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Peptides and Proteins

By

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Peptides and Proteins

Proteins, from the Greek *proteios*, meaning first, are a class of organic compounds which are present in and vital to every living cell. They are linear polymers built of monomer units called amino acids, which are linked end to end by peptide bonds.

Proteins are the most abundant class of biological macromolecules as they represent over 50% of the dry weight of cells. They perform a variety of functions, including the following:

1. **Catalysis:** Catalytic proteins called the enzymes accelerate thousands of biochemical reactions in such processes as digestion, energy capture, and biosynthesis. These molecules have remarkable properties.
2. **Structure:** Structural proteins often have very specialized properties. For example, collagen (the major components of connective tissues) and fibroin (silkworm protein) have significant mechanical strength.
3. **Movement:** Proteins are involved in all cell movements. Actin, tubulin, and other proteins comprise the cytoskeleton. Cytoskeletal proteins are active in cell division, endocytosis, exocytosis, and the ameboid movement of white blood cells.
4. **Defense:** A wide variety of proteins are protective. In vertebrates, keratin, a protein found in skin cells, aids in protecting the organism against mechanical and chemical injury. The blood-clotting proteins fibrinogen and thrombin prevent blood loss when blood vessels are damaged. The immunoglobulins (or antibodies) are produced by lymphocytes when foreign organisms such as bacteria invade an organism.
5. **Regulation:** Binding a hormone molecule or a growth factor to cognate receptors on its target cell changes cellular function. For example, insulin and glucagon are peptide hormones that regulate blood glucose levels.
6. **Transport:** Many proteins function as carriers of molecules or ions across membranes or between cells. Transport proteins include hemoglobin, which carries O_2 to the tissues from the lungs, and the lipoproteins LDL and HDL, which transport water insoluble lipids in the blood from the liver. Transferrin and ceruloplasmin are serum proteins that transport iron and copper, respectively.

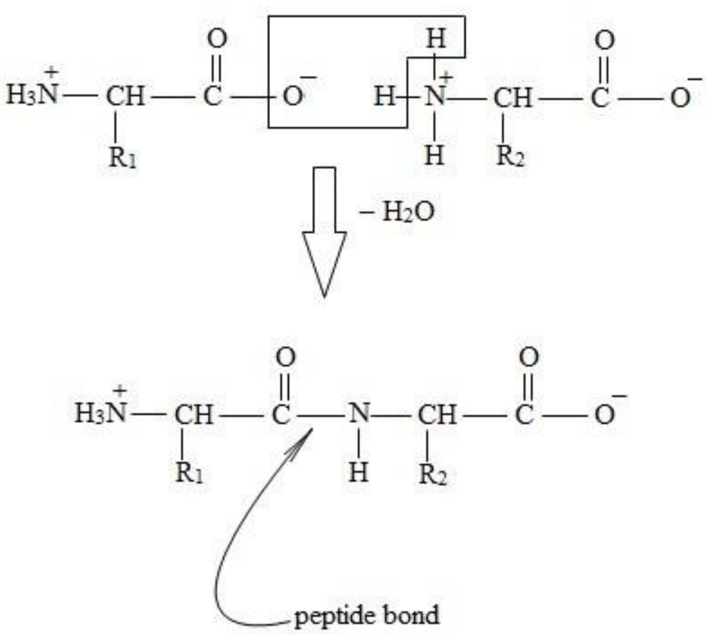
7. **Storage:** Certain proteins serve as a reservoir of essential nutrients. For example, ovalbumin in bird eggs and casein in mammalian milk are rich sources of organic nitrogen during development.

