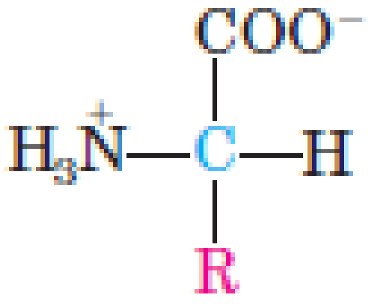
Macromolecules

Amino acids

The amino acids are the building blocks of proteins bound together by covalent bonds (peptide bonds and disulphide bonds).



General structure of an amino acid
R – group is the side chain

Proteins

Protein is the basic component of living cells and is made of carbon, hydrogen, oxygen, nitrogen and one or more chains of amino acids.

Proteins are the polymers of amino acids.

Peptide bond

- A peptide bond is a chemical bond formed between two molecules of amino acids where the carboxyl group of one amino acid molecule reacts with the amino group of the other amino acid molecule, releasing a molecule of water (H_2O) by condensation reaction.
- The resulting CO-NH bond is called a peptide bond, and the resulting molecule is an amide.
- The four-atom functional group -C(=O)NH- is called an amide group or (in the context of proteins) a peptide group.

4 levels of organization

- Primary structure: The linear sequence of amino acids forming the backbone of proteins (polypeptides).
- Secondary structure: The spatial arrangement of protein by twisting of the polypeptide chain.
- Tertiary structure: The three dimensional structure of a functional protein.
- Quaternary structure: Some of the proteins are composed of two or more polypeptide chains referred to as subunits.

Serum Protein

- Serum proteins are also known as blood or plasma proteins.
- They are the proteins present in blood that serve many different functions, including transport of lipids, hormones, vitamins, and minerals in the circulatory system.
- They also help in the regulation of acellular activity and functioning of the immune system.
- Other blood proteins act as enzymes, complement components, protease inhibitors, or kinin precursors.
- These include serum albumin, globulins, and fibrinogen.
- Most blood proteins are secreted by the liver and intestines except for the gamma globulins, which are synthesized by the immune system.

Major proteins in serum

- Blood serum contains two major protein groups: albumin and globulin.
- Both albumin and globulin carry substances through the bloodstream.
- Using protein electrophoresis, these two groups can be separated into five smaller groups (fractions):
    1. Albumin
    2. Alpha-1 globulin
    3. Alpha-2 globulin
    4. Beta globulin
    5. Gamma globulin

Gel electrophoresis of proteins

- Gel electrophoresis is a method for separation and analysis of macromolecules and their fragments, based on their size and charge.
- Protein electrophoresis is a method for analysing the proteins in a fluid or an extract.

Nucleic acids

- Nucleic acids are naturally occurring chemical compounds that serve as the primary information-carrying molecules in cells.
- They play an especially important role in directing protein synthesis and as repositories.
- The two main classes of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- Nucleic acids are the polymers of nucleotides (polynucleotides) held by 3’ and 5’ phosphate bridges.
- Nucleotides are composed of a nitrogenous base, a pentose sugar and a phosphate.

STRUCTURE OF NUCLEOTIDES

Nucleotide = nucleobase + sugar + phosphate.

Nucleoside = base + sugar.

Nucleotide = nucleoside + phosphate.

Nitrogenous bases

- Nitrogenous bases in nucleotides (nucleic acids) are aromatic heterocyclic compounds.
- The bases are of two types:
  - purines
  - pyrimidines

Phosphodiester bonds

- Individual nucleoside triphosphates combine with each other by covalent bonds known as 5′-3′ phosphodiester bonds.
- The phosphate group attaches to the 5′ carbon of the sugar of one nucleotide bonds to the hydroxyl group of the 3′ carbon of the sugar of the next nucleotide.
- Phosphodiester bonding between nucleotides forms the sugar-phosphate backbone.
- The resulting strand of nucleic acid has a free phosphate group at the 5′ carbon end and a free hydroxyl group at the 3′ carbon end.

STRUCTURE OF DNA

- Watson and Crick proposed that DNA is made up of two strands that are twisted around each other to form a right-handed helix.
- The two DNA strands are antiparallel, such that the 3′ end of one strand faces the 5′ end of the other.
- The 3′ end of each strand has a free hydroxyl group, while the 5′ end of each strand has a free phosphate group.
- The sugar and phosphate of the polymerized nucleotides form the backbone of the structure.

STRUCTURE OF RNA

- RNA is a polymer of ribonucleotides held together by 3’, 5’-phosphodiester bridges.
- Although RNA has certain similarities with DNA structure, they have specific differences.

RNA vs DNA

1. Pentose : The sugar in RNA is ribose in contrast to deoxyribose in DNA.
2. Pyrimidine : RNA contains the pyrimidine uracil in place of thymine (in DNA).
3. Single strand : RNA is usually a single stranded polynucleotide. However, this strand may fold at certain places to give a double stranded structure.
4. Chargaff’s rule is not obeyed (guanine content is not equal to cytosine).
5. Susceptibility to alkali hydrolysis.
6. Orcinol colour reaction is only for RNA (orcinol colour reaction due to the presence of ribose).

Carbohydrates

- Carbohydrates are the most abundant organic molecules in nature.
- They are primarily composed of the elements carbon, hydrogen and oxygen.
- The name carbohydrate literally means ‘hydrates of carbon’.
- Carbohydrates are often referred to as saccharides (Greek: sakcharon–sugar).

Polysaccharides

- Polysaccharides (Greek: poly-many) are polymers of monosaccharide units with high molecular weight (up to a million).
- Polysaccharides (or simply glycans) consist of repeat units of monosaccharides or their derivatives, held together by glycosidic bonds.
- They are usually tasteless (non-sugars) and form colloids with water.
- Polysaccharides are linear as well as branched polymers.
- They are primarily concerned with two important functions-structural, and storage of energy.

Heparin

- Heparin is a naturally occurring anticoagulant that prevents the formation and extension of blood clots (Heparin does not break down clots that have already formed).
- Heparin is used to treat and prevent blood clots in the veins, arteries, or lung.
- Heparin is also used before surgery to reduce the risk of blood clots.

Forms of heparin

- Two forms of heparin are used clinically:
  - unfractionated heparin (UF) - with an average molecular weight of 15,000 (range 15 to 100 monosaccaharides)
  - low molecular weight heparin (LMWH) - with molecular weights between 4,000 to 6,500 (range 4 to 40 monosaccaharides)
- The reduction in molecular weight causes a marked change in the heparin activity.
- LMW heparin acts primarily on FXa, whereas UF heparin is an efficient catalyst for inhibition of both thrombin and factor Xa.

Blood group substances

- The oligosaccharide moieties of glycoproteins that appear in many biological fluids (saliva, urine, milk) as well as on the surface of erythrocytes.
- Blood types are determined by the presence or absence of certain **antigens** – substances that can trigger an immune response if they are foreign to the body.
- These antigens, upon reaction with specific antibodies, cause agglutination of the cells to which they are attached.
  - Examples are the A, B and O antigens.