

MICROBIAL PHYSIOLOGY AND BIOCHEMISTRY

Structures and Functions of Biomolecules

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Keywords

Carbohydrates; Isomerism; Monosaccharide; Disaccharide; Polysaccharide; Lipids; Fatty acid; Proteins; Amino acid; Nucleic acid; Nucleotide; DNA; RNA

Structure and function of biomolecules is most fundamental aspect of study of living organisms. There are four major biomolecules namely, carbohydrates, lipids, proteins, nucleic acids which encompasses the life.

Structure and functions of Carbohydrates

Carbohydrates are defined as polyhydroxy aldehyde or ketone with empirical formula $(CH_2O)_n$, simplest being glyceraldehydes (Aldose) or dihydroxy acetone (Ketone).

Based on number of monomeric units, these are classified monosaccharides, disaccharides, oligosaccharides and polysaccharides.

Based on the number of carbon atom, the carbohydrates are classified as triose, tetrose, pentose, hexose and heptose. Fig.1 shows some of the major carbohydrates.

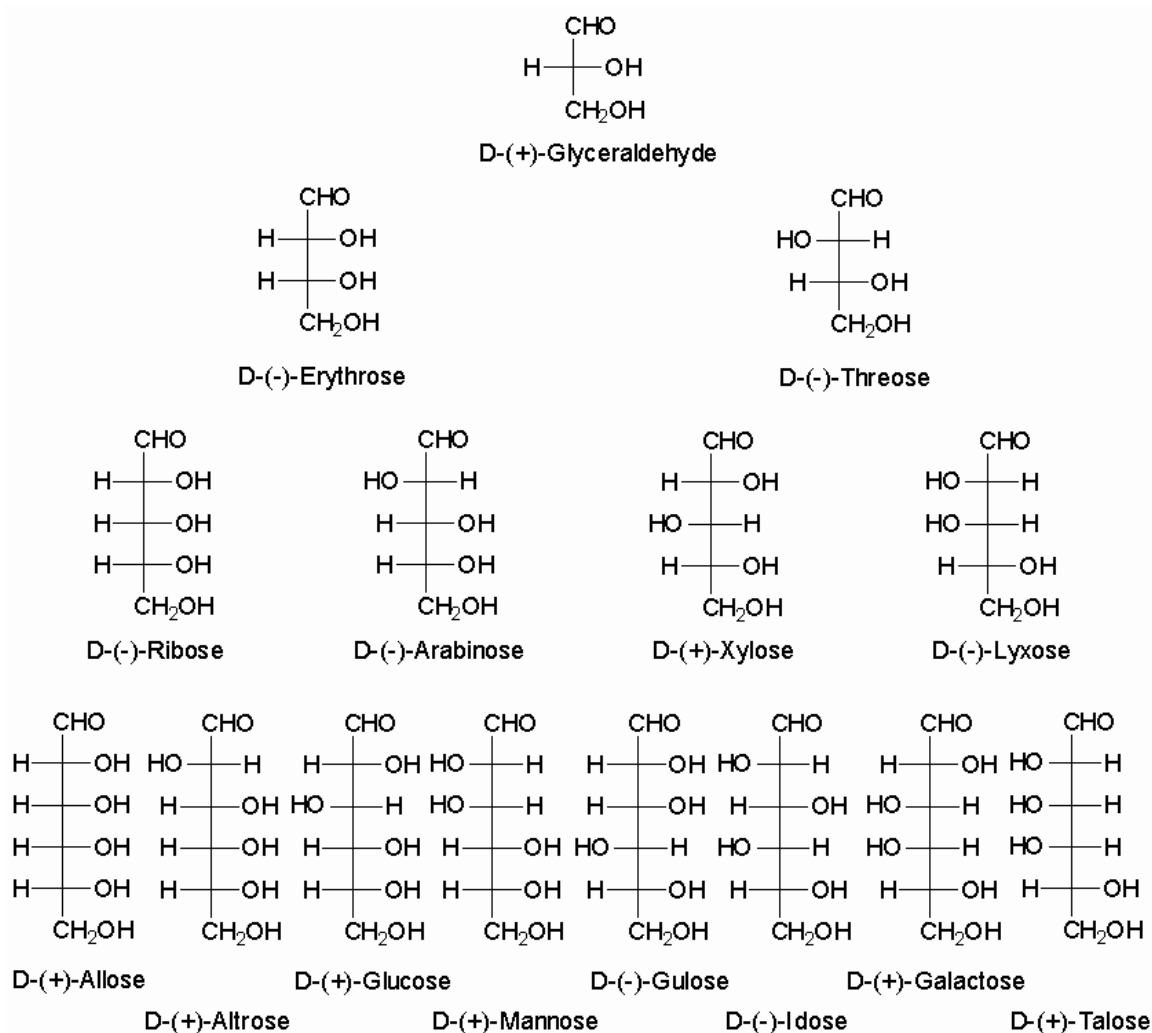


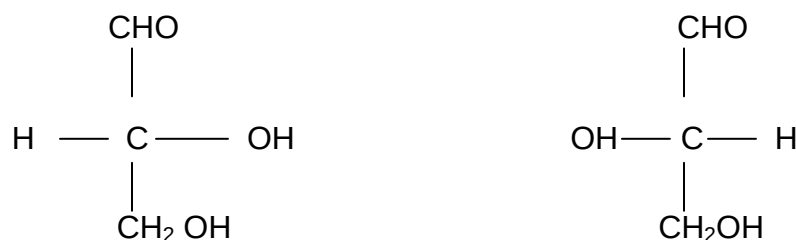
Fig.1: Some of the major carbohydrates

Isomerism

Study of carbohydrates necessitates the concept of isomerism.

- Two broad categories for isomeric forms are
 - (i) Structural isomers
 - (ii) Stereo isomers
- The structural isomers are defined as isomers having same molecule formula but different structures.
- The stereo isomers whereas have same molecular and structural formula but differ in configuration i.e. arrangement of atoms in space.
- Stereo isomers are further sub grouped into optical isomers and geometrical isomers.
- Optical isomerism is more relevant for carbohydrates.

Optical isomerism stems from the presence of chiral centre (asymmetric carbon atom). Chiral center means the carbon atom having four different groups attached to it. This leads to two possibilities by which atoms can be arranged as shown in figure below:



In case of carbohydrates, the simplest compound D-glyceraldehyde is used as reference compound. D- represents the hydroxyl group on right hand side whereas L- has it on the left hand side. These two forms reflect mirror image of each others and called Enantiomers. The stereoisomers which are not enantiomers are termed as distereoisomers.

Van't Hoff formula 2^n works out the numbers of possible optical isomers, where n is the number of chiral carbon. Thus a triose will have 2^1 two optical isomers. In the example of D-glucose, D- Mannose and D- galactose are optical isomers, but these are not enantiomers of each others. These will be called distereoisomers.

