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Study of the chemistry of Amino Acids and their applications

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Abstract
Chemistry of Compounds deal largely with the structure, function, and interactions of cell components and macromolecules such as the chemical structure of amino acids, carbohydrates, proteins, nucleic acids, and other biomolecules. Some of these molecules are large and complex and are called biopolymers. These are made up of similar repeating units called a monomer. Each biopolymer molecule contains different groups of units, for example a protein is a polymer whose units are made up of a different group of 20 or more amino acids. Biochemistry studies the chemical properties of important biomolecules such as proteins and especially the reactions catalyzed by enzymes. The biochemistry of metabolic processes within the cell and of the endocrine system has been extensively studied. Other areas of biochemistry include genetic material (DNA, RNA), transport of materials through the cell membrane, and signal transmission. The results of biochemistry are primarily used in medicine, nutrition, and agriculture. In medicine, biochemists study the causes and treatment of diseases. In the field of nutrition, they study how to maintain health and wellness and study the effects of undernutrition (or malnutrition). In agriculture, biochemists investigate soils and fertilizers and try to find ways to improve crop cultivation, crop storage, and pest control.

Keywords: amino acid, biochemical compound, drugs

Introduction

Proteins can be chemically synthesized by a group of methods known as peptide synthesis, which rely on organic synthesis techniques such as chemical ligation to be largely produced. Chemosynthesis allows incorporation of unnatural amino acids into polypeptide chains, an example being the binding of fluorescent probes to amino acid side chains. These methods are useful in laboratory biochemistry and cell biology, but not for commercial applications. Chemical synthesis is ineffective for polypeptides greater than 300 amino acids, and the synthesized proteins may not readily adopt their normal tertiary structure. Most methods of chemical synthesis start from the C end to the N end, in contrast to the normal biological reaction. Due to the unique properties of poly carbon compounds there is a very wide range of uses for organic compounds. For example, organic compounds are included as basic ingredients in many products such as pharmaceuticals, petrochemical products, plastics, foods, paint, explosives, fertilizers, synthetic rubber, plastics and many other products. And of course (apart from some simple exceptions) it is the basis of all the biological processes that take place in the bodies of living organisms, but rather the compounds of the living organisms themselves, as their components are very complex organic compounds. Also, the different forms and activities of substituents in organic compounds lead to the existence of different functions and forms for these compounds, such as catalyzing enzymes in vital reactions in living systems. These interactions, in one way or another, are the axis around which life forms revolve. Alanine, tryptophan and histidine are essential amino acids for animals. Because it is not synthesized in the human body, it must be derived from the diet. Tyrosine is a semi-essential amino acid; It can be made in the body, but only from phenylalanine. And the absence of the enzyme phenylalanine, used in the synthesis of tyrosine, causes phenylketonuria to leak into the urine, in conjunction with tyrosine, an essential amino acid. Aromatic amino acids have the ability to absorb light due to their double bonds. This property of aromatic amino acids is used to measure the concentration of proteins in an unknown sample. These amino acids are able to absorb light which converts the electron to the excited state, when the electron falls to the ground state it either emits light or energy. Therefore, any molecule capable of emitting light is known as a fluorescent molecule. Tryptophan is widely used as a fluorescent carrier. Animals obtain aromatic amino acids from the diet, but all plants and microorganisms synthesize aromatic amino acids through the metabolic pathway in order to make proteins. Herbicides and antibiotics work by inhibiting the enzymes involved in the synthesis of aromatic acids, thus making them toxic to plants and microorganisms but not to animals. Because of the condensed nature of amino acids, animals lose these energy-costly metabolic pathways, because they can obtain aromatic amino acids by eating other organisms.

