Libsmoldyn User's Manual

for Smoldyn version 2.61

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Chapter 1

About Libsmoldyn

Libsmoldyn is a C and C++ interface to the Smoldyn simulator. Libsmoldyn is complementary to the stand-alone Smoldyn program in that it is a little more difficult to use, but it provides much more flexibility. In addition, Libsmoldyn provides: (*i*) an application programming interface that will be relatively stable, even as Smoldyn is updated and improved, (*ii*) function names that are relatively sensible and that shouldn't collide with other function names in other software, and (*iii*) reasonably thorough error checking in every function which helps ensure that the user is using the function in a sensible way and in a way that won't crash Smoldyn.

I initially planned to use SWIG to provide Libsmoldyn access from several languages but have not pursued this recently. Carlos Lopez's group was adding Libsmoldyn to PySB for a while, to give it Python accessibility, although that project is not ongoing currently.

Libsmoldyn only barely supports graphics at present due to constraints imposed by the glut code library. This will be improved in a future version (by changing to the freeglut library, which doesn't insist on controlling the main event loop, as the glut library does).

Chapter 2

Compiling and linking

2.1 Compiling

Header files

To enable a C or C++ program to call Libsmoldyn, it has to include the Libsmoldyn header file. Libsmoldyn comes with one header file, libsmoldyn.h, which has function declarations for all of the Libsmoldyn functions. For most Libsmoldyn applications, this is the only header file that you will need to include. For Mac and Linux, it is typically installed to /usr/local/include. This is one of the standard system paths, so include it with

```
#include <libsmoldyn.h>
```

If the libsmoldyn.h header file is in some other directory or if your system isn't seeing its path as a system path, then include the file using double quotes rather than angle brackets and/or include more information about the path. For example, `#include "/user/local/include/libsmoldyn.h"`.

Libsmoldyn.h calls a second header file, smoldyn.h, which is also typically installed to /usr/local/include/. If you plan to access the Smoldyn data structure directly, then you will also need to include it with `#include <smoldyn.h>`. In general, it is safe to read from this data structure but it can be dangerous to write to it unless you really know what you are doing. Also, working with this data structure directly bypasses one of the benefits of using Libsmoldyn, which is that the interface should be relatively immune to future Smoldyn developments, because different aspects of the internal data structure get changed once in a while.

The smoldyn.h header calls yet another header file, smoldynconfigure.h, which is also installed by default in /usr/local/include/. That file is automatically generated by the build system. It describes what Smoldyn components are included in the build, what system the build was compiled for, etc. This might be helpful to include for some applications.

Compiling example

In the `examples/S97_libsmoldyn/testcode/` directory, you'll find the testcode.c program. To compile this source code to object code, enter:

```
gcc -Wall -O0 -g -c testcode.c
```

The compile flags `-O0 -g` aren't necessary but can be useful for debugging purposes. If compiling doesn't work at this stage, it's probably because you're missing the header files. Make sure that you have libsmoldyn.h, smoldyn.h, and smoldyn_config.h in the `/usr/local/include` directory.

2.2 Linking

Linking the different object files together to create an executable that actually runs is often one of the greatest frustrations of using software libraries. It should be easy but usually isn't.

The Libsmoldyn library can be linked statically, meaning that the Libsmoldyn code will be copied into the final result, or it can be linked dynamically, so that the final result will simply reference the Libsmoldyn code that is stored separately. Dynamic linking is somewhat more elegant in that it doesn't create unnecessary copies of the compiled code. It can also be easier. On the other hand, it's less convenient if you plan to distribute your software, because then you need to make sure that you distribute the Libsmoldyn header file and library code along with your own software. Also, I can only get the gdb debugger to help find errors within Libsmoldyn if the library is statically linked.

The Libsmoldyn static library is called libsmoldyn_static.a and the Libsmoldyn dynamic library is called libsmoldyn_shared.so (on Linux; the .so suffix is replaced by .dylib on a Mac and by .dll on Windows). By default, these libraries are installed to /usr/local/lib/.

Linking examples

Following are several example for static and dynamic linking. They are shown for C; if you used C++, then link with g++ instead of gcc. The linking options for Smoldyn compiled with OpenGL are shown for Macintosh; these lines are simpler for other systems.

I have had a hard time getting static linking working on a Mac, although apparently it works fine on Ubuntu. The problem is that it doesn't find the standard C++ library. The solution is to build the Smoldyn library without NSV, so that the standard C++ library isn't needed. I also commented out a few "throw" statements from smolsim.c and libsmoldyn.c for this purpose.

Static link, no OpenGL:

```
gcc testcode.o /usr/local/lib/libsmoldyn_static.a -o testcode
```

Static link, with OpenGL:

```
gcc testcode.o /usr/local/lib/libsmoldyn_static.a -I/System/Library/Frameworks/OpenGL.
framework/Headers -I/System/Library/Frameworks/GLUT.framework/Headers -framework GLUT -
framework OpenGL -framework Cocoa -L/System/Library/Frameworks/OpenGL.framework/
Libraries -o testcode -ltiff
```

Dynamic link, no OpenGL:

```
gcc testcode.o -o testcode -lsmoldyn_shared
```

Dynamic link, with OpenGL:

```
gcc test1.o -L/usr/local/lib -I/System/Library/Frameworks/OpenGL.framework/Headers -I/
System/Library/Frameworks/GLUT.framework/Headers -framework GLUT -framework OpenGL -
framework Cocoa -L/System/Library/Frameworks/OpenGL.framework/Libraries -o test1 -
lsmoldyn_shared -ltiff
```

2.3 Using smaller versions of Libsmoldyn

As a default, Smoldyn and Libsmoldyn are compiled with all of their components. However, they can also be compiled without OpenGL, without hybrid simulation (NSV) support, without LibTiff support, etc. Removing these components removes some aspects of the functionality, obviously, but can also simplify linking.

Following is a simple diagram for Smoldyn's code dependencies. Each file depends on the files that are indented below it.

Smoldyn
- OpenGL
- libTiff
- zlib
- libiconv

NSV
boost
VTK

To build with fewer components, you will need to run CMake to compile Smoldyn. This is described in more detail in the Smoldyn Code Documentation, but summarized here for convenience.

I prefer to run CMake from a command line interface. At a command line interface, change directories to cmake. Every time you change CMake settings, you'll probably want to do a clean build. To do so, enter "rm -r *", while in the cmake directory (verify that you're in this directory!), to remove any prior build results. If you're asked about whether manifest.txt should be removed, say yes; this file shows the directories where Smoldyn was installed previously, thus providing information for you to remove it. For a default build, enter "cmake ..". A few test results will be printed out, and then configuring will be complete. When CMake is done, it will have written a lot of stuff to the cmake directory. Important files are "Makefile", which is the standard Makefile for the code and also smoldynconfigure.h, which is a C header file that the Smoldyn code uses for knowing what some important build parameters are.

Once configuring is complete, enter "make". Hopefully, Smoldyn will build, again with build files being put into the cmake directory. Finally, enter "sudo make install" and enter your password, to install Smoldyn to the usual place (/usr/local/bin on Linux and Mac systems).

