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NEWSLETTER

Contents

EDUCATION CORNER

Undergraduate Course: Protein Portraits by Phil McFadden, Ph.D.

Protein Portraits is a nontraditional college course developed around the question of what it might be like to shrink to the nanometer realm for a direct encounter with a protein molecule. Since this question invites artistic interpretation, the course is recommended to students whose tastes include both art and science.

Phil McFadden is an Associate Professor of Biochemistry and Biophysics at Oregon State University. His ten-week lecture course in biochemistry opens the year-long sequence offered to undergraduate and graduate students seeking degrees in biochemistry and biophysics, American Chemical Society-certified chemistry degrees, and professional pharmacy degrees. He has conducted research in protein chemistry and biological sensory systems, and is currently working on the biology and phenomenology of shells with equal footing in Darwin, Schrodinger and Heidegger. Among his most prized possessions is his autographed copy of Albert Lehninger's 1975 edition of Biochemistry.

The course has been offered in various versions around the Oregon State University (OSU) campus. In recent years it has found a home in our Honors College where the atmosphere is enriched by high-performing students from all academic majors. This spring, with nothing to lose and two credit-hours to gain, eleven Honors College students enrolled in Protein Portraits to boldly go where only their imagination could take them. These are the portraits of their ten-week voyage.

The instructor of the course, Phil McFadden, is a professor in the Department of Biochemistry and Biophysics. He teaches the course out of the belief that chemical modeling sets are one of the best toys for kids of all ages. The following interview is distilled from the Protein Portraits course blog at **blogs.oregonstate.edu/psquared.**

Q: ***Dr. McFadden, how does a student taking your course decide which protein to portray?***

A: Easy. I show the students how to use the RCSB Protein Data Bank. David Goodsell?s **Molecule of the Month** is an inspiring starting point. From there, the students are soon able to go off on their own, using the RCSB PDB?s search and 3D visualization tools to find a protein structure that fits their personal interests. By the third or fourth week of the class, most students have made a firm choice of a protein. They know its name, its domain structure, what it does for the organism.

Q: ***What kind of scientific guidance do you give your students for portraying a protein molecule?***

A: It is true that to understand the structures in the PDB archive, students need at least a basic understanding of how amino acids are connected into chains and how those chains fold according to the hierarchy of secondary, tertiary and quaternary structure. Many students have learned these essentials by high school, so all I generally need to do is throw more light on the subject by spinning PDB structures before their eyes. For this course I also feel fortunate that protein scientists have used a good deal of whimsy in the naming systems for various protein structures?what could be more visually affirming than zinc fingers, leucine zippers, and jelly roll domains as proof positive of the utility of depicting proteins as everyday forms?

Q: ***What artistic advice do you offer?***

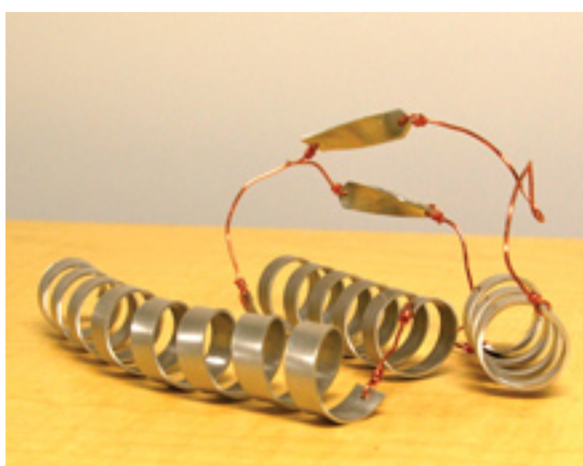
A: I advise them to make an allusion to the biological function of the protein in their artwork. Then I show them inspiring examples of the world?s heritage of protein art: Irving Geiss?s portrayal of sperm whale myoglobin, Roger Hayward?s pastel illustrations of proteins for Scientific American, Jane Richardson?s revolutionary depictions of the structural elements of proteins, and various other masterful illustrations from books and journals published since the 1960s. I also point to the works of contemporary artistic-scientists and scientific-artists such as **David Goodsell?s exciting graphics** and **Julian Voss-Andreae?s wonderful sculptures**. Finally, we are lucky on this campus to be able to stroll across the campus quad to visit the OSU library where Linus Pauling?s many chemical models built out of many sorts of materials (including his earliest models of the alpha helix built from folded paper) are held as historical treasures along with the rest of his archived effects.

Q: ***How did the students? public art show turn out at the end of the term?***

A: It was a lot of fun. Included here are photos of each student?s work along with their authored caption. I should mention that the cost of artistic materials was capped at around $10 per portrait, so you did not see bronze castings or cut crystal at the show. Aside from cost, any artistic medium was permitted.

