Protein Folding – Bernard Beckerman

Purpose
This lesson can be taught in a chemistry class when discussing polymers and their properties or when discussing intermolecular force (IMF) and its effect on molecules, or can be taught in a biology class when discussing proteins and their properties.

Overview
Students will use the interactive software Molecular Workbench to observe and manipulate Molecular Dynamics simulations of proteins. Students will observe protein folding in an isolated environment ("natural" folding) then will induce and study several modes of protein deformation (denaturation).

Student Outcomes

SWBAT identify proteins as the dominant structural building block of life, identify proteins as a polymer made of a sequence of amino acids, relate this sequence to the protein's final shape by understanding the IMFs involved, denature proteins using thermal, mechanical, and chemical means, use a computer model to form an understanding of protein mechanics, identify shortcomings of the model, and understand the hierarchical relationships among several levels of protein structure. Finally, students will use these tools to understand the relationship between themselves and their environment.

Standards Addressed
NGSS: HS-LS1-2, HS-PS1-3

Time
80 minutes (two class periods).

Level
All chemistry levels.

Materials and Tools
- Computers with the Java 7 runtime environment.
- The Molecular Workbench package (http://mw.concord.org/modeler/)
- The attached folder, "denaturation"
- "Proteins" PowerPoint slides
- Exit ticket

Preparation
Make sure that Java 7 works on all computers, and that students have installed and can open the Molecular Workbench simulation environment. Make sure students download and save a copy of the linked folder "denaturation" and have them open the file chargefold.cml from within Molecular Workbench to get started. This should be accomplished before class.

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Prerequisites

Knowledge of intermolecular forces and polymerization can be helpful, but only a basic understanding of these concepts is necessary for the lesson, and can be covered during lecture if necessary.

Background

After water, proteins make up most of our mass [slide 2]. If we want to understand how we are different physically from a glass of water the first step is to understand how proteins behave in our body. [Slide 4] Proteins have several different levels of structure just like books, for instance. Books consist of letters, that make up words, that make up sentences, that make up paragraphs, etc. The letters of the protein world are called amino acids [slide 5]. Each amino acid here is different, but can you spot what is the same between all of them? [Hit forward, still slide 5] These groups on the bottom are what link the amino acids together into a longer chain [slide 6] like this bracelet. Each bead on the bracelet represents a different amino acid, and each of these can be charged, polar, nonpolar, etc. If some beads are magnetic and some are charged, you might imagine the bracelet would start to fold up because of the attractions. To understand how they fold, we first have to zoom out. We do this by simplifying, and giving each different amino acid a letter for short [slide 7]. Now instead of writing out the entire molecular structure of each amino acid we just refer to it by its letter and remember that certain letters are charged, certain letters are polar, etc. [Slide 8] Now that we know about the letters, we can go up to the words, which are small structural motifs or patterns that proteins form. [Transition to computer model with slide 9.]

Teaching Notes

Students can work in groups or alone depending on computer availability, though groups of more than 3 may be unwieldy. If possible the software should be set up beforehand. Students should save their work when moving between pages, and should be shown the last slide in the PPT when ready to print their work out.

Assessment

Students will be assessed formally with a series of questions in the activity that they will print out as per the instructions on slide 11 of the PPT. Students will be assessed informally during the lecture by answering simple multiple-choice questions with their fingers, by instructor engagement during the activity, and with the “Grand Wrap-Up” on slide 10 after the activity, and with an exit ticket.

Additional Information

To change the questions to e.g. relate better to the current coursework, open the software as discussed, click the “Edit” button, then edit as desired. You must do this separately for each page you would like to edit.