Appendix 2: How to 3d print a protein

How to 3d print a protein

This summary is based on the article by Dr. Jessica Polka in the cell biology forum (link here). She deserves all the credt for this protocol, it works well! The following is taken *ver batim* from her excellent summary; please contact Dr. Polka Jessica (contact info here) for questions and be sure to cite her! We have added some details where appropriate, but this protocol is Dr. Polka's invention! If you are looking to access a 3d printer in the UF area, see the links at the end of this appendix for suggestions.

The Protein Data Bank (PDB)

- The PDB was established in 1971 at Brookhaven National Laboratory as the 1st open access digital data resource in all of biology and medicine (more here).
- The PDB provides access to 3D structure data for large biological macromolecules (proteins, DNA, and RNA). Knowledge of the 3D structure for a biological macromolecule is essential for understanding its' role.
- PDB is the leading global resource for experimental data central to scientific discovery, and makes 3D models available to anyone at no charge (only requiring citation).

Be sure to cite the PDB model, as others put hundreds, even thousands, of hours into the creation. Link for how to cite the PDB is here.

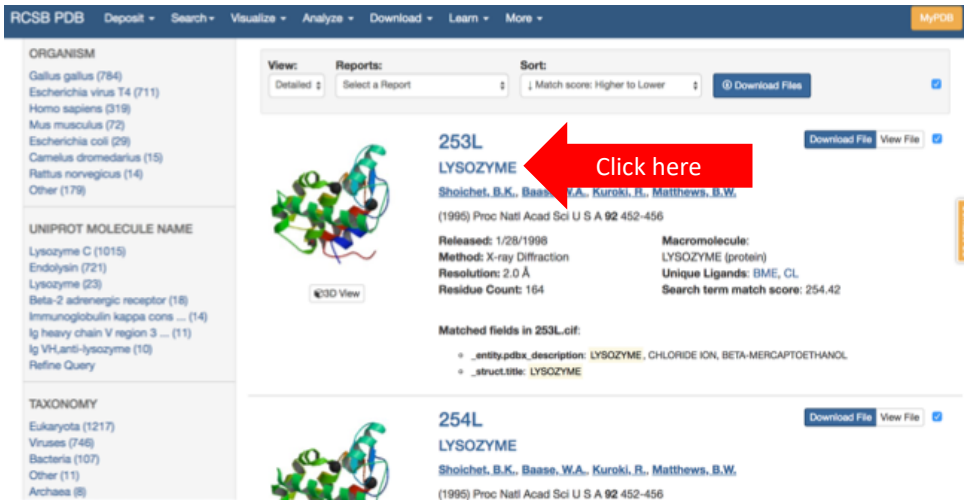
What you need (before you begin)

1) MeshLab (download here)
2) PyMol (download here). * *Note that Pymol may require a license fee, depending on your institution. MeshLab can direcly import PDB files, but Pymol tends to be more diverse and has a better mesh feature.*
3) 3d printer
4) Printing filament.

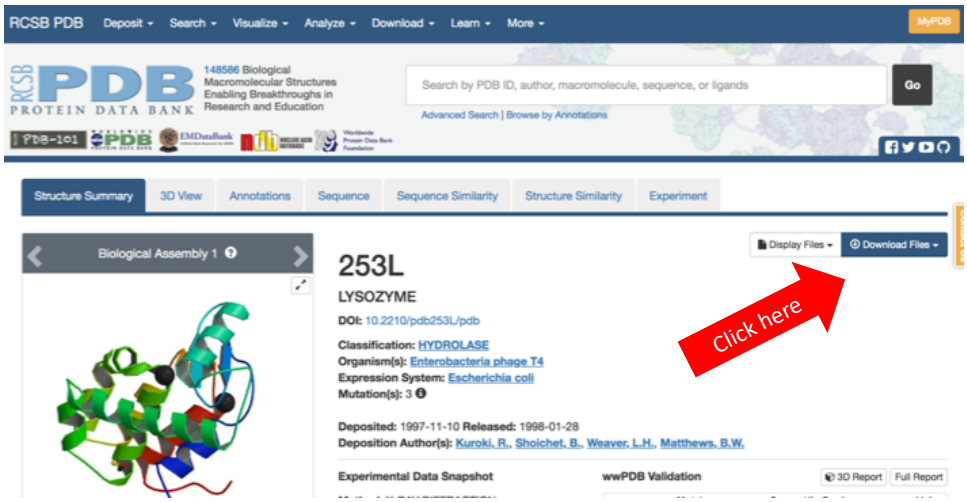
    * Note: We prefer PLA, which is a biodegradable thermoplastic. PLA is safer to use indoors and is generally accepted by our Environmental Health and Safety Office. For more information on choosing filament material see here (link).

