Student Handout 1

Amino Acids - Building Blocks of Proteins

Amino Acids are small molecules used by cells to make proteins.

There are 20 Amino Acids and each one consists of two parts — a ***Backbone*** and a ***Sidechain***. The backbone is the same in all 20 Amino Acids and the sidechain is different in each one.

Each sidechain consists of a unique combination of atoms which determine its 3D shape and its chemical properties.

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.

The activities described in this handout primarily focus on amino acid sidechains. They will help you understand how the unique properties of each sidechain contribute to the structure and function of a protein.

1. First, look at the components in your Amino Acid Starter Kit. Make sure you have:

   - 1 Magnetic **Chemical Properties Circle**
   - 1 Laminated **Amino Acid Sidechain List**
   - 4' **Mini-Toober**
   - 1 Set of **Red and Blue Endcaps**
   - 22 Plastic **Amino Acid Sidechains**
     20 Amino Acids plus,
     1 additional cysteine and
     1 additional histidine
   - 15 Metal **Mini-Toober Clip**s
   - 1 Sheet **Property Coding Labels**
   - 6 **Hydrogen Bond Connectors**

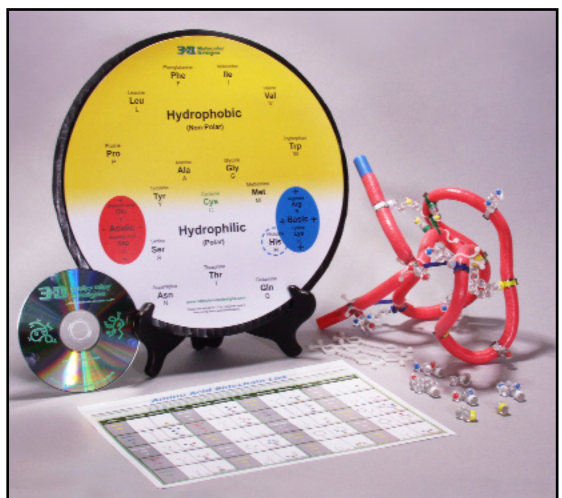

Photo shows the 1-Group Amino Acid Starter Kit.

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3-D Molecular Designs
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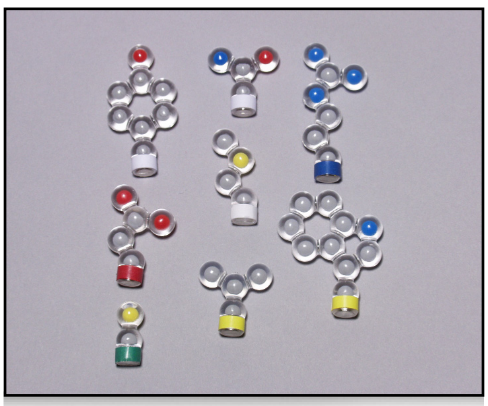
Amino Acid Starter Kit

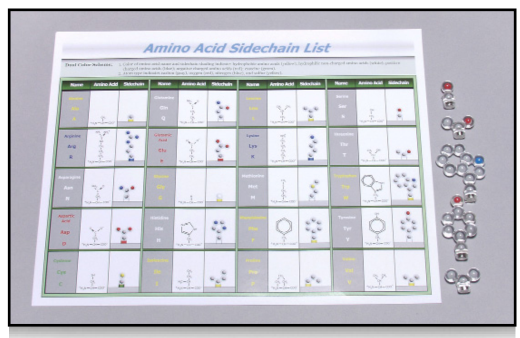
Chemical Properties Circle & Amino Acid Chart

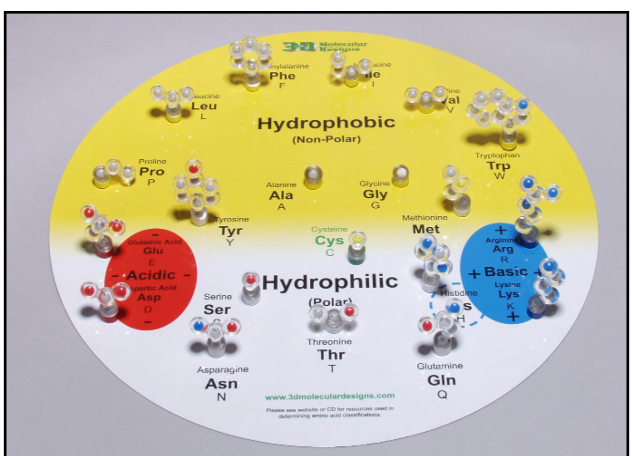
2. Select one of the sidechains. Using the Amino Acid Sidchain List as your guide select a colored label that corresponds to the property of the sidechain you selected. Peel it off of the sheet and wrap it around the base of the sidechain (where the magnet is encased in plastic).