Protein structure:

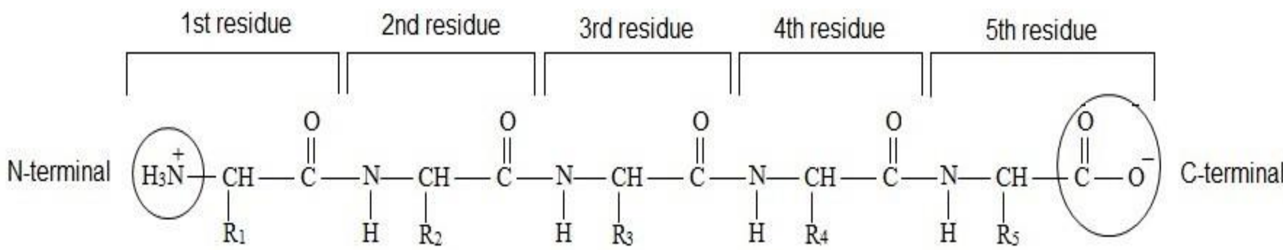
Amino acid molecules can be covalently joined through substituted amide linkages, termed peptide bonds, to yield a protein. Amide linkage (peptide bond) is formed by linking the carboxyl group of one amino acid to the amino group of another amino acid with removal of the elements of water (dehydration). Two amino acid molecules can be covalently joined through a substituted amide linkage, termed a peptide bond, to yield a dipeptide. Three amino acids can be joined by two peptide bonds to form a tripeptide; similarly, amino acids can be linked to form tetrapeptides, pentapeptides, and so forth.

In fact, when a few amino acids are joined in this fashion, the structure is called an oligopeptide. When many amino acids are joined, the product is called a polypeptide. Proteins may have thousands of amino acid residues. Although the terms "protein" and "polypeptide" are sometimes used interchangeably, molecules referred to as polypeptides generally have molecular weights below 10,000, and those called proteins have higher molecular weights.

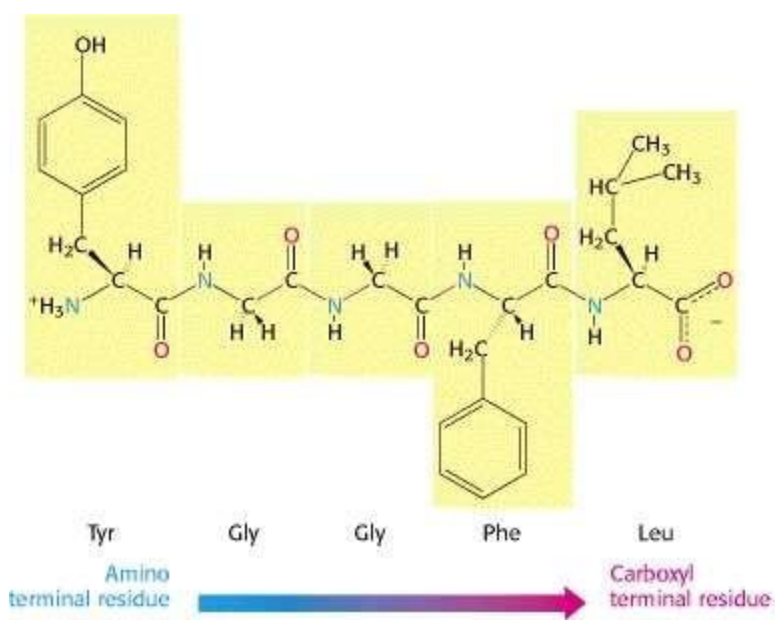
The following figure shows a dipeptide formation by peptide bond. The linking of two amino acids is accompanied by the loss of a molecule of water.



And the following figure shows a peptide chain that consists of five amino acid residues.



A series of amino acids joined by peptide bonds form a polypeptide chain, and each amino acid unit in a polypeptide is called a residue (the part left over after losing a hydrogen atom from its amino group and the hydroxyl moiety from its carboxyl group). A polypeptide chain has polarity because its ends are different, with an α-amino group at one end and an α- carboxyl group at the other end of the chain. By convention, the amino end is taken to be the beginning of a polypeptide chain, and so the sequence of amino acids in a polypeptide chain is written starting with the amino-terminal residue. It is the universal custom to write peptide and protein chains with the N-terminal residue on the left. Thus, in the pentapeptide Tyr-Gly-Gly- Phe-Leu, phenylalanine is the amino-terminal (N-terminal) residue and leucine is the carboxyl- terminal (C-terminal) residue.



