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INTRODUCTION TO PROTEIN

Protein gets its name from a Greek word meaning "first" or "primary" because it is the material of primary importance in every process we associate with being alive. Virtually none of the chemical reactions in a living thing would occur at any useful speed if it were not for those specialized protein molecules called enzymes. Other proteins serve as transport molecules, carrying things in the blood or across membranes or transporting electrons that are removed or added in important chemical reactions. Proteins are the main structural components of claws, hooves, and hair as well as the tough surface layer of skin. Contraction of muscle and movement within living cells is accomplished by protein. Many of the chemical messengers we call hormones are proteins, as are the antibodies that protect us from disease.

Color the heading Amino Acid and titles C through N using the same colors as in previous plates. Now color the ball-and-stick model and the space-filling model at the top of the plate. The sticks that represent shared electrons (bonds) are to be colored gray. Leave the side groups uncolored for now.

Proteins are made up primarily (or exclusively, in some cases) of long chains of amino acids. Amino acids (here illustrated by L-alanine) consist of a two-carbon portion that is common to all amino acids and a side group, which varies from one amino acid to the next. *Carbon* 1 is part of a carboxyl group (—COOH). The carboxyl group gives these molecules their acid properties by dissociating to release a hydrogen ion (proton). Carbon 2 has a nitrogen-containing amino group (NH_2).

In contrast to the situation in carbohydrates, where the right-handed or D-isomers are used for nearly everything, we find that proteins are made exclusively of the left-handed or L-isomers of amino acids. (D-amino acids are found in some antibiotics but not in proteins.)

Color the title ionization and the projection formulae of un-ionized alanine and the alanine zwitterion. Again, the gray bars are shared pairs of electrons.

Under the conditions found in living cells, nearly every molecule of any amino acid is doubly *ionized:* the carboxyl group releases a *hydrogen* ion and becomes negatively charged, while the amino group picks up a hydrogen ion and becomes positively charged. The resulting double ion is called a zwitterion (German: *zwitter,* "hybrid"). Note that in the ionized carboxyl group we use one solid line and one broken line to join each oxygen atom to carbon 1. This is to indicate that each *oxygen* shares 3 electrons (1½ pairs) with the carbon atom. Thus the two oxygen atoms share the negative charge. These are true covalent bonds because a sharing of electrons is involved, but they are unusual in sharing one pair of electrons among one carbon atom and two oxygen atoms. (For convenience, projection formulae are often written as if all the negative charge were on one oxygen atom, but it isn't so).

Color the side groups of the top illustrations. Color the heading Peptide Formation and title S. The conventional color for sulfur is yellow. Then color the L-alanine and the L-cysteine in the bottom half of the plate.

More than 50 different amino acids have been discovered in living things, but only 20 of them are used to make proteins. Of the 20, 19 have exactly the same arrangement of atoms around carbon atoms 1 and 2 that you see here in L-alanine. (The twentieth is almost the same.) They differ in their side groups, which are the groups attached to carbon 2. They are called side groups because they stick out to the side of the long chain that is formed when numerous amino acids are joined together to make a protein. Alanine's side group consists of a carbon atom with three hydrogens attached (known as a methyl group). (Notice that in the lower drawing, the molecule has been flopped over 90 degrees to the right for illustration purposes.) Cysteine has a side group that is similar but includes a *sulfur* atom. Other amino acids have side groups that range from a single hydrogen atom up to a double ring of carbon and nitrogen atoms, as you can see in the next plate.

Color titles B, D, and E, the arrows (B and D), the dipeptide, and the water molecule.

Just as with carbohydrates and fats, proteins are assembled by a *dehydration condensation* of their subunits. The covalent bond joining two amino acids in this way is called a *peptide bond.* The resulting molecule is called a dipeptide. If we add one more amino acid to the chain in the same way, we will have a tripeptide. When we have many amino acids joined in a chain in this way, the molecule is called a polypeptide. A functional protein molecule may consist of a single polypeptide or a number of polypeptides joined together. It may also include some nonpolypeptide portions.