Now, if you have strong scientific credentials, it may be obvious that most of the portraits deviate from the precise 3D coordinates deposited in the PDB. Indeed, I gave the students artistic license to adjust the pose of a protein chain if it helped their art come together. As I explained to them, all of the structures deposited in the PDB have been determined as instrumental averages measured over large populations of protein molecules, so why not give a little extra flexibility to a particular molecule coming to life in the art studio?

Our end-of-term show attracted around a hundred visitors. Ballots were provided to collect votes for the **Most Artistic, Most Scientific, and Overall Awesome**, as noted.



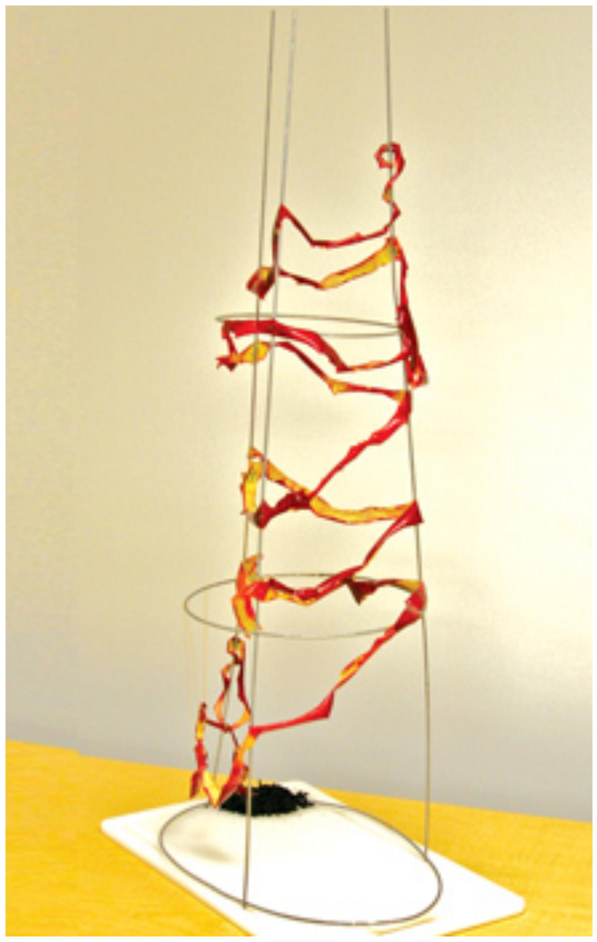
Prion
based on PDB ID: **1qlx**
Artist: Dan Cheung

The human prion protein is found throughout the body, but its function is a mystery. The biggest mystery is how in the misfolded state, a prion can act like a cult figure?it converts normal prions into pathogenic forms, causing deadly neural diseases, such as Creutzfeldt-Jakob disease and the notorious mad cow disease.

Calcitonin
based on PDB ID: **2glh**
Artist: Nathan Forster

Voted: Most Scientific

Bones are a surprisingly dynamic part of an organism?s body in that they are constantly being torn down and built back up by the combined efforts of osteoclasts and osteoblasts. Calcitonin, a molecule produced by the thyroid gland, is the protein responsible for both calcium uptake and telling the osteoblasts to build up new bone. Salmon calcitonin, depicted here with salmon vertebrae as the amino acids, is a prescribed medication for the debilitating bone loss of *osteoporosis. [Thanks go to Dr. Eric Forsman for providing dermestid beetles to clean the vertebrae, and to the Umatilla and Warm Springs Indian Tribes for providing the salmon material.]*



Pectin Lyase

based on PDB ID: **1idk**

Artist: Karen Hoagland

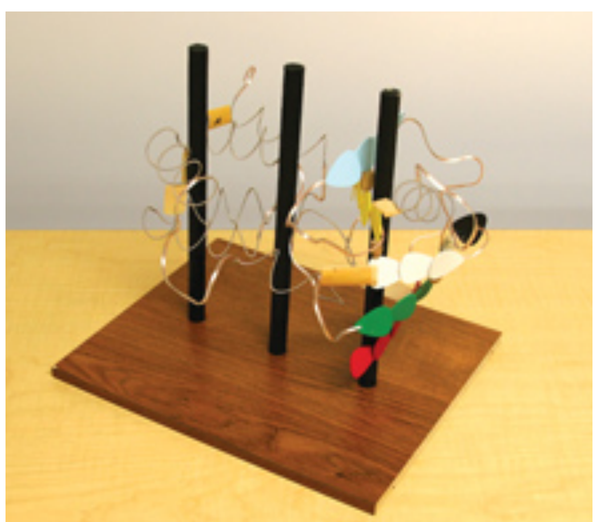
You reach into the fruit bowl and pick up a juicy, bright red apple. You take a huge bite. . . yuck! A big rotten chunk of fruity flesh just spoiled your treat. Blame no other than pectin lyase, the protein that breaks down pectin in the middle lamella of that now-spoiled apple. But don?t get too down on pectin lyase. . . if it wasn?t busy breaking bonds, that apple would still be unripe and bitter!

