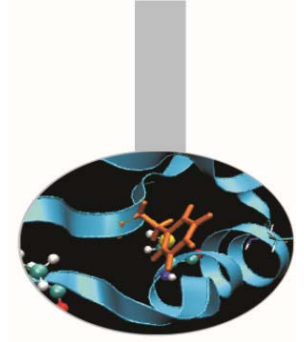


# Blender

**Francesca Delli Ponti** - [f.delliponti@cineca.it](mailto:f.delliponti@cineca.it)  
SuperComputing Applications and Innovation Department



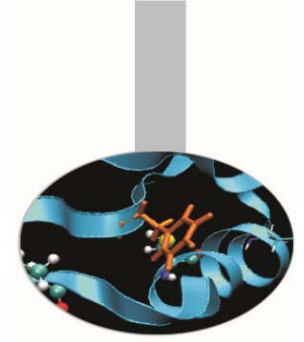


## BLENDER HISTORY

“Blender is a professional free and open-source 3D computer graphics software product used for creating animated films, visual effects, art, 3D printed models, interactive 3D applications and video games. Blender's features include 3D modeling, UV unwrapping, texturing, raster graphics editing, rigging and skinning, fluid and smoke simulation, particle simulation, soft body simulation, sculpting, animating, match moving, camera tracking, rendering, video editing and compositing. It further features an integrated game engine.”

[http://en.wikipedia.org/wiki/Blender\\_\(software\)](http://en.wikipedia.org/wiki/Blender_(software))





## BLENDER HISTORY

“The Dutch animation studio Neo Geo and Not a Number Technologies (NaN) developed Blender as an in-house application. The primary author was Ton Roosendaal, who previously wrote a ray tracer called Traces for Amiga in 1989. The name Blender was inspired by a song by Yello, from the album Baby.

Rosendaal founded NaN in June 1998 to further develop and distribute the program.

... The Blender Foundation initially reserved the right to use dual licensing, so that, in addition to GNU GPL, Blender would have been available also under the Blender License that did not require disclosing source code but required payments to the Blender Foundation. However, they never exercised this option and suspended it indefinitely in 2005. [5] Currently, Blender is solely available under GNU GPL.

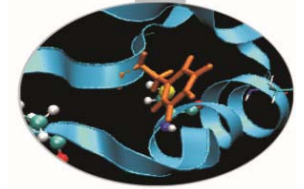
### *Suzanne*

... As a sort-of easter egg, a last personal tag, the artists and developers decided to add a 3D model of a chimpanzee. It was created by Willem-Paul van Overbruggen (SLiD3), who named it Suzanne after the orangutan in the Kevin Smith film Jay and Silent Bob Strike Back.

Suzanne is Blender's alternative to more common test models such as the Utah Teapot and the Stanford Bunny. A low-polygon model with only 500 faces, Suzanne is often used as a quick and easy way to test material, animation, rigs, texture, and lighting setups, and is also frequently used in joke images[citation needed]. Suzanne is still included in Blender. The largest Blender contest gives out an award called the Suzanne Awards.”

[http://en.wikipedia.org/wiki/Blender\\_\(software\)](http://en.wikipedia.org/wiki/Blender_(software))





## BLENDER FOUNDATION

BLENDER

<http://www.blender.org>

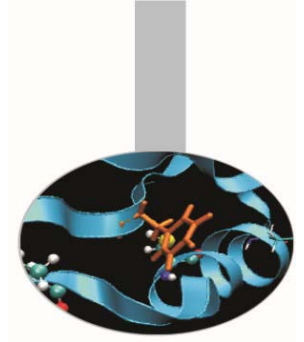
<https://www.blender.org/features/>

<http://www.blender.org/features/projects/>



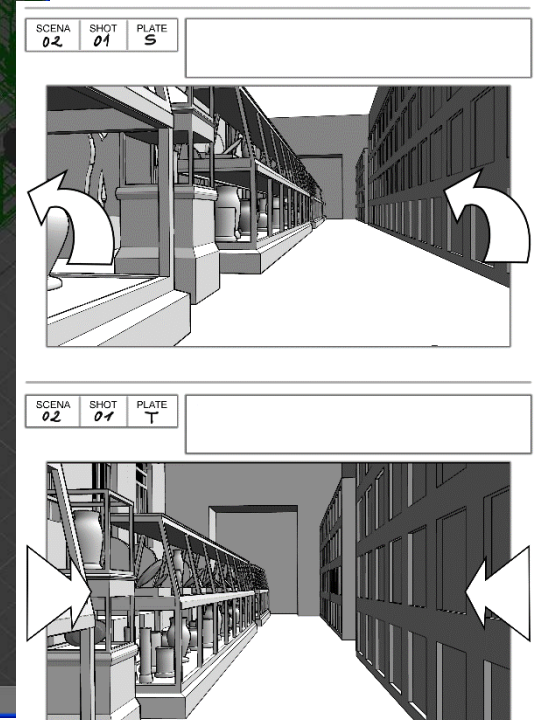
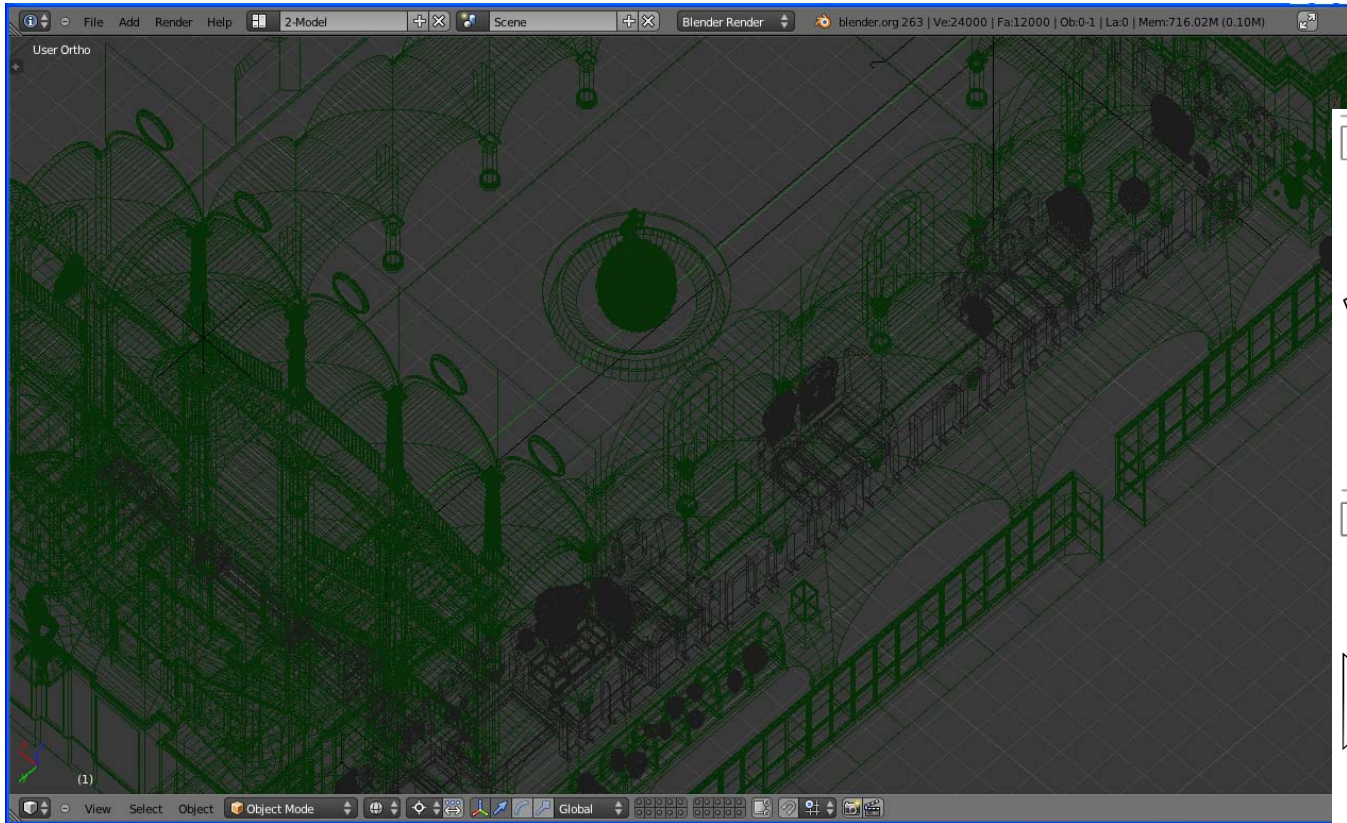
<http://gooseberry.blender.org/>



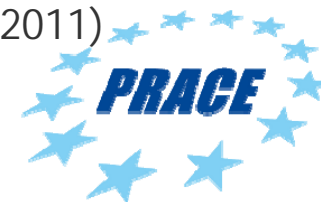


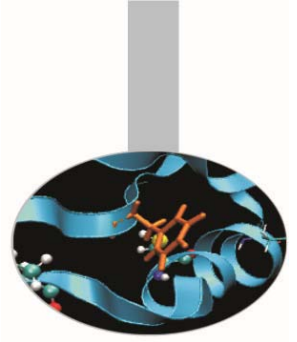
# BLENDER - CINECA APPLICATIONS

- SCENE:



Apa the Etruscan and 2700 years of Bolognese History  
(in ACM SIGGRAPH ASIA 2011, Posters and Sketches Proceedings, Hong Kong, 2011)





## BLENDER - CINECA APPLICATIONS

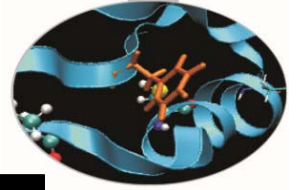
- RENDER:



Apa the Etruscan and 2700 years of Bolognese History  
(in ACM SIGGRAPH ASIA 2011, Posters and Sketches Proceedings, Hong Kong, 2011)

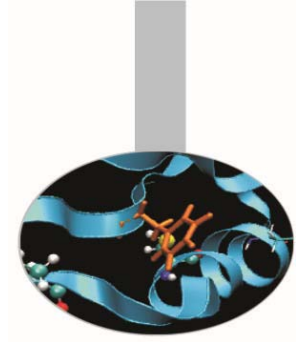
<http://www.cineca.it/it/video/apa-alla-scoperta-di-bologna-i-primi-minuti-del-cartoon-3d>





# Blender 2.78





## WHY BLENDER?

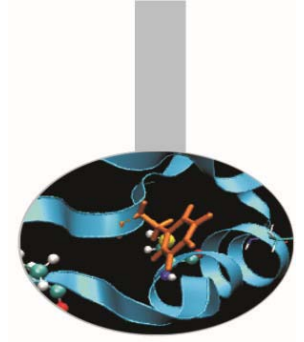
Integrate features of scientific software that not have visualization as main purpose

Moreover:

- open source software (no cost to use it)
- many features (now it could be consider a complete software)
- if something is missing, a large community continuously solves problems and add features and specific modules







## ALTERNATIVE

Many external renderers exist, for scientific purpose is wide used

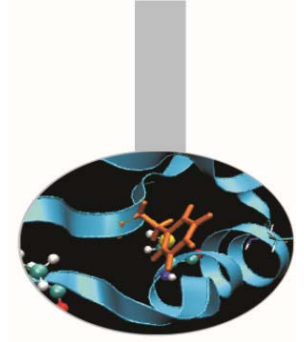
POV-RAY

<http://www.povray.org/>

“It is a ray tracing program which generates images from a text-based scene description” and it “does not include a modeling feature; it is essentially a pure renderer with a sophisticated model description language.”

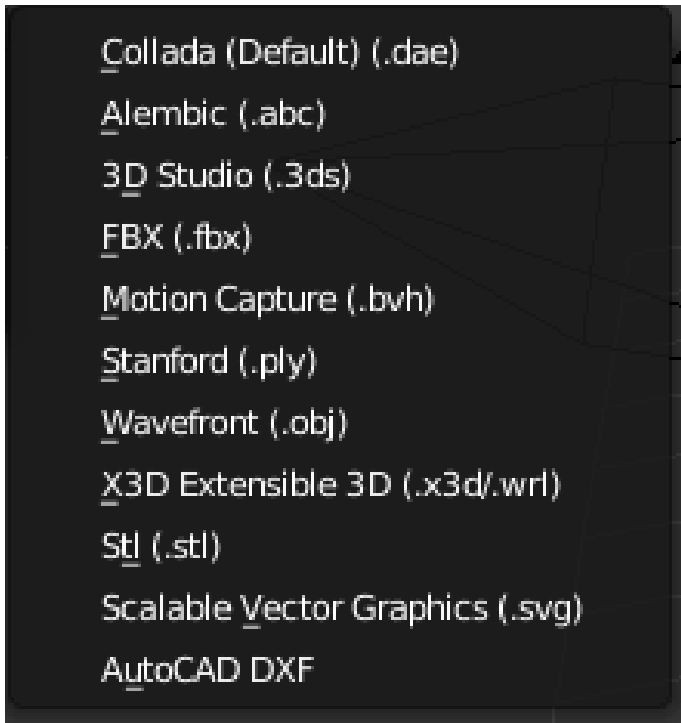
<https://en.wikipedia.org/wiki/POV-Ray>

Blender has much more possibility than a simply renderer!



## HOW TO EXCHANGE FILES

Blender has many format files that could be imported:



just some examples, but the format files that give best result are:

- Obj
- X3d
- Stl (only for geometry)



# HOW TO EXCHANGE FILES

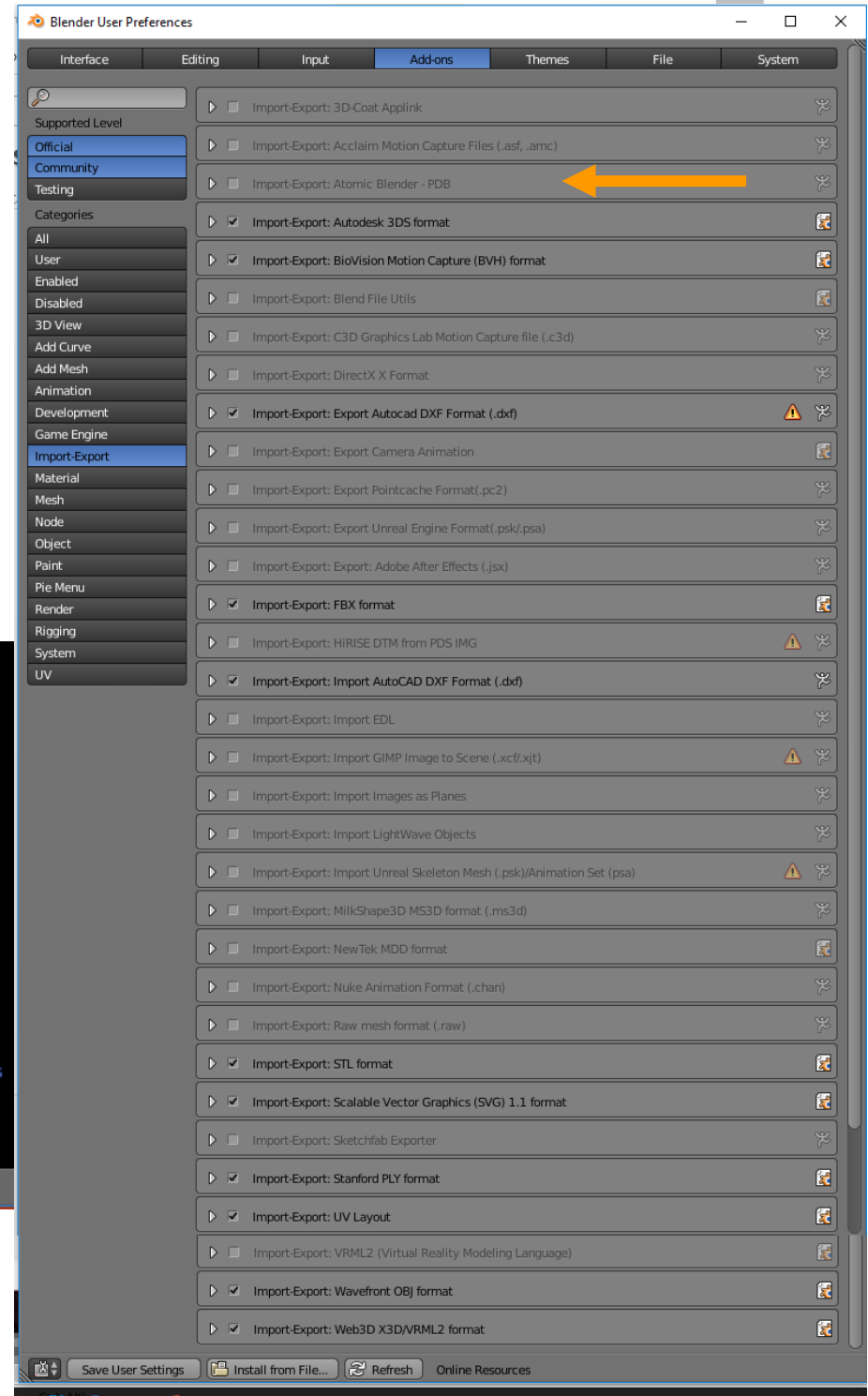
Others modules for different format files could be activated

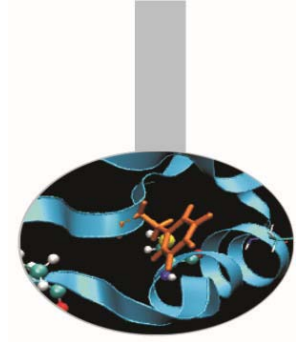


Or programmed using the Blender python console



```
PYTHON INTERACTIVE CONSOLE 3.5.1 (default, Feb 17 2016, 17:09:19) [MSC v.1800 64 bit (AMD64)]  
  
Command History:      Up/Down Arrow  
Cursor:              Left/Right Home/End  
Remove:              Backspace/Delete  
Execute:             Enter  
Autocomplete:        Ctrl-Space  
Zoom:                Ctrl +/-, Ctrl-Wheel  
Builtin Modules:     bpy, bpy.data, bpy.ops, bpy.props, bpy.types, bpy.context, bpy.utils, bgl, blf, mathutils  
Convenience Imports: from mathutils import *; from math import *  
Convenience Variables: C = bpy.context, D = bpy.data  
  
>>> |
```

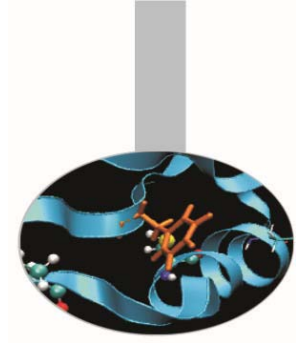




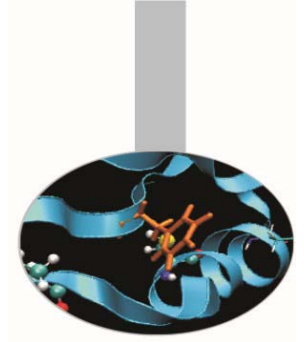
## PROBLEMS

Every software has its specific format file to export models and simulations, so tests are fundamental!!!!

Furthermore not always the object created in a specific software could be exported correctly or at all.



# Basis of Modeling

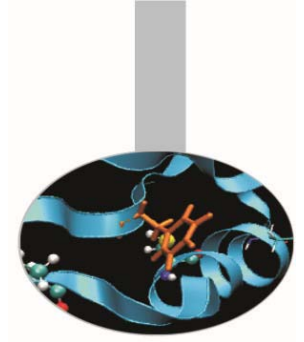


## SCENE

The scene includes points, lines and polygons, they all exist inside a three dimensions space defined by X, Y, Z axis.

In order to compose a scene is necessary:

- define 3D object geometry - OBJECT MODELING
- define texture and material of all objects - SHADING AND TEXTURING
- define scene light for realistic final render - LIGHTING
- realize frame (RENDERING) or export created models in format file for real time navigation



## OBJECT MODELING

- 3D models created with Blender
- 3D models created with others software and imported in Blender
- 3D models from laser scanner

software to manage point clouds

<http://meshlab.sourceforge.net/>

- 3D models from photographs

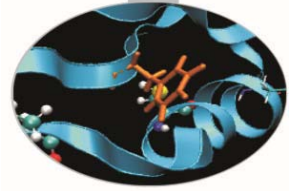
software to create models from photographs

<http://www.photomodeler.com>

<http://www.arc3d.be/>

<http://www.agisoft.com/>





## EXAMPLES OF IMPORTED MODELS

Terrain:

-terrain created with osgdem

<http://openscenegraph.sourceforge.net/documentation/OpenSceneGraph/doc/osgdem.html>

-building with the software City Engine

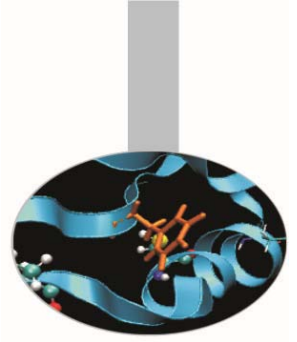
<http://www.esri.com/software/cityengine>



exchange format file: obj



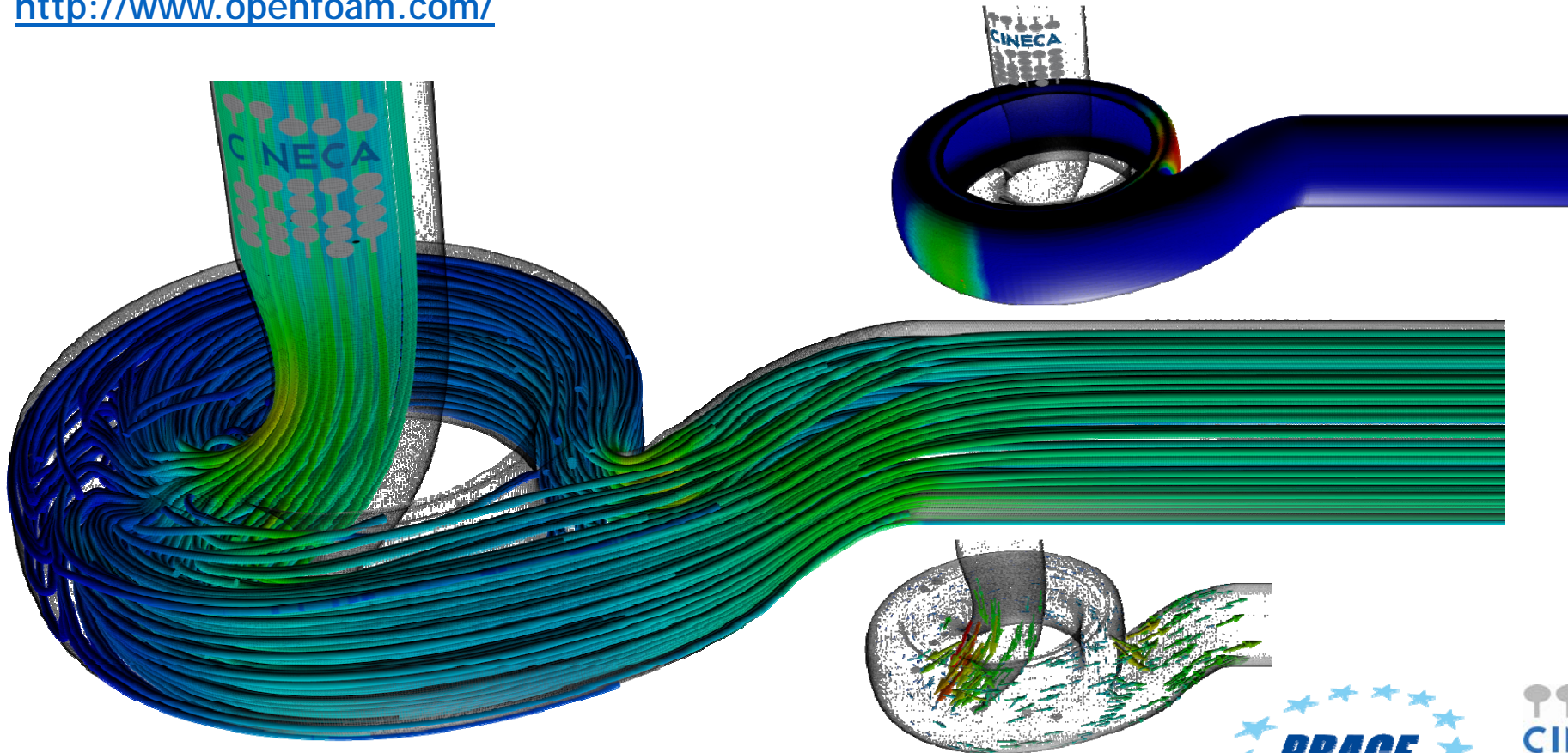




## EXAMPLES OF IMPORTED MODELS

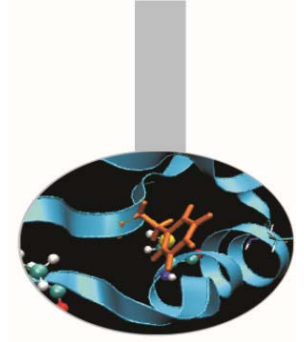
Fluid Dynamics simulation:

-Pump and its flow inside, the model and the simulation were made in OpenFOAM  
<http://www.openfoam.com/>



exchange format file: x3d





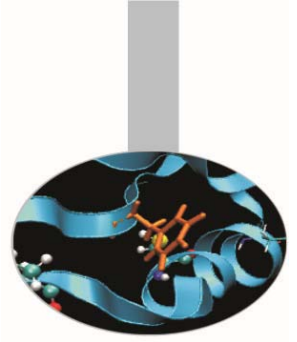
# EXAMPLES OF IMPORTED MODELS

Fluid Dynamics simulation:

-Simulation of hull movement during navigation, made in OpenFOAM  
<http://www.openfoam.com/>

exchange format file: x3d





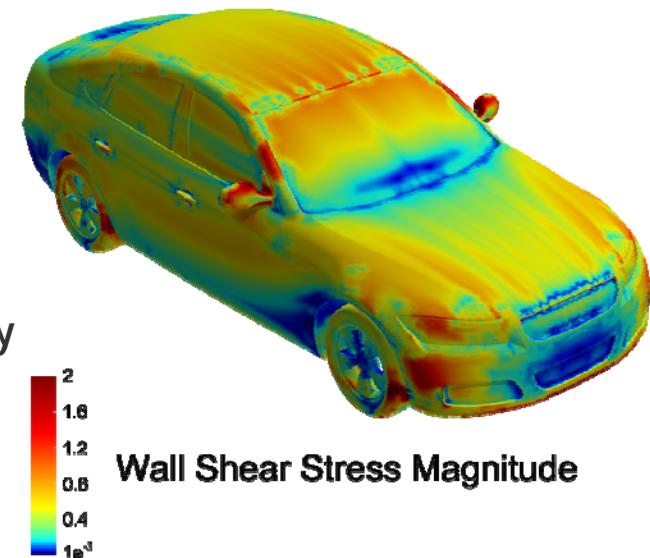
## EXAMPLES OF IMPORTED MODELS

Cars model simulation:

