3d molecular designs
Transforming Science Learning

Make the Complex Easy!

Modeling Proteins and Protein Structure

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Mary Howard

Science Teacher at Washington Township High School in Sewell, NJ

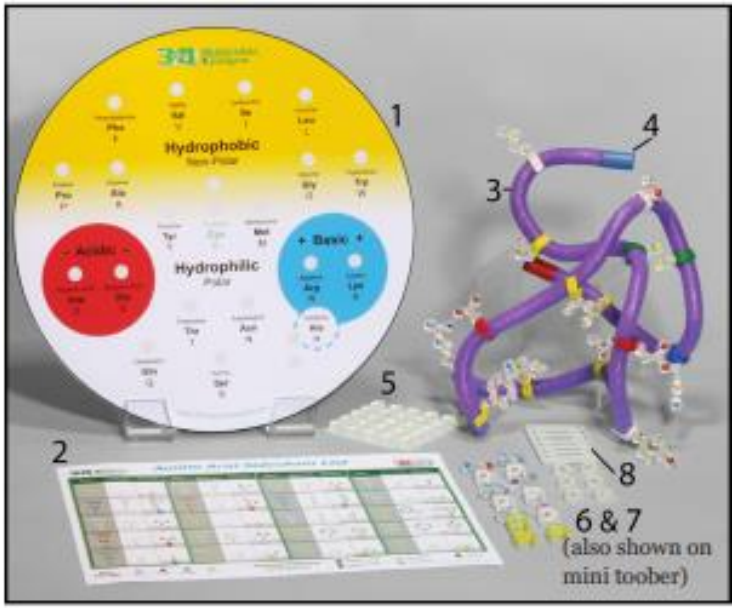
Mary Howard Basic Background

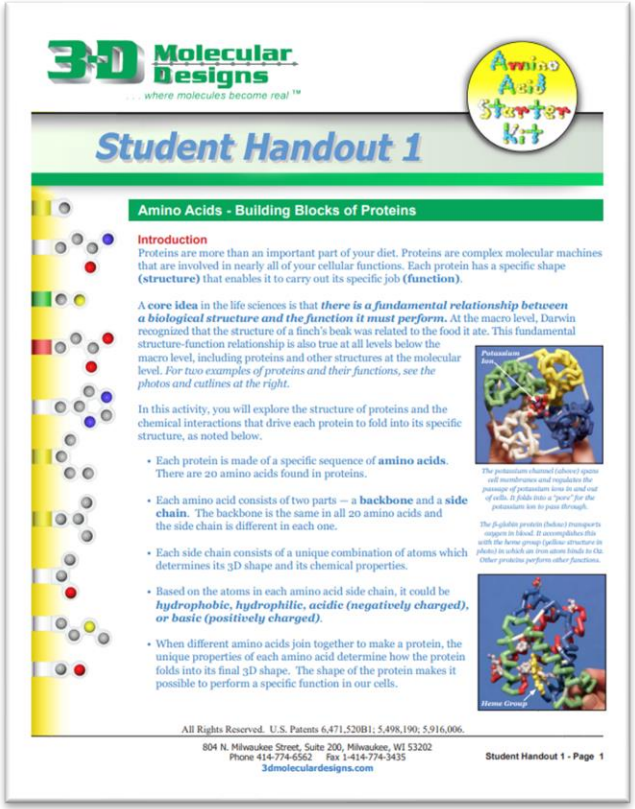
- **Education:**
  - Biochemistry
  - Physiology
  - Education
- **Experience:**
  - Researcher
  - Instructor
- **Science Classroom Strategies**
  - Lectures
  - Digital Activities
  - Laboratory Activities
  - Projects
  - Assessments

Icebreaker

Let's Get Talking with Conversation Cubes

Amino Acid Starter Kit





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Amino Acid Starter Kit

Student Handout 1

Amino Acids - Building Blocks of Proteins

Introduction

Proteins are more than an important part of your diet. Proteins are complex molecular machines that are involved in nearly all of your cellular functions. Each protein has a specific shape **(structure)** that enables it to carry out its specific job **(function)**.

A **core idea** in the life sciences is that ***there is a fundamental relationship between a biological structure and the function it must perform.*** At the macro level, Darwin recognized that the structure of a finch's beak was related to the food it ate. This fundamental structure-function relationship is also true at all levels below the macro level, including proteins and other structures at the molecular level. *For two examples of proteins and their functions, see the photos and cutlines at the right.*

In this activity, you will explore the structure of proteins and the chemical interactions that drive each protein to fold into its specific structure, as noted below.

- Each protein is made of a specific sequence of **amino acids**. There are 20 amino acids found in proteins.
- Each amino acid consists of two parts -- a **backbone** and a **side chain**. The backbone is the same in all 20 amino acids and the side chain is different in each one.
- Each side chain consists of a unique combination of atoms which determines its 3D shape and its chemical properties.
- Based on the atoms in each amino acid side chain, it could be ***hydrophobic, hydrophilic, acidic (negatively charged), or basic (positively charged)***.
- When different amino acids join together to make a protein, the unique properties of each amino acid determine how the protein folds into its final 3D shape. The shape of the protein makes it possible to perform a specific function in our cells.

Potassium Ion

The potassium channel (above) spans cell membranes and regulates the passage of potassium ions in and out of cells. It folds into a "pore" for the potassium ion to pass through.

The β-globin protein (below) transports oxygen in blood. It accomplishes this with the heme group (yellow structure in photo) in which an iron atom binds to O2. Other proteins perform other functions.

Heme Group

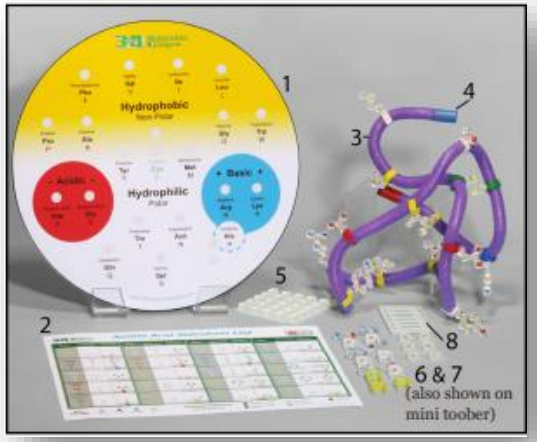
804 N. Milwaukee Street, Suite 200, Milwaukee, WI 53202
Phone 414-774-6562 Fax 1-414-774-3435
3dmoleculardesigns.com

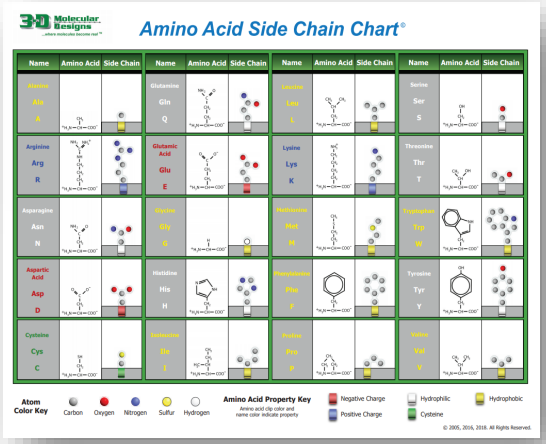
Resources found at:
https://3dmoleculardesigns.com/classroom_resources/flow-of-genetic-information-kit/

Resources and Materials

Kits Used in this workshop:

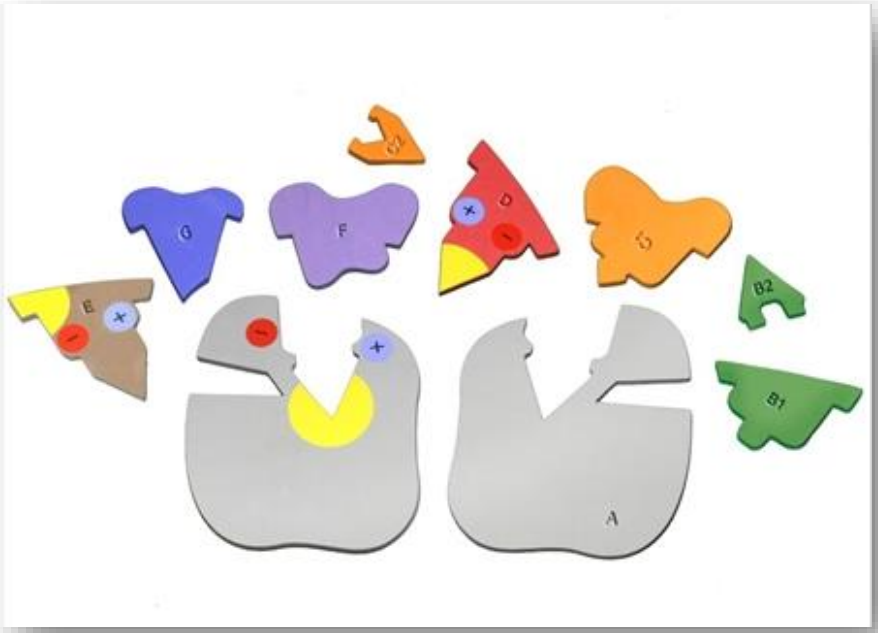
- Amino Acid Building Block Models
- Amino Acid Starter Kit
- Codon Chart
- Handouts

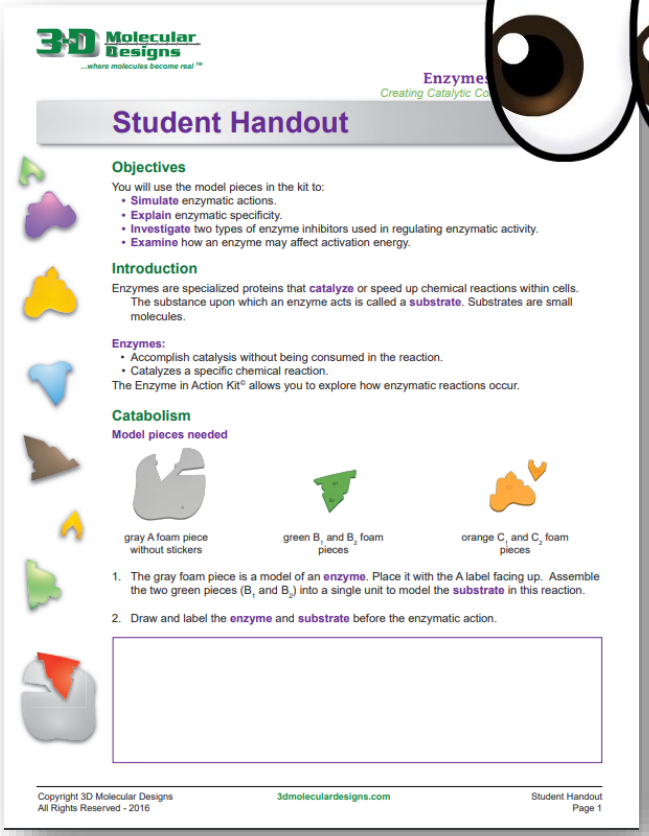




Let's Take A Peek!