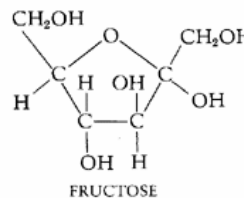
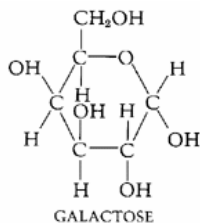
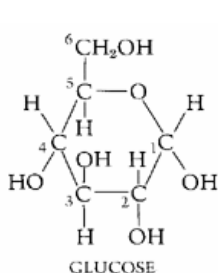
D- glucose and D- Mannose have different configuration only at C-2 carbon. Such carbohydrates which differ in configuration only at one carbon atom are called epimers of each other.

Enantiomers have same Melting point, boiling point, solubility in various solvents except they rotate plane polarized light in opposite direction, one will rotate in clock wise direction called dextrorotatory (represented by +) and other in anti clock wise direction called levorotatory (represented by -).

Structure and functions of major carbohydrates can be summarized as following:

Monosaccharides

- **Glucose**, "blood sugar", the immediate source of energy for cellular respiration
- **Galactose**, a sugar in milk (and yogurt), and
- **Fructose**, a sugar found in honey.



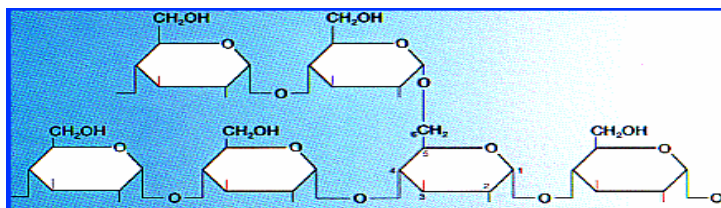
Two monosaccharides are linked by glycosidic bond in α or β anomeric carbon

- **Sucrose** — common table sugar = glucose + fructose linked by α - 1-1 glycosidic bonds
- **Lactose** — major sugar in milk = glucose + galactose linked by β - 1-4 glycosidic bonds
- **Maltose** — product of starch digestion = glucose + glucose linked by α - 1-4 glycosidic bonds

Polysaccharides

- **Starches**

Starches are polymers of glucose. These are predominant storage sugar in plants. Two types of linkage are found in starch:



amylose consists of linear, unbranched chains of several hundred glucose residues (units). The glucose residues are linked by a α - 1-4 glycosidic bond between their C1 and C4 carbon atoms.

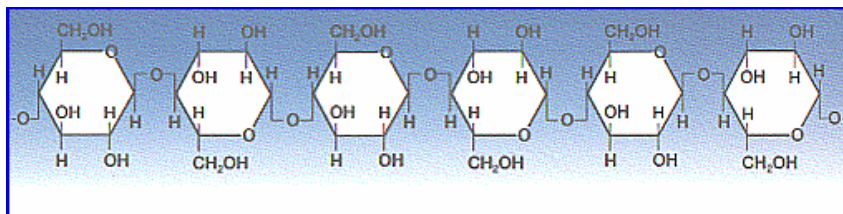
amylopectin differs from amylose in being highly branched. At approximately every thirtieth residue along the chain, a short side chain is attached by a α - 1-6 glycosidic bond to the C 6 carbon atom (the carbon above the ring). The total number of glucose residues in a molecule of amylopectin is several thousand.

Glycogen

Animal's storage sugar is polysaccharide **glycogen**. The structure of glycogen is similar to that of starch, although the branches in glycogen are shorter and more frequent.

Cellulose

Cellulose is probably the single most abundant organic molecule in the biosphere. It is the major structural material of cell wall of the plants. Like starch, cellulose is a polysaccharide with glucose as its monomer which are linked β -1-4 glycosidic bonds in a linear chain.



Functions

Carbohydrates provide the bulk of the calories (4 kcal/g) in most diets, and starches provide the bulk of that. The image shows starch grains (lightly stained with iodine) in the cells of the white potato. Rice, wheat, and corn are also major sources of starch in the human diet. Cellulose is the major constituent of cell wall. Wood, cotton and paper are forms of cellulose. Carbohydrate also forms the part of some glycoproteins. The precise functions of this class of biomolecules in the cells are innumerable.

Structure and functions of Lipids

Lipids are one among four major biomolecules of living systems. By definition these are insoluble or sparingly soluble in aqueous solutions and soluble in organic solvents.

Fatty acids are major constituents of lipids. Fatty acids are mono carboxylic acid containing long-chain hydrocarbon molecules. Some important fatty acids are enlisted in Table 1.

The numbering of carbons in fatty acids begins with the carbon of the carboxylate group. e.g, palmitic acid a 16-carbon fatty acid $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$ is designated as 16:0

Table 1: Some important fatty acids

Representation	Common Name	Structure
4:0	Butyric acid	$\text{CH}_3(\text{CH}_2)_2\text{COOH}$
6:0	Caproic acid	$\text{CH}_3(\text{CH}_2)_4\text{COOH}$
10:0	Decanoic acid	$\text{CH}_3(\text{CH}_2)_8\text{COOH}$
12:0	Lauric acid	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$
14:0	Myristic acid	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$
16:0	Palmitic acid	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
18:0	Stearic acid	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
20:0	Arachidic acid	$\text{CH}_3(\text{CH}_2)_{18}\text{COOH}$

All sets of examples in the above table are fatty acids that contain no carbon-carbon double bonds. These are called saturated fatty acids.

Unsaturated fatty acids are those having carbon-carbon double bonds in between. The numeric representations for these fatty acids consists the number of carbon atoms, followed by the number of sites of unsaturation. The site of unsaturation in a fatty acid is indicated by the symbol (Δ) and the number of the first carbon of the double bond (e.g. oleic acid is a 16-carbon fatty acid with one site of unsaturation between carbons 9 and 10, and is represented by 16:1 Δ^9). Some commonly occurring unsaturated fatty acids are:

18:1 Δ^9	Oleic acid	$\text{CH}_3(\text{CH}_2)_7\text{C}=\text{C}(\text{CH}_2)_7\text{COOH}$
18:2 $\Delta^{9,12}$	Linoleic acid	$\text{CH}_3(\text{CH}_2)_4\text{C}=\text{CCH}_2\text{C}=\text{C}(\text{CH}_2)_7\text{COOH}$
18:3 $\Delta^{9,12,15}$	Linolenic acid	$\text{CH}_3\text{CH}_2\text{C}=\text{CCH}_2\text{C}=\text{CCH}_2\text{C}=\text{C}(\text{CH}_2)_7\text{COOH}$
20:4 $\Delta^{5,8,11,14}$	Arachidonic acid	$\text{CH}_3(\text{CH}_2)_3(\text{CH}_2\text{C}=\text{C})_4(\text{CH}_2)_3\text{COOH}$

Saturated fatty acids having short carbon chain are liquid at room temperature, whereas long carbon chain fatty acids are solid. The presence of double bonds in fatty acids significantly lowers the melting point making them liquid.