The chemical Structure of Amino Acids

Proteins play structural roles. For example, the movement of two proteins (actin and myosin) leads to movement of skeletal muscle. The most important types of proteins are enzymes. These enzymes recognize substances that interact with each other and speed up the reaction between them. Enzymes speed up the reaction by a rate of 1011 or more, as a reaction that may take 3000 years to complete spontaneously may take less than a second in the presence of enzymes. The enzyme itself is not consumed in the reaction and is free until the same reaction occurs with new substances. By using some equations the activity of enzymes can be controlled. Proteins are a series of amino acids. An amino acid consists of a carbon atom bonded to four groups. One of them is the amine group (NH2). One is the carboxyl group (COOH). The third is a hydrogen atom. The fourth is symbolized by (R), and it differs from one amino acid to another. There are twenty amino acids. Some of them have functions by themselves such as glutamate as it is a neurotransmitter. Amino acids can be linked to each other via peptide bonds. This is done by a hydrophobic reaction in which a water molecule is removed and a peptide bond attaches a nitrogen atom in one of the amino acids in the amino group to the carbon atom of the carboxyl group of the other amino acid. The resulting molecule is called a dipeptide. The synthesis of proteins can be described in four levels. Elementary structure, where a protein is made up of a linear chain of amino acids. Binary structure, the protein is coiled around itself in either an α-helix or a β-sheet. Tertiary structure, which is the three-dimensional shape of a protein. The quaternary structure is the structure of a protein made up of several peptide units. Proteins that are consumed in food are broken down into amino acids or dipeptides in the small intestine, which are then absorbed. They can then combine to form a new protein. Plants and bacteria can synthesize all 20 amino acids, while humans and animals can synthesize only half of them. Therefore, there are amino acids called essential, which cannot be synthesized in the body, and non-essential, which can be synthesized. After they have been synthesized, proteins can only survive for a specified period and are then broken down and recycled by the machinery of the cell through a process known as the protein cycle. The lifespan of proteins is measured by their half-lives and includes a wide range, where they can exist for only minutes or many years, the average life of proteins is 1-2 days in mammalian cells, disordered or misfolded proteins degrade faster because they are targeted for destruction or are unstable.

Proteins are important molecules - like other macromolecules involved in the synthesis of many anti-tumor compounds as well as in medicines and the manufacture of some industrial chemical dyes and biological agents such as polysaccharides and nucleic acids - for organisms and contribute to almost all intracellular processes. Many proteins are enzymes that catalyze biochemical reactions and are essential to metabolism. Proteins have structural or motor functions such as actin and myosin in muscle and proteins in the cytoskeleton, which form a scaffolding system that maintains cell shape. Some other proteins are important in transmitting and receiving cell signals, immune responses, cell adhesion, and the cell cycle. It is necessary for the presence of proteins in the diet of animals and humans to provide essential amino acids that cannot be synthesized. Digestion breaks down proteins for use in metabolism if needed.

