(=O)C] E_CAS]
set eh [ens create 67-64-1]
```

This is a rather expensive operation and slow for larger sets of compounds.

## Sybyl Line Notation (SLN)

SLN is fully supported, but not as a built-in format. Encoding and decoding of SLN strings must be performed via string file operations.

Example:

```
filex load sln
set sln [molfile string [ens create CCC] format sln]
set fhandle [molfile open $sln s]
set ehandle [molfile read $fhandle]
molfile close $fhandle
```

In this code sequence, first the SLN I/O handler is loaded (in most toolkit versions, it is not a built-in format). The second line shows how to generate an SLN string by using the molfile string command. The last three line demonstrate the decoding of an SLN string by first opening the string as a file (mode $s$ ), reading the first record from the string file, and finally closing the structure file handle.

## JME strings

JME, the native format of the popular JME Java editor applet by P. Ertl of Novartis, is also fully supported as an external I/O module.

Work with this format follows the same procedures as the SLN case.

## Wiswesser Line Notation

There is a standard property definition for WLN data called E_WLN, but currently neither encoding nor decoding of this format are supported.

## Envelope encodings of SMILES and other structure strings

The toolkit contains utility commands for encoding and decoding arbitrary strings into and from various encoding formats. The encode and decode commands are fully explained in the auxiliary command section.

Examples:

```
molfile read [set fh [molfile open [decode -zip64 $z] s]]; molfile close $fh
ens create [decode -url $z]
puts "<A HREF="[encode -url /cgi/bin/myapp.cgi?smiles=$z]\">"
```

The first line shows how to read a zlib- or gzip-compressed, base64-encoded string which is an image of an arbitrary structure record, for example an MDL Molfile. The second lines demonstrates the decoding of an URL-encoded SMILES string. The final example shows how strings with characters which need to be protected, such as '\#' or ' $\&$ ', can be output in the context of a CGI Web application.

## Property Data Types

All property data has a defined data type. The data type determines how the information is internally managed. All memory, file handles, etc. which are required by a data type are handled by the system and are automatically release when property data is deleted, regardless whether it is a direct discard, or an indirect effect by the deletion of objects holding the data or the result of an invalidation because of object relationship changes.

## Data type handlers

Every data type is associated with a handler module. This handler module provides a predefined set of functions, such as decoding, duplication, deletion, and output formatting. Handlers for the most common data types are built-in. Additional handler modules may be loaded at runtime. This may happen either explicitly, or indirectly by referring to a property which declares itself in its description record to be of a data type which the system does not yet know about. In that case, a handler module is automatically looked up. If it cannot be found, the loading of the property definition fails.

Examples:
typex load floatvolume
filex load gausscube; set ehandle [molfile read test.cub]
The first command explicitly loads the handler for floating-point volume data, which is not in the built-in set. The second line does it indirectly: First the I/O handler for Gaussian cube files is loaded and then a sample cube file is read. The input routine tries to attach the volume data found in the file to the ensemble receives the input data, using the float volume data type. At the moment the input routine refers to property E_VOLUME, its definition is looked up, and when the property definition file for E_VOLUME is read, a handler for its data type P_FVOLUME is located and loaded. Both the paths for property look-up and for I/O handler look-up can be configured on the scripting language level via the global cactvs () control array variable.

## Storage slots

Property attached to objects is kept in slots of a fixed size. If the data is of variable size, part of the slot structure is used to contain a pointer to allocated memory. Because it is more efficient to use only the slot structure, there are several data types for common storage requirements such as float pairs (used for example for 2D display coordinates) which could be stored as a vector, but are implemented as a separate data type. 3D coordinates, even though they always require just 3 dimensions, are manage by the standard float vector type - since three floating point values do not fit into the slot structure, there is no notable efficiency gain in providing a specialized 3-element vector type. Since the slots contain room for both a data pointer and a length field, vectors may be of variable and non-uniform length on each individual data item.

## Internal and external representation

In some cases, there is a distinction between the internal and external representation of property data. For example, internally there is only a single simple floating point type, which stores the data as a double value. However, export functions may distinguish between a single-precision float and a double-precision float, and consequently these two data types have separate output functions. Similarly, various integer types are internally all stored in a long value, but may be output as boolean, byte, short or long values.

## Naming conventions

In the scripting environment, data types are usually addressed by their readable name. data types also have a system name, which can be used as an alias, but usually it is more convenient and more readable to refer to the floating point volume data type as fvolume instead of $\mathrm{P}_{-}$FVOLUME. The latter is the system name which is for example used in property description files.

Subscript names for data with identifiable fields are always spelled in lower case. They must not contain whitespace or punctuation characters.

## Built-in data types

The data types in the standard built-in set are:

[^2]- float
- double
- string
- unicode
- shortstring
- index
- bitset
- intpair
- intquad
- floatpair
- qualifiedint

A single-precision (32-bit) floating point number. Not indexible. Internally stored as a double precision float.

A double-precision (64-bit) floating point number. Not indexible.
An arbitrary-length zero-byte terminated ISO-string. It may contain any character, including control characters such as linefeeds, except the zero byte. This type can be indexed on a word basis.

An arbitrary-length Unicode string. Internally, it is encoded as wchar_t platform-dependent characters, with a zero byte word as terminator.

An optimized string with a maximum length of 8 bytes (16 on 64-byte platforms, but I/O will be limited to 8 characters). Numeric field indexing refers to the character position, not the word as in normal strings.

This type contains 4 unsigned short integers with a special function. The four integers are used to encode group memberships and membership numbers on the ensemble and molecule levels. There are two number pairs, one for the ensemble and one for the molecule attribute. The first number of each pair is the class number, the second the instance number within that class. The fields may be directly addressed by the predefined subscript names eclass, ecount, mclass and mcount.

This is a bit set with a maximum of 32 positions. The names of the positions are specified in the property enumeration field. Using these names, bits may be addressed individually in a property-dependent fashion. Alternatively, a numeric subscript in the range $0 . . .31$ can be used.

A pair of two 32-bit signed integers. They may be individually addressed with the predefined subscript names $x$ and $y$.

A quartet of four 16-bit signed integers. They may be individually addressed with the predefined subscript names $x 1, y 1, x 2$ and $y 2$.

A pair of two single-precision floating point numbers. They may be individually addressed with the predefined subscript names $x$ and $y$.

This is an integer with additional precision, validity and range information. Internally, it consists of a base value, a qualifier (by default, $e q$, other possible qualifiers are $l e, l t, g e, g t$, approx and missing), and positive and negative integer deviation ranges. If the qualifier is missing or null, the default output is $N / A$, and the value or deviations are ignored. If the qualifier is $e q$, and no ranges are set, the display format is the same as for an integer. If the qualifier is not eq and not missing, the output is the base value, followed by the identifier, and then the value range. If positive and negative deviations have the same value, the range is displayed as + -range, otherwise as a pair of negative and positive deviations with explicit signs. For retrieval, specific subfields value, qualifier, +delta, -delta, delta, lowbound and highbound can be used to

- qualifiedfloat
- url
- choice
- blob
- date
obtain specific information. delta is the sum of positive and negative deviations, lowbound the base value minus the negative deviation, and highbound the base value plus the positive deviation. For input, a qualified integer may be specified as a simple integer, a full specification of all fields, or several abbreviated forms.

This datatype is very similar to the qualified integer type, except that the base value and the deviation ranges are floating point numbers.

A raw data block of variable length. The data may contain any byte values, including zero bytes. It is indexible via a numeric subscript allowing access to individual data bytes, which are returned or set as unsigned bytes.

This type describes a date, with a precision of one second. The value used for normal retrieval is an ISO time value (YYYY-MM-DD HH:MM:SS). For setting, the conversion routines understand a couple of standard date formats and will detect them automatically. Additionally, the raw numerical system time value (seconds since 1970), and reserved words such as now and tomorrow are understood. When a toolkit version is providing Tcl scripting capabilities, it will use the rather capable Tcl time decoder in addition to scanning its private lists of standard formats. In case the raw numerical value of a date item is needed for custom formatting, for example with the Tcl clock format command, the nget command should be used. For retrieval only, the reserved subscripts year (including century), month (0-11), day (1-31), hour (0-23), minutes (0-59), seconds (0-59), weekday ( $0-6$, week begins on Sunday) and yearday $(0-365)$ give access to specific time unit values.

This data type encodes an URL. In most respects, it is similar to the string data type, but instead of word indexing, it may be indexed for read access only by the reserved subscript names directory (directory part of pathname, assumes fully specified path name or terminal /), file (filename part of pathname, assumes fully specified path name or terminal /), hash (page location), host (hostname:port combination), hostname (pure hostname without port), href (full url), ip (host IP address), password (password portion of the access credentials, if path of the url), pathname (path to the object on the server, excluding host, password, user, hash, search fields), port, protocol, search (query part of url), target (always empty), text (always empty), user (user portion of access credentials, if specified in the URL), and ipaddr (resolved host name). These field names are the same as in the JavaScript link object, plus some custom additions (user, password, ipaddr). In some output contexts a hyperlink will be written instead of the string data value, for example in HTML table output. This data type currently cannot store target and link text information. These fields will always be empty.

This is a wrapper data object which can hold items of different, but predefined datatypes. The field definition of the associated property definition declares possible values by associating a field name either with a primitive datatype (such as int), or a refer to a property (such as

E_NCBI_PUBLICATION_PATENT). Using the latter construct, very complex nested datatypes of variable layout may be constructed, since the refererred properties may themselves be of a complex structure, including being of the compound and choice data types. The default output format is a list of the name of the field encoded in this object instance, and the value proper. In addition, subfields value, datatype, property, index and name may be used to retrieve specific aspects of a datum.

- bitvector A bit vector of variable length. Individual bits can be selected via a numeric subscript. As in the bit type, bit positions may be also assigned names via the property enumeration values. and these names used for indexing
- bytevector An unsigned byte vector of variable length. Individual elements can be addressed via a numeric subscript.
- shortvector A signed 16-bit integer vector of variable length. Individual elements can be addressed via a numeric subscript.
- intvector A signed 32-bit integer vector of variable length. Individual elements can be addressed via a numeric subscript.
- floatvector A 32-bit single precision float vector of variable length. Individual elements can be addressed via a numeric subscript.
- doublevector A 64-bit double precision float vector of variable length. Individual elements can be addressed via a numeric subscript.
- tensor
- xyvector
- stringvector
- unicodevector
- uint8vector
- compoundvector

A double precision floating point tensor with 9 elements. Individual elements can be addressed via a numeric subscript. In most respects, this data type behaves like a normal floating point vector.

A 2D coordinate vector. Each element consists of a single-precision floating point pair. Numerical element indices will retrieve or set a pair, not individual numbers.

A variable length vector with string elements. The string elements are zero-byte terminated ISO-encoded strings of arbitrary length. It is possible to have NULL elements in the vector. Individual elements can be selected via a numeric subscript.

A variable length vector with unicode elements. The string elements are $w c h a r \_t$-encoded strings of arbitrary length with an all-zero-bytes stop word. It is possible to have null elements in the vector. Individual elements can be selected via a numeric subscript.

A variable length vector with 64 bit unsigned integer elements.
Individual elements can be addressed via a numeric subscript.
A variable length vector with elements that are compound datatypes (see above in this paragraph).

- choicevector A variable length vector with elements that are choice datatypes (see above in this paragraph).
- diskfile A reference to a disk file. If the disk file refers to a file in a temp directory, the file will be automatically deleted when the property data elements gets deleted. This data type maintains an open file pointer to the file. Many platforms have limitations on the number of open file pointers, so this format should not be used when a large number of data instances are managed. If just the name of a file needs to be stored, it can be done as a string value. The default retrieval value of the diskfile data type is its path name. Additional information may be obtained by using the magic subscript names name (file name, same as default), content (data content), size, format (MIME type format, if known), mode (mode bits), owner (owner uid), group (group id), readtime (last file access, st_atime status field), writetime (last file content change, st_mtime status field), createtime (last inode change, st_ctime status field). These indexed attributes are read-only. The time-stamp values are returned as ISO dates in a context where enumerated values are allowed, as seconds since 1970 otherwise.
- mapfile
- dictionary
- tree
- query

Essentially the same as the diskfile type, but the content is kept in memory by memory mapping.

This is a hashed array of keyword/value pairs, similar to array variables in Tcl. Keys data values are arbitrary-length strings. The standard output is a list of keyword/value pairs (suitable for use with the Tcl array set command), and this is also the input format (which can be conveniently generated by the Tcl array get command). This type is indexible by the keywords which can be different in every data instance. For setting, specifying a non-existent keyword creates a new key/value pair, otherwise the old value is changed. For retrieval, a non-existent key results in an error.

This rather complex data type encodes a tree of nodes with the possibility to store a string value at each node. The standard input and output formats for the full tree are, beginning with the root node, a nested list of node name, node value, and the children as additional list elements, where every child node is recursively written as another list of the same format. Every node may be named, and individual nodes can be addressed with a name constructed from the names of the nodes beginning with the root node by concatenating them with a dot as separator character, such as in root.node1.node2. Alternatively, names using the children index number of each node may be used.

This data type is closely related to the tree data type. It encodes query trees for complex atom and conditions. It is for example used in the query subfields of the A_SEARCHINFO and B_SEARCHINFO compound properties. Here, the inner nodes are logical operators (and, or, not), and the leaf nodes are property value comparison expressions. An example for a valid input or output string representation is "and \{A_ELEMENT =

6\} $\left\{\operatorname{Or}\left\{\mathrm{A}_{-} F O R M A L \_C H A R G E<>0\right\}\left\{A \_S I G M A \_C H A R G E \quad|>=| 0.3\right\}\right\} "$, describing a match condition for a carbon atom which either bears a formal charge, or an absolute value of the Gasteiger charge of equal to or more than 0.3.

- compound Compound properties are properties with multiple data fields, where each data field can have its own type. Typical examples are the standard properties for spectra which contain many fields in different formats. This type requires the fields to have property-dependent names. Individual fields may be accessed by using the field name, or a numerical index.
- structure The data value is a molecular ensemble. Such ensembles are not part of the normal object set of the scripting environment and may not participate in datasets or reactions, but otherwise they behave like any other ensemble and show up in the list of registered ensembles. They possess property data of their own, have handles and may be manipulated via these. The value of this data type is the ensemble handle. This type is not indexible. Ensembles which are property data cannot be deleted by normal script commands. They disappear only when the property data they are part of is destroyed.
- reaction Similar to the structure data type, this is a reaction as property data. Neither the reaction nor its ensembles may be deleted by normal means, nor are they part of the normal object set of the scripting environment. This type is not indexible.
- dataset Similar to the structure or reaction data types, this is a complete dataset of ensembles and/or reactions which is property data and not part of the normal object set of the scripting environment. This type is indexible via the numerical dataset object list index in a read-only fashion.
- table Similar to the chemical object data types, the value of field of this data type is a table object. It is not indexible, and the value for reading and setting the property is the table handle.
- network Similar to the chemical object data types, the value of field of this data type is a network object. It is not indexible, and the value for reading and setting the property is the table handle.

The compilation environment has a mechanism to set up the set of built-in data types at compile time. For example, the coorvec extension module is often compiled into stand-alone applications.

## Property-specific element subscript names

Additional subscript names may be provided by setting the fields property attribute. For example, atomic 3D coordinates may also be accessed by the indices $x, y$, and $z$, as in

```
atom get $ehandle $label A_XYZ(x)
```

which is possible only because the equivalent of the command
prop set A_XYZ fields [list "x" "y" "z"]
is executed at start-up. By default, vector types only support numerical indexed access, as in

```
atom get $ehandle $label A_XYZ(0)
```

which is equivalent to accessing the $x$ value.
Bit-based data types, such as the bitset and bitvector types, will also allow the use of the property enumeration values as field names.

```
prop create E_MYBIT data type bit enum "^none:foo:bar"
```

will create a bit property, where the lowest two bits are named foo and bar.

```
ens set $ehandle E_MYBIT 1
puts [ens get $ehandle E_MYBIT]
puts [ens get $ehandle E_MYBIT(bar)]
ens set $ehandle E_MYBIT (bar) 1
puts [ens get $ehandle E_MYBIT]
puts [ens nget $ehandle E_MYBIT]
```

This sequence of commands demonstrates the use of enumeration values for bitsets. First, the property data instance on the ensemble is set to 1 . The retrieval command will return foo as enumerated value, since only this bit is set. The direct check of the bar bit will report 0 . When this bit is also set, the retrieval result will now be the list "foo bar", because now both bit 0 and 1 are set. The numerical value stored in the data slot is now 3, as demonstrated with the last line using the numerical retrieval command nget instead of get. get will use property enumeration values if they are specified, while nget outputs simple numbers if the underlying data type is numeric.

## Subfield data types

The return value of

```
prop get A_XYZ fields
```

is a list, where every element is a nested list containing the field name and field data type, in the form of
\{x float\} \{y float\} \{z float\}
In case of vector types, the field data type is the same as the vector element data type which is already known to the toolkit and therefore should not be set explicitly to avoid conflicts. For compound properties, setting the field values is a requirement, though:
prop create E_MYDATA data type compound fields \{\{field1 int\} \{field2 blob\}\}
If the field value types are not set for compound types, they will default to strings.

## Properties with polymorphic data types

Computation functions may be coded with introspection capabilities. This means, a computation function may look at the current data type of the property and provide data in the requested format.

This feature is actually used for some standard properties. Most of the image- and visualization properties can generate data either as file (data type diskfile), or kept in a memory block (data type $b l o b$ ). Examples of such properties are D_GIF (dataset depiction), E_BARCODE (barcode data as image), E_EMF_IMAGE (structure depiction in MS Windows vector formats) E_EPS_IMAGE (structure
depiction in Encapsulated PostScript), e_GIF (structure depiction in pixel formats), E_VRML (VRML 3D models) and X_GIF (reaction depiction).

The default format of these properties depends on the toolkit version. Generally, full releases will use the diskfile data type, while special-purpose development libraries will use the blob type.

In scriptable toolkit versions, the data type may be changed by statements like

```
prop set E_GIF datatype blob
prop set E_GIF datatype diskfile
```

This should be done only once at the beginning at an application script, before any data is generated. It is possible to work with instances of both data types simultaneously, as will be explained in the next section, but this is usually very inconvenient and error-prone.

## Changing property data types

In principle, it is possible to change the data type of a property after it has been defined. Chemical objects which hold property data in the old format remain linked to a temporary version of the old definition record. The old data type-specific functions are used to manage the property data, thus objects with old data can be safely deleted, written to file, etc. The old property definition record will be discarded only if there are no remaining data instances in the system which used the old definition. However, this old definition is only used for basic property maintenance and retrieval. All query functions on the data status will use the new definition and potentially return wrong results. On the scripting language level, the old definition is inaccessible.

When a data type is changed for a property which has a computation function, special care must be taken to either properly adapt the computation function to use the new data type, or to make sure that the computation function is never called - for example, by removing the computation function within the script as in
prop set \$tmp_changed_property compfuncname \{\}
Reading files which were written with an outdated property definition in an updated environment can be problematic, especially if drastic changes such as a switch from a numeric type to a string type were performed. Especially binary formats are prone to crash the application after such a change. As far as the native Cactvs binary format is concerned (.cbin files), the following changes are safe, and everything else is a potential problem:

- Changing the external type without changes of the internal type, for example going from a short field to an int field.
- Changing the type when incidentally the internal formats have the same layout, for example going from int to date, or from index to intquad.
- Changing the standard size of any vector, matrix, or volume type. The old data will be read with the original size.
- Adding fields to compound properties, or reordering them. Deletion of fields is also possible, but only if the data types of the deleted fields are from the built-in set.
- Renaming enumeration values and other property attributes which only affect output formatting, but not the internal storage format.
- Changing field names, with the exception of compound properties, where these must not be changed in order to allow the later addition and reordering of fields.

The Cactvs scan/query file formats (both sequential and update-able) store definitions of all properties written to the file which are not in the built-in set, or were modified from the original definition. When these files are opened, the stored definitions are read back and supersede any previous definition in the application. An unfortunate side effect is that it is currently not possible to have two of these files open at the same time which contain conflicting property definitions.

The overall safest way to work with custom property definitions is to set them all up before the first chemical objects are created which rely on them, and to think carefully before defining them, so that no data sources with data encoded using conflicting definitions are encountered in a project.

## Reactions

Reactions are major objects which control a collection of molecular ensembles as sub-objects. Their handle has the format reactionx, where $x$ is a number. Any number of reactions may be created. As standard chemical objects, they may manage their own set of dataset-specific property data. The prefix for reaction data is " $X_{-}$". The prefix " $R_{-}$" is already claimed by ring properties. The generic command for working with reactions is the reaction command.

Examples:

```
reaction set $xhandle X_IDENT "catalytic reduction"
```

reaction get \$xhandle X_IDENT

## Creating reactions

Reactions may be created by a number of methods. The supported mechanisms include:

- Decoding of string representations, for example Cactvs serialized reaction objects and Reaction SMILES:

```
set xhandle [reaction create {CC=O.[H][H]>>CCO}]
set xhandle [reaction unpack $packstring]
```

- Input from reaction files:

```
set xhandle [molfile read "myreactionfile.rxn"]
```

This method requires that the file contains reaction data, and that the read scope of the file input handle has been set to reaction. For most file formats which can store reactions this will happen automatically.

- Script-driven assembly:

```
set xhandle [reaction create $reagent_ehandle $product_ehandle]
reaction add $xhandle [list $solvent ehandle "solvent"]
```


## Internal structure of reactions

Reactions contain an arbitrary collection of ensembles as elements. The role of the ensemble is registered in the property E_REACTION_ROLE. The predefined roles are reagent, product, solvent,
catalyst, intermediate, impurity, byproduct, agent (unspecified) and undefined. Additional roles can be created by editing the enumeration values of property E_REACTION_ROLE:

```
prop set E_REACTION_ROLE enum "[prop get E_REACTION_ROLE enum]:resin_material"
```

Usually, reactions contain at least a reagent and product ensemble, but this is not an absolute requirement. The order of the ensembles in the reaction is also arbitrary. One should not rely on the reagent ensemble being the first and the product ensemble being the second ensemble in a reaction.

It is not illegal to have multiple ensembles with the same reaction role within a single reaction, although for practical purposes this should be avoided.

Finding ensembles with a specific role in a reaction is best done by a filter on E_REACTION_ROLE:

```
set reagent_handle [reaction ens $xhandle reagent]
```

If there is no reagent ensemble in the reaction, an empty string is returned. An ensemble can only be a member of a single reaction, or not a member of any reaction. Ensemble membership in reactions is completely independent of membership in datasets.

The reaction handle can be obtained from an ensemble via a standard cross-referencing operation:

```
set xhandle [ens reaction $ehandle]
```

If the ensemble is not part of a reaction, an empty string is returned.

## Reaction substructures

The toolkit supports reaction substructure searching, and SMIRKS transforms. Both require a reaction where the ensembles are not fully saturated with hydrogens. Such reactions may either be generated by specifying a decoder option, or automatically by decoding a Reaction SMARTS string on the fly in the query statement:

```
set rquery_handle [reaction create {[C:1]=[0:2]>>[C:1][0:2] smarts}]
molfile scan $filehandle "reaction >= $rquery_handle} reclist
molfile scan $filehandle {reaction >= [C:1]=[O:2]>>[C:1][0:2]} reclist
ens transform $ehandle {[C:1]=[0:2]>>[C:1][0:2]}
```

An important features for reaction substructure searches are atom maps. An atom map, which is stored in property A_MAPPING, links atoms on the reagent side of a reaction to atoms on the product side. In SMARTS/SMIRKS, these are specified by numbers (positive or zero) prefixed with a colon.

A reaction query " $C=0 \gg C 0$ " will match any reaction which contain a $\mathrm{C}=\mathrm{O}$ group on the reagent side, and a C-O group on the product side. However, there is no requirement that there was any transformation of a keto or aldehyde group - this might simply be a match of a reaction structure which contains un-transformed keto and alcohol groups. Only by forcing the atoms to refer to a set of atoms linked by common mapping numbers actual reaction searching focusing on changed bonds can take place.

## Reading and writing reactions

Reactions can be read and written to file formats which support the storage of reaction data. This includes for example MDL RXN files, MDL RD files, the native Cactvs binary file format (.cbin standard suffix) and the Cactvs query-optimized formats (.cbs standard suffix).

Writing to a format which supports reaction storage is simply achieved by passing a reaction handle as write object. Reaction handles may also be passed to output channels configured to formats which do not support reaction storage, but in this case the reaction is split into individual ensembles and multiple records are output. Example:

```
molfile write myreaction.rxn [reaction create C=O>>CO]
molfile write mydata.sdf [reaction create C=O>>CO]
```

The first example will write a reaction record, while the second example will write two SD file records.

When reading data from reaction files, the read scope parameter of the structure file object must be set correctly. Only if this parameter is set to reaction (and not mol, ens, or dataset), reaction objects will be read. For most file formats, the scope parameter is automatically set to the most complex data object contained in the file. For example, RXN files are automatically opened for reaction input, and SD files for ensemble input. In most cases, reaction files can also be read on an ensemble level. An RXN file opened with read scope ens or mol will appear to contain two records:

```
set fhandle [molfile open mydata.rxn r readscope ens]
set enslist [molfile read $fhandle {} all]
```

The ensemble list will contain two ensembles. The file could also be read with two individual single-record molfile read commands. Reaction-level information is of course lost when files are read this way.

Both RD files and simple Cactvs binary files should be opened with explicit read scopes. The situation is additionally complicated by the fact that both formats could conceivably contain a mixture of structure and reaction records.

## Datasets

Datasets are major objects used to organize collections of ensembles or reactions. Datasets have handles in the form dataset $x$, where $x$ is a number. Any number of datasets may be created. As standard chemical objects, they may manage their own set of dataset-specific property data. The prefix for dataset properties is " $D$ _". The generic command for working with datasets is the dataset command.

Example:

```
dataset set $dhandle D_NAME
dataset get $dhandle D_SIZE
dataset get $dhandle D_GIF
```

The example code sets a dataset name, queries the size (number of elements) of the dataset, and finally generates a panel compound image, where the panel grid is filled with images of the dataset objects.

## Compatibility features

For historical reasons, the alternative name queue for datasets is still supported. This extends even to the decoding of handles - handle queue0 is equivalent to handle dataset0.

Again for historical reasons, a standard empty dataset dataset 0 is automatically created when the toolkit is initialized. This dataset cannot be deleted.

## Elements of datasets

Datasets can contain an arbitrary number of ensembles and/or reactions as elements as an ordered sequence of objects. Datasets which mix ensembles and reactions are possible, but rarely useful. Currently, an ensemble or reaction can only be a member of a single dataset at any time, or be not part of any dataset. By default, ensembles or reactions are created or read without being a dataset member. Ensembles or reactions can be moved between datasets. Many input and creation commands have optional parameters to identify a target dataset and will deposit the newly created objects directly into it.

```
Examples:
set dhandle [dataset create]
ens create CCC 1 $dhandle
molfile read "z.sdf" $dhandle
ens move $ehandle $dhandle
ens move $ehandle {}
```

The example sequence shows how to create a dataset, generate an ensemble in a dataset, read a file directly into a dataset, move an existing ensemble into a dataset and then to remove it from the dataset again.

## Dataset file I/O

When the native Cactvs binary format is used, dataset property data can be stored and retrieved. Unfortunately, standard chemical exchange formats do not support the storage of global dataset-level information. The command sequence

```
molfile write "dataset.cbin" $dhandle1
set fh [molfile open dataset.cbin r readscope dataset]
set dhandle2 [molfile read $fh]
molfile close $fh
```

first writes a dataset identified by the handle $\$$ dhandlel to the file dataset.cbin. By using the standard suffix .cbin, the file is automatically set up to use the native Сactvs binary data format without the need to explicitly set the file format. The write command is supplied with a dataset handle as parameter. For output to file formats which support dataset-level information storage, this implies that the dataset-level property data should also be stored, together with the dataset elements.

When the file is later opened for reading, it must be specified that dataset-level input is requested. The read command will then return the handle of a newly created dataset, which has the dataset property data from the file, and in addition contains newly created instances of all the original elements in the dataset (ensembles or reactions) with their original data. If the read scope is not adjusted to dataset prior to reading, dataset files can still be read as normal structure or reaction files, returning ensemble or reaction handles as the result of read commands, but the dataset-level information is ignored.

If the file in the example were a simple SD file, the write statement would write a set of records for the elements, and the read statement return a dataset with all the original elements, but without the dataset-level information.

## Virtual datasets

The dataset command does not actually need to be used with a proper dataset handle as identifier. The handle parameter may be replaced by a list consisting of any combination of dataset handles, ensemble handles, and reaction handles. If the parameter is anything but a single dataset handle, all specified objects are temporarily moved into a virtual dataset. In case dataset handles are part of the list, the objects contained in the listed dataset are moved into the temporary dataset, not the dataset itself.

When the command has finished, the objects are moved back to their original datasets, in their old position, or reset to their original dataset-less status. A few logical exceptions apply to this rule. For example, the global move command dataset move will of course let the moved objects remain in their new destination and not pop them back into their old place as soon as the command finishes.

## Examples:

```
dataset move [list $ehandle1 $ehandle2 $ehandle3] $dhandle
dataset scan [list $dhandle $ehandle1 $ehandle2] "structure >= clccccc1" enslist
dataset get [dataset list] D_SIZE
```

The first example will append the three ensembles to the specified dataset. The second example performs a substructure search on the combined list of all the elements in the argument dataset and the two additional ensembles. The third example retrieves the total element count of all datasets.

It is possible to set dataset properties on virtual datasets, but of course this information is immediately lost when the virtual dataset is destroyed.

Because a ensemble or reaction can only be a member of a single dataset, multiple listings of the same ensemble or reaction in a virtual dataset list are ignored. The processed virtual dataset contains these objects only once, at the position of their first listing.

## Structure, reaction and dataset file I/O

The toolkit has an extensive system for intelligent structure and reaction I/O. The central object used for this purpose is the molfile major object. A molfile object does not necessarily refer to a file in MDL Molfile format, but can be used to access any identified structure file format.

## Opening and closing structure files

Different from other major objects, molfile objects always refer to one or more files on the file system or an in-memory string representation of a file. They not created with null data, but always refer to some collection of file data. A molfile object is identified by its object handle. The object remains active until it is closed. After that, the handle becomes invalid, but in most cases, the file it referred to is preserved.

```
set fh [molfile open "myfile.sdf"]
molfile close $fh
```

The molfile close command can close all open structure files by passing the special handle all. molfile close all

## File modes

Molfile objects can be opened in different modes. The default mode is $r$, meaning the file is opened for input at the beginning of the file.
set fh [molfile open "myfile.sdf" r]
The statement above is completely equivalent to the statement five lines above. Other important modes are $w$ for overwriting and $a$ for appending to the end of a file. File in formats which can be rewritten on a per-record level without disturbing records behind the rewrite position can also be opened for update with mode $u$.

```
set fh [molfile open "myfile.sdf" w format sdf]
molfile write $fh [ens create CCC]
molfile close $fh
```

The three statements above will write a single MDL SD-file record with the propane molecule to file $m y f i l e . s d f$. If the file existed before, it will be overwritten. If the file had been opened with mode $a$, the record would have been appended. Opening a file which does not yet exist in mode $a$ is equivalent to opening it in mode $w$.

## Input file formats and I/O modules

For input, the format of a file is autodetected. This feature works by looking at data at the beginning of the file. In case the file cannot be rewound for later reading, the bytes needed for peeking are internally buffered. Generally, it is not a good idea to specify the file format for input directly. The format of a file is not determined by looking at the suffix of the filename, but there is a twist explained below.

File I/O in the Сactvs toolkit is extensible by loading I/O modules. Very few I/O formats are built-in. In standard configuration of the basic interpreter, these are only the native formats of the toolkit, SMILES, a couple of MDL formats (SDF, RXN, RDF), and meta formats (mailbox, hitlist). Other interpreters may have an extended set of compiled-in I/O modules. Nevertheless, most standard interpreters will load a couple of additional I/O modules at start-up, and these can be used in the same fashion as built-in modules. The list of auto-loaded I/O modules can be configured in full toolkit installations by editing the siteconfig/cactvsio file.

When a file is opened for reading, the format detection modules of all loaded I/O modules are invoked, with the most recently loaded module first and the built-in modules last. If any of the format detection routines claims it has detected the format, the issue is considered settled and the selected I/O module will handle all further I/O to and from this file.

If the file format identification failed, the toolkit will make an attempt to auto-load a suitable I/O module, if the interpreter has support for loading of dynamic modules. Only in this case is the suffix taken into account.
set fh [molfile open "result.pdb"]
If the interpreter executing the above statement does not have built-in support for PDB files, and the PDB I/O module is not yet loaded, the interpreter will try to locate the module along its search path,
which can be configured in global variable cactvs (filexpath). If the interpreter can find the module named filex pdb.so or filex pdb.dll (following the platform-dependent naming conventions of shared libraries, and using the filename suffix as part of the module name), this module will be automatically loaded, and its format detection routine given a chance to identify the format. However, if a statement like
set $f$ h [molfile open "result"]
fails, because the file result is of a format which cannot be identified by the built-in and currently loaded modules, explicit action needs to be taken. In such cases, explicit loading of a suitable file format can be requested:
filex load pdb
Above statement will load (or reload) the pDB I/O module explicitly. Automatic loading of I/O modules is an incentive to use standard suffixes. However, as long as the proper I/O modules are loaded, omitting suffixes or even using misleading suffixes is no problem.

## Output file formats

The default format for output files is determined by its file name suffix. If no suffix is provided, the system default format (usually SDF) is used.

If the suffix is not associated with a loaded I/O module, the I/O module search path is traversed and the I/O module automatically loaded, if it can be located on the path, and the interpreter is allowed to load extensions.

```
set fh [molfile open "myresult.pdb" w]
```

Above statement will open a PDB file for writing, if the PDB module is loaded, or can be auto-loaded.
However, for output is is customary to specify the format explicitly, if just for resolving suffix use conflicts. For example, the suffix .mol is not specific for any single format, and the actual format used depends on which modules are currently loaded.

```
set fh [molfile open "myresult.mol w format sybyl2]
```

In contrast, above statement is unambiguous. The sybyl2 I/O module is automatically loaded if required and found on the search path. Alternatively, it could be explicitly loaded before executing the file open statement via a
filex load sybyl2
statement, or, if the module is located in a location outside the standard path, with an extended command like
filex load sybyl2 /private/modules/filex_sybyl2.so

## File attributes

Molfile objects have a complex inner structure, and consequently a lot of attributes which can be queried and set. File attributes can be set by the molfile open statement, or at any later time set and queried with the molfile set and molfile get commands. The format pdb and format sybyl2 parts of the molfile open statements used in the sample statements in this section are already examples of file attributes set at the time of opening the file.

```
set fh1 [molfile open infile.pdb r hydrogens add]
set fh2 [molfile open outfile.sdf w format sdf subformat 2D writelist E_WEIGHT]
```

These statements show some typical attributes settings. After the hydrogens add attribute has been set, a standard set of hydrogens will be automatically added to any structure or other object read from the input file. The subformat 2D attribute configures the output file to explicitly use 2D coordinates. They will be computed if not yet present. By default coordinates already present will have precedence, so if the structures to be written to this file are read from a PDB file with atomic 3D coordinates, the written SD file records will have 3D coordinates. The writelist attribute configures a list of properties to be written as SD data fields. Here, we add molecular weight. The default data field list is empty, so no SD data fields are written.

Field attributes can also be queried:

```
set fmt [molfile get $fh format]
set rec [molfile get $fh record]
set line [molfile get $fh line]
```

These sample commands show how to retrieve the file format, the record number (beginning with 1) of the next record to be read or written, and the current line number on the file. With the exception of the line attribute, these fields can also be set:

```
set fh [molfile open datafile.sdf]
molfile set $fh record 5
set eh [molfile read $fh]
```

With this command, the structure read with the molfile read command will be the one in the fifth SDF record.

The most often used file attributes are:

- format The file format. Usually set only for output. Useful to query on input files to learn the actual file format as detected.
- record File record of the next record to be read or written, starting with 1. For normal files, the record position can be set to arbitrary input locations anywhere in the file, regardless whether the location has been visited before or not. In files which cannot be rewound, only forward skipping is possible. It is possible to set the record position on output files, too. However, if the file cannot be rewritten in place, or the file mode is not $u$, all data behind the new location is deleted.
- line The current line number in the file. After a record has been read, it is the number of the last line of the record. Binary files count one line per record. This attribute can be set for bookkeeping purposes, but does not change the actual file position. A newly opened file reports a line number of 0 .
- eof This attribute is set to 1 if the file reached EOF on input. It cannot be set.
- hydrogens The hydrogen addition mode. The default is asis, meaning that no hydrogen manipulation takes place on input and output. Other important modes are add (add standard set), strip (strip all hydrogens except those usually shown in structure drawings) and stripall (remove all hydrogens). Note that there are actually two different hydrogen addition modes, one for output and one for input. The changed or reported attribute is the one belonging to the current file mode (which could be changed with a molfile toggle command).
- eolchars
- fields
- readflags

The end-of-line characters used for output of ASCII files. The default is dependend on the platform ( $\mid n$ on Unix/Linux, $\mid r$ on MacOSX, $|r| n$ on Windows). This attribute does not give information on the type of EOL character used on input files.

The names and possibly data types and other attributes of data fields. The exact meaning of this attribute depends on the file format. For SD files, it is a list of the original names of the SD data fields. For file formats which can have different data content on every record, such as SD and RD files, the attribute is updated after each input record, and it is empty before data has been read. For file formats with a header detailing the data structure, it is filled when the file is opened. With the exception of the CBS and BDB file formats, this attribute is intended to be used for input files only. Setting this attribute does not have any effect on output to, for example, an SD or RD file. Please use the writelist attribute for this function. For CBS and bDB files, setting this attribute changes the global layout of the file. This is explained in more detail in the chapter about database files.
This attribute is a list of flags which control various aspects of structure processing during and immediately after reading, before the handle of the read object is returned as input result. The most important flags from a rather extensive list are:
aroresolver: If this flag is set, bond which are marked as aromatic but do not have a defined Kekulé form are automatically resolved into a Kekulé structure. A common use for this feature is for reading MDL Molfile with type 4 bonds, which are only allowed to be used as query bonds, but are frequently found in registration system data too.
complexresolver: Change the bond type of bonds which cannot be reasonably represented as standard VB bonds into complex bonds, which are exempt from bond electron counting. This is the only flag which is set by default.
fixstereo: Discard wedge bonds on atoms which cannot be stereocenters. This option requires that hydrogens are added during the read (hydrogens add attribute).
mergedata: If a file contains multiple instances of a data field, by default multiple instances of the associated property are attached to the ensemble or other input objects. For example, an SD file record with two <mydata> fields will produce an ensemble with properties E_*MYDATA* and E *мYDAta*/2. If this flag is set, the data of repeated fields is appended to the first property instance. The exact meaning of appended is dependent on the datatype of the property. For the common case of strings, it is appended at the end, separated by a tab. For vector types, additional elements are created.
noeof: Ignore EOF indications on the input channel.
noimplicith: Do not assume the file contains implicit hydrogens. With this option, SMIles data is read in a pseudo-SMARTS fashion, without added hydrogens. This option has no effect on file formats where atoms do not possess an implicit hydrogen count, such as MDL Molfiles.
nometal: If this flag is set, assume that the file does not contain metals, Symbols which look like the element names of metals are instead interpreted as superatoms, for example $A l$ for alanine.

This attribute controls the type of object read from an input file. The default value depends on the format of the input file. For most formats, it is ens, i.e. the object read is an ensemble. For rd files, Rxn files, and reaction smiles the default format is reaction. Files with a data description heade are automatically opened with a read scope matching the file content (i.e. a $B D B$ reaction file is opened in reaction scope, while a structure file is opened for structure input). The allowed values of this attribute depend on the file format. For example, an Rxw file can be read in mode ens, retrieving one half of a reaction per read. Other modes which are allowed for specific formats are mol (reading individual molecules from ensembles and returning them as isolated ensemble objects) or dataset (retrieving complete datasets as dataset objects with structure or reaction subobjects, including dataset-level property data).

- subformat This attribute identifies various format variants of certain file formats. It can be both read, after retrieving a file record, or set to influence the formatting of an output file. The must important subformats are mol2D, $\operatorname{mol} 3 D$, and mol $0 D$ which can be used to identify or control the type of coordinate data in MDL Molfile variants (Molfile, SDF, RXN, RDF).
- writeflags This attribute is a list of flags which control various aspects of file output. The most commonly used flag bits, which are specified as a list of set flags, are:
compute: Attempt to compute properties on in the writelist attribute. By default, they are only written if they are already valid at the moment of writing. No error is raised if computation for a listed property fails. nostereo: Do not output stereo information, even if it is present. This is for example useful in case a 3D compound with arbitrary, but in reality undefined stereochemistry is write as a 2 D structure.
write $0 D$ : Write a 0 D record without coordinate information, if the file format supports this.
write $2 D$ : Write a 2D record with atom display information, if the file format supports this.
write $3 D$ : Write a 3D record with atomic 3D coordinatges, if the file format supports this. The effect of the writexD flags is the same as setting the corresponding file subformat.
writearo: Write aromatic bonds with an aromatic bond type, even if this is questionable, such as in MDL Molfiles which should encode a defined Kekulé structure.
writename: Add the contents of property E_NAME as a name field if this is optional, for example when outputing smiles.
- writelist This is a list of properties which should be output as additional data fields, if the file format supports this. However, by default no attempt is made to actually compute this data. If a property is not present, it is, dependent on the file format, silently ignored or stored as a NULL value.

Computation can be automatically attempted for all listed properties by setting the compute flag of the writeflags attribute. Properties which cannot be output in a file because of restrictions of the file format with respect to supported datatype or property object associations are also silently ignored. The default writelist is empty, meaning that no extra data beyond the minimum defined by the file format is output by default.

- droplist This is a list of properties which should not be output, even if present and listed in the writelist. It effects only file output operations.
- ignorelist This is a property list which affects input only. All properties listed here are ignored and deleted from the read structure object, even if the input record explictly contained this data.

This is an example script showing some common uses of file attributes:

```
prop set E_WEIGHT origname "Molweight"
set fhin [molfile open "infile.sdf" r hydrogens add]
set fhout [molfile open "outfile.sdf" w format sdf writeflags compute \
    droplist "Activity" subformat 2D
set eh [molfile read $fhin]
molfile set $fhout writelist [concat [molfile get $fhin fields] E_WEIGHT]
molfile write $fhout $eh
molfile close all
```

This script converts a (presumably) 3D molecule in file infile.sdf into a 2D record in file outfile.sdf. All SD data fields in the input file are copied to the output file, except for the field Activity. This is done by copying the field information from the input file, extracted after reading the current input record, into the writelist of the output file, but listing the Acitivty field in the droplist. An additional field for the molecular weight is added, under the field label Molweight, and it is computed if necessary.

## One-shot file command shortcuts

Most molfile subcommands accept, in addition to a file handle obtained from from a molfile open statement, the name of an existing file. If the resolution of a file handle fails, an attempt is made to open the identifier as a file for reading, except if the command is an output operation. The write subcommand opens the file in $w$ (overwrite) mode, while the delete, reorg, rewrite and set commands open in $a$ (append) mode. If this operation succeeds, a temporary handle is created, which is automatically released when the command finishes.

Examples:

```
set eh [molfile read myfile.skc]
set nrecs [molfile count myfile.sdf]
```

These commands are identical to the sequence

```
set fh [molfile open myfile.skc]
set eh [molfile read $fh]
molfile close $fh
set fh [molfile open myfile.sdf]
set nrecs [molfile count $fh]
molfile close $fh
```

Here is a very simple output operation:

```
molfile write out.sdf [ens create c1ccccc1]
```

This command creates a single-record MDL Molfile in the current directory, overwriting any existing file of that name.

## Reading structure objects from files

The primary input command is molfile read. It reads the next record from an input file identified via its file handle and returns an object which corresponds to the current read scope of the file handle. In most cases, this is an ensemble object. The input objects are allocated and should be freed if they are no longer needed. Here are some sample commands:

```
set eh [molfile read "mymol.sdf"]
set xh [molfile read [molfile open "reactions.rdf" r record 2 hydrogens add]]
molfile read "bigfile.sdf" [dataset create] all
```

The first line simply tries to open the file mymol.sdf and reads the first record, without performing any kind of modification or standardization on the data.

The second example opens a reaction file and positions the read pointer to the second record. In addition, any object read from the file gets a standard set of hydrogens added. Assuming that the RD file contains reaction information, and the read scope was thus automatically set to reaction, the outer molfile read command returns a reaction object.

The third sample line reads the complete file into a dataset object. The optional third parameter of the molfile read command is a recipient object handle. If, for example, the recipient object is a dataset, and the objects read from the file are ensembles or reactions, these objects are appended to the dataset object. It is also possible to specify an ensemble object (if the read scope is ens), or a reaction object (if the read scope is reaction). In that case, the existing object is cleared, but its handle reused for the new data. This can be useful in case there are references to an exisiting ensemble object which are difficult to update. Instead of omitting this parameter, an empty string may be used.

The optional fourth parameter of molfile read is a record count. Its default value is one. The special value all can be used to read until the end of the file. In case an explicit record count is used, the command returns the list of successfully read object as object handles, even if their number is less than the requested number, provided that at least one object could be read. Otherwise, an error is raised. The distinction between reaching EOF and encountering an input error is easily made with code such as

```
if {[catch {molfile read $fh} eh]} {
    if {[molfile get $fh eof]} {
        # normal eof
    } else {
        # input error
    }
}
```

The molfile hread command has the same syntax as molfile read, but it adds a standard set of hydrogens to the read objects, without permanently changing the hydrogen addition attribute of the file. Example:

```
set elist [molfile hread "myfile.sdf" {} 5]
```

The code above reads the first five structure records from the file and adds hydrogens to the ensembles. The return value is a list of five ensemble handles. If the file contained only a smaller number of records, but at least one record, a shorter object list is returned.

## Looping over files

Processing an input structure file from beginning to end is a very common task. It can be done with code such as this:

```
set fh [molfile open "bigfile.sdf" r]
while {![catch {molfile read $fh} eh]} {
    # process structure here ...
    # now get rid of input object
    ens delete $eh
}
if {![molfile get $fh eof]} {
    # process error
}
molfile close $fh
```

Since this is somewhat cumbersome, and the commonality of the task, the toolkit has a convenience function molfile loop. The sequence above can be simplified to

```
molfile loop "bigfile.sdf" eh {
    # process structure
}
```

The first two mandatory parameters of the molfile loop command are the file handle (or a handle temporarily generated for a one-shot file, as in the example above) and the name of a TcL variable which will hold the handles of the read objects for use within the body of the function. The last (but not always third) parameter is the function body. Any number of scripting commands can be put there.The standard TcL commands break, continue, return and error will work as expected within the loop body, just as they work in a for or while loop. It is possible to loop over reactions or datasets if the read scope is set appropriately. The object handle of the current read item is stored in the variable regardless of its type.

Note that the loop example did not delete the ensemble read from the file. This is done automatically when the loop body was executed and the loop is prepared to execute the next cycle. Any explicit deletion of the input object within the loop is silently ignored. The object is undeletable until the loop body has finished.

The loop finishes silently on EOF. In case an input error is encountered, an error is raised. Thus, no check for distinguishing EOF from a read error is required. If a loop throws an error, the file is damaged.

The loop begins at the current record. If the file is not positioned on the first record, it is not rewound.
The maximum number of iterations of the loop can be limited by an optional iteration count parameter inserted between the storage variable parameter and the function body. A negative value or an empty string indicates an endless loop.

The command variation molfile hloop takes the same parameters as molfile loop, but automatically adds a standard hydrogen set to the input objects. Just like the molfile hread command, it does not permanently change the hydrogen addition attribute of the file.

An example demonstrating a few of the features mentioned in the last paragraphs:

```
set xh_aldol ""
if {[catch {
    molfile hloop reactions.rdf xh 10 {
        if {[reaction get $xh X_NAME] = "Aldol condensation"} {
            set xh_aldol [reaction dup $xh]
            break
        }
    }
} msg]} {
    puts "read error: $msg"
}
if {$xh_aldol!="'\prime} {
    # do something
}
```

This script searches the first ten records of reaction data file reactions.rdf for a reaction with the name "Aldol condensation". Assuming that the RD file contains reactions, the input objects generated by the loop are reactions with fully specified hydrogens. Regardless how the loop is left, the loop input object is automatically deleted. So in case you want to export an object from within the loop, it must be duplicated. The break command exits the loop when the desired reaction was found. The outer catch command wraps the full loop statement. It is triggered when a read error occurred, but not if EOF was found, ten records were examined, or the loop left via the break command. An error message is captured in the msg variable and printed if the catch command triggers.

The execution of molfile loops can be made more robust with two special file attributes which are only checked within these loops. These readflags attributes flags are supported:

- ignoreempty
- ignoreerrors If a read error occurs, the defective record is ignored and the loop tries to resynchronize and continue with the next record. An error is raised only if the resynchronization fails.

The return value of the molfile loop commands is the number of iterations successfully executed. Ignored faulty records are not counted.

Example:

```
set fh [molfile open "big_damaged_file.sdf" r \
    readflags [list aroresolver ignoreempty ignoreerrors]]
set loopcnt [molfile loop $fh eh {
    # process, ignore problems as much as possible
} ]
puts "$loopcount records successfully processed"
```


## Command extensions and modules

The Cactvs toolkit includes a collection of modules which provide additional functionality when loaded. Some library versions may also contain compiled-in versions of these modules.

## Tcl and Tk Packages

All Tcl- and Tk-enabled toolkit versions may load standard Tcl extension packages via the standard Tcl mechanisms. The Tk toolkit is itself available as a package any may be loaded into any plain Tcl-enabled script interpreter. The package require command will take care of package dependencies and automatically load additional packages if required and hide platform specifics such as the suffix of dynamic link libraries, shared libraries, or bundles.

Examples:

```
package require Gd
package require Gdbm
package require Tk
load $cactvs(libdir)/libTktable2.8.so
```

Packages usually provide at least one additional command to the interpreter they were loaded into. By convention, the name of this command is the same as the package name, but spelled in all lower case.

Example:

```
package require Gd
set gdhandle [gd create 100 100]
gd rectangle $gdhandle [gd color new 255 0 0] 0 0 50 50
```

Packages are automatically located in all directories which are listed in the standard Tcl variable tcl_pkgPath. This variable may be changed as needed.
Loading a package more than once does not have any effect. Loaded packages are only accessible in the Tcl interpreter which loaded them. For example, a Tcl interpreter associated with a Tcl computation function does not have access to the commands of a package loaded by the main interpreter, if the main interpreter did not explicitly export the commands to the slave.

## Cactvs Command Extensions

CACTvs command extensions are very similar to Tcl packages. They may even be loaded as such vie the standard Tcl package or load commands. The only major difference is that they contain a table with module information in addition to the standard Tcl module initialization functions. If command extensions are loaded via the cmdx load command, this data is accessible and may be queried in scripts.

Example:

```
cmdx load stat
puts "Version: [cmdx get stat version] by [cmdx get stat author]"
puts "correlation coefficient: [stat r {1 2 3} {5 6 8}]"
```

Command extensions are located automatically in all file system directories and other places, such as databases or Web locations, listed in the control variable cactvs (cmdxpath). This path variable may be changed as needed.

Command extensions are global. Once a command extension has been loaded, it is usable in all slave interpreters, such as computation interpreters associated with properties.

## The Gdbm Module

The Gdbm module is a standard Tcl module. It provides a high-level access to the Gnu Gdbm library. Because this library is under the GPL (not even LGPL) license, it is only part of selected distributions.

The module is usually loaded with a package require command:

```
package require Gdbm
```

The purpose of the module is working with Gdbm files. Gdbm files are simple keyword/value storage files with an efficient, hash-based random access mechanism via the keyword, which can be any string. In principle, these files are comparable to Tcl array variables - but since the content is held on file, they need far less memory resources.

A common application example for these files is the storage of large structure collections, without the overhead of a real database, or a scan file. Structure hashcodes (E_HASHY, E_HASHSY, E_HASHTY, etc.) are useful access keys - but any identifier, such as a record number, E_IDENT ID string, etc. works as well. The value part of an entry may be anything, from a complete structure information (conveniently packaged as pack string - see ens pack command), via a SMILES string (property E_SMILES) to any kind of other information, such as a compound name.

Examples:

```
package require Gdbm
set ghandle [gdbm new test.gdb]
set eh [ens create COC]
set hash [ens get $eh E_HASHY]
gdibm insert $ghandle $hash [ens pack $ehandle]
if {[gdbm exists $ghandle $hash]} {
    set enew [ens unpack [gdbm get $hash]]
}
gdbm close $ghandle
```

The access to an opened Gdbm file is performed via a handle. Commands which open or create a Gdbm file will return a handle, which should be saved and passed to subsequent commands as the file unidentified. The mechanism is essentially the same as for the toolkit chemistry objects, such as ensembles, reactions, or structure files. Handles remain valid until the file is closed.

Gdbm files are platform dependent and cannot be opened on a computer with a different byte ordering. Exchanging these files between e.g. IRIX and Linux computers is not possible. This limitation is inherent to the file format and not a problem of the toolkit.

The Gdbm module commands are detailed in the reference section.

## SQL Expressions

The Cactvs toolkit contains, if the compilation flag for this feature was set, an SQL-compatible function parser which is used in various contexts. Its most important applications are:

- Function columns in table objects
- Row selection in table objects
- General support for free-form data formatting for chemical objects

The parser is used to evaluate expressions which usually involve property data. The mechanism of referring to property data is dependent on the context and will be described in more detail below.

## Function Syntax

The function syntax follows mostly the expected schemes. Normal operators obey the same precedence rules as in C. Parentheses may be used to group expressions.

Examples:
$1+2 * 3$
concat ("a","b","c")
In contrast to standard SQL , case does matter. All function names must be written in lower case. Property references are written as uppercase strings.

Example:
interval (E_WEIGHT,100,250)
An unusual aspect of the function syntax is that some syntax elements use embedded keywords. In addition to the function names, these keywords are reserved. Keywords must be separated by whitespace or punctuation characters from the rest of the expression.

Examples:
substring("abc" from 1 for 2)
3 in (1, 2, 3)
(1/0) is NULL
At every stage during the evaluation of an expression, a check is made whether any of the input parameters for the next step in NULL. If it is, in most cases the full sub-expression will also become nULL. The meaning of NULL is not an empty string, or a NULL pointer. Rather, it indicates unspecified or undefined data. Making decisions with undefined data is not possible. A check whether null equals NULL will also result in NULL: Since both comparison values could be unspecified in different ways, it is not possible to obtain a valid comparison result. However, there are a few functions which allow the explicit test for nUlu values and reacting towards it.

NULL values may for example be encountered by referring to unset table cells if the SQL expressions are used in a table context.

Example:
ifnull (1/0,9999)

## Data types in expressions and functions

The result of a function can only be a signed integer, a double precision floating point value, a date value, or a string. The result data type is usually determined by the functions use in the expression. For mathematical expressions, the arguments are automatically adapted. If any element of a simple mathematical expression is a floating point number, the result will be a float. If a mathematical expression involves string parameters, an attempt will be made to interpret the strings first as an
integer, and then a float if the string is not a simple integer. An initial integer value may again be promoted to a float in case it is used in a floating point context. Date values used in a numerical context will be treated as an integer (internally, dates are stored as seconds since Jan 1st, 1970).

Examples:
$1+2.0$
will yield a floating-point 3.0 as result, while
$1+" 2 "$
will yield an integer result of 3 .
Numerical values which are passed to functions which expect string input parameters are formatted as standard integers or $\% g$ floating point values and then passed as a string.

Property values which are used as function or expression arguments are cast to the expected type. If the property is of a data type which does not provide a suitable cast function to any of the allowed types, an error results. The use of property subfields as function or expression arguments is supported.

Example:

```
set ehandle [ens create {C methane 108-88-3}]
puts [ens expr $ehandle {concat('CAS# ',E_NAME(1),' ',E_WEIGHT)}]
```

This example first generates an ensemble, using the feature to transfer naming information as part of the SMILES string. The name, which here is actually a composite of two parts, is automatically stored as property E_NAME as part of the ensemble information. Access to the second word of the name is possible by means of standard word-based indexing on string data (indices start with 0 ), and that data is then concatenated with the leading constant string. A separator space is added, and then the floating point property value E_WEIGHT of the ensemble is cast to a string (after it was computed on the fly) and appended. The final output of the command is "CAS\# 108-88-3 16.0426".

Using expressions which check for data availability, it is possible to output or import different property data into a column depending on the circumstances.

## Example:

table addcol \$thandle function "ifnull(E_MDLNUMBER,E_COMPANY_IDENT)" molid
This example adds a function column to a table. The name of the column is molid. When an ensemble is later added to the table, it is filled with data from property e_MDLnumber, if is was present or could be computed. Otherwise, data from the second property E_COMPANY_IDENT, which could be an in-house identifier, is used. If that identifier is also missing, the table cell receives a NULL value.

Names of properties or fields/columns may be dynamically constructed by casting a string to a property or field/column reference:
table sqlselect \$thandle \{property(concat("E_","WEIGHT")) between 100 and 250\}
This example will select all table rows from a table where the ensemble molecular weight of the entries lies between 100 and 250 . If a table column with data of property E_WEIGHT exists ${ }^{10}$, it is used
10. This is independent of the column name - we are looking for a column of type property which is linked to property E_WEIGHT
for the scan. Otherwise, a check will be made whether the table rows are associated with ensembles which are still in memory. If that is the case, the weights will be retrieved or calculated from these ensembles. If the ensembles do not exist any longer, or the data was stored without leaving ensemble references, the selection function will see NULL values.

Another application area for SQL expressions is data formatting via the expr command of chemical objects.

For standard ensemble data formatting, it is usually not necessary to use the SQL parser. The standard formatting capabilities built into Tcl will work as least as well. These expressions develop more power when used in the context of table function columns and selection functions.

## Function references to constants and data

These types of data can be used in SQL expressions:

| - Integer constants | Standard signed numbers. |
| :--- | :--- |
| Example: 999 |  |

- Hexadecimal constants
- Floating-point constants
- String constants
- NULL or null
- true or false

These start with a 0 x character pair and continue with a sequence of case-insensitive hex digits ( $0-9$ and a-f). Octal constants are not supported.
Example: 0xff
Floating point constants must contain a decimal point, and may use an exponent. Usually, it is not necessary to specify integral floating point values as such, because integers are cast automatically to floats when required.
Examples:
2., 3.14159, 2.97e6

Strings are started by either a single or double quote, and extend until a closing quote of the same type is found which is not escaped. The escape character is a backslash. The maximum length of a string is currently 8 K . Three-digit octal escape sequences as well as the standard escapes ' $\backslash n$ ', ' $\backslash t$ ', ' $\mid r$ ',,$\backslash b$ ', ' $\backslash f$ ', ' $\backslash v$ ' and ' $\backslash z$ ' are recognized and decoded. Multi-line specification of strings with a backslash as last character on a line is also supported.
Examples:
"Hello World", '"We\tare\tthe\tchampions $\backslash n^{\prime \prime}$
The function evaluation engine is fully null-compliant according to the standard. Constant null values are supported.

These are just alternative names for integer constants 1 and 0 .

- Uppercase property name
Reference to a property attached to the context object. The context object can for example be an ensemble. The expression context must match the property object class - it is for example not possible to refer to an atom property in an ensemble context. Only native Cactvs property names may be used, not original names as they were read from a data file. In order to be able to use property data, the chemical object providing the data must still be around. In the context of tables this means that an update of function cells referring to properties is not possible if the original ensemble or reaction which provided the data is no longer present and (see below) there is no data column which holds a copy of the original ensemble or reaction data.
Example:
E_name
- Uppercase indexed property Properties may be indexed. In contrast to the standard property indexing mechanism in the scripting environment, this index may be a dynamically evaluated SQL function. If the index is a constant field name string and not a numerical index, it must be quoted as a string, which is an important difference to the standard script indexing syntax. Only native Cactvs property names may be used, not original property names as they were read from a data file.
Examples:
E_NAME(0), E_NAME (log10(10)), E_NAME ("somefield")
E_NAME(0), E_NAME (log10(10)), E_NAME ("somefield")
- Field name
If no reserved function name is detected, and a word in the input does not match any of the above constants, it is interpreted as a field name. In a table function or selection context, a field name is interpreted to refer to the name of a table column. If a property name was detected, but the object the expression works on holds the same data already in a field, the data from the field is used. This means that it is for example to refer to a property via its name in the context of a table, if a table column with that data exists, even when the original ensemble which provided the data for the column does not exist any longer.
Example:
col5

The names of built-in functions are reserved and cannot be used as field or property names.

## Numerical operators

Function operators use the standard precedence rules.
This is the set of built-in operators:

```
- Negation (unary operator)
```

```
- Addition of numerical data. If any of the arguments is a float, the result is a float, otherwise an integer.
Subtraction of numerical data. If any of the arguments is a float, the result is a float, otherwise an integer.
Multiplication of numerical data. If any of the arguments is a float, the result is a float, otherwise an integer.
- Division of numerical data. If any of the arguments is a float, the result is a float, otherwise an integer. Division by zero yields a nuld result.
Modulo operator on integer data. Floating point values will be cast to integer. For modulo functionality with floating point conservation, use the \(\bmod ()\) function.
- ** Exponentiation of float data. The result is always a floating point value.
```


## Boolean operators

```
- el <=> e2
- el=e2
- e1 == e2
- e1 != e2
- el <> e2
- e1>e2
- el<e2
- e1>=e2
- el<=e2
- x between l and h
- x in(a1,\ldots.)
Check whether the values of the expressions are equal. This comparison operator will return 1 if both values are NULL.
Check for equality, with type coercion if necessary. NULL is by definition not equal to NULL.
The same as the simple \(=\) operator.
Check for inequality. nULL arguments will always result in a null result.
The same as the \(!=\) operator.
Check weather \(e 1\) is larger than \(e 2\), with type coercion if necessary.
Check weather el is smaller than \(e 2\), with type coercion if necessary.
Check weather \(e 1\) is larger than or equal to \(e 2\), with type coercion if necessary.
Check weather el is smaller than or equal to e2, with type coercion if necessary.
Check whether the value of \(x\) is between the low and high limit expressions \(l\) and \(h\). The comparison values will be cast to the common type. The function may be used with string arguments. If \(x\) is within the range, the result is 1 , otherwise 0 .
- \(x \operatorname{in}(a 1, \ldots)\)
```

If the value of $x$ is equal one of the listed arguments, the result is 1 , otherwise 0 . If any of the arguments are NULL, a NULL $x$ will also be found.

- not el
- !el
- e1 and e2
- e1 \&\&e2
- e1 or $e 2$
- e1 ||e2
- el xor e2
- $e 1^{\wedge} e 2$
- $x$ is not null
- $x$ is null
- $x$ not between $l$ and $h$
- $x \operatorname{not} \operatorname{in}(a 1, \ldots)$
- $s$ like pat [escape $c$ ]
- $s$ not like pat [escape $c$ ]
- $s$ regexp pat

Invert the boolean result of expression el. Inverting NULL gives nULl.

This is an alias to the not comparison operator. However, ! may not be used as a replacement for not where not is a keyword, such is as a not in statement.

Check whether both boolean input values are true. If any of the input arguments cannot be converted to an integer, or are NULL, the result is null.

This is an alias to the and comparison operator. However, \&\& may not be used instead of and in cases where and is a keyword, such as in between statements.

Check whether any of the boolean input values are true. If any of the input arguments cannot be converted to an integer, or are nULL, the result is NULL.

This is an alias to the or comparison operator.
Check whether exactly one of the boolean input values are true. If any of the input arguments cannot be converted to an integer, or are nULL, the result is NULL.

This is an alias to the xor comparison operator.
Return 1 if expression $x$ is not nULL, 0 otherwise.
Return 1 if expression $x$ is NULL, 0 otherwise.
This is the negation of the between range check.
This is the negation of the in() function.
Check whether string $s$ matches the pattern pat. The pattern is mostly matched literally and is anchored to the left and right sides of the string. There are only three characters with special meaning in the pattern string: _ (underscore) matches one arbitrary character, and $\%$ (percent) matches any number of characters, including none. The special meaning of these characters in the pattern can be suppressed be prefixing it with the escape character, which is a backslash by default, but can be set by the optional phrase. The escape character may be escape by itself. The result of this function is a boolean match result value if none of the input parameters is NULL. The comparison is case-sensitive.

This is the negation of the like pattern match function above.
Perform an extended regular expression match of string $s$ against regular expression pattern pat. The result is a boolean match value, or NULL if any of the arguments is null. The comparison is case-sensitive.

```
- s not regexp pat
- s rlike pat
- s not rlike pat
- strcmp(s1,s2)
```

This is the negation of above operator.
This is the same as the regexp operator.
This is the negation of above operator.
Compare strings s1 and s2. If s2 is lexicographically larger than $s 1$, the result is -1 . In the opposite case, the result is 1 . If the strings are equal, the result is 0 . The comparison is case-sensitive.

## Bit operators

| $\bullet \sim$ | Bit-inversion (unary operator) |
| :--- | :--- |
| $\bullet \mid$ | Bit-or |
| $\bullet \&$ | Bit-and |
| $\bullet \wedge$ | Bit-exclusive or |
| - $\ll$ | Leftshift |
| - $\gg$ | Rightshift (performed on unsigned argument) |

All of them are identical to the C language definition, including precedence rules. They are not standard SQL.

## Mathematical functions

This is the set of built-in numerical functions:

| - $\operatorname{abs}(x)$ | Absolute value of float or integer $x$. The data type is preserved. |
| :---: | :---: |
| - $\operatorname{acos}(x)$ | Arc cosine of float $x$. If $x$ is outside the range $-1 \ldots 1$, NULL results. |
| - $\operatorname{asin}(x)$ | Arc sine of float $x$. If $x$ is outside the range $-1 . .1$, NULL results. |
| - $\operatorname{atan}(x)$ | Arc tangent of float $x$. |
| - $\operatorname{atan}(y, x)$ | Arc tangent of $y / x$, using the signs of both parameters to determine the quadrant. |
| - $\operatorname{atan} 2(y, x)$ | Arc tangent of $y / x$, using the signs of both parameters to determine the quadrant. |
| - bit_count $(x)$ | Count the number of set bits in $x$ after casting it to an integer. |
| - bitcount ( $x$ ) | This is an alias to the bit_count () function. |
| - $\operatorname{ceil}(x)$ | Round float $x$ up to the next integer. The result is an integer. |
| - ceiling $(x)$ | Round float $x$ up to the next integer. The result is an integer. |
| - $\operatorname{clamp}(x, l, h)$ | If $x$ is less than $l$, it will be set to 1 . If it is larger than $h$, it will be set to $h$. The function preserves the data type of $x$. |


| - $\cos (x)$ | Cosine of float $x$. |
| :---: | :---: |
| - $\operatorname{deg}(x)$ | Convert float $x$ from radians to degrees. |
| - degrees $(x)$ | Convert float $x$ from radians to degrees. |
| - double ( $x$ ) | Force casting of argument $x$ (can be int, float, string) into a float. |
| - $\exp (x)$ | Natural exponent of a float. |
| - float $(x)$ | Force casting of argument $x$ (can be int, float, string) into a float. |
| - floor ( $x$ ) | Round float $x$ downwards to the next integer. The result is an integer. |
| - $\operatorname{int}(x)$ | Force casting of argument $x$ (can be int, float, string) into an integer. |
| - interval( $n, n 1$ | Compute the interval index of argument n . If $n$ is smaller than $n 1$, the result is 0 . If it is between $n 1$ and $n 2$, the result is 1 , and so forth. If $n$ is larger than any comparison value, the result is the number of comparison values. All arguments are cast to the type of $n$. This function can, in an extension of the SQL standard, used with all data types. |
| - $\operatorname{irand}(x)$ | Produce an integer random number between zero and x-1. |
| - $\operatorname{irnd}(x)$ | This is an alias for the function irand(). |
| - isnull( $x$ ) | If $x$ is NULL, the result is integer 1 , else 0 . |
| - $\log (x)$ | Natural logarithm of float $x$. |
| - $\log 10(x)$ | Decadic logarithm of float $x$. |
| - $\operatorname{pow}(x, y)$ | Raise $x$ to the $y$ th power. Both parameters are floats. |
| - power ( $x, y$ ) | Raise $x$ to the $y$ th power. Both parameters are floats. |
| - $\operatorname{rad}(x)$ | Convert float $x$ from degrees to radians. |
| - radians $(x)$ | Convert float $x$ from degrees to radians. |
| - range $(x, l, h)$ | Check whether $x$ is between (inclusive) the low and high limits $l$ and $h$. The comparison values will be cast to the common type. If $x$ is within the range, the result is 1 , otherwise 0 . This function may be used with string arguments. |

- $\operatorname{round}(x) \quad$ Round float $x$ to the next integer.
- $\operatorname{round}(x, n) \quad$ Round float $x$ on the $n$th decimal place. Positive $n$ indicates fractions after the decimal point, negative x rounds to next 10,100 , etc. A zero $n$ is equivalent to the single-argument version of this function. If $n$ is equal to or smaller than 0 , the result is an integer, otherwise a float.
- $\operatorname{rand}() \quad$ Generate a floating point random number between 0 and 1. The random generator seed is not changed.
- $\operatorname{rand}(x)$ Generate a floating point random number between 0 and 1. The random generator is seeded with integer argument $x$, and will, on consecutive calls, return the same sequence of pseudo-random numbers which is dependent on the seed argument $x$.
- $\operatorname{rnd}() \quad$ This is an alias for the function rand ().
- $\operatorname{rnd}(x) \quad$ This is an alias for the function rand $(\mathbf{x})$.
- $\operatorname{sign}(x)$

The sign of float or integer $x$. The result is an integer $-1,0$, or 1 .

- $\sin (x)$

Sinus of float $x$.

- $\operatorname{sqrt}(x) \quad$ Square root of float $x$. Roots of negative numbers will yield NULL.
- $\tan (x) \quad$ Tangent of float $x$.
- truncate $(x, n)$ Same as round () , except that truncation to the smaller absolute value is performed.


## Date and time functions

- curdate() Get the current time as a string in YYYY:mm:dd format.
- curtime() Get the current time as a string in $\mathrm{HH}: \mathrm{MM}: \mathrm{SS}$ format.
- current_date Get the current date as a string in YYYY-mm-dd format (ISO). This function does not use parentheses!
- current_time Get the current time as a string in HH:MM:SS format. This function does not use parentheses!
- current_timestamp Get the current date and time as a string in YYYY-mm-dd MM:HH:SS format (ISO). This function does not use parentheses!
- date_format $(f, x)$ Format the time specification $x$ with a format string $f$ interpreted by the strftime() C library function.
- dayname $(x)$ Get the English day name (Monday, Tuesday,...) from date specification $x$.
- dayofmonth $(x)$ Get the day of the month (starting with 1 ) from date specification $x$.
- dayofweek $(x)$ Get the day of the week from time specification $x$, using the ODBC encoding standard with $1=$ Sunday, $2=$ Monday, etc. Example:
dayofweek ('2003-1-1').
- dayofyear $(x)$ Get the day of the year (starting with 1) from time specification $x$.
- hour $(x)$ Get the hour from date specification $x$ as an integer.
- minute $(x) \quad$ Get the minute from data specification $x$ as an integer.
- $\operatorname{month}(x) \quad$ Get the month number (1...12) from date specification $x$.
- monthname (x) Get the English month name (January, February,...) from date specification $x$.
- now() Get the current date and time as a string in YYYY-mm-dd HH:MM:SS format (ISO).
- quarter $(x)$ Get the quarter (1...4) from date specification $x$.
- $\operatorname{second}(x) \quad$ Get the second from date specification $x$ as an integer.
- sysdate() Get the current date and time as a string in YYYY-mm-dd HH:MM:SS format (ISO).
- time() Get the current time as number of seconds since Jan 1st, 1970 as an integer value.
- time $(x) \quad$ Decode time specification string $x$ and return the value as seconds since Jan 1st, 1970. The types of dates which can be parsed depend on whether the toolkit was compiled with Tcl support or not. The toolkit directly parses a number of standard formats, such as ISO dates and times, but not any locale-dependent formats such as British/US dates. If the toolkit is compiled with Tcl as scripting language, the Tcl time/date parser will be used in addition to the built-in parser. Example: time (' 2003-1-15') as ISO data will be understood with or without Tcl support.
- time_format $(f, x)$ Format the time specification $x$ with a format string $f$ interpreted by the strftime() C library function.
- unix_timestamp() Get the current time as number of seconds since Jan 1st, 1970 as an integer value.
- unix_timestamp $(x)$ This function name is an alias to the $\operatorname{time}(x)$ function.
- week $(x)$
- week $(x$, mode $)$ Get the week number from date specification $x$. Mode can be one of 0 : week starts on Sunday, week range is $0 . . .53 ; 1$ : week starts on Monday, week range is $0 . . .53$; 2: week starts on Sunday, week range is $1 \ldots . .54 ; 3$ : week starts on Monday, week range is $1 . . .54$.
- weekday $(x)$ Get the day of the week index from date specification $x$. Here Sunday $=0$, Monday $=1$, etc.
- year $(x) \quad$ Get the year as integer (including centuries) from date specification $x$.
- yearweek $(x) \quad$ Get year and week as a six-digit integer in format YYYYWW from date specification $x$. The week begins with Sunday.
- yearweek $(x$, start $)$ Get year and week as a six-digit integer in format YYYYWW from date specification $x$. For start value 0 , the week begins on Sunday, for value 1 on Monday.


## String functions

Get the ASCII/ISO code of first character of string $s$. If the string is empty, the result is 0 .


| - conv( , $_{2}$ fbase,tbase) | Convert the string $s$, which is interpreted as being an unsigned number in base fbase (an integer between 2 and 36). $s$ may also directly be provided as a in integer parameter, in which case the decoder base is ignored. If the first input parameter is a string, it is decoded with the specified base. A new string with the value re-encoded in base tbase (an integer between 2 and 36) is generated. This function does not provide the full capabilities of the SQL function, because it currently does not handle signed numbers. If the target base is 16 , and the input is a string, the string will be (in a diversion from the SQL standard) encoded as a hex-encoded string. |
| :---: | :---: |
| - export_set(bits,on, | nbits]) <br> Construct a string from a bit-encoded integer value bits. The encoding starts with the LSB bits, moving upwards. For every set bit, the on string value is concatenated to the output string and for every unset bit the off string value. Bit positions in the output string are separated by a separator string, which is a comma character by default and may be changed by providing the first optional parameter. By default, all 32 bit positions of the standard toolkit integers are processed, but this number may be adjusted by the last optional parameter. All element and separator strings may be set to an empty string in order to omit them. |
| - find_in_set ( $s, s e t$ ) | Try to find string $s$ in a string-encoded set set. Set elements are separated by a comma. Search string $s$ must not contain commas. The function returns 0 if the string cannot be found, or the set is empty, otherwise the set element position starting with 1 . If any of the arguments is NULL, the result is NULL. |
| - insert( $s, p, l, s n e w)$ | Remove $l$ characters from string $s$, starting at position $p$ (which begins at 1), and replace the removed sequence with string snew. If the length $l$ is zero, the new string is simply inserted at the requested position. A minimal position value of 1 is silently enforced. Inserting beyond the length of the string is the same as a simple concatenation. |
| - instr(s,substr) | This is the same function as locate (), but the arguments are swapped. We love SQL. |
| - lcase( $s$ ) | Concert string $s$ to lower case. |
| - load_file(f) | Load file $f$ and return its content as a string. |
| - left ( $(, l)$ | Return the leftmost $l$ characters from string $s$. If $s$ is shorter than $l, s$ will be passed unchanged. |
| - length(s) | Get length of string $s$. |


| - locate(substr,s) | Locate the position (starting with 1) of the first occurrence of substring substr in string $s$. If the substring is not found, 0 is returned. |
| :---: | :---: |
| - locate(substr,s,p) | Locate the position (starting with 1) of the first occurrence of substring substr in string $s$, beginning the search at position $p$ (also starting with 1 ). If the substring is not found, 0 is returned. |
| - lower(s) | This is an alias for the lcase () function. |
| - $\operatorname{lpad}(s, l, p a d)$ | Left-pad string $s$ by repeating string pad until a length of $l$ is reached. The pad string may be longer than one character, but then only a part of the pad string may be used. The the string is already longer than $l$, it will be truncated. If the pad string is empty or NULL, a space character will be used for padding. |
| - 1 trim $(s)$ | Remove leading whitespace from string $s$. |
| - make_set(bits,s1,s2...) | Construct a string-encoded set by concatenating those element strings which correspond to set bits in the bits argument with a comma. The set element strings should not contain commas themselves. If bit 1 is set, string $s l$ is used, bit 2 decides whether s2 is included, and so forth. |
| - $\operatorname{mid}(s, p, l)$ | Return $l$ characters of string $s$, starting with position $p$ (which begins with 1 ). If the remaining string after position $p$ is shorter than $l$, the rest of the string will be returned. If $p$ is larger than the string length, an empty string is produced. If $p$ is smaller than one, it is implicitly set to 1 . |
| - octet_length(s) | Get length of string $s$. |
| - $\operatorname{ord}(s)$ | Get ASCII/ISO code of first character of string $s$. If the string is empty, the result is 0 . |
| - position(substr in $s$ ) | Locate the position (starting with 1) of the first occurrence of substring substr in string $s$. If the substring is not found, 0 is returned. Note that the parameters are separated by the keyword in, not a comma! |

- regsub(s,pat,rpl[,all])
- repeat $(s, n)$
- replace $\left(s_{2} f, t\right)$
- reverse( $s$ )
- $\operatorname{right}(s, l)$
- $\operatorname{rpad}(s, l, p a d)$
- $\operatorname{rtrim}(s)$
- soundex $(s)$
- $\operatorname{string}(x)$
- substring $(s, p)$
- $\operatorname{substring}(s$ from $p)$
- substring $(s, p, l)$
- $\operatorname{substring}(s$ from $p$ for $l)$

Perform a regular expression substitution on input string $s$. pat is an extended regular expression which is matched in case-sensitive fashion. When a match is found, the matched part of the input string is replaced by the rpl pattern. Within $r p l$, the usual regular expression replacement operators \& (full matched string section) and $\backslash 1 \ldots \backslash 9$ (matched bracketed sub-expressions of the pattern) are recognized. These replacement operators may be escaped by a backslash character in order to prevent their interpretation. By default, only the first match in the input string is substituted. The process may be changed to global substitution by passing a true boolean all parameter as optional argument. The return value is the substituted string. If no match occurred, the original string is copied unchanged. This function is not part of the normal SQL function set.

Concatenate string $s n$ times and return the result. If $n$ is equal to or less than zero, and empty string is produced. When $s$ or $n$ are NULL, the result is also NULL.

Replace all occurrences of substring $f$ in string $s$ by string $t$.
Invert the sequence of characters in string $s$.
Return the rightmost $l$ characters from string $s$. If $s$ is shorter than $l, s$ will be passed unchanged.

Right-pad string $s$ by repeating string pad until a length of $l$ is reached. The pad string may be longer than one character, but then only a part of the pad string may be used. The the string is already longer than $l$, it will be truncated. If the pad string is empty or nULL, a space character will be used for padding.

Remove trailing whitespace from string $s$.
Generate soundex string from input string $s$. Soundex strings allow phonetic comparison of (preferably English) words and phrases.

Cast argument $x$ to a string. If $x$ is already a string, the function does nothing.

Get all characters of string $s$ after position $p$ (beginning with $1)$. If $p$ is smaller than 1 , it is silently set to 1 . If $p$ is beyond the length of the string, an empty string is produced.

The same as above function, just using the keyword from instead of a comma as separator.

This is the same as the mid() function.
This is the same as the mid() function, but the arguments are separated by the keywords from and for.

- substring_index(s,delim,n)
- $\operatorname{trim}(s)$
- $\operatorname{trim}(r$ from $s)$
- trim(both from $s$ )
- trim(leading from $s$ )
- $\operatorname{trim}($ trailing from $s)$
- trim(both $r$ from $s$ )
- trim(leading $r$ from $s$ )
- $\operatorname{trim}($ trailing $r$ from $s)$
- ucase $(s)$
- upper( $s$ )

Return the substring of string $s$ before the delimiter character delim is found abs ( n ) times. If $n$ is positive, the string is scanned from left to right, otherwise in reverse direction. If $n$ is 0 , an empty string is produced. If the delimiter is NULL or an empty string, the result is NULL. Only the first character from the delimiter string is used.

Remove leading and trailing whitespace from string $s$.
Remove leading and trailing instances of string $r$ from string $s$.
Remove leading and trailing whitespace from string $s$.
Remove leading whitespace from string $s$.
Remove trailing whitespace from string $s$.
Remove leading and trailing instances of string $r$ from string $s$.
Remove leading instances of string $r$ from string $s$.
Remove trailing instances of string $r$ from string $s$.
Convert string $s$ to upper case.
This is an alias to the ucase() function.

## Context functions

- file() Get the name of the file which is currently processed in the expression context. If no file is process, NULL is returned.
- record() Get the current record (file/database context) or row (table context) number. Numbering begins with 1 .
- $\operatorname{row}()$ This is an alias to the record() function, which is more readable in the context of table operations.
- session_user() Get name of user.
- system_user() Get name of user.
- user() Get name of user.


## Argument selection and flow control functions

- a1? a2:a3 Return the second argument if $a 1$ (cast to an integer) is not 0 , otherwise return $a 3$. If a1 is nULL, the result is also NULL, regardless of the values of $a 2$ and $a 3$. This is an SQL extension which was modelled after the C language construct.
- case $x$ when $c 1$ then $r 1$ [when $c 2$ then $r 2 \ldots$...] [else $r 99$ ] end

Compare expression value $x$ with the comparison expression values $c 1 \ldots c n$. If any of them is equal to $x$, the corresponding result value $r$ is returned. If none is equal, the return value of the optional else part is returned. If there is no else part, the result is null. The comparison values are cast to the type of $x$.

- case when $e 1$ then $r 1$ [when $e 2$ then $r 2 \ldots$... [else $r 99$ ] end This is a variant of the case statement. Here, individual expressions $e 1 . . . e n$ are evaluated and interpreted as boolean values. If any of them is true, the corresponding return value is extracted. If none of the expressions yields a true result, the optional else part is returned, or NULL if no else part was provided.
- coalesce $(a 1, \ldots)$ Return the first argument which is not nULL with its original data type. If none of the arguments meets this criterion, NULL is returned.
- $\operatorname{elt}(n, S l, \ldots)$ If $n$ is 1 , the first string argument is returned, the second string if $n$ is 2 , and so on. If $n$ is outside the range of supplied strings, the result is NULL.
- field $(s, s l, \ldots)$ Return the index (beginning with 1 ) of the string in the string list beginning with $s l$ which is identical to string $s$. If the first string is not found anywhere in the list, the result is 0 .
- fieldref $(x) \quad$ Force interpretation of string or expression $x$ as a field/column reference. If the reference cannot be resolved, the result is NuLl, otherwise the field value in the expression context. This is an SQL extension.
- if ( $a 1, a 2, a 3$ ) If the value of expression $a 1$ is not an integer zero (after casting, if necessary) and not nULL, the result of expression $a 2$ is passed on, else the result of expression $a 3$.
- ifnull $(a 1, a 2, \ldots) \quad$ This function passes the first non-null argument expression value on. If there are no non-null arguments, the result is null. Standard SQL provides this function only with exactly two arguments.
- largest $(a 1, \ldots) \quad$ This is an alias for function greatest ().
- least $(a 1, \ldots)$ Select the smallest argument. The arguments can be either integers, floats, or strings. If all arguments are integers, the result is an integer. If any float is used, and no strings are involved, the result is a float and all arguments are compared as floats. If any argument is a string, all arguments are converted to strings and case-sensitive string comparison is used. Note that the $\min ()$ function an as aggregate function is in a totally different class and no substitute for this function.
- greatest( $\mathrm{a} 1, \ldots$ ) Same as least(), except that the greatest argument is selected instead of the least.
- nullif( $a 1, a 2$ ) If the result of expression $a 1$ is the same as $a 2$, the return value is nuLL. Otherwise, the result of expression $a l$ is passed on. The comparison values are cast for comparison if necessary.
- property $(x) \quad$ Force interpretation of string or expression $x$ as a property reference. If the property name cannot be resolved, the result is NULL, otherwise the value of the property data in the expression context. This is an SQL extension.
- $\operatorname{propref}(x) \quad$ This is another name for the property () function.
- $\operatorname{smallest}(a 1, \ldots) \quad$ This is an alias for function least().


## Aggregate functions

- average (field $)$ This is an alias for the avg() function.
- $\operatorname{avg}(f i e l d)$ Get the average of the values of all non-null data items in the selected field. If no such item can be found, the result is NULL, otherwise a float value. This function can only be used on numerical fields/columns or strings which can be cast to numbers.
- count $\left(^{*}\right.$ Count the number of records or rows in the data object. No object values are used for the comparison.
- count $($ field $)$ Count the number of non-null values for the specified field in the data object.
- max(field $)$ Get the maximum value among all non-null data items in the selected field/column. If no such item can be found, the result is NULL, otherwise the minimum value in its original data type.
- $\min ($ field $) \quad$ Get the minimum value among all non-null data items in the selected field/column. If no such item can be found, the result is NULL, otherwise the maximum value in its original data type.
- $\operatorname{prod}(f i e l d) \quad$ This is an alias for the product() function.
- product(field) Get the product of the values of all non-null data items in the selected field. If no such item can be found, the result is NULL, otherwise a float value. This function can only be used on numerical fields/columns or strings which can be cast to numbers.
- squaredsum(field) This is an alias for the sqsum() function.
- sqsum(field) Get the sum of the squared values of all non-null data items in the selected field. If no such item can be found, the result is nuLL, otherwise a float value. This function can only be used on numerical fields/columns or strings which can be cast to numbers.
- $\operatorname{std}($ field $) \quad$ This is an alias for the stddev () function.
- stddev(field) Get the sum of the squared values of all non-null data items in the selected field. If no two such items can be found, the result is null, otherwise a float value. This function can only be used on numerical fields/columns or strings which can be cast to numbers.
- $\operatorname{sum}($ field $) \quad$ Sum up the values of all non-nuLu data items in the selected field. If no such item can be found, the result is NULL, otherwise a float value. This function can only be used on numerical fields/columns or strings which can be cast to numbers.


## CACTVS Tcl Scripting Language Reference

## The atom Command

The atom command is the generic command used to manipulate atoms. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

The pseudo atom labels first, last and random are special values, which select the first atom in the atom list, the last, or a random atom.

Examples:

```
atom get $ehandle 1 A_SYMBOL
atom hadd $ehandle 2
```

This is the list of officially supported subcommands:

## atom anchormatch

atom anchormatch ehandle label ss ehandle ?ss_label? ?matchflags? ?ignoreflags? ?atommapvar? ?bondmapvar? ?molmap̄$a r ?$

This command is a variant of the atom match command. The difference is that the full substructure is matched, and not just its first or selected atom. A substructure match anchor between the command atom and the first or selected substructure atom is enforced (see -anchor option of the match ss command).

Example:

```
set eh [ens create CCO]
echo [atom match $eh 3 O(C) (C)]
echo [atom anchormatch $eh 3 O(C)c]
```

The first command matches, because only the first substructure atom is checked. The second fails, even though the first substructure atom is a match - but then its environment does not fit.

## atom angle

atom angle ehandle label label2 label3 ?property?
Compute the angle between 3D atomic coordinates stored in a property between the three atom arguments, which are considered linked in the specified sequence. The source property for atomic coordinates is by default A_XYZ, but another property can be set, which also needs to be an atomic float vector.

The return value is the angle in degrees between the vectors implicitly constructed from the 3D atomic coordinate of the second atom pointing to that of the first, and from the second atom to the third. No bonds need to exist between the atoms. All atoms used in a statement must be different, and possess 3D coordinates initially, or after an automatically started computation of the source property.

## atom append

atom append ehandle label property value ?property value?..

Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:
atom append \$ehandle 1 A_SUPERATOMSTRING "_linker"
atom atom

```
atom atom ehandle label
```

Standard cross-referencing command to obtain the label of the atom as stored in property A_LABEL. This is explained in more detail in the section about object cross-references.

Example:

```
atom atom $ehandle #0
```

returns the label of the first atom of the ensemble atom list.

## atom bonds

```
atom bonds ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the bonds the atom is participating in. This is explained in more detail in the section about object cross-references.

Examples:

```
atom bonds $ehandle 1
atom bonds $ehandle 1 {1 doublebond triplebond} count
```

The first example returns all labels of the bonds atom 1 is participating in. The second example returns the number of double or triple bonds the atom is a part of.

## atom change

atom change ehandle label element ?fragmentlabel? ?removeh?
This command is very similar to the command atom replace. The important difference is that the element parameter is always interpreted as an element symbol encoding, and not primarily as an ensemble handle, ensemble handle/molecule label pair or Smiles string.

The rest of the command is explained in the paragraph on atom replace.
Example:
atom change \$eh 1 C
atom change \$eh 2 Z
The first example changes the atom with label 1 to a neutral carbon atom. Bonds of the old atom 1 are inherited if possible. If this is not possible due to valence violations, an error is raised. The second example changes an atom to a query specification for an electro-negative element.

## atom create

atom create ehandle ?symbol?
Create a new atom in the ensemble. The atom is added without any bonds or charge and the standard set of free electrons. The symbol parameter is usually an element symbol, which is decoded in a case-sensitive fashion. If it is omitted, an unspecified atom is generated. The isotopic element
symbols D and T are recognized and decoded to the corresponding hydrogen isotopes, setting the A_ISOTOPE property.
This command may also be used to add various pseudo and query atoms. Allowable symbols for this purpose are

- 3DPOINT or DU or BQ for points in 3D space
- POLY for polymers, EPAIR
- EP or LP for lone pairs,
-     * or OV for an open valence pseudo atom,
- $\sim$ for a superatom with a yet undefined identifier string,
- HA for a generic hydrogen acceptor,
- HD for a generic hydrogen donor,
- A for a query atom which is not hydrogen,
- Q for a query atom which is a hetero atom (not C or H ),
- M for a query atom which is a metal,
- ? for a query atom which can be any atom
- X for a query element list with the halogens,
- Y for a query element list with the electro-negative elements $\mathrm{N}, \mathrm{O}, \mathrm{Cl}, \mathrm{Br}$
- Z for a query element list with the electro-negative elements $\mathrm{N}, \mathrm{O}, \mathrm{F}, \mathrm{S}, \mathrm{Cl}, \mathrm{Br}, \mathrm{I}$
- L for a query element list with a yet undefined set of elements
- @ for a delocalization anchor
- R for a query atom of type insulator.

Instead of an element symbol, the periodic system number of an element may also be used, optionally prefixed with a hash character (\#) in SMILES style. Additionally, the standard Beilstein query atoms, such as '[Alk]', as well as CCDC element groups, such as '[3A]', are supported.

If the superatom symbol $\sim$ is followed by more characters, these are copied to the superatom identifier string (A_SUPERATOMSTRING property). If a known fragment is specified this way, it may be expanded later.

The command returns the label of the new atom. Note that the command does not require a label parameter, since it creates new atoms.

This command updates the ensemble information and recursively purges information which is susceptible to atom changes. For atom properties which survive this step, a default value is added, if the property is not part of the set of properties managed actively by this command, such as the free electron count and the atom label.

The same command can also be accessed, for historical reasons, via the add subcommand. This alias is deprecated.

The return value is the label of the new atom.
Examples:

```
atom create $ehandle C
atom add $ehandle ?
atom expand $ehandle [atom add $ehandle ~ FMOC]
```

The first example adds a carbon atom to the ensemble. The second line adds an any query atom, which, in the context of a substructure search, matches any atom. The final example adds a superatom named $F M O C$ in the inner command. Since this is a fragment name the library understands by default, it may be expanded to the full FMOC fragment with the outer command.

## atom defined

```
atom defined ehandle label property
```

This command checks whether a property is defined for the atom. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

## Example:

```
atom defined $ehandle 1 A_XYZ
```

checks whether atom 1 is of a type for which $A_{-} X Y Z$ is defined.

## atom delete

atom delete ehandle ?label?...
atom delete ehandle all
Delete zero or more atoms. All bonds which the atoms participate in are also deleted. The electron counts of surviving atoms participating in deleted bonds are automatically updated. Molecule and ring information, and other minor object classes under the control of the ensemble major object which depend on an unchanged atom set are deleted. Any property data which depends on an unchanged atom set is also invalidated, or, if the property is set up to do so, re-computed.

Note that this command does not delete hydrogen atoms the deleted atoms were bonded to. These remain in the ensemble as isolated, now unbonded atoms. The atom xdelete subcommand also deletes these hydrogen atoms.

The special atom label all requests deletion of all atoms. Usually, this is equivalent to ens clear.
The return value of the command is the number of deleted atoms.
Example:
atom delete \$ehandle 1
This command is one of few atom subcommands which do not require an atom label. If no label is given, the command does nothing. This is useful for list expansions where the list might be empty:

```
eval atom delete $ehandle $delatomlist
atom delete $ehandle {*}$delatomlist
```


## atom dget

atom dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the atom get command. The difference between atom get and atom dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, atom get and atom dget are equivalent.

## atom distance

atom distance ehandle label ?label2? ?property?
Compute the distance between two atoms based on the values of a coordinate property. The source property for atomic coordinates is by default A_XYZ, but another property can be set, which also needs to be an atomic float vector.

The command returns the value as a floating point number in the unit of the source property (Angstrom in case the default A_XYZ is used). An equivalent explicit vector arithmetic script is
vec len [vec subtract [ens get \$eh \$label A_XYZ] [ens get \$eh \$label2 A_XYZ]]
If a second atom identifier is not specified, or given as an empty string, the result is a nested list of the distances to all bonded neighbor atoms. Each sublist consists of the partner atom label and the bond length from the current atom to the neighbor.

## atom dup

atom dup ehandle ?label_list? ?datasethandle? ?position?
Duplicate zero or more atoms, plus all the bonds existing between them, into a new ensemble. This command is very similar to ens fragment, and the same caveats about preserved and destroyed data in the duplicate apply.

By default, the new ensemble is appended to the same dataset as the original ensemble, or placed outside of any dataset if the input ensemble was not a dataset member. If the optional dataset handle parameter is specified, the duplicate is directly moved to that dataset. If an empty string is passed, the duplicate is not made a dataset member, even if the input ensemble is in a dataset.

If the duplicate is moved to a dataset, it is appended to the dataset end by default. This happens also if the position parameter is explicitly specified as end or an empty string. Otherwise, the ensemble is inserted at the given position, starting with 0 . If the requested position is larger than the current size of the dataset, the ensemble is appended.

The command returns the handle of the new ensemble object.
Example:
set ehfrag [atom dup \$eh \{*\}\$alist]
atom exists
atom exists ehandle label ?filterlist?

Check whether this atom exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the atom does not exist, or fails the filter, and 1 in case of successful testing.

Example:
atom exists \$ehandle 99
atom expand
atom expand ehandle label ?allowambiguous? ?noimplicith?
This command attempts to expand a superatom. A superatom is either an atom for which the atom type property A_TYPE is set to super (the preferred method), or a standard atom (A_TYPE normal) with certain property data.

For a successful expansion, the first class of explicit superatoms must have a valid A_SUPERATOMSTRING property value which can be located in the table of known superatom identifiers. The second class of normal atoms needs a valid A_TEXTLABEL property data with a known superatom identifier in its label text field. The use of normal atoms as superatom surrogates is deprecated.

If the allowambiguous flag parameter is set, superatoms of uncertain status are expanded. Some superatom names are ambiguous, for example $A l$, which may both refer to the element and alanine. The superatom table protects against unchecked expansion of such atoms by containing an ambiguity flag which is set in such cases.

By default, the fragments from the superatom table are imported with a full set of hydrogens. If the optional noimplicith flag is set, only hydrogens which are explicitly spelled out in the superatom definition are included. For example, superatoms COO and COOH are expanded to the same form with an acidic hydrogen by default, but if the flag is set, only the second form has it.

The command returns 1 if the atom was a superatom and expansion was successful, 0 otherwise. It may also raise an error if a superatom was found, but expansion failed, for example because of an illegal bonding situation which does not allow the creation of the required normal bonds to the expanded fragments.

The expanded superatom and all other atoms in the original ensemble retain their labels.
Only a single level of superatoms is expanded - if the expanded fragment contains another superatom, it remains in its original form.

Examples:
atom expand \$ehandle [atom create \$ehandle ~BOC]
This command immediately expands the freshly created BOC fragment. A command sequence like
atom set \$ehandle [ens create C 0] A_TEXTLABEL(label) COOMe
atom expand \$ehandle 1
also works, but is deprecated.
atom expr
atom expr ehandle label expression

Compute a standard SQL-style property expression for the atom. This is explained in detail in the chapter on property expressions.
atom fill
atom fill ehandle label property value ?property value?..
Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

Example:
atom fill \$ehandle 1 B_COLOR red
sets the color of the first bond atom 1 participates in to red.

## atom filter

atom filter ehandle label filterlist
Check whether an atom passes a filter list. The return value is 1 for success and 0 for failure.
Example:
atom filter \$ehandle 1 [list carbon doublebond]
checks whether the atom is a carbon atom with a double bond.

## atom get

atom get ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:
atom get \$ehandle 1 \{A_SYMBOL A_ELEMENT\}
yields the atomic symbol and the element number of atom 1 as a list. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

```
atom get $ehandle 1 B ORDER ringbond
```

will give the bond orders of all bonds of the atom which are ring bonds.
For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the atom get command are atom new, atom dget, atom nget, atom show, atom sqldget, atom sqlget, atom sqlnew and atom sqlshow.

Further examples:

```
atom get $ehandle 1 A_SYMBOL
atom get $ehandle 1 A_FLAGS (boxed)
```

atom groups
atom groups ehandle label ?filterset? ?filtermode?

Standard cross-referencing command to obtain the labels of the groups the atom is a member of. This is explained in more detail in the section about object cross-references.

Example:
atom groups \$ehandle 1
atom hadd
atom hadd ehandle label ?filterset? ?flags? ?chargedelta?
Add a standard set of hydrogens to the atom. If the filterset parameter is specified, the atom needs to pass the filter set in order to be processed.

Additional operation flags may be activated by setting the flags parameter to a list of flag names, or a numerical value representing the bit-ored values of the selected flags. By default, the flag set is empty, corresponding to the use of an empty string or none as parameter value. These flags are currently supported:

- no2dcoords

Do not assign 2D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 2D coordinates. In any case, 2D coordinates are never added when the ensemble does no already possess valid 2D coordinates.

- no3dcoords

Do not assign 3D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 3D coordinates. In any case, 3D coordinates are never added when the ensemble does no already possess valid 3D coordinates.

- noanions

Do not add hydrogen to atoms with a negative formal charge.

- noatoms

Do not add hydrogen to atoms without any bonds.

- nocations

Do not add hydrogen to atoms with a positive formal charge.

- noelements

Do not add hydrogen if the ensemble consists purely of isolated metal atoms, which probably represent the material in elementary form, or as an alloy.

- noexcessvalences

Similar to nohighvalences, but hydrogen is not added to any atom which is not in its lowest standard bonded valence state.

- nofixatomtext

Do not adjust property A_TEXTLABEL (if present) by removing references to implicit H from it on atoms where hydrogen is added. For example, by default "NHCOOEt" becomes "NCOOEt" after adding an instantiated hydrogen to the nitrogen atom. This reduces confusion on the hydrogen status when rendering all atoms.

- nohighvalences

Do not add hydrogen to atoms which already exceed their lowest standard valence minus any formal charge. This option only applies to elements which have a defined lowest standard valence (this is configurable via the element table).

- nomemory

Do not remember the added hydrogen atoms as automatically added. Normally, a flag is retained as part of the atom information which distinguishes atoms which were added by automatic processing, such as hydrogen addition, from those which were originally input.

- nometals

Do not attempt to add hydrogen to atoms which are metals (as defined in the system element table).

- nospecial

Do not perform hydrogen addition to atoms which participate in non-standard bonds (all bonds with B_TYPE not normal).

- keepflags

For expert use only. Do not discard min/max values and property scope flags for atom properties when hydrogen is added.

- protonate

Add a single proton to the atom. The charge of the atom is increased, only a single hydrogen is added regardless of the standard number of missing hydrogens, and this command will issue the standard property invalidation event for atom and bond changes.

- resetmemory

Reset the origin flag described above for all atoms in the ensemble. All current atoms appear to be part of the original atom set.

If a charge delta parameter is specified, the atomic charge and free electrons of the atom are adapted accordingly before the hydrogens are added. The manipulation of the charge usually changes the number of added hydrogen atoms. It is not possible to change the charge in such a way that the number of free electrons would become negative.

Adding hydrogens with this command, except if the protonate flag is set, is less destructive to the property data set of the ensemble than adding them with individual atom create/bond create commands, because many properties are designed to be indifferent to explicit hydrogen status changes, but are invalidated if the structure is changed in other ways.

The command returns the number of hydrogens which were added.
Example:
set ehandle [ens create $\mathrm{FC}(\mathrm{F})(\mathrm{F})(\mathrm{F})$ ]
atom delete \$ehandle 1
atom hadd \$ehandle 2
transforms tetrafluoromethane to trifluoromethane.

## atom hdup

atom hdup ehandle ?label_list? ?datasethandle? ?position?
Duplicate zero or more atoms, plus all the bonds existing between them, into a new ensemble, and plug all open valences by adding standard hydrogens. This command is similar to ens hfragment, and the same caveats about preserved and destroyed data in the duplicate apply.

By default, the new ensemble is appended to the same dataset as the original ensemble, or placed outside of any dataset if the input ensemble was not a dataset member. If the optional dataset handle
parameter is specified, the duplicate is directly moved to that dataset. If an empty string is passed, the duplicate is not made a dataset member, even if the input ensemble is in a dataset.

If the duplicate is moved to a dataset, it is appended to the dataset end by default. This happens also if the position parameter is explicitly specified as end or an empty string. Otherwise, the ensemble is inserted at the given position, starting with 0 . If the requested position is larger than the current size of the dataset, the ensemble is appended.

The command returns the handle of the new ensemble object.

## atom hstrip

atom hstrip ehandle label ?flags? ?chargedelta?
This command removes hydrogens from the selected atom. By default, all hydrogen atoms are removed.

The flags parameter can be used to make the operation more selective. It may be a list of the following flags:

- deprotonate

If this flag is set, a single proton is removed from the atom. This command variant does issue a standard atom and bond change property invalidation event, and it always ends processing after removing the first proton. Proton removal decreases the charge of the atom by one.

- keepalphawedge

Keep hydrogen atoms which are bonded to an atom which is at the tip of a wedgebond. This flag excludes the case where the bond to the hydrogen atom is the wedge bond - use the keepwedge flag to cover this case.

- keepisotopes

Keep hydrogen atoms which are isotope labels (including enriched/depleted ${ }^{1} \mathrm{H}$ ).

- keeporiginal

Hydrogen atoms which were not automatically added via a hydrogen addition command are retained. Note that these commands can be run in a mode which does not leave information about automatic addition - hydrogens added this way do not survive.

- keepprotons

Keep any molecules which consist only of hydrogen atoms (such as protons, hydride anions, and molecular hydrogen).

- keepspecial

If this flag is set, hydrogens which are usually displayed, such as on aldehydes, wedge bonds, carbon triple bonds or hetero atoms are retained.

- keepwedge

Keep hydrogens which are at the end of a wedge bond, indicating stereochemistry.

- normalize

Normalize the wedge pattern for standard cases, removing excess wedges from hydrogens if the result structure is still stereochemically defined. Hydrogens which lose their wedge in this process are no longer protected by the keepwedge flag.

- wedgetransfer

If a hydrogen atom is removed which is at the end of a wedge, the wedge information is saved by transferring the wedge (changing its up/down status if necessary) to an adjacent, surviving bond. This flag has no effects if the keepspecial or keepwedge flags are set. This flag is set by default.

If the flags parameter is an empty string, or none, it is ignored. The default flag value is wedgetransfer - but the default value is overridden if any flags are set!

If a charge delta parameter is specified, the atomic charge and free electrons of the atom are adapted accordingly before the hydrogens are added. The manipulation of the charge will usually change the number of added hydrogen atoms. It is not possible to change the charge in such a way that the number of free electrons would become negative.

Hydrogen stripping is not as disruptive to the ensemble data content as normal atom deletion, except in case the deprotonate flag is set. The system assumes that this operation is done as part of some file output or visualization preparation. However, if any new data is computed after stripping, the computation functions see the stripped structure, and proceed to work on that reduced structure without knowledge that the structure may contain implicit hydrogens.

The return value of the command is the number of hydrogens removed.
Example:
atom hstrip \$ehandle 1 [list keeporiginal wedgetransfer]

## atom index

atom index ehandle label
Get the index of the atom. The index is the position in the atom list of the ensemble. The first position is index 0 .

Example:
atom index \$ehandle 99
atom invert
atom invert ehandle label
Invert the stereochemistry at the atom, provided it is an sp3-type atomic stereo center, which includes those which use an electron pair as pseudo ligand and allenes with an odd number of atoms. This command updates any atomic stereo descriptors and bond wedges to the ligands if set, but only compute A_LABEL_STEREO. No check it made whether the atom can physically be a stereo center, but if the A_LABEL_STEREO descriptor is zero, or describes non-sp3 types of stereochemistry such as square planar, the command does nothing and returns 0 , but will not raise an error. For odd allenes, bond wedges at the terminal atoms are updated, not those at the center atom.

If stereochemistry was inverted, this command issues a stereo change property invalidation event and additionally invalidates the A_STEREOGENIC and B_STEREOGENIC properties, because the stereo potential of centers which possess two ligand groups which only differ in stereochemistry may have changed.

If the command finds a defined stereo center and succeeds in inverting it, it returns 1,0 otherwise.

## atom local

```
atom local ehandle label propertylist ?filterset? ?parameters?
```

Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

## Example:

```
atom local $ehandle 1 A_LABEL_STEREO
```

Note that very few computation routines currently support the local re-computation of data - in most cases, this command falls back to in a global re-computation.

## atom match

```
atom match ehandle label ss_ehandle ?ss_label? ?matchflags? ?ignoreflags?
```

    ?atommapvar? ?bondmapvar? ?molmapvār?
    Check whether the selected atom matches a substructure. Only the first substructure atom, or the atom selected by the substructure label parameter, is tested. The substructure may be part of any structure ensemble, and even be in the same ensemble as the primary command atom.

The precise operation of the substructure match routine can be tuned by providing a standard set of match flags and feature ignore flags. The default match flag set has set bits for the bondorder, atomtree and bondtree comparison features, and an empty ignore set. If a flag set is specified as an empty string, the default set is used. In order to reset a flag set, an explicit none value must be used. The bit options of the match flag are explained in the documentation of the match ss command.

The command returns 1 for a successful match, 0 otherwise. If an optional atom, bond, or molecule map variable is specified, it is set to a nested list of matching substructure/structure atom, bond or molecule labels. If no match can be found, the variable is set to an empty list. In case only a bond or molecule map variable is needed, an empty string can be used to skip the unused map variable argument positions.

Example:

```
set ss [ens create {[F,Cl,Br,I]} smarts]
set a_is_halogen [atom match $ehandle $label $ss 1]
```

atom mol
atom mol ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the label of the molecule the atom is a member of. This is explained in more detail in the section about object cross-references.

## Examples:

atom mol \$ehandle 1
atom mol \$ehandle 1 heterocycle
The first example returns the label of the molecule. Note that it is possible for pseudo atoms to be outside of any molecule. In this case, an empty string is returned. The second example returns the molecule label if the atom is part of a molecule which contains one or more heterocycles. If the molecule does not contain a heterocycle, an empty string is returned. Note the use of mol in singular - an atom can only be a member of one molecule, or of none.

## atom neighbors

atom neighbors ehandle label ?filterset? ?filtermode? ?sphere? ?allow_dups?
This command (which can also be invoked as subcommand neighbours, or ligands) is a cross-referencing command with some extra options and, in some filter modes, slightly different behavior than the standard object cross-reference subcommands.

In the simplest case, it returns the labels of the immediate neighbor atoms. A neighbor atom is an atom which is bonded via a standard (covalent, btype_normal) or complex (btype_complex) bond to the originating atom. In case the filter list contains bond filters, the bond leading to the originating atom must pass the check, not just any bond of the neighbor atom.

Example:
atom neighbors \$ehandle 1 doublebond
returns all neighbor atom labels which are bonded via a double bond. Neighbor atoms which participate in a double bond with other atoms, but not the originating atom, are not returned.

This command supports a special filtermode value in addition to the standard set (exists, count, exclude, include). The notraverse parameter, followed by a list of atom labels in any of the standard atom specification styles is a list of atoms which are not traversed during sphere expansion.

Example:
atom neighbors [ens create CC(C)C] 2 \{\} \{notraverse \{3 4\}\} 2
only returns the hydrogen atoms 5, 6, 7 on atom 1 , since carbon atoms 3 and 4 are blocked. If the atoms in the traversal block list are part of the requested sphere, they are listed.

By default atoms in the immediate neighborhood are examined, but this change be changed by the sphere parameter. The immediate neighbors are in sphere 1 (the default for this parameter), the next group of atom is in sphere 2, and so on. If the sphere is not 1 , the special filtering of bonds is no longer active and the normal object substitution mechanism for cross referencing is used. When going beyond the first sphere, it is also possible that an atom may be reached by multiple paths of the selected length. By default, these atoms are returned only once, but with the last optional parameter this behavior may be changed.

Example:
atom neighbors \$ehandle 1 \{carbon aroatom\} count 2
counts the number of aromatic carbon atoms in a distance of two bonds.
A positive sphere value only selects atoms in that sphere. A negative sphere parameter value returns a list of all neighbors up to and including the sphere identified by the absolute parameter value.

## atom new

atom new ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the atom get command. The difference between atom get and atom new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## atom nget

```
atom nget ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the atom get command. The difference between atom get and atom nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## atom paths

atom paths ehandle label destlabel ?minlength? ?maxlength? ?filterset? ?atomproperty? ?maxpathcount? ?flags?
This command finds all paths between a pair of atoms, walking along bonds of the types which define molecules. By default, these are bond types normal, complex and 3center, but this can be changed by modifying the control variable ::cactvs(molecule_bond_set).

The return value of the command is a nested list, even it only a single path is found. Every sublist contains all the labels of the atoms in a single path, including those of the start and end atoms. Every bond is used only once in any path, and no path crossings through an atom are allowed. Every atom, with the possible exception of path end points, appear only once in any single path. Paths from an atom via some bonds back to itself are allowed. The atom must be a ring member for such paths to exist.

If the destination atom is specified as an empty string, all possible paths emerging from the source atom and not violating any other specified constraints are returned. This includes shorter sub-paths which are contained in a longer paths - these are reported as separate result items.

By default, all paths of length greater than zero are returned. The lengths of acceptable paths may be specified by the optional parameters. If only the minimum length is set, this value is also used for the maximum length, resulting in only paths of a specific length to be reported. The maximum path count parameter can be used to limit the number of paths found. However, the order of the found paths does depend on the arrangement of the atoms in the bonds, so it is generally not canonic. Omitting this parameter or setting it to a negative value disabled the maximum path count check.

A non-empty filter set can be used to restrict the atoms that are eligible to be part of the path. Normally, these are atom filters, such as !hydrogen, but other types may be used in special circumstances. Bond filters are however applied to the union of all bonds of an atom, not just the specific bond traversed in a path. For example, a doublebond filter lets an atom pass if it participates in any double bond, and does not necessarily mean the bond the atom was reached over in the path. Filters are not applied to the start atom of the path.

The default report value for an atom is its label, i.e. property A_LABEL. However, any other present or computable atom property may be specified instead with the optional atom property parameter. The parameter may also refer to a property subfield in case the property is indexible.

The final optional flag parameter is a list of additional keywords which further modify the path atom selection and result reporting. Currently, the following keywords are recognized:

## - noringchaincrossing

The path may not jump from a chain atom to a ring atom, or vice versa

- concatenate

The report format for each individual path is not a Tcl list, but a string where the report atom property values are directly concatenated

- printbondorder

Every report value after that of the first path atom is prefixed with a character indicating the bond order from the set "-=\#\&" for bond orders one to four, with a colon for aromatic bonds, and a question mark for non-VB bonds. Additionally, a @ is added if the bond closes a ring to the first path atom.

## Example:

atom paths [ens create C1CCC1] 1 1
reports the paths $\{12341\}$ and $\{14321\}$, which correspond to walking the ring clockwise and counter clockwise, respectively.
atom paths [ens create CC=C] 1333 \{\} A_ELEMENT -1 \{printbondorder concatenate\} returns $\{6-6=6\}$.
atom pis
atom pis ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\pi$ systems the atom is a member of. This is explained in more detail in the section about object cross-references.

Examples:
atom pis \$ehandle 1
Get the labels of the $\pi$ systems the atom is participating in. $\pi$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use p or d orbitals, such as in standard covalent multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## atom purge

atom purge ehandle label propertylist/stereo/isotope
Reset existing property data on an atom. In case the argument is a list of property names, the value on that atom only is reset to the default value of the property. In case the property is not present on the ensemble, the command is ignored. The reset via a property list does not trigger a property dependency update. If that is desired, an ens taint command must be explicitly scripted.In case a reset property is a bond property instead of an atom property, the reset is executed for all bond atoms. Other property object class mismatches are currently not supported.

In addition to standard properties, two special pseudo property names are recognized. The stereo code resets all atom-centered stereo information on the atom, including wedges in property B_FLAGS that point to the atom, and will trigger a stereo change event on the ensemble which may invalidate additional data. The isotope code resets property A_ISOTOPE on the atom, marks the isotope data as tainted and run a data dependency check.

## atom replace

atom replace ehandle label fragment/element ?fragmentlabel? ?removeh?

Replace an atom by a fragment. The fragment may be an atom, a molecule, or even a multi-molecule ensemble. The fragment parameter is either an ensemble handle, a SMILES string, or a list of an ensemble handle and a molecule label, identifying one molecule within that ensemble. Ensembles or molecules identified by handles will not be destroyed, because the command works on a duplicate.

If the fragment parameter cannot be decoded as any of those fragment definition styles, an attempt is made to interpret is as an element or pseudo-element symbol. Deuterium and tritium isotopes may be specified as D and H , and standard query atom and superatom specifications are also understood with a syntax identical to the atom create command. For standard element modifications, such as by a molecule editor, the atom change variant of this command is preferred, because that command does not attempt to decode the fragment parameter in the other styles first and thus avoids problems with element symbols that are at the same time valid SMILES strings.

The first atom in the atom list of the selected fragment structure (which does not necessarily corresponds to the lowest label in that structure) is the default link atom on the fragment. The link atom is the fragment atom which replaces the original atom in the input ensemble. A different link atom can be selected by providing a label (not an index) of a fragment atom as optional parameter.

All valence bonds (B_TYPE normal), ionic (B_TYPE ionic) and complex bonds (B_TYPE complex) to the original atom are preserved with their bond order, as are standard bond attributes (property $B_{\text {_ }}$ FLAGS). It is possible to replace atoms with more than one neighbor, or with multiple or aromatic bonds. In the atom change variant of this command, it is an error if the fragment link atom cannot provide sufficient electrons to satisfy the VB bonds of the replaced atom. In atom replace mode, existing bonds that cannot be recreated are silently ignored. If the removeh flag is set, the program will attempt to find required valence electrons by removing hydrogen atoms from the link atom. If no more hydrogens can be found, electron pairs are used as a last resort, but without trying to adjust formal charges. The 2D coordinates of the link atom (property A_XY), if present, are set to the old coordinates of the replaced atom. Other properties are lost or adapted according to the merge functions of the underlying property definitions.

The return value of this command is the label of the fragment link atom, which is the same as the label of the replaced atom. All atom and bond labels in the base fragment are guaranteed to be preserved, with the exception of the labels of the bonds around the replaced atom. formed. The labels of the added fragment are generally changed, but are copied to properties A_LABEL\%, B_LABEL\% etc. before the merge.

Examples:

```
set ehandle [ens create CCBr]
set newlabel [atom replace $ehandle 3 [ens create Cl 0]]
set newlabel [atom change $ehandle 3 Cl]
atom replace $ehandle $newlabel {FC(F)F} 2 1
```

The second line replaces atom 3 (bromine) with a chlorine atom. The chlorine ensemble was generated without hydrogens, to Cl has a bonding electron. Also, the default link atom of the fragment is the only atom, so there cannot be any question about the fragment link location. The new label of the Cl atom is stored - but this is not really required, since it is always 3 , the label of the replaced atom. Line three is the same exchange expressed in the more efficient syntax of the atom change command variant.

The fourth example code line replaces the chlorine atom with a $\mathrm{CF}_{3}$ group. That group is set up by an in-line SMILES string. The fragment link atom is set to 2 (the carbon atom - labels from SMILES decoding follow the atom order). Since this fragment was generated with an extra hydrogen atom on carbon, the final parameter makes sure that this atom is removed before the replacement operation, yielding an electron on the $\mathrm{CF}_{3}$ carbon atom for bonding to the main structure. If the hydrogen removal flag is not set, the operation will fail with this fragment. Without automatic hydrogen removal, the fragment needs to be written as $\mathrm{F}[\mathrm{C}]$ ( F ) F for successful replacement, with explicitly suppressed hydrogen addition at the carbon atom.

## atom rings

atom rings ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the rings the atom is a member of. This is explained in more detail in the section about object cross-references.

## Examples:

```
atom rings $ehandle 1
atom rings $ehandle 1 [list heterocycle aroring]
```

The first example returns the labels of all rings the atom is a member of. If the atom is not in any ring, an empty list is returned. Only labels of rings in the SSSR or ESSSR ring set are returned, even if the currently computed ring set is larger. The second example filters the rings - only heteroaromatic rings are reported.

## atom ringsystems

atom ringsystems ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the ring systems the atom is a member of. This is explained in more detail in the section about object cross-references.

Examples:

```
atom ringsystems $ehandle 1
atom ringsystems $ehandle 1 [list heterocycle aroring]
```

The first example returns the labels of the ring system the atom is a member of. If the atom is not in any ring, an empty list is returned. The second example filters the ring systems - a ring system label is obtained only if that ring system contains one or more hetero aromats.
atom set
atom set ehandle label property value ?property value?..
Standard data manipulation command. It is explained in more detail in the section about setting property data.

Example:

```
atom set $ehandle 1 A_COLOR "blue"
```

The direct change of critical atom type data, such as the element A_ELEMENT, element symbol A_SYMBOL, or atom type A_TYPE should be avoided. It is safer to create a new atom, delete the old atom, and establish new bonds if an atom needs to be changed in its type, or to use the atom replace command. The dedicated creation, deletion and replacement commands will automatically take care of bookkeeping tasks such as electron counting for valence bonds. Also, direct setting of the element
data will render most structure information invalid, since most properties depend directly or indirectly on the element composition. Careful manual locking and updating of property data is required if direct element manipulation is attempted.
atom show
atom show ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the atom get command. The difference between atom get and atom show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, atom get and atom show are equivalent.

## atom sigmas

atom sigmas ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\sigma$ systems the atom is a member of. This is explained in more detail in the section about object cross-references.

Examples:
atom sigmas \$ehandle 1
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## atom sqldget

atom sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the atom get command. The differences between atom get and atom sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

```
atom sqlget
atom sqlget ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the atom get command. The difference between atom get and atom sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.
atom sqlnew
atom sqlnew ehandle label propertylist ?filterset? ?parameterlist?

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the atom get command. The differences between atom get and atom sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## atom sqlshow

atom sqlshow ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the atom get command. The differences between atom get and atom sqlishow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## atom subcommands

atom subcommands
Lists all subcommands of the atom command. Note that this command does not require an ensemble handle, or an atom label.

```
atom surfaces
atom surfaces ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of surface patches the atom is associated with. This is explained in more detail in the section about object cross-references.

Example:

```
atom surfaces $ehandle $label
```

Note that individual surface patches are not required to be associated with any atom.

## atom torsion

```
atom torsion ehandle label label2 label3 label4 ?property?
```

Compute the torsion angle in degrees between the four atoms, which are considered to be linked in the specified sequence, i.e. the first three atoms defined the first plane, and the last three atoms the second plane. The torsion angle is the vector angle of the normals of the two implicitly defined planes and is always in the $+/-180$ degrees range.

The source property for atomic coordinates is by default A_XYZ, but another property can be set, which also needs to be an atomic float vector. All atoms used in a statement must be different, and possess 3D coordinates initially, or after an automatically initiated attempt to compute 3D atomic coordinate property. No bonds need to exist between the atoms.

## atom uncharge

atom uncharge ehandle label

Perform a chemistry-smart transformation of the atom to remove or at least minimize its formal charge. Depending on the atom charge, type and element, this involves addition or removal of hydrogen atoms, or, if these are not available or the element has no clear hydrogen count/formal charge rules, direct editing of the formal charge and modification of the free electron count.

The command returns the number of change operations on the atom. These are either hydrogen additions and deletions, or direct formal charge changes.

## atom valencecheck

atom valencecheck ehandle label
Perform a valence check on the atom, comparing the current bonding situation at the atom to the list of element-specific valence states in the system element table. This command is intentionally quite picky, discouraging for example the use of pentavalent nitrogen. For the calculation of valence, only bonds of type normal are taken into account. Complex bonds and pseudo bond types thus do not interfere in the calculation. Some more exotic metals with many different valence states, or few well-defined covalent compounds, such as vanadium or rhodium, always pass.

The return value of this command is 0 for failure, 1 for pass.
Note that this command assumes that all hydrogen atoms are in place. Processing structures with Implicit hydrogen atoms is not supported.

Example:
atom valencecheck [ens create $\{\mathrm{CN}(=0)=0\}$ ] 2
atom valencecheck [ens create $\{C[N+](=O)[O-]\}] 2$
These sample commands check the valence state of atom 2, the nitrogen atom in two different encodings of nitromethane. The first encoding returns 0 , the second 1 .

## atom vicinity

atom vicinity ehandle label maxdistance ?mindistance? ?filterset?
Get a list of the labels of atoms located in a distance range from a query atom. The distance is computed from the atomic coordinates in property A_XYZ. Query distances are specified in Angstrom. If no minimum distance is given, it is assumed to be zero. Nevertheless, the query atom itself is never part of the returned set.

The reported atoms do not need to be bonded to the query atom directly or indirectly. If no atoms are found in the distance range, or none pass the optional filter set, an empty list results. If there are no atomic 3D coordinates, and these cannot be computed, an error is raised.

## atom xdelete

atom xdelete ehandle ?label?...
atom xdelete ehandle all
This command is a variation of the atom delete command. The only difference is that it also deletes all hydrogen atoms the deleted atoms were bonded to.

The special atom label all requests deletion of all atoms. Usually, this is equivalent to ens clear.
The return value of the command is the number of deleted atoms.

Example:
atom xdelete \$ehandle 1
This command is one of few atom subcommands which do not require an atom label. If no label is given, the command does nothing. This is useful for list expansions where the list might be empty:

```
atom xdelete $ehandle {*}$delatomlist
```


## The bond Command

The bond command is the generic command used to manipulate bond. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

Examples:
bond get \$ehandle 1 B_ORDER
bond atoms \$ehandle 2
This is the list of officially supported subcommands:

## bond align

bond align ehandle label point1 point2
Align the 3D atomic coordinates (in property A_XYZ) of the molecule the first specified atom of the bond is a member of in such a fashion that the first bond atom is positioned on the first point argument, and the vector to the second bond atom points into the same direction as the vector from the first to the second point argument. The bond length is not changed in this process.

The syntax of the point arguments is the generic vector syntax as documented in the vec command. If the bond is selected with an identifier different than an atom pair, the first bond atom is the atom moved to the first point argument. If the atom pair specification syntax is used, the first atom in the specification list is the anchor, which may or may not be the first bond atom.

The command fails if property $A_{-} X Y Z$ is not present on the ensemble and cannot be computed.
Example:
bond align \$eh \{2 1$\} 0 \mathrm{x}$
Atom 2 is moved to the origin, and the bond from atom 2 to atom 1 will point in $x$-direction, i.e. it has a 3D coordinate triple like $\{0.0,0.0,1.5\}$, with the bond length as $z$ component. The other atomic coordinates in the molecule are adjusted accordingly.

The command does not check for coordinate overlap with atoms in other molecules in the ensemble.
In case of special bonds, the second atom may not be in the same molecule as the first. This is legal - its coordinates are only needed to compute the axis and degree of rotation - though the second atom is then not moved by the command.

## bond append

bond append ehandle label property value ?property value?..
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:
bond append \$ehandle 1 B_LABELCOLOR "00"
bond atoms
bond atoms ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the atoms which form the bond. This is explained in more detail in the section about object cross-references.

Examples:
bond atoms \$ehandle 1
bond atoms \$ehandle 1 \{!carbon !hydrogen\} count
The first example returns all labels of the atoms in bond 1 . The second example will compute the number of atoms in the bond which are neither carbon nor hydrogen.

## bond bond

bond bond ehandle label
Standard cross-referencing command to obtain the label of the bond as stored in property b_LABEL. This is explained in more detail in the section about object cross-references.

Example:
bond bond \$ehandle [list 1 2]
returns the label of the bond between atoms 1 and 2 , or an empty string if the bond does not exist.

## bond change

bond change ehandle label bodelta ?chargedelta?
This command changes the order of a bond. It may also be used to create bonds, or to delete bonds.
As in all bond commands, the bond may either be identified by its label or equivalent descriptor, or a set of atom identifiers. In case a new bond is made, a list of atom labels or other atom identifiers is provided as parameter instead of a single bond identifier. The distinction between atom and bond references is performed via the list length of the label parameter. Anything with more than one list element is interpreted as an atom-based specification. The order of atoms in an atom-based specification is arbitrary.

The parameter bodelta is a signed integer which defines the bond order change. If it is 0 , the command does nothing, if the chargedelta parameter is also zero or omitted. If it is less than zero, the bond order is reduced. For VB bonds, the free electron count on the atoms (property A_FREe_electrons) is increased by the old bond order. If the bond is not a valence bond, or the change in bond order is larger than the existing bond order, the bond is deleted. If the change in bond order is positive, and the bond type a normal VB bond, the bond order is increased, provided that the atoms have sufficient free electrons for bonding (property A_FREE_ELECTRONS). A positive $^{\text {F }}$ change in bond order for a non-VB bond has no effect.

If the optional chargedelta parameter is used, electrons which imply formal charge (property A_FORMAL_CHARGE) are transferred between the atoms before the bond operation. The charge difference is applied to the first atom in the specification, and implicitly the second atom is affected inversely. If the bond was specified by a bond label instead of an atom list, the internal order of the atoms in the bond is used.

## Examples:

```
bond change [ens create CC] {1 2} -1
bond change [ens create CC] {2 1} -1 1
set ehandle [ens create C=O]; bond change $ehandle {1 2} -1; ens hadd $ehandle
bond change [ens create {[H+].[OH-]}] {1 2} 1-1
```

The first example line performs a radical dissociation between the carbon atom (atoms 1 and 2 when decoding a SMILES string, the atom labels correspond to the sequence in the SMILES string).

The bond order change is -1 , which cuts the bond because it is only a single bond. Since no charge modification was specified, both atoms end up with a radical electron.

The second line shows the same process as a heterolytic dissociation. The second carbon atom is the recipient of a positive charge, because it was listed first, and the charge delta is +1 . The first carbon atom receives the counter-charge and bears a formal charge of -1 .

The third example performs a bond order reduction on the $\mathrm{C}=\mathrm{O}$ double bond, and then saturates the molecule with hydrogen. The result is a reduction of formaldehyde to methanol.

The final example is a recombination reaction of a proton and a hydroxide anion. Because the proton cannot provide any electrons for the new bond, the first step is a formal transfer of one electron (charge -1) to this atom. Implicitly, it is removed from the other atom of the newly formed bond, which is the negatively charged oxygen atom of the hydroxyl anion. The result is a neutral water molecule.

## bond create

bond create ehandle label ?type?/?order?
bond create ehandle label normal ?order?
This command creates a new bond, or changes the bond order or bond type of an existing bond. In case a new bond is made, a list of atom labels or other atom identifiers is provided as parameter instead of a single bond identifier. The distinction between atom and bond references is performed via the list length of the label parameter. Anything with more than one list element is interpreted as an atom-based specification. The order of atoms in an atom-based specification is arbitrary. In case a new bond is created, the atoms are entered into the bond in that order. Atom orders in existing bonds are not changed.

The default bond type is a valence bond (B_TYPe property value is normal) of bond order 1. If this type of bond is created, the bond type identifier may be omitted and a bond order directly specified as an integer. Valence bonds are electron-counted. In order to succeed, the participating atoms must provide sufficient electrons (property A_FRee_electrons) for the bond. Both atoms must provide the same number of electrons. Charge recombination in bond formation is not supported by this command, but can be achieved with the bond change command. The free electron counts of the bond atoms are automatically updated. The toolkit does not try to generate more free electrons by deleting hydrogen atoms bonded to the bond atoms or similar operations. If this kind of intelligence is required, it must be explicitly scripted.

Setting the bond order of an existing bond to 0 deletes the bond.
Besides normal valence bonds, this command can be used to create or manipulate any other bond type which is known to the toolkit. The names of bond classes understood by this command are parsed from the enumeration value of property B_TYPE and may be changed at runtime.

Non-VB bonds do not involve electron counting. It is possible to change the type of a bond with this command, and in case a VB bond is changed to a non-VB bond, the electrons which were used in the VB bond are assigned to the A_Free_electrons properties of the atoms. In the reverse case the $^{\text {and }}$ command only succeeds if sufficient free electrons are present. The bond order (stored in property B_ORDER) of non-VB bonds is zero and cannot be changed with this command. If the bond type is changed, the bond label may also change. Changing the bond order of an existing bond without a type change is guaranteed to preserve the bond label.

The command can be used to directly create VB bonds with attributes. In addition to a numeric bond order, the following bond types are understood which create (or change to) a VB bond and simultaneously set bond attributes:

- $s / a$

Create or set a query bond of type single or aromatic. The VB bond order is one.

- $s / d$

Create or set a query bond of type single or double. The VB bond order is one.

- $d / a$

Create or set a query bond of type double or aro. The VB bond order is one.

- up

Create or set a single bond with a up wedge from with the tip at the first atom.

- down

Create or set a single bond with a down wedge from with the tip at the first atom.

- crossed

Create or set a double bond with the B_FLAGS attribute crossed (generally interpreted as double bond of unknown stereochemistry).

- either

This is an alias for crossed.

- any

Create or set a query bond of type any. The VB bond order is one.

- dotted

Create or set a single bond with the B_FLAGS display attribute dotted.

- wiggly

Create a single bond which marks undefined double bond stereochemistry.

- wavy

An alias for wiggly.
It is also possible to spell out the bond order (single, double, etc.) instead of using a numerical value.
The attributes B_FLAGS, B_QUERY (flags) and B_QUERY (order) of bonds which are created or edited with a standard attribute-less bond order are reset.

The atom list which serves as a bond identifier or atom set for a new bond may contain more than two atoms. There are bond types like 3-center bonds and R-group alternative connection points, or pseudo bond like bond angles and torsion angles which span three four, or even more atoms.

It is not possible with this command to create bonds which involve the exact same set of atoms as an existing bond but which are of different type. It is also not possible to create bonds which include the same atom more than once.

Changing or creating a bond triggers a bondchange invalidation event. All minor object classes depending on an unchanged bond set (such as rings and molecules) as well as all property data on the ensemble which is directly or indirectly sensitive to changes in the bond set is invalidated if it is not explicitly locked.

The return value of this command is the label of the newly created or updated bond. If the bond was deleted, the return value is zero.

Examples:

```
bond create [list 1 2] 2
bond create [list #3 #5]
bond create {3 4} complex
```

The first line creates a standard valence bond with bond order 2 between the atoms with labels 1 and 2 , or changes the bond order to a double bond. In case of insufficient bonding electrons, an error is raised. The second example create a single bond between atoms with index (not label) 3 and 5. The final example creates a bond of type complex between atoms 3 and 4 , using an abbreviated Tcl list notation. This bond does not perform valence electron counting.

## bond defined

bond defined ehandle label property
This command checks whether a property is defined for the bond. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

Example:
bond defined \$ehandle 1 B_ORDER
checks whether bond 1 is of a type for which bond orders are defined.

## bond delete

```
bond delete ehandle label ?label?...
```

bond delete ehandle all
Delete one or more bonds. The atoms which participate in the bonds are not deleted, but in case the bond is a standard valence bond, their free electron count (property A_FREE_ELECTRONS) is updated. Molecule and ring information, and other minor object classes under the control of the ensemble major object which depend on an unchanged bond set are deleted. Any property data which depends on an unchanged bond set is also invalidated, or, if the property is set up to do so, re-computed.

If the bond which should be deleted does not exist, the request is silently ignored, as long as the bond specification is syntactically correct.

The return value of this command is the total of all bonds successfully deleted.
This command does not try to save stereochemistry by transferring wedge data etc. to an adjacent bond prior to deletion. The xdelete command variant offers this feature.

Example:
bond delete \$ehandle [list 1 2]
bond dget
bond dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the bond get command. The difference between bond get and bond dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, bond get and bond dget are equivalent.

## bond exists

bond exists ehandle label ?filterlist?
Check whether this bond exists. Optionally, a filter list can be supplied to check for the presence of specific features, or checking of the bond type. The command returns 0 if the bond does not exist, or fails the filter, and 1 in case of successful testing.

Examples:
bond exists \$ehandle 99
bond exists \$ehandle [list 1 2]
The second example checks whether a bond between atoms 1 and 2 exists. Instead of using a single label, all bond labels may be substituted by a list of the labels of their atoms.

## bond expr

bond expr ehandle label expression
Compute a standard SQL-style property expression for the bond. This is explained in detail in the chapter on property expressions.

## bond fill

bond fill ehandle label property value ?property value?...
Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

Example:
bond fill \$ehandle 1 A_COLOR red
sets the color of the first atom bond 1 participates in to red.

## bond filter

bond filter ehandle label filterlist
Check whether a bond passes a filter list. The return value is 1 for success and 0 for failure.
Example:
bond filter \$ehandle 1 [list carbon doublebond]
checks whether the bond is a double bond with one or more carbon atoms.

## bond flip

bond flip ehandle label
This utility command manipulates data of property B_FLAGS and possibly B_LABEL_STEREO (and other bond stereo descriptors) plus A_XY and dependent data. If these property data are not already present, the command does nothing.

The mode of operation depends on the bond order.
For single bonds. the command inverts three bit groups in B_fLAGS.

- dashed/dotted

If the bond is a wedge bond (any of the flags highwedge or lowwedge are set), and any of the bits dashed or dotted are set, both dashed and dotted are reset. The result for structure display is that a dashed wedge becomes a solid wedge. If the bond is a wedge bond, but neither dashed or dotted are set, both bits are set. The effect for display is that a solid wedge becomes a dashed wedge. Dashed/dotted bonds which are not wedge bonds are not affected.

- left/right

If the bond has the left or right bit set (the second line of double bonds is plotted to the left or right side of a central bond line and slightly shortened, instead of drawing two equivalent bond lines slightly off left and right of the main axis), the currently set left/right bit is reset, and the other bit set. Bonds without set left or right bits are not affected.

- front/back

If the bond has one of these flags set, it is cleared and replaced by the counterpart.
For double bonds, the command inverts all present bond stereo descriptors (B_LABEL_STEREO, B_CIP_STEREO, B_CISTRANS_STEREO, B_MAP_STEREO, B_HASH_STEREO) if they are set to a value indicating presence of stereochemistry. Stereo-dependent properties such as B_STEREOINFO and B_STEREOGENIC are invalidated if not locked. In addition, if 2D coordinates are valid in A_XY and the bond is not a ring bond, the smaller half of the structure is rotated around the bond axis in pseudo-3D fashion. This involves updating A_XY and the bond display flags in B_FLAGS, and invalidation of property data dependent on these. If the stereochemistry of a ring bond is changed, the 2D coordinates are deleted. Currently, 3D atomic coordinates are not modified.

The command is usually employed in preparation of a pseudo-3D horizontal or vertical flip of a structure drawing. The bond flags are set in such a way that after mirroring the 2D coordinates, the wedge orientation and ring interior positioning of the bonds are correct in the sense that they still describe the same stereo isomer and ring double bonds are plotted with a shortened bond inside the ring.

The command returns 1 if any bits were changed, 0 otherwise.
Example:
bond flip \$handle 1
bond get
bond get ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:
bond get \$ehandle 1 \{B_ISAROMATIC B_ORDER\}
yields the aromaticity status flag and the (Kekulé) bond order of bond 1 as a list. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.
bond get \$ehandle 1 A_ELEMENT ringatom
gives the elements of all atoms in the bonds which are in a ring.
For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the bond get command are bond new, bond dget, bond nget, bond show, bond sqldget, bond sqlget, bond sqlnew and bond sqlshow.

Further examples:

```
bond get $ehandle 1 R_SIZE
bond get $ehandle 1 B_FLAGS(dashed)
```

bond groups
bond groups ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the groups the bond is related to. This is explained in more detail in the section about object cross-references. A bond is considered to be related to a group if all the atoms in the bond are contained in the group.

Example:
bond groups \$ehandle 1

## bond hadd

bond hadd ehandle label ?filterset? ?flags? ?chargedelta?
Add a standard set of hydrogens to the atoms of the bonds. If the filterset parameter is specified, the atoms need to pass the filter set in order to be processed.

This command only adds missing implicit hydrogen. It does not reduce the current bond order.
Additional operation flags may be activated by setting the flags parameter to a list of flag names, or a numerical value representing the bit-ored values of the selected flags. By default, the flag set is empty, corresponding to the use of an empty string or none as parameter value. These flags are currently supported:

- no2dcoords

Do not assign 2D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 2D coordinates. In any case, 2D coordinates are never added when the ensemble does no already possess valid 2D coordinates.

- no3dcoords

Do not assign 3D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 3D coordinates. In any case, 3D coordinates are never added when the ensemble does no already possess valid 3D coordinates.

- noanions

Do not add hydrogen to atoms with a negative formal charge.

- noatoms

Do not add hydrogen to atoms without any bonds.

- nocations

Do not add hydrogen to atoms with a positive formal charge.

- noelements

Do not add hydrogen if the ensemble consists purely of isolated metal atoms, which probably represent the material in elementary form, or as an alloy.

- noexcessvalences

Similar to nohighvalences, but hydrogen is not added to any atom which is not in its lowest standard bonded valence state.

- nofixatomtext

Do not adjust property a_TEXTLABEL (if present) by removing references to implicit H from it on atoms where hydrogen is added. For example, by default "NHCOOEt" becomes "NCOOEt" after adding an instantiated hydrogen to the nitrogen atom. This reduces confusion on the hydrogen status when rendering all atoms.

- nohighvalences

Do not add hydrogen to atoms which already exceed their lowest standard valence minus any formal charge. This option only applies to elements which have a defined lowest standard valence (this is configurable via the element table).

- nomemory

Do not remember the added hydrogen atoms as automatically added. Normally, a flag is retained as part of the atom information which distinguishes atoms which were added by automatic processing, such as hydrogen addition, from those which were originally input.

- nometals

Do not attempt to add hydrogen to atoms which are metals (as defined in the system element table).

- nospecial

Do not perform hydrogen addition to atoms which participate in non-standard bonds (all bonds with B_TYPE not normal).

- keepflags

For expert use only. Do not discard min/max values and property scope flags for atom properties when hydrogen is added.

- protonate

Add a single proton to the atom. The charge of the atom is increased, only a single hydrogen is added regardless of the standard number of missing hydrogens, and this command will issue the standard property invalidation event for atom and bond changes.

- resetmemory

Reset the origin flag described above for all atoms in the ensemble. All current atoms appear to be part of the original atom set.

If a charge delta parameter is specified, the atomic charge and free electrons of the atoms are adapted accordingly before the hydrogens are added. The manipulation of the charge usually changes the number of added hydrogen atoms. It is not possible to change the charge in such a way that the number of free electrons would become negative. This parameter is included for the sake of compatibility with the atom hadd command. It is rarely useful for bonds.

Adding hydrogens with this command, except if the protonate flag is set, is less destructive to the property data set of the ensemble than adding them with individual atom create/bond create commands, because many properties are designed to be indifferent to explicit hydrogen status changes, but are invalidated if the structure is changed in other ways.

The command returns the number of hydrogens which were added in total to both atoms.

## bond hstrip

bond hstrip ehandle label ?flags? ?chargedelta?
This command removes hydrogens from the atoms of the selected by. By default, all hydrogen atoms are removed.

The flags parameter can be used to make the operation more selective. It may be a list of the following flags:

- deprotonate

If this flag is set, a single proton is removed from the atom. This command variant does issue a standard atom and bond change property invalidation event, and it always ends processing after removing the first proton. Proton removal decreases the charge of the atom by one.

- keepalphawedge

Keep hydrogen atoms which are bonded to an atom which is at the tip of a wedgebond. This flag excludes the case where the bond to the hydrogen atom is the wedge bond - use the keepwedge flag to cover this case.

- keepisotopes

Keep hydrogen atoms which are isotope labels (including enriched/depleted ${ }^{1} \mathrm{H}$ ).

- keeporiginal

Hydrogen atoms which were not automatically added via a hydrogen addition command are retained. Note that these commands can be run in a mode which does not leave information about automatic addition - hydrogens added this way do not survive.

- keepprotons

Keep any molecules which consist only of hydrogen atoms (such as protons, hydride anions, and molecular hydrogen).

- keepspecial

If this flag is set, hydrogens which are usually displayed, such as on aldehydes, wedge bonds, carbon triple bonds or hetero atoms are retained.

- keepwedge

Keep hydrogens which are at the end of a wedge bond, indicating stereochemistry.

- normalize

Normalize the wedge pattern for standard cases, removing excess wedges from hydrogens if the result structure is still stereochemically defined. Hydrogens which lose their wedge in this process are no longer protected by the keepwedge flag.

- wedgetransfer

If a hydrogen atom is removed which is at the end of a wedge, the wedge information is saved by transferring the wedge (changing its up/down status if necessary) to an adjacent, surviving bond. This flag has no effects if the keepspecial or keepwedge flags are set. This flag is set by default.

If the flags parameter is an empty string, or none, it is ignored. The default flag value is wedgetransfer - but the default value is overridden if any flags are set!

If a charge delta parameter is specified, the charge and free electrons of the atoms are adapted accordingly before the hydrogens are added. The manipulation of the charge changes the number of added hydrogen atoms. It is not possible to change the charge in such a way that the number of free electrons would become negative. This option is mostly provided for compatibility with the atom hstrip command. It is rarely useful for bonds.

Hydrogen stripping is not as disruptive to the ensemble data content as normal atom deletion, except in case the deprotonate flag is set. The system assumes that this operation is done as part of some file output or visualization preparation. However, if any new data is computed after stripping, the computation functions see the stripped structure, and proceed to work on that reduced structure without knowledge that there are implicit hydrogens.

The return value of the command is the total number of hydrogens removed from all bond atoms.

## bond index

bond index ehandle label
Get the index of the bond. The index is the position in the bond list of the ensemble. The first position is index 0 .

Example:
bond index \$ehandle 99

## bond local

bond local ehandle label propertylist ?filterset? ?parameters?
Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

Example:
bond local \$ehandle 1 B_LABEL_STEREO
Note that very few computation routines currently support the local re-computation of data - in most cases, this command falls back to a global re-computation.

## bond match

bond match ehandle label ss_ehandle ?ss_label? ?matchflags? ?ignoreflags?
?atommapvar? ?bondmapvar? ?molmapvar?
Check whether the selected bond matches a substructure. Only the first substructure bond, or the bond selected by the substructure label parameter, is tested. The substructure may be part of any structure ensemble, and even be in the same ensemble as the primary command bond. Both the bond atoms and the bond proper are checked.

The precise operation of the substructure match routine can be tuned by providing a standard set of match flags and feature ignore flags. The default match flag set has set bits for the bondorder, atomtree and bondtree comparison features, and an empty ignore set. If a flag set is specified as an empty string, the default set is used. In order to reset a flag set, an explicit none value must be used. The bit options of the match flag are explained in the documentation of the match ss command.

The command returns 1 for a successful match, 0 otherwise. If an optional atom, bond, or molecule map variable is specified, it is set to a nested list of matching substructure/structure atom, bond or
molecule labels. If no match can be found, the variable is set to an empty list. In case only a bond or molecule map variable is needed, an empty string can be used to skip the unused map variable argument positions

## Example:

```
set ss [ens create {[F,Cl,Br,I][C,C]} smarts]
set b_is_cxbond [bond match $ehandle $label $ss {} amap]
if {$b_is_cxbond} {
    set b_xatom [lindex [lindex $amap 0] 1]
    set b_catom [lindex [lindex $amap 1] 1]
}
```


## bond mols

```
bond mols ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the label(s) of the molecule the bond is a member of. This is explained in more detail in the section about object cross-references.

## Examples:

```
bond mols $ehandle 1
bond mols $ehandle 1 heterocycle
```

The first example simply returns the label(s) of the molecule the bond is a part of. Note that it is possible for bonds to span more than one molecule - this is the reason why the command name is mols, not mol. If a bond spans more than one molecule, a list of the molecule labels is generated.

The second example returns the molecule label(s) if the bond is part of a molecule which contains one or more heterocycles. If the molecule(s) do not contain a heterocycle, an empty list is returned.

## bond neighbors

bond neighbors ehandle label ?filterset? ?filtermode? ?anchoratomlabel?
This command retrieves neighbor atoms of the bond. The atoms which participate in the bond are not included.

By default, a list with the labels of the atoms passing the optional filter set is the result. The retrieval mode may optionally be changed by supplying a filter mode specification list as in the standard cross referencing commands, such as count or exclude. Both parameters may be set to an empty list or entirely omitted if the default function is needed.

If the optional anchor atom label (or other atom specification) is provided, only atoms which are bonded via a VB or complex bond (B_TYPE normal or complex) to this bond are listed. If the anchor atom is one of the bond atoms, the effects is similar to using the atom neighbors command, except that the other bond atom(s) are excluded. If the anchor atom is not part of the bond, other neighborhood relationships can be explored.

The command may also be invoked with the aliases bond neighbours and bond ligands.
Examples:
bond neighbors [ens create $\mathrm{C}=\mathrm{C}$ ] 1
returns the labels of the hydrogen atoms.

## bond new

bond new ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the bond get command. The difference between bond get and bond new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## bond nget

bond nget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the bond get command. The difference between bond get and bond nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## bond partner

bond partner ehandle bondlabel atomlabel
Return the label of the other atom in the indicated bond. In case the bond contains more than two atoms, the first atom which is not the specified atom is returned. Using an atom label which is not participating in the bond results in an error.

Example:
set a2 [bond partner \$ehandle \$b \$a1]
bond partners
bond partners ehandle bondlabel atomlabel
Return the label of the other atom in the indicated bond. In case the bond contains more than two atoms, a list of the atoms which are not the specified atom is returned. Using an atom label which is not participating in the bond results in an error.

## bond pis

bond pis ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\pi$ systems the bond is related to. This is explained in more detail in the section about object cross-references. A bond is considered to be related to a $\pi$ system if all atoms of the bond are contained in the $\pi$ system.

Examples:
bond pis \$ehandle 1
Get the labels of the $\pi$ systems the bond is related to. $\pi$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use p or d orbitals, such as in standard covalent multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## bond permute

bond permute ehandle label ?targetbondorder?
Change the bond order by rotating the bond orders of Kekulé-style alternating single/double bond aromatic rings the bond is a member of. This is a useful function if aromatic systems need to be manipulated in reaction transforms and similar circumstances. If no target bond order is specified, an attempt is made to flip the bond between single and double. If a target bond order is set, the function does nothing if the current bond has already the desired bond order. The operation does not change atomic charges and does not succeed if any valence violation is encountered. Sydnones and other exotic aromatic systems can thus fail. In case the bond is a member of more than one eligible ring, the ring which is modified should be considered arbitrary.

The function returns one if the operation succeeds (which includes doing nothing is the target bond order is already present) and zero otherwise. An error is raised only if there are problems with the arguments.