The reconstructed wall shear stress through Reduced Order Modelling on DrivAer model (ezRB), courtesy of Angela Scardigli and Haysam Telib - Optimad engineering srl, Filippo Salmoiraghi and Gianluigi Rozza - SISSA mathLab

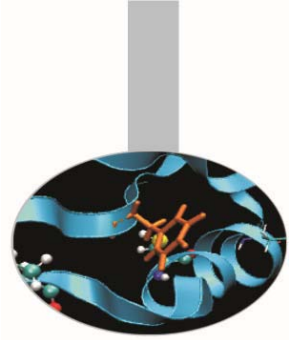
- Model and simulation were made by OpenFOAM  
<http://www.openfoam.com/>

The exported file from OpenFOAM was in VTK (<http://www.vtk.org/>), this couldn't be imported directly inside Blender, we passed through Paraview (<http://www.paraview.org/>) in order to have a model readable in Blender.



exchange format file: VTK → elaboration in Paraview → x3d Blender input file



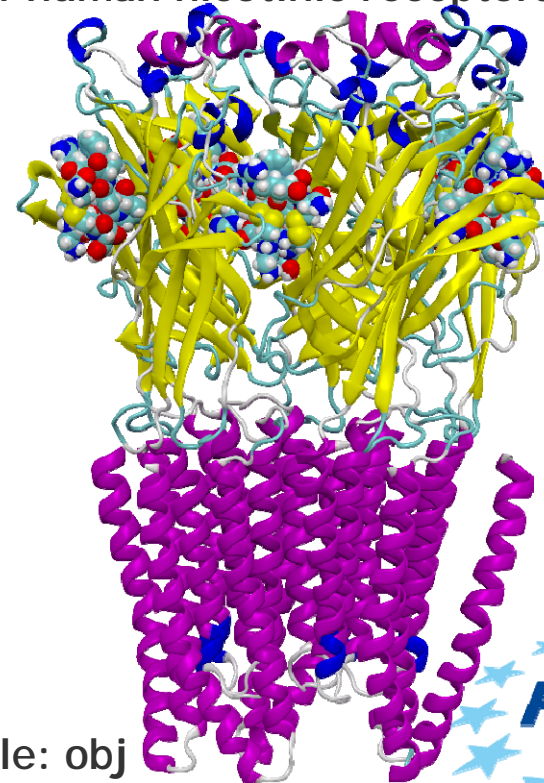
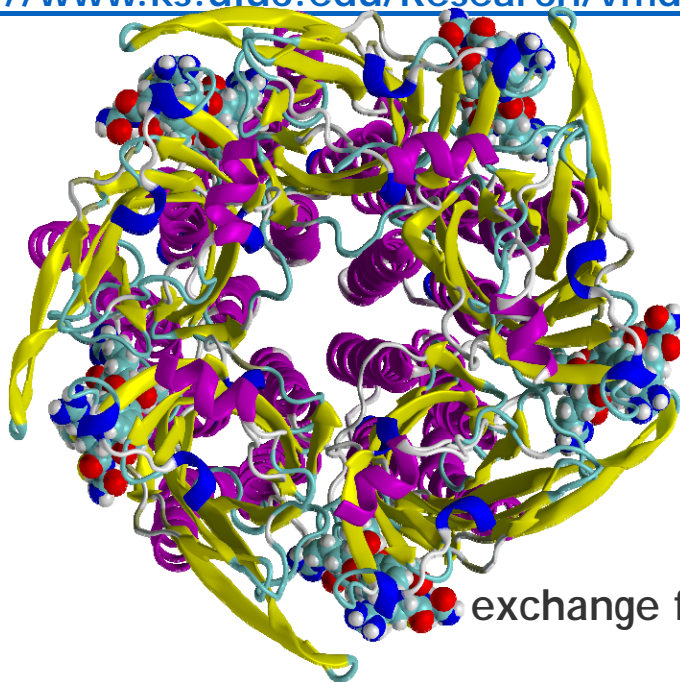


## EXAMPLES OF IMPORTED MODELS

Molecule:

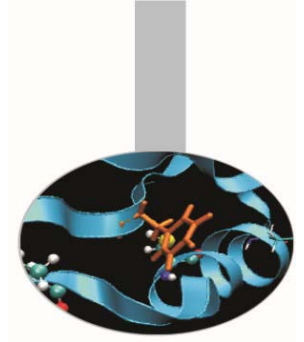
New homology model of human alpha7 nicotinic receptor generated by using the open TMD of the glutamate receptor (PDB entry: 3RIF) and the conotoxin-bound AChBP (PDB entry: 2BYP) to model the LBD. Conotoxin in vdw representation. Thanks to: Letizia Chiodo, Therese Malliavin, Luca Maragliano, Grazia Cottone, Giovanni Ciccotti IS CRA Project HP10BEFJB6 :“Large scale motions in models of human nicotinic receptors”

- The model was made in VMD  
<http://www.ks.uiuc.edu/Research/vmd/>



exchange format file: obj





# OBJECT MODELING

## 3D MODELS

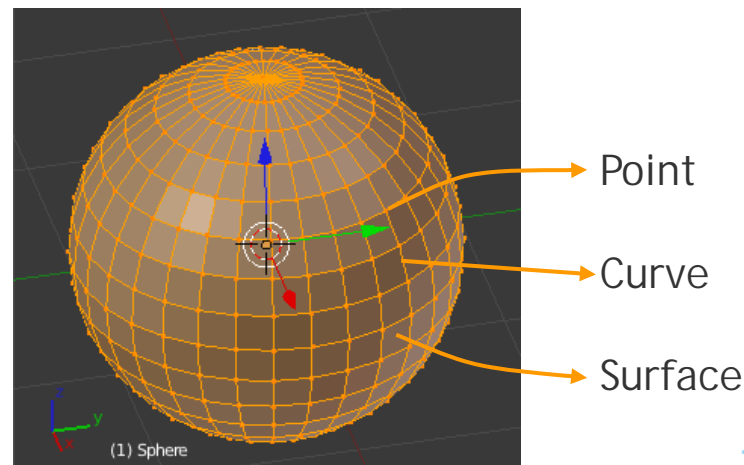
### 3D MODELS

a representation of 3D OBJECTS by using points connected each others by curves that define surfaces like triangles, quadrilaterals or other type.

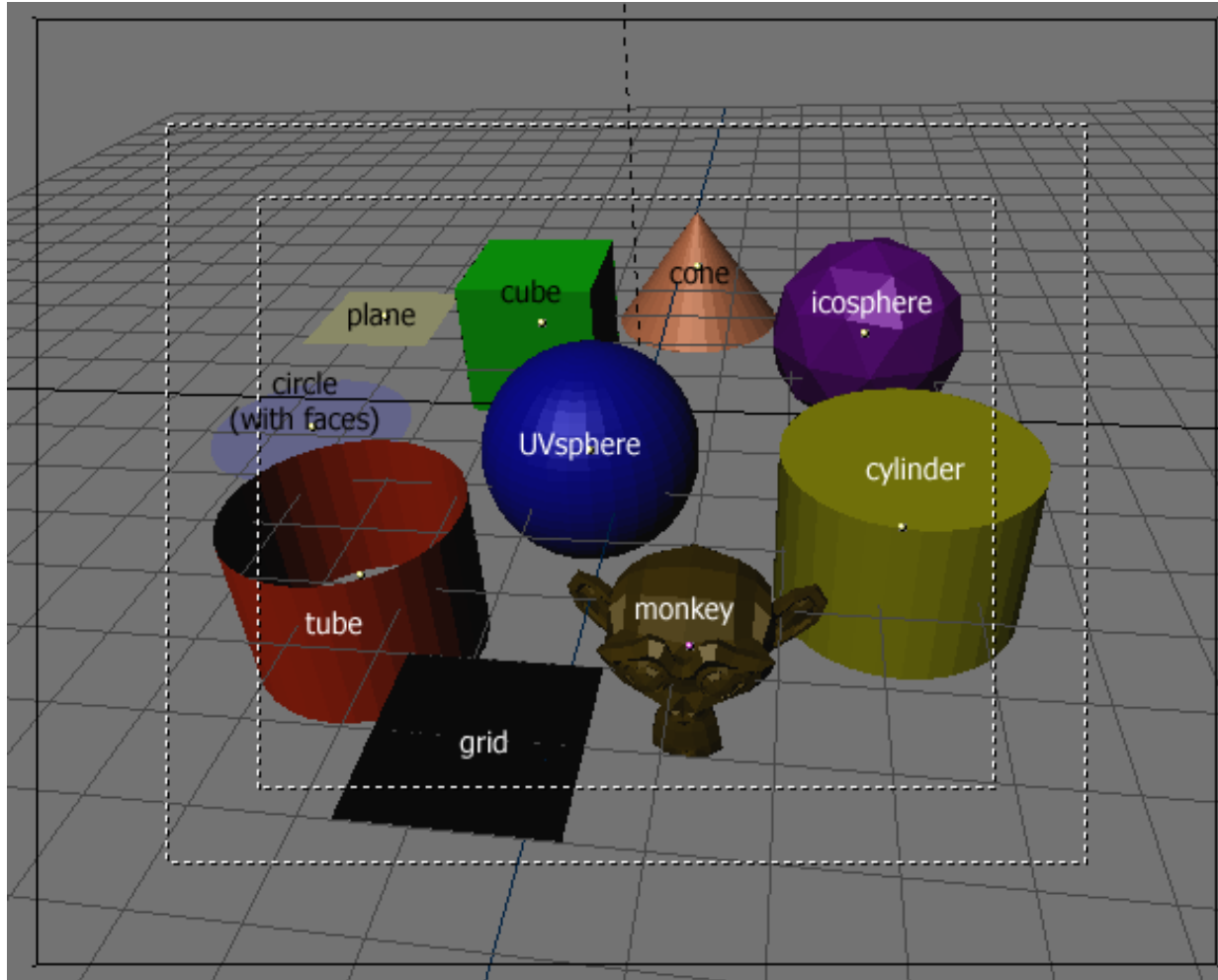
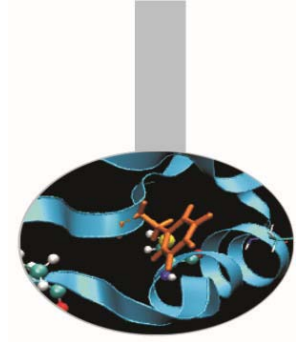
A number of polygons linked together is called polymesh (mesh) and so can define a 3D object.

The coordinates are the geometric information, while the way in which the faces are made from the vertices are the topological information.

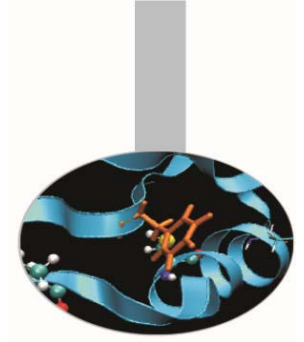
→ The set of faces is called Mesh.



# BLENDER MESH PRIMITIVES



## OBJECT MODELING



- **Box modeling**

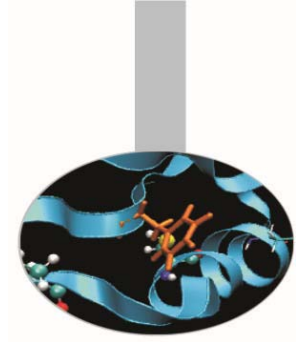
Suited for simple and organic shapes

Starting from simple Mesh type objects (i.e. cube, sphere, ...) by changing vertices, edges and/or polygons 3D complex object can be created

- **Spline modeling**

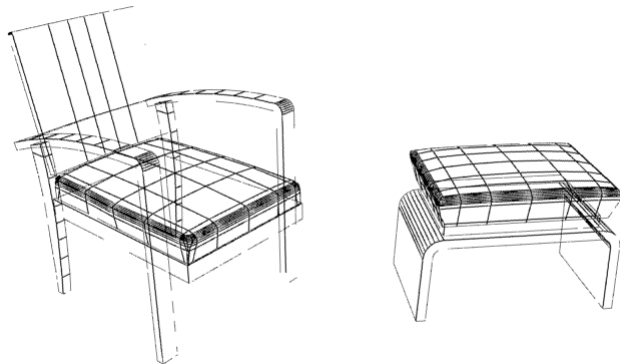
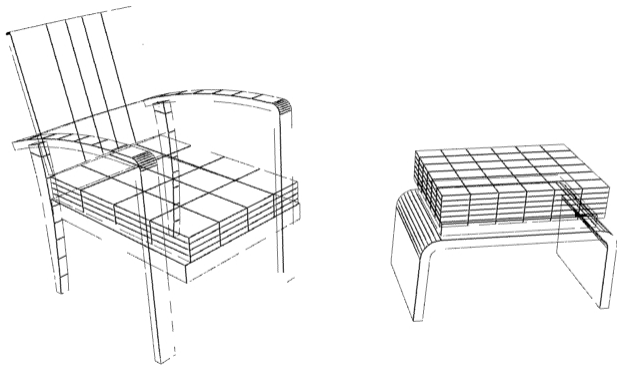
Suited for the design and mechanical models

Starting from a 2D Spline, like a building's plant, with specific operations like extrusion it is possible to obtain 3D object

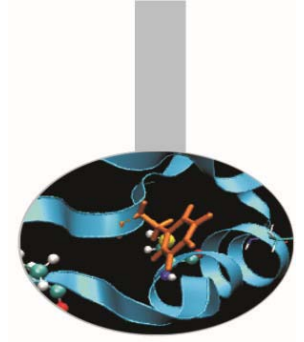


# OBJECT MODELING

Example of BOX MODELING from "MUVI", house of the Thirties



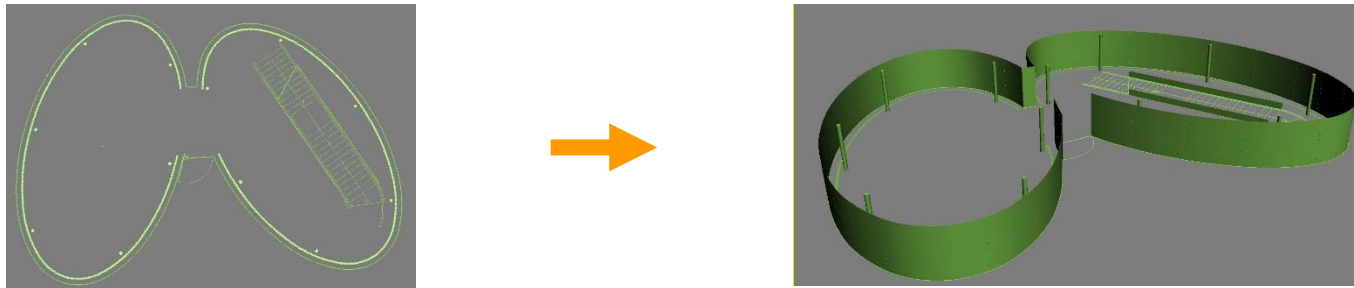




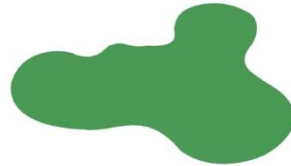
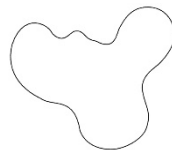
# OBJECT MODELING

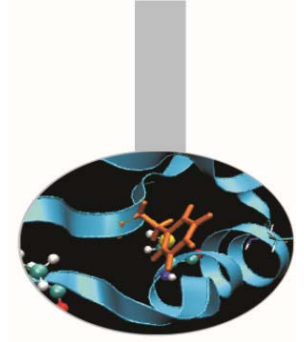
Example of SPLINE MODELING, extruded surface:

surface created by extending a curve along a direction.



Example of extruded surface from "MUVI", house of the Thirties:

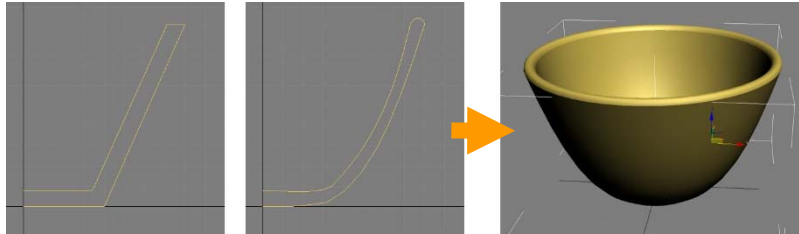




# OBJECT MODELING

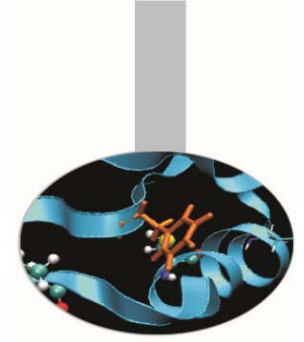
Example of SPLINE MODELING, revolved surface:

surface created using a simple curve, which is rotated about an axis to define a shape.



Example of revolved surface from "MUVI", house of the Thirties:





## SHADING

Each object must be better identified with its own material.

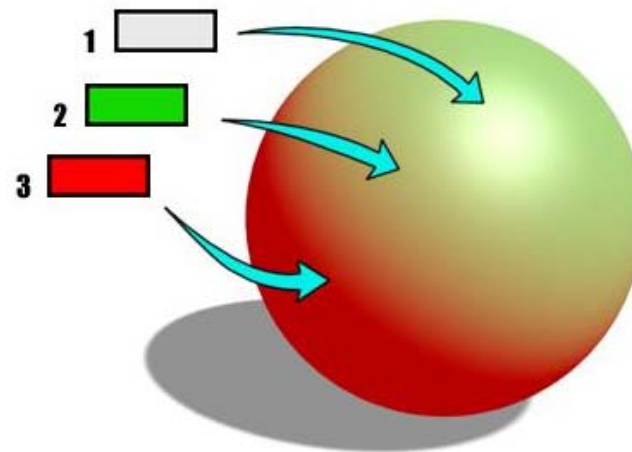
In particular, the material must be defined with different attribute and properties, which identify the material behavior to light.

The shadow and the light parts make an object appear three-dimensional, other information, such as transparency, refraction, roughness or smoothness, give more information of objects.

The following are lighting components:

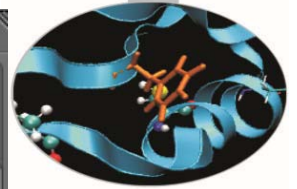
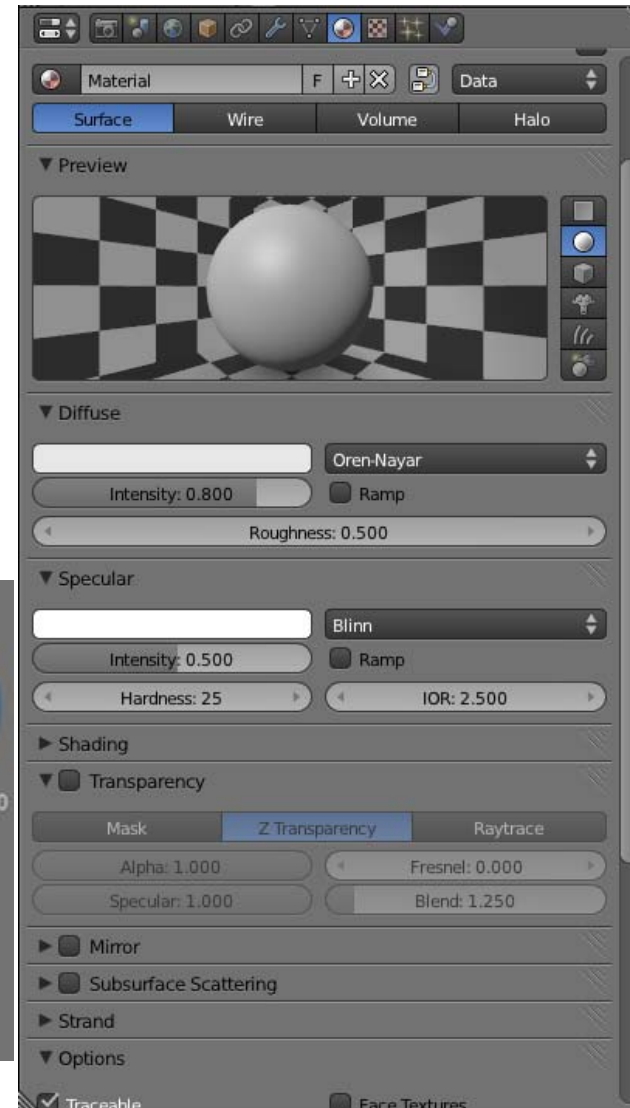
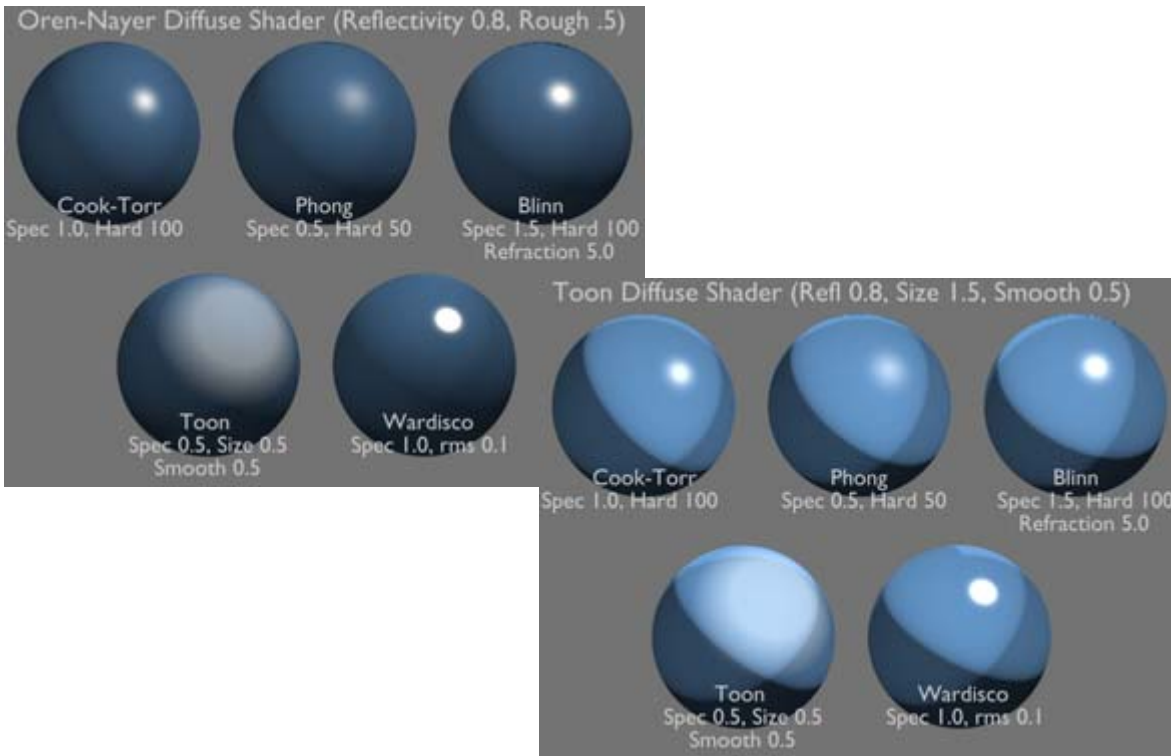
- Ambient (3), color of the shaded part of the material that is still affected by the indirect light;
- Diffuse (2), color of the part directly affected by the light;
- Specular (1), color of the part of a glossy object.

In reality,  
Ambient and Diffuse  
are the same color!

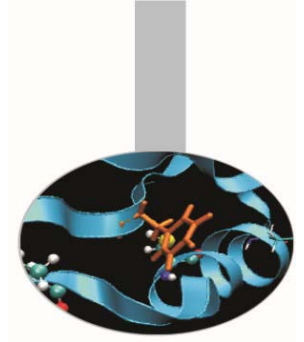


# SHADING

Examples of Blender shading:



[http://wiki.blender.org/index.php/Doc:2.4/Manual/Materials/Properties/Diffuse\\_Shaders](http://wiki.blender.org/index.php/Doc:2.4/Manual/Materials/Properties/Diffuse_Shaders)

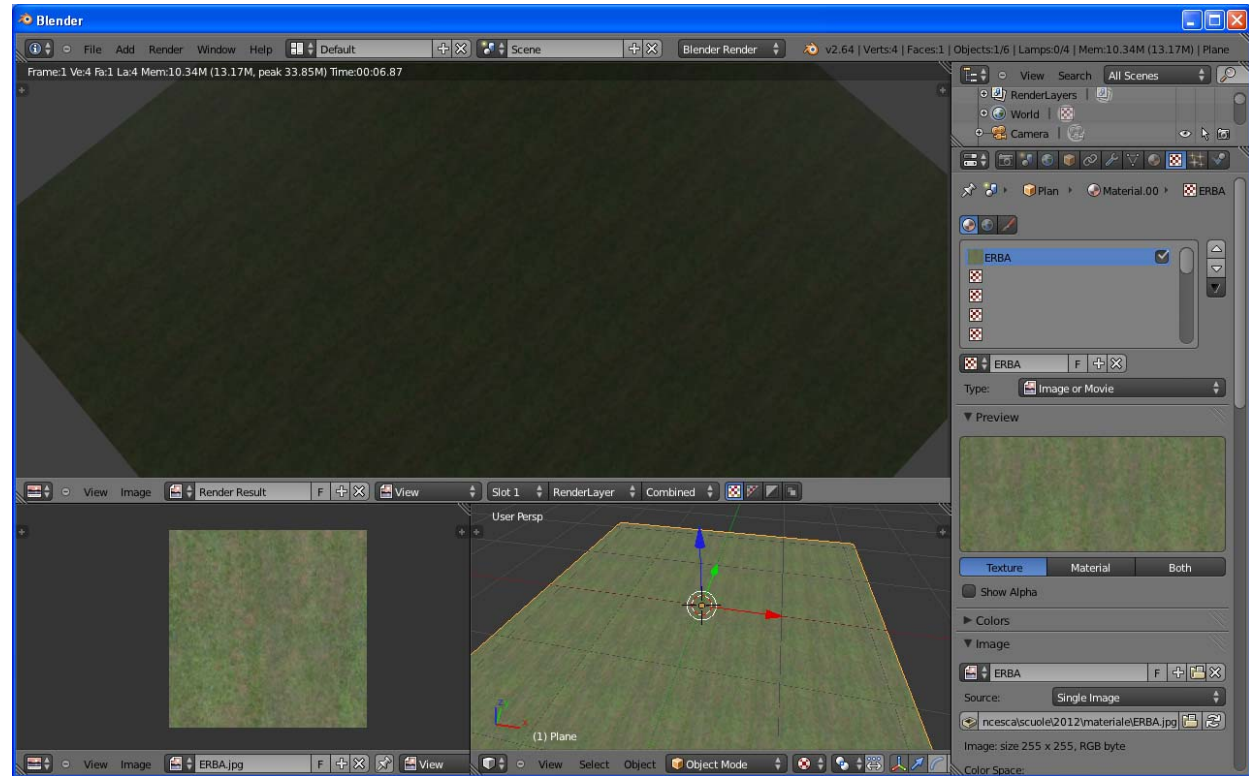


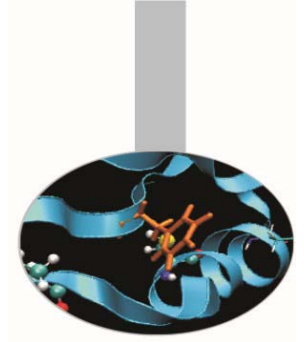
# TEXTURING

Example of texture bitmap



The texture must be elaborated in order to have continuity up-down and left-right to be able to be repeated it over the entire object without discontinuity.



