3d molecular designs
Transforming Science Learning

Why does the egg turn white when I cook it? And Other Stories:

Modeling Protein Structures and Disruptions to their Systems

by Choi Maner
Kohler High School

Choi Maner

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- Science educator for 19 years
- Educator at KHS for 5 years, teaching Biology (General | Honors | AP); Biotechnology; Medical Terminology; and STEM 8
- CBM participant for the following courses:
  - Modeling the Molecular World - 2019
  - Science & Ethics of Genome Editing (Cohort 3) - 2021, 2022
- been using 3Dmol models in the classroom since 2016 (Model teacher since 2021)

Summer Course Opportunities this Summer!

- **Modeling the Molecular World**
  - Session 1: June 26 - June 30
  - Session 2: July 17 - July 21

- **3D Printing for the Biosciences Classroom**
  - July 1 or July 22

Scan the QR code for more information.

Why model protein structures?

Class Objectives:

- Demonstrate how the structure of amino acids dictate their interactions and thus, overall behavior of the protein.
- Demonstrate and explain how denaturation can impact the structure and function of proteins.
- Explain how mutations can alter the structure and function of proteins.

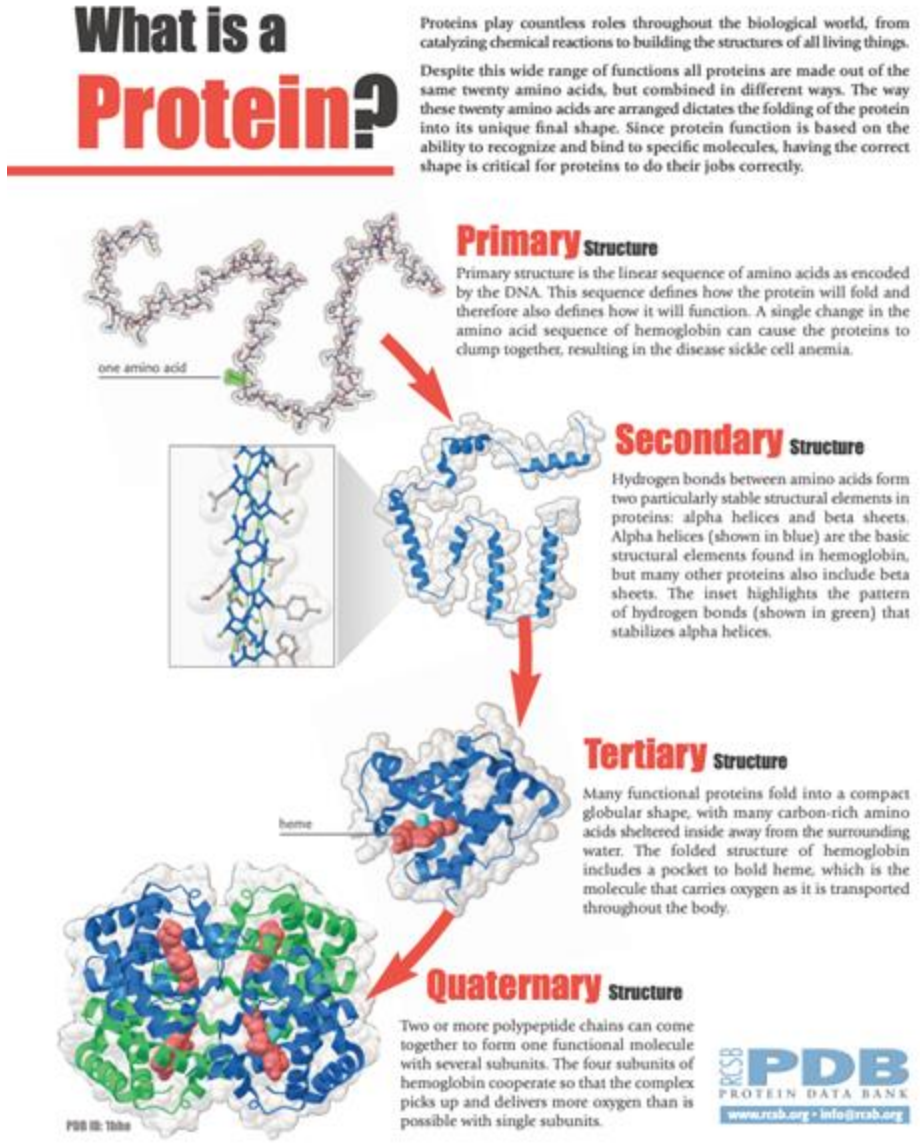


Image credit: RCSB Protein Data Bank

Target WI Science Standards:

Science Practice 2:
Developing and Using Models

Standard SCI.SEP2: Students develop and use models, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Cross-cutting Concept 6:
Structure and Function

Standard SCI.CC6: Students use science and engineering practices, disciplinary core ideas, and an understanding of structure and function to make sense of phenomena and solve problems.

Target WI Science Standards:

Cross-cutting Concept 6:

Structure and Function

SCI.CC6.h Students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.

Why model protein structures?