## bond purge

bond purge ehandle label propertylist/stereo/isotope
Reset existing property data on a bond. In case the argument is a list of property names, the value on that bond only is reset to the default value of the property. In case the property is not present on the ensemble, the command is ignored. The reset via a property list does not trigger a property dependency update. If that is desired, an ens taint command must be explicitly scripted.In case a reset property is an atom property instead of a bond property, the reset is executed for all bonds of the atom. Other property object class mismatches are currently not supported.

In addition to standard properties, two special pseudo property names are recognized.
The stereo code resets all bond-centered stereo information on the bond, and will trigger a stereo change event on the ensemble which may invalidate additional data.

The isotope code resets property A_ISOTOPE on the bond atoms, marks the isotope data as tainted and run a data dependency check.

## bond rings

bond rings ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the rings the bond is contained in. This is explained in more detail in the section about object cross-references.

## Examples:

bond rings \$ehandle 1
bond rings \$ehandle 1 [list heterocycle aroring]
The first example returns the labels of all rings the bond is contained in. If the bond is not in any ring, an empty list is returned. Only labels of rings in the SSSR or ESSSR ring set are returned, even if the currently computed ring set is larger. The second example filters the rings - only heteroaromatic rings are reported.
bond ringsystems
bond ringsystems ehandle label ?filterset? ?filtermode?

Standard cross-referencing command to obtain the labels of the ring systems the bonds is contained in. This is explained in more detail in the section about object cross-references.

Examples:
bond ringsystems \$ehandle 1
bond ringsystems \$ehandle 1 [list heterocycle aroring]
The first example returns the labels of the ring system the bond is contained in. If the bond is not in any ring system, an empty list is returned. The second example filters the ring systems - a ring system label is obtained only if that ring system contains one or more hetero aromats.

## bond rotate

```
bond rotate ehandle label angle
```

This command rotates one half of a molecule in 3 D on property $A_{-} X Y Z$ around the axis defined by the bond. The rotation angle is specified in degrees.

The section of the molecule which is rotated is not arbitrary and independent of the order of the atoms in the bond or bond specification. If there is a difference between the centrality of the atoms of the bond, the part which is less central is rotated. Molecules other than the one containing the rotation bond are not affected. The static section of the molecule also retains all atomic coordinates. If any rotation is performed, (which excludes cases where the rotated bond is terminal - this is a no-op), both the $3 d o p$ and 3 dglobalop property invalidation events are generated.

The command fails if no 3D coordinates are present or can be computed, or if the bond is a ring bond.
Example:
bond rotate \$ehandle [list 5 4] 15
rotates one half of a molecule around the bond between atoms 4 and 5 by 15 degrees.

## bond set

bond set ehandle label property value ?property value?..
Standard data manipulation command. It is explained in more detail in the section about setting property data.

Example:
bond set \$ehandle 1 B_COLOR "blue"
The direct change of critical bond type data, such as the bond order B_ORDER, or bond type B_TYPE should be avoided. Instead, the bond manipulation commands bond create and bond change should be used. The dedicated creation, deletion and modification commands automatically take care of bookkeeping tasks such as electron counting for valence bonds. Also, direct setting of the bond data renders most structure information invalid, since most properties depend directly or indirectly on the bond type and order. Careful manual locking and updating of property data is required if direct bond manipulation is attempted.

## bond show

bond show ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the bond get command. The difference between bond get and bond show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, bond get and bond show are equivalent.

## bond sigmas

bond sigmas ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\sigma$ systems the bond is participating in. This is explained in more detail in the section about object cross-references. A bond is considered to be related to a $\sigma$ system if all atoms of the bond are contained in the $\sigma$ system.

## Examples:

bond sigmas \$ehandle 1
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## bond sqIdget

bond sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the bond get command. The differences between bond get and bond sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and return that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## bond sqlget

bond sqlget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the bond get command. The difference between bond get and bond sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## bond sqlnew

bond sqlnew ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the bond get command. The differences between bond get and bond sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## bond sqlshow

bond sqlshow ehandle label propertylist ?filterset? ?parameterlist?

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the bond get command. The differences between bond get and bond sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## bond subcommands

bond subcommands
Lists all subcommands of the bond command. Note that this command does not require an ensemble handle, or a bond label.

## bond surfaces

bond surfaces ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the surface patches a bond is related to. This is explained in more detail in the section about object cross-references. A bond is considered to be related to a surface element if it is linked to any of the atoms in the bond.

Example:
bond surfaces \$ehandle 1
bond uncharge
bond uncharge ehandle label
This command attempts to combine opposing charges on the atoms of the bond by increasing the bond order. If the bond order was increased, the result is 1 , otherwise 0 . The result for non-VB bonds is always 0 .

Example:
bond uncharge [ens create $\{C[N+]([0-])=0\}]\{23\}$
This example converts the single bond between the nitrogen cation (atom 2) and the oxygen anion (atom 3) to a double bond and thus neutralizes the charges on the atoms.

## bond xdelete

bond xdelete ehandle label ?label?...
Delete one or more bonds, while trying to maintain stereochemistry. The atoms which participate in the bonds are not deleted, but in case the bond is a standard valence bond, their free electron count (property A_FREE_ELECTRONS) is updated. Molecule and ring information, and other minor object classes under the control of the ensemble major object which depend on an unchanged bond set are deleted. Any property data which depends on an unchanged bond set is also invalidated, or, if the property is set up to do so, re-computed. Wedge bonds and other stereochemistry information tied to a deleted bond is transferred to an adjacent bond prior to deletion, if possible.

If the bond which should be deleted does not exist, the request is silently ignored, as long as the bond specification is syntactically correct.

The return value of this command is the total of all bonds successfully deleted.

Example:
bond xdelete \$ehandle [list 1 2]

## The chemobj command

This is an utility command to help with the generalization of commands applied to the various explicitly named chemistry objects in the toolkit.

The following subcommands are supported:

## chemobj class

```
chemobj class objecthandle
```

Returns the class or TcL command name associated with the major object identified by the handle. This command may also be invoked as chemobj tclcommand.

## chemobj eval

chemobj eval subcommandname objecthandle ?args?...
Execute the Tcl command associated with the object. The subcommand name, object handle and optional arguments are all passed to that object-specific command in that order.

This command is intended to make it easier to exploit the regular structure of the chemistry TcL commands, providing an easy method to invoke the same functionality on different kinds of major objects without the need to inspect the handles or perform other checks to identify the object type. This command invokes the original class command. It does not perform error checking on its own. It is only safe to be used with subcommands which use identical syntax, or at least an identical syntax with a specific argument set, for all object classes a script is expected to encounter.

Example:

```
chemobj eval purge $handle $proplist
```

Above command purges the properties in the list from the passed object, regardless whether the object is, for example, an ensemble, a reaction, a dataset or a table.

## chemobj get

chemobj get class/handle attribute
Query information on a chemistry object class. The identifier may either be a class name, as returned by chemobj list, or, for major objects, a valid object handle. The following attributes are recognized:

- affiliation

The institution the author works for.

- author

The author of the object class.

- authorurl

A URL with information on the author, or an empty string if unset.

- class

The class name of the object class, which is also the name of the associated TcL command. This is the same as the tclcommand attribute.

- classuuid

The base class UUID of this object class.

- comment

A free-form string comment on the object class.

- date

The data the module source was last modified.

- doi

A digital object identifier for the object class, if defined.

- email

The email address of the author of the object class.

- infourl

A URL with information on the object class, or an empty string if unset.

- keywords

A list of keywords associated with the object class.

- labelproperty

The name of the property which is used for set minor object labels, e.g. A_LABEL for the atom class, and an empty string for ensembles.

- license

The license class associated with this object class. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the object class license.

- literature

A free-form literature reference.

- name

The primary name of the object class.

- orcid

The ORCID code of the author (see www.orcid.org).

- ownerclass

The class name of the major object which controls objects of this class, e.g ens for atom. For major objects, the class and owner class are the same.

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- propertyprefix

The standard prefix (without the underscore) for the names of properties associated with this object class.

- references

Cross references of the object class. This is a nested list of class UUIDs and reference type tags.

- regid

A numerical registration ID assigned to registered object classes.

- tclcommand

The same as the class attribute.

- version

The version of the object class.

- versionuuid

The UUID associated with this object class version.

## chemobj list

chemobj list ?pattern?
List the currently loaded chemistry object classes with their primary name.

## chemobj tclcommand

chemobj tclcommand objecthandle
Returns the class or TcL command name associated with the major object identified by the handle. This command may also be invoked as chemobj class.

## The connection Command

The connection command is used to access information about links in generic network objects (see network command). In many respects the behavior of connection objects in networks is comparable to that of bonds in ensembles, and the commands for handling connections are similarly structured. For example, just like bonds can be identified by a list of the participating atoms, connections can be selected by a list of the participating vertices.

Pseudo connection labels first, last and random are special values, which select the first connection in the connection list, the last, or a random connection.

The command edge is an alias for connection, allowing the use of a more standard nomenclature, but without the benefit of a matching prefix on the names of connection properties.

The following connection commands are supported:

## connection append

connection append nhandle label property value ?property value?..
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:

```
connection append $nhandle $c C_IDENT "_v2"
```


## connection connection

connection connection nhandle label
Return the connection label stored in property C_LABEL. This is useful in case the label is not the straightforward connection label, but some other specification type, such as a vertex pair.

Example:
connection connection \$nh [list \$v1 \$v2]

## connection create

connection create nhandle vertex_list ?uniqueness? ?property value?...
Create a new connection which links the vertices specified in the vertex list argument. In contrast to the handling of bonds in ensembles, there can be multiple connections with the same set of vertices in a network, and self-links (linked the same vertex as source and destination) are allowed. In some contexts the order of the vertices registered in a connection matters, i.e. the connections are interpreted as directional.

By setting the uniqueness flag, the presence of a connection duplicate is detected and in that case the old label of the existing connection is returned, instead of creating a new connection. The possible values of the uniqueness parameter are no (or 0 , the default), undirected (or 1 , the vertices are matched regardless of the order in the specified list) and directed (or 2, the vertices are matched in the same order as in the argument list).

The magic vertex label value new can be used in the vertex list to automatically create one or more new vertices with this command instead of referring to existing vertices. The new vertices are added
to the vertex list and have the same properties as vertices created explicitly with a vertex create command.

An initial set of property values for the new or re-used connection can be set by the optional property/value arguments.

The command returns the new or old connection label.

## connection defined

connection defined enandle label property
This command checks whether a property is defined for the connection. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The network valid command is used for this purpose

```
connection delete
connection delete nhandle ?label?...
connection delete nhandle all
```

Delete specific or all connection from the network. The vertices participating in the deleted connection remain in the network.

The command returns the number of deleted connections.

## connection dget

connection dget nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the connection get command. The difference between connection get and connection dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, connection get and connection dget are equivalent.

## connection exists

conenction exists nhandle label ?filterlist?
Check whether this connection exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the connection does not exist, or fails the filter, and 1 in case of successful testing.

Examples:
connection exists \$nhandle 99
connection exists \$nhandle [list 1 2]
The second example checks whether a connection between vertices 1 and 2 exists. Instead of using a single label, all connection labels may be substituted by a list of the labels of their vertices.

## connection filter

connection filter nhandle label filterlist
Check whether a connection passes a filter list. The return value is 1 for success and 0 for failure.

## connection get

connection get nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Example:
connection get \$nhandle [list \$v1 \$v2] C_ONTOLOGY_LINK
yields the ontology link type data of connection 1 as a list. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the connection get command are connection new, connection dget, connection nget, connection show, connection sqldget, connection sqlget, connection sqlnew and connection sqlshow.

## connection index

connection index nhandle label
Get the index of the connection. The index is the position in the connection list of the network. The first position is index 0 .

Example:
connection index \$nhandle 99
connection new
connection new nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the connection get command. The difference between connection get and connection new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## connection nget

connection nget nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the connection get command. The difference between connection get and connection nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## connection set

connection set nhandle label property value ?property value?..
Standard data manipulation command. It is explained in more detail in the section about setting property data.

Example:
connection set \$nhandle 1 C_IDENT "bla"
connection show
connection show nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the connection get command. The difference between connection get and connection show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, connection get and connection show are equivalent.

## connection sqldget

connection sqldget nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the connection get command. The differences between connection get and connection sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and return that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## connection sqlget

connection sqlget nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the connection get command. The difference between connection get and connection sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.
connection sqlnew
connection sqlnew nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the connection get command. The differences between connection get and connection sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## connection sqlshow

connection sqlshow nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the connection get command. The differences between connection get and connection sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## connection subcommands

connection subcommands
Lists all subcommands of the connection command. Note that this command does not require a network handle, or a connection label.

## connection vertices

connection vertices nhandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the vertices which are participating in the connection. This is explained in more detail in the section about object cross-references.

Examples:
connection vertices \$nhandle 1

## The dataset Command

The dataset command is the generic command used to manipulate datasets. The syntax of this command follows the standard schema of command/subcommand/majorhandle. Datasets are major objects and thus do not need any minor object labels for identification.

Example:
dataset get \$dhandle D_SIZE
As explained in the introductory section on datasets, a normal persistent dataset handle may be substituted as third argument of the dataset command by an arbitrary list of dataset, ensemble, reaction, table and network handles. Substitution is only allowed in that argument position, not in case where a dataset handle is part of the command arguments of another object command, and not in a different argument position in the context of a dataset command. Such an object list is transformed into a transient dataset for the duration of the command execution. After the command has completed, the elements of the transient dataset are in most cases restored to their original state with respect to dataset membership and position, except in a few documented exceptional circumstances.

As a means to access an embedded dataset object, its handle may be replaced by the handle of the parent object where this is unambiguous, e.g.
ens move \$eh \$thandle
moves the ensemble into the embedded dataset of the table, while
dataset count \$thandle
treats the table argument as part of a transient dataset as described above.
This is the list of currently officially supported subcommands:

## dataset add

dataset add dhandle objhandle ?position?
Add an object to the dataset, relocating it from a current dataset if it exists. If no position is specified, the object is appended to the rear of the dataset object list. The position can either be a numerical zero-based index, or any string beginning with 'e' to indicate the end position.

If the object handle identifies a (local) dataset, and the target dataset does not accept datasets as members, all objects in the source dataset are instead moved to the new dataset, and then the source dataset is destroyed. If ensembles, reactions, tables or networks are moved, they are unlinked from any current datasets, but these original datasets themselves persist.

This dataset command is equivalent to issuing a move command from the object.

## Example:

dataset add $\$ d h$ \$eh end
ens move \$eh \$dh end
These two commands are equivalent.

```
dataset addthread
dataset addthread dhandle ?body?
dataset addthread dhandle count body
```

```
dataset addthread dhandle count substitutiondict body
```

Add one or more script threads to the dataset. By default, a single thread is added, but by setting the count parameter to a higher number multiple threads with the same script body can be added simultaneously, up to a maximum of 32 threads per dataset. It is possible to use this command to add additional threads to a dataset which already has attached threads. These older threads remain active.

The optional substitution dictionary contains a set of percent-prefixed keys and replacement values, following the Tk event procedure model. All such replacements are made before the script is passed to the thread interpreters. A single default substitution replacing the character sequence $\% D$ with the handle of the current dataset is always predefined and cannot be redefined. Replacement token keys (but not necessarily their values) are single case-depended characters, ignoring an optional percent prefix character. Within the script, percent signs which should be preserved as such must be doubled, just like in Tk event substitution commands.

The dataset threads are compatible to those of the standard TcL threads package. Dataset-associated threads are automatically created in preserved state, and a thread: : wait command is automatically appended at the end of the script, so they can be sent additional tasks via the thread : : send facility. If no script body is specified, the initial script consists only of the wait command. Threads can be canceled or joined only if they are stopped the wait statement.

When a dataset is deleted, all threads associated with this dataset need first to be joined, and this can only happen if they have finished processing the main body script and are all in their idle state in the thread: :wait command. Object deletion is postponed until this condition is met. A global join on all currently executing dataset threads is automatically performed when the program exits, before any object clean-up tasks are run. An application where dataset threads are stuck and do not reach their thread: :wait cancellation points cannot be cleanly exited.

Duplicating datasets does not duplicate any associated threads.
The presence of threads on a dataset has consequences for the behavior of the dataset wait and dataset pop commands, as well as object insertion commands associated with other major object classes (e.g. ens move, or molfile read). Please refer to the respective paragraphs for details. The size control mechanism of datasets in the auto mode is also dependent on the presence of absence of linked dataset threads.

Example:

```
dataset addthread $dh 1 [dict create %T $th] {
    while {1}
        set eh [dataset pop %D]
        if {$eh==""} break
        if {[catch {ens get $eh E_CANONIC_TAUTOMER} eh_canonic]} {
            ens delete $eh
            continue
        }
        if {[catch {ens get $eh_canonic E_DESCRIPTORS}]} {
            ens delete $eh
            continue
        }
        table addens %T $eh_canonic
        ens delete $eh
    }
}
```

This code creates a processing thread on the dataset which computes properties on newly arriving ensembles, stores the data in a table (note the table handle substitution via the replacement dictionary) and then deletes the ensemble. The dataset pop command returns an empty string when it is known no more data will arrive, and otherwise blocks until an object for popping is available. This is managed by setting the eod dataset attribute from feeder threads.

The return value of the command is a list of the TcL thread IDs of the newly created threads. These are suitable for use in the dataset jointhreads command or any standard TcL thread package command.

## dataset append

dataset append dhandle property value ?property value?
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

## Example:

dataset append \$dhandle D_NAME "_new"
dataset append \$dhandle eod 1

## dataset assign

dataset assign dhandle srcprop dstprop
Copy data from one property to another. Both properties must be associated with the same object class. The source property (but currently not the destination property) may be specified as an indexed property subfield. There must be a conversion path between the data types of the two properties or property subfields involved for the operation to succeed. For example, assigning a string property to a numeric property succeeds only if the string data items contain suitable numbers.

The original property data remains valid. The command variant dataset rename directly exchanges the property name without any data duplication or conversion, if that is possible. In any case, the original property data is no longer present after the execution of this command variant.

If the properties are not associated with datasets (prefix $D_{-}$), the operation is performed on all dataset member objects.

Example:
dataset assign \$dhandle A_XY A_XY\%
This code snippet creates backup atomic 2D layout coordinates on all dataset ensembles or reactions.

## dataset cancelthreads

dataset cancelthreads ?all?
dataset cancelthreads dhandle ?all?
dataset cancelthreads dhandle threadid..
Cancel (or more precisely, wait for and join) one or more threads associated with the dataset. Dataset threads can only be canceled when they are idle, executing the implicitly added thread: : wait command at the end of their script. Therefore, this command is not just used for clean-up, but also useful for ascertaining that the threads have finished their tasks. The IDs of the threads associated with a dataset can be retrieved as the threads dataset attribute, or saved from the return value of the
original dataset addthread command. The special all thread ID value can be used to cancel all threads of the dataset. This can also be achieved by setting an empty thread ID parameter, or omitting it altogether. If a dataset does not possess threads, this command does nothing. If a thread marked for cancellation has not yet finished, the cancellation command is suspended until it has.

This command can also be invoked without specifying an explicit or transient dataset argument, or passing it as all. In that case, the thread join cleanup is run on all threads of all currently defined datasets. This function is also implicitly run when a a script exits, before performing other application cleanup operations.

Thread cancellation for all dataset threads is implicitly invoked when a dataset is deleted, so an explicit clean-up is not required. However, this also means that a dataset deletion blocks if there are still active threads. It is not possible to forcefully cancel an thread which has entered an infinite loop, so careful programming is required.

The command returns the number of canceled threads.
dataset jointhreads is an alias to this command.
Example:
dataset jointhreads \$dh
dataset cancelthreads \$dh [lindex [dataset get \$th threads] 0]
dataset jointhreads
The first example waits for all threads on the specified dataset to finish. The second command waits for the completion of one specific thread, and the last command waits for all threads on all currently defined datasets.

## dataset cast

dataset cast datasethandle dataset/ens/reaction/table ?propertylist?
Transform the dataset into a different object. Depending on the target object class, the result is as follows:

- dataset

Only supplied for the sake of completeness. This mode does nothing.

- ens

The first ensemble contained in the dataset, or a newly created empty ensemble if no such object exists. The dataset and all its other contents are destroyed in the process.

- reaction

The first reaction contained in the dataset, or a newly created empty reaction if no such object exists. The dataset and all its other contents are destroyed in the process.

- table

A new table with automatically set up columns which are the union of all valid ensemble-class $\left(\mathrm{E}_{-}^{*}\right)$ and reaction-class $\left(\mathrm{X}_{-}^{*}\right)$ properties of the ensembles and reactions in the dataset, and rows with the data of these objects. In addition, these objects are moved into the internal table dataset. The input dataset, and its remaining contents which were not moved to the table, are destroyed.

If the optional property list is specified, an attempt is made to compute the listed properties before the cast operation, so that they may become a part of the new object. No error is raised if a computation fails.

The command returns the handle of the new object, or the input object in case of mode dataset.

## dataset clear

dataset clear dhandle
Delete all objects in the dataset, but keep the dataset object. The return value is the number of deleted objects.

## dataset count

dataset count dhandle|remotehandle ?filterlist?
Get the number of objects in the dataset. If the filter parameter is specified, only those objects which pass the filter are counted.

Example:
dataset count \$dhandle pstereoatom
counts the number of ensembles or reactions in the dataset with one or more potential atom stereo centers.
dataset size is an alias to this command.
This command can be used with remote datasets.
In case a simple count on a local dataset is required, without any filters, the dataset size can also be queried as attribute, as in
set n [dataset get \$dhandle size]
dataset create
dataset create ?objecthandlelist?...
This command creates a new dataset and returns the handle of the new dataset. If the optional object handle lists are provided as arguments, the specified objects (in case of ensemble, reaction, network or table handles), or elements of the object (for a dataset handle, with default accept flags) are moved to the new dataset. In case the accept flags of the target dataset are configured to allow datasets as primary dataset objects, the source dataset argument is not implicitly replaced by its content objects but added as a single object, retaining its objects as content. Otherwise, the source dataset is emptied but remains a valid object.

Besides handles of ensembles, reactions, networks, tables and datasets, which are identified with priority, any string which can be decoded in an ens create statement is also allowed as member initialization identifier.

If the create statement references objects which are not usually accepted by the default settings of the accept table attribute, that attribute is automatically adjusted to allow for these objects.

The command always returns the handle of the new dataset, never the handles of any objects which may have been placed into the dataset

## Examples:

dataset create [list \$eh1 \$eh2] \$dh1
creates a new dataset and move the two specified ensembles \$eh1 and \$eh2, as well as everything contained in the dataset $\$ d h 1$, into the new dataset.
dataset create VXPBDCBTMSKCKZ
Above command matches a partial InChI key, and puts all structures from the NCI resolver which matches the non-stereo/isotope-specific part of their full InChI key, into the new dataset.

```
set ::cactvs(lookupmode) „name_pattern"
dataset create [list "+morphine +methyl"]
```

This command performs a name pattern lookup and puts all structures from the NCI resolver which contain both name fragments in one of their known names into the dataset. The name pattern string needs to be explicitly packed into a list, because otherwise it would be split into two independent list elements.

## dataset dataset

dataset dataset dhandle ?filterlist?
Get the handle of the container dataset the dataset is a member of. If the dataset is not itself a dataset member, or does not pass all of the optional filters, an empty string is returned.

This command is not equivalent to dataset datasets!

## dataset datasets

dataset datasets dhandle ?filterset? ?filtermode? ?recursive?
Return a list of all the datasets that are members in the dataset identified by the command argument handle. Other objects (ensembles, reactions, tables, networks) are ignored. The object list may optionally be filtered by the filter list, and the output further modified by a standard filter mode.

If the recursive flag is set, and the dataset contains other datasets as objects, datasets in these nested datasets are also listed.

This command is not equivalent of the dataset dataset command!
Example:

```
set dlist [dataset datasets $dhandle]
```

dataset defined
dataset defined dhandle property
This command checks whether a property is defined for the dataset. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The dataset valid command is used for this purpose.

## dataset delete

dataset delete ?datasethandlelist/all?...
This command destroys datasets and everything contained therein. The special handle value all may be used to delete all datasets in the application at once.

The command returns the number of datasets which were successfully deleted.
Transient datasets cannot be used with this command. Neither can be datasets which are a component of another object, e.g. the internal datasets of tables or factories. These are only and automatically deleted when their parent object is destroyed. Datasets which are a property value are also undeletable by this command.

It is a common programming error to delete a dataset, or its parent object if one exists, without protecting its current member ensembles or reactions. If they are still needed in later processing they need to be explicitly transferred into another dataset or outside it.

## Examples:

dataset delete all
dataset move \$dhandle \{\}; dataset delete \$dhandle
The first example destroys all datasets defined in the current script and everything contained in them. The second example shows how to delete a dataset and preserve its contents by moving all dataset elements out prior to deletion.

## dataset dget <br> dataset dget dhandle propertylist ?filterset? ?parameterlist?

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the dataset get command. The difference between dataset get and dataset dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, dataset get and dataset dget are equivalent.

```
dataset dup
dataset dup dhandle ?targethandle? ?cleartarget?
```

If the optional arguments are not supplied, the dataset with all data attached to dataset and all objects which are contained in it are duplicated. The command returns a new dataset handle. All duplicated objects in the new datasets also are assigned handles which can be obtained by commands such as dataset list \$dhandle.

It is possible to specify a target dataset as an optional argument. In that case, no new dataset is created, and dataset-level property data on the source dataset is not copied. All objects in the source dataset are duplicated and appended to the end of the target dataset. In case the boolean target clearance flag is set, which is also the default if the parameter is omitted, the target dataset is cleared before the new objects from the source dataset are added. In this command variant, the return value of the command is the target dataset handle.

Examples:
dataset dup \$dhandle
dataset dup [list \$eh1 \$eh2] \$dtarget 0
dataset ens
dataset ens dhandle ?filterset? ?filtermode? ?recursive?

Return a list of all the ensembles in the dataset. Other objects (reactions, tables, datasets, networks) are ignored. The object list may optionally be filtered by the filter list, and the output further modified by a standard filter mode.
If the optional boolean recursive argument is set, ensembles which are a component of a reaction in the dataset are also listed. Furthermore, if the dataset contains datasets as elements, these are recursively traversed, and ensembles in these, as well as ensembles in reactions in these datasets, are listed. If the output mode of the command is a handle list, items found by recursion are appended to the result list in a straight fashion, without the creation of nested lists. By default the recursion flag is off. Regardless of the flag value, ensembles which are associated with rows of a table in the dataset, but are not themselves dataset members, are not output.

Example:
set elist [dataset ens \$dhandle astereogenic]
lists those ensembles in the dataset which have one or more atoms which are potential atom stereo centers.
set cnt [dataset ens \$dhandle \{\} count 1]
returns a count of all ensembles which are either directly members of the dataset, or indirectly as component objects of reactions in the dataset, or which are contained in datasets which are a themselves a member of the primary dataset.

## dataset exists

dataset exists dhandle
Check whether this dataset exists. The command returns a boolean value. This command cannot be used with transient datasets.

Example:
dataset exists \$dhandle
dataset expr
dataset expr dhandle expression
Compute a standard SQL-style property expression for the dataset. This is explained in detail in the chapter on property expressions.

## dataset extract

dataset extract dhandle propertylist ?filterset? ?filterprocs?
This command is rather complex and closely related to the dataset xlabel command. It was designed for the efficient extraction of major or minor object data for filtered subsets of the dataset.
The property list parameter selects the property data which is extracted. Multiple properties may be specified, but they can only be associated with major objects and one arbitrary minor object class. So it is possible to simultaneously extract an ensemble and an atom property, but not an atom and a bond property.

The return value is a nested list of data items for every object which is encountered while traversing the dataset on the level of the minor object associated with the extraction property, or just ensembles
or other major objects if no such property is selected. Every list element is itself a list which contains the extracted property values in the order they are named in the property list parameter.

The objects for which data is returned can further be filtered by a standard filter set, and additionally by a list of filter procedures. These Tcl script procedures are called with the respective object handles and object labels as arguments. For example, a callback function used in an atom retrieval context would be called for each atom with its ensemble handle and the atom label as arguments. If major objects without a label are checked, such as complete ensembles, 1 is passed as the label. The callback procedures are expected to return a boolean value. If it is false or 0 , the object is not added to the returned list, and the other check procedures are no longer called.

The command currently only works on ensembles in the dataset, ignoring any reactions, tables, datasets or networks which may be present.

Because this command is primarily intended for numerical data display, the returned values are formatted as with the nget command, i.e. instead of enumerated values the underlying numerical values are returned.

Example:

```
set dhandle [dataset create [ens create CO] [ens create CN]]
dataset extract $dhandle [list E_NAME A_SYMBOL] !hydrogen
```

This example first creates a dataset with methanol and methylamine. The second line performs the actual extraction and returns

```
{CH4O C} {CH4O O} {CH5N C} {CH5N N}
```

This kind of extracted data is useful for the display of filtered atomic (and other minor object's) property values.

## dataset forget

dataset forget dhandle ?objectclass?
This command is essentially the same as the ens forget (or reaction forget, etc) command. It is applied to all objects in the dataset.

If the object class is dataset, all dataset-level property data is deleted.

## dataset get

dataset get dhandle propertylist ?filterset? ?parameterlist?
dataset get dhandle attribute
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

In addition to retrieving property data, it can also be used to query dataset attributes. The set of supported attributes is detailed in the paragraph on the dataset set command.

## Examples:

dataset get \$dhandle \{D_NAME D_SIZE\}
yields the name and size of the dataset as a list. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

```
dataset get $dhandle [list E_FORMULA E_WEIGHT]
```

gives the formula and molecular weight of all dataset ensembles. The result is delivered as a nested list. The first list are the formulas, the second list contains the weights.

Currently, it is not possible to use filters with this command (and the other retrieval command variants) which are not operating directly on the dataset object, but on objects lower in the hierarchy such as ensembles or atoms.

For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the dataset get command are dataset new, dataset dget, dataset nget, dataset show, dataset sqldget, dataset sqlget, dataset sqlnew and dataset sqlshow.

```
dataset getparam
dataset getparam dhandle property ?key? ?default?
```

Retrieve a named computation parameter from valid property data. If the key is not present in the parameter list, an empty string is returned. If a default value is set, that value is returned in case the key is not found.

If the key parameter is omitted, a complete set of the parameters used for computation of the property value is returned in key/value format.

This command does not attempt to compute property data. If the specified property is not present, an error results.

Example:
dataset getparam \$dhandle E_GIF format
returns the actual format of the image, which could be GIF, PNG, or various bitmap formats.

## dataset hadd

dataset hadd dhandle ?filterset? ?flags? ?changeset?
Add a standard set of hydrogens to all ensembles and reactions in the dataset. If the filterset parameter is specified, only those atoms which pass the filter set are processed.

Additional operation flags may be activated by setting the flags parameter to a list of flag names, or a numerical value representing the bit-ored values of the selected flags. By default, the flag set is empty, corresponding to the use of an empty string or none as parameter value. These flags are currently supported:

- nospecial

Do not perform hydrogen addition to atoms which participate in non-standard bonds (all bonds with B_TYPE not normal).

- no2dcoords

Do not assign 2D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 2D coordinates. In any case, 2D coordinates are never added when the ensemble does no already possess valid 2D coordinates.

- no3dcoords

Do not assign 3D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 3D coordinates. In any case, 3D coordinates are never added when the ensemble does no already possess valid 3D coordinates.

- nometals

Do not attempt to add hydrogen to atoms which are metals (as defined in the system element table).

- noelements

Do not add hydrogen if the ensemble consists purely of isolated metal atoms, which probably represent the material in elementary form, or as an alloy.

- nomemory

Do not remember the added hydrogen atoms as automatically added. Normally, a flag is retained as part of the atom information which distinguishes atoms which were added by automatic processing, such as hydrogen addition, from those which were originally input.

- resetmemory

Reset the origin flag described above for all atoms in the ensemble. All current atoms appear to be part of the original atom set.

- nocations

Do not add hydrogen to atoms with a positive formal charge.

- noanions

Do not add hydrogen to atoms with a negative formal charge.

- nohighvalences

Do not add hydrogen to atoms which already exceed their lowest standard valence minus any formal charge. This option only applies to elements which have a defined lowest standard valence (this is configurable via the element table).

- noatoms

Do not add hydrogen to atoms without any bonds.
Adding hydrogens with this command is less destructive to the property data set of the ensembles or reactions than adding them with individual atom create/bond create commands, because many properties are defined to be indifferent to explicit hydrogen status changes, but are invalidated if the structure is changed in other ways.

If the effects of the hydrogen addition step to the validity of the property data set should not be handled with this standard procedure, it is possible to explicitly generate additional property invalidation events by specifying a list as the optional last parameter, for example a list of atom and bond to trigger both the atom change and bond change events.

The command returns the total number of hydrogens added to all ensembles and reactions in the dataset.

Example:
dataset hadd \$dhandle
dataset hread
dataset hread dhandle ?datasethandle|enshandle? ?\#recs|batch|all?

This command provides the same functionality as dataset read, but additionally adds a stand set of hydrogen atoms to the read duplicate objects.

The command arguments are explained in the section on dataset read.

## dataset hstrip

dataset hstrip dhandle ?flags? ?changeset?
This command removes hydrogens from the dataset ensembles and reactions. By default, all hydrogen atoms in the dataset ensembles or reactions are removed.

The flags parameter can be used to make the operation more selective. It may be a list of the following flags:

- keepspecial

If this flag is set, hydrogens which are usually displayed, such as on aldehydes, wedge bonds, carbon triple bonds or hetero atoms are retained.

- keeporiginal

Hydrogen atoms which were not automatically added via a hadd command are retained.
Note that hydrogen addition commands can be run in a mode which does not leave information about automatic addition - hydrogens added this way will also survive.

- keepwedge

Keep hydrogens which are at the end of a wedge bond, indicating stereochemistry.

- wedgetransfer

If a hydrogen atom is removed which is at the end of a wedge, the wedge information is saved by transferring the wedge (changing its up/down status if necessary) to an adjacent, surviving bond. This flag has no effects if the keepspecial or keepwedge flags are set. This flag is set by default.

- keepprotons

Keep any molecules which consist only of hydrogen atoms (such as protons, hydride anions, and molecular hydrogen).

- keepalphawedge

Keep hydrogen atoms which are bonded to an atom which is at the tip of a wedgebond. This flag excludes the case where the bond to the hydrogen atom is the wedge bond - use the keepwedge flag to cover this case.

- normalize

Normalize the wedge pattern for standard cases, removing wedges from hydrogens if the result is still stereochemically defined. Hydrogens which lose their wedge in this process are no longer protected by the keepwedge flag.

- keepisotopes

Keep hydrogen atoms which are isotope labels (including enriched/depleted ${ }^{1} \mathrm{H}$ ).
If the flags parameter is an empty string, or none, it is ignored. The default flag value is wedgetransfer - but the default value is overridden if any flags are set!

If the changeset parameter is given, all property change events listed in the parameter are triggered.

Hydrogen stripping is not as disruptive to the ensemble or reaction data content as normal atom deletion. The system assumes that this operation is done as part of some file output or visualization preparation. However, if any new data is computed after stripping, the computation functions see the stripped structure, and proceed to work on that reduced structure without knowledge that there are implicit hydrogens.

Example:
dataset hstrip \$dhandle [list keeporiginal wedgetransfer]

## dataset index

dataset index dhandle
dataset index dhandle position
This command comes in two variants. The tree-word version is the generic command to check dataset memberships, which is the same for all objects which can be dataset members, while the second version retrieves object references from this dataset.

This first version gets the position of the dataset in the object list of its parent dataset. If the dataset is not part of a parent dataset, -1 is returned. This is the generic dataset membership test command variant.

This second command variant obtains the object handle of the object at the specified position in this dataset. Position counting begins with zero. If the index is outside the object position range, an empty string is returned. The special value end may be used to address the last object. The indexed object remains in the dataset.

Note that this index command is not equivalent to the standard index command on minor objects which is used to obtain the position of the minor object in the minor object list of the controlling major object. This kind of functionality is not needed for major objects, because they are not contained in any minor object list.

Example:
dataset index \$dhandle end

## dataset jointhreads

dataset jointhreads ?all?
dataset jointhreads dhandle ?all?
dataset jointhreads dhandle threadid..
This is an alias for the dataset cancelthreads command. Please refer to its documentation.

## dataset list

dataset list ?dhandle?
Without a handle argument, the command returns a list of the handles of all existing datasets.
If a dataset handle or transient dataset is passed as third argument, the command returns a list of all major objects in the dataset. This function is different from the behavior of the list subcommand for other major object classes, where the optional argument is a filter list.

Examples:
dataset list

```
dataset list $dhandle
```


## dataset lock

dataset lock filehandle propertylist/dataset/all ?compute?
Lock property data of the dataset handle, meaning that it is no longer subject to the standard data consistency manager control. The data consistency manager deletes specific property data if anything is done to the dataset handle which would invalidate the information. Property data remains locked until is it explicitly unlocked.

The property data to lock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the file object are locked. If the boolean compute flag is set, an attempt is made to compute the property if it is not yet present. Otherwise, a request to lock non-existent data is silently ignored. It is not possible to lock individual property fields.

- all

All valid dataset properties are locked. The compute flag is ignored.

- dataset

This is an object class identifier. All property data which is controlled by the dataset major object and attached to the specified object class is locked. Since datasets do not incorporate minor objects, this identifier is equivalent to all.

A lock can be released by a dataset unlock command.
This command does not recurse into the objects contained in the dataset.
The return value is the dataset handle or, if the dataset was transient, an empty string.

```
dataset loop
dataset loop dhandle objvar ?maxrec? ?offset? body
```

Loop over the elements in a dataset. This command is similar to molfile loop. On each iteration, the variable is set to the handle of the current member object, and then the body code is executed. The variable refers to the original dataset element, not a duplicate. This is different from dataset read.

All operations on the current loop item are allowed, including deletion. However, the next object after the current item must not be deleted or moved, because it is needed for the iteration process.

If a maximum record count is set, the loop terminates after the specified number of iterations. If the maximum record argument is set to an empty string, a negative value, or all, the loop covers all dataset elements. This is also the default.

Within the loop, the standard TcL break and continue commands work as expected. If the body script generates an error, the loop is exited.

If no offset is specified, the loop starts at the first element. Within the loop body, the dataset attribute record is continuously updated to indicate the current loop position. Its value starts with one, like file records in the molfile loop command.

Example:

```
dataset loop $dh eh {
    puts "[ens get $eh E_NAME] at position[ens index $eh]"
}
```


## dataset max

```
dataset max dhandle propertylist ?filterset?
```

Get the maximum value of one or more properties in from the elements in the dataset. The property argument may be any property attached to dataset members, or minor objects thereof. If the filterset argument is specified, the maximum value is searched only for objects which pass the filter set.

## Examples:

```
dataset max $dhandle E_WEIGHT
```

dataset max [list \$ehandle1 \$ehandle2] A_SIGMA_CHARGE carbon

The first example finds the highest molecular weight in the dataset. The second example finds the largest (most positive) Gasteiger partial charge on any carbon atom in the two argument ensembles, which form a transient dataset.

## dataset metadata

dataset metadata dhandle property field ?value?
Obtain property metadata information, or set it. The handling of property metadata is explained in more detail in its own introductory section. The related commands dataset setparam and dataset getparam can be used for convenient manipulation of specific keys in the computation parameter field. Metadata can only be read from or set on valid property data.

## Examples:

array set gifparams [dataset metadata \$dhandle D_GIF parameters]
dataset metadata \$dhandle D_QUALITY comment "This value looks suspicious to me"
The first line retrieves the computation parameters of the property D_GIF as keyword/value pairs. These are read into the array variable gifparams, and may subsequently be accessed as \$gifparams (format), \$gifparams (height), etc. The second example shows how to attach a comment to a property value.

## dataset min

dataset min dhandle propertylist ?filterset?
Get the minimum value of one or more properties from the elements in the dataset. The property argument may be any property attached to dataset sub-elements, or minor objects thereof. If the filterset argument is specified, the minimum value is searched only for objects which pass the filter set.

Examples:
dataset min \$dhandle E_WEIGHT
dataset min [list \$ehañle1 \$ehandle2] A_SIGMA_CHARGE carbon
The first example finds the smallest molecular weight in the dataset. The second example finds the smallest (most negative, or smallest positive) Gasteiger partial charge on any carbon atom in the two argument ensembles, which form a transient dataset.

## dataset molfile

dataset molfile dhandle ?filterset?
Return the handle of the molfile object associated with the dataset as backing page file. If no such file object exists, and empty string is returned.

Example:
set fh [dataset molfile \$dh]
set fh [dataset get \$dh pagefile]
The two commands are equivalent.

## dataset move

dataset move dhandle datasethandle|remotehandle ?position?
Move, depending on the acceptance flags of the destination dataset, either the objects in the dataset or transient dataset into another local or remote dataset, or move the dataset itself. If the destination dataset handle is an empty string, the dataset objects are removed from the original dataset, but not moved into any other dataset. If the destination dataset accepts datasets as members, which is not the default (see the accept attribute in the section on dataset set) the dataset is directly moved as object. Otherwise, its contained objects are moved, under preservation of the object order from the source dataset, and the source dataset is emptied, but not deleted.

Optionally, a position in the new dataset for the first moved object may be specified. This parameter is either an index (beginning with 0 ), or end, which is the default. If the contents of a dataset are spliced into another at a specific position, objects after the first element of the source dataset follow as a block.

Another special position value is random. This value moves to the dataset, or dataset contents, to a random position in the target dataset. Use of this mode with remote datasets is currently not supported.

In case of a transient command dataset the original dataset memberships of the dataset objects are not restored when the command completes.

The return value of the command is the original parent dataset of the command dataset, as it existed before the move. Usually, it is an empty string.

A dataset cannot be moved into itself.
Examples:
dataset move \$dhandle \$dhandle2 0
dataset move \$dhandle \{\}
dataset move [ens list] [dataset create]
The first line moves all objects in the source dataset into the first (and following) positions in the destination dataset. The second example removes all elements from the dataset. This is often useful in order to avoid dataset member destruction with the dataset delete command. The final example shows how to move a set of ensembles (here: all ensembles currently defined in the application) into a newly created dataset via an intermediate, transient dataset.
dataset move \$dhandle vioxx@server55:10001
This command moves all objects in the first dataset to the remote dataset on host server 55 , which listens on port 10001 and requires the pass phrase vioxx for access.

## dataset mutex

dataset mutex dhandle mode
Manipulate the object mutex. During the execution of a script command, the mutex of the major object(s) associated with the command are automatically locked and unlocked, so that the operation of the command is thread-safe. This applies to builds that support multi-threading, either by allowing multiple parallel script interpreters in separate threads or by supporting helper threads for the acceleration of command execution or background information processing. This command locks major objects for a period of time that exceeds a single command. A lock on the object can only be released from the same interpreter thread that set the lock. Any other threaded interpreters, or auxiliary threads, block until a mutex release command has been executed when accessing a locked command object. This command supports the following modes:

- lock

Increase the recursive mutex lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock.

- reset

Release all persistent locks on the object, if they exist.

- test

Return the current persistent lock count on the object. This excludes the transient per-command lock.

- unlock

Decrease the recursive lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock. Unlocking an object which has not been persistently locked results in an error.

There is no trylock command variant because the command already needs to be able to acquire a transient object mutex lock for its execution.

## dataset need

dataset need dhandle propertylist ?mode?
Standard command for the computation of property data, without immediate retrieval of results. This command is explained in more detail in the section about retrieving property data.

If the dataset is not transient, the return value is the dataset handle.
Example:
dataset need \$dhandle D_GIF recalc

## dataset networks

dataset networks dhandle ?filterset? ?filtermode? ?recursive?
Return a list of all the networks in the dataset. Other objects (ensembles, reactions, datasets, tables) are ignored. The object list may optionally be filtered by the filter list, and the result further modified by a standard filter mode argument.

If the recursive flag is set, and the dataset contains other datasets as objects, networks in these nested datasets are also listed.

Example:

```
set n [dataset networks $dhandle {} count]
```

dataset new
dataset new dhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the dataset get command. The difference between dataset get and dataset new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

```
dataset nget
dataset nget dhandle propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data and attributes. It is explained in more detail in the section about retrieving property data.

For examples, see the dataset get command. The difference between dataset get and dataset nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## dataset nitrostyle

dataset nitrostyle dhandle style
Change the internal encoding of nitro groups and similar functional groups in the ensembles and reactions in the dataset. Possible values for the style parameter are:

- asis No change
- ionic Change to encoding to a positive charge on the center atom, and a negative on one of the oxygens
- xionic As above, but also change the encoding of azides, etc.
- neutral Change the encoding to the neutral form with extended valence. pentavalent is an alias.
- xneutral As above, but also change the encoding of azides, etc.

The command returns the dataset handle.

## dataset objects

dataset objects dhandle ?pattern?
This is a non-standard cross-referencing command. The result is a list of all the objects in the dataset, where each result list element is a list consisting of the object type (ens, reaction, table, network, dataset), and the object handle. Optionally, the list objects may be filtered by the filters in the filterset argument.

Example:

```
dataset objects $dhandle ens*
```

is roughly equivalent to
dataset ens \$dhandle
except that the latter only lists the ensemble handles, not pairs of object class name and handle.

## dataset pack

dataset pack dhandle ?maxsize? ?requestlist? ?suppresslist?
Pack the dataset and all objects it contains into a base-64 encoded, compressed string as a serialized object. The string does not contain any non-printing characters, quotation marks or other problematic characters and is thus well suited for storage in database tables and similar applications. These packed strings are portable and platform-independent.

By default, all property data on the dataset and its member objects are stored. By providing a request list of properties which are computed if they are not yet present, and/or a list of properties not to store, the data content may be customized.

The maxsize parameter can be used to limit the maximum length of the packed string by setting a maximum length in bytes. The default value are 128 K bytes. If the string would be longer, an error is generated.

The return value of this command is the packed string.
Example:
dataset pack \$dhandle
dataset pop
dataset pop dhandle|remotehandle ?position? ?timeout?
Remove an object from a dataset. The handle of the selected object is returned, and the object is no longer a member of the dataset when the command completes. If a timeout is specified, it is transferred to the dataset attribute of the same name before the command is executed, as with a dataset set command.

By default the first object in the dataset, at index zero, is returned. A different object can be selected by means of the optional position argument. It can be a numerical index, or end for the last object. If the object index if larger than the maximum index of any object, it is silently rewritten to end.

This command works with remote datasets. In that case, the object is transferred via an intermediate serialized object representation over the network. It is unpacked on the local interpreter, and deleted on the remote interpreter.

If the desired dataset object cannot be found, and a timeout is set, including a negative value for an unlimited wait time, the command suspends execution until the object appears in the dataset, for example from a different script thread or as result of a remote object insertion. If a wait would be executed, but the eod/targeteod parameter pair of the dataset indicate that no further data can be expected, the command returns an empty string instead of the object handle, but does not trigger an error. Otherwise, if the object cannot be delivered immediately or after the timeout, an error results.

Example:
set eh [dataset pop \$eh end]

## dataset properties

dataset properties dhandle ?pattern? ?intersect/union?
Get a list of valid properties of the dataset proper and the dataset objects. By default, both dataset properties (prefix $D_{-}$) as well as the properties of the objects in the dataset (prefix $E_{-}$for ensembles, $X_{-}$for reactions, $T_{-}$for tables, $N_{-}$for networks, $D_{-}$for datasets as members) and the properties of their minor objects (atoms, bonds, etc.) are listed. Property subsets may be selected by specifying a string filter pattern. In case of dataset element properties which are not present in all dataset members, the default intersect mode is union, meaning that all properties are reported for which at least a single instance in any member exists. The alternative mode intersect only lists those dataset element properties which are present at all dataset members.

This command may also be invoked as dataset props.
Example:

```
dataset properties $dhandle D_*
```

dataset props \$dhandle E_* intersect

The first example returns a list of the currently valid dataset-level properties. The second example lists ensemble properties which are present in all dataset objects.

## dataset purge

dataset purge dhandle propertylist ?emptyonly?
Delete property data from the dataset. The properties may be both dataset properties (prefix $\mathrm{D}_{\mathrm{A}}$ ) or properties of the dataset members, such as ensemble or atom properties. If a property marked for deletion is not present on an object, it is silently ignored.

Besides normal property names, a few convenient alias names for common property deletion tasks of ensembles in a dataset, or the reaction ensembles of reactions in the dataset, are defined and can be used as a replacement for the property list. These include:

- atomstereochemistry

Delete all atomic atom stereo descriptors, but keep those for bonds.

- bondstereochemistry

Delete all bond stereo descriptors, but keep those for atoms.

- isotopes

Delete isotope information in A_ISOTOPE and other isotope properties which may be defined in future software versions.

- radicals

Delete atomic radical information in A_RADICAL and other radical-related properties which may be defined in future software versions.

- stereochemistry

Delete all stereochemistry descriptors, including 2D wedges, but not 3D coordinates. The implicit property list includes A_LABEL _STEREO, B_LABEL_STEREO, A_CIP_STEREO, B_CIP_STEREO, A_DL_STEREO, B_CISTRANS_STEREO, A_HASH_STEREO, B_HASH_STEREO, A_MAP_STEREO, B_MAP_STEREO, A_STEREOINFO, B_STEREOINFO, A_STEREO_GROUP, M_STEREO_COUNT, E_STEREO_COUNT and B_FLAGS (only selected bits, the property remains valid if present).

## - wedges

Delete wedge bond flags in property B_FLAGS. If B_FLAGS is not present, the command is ignored and no computation attempt is made.

The optional boolean flag emptyonly restricts the deletion to those properties where all the values for a property associated with a major object (such as on all atoms in an ensemble for atom properties, or just the single ensemble property value for ensemble properties) are set to the default property value.

## Examples:

dataset purge \$dhandle D_GIF
dataset purge [ens list] E_IDENT 1
dataset purge \$dhandle stereochemistry
The first example deletes the property data $D_{-} G I F$ for the selected dataset if it is present. The second example deletes property E_IDENT from all ensembles in the current application if their property value is equal to the default value of E_IDENT. The third examples removes stereochemistry from all dataset ensembles.

## dataset reactions

dataset reactions dhandle ?filterset? ?filtermode? ?recursive?
Return a list of all the reactions in the dataset. Other objects (ensembles, tables. datasets, networks) are ignored. The object list may optionally be filtered by the filter list, and the output further modified by a standard filter mode.

If the optional boolean recursive argument is set, reactions of which ensembles in the dataset are a component are also listed. Furthermore, if the dataset contains datasets as elements, these are recursively traversed, and reactions in these, as well as reactions as components of ensembles in these datasets, are listed. If the output mode of the command is a handle list, items found by recursion are appended in a straight fashion, without the creation of nested lists. By default the recursion flag is off. Regardless of the flag value, reactions which are associated with rows of a table in the dataset, but are not themselves dataset members, are not output.

Example:

```
set xlist [dataset reactions $dhandle]
```

Return a list of the handles of the reactions in the dataset.

```
set cnt [dataset reactions $dhandle {} count 1]
```

returns a count of all reactions which are either directly members of the dataset, or indirectly because ensembles in the dataset are part of a reaction, or which are contained in datasets which are a themselves a member of the primary dataset.

```
dataset read
dataset read dhandle ?datasethandle/enshandle? ?#recs|batch|all?
```

This command returns duplicates of one or more objects from the current dataset iterator position (record attribute). Its arguments mimic those of the molfile read command. The iterator record attribute is automatically incremented. When the end of the dataset is reached, an empty result is returned, but no error is raised.

The return value is usually the handle of the object duplicated from the dataset member at the current read position. If an optional target dataset has been specified. the object is appended to that dataset, and the return value is the target dataset handle. It is also possible to use the magic dataset handles new or \#auto, which create a new receptor dataset.

If instead of a target dataset am existing target ensemble is specified, the recipient ensemble is cleared, and the read dataset object placed into its hull without changing its handle. This requires that the read object is an ensemble, and not a reaction, table, dataset or network, and that only a single item is read. It is also possible to use an empty argument to skip these options.

By default, a single object is duplicated and the iterator record attribute of the dataset incremented by one. With the optional third argument, a different number of objects can be selected for reading as a block. The special value all reads all remaining objects, and batch copies a number of objects corresponding to the batchsize dataset attribute. If there are insufficient objects in the dataset to read all requested records, only the available set is returned, and no error results.

The dataset contents are not changed by this command. All extracted items are object duplicates. In order to fetch original objects from the dataset, use the dataset pop command, or the various object move commands.

The command variant dataset hread provides the same functionality as this command, but additionally adds a standard set of hydrogen atoms to the duplicates.

## dataset rename

dataset rename dhandle srcproperty dstproperty
This is a variant of the dataset assign command. Please refer the command description in that paragraph.

## dataset request

dataset request dhandle propertylist ?reload? ?modelist?
Request property data for a dataset when the dataset is not maintained locally, but a partial shadow copy of a remotely managed dataset. It is assumed to have been only partially transferred via RPC to a slave from a master controller application, for example for display purposes, but without the full data content, which resides on the master.

If the requested property data is already present on the slave, and the reload flag is not set, this command is equivalent to a dataset need command and does not invoke communication with the master. Otherwise, the master is asked to provide the information, which may be calculated on the master only after receiving the request, or even delegated by the master to another remote server for computation.

Once the requested data has been received by the slave, it is added to the property data set of the local dataset copy. The optional modelist parameter is the same as in the dataset need command. This command is used to guarantee that critical or non-computable property data is obtained from the master. Local, unsynchronized data may still be computed by the slave using standard property data access commands. It is currently not possible to send data back to the master.

This command is only available on toolkit versions which have been compiled with RPC support.

In the absence of errors, the command returns a boolean status code. If it is zero, the request failed in a non-critical way. This for example happens in case the dataset is not under control of a remote application.

## Example:

```
if {![dataset request $dhandle A_XY]} {
    dataset need $dhandle A_XY
}
```

is a bullet proof method of guaranteeing that correct atomic 2D display coordinates are present for the dataset structures even if the script is run in a master/slave context.

## dataset rewind

dataset rewind dhandle
Reset the dataset iterator record. This is equivalent to setting the record attribute to one.

## dataset scan

dataset scan dhandle expression ?mode? ?parameters?
Perform a query on the dataset or transient dataset. The syntax of the query expression is the same as that of the molfile scan command and explained in more detail in its section on query expressions. Essentially, this command behaves like an in-memory data file version of the molfile scan command. However, currently queries work on ensembles and reactions as dataset members only. Any table, network or other object which is a member of a scanned dataset is skipped. Skipped items still count as records for positioning and query result output. In the absence of a specified scan record list (order parameter), dataset scans begin at the current position of the iterator record attribute that is shared with the dataset read/hread commands.

The optional parameter dictionary is the same as for molfile scan, but not all parameters are actually used. At this time, only the matchcallback, maxhits, maxscan, order, progresscallback, progresscallbackfrequency, sscheckcallback, startposition and target parameters have an effect. If result ensembles or reactions are transferred to a remote dataset via the target parameter, they are not deleted from the local dataset but duplicates are created instead. This is because the original objects are members of the dataset which, just like a structure file would, should remain unchanged as result of a scan. In contrast, in file scans, the transferred ensembles and reactions were read from file and created as new objects during the scan, and sending these does not change the underlying file. In case a progress callback function is used, the dataset handle is passed as argument in place of the molfile handle in molfile scan.

The return value depends on the mode. The default mode is enslist. The following modes are supported for dataset queries:

- array

The mode parameter is a list consisting of the mode selector array and a nested list of properties and pseudo-properties. Each property item can be a list of one to three elements. The first element is a property or pseudo-property, the second element a name, and the third element again a property or pseudo property. The the second property item list element is omitted, the name is the same as the first element. If the third element is missing, it is assumed to be the pseudo-property record.

In this mode, the scan command returns a list of the names of the created arrays. For each name, a global TcL array variable is created, and for each scan match, an TcL array element with an element name equal to the value of the first item specification index and an element value equal to the value of the third item specification is created. For example, the specification

```
{array {E_NAME name2rec} {record rec2name E_NAME}}
```

results in the creation of two global TcL arrays in the current interpreter, called name2rec and rec2name. The first has elements where the element name is the name of the matching structure (property E_NAME), and the value the file record (the default, because the optional third specification parameter was omitted). The second array has elements where the record number is the array element name, and the corresponding value the structure name. The return value of the TcL statement is the list "name 2 rec rec2name", the names of the two variables created.

If array elements for a specific key already exist, the new value is appended as a list object. The result registration procedure does not overwrite the existing content. So, for example in above case, if there are multiple records with the same structure name, the array element indexed by name would contain a list or records, not just a single record item. Since global arrays are persistent, data is also appended over multiple scan statements. If this is not desired. a statement like unset -nocomplain \$arrayname should be executed before the scan is started. It is legal to use the same array name for the registration of multiple properties. In this case, each match appends a new list element for every reported property, though these lists will not be nested.

- bitvector

Return a string-encoded bit vector (series of 0 s and 1 s ) indicating the match status for every visited record.

- count

Count the number of hits. The result value is an integer.

- delete

Delete hits from the dataset. This is the only scan command which actually changes the dataset.

- ens

Return the handle of the first matching ensemble. The query is stopped at that point. If no hits are found, an empty string is returned. If a local target dataset is specified, a found ensemble is removed from the scanned dataset.

- enslist

Return the handles of all matching ensembles. If no hits are found, an empty list is the result. If a local target dataset is specified, the found ensembles are removed from the scanned dataset.

- exists

A boolean check for the existence of a match. The same as count, except that the scan stops after the first match.

- index

Return the positional index of the first matching dataset object. This is the same as the record mode value minus one.

- indexlist

Return the positional indices of the matching dataset objects. This is the same as the recordlist mode values minus one.

- molfile

The mode parameter is a list consisting of the mode selector molfile and a structure file handle, which must have been opened for writing, appending, or updating. The first matching structure is written to the file, and the command stops at that point. The output file handle attributes determine format, selection of data written, structure encoding conventions such as hydrogen status, etc. If no matching structure is found, nothing is written. In this mode, the return value of the command is the matching record number of the input file, just as in the record mode.

- molfilelist

The mode parameter is a list consisting of the mode selector molfilelist and a structure file handle, which must have been opened for writing, appending, or updating. Matching structures are written to that file. The output file handle attributes determine format, selection of data written, structure encoding conventions such as hydrogen status, etc. If no matching structures are found, nothing is written. This mode is also implicitly selected if a structure file handle is directly provided as mode argument. In this mode, the return value of the command is a list of the matching record numbers of the input file, just as in the recordlist mode

- property

The mode parameter is a list consisting of the mode selector property and a sequence of properties and pseudo-properties. The selected properties for the first match are returned as a list, and the command stops at that point. If there are no hits, an empty string is returned.

- propertylist

The mode parameter is a list consisting of the mode selector propertylist and a sequence of properties and pseudo-properties. The selected properties for all matches are returned as a nested list. If there are no hits, an empty string is returned. This mode is also selected if the mode argument is simply a list of property and pseudo property names without an identifiable mode keyword as first list element.

- reaction

Return the handle of the first matching reaction. The query is stopped at that point. If no hits are found, an empty string is returned. If a local target dataset is specified, a found reaction is removed from the scanned dataset.

- reactionlist

Return the handles of all matching reactions. If no hits are found, an empty list is the result. If a local target dataset is specified, the found reactions are removed from the scanned dataset.

- record

Return the object sequence number of the first hit. Sequence numbers begin, for the sake of comparability with structure file scan record numbers, with one.

- recordlist

Return object sequence numbers of all hits, or an empty list. Sequence numbers begin, for the sake of comparability with structure file scan record numbers, with one.

- table

The mode parameter is a list consisting of the mode selector table and a sequence of properties and pseudo-properties. This scan mode returns a table handle. The table is automatically configured with properly typed columns corresponding to the requested properties. For each hit, a row is added. If there are no hits, a table handle is still returned, but the table does not have any rows. This retrieval mode is only available if the toolkit has been compiled with table support. The individual properties may also be specified each as a list consisting of the property name, and an arbitrary string. In that case, the string is used as the column name. By default, the column names are the same as the name of the property they store. Example:

```
{table {E_NAME name} {E_CAS casno} record}
```

sets up a table with three columns called name, casno and record. The first two columns contain property data from the matching file records, the last one the record in the file which matched.

Instead of the keyword table, an existing table handle may also be used. In that case, any existing matching table columns are automatically re-used to store result data. Additionally specified properties are added as new columns to the right of the previously existing columns. New table rows generated by matches are appended to the bottom of the table.

- tablecollection

Since all objects are already in memory, this mode is identical to the table scan mode for dataset scans. No table reference object duplicates are created. The result table always refers the dataset objects directly.

- vrecord

For dataset scans, this is the same as record.

- vrecordlist

For dataset scans, this is the same as recordlist.
If requested property data is not present on the matched dataset objects, an attempt is made to compute it. If this fails, the table object in retrieval mode table contains NULL cells, and property retrieval as list data produces empty list elements, but no errors. For minor object properties, the property list retrieval modes produce lists of all object property values instead of a single value. In table mode, only the data for the first object is retrieved, which makes this mode less suitable for direct minor object property retrieval.

The following pseudo properties can be retrieved in addition to normal properties:

- avgscore

The average value of all computed scores, such as Tanimoto, Cosine or Tversky similarity scores, in the matching query for this result.

- conformerindex

The index of the matching conformer in case of 3D queries with multiple conformations, -1 if no matching conformer index was determined.

- conformer

A list of the atomic coordinates of the matching conformer, if a 3D query was performed. If this is not the case, an empty vector is the result. The data type of this vector is coorvec ( $\mathrm{x}, \mathrm{y}, \mathrm{z}$-triples as vector elements).

- filename

This property is only provided for compatibility with molfile scan. It is always an empty string in this command.

- index

The object sequence index of the matching object. For datasets, this is the same as the record value minus one.

- image

A structure GIF image (property E_GIF) with highlighted matching substructure atoms and bonds. A normal E_GIF retrieval property would just show the structure, but without highlighting. The data type of this property is the same as that of E_GIF (depending on the configuration, a diskfile reference or an in-memory blob).

- matchatoms

An integer vector holding the labels of all atoms matching the substructures used in evaluating the query expression. If no substructure was used for the match, this vector is empty. highlighatoms is an alias for this pseudo property.

- matchbondatoms

The same as matchbonds, except that each element is a pair of the labels of the matching atoms in the bonds, not the bond label as a single number.

- matchbonds

An integer vector holding the labels of all bonds matching the substructures used in evaluating the query expression. If no substructure was used for the match, this vector is empty. highlightbonds is an alias for this pseudo property.

- matchchount

The first element of the matchcounts array, as described below. If the query does not contain any substructure match nodes, the result is empty.

- matchcounts

An integer vector holding the number of distinct substructure matches for substructure query nodes in the query tree. For normal substructure expressions, this value can only be zero or one because the standard substructure match mode only checks for the presence of any match (match mode first). Additionally, this value can be minus one if the node was never evaluated, for example because it is part of an or expression. Only if the count modifier is used together with the substructure query operator, or the substructure operator is the range operator, the possibility of multiple matches is evaluated and larger values can be obtained. For these operations the match mode is currently always distinctinneratoms (see match ss command).

- maxscore

The maximum value of all computed scores, such as Cosine, Tanimoto or Tversky similarity scores, in the matching query for this result.

- merit

For queries which use a merit/demerit rating scheme (for example, Bruns/Watson queries) this retrieves the accumulated merit/demerit sum of the top-level query node. The query needs to match for this retrieval to work, so in case none of the demerit rules match, you get an empty result, not a default zero merit/demerit value. Internally, there is no distinction between merit and demerit scores. The keyword demerit is an alias for this pseudo-property.

- minscore

The minimum value of all computed scores, such as Cosine, Tanimoto or Tversky similarity scores, in the matching query for this result.

- parent

The parent structure of the matching structure as a packed, base64-encoded serialized object string. If the dataset ensemble does not already contain it, it is computed from the structure as property E_PARENT_STRUCTURE.

- productmatchatoms

The same as the matchatoms pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- productmatchbondatoms

The same as the matchbondatoms pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- productmatchbonds

The same as the matchbonds pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- queryid

The ID of the search tree query item which was responsible for the principal match. Every tree element of a query expression possesses an ID, starting with 1 , and then assigned in incremental sequence from left to right in depth-first manner. For simple property or structure match expressions, the query ID is the ID of the matching branch, i.e. one for single-node expressions. For logical expressions with an or, orcontinue or not node, the overall reported query ID is that of the first matching leaf node. For expressions, where all leaves need to be checked, the query ID is the ID of the and or eor node where all leaves matched, not the ID of any individual leaf node.

- reagentmatchatoms

The same as the matchatoms pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- reagentmatchbondatoms

The same as the matchbondatoms pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- reagentmatchbonds

The same as the matchbonds pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- record

The record number. In the context of in-memory datasets, this is the dataset object list index of the matching object plus one. $r c$ is an alias for this pseudo property. Use the index attribute to directly obtain the dataset index.

- rgatoms $(r g)$

A list of the atom labels in a matching structure which were mapped to an expanded R-group atom in the query. The property index is the name of the R-group of interest defined in the substructure, usually something like R1. If there was no expanded R-group of that name, the result list is empty.

- rgattachments(rg)

A nested list of the atom label pairs of the bonds in a matching structure which connect between the structure framework and the atoms expanded as the named R-group rg. If there was no expanded R-group of that name, the result list is empty.

- score

The first element of the scores array, as described below. If the query does not contain any scoring expressions, the result is empty.

- scores

An integer vector of the results of all query expression branches, in depth-first left-to-right order, which computed a score, such as structure similarity queries with Cosine, Tanimoto or Tversky bitvector comparisons. In case a branch was not evaluated when the match was determined, zero is returned.

- structure

The dataset structure as a packed, base64-encoded serialized object string.

- vrecord

For dataset scans, this is always the same as record.
These pseudo properties are identical to those available for structure file queries. However, structure file queries support a couple of additional pseudo properties which are not available for dataset queries.

Examples:
dataset scan \$dhandle \{E_WEIGHT < 200\} recordlist
dataset scan \$dhandle "structure >= clccccc1" \{table E_NAME E_LOPG record\}
dataset scan \$dhandle "structure >~ \$sshnd 90" \{cmpvalue E_REACTION_ROLE X_IDENT\}
The first example returns the record numbers (dataset member indices plus one) of all structures in the dataset which have a molecular weight of less than 200 .

The seconds example generates a table with columns for name, $\log P$ and record number. The table is filled with data from all structures which contain a phenyl ring as substructure.

The final example returns a nested list of the properties of all dataset structures which have a Tanimoto similarity of $90 \%$ or more to the structure which is represented by its handle stored in the variable $\$$ sshnd. In this example, the ensembles are expected to be also part of a reaction, which is possible since reaction and dataset membership are completely unrelated. Each result list element contains the actual similarity value (which is the only comparison result value with a threshold evaluated in the query, so there is no ambiguity which comparison result cmpvalue refers to), the role
of the ensemble in the reaction (reagent, product, catalyst, etc.) from property E_REACTION_ROLE, and the reaction ID in X_IDENT. The scan mode is here automatically set to propertylist, because the mode list consists exclusively of names of properties and pseudo properties.

Another example:
set is_chno [dataset scan \$ehandle \{formula $=\mathrm{CO}-\mathrm{HO}-\mathrm{NO}-\mathrm{OO}-\}$ count]
This command checks whether the ensemble (which is, for the duration of the command, embedded into a transient dataset) contains only elements $\mathrm{C}, \mathrm{H}, \mathrm{N}$ and O .

## dataset set

dataset set dhandle property value ?property value?...
Standard data manipulation command. It is explained in more detail in the section about setting property data.

In addition to property data, the dataset object possesses a few attributes, which can be retrieved with the get command (but not its related sister subcommands like dget, sqlget, etc.). Many of them are also modifiable via dataset set. These attributes are:

- accept

A bit set indicating the object classes the dataset accepts as members. Currently, this can be any combination of ens, reaction, table, network and dataset. The default acceptance mask is the union of all ens, reaction and table, excluding datasets and networks as allowed dataset objects. If an attempt is made to add an unacceptable object to a dataset, the command (such as ens move, dataset add, etc.) throws an error. If the object added to a dataset is a dataset, but the dataset does not accept datasets as members, the objects contained in the source dataset are added instead.

- affiliation

The institution the author works for.

- author

The author of the dataset, as free-form string data.

- authorurl

A URL with information on the author of the dataset, or an empty string if unset.

- batchsize

The number of objects in the dataset which form a batch. This can for example be used in the dataset read command. The default batch size is 10 .

- category

A category string to be used if the dataset is stored in a repository.

- classuuid

The base class UUID of this dataset object, as associated with its authorship attributes.

- coords
f the toolkit was compiled with factory support, these are the coordinates of the object icon on its workbench, encoded as integer pair. This attribute can be changed.
- counter

An integer counter which is automatically incremented every time an object is moved into the dataset, but not when the object only changes its position within the dataset. It can also be reset to an arbitrary value, and later dataset additions increment the counter from that
user-specified value. It is not decremented when objects leave the dataset, so this attribute is not necessarily the same as the dataset size. The initial counter value at dataset object creation time is zero. Depending on its mode, this attribute may interact with the insertcontrol attribute.

## - datasetcount

A read-only attribute reporting the number of dataset objects currently contained in the dataset.

- date

The date the dataset was defined.

- deletable

A boolean flag indicating whether the dataset can be deleted at this time or not. This is a read-only attribute. Under certain circumstances, such as a pending dataset wait command, or the use of the dataset object as argument to a scripted computation function expecting to be able to set function result data as property values, the dataset is marked as undeletable and any destruction command will silently fail.

- deselection

The inverse of the selection attribute, i.e. get all unselected object indices, or set the selection by providing a list of object indices which are not selected.

- doi

A digital object identifier for the dataset object content, if defined.

- email

A contact email of the author of the dataset.

- enscount

A read-only attribute reporting the number of ensemble objects currently contained in the dataset.

- eod

The value of the end-of-data marker. This attribute is typically used in multi-threaded applications to indicate that feeder threads have exhausted their data supplies and that no further dataset objects are expected to arrive in the dataset. This attribute is internally used by the dataset pop and dataset wait commands to determine whether they should continue to wait or exit with an empty result. The initial value of this attribute is zero.

- eodcheck

Perform a check whether at least one object is in the dataset, or is expected to arrive later. If objects are currently in the dataset, or the eod attribute value is less than the targeteod attribute value, the command returns zero, otherwise one. This check is not reliable for remote datasets.

- failures

A list of properties for which computation failed on this dataset object. This is a read-only attribute. Depending on configuration settings, this information may be used to block pointless attempts at re-computation of incomputable data.

- footer

If the toolkit was compiled with factory support, this is the footer of the object icon on a workbench. This attribute can be changed.

- gflags

If the toolkit was compiled with factory support, this is the currently set object icon rendering flag collection.

- header

If the toolkit was compiled with factory support, this is the header of the object icon on a workbench. This attribute can be changed.

- hidden

Flag indicating whether the dataset is hidden. This is not the same as the invisible state. This attribute is intended to be used for rendering selections. This attribute can be changed.

- highwatermark

An integer specifying a high water mark object on the dataset. Some commands use this attribute for automatic start or cancellation of operations until the object count has decreased to the low water mark, or for automatic start of processing services until the low watermark has been reached again. The default high watermark value is one. The dataset wait command uses this threshold as default command parameter.

- invisible

Flag indicating whether the dataset is invisible. This is not the same as the hidden state. An invisible object is no longer accessible via its handle. This is usually the case for objects which are scheduled for deletion, but still have lingering referring pointers. This attribute is read-only.

- insertcontrol

This parameter controls what happens when an attempt is made to add another object into a dataset. The default mode is $a d d$, which means that the object is inserted in the database if there is no size control active, or room can be made by waiting for already inserted objects to be removed (see sizecontrol parameter). Otherwise, in that mode an error results.

Additional insertion control modes are disabled (all insertions into the dataset are blocked), discardfirst (if the maximum size has been reached, delete first object in dataset to make room), discardlast (if the maximum size has been reached, delete last object in dataset to make room), discardobject (if the maximum size has been reached, delete the object to be inserted), discardalways (never attempt an actual insertion, always delete the insertion object), ignore (if insertion cannot be performed, leave the insertion object where it currently is, with preservation of current dataset membership) and unlink (silently remove the insertion object from its old dataset, if it is a member of one, but do not insert it into the target dataset if that would exceed its maximum size).

If the object cannot be inserted and is deleted (but not if it is just unlinked or ignored, and thus continuing to exist) the dataset counter is still incremented.

The final mode is discardrandom. In this mode, if the maximum size of the dataset has not yet been reached, the object is simply added. Otherwise, a random number between one and the counter attribute of the dataset is computed. If the number is larger than the maximum dataset size, the object to be inserted is deleted, as in the discardnew mode. If the random number is between one and the dataset size, the object in the dataset at the random position is deleted. After that, the new object inserted at its designated position, which is not necessarily the position of the removed object. This mode is intended to support convenient sampling of object subsets. The random procedure yields the same mathematical results as directly picking random objects from the total object pool passing through the dataset, but may be interrupted at any time yielding a random subset of the objects processed so far.

- instanceuuid

The instance UUID of this dataset, as associated with its authorship attributes.

- infourl

A URL with information on the dataset object content, or an empty string if unset.

- keywords

A list of keywords associated with the table object.

- license

The license class associated with this dataset object. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the dataset object license.

- literature

A free-form literature reference for the dataset.

- lowwatermark

An integer specifying a low water mark object count on the dataset. Some commands use this attribute for automatic scheduling or termination of actions. The default low watermark is zero.

- maxsize

The maximum number of objects the dataset will accept. If it is set to a negative value, which is the default, the maximum number of objects is unlimited. The effects of an attempt to overload the dataset depend on the settings of the sizecontrol attribute of the dataset.

- modcount

The modification count on the dataset object. This is a read-only attribute.

- mutexcount

The mutex lock count as a read-only value. This is mostly of interest to developers.

- name

A free-form dataset name as string.

- networkcount

A read-only attribute reporting the number of network objects currently contained in the dataset.

- orcid

The ORCID code of the author (see www.orcid.org).

- pagefile

The handle of a molfile object. If this is set, the current contents of the dataset are deleted, the pageoffset attribute set to the current input position of the file, and a number of records up to the current value of the pagesize attribute are read into the dataset. If this attribute is set to an empty string, the connection between the dataset and the structure file is abolished.

- pageoffset

The file record offset of the first object in the dataset, if the dataset is linked to a file. If this value is changed, and a link is active, dataset objects with file records outside the offset/pagesize window are deleted from the end or beginning, and new objects are added from the backing file as required.

- pagesize

The number of records to keep in the dataset in case it is linked to a file. If this value is changed, and a link is active, dataset members are deleted from the dataset, or added from the backing file as necessary.

- parent

Get the handle of the parent object, if the dataset is an embedded object, e.g. an integral component of a table, factory or station object. If the dataset is a standalone object, an empty string is returned. The parent attribute is not the same as dataset membership (see dataset dataset command), which can be changed (see dataset move command and the accept dataset attribute). This attribute is read-only. An embedded dataset object cannot be dissociated from its owner.

- passphrase

A string which needs to be presented by remote interpreters if they connect to the listener port of the dataset object. An empty string is equivalent to no pass phrase.

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- port

An integer port number at which a listener thread waits for connections from remote interpreters for the addition or removal of objects. If this attribute is set to an empty string, an existing listener thread is terminated and remote connections are no longer accepted.

- pyobject

If the toolkit was compiled with Python support, this attribute reports the memory address of the Python wrapper class instance, if it exists. This attribute is read-only.

- pyrefcount

If the toolkit was compiled with Python support, this attribute reports the reference count of the Python wrapper class instance, if it exists. This attribute is read-only.

- reactioncount

A read-only attribute reporting the number of reaction objects currently contained in the dataset.

- record

The current iterator record position. The first object in the dataset corresponds to record 1.

- refcount

If the TcL interpreter is using native Cactvs objects instead of string-based major object handles and integer-based minor object labels to identify toolkit objects, this returns the number of TcL object references active for this ensemble. This attribute is read-only.

- references

Cross references of the dataset. This is a nested list of class UUIDs and reference type tags.

- regid

For registered datasets, the registration ID. Zero if this is a private dataset.

- room

A read-only integer attribute which indicates whether the dataset has room for the insertion of another object. Datasets without size control always return 1, as do datasets which still have room for more objects. Return value 0 indicates that the maximum size has been reached, and no alternative action has been configured. Other possible special return values are -1 (insertion succeeds, but delete the inserted object), -2 (insertion will silently fail, the object remains in its old dataset membership), -3 (the object will be unlinked from any existing dataset, but silently not inserted into the new dataset) and -4 (the object will not be inserted in the target dataset, instead an application-specific alternative action will be taken). This attribute only checks the capacity of the dataset, not whether it will reject the object because it is of an unsuitable class (see accept attribute). In multi-threaded applications, the status value may become outdated before an insert command on the target dataset can be executed.

- selected

Flag indicating whether the dataset object is selected. This attribute can be changed. This attribute works on the dataset object proper, not its content - see the selection attribute below.

- selection

Upon retrieval, this attribute is a list of the position indices of all objects in the dataset which have the selected status flag. The index begins with zero, and the result is an empty list if there are no selected objects.

On setting, dataset set first clears all dataset object selections. The command dataset append retains it. The argument is then parsed as a list of integer object indices, and the selection flag is set for all those indices where objects can be found in the dataset. Indices outside the range between zero and the dataset size minus one or duplicate index specifications are silently ignored.

To check or set the selection status of the dataset object proper, use the selected attribute.

- size

Get the number of objects in the dataset. This is a read-only attribute. It is equivalent to the dataset count command without any filters.

- sizecontrol

This attribute operations in tandem with the maxsize attribute. It can be set to auto, none, error or block. pause and wait are aliases for block. The default setting is auto. In error mode, any attempt to add an object to a dataset which has already reached its maximum size raises an error. In block mode, the interpreter halts until the object count has decreased below the maximum size and then continue to move the object into the dataset. This mode
is useful when the script is multi-threaded or the dataset operates a listener port for remote commands, because the number of objects in the dataset can change by these methods without involving the paused interpreter. The none mode disables the maximum size monitoring. Finally, the auto mode behaves like the error mode if there is only a single interpreter thread, and the dataset does not listen for remote commands, and like the block mode, if any of these two criteria are met.

## - swapthreshold

The maximum size of a dataset before ensemble and reaction objects in it are automatically swapped to disk, as they are by the explicit commands ens swapout or reaction swapout. The size check is performed at the moment new objects are added, and these new objects are the first to be swapped. The default value for this attribute can be set in the control array element::cactvs(dataset_swap_threshold). Its initial value is 10000 . The default value for the embedded datasets in tables is controlled separately by ::cactvs(table_swap_threshold), which is also initially set to 10000 .

If this value is set to a negative value, all dataset elements which are currently swapped out are loaded back in. If it is set to a positive value, and the number of not currently swapped out objects of the dataset is more than the new limit, excess objects are swapped beginning from the end of the dataset queue until the in-memory object count of the dataset satisfies the new constraint. If the limit is increased, but not set to a negative unlimited value, the object swap status is not modified.

- tablecount

A read-only attribute reporting the number of table objects currently contained in the dataset.

- targeteod

The target value of the eod attribute. Once it matches or exceeds this value, the dataset is not expected to receive any more items. The initial value of this attribute is one.

- threadcount

A read-only attribute returning the number of TcL interpreter threads associated with the dataset. Normal datasets have no associated threads and return zero. This command is equivalent to the length of the list returned by the threads attribute, and the threads included in this count are the same.

- threads

A read-only attribute returning the TcL interpreter thread handles of the threads associated with the dataset (see dataset addthread command). Datasets without threads return an empty list. The handles are compatible with the standard TcL thread package. Remote communication listener threads (see port attribute) are independent of TcL support, do not have a TcL handle, and are not listed by this command.

- timeout

A timeout in seconds to use with the dataset wait command. A negative value means an infinite wait period, and zero no wait period. The default setting is minus one.

- tooltip

If the toolkit was compiled with factory support, this is the tooltip of the object icon on a workbench. This attribute can be changed.

- uuid

The automatically generated object instance UUID. This ID is independent of the UUID triple (class/instance/version) associated with the authorship attributes and intended for public dissemination. This attribute is read-only, unique for every dataset object - even duplicates -, and independent of its contents or pedigree.

- version

A free-form version number of the dataset.

- versionuuid

The version UUID associated with this dataset object as per its authorship attributes.

- $x$

If the toolkit was compiled with factory support, this is the x coordinate of the object icon on its workbench. This attribute can be changed.

- $y$
if the toolkit was compiled with factory support, this is the $y$ coordinate of the object icon on its workbench. This attribute can be changed.


## Examples:

```
dataset set $dhandle D_NAME "New lead structures"
```

dataset set \$dhandle E_NAME "Lead (metal)"

The first line is a simple set operation for a dataset property. The second line shows how to set properties of multiple ensembles in one step. The same property value is assigned to all ensembles.
dataset set $\$ d h a n d l e ~ p o r t ~ 10001 ~ p a s s p h r a s e ~ b l o c k b u s t e r ~$
Set up a listener thread on port 10001 which accepts connections from remote interpreters which need to present the pass phrase as credential. Remote interpreters can add (ens move, reaction move, table move) or remove (dataset pop) objects to or from this dataset, as well as query the dataset object count (dataset count). Objects are transferred over the network connection as serialized objects to and from the remote interpreters.

## dataset setparam

dataset setparam dhandle property key value ?key value?..
Set or update a property computation parameter in the parameter list of a valid property. This command is described in the section about retrieving property data.

Example:
dataset setparam \$dhandle D_GIF comment "Top Secret"

## dataset show

dataset show dhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the dataset get command. The difference between dataset get and dataset show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, dataset get and dataset show are equivalent.

## dataset sort

dataset sort dhandle \{property ?direction? ?cmpflags?\}..
Sort a dataset according to property values of the objects in the dataset. If no sort property set is specified, the default sort properties are E_NATOMS (number of atoms) and, for breaking ties, E_WEIGHT (molecular weight) and finally E_HASHISY (stereo isotope hash code).

Every sort item is interpreted as a nested list and can have from one to three elements. The first, mandatory element is the sort property, or one of the magic names record or random. The next optional element is the sort direction, specified as $u p$ (or ascending) or down (descending). The default sorting order is ascending. The final optional comparison flags parameter can be set to a combination of any of the values allowed with the prop compare command. The default is an empty flag set. Properties in the sort list have precedence in the order they are specified in. Object property values of comparison list entries to the right in this list are only considered if the comparison of all data values of list elements to the left results in a tie.

The magic property name record sorts by the object index in the dataset. Sorting upwards on this property does not change the object sequence in the dataset, and sorting downwards reverses it. This pseudo property is always added as a final implicit criterion, so that the sequence order of objects tied in all explicit comparisons is preserved. The other magic property name random assigns a random value to all dataset objects and sorts on this value, yielding a random object sequence.

The command returns a list of the handles of the objects controlled by the dataset in the newly sorted order. Simultaneously, the objects are physically moved within the dataset, so the sort has a persistent effect. The same result list may later be obtained by a dataset objects command.

It is possible to sort transient datasets, but this makes sense only if the object list sequence returned as command result is captured and used later, because the sort effect is not persistent since there exists no permanent dataset object.

Examples:
dataset sort \$dhandle \{E_NAME up \{ignorecase lazy\}]
The example sorts the dataset according to the compound name (property E_NAME, data type string) in alphabetic order, using a lazy (ignoring whitespace and punctuation) and case-insensitive comparison mode.
dataset sort \$dhandle \{E_NATOMS down\} \{E_NRINGS up\}
Sort the dataset in such a way that the ensembles with the largest number of atoms, and among these those with the smallest number of rings, come first.
dataset sort \$dhandle random
This command randomizes the object order in the dataset.
dataset sort \$dhandle \{*\}\$sortlist
This is the recommended construct when using a sort property list store in a TcL variable as command argument. Older versions of the dataset sort command used a single sort argument parameter instead of a variable-size argument set.

```
dataset sqldget
dataset sqldget dhandle propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the dataset get command. The differences between dataset get and dataset sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## dataset sqlget

dataset sqlget dhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the dataset get command. The difference between dataset get and dataset sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

```
dataset sqlnew
dataset sqlnew dhandle propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the dataset get command. The differences between dataset get and dataset sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## dataset sqlshow

dataset sqlshow dhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the dataset get command. The differences between dataset get and dataset sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## dataset statistics

dataset statistics dhandle property
Get basic statistics on the property values of the objects in the dataset. The property can be a basic property or a property subfield, but its element data type needs to be cast-able to a simple numeric type. In addition, it must be directly attached to any of the objects which can be members of a dataset, e.g. an ensemble property, but not an atom property.

If the property data is not present on any of the objects, an attempt is made to compute it. In case that fails, or a dataset member object is not of a matching type, these objects are silently skipped.

The return value is a list containing, in this order, the number of objects in the dataset which were used for the statistics, the property value sum, the property value average and the property data
standard deviation. The latter three values are floating point, regardless of the property data type. In case any of these values are not computable, for example because there were an insufficient number of objects, the reported value is zero.

The command verb can be abbreviated as stats.
Example:
lassign [dataset statistics \$dh E_WEIGHT] n sum avg stddev]

## dataset subcommands

dataset subcommands
Lists all subcommands of the dataset command. Note that this command does not require a dataset handle.

## dataset tables

dataset tables dhandle ?filterset? ?filtermode? ?recursive?
Return a list of all the tables in the dataset. Other objects in the dataset (ensembles, reactions, datasets, networks) are ignored. The object list may optionally be filtered by the filter list, and the result further modified by a standard filter mode argument.

If the recursive flag is set, and the dataset contains other datasets as objects, tables in these nested datasets are also listed.

Example:

```
set n [dataset tables $dhandle {} count]
dataset taint
dataset taint dhandle propertylist/changeset ?purge?
```

Trigger a property data tainting event which acts on the dataset data, and all objects and their data contained in the dataset.

The parameters of this command are the same as for ens taint and explained there.
Example:

```
dataset taint $dhandle A_XYZ
```

All property data on the dataset and the dataset members is invalidated if it directly or indirectly depends on the 3D atomic coordinates.

## dataset transform

dataset transform dhandle SMIRKSlist ?direction? ?reactionmode?
?selectionmode? ?flags? ?overlapmode? ?\{?exclusionmode? excludesslist\}?
?maxstructures? ?timeout? ?maxtransforms? ?niterations?
This command is complex, but very similar to the ens transform command. Please refer to that command for a full description of the command arguments. The major difference is that the start structure set is not a single ensemble, but rather the set of all ensembles in the dataset. Any dataset items which are not ensembles are ignored. The return value is, just as with the ens transform command, a list of result ensembles. These do not become part of the input dataset.

Example:

```
dataset transform [ens get $ehandle E_KEKULESET] $trafolist bidirectional \
    multistep all {preservecharges checkaro setname}
```

This command first expands an ensemble object into a set of Kekulé structures. The property data type of the e_kekuleset property is a dataset, so its handle is returned, and this dataset is then submitted for further transformation, which in this case involves manipulations of bonds in aromatic systems and thus is dependent on the Kekule structures of the input ensembles.

The dataset variant of the transform command does not allow the use of marked or unmarked atom or bond specifications in the exclusion substructure list. Normal substructures are supported, and are applied to all start structures.

```
dataset unique
dataset unique dhandle {property ?direction? ?cmpflags?}..
```

This command removes duplicate objects from the dataset and destroys them. Object identity is determined by pair-wise comparison of one or more properties. If all these properties are identical for any two objects, one of them is deleted. If no properties are specified, the default is the single property E_HASHISY, the standard isotope- and stereo-aware ensemble hash code.

The command returns the ordered list of objects remaining in the dataset after deletion. The command is closely related to the dataset sort command, and the same restrictions on usable sort properties apply. Internally, the command performs a sort first, in order to avoid a quadratic growth of pair-wise comparisons. This has the side effect that the object order in the dataset is not preserved. Instead, the surviving objects are listed in ascending (by default) or descending (if the corresponding optional sort direction argument is set accordingly) values of the sort properties. The interpretation of the optional comparison flags and sort direction arguments, as well as the priority of the properties, and the special considerations when working on transient datasets, are the same as for the command dataset sort.

Example:

```
molfile read $fh $dh all
dataset unique $dh
```

This command first reads a complete file into a dataset, and then discard duplicates, using the default isotope- and stereo-aware structure hash code.

## dataset unlock

dataset unlock dhandle propertylist/dataset/all
Unlock property data for the dataset object, meaning that they are again under the control of the standard data consistency manager.

The property data to unlock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the dataset object are unlocked. Non-existent data is silently ignored. It is not possible to unlock individual property fields.

- all

All valid dataset object properties are unlocked.

- dataset

This is an object class identifier. All property data which is controlled by the dataset major object and attached to the specified object class is unlocked. Since datasets do not incorporate minor objects, this identifier is equivalent to all.

Property data locks are obtained by the dataset lock command.
This command does not recurse into the objects contained in the dataset.
The return value is the dataset handle, or, if the argument was a transient dataset, an empty string.

## dataset unpack <br> dataset unpack string

Generate a dataset complete with all elements it contains from a packed, base64-encoded serialized object string, as it is generated by the complementary dataset pack command.

The return value is the handle of the new dataset.. All objects in this dataset also are assigned standard handles, which can be retrieved with the usual commands such as dataset ens and dataset reactions.

Note that this command does not take a dataset handle as argument, but a pack string.
Example:
dataset unpack [dataset pack \$dhandle]
This example is effectively the same as a dataset dup operation, but of course less efficient, because the objects have to be serialized, compressed, and base64-encoded and the same sequence of operations run backward again.

```
dataset valid
dataset valid dhandle propertylist
```

Returns a list of boolean values indicating whether values for the named properties are currently set for the dataset. No attempt at computation is made.

Example:
dataset valid \$dhandle D_NAME
reports whether the dataset is named (has a valid D_NAME property) or not.

```
dataset wait
dataset wait dhandle ?size|query? ?script?
```

Suspend the interpreter until the number of objects in the dataset has reached a threshold, or an object which satisfies a query expression can be found. The syntax of query expressions is the same as in the dataset scan command. If no explicit size or a query expression is specified, or an empty string is passed as this parameter, the command uses the value of the highwatermark dataset attribute as default value for an implicit size threshold condition.

Another dataset attribute which has an influence on the execution of the command is the timeout attribute. If the dataset size has not grown to the required size, or no object which satisfies the query expression was added to the dataset after waiting for the timeout number of seconds, an error is raised. By default, the maximum wait period is indefinite, which corresponds to a negative timeout
value. If the timeout value is set to zero, the wait condition must be met immediately, or an error results. However, no error is raised if the eod/targeteod dataset parameter pair indicates that no more data can be expected to be added in the dataset. In that case, the result is an empty string.

If no script body parameter is used, the return value of the command is the number of objects the dataset holds in case of an explicit or implicit size condition, or the handle of the first matching object in case of a query expression.

If the object count already exceeds the threshold, or a matching object can be found at the moment the command is executed, the command returns immediately.

In the presence of a script parameter, the script body is executed whenever the wait condition is met. If the script is ended with a continue statement, or simply reaches the end of the code block, the wait loop is automatically restarted. If the script reports an error, or is left via a break or return statement, the loop is terminated.

This command is mostly useful when running multi-threaded scripts, or when the dataset is operating a remote command listener on a port. Under these circumstances, new objects may arrive in the dataset without participation of the local, stopped interpreter.

While a dataset wait command is pending, the dataset cannot be deleted. Since it is possible that other threads or remote action port monitors further update the dataset between the time the wait condition is met and script processing commences, action scripts should be prepared to see more or less items in the dataset than immediately after the trigger event.

## Example:

```
loop n 1 $nrecs {
    set eh [dataset wait $dh "E_FILE(startrec) = $n"]
    molfile write $fh $eh
    ens delete $eh
}
```

This is a part of a simple write thread which writes back processed ensembles in the same order as they were read from an input file. In case there are multiple processing threads, it is likely to happen that the computation on an ensemble read from a larger input file record finishes before another with a smaller record number and thus the sequence of the ensembles to be written as delivered in the output queue becomes out of sync. By waiting for ensembles in the input record sequence the original order is preserved. More robust versions of such a script should handle the case of ensembles from a specific input record never appearing in the dataset and similar sources of disruption.

## dataset weed

dataset weed dhandle keywords
This command performs standard clean-up operations on all ensembles and reactions in the dataset. The supported operations are described in more detail in the section on the equivalent ens weed command.

The return value of this command is the dataset handle.

```
dataset xlabel
dataset xlabel dhandle propertylist ?filterset? ?filterprocs?
```

This command is rather complex and closely related to the dataset extract command. Its purpose is to extract handle and label information for selected subsets of the dataset. The return value is a nested list. The sublists consist of the object handle, the object label (if the object does not have a label, 1 is substituted), and the dataset object index. The dataset object index starts with zero.

The selection of the class of objects which are extracted is performed indirectly via the property list. For practical purposes, this list should be a single property. Its object association type determines the class of objects selected. For example, A_LABEL or A_SYMBOL returns atom labels, while B_ORDER returns bond labels and E_NAME select complete ensembles (with 1 as pseudo ensemble label).

The returned objects can further be filtered by a standard filter set, and additionally by a list of callback procedures. These TcL script procedures are called with the respective object handles and object labels as arguments. For example, a callback procedure used in an atom retrieval context would be called for each atom with its ensemble handle and the atom label as arguments. If objects without a label are checked, such as complete ensembles, 1 is passed as the label. The callback procedures are expected to return a boolean value. If it is false or 0 , the object is not added to the returned list, and the other check procedures are no longer called.

The command currently only works on ensembles in the dataset, ignoring any reactions, tables, datasets or networks which may be present.

This command is primarily useful for the display of filtered minor object data from datasets, such as atom property values for specific types of atoms.

## Example:

```
set dhandle [dataset create [ens create O] [ens create C=C]]
dataset xlabel $dhandle A_LABEL !hydrogen
dataset xlabel $dhandle B_ORDER doublebond
```

First, a dataset with two ensembles (water and ethene) is created. This dataset is then queried. The first query is for all atoms in it which are not hydrogen. The returned list is

```
{ens0 1 0} {ens1 1 1} {ens1 2 1}
```

In object ens 0 , which is the first object in the dataset, atom 1 passes the filter. In object ens 1 , which is the second object in the dataset, atoms with label 1 and 2 pass. The second query asks for the labels of double bonds in the dataset. The use of property B_ORDER is arbitrary - any other bond property would do as well. The return value of this command is
$\left\{\begin{array}{lll}\{e n s 1 & 1\end{array}\right\}$
which indicates that only the bond with label 1 in object ensl, which is the second object in the dataset, fulfills this condition.

## The ens Command

The ens command is the generic command used to manipulate molecular ensembles. Ensembles are the most commonly used chemistry major object. Ensembles contain atom, bonds, molecules and other minor objects.

The syntax of this command follows the standard schema of command/subcommand/majorhandle. Since molecular ensembles are major objects, they are not addressed via labels.

Similar to the functionality of molfile and dataset objects, ensembles can be persistent, or transient. Persistent ensembles are those created by the ens create command or similar functions. They possess a handle and exist until explicitly deleted. Transient ensembles only exist for the duration of a single command. They are deleted as soon as the command finishes, regardless whether the command was successful or not.

Examples:

```
ens get $ehandle E_SMILES
ens merge [ens create CCC] [ens create CCC]
ens get lycorine E CID
```

This is the list of officially supported subcommands:

## ens add

```
ens add ehandle ?ehandle_list?...
```

This command performs the same operation as the ens merge command, but preserves the ensembles in the merge lists (argument four and onwards). The base ensemble (third argument) is modified.

Please refer to the ens merge command for a more detailed documentation.

## ens align3d

ens align3d ehandle box/center/masscenter/pmi ?usehydrogens?
Perform a 3D alignment by modifying standard atom coordinates property A_XYz.
The possible alignment modes are

- box
move center of enclosing 3 D coordinate box to origin
- center
move average atom coordinates to origin
- masscenter
move mass-weighted atom coordinates to origin
- pmi
align ensemble to principle moments of inertia (largest on X), and move the mass-weighted center to the origin.

By default all atoms are used to compute the alignment rotation and movement vectors, including hydrogens. If these should be omitted from computing the movement vectors (but not the subsequent atom movement), the optional parameter can be set to false.

## ens append

```
ens append ehandle property value ?property value?..
```

Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

```
Example:
ens append $ehandle E_NAME "_linker"
ens assign
ens assign ehandle srcproperty dstproperty
```

Assign property data to another property on the same ensemble. This process is more efficient than going through a pair or ens get/ens set commands, because in most cases no string or Tcl script object representations of the property data need to be created.

Both source and destination properties may be addressed with subfields. A data conversion path must exist between the data types of the involved properties. If any data conversion fails, the command fails. For example, it is possible to assign a string property to a numeric property - but only if all property values can be successfully converted to that numeric type. The reverse example case always succeeds, out-of-memory errors and similar global events excluded.

The original property data remains valid. The command variant ens rename directly exchanges the property name without any data duplication or conversion, if that is possible. In any case, the original property data is no longer present after the execution of this command variant.

## Examples:

```
ens assign $ehandle A_XY A_XY%
ens assign $ehandle E_NMRSPECTRUM(spectrometer) E_METHOD
ens rename $ehandle E_IDENT E_NAME
ens atoms
ens atoms ehandle ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the atoms the ensemble contains as minor objects. This is explained in more detail in the section about object cross-references.

Examples:

```
ens atoms $ehandle
ens atoms $ehandle hydrogen
ens atoms $ehandle !hydrogen count
```

The first example simply returns a list of the labels of the atoms the ensemble contains as minor objects. The second example returns the atom label(s) of all hydrogen atoms in the ensemble. If there are no such atoms, an empty list is returned. The final example counts the number of non-hydrogen atoms in the ensemble.

## ens bonds

ens bonds ehandle ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the bonds the ensemble contains as minor objects. This is explained in more detail in the section about object cross-references.

## Examples:

ens bonds \$ehandle
ens bonds \$ehandle doublebond
ens bonds \$ehandle carbon count
The first example simply returns a list of the labels of the bonds the ensemble contains as minor objects. The second example returns the bonds label(s) of all double bonds in the ensemble. If there are no such bonds, an empty list is returned. The final example counts the number of bonds which involve one or more carbon atoms in the ensemble.
ens cast
ens cast ehandle dataset/ens/reaction/table ?propertylist?
Transform the ensemble into a different object. Depending on the target object class, the result is as follows:

- dataset

A new dataset which contains which contains the ensemble as first and only object.

- ens

Only supplied for the sake of completeness. This mode does nothing.

- reaction

A new reaction, which contains the original and a duplicate of the ensemble as reagent and product components, and an auto-generated 1:1 A_MAPPING property.

- table

A new table with one row and automatically generated columns for all properties of the input ensemble of the ens $\left(\mathrm{E}_{-}^{*}\right)$ object class. The row is filled with the input ensemble data, and the ensemble is moved to the internal dataset of the table.

If the optional property list is specified, an attempt is made to compute the listed properties before the cast operation, so that they may become a part of the new object. No error is raised if a computation fails.

The command returns the handle of the new object, or the input object handle in case of mode ens.

## ens clear

```
ens clear ehandle
```

This command resets an ensemble to a virgin state. All minor objects and all property data of the ensemble are deleted. However, the ensemble handle remains valid, representing an ensemble without any atoms, bonds or other minor objects.
ens copy
ens copy src_ehandle dst_ehandle

Create a copy of the input ensemble in the framework of an existing ensemble. The old data of the destination ensemble is destroyed, but its handle is reused for the copy. The destination handle can be an empty string. In that case, the ensemble is duplicated and a new handle assigned.

This command is useful when references to an ensemble handle are potentially stored in unknown locations and the ensemble data needs to be updated.

The return value of the command is the handle of destination ensemble. It is allowed to copy an ensemble onto itself.

Example:

```
set eh1 [ens create CC]
set eh2 [ens create CCC]
ens copy $eh1 $eh2
```

After the example code sequence, both ensembles represent ethane, the first compound. However, these are independent ensembles. Any further modifications of the ensemble data on any of the ensembles will not be seen by the other.

## ens create

ens create ?codestring? ?mode? ?datasethandle?
This command creates a new molecular ensemble and returns its handle. If none of the optional arguments are specified, or the argument string is an empty string, an empty ensemble without any atoms or bonds is created. These may later be populated with commands like atom create.

If data string may either begin with an automatically recognized prefix, or an automatic format detection process is initiated. Recognized prefixes are:

- cas:

Decode CAS number via commonchemistry.org

- cdx:

Decode base64-encoded ChemDraw CDX data. This is the format sent to Web servers by the ChemDraw browser plug-in.

- chebi:

Decode CHEBI ID

- chembl:

Decode ChEMBL ID

- chemspider:

Decode Chemspider ID

- cid:

Decode PubChem CID

- drugbank:

Decode DrugBank ID

- formula:

Decode as formula, i.e. create elemental atoms, but no bonds

- inchi:

Decode an $\mathbf{I n C r l}_{\mathbf{l}}$ string. Usually this is not a needed prefix since the standard beginning of an INCHI string ( $I n C h I=$ ) is sufficiently unique to prevent misinterpretation. The prefix can be useful in case it is not known whether the InChI string has a proper lead-in. If the $\operatorname{InChI}=$ part has been stripped, the decoder does not automatically recognize the encoding. With the explicit prefix, InChI strings with and without the lead-in are decodable.

- jme:

Decode as data string of JME Java structure editor

- kegg:

Decode KEGG ID

- mcule:

Decode MCULE ID

- mesh:

Decode NCBI Mesh ID

- mfcd:

Decode MDL structure ID. The value following the colon can be either a simple number, or start with the MFCD prefix in upper case.

- name:

Perform name resolution using the NCI resolver, OPSIN, KEGG or ChemSpider, depending on the system configuration. By default, first the NCI resolver and, if that fails, OPSIN are contacted.

- patran:

Decode a Lhasa 1D Patran query pattern. 2D Patran patterns can be decoded with reaction create.

- pdb:

Decode a PDB ID (4 characters, initial number plus 3 alpha characters)

- sid:

Decode PubChem SID

- $\operatorname{sln}$ :

Decode as SLN string

- smarts:

Decode as SMARTS (explicitly not as SMILES)

- smiles:

Decode as SMILES (explicitly not as SMARTS)

- zinc:

Decode ZINC ID

- quoted with ' or "

Handled the same way as the name: prefix. These must be explicit quotes that are part of the string, not string syntax elements of the script. Example: ens create "aspirin" vs. ens create \"aspirin\" or ens create 'aspirin' - the latter two commands work as expected, the first does not, because the quotes are not an actual part of the string, and aspirin can be decoded (in a very lenient fashion) as SMILES, which has precedence.

The colon in the prefix may be omitted (except for the name: item), but this is not recommended, since it may lead to misinterpretation of the data if the prefix is also part of a valid structure encoding.
In addition, URLs as structure data argument are automatically detected and handled specially. If the URL is a data URI, it is unpacked and its payload processed in a second cycle. If it is an HTTP or FTP URL, the file is downloaded and its contents read a a structure file with automatic format detection. This is not identical to data URI processing: Data URIs are again interpreted as command arguments with all prefix and line notation interpretation, while file contents are only interpreted as a record in a structure data file.

If none of the above special cases are recognized, automatic interpretation is performed next. Currently, the encoding then may either be

- a SMILES/SMARTS string (see below on how to distinguish these)
- a hex-encoded smiles/smarts string, as used by some Daylight tools
- an InCHI string, with a proper lead-in (InChI=)
- a Cactvs packed serialized object string, as it is generated by the ens pack command
- a Cactvs Minimol object in binary or base64-encoded form
- a plain text or base64-encoded blob of the contents of a structure file record, such as an MDL SDfile. The format must be identifiable by the currently loaded set of structure file I/O modules. Since the data has no file name, automatic loading of modules is not possible.
- a PubChem CID - any simple integer argument is interpreted as CID
- a CAS number which is looked up on the Internet provided general Internet access is enabled in the toolkit
- an MDL structure ID, starting with a proper lead-in (MFCD), followed by eight digits, which is also resolved by Internet access to the chemsynthesis.com site if possible.
- an InChI key, with or without lead-in (InChIKey=). This only works for keys which can be looked up via the NCI resolver over the Internet.
- a structure file record image as produced by the MYSQL database compress () function (i.e. 4 byte binary uncompressed size prefix plus zlib-compressed content). This is primarily useful when the command is used in the context of the MYsQL database cartridge.
- a compound name as last resort, which is by default looked up via the NCI resolver and the OPSIN service

In the absence of a prefix, the encoding is automatically detected. With the exception of PubChem CIDs, the long form of a database ID must be used, not its simple integer value (i.e. a simple 70 is interpreted as РивСнем CID, while CHEMBL70 or chembl:70 are read as ChEMBL database IDs).

For the base64-encoded compressed records, the compression algorithm may be raw zlib, gzip or zip and its type is automatically detected.

In case one of the smiles-class encoding schemes is used, the mode argument of the ens create command provides finer control of the decoding. By default, or when this argument is an empty string, the string is interpreted as standard smiles, except when there are elements in the string which cannot occur in SMILES but in SMARTS. In SMILES mode, query expressions are only recognized to a very limited degree, and implicit hydrogens are automatically added. This decoding scheme may also be explicitly selected by specifying hadd as mode.

Mode nohadd is essentially the same, but implicit hydrogen addition does not happen. In any case, explicitly encoded hydrogen is decoded and preserved.

Mode smarts (or query) also skips hydrogen addition, but in addition the decoder now fully parses SMARTS, including Recursive SMARTS, but it also becomes less lenient in the area of superatom encodings and similar gray areas, in order to avoid ambiguity. The recognized smiles dialect may be switched via the control variable ::cactvs(smiles_version). The default is Daylight release 4.9 with Cactvs and EliLilly extensions.

Mode $\operatorname{sln}$ forces the interpretation of the input string as Sybyl Line Notation. If the SLN I/O module has already been loaded, interpretation as SLN is automatically attempted in any case, but only after smiles decoding has failed. Since there are strings which are both valid smiles and sln, but mean something different, this automatism can lead to misinterpretation, so if you know you are dealing with SLN, it is a good idea to specify it. The $\operatorname{sln}$ mode attempts to auto-load the sLN I/O module if it is not yet loaded. In case it cannot be loaded, this mode raises an error.

The $3 D$ decoder mode prefers resolution of identifiers as 3D model instead of 2D connectivity. This has an effect only with a few select combination of identifiers and resolvers and should be considered experimental.

In nohadd decoder mode, the structure code is finally, if everything else fails, interpreted as a plain molecular formula. If the string is parsed successfully as a formula, a collection of atoms of the specified elements is created, without any bonds.

By default, or if the final optional parameter is an empty string, the new ensemble is not a member of any dataset. It may be directly made a dataset member if a dataset handle is specified.

## Examples:

```
set eh [ens create]
set eh [ens create CCC]
set sshandle [ens create {[CH3][Cl,Br,I]} smarts]
set eh [ens create [decode -url C%23C] nohadd]
```

In case a structure is encoded as a string in a format which cannot be directly decoded by the ens create command (such as a plain string representation of an MDL molfile), the standard method is to load the appropriate file format decoder (if not built in, this is needed so that automatic format detection of the memory image record works), open the structure string as a memory-based structure file, and read from this file. This technique allows the input of multiple records from the in-memory file and thus is also useful in cases like a multi-record smiles file encoded as a string.

## Example:

```
filex load cdx
set fh [molfile open [decode -base 64 $cdxstring] s]
set eh [molfile read $fh]
molfile close $fh
ens dataset
ens dataset ehandle ?filterlist?
```

Return the dataset handle of the dataset the ensemble is part of. It the ensemble is not member of a dataset, or does not pass all of the optional filters, an empty string is returned.

Example:
ens dataset \$ehandle
ens defined
ens defined ehandle property
This command checks whether a property is defined for the ensemble. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

```
ens dget
```

ens dget ehandle propertylist ?filterset? ?parameterlist?

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ens get command. The difference between ens get and ens dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, ens get and ens dget are equivalent.

## ens delete

```
ens delete all
ens delete ehandlelist ?ehandlelist?...
```

Delete ensembles and the minor objects which are part of the deleted ensembles. The special parameter all may be used to delete all ensembles currently registered in the application, including those which are part of reactions or other major objects. Alternatively, any number of lists of ensemble handles may be specified for specific deletions.

The command returns the number of deleted ensembles.
For historic reasons, the same command may also be invoked as ens destroy.
Example:

```
ens delete $ehandle
ens delete $ehandlelist1 $ehandlelist2
ens dup
ens dup ehandle ?datasethandle? ?position? ?filterset? ?ctonlyflag?
```

Duplicate an ensemble. The return value is the handle of the new ensemble.
The duplicate ensemble is placed into the same dataset as the source, if it is a member of a dataset. Specifying an explicitly empty dataset argument places the duplicate outside any dataset, regardless of the dataset membership of the source ensemble.

If the duplicate is moved to a dataset, it is appended to the dataset end by default. This happens also if the position parameter is explicitly specified as end or an empty string. Otherwise, the ensemble is inserted at the given position, starting with 0 . If the requested position is larger than the current size of the dataset, the ensemble is appended.

The next optional parameter allows the selection of only a subset of atoms to be copied. All atoms which do not pass the filter set are discarded, as are all bonds which connect to discarded atoms. If no atoms pass the filters, the result is an empty ensemble. By default, no atom filtering takes place, and all atoms and bonds of the original ensemble are part of the duplicate.

The final optional parameter can be used to make the duplicate lightweight. If this boolean parameter is set, the duplicate is limited to the basic connectivity information with all atom and bond properties, but it has no copies of properties in other object classes, and no copies of rings, molecules, groups or other minor object classes.

The ens hdup command is a variant of this command. It automatically adds a hydrogen set to the duplicate.

Examples:

```
ens dup sehandle
ens dup sehandle [dataset create] end ringatom
```

The first sample line is a standard use. The second example moves the duplicate into a newly created dataset, and isolates the ring systems. All other atoms are stripped.

## ens exists

ens exists ehandle ?filterlist?
Check whether an ensemble handle exists. The command returns 0 or 1 . Optionally, the ensemble may be filtered by a standard filter list. If filters in the filter list operate on atom, bonds, or other minor objects, it is sufficient if a single minor object of the ensemble passes the filter.

Example:
ens exists \$ehandle chlorine
Check whether the ensemble with the handle in variable \$ehandle exists and, if it exists, whether it contains one or more chlorine atoms.

## ens expand

ens expand ehandle ?allowambigous? ?noimplicith?
This command expands all superatoms in the ensemble. The mechanisms for the expansion of superatoms are described in detail for the atom expand command. This command is functionally equivalent, working on all atoms in the ensemble instead a single atom.

Example:
ens expand \$ehandle

The command returns the total number of successfully expanded atoms.

```
ens expr
ens expr ehandle expression
```

Compute a standard SQL-style property expression for the ensemble. This is explained in detail in the chapter on property expressions.

## ens fill

```
ens fill ehandle property value ?property value?...
```

Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

Example:
ens fill \$ehandle B_COLOR red
sets the color of the first bond in the ensemble to red.
ens filter
ens filter ehandle filterlist
Check whether the ensemble passes a filter list. The return value is 1 for success and 0 for failure.
Example:
ens filter [ens create CCCl] chlorine
checks whether the ensemble contains one or more chlorine atoms. If the filter operates on minor objects of the ensemble, it is sufficient to have a single ensemble minor object pass the filter condition.

## ens forget

ens forget ehandle ?objclass?
Delete specific classes of minor objects and their data from the ensemble data structure. If no object class is specified, all minor object classes except atoms and bonds and the ensemble data are purged.

If the object class ens is specified, all property data attached to the ensemble object class (usually those properties starting with $E_{-} \star$ ) are deleted, but not the ensemble itself.
ens fragment
ens fragment ehandle atomlist ?datasethandle? ?position?
Create a new ensemble from a set of atoms in another ensemble. All bonds existing between those atoms are also preserved. The atoms can be selected with any standard atom selection syntax, with one selector per list element. Duplicate atom specifications are ignored. Atom specifications which cannot be resolved generate an error.

By default, the new ensemble becomes a member of the same dataset (if any) as the source ensemble, but this can be changed with the options firth argument. If no explicit position is given, the ensemble is appended to the dataset. The new ensemble only inherits the selected atoms and bonds plus stable atom and bond properties, but not other minor objects or ensemble data.

The command returns the handle of the new ensemble object.

```
Example:
match ss $substructure $eh amap
set ehfrag [ens fragment $ehandle [unzip $amap 1]]
```

Above code sequence matches a substructure, and then extracts the matched structure part as a new ensemble.
ens get
ens get ehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:

```
ens get $ehandle {M_WEIGHT A_ELEMENT}
```

yields a nested list with two elements. The first element is a list of the molecular weights of all molecules in the ensemble. The second element is a list of the element numbers of all atoms in the ensemble. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

```
ens get $ehandle B_ORDER ringbond
```

gives the bond orders of all bonds of the ensemble which are ring bonds.
The format of the optional parameter list argument is a series of keyword/value pairs, as produced by the TcL command array get or the standard TcL dictionary commands. If a this parameter list is present as argument, and the requested property data is already valid for the ensemble, a check if made if all the specified parameters are the same as the parameters the present property data was computed with. If this is the case, the values are directly returned as usual. Otherwise, the data is discarded and re-computed.

If computation of the property data is performed, either because the parameter set was not matched, or the requested data was not valid, the computation integrates the specified parameter set into the parameters of the computation function. Parameters from the list temporarily override the global settings of these parameters in the property definition. Parameters used by the property computation function but not listed in the local parameter list are neither used for data validity checking, nor their value changed during the computation request. After the computation finishes, the old global parameter settings of the property definition are restored.

The use of a parameter list argument is primarily useful only if a single property is requested with this command, but its use with a multiple-property request is not illegal - the parameter list is simply applied to all properties in sequence.

Example:
ens get \$ehandle E_GIF \{\} [dict create width 200 height 200 bgcolor white]
Variants of the ens get command are ens new, ens dget, ens nget, ens show, ens sqldget, ens sqlget, ens sqlnew and ens sqlshow.

Further examples:
ens get \$ehandle E_NAME

```
ens get $ehandle A_FLAGS (boxed)
```

In addition to property data, the ensemble object possesses a few attributes, which can be retrieved with the ens get command (but not its related sister subcommands like ens dget, ens sqlget, etc.). Some of them are also modifiable via ens set. These attributes are:

- coords

If the toolkit was compiled with factory support, these are the coordinates of the object icon on its workbench, encoded as integer pair. This attribute can be changed.

- deletable

Flag indicating whether this ensemble can be deleted with a standard ens delete command. This attribute is read-only. Ensembles which are, for example, property data values or a part of a molfile loop command cannot be deleted by standard means.

- failures

If the property computation failure cache is active, return a list of all properties which have failed computation for this ensemble after the last structural change. This attribute is read-only.

- footer

If the toolkit was compiled with factory support, this is the footer of the object icon on a workbench. This attribute can be changed.

- gflags

If the toolkit was compiled with factory support, this is the currently set object icon rendering flag collection.

- header
f the toolkit was compiled with factory support, this is the header of the object icon on a workbench. This attribute can be changed.
- hidden

Flag indicating whether the ensemble is hidden. This is not the same as the invisible state.
This attribute is intended to be used for rendering selections. This attribute can be changed.

- incomplete

Boolean status flag indicating an aborted input operation during the read of the structure from file, which returned the structure intact but without the complete set of associated data. An aborted input may be either be the result of an explicitly set input control flag, or by encountering property data which could not be decoded. This attribute is read-only.

- invisible

Flag indicating whether the ensemble is invisible. This is not the same as the hidden state. An invisible object is no longer accessible via its handle. This is usually the case for objects which are scheduled for deletion, but still have lingering referring pointers. This attribute is read-only.

- modcount

Ensemble structure modification count. This attribute is read-only.

- pyobject

If the toolkit was compiled with Python support, this attribute reports the memory address of the Python wrapper class instance, if it exists. This attribute is read-only.

- pyrefcount

If the toolkit was compiled with Python support, this attribute reports the reference count of the Python wrapper class instance, if it exists. This attribute is read-only.

- refcount

If the TcL interpreter is using native Cactvs objects instead of string-based major object handles and integer-based minor object labels to identify toolkit objects, this returns the number of TCL object references active for this ensemble. This attribute is read-only.

- selected

Flag indicating whether the ensemble is selected. This attribute can be changed.

- tooltip

If the toolkit was compiled with factory support, this is the tooltip of the object icon on a workbench. This attribute can be changed.

- uuid

An automatically generated UUID globally identifying the object. This attribute is read-only, different for every ensemble, and not dependent on its contents.

- $x$
f the toolkit was compiled with factory support, this is the x coordinate of the object icon on its workbench. This attribute can be changed.
- $y$

If the toolkit was compiled with factory support, this is the y coordinate of the object icon on its workbench. This attribute can be changed.

```
ens getparam
```

ens getparam ehandle property ?key? ?default?

Retrieve a named computation parameter from valid property data. If the key is not present in the parameter list, an empty string is returned. If the default argument is supplied, that value is returned in case the key is not found.

If the key parameter is omitted, a complete set of the parameters used for computation of the property value is returned in key/value format.

This command does not attempt to compute property data. If the specified property is not present, an error results.

Example:
ens getparam \$ehandle E_GIF format
returns the actual format of the image, which could be gif, png, or various bitmap formats.

```
ens groups
```

ens groups ehandle ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the groups the ensemble contains. This is explained in more detail in the section about object cross-references.

## Example:

```
ens groups $ehandle
ens hadd
ens hadd ehandle ?filterset? ?flags? ?changeset?
```

Add a standard set of hydrogens to the ensemble. If the filterset parameter is specified, only those atoms which pass the filter set are processed.

Additional operation flags may be activated by setting the flags parameter to a list of flag names, or a numerical value representing the bit-ored values of the selected flags. By default, the flag set is empty, corresponding to the use of an empty string or none as parameter value. These flags are currently supported:

- keepflags

For expert use only. Do not discard min/max values and property scope flags for atom properties when hydrogen is added.

- no2dcoords

Do not assign 2D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 2D coordinates. In any case, 2D coordinates are never added when the ensemble does no already possess valid 2D coordinates.

- no3dcoords

Do not assign 3D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 3D coordinates. In any case, 3D coordinates are never added when the ensemble does no already possess valid 3D coordinates.

## - noanions

Do not add hydrogen to atoms with a negative formal charge.

## - noatoms

Do not add hydrogen to atoms without any bonds.

- nocations

Do not add hydrogen to atoms with a positive formal charge.

- noelements

Do not add hydrogen if the ensemble consists purely of isolated metal atoms, which probably represent the material in elementary form, or as an alloy.

- noexcessvalences

Similar to nohighvalences, but hydrogen is not added to any atom which is not in its lowest standard bonded valence state.

- nofixatomtext

Do not adjust property A_TEXTLABEL (if present) by removing references to implicit H from it on atoms where hydrogen is added. For example, by default "NHCOOEt" becomes "NCOOEt" after adding an instantiated hydrogen to the nitrogen atom. This reduces confusion on the hydrogen status when rendering all atoms.

- nohighvalences

Do not add hydrogen to atoms which already exceed their lowest standard valence minus any formal charge. This option only applies to elements which have a defined lowest standard valence (this is configurable via the element table).

- nomemory

Do not remember the added hydrogen atoms as automatically added. Normally, a flag is retained as part of the atom information which distinguishes atoms which were added by automatic processing, such as hydrogen addition, from those which were originally input.

- nometals

Do not attempt to add hydrogen to atoms which are metals (as defined in the system element table).

- nospecial

Do not perform hydrogen addition to atoms which participate in non-standard bonds (all bonds with B_TYPE not normal).

- protonate

Add a single proton to the first suitable atom. The charge of the atom is increased, and only a single hydrogen is added regardless of the standard number of missing hydrogens,. This command does issue the standard property invalidation event for atom and bond changes. In the ensemble command variant, this option is rarely useful. It is supported for compatibility with the atom hadd command.

- resetmemory

Reset the origin flag described above for all atoms in the ensemble. All current atoms act as if they were part of the original atom set.

Adding hydrogens with this command, except wit a set protonate flag, is less destructive to the property data set of the ensemble than adding them with individual atom create/bond create commands, because many properties are designed to be indifferent to explicit hydrogen status changes, but are invalidated if the structure is changed in other ways.

If the effects of the hydrogen addition step to the validity of the property data set should not be handled according to this standard procedure, it is possible to explicitly generate additional property invalidation events by specifying an event list as the optional last parameter, for example a list of atom and bond to trigger both the atom change and bond change events.

The command returns the number of hydrogens which were added.
Example:
set ehandle [ens create \{[c].[C]\}]
ens hadd \$ehandle
adds a total of eight hydrogens to the two carbon atoms, transforming them into methane.

## ens hdup

ens hdup ehandle ?datasethandle? ?position? ?filterset? ?ctonlyflag?
This command is a convenience variant of the ens dup command. It has the same parameters, but also adds a full standard hydrogen set (equivalent to executing an ens hadd \$eh command) to the duplicate.

The command arguments are documented in the paragraph on ens dup.

## ens hfragment

ens hfragment ehandle atomlist ?datasethandle? ?position?
This command has the same arguments as ens fragment. The only difference is that after the duplication all open valences in the fragment are plugged with hydrogen, as if an ens hadd command had been executed immediately after the fragment creation command.

The command returns the handle of the new ensemble object.
ens hstrip
ens hstrip ehandle ?flags? ?changeset?
This command removes hydrogens from the ensemble. By default, all hydrogen atoms in the ensemble are removed.

The flags parameter can be used to make the operation more selective. It may be a list of the following flags:

- deprotonate

If this flag is set, a single proton is removed from the first suitable atom. This command variant does issue a standard atom and bond change property invalidation event, and it always ends processing after removing the first proton. Proton removal decreases the charge of the atom by one. In the ensemble command variant, this flag is rarely useful - it is supported for compatibility with the atom hstrip command

- keepalphawedge

Keep hydrogen atoms which are bonded to an atom which is at the tip of a wedgebond. This flag excludes the case where the bond to the hydrogen atom is the wedge bond - use the keepwedge flag to cover this case.

- keepisotopes

Keep hydrogen atoms which are isotope labels (including enriched/depleted ${ }^{1} \mathrm{H}$ ).

- keeporiginal

Hydrogen atoms which were not automatically added via a hydrogen addition command are retained. Note that these commands can be run in a mode which does not leave information about automatic addition - hydrogens added this way are not retained.

- keepprotons

Keep any molecules which consist only of hydrogen atoms (such as protons, hydride anions, and molecular hydrogen).

- keepspecial

If this flag is set, hydrogens which are usually displayed, such as on aldehydes, wedge bonds, carbon triple bonds or hetero atoms are retained.

- keepwedge

Keep hydrogens which are at the end of a wedge bond, indicating stereochemistry.

- normalize

Normalize the wedge pattern for standard cases, removing excess wedges from hydrogens if the result structure is still stereochemically defined. Hydrogens which lose their wedge in this process are no longer protected by the keepwedge flag.

- wedgetransfer

If a hydrogen atom is removed which is at the end of a wedge, the wedge information is saved by transferring the wedge (changing its up/down status if necessary) to an adjacent, surviving bond. This flag has no effects if the keepspecial or keepwedge flags are set. This flag is set by default.

If the flags parameter is an empty string, or none, it is ignored. The default flag value is wedgetransfer - but this default value is overridden if any flags are set!

If the changeset parameter is specified, the property change events listed in the parameter are triggered after the command.

Hydrogen stripping is not as disruptive to the ensemble data content as normal atom deletion, except when the deprotonate flag is set. The system assumes that this operation is done as part of some file output or visualization preparation. However, if any new data is computed after stripping, the computation functions see the stripped structure, and proceed to work on that reduced structure without knowledge that the structure may contain implicit hydrogens.

The command returns the number of stripped hydrogens.
Example:
ens hstrip \$ehandle [list keeporiginal wedgetransfer]
ens image
ens image ehandle ?width? ?height? ?options?
This command generates a $\mathbf{T \kappa}$ image object displaying the ensemble as an icon. The command is only available in toolkit variants which are linked with the portable Tк GUI toolkit library and which are either statically linked with the GD image drawing library, or can load it dynamically.

The default image size is $64 \times 64$ pixels, but this may be overridden by the width and height parameters. If only width is set, it is also used for the height. The command returns a тк image handle. These images may for example be placed on $\mathrm{TK}_{\mathrm{K}}$ canvases as canvas objects, or used on buttons and other GUI objects.

Because of the small size of the images, atoms are not displayed as symbols, but small color-coded squares. This is a command for the implementation of graphical structure-handling applications with icons. For serious structure visualization, use the E_GIF, E_EMF_IMAGE or E_EPS_IMAGE properties.

Additional options may be added by an arbitrary sequence of option/value pairs. Color names can be those registered in the X11 color database, or a numeric specification in the \#rrggbb format. These options are currently supported:

- -background color

Background color. The default is black.

- -border npixels

Thickness of the image border. The default are 5 pixels.

- -bordercolor color

Border color. The default is blue.

- -cmode none/special/all

Display mode for carbon atoms. The default is special, meaning that only carbon atoms which usually are drawn with a C symbol are displayed as colored rectangle and not just a bond node. Highlighted atoms are always displayed.

- -highlightatom label

Select an atom for highlighting. By default, no atom is highlighted.

- -highlightcolor color

Set the highlighting color. The default is chartreuse.

- -hmode none/special/all

Display mode for hydrogen atoms. The default is special, meaning that only hydrogen atoms which usually are drawn with an H symbol are displayed as colored rectangle. Other hydrogen atoms and the bonds leading to them are suppressed. Highlighted atoms are always displayed.

- -imagename name

Explicitly set a name for the image. By default, a name of the form imagen is automatically generated. It is possible to specify the name of an existing image, which will then be overwritten.

- -linecolor color

Color of bond lines and wedges. The default is white.
Images are cached. If an image for the selected ensemble with the same display attributes exists, it is reused.

Example:
set img [ens image \$ehandle 8080 -border yellow -linecolor blue]
canvas create. canvaswin image 5050 -image \$img
ens index
ens index ehandle
Get the position of the ensemble in the object list of its dataset. If the ensemble is not member of a dataset, -1 is returned.

```
ens list
ens list ?filterlist?
```

This command returns a list of the ensemble handles currently registered in the application. This list may optionally be filtered by a standard filter list. If the filter operates on ensemble minor objects such as atoms or bonds and not directly on the ensemble object, it is sufficient if a single minor object passes the filter.

Example:
ens list halogen
lists the handles of all ensembles in the application which contain one or more halogen atoms.

```
ens lock
```

ens lock ehandle propertylist/objclass/all ?compute?

Lock property data of the ensemble, meaning that it is no longer managed by the standard data consistency manager. The data consistency manager deletes specific property data if anything is done to the ensemble which would invalidate the information. Blocking the consistency manager can be useful when building ensembles from components in a script. Property data remains locked until is it explicitly unlocked.

The property data to lock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the ensembles or ensemble minor objects are locked. If the boolean compute flag is set, an attempt is made to compute the property if it is not yet present. Otherwise, a request to lock non-existent data is silently ignored. It is not possible to lock individual property fields.

- all

All valid ensemble and ensemble sub-object properties are locked. The compute flag is ignored.

- ens,atom,bond,...

These is are object class identifiers. All property data which is controlled by the ensemble major object and attached to the specified object class is locked.

The lock can be released by an ens unlock command.
Example:

```
set eh [ens create CCC]
ens lock $eh A_SYMBOL 1
ens purge $eh A_ELEMENT
atom set $eh 1 A_query(dsearch) 3
ens unlock $eh A_SYMBOL
```

In this example, an ensemble is created, and the atom symbol information is locked. Next, the element number property is deleted, and a query attribute is set. Finally, the lock is released. Had the element symbol information not been locked, the ensemble would have become unusable due to an overzealous data consistency manager. Setting query information in property A_QUERY can have an influence on the atom symbol. So the default action of invalidating A_SYMBOL when manipulating A_QUERY is correct. However, in case there is no element information A_ELEMENT, and no atom symbol information A_SYMBOL, the element information is completely lost, and the ensemble becomes unusable. So in this case, locking A_SYMBOL (or alternatively A_ELEMENT) is required to avoid unexpected side effects of structure editing.

```
ens loop
```

ens look ehandle objvariable ?maxmol? ?offset? body

Loop over all molecules in the ensemble, by providing a temporary ensemble duplicate of each found molecule. The handle of the duplication is stored in the object variable and visible to the loop code.

The loop code cannot delete the duplicate ensemble. It is automatically deleted at the end of each cycle. Changes made to the duplicate molecule are not seen in the base ensemble. It is however possible to explicitly assign data computed on the duplicate ensemble to the base ensemble.

The optional parameters allow more control over which molecules are processed. By default the maxmol parameter is -1 , meaning an unlimited number of fragments are processed, and the offset is zero, meaning that processing begins with the first molecule in the molecule list of the base ensemble.

Within the loop code, the standard TcL commands break and continue work as expected.
The command returns the number of molecule fragments processed.

## Example:

```
set midx 0
ens loop $ehandle ehdup {
    mol set $ehandle [mol mol $ehandle #$midx] M_MYPROP [ens get $ehdup E_MYPROP]]
    incr midx
}
```

The example loop assigns a custom property where the compute function is only defined for a single-fragment ensemble to the equivalent molecule property in a multi-fragment base ensemble.

## ens mask

ens mask ehandle labellist/all property onvalue ?resetvalue?
This command sets property values of a subset of minor objects of one class in the ensemble to a specific value, and optionally resets the values of the same property for all other minor objects of the ensemble which are not named.

The first argument after the ensemble handle is either a list of object identifiers, or the magic value all. Object identifiers are usually the standard numerical labels, but any construct which identifies an atom, a bond, etc. can be used. The next argument identifies the property. The object identifiers in the previous argument must correspond to the object class of the property, i.e. atom label pairs can only be used it the property is a bond property, but simple numerical labels work for all classes. If data for that property is not present on the ensemble, it is instantiated with the default value. The final one or two arguments must be decodable data values for that property.

If the all object subset identifier is used, all values of the property in the ensemble are set to the onvalue. Any reset value specification is ignored.

Otherwise, the explicit label list is processed. If a reset value is given, all values of the property in the ensemble are first reset to that value. If no reset value was specified is, no reset is performed and the current values remain valid. Then, all minor objects in the list are looked up, and their property value set to the onvalue.

Example:
ens mask \$eh [ens atoms \$eh carbon] A_COLOR green black
This command sets the A_COLOR property value for all carbon atoms in the ensemble to green, and all other atoms to black. This is shorter and more efficient then explicitly coding a loop of atom set statements.

## ens match

ens match ehandle ss_ehandle ?matchflags? ?ignoreflags? ?atommapvar? ?bondmapvar? ?molmapvar?

Check whether the ensemble matches a substructure. The substructure may be any structure ensemble, and even be in the same ensemble as the primary command ensemble.

The precise operation of the substructure match routine can be tuned by providing a standard set of match flags and feature ignore flags. The default match flag set has set bits for the bondorder, atomtree and bondtree comparison features, and an empty ignore set. If a flag set is specified as an empty string, the default set is used. In order to reset a flag set, an explicit none value must be used. The bit options of the match flag are explained in the documentation of the match ss command.

The command returns 1 for a successful match, 0 otherwise. If an optional atom, bond, or molecule map variable is specified, it is set to a nested list of matching substructure/structure atom, bond or molecule labels. If no match can be found, the variable is set to an empty list. In case only a bond or molecule map variable is needed, an empty string can be used to skip the unused map variable argument positions.

This is a very simple variant of substructure matching. The match ss command provides many more advanced match determination and match processing options.

## ens max

ens max ehandle propertylist ?filterset?
Get the maximum values of the properties named in the propertylist parameter. The return value of the command is a list of the maximum property values. The objects whose property values are used for the determination of the maximum values may optionally be filtered by a standard filter set. If no objects pass the filter, the result is an empty string.

Example:
ens max \$ehandle A_ELEMENT
computes the maximum element number in the ensemble.

## ens merge

ens merge ehandle ?ehandle_list?...
Merge a set of ensembles into one ensemble. All structure information is accumulated in the first (base) ensemble. Its handle remains unchanged. All other ensembles are destroyed. It is not possible to name an ensemble more than once in the argument lists, and ensembles cannot be merged with themselves.

The merged ensemble has a consistent property set for all minor objects. If the information content of the input ensembles varies, an attempt is made to compute the missing information for ensembles which do not have valid data for each individual property. If the computation fails, the property data is discarded for all merged objects. In addition, a merge property invalidation event is issued, which may lead to additional loss of property data. For surviving properties which have defined a merge update function, this function is then called and may perform additional data adjustments. For example, the $A_{-}$XY 2D plot coordinate property merge function transforms the structure plot coordinates in the new ensemble to a uniform scale and arrange the coordinates for the atoms from the merged ensembles as a sequence of plots from left to right.

The return value of this command is the new first atom label for every merged ensemble, excluding the base ensemble. All minor object labels in the merged ensembles are re-assigned to avoid collisions. The new labels begin with the highest respective minor object label in use in the base ensemble plus one, and are thereafter assigned in sequence.

The ens add command performs the same operation as the ens merge command, but merges duplicates of the input ensembles, thus preserving them.
Example:
ens merge [ens create CC] [list [ens create CCC.CCCC] [ens create C]]

Merge three ensembles into one. The new ensemble contains the molecules ethane, propane, butane and methane in that order.

## ens metadata

ens metadata ehandle property field ?value?
Obtain property metadata information, or set it. The handling of property metadata is explained in more detail in its own introductory section. The related commands ens setparam and ens getparam can be used for convenient manipulation of specific keys in the computation parameter field. Metadata can only be read from or set on valid property data.

## Examples:

array set gifparams [ens metadata \$ehandle E_GIF parameters]
ens metadata \$ehandle E_NAME comment "This is a CAS name in 1995 revision. The IUPAC
name, or any previous $\overline{o r}$ later CAS revision name, look completely different."
The first line retrieves the computation parameters of the property E_GIF as keyword/value pairs. These are read into the array variable gifparams, and may subsequently be accessed as \$gifparams (format), \$gifparams (height), etc. The second example shows how to attach a comment to a property value.

## ens min

ens min ehandle propertylist ?filterset?
Get the minimum values of the properties named in the propertylist parameter. The return value of the command is a list of the minimum property values. The objects whose property values are used for the determination of the minimum values may optionally be filtered by a standard filter set. If no objects pass the filter, the result is an empty string.

Example:
ens min \$ehandle A_FORMAL_CHARGE xatom
gets the lowest value of the formal charge of a hetero atom in the ensemble.

## ens mols

ens mols ehandle ?filterset? ?filtermode?
Standard cross-referencing command to obtain the label(s) of the molecule the ensemble contains as minor objects. This is explained in more detail in the section about object cross-references.

Examples:
ens mols \$ehandle
ens mols \$ehandle heterocycle
The first example simply returns a list of the labels of the molecules the ensemble contains as minor objects. Note that it is possible that there is more than one molecule in the ensemble - this is the reason why the command name is mols, not mol . The second example returns the molecule label(s) of all the molecules in the ensemble which contain one or more heterocycles. If there are no such molecules, an empty list is returned.

## ens move

ens move ehandle ?datasethandle|remotehandle? ?position?

Make the ensemble a member of a dataset, or remove it from a dataset. If the dataset handle parameter is omitted, or is an empty string, the ensemble is removed from its current dataset. If it was not a dataset member, this command does nothing. The dataset handle may be the name of a remote dataset for moving ensembles over a network connection.

If a dataset handle is specified, the ensemble is added to the dataset, and removed from any dataset it was member of before the execution of the command. By default the ensemble is added to the end of the dataset object list, but the final optional parameter allows the specification of an object list index. The first position is index zero. If the parameter value end is used, or the index is bigger than the current number of dataset objects minus one, the ensemble is appended as by the default. It is legal to use this command for moving ensembles within the same dataset.

Another special position value is random. This value moves to the ensemble to a random position in the dataset. Using this mode with remote datasets is currently not supported.

The dataset handle cannot be a transient dataset.
The return value of the command is the dataset membership of the ensemble prior to the move. It is either a dataset handle, or an empty string if it was not member of a dataset.

Examples:
ens move \$ehandle \$dhandle 0
ens move \$ehandle
In the first example, the ensemble is inserted as the first element in a dataset. The second line reverts this operation and removes the ensemble from the dataset.

This command interacts with the insert control mechanism of size-constrained datasets. More information is provided in the description of the sizecontrol dataset parameter.

This command can be used with a remote dataset descriptor. In that case, the ensemble is packed into a serialized object representation, transmitted over the network and restored as member of the remote dataset at the specified position. The local ensemble is deleted if the transfer succeeds.

Example:
ens move \$ehandle blockbuster@server2:9998 end
This command moves the ensemble to the dataset which was set up as listener on port 9998 and pass phrase blockbuster on host server2. The local ensemble is deleted, and its copy is inserted at the end of the remote dataset.

## ens mutex

ens mutex ehandle mode
Manipulate the object mutex. During the execution of a script command, the mutex of the major object(s) associated with the command are automatically locked and unlocked, so that the operation of the command is thread-safe. This applies to builds that support multi-threading, either by allowing multiple parallel script interpreters in separate threads or by supporting helper threads for the acceleration of command execution or background information processing. This command locks major objects for a period of time that exceeds a single command. A lock on the object can only be released from the same interpreter thread that set the lock. Any other threaded interpreters, or auxiliary threads, block until a mutex release command has been executed when accessing a locked command object. This command supports the following modes:

- lock

Increase the recursive mutex lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock.

- reset

Release all persistent locks on the object, if they exist.

- test

Return the current persistent lock count on the object. This excludes the transient per-command lock.

- unlock

Decrease the recursive lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock. Unlocking an object which has not been persistently locked results in an error.

There is no trylock command variant because the command already needs to be able to acquire a transient object mutex lock for its execution.

## ens need

ens need ehandle propertylist ?mode?
Standard command for the computation of property data, without immediate retrieval of results. This command is explained in more detail in the section about retrieving property data.

The return value is the ensemble handle.
Examples:
ens need \$ehandle A_XY recalc
ens need \$ehandle E_EINECS_ID threaded
ens new
ens new ehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ens get command. The difference between ens get and ens new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## ens nget

ens nget ehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ens get command. The difference between ens get and ens nget is that the latter returns numeric data, even if symbolic names for the values are available.

```
ens nitrostyle
ens nitrostyle ehandle style
```

Change the internal encoding of nitro groups and similar functional groups in the ensemble. Possible values for the style parameter are:

- asis No change
- ionic Change to encoding to a positive charge on the center atom, and a negative on one of the oxygens
- xionic As above, but also change the encoding of azides, etc.
- neutral Change the encoding to the neutral form with extended valence. pentavalent is an alias.
- xneutral As above, but also change the encoding of azides, etc.

The command returns the ensemble handle.

## ens op2d

ens op2d ehandle mode ?atomfilter_bit/degrees?
Perform various operations on the standard 2D layout coordinates of the structure (property A_XY). Properties tightly connected to A_XY are also updated (most notably, B_FLAGS to keep wedges in sync with stereochemistry defined in other properties).

In mode rotate, the optional argument is the rotation angle in degrees. If it is not specified, the default are 30 degrees.

For alignment and flipping operations, the atoms which are used to determine the orientation can be filtered by specifying one or more value bits of property A_FLAGS. Only atoms where one or more of these bits are set in A_FLAGS are used for computing the alignment (in modes xalign, yalign, xyalign - all atoms are moved) or are flipped (modes hflip, vflip - unselected atoms are not moved). If no but filter values are specified, or none is used, all ensemble atoms and bonds are processed.

The following modes are supported:

- rotate

Rotate the 2D structure coordinates counterclockwise.

- hflip

Perform a horizontal flip around the X axis, while maintaining stereochemistry.

- vflip

Perform a vertical flip around the Y axis, while maintaining stereochemistry.

- xalign

The largest eigenvector of the unweighted XY coordinates of the selected atoms is aligned with the X axis.

- xyalign

The largest eigenvector of the unweighted XY coordinates of the selected atoms is aligned with the XY diagonal.

- yalign

The largest eigenvector of the unweighted XY coordinates of the selected atoms is aligned with the Y axis.

Additionally, the mode argument may an ensemble handle. In that case, it is interpreted as a substructure, matched onto the ensemble, and if a match is found, the 2 D coordinates of the ensemble atoms are adjusted by scaling and rotation for maximum overlap between the 2 D coordinates of the substructure and the matched part of the ensemble. This mode retains the relative positions of the matched atoms - this is not a full redraw operation around a match template.

## ens pack

ens pack ehandle ?maxsize? ?request_propertylist? ?suppress_propertylist?
Pack the ensemble object into a base64-encoded compressed serialized object string. This string does not contain any non-printable characters and is a full dump of the internal state of the object, omitting only property data that was declared to be so easily re-computed that a dump is not worthwhile. Outside object relationship information, such as the dataset the reaction might be a member of, or associated tables are not included.

The maximum size of the object string (default -1 , meaning unlimited) can be configured by the optional maxsize parameter. The size is specified in bytes. If the pack string would be longer than the maximum size, an error results.

The other two optional parameters allow to request a specific property set to be part of the package, even if it normally would not be included, and to explicitly omit properties from the dump. No property computation is performed, and suppressed properties are not purged from the ensemble.

Ensembles can be restored from a packed object string by the ens unpack and ens create commands.

The ensemble object and its minor objects are unchanged after using this command.
Example:
set dbstring [ens pack [ens create $C C=0]$ ]
ens pis
ens pis ehandle ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\pi$ systems the ensemble contains. This is explained in more detail in the section about object cross-references.

Examples:
ens pis \$ehandle
$\pi$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use p or d orbitals, such as in standard covalent multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## ens prepare

ens prepare ehandle molfilehandle
Prepare the ensemble for output via the specified file handle, for example by pre-computing properties that are needed for output. This has only an effect if the I/O module for the format of the file handle provides an output object preparation function, which is currently only the case for the BDB database format. The output of prepared and unprepared ensembles sent to the same file handle is indistinguishable.

The purpose of this command is to allow the preparation of the ensembles for output in a separate thread. For unprepared ensembles, a significant part of the time to write the record may be spent in computing required data. During this time, the file handle is blocked. Prepared ensembles already contain all required data, and are thus faster to write to file. The total time required in single-thread scripts for a simple molfile write command vs. a ens prepare plus molfile write combo is not much different. However, these operations are largely independent, and on multi-threaded scripts the total time savings can be significant if the two commands are executed in different threads.

## ens properties

ens properties ehandle ?pattern? ?noempty?
Get a list of valid properties of the ensemble and its minor objects. Property subsets may be selected by a non-empty filter pattern, which the property names must match in order to be listed. If the ensemble is a member of a reaction, reaction properties are included in the list. The same mechanism is used for dataset properties.

If the noempty flag is set, only properties where at least one data element controlled by the ensemble (i.e. a value for an atom of the ensemble, etc.) is not the property default value are output. By default, the filter pattern is an empty string, and the noempty flag is not set.

This command may also be invoked as ens props.
Example:
ens properties \$ehandle X_*
ens props \$ehandle
The first example returns a list of the currently valid reaction properties of the reaction the ensemble is a member of, or an empty list if it is not. The second example lists all properties, including those of the ensemble proper, its minor objects such as atoms and bonds, and possibly of the reaction the ensemble is a member of, if it is an reaction ensemble.

## ens purge

ens purge ehandle propertylist/objectclass/specialname ?emptyonly?
Delete property data from the ensemble. The properties may either be properties of a reaction the ensemble is a member of (prefix $x_{-}$), properties of a dataset the ensemble is a member of (prefix $D_{-}$), or properties of the ensemble proper and its minor objects, such as ensemble or atom properties. If a property marked for deletion is not present, it is silently ignored.

If an object class name, such as ens or atom, is used instead of a property name, all properties of that class set on the ensemble are deleted, if they are not locked, or filtered out by the optional empty-only flag.

Setting the optional boolean flag emptyonly allows restricts the deletion to those properties where all the values for a property associated with a major object (such as on all atoms in an ensemble for atom properties, or just the single ensemble property value for ensemble properties) are set to the default property value.

Besides normal property names, a few convenient special names for common property deletion tasks are defined and can be used as a replacement for the property list. These include:

- atomstereochemistry

Delete all atomic atom stereo descriptors, but keep those for bonds.

- bondstereochemistry

Delete all bond stereo descriptors, but keep those for atoms.

- isotopes

Delete isotope information in A_ISOTOPE and other isotope properties which may be defined in future software versions.

- radicals

Delete atomic radical information in A_RADICAL and other radical-related properties which may be defined in future software versions.

- stereochemistry

Delete all stereochemistry descriptors, including 2D wedges, but not 3D coordinates. The implicit property list includes A_LABEL _STEREO, B_LABEL_STEREO, A_CIP_STEREO, B_CIP_STEREO, A_DL_STEREO, B_CISTRANS_STEREO, A_HASH_STEREO, B_HASH_STEREO, A_MAP_STEREO, B_MAP_STEREO, A_STEREOINFO, B_STEREOINFO, A_STEREO_GROUP, M_STEREO_COUNT, E_STEREO_COUNT and B_FLAGS (only selected bits, the property remains valid if present).

- wedges

Delete wedge bond flags in property B_FLAGS. If B_FLAGS is not present, the command is ignored and no computation attempt is made.

Examples:

```
ens purge $ehandle X_IDENT
ens purge $ehandle E_IDENT 1
ens purge $ehandle stereochemistry
```

The first example deletes the property data X_IDENT from the reaction the ensemble is a member of - provided it actually is a reaction ensemble. The second example deletes property E_IDENT from the ensemble if the property value is equal to the default value for $\mathrm{E}_{\text {_ }}$ IDENT. The last example removes all stereochemistry information from the ensemble.

## ens reaction

ens reaction ehandle ?filterlist?
Return the handle of the reaction the ensemble is a member of. Optionally, the reaction may be filtered by a simple filter list. If the ensemble is not part of a reaction, or does not pass the filter, an empty string is returned.

Because an ensemble can only participate in a single reaction, the command is spelled ens reaction in singular.

Example:
ens reaction \$ehandle
ens rebuild
ens rebuild ehandle ?minor_obj_class?

This command discards all minor objects and attached property data of a specific class associated with the ensemble. Afterwards, the minor object set is re-populated by the standard set-up function of the object class, if such a set-up function is defined.

If no minor object class is specified, bonds are regenerated - for example from 3D atomic coordinates. Bonds, molecules (mols), sigma and pi systems (sigmas, pis), rings and ring systems (rings, ringsystems) can all be rebuilt. However, by default no reconstruction function is defined for groups and surface patches (surfaces), although it is possible to set one via the object class manipulation command.

Generally, object sets should only be regenerated under exceptional circumstances, for example in order to undo a manual manipulation. Object sets are automatically generated when they are required - for example, bonds are automatically derived from atomic 3D coordinates if any property data associated with bonds is used in any context, and the ensemble so far did not contain bond information. An explicit request to generate connectivity is rarely needed.

Under normal circumstances, the use of minor object information such as bonds encoded explicitly in an input file is preferable to indirectly derived sets, such as regenerated connectivity. The connectivity algorithm of the toolkit is rather capable, but has its limitations, especially when hydrogen-depleted charged structures are encountered.

Files encoded in a few notorious structure file formats, such as PDB, may contain an incomplete bond set - without any indication that the bond set is incomplete. The PDB input routine tries to detect this, and automatically augments the bond set if obvious deficiencies are found. However, in case of minor omissions in the input data, a PDB structure may be one of the rare cases when an explicit request for a rebuild of the bond set can be helpful.

Besides the set of ensemble minor objects, the pseudo object class aro is also recognized. This keyword triggers a re-evaluation of aromatic systems and re-assign Kekulé bond orders, but not completely redo the bond set.

Example:
ens rebuild \$ehandle bonds
This command discards the old bond set, and generate a new one. This only works if there is information which can be used for regeneration, such as atomic 3D coordinates. If no such information is present, the loss of bonds is irreversible and the ensemble useless for almost all applications short of a simulated plasma torch atomization.