For custom builds, you need to set various options to non-default settings. With a command line interface, list each non-default option on the command line after the "cmake .." start. Following are some helpful build options:

Smoldyn option	default	effect when ON
`-DOPTION_VCELL`	`OFF`	Build for inclusion within VCell
`-DOPTION_NSV`	`ON`	Build with Next Subvolume support
`-DOPTION_PDE`	`OFF`	Build with support for PDE simulation
`-DOPTION_VTK`	`OFF`	Build sith support for VTK visualization
`-DOPTION_STATIC`	`OFF`	Build using static libraries
`-DOPTION_USE_OPENGL`	`ON`	Build with graphics support
`-DOPTION_USE_LIBTIFF`	`ON`	Build with LibTiff support
`-DOPTION_TARGET_SMOLDYN`	`ON`	Build stand-alone Smoldyn program
`-DOPTION_TARGET_LIBSMOLDYN`	`OFF`	Build LibSmoldyn library
CMake option	default	function
`-DCMAKE_BUILD_TYPE`	`Release`	Choose CMake build type
options are: `None`, `Debug`, `Release`, `RelWithDebInfo`, and `MinSizeRel`		
`-DCMAKE_CXX_COMPILER:FILEPATH`	clang	Compile with specific compiler
for example: /usr/bin/g++		

For example, the following line builds Smoldyn and Libsmoldyn for debugging and without the hybrid simulation support:

```
cmake .. -DCMAKE_BUILD_TYPE=Debug -DOPTION_TARGET_LIBSMOLDYN=ON -DOPTION_NSV=OFF
```

Chapter 3

Error trapping

Every function in Libsmoldyn checks that its input values are acceptable and also that no errors arise in the function execution. These errors are returned to the host library in a number of ways. Most Libsmoldyn functions (e.g. `smolRunSim`) return any error codes directly, which makes it easy to see if an error arose. However, a few functions (e.g. `smolNewSim`) return other types of values and so return some other indication of success or failure (e.g. `NULL`). In addition, some functions can raise warnings, which indicate that behavior is unusual but not incorrect.

For all of these errors and warnings, get the details of the problem using the function `smolGetError`, which will return the error code, the name of the function where the error arose, and a descriptive error string. This will also clear the error, if desired. If errors are not cleared, they are left until they are overwritten by subsequent errors. Warnings are also left until they are cleared or overwritten.

When writing code, it can be helpful to put Libsmoldyn into its debugging mode using the `smolSetDebugMode` function. Doing this causes any errors that arise to be displayed to stderr.

The possible error codes are declared in libsmoldyn.h with:

```
enum ErrorCode {ECok=0,ECnotify=-1,ECwarning=-2,ECnonexist=-3,ECall=-4,ECmissing
    =-5,ECbounds=-6,ECsyntax=-7,ECerror=-8,ECmemory=-9,ECbug=-10,ECsame=-11};
```

Their interpretations are:

value	code	interpretation
0	`ECok`	no error
-1	`ECnotify`	message about correct behavior
-2	`ECwarning`	unusual but not incorrect behavior
-3	`ECnonexist`	a function input specifies an item that doesn't exist
-4	`ECsame`	error code should be unchanged from a prior code
-5	`ECall`	an argument of "all" was found and may not be permitted
-6	`ECmissing`	a necessary function input parameter is missing
-7	`ECbounds`	a function input parameter is out of bounds
-8	`ECsyntax`	function inputs don't make syntactical sense
-9	`ECerror`	unspecified error condition
-10	`ECmemory`	Smoldyn was unable to allocate the necessary memory
-11	`ECbug`	error arose which should not have been possible

3.1 Error checking system internal to libsmoldyn.c

This section describes how to write Libsmoldyn functions using error checking. While it is an essential part of all Libsmoldyn functions, these details are not important for most Libsmoldyn users.

1. The first line of every Libsmoldyn function should be `const char *funcname="`*function_name*`";`. This name will be returned with any error message to tell the user where the error arose.

2. Within the function, check for warnings or errors with the `LCHECK` macro. The macro format is `LCHECK(`*condition*`,funcname,`*error_code*`,"`*message*`");`. This checks that the test *condition* is true, and issues a notification, warning, or error when this is not the case. The *message* should be a descriptive message that is under 256 characters in length.

3. Most functions return an "`enum ErrorCode`". If this is the case for your function, and your function might return a notification and/or a warning, then end the main body of the function with `return libwarncode;`. If it cannot return a notification or a warning, then end it with `return ECok;`. Finally, if it does not return an "`enum ErrorCode`", then it needs to return some other error condition that will tell the user to check for errors using `smolGetError`.

4. After the main body of the function, add a goto target called `failure:`.

5. Assuming the function returns an "`enum ErrorCode`", end the function with `return liberrorcode;`.

The `smolSetTimeStep` function provides an excellent and simple example of how Libsmoldyn functions typically address errors. It is:

```
enum ErrorCode smolSetTimeStep(simptr sim,double timestep) {
  const char *funcname="smolSetTimeStep";

  LCHECK(sim,funcname,ECmissing,"missing␣sim");
  LCHECK(timestep>0,funcname,ECbounds,"timestep␣is␣not␣>␣0");
  simsettime(sim,timestep,3);
  return ECok;
 failure:
  return liberrorcode; }
```

The `smolGet...Index` functions are worth a comment. Each of these functions returns the index of an item, such as a species or a surface, based on the name of the item. If the name is not found or other errors arise, then these functions return the error code, cast as an integer. Also, if the name is "all", then these functions return the error code `ECall` and set the error string "species cannot be 'all'", or equivalent. A typical use of these functions is seen in `smolSetSpeciesMobility`, which includes the following code:

```
i=smolGetSpeciesIndex(sim,species);
if(i==(int)ECall) smolClearError();
else LCHECK(i>0,funcname,ECsame,NULL);
```

In this particular case, this function permits an input of "all", so it clears errors that arise from this return value, and leaves `i` as a negative value for later use.

Chapter 4

Libsmoldyn quick function guide

The Libsmoldyn functions correspond relatively closely to the Smoldyn language statements, although not perfectly. However, all functionality should be available using either method. The following table lists the correspondences. Statements preceded by asterisks need to be either entered in statement blocks or preceded by the statement's context (e.g. with `surface` *name*). Where correspondence does not apply, the table lists "N/A".

Statement	Libsmoldyn function
About the input	
#	N/A
/* ... */	N/A
read_file	`smolLoadSimFromFile`, `smolReadConfigString`
end_file	N/A
define	N/A
define_global	N/A
undefine	N/A
ifdefine	N/A
ifundefine	N/A
else	N/A
endif	N/A
display_define	N/A
N/A	`smolSetError`
N/A	`smolGetError`
N/A	`smolClearError`
N/A	`smolSetDebugMode`
N/A	`smolErrorCodeToString`
Space and time	
dim	`smolNewSim`
boundaries	`smolNewSim`, `smolSetBoundaryType`
low_wall	`smolNewSim`, `smolSetBoundaryType`
high_wall	`smolNewSim`, `smolSetBoundaryType`
time_start	`smolSetSimTimes`, `smolSetTimeStart`
time_stop	`smolSetSimTimes`, `smolSetTimeStop`
time_step	`smolSetSimTimes`, `smolSetTimeStep`
time_now	`smolSetTimeNow`
Molecules	
species	`smolAddSpecies`
N/A	`smolGetSpeciesIndex`
N/A	`smolGetSpeciesName`
difc	`smolSetSpeciesMobility`