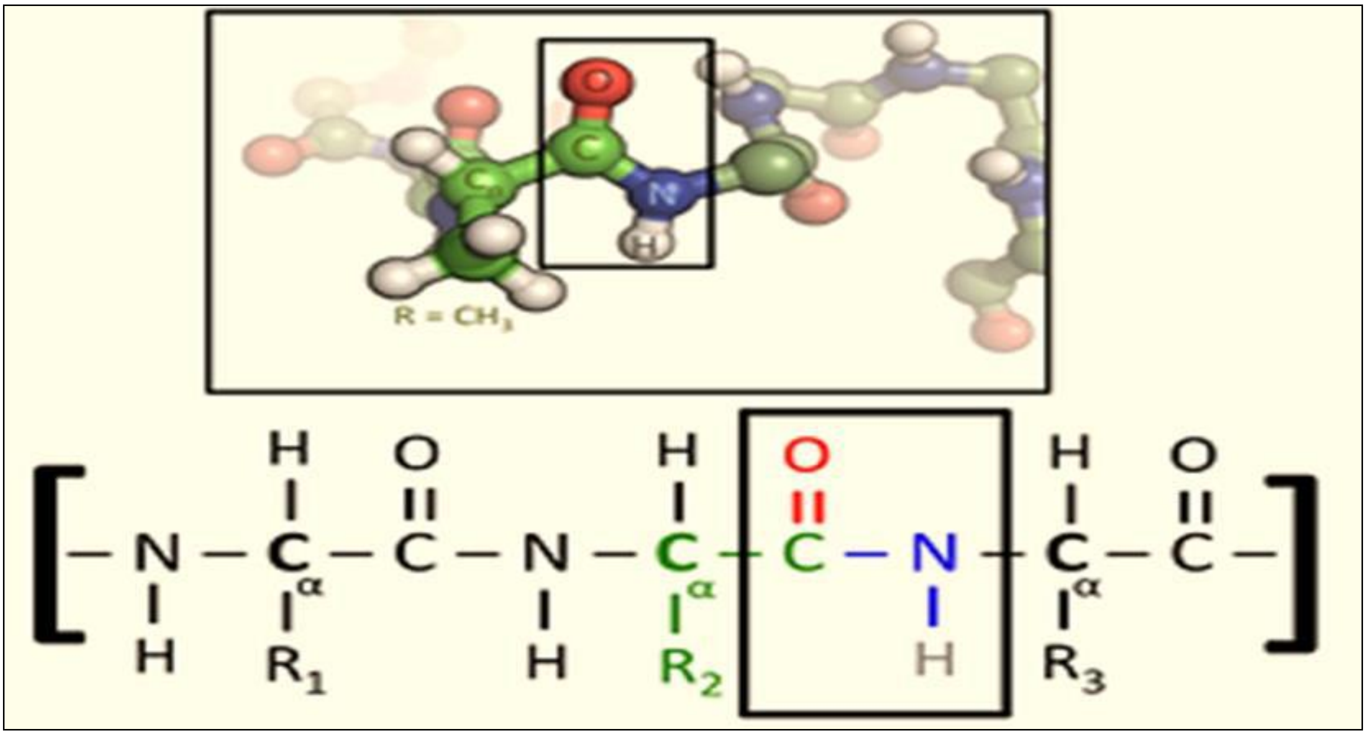

Fig 1: Structures of amino acids in Peptide

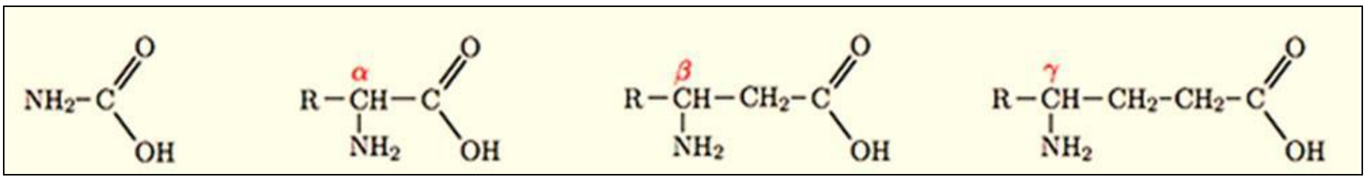

Fig 2: Types of Amino acids

Protein Chemical Synthesis

Proteins are synthesized from amino acids using the information encoded in genes. Each protein has its own sequence of amino acids, which is determined by the nucleotide sequence of the gene encoding that protein. The genetic code consists of groups of three nucleotides called codons, and the combination of each three nucleotides symbolizes an amino acid, for example, AUG (adenine, uracil, guanine) is the symbol for methionine. Since DNA contains four nucleotides, the total number of potential codons is 64 codons, and this number exceeds the number of amino acids, so some amino acids are symbolized by more than one codon. The genes encoded in DNA are transcribed into pre-mRNA by proteins such as RNA polymerase, and most organisms process pre-mRNA (also known as primary transcript) by making various post-translational modifications to form mature messenger RNA, which is then used as a template for protein synthesis by the ribosome. In prokaryotes, mRNA can be used immediately after its production or after binding to the ribosome and moving away from the nucleoid. In contrast, eukaryotes produce the messenger RNA in the cell nucleus and then travel across the nuclear membrane to the cytoplasm where protein synthesis takes place. The rate of protein synthesis is higher in prokaryotes than in eukaryotes and can reach up to twenty amino acids per second. The process of protein synthesis is known from the messenger RNA, during which the messenger RNA is attached to the ribosome, where three nucleotides are read from it each time and each codon is matched against the corresponding codon, which is present in the tRNA molecule that carries with it the amino acid corresponding to the codon that recognizes it, the enzyme synthesizes aminosyl RNA The transporter "loads" the tRNA with the correct amino acids. The developing peptide chain is often called the nascent or nascent chain. Proteins are always synthesized from the N-terminus to the C.-terminus

Isolation of Amino Acids

Proteins can be purified from other cellular components using various techniques such as: differential centrifugation, sedimentation, electrophoresis, and chromatography. Advances in genetic engineering have made it easier to purify proteins by using relevant methods. The methods commonly used to study protein structure include immunohistochemistry, site-specific mutagenesis, sigmoidal crystallography, nuclear magnetic resonance, and mass spectrometry. Most proteins have unique three-dimensional structures, and the shape in which a protein is naturally involved is known as the dormant state. Many proteins can fold without help thanks to the chemical properties of their amino acids, but other proteins need help with molecular chaperones to fold to their natural states. There are four structures of a protein:

- **A. Primary Structure:** a linear sequence of amino acids linked by a peptide bond in a polypeptide.
- **B. Secondary Structure:** These are local structures that are regularly repeated, stable by hydrogen bonds, the most famous examples are: alpha helix, beta sheet and coils. Given that secondary structures are local; Several regions with different secondary structures can be present in the same protein molecule.
- **C. Tertiary Structure:** the general shape that a single protein molecule takes; The steric relationship between the secondary structures of this protein, tertiary structures are usually stabilized by non-local interactions, the most famous of these interactions are the hydrophobic effect as well as salt bridges, hydrogen bonds, disulfide bonds and even post-translational modifications. The term 'tertiary structure' is often used synonymously with fold, the tertiary structure responsible for the primary function of a protein.
- **D. Quaternary Structure:** It is a structure composed of several protein molecules, called in this context subunits, and acts as a single protein complex.

