# Chapter 1-6: Proteins

Organic molecules provide the body with structural materials to form cells, tissues, and organs; regulatory substances to direct and govern the interactions of molecules; and energy to fuel the chemical operations of cells.

In previous plates, we discussed the structure and function of carbohydrates and lipids, and here we will examine proteins. Proteins are vital to the formation and function of many cellular structures and processes. They are also among the most diverse organic molecules in the living organism.

This plate shows how amino acid subunits are joined to form protein molecules. Once formed, proteins can assume a number of shapes, as the remainder of the plate will illustrate.

Proteins are molecules that are formed from units called amino acids. A protein may contain as few as ten amino acids, or it may contain thousands. The sequence of amino acids in proteins gives them unique functional characteristics.

In this plate, we show how amino acids combine with one another to form a linear protein called a peptide. The upper portion of the plate shows **two amino acids (A)** outlined by brackets. Each amino acid contains a **carboxyl group (B)** (shaded on the left amino acid and outlined on the right one). Amino acids also contain **amino groups (C)**. In the left amino acid, the amino group is outlined, and in the right one, it has been shaded. Light colors are recommended to color these groups. The amino group contains nitrogen and hydrogen atoms. The –R stands for a general alkyl group, and each of the twenty amino acids bear a distinct alkyl sidechain.

In the synthesis of a peptide, the –OH group of the carboxyl group of one amino acid and the –H of the amino group of the next amino acid are enzymatically removed. The nitrogen from one amino acid bonds with the carboxyl carbon of the adjacent amino acid, and this bond is called the **peptide bond (D)**. We have now formed a dipeptide, the smallest protein. In the course of the formation of the peptide bond, a molecule of water ($H_2O$) is given off.

Notice the far right side of the dipeptide, where it could join with the carboxyl group of an adjacent amino acid, and the far left of the dipeptide, where it could also be extended. Additional amino acids are added to the growing chain of peptides, and when the final amino acid has been added, a polypeptide results.

The order and number of amino acids in the peptide chain is determined by the cell's genes; this is discussed in a future plate. Once the peptide has formed, additional modifications occur, as the following diagrams illustrate. Continue your coloring as you read below.

As amino acids are added to the growing peptide, a polypeptide results, and when the polypeptide is modified to its working structure, it is called a protein.

The linear sequence of amino acids in a protein is referred to as a protein's primary structure. In the diagram entitled Primary Structure, we show six amino acids (A) linked together by peptide bonds (D). You may choose to color the six amino acids different colors. The amino acids in this peptide are valine (val), leucine (leu), lysine (lys), tyrosine (tyr), and histidine (his).

The secondary structure of proteins refers to the folding and twisting patterns of the protein chain. One pattern that proteins can assume is a **helix (E)**, indicated by the bracket. The individual amino acids in the helix can be seen.

Certain polypeptide chains fold back on themselves to form **folded proteins (F)**. These proteins are globular proteins, and their three dimensional shape is shown. The protein in the figure is one of the four polypeptides in a hemoglobin molecule of the human blood cell, and the **heme group (G)** is found within the folded protein.

The final structure we show is the quaternary structure, in which **multiple polypeptides (H)** are organized together. The four chains ($H_1$, $H_2$, $H_3$, $H_4$) are different, but one is identical to the folded protein of the tertiary structure shown earlier. This is the final structure of the hemoglobin protein found in red blood cells. It is important for the transport of oxygen throughout the body.

Name: ______________
Blk: ___ Date: ________
Marked by: ______________

## Princeton Review: Proteins

1. a) What are the units that make up protein molecules?
   b) How many may there be in a protein?
   c) What gives proteins their functional characteristics?

2. What is a peptide?

3. Identify the three chemical groups that make up an amino acid

4. a) How many different amino acids are there?
   b) How do they differ from each other in structure?

5. a) In a peptide, where are the two amino acids linked together?

   b) What is a by-product of this reaction?
   c) Name this type of chemical bond:

6. What "decides" the order and number of amino acids in a polypeptide?

7. Is a polypeptide the same as a protein? _____ Explain:

8. Define the following terms:
   a) primary structure:
   b) secondary structure:

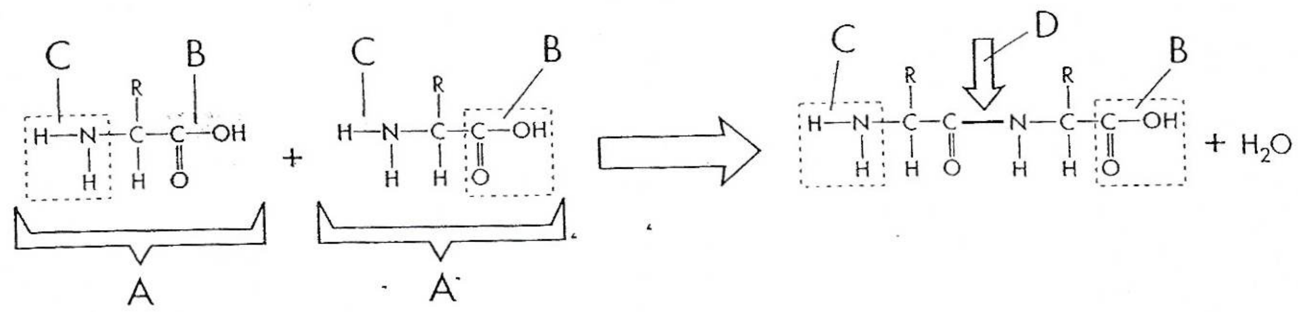
9. What is the most common secondary structure?

