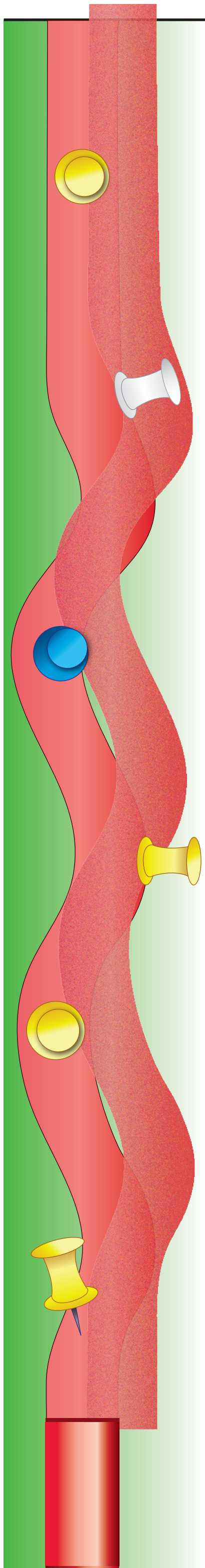
3-D Molecular Designs

...where molecules become real ™

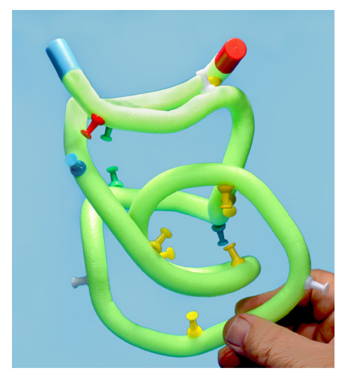


Protein Folding with 15 Tacks and a 1-Meter Mini Toober

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 life sciences is that ***there is a fundamental relationship between 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 the finch 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.

The protein models shown above and below were made following the directions on the next page.



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

Each protein is made of a specific sequence of **amino acids**. There are 20 amino acids involved in protein structure. Each amino acid consists of a unique combination of atoms and has a specific shape. The combination of atoms in each amino acid determines its properties which in turn cause the protein to fold into its correct structure. Amino acids are often called the **"building blocks"** of proteins and they can combine into hundreds of thousands of different sequences.

Based on the atoms in each amino acid, the amino acid could be ***hydrophobic, hydrophilic, positively charged, or negatively charged***.

Hydrophobic and Hydrophilic Properties

What do you think hydrophobic means? Separate the word 'hydrophobic' into its two parts — hydro and phobic. Hydro means water and phobia means fear or dislike, so hydrophobic side chains (yellow tacks) don't like water. Hydrophobic side chains are also referred to as non-polar side chains.

Now can you guess what hydrophilic means? Philic means likes or attracted to, so hydrophilic side chains (white tacks) like water. Hydrophilic side chains are also referred to as polar side chains.

Acidic and Basic

Can you think of acids you have around your house? Lemon and fruit juices, vinegar and hydrogen peroxide, phosphoric acid (in dark sodas) are common household acids. Acids taste sour and are typically liquids.

Can you think of bases you have around your house? Tums, baking soda, drain cleaner and soap are common bases. Bases taste bitter and can be a liquid or solid.

What happens when you mix lemon juice or vinegar with baking soda? They neutralize each other.

Disulfide Bonds

A cysteine can interact with another cysteine to form a disulfide bond that helps stabilizes the folded protein.

Activity

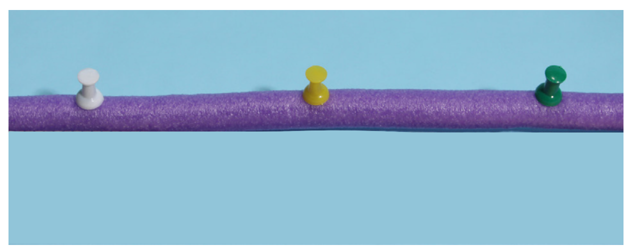
With 15 tacks and a mini toober you can explore the principles of chemistry that drive protein folding. The color-coded tacks represent the properties of the amino acids.