Class Objectives:

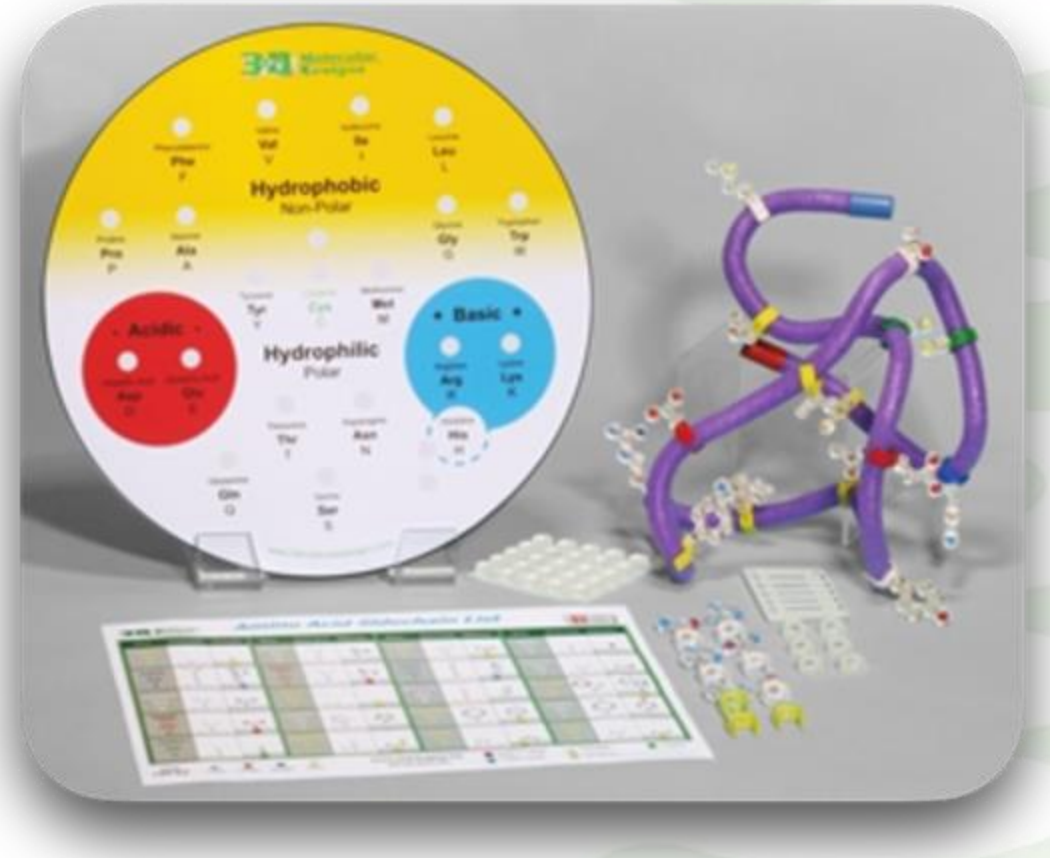
- Demonstrate how the structure of amino acids dictate their interactions and thus, overall behavior of the protein.

- Demonstrate and explain how denaturation can impact the structure and function of proteins.

Workshop Outcomes

Educators attending this workshop will:

- Model and visualize the formation of primary, secondary and tertiary protein structures, using the Amino Starter Kit.
- Also build quaternary structures and manipulate their models further to demonstrate and explain how environmental factors can disrupt the molecular structure and denature proteins.

