AMINO ACIDS AND PROTEINS

Organization

Amino acids
- Amino acids are the fundamental building blocks of peptides and proteins. Amino acids are bonded by peptide bonds to form organizational units based upon the number of amino acids and structural shape.

- Peptides
  - The peptides are molecules formed from amino acids that exist as: dipeptides (which contain two amino acids), tripeptides (which contain three amino acids, and polypeptides (which contain many amino acids).
- Proteins
  - Proteins are molecules formed from coils (alpha-helices) of chains of amino acids. In addition to amino acids, proteins may contain other groups (such as the heme group of hemoglobin).
- Peptides and proteins typically exist as molecules with complex structural organization. Hydrogen bonds and disulfide bonds form between peptide chains or different parts of a peptide chain, and are essential in provided the specific structure for the peptide or protein.

Amino Acids

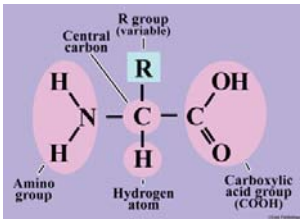

Fig 3B-1

- All amino acids have a central carbon that is covalently bonded at four sites to the following: (1) an amino group, NH2, (2) an organic acid group, COOH, (3) a single hydrogen atom (H), and (4) a side chain called the “R” group.

Amino Acids

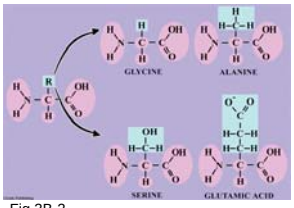

Fig 3B-2

- Different amino acids are formed by a replacement of the “R” group with a specific chain of atoms (or atom for the formation of glycine).
- Since amino acids are combined into proteins by bonding at the carboxyl and amino groups, and these sites are usually not available for chemical reactions, it is the “R” groups that determine the role of the amino acids in proteins.

Utilization of Amino Acids

Three utilizations of amino acids are:
(1) protein synthesis,
(2) synthesis of non-protein compounds, and
(3) a source of energy.

Protein Synthesis

- Amino acids are used in the manufacture of the body’s proteins by a cellular process called protein synthesis. Protein synthesis involves the processes of transcription and translation.
- Transcription
  - The first process, transcription, is the rewriting of the information of DNA (a gene) into a strand of messenger RNA (mRNA).
- Translation
  - In the cytoplasm, the process of translation converts in information of mRNA into peptides and proteins. Once produced the peptides and proteins function in various metabolic pathways.

Synthesis of Non-protein Compounds

- Amino acids are used in the manufacture of many non-protein compounds.
  - Among these are the neurotransmitters called epinephrine (adrenaline) and norepinephrine (noradrenaline), histamine, and the nitrogen-containing bases (purines and pyrimidines), which are components of the nucleotides of nucleic acids (RNA and DNA).
  - Some amino acids can also be used to produce carbohydrates (gluconeogenesis) and lipids (lipogenesis).

Amino acids as a Source of Energy

- Amino acids can be catabolized and used as a source of fuel. A low percentage of energy (about 10%) is normally derived from amino acid catabolism.

Dehydration Synthesis

- In protein synthesis smaller units (such as two amino acids, or an amino acid added to a chain of amino acids) are joined by a reaction called dehydration synthesis. Each time a protein dehydration synthesis reaction occurs, the result is a larger amino acid based molecule and a molecule of water.

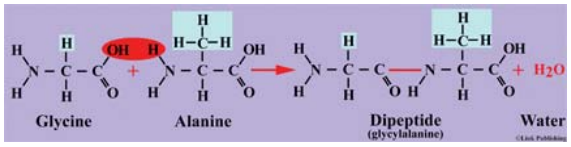

Fig 3B-4

Hydrolysis

- Large molecules such as proteins and peptides can be split into smaller units by hydrolysis (digestion). Hydrolysis of proteins splits peptide bonds and water molecules. Water molecules are split so that their components can complete the fragmented molecules (at the location of the prior peptide bonds).
- The hydrolysis (digestion) of proteins (called proteolyses) involves enzymes called proteases.

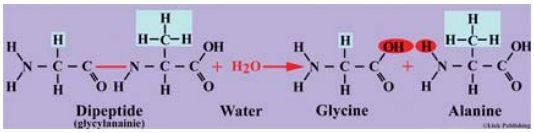

Fig 3B-6

PROTEIN STRUCTURE

Four organizational levels describe the structure of proteins.
In increasing complexity the levels are:

1-Primary level
2-Secondary level
3-Tertiary level
4-Quaternary level

Primary Level

- The primary level of organization is the **linear sequence** of amino acids in the peptide chain. As the amino acids are assembled into peptide chains interactions (especially hydrogen bonding and disulfide bonds) among the amino acid side chains produce a structural organization called secondary structure.

Fig 3B-8

Secondary Level

- The secondary level of organization is produced by interactions of amino acids
  - (1) between two or more peptides or
  - (2) different parts of a peptide.
- Amino acids with side-to-side interactions commonly form pleated sheets (beta, b pleated sheets), and those with interactions within the polypeptide chain form helices (alpha, a helices, which are turns in a right-handed direction).

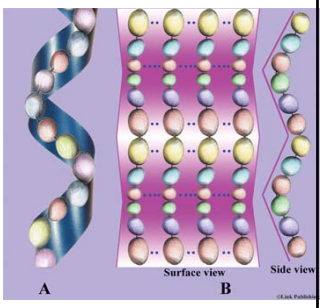

Fig 3B-9

- Secondary structure is frequently found in proteins that have structural functions such the protein collagen, which is commonly found in tendons, ligaments, and other dense connective tissues.

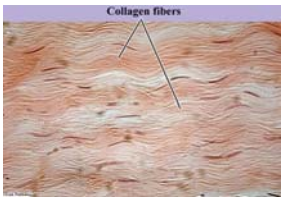

Fig 3B-10

Tertiary Level

The tertiary level of organization is produced by interactions among amino acids which fold the pleated sheet or helix into a three dimensional structure.

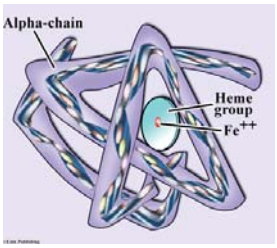

Fig 3B-11

Quaternary Level

- The quaternary level of organization is produced by interactions that bond two or more subunits (polypeptide chains) into complex proteins.

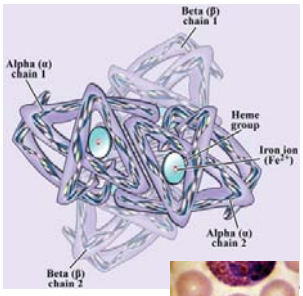

Fig 3B-12

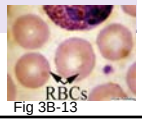

Fig 3B-13

PROTEIN DENATURATION

- The shape of the protein (or polypeptide chain) is a factor that is essential in its function. A protein (or polypeptide chain) is denatured when it is subjected to conditions which modify the interactions (such as hydrogen and disulfide bonds) among its amino acids resulting in a **structural modification that alters the ability of the protein to perform is normal functions**.
- Common factors that denature proteins are changes in temperature and changes pH (acidity or alkalinity)