Name: *Period:*

2 The Chemistry of Life
Modeling Protein Structure

Introduction:

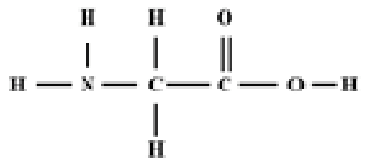
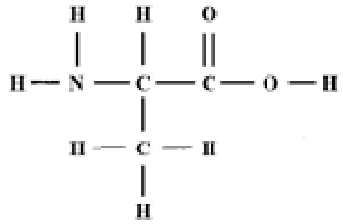
All living things are composed of many chemical compounds. Four such compounds are carbohydrates, lipids, nucleic acids, and proteins. ***Carbohydrates*** are the primary source of fuel for the cell and can be used for structure. ***Lipids*** are a part of all cellular membranes and may also be stored within a cell as energy. ***Nucleic acids*** include RNA and DNA, which serve as the hereditary molecules of the cell. ***Proteins*** form enzymes and are part of almost all structures within a cell. Therefore, they are essential for cell growth and repair.

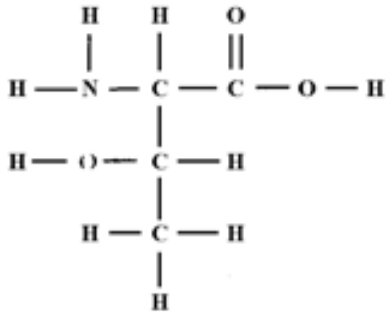
These four compounds are ***polymers*** known as macromolecules, which means big molecule. Carbohydrates, nucleic acids, and proteins consist of many smaller molecules called monomers joined together while fats consist of glycerol and three fatty acid molecules joined together.

The ***monomers*** - smaller molecules - that make up proteins are called ***amino acids***. There are about twenty different amino acids that can join together in any possible way to form proteins. However, a protein may be made of two separate chains of amino acids. Insulin, for example, has one chain with 21 amino acids and a second with 30. Frederick Sanger found that the sequence for a protein is very specific, meaning that all human insulin will have the same arrangement and number of amino acid molecules in its make-up.

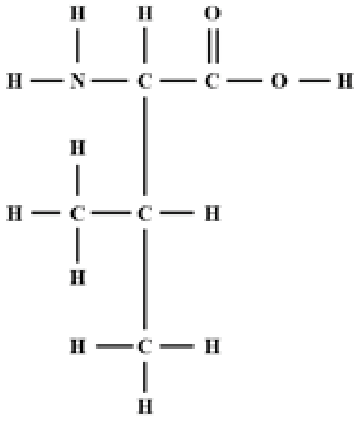
Procedure: Amino Acids

Examine the structural formulas and corresponding models of four of the twenty different amino acids used to build proteins.

 Glycine	 Alanine



Threonine



Valine

1. The element nitrogen (N) is present in all amino acids. Use your textbook to examine the structural formula of glucose, a monomer of carbohydrates, on page 45 and the structural formula of a triglyceride lipid on page 46. Is nitrogen present in lipids and carbohydrates?

2. What is the molecular formula of glycine? Add the correct subscripts. C H O N

3. What is the molecular formula of alanine? Add the correct subscripts. C H O N

4. Are the molecular formulas for all amino acids the same?

5. Again refer to the structural formula for a triglyceride lipid on page 46. What functional group, or end arrangement of atoms, is present in amino acids that was also present in fatty acids?

6. Another functional group in all amino acids consists of a nitrogen atom and two hydrogen atoms. This group is called an amino group. Do all structural formulas for each amino acid have an amino group?

7. All amino acids contain five basic parts. Draw the general structure of an amino acid below, and circle the five basic parts.