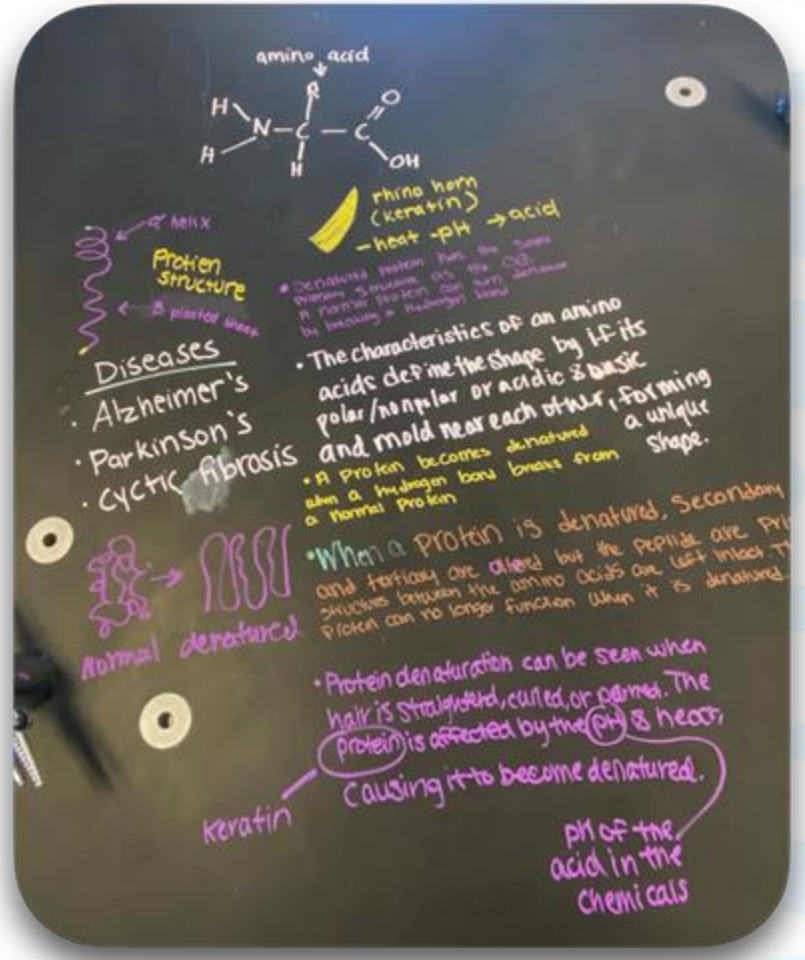


Workshop Outcomes

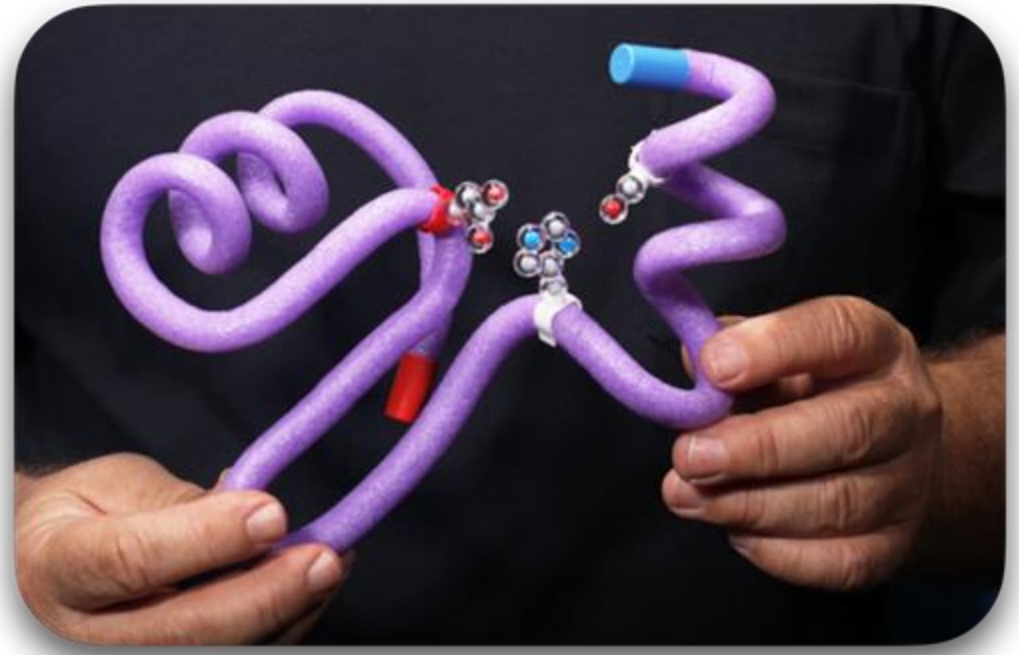
Educators attending this workshop will:

- Also discuss how mutations can impact the structure and function of these biological molecules.

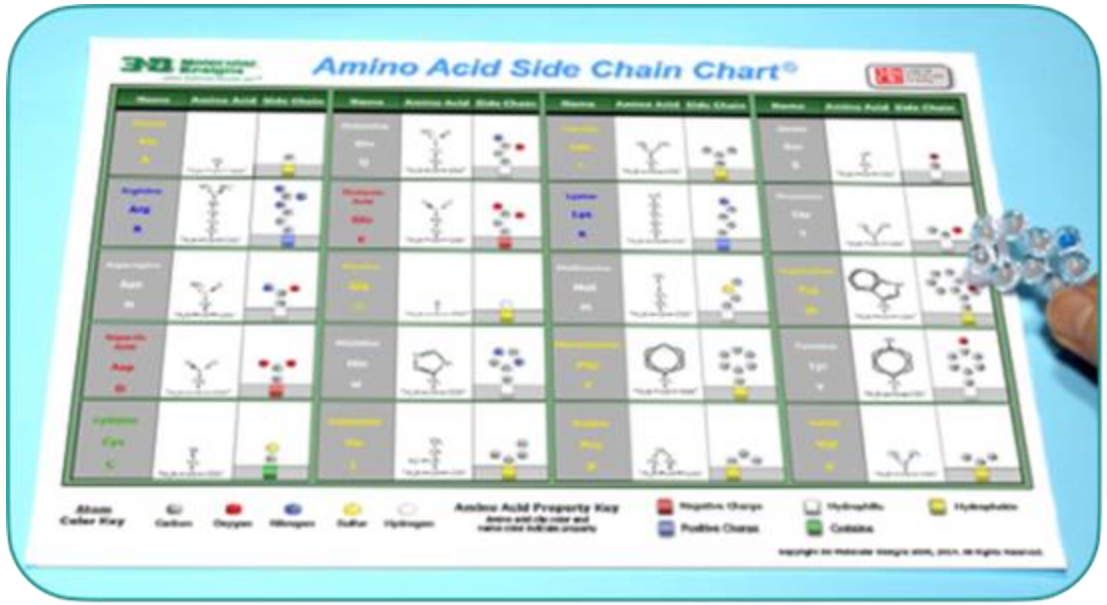
- Discuss and share strategies on how this activity can be implemented in different grade and subject levels, including other phenomena that these models can demonstrate and explain.