difm	`smolSetSpeciesMobility`
drift	`smolSetSpeciesMobility`
mol	`smolAddSolutionMolecules`
surface_mol	`smolAddSurfaceMolecules`
compartment_mol	`smolAddCompartmentMolecules`
molecule_lists	`smolAddMolList`
mol_list	`smolAddSpecies`, `smolSetMolList`
N/A	`smolGetMolListIndex`
N/A	`smolGetMolListName`
max_mol	`smolSetMaxMolecules`
N/A	`smolGetMoleculeCount`
Graphics	
graphics	`smolSetGraphicsParams`
graphic_iter	`smolSetGraphicsParams`
graphic_delay	`smolSetGraphicsParams`
frame_thickness	`smolSetFrameStyle`
frame_color	`smolSetFrameStyle`
grid_thickness	`smolSetGridStyle`
grid_color	`smolSetGridStyle`
background_color	`smolSetBackgroundStyle`
display_size	`smolSetMoleculeStyle`
color	`smolSetMoleculeStyle`
tiff_iter	`smolSetTiffParams`
tiff_name	`smolSetTiffParams`
tiff_min	`smolSetTiffParams`
tiff_max	`smolSetTiffParams`
light	`smolSetLightParams`
text_color	`smolSetTextStyle`
text_display	`smolAddTextDisplay`
Run-time commands	
output_root	`smolSetOutputPath`
output_files	`smolAddOutputFile`
append_files	`smolAddOutputFile`
output_file_number	`smolAddOutputFile`
cmd	`smolAddCommand`, `smolAddCommandFromString`
Surfaces	
start_surface	`smolAddSurface`
new_surface	`smolAddSurface`
* name	`smolAddSurface`
N/A	`smolGetSurfaceIndex`
N/A	`smolGetSurfaceName`
* action	`smolSetSurfaceAction`
* rate	`smolSetSurfaceRate`
* rate_internal	`smolSetSurfaceRate`
* color	`smolSetSurfaceFaceStyle`, `smolSetSurfaceEdgeStyle`
* thickness	`smolSetSurfaceEdgeStyle`
* stipple	`smolSetSurfaceEdgeStyle`
* polygon	`smolSetSurfaceFaceStyle`
* shininess	`smolSetSurfaceFaceStyle`
* panel	`smolAddPanel`
N/A	`smolGetPanelIndex`
N/A	`smolGetPanelName`
* jump	`smolSetPanelJump`
* neighbors	`smolAddPanelNeighbor`

* unbounded_emitter	`smolAddSurfaceUnboundedEmitter`
* end_surface	N/A
epsilon	`smolSetSurfaceSimParams`
margin	`smolSetSurfaceSimParams`
neighbor_dist	`smolSetSurfaceSimParams`
Compartments	
start_compartment	`smolAddCompartment`
new_compartment	`smolAddCompartment`
* name	`smolAddCompartment`
N/A	`smolGetCompartmentIndex`
N/A	`smolGetCompartmentName`
* surface	`smolAddCompartmentSurface`
* point	`smolAddCompartmentPoint`
* compartment	`smolAddCompartmentLogic`
* end_compartment	N/A
Reactions	
reaction	`smolAddReaction`
N/A	`smolGetReactionIndex`
N/A	`smolGetReactionName`
reaction_cmpt	`smolSetReactionRegion`
reaction_surface	`smolSetReactionRegion`
reaction_rate	`smolAddReaction`, `smolSetReactionRate`
confspread_radius	`smolSetReactionRate`
binding_radius	`smolSetReactionRate`
reaction_probability	`smolSetReactionRate`
reaction_production	`smolSetReactionRate`
reaction_permit	not supported
reaction_forbid	not supported
product_placement	`smolSetReactionProducts`
Ports	
start_port	`smolAddPort`
new_port	`smolAddPort`
* name	`smolAddPort`
N/A	`smolGetPortIndex`
N/A	`smolGetPortName`
* surface	`smolAddPort`
* face	`smolAddPort`
* end_port	N/A
N/A	`smolAddPortMolecules`
N/A	`smolGetPortMolecules`
Simulation settings	
rand_seed	`smolSetRandomSeed`
accuracy	not supported
molperbox	`smolSetPartitions`
boxsize	`smolSetPartitions`
gauss_table_size	not supported
epsilon	`smolSetSurfaceSimParams`
margin	`smolSetSurfaceSimParams`
neighbor_dist	`smolSetSurfaceSimParams`
pthreads	not supported
Libsmoldyn actions	
N/A	`smolUpdateSim`
N/A	`smolRunTimeStep`
N/A	`smolRunSim`

N/A	`smolRunSimUntil`
N/A	`smolFreeSim`
N/A	`smolDisplaySim`
N/A	`smolPrepareSimFromFile`

Chapter 5

Libsmoldyn header file

Following is the entire Libsmoldyn header file, libsmoldyn.h. This lists all of the function declarations. If there is a discrepancy between declarations listed here and those listed in following sections, the ones shown here are almost certainly the correct ones. This file references smoldyn.h, which lists all of the data structure declarations and enumerated type definitions.