Combining Amino Acids to Form a Protein:

A protein is composed of many amino acids joined together chemically. A person's gene will determine the make-up of the protein. Genes specify the number and sequence of the amino acids that will form the specific protein. Proteins may be very large, consisting of 500 or more amino acids, or they may be very small, just a few amino acids. It is the types of proteins that each organism produces that makes it different from all other creatures. Thus, a person's genes make them different from another person because the expression of genes determines the proteins that make up our body's physical appearance.

Directions:

Examine the cut out models. Notice that all four are similar in that they contain a removable H group (which corresponds to a hydrogen in the amino arm) and a removable OH group (which corresponds to the OH group in the carboxyl arm). Bonding sites allow for the joining of two molecules. Without these bonding sites, the molecules will not join.

8. Try to join a valine and a threonine. Will they bind together without bonding sites?

9. Explain how you could create bonding sites on your models of valine and threonine.

Now that bonding sites have been created, join the alanine and threonine. Be sure to keep the pieces you removed to create the bonding sites as you will use them later. Now use the same technique to join an alanine to the threonine and a glycine to the alanine. When you are finished, you should have four amino acids joined together in the order: valine - threonine - alanine - glycine. Remove only enough H and OH groups to create the required bonding sites.

10. The H and OH groups can now be joined together. What chemical substance is formed when the H and OH are joined?

This type of reaction, in which larger molecules (polymers) are constructed from smaller molecules (monomers) by losing a water molecule is called dehydration synthesis, or a condensation reaction.

11. Explain why these are appropriate names for this type of reaction.

12. How many molecules of water are formed when four amino acids join together? With eight?

Remember, the order of amino acids determines protein. Imagine that the protein you made results in blue eyes. Other combinations of amino acids result in the formation of a different protein. Construct a protein different from the one suggested above. Let's call this protein "brown eyes". This new protein was caused by a change in the DNA. A change in the gene, or DNA, will produce a different arrangement of the amino acids and therefore a physically different protein results.

Show your model of a protein to your teacher.

13. How might a human muscle protein differ from a cow muscle protein?

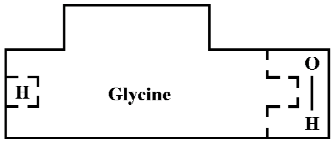
14. What purpose is served by the loss of H and OH atoms from the two smaller molecules as they join together during a condensation reaction?

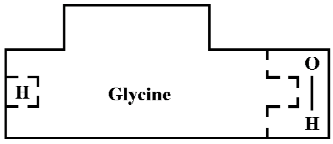
15. All macromolecules may undergo a process called hydrolysis (hydro means "water" and lysis means "to break apart") in which water molecules, with the aid of an enzyme, break the polymer down into the smaller monomers from which it is made. In the protein you constructed, how many molecules of water must be used to break apart the four amino acids?

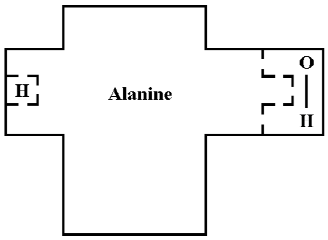
To what are the water molecules (H and OH) reattached?

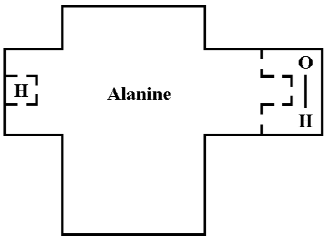
16. A protein consisting of ten amino acids undergoes hydrolysis, or digestion. How many water molecules must be broken down and reattached to the amino acid molecules during this process?