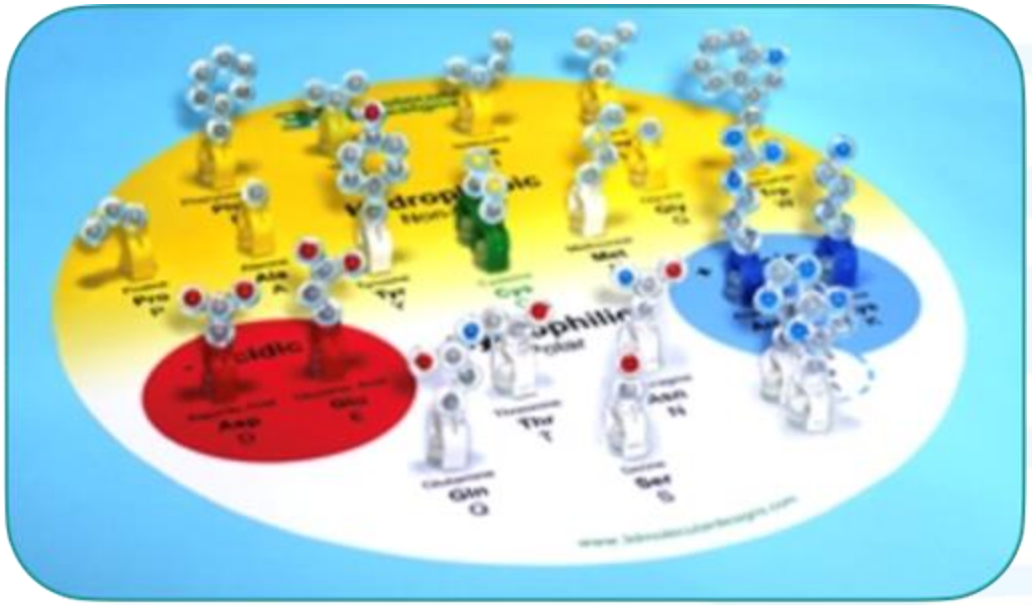


The objective is to bring these ideas to your classroom and help your students have a better appreciation and understanding of biomolecular processes while keeping them engaged and curious about explaining complex biological phenomena.



Step 1: Identify and sort the amino acids.





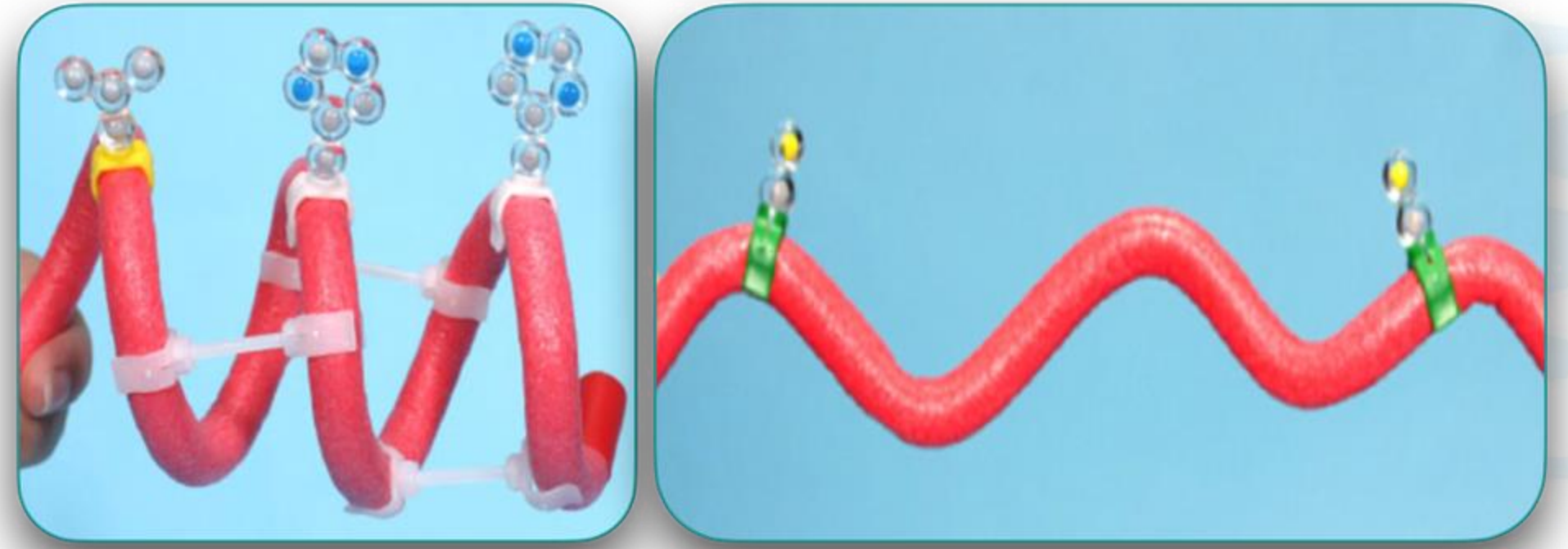
Step 2: Let's form a primary structure.

- Choose 15 amino acids with the following side chains from your kit:
  - 2 cysteine side chains (**green**).
  - 2 acidic side chains (**red**).
  - 2 basic side chains (**blue**).
  - Your favorite 3 hydrophilic amino acids (**white**).
  - Your favorite 6 hydrophobic amino acids (**yellow**).