Lab:
Enzymes in Action





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Enzymes
Creating Catalytic Co

Student Handout

Objectives

You will use the model pieces in the kit to:
- **Simulate** enzymatic actions.
- **Explain** enzymatic specificity.
- **Investigate** two types of enzyme inhibitors used in regulating enzymatic activity.
- **Examine** how an enzyme may affect activation energy.

Introduction

Enzymes are specialized proteins that **catalyze** or speed up chemical reactions within cells. The substance upon which an enzyme acts is called a **substrate**. Substrates are small molecules.

Enzymes:
- Accomplish catalysis without being consumed in the reaction.
- Catalyzes a specific chemical reaction.

The Enzyme in Action Kit© allows you to explore how enzymatic reactions occur.

Catabolism

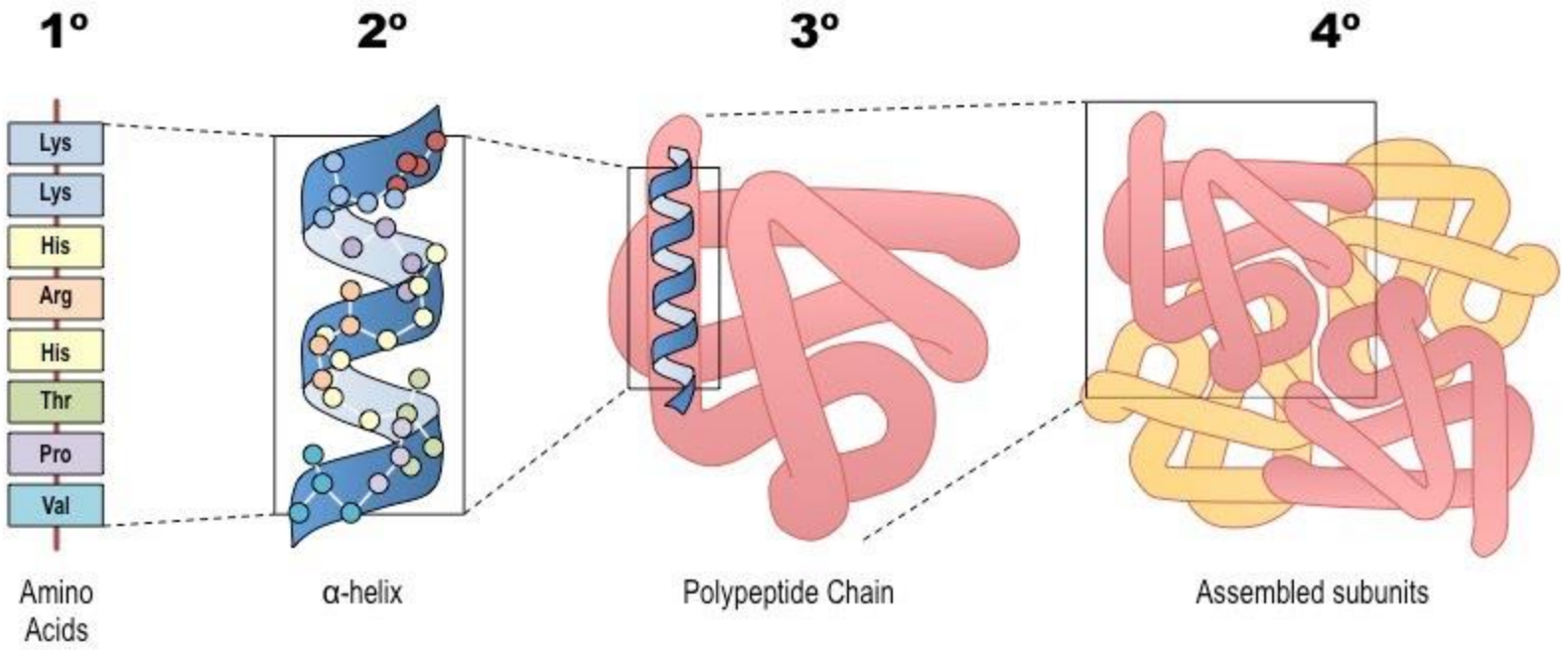
Model pieces needed

gray A foam piece without stickers | green B_1 and B_2 foam pieces | orange C_1 and C_2 foam pieces

1. The gray foam piece is a model of an **enzyme**. Place it with the A label facing up. Assemble the two green pieces (B_1 and B_2) into a single unit to model the **substrate** in this reaction.
2. Draw and label the **enzyme** and **substrate** before the enzymatic action.

Resources for this lab found at:
https://3dmoleculardesigns.com/classroom_resources/enzymes-in-action-kit/

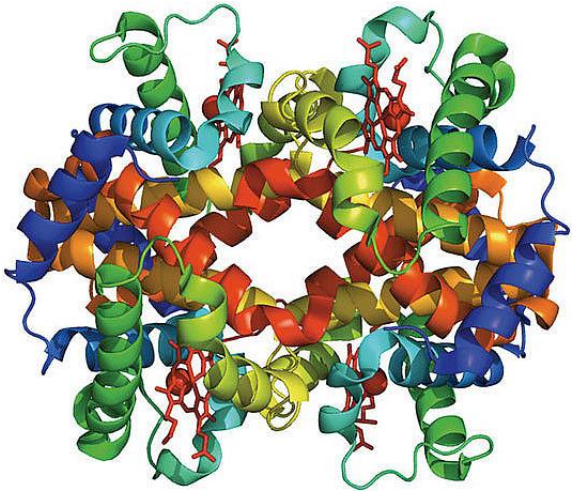
Protein Structure



How can students learn the concept of the Protein Structure through Modeling?

Protein Structure

- Primary Structure
- Secondary Structure
- Tertiary Structure
- Quaternary Structure



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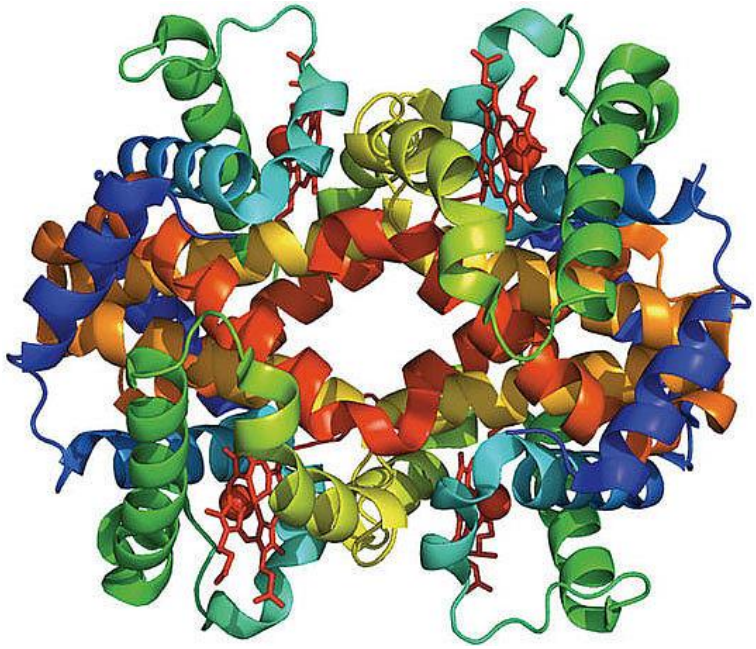
Protein Structure; How do I start?



Amino Acid Structure

Amino Acid Building Block Kit

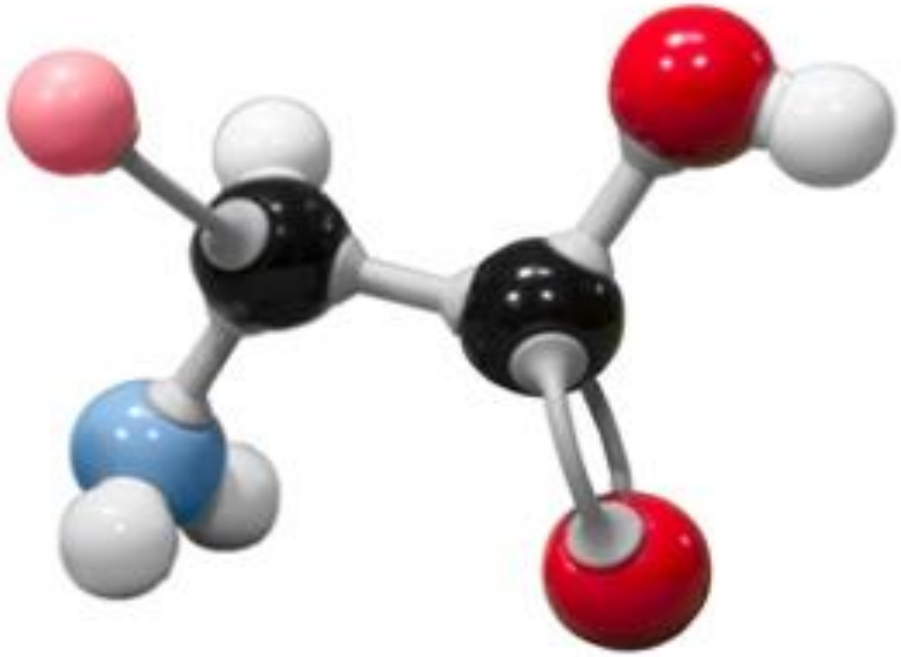
Resources found at:
https://3dmoleculardesigns.com/classroom_resources/flow-of-genetic-information-kit/

Can you Build an Amino Acid?