If you compiled and installed Smoldyn using the default configuration, both files should be in your /usr/local/include/smoldyn directory. Also in this directory is the smoldyn_config.h file. This file was used for compiling Smoldyn and Libsmoldyn but is not needed afterwards. Nevertheless, it's copied to the /usr/local/include/smoldyn directory so that programs that call Libsmoldyn can know what options Libsmoldyn was built with.

```
/* Steven Andrews, started 10/22/2001.
 This is an application programming interface for the Smoldyn program.
 See documentation called SmoldynUsersManual.pdf and SmoldynCodeDoc.pdf, and the
     Smoldyn
 website, which is at www.smoldyn.org.
 Copyright 2003-2016 by Steven Andrews.  This work is distributed under the terms
 of the Gnu Lesser General Public License (LGPL). */

#ifndef __libsmoldyn_h__
#define __libsmoldyn_h__

/* The following Swig directives are only read by the swig program */
#ifdef SWIG
%module libsmoldyn
%{
#define SWIG_FILE_WITH_INIT
#include "libsmoldyn.h"
%}
#endif


#include "smoldyn.h"

enum ErrorCode {ECok=0,ECnotify=-1,ECwarning=-2,ECnonexist=-3,ECall=-4,ECmissing
    =-5,ECbounds=-6,ECsyntax=-7,ECerror=-8,ECmemory=-9,ECbug=-10,ECsame=-11,
    ECwildcard=-12};

#ifdef __cplusplus
extern "C" {
#endif

/****************************** Miscellaneous *******************************/
```

```
double          smolGetVersion(void);

/********************************** Errors **********************************/

void            smolSetLogging(FILE *logfile,void (*logFunction)(simptr,int,const
    char*,...));
void            smolSetThrowing(int corethreshold,int libthreshold);
void            smolSetError(const char *errorfunction,enum ErrorCode errorcode,
    const char *errorstring);
void            smolSetErrorNT(const char *errorfunction,enum ErrorCode errorcode,
    const char *errorstring);
enum ErrorCode smolGetError(char *errorfunction,char *errorstring,int clearerror);
void            smolClearError(void);
void            smolSetDebugMode(int debugmode);
char*           smolErrorCodeToString(enum ErrorCode erc,char *string);

/******************************** Sim structure ********************************/

simptr          smolNewSim(int dim,double *lowbounds,double *highbounds);
enum ErrorCode smolUpdateSim(simptr sim);
enum ErrorCode smolRunTimeStep(simptr sim);
enum ErrorCode smolRunSim(simptr sim);
enum ErrorCode smolRunSimUntil(simptr sim,double breaktime);
enum ErrorCode smolFreeSim(simptr sim);
enum ErrorCode smolDisplaySim(simptr sim);

/************************* Read configuration file *************************/

simptr          smolPrepareSimFromFile(const char *filepath,const char *filename,
    const char *flags);
enum ErrorCode smolLoadSimFromFile(const char *filepath,const char *filename,
    simptr *simpointer,const char *flags);
enum ErrorCode smolReadConfigString(simptr sim,const char *statement,char *
    parameters);

/***************************** Simulation settings *****************************/

enum ErrorCode smolSetSimTimes(simptr sim,double timestart,double timestop,double
    timestep);
enum ErrorCode smolSetTimeStart(simptr sim,double timestart);
enum ErrorCode smolSetTimeStop(simptr sim,double timestop);
enum ErrorCode smolSetTimeNow(simptr sim,double timenow);
enum ErrorCode smolSetTimeStep(simptr sim,double timestep);
enum ErrorCode smolSetRandomSeed(simptr sim,long int seed);
enum ErrorCode smolSetPartitions(simptr sim,const char *method,double value);

/********************************** Graphics **********************************/

enum ErrorCode smolSetGraphicsParams(simptr sim,const char *method,int timesteps,
    int delay);
enum ErrorCode smolSetTiffParams(simptr sim,int timesteps,const char *tiffname,int
     lowcount,int highcount);
enum ErrorCode smolSetLightParams(simptr sim,int lightindex,double *ambient,double
     *diffuse,double *specular,double *position);
enum ErrorCode smolSetBackgroundStyle(simptr sim,double *color);
enum ErrorCode smolSetFrameStyle(simptr sim,double thickness,double *color);
enum ErrorCode smolSetGridStyle(simptr sim,double thickness,double *color);
enum ErrorCode smolSetTextStyle(simptr sim,double *color);
enum ErrorCode smolAddTextDisplay(simptr sim,char *item);
```

```
/***************************** Runtime commands ******************************/

enum ErrorCode smolSetOutputPath(simptr sim,const char *path);
enum ErrorCode smolAddOutputFile(simptr sim,char *filename,int suffix,int append);
//?? needs function for setting output precision
enum ErrorCode smolAddCommand(simptr sim,char type,double on,double off,double
    step,double multiplier,const char *commandstring);
enum ErrorCode smolAddCommandFromString(simptr sim,char *string);

/******************************** Molecules **********************************/

enum ErrorCode smolAddSpecies(simptr sim,const char *species,const char *mollist);
int            smolGetSpeciesIndex(simptr sim,const char *species);
int            smolGetSpeciesIndexNT(simptr sim,const char *species);
char*          smolGetSpeciesName(simptr sim,int speciesindex,char *species);
enum ErrorCode smolSetSpeciesMobility(simptr sim,const char *species,enum
    MolecState state,double difc,double *drift,double *difmatrix);
//?? needs function smolSetSpeciesSurfaceDrift
enum ErrorCode smolAddMolList(simptr sim,const char *mollist);
int            smolGetMolListIndex(simptr sim,const char *mollist);
int            smolGetMolListIndexNT(simptr sim,const char *mollist);
char*          smolGetMolListName(simptr sim,int mollistindex,char *mollist);
enum ErrorCode smolSetMolList(simptr sim,const char *species,enum MolecState state
    ,const char *mollist);
enum ErrorCode smolSetMaxMolecules(simptr sim,int maxmolecules);
enum ErrorCode smolAddSolutionMolecules(simptr sim,const char *species,int number,
    double *lowposition,double *highposition);
enum ErrorCode smolAddCompartmentMolecules(simptr sim,const char *species,int
    number,const char *compartment);
enum ErrorCode smolAddSurfaceMolecules(simptr sim,const char *species,enum
    MolecState state,int number,const char *surface,enum PanelShape panelshape,
    const char *panel,double *position);
int            smolGetMoleculeCount(simptr sim,const char *species,enum MolecState
     state);
enum ErrorCode smolSetMoleculeStyle(simptr sim,const char *species,enum MolecState
     state,double size,double *color);

/******************************** Surfaces ***********************************/

enum ErrorCode smolSetBoundaryType(simptr sim,int dimension,int highside,char type
    );
enum ErrorCode smolAddSurface(simptr sim,const char *surface);
int            smolGetSurfaceIndex(simptr sim,const char *surface);
int            smolGetSurfaceIndexNT(simptr sim,const char *surface);
char*          smolGetSurfaceName(simptr sim,int surfaceindex,char *surface);
enum ErrorCode smolSetSurfaceAction(simptr sim,const char *surface,enum PanelFace
    face,const char *species,enum MolecState state,enum SrfAction action);
enum ErrorCode smolSetSurfaceRate(simptr sim,const char *surface,const char *
    species,enum MolecState state,enum MolecState state1,enum MolecState state2,
    double rate,const char *newspecies,int isinternal);
enum ErrorCode smolAddPanel(simptr sim,const char *surface,enum PanelShape
    panelshape,const char *panel,const char *axisstring,double *params);
int            smolGetPanelIndex(simptr sim,const char *surface,enum PanelShape *
    panelshapeptr,const char *panel);
int            smolGetPanelIndexNT(simptr sim,const char *surface,enum PanelShape
    *panelshapeptr,const char *panel);
char*          smolGetPanelName(simptr sim,const char *surface,enum PanelShape
    panelshape,int panelindex,char *panel);
```

```
enum ErrorCode smolSetPanelJump(simptr sim,const char *surface,const char *panel1,
    enum PanelFace face1,const char *panel2,enum PanelFace face2,int
    isbidirectional);
enum ErrorCode smolAddSurfaceUnboundedEmitter(simptr sim,const char *surface,enum
    PanelFace face,const char *species,double emitamount,double *emitposition);
enum ErrorCode smolSetSurfaceSimParams(simptr sim,const char *parameter,double
    value);
enum ErrorCode smolAddPanelNeighbor(simptr sim,const char *surface1,const char *
    panel1,const char *surface2,const char *panel2,int reciprocal);
enum ErrorCode smolSetSurfaceStyle(simptr sim,const char *surface,enum PanelFace
    face,enum DrawMode mode,double thickness,double *color,int stipplefactor,int
    stipplepattern,double shininess);

/******************************** Compartments ********************************/

enum ErrorCode smolAddCompartment(simptr sim,const char *compartment);
int            smolGetCompartmentIndex(simptr sim,const char *compartment);
int            smolGetCompartmentIndexNT(simptr sim,const char *compartment);
char*          smolGetCompartmentName(simptr sim,int compartmentindex,char *
    compartment);
enum ErrorCode smolAddCompartmentSurface(simptr sim,const char *compartment,const
    char *surface);
enum ErrorCode smolAddCompartmentPoint(simptr sim,const char *compartment,double *
    point);
enum ErrorCode smolAddCompartmentLogic(simptr sim,const char *compartment,enum
    CmptLogic logic,const char *compartment2);

/******************************** Reactions ********************************/

enum ErrorCode smolAddReaction(simptr sim,const char *reaction,const char *
    reactant1,enum MolecState rstate1,const char *reactant2,enum MolecState rstate2
    ,int nproduct,const char **productspecies,enum MolecState *productstates,double
     rate);
int            smolGetReactionIndex(simptr sim,int *orderptr,const char *reaction)
    ;
int            smolGetReactionIndexNT(simptr sim,int *orderptr,const char *
    reaction);
char*          smolGetReactionName(simptr sim,int order,int reactionindex,char *
    reaction);
enum ErrorCode smolSetReactionRate(simptr sim,const char *reaction,double rate,int
     type);
enum ErrorCode smolSetReactionRegion(simptr sim,const char *reaction,const char *
    compartment,const char *surface);
enum ErrorCode smolSetReactionProducts(simptr sim,const char *reaction,enum
    RevParam method,double parameter,const char *product,double *position);

/********************************** Ports **********************************/

enum ErrorCode smolAddPort(simptr sim,const char *port,const char *surface,enum
    PanelFace face);
int            smolGetPortIndex(simptr sim,const char *port);
int            smolGetPortIndexNT(simptr sim,const char *port);
char*          smolGetPortName(simptr sim,int portindex,char *port);
enum ErrorCode smolAddPortMolecules(simptr sim,const char *port,int nmolec,const
    char *species,double **positions);
int            smolGetPortMolecules(simptr sim,const char *port,const char *
    species,enum MolecState state,int remove);

/********************************** Lattices **********************************
```

```
    */

enum ErrorCode smolAddLattice(simptr sim,const char *lattice,const double *min,
    const double *max,const double *dx,const char *btype);
enum ErrorCode smolAddLatticePort(simptr sim,const char *lattice,const char *port)
    ;
enum ErrorCode smolAddLatticeSpecies(simptr sim,const char *lattice,const char *
    species);
int            smolGetLatticeIndex(simptr sim,const char *lattice);
int            smolGetLatticeIndexNT(simptr sim,const char *lattice);
char*          smolGetLatticeName(simptr sim,int latticeindex,char *lattice);
enum ErrorCode smolAddLatticeMolecules(simptr sim,const char *lattice, const char
    *species,int number,double *lowposition,double *highposition);
enum ErrorCode smolAddLatticeReaction(simptr sim,const char *lattice,const char *
    reaction, const int move);


#ifdef __cplusplus
}
#endif


#endif
```

