20
PROTEIN STRUCTURE I

The structure of most proteins is very complex, with numerous twists and folds of the various parts and numerous additional chemical bonds to stabilize the protein in a particular three-dimensional shape. To make some sense out of protein structure, we customarily divide it into four levels: primary, secondary, tertiary, and quaternary. The first two levels are discussed in this plate, the latter two in Plate 21.

Color the heading Primary Structure and titles A through F with pale colors. Color the related illustration at the upper right.

The linkage of specific amino acids in a specific sequence by peptide bonds is referred to as the primary structure. If the primary structure is correct, the protein will twist and fold itself into all of the other levels of structure spontaneously, provided that the conditions around it (temperature, pH, concentration of other molecules) are correct. In a few proteins the primary structure also includes disulfide bridges between two separate polypeptide chains. We see this illustrated in the first section of the plate. Two molecules of the amino acid *cysteine* lose their hydrogen atoms to some other molecules and join to each other by forming a covalent bond between their sulfur atoms, thereby forming a bridge between two polypeptide chains. Such a bridge is called a *disulfide bridge.*

Color the remaining headings. Color the section under each heading as you come to it in the text below. Note that you will color the individual atoms of the α helix at the left and the β pleated sheet at the bottom, but you will color only lines representing the polypeptide backbone in the collagen triple helix. Shared electrons, represented by sticks in the α helix and β pleated sheet, are to be colored gray.

Under the conditions found in the cells of living things, a new polypeptide chain will begin to form hydrogen bonds with adjacent molecules or between different parts of itself as soon as it is formed. Hydrogen bonds are rather weak, and as collisions occur with other molecules, some hydrogen bonds are broken and new ones are formed, with the polypeptide taking a variety of shapes as the atoms rotate around one another. For any particular polypeptide there is usually one particular pattern of folding that allows a large number of hydrogen bonds to form, thereby stabilizing the molecule in that particular shape. The first level of such folding and hydrogen bonding after the polypeptide is formed is called the secondary structure.

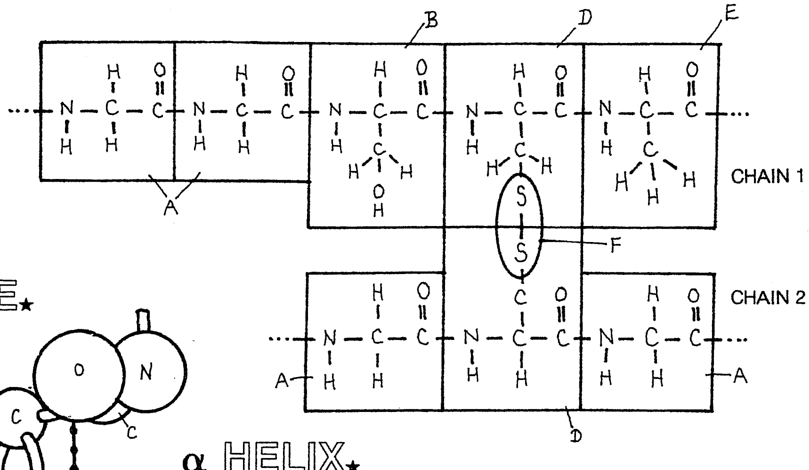
One of the common forms of secondary structure is called the α helix. It is a helix because it twists like a corkscrew. The letter alpha (α) was given to it because it was the first secondary structure discovered and alpha is the first letter in the Greek alphabet. As you can see in the plate, the slightly negative *oxygen atom* of each carboxyl group forms a hydrogen bond with the slightly positive *hydrogen atom* of the amino group of the fourth amino acid down the chain. When the molecule is twisted up into a helix, many separate hydrogen bonds hold it in that position. Only a portion of any given protein is usually in the helix form. Some proteins have more than 90 percent of their amino acids twisted into an α helix; others have only a very small percentage.

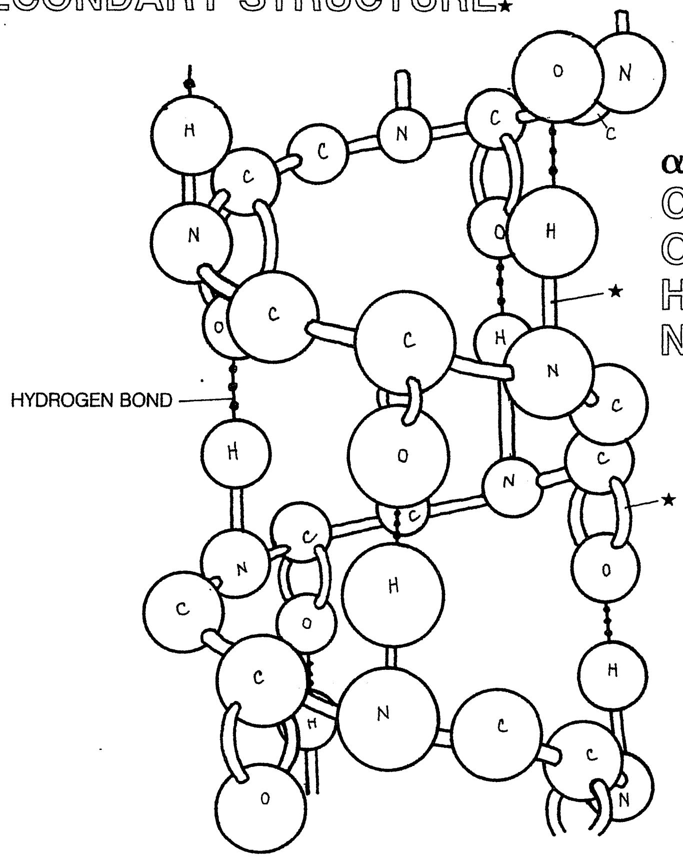
Another kind of secondary structure found in proteins is called the β pleated sheet, after beta (β), the second letter in the Greek alphabet, because it was the second secondary structure discovered. In this form the polypeptide chains are stretched out instead of coiled up, and large numbers of them lie side by side connected to one another by numerous hydrogen bonds to form a pleated sheet. The illustration in this plate shows only a small portion of two polypeptide chains in such a sheet. Many thousands of such chains make up a protein such as silk. The *side groups* project above and below the sheet to connect to similar sheets above and below this one.

The third kind of secondary structure is found only in collagen, the protein that makes up the strong fibers of tendons, ligaments, and other types of connective tissue. Collagen is made up almost entirely of only three amino acids, one of them proline. You may remember from Plate 19 that proline is the one amino acid that has its amino and carboxyl portions formed into a ring. This prevents it from turning at the correct angle to form an α helix. Instead, three separate polypeptide chains (two of them identical, the third slightly different) twist up into a triple helix and hydrogen-bond to one another. It is claimed that the tensile strength of collagen is nearly that of steel.

PROTEIN STRUCTURE I.

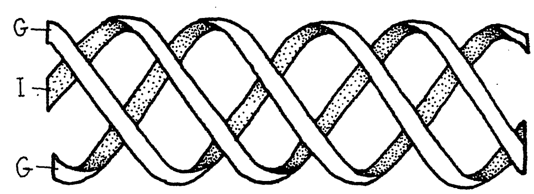
PRIMARY STRUCTURE★
GLYCINE A
SERINE B
CYSTEINE D
ALANINE E
DISULFIDE BRIDGE F
SECONDARY STRUCTURE★





α HELIX★
CARBON C
OXYGEN O
HYDROGEN H
NITROGEN N

COLLAGEN TRIPLE HELIX★
α1 CHAIN G
α2 CHAIN I



β PLEATED SHEET★
SIDE GROUP J