Model Color Coding Key

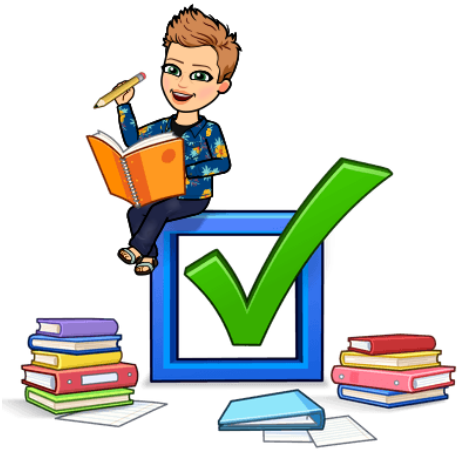
Carbon (black)
Oxygen (red)
Nitrogen (blue)
R-Groups Representing Side Chains
Hydrogen (white)
Hydrogen Bonds (short white posts)
Single Covalent Bonds (short, gray, thick post)
Double Covalent Bonds (long, gray, thin post)
Link Remover

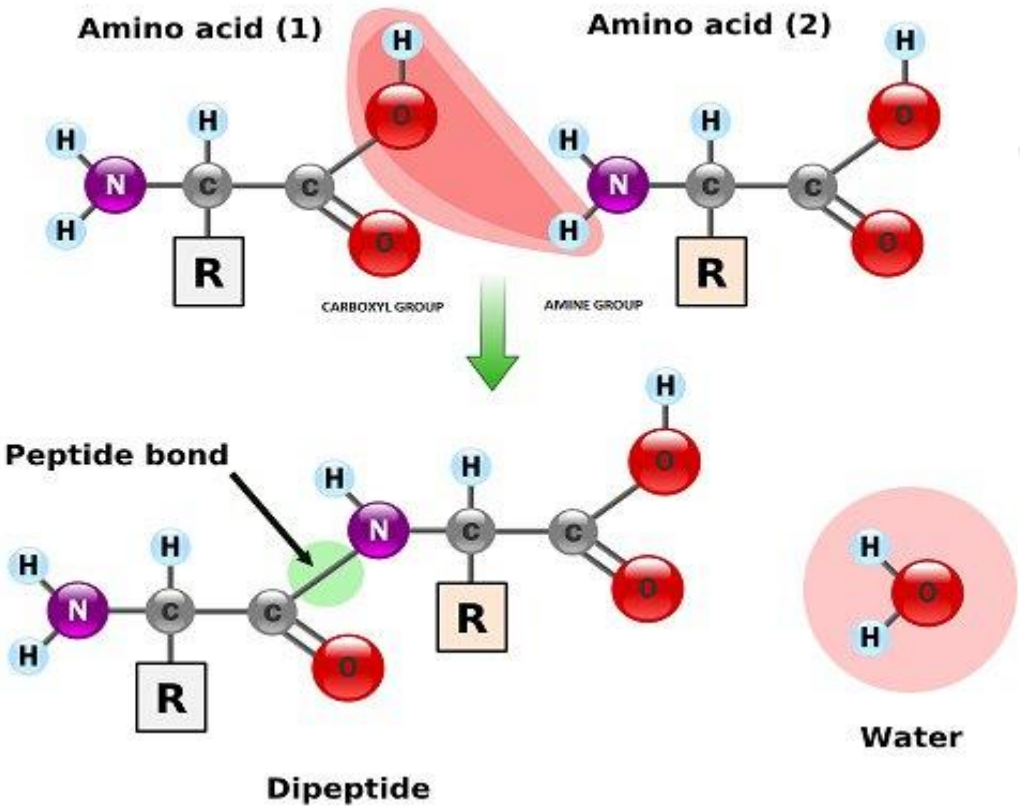
Proteins Are Made of Amino Acids



Can you Build Polypeptides?

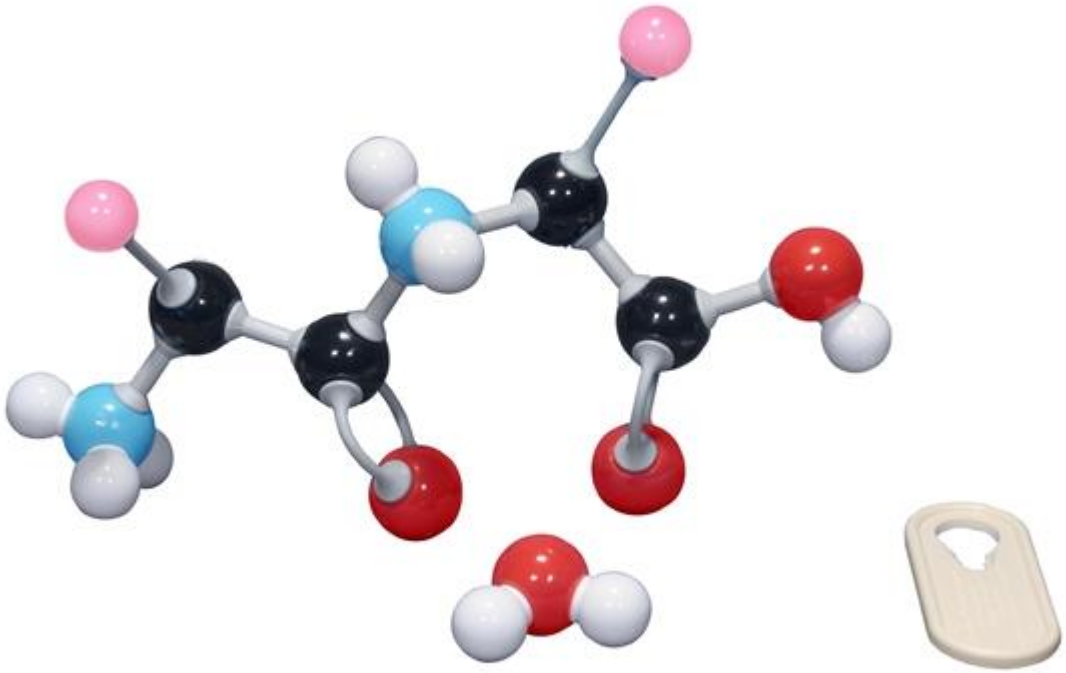
My Favorite:





Listen for whispers of "Whoa" as your students notice the water molecules that appear when peptide bonds form!

Challenge your students:



Can you make a dipeptide? Polypeptide?

Highlights: Versatility

- **Topics to Explore**
  - **Dehydration Synthesis and Hydrolysis**
  - **Covalent Bonding**
  - **Amino Acid Side Chains**

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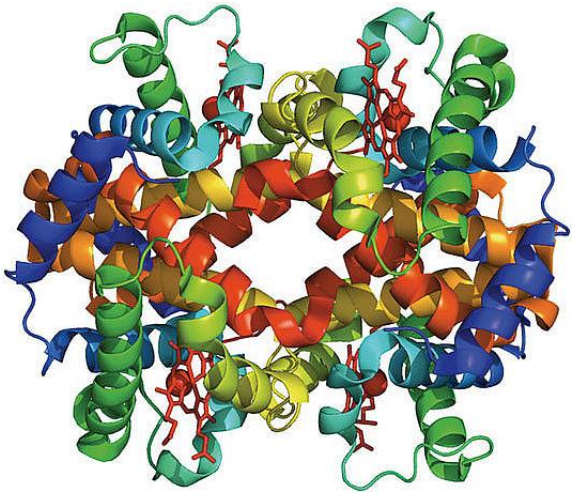

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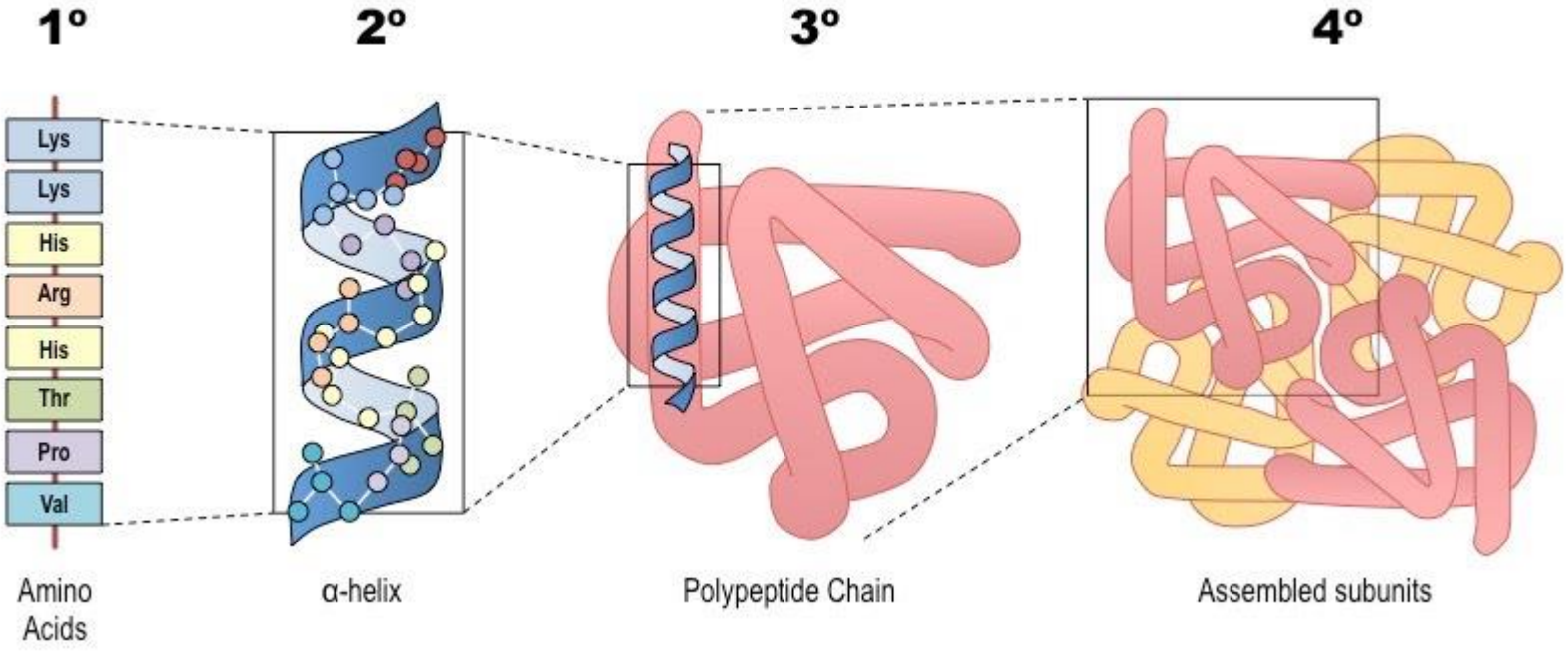
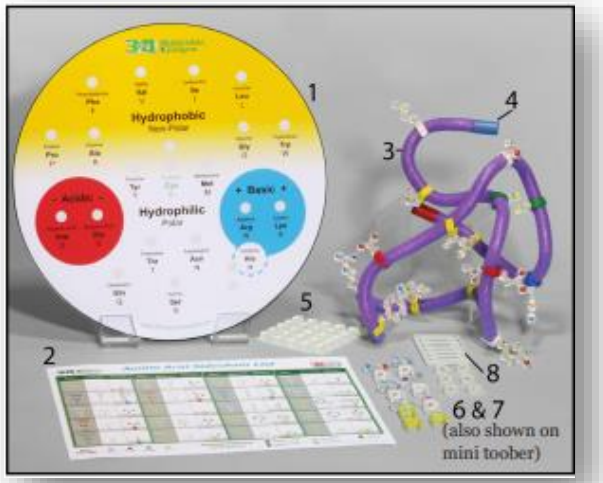
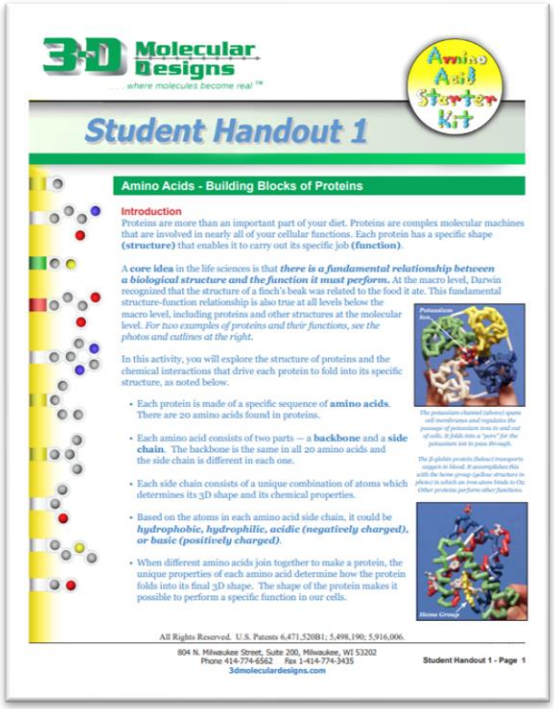