Chapter 6

Libsmoldyn functions

6.1 General comments

None of the functions allocate memory, except within the simulation data structure. This means, for example, that all functions that return strings do not allocate these strings themselves, but instead write the string text to memory that the library user allocated and gave to the function. All strings are fixed at `STRCHAR` characters, where this constant is defined in string2.h to 256 characters.

6.2 Miscellaneous

`double smolGetVersion(void);`
Returns the Smoldyn version number.

6.3 Errors

`void smolSetError(const char *errorfunction,enum ErrorCode errorcode,const char *errorstring);`
This function is probably not useful for most users. Sets the Libsmoldyn error code to `errorcode`, error function to `errorfunction`, and error string to `errorstring`. The sole exception is if `errorcode` is `ECsame` then this does nothing and simply returns. Back to it's normal operation, this also either sets or clears the Libsmoldyn warning code, as appropriate. If `errorstring` is entered as `NULL`, this clears the current error string, and similarly for `errorfunction`.

`enum ErrorCode smolGetError(char *errorfunction,char *errorstring,int clearerror);`
Returns the current LibSmoldyn error code directly, returns the function where the error occurred in `errorfunction` if it is not `NULL`, and returns the error string in `errorstring` if it is not `NULL`. Set `clearerror` to 1 to clear the error and 0 to leave any error condition unchanged.

`void smolClearError(void);`
Clears any error condition.

`void smolSetDebugMode(int debugmode);`
Enter `debugmode` as 1 to enable debugging and 0 to disable debugging. When debug mode is turned on, all errors are displayed to stderr, as are all cleared errors. By turning on debug mode, you can often avoid checking for errors with additional code and you also typically don't need to call `smolGetError`.

`char* smolErrorCodeTostring(enum ErrorCode erc,char *string);`
Returns a string both directly and in `string` that corresponds to the error code in `erc`. For example, if `erc` is `ECmemory`, this returns the string "memory".

6.4 Sim structure

`simptr smolNewSim(int dim,double *lowbounds,double *highbounds);`
Creates and returns a new sim structure. The structure is initialized for a `dim` dimensional system that has boundaries defined by the points `lowbounds` and `highbounds`. Boundaries are transmitting (modify them with `smolSetBoundaryType`). Returns `NULL` upon failure.

`enum ErrorCode smolUpdateSim(simptr sim);`
Updates the simulation structure. This calculates all simulation parameters from physical parameters, sorts lists, and generally does everything required to make a simulation ready to run. It may be called multiple times.

`enum ErrorCode smolRunTimeStep(simptr sim);`
Runs one time step of the simulation. Returns an error if the simulation terminates unexpectedly during this time step or a warning if it terminates normally.

`enum ErrorCode smolRunSim(simptr sim);`
Runs the simulation until it terminates. Returns an error if the simulation terminates unexpectedly during this time step or a warning if it terminates normally.

`enum ErrorCode smolRunSimUntil(simptr sim,double breaktime);`
Runs the simulation either until it terminates or until the simulation time equals or exceeds `breaktime`.

`enum ErrorCode smolFreeSim(simptr sim);`
Frees the simulation data structure.

`enum ErrorCode smolDisplaySim(simptr sim);`
Displays all relevant information about the simulation system to stdout.

6.5 Read configuration file

`simptr smolPrepareSimFromFile(char *filepath,char *filename,char *flags);`
Reads the Smoldyn configuration file that is at `filepath` and has file name `filename`, sets it up, and outputs simulation diagnostics to stdout. Returns the sim structure, or `NULL` if an error occurred. `flags` are the command line flags that are entered for normal Smoldyn use. Either or both of `filepath` and `flags` can be sent in as `NULL` if there is nothing to report. After this function runs successfully, it should be possible to call `smolRunSim` or `smolRunTimeStep`.

`enum ErrorCode smolLoadSimFromFile(char *filepath,char *filename,simptr *simpointer,char *flags);`
Loads part or all of a sim structure from the file that is at `filepath` and has file name `filename`. Send in `simpointer` as a pointer to sim, where sim may be an existing simulation structure that this function will append or `NULL` if it is to be created by this function. `flags` are the command line flags that are entered for normal Smoldyn use. Either or both of `filepath` and `flags` can be sent in as `NULL` if there is nothing to report. After this function runs successfully, call `smolUpdateSim` to calculate simulation parameters.

`enum ErrorCode smolReadConfigString(simptr sim,char *statement,char *parameters);`
Reads and processes what would normally be a single line of a configuration file. The first word of the line is the statement name, entered here as `statement`, while the rest of the line is entered as `parameters`. Separate different parameters with spaces. The same parser is used as for normal Smoldyn configuration files. This function does not make use of block style input formatting, such as for surface definitions. This means that a new surface needs to declared with "`new_surface` *name*" and all subsequent surface definitions need to start with "`surface` *name*". Analogous rules apply to compartments and port.

6.6 Simulation settings

`enum ErrorCode smolSetSimTimes(simptr sim,double timestart,double timestop,double timestep);`
Sets all of the simulation time parameters to the values entered here. In addition the simulation "time now" is set to `timestart`.

`enum ErrorCode smolSetTimeStart(simptr sim,double timestart);`
Sets the simulation starting time.

`enum ErrorCode smolSetTimeStop(simptr sim,double timestop);`
Sets the simulation stopping time.

`enum ErrorCode smolSetTimeNow(simptr sim,double timenow);`
Sets the simulation current time.

`enum ErrorCode smolSetTimeStep(simptr sim,double timestep);`
Sets the simulation time step, which must be greater than 0.

`enum ErrorCode smolSetRandomSeed(simptr sim,double seed);`
Sets the random number generator seed to `seed` if `seed` is at least 0, and sets it to the current time value if `seed` is less than 0.

`enum ErrorCode smolSetPartitions(simptr sim,char *method,double value);`
Sets the virtual partitions in the simulation volume. Enter `method` as "molperbox" and then enter `value` with the requested number of molecules per partition volume; the default, which is used if this function is not called at all, is a target of 4 molecules per box. Or, enter `method` as "boxsize" and enter `value` with the requested partition spacing. In this latter case, the actual partition spacing may be larger or smaller than the requested value in order to fit an integer number of partitions into each coordinate of the simulation volume.

6.7 Graphics

`enum ErrorCode smolSetGraphicsParams(simptr sim,char *method,int timesteps,double delay);`
Sets basic simulation graphics parameters. Enter `method` as "none" for no graphics (the default), "opengl" for fast but minimal OpenGL graphics, "opengl_good" for improved OpenGL graphics, "opengl_better" for fairly good OpenGL graphics, or as `NULL` to not set this parameter currently. Enter `timesteps` with a positive integer to set the number of simulation time steps between graphics renderings (1 is the default) or with a negative number to not set this parameter currently. Enter `delay` as a non-negative number to set the minimum number of milliseconds that must elapse between subsequent graphics renderings in order to improve visualization (0 is the default) or as a negative number to not set this parameter currently.