- Randomly distribute them on the **TOOBER**. (Space them about 6.5 cm apart to get an even distribution).

Step 3: Form a secondary structure.

Why are secondary structures important to protein structure and function?



Step 4: Let's build the tertiary structure.

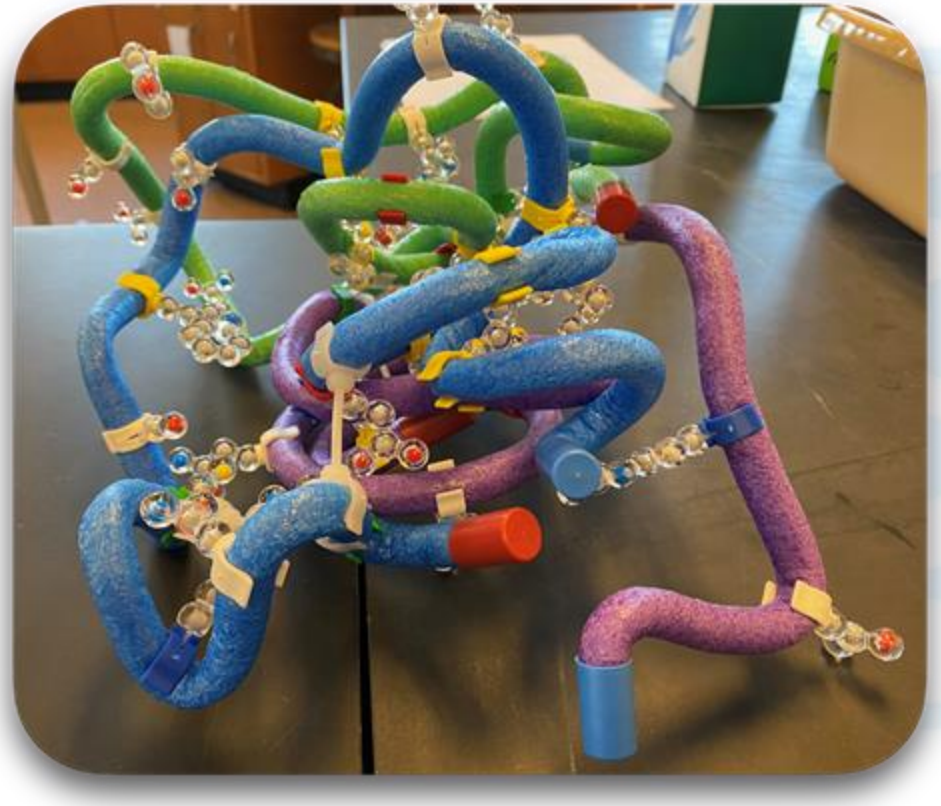
Fold your protein according to basic principles of chemistry and physics:

- In an aqueous environment, where do you expect the **hydrophobic** side chains to fold? Why?
- Likewise, consider where the **hydrophilic** side chains would fold.
- What interaction may occur between **acidic** and **basic** amino acids?
- What interaction may occur between **cysteine** amino acids?

Step 5: Build the quaternary structure.

Using the tertiary structures that your table group built, make a multi-domain protein.

Keep in mind the basic principles of chemistry and physics!