Why and How Do Polypeptides Fold into their Protein Structure?

Amino Acid Starter Kit





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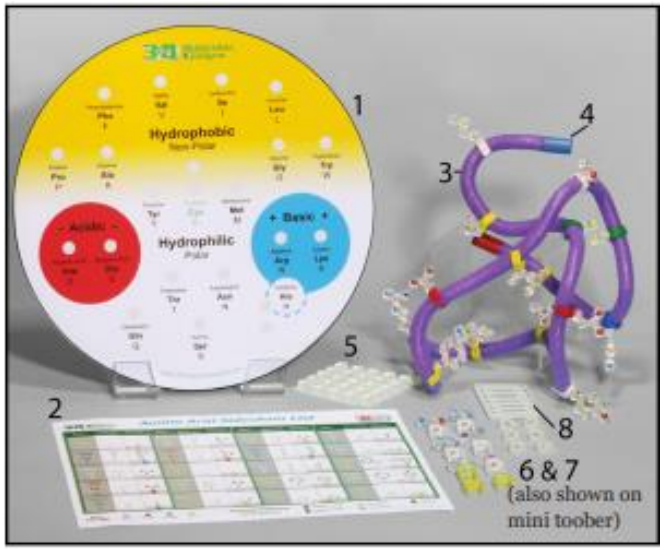
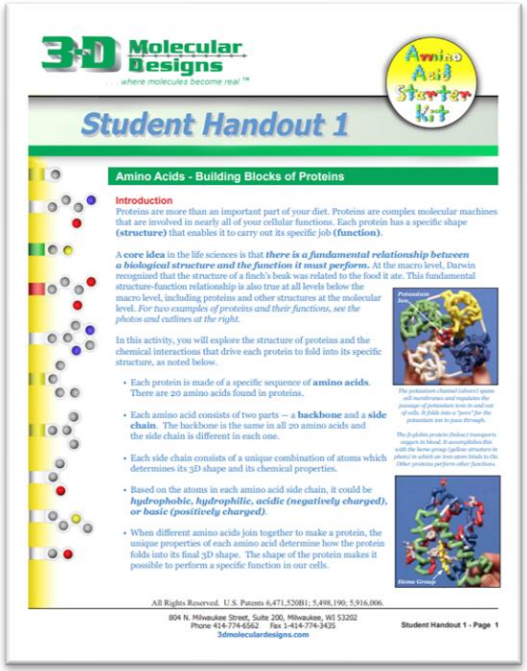
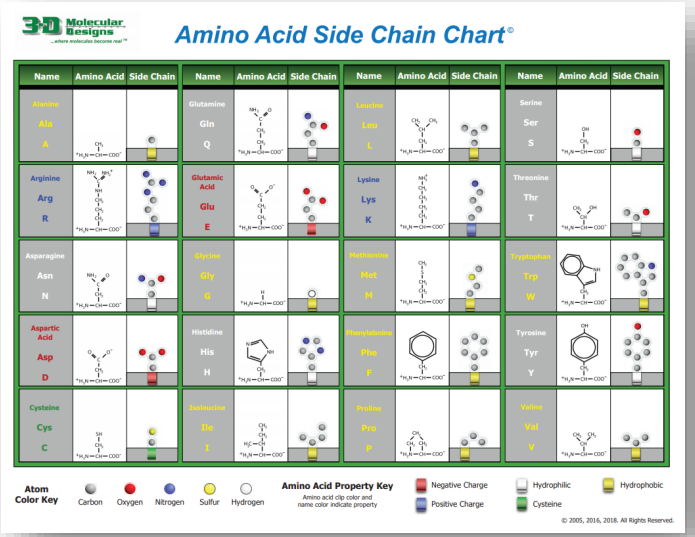
Classroom Tips:

Supplies:

- Protein Folding Kit
  - Amino Acid Side Chain Chart
- Meter/Yard Stick
- Lab Handout

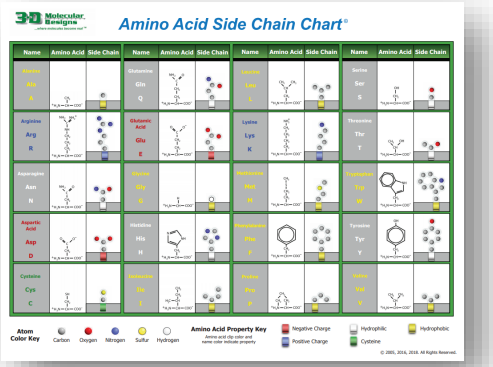


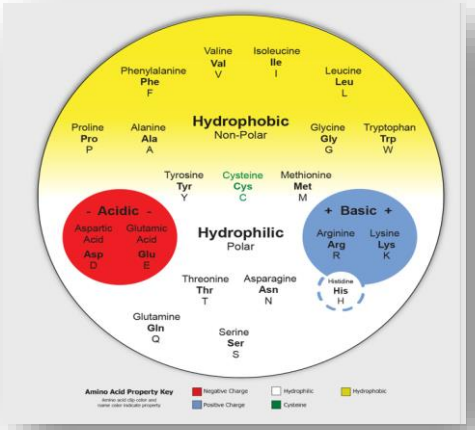




Amino Acid Starter Kit

- **Give it a try!**





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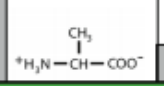
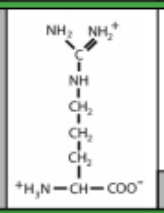
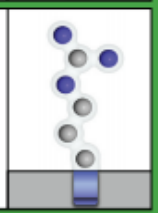
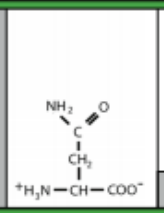
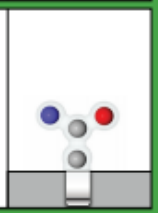
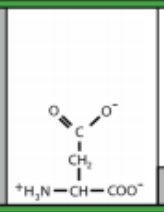
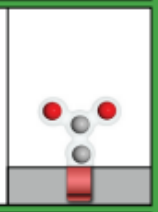
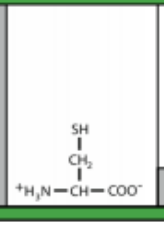
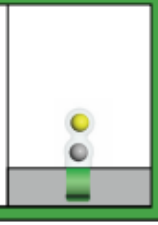
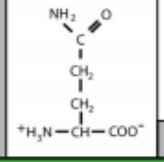
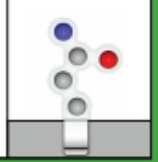
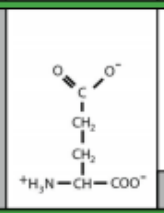
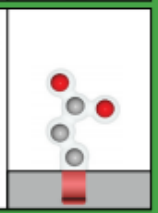
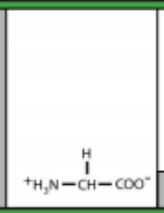
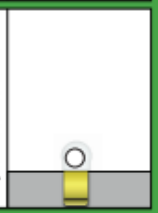
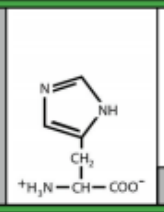
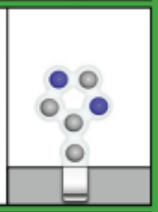
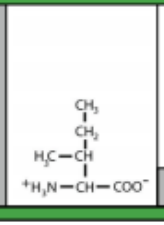
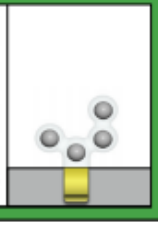
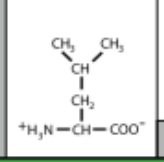
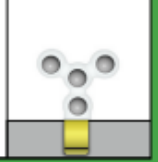
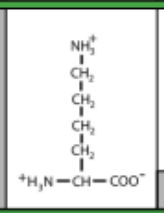
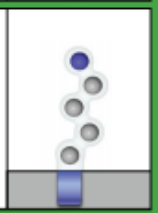
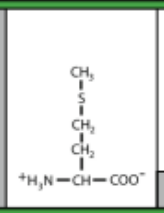
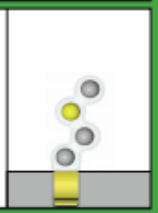
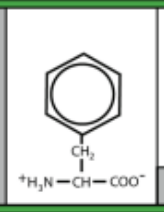
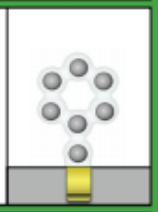
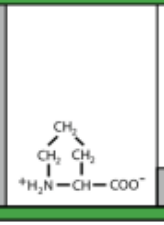
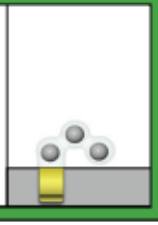
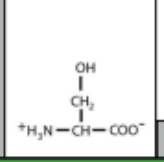
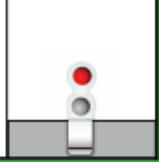
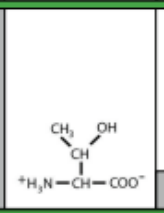
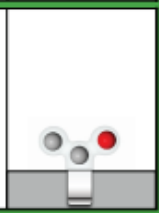
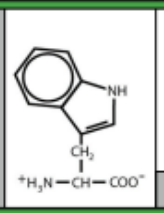
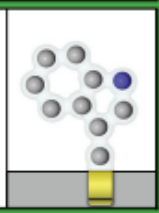
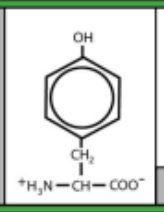
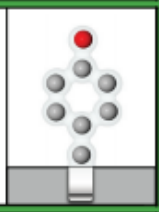
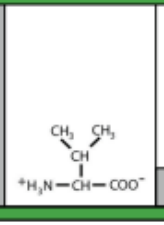
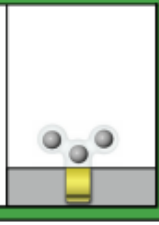
Amino Acid Side Chain Chart©