The colored areas on the magnetic circle and the colored labels on the sidechains reflect the chemical properties according to the following coloring scheme:

Hydrophobic Sidechains are	Yellow
Hydrophilic Sidechains are	White
Acidic Sidechains are	Red
Basic Sidechains are	Blue
Cysteine Sidechains are	Green

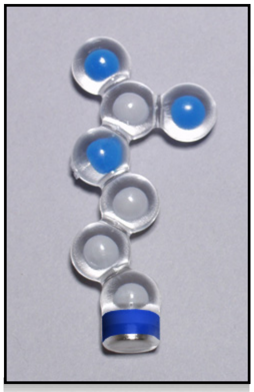






Place amino acid sidechain on the magnetic Chemical Properties Circle according to its chemical properties. You will need to consult the Amino Acid Sidechain List in your kit to find the name of each sidechain, so you can position it correctly on the circle.

Chemical Properties Circle (continued)



3. After each sidechain has been correctly positioned on the circle, look at the colored balls in each sidechain. Scientists established this CPK Coloring Scheme to make it easier to identify specific atoms in models of molecular structures.

Carbon is	Gray
Oxygen is	Red
Nitrogen is	Blue
Hydrogen is	White
Sulfur is	Yellow

CPK Coloring Scheme

Describe Your Observations

- Do you see similarities or patterns in the sidechains? ________________ Explain what you observed:

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- Hydrophobic sidechains are composed primarily of ______________________________ atoms.
- Acidic sidechains contain two ___________________ atoms. This is called a carboxylic acid functional group.
- Basic sidechains contain ____________________________ atoms. This is called an amino functional group.
- Hydrophilic sidechains have various combinations of

____

____.

- An exception to the above observation is:

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- Optional Activity - Amino Acids Jmol

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Folding a 15-Amino Acid Protein

Once you have explored the chemical properties and atomic composition of each sidechain, you are ready to predict how proteins spontaneously fold into their 3D shapes.

Predict what causes proteins to fold into their 3D shapes.

- From your experience with *oil* and *water*, which sidechains might position themselves on the interior of a protein, where they are shielded from water? ______________________________

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- From your experience with magnets or electricity, which sidechains might be attracted to each other?

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- Would the final shape of a protein be a *high energy state* or a *low energy state* for all of the atoms in the structure?

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Why? ____

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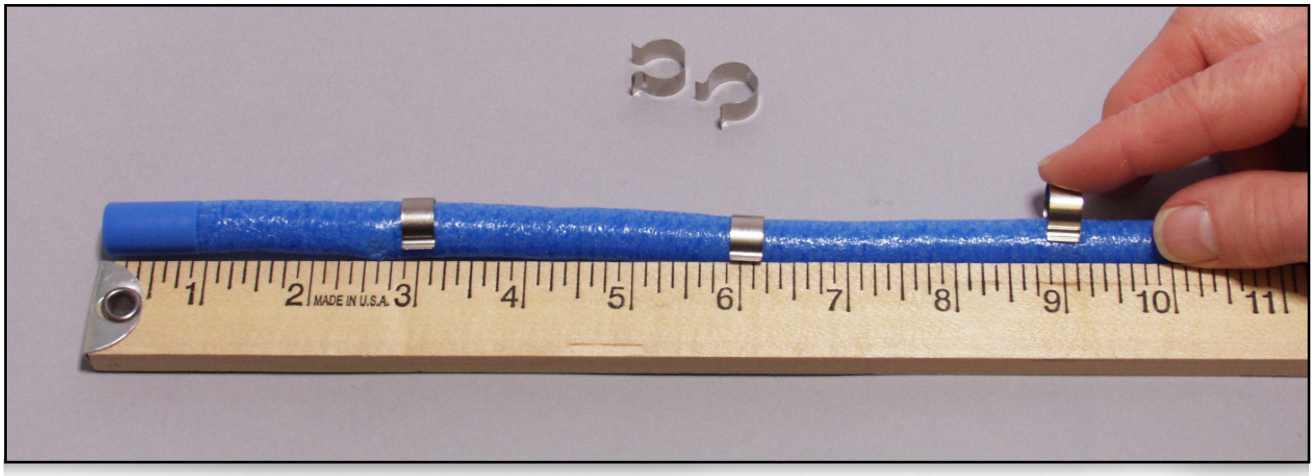
Folding a 15-Amino Acid Protein (continued)

1. Unwind the 4-foot Mini-Toober (foam covered wire) that is in your kit. Place a blue end cap on one end and the red end cap on the other end. The blue end cap represents the N-terminus (the beginning) of the protein, and the red end cap represents the C-terminus (the end) of the protein.

