Evaluation

1. The correct sequence in cell cycle is
   a. S-M-G1-G2
   b. S-G1-G2-M
   c. G1-S-G2-M
   d. M-G-G2-S

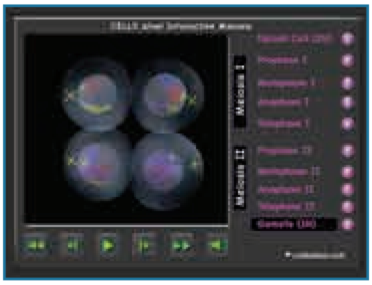
5SD2HH

2. If cell division is restricted in G1 phase of the cell cycle then the condition is known as
   a. S Phase
   b. G2 Phase
   c. M Phase
   d. G_0 Phase
3. Anaphase promoting complex APC is a protein degradation machinery necessary for proper mitosis of animal cells. If APC is defective in human cell, which of the following is expected to occur?
   a. Chromosomes will be fragmented
   b. Chromosomes will not condense
   c. Chromosomes will not segregate
   d. Recombination of chromosomes will occur
4. In S phase of the cell cycle
   a. Amount of DNA doubles in each cell
   b. Amount of DNA remains same in each cell
   c. Chromosome number is increased
   d. Amount of DNA is reduced to half in each cell
5. Centromere is required for
   a. transcription
   b. crossing over
   c. Cytoplasmic cleavage
   d. movement of chromosome towards pole
6. Synapsis occur between
   a. mRNA and ribosomes
   b. spindle fibres and centromeres
   c. two homologous chromosomes
   d. a male and a female gamete
7. In meiosis crossing over is initiated at
   a. Diplotene
   b. Pachytene
   c. Leptotene
   d. Zygotene
8. Colchicine prevents the mitosis of the cells at which of the following stage
   a. Anaphase
   b. Metaphase
   c. Prophase
   d. interphase
9. The paring of homologous chromosomes on meiosis is known as
   a. Bivalent
   b. Synapsis
   c. Disjunction
   d. Synergids
10. Anastral mitosis is the characteristic feature of
    a. Lower animals
    b. Higher animals
    c. Higher plants
    d. All living organisms
11. Write any three significance of mitosis
12. Differentiate between mitosis and meiosis
13. Given an account of G_0 phase
14. Differentiate cytokinesis in plant cells and animal cells
15. Write about Pachytene and Diplotene of Prophase I

ICT Corner

Cell division

How cells are multiply? →

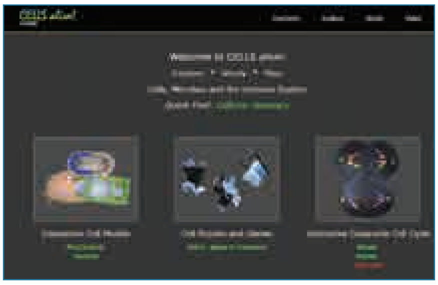


Steps

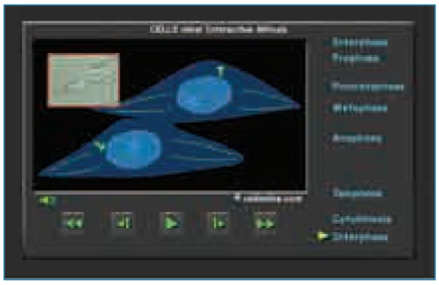
- Scan the QR code
- Click Mitosis and start the animation press play
- Select mitosis in the top of the page – play it - use forward button to slow down
- Select meiosis in the top of the page – play it - use forward button to slow down

Activity

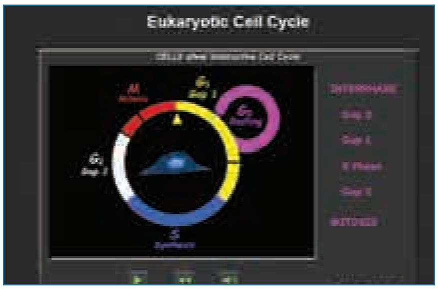
- Select meiosis and cell cycle.
- Record your observations.



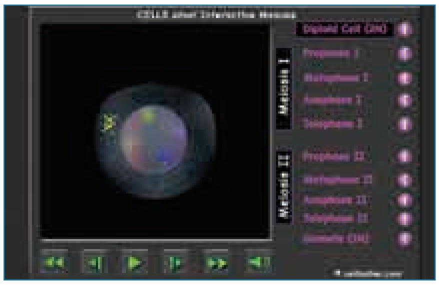
Step 1



Step 3



Step 2



Step 4

URL:

https://www.cellsalive.com/

* Pictures are indicative only

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Chapter 8

Biomolecules

5SLXJ5

Learning Objectives

The learner will be able to,

- *List out the inorganic and organic components of a cell.*
- *Understand about bonding pattern of water and properties of water.*
- *Familiarise with the classification of carbohydrates and its functions.*
- *Recognise the basic structure of carbohydrates, proteins, lipids and nucleic acids and differentiate the various pattern of classification with respect to structure.*
- *Identify the structure and functions of carbohydrates.*
- *Familiarise with the general structure of amino acids and its classification based on the functional group.*
- *Comparative study of the primary, secondary, tertiary and quaternary structure of proteins.*
- *Know the structure and classification of enzymes.*
- *Know about the factors affecting the mode of action of enzymes with relevant examples.*
- *Understand lipids as a biomolecule and discuss the properties of lipids.*
- *Have a deeper knowledge about structure of nucleic acids.*
- *Recognize nucleic acids as a polymer which plays a vital role in carrying the genetic information.*
- *Learn about the different forms of DNA and types of RNA.*