Ovalbumin

based on PDB ID: **1ova**

Artist: Danika Kusuma

The fluff of a marshmallow, the taste of a pretzel, the white of an egg omelet. . . To say that this egg protein is not all it?s cracked up to be would be something of an outrageous fib! This storage protein has multifarious uses, one of which creates that slight crispy texture to the surface of your humble pretzel. Isn?t it eggcellent?



Harmonin

based on PDB ID: **2kbs**

Artist: Jason S. Lusk

Of the myriad functions of proteins, among the most crucial are those that work in the ensembles that enable us to perceive our world. Harmonin is one such player in a chain of structures that give us our sense of hearing, from a beautiful chord played on a guitar to the powerful roar of thunder. This portrait of harmonin is built of materials (guitar picks, guitar strings, speaker wire and woodwind reeds) that would never have been invented were harmonin not working to help transmit sound vibrations through the inner ear.

ATP Synthase

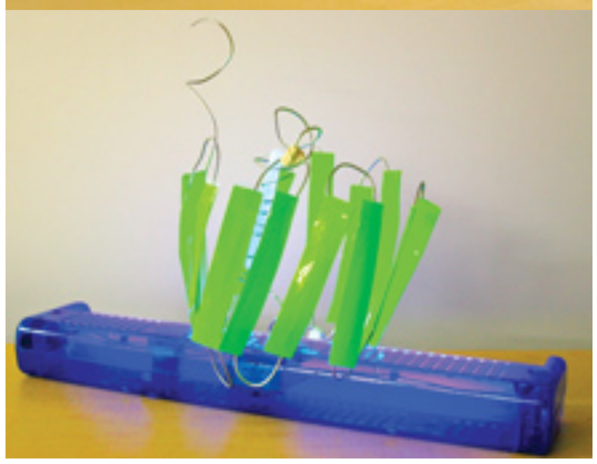
based on PDB ID: **1e79** and **1c17**

Artist: Valerie Mullen

Voted: Overall Awsome

Imagine those lazy summer days?nothing to do but sip lemonade and sit in the garden reading. It seems as if you are expending a minimum amount of energy, but in truth your body is still producing

massive quantities of ATP. The powerhouse protein that makes everything possible is ATP synthase: one of the most highly conserved and ubiquitous proteins you?ll find in nature. Yet we still don?t know its exact workings. Interested? Come take a closer look?



Dronpa

based on PDB ID: **2ie2**

Artist: Thi Nguyen

A careful balance between dark and light is achieved by dronpa, an engineered protein whose fluorescent glow is switched on and off by changing the wavelength of light that is shone upon it. This lovely behavior explains the name?a fusion of the ninja term for vanishing, dron, and the abbreviation for photoactivation, pa.

Dead Box Protein 5

based on PDB ID: **2kbf**

Artist: Callia Palioca

Voted: Most Artistic

Like a hand carefully untangling precious jewelry, the Dead Box Protein 5 unravels RNA strands. Found in many organisms and performing many functions, it primarily serves as an RNA helicase that enables the RNA strand formed after transcription to be functional. Here, the protein moves the RNA as it opens and closes. Though ancient and perhaps weary from its continual labor, this protein is certainly nt just a ?dead? box.

Clathrin

based on PDB ID: **1xi4**

Artist: Audrey Riesen

Voted: Most Artistic

You wouldn?t want to brave the elements without the proper outerwear? and neither do the vesicles that carry cargo such as enzymes throughout the interior of the cell. These vesicles wear a coat of their own?a delicate and beautiful polyhedral lattice formed when numerous three-armed clathrin triskelions join forces. So, my dears, grab your hats! We?re going out!

Green Fluorescent Protein (GFP)

PDB ID: **1ema**

Artist: Elizabeth Runde

GFP is composed of a barrel of beta sheets and a light-emitting chromophore within. By teaming up with aequorin (which glows blue), GFP produces the eerie green light that jellyfish are known for. GFP has spurred many new technologies, from tracer studies with fluorescent microscopes to those creepy glow-in-the-dark cats produced by genetic engineering.

Ubiquitin

based on PDB ID: **1ubq**

Artist: Minhazur Sarker

Garbage: it?s all around us, even in our body! Ubiquitin is a special protein that functions to eliminate the proteins we do not need anymore. A link, via a covalent attachment, joins ubiquitin proteins together, and when 4 are strung together, they move the garbage protein to a proteasome, which runs the process of destruction. [Note: One evening, the ubiquitin portrait was thrown out as trash by the custodial service. Evidently the protein was fully active, marking its own disposal.]

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