## ens rename

ens rename ehandle srcproperty dstproperty
This is a variant of the ens assign command. Please refer the command description in that paragraph.
ens replace
ens replace ehandle property ?preserved_properties/all?
Substitute the ensemble with data from an ensemble property of that ensemble. The original handle is preserved. The original structure data, with the exception of explicitly saved properties, is discarded.

The exact type of operation depends on the data type of the property. The following data types are currently supported:

- structure

Replace command ensemble directly with the property data.

- string

Try to interpret the string as a structure line notation (as in ens create).

- url

Try to download the file behind the Internet address and read it as a structure file.

- blob

Try to read the contents as an in-memory structure file record.

- diskfile, mapfile

Try to read it as a single-record structure file.
Any other property data type, NULL values of the property, non-ensemble properties, or malformed data result in an error and the original structure remains unchanged.

The structure source property is not a property of the replaced ensemble. In that ensemble, by default all other ensemble properties of the original are also purged, and all ensemble properties of the replacement structure are retained. However, by specifying a list of properties to be transferred, or using the special argument all, all or a subset of the ensemble property data of the original ensemble can be transferred to the replacement structure and thus saved. Under these circumstances, property data from the original ensemble has precedence and overwrites existing values of the same property on the replacement ensemble. However, all ensemble properties on the replacement ensemble which are not overwritten remain present in the result ensemble. It is not possible to transfer atom, bond, or any other ensemble minor object property data to the replacement structure directly with this command.

The command returns the original, unchanged ensemble handle.
Example:
ens replace \$eh [ens get \$eh E_CANONIC_TAUTOMER] [list E_IDENT E_NAME]
This command replaces the current structure with the canonic tautomer. The values of properties E_IDENT and E_NAME are transferred from the original form to the new form.

## ens replicate

ens replicate ehandle ?count?
This command duplicates all molecules in the ensemble and appends them to the atom, bond and other minor object lists of the ensemble.

The default replication count is one, but any other number of duplications may be chosen by an appropriate count parameter. If the count is less than one, the command is silently ignored.

The command returns the original ensemble handle. As part of the integration step, merge property invalidation events are generated.

The ens dup command generates a new ensemble, while this command expands the current ensemble.

Example:

```
echo [ens get [ens replicate [ens create C.CC]] E_SMILES]
```

This prints C.CC.C.CC as result SMILES string, because both molecules in the original ensemble were duplicated and appended to the existing ensemble data.

```
ens rings
ens rings ehandle ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the rings the ensemble contains. This is explained in more detail in the section about object cross-references.

## Examples:

```
ens rings $ehandle
ens rings $ehandle [list heterocycle aroring]
```

The first example returns the labels of all rings the ensemble contains. If the ensemble does not contain any rings, an empty list is returned. Only labels of rings in the SSSR or ESSSR set are returned, even if the currently configured ring set is larger. The second example filters the rings only heteroaromatic rings are reported.

## ens ringsystems

```
ens ringsystems ehandle ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the ring systems the ensemble contains. This is explained in more detail in the section about object cross-references.

Examples:

```
ens ringsystems $ehandle
ens ringsystems $ehandle [list heterocycle aroring]
```

The first example returns the labels of all ring systems the ensemble contains. If the ensemble does not contain any ring systems, an empty list is returned. The second example filters the ring systems - a ring system label is included in the output list only if that ring system contains one or more hetero aromats.
ens rotate
ens rotate ehandle angle axis ?center?
Rotate the ensemble in 3D space by manipulating property $\mathrm{A}_{-} \mathrm{XYZ}$.
The angle argument is a floating-point number in degrees. The axis argument is a 3D vector in standard notation, i.e. usually a list of three floating point numbers for the $x, y$ and $z$ components. If the last optional argument is omitted, the center of rotation is the 3D unweighted coordinate average of all ensemble atoms with valid 3D coordinates, which is computed as property e_center. If the center argument is specified, it is expected to be a 3D point which is used as center of rotation instead.

This operation triggers a $3 d g l o p$ property invalidation event.
Example:
ens rotate \$eh $60\left\{\begin{array}{lll}0 & 0 & 1\end{array}\right\}$

Rotate the ensemble 60 degrees counterclockwise around the $z$ axis.

```
ens scan
ens scan ehandle expression ?mode? ?parameters?
```

Perform a query on the ensemble object. The syntax of the query expression and the optional selection list is the same as that of the dataset scan command with a transient dataset consisting of the current ensemble only. For more details, please refer to the paragraphs on dataset scan and molfile scan.

The return value depends on the mode. The default query mode, this is different from the default in dataset scan, is exists.

## ens set

ens set ehandle property value ?property value?..
Standard data manipulation command for setting property data. It is explained in more detail in the section about setting property data.

Example:
ens set \$ehandle E_NAME "Pharmacon X-25"
ens setparam
ens setparam ehandle property key value ?key value?...
Set or update a property computation parameter in the metadata parameter list of a valid property. This command is described in the section about retrieving property data. The current settings of the computation parameters in the property definition are not changed.

Example:

```
ens setparam $ehandle E_GIF comment "Top Secret Lead Structure"
ens setup
ens setup ehandle ?minorobjclass?
```

Query the status of the minor object lists in the ensemble, or initialize one of these to an empty list.
If no class is specified, a dictionary with all currently registered minor object classes of the ensemble is returned. The object class names are the key, the value is a boolean flag for the status.

If an object class argument is supplied, the object class is instantiated on the ensemble, if necessary by auto-loading an object class handler module. Unknown object class names result in an error. If the minor object class is already instantiated, it is not changed. Otherwise, an empty minor object set is added. This is even the case if the minor object class handler provides a default object setup function (see ens rebuild command). Instantiating an object class with this command always creates an empty collection of the minor objects associated with the ensemble.

Minor object lists are usually implicitly instantiated, as in

```
ens get $eh M_LABEL
```

which automatically sets up the molecule/fragment object set if it is not yet present, and populates it with objects identifying disconnected fragments in the ensemble, or

```
group create $eh [list $a1 $a2 $a3]
```

which adds a group to the ensemble, again automatically initializing the group object set if it was not initialized.

The ens setup command is intended for special circumstances and not commonly used.

## ens show

ens show ehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ens get command. The difference between ens get and ens show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, ens get and ens show are equivalent.
ens sigmas
ens sigmas ehandle ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\sigma$ systems the ensemble contains. This is explained in more detail in the section about object cross-references.

Examples:
ens sigmas \$ehandle
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.
ens sort
ens sort ehandle ?sort_property? ?relabel? ?duplicate? ?datasethandle? ?position?
Sort the atoms in an ensemble according to a property value. The default property is A_LABEL, the standard atom label. The first optional argument can be used to sort on a different property, or a property field. However, the property must be either an atom property, or a molecule property. If the relabel flag is set, the ensemble atoms and molecules are renumbered after the sort in ascending order, starting with one. By default, atoms and molecules retain their original labels even if they change positions. If the duplicate flag is set, the sort operation works on a duplicate of the original ensemble. If the flag is unset, or the argument omitted, the operation modifies the original ensemble object.

The final two optional arguments allow the direct transfer of the modified ensemble or duplicate into a dataset, similar to an ens move command. The ensemble may be inserted into a specific position of a target dataset. If the special value end is used, or the zero-based position index is beyond the current end of the target dataset, the ensemble is simply appended. By default the ensemble is not moved, and if it is moved without an explicit position, it is appended.

The sequence of the atoms in the ensemble is rearranged so that the atoms are in ascending order of the values of the sort property or property field. Indirectly, molecules are also rearranged to correspond to the sequence of the first atoms in every molecule. This operation triggers a shuffle property invalidation event. If the renumbering option is selected, the atom and molecule sets are re-labeled with their standard label properties (i.e. A_LABEL for atoms, M_LABEL for molecules) in
ascending order, starting with one. Other minor object collections remain in their original sequence and retain their current labels. Certain important properties which, if present, are dependent on atom label values, notably A_LABEL_STEREO, B_LABEL_STEREO and B_FLAGS, are specifically adjusted to the new labeling scheme instead of being invalidated.

The command returns an ensemble handle. If the operation was operating on a duplicate, it is the handle of the new ensemble, otherwise that of the original ensemble.

```
ens split
```

ens split ehandle ?dropsize? ?splitproperty?
Split the molecules of the ensemble into individual ensembles. The return value is a list of the handles of the new ensembles. The input ensemble is modified, and its old handle may be returned as one of the new single-molecule ensemble handles. If the input ensemble contains only a single molecule, and that molecule passes the optional size filter, the command is a no-op. If the input ensemble is a member of a reaction, the result ensembles become part of that reaction in the same role.

The optional dropsize parameter is a minimum value for the number of atoms in the molecules. If this is not an empty string, molecules which have less atoms than the minimum are deleted. If all molecules in the input ensemble are smaller than the required size, an empty list is returned and the input ensemble is destroyed.

The optional splitproperty argument can be used to spit the ensemble on values of a molecule property, which needs to be either already set or computable, instead of simply separating fragments on connectivity. All molecules in the input ensemble which have a common value of this property are put into a joint result ensemble, and each distinct split property value starts a new result ensemble. Molecules with a common property value do not need to be present in the input ensemble in a consecutive sequence, nor are there any special requirements for the data type or value range of the split property, as long as the data type has a comparison function. If the values of the split property are distinct over all molecules in the input ensemble, the outcome of command is indistinguishable from running it without any split property.

Example:
lassign [ens split [ens create "CC.CC"]] eh1 eh2
This example creates an ensemble with two ethane molecules, splits it, and assigns the two new ensemble handles to variables ehl and eh2.

```
set elist [ens split $eh {} M REACTION LABEL]
```

Split ensemble along the original reagent or product data blocks found in an RXN or RDF file.

## ens sqldget

ens sqldget ehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ens get command. The differences between ens get and ens sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.
ens sqlget
ens sqlget ehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ens get command. The difference between ens get and ens sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## ens sqlnew

ens sqlnew ehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ens get command. The differences between ens get and ens sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## ens sqlshow

ens sqlshow ehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ens get command. The differences between ens get and ens sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## ens subcommands

ens subcommands
Lists all subcommands of the ens command. Note that this command does not require an ensemble handle.

## ens surfaces

ens surfaces ehandle ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of surface patches the ensemble contains. This is explained in more detail in the section about object cross-references.

Example:
ens surfaces \$ehandle carbon
This example lists all surface patches which are associated with carbon atoms. Surface patches associated with other atoms, or with no atoms, are not listed.
ens swapin
ens swapin ehandle

Swap an ensemble from the disk store fully back into memory, and disable further automatic loading and shelving. If the ensemble was not swapped out, the command does nothing.
The command returns the ensemble handle.

## ens swapout

ens swapout ehandle
Remove most of the ensemble data from memory and store it in a temporary disk store. The ensemble handle remains valid. As soon as it is used in a command again after this command has been executed, the swapped ensemble data is automatically reloaded from file, and then stored again when the object lock is released. To disable the automatic swapping of an ensemble, use the ens swapin command.

This command is intended to be used in cases where a large number of ensembles must be kept in memory. Its routine use is not encouraged - it is only useful in case the programmer knows about access patterns. In other cases, the standard virtual memory mechanism of the operating system might yield better performance results.

The ensembles are stored as binary blobs in a key/value store in a process-specific swap directory cactvs $\% d$, ( $\% d$ is replaced by the process ID) which is created automatically in the standard temporary directory. When an ensemble is deleted, its swap record is also removed, if one was created during the lifetime of the ensemble. When a Cactvs application program exits, the swap store as well as the swap directory are automatically deleted, even without explicit deletion of the last set of ensembles in memory. In case of program crashes, the swap directory and its contents may however survive. If ensemble swapping is used with unstable applications, the temporary directory should be checked from time to time.

The command returns the ensemble handle.
Example:
ens swapout \$ehandle
ens tables
ens tables ehandle ?filterlist?
Return a list of the handles of all table objects the ensemble is associated with. Optionally, the table set may be filtered by a simple filter list. If the ensemble is not related to any table, or none of these tables passes the filter list, an empty string is returned.

This command is only available if the toolkit was compiled with table support.
Example:
ens tables \$ehandle
ens taint
ens taint ehandle propertylist/changeset ?purge?
Issue a property data tainting event which acts on the ensemble data.
If the ensemble is a member of a dataset, the dataset and its objects are not tainted.
The event list may contain any number of the following items:

- A property name.

In that case, all properties which depend on the specified one are invalidated. If the optional purge parameter flag is also set, the specified property itself is also deleted. By default the self-deletion flag is not set.

- An object class

All properties which a sensitive to changes in the object class collection associated with the target ensemble are deleted. Example:

```
ens taint $eh atom
```

This deletes all properties which are sensitive to changes in the atom make-up of the ensemble.

- 2dop

All properties which are dependent on 2D layout coordinates are invalidated.

- 3drelative

All properties which are dependent on relative inter-atomic 3D atomic coordinate changes are invalidated.

- 3dabsolute

All properties which are dependent on absolute 3D atomic coordinate changes are invalidated.

- dup

All properties which do not survive duplication of the underlying object are invalidated.

- hadd

All properties which are sensitive to hydrogen addition or deletion via dedicated hydrogen processing commands, which do not trigger the default atom and bond change events associated with atom addition or deletion and bond changes, are purged.

- merge

All properties which are invalidated by merging ensembles are invalidated.

- shuffle

All properties which are dependent on the order of minor objects in the ensemble are purged.

- stereo

All properties which are invalidated by stereo changes are dropped.

## ens transfer

ens transfer ehandle target_ehandle propertylist
Move property data from one ensemble to another, without going through an intermediate scripting language object representation. If the property is not already valid on the source ensemble, an attempt is made to compute it.

If the property is not an ensemble property, the number of property-associated minor objects is usually expected to be the same in both ensembles, and expected to have the same label set, tough it is not required that they are in the same sequence. Property data is assigned to the target ensemble minor objects with the minor object label as reference key. In case of a label set or object count mismatch between the two ensembles, no error is raised. Excess source data items are discarded, and
excess target minor objects, or those with unmatched labels, retain their original value if the property was present on the target, or are set to the default value if the property was freshly instantiated.

Properties which are not ensemble or ensemble minor object properties cannot be transferred. The two ensembles cannot be the same.

The return value of the command is the target ensemble handle.
Example:
ens transfer \$eh \$eh2 E_EMF_IMAGE
This copies property $\mathrm{E}_{-} \mathrm{EMF}$ _IMAGE from the first ensemble to the second.

## ens transform

```
ens transform ehandle SMIRKSlist ?direction? ?reactionmode? ?selectionmode?
    ?flags? ?overlapmode? ?{?exclusionmode? excludesslist}? ?maxstructures?
    ?timeout? ?maxtransforms? ?niterations?
```

This command applies one or more SMIRKS transforms to an ensemble and returns a list of ensemble handles of transformation products. The transformation products are filtered for duplicates. The original start structure is never returned - if a transform set does not match, an empty list is returned.

The required parameter after the ensemble handle is a list of SMIRKS lines, where each SMIRKS line is itself a list. A SMIRKS line is in the simplest case a simple SMIRKS transform without any extra data, but it may be padded by additional parameters which apply only to the application of that transform. If these optional parameters local to the current transform are not specified, their global counterpart on the command line is used instead. The syntax of an individual SMIRKS line is

SMIRKStransform ?step? ?direction? ?flags? ?overlapmode?
The SMIRKS transform part is the only required list element. It may be provided either as a string in standard Daylight notation, or as a handle of a reaction, which should have been decoded in SMIRKS mode (see reaction create command). Care should be taken to pass SMIRKS strings as a proper list elements, because it may contain whitespace and naming information after the actual transform code. Example:
ens transform \$ehandle [list [list \{[C:1][C:2]>>[C:1]=[C:2] Dehydrogenation\} 1]]
The string Dehydrogenation is part of the transform specification string and not the transform step. The name string is attached to the (intermediate, in this case) transform reaction object as property X_NAME and can be used to track the reaction history of transform result structures.

The optional step element in a transform line (a positive integer or 0 ) identifies the reaction step of the transform. Transform sets of different step numbers are isolated from each other and do not interact. Transforms are executed in ascending step number. Transforms with different step numbers need not to be sorted, and the step numbers neither need to begin with one, nor form an uninterrupted sequence. A step number of 0 disables the transform. The default step number is one. All transforms of the same step number are essentially executed in parallel and may interact with each other.

The third and again optional element of transform lines is the direction identifier. It may be either forward, backward, or bidirectional. In forward mode, only the left part of a transform is used for matching, and the matched structure part is modified according to the description on the right side. backward works the other way around, and in bidirectional mode, both sides of the transform scheme are independently matched, and, if the match is successful, transformed to the other side. If
this parameter is not specified, or specified as an empty string, the global direction parameter from the command line is substituted.

The fourth and once more optional element of a transform line is a list of flag words. Every word sets an additional flag. Currently, the following flag words are recognized:

- filtercharges

If set, use the localization of formal charges on atoms as a criterion to distinguish transformation results. By default, the standard hashcoding process is used which does not care about the placement of formal charges as long as these forms are interconvertible. For example, with the standard duplicate filtering process, pentavalent and ionic forms of nitro groups are considered equivalent. However, this will also prevent transforms which convert one form of a nitro group into another from working, since the transform result is discarded as being equivalent to the input structure. In order for this kind of transform to function as expected, the filtercharges flag must be set, which configures the duplicate filter to distinguish between the two forms. In that case, the preservecharges flag (see below) must not be set in order to allow the transformation to change the charge, but the checkcharges flag (see below) should be set in order to restrict the match of the transform to a specific ionic or pentavalent form.

- checkcharges

If set, formal charges on the match side of the transform must exactly match the charges on the matched structure atoms. By default, charges are not used for determining a match. This flag should be set if the transform pattern should only match specific charges.

- preservecharges

If set, charges are not modified after a transform is matched. By default, the charge of matched atoms is set to the charge of the matching atom in the transform template, as long as the atom has sufficient free electrons to allow the charge change. Atoms which are newly introduced by the transform always bear the charge specified in the transform description. This flag does not influence the match process - charges specified in the transform may still be used for selecting specific atoms via the checkcharges flag

- filterradicals

If set, use the localization of free electrons on atoms as a criterion to distinguish transformation results. By default, the standard hashcoding process is used which does not care about the placement of electrons as long as these are interconvertible. However, this also prevents transforms which convert from one electron localization scheme to another without accompanying atom or bond changes from working, since the results are discarded as being equivalent to the input structure.

- filterstereo

This flag instructs the duplicate detection mechanism to use stereo-specific hash codes for duplicate removal. This flag is not exclusive to the filterisotopes flag - both attributes are used to select a suitable hash code.

- checkstereo

If set, the stereochemistry on the match side of the transform must match the stereochemistry on the matched structure atoms. By default, stereochemistry is not used for matching.

- preservestereo

If set, atom and bond stereochemistry are not changed on matched atoms and bonds. By default, changes do occur - changed atoms or bonds have their stereochemistry reset if the transform pattern does not contain stereochemistry, or set to a specific stereochemistry if it does. If only the right side of a transform contains stereochemical descriptors, the stereochemistry of the transformed product is set to that of the template (for example, a cis double bond). If both the left and right side of a transform contain stereochemistry, the chemistry at the transform product is inverted or retained, depending on the stereochemistry change in the transform. Having stereochemistry only on the left side is possible, and potentially useful for selecting specific enantiomers or diastereomers via the checkstereo flag, but results in a reset (if this flag is not set) or retained (if this flag is set) stereochemistry in the transformed ensemble.

- absolutestereo

If this flag is set, the stereochemistry of the right side of a transform is transferred unchanged to the transform result ensemble, without attempting to interpret the operation as a reaction with stereochemistry inversion or retention by examination of the pattern on the left side. If the left side does not contain stereochemistry, the behavior induced by this flag is already the default and it has no effect. It also has no effect if the right side of the transform does not specify stereochemistry.

- checkaro

If set, aromaticity checking takes place. Atoms specified as aromatic in the transform pattern only match aromatic atoms in the target ensemble, and all other atoms only match non-aromatic atoms. By default, the aromaticity status of atoms is ignored in evaluating the pattern match.

- nochargepaircollapse

Disable the feature that bonds which connect atoms of opposite +1 and -1 formal charges are also matched by the equivalent bond with a bond order increased by one and neutral atoms.

- changeelements

If set, the element number and atom type of matched atoms is changed to that of the matching right side template. By default, atom type and element number of atoms which are not newly added are preserved in the transformed ensembles. This is usually desirable for the use of element lists and other generic expressions as part of transform patterns. If this flag is set, the atom is changed to the exact template definition - including changes to any atoms, element lists, or complete atomic recursive SMARTS expressions.

- removeh

If set, an attempt is made to rescue bond changes which would fail because of insufficient electrons for bond manipulations by deleting a minimum number of hydrogen atoms on the bond atoms needed for the bond creation or bond order change. Without this option, a transform like [C:1] [C:2]>>[C:1]=[C:2] usually does work, since Cactvs is designed to work on structures with a full hydrogen set. When this flag is set, the transform succeeds if C 1 and C 2 both have at least one hydrogen. Alternatively, the transform can be specified with explicit hydrogens as in [\#1] [C:1][C:2][\#1] >>[C:1]=[C:2]. In that form, it always removes the hydrogens because they do not appear on the right side. This is form is slightly more complex and different from the Daylight mechanism.

- nohadd

Part of the normal transformation procedure is a final hydrogen addition step before duplicate checks etc. are performed. This default behavior is designed to result in standard fully hydrogen-complete structures. If this flag is set, this step is omitted. This can for example be useful to avoid the addition of hydrogens to atoms with different default hydrogen addition characteristics if formal atomic charges have been moved. This option does apply to the input structure(s) of this command but only the first structure duplicate entered into the processing queue.

- chargeradicals

If this flag is set, radicals which are generated as result of a transform are charged using chemistry common sense. A cleaner and preferable method is to explicitly encode charge in the transform.

- dropradicals

If this flag is set, transform result structures are discarded if they are radicals. In case the chargeradicals flag is also set, the radical check is performed after the attempt to charge standard radical centers and may thus be used as a second line of defense against unreasonable structures.

- setpathname

If this flag is set, the name (property E_NAME) of the result ensembles is set to display the transformation sequence the structure underwent from the input structure. The name is formatted as a TcL-conforming list with one element for each transform applied. The first character of each list element is either ' $>$ ' or ' $<$ ' to indicate application of the transform in forward or reverse direction. It is followed by either the transform name (property x_NAME), if it is available, or the transform index number (starting with 0 ). Any initial name of the start structures of the transformation is cleared, so that the result name only contains transform path information.

- appendpathname

As above, except that the content of an existing property E_NAME on the input ensembles is not overwritten. Transform path information is always appended. If the input structure does not have initial name information, the operation of the two flags is indistinguishable.

- preservecoordinates

If this flag is set, 2D and 3D coordinates of the transform ensemble are retained. Newly added atoms are set to a magic coordinates value. By default, a successful transformation invalidates 2D and 3D coordinates, as well as all property data dependent on these.

- checkwedges

If this flag is set, bonds in the transform ensemble must match the wedge style specified in the left side of the transform template. This is useful only under very specific circumstances, since the style and placement of wedges does not uniquely identify a stereo isomer. Checking stereochemistry is therefore usually performed via the checkstereo flag, which relies on the comparison of stereo descriptors instead of wedges.

- preservewedges

If set, the wedge status of bonds matching the transform pattern is preserved. By default, wedges involving bonds which are changed, or which connect atoms which are changed (or deleted and then re-added in other form), are reset. Note that this flag operates
independently of the set of stereo flags listed above. In most cases, the desired mode of stereochemistry processing should be selected by specifying these flags, and the wedges regenerated as needed. If combined with stereochemistry changes, the use of this flag may otherwise lead to conflicting stereochemical information on the result ensembles.

- filterisotopes

This flag instructs the duplicate detection mechanism to use hash codes which use isotope labeling information for duplicate removal. This flag is not exclusive to the filterstereo flag - both attributes can be combined to select a suitable hash code.

- checkkekule

If this flag is set, bond orders of aromatic systems in the substrate molecules must be matched exactly as specified in the transform.

- filterkekule

This flag instructs the duplicate detection mechanism to use compute hash codes which are dependent on the exact bond order - including that of Kekulé structures of aromatic systems - for duplicate removal.

- anyrequired

If this flag is set, only result structures which were generated by the application of at least one of all transforms marked with this flag are accepted as final results. By default, the result set is not filtered by its origination from any specific transform.

- allrequired

If this flag is set, only result structures which were generated by the combined application of all transforms marked with this flag are accepted as final results. If any of the transforms marked with this flag did not contribute to a result structure, it is discarded. By default, the result set is not filtered by its origination from any specific transform.

- distinctpatternmatch

If this flag is set, the match mode of the substructure side of the transform is changed. The default match mode is all, meaning that all possible orientations of the substructure are generated, except in case of a transform application mode first, where the substructure match mode is also first. If this flag is set, the match mode is changed to distinct. In this mode, only pattern matches which differ in the set of structure atoms matched are generated, removing alternative mappings of the substructure on the same set of structure atoms. This mode is faster and can reduce the number of computation steps significantly, but the applicability of this match mode for the generation of the full set of desired transform results must be determined by the programmer with an eye for possible asymmetry of the matched structures outside the atom set of the transform substructure.

- restricthydrogenmatch

If set, hydrogen matches are not permuted. This means that, for example, the first explicit hydrogen around a transform substructure atom can only match the first hydrogen around a structure atom, not all of them (for example, all 3 in a methyl structure group) in different matches. This is an optimization which is frequently useful, if the transform results are guaranteed to be identical regardless of which hydrogen atom was matched - for example, when generating tautomers. However, if extended attributes of the structure hydrogen atoms are significant, such as 3D position, charge or isotope labels, etc., setting this flag can lead to the non-generation of distinct result structures.

- setatommatch

If this flag is set, the atom labels (A_LABEL) of the stored atoms on the left (substructure) side of the transform are stored on the transformation result ensembles as property A_SSMATCH. Atoms which are not matched are assigned a zero value.

In case a transform result structure is the product of more than one transform, each transformation step adds a new property instance A_SSMATCH, A_SSMATCH/2, and so on. Pre-existing A_SSMATCH properties on the transform input ensemble are not deleted. If these exist, the new data is stored in the next unused property instance after the current instance with the highest slot number.

- setbondmatch

This option is very similar to setatommatch described above, except that matching left-side substructure bond labels B_LABEL are stored in property B_SSMATCH.

- setatomstatus

If this flag is set, the status of the atom during the last transform is marked in property A_TRANSFORM_STATUS. Possible values are none: atom did not participate, matched: it was matched by the transform substructure, but did not change, changed: one or more atom attributes, including possibly the element number, we edited, new: the atom was added by the transform.

In case a transform result structure is the product of more than one transform, each transformation step adds a new property instance A_TRANSFORM_STATUS, A_TRANSFORM_STATUS/2, and so on. Pre-existing A_TRANSFORM_STATUS properties on the transform input ensemble are not deleted. If these exist, the new data is stored in the next unused property instance after the current instance with the highest slot number.

- setbondstatus

This option is very similar to setatomstatus described above, except that bond history is stored in property B_TRANSFORM_STATUS.

- linkreaction

Ensembles which are created via a transform for which this flag is set are linked to an automatically created reaction object in which the transform result ensemble is the reaction product, and a duplicate of the input ensemble the reagent. In addition, the X_NAME and E_REACTION_ROLE properties are set. The return value of the ens transform command is still a list of the handles of the transform result ensembles. The additional reagent ensemble handles are not included, and neither are the handles of the reactions. In order to access the reaction information, a lookup command such as ens reaction with a result ensemble as argument can be used.

- chargeneutral

If set, the sum of all changes in the formal atom charges in the set modified by the application of the transform, excluding any atoms which are deleted or added, must be zero. This is helpful for example for charge redistribution transforms. For example, a transform like

```
[*;+1:1]=[*:2][N:3]>> [*:1][*:2]=[N;+1:3]
```

only works on structures where the nitrogen atom is neutral, because otherwise the total charge of the match three atom block would change. It would be possible to achieve the same effect with explicit indication of allowed charges on all involved atoms, but this flag can be convenient.

- nitrorecoding

If this flag is set, the input structure duplicate(s) entered as start compound in the transform processing queue is standardized to possess the neutral, pentavalent form of nitro groups and similar groups. This option does not change the input structure(s) of this command but only the first structure duplicate entered into the processing queue..

- kekulize

If this flag is set, a new Kekule form of aromatic systems in the transformed structure is constructed. This is useful when the matching pattern did not check for explicit single and double bonds, so that after applying the transformation the Kekule pattern may be wrong, for example after swapping an electron-pair donating N witch a normal pi-bonded C atom. Still, it is generally recommended to use explicit bond order manipulation since that method is more robust.

- lockimplicitbonds

Bonds in the transform structure which are represented by bonds with an implicit bond order on the right side of the pattern (in forward direction, left side for reverse transforms) do not get their bond order adjusted, with the rationale that these pattern bond orders are not well defined anyway.

- keepiterationintermediates

If this flag is set, and multiple iterations are run, the results from intermediate iteration steps are part of the returned set. By default, only the results of the last iteration are returned.

The fifth, final, and again optional element of a SMIRKS line is the overlap mode. Again, if this parameter is omitted or supplied as an empty string, the global default from the command line is used. The overlap mode determines whether a transform substructure which consists of multiple disconnected fragments may match onto common target structure atoms or bonds. The following values are supported:

- none

No overlap of the substructure fragments, neither on atoms nor on bonds. This is the default mode, and the most commonly used.

- distinctmols

All disconnected fragments in the substructure must match different molecules in the target structure. This is a useful mode to prevent, for example, intra molecular reactions.

- any

Any overlap of the substructure fragments is possible. This mode is rather useless for transforms.

- nobonds

Atoms may overlap, but not bonds. This mode is actually highly useful in some contexts.

- noembed

Atoms and bonds may overlap, but no substructure fragment may be completely embedded in the structure part matched by another fragment, meaning that at least one of any pair of matching substructure fragments must match an atom which is not matched by the other fragment.

- distinctatoms

Between any pair of matched substructure fragments, both fragments must match at least one atom not matched by the other fragment.

Every SMIRKS line follows the outlined scheme, and all settings within that line are applicable only to the current transform scheme.

There is no general limit for the maximum number of transforms in this command. However, if transforms are combined with exclusion substructures, and these exclusion substructures are to be applied on a per-transform basis, (see below), the highest transform index for which an applicability flag can be set is 63 . Every transform which is applied in bidirectional fashion, either by global configuration or transform-specific flags, is counted twice toward this limit.

All parameters after the SMIRKS lines list act globally. The third and optional direction parameter, command word number five, sets the default for the directionality of all transforms for which no local override was set in their respective SMIRKS lines. If this parameter is not specified, the default is forward.

The optional reaction mode, parameter four and command word six, does not have a counterpart in the SMIRKS lines. This parameter determines how the possibility of multiple matches of a transform substructure in the target molecules is handled. It can be one of these values:

- first

Only the first match which is found is executed, all other possible matches are disregarded. The location of the first match should be considered random.

- exhaustive

Only those transform products where all possible match sites have been processed are produced. For example, a structure with two reaction sites A and B, only the product where both A and B have been transformed is reported - provided that the initial transformation of A or B did not influence the possibility of matching the second part. So, in case of the hypothetical hydrolysis of a dihalogene compound with explicit water molecules, the fully reacted product will only be obtained if the input ensemble contained two water molecules. Otherwise, one (in case of symmetry) or both products of a single hydrolysis step are obtained. This mode operates by generating the intermediate products and re-submitting them. If these generate one or more new compounds, they are discarded from the result list. An older and still recognized name of this reaction mode is all.

## - singlestep

All matches are found and the transform executed, but the transform results are not re-submitted for matching as they are in the exhaustive mode. All different products which result from a single application of the transform are returned. For hypothetical example of the hydrolysis of an asymmetrical dihalogene compound, both partial hydrolysis products are generated, but not the fully hydrolyzed end product.

- multistep

This mode generates all transform products by systematically applying the transforms to all structures and re-submitting the results again and again, until no new compounds are generated. In contrast to the exhaustive mode, intermediate products which further react are not discarded. The hypothetical example of the hydrolysis of an asymmetrical dihalogene compound yields three products - two partial hydrolysis products, and the fully hydrolyzed end product.

The default value for the reaction mode is first.
The next optional command parameter, the selection mode, (command argument five and command word seven) again has no counterpart in the SMIRKS line parameters. It determines the interaction
of transforms of the same step number. All these transforms form a group. This parameter determines which of the transforms from the current group are executed, and in which order. The parameter can be set to one of the following values:

- first

The first transform from the current group which matches is processed according to the reaction mode setting. All other transforms in the group are ignored, regardless whether they would match or not.

- sequence

All transforms in the current group are applied once in the order they are specified, with the current reaction mode. Each transform is applied to the result ensembles of the previous transform, or the start ensemble for the first transform. All results, including those which did undergo further changes by later transforms, are returned.

- seqendpoints

Similar to the sequence mode, but only those result ensembles which did not lead to further transformation results (either actually generated, or discarded as duplicates) are returned. Again, each transform in the sequence is only applied to the result structures of the previous transform.

- endpoints

Similar to the all mode, but every transform is applied to all result ensembles which have accumulated before. Only those ensembles which did not yield additional, structurally distinguishable result ensembles are returned as final result.

- all

All transformations are applied to all result ensembles. This process is repeated until no additional, structurally distinguishable result ensembles are generated ${ }^{1}$. The full set of result ensembles is returned.

- newseqendpoints

This mode is similar to the seqendpoints mode. In seqendpoints mode, if a transform does not match any of the current input structures, an empty set is passed on to the next transform as input data. Thus, the transforms which follow a failing transform cannot produce any results themselves and are effectively ignored. In this mode, if a transform does not yield any results on the current input set, the current input set is re-used for the next transform, so that transforms which do not match cannot interrupt the chain. If the current transform yields results, that result set is used. The final result set is filtered, as in the endpoints and seqendpoints modes, to contain only structures which did not produce any transform results themselves.

- parallel

All transforms of the current group are applied, but only to the start structure set, not to any results produced by the successful application of any previous transform.

The default selection mode is first.
The next and again optional flags parameter (command argument six, command word eight) defines the default for those transforms which do not possess an override flag set in their SMIRKS line. Note that if a flag set specified on a SMIKRS line it completely replaces the default flag set. It does not simply add or bit-or more flags compared to the global setting. The default flag set is empty.

1. Do not use this mode with transforms which add a group which is again matchable by the transform - you will face a runaway polymerization-style reaction!

Similarly, the overlap mode parameter (command argument seven, command word nine) sets the default for handling potential overlap when matching disconnected transform fragments onto the structure to be transformed. The default setting is none, disallowing any fragment overlap. If the transforms only consists of a single fragment in the applicable direction(s), there is no effect of this parameter.

The excludesslist parameter (command parameter eight, command word ten) again has a potentially complex internal structure. It defines exclusion fragments. An exclusion fragment blocks all sections of the target structure from matching any transform substructure, either by preventing the match of transform atoms (the default) or transform bonds. This is a useful feature for example to easily prevent amide groups from matching amino group transforms. The default exclusion substructure list is empty. The parameter is a list. Every list element can be a simple structure identifier, or a list of a structure identifier and a transform index list.

Structure identifiers recognized by this command are:

- ensemble handles

This selects the complete parameter ensemble as exclusion substructure.

- lists of an ensemble handle and a molecule label

This selects a specific molecule from the ensemble as exclusion substructure,

- SMARTS strings

The SMARTS string is temporarily decoded and used like an ensemble handle. The transient ensemble is automatically destroyed when the ens transform command has finished.

If the exclusion substructure identifier is not associated with a transform index list, the substructure applies to all transforms. The optional transform index list consists of an arbitrary number of transform indices in the range $0 \ldots 63$. If a transform index list is supplied, the exclusion substructure applies only to the listed transforms. Note that it is not possible to set individual exclusion indices for transforms beyond the 64th, even though it is allowable to use any number of transforms in the transform list. All ensembles, including intermediate result ensembles, are checked against all applicable exclusion structures immediately before the application of a transform is attempted.

The exclusion substructure specification list may be prepended by a magical list element with value (marked)atoms, (marked)bonds, unmarkedatoms or unmarkedbonds. These control the mechanism how matched substructures are marked in the transform source structure. The default mode is atoms, where excluded atoms are prevented from matching transform pattern atoms. The bonds mode switches this to preventing a bond match. The difference is that in bonds mode, transform pattern atoms can still overlap, by a single atom, excluded regions, but not change bonds therein, while in atoms mode absolutely no atom or bond overlap between excluded regions and transform patterns is allowed. The unmarked variants operated with a reversed exclusion set - i.e. atoms or bonds which are not matched are excluded from the structure region eligible for transform application.

In case the exclusion mode is (marked)atoms or unmarkedatoms, an atom identifier, i.e. any notation which is supported to identify an atom in the atom command, may also be used in addition to the three substructure specification styles listed above to directly exclude a single atom from matching by all transforms. In (marked)bonds or unmarkedbonds marker mode, bond identifications in the same style as supported by the bond command, such as bond labels or bond atom label pairs, are similarly allowed as additional direct bond exclusion specifications, and these again apply to all transforms.

Exclusion markings, once set for the input structure, are inherited by newly generated result structures, so that the protection remains active even for structures undergoing sequences of transformations.

The related dataset transform command does not support direct atom or bond exclusion marking, even if the dataset only contains a single structure.

An example for an exclusion list:
ens transform \$eh \$tlist ... [list "atoms" $\{\mathrm{C}(=\mathrm{O})[\mathrm{NH} 2]\}\{\{\mathrm{C}[\mathrm{NH}] \mathrm{C}\}$ \{0 1\}\} 1]
This exclusion set protects amide groups (the first substructure) from all transforms, secondary amines including their immediate carbon neighbor atoms from the first two transforms in the set (index 0 and 1 , the transform set is specified in the tlist variable), and the single atom with label $l$ in the input ensemble. The exclusion marker mode is explicitly spelled out as atoms in first exclusion list element, which however is already the default.

Another example:

```
ens transform $eh $tlist ... [list „unmarkedatoms" {*}$statoms]
```

This transform only operates on the atoms of which the labels or other identifiers are included in the list in variable statoms. All other parts of the structure are excluded and cannot participate in the transform.

The next optional global command parameter (parameter nine, command word eleven) is the maximum number of result ensembles to generate. The input ensemble is not counted. As soon as the maximum is reached, the command finishes and returns the result ensembles which were generated so far. If the maximum number of results is set to a negative number (the default), no limit applies. If it is set to zero, the transform command is effectively disabled. The global control variable $\therefore$ cactvs(setsize_exceeded) is set to 1 if the specified maximum number of result ensembles was going to be exceeded. At the beginning of the execution of the ens transform command, this control variable is reset to zero. The limit applies to the total of generated unique structures, which is not necessarily the same as the number of output structures in case the processing mode dictates that they are processed further and not included as intermediates in the result set. In the special case of exhaustive transform application, the parameter limits the size of the intermediate result set after each pass, not the overall total of unique structures.

The timeout parameter (command parameter ten, command word twelve) can be used to set a time limit in seconds for the command execution. If this parameter is set to 0 or a negative number, no timeout applies. This is the default. Otherwise, the generation of result ensembles is stopped after the specified time, and the command returns with the results generated so far. The global control variable $::$ cactvs(interrupted) is set to 1 if a timeout occurs. It is reset to 0 at the beginning of the execution of the command.

The second last parameter (command parameter eleven, command word thirteen) can be used to limit the number of transforms applied to the starting structure and intermediate structures. If this parameter is not specified, or specified as an empty string or a negative value, no limit is imposed. If this parameter or the timeout option is used, the result set may become dependent on the atom and bond order of the input structure because the traversed part of the possible transform match space is different and might yield different and/or a different number of results when the timeout or application count restriction is triggered.

The final optional parameter (command parameter twelve, command word fourteen) is an iteration count. Its default value is one, meaning that the whole transformation process is only executed once. If set to a larger value, the transformation routine calls itself recursively. This is equivalent to first running ens transform with a start structure, and then repeatedly execute dataset transform commands for the second and later iterations with the last result set. All limits and other control parameters are passed in the original configuration, and apply only to the next iteration, not globally over the sum of all transform cycles. By default, the result set of this mode is what the last iteration produced, but this can be changed to the union of all iteration results by the
keepiterationintermediates flag. Uniqueness checking of result structures is applied to the full return set. If the parameter is set to zero or a negative value, no transformations are executed. If the setpathname flag is set, it is automatically switched to appendpathname for the second and later cycles, so that the name mirrors the full transformation history and is not reset in each cycle.

Example:

```
set t1 {{[0,S;X1:1]=[C:2x1][C:3X4][#1:4]>>[#1:4][0,S;X2:1][C:2x1]=[C:3]
enol/thioenol}}
set elist [ens transform $eh [list $tl] bidirectional multistep all preservecharges
none]
```

This example is part of a tautomer generator. The full standard generator in the toolkit uses a lengthy list of transform schemes and not just the one sample keto/enol schema displayed here. Because the operation is bidirectional, the transform transforms ketones into enols, and vice versa. If more than one interchangeable group exists, all intermediate structures are generated (multistep reaction mode). All results are retained (all selection mode), and all intermediate structures are again subjected to all transforms (this does not have any effect with a single transform, but the real application uses a set of transforms). Finally, charges should not be changed (preservecharges flags), and fragment overlap is not allowed (none overlap mode) - this again is without effect in this sample transform, because it does not consist of disconnected fragments on either side.

Multiple structures may be jointly transformed in a single command by means of the very similar dataset transform command.

## ens translate

ens translate ehandle pt1 ?pt2?
Move the atoms of the ensemble by modifying their 3D coordinates in property A_XYz. The first argument is interpreted as a 3D vector if this is the only coordinate argument. All atoms with valid 3D coordinates are moved according to the vector coordinates. In case a second argument is supplied, both arguments are interpreted as points in 3D space. The ensemble atoms are moved according to the difference vector between the second and the first point.

This operation triggers a 3dglop property invalidation event.
Examples:
ens translate $\$$ eh $\{0 \quad 0 \quad 1\}$
ens translate \$eh [atom get \$eh \$a1 A_XYZ] [atom get \$eh \$a2 A_XYZ]
ens trim
ens trim ehandle ?propertylist?
Reduce the information content of a structure to a standard minimum set and discard any additional information. This process minimizes the storage requirements of the ensemble. The properties of the
internally defined minimum set are computed if required. The retained property set is designed to support a faithful representation of connectivity including bond and atom labels and types as well as formal charges, stereochemistry, isotopes, 2D and 3D coordinates, but not of auxiliary additional attributes of atoms, bonds or other minor objects.

The optional fourth argument is a list of properties which should be retained in addition to the standard set. If any of these are not present on the ensemble to be trimmed, they are silently ignored and no attempt is made to compute them. Specifying properties of the standard retention set in this list is allowed but has no additional effect.

The return value of the command is a list of the remaining properties of the ensemble.
Example:

```
ens trim $ehandle {E GIF E SMILES}
```


## ens uncharge

ens uncharge ehandle
Attempt to remove charges on atoms in a chemically sensible way. Charge removal by default happens via addition or removal of protons. In cases where this does not make chemical sense, a direct charge manipulation may be performed instead. Charged metal ions and other charged species without an obvious method for neutralization remain unchanged.

The command returns the number of atoms which were neutralized.
Example:
ens uncharge [ens create $\{[\mathrm{NH} 3+] \mathrm{CC}(=\mathrm{O})[\mathrm{O}-]\}]$
This sample line removes a proton from the charged amino group and add a proton to the charged carboxyl group of the initial glycine zwitterion. The returned result value is 2 . In this example the total hydrogen count has not changed. In case of an unbalanced set of positive and negative, modified charged centers this is usually not the case.

## ens unlock

ens unlock ehandle propertylist/objclass/all
Unlock property data for the ensemble, meaning that they are again under the control of the standard data consistency manager.

The property data to unlock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the ensemble, or ensemble minor objects are unlocked. Non-existent data is silently ignored. It is not possible to unlock individual property fields.

- all

All valid ensemble or ensemble minor object properties are unlocked. Ensemble properties and ensemble minor object properties are not affected.

- ens,atom,bond...

These are object class identifiers. All property data which is controlled by the ensemble major object and attached to the specified object class is unlocked.

Property data locks are obtained by the ens lock command.

## Example:

```
set eh [ens create CCC]
ens lock $eh A_SYMBOL 1
ens purge $eh A_ELEMENT
atom set $eh 1 A_query(dsearch) 3
ens unlock $eh A_SYMBOL
```

In this example, an ensemble is created, and the atom symbol information is locked. Next, the element number property is deleted, and a query attribute is set. Finally, the lock is released. Had the element symbol information not been locked, the ensemble would have become unusable due to an overzealous data consistency manager. Setting query information in property A_QUERY can have an influence on the atom symbol. So the default action of invalidating A_SYMBOL when manipulating A_QUery is correct. However, in case there is no element information A_element, and no atom symbol information A_SYMBOL, the element information is completely lost, and the ensemble becomes unusable. So in this case, locking A_SYmbol (or alternatively A_Element) is required to avoid unexpected side effects of structure editing.

## ens unpack

```
ens unpack packstring
```

Unpack a base64-encoded serialized object string which was created by an ens pack command. The return value of this function is the handle of the newly created ensemble object, which is an exact duplicate of the packed original ensemble.

Packed ensembles may also be unpacked by the ens create command.
Example:

```
set packdata [ens pack [ens create CCCl]]
```

set ehandle [ens unpack \$packdata]
ens valencecheck
ens valencecheck ehandle ?failedatomvariable?
Perform a valence check on the ensemble, comparing the current bonding situation at all atoms to the list of element-specific valence states in the system element table. This command is intentionally quite picky, discouraging for example the use of pentavalent nitrogen. For the calculation of valence, only bonds of type normal are taken into account. Complex bonds and pseudo bond types thus do not interfere in the calculation. Some more exotic metal atoms with many different valence states, or few well-defined covalent compounds, such as vanadium or rhodium, always pass.

The return value of this command is the number of atoms which failed the valence check. If the optional failedatomvariable argument is specified, it is the name of a variable which receives a list of the atom labels which failed the check, or is set to an empty list in case no problems were found.

Note that this command assumes that all hydrogen atoms are in place. Processing of structures with implicit hydrogen atoms is not supported.

Example:
ens valencecheck [ens create $\{C N(=O)=O . C[N+](=O)[O-]\}]$ badatoms
This sample command checks the valence situation of nitrome thane in two encoding formats. The first molecule, using a pentavalent nitrogen encoding, is responsible for the result value 1 , indicating
one failed atom, and the variable badatoms is set to 2 , the label of the pentavalent nitrogen atom. The second molecule passes the check and reports no additional problems.

## ens valid

ens valid ehandle propertylist
Returns a list of boolean values indicating whether values for the named properties are currently set for the ensemble. No attempt at computation is made.

Example:
ens valid \$xhandle X_IDENT
will report whether the ensemble has a standard ID (has a valid E_IDENT property) or not.

## ens vector

ens vector ehandle property vectorname ?invert? ?integrate?
Map ensemble property data to a BLt library vector object. Please refer to the BLt manual pages for more information on these. BLt vector objects are very useful, for example, for the efficient set-up of GUI graphing widgets which are provided by the BLt Tк extension. This command automatically attempts to load the BLt Tcl module if necessary. If that fails, an error results.

The vectorized property data must be of a vector type, and the element type of the vector must either be a simple numeric type, or a bit for bitvectors, or a floating-point pair. It is possible to address a property subfield, for example the $\mathrm{X} / \mathrm{Y}$ data points of a spectrum which are typically stored as a field in a complex compound property.

If the invert flag is set, the stored BLt vector object values are set to 1.0 minus the property data value. By default, this flag is not active. If the integrate flag is set, the BLt vector object element values are set to the sum of all preceding property data values. This flag is also disabled by default.

If the property data type is a float pair vector, two vector objects are created in the BLt namespace, with suffixes _ $X$ and _Y. For simple vector types, the vector name is used directly. It is possible to overwrite existing BLT vectors of the same name with this command.

The return value of the command is a list of the generated name of the vector, followed by the minimum and maximum data values in that vector object. These may the different from the ensemble property data values because of the application of the invert or integrate flags.For float pair vectors, the same information is repeated for the second vector object.

## ens weed

```
ens weed ehandle keywords
```

This command performs a number of common clean-up and standardization operations on the ensemble, which are especially useful in the context of processing PDB files. The ensemble is potentially modified, but keeps its handle, which is returned as command result. In addition, properties A_XYZ and A_RESIDUE, which are normally susceptible to bond manipulations, are locked and retained.

The keywords argument selects the desired set of operations. Most of the keywords are single words, but the minsize and maxsize as well as the minaminoacids and maxaminoacids keywords take an additional integer number as argument. The following operations are currently supported:

- carbonless

Remove all molecules which do not contain carbon.

- disulphides

Split and hydrogenate all disulfide bridges. This operation can change the molecule and ring set.

- duplicates

Remove all molecules which are duplicates (taking isotope labels and stereochemistry into account) of another molecule in the ensemble. Only a single instance of any duplicate molecule is retained. Internally, this is a check on property m_HASHISY.

- hydrogenless

Remove all molecules which do not contain hydrogen.

- inorganic

Remove all inorganic molecules.

- ligands

Remove all molecules which do not consist exclusively of linked standard amino acids. This flag is complementary to proteins.

- maxaminoacids $n$

Discard all molecules from ensemble which consist only of linked standard amino acids and contain more than the specified number of them. This operation requires an additional integer after the keyword.

- maxsize n

Discard all molecules from ensemble which have more than the specified number of atoms. This operation requires an additional integer after the keyword.

- metalatoms

Remove all metal atoms from the ensemble. This operation can change the molecule and ring set.

- metalions

Remove all molecules which are unbonded metal atoms. Bonded metal atoms are not affected.

- metaloxygenbonds

Remove all bonds between metal atoms and oxygen atoms. This operation can change the molecule and ring set.

- minaminoacids $n$

Discard all molecules from ensemble which consist only of linked standard amino acids and contain less than the specified number of them. This operation requires an additional integer after the keyword

- minsize $n$

Discard all molecules from ensemble which have less than the specified number of atoms. This operation requires an additional integer after the keyword.

- proteins

Discard all molecules which only consist of linked standard amino acids. This is a shortcut for minaminoacids 0 .

- proteinhetatmbonds

Discard all bonds between the protein core and heterogens, i.e. all bonds where the property field A_RESIDUE (HETATOM) is different among the involved bond atoms. This operation can change the molecule and ring set.

- proteinspecialbonds

Discard all special bonds (i.e. complex bonds, link bonds, etc.) where at least one atom is from the protein, i.e. was encoded with an ATOM line in a PDB file, not hetatm. This operation can change the molecule and ring set.

- specialbonds

Delete all bonds which are not VB bonds. This operation can change the molecule and ring set.

- water

Discard water molecules, i.e. all molecules which consist of one oxygen atom, any number of hydrogen atoms, and no other element.

The order of the keywords is not important. The sequence of operations is always
metalatoms $>$ specialbonds $>$ proteinspecialbonds,proteinhetatmbonds $>$ metaloxygenbonds $>$ disulphides $>$ carbonless,hydrogenless,inorganic,maxsize,metalions,minsize,water $>$ maxaminoacids,minaminoacids $>$ duplicates

Applied operations which potentially change the set of molecules and rings trigger an automatic re-evaluation of this data after the operation block has been executed.

## Example:

The code below is part of a reliable PDB ligand extractor.

```
ens weed $eh {metaloxygenbonds water proteinspecialbonds duplicates minsize 10 \
maxsize 300 maxaminoacids 6 disulfides}
if {[ens get $eh E_NATOMS]==0} {
# try again with additional bond cut step. Cannot do this by default, because
# there are plenty of ligands with embedded amino acid parts
# that are encoded as ATOM lines. PDB files suck.
    molfile backspace $fh
    set eh [molfile read $fh]
    ens weed $eh {metaloxygenbonds water proteinspecialbonds proteinhetatmbonds \
duplicates minsize 10 maxsize }300\mathrm{ maxaminoacids 6 disulfides}
}
ens xhandle
ens xhandle ehandle
```

Return the remote handle of the ensemble if it was exported and is currently under the control of a live-linked application. In case the ensemble is not exported, an error results.

## The group Command

The group command is the generic command used to manipulate groups. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

Pseudo group labels first, last and random are special values, which select the first group in the group list, the last, or a random group.

Example:
group get \$ehandle 1 G_SIZE
This is the list of officially supported subcommands:

## group add

group add ehandle label objectlist
Add more atoms or groups as members to an existing group. A group cannot be added to itself, and the formation of cyclic dependencies is illegal. It is however possible to add an atom or group more than once to a group, and an atom or a group may be a member of an arbitrary number of groups.

Adding objects to a group triggers a groupchange property invalidation event and may thus have an influence on the validity of chemical object data.

The use of an empty object list is possible and does not change the group, nor is an invalidation event issued.

The object list syntax is the same as in the group create command.
The command returns the group label.

## Examples:

```
group add $ehandle $glabel 1
group add $ehandle $glabel [list "group" [group create $ehandle [list 5 7]]]
```

The first sample line simply adds the atom with label 1 to the group. The second line adds a newly created group with atoms 5 and 7 to the existing group as a recursive group element.

## group append

group append ehandle label property value ?property value?..
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:
group append \$ehandle 1 G_NAME "_linker"
group atoms
group atoms ehandle label ?filterset? ?filtermode?
List the labels of all atoms which are in the group. There are two different modes of operation, depending on whether the group contains at least one atom as member object.

If there is a member atom: Group member objects which are not atoms, such as bonds or recursive groups, are omitted from output, as are atoms which are only indirectly a group member via a recursive group.

Without atoms in the group, atoms which are components of the group objects are listed.
In other respects, this is a standard cross-referencing command. The usage of the filterset and filtermode parameter is explained in the section about object cross-references.

Example:

```
set gh [group create $ehandle [list 1 2 3]]
```

group atoms \$ehandle $\$ g h$ carbon
gets the labels of the carbon atoms in the group.

```
set gh [group create $ehandle [list [list „bond" 1]]]
```

group atoms \$ehandle \$gh
while this command on a group which only contains bonds, but no atoms, reports the atom labels of the bond in the group.

## group bonds

group bonds ehandle label ?filterset? ?filtermode?
Retrieve the labels of bonds which are associated with a group. There are two different modes of operation, depending on whether the group contains at least one bond as member object.

If there is a member bond, Group member objects which are not bonds, such as atoms or recursive groups, are omitted from output, as are bonds which are only indirectly a group member via a recursive group.

Otherwise, a bond is considered to be associated with a group if all atoms of the bond are group members. All bond atoms must be in the same group object, i.e. indirect memberships via recursive groups are ignored. Bonds are not associated with a group if only some of their atoms are members of the group.

In other respects, this is a standard cross-referencing command. The usage of the filterset and filtermode parameter is explained in the section about object cross-references.

## Example:

```
set gh [group create $ehandle [list 1 2 3]]
group bonds $ehandle $gh {1 doublebond triplebond}
```

gets the bond labels of all double and triple bonds between the group atoms.

```
set gh [group create $ehandle [list [list „bond" 1]]]
group bonds $ehandle $gh
```

while this command directly lists the bond in the group.

## group create

group create ehandle objectlist
Create a new group containing atoms or other minor objects, including other groups as member elements.

The object list parameter is a list of object identifiers. An object identifier is either a single-element simple identifier, in which case it is interpreted as an atom identifier (usually a label, but all other identifiers are possible), or a two-element list. If the second form is used, the list must consist of an object class name, followed by an object identifier (usually a label, but all types of minor object identifiers are possible).

Specifying a member object which cannot be resolved produces an error. However, it is no error for an atom or a group to be listed more than once as a member of a group, nor is there any restriction of how many groups an atom or other minor object can be a member. However, circular relationships are illegal, and a group cannot be a member of itself. Duplicate objects in a group are allowed and not filtered when a group is set up.

Creating a new group triggers the group and groupchange invalidation events and may thus influence the validity of chemical object data.

The creation of empty groups by supplying an empty object list is possible.
The return value of this function is the label of the new group.
Examples:

```
set g1 [group create $ehandle {1 2 3}]
set g2 [group create $ehandle [list [list "group" $g1] 4 [list "atom" #5]]]
```

The first line creates a simple group with atoms 1,2 and 3 . The second line builds a recursive group which contains the first group (identified as a group reference by prefixing its label with a group object class name), the atom with label 4 , and the atom with index 5 (which could have any label).

## group defined

group defined ehandle label property
This command checks whether a property is defined for the group. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

Example:
group defined \$ehandle 1 G_XYZ
checks whether group 1 is of a type for which $G_{-} X Y Z$ is defined.

## group delete

group delete ehandle ?label?...
group delete ehandle all
Delete a set of groups. Groups are either identified by a standard group identifier (usually a label), or the reserved word all.

If a deleted group contains as a member another group, that group is also deleted in a recursive fashion. If this behavior is not wanted, recursive groups should be explicitly unlinked from their base groups by means of the group remove command.

Deleting a group triggers the group and groupchange invalidation events and may thus influence the validity of chemical object data. If an empty object list is used, the command does nothing, and no invalidation event is generated.

This command returns the number of deleted groups on the first level, i.e. recursive group deletions are not counted.

Examples:
group delete \$ehandle all
group delete \$ehandle [ens groups \$ehandle xatom]
The first example deletes all groups in the ensemble. The second example deletes all those groups which contain one or more hetero atoms as members.

## group dget

group dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the group get command. The difference between group get and group dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, group get and group dget are equivalent.

## group dup

group dup ehandle label ?datasethandle? ?position?
Duplicate the atoms and bonds of a group into a new ensemble. The function returns the new ensemble handle.

By default, the new ensemble is appended to the same dataset as the original ensemble, or placed outside of any dataset if the input ensemble was not a dataset member. If the optional dataset handle parameter is specified, the duplicate is directly moved to that dataset. If an empty string is passed, the duplicate is not made a dataset member, even if the input ensemble is in a dataset.

Example:
group dup \$ehandle 1 [dataset create]
duplicates the group with label one and move the new single-molecule ensemble into a newly created dataset.

## group exists

group exists ehandle label ?filterlist?
Check whether this group exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the group does not exist, or fails the filter, and 1 in case of successful testing.

Example:
group exists \$ehandle 99
group expr
group expr ehandle label expression
Compute a standard SQL-style property expression for the group. This is explained in detail in the chapter on property expressions.

## group fill

group fill ehandle label property value ?property value?...
Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

Example:
group fill \$ehandle 1 B_COLOR red
sets the color of the first bond group 1 contains or is associated with to red.

## group filter

group filter ehandle label filterlist
Check whether a group passes a filter list. The return value is 1 for success and 0 for failure.
Example:
group filter \$ehandle 1 [list carbon doublebond]
checks whether the group contains one or more carbon atoms and one or more double bonds. The double bond does not need to be with a carbon atom.
group get
group get ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:
group get \$ehandle 1 \{G_SIZE A_ELEMENT\}
yields a list with two elements, consisting of the group size (count of group members) as the first element and the element numbers of all atoms in the groups as a nested list as the second result list element. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

```
group get $ehandle 1 B_ORDER ringbond
```

gives the bond orders of all bonds of associated with the group which are ring bonds.
For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the group get command are group new, group dget, group nget, group show, group sqldget, group sqlget, group sqlnew and group sqlshow.

Further examples:

```
group get $ehandle 1 E_NAME
group get $ehandle 1 A_FLAGS(boxed)
```

group group
group group ehandle label

Standard cross-referencing command to obtain the label of the group as stored in property G_LABEL. This is explained in more detail in the section about object cross-references. Note that there is also a group groups (plural groups) command which has a different function.

Example:
group group \$ehandle \#0
returns the label of the first group of the ensemble group list.

## group groups

group groups ehandle label ?filterset? ?filtermode?
List the labels of all groups which are members of the group. Group member objects, such as atoms, which are not groups are omitted, as are groups which are only indirectly a group member via a recursive group.

In other respects, this is a standard cross-referencing command. The usage of the filterset and filtermode parameter is explained in the section about object cross-references. Note that there is also a group group (singular group) command which has a different function.

## Example:

group groups \$ehandle 1
gets the labels of the groups which are a (recursive) member of group 1.
group hdup
group hdup ehandle label ?datasethandle? ?position?
This command provides the same functionality as group dup, except that it also adds a standard set of hydrogens to the new ensemble.

## group index

group index ehandle label
Get the index of the group. The index is the position in the group list of the ensemble. The first position is index 0 .

Example:
group index \$ehandle 99

## group local

group local ehandle label propertylist ?filterset? ?parameters?
Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

Example:
group local \$ehandle 1 A_LABEL_STEREO
Note that very few computation routines currently support the local re-computation of data - in most cases, this command falls back to a global re-computation.

## group match

group match ehandle label ss_ehandle ?ss_label? ?matchflags? ?ignoreflags?
?atommapvar? ?bondmapvar? ?molmapvar?
Check whether the selected group matches a substructure. Only the first substructure group, or the group selected by the substructure label parameter, is tested. The substructure may be part of any structure ensemble, and even be in the same ensemble as the primary command group. Both the atoms in the group and the bonds between them are checked.

The precise operation of the substructure match routine can be tuned by providing a standard set of match flags and feature ignore flags. The default match flag set has set bits for the bondorder, atomtree and bondtree comparison features, and an empty ignore set. If a flag set is specified as an empty string, the default set is used. In order to reset a flag set, an explicit none value must be used.

The command returns 1 for a successful match, 0 otherwise. If an optional atom, bond, or molecule map variable is specified, it is set to a nested list of matching substructure/structure atom, bond or molecule labels. If no match can be found, the variable is set to an empty list. In case only a bond or molecule map variable is needed, an empty string can be used to skip the unused map variable argument positions.

Example:

```
set ss [ens create {c1ccccc1} smarts]
set g_contains_phenyl_ring [group match $ehandle $label $ss]
```


## group mols

group mols ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the molecules the atoms in the group are a member of. This is explained in more detail in the section about object cross-references.

Examples:

```
group mols $ehandle 1
group mols $ehandle 1 heterocycle
```

The first example is simple retrieval, the second line filters the molecules and lists only the labels of those molecules which contain one or more heterocycles.

## group new

group new ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the group get command. The difference between group get and group new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## group nget

group nget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the group get command. The difference between group get and group nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## group objects

group objects ehandle label ?filterset? ?filtermode?
This is a cross-referencing command specific to groups. The standard operation of cross-referencing commands and the use of the optional parameters are explained in the object referencing section of this manual.

The difference of this command to the group atoms, group bonds or group groups commands is that this command lists all object classes present in the group. Every listed item is output as a list with two elements - the first being the object class (atom, bond or group), the second being the object label. This list is suitable for use in a group create or group add statement.

Example:

```
group create $ehandle [group objects $ehandle 1]
```

This command duplicates the group with label 1.

## group pis

group pis ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\pi$ systems the group is associated with. This is explained in more detail in the section about object cross-references.

Examples:
group pis \$ehandle 1
$\pi$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use p or d orbitals, such as in standard covalent multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## group remove

group remove ehandle label objectlist
Remove group elements from a group. The removed objects are not deleted from the ensemble, they simply are no longer a group member. The syntax of the object list is the same as in the group add and group create commands. The groups the objects are removed from also remain in existence.

Removing an object from a group triggers a groupchange property invalidation event and may thus have an influence on the validity of chemical object data.

The command returns the number of removed group elements.
Examples:
group remove \$ehandle 1 [group atoms \$ehandle 1 hydrogen]
This command removes all hydrogen atoms from group 1.
group rings
group rings ehandle label ?filterset? ?filtermode?

Standard cross-referencing command to obtain the labels of the rings the group is associated with. This is explained in more detail in the section about object cross-references. Rings which only partially overlap with the group are included.

Examples:
group rings \$ehandle 1
group rings \$ehandle 1 [list heterocycle aroring]
The first example returns the labels of all rings the group overlaps with. If the group does not overlap with any ring, an empty list is returned. Only labels of rings in the SSSR or ESSSR set are returned, even if the currently computed ring set is larger. The second example filters the rings - only heteroaromatic rings are reported.

## group ringsystems

group ringsystems ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the ring systems the group is associated with. This is explained in more detail in the section about object cross-references. Ring system which only partially overlap with the selected group are listed.

## Examples:

```
group ringsystems $ehandle 1
```

group ringsystems \$ehandle 1 [list heterocycle aroring]

The first example returns the labels of all ring systems the group is associated with. If the group does not overlap with any ringsystem, an empty list is returned. The second example filters the ring systems - a ring system label is added to the output list only if that ring system contains one or more hetero aromats.

## group set

group set ehandle label property value ?property value?..
Standard data manipulation command for setting property data. It is explained in more detail in the section about setting property data.

Example:
group set \$ehandle 1 G_CONSTRAINT [list "distance" [list 3.0 4.0]]

## group show

group show ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the group get command. The difference between group get and group show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, group get and group show are equivalent.
group sigmas
group sigmas ehandle label ?filterset? ?filtermode?

Standard cross-referencing command to obtain the labels of the $\sigma$ systems the group is associated with. This is explained in more detail in the section about object cross-references. An association is assumed if any atoms of the $\sigma$ system is a group member. Recursive groups are not searched.

Examples:
group sigmas \$ehandle 1
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## group sqldget

group sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the group get command. The differences between group get and group sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## group sqlget

group sqlget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the group get command. The difference between group get and group sqlget is that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## group sqlnew

group sqlnew ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the group get command. The differences between group get and group sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## group sqlshow

group sqlshow ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the group get command. The differences between group get and group sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## group subcommands

group subcommands
Lists all subcommands of the group command. Note that this command does not require an ensemble handle, or a group label.

## group surfaces

group surfaces ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of surface patches the group is associated with. This is explained in more detail in the section about object cross-references.

Example:
group surfaces \$ehandle \$label
Note that surface patches do not need to be associated with an atom, and if they are not, they are implicitly not associated with any group.

## The mol Command

The mol command is the generic command used to manipulate molecules. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

The mol command supports, in addition to the normal label decoding process, the magic value primary as molecule label. The primary molecule is determined, in this order, by the maximum value of properties m_HEAVY_ATOM_COUNT, M_NATOMS and m_HASHISY. When there is more than one molecule where all properties are top-rated, the first molecule of these in the molecule list is chosen. An empty ensemble has no primary molecule. The pseudo molecule labels first, last and random are additional special values, which select the first molecule in the molecule list, the last, or a random molecule.

Examples:

```
mol get $ehandle 1 M WEIGHT
mol delete $ehandle 2
mol dup $ehandle primary
set pmol_label [mol mol $ehandle primary]
```

This is the list of officially supported subcommands:

## mol append

mol append ehandle label property value ?property value?..
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

## Example:

mol append \$ehandle 1 M_NAME "_linker"
mol align3d
mol align3d ehandle label box/center/masscenter/pmi ?usehydrogens?
Modify fragment atom coordinates in property A_XYZ. The arguments are the same as for the ens align3d command, except that only the selected fragment is processed.
mol atoms

```
mol atoms ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the atom in the molecule. This is explained in more detail in the section about object cross-references.

Example:
mol atoms \$ehandle !hydrogen
returns the labels of the non-hydrogen atoms in the molecule.

## mol bonds

mol bonds ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the bonds the molecule contains. This is explained in more detail in the section about object cross-references. Bonds which cross into other
molecules are not listed. Such bonds may exist if they are not of a bond type which is used to group atoms into molecules.

Examples:
mol bonds \$ehandle 1
mol bonds \$ehandle 1 \{1 doublebond triplebond\} count
The first example returns all labels of the bonds molecule 1 contains. The second example returns the number of double or triple bonds in the molecule.

## mol defined

```
mol defined ehandle label property
```

This command checks whether a property is defined for the molecule. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

Example:
mol defined \$ehandle 1 M_NAME
checks whether molecule 1 is of a type for which M_NAME is defined.
mol delete
mol delete ehandle ?abel?...
mol delete ehandle all
Delete molecules from the ensemble. All minor objects on the same ensemble which contain atoms from the deleted molecules, such as rings, groups and ring systems, are also deleted. However, these minor object sets are not completely destroyed and property data on the remaining objects remains valid, if those properties are not invalidated by merge events.

Deleting a molecule triggers a merge invalidation event, but not atomchange/bondchange events. Property data which is susceptible to this invalidation mode is recursively deleted from the ensemble.

The special label all deletes all molecules in the ensemble. Usually this is equivalent to ens clear, but in theory there may exist atom-class objects which are not part of a molecule, and these are then retained.

The command returns the number of deleted molecules.
Example:
mol delete \$ehandle 1
mol dget
mol dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the mol get command. The difference between mol get and mol dget is that the latter does not attempt computation of property data, but rather initializes the property values to
the default and return that default if the data is not yet available. For data already present, mol get and mol dget are equivalent.
mol dup
mol dup ehandle label ?datasethandle? ?position?
Duplicate a single molecule into a new ensemble. The function returns the new ensemble handle.
By default, the new ensemble is appended to the same dataset as the original ensemble, or placed outside of any dataset if the input ensemble was not a dataset member. If the optional dataset handle parameter is specified, the duplicate is directly moved to that dataset. If an empty string is passed, the duplicate is not made a dataset member, even if the input ensemble is in a dataset.

The new ensemble preserves ring information and associated property data and other minor object data from the original ensemble for all minor objects which exclusively refer to atoms which are part of the duplicated molecule. Minor objects outside the duplicated molecule, or spanning multiple molecules are not duplicated.

Example:
mol dup \$ehandle 1 [dataset create]
Duplicate the molecule with label one and move the new single-molecule ensemble into a newly created dataset.
mol exists

```
mol exists ehandle label ?filterlist?
```

Check whether this molecule exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the molecule does not exist, or fails the filter, and 1 in case of successful testing.

Example:
mol exists \$ehandle 99
mol expand
mol expand ehandle label ?allowambigous? ?noimplicith?
This command expands all superatoms in the molecule. The mechanisms for the expansion of superatoms are described in detail for the atom expand command. This command is functionally equivalent, working on all atoms in the molecule instead a single atom.

Example:
mol expand \$ehandle 1
The command returns the total number of successfully expanded atoms.

## mol expr

mol expr ehandle label expression
Compute a standard SQL-style property expression for the molecule. This is explained in detail in the chapter on property expressions.

## mol fill

mol fill ehandle label property value ?property value?...
Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

Example:
mol fill \$ehandle 1 B_COLOR red
sets the color of the first bond molecule 1 contains to red.

## mol filter

mol filter ehandle label filterlist
Check whether a molecule passes a filter list. The return value is 1 for success and 0 for failure.
Example:
mol filter \$ehandle 1 [list carbon doublebond]
checks whether the molecule contains one or more carbon atoms and one or more double bonds. The double bond does not need to be with a carbon atom.
mol get
mol get ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:
mol get \$ehandle 1 \{M_WEIGHT A_ELEMENT\}
yields a list with two elements, consisting of the molecular weight as the first element and the element numbers of all atoms in the molecule as a nested list as the second result list element. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

```
mol get $ehandle 1 B_ORDER ringbond
```

gives the bond orders of all bonds of the molecule which are ring bonds.
For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the mol get command are mol new, mol dget, mol show, mol sqldget, mol sqlget, mol sqlnew and mol sqlshow.

Further examples:

```
mol get $ehandle 1 E_NAME
mol get $ehandle 1 A_FLAGS (boxed)
```

mol groups
mol groups ehandle label ?filterset? ?filtermode?

Standard cross-referencing command to obtain the labels of the groups the molecule contains. This is explained in more detail in the section about object cross-references. Groups which contain atoms from more than one molecule are included.

Example:
mol groups \$ehandle 1
mol hadd
mol hadd ehandle label ?filterset? ?flags?
Add a standard set of hydrogens to the molecule. If the filterset parameter is specified, only those atoms which pass the filter set are processed.

Additional operation flags may be activated by setting the flags parameter to a list of flag names, or a numerical value representing the bit-ored values of the selected flags. By default, the flag set is empty, corresponding to the use of an empty string or none as parameter value. These flags are currently supported:

- keepflags

For expert use only. Do not discard $\mathrm{min} / \mathrm{max}$ values and property scope flags for atom properties when hydrogen is added.

- no2dcoords

Do not assign 2D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 2D coordinates. In any case, 2D coordinates are never added when the ensemble does no already possess valid 2D coordinates.

- no3dcoords

Do not assign 3D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 3D coordinates. In any case, 3D coordinates are never added when the ensemble does no already possess valid 3D coordinates.

- noanions

Do not add hydrogen to atoms with a negative formal charge.

- noatoms

Do not add hydrogen to atoms without any bonds.

- nocations

Do not add hydrogen to atoms with a positive formal charge.

- noelements

Do not add hydrogen if the ensemble consists purely of isolated metal atoms, which probably represent the material in elementary form, or as an alloy.

- noexcessvalences

Similar to nohighvalences, but hydrogen is not added to any atom which is not in its lowest standard bonded valence state.

- nofixatomtext

Do not adjust property A_TEXTLABEL (if present) by removing references to implicit H from it on atoms where hydrogen is added. For example, by default "NHCOOEt" becomes "NCOOEt" after adding an instantiated hydrogen to the nitrogen atom. This reduces confusion on the hydrogen status when rendering all atoms.

- nohighvalences

Do not add hydrogen to atoms which already exceed their lowest standard valence minus any formal charge. This option only applies to elements which have a defined lowest standard valence (this is configurable via the element table).

- nomemory

Do not remember the added hydrogen atoms as automatically added. Normally, a flag is retained as part of the atom information which distinguishes atoms which were added by automatic processing, such as hydrogen addition, from those which were originally input.

- nometals

Do not attempt to add hydrogen to atoms which are metals (as defined in the system element table).

- nospecial

Do not perform hydrogen addition to atoms which participate in non-standard bonds (all bonds with B_TYPE not normal).

- protonate

Add a single proton to the molecule, to the first suitable atom. The charge of the selected atom is increased, only a single hydrogen is added regardless of the standard number of missing hydrogens, and this command will issue the standard property invalidation event for atom and bond changes. In the molecule command variant, this option is rarely useful. It is supported for compatibility with the atom hadd command.

- resetmemory

Reset the origin flag described above for all atoms in the ensemble. All current atoms appear to be part of the original atom set.

Adding hydrogens with this command, except if the protonate flag is set, is less destructive to the property data set of the ensemble than adding them with individual atom create/bond create commands, because many properties are designed to be indifferent to explicit hydrogen status changes, but are invalidated if the structure is changed in other ways.

The command returns the number of hydrogens which were added.
Example:
set ehandle [ens create \{[C].[C]\}]
mol hadd \$ehandle 1
adds four hydrogens to the first carbon atom, transforming it into methane, but leave the second carbon atom untouched.
mol hdup
mol hdup ehandle label ?datasethandle? ?position?
This command provides the same functionality as mol dup, except that it also adds a standard set of hydrogens to the new ensemble.

## mol hstrip

mol hstrip ehandle label ?flags?
This command removes hydrogens from the selected molecule. By default, all hydrogen atoms in the molecule are removed.

The flags parameter can be used to make the operation more selective. It may be a list of the following flags:

- deprotonate

If this flag is set, a single proton is removed from the first suitable atom. This command variant triggers a standard atom and bond change property invalidation event, and it always ends processing after removing the first proton. Proton removal decreases the charge of the atom by one. In the molecule command variant, this flag is rarely useful - it is supported for compatibility with the atom hstrip command.

- keepalphawedge

Keep hydrogen atoms which are bonded to an atom which is at the tip of a wedgebond. This flag excludes the case where the bond to the hydrogen atom is the wedge bond - use the keepwedge flag to cover this case.

- keepisotopes

Keep hydrogen atoms which are isotope labels (including enriched/depleted ${ }^{1} \mathrm{H}$ ).

- keeporiginal

Hydrogen atoms which were not automatically added via a hydrogen addition command are retained. Note these commands commands can be run in a mode which does not leave information about automatic addition - hydrogens added this way are not protected.

- keepprotons

Keep any molecules which consist only of hydrogen atoms (such as protons, hydride anions, and molecular hydrogen).

- keepspecial

If this flag is set, hydrogens which are usually displayed, such as on aldehydes, wedge bonds, carbon triple bonds or hetero atoms are retained.

- keepwedge

Keep hydrogens which are at the end of a wedge bond, indicating stereochemistry.

- normalize

Normalize the wedge pattern for standard cases, removing excess wedges from hydrogens if the result structure is still stereochemically defined. Hydrogens which lose their wedge in this process are no longer protected by the keepwedge flag.

- wedgetransfer

If a hydrogen atom is removed which is at the end of a wedge, the wedge information is saved by transferring the wedge (changing its up/down status if necessary) to an adjacent, surviving bond. This flag has no effects if the keepspecial or keepwedge flags are set. This flag is set by default.

If the flags parameter is an empty string, or none, it is ignored. The default flag value is wedgetransfer - but the default value is overridden if any flags are set!

Hydrogen stripping is not as disruptive to the ensemble data content as normal atom deletion, except when the deprotonate flag is set. The system assumes that this operation is done as part of some file output or visualization preparation. However, if any new data is computed after stripping, the computation functions see the stripped structure, and proceed to work on that reduced structure without knowledge that the structure may contain implicit hydrogens.

The return value of the command is the number of hydrogens removed.
Example:
mol hstrip \$ehandle 1 [list keeporiginal wedgetransfer]
mol image
mol image ehandle label ?width? ?height? ?options?
This command generates a Tk image object displaying the molecule as an icon. The command is only available in toolkit variants which are linked with the portable Tk GUI toolkit library and which are either statically linked with the GD image drawing library, or can load it dynamically.

The default image size is $64 \times 64$ pixels, but this may be overridden by the width and height parameters. If only width is set, it is also used for the height. The command returns a Tk image handle. These images may for example be placed on Tk canvases as canvas objects, or used on buttons and other GUI objects.

Because of the small size of the images, atoms are not displayed as symbols, but small color-coded squares. This is a command for the implementation of graphical structure-handling applications with icons. For serious structure visualization, use the E_GIF, e_EMF_IMAGE or E_EPS_IMAGE properties.

Additional options may be added by an arbitrary sequence of option/value pairs. Color names can be those registered in the X11 color database, or a numeric specification in the \#rrggbb format. These options are currently supported:

- -background color

Background color. The default is black.

- -border npixels

Thickness of the image border. The default are 5 pixels.

- -bordercolor color

Border color. The default is blue.

- -cmode none/special/all

Display mode for carbon atoms. The default is special, meaning that only carbon atoms which usually are drawn with a C symbol are displayed as colored rectangle and not just a bond node. Highlighted atoms are always displayed.

- -highlightatom label

Select an atom for highlighting. By default, no atom is highlighted.

- -highlightcolor color

Set the highlighting color. The default is chartreuse.

- -hmode none/special/all

Display mode for hydrogen atoms. The default is special, meaning that only hydrogen atoms which usually are drawn with an H symbol are displayed as colored rectangle. Other hydrogen atoms and the bonds leading to them are suppressed. Highlighted atoms are always displayed.

- -imagename name

Explicitly set a name for the image. By default, a name of the form imagen is automatically generated. It is possible to specify the name of an existing image, which will then be overwritten.

- -linecolor color

Color of bond lines and wedges. The default is white.
Images are cached. If an image for the selected molecule with the same display attributes exists, it is reused.

Example:

```
set img [mol image $ehandle 1 80 80 -border yellow -linecolor blue]
canvas create .canvaswin image 50 50 -image $img
```


## mol index

```
mol index ehandle label
```

Get the index of the molecule. The index is the position in the molecule list of the ensemble. The first position is index 0 .

Example:
mol index \$ehandle 99
mol local
mol local ehandle label propertylist ?filterset? ?parameters?
Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

Example:
mol local \$ehandle 1 A_LABEL_STEREO
Note that very few computation routines currently support the local re-computation of data - in most cases, this command falls back to a global re-computation.

## mol match

```
mol match ehandle label ss_ehandle ?ss_label? ?matchflags? ?ignoreflags?
    ?atommapvar? ?bondmapvar? ?molmapvar?
```

Check whether the selected molecule matches a substructure. Only the first molecule, or the molecule selected by the substructure label parameter, is tested. The substructure may be part of any structure ensemble, and even be in the same ensemble as the primary command molecule. Both the atoms in the molecule and the bonds between them are checked.

The precise operation of the substructure match routine can be tuned by providing a standard set of match flags and feature ignore flags. The default match flag set has set bits for the bondorder, atomtree and bondtree comparison features, and an empty ignore set. If a flag set is specified as an empty string, the default set is used. In order to reset a flag set, an explicit none value must be used. The bit options of the match flag are explained in the documentation of the match ss command.

The command returns 1 for a successful match, 0 otherwise. If an optional atom, bond, or molecule map variable is specified, it is set to a nested list of matching substructure/structure atom, bond or
molecule labels. If no match can be found, the variable is set to an empty list. In case only a bond or molecule map variable is needed, an empty string can be used to skip the unused map variable argument positions.

Example:
set $s s$ [ens create \{c1ccccc1.c1ncccc1\} smarts]
set m_contains_phenylring [mol match \$ehandle \$label \$ss 1]
mol mol
mol mol ehandle label
Standard cross-referencing command to obtain the label of the molecule as stored in property m_LABEL. This is explained in more detail in the section about object cross-references.

Example:
mol mol \$ehandle \#0
returns the label of the first molecule of the ensemble molecule list.

```
mol mol $ehandle primary
```

returns the label of the primary molecule in the ensemble.

## mol new

mol new ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the mol get command. The difference between mol get and mol new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## mol nget

mol nget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the mol get command. The difference between mol get and mol nget is that the latter always returns numeric data, even if symbolic names for the values are available.
mol pis
mol pis ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\pi$ systems the molecule contains. This is explained in more detail in the section about object cross-references.

Examples:
mol pis \$ehandle 1
$\pi$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use p or d orbitals, such as in standard covalent multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## mol replicate

mol replicate ehandle label ?count?
Add duplicates of the selected molecule to the command ensemble. The default number of duplicates is one, but any other number may be requested by setting the count parameter. If the count is less than one, the command is silently ignored.

The command returns the labels of all newly created molecules as a list. New molecule labels begin at one plus the highest old label. All atoms, bonds and other chemistry objects which are created by the command are appended to the object lists in the ensemble and will thus bear higher labels than any existing label of their class in the ensemble. This command triggers a merge property invalidation event.

The mol dup command duplicates a molecule into a new ensemble, which is quite different from what this command does.

Example:

```
set eh [ens create C.CC]
mol dup $eh 1 2
echo [ens get $eh E_SMILES]
```

returns C.CC.C.C, because the first molecule (label one) was duplicated twice.

## mol rings

mol rings ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the rings the molecule contains. This is explained in more detail in the section about object cross-references. Rings which are not restricted to the selected molecule are listed. Under certain circumstances, it is possible to have rings which span more than one molecule.

Examples:

```
mol rings $ehandle 1
mol rings $ehandle 1 [list heterocycle aroring]
```

The first example returns the labels of all rings the molecule contains. If the molecule does not contain any rings, an empty list is returned. Only labels of rings in the SSSR or ESSSR set are returned, even if the currently computed ring set is larger. The second example filters the rings - only heteroaromatic rings are reported.

## mol ringsystems

mol ringsystems ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the ring systems the molecule contains. This is explained in more detail in the section about object cross-references. Ring systems which are not restricted to the selected molecule are listed. Under certain circumstances, it is possible to have ring systems which span more than one molecule.

Examples:

```
mol ringsystems $ehandle 1
mol ringsystems $ehandle 1 [list heterocycle aroring]
```

The first example returns the labels of all ring systems the molecule contains. If the molecule does not contain any ring systems, an empty list is returned. The second example filters the ring systems - a ring system label is included in the output list only if that ring system contains one or more hetero aromats.

## mol rotate

mol rotate ehandle label angle axis ?center?
Rotate the molecule in 3D space on property A_XYZ. This command requires 3 D atomic coordinates. If these are not yet present, an attempt is made to compute them. The rotation angle is specified in degrees. The first point is the axis vector - it can be specified in any format the TcL vec command understands. By default the center of rotation is the center of the molecule bounding box, but by providing explicit center coordinates, any center of rotation can be set.

This command triggers a 3Dop property invalidation event.
Example:
mol rotate \$ehandle 150 \{1 1 0 \}
rotates the molecule around its center 50 degrees counter-clockwise along the 45 -degrees xy-diagonal.
mol set
mol set ehandle label property value ?property value?..
Standard data manipulation command for setting property data. It is explained in more detail in the section about setting property data.

Example:
mol set \$ehandle 1 M_NAME "Pharmacon X-25"
mol show
mol show ehandle label propertylist ?filterset?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the mol get command. The difference between mol get and mol show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, mol get and mol show are equivalent.

## mol sigmas

mol sigmas ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\sigma$ systems the molecule contains. This is explained in more detail in the section about object cross-references.

Examples:
mol sigmas \$ehandle 1
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond
in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## mol sqldget

mol sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the mol get command. The differences between mol get and mol sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## mol sqlget

mol sqlget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the mol get command. The difference between mol get and mol sqlget is that the SQL command variant formats the data as SQL values rather than for TCL script processing.
mol sqlnew
mol sqlnew ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the mol get command. The differences between mol get and mol sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## mol sqlshow

mol sqlshow ehandle label propertylist ?filterset?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the mol get command. The differences between mol get and mol sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## mol subcommands

mol subcommands
Lists all subcommands of the mol command. Note that this command does not require an ensemble handle, or a label.

## mol surfaces

mol surfaces ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of surface patches the molecule is associated with. This is explained in more detail in the section about object cross-references.

Example:
mol surfaces \$ehandle \$label
Note that surface patches are not required to be associated with any atom, and if they are not, they are implicitly not associated with any molecule.

## mol translate

mol translate ehandle label pt1 ?pt2?
Move a molecule in 3D space. This command requires atomic 3D coordinates in property A _XYZ and will attempt to compute them if they are not yet present. If no 3D atomic coordinates can be generated, the command fails with an error.

The movement vector may either be specified by a single vector, or two points. If two points are used, the subtraction of the second point from the first is used to compute the movement vector. Both point/vector arguments understand the same vector notation syntax as the vec command.

This command triggers a 3 Dglop property invalidation event.
Example:
mol translate \$ehandle $1\left\{\begin{array}{llllll}1 & 0 & 0\end{array}\right\}\{2000\}$
moves the molecule one Ångstrom in x-direction.

## mol valencecheck

mol valencecheck ehandle label ?failedatomvariable?
Perform a valence check on the molecule, comparing the current bonding situation at all atoms to the list of element-specific valence states in the system element table. This command is intentionally quite picky, discouraging for example the use of pentavalent nitrogen. For the calculation of valence, only bonds of type normal are taken into account. Complex bonds and pseudo bond types thus do not interfere in the calculation. Some more exotic metal atoms with many different valence states, or few well-defined covalent compounds, such as vanadium or rhodium, always pass.

The return value of this command is the number of atoms which failed the valence check. If the optional parameter failedatomvariable is specified, it is the name of a variable which is set to a list of the atom labels which did fail, or is set to an empty list in case no problems were found.

Note that this command assumes that all hydrogen atoms are in place. Checking ensembles with implicit hydrogen atoms is not supported.

Example:
mol valencecheck [ens create $\{C N(=O)=O . C[N+](=O)[O-]\}] 1$ badatoms
mol valencecheck [ens create $\{C N(=O)=O . C[N+](=O)[O-]\}] 2$ badatoms
These sample commands check the valence situation of nitromethane in two encoding formats. The first molecule, using a pentavalent nitrogen encoding, returns 1 , indicating one failed atom, and the variable badatoms is set to 2 , the label of the pentavalent nitrogen. The second molecule, checked
with the line below, passes without problems, with a return value of 0 and an empty badatoms variable.

## The molfile Command

The molfile command is the generic command used to manipulate chemical structure and reaction files. These can be of any supported format, not just MDL molfiles.

Molfiles are major objects. They are uniquely identified by their label alone. Molfiles do not contain minor objects.

Example:

```
set fhandle [molfile open myfile.sdf]
set ehandle [molfile read $fhandle]
molfile get $fhandle record
```

As explained in more detail in the section about working with structure files, the molfile handle identifier can be replaced by a file name. This file is automatically opened, the command executed, and the file closed in a single one-shot operation.

In the context of structure files, file-related data is usually provided as attributes. However, molfiles can store property data like any other chemistry object.

Example:
molfile get \$fhandle F_COMMENT
This is the list of currently officially supported subcommands:

## molfile append

```
molfile append filehandle property value ?property value?..
```

Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data. This is not a command to append file records. Use the molfile write command for this purpose.

Example:

```
molfile append $fh F_GAUSSIAN_JOB_PARAMS(route) "Opt=(AddRed,CalcFC)"
```

molfile backspace

```
molfile backspace filehandle ?nrecords?
```

Position the file pointer backwards. If no record counter is specified, the file is backspaced by a single record. It is an error to attempt to reposition the file before the beginning of the file.

Examples:

```
molfile backspace $fh
molfile set $fh record [expr [molfile get $fh record]-1]
```

These two sample lines provide identical functionality.
The molfile backspace command is often used in combination with the molfile copy command in order to copy records with specific properties verbatim:

```
set eh [molfile read $fh]
if {[strucuture_passes_condition $eh]} {
    molfile backspace $fh
    molfile copy $fh $outfilehandle
```


## molfile close

```
molfile close ?filehandle? ...
```

molfile close all
Close one or more file handles. If the file handle corresponds to a scratch file, the file is deleted. If it corresponds to a pipe, all programs in the pipe are shut down.

If all is passed instead of a set of file handles, all currently opened structure files are closed. Standard TcL files are not affected.

It is a good idea to close files when they are no longer needed. In addition, while most file format I/O modules commit all data to disk after each record has been written, so that a clean close-down is not absolutely required, there are file formats for which the I/O module has a cleanup or finalization routine which is only called if the file is properly closed.

The command returns the number of files which were closed.
Example:

```
set fhandle [molfile open scratch]
molfile close $fhandle
```

The example closes a scratch file, which is automatically deleted from disk when it is closed.
On normal interpreter program exit, the close functions of all remaining open file handles are automatically called.

## molfile copy

molfile copy filehandle ?channel? ?count? ?record?
Copy a record to a TcL channel, to a Cactvs structure file handle, or retrieve it as a byte image. No interpretation or formatting of the data in the file record(s) takes place - the data is copied verbatim, byte by byte.

If file format conversion is desired, the data items (ensembles, reactions, datasets) must be explicitly read (molfile read command) as chemistry objects and written to another molfile opened for output in the desired format (molfile write command). That procedure involves re-formatting and potential loss of formatting or information which was not captured by the input routine, or cannot be written by the output routine.

By default the next record after the current file pointer position is returned as a byte image. The optional parameters allow the selection of a specific record (beginning with 1 for the first record), the copying of multiple records in one command (by default, a single record is copied), and output to alternative TCL channels or CACTVS molfile structure file handles. If an empty string or the value 0 are used as start record number, the file is copied from the current position. If the record number is negative, it is interpreted as offset from the current position. Therefore, passing -1 as parameter instructs the command to backspace by one record prior to copying. Not all files can be backspaced. If the special count values end or all are used, all remaining records in the input file are copied. Otherwise, if the number of available records is smaller than the requested copy count, an error results.

If the output channel argument is omitted, or set to an empty string, the record(s) are returned as a byte sequence command result. Otherwise, the data is written to the file handle the argument is connected to. For Cactvs molfile handles, the destination is the current write position of the underlying file handle. On Unix/Linux systems, writable active TcL file or socket handles (in the form filexxx or sockxxx ) are also supported, but not on Windows. Additionally, the special output channel names stdout and stderr can be used. If output is written to a channel, and not returned as blob, the number of actually copied records is returned as the command result.

The I/O modules for $c t x$ and $s d f$ formats provide optimized fast copy routines and are thus notably faster to copy then other file formats without explicitly encoded record positions. These still need to read the file line by line and maintain a parser state, though they can avoid decoding the record contents as structures or reactions.

## Example:

```
set eh [molfile read $fhandle]
set fhout [open "metal_compounds.sdf" w]
if {[ens atoms $eh metal exists]} {
    molfile copy $fhandle $fhout 1 [expr [molfile get $fhandle record]-1]
}
```

This example reads a structure from an input file, checks whether is contains a metal atom, and if yes, copies the record unchanged to an output file, which is opened as a simple TcL text file channel in this example. The expression which forms the last parameter backspaces the input file by one record, so that the same record which was just read can be copied. A simpler solution for the same functionality is to simply pass -1 as argument. This works of course only if the input file can be repositioned backwards. i.e. normal text files are fine, standard input or a socket connection do not work.

## molfile count

molfile count filehandle ?maxrecs? ?readscope?
Count the number of records in the file.
If the file format contains an internal or external record index with information about the complete file, the answer is produced from the index, and thus is typically obtained fast. Otherwise, the file is skipped from the current position until the end, and the sum of the number of records encountered while skipping and the record index when the count started is returned. In case of files which are rewindable, the original input file pointer position is then be restored. On non-rewindable files, the file contents are consumed, and no return to the old input position is possible. For files which are opened for writing, the count usually is simply the current output position, except for those few file formats which support in-file record replacement in combination with a complete file index. In the latter case, the count is again extracted from the index.

During the record skipping part the file contents are not physically read if possible. Rather, the skip function of the responsible file format I/O module is used to scan the file effectively. After arriving at the end of the file, a full in-memory record position index has been assembled for the file, and future record selection within files which support re-positioning is fast.

The type of record boundaries counted depends on the input scope of the file. For file formats which support multiple input modes, such as for extraction of ensembles or molecules or datasets, the count is dependent on the type of object which is configured to be read. If the file input object type is changed, the in-memory record index table is discarded.

If the maxrecs parameter is specified, and is not a negative number, it is the maximum count reported. No attempt is made to position the file beyond this mark during the count process. This has no effect on future input operations - these may still proceed beyond the reported count. This option is not intended to be generally useful, but is used for example in the structure browser $c s b r$ with the $-m$ option to enable quick inspection of a file without full scanning.

The optional readscope parameter can be used to temporarily modify the read scope under which the file is processed. It can be any of the generally recognized values (mol, ens, reaction, dataset). If the file format does not support the specified mode, its default mode is silently used. If the file is not positioned at the beginning of the data, the count reports the sum of the currently known records as perceived by the previous read scope, and the remaining file records under the new one. If these values are different, the result may only be useful under very specific circumstances. The the parameter is not set, or an empty string is passed, the currently set, or, for one-shot file operations, the default read scope, is used.

Example:
set nrecs [molfile count "thefile.sdf"]
set nrecs [molfile count "test.spl" -1 mol]
molfile dataset
molfile dataset filehandle
Return the handle of the dataset associated with the file handle. If no such dataset is set, the command returns an empty string. The command
molfile get \$filehandle dataset
is equivalent.
This command is different from the dataset commands for ensembles, reactions or tables, where it indicates membership in a dataset. File objects cannot be a member of a dataset. This dataset association is explained in more detail in the molfile set command section.

## molfile defined

molfile defined filehandle property
This command checks whether a property is defined for the structure file. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The molfile valid command is used for this purpose.

## molfile delete

molfile delete filehandle recordlist ?rebuild_index?
Delete records from the file. The file must have been opened for writing or update, and be rewindable. In case the file is not a simple record sequence, the I/O module for its format must provide a deletion function, or the operation will fail.

The deletion record list is a set of record numbers in any order. They are sorted and duplicates removed. It is no error to specify an empty removal record list. The record numbering starts with one, and the record numbers are referring to the record numbering at the moment the command is issued. There is no need to compensate for intermediate record numbering shifts when more than one record is deleted.

The optional index rebuild parameter, a boolean value, can be set to optimize the deletion process for files in formats which maintain field index information. By default, indices are updated as part of the deletion process. In case many records are deleted, it may be more efficient to drop the indices prior to the deletions and rebuild them after the records have been removed. In order to select this alternative procedure, a true parameter value can be set. At this time, the only file format which actually can use that parameter is the $b d b$ database file format.

In case the file is to be truncated, the molfile truncate command is usually more efficient.
This command returns the number of deleted records. It does not close or destroy the file handle, or the underlying file.

## molfile dget

molfile dget filehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the molfile get command. The difference between molfile get and molfile dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, molfile get and molfile dget are equivalent.
molfile dup
molfile dup filehandle
This command duplicates a file handle. The duplicate handle points to the same underlying file or other data channel, is opened in the same access mode, and positioned at the same record. Also, all file object attributes and file properties are set to identical values.

Currently, it is not possible to duplicate virtual file sets opened by a molfile lopen command.
The command returns a new file handle.

## molfile exists

molfile exists filehandle
Check whether a file handle is currently in use. The return value is the boolean result. No error is raised if the file handle cannot be decoded.

## molfile extract

molfile extract filename retrievallist
Extract the contents of data fields from the file, without reading full structure or reaction records i f possible. This operation requires a support function in the I/O module for the file format. Generally, only formats optimized for query operations, such as the Састvs $b d b$ and $c b s$ formats provide such a function in their I/O module.

This command is essentially a shortcut for a molfile scan command with an empty query condition and a propertylist retrieval mode. Please refer to that command for details about the possible contents of the retrieval list.

The result is a nested list of extracted property values, with one outer list element for every file record to the end of the file, and inner list with one element per retrieval field.
molfile filter
molfile filter filehandle filterlist
Check whether the structure file passes a filter list. The return value is 1 for success and 0 for failure.
Example:
molfile filter \$fhandle \$filter

## molfile fullscan

molfile fullscan filehandle queryexpression ?mode? ?selectlist? ?parameters?
This command is the same as molfile scan, except that an automatic rewind (see molfile rewind) is performed before the query is executed. The same effect can be achieved by setting the startposition parameter value to 1 .

## molfile get

```
molfile get filehandle propertylist ?filterset? ?parameterlist?
```

molfile get filehandle attribute

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

The molfile object possesses a rather extensive set of built-in attributes, which can be retrieved with the get command (but not its related subcommands like dget, sqiget, etc.). Most of them can also be manipulated with a set command. In addition, molfile objects can possess file-level properties. The standard prefix for these is $\mathrm{F}_{-}$.

Example:

```
set c [molfile get $fhandle F_COMMENT]
```

These built-in attributes are:

- atomlabelproperty

The name of a property which holds data for a parallel user-defined atom numbering scheme (see writeflags/writelabels attribute) which can be output by some I/O modules. The default property is A_LABEL. The property must be associated with atoms, but is not required to be an integer, if the I/O modules supports alternative data types (i.e. for CDX/CDXML the label data in the file format is internally a string, and any different property data type is converted as necessary). This attribute has an effect only if the writelabels flag is also set in the writeflags attribute.

- authorization

A service authorization URL, which might for example be presented to the user for approval of access to a resource. In the case of dropbox file access, this data is copied from the global value of the I/O module (see filex get command). For normal files, this attribute is empty, and setting it to a string value has no effect.

- batchsize

The number of records in a standard processing batch. The default batch size are 10 records.

## - bondlength

The standard bond length to be used in the file. The unit is points ( $1 / 72 \mathrm{inch}$ ). If the value is negative (the default), the standard format-specific bond length is used. This attribute is only supported in a few graphics-oriented file formats, such as CDX or SKC files, or EMF images.

- cachesize

The size of the record prefetch cache the file should use. Normally, the size is zero and no such cache is employed. The I/O modules for a few file formats, such as PuвСнем CID and SID files, where the individual retrieval of a record via the Internet is almost as expensive as fetching a sizable batch, use a cache if allowed and prefetch multiple records when a record read operation is performed and the cache is empty or the requested record is not in the cache. A later read can, if the input record is in the cached set, return the data without establishing a new network connection.Using a cache is beneficial only when the expected access pattern is linear and in ascending record order. It decreases performance if the record access pattern is random and not limited to a continuous record set that fits into the cache.

- chain

A single-letter code indicating the chain to be read from records with structure disorder data. These can for example be found in PDB files. The default value '?' automatically selects the first chain which is encountered in the file record. After a record has been read, the attribute is set to the actual character of the chain which was selected, so it needs to be reset in case more than one record is input via this file handle. If the chain character is set to an empty string, all atoms are read from files even if they belong to multiple overlapping disordered structure instances. This can of course lead to problems in connectivity representation. The alternative name disordered is an alias for this attribute.

- compact

A boolean flag indicating whether the file is present in a abridged form, or should be written as compact as possible. This attribute effects few file formats. An example is the native Cactvs ASCII format (cascii).

- complexresolver

A boolean flag which enables or disables bond type processing after input. It the flag is on, typical complex bonds between metal atoms and ligands, or between metal atoms, are recognized and re-coded as complex bonds, which provide connectivity, but do not participate in valence electron counting. In many cases, this improves the general representation quality of the structures. However, since most chemical data exchange formats do not support this type of bonds, it can also make export of the data difficult. By default, this flag is on. For maximum portability, it should be switched off. This attribute is a convenience shortcut operating on the readflags attribute.

- computationlog

A read-only attribute. It is a list of all properties which were computed during a record write operation. This can be used to determine which effects the output has had on the information content of a written object, or to optimize I/O throughput by performing pre-computation of these properties in a separate thread.

- compression

The detected file compression type. It can be one of none, compress, pack, gzip or bzip2. Compressed files are automatically opened for reading via a pipe to the suitable decompressor program, if it can be located. This attribute can also be set, but it currently has no effect on the actual output in any format. In order to write compressed files, open an output as a pipe to a compressor program.

- ctime

A read-only attribute reporting the time of the last status change of the file. Its unit are seconds since January 1st, 1970. This value is meaningful only for normal disk files.

- deletable

Flag indicating whether this molfile can be deleted or closed with a standard molfile close command. The attribute is read-only. Molfiles which are, for example, property data values or a part of a molfile loop command cannot be deleted by standard means.

- deselection

This somewhat awkwardly named attribute is the inverse of the selection attribute. For further explanation, refer to the paragraph on selection.

- device

A read-only attribute reporting the device number of the file. This is meaningful only for normal disk files, and only supported on Unix/Linux.

- droplist

A list of properties which are not to be written to the file, even if they are already present on output objects and the file format can encode them. Naming a property in this list does not delete them from the property set of objects which are written to the file, just suppresses their output.

- embedformat

The format of embedded objects encoded in another format. This is meaningful only for a few file formats, for example zip (which contains single-record files of a different type) or $r t f$ (which may contain $c d x$ or $s k c$ embedded OLE objects). If this attribute is not set, the default depends on the wrapper format (i.e. SDF files for $z i p, c d x$ OLE objects for $r t f$ ).
Setting it to an empty string or none disables embedding where applicable. The attribute is updated on input and can be read when a file record is input which contains embedded data.

- encoding

The detected encoding type of the file. It can be one of ascii, binary or unicode. This is a read-only attribute.

- eof

This read-only boolean attribute indicates whether the file read pointer is at the end of the file.

- eolchars

A sequence of characters which are used as line terminators for the output of text-based file formats which do not define a specific line end character. The default value is
platform-dependent. It is a single newline character on Linux/Unix, CR/LF on Windows and a single CR on Macs. This attribute has no effect on input. All input routines automatically recognize and read all three variants on all platforms.

On setting, the magic strings windows, mac (both checked for the first three characters only) as well as unix and linux are translated to the standard platform line terminators and not copied verbatim. Alternative names for these standard system encodings are $c r l f, c r$ and $l f$. The special value default resets the attribute to the platform-dependent default.

- eor

A read-only attribute which indicates at what type of record terminator the current read position is located. Possible values are none, mol, ens, reaction and dataset. The none value indicates that reading did stop in the middle of a record due to some problem.

- errorproperty

A read-only attribute which holds the name of the last property where input failed. This is not supported by all file I/O modules. It is especially useful for binary formats where a line number cannot be used for simple visual inspection of an input problem.

- failures

A list of properties for which computation failed on this file object. This is a read-only attribute. Depending on configuration settings, this information may be used to block pointless attempts at re-computation of incomputable data.

- $f d$

A read-only attribute which reports the system channel number the file object is associated with.

- fields

This is a list of the names and potentially attributes of data fields in the file. For simple formats such as SD files, this is simply a list of property names, and it is updated after each read record to track a potentially changing field set. For more complex formats such as $b d b$ and $c b s$, every list item is a nested list which contains the field name, field flags, field object class association and partition file. The field output for simple formats such as SD is controlled via the writelist attribute, and the value of the fields attribute has no effect on output. However, the I/O modules for complex database-type formats such as $b d b$ and $c b s$ provide a handler function which translates an updated value of this attribute into a changed database layout. Depending on the I/O module, this may be supported only for an empty file $(c b s)$, or may be possible even for files which already store records ( $b d b$ ). This attribute can also be addressed by the alias fieldnames.

- filelock

On reading, this is a boolean flag indicating whether a file lock is currently set on the file or not. On setting, the argument can be release, trylock, forcelock or test. The first variant attempts to release an existing file lock, the second variant attempts to set a file lock, but returns immediately if that is not possible, the third variant blocks until the lock can be established, and the fourth version tests for the presence of a lock. The return value is a boolean status result. This command is not supported on Windows. File locking may pose special problems if the file is not residing on a local file system. The underlying system call is lockf64() or $\operatorname{lockf().~Please~consult~your~operating~system~manual~for~more~details.~}$

- fileset

A read-only attribute containing a list of the names of the physical files which are behind the file handle. For normal files, this is a single list element for a single file. However, for file handles opened by means of the molfile lopen command to access a virtual file assembled from multiple physical files, this can be a list with more than one element.

- filter

A query expression (see molfile scan command) which input records must match to yield a result object when a molfile read command is run. The read command is automatically looped until a matching record is found, or the end of the input source is reached. Since the test is only applied after a prospective input object has already been fully read internally, this style of record filtering is in many cases considerably less effective than using molfile scan for file formats which possess query acceleration features, such as CBS, BDB or the Pubchem virtual file module. For the reading of simple text files, such as SDF, there is no performance difference to using molfile scan in the ens or reaction object retrieval mode, and this type of filter which can be easily adjusted or disabled (by setting it to an empty string) can be convenient.

- fontsize

The standard font size for text in graphics-oriented formats, such as CDX or SKC. The value is a floating point number measured in points ( $1 / 72$ inch). A value of zero or less, which corresponds to the default, lets the software chose a suitable value, which is dependent on scaling and bond length.

- fold

The number of characters after which the software should look for a good position to use a continuation character and line break. This is only used in a few formats, such as SLN.

- format

The standard name of the file format the molfile object is linked to. This is normally only set in scripts for output files, because the format for input files is auto-detected.
Nevertheless, it is possible to set a format explicitly also for input files, and even to switch it when records have already been read. When setting a format, generally a set of alias names are recognized in addition to the short official name.

- from

The sender of a file. This is only set when the file has been extracted from a mail message or attachment.

- handle

The handle of the file as a read-only attribute. Not generally useful, because in standard access modes you already need the handle to identify the file object.

- height

The maximum height of a structure or reaction depiction in points ( $1 / 72$ of an inch). This is only used for graphics-oriented formats, such as CDX, SKC or EMF. If the attribute is set to a negative value, which is the default, the size is indirectly controlled by the bond length and atom coordinates. In case this attribute is set to a positive value, and the depiction would exceed the maximum height, it is automatically scaled down proportionately.

- hidden

Flag indicating whether the molfile is hidden. This is not the same as the invisible state. This attribute is intended to be used for rendering object selections. This attribute can be set.

- highmaprecord

The maximum record to include in a memory-mapped section of the file for accelerated read access. If set to a negative value, which is the default, the system automatically determines if mapping is worthwhile, and if it is, map the full file. This attribute is primarily useful for the acceleration of queries which repeatedly operate in a section of a larger file, for example when running distributed queries with multiple processes handling different parts of a large file.

- host

This is a shortcut for the host name part of a file or virtual file addressed via an URL. For simple retrieval it is equivalent to the URL field attribute url(hostname). For some I/O modules, for example the interface to access MYsqL tables as virtual structure files, a change of the host name does have an effect and results in (re)-connection to a different database host. For normal files accessed via a URL a change of the attribute is ignored after the file has been opened. Files that are not associated with an URL have an empty host name value.

- hydrogenfilter

A hint about the desired output style of hydrogen atoms of the structure. In contrast to the hydrogens attribute, this hint does not actually change the structure by adding or removing hydrogen atoms, neither on the original output object nor a temporary processed structure or reaction duplicate. Not all I/O modules support this flag. Its availability can be queried via the capabilities attribute of the filex command for the format. The possible values are default (or -1 ), which is the default and selects the default hydrogen write mode of the file format, none (or 0) which suppresses hydrogen output, special (or 1) which writes hydrogens shown normally with a symbol only, and all (or 2), which writes all extant hydrogens. Since this attribute does not change the hydrogen atom set, setting for example the mode to all when there are no hydrogens attached to the structure has no effect.

- hydrogens

The hydrogen processing mode of the file. Its default can be controlled via the system variable $::$ cactvs(default_hydrogen_addition_mode). Its standard setting is asis, meaning the hydrogen set is to kept as it stored in the objects for output, or defined in the original file records for input. Possible modes for this attribute, or the system control variable, are add (add a complete standard set of hydrogens), asis (keep unchanged), strip (strip hydrogens except those which are normally displayed, such as bonded to hetero atoms or at stereo centers), stripall (strip all hydrogen), stripadded (strip all hydrogens which were added by a hydrogen add command, automatic hydrogen addition on input, or similar mechanisms) and addblind (which is the same as add, but does not register the added hydrogen atoms as implicit in property A_IMPLICIT). When writing a structure object to a file with enabled hydrogen processing, the original object is not changed. Hydrogen processing takes place on a ephemeral duplicate object. On input, hydrogens which are no explicitly encoded, but defined via implicit valence rules in the format specification are still instantiated in asis mode. For example, a single C atom in an MDL Molfile is read as a single atom, because there are no default valence rules, but a C as a SMILES string is expanded into one carbon plus four hydrogen atoms. For a method to suppress the expansion of valence-implicit hydrogen atoms, see the readflags attribute.

- hydrogenstatus

An enumerated value providing information about the hydrogen status of the file. Possible values are unknown, complete (all hydrogens present), partial (some hydrogens present) and missing (no hydrogens present). This attribute is updated when data is read from files which encode this information. It may also be set and has an effect on some post-processing operations on objects read from the file.

- ignoreempty

A boolean flag which instructs, when set, the I/O module of the file format associated with the molfile object to ignore empty records without atoms when reading from the file. By default, this flag is not set and empty records are retrieved as empty ensembles or other objects.

- ignoreerrors

A boolean flag which tells the I/O module of the file format associated with the molfile object to ignore errors and to attempt to read or write the next record instead. By default the flag is not set and errors in I/O result in Tcl script command errors.

- ignorelist

A list of properties which should not be read from the file, even if they are explicitly encoded in the records.

- incomplete

This is a boolean read-only boolean flag which indicates that a record was only read partially. This is the same as checking for the presence of the incomplete flag in the flags attribute.

- inode

A read-only attribute reporting the inode number of the file. This is meaningful only for normal disk files, and only supported on Unix/Linux.

- invisible

Flag indicating whether the molfile object is invisible. This is not the same as the hidden state. An invisible object is no longer accessible via its handle. This is usually the case for objects which are scheduled for deletion, but still have lingering referring pointers. This attribute is read-only.

- iscompressed

A boolean read-only attribute which is set when the file is compressed by one of the recognized compression algorithms (gzip, bzip2 by default). In that case, the file is not accessed directly but via a pipe the the appropriate decompression program, which changes the file handling characteristics.

- ismapped

A boolean read-only attribute which is set when the file is read via a memory-mapping method.

- ispipe

A boolean read-only attribute which is set when the file is accessed via a pipe, either because it was explicitly opened to a pipe, or because decompression (gzip, bzip2) or character encoding (iconv) programs where automatically spliced in.

- jstreversal

A boolean flag indicating whether the JST special encoding variant for MDL Molfiles should be used.

- lastrecord

The value of the file record read position before the last molfile read command. This is normally the value of the record molfile attribute after the read operation minus one and corresponds to the file record number of the read object in the data file.

- line

A read-only attribute returning the current line number. $l c$ is an alias name for this attribute. Generally this attribute is meaningful only for text-based file formats. For most binary formats, the value of this attribute is the same as the record number. This line number always refers to the current physical file. To get the global line number of a virtual file set, use the vline attribute.

- loopitem

The current file input item in molfile loop statement. This is the same as the content of the loop variable. If no loop is active, this is an empty string. This is a read-only attribute.

- lowmaprecord

The minimum record to include in a memory-mapped section of the file for accelerated read access. If set to a negative value, which is the default, the toolkit automatically determines if mapping is worthwhile, and if it is, map the full file. This attribute is primarily useful for the acceleration of queries which repeatedly operate in a section of a larger file, for example when running distributed queries with multiple processes handling different parts of a large file.

- mailencoding

This is a read-only attribute which is only set if the file has been extracted from an email message or attachment. Possible values are unknown, ascii, iso (for ISO 8859-1), quoted (for quoted printable), base64 and utf8.

- mailproperties

This is a read-only attribute which is only set if the file has been extracted from an email message or attachment. It is a list of properties which were requested for computation in a header field. This attribute is typically used for setting up email-based property computation services.

- maxblobsize

The maximum size of Састvs ensemble or reaction blobs which are part of the file records, measured in bytes. This attribute only applies to those few file formats which store structure and reaction data as CACTvs toolkit blobs. Currently these are CBS and BDB. If the blob size exceeds the limit, the input or output of the record fails. The default value are 256 K , which is more than sufficient for standard applications. If the attribute is changed, a minimum value of 64 K is silently enforced. Increasing the attribute can have a small negative effect on I/O performance, but is otherwise safe.

- mimeboundary

This is a read-only attribute which is only set if the file has been extracted from an email message or attachment. This is the string which was used to separate MIME data blocks in the message.

- mimedefaulttype

A read-only attribute giving the default MIME type associated with the current file format.

- mimetype

The currently configured MIME type for the file. Initially, it is set to the default type (attribute mimedefaulttype). However, it can be changed, and it is used for transmitting the file data via various types of Internet connections.

- modcount

The molfile object modification count. This is a read-only attribute.

- mode

This is a read-only attribute which describes the general file access mode which was established when the file handle was created by a molfile open or molfile lopen command. Possible values are append, pipe, read, string, write and update. Note that in this attribute there is no difference between the standard read and the restricted read-only modes (see molfile open). The file mode cannot be changed at a later time by directly changing the mode attribute. However, with some limitations, a file may be switched back and forth between input and output modes with the aid of the molfile toggle command.

- mtime

A read-only attribute reporting the time of the last modification of the file. The unit is seconds since January 1st, 1970. This value is meaningful only for normal disk files.

- name

On input, this attribute simply reports the full path name of the underlying file, or the original magic name in case of special files. This attribute can also be set, and in case of normal disk files, the physical file is renamed, too, if the file access permissions are sufficient for this operation.

- nitrostyle

The nitro (and similar) group encoding conventions associated with the file handle. There are actually independent settings of this attribute for input and output. The version reported by the command is dependent on whether the file is in input or output mode. Possible values are asis, ionic neutral, xionic and xneutral. The default input value is ionic, while the default output value is asis. When the value is modified, the new value is stored both for input and output. If the value is not asis and a structure item is read, its nitro group (and related groups) connectivity is automatically adjusted to the preferred style. If processing is requested for output, the connectivity change is performed on a temporary duplicate, so that the original output object is not modified.

- nullstring

A string which on input is used to identify nULL values, or used on output to encode NULL values. This attribute is only used by a few I/O modules. The most important application is in reading text-based tables with embedded structure notations by means of the table structure I/O module.

- offset

A read-only attribute reporting the current byte offset position of the read or write pointer. It is not meaningful for all types of data channels.

- orientation

This value can be none (the default), landscape or portrait. It describes the orientation of a drawing area specified via the paper attribute. Few I/O modules use this information. The most important formats which implement this is are CDX and CDXML.

- originalname

The name as originally used to create the molfile object. The standardized name, with path information in case of disk files, can be accessed via the name attribute. Changing this attribute has no effect on the file system. This is different from the handling of the name attribute.

- pagecount

The number of (vertically stacked) pages in the document. This attribute is currently only used for the CDX and CDXML formats.

- paper

An attribute describing the size of the drawing areas for formats such as CDX or CDXML, which can encode this type of information. Possible values are none (the default), a3, a4, $a 5, a 6, a 7, b 3, b 4, b 5, b 6$, letter, legal and executive. The associated orientation of the drawing orientation can be set via the orientation attribute.

- parameters

A free-form string which can be used to pass additional, non-standardized parameters to a file format I/O module. Few I/O modules use this, one example is the XFIG output code.

- password

A file access password. It is used in various contexts, for example for authentication when using URL-based access to files, to enable the I/O of encrypted records in files which support partial data encryption, such as the CACTvs CBS and BDB formats, or to proceed with the execution of a remote query received via a listener port. In most cases a change of the attribute value after a file has been opened has no effect. An exception are modules which access database tables as virtual structure files. These will react to a changed user name with re-authentication to the database and table, which may result in different access permissions.

- polysymbol

A free-form string used to override the standard symbol used by a file format I/O module to indicate polymer components. If set to an empty string, the standard symbol is used, which depends on the file format. The default is an empty string.

- port

The number of a port on which the file handler should accept remote query requests. If set to a negative value (the default), no such requests are accepted, and in case a monitor thread was executing before the value was changed, it is shut down. If a positive port number is set, a monitor thread is automatically started as listener on the specified port.

- position

This read-only attribute describes the relative position of the read or write pointer in the full file, as an integer in the range between 0 and 100. It is primarily intended to be used in progress meters and similar widgets. In case the relative position is unknown, for example because the total size of the input file is unknown, the value is zero.

- preservelist

A list of properties which should not be changed if a file record is updated, even if the value in principle depends on, for example, changed connectivity of the main structure record. Currently, the only I/O module which supports this feature is BDB.

- previousrecord

This read-only attribute is a convenience function to obtain the value of the record number of the file handle that before the current record was read. Usually, it is the same as the record attribute minus one, but if reactions from files where reagents and products are separate sub-records, or complete datasets were read, the difference may be larger.

- pyobject

If the toolkit was compiled with Python support, this attribute reports the memory address of the Python wrapper class instance, if it exists. This attribute is read-only.

- pyrefcount
f the toolkit was compiled with Python support, this attribute contains the reference count of the Python wrapper class instance, if it exists. This attribute is read-only.
- reactioncolumn

This attribute is the numerical index of a column in table-style data files which are, for example, read by the reaction table I/O module. The column is expected to contain a string notation for the reaction object which is returned by a molfile read operation. To this decoded object the contents of the other columns is attached as property data. Typically the content of the structure column is a Reaction SMILES string or similar line notation. A negative value of this attribute indicates that the presence of structure data in a specific column is unconfirmed. In that case, an attempt is made to determine the reaction column automatically, and the attribute is updated accordingly. However, setting it explicitly may still be required in case there are multiple columns with reaction data, or there are too many unreadable or NULL row entries to allow automatic determination.

- reactionscreen

The name of the property which is used for bitvector screening in filtering records for reaction transform matching. Its default default value is controlled by the global variable : :cactvs (default_reaction_screen_property) and is usually x_SCREEN. If a file is opened that contains information about the screen property set when the file was written (for example, CBS and BDB formats), this attribute is automatically set to the value stored in the file.

- readflags

This attribute controls a set of input processing flags. If the attribute is queried, the result is a list of the names of all flags which are currently set. For modification, the preferred method is to use the bit manipulation prefixes for generic bitset operations. In case just additional flags should be activated, the molfile append command can also be conveniently used. There are also a few shortcut alias attribute names which set or reset selected, frequently used flags directly (complexresolver). The following flag names are currently recognized:

- none
no flags.
- aroresolver
resolve aromatic bonds into a Kekulé form. A frequent application is the input of records from MDL SD files which are not used as query structures, but where aromatic bonds in the original data are nevertheless and illegally encoded as the aromatic structure query bond type.


## - autowrap

When the end of the file has been reached, automatically start reading from the beginning of the file again, until the full file has been scanned once. This operation effects only the molfile scan command and is used there in order to perform full-file queries starting from an arbitrary position in the middle of the file.

- basiconly
only read basic property data set, not full record. This is supported in CBIN, CBS and BDB formats in order to accelerate fast filter and query operations.
- chargebalancer

Try to neutralize and balance charges.

- chargecombiner

Try to merge opposing charge pairs where possible, changing the bond orders of paths between them if necessary.

- complexresolver
perform a bond analysis and re-code typical bonds in metal complexes as non-VB bonds, which do not participate in valence electron counting. For a more detailed explanation, see the alias shortcut complexresolver. This flag is set by default.
- continueafterhetatm

For PDB files, consider any atom line after the first HETATM to be a heterogen, regardless of the line type. This feature helps to cope with ligands which contain amino acid substructures and which some other PDB write software misclassified as part of the protein.

- fixdoublespace

If set, this flag instructs I/O modules with support for this feature to read structure files which contain one spurious empty line after each data line, which unfortunately appears to happen sometimes when DOS-encoded files are transferred to Apple systems. This is not the same as reading CR/LF files on CR-only or nL-only platforms, or vice versa, which is always possible and fully automatic. This flag addresses the problem that, due to mishandling by obscure transfer software, duplicated eol-markers are introduced in the file (two identical CR/LF, or CR, or NL pairs after each data line).

- fixstereo

Remove spurious stereo descriptors on atoms and bonds which are not stereogenic.

- fixwedges

Re-code wedges which are attached with the broad base to a stereo center (for example as written by IDBS software) into standard IUPAC format with tips at the stereo centers.

- hetatmonly

In PDB files, read only hetatm lines.

- ignorecr

Allow an isolated carriage return (ASCII 13) character without following NL (ASCII 10) character as data content instead of examining it as potential line break symbol. This flag is necessarily ignored on Mac-style input files which only use CR as EOL markers.

- ignoreitherdb

If set, ignore any either attribute data for double bonds in MDL Molfiles. Instead, determine their stereochemistry from coordinates.

- ignoreempty

When reading an empty record, with no atoms, from a multi-record file, ignore the record and immediately proceed with the next.

- ignoreerrors

When reading a corrupted record from a multi-record file, ignore the error and instead attempt to re-synchronize and read the next record.

- ignorenorecall

If set, the norecall field flag supported in some file formats (CBS, BDB) is ignored. By default, data from fields which carry this flag is not merged into the property set of ensembles or reactions when they are retrieved as objects from these files, as an optimization to avoid recalling data which is useful for queries, but not so much as object data (for example, screen bits, element counts). With a set attribute flag, all fields of the record are attached as property data to recalled objects.

- ignorevisibility

Ignore any display attributes in the input data which would make atoms or bonds invisible in renderings.

- latehprocessing

If this flag is set, the standard hydrogen addition/removal operations are performed after other selected processing steps have been performed. By default, hydrogen processing takes place before charge equilibration, radical charging, etc. This flag should be set if the hydrogen set in the file records is known to be complete, but the charge and radical situation is dubious.

- lockmemory

Lock the shared memory mapping arena of the file into memory, preventing it from being swapped out. This is only supported on Linux, and has an effect only if the sharedmap flag has been set. Depending on the size of the arena, and the system configuration, this operation may require enhanced privileges.

- logqueries

If the file formats supports operation logging, activate the log.

- keepcoords

In case multiple molecules or ensembles are read in one operation, the system normally verifies that they do not have overlapping 2D display coordinates, and moves them apart if necessary. If this flag is set, the 2D display coordinates in property $\mathrm{A}_{-} \mathrm{XY}$ are always passed unchanged.

- mergedata

In case there are repeat instances of the same data item in an input record, attempt to append it in a suitable fashion to the first property instance on the input object. By default, multiple data items with the same name are not merged, but result in multiple property data instances. This is a problem which is encountered typically while reading data from formats with limited syntactic expressiveness that cannot properly distinguish between these cases.

- multibondcheck
attempt to correct unlikely clusters of multiple bonds.
- nocoordinatecheck
do not attempt to discover and fix mixed-in missing 2D or 3D coordinates, for example encoded as all- 0 values. All coordinate data is to be preserved verbatim.
- noorigin
do not register the origin of the property data values from the current file as metadata information.
- noeof
do not attempt to detect EOf. More data may be coming.
- noimplicith
do not add a standard valence set of hydrogens to explicitly encoded atoms, even if the file format specification defines such a set. The most common application is for reading SMILES strings without the default hydrogen atoms. nohadd is a (slightly misleading) alias for this flag. This flag is independent of the generic hydrogen addition/removal processing option, which can be configured with the hydrogens attribute.
- nometa
if this flag is set, it asserts that the file does not contain metal atoms. This is for example useful for reading PDB files which frequently possess ambiguous encodings such as $C A$ for calcium or alpha carbon.
- nometalh
suppress addition of hydrogens to metal atoms.
- noradicals
assert that the file does not contain records with atoms that are radicals. This is a hint which is used for hydrogen addition, radical charging, and other operations.
- pedantic
apply pedantic checking of file syntax rules. For some frequently abused file formats, such as MDL Molfiles or PDB, this may result in quite a percentage files being rejected for file format specification violations.
- radicalcharger

Edit radicals which are typically formed by reading a file without formal atomic charge information by adding standard formal charges, for example replacing $\mathrm{NR}_{4}$ with $\mathrm{N}^{(+)} \mathrm{R}_{4}$ and OR with $\mathrm{O}^{(-)} \mathrm{R}$. This only works reasonably well if the file contains a complete hydrogen set.

- readas2d

Force the interpretation of atomic coordinates as 2D, regardless of the file type encoding or presence of a third coordinate column, which may have been abused as an additional atom data store.

- readparity

If this flag is set, the parity fields in MDL Molfiles and derivatives are read and the data stored in property A_LABEL_STEREO. In accordance with MDL rules, this field is normally ignored, and stereochemistry decoded from wedge bonds and atom coordinates.

- sharedmap

If the file is memory-mapped, use a shared memory segment for the data. This can be useful if there are many processes accessing the same file for reading. This flag is only supported on Unix/Linux.

- simpleradicals

If this flag is set, the input file is assumed to contain only simple doublet radicals, if any. Any encoding of other, probably miscoded radical forms is changed to a doublet.

- tautoresolver

Perform a tautomer standardization on the read structure. This operation invalidates numerous atom and bond properties, such as coordinates, but in this special case all ensemble properties which were attached to the processed structure are retained, regardless of their sensitivity toward atom and bond changes. Tautomer resolution requires a complete hydrogen set, so either these must be present in the input file, or a suitable hydrogen addition mode must have been set on the file handle. The processing behind this input option is comparatively expensive. For normal input, when speedy input and maximum fidelity of the data to the original file is desired, this flag should not be set.

- readkey

This attribute is only used in certain library configurations which have been configured to restrict read access to specific types of files. The key and data computed from the file name must together match the signature. Usually restricted applications have a compiled-in signature, and one or more read keys which enable read access to the same number of specific files.

- readkeysignature

This attribute is used for certain library configurations which have been configured to restrict read access to specific files. This signature is required to verify the read access key.

- readkeystatus

A read-only attribute which reports the access key status for a file for which a read key has been specified. It can be unchecked, verified or error.

- readscope

This attribute controls which types of objects are read from a file, in case the file contains more than one object type. For example, MDL RXN files can be read as en ensemble record stream, or as a reaction record stream. CACTVs CBIN files can be read as a multi-record stream of individual ensemble or reaction records, or as a single dataset with additional dataset properties. CTX files allow access to individual molecules or ensembles. The hierarchical FDA SPL format supports read modes for molecules, ensembles, and datasets. The default value for this attribute depends on the file format and is automatically updated whenever the
format is analyzed or changed. It is generally set to the most commonly used access variant for that format, for example reactions for RXN files and ensemble streams for CBIN, but it may also be set explicitly. Possible values are none, mol, ens, reaction, dataset and auto. In case a file format does not support a specific variant, the next supported type to the right in this sequence is automatically used. The auto mode performs a new content analysis for every record and use the most suitable scope. Examples where this is useful are RDF files with mixed structure and reaction records, or RTF documents which mix reaction and structure OLE objects. The dataset mode is potentially dangerous when reading large multi-record files which do not contain multiple smaller datasets. In that case, the whole file is interpreted as a single dataset, and that can lead to a large amount of memory being consumed.

- record

The number of the next record to be read or written, starting with one. This value always refers to the current physical file. In case a virtual file is read, the vrecord attribute can be used to address the global record number. $r c$ is an alias name for the attribute. It is possible to set this attribute in order to reposition the file pointer. In case the file is opened for output, and is not in update or append mode, this operation truncates the file. Repositioning while reading does not modify the file. It is not possible to position the file pointer any further to the rear of a file than immediately behind the end of the last existing record. When setting the value, the magic record numbers last (to set the file pointer so that the last record is accessed) and end (to set the file pointer immediately after the last record) are supported for convenience.

- recordtable

This is a read-only attribute. It returns a nested list of the attributes of the currently known record positions in the file. Every list element is itself a list which contains, in this order, the record number, the file offset, the line number (which is the same as the record number for binary formats), the eor type of that record, a boolean flag indicating whether the record is physically present in the disk file (0) or virtual (1)., and the original file name used to create the handle. In case of multi-file handles, this is not a constant over all records. In order to guarantee that all records of a file and their offsets are known, execute for example a molfile count command before querying the record table.

- refcount

If the TCL interpreter is using native CACTvs objects instead of string-based major object handles and integer-based minor object labels to identify toolkit objects, this returns the number of TcL object references active for this molfile. The attribute is read-only.

- replyto

The future recipient of a file. This is only set when the file has been extracted from a mail message or attachment. In order to send mail messages to specific destinations via the mail wrapper I/O module, this attribute may also be set.

## - resolution

A resolution value in DPI (dots per inch). The default value is 0 , meaning that it is undefined. This information can be used by a couple of I/O modules, for example for reading structure data from image files by performing chemical OCR via the interface to the OSRA program.

- returnformat

The name of the desired return format if the original file was received by mail. This is only set when the file has been extracted from a mail message or attachment.

- scandata

This is a read-only attribute which reports statistics on the last molfile scan command. The returned data is a TcL dictionary with keys start_time (in seconds since 1970-1-1), stop_time (in seconds since 1970-1-1), scan_time (in seconds), ens_read (count of ensemble objects instantiated), miniens_read (count of Minimol objects decoded), reactions_read (count of reaction objects instantiated), properties_read (count of property records read), ens_screened (count of bit-screen filtering operations performed for substructure/superstructure searches), reactions_screened (count of bit-screen filtering operations performed for reaction matching), records_examined (count of records looked at), records_matched (number of matched records), start_record (record the scan started at), end_record (last visited record), eof_reached (boolean indicator whether the end of the file was reached), max_mmap_used (maximum used size of memory mapping arena), max_mmap_requested (maximum requested size of memory mapping arena), records_skipped (number of records which where skipped with need for re-synchronization), records_repositioned (number of records which were finished without the need for a re-synchronizing skip operation) scores_computed (the number of scoring function calls executed).

- selected

Flag indicating whether the molfile object is selected. This attribute can be changed.

- selection

This attribute is not a molfile handle attribute, but a flag attached to individual records. If queried, the return value is a list of all record numbers for which this flag is set. Using molfile set with a list of record numbers in any order to modify the attribute resets the current flags, and creates a new set. Modifying the attribute via molfile append adds selection flags without resetting the current selection. The selection flag can only be set for existing records. If an attempt is made to set the selection flag ahead of the currently known position set, the command scans the record structure (as in molfile count), which can be a problem in case of non-rewindable input. In order to facilitate resetting of selection flags, the virtual attribute deselection can be accessed as the inverse of the selection. Setting it to an empty list selects all records up to the end of the file (again this triggers automatic forward scanning, if necessary), and appending a list of records removes them from the selection. The default value of the selection flag for any record is false.

- separator

A string containing one or more column separator characters. This is used for example by the structure and reaction table I/O module. The attribute is also set when a table with an auto-detected separator character was read via the file handle. The default separator is a single tab character.

- sessionkey

A free-form string intended to be used to identify sessions.

- shmid

In case the memory map arena of the file is in shared memory, this is the shared memory key as read-only value. If the file is not mapped into shared memory, or on platforms where memory mapping is not supported, the value is always minus one.

- signature

The signature of a mail message. This is only set when the file has been extracted from a mail message or attachment.

- similarityproperty

The name of the property which is used for bitvector similarity computation in file scans. Its default default value is controlled by the global variable
: :cactvs (default_similarity_property) and is usually either E_SCREEN or E_QUERY_SCREEN. If a file is opened that contains information about the similarity property set when the file was written (for example, CBS and BDB formats), this attribute is automatically set to the value stored in the file.

- size

The file size in bytes as read-only data. In case it is not known, for example because the file is accessed via a special stream or a pipe, zero is reported.

- sizehint

The expected maximum record count of the file. This attribute is used by some I/O modules to pre-allocate room in files with complex storage layout, in order to avoid the need for expensive re-organization during later record writes. The CBS format especially benefits from this information. File formats which are simple record sequences have no use for this information. A value of zero, which is the default, specifies an unknown future size. If the final size is not known exactly, it is generally preferable to overestimate it somewhat than to be slightly short.

- statusflags

A list of boolean flags which describe the status of the machinery behind the I/O operations of this handle. All set flags are reported. When checking for the presence of a flag, make sure not to use simple string comparison, because other flags may also be set. While it is possible to change the flags, this is not a common operation, and if done carelessly can disrupt the I/O functionality of the handle. The older attribute name flags is still a valid alias. The following flags are commonly seen:
append - all file output is append to the end of the file, ignoring the current write pointer position.
binary - the file is binary, without a line structure.
bzip2-compressed - the file is accessed via a pipe to the bzip2 program.
checkedbinary - the file contents were checked to determine whether they contain non-ASCII characters.
edited - the file contains virtual edited records, or virtual deletes.
fakeposition - the file has no meaningful offset positions for the beginnings of records, the offset data structures contain other forms of access information
gzip-compressed - the file is accessed via a pipe to the gzip program.
incomplete - the last file record was not read completely. This can be intentional in file formats which support basic and extended data groups, or can be an indication of a non-critical decoder problem.
indexed - the file is accessed via an index file with record positions, not directly.
nommap-memory-mapping of the file contents is suppressed.
initialized - an initialization function of in the associated I/O module has been called
locked - there is currently a flock()/lockf() style file lock active on the file.
mapallocated - the memory mapping arena for the file was allocated and filled via some read operation, not mmap()ed.
memlocked - a mapping of the file are locked into memory and are not swapped out.
readable - the file handle can be read from.
readonly - the file has been opened for read-only access, without the possibility to switch the handle to a different mode.
remotefs - the physical file resides on a non-local file system.
rewindable - the file can be rewound if necessary
scratch - the file is a scratch file and is automatically deleted when the file is closed.
shared - the file contents reside in shared memory.
validcount - the current number of known positions is known to correspond to the total of records in the file.
virtual - the file is a virtual file build from multiple physical files.
ucs 2 -encoded - the file is accessed via a pipe to the iconv program.
url - the file is accessed via a URL, not a file system path.
updating - the file is currently being updated
writeable - the file handle can be written to.
$x d r$ - the file is associated with an XDR encoder or decoder structure.

- style

A free-format string identifying a predefined attribute bundle for graphics-oriented file formats. This is currently supported for CDX, CDXML, SKC and TGF, where, for example, the acs value selects settings corresponding to the "ACS Journal" settings in ChemDraw or ISISDraw.

- structurecolumn

This attribute is the numerical index of a column in table data files which are, for example, read by the structure table I/O module. The column is expected to contain a string notation for the basic structure object which is returned by a molfile read operation. This string is decoded and the content of the other columns is attached as property data to this object. Typically the content of the structure column is a SMILES, SLN or InChI string. A negative value of this attribute indicates that the presence of such structure data is not confirmed. In that case, an attempt is made to determine the structure column automatically, and the attribute is updated accordingly. However, setting it explicitly may still be required in case there are multiple column with structure data, or there are too many unreadable or NuLL row entries to allow automatic determination.

- subformat

A enumerated value which encodes the subtype of the main file format. The most common values are mol2d, mol3d and mol0d, to indicate structure records with 2D or 3D or no coordinates. The type reaction can be encountered for RDF and CTX files with reaction data,
since these can also be structure files in other cases. The attribute is automatically set when a file is read,. For some formats a explicit specification of the attribute controls the output formatting, for example for all file formats which contain an MDL ctab block, which can store either 2D, 3D, or 0D information, but not simultaneously.

- substructurescreen

The name of the property which is used for bitvector screening in filtering records for substructure matching. Its default default value is controlled by the global variable
: :cactvs (default_substructure_screen_property) and is usually either E_SCREEN or E_QUERY_SCREEN. If a file is opened that contains information about the screen property set when the file was written (for example, CBS and BDB formats), this attribute is automatically set to the value found in the file.

- superstructurescreen

The name of the property which is used for bitvector screening in filtering records for superstructure matching. Its default default value is controlled by the global variable
: :cactvs (default_superstructure_screen_property) and is usually either
E_NO_HYDROGEN_SCREEN or E_NO_HYDROGEN_QUERY_SCREEN. If a file is opened that contains information about the screen property set when the file was written (for example, CBS and BDB formats), this attribute is automatically set to the value found in the file.

- template

The name of a template file to be used for output formatting. At this time, only the RTF I/O module uses this information. It switches between de novo RTF formatting and replacing chemistry tags in the template file. If this value is set to an empty string, no template is used.

- timeout

The maximum number of seconds to spend in a molfile scan command. When the time is exhausted, the scan terminates after the respective current record has been cleanly processed by all query threads, even if the end of the file has not been reached. Setting the attribute to zero, which is the default, allows an unlimited time to be spent on a query. Another function where the timeout value is used is in reading a record via an Internet connection, for example an $h t t p$ or $f t p$ URL. If the timeout expires and the record has not been downloaded, an error results.

- url

A read-only attribute with the URL in case the file is accessed via an Internet connection. If no such connection exists, the result is an empty string. If a URL has been set, this attribute may be indexed using the same fields as a URL property data item in order to retrieve URL components.

The allowed field names are hash, host, hostname, href, pathname, port, protocol, search, user, password, directory, file, ipaddr, lastmodified and mimetype. Note that in this context the port field name is the port the file is transferred via the Internet connection, which generally is not the same as the listener port for remote requests (see molfile get attribute port). Likewise, the mimetype here is the MIME type as reported by the server, not the file MIME type defined by the file format handler module. Example:
set ip [molfile get \$fh url(ipaddr)]

- user

This is a shortcut for the user name part of a file or virtual file addressed via an URL. For simple retrieval it is equivalent to the URL field attribute $u r l(u s e r)$. For some I/O modules, for example the interface to access MYsQL tables as virtual structure files, a change of the user
name has an effect and results in a re-authentication of the database and table access, which can result in different access permissions. For normal files accessed via a URL a change of the attribute is ignored after the file has been opened. Files that are not associated with an URL have an empty user name value.

- uuid

An automatically generated UUID globally identifying the molfile object. This attribute is read-only, different for every molfile, and not dependent on the contents or format of the disk file this object is associated with.

- valencelevel

For files which support this concept, an indicator what kind of structure (stable, intermediate, MS ion, etc.) is stored in the file.

- version

The file format version as a string. This attribute is set automatically when a file is opened for reading. If it is not set, files are generally read or written in the latest supported version. If a data file contains a known version indicator, input routines in some cases adjust to older encoding standards. The I/O modules of some file formats support the writing of old versions. An example are the CDX and CDXML modules, which in the context of file versions explicitly set to less than 8.0 do not write the InterpretChemically tag which is not understood by older ChemDraw releases.

- vline

The current virtual line count as a read-only attribute. For simple files, this is identical to the standard line count (attribute line or $l c$ ). However, for virtual files opened by means of the molfile lopen command, this attribute is the global line number in the virtual file, while line/lc refers to the line count within the current physical file. The attribute name $v l c$ is an alias.

- vrecord

The virtual record number of the next record to be read, starting with one. For simple files, this is identical to the standard record count (attribute record or $r c$ ). However, for virtual files opened by means of the molfile lopen command, this attribute is the global record number in the virtual file, while record/rc refers to the record count within the current physical file. The attribute name $v r c$ is an alias. This attribute can be set and changing it results in repositioning of the file pointer, and potentially even a change in the active physical file.

Since virtual files which refer to multiple physical files can only be opened for reading, this attribute has no meaning for output files that is any different than that of the standard record attribute. When setting the attribute, the special values end and last can be used to position the file pointer behind the last, or before the last record.

- width

The maximum width of a structure or reaction depiction in points ( $1 / 72$ of an inch). This is only used for graphics-oriented formats, such as CDX, SKC or EMF. If the attribute is set to a negative value, which is the default, the size is indirectly controlled by the bond length and atom coordinates. In case this attribute is set to a positive value, and the depiction would exceed the maximum width or height, it is automatically scaled down proportionately.

- writeend

An enumerated value indicating what kind of record end marker should be written on output, if the file format has such a concept. Possible values are none, mol and block. The default value is block, which translates into the standard record terminator for almost all file formats. The mol type is only significant for CTX format output. The none value can be useful if a programmer wants to add custom data to the end of a record and then writes an end marker himself, as it could be done without too much effort for example for an SD file.

- writeflags

A collection of boolean flags controlling output details. When queried, this attribute returns a list of the names of all set flags. Modification of this flag supports the standard bit manipulation prefixes. The following flag names are currently recognized:

## none - no flags

computeprops - attempt to compute properties in the write list if they are not yet present in the output objects.
miniheader - keep the file header as concise as possible.
multiwriter - prepare the file to handle multiple simultaneous writers. The only file format I/O module which currently supports this is BDB.
noimplicith - do not output hydrogen atoms which were added as implicit atoms.
nopropertymapping - always synthesize property descriptions, do not attempt to map them onto existing standard system definitions. The only module currently supporting this feature is the РивСнеm ASN. 1 module.
nostereo - do not write stereo information into the file, even if present in the output structures.
nostereoperception - do not attempt to perceive stereochemistry from the available object data such as 2D coordinates and wedges, or 3D atomic coordinates, even if the file format normally requires this information.
omitct - if the inclusion of a structure connectivity table is optional, this flag can be used to suppress the output this block.
pedantic - perform pedantic output format checking, for example by refusing to write long lines in text formats which exceed the exact format specification, or refusing to write structures with more atoms than officially supported.
rawcoordinates - do not perform any coordinate checking, scaling, and centring but write the coordinates exactly as they are currently stored.
recalcbaseprops - if the output file content is a single property (for example E GIF for GIF or PNG files, E_EMF_IMAGE for EMF and WMF files), force recalculation of this property before output
supergroupexpansion - If a file format can either be written with expanded or contracted
 the default is to write them contracted. If this flag is set, the expanded form is used instead. This option affects few file formats (currently $c d x$ and $c d x m l$ ). It does not perform expansion of superatoms which are only present as a single pseudo atom in the ensemble by decoding their tag (see ens expand command to achieve this). Rather, it expects the full set of atoms of the expanded form in the ensemble, plus one or more properly set up group objects indicating the atoms of the expanded form of a functional group or fragment which are not shown in the contracted style. If these groups are present, only the first atom in any group is shown, with the G_NAME data as atom tag, which overrides all other label information. However, the output file still contains the hidden atoms and their data. Tools like ChemDraw use this data to support interactive group expansion utilizing the original layout coordinates of the previously hidden atoms and other information.
synchronous - use synchronous writes for files which normally use buffering to increase performance, for example in the $b d b$ format.
splitmol - Split output into individual ensembles and write each molecular fragment as a separate record.
upgrade - if this flag is set, and the format of a file is not of the most current version, but there is an upgrade function available in the support library, invoke the upgrade function to change the file layout to the most current version. The $b d b$ module is the only one which currently supports this feature.
write $0 d$ - write records without coordinates if possible
write $2 d$ - write 2D records if possible
write $3 d$ - write 3D records if possible
writearo - write aromatic bonds instead of a Kekulé form if the file format supports this. An example where this makes sense are SMILES files. A counterexample are MDL
Molfiles - you can enforce the encoding of aromatic bonds of non-query structures as the aromatic query bond type with this option, but that is technically incorrect and violating the format specification. Nevertheless, there are third party programs which require data in that format aberration for further processing.
writecolor - write atom and bond colouring information if this is an optional part of the file format specification.
writeenzymes - if the output data contains enzyme superatoms, include them in the output if that is an option. The SDF3000 I/O module is an example for a module recognizing this flag.
writelabels - write explicit atom labels, as defined in the attribute atomlabelproperty, if the file format supports it. This does not override the natural numbering of the written atom objects. It only applies to formats which support a parallel user-defined labelling scheme, such as $C D X / C D X M L$.
writename - write a structure name section if this is optional information in the output. An example are SMILES files.

- writekey

This attribute is only used in certain library configurations which have been configured to restrict write access to specific types of files. The key and data computed from the file name must together match the signature. Usually restricted applications have a compiled-in signature, and one or more write keys which enable write access to the same number of specific files.

- writekeysignature

This attribute is used for certain library configurations which have been configured to restrict write access to specific files. This signature is required to verify the write access key.

- writekeystatus

A read-only attribute which reports the access key status for a file for which a write key has been specified. It can be unchecked, verified or error.

- writelist

A list of properties that should be included in the output if the file format supports this.
Standard properties defining basic connectivity etc. usually do not need to be listed because they are written out by default where needed. Normally, this list contains only ensemble- or reaction-level properties, like SD data fields. Properties listed both in the write list and the drop list are not written. By default properties listed here are not computed. If they are not already present in the output objects, they are omitted. The computeprops bit in the writeflags attribute can be used to automatically initiate a computation attempt. Still, if a computation attempt fails, the output of that property data is silently omitted.

The attribute list above is also referenced by the molfile set command. This is the reason why it contains information about the read-only status of the individual attributes. Only attributes that can be set can be addressed by the molfile set command.

For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Filters in the optional filter set must apply directly to the file object. Filters which operate on other object types are ignored.

Variants of the molfile get command are molfile new, molfile dget, molfile nget, molfile show, molfile sqldget, molfile sqlget, molfile sqlnew, and molfile sqlshow. These only apply to retrieval of file-level property data, not the attributes.

## molfile getline

molfile getline filehandle ?skiprecord?
Read a text line from the file, with repositioning of the file pointer. This operation is only possible on text files which have been opened for reading. The command is not frequently used, because it tends to disrupt the normal file record parsing.

If the skiprecord boolean argument is set, the file is positioned to the beginning of the next record after the line has been retrieved.

The command returns the line read. Line termination characters are removed.
molfile getparam
molfile getparam filehandle property ?key? ?default?

Retrieve a named computation parameter from valid property data. If the key is not present in the parameter list, an empty string is returned. If the default argument is supplied, that value is returned in case the key is not found.

If the key parameter is omitted, a complete set of the parameters used for computation of the property value is returned in key/value format.

This command does not attempt to compute property data. If the specified property is not present, an error results.

Example:
molfile getparam \$fhandle F_QUERY_GIF format
returns the actual format of the data in that property, which could be a GIF, PNG or a bitmap format.

## molfile hloop

molfile hloop filehandle objvar ?maxrec? body
This command is functionally equivalent to the molfile loop command. The difference is that for the duration of the loop command hydrogen addition is enabled for the file handle. The original hydrogen addition mode of the file object is restored when the loop finishes.

## molfile hread

molfile hread filehandle ?datasethandle/enshandle? ?recordcount?
This command is identical to the molfile read command, except that standard hydrogen addition is enabled for the duration of the command. The original hydrogen mode is reset when the command completes.

Example:
set eh [molfile hread "myfile.mol"]
This is a simple single-record structure input with hydrogen addition, using a file name instead of a file handle. The file is automatically opened and then close for the duration of the command.

## molfile list

molfile list ?filterlist?
This command returns a list of the molfile handles currently registered in the application. This list may optionally be filtered by a standard filter list.

Example:
molfile list
lists the handles of all open molfiles in the application.
molfile lock
molfile lock filehandle propertylist/objclass/all ?compute?
Lock property data of the file handle, meaning that it is no longer subject to the standard data consistency manager control. The data consistency manager deletes specific property data if anything is done to the file handle which would invalidate the information. Property data remains locked until is it explicitly unlocked.

The property data to lock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the file object are locked. If the boolean compute flag is set, an attempt is made to compute the property if it is not yet present. Otherwise, a request to lock non-existent data is silently ignored. It is not possible to lock individual property fields.

- all

All valid file properties are locked. The compute flag is ignored.

- molfile

This is an object class identifier. All property data which is controlled by the file major object and attached to the specified object class is locked. Since files do not incorporate minor objects, this identifier is equivalent to all.

The lock can be released by a molfile unlock command.
This command is a generic property data manipulation command which is implemented for all major objects in the same fashion and is not related to disk file locking. Disk file locks can be set or reset by modifying the molfile object attribute lock. This is explained in more detail in the paragraph on the molfile get command.

The return value is the molfile handle.

## molfile loop

molfile loop filehandle objvar ?maxrec? body
Execute a loop over the file. Objects are read from the file from the current file position onwards. The type of object read (usually ensemble or reaction, but in principle also a table or dataset object) depends on the read scope of the file. The handle of every object input from a file record is assigned to the specified TcL object variable. Next, the TcL script code in the body argument is executed. The body code typically uses the value of the variable to perform some operations with the currently read object. After the body code has been executed, the object which was just read is deleted, and the cycle is repeated, either until EOF has been reached on the file (the default), or the maximum number of records specified by the optional parameter has been reached, whichever comes first. In either case, no error is generated when the end of file has been reached. Setting the maximum record count parameter to an empty string, or to a negative value, results in the default processing style running until the end of the file.

Within the body, the standard TcLbreak and continue commands work as expected. If the loop code generates an error, the loop is terminated and the error reported. Programs should not expect that the same object handle value stored in the variable is reused in each iteration.

Since the input objects are automatically deleted after they have been processed, it is not required to delete them in the loop code. Deletion requests on the loop object executed within the loop are ignored. Any other operation on the structure object is allowed. The loop code may perform repositioning operations on the input file, but not close it.

The return value is the number of processed records.
Example:

```
set th [table create]
table addcol $th E_NAME
```

```
table addcol $th E_WEIGHT
molfile loop $myfile eh {
    table addrow $th #auto end [list [ens get $eh E_NAME] [ens get $eh E_WEIGHT]]
}
```

This sample loop successively reads all records from the file and stores the ensemble handles in variable $e h$. In the loop body, the handle is used to extract name and molecular weight information from the structure and store it in a table object.

## molfile lopen

molfile lopen filelist ?mode? ?attribute value?...
Open a list of files as a virtual file. The files identified by the file list items are implicitly concatenated in the list order. In addition to normal files, the standard set of special input types such as URLs, pipes, TcL file handles or standard channels may be used. This command returns a single file handle, regardless of the number of input files passed as parameter.

A file list can only be opened for read operations on input objects. Writing, appending, updating or string input are not supported.

Most input file operations can be performed on virtual files. One important exception is currently file scanning with query expressions. This only works for lists of standard sequential files, not files which contain optimized query layouts, such as the native CACTvs CBS and BDB file formats. These can only be used as a single file for molfile scan commands. However, simple structure input is possible across file boundaries even with these formats.
The rest of the options are processed in the same way as the standard molfile open command.
Example:
set fhandle [molfile lopen [lsort [glob *.mol]]]

## molfile max

molfile max filehandle property ?filterset?
Scan the file for the maximum value of the the specified property from the current read position to the end of the file. If no error occurs, the file is at end-of-file after the end of the command.

If a filter set is provided, it is applied to the objects read from the file during the scan, not the molfile object proper. Objects which do not pass the filter are ignored.

The property may correspond either to a data column in the file, or to a computable property on the structure or reaction objects read during the scan. Read objects are transient and automatically discarded. The property argument may contain a field specification, and in that case, only the field value is compared.

The maximum value determination uses the standard property comparison function associated with its data type. For properties which are implicitly defined during file I/O, an explicit property definition with a correct data type may be beneficial. For example, when testing the values of an SD data field, by default the data is read as an implicitly created string property. If the field content is actually an integer, the comparison as a string value does not yield the same results as when the data is compared as an integer. For file formats which encode a proper data type of its contents this is not necessary.

The return value is the maximum property or property field value found, or an empty string if no input was processed.

## molfile metadata

molfile metadata filehandle property field ?value?
Obtain property metadata information, or set it. The handling of property metadata is explained in more detail in its own introductory section. The related commands molfile setparam and molfile getparam can be used for convenient manipulation of specific keys in the computation parameter field. Metadata can only be read from or set on valid property data.

## molfile min

molfile min filehandle property ?filterset?
Scan the file for the minimum value of the the specified property from the current read position to the end of the file. If no error occurs, the file is at end-of-file after the end of the command.

If a filter set is provided, it is applied to the objects read from the file during the scan, not the molfile object proper. Objects which do not pass the filter are ignored.

The property may correspond either to a data column in the file, or to a computable property on the structure or reaction objects read during the scan. Read objects are transient and automatically discarded. The property argument may contain a field specification, and in that case, only the field value is compared.

The minimum value determination uses the standard property comparison function associated with its data type. For properties which are implicitly defined during file I/O, an explicit property definition with a correct data type may be beneficial. For example, when testing the values of an SD data field, by default the data is read as an implicitly created string property. If the field content is actually an integer, the comparison as a string value does not yield the same results as when the data is compared as an integer. For file formats which encode a proper data type of its contents this is not necessary.

The return value is the maximum property or property field value found, or an empty string if no input was processed.

## molfile mutex

molfile mutex filehandle mode
Manipulate the object mutex. During the execution of a script command, the mutex of the major object(s) associated with the command are automatically locked and unlocked, so that the operation of the command is thread-safe. This applies to builds that support multi-threading, either by allowing multiple parallel script interpreters in separate threads or by supporting helper threads for the acceleration of command execution or background information processing. This command locks major objects for a period of time that exceeds a single command. A lock on the object can only be released from the same interpreter thread that set the lock. Any other threaded interpreters, or auxiliary threads, block until a mutex release command has been executed when accessing a locked command object. This command supports the following modes:

- lock

Increase the recursive mutex lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock.

- reset

Release all persistent locks on the object, if any exist.

- test

Return the current persistent lock count on the object. This excludes the transient per-command lock.

- unlock

Decrease the recursive lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock. Unlocking an object which has not been persistently locked results in an error.

There is no trylock command variant because the command already needs to be able to acquire a transient object mutex lock for its execution.

## molfile need

molfile need filehandle propertylist ?mode?
Standard command for the computation of property data, without immediate retrieval of results. This command is explained in more detail in the section about retrieving property data.

The return value is the file handle.
Example:
molfile need \$fhandle F_AVERAGE_ATOM_COUNT
molfile new
molfile new filehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the molfile get command. The difference between molfile get and molfile new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## molfile nget

molfile nget filehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the molfile get command. The difference between molfile get and molfile nget is that the latter always returns numeric data, even if symbolic names for the values are available.
molfile open
molfile open filename ?mode? ?attribute value?...