Chapter Outline

8.1 Water
8.2 Primary and Secondary Metabolite
8.3 Carbohydrates – Classification and Structure
8.4 Lipids – Classification and Structure
8.5 Proteins and Amino Acids – Classification and Structure,
8.6 Enzymes – Classification, Nomenclature, Structure and Concepts, Mechanism of Enzyme Action, Activation energy, factors affecting enzyme action.
8.7 Nucleic Acids general Structure and composition – Forms of DNA and Types of RNA.

Biomolecules

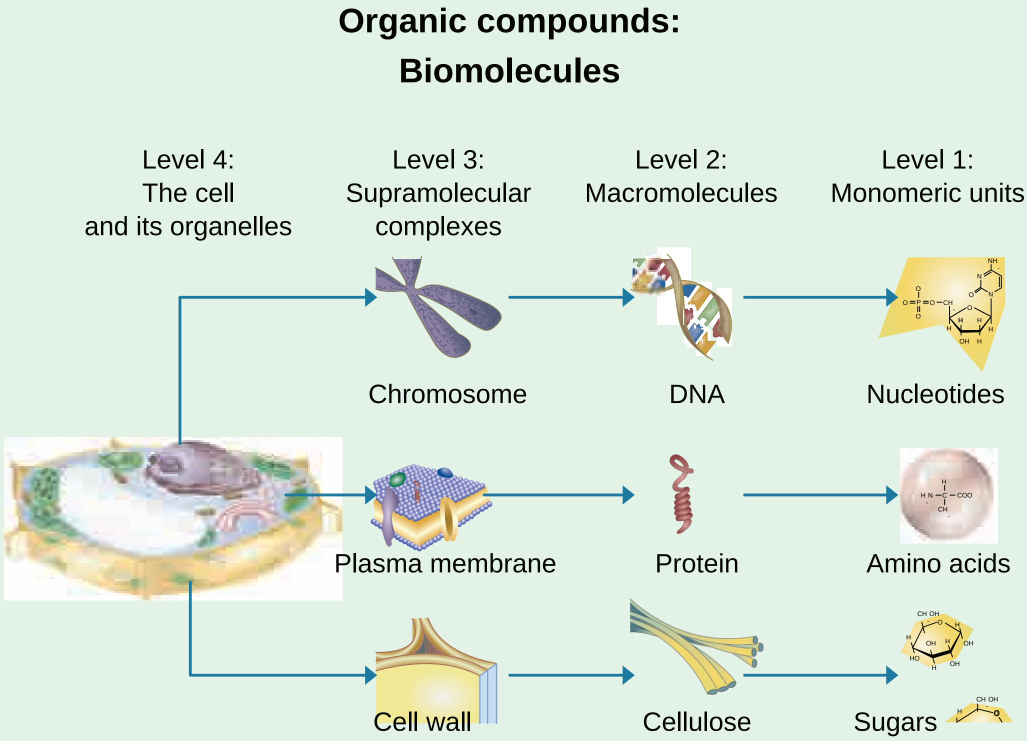


Figure 8.1: Components of cell

Having learnt the structure of the cell, we can now understand that each component of the cell is responsible for a specific function. The cell components are made of collection of molecules called as **cellular pool**, which consists of both inorganic and organic compounds. Inorganic compounds include salts, mineral ions and water.

Organic compounds are carbohydrates, lipids, amino acids, proteins, nucleotides, hormones and vitamins. Some organic molecules remain in colloidal form in the aqueous intracellular fluid. Others exist in non-aqueous phases like the lipid membrane and cell walls. The cell maintains this pool by the intake and elimination of specific molecules (Figure 8.1).

The minerals essential for plant growth are of two types: **macronutrients**, which are required in larger amounts (Eg. Potassium, phosphorus, calcium, magnesium, sulphur and iron) and **micronutrients**, which are required in trace amounts (Eg. Cobalt, zinc, boron, copper, molybdenum and manganese) and are essential for enzyme action. Example, Manganese is required for activity of enzyme needed for synthesis of oligosaccharides and glycoproteins. Molybdenum is necessary for fixation of nitrogen by enzyme nitrogenase.