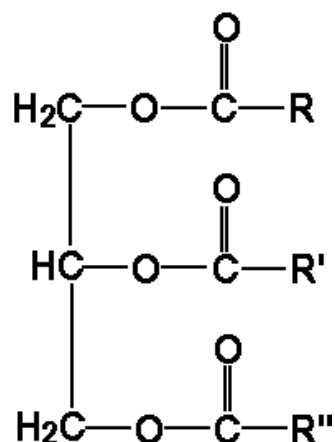
Classification of lipids

Lipids are generally classified into seven groups viz.

1. Acyl glycerols
2. Phospholipids
3. Sphingolipids
4. Glycolipids
5. Alkyl glyceryl ethers
6. Terpenoids
7. Wax

Acyl glycerols

Also called Triacylglycerides or neutral lipids, these are composed of a glycerol backbone, in which each alcoholic group is esterified by fatty acids. Following is the typical triglyceride structure in which fatty acids are indicated by R.



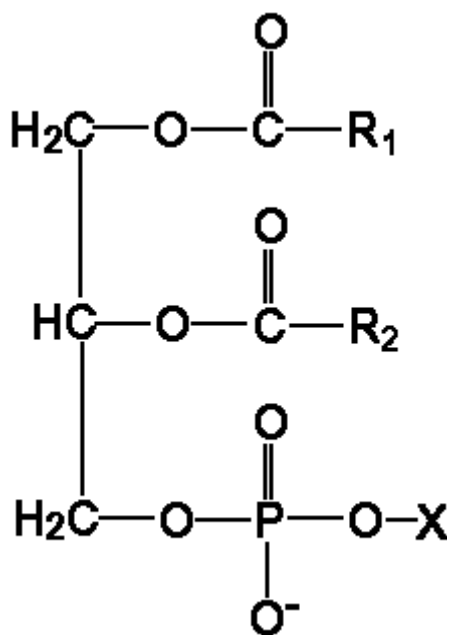
These are most commonly occurring form of lipids in cell, stored in adipose or fat depot, serve as major energy source.

Phospholipids

The basic structure of phospholipids is very similar to that of the triacylglycerides except that Carbon -3 (*sn*3, *carbon numbers in lipids are conventionally termed as sn*) of the glycerol backbone is esterified by phosphoric acid. This basic block of the phospholipids is called phosphatidic acid.

Several different types of phsopholipids are formed by further attachment of different groups at Phosphatidic acid C-3 phosphoric acid.

- Ethanolamine (phosphatidylethanolamine), Choline (phosphatidylcholine, also called lecithins),
- Serine (phosphatidylserine),
- Glycerol (phosphatidylglycerol),
- *myo*-inositol (phosphatidylinositol and diphosphatidylglycerol more commonly known as cardiolipins).

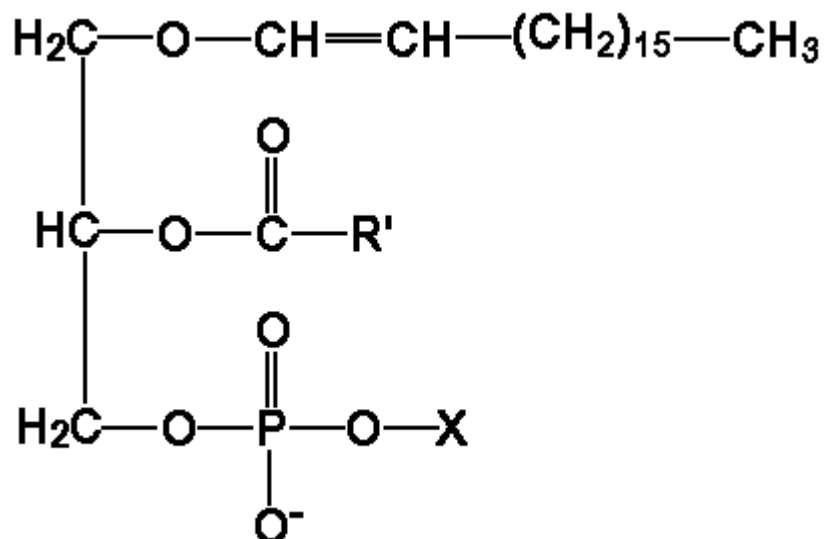


X -represent substituent group

Phospholipids are amphipathic in nature due to presence of both hydrophilic (charged substitution at C-3) and hydrophobic (fatty acid chains at C1 and 2. This property makes them essential components of membrane.

Glycerol ethers

Also called plasmalogens, these contain either an *O*-alkyl (-O-CH₂-) or *O*-alkenyl ether (-O-CH=CH-) species at C-1 (*sn*1) of glycerol. A basic *O*-alkenyl ether species is shown in the Figure below:

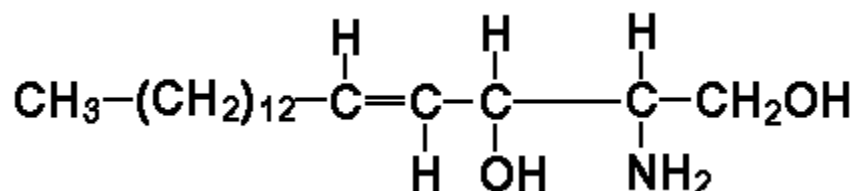


Basic structure of typical plasmalogens

One of the physiologically important alkyl ether plasmalogens is platelet activating factor (PAF) which is a choline plasmalogen in which the C-2 (*sn*2) position of glycerol is esterified with an acetyl group instead of a long chain fatty acid. PAF mediates hypersensitivity and acute inflammatory reactions.

Sphingolipids

Sphingolipids are composed of a backbone of sphingosine, which is derived from glycerol. The structure of sphingosine is shown below:



Sphingolipids are predominately present in the myelin sheath of nerve fibers. Some of the important sphingolipids are:

- **Ceramides** – In this case the sphingosine is N-acetylated at CH₂OH by a variety of fatty acids generating different types of **ceramides**.

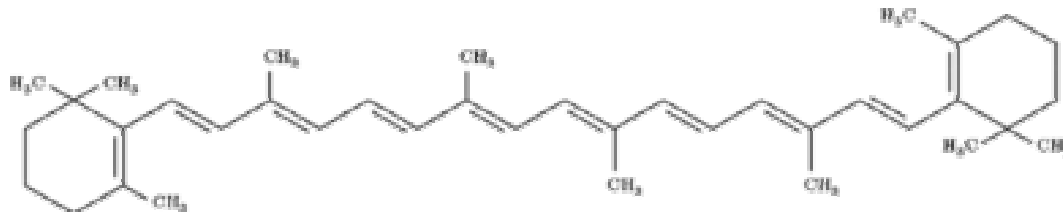
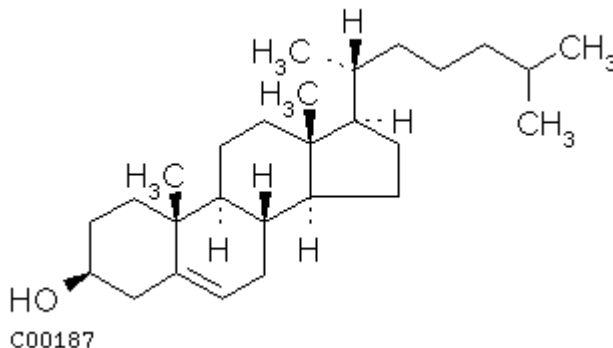
- **Sphingomyelin** is an abundant sphingolipid in which CH_2OH is esterified by phosphoric acid and choline instead of fatty acid.
- **Glycosphingolipids** other major class of sphingolipids are generated by substitution of carbohydrates at CH_2OH . Cerebrosides and Gangliosides are major classes of glycosphingolipids:
 - o **Cerebrosides:** also called galactocerebrosides because galactose is the carbohydrate
 - o **Gangliosides:** it also contains sialic acid.