Step-by-step instructions

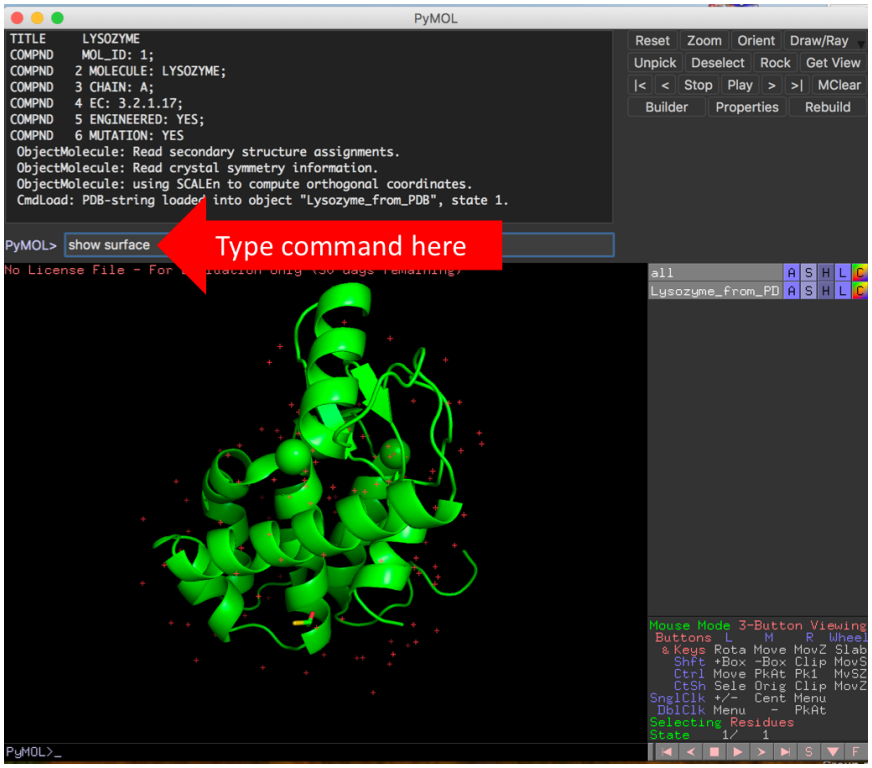
1) Find your protein of interest in the Protein Data Bank (link here). For example, search for "lysozyme" to find a structure.
2) Click on the name of the protein you are interested in



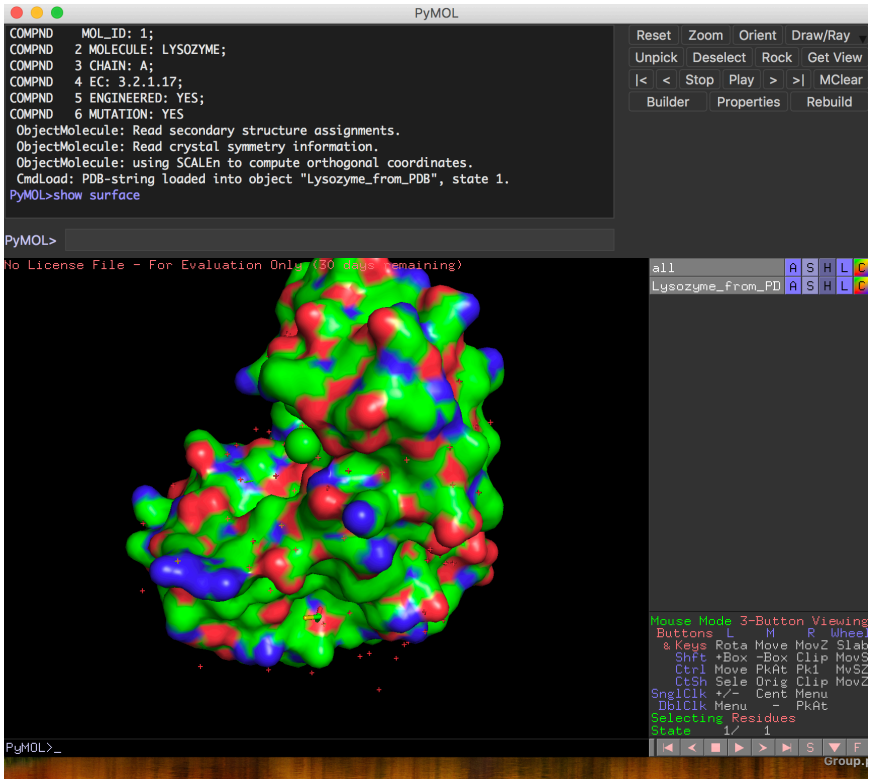
3) Click on "Download files", choose "PDB format" and save the file to your desktop or other file folder