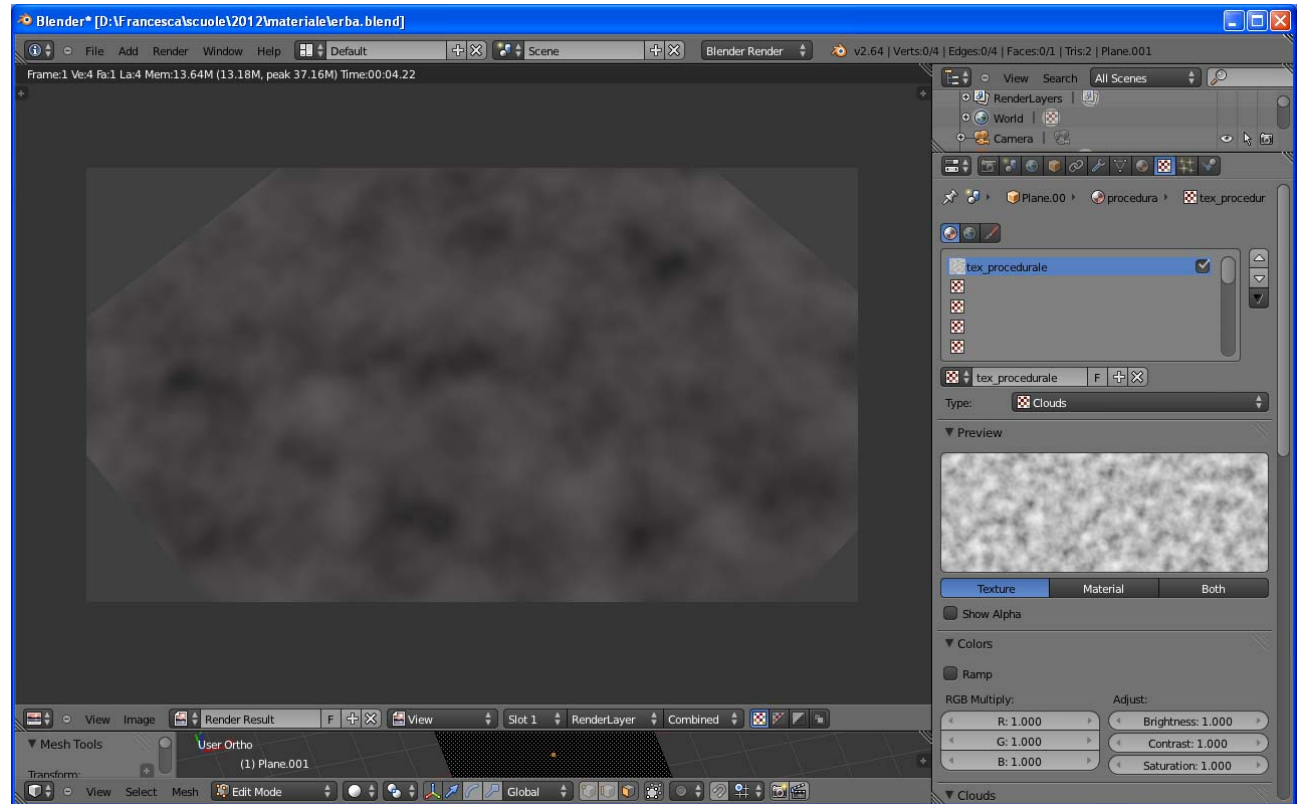
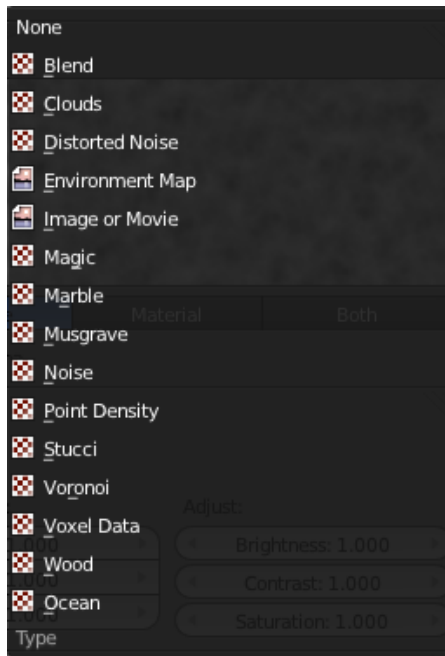


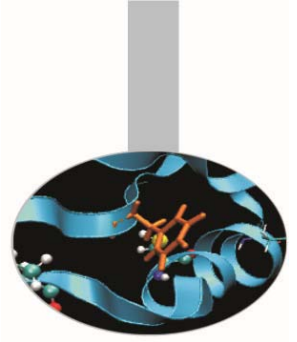
# TEXTURING

## Procedural texture

a computer-generated image created using an algorithm in order to create a realistic representation of natural elements.

### Blender procedural texture:

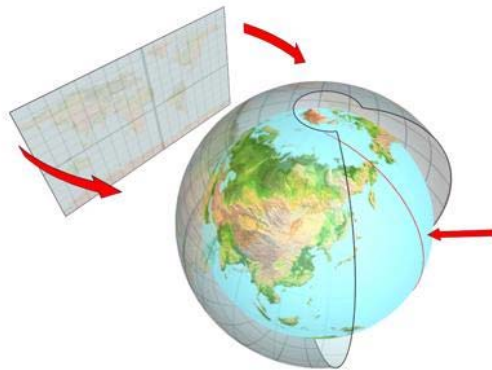




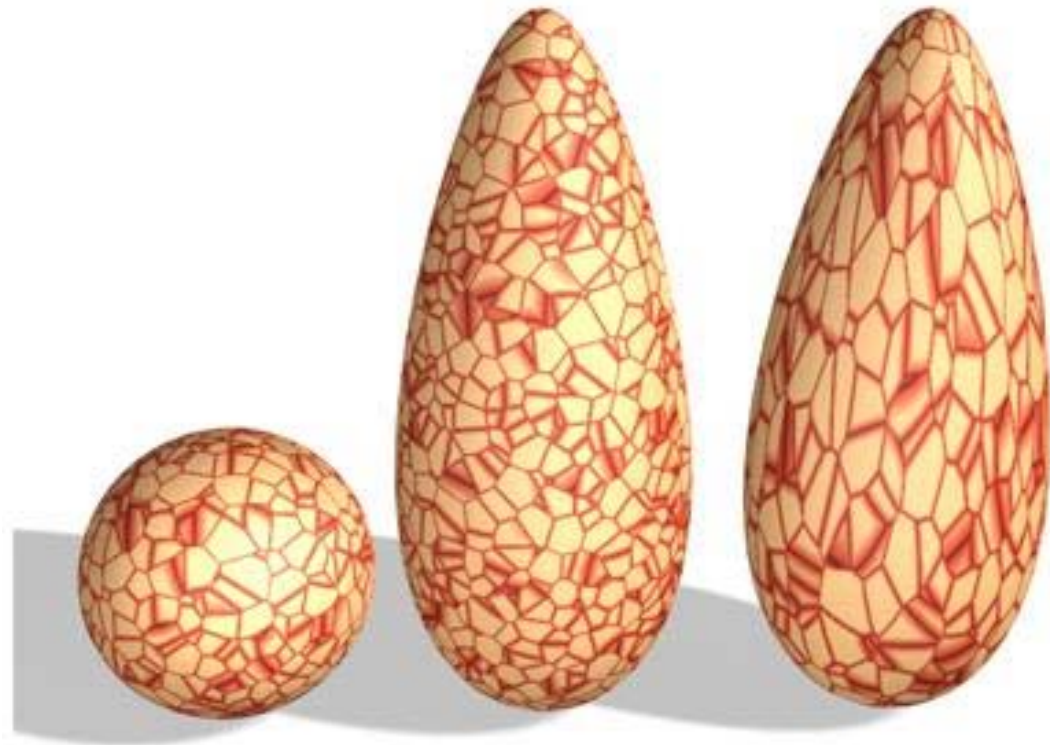
# TEXTURING

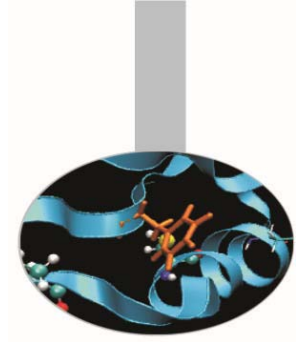
In order to correctly apply a texture must be set up texture coordinates, that define how is visualize on a object:

- projection method,
- orientation,
- repetition.



Example of a spheric projection



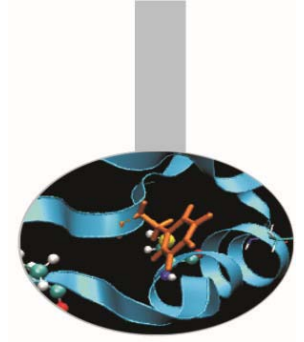


# SHADING/TEXTURING

Example from "MUVI", house of the Thirties



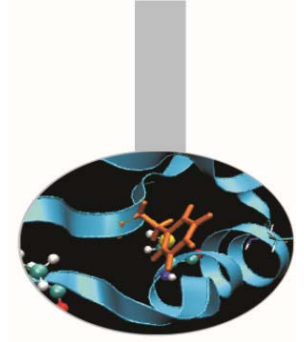




## SHADING/TEXTURING

Example from "MUVI", house of the Eighties





## LIGHTING

Lighting is a necessary step and is recommended even before the definition of the materials, in this way (with neutral material for all objects in the scene) can be better valuated the effect of the lights.

Below three general types of light that can be used:

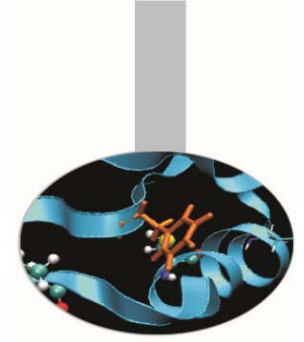
- **Omni** (points of light that emit in all directions);
- **Spot** (cones of light used for simulate lamps or projectors);
- **Direct** (cylinders of light, usually used to simulate sunlight).

Each light can be customized by location and illumination intensity parameters, like decay, color, ...

For real-time navigation is useful to develop the textures so that they contain lighting and rendering information through a procedure called Render to Texture:

shadows and multi-texture are compacted into a single texture.





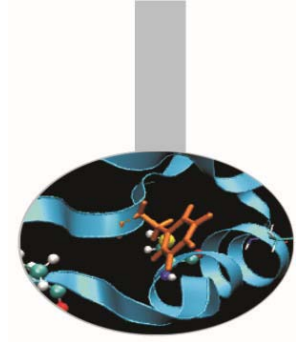
## RENDERING

The set of operations required to transform a three-dimensional model (all 3D objects in the scene and their properties) in a two-dimensional visual representation (bitmap), depending on the view parameters and the type of the chosen mode of visual presentation .

By using algorithms that allow to make the effects of **Global Illumination** it is possible to achieve realistic effects of the scene.

**GLOBAL ILLUMINATION definition:**

It is a method (algorithm) of computation for light calculation in the scene which, takes in to account the light bounces from the neighboring surfaces, along with the normal illumination of direct lights. In Other words GI calculates the Indirect light also, thus it makes the renders more photo-realistic.



## RENDERING

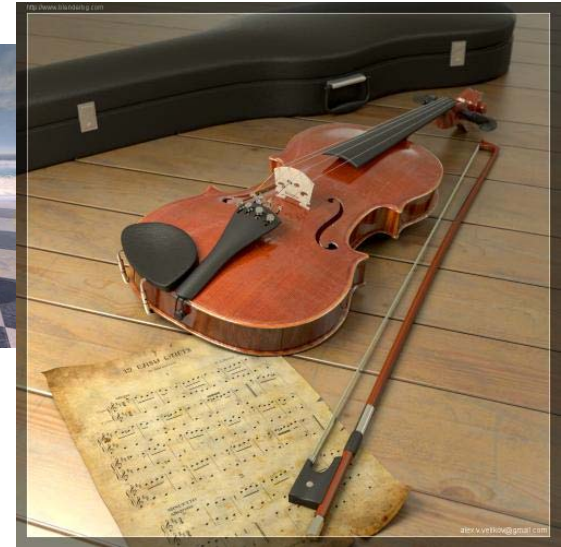
YafaRay

<http://www.yafaray.org/>



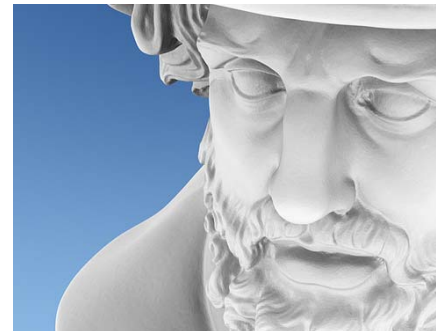
LuxRender

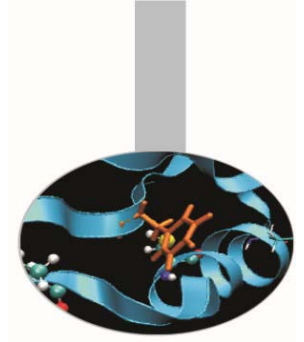
<http://www.luxrender.net/>



Aqsis Renderer

<http://www.aqsis.org/>





## RENDERING

Blender has two type of render:

- Blender Render
- Cycles Render

Blender now features a powerful new unbiased rendering engine called Cycles that offers stunning ultra-realistic rendering. The built-in Cycles rendering engine offers:

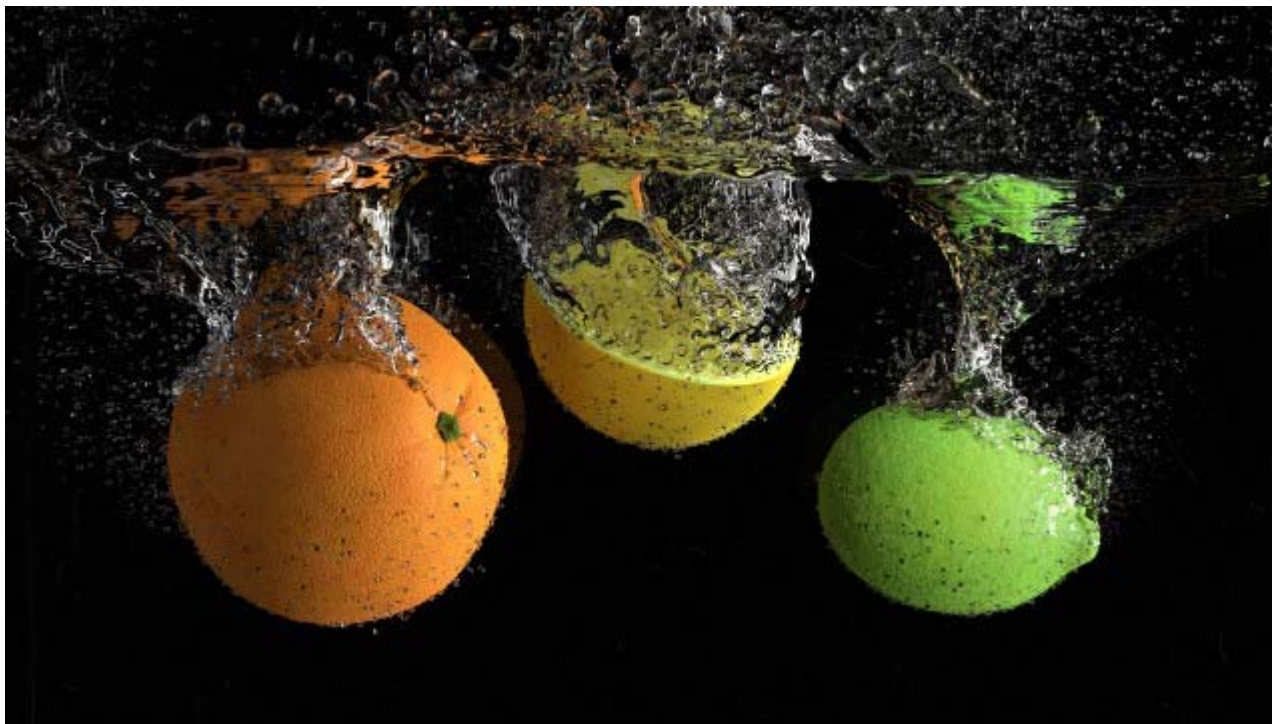
Photorealistic Rendering

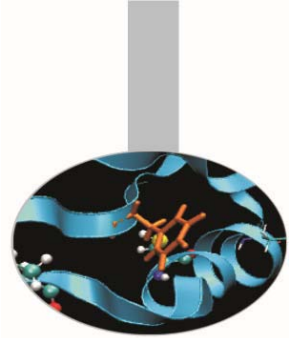
GPU & CPU rendering

Realtime viewport preview

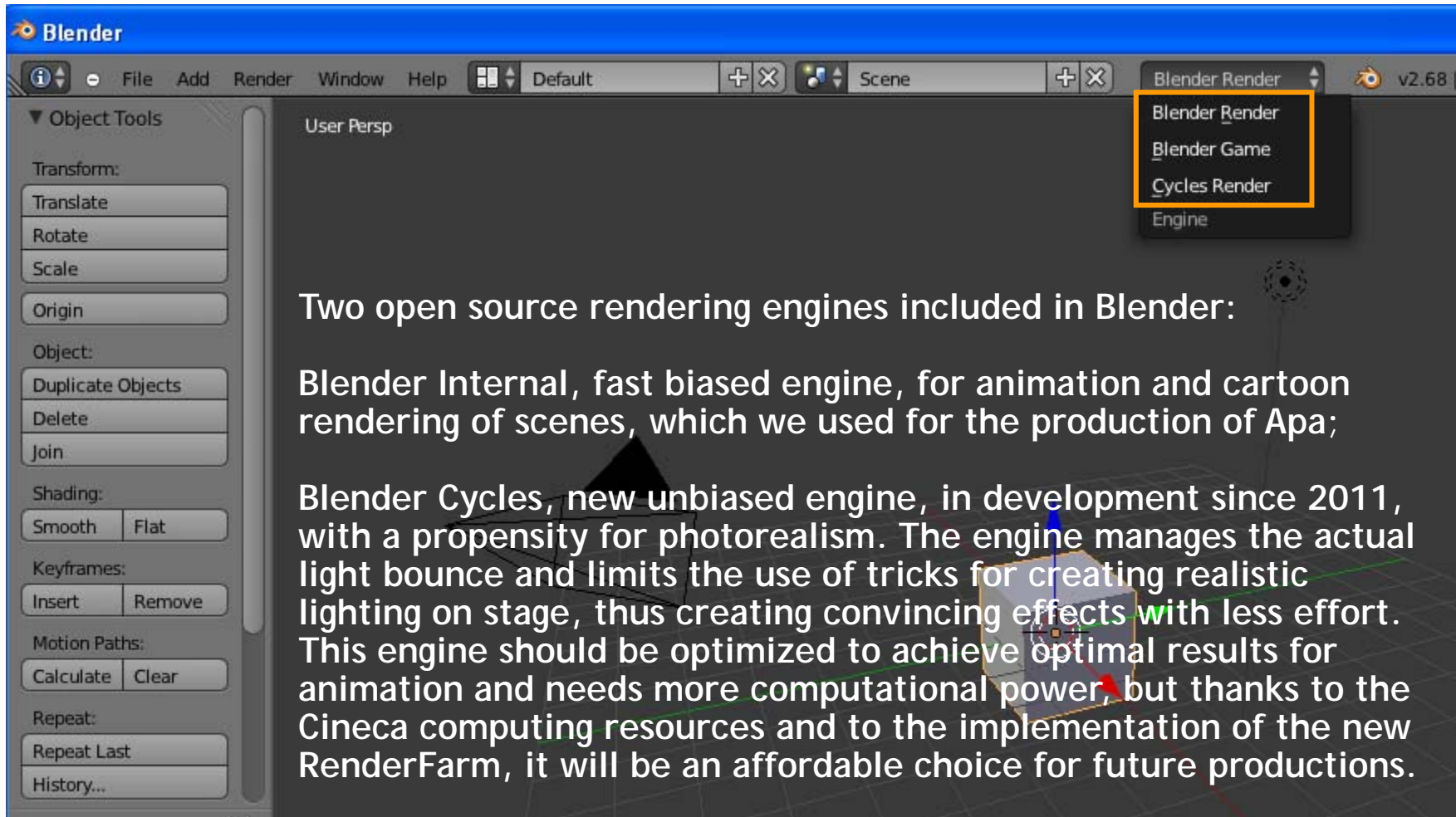
HDR lighting support

Permissive License for linking with external software





# RENDERING

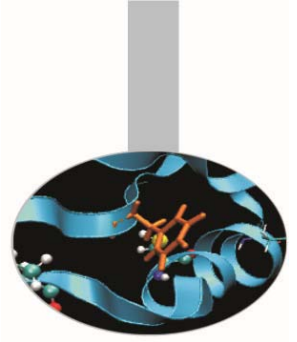


Two open source rendering engines included in Blender:

Blender Internal, fast biased engine, for animation and cartoon rendering of scenes, which we used for the production of Apa;

Blender Cycles, new unbiased engine, in development since 2011, with a propensity for photorealism. The engine manages the actual light bounce and limits the use of tricks for creating realistic lighting on stage, thus creating convincing effects with less effort. This engine should be optimized to achieve optimal results for animation and needs more computational power, but thanks to the Cineca computing resources and to the implementation of the new RenderFarm, it will be an affordable choice for future productions.



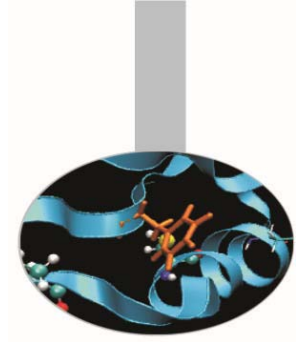


## REAL TIME - RENDER TO TEXTURE

### Render to Texture

This operation allows to precompute light and shadow information on the individual objects, necessary for real-time navigation.





## WEB

By exporting models in format x3d it is possible to put the model in a html page and navigate it freely (<http://www.x3dom.org/> ).

[https://hpc-forge.cineca.it/files/visit\\_3Dmodels/public/ChiostroIII\\_X3D/ChiostroIII.html](https://hpc-forge.cineca.it/files/visit_3Dmodels/public/ChiostroIII_X3D/ChiostroIII.html)

### MUSEO VIRTUALE DELLA CERTOSA: Chiostro III

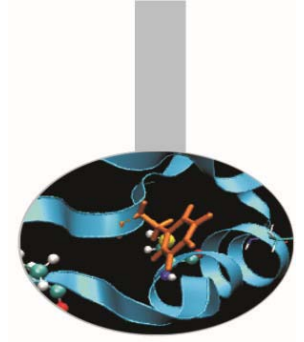
Prove di navigazione del modello in x3d.