```
molfile open filename ?mode? ?attributedict?
```

This command opens a structure file or other input source for input or output. The filename argument may be any of:

## - A disk file

This is the most common case. File names may be absolute or relative. On the Windows platform, the path naming follows the TcL convention, with backslashes replaced by forward slashes, and optional drive letters, in the same way as the standard TcL open command. Tilde substitution is also supported and built into the command. In case a file name could possibly collide with a reserved name, the file name can be prefixed with ./ in order to force interpretation as a file name. File name expansion can be conveniently performed by means of the standard TcL glob command. File names must currently be spelled in the 8-bit ISO8859-1 character set. Unicode file names are not yet supported. On Unix platforms, named pipes and sockets may also be opened with this command.

Examples:

```
molfile open ./stdout r
molfile open ~theuser/data/newleads.sdf
molfile open C:/temp/calicheaamycin.pdb w
```

- A standard channel

The file names stdout, stderr and stdin are reserved and connect the file handle to a standard I/O channel. stdout and stderr can only be opened for output, and stdin can only be read from. The character '-' (minus) is an alternative name for standard input.

Example:

```
molfile open stdout w format mdl
```

molfile open ./stdout

The first line opens an MDL file for output on standard output. The second sample line opens the file in the current directory which is named "stdout" for input. By prefixing file names with directory information any file with a reserved name can be opened as standard file.

## - A scratch file

The name scratch is reserved as the name of a generic scratch file. The file is initially opened for writing, but may be switched to input later by a molfile toggle command. The magic filename is translated into the name of a platform-specific temporary file. Every invocation of this command variant generates a new scratch file, with a different name. The true file name can be obtained with an attribute query:

```
set fh [molfile open scratch]
set name [molfile get $fh name]
```

Scratch files are automatically deleted when they are closed, or when the program exits.

- A pipe

If a file name starts with a vertical bar character "|", a pipe is opened from (in read mode) or to (write mode) the commands listed after the bar.

Example:

```
molfile open "|gzip >thefile.sdf.gz" w format mdl
```

When the file is closed, the pipe and all programs connected to it are automatically shut down. Pipes cannot be rewound, or switched from input to output and vice versa.

## - An URL

The Cactvs toolkit supports reading from various types of URLs. Currently, the schemes $f t p$, http, file and gopher are supported. file URLs are just another notation for normal disk files, as described above. From among the other URL schemes, only ftp and http connections may be opened for writing. The support for $f t p$ URLs includes username and password components. If the server side supports it, passive ftp is the preferred mode. Http connections opened for writing use the pur http command, which often is not activated in standard Web server set-ups and may therefore be of limited practical usefulness. URL connections can be rewound and backspaced, but this is costly because the existing connection has to be disconnected and the initial data from the beginning of the file to the desired position needs to be re-transferred and discarded.

Examples:
set fh [molfile open http://www.yourcompany.com/repository/jcamp/ir1.jcp]
molfile open ftp://yourid:yourpasswd@ftp.yourcompany.com/upload/ideas.sdf

- A directory

If the target is a directory, all files in the directory are scanned. Those files which were identified as structure data files by any of the built-in or currently loaded I/O module extensions are concatenated to a virtual file which comprises all individual files. The order in which the files are concatenated is largely unpredictable, because it is defined by the order of the file name entries in the directory, and not any alphabetic sort criterion. The files may be of different formats, and may be any mixture of single-record and multi-record files. Subdirectories of the opened directory are not entered by default, but this may be activated by appending a , $\mathrm{d}^{\text {‘ }}$ character to the open mode. Directories may only be opened for reading.

Example:

```
set fh [molfile open .]
set fh [molfile open $mydir rd]
```

The second example opens not only perceived structure files in the source directory, but also in all subdirectories thereof.

## - A string

The Cactvs toolkit can read most file formats directly from a string. There is no need to write structure data which was obtained as a string image to a temporary file to decode it. Data strings are opened as structure file with mode 's'. Only input is possible, but navigation within the string with molfile rewind etc. works as expected. The complementary molfile string command can be used to generate a string image of a file record.

Example:

```
set fh [molfile open $thedatablob s]
set eh1 [molfile read $fh]
set eh2 [molfile read $fh]
molfile close $fh
```

- A TcL file or socket handle.

Any file name beginning with file or sock, and where the rest of the file name is a sequence of digits, are interpreted as references to TcL file handles.

Example:

```
set tcl_fh [open thefile.txt w]
set cactvs_fh [molfile open $tcl_fh w]
```

A Tcl handle can only be accessed by this command in a mode which is compatible to the mode it was opened with, i.e. it is not possible to write to a file via a Tcl handle if it was opened for reading. If a structure file coupled to a TcL handle is closed with a molfile close command, the TcL handle remains valid, and my be used freely once the association to the structure file I/O object is broken. Closing the Tcl handle while the piggybacked structure file handle is being used is illegal. No input, output or positioning should be performed on the TCL handle with standard TcL commands while it is being referred to by a molfile object.

This functionality is not available on Windows, because on this platform Tcl internally uses Windows handles for I/O, while the Cactvs toolkit builds on standard Posix C library FILE pointers.

- A virtual file

Some I/O modules implement access to a variety of information sources as a virtual file, which has neither a presence on the local disk, nor is one of the standard magic file names or access methods. Such virtual file names are by convention written with pointed brackets.
Example:

```
set fh [molfile open <pubchem>]
```

This command loads the РивСнем virtual file access module, and returns a handle which may be used in a similar fashion as, for example, a handle to a huge local SD file. Depending on the I/O module, various operations on the handle may be optimized to be performed remotely. For example, the PивСнем module offloads as many query operations of molfile scan commands as possible to the NCBI computers and downloads result structures only if they are needed as results, or query sub-expressions were specified which cannot be processed by the NCBI system.

The first optional parameter is the file access mode. It may be one of:

- r

Open for reading, but with the option of later changing the mode to writing or appending. This is the default.

- rt

As above, but automatically start a thread which immediately starts gathering file status information, such as the record count and record positions. This mode can be useful when operations, such as reading data for display, are to be commenced immediately, but ultimately overall record count information needs to be displayed, which can take a while to collect for larger files. The status thread is only started for rewindable files, and has no effects on files which directly provide record index and total record count information.

Operations which would duplicate the efforts of the statistics thread, such as molfile count, are automatically blocked until the thread has completed,, and then directly use its results. Operations which change the nature of the access to the file, or its record contents or positions, silently terminate the status thread.

- ro or rot

Open for read-only. If a file is opened in this mode, it is not possible to switch to write access later via a molfile toggle command. If the file permissions do not allow write access, the standard ' $r$ ' mode automatically falls back to this variant. Mode 'rot'" is also possible and additionally starts a file status thread (see mode ' $r$ 't').

- w

Open for writing. If the file exists, it is overwritten. If not overridden by an explicit format specification, the file format is inferred from the suffix of the file name, if possible.

- a

Open for appending. If the file exists, new data written to it is appended. If not overridden by an explicit format specification, the file format is inferred from the suffix of the file name, if possible. Not all file formats support appending.

- u

Open an existing file for updating, i.e. the replacement of specific records. Not all file formats support this mode. It is generally useful for database-style formats such as Cactvs BDB and, to a limited degree, CBS. It can also be used for simple record sequence files like SD, though in this case it can be inefficient because a lot of data copying may be required to adjust the file layout. For single-record file formats, this command is not useful, and multi-record files which are not simple record sequences and for which the I/O module does not provide a special function, this mode is not supported.

- s

Open string image of a file. If the mode is used, the file name is interpreted as in in-memory image of a structure file in any of the formats the toolkit understands, and not as a file name, URL, or any of the other types of input objects. Binary file formats may be used with this command.

- p

Open in pipe reader mode. The input is expected to be a pipe or socket, where sporadically new data is posted. If an attempt is made to read from the file, a check is made if any data is present. If no data is waiting, the input command immediately returns without blocking. At a later time, new data may be present and the input succeed. If just a single byte of data is present on a pipe input channel, the read routine hangs on until the record for which input has begun has been read completely.

- R, Ro, Rot

Open the file for reading and infer the format of the file from the suffix alone, without actually attempting to read the initial section of the file contents, which is the default method to determine its format. This mode can be useful in case the data contains text with embedded structure data, where the plain text is read by scripted commands and the occasional embedded structure or reaction record is to be extracted by means of molfile read commands. For such files, an automatic format detection would fail. The ' $o$ ' and ' $t$ ' flags may also be appended, and have the same meaning as in the standard ' $r$ ' mode.

For some files and file formats, two more mode characters have meaning if appended to the primary mode: They are silently ignored if the file argument or file format do not support them.

- d

Recursive opening. This is for example useful when opening a directory as a virtual file for input. If this flag is set, the all files recursively found under the specified directory form the virtual file, not just the files directly located under the specified directory.

- f

Fast mode. The file is opened for maximum performance, taking chances with respect to data integrity in case of program or computer crashes, etc. One file format where this flag is supported is the Cactvs Data Archive (CDA) format.

The remaining parameters of the molfile command are optional keyword/value pairs, or alternatively a single dictionary with the same function. The processing of these parameters is exactly the same as in the molfile set command.

Example:

```
set fhandle1 [molfile open thefile.pdb]
molfile set $fhandlel hydrogens add nitrosyle ionic
set fhandle2 [molfile open thefile.pbp r hydrogens add nitrostyle ionic]
```

The first two lines and file final line perform exactly the same task: Open an input file, and set up input flags so that a complete set of hydrogens is added, and nitro groups and similar groups are converted to an ionic (as opposed to pentavalent) representation.

When a file is opened for reading, its format is automatically determined. Do not use the format attribute except under very special circumstances.

The command returns the file handle of the opened input file. This is the handle which is required by most other molfile commands which refer to an opened file.

Depending on the encoding of the opened file, the actual access mode to the file may be different than expected. In case a disk file is compressed with gzip or bzip2, the file is opened via a pipe to the responsible decompressor program. Likewise, an UCS-2 encoded file is opened via a pipe to the iconv program which converts the contents to the UTF-8 encoding. Files which are opened indirectly via such helper pipes have different access characteristics than directly addressed files. For example, backspacing is expensive, because the pipe has to be closed, re-opened, and the data stream skipped to the desired position. This takes much longer than simply repositioning a file pointer.

## molfile properties

molfile properties filehandle ?pattern? ?noempty?
Generate a list of the names of all properties attached to the molfile object. Optionally, the list may be filtered by a string match pattern.

In most cases, this list is empty. Only structure file properties, such as $\boldsymbol{F}_{-}$COMMENT, etc., are listed, but no object attributes, such as readflags, nitrostyle, etc. Few file formats support the concept of storing file-level properties, and therefore an empty property set is usually reported. Since file objects do not contain minor objects, and currently cannot be a member of other major objects such as datasets or reactions, no properties belonging to other classes except file objects are ever listed.

If the noempty flag is set, only properties where at least one data element is not the property default value are output. By default, the filter pattern is an empty string, and the noempty flag is not set.

The property list may become modified by input operations. In some cases, the defined file-level properties may vary with the record position, or may become only available only after the first input operation, not immediately after opening the file.

The command may be abbreviated to props instead of the full name properties.
Example:
set plist [molfile properties \$fhandle]
molfile purge
molfile purge filehandle propertylist/molfile/all ?emptyonly?
Delete property data from the molfile object. Only molfile property data may be deleted with this command (these usually have a $\mathrm{F}_{-}$prefix). Molfile attributes are not deletable.

If the optional flag is set, only file property values which are identical to the default of the property are deleted. By default, or when this flag is 0 , properties are deleted regardless of their values. In case a listed property is not present, or not a file property, the request is silently ignored, but using property names which cannot be resolved leads to an error. If the object class name molfile is used instead of a property name, all file-level property data is deleted from the molfile object.

Example:

```
molfile purge $fhandle F_COMMENT
```

molfile purge \$fhandle all

The first command deletes a specific property, the second command deletes all file property data associated with the handle.

## molfile putline

molfile putline filehandle ?lines?
Write user-specified string lines to a file, bypassing the normal record writing mechanism. This operation is only supported on files which are opened for output and contain text data. The lines should not contain end-of-line characters. These are automatically supplied depending on the file object configuration set set in the eolchars attribute.

The command returns the file handle.

## molfile read

molfile read fhandle ?datasethandle/enshandle/\#auto/new? ?flags?? ?recordcount?
molfile read fhandle ?datasethandle/enshandle/\#auto/new ?flags?? ?attributedict?
This important command reads chemistry objects from a structure file. The type of objects returned depends on the read scope of the file. They can be ensembles, reactions, or datasets. Read scope mol returns single-molecule ensembles, but (with I/O modules supporting this feature) reads only individual molecules into the output ensemble, splitting a multi-molecule file data ensemble if necessary. The return value of the command is a list of all objects which were generated, except when the \#auto dataset creation method was used, or an unlimited number of objects was read into a dataset. In that case, the recipient dataset handle is returned.

By default, the returned objects are not a member of any dataset. If a dataset handle is passed as fourth parameter, the returned objects are appended to that dataset if possible. The special value \#auto or new creates a new dataset as container. This is equivalent to using the nested statement [dataset create] as dataset handle argument. If the fourth parameter is an ensemble handle, and the object read from the file is also an ensemble, the read data is stored in the shell of the old ensemble, after all old ensemble data has been deleted. Its object handle remains unchanged, as is its dataset membership. The reuse of reaction handles is currently not supported. This parameter can be skipped by specifying an empty string.

In addition to passing an empty string, or a simple dataset or ensemble handle, as the fourth command argument, a list consisting of a handle and a modifier flag set can be specified. The only flag value which is currently recognized is checkroom. If that flag is set, and the input objects are to become members of a dataset with enabled maximum size or insertion mode control, a test is made whether the dataset has sufficient room to allow the insertion of the new object(s), or whether a suitable alternative action is configured to handle the read object in a different fashion, such as discarding it. If that is not the case, the command returns immediately, without performing any input, and returns an empty string. If the test succeeds, the input operation is atomic, since the dataset is locked for the full duration of the command, so that no other threads can manipulate its status between the initial check and the file input result object transfer.

The final optional parameter is either a single argument specifying the number of objects which should be read, or a dictionary with key/value attributes. The default is equivalent to passing a simple numerical value of one, in the first, simple format. In order to read until the end of the file, the special value all may be used instead of a numerical count. With an all parameter value, the input operation is finished when no more data is available on the file. Until this condition is met, an unlimited number of records is read. No error is generated when EOF is met. There are also no EOF errors reported if a numerical record count of more than one was specified, and at least one object could be successfully read. Another magical value of the simple argument form is batch, which is substituted by the batch record set size configured on the molfile handle (see molfile get/set).

In the second form of the final parameter, an attribute dictionary is persistently applied equivalent to a molfile set command before the input commences. Standard file handle attributes and an input limit may be both set in parallel by using the special attribute name limit as part of the dictionary. It is only recognized in this context, but not with molfile set or molfile string. The allowed values of the limit attribute are the same as in the simple command variant.

The command raises an error if input could not be completed, regardless whether the reason is a file syntax error, or simple EOF (but see above for exceptions). If an input error occurs, the EOF attribute of the file handle should therefore be checked in order to distinguish between these two conditions. In case the input file was opened for pipe reading (mode 'p'), or is connected to a TcL channel, an EOF report may only indicate that no current data is available on the pipe or TCL channel, but it could still arrive at a future point in time.

```
Examples:
if {[catch {molfile read $fhandle} ehandle]} {
    if {![molfile get $fhandle eof]} {
        puts "Error: $ehandle"
    }
} else {
    puts "Read [ens get $ehandle E_NAME]"
}
```

The prototypical snippet above shows the input of the next ensemble record from a previously opened file, with proper error checking.
molfile read "acd.sdf" [dataset create] all
This sample command reads a complete input file (we are using the single-operation feature of the molfile command to open and close the file acd.sdf automatically for the duration of this command) into a newly created dataset in memory. Reading huge datasets is of course not necessarily a good idea without large amounts of RAM. On typical current workstations, 10.000 or 20.000 compounds are no problem, but beyond that the risk of running out of memory is a real problem.
molfile reorganize
molfile reorganize filehandle
This command only has an effect for file formats for which the I/O module provides a reorganizer function. This function typically optimizes and compacts the file for input and queries, and should usually be called after all records have been written. Writing to a reorganized file is typically at least initially slower than writing to a file which has not been processed.

The function returns a boolean value indicating whether any reorganization has actually been performed. In case the command is applied to a file which is not writable, an error results.

## molfile rewind

molfile rewind filehandle
Reposition the file before first record, and clear all error status information. If the file is already at the first record, and no error condition is set, this command does nothing.

Not all file channels can be rewound, and for some which can, it can be an expensive operation. For example, standard input or pipe input channels are not rewindable, and an FTP URL channel has to be closed and re-opened.

Rewinding a virtual file set positions the file pointer before the first record of the first file in the set.
Standard text-stream style output files can be rewound, too. This effectively truncates them. Files which are opened for appending are truncated to their original length.

Rewinding is not necessary in all cases. The molfile scan command automatically rewinds the input file if it is at EOF at the begin of a scan.

The return value of the command is the file handle.

## molfile rewrite

molfile rewrite filehandle recordlist propertylist ?values? ?filter? ?callback?
This command updates specific property fields in a file, without rewriting the complete record. This is only supported if the file was opened for writing or updating, and the I/O module for the format of the file supports this operation by a special function. This typically limits the applicability of this command to database-style file formats such as CACTvs CBS and BDB.

The record list parameter is either a list of numerical records, with one as the first file record, or one of the special values all (all file records are updated), current, next, previous (the indicated record is updated), or a table handle, optionally followed by a table column name. In the last case, the table
is expected to contain the data for rewriting, and in case a column name is specified, that column should contain the applicable record numbers. If the table version is selected without a record column, the file records from one to the number of table rows is updated. None of the special values can be combined with the simple numerical record sequence style. If the parameter is a numerical record sequence, the order of the records is significant.

The values list can be empty, or it must match the length of the property list. In the latter case, every specified value must be a valid value for the property in the same list index position. Note that while it is possible to manipulate multiple records in one step with this command, it is not possible to assign a different set of values to the data fields for each processed record. For this operation, multiple rewrite statements must be issued. If the value list is absent, or empty, the values are recomputed from the structure or reaction object that is temporarily read from the file record for this purpose. This is a useful feature in case the computation function for a computable property has changed. In case the record list references a table instead of a numerical record list or a magic record name, the value list is ignored. Instead, the table is expected to contain table columns which match the properties in the list, but not necessarily in the same column order, or containing exclusively the properties in the list.

The optional filter argument is a query expression in the same style as used in the molfile scan command. If a filter expression is supplied, only records which match the expression are changed. Non-matching records are skipped. In case no filter is used, all records selected by the record list are processed

After processing, the file pointer is on the last processed record.
If the name of a TcL callback procedure is specified, it is called after each processed record. The TcL procedure arguments depend on the processing mode. In case of table-based processing, the arguments are the table handle, the current table row, the file handle and the current file record.

This command is not fully implemented yet. CBS files currently only support re-computation of property data from object data, not updates from explicit value lists. Neither BDB nor CBS I/O modules currently call the TcL callback procedure except in table-based processing mode.

The command returns the number of updated records.
Example:

```
molfile update $fh current E_NAME "Black tar, grade A"
molfile update $fh all E_XLOPG2
molfile update $fh [list $mytable records] [list E_IDENT E_REGID]
```

The first command changes the property field E_NAME in the current record to the specified value. The second variant recomputes all E_XLOGP2 values in the file from the stored structure data - for example after updating the computation function of that property, or having added it as a new field to the file. The final version changes the fields E_IDENT and E_REGID for the records stored in table column records, replacing them with the data found in the table columns of the same name.

A complication in the use of this command is that database-type files like the CACTvs CBS and BDB formats store property definitions themselves. After opening the file, a newly set up property definition, which may for example possess an upgraded computation function, can have been replaced by the old definition from the file. In that case, the new property definition must be explicitly re-read to gain the upper hand again, for example with a prop read command.
molfile scan
molfile scan filehandle|remotehandle expression ?mode? ?parameters?
Execute a query on the file and return results. The structure file is scanned, by default starting from its current read position, and results are gathered until either the end of the file has been reached (or the scan wrapped once around the file, if the wraparound file flag has been set) or a scan condition caused the stopping of the scan procedure. If the scan finished without reaching the end of the file, it can be resumed with another molfile scan command at a later time.

The file scan works in principle on any file, but with very different efficiency. Files managed by file format I/O modules which support direct field access, and can supply structure and reaction data in binary form, can be queried much (often a factor of 1000 or more) faster than, for example, a plain SD file. In the latter format, every record needs to be fully parsed, the structure compared against the query expression, and most of the structure data is discarded immediately after the record has been checked. Files in formats which support various types of indexing for numerical values, bit-screen filtering for super- and substructure searches, hash codes for full-structure matching and other means of acceleration can be effectively queried with typical expressions in a few seconds, even while containing millions of compounds.

The two basic built-in CACTVs formats for effective searching are CBS (static files, good performance on CDROM and other linear media) and BDB (efficiently updateable, and with more advanced indexing than CBS). In contrast the systematic reading of a million-record SD file takes a few hours. Nevertheless, the feature of universal query support is very useful for working with typical data sets of a few thousand records. These do not need to be converted from their original formats to a query file for a quick exploratory data scan.

## Query expression syntax classes

The toolkit currently supports two syntactically unrelated classes of query expressions: Native Cactvs expressions, which are described below, and Bruns/Watson structure queries as described in J. Med. Chem. 2012, 55, 9763-9772, The exact syntax supported is that of the internal Lilly suite in October 2014, which is significantly extended from the description in the paper, but also discards some outdated syntactic elements briefly mentioned in the paper.

## Example:

```
set demerits [molfile scan $fh [read_file 9 aminoacridine.qry] {record demerit}]
```

This expression returns a nested list of records which match the query, and their merit/demerit score computed by that rule. Note that records which do not match the expression are omitted, they do not report a zero demerit in the result. Internally,, Bruns/Watson queries are mapped to the standard toolkit query expression data structure. Many of the queries in the standard Lilly rule set can be expressed equivalently as a native query. However, at this time there are a few specific Lilly query features which cannot be expressed in native toolkit syntax.

If a query expression cannot be parsed as Bruns/Watson code, an attempt is made to interpret is as native Cactvs expression, and all error messages relate to that interpretation attempt. The following paragraphs all apply exclusively to the native toolkit expression style.

## Branch node expression classes

The expression argument is a tree of individual query statements. It is formatted as a nested Tcl list. The he allowed depth of branching as well as the allowed number of leaf nodes is unlimited. The following branch operations are supported in this tree:

- and

One to any number of child branches. The branch query only succeeds if all branches match.

- or

One to any number of child branches. The branch query succeeds if any of the branches match. As soon as the first branch is a match, the other child branches are no longer executed. This is usually desired because it accelerates the processing of the query. However, in some circumstances, for example when computing similarity scores or coloring matched atoms or bonds, this is not the desired behavior. The orcontinue operator has the same query branch logic, but all branches are visited.

- orcontinue

See above, an or operator variant where all child branches are always executed. This can also be written as orcont.

- xor

One to any number of child branches. The branch query succeeds if an odd number of the child branches match. eor is an alias name of the operator.

- not

Exactly one child branch. This operator inverts the match/nomatch status of the child branch, and lets all other status conditions reported by the child branch pass unchanged.

- bind objclass

One or an odd number of child branches. This is a rather unique operator. Its effect is to force the use of the same minor object in all controlled branches. For example, if the child branches were to contain two molecule property checks connected by an and operator, by default the molecules of database structure ensembles which pass these conditions are independent and can be different. If a bind node is located upstream, those two molecules must be the same. Only when the first of a series of conditions is checked, all molecules are iterated as potential matches. If the query continues with a match of the first condition, the molecule is no longer unbound, and only the molecule already matched with the first condition is tested with the other conditions. Bind nodes can be used with any ensemble minor object class on structure queries (such as atom, mol, ring) or ensembles (ens) on reaction queries. The objclass argument part must be set to the desired class name. Bind nodes only affect controlled nodes which are property queries with properties belonging to the bound object class.

If more than one branch is specified, the query expression branches (first, third, etc. argument) are linked by an identifier which determines how these branches interact under the umbrella of the bind node. The link argument it itself a list. Its first element is the link type identifier (currently one of independent, singlebond or doublebond). Except in case of the first mode, the next element is the index (starting with 0 ) of the query branch in the bind node. It must refer to an existing branch index, i.e. forward declarations are not possible. For the determination of the branch index only the query branches count. The interspersed link arguments do not generated query branches.

If the mode is not independent, the allowed atoms or other minor objects which are tested in the additional branches depend on the current minor object in the referred branch. In modes singlebond and doublebond, these can only be atoms linked via the specified bond type to the referrer object, not the full atom set of the tested ensemble. In case of linked query branches, these are recursively checked. If a minor object in the leading branch matches, but fails to match in a dependent linked branch, more allowed minor object combinations are tested until they are exhausted or a combination of suitable minor objects is found which matches all branches. In any case, a minor object is only utilized once per bind node, so that for example a chain of three singlebond connected query branches needs to match three different atoms - the third branch cannot go back on the bond between the atoms selected for the first and second branch matches.

Example:

```
set q {
bind atom {and {A_ELEMENT in {7 8 16}} {A_NEIGHBORS = 2} {A_RING_COUNT = 0}}
{singlebond 0}
{and {A_ELEMENT = 6} {A_UNSATURATION = 0} {A_RING_COUNT = 0}}
{singlebond 1}
{and {A_ELEMENT in {7 8 16}} {A_NEIGHBORS = 2} {A_RING_COUNT = 0}}
}
molfile scan $fh $q
```

This query tests for a fragment of three atoms, which are connected by single bonds and where the individual atoms are each subject to a check on different set of atomic attribute conditions. The same query could also be realized as a SMARTS pattern. The advantage of this notation is that arbitrary properties can be used as attributes and an extended operator set and the full set of comparison mode flags is available. The disadvantage is a less readable pattern representation, and that no substructure query accelerator techniques such as bitvector screening are automatically employed.

- passswitch

A switch where a single child node depending on the current value of the pass index is selected. All other child nodes are ignored in that query pass. This is internally used for smart similarity queries and of limited usefulness for normal user-written queries, but it may be used in expert queries. In standard queries, only a single pass, with index zero, is ever executed. The maximum number of passes of a query is determined by the largest number of child nodes in any passswitch node in the query.

Here are a few simple expression patterns:

```
molfile scan $fh $leafexpression1
molfile scan $fh [list "and" $l1 $l2]
molfile scan $fh [list "or" $l1 [list "and" $l2 $l3 $l4]]
molfile scan $fh [list "orcontinue" [list not $l1] [list "xor" $l2 $l3]]
molfile scan $fh [list bind mol [list and $l1 $l2]]
```

All branch nodes need to end in leaf expression nodes. An empty query expression is valid and matches every input record. Also, it is legal and actually a common case to have an expression which is just a single leaf node expression. The order of the branches does not matter. An automatically invoked optimizer sorts the branches, and simplify them, in order to achieve maximum performance.

## Leaf node expression classes

These are the supported classes of leaf node expressions:

- all

This is just a placeholder. It will matches every record.

## - filename

A condition on the name of the current physical file. This is only useful for scans involving virtual files.

- formula

A molecular formula expression.

- isnull

Check whether property data is absent.

- notnull

Check whether property data is present.

- property

A condition of a property value. If possible, this is evaluated without reading a full structure or reaction object from the file. However, if necessary, the checked property data is extracted from, or even computed on, the full record data item. The first word of a property leaf node expression is the name of the property, not the class name.

- reaction

A reaction query to find records with reactions containing specific bond transformations.

- record

A condition on the file record of the current physical file. For simple single-file scans, this is the same as the virtual record.

- smartsearch

A special variant on the structure search node. This node is internally expanded into four internal alternative queries controlled by a pass-dependent switch node. The expanded queries are a full structure query, a substructure query, and Tanimoto similarity queries with thresholds of $95 \%$ and $90 \%$. The complete query is automatically re-run with the next branch of the series of alternative queries until at least one hit has been found. This query mode only works on data sources where the file or other input source can be repositioned to the original start position if a second or later pass is required.

- structure

A structure match operation on the primary database structure, a derived version thereof, or a reaction component. This type of query supports a variety of full-structure, substructure, superstructure and similarity matching methods. Some of these expressions, such as full-structure queries, are internally rewritten to property queries. For full-structure queries, these are hash code checks. Others, such as substructure matching, are handled by special routines. The first word of the leaf node specification can either be structure, for the main record structure, which is expected to be cleaned up and standardized, or any other of the recognized structure file ensemble classes (reagent, product, solvent, catalyst, parent,
scaffold, original, deprotected, salt). If a tested file record does not contain the requested structure variant, an attempt is made to derive it from the main record structure. This works with, for example, the parent structure, but not, for example, for obvious reasons with the original.

- vrecord

A condition on the virtual file record. For simple files, this is the same as the physical record.
The various leaf expression classes have different syntax schemes, which are explained in the next paragraphs.

## record and vrecord expressions

The record and vrecord expression classes are always written with three list elements: The expression class name, the operator, and the value or value list. The operators can be from the standard six numerical types, the range operator (<->), and the in or notin set operators. Numerical comparisons require a single comparison value, the range operator a pair of values, and the set operators a list. Examples:
"record <= 100"
"vrecord <-> \{1 1000\}"
"record in $\{1719$ 230\}"

## filename expressions

The filename expression class is even simpler. It always consists of three elements: The expression class name, the operator (which can only be $=$ or $!=$ ), and the file name. The actual file comparison operation uses device and inode identifiers on Linux/Unix platforms if the file is accessible, so the exact spelling of any path components does not matter. Example:
"filename $=$ part1.sdf"

## isnull and notnull expressions

The isnull and notnull expression classes are written with two elements. The first is the class name, and the second a property name. The property name may be qualified with an ensemble class modifier. If the modifier is not specified, the query applies to the main database structure. Otherwise, the property of the specified ensemble class is addressed. Examples:

```
"isnull E_NAME"
"notnull product:E_ASSAY_RESULT"
```


## property expressions

The property query expression class is a little bit more complex. It has a variable number of elements, between three and eight. The general syntax scheme is

```
property {operator ?modifiers?..} value ?threshold? ?multimode? ?filter? ?c1? ?c2?
```

The first three elements are always the property name, which can be qualified with an ensemble class, the comparison operator, and one or more values. The number of required values is dependent on the operator. The comparison operator can be a nested list. It needs to contain as a list element the basic comparison operator (numerical, range or in/notin set operators) and may additionally contain modifier words, which are translated into flags potentially influencing the datatype-specific comparison functions. It depends on the data type of the property whether any flag word has an effect.

If the object flag word is supplied as part of the operator list, the value part of the query is parsed as a chemistry object handle, more specifically an ensemble handle, a decodable string representation of an ensemble, a reaction handle, or a decodable string representation of a reaction. The ensemble variants are accepted if the query property is attached to an ensemble or an ensemble minor object, and the reaction variants can be used if the property is reaction-related. The value of the query is then automatically extracted, even computed if needed, from the object. Properties with subfields can be entered with the basic name, or any qualified subfield name. In addition, the property name may be prefixed by a structure class designator (see paragraph on structure queries). By default a property is assumed to be data of the main structure of the file record, or the main reaction. Examples:

```
"E_NAME = methane"
"solvent:E_NAME {in ignorecase} [list benzene toluene ethylbenzene]"
"E_IRSPECTRUM(source) {= shell nocase} *bruker*"
"E_WEIGHT {<= object} $ehtest"
"E_CAS {= ignoredashes ignorecase} 88337-96-6"
```

These are the comparison flag words which are recognized:

- absolute

Use absolute numerical values for comparison.

- alternative

Use alternative variant of comparison algorithm, if supported. For example, the bitset/bitunset comparison methods by default report 0 (equality) only if all bits are identical. The alternative version reports 0 when there is any common bit.

- approximate

Use an approximate version of the comparison operator. For strings, this means that case, whitespace, numbers and punctuation are ignored. For floating point data, it means that the comparison employs rounded integer values. This can also be specified by an at @ character directly attached to the operator.

- asnumber

Extract number from, for example, a string and use that for numerical comparison instead of literal comparison.

- bitset

Interpret the query expression value as bit mask and check whether all bits in that mask are also set in the file value.

- bitunset

Interpret the query expression value as bit mask and check whether all bits in that mask are unset in the file value.

- contained

Test whether the query expression value is contained in the file value. For strings, this is simple substring matching. For vectors, this is an element match.

- cosine

Compute cosine similarity coefficient percentage from query expression and file value and remember this as score. This comparison is only supported for bit vectors.

- correlation

Compute correlation coefficient from numerical vector types.

- dice
compute Dice similarity coefficient on bit vectors, bit sets or strings (via bigraphs).
- euclidean

Compute Euclidean distance from numerical vector types.

- extended

Use an extended version of a comparison method. For example, in conjunction with regular expressions, this enables extended regexp syntax.

- glob

Interpret query value as shell expression. This can also be specified by an asterisk * character directly attached to the operator.

- ignorecase

Ignore case for string-related comparisons. This can also be specified by an $i$ character directly attached to the operator.

- ignoredashes

Ignore dash/minus characters in string-related comparisons

- ignorewhitespace

Ignore whitespace in string-related comparisons

- ignorezero

For numerical vector comparisons, ignore zero elements.

- needelementmatch

For vector comparisons with the contained flag, the default method is to check whether all elements of the query vector value compare to one element in the file vector data, but not necessarily in the same position. If this flag is supplied additionally, any single element match will suffice for a positive comparison result.

- needelementmismatch

For vector comparisons with the contained flag, the default method is to check whether all elements of the query vector value compare to one element in the file vector data, but not necessarily in the same position. If this flag is supplied additionally, there needs to be at least one element mismatch for a positive comparison result.

- object

Decode value as object, and compute comparison value from it The the object is a string representation, the object is only created temporarily and discarded as soon as the value was obtained. Persistent objects that are addressed via their handles remain valid and unchanged, except that their property data set is potentially extended by the computation.

- precision

Use the precision as defined in the property description to check for equality. By default, full CPU precision is used.

- regexp

Interpret query value as regular expression. This can also be specified by a tilde $\sim$ character directly attached to the operator. Starting with toolkit version 3.352, the regular expression syntax on all platforms is that of the PCRE library, also known as the Perl style.

- swap

Swap left and right side of the expression in the comparison. This makes especially sense for asymmetric operations such as regular or shell expressions. With a swap word, the regular or shell expression is the string from the file, not the written query value.

- tanimoto

Compute Tanimoto similarity coefficient percentage from query expression and file value and remember this as score. This comparison is only supported for bitsets and bit vectors.

- tversky

Compute Tversky similarity coefficient percentage from query expression and file value and remember this as score. This comparison is only supported for bitsets and bit vectors.

- trim

Ignore leading and trailing whitespace. Spaces in the middle of a string are still significant.

- unique

Hint for the query processor that the value is expected to match only once in the file, if at all. This is useful for query optimization. If a hit has been found, additional records need not to be checked.

- vectorrange

For numerical vector comparisons. The query expression value vector is expected to contain twice as many elements as the file values. Every pair of values in the query vector is interpreted as a required upper and lower bound for the file values.

- withdigits

In conjunction with the approximate modifier, make digits significant again.
If the operator is the in or notin word, the value part is interpreted as a list. The value, or value list item, must be parseable according to the property data definition definition. Enumerated values and similar encodings may be used if properly defined in the property descriptor record.

If the comparison function computes a score (for example, the Tversky or Tanimoto variants), the next optional argument is a threshold value which needs to be exceeded to register as hit. If the threshold parameter is not specified, or given as a negative value, any score passes. Example:

```
"E_SCREEN {>= tanimoto object} $eh 95"
```

The next two optional arguments concern the case when there is more than one file data value to compare against the expression value. This generally happens when the tested property is not a major object property, but a minor object property, such as an atom or molecule property. In that case, the database record often contains multiple values, because there is more than one atom, or more than one molecule in the structure in the record. The first argument is the general match criterion. It can be set to one, all, none, or both. The default is one. Mode one means that it is sufficient if one of the record values matches. Mode all requires all to match, mode none requires that none matches, and mode both requires that there are both matches and mismatches.

The next optional parameter is a filter which can be used to restrict the values tested. If it is not present, or an empty string, no filter is applied. Example:
"A_ELEMENT = 6 \{\} all ringatom"
Above expression checks whether all ring atoms in the structure are carbon. Any record with a hetero ring atom fails the test.

The final two optional arguments are integer constants which may be used by the comparison operation. If they are not specified, both are implicitly passed as zero. If the first is specified, but not the second, the second is set to 100 minus the first value. Almost all comparison operations on the various data types ignore these.

One comparison mode which does make use of them is the Tversky bit vector similarity score. Here $c 1$ and $c 2$ are the weights of the bits in the first and second compared value. For scoring, both parameters are divided by one hundred and the floating point results are used as weight multipliers. Example:
"E_SCREEN \{>= tversky object\} \$eh 90 \{\} \{\} 30 70"
Above expression computes a Tversky score on the standard structure search screen E_SCREEN with $30 \%$ weight for the database structure features and $70 \%$ of the query structure features (i.e. imbalanced towards a substructure rating), and report the record if the score is $90 \%$ or higher.

Starting with version 3.358 of the toolkit, property expressions where the data type of the query property is structure or reaction are no longer parsed as standard property expression, but as structure or reaction query expressions, respectively. Example:
"V_ONTOLOGY_TERM(substructure) $\{>=$ swap stereo isotope charge\} \$eh"
Since the data type of the subfield of v _ONTOLOGY_TERM is structure, the syntax rules of normal property expressions no longer apply. Instead, the syntax for structure expressions explained below is substituted.

## structure expressions

Structure expressions are used to invoke structure comparison operations, such as sub- and superstructure search. The expression is a list, with three to six elements. A structure expression starts with the structure identifier, followed by the operator, which, as in property queries, may be written as a list with auxiliary modifier words, and as third mandatory argument the comparison structure source.

The structure identifier is the name of a structure class. Usually it is present as part of the record in the queried file, but some structure classes can be computed from the main structure if necessary. If a structure class can neither be found in a file record, nor computed, the node will not match. The following structure classes are supported:

- structure

The main structure. Usually expected to be a standardized, normalized form.

- original

An original structure, un-standardized. deposited is an alternative name.

- salt

A salt form

- deprotected

A variant without protective groups

- parent

A parent compound. There is a standard computation function for this form.

- scaffold

A structure core, isolated by some algorithm.

- reagent

A reagent ensemble. Usually this is a part of a reaction record, but it can be present also on its own.

- product

A product ensemble. Usually this is a part of a reaction record, but it can be present also on its own.

- solvent

Solvent for a reaction. Usually this is a part of a reaction record, but it can be present also on its own.

- catalyst

Catalyst for a reaction. Usually this is a part of a reaction record, but it can be present also on its own.

At minimum, the operator section contains a standard numerical operator symbol. Additionally, modifier words may be present as additional list elements. The following operators are supported.

- =

Structure identity, i.e. full-structure search. This is internally re-written to an equivalent hash code search as a property comparison node. A suitable hash code is automatically selected depending on the operator modifiers such as stereo and isotope.

- !=

Structure inequality, i.e. a negated full-structure search. This is internally re-written to an equivalent hash code search as a property comparison node. A suitable hash code is automatically selected depending on the operator modifiers such as stereo and isotope.

- >=

Substructure search.

- >

Substructure search, excluding identity.

- $<=$

Superstructure search. This operation ignores hydrogens on the database structures (see below).

- <

Superstructure search, excluding identity. Superstructure search ignores hydrogens on the database structures when the database entries are used as sub-graphs - otherwise a normal, fully specified database molecule will not match much. For the identity check, hydrogens are significant.

- $\sim>=$ or $\sim>$

Tanimoto similarity search with a reporting limit. This is internally re-written to an equivalent property search.

- \%>= or \% ${ }^{\text {> }}$

Tversky similarity search with a reporting limit. This is internally re-written to an equivalent property search.

- <->

Substructure match count range search. This automatically changes the substructure match mode to distinctinneratoms (see match ss command and the count modifier below). It is possible to use a lower bound of zero which lets structure mismatches pass the query condition. This can be useful when match-dependent data is retrieved, for example the matchcounts pseudo property (see below).

The default substructure match mode has the bondorder, useatomtree and usebondtree flags set (see match ss command). The initial flag set can be modified with modifier words linked to the operator. As far as it makes sense, the modifier words also change the operation of derived query modes, such as full-structure matching via hash codes.

These are the modifier words which can be used in structure expressions:

- absolutestereo

Perform absolute stereo matching. By default, stereochemistry is not used in the query, except if set up explicitly as atom- or bond-specific query attribute in properties A_QUERY and B_QUERY as part of the query substructure specification. An alternative syntax is to directly attach an uppercase $S$ character to the operator.

- allowmissingstereo

If set, absent stereochemistry descriptors in file structures can be matched by explicit stereo centers in the query structure. However, stereo center mismatches still lead to a match failure.

- anyfragment

Report a match for full-structure search if any molecule of the file structure is identical to the query structure. For substructure/superstructure queries, this flag has no effect, since their default operation mode already covers the effects of the flag.

- anyoverlap

If the substructure contains multiple fragments, they may match overlapping parts of the structure ensembles. By default, matched substructure fragments cannot overlap. This flag cannot be combined with atomoverlap.

- arotautomer

A more aggressive form of the tautomer mode. In this mode, tautomers involving the dissolution of aromatic systems are also found, in addition to the more low-energy tautomer forms matched with the normal tautomer mode.

- atomoverlap

If the substructure contains multiple fragments, they may match overlapping atoms, but not overlapping bonds. By default, matched substructure fragments cannot overlap at all. This flag cannot be combined with anyoverlap.

- charge

Match formal charges of query atoms. By default, charges are not compared, except if set up explicitly as atom-specific query attribute in property A_QUERY in the query substructure specification.

- count

For substructure and superstructure matching, check not only for the presence of a match, but count the number of distinct matches equivalent to the match mode distrinctinneratoms in the match ss command. The normal substructure match mode is equivalent to the first mode in the match ss command, yielding only counts zero or one.

- emptyssismismatch

By default, a substructure without any atoms matches anything. If this flag is set, it matches nothing instead.

- exactaro

Match aromatic bonds exactly. By default, simple single or double query structure bonds match structure file record aromatic bonds.

- exactringsystem

Rings in substructure fragments must match complete ring systems only. For example, with this flag a benzene substructure no longer matches naphthalene, anthracene, etc. Non-ring parts of the substructure can still, if other query attributes do not prevent this, match both ring and chain parts of file structures. For full-structure queries, this flag has no effect.

- extended

Use extended versions of the match procedures. For similarity queries, this enables the PubChem extended scoring mechanism. If the query structure is identical to a file structure both in stereochemistry and isotope labels, an artificial score of 104 is computed, 103 if isotopes or stereochemistry match, but only one of these, 102 for basic equivalence of connectivity without isotopes or stereochemistry, and 101 for a tautomer. Compounds which are not structurally identical to the query structures using one of these criteria are scored normally.

- fragmentsplit

Treat every molecule in the query structure as a separate fragment. The query ensemble is implicitly split, and every component therein is stored in an independent structure expression node. These nodes are then connected with an or or orcontinue branch mode. This is similar to using a file handle pointing to a file with multiple records as query structure data source (see below).

- framework

Substructure carbon atoms cannot have any unmatched, directly bonded carbon or hetero atom neighbors in the structure. Unmatched bonded hydrogen is allowed. This flag has an effect only for sub- and superstructure match modes.

- implicitsinglearo

If this flag is set, bonds which were created with an implicit bond order when the query structure was decoded are matched as if they were explicit single/aro query bonds. This is a useful mode for emulating Daylight software.

- isotope

Perform isotope matching. By default, isotope labels are not used in the queries, except if set up explicitly as atom-specific query attribute in property A_QUERY in the query structure specification. An alternative syntax is to directly attach an $i$ character to the operator.

- matchallheavyatoms

Require that all heavy atoms in the file structures are matched. This feature generates matches of file structures similar to full-structure matches while allowing the use of substructures with variable match conditions, such as atom lists.

- nobondorder

Do not compare bond orders. This flag has an effect only for sub- and superstructure match modes.

- nochainonaro

Do not match chain parts of the query substructure on aromatic bonds in the file structures. This flag has an effect only for sub- and superstructure match modes.

- nochainonring

Do not match chain parts of the query substructure on ring bonds in the file structures. This flag has an effect only for sub- and superstructure match modes.

- nodoubleonaro

Do not match otherwise unmarked double bonds in the substructure onto aromatic bonds of the structures.

- noquerytree

Deactivate extended matches requiring full checks of the query tree fields in the A_QUERY and B_QUERY properties in the query structures. Certain query inputs need these trees for precise matching, because the query cannot be expressed as a flat set of query attributes. Examples for queries requiring tree matching for proper execution are complex SMARTS expressions beyond those using only simple explicit or implicit and in atomic or bond expressions, and Recursive SMARTS. Disabling the flag may lead to a small speed-up for simple substructure queries.

- nosingleonaro

Do not match otherwise unmarked single bonds in the substructure onto aromatic bonds of the structures.

- nosubstructureh

For substructure match, ignore any hydrogens present in the query structure. This is a convenient shortcut to allow the use of hydrogen-complete structures as simple substructures. A similar scheme is automatically invoked for superstructure search, where hydrogens in the file structures are ignored in matching.

## - reactionflags

Match reaction transform flags in the substructure. Both query and file structures need to have data for property B_REACTION_CENTER set. The supported set of comparisons is compatible with MDL's ISIS database. Note that this flag can be used gainfully in structure expressions for half-reaction matching. It is not limited to full reaction queries. This flag is on by default in reaction queries, but off for structure queries.

- relativestereo

Perform relative stereo matching. By default, stereochemistry is not used in the query, except if set up explicitly as atom- or bond-specific query attribute in properties A_QUERY and B_QUERY in the query structure specification. An alternative syntax is to directly attach a lowercase $s$ character to the operator.

- sethighlight

In case structure ensembles are retrieved from the file (molfile scan modes ens, enslist, reaction or reactionlist), the bonds and atoms matched by a substructure are marked in the returned structure-side ensembles with the highlight flags in properties B_FLAGS and A_FLAGS. In case multiple matches occur, the highlight set is an union of all processed matching substructure mapping. This flag is also automatically set if the property retrieval set in the molfile scan command includes related pseudo properties, such as matchatoms or matchbonds.

- setmatchproperty

In case structure ensembles are retrieved from the file (molfile scan modes ens, enslist, reaction or reactionlist), the bonds and atoms matched by a substructure are marked in the returned structure-side ensembles by attached properties A_SSMATCH and B_SSMATCH. These are set to the labels of the matching substructure atoms or bonds. Unmatched structure ensemble parts have match property values of zero. In contrast to the sethighlight flag, this option attaches a new match property instance for any successful and processed match. Returned ensembles may therefore possess series of property instances like A_SSMATCH, A_SSMATCH/2... and so on.

- swap

Swap the left and right structures in the query. This means, for example, that the database is expected to contain substructure definitions, and the query value argument a fully defined structure. This is not exactly the same as a superstructure search because of the different style how hydrogens are handled. For superstructure search, hydrogen atoms in the file records are ignored, generating a simplified structure from the record data for matching, but in case of a swapped substructure search, the file record is submitted as substructure for matching without any processing.

- tautomer

Match tautomers of the query structure. If this flag is active, non-aromatic single and double bonds in tautomer systems need not to be matched exactly, as long as the overall bond order count is a match. Mobile hydrogens can either be specified explicitly, or a full implicit set can be used if the useimplicith flag of property B_ISTAUTOMERIC is set. The standard mode does not consider tautomeric forms which destroy aromatic systems. If you need to find matches between aromatic and non.aromatic tautomer systems, use the more aggressive arotautomer mode.

- unique

Hint for the query processor that the query ensemble is expected to be matched only once in the file, if at all. This is useful for query optimization. If a hit has been found, additional records need not to be checked.

Many of these global flags can be overridden, or activated on a local level, for individual atoms or bonds, in the A_QUERY and B_QUERY properties. For example, A_QUERY has fields for flags which can
request the matching of stereo or charges for specific atoms, or to allow missing stereochemistry at a specific center. These per-atom or per-bond requests override global query flag settings.

The third mandatory expression list element is the structure source. It can be one of

- an ensemble handle

The ensemble is directly decoded.

- a list of ensemble handle and molecule label

The fragment indicated by the molecule label is extracted from the ensemble and used for the query as isolated entity. If the molecule label cannot be found, an error is reported.

- structure line notation string

For example, a SMARTS/SMILES/SLN/InChI/CID string or a packed Cactvs ensemble anything which can be decoded by the ens create command. The string is decoded into a transient ensemble, which is automatically discarded when it is no longer needed. The exact decoding specifications depend on the operator. For full-structure search, a fully specified structure is created, while for substructure-type queries implicit hydrogens are not attached, and the full range of query specifications of the encoding format is allowed.

- a dataset handle

A dataset containing at least one ensemble. All dataset objects are checked, and internally for every ensemble a separate expression node is created. The nodes are then linked via an or or orcontinue (in case a scoring operator is used) branch node. Dataset objects which are not ensembles are silently ignored. The hydrogen status of the dataset ensembles is not changed. In case there is only a single ensemble in the dataset, this command is indistinguishable from using the ensemble handle directly. In case the dataset does not contain any ensembles, an error is raised.

- a molfile handle

An opened structure file. All remaining records are read, and internally for every record a separate structure expression node is created. The nodes are then linked via an or or orcontinue (in case a scoring operator is used) branch node. If the match operation is full-structure, the file is read with automatic hydrogen addition (see molfile set), otherwise without any conversion flags. However, since the hydrogen addition flag is the only file attribute which may be temporarily overridden, other molfile object attributes may be set before the file is used in the query expression. Of course, using a file with a huge number of records in this fashion may cause problems. In case the file does not contain any records behind the read pointer at the time the command is parsed, an error is raised.

Query specifications found in structure sources are understood in a variety of formats. DAYLIGHT and MDL formats are decoded and translated into an internal representation in an almost completely compatible fashion. That includes Recursive SMARTS, ISIS 3D queries, MDL stereo groups and MDL reaction queries. A significant range of Sybyl SLN and CambridgeSoft ChemFinder query expressions are also understood, as well as features found in the CSD ConQuest software. Finally, in CACTvs there is no fundamental difference between a query fragment and a normal structure object. Query structures are just structures with additional information stored in properties A_QUERY, B_QUERY and possibly b_REACTION_CENTER. For basic matching, any structure object will do, even if they do not possess these query attribute properties. However, an eye should be kept in the hydrogen status of query fragments. If no specific flags are set, substructure matches attempt to match hydrogen atoms just like any other atom. Example:

```
set ehss [ens create C]
set ehss [ens create C smarts]
```

The upper substructure ensemble does not, in the absence of hydrogen ignore flags, match any structure ensemble except those which contain a full methane (one C plus four H ) molecule as fragment, because that is what the substructure represents. The second code line decodes the substructure in full SMARTS mode. Not only now the full range of SMARTS expressions can be parsed (though absent in this example), but the structure is also be created without implicit hydrogens. The first substructure could still be used in a molfile scan command as a simple carbon match test if the nosubstructureh modifier flag were supplied.

In order to read query structures from a file, the following generic open statement is the standard approach:

```
molfile open $file r hydrogens asis readflags noimplicith
```

Simple query formats, such as MDL ISIS query Molfiles, are read into a flat set of attributes. More complex formats, such as SMARTS, may require the use of a tree of expressions on individual atoms and bonds, similar to the overall query tree with branch and leaf nodes described here for the molfile scan command. These complex formats are nevertheless also translated, to the degree possible, to the flat model. For example, a SMARTS expression with only uses simple atom lists or atom and bond query attributes all connected just by and can be fully represented in this way. This also means that, format translation into other query file formats is also possible for these simple expressions. The use of the full query trees in matching can in some cases be a performance issue. The noquerytree flag is available to restrict the match to those parts of the full query which can be expressed in the flat model.

The fourth and optional expression list element in the query expression is used only for a few match modes. If it is not set, the default value is minus one.

- similarity queries: The minimum score required to report a hit
- substructure count ranges: A list of the acceptable minimum and maximum occurrence counts of the substructure. If only a single value is supplied, is is used both as minimum and maximum value.


## Example:

"structure ~=> \$eh 90"
$" p r o d u c t<->C(=O) \backslash[\mathrm{OH} \backslash]\left\{\begin{array}{ll}2 & 3\end{array}\right\} "$
The first sample expression is a standard Tanimoto similarity query, with a $90 \%$ threshold. The second query matches product structures with two to three carboxyl groups.

Optional expression list elements five and six correspond to the $c 1$ and $c 2$ parameters in property query expressions. These are currently only used in Tversky similarity queries:

```
"structure %>= $eh 90 30 70"
```

This is an expression for a skewed Tversky similarity ( $70 \%$ query structure, $30 \%$ file structure weight) with a $90 \%$ reporting threshold.

If the file format supports it, bitvector screening is automatically be applied to reduce the number of records for which structures need to be pulled and sent to graph-based substructure matching. The default structure match screening property is E_SCREEN. The standard versions of E_SCREEN implement three predefined fragment sets. The higher sets are identical to the lower ones in the
leading bits. Sets zero to two , which yield bit vectors of increasing length and selectivity, but also storage requirements can be requested by setting

```
prop setparam E_SCREEN extended 0/1/2
```

The bit set read from the query file must correspond to the parameter setting for E_SCREEN in the current TcL interpreter, if the screen bits are automatically computed on the query structure. The CBS and BDB file formats, which are optimized for structure query operations, contain screen bit version information in the file header and automatically configure the property parameter setting when the file is opened. For other file formats with screen bits this needs to be done explicitly in the application script. It is also possible to change the structure bit-screen property associated with a file by setting the appropriate molfile handle attribute, so it is easily possible to use custom screen bit sets instead of the default property.

Starting with version 3.358 of the toolkit, property query expressions where the data type of the property is structure are automatically parsed as structure expressions.

## smartsearch expressions

This query expression takes the same arguments as a structure expression. It is internally expanded into four alternative queries, linked by a pass-dependent switch control node. The four alternative queries are a full-structure query (equivalent to operator $=$ in a structure query), a substructure query (operator $>=$ ), and two Tanimoto similarity queries with thresholds of $95 \%$ and $90 \%$ (operator $\sim>=$ ).

When such a query expression is a component of query expression tree, the query is first run with the full-structure query. If that query yields less results than the pass match limit (by default one, i.e. the query does not match anything, this can be configured via the molfile passlimit attribute), the input data source is repositioned to the original start record and then the substructure query is run, and if that run also does not yield sufficient hits, the two similarity queries are tried one after another.

Running the second and later alternatives is only possible of the data source can be repositioned to the original start position of the first pass. If that fails, the query is silently terminated early. The pass match limit comparison triggering the possible re-execution of the query is with the global hit count of the query, not the number of hits returned by the smartquery branch. If other parts of a complex query produce sufficient hits, the query is not re-run even if a smartquery branch did not return any hits.

Hits returned in different passes can be distinguished by including the pass pseudo-property in the retrieval data.

By convention, smartsearch expressions are written with an = operator. The actual operator in a smartsearch expression is ignored, but modifiers are not. So specifying options like the use of stereochemistry or isotopes is supported and useful.

It is possible to have multiple smart search expressions in a query. The query pass index for these is incremented in parallel, not independently.

The smart search feature was inspired by a similar functionality in the Accelrys Isentris system.
Examples:
"smartsearch $=$ c1ncccc1"
"smartsearch $\{=$ stereo\} \"L-lysine\""

## formula expressions

Formula expressions are used to match file structures by element composition. Conceptionally, this is a special syntax for a complex property match on file structure properties E_ELEMENT_COUNT and m_element_count. A formula search expression is always a list of three elements. The first element is always formula, the second element the comparison operator, and the third word the formula specification. The following operators are supported:

- =

Match the formula specification. There cannot be any elements present in the structure which are not mentioned in the formula.

- >=

Match the formula specification. Elements which are not mentioned in the formula may be present in the tested structure.

- >

Match the formula specification. At least one element which is not mentioned in the formula must be present in the tested structure.

For formula queries, there are no modifier words for the operator.
The syntax of the formula is built on the lowest level by element or pseudo-element symbols, which may be grouped into sum or difference expressions and may possess a prefixed count multiplier. The symbol or symbol group can then be suffixed by a simple count, or an open or closed count range. If no count range is specified, the default count is one. In case an element is entered more than once, all counts for that element are added. Finally, the expression may be grouped by period characters into sub-expressions to be applied to different molecular fragments in the tested structures.

Besides normal elements, the following pseudo-elements, which are compatible to the set of the CSD ConQuest software, are recognized:

- ?

An atom in the tested structure which is not a simple element.

- [Any]]

Any atom which is a simple element (SLN syntax)

- [Hev]

Any atom which is a simple element and not hydrogen (SLN syntax)

- [Het]

Any atom which is a simple element and neither carbon nor hydrogen (SLN syntax)

- [1A]

Elements from the first PSE main group, excluding hydrogen (Li, Na, ..).

- [2A]
elements from the second PSE main group ( $\mathrm{Be}, \mathrm{Mg}, .$. )
- [3A]

Elements from the third PSE main group (B, Al, ..)

- [4A]

Elements from the fourth PSE main group (C, Si, ..)

- [5A]

Elements from the fifth PSE main group (N, P, ..)

- [6A]
- Elements from the sixth PSE main group ( $\mathrm{O}, \mathrm{S}, .$. )
- [7A] or [Hal]

Elements from the seventh PSE main group ( $\mathrm{F}, \mathrm{Cl}, .$. )

- [8A]

Elements from the eighth PSE main group ( $\mathrm{He}, \mathrm{Ne}, .$. )

- [1B]

Elements from the first PSE minor group ( $\mathrm{Cu}, \mathrm{Ag}, .$.

- [2B]

Elements from the second PSE minor group ( $\mathrm{Zn}, \mathrm{Cd}, .$.

- [3B]

Elements from the third PSE minor group (Sc, Y, ..)

- [4B]

Elements from the fourth PSE minor group (Ti, $\mathrm{Zr}, .$. )

- [5B]

Elements from the firth PSE minor group ( $\mathrm{V}, \mathrm{Nb}, .$. )

- [6B]

Elements from the sixth PSE minor group (Cr, Mo, ..)

- [7B]

Elements from the seventh PSE minor group (Mn, Tc, ..)

- [8B]

Elements from the full eighth PSE minor group ( $\mathrm{Fe}, \mathrm{Co}, \mathrm{Ni}, \mathrm{Ru}, \mathrm{Rh}, .$.

- [8X]

Elements from the first column of the eighth PSE minor group (Fe, Ru, ..)

- [8Y]

Elements from the second column of the eighth PSE minor group (Co, Rh, ..)

- [8Z]

Elements from the third column of the eighth PSE minor group ( $\mathrm{Ni}, \mathrm{Pd}, .$. )

- [1M]

Metals from the first and second main groups ( $\mathrm{Li}, \mathrm{Na}, \mathrm{Mg}, \mathrm{K}, \mathrm{Ca}, .$. )

- [2M]

Metals from the third to sixth main groups ( $\mathrm{Al}, \mathrm{Ga}, \mathrm{Ge}, \mathrm{Sb}, .$. ; but not $\mathrm{Si}, \mathrm{As}, \mathrm{Se}, \mathrm{Te}$ )

- [3M]

All main group metals (union of $[1 \mathrm{M}]$ and $[2 \mathrm{M}]$ )

- [TR]

11 transitions group metals, no main group elements or lanthanides/actinides

- [LN]

Lanthanides

- [AN]

Actinides (no, this is not [AC]!)

- [4M]

All metals in the PSE

- [NM]

All non-metallic elements
Element items can be grouped with round brackets into sums or differences. However, this is no full arithmetic expression parser. Element symbols can only be used as stand-alone syntactic elements, bracketed all-sum expressions, or bracketed all-difference expressions.

An element or an arithmetic group can have an appended count. This count can be:

- missing

The default count is one.

- a simple integer

The count must be matched exactly.

- a full integer range

The count must lie between the minimum and maximum values.

- an open range

Left-open ranges have an implicit minimum count of zero, right-open ranges an implicit maximum count of infinity.

- an asterisk

This is the same as a right-open range starting with zero, i.e. zero to any number of occurrences.

- a plus character

This is the same as a right-open range starting with one, i.e. one to any number of occurrences.

- a standard numerical comparison operator, followed by a number

The value is compared according to the specification. This is a CSD compatibility feature.

## Examples:

```
"formula = C6H6"
"formula = C5-6H6-"
"formula >= (Cl+Br)2"
"formula > \[4M\]>=3"
"formula = (2C-H)-6"
"formula = CH3COOH"
```

```
"formula = \[Het\]>1
```

The first expression is a simple search which matches any ensemble with a composition of six carbon and six hydrogen atoms. The second looks for compounds with five to size carbon and six or more hydrogens, but no other elements. The third line finds compounds where the sum of chlorine and bromine atoms is two. Other elements may be present but are not required, so this expression matches $\mathrm{Cl}_{2}, \mathrm{Br}_{2}$ and ClBr as well as dichlorobenzene. The fourth expression finds structures with three or more metal atoms. The fifth expression finds compounds where twice the sum of the carbon atoms minus the hydrogen atoms has a value up to six. The next line finds compounds with a formula of $\mathrm{C}_{2} \mathrm{H}_{4} \mathrm{O}_{2}$. The counts for repeated elements are summed up. The last example matches any compound with one or more hetero atoms.

Periods can be used to define separate formula sections. These are applied to individual molecules in the tested structures, not the full ensemble. If a single dot is specified at the beginning or end of the expressions, it signifies a single expression section to be applied to a molecule. When a test for formula sections is applied, all permutations of possible matches between the molecules in an ensemble and the formula expression sections are tried. It is neither required to have any specific order of the molecules in the ensemble, nor in the formula expression sections, not is there a need for a match between the molecule and expression section count. However, every expression section in a formula needs to match a different molecule in the tested ensemble.

Examples:
"formula $=$ C6H6.C7H8"
"formula $=. \mathrm{H} 2 \mathrm{O}^{\prime}$
The first expression looks for ensembles which contain one molecule with the formula $\mathrm{C}_{6} \mathrm{H}_{6}$, and another with formula $\mathrm{C}_{7} \mathrm{H}_{8}$. The second expression matches ensembles with one or more water molecules. In both cases, molecules/fragment with different composition may be present in the record. In order to test for two or more formulae with the additional conditions that there are no other molecules/fragments, use two formula expression nodes connected with an and branch node, as in
and "formula $=\mathrm{C} 6 \mathrm{H} 6 . \mathrm{C} 7 \mathrm{H} 8$ " "formula $=\mathrm{C} 6 \mathrm{H} 6 \mathrm{C} 7 \mathrm{H} 8$ "
Element symbols which stand for specific isotopes, such as $D$ for deuterium, are currently not processed. $D$ is read as a simple alias for hydrogen, disregarding the isotope label.

It is possible to use an ensemble handle instead of a formula expression. In that case, the elemental formula of that ensemble is used in the query, as computed by property e_FORMULA.

## reaction expressions

Reaction expressions are the construct used for reaction substructure searches, for example when looking for certain bond transformations in a database of reactions. Obviously, the scanned file needs to contain reaction information for this to succeed.

An important aspect for reaction searches are atom mapping numbers, which link atoms in the reagent ensemble to the product ensemble, and likewise in the transformation scheme which needs to be matched. The central property for this is A_MAPPING. If this property is present, it is used to restrict matches to those reactions which embody a certain transformation, and are not a simple pair of ensembles which match substructures of the left and right part of the query transformation somewhere in their connectivity. Nevertheless, it is still possible to query reaction without a mapping scheme. That is identical to a pair of substructure searches. Also, individual parts of a reaction (the reagent and product ensembles, but potentially also the catalyst or solvent entries) can
be used as targets for single-ensemble sub/super/full-structure searches via structure query expressions (see above).

A reaction expression is a list of three to six elements. The first element is always reaction, the second element the operator, and the third element the reaction source. The following operators can be used:

- =

Reaction identity, i.e. full-structure reaction search. This is internally re-written to an equivalent hash code search as a property node.

- !=

Reaction inequality, i.e. a negated full-structure reaction search. This is internally re-written to an equivalent hash code search as a property node.

- >=

Reaction substructure search.

- >

Reaction substructure search, excluding identity.

- <=

Reaction superstructure search.

- <

Reaction superstructure search, excluding identity.

- $\sim>$ or $\sim>=$

Reaction Tanimoto similarity search with a reporting threshold.

- $\%>$ or $\%>=$
- Reaction Tversky similarity search with a reporting threshold.

Similar to structure query expressions, the operator can be modified by adding flag words as additional list elements to the operator list element. The following flags are recognized:

- absolutestereo

Perform absolute stereo matching. By default, stereochemistry is not used in the query, except if set up explicitly as atom- or bond-specific query attribute in properties A_QUERY and B_QUERY. An alternative syntax is to directly attach an update $S$ character to the operator.

- allowmissingstereo

If set, absent stereochemistry descriptors in file structures can be matched by explicit stereo centers in the query structure. However, stereo center mismatches still lead to a match failure.

- anyfragment

Report a match for full-structure search if any molecule of the file structure is identical to the query structure. For substructure/superstructure queries, this flag has no effect, since their default operation mode already covers the effects of the flag.

- anyoverlap

If the substructure contains multiple fragments, they may match overlapping parts of the structure ensembles. By default, matched substructure fragments cannot overlap. This flag cannot be combined with atomoverlap.

- atomoverlap

If the substructure contains multiple fragments, they may match overlapping atoms, but not bonds. By default, matched substructure fragments cannot overlap. This flag cannot be combined with anyoverlap.

- bidirectional

If the query reaction does not match, try to match it also in the reverse reaction direction.

- charge

Match formal charges of query atoms. By default, charges are not compared, except if set up explicitly as atom-specific query attribute in property A_QUERY.

- emptyssismismatch

By default, a substructure without any atoms matches anything. If this flag is set, it matches nothing instead.

- exactaro

Match aromatic bonds exactly. By default, simple single or double query structure bonds match structure file record aromatic bonds.

- exactringsystem

Rings in substructure fragments must match complete ring systems only. For example, with this flag a benzene substructure no longer matches naphthalene, anthracene, etc. Non-ring parts of the substructure can still, if other query attributes do not prevent this, match both ring and chain parts of file structures. For full-structure queries, this flag has no effect.

- extended

Use extended versions of the match procedures. For similarity queries, this enables the PubChem extended scoring mechanism. If the query structure is identical to a file structure both in stereochemistry and isotope labels, an artificial score of 104 is computed, 103 if isotopes or stereochemistry match, but only one of these, 102 for basic equivalence of connectivity without isotopes or stereochemistry, and 101 for a tautomer. Compounds which are not structurally identical to the query structures using one of these criteria are scored normally.

- framework

Substructure carbon atoms cannot have any unmatched, directly bonded carbon or hetero atom neighbors in the structure. Unmatched bonded hydrogen is allowed. This flag has an effect only for sub- and superstructure match modes.

- implicitsinglearo

If this flag is set, bonds which were created with an implicit bond order when the query structure was decoded are matched as if they were explicit single/aro query bonds. This is a useful mode for emulating Daylight software.

- isotope

Perform isotope matching. By default, isotope labels are not used in the queries, except if set up explicitly as atom-specific query attribute in property A_QUERY. An alternative syntax is to directly attach an $i$ character to the operator.

- matchallheavyatoms

Require that all heavy atoms in the file structures are matched. This feature generates matches of file structures similar to full-structure matches while allowing the use of substructures with variable match conditions, such as atom lists.

- nobondorder

Do not compare bond orders. This flag has an effect only for sub- and superstructure match modes.

- nochainonaro

Do not match chain parts of the query substructure on aromatic bonds in the file structures. This flag has an effect only for sub- and superstructure match modes.

- nochainonring

Do not match chain parts of the query substructure on ring bonds in the file structures. This flag has an effect only for sub- and superstructure match modes.

- nodoubleonaro

Do not match otherwise unmarked double bonds in the substructure onto aromatic bonds of the structures.

- noquerytree

Deactivate extended matches requiring full checks of the query tree fields in the A_QUERY and B_QUERY properties in the query structures. Certain query inputs need these trees for precise matching, because the query cannot be expressed as a flat set of query attributes. Examples for queries requiring tree matching for proper execution are complex SMARTS expressions beyond those using only simple explicit or implicit and in atomic or bond expressions, and Recursive SMARTS. Disabling the flag may lead to a small speed-up for simple substructure queries.

- noreactionflags

Do not match reaction transform flags in the substructure. If reaction flags are checked, which is the default for reaction queries but not for structure queries, both query and file structures need to have property B_REACTION_CENTER set for this to work. The supported set of comparisons is compatible with MDL's ISIS database. For standard reaction queries which check for specific bond changes, this flag should not be set.

- nosingleonaro

Do not match otherwise unmarked single bonds in the substructure onto aromatic bonds of the structures.

- nosubstructureh

For substructure match, ignore any hydrogens present in the query structure. This is a convenient shortcut to allow the use of hydrogen-complete structures as simple substructures. A similar scheme is automatically invoked for superstructure search, where hydrogens in the file structures are ignored in matching.

- relativestereo

Perform relative stereo matching. By default, stereochemistry is not used in the query, except if set up explicitly as atom- or bond-specific query attribute in properties A_QUERY and B_QUERY. An alternative syntax is to directly attach a lowercase $s$ character to the operator.

- sethighlight

In case structure ensembles are retrieved from the file (molfile scan modes ens, enslist, reaction or reactionlist), the bonds and atoms matched by a substructure are marked in the returned structure-side ensembles with the highlight flags in properties B_FLAGS and A_FLAGS. In case multiple matches occur, the highlight set is an union of all processed matching substructure mapping. This flag is also automatically set if the data retrieval set in the molfile scan command includes related pseudo properties, such as matchatoms or matchbonds.

- setmatchproperty

In case structure ensembles are retrieved from the file (molfile scan modes ens, enslist, reaction or reactionlist), the bonds and atoms matched by a substructure are marked in the returned structure-side ensembles by attached properties A_SSMATCH and B_SSMATCH. These are set to the labels of the matching substructure atoms or bonds. Unmatched structure ensemble parts have match property values of zero. In contrast to the sethighlight flag, this option attaches a new match property instance for every successful and processed match. Returned ensembles may therefore possess series of properties like A_SSMATCH, A_SSMATCH/2... and so on.

- unique

Hint for the query processor that the query reaction is expected to be matched only once in the file, if at all. This is useful for query optimization. If a hit has been found, additional records need not to be checked.

The third mandatory parameter is the query reaction source. It can be any of

- A reaction handle

The handle is decoded directly.

- A dataset handle

A dataset containing at least one reaction. All dataset objects are checked, and internally for every reaction a separate expression node is created. The nodes are then linked via an or or orcontinue (in case a scoring operator is used) branch node. Dataset objects which are not reactions are silently ignored. The hydrogen status of the dataset reactions is not changed. In case there is only a single reaction in the dataset, this command is indistinguishable from using the reaction handle directly. In case the dataset does not contain any reactions, an error is raised.

- reaction line notation string

A string representation of a reaction, in any format that can be decoded by the reaction create statement, for example a Reaction SMILES, SMIRKS or a CACTvs serialized reaction object string. This query reaction is only temporarily instantiated and automatically deleted when the command finishes.

Reading one or more query reactions from a file handle directly in the query statement, as it is possible for structure queries, is currently not supported. Also, the tautomer match mode is not available for reaction matching because it interferes with atom map processing.

The optional query list items four to six are identical to those for structure query expressions. They represent a reporting threshold value and the $c 1$ and $c 2$ comparison algorithm parameters. Please refer to the paragraph on structure match expressions for more details.

The general approach to reaction sub- and superstructure matching is as follows:

- Perform bit vector screening for acceleration, if supported by the file format. The default reaction screen property is x_SCREEN. The name of the reaction screen bit property can be changed by setting the appropriate molfile handle attribute, so it is easily possible to use a custom reaction screen.
- Match the reagent side from the file record onto the reagent side of the query reaction, just like a structure query expression. If possible, structure screening (see paragraph on structure match expressions) is used as an acceleration filter in addition to the reaction screen.
- If atom mapping information is available, use it to set up a match constraint table for the product side, i.e. allow the product side substructure atoms with an atom mapping label which has a counterpart in a reagent substructure atom mapping value to match only the atom in the file product structure which has the same mapping label as the reagent side atom which was matched by the reagent substructure. For this to work, there need to be two matching pairs of mapping values on the reaction substructure and file reaction, though they of course can be different in both reactions. In case a 1:1 relationship cannot be established for an atom, the matching of this atom is not restricted.
- Match the product side, using mapping constraints where possible, and also using structure screens if available.
- If any of the previous steps fail, abort the sequence early, but if bidirectional matching is allowed, try again with the roles of the reaction substructure reagent and product ensembles swapped.
Besides the ensemble-level query attribute properties A_QUERY and B_QUERY, reaction matches also make use of B_REACTION_CENTER (for constraints on the type of transformation a bond undergoes) and e_reaction_role (for the identification of reagent and product ensembles in the reaction object).

Reaction similarity queries use the reaction screen set (by default, property x_SCREEN) instead of the structure screen that is used for structure similarity. This operation returns a single score. There is no scoring of the reagent or product ensembles.

Full-structure reaction matches are performed via hash code checks both the reagent and product sides. Atom mapping information is not used for this query operation. The suitable hash code is automatically selected depending on the operator modifiers (stereo, isotopes).

Starting with version 3.358 of the toolkit, property query expressions where the data type of the property is reaction are automatically parsed as reaction expressions.

## Scan modes

The return value of the molfile scan command depends on the query mode. The default mode is enslist for the molfile scan command, but may be different when scanning other objects, such as datasets, networks or tables. The following modes are supported for file queries via the molfile scan command. Scan modes for other objects may include specific additional modes, while disallowing others.

## - array

The mode parameter is a list consisting of the mode selector array and a nested list of properties and pseudo-properties. Each property item can be a list of one to three elements. The first element is a property or pseudo-property, the second element a name, and the third element again a property or pseudo property. The the second property item list element is omitted, the name is the same as the first element. If the third element is missing, it is assumed to be the pseudo-property record. In this scan mode, the molfile scan command returns a list of the names of the created arrays. For each name, a global TcL array variable is created, and for each match, an TcL array element with an element name equal to the value of the first item specification index and an element value equal to the value of the third item specification is created. For example, the scan mode specification

```
{array {E_NAME name2rec} {record rec2name E_NAME}}
```

results in the creation of two global TcL arrays in the current interpreter, called name2rec and rec2name. The first has elements where the element name is the name of the matching structure (property E_NAME), and the value the file record number (because is is the default). The second array has elements where the record number is the array element name, and the corresponding value the structure name. The return value of the TcL statement is the list "name 2 rec rec2name", the names of the two variables created.

If array elements for a specific key already exist, the new value is appended as a list object. The result registration procedure does not overwrite the existing content. So, for example in above case, if there are multiple records with the same structure name, the array element indexed by name would contain a list or records, not just a single record. Since global arrays are persistent, data is also appended over multiple scan statements. If this is not desired. a statement like unset -nocomplain \$arrayname should be executed before the scan is started. It is legal to use the same array name for the registration of multiple properties. In this case, each match appends a new list element for every reported property, though these lists will not be nested.

- bitvector

Return a string-encoded bit vector (series of 0 s and 1 s ) indicating the match status for every visited record.

- count

Just count the number of hits, but do not report details. The result value is an integer.

- delete

Delete hits from the file, if this is possible. This operation is performed after the scan has completed, not during the scan, so that file record numbers etc. do not change within a query.

- ens

Return the handle of the first matching ensemble. The query is stopped at that point. If no hits are found, an empty string is returned.

- enslist

Return the handles of all matching ensembles. If no hits are found, an empty list is the result.

- exists

Return a boolean flag indicating whether any hit exists. This is very similar to the count mode, except that query processing is stopped after the first match.

- index

The file position index of the first matching object. This is the same as the record mode, except that each hit value is one less, since indices start at zero. The query is stopped after the first hit.

- indexlist

A variant of the recordlist mode. The returned values are one less than the records, since indices start at zero.

- molfile

The mode parameter list consists of the mode selector molfile and a structure file handle, which must have been opened for writing, appending, or updating. The first matching structure is written to the file.After this, the query stops. The output file attributes determine format, selection of data written, structure encoding conventions such as hydrogen status, etc. If no matching structure is found, nothing is written. In this mode, the return value of the command is the matching record number of the input file, just as in the record mode.

- molfilelist

The mode parameter is a list consisting of the mode selector molfilelist and a structure file handle, which must have been opened for writing, appending, or updating. Matching structures are written to that file. The output file attributes determine format, selection of data written, structure encoding conventions such as hydrogen status, etc. If no matching structures are found, nothing is written. This mode is also implicitly selected if a structure file handle is directly provided as mode argument. In this mode, the return value of the command is a list of the matching record numbers of the input file, just as in the recordlist mode

- property

The mode parameter is a list consisting of the mode selector property and a sequence of properties and pseudo-properties. The selected properties for the first match are returned as a list. If there are no hits, an empty string is returned. The query stops after the first match.

- propertylist

The mode parameter is a list consisting of the mode selector propertylist and a sequence of properties and pseudo-properties. The selected properties for all matches are returned as a nested list. If there are no hits, an empty string is returned. This mode is also selected if the mode argument is simply a list of property and pseudo property names without an identifiable mode keyword as first list element.

- reaction

Return the handle of the first matching reaction. The query is stopped at that points. If no hits are found, an empty string is returned.

- reactionlist

Return the handles of all matching reactions. If no hits are found, an empty list is the result.

- record

The record number of the first file record which matches. In case a single physical file is searched, this is the same as vrecord, but if the scanned file is a virtual file consisting of multiple physical component files, this is the record number in the matching physical file. The scan is stopped when the first match has been found. If there are no matches, an empty string is returned.

- recordlist

The same as the record mode, except that more than one match is potentially reported. In case a virtual file is searched, it is possible that duplicate values are returned, because the same record number from different physical files may be a hit. For unique record numbers, use the vrecordlist variant.

- table

The mode parameter is a list consisting of the mode selector table and a sequence of properties and pseudo-properties. This scan mode returns a table handle. The table is automatically configured with properly typed columns corresponding to the requested properties. For each hit, a row is added. If there are no hits, a table handle is still returned, but the table does not have any rows. This retrieval mode is only available if the toolkit has been compiled with table support.

The individual properties may also each be specified as a list consisting of the property name, and an arbitrary string. In that case, the string is used as the column name. By default, the column names are the same as the name of the property they store. Example:

```
{table {E_NAME name} {E_CAS casno} record}
```

sets up a table with three columns called name, casno and record. The first two columns contain property data from the matching file records, the last one the record in the file which matched.

Instead of the keyword table, an existing table handle may also be used. In that case, any existing matching table columns are automatically re-used to store result data. Additionally specified properties are added as new columns to the right of the previously existing columns. New table rows generated by matches are appended to the bottom of the table.

## - tablecollection

This mode is mostly identical with the table mode, and takes the same column specification parameters. The important difference is that this scan mode always retrieves the full objects associated with the filled table rows (ensembles or reactions). They are preserved and their relationship with the table marked. This can be useful if at a later stage in handling the table additional data needs to be computed or retrieved from an object. On the other hand this mode can be memory-intensive if many objects are created. Referral to associated objects may happen indirectly, for example with image columns where the exact image property is unknown until output time when the storage format is selected.

The scan command mode returns the table handle as result. The associated row objects are stored in the general namespace, and are not be a member of any dataset. They are visible like any other object of their type, for example via ens list or reaction list commands. Commands table ens and table reaction are useful to get the object subset associated with this table. Note that these table-associated objects are not automatically deleted when the table is destroyed - only their association is severed. If they are no longer needed, they should be destroyed explicitly.

## - vrecord

If the scan is executed on a single file, this is the same as record. In case a virtual file which consists of multiple physical files is searched, this is the virtual file record number, i.e. the overall record number in the concatenated component files.

- vrecordlist

If the scan is executed on a single file, this is the same as recordlist. In case a virtual file which consists of multiple physical files is searched, this is a list of the virtual file record numbers, i.e. the overall record numbers in the concatenated component files.

If requested property data is not present on the object representing a hit, an attempt is made to compute it. If this fails, the retrieval modes table and tablecollection generate null cells, and property retrieval as list data produces empty list elements, but no errors. For minor object properties, the property list retrieval modes produces lists of all object property values instead of a single value. In table-based mode, only the data for the first minor object associated with the major object is retrieved, which makes this mode less suitable for direct minor object property retrieval.

## Pseudo properties for retrieval

The following pseudo properties can be retrieved in property/properylist scan modes or as table values, in addition to standard property data:

- avgscore

The average value of all computed scores, such as Tanimoto or Tversky similarity scores, in the matching query for this result.

- conformerindex

The index of the matching conformer in case of 3D queries with multiple conformations, -1 if no matching conformer index was determined.

- conformer

A list of the atomic coordinates of the matching conformer, if a 3D query was performed. If this is not the case, an empty vector is the result. The data type of this vector is coorvec ( $\mathrm{x}, \mathrm{y}, \mathrm{z}$-triples as vector elements).

- filename

The name of the physical file the match occurred in. For normal, single-file scans, this is not interesting. However, for virtual files, only the combination of the pseudo properties filename and record is a complete reference.

- image

A structure GIF image (property E_GIF) with highlighted matching substructure atoms and bonds. A normal E_GIF retrieval property would just show the structure, but without highlighting. The data type of this property is the same as that of E_GIF (depending on the configuration, a diskfile reference or an in-memory blob).

- index

This is the same as record, except that the value is one less, since indices start with zero.

- matchatoms

An integer vector holding the labels of all atoms matching the substructures used in evaluating the query expression. If no substructure was used for the match, this vector is empty. highlighatoms is an alias for this pseudo property.

- matchbondatoms

The same as matchbonds, except that each element is a pair of the labels of the matching atoms in the bonds, not the bond label as a single number.

- matchbonds

An integer vector holding the labels of all bonds matching the substructures used in evaluating the query expression. If no substructure was used for the match, this vector is empty. highlightbonds is an alias for this pseudo property.

- matchchount

The first element of the matchcounts array, as described below. If the query does not contain any substructure match nodes, the result is empty.

- matchcounts

An integer vector holding the number of distinct substructure matches for substructure query nodes in the query tree. For normal substructure expressions, this value can only be zero or one because the standard substructure match mode only checks for the presence of any match (match mode first). Additionally, this value can be minus one if the node was never evaluated, for example because it is part of an or expression. Only if the count modifier is used together with the substructure query operator, or the substructure operator is the range operator, the possibility of multiple matches is evaluated and larger values can be obtained. For these operations the match mode is currently always distinctinneratoms (see match ss command).

- maxscore

The maximum value of all computed scores, such as Tanimoto or Tversky similarity scores, in the matching query for this result.

- merit

For queries which use a merit/demerit rating scheme (for example, Bruns/Watson queries) this retrieves the accumulated merit/demerit sum of the top-level query node. The query needs to match for this retrieval to work, so in case none of the demerit rules match, you get an empty result, not a default zero merit/demerit value. Internally, there is no distinction between merit and demerit scores. The keyword demerit is an alias for this pseudo-property.

- minscore

The minimum value of all computed scores, such as Tanimoto or Tversky similarity scores, in the matching query for this result.

- pass

The pass number of the query execution. Normal queries, i.e. those without smartquery nodes and without hand-crafted passswitch nodes are executed only once, and the pass is always zero.

- parent

The parent structure of the matching structure as a packed, base64-encoded serialized object string. If the structure file does not contain a precomputed parent structure, or the main file structure contains it as property, it is computed from the main file structure as property
E_PARENT_STRUCTURE.

- productmatchatoms

The same as the matchatoms pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- productmatchbondatoms

The same as the matchbondatoms pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- productmatchbonds

The same as the matchbonds pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- reagentmatchatoms

The same as the matchatoms pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- reagentmatchbondatoms

The same as the matchbondatoms pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- reagentmatchbonds

The same as the matchbonds pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- record

The physical record number of the current physical file. For normal, single-file scans this is the same as the virtual record. For virtual files, this property needs to be combined with the filename pseudo property to obtain a complete reference.

- rgatoms(rg)

A list of the atom labels in a matching structure which were mapped to an expanded R-group atom in the query. The property index is the name of the R-group of interest defined in the substructure, usually something like $R 1$. If there was no expanded R-group of that name, the result list is empty.

- rgattachments(rg)

A nested list of the atom label pairs of the bonds in a matching structure which connect between the structure framework and the atoms expanded as the named R-group rg. If there was no expanded R-group of that name, the result list is empty.

- score

The first element of the scores array, as described below. If the query does not contain any scoring expressions, the result is empty.

- scores

An integer vector of the results of all query expression branches, in depth-first left-to-right order, which computed a score, such as structure similarity queries with Tanimoto or Tversky bitvector comparisons. In case a branch was not executed when the match was determined, zero is entered.

## - structure

The dataset structure as a packed, base64-encoded serialized object string.

- vrecord

The virtual record number. For single-file scans this is the same as the physical record number.

## Record visitation order

The optional visitation order parameter, one of the optional query parameters listed in the next section, is primarily intended to be used for convenient execution of queries on a subset of records which were selected by a previous query on the same file. It can either be a numerical record list, with the first file record indicated as record one, or one of the keywords sortup or sortdown, followed by a property name. If this parameter is not set, or set to an empty string, or the magic string all, records are visited from the current input position in simple sequential order. If the query parameter dictionary additionally contains a startposition value, this start position refers to the index (plus one) of the first element of the specified record set, not to the original underlying file.

In the record list variant of this argument, the specified (virtual) records in the file are visited in the list order, and all other file records are ignored. For optimum performance, the records should be sorted in ascending order, but this is not necessary, and, since it does affect the order of the returned results, record visitation sets with record sequences in custom order sorted to some criterion can have uses. A suitable format for a record list is a saved result of molfile scan in the recordlist or vrecordlist scan modes. It is possible to use a sorted record list with a non-rewindable input file, but an unsorted list will fail in that case if the file input pointer needs to be positioned backwards.

The sort property option variant implies a visit of all file records, but in the order of the values of a property in that file, not the native record sequence in the file. Using this access method is not too much overhead for indexed file formats such as CBS or BDB with an index on the sort property, but a serious performance hit for standard text files. This method cannot be used with files which cannot be rewound and do not have the sort property data in some direct access field, since it requires a full pass through the file to gather the sort property data values before the actual query is processed.

## Examples:

```
molfile scan $fh "structure >= C1NCCC1" vrecordlist \
    [dict create "order" [list 3 6 29 157]]
molfile scan $fh "structure ~>= $ehcmp 90" {table E_SMILES score} \
    [dict create "order" {sortup E_WEIGHT}}
```


## Query parameters

The final optional parameter is a keyword/value list of various additional attributes for fine-tuning the execution of the query. The following keywords are recognized:

- branchmaxhits number

Set a maximum number of hits for every branch below the root node of the query. This is a per-branch version of the more commonly used maxhits option, which sets a global hit limit. By default the limit recursively applies to all nodes below the root, but this option is often combined with the branchnodetype option. If the latter is set, the limit only applies to those nodes which are of the specified type. Any nodes which have accumulated the specified maximum number of hits during the execution of a scan command no longer match regardless of the contents of additional records they are tested against. The hit count is increased whenever the branch returns a positive result, even if an overall positive match is not found because conditions in other branches are not met. The option can also be applied to logical nodes, such as and or or. In case of or nodes and in circumstances with similar optimization opportunities, the use of this option does not force the execution of lower branches if the match result of the node can already be determined by a partial testing of its branches, so the count may be less than expected.

- branchnodetype nodeclass

This option is useful only in combination with a branchmaxhits option. If it is set to the name of a query node class, such as structure, reaction, formula or property, the limit only applies to those nodes below the root node which are of the specified type.

- fullblockscan auto/no/yes

Ths parameter can be set to the values auto (or -1 ), no (or 0 ) and yes (or 1). The default value is auto. If this flag is true, scanning does not immediately stop after the maxhits or maxscan limits have been reached. Instead, each query thread completes its currently allocated file section, but not pick up more work afterwards. This guarantees that a subsequent query on the file can resume after the last visited record, without omitting to test records in file sections where the threads did not complete their task. However, in the full block scan mode the maxhits and maxscan parameters are then only a guideline, since the threads will scan more records, and possibily generate more hits, until they have finished their block. In auto mode, the full block scan mode is active if more than one thread is actually spawned, and inactive when there is only a single thread processing the query.

- matchcallback procname

The name of a TcL procedure in the current interpreter which is called upon each match after processing all standard query conditions, as well as once each for initialization and finalization. In some scan modes, the function is also be called to report a mismatch. The parameters passed to the function are the callback mode as a string (one of init, match, mismatch or final), the current number of hits, and a reference for the match results accumulation object. The format of the latter depends on the scan mode - for example, in scan mode bitvector it is the evolving string representation of the result vector, while in scan mode propertylist is is a nested list of property values extracted so far. The structure of the result accumulator is usually the same as the final result of the scan operation. Setting the procedure name to an empty string is the same as omitting this attribute - no TcL procedure is called.

- maxhits number

The maximum number of hits to report. If this number has been reached, the scan stops. If it is set to a negative value, which is the default, an unlimited number of hits could be reported.

- maxscan number

The maximum number of records to scan in all query threads combined. If this number has been reached, the scan is stopped (but see fullblockscan parameter). If set to a negative value, which is the default, an infinite number of records could be scanned.

## - maxthreads number

The maximum number of threads to use for scanning. By default, only a single thread is used. The use of multiple threads can significantly accelerate the processing of large input files, but for input data sets with less than 5 K text records, or 50 K binary and indexed records the overhead is likely to outweigh the gains. If multiple threads are used, a rule of thumb is that maximum acceleration on a sufficiently large file, with plenty of memory and no competing processor load, is observed with two query threads per processor core. If set to a negative value, the internally used maximum number of threads is adjusted to the number of visible processor cores and number of threads already internally spawned for other purposes. Because of the need to have multiple concurrent read positions for multi-threaded searching, files which cannot be rewound are always the processed by a single thread. If the query file has less records than the maximum number of threads multiplied by the thread block size, the actual number of threads used can be smaller then specified..

- order order_list

Specify a scan order. By default, the data records are visited in increasing sequence from the current start position. The format of the value part of this dictionary pair has been described in the previous section. For more information, please refer to the paragraph on the record order list.

- passlimit number

The number of accumulated hits which will prevent the execution of another query pass, typically with relaxed match conditions, in smartquery expressions and similar constructs. The default value is one, i.e. no additional passes will be executed if there is at least one match.

## - progresscallback procname

The name of a TcL function which is called regulary during the file scan. That function could, for example, update a progress bar. The arguments to that function are, in this order, the operation code (init, scan, final), the handle of the scanned object (a molfile handle for the molfile scan command), the current number of record scans performed so far, the hit count and the full scanned object size (file record count, dataset element count) counted as records. If the object size is not known, minus one is passed. The init and final function calls are made only once each, and before respectively after any scan calls for the execution of this statement. The short form callback is an alias for this keyword. Setting the option to an empty string disables all progress callback function calls.

- progresscallbackfrequency number

The frequency of callback function invocations, measured as the number of records scanned between calls. If set to a negative value, the default is used (currently one call per 100 K records scanned). If set to zero, the callback function is not called during the scan, but still for initialization and finalization. The short form callbackfrequency is an alias for this keyword.

- sscheckcallback procname

The name of a TcL procedure which is called after all preliminary checks of a substructure or superstructure match operation have succeeded. Records which are skipped by screening mechanisms or where standard sub/superstructure query attributes already exclude a match do not trigger a function call. This function can be used to add additional criteria to the query which cannot be expressed by standard means.

The arguments passed to this function are, in this order, the substructure object handle, the structure object handle, a nested list with label pairs of all matched substructure and structure atoms, and a nested list with label pairs of all matched substructure and structure bonds. In case of superstructure searches, the roles of substructure and structure are reversed, i.e. the substructure handle and the listed atoms and bonds refer to the current structure read from the scanned data source. The check function should either return 1 for a successful final check, or 0 , which leads to a rejection of the match. It is also possible to raise an error, which terminates the query with an error, or exit with a break, which terminates the query without an error.

While the callback routine is free to perform any additional match analysis, it must neither delete the structure or substructure, nor change its connectivity (remove or add atoms and bonds), nor discard or invalidate any property data used in the matching process. The computation or setting of any additional property data on the substructure or structure ensembles is allowed.

- startposition number

A specific record to begin the scan at. By default the scan begins at the current read position of the file, except when it is at EOF. In that case, the file is automatically rewound. If a record visitation order list is used, the start position parameter indicates the record list index plus one to use as first file record to visit, not the file record proper.

- target datahsethandle/remotedataset

The value of this argument is a local or remote dataset handle. If the result of the scan are ensembles (query modes ens or enslist), reactions (query modes reaction or reactionlist) or a table object (mode table or tablecollcetion), the object is moved to the specified dataset. In case the dataset is local, the move happens during the query, so that a different script thread could already begin further processing. Data transfer to remote datasets is performed in a single batch just before the query command finishes. For query modes which do not generate chemical objects, such as the recordlist, property or count modes, this parameter is ignored.

- threadblocksize number

If multiple threads are used, each thread processes a section of the file. If it completes the section, it will then request the allocation of a new section after the last section already allocated to any worker thread. If this parameter is set to a negative value, which is the default, a suitable thread block size is automatically determined from the file characteristics. It will then be typically a value between 10 K and 100 K records.

## More typical examples

## Examples:

```
molfile scan $fh {structure = clcccccl} recordlist
molfile scan $fh {E_WEIGHT < 100} {propertylist E_SMILES E_NAME E_WEIGHT}
```

```
molfile scan $fh {notnull E_CAS} {table E_SMILES E_CAS}
molfile scan $fh {structure ~>= c1nnccc1 90} {score record}
molfile scan $fh "and {structure >= $ehss} {formula >= N3}}" ens
```


## Distributed queries

Molfile object handles can be configured to listen on specific ports for remote scan requests. The syntax of a remote scan request is the same as for a normal file. The only exception is the handle argument. The command is executed asynchronously. Since because of this no direct results are returned, the remote scans are typically of a type which yields network-transferable objects (modes ens, enslist, reaction, reactionlist, table) and specify a target dataset object on the local system.

On the local system, a typical set-up looks like this:

```
set dh [dataset create]
dataset set $dh port 10001
molfile scan $remotehost:10002 {structure >= c1ncccc1} \
    {table record E_NAME E_CAS} {} {target $localhost:10001 startposition 1}
while {![dataset tables $dh {} count]} {
    sleep 1
}
```

In above code, we first create a recipient dataset object, and configure it to listen on port 10001 for incoming Cactvs objects - we are expecting a table object as result later. We then issue the query for execution on the remote host, and wait until the table object containing the results has arrived.

On the remote server, the set-up could look like this:

```
molfile open $dbfile r port }1000
```

vwait

Here the database file is opened, and a port for incoming requests opened. The vwait TcL statement does nothing, but keeps the interpreter running, while waiting for and processing events such as incoming scan commands. In this sample set-up, the remote server needs to be started first, because otherwise the connection to the remote file fails on the client.

Since execution of remote queries is asynchronous, the client could issue multiple query requests to different remote handles and then wait until results from all these requests have been collected, or a timeout or other error condition has been reached. The results could arrive in any order. The scan commands for a group of servers could, for example, specify different start positions and maximum scan values for distributed searching of a big file, or could gather results from different small files. Additionally, the use of multiple scan threads could be requested on the server by passing appropriate parameters in the control section of the command. Nevertheless, only a singled remote scan command per TcL script thread is executed on the server at any time. If multiple scans need to be executed in parallel on a single server, a collection of script threads need to be created via the Thread package, and then every thread told to open its own port listener.

The mechanism for the reception of messages for remote scans on molfile handles which listen on ports is subtly different from the processing of commands sent to listening dataset objects. The execution of scans requires active collaboration of a TcL interpreter. Commands are only read and processed when the interpreter is idle, for example while sitting in a vwait or sleep statement. In contrast, dataset object listeners do not rely on TcL interpreters, and are implemented as independent threads. Remote dataset commands, such as ens move or dataset pop with a remote dataset handle, are therefore executed at any time when a mutex lock on the database object and other accessed objects can be secured.

## molfile set

```
molfile set filehandle ?property/attribute value?...
```

molfile set filehandle attribute_dictionary

A standard data manipulation command. It is explained in more detail in the section on setting property data. The alternative short form with the single dictionary argument is functionally equivalent to using the expanded dictionary as separate property and value arguments.

## Examples:

molfile set \$fhandle F GAUSSIAN_JOB PARAMS (link0) [list \}
"\%chk=144_303_2EVE_PDB_Opt8.chk" "\%mem=128MB" "\%nprocshared=2"]
The command can also be used to set a broad range of object attributes. The list of attributes is documented in the section on the molfile get command.

In case a set command is applied to a virtual file, the command applies to the current physical file only, if this makes sense.

Example:
molfile set \$fhandle record 2
Above command repositions the file read/write pointer to the second record.
This command supports a special attribute value syntax for manipulating bitset-type attributes (only attributes, not property values). If the first character of the argument is a minus character (-), the named bits in the set identified by the remainder of the argument are unset. If it is a plus $(+)$, they are additionally set. With an equal sign $(=)$, or no special lead character, the flag set replaces the old value. A leading caret character $\left(^{\wedge}\right)$ toggles the selected bits.

Example:

molfile setparam
molfile setparam filehandle property key value ?key value?...
Set or update a property computation parameter in the metadata parameter list of a valid property. This command is described in the section about retrieving property data. The current settings of the computation parameters in the property definition are not changed.

## molfile show

molfile show filehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the molfile get command. The difference between molfile get and molfile show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, molfile get and molfile show are equivalent.

```
molfile skip
molfile skip filehandle ?recordcount?
```

Skip records in a file opened for input. If the file pointer is at the beginning of a new record, this next record is the first skipped. If the file pointer is stuck in the middle of a record, for example because
a molfile read command failed due to a file syntax error, the first record counted is the remainder of the current record. An attempt is made to re-synchronize to the beginning of the next record.

By default a single record is skipped. If the record count parameter is specified, more than one record can be skipped. Because of the partially read 1 record re-synchronization feature, negative record counts are not allowed in this command. The molfile backspace and molfile set record commands can be used to go back in a file.

The command returns the number of the next record to be read. In case an attempt was made to position behind the end of a file, or a record re-synchronization failed, an error is reported.

## molfile sort

molfile sort fhandle \{\{propertylist ?direction? ?cmpflags?\}..\} ?outfile/handle?
Sort the records in the file according to the values of one or more properties or property subfields contained in the file records, or computable on the objects read from the file. The output are byte-for-byte identical images of the input records, not records reconstructed from input data objects.

The property sort list consists of zero or more sort specification elements. Every specification element is parsed as a sublist, but only the first element therein is mandatory. This element is either a property name, a property subfield name, or one of the magic names \#record or record (for the file record) or \#random or random (for a random number assigned to that record). The optional sort direction element may be $u p$ or down. The default sort direction is upwards. The final optional comparison flags parameter can be set to a combination of any of the values allowed with the prop compare command. The default is an empty flag set.

The first property or magic name in the sort list has the highest priority. In addition to the specified properties, the original record number is implicitly added as tie breaker to yield a stable sort. This automatic value is always sorted upwards. If an empty property list is specified, the result is thus a simple file copy without record rearrangement.

The sort properties do not need to be already present in the file. If necessary, an attempt is made to compute these on the objects read from the file in the first pass. It is possible to sort on properties which are not of the object class read from the file, for example atom properties when ensembles are read, or ensemble properties when reactions are read. In that case, the record is output at the position determined by the lowest sort rank of the property of that object, for example the minimum or maximum value of all values of an atom property in an ensemble. Additional data instances of the property associated with a given record are ignored, so no record duplicates are output.

The optional output parameter can either be the handle of an opened TcL channel, including standard output and standard error or the name of a (preferably new) file, or a pipe construct. Output is appended to this output channel. If the parameter is omitted, the output is first written to a temporary file, the original file deleted and the temporary file renamed to the original file. In that case, the original file handle is automatically re-opened for reading on the new file. The input file handle must be positionable, because file records are accessed twice, once for reading the sort data and once for copying the records out. Sorting from standard input, pipes or other non-rewindable sources is therefore not supported, and neither is the sorting of files which are not simple record sequences. Sorting such files is currently only possible by using explicitly scripted record data buffering mechanisms.

On Windows, output to an open TcL file handle is not supported, except for the standard output and error channels.

The return value of the command is the number of records written. The position of the sort file handle is set to the same location as before the command.

Examples:
molfile sort \$fh \{\{E_NAME up \{dictionary nocase\}\}\} dict.sdf
molfile sort myfile.sdf \{\{record down\}\}
set fhtcl [open "randomized.sdf" w]; molfile sort \$fh \{\{random\}\} \$fhtcl
molfile sort \$fh \{\{A_ELEMENT down\} \{E_WEIGHT up\}\} "|gzip >heavy.sdf.gz"
The first example creates a new file dict.sdf which contains the remaining records in the file associated with the file handle sorted by the value of property E_NAME in case-insensitive dictionary order. The second example reverses the order of the records in the file, replacing the original file in the process. The third example randomizes the record sequence in the original file, outputting the records in a new file which was opened for writing as a normal TcL text file. The final example outputs a compressed SD file, with structures sorted by the heaviest element in the ensembles, and using the molecular weight as tie breaker.
molfile sqldget
molfile sqldget filehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the molfile get command. The differences between molfile get and molfile sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## molfile sqlget

molfile sqlget filehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the molfile get command. The difference between molfile get and molfile sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## molfile sqlnew

molfile sqlnew filehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the molfile get command. The differences between molfile get and molfile sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for Tcl script processing.
molfile sqlshow
molfile sqlshow filehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the molfile get command. The differences between molfile get and molfile sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## molfile string

```
molfile string enshandle/reactionhandle/datasethandle ?attribute value?...
molfile string enshandle/reactionhadle/datasethandle? ?attribute_dict?
```

This command byte vector representation of a structure file. The third argument to this command is an ensemble, reaction or dataset handle, not a file handle as for other molfile commands.

If the selected output format module supports direct output into a string, the record image is created without intermediary forms. Otherwise, a anonymous temporary file is opened, the ensemble or reaction(s) written to that file, and the file content returned as string with all newlines etc.. The file is then removed.

Writing to binary formats is possible. The return value of the command is a byte vector, not a simple text string, so it may contain NUL bytes. By default, in the absence of an explicit format specification, a MDL Molfile is written.

The remaining parameters are interpreted as in the molfile set command. There are two equivalent command variants, either using attribute and value argument pairs or a dictionary as a single argument. The parameters in the extra arguments or dictionary are typically used to set a hydrogen status, select the output format, etc.

Example:
set jmestring [string trim [molfile string [ens create C1CC1] format jme]]
The example creates an input string for the popular JME Java structure editor by P. Ertl/Novartis. The string trim statement deletes the trailing newline. The necessary JME output module is automatically loaded if it is not already loaded or compiled-in when the format parameter is decoded.

String record representations generated by this command can be opened for input as string data with the $s$ mode of the molfile open command:

```
set fh [molfile open [molfile string $eh] s]
```

molfile subcommands
molfile subcommands
Lists all subcommands of the molfile command. Note that this command does not require a molfile handle.
molfile sync
molfile sync filehandle

This command synchronizes the file contents with the file system. The I/O modules for most file formats automatically performs a simple file buffer flushing upon finishing the output of a record, so this command is needed only under special circumstances where complete file system synchronization is required, the file was written without immediate commits, the I/O module for the file format provides a special synchronization function, or the output was done via asynchronous I/O. In any case, every file is fully synchronized when it is closed, so calling this function for normal output operations is not required.

The command returns the file handle.

## molfile toggle

molfile toggle filehandle
Switch a file from input to output, or vice versa. If the file was in write, append or update mode when the command is executed, the file is rewound and the read pointer is now pointing to the first record, or the original end point for append files. If the file was configured for input, the file output mode is changed to append if the file is a normal file. If the file is a scratch file, the file is truncated to an empty file and the write position set to the first record.

Not all file types can be toggled. Special file types except FTP streams cannot, and it is not possible to toggle a simple disk file which was originally opened in read only mode (see molfile open command).

The command returns the molfile handle.
molfile truncate
molfile truncate filehandle ?record?
Truncate a file. If no explicit record is given, the file is truncated after the current record. In case the current record count of the file is less than the specified record, the command raises an error.

Only files which are rewindable can be truncated. In addition, the program must have write permission to the file, although it is not required that the file handle is opened for writing. The I/O modules for files formats which are not a simple record sequence must provide a truncation function or the operation will fail.

The command returns the molfile handle.

## molfile unlock

molfile unlock filehandle propertylist/molfile/all
Unlock property data for the file object, meaning that they are again under the control of the standard data consistency manager.

The property data to unlock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the file object are unlocked. Non-existent data is silently ignored. It is not possible to unlock individual property fields.

- all

All valid file object properties are unlocked.

- molfile

This is an object class identifier. All property data which is controlled by the molfile major object and attached to the specified object class is unlocked. Since files do not incorporate minor objects, this identifier is equivalent to all.

Property data locks are obtained by the molfile lock command.
This command is a generic property data manipulation command which is implemented for all major objects in the same fashion and is not related to disk file locking. Disk file locks can be set or reset by modifying the molfile object attribute lock. This is explained in more detail in the paragraph on the molfile get command.

The return value is the molfile handle.

## molfile upgrade

molfile upgrade filehandle
If the I/O module provides a function to upgrade the format of an older file to the latest version of the format, for example after a support library upgrade, that function may be used. The only format which currently supports this feature is BDB.

The command returns the molfile handle.

## molfile valid

molfile valid filehandle propertylist
Returns a list of boolean values indicating whether values for the named properties are currently set for the structure file. No attempt at computation is made.

Example:
if [molfile valid \$fhandle F_COMMENT] \{...\}

## molfile vappend

molfile vappend filehandle objectlist
Virtually append records to an open file handle. The underlying file is not modified, but all future input operations on this file behave as if the extra records were present.

Because no actual output is generated, this command can only be applied on files opened for reading, not output files. In addition, the file handle needs to refer to a normal disk file and to support going backwards in the file, i.e. this command cannot be used on structure files opened via URLs, standard I/O channels, socket connections or composite virtual files with multiple physical files or the contents of a directory. The file format must support multiple records and the records must be encoded as a simple concatenated byte sequence. Examples for formats which work are SMILES or SD files for structures, or RXN or RD files for reactions.

The object list may contain ensemble, reaction or dataset handles. The data is split into virtual records according to the storage capabilities of the file. The format of the data written to the virtual records can be controlled by setting the writelist, droplist and hydrogens status attributes on the file handle.

When executed for the first time on a file handle for which the record count is yet unknown, the existing file records must be tallied and all current physical record positions be registered. For very
large files, this can take some time. However, this is not equivalent to reading the complete file, so it does not consume much memory and the command can in principle work on arbitrarily large files.

Virtual records are held as string images in memory. A couple of thousand such records should not be a problem for typical workstations, but for systematic editing of large files where every record is touched an explicit scripted input/output loop is preferable.

The return value is the new record count of the file.
Changes to the file can be committed to disk by means of the molfile vrewrite command.
Example:
molfile vappend \$fhandle [ens create c1ccccc1]
molfile vdelete
molfile vdelete filehandle recordlist
Virtually delete records from an open file handle. The underlying file is not modified, but all future input operations on this file behave as if the specified records had been deleted.

Because no actual output is generated, this command can only be applied on files opened for reading, not output files. In addition, the file handle needs to refer to a normal disk file and to support going backwards in the file, i.e. this command cannot be used on structure files opened via URLs, standard I/O channels, socket connections or composite virtual files with multiple physical files or the contents of a directory. The file format must support multiple records and the records must be encoded as a simple concatenated byte sequence. Examples for formats which work are SMILES or SD files for structures, or RXN or RD files for reactions.

When executed for the first time on a file handle for which the record count is yet unknown, the existing file records must be tallied and all current physical record positions be registered. For very large files, this can take some time. However, this is not equivalent to reading the complete file, so it does not consume much memory and the command can in principle work on arbitrarily large files.

The record list is a list of integer values, with one as the first file record. The list does not need to be sorted, and duplicate record numbers or record numbers out of range are ignored. It is possible to virtually delete file records which are themselves virtual, i.e. were added by the vappend, vreplace or vinsert subcommands and are not physically present in the file.

Virtually deleted records have negligible memory demands, but will slightly slow down input operations on edited files.

The return value is the new record count of the file.
Changes to the file can be committed to disk by means of the molfile vrewrite command.
Example:
molfile vdelete \$fhandle [list 39 6]
molfile vinsert
molfile vinsert filehandle objectlist
Insert virtual records for the specified objects into the file. The insertion position is before the current read position.

Except for the difference in the location where the virtual records are inserted, the command is equivalent to the molfile vappend command and has the same features and limitations. Please refer to that command for details.

## molfile vreplace

molfile vreplace filehandle objectlist
Insert virtual records for the specified objects into the file. The current input record is virtually overwritten.

Except for the difference in the location where the virtual records are inserted, and the fact that an existing record is replaced, the command is equivalent to the molfile vappend command and has the same features and limitations. Please refer to that command for details.

It is possible to replace a record which is itself virtual, i.e. was introduced by a vappend, vinsert or vreplace subcommand. If more than one output object is passed, or the object is written as multiple file records, additional virtual records are created and the record count of the file increased accordingly.

Example:

```
set eh [molfile read $fh]
ens expand $eh
molfile backspace $fh
molfile vreplace $fh $eh
ens delete $eh
```

This command sequence virtually replaces a record with a version where superatoms are expanded.

## molfile vrewrite

molfile vrewrite filehandle ?filename?
Commit all virtual record additions, deletions or replacements to a physical file. If no file name is given, the current file name is used. After writing, the file handle remains valid. It is open for reading, and positioned before the first record. At this moment, the file no longer contains any virtual modifications, but the file handle may again be subjected to virtual edit operations. In case a file name is specified, and is not the same as the name of the current file, the file handle refers to the new file when the command has finished.

All valid records are copied verbatim to the new file, without going through decoding and re-encoding or records (see molfile copy command). A temporary file in the same directory as the current file is created, and sufficient disk space needs to be present to hold both the original file and the edited version at the same time. In case a problem occurs, the temporary file is deleted and the current file remains active. Only if all write operations succeed the old file is deleted and the temporary file renamed if necessary. In case a file name is specified, and it is not the same as that of the current file, the original file remains untouched, but is no longer linked to the molfile handle. For large files, this operation can take some time because massive amounts of data may need to be moved.

If the file referenced by the file handle has not been edited with virtual record operations (vappend, vdelete, vinsert, vreplace), the command does nothing and is equivalent to a molfile rewind.

The command returns the number of records written.

Example:

```
set fh [molfile open „myfile.sdf"]
molfile vinsert $fh 1 [ens create clnccccl]
molfile vrewrite $fh „myfile_with_pyrdine_inserted_in_rec_1.sdf"
```

molfile write
molfile write filehandle ?objecthandle?...
This commands writes structure and reaction data to a file. Object handles may be ensemble handles, reaction handles, dataset handles, or molfile handles.

If an object is an input molfile handle, objects are read from the file until EOF is encountered if the output file supports multiple records. If the output file type is single-record, only the next record is read. The types of objects which are collected from the input molfile handle are dependent on its read scope. These objects are then treated as if they were used as parameter objects directly. Objects obtained via a molfile handle are automatically deleted after they have been written. If the input file is already at EOF when the command is executed, no objects are read, and no error is generated. However, this does not trigger the nULL record output handling described below, because the file object was specified as an argument.

The type of data which is actually written to the file depends on its format. A file opened for ensemble output can be fed with any type of handle. If reactions or datasets are passed, these are taken apart and written as individual records. If the output file is a reaction file, and an ensemble is passed, the reaction it is a member of is looked up and used as output object. If the ensemble is not a reaction ensemble, an attempt is made to store it as a plain ensemble outside any reaction. If the output routine rejects this, an error is raised. In case of datasets passed as objects for reaction output, the individual dataset objects (ensembles or reactions) are written, in combination with reaction reference substitution in case ensembles instead of reactions are found. For full-dataset output, it is legal to pass non-dataset objects. No dataset-level information is written and the objects stored as an anonymous dataset.

It is legal to supply no object handles at all. Normally, this means that simply no output is performed. However, I/O modules for specific file formats may support the output of special null records. In that case, the output function is called once without any objects. An example are Gaussian job files, which allow you to write records in multi-link files, where the computation instructions are taken from the file property F_GAUSSIAN_JOB_PARAMS, without supplying a structure record. $^{\text {and }}$

As part of the output process, new information may be computed on the objects. In case the active settings on the output molfile handle demand a structural change of an object, for example the addition or removal of hydrogen atoms, or the re-coding of ionic versus pentavalent nitro groups and similar functionality, the write objects are temporarily duplicated and these duplicates undergo the structure changes. The original output objects are never indirectly edited in their connectivity by this command.

The writelist attribute of molfiles may be set to a list of properties which should be included in the output. This has an effect only for file formats which support the storage of custom data values and which can cope with the data types of the listed properties. By default, no attempt is made to actively compute these properties for output. If they are not present in the input data, their output is silently omitted, or NULL values are written, depending on how the output format encodes these things. However, if the computeprops flag is set on the output molfile, an attempt for computation is made, and after output, the objects retain this additional data if the computation succeeds.

If the hydrogen set mode of the output molfile calls for a change in hydrogen status, the stage when these computations are performed depends on the hydrogen addition mode. If the output mode calls for potential hydrogen additions, the computations are executed after the addition - and this means, on the temporary duplicate, so the original object does not see the new property data. If the hydrogen mode does not change the hydrogen set, or potentially removes hydrogens, computations are performed on the original objects and then the object is potentially duplicated, with all its data, for hydrogen removal and output. In the latter case, the additional property data is visible on the original input objects.

The command returns a list of the object handles which were actually written to file. In cases like a reaction being split into ensembles, or a dataset taken apart, this is not necessarily the same object handle collection as the input object list. For output from an input molfile argument, the total number of objects written is returned instead, because the read objects are not retained.

Examples:

```
molfile write "myfile.sdf" $eh1 $eh2
set fhandle [molfile open z.cbin w hydrogens add format cbin]
molfile write $fhandle $dset1
molfile write $fhandle $dset2
molfile close $fhandle
```

The first sample line uses the single-shot file operation feature of the molfile command. Instead of a molfile handle, a file name is passed, and that file is automatically opened, the output performed, and then the file is closed. Two ensembles are written with a single statement to the output file $m y f i l e . s d f$. The desired file format is guessed from the file name suffix. No change in hydrogen status, etc. is performed, and no extra data is written out.

The next four example lines show how two complete datasets can be written to a native Cactvs toolkit binary file. Hydrogens are added to structures or reactions in the dataset - but the original dataset elements are not changed, since the addition is performed on temporary object duplicates. Also, the Cactvs binary format is requested explicitly by setting the format attribute. In this case, this is not really required, since the file format could also be guessed from the file name suffix. However, in case a non-standard file name suffix is used, formats must be specified explicitly, or the default format (MDL SD-file) is used. If the CACTvs binary file is later opened for reading with a read scope of dataset, all dataset elements plus the dataset-level property data can be recovered.

## The network Command

The network command is the major object command for network objects. These are a high-level abstraction for any kind of data relationship which can be expressed as a network of vertices and connections. Network objects do not have a direct relationship with ensemble or reaction objects, but of course network nodes or connections can store ensemble or reaction data. However, these are then stored as vertex or connection properties of the respective type and not as direct memberships, like ensembles or reactions which are a member of a dataset object.

The syntax of this command follows the standard schema of command/subcommand/majorhandle. Networks are major objects and thus do not need any minor object labels for identification.

There are currently no transient network objects.
Examples:

```
network get $nhandle N_CONNECTION_COUNT
```

This is the list of currently officially supported subcommands:

## network append

network append nhandle property value ?property value?
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:

```
network append $nhandle N_NAME "_new"
```


## network assign

network assign nhandle srcprop dstprop
Copy data from one property to another. Both properties must be associated with the same object class. The source property (but currently not the destination property) may be specified as an indexed property subfield. There must exist a conversion path between the data types of the two properties or property subfields involved for the operation to succeed. For example, assigning a string property to a numeric property succeeds only if the string data items contain convertible numbers.

The original property data remains valid. The command variant network rename directly exchanges the property name without any data duplication or conversion, if that is possible. In any case, the original property data is no longer present after the execution of this command variant.

If the properties are not associated with reactions (prefix $\mathrm{N}_{-}$), the operation is performed on all network nodes or vertices if appropriate.

Examples
network assign \$nh V_IDENT V_NAME

## network connections

network connections nhandle ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the connections the network contains as minor objects. This is explained in more detail in the section about object cross-references.

Examples:

```
network connections $nhandle
filter create isa_link property C_ONTOLOGY_LINK value is_a operator =
network connections $nhandle isa_link
```

The example simply returns a list of the labels of the connections the network contains as minor objects. The second example restricts these to the subset where property C_ONTOLOGY_LINK has a specific value.

## network create

```
network create ?attribute value?...
network create ?dictionary?
```

Create a new network object. All networks are created empty. The optional attribute keyword/value list or single-parameter dictionary is processed just as with a network set command.

The return value of the command is the new network object handle.

## network dataset

network dataset nhandle =filterlist?
Return the dataset handle of the dataset the network is member of. It the network is not member of a dataset, or does not pass all of the optional filters, an empty string is returned.

Example:

```
network dataset $nhandle
```


## network defined

```
network defined nhandle property
```

This command checks whether a property is defined for the network. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The network valid command is used for this purpose.

## network delete

network delete all
network delete ?nhandle?...
Delete network objects and all their associated vertices and connections. The special parameter all may be used to delete all networks currently registered in the application. Alternatively, any number of network handles may be specified for specific object deletions.

The command returns the number of deleted networks.
Example:

```
network delete all
network delete $nhandle
```


## network dget

network dget nhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the network get command. The difference between network get and network dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, network get and network dget are equivalent.

## network dup

network dup nhandle ?dataset? ?position?
Duplicate a network with all minor objects and all attached data on the network object proper and its minor objects.

The duplicate network is placed into the same dataset as the source, if it is a member of a dataset. Specifying an explicitly empty dataset argument places the duplicate outside any dataset, regardless of the dataset membership of the source network.

If the duplicate is moved to a dataset, it is appended to the dataset end by default. This happens also if the position parameter is explicitly specified as end or an empty string. Otherwise, the network is inserted at the given position, starting with 0 . If the requested position is larger than the current size of the dataset, the reaction is appended.

Example:
network dup \$nhandle
The command returns a new network handle.

## network exists

network exists nhandle ?filterlist?
Check whether a network handle exists. The command returns 0 or 1 . Optionally, the network may be filtered by a standard filter list.

Example:

```
network exists $nhandle
```

network expr
network expr dnandle expression
Compute a standard SQL-style property expression for the network. This is explained in detail in the chapter on property expressions.

## network filter

```
network filter nhandle filterlist
```

Check whether the network passes a filter list. The return value is 1 for success and 0 for failure.

## network get

```
network get nhandle propertylist ?filterset? ?parameterlist?
```

network get nhandle attribute

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:
network get \$nhandle \{N_VERTEX_COUNT N_NAME\}
yields the vertex count and name of the network as a list. If the information is not available, an attempt is made to compute it. If the computation fails, an error results.

For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the network get command are network new, network dget, network nget, network show, network sqldget, network sqlget, network sqlnew, and network sqlshow.

In addition to property data, the network object possesses a few attributes, which can be retrieved with the get command (but not its related sister subcommands like dget, sqlget, etc.). Some of them are also modifiable via network set. These attributes are:

- affiliation

The institution the author works for.

- author

The author of the network, as free-form string data.

- authorurl

A URL with information on the author, or an empty string if unset.

- category

A category string to be used if the network is stored in a repository.

- classuuid

The base class UUID of this network object, as related to its authorship attribute set.

- coords

If the toolkit was compiled with factory support, these are the coordinates of the object on its workbench, encoded as integer pair. This attribute can be changed.

- deletable

Flag indicating whether the network can be deleted with a standard network delete command. This attribute is read-only. Networks which are, for example, property data values or a part of a molfile loop command cannot be deleted by standard means.

- date

The date the network structure was defined.

- doi

A digital object identifier for the network object content, if defined.

- eolchars

The default eol character(s) to use when writing the table to text files. The default is the standard platform EOL character(s).
The magic strings windows, mac (both checked for the first three characters only) as well as unix and linux are automatically translated to the standard platform line terminators and not copied verbatim. Alternative names for these standard system encodings are $c r l f, c r$ and lf. The special value default resets the attribute to the platform-dependent default.

- email

A contact email of the author.

## - failures

A list of properties for which computation failed on this network object. This is a read-only attribute. Depending on configuration settings, this information may be used to block pointless attempts at re-computation of incomputable data.

- footer

If the toolkit was compiled with factory support, this is the footer of the object icon on a workbench. This attribute can be changed.

- gflags

If the toolkit was compiled with factory support, this is the currently set object icon rendering flag collection.

- header

If the toolkit was compiled with factory support, this is the header of the object icon on a workbench. This attribute can be changed.

- hidden

Flag indicating whether the network is hidden. This is not the same as the invisible state. This attribute is intended to be used for rendering selections. This attribute can be changed.

- invisible

Flag indicating whether the network is invisible. This is not the same as the hidden state. An invisible object is no longer accessible via its handle. This is usually the case for objects which are scheduled for deletion, but still have lingering referring pointers. This attribute is read-only.

- infourl

A URL with information on the network object content, or an empty string if unset.

- keywords

A list of keywords associated with the network object.

- license

The license class associated with this network object. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the network object license.

- literature

A free-form literature reference.

- modcount

Network structure modification count. This attribute is read-only.

- name

A free-form network name as string.

- orcid

The ORCID code of the author (see www.orcid.org).

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- pyobject

If the toolkit was compiled with Python support, this attribute reports the memory address of the Python wrapper class instance, if it exists. This attribute is read-only.

## - pyrefcount

If the toolkit was compiled with Python support, this attribute reports the reference count of the Python wrapper class instance, if it exists. This attribute is read-only.

- record

The current iterator record. The pseudo records follow the vertex list, the first vertex is record one.

- refcountt

If the TCL interpreter is using native Cactvs objects instead of string-based major object handles and integer-based minor object labels to identify toolkit objects, this returns the number of TcL object references active for this network. This attribute is read-only.

- references

Cross references of the network. This is a nested list of class UUIDs and reference type tags.

- regid

For registered data networks, the registration ID. Zero if this is a private network object.

- selected

Flag indicating whether the ensemble is selected. This attribute can be changed.

- tooltip

If the toolkit was compiled with factory support, this is the tooltip of the object icon on a workbench. This attribute can be changed.

- uuid

An automatically generated UUID globally identifying the object. This attribute is read-only, different for every network, and not dependent on its contents.

- version

A free-form version number of the network.

- versionuuid

The version UUID associated with this network object as per its authorship attributes.

- $x$

If the toolkit was compiled with factory support, this is the x coordinate of the object on its workbench. This attribute can be changed.

- $y$
f the toolkit was compiled with factory support, this is the y coordinate of the object on its workbench. This attribute can be changed.


## network getparam

network getparam nhandle property ?key? ?default?
Retrieve a named computation parameter from valid property data. If the key is not present in the parameter list, an empty string is returned. If the default argument is supplied, that value is returned in case the key is not found.

If the key parameter is omitted, a complete set of the parameters used for computation of the property value is returned in key/value format.
network index
network index nhandle

Get the position of the network in the object list of its dataset. If the network is not member of a dataset, -1 is returned.

## network list

network list ?filterlist?
Without a filter list argument, the command returns a list of the handles of all existing network objects.

If a filter list is specified, only those networks which pass all filters are listed. Filters may refer to the minor objects of networks (i.e. vertices and connections). In that case, a filter succeeds if any vertex or connection passes the filter.

Examples:
network list

## network lock

network lock nhandle propertylist/objclass/all ?compute?
Lock property data of the network, meaning that it is no longer controlled by the standard data consistency manager. The data consistency manager deletes specific property data if anything is done to the network which would invalidate the information. Blocking the consistency manager can be useful when building networks from components in a script. Property data remains locked until is it explicitly unlocked.

The property data to lock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the network or network minor objects are locked. If the boolean compute flag is set, an attempt is made to compute the property if it is not yet present. Otherwise, a request to lock non-existent data is silently ignored. It is not possible to lock individual property fields.

- all

All valid network and network minor object properties are locked. The compute flag is ignored.

- vertex, connection.network

These is are object class identifiers. All property data which is controlled by the network major object and attached to the specified object class is locked.

A lock can be released by a network unlock command.

## network max

network max nhandle propertylist ?filterset?
Get the maximum values of the properties named in the propertylist parameter. The return value of the command is a list of the maximum property values.

While it is possible to work with network properties, this is pointless since there is only a single instance of a network property per network. Usually, vertex or connection minor object properties are tested. The objects whose property values are used for the determination of the maximum values
may optionally be filtered by a standard filter set. If no objects pass the filter, the result is an empty list.

Example:
network max \$nhandle V_LEVEL
computes the maximum value of the V _LEVEL property over all vertices.

## network metadata

network metadata nhandle property field ?value?
Obtain property metadata information, or set it. The handling of property metadata is explained in more detail in its own introductory section. The related commands network setparam and network getparam can be used for convenient manipulation of specific keys in the computation parameter field. Metadata can only be read from or set on valid property data.

## network min

network min nhandle propertylist ?filterset?
Get the minimum values of the properties named in the propertylist parameter. The return value of the command is a list of the minimum property values.

While it is possible to work with network properties, this is pointless since there is only a single instance of a network property per network. Usually, vertex or connection minor object properties are retrieved. The objects whose property values are used for the determination of the minimum values may optionally be filtered by a standard filter set. If no objects pass the filter, the result is an empty list.

Example:
network min \$nhandle V_LEVEL
computes the minimum value of property $\mathrm{v}_{\mathrm{C}}$ LEVEL over all vertices of the network.

## network move

network move nhandle ?datasethandle|remotehandle? ?position?
Make a network a member of a dataset, or remove it from a dataset. If the dataset handle parameter is omitted, or is an empty string, the network is removed from its current dataset. If it was not a dataset member, this command does nothing. The dataset handle may be the name of a remote dataset for moving networks over a network connection.

If a dataset handle is specified, the network is added to the dataset, if allowed by the acceptance bits of the dataset, and removed from any dataset it was member of before the execution of the command. By default the network is added to the end of the dataset object list, but he final optional parameter allows the specification of an object list index. The first position is index zero. If the parameter value end is used, or the index is bigger than the current number of dataset objects minus one, the network is appended as per the default. It is legal to use this command for moving networks within the same dataset.

Another special position value is random. This value moves to the network to a random position in the dataset. Using this mode with remote datasets is currently not supported.

By default, datasets do not accept networks as objects. This must be explicitly enabled by modifying the acceptance bits, as for example in
dataset append \$dhandle accepts network
The dataset handle cannot be a transient dataset.
The return value of the command is the dataset membership of the network prior to the move. It is either a dataset handle, or an empty string if it was not member of a dataset.

## Examples:

```
network move $nhandle $dhandle 0
```

network move \$nhandle
In the first sample line, the network is inserted as the first element in a dataset. The second line reverts this operation and removes the network from the dataset.

This command can be used with a remote dataset descriptor. In that case, the network is packed into a serialized object representation, transmitted over the network and restored as member of the remote dataset at the specified position. The local network is deleted if the transfer succeeds.

## network mutex

network mutex nhandle mode
Manipulate the object mutex. During the execution of a script command, the mutex of the major object(s) associated with the command are automatically locked and unlocked, so that the operation of the command is thread-safe. This applies to builds that support multi-threading, either by allowing multiple parallel script interpreters in separate threads or by supporting helper threads for the acceleration of command execution or background information processing.

This command locks major objects for a period of time that exceeds a single command. A lock on the object can only be released from the same interpreter thread that set the lock. Any other threaded interpreters, or auxiliary threads, block until a mutex release command has been executed when accessing a locked command object. This command supports the following modes:

- lock

Increase the recursive mutex lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock.

- reset

Release all persistent locks on the object, if they exist.

- test

Return the current persistent lock count on the object. This excludes the transient per-command lock.

- unlock

Decrease the recursive lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock. Unlocking an object which has not been persistently locked results in an error.

There is no trylock command variant because the command already needs to be able to acquire a transient object mutex lock for its execution.

## network need

network need nhandle propertylist ?mode?
Standard command for the computation of property data, without immediate retrieval of results. This command is explained in more detail in the section about retrieving property data.

The return value is the network handle.
Example:
network need \$nhandle V_LEVEL recalc

## network new

network new nhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the network get command. The difference between network get and network new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## network nget

network nget nhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the network get command. The difference between network get and network nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## network pack

network pack nhandle ?maxsize? ?request_propertylist? ?suppress_propertylist?
Pack the network object into a base64-encoded compressed serialized object string. This string does not contain any non-printable characters and is a full dump of the internal state of the object, omitting only property data that was declared to be so easily re-computed that a dump is not worthwhile. The network vertex and connection minor objects and their property data are part of the dump.

The maximum size of the object string (default -1 , meaning unlimited) can be configured by the optional maxsize parameter. The size is specified in bytes. If the pack string would be longer than the maximum size, an error results.

The other two optional parameters allow to request a specific property set to be part of the package, even if it normally would not be included, and to explicitly omit properties from the dump. No property computation is performed, and suppressed properties are not purged from the ensemble.

The command returns the pack string.

## network properties

```
network properties nhandle ?pattern? ?noempty?
```

Get a list of valid properties of the network proper and its vertex and connection minor objects.
The list can be filtered by a string match pattern. If the noempty flag is set, only properties where at least one data element controlled by the network (i.e. a value for an vertex of the network, etc.) is not the property default value are output. By default, the filter pattern is an empty string, and the noempty flag is not set.

Example:
network properties \$nhandle N_*

## network purge

network purge nhandle propertylist/network/vertex/connection ?emptyonly?
Delete property data from the network. The properties may be network properties (prefix n_), or properties of the network minor objects, i.e. vertices ( $\operatorname{prefix} \mathrm{v} \_$) and connection ( prefix $_{\mathrm{c}}^{\mathrm{c}}$ ). If a property marked for deletion is not found on the associated objects, it is silently ignored.

The optional boolean flag emptyonly allows to restrict the deletion to those properties where all the values of a property associated with a network object (such as on all vertices in a network for vertex properties, or just the single network property value for network properties) are set to the default property value.

In addition to property names, the object class names network, vertex or connection may be used. These delete all property data of that class from the network. They do not delete the objects proper, e.g. all vertices are still present after a network purge \$nh vertex, though without any data that was not locked.

Examples:

```
network purge $nhandle N_NAME
network purge $nhandle V_ONTOLOGY_TERM 1
network purge $nhandke connection
```


## network read

network read filename ?maxdefinitions?
Read network data from a file and create a new network object.
The filename argument can either be a disk file name, a pipe to an external generator program which starts with a vertical bar and is followed by the pipe programs and their parameters, the magic file name stdin, or, on Unix-class systems, an existing TcL file or socket handle.

Currently, there are seven network file formats which can be read. These are automatically identified by peeking into their contents, not by their file name. The recognized formats are:

- the native CActvs network object dump file (standard suffix .nbin),
- OBO ontology definition files in version 1.2 (standard suffix .obo).
- GeneOntology ontology definition files (standard suffix .go)
- SIF network files (standard suffix .sif)
- GML network files (standard suffix .gml)
- XGMML network files (standard suffix.$x g m m l$ or.$g r$ )
- KEGG metabolism networks (standard suffix .kgml or .kegg)
- KNIME network data files (standard suffix .knet). These can only be read from a disk file, not a pipe or other data channel because they are internally a zipped collection of data files.

All of these formats can store only a single top-level network, so there are no record positioning commands for network data input. Nested networks, for example in the GML or XGMML formats, are currently not directly readable. Some additional network file formats can currently be written, but not read (for example, GraphVIz.$g v$ and KNIME $B E E F$ ).

The optional definition count argument can be used to stop reading a file after the specified number of vertex definitions have been read. This is basically a debug feature which allows program testing with a smaller network. The option is not supported with native Сactvs network dump files.

The command returns the handle of the new network object.
Example:

```
set nh [network read "chebi.obo"]
```


## network rename

network rename nhandle srcproperty dstproperty
This is a variant of the network assign command. Please refer the command description in that paragraph.

## network rewind

```
network rewind nhandle
```

Reset the network iterator position. This is equivalent to setting the record network attribute to one.

## network scan

network scan nhandle expression ?mode? ?parameters?
Perform a query on the network. The syntax of the query expression is the same as that of the molfile scan command and explained in more detail in its section about query expressions. In many aspects, this command behaves like an in-memory data file version of the molfile scan or dataset scan commands. The main difference is that the primary objects that are scanned are the vertices of the network, and their property data (or indirectly, the data of the network major object, or the directly attached connection minor objects) is what is checked when determining a match or mismatch.

The optional parameter dictionary is the same as for molfile scan, but not all parameters are actually used. At this time, only the matchcallback, maxhits, maxscan, order, progresscallback, progresscallbackfrequency, sscheckcallback, startposition and target parameters have an effect. In case a progress callback function is used, the network handle is passed as argument in place of the molfile handle in molfile scan.

The vertices of the network are visited in the order of their index value (see vertex index command). This index value plus one is used also used as a replacement for the record number of a vertex in the dataset.

The return value depends on the mode. The default mode is vertexlist. The following modes are supported for dataset queries:

- array

The mode parameter is a list consisting of the mode selector array and a nested list of properties and pseudo-properties. Each property item can be a list of one to three elements. The first element is a property or pseudo-property, the second element a name, and the third element again a property or pseudo property. The the second property item list element is omitted, the name is the same as the first element. If the third element is missing, it is assumed to be the pseudo-property record. In this mode, the scan command returns a list of the names of the created arrays. For each such name, a global TcL array variable is created, and for each match, an TcL array element with an element name equal to the value of the first item specification index and an element value equal to the value of the third item specification index is created. For example, the specification
\{array \{V_LABEL id2rec\} \{record rec2id V_LABEL\}\}
creates two global TcL arrays in the current interpreter, called id2rec and rec2id. The first has elements where the element name is the label of the matching vertex (property v_LABEL), and the value the pseudo-record number (the default since the third list parameter is omitted). The second array has elements where the record number is the array element name, and the corresponding value the vertex label. The return value of the TcL statement is the list "id2rec rec2id", the names of the two variables created.

If array elements for a specific key already exist, the new value is appended as a list object. The registration procedure does not overwrite existing content. Since global arrays are persistent, data is appended over multiple scan statements. If this is not desired. a statement like unset -nocomplain \$arrayname should be executed before the scan is started. It is legal to use the same array name to register multiple properties in the array. In that case, any match appends a new list element for every property. The list is however not nested.

- bitvector

Return a string-encoded bit vector (series of 0s and 1s) indicating the match status for every visited vertex.

- count

Count the number of hits. The result value is an integer.

- delete

Delete hit vertices from the network. This is the only scan command which actually changes the network.

- exists

A boolean check for the existence of a hit. The same as count, except that the scan stops after the first match.

- file

The mode parameter is a list consisting of the mode selector file and a molfile handle, which must have been opened for writing, appending, or updating. The first matching vertex is written to the file. After that. the scan stops. File attributes determine format, selection of
data written, structure encoding conventions such as hydrogen status, etc. If no matching vertex is found, nothing is written. This mode only works with structure files that can accept a vertex or a network object as output target. There are no I/O modules in the standard toolkit package which currently have this capability.

- filelist

The mode parameter is a list consisting of the mode selector file and a molfile handle, which must have been opened for writing, appending, or updating. Matching vertices are written to that file. File attributes determine format, selection of data written, structure encoding conventions such as hydrogen status, etc. If no matching vertex is found, nothing is written. This mode will only work with structure files that can accept a vertex or a network object as output target. There are no I/O modules in the standard toolkit package which currently have this capability

- index

This is the same as record, except that the returned value is one less, since indices start with zero.

- indexlist

This is the same as recordlist, except that the returned value is one less, since indices start with zero

- property

The mode parameter is a list consisting of the mode selector property and a sequence of properties and pseudo-properties. The selected properties for the first match are returned as a list.After the first match, the scan stops. If there are no hits, an empty string is returned. Properties which can be used in network scans are either of the vertex class (prefix V, the most common case for network queries), class network (prefix N , of limited value since there is only a single network scanned, and the property values are thus the same for all matches), or of the connection class (prefix C). Connection properties are reported as lists which contain the data of all connections the matching vertex participates in.

- propertylist

The mode parameter is a list consisting of the mode selector propertylist and a sequence of properties and pseudo-properties. The selected properties for all matches are returned as a nested list. If there are no hits, an empty string is returned. This mode is also selected if the mode argument is simply a list of property and pseudo property names without an identifiable mode keyword as first list element.

- record

Return the sequence number of the first hit. Sequence numbers begin, for the sake of comparability with structure file scan record numbers, with one and are equivalent to the vertex index position plus one. The scan stops after the first match.

- recordlist

Return sequence numbers of all hits, or an empty list. Sequence numbers begin, for the sake of comparability with structure file scan record numbers, with one and are equivalent to the vertex index position plus one.

- table

The mode parameter is a list consisting of the mode selector table and a sequence of properties and pseudo-properties. This scan mode returns a table handle. The table is automatically configured with properly typed columns corresponding to the requested properties. For each hit, a row is added. If there are no hits, a table handle is still returned, but the table does not have any rows. This retrieval mode is only available if the toolkit has been compiled with table support. The individual properties may also be specified each as a list consisting of the property name, and an arbitrary string. In that case, the string is used as the column name. By default, the column names are the same as the name of the property they store. Example:

```
{table V_LABEL N_CONNECTION_COUNT C_LABEL C_ONTOLOGY_LINK}
```

sets up a table with four columns that store the matching vertex label, the network connection count (the same value for all rows, since all matches are all on the same network), and the labels and link types of the connections attached to the matched vertex. The latter two columns are automatically stored as vector types, since there are potentially multiple values associated with a single matching vertex.

Instead of the keyword table, an existing table handle may also be used. In that case, any existing matching table columns are automatically re-used to store result data. Additionally specified properties are added as new columns to the right of the previously existing columns. New table rows generated by matches are appended to the bottom of the table.

- tablecollection

Since all objects subject to scans with this command are already in memory, this mode is identical to the table scan mode for network scans. No duplicate table reference objects are created. The result table always refers the network objects directly.

- vrecord

For network scans, this is the same as record.

- vrecordlist

For network scans, this is the same as recordlist.

- vertex

Report the label of the first matching vertex. This is functionally equivalent to the mode property V_LABEL, though internally optimized. The scan stops after the first match.

- vertexlist

Report a list of the labels of the matching vertices. This is functionally equivalent to the mode propertylist V_LABEL, though internally optimized.

If requested property data is not present on vertices to be tested, an attempt is made to compute it. If this fails, in retrieval mode table nulu cells are generated, and property retrieval as list data produces empty list elements, but no errors.

The following pseudo properties can be retrieved in addition to normal properties:

- avgscore

The average value of all computed scores, such as Tanimoto, Cosine or Tversky similarity scores, in the matching query for this result.

- conformerindex

The index of the matching conformer in case of 3D queries with multiple conformations, -1 if no matching conformer index was determined.

- conformer

A list of the atomic coordinates of the matching conformer, if a 3D query was performed. If this is not the case, an empty vector is the result. The data type of this vector is coorvec ( $\mathrm{x}, \mathrm{y}, \mathrm{z}$-triples as vector elements).

- filename

This pseudo-property is only provided for compatibility with molfile scan. It is always an empty string.

- image

A structure GIF image (property E_GIF) with highlighted matching substructure atoms and bonds. A normal E_GIF retrieval property would just show the structure, but without highlighting. The data type of this property is the same as that of E_GIF (depending on the configuration, a diskfile reference or an in-memory blob).

- index

This is the same as record, except that the retrieved value is one less, since indices start with zero.

- matchatoms

An integer vector holding the labels of all atoms matching the substructures used in evaluating the query expression. If no substructure was used for the match, this vector is empty. highlighatoms is an alias for this pseudo property.

- matchbondatoms

The same as matchbonds, except that each element is a pair of the labels of the matching atoms in the bonds, not the bond label as a single number.

- matchbonds

An integer vector holding the labels of all bonds matching the substructures used in evaluating the query expression. If no substructure was used for the match, this vector is empty. highlightbonds is an alias for this pseudo property.

- matchchount

The first element of the matchcounts array, as described below. If the query does not contain any substructure match nodes, the result is empty.

- matchcounts

An integer vector holding the number of distinct substructure matches for substructure query nodes in the query tree. For normal substructure expressions, this value can only be zero or one because the standard substructure match mode only checks for the presence of any match (match mode first). Additionally, this value can be minus one if the node was never evaluated, for example because it is part of an or expression. Only if the count modifier is used together with the substructure query operator, or the substructure operator is the range operator, the possibility of multiple matches is evaluated and larger values can be obtained. For these operations the match mode is currently always distinctinneratoms (see match ss command).

- maxscore

The maximum value of all computed scores, such as Cosine, Tanimoto or Tversky similarity scores, in the matching query for this result.

- merit

For queries which use a merit/demerit rating scheme (for example, Bruns/Watson queries) this retrieves the accumulated merit/demerit sum of the top-level query node. The query needs to match for this retrieval to work, so in case none of the demerit rules match, you get an empty result, not a default zero merit/demerit value. Internally, there is no distinction between merit and demerit scores. The keyword demerit is an alias for this pseudo-property.

- minscore

The minimum value of all computed scores, such as Cosine, Tanimoto or Tversky similarity scores, in the matching query for this result.

- parent

The parent structure of the matching structure as a packed, base64-encoded serialized object string. If the dataset ensemble does not already contain it, it is computed from the structure as property E_PARENT_STRUCTURE.

- productmatchatoms

The same as the matchatoms pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- productmatchbondatoms

The same as the matchbondatoms pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- productmatchbonds

The same as the matchbonds pseudo property, but for the ensemble on the right side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- queryid

The ID of the search tree query item which was responsible for the principal match. Every tree element of a query expression possesses an ID, starting with 1 , and then assigned in incremental sequence from left to right in depth-first manner. For simple property or structure match expressions, the query ID is the ID of the matching branch, i.e. one for single-node expressions. For logical expressions with an or, orcontinue or not node, the overall reported query ID is that of the first matching leaf node. For expressions, where all leaves need to be checked, the query ID is the ID of the and or eor node where all leaves matched, not the ID of any individual leaf node.

- reagentmatchatoms

The same as the matchatoms pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- reagentmatchbondatoms

The same as the matchbondatoms pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- reagentmatchbonds

The same as the matchbonds pseudo property, but for the ensemble on the left side of a matching reaction, not a simple structure. If no reaction was matched, this is an empty list.

- record

The record number. In the context of in-memory datasets, this is the dataset list index of the matching object plus one. $r c$ is an alias for this pseudo property.

- rgatoms(rg)

A list of the atom labels in a matching structure which were mapped to an expanded R-group atom in the query. The property index is the name of the R-group of interest defined in the substructure, usually something like $R 1$. If there was no expanded R-group of that name, the result list is empty.

- rgattachments(rg)

A nested list of the atom label pairs of the bonds in a matching structure which connect between the structure framework and the atoms expanded as the named R-group rg. If there was no expanded R-group of that name, the result list is empty.

- score

The first element of the scores array, as described below. If the query does not contain any scoring expressions, the result is empty.

- scores

An integer vector of the results of all query expression branches, in depth-first left-to-right order, which computed a score, such as structure similarity queries with Cosine, Tanimoto or Tversky bitvector comparisons. In case a branch was not executed when the match was determined, zero is entered.

- structure

The matched structure as a packed, base64-encoded serialized object string.

- vrecord

For network object scans, this is always the same as record.
These pseudo properties are identical to those available for structure file queries. However, structure file queries allow the use of a couple of additional pseudo properties which are not supported for network queries.

## network set

network set nhandle ?property value?...
network set nhandle ?dictionary?
Standard data manipulation command. It is explained in more detail in the section about setting property data.

## network setparam

network setparam nhandle property key value ?key value?..
Set or update a property computation parameter in the metadata parameter list of a valid property. This command is described in the section about retrieving property data. The current settings of the computation parameters in the property definition are not changed.

## network show

network show nhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the network get command. The difference between network get and network show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, network get and network show are equivalent.

## network sqldget

network sqldget nhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the network get command. The differences between network get and network sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## network sqlget

network sqlget nhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the network get command. The difference between network get and network sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## network sqlnew

network sqlnew nhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the network get command. The differences between network get and network sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## network sqlshow

network sqlshow nhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the network get command. The differences between network get and network sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## network subcommands

network subcommands
Lists all subcommands of the network command. Note that this command does not require a network handle.

## network unlock

network unlock nhandle propertylist/objclass/all
Unlock property data for the network, meaning that they are again under the control of the standard data consistency manager.

The property data to unlock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the network, or network minor objects are unlocked. Non-existent data is silently ignored. It is not possible to unlock individual property fields.

- all

All valid network or network minor objects properties are unlocked.

- vertex, connection, network

These are object class identifiers. All property data which is controlled by the network major object and attached to the specified object class is unlocked.

Property data locks are obtained by the network lock command.

## network unpack

network unpack packstring
Unpack a base64-encoded serialized object string which was created by a network pack command. The return value of this function is the handle of the newly created network object, which is an exact duplicate of the packed original network.

## Example:

```
set packdata [network pack $nhandle]
set nhandle [network unpack $packdata]
```


## network valid

```
network valid nhandle propertylist
```

Returns a list of boolean values indicating whether values for the named properties are currently set for the network. No attempt at computation is made.

Example:
network valid \$nhandle V_ONTOLOGY_TERM
will report whether the network has ontology term definitions attached to its vertices or not.

## network vertices

network vertices nhandle ?filterset? ?filtermode?

Standard cross-referencing command to obtain the labels of the vertices the network contains as minor objects. This is explained in more detail in the section about object cross-references.
Examples:
network vertices \$nhandle
filter create rootnode property V_LEVEL value 0 operator =
network vertices \$nhandle rootnode
The example simply returns a list of the labels of the vertices the network contains as minor objects. The second example restricts these to the subset where property $\mathrm{v}_{\mathrm{L}}$ LeVEL has a specific value.

## network write

network write nhandle filename ?format?
Write the contents of a network object to a file. The output file format is deducted from the suffix of the file name. If it is not recognized, the native toolkit format (default suffix .nbin) is used. This default mechanism can be overridden by giving an explicit format name in the optional argument.

The currently supported network output formats are Cactvs native (.nbin), SIF (.sif), GML (.gml), XGMML (. $x g m m l, . g r$ ), KNIME network data (.knet), BEEF (.beef)., GraphViz (.gv), and KEGG metabolic network (.kgml). OBO and GeneOntology ontology files can only be read, but not written. Predefined format alias names include knime for KNET files, and bisonet for BEEF. Zipped BEEF files cannot be written directly at this time, but can readily be obtained by first writing an unpacked $B E E F$ file and then running an external standard zip-compatible compressor on it.

The file name may be either a disk file name, one of the magic file names stdout or stderr, a pipe construct, or, on Unix-class operating systems, an open TcL file or socket handle.

The command returns the network handle.

## The pi Command

The pi command is the generic command used to manipulate $\pi$ systems. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

Pseudo $\pi$ system labels first, last and random are special values, which select the first $\pi$ system in the $\pi$ system list, the last, or a random $\pi$ system.

Examples:

```
pi get $ehandle 1 P_ATOMS
```

This is the list of officially supported subcommands:

```
pi append
pi append ehandle label property value ?property value?..
```

Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:

```
pi append $ehandle 1 P_NAME "_uvactive"
```

pi atoms
pi atoms ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the atom in the $\pi$ system. This is explained in more detail in the section about object cross-references.

Example:

```
pi atoms $ehandle 1 carbon
```

returns the labels of the carbon atoms in the $\pi$ system.