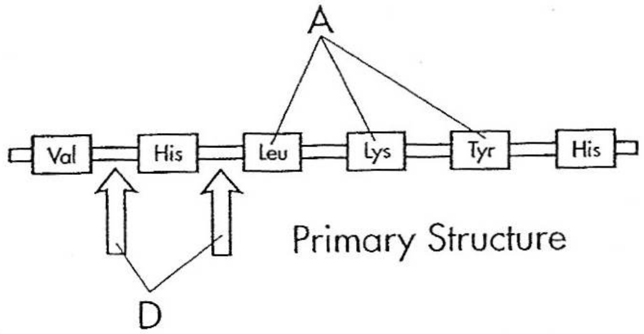
10. a) What happens to the secondary structure to generate a tertiary structure?

    b) The two names for this kind of protein: i) ii)

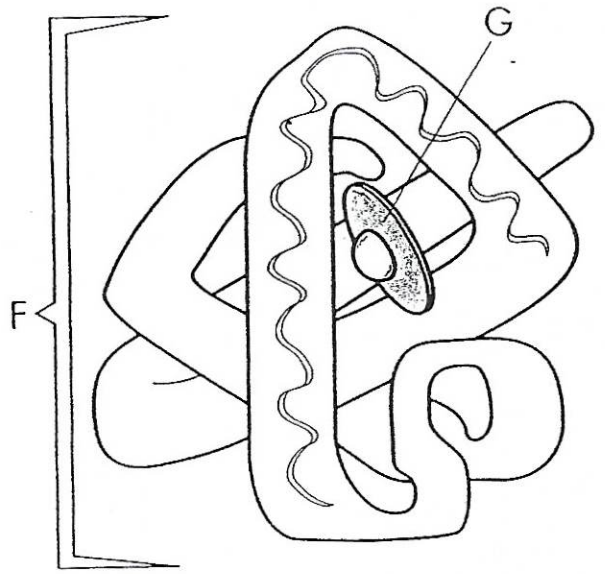
11. a) How is quaternary protein structure created?

    b) What protein is described as an example?
    c) How many polypeptides make up this molecule?
    d) Where is this protein found?
    e) What is its function?

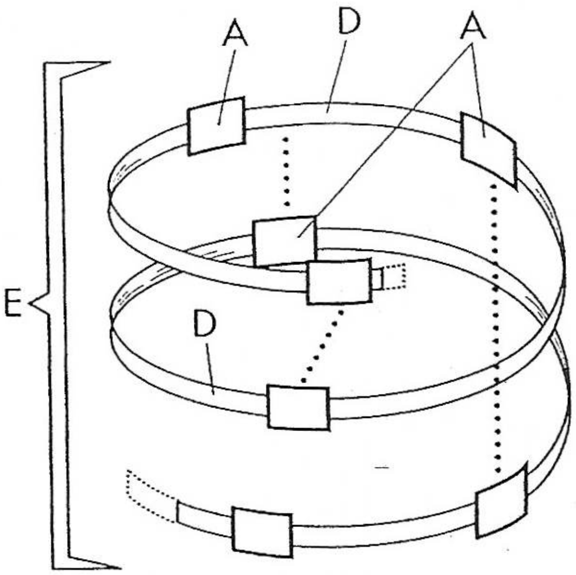


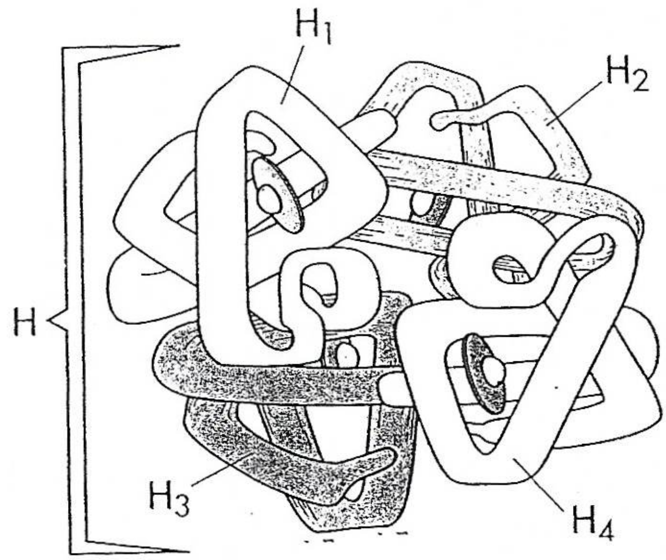

Primary Structure




Tertiary Structure




Secondary Structure




Quaternary Structure

Proteins

- ○ Amino Acids ............ A
- ○ Carboxyl Group ........ B
- ○ Amino Groups .......... C
- ○ Peptide Bond .......... D
- ○ Helix .................. E
- ○ Folded Protein ........ F
- ○ Heme Group ............ G
- ○ Multiple Polypeptides .......... H
- ○ Chain #1 .............. $H_1$
- ○ Chain #2 .............. $H_2$
- ○ Chain #3 .............. $H_3$
- ○ Chain #4 .............. $H_4$