Lato EST | Tomba Ulivi | Inizio lato SUD | Lato SUD | Lato SUD-OVEST | Lato OVEST | Lato NORD-OVEST | Lato NORD | Centro Chiostro | Percorso



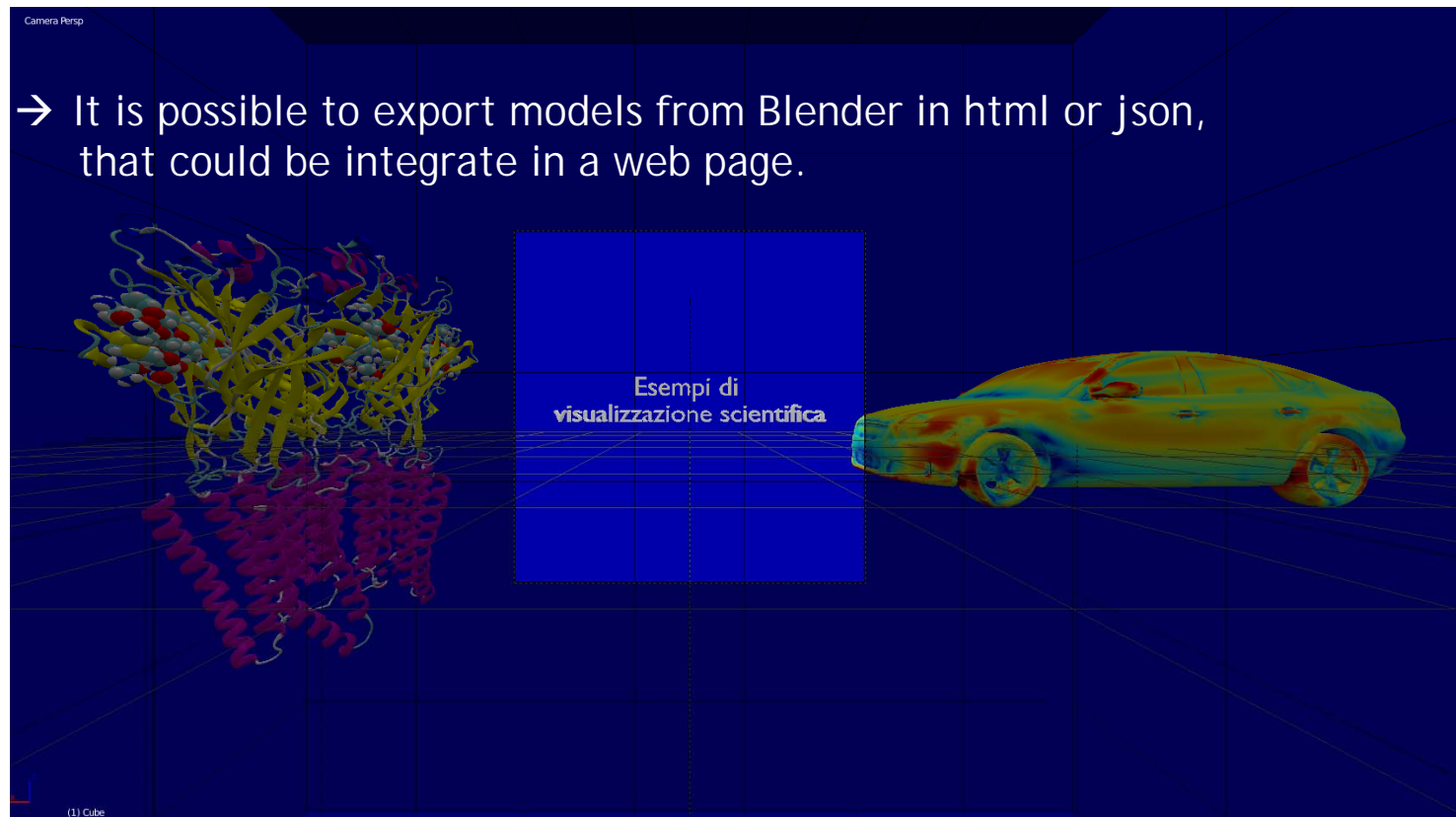




## WEB

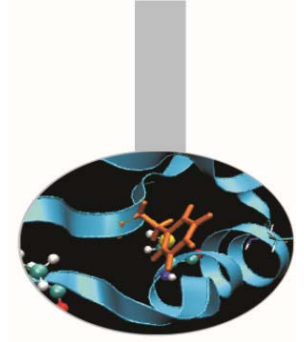
New instrument is **Blend4web**

<https://www.blend4web.com/en/>



<http://www.hpc.cineca.it/content/virtual-reality>

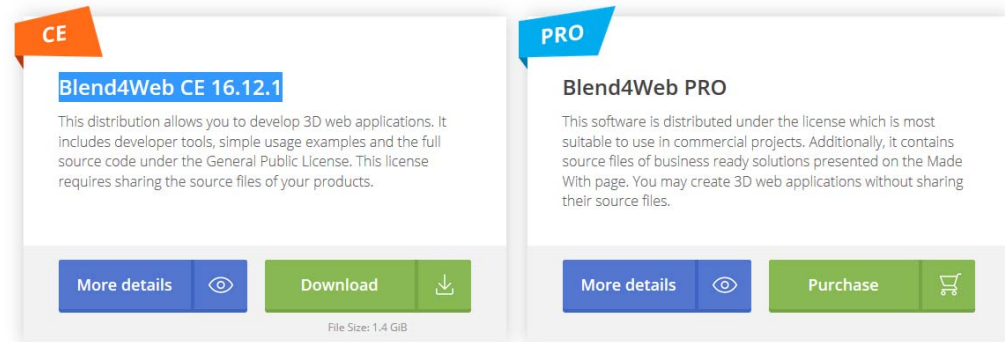








# BLEND4WEB - HOW TO INSTALL

Blender with Blend4web could be installed in two way, got to page <https://www.blend4web.com/en/downloads/>

- Download all the packages with blender <https://www.blend4web.com/en/>



**CE**  
**Blend4Web CE 16.12.1**  
This distribution allows you to develop 3D web applications. It includes developer tools, simple usage examples and the full source code under the General Public License. This license requires sharing the source files of your products.  
More details  **Download**   
File Size: 1.4 GiB

**PRO**  
**Blend4Web PRO**  
This software is distributed under the license which is most suitable to use in commercial projects. Additionally, it contains source files of business ready solutions presented on the Made With page. You may create 3D web applications without sharing their source files.  
More details  **Purchase** 

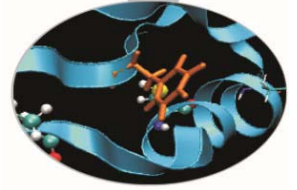
- Install Blender and the Blend4web add-on separately

## Blender Add-on

Although the Blender add-on is included in the Blend4Web SDK distributions, it can be installed and used separately as well. This option suits users who need only HTML export or tools such as the normal editor. Please note that some SDK features (Scene Viewer, Project Manager, Fast Preview) along with source files of the examples and tutorials are not available. The add-on is licensed under the GPL.

[Download \(version 16.12.1, 4 MiB\)](#)





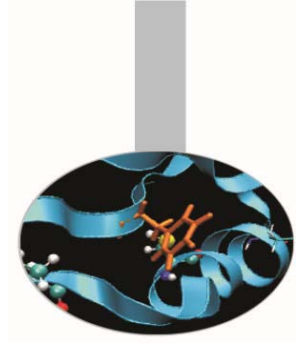
# BLEND4WEB - ACTIVATE THE ADD-ON

Search blend4web

Activate the add-on

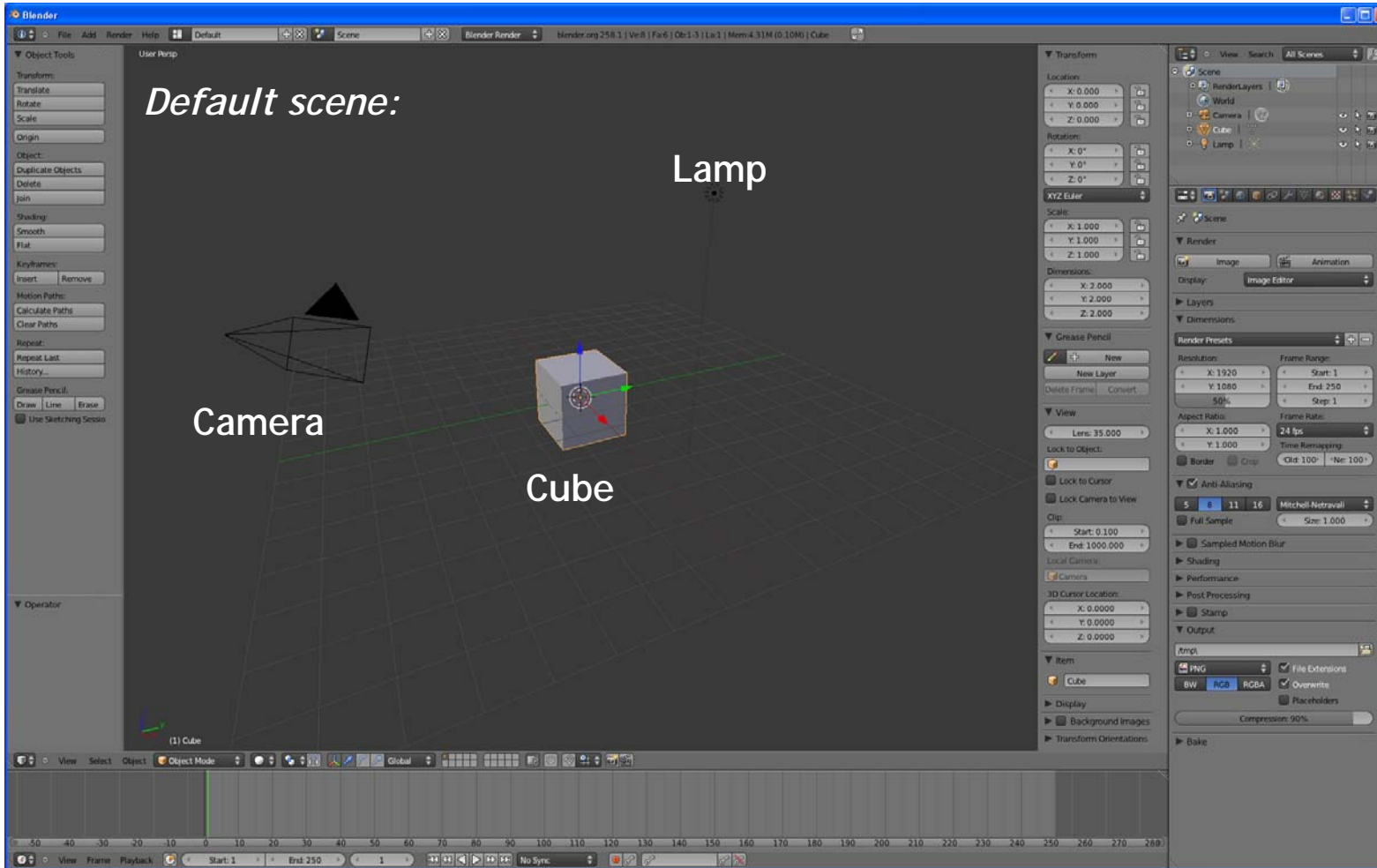
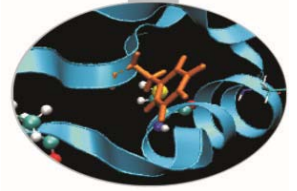
So you'll find as export format files html and json:

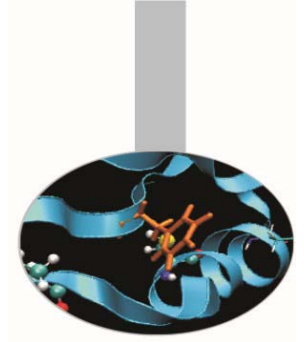
- Collada (Default) (.dae)
- Alembic (.abc)
- 3D Studio (.3ds)
- FBX (.fbx)
- Motion Capture (.bvh)
- Stanford (.ply)
- Wavefront (.obj)
- X3D Extensible 3D (.x3d)
- Stl (.stl)
- Autocad (.dxf)
- Blend4Web (.json)
- Blend4Web (.html)



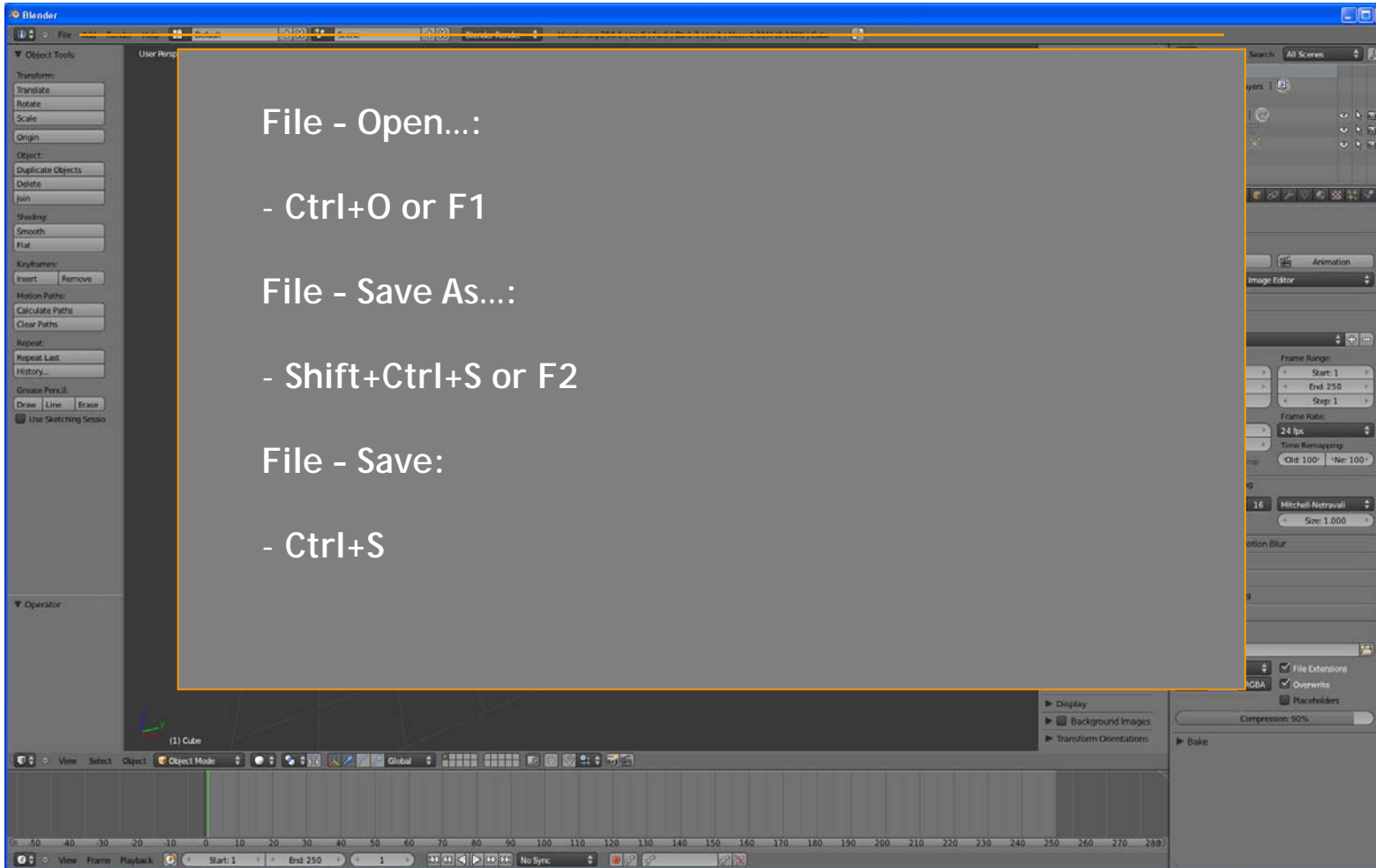
# Blender interface

# INTERFACE





# INTERFACE

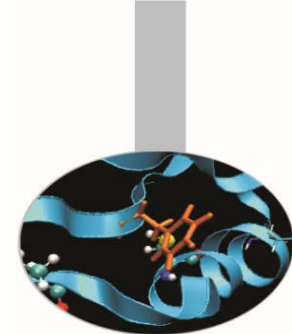


The image shows the Blender 2.79 interface. A central grey box with an orange border contains the following text:

- File - Open...:  
- Ctrl+O or F1
- File - Save As...:  
- Shift+Ctrl+S or F2
- File - Save:  
- Ctrl+S

The background interface includes the left-hand 'Tools' shelf with categories like Transform, Object, Shading, and Keyframes. The top status bar shows 'Object Mode' and 'Global'. The bottom timeline shows frame 1 of 250.



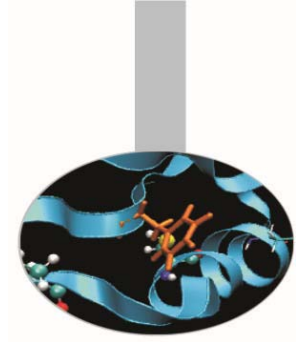


# INTERFACE

The screenshot shows the Blender 2.79 interface with several key components labeled:

- Info**: Located at the top center of the interface.
- Default Settings**: An orange arrow points to the top-left corner of the 3D Viewport, where the default settings for the current object are displayed.
- 3D View**: The central 3D viewport showing a wireframe cube and a solid cube with a 3D space axis.
- 3D space axis**: A red circle highlights the 3D space axis (X, Y, Z) in the bottom-left corner of the 3D Viewport.
- Outliner**: Located in the top-right corner, showing a list of objects in the scene.
- Properties**: Located in the bottom-right corner, showing the properties of the selected object (Cube).
- Timeline**: Located at the bottom of the interface, showing the current frame (1) and the total number of frames (250).





# INTERFACE - USER PREFERENCES

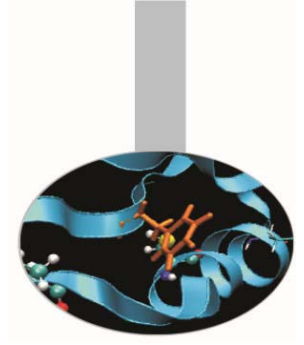
*Import/Export modules*

Modules of import or export different file format can be chosen in the User Preferences window and let them visible in the Info window (File - Import, Export)

The screenshot shows the Blender 2.58.1 interface. The 'Add-Ons' window is open, displaying a list of modules under the 'Import/Export' category. The 'Official' and 'Community' sections are visible. The 3D viewport shows a cube in Object Mode. The Properties panel on the right is set to the 'Render' tab, showing various settings like resolution, frame range, and output format.

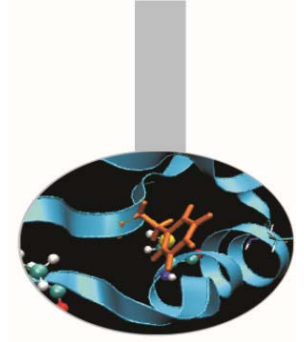






# SHORTCUT

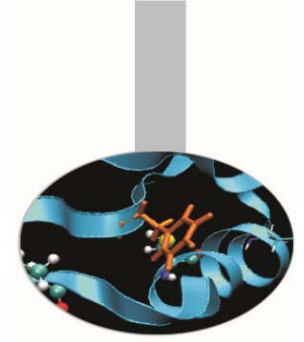
Combinations of keys that are used for a lot of commands (keyboard and/or mouse) instead of using tool bar, faster in the modeling stage.



# INTERFACE

Some factory windows settings





# INTERFACE

Drag the windows corner when highlighted

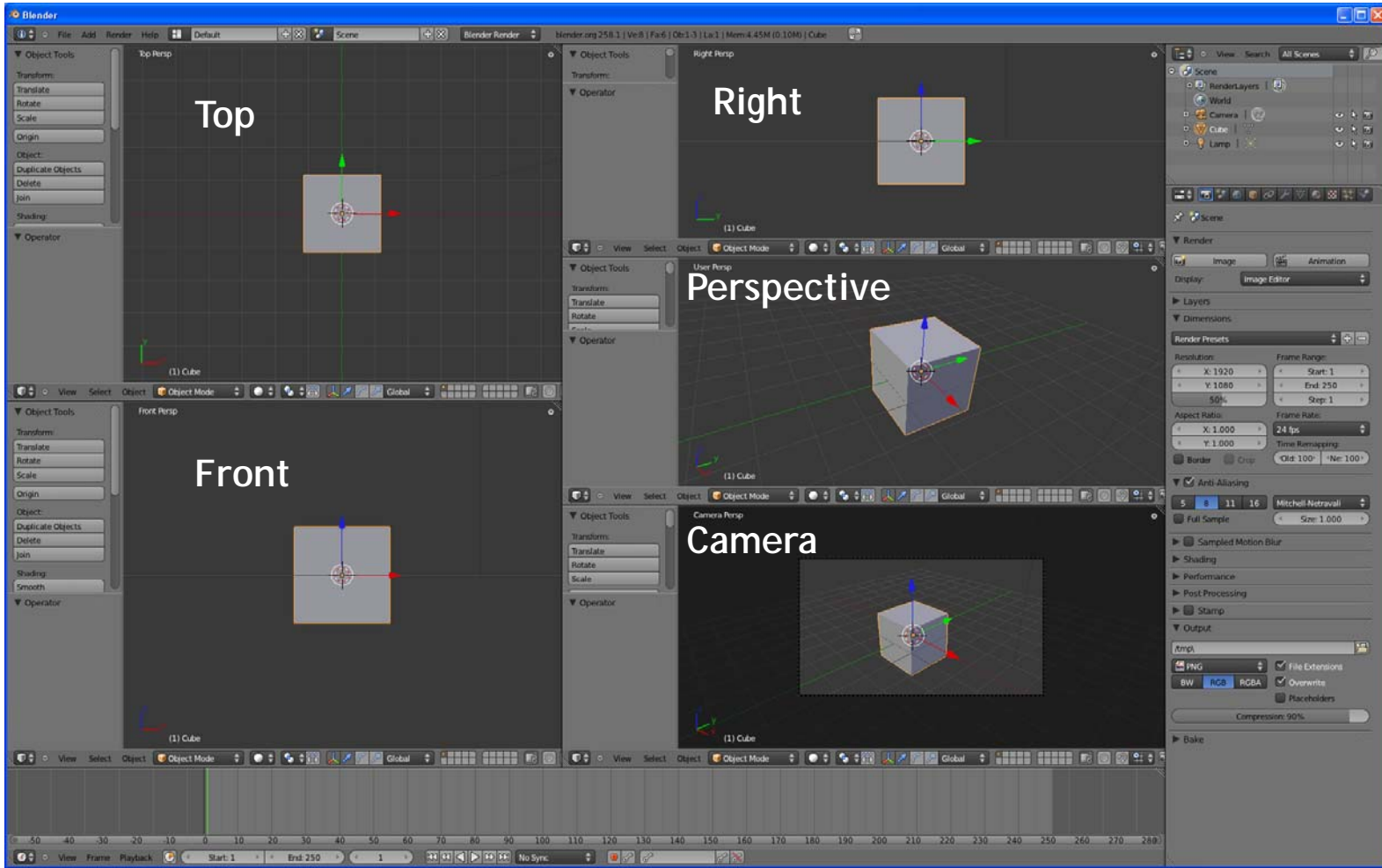
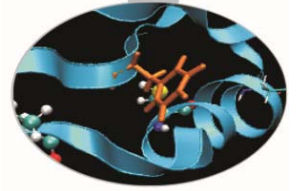
By putting mouse on window border will appear a double arrow, with click right button mouse it is possible to chose between:

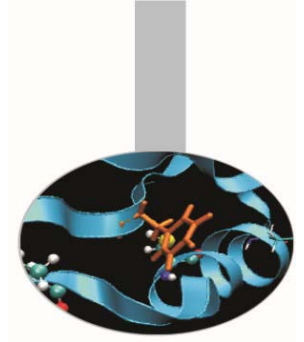
- SPLIT → split selected area into new windows
- JOIN → join selected areas into new window