```
pi bonds
pi bonds ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the bonds the $\pi$ system contains. This is explained in more detail in the section about object cross-references. Technically, a $\pi$ system contains atoms, not bonds. This command lists all bonds which exist between atoms in the $\pi$ system. Bonds involving only a single atom in a $\pi$ system are excluded.

Examples:

```
pi bonds $ehandle 1
pi bonds $ehandle 1 {1 doublebond triplebond} count
```

The first example returns all labels of the bonds $\pi$ system 1 contains. The second example returns the number of double or triple bonds in the $\pi$ system.
pi create
pi create ehandle ?atom?...
Define a new $\pi$ system from an atom set. A new $\pi$ system is always created, even if one with the same atoms already exists. No check on the presence of $\pi$ electrons is performed. Before the command is
executed, the default $\pi$ system set is automatically instantiated if it was not yet computed. Adding a new $\pi$ system invalidates properties which are sensitive to $\pi$ system changes.

The command returns the label of the new $\pi$ system.

## pi defined

pi defined ehandle label property
This command checks whether a property is defined for the $\pi$ system. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

## pi delete

pi delete ehandle ?label?...
This command removes $\pi$ systems from the ensemble $\pi$ system list and destroys them. A pi property invalidation event is generated and thus the command may indirectly change the ensemble data.

This command is rarely used. $\pi$ systems are usually generated and destroyed automatically.
The command returns the number of deleted items.
pi dget
pi dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the pi get command. The difference between pi get and pi dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and returns that default if the data is not yet available. For data already present, pi get and pi dget are equivalent.
pi exists
pi exists ehandle label ?filterlist?
Check whether this $\pi$ system exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the $\pi$ system does not exist, or fails the filter, and 1 in case of successful testing.

Example:
pi exists \$ehandle 99
pi expr
pi expr ehandle label expression
Compute a standard SQL-style property expression for the $\pi$ system. This is explained in detail in the chapter on property expressions.
pi fill
pi fill ehandle label property value ?property value?...

Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

## pi filter

pi filter ehandle label filterlist
Check whether a $\pi$ system passes a filter list. The return value is 1 for success and 0 for failure.
Example:

```
pi filter $ehandle 1 [list carbon doublebond]
```

checks whether the $\pi$ system contains one or more carbon atoms and one or more double bonds. The double bond does not need to contain a carbon atom.

```
pi get
pi get ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

```
pi groups
pi groups ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the groups the $\pi$ system overlaps with. This is explained in more detail in the section about object cross-references. An overlap between a $\pi$ system and a group is established when there are common atoms which are contained in both objects.

Example:
pi groups \$ehandle 1
pi index
pi index ehandle label
Get the index of the $\pi$ system. The index is the position in the $\pi$ system list of the ensemble. The first position is index 0 .

Example:
pi index \$ehandle 99
pi local
pi local ehandle label propertylist ?filterset? ?parameters?
Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

## pi match

```
pi match ehandle label ss_ehandle ?ss_label? ?matchflags? ?ignoreflags?
    ?atommapvar? ?bondmap
```

Check whether the selected $\pi$ system matches a substructure. Only the first substructure $\pi$ system, or the $\pi$ system selected by the substructure label parameter, is tested. The substructure may be part of any structure ensemble, and even be in the same ensemble as the primary command $\pi$ system. Both the atoms in the $\pi$ system and the bonds between them are checked.

The precise operation of the substructure match routine can be tuned by providing a standard set of match flags and feature ignore flags. The default match flag set has set bits for the bondorder, atomtree and bondtree comparison features, and an empty ignore set. If a flag set is specified as an empty string, the default set is used. In order to reset a flag set, an explicit none value must be used.

The command returns 1 for a successful match, 0 otherwise. If an optional atom, bond, or molecule map variable is specified, it is set to a nested list of matching substructure/structure atom, bond or molecule labels. If no match can be found, the variable is set to an empty list. In case only a bond or molecule map variable is needed, an empty string can be used to skip the unused map variable argument positions.

## Examples:

```
pi match [ens create C=CCC=N] 1 C=C
pi match [ens create C=CCC=N] 1 N=C
pi match [ens create C=CCC=N] 2 C=C
pi match [ens create C=CCC=N] 2 N=C
```

The first and last commands match, the second and third do not.

## pi mol

pi mol ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the molecules the $\pi$ system is contained in. This is explained in more detail in the section about object cross-references.
pi new
pi new ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

The difference between pi get and pi new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## pi nget

pi nget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the pi get command. The difference between pi get and pi nget is that the latter returns numeric data, even if symbolic names for the values are available.

```
pi pi
pi pi ehandle label
```

Standard cross-referencing command to obtain the label of the $\pi$ system as stored in property P_LABEL. This is explained in more detail in the section about object cross-references.

Example:

```
pi pi $ehandle #0
```

returns the label of the first $\pi$ system of the ensemble $\pi$ system list.
pi rings
pi rings ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the rings the $\pi$ system is associated with. This is explained in more detail in the section about object cross-references. Rings which only partially overlap with the $\pi$ system are included.

Examples:

```
pi rings $ehandle 1
pi rings $ehandle 1 [list heterocycle aroring]
```

The first example returns the labels of all rings the $\pi$ system overlaps with. If the $\pi$ system does not overlap with any ring, an empty list is returned. Only labels of rings in the SSSR or ESSSR set are returned, even if the currently computed ring set is larger. The second example filters the rings - only heteroaromatic rings are reported.

## pi ringsystems

pi ringsystems ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the ring systems the $\pi$ system is associated with. This is explained in more detail in the section about object cross-references. Ring systems which only partially overlap with the $\pi$ system are included.

```
pi set
pi set ehandle label property value ?property value?..
```

Standard data manipulation command. It is explained in more detail in the section about setting property data.
pi show
pi show ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the pi get command. The difference between pi get and pi show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, pi get and pi show are equivalent.

## pi sigmas

pi sigmas ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\sigma$ systems the $\pi$ system overlaps with. This is explained in more detail in the section about object cross-references.

Examples:
pi sigmas \$ehandle 1
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## pi sqldget

pi sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the pi get command. The differences between pi get and pi sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## pi sqlget

pi sqlget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the pi get command. The difference between pi get and pi sqlget is that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## pi sqlnew

pi sqlnew ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the pi get command. The differences between pi get and pi sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## pi sqlshow

pi sqlshow ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the pi get command. The differences between pi get and pi sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## pi subcommands

pi subcommands

Lists all subcommands of the pi command. Note that this command does not require an ensemble handle, or a label.

```
pi surfaces
pi surfaces ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of surface patches the $\pi$ system is associated with. This is explained in more detail in the section about object cross-references.

Example:
pi surfaces \$ehandle \$label
Note that surface patches do not need to be associated with an atom, and if they are not, they are implicitly not associated with any $\pi$ system.

## The reaction Command

The reaction command is the generic command used to manipulate reactions. The syntax of this command follows the standard schema of command/subcommand/majorhandle. Reactions are major objects and thus do not need any minor object labels for identification.

Examples:
reaction get \$xhandle X_IDENT
This is the list of currently officially supported subcommands:

## reaction add

```
reaction add xhandle ?ReactionSMILES/SMIRKS/BASE64Blob? ?decodermode?
reaction add xhandle ?ehandle?...
reaction add xhandle ?{ehandle role}?...
```

Add ensembles to a reaction. The syntax of the various variants to specify ensembles and their reaction roles are the same as in the reaction create command.

Example:
reaction add [reaction create] \$reagent_ehandle \$product_ehandle
reaction append
reaction append xhandle property value ?property value?
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:

```
reaction append $xhandle X_NAME "_new"
reaction assign
reaction assign xhandle srcprop dstprop
```

Copy data from one property to another. Both properties must be associated with the same object class. The source property (but currently not the destination property) may be specified as an indexed property subfield. There must be a conversion path between the data types of the two properties or property subfields involved for the operation to succeed. For example, assigning a string property to a numeric property succeeds only if the string data items contain suitable numbers.

The original property data remains valid. The command variant reaction rename directly exchanges the property name without any data duplication or conversion, if that is possible. In any case, the original property data is no longer present after the execution of this command variant.

If the properties are not associated with reactions (prefix $x_{-}$), the operation is performed on all reaction ensembles.

Examples:
reaction assign \$xh A_XY A_XY\%
This code snippet creates a backup atomic 2D layout coordinates on all reaction ensembles.
reaction rename $\$ x h$ X_IDENT X_NAME

Reassign the data in property $X_{\text {_I }}$ IDENT to property X_NAME. If possible, this is done without memory reallocation and decoding/encoding procedures.

## reaction cast

reaction cast xhandle dataset/ens/reaction/table ?propertylist?
Transform the reaction into a different object. Depending on the target object class, the result is as follows:

- dataset

A new dataset which contains which contains the reaction as first object.

- ens

The reagent ensemble of the reaction, or the first other ensemble in the reaction is there is no reagent, or a newly created empty ensemble as last resort. The rest of the reaction and reaction ensembles are destroyed.

- reaction

Only supplied for the sake of completeness. This mode does nothing.

- table

A new table with one row and automatically generated columns for all properties of the input reaction of the reaction ( $\mathrm{X}_{-}^{*}$ ) object class. The row is filled with the input reaction data, and the reaction is moved to the internal dataset of the table.

If the optional property list is specified, an attempt is made to compute the listed properties before the cast operation, so that they may become a part of the new object. No error is raised if a computation fails.

The command returns the handle of the new object, or the input object handle in case of mode reaction.

## reaction clear

```
reaction clear xhandle ?role? ?deleteensembles?
```

Remove and optionally delete ensembles of a reaction. By default, all reaction ensembles are moved out of the reaction, but they are not deleted. If a reaction role is given (possible roles are taken from the enumeration of property E_REACTION_ROLE, the default set is unknown, reagent, product, solvent, catalyst, intermediate, impurity, byproduct, agent and waste), only those ensembles with the specified role are removed. If the deleteensemble flag is set, targeted ensembles are not simply removed from reaction membership, but destroyed.

The command returns the count of removed or deleted ensembles.
Examples:
reaction clear \$xhandle
reaction clear \$xhandle solvent 1
The first example removes all ensembles from the reaction, but keeps them in memory, and they can still be accessed via their handles. The second example removes all solvent ensembles from the reaction and destroys them.

## reaction copy

reaction copy src_xhandle dst_xhandle
Create a copy of the input reaction in the framework of an existing reaction. The old data of the destination reaction is destroyed, but its handle is reused for the copy. The destination handle can be an empty string. In that case, the reaction is duplicated and a new handle assigned.

This command is useful when references to a reaction handle are potentially stored in unknown locations, and the reaction needs to be updated.

The return value of the command is the handle of destination reaction. It is allowed to copy a reaction onto itself.

```
reaction create
reaction create ?ReactionSMILES/SMIRKS/BASE64Blob/KEGGID/patran? ?decodermode?
reaction create ?ehandle?...
reaction create ?{ehandle role}?...
```

This command creates a new reaction. Without any parameters, an empty reaction without any ensembles in it is made. The return value is the new reaction handle.

## Example:

set xhandle [reaction create]
The first variant for creating a reaction with data is the use of a single-argument line notation. The supported line notations include Reaction SMILES or SMIRks, hex-encoded versions thereof, a KEGG reaction identifier in the form RPxxxxx, a Cactvs base64-encoded serialized reaction object string (see reaction pack), or a base64-encoded compressed file content, such as an MDL RXN file record. For the last variant, the compression algorithm may be raw zlib, gzip or zip and is automatically detected. Additionally, any of those forms may be passed as a data URI. If a data URI is detected, its payload is extracted and used as argument in a second pass. The data for the decoding of KEGG IDs is downloaded from the KEGG site via an http connection and requires that the interpreter is allowed port 80 Internet access.

Similar to the ens create command, it is also possible to prefix the structure encoding, if it is a line notation or an encoding without line breaks, with smiles: smirks: or kegg: in order to explicitly name the encoding of these formats.

The only multi-line encoding recognized by this command are LhasA PATRAN reaction patterns. They are automatically decoded in a form which makes them suitable for use in lhasa reaction processor objects. Reactions stored in uncompressed files must be read by means of a molfile read command.

Without setting a specific decoder mode in the following optional argument, the data string is decoded in the format-specific default mode (i.e. as standard SMILES strings for the SMILES family) and molecules with a complete hydrogen set are generated if the encoding supports such a distinction.

For Reaction Smiles variants, the explicit decoder modes smarts, hadd, nohadd, pattern or patran and transform can be requested. In smarts mode, full SMARTS or SMIRKS encodings are recognized, which are useful for reaction substructure searches or SMIRKS transforms. No implicit hydrogen is added in that mode. The nohadd mode does not supports SMARTS constructs, but no implicit hydrogens are instantiated either.The hadd mode adds a standard hydrogen set. The transform mode
is similar to the smarts mode, but additionally hydrogen atoms encoded explicitly are not instantiated but rather translated into a hydrogen count query specification. This is useful for some classes of SMIRKS transforms. SMILES atom mapping specifications are allowed in all modes. The explicit pattern or patran modes should be used when decoding patran patterns - but then this is already the default for this type of data.

In case the argument is a Reaction SMILES variant and an agent in Daylight nomenclature is specified (the middle section between the >> characters), it is assigned the reaction role agent, which is rather unspecific. It may subsequently be changed by setting the E_REACTION_ROLE property of the agent ensemble.

Ensembles which are decoded from the arguments have normal handles and may be addressed via these just like ensembles which are not part of a reaction.

Examples:

```
set xhandle [reaction create C=O>Cc1ccccc1>CO]
ens set [reaction ens $xhandle agent] E_REACTION_ROLE solvent
set xhandle [reaction create {[C:1]=[0:2]>>[C:1][O:2]} smarts]
set xhandle [reaction create KEGG:RP09586]
```

A second reaction create command variant uses a set of ensemble handles as arguments and makes these ensembles members of the newly created reaction. The reaction role of the ensembles is determined by default by their position in the argument list. The first ensemble is the reagent, followed by product, solvent, catalyst, intermediate, impurity, byproduct, agent and waste in that order. It is possible to skip a role by providing an empty string as parameter placeholder. If necessary, ensembles are removed from an existing reaction and transferred to the new one, since an ensemble cannot be a member of more than one reaction at a time. In case the default order-dependent reaction role assignment is not convenient, any argument may be specified as a list of two components instead. In that notation, the first list element is the normal ensemble handle and the second the applicable role designator encoded as a string from above set.

Examples:
set xhandle [reaction create \$reagent_ehandle [ens create CO] \{\} \{[Pt]\}]
This example creates a reaction from an existing reagent ensemble and then adds a product ensemble and platinum as catalyst. The solvent parameter position is skipped by entering an empty string.

Finally, it is possible to explicitly specify the role by not just providing an ensemble handle as parameter, but a list consisting of an ensemble handle and its reaction role.

Example:

```
set xhandle [reaction create [list $product_handle product] \
    [list [ens create {[Pt]} catalyst]]
reaction dataset
reaction dataset xhandle ?filterlist?
```

Return the dataset handle of the dataset the reaction is a member of. It the reaction is not member of a dataset, or does not pass all of the optional filters, an empty string is returned.

Example:
reaction dataset $\$ x h a n d l e$

## reaction defined

reaction defined xhandle property
This command checks whether a property is defined for the reaction. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The reaction valid command is used for this purpose.

## reaction delete

```
reaction delete all
```

reaction delete xhandlelist ?xhandlelist?...

Delete reactions and the ensembles which are part of the deleted reactions. The special parameter all may be used to delete all reactions currently registered in the application. Alternatively, any number of lists of reaction handles may be specified for specific reaction deletions.

The command returns the number of deleted reactions.
Example:
reaction delete \$xhandle
reaction delete \$xhandlelist1 \$xhandlelist2

## reaction dget

reaction dget xhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the reaction get command. The difference between reaction get and reaction dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, reaction get and reaction dget are equivalent.

## reaction dup

reaction dup xhandle ?dataset? ?position?
Duplicate the specified reaction and its ensembles. The return value is the new reaction handle. The duplicated reaction ensembles are also assigned unique handles.

The duplicate reaction is placed into the same dataset as the source, if that one is in a dataset.
Specifying an explicitly empty dataset argument places the duplicate outside any dataset, regardless of the dataset membership of the source reaction.

If the duplicate is moved to a dataset, it is appended to the dataset end by default. This happens also if the position parameter is explicitly specified as end or an empty string. Otherwise, the reaction is inserted at the given position, starting with 0 . If the requested position is larger than the current size of the dataset, the reaction is appended.

Example:
set xhdup [reaction dup \$xhandle]
reaction ens
reaction ens xhandle ?filterlist?

Return a list of the handles of the ensembles which are a part of the reaction. Optionally, these ensembles may be filtered by a simple filter list.

Example:
reaction ens \$xhandle metal
Find all ensembles in the reaction which contain one or more metal atoms.

## reaction exists

```
reaction exists xhandle ?filterlist?
```

Check whether a reaction handle exists. The command returns 0 or 1 . Optionally, the reaction may be filtered by a standard filter list. If filters in the filter list operate on ensembles, it is sufficient if a single ensemble of the reaction passes the filter.

Example:
reaction exists \$xhandle solvent
Check whether the reaction with the handle in variable \$xhandle exists and, if it exists, whether it contains a solvent ensemble.

```
reaction expand
reaction expand xhandle ?allowambigous? ?noimplicith?
```

This command expands all superatoms in the ensembles of the reaction. The mechanisms for the expansion of superatoms are described in detail for the atom expand command. This command is functionally equivalent, working on all atoms in all of the reaction ensembles instead a single atom.

Example:

```
reaction expand $xhandle
```

The command returns the total number of successfully expanded atoms in all reaction ensembles.

```
reaction expr
```

reaction expr xhandle expression

Compute a standard SQL-style property expression for the reaction. This is explained in detail in the chapter on property expressions.

## reaction filter

```
reaction filter xhandle filterlist
```

Check whether the reaction passes a filter list. The return value is 1 for success and 0 for failure.
Example:
reaction filter [reaction create $\{C=C>[P t]>C C\}$ ] platinum
checks whether the reaction involves a platinum atom in any role. ${ }^{2}$ If the filter operates on ensembles or minor objects, it is sufficient to have a single ensemble or ensemble minor object pass the filter condition.
2. A filter testing for the presence of any element is automatically created when an element name is used as a filter name. Element filters except for the most common ones (carbon, etc.) do not show up in the filter list before they are instantiated.

## reaction forget

```
reaction forget xhandle ?minor_obj_class?
```

This command is essentially the same as the ens forget command. It is applied to all ensembles in the reaction.

## reaction get

reaction get xhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:
reaction get \$xhandle \{X_IDENT X_NAME\}
yields the ID and name of the reaction as a list. If the information is not available, an attempt is made to compute it. If the computation fails, an error results.
reaction get \$xhandle \{E_FORMULA E_WEIGHT\}
reports the formula and molecular weight of all reaction ensembles. The result is delivered as a nested list. The first list contains the formulae, the second list contains the weights.

Currently, it is not possible to use filters with this command (and the other retrieval command variants) which are not operating directly on the reaction object, but on objects lower in the hierarchy such as ensembles or atoms.

For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the reaction get command are reaction new, reaction dget, reaction nget, reaction show, reaction sqldget, reaction sqlget, reaction sqlnew, and reaction sqlshow.

In addition to property data, a reaction object possesses a few attributes, which can be retrieved with the get command (but not its related sister subcommands like dget, sqlget, etc.). Some of them are also modifiable via reaction set. These attributes are:

- coords

If the toolkit was compiled with factory support, these are the coordinates of the object icon on its workbench, encoded as integer pair. This attribute can be changed.

- deletable

Flag indicating whether the reaction can be deleted with a standard reaction delete command. This attribute is read-only. Reactions which are, for example, property data values or a part of a molfile loop command cannot be deleted by standard means.

- failures

If the property computation failure cache is active, return a list of all properties which have failed computation for this ensemble after the last structural change. This attribute is read-only.

- footer

If the toolkit was compiled with factory support, this is the footer of the object icon on a workbench. This attribute can be changed.

- gflags

If the toolkit was compiled with factory support, this is the currently set object icon rendering flag collection.

- header

If the toolkit was compiled with factory support, this is the header of the object icon on a workbench. This attribute can be changed.

- hidden

Flag indicating whether the reaction is hidden. This is not the same as the invisible state. This attribute is intended to be used for rendering selections. This attribute can be changed.

- incomplete

Boolean status flag indicating an aborted input operation during the read of the structure from file, which returned the structure intact but without the complete set of associated data. An aborted input may be either be the result of an explicitly set input control flag, or by encountering property data which could not be decoded. This attribute is read-only.

- invisible

Flag indicating whether the ensemble is invisible. This is not the same as the hidden state. An invisible object is no longer accessible via its handle. This is usually the case for objects which are scheduled for deletion, but still have lingering referring pointers. This attribute is read-only.

- modcount

Reaction data modification count. This attribute is read-only.

- pyobject

If the toolkit was compiled with Python support, this attribute reports the memory address of the Python wrapper class instance, if it exists. This attribute is read-only.

- pyrefcount

If the toolkit was compiled with Python support, this attribute reports the reference count of the Python wrapper class instance, if it exists. This attribute is read-only.

- refcount

If the TCL interpreter is using native Cactvs objects instead of string-based major object handles and integer-based minor object labels to identify toolkit objects, this returns the number of TcL object references active for this ensemble. This attribute is read-only.

- selected

Flag indicating whether the reaction is selected. This attribute can be changed.

- tooltip

If the toolkit was compiled with factory support, this is the tooltip of the object icon on a workbench. This attribute can be changed.

- uuid

An automatically generated UUID globally identifying the object. This attribute is read-only, different for every reaction, and not dependent on its contents.

- $x$

If the toolkit was compiled with factory support, this is the $x$ coordinate of the object icon on its workbench. This attribute can be changed.

- $y$

If the toolkit was compiled with factory support, this is the $y$ coordinate of the object icon on its workbench. This attribute can be changed.

## reaction getparam

reaction getparam xhandle property ?key? ?default?
Retrieve a named computation parameter from valid property data. If the key is not present in the parameter list, an empty string is returned. If the default argument is supplied, that value is returned in case the key is not found.

If the key parameter is omitted, a complete set of the parameters used for computation of the property value is returned in key/value format.

This command does not attempt to compute property data. If the specified property is not present, an error results.

Example:
reaction getparam \$xhandle X_GIF format
returns the actual format of the image, which could be GIF, PNG, or various bitmap formats.

## reaction hadd

reaction hadd xhandle ?filterset? ?flags? ?changeset?
Add a standard set of hydrogens to the ensembles of the reaction. If the filterset parameter is specified, only those atoms which pass the filter set are processed.

Additional operation flags may be activated by setting the flags parameter to a list of flag names, or a numerical value representing the bit-ored values of the selected flags. By default, the flag set is empty, corresponding to the use of an empty string or none as parameter value. These flags are currently supported:

- keepflags

For expert use only. Do not discard min/max values and property scope flags for atom properties when hydrogen is added.

- no2dcoords

Do not assign 2D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 2D coordinates. In any case, 2D coordinates are never added when the reaction ensemble does no already possess valid 2D coordinates.

- no3dcoords

Do not assign 3D coordinates to the added hydrogens, even if the rest of the atoms in the ensemble have valid 3D coordinates. In any case, 3D coordinates are never added when the reaction ensemble does no already possess valid 3D coordinates.

- noanions

Do not add hydrogen to atoms with a negative formal charge.

- noatoms

Do not add hydrogen to atoms without any bonds.

- nocations

Do not add hydrogen to atoms with a positive formal charge.

- noelements

Do not add hydrogen if the reaction ensemble consists purely of isolated metal atoms, which probably represent the material in elementary form, or as an alloy.

- noexcessvalences

Similar to nohighvalences, but hydrogen is not added to any atom which is not in its lowest standard bonded valence state.

- nofixatomtext

Do not adjust property a_TEXTLABEL (if present) by removing references to implicit H from it on atoms where hydrogen is added. For example, by default "NHCOOEt" becomes "NCOOEt" after adding an instantiated hydrogen to the nitrogen atom. This reduces confusion on the hydrogen status when rendering all atoms.

- nohighvalences

Do not add hydrogen to atoms which already exceed their lowest standard valence minus any formal charge. This option only applies to elements which have a defined lowest standard valence (this is configurable via the element table).

- nomemory

Do not remember the added hydrogen atoms as automatically added. Normally, a flag is retained as part of the atom information which distinguishes atoms which were added by automatic processing, such as hydrogen addition, from those which were originally input.

- nometals

Do not attempt to add hydrogen to atoms which are metals (as defined in the system element table).

- nospecial

Do not perform hydrogen addition to atoms which participate in non-standard bonds (all bonds with B_TYPE not normal).

- protonate

Add a single proton to the first suitable atom. The charge of the atom is increased and only a single hydrogen is added regardless of the standard number of missing hydrogens, and this command does issue the standard property invalidation event for atom and bond changes. In the reaction command variant, this option is rarely useful. It is supported for compatibility with the atom hadd command.

- resetmemory

Reset the origin flag described above for all atoms in the reaction ensembles. All current atoms appear to be part of the original atom set.

Adding hydrogens with this command is less destructive to the property data set of the reaction ensembles than adding them with individual atom create/bond create commands, except in case the protonate flag is set, because many properties are designed to be indifferent to explicit hydrogen status changes, but are invalidated if the structure is changed in other ways.

If the effects of the hydrogen addition step to the validity of the property data set should not be handled according to this standard procedure, it is possible to explicitly generate additional property invalidation events by specifying an event list as the optional last parameter, for example a list of atom and bond to trigger both the atom change and bond change events.

The command returns the number of hydrogens which were added to all reaction ensembles.
Example:
set xhandle [reaction create $\{[\mathrm{C}]=[\mathrm{C}] \gg[\mathrm{C}]-[\mathrm{C}]\}]$
reaction hadd \$xhandle
adds a total of ten hydrogens to the two reaction ensembles, transforming them into hydrogen-complete ethene and ethane.

## reaction hdup

reaction hdup xhandle ?dataset? ?position?
This command performs the same operation as the reaction dup command, but additionally adds a standard set of hydrogens to all ensembles of the duplicated reaction.

## reaction hstrip

reaction hstrip ehandle ?flags? ?changeset?
This command removes hydrogens from all ensembles in the reactions. By default, all hydrogen atoms on the ensemble are removed.

The flags parameter can be used to make the operation more selective. It may be a list of the following flags:

- deprotonate

If this flag is set, a single proton is removed from the first suitable atom. This command variant triggers a standard atom and bond change property invalidation event, and it always ends processing after removing the first proton. Proton removal decreases the charge of the atom by one. In the reaction command variant, this flag is rarely useful - it is supported for compatibility with the atom hstrip command

- keepalphawedge

Keep hydrogen atoms which are bonded to an atom which is at the tip of a wedgebond. This flag excludes the case where the bond to the hydrogen atom is the wedge bond - use the keepwedge flag to cover this case.

- keepisotopes

Keep hydrogen atoms which are isotope labels (including enriched/depleted ${ }^{1} \mathrm{H}$ ).

- keeporiginal

Hydrogen atoms which were not automatically added via a hadd command are retained.
Note that hydrogen addition commands can be run in a mode which does not leave
information about automatic addition - hydrogens added this way will also survive.

- keepprotons

Keep any molecules which consist only of hydrogen atoms (such as protons, hydride anions, and molecular hydrogen).

- keepspecial

If this flag is set, hydrogens which are usually displayed, such as on aldehydes, wedge bonds, carbon triple bonds or hetero atoms are retained.

- keepwedge
keep hydrogens which are at the end of a wedge bond, indicating stereochemistry.
- normalize

Normalize the wedge pattern for standard cases, removing wedges from hydrogens if the result is still stereochemically defined. Hydrogens which lose their wedge in this process are no longer protected by the keepwedge flag.

- wedgetransfer

If a hydrogen atom is removed which is at the end of a wedge, the wedge information is saved by transferring the wedge (changing its up/down status if necessary) to an adjacent, surviving bond. This flag has no effects if the keepspecial or keepwedge flags are set. This flag is set by default.

If the flags parameter is an empty string, or none, it is ignored. The default flag value is wedgetransfer - but the default value is overridden if any flags are set!

If the changeset parameter is used, all property change events listed in the parameter are triggered.
Hydrogen stripping is not as disruptive to the data content of the reaction ensembles as normal atom deletion, except in case the deprotonate flag is set. The system assumes that this operation is done as part of some file output or visualization preparation. However, if any new data is computed after stripping, the computation functions see the stripped structure, and proceed to work on that reduced structure without knowledge that there are implicit hydrogens.

The command returns the total number of hydrogens stripped from all reaction ensembles.
Example:
reaction hstrip \$xhandle [list keeporiginal wedgetransfer]

## reaction index

reaction index xhandle
Get the position of the reaction in the object list of its dataset. If the reaction is not member of a dataset, -1 is returned.
reaction list
reaction list ?filterlist?
This command returns a list of the reaction handles currently registered in the application. This list may optionally be filtered by a standard filter list. If the filter operates on the reaction ensembles and not on the reaction object, it is sufficient if a single reaction ensemble passes the filter.

Example:
reaction list solvent
lists the handles of all reactions in the application which contain a solvent ensemble.

## reaction lock

reaction lock xhandle propertylist/reaction/all ?compute?
Lock property data of the reaction, meaning that it is no longer subject to the standard data consistency manager control. The data consistency manager deletes specific property data if anything is done to the reaction which would invalidate the information. Blocking the consistency manager can be useful when building reactions from components in a script. Property data remains locked until is it explicitly unlocked.

The property data to lock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the reaction, reaction ensembles, or ensemble minor objects are locked. If the boolean compute flag is set, an attempt is made to compute the property if it is not yet present. Otherwise, a request to lock non-existent data is silently ignored. It is not possible to lock individual property fields.

- all

All valid reaction properties are locked. Ensemble properties and ensemble minor object properties are not affected. The compute flag is ignored.

- reaction

This is an object class identifier. All property data which is controlled by the reaction major object and attached to the specified object class is locked. Since reactions do not contain minor objects, this identifier is equivalent to all.

The lock can be released by a reaction unlock command.
Example:

```
set xhandle [reaction create {C=C>[Pt]>CC}]
reaction lock $xhandle X_GIF 1
reaction clear $xhandle agent
reaction unlock $xhandle X_GIF
```

In this example, first a reaction depiction in property data $X_{-}$GIF is generated and locked. After that, the reaction and reaction ensembles can be manipulated without losing the image data. The agent is removed in the next step - but the X_GIF image which shows the catalyst and which normally would have been deleted when the agent is removed is kept. Finally, the image property data is put back under the standard control of the data consistency manager.

## reaction max

reaction max xhandle propertylist ?filterset?
Get the maximum values of the properties named in the propertylist parameter. The return value of the command is a list of the maximum property values. While it is possible to work with reaction properties, this is pointless since there is only a single instance of a reaction property per reaction. Usually, ensemble or ensemble minor object properties are retrieved. The objects whose property values are used for the determination of the maximum values may optionally be filtered by a standard filter set.

Example:
reaction max \$xhandle E_WEIGHT \{1 reagent product\}
computes the maximum molecular weight from the reagent and product ensembles, ignoring other reaction ensembles such as solvents or catalysts.

## reaction metadata

reaction metadata xhandle property field ?value?
Obtain property metadata information, or set it. The handling of property metadata is explained in more detail in its own introductory section. The related commands reaction setparam and reaction getparam can be used for convenient manipulation of specific keys in the computation parameter field. Metadata can only be read from or set on valid property data.

## Examples:

```
array set gifparams [reaction metadata $xhandle X_GIF parameters]
reaction metadata $xhandle X CONDITIONS comment "Check with legal dept whether
oxidation in molten Pu metal requires regulatory approval"
```

The first line retrieves the computation parameters of the property X_GIF as keyword/value pairs. These are read into the array variable gifparams, and may subsequently be accessed as \$gifparams (format), \$gifparams (height), etc. The second example shows how to attach a comment to a property value.

## reaction min

reaction min xhandle propertylist ?filterset?
Get the minimum values of the properties named in the propertylist parameter. The return value of the command is a list of the minimum property values. While it is possible to work with reaction properties, this is pointless since there is only a single instance of a reaction property per reaction. Usually, ensemble or ensemble minor object properties are retrieved. The objects whose property values are used for the determination of the minimum values may optionally be filtered by a standard filter set.

## Example:

reaction min $\$ x h a n d l e ~ E \_W E I G H T ~\{1 ~ r e a g e n t ~ p r o d u c t\} ~$
computes the minimum molecular weight from the reagent and product ensembles, ignoring other reaction ensembles such as solvents or catalysts.

## reaction move

reaction move xhandle ?datasethandle|remotehandle? ?position?
Make a reaction a member of a dataset, or remove it from a dataset. If the dataset handle parameter is omitted, or an empty string, the reaction is removed from its current dataset. If it was not a dataset member, this command does nothing. The dataset handle may be the name of a remote dataset for moving reactions over a network connection.

If a dataset handle is specified, the reaction is added to the dataset, and removed from any dataset it was member of before the execution of the command. By default the reaction is added to the end of the dataset object list, but he final optional parameter allows the specification of an object list index. The first position is index zero. If the parameter value end is used, or the index is bigger than the current number of dataset objects minus one, the reaction is appended as by the default. It is legal to use this command for moving reactions within the same dataset.

Another special position value is random. This value moves to the reaction to a random position in the dataset. Using this mode with remote datasets is currently not supported.

The dataset handle cannot be a transient dataset.
The return value of the command is the dataset membership of the reaction prior to the move. It is either a dataset handle, or an empty string if it was not member of a dataset.

## Examples:

```
reaction move $xhandle $dhandle 0
```

reaction move \$xhandle

In the first sample line, the reaction is inserted as the first element in a dataset. The second line reverts this operation and removes the reaction from the dataset.

This command can be used with a remote dataset descriptor. In that case, the reaction is packed into a serialized object representation, transmitted over the network and restored as member of the remote dataset at the specified position. The local reaction is deleted if the transfer succeeds.

## reaction mutex

```
reaction mutex xhandle mode
```

Manipulate the object mutex. During the execution of a script command, the mutex of the major object(s) associated with the command are automatically locked and unlocked, so that the operation of the command is thread-safe. This applies to builds that support multi-threading, either by allowing multiple parallel script interpreters in separate threads or by supporting helper threads for the acceleration of command execution or background information processing.

This command locks major objects for a period of time that exceeds a single command. A lock on the object can only be released from the same interpreter thread that set the lock. Any other threaded interpreters, or auxiliary threads, block until a mutex release command has been executed when accessing a locked command object. This command supports the following modes::

- lock

Increase the recursive mutex lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock.

- reset

Release all persistent locks on the object, if they exist.

- test

Return the current persistent lock count on the object. This excludes the transient per-command lock.

- unlock

Decrease the recursive lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock. Unlocking an object which has not been persistently locked results in an error.
There is no trylock command variant because the command already needs to be able to acquire a transient object mutex lock for its execution.

## reaction need

reaction need xhandle propertylist ?mode?
Standard command for the computation of property data, without immediate retrieval of results. This command is explained in more detail in the section about retrieving property data.

The return value is the reaction handle.
Example:
reaction need \$xhandle E_WEIGHT recalc

## reaction new

reaction new xhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the reaction get command. The difference between reaction get and reaction new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## reaction nget

reaction nget xhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the reaction get command. The difference between reaction get and reaction nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## reaction nitrostyle

reaction nitrostyle xhandle style
Change the internal encoding of nitro groups and similar functional groups in the ensembles of the reaction. Possible values for the style parameter are:

- asis No change
- ionic Change to encoding to a positive charge on the center atom, and a negative on one of the oxygens
- xionic As above, but also change the encoding of azides, etc.
- neutral Change the encoding to the neutral form with extended valence. pentavalent is an alias.
- xneutral As above, but also change the encoding of azides, etc.

The command returns the reaction handle.

## reaction pack

reaction pack xhandle ?maxsize? ?request_propertylist? ?suppress_propertylist?
Pack the reaction object into a base64-encoded compressed serialized object string. This string does not contain any non-printable characters and is a full dump of the internal state of the object, omitting only property data that was declared to be so easily re-computed that a dump is not worthwhile. The reaction ensembles and their property data are part of the dump. Further object relationships, such as datasets the reaction or reaction ensembles might be a member in, or table associations are not saved.

The maximum size of the object string (default -1, meaning unlimited size) can be configured by the optional maxsize parameter. The size is specified in bytes. If the pack string would be longer than the maximum size, an error results.

The other two optional parameters allow to request a specific property set to be part of the package, even if it normally would not be included, and to explicitly omit properties from the dump. No property computation is performed, and suppressed properties are not purged from the reaction.

Reactions can be restored from a packed object string by the reaction unpack command.
The reaction object and its ensembles remain in existence after using this command.
Example:
set dbstring [reaction pack [reaction create CC=O>>CCO]]

## reaction properties

reaction properties xhandle ?pattern? ?intersectmode?
Get a list of valid properties of the reaction proper and the reaction ensembles. By default, reaction properties (prefix x_), dataset properties (prefix $D_{-}$), as well as the properties of the ensembles in the reaction (prefix $\mathrm{E}_{-}$) and the properties of their minor objects (atoms, bonds, etc.) are listed.

Property subsets may be selected by a non-empty filter pattern. In case of reaction ensemble or minor ensemble object properties which are not present in all reaction ensembles, the default intersect mode is union, meaning that all properties are reported for which at least one instance exists. The alternative mode intersect only lists those ensemble properties which are present in all reaction ensembles.

This command may also be invoked as reaction props.
Example:
reaction properties \$xhandle X_*
reaction props \$xhandle E_* intersect
The first example returns a list of the currently valid reaction properties. The second example lists all reaction properties which are present in all reaction ensembles.

## reaction purge

reaction purge xhandle propertylist/reaction/specialname ?emptyonly?
Delete property data from the reaction. The properties may be reaction properties (prefix $x \_$), dataset properties (prefix $D_{-}$) or properties of the reaction ensembles, such as ensemble or atom properties. If a property marked for deletion is not present on an object, it is silently ignored. If the reaction is not a dataset member, a request for the deletion of dataset properties is also ignored. If the object class name reaction is used instead of a specific property name, all reaction property data ( x _ prefix) is deleted from the reaction.

Besides normal property and class names, a few convenient special names for common property deletion tasks on the ensembles of the reaction are defined and can be used as a replacement for the property list. These include:

- atomstereochemistry

Delete all atomic atom stereo descriptors, but keep those for bonds.

- bondstereochemistry

Delete all bond stereo descriptors, but keep those for atoms.

- isotopes

Delete isotope information in A_ISOTOPE and other isotope properties which may be defined in future software versions.

- radicals

Delete atomic radical information in A_RADICAL and other radical-related properties which may be defined in future software versions.

- stereochemistry

Delete all stereochemistry descriptors, including 2D wedges, but not 3D coordinates. The implicit property list includes A_LABEL _STEREO, B_LABEL_STEREO, A_CIP_STEREO, B_CIP_STEREO, A_DL_STEREO, B_CISTRANS_STEREO, A_HASH_STEREO, B_HASH_STEREO, A_MAP_STEREO, B_MAP_STEREO, A_STEREOINFO, B_STEREOINFO, A_STEREO_GROUP, M_STEREO_COUNT, E_STEREO_COUNT and B_FLAGS (only selected bits, the property remains valid if present).

- wedges

Delete wedge bond flags in property B_FLAGS. If B_FLAGS is not present, the command is ignored and no computation attempt is made.

The optional boolean flag emptyonly can be used to to restrict the deletion to those properties where all the values for a property associated with a major object (such as on all atoms in an ensemble for atom properties, or just the single ensemble property value for ensemble properties) are set to the default property value.

Examples:

```
reaction purge $xhandle X_IDENT
reaction purge $xhandle E_IDENT 1
```

The first example deletes the property data $X_{-}$IDENT for the selected reaction if it is present. The second example deletes property E_IDENT from all ensembles in the reaction if the property value on that ensemble is equal to the default value for E_IDENT.

## reaction remove

reaction remove xhandle ?enslist?...
Remove the ensembles in the ensemble lists from the reaction. If an ensemble from the list is not part of the reaction, it is ignored. Removed ensembles are not destroyed and remain accessible via their handles.

The command returns the number of removed ensembles.
Examples:

```
reaction remove $xhandle $ehandle
reaction remove $xhandle [reaction ens $xhandle]
```

The first example removes the ensemble from the reaction if it is part of the reaction. The second example removes all ensembles from the reaction - this is essentially the same as reaction clear.
reaction rename
reaction rename xhandle srcproperty dstproperty

This is a variant of the reaction assign command. Please refer the command description in that paragraph.

## reaction reorder

reaction reorder xhandle
Sort the ensembles in the reaction into standard sequence (reagent/product/solvent/catalyst/ intermediate/impurity/byproduct/agent/waste). In addition, empty reagent and product (but not solvent, etc.) ensembles are automatically created in the reaction in case they are not present.

The command returns the ensemble handle.

## reaction scan

reaction scan xhandle expression ?mode? ?parameters?
Perform a query on the reaction object. The syntax of the query expression and the optional selection list is the same as that of the dataset scan command with a transient dataset consisting of the current reaction only. For more details, please refer to the paragraphs on dataset scan and molfile scan.

The return value depends on the mode. The default query mode, different from the default in dataset scan, is exists.

In case the query contains ensemble structure match conditions which are not part of a reaction query, or there are ensemble data retrieval specifications, these are tested on and applied to the reagent ensemble of the reaction. Reactions which do not possess a reagent ensemble (half reactions, etc.) are ignored.

## reaction set

reaction set xhandle property value ?property value?...
Standard data manipulation command. It is explained in more detail in the section about setting property data.

## Examples:

```
reaction set $xhandle X_NAME "New multi-component reaction"
reaction set $xhandle E_IDENT "X-124"
```

The first line is a simple set operation for a reaction property. The second line shows how to set properties of multiple ensembles in one step. The same property value is assigned to all ensembles.

## reaction setparam

reaction setparam xhandle property key value ?key value?...
Set or update a property computation parameter in the metadata parameter list of a valid property. This command is described in the section about retrieving property data. The current settings of the computation parameters in the property definition are not changed.

Example:
reaction setparam \$xhandle X_GIF comment "Top Secret"

## reaction show

```
reaction show xhandle propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the reaction get command. The difference between reaction get and reaction show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, reaction get and reaction show are equivalent.

## reaction sort

```
reaction sort xhandle ?sort property? ?relabel? ?duplicate? ?datasethandle?
```

?position?

This command applies the ens sort command to all reaction ensembles. Please refer to the descriptors of the ens sort command for an explanation of the parameters.

The command returns the reaction handle.

## reaction split

reaction split xhandle ?dropsize? ?splitproperty?
Split the molecules of the ensembles in the reaction into individual ensembles. The return value is a list of all ensemble handles in the reaction after the operation, similar to the output of a reaction ens command. The initial reaction ensembles are modified, and their old handles may be reused as one of the new single-molecule ensemble handles. If an input ensemble contains only a single molecule, and that molecule passes the optional size filter, the command is a no-op for that ensemble. All result ensembles remain members of the reaction.

The optional dropsize parameter is a minimum for the number of atoms in any of the molecules. If this is not an empty string, molecules which have less atoms than the minimum are deleted from all reaction ensembles. If all molecules in a reaction ensemble are smaller than the required size, the ensemble is destroyed.

The optional split property argument can be used to spit an ensemble on values of a molecule property, which needs to be either already set or computable, instead of simply separating fragments on connectivity. All molecules in an input ensemble which have a common value of this property are put into a joint result ensemble, and each distinct property value starts a new result ensemble. Molecules with a common property value do not need to be present in the input ensemble in a consecutive sequence, nor are there any special requirements for the data type or value range of the split property, as long as the data type has a comparison function. If the values of the split property are distinct over all molecules in an input ensemble, the outcome of command is indistinguishable from running it without any split property.

Comparison of property values is performed separately within every reaction ensemble, not across the complete ensemble set in the reaction.

## reaction sqldget

reaction sqldget xhandle propertylist ?filterset? ?parameterlist?

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the reaction get command. The differences between reaction get and reaction sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## reaction sqlget

reaction sqlget xhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the reaction get command. The difference between reaction get and reaction sqlget is that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## reaction sqlnew

reaction sqlnew xhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the reaction get command. The differences between reaction get and reaction sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## reaction sqlshow

reaction sqlshow xhandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the reaction get command. The differences between reaction get and reaction sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## reaction subcommands

reaction subcommands
Lists all subcommands of the reaction command. Note that this command does not require a reaction handle.

## reaction swapin

reaction swapin xhandle
Swap a reaction from the disk store fully back to memory, and disable further automatic loading and shelving. If the reaction was not swapped out, the command does nothing.

The command returns the reaction handle.

## reaction swapout

```
reaction swapout xhandle
```

Release most of the reaction data from memory and store it in a temporary disk store. The reaction handle remains valid. As soon as it is used in a command again after this command has been executed, the swapped reaction data is automatically reloaded from file, and then stored again when the object lock is released. To disable the automatic swapping of a reaction, use the reaction swapin command.

This command is intended to be used in cases where a large number of reactions must be kept in memory. Its use is not generally encouraged - it is only useful in case the programmer knows about access patterns. In other cases, the standard virtual memory mechanism of the operating system might yield better performance results.

The reactions are stored as binary blobs in a key/value store in a process-specific swap directory cactvs $\% d$, (\%d is replaced by the process ID) which is created automatically in the standard temporary directory. When a reaction is deleted, its swap record is also removed, if one was created during the lifetime of the reaction. When a Cactvs application program exits, the swap store as well as the swap directory are automatically deleted, even without explicit deletion of the last set of reactions in memory. In case of program crashes, the swap directory and its contents may however survive. If reaction swapping is used with unstable applications, the temporary directory should be checked from time to time.

The command returns the reaction handle.
Example:
rection swapout \$xhandle

## reaction tables

reaction tables ehandle ?filterlist?
Return a list of the handles of all table objects the reaction is associated with. Optionally, the table set may be filtered by a simple filter list. If the reaction is not related to any table, or none of these tables passes the filter list, an empty string is returned.

This command is only available if the toolkit was compiled with table support.
Example:
reaction tables \$xhandle

## reaction taint

reaction taint xhandle propertylist/changeset ?purge?
Trigger a property data tainting event which acts on the reaction data, and the data of all ensembles in the reaction. If the reaction is a member of a dataset, or its ensembles are, the dataset and its objects are not tainted.

The command arguments are the same as for the ens taint command and explained there.
reaction transfer
reaction transfer xhandle target_xhandle propertylist

Move property data from one reaction to another, without going through an intermediate scripting language object representation. If the property is not already valid on the source ensemble, an attempt is made to compute it.

If the property is not a reaction property, but an ensemble property, or a property of ensemble minor objects, the property data is transfered between all ensemble pairs in the two reactions which serve the same reaction role (reagent, product, etc). The order of these ensembles in their reactions is arbitrary. Further processing of the data in each ensemble pair is then performed as in an ens transfer command. Please refer to the documentation of that command for additional information.

The return value of the command is the target reaction handle.

## Examples:

```
reaction transfer $xh $xh2 X IDENT
reaction transfer $xh $xh2 A MAPPING
```

The first example is a simple data copy. The second example transfers atom property A_MAPPING between the reagent and product ensembles of the reaction, and any other reaction ensemble where the property is valid, and a pair of ensembles with the same reaction role can be found. The order of the atoms in an ensemble pair is not required to be identical - property A_LABEL is used to identify corresponding atoms.

## reaction trim

reaction trim xhandle ?propertylist?
Reduce the information content of a reaction to a standard minimum set and discard any additional information. This process minimizes the storage requirements of the reaction. The properties of the minimum set are computed if required. The retained property set is designed to support a faithful representation of the connectivity of the reaction ensembles including bond and atom labels and types as well as formal charges, stereochemistry, isotopes and atom mapping information, but not of any 2D or 3D coordinates or auxiliary additional attributes of atoms, bonds or other chemical objects or the reaction object proper.

The optional fourth argument is a list of properties which should be retained in addition to the standard set. If any of these are not present on the reaction (or its ensembles) that is to be trimmed, they are silently ignored and no attempt is made to compute them. Specifying properties of the standard retention set in this list is allowed but has no additional effect.

The return value of the command is a list of the remaining properties of the reaction and the reaction ensembles. The properties of the latter are reported as the union of the properties of the individual reaction ensembles (see reaction props command).

Example:
reaction trim \$xhandle \{X_SMILES E_NAME X_NAME\}
reaction unlock
reaction unlock xhandle propertylist/reaction/all
Unlock property data for the reaction, meaning that they are again under the control of the standard data consistency manager.

The property data to unlock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the reaction, reaction ensembles, or ensemble minor objects are unlocked. Non-existent data is silently ignored. It is not possible to unlock individual property fields.

- all

All valid reaction properties are unlocked. Ensemble properties and ensemble minor object properties are not affected.

## - reaction

This is an object class identifier. All property data which is controlled by the reaction major object and attached to the specified object class is unlocked. Since reactions do not contain minor objects, this identifier is equivalent to all.

Property data locks are obtained by the reaction lock command.

## Example:

```
set xhandle [reaction create {C=C>[Pt]>CC}]
reaction lock $xhandle X GIF 1
reaction clear $xhandle agent
reaction unlock $xhandle X_GIF
```

In this example, first a reaction depiction in property data X_GIF is generated and locked. After that, the reaction and reaction ensembles can be manipulated without losing the image data. The agent is removed in the next step - but the X_GIF image which shows the catalyst and which normally would have been deleted when the agent is removed is kept. Finally, the image property data is put back under the standard control of the data consistency manager.

## reaction unpack

reaction unpack packstring
Unpack a base64-encoded serialized object string which was created by a reaction pack command. The return value of this function is the handle of the newly created reaction object, which is an exact duplicate of the packed original reaction.

Reactions may also be unpacked by a reaction create command.
Example:

```
set packdata [reaction pack [reaction create C=O>>CO]]
set xhandle [reaction unpack $packdata]
```


## reaction valid

reaction valid xhandle propertylist
Returns a list of boolean values indicating whether values for the named properties are currently set for the reaction. No attempt at computation is made.

Example:
reaction valid \$xhandle X_IDENT
reports whether the reaction has a standard ID (has a valid X_IDENT property) or not.

## reaction weed

reaction weed xhandle keywords
This command performs standard clean-up operations on all ensembles in the reaction. The supported operations are described in more detail in the section on the equivalent ens weed command.

The return value of this command is the reaction handle.

## The ring Command

The ring command is the generic command used to manipulate rings. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

Pseudo ring labels first, last and random are special values, which select the first ring in the ring list, the last, or a random ring.

Examples:
ring get \$ehandle 1 R_SIZE
This is the list of officially supported subcommands:
ring append
ring append ehandle label property value ?property value?..
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:

```
ring append $ehandle 1 R_NAME "_centroid"
```

ring atoms

```
ring atoms ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the atom in the ring. This is explained in more detail in the section about object cross-references.

Example:

```
ring atoms $ehandle 1 carbon
```

returns the labels of the carbon atoms in the ring.

## ring bonds

```
ring bonds ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the bonds the ring contains. This is explained in more detail in the section about object cross-references. Technically, a ring contains atoms, not bonds. This command lists all bonds which exist between consecutive atoms in the ring and which are of a type which matches the current ring bond mask.

## Examples:

```
ring bonds $ehandle 1
ring bonds $ehandle 1 {1 doublebond triplebond} count
```

The first example returns all labels of the bonds ring 1 contains. The second example returns the number of double or triple bonds in the ring.

## ring defined

```
ring defined ehandle label property
```

This command checks whether a property is defined for the ring. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

Example:
ring defined \$ehandle 1 R_AROMATIC
checks whether ring 1 is of a type for which property R_AROMATIC is defined.

## ring delete

ring delete ehandle ?label?...
This command removes rings from the ensemble ring list and destroys them. A ring property invalidation event is generated and thus the command may indirectly change the ensemble data.

This command is rarely used. Rings are usually generated and destroyed automatically.
The command returns the number of deleted items.

## ring dget

ring dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ring get command. The difference between ring get and ring dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, ring get and ring dget are equivalent.

## ring exists

ring exists ehandle label ?filterlist?
Check whether this ring exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the ring does not exist, or fails the filter, and 1 in case of successful testing.

Example:
ring exists \$ehandle 99
ring expr
ring expr ehandle label expression
Compute a standard SQL-style property expression for the ring. This is explained in detail in the chapter on property expressions.
ring fill
ring fill ehandle label property value ?property value?...
Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

## Example:

```
ring fill $ehandle 1 B_COLOR red
```

sets the color of the first bond ring 1 contains to red.

## ring filter

ring filter ehandle label filterlist
Check whether a ring passes a filter list. The return value is 1 for success and 0 for failure.
Example:

```
ring filter $ehandle 1 [list carbon doublebond]
```

checks whether the ring contains one or more carbon atoms and one or more double bonds. The double bond does not need to contain a carbon atom.

```
ring get
ring get ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:

```
ring get $ehandle 1 {R_SIZE A_ELEMENT}
```

yields a list with two elements, consisting of the ring size as the first element and the element numbers of all atoms in the ring as a nested list as the second result list element. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

```
ring get $ehandle 1 B_ORDER cxbond
```

reports the bond orders of all bonds of the ring which are carbon-heteroatom bonds.
For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the ring get command are ring dget, ring new, ring nget, ring show, ring sqldget, ring sqlget, ring sqlnew, and ring sqlshow.

Further examples:

```
ring get $ehandle 1 E_NAME
ring get $ehandle 1 A_FLAGS (boxed)
```

ring groups

```
ring groups ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the groups the ring overlaps with. This is explained in more detail in the section about object cross-references. An overlap between a ring and a group is established when there are common atoms which are contained in both objects.

Example:

```
ring groups $ehandle 1
```


## ring index

ring index ehandle label

Get the index of the ring. The index is the position in the ring list of the ensemble. The first position is index 0 .

Example:
ring index \$ehandle 99
ring ligands
ring ligands ehandle label ?filterset? ?filtermode?
Get the labels of atoms that are ligands to the current ring, i.e. they are not member of the ring, but directly bonded to it. The filterset and filtermode parameters work as with other object cross-reference commands.

If the filter set contains a bond filter, it is applied to the bond linking the result atom to the ring. This means it is not sufficient for the atom to have any bond which passes the filter, but the bond to the ring must be among them.

Example:
set nonringsubcnt [rings ligands \$eh \$rlabel \{!hydrogen !ringatom\} count]
ring local
ring local ehandle label propertylist ?filterset? ?parameters?
Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

Example:

```
ring local $ehandle 1 A_LABEL_STEREO
```

Note that very few computation routines currently support the local re-computation of data - in most cases, this command falls back to a global re-computation.

## ring match

```
ring match ehandle label ss_ehandle ?ss_label? ?matchflags? ?ignoreflags?
    ?atommapvar? ?bondmapvar? ?molmapvar?
```

Check whether the selected ring matches a substructure. Only the first substructure ring, or the ring selected by the substructure label parameter, is tested. The substructure may be part of any structure ensemble, and even be in the same ensemble as the primary command ring. Both the atoms in the ring and the bonds between them are checked.

The precise operation of the substructure match routine can be tuned by providing a standard set of match flags and feature ignore flags. The default match flag set has set bits for the bondorder, atomtree and bondtree comparison features, and an empty ignore set. If a flag set is specified as an empty string, the default set is used. In order to reset a flag set, an explicit none value must be used.

The command returns 1 for a successful match, 0 otherwise. If an optional atom, bond, or molecule map variable is specified, it is set to a nested list of matching substructure/structure atom, bond or molecule labels. If no match can be found, the variable is set to an empty list. In case only a bond or molecule map variable is needed, an empty string can be used to skip the unused map variable argument positions.

Example:

```
set ss [ens create {c1ccccc1} smarts]
set r_is_phenyl [ring match $ehandle $label $ss]
ring mols
```

```
ring mols ehandle label ?filterset? ?filtermode?
```

```
ring mols ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the molecules the ring is contained in. This is explained in more detail in the section about object cross-references. Under specific circumstances, it is possible to have rings which span more than one molecule.

## Examples:

```
ring mols $ehandle 1
ring mols $ehandle 1 [list heterocycle aroring]
```

The first example returns the labels of all molecules the ring is a part of. The second example filters the molecules - only molecules which contain heteroaromatic rings are reported. The ring filter is applied to the molecule because this is the return object, not the ring, so this filter does not require the ring the command was issued for to be in that class.

```
ring new
ring new ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ring get command. The difference between ring get and ring new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## ring nget

ring nget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ring get command. The difference between ring get and ring nget is that the latter always returns numeric data, even if symbolic names for the values are available.

```
ring pis
ring pis ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the $\pi$ systems the ring overlaps with. This is explained in more detail in the section about object cross-references.

Examples:

```
ring pis $ehandle 1
```

$\pi$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use p or d orbitals, such as in standard covalent multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

```
ring ring
ring ring ehandle label
```

Standard cross-referencing command to obtain the label of the ring as stored in property R_LABEL. This is explained in more detail in the section about object cross-references.

Example:
ring ring \$ehandle \#0
returns the label of the first ring of the ensemble ring list.

## ring ringsystem

ring ringsystem ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the ring system the ring is a member of. This is explained in more detail in the section about object cross-references.

Examples:

```
ring ringsystem $ehandle 1
ring ringsystem $ehandle 1 [list heterocycle aroring]
```

The first example returns the label of the ring system the ring is a member of. The second example filters the ring system - a ring system label is obtained only if that ring system contains one or more hetero aromats. These filters are applied to the ring system, meaning that they are implicitly applied to all rings in the ring system, not just the ring used for the query command.

Since a ring can only be a member of a single ring system, the command spells the target in singular.
ring set
ring set ehandle label property value ?property value?..
Standard data manipulation command. It is explained in more detail in the section about setting property data.

Example:

```
ring set $ehandle 1 R_NAME "The central pharmacophore"
ring show
ring show ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ring get command. The difference between ring get and ring show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, ring get and ring show are equivalent.

## ring sigmas

ring sigmas ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\sigma$ systems the ring overlaps with. This is explained in more detail in the section about object cross-references.

Examples:
ring sigmas \$ehandle 1
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

```
ring sqldget
ring sqldget ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ring get command. The differences between ring get and ring sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

```
ring sqlget
ring sqlget ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ring get command. The difference between ring get and ring sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## ring sqlnew

ring sqlnew ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ring get command. The differences between ring get and ring sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## ring sqlshow

ring sqlshow ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ring get command. The differences between ring get and ring sqlishow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## ring subcommands

ring subcommands
Lists all subcommands of the ring command. Note that this command does not require an ensemble handle, or a label.
ring surfaces
ring surfaces ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of surface patches the ring is associated with. This is explained in more detail in the section about object cross-references.

Example:
ring surfaces \$ehandle \$label
Note that surface patches do not need to be associated with an atom, and if they are not, they are implicitly not associated with any ring.

## The ringsystem Command

The ringsystem command is the generic command used to manipulate ring systems. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

Pseudo ring system labels first, last and random are special values, which select the first ring system in the ring system list, the last, or a random ring system.

Examples:
ring get \$ehandle 1 Y_NATOMS
The command can also be invoked as shortened alias ringsys.
The default property name prefix for ringsystem-level properties is $Y_{-}$. The $R_{-}$prefix is used for more commonly encountered ring properties.

This is the list of officially supported subcommands:

## ringsystem append

```
ringsystem append ehandle label property value ?property value?..
```

Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:
ringsystem append \$ehandle 1 Y_NAME "_centroid"

## ringsystem atoms

ringsystem atoms ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the atom in the ring system. This is explained in more detail in the section about object cross-references.

Example:
ringsystem atoms \$ehandle carbon
returns the labels of the carbon atoms in the ring system.

## ringsystem bonds

ringsystem bonds ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the bonds the ring system contains. This is explained in more detail in the section about object cross-references.

Technically, a ring system contains atoms, not bonds. This command lists all bonds which exist between atoms in the ring system and which are of a type which matches the current ring bond mask and which are ring bonds.

Examples:

```
rinsysg bonds $ehandle 1
ringsystem bonds $ehandle 1 {1 doublebond triplebond} count
```

The first example returns all labels of the bonds ring system 1 contains. The second example returns the number of double or triple bonds in the ring system.

## ringsystem create

ringsystem create ehandle atomlist
This command can be used to manually create a ring system or pseudo ring system from an arbitrary collection of atoms. No check is made whether the atoms actually form a valid ring system. The result value of the command is the label of the newly created ring system. This command generates a ringsystem property invalidation event and may thus indirectly influence the ensemble data.

By default, ring systems are automatically created whenever they are referenced and not yet set up for the context ensemble.

Example:
ringsystem create \$ehandle \{1 2 3\}

## ringsystem defined

ringsystem defined ehandle label property
This command checks whether a property is defined for the ring system. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

Example:
ringsystem defined \$ehandle 1 Y_NAME
checks whether ring system 1 is of a type for which property Y_NAME is defined.

## ringsystem delete

ringsystem delete ehandle ?label?...
This command removes ring systems from the ensemble ring system list and destroys them. A ringsystem property invalidation event is generated and thus the command may indirectly change the ensemble data.

The command returns the number of deleted items.
This command is rarely used. Ring systems are usually generated and destroyed automatically.

## ringsystem dget

ringsystem dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ringsystem get command. The difference between ringsystem get and ringsystem dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, ringsystem get and ringsystem dget are equivalent.

## ringsystem exists

```
ringsystem exists ehandle label ?filterlist?
```

Check whether this ring system exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the ring system does not exist, or fails the filter, and 1 in case of successful testing.

Example:
ringsystem exists \$ehandle 99
ringsystem expr
ringsystem expr ehandle label expression
Compute a standard SQL-style property expression for the ring system. This is explained in detail in the chapter on property expressions.

## ringsystem fill

ringsystem fill ehandle label property value ?property value?...
Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

Example:
ringsystem fill \$ehandle 1 A_COLOR red
sets the color of the first atom ring system 1 contains to red.

## ringsystem filter

ringsystem filter ehandle label filterlist
Check whether a ring system passes a filter list. The return value is 1 for success and 0 for failure.
Example:
ringsystem filter \$ehandle 1 [list carbon doublebond]
checks whether the ring system contains one or more carbon atoms and one or more double bonds. The double bond does not need to include a carbon atom.

```
ringsystem get
ringsystem get ehandle label propertylist ?filterset? ?parameterlist?
```

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:

```
ringsystem get $ehandle 1 {Y_NATOMS A_ELEMENT}
```

yields a list with two elements, consisting of the ring system size as the first element and the element numbers of all atoms in the ring system as a nested list as the second result list element. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

```
ringsystem get $ehandle 1 B ORDER cxbond
```

reports the bond orders of all bonds of the ring system which are carbon-hetero bonds.

For the use of the optional property parameter list argument, refer to the documentation of the ens get command.
Variants of the ringsystem get command are ringsystem dget, ringsystem new, ringsystem nget, ringsystem show, ringsystem sqldget, ringsystem sqlget, ringsystem sqlnew, and ringsystem sqlshow.

Further examples:
ringsystem get \$ehandle 1 E_NAME
ringsystem get \$ehandle 1 A_FLAGS (boxed)

## ringsystem groups

ringsystem groups ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the groups the ring system overlaps with. This is explained in more detail in the section about object cross-references. An overlap between a ring system and a group is established when there are common atoms which are contained in both objects.

Example:
ringsystem groups \$ehandle 1
ringsystem index
ringsystem index ehandle label
Get the index of the ring system. The index is the position in the ring system list of the ensemble. The first position is index 0 .

Example:
ringsystem index \$ehandle 99

## ringsystem ligands

ringsystem ligands ehandle label ?filterset? ?filtermode?
Get the labels of atoms that are ligands to the current ring system, i.e. they are not member of the ring system, but directly bonded to it. The filterset and filtermode parameters work as with other object cross-reference commands.

If the filter set contains a bond filter, it is applied to the bond linking the result atom to the ring system. This means it is not sufficient for the atom to have any bond which passes the filter, but the bond to the ring must be among them.

Example:
set subcnt [ringsystem ligands \$eh \$ylabel \{!hydrogen\} count]

## ringsystem local

ringsystem local ehandle label propertylist ?filterset? ?parameters?
Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

Example:

```
ringsystem local $ehandle 1 A_LABEL_STEREO
```

Note that very few computation routines currently support the local re-computation of data - in most cases, this command falls back to a global re-computation.

## ringsystem match

ringsystem match ehandle label ssehandle ?sslabel? ?matchflags? ?ignoreflags? ?atommapvar? ?bondmapvar? ?molmapvar?

Check whether the selected ringsystem matches a substructure. Only the first substructure ring system, or the ring system selected by the substructure label parameter, is tested. The substructure may be part of any structure ensemble, and even be in the same ensemble as the primary command ring system. Both the atoms in the ringsystem and the bonds between them are checked.

The precise operation of the substructure match routine can be tuned by providing a standard set of match flags and feature ignore flags. The default match flag set has set bits for the bondorder, atomtree and bondtree comparison features, and an empty ignore set. If a flag set is specified as an empty string, the default set is used. In order to reset a flag set, an explicit none value must be used.

The command returns 1 for a successful match, 0 otherwise. If an optional atom, bond, or molecule map variable is specified, it is set to a nested list of matching substructure/structure atom, bond or molecule labels. If no match can be found, the variable is set to an empty list. In case only a bond or molecule map variable is needed, an empty string can be used to skip the unused map variable argument positions.

Example:

```
set ss [ens create {c1ccccc1.c1ncccc1} smarts]
set rs_contains_phenyl [ringsystem match $ehandle $label $ss 1]
```


## ringsystem mols

ringsystem mols ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the molecules the ring system participates in. This is explained in more detail in the section about object cross-references. Under specific circumstances, it is possible to have ring systems which span more than one molecule.

Examples:
ringsystem mols \$ehandle 1
ringsystem mols \$ehandle 1 [list heterocycle aroring]
The first example returns the labels of all molecules the ring system is a part of. The second example filters the molecules - only molecules which contain heteroaromatic rings are reported. The ring filter is applied to the molecule because this is the return object, not the ring, so this filter does not require the ring the command was issued for to be in that class.

## ringsystem new

ringsystem new ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ringsystem get command. The difference between ringsystem get and ringsystem new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## ringsystem nget

ringsystem nget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ringsystem get command. The difference between ringsystem get and ringsystem nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## ringsystem pis

ringsystem pis ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\pi$ systems the ring system overlaps with. This is explained in more detail in the section about object cross-references.

Examples:
ringsystem pis \$ehandle 1
$\pi$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use p or d orbitals, such as in standard covalent multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## ringsystem rings

ringsystem rings ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the ring system the ring is a member of. This is explained in more detail in the section about object cross-references.

## Examples:

```
ringsystem rings $ehandle 1
```

ringsystem rings \$ehandle 1 [list heterocycle aroring]
The first example returns the labels of the rings which are contained in the ring system. The second example filters the ring system - a ring label is obtained only if that ring system contains one or more heteroaromatic rings. These filters are applied to the individual rings in the ring system, not the command ringsystem.

## ringsystem ringsystem

ringsystem ringsystem ehandle label
Standard cross-referencing command to obtain the label of the ring. This is explained in more detail in the section about object cross-references.

Example:
ringsystem ringsystem \$ehandle \#0
returns the label of the first ring system of the ensemble ring system list.

## ringsystem set

ringsystem set ehandle label property value ?property value?..

Standard data manipulation command. It is explained in more detail in the section about setting property data.

Example:
ringsystem set \$ehandle 1 Y_NAME "The central pharmacophore"
ringsystem show
ringsystem show ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ringsystem get command. The difference between ringsystem get and ringsystem show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, ringsystem get and ringsystem show are equivalent.

## ringsystem sigmas

ringsystem sigmas ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\sigma$ systems the ring system overlaps with. This is explained in more detail in the section about object cross-references.

Examples:
ringsystem sigmas \$ehandle 1
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## ringsystem sqldget

ringsystem sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ringsystem get command. The differences between ringsystem get and ringsystem sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## ringsystem sqlget

ringsystem sqlget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ringsystem get command. The difference between ringsystem get and ringsystem sqlget is that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## ringsystem sqlnew

ringsystem sqlnew ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ringsystem get command. The differences between ringsystem get and ringsystem sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## ringsystem sqlshow

ringsystem sqlshow ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the ringsystem get command. The differences between ringsystem get and ringsystem sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## ringsystem subcommands

ringsystem subcommands
Lists all subcommands of the ringsystem command. Note that this command does not require an ensemble handle, or a label.

## ringsystem surfaces

ringsystem surfaces ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of surface patches the ring system is associated with. This is explained in more detail in the section about object cross-references.

## Example:

ringsystem surfaces \$ehandle \$label
Note that surface patches do not need to be associated with an atom, and if they are not, they are implicitly not associated with any ring system.

## The sigma command

The sigma command is the generic command used to manipulate sigma systems. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

Sigma properties begin with an $\mathrm{S}_{-}$,
Pseudo sigma system labels first, last and random are special values, which select the first sigma system in the sigma system list, the last, or a random item.

This is the list of officially supported subcommands:

```
sigma append
sigma append ehandle label property value ?property value?..
```

Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

## sigma atoms

sigma atoms ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the atoms in the $\sigma$ system. This is explained in more detail in the section about object cross-references.

## sigma bonds

sigma bonds ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the bonds between the atoms associated with a $\sigma$ system. This is explained in more detail in the section about object cross-references.

## sigma create

sigma create ehandle ?atom?...
Define a new $\sigma$ system from an atom set, which may be empty. A new system is always created, even if one with the same atoms already exists. Adding a new system invalidates properties which are sensitive to sigma set changes.

The command returns the label of the new $\sigma$ system.

## sigma defined

```
sigma defined ehandle label property
```

This command checks whether a property is defined for the $\sigma$ system. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

## sigma delete

sigma delete ehandle ?label?...
sigma delete ehandle all
This command deletes specific or all $\sigma$ systems from the ensemble. A sigma property invalidation event is generated and thus the command may indirectly change the ensemble data.

The command returns the number of deleted items.

## sigma dget

sigma dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the sigma get command. The difference between sigma get and sigma dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and returns that default if the data is not yet available. For data already present, sigma get and sigma dget are equivalent.

## sigma exists

sigma exists ehandle label ?filterlist?
Check whether this $\sigma$ system exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the system does not exist, or fails the filter, and 1 in case of successful testing.
sigma expr
sigma expr ehandle label expression
Compute a standard SQL-style property expression for the $\sigma$ system. This is explained in detail in the chapter on property expressions.

## sigma fill

sigma fill ehandle label property value ?property value?...
Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

## sigma filter

sigma filter ehandle label filterlist
Check whether a $\sigma$ system passes a filter list. The return value is 1 for success and 0 for failure.

## sigma get

sigma get ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.
sigma groups
sigma groups ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the groups the $\sigma$ system overlaps with. This is explained in more detail in the section about object cross-references. An overlap between a $\sigma$ system and a group is established when there are common atoms which are contained in both objects.

Example:
sigma groups \$ehandle 1
sigma index
sigma index ehandle label
Get the index of the $\sigma$ system. The index is the position in the sigma set of the ensemble. The first position is index 0 .

Example:
sigma index \$ehandle 99
sigma local
sigma local ehandle label propertylist ?filterset? ?parameters?
Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

## sigma mol

sigma mol ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the label of the molecule a $\sigma$ system is part of. This is explained in more detail in the section about object cross-references.

## sigma new

sigma new ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

The difference between sigma get and sigma new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## sigma nget

sigma nget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the sigma get command. The difference between sigma get and sigma nget is that the latter always returns numeric data, even if symbolic names for the values are available.
sigma pis
sigma pis ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\pi$ systems the $\sigma$ system overlaps with. This is explained in more detail in the section about object cross-references.

Examples:
sigma pis \$ehandle 1

```
sigma rings
sigma rings ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the rings the $\sigma$ system is associated with. This is explained in more detail in the section about object cross-references. Rings which only partially overlap with the sigma system are included.

## sigma ringsystems

sigma ringsystems ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the ring systems the $\sigma$ system overlaps with. This is explained in more detail in the section about object cross-references.

```
sigma set
sigma set ehandle label property value ?property value?..
```

Standard data manipulation command. It is explained in more detail in the section about setting property data.
sigma show
sigma show ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the sigma get command. The difference between sigma get and sigma show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, sigma get and sigma show are equivalent.

## sigma sigma

sigma sigma ehandle label
Standard cross-referencing command to obtain the label of the $\sigma$ system as stored in property S_LABEL. This is explained in more detail in the section about object cross-references.

Example:
sigma sigma \$ehandle \#0
returns the label of the first $\sigma$ system of the ensemble sigma set.

## sigma sqldget

sigma sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the sigma get command. The differences between sigma get and sigma sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## sigma sqlget

sigma sqlget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the sigma get command. The difference between sigma get and sigma sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## sigma sqlnew

sigma sqlnew ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the sigma get command. The differences between sigma get and sigma sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## sigma sqlshow

sigma sqlshow ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the sigma get command. The differences between sigma get and sigma sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## sigma subcommands

sigma subcommands
Lists all subcommands of the sigma command. Note that this command does not require an ensemble handle, nor a label.

## sigma surfaces

sigma surfaces ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the surface patches the sigma system is associated with. This is explained in more detail in the section about object cross-references.

## The surface command

The surface command is the generic command used to manipulate surface patches. The syntax of this command follows the standard schema of command/subcommand/majorhandle/minorlabel.

Surface properties begin with an $O_{-}$, not $S_{-}$(which is reserved for sigma systems). The mnemonic behind this is that these are Oberfläche properties (German for surface).

Pseudo surface system labels first, last and random are special values, which select the first surface patch in the surface patch list, the last, or a random patch.

Examples:

```
surface get $ehandle 1 O_COLOR
```

This is the list of officially supported subcommands:

## surface append

```
surface append ehandle label property value ?property value?..
```

Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:

```
surface append $ehandle 1 O_ID "_accessible"
surface atoms
surface atoms ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the atoms in the surface patch. This is explained in more detail in the section about object cross-references. Note that patches may not be associated with any atom.

Example:
surface atoms \$ehandle 1 carbon
returns the labels of the carbon atoms associated with the patch.

```
surface bonds
surface bonds ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the bonds between the atoms associated with a patch. This is explained in more detail in the section about object cross-references. In many cases, patches are associated with one or no atom. In that case, there are no bonds to retrieve.

Examples:

```
surface bonds $ehandle 1
surface bonds $ehandle 1 {1 doublebond triplebond} count
```

The first example returns all labels of the bonds between the atoms in patch one. The second example returns the number of double or triple bonds between the atoms in the patch.

## surface create

surface create ehandle ?atom?...

Define a new surface patch from an atom set, which may be empty. A new patch is always created, even if one with the same atoms already exists. Adding a new patch invalidates properties which are sensitive to patch set changes.

The command returns the label of the new patch.

## surface defined

surface defined ehandle label property
This command checks whether a property is defined for the surface patch. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The ens valid command is used for this purpose.

## surface delete

surface delete ehandle ?label?...
This command removes surface patches from the ensemble patch set. A surface property invalidation event is generated and thus the command may indirectly change the ensemble data.

The command returns the number of deleted items.

## surface dget

surface dget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the surface get command. The difference between surface get and surface dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and returns that default if the data is not yet available. For data already present, surface get and surface dget are equivalent.

## surface exists

surface exists ehandle label ?filterlist?
Check whether this patch exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the patch does not exist, or fails the filter, and 1 in case of successful testing.

Example:
surface exists \$ehandle 99
surface expr
surface expr ehandle label expression
Compute a standard SQL-style property expression for the surface patch. This is explained in detail in the chapter on property expressions.
surface fill
surface fill ehandle label property value ?property value?...

Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

## surface filter

surface filter ehandle label filterlist
Check whether a surface patch passes a filter list. The return value is 1 for success and 0 for failure.
Example:
surface filter \$ehandle 1 [list carbon doublebond]
checks whether patch is associated with one or more carbon atoms and one or more double bonds. The double bond does not need to contain a carbon atom.

## surface get

surface get ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

## surface groups

surface groups ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the groups the surface patch overlaps with. This is explained in more detail in the section about object cross-references. An overlap between a surface patch and a group is established when there are common atoms which are contained in both objects.

Example:
surface groups \$ehandle 1

## surface index

surface index ehandle label
Get the index of the surface patch. The index is the position in the patch set of the ensemble. The first position is index 0 .

Example:
surface index \$ehandle 99
surface local
surface local ehandle label propertylist ?filterset? ?parameters?
Standard data manipulation command for reading and recalculating object data. It is explained in more detail in the section about retrieving property data.

## surface mols

surface mols ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the molecules a patch is contained in. This is explained in more detail in the section about object cross-references. It is possible to have
patches which span more than one molecule. Patches which are not associated with any atom also have no molecule association.

## surface new

surface new ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

The difference between surface get and surface new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## surface nget

surface nget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the surface get command. The difference between surface get and surface nget is that the latter always returns numeric data, even if symbolic names for the values are available.
surface pis
surface pis ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the $\pi$ systems the surface patch overlaps with. This is explained in more detail in the section about object cross-references.

Examples:
surface pis \$ehandle 1

## surface rings

surface rings ehandle label ?filterset? ?filtermode?
Standard cross-referencing command to obtain the labels of the rings the surface patch is associated with. This is explained in more detail in the section about object cross-references. Rings which only partially overlap with the patch are included.

## Examples:

```
surface rings $ehandle 1
surface rings $ehandle 1 [list heterocycle aroring]
```

The first example returns the labels of all rings the patch overlaps with. If the patch does not overlap with any ring, an empty list is returned. Only labels of rings in the SSSR or ESSSR set are returned, even if the currently computed ring set is larger. The second example filters the rings - only heteroaromatic rings are reported.

## surface ringsystems

```
surface ringsystems ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the ringsystems the surface patch overlaps with. This is explained in more detail in the section about object cross-references.

Examples:
surface ringsystems \$ehandle 1
surface set
surface set ehandle label property value ?property value?..
Standard data manipulation command. It is explained in more detail in the section about setting property data.

## surface show

surface show ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the surface get command. The difference between surface get and surface show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, surface get and surface show are equivalent.

```
surface sigmas
surface sigmas ehandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the $\sigma$ systems the surface patch overlaps with. This is explained in more detail in the section about object cross-references.

Examples:
surface sigmas \$ehandle 1
$\sigma$ systems are a rather exotic feature and not commonly used. These are essentially descriptions of bonding interactions which use s orbitals, such as normal, covalent single bonds, or the central bond in multiple bonds. A simple double bond is described with one $\sigma$ system and one $\pi$ system in this representation.

## surface sqldget

surface sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the surface get command. The differences between surface get and surface sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## surface sqlget

surface sqlget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.
 sqlget is that the SQL command variant formats the data as SQL values rather than for Tcl script processing.

## surface sqlnew

surface sqlnew ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the surface get command. The differences between surface get and surface sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## surface sqlshow

surface sqlshow ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the surface get command. The differences between surface get and surface sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## surface subcommands

surface subcommands
Lists all subcommands of the surface command. Note that this command does not require an ensemble handle, nor a label.

## surface surface

surface surface ehandle label
Standard cross-referencing command to obtain the label of the surface patch as stored in property O_LABEL. This is explained in more detail in the section about object cross-references.

## Example:

surface surface \$ehandle \#0
returns the label of the first surface patch of the ensemble patch set.

## The table Command

The table command is the generic command used to manipulate Cactvs table objects. The syntax of this command follows the standard schema of command/subcommand/tablehandle/args. Table objects are major objects just like ensembles, reactions or datasets and have, in addition to object-specific commands, the standard command set for major objects and can possess table-level properties, which start by convention with prefix $T_{-}$. Example:
table get \$thandle T_XYPLOT
Because tables are pure major objects without an internal set of minor objects, there are no minor object labels. Nevertheless, there are mechanisms to address columns, rows and cells. Commands which address rows or columns use a syntax schema of command/subcommand/tablehandle/address/args.

Depending on the context, column and row arguments to table commands can be either single addresses, or address ranges. Single addresses are identified either by a numerical row or column index starting with zero, the magic names end or last, or a symbolic name which is was assigned to the row or column at some time during its existence. Columns can have additional alias names. Examples:

```
table getcol $thandle last datatype
```

table getcol \$thandle 0 data

Address ranges are specified by two simple addresses, separated by a dash character. These ranges can also be open, meaning that if there is no name component to the left of the dash, start column or row zero is implied, and if there is no name component to the right of the dash, the rightmost column or bottommost row is the end of the range. When a column or row range without any range dashes is specified, the range only includes that single item. Finally, the magic names all or * select all current columns or rows. Examples:

```
table delrow $thandle 3-last
table dupcol $thandle E_NAME end
```

Table objects can store output formatting information in different places - globally, on columns, rows and individual cells. The precedence for these formats is cell $>$ row $>$ column $>$ global. The fonts, font sizes and colors, for which there can only be one value, that are used for the output of a specific cell are determined by the location with the highest precedence where the attribute is set to a definite value (i.e. in the case of fonts, the location where a font name and not an empty string is provided). General formatting flags are bit-ored from all locations. There is currently no method to suppress the use of a formatting flag on output which is set in any checked location. Example:

```
table setcol $thandle 0 bgcolor white
table setrow $thandle 1 bgcolor red
```

All cells in row one are output with a red background, provided that there are no cell-level overrides, and that the output format supports cell coloring.

Tables possess an internal utility dataset. Its handle can be retrieved with

```
table get $thandle dataset
```

This internal dataset is useful to store objects which are referenced by rows. Normally, these referenced objects which are introduced by command such as table addens or table addreaction are not destroyed when the table is deleted. However, when they are moved into the internal dataset, are will be deleted with the table, just like other objects in a dataset object when that dataset object
is destroyed. In case of table file formats which store both table cell data and structure or reaction objects, the associated objects are moved to the internal dataset when such a file is read.

This is the list of officially supported subcommands:

## table addcol

table addcol tablehandle columntype ?property|datatype|expression? \} ?name? ?position? ?width?

This command adds a new column to the table. All data values for the new column in existing rows are initially set to NULL, with the exception of function columns, which are set to the computed value as far as that is possible from the current table content.

The column type argument can be one of:

- data

A data column with cells of a specific data type which is not associated with a Cactvs property, or where the property association is unknown. If no data type is supplied in the next argument, the default is double.

- function

A data column with cells which contain dynamically computed values. The next argument is the SQL-style function expression. If that argument is not provided, the function result for the cell values will always be NULL. formula is an alias column type name for this type.

- image

Add an structure or reaction image column. This is a special type of property column. The property behind this column is dynamically adapted according to chosen output formats. For example, it is E_Gif for HTML pages, e_emf_image for Windows Excel, and e_pict_IMAGe for Mac Excel output. For this column type, the next optional argument is immediately the column name, not the detail type specification.

- none

An unspecified column. Useful as place holder in case this is defined later, or to add spacer columns. For this column type, the next optional argument is immediately the column name, not the detail type specification.

- property

A data column with cell values which are linked to a Cactvs property. The fundamental data type, as well as enumeration values, formatting conventions etc. are all inherited from the property definition. If the property name is not supplied in the next argument, the default is property E_NAME. Property-associated columns are especially useful for automatic transfer of chemical object data into a table by means of the table addens and table addreaction commands.

The content of the argument of the column type specification must be appropriate to the previous argument, i.e. a data type for columns of type data, a property name for columns of type property, or a parseable SQL expression for columns of type function.

For data and property type columns, the column type may also be omitted and the property or data type name written immediately. These two lines are equivalent:

```
table addcol $thandle property E XLOGP2 xlogp
table addcol $thandle E_XLOGP2 xlogp
```

Columns can be given a user-defined name. If the optional name argument is not given, a synthetic name is automatically supplied. For property columns, it is the name of the property. For other columns, it is the column index appended to the column type, as in datal for a data column with column index one.

By default, columns are appended to the right. This is also done if the optional position argument is end, an empty string, of a column index beyond the current maximum column index. Otherwise, the column is inserted into the specified position and all other columns behind it are moved one position to the right. No columns are overwritten. Existing cell data is also moved if necessary. It is not possible to add a column to the right beyond the rightmost column in a way that undefined column slots result.

The final optional argument defines the column width, which is only used for output formatting. It is the same as the column attribute width and described in the paragraph on the table setcol command. If this argument is omitted, the width is undefined and defaults are used.

The return value of the command is the new number of columns in the table.

## table addrow

table addrow tablehandle ?name|\#auto? ?position? ?coldatalist?
Add a row to an existing table. By default, all cell data values of the newly added row are set to NULL.
Table rows can be named. If the name argument is omitted, set to an empty string, or \#auto is used as magic name, the standard automatically generated row name, of the form \#rowcount, is used, with the row count replaced by the integer value. Note that this name uses the total row count of the table after adding the new row, not the insert position. This makes it less likely to accidentally generate duplicate row names if multiple rows are inserted into the same position.

By default, the new row is appended to bottom of the table. This also happens if the optional position argument is end, or larger than the current maximum row index, which starts with zero. If any other valid row index is given, the new row is inserted into that position and the rest of the rows behind it are moved. No existing rows are overwritten. It is not possible to add a row beyond the current end of the table in such a fashion that undefined rows result.

Finally, it is possible to initialize the cell values of the new row. If that option is chosen, the length of the column data list must be the same as the number of columns in the table, and every column data value must be decodable according to the respective column data type.

If data is extracted from chemical objects and stored in a table object, it is usually more convenient to use the table addens and table addreaction commands than to script sequences of table addrow statements.

The table must be editable for this command to be usable.
The return value of the command is the new number of rows in the table.

## table adddataset

table adddataset tablehandle datasethandlelist ?objclass? ?filterlist? ?position? ?mode?

This command performs a table addens command for each ensemble in the datasets, and a table addreaction command for each reaction. The command arguments are interpreted as described in each specialized command, and have the same defaults if they are not set explicitly.

If a dataset contains other objects besides ensembles and reactions, these objects are ignored in the table data setting operation. If the mode is set to destroy, not only the ensembles or reactions in the dataset are deleted, but the complete dataset with all its content, including other objects which are not reactions or ensembles. With mode move, ensembles and reactions are removed from the source dataset and transferred to the internal table dataset. In this mode, other dataset content objects that are not reactions or ensembles remain in the source dataset, and the dataset is preserved.

The command returns the number of added table rows.

## table addens

table addens tablehandle enslist ?objclass? ?filterlist? ?position? ?mode?
Capture data from a list of ensembles in a table object. One or more new rows are added, and all table columns for these rows which refer to property data present or computable on the ensemble are filled. In addition, references between the new rows and the ensemble are registered.

The object class determines how many rows are added per ensemble. It can be ens, or the type of any ensemble minor object. One row is added for each ensemble minor object (or the ensemble proper, in case the attachment type is ens), provided it passes the filters if a filter list is specified. If the object class argument is not specified, or given as an empty string or the special value auto or \#auto, an attempt is made to determine it automatically. If only data columns of ensemble properties are found, it is then set to ens, but if there are any data columns of properties related to ensemble minor objects except molecules, the object class is that class. If there are only molecule and ensemble properties, the class is mol . For each object of the selected class in the ensemble, one row is added, and the cells filled with the data extracted from the associated ensemble or ensemble minor object.

For example, assume the object class is atom; let there be table data columns of atom, molecule, and ensemble properties; and let there be four atoms and two molecules in an ensemble to be processed. In that case, total of four rows are added, with the ensemble property data cells holding the same data for all four rows, and the molecule property data cells holding two duplicates for two rows each, and every atom data cell the data of one of the four different atoms. As long as all minor objects for which a row is added (with the exception of molecules) are completely contained in exactly one larger object of the involved classes, property types can be freely combined. For example, atom properties and molecule or ensemble properties mix, because every atom is only a member of one molecule and one ensemble. However, the results from combining atom and bond or ring properties are, while still deterministic, probably not useful for any real application. The same is true for a mismatch of the column properties and an explicit object class, i.e. combining atom properties with a bond object class is not likely to be useful.

If the filter list argument is specified, rows are only added for the objects which pass the filter. Those which do not pass the filter are silently skipped. The type of filters which are suitable are usually determined by the selected object class. For example, if a row is added for each atom, atom filters are certainly useful. However, more exotic combinations are possible - for example, atom filters may be used in combination with a mol object class - in that case only data rows for molecules in which one or more atoms pass the filter are added.

Only cells in property and function columns are populated with values by this command. Any cells in pure-data columns without a property descriptor are set to NULL.

By default, the new row or rows are added at the bottom of the table. If desired, a different row index may be given, with index zero resulting in the insertion of the first new row as the first table row, and any additional new rows immediately behind it. The special position end may be used to explicitly append to the table.

By default, the ensemble objects providing the data are preserved. The optional mode argument can be set to change their fate. Its possible values are preserve (the default), delete (the ensembles are destroyed after setting the table row data) and move (the ensembles are moved to the internal dataset object of the table). In mode delete, the relationship between rows and the ensemble is not preserved, because the ensemble is gone after the row addition.

The command returns the number of added table rows.
Example:
table addens \$th \$eh
table addfile
table addfile tablehandle molfilehandlelist/filenamelist ?objclass? ?filterlist? ?position? ?mode?
This command performs the equivalent of a table addens or table addreaction command for every ensemble or reaction which can be read from the structure file handles. The type of object read from the file, in case there are multiple possibilities, is determined by the configuration of the file handle. Please refer to the section on the table addens and addreaction commands for additional explanations. The command arguments after the file handles are interpreted as in these commands.

Input starts from the current file position of every specified file handle. The command fails if any file cannot be read to the end. The files are positioned at eor after a successful operation.

If a file handle list argument is not a molfile object handle, an attempt is made to interpret it as the name of a structure or reaction data file. If such a file exists, is readable, and of a recognized file format, it is transiently opened in read-only mode with default settings and automatically closed when the command completes. This is equivalent to the handling of transient files in the molfile command.

Different from the table adddataset/addens/addreaction commands, the default object addition mode of this command is delete. In this mode, the read ensemble or reaction objects are deleted after the table cells have been filled from the current object, so there is no persistent table row association with a structure object. In mode preserve, the ensembles remain in memory, and in mode move, they are also kept, but moved to the internal table dataset. The latter two modes can of course greatly increase the memory requirements, so these modes should not be used indiscriminately.

The command returns the total number of added table rows.

## table addreaction

table addreaction tablehandle reactionhandlelist ?objclass? ?filterlist? ?position? ?mode?

Capture data from one or more reactions in a table object. One or more new rows are added, and all table columns for these rows which refer to property data present or computable on the reactions are filled. In addition, a reference is created between the new table rows and the reactions, or, with an ens object class, the reaction ensembles.

If the object class is reaction, a single row is added per reaction and reaction-level property data is copied. Alternatively, it may be specified as ens, which is equivalent to the execution of one table addens command for every reaction ensemble. If this argument is not specified explicitly, or given as an empty string or the special value auto or \#auto, it is automatically determined from the column types present. If any data columns are reaction properties, the object class is set to reaction, otherwise ens.

If the filter list argument is specified, only reactions or ensembles which pass the filter are added. Those which do not pass the filter are silently skipped.

By default, the new row or rows are added at the bottom of the table. If desired, a different row index may be specified, with index zero resulting in the insertion of the first new row as the first table row, and any additional new rows immediately behind it. The special position end may be used to explicitly append to the table.

By default, the reaction objects are preserved. The optional mode argument can be set to change their fates. Its possible values are preserve (the default), delete (the reactions and all their ensembles are destroyed after setting the table row data) and move (the reactions are moved to the internal dataset object of the table). In mode delete, the relationship between rows and the reaction or reaction ensembles is not preserved, since the reaction is gone after the command.

The command returns the number of added table rows.

## table append

table append tablehandle property value ?property value?..
Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

Example:
table append \$ehandle T_COMMENT "\nI still do not think this data makes sense!"
table assign
table assign tablehandle srcprop dstprop
Copy data from one property to another. Both properties must be associated with the same object class. The source property (but currently not the destination property) may be specified as an indexed property subfield. There must be a conversion path between the data types of the two properties or property subfields involved for the operation to succeed. For example, assigning a string property to a numeric property succeeds only if the string data items contain suitable numbers.

The original property data remains valid. The command variant table rename directly exchanges the property name without any data duplication or conversion, if that is possible. In any case, the original property data is no longer present after the execution of this command variant.

## Examples

table assign \$th T_IDENT T_NAME

## table blockloop

table blockloop tablehandle blockcolumn rowvariable ?maxblocks? ?offset? body
This command is a convenience function for looping over the contents of a table. It is a more complex version of the table loop command. It works on blocks of rows which have the same value in a column instead of a single row.

The contents of one or more rows are stored as a nested list in the global TcL row variable. The inner objects are either lists that contain one cell data element per table column (with a list table iterator) or dictionaries with column names as keys. In each iteration, after the variable has been updated, the Tcl code in the body argument is executed. The standard TcL loop control constructs break and continue work as expected within the loop. The iteratorstyle table attribute controls the formatting of the elements of the outer list. The default iterator mode is list.

The length of the nested list in the variable is determined by the number of consecutive rows which have the same value in the data cell of the block column as the current row. The next iteration of the loop continues with the first row which has a value in the block column data cell that is different from the current value. Note that this command does not sort the table. If the same block column cell value appears in rows which are not consecutive, multiple blocks are processed with the same value. If the block column is an empty string, or the special row name \#name, the block membership is determined by the row name.

By default, the iteration continues until the end of the table, but an upper limit may be specified in the optional maxblocks parameter. If this parameter is explicitly set to a negative value, the loop runs to the end of the table. The default starting point of the loop is the first row. This can be changed by giving an explicit offset in the second optional parameter.

## Example:

```
table cluster $thandle E_SCREENING_RESULT jarvispatrick {colname clusters}
table sort $thandle clusters
table blockloop $thandle clusters rowvar {
    foreach row $rowvar {
        lassign $row cpdname clusterid
    }
}
```

The loop is executed once per cluster with the variable set to the row data block of all structures in that cluster.

The return value of the command is the number of loop iterations processed. The last value of the loop variable remains accessible outside the loop.

The commands table dictblockloop and table listblockloop are variants of this command which ignore the configured iterator style attribute of the table.
table cast

```
table cast tablehandle dataset/ens/reaction/table ?propertylist?
```

Transform the table into a different object. With the exception of the table target object class, which does nothing, the table is destroyed in the process. Depending on the target object class, the result is as follows:

- dataset

A new dataset which contains all the reaction and ensemble objects associated with the table rows, without duplicates. Rows without an ensemble or reaction association generate a new empty ensemble. The property set of the objects in the new dataset is automatically augmented with the data of the associated table row.

- ens

The ensemble associated with the first table row, or an empty ensemble if no such association exists. The ensemble property set is automatically augmented with the row data.

- reaction

The reaction associated with the first table row, or an empty reaction if no such association exists. The reaction property set is automatically augmented with the row data.

- table

Only supported for the sake of completeness, this mode does nothing.
If the optional property list is specified, an attempt is made to compute the listed properties before the cast operation, so that they may become a part of the new object. No error is raised if a computation fails.

The command returns the handle of the new object, or the input object in case of mode table.

## table celldata

table celldata tablehandle row column ?value? ?flags?
In the simple form without the optional flags argument, this command is essentially a shortcut for the table setcell and table getcell commands with the value attribute.

If the flags argument is used, setting of the cell data can be modified. The flags argument can be one or more of the following words:

- append

The data is appended to the current cell data, if the data type of the cell supports the concept of appending. The default is to replace it.

- clear

Set the cell to a null value. The value argument is ignored.

- force

Override any editing locks on the table, column, row or cell.

- recall

Return the old value of the cell before the update as command result.

- recallnew

Return the new value of the cell after the update. Because of the formatting implied by, for example, columns which hold property values and where the property definition contains enumerations, constraints, precision limits, etc., this may not be exactly the value argument which is input.

- settime

Set the update time stamp on the table. By default, this is not done due to its inherently expensive character because it needs to issue a system call.

## table clear

table clear tablehandle
Reset a table. All rows and columns as well as table-level property data are removed, and user-configurable attributes are reset to default values. However, the table handle remains valid and can be re-used to set up a new table.

The table needs to be editable to allow this command to succeed.
The command returns the table handle.

## table clone

```
table clone srctablehandle ?dsttablehandle? ?columnrangelist?
```

Copy the table definition from the source to another table. If a destination table is specified, all cells, rows and columns of the destination table are deleted before the information is copied from the source.

If the destination handle is omitted, or specified as an empty string, or the special names new or \#auto are used, a new table is created and the command has a similar effect as table dup.

The optional column range list argument can be used to copy only some of the columns. By default, all columns are copied.

This command is similar to table copy, except that no row and cell data is copied. The destination table has the same column layout and other global attributes of the source table, but now rows or cells.

The command returns the handle of the destination table, which may just have been created.

## table cluster

table cluster tablehandle columnrangelist method ?parameterlist?
Perform clustering on table data and add the clustering results as an additional table column. The currently supported methods are kmeans, fuzzykmeans, centroid, ward and jarvispatrick. The optional parameter list argument is a standard keyword/value dictionary. Currently the following parameters are recognized:

- colname

The name of the newly added result column. If it is not set, or set to an empty string, the default name is cluster.

- epsilon

The epsilon value, i.e. the minimum total value the cluster centroids need to have moved as result of the last iteration to start another iteration cycle. Only used in fuzzy KMeans clustering, where the default value is 0.001 . If the total movement of the centroids is less than that, the iteration is stopped immediately.

- exponent

The exponent used in the distance law to compute the location of the cluster centroids. Only used in fuzzy KMeans clustering, where the default is 1.5 .

- maxncycles

The maximum number of iteration cycles. Only used in normal and fuzzy KMeans clustering. If the cluster membership does not change during a cycle in normal KMeans clustering, or the total movements of the cluster centroids is less than the epsilon value in fuzzy KMeans clustering, iteration is stopped early even if the maximum number of iterations has not yet been reached.

- ncluster

The number of clusters to find. Used in normal and fuzzy KMeans clustering and for the Centroid and Ward methods. Jarvis-Patrick clustering determines the number of clusters algorithmically.

- ncommon

The minimum number of elements needed to be in common among the number of examined closest neighbor points for joint cluster membership. Only used in Jarvis-Patrick clustering. This value must be less than or equal to the nexamine parameter. The default value is one.

- nexamine

The number of closest neighbor points to examine for being in the joint neighborhood of two points which could potentially be in the same cluster. Only used in Jarvis-Patrick clustering. The default value is two.

- nsteps

The number of merge steps. Only used in the Centroid and Ward methods. The default value is the minimum of 5 and the number of eligible rows.

- position

The column position where the result column is inserted. It can be either a numerical index, or the special name end for addition to the right of the current columns. which is the default.

The data type of the result column depends on the selected clustering method:

- centroid

The result column is an integer vector with a length equal to the number of merge steps plus one. Initially, and this is recorded in vector element zero, every eligible row is in its own cluster, so all cluster IDs in the range from one to nrows are used. After each merge step, a new vector index is filled for all rows. All values are the same as that of the previous index, except that the cluster ID of the cluster with the higher value of the merged pair is withdrawn and its value replaced by the ID of the other cluster in all rows in the absorbed cluster. If a full merge is performed, all rows will end up as members of cluster one. Rows which are not eligible for clustering retain a cluster number of zero during all merge steps. The merge distances for all steps are stored in a double vector as column header data.

- fuzzykmeans

The result column is a double vector, with the number of elements equal to the requested cluster number (ncluster parameter). Every element holds the fractional membership value for that cluster.

- jarvispatrick

The result column is of type simple integer. It holds the number of the cluster the row is a member of. Cluster numbers begin with one. In case the row data is NULL or otherwise excluded from clustering, it is set to zero.

## - kmeans

The result column is of type simple integer. It holds the number of the cluster the row is a member of. Cluster numbers begin with one. In case the row data is null or otherwise excluded from clustering, it is set to zero.

- ward

The result data format is the same as for the centroid method.
Data columns which are used as input data must be convertible into floating-point values. Multiple columns may be used in parallel, but it is the responsibility of the script writer to perform any scaling and other data preparation steps.

The return value is the number of clusters found, after the last iteration or merge step, if applicable.

## table compare

table compare tablehandle1 tablehandle2 ?rowmode? ?comparisoncolumn?
This command is a dry-run version of the table merge command. Instead of actually modifying the first table, this command sets the selected row attribute on both tables to indicate which rows from both tables would be present in a new combined table.

The meaning of the parameters are the same as in the table merge command.

## table copy

table copy srctablehandle ?dsttablehandle? ?columnrangelist?
Copy the table definition and table cell data to another table. If a destination table is specified, all cells, rows and columns of the destination table are deleted before the information is copied from the source.

If the destination handle is omitted, or specified as an empty string, or the special names new or \#auto are used, a new table is created and the command has a similar effect as table dup.

The optional column range list argument can be used to copy only some of the columns. By default, all columns are copied.

A related command is table clone, which also adjusts the column definitions and other attributes of the destination table to match that of the source, but does not transfer row and cell data.

The command returns the handle of the destination table, which may just have been created.

## table create

```
table create packstring|aid
table create ?property|image|none|enshandle|reactionhandle|datasethandle|
molfilehandle|tablehandle?..
```

Create a new table. The return value of the command is the new table handle.
The first variant of the command generates a fully initialized table with row and column specifications, cell data and potentially table properties. The single argument can either be a serialized packed table string (see table pack command), or a PubChem assay identifier (AID). AIDs are simple integers, or integers prefixed with $A I D$. For these, the full assay content is downloaded from PubChem. Depending on the size of the assay, this can take a minute or more.

## Example:

```
set th [table create 67]
```

The second variant initially creates an empty table. By supplying additional arguments, one or more columns can be specified in a single statement, and/or ensemble and reaction data added to the specified columns. These are shorthand notations for table addcol or table
addens/addreaction/adddataset/addfile commands. Optional arguments that are a property name, or the special names image or none are equivalent to

```
table addcol $thandle $arg
```

(one such statement per additional argument) and the chemistry object handle arguments are handled the same way as writing one or more of

```
table addens $thandle $arg
```

or
table addreaction \$thandle \$arg
If a table handle is used as an argument, its column structure and global table properties and attributes, but not its rows and cell data, are copied as with the table clone command.

The full command equivalents of the shortcuts offer more options for control of the row or column addition modes, so this abbreviated command variant is only used in simple cases. Ensemble or reaction handles as row data sources should be supplied after column type or table handle arguments, otherwise the cell data of these columns rows already existing when a column is added is set to NULL.

Example:

```
set th [table create E_NAME E_SMILES E_XLOGP2 E_WEIGHT image]
```


## table data

table data tablehandle ?rowrangelist? ?columnrangelist? ?nullvalue?
Extract cell data from a table as a nested Tcl list. By default, the full table content is returned. The optional parameters allow the selection of a specific subset of the rows and/or columns. The final optional parameter can be used to control the output format of NuLL data. If that parameter is omitted, the global style defined by the undefined table attribute (see table get/set) is used.

For historical reasons, the variant table print is an alternative name for this command.
Example:
set elements [lsort [table data table0 all symbol]]
This command retrieves an alphabetically sorted list of the atom symbols of the PSE.

## table dataset

table dataset tablehandle ?filterlist?
If the table is a member of a dataset, report the handle of the dataset object. If the table is not a member of a dataset, or does not pass all of the optional filters, an empty string is the result.

This command is different from table get thandle dataset. The latter retrieves the handle of the internal dataset which is an integral part of the table data structure.

## table defined

table defined tablehandle property
This command checks whether a property is defined for the table. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The table valid command is used for this purpose.

## table delcols

table delcols tablehandle ?columnrange?..
Delete a set of column ranges, including cell data under these columns, from the table. All selected columns are deleted in a single operation, so all column addresses refer to the original table, not those after deletion of column sets defined in arguments to the left in the same command.

The command may also be written as table delcol.
The return value is the number of deleted columns.

## table delete

table delete ?tablehandle?...
table delete all
Destroy one or more table objects. The special handle all can be used to remove all deletable tables. Tables with the undeletable status flag (see table set) are not affected. It is also not possible to delete the three system tables (element data, expansion fragments and SMILES macros). Finally, tables with a reference count of two or more, as they are produced by the definition of table slices, are also not deleted by this command. The referring slice tables need to be removed first before the underlying base table can be deleted.

Objects referenced by table rows, as introduced by table addens or table addreaction commands, are usually not deleted, except when they were put into the internal table dataset object.

The return value is the number of successfully deleted tables.

## table delrows

```
table delrows tablehandle ?rowrange?..
```

Delete a set of row ranges, including cell data in these rows, from the table. All selected rows are deleted in a single operation, so all row addresses refer to the original table, not those after deletion of rows sets defined in arguments to the left in the same command.

The return value is the number of deleted rows.
Example:
table delrows \$thandle all
table dget
table dget tablehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the table get command. The difference between table get and table dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, table get and table dget are equivalent.
table dictblockloop
table dictblockloop tablehandle rowvariable ?maxrows? ?offset? body
This command is a variant of the table blockloop command. It stores the row data as a dictionary in the loop variable, with the column names as keys. The value of the iterator style table attribute is ignored.

Please refer to the table blockloop command description for more information.

## table dictloop

table dictloop tablehandle rowvariable ?maxrows? ?offset? body
This command is a variant of the table loop command. It stores the row data as a dictionary in the loop variable, with the column names as keys. The value of the iterator style table attribute is ignored.

Please refer to the table loop command description for more information.

## table dup

```
table dup tablehandle ?rowrangelist? ?columnrangelist?
```

Duplicate a table. The return value is the handle of the duplicate. Only the table data content is duplicated, not any slices which refer to the duplicate, or any ensembles or reactions which hold a reference to the original table. However, these references to ensembles or reactions are copied to the new table, so that the objects refer to both tables simultaneously after the copying. System tables can be duplicated just as any other table.

By default, the full table content is duplicated. The optional parameters can be used to restrict duplication to a row and/or column subset.

This command does not follow the standard $d u p$ command syntax of other major objects. It is not possible to move the duplicate table directly into a dataset.

Example:

```
set thnew [table dup $th]
```

table dupcols
table dupcols tablehandle columnrange ?destination?
Duplicate one or more columns, including the cell data, within a table. If the destination, a simple column address, is not specified, the duplicated columns are inserted on the right of the table. The destination cannot be in the range of the source columns.

The command may also be written as table dupcol.
The return value is the new number of columns.

## table ens

table ens tablehandle
Return a list of the handles of all ensembles which are referenced by the table. Every ensemble is reported only once, even if it is referenced by multiple rows. Rows with ensemble references are usually added to tables my means of the table addens command. In case a row has no ensemble reference, it is ignored, and no output is produced.

## table exists

table exists tablehandle ?filterlist?
A boolean check whether the table identified by the handle argument currently exists. Additionally, a filter list can be specified. The table is then reported only as existing if it also passes the filters.

## table export

table export tablehandle ?host:?port/stdout ?exportflags?
Perform an RPC stream table data export via a specified socket connection number, or standard output. In contrast to the same functionality invoked by setting the export table export attribute (see table set/get), the data transfer started by this command is synchronous, and the command only returns when the table content has been fully transmitted.

The optional export flags argument is the same as for the table set/get command and has the same possible values and effects, except that the export flags are not permanently set as table attributes. The old flag setting is restored when the command finishes.

For tables that are registered KNIME output tables (e.g. one of the maximum of three tables in global control variables : :cactvs (knime_output[123]_table) the host/port or standard output parameter may be omitted. These tables are then exported via their pre-configured channels. If they were configured for background stream export, the command starts an export thread and returns immediately instead of executing the normal synchronous transmission.
table expr
table expr tablehandle expression
Compute a standard SQL-style property expression for the table. This is explained in detail in the chapter on property expressions.

## table fill

```
table fill tablehandle property value ?property value?...
```

Standard data manipulation command for setting data, ignoring possible mismatches between the lengths of the lists of objects associated with the property and the value list. It is explained in more detail in the section about setting property data.

Since tables do not possess minor objects and the length of table property data lists is always one, this command is present mainly for sake of compatibility with other major object commands.

## table find

table find tablehandle column|all operator value ?mode?

This command is very similar to the table select command. The difference is that this command stops the scan after the first matching row was found. Please refer to the section on that command for an explanation of the command arguments.

The command uses index information if the search operation allows it and a column index has been set. For large tables, this can make a big difference in search speed.

Example:
set r [table find \$thandle E_CID = 5]
The result is the row index of the matching row, or minus one if no such row was found.

## table flatten

table flatten tablehandle ?columnrange?
This operation simplifies the data types represented in the table. Сactvs table columns can hold any data type the toolkit knows to manage via its data handler modules, including for example vector types, which are generally beyond the scope of traditional table formats.

This command attempts to simplify column types to elementary types, such as strings and numerics. In order to do that, columns with complex data types are split up. For example, a float vector column is replaced by a range of float columns, which are inserted immediately to the right of the original column. The number of these columns is determined by the longest vector found in the data cells under the original column, but it is at least one. The names of the new columns are either set to the names of the property subfields (for example, for column data of type compound), or use the original column name with a bracketed suffix, for example E_XYEXTENT ( 0 ). The first suffix is either zero or one, depending on the setting of the offset table attribute (see table get). The original column with the complex data is deleted. For columns which are already of a simple type, or of a type which is not handled by the current implementation, the command does nothing.

Currently, this function is only implemented for standard vectors (integer and float type vectors, bitvectors, plain and Unicode string vectors) and the special data types compound, choice, intpair, floatpair and intquad. Other complex data types are not processed.

If no column range is specified, all table columns are processed. Table columns which are of an elementary data type are skipped.

The return value is the number of columns after the flattening operation.

## table get

table get tablehandle propertylist ?filterset? ?parameterlist?
table get tablehandle attribute
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For the use of the optional property parameter list and filter arguments, refer to the documentation of the ens get command.

In addition to retrieving property data, this command is also used to retrieve a large set of attribute values from the table object. Many of these attributes can also be set. Table objects have the following public attributes:

- affiliation

The institution the table author works for.

- author

The author of the table, as free-form string data.

- authorurl

A URL with information on the author, or an empty string if unset.

- bgcolor

The global table background color. If unset, an the result is an empty string.

- carbondisplaymode

The default mode for carbon atom rendering of embedded structure or reaction images. It can be either none (no symbols), special (special C atoms have symbols) or all (all carbon atoms are rendered with explicit symbols).

- category

A category string to be used if the table is stored in a repository.

- classuuid

The base class UUID of this table object

- colblocksize

Set the column block size. If this value is larger than one, the default, the layout of some table output formats is adjusted to use repeated blocks of data instead of a simple matrix. For non-rotated table output, a new row is only started after the set number of entries, each with their normal item column count, have been written, instead of starting a new row after each physical table row. For rotated layout, a new printed set of rows, each set comprising of a number of rows equivalent to the physical table columns, is already forced after the specified number of rows have been printed left to right, instead of printing all selected rows left to right. This formatting option is currently only supported for Excel $x l s$, HTML (table and page) and CDXML layout.

- collengths

The width of all columns as a list. Columns with undefined widths report minus one. This is a read-only attribute. Note that this attribute defines an object length (for example, a character count), not a formatting width, which is defined by the widths attribute.

- colnames

The names of all columns as a list. This is a read-only attribute.

- colproperties

A list of the properties of all table columns. If a column is not a property column, an empty string element is inserted. This is a read-only attribute. This attribute can also be addressed via its alias names colprops, props or properties.

- coltypes

The column types of all columns as a list. This is a read-only attribute.

- comment

A free-form comment string.

- coords

If the toolkit was compiled with factory support, these are the coordinates of the object icon on its workbench, encoded as integer pair. This attribute can be changed.

- dataset

A deprecated alternative name for the internaldataset attribute.

- datatypes

A list of all the data types of the table columns. This is a read-only attribute. This attribute can also be addressed via its alias coldatatypes.

- date

The date the table configuration was defined.

- deletable

Flag indicating whether the table can be deleted with a standard table delete command. This attribute is read-only. tables which are, for example, property data values or a part of a molfile loop command cannot be deleted by standard means.

- displaywidths

A list of the widths of all table columns. This is a read-only attribute. Table columns which have no explicit width contribute an empty string, not a negative or zero value. This is for compatibility with Tk widget configuration. Note that this is the formatting width, for example defined as pixel count or points, not an object length, such as a character count. The latter attribute can be queried by the collengths attribute. widths is an alias name for this attribute.

- doi

A digital object identifier for the table object content, if defined.

- editable

Boolean flag reporting whether the table is editable.

- email

A contact email of the author.

- embedfileformat

The output file format of embedded objects in the table. This applies for example to tables which are written as Excel or ExCEL XML, where associated structures may be written as CDX or SKC oLe objects. For table output in formats which do not support this kind of embedding, the attribute is ignored. If the attribute is set to an empty string, or none, embedding is disabled where applicable, i.e. embedded Excel XML structure images are plain WMF/EMF drawings, not ole objects. Otherwise, the attribute must be resolvable to a I/O module name for molfile objects (see filex command).

- ens

A list of all ensembles associated with the table rows. This is a read-only attribute. If a structure data column is associated with the table, an attempt is made to automatically instantiate the ensembles.

- ensrowcount

The number of rows which are associated with any ensemble. This is a read-only attribute. If a structure data column is associated with the table, an attempt is made to automatically instantiate the ensembles.

- ensrows

A list of the row indices of those rows which are associated with an ensemble. This is a read-only attribute. If a structure data column is associated with the table, an attempt is made to automatically instantiate the ensembles.

- eod

The value of the end-of-data marker. This attribute is typically used in multi-threaded applications to indicate that feeder threads have exhausted their data supplies and that no further table rows are expected to arrive. This attribute is internally used by the table pop and table wait commands to determine whether they should continue to wait or exit with an empty result. The initial value of this attribute is zero.

- eodcheck

Perform a check whether at least one row is in the table, or is expected to arrive later. If rows are currently in the table, or the eod attribute value is less than the targeteod attribute value, the command returns zero, otherwise one. This attribute is read-only.

- eolchars

The end-of-line chars for text-based table output. The default is platform-dependent (NL on Linux/Unix, CR on Mac, CR/NL on Windows).
The magic strings windows, mac (both checked for the first three characters only) as well as unix and linux are automatically translated to the standard platform line terminators and not copied verbatim. Alternative names for these standard system encodings are $c r l f, c r$ and $l f$. The special value default resets the attribute to the platform-dependent default.

- export

The destination host and port for a row export background thread. If no such thread is executing, the query result is an empty string. Otherwise, it is the host name, followed by a colon separator and the destination port number.

If this attribute is set, any currently executing transfer thread for the table is shut down. If the argument is not an empty string, it can be specified as either an integer (optionally prefixed by a colon), which is interpreted as a port number on the local host, or a host/port combination separated by a colon, or the special string stdout. In the first two cases, an export thread is started and attempts to connect to the specified port, on which a complementary import thread (see import attribute) must already be listening. If the special value stdout is used, the export thread is connected to the standard output channel of the application, not to a socket. The export thread then continuously attempts to move table rows beginning at the top of the local table via the connection to the remote table. It appends them to the end of the remote table, and optionally removes them locally if this operation succeeds.

The column definitions of the remote table are automatically adjusted when the connection is first established. If a row transfer fails, it is silently retried for the failed row after a short pause, so if the remote table is temporarily full, no error results. Row transfer threads only exchange basic cell data and, upon initialization, the most important aspects of column definitions but not more advanced row, column or cell attributes.

Neither the export nor the import threads need to be native Cactvs toolkit implementations - this feature was primarily added to support table row data streaming from and to KNIME workspaces with the aid of suitable nodes. It is possible to use connected import/export threads within a single application, but not on the same table. The table export command is a synchronous variant of this functionality.

- exportflags

A combination of the following possible values:
none - no flags set, in setting can be substituted by an empty string
removerows - if set, remove successfully transferred table rows from the source table. By default, the source table is not changed.
nowait - Do not wait for more table rows to arrive after the last accessible row has been transmitted, even if the eod attribute for the table has not been set. By default, the export thread or command pauses and waits for other threads to add more data to the table as long as the eod flag does not match the targeteod value.
autoretry - Continue to try to connect to the import client if initial attempts fail. By default, the attempt is only repeated until the normal connection timeout (which can be set in : :cactvs (connect_timeout)) has been reached.
knimedatatypes - if set, only data types which have a direct equivalent in the KNIME system are transferred. Other types are recoded as string data. This option is usually used when connecting to a TableRPCStreamReader or CactvsSourceScript node in a KNIME workspace. By default, the full range of Cactvs data types is used. Export flags should be set before the export thread is started as side effect of setting the export table attribute.

- exporthost

The destination host name of the currently executing row export thread, or an empty string if none is running. This is a read-only attribute. Export threads are configured by setting the host and port components simultaneously with the export attribute.

- exportport

The port number of the currently executing row export thread, or minus one if none is running. This is a read-only attribute. Export threads are configured by setting the host and port components simultaneously with the export attribute.

- failures

A list of properties for which computation failed on this table object. This is a read-only attribute. Depending on configuration settings, this information may be used to block pointless attempts at re-computation of incomputable data.
fgcolor
The global table foreground color. If unset, an the result is an empty string.

- fileformat

The format of the file the table was read from. none is returned if the table was not read from a file.

- filename

The full path name of the file the table was read from. If the table was not read from a file, an empty string is returned.

- font

The global output font name, or an empty string if it is not set.

- fontsize

The global font size in points. If not set, zero is reported.

- footer

A free-form table footer text.

- footercolor

The table footer color, or an empty string if not set.

- footerfont

The table footer font name, or an empty string if not set.

## - footerfontsize

The table footer font size, or zero if not set.

- footerformat

The table footer format flag set. The set is the same as for the format attribute.

- format

The current set of global format flags. This is a keyword list which can contain the flags
none -no flags, equivalent to empty string
left - left-aligned text), center (centered text
right - right-aligned text), bold (bold text
highlight - cell highlight), texthighlight (text highlight
histogram - plot histogram instead of data if supported by output format
border - use extra cell border
padding - use extra interior cell padding
expand - format as auto-expand item
top - text aligned vertically to top
middle - text centered vertically in middle of cell
bottom - text aligned vertically to bottom
multiline - format cell data in multiple lines if possible
gcolor - has explicit foreground color
bgcolor - has explicit background color
italic - use cursive text), underline (use underlined text
embedded - embed content of data which are external references, such as linked files into the output, instead of passing the reference
mdlnote - augment call data with MDL Molfile note text of associated ensemble or reaction smilesnote - augment cell data with SMILES note text of associated ensemble or reaction vertical - use vertical text if supported
precision - use property precision data for formatting
$h t m l$ - data is expected to be already HTML-encoded, no additional formatting for HTML table output
merge - merge column with column on the left to multi-row column if supported
The flag set is the same in all contexts. However, not all make sense everywhere (i.e. the merge flag is only useful in column formats, not globally or on individual cells), and other require additional data (the fgcolor/bgcolor flags).

- framecolor

The color of frames around objects in certain output contexts, for example around embedded images or OLE objects. This attribute is evaluated only if the rendering is executed implicitly, for example during an output operation. If, for example, an explicit E_GIF or E_EMF_IMAGE image is set as cell data, the parameters that were in effect when these images were generated are not checked. The default frame color is black. It is sometimes useful to set it to the background color or the rendering, i.e. white, or to suppress frame output altogether (see table write).

- gflags

If the toolkit was compiled with factory support, this is the currently set object icon rendering flag collection.

- header

A free-form header text.

- headercolor

The table header color, or an empty string if not set.

- headerdata

A list of the values of the header data for all columns. This is a read-only attribute.

- headerfont

The table header font name, or an empty string if not set.

- headerfontsize

The table header font size, or zero if not set.

- headerformat

The table header format flag set. The flag set is the same as for the format attribute.

- heights

A list of all row heights. This is a read-only attribute. Rows for which a height has not been set contribute an empty string.

- hidden

Flag indicating whether the table is hidden. This is not the same as the invisible state. This attribute is intended to be used for rendering selections. This attribute can be changed.

- highlightcolor

The default color for highlighting. It is set by default to red.

- highlightfont

The default font for highlighted text output, or an empty string if not set.

- highlightfontsize

The font size of the highlight font, or zero if not set.

- highlightformat

The format flags used by default for highlighting. The set of flags is the same as for the format attribute. The default flag set is bold and underline (plus fgcolor, because the foreground color is set, see highlightcolor attribute).

- httpheader

The type of MIME header to add to table output. It can be 0 (no header, the default), 1 (basic MIME header) or 2 (full header with status code).

- hydrogendisplaymode

The default mode for hydrogen atom rendering of embedded structure or reaction images. It can be either none (no symbols), special (special H atoms have symbols) or all (all hydrogen atoms are rendered with explicit symbols).

- imagedirectory

The name of a directory to store images and other external files in which, depending on the output format, cannot be stored directly in the table file.

## - imagemenuoptions

A keyword list to select the inclusion of specific image menu options in table file formats which support such a feature (currently, only HTML).

- imageurl

The base URL component used for linking images in the image directory (attribute imagedirectory). In HTML output, this component and the name of image files were once combined to add working image links to the output file. Since in current toolkit versions, HTML output employs data URI encoding of the images as replacement for external linking, this attribute is deprecated.

- importflags

A combination of any of the following flags:
none - no flags set, on setting can be substituted by an empty string
clearcolumns - before parsing the initialization command after being connected to a table export server, delete all column definitions. By default these are preserved, except that columns in the incoming table stream which cannot be matched to any columns of the recipient table are automatically added.
clearrows - deleted all rows of the recipient tables after being connected to an export server. By default, existing rows are kept and new rows appended to the end.
autoexit - After processing a complete export request from an export server, exit the listener thread. By default, the listener thread remains active an accepts additional connection requests.

The import flags should be set before a listener thread is started by setting the importport table attribute.

- importport

The port number of the listener thread of the table for remote row-by-row table data transfer (see export attribute). If no such thread is running, which is the default, the reported value is minus one. Changing this attribute shuts down any currently executing import thread, and, if the value is positive, starts a new thread listening on the indicated port. If the special attribute value stdin is used, the import thread reads from standard input, not a socket connection. It is possible to performed threaded import and export within the application concurrently, but not on the same table. The table import command is a synchronous variant of this functionality.

- importscript

The text of a Tcl script which was received as part of an RPC table data transfer. Usually, it originates from a KNIME node the application is interacting with. The script is reset at the beginning of each RPC import. The arrival of a script can be waited for with the table wait command. Scripts are always received after the columns and other table definitions have
been adjusted, but before the cell data was received. The table import command automatically executes a script if it was received and after the import is complete. In case the import runs in a background thread, the script needs to be executed explicitly with a TcL eval statement, and this may happen at a time when the import is still running. See the table wait command for a mechanism to wait for completion of the import if this is not desired.

- infourl

A URL with information on the object content, or an empty string if unset.

- internaldataset

The handle of the internal table dataset object which is part of every table. It is not the handle of a dataset the table may be a member of, as retrieved by the table dataset command. The attribute name may be shortened to simply dataset. It is a read-only value - it is not possible to change an internal table dataset since it is an integral part of the data structure.

- invisible

Flag indicating whether the table is invisible. This is not the same as the hidden state. An invisible object is no longer accessible via its handle. This is usually the case for objects which are scheduled for deletion, but still have lingering referring pointers. This attribute is read-only.

- iteratorstyle

The default style of row data stored in the loop variable of the table loop command. It can either be list (or tuple, for Python compatibility) or dictionary. In list mode, the row data is presented as a simple list and elements are accessed via the list index. In dictionary mode, the data is presented as a dictionary, with the column names as keys. The default iterator style is list. More information can be found in the command description of table loop.

- keywords

A list of keywords associated with the table object.

- license

The license class associated with this table object. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the table object license.

- literature

A free-form literature reference for the data content of the table.

- markcolor

The color of markings and annotations in certain output contexts, for example in embedded images or OLE objects. This attribute is evaluated only if the rendering is executed implicitly, for example during an output operation. If, for example, an explicit E_GIF or E_EMF_IMAGE image is set as cell data, the parameters that were in effect when these images were generated are not checked. The default mark color is pure blue.

- maxrows

A maximum number of rows allowed in the table. Attempts to add more rows fail, or, if the table has an active background export thread, block. Setting it to a negative value, the default, disables this limit.

- modcount

The table content modification count

- name

A free-form table name as string

- ncols

The number of columns in the table. This attribute may be used in a table set command to reduce the number of columns, but not to enlarge the table.

- note

Arbitrary data added as note data. This is usually only used on a lower level to added notes to individual cells.

- nrows

The number of rows in the table. This attribute may be used in a table set command to reduce the number of rows. Adding table rows is also possible by manipulating this attribute. In that case, all new data cells are set to NULL.

- notesize

The size of the table-level note data. This is a read-only attribute.

- nullensrows

A list of the row indices of those rows which are not associated with an ensemble. This is a read-only attribute. If a structure data column is associated with the table, an attempt is made to automatically instantiate the ensembles.

- nullreactionrows

A list of the row indices of those rows which are not associated with a reaction. This is a read-only attribute. If a reaction data column is associated with the table, an attempt is made to automatically instantiate the reactions.

- offset

This attribute can be either zero or one. It influences the naming of flattened columns (see table flatten command)

- onclick

For HTML output, the name of a JavaScript function to be called when a table cell is clicked. The function is called with three arguments: The automatically generated DOM ID of the table cell, and the row and column indices, starting with zero.

- onmouseover

For HTML output, the name of a JavaScript function to be called when a the mouse is moved over a table cell. The function is called with three arguments: The automatically generated DOM ID of the table cell, and the row and column indices, starting with zero.

- onmouseout

For HTML output, the name of a JavaScript function to be called when a the mouse is moved away from a table cell. The function is called with three arguments: The automatically generated DOM ID of the table cell, and the row and column indices, starting with zero.

- orcid

The ORCID code of the author of the table (see www.orcid.org).

- orientation

This value can be none (the default), landscape or portrait. It describes the orientation of a drawing area specified via the paper attribute. Few I/O modules use this information. The most important formats which implement this is are CDX and CDXML.

- paper

An attribute describing the size of the drawing areas for formats such as CDX or CDXML, which can encode this type of information. Possible values are none (the default), $a 3, a 4$, $a 5, a 6, a 7, b 3, b 4, b 5, b 6$, letter, legal and executive. The associated orientation of the drawing orientation can be set via the orientation attribute

- parameters

A keyword/value dictionary of format-specific output options which are not represented by a general table object attribute. I/O modules may possess individual additional control parameters (see tablex get/set commands). The default values for these are automatically added to the parameters table attribute when a table file is written, and may be examined afterwards, but key/value pairs which have been explicitly configured via this attribute are not overwritten and take precedence.

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- pyobject

If the toolkit was compiled with Python support, this attribute reports the memory address of the Python wrapper class instance, if it exists. This attribute is read-only.

- pyrefcount

If the toolkit was compiled with Python support, this attribute reports the reference count of the Python wrapper class instance, if it exists. This attribute is read-only.

- reactioncolumn

The index of the first column which has the reactionsource attribute set. If no such column can be found, the result is minus one. This attribute is read-only.

- reactioncolumnfileformat

The file format associated with columns which contain decodable reaction data. By default, this attribute is unset, which means that an attempt is made to automatically detect the format, as with a reaction create command.

- reactionimageproperty

The name of a property to use for rendering reaction images in formats which allow the inclusion of images in multiple formats, such as HTML. In that case, supported properties include $x_{-}$GIF, $X_{-}$SVG_IMAGE and X_PDF_IMAGE. In table file formats which cannot include images, or support only a single image format, this attribute is ignored.

- reactions

A list of all the reactions associated with the table rows. This is a read-only attribute.

- reactionrowcount

The number of rows which are associated with a reaction. This is a read-only attribute. If a reaction data column is associated with the table, an attempt is made to automatically instantiate the reactions.

- reactionrows

A list of the row indices of those rows which are associated with a reaction. This is a read-only attribute. If a reaction data column is associated with the table, an attempt is made to automatically instantiate the reactions.

- record

The current table row iterator record. The first row is record one.

- refcount

If the TcL interpreter is using native Cactvs objects instead of string-based major object handles and integer-based minor object labels to identify toolkit objects, this returns the number of TCL object references active for this table. This attribute is read-only.

- references

Cross references of the table. This is a nested list of class UUIDs and reference type tags.

- regid

For registered data tables, the registration ID. Zero if this is a private table.

- rownames

A list of the names of all rows. This is a read-only attribute.

- rownametype

This can be either string, or numeric, and has an effect on how row names are compared during sorting and other operations. The names are nevertheless always stored as strings.

- selected

Flag indicating whether the table is selected. This attribute can be changed. This flag is unrelated to row or column selections - it is a standard major object flag.

- selectedcolumns

The currently selected set of columns, as a numerical list of column indices.

- selectedrows

The currently selected set of rows, as a numerical list of row indices.

- separator

The current separator character. This is updated if table data is read from a text file with automatic detection of the separator character or with an explicitly named separator (see table read command). It also has an effect on formatting of ASCII table output. The default separator is a tab character. If you set it to a string which has more than one character, only the first character is actually recorded.

- sizehint

An integer indicating the expected maximum row count of the table. This is used for internal optimizations. A value of minus one indicates that no size hint is in effect.

- soapmethod

The name of a method which is used for SOAP data exchange involving this table.

- soapschema

The name of a schema which is used for SOAP data exchange involving this table.

- structurecolumn

The index of the first column which has the structuresource attribute set. If no such column can be found, the result is minus one. This attribute is read-only. The attribute name enscolumn is an alias.

- structurecolumnfileformat

The file format associated with columns which contain decodable structure data. By default, this attribute is unset, which means that an attempt is made to automatically detect the format, as with a ens create command. The attribute name enscolumnfileformat is an alias.

- structureimageproperty

The name of a property to use for rendering structure (ensemble) images in formats which allow the inclusion of images in multiple formats, such as HTML. In that case, supported properties include E_GIF, E_SVG_IMAGE and E_PDF_IMAGE. In table file formats which cannot include images, or support only a single image format, this attribute is ignored.

- stylef

The name of a predefined output style. This is currently only used by the CDX and CDXML table output formats, which support both the ChemDraw default style and the ACS journal style (acs).

- symboldisplaymode

The default mode for atom rendering of embedded structure or reaction images. It can be either none (no symbols), symbol (element symbols), label (atom labels), index (atom list index), box (colored square marker), compact (symbols with contracted atoms) or residue (A_RESIDUE label)

- targeteod

The target value of the eod attribute. Once it matches or exceeds this value, the table is not expected to receive any more rows. The initial value of this attribute is one. This attribute is for example checked by processing threads.

- title

A free-form table title text.

- titlecolor

The table title color, or an empty string if not set.

- titlefont

The table title font name, or an empty string if not set.

- titlefontsize

The table title font size, or zero if not set.

- titleformat

The table title format flag set. The set is the same as for the format attribute.

- tooltip

If the toolkit was compiled with factory support, this is the tooltip of the object icon on a workbench. This attribute can be changed.

- undefined

This attribute controls the I/O of undefined cell data. It is a string consisting of one or more words, separated by commas. The first word is used for string-based output of nuLl cell values. All words are recognized when decoding cell data from strings. Any input matching any of the words are stored as a null value. The default value is
„NULL,N/A,UNDEF,UNDEFINED,UNSET,NOTSET". With this string, NULl cells are printed as "NULL", and a total of six magic words for the input of NULL data are recognized.

- uuid

An automatically generated UUID globally identifying the object. This attribute is read-only, different for every table, and not dependent on its contents.

- variable

The name of a global Tcl array variable in the base interpreter which is linked to the table. Table updates are reflected in the variable contents, and changes of the variable elements will change the table object contents. The 2-dimensional TcL array variable uses numerical row and column indices. If there is no linked variable, which is the default, the result is an empty string.

- version

A free-form version number of the table.

- versionuuid

The UUID associated with this table object version.

- $x$

If the toolkit was compiled with factory support, this is the x coordinate of the object icon on its workbench. This attribute can be changed.

- $y$

If the toolkit was compiled with factory support, this is the y coordinate of the object icon on its workbench. This attribute can be changed.

Table attributes which are not marked read-only can be set by the table set command.
Variants of the table get command are table new, table dget, table nget, table show, table sqldget, table sqlget, table sqlnew, and table sqlshow. These commands only work on property data and cannot be used to access attributes.

## table getcell

table getcell tablehandle row column ?attribute?
Get the cell data value, or a cell attribute. The following cell-level attributes are supported:

- bgcolor

The background cell color, if it is set on the cell level.

- comment

A free-form text comment

- fgcolor

The foreground cell color, if it is set on the cell level.

- format

Cell-level format flags. This is the same set as for the global table attribute of the same name, which is explained in the section describing the table get command.

- mergedbgcolor

The effective cell background color, merged from cell $>$ row $>$ column $>$ table format specifications.

- mergedfgcolor

The effective cell foreground color, merged from cell $>$ row $>$ column $>$ table format specifications.

- mergedformat

The effective format flags for the cell, merged from cell $>$ row $>$ column $>$ table format specifications.

- image

A Tk image handle when the table object is linked to a Tк table widget.

- note

A free-form cell note. In output formats such as MS Excel this is displayed as a tool tip. Note that this data can be binary.

- notesize

The size of the note, in bytes.

- tag

The cell tag in a linked Tk table widget.

- value

The cell data value.

- window

The name of a linked $\mathrm{T}_{\mathrm{k}}$ window displaying cell contents.
The attributes image, tag and window are only useful for developers who want to display a Cactvs table in a GUI tool developed with the Tk toolkit and its table widget.

If the last optional command argument is omitted, it is assumed to be value.

## table getcol

table getcol tablehandle column ?attribute?
Get data from a specific column. All attributes which can be set (see table setcol command), can also be read. In addition, the following attributes can only be read, but not set:

- avg

The computed average value of the column data cells. NuLL cells are ignored. This operation only succeeds on numerical table columns. average is an alias.

- data

A list of all the values of the column data cells. The size of the returned list is the same as the row count. values is an alias.

- data(fieldname)

This form is a variant of above command. It is used to access a specific data subfield of the column data, or perform datatype-specific conversion operations. The allowed field names are determined by the specification of the column property, if it exists, and/or the column datatype. If the column data is already a property subfield, the field name signifies further indexing from that property data subset onwards. At this time, not all indexing operations possible in other index-driven commands are available, especially index accesses where individual data items determine success or failure (such as key-indexed dictionary values) are not possible.

- exists

A boolean pseudo-attribute indicating whether the column with the specified identifier exists in the current table or not.

- index

The numerical column index of the specified column identifier. If the identifier cannot be resolved, minus one is reported.

- max

The computed maximum value of the column data cells. NuLL cells are ignored. This operation only succeeds on numerical table columns.

- min

The computed minimum value of the column data cells. Null cells are ignored. This operation only succeeds on numerical table columns.

- notesize

The byte length of the note attribute. If no note is attached, the result is zero.

- propertyfield

The property subfield index of the column. If the column is not a property column, or the column is specified to contain data of a complete property record, not just a subfield, the value minus one is returned.

- stddev

The computed standard deviati8on of the column data cells. NuLl cells are ignored. This operation only succeeds on numerical table columns.

- sum

The computed sum of the column data cells. NuLL cells are ignored. This operation only succeeds on numerical table columns.

The exists and index attributes allow the specification of non-existing column identifiers. In all other cases, an error is raised if the column cannot be identified.

If the last optional command argument is omitted, it is assumed to be data.
Example:
table colget $\$$ th mycol
table colget $\$$ th mycol data(CHF)
The first form retrieves all column data values in standard format. The second form assumes that the column supports index $C H F$, which is for example the case if the column data type is currency. In that case, the returned values are automatically converted from whatever original currency it is in.

## table getrow

table getrow tablehandle rowrange ?attribute?
Get data from a specific row range. All attributes which can be set (see table setrow command), can also be read. In addition, the following attributes can only be read, but not set:

- data

A nested list of all the values of the data cells of the row set. The size of the returned inner list is the same as the column count, and the size of the outer list the row count between the first and last specified rows. values is an alias.

- dictdata

The same as data, except that the row information is returned as a dictionary, with the column names as keys. dictvalues is an alias.

- exists

Report as a boolean value whether the specified row range could be resolved.

- index

The list of numerical row indices of the specified row identifiers. If the row range cannot be resolved, a single minus one value is reported.

- objclass

The class of objects, such as ens, reaction or atom, associated with the row. The default attachment, even for rows which are not connected to a chemistry object, is ens.

- notesize

The byte length of the note attributes. If no note is attached, the result is zero for that row. If the last optional command argument is omitted, it is assumed to be data.
table getparam
table getparam tablehandle property ?key? ?default?
Retrieve a named computation parameter from valid property data. If the key is not present in the parameter list, an empty string is returned. If the default argument is supplied, that value is returned in case the key is not found.

If the key parameter is omitted, a complete set of the parameters used for computation of the property value is returned in key/value format..

## table import

table import tablehandle portnumber/stdin ?importflags?
Perform an RPC stream table data import via a specified port number, or standard input. In contrast to the same functionality invoked by setting the importport table import attribute (see table set/get), the data transfer started by this command is synchronous, and the command only returns when the end of data marker has been received.

The optional import flags argument is the same as for the table set/get command and has the same possible values and effects, except that the import flags are not permanently set as table attributes. The old flag setting is restored when the command finishes. Another difference to the background version is that this command always automatically returns after a complete table data set has been received, so that explicitly setting the autoexit flag has no effect.

If an embedded TcL script was received as part of the import, it is automatically executed after all table data has been received.
table index
table index tablehandle
Get the position of the table in the object list of its dataset. If the table is not member of a dataset, -1 is returned.

## table innerjoin

table innerjoin tablehandle1 tablehandle2 ?col1? ?col2? ?cmpflags?
table join tablehandle1 tablehandle2 ?coll? ?col2? ?cmpflags?
Perform a relational inner join on two tables and return the handle of a newly created join table. The source tables remain unchanged. If no explicit table columns are specified, in both tables the first column is used. If only one column name or index is specified, it applies to both tables. With two column names or indices, the first is used to select the join column on the first input table, and the second on the other table.

This command explanation is also referenced by the table object subcommands leftjoin, rightjoin, and outerjoin. This is the reason why the explanation of some command features goes beyond describing exclusively the innerjoin subcommand.

The result table always contains, in this order, the columns of the first table, followed by those of the second table, with the exception of the omitted join column of the second table. The names of columns originating from the second table are adjusted if necessary to avoid duplication of column names in the result table. Data attached to rows on either input table outside of cell values, such as structure or reaction references, are not copied to the output table.

By default, the join condition is a simple equality check on the data of a single column from each table. The data value comparison method may be modified, for example to use case-insensitive or punctuation-ignorant comparison, by the last optional argument. The recognized values in this flag set are dependent on the column data types and the same as in the prop compare command. At this time, the fundamental comparison operator is always an equality check - other operators such as less than etc. are not supported. The row values of the join columns are not required to be sorted in either input table. null data values in the comparison column never match another data value, even if it also is NULL, following the standard rules of relational algebra. Parallel joining on multiple columns is not yet supported.

The column data types are not required to be identical. If they disagree, an attempt is made to cast the data values of the first table to the datatype of the column of the second table. If that fails, the input row of the first table is skipped and never included in the result table, even in left, right or outer joins.

In an inner join, rows from the first able are omitted in the output if there is no matching column value in the second table. If either table has more than one matching row for a column value, multiple combined output rows result from that pairing, with all possible combinations of row data blocks (but not individual column values) from either table expanded.

The subcommand aliases join and innerjoin are functionally identical.
The table leftjoin, table rightjoin and table outerjoin commands are extensions of the fundamental inner join operation. These generate selected additional rows in the output for rows from the tables which do not match a counterpart in the join column.
table leftjoin
table leftjoin tablehandle1 tablehandle2 ?col1? ?col2? ?cmpflags?
Perform a relational left join on two tables and return the handle of a newly created join table. The command arguments and result value are explained in the table innerjoin command.

The difference between a standard inner join and a left join is that rows from the first input table which do not match any values of the join column in the second table are still output, with all column data originating from the second table set to NULL values.

## table list

table list ?filterlist?
Without a filter list argument, the command returns a list of the handles of all tables currntly existing in the application, including those of the system tables.

If a filter list is specified, only those tables which pass all filters are listed.
Examples:

```
table list
```

table listblockloop
table listblockloop tablehandle rowvariable ?maxrows? ?offset? body
This command is a variant of the table blockloop command. It stores the row data as a simple nested list in the loop variable, without column names. The value of the iterator style table attribute is ignored.

Please refer to the table blockloop command description for more information.
For the sake of compatibility with the Pүтнon interface syntax, the command may also be invoked as table tupleblockloop.

## table listloop

table listloop tablehandle rowvariable ?maxrows? ?offset? body
This command is a variant of the table loop command. It stores the row data as a simple list in the loop variable. The value of the iterator style table attribute is ignored.

Please refer to the table loop command description for more information.
For the sake of compatibility with the Python interface syntax, the command may also be invoked as table tupleloop.

## table lock

table lock tablehandle propertylist/table/all ?compute?
Lock property data of the table, meaning that it is no longer subject to the standard data consistency manager control. The data consistency manager deletes specific property data if anything is done to the table which would invalidate the information. Blocking the consistency manager can be useful when building tables from components in a script. Property data remains locked until is it explicitly unlocked.

The property data to lock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the table are locked. If the boolean compute flag is set, an attempt is made to compute the property if it is not yet present. Otherwise, a request to lock non-existent data is silently ignored. It is not possible to lock individual property fields.

- all

All valid table properties are locked. The compute flag is ignored.

- table

This is an object class identifier. All property data which is controlled by the table major object and attached to the specified object class is locked. Because a table currently does not have minor objects, this command does the same as the all variant.

The lock can be released by an table unlock command.
The return value is the table handle.

## table loop

table loop tablehandle rowvariable ?maxrows? ?offset? body
This command executes a loop over the rows of a table. On each iteration, the global TcL variable rowvariable is set to a list of the cell values of the current row, and then the body argument is executed as script. The body script may use the standard TcL loop control commands continue and break.

By default, the loop runs from the first row to the end of the table. The optional arguments can be used to set a maximum iteration count, and to change the starting point of the loop. If the maximum iteration count is explicitly set to a negative value, the loop runs to the end of the table.

The content of the row variable is dependent on the configured table iterator style (see iteratorstyle table attribute). It can either be a list, with simple cell values, or a dictionary with column name and cell values. The default is the list style.

Example:

```
table loop $th rowvar {
    echo "Col0: [lindex $rowvar 0] Col1: [lindex $rowvar 1]"
}
```

The table blockloop command is a more complex variant of this command. It operates on blocks of rows with a common cell value in a column instead of simply stepping from one row to the next.

The table listloop variant of this command always stores the row data as a list in the loop variable. The value of the iterator style table attribute is ignored.

The table dictloop variant of this command always stores the row data as a dictionary in the loop variable, with the column names as keys. The value of the iterator style table attribute is ignored.

The return value of the command is the number of loop iterations processed. The last value of the loop variable remains accessible outside the loop.

## table merge

table merge tablehandle1 tablehandle2 ?rowmode? ?columnmode? ?comparisoncolumn?
Merge two tables into one. The first table is updated. The second table remains valid and retains all its data. It is not possible to merge a table with itself.

The first table will usually be subject to row and column updates. What kind of updates are performed is determined by the row and column modes. The row mode can be one of:

- append

All rows from the second table are appended to the first, without checking for duplicates.

- exclusive

Any rows which are present in both tables are deleted from the first table. In addition, rows from the second table which do not match rows in the first table are appended. This is the opposite of the intersect mode.

- intersect

Rows from the first table which have no equivalent in the second table are deleted from the first table. Matching rows remain unchanged in the first table, and no data is ever appended to the first table.

- join

This mode is a combination of the transfer and union modes.

- replace

The data of rows which have a duplicate in the first table overwrites all data cells in the matching row in the first table. This can be used, depending on the column mode, to add or update column data which is not present or nulL in the first table. The difference to the transfer mode is that even non-NuLL cells in the first table are overwritten by data from the second table. Rows from the second table which do not match a row in the first table are ignored.

- second

Rows in the second table which do not match any rows in the first table are appended to the first table. All original rows in the first table are deleted. This is similar to the subtract mode, with the order of the tables reversed.

- subtract

Only rows from the first table which do not match rows from the second table are retained in the first table. Matching rows are deleted. No data is appended.

- transfer

The data of rows which have a duplicate in the first table overwrites null data cells in the matching row in the first table. This can be used, depending on the column mode, to add or update column data which is not present in the first table. The difference to the replace mode is that non-NULL cells in the first table are not overwritten by data from the second table. Rows from the second table which do not match a row in the first table are ignored.

- union

Rows from the second table for which there is no duplicate in the first table are appended to the first table. This is the default row mode. Rows which are duplicates are skipped.

The comparisoncolumn parameter determines which column is used to check for duplicate rows. By default, it is \#name, i.e. the row name is used and not any column data. For tables without explicit row names, this is the row index. For tables which were generated by direct output from the molfile scan command, it is automatically set to the matched file record number. Query result tables from the same file can therefore be merged easily. Instead of the row name, any cell data of a real column in the first table may be used for identity checks. However, this column must have an equivalent in the second table, or an error results.

The column mode determines which column definitions from the second table are added to the first table, and whether any columns on the first table are deleted if there is no corresponding column in the second table. The supported column modes are:

- append

All columns of the second table are appended to the right of the current table. This can lead to duplicate column names and is not a frequently used mode. Old row data on the first table becomes NULL for these new columns.

- left

The columns on the first table are not changed.

- intersect

All columns on the first table for which no equivalent column exists in the second table are deleted in the first table. Columns in the second table without an equivalent in the first table are ignored and their cell data will not be copied from the second table. This is the default column merge mode.

- right

The second table determines the column set. Any column on the first table for which there is no equivalent in the second table are deleted, and any column definitions in the second table for which there is no equivalent in the first table are added to the first table. Old row data on the first table becomes null for these new columns.

- union

Any columns on the second table for which no equivalent column exists are recreated on the first table. Old row data on the first table becomes NULL for these new columns.

The order of the columns on the two merged tables is not important for property columns. Column matching uses property definitions and subfield indices to find equivalent columns regardless of their name. Pure data columns without property definitions require a matching name and data type in order to be perceived as equivalent. The column modes left, intersect and union are most often used. If the two tables have identical column sets, the merge result are the same in all these modes.

If property $T_{\text {_ }}$ QUERY is valid on both tables, and it describes a query on the same data source, it is updated on the first table to represent a single query which would yield the results of the merged table. This is done by manipulating the query tree in that property by combining the old two trees under a suitable logical operator such as and or or. This is intended to facilitate convenient management of query results in tables, as they are, for example, produced by a molfile scan command with direct table output.
table metadata
table metadata tablehandle property field ?value?

Obtain property metadata information, or set it. The handling of property metadata is explained in more detail in its own introductory section. The related commands table setparam and table getparam can be used for convenient manipulation of specific keys in the computation parameter field. Metadata can only be read from or set on valid property data.
table move
table move tablehandle ?datasethandle|remotehandle? ?position?
Make a table a member of a dataset, or remove it from a dataset. If the dataset handle parameter is omitted, or an empty string, the table is removed from its current dataset. If it was not a dataset member, this command does nothing. The dataset handle may be the name of a remote dataset for moving tables over a network connection.

If a dataset handle is specified, the table is added to the dataset, and removed from any dataset it was member of before the execution of the command. By default the table is added to the end of the dataset object list, but he final optional parameter allows the specification of an object list index. The first position is index zero. If the parameter value end is used, or the index is bigger than the current number of dataset objects minus one, the table is appended as by the default. It is legal to use this command for moving tables within the same dataset.

Another special position value is random. This value moves to the table to a random position in the dataset. Using this mode with remote datasets is currently not supported.

The dataset handle cannot be a transient dataset. It is not possible to move a table into its own built-in dataset.

The return value of the command is the dataset membership of the table prior to the move. It is either a dataset handle, or an empty string if it was not member of a dataset.

## Examples:

table move \$thandle \$dhandle 0
table move \$thandle
In the first sample line, the table is inserted as the first element in a dataset. The second line reverts this operation and removes the table from the dataset.

This command can be used with a remote dataset descriptor. In that case, the table is packed into a serialized object representation, transmitted over the network and restored as member of the remote dataset at the specified position. The local table is deleted if the transfer succeeds.

## table movecols

table movecols tablehandle columnrange ?destination?
Move one or more columns, including their cell data. If the destination, a simple column address, is not specified, the selected columns are moved to the right of the table. The destination cannot be in the range of the source columns.

The command may also be written as table movecol.
table moverows
table moverows tablehandle columnrange ?destination?

Move one or more rows, including their cell data. If the destination, a simple row address, is not specified, the selected rows are moved to the bottom of the table. The destination cannot be in the range of the source rows.

The command may also be written as table moverow.

## table mutex

table mutex tablehandle mode
Manipulate the object mutex. During the execution of a script command, the mutex of the major object(s) associated with the command are automatically locked and unlocked, so that the operation of the command is thread-safe. This applies to builds that support multi-threading, either by allowing multiple parallel script interpreters in separate threads or by supporting helper threads for the acceleration of command execution or background information processing. This command locks major objects for a period of time that exceeds a single command. A lock on the object can only be released from the same interpreter thread that set the lock. Any other threaded interpreters, or auxiliary threads, block until a mutex release command has been executed when accessing a locked command object. This command supports the following modes:

- lock

Increase the recursive mutex lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock.

- reset

Release all persistent locks on the object, if they exist.

- test

Return the current persistent lock count on the object. This excludes the transient per-command lock.

- unlock

Decrease the recursive lock count on the object. The command returns the current lock count after the command, excluding the transient single-command lock. Unlocking an object which has not been persistently locked results in an error.

There is no trylock command variant because the command already needs to be able to acquire a transient object mutex lock for its execution.

## table need

table need tablehandle propertylist ?mode?
Standard command for the computation of property data, without immediate retrieval of results. This command is explained in more detail in the section about retrieving property data.

The return value is the table handle.
Example:

```
table need $th T_XYPLOT recalc
```

table new
table new tablehandle propertylist ?filterset? ?parameterlist?

Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the table get command. The difference between table get and table new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## table nget

table nget tablehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the table get command. The difference between table get and table nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## table normalize

table normalize tablehandle column ?singlerow?
Normalize a table column with numerical data to an average value of zero and a standard deviation of one.

If the data type of the column is a floating-point vector type (vectors of floats or doubles), and the singlerow flag is set, the normalization is performed individually on each vector in the cells of the selected column and not over all rows together.

The return value of the command is a list of the offset and scaling factors used to normalize the data column, in that order. In case the singlerow command variant was used, the return value is a list of these number pairs with one list element per row.

If the command is used on float or double vector columns in normal mode, all vector elements are treated as independent data values.

It is possible to normalize integer-type columns. However, since this command does not change the data types of the columns, only the offset and scaling values are reported but the column data is not changed because this cannot be done in a reasonable fashion.

Any attempt to normalize non-numeric columns results in an error.

## table outerjoin

table outerjoin tablehandle1 tablehandle2 ?col1? ?col2? ?cmpflags?
Perform a relational outer join on two tables and return the handle of a newly created join table. The command arguments and result value are explained in the table innerjoin command.

The difference between a standard inner join and an outer join is that rows from either the first input table which do not match any values of the join column in the second table, or from the second input table which do not match any values of the join column in the first table, are still output, with all column data originating from the respective other table set to NULL values. The outer join is a fusion of a left and right join.

## table pack

table pack tablehandle ?rowrangelist? ?columnrangelist? ?maxsize?
Pack the table into a compressed, base64-encoded, serialized object string. This string can be used with a table unpack command to restore the table.

By default the full table is packed, but the optional range parameters, which are both range lists, can be used to pack a subset of the table.

The maximum size of the object string (default -1 , meaning unlimited size) can be configured by the optional maxsize parameter. The size is specified in bytes. If the pack string would be longer than the maximum size, an error results.

Note that this command does not pack ensembles or reactions which are associated with a table. If a table is restored, this linkage is lost.

The return value of the command is the pack string.
Example:

```
set ts [table pack table0 {F Cl Br I} {vdwradius covradius}]
```

This command copies the Van der Waals and covalent radii of the halogens from the PSE table into a pack string. The string can be restored to a subset table with a

```
set thnew [table unpack $ts]
```

table poploop
table poploop tablehandle ?mode? varname body
Perform the table poprow command (see below) in a loop. The loop is repeated until no more rows can be extracted from the table. In each iteration, the extracted table data is stored in the specified variable, the row is deleted, and the code in the body executed. If execution of the body code results in an error, the loop is stopped immediately. It can also be left early without raising an error by executing a standard TCL break or return loop control command in the body

The possible values of the optional mode argument are the same as in the table poprow command, as is the default mode list.

The return value is the number of rows processed. The last value of the loop variable remains accessible outside the loop.

## Example:

```
table wait $::cactvs(knime_input1_table) definition
table clone $::cactvs(knime_input1_table) $::cactvs(knime_output1_table)
table addcol $::cactvs(knime_output1_table) property E_WEIGHT Weight
table export $::cactvs(knime_output1_table)
table poploop $::cactvs(knime_input1_table) ens eh {
    table addens $::cactvs(knime_output1_table) $eh
    ens delete $eh
}
table set $::cactvs(knime_output1_table) eod 1
```

This is a typical stream processing command sequence for a Cactvs knime bridge node script. Using this kind of construct, with background import and export threads for the table data, arbitrarily large tables may be processed without memory strain.

## table poprow

table poprow tablehandle ?mode?
Remove the first row of the table and return its content as result. The form of the result can be modified by the optional mode parameter. Its possible values are:

- list

This is the default. The row data is returned as a standard TcL list.

- dict

The row data is returned as a TcL dictionary. The primary column names are the dictionary keys. For columns without a name, a synthetic name in the form col\%d is generated.

- ens

Return an ensemble object. The source of the ensemble is, in this order, either an existing association of the row with an ensemble, the first column marked as structure source (see description of column flags), or an empty ensemble constructed on the fly. Column data which is not already present on the result structure is attached as ensemble properties if possible. If a column is already a property column, and the column property is an ensemble property, it is directly attached to the ensemble. For other column data, with the exception of explicit property data of incompatible objects, synthetic property definitions are automatically created. nULL data is skipped.

- reaction

As above, but the result is a reaction object. The source is either an existing row association with a reaction, a reaction source column, or a newly constructed empty reaction.

- object

The return value is an automatically chosen major object, either an ensemble or a reaction, depending on the type of existing row associations, source columns, or present property types. This mode can also be selected as auto or \#auto.

For this command to work, the table needs to be editable. If there are no more table rows, an empty result is returned. If the table has an active background import thread, the command blocks until the import thread has added another row, or has terminated.

The command may be abbreviated as table pop.

## table properties

table properties tablehandle ?pattern? ?noempty?
Return a list of the valid properties on the table object. If desired, the property list can be filtered by the optional string match pattern. Since tables incorporate no minor objects, only true table properties (standard prefix $T_{-}$) are listed. Properties of ensembles or reactions associated with the table are not output because these are not component objects, just cross-references.

If the noempty flag is set, only properties where at least one data element is not the property default value are output. By default, the filter pattern is an empty string, and the noempty flag is not set.

The command may also be written as short form table props.
Example:
set plotproplist [table props \$th T_*PLOT*]

## table purge

table purge tablehandle propertylist/table ?emptyonly?
Delete property data from the table. In contrast to performing property deletions on, for example, ensembles this operation does not branch out to properties which are stored on objects linked to the table. Ensemble or reaction references are not traversed because they are not true container object memberships.

This command only deletes proper table properties (usually starting with $T_{-}$). If the object class name table is used instead of a property name, the data of all table properties is deleted.

The optional boolean flag emptyonly restricts the deletion to those properties where the value of a property is identical to the default.

## table rank

table rank tablehandle ?method? ?\{column ?direction ?cmpflags??\}?..
Rank the table rows according to data in specific columns. The command returns a list of the individual ranks of the rows, with one numeric list item per row and in order of the rows. It does not sort the table.

There are three different ranking schemes:

- centered

If there are multiple rows of the same superiority, their rank is the average position in the result list. For example, if there are two entries which would occupy both second place, their rank is both 2.5 , the average of position 2 and 3 in the list. The next rank assigned is fourth place.

- olympic

If there are multiple rows of the same superiority, they all get assigned the highest unclaimed rank. The next tier receives ranks which skip those which would have been assigned had the ranks of the superior positions been all different. For example, if there are two rows with first rank, the next assigned rank is third. This is the default method.

- sequence

If there are multiple rows of the same superiority, they all get assigned the highest open rank. The next tier get ranks in immediate sequence, without correcting for ties. For example, if there are two tied top rows, they both get first rank, and the next rank assigned is second.

The rest of the optional arguments select the columns to use for ranking, and the comparison operations used to determine the rank. Each argument is a list of one to three elements. The first list element, the column name, is mandatory. The special column name \#name can be used to use the row name as criterion, and \#random as tiebreaker which prevents any ties.

If the next element is not supplied, the sort direction for rank comparisons is $u p$, meaning that lower values imply a higher (numerically lower) rank. The sort order can also be specified as down, which inverts this.

Finally, the comparison operation can be influenced by providing a list of comparison flags. These the same as used with the prop compare command.

In case multiple comparison columns are given, columns to the left have precedence over columns to the right.

Not specifying any comparison column is syntactically allowed, but reports all rows as of the same rank.

## table randomize

table randomize tablehandle ?seed?
Shuffle the rows of the table in a pseudo-random fashion. If the seed argument, an integer, is provided, it is used to seed the random generator. If the command is called the first time without a seed, the current time stamp is automatically provided as seed and the random number sequence becomes unpredictable. Subsequent calls of the command without a seed parameter continue with the random number sequence defined by the seed, until the command is again called with a seed argument. The random generator is then re-seeded and the number sequence specific to the seed is re-started.

This command is useful for testing the robustness of algorithms with respect to data ordering.

## table reactions

table reactions tablehandle
Return a list of the handles of all reactions which are referenced by the table. Every reaction is reported only once, even if it is referenced by multiple rows. Rows with reaction references are usually added to tables my means of the table addreaction command. In case a row has no reaction reference, it is ignored, and no output is produced.

## table read

```
table read filename ?parameter value?...
table read filename ?dictionary?
```

Read a table file into a newly allocated Cactvs table object and return the handle of the new table if the operation succeeded. The column data types and other attributes of the new table are set appropriately according to the data found in the file. This is even true for pure ASCII text tables, because an attempt is made to promote the column formats to integers, floats or booleans after the data has been read initially as strings, if the data content allows the conversion.

Besides a normal file name, it is also possible to specify stdin as magic file name to read from standard input, or a pipe by starting the file name argument with the "" character. If a normal file is used, and the suffix cannot be identified by the currently loaded table file format I/O handlers, an attempt is made to auto-load a handler by constructing a standard module name from the suffix (see tablex command for more information about table file format handlers).

Additional optional parameters to control the input can be specified either as a number of keyword/value argument pairs, or a single dictionary argument. The recognized control keywords are the same for both variants.

By default, the file format is identified automatically. However, in order to enforce reading the input source as a specific format, for example in case of an ASCII table file with confusing separator characters, it is possible to explicitly state the format with the format parameter. If the handler for that format is not yet loaded, again an attempt at auto-loading it is made.

In some cases it may not be possible to automatically detect whether the table file contains column names or not. The colnames parameter allows the programmer to provide this information explicitly. In a similar fashion, a rownames parameter determines whether the first column is read as row names, or as data column, if this information is not explicitly encoded in the file.

The separator parameter provides a way to explicitly define a separator character for ASCII-style text tables. By default, an attempt is made to determine the separator character automatically if the table file format is identified as an ASCII-based format with a variable separator. This option is ignored for file formats with a more advanced internal structure.

CACTvs table objects can represent only a single table, not multiple tables forming a sheet collection, notebook or similar construct in the input file. In case files are read which contain multiple tables, for example sqlite, xlsx or fits files, the desired table can be selected via the sheetname option. The alternative parameter name table is an alias for sheetname. If a multi-table file is read, and no such sheet name provided, the first table from the file is the one extracted. There is currently no way to read multiple tables from such a file with a single command, nor a method to query the number or names of sheets or tables present.

If skiperrors parameter is set, rows which cannot be decoded are ignored. This is useful for example in case there are trailing blank or comment lines in the file. However, the read command will then also remain silent in case all rows fail, for example because of a mis-identification of the file format, so this option should be used with care.

If a read table file contains, besides the cell data, structure or reaction object data, as it is possible for example with native CACTVs or KNIME table files, these objects are automatically read and moved into the internal table dataset object. Proper row references to these objects are also established.
table load is an alternative command name.
Example:
set th [table read \$file colnames 1 separator "!"]
This reads a slightly unusual ASCII table with exclamation marks as separators, and column names in the first row.
table readblob
table read data ?parameter value?...
table read data ?dictionary?
This command is the same as the table read command, except that is reads from an in-memory blob instead from a file. If the responsible table I/O module for the table file format does not support in-memory decoding, a temporary file is automatically created and removed after reading.

Currently, automatic format detection of in-memory table data does not work in some cases, or forces the inefficient use of a temporary file. It is advisable to specify an explicit file format in the optional arguments to avoid this problem.
table loadblob is an alternative command name.

## table recalc

table recalc tablehandle ?rowrangelist? ?columnrangelist?

Recompute the values of all cells which are linked to column computation functions in the specified block. The default re-computation block is the complete set of rows and columns. This command does not affect cell data which is not linked to a function.

The return value is a boolean value indicating whether all requested values could be computed.

## table rename

table rename tablehandle srcproperty dstproperty
This is a variant of the table assign command. Please refer the command description in that paragraph.

## table replot

table replot tablehandle ?rowrange? ?columnrange?
Replot structure and reaction images embedded in the table. The default replot block is the complete set of rows and columns. The command only affects data cells of columns of type image.

The command returns the table handle.

## table rewind

table rewind tablehandle
Reset the table iterator record. This is equivalent to setting the record table attribute to one.
The command returns the table handle.

## table rightjoin

table rightjoin tablehandle1 tablehandle2 ?coll? ?col2? ?cmpflags?
Perform a relational right join on two tables and return the handle of a newly created join table. The command arguments and result value are explained in the table innerjoin command.

The difference between a standard inner join and a right join is that rows from the second input table which do not match any values of the join column in the first table are still output, with all column data originating from the first table set to null values.

## table scan

table scan tablehandle expression ?mode? ?parameters?
This command is a variation of the dataset scan command. The query expression is matched, in row order, on all ensemble or reaction objects associated with the table rows, i.e. the same objects as reported by the table ens and table reactions commands. An attempt is made to automatically instantiate these objects if a row currently has no association, but a structure source column has been configured via the structuresource or reactionsource attribute. Rows which do not possess a structure or reaction reference even after this attempts are skipped and can never return a match.

The default retrieval mode for this scan command variant is rowlist, which is an alias of the indexlist mode of dataset scans. In this mode, matching row indices are returned as a list. If an ensemble or reaction is associated with multiple rows, it is tested repeatedly for every row it is associated with.

For further information on the operation of this command and the use of the various arguments, refer to the paragraph on dataset scan.

The optional parameter dictionary is the same as for molfile scan, but not all parameters are actually used. At this time, only the matchcallback, maxhits, maxscan, order, progresscallback, progresscallbackfrequency, sscheckcallback, startposition and target parameters have an effect. In case a progress callback function is used, the table handle is passed as argument in place of the molfile handle in molfile scan.

This command does not operate on table cell data, but exclusively on the associated structures, reactions, and their present or computable data. For queries on table cell data, use the table find command. However, the delete query mode of this command does indeed remove matching table rows, not delete the associated objects.

## table select

table select tablehandle column|all operator value ?mode?
Perform a scan over the table and mark all rows which match a value. This command processes multiple matches. For a simple version of the command which stops after the first match, see table find.

The default mode is new, which resets all current select flags on the rows before running the command. The alternative modes are or, which just sets additional flags, and, which resets the selection flag for rows which are currently selected but not pass the new expression, and eor or xor, which invert the selection flag on all rows which are matched.

The column argument is either the name or index of an existing table column, or the magic word all, which runs the scan on all columns. There is currently no support for scans which use more than one, but not all columns. The special column name \#name to test the row names is also supported.

For single-column scans, the value argument needs to be a string which can be decoded as the data type of the scan column. For all scans, the argument is parsed separately for each column. Only columns where the data successfully decodes according to their data type are searched. Other columns where the value argument cannot be parsed are silently skipped.

The operator argument is a standard arithmetic operator, optionally modified by either single-character modifier flags, or specified as a list with the symbolic names of these modifier flags. The syntax of this argument is compatible to that of property query leaf expressions of the molfile scan command. The operators in and notin are also supported. In that case, the value argument must be a valid list. The list is split, and each element parsed and matched separately. For the in operator, rows where any of the multiple elements match with an equality comparison are selected. For a notin match, none of the elements must match in an equality comparison.

Examples:

```
table select $thandle E_NAME *= "*chloro*"
table select $thandle E_NAME {= shell} "*chloro*"
table select $thandle E_WEIGHT <= 200
table select $thandle SID in [ens get $eh E_SIDSET]
```

The first two sample statements are equivalent and both perform a shell-syntax string match on the column E_NAME, matching any data which contains the substring chloro. The third example performs
a simple numeric comparison, and the last example tests whether the $S I D$ column data value is one of a list of alternatives.

The result is a list of the row indices of all selected rows after the operation.
This command has limited power in the types of comparison operations it supports. For a more extensive search capability please refer to the table sqlselect command. However, in many cases this simpler command is much faster than the SQL version, especially if it operates on columns with indices and uses a search operator which can make use of the index information.

This command does not support data access via linked ensembles or reactions. It can only test cell data directly stored in the table.

## table set

table set tablehandle property value ?property value?...
Standard data manipulation command. It is explained in more detail in the section about setting property data.

## Examples:

```
table set $thandle T COMMENT "This data, if leaked in an appropriate fashion, will
lead to the waste of years of research by our competitors"
```

The command can also be used to set a multitude of table-level attributes. The list of attributes is documented in the section on the table get command.

Example:
table set \$thandle bgcolor "grey80" imagedirectory "/www/images" imageurl "."
table setcell
table setcell tablehandle row column ?attribute value?..
Set the cell data value, or a cell attribute. The following cell-level attributes are supported:

- bgcolor

The background cell color, for output in formats which support this.

- comment

A free-form text comment.

- fgcolor

The foreground cell color, for output in formats which support this

- format

Cell-level data format flags. This is the same set as for the global table attribute of the same name, which is explained in the section describing the table get command.

- image

A $\mathbf{T k}_{\mathrm{k}}$ image handle if the table object is linked to a $\mathbf{T} \kappa$ table widget.

- note

A cell note, which can be a block of arbitrary bytes, not just a string. In output formats such as MS Excel this is displayed as a tool tip.

- shape

Set a KNIME-compatible graph rendering shape for the cell. Valid shape names are default, rectangle, circle, triangle, revtriangle, diamond, asterisk, cross, xshape, hline and vline.

- shapesize

Set a KNIME-compatible graph rendering shape size multiplier for the cell. This is a floating-point attribute, and 1.0 is the default.

- tag

The cell tag in a linked $\mathbf{T} \kappa$ table widget.

- value

The cell data value. It must be encoded in a format which can be decoded as the data type specified in the column definition.

- window

The name of a $\mathbf{T k}$ window displaying cell contents.
The attributes image, tag and window are only useful for developers who want to display a Cactvs table in a GUI tool developed with the $\mathrm{T}_{\mathrm{K}}$ toolkit and its table widget.

## table setcol

table setcol tablehandle column ?attribute value?...
Set column attributes. The following column-level attributes can be set:

- alias

An alias name for the column which can be used to identify it in addition to its numerical index or primary column name.

- bgcolor

The background column color, for output in formats which support this.

- bgcolorfunction

An SQL-style function to compute the background color. If this is set, it has precedence over direct color specification via the bgcolor attribute, but has lower precedence that a background color specified directly on a cell.

- comment

A free-form text comment.

- dataformat

A formatting string which is used in text-oriented formats (i.e. HTML, ExCEL) to reformat the data cell value on file output. Every instance of ' $\% s$ ' in the formatting string is replaced by the cell value string, and that result be written to the file. The original cell content remains unchanged. With an empty formatting string (the default) the normal raw data formatting is used.

- datatype

The column data type, which can be any data type a property definition can use. This attribute can only be set on columns of type data which are not associated with properties, or function columns. If there are already rows in the table when the command is executed, an attempt is made to cast the column values from their original data type to the new one. If this does not succeed, failing cells are set to NULL values.

The special value auto or \#auto can only be used when there are already data rows. With this command argument, and if the current data type is string, and the columns are not associated with a property and its native data type, the string contents of the data cells are analyzed across all rows, an optimally matching numerical data type (boolean, integer, double, date, uint64) is determined and the column data type as well as the cell data contents are updated. This variant is usually used after reading some table data from a file in a format without explicit column data type information. For these inputs, the data is initially stored as string columns in the table object.

- dbflags

This attribute encodes a set of hint flags for setting up SQL database columns for storing data of this table column. It format is the same of the dbflags attribute of property definitions (see prop set command). This column flag overrides the corresponding flag of a property linked to the column.

- dbindex

Specify the type of index to be used on SQL database tables which are derived from this CACTvs table column. Possible values are none (the default, no index), generic (simple index with support for multiple identical values) and unique (primary index with no duplicate column data values).

- description

A free-form textual description of the column.

- displaywidth

A field output formatting width, usually defined in characters. This attribute is different from the fieldlength attribute, which defines an inherent data size. If the width is negative, the attribute is considered unset.

- editable

A boolean flag indicating whether this column is editable or not. The default is editable.

- fgcolor

The foreground column color, for output in formats which support this.

- fgcolorfunction

A SQL-style function to compute the foreground color. If this is set, it has precedence over direct color specification via the fgcolor attribute, but has lower precedence that a
foreground color specified directly on a cell.

- fieldlength

The inherent field length, in characters or significant digits. This is attribute is different from the displaywidth attribute, which is only used for output formatting. A negative value makes the attribute unset.

## - flattening

A boolean flag indicating if the column data should automatically be temporarily flattened (see table flatten command) on output.

- font

The column-level output font name, or an empty string if it is not set.

- fontsize

The column-level font size in points. If not set, zero is reported.

- format

Column-level data format flags. This is the same set as for the global table attribute of the same name, which is explained in the section describing the table get command.

- function

A SQL-style generator expression for the data in the column cells. This attribute has an effect only if the column type if type function. Cell data values are automatically recomputed when the function definition changes, or any of the data in the column the function references.

- headerbgcolor

The background color of column headers. If not set, use an empty string.

- headerdata

A data value for the column header data field. When set, it must be decodable by the input function for the column header data type. Note that this is data for the independent header data field, not for the main column cells.

- headerfgcolor

The foreground color of column headers. If not set, use an empty string.

- headerfont

The font to use for column headers, or an empty string if not set.

- headerfontsize

The size of the font for column headers. If not set, zero is reported.

- headerformat

Column header data format flags. This is the same set as for the global table attribute format, which is explained in the section describing the table get command.

- headerproperty

The name of a property to associate the header data field with. If it is changed, existing column header data is discarded. Note that this is property which is independent of the main column cell property (attribute property).

- imageparameters

A keyword/value parameter set to be used for the computation of images. This attribute has an effect only on columns of type image. Any parameter defined here overrides the parameter of the same name in the global parameter settings on the image property (i.e. E_GIf, E_EMF_IMAGE, etc.). The parameter override is only temporary while the image data is computed. The global parameter set is not changed permanently.

- imageborder

An integer image border value to be used when images are embedded in some output formats. For example, in HTML output this is used for the border attribute in the $<$ img $>$ tag.

- indexed

A boolean flag indicating whether the data of the table column is currently indexed or not. Index creation or re-creation can be forced by setting it to true, and the index can be torn down by setting it to false. Note that this is not the same as the database index attribute dbindex. This index is an in-memory index on the column data which is used to accelerate simple look-ups via the table find command group. The read-only attribute index (see table getcol) is again not the attribute as this one.

- isname

A boolean flag indicating that the column data contains names of persons. If set, table sort and comparison functions use a special string comparison algorithm to deal with titles and other personal name prefixes properly. This flag is ignored for columns which do not hold string data.

- name

The primary name of the column. Columns should avoid duplicate names, though this is not illegal. In case multiple identical column names are desired, a suitable set of unique and different alias names should be configured, and columns only be identified by these alias names.

- note

An arbitrary sequence of bytes attached as a column-level note.

- precision

The precision of numerical column data values, in significant digits. This attribute overrides any precision defined for properties linked to the column. Negative precisions (presumably meaning that the numeric value is only precise to tens, hundreds etc. range) are currently not supported. Setting this attribute also sets the precision column format flag as a side effect.

- property

The name of the property the column data is associated with. If this attribute is set, it also automatically defines the column data type, precision and unit by copying those values from the property definition record. If the property is changed, any current data values on this column are deleted. If the table rows are still associated with chemical objects, an attempt is made to re-fill the column data cells.

It is possible to define table columns which only refer to a specific subfield of a property. In that case, the name of the property is specified with standard subfield addressing syntax:
table setcol \$thandle \$col property E_IRSPECTRUM(source)

- reactionsource

A boolean flag indicating that the data in this table column is a string-based reaction encoding in a format which could, for example, be decoded with a reaction create command. This information can be used to restore reaction information for tables where the rows have no references to external reaction objects.

- shape

Set a KNIME-compatible graph rendering shape for the column. Valid shape names are default, rectangle, circle, triangle, revtriangle, diamond, asterisk, cross, xshape, hline and vline.

- shapesize

Set a KNIME-compatible graph-rendering shape size multiplier for the column. This is a floating-point attribute, and 1.0 is the default.

- structuresource

A boolean flag indicating that the data in this table column is a string-based structure encoding in a format which could, for example, be decoded with an ens create command. This information can be used to restore structure information for tables where the rows have no references to external ensemble objects.

- transform

A transformation function for numerical table data values. The currently supported types are linear (the default), inv (negated), abs (use absolute value), log or $\ln$ (natural logarithm), $\log 10$ (decadic logarithm), $\log 2$ (logarithm base 2), -log (negative natural logarithm), -log10 or $p$ (negative decadic logarithm), -log2 (negative logarithm base 2), percent (multiplied by 100 ) and score (divided by 100). This attribute is for documentation only. The column data values are not updated by changing this attribute.

- type

The table column type. Possible values are none, data (data defined via a property or at least a data type), image (an image of the structure or reaction associated with a data row, with the image property automatically chosen to be suitable for a specific output format) and function for data columns which are dynamically computed and updated from the contents of other columns by means of SQL-style expressions (see function attribute). If the column type is changed, any previous cell data for that column is deleted. If the table rows are still associated with chemical objects, and attempt is made to re-fill the column cells.

- unit

A free-form string describing the unit of the data.

- urn

A URN associated with the column.

## table setparam

table setparam tablehandle property ?keyword value?...
Set parameter values in the metadata section of existing property data attached to the table. This command does not change the parameters for computations in the property definition (see prop setparam command for this function). It only stores its data in the parameter set which was copied into the metadata when the property was computed for the table.

This command does not attempt to compute property data. If the specified property is not present, an error results.
table setrow
table setrow tablehandle rowrange ?attribute value?...

Set row attributes for one or more table rows. The following row-level attributes can be set:

- alias

An alias name for the row which can be used to identify it in addition to its numerical index or primary row name.

- bgcolor

The background row color, for output in formats which support this.

- data

A list of the cell values for the row. The length of the list must be the same as the number of table columns. If more than one row is selected, the same values are entered for all these rows. values is an alias for this attribute.

- editable

A boolean flag indicating whether this row is editable or not. The default is editable.

- ens

Associate an ensemble with the table row. If this ensemble is not the same as the one currently associated, the old row data is invalidated, and an attempt is made to re-fill the row with data from the new ensemble. On retrieval, if no explicit ensemble association is set, but a column of the table is marked as structure source (see table setcol command), an attempt is made to create the ensemble from the data in the columns marked with this flag. These are scanned from left to right. If the data conversion from any of those succeeds, the new ensemble is automatically and permanently associated with the row, and the scan is stopped. An automatically created ensemble exists independently of the table in the normal chemical objects set, and must be explicitly deleted when no longer needed. structure is an alias for this attribute.

- fgcolor

The foreground row color, for output in formats which support this.

- font

The row-level output font name, or an empty string if it is not set.

- fontsize

The row-level font size in points. Setting is to zero disables the attribute for this row.

- format

Row-level data format flags. This is the same set as for the global table attribute of the same name, which is explained in the section describing the table get command.

- height

An integer attribute to set the row height in various output formats, for example Excel or HTML. The unit depends on the output formats - usually these are pixels.

- label

Associate the row with a minor object label. This makes only sense if the table row is also associated with an ensemble, and holds minor object data, such as atom or bond properties. If the value is set to minus one, the label is undefined.

- name

Set the name of the row as arbitrarily formatted string. By default, and if row names were not read from file, rows do not have names and are addressed by their numerical indices. If an empty string is passed, this is interpreted as no name. It is not illegal to have multiple rows with the same name, but in that case care should be taken to identify them by their row index, or a suitably set unique alias.

- note

An arbitrary sequence of bytes attached as a row-level note.

- reaction

Associate a reaction with the table row. If this reaction is not the same as the one currently associated, the old row data is invalidated, and an attempt is made to re-fill the row with data from the new reaction. On retrieval, if no explicit reaction association is set, but a column of the table is marked as reaction source (see table setcol command), an attempt is made to create the reaction from the data in the columns marked with this flag. These are scanned from left to right. If the data conversion from any of those succeeds, the new reaction is automatically and permanently associated with the row, and the scan is stopped. An automatically created reaction exists independently of the table in the normal chemical objects set, and must be explicitly deleted when no longer needed.

- shape

Set a KNIME-compatible graph rendering shape for the row. Valid shape names are default, rectangle, circle, triangle, revtriangle, diamond, asterisk, cross, xshape, hline and vline.

- shapesize

Set a KNIME-compatible graph rendering shape size multiplier for the row. This is a floating-point attribute, and 1.0 is the default.

- selected

Mark the rows as selected or deselected, depending on the value argument.

## table show

table show tablehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the table get command. The difference between table get and table show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, table get and table show are equivalent.

## table sort

table sort tablehandle ?\{column ?direction ?cmpflags??\}?..
Sort the rows of a table according to the cell values in one or more columns. Every sort criterion argument after the table handle argument is a list of between one and three elements. In the simplest case, it is just the name of a single column. Additionally, a sort direction ( $u p$ or down, the default is $u p$ ) can be specified, plus comparison flags. The comparison flags argument supports the same set of flags as in the prop compare command and is explained there in detail.

Sort columns to the left in the column specification have precedence over those on the right. The special column name \#name or \#rowname can be used to sort on the row names, \#row (or \#record) to sort on the row number, and \#random to sort on a random value assigned to every row, effectively duplicating the table randomize command. The row number criterion is also always added implicitly as an additional rightmost sort column to yield a stable sort. If an unstable sort is required, add a final explicit \#random sort column, which has precedence over the implicit row number sort.

The command returns the table handle.

## table sqldget

table sqldget ehandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the table get command. The differences between table get and table sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for $\mathbf{T c l}$ script processing.

## table sqlfind

```
table sqlfind tablehandle expression ?nmax? ?offset? ?mode?
```

This command is very similar to the table sqlselect command, except that the query execution stops after the first matched row.

The result is the index of the matched row, or minus one in case no row matches.

## table sqlget

table sqlget tablehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the table get command. The difference between table get and table sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## table sqlnew

table sqlnew tablehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the table get command. The differences between table get and table sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## table sqlselect

table sqlselect tablehandle expression ?nmax? ?offset? ?mode?

Perform a SQL-style select operation on the table and set the selected row flags depending on whether the row was selected by the query. This command yields multiple matches. For a simple version of the command which stops after the first match, see table sqlfind.

The default mode is new, which resets all current select flags on the rows before running the command. The alternative modes are or, which just sets additional flags, and, which resets the selection flag for rows which are currently selected but not pass the new expression, and eor or xor, which invert the selection flag on all rows which are matched.

By default the number of selected rows is unlimited. This can be explicitly requested by setting the first optional parameter to a negative value. Any positive value stops the execution of the command after the specified number of matched rows have been processed. The second optional parameter is the index of the first row where processing starts. The default is zero, meaning that the table scan is started at the top.

The expression argument is an SQL expression which checks cell values. The syntax of this expression is that of the where clause of an SQL statement. The syntax is compatible to the SQL dialect used in the MrSQL database. Almost all SQL functions that database provides in the 4.1 release can be used here, including aggregate functions and function columns which are dynamically computed. However, only columns in the local table can be used. Cross-referencing to other tables is not supported.

## Example:

table sqlselect \$thandle "E_WEIGHT>avg(E_WEIGHT) and E_NROTBONDS<5"
where E_WEIGHT and E_NROTBONDS are either the names of existing table columns, or the table has retained active row references to ensembles. In case a reference is used, the data is obtained indirectly by reading existing property data from the linked ensemble, or even by computing it on the fly. This type of ensemble- or reaction-linked computation is only possible for column names which can be identified as properties. Existing table columns which are used in the expression can be property columns, function columns, or simple data columns. The use of existing columns has precedence over references, even if the cell data is, for example, NULL and not identical to what would be obtained from the structure object.

Ensemble or reaction references in rows are conveniently introduced by using table addens or table addreaction commands to fill the rows. They are silently lost if the ensembles or reactions which provided the data are deleted from memory. It is possible to save tables in the native Cactvs format with all reference objects, so that they could be restored from a file, but this is not the default. Normally, tables lose object references when written to file and re-read.

The result is a list of the row indices of all selected rows after the operation.
This command is very powerful, but can be overkill in many circumstances. For a simpler, and in many cases faster, alternative refer to the table select command.
table sqlshow
table sqlshow tablehandle propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the table get command. The differences between table get and table sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## table string

table string tablehandle ?format? ?parameter value?...
table string tablehandle ?format? ?optiondictionary?
Encode the contents of the table as a blob image of an file of the specified format. Except that the output goes to a blob instead of a file, this command is the same as table write.

The result value is a byte vector, not a string, so this command can be used with binary table formats.

## table unlock

table unlock tablehandle propertylist/table/all
Unlock property data for the table, meaning that they are again under the control of the standard data consistency manager.

The property data to unlock can be selected by providing a list of the following identifiers:

- Property names

Valid property instances on the table are unlocked. Non-existent data is silently ignored. It is not possible to unlock individual property fields.

- all

All valid table properties are unlocked.

- table

This is an object class identifier. All property data which is controlled by the table major object and attached to the specified object class is unlocked. Since tables currently do not have minor objects, this command does the same as the all variant.

Property data locks are obtained by the table lock command.
The return value is the table handle.

## table unpack

table unpack datastring
Unpack a table from a compressed serialized object string. The string must have been produced by the table pack command.

Packed tables may also be unpacked by the table create command.
The return value is the handle of the newly allocated, unpacked table.

## table valid

table valid thandle propertylist
Returns a list of boolean values indicating whether values for the named properties are currently set for the table. No attempt at computation is made.

Example:
table valid \$thandle T_COMMENT
reports whether the table has a comment property attached or not.

## table varexport

table varexport tablehandle ?varname? ?reset?
Export the table contents into a global TcL array variable in the main interpreter. If the boolean reset flag is given as true, any previous variable contents are erased. If the variable name is not specified, the variable name set via the variable table attribute (see table get command) is used. If the variable name is unset or an empty string, the command does nothing. The variable table attribute is updated if a variable name is supplied.

The rows and columns of the table are translated into a comma-separated numerical index in the array variable, i.e. the cell at the first row and column in the table has the array index " 0,0 ". The addressing is scheme is row-first.

This command establishes a variable trace link between the variable and the table. Any data updates in either the table or the TcL variable is automatically reflected in the other object.

## table varimport

table varimport tablehandle ?varname?
Import cell data from a global TcL array variable in the main interpreter. The array variable is expected to use row and column addressing with row-first numerical, comma-separated indices, and to contain element data which is compatible with the column data types of the table.

If the variable name is not specified, it is taken from the variable table attribute (see table get command). If the variable name is not set, or an empty string, the command does nothing. In any case, the variable table attribute is not changed, and no automatic update link between the TcL variable and the table is established. Existing table cells for which no array variable element exists remain unchanged. Array variable elements which do not correspond to existing table cells are ignored.

## Example:

```
set tvar(0,0) "data_for_row0_col0"
set tvar(0,1) "data_for_row0_col1"
table varimport $thandle tvar
```

If the tvar variable did not exist before, and the table has at least one row and two columns, and these cells can accept string data, the first two table cells in row zero are updated.

The use of this command with variables which are linked to the table object (via table varexport or table set commands) is not required, since data changed a linked variable is automatically propagated.
table wait
table wait tablehandle conditionflags

Suspend execution of the current thread until one or more conditions on the table have been reached. While waiting, the mutex lock on the table is released, so that other threads can manipulate it. While a wait operation is in progress, the table cannot be deleted.

The flags may be a list of one or more of the following flags, plus none or an empty string if no flags should be set:

- definition

A background table import operation has completed to the degree that all column definition and other global table attributes have been completed.

- eod

The end-of-data condition has been reached (see the eod, targeteod and checkeod table attributes)

- export

A background table export operation has finished (see export and exportflags attributes)

- hasrows

The table has one or more rows of data.

- import

A background table import operation has finished (see importport attribute)

- norows

The table contains no (more) rows

- script

A script embedded in an RPC input stream was received. This flag is reset when an RPC transfer for the table begins, and set when either the script was received, or a status flag that no script will me sent in the transmission. In the latter case, the importscript attribute of the table is set to an empty string. Scripts are always transmitted after the table column definition and other structure information has been sent, but usually before all cell data has been transmitted.

## table write

```
table write tablehandle ?filename? ?format? ?parameter value?..
```

table write tablehandle ?filename? ?format? ?optiondictionary?
Save the contents of the table to a file. If no filename is specified, the same name as that the table was originally read from, or set via a table set command, is used. If this name is not set, an error results. Besides a normal file name, standard output and standard error (stdout, stderr) as well as, except on Windows, an open TcL file or socket handle may be specified. If the file name begins with a vertical bar, a pipe channel is opened. If the file name is set, it is remembered as future default.

If no explicit table file format is specified, an attempt is made to infer the format from the file name suffix. If necessary, table I/O modules are loaded automatically. If none of these measures are able to automatically choose an format, the original table format is used if it is defined. If still no table file format can be identified, an error is reported. Otherwise, the selected file format is remembered as future default.

The rest of the optional arguments are either keyword/value pairs (an even number of additional command arguments) or a single dictionary argument with the same possible set of keyword/value pairs. The following keywords are recognized:

## - colblocksize

The column block size. specified as an integer of 1 (the default, no column blocking) or more. Not many table formats support the combination of columns into blocks. This is the same attribute as can be set or retrieved for the table as a table-level attribute, but if used in this context, it is not permanently changed. After the command completes, the old value is restored.

- colnames

A boolean flag indicating whether the column names shall be included in the output or not. This flag is only honored when the file format allows a choice whether to include these or not.

- columns

The argument is a column range list. Only the selected columns are output. By default, all columns are written. The alias cols is also recognized.

- compact

A boolean attribute. If set, the output is formatted in a compact style, if the format supports distinct compact/compressed and expanded/beautified/human-readable representations. For most formats, this flag is ignored.

- embedfileformat

The format of embedded objects in the table. This is equivalent to setting the same attribute with a table set command. It is explained in the paragraph about the table get command.

- flatten

A boolean flag indicating whether the data of columns of complex data types such as vectors and compound properties should be temporarily expanded into columns of simpler data types. Please refer to the table flatten command for more details. In any case, this variant of the flattening operation is transient and the table is restored to the same column set after the write as it had when the command was started. The default value for this option is dependent on the selected output format. If output is in a format which does not support vector data in cells, flattening is performed by default. For output in vector-capable formats, column flattening is disabled by default.

- frame

A boolean value indicating whether certain graphical representations of structures or reactions should be wrapped in a frame or not. Examples are embedded OLE objects in XLSX and RTF output. By default, a frame is drawn around the structure or reaction rendering in these formats, ensuring, for example, uniform size and centering of the images in the output file. This option has only an effect if the rendering is produced implicitly at output time. If cell data has been explicitly set to, for example, an E_GIF or E_EMF_IMAGE, the presence or absence of a frame in the drawing is not checked and must have been configured by suitable property computation parameters when the image was computed. It is also possible to retain an invisible frame by setting its color to the background color, see framecolor table object attribute.

- mode

The output mode for the table, interpreted like the standard text file output modes. The value can be either $w$ or $a$, and is ignored for most table file formats. The only exception are those formats which can store more than one table in the file. For these files, the current table may either be added or replaced in mode $a$ (depending on the sheet name), or a new file is written with the current table as only data in mode $w$. The default value of this option is $w$, and it is not supported for direct string output (table string command), where the implied value is always $w$.

- monochrome

If this boolean value is set, the output of structure and reaction drawings is configured to be monochrome, i.e. use only black and white rendering colors. This applies only to renderings which are created at the moment the file is written (e.g. OLE objects or generic image class columns), but not if, for example, a GIF or EMF image has been set as explicit cell data - these are not re-computed. Cell property data formatting colors are not modified by this flag. The values of the framecolor and markcolor table attributes are ignored when the flag is set.

- overspill

A boolean flag which can be set to prevent distributing tables onto multiple pages if the rendering of the table is larger than the configured paper size. This option has an effect only for output formats which use the concept of a paper as drawing area, such as RTF or CDXML and generally provide means to manually reformat the table in the native editing program (e.g. MS Word for RTF or ChemDraw for CDXML, but not PDF).

- pagebreaks

A boolean attribute which influences the placement of page breaks in some output formats, for example CDXML tables. If set, a new page is started at the end of a column block in rotated mode. By default, the current page is filled until no additional row or column can be placed.

- paperorientation

The orientation of the paper for print output, specified as portrait or landscape. The default is portrait. This is not the same as the rotate attribute, which controls the layout of the table data, not the dimensions of the output medium. Only output formats which use paper-based formatting (currently this is jut PDF) use this attribute. The parameter may also be abbreviated to orientation.

- papersize

The size of the paper, specified as a standard name such as $A 4$ or letter, to be used for formatting. This attribute is currently only used for PDF output and has no effect for other formats. This parameter may be abbreviated to simply paper. If this parameter is not set, the default paper size, which is configurable via the $: \because$ cactvs(paper_size) control variable, is used.

- rotate

A boolean flag which will, if set, virtually rotate the table by 90 degrees counterclockwise for output, thus swapping rows and columns. This is supported only for a few formats, such as HTML and Excel. The table object in memory does not change by this operation. The attribute controls the layout of the table output, not the dimensions of the output medium (see paperorientation parameter).

- rownames

A boolean flag indicating whether the row names shall be included in the output or not. This flag is only honored when the file format allows a choice whether to include these or not.

- rows

The argument is a row range list. Only the selected rows are output. By default, all rows are written.

- sheetname

The name of the sheet the current table is stored in, if the selected output file format supports this concept. The default sheet name is dependent on the output format.

## - structures

A boolean flag indicating whether structures (ensembles and reactions) associated with the table rows should be included in the file. This option has an effect only for a few formats where this is supported, for example the native binary Cactvs table format. Only the primary row object is written - if cell data has been set from other structure objects, their association is not remembered and they are not included in the output.

## The vertex Command

The vertex command is used to access information about vertices in generic network objects (see network command). In many respects the behavior of vertex objects in networks is comparable to that of atoms in ensembles, and the commands for handling vertices are similarly structured.

Pseudo vertex labels first, last and random are special values, which select the first vertex in the vertex list, the last, or a random vertex.

The command node is an alias for vertex, allowing the use of a more standard nomenclature, but without the benefit of a matching prefix on the names of vertex properties. The prefix for vertex properties is $V_{-}$.

The following vertex commands are supported:

```
vertex append
vertex append nhandle label property value ?property value?..
```

Standard data manipulation command for appending property data. It is explained in more detail in the section about setting property data.

## vertex children

```
vertex children nhandle label ?filterset? ?filtermode? ?sphere? ?allow dups?
```

This is a variant of the vertex neighbors command, with the additionally applied constraint that all matching vertices must have a value of property v _LEVEL which is exactly higher by one than that of the originating vertex.

The command parameters are explained in the paragraph on command vertex neighbors.
The vertex parents command can be used to find parents instead of children.

## vertex connections

```
vertex connections vhandle label ?filterset? ?filtermode?
```

Standard cross-referencing command to obtain the labels of the connections the vertex is participating in. This is explained in more detail in the section about object cross-references.

Example:

```
vertex connections $nh $v
```

vertex create
vertex create nhandle ?property value?...
Create a new vertex in the existing network object. The new vertex is created without any connections or initial data except for its automatically assigned label.

An initial set of vertex properties can be set by the optional property/value arguments.
The commands returns the label of the new vertex.

## vertex defined

vertex defined nhandle label property
This command checks whether a property is defined for the vertex. This is explained in more detail in the section about property validity checking. Note that this is not a check for the presence of property data! The network valid command is used for this purpose.

## vertex delete

```
vertex delete nhandle ?label?...
```

vertex delete nhandle all
Delete specific or all vertices and all connections a deleted vertex is participating in.
The command returns the number of deleted vertices.

## vertex dget

vertex dget nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the vertex get command. The difference between vertex get and vertex dget is that the latter does not attempt computation of property data, but rather initializes the property values to the default and return that default if the data is not yet available. For data already present, vertex get and vertex dget are equivalent.

## vertex exists

vertex exists nhandle label ?filterlist?
Check whether this vertex exists. Optionally, a filter list can be supplied to check for the presence of specific features. The command returns 0 if the vertex does not exist, or fails the filter, and 1 in case of successful testing.

Example:
vertex exists \$nh 99

## vertex filter

```
vertex filter nhandle label filterlist
```

Check whether a vertex passes a filter list. The return value is 1 for success and 0 for failure.
Example:

```
filter create rootnode property V_LEVEL value 0 operator =
```

vertex filter \$nh \$v rootnode

## vertex get

vertex get nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

Examples:
vertex get \$nhandle 1 \{V_LABEL V_IDENT\}
yields the label and ID data of vertex 1 as a list. If the information is not yet available, an attempt is made to compute it. If the computation fails, an error results.

```
vertex get $nhandle 1 C_ONTOLOGY_LINK
```

gets the ontology link types of all connections the vertex participates in.
For the use of the optional property parameter list argument, refer to the documentation of the ens get command.

Variants of the vertex get command are vertex new, vertex dget, vertex nget, vertex show, vertex sqldget, vertex sqlget, vertex sqlnew and vertex sqlshow.

Further examples:
vertex get \$nhandle 1 V_ONTOLOGY_TERM(structurehash)

## vertex index

vertex index nhandle label
Get the index of the vertex. The index is the position in the vertex list of the network. The first position is index 0 .

Example:
vertex index \$nhandle 99
vertex neighbors
vertex neighbors nhandle label ?filterset? ?filtermode? ?sphere? ?allow_dups?
This command (which can also be invoked as subcommand neighbours) is a cross-referencing command with some extra options and, in some filter modes, slightly different behavior than the standard object cross-reference subcommands.

In the simplest case, it returns the labels of the immediate neighbor vertices. A neighbor vertex is a vertex which is linked via a connection to the originating vertex. In case the filter list contains connection filters, the connection leading to the originating vertex must pass the check, not just any connection of the neighbor vertex.

Example:

```
filter create onto_isa property C_ONTOLOGY_LINK value is_a operator =
```

vertex neighbors \$nhandle 1 onto_isa
returns a list of neighbor vertex labels which are linked via a connection which encodes an ontological "is a" definition. Neighbor vertices which participate in such a link with another vertex, but not the originating vertex, are not returned.

This command supports two special filtermode values in addition to the standard set (exists, count, exclude, include). The incoming mode only sees links where the originating or previous vertex is the last vertex in the vertex list of any passed connection. The outgoing mode only sees links where the originating or previous vertex is the first vertex in the vertex list of any passed connection.

Example:
vertex neighbors \$nh \$vlabel \{\} outgoing
only returns the links where the originating vertex is the first vertex in the connection linking the originating vertex to its neighbor. In applications where the connections are set up in a directional
fashion, or example in networks representing an ontology with "is a" relationships, this mode allows the traversal of the network in the direction of increasingly generic terms.

By default vertices in the immediate neighborhood are examined, but this change be changed by the sphere parameter. The immediate neighbors are in sphere 1 (the default for this parameter), the next group of vertices is in sphere 2 , and so on. If the sphere is not 1 , the special filtering of connections is no longer active and the normal object substitution mechanism for cross referencing is used. When going beyond the first sphere, it is also possible that a vertex may be reached by multiple paths of the selected length. By default, these vertices are returned only once, but with the last optional parameter this behavior may be changed.

A positive sphere value only selects vertices in that sphere. A negative sphere parameter value returns a list of all neighbors up to and including the sphere identified by the absolute parameter value.

## Example:

```
vertex neighbors $nh $vlabel {} outgoing -5
```

Above example reports the labels of all vertices of to a distance of 5 steps from the starting point which can be reached via outgoing directional connections.

## vertex new

vertex new nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the vertex get command. The difference between vertex get and vertex new is that the latter forces the re-computation of the property data, regardless whether it is present and valid, or not.

## vertex nget

vertex nget nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the vertex get command. The difference between vertex get and vertex nget is that the latter always returns numeric data, even if symbolic names for the values are available.

## vertex parents

vertex parents nhandle label ?filterset? ?filtermode? ?sphere? ?allow_dups?
This is a variant of the vertex neighbors command, with the additional automatically applied constraint that all matching vertices must have a value of property v _ LeveL which is exactly one less than that of the originating vertex.

While it would often be expected that there is only a single parent to a vertex, this is not a condition enforced in a generic network, and potentially multiple parents can be found and reported by this command. In any case, the command alias vertex parent in singular is also recognized.

The command parameters are explained in the paragraph on command vertex neighbors.

The vertex children command can be used to find children instead of parents.

## vertex paths

vertex paths nhandle startlabel destlabel ?parameters?
This command finds paths between a pair of vertices, traversing connections.
The return value of the command is a nested list, even it only a single path is found. Every sublist contains all the labels (if this is not overridden in the parameter dictionary) of the vertices in one path, including those of the start and end vertices. Every connection is used only once in any path, and no path crossings through a vertex are allowed. Every vertex, with the possible exception of path end points, appear only once in any single path. Paths from a vertex via some connections back to itself are allowed. The vertex must be a member of a cyclic connection for such paths to exist.

If the destination vertex is specified as an empty string, all possible paths emerging from the source vertex and not violating any other specified constraints are returned. This includes shorter sub-paths which are contained in a longer paths - these are reported as separate result items.

The optional parameter dictionary can be used to further customize the path walking and result reporting. The following dictionary keywords are recognized:

- filters

A filter set specification to limit the set of vertices and/or connections which can be a part of the path. The default filter set is empty and all vertices and connections can be used in the path.

- flags

A collection of keywords which further modify path traversal and result reporting. Currently, the following flag words are recognized:

## none

Equivalent to not setting any flag

## ascending

Property V _ Leved must increase on each path node, but not necessarily in an uniform manner.

## descending

Property v_Level must decrease on each path node, but not necessarily in an uniform manner.

## constant

Property v_Level must be constant on path nodes

## different

Property v_Level must be different from node to node. The same value may be encountered at multiple nodes, as long as these are not direct neighbors in the path.

## concatenate

Return path as concatenated string, not as list elements

## outgoing

Path connections must be traversed from first to second node in connection definition. This option is useful only if the connections have been set up in a directional fashion.

## incoming

Path connections must be traversed from second to first node in connection definition. This option is useful only if the connections have been set up in a directional fashion.

## rootfinder

Path connections must first be traversed in incoming or outgoing direction, and then in reverse direction to the target node. The point of inversion can be anywhere in the path, but there can only be one.

## minlength

Only report the found paths of minimum length, and those that are the minimum length or less after the lengthfuzz parameter is subtracted, if one was specified. This flag bit is not identical to the parameter of the same name in the general parameter dictionary.

## maxlength

Only report the found paths of maximum length, and those that are the maximum length or more after the lengthfuzz parameter is added, if one was specified. This flag bit is not identical to the parameter of the same name in the general parameter dictionary.

## endpoints

Only report the terminal nodes of found paths, as simple list elements, not the complete path. In addition, reporting of terminal nodes which are contained in the full paths of longer matches are suppressed. The encounter check uses vertex identities, not the properties which are reported in the result. For example, if the result set consists of vertex labels 1-2, $1-2-3$, and 1-2-4-5, the result is a list with elements 3 and 5.

- length

A specific length all reported paths must have. This is equivalent to setting the maxlength and minlength parameters to the same value.

## - lengthfuzz

A fuzz value to allow paths slightly longer than the minimum or slightly shorter than the maximum length to be still reported, if the minlength or maxlength options are set in the flags parameter. The default fuzz is zero.

- maxlength

The maximum length of reported paths. The default maximum path length is 30 . The path length is defined as the number of nodes in the path.

- maxpaths

The maximum number of paths returned. If there are more paths, traversal is stopped early. The default value is -1 , indicating an unlimited number of reported paths. The order in which paths are found depends on the internal representation of the network and is not guaranteed to be canonic.

- minlength

The minimum path length of reported paths. The default minimum path length is 2 , i.e. a path cannot consist only of the start node.

- property

The name of the property whose values are reported as path elements. The default is V_LABEL, the standard vertex identifier. The use of a property name with a subfield instead of a simple property name is also supported.

## Example:

```
vertex paths network0 $v1 $v2 \
    [dict create property V_ONTOLOGY_TERM(id) flags outgoing]
```

This example returns all paths from network vertex $v l$ to $v 2$ in outgoing direction. The reported path data is the value of field $i d$ of property $\mathrm{v}_{-}$ontology_term on every vertex in the paths.

## vertex set

vertex set nhandle label property value ?property value?..
Standard data manipulation command. It is explained in more detail in the section about setting property data.

Example:
vertex set \$nhandle 1 V_IDENT "V1294"

## vertex show

vertex show nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the vertex get command. The difference between vertex get and vertex show is that the latter does not attempt computation of property data, but raises an error if the data is not present and valid. For data already present, vertex get and vertex show are equivalent

## vertex sqldget

vertex sqldget nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the vertex get command. The differences between vertex get and vertex sqldget are that the latter does not attempt computation of property data, but initializes the property value to the default and returns that default, if the data is not present and valid; and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## vertex sqlget

vertex sqlget nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the vertex get command. The difference between vertex get and vertex sqlget is that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## vertex sqlnew

vertex sqlnew nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the vertex get command. The differences between vertex get and vertex sqlnew are that the latter forces re-computation of the property data, and that the SQL command variant formats the data as SQL values rather than for TCL script processing.

## vertex sqlshow

vertex sqlshow nhandle label propertylist ?filterset? ?parameterlist?
Standard data manipulation command for reading object data. It is explained in more detail in the section about retrieving property data.

For examples, see the vertex get command. The differences between vertex get and vertex sqlshow are that the latter does not attempt computation of property data, but raises an error if the data is not present and valid, and that the SQL command variant formats the data as SQL values rather than for TcL script processing.

## vertex subcommands

vertex subcommands
Lists all subcommands of the vertex command. Note that this command does not require a network handle or vertex label.

## vertex vertex

vertex vertex nhandle label
Return the vertex label stored in property V_LABEL. This is useful in case the label used in the command is not a straightforward numerical label but some other vertex identification format.

## Substructure Match Commands

Substructure matching is a complex functionality. While a limited number of object commands are supplied (ens match, mol match, etc.), comprehensive match functionality is accessible via special commands. The match command implements various structure matching commands.

## match ss

The match ss command matches substructures. Its syntax scheme is
match ss ?-option value?... ss_spec st_spec ?atommapvar? ?bondmapvar? ?molmapvar?
Structure and substructure may both be independently specified in several different formats:

- An ensemble handle

This is probably the most common format. It is allowed to match a structure or a part of it onto itself. Example:

```
match ss $ss_handle $st_handle
```

- A list of an ensemble handle and a molecule label.

This short-cut selects one molecule from the substructure or structure ensemble for matching. All other molecules in the ensemble are ignored. Example:

```
match ss $ss_handle [list $st_handle 1]
```

- A smiles or smarts string.

The argument is interpreted as a SMARTS expression, with full query feature support and without implicit hydrogen addition for the substructure argument and as standard SMILES for the structure argument. The temporarily decoded structure is automatically destroyed after the command has completed. However, for the sake of performance, decoded substructure SMARTS structures are cached, so that it is only a small performance hit if the same substructures are repeatedly passed to this command. The exact size of the SMILES/SMARTS cache varies, but is usually around 500 substructures. Example:

```
match ss clccccc1 $st_handle
```

- Another standard string-based structure representation

This includes packed ensemble serialized ensemble object strings, and hex-encoded smiles. These specifications are essentially managed like smiles/smarts strings, but the decoded structures are not cached.

The return value of the command is the number of successful matches. For simple match modes, which return only a match/nomatch result, this is 0 or 1 , but modes which can produce multiple matches may return higher counts.

The final three optional parameters are names of variables which receive atom, bond and molecule mapping information. If these parameters are not supplied, or a variable name is spelled as an empty string, no variable is created or modified. If a variable is specified, but no match is found, the map variables are set to empty strings.

For match modes which can only return a single match, these map variables are simple nested lists. Each list element contains a substructure and a structure object label, in this order. The number of elements in the result list corresponds to the number of substructure objects. Example:
match ss CN CCN amap bmap mmap
The variable amap is set to "\{12\}\{23\}", which is the first match of the C-N substructure fragment on the ethylamine structure. The numbers are atom labels - in case of SMILES strings, atom labels are assigned in the order the atoms appear in the string. The bmap variable is set to " $\{12\}$ ", since only a single bond is involved. The first bond of the substructure matches the second bond of the structure. Finally, the mmap variable is set to "\{lll $11 \begin{aligned} & 1\end{aligned}$ ", because both substructure and structure contain only a single molecule, which was assigned the default label 1 . The bond and mol map results are still nested lists, even if they appear in this simple example as plain lists

There is no guarantee that the lowest possible labels are use for a simple match - the match algorithm uses internal optimizations for choosing good start atoms for matches. Matches should not be expected to start with an atom with the lowest label. Match result variables are filled in the order of the objects in the internal object lists, which also is not necessarily an ascending label sequence.

These nested result lists can easily be transformed to an TcL array with a statement like

```
array set array_amap [join $amap]
```

The array variable array_amap now contains elements which are named with the substructure labels, and have values which correspond to the structure labels. The unzip command is also useful to isolate substructure or atom label sets.

In case a match mode is invoked which can return more than one match, the map variables are constructed with an additional nesting level. They are a list, where each element describes one match. Each of these elements for a specific match is formatted as in above description of simple match results. Note that the actual number of reported matches does not influence the scheme - if there is a theoretical possibility that more than one match can be found, the maximum nesting level is 3 , not 2 , even if only a single match is finally found.

## Example:

```
set nmatches [match -mode distinct CC CCC amap]
```

Here, the match count is 2 (the distinct mode reports matches which differ by at least one structure atom from any previous match - the all mode reports 4 matches, which include reversals of the CC
 substructure atom 1 on structure atom 1 , and 2 on 2 , the second match maps substructure atom 1 on structure atom 2, and substructure atom 2 on structure atom 3 .

The match ss command has a large number of options, which can be used to fine-tune the matching process. Any number of options, in any order, may be inserted before the substructure specification. This is the list of options:

```
-align
    -align none/rotate/redraw/xaxis/yaxis/diagonal/combined
```

If a match was successful, change the layout of the structure by modifying the $A_{-} X Y$ atomic 2 D coordinates property.

Mode none, which is the default, does not perform any 2D coordinate changes.

In modes xaxis, yaxis and diagonal, the coordinates of the matched structure atoms are extracted and the largest principal component/eigenvector of these computed. The structure is then rotated in such a way that this eigenvector is aligned to the x -axis, y -axis, or diagonal (lower left to upper right). No coordinates of the substructure atoms are used.

In rotate mode, the structure is rotated in steps of 15 degrees, with and without a flip. The orientation which is in best alignment with the coordinates of the matched substructure atoms is retained.

In redraw mode, the structure is completely redrawn, using the coordinates of the matching substructure atoms as starting point. The rest of the structure is drawn around it. The matched structure atoms possess the same coordinates as the matching substructure atoms.

There are some limitations in this mode, which are automatically enforced by setting the corresponding match control flags. First, it is not possible to match partial ringsystems. A substructure ring atom must match the same class of ring system, i.e. a substructure 6-membered ring fragment only matches a structure benzene or cyclohexane ring, but not naphthalene, adamantane, etc. This limitation is deeply rooted in the 2D layout generator, which treats ring systems different from the acyclic connections. Acyclic substructure atoms can only match acyclic structure atoms, with the exception that a terminal acyclic substructure atom may still match a structure ring atom.

The final mode besteffort combines the redraw and rotate modes - if a match in mode redraw fails, the match attempt is automatically repeated in mode rotate, which has relaxed match conditions with respect to ring system checks.

## .allowmissingstereo

-allowmissingstereo none/atoms/bonds/both
If not set to none, the default, stereogenic atom or bond centers on the structure side may be matched by corresponding centers on the substructure with defined stereochemistry if they do not possess a non-zero stereo descriptor in A_LABEL_STEREO or B_LABEL_STEREO. If there is a structure-side stereo descriptor on the matched center, the normal stereo match process applies (i.e. absolute or relative stereo matching). This is a global option which applies to the complete substructure pattern. There are also atom- and bond-specific bits in A_QUERY and B_QUERY to control this feature on a local level in the pattern.

## -anchor

-anchor nested_anchor_atom_list
This option defines restrictions on which substructure and substructure atoms must match. The argument is a nested list. where each outer list element is a list of two elements. Each of the inner list elements is either an atom label, an empty string, or the word any. The latter two options are equivalent. The first item identifies a substructure atom, the second a structure atom. If any or an empty identifier is used, it is used as a wildcard. If two atom labels are used, the two atoms must map onto each other in all reported matches. If these atoms are incompatible, no matches are found. If a wildcard is used, it means that the other atom must be part of the match, but without the need to match any specific counter atom. If fuzzy matching is used, this can make sense even on the substructure side. The use of a pair of wildcards is not illegal, but has no effect.

Example:

```
match ss -anchor {{1 2} {any 3}} $sshandle $ehandle
```

This sample line forces the match of substructure atom 1 onto structure atom 2, and the inclusion of structure atom 3 in the match, if one exists given the query features in the substructure specification plus the anchor constraints.

## -atomhighlight

-atomhighlight none/structure/substructure/both
If this flag is set, all matched atoms in the structure (modes structure or both, or numeric encodings 1 or 3 ) or substructure (modes substructure or both, or the equivalent numeric encodings 2 or 3 ) have the highlight flag set in property A_FLAGS. In case multiple matches are generated, the result depends on the -multihighlight option setting. By default, only the first match is highlighted, but highlighting the union of all found matches is also possible. This option does not reset existing atom highlight flags - see the -clearatomhighlight option for this functionality. By default this function is disabled (equivalent to mode none or 0).

## -atommapproperty

```
-atommapproperty none/structure/substructure/both
```

If this flag is set, for each match a new instance of property A_SSMATCH is attached to the structure (in modes structure or both, or numeric encodings 1 or 3 ) ensemble, or a new instance of property A_STMATCH to the substructure (in modes substructure or both, or the equivalent numeric encodings 2 or 3) ensemble - the first match is recorded in A_SSMATCH or A_STMATCH, the second in A_SSMATCH/2 or A_STMATCH/2, and so on. If instances of this property are already set on the structure or substructure ensembles, the new instances start with the highest existing instance number plus one. Structure or substructure atoms which are not used in a match have their respective A_SSMATCH or A_STMATCH data set to 0 . Matched structure atoms are marked with the atom label of the matching substructure atom, and matched substructure atoms with the atom label of the matching structure atom. By default, this flag is not active (equivalent to mode none or 0 ).

## -bondhighlight

-bondhighlight none/structure/substructure/both
If this flag is set, all matched bonds in the structure (modes structure or both, or numeric encodings 1 or 3 ) or substructure (modes substructure or both, or the equivalent numeric encodings 2 or 3) have the highlight flag set in property B_FLAGS. In case multiple matches are generated, the result depends on the -multihighlight option setting. By default, only the first match is highlighted, but highlighting the union of all found matches is also possible. This option does not reset existing bond highlight flags - see the -clearbondhighlight option for this functionality. By default this function is disabled (equivalent to mode none or 0 ).

## -bondmapproperty

```
-bondmapproperty none/structure/substructure/both
```

If this flag is set, for each match a new instance of property $B_{-}$SSMATCH is attached to the structure (in modes structure or both, or numeric encodings 1 or 3 ) ensemble, or a new instance of property B_STMATCH to the substructure (in modes substructure or both, or the equivalent numeric encodings 2 or 3) ensemble - the first match is recorded in B_SSMATCH or B_STMATCH,
the second in B_SSMATCH/2 or B_STMATCH/2, and so on. If instances of this property are already set on the structure or substructure ensembles, the new instances start with the highest existing instance number plus one. Structure or substructure bonds which are not used in a match have their respective B_SSMATCH or B_STMATCH data set to 0 . Matched structure bonds are marked with the bond label of the matching substructure bond, and matched substructure bonds with the bond label of the matching structure bond. By default, this flag is not active (equivalent to mode none or 0 ).

## -bondorder

```
-bondorder 0/1/2
```

This flag determines whether the bond orders of substructure and structure bonds outside aromatic systems is used for determining a match. By default this flag is set, but may be disabled with this option. This option affects only the basic bond match. Bond match query expressions which explicitly or implicitly refer to property B_ORDER always use their comparison results to determine matches. In rarely used mode 2 , bond order matching is only used for terminal structure bonds (i.e. those which contain an atom which participates only in a single bond).
-burn
-burn 0/1
If this flag is set, all matched structure atoms are excluded from any further match during the execution of the current command. Effectively, the matched structure atoms are added to the structure exclusion list (see -exclude_st option). This is an rather exotic option for special-purpose applications, which has an effect only in match modes which generate more than a single match. By default this flag is not set.
-chain
-chain 0/1
If set, this flag allows additional matches after the first match only if these matches are chained to a previous match, i.e. they do not overlap with any previous match, but a normal or complex bond exists between at least one structure atom of the new match and a structure atom of a previous match. In more complex cases, the results of this command variant can depend on the atom order. For example in case of a structure which contains a left part $A$ and a right part $A A$ linked by some construct, matching with substructure fragment $A$ returns a single hit if the left part is matched first, but two fragment matches if the right part is matched first. However, within a single chain of building blocks in the structure it does not matter where the first match occurs - the chain fragment is recursively appended in all directions and ultimately cover all linked blocks. The chain does not need to be linear - rings or star topologies can be matched, too. Obviously, this option has no effect in match mode first, because specific results are only generated when more than a single match is sought.

## -charge

-charge 0/1
This flag determines whether atomic formal charges on the substructure and substructure atoms are used for determining the possibility of an atom match. By default, formal charges are ignored. This option only affects the standard match attributes. Atom query expressions which
explicitly refer to property A_FORMAL_CHARGE always use their comparison result to determine matches.

## -clearatomhighlight

-clearatomhighlight 0/1
If this flag is set, all highlight bits in property A_FLAGS are reset on the structure (and possibly the substructure) ensemble before the first match is processed. By default, this flag is not set and any existing A_FLAGS highlight bit pattern remains unchanged. Because the reset is performed in the routine where the highlight bits are set, this option is effective only in combination with the -atomhighlight option. The decision whether to reset the flags on the structure or substructure side, or both sides, follows the setting of the -atomhighlight mode.

## -clearbondhighlight

-clearbondhighlight 0/1
If this flag is set, all highlight bits in property B_FLAGS are reset on the structure (and possibly the substructure) ensemble before the first match is processed. By default, this flag is not set and any existing B_FLAGS highlight bit pattern remains unchanged. Because the reset is performed in the routine where the highlight bits are set, this option is effective only in combination with the -bondhighlight option. The decision whether to reset the flags on the structure or substructure side, or both sides, follows the setting of the -bondhighlight mode.
-cmpflags
-cmpflags flags
This option provides a direct access to the full set of flags which modify the substructure match process. The more common flags can be set or unset with specific options of this command for convenience. The default flag set is bondorder|useatomtree|usebondtree.

The flag set can either override the default flags (if specified as simple attribute list), added to them (if prefixed with a ' + '), removed, (if prefixed with a '-'), or toggled (if prefixed with a ${ }^{\prime} \wedge '$ ).

These are generally useful flags recognized:

- none

No flags

- arotautomer

See tautomer flag.

- atomlistcontained

When this flag is set and matching a structure side atom list onto a substructure side atom list, the match is only successful if all elements of the structure list are also listed in the substructure list. The substructure list may contain additional elements. By default, an single common element between the lists is sufficient for a positive match. This flag cannot be used together with atomlistidentity.

- atomlistidentity

When this flag is set and matching a structure side atom list onto a substructure side atom list, the match is only successful if the lists contain the same set of allowed elements, though they do not need to be listed in the same order. By default, an single common element between the elements is sufficient for a positive match. This flag cannot be used together with atomlistcontainer.

- bondorder

Match bond order of non-aromatic bonds. This flag should usually be set.

- bondreaction

Match reaction query bond attributes against structure property B_REACTION_CENTER, if present. By default, bond query attributes are not checked for match.

- chained

If multiple matches are found, matches after the first must be aligned in such a way that they are adjacent to an atom matched by a previous match. This flag is used to extract polymer patterns. The use of this flag is explained in more detail in the paragraph on the -chain option.

- charge

Match the formal charge of atoms. Query charges specified in A_QUERY field or part of a atom query expression are always matched, but formal charges on atoms in A_FORMAL_CHARGE are not by default.

- daylight

Use daylight aromaticity for matching, regardless of the currently configured global aromaticity system. This is equivalent to using the -daylightaro option and explained in more detail in its paragraph.

- excludesmartsenvironment

Standard recursive SMARTS matches have no knowledge which atoms and bonds were already matched in upper recursion levels, and all neighbor atoms are again available for re-matching in the new recursion level. If this flag is set, atoms which are already matched by upper recursion level are no longer eligible for re-matching and are effectively removed from the structure visible to the new level.

- fixedframework
if set, the matched structure part cannot be bonded to unmatched non-hydrogen atoms.
- generalizeheteroatoms

Any substructure atom which is not carbon or hydrogen matches any structure atom which is not carbon or hydrogen.

- implicitissinglearo

If set, all bonds which were encoded with an implicit bond order, for example when decoding SMARTS strings, and where this bond status is registered in B_QUERY (flags), are matched as if they were explicitly specified as a single_or_aromatic query bond. This matches the default behavior of Daylight-conforming SMARTS matching.

- isotope

Substructure atoms with an isotope label only match structure atoms with of the same isotope. By default, isotope labels are ignored in matching.

- kekuleeven

The Kekule bond orders of even-membered aromatic rings must match that of the substructure. By default, the formal bond order of aromatic systems is not checked. See also the -kekule option for additional information.

- kekuleodd

The Kekule bond oder of odd-membered aromatic rings must match that of the substructure. By default, the formal bond order of aromatic systems is not checked. See also the -kekule option for additional information.

- matchallheavyatoms

If set, the substructure must cover all non-hydrogen atoms of the structure ensemble for a successful match.

- matchatomringcount

The ring count (in the ESSSR) of the substructure atoms must be the same as that of matched structure atoms. This prevents matching of substructures that are embedded in larger ring systems.

- matchbondringcount

The ring count (in the ESSSR) of the substructure bonds must be the same as that of matched structure bonds. This prevents matching of substructures that are embedded in larger ring systems.

- matchfullens

Matching substructure must match all atoms in the ensemble, including all hydrogen atoms.

- matchfullmolecule

A matching substructure must match all atoms of a fragment, including all hydrogen atoms. There may be unmatched fragments present in the structure ensemble.

- matchfullringsystem

If set, the substructure must match any ring systems of the structure completely or not at all, but not partially. Every ring system is tested independently.

- no3dcoordinatecomputation

When performing a 3D match, no attempt should be made to compute 3D atomic
coordinates of structure ensembles if they do not yet possess them. Instead, the 3D match immediately fails.

- noaliphaticonaro

If set, aliphatic substructure atoms cannot match aromatic structure atoms, even if the other match flags indicate that aromaticity should not be checked.

- noalkyllink

This is an additional criterion for the terminal match flag. If it is set, the single allowed non-hydrogen bond leading from the the matched structure part to the unmatched structure part cannot lead to an unsubstituted carbon with only carbon and hydrogen neighbors.

## - noarobondfg

If set, carbon structure atoms which participate in an aromatic bond are not considered functional groups. This has an effect on matching special pseudo-atoms, such as insulator or terminator fragments.

- noatomstereook

If set, query atoms with specified atom stereochemistry, and general stereochemistry match options active, can match a structure atom without stereochemistry, but not with different stereochemistry. For individual atoms, this can be configured in A_QUERY.

- nobondstereook

If set, query bonds with specified atom stereochemistry, and general stereochemistry match options active, can match a structure bond without stereochemistry, but not with different stereochemistry. For individual bonds, this can be configured in B_QUERY.

- nochainonaro

Substructure bonds that are not ring bonds cannot match aromatic structure bonds.

- nochainonring

Substructure bonds that are not ring bonds cannot match structure ring bonds.

- nochargepaircollapse

Control the match feature that bonds which connect two atoms with opposite formal charges +1 and -1 also match an increased bond order, e.g. a substructure ionic nitro group also matches a pentavalent structure group, and vice versa. This feature is enabled by default, setting this flag switches it off.

- nodoubleonaro

If set, non-aromatic double query bonds do not match aromatic structure bonds. By default they do.

- noheterofg
f set, carbon structure atoms which participate in a bond connecting to a hetero atom are not considered functional groups. This has an effect on matching special pseudo-atoms, such as insulator or terminator fragments.
- nomultibondfg

If set, carbon structure atoms which participate in a multiple, non-aromatic bonds are not considered functional groups. This has an effect on matching special pseudo-atoms, such as insulator or terminator fragments.

- nosingleonaro

If set, single query bonds do not match aromatic structure bonds. By default they do.

- nosmallerring

A matched structure atom cannot be a member of a ring of size 8 or smaller if this ring is smaller than the smallest ring of the matching substructure atom.

- nosuperatomonh

Superatoms (like Beilstein query atoms) in the substructure cannot match a single hydrogen in the structure. Expanding superatoms matching multiple structure atoms, such as alkyl, still match hydrogens attached to inner atoms, such as the hydrogen atoms in a methyl group.

- nullsubstructureismismatch

If this flag is set, a substructure without any atoms does not match any structure. By default, it reports a successful match.

- openhcount

If set, all hydrogen ligand count query attributes are interpreted as lower limits, not as exactly required values.

- piaroatoms

If set, structure atoms which possess $\pi$ electrons and are ring atoms are considered aromatic, even if they are not a member of a full aromatic system.

- relativestereo

If set, stereo query atoms outside explicit stereo groups can match either enantiomer, but only in a synchronized fashion, e.g. an R/S or $S / R$ configuration, but not $S / S$ or $R / R$. This flags implies setting the stereo flag to switch on general stereochemistry matching.

- relaxedmatchatomringcount

A variant of matchatomringcount. A substructure atom can only match if it has the same ESSSR ring count in structure and substructure, or if the substructure atom is not a ring atom and simultaneously a terminal atom. This rather exotic option is used internally for 2D drawing template alignment.

- relaxedmatchbondringcount

A variant of matchbondringcount. A substructure bond can only match if it has the same ESSSR ring count in structure and substructure, or the substructure bond is not a ring bond, and at least one of the atoms of the bond is a terminal atom. This rather exotic option is used internally for 2D drawing template alignment.

- remembermatches

This is an optimization flag. If set, once a match or mismatch between a substructure and substructure atom or bond has been established. it is remembered and not re-checked during atom-by-atom matching. This flag is incompatible with some advanced match options (such as context-sensitive custom callback functions, or SMARTS environment manipulations), but safe for standard SMARTS or MDL-style structure matching. In that case, time savings can be significant especially in match modes returning more than one match.

- restricthydrogenmatches

If set, an explicit hydrogen atom on a substructure fragment can only match hydrogen atoms on the structure which have the same ligand sphere hydrogen index. This avoids the permutation of many hydrogen mappings in match modes which return more than one result. For example, a substructure with two explicit hydrogen atoms bonded to a central carbon atom matches a structure methyl group in six different mapping without this flag, but only one with it. In that mapping, the first substructure H ligand matches the first structure H ligand, and the second substructure H ligand the second structure H ligand. The matching of hydrogen substructure atoms onto different structure atoms is not affected. When using this flag, the true equivalence of the matched structure atoms is not tested - so if isotope labeling of structure H atoms or their 3D coordinates are of significance for the match, it should not be used.

- restrictanyatommatches

If set, any query atoms occurring simultaneously on the substructure and structure sides cannot match each other. They each can only match atoms in the other fragment which are not of the any query type.

- singleattachmentsuperatomsonly

If set, expanding superatoms can only match structure parts which are connected by a single bond to the matched core.

- singleonany

If set, only multiple, non-aromatic bond s in the query need to match the bond order of the structure. Single bonds of the substructure match any structure bond order.

- stereo

Match stereochemistry. In the absence of a set flag for relative stereochemistry (relativestereo) matching this selects matching of absolute stereochemistry. Explicit absolute/relative stereochemistry match instructions, for example via MDL stereo groups, are always matched as specified. This flag only applies to specified atomic stereo centers outside query stereo groups.

- strictexclusion

See-strictexclusion option.

- tautomer

Match tautomeric structure forms. For this, the substructure must contain mobile hydrogens which can be linked to a tautomeric systems in the substructure. If this is the case, and the structure also contains tautomeric parts, the bond orders in the tauto systems need only to match as a sum of bond orders. The hydrogen is not fixed and may match a structure part which is distant from its original attachment point. This version of tautomer matching does not allow tautomer systems to traverse and implicitly dissolve or create aromatic systems. The arotautomer flag is a more aggressive variant which allows this.

- terminall

A successful match has at most one (or another limit, as specified by the maxopenlinks parameter) substructure atom where its matched structure atom has bonds to unmatched structure parts that are not simple hydrogen atoms, and there is at maximum one such bond to an unmatched non-H atom on the structure continuation atom.

- terminal2

A successful match has at most one (or another limit, as specified by the maxopenlinks parameter) substructure atom where its matched structure atom has bonds to unmatched structure parts that are not simple hydrogen atoms, and there are at maximum two such bonds to an unmatched non- H atom on the structure continuation atom.

- terminalbondorder

If set, bond order matching is only performed for structure bonds which are terminal, i.e. where one of the atoms of the bonds only participates in a single bond.

- unsetaromaticisaliphatic

Any substructure atom which is neither in a complete auto-identified aromatic system, nor has an aromatic A_QUERY attribute implicitly bears an aliphatic query attribute.

- useatomtree
heck the full atom attribute query expression tree if present for an atom. If not set, only the flat MDL-style single-level attribute set without logic is used. This flag should be set for normal queries.
- usebondtree

Check the full bond attribute query expression tree if present for a bond. If not set, only the flat MDL-style single-level attribute set without logic is used. This flag should be set for normal queries.

- varbondglobal

If this flag is set, and a parameter for the maximum allowed deviation of fractional bond orders in structure property B_ORDER_ESTIMATE is set, the average absolute deviation of the found structure bond orders in the matched part versus the requested value in non-zero B_QUERY (varbo) substructure values is checked and the match fails if it exceeds the threshold. The -varbondglobal command option sets this flag as a side effect. f that option is not used, the default maximum deviation parameter is 0.0 , i.e. it is very strict

- varbondlocal

If this flag is set, and a parameter for the maximum allowed deviation of fractional bond orders in structure property B_ORDER_ESTIMATE is set, a bond match fails if the absolute difference of the fractional bond order in structure property B_ORDER_ESTIMATE versus the requested query bond order in a non-zero B_QUERY (varbo) value exceeds the threshold. The -varbondlocal command option sets this flag as a side effect. If that option is not used, the default maximum deviation parameter is 0.0 , i.e. it is very strict

- wedge

Match the presence and style of wedge bonds as graphical attributes. This is not the same as matching stereochemistry, since a common stereochemical configuration can have multiple valid wedge representations!

## -command

-command tcl_command
Define a Tcl callback function which is called when a new match is found and all property-based constraints have been checked. This function is called with four parameters. The first two parameters are the handles of the substructure and structure ensembles. The third parameter is a nested list of label pairs (substructure atom label/structure atom label) for all substructure atoms which are currently matched to a structure atom. The fourth parameter is a nested list of label pairs (substructure bond label/structure bond label) for all substructure bonds which are matched to a structure bond. The format of these arguments is the same as that of the map variables of the match command for single-match modes. Within the callback functions, the match can be further evaluated in ways not possible by the standard match options.

If the function returns 0 , any non-numeric value, or throws an error, the post-processing of completed matches, such as atom or bond highlighting, is not executed and the match discarded.

While the callback routine is free to perform any additional match analysis, it must neither delete the structure or substructure, nor change its connectivity (remove or add atoms and bonds), nor discard or invalidate any property data used in the matching process. The
computation or setting of additional property data on the substructure or structure ensembles is allowed.

By default, or in case an empty string is passed as callback procedure name, no callback is executed.

Example:

```
proc my_match_check {ens_ss ens_st amap bmap} {
    puts $amap
    return 1
}
match ss -command my_match_check CC CC
```

This example outputs " $\{11\}\{22\}$ ", which is the atom mapping of the match found.

## -creategroup

-creategroup 0/1
If this flag is set, every match creates a new group minor object on the structure ensemble. The atoms in the group are all those structure atoms which were matched by the substructure. The group name (property G_NAME) is set to the name of the substructure (property E_NAME). By default, no groups are generated as side effects of a match.

## -daylightaro

```
-daylightaro 0/1
```

If the flag is set, the use of Daylight aromaticity in the matching is enforced both on the structure and substructure side regardless of the global aromaticity system setting. For the substructure, this applies to implicitly defined aromaticity, for example the presence of a complete aromatic ring with all defined bond orders and elements, not explicit query attributes.
-exclude_ss
-exclude_ss label_list
-excludelabels_ss label_list
This option allows the exclusion of a set of substructure atoms from the match process. All atoms which are listed here are completely ignored by the match algorithm. By default, or when an empty list is passed, all substructure atoms of the ensemble or molecule (if the handle/molecule label specification was used) are used for matching.

Example:
match ss -exclude_ss [ens atoms \$sshandle hydrogen] \$sshandle \$sthandle
This example does not use any hydrogens on the substructure for matching. This is more efficient and stripping and possibly re-attaching the hydrogen atoms from the substructure.

All substructure atom exclusion options can be combined, but not repeated, and are cumulative.

```
-exclude_st
```

    -exclude_st label_list
    -excludelabels_st label_list
    This option allows the exclusion of a set of structure atoms from the match process. All atoms which are listed here are completely ignored by the match algorithm. By default, or when an empty list is passed, all structure atoms of the ensemble or molecule (if the handle/molecule label specification was used) are available for matching.

All structure atom exclusion options can be combined, but not repeated, and are cumulative.
-exclude_st_root
-exclude_st_root label_list
-excludelabels_st_root label_list
This set of structure atoms to be excluded is similar to the one specified with -exclude_st. The difference is that this exclusion only applies to the first level of matching. In deeper match levels, for example recursive SMARTS expressions, these atoms are no longer blocked.

All structure atom exclusion options can be combined, but not repeated, and are cumulative.

## -excludeenvironment

-excludeenvironment 0/1
If this flag is set and a recursive SMARTS expression is processed, all parts of the structure which are already matched are excluded from the recursive match check. By default, a new recursion level does not have any knowledge about previous matches and may match all atoms in the structure.

Example:

```
match ss -excludeenvironment 0 {C[$(OC)]} CO
match ss -excludeenvironment 1 {C[$(OC)]} CO
```

The first example does match, because the carbon of the recursive fragment may match on the same structure carbon as the first carbon atom in the substructure. In the second case, the structure carbon is marked as already matched, and there is no place to map the recursive fragment carbon, so no match is found.

## -excludeflags_ss

-excludeflags_ss flag_value
This option allows the exclusion of substructure atoms from the match procedure which have at least one of potentially several bits set in the A_FLAGS property. The decoded flag values are used as a bit mask, and all structure atoms which have one or more bits of the mask set are hidden from further processing.

Example:

```
match ss -excludeflags_ss [list starred boxed] $ss_handle $st_handle
```

This example ignores all substructure atoms which have been marked with the starred or boxed attribute.

All substructure atom exclusion options can be combined, but not repeated, and are cumulative.

## -excludeflags_st

-excludeflags_st flag_value
This option allows the exclusion of structure atoms from the match procedure which have at least one of potentially several bits set in the A_FLAGS property. The decoded flag values are used as a bit mask, and all structure atoms which have one or more bits of the mask set are hidden from further processing.

Example:

```
match ss -excludeflags_st [list starred boxed] $ss_handle $st_handle
```

This example ignores all structure atoms which have been marked with the starred or boxed attributes.

All structure atom exclusion options can be combined, but not repeated, and are cumulative.

## -excludestructures

-excludestructures ens_mol_list
Specify of set of exclusion fragments. These structure fragments are exhaustively matched as substructures on the structure, and all structure atoms and bonds they match are excluded from the actual match procedure invoked by this command. The exclusion fragment substructure match is always performed with the default mode settings - options like -bondorder or -charge are only applied to the final match. The exclusion fragments may be specified in the same styles as the main substructure and structure, i.e. as an ensemble handle, a list of an ensemble handle and a molecule label, or as a SMILES/SMARTS string.

Example:

```
match ss {[OH]} CC(=O)O
match ss -excludestructures {C(=O)[OH]} {[OH]} CC(=O)O
```

The first example matches the hydroxyl group of the structure, which is acetic acid. In order to prevent of match of hydroxyl groups which are part of carboxylic acid groups, carboxylic acid groups can be ignored on the structure with a statement like in the second example. Of course, this example could be easily made more generic, such as hiding all groups which have the hydroxyl group attached to any non-carbon, or carbon with any other hetero atom neighbor, as in

```
match ss -excludestructures {[!C,C&x{2-}][OH]} {[OH]} $sthandle
```

All structure atom or fragment exclusion options can be combined, but not repeated, and are cumulative.
-exclude_ss_h
-exclude_ss_h 0/1
If this flag is set, all substructure hydrogen atoms are ignored in the match process. By default, all atoms in the substructure are used.

All substructure atom exclusion options can be combined, but not repeated, and are cumulative.

```
-exclude_st_h
```

    -exclude_st_h 0/1
    If this flag is set, all structure hydrogen atoms are ignored in the match process. By default, all atoms in the structure are used.

All structure atom exclusion options can be combined, but not repeated, and are cumulative.

## -fixedframework

-fixedframework 0/1
If this flag is set, all carbons in the structure are prevented from possessing any unmatched hetero atom or carbon neighbors. Matched structure hetero atoms may be bonded to unmatched hetero atoms or carbon atoms. By default, the flag is not set. The acceptability of extra unmatched hydrogen, carbon, or hetero atom neighbors may be additionally controlled on the atomic level by setting the appropriate flags in property A_QUERY (flags) on the substructure.

## Example:

```
match ss -fixedframework 1 CC CCO
```

match ss -fixedframework 1 CCO CCOC
The first example does not match, because in all possible match orientations there is one matched carbon with bonded to an unmatched hetero atom (the oxygen atom). The second example does match - the matched hetero atom may possess bonds to unmatched non-hydrogen atoms - the methyl group in this case.

This match option is useful for locating starting materials for synthesis in vendor catalogs.

## -forceringmatch

-forceringmatch no/strict/relaxed
This option controls the matching of the substructure into structure ring systems. If the option is not specified, or set to $n o$ (or 0 ), the matching is only controlled by explicitly set atom and query attributes, such as the number of ring bonds, or membership of rings of specific size.

The option value strict allows the matching of substructure atoms or bonds which are members of rings only onto structure parts in ring systems of the same class, i.e. the same set of rings of a given size and arrangement, but without consideration of atoms, bond orders, aromaticity, etc. With this option, a phenyl substructure fragment no longer matches a naphthalene structure, and acyclic substructure atoms or bonds can only match acyclic structure parts. All other query attributes, such as bond order, element type, aromaticity, etc. are applied in addition to this constraint.

The relaxed mode has basically the same constraints, but with one small exception: A terminal substructure atom (an atom which has only a single bond, and thus cannot be a ring member) may match onto structure atoms in ring systems, if the normal query attributes allow this.The relaxed mode is automatically enforced if the -align option with value redraw is specified.
-fuzz
-fuzz n
If this option is used with a value $n$ larger than zero, fuzzy substructure matching is activated. In this mode, it is no longer required that all substructure atoms are mapped to structure atoms. Up to $n$ atoms may fail. Within the A_QUERY property, fields are provided which allow a more
detailed specification whether a substructure atom may be in the fail set, and how much fuzz is allowed in its immediate neighborhood. The -anchor option is also useful to force the use of some critical substructure atoms in the found matches.

This match variant is computationally significantly more expensive than the standard match procedure, and can generate a large set of matches if a match mode which can generate more than one match is used.

Example:

```
match ss -fuzz 1 ClCCCl CCCl
match ss -fuzz 1 ClCCCl CCl
match ss -fuzz 1 ClCCCl ClCCl
```

The first example matches, since there is only a single unmatched substructure atom in the best mapping - one of the chlorine atoms- , but the second and third do not. The third example demonstrates that fail atoms are straightforwardly ignored, but their unmatched neighbors are not allowed to start new implicit fragments. The second chlorine atom in the substructure cannot match because it remains tethered to the main fragment, even if the excess carbon atom in the substructure is designated as the one allowed failure atom. Both example two and three will however match with a fuzz of 2 .
-include_ss
-include_ss labellist
-includelabels_ss labellist
Select substructure atoms for use in matching. By default, all substructure atoms are used. If both an inclusion list and an exclusion list (option -exclude_ss) are specified, the inclusion list is processed first. From the remaining atoms, those which are also listed in the exclusion list are removed.

```
-include_st
-include_st label_list
-includelabels_st label_list
```

Select structure atoms for use in matching. By default, all structure atoms are used. If both an inclusion list and an exclusion list (option -exclude_st) are specified, the inclusion list is processed first. From the remaining atoms, those which are also listed in the exclusion list are removed.
-includeflags_ss
-includeflags_ss flag_value
This option allows the selection substructure atoms for the match procedure which have one of potentially several bits set in the A_FLAGS property. The decoded flag values are used as a bit mask, and only those structure atoms which have one or more bits of the mask set are selected for matching. By default, all substructure atoms are used for matching. If both an inclusion flag set and exclusion flag set (option -excludeflags_ss) is specified, the inclusion list is processed first. From the remaining atoms, those which match the exclusion filter are removed.

## -includeflags_st

-includeflags_st flag_value
This option allows the selection structure atoms for the match procedure which have one of potentially several bits set in the A_fLAGS property. The decoded flag values are used as a bit mask, and only those structure atoms which have one or more bits of the mask set are selected for matching. By default, all structure atoms are used for matching. If both an inclusion flag set and exclusion flag set (option-excludeflags_st) is specified, the inclusion list is processed first. From the remaining atoms, those which match the exclusion filter are removed.
-isotope
-isotope 0/1
This flag determines whether isotopic labeling is used for matching. By default, isotope label matching is not performed. If this flag is set, substructures with an isotope label must map onto a structure atom with the same isotope label. Even if this option is not set, explicit references to property A_I ISOTOPE in $^{\text {in }}$ atom query expressions are always evaluated and used to determine the match.

## -kekule

```
-kekule none/odd/even/all
```

By default (value none or 0), the Kekulé bond order of aromatic bonds is not used for matching. A substructure aromatic bond matches a structure aromatic bond, regardless of whether their Kekulé bond orders are the same or not. If this flag is set to all (or 3), aromatic bonds are compared with the drawn bond order. This can be useful for example in order to find a sequence of atoms for perform a reaction transformation which allows a simple change of bond orders in the path without a complete rearrangement of the full $\pi$ system. The modes odd and even are useful for controlled matching of certain heteroaromatic systems. In mode odd (or 1), the Kekulé bond order is used for all bonds which are only a member of aromatic rings with an odd number of atoms, while the order of bonds in even aromatic systems (including those which are simultaneously a member in an odd aromatic system) is disregarded. Mode even (or 2) is the complementary counterpart.
-limit
-limit n
Set the maximum number of reported substructure matches to $n$. Any additional matches which might be present are ignored.
-mode
-mode
first/all/distinctatoms/distinctheayatoms/distinctinneratoms/distinctbonds/n ocommon/unique/distinctssatoms/dualdistinct/distinctmols/distinctfirstatom
This important option determines the match mode. The default mode is first. In mode first, only the first, if any, match is returned, and any list variables used to capture the atom, bond or molecule maps use only a single level of nesting.

Mode all reports all (subject to a potentially set maximum number of results, see -limit option) all possible matches, which differ in at least one atom mapping relationship to any other reported match.

Example:
set nmatch [match ss -mode all CC CCC]
returns 4, because the C 2 fragment can be embedded in forward and backward direction, and matched on either the first two or last two carbon atoms of the propane structure.

Mode distinctatoms only reports matches which map onto a different set of structure atoms. Example:

```
set nmatch [match ss -mode distinctatoms CC CCC]
```

returns 2 for the mapping of the substructure onto the first two, and the last two carbon atoms. The backward matches of the C2 fragment are not reported, because they do not cover a new set of atoms.

Mode distinctheavyatoms is similar to the distinctatoms mode, but only uses non-hydrogen substructure atoms for determining whether a match should be considered new and included.

Example:

```
set nmatch [match ss -mode distinctatoms {CC[#1]} CCC]
set nmatch [match ss -mode distinctheayatoms {CC[#1]} CCC]
```

The first example reports an astonishing 10 matches, because the hydrogen atom can be mapped to either of the three terminal hydrogens, or two central hydrogens, and there are two distinct embeddings of the substructure C2 fragment. Mode distintheavyatoms reduces the number of reported hits to 2 , because only the atom mappings of the two carbons in the substructure are considered. In many cases, hydrogens can be considered equivalent, and in these cases this mode comes in handy.

Mode distinctinneratoms is similar to distinctheavyatoms, but instead of ignoring all hydrogen atoms on the substructure when determining the novelty of a match, all terminal atoms (those with less than two bonds) are ignored in filtering new matches.

Mode distinctfirstatom is another mode with a modified view of what are distinct matches. This mode only looks at the structure atom matched by the first substructure atom.

Mode distinctmols requires that the substructure matches a different molecule in the structure ensemble in each accepted match.

Mode distinctbonds uses the set of matched structure bonds to determine whether a match is novel. For cage structures, there may be multiple matches of the same structure atoms, but matching different bond paths.

Mode unique is a stricter version of mode distinctatoms. Here, the matched atoms must additionally be topologically different, as determined by property A_HASH (when matching without stereochemistry) or A_STEREO_HASH (in stereo match mode).

Mode nocommon only reports matches which do not share any common atoms. Example:
set nmatch [match ss -mode nocommon CC CCC]
returns only a single match, because the middle carbon atom in the structure is already matched by the first match. Unfortunately, the results of this match mode may depend on the numbering of atoms. If, by change, a C 2 substructure fragment is first matched in the middle of a C 4 chain, only a single match is found, but if it matches first at one of the ends, two matches are found, because the middle match, if found next, is discarded and then the other terminal match is accepted. The described effect is not a problem in all cases, depending on the nature of the substructure, but using this mode requires careful analysis.

Modes distinctssatoms and dualdistinct are only useful in contexts where only a part the substructure may be matched, for example when using the -fuzz option. Mode distinctssatoms is essentially the same as mode distinctatoms, only that the matched atoms on the substructure side are checked, not those on the structure side. Mode dualdistinct uses substructure atom/structure atom pairs instead of simple atom identities as criterion of distinctiveness.
-mapanchor
-mapanchor 0/1
If this flag is set, an anchor set (see option -anchor) is automatically constructed from the values of the A_MAPPING properties on the substructure and structure. A_MAPPING is the default property to encode reaction mapping information. Both substructure and structure must possess valid A_MAPPING data, otherwise this option is ignored. If this condition is fulfilled, any substructure atom which has a non-negative mapping number ${ }^{3}$ is anchored to its counterpart on the structure side with the same mapping number. If no such number is present, the command immediately returns zero matches and empty atom/bond/mol mapping variables, if these were specified. This option can be combined with a normal -anchor option. The anchor tables are cumulative in this case.

## -maxopenlinks

-maxopenlinks n
Limit the number of open links of the substructure embedded in a match. Any continuation of the structure from the matched substructure into the unmatched parts except by hydrogen atoms is considered an open link. Example:

```
match ss -mode distinct CC CCCC
match ss -mode distinct -maxopenlinks 1 CC CCCC
```

The first example reports three matches, the second only two.
In the latter case, the substructure matches only at either end, because in case of a match in the the middle of the C 4 carbon chain there would be two continuation links. The -terminal option is equivalent to using this mode with an open link count of one.
-multihighlight
-multihighlight 0/1
If this option is set, and the options -atomhighlight and/or -bondhighlight are used, and more than one match is generated, the highlight atom and/or bond attributes are also set for the second
3. A negative atom mapping value indicates an unmapped atom.
and further matches, resulting in a highlight set which is the union of all matches. By default, only the first match is highlighted, even if more than one match is generated and reported.
-noaliphaticonaro

```
-noaliphaticonaro 0/1
```

If this flag is set, aliphatic bonds do not map on aromatic bonds. By default, and in the absence of other criteria determining the match of a bond, both single and double (but not triple or higher) aliphatic substructure bonds match aromatic structure bonds, and vice versa. If the flag is set, substructure bonds which are not marked aromatic, either by explicit attribute setting or indirectly by aromaticity analysis of the substructure fragment, do not match aromatic structure bonds. By default, this flag is not set. This option does not influence the processing of bond query expressions which explicitly reference properties such as B_ORDER Or B_ISAROMATIC. These are evaluated in any case.

## -noarobondfg

-noarobondbg 0/1
If this flag is set, aromatic bonds are not considered functional groups. This flag influences the interpretation of the insulator and separator pseudo-atoms, which are constructs used to separate functional groups in the match process. By default, aromatic bonds are considered part of a functional group.
-nodoubleonaro

```
-nodoubleonaro 0/1
```

If this flag is set, double bonds do not map on aromatic bonds. By default, and in the absence of other criteria determining the match of a bond, both single and double (but not triple or higher) aliphatic substructure bonds match aromatic structure bonds, and vice versa. If the flag is set, substructure double bonds which are not marked aromatic, either by explicit attribute setting or indirectly by aromaticity analysis of the substructure fragment, do not match aromatic structure bonds. By default, this flag is not set. This option does not influence the processing of bond query expressions which explicitly reference properties such as B_ORDER or B_ISAROMATIC. These are evaluated in any case.
-noheterofg

```
-noheterofg 0/1
```

If this flag is set, bonds to hetero atoms are not considered part of functional groups. This flag influences the interpretation of the insulator and separator pseudo-atoms, which are constructs used to separate functional groups in the match process. By default, bonds involving a hetero atom are considered part of a functional group.

## -nomultibondfg

```
-nomultibondfg 0/1
```

If this flag is set, non-aromatic multiple bonds are not considered part of functional groups. This flag influences the interpretation of the insulator and separator pseudo-atoms, which are
constructs used to separate functional groups in the match process. By default, non-aromatic multiple bonds are considered part of a functional group.
-nosingleonaro
-nosingleonaro 0/1
If this flag is set, single bonds do not map on aromatic bonds. By default, and in the absence of other criteria determining the match of a bond, both single and double (but not triple or higher) aliphatic substructure bonds match aromatic structure bonds, and vice versa. If the flag is set, substructure single bonds which are not marked aromatic, either by explicit attribute setting or indirectly by aromaticity analysis of the substructure fragment, do not match aromatic structure bonds. By default, this flag is not set. This option does not influence the processing of bond query expressions which explicitly reference properties such as B_ORDER or B_ISAROMATIC. These are evaluated in any case.
-nochainonaro
-nochainonaro 0/1
If this flag is set, substructure chain bonds (acyclic bonds) do not match on aromatic structure bonds. By default, and if no options prohibiting this like -nosingleonaro or -nodoubleonaro are set, single and double chain bonds can match aromatic structure bonds.

## -omitrecursion

-omitrecursion 0/1
This options influences the way matches of recursive SMARTS fragments are reported. Internally, the first atom of a recursive fragment is represented by an any atom on the basic substructure. This placeholder atom and its mapped structure counterpart are reported in atom maps, and the bonds leading to the placeholder in bond maps. If this flag is set, the placeholder atom and its bonds are omitted from the maps.

Example:

```
match ss -omitrecursion 0 {C[$(OC)]} COC amap
match ss -omitrecursion 1 {C[$(OC)]} COC amap
```

In the first example, the atom map contains the pairs " $\{11\}\{22\}$ ", while in the second example only " $\{11\}$ " is returned as atom map.

In any case, detailed mapping information about all the atoms and bonds of the recursive fragment is currently not directly available on the script level.

## -openhcount

-openhcount 0/1
If this flag is set, all hydrogen counts are considered minimum values. If a matched structure atom possesses more hydrogens, the match still succeeds, even if the original comparison operator uses equality as criterion, provided that the compared property value is A_HCOUNT, the standard hydrogen count property, which is the default used by the various query syntax decoders of the toolkit. This option is unusual because it is also applied to comparisons in atom or bond query expressions. By default, this flag is not set.

```
Example:
match ss -openhcount O {[C;H2]} CC
match ss -openhcount 1 {[C;H2]} CC
```

The first example does not match, because both carbon atoms in the structure possess three hydrogen atoms, not two, while the second attempt succeeds. Note that the simple specification

```
match ss -openhcount x {[CH2]} CC
```

succeeds regardless of the setting of this flag. This is a side effect of the implicit expansion of SMARTS hydrogen atoms when they appear directly behind the atom symbol in the default SMARTS decoder mode, which is described in detail in the section about the handling of smiles strings.

Alternatively, it is of course possible to either use standard SMARTS or-connected hydrogen count alternative values, or use the toolkit-specific range extensions, as in

```
match ss {[C;H2,H3]} CC
match ss {[CH{2-}]} CC
```

but in many cases this makes the query more complicated than necessary.

## -overlap

-overlap none/any/nobonds/noembedding/distinctatoms/distinctmols
This option controls how potential overlap of multiple substructure fragments on the target structure is handled. If the substructure contains only a single fragment, this option has no effect.

The default mode is none. In this mode, no overlap of substructure fragments on the target structure may occur. All fragments must be matched side by side, matching different structure parts.

Mode distinctmols is even more restrictive than mode none. In this mode, only one substructure fragment may be matched onto each structure fragment (i.e. molecule).

In mode any, every substructure fragment is treated independently of any other substructure fragment. No information about any match by other fragments is used. Arbitrary overlap of the fragments on the target structure is allowed.

Mode nobonds allows the overlap of atoms, but not of bonds. In effect, multiple fragments may overlap at the edges, but not share any larger structure parts.

In mode noembedding, atoms and bonds may overlap, but no substructure fragment may be completely embedded into the matched structure part covered by another fragment, meaning that at least one of any pair of matching substructure fragments must match an atom which is not matched by the other fragment.

Mode distinctatoms is similar to mode noembedding, but in this mode any pair of matching substructure fragments at least one structure atom must be matched by each substructure fragment which is not matched by the other.

Because internally bitsets are used to track the mapping of substructure fragments, the maximum number of fragments which may be used in any mode but none or distinctmols is 64 . The none and distinctmols modes do not have a maximum fragment count.

## -pionaro

-pionaro 0/1
If this flag is set, any bond between atoms which are part of a $\pi$ system can match an aromatic bond. This option is intended to allow the reproduction of the behavior of the Daylight toolkit, which has a much broader idea about which ring systems are aromatic than the Cactvs toolkit in its default aromaticity mode. The Daylight toolkit recognizes rings with exocyclic keto groups, such as purines and pyrimidines, as aromatic, while this toolkit does not. If the option flag is set, aromatic fragments match on such systems. By default, the flag is not set.

## -rotateterminals

-rotateterminals 0/1
If set, the 2 D bond direction of matched structure-side terminal atoms (i.e. atoms with only a single bond) is adjusted to match that of the direction of the matched substructure-side bond. This option is for example useful to force the same orientation of hydrogens as in a template. Obviously, this option requires for useful results that the general orientation of the matched structure part is the same as that of the substructure pattern. This is usually enforced by combining this option with the -align option in the rotate, redraw or besteffort modes.
-stereo
-stereo none/absolute/relative
This option controls the global use of stereochemistry information of the substructure in the match process. By default, stereochemistry is ignored. If this flag is set, stereochemistry present in the substructure is checked against the stereochemical features in the structure. Stereo checks are performed on a pseudo-3D model of the compound and do not use simple descriptor values such as R and S .

If a stereo center in the substructure is unspecified, any stereochemistry, including unspecified stereochemistry, is allowed on the structure side in the matching atoms or bonds. If stereochemistry on an atom or bond of the substructure is specified, it must match the features found in the structure. Unspecified stereochemistry for the matched bond or center on the structure normally leads to a mismatch, except in case a nostereook flag has been set in A_QUERY (flags) or B_QUERY (flags) for the substructure atoms or bonds. Currently, the substructure match system handles stereochemistry of tetrahedral centers (including those which involve free electron pairs), cis/trans double bonds, allenes (both odd and even) and square planar geometries. Other geometries such as pentagonal bipyramids or octaeders are not yet supported.

With stereo match mode absolute, the pseudo-3D configuration of substructure and structure must match at all stereo centers and diastereomeric bonds specified in the substructure. The alternative mode relative allows the opposite configuration at stereo centers (but not bonds), provided that all matched stereo centers possess the opposite configuration. For example, an S,S-substructure would match both an S,S- and R,R-structure, but not the S,R or R,S-isomer. In effect, only stereo isomers are matched, but not diastereomers. The relative mode is obviously useful only when more than one stereo center needs to be matched.

Explicit atom stereo groups, such as the MDL stereo groups, override the global absolute or relative settings for the atoms involved.

## Examples:

```
match ss -stereo none {[Cl,Br,I][C@H](CC)C} {C[C@H](CCC)Cl}
match ss -stereo absolute {[Cl,Br,I][C@H](CC)C} {C[C@H](CCC)Cl}
match ss -stereo absolute {[Cl,Br,I][C@H](CC)C} {C[C@@H](CCC)Cl}
match ss -stereo absolute {[Cl,Br,I][C@H](CC)C} {C[CH](CCC)Cl}
```

In this example set, the first line matches, because stereochemistry is ignored. The second line does not match, because the target structure represents the opposite stereo isomer. The third line does match, and the last line fails again because the substructure requested matching stereochemistry at a center for which no stereochemical information was available on the structure.

## -strictexclusion

```
-strictexclusion 0/1
```

This is an expert option which controls how substructure fragments are handled which exclusively consist of atoms which bear the attribute that they should not be matched. By default, an attempt to match these fragments is performed after all other substructure fragments have been matched, and their matched structure parts are blocked. If at this point a match of any such fragment succeeds, the match is a failure. However, at this stage, structure parts which could match the exclusion fragment are potentially covered by other substructure fragments and thus protected, if the overlap mode disallows overlaps. If the flag is set, the check of these fragments is performed before the normal substructure fragments are processed. If a match occurs, the match process is immediately aborted.

## -strictsmarts

```
-strictsmarts 0/1
```

If set, substructure argument specifications are decoded as strict SMARTS definitions. This means for example that the non-aromaticity of upper-case elements in SMARTS is enforced. Atoms for which aromaticity is not relevant need to be encoded with \# notation, or as uppercase and lowercase element symbol pair. This flag only has an effect if the substructure is decoded within the match command. If the handle of an existing ensemble is used as substructure specification, its internal representation and match behavior is not changed and was already defined by whatever decoder options were used when it was created.

## -tauto

## -tauto none/basic/advanced

By default, bond orders and location of hydrogen atoms in the structure are fixed. A tautomer of a compound is considered a different chemical entity and does not match another tautomer. If the tautomer match mode is explicitly set to none, the match procedure continues to work in this style.

The alternative tautomer match modes basic and advanced introduce flexibility - at the cost of longer processing times, and a risk of obtaining matches which are surprising at first glance.

Examples:

```
match ss -tauto none {C=CO[H]} CC(=O)C
match ss -tauto none {CC=O} C=C(O)C
```

```
match ss -tauto basic {C=CO[H]} CC(=O)C
match ss -tauto basic {CC=O} C=C(O)C
```

The first two sample lines with the substructures of an enol and a keto group do not find a match with the structures of acetone and its keto form. The second pair of lines does find matches in both cases.

Atom and bond maps can be used with tautomeric matches, but the results can be surprising. The bond of a wandering hydrogen atom in the substructure is matched to the bond with the hydrogen in the original structure. However, since the substructure hydrogen atom may actually have been matched against a different virtual structure than the one passed to the match routine, the partner atoms of the bonds to the hydrogens in the substructure and structure may not have been mapped onto each other!

The difference between the basic and advanced modes is that the basic mode does not disturb aromatic systems, while the advanced mode considers forms which involve the conversion of aromatic systems into quinoids and vice versa, at the cost of extra processing time and less precisely defined matches.

## -terminal

```
-terminal 1/0
```

This is another expert flag, and equivalent to the -maxopenlinks option with a link count of one. If it is set, a maximum of one bond, with the exclusion of bonds to hydrogen, may lead from the matched part of the structure to any non-hydrogen unmatched atoms. Essentially, the substructure is mapped into peripheral regions of the structure.

Example:

```
set nmatch [match ss -mode all CO C(O)C(O)C]
set nmatch [match ss -mode all -terminal 1 CO C(O)C(O)C]
```

In this example, the first line returns two matches, since the CO fragment can be matched onto both CO groups in the structure. The second line finds only a single match. The substructure cannot be matched onto the seconds CO group, because in that match the structure carbon atom has two unmatched non-hydrogen neighbors, one leading to the first CO group, and the other to the methyl group.

## -transferstereo

```
-tramsferstereo none/atoms/bonds/both
```

If not set to none, the default, stereogenic atoms and/or bonds in the structure that are matched by substructure atoms or bonds with defined stereochemistry, but do not already possess their own stereochemistry descriptors, inherit stereochemistry from the substructure. This is done by setting properties A_LABEL_STEREO or B_LABEL_STEREO in such a fashion that the absolute configuration is the same as in the substructure. Depending on the atom and bond labeling of the structure vs. substructure, this is not necessarily the same descriptor value. In order for such a match to succeed, missing atom or bond stereochemistry on the structure side needs to be allowed (see-allowmissingstereo option).

## -timeout

-timeout nsecs
Set a time-out for the match operation. By default, or when a value of zero is given, the routine does not time out. If a time-out occurs, the match procedure is stopped. If any matches have been found so far, these are reported as results, without raising an error.

## -useatomtree

-useatomtree 0/1
This flag is set by default, but may be reset with this option. If the flag is set, atom query expression trees present in property A_QUERY (query) are evaluated and used to determine match possibilities. If this flag is not set, query trees are ignored and only the flat atom match attribute set is used.
-usebondtree
-usebondtree 0/1
This flag is set by default, but may be reset with this option. If the flag is set, bond query expression trees present in property B_QUERY (query) are evaluated and used to determine match possibilities. If this flag is not set, query trees are ignored and only the flat bond match attribute set is used.
-varbondglobal
-varbondglobal maxdelta
If this option is used, the global use of approximated fractional bond orders for coordinate compound hypergraph matching is enabled for bonds with explicit approximated bond order request values stored in property B_QUERY (varbo). The maxdelta parameter is the maximum allowed average deviation of the matched structure bonds (with fractional order in B_ORDER_ESTIMATE) vs. the substructure bonds that have a specified value in B QUERY (varbo) .
-varbondlocal
-varbondlocal maxdelta
If this option is used, the use of approximated fractional bond orders for coordinate compound hypergraph matching is enabled for bonds with explicit approximated bond order request values stored in property B_QUERY (VARBO). The maxdelta parameter is the maximum allowed individual deviation of the fractional query bond orders in B_QUERY (varbo) from the structure-side fractional bond order values of matched bonds stored in property B_ORDER_ESTIMATE.
-wedge
-wedge 0/1
If this flag is set, matching bonds on the substructure and structure sides must possess identical wedge attributes (both wedge tip location and up or down direction). This option should be used only under very specific circumstances. It is not a replacement for stereo center matching, since wedges can be placed onto different bonds around a stereo center, and still represent the same stereo isomer.

## Tips and Tricks

The following code snippet performs a simple maximum common substructure search, using the fuzzy substructure match capabilities of the toolkit:

```
proc max_common_ss {eh1 eh2} {
    set n1 [ens atoms $eh1 count]
    set n2 [ens atoms $eh2 count]
    if {$n1<$n2} {
        set ss $eh1; set st $eh2
    } else {
        set ss $eh2; set st $eh1
    }
    loop i 0 [ens atoms $ss count] {
        set n [match ss -mode unique -fuzz $i $ss $st]
        if {$n} break
    }
    return $n
}
```


## Commands for Non-Chemical Objects

The Cactvs system maintains a set of objects which are not directly connected with chemical entities. These objects do not participate in the standard property scheme. Rather, they are configurable only through a set of fixed attributes, which is not extensible.

The following commands are currently used to manage non-chemical objects:

- cmdx

Tcl extensions similar to standard Tcl packages, but with more metadata

- dbase
perform interaction with database servers
- dbx
manage database interface modules
- factory
manage chemical data processing workspaces
- filex
manage handler modules for chemical file formats
- filter
manage property filters
- Ihasa
manage Lhasa-style chemical reaction rule processing
- keyx
handler modules for associating property data with keys from database tables
- prop
manage property definitions
- repx
manage interface modules for handling alternative representations of chemical objects
- soap
manage SOAP communication and XML parsing
- station
manage pipelined chemical structure data processor objects
- tablex
manage handler modules for table file formats
- typex
manage handler modules for extended data types


## The cmdx Command

The cmdx command is used to manage Tcl command extensions. Cactvs Tcl command extensions are an upward-compatible extension to standard TcL packages. It is possible to load them by means of the standard Tcl commands load or package require, but if loaded in that fashion, the additional metadata and attributes are not accessible.

The following subcommands exist:

## cmdx defined

cmdx defined cmd
Check whether a module for the specified command is either already loaded, or available. If a module can be found, and it not yet loaded, it is automatically loaded.

The return value is a boolean status code. No error is generated when the command cannot be resolved to a module.

## cmdx exists

cmdx exists cmd
Check whether a module for the specified command is already loaded. No attempt is made to auto-load a module if it is not already loaded.

The return value is a boolean status code. No error is generated when the command cannot be resolved to a module.

## cmdx get

cmdx get cmd attribute
Query the value of an attribute of the extension module. Tcl command extension modules are static. There are no $\mathbf{c m d x}$ create or cmdx set commands to define command extensions in a script, or to modify the attribute set of a module. The following attributes can be queried:

- affiliation

The institution the author works for.

- author

The author of a command extension, as free text.

- authorurl

A URL with information on the author, or an empty string if unset.

- category

A category string to be used if the module is stored in a repository.

- classuuid

The base class UUID of this module.

- comment

A free-form comment.

- date

The date of the last change of the module source code.

- doi

A digital object identifier for the module, if defined.

- email

An email address of the author to facilitate contact.

- infourl

A URL with information on the module, or an empty string if unset.

- keywords

A list of keywords associated with the module.

- license

The license class associated with this module.

- licenseurl

A URL with details about the module license.

- literature

A free-form literature reference.

- name

The name of the command.

- objectfile

The full path name of the loaded object file.

- orcid

The ORCID code of the author (see www.orcid.org).

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- references

Cross references of the module. This is a nested list of class UUIDs and reference type tags.

- regid

In case this is a registered module, its official ID. Unregistered modules report zero.

- sourcefile

The name of the source file of the module, if available.

- version

Version information.

- versionuuid

The version UUID associated with this module.

## cmdx list

cmdx list ?pattern?
Get a list of all currently loaded CACTVS TcL command extensions. This list does not include standard TCL extensions. If desired, the list can be filtered by a string match pattern.
cmdx load
cmdx load cmd ?objectfile?

Explicitly load a command extension module. If the module is already loaded, the current version is unloaded first. If no specific object file (a shared library on Unix/Linux, a DLL on Windows, a bundle file for MacOSX) is specified, the standard name of the module file is automatically generated from the data type name, and then the file searched in the directories in the data type handler module path. The module path can be customized in the control variable $\therefore$ :cactvs(cmdxpath).

After loading, the cmd command is available in the interpreter which executed the script command. It is essentially indistinguishable from built-in commands. Command extensions are global and automatically available both in TcL slave interpreters (for scripted property computations) and forked threading TCL interpreters, provided that these interpreters are created after the extension has been loaded into the main interpreter. Pre-existing interpreters of these types do not retroactively obtain access to the command when it is loaded into the main interpreter. Loading extensions directly into slave interpreters or thread interpreters is not possible, because these do not support the cmdx command. Because of these complications, command extensions should preferably be loaded at the very beginning of a script, before threads are forked or property slave interpreters are instantiated.

The return value of the command is the slot in the command extension table the module has been loaded into.

## cmdx subcommands

cmdx subcommands
Return a list of all subcommands of the cmDx command.

## cmdx unload

cmdx unload ?cmd?..
Unload one or more Tcl extension modules. It is an error to specify the name of a module which is not loaded. It is not advisable to unload a command extension which has already been exported to slave or thread interpreters, because this can lead to crashes if these interpreters attempt to use the extension after it has been unloaded.

## The dbx command

The typex command is used to manage database driver extensions. The command has the following subcommands:

## dbx defined

dbx defined dbtype
Check whether a driver module for the specified database type is either already loaded, or available. If a module can be found, and it not yet loaded, it is automatically loaded.

The return value is a boolean status code. No error is generated when the database type cannot be resolved to a module.

## dbx exists

dbx exists dbtype
Check whether a driver module for the specified database type is already loaded. No attempt is made to auto-load a module if it is not already loaded.

The return value is a boolean status code. No error is generated when the database type cannot be resolved to a module.

## dbx get

dbx get dbtype attribute
Get an attribute the database driver module. The following attributes can be queried:

- aliases

A list of recognized alias names of the database type.

- builtin

A flag indicating whether this driver module is built-in. Built-in module cannot be unloaded.

- affiliation

The institution the author works for.

- author

The author of the module, as free-format text.

- authorurl

A URL with information on the author, or an empty string if unset.

- blobsize

The default maximum binary blob size.

- category

A category string to be used if the module is stored in a repository.

- classuuid

The base class UUID of this database interface module

- comment

A free-form comment

- date

The date the module source code was last changed.

- doi

A digital object identifier for the module, if defined.

- email

An email contact address of the developer of the module.

- flags

A collection of flags indicating special capabilities of the module. The only flag currently
used is sqlarrays, indicating support for arrays as column data types.

- history

Module history data

- infourl

A URL with information on the module, or an empty string if unset.

- keywords

A list of keywords associated with the module.

- license

The license class associated with this module. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the module license.

- literature

A free-form literature reference.

- name

The official name of the module. Since the information may be queried via an alias name, this can be different from the command argument.

- orcid

The ORCID code of the author (see www.orcid.org).

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- port

The default TCP/IP port used for communication with database servers.

- protocolversion

The primary protocol version this module supports.

- references

Cross references of the module. This is a nested list of class UUIDs and reference type tags.

- regid

For officially registered data driver modules handlers, this is the assigned registration ID. Unregistered modules report zero.

- slot

The driver table slot this module is loaded into.

- textsize

The default maximum text blob size.

- version

Version information for the module.

- versionuuid

The UUID associated with this module version.

```
dbx list
dbx list ?pattern?
```

Return a list of all currently loaded database driver modules. The output may be filtered by a string pattern.

## dbx load

dbx load dbtype ?objectfile?
Load or re-load a database interface module. If no object file name is specified, the name of the shared library, DLL or bundle is automatically constructed from the database type name, and the module is located by traversing the database module path, which is accessible via the control array element $: \because$ cactvs(databasepath), but this mechanism can be overridden by specifying an explicit object file with or without a path.

Example:
dbx load mysql
Above statement locates and loads the standard driver for interacting with Mysql and Mariadb databases. Depending on the platform, the object file would be named dbx_mysql.so, dbx_mysql.dll, etc.. It is located in the module directory of a standard Cactvs distribution. The return value of the command is the driver table slot number the module was loaded into.

In case the interface module is already loaded, the current module is unloaded first, so this command can be used to update a driver in a running application. Nevertheless, swapping a driver while database access objects which rely on this driver are in existence in the current process is usually not a good idea, though the details on whether this is possible or not depend on the module implementation.

## dbx subcommands

```
dbx subcommands
```

This command returns a list of all the defined subcommands of the dbx command.

## dbx unload

dbx unload ?dbtype?..
Unload zero or more database connector modules. Built-in modules cannot be unloaded. Unloading connector modules for which there are currently active database management objects is potentially dangerous.

## The dbase Command

The dbase command is used to interact with database servers. While the command provides a generic, database-independent set of features, the actual interaction is performed via loadable database driver modules. These are either loaded explicitly (via the dbx load command) or automatically be referring a known database type name.

The dbase command provides the following subcommands:

```
dbase close
dbase close all
dbase close ?dbhandle?...
```

Close open database connections held by the specified database access objects and destroy the connection manager objects. The handles passed to this command are no longer valid after the command has been executed.

The magic handle name all can be used to close all currently opened database connections.
Example:

```
dbase close all
```

The return value is the number of closed database objects. For the sake of consistency with other object commands, the command dbase delete is an alias to this command. Both commands do not delete any database on the server.

## dbase colquery

dbase colquery dbhandle sqlstatement ?tablehandle?
This command is a variant of the dbase query command. By default, the command returns a nested list of rows and columns. This command only returns the first result column, if any are produced, and omits the outer nesting level. This can make the processing of results easier. Example:
set smileslist [dbase colquery \$dbhandle "select smiles from moltable"]
If a tareget table handle was supplied, the return value is a list of the table handle, the row count, and the column count, which is always one.

The command can also be accessed under the name columnquery.

## dbase connect

dbase connect dbhandle
Establish a connection to the database server. An error is thrown if the connection does not succeed. This statement is primarily useful to verify the correctness of the attributes set by means of dbase create and dbase set commands. For the execution of database commands it is not required. In case a database connection was not yet established when communication with the server is required, an attempt to open the connection is made automatically.

If the $d s n$ (data source name) attribute has been set, it has precedence over the connection parameters defined by the database host, port, database, user etc. attributes.

## dbase create

dbase create ?attribute value?...
Create a new database access object. Any number of database access objects can be in existence at the same time, and be connected to the same or different databases, potentially using different database drivers. If no attributes are specified, a default database object is created. Some of the default values can be modified via elements in the ::cactvs() control array:

- default_database

The name of the database. The default is the user name.

- default_database_host

The database host. The default is localhost.

- default_database_options

An option string for drivers which support this. Empty by default.

- default_database password

The database password, if required. Empty by default.

- default_database_type

The database type. Set to mysql by default. The default port is automatically set to the default communication port of the database type (3306 for the mysql case).

- default_database_user

The user name used to connect to the database. By default, this is the same as the user name.
The attributes which may be set by this command the same as in the dbase set command and explained there. The return value of the command is the database object handle, which is used to identify the object in all further operations.

Example:

```
dbase create dbtype mysql database samples host db3 user beaker password muppet
```

Note that this command only sets up the database interface configuration, but does not immediately open a connection. A connection to the database is only opened the first time there is a need to communication with the database server, of the dbase connect command is executed. Until then, it is for example possible to set additional parameters via the dbase set command which are used when the connection is finally established.

## dbase disconnect

dbase disconnect dbhandle
Close the connection to the database established via a dbase connect command or implicitly by data retrieval commands. The interface object remains valid and can, potentially after a change of attributes, reconnect to a database.

In case the interface object was not yet connected, the command does nothing.
dbase dup
dbase dup dbhandle
Duplicate the attributes of an existing database interface object into a new object. The return value is the handle of the new interface object.

This command only copies the configuration options, but does not inherit the database connection, or any related state information. The new interface object is in the same state as if it were created via a dbase create statement with a complete set of attribute and value pairs.

## dbase exec

dbase exec dbhandle sqlstatement ?tablehandle?
This command is a variant of the dbase query command. The difference is that any returned results are discarded and the return value is the current value of the iserror attribute. In case of severe errors. a TCL error is generated.

## dbase exists

dbase exists dbhandle ?database?
Test whether the specified database is visible via the current connection or not. If no database name is specified, the value of the database attribute of the interface object is used for the test. The return value is the boolean test result. If the connection cannot be established, an error is generated.

## dbase flush

dbase flush ?dbhandle?
This command flushes the internal database caches globally or only those associated with the connection. The toolkit remembers certain information, such as database and table names, or database column types, in order to accelerate processing. In case the database content was modified by deleting, adding or altering tables, or full databases have been deleted, renamed, or created, it is advisable to use this command to make sure that the cached information does not become outdated and a source of error.

In circumstances where a database my be accessed via more than one connection, it is best to flush the caches globally, or on all connections which operate on that database if the exact set of affected interface objects is known. Extraneous flushing of the caches does not change any valid results, but can lead to performance degradation.

## dbase get

dbase get dbhandle attribute
Read a database interface object attribute. The list of attributes is explained in the paragraph on the dbase set subcommand.

Example:

```
set id [dbase get $dbhandle insertid]
```

dbase itemquery
dbase itemquery dbhandle sqlstatement ?tablehandle?
This command is a variant of the dbase query command. By default, the query command returns a nested list of rows and columns. This command only returns the first result item, from the first row and first column, if any are returned, and omits the standard two layers of list wrappers. This can make the processing of results easier. Example:

```
set size [dbase itemquery $dbhandle "select count(*) from moltable"]
```

If a table handle is specified as target, the return value is a list of the table handle, row count and column count.

## dbase list

dbase list ?pattern?
Return a list of all currently defined database connector handles.

## dbase query <br> dbase query dbhandle sqlstatement ?tablehandle|new?

Execute an SQL statement on the database server. The allowed SQL syntax is dependent on the capabilities of the connected server.

The default return value is, in the absence of the optional table handle argument, a nested list of rows and columns, with the rows as the outer list level. The maximum number of returned rows can be controlled by means of the maxrows interface object attribute. If table column data type information is available, the internally used TcL result objects are matched to the column type for increased performance. Otherwise, the returned items are strings.

This command is not limited to the execution of SQL select statements. Any supported statement can be executed. In case it does not return a result tuples, an empty set is returned.

In case the optional target table handle argument is supplied, the result is directly stored in the specified table object. When the argument is present and explicitly set to an empty string, or the magic value new, a new table is created, which is automatically destroyed in case the command fails. An attempt is made to map existing table columns to the names of the database query result columns. In case no matching table object columns can be found, they are added automatically on the right with suitable data types, names, precision, width, and so on. Existing table columns which do not receive data from the result set are set to null values in the new rows. Existing table object rows are not deleted when the command is run. The retrieved rows from the database result set are appended. In this mode, the return value of the command is a list of the table handle, the number of rows and the number of columns of the table after the operation.

## Example:

```
set th [table create]
lassign [dbase query $dbhandle \
    "select smiles,name from moltable where logp between 5.0 and 6.0" $th] \
    dummy nrows ncols]
```


## dbase rowquery

dbase rowquery dbhandle sqlstatement ?tablehandle?
This command is a variant of the query command. By default, that subcommand returns a nested list of rows and columns. This command only returns the first result row, if any are received, and omits the column nesting level. This can make the processing of results easier. Example:
dbase rowquery \$dbhandle "select smiles, weight from moltable where cas=' $71-43-2$ " "
If a target table handle was supplied, the return value is a list of the table handle, the table row count (usually one, but in case the command did not return a value, zero) and the column count.

## dbase set

dbase set dbhandle ?attribute value?
Set one or more attributes of the database interface object. Not all attribute changes have an effect after the database connection has been established. Generally, attribute changes which would necessitate the closing and re-opening of the database connection to a different host, or with different access credentials, are ignored after the connection has become active. If such a change is needed, a dbase reset command should be issued, or the current interface object should be discarded and a new one created.

Some attributes are read-only. They are listed here nevertheless, because the dbase get command refers to this section.

The following attributes are currently supported:

- appname

The application name, which may be of interest to the database interface driver. By default it is set to an empty string, and most database interfaces ignore this attribute.

- blocksize

The transmission block size used for database communication. The default, and in anything by exceptional circumstances the only value ever needed, is -1 , which means to use the driver-specific default. This attribute is only of interest to database drivers which support this concept, for example the TDS driver for connecting to MS SQL SERVER databases.

- clientinfo

The client-info string provided by the database interface library, if it has such a feature. This attribute is read-only.

- clientname

The client name, which may be of interest to the database interface driver. By default it is set to an empty string, and most database interfaces ignore this attribute.

- connected

A boolean read-only value indicating whether the connection to the database server has been established or not.

- connectionstring

For database interface libraries which support this concept, a connection string encapsulates all required access information into a single string. If it is not set, an attempt is made to construct a suitable connection string from the basic host, port, user, password etc. attributes if the interface requires it. An explicitly set connection string is reset if the host, port etc. attributes of the interface object are changed.

- database

The name of the current database. If it is changed between calls to the database server, interface commands are automatically issued to synchronize the name of the current database before the next SQL command is executed. The name of the initial database is copied from the value of the control variable : :cactvs (default_database) if it has not been set explicitly by means of dbase create or dbase set statements. In case of the Oracle interface, the value is a service/schema name from the Oracle tnsnames.ora configuration file, since Oracle does not have a simple concept of a database.

This attribute is not the same as databases (plural).

- databases

This is a read-only attribute. It returns a list of the databases which are visible via the current connection. In case of Oracle, the list only contains the current service/schema name. No attempt is made to parse the tnsnames.ora configuration file.

This attribute is not the same as database (singular).

- dbtype

The type of the database to connect to. The default is copied from the value of the control variable : :cactvs (default_database_type). If a driver for the specified database type is not yet loaded, an attempt is made to auto-load it. The possible values for this attribute depend on the set of available database interface modules. Examples are mysql, odbc, tds (to connect to MS SQL SERVER), postgres and oracle.

- description

A free-form string which can be used to add a descriptive text. The default is an empty string.

- domain

The database domain, if the database driver uses this concept. The default is an empty string.

- driver

The name of the driver module for meta-interfaces such as ODBC.

- dsn

For the ODBC driver, the data source name. In a properly configured ODBC environment, this name is used to look up other required connection data, such as host name and applicable driver module, via a single identifier. In a Cactvs installation, the database source name definition file resides in the $o d b c$ subdirectory of the data directory (control variable : :cactvs (data_directory)). The DSN string is reset when the host, port, user, password or database attributes are modified.

- host

The name of the database host. The default database host is copied from the value of the control variable : :cactvs (default_database_host).

- hostinfo

The host-into string provided by the database interface library, if it has such a feature. This attribute is read-only.

- insertid

The last automatically generated id received from the database, for example from inserts into database tables with auto-increment columns. This is not supported on all database interfaces - for example, Oracle requires you to query sequence data explicitly. The value is read-only.

- iserror

A read-only boolean flag to indicate that the last database operation resulted in an error or warning. Not all database operation problems are translated into TcL script language errors. In order to become aware of non-critical problems, is flag should be checked in robust applications.

- language

The language used for database interface messages, if the interface library supports this.

- logfile

The name of a file to use logging for this connection, if the database interface library supports such a feature.

- maxrows

The maximum number of rows read in a result set from a query. If the database interface supports this function, this is enforced on the server side. In any case, the dbase query command variants honor this attribute on the client side. If this attribute is set to zero or a negative value (the default), no row limit applies.

- message

The last message string received from the database. This attribute is read-only. $m s g$ is an alias for this attribute.

- null

The string value used to represent null database values in Tcl return results. By default, it is am empty string, but this is indistinguishable from zero-length strings and therefore it is sometimes useful to change it to something else, such as the string "NULL".

- options

An option string which is passed to the database driver, if it supports this concept. The default option string is copied from the value of the control variable
::cactvs (default_database_options).

- password

The password sent to the database server as part of the credentials. If no password is needed, use an empty string. The default password is copied from the value of the control variable
: :cactvs (default_database_password).

- port

The communication port used to talk to the database server. When the database type is set, it is automatically set to the default port for that database (i.e. 3306 for $m y s q l$ ). If a custom port is used, you therefore need to set it after the database type has been specified.

- protocolinfo

The protocol-info string provided by the database interface library, if it has such a feature. This attribute is read-only.

- protocolversion

The protocol version used by the interface library, if it can supply this information. This attribute is read-only.

- query

The last SQL query executed on the database. This attribute is automatically updated when dbase query/exec/rowquery/colquery/itemquery commands are run, but there are also some conditions when implicitly assembled SQL commands are run which are also tracked here. Setting this attribute is possible, but pointless in normal script environments.

- serverinfo

The server-info string provided by the database interface library, if it has such a feature. This attribute is read-only.

- socket

A the name of an Unix domain named socket, if it is used by the database interface. This attribute should be considered read-only except for database wizards who need to cope with non-standard database server installation settings on the local host.

- table

The current table of interest. This is used for example in constructing database URLs. It has no direct influence on SQL query or command execution, and is not automatically updated when running SQL commands.

- tables

This is a read-only attribute. It returns a list of the database tables visible in the current database via the current connection.

- textsize

The maximum text block size used in database communication. The default, and in anything by exceptional circumstances the only value ever needed, is -1 , which means to use the driver-specific default. This attribute is only of interest to database drivers which support this concept, for example the TDS driver for connecting to MS SQL Server databases.

- trace

A boolean flag which is used to enable or disable SQL statement execution tracing. By default tracing is off. The output is written to the file specified in the tracefile attribute.

- tracefile

The name of a file to write database access trace information to. The default is sql.log.

- timeout

The time-out value in seconds. If a database response it not received in time, an error results. If the value is set to 0 (the default), no time-out is active.

- url

A database URL constructed from the currently set database object attributes (host, port where applicable, database/schema/service name, user, password, table of interest, query). This argument is read-only.

- user

The user name used to provide credentials to the database server. By default, it is the database user set in :: cactvs (default_database_user), which again by default is the same as the login user name.

## dbase subcommands

dbase subcommands
This command returns a list of all the defined subcommands of the dbase command.

## The filex Command

The filex command manages chemical structure and reaction file I/O modules. In many cases, actively loading of I/O modules is not required because of the built-in auto-load mechanism. If the toolkit encounters a file of unknown type, an attempt is made to load a suitable module by constructing the name of the module from the file suffix. However, that mechanism fails in case the file does not have a suffix, or a non-standard suffix, or the data source is not a file but some other stream, such as a network connection, a pipe, or a standard I/O channel. In these cases, explicit managing of I/O modules is required.

The filex command has the following subcommands:

## filex defined

filex defined format
A check to determine whether the specified format is supported by an I/O module. In case the appropriate handler is not yet loaded, an attempt at auto-loading is made. For the equivalent command without auto-loading, see filex exists. The result value is a boolean status code.

## filex exists

filex exists format
A check to determine whether an I/O module for the specified format is currently loaded. This command variant does not attempt auto-loading. The format name may be either the primary name of a loaded module, or any of alias format name aliases the module recognizes. For the equivalent command with auto-loading, see filex defined. The result value is a boolean status code.
filex get
files get format attribute
Query the value of an attribute of the I/O module. The list of attributes is detailed in the paragraph on the filex set command.

In case the format argument cannot be resolved by an active module, an attempt to auto-load a suitable module is made.

## filex list

filex list ?pattern?
List the names of all currently loaded I/O modules. A string match pattern may be used to filter the result list. The variant filex modules is an alias to this command.

## filex load

filex load format ?objectfile?
filex load all
Explicitly load an I/O module. If the module is already loaded, the current version is unloaded first. If no specific object file (a shared library on Unix/Linux, a DLL on Windows, a bundle file for MacOSX) is specified, the standard name of the module file is automatically constructed from the format name, and then the file searched in the directories in the I/O module path. The module path can be customized in the control variable : :cactvs (filexpath).

The return value of the command is the slot in the module table the module has been loaded into. This corresponds to the value of the slot attribute which can be queried via filex get.

The second form of the command scans the currently set I/O module extension search path and loads all accessible modules which are not yet in memory. Modules which are already active in the running application are not unloaded, and only a single instance of each I/O module, even if present under various alias names in the module directories, is loaded. This form of the command does not return a value.

## filex modules

filex modules ?pattern?
This is an alias for filex list.

## filex set

filex set format ?attribute value?..
Set attributes of the I/O module. Compared to other classes of modules, there are rather few attributes in a module which can be set in a meaningful manner. Some of the listed attributes are read-only. They are included in this section because it is cross-referenced from the filex get command. These are the supported attributes:

- affiliation

The institution the author of the module works for.

- aliases

A list of alternative names of for the formats the module supports.

- author

The author of the module.

- authorization

An authorization string, for example a service login URL. This is for example used in the dropbox meta I/O module. In that case, it is a Web URL generated by the module from the compiled-in application secret. Using that URL, the user must log into a Dropbox account and approve access to the files of that account by the application. Only after this has been performed, opening Dropbox files with a molfile open command succeeds.

- authorurl

A URL with information on the author, or an empty string if unset.

- builtin

A boolean read-only boolean flag indicating whether the module is built-in.

- capabilities

A list of features and behaviors the I/O module supports. Only a few of the flags which can be found here can be changed in a productive fashion. These include:

## disabled

Temporarily disable this module, without unloading it

## nommap

Never attempt to memory-map files of this format

- category

A category string to be used if the module is stored in a repository.

- classuuid

The base class UUID of this module.

- comment

A free-form string comment on the module.

- date

The data the module source was last modified.

- doi

A digital object identifier for the module, if defined.

- email

The email address of the author of an I/O module.

- ensproperty

The name of a property which is used to store structure information in the file. This is only used for file formats where storing structure data is a minor objective, not for standard chemical structure exchange formats.

- functions

This attribute is a read-only list of the classes of available functions in the function table of the module. Developers can use this information to determine whether a module is input-only or output-only, or supports acceleration methods for scanning structure files.

- id

The internal format ID of the module in the current program run. This is usually identical to the slot in the extension table for module was loaded or compiled into.

- infourl

A URL with information on the module, or an empty string if unset.

- keywords

A list of keywords associated with the module.

- license

The license class associated with this module. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the module license.

- literature

A free-form literature reference.

- mimetype

The MIME type associated with the file format, for example chemical/x-mdl-molfile. This information is used for constructing HTTP headers for data transfer in Web environments and similar tasks.

- name

The primary name of the format the I/O module handles.

- nitrostyle

The style of nitro groups and similar groups in the file, i.e. whether these are preferably encoded with pentavalent nitrogen or a charge pair. Possible values are asis (does not matter, or unknown), ionic, neutral, xionic and xneutral. If this value is not asis, structures written to the file are automatically adapted. This is performed on duplicates of the output structures, so the objects used in a molfile write or similar command does not change. On the other hand, the requirement to duplicate the object, manipulate the duplicate, and destroy it after it has been used can be time-consuming.

- objectfile

The full path name of the loaded object file or dynamic library. This attribute is read-only.

- orcid

The ORCID code of the author (see www.orcid.org).

- parameters

A dictionary of format-specific keyword/value pairs which are not represented as a general molfile object attribute. When a file of a specific format is opened, the data from the corresponding I/O module is copied to the parameters attribute of the molfile object, where it may be further customized by molfile set commands before an input or output operation. Changing this attribute in the I/O module modifies the initial content of the parameters attribute of all molfile objects associated with this format created in the future. Explicitly changing the format of a molfile object refreshes the parameter set.

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- reactionproperty

The name of a property which is used to store reaction information in the file. This is only used for file formats where storing reaction data is a minor objective, not for standard chemical structure exchange formats.

- readflags

A list of flags to adjust input behavior. Not all flags are supported for all I/O modules. Unsupported flags are silently ignored. The flag set is copied as default to any molfile object which uses the I/O handler module. The flag set is the same as for the molfile readflags attribute, but only a subset of these flags make sense as presets. The flags can be modified on the I/O module level if desired:

- none

The same as an empty list; no flags are set.

- aroresolver

If set, resolve bonds marked in the file as aromatic into a Kekulé system. This includes resolution of bonds which are explicitly marked as query bonds (i.e. bond type 4 in MDL Molfiles). This is very useful to fix frequently seen MDL Molfiles which encode structures, not queries, but nevertheless use an aromatic bond type in violation of the file format specification. Aromatic system resolution works much more robustly for structures with a complete set of hydrogens. It is advisable to combine this flag with automatic hydrogen addition.

## - autowrap

If set, the file is automatically rewound if the end of the file is reached, and the start record of the operation has not yet been encountered again. This behavior only applies to the molfile scan command, not to normal record input. Wrapping is not possible on data source which cannot be rewound.

- basiconly

Only read basic connectivity information, but not additional properties. Supported only on formats which use the native Cactvs structure data storage system (cbin, cbs, bdb).

- chargebalancer

If set, perform a charge balancing step after reading, in an attempt to obtain a neutral structure.

- chargecombiner

If set, perform a charge combination step after reading, in an attempt to obtain a neutral structure.

- complexresolver

If set, try to resolve a purely VB-based structure representation into a representation which utilizes complex bonds for bonds between ligands and metal centers which cannot be described well with electron-counted VB bonds.

- fixdoublespace

If set, this flag instructs I/O modules with support for this feature to read structure files which contain one spurious empty line after each data line, which unfortunately appears to happen sometimes when DOS-encoded files are transferred to Apple systems. This is not the same as reading CR/LF files on CR-only or nL-only platforms, or vice versa, which is always possible and fully automatic. This flag addresses the problem that, due to mishandling by obscure transfer software, duplicated eol-markers are introduced in the file (two identical CR/LF, or CR, or NL pairs after each data line).

- fixstereo

If set, remove spurious atom and bond stereo descriptors assigned to non-stereogenic centers.

- fixwedges

If set, invert wedge bonds encoded with the base at the stereo center to the
IUPAC-conforming style with the tips at the stereo center.

- ignoreempty

If set, records which do not contain any atoms are silently ignored and the next record with atoms is returned instead.

## - ignoreerrors

If set, ignore records with raise errors on file input. Instead, silently attempt to re-synchronize the read pointer and proceed with the next record, until the end of the file has been reached, or an undamaged record could be read successfully.

- ignorevisibility

Ignore any object visibility information in the file and read all data as visible objects.

- ignorecr

Allow an isolated carriage return (ASCII 13) character without following NL (ASCII 10) character as data content instead of examining it as potential line break symbol. This flag is necessarily ignored on Mac-style input files which only use CR as EOL markers.

- ignoreeitherdb

If set, ignore the either flag for double bonds when reading MDL Molfiles. The default is to translate it into the crossed bit of the B_FLAGS property.

- keepcoords

If set, always keep atomic 2D layout coordinates, even if they are, for example in reactions, overlapping on the reagent and product sides. By default the coordinates of molecules are adjusted if necessary to be non-overlapping. This is done by moving molecules only, not by scaling the coordinates, and never by recomputing any coordinates.

- latehprocessing

If set, hydrogen modification (addition, deletion) is performed after standardization operations (see various resolver attributes). By default, hydrogen addition is performed before these routines are called.

- mergedata

If this flag is set, multi-line input from SD file data lines into a simple string property is merged into a single string value, with tab characters indicating the newlines in the file. By default, in such cases every line of a multi-line data item is stored as a new property instance. This is equivalent to the property attribute mergedata (see prop set command).

- multibondcheck

If set, attempt to intelligently resolve any atoms with excessive multiple bonds consuming bond electrons in excess of the available number by recoding such bonds as charge pairs.

- nocoordinatecheck

If set, no attempt is made to add missing coordinates, for example for automatically added hydrogen atoms, to the 2D and 3D coordinate sets, if such coordinates were present in the original record.

- noimplicith

Do not add implicit hydrogen. This flag only applies to file formats which exactly define a default number of hydrogens (for example, SMILES) as implicit part of the structure . It has no effect in file formats which just tend to omit hydrogen (for example, MDL Molfiles).

## - nometal

Assert to the file input routine that the input does not contain any metal atoms. In that case ambiguous atom symbols, for example $C A$ or $C D$ in PDB files, are interpreted as carbon (in alpha and delta position), and not as calcium or cadmium.

## - nometalh

Assert that none of the metal atoms in the structure has any missing hydrogen ligands. If set, hydrogen addition, if selected, skips the processing these atoms.

- noorigin

By default, every ensemble or reaction read from a file is augmented with a property E_FILE Or X_FILE, indicating the origin of the record by recording the file name, record number and other information in the automatically attached property. If this information is not of interest, this wasteful step can be suppressed by setting the flag.

- noradicals

Assert that the file does not contain any radicals. This can for example be helpful in the resolution of aromatic systems (see aroresolver attribute).

- pedantic

Strictly adhere to the format specification and flag any deviation as error. This is feature is only well implemented for MDL Molfiles. It is intended to be used for strict format checking.

- radicalcharger

Edit radicals which are typically formed by reading a file without formal atomic charge information by adding standard formal charges, for example replacing $N R_{4}$ with $N^{(+)} R_{4}$ and OR with $\mathrm{O}^{(-)} \mathrm{R}$. This only works reasonably well if the file contains a complete hydrogen set.

- readas2d

Force interpretation of the atomic coordinates in the record as 2D display coordinates (property A_XY), even if syntax or data items in the file indicate the presence of 3D coordinates. This is useful for simple reading of records where 3D coordinate fields were abused for storing display coordinates.

- readparity

For MDL Molfiles, read the parity information. By default, as recommended by MDL, this information is not read and parity is instead computed from wedges if needed.

- simpleradicals

Assume that any radical encountered is a singlet, and not anything more complex such as triplets etc., regardless what the file encodes.

- tautoresolver

Perform a tautomer standardization on the read structure. This operation invalidates numerous atom and bond properties, such as coordinates, but in this special case all ensemble properties which were attached to the processed structure are retained, regardless of their sensitivity toward atom and bond changes. Tautomer resolution requires a complete hydrogen set, so either these must be present in the input file, or a suitable hydrogen addition mode must have been set on the file handle. The processing behind this input option is comparatively expensive. For normal input, when speedy input and maximum fidelity of the data to the original file is desired, this flag should not be set.

- regid

A numerical registration ID assigned to registered modules.

- references

Cross references of the module. This is a nested list of class UUIDs and reference type tags.

- slot

The slot the module was loaded into. This attribute is read-only.

- sourcefile

The name of the source file of the module. This attribute is read-only.

- suffixes

A list of the file suffixes this module recognizes as typical for the implemented format. If a file with a suffix is opened for writing without specifying an explicit format, the last loaded module which has the suffix in its list determines the automatically assigned format.
Suffixes are ignored as format identifier for file input and updates. In these cases, the file contents are analyzed to determine the format. This attribute is read-only.

- version

The version of the module as a free-form string.

- versionuuid

The version UUID associated with this module version.
In case the format argument cannot be resolved by an active module, an attempt to auto-load a suitable module is made.

## filex subcommands

filex subcommands
List all supported subcommands of the filex command in an installation.

## filex unload

filex unload ?format?..
Unload zero or more I/O modules. It is an error to specify the name of a module which is not loaded.
Built-in I/O modules cannot be unloaded. If the use of one of these needs to be switched off, it is possible to set the disabled flag of the capabilities module attribute via the filex set command.

## The filter Command

The filter command is used to manage filter objects. Filter objects are a convenient method to quickly access subsets of objects, for example subsets of atoms or bonds with specific properties.

A filter basically consists of the name of a property which is used as foundation for the comparison. It also defines a comparison operator and one or more comparison values. Objects whose property values of the filter property pass the test are passed on to further processing.

The filter command has the following subcommands:

## filter create

filter create filtername ?attribute value?..
Create a new filter. In case the filter already exists, this is the same as filter set. A default filter without any other configured attributes does nothing and lets everything pass. The supported attributes and values are explained in the paragraph on the filter set command.

The return value is the filter name.

## filter defined

```
filter defined filtername
```

A boolean check whether the filter is available. In case it is not yet in memory, an attempt is made to auto-load or auto-instantiate it. For a command variant without auto-loading, see filter exists.

## filter exists

filter exists filtername
A boolean test whether the filter is current defined and loaded. No attempt is made to auto-load it. For a command with auto-loading, see filter defined.

## filter delete

filter delete ?filtername?..
Delete zero or more filters. Note that it is possible to delete built-in filters. An attempt to delete a non-exiting filter raises an error. The return value of this command is the number of deleted filters.

## filter get

filter get filtername attribute
Query an attribute from a filter definition. The supported attributes are detailed in the paragraph on the filter set subcommand.

If the specified filter is not yet loaded, an attempt to auto-load a definition file is made.

## filter list

filter list ?pattern?
Get a list of all currently loaded filters, including the built-in filter definitions. If desired, a string match pattern can be supplied to filter the reported set.

## filter load

```
filter load filtername
filter laod all
```

Attempt to explicitly load a filter via the auto-loader mechanism. If the filter is already in memory, the command has no effect. In case auto-loading fails, an error results. The return value is the filter table slot index the filter is loaded into.

The second form of the command scans the currently set filter search path and loads all accessible filters which are not yet in memory. Filters which are already active in the running application are not unloaded, and only a single instance of each I/O filter, even if present under various alias names in the filter directories, is loaded. This form of the command does not return a value.

## filter query

filter query keyword ?objectclass? ?mode? ?casesensitivity?
Search the internal filter database by matching the keyword against a standard set of filter attributes, such as name, description, keywords, category, comment and UUIDs. Only the current memory database is checked, no auto-loading or repository checks are performed.

By default all filter definitions are matched. The object class argument (such as atom) can be used to limit the search to filters using a property of a specific property class. Providing an empty argument is the same as omitting the argument.

The optional mode argument changes the string comparison mode. The default is equal, other possibilities are substring, left (match beginning of string), right (match end of string), like (as the SQL operator), glob or regexp.

The final argument can be case (case-sensitive matching) or nocase (case-insensitive comparison, this is the default).

The return value is a list of the version UUIDs of the matched filters.

## filter read

filter read filename
Read a filter definition file with one or more filter definitions. In case a filter is already defined, its definition is overwritten by what is found in the input file.

The return value is a list of two elements. The first element is the total number of filter definitions read from the file. The second element is the name of the first filter read.
filter set
filter set filtername ?attribute value?...
Set one or more filter attributes. Some of the attributes listed below are read-only. They are included here because the filter get subcommand refers to this section. The following attributes are supported:

- affiliation

The institution the author of the filter definition works for.

- aliases

A list of alias names for the filter.

- author

The name of the author of the filter definition as free text.

- authorurl

A URL with information on the author, or an empty string if unset.

- category

A category string to be used if the filter is stored in a repository.

- classuuid

The base class UUID of this filter.

- comment

A free-form comment string.

- date

The date of the last change in the filter definition.

- doi

A digital object identifier for the filter, if defined.

- email

An email contact address of the author of the filter.

- field

The name of a field of the filter property. In case the complete property is used, which is the default, this is an empty string. This field may also be set directly by using subfield notation in the property attribute.

- fieldindex

In case a only a field of the filter property is used for comparison, this is the numerical index, starting with 0 , of the field in the property. This is a read-only attribute and automatically updated then setting the subfield attribute. If the complete property data is used, by the filter, the value of this attribute is -1 .

- file

The full path name of the file the filter definition was read from, or an empty string if the filter is built-in or defined in the script. This is a read-only attribute.

- flags

Various flags to modify the operation of the filter. The flag set can be any combination of words from the set

- notavail_fail

If set, the filter fails if the filter property cannot be computed, but no error is raised

- notavail_pass

If set, filter always passes if the filter property cannot be computed, but no error is raised

- nocompute

If set, do not attempt to compute the filter property on the filtered object, if it is not yet present, this condition is treated as a failed computation

## - recompute

If set, the filter property is recomputed once when the filter data is prepared for a filter operation. For example, the property of an atom filter is re-computed once before an ens atoms command, but not for the filter test of each individual atom.

The get variant of this command can additionally return several flag words describing the current internal state of the filter definition.

- infourl

A URL with information on the filter, or an empty string if unset.

- keywords

A list of keywords associated with the filter.

- license

The license class associated with this filter Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the filter license.

- literature

A free-form literature reference.

- mode

The filter operation mode. This is an important, but complex attribute. The default value is simple, and this is what is needed in almost all standard applications. The possible values for this attribute are:

- simple

Straightforward application of the filter. The property values of the filtered chemistry objects are directly compared to the filter values. In case the filter property has a width of more than one slot (see width attribute of property definitions), it is sufficient if any of the multiple values passes the filter.

- all

Only usable for properties with a width of more than one. In this mode, all of the multiple property slot values of a chemistry object must pass the filter.

- diff

Only usable for properties with a width of more than one. In this mode, among the multiple property slot values on a tested object there must be some which pass, and some which fail.

- allatoms

Instead of using the filtered chemistry object, use all atoms the chemistry object contains. All atoms must pass the filter condition.

- someatoms

Instead of using the filtered chemistry object, use all atoms the chemistry object contains. Some atoms must pass the filter condition.

- noatoms

Instead of using the filtered chemistry object, use all atoms the chemistry object contains. No atoms must pass the filter condition.

- diffatoms

Instead of using the filtered chemistry object, use all atoms the chemistry object contains. There must be atoms which pass the filter as well as atoms which fail.

- allneighbors

Instead of using the filtered chemistry object, use all neighbor objects of the same type. All neighbors must pass the filter condition. Currently, neighborship is only defined for atom and bond objects.

- someneighbors

Instead of using the filtered chemistry object, use all neighbor objects of the same type. All neighbors must pass the filter condition. Currently, neighborship is only defined for atom and bond objects.

- noneighbors

Instead of using the filtered chemistry object, use all neighbor objects of the same type. All neighbors must pass the filter condition. Currently, neighborship is only defined for atom and bond objects.

- diffneighbors

Instead of using the filtered chemistry object, use all neighbor objects of the same type. There must be neighbors that pass the filter condition as well as neighbors which fail. Currently, neighborship is only defined for atom and bond objects.

## - name

The primary name of the filter. Since alias names are also used to resolve a filter reference, this may be different from the argument supplied in the command.

- operator

The operator used for comparing the filter value(s) to the property values of the compared chemical objects. It can be one of

- exact
object and primary filter value must match
- smaller
object value must be smaller than the primary filter value
- larger
object value must be larger than the primary filter value
- range
object value must be between the primary and secondary filter values
- not
object and primary filter value must not match
- bitset
object value must have all on bits in the primary filter value also set
- bitunset
object value must not have any bit of the on bits in the filter value set
- alternative
object value must be equal to the primary or secondary filter value
- neither
object value must be different both from both filter values
- le
object value must be larger or equal to the primary filter value
- ne
object value must be smaller or equal to the primary filter value
The standard mathematical operator notation $>,>=,==$ etc. may also be used to identify the operator.
- orcid

The ORCID code of the author (see www.orcid.org).

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- property

The name of the property associated with the filter. In the context of the filter create or filter set commands, the property name argument may include a field component. If a field is specified as part of the name, the subfield and subfieldindex attributes are also set as a side effect. Example:
filter create alphac property A_RESIDUE (atomtag) value "CA" operator =
This defines a filter alphac which selects all atoms which have the value $C A$ in the field atotmag of the A_RESIDUE property, which is for example filled when reading PDB files.

- references

Cross references of the filter. This is a nested list of class UUIDs and reference type tags.

- regid

If the filter is registered, this is its registration ID. Unregistered filters have a zero registration ID.

- valuel

The primary filter comparison value. This may also be simply written as value without the rank indicator. The value can be specified in any notation which can parsed as data value of the filter property. Changed filter values are parsed after the filter set or filter get command has processed all its arguments. The order of arguments does not matter, but at the end of the command, the property and data value must be compatible.

- value2

The secondary filter comparison value. The same restrictions apply as for the primary filter comparison value.

- value 3

The auxiliary filter comparison value. The same restrictions apply as for the primary filter comparison value. This value is not used directly in conjunction with any of the scriptable comparison operators, but it does have a role in some internal functions.

- version

The version of the filter definition as free-form string.

- versionuuid

The version UUID associated with this filter version.
If the filter argument is not yet loaded, an attempt to auto-load the definition file is made.

## filter subcommands

filter subcommands
Get a list of all supported subcommands of the filter command in this particular application.

## filter write

```
filter write filtername ?filename?
```

Write the current definition of the filter to a file in XML format. The file can be loaded into future script interpreters explicitly (see filter read command) or implicitly via the filter definition auto-load mechanism. If no file name is given, the name of the file is automatically constructed from the filter name in lower case and the suffix .fil. In addition to normal file names, the magic names stdout and stderr may be used, as well as already opened TcL socket and file handles, plus pipes indicated by a file name which starts with " $\mid$ ". Writing to TcL channels is not supported on the MS Windows platform.

It is possible and sometimes useful to write out built-in filter definitions.

## The json command

The json command is used to facilitate network communication by means of exchanging JSON-RPC messages. JSON message objects are also useful to parse other styles of JSON-formatted data which are not really JSON-RPC but use basic JSON encodings.

JSON objects are created like other toolkit objects, and have internal state, so it is possible to communicate with multiple sources simultaneously by creating a JSON object for every channel.

JSON objects share many characteristics with SOAP objects, and many commands are identical or at least very similar.

Only interpreters compiled with JSON support contain this command.
These are the currently supported JSON object commands:

```
json append
json append jsonhandle ?attribute value?...
```

This is a variant of the json set command. The difference is that the supplied data is appended to the current attribute value instead of replacing it. In case appending is not a possible operation, the result is the same as using json set.

The set of supported attributes is explained in the paragraph on json set.

## json create

```
json create ?attribute value?...
```

Create a new JSON object. The return value is the object handle. If no additional attributes are specified, an empty object with default settings is created. Processing of specified optional attribute/value pairs is performed in as an identical fashion to the json set command.