Glycolipids

They are carbohydrate containing derivative of triglycerides. Galactose is predominant carbohydrate present in glycolipids. 3-*sn* monogalactosyl galactosyl diacyl glycerol and 3-*sn* digalactosyl diacyl glycerol are commonly present in membrane structures especially in the chloroplast membrane.

Terpenoids and Sterols

These are very distinct group of lipids composed of the monomer repeating units called “isoprenoid units”. Steroids, carotenoids, rubber and terpenes fall in this class of lipids. Structure of β -carotene and cholesterol, few among important compound of this class are shown below.



Waxes

Waxes are class of lipids found as protective coating on fruits and leaves or secreted by insects. Chemically these are complex mixture of long chain alkanes and derivatives of secondary alcohol and ketones.

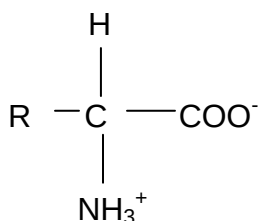
Major functions of lipids

Lipids perform and are involved in variety of important cellular functions. However, following are some of the major physiological functions attributed to lipids:

1. Energy source in animals, insects, birds and high lipid seeds e.g. triacyl glycerols.
2. Some of the lipids derivatives serve as vitamins and hormones e.g. Prostaglandins.
3. Essential components of biological membranes e.g. shingolipids and glycoloipids.
4. As lipo-proteins in protein modification and recognitions.

Structure and Functions of Proteins

Proteins, one of the most important class of biomolecules, which are responsible for wide array of cellular activities. Proteins are constituted by **amino acid** as monomeric unit or building blocks. A typical amino acid has the amino, carboxyl moieties and "R" group (also called as side chain).

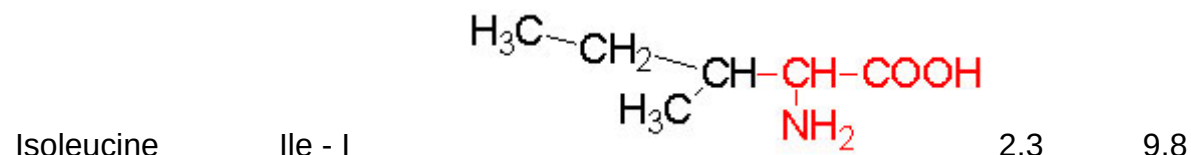
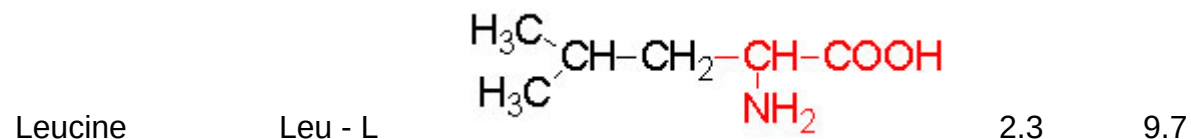
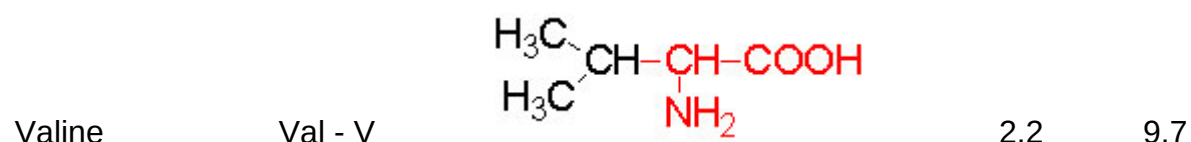


The nature of R-group varies from amino acid to amino acid. There are a total of 20 amino acids which make up proteins. At physiological pH, amino acids exist in zwitterion form. Zwitterions can be defined as the molecule carrying equal and opposite charge, thus having no net charge.

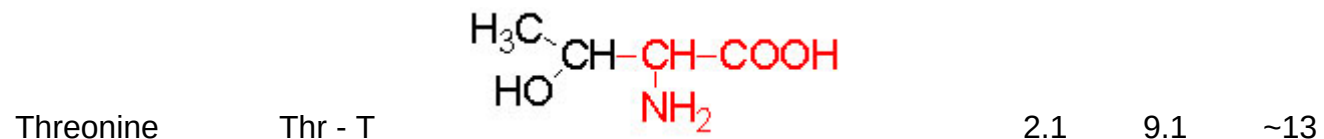
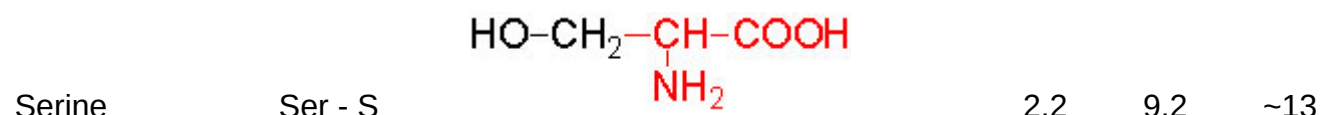
Each functional group of amino acid has a fixed pKa value enlisted in Table 2. Thus, the ionization state of amino acids will be pH dependent.

Table 2: Functional groups and pKa values of different amino acids

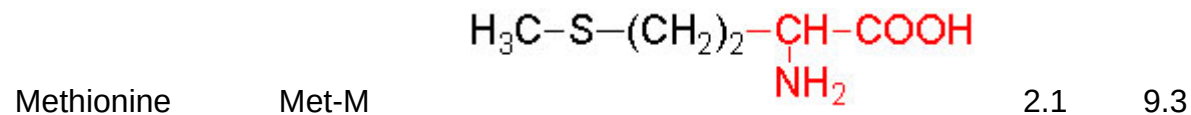
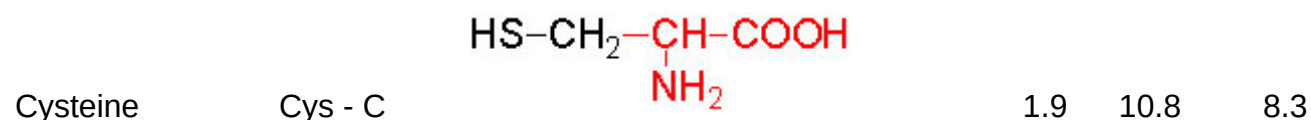
Amino Acid	Symbol	Structure	*pK ₁ (COOH)	pK ₂ (NH ₂)	pK R Group
Amino Acids with Aliphatic R-Groups					
Glycine	Gly - G	$\text{H}-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	2.4	9.8	
Alanine	Ala - A	$\text{CH}_3-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	2.4	9.9	



