Building Blocks of Proteins

CLASS COPY!!

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 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 determine its 3D shape and its chemical properties.

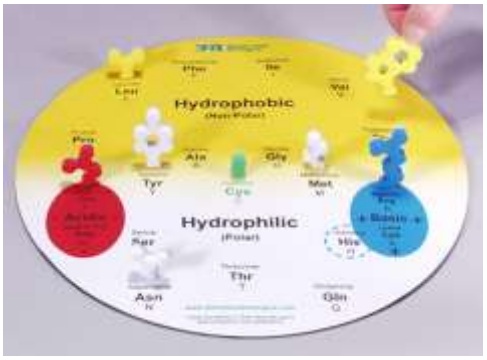
When different amino acids join together to make a protein, the unique properties of each amino acid determine how the protein folds into its final 3D shape. The shape of the protein makes it possible to perform a specific function in our cells.

The activities described in this handout primarily focus on amino acid side chains. They will help you understand how the unique properties of each side chain 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:

    - Chemical Properties Circle
    - Amino Acid Chart
    - Mini-Toober (foam-covered wire) with one Blue End Cap and one Red End Cap
    - 21 Foam Amino Acid Side chain Models with Magnets
    - 15 U-shaped Metal Clips
    - Hydrogen Bond Connectors

2. Place each foam amino acid side chain on the magnetic Chemical Properties Circle according to its chemical properties. The side chains are colored to reflect their chemical properties according to the following coloring scheme:



    - Hydrophobic Side chains are yellow
    - Hydrophilic Side chains are white
    - Acidic Side chains are red
    - Basic Side chains are blue
    - Cysteine Side chains are green

    You will need to consult the Amino Acid Side Chain List in your kit to find the name of each side chain, so you can position it correctly on the circle.

    - Carbon is gray
    - Oxygen is red
    - Nitrogen is blue
    - Hydrogen is white
    - Sulfur is yellow

3. Turn all of the side chains so that the colored side (yellow, white, red, blue) of each one is facing you as you read the names of the side chains. Now rotate the circle so that the names of the side chains are upside down and the gray side of each side chain is facing you. Examine the side chains and their positions on the circle.

4. **<u>In complete sentences</u>**, **<u>answer the following questions in your lab</u>** book or on a sheet of paper:

    a. How are hydrophobic (*water-fearing*) and hydrophilic (*water-loving*) side-chains different from each other in terms of the kinds of atoms they contain? Describe the atoms found in each of the following types of side chains:

        Hydrophobic/non-polar _____
        Negatively charged/ Hydrophilic/ polar _____
        Positively charged/ Hydrophilic/ polar _____
        Uncharged/ Hydrophilic/ polar_____

    b. As you know, water molecules are formed upon making a polypeptide and as a result, water is found around the newly-made polypeptide chain. How do you think the hydrophobic side chains react to this aqueous (wet) environment?

    c. Acidic side chains (R-groups) are negatively charged and basic side chains are positively charged. They also are hydrophilic (attracted to water).

        i. How do you think the acidic and basic side chains will react to each other?
        ii. How do you think the acidic side chains will react to other acidic side chains?
        iii. How do you think the basic side chains will react to other basic side chains?

5. Show your completed questions to Ms. vB for a stamp.

6. Next you will begin to build a protein based on a DNA sequence. Ms. vB will give you a DNA sequence which you must transcribe and translate into an amino acid code. In your lab book, create a table in which you record the DNA sequence you were provided, the complementary mRNA sequence that is transcribed and the amino acid sequence that is translated. Please also record which number DNA sequence you were given.

7. Once you have explored the chemical properties and atomic composition of each side chain and completed the transcription and translation of the DNA code, you are ready to predict your protein will spontaneously fold up into a 3D shape. Unwind the 4-foot Mini-Toober (foam covered wire) that is in your kit. Notice the blue and red end caps on the ends of your mini-toober. The blue end cap represents the N-terminus (the beginning, the side with the NH3) of the protein, and the Red End Cap represents the C-terminus (the end, the side with the COOH) of the protein.

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

9. **<u>In your lab book</u>**: what part of the polypeptide does the toober represent? The clips?

10. Select methionine from the chemical properties circle and place it on the clip closest to the blue end cap. Then, place the remaining amino acids according to the order determined by the DNA. You may need to share amino acids with other people in your row (just make sure they all get back to where they belong!).

11. **In your lab book**: the sequence of amino acids represents what level of the proteins structure?

12. **In your lab book**: Make some rules about your sequence based on the amino acid properties. (**Hint**: some may fall into more than one category)

    - Which amino acids will try to avoid water by folding to the inside? (These are hydrophobic.)
    - Which will seek water by folding to the outside? (These are hydrophilic.)
    - Which will attract each other because they have different charges (acids/bases)?
    - Which will repel each other because they have the same charges?
    - Which amino acids will find each other to form a covalent disulfide bond?

13. Now you can begin to fold your 15-amino acid protein according to the chemical properties of its side chains. Remember all of these chemical properties affect the protein at the same time! As you continue to fold your protein to apply each new property listed above, you will probably find that some of the side chains you previously positioned are no longer in place. For example, when you paired a negatively charged side chain with a positively charged one, some of the hydrophobic side chains probably move 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. The final shape of your protein when it is folded is called the Tertiary Structure.

14. In your lab book, sketch the Tertiary Structure of your protein. Or, you may take a photograph, print it, and tape it into your book. Give the picture a title and label each amino acid. Color code your sketch so that you can tell the properties of the amino acids (polar, non polar or ionic).

15. Show your completed protein model and sketch to Ms. vB for a stamp.

16. In your lab book:

    - 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 why or why not.
    - Explain why a DNA mutation might affect the shape of the protein that is produced from a gene.