Amino Acids

*Amino acid* - is a molecule that contains a carboxyl group and an amino group: serves as the monomer subunit of proteins.

All proteins are polymers, composed of monomers called amino acids. There are three parts that makeup an amino acid. Two of the three parts are the same in each amino acid. Each amino acid has a central carbon with a carboxyl group (-COOH) and an amino group (NH₂) attached at each end. The central carbon also has a radical group (*R*-group) attached to it, this leads to variation between amino acids.

![Amino Acid Structure](image)

**Figure 1, Every Amino Acid has a central carbon atom with a carboxyl group at one end and an amino group at the other end, as well as a hydrogen atom and an R group. pg. 39**

There are 20 different amino acids, 8 essential and 12 non-essential. An essential amino acid can only be obtained through your diet, while the other 12 can be synthesized by your cells.
Figure 2: The structures of 20 amino acids found in proteins. Pg. 40
Proteins

*Protein* - is a large molecule that consists of many amino acid subunits that are joined together by peptide bonds folded into a specific three-dimensional shape.

Proteins are the most diverse molecule in living systems, carrying out vital structural and functional roles.

There are thousands of different types of proteins, performing many vital tasks.

Other roles of proteins; hormones, which are chemical messengers, transport proteins, carry substances across biological membranes, recognition and receptor proteins, found on the surface of cell membranes, enzymes, which control the rate of biological reactions, and finally antibodies, which is your immune response to internal infections.

Table 1: Different Types of Proteins and their Function. pg. 41

<table>
<thead>
<tr>
<th>Type of Protein</th>
<th>Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>- framework support</td>
<td>- hair, tendons, and ligaments</td>
</tr>
<tr>
<td>Defensive</td>
<td>- infection fighters</td>
<td>- antibodies</td>
</tr>
<tr>
<td>Signal</td>
<td>- messenger</td>
<td>- hormones</td>
</tr>
<tr>
<td>Carrier</td>
<td>- transport of materials</td>
<td>- hemoglobin</td>
</tr>
<tr>
<td>Recognition and Receptor</td>
<td>- cellular markers</td>
<td>- major histocompatibility complex</td>
</tr>
<tr>
<td>Enzyme</td>
<td>- catalyst</td>
<td>- amylase</td>
</tr>
<tr>
<td>Motile</td>
<td>- movement</td>
<td>- actin and myosin</td>
</tr>
</tbody>
</table>
**Peptides**

*Peptide bond* - is a covalent bond that links amino acids.

*Peptide* - is a chain of amino acid subunits that are connected by peptide bonds.

*Polypeptide* - is a peptide with more than 50 amino acids.

Proteins are polymers, made up of monomers (amino acid subunits). The amino acids are bonded together by covalent bonds, by a dehydration reaction. The amino group (\(\text{NH}_2\)) of one amino acid \(N\text{-terminal}\) will form a bond with a carboxyl group (\(-\text{COOH}\)) of another amino acid, \(C\text{-terminal}\).

**Figure 4: Peptide bond forms between two amino acids in a growing chain through a dehydration synthesis reaction. pg 42**

![Diagram of peptide bond formation](image)
**Protein Structure**

There are four different levels of structure, each level is more complex than the other.

**Primary**

The primary structure is a linear sequence of amino acids. The number and sequence of amino acids determines the type and function of the protein molecule.

\[
20^2 = 400 \quad \text{different combinations} \\
20^3 = 8000 \quad \text{different combinations}
\]

**Secondary**

Protein coil and fold into patterns. At the secondary level, the chain folds upon itself because of hydrogen bonding. There are two types, the *beta – pleated sheet* and the *alpha – helix*.

**Tertiary**

At the third level, the protein takes on a three dimensional shape, created by the interaction of the R-groups. The intermolecular bonds that can form are; ionic bonds, hydrogen bonds, hydrophobic interactions and disulfide bridges.

**Quaternary**

At the fourth level, two or more polypeptides interact together.
This figure shows the types of bonds and bridges found in the quaternary structures.

Figure 5: a) primary, b) secondary, c) tertiary, and d) quaternary structure.

**Denaturation** - is the loss of both the structure and function of a protein.

Denaturing of proteins can be caused by changes in temperature and pH levels. The change in the structure of the protein will make it inactive. These changes can be permanent if bonds are broken or temporary if only a change in shape.

**Protein Prosthetic Groups**

Are non-protein components that interact with a protein making it functional.

E.g. hemoglobin and enzymes
Nucleic Acids

Nucleic acid is responsible for the synthesis of proteins. DNA, which stores the genetic information, is found in the nucleus and RNA, communicates to the ribosome to produce a specific protein, can be found in the nucleus and cytoplasm.

Nucleic acids can transport chemical potential energy. These molecules are Adenosine triphosphate (ATP) and guanosine triphosphate (GTP).

Nucleic acids can also be electron carriers, found in the electron transport chain. These molecules are Nicotinamide adenine di-nucleotide (NAD+) and Flavin adenine di-nucleotide (FAD).

Nucleotides

*Nucleotide* - is the building block of nucleic acids; consist of a 5-carbon sugar, a nitrogenous base, and one to three phosphate groups.

![Chemical structure of a nucleotide](image)

Figure 7: The chemical structure of a nucleotide. pg.45

Nucleic acids are polymers made up of nucleotides, monomer subunits. Nucleotides are grouped into Purines (double ringed structure) and pyrimidines (single ringed structure).

There are two Purines; adenine and guanine.

There are three pyrimidines; thymine, cytosine, and uracil.
There are four different subunits for the production of Deoxyribonucleic acid (DNA). These nucleotides are; adenine, thymine, cytosine, and guanine.

There are also four subunits for the production of Ribonucleic acid (RNA). These nucleotides are; adenine, cytosine, guanine, and uracil.

![Nucleotide base chemical structures](image)

**Figure 8: Nucleotide base chemical structures, pg. 45**

**DNA and RNA: Nucleotide Polymers**

DNA and RNA are polynucleotide chains, where a phosphate group is bonded to the 5-carbon of one sugar group and to the 3-carbon of another sugar group, creating a phosphodiester bond, holding two nucleotides together in a single strand.

*Phosphodiester bond* - is a link that is formed between nucleotides by a phosphate bridge.

DNA is a double stranded molecule, where each strand contains a backbone sequence (sugar and phosphate) and rungs (nitrogen bases). Each strand runs in the opposite direction from the other and is held together by hydrogen bonds between the nitrogen base pairs.

*Anti-parallel* - is oriented in the opposite directions.
Complementary base pairs occur between purines and pyrimidines.

Adenine can only form 2 hydrogen bonds, with its complementary base, thymine.

Guanine can only form 3 hydrogen bonds, with its complementary base, cytosine.

DNA is a double stranded molecule held together by hydrogen bonds. These hydrogen bonds lead to the helical twist of the DNA molecule, a double helix.

In an RNA molecule thymine is replaced with the nitrogen base, uracil. RNA is a single stranded molecule, shorter in length in comparison to the DNA molecule.