Directions

1. Select 15 colored tacks according to the list below. The chart below indicates the properties of the colored side chains.
    - 2 blue tacks
    - 2 red tacks
    - 6 yellow tacks
    - 3 white tacks
    - 2 green tacks

Blue tacks represent basic amino acids (+charge)
Red tacks represent acidic amino acids (- charge)
Yellow tacks represent hydrophobic (non-polar) amino acids
White tacks represent hydrophillic (polar) amino acids
Green tacks represent cysteine amino acids

2. Mix your colored tacks together and place them on the mini toober about 6 centimeters apart.

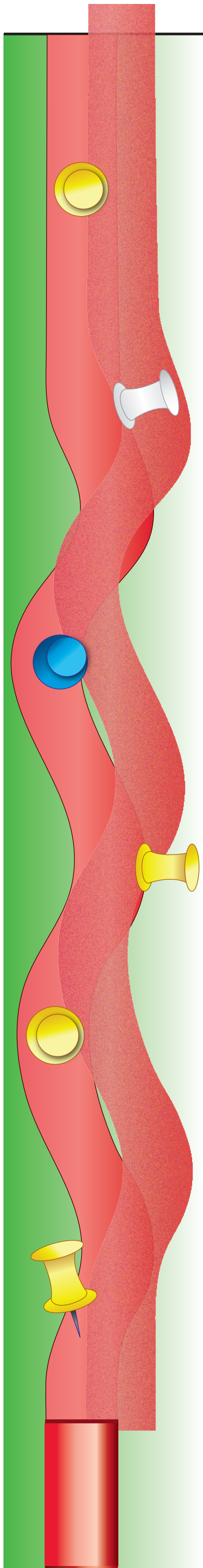


Note: As you push the tacks into the mini-toober, they may hit the wire in the middle and not go in all of the way. Reposition your tack so that it goes slightly above or below the wire.

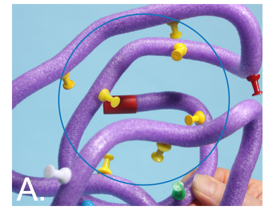
Be careful not to push the tack through to the other side of the mini toober where it can poke your finger. If you compress the foam near a tack it could also poke your finger. Also be careful not to tear the foam with the tack.

3. Now fold your protein, following the principles of chemistry that drive protein folding.

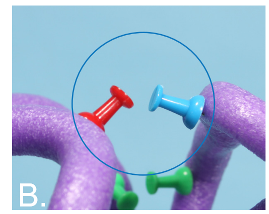
A stable protein simultaneously satisfies all of the principles of chemistry that drive protein folding, as described in A through D below and on the next page.



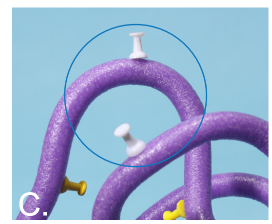
A. **Hydrophobic** (non polar) amino acid buried on the inside of the globular protein, where they are hidden from polar water molecules



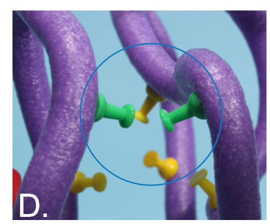
B. Charged amino acids (blue and red tacks) will be on the surface of the protein where they often neutralize each other to form an electric bond (salt bridges).



C. Hydrophilic (polar) amino acids (white tacks) will be on the surface of the protein where they can interact with water by forming hydrogen bonds.



D. Cysteine amino acids (green tacks) often interact with each other to form covalent disulfide bonds that stabilize protein structure.



A chart of the side chains and their properties is on page 4.

Discussion

Proteins perform critical functions in all of our cells. Without proteins life wouldn't exist. With your group or class, can you 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.

Amino Acid Side Chain Chart©

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Name	Amino Acid	Side Chain	Name	Amino Acid	Side Chain	Name	Amino Acid	Side Chain	Name	Amino Acid	Side Chain
Alanine Ala A			Glutamine Gln Q			Leucine Leu L			Serine Ser S		
Arginine Arg R			Glutamic Acid Glu E			Lysine Lys K			Threonine Thr T		
Asparagine Asn N			Glycine Gly G			Methionine Met M			Tryptophan Trp W		
Aspartic Acid Asp D			Histidine His H			Phenylalanine Phe F			Tyrosine Tyr Y		
Cysteine Cys C			Isoleucine Ile I			Proline Pro P			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