`enum ErrorCode smolSetTiffParams(simptr sim,int timesteps,char *tiffname,int lowcount,int highcount);`
Sets parameters for the automatic collection of TIFF format snapshots of the graphics window. `timesteps` is the number of simulation timesteps that should elapse between subsequent snapshots, `tiffname` is the root filename of the output TIFF files, `lowcount` is a number that is appended to the filename of the first snapshot and which is then incremented for subsequent snapshots, and `highcount` is the last numbered file that will be collected. Enter negative numbers for `timesteps`, `lowcount`, and/or `highcount` to not set these parameters, and enter `NULL` for `tiffname` to not set the file name.

`enum ErrorCode smolSetLightParams(simptr sim,int lightindex,double *ambient,double *diffuse,double *specular,double *position);`
Sets the lighting parameters that are used for the rendering method "opengl_better". Enter `lightindex` as -1 for the global ambient light (in which case `diffuse`, `specular`, and `position` should all be `NULL`)

or as 0 to 8 for one of the 8 light sources. For each light source, you can specify the 4-value color vector for the light's ambient, diffuse, and specular properties (all values should be between 0 and 1). You can also specify the 3-dimensional position for the light. To not set a property, just enter the respective vector as `NULL`.

`enum ErrorCode smolSetBackgroundStyle(simptr sim,double *color);`
Sets the color of the graphics display background. `color` is a 4-value vector with red, green, blue, and alpha values.

`enum ErrorCode smolSetFrameStyle(simptr sim,double thickness,double *color);`
Sets the thickness and the color of the wire frame that outlines the simulation system in the graphics window. Enter `thickness` as 0 for no frame, as a positive number for the number of points in thickness, or as a negative number to not set this parameter. Enter `color` as a 4-value vector with the frame color, or as `NULL` to not set it.

`enum ErrorCode smolSetGridStyle(simptr sim,double thickness,double *color);`
Sets the thickness and the color of a grid that shows where the partitions are that separate Smoldyn's virtual boxes. Enter `thickness` as 0 for no grid, as a positive number for the number of points in thickness, or as a negative number to not set this parameter. Enter `color` as a 4-value vector with the grid color, or as `NULL` to not set it.

`enum ErrorCode smolSetTextStyle(simptr sim,double *color);`
Sets the color of any text that is displayed to the graphics window. `color` is a 4-value vector with red, green, blue, and alpha values.

`enum ErrorCode smolAddTextDisplay(simptr sim,char *item);`
Adds `item` to the list of things that Smoldyn should display as text to the graphics window. Currently supported options are "time" and the names of species and, optionally, their states. For species and states, the graphics window shows the number of molecules.

6.8 Runtime commands

`enum ErrorCode smolSetOutputPath(simptr sim,char *path);`
Sets the file path for text output files to `path`.

`enum ErrorCode smolAddOutputFile(simptr sim,char *filename,int suffix,int append);`
Declares the file called `filename` as a file for output by one or more runtime commands. Note that spaces are not permitted in the file name. If `suffix` is non-negative, then the file name is suffixed by this integer, which can be helpful for creating output file stacks. Enter `append` as 1 if any current file should simply be appended, or to 0 if any current file should be overwritten.

`enum ErrorCode smolAddCommand(simptr sim,char type,double on,double off,double step,double multiplier,char *commandstring);`
Adds a run-time command to the simulation, including its timing instructions. This function should generally be called after `smolSetSimTimes` to make sure that command times get set correctly. The following table lists the command type options along with the other parameters that are used for each type. Parameters that are not required are simply ignored. The `commandstring` is the command name followed by any command parameters.

type	meaning	on	off	step	multiplier
Continuous time queue					
b	before simulation	-	-	-	-
a	after simulation	-	-	-	-
@	at fixed time	time	-	-	-
i	fixed intervals	time on	time off	time step	-
x	exponential intervals	time on	time off	min. time step	multiplier

	Integer time queue				
B	before simulation	-	-	-	-
A	after simulation	-	-	-	-
&	at fixed iteration	iteration	-	-	-
I	fixed iteration intervals	iter. on	iter. off	iter. step	-
E	every time step	-	-	-	-
N	every n'th time step	-	-	iter. step	-

`enum ErrorCode smolAddCommandFromString(simptr sim,char *string);`
Defines a runtime command, including its execution timing parameters, from the string `string`. This string should be identical to ones used in configuration files, except that they do not include the "cmd" statement.

6.9 Molecules

`enum ErrorCode smolAddSpecies(simptr sim,char *species,char *mollist);`
Adds a molecular species named `species` to the system. If you have already created species lists and want all states of this species to live in a specific list, then enter it in `mollist`; otherwise, enter `mollist` as `NULL` or an empty string to request default behavior.

`int smolGetSpeciesIndex(simptr sim,char *species);`
Returns the species index that corresponds to the species named `species`. Upon failure, this function returns an error code cast as an integer.

`char* smolGetSpeciesName(simptr sim,int speciesindex,char *species);`
Returns the species name that corresponds to the species index in `speciesindex`. The name is returned both in `species` and directly, where the latter simplifies function use. Upon failure, this function returns `NULL`.

`enum ErrorCode smolSetSpeciesMobility(simptr sim,char *species,enum MolecState state,double difc,double *drift,double *difmatrix);`
Sets any or all of the mobility coefficients for species `species` (which may be "all") and state `state` (which may be `MSall`). `difc` is the isotropic diffusion coefficient, `drift` is the drift vector, and `difmatrix` is the square of the anisotropic diffusion matrix (see the User's manual). To not set coefficients, enter a negative number in `difc` and/or enter a `NULL` pointer in the other inputs, respectively.

`int smolAddMolList(simptr sim,char *mollist);`
Adds a new molecule list, named `mollist`, to the system.

`int smolGetMolListIndex(simptr sim,char *mollist);`
Returns the list index that corresponds to the list named `mollist`.

`char* smolGetMolListName(simptr sim,int mollistindex,char *mollist);`
Returns the molecule list name that corresponds to the molecule list with index `mollistindex`. The name is returned both in `mollist` and directly. On error, this function `NULL`.

`enum ErrorCode smolSetMolList(simptr sim,char *species,enum MolecState state,char *mollist);`
Sets the molecule list for species `species` (which may be "all") and state `state` (which may be `MSall`) to molecule list `mollist`.

`enum ErrorCode  smolSetMaxMolecules(simptr sim,int maxmolecules);`
Sets the maximum number of molecules that can simultaneously exist in a system to `maxmolecules`. At present, this function needs to be called for a simulation to run, although it will become optional once dynamic molecule memory allocation has been written.

`enum ErrorCode smolAddSolutionMolecules(simptr sim,char *species,int number,double *lowposition,double *highposition);`
Adds `number` solution state molecules of species `species` to the system. They are randomly distributed within the box that has its opposite corners defined by `lowposition` and `highposition`. Any or all of these coordinates can equal each other to place the molecules along a plane or at a point. Enter `lowposition` and/or `highposition` as `NULL` to indicate that the respective corner is equal to that corner of the entire system volume.

`enum ErrorCode smolAddCompartmentMolecules(simptr sim,char *species,int number,char *compartment);`
Adds `number` solution state molecules of species `species` to the compartment `compartment`. Molecules are randomly distributed within the compartment.