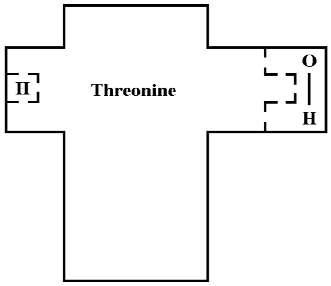
Cut Out Models for the Protein Worksheet

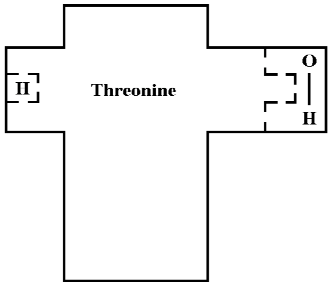


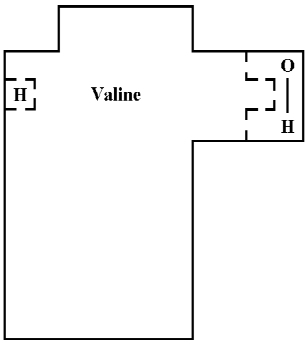


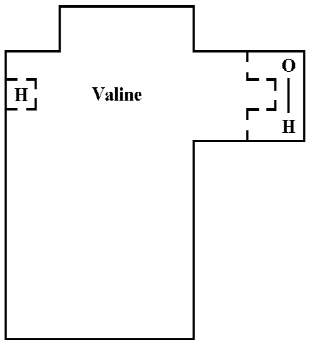









H
Valine
O
H


H
Valine
O