Area Options  
Split Area  
Join Area

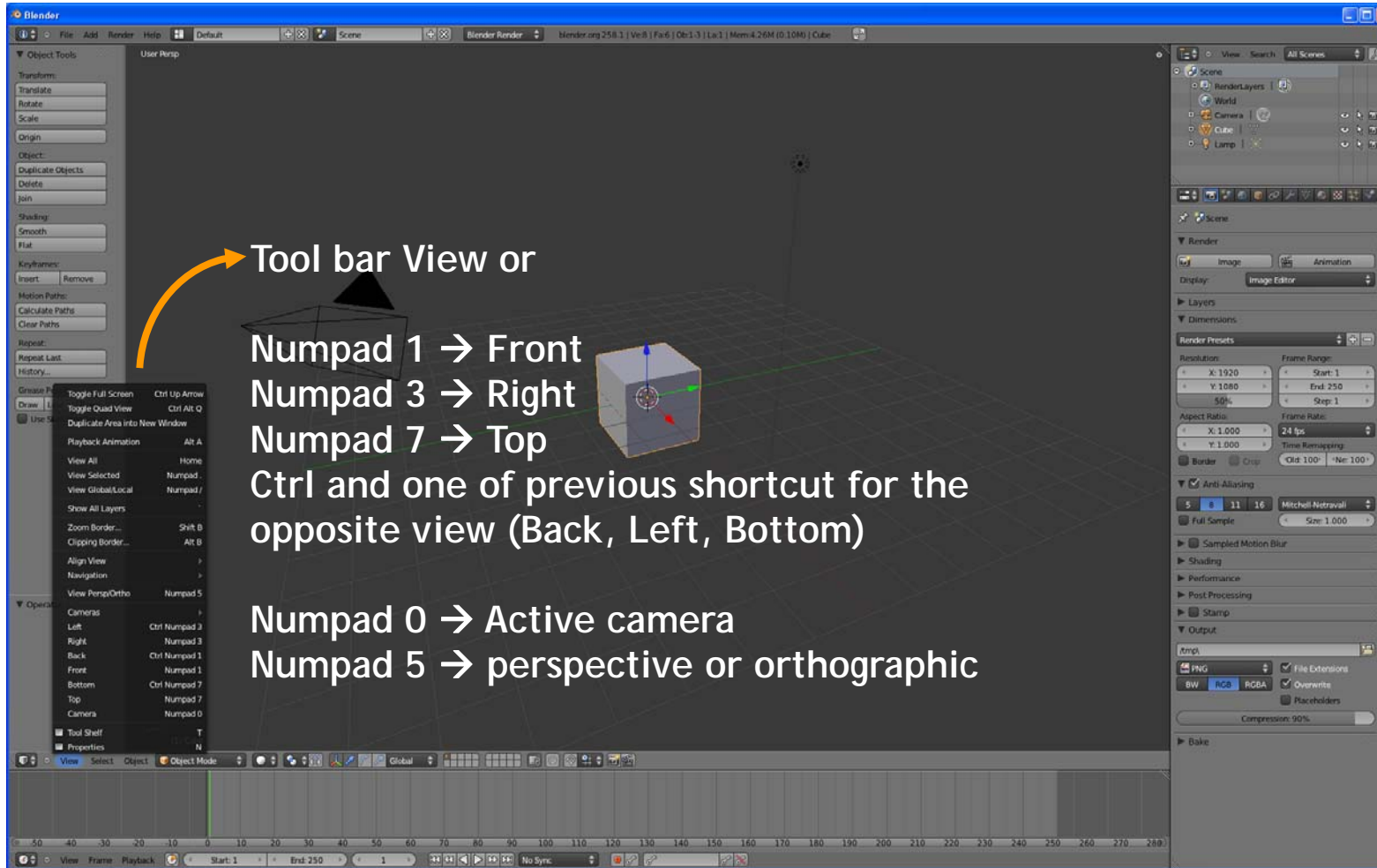


# INTERFACE



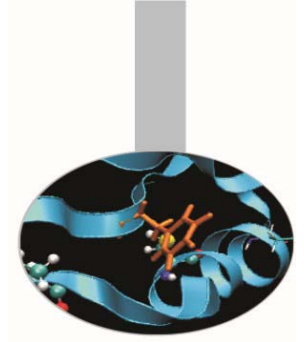


# INTERFACE

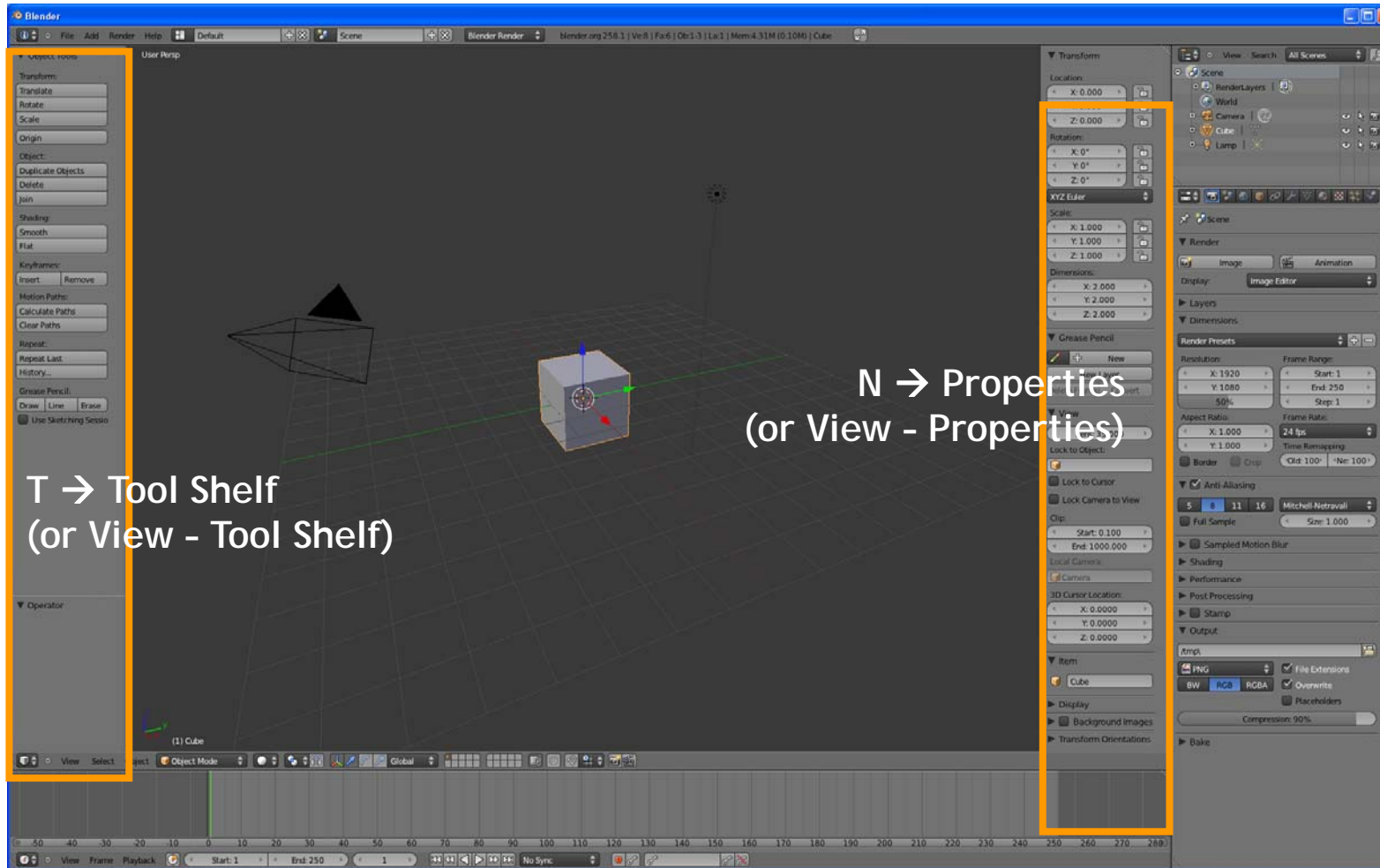


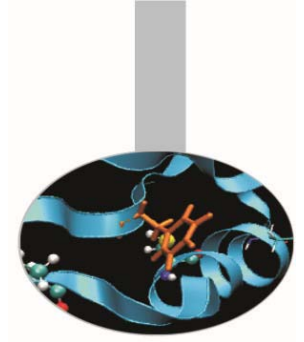
**Tool bar View or**  
**Numpad 1 → Front**  
**Numpad 3 → Right**  
**Numpad 7 → Top**  
**Ctrl and one of previous shortcut for the opposite view (Back, Left, Bottom)**  
**Numpad 0 → Active camera**  
**Numpad 5 → perspective or orthographic**





# INTERFACE





# INTERFACE

Cursor

Origin and axes object

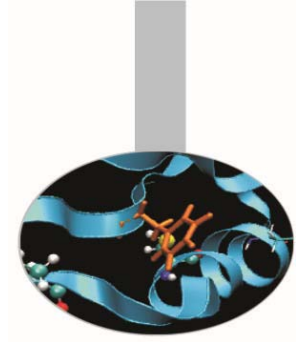
3D grid

Object properties

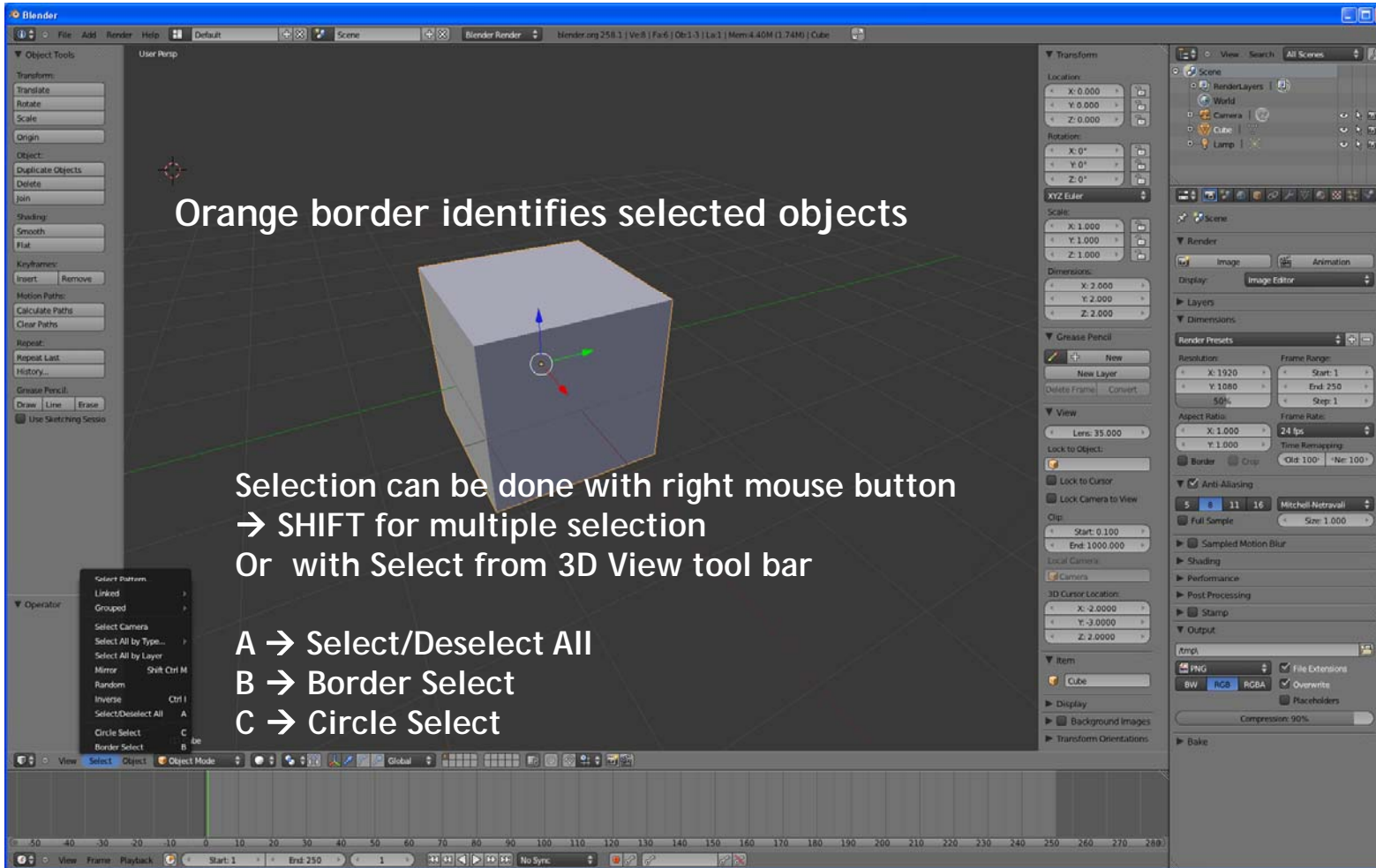
View properties

Position of 3D cursor can be defined manually or by clicking left mouse button





# INTERFACE



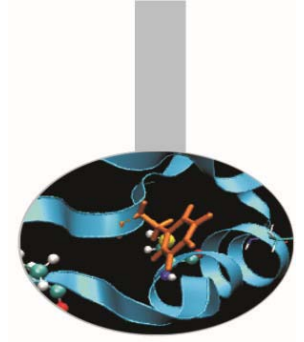
Orange border identifies selected objects

Selection can be done with right mouse button  
 → SHIFT for multiple selection  
 Or with Select from 3D View tool bar

A → Select/Deselect All  
 B → Border Select  
 C → Circle Select

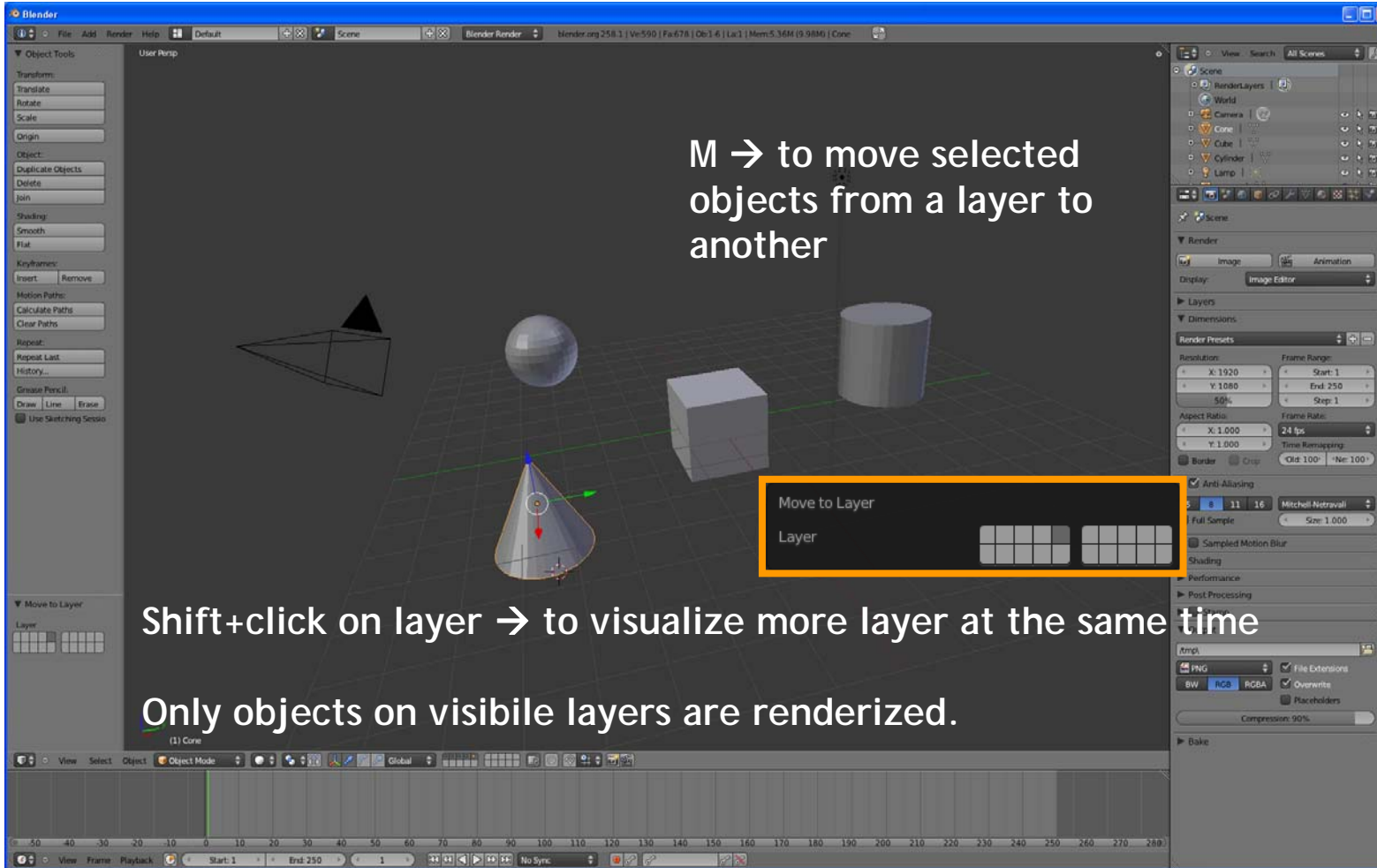






# LAYER

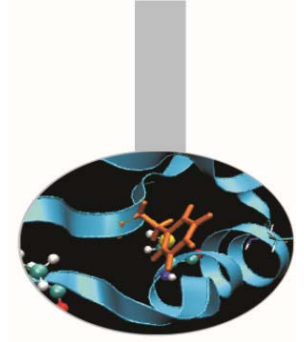
M → to move selected objects from a layer to another



Shift+click on layer → to visualize more layer at the same time

Only objects on visible layers are rendered.





# INTERFACE

**UNDO:**

- Ctrl+Z

**REDO:**

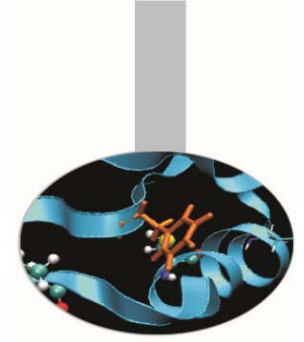
- Shift+Ctrl+Z

**HISTORY:**

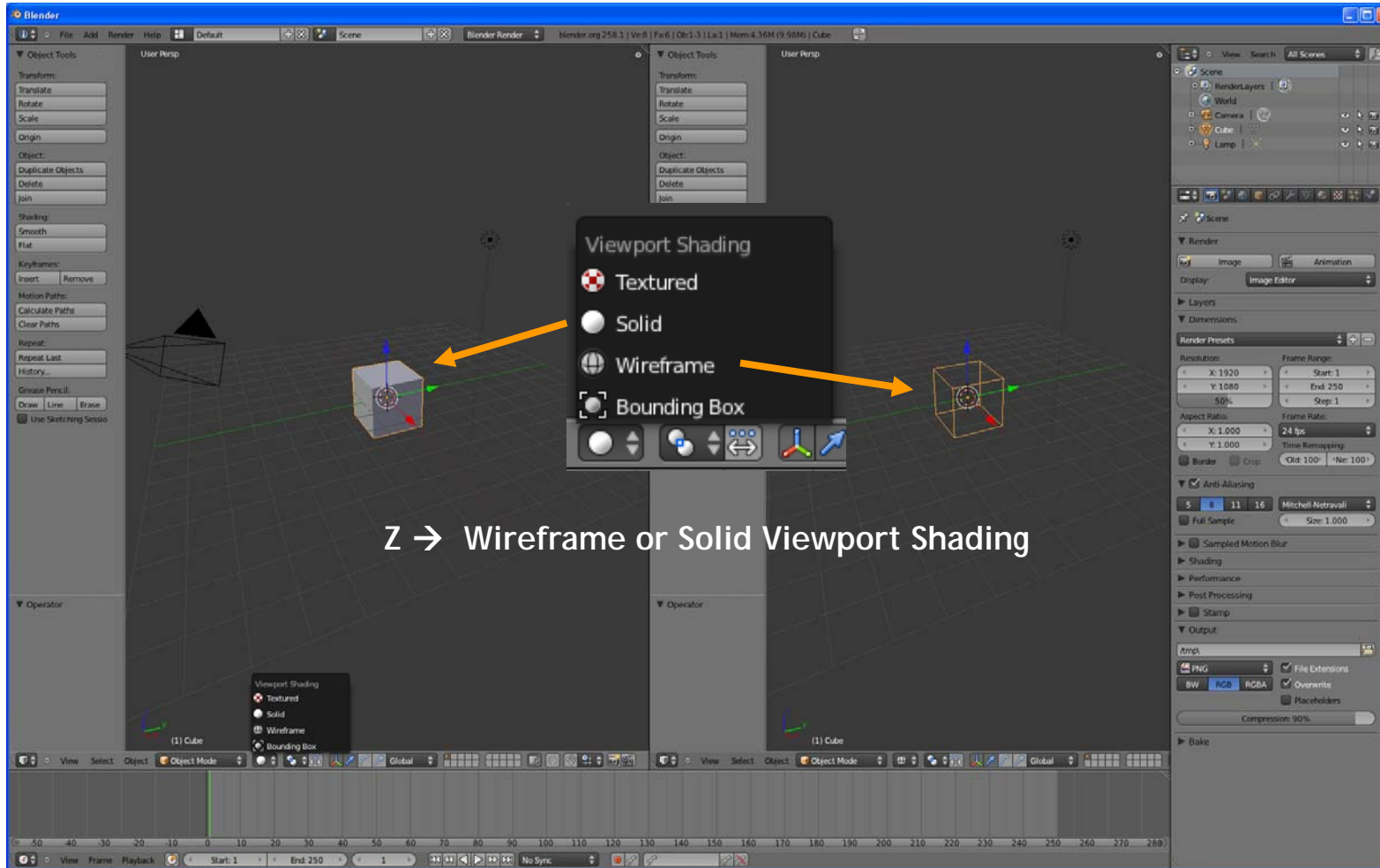
- Ctrl+Alt+Z

All action are visualized and it is possible to choose from which action restart modeling

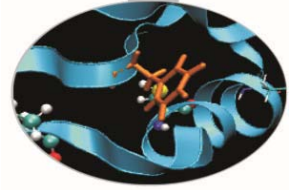




# INTERFACE



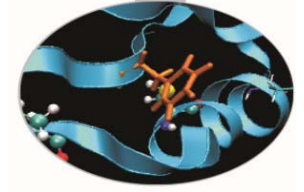
# INTERFACE



**Movement inside windows**

Center mouse button pressed → View rotation  
Shift+center mouse button pressed → View translation  
Ctrl+center mouse button pressed → View zoom



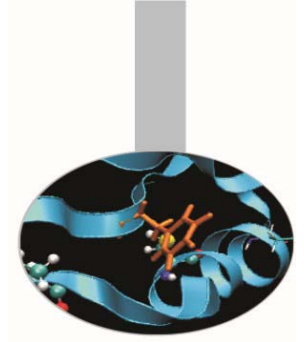


# INTERFACE

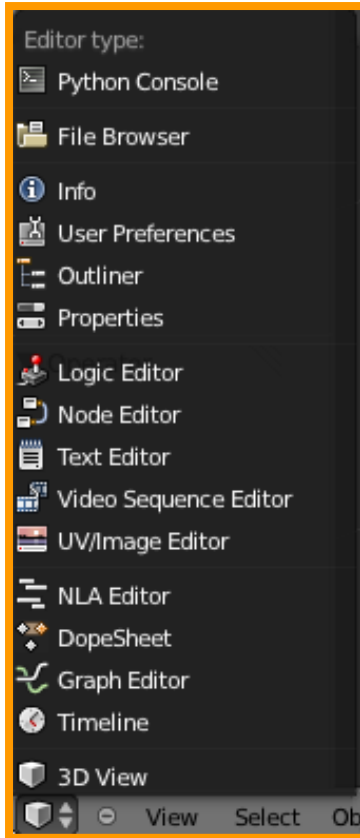
Some keys have multiple choices (Slider Button) and are recognized by the double arrows on the side:

- Editor type:
- Python Console
- File Browser
- Info
- User Preferences
- Outliner
- Properties
- Logic Editor
- Node Editor
- Text Editor
- Video Sequence Editor
- UV/Image Editor
- NLA Editor
- DopeSheet
- Graph Editor
- Timeline
- 3D View





## INTERFACE



**PYTHON CONSOLE** - to directly use python in Blender

**FILE BROWSER** - used to organize, load and save files

**INFO** - provides information and options for managing files, windows and engines

**USER PREFERENCES** - customize Blender to your work style and computer

**OUTLINER** - helps you find and organize your objects

**PROPERTIES** - shows the several attributes of the currently selected object

**LOGIC EDITOR** - a game logic editing window

**NODE EDITOR** - allows you to use nodes for texturing, materials and compositing

**TEXT EDITOR** - keep notes and documentation about your project, and write Python scripts

**VIDEO SEQUENCE EDITOR** - assemble video sequences into a film strip

**UV/IMAGE EDITOR** - an image editor with advanced UV management tools

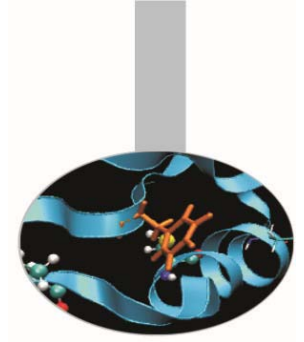
**NLA EDITOR** - manage non-linear animation action sequences

**DOPE SHEET** - combine individual actions into action sequences

**GRAPH EDITOR** - manage animation keys (and drivers) and inter/extrapolation of these

**TIMELINE** - controls for animation playback

**3D VIEW** - a graphical view of your scene



# PYTHON CONSOLE

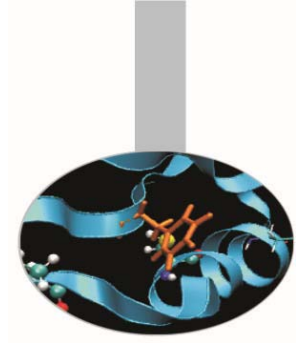
```
Command History:
Cursor: Left/Right Home/End
Remove: Backspace/Delete
Execute: Enter
Autocomplete: Ctrl-Space
Zoom: Ctrl +/-, Ctrl-Wheel
Builtin Modules: bpy, bpy.data, bpy.ops, bpy.props, bpy.types, bpy.context, bpy.utils, bgl, blf, mathutils
Convenience Imports: from mathutils import *; from math import *
Convenience Variables: C = bpy.context, D = bpy.data

>>> import bpy
>>> for i in bpy.data.objects:
...     print(i)
...
<bpy_struct, Object("Camera")>
<bpy_struct, Object("Cube")>
<bpy_struct, Object("Lamp")>

>>> |
```

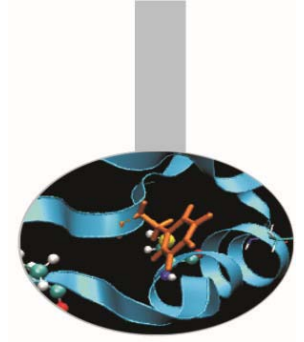
<https://www.blender.org/api/>





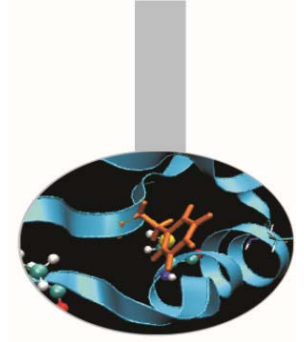
# Create and modify object





# ADD MESH

The screenshot displays the Blender 2.58.1 interface. The 'Add' menu is open, showing the 'Mesh' category selected. A 'Mesh' list overlay is positioned in the center-right, listing various mesh objects: Plane, Cube, Circle, UV Sphere, Icosphere, Cylinder, Cone, Grid, Monkey, and Torus. The 'UV Sphere' option is highlighted in the menu. In the 3D viewport, a sphere is visible, and a yellow arrow points from the 'UV Sphere' menu item to it. Another yellow arrow points from the 'Mesh' list overlay to the sphere. The right-hand side of the interface shows the 'Properties' panel with various settings for the selected object, including resolution, frame range, and output format.



# MODIFY OBJECTS

Objects can be modified with two main method:

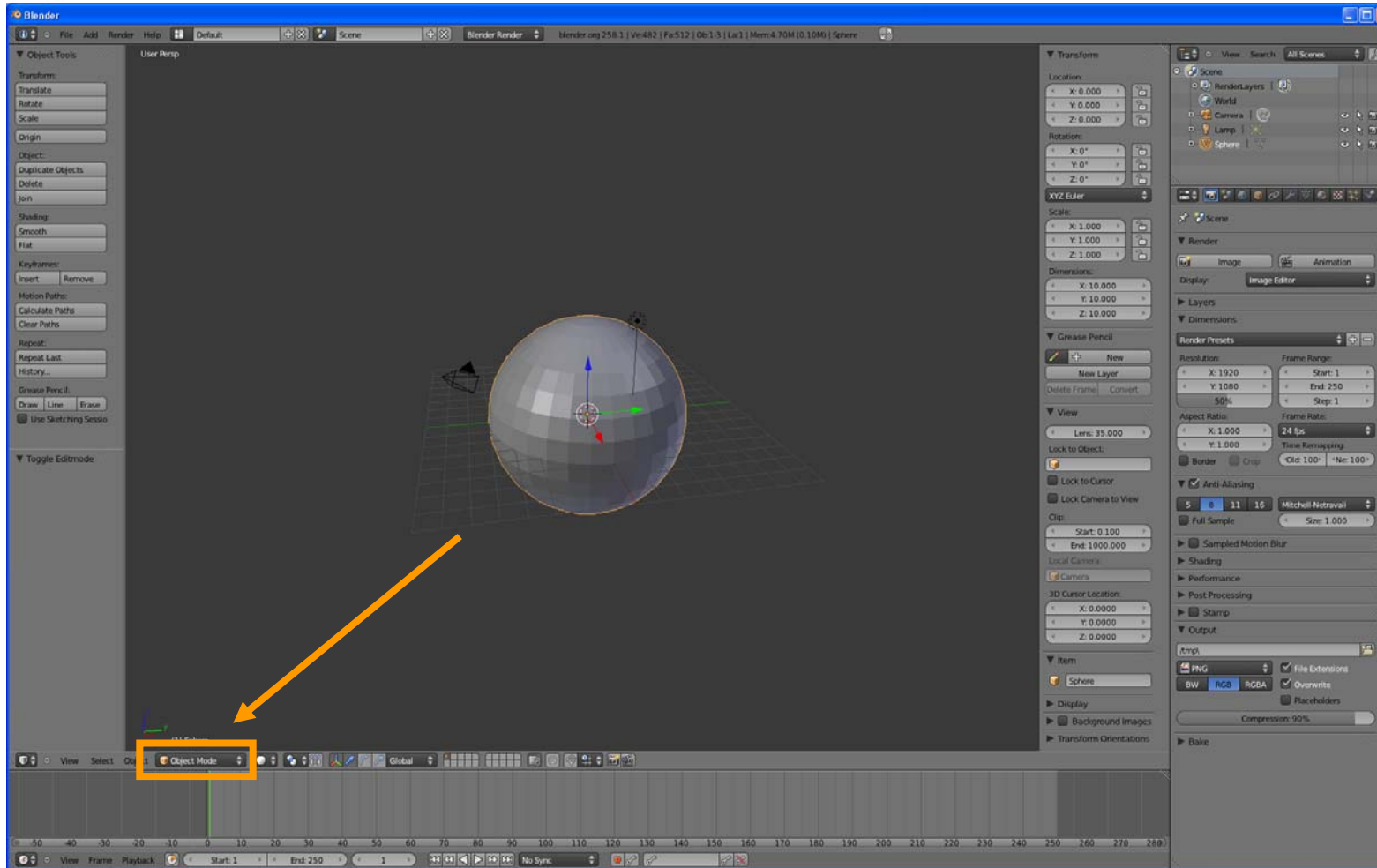
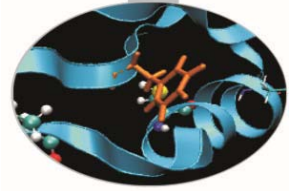
- OBJECT MODE: on the whole object
- EDIT MODE: on vertices, edges and/or faces

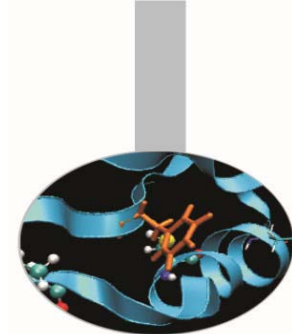
Mode:

- Weight Paint
- Texture Paint
- Vertex Paint
- Sculpt Mode
- Edit Mode
- Object Mode

TAB → Object Mode or Edit Mode

# OBJECT MODE

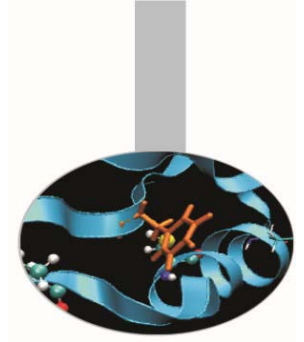




# OBJECT MODE

**Object - Transform**  
 G → Grab/Move  
 R → Rotate  
 S → Scale





# SNAP

The screenshot shows the Blender 2.58.1 interface. The 'Snap' menu is open, listing various snapping options. An orange arrow points from the 'Snap' menu to a text box. Another orange arrow points from the 'Set Origin' menu to a text box. The interface includes a 3D viewport with a cube and a camera, a left-hand toolbar, and a right-hand properties panel.