`enum ErrorCode smolAddSurfaceMolecules(simptr sim,int speciesindex,enum MolecState state,int number,int surface,enum PanelShape panelshape,int panel,double *position);`
Adds `number` molecules of species `species` and state `state` to surface(s) in the system. It is permissible for `surface` to be "all", `panelshape` to be PSall, and/or `panel` to be "all". If you want molecules at a specific position, then you need to enter a specific surface, panel shape, and panel, and then enter the position in `position`.

`int smolGetMoleculeCount(simptr sim,char *species,enum MolecState state);`
Returns the total number of molecules in the system that have species `species` ("all" is permitted) and state `state` (`MSall` is permitted). Any error is returned as the error code cast as an integer.

`enum ErrorCode smolSetMoleculeStyle(simptr sim,const char *species,enum MolecState state,double size,double *color);`
Sets the graphical display parameters for molecules of species `species` ("all" is permitted) and state `state` (`MSall` is permitted). Enter `size` with the drawing size (in pixels if graphics method is "opengl" and in simulation system length units for better drawing methods) or with a negative number to not set the size. Enter `color` with the 3-value color vector or with `NULL` to not set the color.

6.10 Surfaces

`enum ErrorCode smolSetBoundaryType(simptr sim,int dimension,int highside,char type);`
Sets the molecule interaction properties for a system boundary that bounds the `dimension` axis. Enter `dimension` as -1 to indicate all dimensions. Set `highside` to 0 for the lower boundary, to 1 for the upper boundary, and to -1 for both boundaries. The boundary type is entered in `type` as 'r' for reflecting, 'p' for periodic, 'a' for absorbing, or 't' for transmitting. Note that Smoldyn only observes these properties if no surfaces are declared; otherwise all boundaries are transmitting regardless of what's entered here.

`int smolAddSurface(simptr sim,char *surface);`
Adds a surface called `surface` to the system.

`int smolGetSurfaceIndex(simptr sim,char *surface);`
Returns the surface index that corresponds to the surface named `surface`. The index is non-negative. On failure, this returns an error code cast as an integer.

`char* smolGetSurfaceName(simptr sim,int surfaceindex,char *surface);`
Returns the surface name for surface number `surfaceindex` both directly and in the `surface` string. On failure, this returns `NULL`.

`enum ErrorCode smolSetSurfaceAction(simptr sim,char *surface,enum PanelFace face,char *species,enum MolecState state,enum SrfAction action);`
Sets the action that should happen when a molecule of species `species` (may be "all") and state `state` (may be `MSall`) diffuses into face `face` (may be `PFboth`) of surface `surface`. The action is set to `action`.

`enum ErrorCode smolSetSurfaceRate(simptr sim,char *surface,char *species,enum MolecState state,enum MolecState state1,enum MolecState state2,double rate,char *newspecies,int isinternal);`

Sets the surface interaction rate(s) for surface `surface` (may be "all") and species `species` (may be "all") and state `state`. The transition being considered is from `state1` to `state2` (this function uses the tri-state format for describing surface interactions, shown below). The interaction rate is set to `rate`, which is interpreted as a probability value for internal use if `isinternal` is 1 and as a physical interaction coefficient if `isinternal` is 0. If the molecule ends up interacting with the surface, it changes to new species `newspecies`. Enter `newspecies` as either `NULL` or an empty string to indicate that molecules should not change species upon interactions. The molecule states are most easily understood with the following table. If the action listed in the table is in italics, then the corresponding combination of states is not a permitted input.

interaction class	tristate format			action
	`state`	`state1`	`state2`	
collision from solution state	soln	soln	soln	*reflect*
	"	"	bsoln	transmit
	"	"	bound	adsorb
	"	bsoln	soln	transmit
	"	"	bsoln	*reflect*
	"	"	bound	adsorb
action from bound state	"	bound	soln	desorb
	"	"	bsoln	desorb
	"	"	bound	*no change*
	"	"	bound'	flip
collision from bound state	bound	soln	soln	*reflect*
	"	"	bsoln	transmit
	"	"	bound	hop
	"	"	bound'	hop
	"	bsoln	soln	transmit
	"	"	bsoln	*reflect*
	"	"	bound	hop
	"	"	bound'	hop
action from bound state	"	bound	soln	desorb
	"	"	bsoln	desorb
	"	"	bound	*no change*
	"	"	bound'	flip
impossible	"	bound'	any	*nonsense*

`int smolAddPanel(simptr sim,char *surface,enum PanelShape panelshape,char *panel,char *axisstring,double *params);`

Adds or modifies a panel of shape `panelshape` of surface `surface`. `axisstring` lists any text parameters for the panel, which in practice is only a single word that gives the orientation of a rectangle panel (e.g. "+0" or "-y"). `params` lists the numerical parameters for the panel location, size, and drawing characteristics. These are exactly the same parameters that are listed for the "panel" statement in Smoldyn configuration files, with the sole exception that the first rectangle "parameter" is actually a string that is entered in `axisstring`. `panelname` is an optional parameter for naming the panel; if it is included and is not an empty string, the panel is named `panelname`. If this panel name was already used by a panel of the same shape, then this function overwrites that panel's data with the new data. If the name was already used by a panel with a different shape, then this creates an error, and if the name was not used before, then a new panel is created. To use default panel naming, send in `panelname` as either `NULL` or as an empty string. In the latter case, `panelname` is returned with the newly assigned default name.

`int smolGetPanelIndex(simptr sim,char *surface,enum PanelShape *panelshapeptr,char *panel);`
Returns the panel index for the panel called `panel` on surface `surface`. If `panelshapeptr` is not `NULL`, this also returns the panel shape in `panelshapeptr`. On failure, this returns the error code cast as an integer.

`char* smolGetPanelName(simptr sim,char *surface,enum PanelShape panelshape,int panelindex,char *panel);`
Returns the name of the panel that is in surface `surface`, has shape `panelshape`, and has index `panelindex`, both directly and in the string `panel`. On failure, this returns `NULL`.

`enum ErrorCode smolSetPanelJump(simptr sim,const char *surface,const char *panel1,enum PanelFace face1,const char *panel2,enum PanelFace face2,int isbidirectional);`
Sets a jumping link between face `face1` of panel `panel1` and face `face2` of panel `panel2` of surface `surface`. The link goes from `panel1` to `panel2` if `bidirectional` is entered as 0 and goes in both directions if `bidirectional` is entered as 1. None of the surface, panel, or face entries is allowed to be "all". This does not set the actions of any species to "jump", which has to be done using the `smolSetSurfaceAction` function.

`enum ErrorCode smolAddSurfaceUnboundedEmitter(simptr sim,const char *surface,enum PanelFace face,const char *species,double emitamount,double *emitposition);`
Adds information about a point molecular source so that face `face` of surface `surface` can have its absorption properties calculated so that the molecular concentrations will become the same as they would be if the surface weren't there at all. The point molecular source emits molecules of species `species`, with a rate of `emitamount` and is at location `emitposition`. The emission rate does not need to be in absolute units, but only has to be correct relative to other unbounded emitters. None of the inputs to this function are allowed to be "all".

`enum ErrorCode smolSetSurfaceSimParams(simptr sim,const char *parameter,double value);`
Sets the surface simulation parameter named with `parameter` to value `value`. The possible parameters are "epsilon", "margin", and "neighbordist". In all cases, the defaults are nearly always good, although this function allows them to be modified if desired. Epsilon is the maximum distance away from a surface that Smoldyn is allowed to place a surface-bound molecule. Margin is the distance inside from the edge of a surface panel that Smoldyn will place surface-bound molecules that hop onto this panel. Neighbor distance is the maximum distance over which surface-bound molecules are allowed to hop to transition from one panel to a neighboring panel.