```
json delete
json delete ?jsonhandle?...
json delete all
```

Destroy one or more JSON objects. The special handle all can be used to remove all JSON objects currently existing in the application.

For the sake of consistency with commands of similar objects, json close is an alias to this command.

The return value is the number of successfully deleted JSON objects.

## json error

```
json error jsonhandle ?errormessage? ?channel? ?errorcode? ?errordata? ?id?
```

Assemble and potentially send a properly formatted JSON-RPC error message. The formatted message is stored in the result attribute of the JSON object, returned as command result, and also sent via the channel if either the argument is a valid TcL channel handle, or the object has an associated channel in the internal attribute set.

All message parameters are taken from the internal object attribute set if they are not explicitly set in the arguments. If arguments are set, the corresponding object attributes are also updated. Any arguments must be properly formatted - the error code and ID are an integer, the error message a simple string, and the error data a complete JSON object encoding.

Since this command is a reply to a specific message ID, the internal object ID attribute is not incremented, as in the json request command.
json get
json get jsonhandle attribute
Query the value of an attribute of a JSON object. The list of recognized attributes is explained in the paragraph on the json set command.

The return value of the command is the value of the attribute.

## json list

json list ?pattern?
Return a list of the handles of all currently existing JSON objects in the application. If desired, the list can be filtered by a string pattern.
json parse
json parse jsonhandle ?data?
Parse a JSON-RPC message. If the data argument is set, its value used. Otherwise the parsed data is the value currently stored in the body object attribute, which is for example set by the json read command. The command does not replace the body attribute of the object if an explicit argument is set.

The command resets the ID, error code, error message, error data and result attributes of the object and then re-populates those object fields for which data is found in the message.

The return value of the command is one, if the message was a valid result reply, and zero if the message was an error report. In case of a syntax error in the parsed data, a Tcl error is generated.

After parsing, the result and errordata object attributes, if they were set during the parse, are still JSON object encodings. In most cases these are further dissected by the application of a decode -json command.

## json read

json read jsonhandle ?channel?
Read one JSON-RPC message from the channel. If no channel argument is supplied, the internal channel handle of the object is used. It the channel argument is set, the internal handle is also updated.

The command recognizes HTTP headers in the input stream and stores these separately from the message body in the internal header object attribute. Only a single message is read from the channel, so in case there are multiple messages queued, the command must be repeatedly invoked. The complete message text, without header if there was one, is stored in the body object attribute.

The command returns the full message text, which is the same as the body attribute. It is not parsed or analyzed further. This command does not alter the errorcode, errormessage, errordata or result fields of the object. In most cases, the next step after reading a message is to analyses it with a json parse command.

## json respond

json respond jsonhandle ?result? ?channel? ?id?
Assemble and potentially send a properly formatted JSON-RPC result message. The formatted message is stored in the result attribute of the JSON object, returned as command result, and also sent via the channel if either the argument is a valid TcL channel handle, or the object has an associated channel in the internal attribute set.

All parameters are taken from the internal object attribute set if they are not explicitly set in the arguments. If arguments are supplied, the corresponding object attributes are also updated. Any arguments must be properly formatted - the result argument is a JSON object encoding and the ID is an integer.

Since this command is a reply to a specific message ID, the internal object ID attribute is not incremented as in the json request command.

The command can also be spelled as json reply.

## json request

json request jsonhandle ?method? ?channel? ?parameters?
Assemble a properly formatted JSON-RPC request and potentially send it. The formatted message is returned as command result, and also sent via the channel if either that argument is a valid TcL channel handle, or the object has an associated channel in the internal attribute set.

All parameters are taken from the internal object attribute set if they are not explicitly set in the arguments. If arguments are supplied, the corresponding object attributes are also updated. Any arguments must be properly formatted - the method name is a simple string, and the parameters are a dictionary.

The internal message ID attribute of the object is incremented when this command is run, and the new value is transmitted. The first message ID of a newly created JSON object is one. To send a message without an ID, use the json send command.

## json send

json send jsonhandle ?method? ?channel? ?parameters?
This command is essentially the same as json request, except that this is a notification for which no response is expected. The ID value in the message text is therefore always null, and internal ID attribute of the object is not incremented.

## json set

json set jsonhandle ?attribute value?..
Set one or more attributes of a JSON object. Since this paragraph is also referenced from the json get subcommand, the attribute set listed here includes attributes which cannot be set, or for which setting them to a scripted value does not usually make sense.

The currently supported set of attributes is:

- body

The body part of the last received or sent JSON-RPC message. This attribute is not usually set.

- bodylength

The length of the body in bytes. This is a read-only attribute.

- channel

The communication channel associated with the JSON object. This is a standard TcL channel handle. It is possible to set it to an empty string, which indicates that no channel is set.

- errorcode

The error code from the last JSON parsing step as integer value. If no error occurred, the value is 0 .

- errormsg

The message of a JSON error, either as extracted from a JSON-RPC message, or set in preparation of sending an error message. If set, it must be formatted as a simple string.

- errordata

Auxiliary informative data in an JSON error message, as per the JSON-RPC specification. This information is either extracted from a JSON message, or set in preparation for sending an error report. If set, it must be a properly formatted JSON object.

- header

The header part of the last received JSON-RPC message. This attribute is not usually set.

- headerlength

The length of the header in bytes. This is a read-only attribute.

- host

The host the JSON object communicates with.

- id

The JSON-RPC message ID. For sent messages, this is automatically incremented. If a received message contains a NULL ID, the value is set to zero.

- method

The method name extracted either from the last received JSON-RPC message, or set in preparing to transmit a message.

- parameters

The JSON-RPC method parameters. If queried, this is a dictionary of name/value pairs. In order to set these, a properly formatted dictionary must be supplied. The formatting is the same as for the parameters attribute of property definitions.

- port

The port the JSON object uses for network communication. The default is 80 , the standard HTTP port.

- result

The method invocation result data extracted from the last received JSON-RPC message, or the data which is sent with the next response. If set, its format must be a properly formed JSON object. For further analysis, this value is usually decoded with a decode -json statement.

- uri

The URI associated with a JSON-RPC service.

## json subcommands

json subcommands
This command returns a list of all the defined subcommands of the json command.

## The keyx Command

This command is deprecated and intentionally undocumented.

## The prop Command

The prop or property command is used to create, modify, query and delete property definitions.
The command has the following subcommands:
prop alias
prop alias
prop alias propertyname aliasname ?propertyname aliasname?...
This command defines an alias name for a property name. After defining an alias, any time the alias name is used as a property name, it is silently and automatically translated to the original property name. It is possible to map an alias name to another alias. Name resolution recursively proceeds until the name can no longer be resolved. Aliases have precedence over basic property names. If an alias name is the same as an existing property name, that existing property becomes effectively invisible and is replaced by the property the alias links to.

The name the alias maps to must be resolvable at the time of definition.
In case the command is used without arguments, it returns a dictionary of current alias definitions. The keys are the recognized alias names and the values the property or second-level alias name the keys are translated to.

Example:
prop alias E_NATOMS E_ATOM_COUNT
After execution, the number of atoms in an ensemble can both be queried via property $\mathrm{E}_{-}$NATOMS (original name) and E_ATOM_COUNT (new alias name).

The default start-up files of the toolkit include a set of alias definitions which map older, less systematic property names as aliases to current official property names.

## prop check

prop check propertyname ?objecthandle?...
Verify the syntactic correctness of property data on a list of major objects, such as ensembles, reactions or datasets. The return value is a boolean list of check results, 1 if the data is formatted correctly, 0 if not. If the property is not set for the object, the returned status value is -1 .

In case there is no check function (attribute checkfunction, see prop set) defined, or it cannot be found, an error results. More details on the operation of the check function can be found in the prop set subcommand documentation.

Example:
prop check E_CAS \$eh
This command checks, if property E_CAS is set for the ensemble, whether it is formatted correctly by calling the TcL check function defined for E_CAS. For this property, the check function runs the CAS check digit algorithm on the data value. It catches encoding errors where the check digit does not match the value as re-computed from the other digits.

## prop compare

prop compare propertyname value1 value2 ?cmpflags? ?param1? ?param2?
prop compare propertyname(field) value1 value2 ?cmpflags? ?param1? ?param2?
prop compare datatypename value1 value2 ?cmpflags? ?param1? ?param2?
Compare two property values. In the first two forms, the name of the property, or of a property field, is used primarily to get the data type for the decoding of the comparison values and the selection of the applicable comparison function. Alternatively, a data type name can also be supplied directly.

The value parameters are expected to be suitable string representations for the underlying data type. If the property name form of the command is used, they may be specified as enumerated values and other formats which can only be decoded with the aid of information attached to a specific property. The comparison values are converted using the string or TcL object input function associated with the data type. If the property name form is used, they are also subject to any other tests associated with the property, such as constraints or regular expression pattern matches.

The cmpflags argument is a list of words which are used to select specific comparison function modes. The default is an empty list. In that case, no c modification flags are passed to the comparison function. In case a mode bit is selected which is not supported by a specific comparison function, it is silently ignored. Some of the flags may be combined to yield specific useful comparison results, but it is the responsibility of the implementation of a data-type specific comparison function to determine which flags can be combined, and which have precedence in case of conflicts. The following words are currently recognized:

- none

Equivalent to an empty string, no bits set

- absolute

For numerical comparisons, use the absolute value.

- anymatchelement

In case of data types with separate elements (vectors, etc.) check whether any element in the first value is identical to the corresponding element in the second vector. If yes, return 1, else 0 .

- anymisselement

In case of data types with separate elements (vectors, etc.) check whether any element in the first value is different from the corresponding element in the second vector. If yes, return 1, else 0 .

- approximate

Perform an approximate comparison. For string types, this means that white space, punctuation characters, digits and character case are ignored. If combined with the withdigits flag, the comparison takes digits into account, but still ignore whitespace, punctuation and case.

For floating-point comparisons, this flag indicates that rounded integers should be used for comparison, not the float values.

If the toolkit was compiled with support for the TRE library, this attribute can also be used in combination with a regular expression comparison. In that case, the result is a percentage similarity score between the query expression and the test string, with character substitutions, deletions and insertions all having the same weight.

- asnumber

In case of strings, compare string contents as signed floating point numbers instead of characters.

- bitcount

For bit vector and integer types, compare the number of set bits, not the numerical value.

- bitset

For bit vector and integer types, check whether all set bits in the second argument are also set in the first argument. The return value is -1 if the second argument contains set bits which are not in the first argument, 0 if the values are identical, and 1 if the first value contains set bits that are not set in the second argument. In case there are set bits in either of the two arguments with no corresponding set bit in the other argument, the return value is -1 .

- bitunset

For bit vector and integer types, check whether all unset bits in the second argument are also unset in the first argument. The return value is -1 if the second argument contains unset bits which are not in the first argument, 0 if the values are identical, and 1 if the first value contains unset bits that are not unset in the second argument. In case there are unset bits in either of the two arguments with no corresponding unset bit in the other argument, the return value is -1 .

- contained

Check whether the value of the second argument is contained in the first. return 1 if it is, 0 otherwise. For strings, this is a substring search. For integers and bit types, it counts the number of common bits. For vectors, it checks whether all elements of the second argument are also found in the first vector, but there is no requirement that the matching element indices are the same.

- correlation

For bit types and numerical vector types, compute the correlation coefficient between the vector arguments. The result is multiplied by 100 and rounded to the next integer.

- cosine

This operation is only supported for bit vectors. It returns the cosine similarity coefficient as an integer, multiplied by one hundred.

- dice

Compute scaled (0..100) Dice similarity coefficient for bit vectors, bit sets and strings (via bigraphs).

- dictionary

Compare strings in dictionary order.

- euclid

For bit types and numerical vector types, compute the Euclidean distance between the points represented by the vector arguments. The result is rounded to the next integer.

- extended

For string comparisons with regular expressions, use extended regular expression syntax.

- glob

For string comparisons, the second value is interpreted as a shell-style glob expression. The return value is 1 if the expression matches, 0 otherwise. The position of the expression argument vs. the simple string can be changed with the swap flag.

- ignorecase

For string-type comparisons, ignore character case.

- ignoredashes

Ignore any dash/minus characters in string comparisons. This is useful for comparing CAS numbers with non-standard separator locations.

- ignorewhitespace

For string comparisons, ignore white space, but not character case.

- left

For string comparisons, match the left side of the target strings.

- like

For string comparisons, interpret the comparison value as SQL-style like pattern.

- precision
use the precision as defined by the property attribute precision for comparison, instead of the native data type precision. If the first optional parameter of the command is specified, its value is used instead of the precision set in the property definition. The precision value an integer, defining the number of significant digits after the decimal point. Negative values are allowed to define significance limited to differences in tens or hundreds in a property value.
- overlap

This operation is only supported for the float pair type. For each value, the pair defines a minimum and maximum range. If the ranges overlap, zero is returned, otherwise -1 (in case the first range is entirely to the left) or 1 (in the opposite case).

- regexp

For string comparisons, the second value is interpreter as a regular expression. The return value is 1 if the expression matches, 0 otherwise. This flag can be combined with the ignorecase and extended flags, which further modify the interpretation of the regular expression. The argument position of the expression argument vs. the comparison string can be changed with the swap flag. Starting with toolkit version 3.352, the regular expression syntax on all platforms is that of the PCRE library, i.e. the Perl style.

- right

For string comparisons, match the right part of the target string.

- swap

Exchange the left/right roles of the arguments. This also affects the special interpretation of arguments in certain positions, as with the glob and regexp modifiers.

- trim

In case of string comparisons, ignore leading and trailing white space, but not embedded.

## - tanimoto

For bit types and numerical vector types, compute the Tanimoto coefficient. The result is multiplied by 100 and rounded to the next integer.

- tversky

For bit vectors, compute the Tversky score between the vector arguments. This is one of the few modes where the extra arguments have an effect. Here, they are expected to be values in the $0 . .100$ range. They are divided by 100 and used as floating-point $c 1$ and $c 2$ parameters. In case both are set to 50 , the result is the same as a Tanimoto comparison. Note that the default values of zero for the extra arguments are not useful for this mode and reasonable values must be supplied.

- withdigits

For approximate string comparisons, recognize and compare digits. By default, they are ignored in that mode. In any case, approximate string comparisons ignore white space and punctuation.

The return value is the integer value returned by the comparison function. For most modes, this is either 0 (values are equal), 1 (left value is larger) or -1 (right value is larger). Some modes do however return other values. For example, similarity bit vector or bit set comparisons return a value between 0 and 100 .

The default values for the optional extra parameters are both zero.
Example:
prop compare E_SCREEN [ens get \$eh1 E_SCREEN] [ens get \$eh2 E_SCREEN] tanimoto
This command performs a Tanimoto comparisons on the screening vectors of the two ensembles and returns a score in the range $0 . .100$.

## prop configure

prop configure propertyname
Execute the property configuration function (attribute configfunction). If there is no function defined, or the execution of the configuration function fails, the command does nothing. By convention, a property configuration function opens a $\mathrm{TK}_{\mathrm{K}}$ window with various GUI elements for the convenient adjustment of computation parameters. Because this is usually a graphical operation, and the overhead of extending the property slave interpreter to a fully GUI-enabled version, this command is always executed in the global interpreter.

Note that this function usually does not directly result in the change of property attributes and parameters. The standard approach is to set up and display a Tk window, which remains open until it is closed by the user, while this command returns immediately. Changes from adjustments in the property panel take effect asynchronously only after an apply button has been pressed by the user.

## prop create

prop create propertyname ?attribute value?...
Create a new property definition, and optionally set attributes.

The name of the new property must conform to the general property naming conventions in the toolkit. Indexed fields, instance identifiers, registration ID and other name parts aside from the base name are ignored.

In case a property definition for the same property name is available, and either already loaded or can be found by in the property autoloader path, the command internally succeeds, but still returns a TcL error. This is intended to prevent the accidental overwriting of system property definitions, which can lead to problems which are difficult to detect and may lead to crashes, for example when the data type of an internally used property is changed in an incompatible fashion. Acceptance of the command when overwriting is desired can be forced by surrounding it in a catch statement.

A property created without additional attributes has no associated functions, is of data type string and generally has empty default values for all attributes. The only exception is the URN namespace, which is set to the local namespace, and the creation date, which is set to the current time. In addition, the property object class is automatically set from the prefix of the specified name.

The processing of the attribute/value pairs is equivalent to a prop set command. The possible attributes are described under that subcommand.

Example:
prop create A_MYPROPERTY datatype int author "A. Nonymouse"
This statement creates an atom property (determined by the standard A_prefix) of data type integer and a curious author attribution.

## prop defined <br> prop defined propertyname

Attempt to resolve the specified property name. If the property name is not yet part of the internal property database, an attempt is made to resolve it via the auto-loading mechanism. This is different from the similar prop exists command. The boolean return value is zero if the property name could not be resolved, one otherwise.
prop available is a deprecated alias of this command.

## prop delete

prop delete propertyname ?force?
This command deletes a property definition from memory. It does not remove the files the property is defined by, if it exists. Property names which are not defined when the command is run are silently ignored. By default built-in properties cannot be deleted. In order to force this, the optional fourth boolean parameter must be set. Deleting built-in properties is risky and can lead to crashes if the property is required as part of internal computations.

The property is not actually removed from the internal database until all instances of data of that property attached to chemical objects have been deleted. In such a case, the property name is not usable any longer in script commands, but implicitly information such as data type and formatting instructions are still used until all data associated with the original definition has been purged. The name of a half-deleted property still shows up in commands like ens props, but commands such as ens get fail, even for existing property data because the translation of the property name in the request to the internal data structure is no longer possible. However, operations such as file I/O which do not rely on properties looked up by string name may still succeed. The deletion of chemical
objects with data from deleted properties always succeeds, decrements the reference counts and frees memory.

It is possible to re-define a property with the same name as a deleted one, even if there is still pending data. However, this is highly discouraged and potentially confusing.

If the supplied property name is an alias, the property the alias is pointing to is deleted, not the alias definition (see prop unalias for this function). In addition, all alias definitions which point to the deleted property are also recursively deleted.

## prop dup

prop dup propertyname newpropertyname
Create a new property definition using an existing definition as a template. In typical cases, the property duplicate is further customized by prop set commands. The new property name should not be the name of an existing property, though this is not illegal. In that case, it hides the definition of the original name similar to an alias definition.

The return value of this function is the name of the duplicated property.
prop exists
prop exists propertyname
This command checks whether a property is currently loaded in the in-memory database. No attempt is made to look up the definition via the auto-loading mechanism if it is not yet present. The boolean return value is zero if the definition is currently unknown, one otherwise. For a related command with implied auto-loading, see the prop defined command.

## prop get

prop get propertyname attribute
Get the value of a property attribute. The property attributes are explained in the paragraph dealing with the prop set subcommand. The return value is the current setting of the requested attribute.

The parameters attribute is a special case in multi-threaded scripts. Its value is thread-local. Every thread may have a different parameter set for each property. In order to obtain the base parameter set, the attribute globalparameters may be read.

## prop getparameter

prop getparameter propertyname parametername ?usedefault?
Get the value of a computation function parameter, or of a computation function default parameter.If the last command argument is not specified, or set to a boolean false, the queried parameter collection is the current parameter set (property attribute parameters). Otherwise, it is the default parameter collection (property attribute defaultparams). If the requested parameter is not found in the parameter set, an error results. Otherwise, the result of the command is the retrieved parameter value.

In a multi-threaded environment, a returned parameter value (but not a default parameter value) is thread-dependent. Every script thread has an independent property computation parameter set which is copied from the global value in the base interpreter the first time a property is referenced in a thread.

This command may be abbreviated to prop getparam.

## prop isdefault

prop isdefault propertyname value
Check whether a property data value is the same as the property default value. The return value is the boolean test result.

## prop ismagic

prop ismagic propertyname value
Check whether a property data value is the same as the property magic value. The return value is the boolean test result.
prop list
prop list ?pattern? ?computable_only?
List all currently loaded property definitions, including built-in definitions. If desired, a string pattern filter can be supplied to select only specific properties. The optional fourth parameter can be used to restrict the list to properties which are associated with a computation function.

Example:
prop list E_* 1
lists all currently defined and loaded ensemble property definitions which are computable.
Computability is only checked at the property definition level. It is no guarantee that the property computation succeeds for any specific ensemble or other chemistry object.

## prop query

prop query keyword ?objectclass? ?mode? ?casesensitivity?
Search the internal property database by matching the keyword against a standard set of property attributes, such as name, description, keywords, category, comment and UUIDs. Only the current memory database is checked, no auto-loading or repository checks are performed.

By default all property definitions are matched. The object class argument (such as atom) can be used to limit the search to properties for a specific object class. Providing an empty argument is the same as omitting the argument.

The optional mode argument changes the string comparison mode. The default is equal, other possibilities are substring, left (match beginning of string), right (match end of string), like (as the SQL operator), glob or regexp.

The final argument can be case (case-sensitive matching) or nocase (case-insensitive comparison, this is the default).

The return value is a list of the version UUIDs of the matched properties.
prop read
prop read filename ?doinstances?

Read a file with one or more property definitions. All property definitions found in the file are added to the internal in-memory database. By default, or when the doinstances parameter is set to 0 , a definition from the file which refers to the same property as one already loaded implicitly deletes the old definition (see prop delete for a discussion of the consequences of this operation) from memory before the new definition is added. If the optional argument is set to a true boolean value, an additional definition with an instance number one higher than the highest currently defined instance is created instead.

The return value of the command is a list where the first element is the total number of property definitions read from the file, and the second element the name of the first read property.

## prop reload

prop reload propertyname
A convenience command for property computation module development. It first attempts to delete the current property definition. If this fails because its reference count is not zero, and attempt is made to reach zero by deleting all objects which may contain property data of the object class the property is associated with (e.g. ensembles if the property is an atom, ring or ensemble property). If the deletion now succeeds, the property is auto-loaded again, presumably with an updated processing script or module. Specifying an unknown property, a property where the reference count cannot be decremented to zero, or for which the definition cannot be found in the property loader path is an error.

The command returns the property name.

```
prop set
prop set propertyname ?attribute value?...
```

This command is used to modify the attribute sets of existing property definitions. If the property name cannot be resolved, an error results. The following attributes are currently supported:

- access

This argument controls the general access to property computation servers which accept remote requests. This is an enumerated property with possible values none (unset, no access by anyone if running as server), private (access only if client user is the same as server user, and client and server are on the same subnet), local (client user must be valid on local host, and client and server are on the same subnet), registered (client user must be in net group named propname_users), and finally free (no first line access checking on user IDs, subnets or net groups). If this access condition lets a request pass, script-based access checking still applies. This attribute has no effect on property computations which do not operate over a client/server connection.It has no effect in standard local scripts.

- accessfunction

This name of an access check procedure if the property is computed on a server and remote requests are accepted. If there is no access function, only rudimentary access control (see access attribute) is performed. If an access function is set, it is called with the handle of the chemistry object the computation is requested for, and the name of the property.
Additionally, request information including user name, email, host and password are stored in the global array variable : :server. The access function may reject requests based both on the variable contents (wrong password, etc.) or the data of the chemical object the computation is requested for (too many heavy atoms, etc.). In order to reject a request, the
access function can either return a boolean false value, or throw an error. Currently, the access check function is always executed in the global interpreter. Different from the computation, verification and configuration TcL script functions, the access function is never automatically integrated into property definition files written by the prop write command. This function is intended to remain confidential and local. The access function is only called if a computation request is executed in a client/server relationship. It has no effect in standard local scripts.

- affiliation

The institution the author of the property definition works for.

- altdatatypes

A list of alternative data types the property functions can handle. For example, most image types such as E_GIF or E_EPS_IMAGE can be computed both as datatype diskfile and blob. If a list of alternative data types is set, the property can only be reconfigured to use one of these (for details refer to the datatype attribute). If no list of alternative data types is specified, the data type can only be changed between types which use the same internal representation (e.g. float and double, or int and short).

- altmodule

The name of an alternative structure representation interface module. Properties which have this attribute set are not computed on the normal internal САстvs data structure, or by calling an external program by means of a script, but are linked with a third-party software component and interface code to translate between the data structures of Cactvs and the other program. This attribute is rarely encountered in normal use scenarios.

- application

The name of an external application which generates the property data. This is a free-form string.

- applicationdate

The release or version date of an external application which generates the property date. Must be a valid date specification.

- applicationversion

The version of an external application which generates the property data. This is a free-form string.

- attachment

This is a deprecated alias name for the objclass attribute.

- author

The author of the property definition. This is a free-form string.

- authorurl

A URL with information on the author, or an empty string if unset.

- auxdata

This is the name of a file with arbitrary additional data the property computation function may need to perform its duties. When a property definition file is written with the prop write command, this data is encapsulated in the definition file. When the definition file is later read by an application, the data is written out to a temporary file, and the file name
returned for this attribute is the name of the temp file, not the original file name. By this mechanism, it is not required to supply auxiliary data files as a separate files which may be difficult to locate and are easy to get lost. If this field is empty, no auxiliary data file is present.

- category

A category string to be used if the property definition is stored in a repository.

- charset

The character set this property uses for encoding and decoding. While this attribute is currently maintained as a free-form text field, it should only be set to values in standard character set syntax, such as $I S O-8859-1$. The latter value is the default in case it is not set.

- checkfunction

The name of a scripted TcL procedure designed to verify that a value of a property is correct. This function is called with the property name and a chemistry major object handle as arguments. It should return 1 if the property data is set and the check succeeds, or 0 otherwise. It should not attempt to compute the data if it is not present. If the function can be found in the private slave interpreter of the property, it is executed there. Otherwise, an attempt is made to locate and run it in the main interpreter. When a property definition file is written with prop write, and the function can be located, it is encapsulated in the definition file and is available for all further interpreters which read the definition file. Example:

```
prop check E_CAS $eh
```

This command checks, if property E_CAS is set for the ensemble, whether it is formatted correctly by calling the TcL check procedure defined for E_CAS. With this example property, the check function runs the CAS check digit algorithm on the data value. It catches cases where the re-computed check digit does not match the one found in the data.

- classuuid

The base class UUID of this property.

- comment

A free-form text comment.

- computefunction

The name of the computation function. For computation functions implemented as compiled code, this data is for information only and cannot be changed in scripts. For scripted functions, this is the name of the function which performs the computation. The function is called with the handle of the chemical object as parameter. In case the computation succeeds, the function should attach the property data to the object. In case of an error, an error condition should be raised in the script.

If the function can be found in the private slave interpreter of the property, it is executed there. Otherwise, an attempt is made to locate and run it in the main interpreter. When a property definition file is written with prop write, and the function can be located, it is encapsulated in the definition file and is available for all further interpreters which read the definition file. Example:

```
ens get $eh E_CAS
```

This request calls the TcL script function $C S g e t E \_C A S$ which is defined in the property definition file as computation function for $\mathrm{E}_{-}$CAS.
Properties which cannot be computed have an empty compute function name.
In case of TcL script computation functions, all default and current computation parameters are automatically copied to the global (to the property slave interpreter, not visible in the main interpreter) array : : params. This is done by first traversing the default parameter list and then the current list, so that parameters in the current list overwrite any default values. In addition, the current property computation time-out value is stored in
: :params (timeout). Alternatively, the parameter values can be queried by prop getparam commands in the function. In multi-threaded scripts, each thread interpreter sees its private version of property computation parameters. Therefore, it is possible to compute different versions of the same property in parallel threads.

## - configfunction

The name of the configuration function for the property. This is a TcL script function which is supposed to present a $\mathbf{T \kappa}^{\text {p }}$ panel with configuration options for that property. The apply function associated with the panel should modify the current parameter set of this property. The function is called with the property name as only parameter. Different from computation and check functions, this function is always executed in the main interpreter, in order to avoid the need to extend the slave interpreter into a full Tk-enabled interpreter with much larger overhead. When a property definition file is written with prop write, and the function can be located, it is encapsulated in the definition file and is available for all further interpreters which read the definition file. Example:

```
prop configure E_GIF
```

This command calls the configuration function for property E_GIF, which attempts to display a pretty large GUI panel with lots of sliders and dials allowing the user to adjust the rendering parameters.

Properties which cannot be configured graphically have an empty configuration function name.

- constraints

A set of flags to impose additional constraints on property values. Attempting to set a property value which does not meet these constraints in a script raises an error, or the value may be implicitly modified to fit the constraint. The check only applies to string conversions and conversions from TcL or PYтноn script interpreter objects. It is still possible to set a value in violation of the constraints by rogue compiled code in computation functions and by similar means. Not all flags are implemented, or make sense, for all data types.
Implementing constraint checks is the responsibility of the data type handler module. Flags not supported for a specific data type are silently ignored. Any combination of flags can be supplied as a list argument. The currently supported values are

- none
no constraints, other than the native capabilities of the underlying data type
- notnegative
no negative numerical value
- notpositive
no positive numerical value), notzero (no zero value)
- nolowercase
no lower-case characters)
- nouppercase
no uppercase characters
- trimmed
leading and trailing white space are removed
- nowhitespace
all white space is removed
- odd
numerical value must be odd
- even
numerical value must be even
- notempty
input cannot be an empty string)
- maptolowercase
translate to lower case
- maptouppercase
translate to upper case
- mapwhitspace
all white space sequences are translated to a single underscore character
- no8bitchars
characters cannot have 8th bit set
- maptotitle
translate to title formatting, with first letter of every word in upper case and all other letters in lower case

Example:
prop set E_ID constraints \{notzero notnegative\}
Assuming that E_ID has a numerical data type, any attempt to set it to 0 or a negative value in a script will fail.

Another method to apply constraints to property data is by means of the regexp and regexpflags attributes. Both methods may be used in combination.

- cost

This is an integer parameter which is intended to give a rough estimate of the cost involved in computing a property. The default value is 1 . Currently, its only use if when merging ensembles with different sets of property data. Here, no attempt is made to compute properties which have a cost of more than 5 and are only present on one of the ensembles.

- ctxkey

The tag for this property in the ctx file format. If it is not set, a reasonable default tag is derived from the property name. This attribute is deprecated, the more general filetags attribute is the recommended replacement.

- datatype

The attribute sets the data type of the property. The exact set of possible data types varies. Besides the rich set of built-in data types, an attempt is also made to locate a property handler module with the specified name in case the argument cannot be resolved with the built-in and currently loaded I/O handler modules. The default value is string - a simple 8-bit ISO 8859-1 string property.

It is not possible to change the data type of a property if data instances of that property exist on chemical objects in the current application, and the internal representation of the old and new type is not identical. For example, it is possible to switch between bool and int types, but not between int and string, if active data of the old type has already been stored.
The altdatatypes attribute imposes additional restrictions on possible values of this attribute.

- date

This attribute stores the date of the property definition. It is used for information purposes only. If a new property is defined, it is initialized to the current date.

- dbflags

This attribute encodes a set of hint flags for setting up SQL database columns for storing data of that property. The argument is a list of words representing bits which should be set. The following flags are currently supported:

- none
the default, no special treatment, key - property data will likely be used as query key,
- primarykey
column is a primary key for the table
- notnull
disallow the storage of $N U L L$ values for that data
- indexed
set up index on the property column,
- fixedlen
set up database column as fixed-width data, with actual width stored in the length attribute
- timeonly
for datetime data type, store only time part
- dateonly
for datetime data type, store only date part.
- default

This attribute defines the default value for the property. Usually, the syntax for this item is the same as setting a specific data value, but data type handlers can set up a special default value decoder function. For example, array types allow a syntax like 10:0 for a default value of 10 elements set to 0 each, but this syntax is not supported when setting individual data instances.

In case of properties of complex multi-field structure, the default value is a list of values in the order of the field definitions. The the default value list is shorter than the field list, the remaining fields have a zero/empty default value.

Property data values which are identical to the default are not written explicitly in native CACTvs binary files. If such data is restored, and the default value has changed, the input data assumes the new default value because it is set from the current property definition, not the file contents.

- defaultparams

The default set of parameters, as a keyword/value list or dictionary. The syntax is the same as that of the parameters attribute. This attribute set is intended to be used as a quick way to reset the normal parameter set after changes have been made. Example:

```
prop set $p parameters [prop get $p defaultparams]
```


## - deletefunction

This is the name of a TcL function which is called whenever property data instances are deleted. The only argument to the function is the value of the data item. This function may perform custom clean-up operations, such as taking down editing forms.

If the function can be found in the private slave interpreter of the property, it is executed there. Otherwise, an attempt is made to locate and run it in the main interpreter. When a property definition file is written with prop write, and the function can be located, it is encapsulated in the definition file and is available for all further interpreters which read the definition file.

- depends

A list of properties which this property depends on as input data when it is computed. This information is used to automatically invalidate or re-compute data instances when underlying, more basic data changes on the chemical object. This is a recursive process. The invalidation of one set of properties is cascaded to all property instances on the chemical object which themselves depend on the just invalidated data. An update cascade can be triggered for example implicitly by statements such as atom set or ens new, or explicitly by ens taint. Note that simple data deletion commands such as ens purge are not triggers. Property data can be prevented from auto-deletion by using lock statements such as ens lock. The updated data which acts as the trigger is never itself deleted, even if a dependency cycle exists.

For this argument, it is explicitly allowed to set dependency property names which are not yet defined. No attempt is made to resolve these, but every loading or creation of a new property definition in another context will lead to a regeneration of the pre-parsed form of dependencies on all current internally held property definitions, potentially adding more, or different, dependency links. Property names which cannot be resolved are silently ignored.

- description

This is a free-form string which describes the property.

- displaywidth

A default value for the width of a display column, measured in characters. The default value is negative, meaning that scaling is dynamic.

- doi

A digital object identifier for the property, if defined.

- email

The email address of the creator of the property definition, useful in case a definition file is distributed and anybody has questions.

- enum

This attribute defines enumerated symbolic names for specific property values. They can be used for mnemonic data input, and many output modes also use these names by default (cf. ens get vs. ens nget). Input of enumerated values is always case-insensitive. It is not illegal to store data values of an enumerated property which are not represented by a corresponding symbolic name. These values are simply encoded as or decoded from numerical values.

For properties which consist of multiple independent sub-items, or sub-item data types, the enumeration is a list. The list is split, and each element applies to a different field in the order of field definitions. Examples for this are the compound and choice types, but not simple vectors. For simple vectors, the enumerated names apply to each element.

The enumeration is a string, where blocks corresponding to a specific value are separated by a colon. In the absence of an explicit value designator, the first block corresponds to value zero. Multiple words separated by commas are interpreted as alias names. On output, the first word is used as the canonic designator. Example:

```
prop set E_CLEARANCE enum \
"public:prívate:topsecret, destroy_before_reading"
```

The enumeration defines symbolic names for value 0 (public), 1 (private) and 2 (topsecret, or alias destroy_before_reading). On output, a data value 2 is always displayed as topsecret .

There are a couple of additional syntax elements. A code which is not in the automatic value sequence can be specified with $\mathrm{a}=n$ construct. The next value block, if it has not an explicit value designation of its own, is the value of the previous block plus one. Here is the enumeration for property A_LABEL_STEREO, with codes for standard parities and square planar stereochemistry:
$M,-=-1:$ undef $=0: P,+=1: U, C=2: Z, N=3: X=4$
The normal $0,1,2 \ldots$ implicit value sequence can be changed to a power-of-two sequence by prefixing the enumeration string with a " $\wedge$ " character. In that case, the implicit numerical value o the blocks are zero, one, two, four, etc. For bit types (64-bit set and bit vector), this interpretation of the enumeration string is automatic and does not need to be spelled explicitly. Output of data items for properties with a bit-based implicit or explicit enumeration string consists of a set of all words with corresponding set bits, and one possible input format is a list of words for all bits that are set.

A final syntactic shortcut is the use of the "@" character as prefix. In that case, the enumeration is interpreted as a symmetric value set centered around zero. If there are three value blocks in the enumeration string, and no explicit value designations, the encoded numerical values are, from left to right, minus one, zero and plus one.

Characters with special meaning in parsing enumeration strings (equal, comma, colon) cannot be part of a symbolic name. Prefix characters may be used in enumeration names, but not as part of the first word.

## - fielddatatypes

A list of the field data types defined for the property. This is a subset of the information encoded by the fields attribute, and read-only.

## - fieldindices

A list of the choice indices of the field definitions. This attribute is useful only for choice and choicevector properties. This is a read-only attribute.

## - fieldnames

A list of the field names defined for the property. This is a subset of the information encoded by the fields attribute, and read-only.

## - fieldproperties

A list of the secondary properties associated with the fields of the current property. Fields which are not property-associated report an empty element. This is a subset of the information encoded by the fields attribute, and read-only.

- fields

This attribute describes fields of a property. Its exact meaning depends on the data type of the property. The attribute is a nested list. Each list element is a list which contains a field name, its data type (optional, defaults to string) and its unit (optional, defaults to undefined). Simple properties which do not have sub-items do not possess a field set. For simple vectors, field names may be defined to facilitate convenient vector element access, but they have no effect on the internal representation of the property values. Example:

```
prop set A_XYZ fields {x y z}
echo [atom get $eh $label A_XYZ(x)]
```

The code above shows you how to name elements in a simple vector, and how to use them conveniently for retrieval. For the bit and bitvector data types, such fields are interpreted as individual bits.

However, the field set is essential for the definition of properties with a complex internal structure, such as data types compound and choice, and the vector variants thereof. For these types, the field set should be set up when the property is defined, and not changed at any time later. Example:

```
prop create E_MYCOMPOUND datatype compound \
fields {{name string} {fval double angstrom} \ {timestamp date}}
```

The statement above defines a compound property with three fields of different data types, one of them with a standard unit. Another use is for the definition of choice properties, which hold one of several possible variants of data, possibly of different data types:

```
prop create E_MYCHOICE datatype choice \
fields {{name string} {ival int} {timestamp date}}
```

The difference is that the example compound property contains three parallel fields of different data types, while the choice property has just a single field, but it can be of one of three different data types at any time. For the compound example, the string input or output form of a property value is a list of three values, where each element is parsed or formatted according to the data type of the field. For the choice example, the string format is a single two-element list, where the first element is the field name, which implicitly defines the data type, and the second element the value. Another example:

```
prop create E_MYCOMPOUNDVEC datatype compoundvec \
field {{name string} {ival int} {timestamp date}}
```

This is the specification for a compound vector. Each vector element is a compound of three data items. It could be set to a vector with two elements with a statement like

```
ens set $eh E_MYCOMPOUNDVEC \
{{"name1" 1 now} {"name2" 2 tomorrow}}
```

In the same fashion, choice vectors may be defined and set. A choice vector has a single data item per element, but each of these elements can be of a different data type from among the selection defined in the field set.

In addition to having a simple basic data type, the fields of complex data types can also be indirectly defined by a reference to a secondary property, which defines the structure of that field. These indirect references can be of complex types themselves. If the secondary property has a defined unit, this unit automatically sets the field unit, too. Example:

```
prop create T_NCBI_PUBLICATION_PATENT_ID \
datatype compound \
fields {{country string} {id T_NCBI_BIBLIO_PATENT_ID} {doc-type string}}
```

This compound property has three fields. The first and second are simple basic types, but the third is a complex property of type compound with its own fields, which potentially could themselves be recursively defined by more property references. The string representation of data for this definition is a list of three elements, where the middle element is itself a (potentially deeply nested) list.

If an input list for a complex property is shorter than the size of the field list, the rest of the items are set to their respective default values.

If the data type of a field cannot be decoded from the information currently in memory, an attempt is made to auto-load the data type I/O handler or, in case of property references, a property definition. If that fails too, an error occurs. Data types must be specified in lower case. This is needed to distinguish them from property names, which are upper case.
In case of symbolic names assigned to vector fields, the data type of the field is ignored and can be omitted, since it directly follows from the vector definition.

The native Cactvs file formats are designed to cope with complex property data for which the field definitions have changed between the time the file was written and when the data is read again. Every field is stored with its explicit name and data type. If the current property definition has additional fields compared to what is stored in the file, these fields are initialized to the default value. Fields which are no longer present in the property definition, but whose data type can be decoded from the information in the file are skipped and ignored.

If a prop get command is executed for this attribute, the output is a nested list. Each field description always contains the field name and the data type. If the property is of the choice or choicevector data type, the choice index of this field is appended next. Finally, there can be a property reference or unit element which is appended only if a secondary property reference or a standard unit is defined for the field. Ultimately, each field record can consist of two to four elements.

- fieldunits

A list of the units of the fields defined for the property. Fields without a defined standard unit report an empty element. This is a subset of the information encoded by the fields attribute, and read-only.

- filetags

A dictionary of the tags to be used for storing property data in various file formats.
Currently, only the cml , cex and $c t x \mathrm{I} / \mathrm{O}$ modules make use of this information. The keys of the dictionary entries are the file format names, the values the associated tag strings. This attribute does not trigger the autoloading of the specified I/O modules at the moment the attribute is set. Rather, these tags are resolved or disabled when a matching I/O module is loaded or unloaded by another mechanism, for example explicit loading (filex load) or implicitly via a file suffix match. There can only be one tag per file format - the last is used in case of duplicates -, and the total number of different file formats a tag can be set for is ten per property, though the tag/file format sets of different properties do not need to be identical.

## - filters

This attribute is a list of filters which limit the definition range of a property to a subset of objects. Example:

```
prop set A_FREE_ELECTRONS filters classicatom
```

This statement, which just mirrors the actual definition of property A_FREE_ELECTRONS, tells the toolkit that the concept of free electrons is meaningful only for classic atoms with are an element, but not for super-atoms, query atoms and similar constructs which are subclasses of the atom minor object. In case there are multiple filters, the object must pass all of them in order to make a property data item defined. In case a specified filter name is not yet defined, an attempt to autol.oad the filter definition is made.

Currently, there is a maximum of 10 filters per property definition.

- flags

The flags attribute holds a collection of general flags which encode the status and operation mode of the property. This is an enumerated set. Currently supported flag names include

- autobackup
when property is changed via script, automatically save last values in backup property, i.e. A_LABEL in A_LABEL\%


## - expandpriority

if a chemistry object such as an atom which hold a data item of this property is replaced by, for example, an expanded fragment, this data is transferred to the first replacement atom of the expanded fragment, and not computed from the properties of the new atom.

- fixedlength
the size of property data is constant, even for data types where each data item could have an individual size, for example vector types, or strings. This information is useful to optimize storage layouts in various contexts. The actual length of the data item is either taken from the length property attribute, or from a sample data item on a chemical object which is expected to be a representative with the correct length. The short form fixedlen is an alias-
- globalexecution
execute computation script and other scripts associated with this property always in the global interpreter, not a property-specific slave.
- labelkey
this property is the minor object label key property for the object class it is associated with. For atoms, this is A_LABEL, for bonds, B_LABEL, etc. There can only be one such property per object class, and there must be one such property for all object classes which are not major objects. Changing the label key properties should only be attempted under extraordinary circumstances.
- localupdate
the property computation function supports the update of a single specific object, not all objects of the same class linked to a major object (i.e. it can recompute data on a single atom and not just all atoms in the ensemble). This flag is for information only. Do not set it directly.
- locked
if set, the property cannot be overwritten by reading property definition records describing properties with the same name. Individual attributes of the property may still be changed, including resetting this flag by script commands. This attribute is for example useful when the current definition of a property should be maintained after opening a $c b s$ or $b d b$ file - these include the property definitions used at the time the file was written.
- mergedata
merge multi-line input data into a single data item, for example a string with tab separators. Has an effect only for input from multi-line MDL SD data fields.
- mergedefault
if data of a non-computable property is present only on one object in an object merge operation, by default this property data is discarded in the process because there is no way to obtain it for the second object. If this flag is set, the object without the data is instead initialized with default data for the property, and the merge does not discard the original information from the object where it was present.
- none
no flags are set. On setting, you can also pass an empty string.
- portable
the property has no OS-dependent components such as DLLs or shared libraries for the computation module, or at least such components are available for all currently supported toolkit platforms.


## - trace

for scripted properties, trace execution when the computation function is called.

- trusted
the property is trusted, relax usage restrictions and safety belt features.
- nominmax
property has no definition of, or use for, minimum and maximum property values. This can reduce memory usage and increase performance.
- nosighandler
run without signal handler to trap core dumps etc. even if property is not trusted. Signal handlers are expensive to set up and tear down, so if a function of an untrusted is called millions of times, this can significantly improve performance.
- notimeout
disable computation timeout watchdog, even if a timeout value is set.
- synthetic
the property was synthesized from minimal information without a proper property definition. Its name contains an asterisk to make this immediately obvious.This flag is for information only, do not set it directly.
- timing
measure execution time for each computation function call and store in property metadata record on the major object the computation was performed for.
- threadtrace
trace multi threading-related synchronization operations.
The standard bit set manipulation prefixes (+,-,^) are supported. Example:
prop set A_XY flags + notimeout/trace
This command adds two flags to the current flag set.
- format

Internal use only

- functionsource

The source code of all of the script functions which are contained in the property definition. Code for functions which are not defined in the definition file, but for example reside in global library source files, are not returned.

- functiontype

The type of computation function this property provides. Possible values are none (no computation function), $c$ (built-in function), $c d y n$ (dynamically loaded C module), tclscript (interpreted TCL script), syncserver (synchronous client/server computation, CACTvs native RPC protocol), asyncserver (asynchronous client/server computation, Cactvs native RPC protocol), mail (send request and receive answer by email), altrepmodule (via an alternative data representation module), default (pseudo-function, a computation request always results in default values as result), disabled (temporarily disabled) and soap (communication via SOAP-based service). Python-enabled toolkit versions additionally support the pythonscript function type.

In most cases,.the function type is defined once when the property is set up and not changed later. One potentially useful application of changing the function type is when a computation is farmed out to a public or access-controlled server, for example because a local optional computation module is missing. Example:

```
prop set A_XYZ functiontype syncserver \
host wWw.xemistry.com port }17890\mathrm{ password xxx
```

After this statement, requests for atomic 3D coordinates will no longer be made by attempting to load a local module and execute the coordinate generation code on the client machine, but by communicating with the server specified above. this is a sample host name and not a real publicly accessible service.

- globalparameters

This is the global version of the current parameter set. Its meaning is explained in the paragraph detailing the parameters attribute.

- helpful

This is a list of source data properties which can be helpful for computing this property, but do not need to be present for the computation to succeed. This is for example used as a hint in network communication. If the property data is already present, it is sent, but no attempt is made to compute it, and the computation function will either do without these additional data, or compute it itself. This attribute has no effect for local computations. Its counterpart is the required attribute.

- host

The name of the host to contact to request a remote computation for this property. This applies only to properties which are farmed out to servers and is ignored otherwise.

- id

Get the internal integer ID code of the property. An ID value is automatically assigned when a property is created or, for built-in properties, on start-up. This is a read-only attribute and cannot be set.

- indirect

If this attribute is set to the name of another property, the computation function of that other property is expected to compute the data for this property as a side effect. This property should be listed in the windfall attribute of the second property. When the computation of this property is requested in a script, the request is re-schedule as a computation request for the indirect property.

This mechanism is useful because you only need to maintain a single computation module or script for a set of properties which are computed synchronously. One of the properties provides the computation function, and lists the other properties in its windfall attribute. The other properties from the group all simply refer via an indirect attribute to the single property with the computation function.

- infourl

A URL with information on the property definition, or an empty string if unset.

- invalidation

This set of flags describes under which circumstances the property data attached to an object is automatically discarded. The flag sets augments the property dependency relationships defined via the depends attribute. These are s global operations on a structure beyond the scope of isolated property data changes. With the exception of the never value, multiple code words can be usefully combined into a list. The currently supported flags are:

- never
no automatic invalidation
- atomchange
any major atom change in an ensemble, such as an atom type or element change, or the addition or deletion of atoms
- bondchange
any major bond change in an ensemble, such as a bond type or order change, or the addition or deletion of bonds
- stereochange
any stereochemistry change in an ensemble
- groupchange
any major group data change in an ensemble, similar to the atomchange and bondchange criteria
- merge
data of two objects is merged
- 3dop
the 3D structure of an ensemble changes in a way that affects inter-atomic distances
- 3dglop the 3D coordinates of an ensemble change globally, but inter-atomic distances remain constant
- shuffle
the order of atoms changes in an ensemble
- hadd
hydrogens are automatically added or removed to an ensemble
- $d u p$
a major object is duplicated.
- atom
the atom list composition changes for an ensemble
- bond
the bond list composition changes for an ensemble
- mol
the molecule list composition changes for an ensemble
- ring
the ring list composition changes for an ensemble
- sigma
the sigma system list composition changes for an ensemble
- pi
the pi system list composition changes for an ensemble
- group
the group list composition changes for an ensemble
- surface
the surface patch list composition changes for an ensemble
- ringsystem
the ringsystem list composition changes for an ensemble
- reaction
reaction membership changes for an ensemble, or the ensemble set changes for a reaction
- dataset
dataset membership changes, either for an object in a dataset, or the dataset object proper for which the object set changes
- file
the association of an object with a structure file changes, for either of the sides
- table
the association of an object with a table object changes, for either of the sides
- network
the association with a network object changes
- vertex
the vertex list composition changes on a network object
- connection
the connection list composition changes on a network object
Example:
prop set E_MY_UNIQUE_ID invalidation dup
Property data for E_MY_UNIQUE_ID is discarded from the cloned structure when duplicating ensembles.

A signal indicating that certain operations have taken place can be explicitly sent by the taint major object subcommands. Example:
ens taint \$eh \{atomchange bondchange\}
Above command leads to the shedding of all property data on the ensemble which is not robust with respect to atom and bond edits. These events are always global on the controlling major object. It is not possible to signal an update event for a single atom or bond.

- keycolumn

The name of a database column for keyed properties which are retrieved from a database-style source. In case of data sources which do not have a concept of columns, this is an empty string.

- keydatatype

The data type of the access key of a keyed property. If the key is another property (keyproperty attribute), the data type is derived from the property definition of the key property and potentially its field index and should not be changed. For keys which are not properties, this attribute must be set. It can be any supported property data type, including those which need to be loaded as external handler module on demand.

- keyenum

An enumeration similar to the enum attribute for the encoding and decoding of key values for keyed properties. It the key is a property, this attribute overrides the enum attribute the key property might possess itself in the context of key operations.

- keyproperty

The name of a property which is used as access key to obtain property values by retrieval from an external data source. This must be resolvable to a property definition. If no key property is used, this is an empty string.

- keyreference

The data source for key-based property retrieval, encoded as a URN. The protocol field of the URN determines the name of the key resolver used. An attempt is made to auto-load the proper key resolver module if the handler has not yet been loaded. The rest of the URN fields are interpreted by the resolver module. They usually follow the standard URN syntax with user IDs, passwords, hosts, ports, and a file or database table component, with reasonable defaults if any parts are not specified.

- keywords

A list of keywords associated with the property.

- length

The data length of the property. A value of -1 (the default) indicates that the length should be expected to vary. The exact interpretation of the attribute is dependent on the data type. For example, for strings and Unicode strings it is the character count, for blobs the byte count, and for vectors of constant element size (for example, floating-point and integer vectors) the element count. If a length is set, it is only used as a hint for internal optimizations. It becomes a binding statement only if the fixedlength bit in the flags property attribute and/or the dbflags attribute has been set.

- license

The license class associated with this property. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the property license.

- literature

This is a free-form string for a literature reference describing the meaning and/or algorithm behind the property.

## - logfile

In case the property logging mode is set to write to a file, this is the name of the file the log output is written to.

- logmode

This attribute is an enumerated set of words which describe the handling of log or debug output during calls of the property computation routine. If any mode except ignore is set, standard output and standard error are redirected to the selected output channel before the function is called, and restored to the previous channels afterwards. The default should be ignore, because redirection involves several system calls and therefore can significantly slow down the computation of trivial properties. The supported values are:

- ignore
neither redirection nor restoration
- suppressed
redirection to /dev/null or NUL on Windows
- console
redirection to the /dev/console (not on Windows)
- filewrite
redirect to the file specified in attribute logfile. The file is deleted before each computation function call.
- fileappend
redirect to the file specified in attribute logfile. The output is appended.
- stdout
redirect both standard output and standard error to original standard output
- stderr
redirect both standard output and standard error to original standard error
- magic

Define a magic value for the property. This is a convenient way to mark one specific property data value as an indicator for a special condition outside the normal validity range of the property. The attribute must be a parseable representation of a property value.

Magic values are not written out explicitly in native Cactvs binary files. If therefore the magic value changes, newly read magic property data values automatically assume the current magic value because they are set from the current property definition, not the file contents.

- max

The maximum expected property value. This value is not enforced - it is primarily intended to be used to compute color scales etc. from property values. See also the $\min$ attribute. The attribute must be set to a valid string representation which can be decoded with the current property definition, and should not be the same as either the magic or null attributes.

- menugroup

The name of a menu group the property should be sorted into under the name specified in menuname. This is only used in graphical user interfaces.

- menuпате

This is an alternative, user-friendly name to be used in menu displays and similar circumstances. This attribute is a free-form string. Since it is not decoded as property name, it does not need to adhere to the Састvs property naming conventions.

- mergefunction

The name of a function which is called when property data attached to a major object is prepared for merging, for example in the context of the ens merge command. The type of the function must be the same as that of the compute function. In case this is a TcL procedure, it is called with the the two object handles as argument.

If the merge function can be found in the private slave interpreter of the property, it is executed there. Otherwise, an attempt is made to locate and run it in the main interpreter. When a property definition file is written with prop write, and the function can be located, it is encapsulated in the definition file and is available for all further interpreters which read the definition file.

The purpose of the merge function is to modify the data values in the second object in order to prepare its merge with the first object. It must not perform any merge operation itself. For example, the built-in merge functions for minor object labels (properties A_LABEL, B_LABEL, etc.) adds an offset to the label values of the second object in order to avoid the assignment of identical labels to two minor objects in the merged ensemble. The merge function for atomic 2D coordinates (property A_XY) scales the coordinates of the second object to fit with the scaling of the first, and then adjust the coordinates so that the structures are displayed side by side after merging.

- min

The minimum expected property value. This value is not enforced - it is primarily intended to be used to compute color scales etc. from property values. See also the max attribute. The attribute must be set to a valid string representation which can be decoded with the current property definition, and should not be the same as either the magic or null attributes.

- name

This is the name of the property. Changing it after it has been defined originally is generally considered bad style, but it is possible. Internal data references use pointers, not strings with names.

- nativename

Internal use only.

- null

The string representation of the first null property value. Usually this is set to the same string as the magic attribute, or an empty string. The value must be a valid string representation that can be decoded with the current property definition if it is not an empty string. An empty string disables the null value check and is not parsed, even if that is a valid representation of a property value.

- null1

This is an alias for the null attribute above.There are a maximum of three recognized null values - this follows the SPSS statistical analysis package data model. The second value is only applied if the first value is set, and the third only if the first and second are defined.

- null2

The second null value.

- null3

The third null value.

- nullrange

A list with a pair of elements defining an inclusive lower and upper value limit for property values regarded as null data. The format of each of those elements is the same as for the null attribute described above. This range criterion is distinct from the normal null parameter - both may be used in combination. For properties where the associated property data type does not support larger/smaller comparisons, this attribute is not useful.

- objclass

The name of a chemical object class the property is attached to. By default, this is automatically set by decoding the prefix of the property name, and it is highly recommended that you do not override this automatic prefix scheme. attachment is an alias for this attribute.

- objectfile

This is the name of the shared object (DLL, Bundle) file for a dynamically loaded computation modules. This attribute is empty for properties which do not possess a compiled computation module.

- originalname

The original name of the property. When data is read from a file, and the tag the data is stored under does not match the Састvs property name, this attribute is automatically globally updated and set to the name as found in the file. There is currently no mechanism to remember multiple original names from different files in parallel.

When property data is written to a file, and an original name is set for an output property, this name is used in preference to the Сactvs name if the file syntax allows it. For example, this is the attribute which should be changed in order to set arbitrary SD data field names for property data.

This attribute can be set to arbitrary strings and does not need to follow the Сactvs property naming conventions. Nevertheless, names set via this attribute are used to resolve properties only as fall-back. The priorities for name resolution are aliases first, then proper Cactvs names, and finally original names. Menu names are never used for property lookup.

- orcid

The ORCID code of the author of the property definition (see www.orcid.org).

- outputlevel

Deprecated. Originally intended to allow the selection of groups of properties up to a certain level of importance in output sets without the need to name them explicitly. The higher the specified level for a property, the more important it is supposed to be. Its output level value is compared to the output level of, for example, a structure file handle, and the property is included if its level is equal to or larger than the file object level. In practical experience, this does not work too well. In any case, the decision to include or suppress the data of a property via this criterion can be overruled by the property outputmode attribute, and the write and suppress lists of structure file objects.

## - outputmode

This attribute is one of several attributes which control whether data for a property is included in output or not. It can be one of three values:

- suppressed the data is never output
- standard
the property output is decided by other factors, such as the outputlevel attribute or property control lists of structure file objects
- forced
the property is always written, regardless of other settings.
The default value is standard.
- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

## parameters

This is a keyword/value list of the adjustable parameters used in the property computation routine. It must be set as a proper TcL list with an even number of elements. or, equivalently, a TcL dictionary.

For multi-threaded scripts, this attribute is thread-local. When a script thread first refers to a property, its thread-local parameter set is copied from the current global setting. All further manipulations only change the thread-local copy. The only exception is the base thread, which updates the master copy. In case a script thread needs to change or query the global setting, it can use the globalparameters attribute. For the base thread, these two attribute names are identical. The split of the parameter set into thread-local versions allows multiple threads to compute different variants of data for the same property simultaneously.

Convenient methods to access the parameter set are via statements like

```
array set params [prop get $pname parameters]
set paramdict [dict create {*}[prop get $pname parameters]
```

The first example initializes the array variable params to proper element names and values. The second method initializes a TcL dictionary.

The reverse path is also straightforward:

```
prop set $pname parameters [array get params]
```

Please refer also to the paragraph about the computefunction attribute for more details on how to access the parameter set in computation functions.

- password

A free-'form text password which is transmitted as part of the request data for computations which are performed on a remote server. The server may use this information to grant or deny the processing request. This attribute is not used for local computations.

- port

The port used to contact a remove computation server. The default port for distributed Cactvs computation servers is 16520 . For local computations, this attribute is ignored.

## - precision

The number of significant digits after the decimal point for floating-point data.

- precompute

This is a list of properties for which an attempt is made to pre-compute them before the computation function for this property is called. In case the computation fails, it is silently ignored.

This attribute is primarily useful to control the location of computation for low-level property data when using server-based set-ups. In case the computation is performed implicitly in the computation function running on a server, the low-level computations also take place there if they are not themselves farmed out. If these properties are listed as precompute properties, they are computed on the client side before the request is sent.

- profile

Internal use only.

- regexp

This attribute provides a method to check the encoding of property data values that are read from strings, or from TcL interpreter objects. The argument is a regular expression. If input data does not match it, it is rejected. The check is only performed at the time of input via the handler function. Compiled code manipulating internal data structures directly can still produce data which does not pass the expression filter.

Data format handler modules need to implement this function individually. At this time, the data types which support this are string, stringevector, unicode and unicodevector. Data format handlers which do not support regular expression filtering silently ignore it. The match operation of the regular expression can be further controlled with the regexpflags attribute.

This attribute can be used in combination with the constraints attribute.
Example:
prop set E_REGID regexp \{TinyPharma[0-9]+\}

- references

Cross references of the property definition. This is a nested list of class UUIDs and reference type tags.

- regexpflags

This set of flags controls the match condition for regular expressions set via the regexp attribute. It is a set of flags. The currently supported flags

- none
no flags, can also be set as empty string
- extended
use extended regular expression syntax
- nocase
ignore case
Example:
prop set E_REGID regexpflags \{nocase extended\}
- regid

The official registration ID of the property. Properties of general usefulness can be registered and be assigned an official numerical identifier. This attribute must be set by a (potentially, digitally signed) property definition record. It cannot be set by script commands.

- required

This attribute is a list of properties which need to be present before a remote or threaded computation of property data can be attempted. In client/server computations, the client tries to compute all these properties and send the data (together with helpful, but not mandatory data - see helpful attribute) to the server. In case of a threaded property computation, the required properties are computed on the original object before it is duplicated for use with the independent thread. This attribute has no effect on local computations.

- scale

A scaling value for numerical data. The default is 1.0 . This attribute is defined, but currently only passed on for MDL XDF file format output. It has no effect on the interpretation of property data

- separator

A field separator which enables word-indexed addressing in string-style property data types. Example:

```
prop create E_MYID separator :
set eh [ens create $smiles]
ens set $eh E_MYID "p345:c64587:u45"
ens show $eh E_MYID(1)
```

This returns "c64587". In case the separator is more than a single character, any of the listed characters is considered a word boundary. The split occurs on any sequence of characters from the separator set. The default separator is white space.

- sourcefile

The name of the source file of a compiled property computation module. No guarantee is given that the file is contained in any specific toolkit distribution.

- status

A read-only attribute which lists the currently set flags in the internal status word of the property. This is primarily useful for debugging purposes.

- testdata

The name of a file with sample structures and result data which can be used to verify the correct computation of property data in an installation. It should contain a reasonable set of structurally different structures and result data for this property which has been verified to be correct. The most suitable type of file for this data is a native Cactvs binary structure file.

When a property definition file is written with the prop write command, this data is encapsulated in the definition file. When the definition file is later read by an application, the data is written out to a temporary file, and the file name returned for this attribute is the name of the temp file, not the original file name. By this mechanism, it is not required to supply test data files as a separate files which may be difficult to locate and are easy to get lost.

If this field is empty, which is the default, no test data is present.

## - timeout

A timeout for the property computation in seconds. If it is set to zero, the default, no timeout is in effect. Once a property computation exceeds its maximum computation time, it is aborted, and the computation fails. The timeout value is the total CPU time spent in the call to the computation routine. This includes all time spent with the computation of low-level properties which are requested inside the computation function of the current property.
Computation aborts can lead to serious memory leaks. Time-outs should therefore not be used without need. Additionally, checking the time and setting interrupt handlers involves multiple system calls. The computation of trivial properties can slow down significantly if time-outs are enabled.

Time-outs may be stacked if required, i.e. a timed computation routine can request the computation of another timed property. In that case, in the inner computation routine, both timers are active, and the timeout of any of these will lead to an overall computation failure.

- trace

This is a deprecated attribute to control the tracing of computations in script functions. Please use the flags attribute.

- traits

A couple of indicator bits describing the general type of the property. The value can currently be none, or any combination of hashcode, stereodescriptor, rendering, pixelimage, vectorimage, linenotation, 3dmodel, spectrum and interactive.

- unit

An information string describing the unit the proper data is using. The string is not parsed to enforce a recognized set of units, but built-in unit conversions only work if a standard unit is used. Supported unit sets currently include length, energy, mass, time, pressure, temperature, volume and mols. For any of these, a standard range of units is recognized (e.g. picoseconds $/ p s$ to years $/ y$ for time, and Joules, $k c a l s$, etc. for energy).

- version

The version of the property definition. This is a free-form string.

- versionuuid

The version UUID associated with this property definition version.

- width

The width of the property. This is the number of slots the property is occupying in the data storage area of chemistry objects. The vast majority of properties has a width of one, and this is the default. The only standard exception are certain bond properties which are
directional, i.e. there are two values, one for looking from the first atom to the second, and a different value for looking into the reverse direction. These bond properties have a width of two. In principle, it is possible to define properties of larger width, or to use this functionality on properties which are not attached to bonds.

Property values of properties which are of a width larger than one are returned and input as lists in TCL scripts. The length of these lists must be the same as the width in the property definition. It is not possible to access single-slot subsets of the property data directly.
Use of this feature is no longer recommended. For multi-value properties, the use of compound data type properties, or a split into two independent properties are often better solutions.

- windfall

A set of properties that is attached as result data as a side effect of computing this property. For local computations, this is for information only. For server property computations, it prepares the client to expect these additional property data records to be transmitted. Note that this list is not supposed to include minor, dependent properties which are needed as input for the computation. Rather, this should be used if there are two or more potentially interesting result properties which are most conveniently computed in parallel, and where computation of any of the additional properties in a separate request would essentially require to run the same computation over again.
In a typical set-up, the windfall properties do not define their own computation functions, but redirect to the computation of this property via an indirect attribute, resulting in a set of two or more properties which are always computed together and where the combined computation function is maintained in a single place, on the property which lists them as windfall results.

The prop set command supports a special attribute value syntax for manipulating bitset-type attributes. If the first character of the argument is a minus character ( - ), the named bits in the set identified by the remainder of the argument are unset. If it is a plus ( + ), they are additionally set. With an equal $\operatorname{sign}(=)$, or no special lead character, the flag set replaces the old value. A leading caret character $\left({ }^{\wedge}\right)$ toggles the selected bits.
Example:

```
prop set E_SCREEN flags +locked:fixedlength
prop set E_SCREEN flags -locked
prop setparameter
prop setparameter propertyname ?parameter value?...
prop setparameter propertyname dictionary
```

Set zero or more computation parameters. In multi-threaded scripts, this effects only the thread-local parameter set. Only the base interpreter, and its slaves, manipulate the global parameter set, in addition to its own thread-local set.
In the second command variant, the dictionary argument must be a properly formed TcL dictionary with suitable keyword/value pairs. If that is the case, the dictionary is implicitly expanded and processing proceeds as in the first command variant.

An attempt to set a parameter whose name is not listed in the current parameter set fails with an error. This is a safety mechanism to prevent typos in parameter names. Nevertheless, setting such an unknown parameter does succeed internally. In order to force the addition of a new parameter, the statement can be written with a catch command:

```
catch {prop setparam $pname my_new_parameter "New World!"}
```

This command can be abbreviated as prop setparam.
There is no command to unset a single parameter. This can be done by retrieving and manipulating the complete parameter list via a command like

```
set d [dict create {*}[prop get $propname parameters]]
dict unset d $obsolete_param
prop set $propname parameters $d
prop sqldecode
prop sqldecode propertyname value
```

Attempt to decode a property value from a string formatted in SQL-style encoding. If it succeeds, its standard Tcl representation is returned. Otherwise, an error results.
prop sqlencode
prop sqlencode propertyname value
Encode a property value in SQL formatting. The value parameter must be a valid representation of the property value in its TcL format. If the decoding succeeds, and the data type handler supports SQL formatting, the returned value is suitable for constructing SQL statements.
prop sqlformat is an alias for this command.
prop string
prop string propertyname
Get the XML-style property definition record as a string. This is equivalent to writing out the property definition and reading the output file as text data.

## prop subcommands

prop subcommands
This command returns a list of all the subcommands of the prop command.

## prop unalias

prop unalias ?alias_name?...
Remove one or more alias definitions introduced by a prop alias command. If a specified alias name does not exist, it is silently ignored. If an existing property was hidden by an alias definition, it becomes visible again. However, existing property data in the name of the old alias on chemical objects continues to refer to the property definitions it was alias-mapped to when it was created.

## prop write

prop write propertyname ?filename?

Write the current definition of the property to a file. The file can be loaded into future script interpreters explicitly (see prop read command) or implicitly via the property definition auto-load mechanism. If no file name is given, the name of the file is automatically constructed from the property name in lower case and the suffix .xpd for the new-style xmL property definitions.

In addition to normal file names, the magic names stdout and stderr may be used, as well as already opened TcL socket and file handles, plus pipes indicated by a file name which starts with " "'. Writing to TcL channels is not supported on the MS Windows platform.If the file name argument is a directory, the file name is still automatically generated, and the file written in that directory. If a file name with an explicit .prp suffix is specified, the output is written in the legacy keyword/value ASCII-based file format. Old property definition files continue to be supported for both input and output. They are backward-compatible with earlier toolkit versions, though they cannot store all content of the newer XML format.

If the output is written to a regular file named in the command, the suffix .xpd is automatically added if necessary, and the output contain a single property definition record. By writing to a TcL channel, it is possible to write multiple properties into a single file, and these can be read in a single operation by the prop read command. For explicit file input, neither one of the two standard suffixes nor the standard file name derived from the property name are mandatory, but the naming convention must be adhered to in order to enable auto-loading of property definitions.

It is possible to write out built-in property definitions. For reference purposes, current toolkit distributions contain a BUILTIN directory which contains dumps of the property definitions of the built-in property set.

The command returns the name of the file written to.

## The repx Command

intentionally undocumented, internal use only

## The report Command

The report command is used to interact with report objects. The purpose of report objects is to generate reports in PDF or HTML format from structure data. PDF files can contain a hidden structure-searchable database with the structure and rendered or auxiliary data items.

The format of a report is defined by an XML style file, which describes a record box with arbitrary positioning of data or image fields. These record boxes can be stacked horizontally and vertically on report pages. The XML style file is embedded in PDFs written by report objects, so these files can contain both human-readable and computer-readable data content plus the layout information used to generate the file. It is for example possible to re-render content with a different style file, or use the style file extracted from a template file to render additional documents in exactly the same style.

The unit for describing report object placements are 72 DPI pixels. The are converted and/or scaled to the selected output format.

```
report create
report create ?attribute value?...
```

Create a new report object. Additionally, an set of attributes of the object may be defined in the same statement. The settable attributes are the same as in the report set command.

The command returns the handle of the new report object.

```
report delete
report delete ?handle?...
report delete all
```

Delete one of more report objects which are identified by their handles. The second variant deletes all currently defined report objects.

Example:
report delete $\{*\}$ [report list]
This command is equivalent to report delete all.

## report get

report get handle attribute
Query an attribute of a report object. The currently supported attributes are:

- affiliation

The institution the author of the report works for.

- author

The author of the report, as free-form text.

- authorurl

A URL with information on the author, or an empty string if unset.

- border

The distance between the paper or HTML page and the first elements of a data box.

## - boundingbox

A list of the upper left $\mathrm{x} / \mathrm{y}$ and lower right $\mathrm{x} / \mathrm{y}$ coordinates of the current layout, with all scaling and offset computations applied. This is a read-only attribute.

- category

A category string to be used if the report definition is stored in a repository.

- classuuid

The base class UUID of this report.

- comment

A free-form comment.

- date

The date of the last change of the report.

- dbfields

A nested list of the columns defined for the embedded structure and reaction database. Each field is reported as a list of the property or pseudo-property name of the field, the true database column name, a bitset set of any database field attributes set on the field (from the bit set of none, index, unique, notnull, nocompute), the name of the SQLITE database type used to encode the field, and the field length, which is zero if it is not defined.

If database fields have not yet been defined on the report object, querying or setting this attribute instantiates a standard set for a structure (but not reaction) database. Additionally, all properties currently associated with a data display field in the layout are automatically added, so that every visible data value can also be read from the database.

When setting this attribute, every field sublist must contain only between one and three elements. The last two items reported are automatically deduced from the type of data to be stored. If no explicit field name is specified, the field name is copied from the first argument. If no third element is supplied, the database column has no auxiliary SQL attributes, i.e. it is not indexed, may contain multiple entries of the same value, can be NULL, and an attempt will be made to compute its value when a structure or reaction record is written and the ensemble or reaction does not currently hold a value for the property or pseudo-property of the database column.

- dbfilename

The name of the SQLITE database file with the structure- and data-searchable content associated with this report object. It can also be set, though usually its name is auto-generated. Initially, an empty return value indicates that no file name has been set.

- doi

A digital object identifier for the report, if defined.

- email

An email contact address of the author.

- eolchars

The end-of-line character to use in ASCII-formatted output, such as the HTML report style. The default value is the platform style (Windows, Mac or Unix/Linux). It can be set to any string. Additionally, the magic values win (or crlf), mac (or cr) and linux (or unix, or lf) are recognized.

- footer

The center-aligned page footer text, which can contain placeholders. The default is an empty string.

- header

The center-aligned page header text, which can contain placeholders. The default is an empty string.

- htmlfilename

The name of the file with the HTML-formatted rendering of the report content. Usually, this is automatically set. The initial value is an empty string, which results in an automatically generated name if a HTML file is written.

- infourl

A URL with information on the report, or an empty string if unset.

- keywords

A list of keywords associated with the report

- leftfooter

The left-aligned page footer text, which can contain placeholders. The default is an empty string.

- leftheader

The left-aligned page header text, which can contain placeholders. The default is an empty string.

- versionuuid

The instance UUID associated with this report

- license

The license class associated with this report. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the report license.

- literature

This is a free-form string for a literature reference describing the meaning and/or algorithm behind the report.

- maxpages

The maximum number of pages to write, in PDF or HTML format. If the current data set is too large to fit into this number of pages, the rest is silently omitted. A negative value, which is the default, allows an unlimited number of pages. In any case, the maximum page count of a PDF report is 9999 pages. This is due to a limitation in the PDF rendering library.

- maxrecs

The maximum number of records to write, which is the same as the number of top-level data boxes. The actual size of the dataset or structure file used as data source for the report may be larger, if a filtering mechanism, such as selection processing, is set. Records in excess of the maximum are silently omitted. A negative value, which is the default, allows an unlimited number of records.

- name

The primary name of the report.

- orcid

The ORCID code of the author of the report (see www.orcid.org).

- orientation

The page orientation, which can either be portrait (the default) or landscape.

- ownerpassword

The owner password for generated PDF files. An empty string, which is the default, indicates that no password is set. For HTML output, this attribute is ignored.

- paper

The size of paper, such as A4, A3 or letter, which is used to format the output as PDF or HTML. This parameter has an effect even on HTML output, since the code contains page breaks for nice printing. The default is the toolkit default paper, which itself is usually A4 or letter

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- pdffilename

The name of the file with the PDF-formatted rendering of the report content. Usually, this is automatically set. The initial value is an empty string, which results in an automatically generated name if a PDF file is written.

## - references

Cross references of the report. This is a nested list of class UUIDs and reference type tags.

- regid

For registered reports, the registration ID. Unregistered modules report zero.

- rightfooter

The right-aligned page footer text, which can contain placeholders. The default is an empty string.

- rightheader

The right-aligned page header text, which can contain placeholders. The default is an empty string.

- scale

A scaling factor to convert the 72-DPI internal coordinates to print coordinates. The default scale is 1.0 . If set, the magic value \#auto is also recognized, which sets the scaling factor so that the configured number of horizontal and vertical blocks with the current style file just fit onto the configured paper type. Please refer also to the interacting xblocks and yblocks attributes. Automatic setting of this attribute is only possible if a style file has been read, because it requires the box layout data.

- spacing

The number of pixels between top-level data boxes if more than one is stacked in x or y direction. The default spacing is 1 .

- styledata

The contents of the current style file, in original XML formatting. This data can be set either directly as a string, or indirectly via the stylefilename attribute. If set directly, the stylefilename atribute is reset.

- stylefilename

The name of the XML file with report render style information. Its initial value is an empty string. If this attribute is set, the file contents are parsed and stored internally. The file contest are then available as in the styledata attribute.

- title

The title of the report as a free-form string. In HTML reports, it is used as page title. In PDF, it is part of the document metadata.

- userpassword

The user password for PDF documents. By default, it is an empty string, which means that no password is set. For HTML output, the attribute is ignored.

- version

A version string

- versionuuid

The version UUID associated with this report version.

- xblocks

The number of top-level data boxes to arrange in horizontal direction on a document page. When it is set, the magic words \#auto is recognized, which computes the maximum number of boxes which can be placed without overspill on the page using the current border, spacing and scaled top-level box size. Please refer also to the interacting scale attribute. Automatic setting of this attribute is only possible if a style file has been read, because it requires the box layout data.

- yblocks

The number of top-level data boxes to arrange in vertical direction on a document page. When it is set, the magic words \#auto is recognized, which computes the maximum number of boxes which can be placed without overspill on the page using the current border, spacing and scaled top-level box size. Please refer also to the interacting scale attribute. Automatic setting of this attribute is only possible if a style file has been read, because it requires the box layout data.

```
report list
```

report list ?pattern?
Return the handles of all currently defined report objects. The handles may optionally be filtered by a standard Tcl string match condition.
report set
report set handle ?attribute value?..
Set attributes of the report object. The attributes are explained in the section on the report get command.

Example:

```
report set $rhandle stylefile "mystyle.xml" paper A4 xblocks 2 yblocks #auto \
    scale #auto
```

This is a typical page set-up operation. The PDF or HTML form of the report will contain 2 top-level boxes arranged horizontally, a suitable (as computed from the aspect ratio of the paper) number of vertically stacked blocks, and everything scaled so that either the horizontal or vertical extent of the block stacks, plus the border, just fit onto the selected paper, without overspill.

## report subcommands

report subcommands
Return a list of all subcommands of report objects. The command does not have any parameters.

## The soap Command

The soap command is used to facilitate networked communication by means of SOAP messages. SOAP message objects are also useful to parse other styles of XML-formatted messages which are not really SOAP, for example NCBI Entrez eutils result messages.

SOAP objects are created like other Cactvs objects, and have internal state, so it is possible to communicate with multiple sources simultaneously by creating a SOAP object for every channel.

SOAP objects share many characteristics with JSON objects, and many commands are identical or at least very similar.

These are the currently supported SOAP object commands:

## soap append

soap append soaphandle ?attribute value?...
This is a variant of the soap set command. The difference is that the supplied data is appended to the current attribute value instead of replacing it. In case appending is not a possible operation, the result is the same as using soap set.

The set of supported attributes is explained in the paragraph on soap set.

## soap create

soap create ?attribute value?...
Create a new SOAP object. The return value is the object handle. If no extra attributes are specified, an empty object with default settings is created. Processing of specified optional attribute/value pairs is performed in as an identical fashion to the soap set command.

```
soap delete
soap delete ?soaphandle?...
soap delete all
```

Destroy one or more SOAP objects. The special word all can be used to remove all SOAP objects currently defined in the interpreter.

For the sake of consistency with the commands for other objects, soap close is an alias to this command.

The return value is the number of successfully deleted SOAP objects.

## soap error

```
soap error soaphandle ??message? channel? ?code? ?factor?
```

Send a properly formatted SOAP error message over a TCL channel to a client, or at least prepare it. If any of the optional arguments behind the channel argument are provided, they are processed like soap set commands and change the internal attributes of the object.

In the generated message, the message, code and factor values are wrapped into XML tags of type faultstring, faultcode and faulffactor, respectively. Usually, the factor value should be set to the URI of the service, which could be stored in the uri attribute of the SOAP object. This core information
is then embedded into a standard SOAP fault envelope. If no channel argument or an empty string is specified, and the internal channel of the SOAP object is undefined, no data is transmitted over the channel, but the message is still formatted. If a valid channel was specified, or the SOAP object has a valid internal channel, the message is immediately transmitted.

The return value of the command is the complete SOAP error message, with header and body. The internal header and body fields of the SOAP object are also updated and allow subsequent individual retrieval of these components.

## soap find

soap find soaphandle taglist ?mode? ?contentflags?
Find the contents and/or attributes of specific XML tags in a message. The computation of a parse tree (see soap parse command) is a prerequisite for this function. If a parse tree does not yet exist, but the SOAP object has body data, an automatic attempt is made to execute a parse of the full message body data.

The command returns data found inside the first of potentially multiple query tags which matches in case-sensitive fashion a tag in the parse tree, which is traversed depth-first.

The mode argument determines the reporting mode. It can be one of

- first

Find the first instance of tag and return single data item.

- next

Find the next instance of tag after current position, or begin of message if this is the first query, and return single data item.

- a numerical index

Find the $n t h$ instance of the tag and return single data item. The index starts with zero.

- all

Return all matching tag contents as a list of data item information. This is the default mode.
The type of tag content reported can be configured by the contentflags argument. The argument can be an arbitrary list made from the words

- tag

The name of the tag itself.

- attributes

The attributes of the tag, as name/value dictionary.

- chardata

The character data in the tag, excluding embedded inner tags, possibly trimmed (see trimmed flag word).

- children

If set, include the same data as for the matched tag recursively for all its children, as nested lists.

- trimmed

Remove left and right white space from the returned chardata value.

- noleafchildren

If children is set, omit output of an empty children list if a node has no children.
The default output selection is just chardata. If multiple content flags are selected, the order of the elements in an item output list is tag, attributes, chardata and finally children. If a query fails to yield any results, an empty string is returned. In reporting mode all, the item output lists are themselves list elements of the overall result list.

This command is not SOAP-specific but can work in principle on any XML data, for example Entrez eutils output.

## soap get

soap get soaphandle attribute
Query the value of an attribute of a SOAP object. The list of recognized attributes is explained in the paragraph on the soap set command.

The return value of the command is the value of the attribute.

```
soap list
```

soap list ?pattern?

Return a list of all currently existing soap objects in the interpreter. If desired, the list can be filtered by a string pattern.

## soap parse

soap parse soaphandle ?starttag? ?class? ?data?
Parse an XML message stored in the body attribute of the object and create the parse tree which is the prerequisite for retrieval of message content via the soap find command. If a data argument is supplied, it replaces the body data of the object.

By default, or when the start tag argument is set to an empty string, the complete message is parsed. Optionally, processing can be limited to a subsection of the full data that starts with the specified tag. In that case, only the content between the first opening and closing tags matching the supplied start tag is analyzed, and the argument replaces the tag attribute of the SOAP object. In case of multiple tags with the same name in the parsed data, an additional class attribute can be specified as a second element. If this optional filtering argument is used, the first tag block matching both the tag name and having a matching class attribute is extracted and parsed. If the class argument is omitted, or empty, no class filtering is performed.

The result of the command is the parse tree in nested list representation. This is the same data as the parsetree attribute which can be queried via soap get.

## soap read

soap read soaphandle ?channel?
Read a message with a MIME header from a channel. If the channel argument is not supplied, the internally configured SOAP object channel is used. The internal header and body attributes of the object are updated when the read succeeds. Note that this command works with any communication which uses a MIME header and body data. It is not limited to reading SOAP messages, or even plain XML data.

The reader supports chunked data transmission.
The return value of the command is the received body text. In most applications, this command is followed by a soap parse command, and then multiple soap find commands.

## soap reformat

soap reformat soaphandle ?string?
Pretty-print an XML blob, with properly indented nested tags for easy visual inspection. If no explicit string is specified, the current body attribute value of the soap object is used. The return value of the command is the reformatted content. The original data is not changed.

This command assumes that the input is not pre-formatted. It does not attempt to remove existing line feeds for formatting whitespace on the input, but rather adds it own formatting on top.

## soap request

soap request soaphandle ?method? ?channel? ?parameters? ?uri?
Call a SOAP handler on a remote server, or at least prepare the message to do that. If any of the optional arguments with the exception of the channel argument are provided, they are processed like soap set commands and change the internal attributes of the object. If the uri argument is not supplied, and the SOAP object has no configured uri attribute, a default URI to be used as part of the HTTP POST instruction in the header is constructed from the host, port and method attributes. This URI is not directly used to open a communication channel, though - the TcL transmission channel can be opened by any suitable means.

If the channel argument is not supplied, or written as an empty string, and the object has no valid internal handle, the message is just assembled. Otherwise, it is transmitted directly. Using a channel argument does not update the internal channel attribute of the object.

The return value of the command is the complete SOAP error message, with header and body. The internal header and body fields of the SOAP object are also updated and allow subsequent individual retrievals of these components.

Note that this command just sends the request, but does not wait for or read the server response. Use the soap read command for this purpose.

## soap respond

soap respond soaphandle responsedata ?channel? ?method? ?namespace?
Send a properly formatted SOAP response message over a TCL channel to a client, usually as a response to receiving a SOAP request message from that client. If any of the optional arguments behind channel are provided, they are processed like soap set commands and change the internal attributes of the object

In the generated message, the responsedata value is wrapped into an XML tag of type <methodResponse>, where method is replaced by the name of the configured SOAP method. This core information is then embedded into a standard SOAP envelope and transmitted over the channel. If no channel argument is given, and the internal channel of the SOAP object is undefined, the message is just formatted, but not transmitted.

The return value of the command is the complete SOAP message, with header and body. The internal header and body fields of the SOAP object are also updated and allow subsequent individual retrievals of these components.
soap set
soap set soaphandle ?attribute value?..
Set one or more attributes of a SOAP object. Since this paragraph is also referenced from the soap get subcommand, the attribute set listed here includes attributes which cannot be set, or for which setting them to any scripted value does not usually make sense.

The currently supported set of attributes is:

- body

The body part of the last received SOAP message. This attribute is not usually set.

- bodylength

The length of the body, in bytes. This is a read-only attribute.

- channel

The communication channel associated with the SOAP object. This is a standard TcL channel handle. It is possible to set it to an empty string, which indicates that no channel is set.

- errorcode

The error code from the last XML parsing step as integer value. If no error occurred, the value is 0 .

- errorcolumn

The column the XML parser detected the last error.

- errorfactor

The factor leading to an error, either as received from a SOAP message, or set in preparation of sending an error message. Standard practice is to send the URI of the failed service in this field.

- errorline

The line the XML parser detected the last error.

- errormsg

The message of a SOAP error, either as extracted from a SOAP message, or set in preparation of sending an error message.

- header

The header part of the last received SOAP message. This attribute is not usually set.

- headerlength

The length of the header, in bytes. This is a read-only attribute.

- host

The remote host the SOAP object communicates with.

- method

The method identification of either the last received SOAP message, or set in preparation to send a message.

- namespace

The SOAP method namespace. It can be set to an empty string in order to avoid using method namespace attributes in sent XML messages altogether. The namespace suppression only applies to the method section. The overall SOAP envelope will still contain a standard set of namespace references.

- parameters

The SOAP method parameters. If queried, this is a dictionary of name/value pairs. In order to set these, a properly formatted dictionary must be supplied. The formatting is the same as for the parameters attribute of property definitions.

- parsetree

A nested list representation of parse tree generated by the last successful XML content parse by means of the soap parse command. This is a read-only attribute, and primarily useful for debugging.

- port

The port the SOAP object uses for network communication. The default is 80 , the standard HTTP port.

- response

The response part of the last SOAP message, in parse tree representation. This is a read-only attribute.

- result

The pure method invocation result data extracted from the last SOAP message. This is a read-only attribute.

- tag

The current start tag for parsing a subsection of XML message content, see soap parse command.

- uri

The URI associated with a SOAP service.

## soap subcommands

soap subcommands
This command returns a list of all the subcommands of the soap command.

## The tablex Command

The tablex command is used to manage table file format handler extensions. The command has the following subcommands:

## tablex defined

tablex define format
A boolean check whether a specific table file format is supported by an $\mathrm{I} / \mathrm{O}$ handler. If the format is not yet known, an attempt is made to locate and auto-load the I/O module. For an equivalent command without auto-loading, see tablex exists.

## tablex exists

tablex exists format
A boolean check whether a specific table file format is supported by an I/O handler. No attempt is made to auto-load a handler module if it is not already in memory. The name can be the primary name of the table file format, or any recognized alias. For an equivalent command with auto-loading, see tablex defined.
tablex get
tablex get format attribute
Query the value of an attribute of the table file format handler. The list of supported attributes is described in the section on the tablex set command.

If the format is not yet known, an attempt is made to auto-load it.

## tablex list

tablex list ?pattern?
Return a list of all currently supported table formats, including those handled by built-in format handlers. If desired, the list can be filtered by a string pattern.

## tablex load

```
tablex load format ?objectfile?
```

tablex load all

Explicitly load a table file format handler module. If the module is already loaded, the current version is unloaded first. If no specific object file (a shared library on Unix/Linux, a DLL on Windows, a bundle file for MacOSX) is specified, the standard name of the module file is automatically generated from the data type name, and then the file searched in the directories in the data type handler module path. The module search path can be customized in the control variable : : cactvs (tablexpath) .

The return value of the command is the slot in the table file format module table the module has been loaded into. This corresponds to the value of the slot attribute which can be queried via tablex get.

The second form of the command scans the currently set table format extension search path and loads all accessible modules which are not yet in memory. Modules which are already active in the running application are not unloaded, and only a single instance of each I/O module, even if present
under various alias names in the module directories, is loaded. This form of the command does not return a value.

## tablex subcommands

tablex subcommands
Return a list of all supported subcommands of the tablex command in the current interpreter.

## tablex set

tablex set format ?attribute value?.
Set one or more attributes of the table file format handler. Some attributes are read-only. They are still listed here because the tablex get command refers to this section. The following attributes are recognized:

- affiliation

The institution the author of the table extension definition works for.

- aliases

A list of alternative names that are recognized as alternative names for the table file format.

- author

The author of the module, as free-form text.

- authorurl

A URL with information on the author, or an empty string if unset.

- builtin

A boolean flag indicating whether the format handler is built-in. This is a read-only attribute.

- category

A category string to be used if the table extension is stored in a repository.

- charset

The character set the file format uses.

- classuuid

The base class UUID of this module.

- comment

A free-form comment.

- date

The date of the last change of the module source code.

- doi

A digital object identifier for the module, if defined.

- email

An email contact address of the author.

- features

A list of the types of functions the module provides in its function table. Function types include check (auto-identify file format), read (read that format) and write (write that format).

- infourl

A URL with information on the module, or an empty string if unset.

- keywords

A list of keywords associated with the module.

- license

The license class associated with this module. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the module license.

- literature

This is a free-form string for a literature reference describing the meaning and/or algorithm behind the module.

- mimetype

The MIME type of the table file format, for example application/ms-excel.

- name

The primary name of the table file format. Because the format may have been specified via an alias name, this may not be the same as he command parameter.

- objectfile

The full path name of the object file (shared library, DLL or bundle file) of the module. For built-in modules, this is an empty string.

- orcid

The ORCID code of the author of the module (see www.orcid.org).

- parameters

A keyword/value dictionary of format-specific I/O attributes with their default values which are not represented as general table object attributes. Upon file output with a specific format, parameters from this dictionary which have not been explicitly configured in the parameters attribute of the table object to be written are added from the table I/O module instance to it. Dictionary keys already set as a custom table parameters entry are not overwritten.

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- references

Cross references of the module. This is a nested list of class UUIDs and reference type tags.

- regid

For registered modules, the registration ID. Unregistered modules report zero.

- slot

The table file format handler table slot the module is loaded into. This attribute is read-only.

- sourcefile

The source file of the module, if available.

- suffixes

A list of file name suffixes associated with this format. This is a read-only attribute.

- version

A version string

- versionuuid

The version UUID associated with this module version.

## tablex unload

tablex unload ?format?..
Unload one or more table file format handler modules. It is an error to specify the name of a module which is not loaded. Built-in modules cannot be unloaded.

## The typex Command

The typex command is used to manage data type handler extensions. The command has the following subcommands:

## typex defined

typex defined datatypename
A boolean check whether a specific data type is supported by a data type handler. If the format is not yet known, an attempt is made to locate and auto-load the handler module. For an equivalent command without auto-loading, see typex exists.
typex exists
typex exists datatypename
A boolean check whether a specific data type is supported by a data type handler. No attempt is made to auto-load a handler module if it is not already in memory. The name can be the primary name of the data type, or any recognized alias. For an equivalent command with auto-loading, see typex defined.

## typex get

typex get datatypename attribute
Query the value of an attribute of the data type handler. Note that data type handlers are static - it is neither possible to define them on the command line, nor to change any attribute. Therefore, there are no typex create or typex set commands.

The following attributes are recognized:

- aliases

A list of recognized alias names of the data type.

- affiliation

The institution the author works for.

- author

The author of the module, as free-format text.

- authorurl

A URL with information on the author, or an empty string if unset.

- builtin

A boolean flag indicating whether this is a built-in type. This is a read-only attribute.

- category

A category string to be used if the module is stored in a repository.

- classuuid

The base class UUID of this type extension

- cmpops

A list of the comparison operation flags the handler supports. Please refer to the prop compare command for a list of possible flags.

- comment

A free-form comment

- date

The date the module source code was last changed.

- doi

A digital object identifier for the module, if defined.

- elementsize

In case the data type has vector elements or other components which can be addressed in a vector-like fashion, and the size of these components is constant, this attribute reports the size of an element. A zero size is reported if this attribute is not applicable.

- elementtype

The data type of vector elements or other components which can be addressed in a vector-like fashion. For data types without sub-elements of a constant type, this is an empty string.

- email

An email contact address of the developer of the module.

- flags

A collection of flags reporting specific properties of the datatype. The currently supported set is:

- none

No flags

- indexable

The data type supports the extraction of components.

- knimecompatible

This data type has a compatible data type in the KNIME system.

- multiline

The data type produces multi-line file output in standard formatting

- needswritelock

Internal use only.

- nominmax

The data type has no reasonable definition, or use of, minimum and maximum values.

- precision

The data type supports the concept of numerical precision.

- simplenumeric

This is a simple numeric type.

- vector

The data type is a vector type with identical elements that can be accessed by a numeric index.

- infourl

A URL with information on the module, or an empty string if unset.

- keywords

A list of keywords associated with the module.

- license

The license class associated with this module. Setting the license to a standard type updates the associated URL with a standard location.

- licenseurl

A URL with details about the module license.

- literature

A free-form literature reference.

- isarray

A boolean flag indicating whether this data type is an array or not.

- name

The primary name of the data type. Since the information may be queried via an alias name, this can be different from the command argument.

- objectfile

The full path of the object file (DLL, shared library or bundle file) of dynamically loaded modules. For built-in handlers, this is an empty string.

- orcid

The ORCID code of the author (see www.orcid.org).

- path

The repository path for displaying hierarchical repository trees. This attribute is independent of any file system paths.

- references

Cross references of the module. This is a nested list of class UUIDs and reference type tags.

- regid

For officially registered data type handlers, this is the assigned registration ID. Unregistered modules report zero.

- slot

The slot in the handler table the module was loaded into.

- sourcefile

The name of the source file for the module, if it is available.

- $s q l$

The SQL type name of the data type. In case there is no applicable SQL data type, this is an empty string.

- sqlarray

The PostgresQL-style type name of SQL arrays of the data type. In case there is no such SQL type, this is an empty string.

- version

Version information for the module in free format.

- versionuuid

The UUID associated with this module version.

- xml

The XML type name of the data type.

```
typex list
typex list ?pattern?
```

Return a list of all currently loaded data types, including those handled by built-in data type handlers. If desired, the list can be filtered by a string pattern.

## typex load

typex load datatypename ?objectfile?
typex load all
Explicitly load a data type handler module. If the module is already loaded, the current version is unloaded first.

If no specific object file (a shared library on Unix/Linux, a DLL on Windows, a bundle file for MacOSX) is specified, the standard name of the module file is automatically generated from the data type name, and then the file searched in the directories in the data type handler module path. The module search path can be customized in the control variable : :cactvs (typexpath) .

The return value of the command is the slot in the handler module table the module has been loaded into. This corresponds to the value of the slot attribute which can be queried via typex get.

The magic name all instructs the program to traverse the data type extension search path and to load all data type extension modules found which are not yet loaded. In that case, the return value of the command is empty.

## typex subcommands

typex subcommands
Return a list of all subcommands of the typex command in the current interpreter.

## typex unload

typex unload ?datatypename?..
Unload zero or more data type handler modules. It is an error to specify the name of a module which is not loaded. Built-in handler modules cannot be unloaded. Unloading a handler module when there is still property data of that type linked to chemical objects lead to memory leaks and/or confusing error messages when operating with these objects.

## The Idap Module

Various operations on LDAP directories are supported after loading the external Ldap TcL module. Only after loading the module, the ldap extension command is accessible.

Example:
package require Ldap
The next step is usually the establishment of a connection (bind) to a known LDAP server. In many cases credentials are required for a successful bind with a DN containing a user name. After a completed bind, a handle is returned. This handle can be used for further operations, such as information retrieval, until the connection is closed by an unbind command.

The general syntax of the ldap command follows the usual command/subcommand/handle/ parameters syntax.

Examples:

```
set lhandle [ldap bind $host $port $binddn $passwd]
ldap unbind $lhandle
```

The LDAP module currently only supports synchronous operations.
This is the list of subcommands:
Idap add
ldap add ldhandle dn attribute_list
Add one or more attributes to an existing DN. Other than that the default mode is LDAP_MOD_ADD, this command is identical to ldap replace.

## Idap addrdn

ldap addrdn ldhandle dn newrdn
Add a new relative DN to an existing LDAP directory identified by the base DN .

## Idap bind

```
ldap bind host ?port? ?bindDN? ?password?
ldap open host ?port? ?bindDN? ?password?
```

Open a connection to an LDAP server and return the connection handle. Only the host parameter is required. If no port is specified, or an empty string, the default LDAP port (389) is used. If no distinguished name for binding is supplied, or an empty string, an anonymous bind is attempted. If an access control password is required, it may be supplied as last parameter.

The open command alternative is simply an alias intended to provide the standard command nomenclature for opening connections or files.

Example:
set lh [ldap bind \$host 389 "cn=mr_x, cn=users,dc=chemcodes,dc=com" \$themagicword]

## Idap delete

ldap delete ldhandle ?dn?...

This command deletes one or more DNs from the current LDAP server.

## Idap get

ldap get ldhandle attribute
Query status information about the LDAP connection. Currently, the following attributes can be queried:

- derefmode

Get the method for dereferencing aliases. The value must be one of never, searching finding (i.e when locating a base object, but not when searching under it), or always.

- sizelimit

The maximum number of returned responses. The default is 0 , meaning no limit on the number of responses.

- timelimit

A timeout value in seconds for server queries. The default is 0 , meaning no time limit.

## Example:

```
set tl [ldap get $ldhandle timelimit]
```

Idap list

```
ldap list ?pattern?
```

List all currently open LDAP connections. A list of the connection handles is returned Optionally, the handles, which are of the form ldap\%d, may be filtered by a string pattern.

Example:
ldap list
Idap replace
ldap replace ldhandle dn attribute_list
This command can be used to add, replace or delete one or more attributes of a DN. The attribute list is a standard TcL list, where each attribute is a list element. The list elements must be of the form attribute $=$ value, or simply attribute for deletions. Optionally, they may be prefixed by one of the characters " $+"$ (add attribute), " $="$ (replace attribute, or create new if not existing), and "-" (delete attribute). The implicit default is " $=$ ". It is possible to add multiple instances of attributes, such as a set of e-mail addresses in the form

```
set alist [list "+mail=wdi@chemcodes.com" "+mail=wdi@xemistry.com"]
```

The ldap add command is a variant of this command - the only difference is that the default modification mode is LDAP_MOD_ADD instead of LDAP_MOD_REPLACE, corresponding to am implicit "+" prefix instead of "=".

## Example:

```
ldap replace $ldhandle "cn=wdi,cn=users,dc=chemcodes,dc=com" \
    "mail=wdi@chemcodes.com"
```


## Idap replacerdn

ldap replacerdn ldhandle dn newrdn

Replace a DN in an LDAP directory. The old DN is deleted, and replaced by the new DN, which may be specified relative to the old.

## Idap search

ldap search ldhandle baseDN ?scope? ?getdn? ?filter? ?attributelist?
Query an LDAP server for information. Besides an active LDAP connection, the minimal argument set is only the base DB , the root from where the query should start on the connected server.

The optional scope argument may be default or an empty string (the default setting), base (search only the base object), one or level (search one level of sub-objects), or subtree (can be shortened to sub, search all sub-objects of the base object).

The getdn parameter is a boolean flag. If it is set, the first element of each response sublist is the DN of the entry. By default, only the attribute data is returned.

The filter parameter is a standard LDAP filter, which can be used to select subsets of directory entries. An empty string in this position, or omitting the parameter, disables filtering.

Finally, the last parameter is the set of attributes which should be returned. If it is omitted, or an empty string, all attributes of each matched entry are returned. If a requested attribute is not present in a matching record, it is silently omitted from the result list.

If no errors occurred, the result is a triply nested list. The outermost list contains one element for each entry. If a maximum number of responses was set to a positive value (sizelimit configuration parameter, see ldap set command), the maximum number of list elements is defined by this parameter. Each outer list element is itself a list. The middle lists contain one element for each returned attribute. Each of these is formatted as another sublist with attribute and value list elements. The attributes are returned in the order they were specified, provided that they are found in the returned set. If requested attributes are not present, they are silently omitted from the result list.

The command currently does support the retrieval of binary data.
Example:
ldap search \$ldhandle "cn=users,dc=chemcodes, $d c=c o m "$ one 0 \{\} [list mail phone]
returns a nested list of addresses, in the format
\{\{mail user1@addr1\} \{phone $x x x-100\}\}$ \{ \{mail user2@addr2\} \{phone $x x x-105\}\} .$.
if both the mail and phone attributes are present.
The retrieval of the e-mail address of user wdi may be achieved either by using a filter, or a more specific DN:

```
ldap search $ldhandle "cn=users,dc=chemcodes,dc=com" one 0 cn=wdi "mail phone"
ldap search $ldhandle "cn=wdi,cn=users,dc=chemcodes,dc=com" one 0 {} "mail phone"
```

The filter argument ${ }^{4}$ is a string representation of the filter to apply in the search. Simple filters can be specified as attributetype $=$ attributevalue. More complex filters are specified using a prefix notation according to the following BNF:
<filter> ::= '(' <filtercomp> ')'
<filtercomp> : := <and> | <or> | <not> | <simple>
<and> ::= '\&' <filterlist>
<or> ::= '|' <filterlist>
4. Description of filters copied from the OpenLDAP man page for ldap_search(3)

```
<not> ::= '!' <filter>
<filterlist> ::= <filter> | <filter> <filterlist>
<simple> ::= <attributetype> <filtertype> <attributevalue>
<filtertype> ::= '=' | '~=' | '<=' | '>='
```

The ' $\sim=$ ' construct is used to specify approximate matching. The representation for <attributetype> and <attributevalue> are as described in RFC 2254. In addition, <attributevalue> can be a single * to achieve an attribute existence test, or can contain text and *'s interspersed to achieve substring matching.

For example, the filter "mail=*" finds any entries that have a mail attribute. The filter
"mail=*@terminator.rs.itd.umich.edu" will find any entries that have a mail attribute ending in the specified string. To put parentheses in a filter, escape them with a backslash '\' character. See RFC 2254 for a more complete description of allowable filters.

## Idap set

ldap set ldhandle attribute value ?attribute value?...
Set one or more attributes for an LDAP connection. Currently, the following attributes can be set:

- derefmode

Set the method for dereferencing aliases. The value must be one of never, searching finding (i.e when locating a base object, but not for searching under it), or always.

- sizelimit

The maximum number of response record to accept. If set to 0 , any number of responses are accepted.

- timelimit

The maximum time in seconds to wait for a server response. If set to 0 , no timeout occurs.
Example:
ldap set $\$ 1$ dhandle sizelimit 5 timelimit 500

## Idap unbind

```
ldap unbind ldhandle ?ldhandle?...
ldap close ldhandle ?ldhandle?...
ldap unbind all
ldap close all
```

The first variant unbinds or closes (these are equivalent commands) a specific set if LDAP connections. All resources associated with the connection are freed, and the handles invalidated. However, they may later be reassigned to new connections.

The second alternative closes all currently opened LDAP connections.
The command returns the number of closed connections.
Example:
ldap close all
Idap verify
ldap verify ldhandle bindDN password
ldap verify host port bindDN password

Perform a basic (LDAP_AUTH_SIMPLE) user/access verification. The first variant uses an existing handle and attempts to re-bind it with a different distinguished bind name. The connection remains bound to the new address and DN.

The second variant temporarily creates a new LDAP connection and attempts to bind. The parameters have the same meaning as in the ldap bind command. The status is saved and then the connection is immediately closed. No persistent LDAP object is created.

This command returns 1 for a successful bind, and 0 for failure.
Example:
ldap verify \$host "" "dn=wdi,dn=users,dc=chemcodes,dc=com" \$mypwd

## The gdbm Module

The gdbm extension command is provided by the external Gdbm TcL module. It must be loaded before the command become available.

Example:

```
package require Gdbm
```

Gdbm files need to be opened or created before any operations on them can commence. Afterwards, the access object is identified by a handle, which is returned by the opener commands. When they are no longer in use, they should be closed. Gdbm files have different internal structure on 32 vs. 64 bit systems, and are byte-order-dependent. They are therefore best suited for local, temporary files.

The general syntax of the gdbm command follows the usual command/subcommand/handle/parameters syntax. The gdbm command is to a large degree compatible to the newer and generally preferred tc command, which performs the same types of operations on Tokyo Cabinet files. The latter command can be significantly faster for large files, generated more compact data files, and these data files are $32 / 64$-bit clean and byte-order-independent and thus much more portable between systems.

## Examples:

```
set gdhandle [gdbm open mygdbmfile.gdb]
set data [gdbm get $gdhandle $key]
gdibm close $gdhandle
```

This is the list of subcommands:

```
gdbm add
gdbm add gdhandle ?-nocase? key ?data?...
```

Append the listed data items as Tcl list elements to the entry identified by the key. If no such record exists, a new record with the initial set of list items is created. If any of the data items are already present in the current value list, they are ignored, so duplicates are not added. The duplicate check is performed in case-insensitive fashion if the -nocase flag is used.

The gdbm append command performs a similar operation, but without a duplicate check.
The command returns the updated entry value list.
This command only works if an existing value is a properly formatted TcL list.
Example:
gdbm append \$gdhandle "project_\$projectid" [ens get \$eh E_IDENT]

## gdbm append

gdbm append gdhandle key data ?data?...
Append the data items as TcL list elements to the entry identified by the key. If no such record exists, a new record with the initial set of list items is created. No duplicate check is performed for the added list elements - this is the difference to the gdbm add command.

The command returns the updated entry value list.
This command only works if an existing value is a properly formatted TcL list.

Example:

```
gdbm append $gdhandle "project_$projectid" [ens get $eh E_IDENT]
gdbm close
gdbm close ?gdhandle?...
gdbm close all
```

This command closes opened GdBm files. After a file has been closed, its handle becomes invalid, but may the reissued for another opened GdBm file again.

The first version of the command closes specific files. The second version closes all open Gdвm files in the current application. Both variants return the number of closed files as result.

Example:
gdbm close \$gdhandle
gdbm count
gdbm count gdhandle ?pattern?
Count the number of keys in the file. If a pattern argument is given, only the file entries with a matching key are counted. The command returns the number of passing keys.

Unfortunately, Gdbm files no not maintain an internal record count, so this command has to loop through all keys, which can take a substantial amount of time for large files.

The command gdbm size is an alias for this command.
Example:
set size [gdbm count \$gdhandle]
gdbm create
gdbm create filename ?modelist? ?filemode? ?blocksize?
This command is the same as the command gdbm open, except that the default file access mode to be used if no explicit mode list is specified is create instead of read.

Example:
set gdhandle [gdbm create thefile.gdb]

## gdbm delete

gdbm delete gdhandle key ?ispattern?
If no ispattern boolean argument is given, or it is not a true value, the record matching the key exactly is deleted. If the entry did exist and could be deleted, 1 is returned, 0 otherwise.

If the ispattern flag is set, the key argument is interpreted as a string match pattern. All records with keys matching the pattern are deleted. In this case, the return value is the number of deleted entries.

Example:
gdbm delete \$gdhandle count* 1
deletes all records with keys starting with count.

## gdbm dump

gdbm dump gdhandle ?file/pipe/std_channel/tcl_channel? ?keypattern? ?datapattern?
If no file or channel handle is specified, or an empty string is used, this command is used to obtain the complete contents of a Gdbm file as a dictionary. If non-empty filter patterns are set, only those key/value pairs where the key or data part matches the respective pattern are reported.

If a file name, a Unix pipe in standard notation, a standard channel or a valid TcL channel handle argument is specified, and the target is writable, the filtered key/value pairs are written to that channel. Every key/value pair is formatted as a simple two-element TcL list and written to the file. In this mode, the return value is the number of lines written.

Example:
gdbm dump \$gdhandle stdout

## gdbm exists

gdbm exists gdhandle key
This command returns 1 if the key is in the Gdbm file, 0 otherwise.
Example:
set isknown [gdbm exists \$gdhandle [ens get \$ehandle E_HASHY]]

## gdbm first

gdbm first gdhandle ?pattern?
Returns the key of the first file entry. In case a pattern is specified, the first entry whose key matches the pattern is retrieved. If no key can be found, an error results.

Example:
gdbm first \$gdhandle Z* $^{*}$
returns the first key which starts with a (case-sensitive) Z. Keys are returned in an unpredictable order.

This command is typically used in combination with subsequent gdbm next commands.

## gdbm get

gdbm get gdhandle key ?silent? ?defaultvalue?
Retrieve the data value associated with the specified key. If the key does not exist, and a default value was specified, the default value is returned instead. Without a default value, the result is an empty string if the silent flag is set, or an error otherwise.

This command may return binary data with non-printable characters.

## Example:

gdbm get \$gdhandle [gdbm first \$gdhandle]

## gdbm incr

gdbm incr gdhandle key ?delta?

Increment the data value stored under the specified key by the delta value. If no delta value is specified, it defaults to one. If the key does not exist, a new key/value pair with an initial data value of the delta is created. If the entry exists, but the data value is not a valid integer, an error is raised.

The return value of this command is the incremented value.
Example:
gdbm insert \$gdhandle "count_dracula" 5
puts [gdbm inc \$gdhandle "count_dracula"]
This command sequence updates the file, and outputs 6 .

## gdbm index

gdbm index gdhandle index ?pattern?
Return the $n$th key in the database if no pattern is specified, or the $n t h$ key which matches the pattern. The key index starts with zero.

## Example:

gdbm index \$gdhandle 10 cpdname*
returns the key for the eleventh file record which starts with the string cpdname. If no such key exists, an error is raised.

```
gdbm insert
gdbm insert gdhandle key value ?key value?...
gdibm insert gdhandle dict
```

Insert one or more new key/value pairs into the file. The values may be binary data. If a key already exists, the return value for that key/value pair is 0 and the old data is not overwritten. If a key is not in the database, 1 is returned for that item pair and the data is stored in the file.

If only a single argument is used after the handle, it is expected to be a properly formed TCL dictionary. In that case, all dictionary elements are processed as if they were spelled out as individual key/value pairs.

The return value is a list of boolean flags indicating success or failure for the operation on each key/value pair. No error is raised if a write operation fails.

Example:
gdbm insert \$gdhandle [ens get \$ehandle E_HASH] [ens get \$ehandle E_GIF]
gdbm insert \$gdhandle [array get : : params]
gdbm keys
gdbm keys gdhandle ?pattern?...
This command returns a list of all keys in the file. Keys may optionally be filtered by one or more string match patterns.

The related gdbm match command can be used to obtain a list of keys which are filtered by the value component and not the key name.

Example:

```
set keylist [gdbm keys $gdhandle project${id}*]
```


## gdbm linkvar

gdbm linkvar gdhandle ?-loadall? ?-preserve? varname
This command establishes a link between a Gdbm file and a Tcl array variable. If the variable is already in existence, it is deleted prior to recreation as a linked array variable. This can be prevented by using the -preserve option.

After the link has been formed, any read access by a TcL script to an element of the array variable retrieves the data value from the file which corresponds to the array element name as key, if the variable element is not yet set. If the variable element already exists, it takes precedence over the file contents, but this can only happen if the -preserve option was used when the variable was linked. In case file retrieval is initiated, and the key does not exist in the file, an error is generated.

Assigning a value to an array element replaces or creates the corresponding file entry. If an array element is deleted (for example by the TcL unset command), the corresponding key and value in the file are also deleted. Replacement and deletion operations require a file opened for write access.

If the -loadall option is used, all array elements are immediately loaded by looping over all file keys when the command is run. By default, data is retrieved from the file only when an array element is explicitly accessed. If this option is used, the array names command immediately shows all file keys, not just the ones currently loaded.

Since Gdbm data, once retrieved from the file by accessing the linked array element, is never deleted from memory, the use of this utility is not recommended for large files.

It is possible to link multiple variables to a single Gdbm file.
Gdbm files must not be closed when variable links to the closed file are active. Currently, there is no mechanism to detect that the target of a variable link as gone away., so this cannot be handled automatically. Variable links can be removed by the gdbm unlinkvar command.

Example:
gdbm linkvar \$gdhandle g_array
puts "Key: \$thekey Value: \$g_array(\$thekey)"
set g_array(\$newkey) \$newvalue
unset g_array(\$thekey)

## gdbm list

gdbm list gdhandle ?pattern?
Get a list of currently active GdBm file handles. If no files have been opened, an empty list is returned. Optionally, a string filter pattern can be specified.

Example:
gdbm list
gdbm loop
gdbm loop gdhandle keyvar datavar ?pattern? body
Run a loop over all file entries. If a string filter pattern is specified, only those records with a matching key are visited. After retrieving the key and data values, the key and data variables are initialized to the current key and data values, and then the commands in the body section are executed.

In the body, the break or return command may be used to force an early exit from the loop, and the continue statement also works as expected. In case an uncaught error occurs in the body, the loop terminates with an error message.

If the loop was not terminated due to an error, the result value is the number of visited keys.

## Example:

```
gdbm loop $gdhandle key data {
    puts "Key: $key with value $data"
}
```


## gdbm match

gdbm match gdhandle ?pattern?
This command returns a list of all keys where the data value matches the filter pattern. This is similar to the gdbm keys command, with the difference that in that command the key names are used for filtering, not the data values.

Example:
set keylist [gdbm match \$gdhandle *nitro*]

## gdbm new

gdbm new filename ?modelist? ?filemode? ?blocksize?
This command is the same as the command gdbm open, except that the default file access mode to be used if no explicit mode list is specified is new instead of read.

Example:

```
set gdhandle [gdbm new thefile.gdb]
```


## gdbm next

gdbm next gdhandle key ?pattern?
Get the next key after the specified key which matches the pattern. If no pattern is specified, no key filtering is performed. If no key can be found, an error is raised, otherwise the key is returned as function result.

A starting point for a key traversal is usually obtained via a gdbm first or gdbm index command.
Example:
gdbm next \$gdhandle name20 name*
produces the next key after the current key name 20 matching the pattern name*. This key is not necessarily name 21 , or any other predictable value. Rather, the key sequence in the database is determined by its internal hash, and the ordering is pseudo-random. The only guarantee is that with a gdbm first/gdbm next loop all keys are ultimately visited. A deletion of the current key is allowed and guaranteed to not disturb the traversal sequence.

## gdbm open

gdbm open filename ?modelist? ?filemode? ?blocksize?
Open an existing Gdbm file, or create a new one. The command returns a new object handle. The default mode is read, opening the file for reading. In this case, the file must already exist, and have
been written on a computer with the same byte ordering and integer size. The modelist parameter may consist of a list of the following options:

- read

Open for reading only, the file must exist.

- write

Open for reading and writing, the file must exist

- create

Open for reading and writing, the file is created if it does not yet exist. The contents of an existing file are not modified.

- new

Open for reading and writing, an old file is deleted if it exists

- fast

Adds the fast attribute - file updates are not committed immediately to disk, at the risk of losing data or file corruption if the program exits or crashes before the file is properly closed, or a gdbm sync command is issued.

It is sufficient to specify the first letter of the mode options. Combining any of the first four file access modes does not make sense, though. In standard applications, the mode list is either a single word describing the access mode, or a list of the fast attribute and the access mode. It is also possible to set the fast flag directly by appending it to the file access mode, as in

```
set gdhandle [gdbm open thefile.gdb cf]
```

The optional filemode parameter determines the Unix-style octal file access bits which have an effect only in case a new disk file is created. Finally, the rarely used blocksize parameter determines the page block size of the Gdbm file and is again only used in case a new file is created. By default the value is 0 , meaning that a reasonable default value depending on the type of file system the file resides on is chosen.

This command returns a Gdbm file handle in the form $\mathrm{gdbm} \% \mathrm{~d}$ which can be used in subsequent gdbm commands, until the file is closed and the handle becomes invalid.

## gdbm reorganize

gdbm reorganize gdhandle
gdbm reorg gdhandle
Compact the data file. This can be useful after many deletions. The underlying Gdвm library copies the entries to another file, which ultimately replaces the original file. Thus, in worst case, sufficient disk space for two parallel files with the original file size must be available. This command requires write access to the Gdbm file.

For large files, this command can take a long time to complete.
Example:
gdbm reorg \$gdhandle

## gdbm replace

```
gdbm replace gdhandle key value ?key value?...
```

gdbm replace gdhandle dict

Store one or more specified values which may be binary data, under the given keys. If a key is already in use, the old value is overwritten. If only a single argument is used after the handle, it is expected to be a properly formed TcL dictionary. In that case, all dictionary elements are processed as if they were written out as individual key/value pairs.

The return value is a list of boolean flags indicating success or failure for the operation on each $\mathrm{key} / \mathrm{value}$ pair. No error is raised if a write failed.
gdbm set is an alias for this command.
Examples:
gdibm replace \$gdhandle \$thekey \$newdata \$key2 \$moredata
gdbm replace \$gdhandle [array get ::params]

## gdbm restore

gdbm restore gdhandle filename ?callback?
This command reads a text file which usually was produced by the gdbm dump command and adds its contents to the current Gdвm file. Every line of the file is expected to contain a properly formatted two-element TcL list. The list is split into the key and data parts and the contents are written to the Gdbm file, replacing old entries in case of existing keys.

The input file may be gzip-compressed or plain ASCII text.
The command gdbm readfile is an alias for this command.
The return value is the number of file lines read.
Example:
gdbm restore \$gdhandle "we_will_never_need_this_backup.txt"
gdbm sync
gdbm sync gdhandle
Synchronize the in-memory and disk status of the file. All pending changes are committed to disk. This command has an effect only if the file was opened in fast mode (see gdbm open command).

Example:
gdbm sync \$gdhandle

## gdbm unlinkvar

gdbm unlinkvar gdhandle ?-preserve? varname
Unlink a Tcl array variable from a Gdbm file. If the -preserve option is not used, the variable is also deleted from the Tcl interpreter. The association between array variable and Gdbm file is also automatically broken when the variable is deleted by other means, such as a TcL unset command.

The Gdbm file contents are not modified by unlinking by means of executing this command, or by any other methods of variable deletion.

Variable links are created with the gdbm linkvar command.
Example:

```
gdbm unlinkvar $gdhandle g_array
```


## The tc Module

The tc (Tokyo Cabinet) extension command is provided by the external Tc Tcl module. It must be loaded before the command becomes available.

Example:
package require Tc
Tokyo Cabinet files need to be opened or created before any operations on them can commence. Afterwards, they are identified by a handle, which is returned by the opener commands. When a file are no longer in use, it should be closed.

The general syntax of the tc command follows the usual
command/subcommand/handle/parameters syntax. This command is designed to be compatible to the older gdbm command, which performs the same type of operations on Gdbm files. Gdbm files generally require significantly more disk space, and are slower for larger data sets. Another big advantage or Tc versus Gdbm is that the Tc files are 32/64-bit-clean and byte-order independent and thus are more easily exchanged between systems. On the other hand, the underlying Tokyo Cabinet library is currently not supported on Windows, and therefore this command is also unavailable on that platform

At this time, only Tc hash data bases are supported, and this Tokyo Cabinet database type is implied in all commands.

Examples:

```
set tchandle [tc open myfile.tch]
set data [tc get $tchandle $key]
tc close $tchandle
```

This is the list of of subcommands:
tc add
tc add tchandle ?-nocase? key ?data?...
Append the listed data items as Tcl list elements to the entry identified by the key. If no such record exists, a new record with the initial set of list items is created. If any of the data items are already present in the existing value list, they are ignored, so duplicates are not added. The duplicate check is performed in case-insensitive fashion if the -nocase flag is used.

The tc append command performs a similar operation, but without a duplicate check.
The command returns the updated entry value list.
This command only works if any existing value is a properly formatted TcL list.
Example:
tc append \$tchandle "project_\$projectid" [ens get \$eh E_IDENT]
tc append
tc append tchandle key data ?data?...

Append the data items as TcL list elements to the entry identified by the key. If no such record exists, a new record with the initial set of list items is created. No duplicate check is performed for the added list elements - this is the difference to the tc add command.

The command returns the updated entry value list.
This command works only if any existing value is a properly formatted TcL list.
Example:
tc append \$tchandle "project_\$projectid" [ens get \$eh E_IDENT]
tc close
tc close ?tchandle?...
tc close all
This command closes opened Tokyo Cabinet files. After a file has been closed, its handle becomes invalid, but may the reissued for another opened Tokyo Cabinet file again.

The first version of the command closes specific files. The second version closes all open Tokyo Cabinet files. Both variants return the number of closed files as result.

Example:
tc close \$tchandle
tc count
tc count tchandle ?pattern?
Count the number of keys in the file. If a pattern argument is given, only the file entries with a matching key are counted. The command returns the number of passing keys.

Unfortunately, Tokyo Cabinet files no not maintain an internal record count, so this command has to loop through all keys, which can take a substantial amount of time for large files.

The command tc size is an alias for this command.
Example:

```
set size [tc count $tchandle]
```

tc create
tc create filename ?modelist? ?filemode?
This command is the same as the command tc open, except that the default file access mode to be used if no explicit mode list is specified is create instead of read.

Example:
set tchandle [tc create thefile.tch]
tc delete
tc delete tchandle key ?ispattern?
If no ispattern boolean argument is given, or it is not a true value, the record matching the key exactly is deleted. If the entry did exist and could be deleted, 1 is returned, 0 otherwise.

If the ispattern flag is set, the key argument is interpreted as a string pattern. All records with keys matching the pattern are deleted. In this case, the return value is the number of deleted records.

Example:
tc delete \$tchandle count* 1
deletes all records with keys starting with count.

## tc dump

tc dump tchandle ?file/pipe/std_channel/tcl_channel? ?keypattern? ?datapattern?
If no file handle is passed, or an empty string is used as file handle, this command is used to obtain the complete contents of a Tokyo Cabinet file as a dictionary. If non-empty filter patterns are specified, only those key/value pairs where the key or data part matches the respective pattern are reported.

If a file name, a Unix pipe in standard notation, a standard channel or a valid TcL channel handle argument is specified, and the target is writable, the filtered key/value pairs are written to that channel. Every key/value pair is formatted as a simple two-element TcL list and written to the file. In this mode, the return value is the number of lines written.

Example:
tc dump \$tchandle stdout
tc exists
tc exists tchandle key
This command returns 1 if the key is in the Tokyo Cabinet file, 0 otherwise.
Example:
set isknown [tc exists \$tchandle [ens get \$ehandle E_HASHY]]
tc first
tc first tchandle ?pattern?
Returns the key of the first file entry. In case a pattern is specified, the first entry whose key matches the pattern is retrieved. If no key can be found, an error results.

## Example:

tc first \$tcandle $\mathrm{Z}^{*}$
returns the first key which starts with a (case-sensitive) Z. Keys are returned in an unpredictable order.

This command is typically used in combination with subsequent te next commands.

```
tc get
tc get tchandle key ?silent? ?defaultvalue?
```

Retrieve the data value associated with the specified key. If the key does not exist, and a default value was specified, the default value is returned instead. Without a default value, the result is an empty string if the silent flag is set, or an error otherwise.

This command may return binary data with non-printable characters.

Example:

```
tc get $tchandle [tc first $tchandle]
tc incr
tc incr tchandle key ?delta?
```

Increment the data value stored under the specified key by the delta value. If no delta value is specified, it defaults to one. If the key does not exist, a new key/value pair with a data value of the delta is created. If the entry exists, but the data value is not a valid integer, an error is raised.

The return value of this command is the incremented value.
Example:
tc insert \$tchandle "count_dracula" 5
puts [tc incr \$tchandle "count_dracula"]
This command sequence updates the file, and outputs 6 .
tc index
tc index tchandle index ?pattern?
Return the $n t h$ key in the database if no pattern is specified, or the $n t h$ key which matches the pattern. The key index starts with zero.

Example:
tc index \$tchandle 10 cpdname*
returns the key for the eleventh file record which starts with the string cpdname. If no such key exists, an error is raised.
tc insert

```
tc insert tchandle key value ?key value?...
tc insert tchandle dict
```

Insert one or more new key/value pairs into the file. The values may be binary data. If the key already exists, the return value for that key/value pair is 0 and the old data is not overwritten. If the key is not in the database, 1 is returned for the item pair and the value is stored in the file.

If only a single argument is used after the handle, it is expected to be a properly formed TCL dictionary. In that case, all dictionary elements are processed as if they were spelled out as individual key/value pairs.

The return value is a list of boolean flags indicating success or failure for the operation on each key/value pair. No error is raised if a write operation fails.

Example:

```
tc insert $tchandle [ens get $ehandle E_HASH] [ens get $ehandle E_GIF]
tc insert $tchandle [array get ::params]
```

tc keys
tc keys gdhandle ?pattern?...

This command returns a list of all keys in the file. Keys may optionally be filtered by one or more string match patterns.

The related tc match command can be used to obtain a list of keys which are filtered by the value component and not the key name.

Example:
set keylist [tc keys \$tchandle project\$\{id\}*]
tc linkvar
tc linkvar tchandle ?-loadall? ?-preserve? varname
This command establishes a link between a Tokyo Cabinet file and a TcL array variable. If the variable is already in existence, it is deleted prior to recreation as a linked array variable. This can be prevented by using the -preserve option.

After the link has been formed, any read access by a TcL script on an element of the array variable retrieves the data value from the Tokyo Cabinet file which corresponds to the array element name as key, if the variable element is not yet set. If the variable element already exists, it takes precedence over the file contents, but this can only happen if the -preserve option was used when the variable was linked. In case file retrieval is performed, and the key does not exist in the file, an error is generated.

Assigning a value to an array element replaces or creates the corresponding Tokyo Cabinet file entry. If an array element is deleted (for example, by a Tcl unset command), the corresponding key and value in the file are also deleted. Replacement and deletion operations require a Tokyo Cabinet file opened for write access.

If the -loadall option is used, all array elements are immediately loaded by looping over all Tokyo Cabinet file keys when the command is executed. By default, data is retrieved from the file only when an array element is explicitly accessed. If this option is used, the array names command immediately shows all file keys, not just the ones currently loaded.

Since Tokyo Cabinet data, once retrieved from the file by accessing the linked array element, is never deleted from memory, the use of this mechanism is not recommended for large files.

It is possible to link multiple variables to a single Tokyo Cabinet file.
Tokyo Cabinet files must not be closed when variable links to the file are active. Currently, there is no mechanism to detect that the target of a variable link as gone away, so this cannot be handled automatically. Variable links can be removed by the te unlinkvar command.

Example:
tc linkvar \$tchandle g_array
puts "Key: \$thekey Value: \$g_array(\$thekey)"
set g_array(\$newkey) \$newvalue
unset g_array(\$thekey)
tc list
tc list tchandle ?pattern?
Get a list of currently active Tokyo Cabinet file handles. If no files have been opened, an empty list is returned. Optionally, a string filter pattern can be specified.