**Shift+S → Snap**

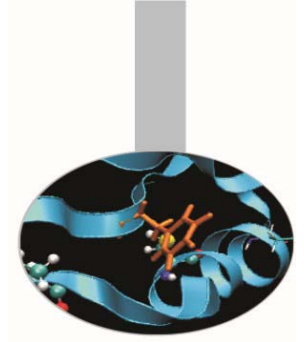
- Snap
  - Selection to Grid
  - Selection to Cursor
  - Cursor to Selected
  - Cursor to Center
  - Cursor to Grid
  - Cursor to Active

**Set Origin**

- Geometry to Origin      Shift Ctrl Alt C
- Origin to Geometry      Shift Ctrl Alt C
- Origin to 3D Cursor      Shift Ctrl Alt C

**SHIFT + CTRL + ALT + C → set origin**





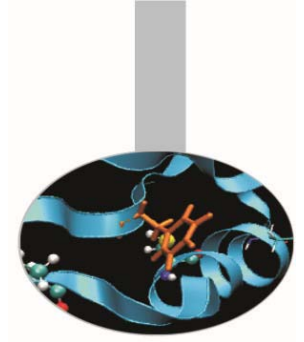
# PIVOT POINT

Pivot Point

- Active Element
- Median Point
- Individual Origins
- 3D Cursor
- Bounding Box Center

An object transformation (scale or rotation) are made respecting a pivot point





# 3D MANIPULATOR

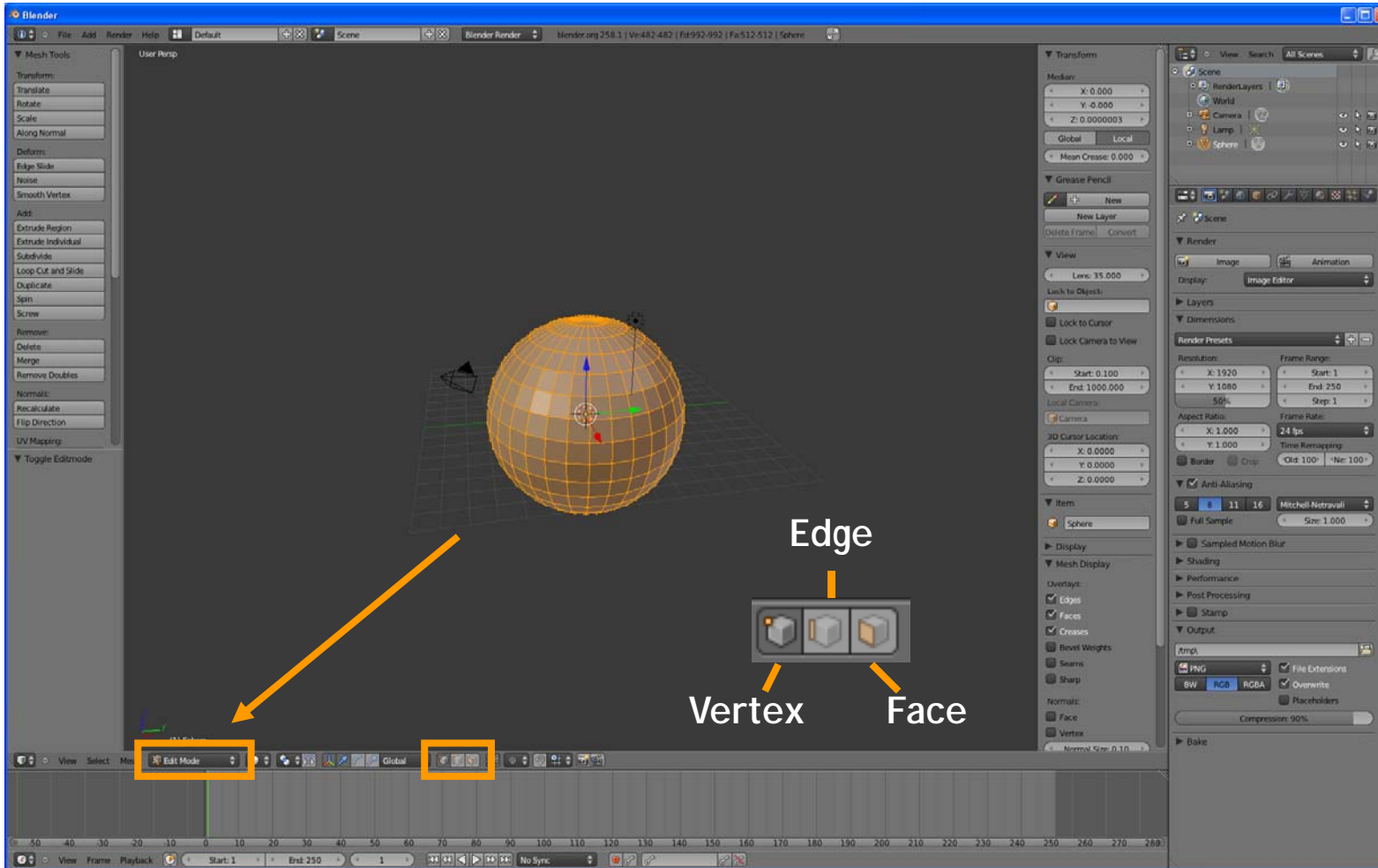
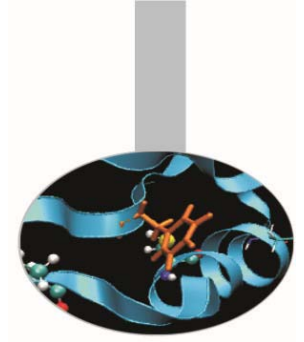
The image displays the Blender 2.58.1 interface with four different 3D manipulator widgets for a cube, each highlighted with an orange border:

- Translate manipulator:** Shows a cube with three colored axes (red, green, blue) and a white circle at the center.
- Rotate manipulator:** Shows a cube with three colored axes and three curved colored arcs (red, green, blue) representing rotation paths.
- Translate, Rotate, Scale manipulator:** Shows a cube with three colored axes and three curved colored arcs, similar to the rotate manipulator but with a different internal structure.
- Scale manipulator:** Shows a cube with three colored axes and a white circle at the center, similar to the translate manipulator.

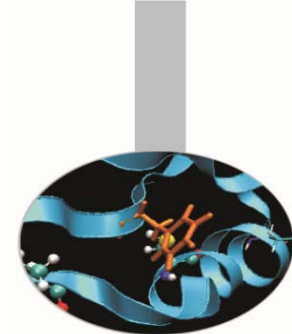
At the bottom center, a text box says "Use a 3D manipulator widget for controlling transforms". Below it, a small menu is visible with options: Orientation, View, Normal, Gimbal, Local. The "Global" option is highlighted with an orange box.



# EDIT MODE



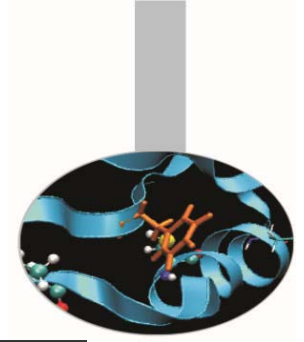




# EDIT MODE

**Mesh - Transform**  
**G → Grab/Move**  
**R → Rotate**  
**S → Scale**





# EDIT MODE

- Show/Hide
- Proportional Editing Falloff
- Proportional Editing
- AutoMerge Editing
- Normals
- Faces
- Edges
- Vertices
- Delete... X
- Add Duplicate Shift D
- Extrude Individual
- Extrude Region E
- UV Unwrap...
- Snap
- Mirror
- Transform
- Undo History Ctrl Alt Z
- Redo Shift Ctrl Z
- Undo (1) Sphere Ctrl Z

Mesh Edit Mode

- Recalculate Outside Ctrl N
- Recalculate Inside Shift Ctrl N
- Flip Normals

- Merge Alt M
- Rip V
- Split Y
- Separate P
- Smooth Vertex
- Remove Doubles
- Vertex Sort
- Vertex Randomize
- Select Vertex Path
- Blend From Shape
- Blend Vertex Group
- Shape Propagate
- Vertex Groups
- Hooks

- Make Edge/Face F
- Subdivide
- Mark Seam
- Clear Seam
- Mark Sharp
- Clear Sharp
- Rotate Edge CW
- Rotate Edge CCW
- Edge Slide
- Edge Crease Shift E
- Edge Loop
- Edge Ring
- Loop to Region
- Region to Loop

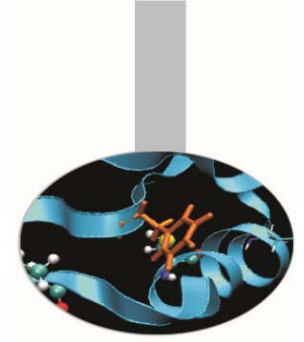
- Flip Normals
- Make Edge/Face F
- Fill Alt F
- Beautify Fill Shift Alt F
- Solidify
- Sort Faces
- Make F-gon
- Clear F-gon
- Quads to Tris Ctrl T
- Tris to Quads Alt J
- Edge Flip Shift Ctrl F
- Shade Smooth
- Shade Flat
- Rotate Edge CW
- Rotate UVs
- Mirror UVs
- Rotate Colors
- Mirror Colors

Ctrl+V

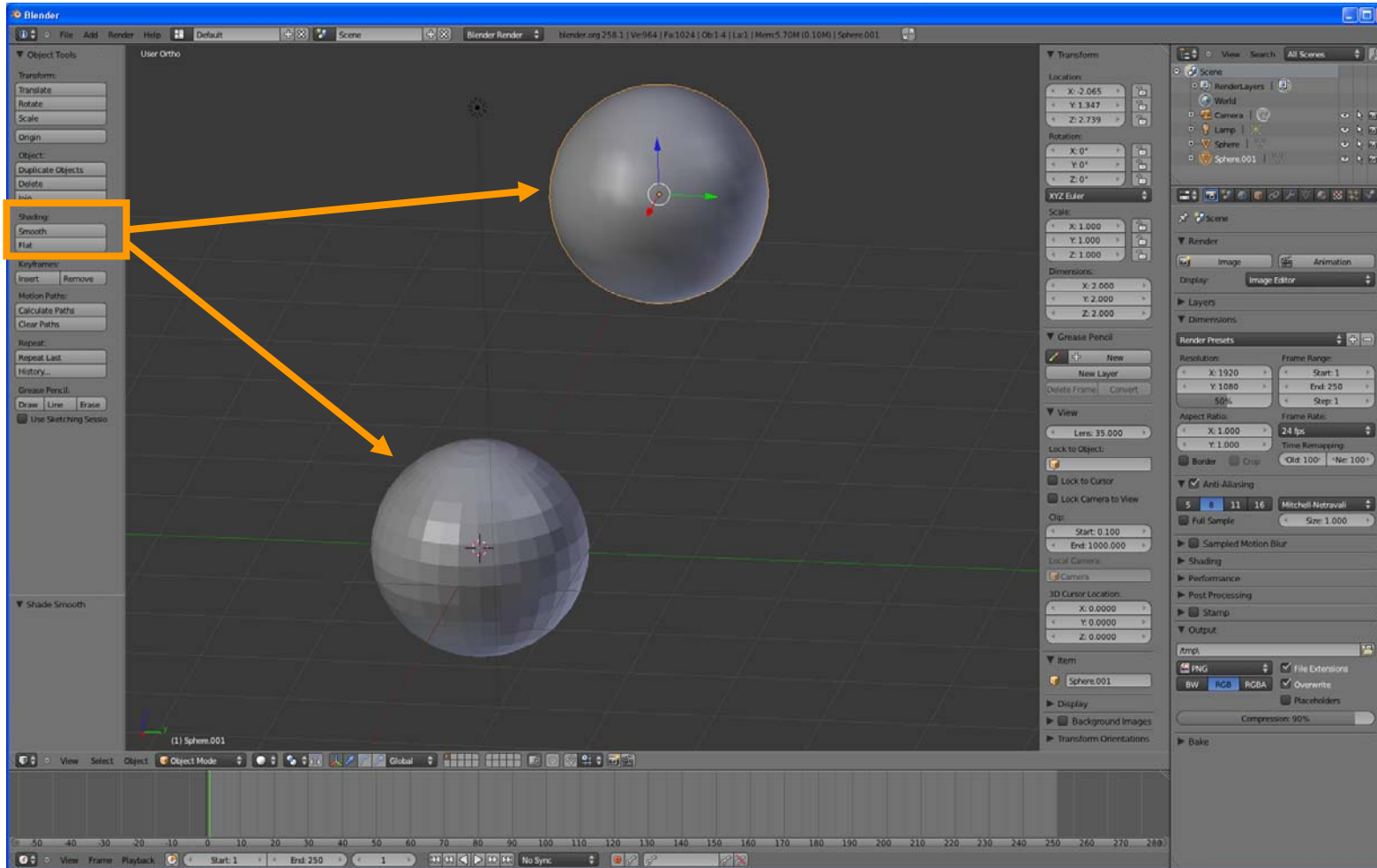
Ctrl+E

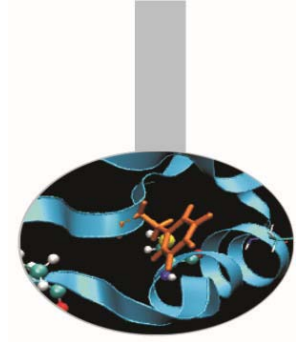
Ctrl+F





# OBJECT MODE - SMOOTH SHADING

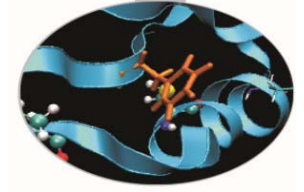




# EDIT MODE - SMOOTH SHADING

In Edit Mode it is possible to select only part of sphere to render it smooth



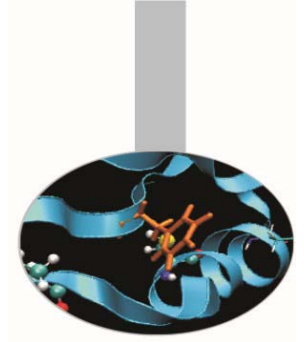


# EDIT MODE - FACES - SUBDIVIDE

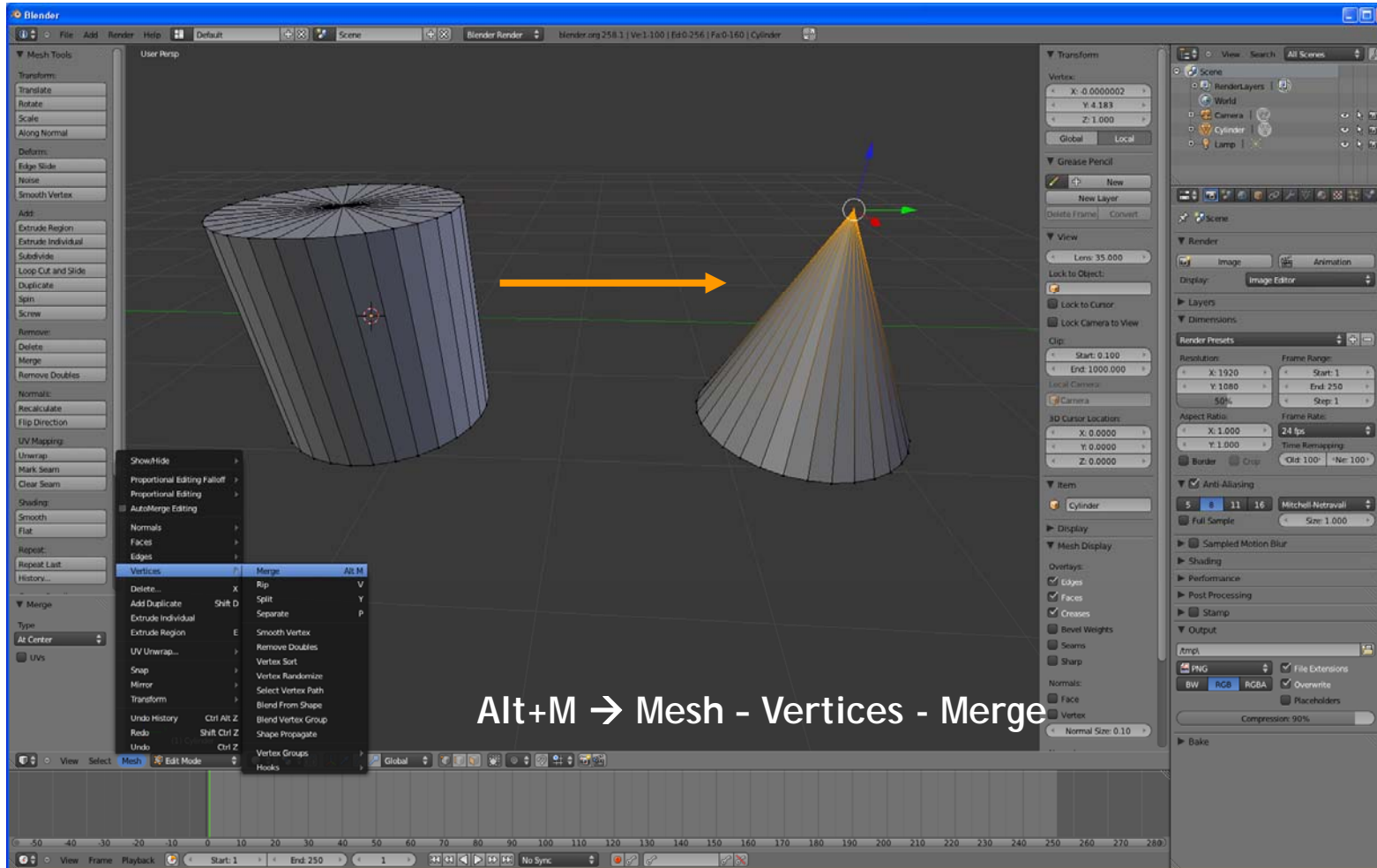
W → special comands panel

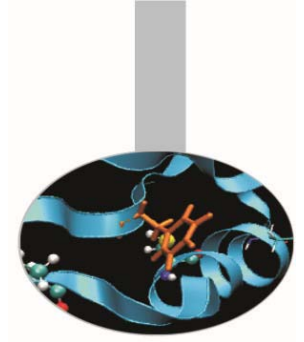
- Specials
- Subdivide
  - Subdivide Smooth
  - Merge... Alt M
  - Remove Doubles
  - Hide H
  - Reveal Alt H
  - Select Inverse Ctrl I
  - Flip Normals
  - Smooth
  - Shade Smooth
  - Shade Flat
  - Blend From Shape
  - Shape Propagate
  - Select Vertex Path





# EDIT MODE - VERTEX - MERGE



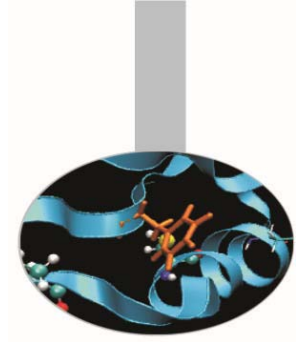


# EDIT MODE - EXTRUDE

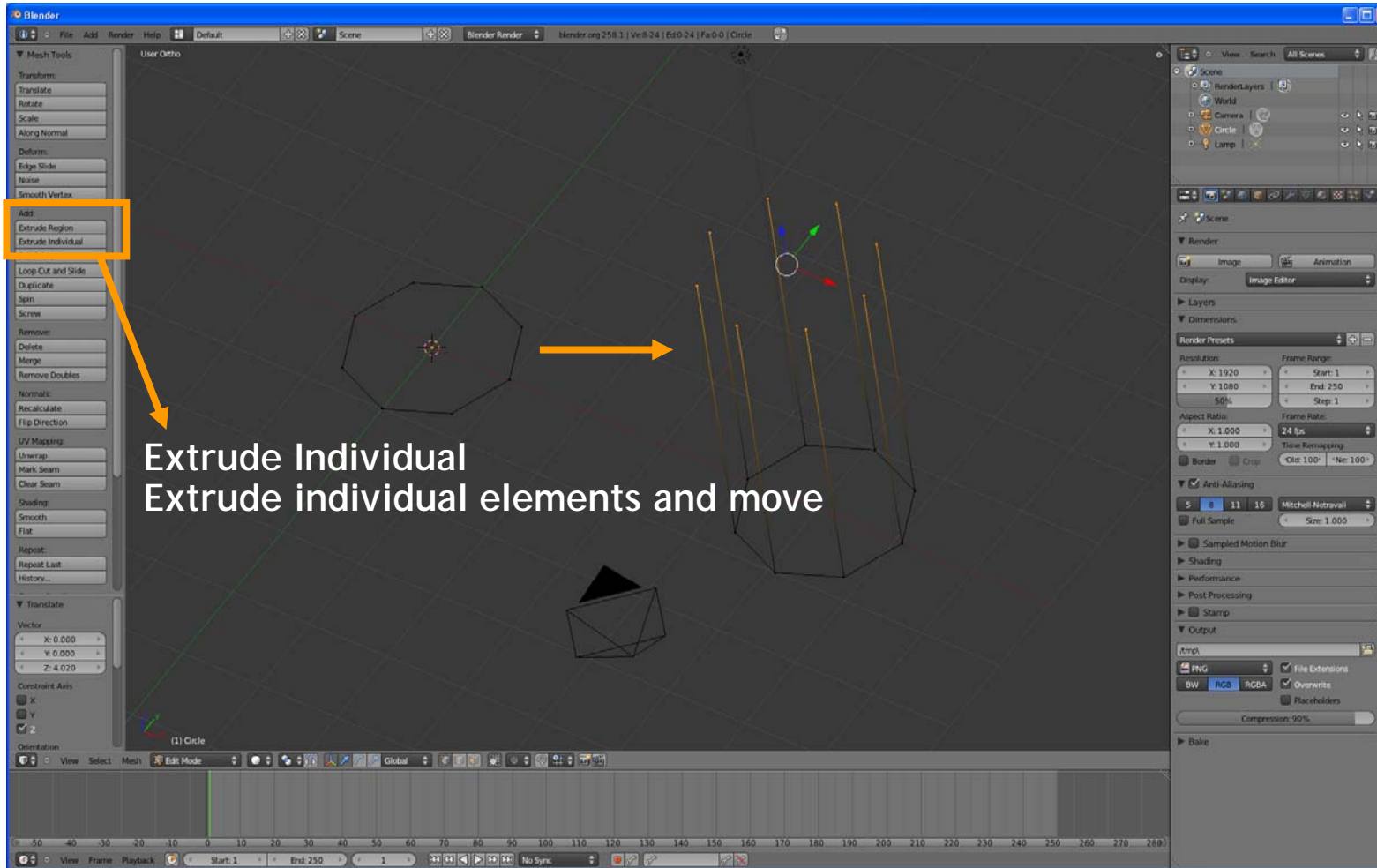
E → Extrude Region  
Extrude and move along normals

The screenshot displays the Blender 2.58.1 interface. On the left, the 'Tools' shelf is open to the 'Add' category, where 'Extrude Region' is highlighted with an orange box. An orange arrow points from this box to the text 'E → Extrude Region Extrude and move along normals'. In the center viewport, a circle is being extruded into a cylinder. A second orange arrow points from the circle to the resulting cylinder. The right sidebar shows the 'Render' properties panel. At the bottom, the status bar indicates the extrusion distance: 'D: 3.5671 (3.5671) along global Z'.