`enum ErrorCode smolAddPanelNeighbor(simptr sim,const char *surface1,const char *panel1,const char *surface2,const char *panel2,int reciprocal);`
Adds panel `panel2` of surface `surface2` as a neighbor of panel `panel1` or surface `surface1`, meaning that surface-bound molecules will be allowed to diffuse from `panel1` to `panel2`. These are not allowed to be the same panel. Also, "all" values are not permitted. Otherwise, essentially any possible entries are legitimate. If surface-bound molecules should also be allowed to diffuse from `panel2` to `panel1`, enter `reciprocal` as 1; if not, enter `reciprocal` as 0.

`enum ErrorCode smolSetSurfaceStyle(simptr sim,const char *surface,enum PanelFace face,enum DrawMode mode,double thickness,double *color,int stipplefactor,int stipplepattern,double shininess);`
Sets the graphics output style for face `face` of surface `surface`. `mode` is the drawing mode; enter it as `DMnone` to not set this parameter and otherwise enter it as `DMno` to not draw the surface, `DMvert` for vertices, `DMedge` for edges, or `DMface` for faces. The `thickness` parameter gives the point size or line width for drawing vertices or edges, or can be entered as a negative number to not set this parameter. `color` is the 4-value color vector for the surface, or can be entered as `NULL` to not set this parameter. `stipplefactor` is the repeat distance for the entire edge stippling pattern, or can be entered as a negative number to not set it. `stipplepattern` is the edge stippling pattern, which needs to be between 0 and 0xFFFF, or can be entered as -1 to not set this parameter. And `shininess` is the

surface shininess, for use with lighting in the "opengl_better" graphics display option, or can be entered as -1 to not set this parameter. The parameters `thickness`, `stipplefactor`, and `stipplepattern` only apply to edge style drawing modes and ignore any input in the `face` entry. The `shininess` parameter only applies to the face style drawing modes.

6.11 Compartments

`int smolAddCompartment(simptr sim,char *compartment);`
Adds a compartment called `compartment` to the system.

`int smolGetCompartmentIndex(simptr sim,char *compartment)`
Returns the index of the compartment named `compartment`. On failure, this returns an error code cast as an integer.

`char* smolGetCompartmentName(simptr sim,int compartmentindex,char *compartment)`
Returns the name of the compartment that has index `compartmentindex` both directly and in the string `compartment`. Returns `NULL` if an error arises.

`enum ErrorCode smolAddCompartmentSurface(simptr sim,char *compartment,char *surface);`
Adds surface `surface` as one of the bounding surfaces of compartment `compartment`.

`enum ErrorCode smolAddCompartmentPoint(simptr sim,char *compartment,double *point);`
Adds `point` as one of the interior-defining points of compartment `compartment`.

`enum ErrorCode smolAddCompartmentLogic(simptr sim,char *compartment,enum CmptLogic logic,char *compartment2);`
Modifies the current definition of compartment `compartment` using a logical rule specified in `logic` and the definition of `compartment2`.

6.12 Reactions

`enum ErrorCode smolAddReaction(simptr sim,const char *reaction,const char *reactant1,enum MolecState rstate1,const char *reactant2,enum MolecState rstate2,int nproduct,const char **productspecies,enum MolecState *productstates,double rate);`
Adds reaction named `reaction` to the system. This reaction can have up to two reactants, whose species are listed in `reactant1` and `reactant2` and whose states are listed in `rstate1` and `rstate2`. If the reaction has fewer than two reactants, set either or both of `reactant1` and `reactant2` to either `NULL` or an empty string. State the number of reaction products in `nproduct`, list their species in `productspecies`, and list their states in `productstates`. To set the reaction rate, enter it in `rate`; otherwise, enter `rate` as a negative number.

`int smolGetReactionIndex(simptr sim,int *orderptr,char *reaction);`
Returns the index and order for the reaction that is named `reaction`. If the order is known, send in `orderptr` pointing to this value. If it is not known, send in `orderptr` equal to either `NULL` or pointing to a negative number; in this case, it will be returned pointing to the reaction order, if the reaction was found. On failure, this returns the error code, cast as an integer.

`char* smolGetReactionName(simptr sim,int order,int reactionindex,char *reaction);`
Returns the name of the reaction that has reaction order `order` and index `reactionindex` in the string `reaction`. Also returns the result directly. Returns `NULL` if an error arises.

`enum ErrorCode smolSetReactionRate(simptr sim,int order,char *reaction,double rate,int isinternal);`
Set the reaction rate to `rate`. If this value is to be interpreted as an internal reaction rate parameter, meaning the production rate for zeroth order reactions, the reaction probability for first order reactions, or the binding radius for second order reactions, then set `isinternal` to 1. Rather than calling this

function at all, it's usually easier to use the `rate` parameter of the `smolAddReaction` function, although that doesn't cope with internal rate values.

`enum ErrorCode smolSetReactionRegion(simptr sim,const char *reaction,const char *compartment,const char *surface);`
Limits the spatial region where a reaction can take place to the compartment `compartment` and/or the surface `surface`. To not set one of these limits, enter `compartment` and/or `surface` as `NULL`. To remove a previously set limit, enter `compartment` and/or `surface` as the empty string, "".

`enum ErrorCode smolSetReactionProducts(simptr sim,const char *reaction,enum RevParam method,double parameter,const char *product,double *position);`
Sets the reaction product parameters for reaction `reaction`. At a minimum, the `method` reversible parameter is required. Most of these methods require a single parameter, entered in `parameter`. A few methods also require a product, in `product` and the relative position of this product in `position`.

method	parameter	product	position
RPnone	-	-	-
RPirrev	-	-	-
RPconfspread	-	-	-
RPbounce	σ_u	-	-
RPpgem	ϕ	-	-
RPpgemmax	ϕ_{max}	-	-
RPpgemmaxw	ϕ_{max}	-	-
RPratio	σ_u/σ_b	-	-
RPunbindrad	σ_u	-	-
RPpgem2	ϕ	-	-
RPpgemmax2	ϕ_{max}	-	-
RPratio2	σ_u/σ_b	-	-
RPoffset	-	product number	relative position
RPfixed	-	product number	relative position

If `method` is `RPbounce`, then a negative number for the `parameter` indicates default bounce behavior, which is that molecules are separated by an amount that is equal to their previous overlap.

6.13 Ports

`enum ErrorCode smolAddPort(simptr sim,const char *port,const char *surface,enum PanelFace face);`
Adds a port to the simulation. The port will be named `port` and will port at the `face` face of surface `surface`.

`int smolGetPortIndex(simptr sim,const char *port);`
Returns the index of the port named `port`.

`char* smolGetPortName(simptr sim,int portindex,char *port);`
Returns the name of the port with index `portindex`, both directly and in `port`.

`enum ErrorCode smolAddPortMolecules(simptr sim,const char *port,int nmolec,const char *species,double **positions);`
Adds `nmolec` molecules to Smoldyn's import buffer of port `port`. These molecules will all have species `species` and state `MSsoln`. Enter `positions` as `NULL` to have the molecules positioned randomly over the porting surface and as an `nmolec` length list of position vectors to have them located at those specific initial positions. These initial positions should be close to the porting surface, and on the Smoldyn system side of it.

`int smolGetPortMolecules(simptr sim,const char *port,const char *species,enum MolecState state,int remove);`

Returns the number of molecules that are in Smoldyn's export buffer of port `port`. Enter `species` with the species of the molecules that should be retrieved, or "all" for all species. Enter `state` with the states of the molecules that should be retrieved, or `MSall` for all states. Enter `remove` with 1 to remove molecules from the export buffer after they are retrieved or with 0 to leave them in the buffer. If an error arises, this returns the error code cast as an integer.