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A Kinesthetic Approach to Exploring the Levels of Protein Structure

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Extended Abstract

The four levels of protein structure/folding is an abstract concept that many students have difficulty describing. Students in an introductory general biology course often lack background knowledge in biochemistry which is not part of the standard high school chemistry curriculum. Even students that successfully memorize descriptions of each level often struggle with the application of this idea and the implication of mutations on protein function. The modeling activity described here employs the concrete – representational – abstract instructional strategy that has been effective in math classrooms where a concrete activity involves manipulatives, the representational portion includes drawing, and then the abstract concept can be applied to new scenarios.

The manipulative in this activity allows students to use a hands-on approach to construct a protein model with primary, secondary, and tertiary structure using components from the 3-D Molecular Designs Amino Acid Starter Kit (https://www.3dmoleculardesigns.com/Education-Products/Amino-Acid-Starter-Kit.htm). Students complete a workbook-style handout that reviews important topics such as functional groups and polarity. In the first part of the activity, students identify the 20 different amino acids by their side chains and group them into categories of hydrophilic, hydrophobic, acidic, and basic. Next, the amino acid models are attached to a piece of foam-covered wire to build the primary structure of the protein. One region of the wire is coiled to form an alpha helix and tertiary structure is added by folding the wire to create disulfide bonds, hydrophobic interactions, and ionic bonds. Students then represent their folded polypeptide by sketching the structure in their worksheet. The final part of the exercise asks students to apply their knowledge to see how their protein would change if a particular mutation occurred. This activity was adapted for remote delivery by recording a video of the instructor assembling the protein model and having students complete the worksheet by watching the video. A copy of the student worksheet can be found by clicking on the supplemental materials link below.

To assess the effect of this activity on student learning, students in the face-to-face class were given an open-ended pre-test question before the activity and asked to assess their own level of confidence in their answer. Students were asked: “Explain how the four levels of protein structure represent an emergent property within the molecular level of the biological hierarchy. Include a specific protein example (indicate its highest level of folding) and describe its function (including how the structure relates to function).” Their responses were compared to scores and confidence assessment on a similar unit exam question about two weeks after the activity. 74% of students scored higher on the test question and the number of students earning full credit was dramatically increased. Nearly all students (91%) reported increased confidence with their unit exam answers and the number of students that were overconfident decreased by one third. Students taking the course remotely were asked the same unit exam question and their scores were comparable; 72% of students scored at least 2 out of 5 points on the test question (compared to 64% in the face-to-face course). Student feedback was also collected informally,

and comments indicate that this hands-on activity was more engaging and helpful than visual or aural instructional methods.

Keywords: protein folding, mutation, model building

Link To Supplemental Materials: https://doi.org/10.37590/able.v42.sup27

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