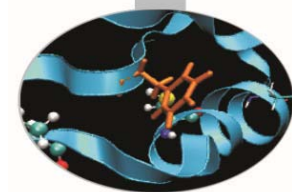




# EDIT MODE - EXTRUDE







# EDIT MODE - SPIN

Blender

Mesh Tools

Transform:

- Translate
- Rotate
- Scale
- Along Normal

Deform:

- Edge Slide
- Noise
- Smooth Vertex

Add:

- Extrude Region
- Extrude Individual
- Subdivide
- Loop Cut and Slide
- Duplicate
- Spin
- Screw

Remove:

- Delete
- Merge
- Remove Doubles

Normals:

- Recalculate
- Flip Direction

UV Mapping:

- Unwrap

Operator

Blender

Mesh Tools

Transform:

- Translate
- Rotate
- Scale
- Along Normal

Deform:

- Edge Slide
- Noise
- Smooth Vertex

Add:

- Extrude Region
- Extrude Individual
- Subdivide
- Loop Cut and Slide
- Duplicate
- Spin
- Screw

Remove:

- Delete
- Merge
- Remove Doubles

Normals:

- Recalculate
- Flip Direction

UV Mapping:

- Unwrap

Operator

Spin

- Steps: 24
- Dupli
- Degrees: 360.000
- Center: X: 0.000, Y: 0.000, Z: 0.000
- Axis: X: 0.000, Y: 0.000, Z: 1.000

Spin parameters

(1) Circle

View Select Mesh Edit Mode

Start: 1 End: 250

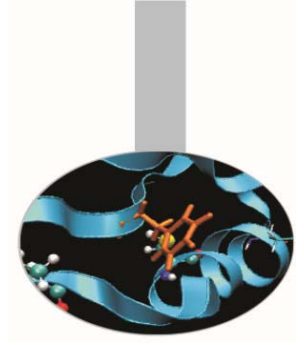
View Frame Playback

(1) Circle

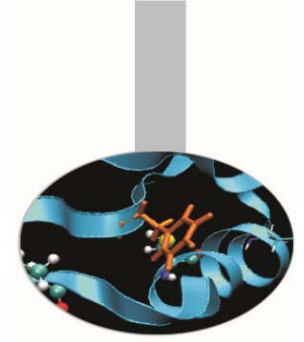
View Select Mesh Edit Mode

Start: 1 End: 250

View Frame Playback



# Properties



# PROPERTIES



Render

Scene

World

Object

Object Constraints

Modifiers

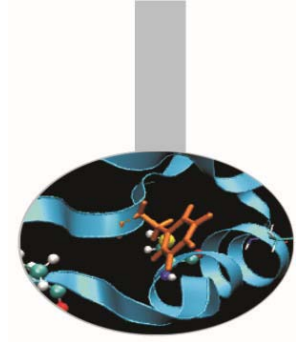
Object Data

Material

Texture

Particles

Physics



# PROPERTIES - MATERIAL

Diffuse Shader Model  
Fresnel  
Minnaert  
Toon  
Oren-Nayar  
Lambert  
Oren-Nayar

Object color parameters

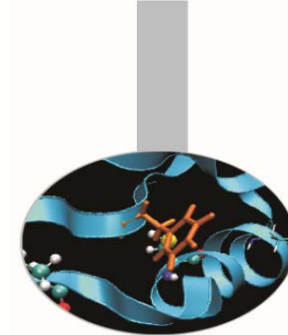
Specular Shader Model  
Ward  
Toon  
Blinn  
Phong  
CookTorr  
Blinn

Diffuse  
Oren-Nayar  
Intensity: 0.800  
Roughness: 0.500

Specular  
Blinn  
Intensity: 0.500  
Hardness: 50  
IOR: 5.000

[http://wiki.blender.org/index.php/Doc:Manual/Materials/Properties/Diffuse\\_Shaders](http://wiki.blender.org/index.php/Doc:Manual/Materials/Properties/Diffuse_Shaders)





## CPK coloring

“In chemistry, the CPK coloring is a popular color convention for distinguishing atoms of different chemical elements in molecular models.”

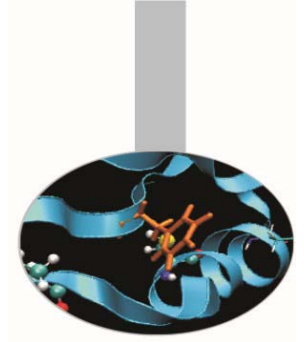
“Typical CPK color assignments include:

|   |  |               |
|---|--|---------------|
|    | hydrogen (H)                                   | white         |
|    | carbon (C)                                     | black         |
|    | nitrogen (N)                                   | dark blue     |
|    | oxygen (O)                                     | red           |
|    | fluorine (F), chlorine (Cl)                    | green         |
|    | bromine (Br)                                   | dark red      |
|    | iodine (I)                                     | dark violet   |
|  | noble gases (He, Ne, Ar, Xe, Kr)               | cyan          |
|  | phosphorus (P)                                 | orange        |
|  | sulfur (S)                                     | yellow        |
|  | boron (B), most transition metals              | peach, salmon |
|  | alkali metals (Li, Na, K, Rb, Cs, Fr)          | violet        |
|  | alkaline earth metals (Be, Mg, Ca, Sr, Ba, Ra) | dark green    |
|  | titanium (Ti)                                  | gray          |
|  | iron (Fe)                                      | dark orange   |
|  | other elements                                 | pink          |

Several of the CPK colors refer mnemonically to colors of the pure elements or notable compound.”

[https://en.wikipedia.org/wiki/CPK\\_coloring](https://en.wikipedia.org/wiki/CPK_coloring)

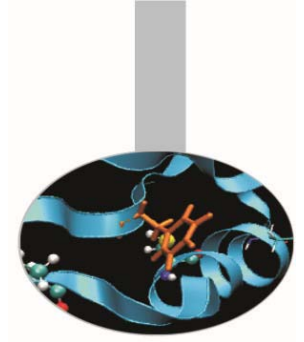




# PROPERTIES - TEXTURE

The screenshot shows the Blender 2.58.1 interface with a material editor. The texture properties panel is open, showing a list of texture types. A dropdown menu is open, listing the following options: None, None, Blend, Clouds, Distorted Noise, Environment Map, Image or Movie, Magic, Marble, Musgrave, Noise, Point Density, Stucci, Voronoi, Voxel Data, Wood, and Type. An orange arrow points from the 'None' option in the dropdown to the 'None' option in the texture type list on the right.

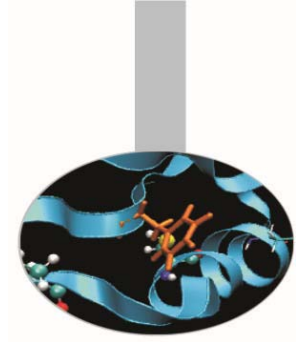




# PROPERTIES - MATERIAL

The screenshot displays the Blender 2.58.1 interface in Object Mode. The central 3D viewport shows a scene with a sphere, a cube, and a cylinder. The right-hand side of the interface contains the Properties panel for the selected object, which is a cylinder. The 'Material' tab is active, and the 'Transparency' section is expanded and highlighted with an orange box. This section includes three tabs: 'Mask', 'Z Transparency', and 'Raytrace'. The 'Z Transparency' tab is selected, showing the following settings: Alpha: 0.200, Fresnel: 0.000, Specular: 1.000, and Blend: 1.250. An orange arrow points from the 'Z Transparency' tab in the main Properties panel to a smaller, detailed view of the 'Z Transparency' settings at the bottom of the image.





# PROPERTIES - MATERIAL

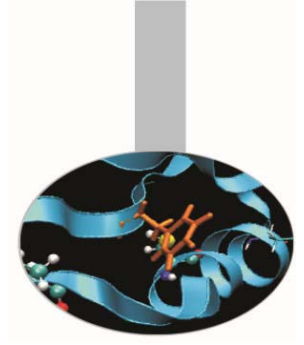
The image shows the Blender 2.58.1 interface with a scene containing a green sphere, a red cube, and a yellow cylinder. The Properties panel on the right is set to the Material tab, showing the Mirror material properties. The Mirror properties are highlighted with an orange box. An arrow points from the Mirror properties in the Properties panel to a larger, detailed view of the Mirror properties panel.

**Mirror Properties:**

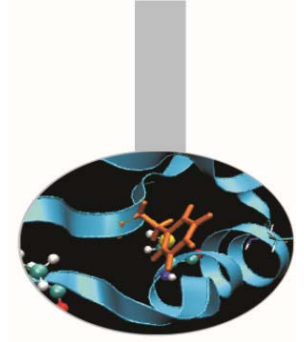
- Reflectivity: 0.500
- Fresnel: 0.000
- Blend: 1.250
- Depth: 2
- Max Dist: 0.000
- Fade To: Sky
- Gloss: Amount: 1.000
- Threshold: 0.005
- Samples: 18
- Anisotropic: 1.000



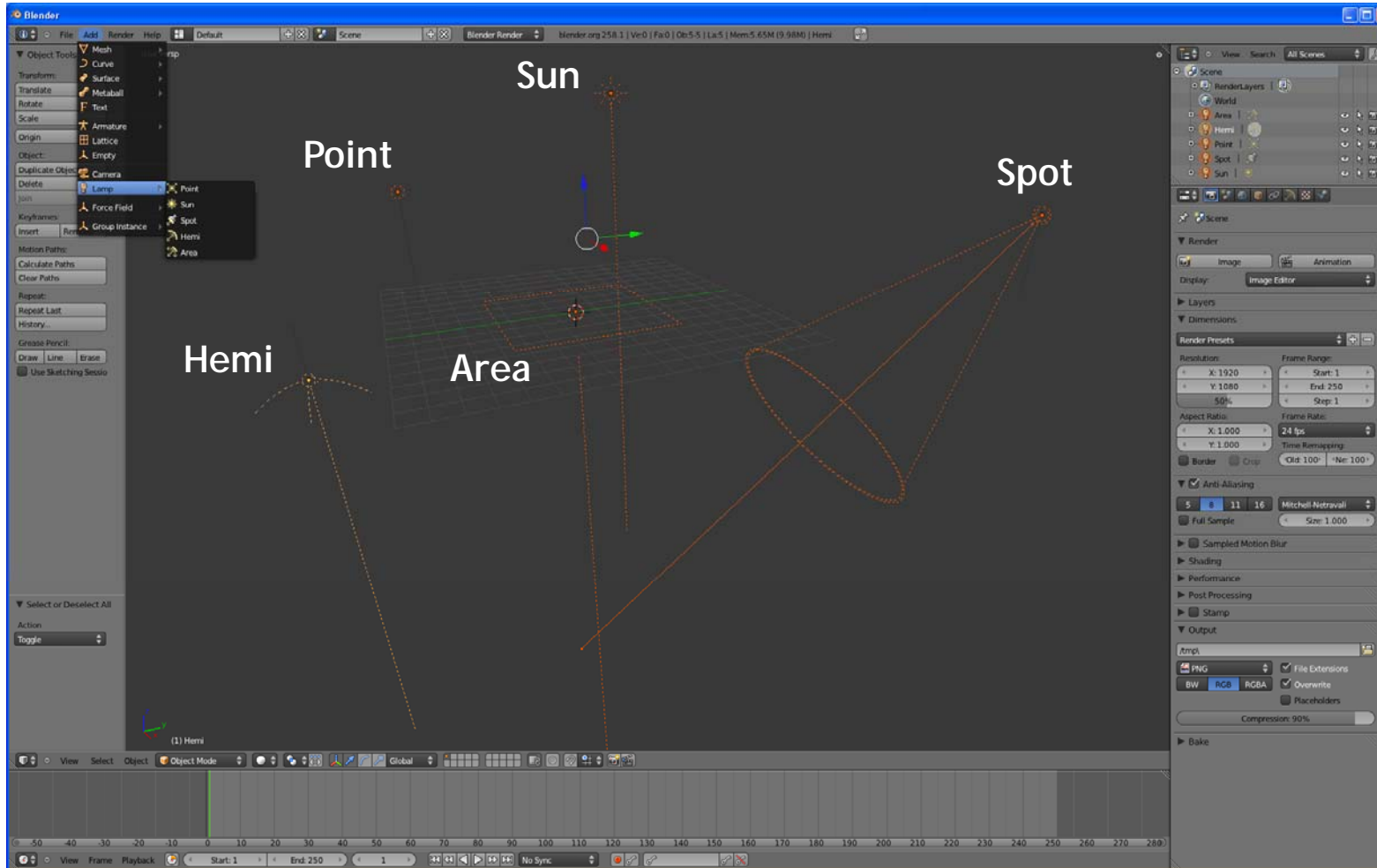




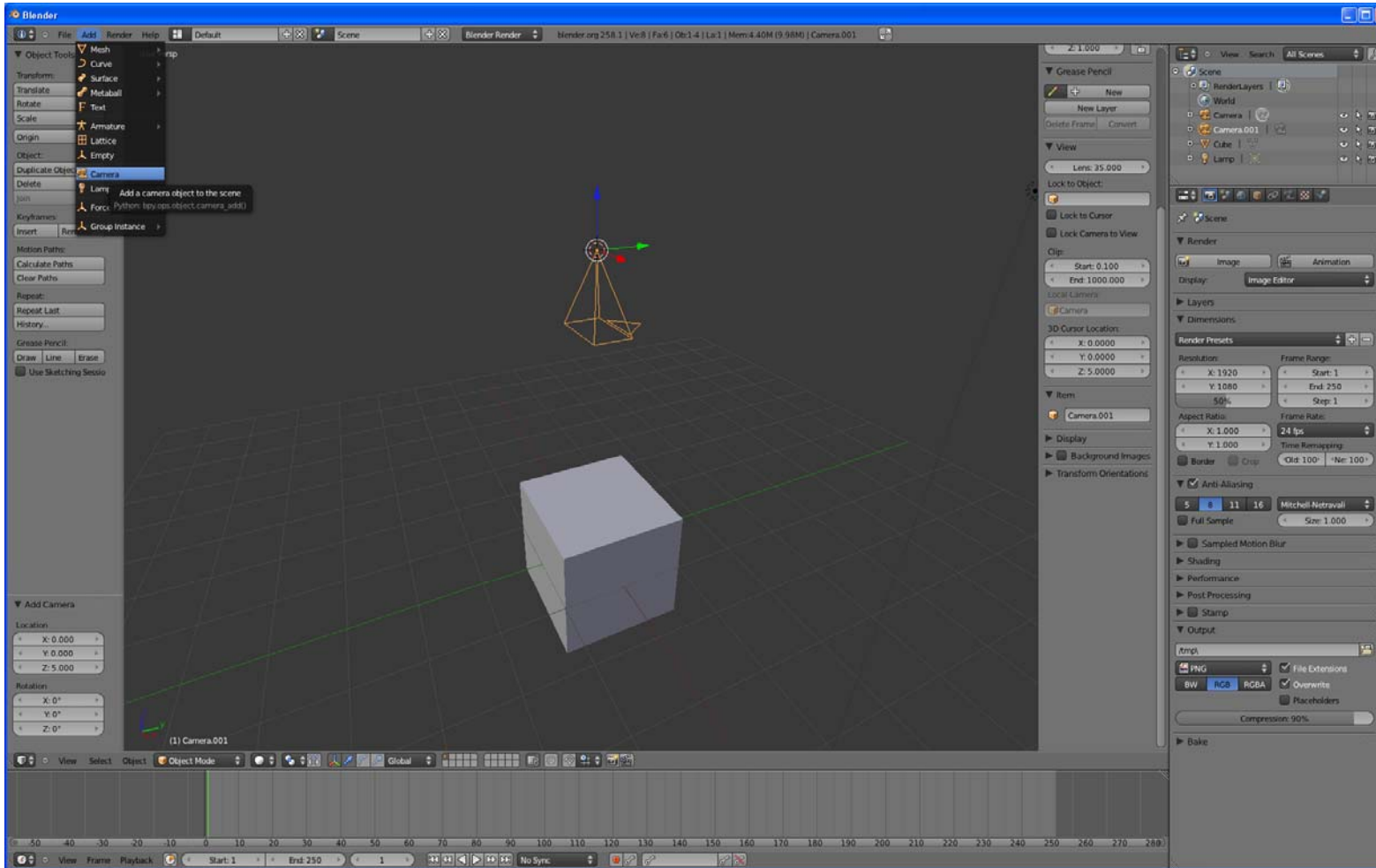
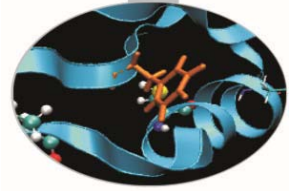
# Render an image

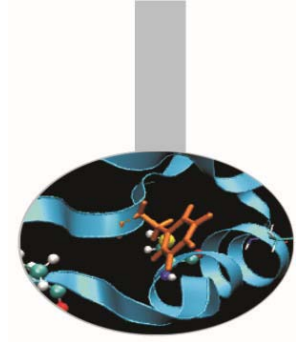


# ADD LAMP



# ADD CAMERA





# PROPERTIES - RENDER

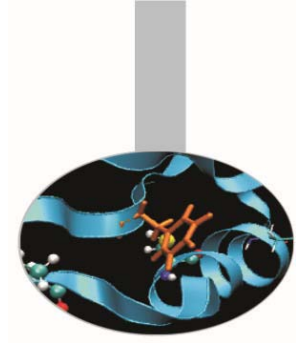
The screenshot shows the Blender 2.58.1 interface with the Render properties panel open. The central 3D viewport displays a yellow cube. The Render properties panel on the right is annotated with orange boxes and text:

- Render:** A box highlights the top of the panel with the text "F12" and "Ctrl+F12".
- Image resolution:** A box highlights the Resolution section (X: 1920, Y: 1080) with the text "Image resolution".
- Output format file:** A box highlights the Output section (PNG, RGB, Overwrite) with the text "Output format file".

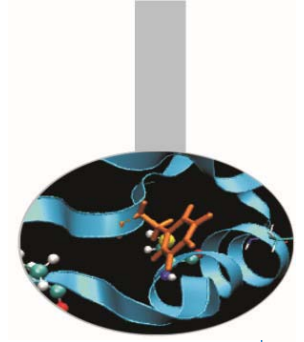
At the bottom, a separate box contains the text "Render F3 → to save render" above a small image of the yellow cube.

Render  
F3 → to save  
render

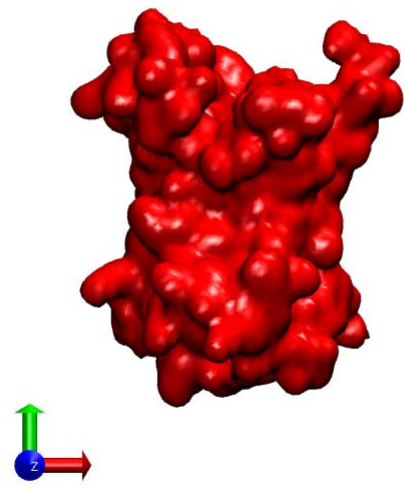
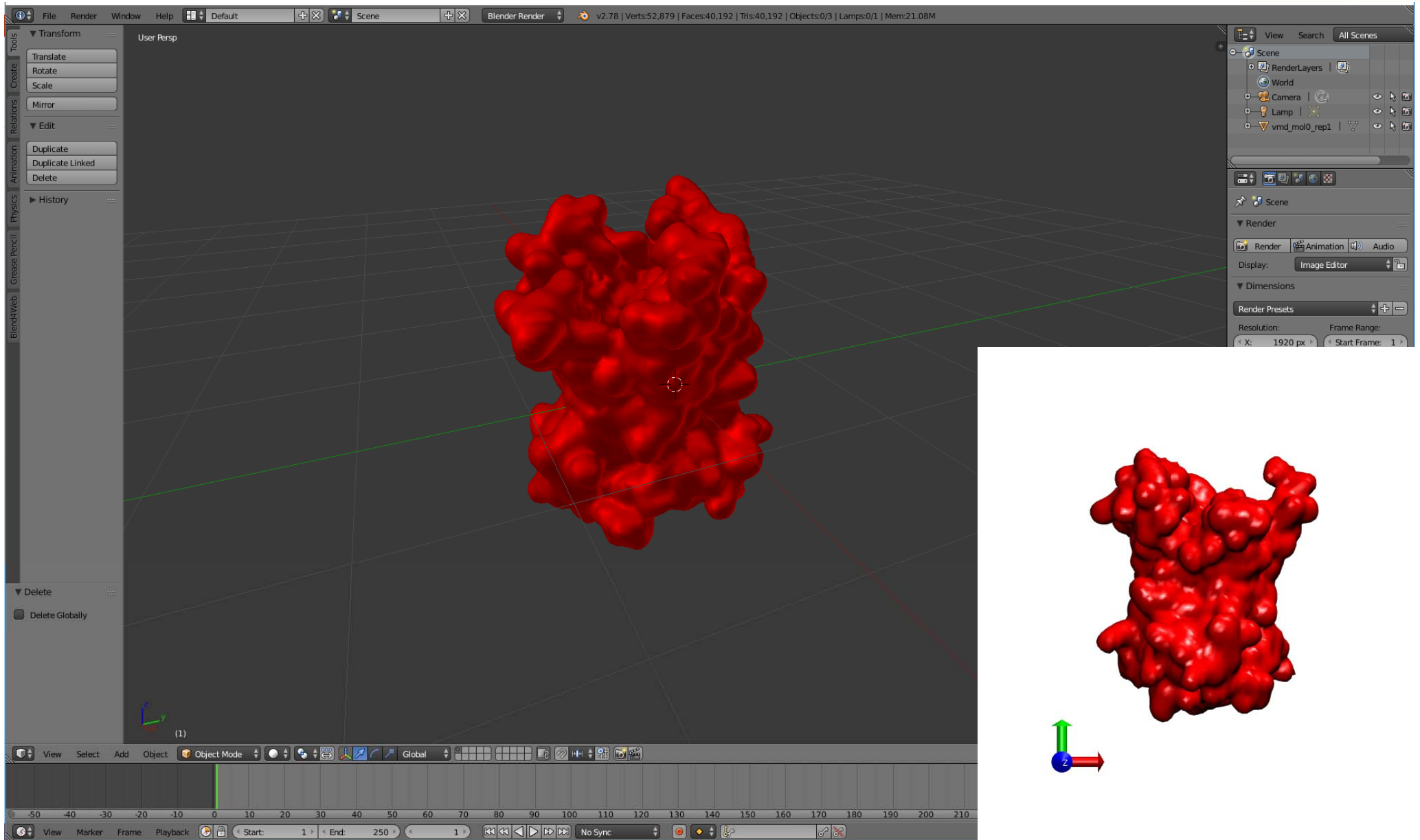


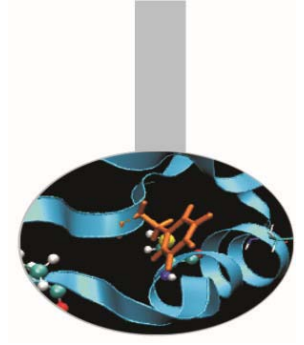


# Tutorial 1 Import obj file



# ATP/ADP MITOCHONDRIAL CARRIER

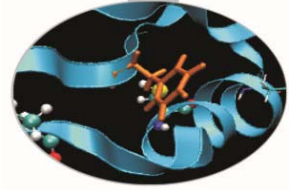




# Tutorial 2

## Create molecules in Blender

# METHANE MOLECULE (CH<sub>4</sub>)



**CTRL+P → Parent Hydrogen to bond**

**Shif + D → duplicate object**

Blender 2.78 | v2.78 | Verts:2,666 | Faces:2,696 | Tris:5,296 | Objects:1/11 | Lamps:0/1 | Mem:12.81M | Sphere.001

View Search All Scenes

- World
- Camera
- Lamp
- Sphere.001
- bond
  - Cylinder
  - hydrogen
  - bond.001

Carbon

Carbon

Surface Wire Halo

Preview

Diffuse

Intensity:

Specular

Ambient: 1.000

Translucency: 0.000

Transparency

Mask Z Transparency

Alpha: 1.000

Specular: 1.000

Mirror

Subsurface Scattering

Strand

Options

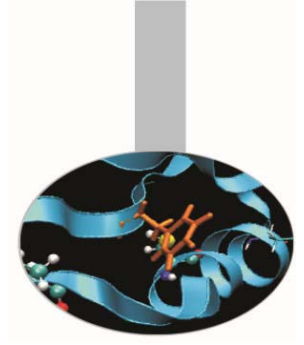
Traceable

Full Oversampling

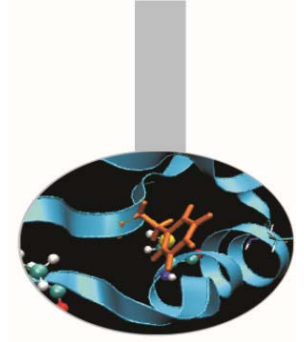
Face Textures

Face Textures Alpha






# Tutorial 3 Import PDB file



PDB







[www.rcsb.org/](http://www.rcsb.org/)

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Search by PDB ID, author, macromolecule, sequence, or ligands Go

Advanced Search | Browse by Annotations | Search History (2) | Previous Results (128)







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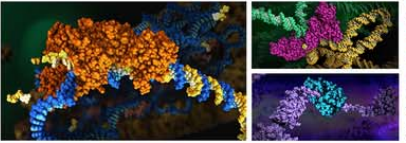
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[Search](#)  
[Visualize](#)  
[Analyze](#)  
[Download](#)  
[Learn](#)

### A Structural View of Biology

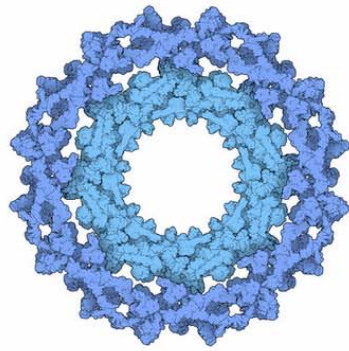
This resource is powered by the Protein Data Bank archive-information about the 3D shapes of proteins, nucleic acids, and complex assemblies that helps students and researchers understand all aspects of biomedicine and agriculture, from protein synthesis to health and disease.

As a member of the wwPDB, the RCSB PDB curates and annotates PDB data. The RCSB PDB builds upon the data by creating tools and resources for research and education in molecular biology, structural biology, computational biology, and beyond.