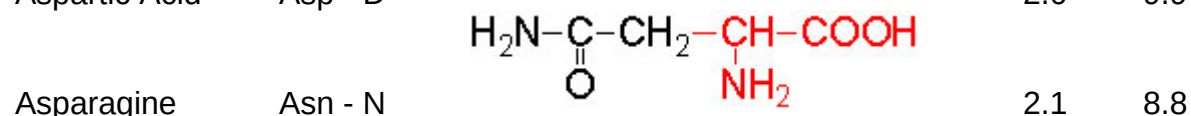
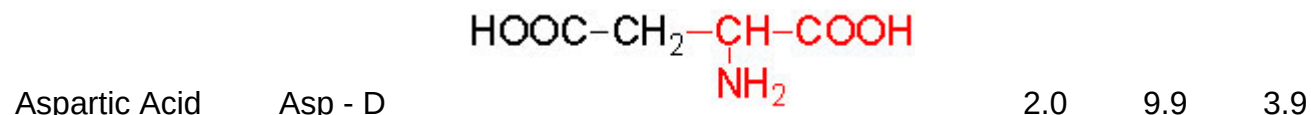
Non-Aromatic Amino Acids with Hydroxyl R-Groups



Amino Acids with Sulfur-Containing R-Groups



Acidic Amino Acids and their Amides

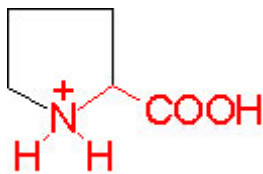


Glutamic Acid	Glu - E	$\text{HOOC}-\text{CH}_2-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	2.1	9.5	4.1
Glutamine	Gln - Q	$\text{H}_2\text{N}-\underset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{CH}_2-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	2.2	9.1	
Basic Amino Acids					
Arginine	Arg - R	$\text{HN}-\underset{\text{NH}_2}{\underset{\text{C}=\text{NH}}{\mid}}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	1.8	9.0	
Lysine	Lys - K	$\text{H}_2\text{N}-(\text{CH}_2)_4-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	2.2	9.2	10.8
Histidine	His - H	$\text{HN}-\text{C}_5\text{H}_4\text{N}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	1.8	9.2	6.0
Amino Acids with Aromatic Rings					
Phenylalanine	Phe - F	$\text{C}_6\text{H}_5-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	2.2	9.2	
Tyrosine	Tyr - Y	$\text{HO}-\text{C}_6\text{H}_4-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	2.2	9.1	10.1
Tryptophan	Trp-W	$\text{C}_8\text{H}_6\text{N}-\text{CH}_2-\underset{\text{NH}_2}{\text{CH}}-\text{COOH}$	2.4	9.4	

Imino Acids

Proline

Pro - P



2.0

10.6

* All amino acids except glycine (R = H) are chiral. Every Amino acid in biological system exists in the L-configuration, where "L" implies that the amino acid confirmation similar to L-glyceraldehyde.

Each amino acid has a standard three letter and one letter abbreviations which are used instead of full name. The properties of each amino acid are dictated by the side chain, which can vary in size, shape, charge, reactivity and ability to hydrogen bond. The amino acids are grouped according to the properties of their side chains:

1. Amino acids with non-polar or hydrophobic R group- aliphatic

The first six amino acids, glycine (GLY, G), alanine (ALA, A), Methionine (Met, M), valine (VAL, V) leucine (LEU, L), and isoleucine (ILE, I), proline (PRO) and are aliphatic in nature. Glycine is smallest. Glycine and alanine are too small to have a hydrophobic effect. Methionine is sulphur containing amino acid. Valine, leucine and isoleucine are considerably hydrophobic.

Aromatic: Phenylalanine (PHE, F), tryptophan (TRP, Y) and tyrosine (TYR, W) are aromatic in nature. These contain aromatic side chain. They are specifically absorb at 280 nm thus form the basis of quantitative estimation of protein by ultra violet (UV) method.

2. Amino acids with polar but uncharged R group

The amino acids are sulfur containing, namely cysteine (CYS, C), two hydroxyl-containing amino acids, serine (SER, S) threonine (THR, T) and amide containing Asparagine (ASN, N) and glutamine (GLN, Q). One typical imino acid, Proline (PRO, P) is also found in this category. Because of its cyclic structure, it leads to bending of protein chain. Proline is an imine and usual in that its nitrogen atom present as secondary. Cysteine is involved in inter molecular disulfide bond (called cystine) with other cysteine of the polypeptide chain. These disulfide bonds are the only covalent bond beside peptide bond in the protein and impart stability to the protein. Ser and Thr have side chains which can hydrogen bond to water or to other groups on neighbouring macromolecules. Asn and Gln are amide of acidic amino acids- aspartic and glutamic acid

3. Polar positively charged amino acids

The amino acids lysine (LYS, K), arginine (ARG, R) and histidine (HIS, H) are considered basic hydrophilic, since they contain basic side chain groups that will have a positive charge at pH 7.4.

4. Polar negatively charged amino acids

The amino acids aspartic acid (ASP, D) and glutamic acid (GLU, E) are considered acidic hydrophilic, since they contain acidic side chain groups that will have a negative charge at pH 7.4.

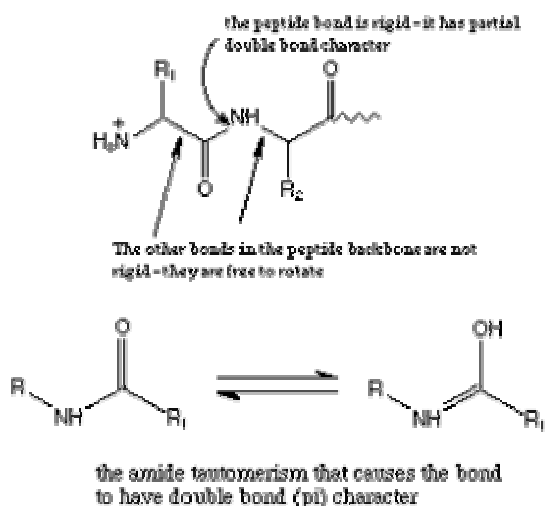
Peptide bonds

Protein chains are held together by peptide bonds, which are simply amide linkages between alpha amino and carboxylic group of neighbouring amino acids. When amino acids are linked, through peptide bonds, the species is called a polypeptide. Their molecular weights are expressed in Daltons, (1 Dalton is equal to 1 atomic mass unit).



Each peptide chain has two free ends, the amino terminus or N-terminal, which is on the left, and the carboxyl terminus or C-terminal, which is on the right. The peptide chains is represented from N-terminal to C-terminal and the sequence of amino acid is written in three letter abbreviations e.g. Met-Ser-Tyr- Cys- Val- Lys-Ala.

