Proteins:
Making Bio-Inspired Connections

Project Overview

Abstract
This two week long high school biology curriculum introduces proteins, their properties, how they are created and how humans can use inspiration from proteins to solve real-world problems. Students learn about proteins and their properties before engineering a tensegrity model of hemoglobin from straws and rubber bands. Gene expression – transcription and translation is discussed and modeled through the creation of bracelets that represent the first few amino acids in a selected protein. This activity addresses negative feedback loops, as the protein selected is considered low or lacking in the system. Finally, the students will use modern biotechnology created by MIT to conduct a protein assay using the ampli "little devices". This activity covers microfluidics, antibodies/antigens and engineering skills.

Introduction to RET I (2014) Research Project
My RET I research project was focused on adhesive properties of a protein in the plaques of local mussels. Possible applications of this research would include glues that are applied in wet, uneven surfaces such as dental glue, surgical glue and glue that could be applied underwater.

Marine mussels are known to have adhesive in wet environments despite conditions that are not ideal for adhesion. *Mytilus Californianus* is a model organism and subject of interest for applications of wet adhesion. A modified tyronsine residue; 3,4dihydroxyphenylalanine (Dopa), the adhesive protein found in mussel plaques, was measured using cyclic voltammetry for its electrochemical properties over a course of seven days. The oxidation potential of Dopa decreases with time, then increases slightly at day five, and levels off after day 6. This can be attributed to the antioxidant effect of mfp-6 which is also located at the plaque/substrate interface. For optimal adhesion, surfaces are required to be containment and moisture free. To understand how mussels prepare surfaces, a mechanical testing device was employed to calculate the maximum adhesion forces of plaques on different substrates. Mechanical testing of 24-hour plaques on bound gold, glass, and biofilm slides initially show that mussels have greater adhesion with the "unclean" biofilm substrate than any other substrate. However, sufficient data has not been collected to confirm any conclusions. Further investigation will confirm redox potentials of dopa over longer periods of time at different scan rates.

During RET I, I was able to invigorate my love for science. I was given the opportunity to learn new methods and create my own protocols for something that had never been done before.

RET II (2015) Curriculum Rationale

The original inspiration for this curriculum stemmed from my RET I research experience. I was fascinated by the bio-inspiration driven research. In my research, one specific protein was the catalyst for the potential to have commercially made products that could improve efficiency for the user. Proteins are a part of the central dogma of biology and yet, they do not get as much attention as DNA in biology. In addition to encouraging the use of engineering skills, this curriculum also focuses on ensuring a solid understanding of the central dogma in a gene expression hands-on activity.

Learning Objectives

After completion of this unit of activities, students will be able to explain proteins – their monomers, specificity due to shape, and the variety of proteins; they will also be able to give a detailed account of transcription and translation and they will be able to consider possible applications of research using proteins.

Next Generation Science Standards Addressed

HS-LS1-1Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS1-3Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS3-1Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

<u>Science and Engineering Practices</u>
Constructing Explanations and Designing Solutions
Planning and Carrying Out Investigations
Asking Questions and Defining Problems

<u>Disciplinary Core Ideas</u>
Physical Sciences
PS1: Matter and Its Interactions
PS1.A: Structure and Properties of Matter
PS1.B: Chemical Reactions
PS1.C: Nuclear Processes

Life Sciences
LS1: From Molecules to Organisms: Structures and Processes
LS1.A: Structure and Function
LS1.B: Growth and Development of Organisms
LS1.C: Organization for Matter and Energy Flow in Organisms
LS1.D: Information Processing
LS3.A: Inheritance of Traits

Engineering, Technology and Applications of Science
ETS1.B: Developing Possible Solutions

<u>Crosscutting Concepts</u>
Structure and Function
Stability and Change
Cause and Effect
Scale, Proportion, and Quantity
Systems and System Models