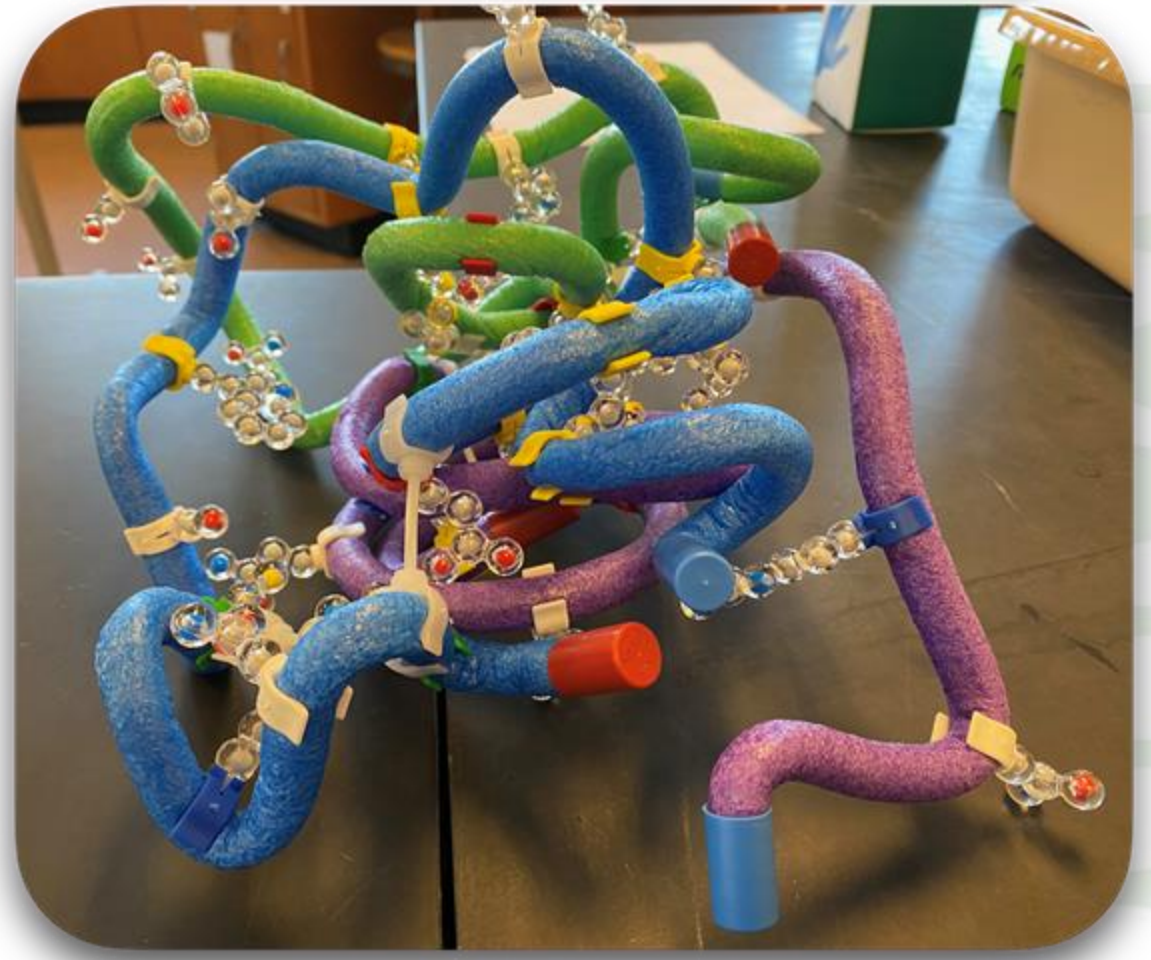


Step 6: Observe and compare the structure of your proteins.

What factors could change the shape (denature) of a protein?

What factors could alter its structure?

What factors could impact its function?



Step 7: Denature your protein.

“Why does the egg turn white when I cook it?”

Simulate denaturation by unraveling the domains.

- How does this impact the active site on the protein?
- How does this impact the function of the protein?

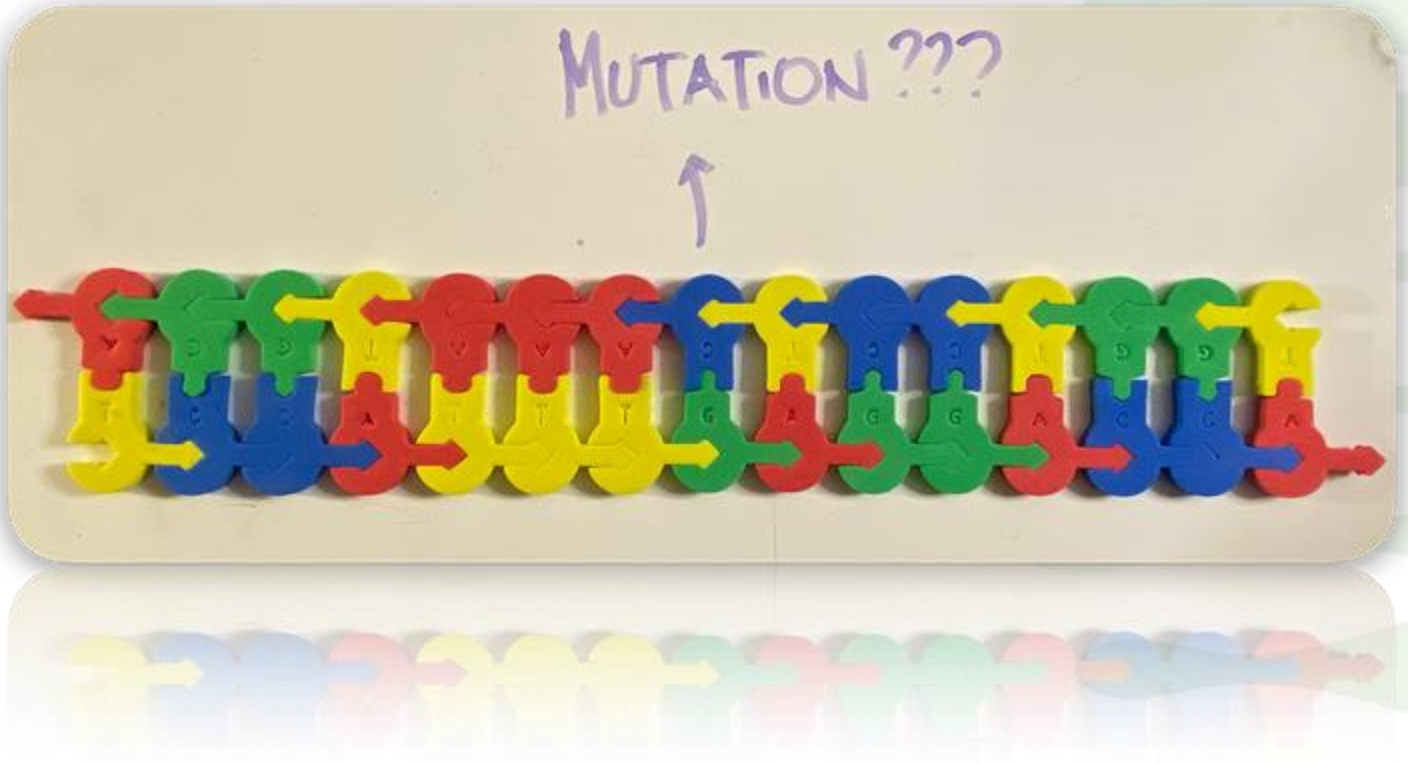
Step 8: What about mutations?