```
Example:
tc list
tc loop
tc loop tchandle keyvar datavar ?pattern? body
```

Run a loop over all file entries. If a filter pattern is specified, only those records with a matching key are visited. After retrieving the key and data values, the key and data variables are initialized to the current key and data values, and then the commands in the body section are executed. In the body, the break or return command may be used to force an early exit from the loop, and the continue statement also works as expected. In case an uncaught error occurs in the body, the loop is terminated.

If the loop was not terminated due to an error, the result value is the number of visited keys.

## Example:

```
tc loop $tchandle key data {
    puts "Key: $key with value $data"
}
tc match
tc match tchandle pattern
```

Return a list of all keys where the data value matches the filter pattern. This is similar to the tc keys command, but in that command the key names are used for filtering, not the data values.

Example:
set keylist [tc match \$tchandle *nitro*]
tc new
tc new filename ?modelist? ?filemode?
This command is the same as the command tc open, except that the default file access mode to be used if no explicit mode list is specified is new instead of read.

Example:

```
set tchandle [tc new thefile.tch]
```


## tc next

tc next tchandle key ?pattern?
Get the next key after the specified key which matches the pattern. If no pattern is specified, no key filtering is performed. If no key can be found, an error is raised, otherwise the key is returned as command result.

A starting point for a key traversal is usually obtained via a tc first or tc index command.
Example:
tc next \$gdhandle name20 name*
produces the next key after the current key name 20 matching the pattern name*. This key is not necessarily name 21 , or any other predictable value. Rather, the key sequence in the database is determined by its internal hash, and the ordering is pseudo-random. The only guarantee is that with
a tc first/tc next loop all keys are ultimately visited. A deletion of the current key is allowed and guaranteed to not disturb the traversal sequence.

## tc open

tc open filename ?modelist? ?filemode?
Open an existing Tokyo Cabinet file, or create a new one. The command returns a new object handle. The default mode is read, opening the file for reading. In this case, the file must already exist. The modelist parameter may consist of a list of the following options:

- read

Open for reading only, the file must exist.

- write

Open for reading and writing, the file must exist

- create

Open for reading and writing, the file is created if it does not yet exist. The contents of an existing file are not changed.

- new

Open for reading and writing, an old file is deleted if it exists

- fast

Adds the fast attribute - file updates are not committed immediately to disk, at the risk of losing data or file corruption if the program exits or crashes before the file is properly closed, or a te sync command is issued.

- zlib

Stored data is zlib-compressed.
It is sufficient to specify the first letter of the mode options. Combining any of the first four file access modes does not make sense, though. In standard applications, the mode list is either a single word describing the access mode, or a list of the fast or zlib attributes and the access mode. It is also possible to set the fast or zlib flags directly by appending it to the file access mode, as in

```
set tcandle [tc open thefile.tch cfz]
```

The optional filemode parameter determines the Unix-style octal file access bits which have an effect only in case the file is created.

This command returns a Tokyo Cabinet file handle in the form $t c \% d$ which can be used in subsequent te commands, until the file is closed and the handle becomes invalid.

## tc reorganize

tc reorganize tchandle
tc reorg tchandle
Compact the data file. This can be useful after many deletions. This command requires write access to the file.

For large files, this command can take a long time to complete.
Example:

```
tc reorg $tchandle
```

tc replace

```
tc replace tchandle key value ?key value?...
```

tc replace tchandle dict

Store one or more specified values which may be binary data, under the given keys. If a key is already in use, the old value is overwritten. If only a single argument is used after the handle, it is expected to be a properly formed TcL dictionary. In that case, all dictionary elements are processed as if they were spelled out as individual key/value pairs.

The return value is a list of boolean flags indicating success or failure for the operation on each $\mathrm{key} / \mathrm{value}$ pair. No error is raised if a write failed.
tc set is an alias for this command.
Examples:
tc replace \$tchandle \$thekey \$newdata \$key2 \$moredata
tc replace \$tchandle [array get : :params]
tc restore
tc restore tchandle filename ?callback?
This command reads a text file which usually was produced by the tc dump command and adds its contents to the current Tokyo Cabinet file. Every line of the file is expected to contain a properly formatted two-element TcL list. The list is split into the key and data parts and the contents are written to the Tokyo Cabinet file, replacing old entries in case of existing keys.

The input file may be gzip-compressed or plain ASCII text.
The command tc readfile is an alias for this command.
The return value is the number of file lines read.
Example:
tc restore \$tchandle "totally_superfluous_backup.txt"
tc sync
tc sync tchandle
Synchronize the memory and disk status of the file. All pending changes are committed to disk. This command has an effect only if the file was opened in fast mode (see tc open command).

Example:
tc sync \$tchandle

## tc unlinkvar

tc unlinkvar tchandle ?-preserve? varname
Unlink a TcL array variable from a Tokyo Cabinet file. If the -preserve option is not used, it is also deleted from the TcL interpreter. The association between array variable and Tokyo Cabinet file is also automatically broken when the variable is deleted by other means, such as a TCL unset command.

The Tokyo Cabinet file contents are not modified by unlinking by means of executing this command or any other method of variable deletion.

Variable links are created with the tc linkvar command.
Example:
tc unlink \$tchandle g_array

## The memcache Command Extension

The memcache command extension provides an interface to the memcached memory data caching daemon. This is a useful functionality especially for the implementation of stateful CGI and FCGI applications. This module is now the preferred replacement for the older netcache daemon interface. Current toolkit packages contain both the interface module, and a compiled version of the daemon proper.

The command is thread-safe.
These are the supported subcommands:

## memcache append

memcache append mchandle data
memcache append mchandle key data ?ttl_secs? ?flags?
This command is a variant of the memcache put command which appends its data instead of replacing it, if a record already exists for the key. If no such record exists, the command is equivalent to memcache put.

For the explanation of the arguments, please refer to the paragraph on memcache put below.
Example:
memcache append \$mch \$key \$moredata
memcache create
memcache create ?host:port/socketfile?..
Create a new memcached interface object. The command returns a handle of the new object which is used by other memcache commands to identify the object. Multiple interface objects may be used in parallel in an application.

The arguments identify the servers to contact. In case multiple servers are listed, tuples are stored on or retrieved from one of the servers selected in constant but pseudo-random fashion from the key value, resulting in load-balancing.

Servers are identified either by a host name, optionally with an addition custom port number, or the name of a named socket in file system space. An argument is interpreted as a socket name if it contains path separator characters ("/" or " ""), starts with a dot, or starts/ends with a vertical bar """ or equality sign " $=$ ". If the bar or equality sign are present, it is automatically stripped from the actually used socket name. An attempt is then made to check whether the named socket already exists and can be accessed. If this is not the case, an attempt is made to set it up, and an error results if this operation does not succeed.

Alternatively, servers can be named in the classical hostname:port fashion, where the port part is optional. If no port is specified, the default memcached port 11211 is used. The host name of a server specified here must be resolvable, but at the moment the interface object is created it is not required that a daemon is already listening at the port.

Examples:

```
set mch [memcache create cachehost1 cachehost2]
set mch [memcache create ./mysocket]
```


## memcache delete

memcache delete all
memcache delete ?mchandle?..
The first command version deletes all active memcache interface objects, after properly closing their connections. The second variant closes and deletes specific handles. The command returns the number of deleted interface objects.

The functionality of the first command variant is automatically executed if the memcache command extension is unloaded.

Deleting an interface handle does not immediately delete the tuples created via this interface on the daemon. The data remains stored until its time-to-live expires, and may be fetched by other interface object instances, even in different processes on different hosts, if they connect to the same daemon and supply the proper keys. To delete tuples, use the memcache remove command.

Deleting an interface handle furthermore does not delete any named sockets associated with the handle, regardless whether these were already present when the object was created, or whether they were automatically set up as a side effect of the object creation.

Example:
memcache delete $\$ \mathrm{mch}$

## memcache get

memcache get mchandle key ?listindex?
Retrieve the data associated with the specified key. The data, which can be binary in nature, is returned as the command result. In case there is no tuple associated with the key, including due to expiration of the lifetime of data associated with the key on the remote daemon, an error results.

If the optional list index is specified, the data is expected to be a properly formed TcL list. If interpretation as list succeeds, only the selected list element is returned. If the list index is larger than the number of list items in the data, an empty string is the result, but no error is raised.

Example:
set data [memcache get \$mch \$key]
memcache list
memcache list ?pattern?
Get a list of currently used memcache object handles. If no memcache objects have been created, an empty list is returned. Optionally, a string filter pattern can be specified.

Example:
memcache list

## memcache put

```
memcache put mchandle data
memcache put mchandle key data ?ttl_secs? ?flags?
```

Store data on memcache daemon. The data is stored as an opaque byte array and can be of any type. It is not necessary to base64-encode the data or protect it in any other fashion.

The first command variant automatically assigns an unique key and stores the data with it.
The second variant is more flexible. If the key parameter is an empty string, a new unique key is automatically generated. However, with an explicit key, data can be replaced if the key is already in use. If an explicitly specified key does not exist, a new tuple is silently created. Keys are also byte arrays and could potentially be binary data, but commonly some readable string encoding is used. Optionally, the time-to-live of the data on the daemon can be specified. The default lifetime is 8 hours.

Tuples which are in the store longer than their lifetime are automatically retired by the daemon. Attempts to access them via their key after this point in time results in an error. The final optional argument is an integer, which can be stored as an additional tuple component.

The command returns the key of the tuple, which may have been assigned automatically.
Example:
set key [memcache put \$nh \$data1]
memcache put \$nh \$key \$data2

## memcache remove

memcache remove mchandle key ?ttl_secs?
Delete a tuple on the remote daemon. If the key is not valid, an error results. By default the deletion becomes effective immediate. Alternatively a time-to-live value can be specified, which schedules tuple deletion for a time in the future.

This command does not delete the interface object. For this purpose, use the memcache destroy command.

Example:
catch \{memcache remove \$mch \$key\}
This statement removes the tuple, and ignores any errors in case the key is not stored or has already timed out

## memcache start

memcached start mchandle
Attempt to start all required memcached daemons associated with an interface object. If all connections are already being served, this command does nothing.

Otherwise, the command will try to start memcached executable(s) with properly configured options for a rendezvous on the named socket or socket port as specified during the interface object creation. This autostart mechanism obviously only works of the daemon is running on the same host as the application, the memcached executable is found in the search path, and the effective user of the application has sufficient permissions. Other start mechanisms must be used to assure that the required daemons are listening when using remote ports.

If there were unserved connections, and they could be activated by starting the daemon locally, the command result is 1 . If any required start attempt failed, the result is 0 . If the command did not need to perform any action, the result is -1 .

Any newly started daemon has an empty tuple storage and no memory of any data stored by daemons previously serving the same connection.

## memcache status

memcache status mchandle
Get the status of all daemons connected to the handle. If there is only a single daemon associated with the interface object, the result is a status dictionary with parameter/value pairs, otherwise a list of such dictionaries in the order of the daemons were named when the interface object was constructed. The exact contents of a status dictionary is dependent on the version of the memcached serving the connection.

In case any of the daemons associated with the interface object cannot be contacted, an error results.
Example:
echo [dict get [memcache status \$mchandle] uptime]

## memcache stop

memcache stop mchandle
Attempt to stop all memcached daemons associated with an interface object by sending them termination signals. This works only with local daemons and requires that the effective user of the application has sufficient rights. It has no effect on any remote daemon process.

As a side effect, all active connections to servers are closed, but they are re-activated automatically if the daemons are available once more at a time when later commands are executed with the interface object. The command does not destroy or invalidate the interface object proper. Daemons can, for example, be restarted manually or by means of the memcache start command. However, restarted daemons have no memory of tuples stored previously, so a total data loss is always a consequence when a daemon was successfully terminated by means of this command, or died because of any other reason.

The return value of the command is 1 if all daemon processes could be terminated, 0 if there were any problems such as insufficient permissions or remote daemons, and -1 if no action was required.

## memcache valid

memcache valid mchandle key
A boolean check whether a given key is valid, i.e. whether data was stored with this key and has not expired. If the key is not valid, zero is returned, not an error.

## Example:

if $\{!$ [memcache valid \$mch \$mykey]\} \{....

## The netcache Command Extension

The netcache command extension provides an interface to the NCBI netcache memory data caching daemon. This is a useful functionality especially for the implementation of stateful CGI and FCGI applications.

Since the NCBI Toolkit, which provides the basic interface functions, is difficult to compile on many platforms, this command extension is only provided as part of the standard toolkit distributions for a few select platforms. Even these packages do not contain the netcache daemon proper, only the interface module. Setting up a netcache environment is probably not justified for most application scenarios, especially since the simpler and much more portable memcache command extension and associated daemon with near equivalent functionality are now a standard toolkit component.

This command extension is thread-safe.
These are the subcommands:

## netcache create

netcache create clientname ?host? ?port? ?lbname?
Create a netcache daemon interface object. The command returns a handle for this object which is used by all other netcache commands to identify the interface. Multiple interfaces can be in use simultaneously.

The clientname argument is an arbitrary string which is used to identify an application, or application component. The optional host and port arguments specify the server the storage daemon is running on. If not set, they default to localhost and the default netcache port 9001 . The final argument can be used to select a load balancer component. Please refer to the NCBI netcache documentation for details. The default is an empty string, i.e. the host/port combination directly selects the physical server.

Example:
set nhandle [netcache create "killerapp" \$cachehost]

## netcache delete

netcache delete all
netcache delete ?nhandle?..
The first command version deletes all active netcache interface objects, after properly closing their connections. The second variant closes and deletes specific handles. The command returns the number of deleted interface objects.

The functionality of the first command variant is automatically executed if the netcache command extension is unloaded.

Deleting an interface handle does not immediately delete the tuples created via this interface on the daemon. The data remains stored until the time-to-live expires, and may be fetched by other interface object instances, even in different processes on different hosts, if they connect to the same daemon, use the same client name, and supply the proper keys. To delete tuples, use the netcache remove command.

Example:

```
netcache delete $nh
```


## netcache get

netcache get nhandle key ?listindex?
Retrieve the data associated with the specified key. The data is returned as the command result. In case there is no tuple associated with the key, including due to expiration of the lifetime of data associated with the key on the remote daemon, an error results. The returned data can be binary.

If the optional list index is specified, the data is expected to be a properly formed TcL list. If interpretation as list succeeds, only the selected list element is returned. If the list index is larger than the number of list items in the data, an empty string is the result, but no error is raised.

Example:

```
set data [netcache get $nh $key]
```

netcache list
netcache list ?pattern?
Get a list of currently used netcache object handles. If no netcache objects have been created, an empty list is returned. Optionally, a string filter pattern can be specified.

Example:
netcache list
netcache put
netcache put nhandle data
netcache put nhandle key data ?ttl_secs?
Store data on a netcache daemon. The data is stored as an opaque byte array and can be of any type. It is not necessary to base64-encode the data or protect it in any other fashion.

The first command variant automatically assigns an unique key and stores the data with it.
The second variant is more flexible. If the key parameter is an empty string, a new unique key is automatically generated. However, with an explicit key, data can be replaced if the key is already in use. If an explicitly specified key does not exist, a new tuple is silently created. Keys are also byte arrays and could be binary, but commonly some readable string encoding is used. Optionally, the time-to-live of the data on the daemon can be specified. The default value is part of the netcache daemon configuration and cannot be queried directly. Tuples which are in the store longer than their allowed time are automatically retired by the daemon. Attempts to access them via their key after this point in time results in an error.

The command returns the key of the tuple, which may have been assigned automatically.
Example:
set key [netcache put \$nh \$data1]
netcache put \$nh \$key \$data2

## netcache remove

netcache remove nhandle key
Delete a tuple on the remote daemon. If the key is not valid, an error results.

This command does not delete the interface object. For this purpose, use the netcache destroy command.

Example:
catch \{netcache remove \$nh \$key\}
This statement removes the tuple, and ignores any errors in case the key is not stored or has timed out.

## netcache valid

netcache valid nhandle key
A boolean check whether a given key is valid, i.e. whether data was stored with this key and has not timed out. If the key is not valid, zero is returned, not an error.

Example:
if $\{![$ netcache valid \$nh \$mykey]\} \{ ....

## The pubchem Command Extension

The pubchem command enables the toolkit to talk directly to the NCBI PuвСнем database server. This command is implemented as a Cactvs command extension, not a standard TcL module, because it links into Cactvs-specific internal data structures and cannot be loaded into a standard TcL interpreter.

The command extension can be explicitly loaded via a
cmdx load pubchem
The command is also auto-loaded in standard interpreters, if the command extension module can be found in the search path. It is a built-in command in some versions of the csweb CGI interpreter.

The command is currently not part of the standard toolkit distribution.
These are the subcommands of the extension:

## pubchem cigs

pubchem cigs cidvalue ?type?
Get structure identity group information of a CID. If no type parameter is given, or it is given as all, the full set of CIGs is returned as a list in the order tautomer, connectivity, stereo, isotope and exact.

If a type parameter is specified, as one of the allowed values all, tautomer, connectivity, isotope and exact or its abbreviation $a, t, c, i$ or $e$, only the selected group identifier is reported.

If the CID is not found in the database, an error is reported.
Example:
echo [pubchem cigs \$cid t]
pubchem dump
pubchem dump ?updateonly? ?settimestamp? liveVar deadVar
This command is used to get information about changes in the main PCCompound database since the last query. By default, both the updateonly and settimestamp flags are unset. The command sets the two variables named in the arguments to a list of CID identifiers. If the updateonly flag is set, only CIDs which have changed (i.e. were added, modified, or deleted) since the last time stamp setting are reported. Records which are still in the database are stored in the live variable, deleted records are returned in the dead variable. If the updateonly flag is not set, all database identifiers are returned.

The settimestamp flag controls whether this query should automatically set the processing time stamp of the returned records to the current time, thus marking the database records as synchronized. Records with an updated time stamp are excluded from the result list of further pubchem dump commands with the updateonly flag set.

This command can take a couple of seconds to execute, and the result lists can be large (up to a million or more list elements).

## pubchem fetchblob

pubchem fetchblob sid sidvalue

```
pubchem fetchblob cid cidvalue
```

This command retrieves a binary ASN. 1 structure record blob from the database. The command comes in two variants. Retrieval via the SID returned the complete structure record, with all embedded structure forms and their CIDs, while access via a CID only yields that structure and its property data.

The raw blob data is returned as result. If the queried SID or CID does not exist in the database, an error is raised.

For historical reasons, the command can also be used without the sid or cid access type identifier. This form is equivalent to access via an SID.

Example:

```
set blob [pubchem fetchblob cid 999]
filex load asnb
set eh [molfile read [molfile open $blob s]]
```

This command sequence creates an ensemble object from the ASN. 1 blob. Note that in most cases the pubchem fetchens command is more convenient to use for this purpose. Structure processing options should be completely disabled in order to avoid any change when reading compound data from raw blobs, as in

```
molfile set $fh readflags {}
```


## pubchem fetchens

```
pubchem fetchens sid sidvalue
pubchem fetchens cid cidvalue
```

This command retrieves an ensemble from the PubChem database via an SID or CID identifier. The return value of the command is a new ensemble handle. In case an SID or CID is not found in the database, an error is raised.

If the retrieval is made via a CID, only that CID and its associated data is returned. For access via SID, the full content of the ASN. 1 record is encoded in the returned ensemble. The connectivity of the structure for which its handle is returned is that of the deposited structure. Standardized compounds and other structure variants of the deposited structure are attached to this base structure as one or more properties E_NCBI_COMPOUND of datatype ensemble. These secondary property-encoded ensembles store the data registered for them in the database in their own independent set of properties. In theory, this could include further structure derivatives that are again stored as properties E_NCBI_COMPOUND.

For historical reasons, the command can also be used without the sid or cid access type identifier. This form is equivalent to access via an SID.

All structure processing options are disabled when decoding the blob into the ensemble, so the returned structure is a faithful representation of the original data, including all bond types, bond annotations and charges.

Example:

```
set eh [pubchem fetchens sid 999]
set ehstd [ens show $eh E_NCBI_COMPOUND]
set stdcid [ens show $ehstd E_NCBI_COMPOUND_ID(id)]
```

This example retrieves a full PuвСнем record via an SID, isolates the first structure variant encoded in the record (which is the default standardized form), and then reads out from that standardized form its CID

## pubchem setdbhosts

pubchem setdibhosts hostlist
This command changes the default set of database cluster hosts from the compiled-in default. The hostlist parameter is a list of one or more host names in standard TcL notation.

Example:
pubchem setdbhosts [list DDDSQL10 DDDSQL11]

## pubchem sidlist

pubchem sidlist cidlist
This command returns a nested list of SIDs associated with CIDs. For each CID in the cidlist parameter a list element is returned which contains the list of associated SIDs.

Example:

```
set cidlist [list 1 2 3]
set sidlist [pubchem sidlist $cidlist]
foreach cid $cidlist sidset $sidlist {
    puts "CID $cid is associated with [llength $sidset] SIDs"
}
pubchem sids
pubchem sids cid
```

This command returns a list of all SIDs a CID is associated with. An error is raised if the CID is not found int the database.

## pubchem synonyms

pubchem synonyms sid sidvalue
pubchem synonyms cid cidvalue
Get the list of synonyms associated with a SID or CID. The command returns a string list. In case there are no synonyms, or the identifier is not found in the database, an error is returned.

The synonyms list contains only names registered in the global synonyms data block of the ASN. 1 specification. It does not report any additional names which may be stored in property data areas of individual compounds of the record.

## pubchem subcommands

pubchem subcommands
Return a list of the subcommands of the pubchem command.

## Auxiliary Tcl Commands

Beside the listed commands for manipulating chemical and non-chemical objects, the standard TcL scripting interface is enhanced with a collection of additional commands which do not belong to one of the two big groups. This is a list of these commands:

- alarm

Access to the standard alarm () C library function. Only relevant for the Windows version, because on Unix the equivalent alarm command provided by the TcLX library is available.

- bitvector

Operate on string representations of bit vectors

- bread

Read binary data

- bwrite

Write binary data

- color

Decode color specifications

- creverse

Reverse string

- daemonize

Convert normal process into demon process (Unix versions only)

- decode

Decode data in various encoding and compression schemes

- encode

Encode data in various encoding and compression schemes

- fcgi

Perform I/O as a FASTCGI application

- fetch

Retrieve data via URLs

- filecheck

Check file formats

- ldelete

Delete selected elements from a TcL list

- lineintersect

Check whether line segments overlap

- lreverse

Reverse TcL list

- 1search

Extended features vs. the standard TCL version

- lsum

Compute sum over list elements

- lvardelete

Delete selected elements from a TcL list variable

- mailcap
get standard opener/viewer for MIME-typed files
- map
systematically apply command to list elements
- mimetype
get MIME type from file extension
- parse
verify decodability of strings representing of certain data types
- passwd
operations on standard Unix-style passwords
- post
simulate the posting of a HTML form
- python
execute commands in a Python interpreter
- quote
properly quote strings
- random
generate thread-local random numbers
- rpc
get information about rpc services (Unix only)
- screen
perform structure fragment screening operations with bitvectors
- tmpdir
get current temporary directory
- tmpfile
get TcL file handle of file opened for reading and writing in temporary directory.
- tmpname
obtain name of a new tmp file
- uncgi
decode WWW form data for CGI applications
- unzip
extract data from nested lists
- vec
basic vector operations
- zip
merge lists in an interleaved fashion


## Mathematical expression enhancements

In addition to these commands, the TcL math expression engine was extended by the following functions:

- bitrange(low,high)

Return a wide integer with all bits set between the specified positions, with the lowest bit position starting as zero, and inclusive boundaries. If the low position is specified as a negative number, the start position is the lowest bit (zero). If the high position is specified as a negative number, the stop position is the highest bit in use in a wide integer, which may be platform-dependent but usually is 63 for 64-bit wide integers. If both positions are specified as negative numbers, the result is zero and not a word with all bits set.

- $\operatorname{clamp}(x, l o w, h i g h)$

Restrict x to minimum low and maximum high. This is an alias for the limit function.

- $c m p(x, y)$

Returns 0 if the values are equal, -1 if $y$ is larger than $x$, or 1 otherwise.

- $\operatorname{deg}(x)$

Convert radians to degrees

- $f f s(x)$

Get the position of the first bit set in the input value interpreted as unsigned wide integer. Bit position numbering begins with one. If no bits are set, zero is returned.

- $f l s(x)$

Get the position of the last bit set in the input value interpreted as unsigned wide integer. Bit position numbering begins with one. If no bits are set, zero is returned.

- gfraction(minvalue,maxvalue,nticks)

Suggest a nice value for the number of fractional digits for the numeric tick labels of a graph display of data where the values for the axis lie between the minimum and maximum arguments, and the axis has approximately the specified number of ticks.

- gmax(minvalue,maxvalue,nticks)

Suggest a nicely rounded maximum value for a graph display of data where the values for the axis lie between the minimum and maximum arguments, and the axis has approximately the specified number of ticks.

- gmin(minvalue,maxvalue,nticks)

Suggest a nicely rounded minimum value for a graph display of data where the values for the axis lie between the minimum and maximum arguments, and the axis has approximately the specified number of ticks.

- gstep(minvalue,maxvalue,nticks)

Suggest a suggest nicely rounded tick step value for a graph display of data where the values for the axis lie between the minimum and maximum argument, and the axis has approximately the specified number of ticks.

- htonl( $x$ )

Get integer value in network byte order

- limit(x,low,high)

Restrict x to minimum low and maximum high. This is an alias for the clamp function.

- $\max (x, y)$

Get the maximum of the two input values. The result type depends on the input data and automatically uses the required type to represent the result in its full precision.

- $\min (x, y)$

Get the minimum of the two input values. The result type depends on the input data and automatically uses the required type to represent the result in its full precision.

- $\bmod (x, y)$

Compute $x$ modulo $y$. This functions can process floating point values, whereas the standard TcL \% operator does not.

- $n t o h l(x)$

Get integer value in host byte order

- pi()

Returns $\pi$ with full precision.

- pix2pt(x)

Convert the pixel count argument to a points value, assuming a resolution of 72 dpi .

- pt2pix(x)

Convert the typographical points argument to a pixel count value, assuming a resolution of 72 dpi.

- $\operatorname{rad}(x)$

Convert degrees to radians.

- $\operatorname{rnd}(x)$

Get an integer random number between zero and the integer parameter minus one. This function is integrated with the random command extension and is affected if the random generator state is modified via this command. Every interpreter thread (but not slave interpreter) has its own independent random number generator.

- range(x,low,high)

Check whether value is within range. The result is either 0 or 1.

- $\operatorname{sqr}(x)$

Square value of $x$.

- zero(x)

Check whether value is close to zero. Usually, this means the argument is within $+/-.00001$ to zero, but this is configurable.

## bitvector

bitvector subcommand vector ?vector?...

This command provides basic functionality for the processing of bit vectors on a string level. Bit vectors understood by this command consist of 0 and 1 characters, optionally prefixed by a percent or $B$ character. Bitvectors with this encoding style can, for example, be obtained from a TCL data recall command on chemistry object bitvector data item.

Example:

```
set vector [ens get $ehandle E_SCREEN]
```

The following subcommands are available:

```
bitvector and vector ?vector?...
bitvector or vector ?vector?...
bitvector xor vector ?vector?...
bitvector nand vector ?vector?...
bitvector nor vector ?vector?...
```

These are the standard boolean operations. nand and nor yields the inverted result of the and and or operations. If not arguments except the first are given, the result is the input vector for and, or, xor, and the inverted input vector for the rest. In case the vectors are of different lengths, they are virtually padded with zero bits to the size of the largest vector.

```
bitvector not vector
```

Invert the vector in bit-wise fashion.

```
bitvector test1 vector ?offset? ?len?
bitvector test0 vecvtor ?offset? ?len?
```

Return a list of the vector positions (starting with 0 ) which have a set or unset bit. Optionally, an offset for the first bit to be tested, and the maximum number of bits to be tested may be specified. By default, testing begins with the first vector position (index 0 ) and continues until the end of the vector. The subcommand testl may be abbreviated to test.

```
bitvector create length ?value?
```

Generated a new vector of the specified length. By default, it is set to all zeros. The value parameter, which may be 0 or 1 , can be used to generate a vector with all set bits.

```
bitvector screen vectorl vector2
```

Perform a screening operation on the bitvector. This command returns the first index position where a bit is set in the second vector, but not in the first. If all set bits in the second vector have counterparts in the first vector, minus one is returned.

```
bitvector count vector1 ?vector2?...
```

Count the total number of set bits in all the specified vectors.

```
bitvector distance vector1 vector2
```

Compute the Hamming distance between the vectors.

## bread

```
bread tcl_filehandle format ?var..?
```

This command reads formatted binary data from an output channel. The specified TcL channel is automatically configured for binary data for the duration of the command and then restored to the original state.

The command is complementary to the bwrite command described below and uses the same formatting specifications.

Multiple values sharing the same format can be read in one statement with a set of recipient variables is specified. The return value is the value of the last item read. If no variables are used, one item is read and returned, but not stored in a variable.

Example;
set $s$ [bread \$channel string16]

## bwrite

```
bwrite tcl_filehandle format data ?data?...
```

This command writes formatted binary data to an output channel. The specified TcL channel is automatically configured for binary data for the duration of the command and then restored to the original state.

If more than one data item is specified, the same format is used for all the data items. For most formats, the binary data layout is not changed and it thus platform-dependent. The exception are those formats which are prefixed with an X: These follow the platform-independent XDR encoding standard (RFC 1014) in their layout (network byte order, MSB first), but not in the stored item size (the byte size of smaller objects is not expanded to multiples of four). The following formats are supported:

- long, int

4-byte signed integer

- ulong, uint

4-byte unsigned integer

- xlong, xint

4-byte signed integer, MSB layout

- xulong, xuint

4-byte unsigned integer, MSB layout

- short

2-byte signed integer

- ushort

2-byte unsigned integer

- xshort

2-byte signed integer, MSB layout

- xushort

2-byte unsigned integer, MSB layout

- char, xchar

1-byte character

- ulong8

8-byte unsigned integer

- xulong8

8-byte unsigned integer, MSB layout

- float

4-byte floating point number

- xfloat

4-byte floating point number, MSB layout

- double

8-byte floating point number

- xdouble

8-byte floating point number, MSB layout

- string
character string. If no length is specified, it is terminated by a zero byte.
The string format may contain additional length and pad character specifications. If a pad character is used, it must be supplied as its ISO Latin code. This makes it simple to use zero bytes as filler.

Example:

```
bwrite stdout string16:[ctype ord x]
```

writes a string which always occupies exactly 16 bytes. If it is longer, the extra characters are ignored. If it is shorter, it is padded with "x" characters. A zero byte is not written, because this string has an explicit length.

The bread command provides the complementary functionality to read binary data into variables using the same format specifications as template.

## creverse

creverse string
Reverse a string.
Example:
creverse abc
returns $c b a$.
color
color ?-alpha? ?-depth n? ?-hex? ?-name? ?-shade delta? colorname/colorspec
Decode a color name. On Unix systems, color names are looked up in the local X11 color database. On the PC platform, a representative $\mathbf{X 1 1}$ color database dump is compiled into the application. In addition to English color names, the standard hex color notation, such as \#rrggbb or \#rgb, may be used, with or without alpha channel data. If a hex color notation has 4,8 or 16 hex digits, the value is interpreted as \#rgba, \#rrggbbaa and \#rrrrggggbbbbaaaa, respectively. In case of 12 hex digits ( 12 is both divisible by 3 and 4 ), the interpretation \#rrrrggggbbbb takes precedence. Color names are case-insensitive.

By default, a color depth of 16 bits is assumed, and the returned color component values are thus in the range $0 . .65535$. Smaller or larger color component value ranges may be specified by an explicit depth value, which must be in the range between 2 and 24 .

If the -shade option is used, the decoded color value is darkened or brightened by the specified amount by component-wise addition before it is output in the selected format. The shading value is scaled according to the selected color depth, i.e. with a color depth of 8 , the useful minimum and maximum scale values are -255 and +255 , while with a color depth of 16 the limits are -65525 and +65535 . The transformed color values are automatically clamped to the white and black extremes, so the output will always be a valid color representation. Shading is not applied to the alpha/opacity channel. A shading value of zero has no effect in any color depth.

The default return format is a list with the decimal RGB values of the decoded color. If the -hex option is set, the output is formatted as a single hex-encoded color value. If the -alpha option is given, the format of the output includes the opacity value as the fourth component in RGBA order, either as an additional list element or appended to the hex string.

With the -name option the command attempts to find the most closely matching color name in the database for the decoded and transformed color values and return that name instead of a color component list or hex encoding.

The command may also be spelled colour instead of color.
Example:

```
color -depth 8 -hex Red
```

returns \#FF0000.
color -depth 8 -shade -0x10 -hex \#808080
returns \#707070

## daemonize

daemonize ?priority? ?closefiles?
Transform the current process into a daemon process which is decoupled from all control terminals and runs in the background until finished or terminated. The current process is forked, and the old foreground process exited.

By default, the background process priority is unchanged. Alternatively, a new priority may be specified as the first optional argument. If it not an empty string, an attempt is made to set the process priority to the new value. No error message is generated when the attempt fails. Useful priority values depend on the platform. On Linux, the range is $0 \ldots 20$, with 20 being the lowest priority. Increasing the priority, by using a value lower than the current process value, requires non-standard permissions, usually an effective application user ID of root.

By default, all open file handles are closed. If the optional closefiles parameter is set to 0 , most file handles are kept open. An exception are the standard input, output and error channels. These are always redirected to $/ \mathrm{dev} / \mathrm{mull}$, regardless of the option value. Note that the closing of the file descriptors does not automatically invalidate any TcL scripting language references to these, such as standard TcL file or socket handles, or toolkit molfile handles. These should be explicitly closed by the application script before this function is called. Otherwise, any use of these stale handles results in errors.

This command is only available on Unix-based platforms.

## decode

decode mode data ?key?
This command decodes a number of commonly encountered encoding formats for string and binary data. The decoded data is returned as command result. The mode parameter decides which decoding scheme is used:

- -base64

The data argument is expected to be a standard base64 encoding or the URL variant thereof (with - and _ replacing the + and $=$ characters). The data characters may be either written as one unbroken sequence or follow RFC2045, which mandates embedded line breaks and an encoding data characters count divisible by four. The appropriate subformat is automatically detected. The decoded data may be binary.

- -bitset

Decode a collection of symbolic bit names via a standard toolkit bitset enumeration value specification, as it is used for example in property definitions. The enumeration definition syntax is documented in the paragraph dealing with the enum property attribute. This command variant uses the syntax

```
decode -bitset symvalue enum_spec
```

The return value is a wide integer value with all bits set according to the decoded symbolic value string. If the value cannot be decoded, an error results. An empty value argument always yields zero as result. Example:

```
decode -bitset a|c none:a,alpha:b,beta:c:d
```

The return value is 5 , which is combined from set bit index 0 for $a$ and set bit index 2 for $c$. For bitsets, the first colon-separated word in the enumeration specification contains one or more aliases for zero set bits, which corresponds to the numerical result zero. Instead of a vertical bar, whitespace may also be used as bit position name separators.

- -datauri

Decode the payload of a data URI in base 64 or URL encoding. The MIME type and character set information are not used and ignored if present. The URI may encode binary data.

- -dataurl

An alias for-datauri

- -enum

Decode a symbolic name via a standard toolkit enumeration value specification, as it is used for example in property definitions. The enumeration definition syntax is documented in the paragraph dealing with the enum property attribute. This command variant uses the syntax

```
decode -enum symvalue enum_spec
```

The return value is the integer value linked to the symbolic value argument. If the value cannot be decoded, an error results. Example:
decode -enum b a, alpa:b,beta:c=99

The returned value is 1 , which is the default value of symbolic name $b$, or its alias beta, taken from its colon-separated word index. The word index is used in the absence of an explicit value, as it is specified in the example for value $c$.

- -formula

The input is expected to be an Unicode string representing a molecular formula in standard notation with element counts encoded in subscript digits, and charges encoded with superscript digits or plus/minus characters. The output is the plain ISO-8859-1 string form of the same formula.

- -gzip

Because the zlib and gzip formats are automatically distinguished, this is an alias for -zlib.

- -gzip64

Because the zlib and gzip formats are automatically distinguished, this is an alias for -zlib64.

- -hex

The data is expected to be a sequence of hex digit pairs, specifying the ISO Latin value of the decoded character at every position. White space between hex characters is ignored, but other non-hex characters raise an error.

- -html

The input data is expected to be HTML text with entity encodings, such as \" for a quotation mark. These entity encodings are resolved to a standard ISO Latin encoding. Note that there are entities which cannot be represented in the ISO Latin encoding. These are passed unchanged. This mode also decodes XML encoding, which uses a smaller set of entities. Neither HTML nor XML decoding removes tags.

- -json

Decode a JSON object into an equivalent TCL list (for array elements) and dictionary (for map elements) representation. This option is only available if the interpreter was compiled with JSON support.

- -mysql

Decode a binary blob as produced by the Mysql database function compress (). This is primarily useful in the context of the Mysql database cartridge. The data consists of a 4-byte binary header with the decompressed data length, followed by zlib-compressed data. An empty string is encoded verbatim.

- -paper

Decode a paper size such as $A 4$ or letter. If the paper size is known, return a list with the width and height of the format, in that order. If the format is unknown, an error results.

- -pdf

Decode input as a PDF string. If the first character is an opening parenthesis, and the last character a closing PARENTHESIS, these are also stripped.

- -python

Decode a standard Python string object representation, for example a quoted string, a simple number, or a tuple, list or dictionary. The result is a suitable TcL interpreter value object containing the equivalent information.

- -quoted-printable

The input is expected to use quoted-printable representation, such as $=20$ for a space character. The output in in ISO Latin.

- -rc4

The input data are bytes encoded with an RC4 cipher. This command version requires an additional argument after the data argument which is used as the decoder key.

- -rfc 2045

This is the same as -base 64.

- -robustzip

Slower than -zip, but more robust against extreme compression factors and data corruption.

- $-r t f$

Strip formatting information from RTF text. Only the plain text parts, encoded as ISO Latin, remain. Leading and trailing white space is removed. The only formatting instruction which leaves a trace in the decoded text is par (paragraph break), which is translated into a space character. The decoder implements a minimal RTF parser, so that any legal RTF string can be submitted, regardless of the specific formatting instructions it contains.

- -suffix

Get the name of the most common chemistry structure or reaction file format using the suffix of a passed file name argument. If this is not a known suffix, the return value is unidentified. The returned name is suitable for use with the filex command. The argument file is not required to exist - it is only used to extract the suffix. This command does not try to match table or network file extensions, but it ignores known compression suffixes such as $. g z, . Z$ or.$b z$ in determining the applicable core file suffix.

- -url

The input data is expected to be in URL encoding, with + for space and/or $\% x x$ (such as $\% 20$ for space) hexadecimal three-letter encodings for other letters. These encodings are resolved to ISO Latin.

- -urlvbar

The input data is expected to be in URL encoding, with + for space and/or $\% x x$ (such as $\% 20$ for space) hexadecimal three-letter encodings for other letters. These encodings are resolved to ISO Latin. Vertical bar characters are translated to the system default line end character(s).

- -zlib

The input data is expected to be zlib-compressed. Both direct zlib compression and string images of gzip-compressed files (which use a different header) are accepted. The subformat is automatically recognized. gzip header information, such as comments and the original file name, will not be preserved.

- -zlib64

This is a convenient combination of base64 decoding and zlib decompression. It is equivalent to first performing a -base64 decoding, followed by a -zlib step.

The decoded data may contain zero-bytes and other special characters and may thus need special care in further processing. The counterpart of the decode command is the encode command, which can be used to encode data in all recognized decoder formats.

For historical reasons, the $-z l i b^{*}$ variants can also be invoked as the same command starting with -zip*.

## encode

encode mode data ?mode_arg?
This command is the counterpart to the decode command. It is not completely identical, tough - the decoder automatically recognizes certain variants of encoding schemes, which need to be specified in detail on the encoder side. The encoded datam which may be binary, is returned as command result. The possible encoding modes are:

- -base64

Encode in base64 format. The result string contains only printable characters. All data is packed into a long string without any line breaks. For line breaks after a maximum of 76 characters, use RFC2045 encoding.

- -base64url

This is the same as -base64, except that the (not-quite-standardized, but frequently encountered) URL-safe encoding variant is used, which uses the '-' and '_' characters as replacements for ' + ' and ' $=$ ' which need to be escaped in URLs. This is not the same as the more portable URL-encoding of the original base64 string, which would replace these characters by escaped notations.

- -bitset

Encode an integer value to a combination of symbolic bit position names with a standard toolkit bitset enumeration specification, as it is for example used in property definitions. The syntax of this specification is explained in the paragraph on the enum property attribute. The command requires an extra mode argument for the enumeration definition string. In case a set bit in the numeric argument is not covered by the enumeration string, no error is raised. Instead, the numerical value of the bit is inserted. Example:

```
encode -enum 3a:b:c
```

returns 'b|c'.

- -boolean

Take boolean value in any of the forms recognized by TcL and returned it as true or false value.

- -csource

Encode the data bytes as a comma-separated, hex-encoded byte sequence suitable for inclusion in C source files.

- -cstring

Encode special characters such as $t a b, v t a b, c r, l f$ as their C-style backslash encodings.

-     - crc32

Compute the CRC32 checksum of the input data.

- -datatag

Output a complete HTML tag (<img> or <object>) with an embedded data URI encoding of the data argument with an appropriate MIME type and the data encoded in base64 format. This is useful for the generation of HTML pages with images where the images need not to be stored in external files. The encoded data must be a GIF, PNG, JPEG, SVG or PDF image, which is verified by identifying the magical header bytes. PDF input results in an <object> tag, the other types yield <img>. This command variant accepts an optional third argument. If it is set, it is used as the content of the "alt" tag attribute. Example:

```
prop set E_GIF datatype blob
encode -datatag [ens get $eh E_GIF] „Image of [ens get $eh E_IDENT]"
```

- -datauri

Create a data URI in the format data:mimetype;base64,payload from the input data in base 64 encoding. The default MIME type is application/octet-stream, but this can be overridden by using the optional mode parameter. No attempt is made to automatically determine the MIME type of the input.

- -dataurl

This is an alias for -datauri.

- -enum

Encode an integer value to a symbolic name with a standard toolkit enumeration specification, as it is for example used in property definitions. The syntax of this specification is explained in the paragraph on the enum property attribute. For this mode, extra mode argument is required and is the enumeration definition string. In case the numeric argument value is not covered by the enumeration string, no error is raised. Instead, the return value is the numeric input. Example:

```
encode -enum 2 a:b,beta:c,gamma
```

returns ' $c$ '.

- -formula

The input is a plain ISO-8859-1 string representing a molecular formula in standard notation. The output is the same string, but with element count subscripts and charge superscripts encoded as Unicode sub/superscript characters in UTF8 encoding.

- -gzip

Encode in the format of the gzip program.

- -gzip64

Encode in the format of the gzip program, and then encode the result in the -base64 format.

- -gzip64url

Perform gzip compression first, then encode the result in the -base64 format, and finally perform URL encoding of the result, which is required because base64 can contain the characters,$+=$ and $/$, which need to be escaped for URL contexts.

- -hex

Encode by representing every input byte by a pair of hex digits.

- -hexbytes

Encode by representing every input byte by a pair of hex digits, with a space between digit pairs.

- -html

Encode for HTML display, using entities like \" for certain characters such as the quotation mark which can interfere with the tag structure.

- -html0

Encode for HTML display, using entities like \" for certain characters such as the quotation mark which can interfere with the tag structure. This command variant however passes zero bytes verbatim, instead of encoding them as $\& \# 0 ;$. Use of this command variant is discouraged. It it a hack which can be used to pass 0 bytes in simulated file uploads on certain browsers.

- -imgtag

An alias for -datatag. Despite the name, this also covers auto-generated <object> and <embed> tags.

- -jsarray

Encode the argument, which must be a properly formed TcL list, as a JavaScript array initialization string suitable for inclusion into program-generated JavaScript code.

- -jsdict

Encode the argument, which must be a properly formed Tcl dictionary, as a JavaScript named object attribute initialization string suitable for inclusion into program-generated JavaScript code.

- -jsnative

Encode the argument in the JavaScript type corresponding most closely to the TcL argument object type. This is not foolproof since the TcL object may temporarily be represented as string, depending on how it was set up and which operations it was subjected to, even if it could be represented as a more efficient type. However, usually it works, and the TcL objects returned as the result of toolkit commands are of a suitable optimized type, not generic TcL strings.

- -jsstring

Encode argument as a single-quoted JavaScript string suitable for inclusion into program-generated JavaScript code.

- -quoted-printable

Encode using the quoted printable standard.

- -qrcode

Return a QRCode as PNG data URL string encoding the argument value. Usually it is a URL.

- -md5

Compute an MD5 hash code from the input string.

- -pdf

Encode input data as a syntactically correct PDF string. The outer parenthesis pair is added automatically.

- -python

Encode a Tcl interpreter value object, such as an integer, string, list or dictionary, into the standard string representation of the equivalent Python object. The proper operation of this command depends on the TcL argument having the proper type. Since the command does not know the expected type, care must be taken when passing arguments - no automatic
TcL-style conversion, for example from a string to a list or dictionary, is performed. These operations must be explicitly coded if needed.

- -rc4

Encrypt data using the RC4 algorithm. This encoding scheme needs an extra argument. The next argument after data is the encryption key. Encryption is symmetric. Re-application of the encoder command with the same key on the encryption result restores the original data.

- -regsub

Encode special regular expression characters in a replacement string, such as \& and $\backslash 1$, in such a way that they are not substituted by the next regular expression substitution operation and are afterwards again encoded in their original form.

- -rfc 2045

Encode in base64 format, but enforce line breaks every 76 characters.

- -rtf

Encode in such as way that the character sequence does not break the file syntax when inserted as string into an RTF file. Opening and closing curly brackets as well as backslash characters are escaped.

- -sql

Escape characters so that a well-formed SQL string results. The string does not contain the leading and trailing single quotes needed for use in an SQL statement.

- -url

Encode for use in URLs, replacing space characters by + and other interfering characters by a $\% x x$ character triple, where the last two characters are hex digits for the ISO Latin character code. Additionally, linefeeds in the input in any format (Unix, PC, Mac) are standardized to a CR/LF sequence.

- -urlbinary

The same as -url, except that linefeeds are not normalized. This is similar to the JavaScript function encodeURI().

- -urlbinaryparameter

An alias to -urlbinarycomponent

- -urlbinarycomponent

The same as -urlcomponent, except that linefeed standardization of the encoded data is also suppressed.

- -urlcomponent

The same as -url, except that characters in the set $\&=? / ;:$ are also percent-encoded to avoid interference with the section structure of an URL. This is similar to the JavaScript encodeURIComponent() function.

- -urlparameter

An alias to -urlcomponent.

- -urlvbar

Encode for use in URLs, replacing space characters by + and other interfering characters by a $\% x x$ character triple, where the last two characters are hex digits for the ISO Latin character code. Additionally, line feeds in any of the standard forms (Unix, PC, Mac) are translated into a single vertical bar character.

- -xml

Encode for usage in XML contexts. This encoding replaces the characters $>,<$, ", ' and $\&$ by entities, but leave other characters, which would be converted into entities in HTML encoding, intact.

- -zlib

Perform zlib compression on the data. The result cannot be directly stored as a gzip-compatible file. These files contain an extra header.

The result of this command is likely to contain zero bytes and other special characters. Further processing of this data may require caution.

- -zlib64

Perform zlib compression first, and then encode the result in the -base64 format.

- -zlib64url

Perform zlib compression first, then encode the result in the -base64 format, and finally perform URL encoding of the result, which is required because base64 can contain the characters,$+=$ and $/$, which need to be escaped for URL contexts.

The -zlib* encoding variants can also be invoked as the same command starting with -zip*.

## fcgi

fcgi subcommand ?args?
This command manages I/O when running an application script as an FastCGI (FCGI) Web application. Only selected interpreters provide this command, for example the standard tclcactvs and the stand-alone csweb variant.

In addition to providing the fcgi command, these interpreters also register additional pre-opened TcL channels fcgi-stdin,fcgi-stdout and fcgi-stderr. Reading from or writing to these channels with the normal TcL I/O commands directly moves the data to or from the FCGI server communication channels.

The following subcommands are supported:
fcgi accept ?redirect? ?autoexit?
This command enables FCGI-style socket communication with the Web server controlling this application and is usually the first command in an FCGI application.

If the redirect flag is set (it is set by default), the stdout, stderr and stdin TcL channels are redirected to the corresponding FCGI multiplex socket. All normal TcL I/O commands automatically use the multiplex socket instead of the standard channels if they are referring implicitly or explicitly to the standard channels. In addition, Web-typical properties like E_GIF,

E_VRML, E_PICT_IMAGE, E_EPS_IMAGE, E_SVG_IMAGE, E_EMF_IMAGE and X_GIF are aware of this redirection and also send their output to the socket in case it is sent to one of the standard channels instead of a disk file. The current redirection status is mirrored in the read-only control variable : :cactvs (fcgi_redirect).

If the autoexit flag is set (it is also set by default), the application automatically exits if the socket communication results in an error or EOF. The return value is a status code and zero in case a normal communication was initiated. In case automatic exiting is disabled, a negative status code is returned if there is an error.

```
fcgi finish ?redirect?
```

This command finishes the processing of a request. All buffered output is flushed to the server. The next request can then be waited for by a new call to fcgi accept.

If the redirect flag is set (it is set by default), any existing stdout, stderr and stdin redirections the toe FCGI socket are canceled. All standard channels as seen by the script interpreter and certain image properties (see description of fcgi accept command) are reconnected to their original streams. The current redirection status is mirrored in the read-only control variable
: :cactvs (fcgi_redirect).
fcgi puts ?-nonewline? ?channel? data
This command is the same as the standard TcL puts command, except that it operates on the stdout and stderr equivalents of the FCGI communication model. In case a channel is specified, only stdout and stderr are possible argument values. The command is primarily useful in case the automatic redirection feature of the fcgi accept command was not used. Output is only possible after the invocation of an fcgi accept command and before the issue of a closing fcgi finish command.
fcgi read
This command reads the FCGI equivalent of stdin until EOF is encountered and returns the data as a byte vector. In case FCGI redirection is active, the standard TCL read command can be used as an equivalent.
fcgi redirect ?on/off?
This command may be used to explicitly invoke or cancel the redirection of the standard TcL channels stdin, stdout and stderr to the FCGI equivalents. In case no boolean redirection argument is given, the current redirection status is reported. In case a new status is set, the command returns the previous status. The current redirection status is also mirrored in the read-only control variable : :cactvs (fcgi_redirect).

```
fcgi status code
```

This command can be used to set the exit status when the automatic exiting feature of the fcgi accept command is used. This command may be called any time.

Example:

```
while {[fcgi accept]>=0} {
    set data [read stdin]
    if {$data=="\prime\prime} { set data $env(QUERY_STRING) }
    uncgi $data params
    do_something $params(form_url_arg1) $params(form_url_arg2)
    fcgi finish
```

\}
This code snippet shows a typical main loop in an FCGI application. Standard I/O redirection is used for convenience, and in case there are any communication errors with the Web server, or shutdown instructions, like closing of the stdin channel, are received from the server, the application exists. If the application scripts exits, it is (in a typical set-up, this depends on the Web server configuration) be restarted by the Web server at a later time when the next request comes in.

## fetch

fetch ?-agent agent? ?-cookie cookie? -header no/yes/exclusive? \}
?-modified time_in secs? ?-password password?
?-referer referer? ? -setcookie cookie? ?-timeout nsecs? \}
?-tofile 0/1? ?-user username? url ?statusvar?
This command is used to retrieved data from network locations identified by URLs. The default action is to fetch the data and return is as uninterpreted byte data, but without protocol header information. The following options can be used to modify the command action:

- -agent agent

Transmit a specific User-Agent HTTP header string. The default is an innocuous Mozilla browser name. If the parameter is set to an empty string, no agent name is transmitted.

- -cookie cookie

When requesting the data, transmit the cookie string as part of the request in protocols which support this. Cookies may be required for access control, or encode modal information.

- -header no/yes/exclusive

This option determines whether header information should be retrieved. By default, header data is discarded. The exclusive mode only reports the header and discards any body information. This option only makes sense for protocols which differentiate between header and body information.

- -modified time_in_secs

Only fetch the data if it has been modified since the specified time stamp. The format of the time value is seconds since epoch, this is the same type as returned by the standard TCL clock seconds format.

- -password pwd

A password to be used with the user name to supply credentials to the remote server. Alternatively, it can also be specified as part of the URL in standard notation.

- -referer referer

A referer string to pass to the server.

- -setcookie cookie

When requesting the data, include header lines to set the specified cookie in protocols which support this.

- -timeout nsecs

Set the timeout in seconds. The default timeout is 30 seconds. If the data could not be retrieved completely within the specified time frame, an error is produced.

- -tofile $0 / 1$

Output to a temporary file instead of an in-memory image. The return value is the handle of a TcL file channel. Option-file is an alias.

- -user username

A user name to present to the remote server. Alternatively, it can also be specified as part of the URL in standard notation.

The url argument is a standard Internet URL. The exact types of supported URLs vary with the interpreter and, for database URLs, also depend on loaded database I/O modules. A basic set consisting of the file:, http:, ftp: and gopher: protocols and URL encoding standards is always supported. FTP transfer uses passive mode where possible. All standard protocol drivers also support the transport of user id and password information.

If a status variable parameter is specified, it is interpreted as the name of a TCL array variable which is created if necessary, reset and filled with status information. Its elements are size (the download data size, without header), lastmodified (the remote file modification date), location (the last download URL, which can be different from the original retrieval URL in case of redirects), mimetype (the mime type of the data, as perceived by the remote server), various cookie data variants (see below) and finally status for the integer return status code.

The elements for the cookie data element encoding variants are named cookies (a list of all received cookies in Netscape format), cookiedicts (the same as list of dictionaries), and individual per-cookie elements cookie\%d and cookiedict $\%$ d, where the placeholder is the cookie index starting with zero. The Netscape cookie format is a tab-separated string of six elements encoding the cookie domain, its domain access flag, the path, secure access flag, expiration date, cookie name and value. Splitting these strings to access individual data items should be done explicitly on the tab character since implicit list conversion is not reliable for this encoding. In the dictionary list and individual cookie dictionary encoding variants, the dictionaries contain the same information properly isolated under the keys domain, domainaccess, path, secureconnection, expiration, name and value. The individual cookie strings are simplified data representations pre-formatted in the style "name=value" or "name=value ; Path=path" (the latter only if an explicitly path was specified) which is usually the proper form to use when constructing a custom MIME header with a Cookie: or SetCookie: tag.

If the program is run in -header exclusive mode, the command result is a list of the status variable values size, lastmodified, mimetype, code, location and cookies, in the order listed, instead of the fetched data.

The modification time as well as cookie expiration dates in the status are returned as an integer (seconds since midnight, Jan $1^{\text {st }}$, 1970, epoch), suitable for formatting by means of the standard TCL clock format command. If a modification or expiration date could not be determined, the reported time value is minus one.

The mime type information may contain, after a semicolon separator, additional encoding information if reported in this fashion by the server.

Example:

```
set data [fetch -timeout 10 ftp://$user:$passwd@$host/$path/$file v_status]
set mimetype $v_status(mimetype)
```


## filecheck

filecheck type filename
This command is used to check formats and attributes of files. The result is either 1 , if the file is of the checked type, or 0 if it is not. In case of errors, such as a non-existing file, a standard error condition is raised. These file type checks are currently supported:

- binary

Check whether file looks like a binary (not text) file.

- bzip2 (or bzip)

Check whether file is bzip2-compressed.

- compressed

Check whether file is of a recognized compression type.

- directory

Check whether path is an existing directory.

- dll

Check whether file is a shared library of any type (shared, DLL, bundle). Same as sharedlib test.

- filter

Check whether file is a Састvs filter definition file.

- factory

Check whether file is a Састvs factory definition file. Factory parameter files are not factory definition files.

- file

Check whether path is a normal file (and not a directory, link, socket, etc.)

- gif

Check whether file is a GIF image.

- gzip

Check whether file is gzip-compressed.

- html

Check whether file is a HTML file.

- image

Check whether file is an image in a suitable Web format (GIF,JPEG,PNG)

- jpeg (or jpg)

Check whether file is a JPEG-encoded image.

- link

Check whether path is a link (and not a file, directory, socket, etc.)

- local

Check whether file resides on a local file system. Not supported on all platforms.

- object

Check whether file is an object file.

- pdf

Check whether file is a PDF file.

- postscript

Check whether file is a PostScript file.

- png

Check whether file is a PNG-encoded image.

- property

Check whether file is a Cactvs property definition file. Both the old keyword/value format and the new XML format are recognized.

- repository

Check whether file s a CACTvs repository in SQLITE format.

- sharedlib

Check whether file is a shared library of any type (shared, DLL, bundle). Same as $d l l$ test.

- shellscript

Check whether file is a shell script.

- special

Check whether file name is one of the magic names recognized by CACTvs, such as stdin or stdout.

- sqlite

Check whether file as SQLIte version 3 database file.

- station

Check whether file is a station definition file. Station parameter files are not station definition files.

- tmpfile

Check whether file is residing in the current tmp directory.

- ucs2encoded

Check whether file is encoded in 16-bit Unicode, in either of the two possible byte orders.
These tests operate by examining the first bytes of a file, not by a simple match of suffixes. File checks which rely on platform-specific binary data layout information only work for the current platform. On a Sun, a OSX bundle will not be recognized, and vice versa.

## Idelete

ldelete ?mode? list pattern ?pattern?...
Delete elements from a list. The first optional parameter selects the match mode for the patterns. If can be one of -exact, -nocase, -substring, -regexp, -glob or -index. The standard option list terminator "--" may also be used. The default mode is exact. The index mode expects element indices starting with 0 as pattern arguments.

All list elements which match any of the patterns are removed. The command returns the shortened list, preserving the order of the surviving elements.

Example:
ldelete -regexp [list a aa ad] \{a[abc]+\}
returns "a ad".

## lineintersect

```
lineintersect x1 y1 x2 y2 x3 y3 x4 y4
lineintersect {x1 y1} {x2 y2} {x3 y3} {x4 y4}
```

Test whether the line segments from $x 1 / y 1$ to $x 2 / y 2$ crosses the line segment from $x 3 / y 3$ to x4/y4.

The return value is a simple boolean flag. It does not report the intersection coordinates.

## Isearch

lsearch ?modeflags? list pattern
This is an extended, but compatible version of the standard TcL lsearch command.
The mode flags may be any combination of -exact, -nocase, -substring, -regexp, -glob, -first, -all and the option terminator "--". The default mode is the combination of glob and first, the same as for the standard isearch command.

Just as the standard command, matching list indices are returned. In mode first, which corresponds to the default behavior, the result is the list index $>=0$ of the first matching element, or -1 if the pattern cannot be found. In mode all, a list of the indices of all matching list elements is returned, or an empty list if no element matches.

Example:
lsearch -exact -all $\{\mathrm{a}$ b c a b c\} a
returns "0 3".

Isum
lsum nmbers...
Sum up all number arguments and return the result. All arguments must be numbers.

## Ivardelete

lvardelete ?mode? listvar pattern ?pattern?...
Delete elements from a list variable. The first optional parameter selects the match mode for the patterns. If can be one of -exact, -nocase, -substring, -regexp, -glob or -index. The standard option list terminator "--" may also be used. The default mode is exact. The index mode expects element indices starting with 0 as pattern arguments.

All list elements which match any of the patterns are removed from the variable. Additionally, the command returns the shortened list, preserving the order of the surviving elements.

Example:

```
set mylvar [list a b c d]; lvardelete myar b d
```

returns "a c" and sets the variable to the same value.
mail
mail ?-debug 0/1? ?-file filename? ?-from from address? ?-secure 0/1?
?-smtphost hostname? ?-smptpassword password? ?-stmpport port? ?-smptuser userid? recipient_address_list ?subject? ?body?

Send a simple iso-encoded plain-text email message to one or more recipients. The only required argument is the recipient email address list. Without subject and body arguments, an empty message is sent. If the recipient address list is an empty list, or only contains empty elements, the command silently does nothing. Address list elements which are not empty strings and ignored must pass a simple email address pattern test before a mail delivery attempt is made.

The optional smtp* arguments specify the access parameters to the mail host. If these options are not set, they are read from the corresponding control variable elements, i.e.
::cactvs (smpt_host), ::cactvs(smpt_port), etc. If the -secure option is set, an attempt is made to use encrypted smpts communication instead of the plain smtp protocol, though the initial protocol negotiation still uses plain smtp if the smtp port is not explicitly set to 465. In absence of an -from argument, the sender address is copied from ::cactvs (user_email). There is no required relationship between the from address and the mail host access parameters. The default smtp port used by this command is 587 , not the old standard 25 .

Experience teaches that talking to mail servers can be tricky. When the -debug option is set, trace output from the communication attempts is printed on standard error. This is highly useful to pinpoint connection problems.

Finally, the -file option allows the direct upload of an existing, readable file as the message. The file contents are sent as message data, not as an attachment. If both an upload file and a body argument are specified, the file is inserted first.

The message content is sent as plain IsoLatin (ISO8859-1) encoded message. The nature of line-break characters in the message is not preserved, and additional line breaks are inserted if any line is longer than 998 characters, the maximum line length in a standard smtp message.

This command currently neither supports pop-before-smtp authorization, nor the sending of attachments.

Example:

```
mail -smtphost smtp.gmail.com -smtpuser $user -smtppassword $pw \
    -secure 1 wdi@xemistry.com "Hi" "This\nis a message\n"
```

Above sample command sends a message via Google mail. Of course, a Gmail account bound to the user and password variables must exist for this command to succeed.

## mailcap

```
mailcap mimetype
```

Return the standard opener/viewer for files of the specified MIME type. The result is dependent of the local configuration. On Windows, the command attempts to find a suitable opener in the registry, and if it is found, the return value usually contains Windows-specific placeholder tags.

Example:

```
mailcap chemical/pdb
```

might return something like "rasmol -pdb \%s"

```
parse
parse base64 arg
parse casrn arg
parse color arg
parse datauri arg
parse dictionary arg
parse doi arg
parse domain arg
parse element arg
parse elementlist arg
parse email arg
parse formula arg
parse hash arg
parse hex arg
parse inchi arg
parse inchikey arg
parse ipaddr arg
parse jme arg
parse lillyrule arg
parse list arg
parse minimol arg
pasre nativequery arg
parse orcid arg
parse propertylist arg
parse query arg
parse queryformula arg
parse retrievallist arg
parse sln arg
parse smarts arg
parse smiles arg
parse superatom arg
parse uuid arg
parse xml arg
```

This command checks whether the argument can be parsed as the data type indicated. The result is a boolean value. No error is raised if the parsing fails, and the parsed data structure is discarded. The following data types are currently understood:

- base64
base64-encoded data
- casrn
a Chemical Abstracts registry number. Only the syntactical correctness, including the check digit, is verified, not whether the number is valid.
- color
a valid color specification, either as a recognized name, or in hash notation.
- datauri
a valid data URI.
- dataurl
this is an alias to subcommand daturi.
- dictionary
a TcL dictionary, i. e. either a TcL dictionary object, or a properly formed list of keyword and value pairs, as they are also used in some CaCTvs interface functions, for example the parameters attribute of property definitions.
- doi
a properly formed DOI (digital object identifier).
- domain
a properly formed domain name. Only the generic syntax is checked, no DNS look-up is performed. The domain must contain at least one dot.
- element
an element symbol. Case is disregarded.
- elementlist
a list of element symbols, as they are for example used in the list field of the A_QUERY property to specify an element list for substructure matching. Superatoms and other element extensions are not allowed here.
- email
a properly formed email address.
- formula
a plain molecular formula, without query expressions such as count ranges or pseudo elements.
- hash
a Cactvs 64bit hash code
- hex a hexadecimal number. Extra white space is allowed.
- inchi
an InChI string. This is only supported in interpreter versions with InChI support. InChI support needs to be compiled-in. It cannot be loaded as I/O module.
- inchikey
a InChI key/hash string. This is only supported in interpreter versions with InChI support. InChI support needs to be compiled-in. It cannot be loaded as I/O module.
- ipaddr
a properly formed IP4 address in dot-separated bytes in decimal encoding.
- jme
a MolInspiration Java Molecule Editor structure string. This requires the presence of the JME I/O module. An attempt is made to auto-load it if it is not in memory. If the module cannot be loaded, an error results, even if the string is syntactically correct.
- lillyrule

Check syntax of a match expression in Bruns/Watson notation (J. Med. Chem. 2012, 55, 9763-9772

- list
a properly formed TcL list
- minimol
a Cactvs Minimol in binary or hex-encoded variants
- nativequery
a query expression, as used in molfile scan and other scan commands, in native toolkit notation.
- orcid
a properly formatted ORCID (www.orcid.org) identifier. Both the general format and the check digit are verified, but not whether this ID has been issued.
- propertylist
a list of toolkit property names. An attempt is made to auto-load properties for which no definition is in memory. This command can also be spelled as proplist.
- query
a query expression, as used in molfile scan and other scan commands. Both the native style and the Bruns/Watson notation are recognized.
- queryformula
a formula query expression, as used in the molfile scan and other scan commands.
- retrievallist
a data retrieval list, as used in molfile scan and other scan commands.
- $\operatorname{sln}$
a valid Sybyl line notation string. This requires the presence of the SLN I/O module. An attempt is made to auto-load it if it is not in memory. If the module cannot be loaded, an error results, even if the string is syntactically correct.
- smarts
a valid SMARTS string, including Recursive SMARTS
- smiles
a valid SMILES string
- superatom
a superatom which can be decoded from the current superatom table entries without ambiguity
- uuid
an UUID in standard 8-4-4-4-12 notation, checked in case-independent fashion
- xml
a well-formed XML document


## passwd

```
passwd encode cleartext_pw ?salt?
passwd decode encrypted_pw cleartext_pw
```

The first command variant encodes a clear-text password with the standard Unix crypt() algorithm. A salt value for the password generation may be specified as exactly two letters from the set "a-zA-Z0-9./". If no salt is specified, a random value is used. The command returns the encoded version of the clear text.

The second variant returns 0 or 1 , depending on whether the clear text password matches the encrypted version or not.

This command is supported on Windows, the crypt () function is provided by a compatibility function compiled into the library code.

Example:

```
passwd encode topsecret XX
```

yields something like "XX9Kadd0cpq.o".

```
passwd decode XX9 topsecret
```

returns 0 , while

```
passwd decode XX9Kadd0cpq.o topsecret
```

returns 1 . Note that without the specification of a salt parameter the encoded result is different each time in a random fashion. However, the password check works without knowing the salt with encrypted passwords encoded with each possible salt.
post
post ?-agent agent? ?-boundary text? ?-cookie cookietext? ?-contenttype type? ?-cookie cookietext? ?-debug 0/1? ? host hostname? ?-language languagecode? ?-password pwd? ?-raw? ?-referer referer? ?-setcookie cookie? ?-timeout nsecs? ? -uploads uploaddictionary? ?-user username? ?-xheader headerline? url
?fielddictionary/rawdata? ?statusvar?
Assemble the code for a HTTP or HTTPS POST message in (by default) multipart/form-data encoding, transmit it to a remote server and read the response.

In the standard command mode, the field dictionary parameter is a list of field names and their contents to include in the POST message. The transfer format is binary, so it is possible to send byte array data. The default individual field mime format is text/plain, but PNG and GIF images as field data are automatically recognized and sent as image/png and image/gif, respectively. In order to mirror the data encoding characteristics of file upload HTML form elements faithfully, an optional uploads dictionary can be provided. It is a key/value set where the keys are field
names that are file upload elements in the emulated Web form. They also need to be contained in the field dictionary as field name / field data pair. Field names only present in the uploads directory are ignored. The upload dictionary values are the filename attribute of the transmitted fields. The encoding of transmitted data for fields in this dictionary is modified so that the content type is always set to application/octet-stream instead of text/plain. Whether the configuration of the upload dictionary is required or not when emulating the submission of forms with upload fields depends on the extent of the data analysis performed on the side of the contacted server, but its use does not potentially introduce new problems. File contents are not automatically opened and read. Their contents must be provided in the field dictionary.

If the -raw flag is set, no interpretation of the field dictionary parameter takes place. Instead, the value of this parameter is transmitted verbatim as byte sequence in the message body. In this mode, it is assumed that it already contains all field formatting and only needs to be augmented with the HTTP header data.

The other optional parameters allow the setting of additional fields in the header of the POST command. The -boundary attribute is the MIME separator string. Its default value is a random string that is highly unlikely to occur in any transmitted data. The default content type for the form submission is multipart/form-data, but this may be adjusted with the -contenttype parameter. The short argument forms multipart (or formdata) and urlencoded select the standard encodings multipart/form-data and application/x-www-form-urlencoded. Other values of this option are sent verbatim to the server after a Content-Type: keyword. The additional attributes of file upload fields are ignored in urlencoded mode.

The argument of the -language option is passed to the Accept-Language: HTTP header field. By default the Host: HTTP header is extracted from the destination URL, but a custom value can be set with the -host option. The -xheader parameter allows the inclusion of a custom line in the header. It should be provided without linefeeds, and must contain the header field name. The other parameters have the same meaning as in the related fetch command.

If the name of a status variable is specified, it is created or reset in the local namespace, and filled with the elements status (the HTTP server error code, 200 for normal retrieval), size (the length of the received content in bytes), cookies (a list of all cookies received in Netscape string format), cookiedicts (a list of cookies in dictionary form), location (the response URL, which can be different from the command argument in case of server redirection), lastmodified (the modification time stamp of the result data, if available, -1 otherwise) and contenttype and mimetype (the MIME type of the response). In addition, every cookie is individually stored as element cookiedict \%d, starting with index zero and with the seven elements domain, domainaccess, path, secureconnection, expiration, name and value that are contained in the standard Netscape cookie encoding. The variable element names are compatible to those used in the fetch command.

It is possible to omit the field dictionary argument if an empty message is to be sent. The URL may also contain field arguments in URL encoding, but whether these are recognized in addition to the data in the field dictionary depends on the destination server configuration.

Example:

```
set data [post -contenttype urlencoded -cookie $c -debug 0 \
-xheader "X-CSRFToken: [dict get $dcsrf value]" \
-referer https://mcule.com/search/ \
https://mcule.com/search/post \
```

```
[dict create csrfmiddlewaretoken [dict get $dcsrf value] mode exact structure_2
$mdata]]
```


## python

python eval expression
python exec statements
Execute a Python command or expression. This command is only available in interpreters which include a Python subsystem.

For the eval variant, only a single statement may be processed, and the result of that statement is returned to TcL. Longer statement blocks can be processed with the exec command variant, but in that case the result is always an empty string if no error occurs. This is a limitation of the Python API. In case an error is raised, its description is transferred back as TcL result string, and the command also reports an error.

The Python interpreter version is 3.3. It is fully featured with access to the complete Python standard library, and can be instructed to import additional modules.

At this time, only a single primary Python interpreter exists in Python-enabled toolkit applications. It is mutex-protected and can be called from multiple TcL threads, but not simultaneously. Property computation Python slave interpreters are internally used, but not accessible via this command.

The Python interpreter has already imported the pycactvs and sys Python modules. All pycactvs functions and other objects are explicitly imported and can by used without a module prefix. The pycactvs.tcl() and pycactvs.tcll() functions allow scripts to double back and execute a Tcl command in the main Tcl interpreter from within Python.

Examples:

```
set five [python eval " 2+3"]
python exec "print('hello world')"
set eh [python eval "tcl(`ens create CCC')"]
```

The first example computes a simple expression in Python and returns the result. It is automatically efficiently encoded as a TcL integer object.

The last example executes a command in the Python interpreter, which itself turns back to the TcL interpreter to execute an ens create statement. Toolkit objects are shared between the Python and TcL interpreters. The newly created ensemble object is known and accessible in both languages simultaneously.

## quote

quote arg
Perform an efficient string quoting operation. The result is a string which contains only 7-bit printable characters. Characters outside this range are encoded as backslash-encoded octets or standard backslash escape sequences such as ' $\mid t$ ' or ' $\backslash \backslash$ '. The code for this command was copied from the TcL Netscape plug-in.
random

```
random limitval ?sequencesize ?seedval|reset?
random seed ?seedval'?
random reset
random hex32 ?seedval/reset?
random hex64 ?seedval/reset?
random hex128 ?seedval/reset?
random uuid
```

Generate integer pseudo-random numbers. In the simplest command variant, the limitval parameter is an upper exclusive bound. The returned pseudo-random number is in the range 0 to limit-1. By default, only a single number is returned. If a non-empty sequencesize parameter is added, the specified number of pseudo-random numbers is returned as a list. If the third optional parameter is reset, the random number generator is reset to its default start state. Alternatively, a numerical seed value can is used to initialize it to a different initial state before computing the random numbers..The random numbers are always the same sequence for a given initial state. If this is not desired, some pseudo-random seed, such as the current clock click value, should be used.

The random seed and random reset command variants can be used to manipulate the state without starting the random number generation. The seed subcommand without a seed argument uses a combination of a high-resolution timer and the process ID as seed value and is the recommended method to set up the generator for non-repeatable randomness.

The random hexxx variants directly return hex string encodings of 32 , 64 or 128 bit integers, which possess fixed string lengths of 8,16 and 32 characters, respectively. Optionally, this operation again can be combined with a reset operation or a seed value.

The uuid subcommand generates a new UUID. This function is independent of the normal random state.

This command is thread-aware. Every script thread has its own random state, and random number generation or state manipulation in one thread has no effect on any other interpreter thread. The uuid subcommand is the sole exception - it is not thread-aware, and not coupled to the thread-local random state of the other commands.

This random number command overrides the standard TcLX command of the same name and provides a superset of its functionality, in addition to thread-awareness.

Example:
random seed
foreach $r$ [random 16 8] \{...\}
rpc
rpc bynumber servicenumber
rpc byname servicename
Look up RPC services by name or service number. If the service can be found, the result is a list consisting of the service name, the service number, and a list of all name aliases.

This command is supported on Linux/Unix only.

## screen

screen ?-aromatch lenient|normal|strict? ?-frags? ?-hydrogens
ignore|match|mark? ?-mode ligands|smarts? ?-nobondorder? ?-tauto? ehandle patternlist ?exactmatchvar?

Perform fragment-based bit screening on an ensemble object. If the -frags option is not set, he result is a bit vector of the same length as the pattern list, with bits set to zero or one depending on whether a pattern fragment matches or not. If -frags option is set, the return value is a list of the patterns which match, copied verbatim from the pattern list argument.

If the optional exact match variable parameter is given, it is the name of a TcL variable which is set to one if the input ensemble is of exactly the same connectivity (without stereochemistry or isotopes) as one of the pattern fragments. If no pattern is an exact match, it is set to zero.

The expected format of the pattern list depends on the match mode. The default match mode is ligands, which can be explicitly set by supplying the argument to -mode. The other possible match mode is smarts, set by -mode smarts.

In smarts mode, the patterns are normal SMARTS strings. These are cached internally, so if patterns are reused, and the total number of patterns is not too large for the cache, they are not decoded anew for every command invocation.

In ligands mode, a simpler pattern language which is faster to decode and match is used. The patterns are either two element symbols, connected by a bond symbol (- for single bond, = for double, * for triple, \# for quadruple, $\sim$ for aromatic - note that this is different from SMILES!), or an element, followed by a sequence of bracketed ligands, each with a preceding bond symbol. Patterns like these describe one central atom (the first element in the pattern), with one or more ligands. Examples are " $P=O$ " or " $C(-C l)(=O)$ " or " $C(-H)(\sim C)(\sim C)$ ". For internal reasons, all multiple bonds in a pattern must be written before any aromatic bond.

The -aro option controls how aromatic systems in the ensemble are matched. The default is normal, meaning that single and double bonds in SMARTS patterns match aromatic bonds in the ensemble, regardless of their Kekulé bond order, and single bonds in ligands patterns match aromatic ensemble bonds. In strict mode, non-aromatic bonds in the pattern do not match aromatic ensemble bonds. This mode has an effect only for smarts matching, not ligand matching. The aro match mode lenient only has an effect on matching ligand patterns. If not selected, ligand pattern double bonds do not match aromatic ensemble bonds. If the mode is lenient, they do.

If the -tauto flag is set, the matching of both ligand and SMARTS patterns is further modified. In ligands mode, tautomeric ensemble bonds (as per property B_ISTAUTOMERIC) are excluded from any match which requires an exact bond order match. In smarts mode, the matched fragment must be compatible with a tautomeric form with shifted bond orders and relocated hydrogen atoms. This flag is intended to be used to construct a screening bit string for tautomer-tolerant substructure searches. Because less patterns can be positively identified to be matching under these circumstances, these bit strings have generally less bits set, and are therefore less effective filters.

If the -nobondorder flag is set, bond orders of pattern fragments of both types are ignored.
The -hydrogen option controls how patterns with hydrogen atoms are handled. By default, in mode match, they are matched like any other pattern. In mode ignore, patterns with hydrogen never match. This is the mode to use if a screen vector for superstructure search is constructed.

In mode mark, any pattern which contains a hydrogen atom reports a match, and any pattern which does not a mismatch. This mode is intended to be used for construction of bit masks for the removal of any bits from a screen vector which are hydrogen-dependent. This allows for example the re-use of a substructure screen vector for superstructure search.

## tmpdir

tmpdir
This command returns the current directory for temporary files ("/tmp" or „C:/temp" or similar).

## tmpname

tmpname ?prefix? ?directory? ?suffix?
Generate a valid name for a temporary file. The file name prefix as well as suffix may be specified, as well as the directory. If these parameters are omitted, a temporary file in the standard tmp directory and with a file name prefix derived from the application name (obtained via invoking the command infox appname) is generated. If the directory name parameter is empty, the default tmp file directory is used.

Example:

```
tmpname myapp {} .res
```

returns something like /tmp/mya2462.res, dependent on the operating system and local set-up.

```
uncgi
uncgi ?-noreset? cgi_string ?arrayvar? ?notrimfields? ?fieldname default?...
```

This command decodes CGI data, as it is delivered to a CGI application from data input in a WWW form via the Web server. It automatically recognizes the two standard transfer formats application/x-www-form-urlencoded and multipartform-data and adjusts the decoding process accordingly.

The cgi_string input data can be obtained either from the qUERY_STRING environment variable (PUT forms, or direct CGI URLs), or from reading the stdin channel (POST forms). A typical code snippet in case the data submission method is not known is:

```
fconfigure stdin -translation binary
set data [read stdin]
if {$data==""'} { set data $env(QUERY_STRING) }
uncgi $data params
```

The return value of this command is a dictionary with name/value pairs. This dictionary can be read into an array variable by the standard array set TcL command. If the optional arrayvar parameter is used, an array variable of that name is automatically created or reset and filled with the decoded data in the form of array elements.

By default, leading and trailing white space is removed from the decoded data. Fields for which this white space removal should not be performed can be listed as a standard TcL list in the notrimfields parameter. These fields are decoded without any processing.

Note that it is generally advisable to set the stdin input channel to binary mode before reading the CGI data. On Unix, this is likely to be a no-op, but the transfer of binary data on Windows usually does not work at all without this setting.

For security reasons, certain XML/HTML-style tags, including their inner text if they possess it, are automatically removed from the input data. The currently deleted tag list is <embed>, <frame>, <iframe>, <img>, <object>, <script> and <style>. This tag deletion cannot be suppressed.

Data of type multipart/form may transfer additional parameter attributes for the data together with the actual content. In case of file uploads from Web forms, the original client-side file name is captured in an additional result element named by appending "_filename" to the basic data field name. The MIME type of the data, if transmitted, is similarly stored in an extra element with the appended name part "_type".

A single unnamed field in the data string is accepted by the decoder. The data is stored as element unnamed in the decoded result.

In case a field name is occurring more than once in a data string, the additional instances are appended to the first instance as list elements. The final content of the decoded field is then a list of all values found in the input.

If an output variable parameter is used, all existing array elements are removed before decoding starts. In case results should be accumulated, the -noreset option can be used to suppress the variable reset step.

After the parameter listing fields not to be trimmed an arbitrarily long list of pairs of field names and their default values can be specified. If a field name listed there was not present in the input data, it is set in the result list and array variable with the default value following the field name.

Example:
URL: http://www.example.com/cgi-bin/doit.tcl?a=alpha\&b=beta\&b=gamma
The data sent by invoking the CGI script via this direct URL can be decoded in the doit.tcl script with the statement
uncgi \$env(QUERY_STRING) params
An array variable named params is set up, or reset if already present, and it contains exactly two elements: Element $a$ with value "alpha", and element $b$ with value "beta gamma"

## unzip

```
unzip nested_list ?index?
```

Extract a list of indexed elements from a nested list. From each element of the nested input list, the element indicated by the index parameter is selected and appended to the result list. If the index parameter is omitted, the default is zero. If a selected list element does not exist, an empty string is substituted.

Example:
set 12 [unzip $\left\{\left\{\begin{array}{llll}\text { a } & 1\} & \{b & 2\}\end{array}\right\}\right.$ 1]
The 12 variable is set to a list with elements 1 and 2 .
vec
vec subcommand ?args?
This command provides a couple of useful 3D vector manipulation commands. Internally, the vectors are standard TcL list objects, with floating-point element objects, so operations are not blazingly fast but still reasonably effective for routine vector arithmetic. Vectors are not objects, there is nothing to destroy when they are no longer needed. This simple utility command only supports vectors and points of 3 dimensions.

Vectors can be decoded from a variety of string representations. A vector can be made from

- one of the reserved names $x, y, z, x y, x z, y z$ or $x y z$, optionally prefixed by a minus sign. These forms generate a 3D vector of length one pointing into the indicated positive or negative direction.
- By the reserved name origin (or $o$ ). This sets up a $0.0 / 0.0 / 0.0$ origin point.
- A triple of floating point values.

The vector components are directly taken from these numbers. No normalization takes place.

- A pair of floating point values.

The z coordinate is set to zero. The $x / y$ parts are not normalized.

- A single floating point value.

All vector components are initialized to that value. No normalization is performed.
The following subcommands are understood:

```
vec add v1 v2 ?v3...?
vec plus vl v2 ?v3...?
vec + v1 v2 ?v3...?
```

Add two or more vectors. The return value is the vector sum.

```
vec angle v1 v2
vec deg v1 v2
```

Compute the vector angle between $v 1$ and $v 2$ in degrees. See also rad subcommand.

```
vec create arg1 ?arg2 arg3?
```

Generate a vector. If only one argument is given, any of the standard representations is accepted. In case three arguments are provided, they are internally concatenated and this list submitted to the decoding procedure. The command result, if the arguments could be decoded, is the numerical vector representation. In the single-argument form, this command can be bypassed by directly using the vector data as argument to other vector commands.

```
vec dot v1 v2
vec * v1 v2
```

Compute the dot product of the two vectors. The result is a floating point value.

```
vec fitline p1 p2 ?p3...?
```

Fit a line to a set of points. The return value is a line point and the direction vector.

```
vec fitplane p1 p2 p3 ?p4...?
```

Fit a plane to a set of points. The result is returned in Hesse normal form: The closest distance of a plane point to the origin, and the normal vector of the plane.

```
vec len v1
vec len p1 p2 ?p3...?
```

If only a single argument is specified, interpret it as vector and compute its length. In case multiple arguments are used, compute the length of the straight, acyclic path between the points.

```
vec dist p1 p2 ?p3...?
```

Return a list of the distances between point one and two, two and three, and so on. For two arguments, the result is the same as using vec len, but if there are additional points, the individual distances between the waypoints are returned as a list instead of the total length of the path.

```
vec midpoint v1 v2 ?v3...?
vec centroid v1 v2 ?v3...?
```

These command aliases compute the centroid of the points passed as argument. The return value are the centroid point coordinates.

```
vec negate v1
```

Negate the vector. This is equivalent to scaling with minus one.

```
vec normalize v1
vec unit vl
```

Normalize vector to length one. The normalized vector elements are the return value.

```
vec plane v1 v2 ?v3...?
```

Compute a plane (fitted in case more than two vectors are specified) spanned by the specified vectors. The result are two orthogonal plane vectors.

```
vec planenormal p1 p2 p3
```

Get the normal vector of the plane specified by the three points.

```
vec product v1 v2
vec crossproduct v1 v2
vec x v1 v2
```

Compute the vector cross product of the two passed vectors. The return value is the cross product vector. The subcommand may be abbreviated as cross or prod.

```
vec pt_line_dist pt l_anchor l_vec
```

Compute the distance between a point (coordinates in first argument) and a line in 3D space (specified by an anchor point on the line and the direction vector).

```
vec pt_plane_dist pt l_anchor l_vec
```

Compute the distance between a point (coordinates in first argument) and a plane in 3D space (specified by an anchor point on the plane and the plane normal vector).

```
vec rad v1 v2
```

Compute the vector angle between $v 1$ and $v 2$ in radians. See also angle/deg subcommand.

```
vec scale v1 floatval
```

Scale length of vector $v l$ by the specified floating point factor. The return value is the scaled vector.

```
vec subtract v1 v2 ?v3...?
vec minus v1 v2 ?v3...?
vec - v1 v2 ?v3...?
```

Subtract one or more vectors from $v 1$. The return value is the result of the subtraction.
zip
zip list1 ?listn?..
Merge one or more lists. The result is a nested list where each element is a sequence of input list elements at the corresponding position. The size of the largest input list determines the output. If any input lists are shorter than another input list, empty elements are substituted.

Example:
set 1 [zip \{a b c\} \{1 2\}]
The result is a single list , $\left\{\begin{array}{l}\text { a } \\ 1\}\end{array}\right\} \begin{array}{ll}\text { b } & 2\}\end{array}$ \{c $\}\}^{\prime \prime}$
It is possible and sometime useful to use only a single argument list. Here, every element is reformatted so that itself is a proper nested list. Example:
set $1[\operatorname{zip}\{a \quad\{b c\} d\}]$
The result is a list „\{a \{\{bc\}\} d\}" with an extra nesting level to protect the middle element so that it can a reclaimed unchanged by un-zipping with a command like

```
set l0 [unzip $l 0]
```


## Tcl Environment

When a Tcl script is started, the standard set of Tcl and, if running with the Tk widgets support, Tк variables is available in the interpreter.

In addition, the toolkit provides access to internal toolkit status information via the global array variable cactvs. It is automatically present both in the top-level interpreter and in slave and thread interpreters. Many of the elements in the array may be modified by script commands. If they are manipulated this way, their effects are immediate, but not persistent, and visible in all interpreters.

In case the current application includes a Python interpreter, it contains an equivalent global dictionary. Changes made in any language to the control variable are visible in the other.

Parameter changes are forgotten the next time the interpreter is executed.

- cactvs(application)

Short application name.

- cactvs(application_long_name)

Long name of application.

- cactvs(application_mode)

A code for the type of application context the Tcl interpreter is operating in. Possible values are 0 (undefined), 1 (simple standalone executable), 2 (executable running encapsulated TcL script), 3 (full interactive interpreter), 4 (restricted interactive interpreter), 5 (full interpreter running command script), 6 (restricted interpreter running command script), 7 (link library for 3rd party application), 8 (TcL module for 3rd party TcL interpreter), 9 (TcL module for TcL Web browser plug-in), 10 (Python module with secondary Tcl partner interpreter for 3rd party Рчтно~ interpreter) or 11 (database UDF module).

- cactvs(aromaticity_model)

The aromaticity model to use. Possible values are cactvs (the default), daylight (which has some nasty problems, but using it will improve compatibility of the results of smarts matching with Daylight software, and tripos, for a really weird and not very useful system.

- cactvs(async_computation_receiver_port)

Port number used for asynchronous networked property computation requests.

- cactvs(auto_vector_extension)

A boolean flag which controls the behavior of the toolkit when individual elements of vector property data are set with an element index that is larger than the current size of the vector. By default, only existing vector indices ( 0 to $\$$ size-1) and the new element just beyond current vector size ( $\$$ size) may be used. If the flag is set, any vector index may be addressed. Missing vector elements between the newly set element and the current vector size are filled with default values.

- cactvs(auxdatapath)

Search path for auxiliary data files required by computational modules.

- cactvs(base_os)

The operating system core version, i.e. something like Linux 2.6 or Linux3.11 for Linux distributions. This is a read-only string.

- cactvs(bmp_support)

Boolean flag indicating whether this toolkit version support image generation in various legacy Windows bitmap formats.

- cactvs(build_date)

The date this executable was built, in seconds since 1970, suitable for use with clock
format command.

- cactvs(bunzip2_program)

The fully resolved path name of the bunzip2 program used for I/O of bz2-compressed files.

- cactvs(byte_order)

A read-only element informing about the byte order of the current platform. It is set to to either littleendian or bigendian.

- cactvs(cache_lifetime)

Cactvs maintains a cache in the user's home directory to cache files obtained from databases and Internet URLs. This parameter defines the lifetime of objects in the cache in seconds. Older objects are searched again in the standard search path.

- cactvs(captcha_image_file)

The name of the file with last Сартсна image received as result of an attempt to contact an Internet service. This can happen for example when up- or downloading a Google Docs spreadsheet table file. If no such file exists, the element is an empty string. The file is also deleted and the variable is reset when a decoded Сартсна was successfully used for log-in.

- cactvs(captcha_string)

The decoded contents of the Captcha image file above. Its contents are used when attempting to access protected Internet sites. This variable must be set with user interaction. By default, it is a null string.

- cactvs(captcha_token)

The access token associated with the Сартсна image file and decoded string. This is used as credential for Internet service log-ins. The variable is typically set together with the САРтсна image file when a service requires additional authentication. Scripts would then present the image, get the user to decode it, store the decoded string in the cactvs (captcha_string) variable and then attempt another log-in. Modules which support САРтсна log-ins automatically read and set the САРтсна variables in the course of their operation.

- cactvs(cmdxpath)

Search path for Tcl command extension modules. The standard Tcl package path is automatically added to this search path. The main difference between a CActvs Tcl expansion and a standard TCL package is the presence of a descriptor structure with metadata. Cactvs Tcl extensions may be loaded as normal TcL packages, but then do not provide access to the module description data via the $\mathbf{c m d x}$ command.

- cactvs(color_support)

A read-only boolean flag indicating if the decoding of named colors is supported, either by access to a local X11 color names database or by a compiled-in database.

- cactvs(compatible)

Regular expression used to match compatible OS variants for dynamically loading modules.

- cactvs(compress_support)

A read-only boolean flag indicating that the processing of compressed data is supported.
This includes zlib and gzip compression and on most platforms bzip2. Internally, some data file formats use the lzo compression format.

- cactvs(connect_timeout)

The maximum number of seconds to wait and, if necessary, retry after a short break in the process of establishing a socket connection. If set to zero, only a single connection attempt is made. Setting it to a negative value configures an unlimited number of connection attempts - but then a command trying to connect to a dead service never returns.

- cactvs(cpu_limit)

A read-only variable describing any hard CPU execution time limits set for the interpreter. If the value is -1 , which is the default, no limits have been set. Setting a CPU limit is only supported for specific interpreters on certain platforms (for example, tclcactvs on Linux), and limits must be set at start-up (option -C for tclcactvs).

- cactvs(crypt_support)

A read-only boolean flag indicating whether the application support encryption by the crypt (and other) algorithms.

- cactvs(currency_converter_host)

The default currency exchange rate host. If set to an empty string, Internet-based currency conversion is disabled. Conversion is automatically run if a monetary value is requested in a different currency from the one the data is stored in, and the exchange rate has not yet been cached, Example:
ens set \$eh E_PRICE "100.50 EUR"
ens get \$eh E_PRICE (USD)

- cactvs(data_directory)

The name of the installation directory which contains script libraries, filters, bitmaps, help files and other auxiliary files needed for the proper operation of the toolkit. The stand-alone interpreter csweb (and its variants) are the only toolkit applications which do not access this resource.

- cactvs(database_file_key)

An integer indicating that for access to data files a suitable file key must be present. The default value is zero, meaning that no such key is needed. This is only used in very special circumstances when a Cactvs library was built to allow operation only on specifically named files.

- cactvs(database_log_file)

The name of a file to write logging information for database accesses to.

- cactvs(database_log_mode)

An boolean value indicating the current log mode. Disabled logging is represented by value 0 .

- cactvs(databasepath)

Search path for database connector modules.

- cactvs(dataset_count)

The current number of dataset objects. Note that not all datasets necessarily have TcL handles, so there may be a discrepancy between this value and the result list length of the dataset list command.

- cactvs(dataset_swap_threshold)

Maximum size of datasets before disk swapping of contained objects is automatically performed. The default value is 10000 . A negative value disables automatic disk swapping.

- cactvs(datatool_program)

The name or, if not found in a standard location, fully specified path of the NCBI datatool program. This program is needed to process PubChem ASN. 1 data in text format. For binary ASN. 1 data, this program is not used.

- cactvs(db_support)

A read-only boolean flag indicating whether this interpreter supports database access functions and loadable database client modules (dbase and dbx TcL commands).

- cactvs(default_currency)

The default currency, which is implicitly assumed when dealing with currency data without an explicit currency indicator. The string should be set to the standard international trade name of the selected currency (i.e. EUR, USD, JPY) though a couple of colloquial names are also recognized (Euro, US\$, Yen). In any case, a maximum of four characters are significant.

- cactvs(default_database)

Name of the default database. These default values are used to initialize $d b x$ database interface objects and do not directly influence operation.

- cactvs(default_database_host)

Default database host.

- cactvs(default_database_options)

Default database options to use in the connection string. The format is database-dependent.

- cactvs(default_database_password)

Default database access password.

- cactvs(default_database_type)

Type of the default database (mysql, oracle, etc.).

- cactvs(default_database_user)

Default database user.

- cactvs(default_hydrogen_addition_mode)

The default hydrogen processing mode for file objects. Possible values are asis, add, strip, stripall, and addblind. More information can be found in the documentation of the molfile set command in the section describing the hydrogens attribute.

- cactvs(default_reaction_screen_property)

The default property to use for reaction query screening. This is typically $x_{-}$SCREEN.

- cactvs(default_similarity_property)

The default property to use for similarity queries. This is typically e_SCREEN.

- cactvs(default_substructure_screen_property)

The default property to use for substructure query screening. This is typically either E_SCREEN or E_QUERY_SCREEN.

- cactvs(default_superstructure_screen_property)

The default property to use for superstructure query screening. This is typically either
E_NO_HYDROGEN_SCREEN Or E_NO_HYDROGEN_QUERY_SCREEN.

- cactvs(dependency_warning)

If set, warn about property dependencies detected when parsing a property definition which involves dependent properties which are not yet known. Having such dependencies is not illegal, and the dependencies are updated at a later time when the unresolved, referred property has been set up. However, in case these properties are never read, dangling dependencies are never resolved and ignored, and this may indicate a programming error.

- cactvs(distribution)

The platform this package was compiled for, including distribution information. Example: Linux2.6-SuSE10.2-64. This element is read-only.

- cactvs(do_database_lookup)

If set, look-up of extension modules in databases is enabled.

- cactvs(do_signals)

If set (which is the default), untrusted or flaky property computation modules may be executed with a set of signal handlers in place, which try to recover from segmentation fault errors and other signals. Recovery is not guaranteed to work if the module corrupted working memory. The signal handler overhead is not insignificant, and properties should be configured to rely on installed signal handlers only if required, and where the problem is not fixable, for example because the source code is not available.

- cactvs(do_timeouts)

If set, allow time-outs in property computations to occur. This flag is on by default.

- cactvs(download_package)

The name of the package as downloaded from the Xemistrry web site. This is usually a name constructed following the pattern cactvstools-\$(distribution)-\$(version)\$(licensee).tar.gz, where the dollar parts are substituted by the distribution and version information. Academic packages do not have the licensee part.

- cactvs(download_url)

The address of the directory page for the download area this packages originates from. For academic packages, this is usually http://www.xemistry.com/academic.

- cactvs(dynamic_loader_mode)

If this flag is to a positive value (it is set by default), the toolkit allows the loading of dynamic extension modules of all supported classes if not prohibited by class-specific flags. Specifically, a value of one allows loading of modules found in the trusted path, a value of two loading from both the standard and trusted path, with the trusted path having preference, and a value of three again loading from both paths, but the the standard path having preference.

- cactvs(element_sequence)

A list of the numbers of the elements of the periodic system in standard formula sequence ( $6=$ carbon, $1=$ hydrogen, $0=$ pseudo-atoms, $89=$ Actinium, and so forth).

- cactvs(ens_count)

The current number of ensemble objects. Note that not all ensembles necessarily have TcL handles, so there may be a discrepancy between this value and the result list length of the ens list command.

- cactvs(eol)

The platform-dependent default end-of-line character(s).

- cactvs(eutilshost)

The name of the host with the NCBI Eutils suite of Entrez database access services. If set to an empty string, Entrez access is disabled. Setting it to a different host is only useful if you run an Entrez clone in-house. The default is eutils.ncbi.nlm.nih.gov.

- cactvs(executable_type)

The platform model the executable was compiled for. It is either 32 or 64 bits. This information is read-only.

- cactvs(executablepath)

Search path for executable programs, such as compressors and decompressors.

- cactvs(explicit_stereo_h)

A global formatting flag used by various property computation routines and file I/O modules which indicates preference to retain hydrogens at stereo centers for maximum interpretation reliability, or whether to strip them and to rely on the proper re-attachment by a reader or decoder. By default this flag is set, i.e. stereo hydrogen is preferentially retained.

- cactvs(expr_support)

A read-only boolean flag which indicates whether the application supports SQL-style expressions on data attached to objects, for example via the expr object commands.

- cactvs(extension_support)

A read-only boolean flag which indicates whether this interpreter is capable of loading extension modules, for example file I/O format handlers or datatype handler modules.

- cactvs(extra_format_flags)

A list of the names of extra formatting bits which should be used for property data formatting in the interpreter. By default this is an empty list.

- cactvs(fcgi_redirect)

This read-only boolean variable is an indicator on whether the stdout, stderr and stdin standard I/O channels have been redirected to the corresponding FCGI channels. To activate or cancel redirection, use the fcgi TcL command, which is available in some interpreter versions (tclcactvs, csweb).

- cactvs(fcgi_support)

A read-only boolean flag indicating whether this application was compiled with FCGI (fast CGI) support. This flag informs about the availability of the fcgi script command as well as the ability of various output mechanisms to directly stream into an FCGI channel, or a standard channel redirected into a FCGI channel.

- cactvs(filexpath)

The search path for structure file I/O module extensions

- cactvs(filterpath)

The search path for filter definitions.

- cactus(fontpath)

The search path for TrueType fonts used by several imaging modules.

- cactvs(full_smarts_support)

A read-only boolean flag indicating whether this interpreter was compiled with a full SMARTS parser. SMILES and some basic SMARTS (essentially the flat match attribute level as found in query Molfiles) can be processed even if this capability was not added.

- cactus(gdbm_support)

A read-only boolean flag indicating whether this interpreter was compiled with GDBM $\mathrm{key} / \mathrm{value}$ store support.

- cactvs(gunzip_program)

The fully resolved path name of the gunzip program used for I/O of gzip-compressed files. An external decoder is only forked if the file is a simple file, and might contain formatting features which cannot be resolved by the simple zlib-based internal program emulation.

- cactvs(gzip_program)

The fully resolved path name of the $g z i p$ program used for I/O of $g z i p$-compressed files. An external decoder is only forked if the file is a simple file, and might contain formatting features which cannot be resolved by the simple zlib-based internal program emulation.

- cactus(host)

The name of the computer the interpreter is running on. Read only.

- cactvs(host_domain)

Domain name of the host, if identifiable.

- cactvs(host_ip)

The IP address of the computer the interpreter is running on. Read-only. Depending on the number of network interfaces detected, additional read-only entries named host_ip2 etc. may be present.

- cactvs(iconv_program)

The fully resolved path name of the iconv program used for I/O of files encoded in UCS-2 and other non-ASCII encodings of text data.

- cactvs(inchi_support)

A read-only boolean flag indicating whether this interpreter supports operations with InChI strings, including decoding of such strings in the ens create command, computing the E_INCHI, E_STDINCHI, E_INCHIKEY and E_STDINCHIKEY properties, and I/O support for InChI files with or without auxiliary data.

- cactvs(internet_lookup_level)

This element controls the extent to which Internet-based operations can be implicitly executed. If set to level 0, no external Internet communication takes place. Level one enables the use of Internet services in computational modules and file I/O modules. They are still subject to fine-grained control from the settings of the host control variables and the structure security flag. Level 2 additionally enables the lookup of property definitions and extension modules in Internet repositories named in the search paths. The default Internet lookup level is one.

- cactvs(internet_support)

A read-only boolean flag informing whether this interpreter was compiled with support for accessing Internet resources, for example via URLs or SOAP messages.

- cactvs(interrupted)

A flag set when an interrupt (user pressing ctrl-c, time-out of operation with time limit) occurred. Commands which can be interrupted, or have a time-out, reset the variable to 0 when the command execution begins. Examples: The molfile scan and ens transform commands. Note that this variable is global, so when multiple script threads are run, this value may be unreliable.

- cactvs(io_support)

A read-only boolean flag indicating whether this interpreter supports file-based chemistry data I/O. This flag is only unset in a few specialized link libraries where chemistry data is directly stored in the internal data structures by a third-party application program.

- cactvs(is_slave)

A read-only boolean flag indicating whether this interpreter is a slave interpreter (for example, a property computation interpreter for scripted properties) or not. Thread main interpreters are not slaves.

- cactvs(itcl_support)

A read-only boolean flag indicating whether the ITCL TCL object-oriented programming extension commands are available in this interpreter as a compiled-in component. If not, the Itcl module may still be loaded with standard TcL load or package commands.

- cactvs(java_class_path)

The Java VM class path, if this is an executable which also has a Java VM compiled in.

- cactvs(json_support)

A read-only boolean flag indicating whether the application was compiled with an integrated JSON parser. This flag informs about the availability of the json script command, and support for various json-based encoding and decoding schemes, for example for table data I/O.

- cactvs(keyxpath)

The database key extension module search path.

- cactvs(knime_input1_table)

This read-only variable only exists if the interpreter is linked to a KNIME node. It contains the handle of the table associated with the first output port of the KNIME node, or an empty string if no such port exists. The table has been automatically set up and configured.

- cactvs(knime_input2_table)

This read-only variable only exists if the interpreter is linked to a KNIME node. It contains the handle of the table associated with the second output port of the KNIME node, or an empty string if no such port exists. The table has been automatically set up and configured.

- cactvs(knime_input3_table)

This read-only variable only exists if the interpreter is linked to a KNIME node. It contains the handle of the table associated with the third input port of the KNIME node, or an empty string if no such port exists. The table has been automatically set up and configured.

- cactvs(knime_output1_table)

This read-only variable only exists if the interpreter is linked to a KNIME node. It contains the handle of the table associated with the first output port of the KNIME node, or an empty string if no such port exists. The table has been automatically set up and configured.

- cactvs(knime_output2_table)

This read-only variable only exists if the interpreter is linked to a KNIME node. It contains the handle of the table associated with the second input port of the KNIME node, or an empty string if no such port exists. The table has been automatically set up and configured.

- cactvs(knime_output3_table)

This read-only variable only exists if the interpreter is linked to a KNIME node. It contains the handle of the table associated with the third input port of the KNIME node, or an empty string if no such port exists. The table has been automatically set up and configured.

- cactvs(knime_interface_mode)

This read-only variable only exists if the interpreter is linked to a KNIME node. It contains a string describing the node connectivity. Examples are inputl (one input port, no output ports), output2 (two output ports, no inputs), bridgel1 (one input, one output), bridge12, (one input, two outputs) etc.

- cactvs(largefile_support)

A read-only boolean flag indicating if this version of the library supports 64-bit file operations. There are probably no platforms that are still supported which do not allow operations on files with more then 4 GB .

- cactvs(lhasa_support)

A read-only boolean flag indicating that the interpreter supports the lhasa object which understands Lhasa reaction transforms and the parsing of Patran and Chmitrn data.

- cactvs(library_directory)

The path of the directory where the bundled link libraries for this installation are stored. For stand-alone applications, this element is empty.

- cactvs(license_comment)

Comments regarding the license. Read only.

- cactvs(license_developer)

Developer of an application. Read only.

- cactvs(license_hostname)

Name of licensed host, empty if not set. Read-only.

- cactvs(license_hostid)

Host-ID of licensed host, 0 if not set. More elements license_hostid 2 to license_hostid10 are present if multiple host IDs are covered by a license. Since academic packages are not bound to host IDs, this array element is not present in such packages. If present, this is a read-only element.

- cactvs(license_ip)

IP-address for licensed host, 0 if not set. More fields license_ip 2 to license_ip10 are provided if multiple IP addressed are covered by a license. Since academic packages are not bound to IP addresses, this array element is not present in such packages. If present, this is a read-only element.

- cactvs(license_maxversion)

Maximal toolkit version covered by license. 0 if not set.

- cactvs(license_minversion)

Minimal toolkit version covered by license. 0 if not set.

- cactvs(license_netmask)

Network mask for license. 0 if not set. Read only.

- cactvs(license_network)

Network address for license. 0 if not set. Read only.

- cactvs(license_serial)

Serial number of license. 0 if not set. Read only.

- cactvs(license_support)

A read-only boolean flag indicating whether this interpreter support license handling.

- cactvs(license_timeout)

Time-out date for license in standard Unix notation (seconds since 1970). 0 for permanent licenses. Read only. Use the clock format command to convert it into a readable representation.

- cactvs(license_type)

License type (commercial, academic, government, evaluation). Read only.

- cactvs(license_user)

Licensed host account user name, not present if not set. More elements license_user 2 to license_user 10 are present if multiple user names are covered by a license. Since academic packages are not bound to users, this array element is not present in such packages. If present, this is a read-only element.

- cactvs(licensee)

Licensee of the basic toolkit. Read only. This is a free-form string, not a host account name (see above).

- cactvs(licensor)

Licensor name. Read only.

- cactvs(lookuphosts)

A list of the names of the hosts used for lookup operations (such as chemical name and CAS number resolution in the ens create command). The default host list is cactus.nci.nih.gov (NCI resolver) and opsin.ch.cam.ac.uk (systematic name resolver). www.genome.jp (KEGG) and chemspider.com are also supported as an additional resolvers and can be added or replaced if desired.

If this array element is set to an empty string, compound name lookup/resolution is disabled. Operations involving contacting the name lookup hosts are not controlled by the
: :cactvs (structure_security) variable setting, because no connection tables are transmitted.

It is possible to attach a directory/file part to the host name for the NCI resolver. If a lookup host is specified in this fashion, the default path (/chemical/structure) is overridden. This feature allows access to experimental releases of this service.

- cactvs(lookupmode)

This array element can be used to fine-tune the operation of the NCI resolver. By default, this element is unset, and the default resolver mode is selected when the resolver host is contacted. One useful supported value is name pattern, which invokes substring name search on the resolver.

- cactvs(lzo_support)

A read-only boolean flag indicating whether the interpreter supports the Lzo compression/decompression scheme. This method can for example be used in Minimol compression, resulting in a somewhat faster decompression compared to standard ZLIB.

- cactvs(malloc_bytes)

Total count of allocated bytes. Only updated when memory debugging is active.

- cactvs(malloc_count)

Count of memory allocation operations. Only updated when memory debugging is active.

- cactvs(malloc_free)

Count of memory release operations. Only updated when memory debugging is active.

- cactvs(malloc_total)

Currently allocated memory byte count. Only updated when memory debugging is active, and only valid on Windows (where you can obtain the original allocation size of a memory block from its address).

- cactvs(max_threads)

The maximum number of threads which can concurrently use the library. Both TcL interpreter threads and threads without an interpreter are counted. This is a read-only value.

- cactvs(maximum_ring_count)

The maximum number of rings allowed in an ensemble. This value is primarily intended to act as a safeguard against the processing of structures with insane numbers of rings, as it can happen while decoding overlapping 3D structures, and not as a principal limitation of the toolkit. The default value of 1000 is certainly sufficient even for large proteins.

- cactvs(maximum_stereo_distance)

The maximum number of bonds traversed to check stereogenicity, and, indirectly, compute various stereo descriptors. Ligands which differ only beyond this bond distance are not considered different for the purpose of stereo handling. The default value is 22, which corresponds to the maximum required value to handle all entries in the FDA registry.

- cactvs(memory_limit)

A read-only variable indicating any hard memory limits which have been set for the application. In case this value is -1 , no limits are set, which is the default. Memory limits can only be set for certain interpreter versions (for example, tclcactvs on Linux), and only on start-up (option -M for tclcactvs).

- cactvs(minimol_support)

A read-only boolean flag which indicates whether this interpreter has support for Minimols.

- cactvs(mmap_buffer_size)

The maximum length of the memory map buffer for field-based file I/O, in bytes. This attribute affects only a few file formats which can utilized large memory buffers, most notably the $c b s$ search file format. If the data size of a field exceeds this limit, the data are read by means of traditional file I/O and not consume system memory resources.

- cactvs(mmap_high_threshold)

Maximum size of files which should use memory mapping for accelerated reading. Note that this limited applies only to full file mapping - file formats with direct access query fields will still map those fields for accelerated access.

- cactvs(mmap_low_threshold)

Minimum size of files read via memory mapping for accelerated reading.

- cactvs(molecule_bond_set)

A bit set of those bond types which contribute to grouping atoms into molecules. The default set consists of the bond types normal, complex, and 3center.

- cactvs(molfile_count)

The number of currently active molfile object handles. Note that not all structure file access objects necessarily have TcL handles, so there may be a discrepancy between this value and the result list length of the molfile list command.

- cactvs(multithreaded)

A read-only boolean flag indicating whether this interpreter supports multi-threaded scripts. This is not equivalent to the thread_support flag. The latter is a prerequisite and indicates that the core library supports multiple threads.

- cactvs(namespace)

The local URN namespace, which is for example used during property look-up. By default, it is set to .local.

- cactvs(namespacepath)

The namespace resolution path.

- cactvs(network_count)

The current number of network objects. Note that not all networks necessarily have TcL handles, so there may be a discrepancy between this value and the result list length of the network list command.

- cactvs(network_support)

A read-only boolean flag indicating whether this application was compiled with support for the network object, including its vertex and connection minor objects, plus the associated script commands of the same name.

- cactvs(no_file_extensions)

If set to 1 , no file format extensions are loaded, even if they are listed in the local system configuration file for automatic loading. Also, automatic look-up for extension modules on file suffixes is blocked.

- cactvs(no_proxy_hosts)

A comma-separated list of host names which should be contacted directly, not via the proxy host. This variable is only used if a proxy has been configured. The default is an empty list.

- cactvs(no_rpc)

If this flag is set, RPC communication with other CACTvs applications is disabled. Since the Windows port currently does not support RPC inter-process communication, this flag has no effect on that platform.

- cactvs(objectpath)

Search path for compiled objects used by property computation modules, including dynamic shared objects, OSX bundles or Windows DLLs.

- cactvs(ocrhost)

The host to use when performing chemical structure drawing OCR, for example when reading GIF or PNG files as chemical structure files where these image do not possess hidden embedded structure data. The default host cactvs.nci.nih.gov runs the OSRA service.

- cactvs(online)

Flag indicating whether the local host has Internet access. Automatically updated.

- cactvs(openphacts_id)

The application ID for accessing OpenPhacts data.

- cactvs(openphacts_key)

The key for accessing OpenPhacts data.

- cactvs(os)

The name of the operating system the interpreter is running on, in the full nomenclature used also to name the toolkit packages, i.e. with the name of the operating system distribution. Read only.

- cactvs(osra_program)

The name or full path of a local installation of the OsRa chemical OCR program. If it is found, it is used in preference to the Web service, which is advantageous in case of confidential data.

- cactvs(paper_size)

The default paper size. Usually set to $A 4$, or Letter, but the standard range of DIN and US sizes is recognized.

- cactvs(persistent_bond_set)

Bit set of bonds which are persistent, meaning that they are not completely discarded when the structure changes. The default set consists of the bond types normal, complex, 3center, search_not, and rgroup.

- cactvs(platform)

Platform information - unix, mac or windows.

- cactvs(private_attributes)

A modifyable value which determines whether Рутном wrapper objects of core toolkit objects may store additional private attributes, in addition to the standard toolkit-implemented attributes. By default this flag is unset to catch errors in the naming of attributes. If set, any attribute that is not a standard attribute is stored in a private object dictionary, without rasing an error.

- cactvs(processor_count)

The number of processor cores seen by the interpreter. There is no distinction between multi-core and multi-die processors. This attribute is read-only.

- cactvs(property_definition_count)

The number of properties currently registered in the core. This attribute is read-only.

- cactvs(property_lock)

If set, properties cannot be deleted from the internal property database, and many operations changing the character of a property are also disabled. This is normally only used in multi-threaded scripts where locking the property database can give a significant speed boost because it eliminates the need to look and unlock individual property definitions.

- cactvs(propertypath)

The search path for property definitions.

- cactvs(proxy_host)

The name of a proxy server which is used as an indirect Internet access gateway. All standard Internet-access operations will automatically reroute requests via this proxy, if a proxy host is set. If the string is empty, which is the default, direct Internet access without a proxy is used.

- cactvs(proxy password)

A password which is supplied to the Internet proxy server, if one has been configured.

- cactvs(proxy_user)

The username to supply to the Internet proxy server, if one has been configured.

- cactvs(pubchemhost)

The host name which is used for PubChem-related data retrieval via the PUG interface, or screen scraping of certain information pages. The default is pubchem.ncbi.nlm.nih.gov.

- cactvs(python_error_nessage

The last error message generated by a Python interpreter. If the current application does not contain an embedded Python interpreter, this is always an empty string.

- cactvs(python_support)

A boolean read-only flag indicating whether a parallel Рүтном interpreter is available in this application, which can be accessed with the python command, or indirectly by using properties with computation functions written in PYthon.

- cactvs(qlz_support)

A read-only boolean read-only attribute indicating whether the object swap system uses the faster QLZ compressor instead of slower zuIB compression.

- cactvs(reaction_count)

The current number of reaction objects. Note that not all reactions necessarily have TcL handles, so there may be a discrepancy between this value and the result list length of the reaction list command.

- cactvs(release_date)

Release date of the toolkit, in standard Unix format as seconds since 1970, intended for use with the clock format command. Read only.

- cactvs(repository_support)

A read-only boolean flag indicating whether this interpreter supports repository objects.

- cactvs(repxpath)

The alternate representation module search path

- cactvs(ring_bond_set)

Bit set of bond types which define rings in structures. The default set consists of the bond types normal, complex, and 3center.

- cactvs(ringset)

The type of ring set computed by default.

- cactvs(rpc_id)

ID of RPC communication protocol between Cactvs processes.

- cactvs(rpc_support)

A read-only boolean flag indicating whether this application was compiled with support for RPC-based socket-facilitated data exchange between CaCtvs applications, for example remote property calculations. This flag only informs about that specific data exchange mechanism. The availability of other socket-based mechanisms (remote datasets, remote query processing, table row data transfer, file access via URLs, etc.) are not covered.

- cactvs(rpc_version)

Version of RPC communication protocol.

- cactvs(script)

The read-only name of the currently executed application script. Empty if no script is run. Depending on the main interpreter type, this is either a Tcl or a Python script.

- cactvs(script_url)

If the script interpreter executes a script obtained by Internet access via an URL, the URL is listed here. Read only.

- cactvs(secondary_script)

The read-only name of the secondary application script, i.e. the helper Python script when running a main Tcl script, or the helper Tcl script when running a main Python interpreter. If no such string is used, this is an empty value.

- cactvs(setsize_exceeded)

Flag indicating that a command which allows the specification of a maximum number of result objects has exceeded this number. Commands which can be controlled in this manner reset the variable to 0 when the command execution begins. Example: The ens transform command. This is a global element and may be unreliable in case multiple script threads are used.

- cactvs(smiles_version)

The version of SMILES/SMARTS to use. Currently, it can be set to 4.9 or 4.3 (or any value below 4.9). The difference is that in version 4.9 the $x$ atom attribute is interpreted according to the newly introduced Daylight definition (number of ring bonds), while before that this letter was unused and interpreted as an Cactvs extension (number of heteroatom ligands). In 4.9 mode, the former $x$ extension is now accessed via the letter $z$. The default is 4.9 , i.e. full support of the most current Daylight definition.

- cactvs(smtp_host)

The default mail host to use when sending email with the mail command.

- cactvs(smtp_password)

The password to use when connecting to above mail host.

- cactvs(smtp_port)

The port to use to connect to the mail host. The default is 587 , the newer recommended value both for smtp and smpts transfers. Some mail host may require other ports, such as the old standard 25 , or the alternative port 465 for direct smpts without negotiation.

- cactvs(smtp_user)

The user ID to use when connecting to above mail host.

- cactvs(soap_method)

Name of default method called via SOAP request.

- cactvs(soap_schema)

Default SOAP communication schema name.

- cactvs(soap_uri)

Default URI associated with SOAP communication schema.

- cactvs(source_lookup)

If this boolean flag is set, the system will attempts to retrieve source code of modules obtained via Internet connections.

- cactvs(sourcepath)

The search path for source code for extension modules.

- cactvs(standalone)

A read-only boolean flag which is set for applications which encapsulate an application script and an interpreter into a single, stand-alone executable.

- cactvs(stationpath)

The directory path where to look for auto-loaded station definition files.

- cactvs(strict_smarts)

If set, SMARTS specifications are interpreted according to strict Daylight specs. The default interpretation is more lenient, for example the aliphatic attribute of upper-case element symbols is not enforced to avoid the need for lengthy aromatic/aliphatic alternative symbols or \# notation. Even without this flag, there are various methods to decode a substructure specification according to strict Daylight rules, for example by appending a ! character to the SMARTS string, or using appropriate decoder flags in ens create or molfile read commands. This option only applies to newly decoded SMARTS substructures.
Substructures read from files such as cbin/cbase/bdb which encode the internal object structure of the toolkit already contain the interpretation implicitly and persistently as part of the atom and bond attribute set.

- cactvs(structure_security)

If this boolean flag is set, no structure or reaction information is sent over Internet connections as a decodable connection table. It is off by default for academic distributions, but on for commercial packages.

If it is on, Internet lookup is still allowed by means of sending identifiers which are likely to be non-confidential (for example, CAS numbers, or PubChem CIDs and SIDs) or which cannot be reversed (Састvs hash codes). However, implicit sending of the structure as connection table to Internet services which provide computation or identifier lookup is suppressed if the flag is on. For example, computation of property E_CID for the PubChem identifier by means of contacting the PubChem database then always fails, regardless whether the structure has a CID or not, because that operation would require a potentially confidential structure to be sent as decodable InChI string to that database.

This flag can be changed by developers who know what they are doing. Also, direct scripting of any type of Internet access is possible regardless of the flag setting. This flag is a basic safeguard against unintentional data leakage.

- cactvs(swap_count)

The number of objects which are currently swapped out (see ens swapout, reaction swapout commands). This element is read-only.

- cactvs(swap_directory)

The name of a directory to use for ensemble and reaction swapping. By default it is initially an empty string, which is replaced by an automatically created process-specific subdirectory of the system temp directory once the swap subsystem has been initialized.

If this element is set to the name of an existing, writable directory before the first swap operation commences, that directory will be used instead. Changing the control variable value after the first object has been swapped has no effect. An automatically set up swap directory is deleted upon program shutdown. In a user swap directory, only the swap files are removed when the program exits.

- cactus(swap_store_type)

Select the type of object store used to swap out excessive numbers of ensemble and reaction objects (see for example the swapthreshold dataset object attribute). The default store is $g d b m$ (simple key/value store), but it may also be set to none (use separate native Cactvs binary files) or tokyocabinet (advanced key/value store). The tokyocabinet store is not supported on Windows. Setting this attribute has only an effect before the first object is swapped out. If a method is set which is not supported, the best available method is automatically selected when the first object is swapped out, and the array variable element updated to the actually employed method.

- cactvs(swap_support)

A read-only boolean flag indicating whether this interpreter supports the swapping of objects to a disk store.

- cactvs(system_error_code)

The error code of the last Cactvs library error of the current thread. Custom errors, for example raised by modules which use a custom message and not the standard message table have an error code of minus one. This is a read-only element, and thread-local.

- cactvs(system_error_message)

The last raw CACTvs library error message of the current thread, without any formatting for the TcL interpreter. Most library messages also generate a Tcl error message, but there are many error messages in the toolkit related, for example, to command syntax problems which are part of the scripting layer and not handled by the core library. Such errors do not change the library message. This is a read-only element, and thread-local.

- cactvs(table_count)

The current number of table objects in the application. Note that not all tables necessarily have TcL handles, so there may be a discrepancy between this value and the result list length of the table list command.

- cactvs(table_support)

A read-only boolean flag indicating whether this application was compiled with support for the chemistry-aware table object, and the associated table and tablex commands.

- cactvs(table_swap_threshold)

Maximum size of datasets embedded in tables before disk swapping of contained objects is automatically performed. The default value is 10000 . A negative value disables automatic disk swapping. This object-specific control value overrides the generic dataset object swap threshold in cactvs (dataset_swap_threshdold).

- cactvs(tablexpath)

The search path for table I/O module extensions

- cactvs(tcl_error_message)

The last Tcl error message generated by the interpreter. This is a read-only element, and thread-local.

- cactvs(tcl_support)

A read-only boolean flag indicating whether this interpreter support TcL as scripting language. If seen from the TcL side, this is obviously always true, but there may be Рчтнon-only interpreters where this flag is not set.

- cactvs(testdatapath)

The search path for test data associated with extension modules for self-tests.

- cactvs(test_interpreter)

The name of a TcL slave interpreter which has been set up for regression testing. Usually an empty string and not used in user applications.

- cactvs(thread_count)

The current number of threads registered with the core library. This value cannot exceed the upper limit compiled into the toolkit, which can be learned from : : cactvs (max_threads).

- cactvs(thread_support)

A read-only boolean flag indicating whether the core library supports multiple threads. This is not equivalent tot he multithreaded flag, which indicates that multi-threaded TcL script interpreters are supported. There are configurations which do not allow multiple parallel scripts, but support implicit multi-threading on operations such as file scanning from a single Tcl interpreter.

- cactvs(timezone)

The current time zone in minutes west of GMT. This is used when setting up and storing time/date values. If the system clock is on GMT time, the value is always zero.

- cactvs(tk_support)

A read-only boolean flag indicating whether this interpreter supports the $\mathrm{Tk}_{\mathrm{k}}$ graphical toolkit as a compiled-in module. If not set, it is still possible to load Tk as dynamic module with the standard load or package TcL commands.

- cactvs(tmpdir)

The name of the directory for temporary files. This path can be changed if desired. By default it is the standard system temp directory.

- cactvs(tokyocabinet_support)

A read-only boolean attribute indicating support of the Tokyo Cabinet key/value store. It this is available, the default object swap store is a Tokyo Cabinet file (instead of $g d b m$ or separate native binary object serialization files), and the tc TcL command extension module is present. Currently, the Windows version of the Cactvs suite does not support Tokyo Cabinet.

- cactvs(trace)

A bit combination of flags to trace various subsystems. Symbolic names for the subsystems are translated into the proper bit. Example:

```
set cactvs(trace) ss
```

traces substructure matching.

- cactvs(tre_support)

A read-only boolean flag indicating whether this interpreter supports extended regular expressions, and approximate regular expressions by means of the Tre library. If it is not set, only standard PCRE/PERL regular expressions are supported.

- cactvs(trusted_executable_directory)

The name of a directory which contain only trusted executables which may be invoked by the toolkit. Usually, this is the installation directory for executables bundled with the toolkit.

- cactvs(trusted_objectpath)

A search path for trusted shared libraries, OSX bundles and Windows DLLs implementing extension modules. Depending on the extension loaded mode, objects in this path may still be loaded even if the loading of modules from the full set of search paths is disabled. See also : :cactvs (dynamic_loaded_mode).

- cactvs(trusted_scriptpath)

A search path for sources of trusted scripts. Scripts from this source may be loaded and executed even if normal script auto-loading is disabled.

- cactvs(typexpath)

The search path for handlers of additional data types.

- cactvs(use_bad_property_cache)

If this boolean flag is set, the toolkit remembers property names for which the look-up of property definition records failed. Since the look-up path can involved lengthy database searches and Internet accesses, this flag can in some cases prevent poor performance because of repeated failure to identify the same property name. On the other hand, if this flag is set, adding a new property definition during the runtime of an application after a look-up for this new property has failed has no effect and such a property definition needs to be loaded explicitly.

- cactvs(use_reference_objects)

A flag indicating what type of TcL interpreter data value objects are used for toolkit objects. The default value of zero indicates that object handles obtained from earlier commands are strings which are decoded when a command is executed. A value of one indicates that the interpreter objects are actually wrappers for pre-resolved pointers. Using reference objects speeds up scripts, but slightly changes the pattern of handle allocations, and under many circumstances requires extra memory because toolkit objects remain in a zombie state until all interpreter reference objects have been reclaimed.

- cactvs(user_affiliation)

The company, university or other institution the user is working for. This information is used in pre-setting various header data blocks. The veracity of this item is not checked.

- cactvs(user_email)

The e-mail address of the user, initially guessed by the library. This information is used in pre-setting various header data blocks, and also for Web data sources which require some identification. The veracity of this item is not checked.

- cactvs(user_id)

The current system user name, as extracted from the login data or similar sources. Read only.

- cactvs(user_name)

The full name of the user, if it could be determined. Works reliably only on IRIX. This information is used in pre-setting various header data blocks. The veracity of this item is not checked.

- cactvs(uuid_support)

A read-only flag indicating whether the toolkit was compiled with support for handling and generating UUIDs. This is usually true.

- cactvs(value_buffer_size)

The maximum size of a single property data element may request when it is converted to a string. Normally set to something big like 256 K , but can be reduced to cope with external tools which have maximum line sizes, etc.

- cactvs(version)

Version number of the Сactvs toolkit. Read only.

- cactvs(wedge_interpretation)

This attribute can be used to switch the stereochemical interpretation of wedge bonds. The default model is cactvs, the other possible value is $i d b s$ for compatibility with IDBS software. In Cactvs mode, the stereo center is always at the wedge tips. In IDBS mode, bonds which go down have the wedge base at the stereo center. This flag also changes the style of generated wedges in 2D layouts (properties A_XY and B_FLAGS).

- cactes(wrapper)

A read-only string which holds the name of a wrapper program (usually a Bourne shell or MSDOS script) invoking the interpreter, and possibly also setting a program script as hidden argument. For standard Cactvs installations, these are the cs?? scripts. In case a raw interpreter without a wrapper is run, this string is empty.

- cactvs(xdr_support)

A read-only boolean attribute which indicates whether this application supports XDR-based Cactvs object streams. This feature is required for native Cactvs file I/O, handling serialized packed object strings, the object swap store, and other toolkit functions.

- cactvs(xml_support)

A read-only boolean attributes which indicates whether the application was compiled with an integrated XML parser. This affects the availability of the soap command, as well as support for various $X M L$-based chemical structure and reaction or table data file formats.

## Standard Filters

This section lists the filters which are built into the standard library or are shipped as filter definition files in the standard distribution.

The following table contains the filter name in the first column and the property the filter operates on in the second column. The third column is an explanation.

Standard Filter Table

| Oneighbors 1neightbor 2neighbors... 12neighbors | A_NEIGHBORS | An atom with a specific number of bonded neighbor atoms. |
| :---: | :---: | :---: |
| 3datom | A_TYPE | An atom or pseudo atom which may have a 3D coordinate. This includes classical atoms, 3D points, open valences, electron pairs, super atoms and polymers. |
| 3dpoint | A_TYPE | An pseudo atom which is just a point in 3D space, but probably with property data such as NMR shielding values which are also applicable to classical atoms. |
| acidic | A_HYDROGEN_BONDING | A hydrogen atom which is acidic. |
| agent | E_REACTION_ROLE | The role of an ensemble in a reaction is agent. |
| ahspecial | A_HSPECIAL | A special hydrogen, i.e. one which is usually displayed in depictions, such as hydrogen at stereo centers or stereo double bonds, or on aldehydes. |
| alinker | A_FRAMEWORK | An atom which is a ring system linker in the framework nomenclature (ring/chain/linker). |
| ametal | A_ISMETAL | A metal atom. |
| anglebond | B_TYPE | A filter for pseudo bonds of type bond angle. The toolkit supports as a pseudo-bond type the encoding of bond angles (angle between two bonds, involving three atoms with one atom common to both bonds). |
| anyatom | A_QUERY | The atom is an any atom specification for substructure searching. |
| aopen | A_TYPE | An atom of type open or rgroup attachment point. |
| apicenter | A_PICENTER | An atom which is a $\pi$ center. |
| aroatom | A_ARORING_COUNT | An atom which is part of an aromatic system. |
| arobond | B_ARORING_COUNT | A bond which is part of an aromatic system. |
| aroring | R_AROMATIC | An aromatic ring. |
| aroringsystem | Y_AROMATIC | A ring system that is fully aromatic, i.e. all rings in it are aromatic rings. |
| arrowbond | B_FLAGS | The bond is marked with one of the display attribute bits for parallel arrows. |
| asidechain | A_FRAMEWORK | An atom which is a side chain in the framework nomenclature (ring/chain/linker). |
| asteriskatom | A_FLAGS | The attribute bit for an asterisk marker is set. |

Standard Filter Table

| astereogenic | A_STEREOGENIC | An atom which can be a stereo center. |
| :---: | :---: | :---: |
| aunsub | A_HETERO_COUNT | An atoms which is unsubstituted by hetero atoms. |
| basic | A_HYDROGEN_BONDING | An atom which is basic, i.e. is easily protonated. |
| blinker | B_FRAMEWORK | A bond which is a linker bond in the framework nomenclature (ring/chain/linker). |
| boron | A_ELEMENT | The element of the atom is boron. |
| boxedatom | A_FLAGS | The boxed attribute has been set for the display flags of the atom. |
| bromine | A_ELEMENT | The element of the atom is bromine. |
| bstereogenic | B_STEROGENIC | The bond can be a stereo center. |
| byproduct | E_REACTION_ROLE | The role of an ensemble in a reaction is byproduct. |
| carbocycle | A_ELEMENT | The ring contains only carbon. |
| carbon | A_ELEMENT | The element of the atom is carbon. |
| catalyst | E_REACTION_ROLE | The role of an ensemble in a reaction is catalyst. |
| cbond | A_ELEMENT | A bond with one or more carbon atoms in it. |
| ccbond | A_ELEMENT | The bond is a carbon-carbon bond. This is a real bond filter - the atom property is used in a special mode to check on all bond atoms directly |
| chalcogen | A_IUPAC_GROUP | The atom is a chalcogen (PSE group VIa). |
| chargedatom | A_FORMAL_CHARGE | The atom bears formal charge. |
| chbond | A_ELEMENT | The bond is a carbon-hydrogen bond. This is a real bond filter - the atom property is used in a special mode to check on all bond atoms directly |
| chlorine | A_ELEMENT | The element of the atom is chlorine. |
| classicatom | A_TYPE | A classical atom from the periodic system. The toolkit supports operation with pseudo atoms, such as superatoms, atom query specifications, or 3D points. The class of atoms is set in the property A_TYPE. This filter checks that A_TYPE is normal |
| classicbond | B_TYPE | A classical bond between two classical atoms with a defined bond order and valence electrons which are subtracted from the free electron count of the participating atoms. The type of bonds is stored as data of property B_TYPE, which is also the property this filter operates on. |
| classicmol | M_ATOM_RANGE | The Molecule has at lease one classic atom. |
| classicring | A_TYPE | The ring only consists of classical atoms and no pseudo atoms, such as 3D points, superatoms, query specifications, etc |
| cneighbor | A_ELEMENT | The atom is bonded to at least one carbon atom. |
| complexbond | B_TYPE | The bond is of type complex. |
| crossedbond | B_TYPE | The bond has the crossed display attribute set. |

Standard Filter Table

| cxbond | A_ELEMENT | The bond is a carbon-hetero bond. |
| :---: | :---: | :---: |
| dashbond | B_FLAGS | The bond has any of the display attribute bits for dashed/stippled rendering set. |
| doublebond | B_ORDER | The bond is a double bond (bond order 2). This includes Kekulé bonds in aromatic systems. |
| edgebond | B_FLAGS | The bond is displayed. This bit is usually set by the Tk plotbond command and is not computable. |
| envelope | R_TYPE | The ring is an envelope ring. |
| excludeatom | A_QUERY | The atom is a substructure match specification which should not be matched. |
| flagbond | B_FLAGS | The bond has any display attribute flag set. |
| fluorine | A_ELEMENT | The element of the atom is fluorine. |
| hacceptor | A_HYDROGEN_BONDING | The atom is a hydrogen acceptors, i.e. its A_HYDROGEN_BONDING value is either basic or acceptor. |
| hdonor | A_HYDROGEN_BONDING | The atom is a hydrogen donor, i.e. its A_HYDROGEN_BONDING value of either donor or acidic. This attribute applies to the hydrogen atom directly, not the atom the hydrogen atom is bonded to. |
| halogen | A_IUPAC_GROUP | The atom is a halogen (PSE group VIIa). |
| $\begin{aligned} & h 0 \\ & h 1 \\ & h 2 \\ & h 3 \end{aligned}$ | A_HCOUNT | The atom has exactly $n$ bonded hydrogens. This are aliases for filter names hydrogen0.. 3 . |
| hbond | A_ELEMENT | A bond with one or more hydrogen atoms participating. |
| heteroatom | A_ELEMENT | The atom is a hetero (not $\mathrm{C}, \operatorname{not} \mathrm{H})$ atom. |
| heterocycle | A_ELEMENT | The ring is heterocycle. |
| hneighbor | A_ELEMENT | The atom is bonded to a hydrogen atom. |
| hxbond | A_ELEMENT | A bond between hydrogen and hetero atom. |
| impurity | E_REACTION_ROLE | The role of an ensemble in a reaction is impurity. |
| insatring | R_UNSATURATED | The ring is unsaturated. Aromatic rings are not considered to be unsaturated. The xinsatring filter does not have this extra condition. unsatring is an alias. |
| intermediate | E_REACTION_ROLE | The role of an ensemble in a reaction is intermediate. |
| iodine | A_ELEMENT | The element of the atom is iodine. |
| isotopeatom | A_ISOTOPE | The atom has an isotope label. |
| kring | R_TYPE | The ring is in the K set. |
| largering | R_SIZE | The ring is larger than 7 members. |
| listatom | A_QUERY | The atom is an element list for substructure searches. |
| macrocycle | R_SIZE | The ring is of size 12 or more. |
| mediumring | R_SIZE | The ring is of size 5-7. |

Standard Filter Table

| multibond | B_ORDER | This is a multiple bond with bond order > 1. Kekule <br> aromatic bonds are included. |
| :--- | :--- | :--- |
| multiringbond | B_RING_COUNT | The bond is member in more than one ring. |
| multiringatom | A_RING_COUNT | The atom is member in more than one (non-envelope) <br> ring. |
| multiringsystem | Y_RING_COUNT | The ring system consists of two or more rings. |
| nitrogen | Y_RING_COUNT | The element of the atom is nitrogen. |
| nodeatom | A_FLAGS | The atom is displayed as a node (bond line node or <br> symbol) or is completely omitted (for example, nor- <br> mal hydrogen atoms). The A_FLAGS bit is usually set <br> by the Tk plotatom command. However, it may also <br> the set by a standard computation of A_FLAGS. |
| nofilter | E_NONE | This filter does nothing. Convenient in places where <br> an empty string causes formatting or syntactic prob- <br> lems. |
| openvalences | A_HYDROGENS_NEEDED | The atom has open valences. |
| oxygen | A_ELEMENT | The element of the atom is oxygen. |
| phosphorus | A_ELEMENT | The element of the atom is phosphorus. |
| plotatom | A_XY | A_COLOR |
| plotatom3D | A_XYZ | The atom has valid 2D display coordinates. |
| plotbond | A_XY | The atom has valid 3D display coordinates. |
| rgroupanchor | A_QUERY | The bond has valid 2D display coordinates. This is in- <br> directly determined via display coordinates of the at- <br> oms of the bond. |
| rgroupatom | The atom belongs to an R-group definition. |  |
| rearches |  |  |

Standard Filter Table

| rgroupbond | B_TYPE | The bond is linking an R-group definition to a core structure. |
| :---: | :---: | :---: |
| ring3 ring4 ring5 ring6 ring7 ring8 ring9 ring10 | R_SIZE | Ring is of the specified size. |
| ringatom | A_RING_COUNT | The atom is a a member of a ring. |
| ringbond | B_RING_COUNT | The bond is a a member of a ring. |
| satring | R_UNSATURATED | The ring is saturated. |
| searchatom | A_TYPE | A pseudo atom which is a search specification. |
| silicon | A_ELEMENT | The element of the atom is silicon. |
| simplering | R_TYPE | The ring is a simple (non-envelope) ring |
| singlebond | B_ORDER | A single bond. This includes single Kekulé bonds. |
| slashbond | B_FLAGS | The slashed display attribute bit has been set on the bond. |
| smallring | R_SIZE | The ring is of size 3-4. |
| solvent | E_REACTION_ROLE | The role of an ensemble in a reaction is solvent. |
| sp_atom | A_HYBRIDIZATION | The atom is $s p$-hybridized. |
| sp2_atom | A_HYBRIDIZATION | The atom is $s p 2$-hybridized. |
| sp3_atom | A_HYBRIDIZATION | The atom is $s p 3$-hybridized. |
| sp3sp3_bond | A_HYBRIDIZATION | The bond is between two sp3-hybridized atoms. |
| splitbond | B_FLAGS | The split display attribute bit has been set on the bond. |
| sssrring | R_TYPE | Ring is in SSSR set. |
| standardatom | A_TYPE | An atom which is either a classical atom, or a search specification. |
| stereoatom | A_STEREOINFO | The atom has a valid stereo descriptor. |
| stereobond | B_STEREOINFO | The bond has a valid stereo descriptor. |
| stereosphere | A_STEREOGENIC | An atom which is a ligand to a possible atomic stereo center |
| structurebond | B_TYPE | A bond or type normal or complex. These are the bonds which usually define which atoms in an ensemble belong to a common molecule. |
| sulphur | A_ELEMENT | The element of the atom is sulfur. |
| superatom | A_TYPE | The atom is a super atom pseudo atom. |

Standard Filter Table

| symbolatom | A_FLAGS | The atom is displayed with a symbol, and not suppressed or only display as node without a symbol. The A_flags bit is usually set by the Tk plotatom command. However, it may also be set by a standard computation of A_FLAGS. |
| :---: | :---: | :---: |
| tautobond | B_ISTAUTOMERIC | The bond is part of a tautomer system. |
| terminalatom | A_TERMINAL_DISTANCE | The atom is terminal, i.e. among the outermost atoms in the structure. |
| terminalbond | A_TERMINAL_DISTANCE | The bond is terminal, i.e. leads to an atom which is among the outermost atoms in the structure. |
| torsionbond | B_TYPE | A pseudo bonds of type torsional angle, involving four atoms. |
| triplebond | B_ORDER | A triple bond with bond order 3. |
| valence0 valence1 valence2 valence3 valence4 valence5 valence6 valence 7 valence8 | A_VALENCE | An atom with specific valence. These filters may also be abbreviated as $v 0, v 1, . . v 8$. |
| varbond | B_QUERY | The bond has been specified to match different bond orders in a substructure query specification. |
| wavybond | B_FLAGS | The wavy display attribute flag has been set for the bond. |
| wedgebond | B_FLAGS | The bond has a wedge bit set |
| xbond | A_ELEMENT | A bond with one or more hetero atoms participating. |
| xinsatring | B_ORDER | This is a ring with double bonds in the ring. In contrast to the insatring filter, this filter does not take aromaticity into account. A phenyl ring with Kekulé double bonds passes this filter, but not the insatring filter. |
| xneighbor | A_ELEMENT | The atom is bonded to hetero atom- |
| xsssrring | R_TYPE | The ring is in the extended SSSR set. |
| xxbond | A_ELEMENT | A bond between two hetero atoms. |

This table only lists the most important element filters (the built-in set). The full set of elements in the periodic system is also provided as an element filter. All simple element filters have an alias name which corresponds to their atomic symbol, so using filter $c$ is equivalent to using the filter carbon.

Most of these filters have additional aliases, and some scripts still use the old, non-systematic filter names. In order to obtain the listed name of a filter from any alias, use the following command:
lindex [filter get \$name aliases] 0

## System Tables

Сactvs TcL interpreters with table support start up with three predefined tables, which are accessible via their standard handles table0, table1 and table2. They are write-protected by default, but by setting the editable attribute this can be changed.

If an interpreter is started in a KNIME context, additional tables may be automatically present.

## The PSE table

This table has handle table0. It contains basic physical and display data for all elements. The rows are addressable via the periodic system number or the standard element symbol. Row zero contains pseudo data for an undefined element.

The columns are:

- symbol

The element symbol as a string.

- name

The English name of the element.

- number

The element number in the PSE as an integer.

- group

The PSE group using new-style IUPAC group indices $1 . .18$, plus 19 for lanthanides and 20 for actinides.

- pserow

PSE row, starting with 1 .

- shellelectrons

The standard number of shell electrons.

- ismetal

Flag for metals

- weight

The standard atomic weight in $\mathrm{gr} / \mathrm{mol}$.

- vdwradius

Standard Van-der-Waals radius in Ångstrom.

- covradius

Standard covalent bonding radius in Ångstrom.

- color 1

Default rendering color for bright backgrounds

- color2

Default rendering color for dark backgrounds.

- valences

Standard accessible atomic valences in compounds with this element. This column is an integer vector. For example, for sulfur the cell contains the values 2, 4 and 6.

- isotopes

Standard isotopes of the element occurring naturally, or with precedence for chemical use as isotope label etc. This column is a compound vector. Every vector element is a list of the nucleon count (integer), the isotope mass (double, gr/mol), the natural abundance (double, range $0 . .1$ ) and the half life in seconds. Stable isotopes have an infinite half life.

- allisotopes

As above, but with a full set of known isotopes, copied from
http://www.sisweb.com/referenc/source/exactmas.htm

- sequence

The precedence of the element in constructing an elemental formula, following the $\mathrm{C} / \mathrm{H} /$ alphabetic convention. The value for C is one.

## The Superatom table

This table has handle tablel. It contains information about common superatom fragments. This information is for example used superatom expansion or contraction of chemical groups for display.

The columns are:

- name

An expanded, human-readable name of the fragment

- codes

A string list of recognized names for the fragment. There is often more than one code, and the list contains reversed entries such as MeO plus $O M e$, since superatom name matching does not automatically match reversed names - that could lead to mis-classifications in some cases.

- smiles

A SMILES representation of the fragment. The first atom is always a * placeholder indicating the primary connection point. Secondary connection points may be present in any position. On expansion, the connection points are not used.

- expandable

Flag indicating that this fragment is handled by normal expansion commands, such as ens expand.

- contractable

Flag indicating that this fragment can be contracted as superatom in structure renderings.

- level

The minimum contraction level to actually perform group contraction for rendering. This is currently a value between 1 (routinely abbreviated) to 3 (exotic case only recognized by specialists).

- flags

Substructure match flags to be added to the standard set when trying to detect the fragment in a structure, such as forcing a match which does not link via a simple alkyl chain, preventing for example the use of an n-propyl group as a partial abbreviation for an $n$-octyl group.

- textlabel

The standard display symbol of the contracted group, as it is stored in property
A_TEXTLABEL.

- structure

The handle of the decoded SMILES from the third column. Decoding is performed in a lazy fashion, so initially this cell is empty.

- substructure

The handle of the SMARTS-decoded SMILES from the third column. Decoding is performed in a lazy fashion, to initially this cell is empty.

## The SMARTS Macro table

This table has handle table 2 and is initially empty. If content is added, it is automatically used in all SMILES and SMARTS expansions which use macro syntax.

The columns are

- name

A name for the macro. This is what is recognized in the input SMILES.

- pattern

The SMILES/SMARTS pattern this macro expands to

- set

A set name for this fragment. Set names are an argument to SMILES/SMARTS decoder functions. Only those macros in the table that match the set name are used, if it is not an empty string.

## SMILES and SMARTS dialects

The toolkit supports the complete range of the Daylight SMILES, SMARTS, Reaction SMILES and SMIRKS standards, including Recursive SMARTS.

The global control variable : :cactvs (smiles_version) can be set to a Daylight release number. The setting of this variable influences various aspects of encoding and decoding of SMARTS data. The default value is 4.9 - the version best known for finally introducing the $x$ ring bond count atom attribute. This is the most recent major Daylight SMILES/SMARTS definition update.

In SMARTS context a simple ' H ' atom attribute without a count is always interpreted by the toolkit as a hydrogen atom for explicit matching, not the hydrogen neighbour count. This behaviour is standard in Daylight tools since the 4.51 release.

Octahedral and bi-pyramidal stereochemistry in SMILES is read and written, but currently not checked by the substructure match routines. Allenes and square planar stereochemistry are fully supported.

Besides supporting the standard syntax and attributes of both atoms and bonds, a significant number of enhancements are also recognized:

## Attribute ranges

In addition to a simple numerical count (as in '[X2]'), bracketed open and closed ranges are supported, as in ' $[\mathrm{X}\{1-\}]^{\prime},[\mathrm{X}\{-3\}]$ ' or ' $[\mathrm{X}\{2-3\}]^{\prime}$ ' This feature is available for every attribute which can take a count. It is also possible to use the EliLilly operator extensions for (with the exception of a closed range, which cannot be expressed) the same purpose, as in ' $[\mathrm{X}>1]^{\text {' }}$ or $[\mathrm{X}<=3]$ '

## Match count prefixes

The SMARTS expression may be prefixed by a simple count, or an operator and a count. The SMARTS must then match the required number of times. The match mode is automatically adjusted if required. Example:

```
set ss [ens create {>4a-[F,Cl,Br,I]} smarts]
```

This matches compounds which contain 4 or more halogens substituting aromatic rings.

```
set ss [ens create {O[R]} smarts]
```

This matches compounds which do not contain rings.

## Strict interpretation suffix

The default SMARTS interpretation in Cactvs is more lenient than the original Daylight definition. Specifically, the aliphatic attribute of upper-case element symbols is not enforced by default. Most match commands provide options to fine-tune the interpretation, and it is also possible to switch the toolkit globally into a strict SMARTS interpretation mode.

As a convenience, it is possible to request strict interpretation of a SMARTS string regardless of command options and global configuration by appending an exclamation mark to the string.

Example:
set ss [ens create C1CCCCC1!]
This SMARTS does not match benzene, which in default toolkit mode without the suffix is matched.

## Additional atom attributes

- $a$

Besides supporting its standard meaning without a suffix, the toolkit version allows a count to this attribute. If a count is set, the atom must be part of the count or more aromatic bonds. The associated property is A_AROBOND_COUNT. For example, [a3] matches the two central carbon atoms of naphthalene, but not the other ring atoms.

- $D$

If used without a count, this symbol defines a deuterium atom.

- e

An atom attribute for the ring pi electron count of all ESSSR rings the atom is part of. If there is more than one such ring, a match in any of these is sufficient. If no number modifier is supplied, the condition requires the presence of one or more pi electrons in the ring. The associated property is R_PI_ELECTRON_COUNT.

- G

The same as the ' $i$ ' attribute. This is an Eli Lilly internal tools compatibility feature.
Example:
set ss [ens create $\{[a D 3]-[\mathrm{GO} ; \mathrm{CH}>0, \mathrm{O}, \mathrm{N}]\}$ smarts]

- HA

A hydrogen acceptor atom. This interpretation has precedence over the rather pointless "hydrogen\&aliphatic" standard SMILES interpretation.

- HD

A hydrogen donor atom.

- $i$

An atom attribute checking for in/unsaturation. If a number modifier is specified, it requests a specific number of $\pi$ bond participations (e.g. $i 2$ on carbon matches either an allene, or an alkyne). The associated property is A_UNSATURATION.

- $T$

With a count, it is the same as the $z$ attribute. This is an Eli Lilly internal tools compatibility feature. If used without a count, it defines a tritium atom. Example;
set ss [ens create \{[CT1]\#C\} smarts]

- $X$

If used without a number modifier, which is illegal in standard SMARTS, this matches a hetero atom.

- $z$

An atom attribute indicating a required number of hetero atom neighbors. If no numeric modifier is supplied, one or more hetero neighbors are required. The property associated with this attribute is A_HETERO_SUBSTITUENT_COUNT.

- Z

An atom attribute indicating a required number of aliphatic hetero atom neighbors. If no numeric modifier is supplied, one or more hetero neighbors are required. The property associated with this attribute is A_ALIHETERO_SUBSTITUENT_COUNT.

- $\wedge^{\wedge}[0123456]$

An atom attribute where a following digit is required. This attribute checks the atom hybridization: $0=\mathrm{s}, 1=\mathrm{sp}, 2=\mathrm{sp} 3,3=\mathrm{sp} 3,4=\mathrm{sp} 3 \mathrm{~d}, 5 / 6=\mathrm{sp} 3 \mathrm{~d} 2$. The property associated with this attribute is A_HYBRIDIZATION.

-     * and ?

These two symbols both specify an 'any' atom.

- \#X

This atom symbol matches a hetero atom. It is a MOE compatibility feature.

- \$ $\$(. .$.

This is a variation of normal recursive SMARTS. Standard recursive SMARTS does not know about atoms and bonds already matched in upper levels - the complete structure can be matched by the atoms in the recursive expression. This variant blocks all atoms and bonds already matched in any previous recursion level.

- |

The vertical bar as bond symbol encodes a bond of type complex. This is a bond which is similar to a standard valence bond, for example with respect to defining molecular fragments, but is not electron-counted.

- /IWfss

A Lilly extension: number of SSSR rings in the ring system the atom is a member of. Example:
set $s s$ [ens create \{[/IWfsslo,s]1:c:c:c:c1\} smarts]

- /IWspch

A Lilly extension: The 0 or 1 suffix requires that the matched atom is part of the core, or the Molecular Spinach part of the structure. The associated property is A_LILLY_SPInACH, the literature reference is J. Med. Chem. 2012, 55, 9763-9772.. Example:

```
set ss [ens create {[/IWfsslo,s]1:c:c:c:cl} smarts]
```

- /IWhr

A Lilly extension: Number of hetero atoms in one SSSR ring the atom is a member of. Example:

```
set ss [ens create {[/IWhrln]} smarts]
```

- /IWrid

A Lilly extension. Atoms marked with the same ring ID must be a member of a common SSSR ring. Atoms with a different ring ID must be a member of at least one different SSSR ring. The set of chain atoms forms a pseudo-ring class and can also be tagged. Example:

```
set ss [ens create {Cl-[/IWridla].Cl-[/IWridla]} smarts]
set ss [ens create {Cl-[/IWrid1].Cl-[/IWrid2]} smarts]
```

- /IWfsid

As above, but applies to ring systems, not rings. Example:

```
set ss [ens create {Cl-[/IWfsidla].Cl-[/IWfsidla]} smarts]
```

- /IWAr

A Lilly extension. The attribute checks whether the atom is alpha to an aromatic ring. The associated property is A_ALPHA_ARO_COUNT. Example:

```
echo [match ss {[/IWAr1Cl]} c1ccccc1Cl=CCl] (expect 1)
```

- /IWVy

A Lilly extension. The attribute checks whether the atom is alpha to a vinyl, non-aromatic group. The associated property is A_ALPHA_UNSAT_COUNT. Example:

```
echo [match ss {[/IWVy1Cl]} C=CCl] (expect 1)
```


## Operator-chained matches

The toolkit supports to a limited degree the Lilly extensions for chained matches. In these, multiple SMARTS fragments (which each may consist of multiple dot-disconnected parts) are linked via a $\& \&, \|$ or ${ }^{\wedge \wedge}$ duplicate operator. Each fragment is handled independently, as a separate structure object, without regard to match overlaps as in Recursive SMARTS or explicit setting of the fragment overlap mode in substructure matching.

Example:
set $s s$ [ens create $\{[n D 3]-S(=O)(=0) \& \& 0[a D 3]-[G 0 ; C H>0, O, N]\}$ smarts]
The current implementation does not take operator precedence into account, as the original Lilly code does. It is possible to combine, for example, $\|$ and $\& \&$ parts in one query string, but the fragments are checked in strict left-to-right order, without precedence for the and part.

Only those parts of the expression are checked which are require to obtain the final match results. In case of an or expression, the match processing stops after the first fragment match has been found.

## EliLilly extended SMARTS

As described above, the toolkit has near complete support for the published EliLilly SMARTS extensions, including match count prefixes, custom attributes, attribute count operators and chained matches.

## Extended hydrogen handling

The H symbol may be used as an explicit hydrogen atom outside brackets, even though it is not in the official organic subset element set.

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[^0]:    4. The standard process to compute property data is fully automatic and does not let the programmer influence the computation path followed. Experimental features involving an exhaustive generation of paths from source data to requested data and the use of rating functions to select preferred paths exist, but are not contained in the standard toolkit distributions. For standard applications, the default computation path is nearly always effective.
[^1]:    5. This is actually only true if there is no image cropping. The width field is the original width of the image used for drawing the structure. The final image height and width are provided in the croppedwidth and croppedheight fields. If cropping is disabled, these are the same as the original width and height values.
    6. Under certain circumstances, it is possible that an input operation consumes more than one file record. This is the reason why two record numbers are stored in these property data instances. For standard applications, both record numbers have the same value.
[^2]:    - boolean Internally a long integer, this type as import and export functions for encodings such as T/F, and may be stored as a bit or byte on compact formats. This type is not indexible.
    - byte An 8-bit signed integer. Internally managed as a long integer and not indexible.
    - short A 16-bit signed integer. Internally managed as a long integer and not indexible.
    - int A 32-bit signed integer. Internally managed as a long integer and not indexible.
    - uint8 A 64-bit (8-byte) unsigned integer, which is primarily used for hashcodes. Not indexible. The standard method of input and output for this data type is as a 16-character hex string, not a decimal number.