To name peptides, the names of acyl groups ending in yl are used. Thus if the amino acids glycine and alanine condense together, the dipeptide formed is named glycylalanine. Higher peptides are named similarly, e.g. alanylleucyltryptophan. Thus the name of the peptide begins with the name of the acyl group representing the *N*-terminal residue, and this is followed in order by the names of the acyl groups representing the internal residues. Only the *C*-terminal residue is represented by the name of the amino acid, and this ends the name of the peptide. Formulas should normally be written in the same order, with the *N*-terminal residue on the left, and the *C*-terminal on the right.

Classification of Proteins:

Proteins may be classified according to their chemical composition, their shape, or their function. Protein composition and function are treated in detail in a biochemistry course. For now, we briefly survey the types of proteins and their general classifications. Proteins are grouped into simple and conjugated proteins according to their chemical composition.

1. **Simple proteins:** are those that hydrolyze to give only amino acids. All the protein structures we have considered so far are simple proteins. Examples are insulin, ribonuclease, oxytocin, and bradykinin.
2. **Conjugated proteins:** are bonded to a non-protein prosthetic group such as a sugar, a nucleic acid, a lipid, or some other group.
   - **Glycoproteins:** are proteins that contain oligosaccharide chains (glycans) covalently attached to polypeptide side-chains, such as mucins.
   - **Phosphoproteins:** are proteins which are chemically bonded to a substance containing phosphoric acid, such as casein.
   - **Metalloprotein:** A protein that contains a metal ion as cofactor, for example: ferritin and hemoglobin.
   - **Lipoproteins:** A lipoprotein is a biochemical assembly that contains both proteins and lipids water-bound to the proteins, such as chylomicrons.
   - **Nucleoproteins:** A proteins that is structurally associated with nucleic acids such as ribosomes, viruses.

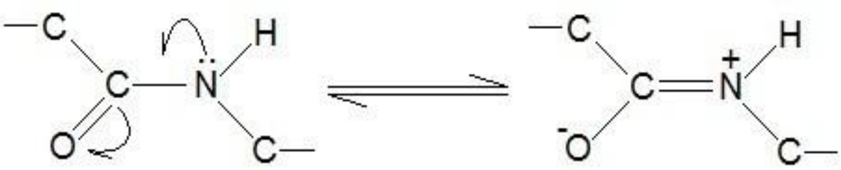
Also, proteins can be classified according to their shape into fibrous or globular proteins.

1. **Fibrous proteins** are stringy, tough, and usually insoluble in water. They function primarily as structural parts of the organism. Examples of fibrous proteins are α-keratin in hooves and fingernails, and collagen in tendons.
2. **Globular proteins** are somewhat water-soluble (forming colloids in water), unlike the fibrous proteins. They are folded into roughly spherical shapes. They usually function as enzymes, hormones, or transport proteins.

Types of Chemical Bonds in Proteins:

First: Two types of covalent bonds that include.

1. **Peptide bonds:** A peptide bond is a chemical bond formed between two molecules when the carboxyl group of one amino acid reacts with the amino group of another amino acid, releasing a molecule of water (H_2O). Examination of the geometry of the protein backbone reveals that the peptide bond is essentially rigid and planar. Thus for a pair of amino acids linked by a peptide bond, six atoms lie in the same plane: the α-carbon and CO group of the first amino acid and the NH group and α-carbon atom of the second amino acid. The peptide bond has considerable double-bond character due to a resonance structure (as shown in the figure below), which prevents rotation about this bond and thus constrains the conformation of the peptide backbone. The double bond character is also expressed in the length of the bond between CO and the NH groups. The C-N distance in a peptide bond is typically 1.32 Å, which is between the values expected for a C-N single bond (1.49 Å) and a C=N double bond (1.27 Å).



2. **Disulfide bonds:** Second kind of covalent bonds is possible between any cysteine residues present. Cysteine residues can form disulfide bridges (also called disulfide linkages) which can join two chains or link a single chain into a ring. Mild oxidation joins two molecules of a thiol into a disulfide, forming a disulfide linkage between the