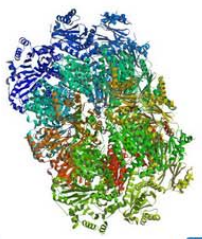
### A Molecular View of HIV Therapy


 2016 FASEB BioArt Winner  
 View animation on PDB-101




### January Molecule of the Month


 Nuclear Pore Complex


Latest Entries *As of Tuesday Jan 10*



**Features & Highlights**

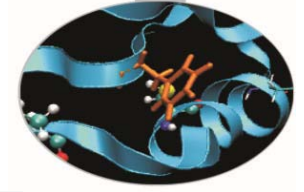
- 
**View Validation in 3D**  
 Visualizing structure quality metrics in three dimensions » 10/11
- 
**Explore Ligand Interactions in 3D**  
 Analyze small molecule interactions with NGL » 10/11
- 
**New Images for Transmembrane Proteins**  
 Access multiple high resolution images » 10/11

**News**


**Winter Newsletter Published**  
 2016 milestones and recent websites tools and features are highlighted. RCSB PDB members also report on the events of the *Aesthetics and the Life Sciences* symposium. » 01/10


2016 FASEB BioArt Winner » 01/03





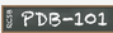





# PDB





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 An Information Portal to 125795 Biological Macromolecular Structures

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[Advanced Search](#) | [Browse by Annotations](#) | [Search History \(2\)](#) | [Previous Results \(128\)](#)

**Advanced Search Interface**

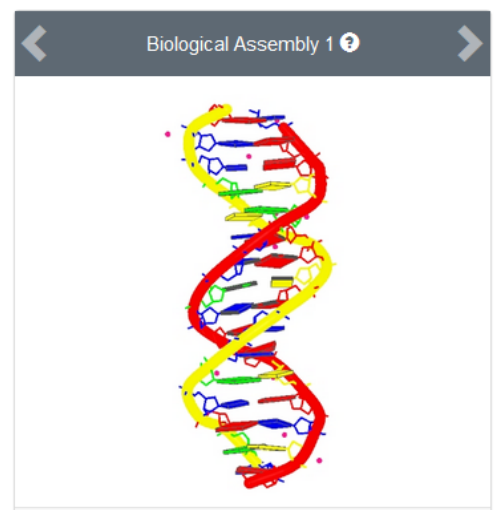
Search by title record (PDB 'TITLE' record or mmCIF \_struct.title value)

Contains:

[Result Count](#)  
**128**  
**PDB Entries**  
**(Structures)**  
**52**

[Structure Summary](#) | [3D View](#) | [Experiment](#) | [Literature](#)

Retrieve only representatives at 90% Match  of the above conditions.

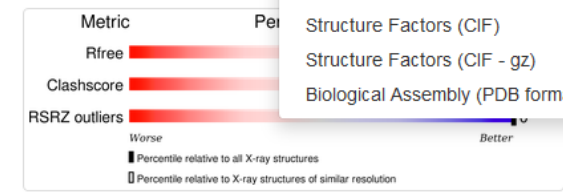


## 3BSE

Crystal structure analysis of a 16-base-pair B-DNA  
 DOI: [10.2210/pdb3bse/pdb](#) NDB: [BD0105](#)  
 Classification: [DNA](#)  
 Deposited: 2007-12-23 Released: 2008-12-23  
 Deposition author(s): [Narayana, N.](#)  
 Structural Biology Knowledgebase: [3BSE](#) [SBKB.org](#)

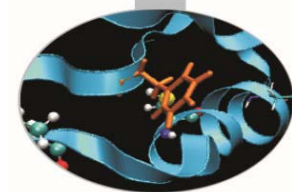
**Experimental Data Snapshot**  
 Method: X-RAY DIFFRACTION  
 Resolution: 1.6 Å  
 R-Value Observed: 0.221

### wwPDB Validation



[Display Files](#) | [Download Files](#)

- FASTA Sequence
- PDB Format
- PDB Format (gz)
- PDBx/mmCIF Format
- PDBx/mmCIF Format (gz)
- PDBML/XML Format (gz)
- Structure Factors (CIF)
- Structure Factors (CIF - gz)
- Biological Assembly (PDB format - gz) (A+S)



# PDB


 An Information Portal to  
 125795 Biological  
 Macromolecular Structures



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**Advanced Search Interface**

Structure Title

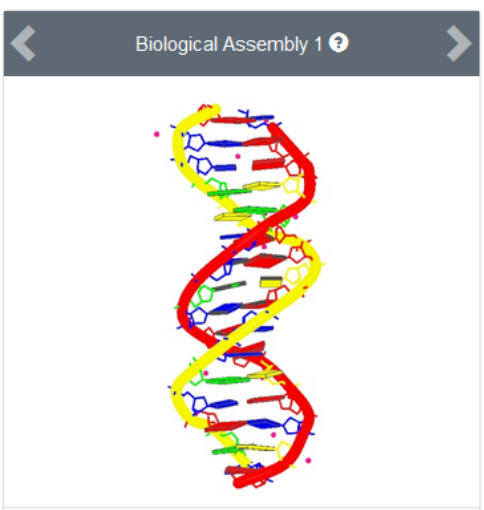
Search by title record (PDB 'TITLE' record or mmCIF\_struct.title value)

Contains:  Result Count: 128 PDB Entries (Structures) 52

Structure Summary | 3D View | Experiment | Literature

Retrieve only representatives at 90% Match  of the above conditions.

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View in 3D: [NGL](#) or [JSmol](#) or [PV](#) (in Browser)

## 3BSE

Crystal structure analysis of a 16-base-pair B-DNA

DOI: [10.2210/pdb3bse/pdb](#) NDB: [BD0105](#)

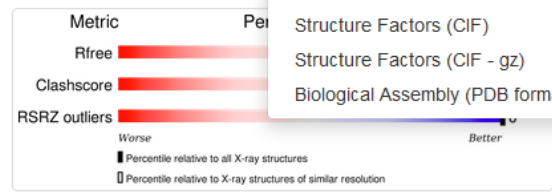
Classification: [DNA](#)  
 Deposited: 2007-12-23 Released: 2008-12-23  
 Deposition author(s): [Narayana, N.](#)

Structural Biology Knowledgebase: [3BSE](#) [SBKB.org](#)

### Experimental Data Snapshot

Method: X-RAY DIFFRACTION  
 Resolution: 1.6 Å  
 R-Value Observed: 0.221

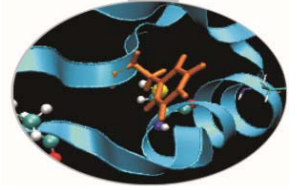
### wwPDB Validation



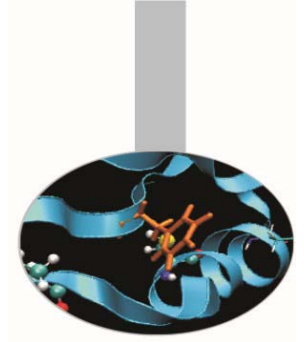
|

- FASTA Sequence
- PDB Format
- PDB Format (gz)
- PDBx/mmCIF Format
- PDBx/mmCIF Format (gz)
- PDBML/XML Format (gz)
- Structure Factors (CIF)
- Structure Factors (CIF - gz)
- Biological Assembly (PDB format - gz) (A+S)

# PDB



The screenshot displays the Blender 2.78 interface. The main 3D viewport shows a complex scene of spheres representing a protein structure, with a central green sphere and a yellow sphere. The File menu is open, showing the 'Import' option selected, with a sub-menu listing various file formats, including 'Protein Data Bank (.pdb)'. The Properties panel on the right shows the 'Render' settings, including resolution (1920 px x 1080 px), frame range (1 to 250), and output format (PNG, 8-bit color depth, 15% compression). The status bar at the bottom indicates the current scene is 'Sticks\_Calcium' and the frame range is 1 to 250.



# PDB

The screenshot shows the Blender 2.78 interface with a 3D molecular model of a protein structure. The interface includes various toolshelves, a 3D viewport, and property panels for Transform, Grease Pencil Layers, and View. The timeline at the bottom shows a keyframe at frame 180.

Insert single keyframe

Add Object Constraint

Copy Rotation

Target: Carbon

Vertex Group:

X  Y  Z

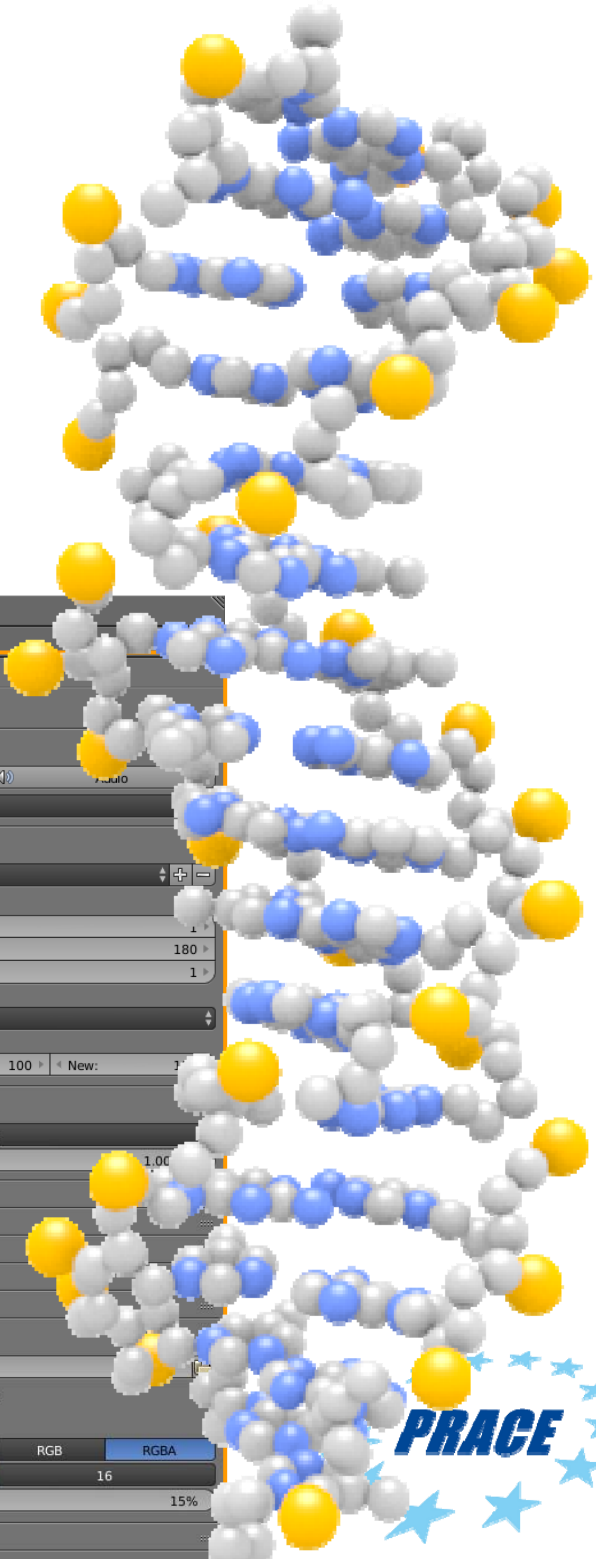
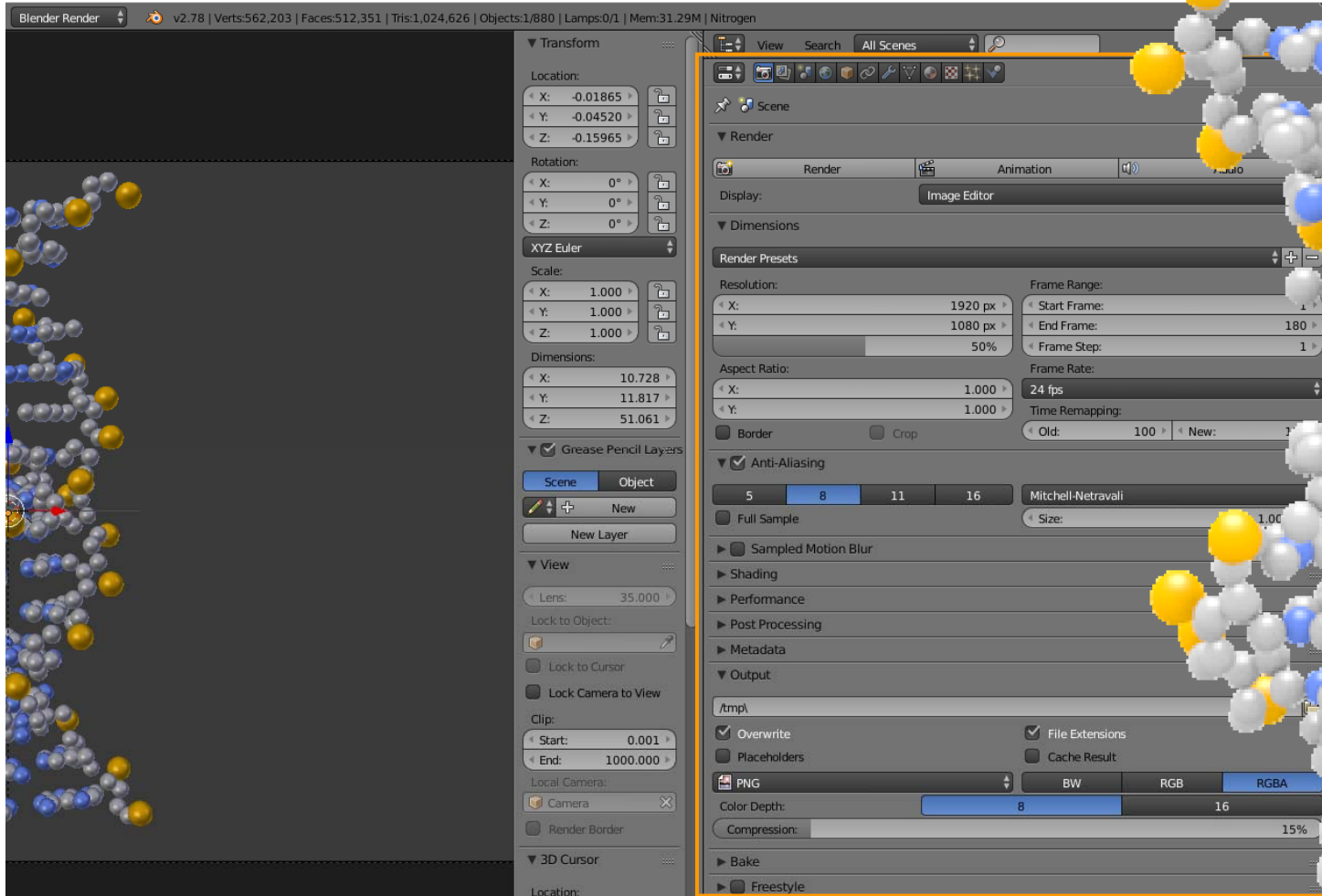
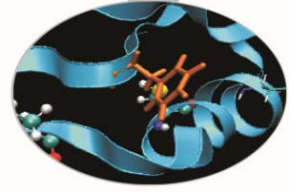
Invert  Invert  Invert

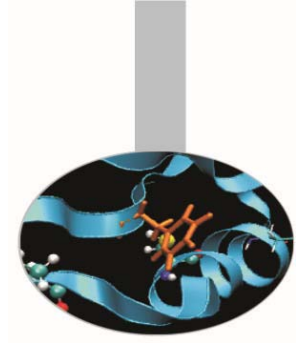
Space: World Space ↔ World Space

Influence: 1.000

Add object constraint → copy rotation

# RENDER IMAGE WITH TRANSPARENT BACKGROUND



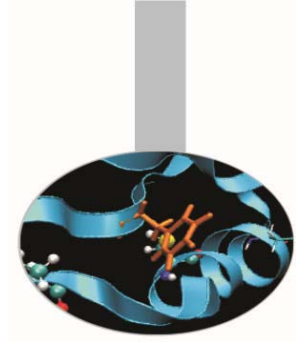


# Tutorial 4

## Simulation Jmol files



# JMOL



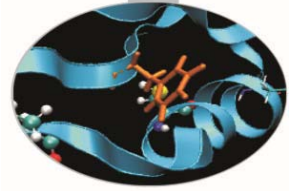
X3d files imported of the single structures:

$\text{BH}_3$   $\text{NH}_3$

The screenshot displays the Blender 2.78 interface. The central 3D viewport shows two molecular models: a pink and white  $\text{BH}_3$  molecule on the left and a blue and white  $\text{NH}_3$  molecule on the right. The text "X3d files imported of the single structures:" is overlaid in orange. The interface includes a top menu bar, a left-hand toolbar with various tools like Translate, Rotate, Scale, and Mirror, and a right-hand Properties panel with sections for Transform, View, and Material. The bottom of the screen shows a timeline and playback controls.



# JMOL

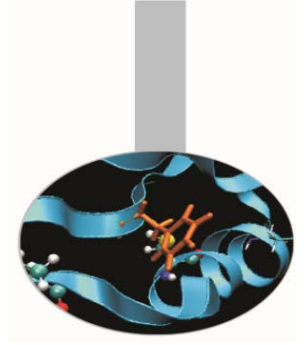


X3d files imported of the single structures:

$\text{BH}_3$        $\text{NH}_3$

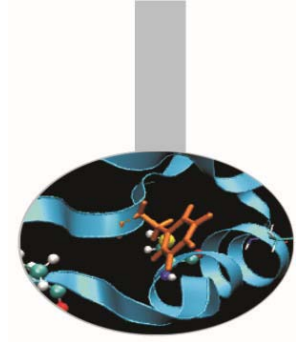
The image shows a Blender 2.78 interface with two 3D molecular models. The left model is labeled  $\text{BH}_3$  and is colored pink and white. The right model is labeled  $\text{NH}_3$  and is colored blue and white. An orange arrow points from the text 'X3d files imported of the single structures:' to a zoomed-in inset of the two models. The interface includes various panels like Transform, Properties, and Outliner.





# Tutorial 5

## Simulation Jmol files

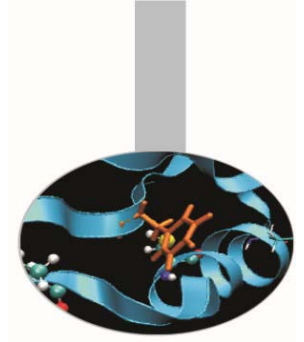


# JMOL

X3d files imported of the single structures:

The screenshot displays the Blender 2.78 software interface. The central 3D viewport shows two molecular models: a water molecule (H<sub>2</sub>O) with one red oxygen atom and two white hydrogen atoms, and a hydrogen chloride molecule (HCl) with one green chlorine atom and one white hydrogen atom. The text 'X3d files imported of the single structures:' is overlaid in orange. The interface includes a top menu bar, a left-hand toolbar with 'Tools' and 'Edit' sections, a right-hand properties panel for the selected object 'CL', and a bottom timeline and status bar.





# JMOL

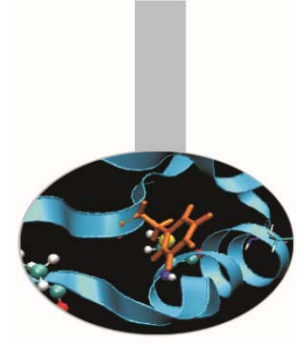
X3d files imported of the single structures:

- H<sub>2</sub>O

- HCL

(1) CL

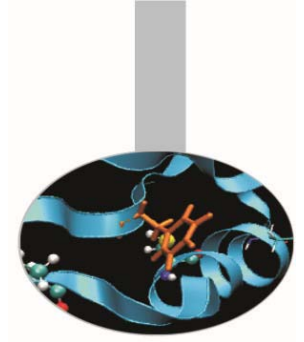




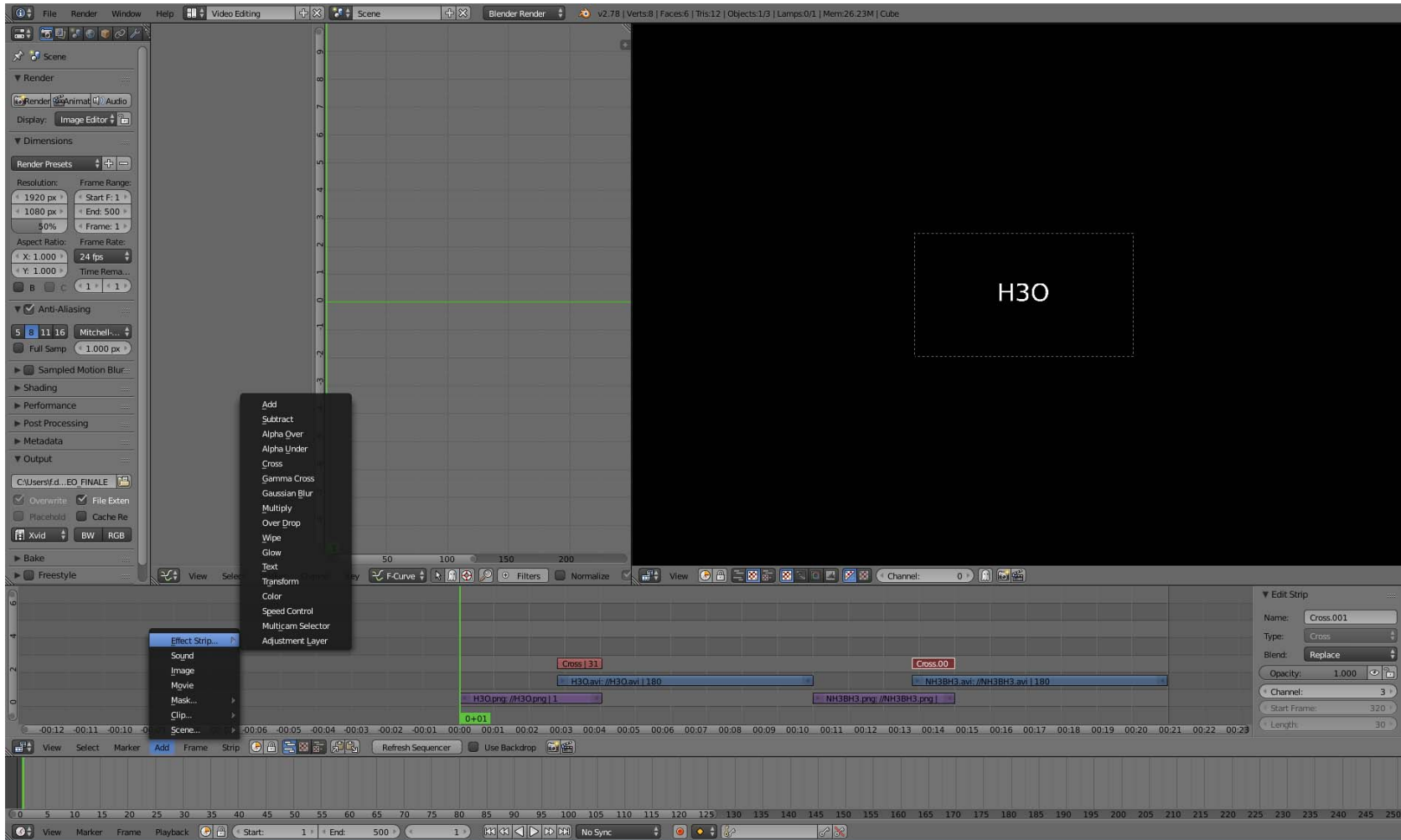
# Tutorial 6

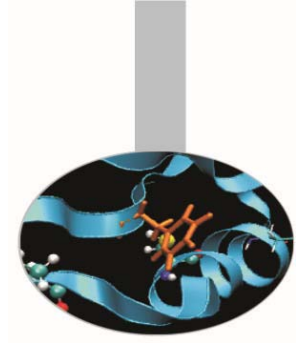
## Elaborate and create a video





# VIDEO EDITING

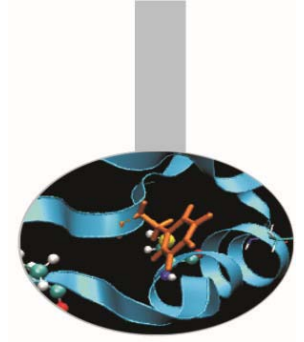




# Tutorial 7

## Import obj from VMD





# VMD

```

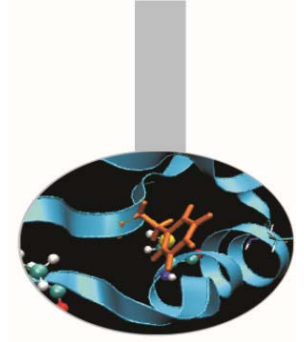
PYTHON INTERACTIVE CONSOLE 3.5.1 (default, Feb 17 2016, 17:09:19) [MSC v.1800 64 bit (AMD64)]

Command History:  Up/Down Arrow
                  Left/Right Home/End
Remove:           Backspace/Delete
Execute:          Enter
Autocomplete:    Ctrl-Space
Zoom:            Ctrl +/-, Ctrl-Wheel
Builtin Modules: bpy, bpy.data, bpy.ops, bpy.props, bpy.types, bpy.context, bpy.utils, bgl, blf, mathutils
Convenience Imports: from mathutils import *; from math import *
Convenience Variables: C = bpy.context, D = bpy.data

>>> import bpy
>>> for mat in bpy.data.materials:
...   mat.diffuse_shader = 'OREN_NAYAR'
...   mat.diffuse_intensity = 1.0
...   mat.roughness = 0
...   mat.specular_shader = 'BLINN'
...   mat.specular_intensity = 1.0
...   mat.specular_hardness = 50
...   mat.specular_ior = 10
...   mat.raytrace_mirror.use = 1
...   mat.raytrace_mirror.reflect_factor = 0.1
>>>
    
```

import bpy  
for mat in bpy.data.materials:  
mat.diffuse\_shader = 'OREN\_NAYAR'  
mat.diffuse\_intensity = 1.0  
mat.roughness = 0  
mat.specular\_shader = 'BLINN'  
mat.specular\_intensity = 1.0  
mat.specular\_hardness = 50  
mat.specular\_ior = 10  
mat.raytrace\_mirror.use = 1  
mat.raytrace\_mirror.reflect\_factor = 0.1





## LINK

→Official website:

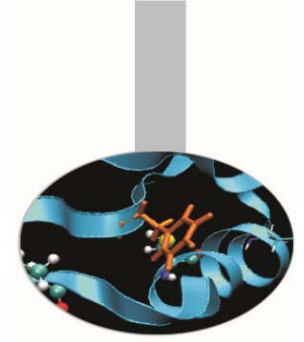
- <http://www.blender.it>
- <http://www.blender.org>

→Documentation:

- [http://wiki.blender.org/index.php/Main\\_Page](http://wiki.blender.org/index.php/Main_Page)
- <http://www.blendermagazineitalia.it/>
- [http://en.wikibooks.org/wiki/Blender\\_3D:\\_Noob\\_to\\_Pro](http://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pro)

→Library:

- <http://www.blendswap.com/>



## SOME LINK OF SPECIFIC TUTORIAL

Blender for chemistry:

<http://blender.freemovies.co.uk/chemistry/>

Blender for biologist:

<http://www.bioblender.eu/>

<http://www.bioblender.eu/Database/BioBlenderTutorial.pdf>

<https://www.youtube.com/watch?v=1QHR8WU2y4w>