4) Open PyMol, and open the PDB file (File-Open-choose pdb file). You should begin with a ribbon structure as shown below. Type "show surface" in the command line and push Enter.

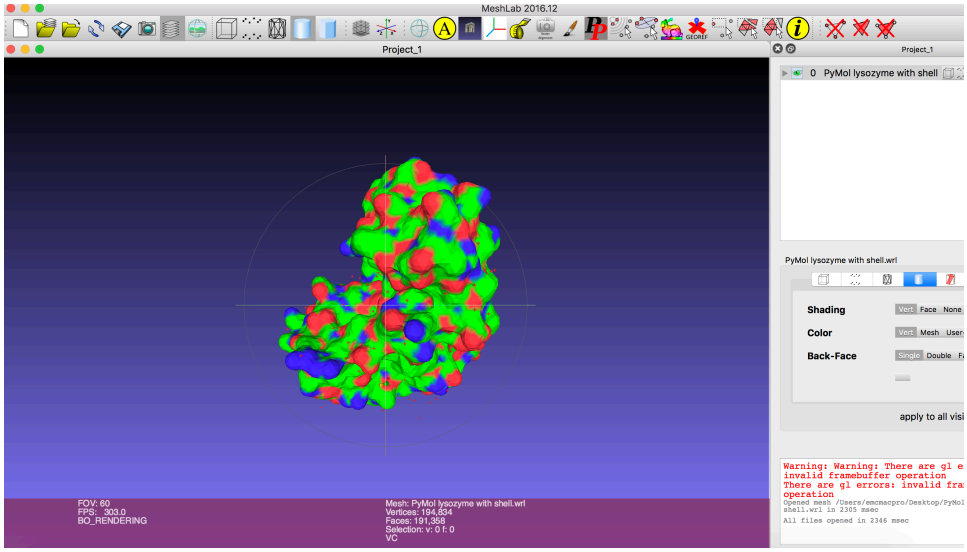


5) You should see a shell created around the ribbon structure as shown below.



6) Export VRML file with the high resolution shell creted by PyMo (File-Export Image As-VRLM2). Save the file to your desktop or other file folder.
7) Open MeshLab. Open MeshLab, and then open your .wrl file created in step 6. To open the file, Click File-Import Mesh and then choose your file.

   ** Note: If using a Mac you may have to open MeshLab using the Finder, instead of launchpad. Open Finder, Click on Applications, and then find MeshLab. Control-Click on the application name, and then click Open when the prompt opens. The file from the link above is safe and can be opened with no security issues. Using MeshLab is important, as most 3d printers cannot open a VRLM or .wrl file. MeshLab is used to create a .stl file, which can be interpreted by all 3d printers.*



8) Click File-Export Mesh and export the file as a .stl for 3d printing. Click File-Export Mesh As, choose a name and location, choose .stl format, and click on on the saving options screen.

   ** Note: If necessary, MeshLab can be used to scale the file. Click Filters-Normals, Curvature and Orientation-Transform:Scale, Normalize. Enter the scaling effect in any of the x, y, or z axes and push enter.*

9) Open the .stl file in the 3d printer and prepare the mesh.

   ** Note: We typically print with at least 5-10% fill density, but this varies by printer. Hollow objects are possible if you are an experienced 3d printer. I suggest either adding a rectangular base, or simply "melting" the bottom ½ cm to avoid the complex 3d geometry of the proten from causing structural instatilbility while printing. With a fill*

density of 5% one hand-sized protein requires approximately 3 hours to print on our printer.

For access to 3d printing services in Gainesville, FL, we recommend the following:

- University of Florida Marston Science Library (link here)
- Infinity Fab Lab at the University of Florida (link here)
- General quote for 3d printing services in Gainesville, FL (link here)
- Alachua County MakerSpace (link here)