Name	Amino Acid	Side Chain
Alanine Ala A		
Arginine Arg R		
Asparagine Asn N		
Aspartic Acid Asp D		
Cysteine Cys C		

Name	Amino Acid	Side Chain
Glutamine Gln Q		
Glutamic Acid Glu E		
Glycine Gly G		
Histidine His H		
Isoleucine Ile I		

Name	Amino Acid	Side Chain
Leucine Leu L		
Lysine Lys K		
Methionine Met M		
Phenylalanine Phe F		
Proline Pro P		

Name	Amino Acid	Side Chain
Serine Ser S		
Threonine Thr T		
Tryptophan Trp W		
Tyrosine Tyr Y		
Valine Val V		

Atom Color Key

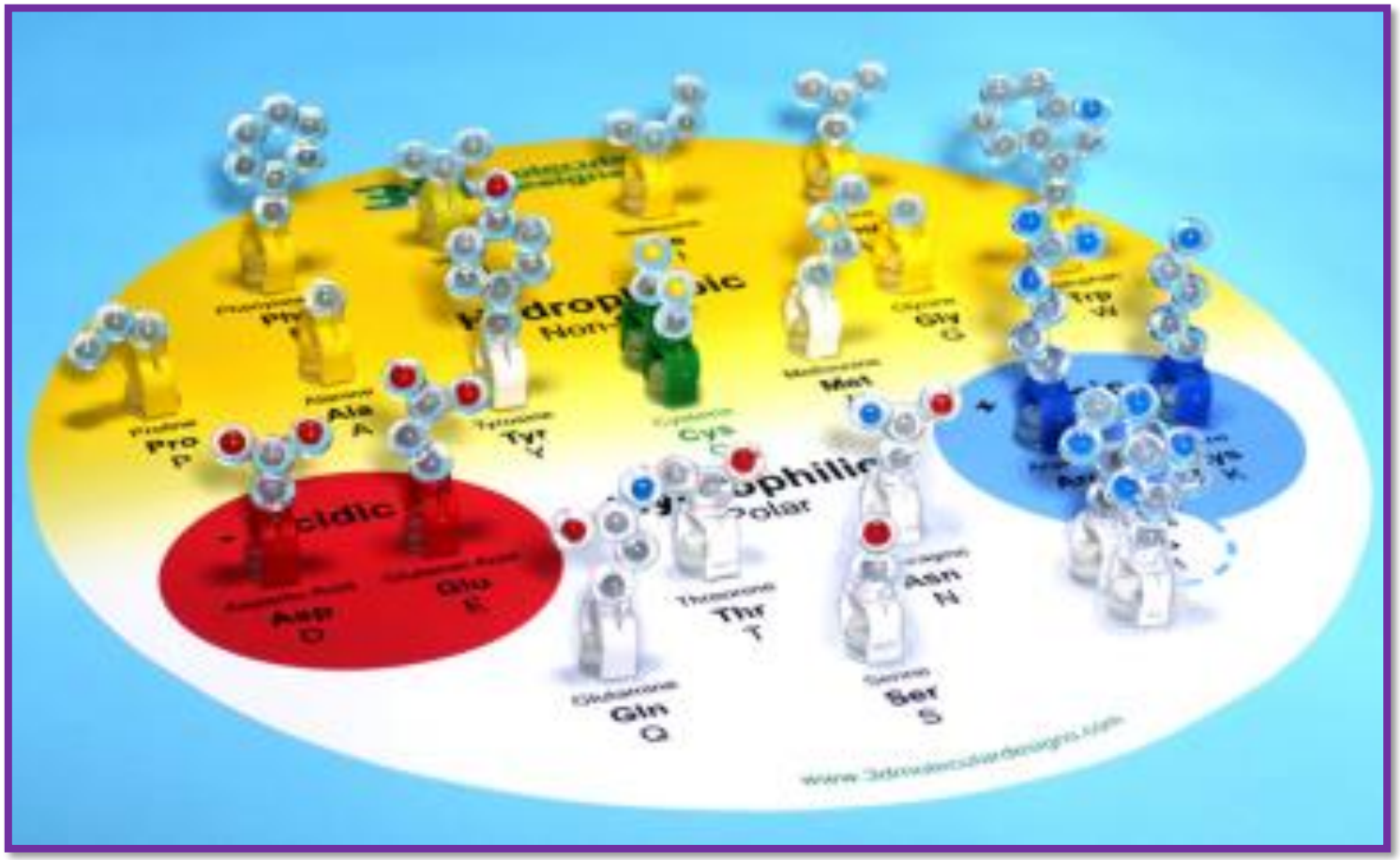
Carbon · Oxygen · Nitrogen · Sulfur · Hydrogen

Amino Acid Property Key

Amino acid clip color and name color indicate property

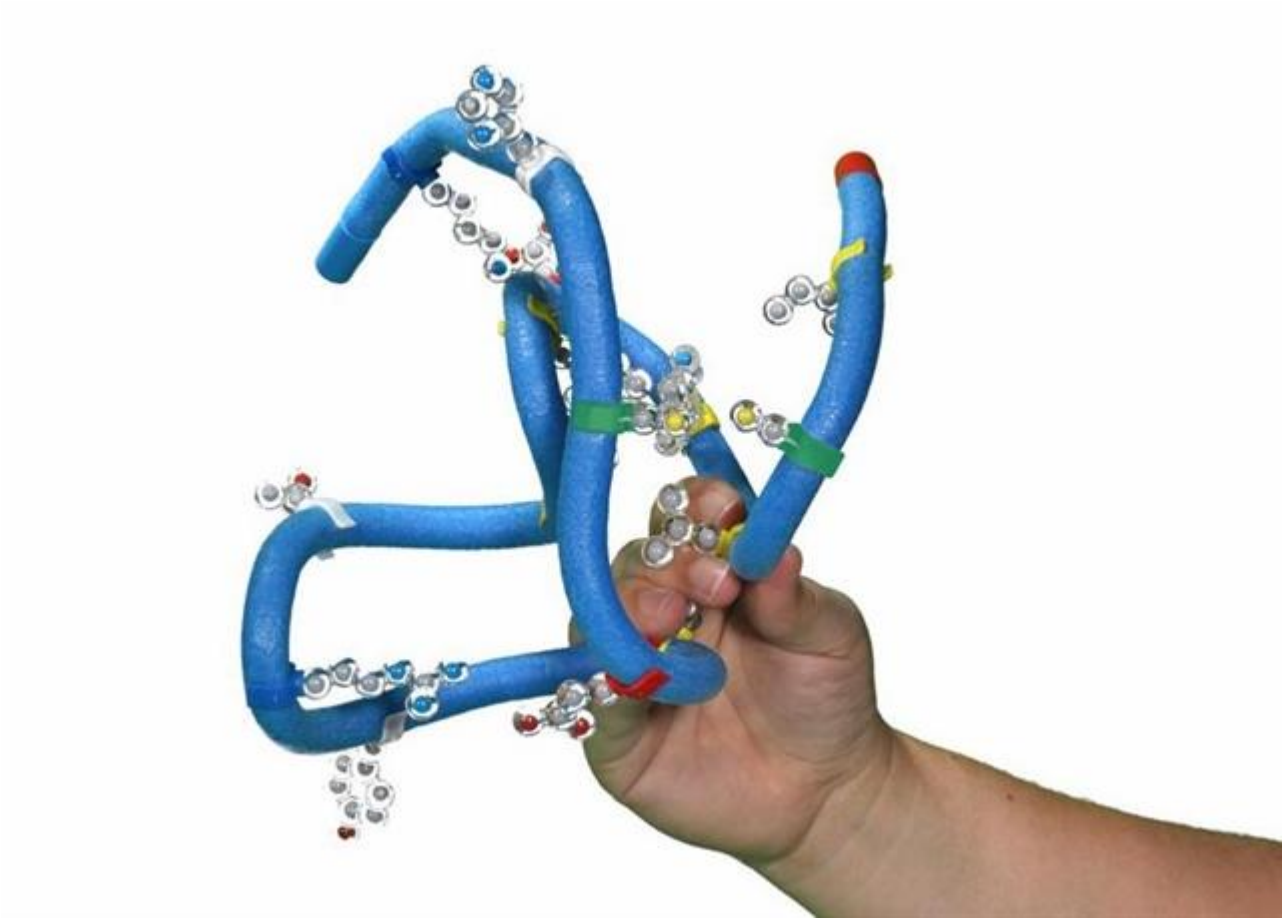
Negative Charge · Positive Charge · Hydrophilic · Cysteine · Hydrophobic