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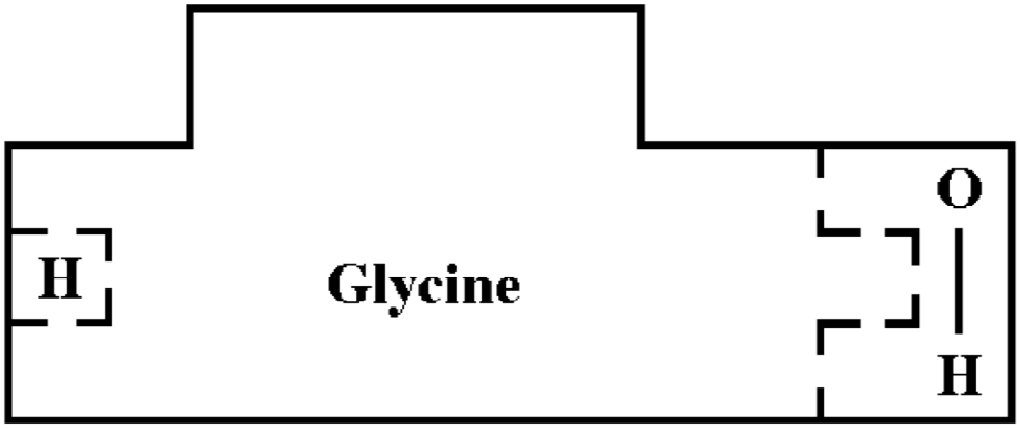
H
Glycine
O
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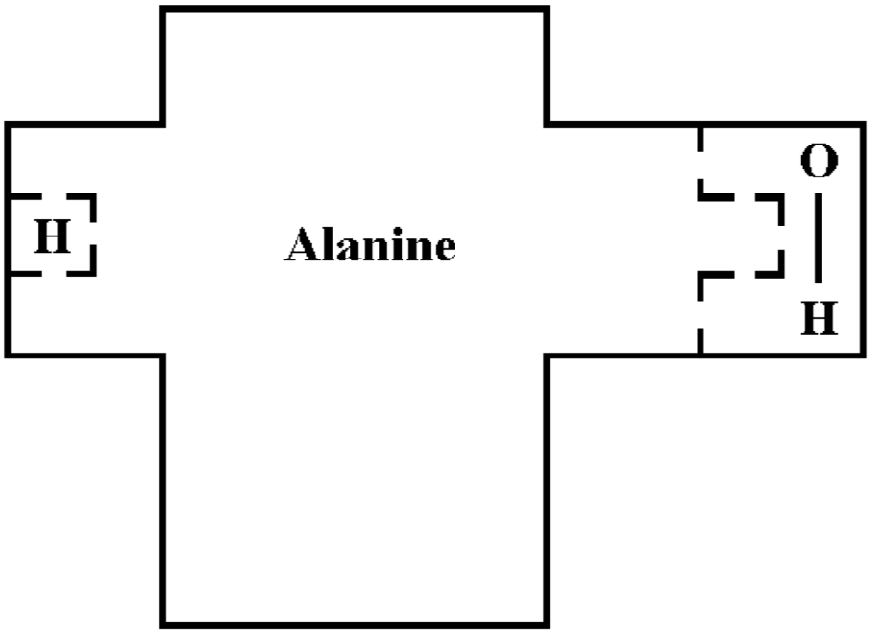
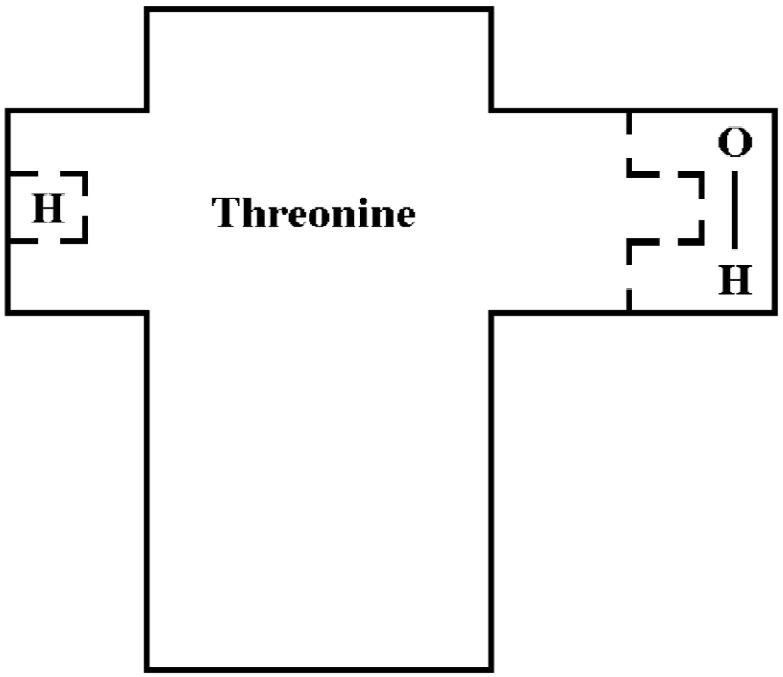
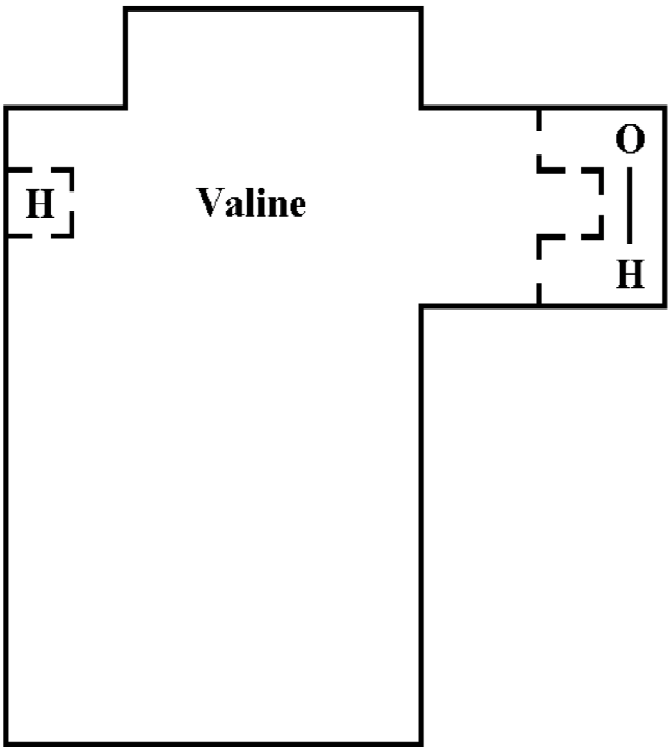

H
Alanine
O
H


H
Threonine
O
H


H
Valine
O
H