Proteins are not solid molecules, because in addition to these kinds of structures they take on; It can switch between several related structures while performing its functions. These changes in structures due to the performance of the tertiary or quaternary function are called “morphology”, and the transformation between them is called “morphological changes”. These changes are often caused by the binding of a substrate molecule to the active site of an enzyme, or to a region of a protein that contributes to the catalysis. In solutions, proteins undergo structural transformations as well due to thermal vibrations and collisions with other molecules. Informally, proteins related to standard tertiary structures can be divided into three main categories: globular proteins, rigid proteins and membrane proteins. Almost all globular proteins are soluble in solutions and many are enzymes. Solid proteins are often structural, such as collagen, which is one of the main components of connective tissue, and keratin, the protein that makes up hair and nails. Membrane proteins act as receptors or provide channels for the passage of polar or charged molecules across the cell membrane. Proteins have a special case of intra-molecule hydrogen bonds, which are poorly protected from water, which means they are subject to self-dehydration and are called dehydronates.

Peptide Content of Amino Acids

Most proteins consist of linear polymers consisting of a chain of up to 20 different L-α amino acids. All proteino-genic amino acids possess common structural features, including an α-carbon to which an amino group, a carboxyl group and a variable side chain are attached. Only proline differs from this basic structure as it contains an unusual ring at the amino terminus which forces the amide moiety CO–NH to adopt a fixed structure. Standard amino acid side chains, which are detailed in the Standard Amino Acids List, have a wide variety of chemical structures and properties. The combination of these side chains of all amino acids in a protein ultimately determines its tertiary structure and chemical reactivity. The amino acids in a polypeptide are linked by peptide bonds, and when they are linked in a protein chain, one amino acid is called a building unit, and the chains of carbon, nitrogen and oxygen atoms associated with the basic chain or backbone of the protein are known. The peptide bond has two resonance structures that contribute to some of the properties of the double bond and prevent rotation about its axis, in which the atoms attached to the alpha carbon are at about the same level. The other two pairs of angles in the peptide bond determine the local shape taken by the protein backbone. The end containing a free amino group is known as the amino terminus or N terminus, while the terminus of a protein containing a free carboxylic group is called the carboxylic terminator or C terminator (the protein sequence is written from the amino terminus to the carboxylic terminus, from left to right). The words: protein, polypeptide and peptide are slightly opaque and may overlap in their meaning. The word protein is usually used to refer to a complete biological molecule with a stable structure, while the word peptide is used mostly with oligomeric amino acids that often do not have a stable three-dimensional structure. The boundaries between these two words are not precisely defined and are often between 20-30 units. The word polypeptide can refer to any single linear chain of amino acids regardless of its length, but the use of a polypeptide usually implies the absence of a specific structure for that linear chain.

Chemical Analysis of Amino Acids

To carry out laboratory studies, the protein must be purified from the rest of the cell components. This process usually begins with cell lysis, in which the cell membrane ruptures and its components spill into a solution known as a crude lysis solution. The resulting mixture can be purified using ultracentrifugation, which breaks down cell components into parts containing soluble proteins, lipids and membrane proteins, cellular organelles and nucleic acids, and precipitation by a method known as salt separation can concentrate the proteins from this crude mixture. Then various chromatography methods are used to isolate the target protein or proteins based on properties such as molecular weight, net charge and bonding affinity. The level of purification can be monitored using various types of gel electrophoresis if the desired protein's molecular weight and isoelectric point are known, by spectroscopy if the protein has distinct spectroscopic properties, or by enzymatic assay if the protein has enzymatic activity. In addition, proteins can be isolated according to their charges using an isoelectric well.

For natural proteins, a series of purification steps may be necessary to obtain a protein sufficiently purified for laboratory use. To simplify this process genetic engineering is often used to add additional chemical features to proteins that make them easier to purify without affecting their structure or activity. The "label" consists of a specific amino acid sequence, mostly histidine units (and the name histidine), that is attached to one end of the protein, and as a result, when the crude solution passes a nickel-containing chromatogram the histidine units bind to the nickel and adhere to the strand, while the non-tagged components From the crude solution pass unhindered. Several markers have been developed to help researchers purify specific proteins from complex mixtures.

Conclusion

Proteins are very large molecules that are part and basic unit in the chemical structure of amino acids consisting of monomers called amino acids. In the body there are 20 amino acids, each one forming a carboxyl group, an amine group, and a side chain (known as an R group). The R group is what makes each amino acid different, and the properties of this group greatly influence the 3D shape of a protein. When amino acids combine, they form a special bond called a peptide bond through a dehydration reaction, and they become polypeptides.

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