What if there was a mutation that occurred in the DNA?

How would you model:

- silent mutation?
- missense mutation?
- nonsense mutation?
- frameshift?

Let's share ideas!



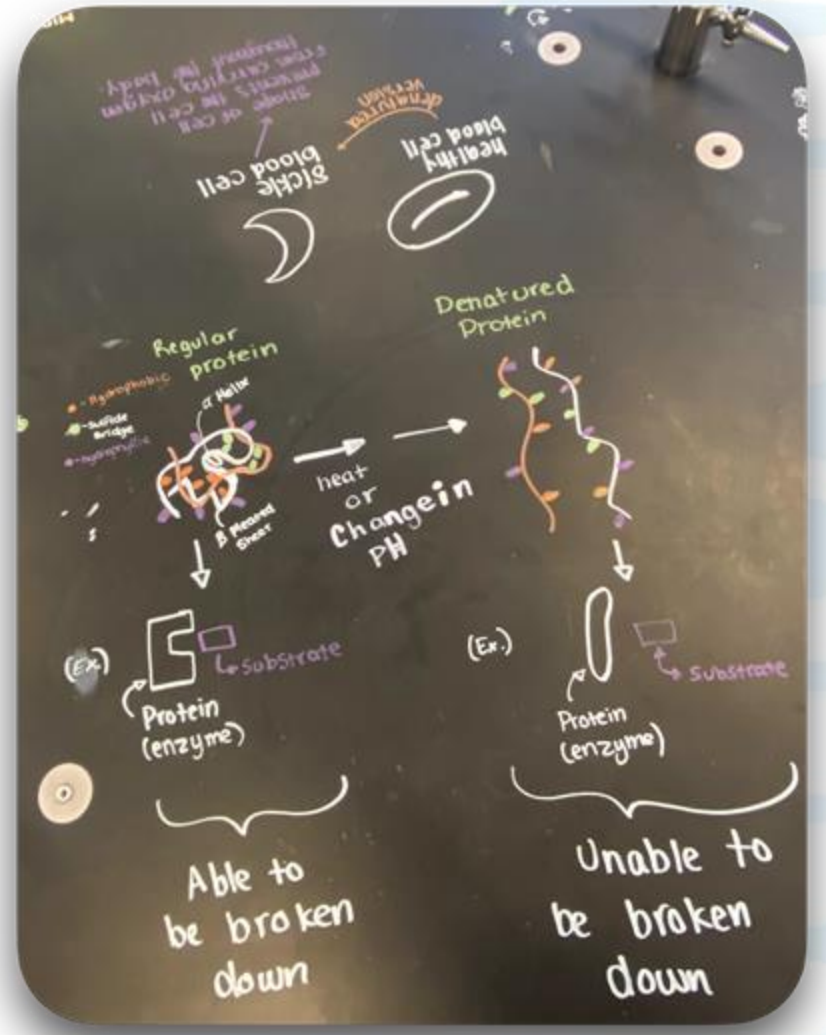
Classroom strategies

Connection to multiple topics, such as

- Enzymatic activity
- Gene expression
- Mutations
- Diseases + case studies

How would you use this in your classroom?

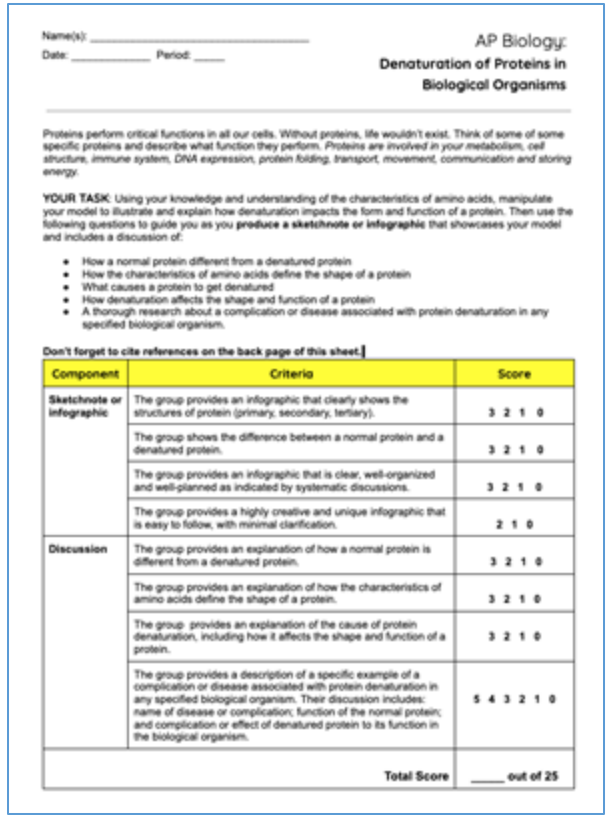
Let's share ideas!