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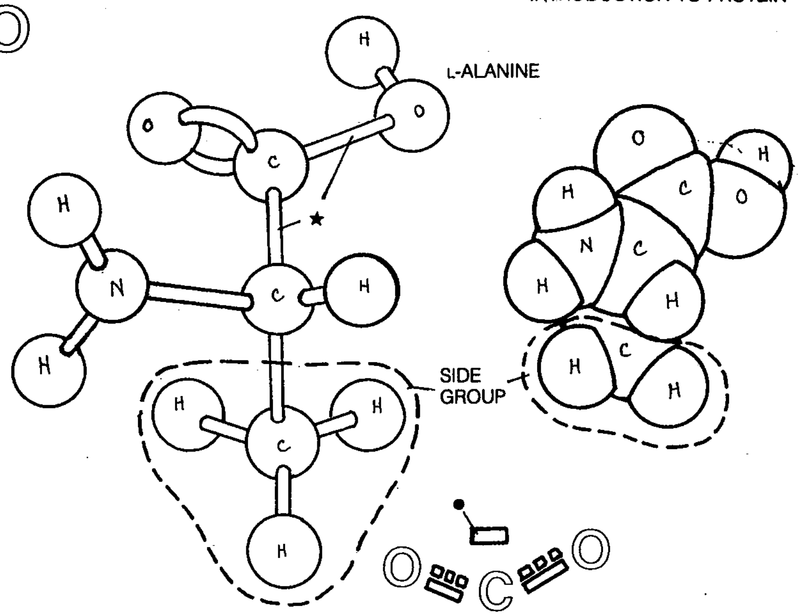
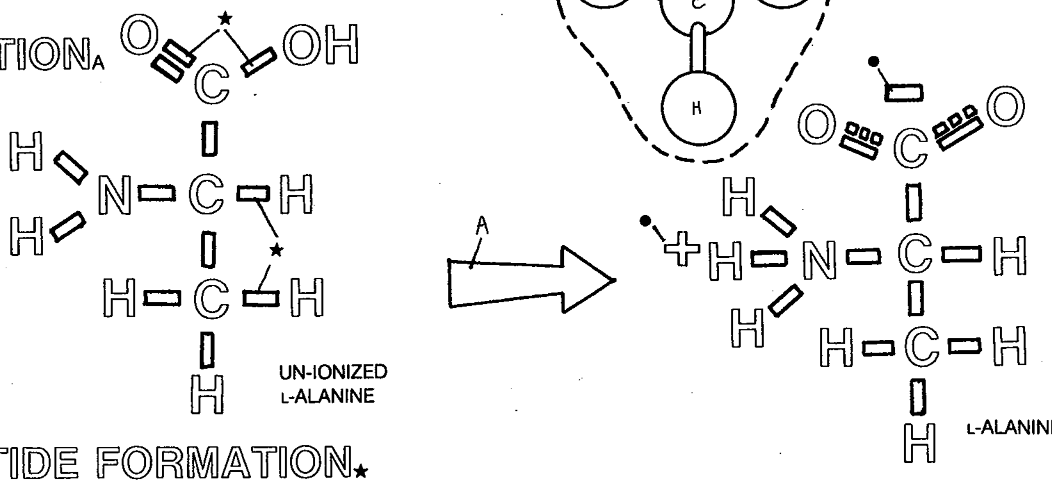
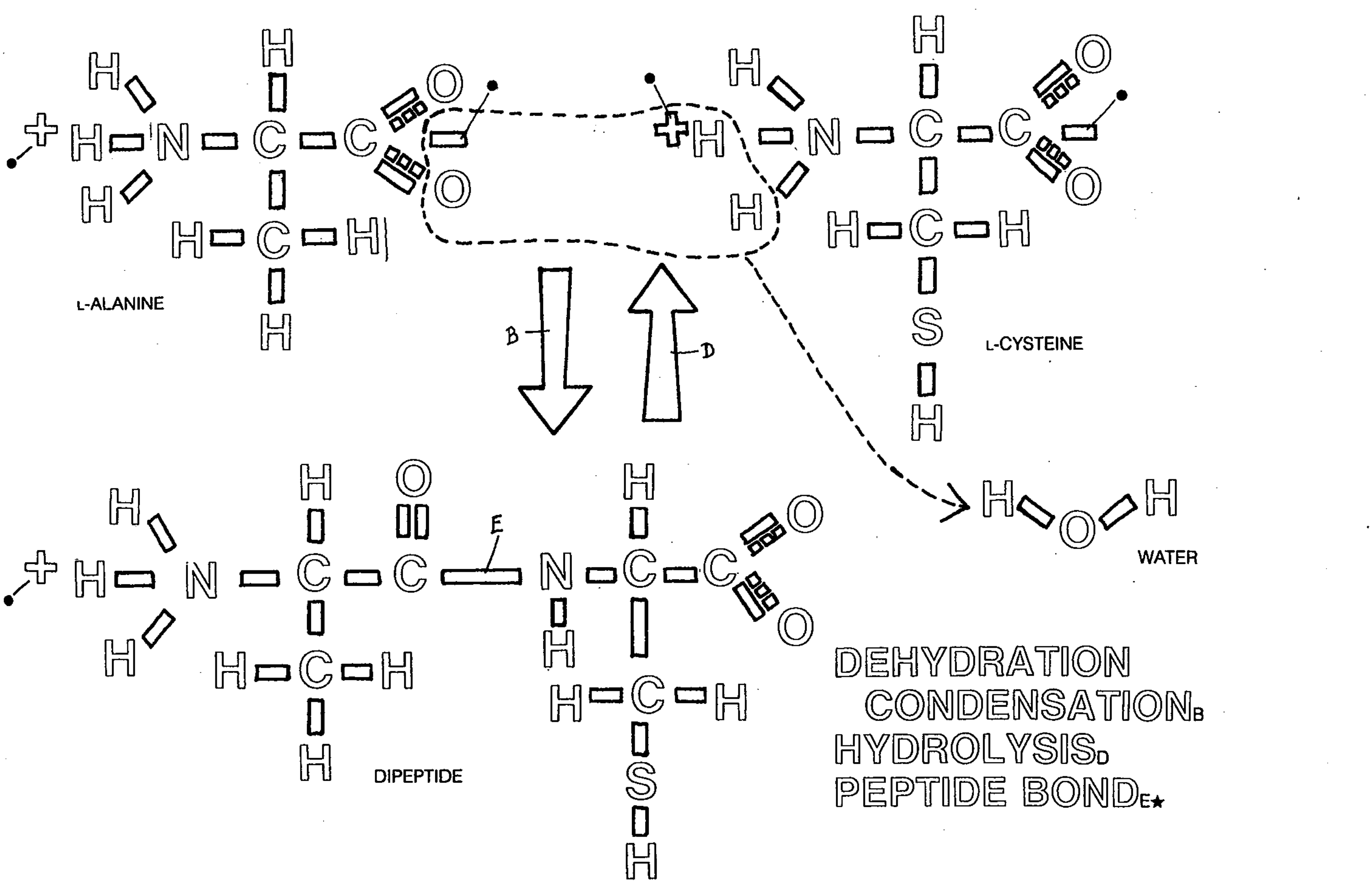
AMINO ACID★
- CARBON C
- HYDROGEN H
- OXYGEN O
- NITROGEN N
- SULFUR S



IONIZATION A



PEPTIDE FORMATION★



DEHYDRATION CONDENSATION B
HYDROLYSIS D
PEPTIDE BOND E★