Highlights: Students See Side Chains Sorted by Their Chemical Properties



Protein Folding

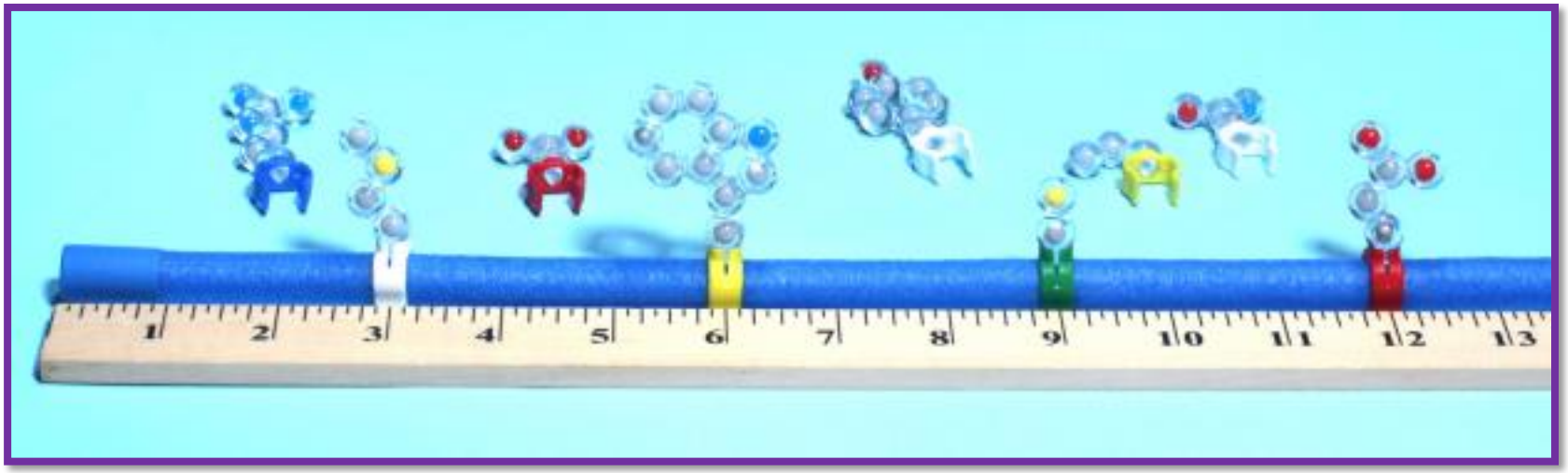
- **Give it a try!**



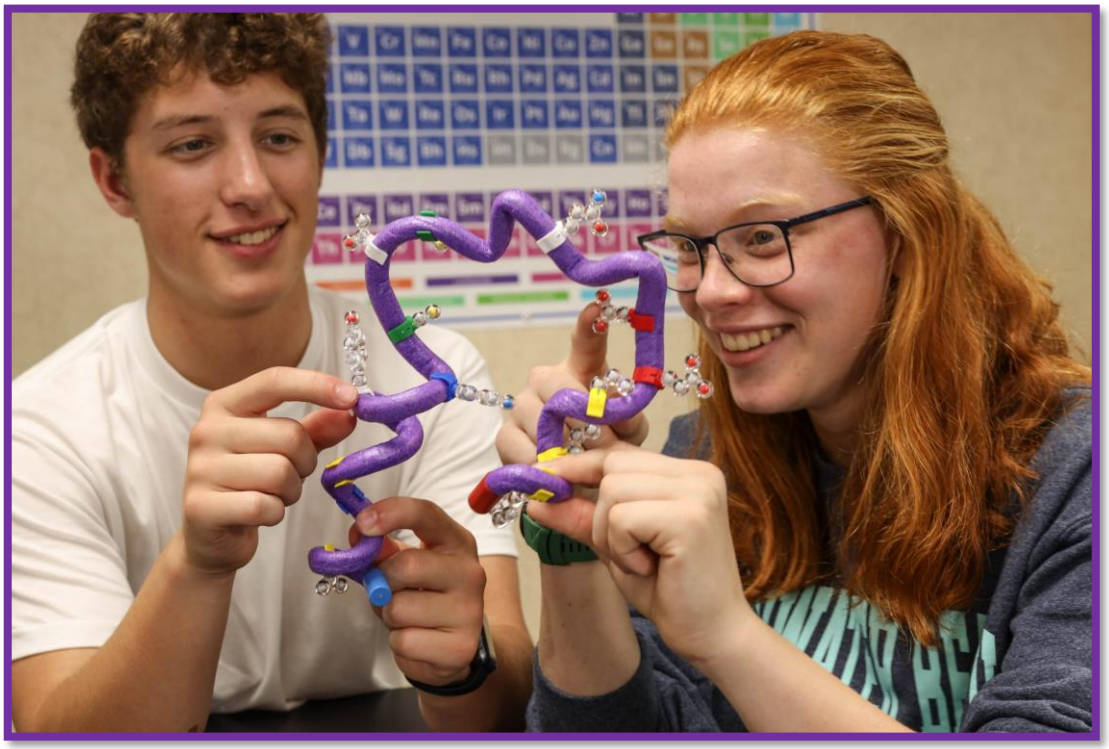
Classroom Tips:

Pick:

- 6 Hydrophobic side chains
- 2 Acidic side chains
- 2 Basic side chains
- 2 Cysteine
- 3 Hydrophilic

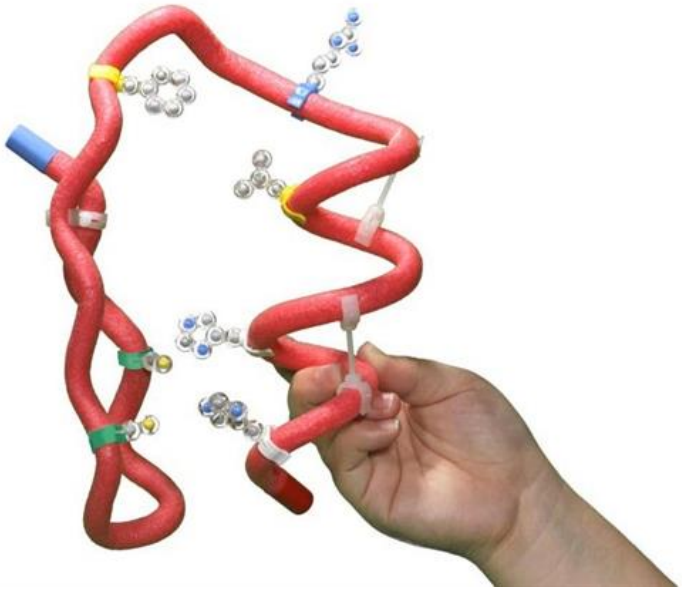


My Favorite:



Listen for whispers of “Whoa” as your students notice the water molecules that appear when peptide bonds form!

Highlights:
Concept of Structure/Function



- **Topics to Explore**
  - **Patterns Within and Between Side Chains**
  - **Discuss Chemical Properties of Side Chains**
  - **Examine Different Secondary Structure**

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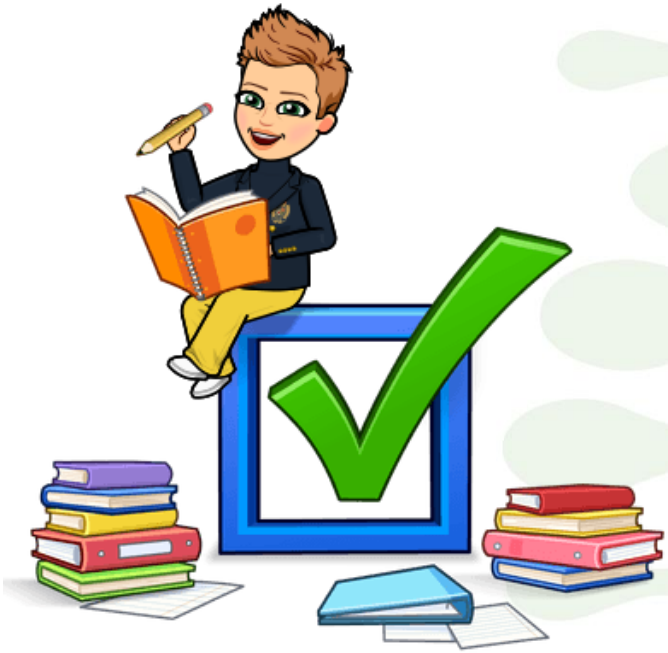
What's Next?

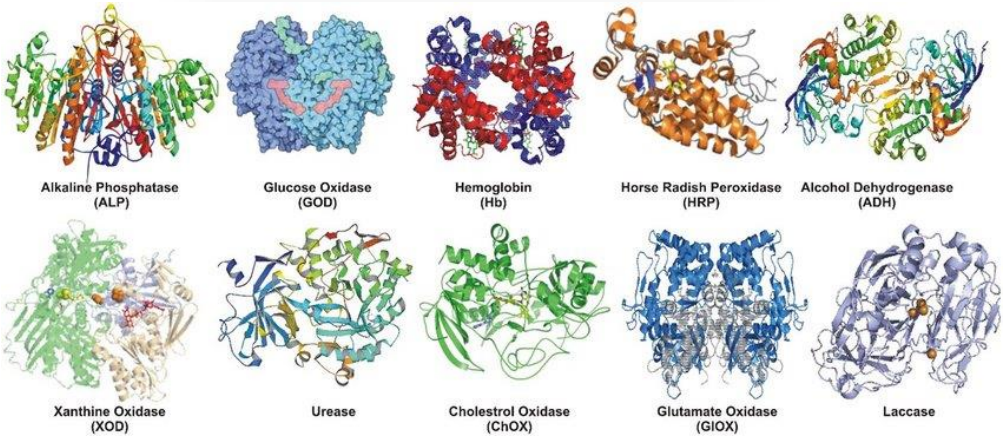
- I finished the lab, Now What?

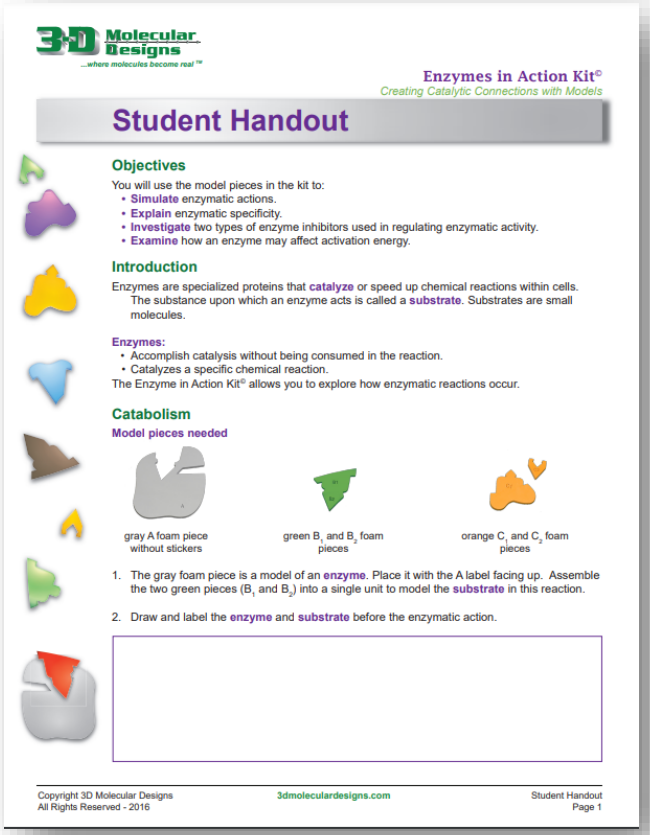
Examples and Suggestions

- **Enzymes:**
  - **Enzyme Action**
  - **Lactose Intolerance**
- **Hemoglobin:**
  - **Genetics**
  - **Hemoglobin Disorders**



Lab: Enzymes in Action





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Enzymes in Action Kit©
Creating Catalytic Connections with Models

Student Handout

Objectives

You will use the model pieces in the kit to:
- **Simulate** enzymatic actions.
- **Explain** enzymatic specificity.
- **Investigate** two types of enzyme inhibitors used in regulating enzymatic activity.
- **Examine** how an enzyme may affect activation energy.