The peptide bond itself is rigid, and thus is not free to rotate. This rigidity leads to only a definite possible conformation to protein structure.



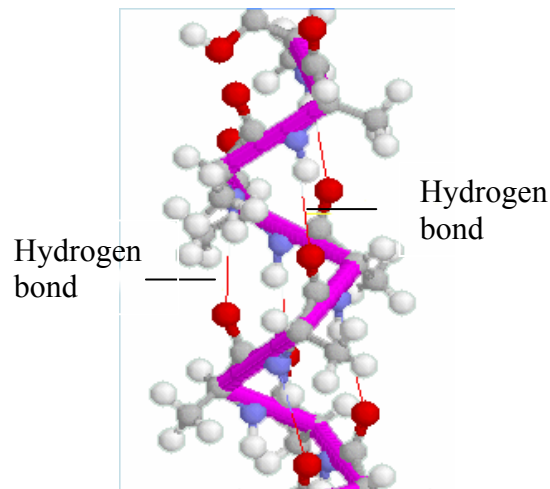
Structure of Proteins

Proteins have a total of four levels of structures:

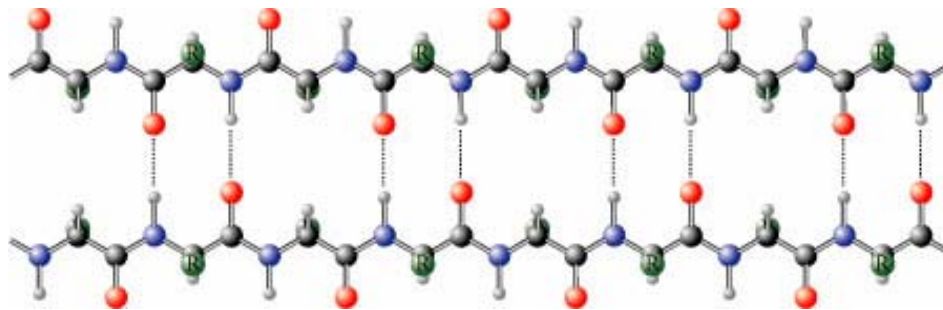
Primary structure - the simple amino acid sequence of a protein is called as its primary structure. Since the possible way of arrangement of the chain will depend on the sequence of amino acid residues leading to proper protein folding, the primary structure dictate three dimensional structure,

Secondary structure – defines the interaction of closely located amino acids in a chain. Two main types of secondary structures observed in the proteins are helices and pleated sheets.

- **Alpha helix** is a helical structure around an axis. This is coiled in clockwise (right handed) manner. It has an average of 3.6 amino acids per turn. The helix is stabilized by hydrogen bonding between the carbonyl of each first amino acid of the chain to the NH of the amino acid four residues away. All main chain amino and carboxyl groups are thus hydrogen bonded, and the R groups stick out from the structure in a spiral arrangement.



- **Beta pleated sheet** is composed of two or more straight chains that are hydrogen bonded side by side. If the amino termini are on the same end of each chain, the sheet is termed **parallel**, and if the chains run in the opposite direction (amino terminal on opposite ends), the sheet is termed **antiparallel**. Pleated sheets may be formed from a single chain if it contains a **beta turn**, which forms a hairpin loop structure. Often a proline can be found in a beta turn, since it places a "kink" in the chain.



Tertiary structure - refers to the arrangement of amino acids in the space i.e. in three dimensional form. Distinct amino acid are brought closer in chain are further linked by polar-polar interaction, hydrophobic interaction, ionic interaction, disulfide, Van der Waals forces and hydrogen bonds. Hydrophobic amino acids, are buried inside the core of protein and charged

and polar group are located on the surface. which tend to cluster and exclude water. This allows a protein to have greater water solubility.

If protein consists of more than one polypeptide chains, their association with each other – implies the Quaternary structure. Accordingly protein are termed as dimeric (wherein one chain is referred as monomeric unit), trimeric or oligomeric. If the chains are similar i.e. have same amino acid sequence these are called homomeric or heteromeric if chains are different.

Functions of proteins

As far as functions are concerned proteins carry out most diverse and possibly the largest volumes of cellular functions. Some of the key functions are summarized as below:

- Biocatalysis- Almost all the biological reactions are catalyzed by the enzymes. These are substrate specific and carry out reactions at very high rates under mild physiological conditions. Several thousand enzymes have been identified to date.
- Membrane are constitute of lipoprotein and some proteins are integral part of membrane. Receptors found on the membrane are also protein in nature.
- Transport and storage proteins - small molecules are often carried by proteins in the physiological setting e.g. haemoglobin is responsible for the transport of oxygen to tissues
- Muscle are made up of proteins and their contraction is done by actin and myosin.
- Mechanical support - skin and bone are strengthened by the protein collagen.
- Antibodies of immune system are protein structures.
- Many of the hormones and growth factors such as insulin or thyroid stimulating hormone are proteins.

Structure and Functions of Nucleic Acids

Nucleic acid are most important biomolecules of the cells forming very basis of central dogma of life. Nucleotides are their monomeric unit or building blocks.

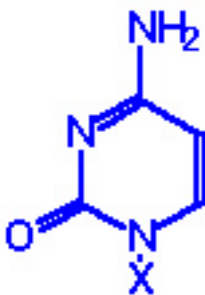
Nucleotides

Nucleotides are composed of three components namely: nitrogenous bases, sugar and phosphoric acid.

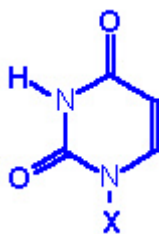
Nitrogenous bases: Purines and Pyrimidines are two types of bases which occur in nucleotides.

There are five major bases found in cells. The derivatives of purine are called adenine and guanine, and the derivatives of pyrimidine are called thymine, cytosine and uracil. The common

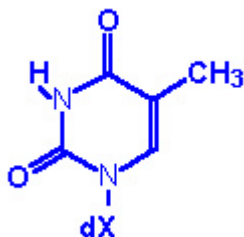
abbreviations used for these five bases are, **A, G, T, C** and **U**. DNA contains A, G, C and T, whereas RNA contains A, G, C and U bases. Their structures are as following:



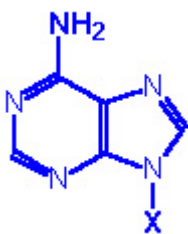
Cytosine, C



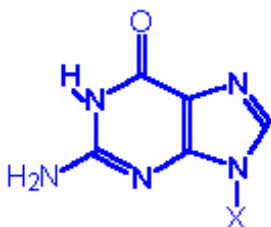
Uracil, U



Thymine, T



Adenine, A



Guanine, G

Sugar: Ribose and 2-deoxy ribose are the sugars found in RNA and DNA respectively. Sugar is attached to the position 'X' as shown above in case of each base. Base + sugar is called nucleoside.

Phosphoric acid: get attached to C-5 OH group of the sugar.