2. Select 15 metal u-shaped clips from your kit. You will also need a ruler.

   Beginning at the N-terminus of your mini-toober, measure about three inches from the end of your mini-toober and slide the first clip into place there. (See photo.)

   Place the rest of the clips three inches apart on your mini-toober until all are attached to the mini-toober.



Find the part of the drawing that represents the ***backbone*** section of the amino Acid. What do you think the clips represent?

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Folding a 15-Amino Acid Protein (continued)

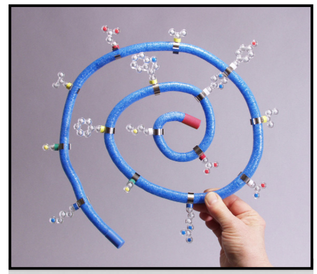
6 Hydrophobic sidechains
2 Acidic sidechains
2 Basic sidechains
2 Cysteine sidechains
1 Methionine sidechain
2 other Polar sidechains

3. Select methionine from the chemical properties circle and place it on the clip closest to the blue end cap.

   Choose any other sidechains from the chemical properties circle as long as you have the right number of each color, as indicated in the chart to the right.

   Mix the Sidechains together and place them (in any order you choose) on your mini-toober.

   > Option: Before placing the sidechains on the metal clips, place the chemical property label on the clip to correspond with the one on the sidechain. This will help you as you fold your protein.



   The sequence of Amino Acid Sidechains that you determined when placing them on the mini-toober is called the ***Primary Structure*** of your protein. As a general rule the final shape of a protein is determined by its primary structure (the sequence of its Amino Acids).

4. Now you can begin to fold your 15-amino acid protein according to the chemical properties of its sidechains. Remember all of these chemical properties affect the protein at the same time!

   - Start by folding your protein so that all of the hydrophobic sidechains are *buried* on the inside of your protein, where they will be hidden from polar water molecules.

   - As you continue to fold your protein to apply each new property listed below, you will probably find that some of the sidechains you previously positioned are no longer in place. For example, when you paired a negatively charged sidechain with a positively charged one, some of the hydrophobic sidechains probably moved to the outer surface of your protein. Continue to fold until the hydrophobic ones are buried on the inside again. Find a shape in which all the properties apply.

   - Next, fold your protein so the acidic and basic ***(charged)*** sidechains are on the outside surface of the protein and pair one ***negative*** sidechain with one ***positive*** sidechain so that they come within one inch of each other and neutralize each other. This positive-negative pairing helps stabilize your protein.

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Folding a 15-Amino Acid Protein (continued)

- Continue to fold you protein making sure that your polar sidechains are also on the outside surface of your protein where they can hydrogen bond with water.

- Last, fold your protein so that the two cysteine sidechains are positioned opposite each other on the inside of the protein where they can form a covalent disulfide bond that helps stabilize your protein.

The final shape of your protein when it is folded is called the ***Tertiary Structure***

- Why should Methionine be next to the Blue End Cap?

- What happened as you continued to fold your protein and applied each new chemical property to your protein?

- Were you able to fold your protein, so that all of the chemical properties were in effect at the same time?

- If not, do you have any ideas why you weren't able to fold your protein in a way that allowed all of the chemical properties to be in effect simultaneously?

- Did your protein look like the proteins other students folded?

  Explain.

- How many different proteins, 15 amino acid long, could you make given an unlimited number of each of the 20 amino acids?

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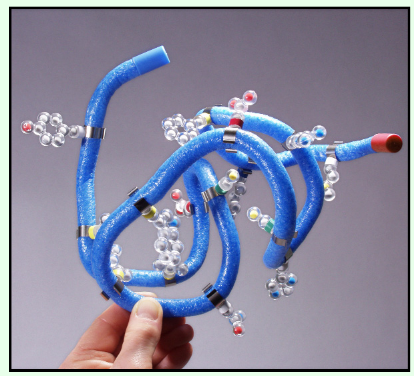
15-Amino Acid Protein Questions (continued)

-Most real proteins are actually in the range of 300 amino acids long. How many different possible proteins, 300 amino acids in length, could exist?

-How many different proteins are found in the human body? (Another way to ask this question is —How many different genes are there in the human genome?)

- Assuming that all human proteins are 300 amino acids long, what fraction of the total number of possible different proteins is found in the human body?



- Why do you think there are fewer actual proteins than possible ones?

15-Amino Acid Protein Questions (continued)

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Record the sequence of amino acids in your protein, starting with the N-terminus (blue end cap).

This is the ***Primary Structure*** of your protein.

In the space below, sketch the ***Tertiary Structure*** of your protein.

The next student handout provides folding activities and information that will help you understand the ***Secondary Structure*** of proteins.

- Optional Activity - Basic Priciples of Chemistry that Drive Protein Folding Part 1 Jmol
Basic Priciples of Chemistry that Drive Protein Folding Part 2 Jmol

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