Introduction

Enzymes are specialized proteins that **catalyze** or speed up chemical reactions within cells. The substance upon which an enzyme acts is called a **substrate**. Substrates are small molecules.

Enzymes:
- Accomplish catalysis without being consumed in the reaction.
- Catalyzes a specific chemical reaction.

The Enzyme in Action Kit© allows you to explore how enzymatic reactions occur.

Catabolism

Model pieces needed

gray A foam piece without stickers | green B_1 and B_2 foam pieces | orange C_1 and C_2 foam pieces

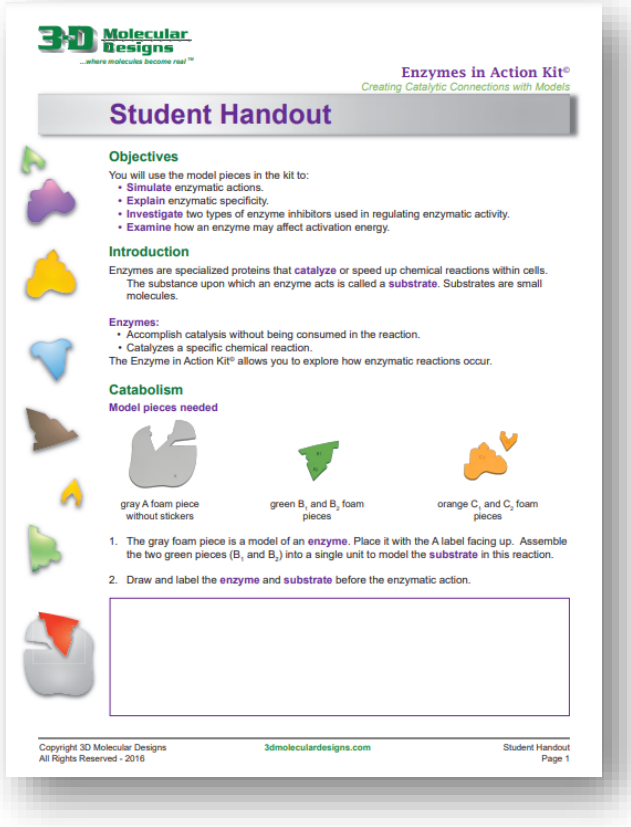
1. The gray foam piece is a model of an **enzyme**. Place it with the A label facing up. Assemble the two green pieces (B_1 and B_2) into a single unit to model the **substrate** in this reaction.
2. Draw and label the **enzyme** and **substrate** before the enzymatic action.

Resources for this lab found at:
https://3dmoleculardesigns.com/classroom_resources/enzymes-in-action-kit/

Lab: Enzymes in Action

Highlights:

- Enzyme Substrate Interaction
- Active Sites and Specificity
- Competitive/Allosteric Inhibition
- Lock-and-Key/Induced Fit



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Activity: Lactose Intolerance

Got Lactase? Making of the Fittest
The Co-evolution of Genes and Culture

Animations

Natural Selection for Lactose Tolerance

Interactive Videos

Interactive Assessment for *Got Lactase? The Co-evolution of Genes and Culture*

Lessons

Lactose Intolerance: Fact or Fiction

Click & Learn

Recent Adaptations in Humans

Click & Learn

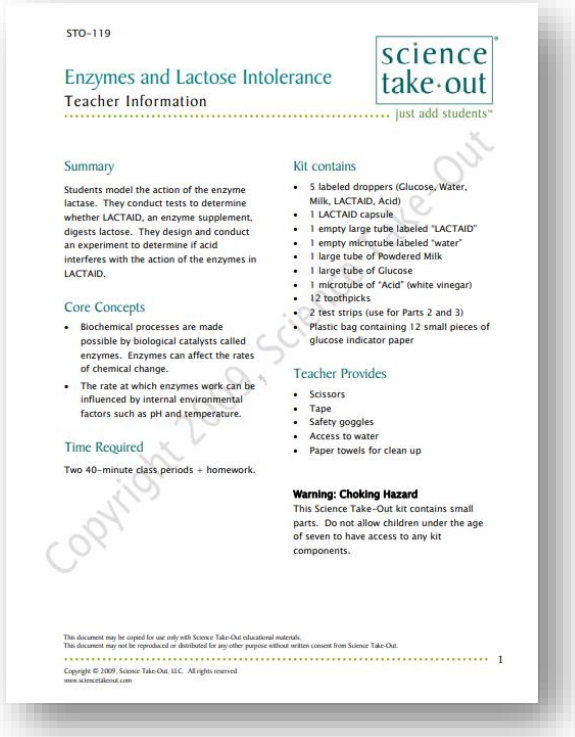
Regulation of the Lactase Gene

Sources for this activity found at:
https://www.biointeractive.org/classroom-resources/making-fittest-got-lactase-co-evolution-genes-and-culture

Activity: Lactose Lab

Science Take-Out

Enzymes and Lactose Intolerance



STO-119

Enzymes and Lactose Intolerance

Teacher Information

science take·out

just add students™

Summary

Students model the action of the enzyme lactase. They conduct tests to determine whether LACTAID, an enzyme supplement, digests lactose. They design and conduct an experiment to determine if acid interferes with the action of the enzymes in LACTAID.

Core Concepts

- Biochemical processes are made possible by biological catalysts called enzymes. Enzymes can affect the rates of chemical change.
- The rate at which enzymes work can be influenced by internal environmental factors such as pH and temperature.

Time Required

Two 40-minute class periods + homework.

Kit contains

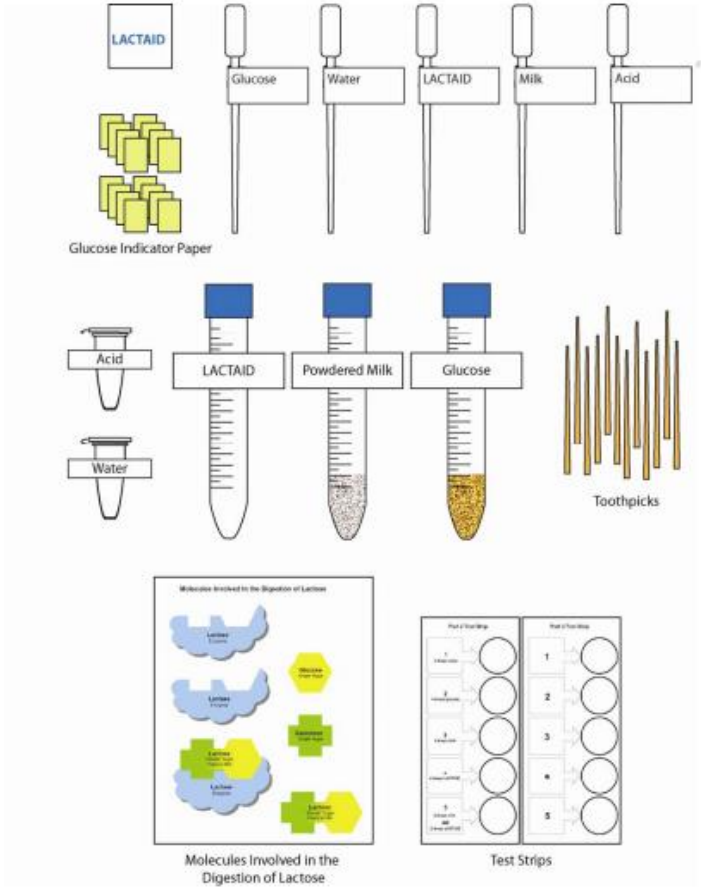
- 5 labeled droppers (Glucose, Water, Milk, LACTAID, Acid)
- 1 LACTAID capsule
- 1 empty large tube labeled "LACTAID"
- 1 empty microtube labeled "water"
- 1 large tube of Powdered Milk
- 1 large tube of Glucose
- 1 microtube of "Acid" (white vinegar)
- 12 toothpicks
- 2 test strips (use for Parts 2 and 3)
- Plastic bag containing 12 small pieces of glucose indicator paper