Polynucleotides

Polynucleotides are formed by joining of nucleotides by phosphodiester linkages. The bond formation takes place between the alcohol of a 5'-phosphate of one nucleotide and the 3'-hydroxyl of the next, resulting into a **phosphodiester bond**. In DNA and RNA the nucleotides are arranged in linear way and proceeds in the 5' ----> 3' direction. A common representation of polynucleotide for example can be seen as below:



Structure of DNA

Based on the assumptions of Chargoff and Utilizing X-ray diffraction data, obtained from crystals of DNA, James Watson and Francis Crick proposed a model for the structure of DNA in 1953. The discovery of DNA structure is one of the hall mark of the modern molecular biology. They established that DNA has a double helical structure comprising of two complementary antiparallel polynucleotide strands, wound around each other in a rightward direction. They proposed that the bases are in the interior of the helix and extended at 90 degree perpendicular to the axis of the helix. Purine Bases form base pairs and as a thumb rule- A will pair with T, and C with G. According to this pattern, known as Watson-Crick base-pairing. The bases form hydrogen bonds with each other and impart stability to the structure. The base-pairs composed of G and C contain three H-bonds, whereas those of A and T contain two H-bonds. For this reason G-C base-pairs is stronger than A-T base-pairs. The outcome will be that DNA having more GC base pairs will be more stable than the one having more AT pairs. A typical structure of DNA is shown in Fig. 2

Following are specific features of DNA structure

- It is double helical structure. One polynucleotide chain forms one strand. Two such strands form double helix.
- Chain has sugar phosphate backbone and the bases are arranged perpendicular to the chain.
- Two strands are antiparallel to each other : one in 5' ----> 3' direction and the other in the 3' ----> 5' direction.
- A and T ; and G and C occur as complementary and form base pair with corresponding complementary base in opposite strand.
- One turn of the helix is $3.4 \text{ \AA}$ and 10 base pairs are found per turn with rise of $3.4 \text{ \AA}$.
- On the surface of double helix two deep grooves are found which are called major and minor grooves.
- Helix is right handed along the axis

The double helix of DNA exist in several different forms. The B-form is most prevalent under physiological conditions of the cell. A and Z are other two reported for the DNA.

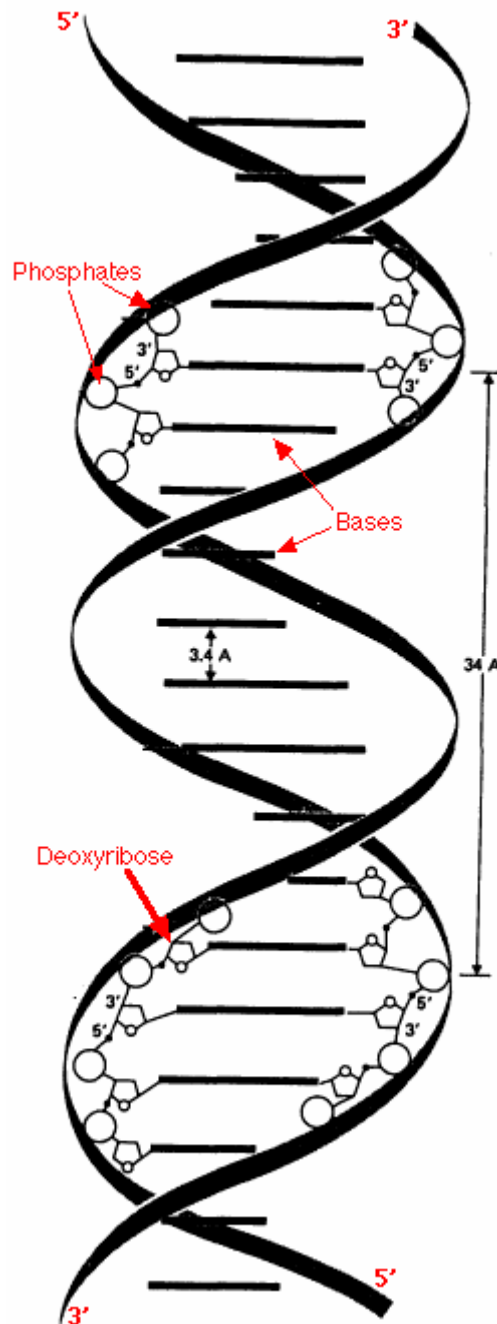


Fig. 2: Double helix structure of DNA

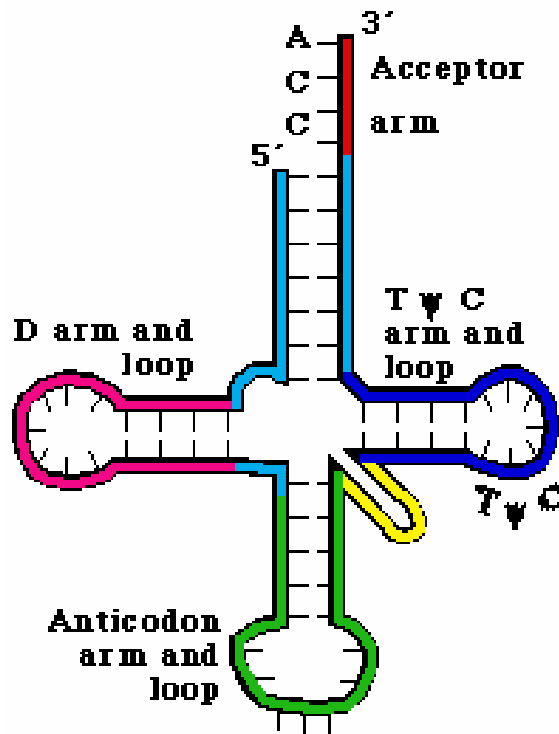
Structure of RNA

Unlike DNA, RNA are single stranded polynucleotide. It contains Uracil base instead of thymine, thus four bases of RNA are A, U, G and C. There are three types of RNA present in the cell:

- Messenger RNA
- Transfer RNA
- Ribosomal RNA

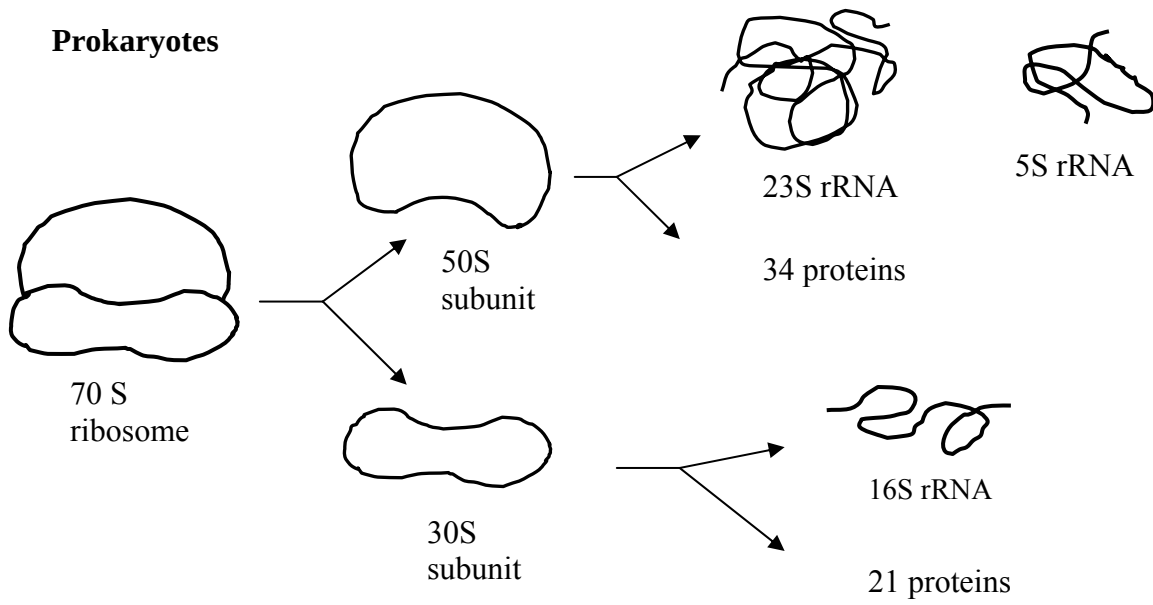
Messenger RNA (m-RNA) - does not contain very organized secondary structure. The polypeptide is linear in general, except acquiring hairpin structure at some places due to the base pairing between complementary base pairs of the chain. Messenger RNA is generated in the nucleus as the complementary copy of DNA strand by a process called transcription. It therefore carries the genetic information of the DNA to be used for protein synthesis.

Transfer RNA (t-RNA): have well defined clover leaf structure as shown in fig. It has four arms, which are designated as Dihydrouridine (DHU), anticodon, pseudouridine (T ψ C) arms and one small optional arm. 3' of the t-RNA has conserved sequence CCA at which specific amino acid is attached. Anticodons located at anticodon arm form complementary base pairs with codon during protein synthesis process. Thus the role of t₋RNA is to transfer amino acid for protein synthesis.

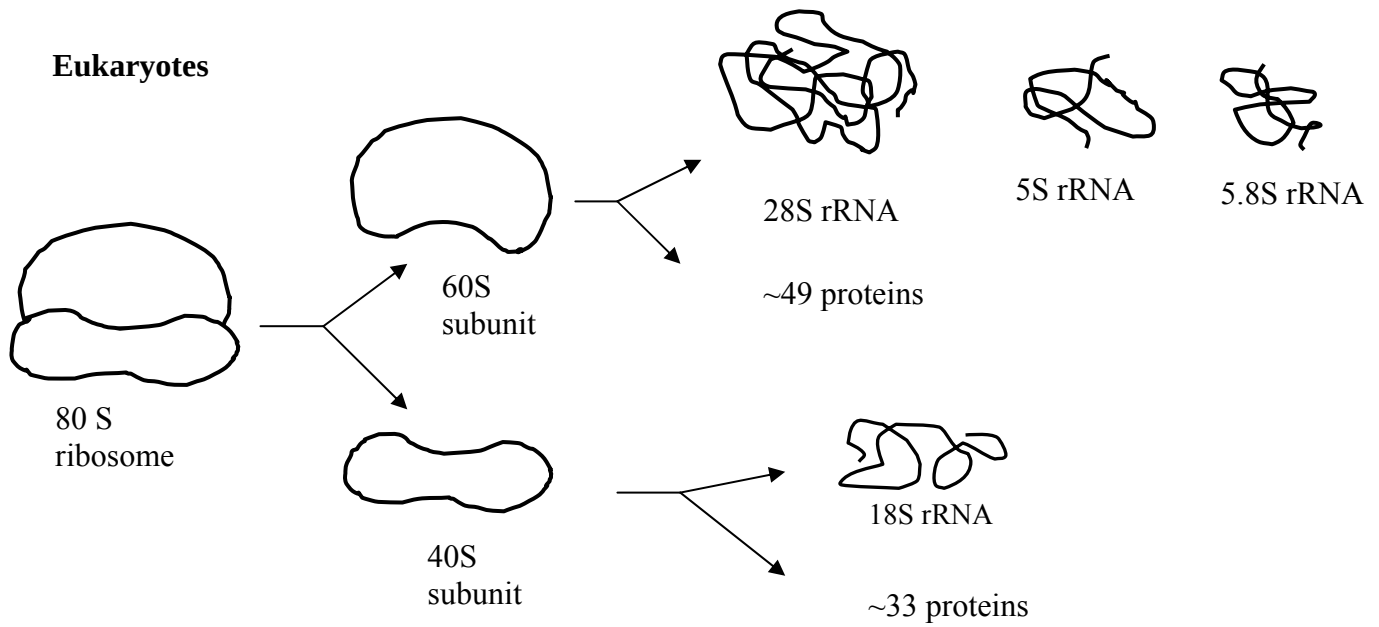


Ribosomal RNA (r-RNA): It forms complex with protein to form cell organelle called ribosomes. The structure of ribosome is shown below. The RNA and protein constitution of ribosome is also summarized in the same. Ribosomes are the site of the protein synthesis in the cell.

Prokaryotes

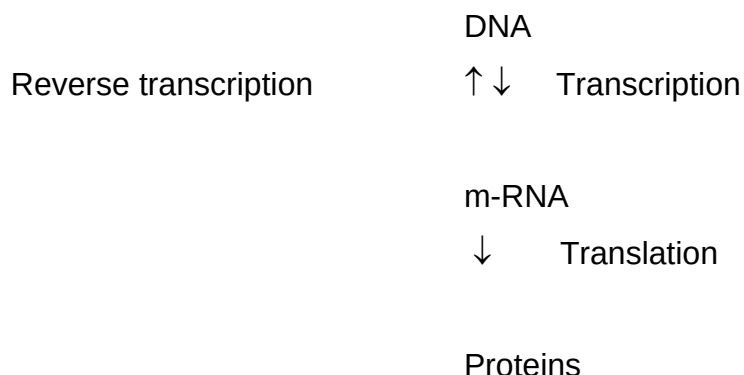


Eukaryotes



Functions of Nucleic acid

The concept of central Dogma explains the functions of nucleic acid in nutshell as below:



First and foremost is that DNA is very basis of life. It is the master molecule responsible for hereditary and genetic material of the cell carrying all the in formations

- It is able to replicates it self during cell division and the process called replication.
- It synthesise a complementary messenger RNA which is responsible for carrying the information for protein synthesis.
- It also regulates protein synthesis.

Suggested Readings

1. A.L. Lehninger, D.L. Nelson and M.M. Cox. Principles of Biochemistry, McMillan Worth (2004).
2. L.Stryer, Biochemistry, W.H. Freeman, New York (1996).
3. E.E. Conn and P.K. Stumph. Outlines of Biochemistry, John Wiley and Sons, New York (1987).
4. D. Voet and J.G. Voet. Biochemistry. John Wiley and Sons, Canada (2004).