Classroom strategies

Protein Modeling Protocols:

- version 1 →
- version 2 (SBG) →



Name(s): _____

Date: _____ Period: ____

AP Biology:
Denaturation of Proteins in Biological Organisms

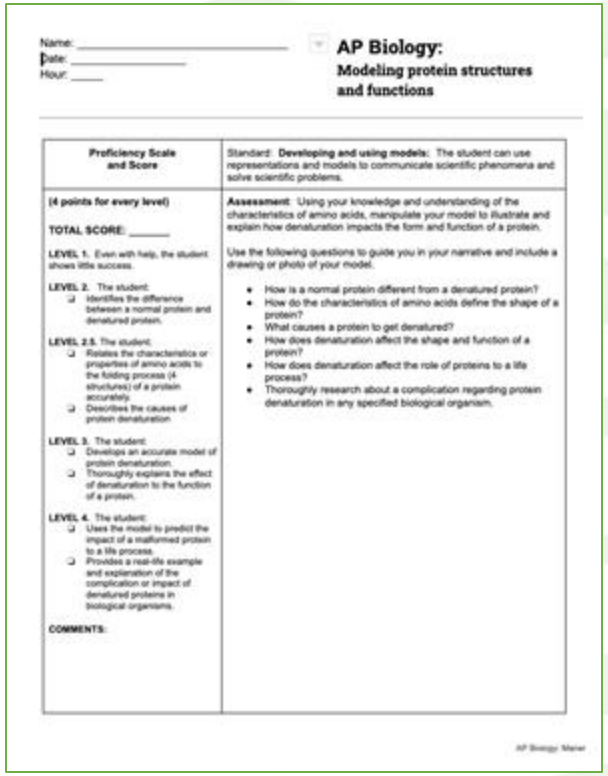
Proteins perform critical functions in all our cells. Without proteins, life wouldn't exist. Think of some of some specific proteins and describe what function they perform. *Proteins are involved in your metabolism, cell structure, immune system, DNA expression, protein folding, transport, movement, communication and storing energy.*

YOUR TASK: Using your knowledge and understanding of the characteristics of amino acids, manipulate your model to illustrate and explain how denaturation impacts the form and function of a protein. Then use the following questions to guide you as you **produce a sketchnote or infographic** that showcases your model and includes a discussion of:

- How a normal protein different from a denatured protein
- How the characteristics of amino acids define the shape of a protein
- What causes a protein to get denatured
- How denaturation affects the shape and function of a protein
- A thorough research about a complication or disease associated with protein denaturation in any specified biological organism.

Don't forget to cite references on the back page of this sheet.

Component	Criteria	Score
Sketchnote or infographic	The group provides an infographic that clearly shows the structures of protein (primary, secondary, tertiary).	3 2 1 0
	The group shows the difference between a normal protein and a denatured protein.	3 2 1 0
	The group provides an infographic that is clear, well-organized and well-planned as indicated by systematic discussions.	3 2 1 0
	The group provides a highly creative and unique infographic that is easy to follow, with minimal clarification.	2 1 0
Discussion	The group provides an explanation of how a normal protein is different from a denatured protein.	3 2 1 0
	The group provides an explanation of how the characteristics of amino acids define the shape of a protein.	3 2 1 0
	The group provides an explanation of the cause of protein denaturation, including how it affects the shape and function of a protein.	3 2 1 0
	The group provides a description of a specific example of a complication or disease associated with protein denaturation in any specified biological organism. Their discussion includes: name of disease or complication; function of the normal protein; and complication or effect of denatured protein to its function in the biological organism.	5 4 3 2 1 0
	Total Score	____ **out of 25**



Name: _____

Date: _____

Hour: _____

AP Biology:
Modeling protein structures and functions

Proficiency Scale and Score	Standard: **Developing and using models:** The student can use representations and models to communicate scientific phenomena and solve scientific problems.
(4 points for every level) **TOTAL SCORE:** _____ **LEVEL 1.** Even with help, the student shows little success. **LEVEL 2.** The student: ❑ Identifies the difference between a normal protein and denatured protein. **LEVEL 2.5.** The student: ❑ Relates the characteristics or properties of amino acids to the folding process (4 structures) of a protein accurately ❑ Describes the causes of protein denaturation **LEVEL 3.** The student: ❑ Develops an accurate model of protein denaturation ❑ Thoroughly explains the effect of denaturation to the function of a protein. **LEVEL 4.** The student: ❑ Uses the model to predict the impact of a malformed protein to a life process. ❑ Provides a real-life example and explanation of the complication or impact of denatured proteins in biological organisms. **COMMENTS:**	**Assessment**: Using your knowledge and understanding of the characteristics of amino acids, manipulate your model to illustrate and explain how denaturation impacts the form and function of a protein. Use the following questions to guide you in your narrative and include a drawing or photo of your model. • How is a normal protein different from a denatured protein? • How do the characteristics of amino acids define the shape of a protein? • What causes a protein to get denatured? • How does denaturation affect the shape and function of a protein? • How does denaturation affect the role of proteins to a life process? • Thoroughly research about a complication regarding protein denaturation in any specified biological organism.

Questions?

How do I get these models and materials?

Kits and materials are available for purchase and use at **3dmoleculardesigns.com**.
Scan the QR Code below for more details.

You can also borrow them from the **lending library**!
Scan the QR Code below for more details.

Thank you!

Please scan the QR code

AND

fill out the survey for a chance to win a $250 gift card from 3dmoleculardesigns!

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