Teacher Provides

- Scissors
- Tape
- Safety goggles
- Access to water
- Paper towels for clean up

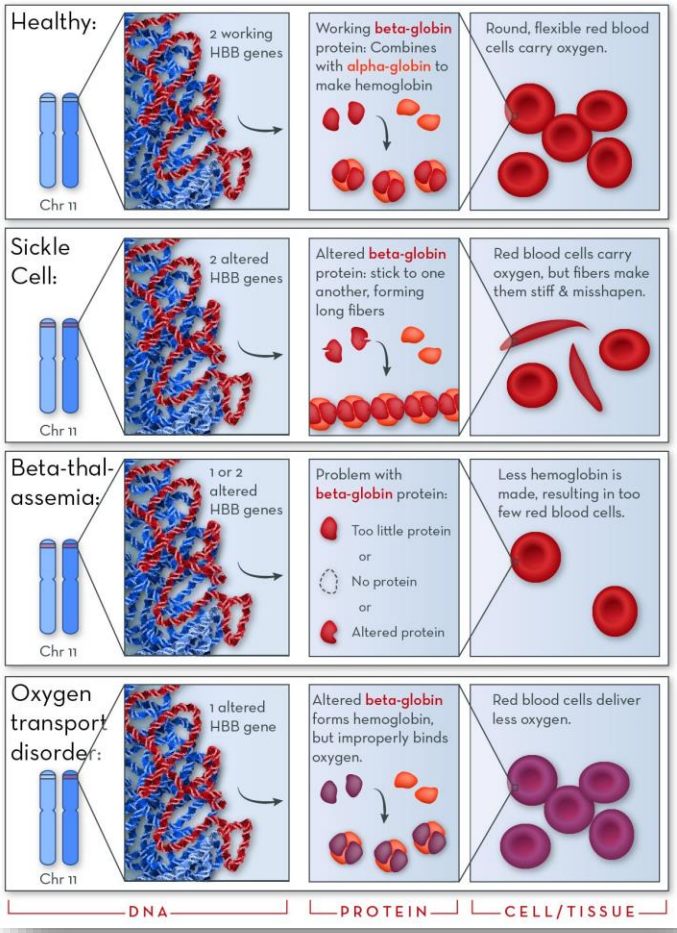
Warning: Choking Hazard

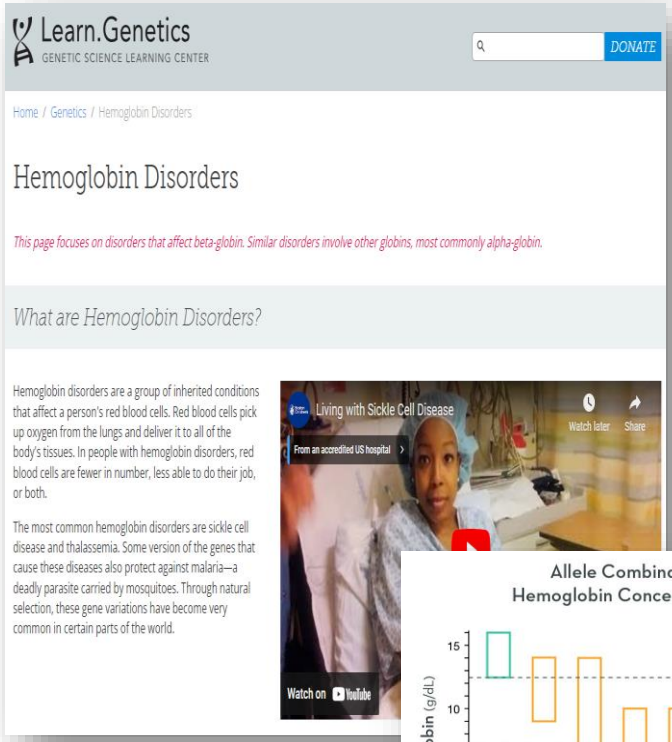
This Science Take-Out kit contains small parts. Do not allow children under the age of seven to have access to any kit components.

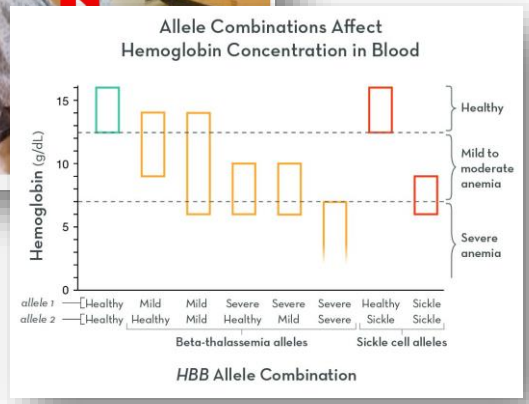


Sources for this activity found at: https://www.sciencetakeout.com/product/enzymes-and-lactose-intolerance-group/

Activity: Hemoglobin Disorders

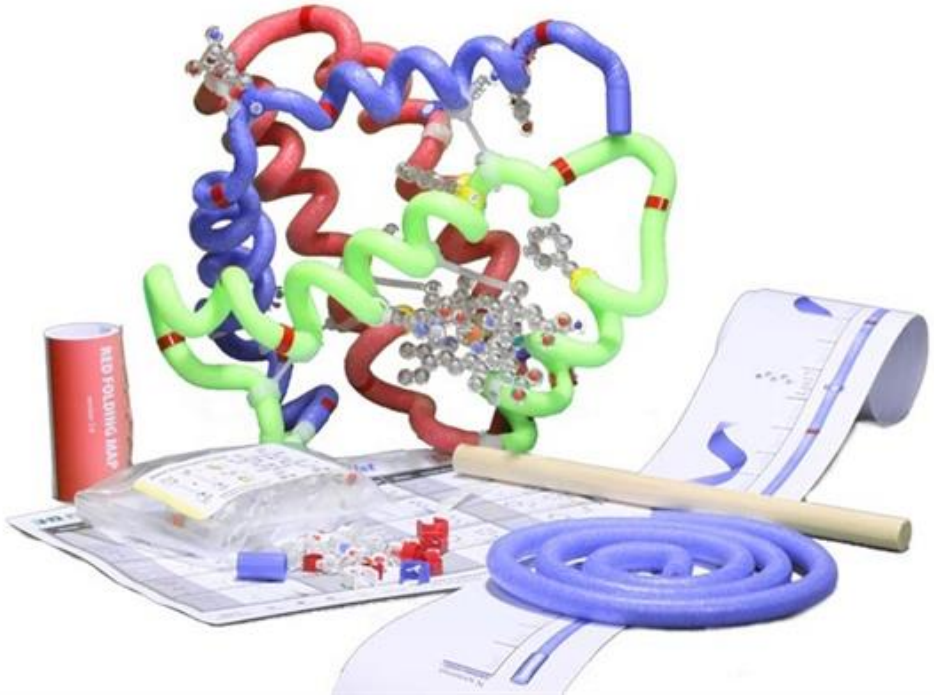






Sources for this activity found at:
https://learn.genetics.utah.edu/content/genetics/hemoglobin

Activity: ß-Globin Folding Kit©



Resources for this lab found at:
https://3dmoleculardesigns.com/classroom_resources/s-globin-folding-kit/

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Reflection Activity

- Where do you see this fitting into your curriculum?
- What Lingering Questions Do You Still Have?
- What Does This Look Like Implemented in Your Classroom?
- What Other Resources Would You Use With this topic? (Make a Suggestion!)

Give Away!

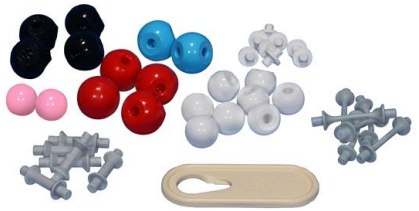
Enzyme in Action Kit

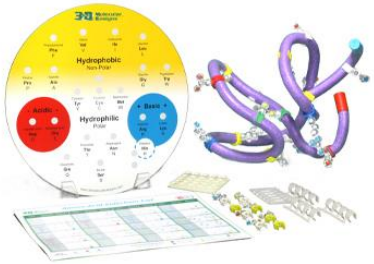
- Purchase kits at **3dmoleculardesigns.com**.
- Receive 20% off most items in our catalog with Discount Code FC23..

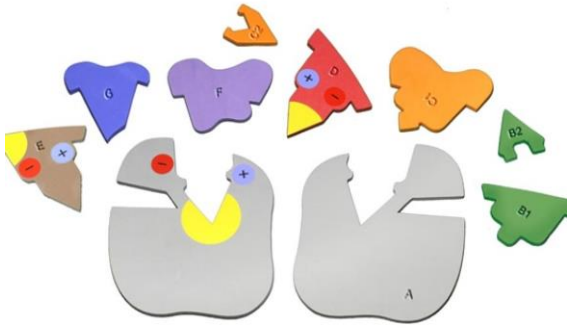
Resources and Materials

Kits Used in this workshop:

- **Amino Acid Building Blocks**
  Amino Acid Starter Kit
- **Enzymes in Action Kit**







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- Receive 10% off most items in our catalog. *Student Modeling Packs are not eligible for discount.*

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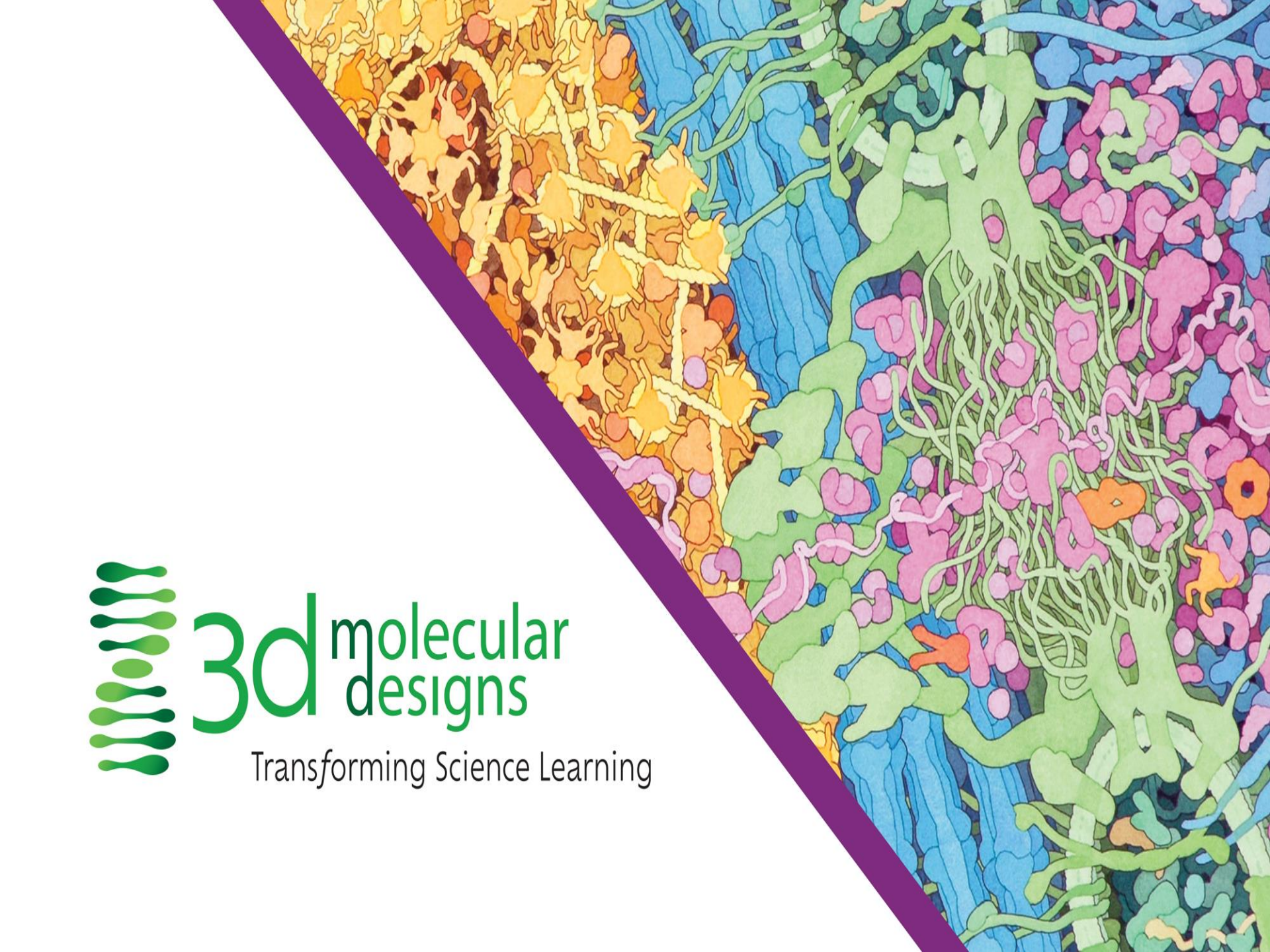
3d molecular designs
Booth



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