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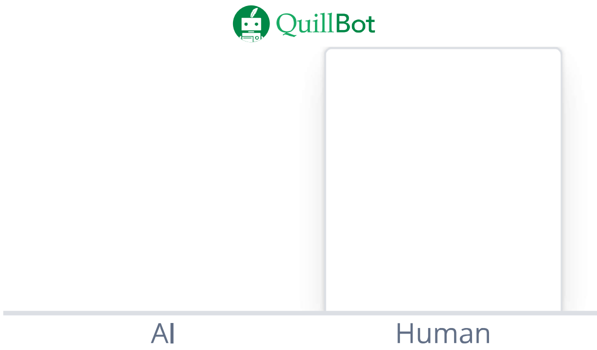

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Caution: Our AI Detector is advanced, but no detectors are 100% reliable, no matter what their accuracy scores claim. Never use AI detection alone to make decisions that could impact a person's career or academic standing.

1.1. Introduction to Amino Acids

Amino acids are the basic constituents of life and are vital in almost all biological reactions. These are organic compounds, which contain an amine functional group, and carboxyl functional group bound to a unique side chain, the central alpha carbon forming the distinct structure of the twenty naturally occurring proteinogenic amino acids which make up proteins in all living matter, coded by the universal genetic code.[3]

All of the 20 amino acids are needed by the human body to perform properly, and nine of them are considered essential (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine) and must be consumed in the diet.[7] The rest form nonessential amino acids and can be synthesized internally. Amino acids have characteristic physicochemical properties, i.e., those dictated by their side chains (R group), such as the single proton in glycine up to complex aromatic rings in tryptophan and tyrosine. For illustration, some representative amino acids are shown: glycine (simplest, with hydrogen as the side chain, Fig. 1.2), alanine (with a methyl side chain, Fig.1.3), and serine (with a hydroxymethyl group, Fig. 1.4).

Fig 1.1 structure of glycine.

Fig. 1.2 Structure of Alanine

Fig. 1.3 Structure of Serine

The structural variability of amino acids does not only exist in the side chain, but extends to vital stereochemical issues. All naturally occurring amino acids with the exception of glycine are chiral: they have a chiral center at the alpha carbon; naturally occurring amino acids are in the L-configuration. This chirality is central to protein folding, enzyme processes, and molecular recognition processes which operate the science of life on a molecular basis.

In addition to being components of proteins, amino acids are vital in other biological processes such as conversion to carbohydrates (via glucogenic amino acids), precursors of specialised products (like amino-acid-derived neurotransmitters such as serotonin) among others.[20,35]

Amino acids play a number of important biological and chemical roles in the rest of the body, such as construction and restoration of tissue, enzyme production and activity, and food breakdown as well as transporting molecules.[5] They are vital to muscle growth, repair, and hypertrophy through protein synthesis; maintaining immune status by producing antibodies; and hormone regulation.[34] Amino acids also play a role in the structural stability of metalloproteins by binding metal ions and making stable complexes that help maintain the protein as a whole and ensure proper protein fold.[19]

The characterization of amino acids and their derivatives has advanced greatly since the discovery of chemical aspects of amino acids in the early 19th century, further developments in analytical techniques, specifically nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry, have resulted in our inimitably deeper understanding of the structures, compositions and mechanisms of amino acids and their derivatives.[4]

1.2. Introduction to Artificial Amino Acids and Their Uses

Unnatural amino acids, or artificial amino acids, are a quickly growing group of amino acids that are typically outside the set of twenty defined amino acids. The artificial derivatives have become vital in peptide- and peptidomimetic-based drugs, and their utility can be demonstrated using clinically approved drugs which include methyldopa, baclofen, and gabapentin.[12] Artificially produced amino acids have now become requisite in both modern applications in medicinal chemistry, materials science, and chemical biology.

Fig 1.4. structure methyldopa

Fig 1.5 structure of gabapentin.

Artificial amino acids as building blocks: The unusual amino acids provide a key scaffold in modern medicinal chemistry, offering the ease of synthesis and propensity to functionalization of the amine and carboxyl unit, along with the chiral tether of a central core.11 Artificial amino acids may provide such modifications at any of several points: the amino acid side chain, backbone structure, or the addition of substituting groups at the 1-carbon position. The 1-quaternary amino acids described in this project represent a special subgroup

1.2.1. Pharmaceutical Applications

The unnatural amino acids are useful components in the synthesis of a broad variety of pharmaceuticals, with biological activity as free acids, as prosthetic groups of bioactivity, and as constituents of biological linear or cyclic peptides.[25] Unnatural amino acids can play three important roles in the design and synthesis of peptidomimetics (compounds that replicate the biological activity of peptides but possess better pharmacokinetic properties): as prosthetic groups in bioactive linear or cyclic peptides; as bacterial translation stops; and as synthesis tools.

Although instances of their capabilities of regulating receptors and modulating disease pathways have been observed, progress with regard to peptide development that are drug like presents a problem, and unnatural amino acids are often used as important tools in seeking to optimize physicochemical properties and improve target selectivity.[12] Incorporation of alpha quaternary amino acids in peptide sequences aid towards resistance to degradation by proteases, a driving factor in rejecting the use of natural peptides based-therapeutics.

The introduction of unnatural amino acids in protein engineering and drug discovery has a great value as it has become possible to create proteins with improved stabilities and activities.[23] This property is specifically useful in the development of mimetics and cyclic peptides with improvement in binding affinity and selectivity towards target proteins. For example, replacing natural amino acids with N-methylated amino acids such as N-Methylglycine (sarcosine), N-Methylalanine, in cyclic peptides has been shown to increase stability against proteolytic degradation, promote binding affinity to target proteins and increases selectivity, reducing off target interaction and side effects.

Fig 1.6 N-methylglycine

Fig 1.7 N-Methyl-L-alanine

The use of unnatural amino acids as building blocks to produce different pharmaceuticals has found application by many researchers as ways of developing artificial antimicrobial peptides with a particular structure and physicochemical properties.[26] It shows the current scope of application of artificial amino acids in solving modern problems relating to the pharmaceutical industry such as antibiotic resistance.

Artificial amino acids containing quaternary centers at the α-carbon position have emerged as particularly valuable pharmaceutical building blocks due to their enhanced stability and unique structural properties. These enantiopure quaternary amino acids, carrying two carbon-based substituents at the α-carbon, are of great commercial value in pharmaceutical development and serve as important tools for peptide secondary structure modification and stabilization.[37] The quaternary substitution pattern provides improved biopharmaceutical properties and proteolytic resistance, addressing a major limitation of natural peptide-based therapeutics.[38],[39]

1.2.2. Materials Science and Biotechnological Applications

Incorporation of unnatural amino acids into proteins can enable new physicochemical requirements and cell-specific activities, and there has been a lot of progress in the area of cell-free protein synthesis methods to enable precise and efficient incorporation of unnatural amino acids into proteins.[8] Post-synthetic modification of proteins has led to new capabilities in materials science-specific applications, notably the design of functional materials and biomaterials.

The characteristic structures displayed by α-quaternary amino acids enable artificers to use them as very good material building blocks aimed at developing materials with a given mechanical, thermal, and chemical properties.[40]. In the study of polymers, the addition of artificial amino acids to polymer backbones has the potential to dramatically shift material properties, such as raising glass transition temperatures to high temperature uses.

Fig 1.8 Tert-Leucine

Amino acid-based polymers have a high biocompatibility suitable in biomedical applications such as bioactive agents in drug delivery system, tissue engineering scaffolding, biodegradable implants, and devices. Managed degradation of these materials with either enzyme or hydrolytic degradation enables continuous or