Component	% of the total cellular mass
Water	70
Proteins	15
Carbohydrates	3
Lipids	2
Nucleic acids	6
Ions	4

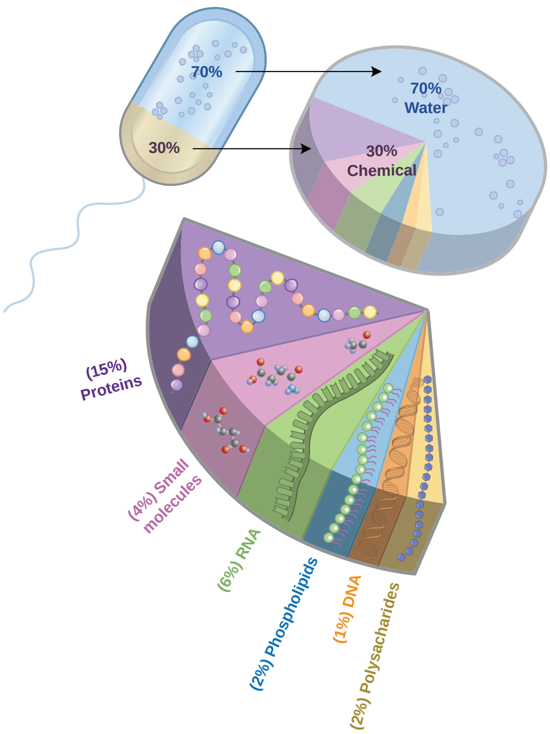


Figure 8.2: Percentage of biomolecules in cell

8.1 Water

Water is the most abundant component in living organisms. Life on earth is inevitably linked to water. Water makes up 70% of human cell and upto 95% of mass of a plant cell (Figure 8.2).

DO YOU KNOW?

Masaru Emoto discovered that crystals formed in frozen water reveal changes when specific, concentrated thoughts are directed toward them. This crystal structure shows joy mood

Figure 8.3

8.1.1 Chemistry of Water

Water is a tiny polar molecule and can readily pass through membranes. Two electronegative atoms of oxygen share a hydrogen bonds of two water molecule. Thus, they can stick together by cohesion and results in lattice formation (Figure 8.4).

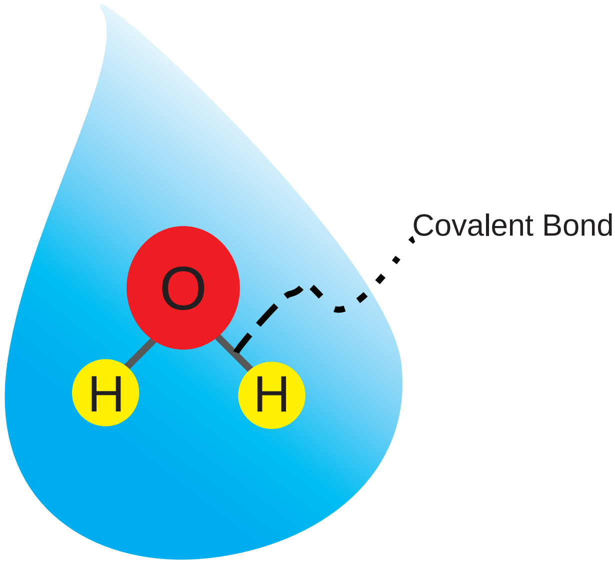


Figure 8.4: Water molecule

8.1.2 Properties of Water

- Adhesion and cohesion property
- High latent heat of vaporisation
- High melting and boiling point
- Universal solvent
- Specific heat capacity

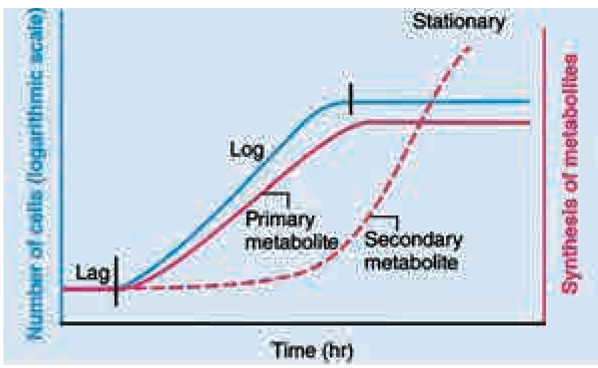


Figure 8.5: Synthesis of metabolites during growth

8.2 Primary and Secondary Metabolites

Most plants, fungi and other microbes synthesizes a number of organic compounds. These components are called as **metabolites** which are intermediates and products of metabolism. The term metabolite is usually restricted to small molecules. It can be catergorized into two types namely primary and secondary metabolites based on their role in metabolic process (Figure 8.5).

Primary metabolites are those that are required for the basic metabolic processes like photosynthesis, respiration, protein and lipid metabolism of living organisms.

Secondary metabolites does not show any direct function in growth and development of organisms.

Metabolites	Examples
Primary	
Enzymes	Protease, lipase, peroxidase
Amino acid	Proline, leucine
Organic acid	Acetic acid, lactic acid
Vitamins	A, B, C
Secondary	
Pigments	Carotenoids, anthocyanins
Alkaloids	Morphine, codeine
Essential oil	Lemon grass oil, rose oil
Toxins	Abrin, ricin
Lectins	Concanavalin A
Drugs	Vinblastin, curcumin
Polymeric substances	Rubber, gums, cellulose

DO YOU KNOW?

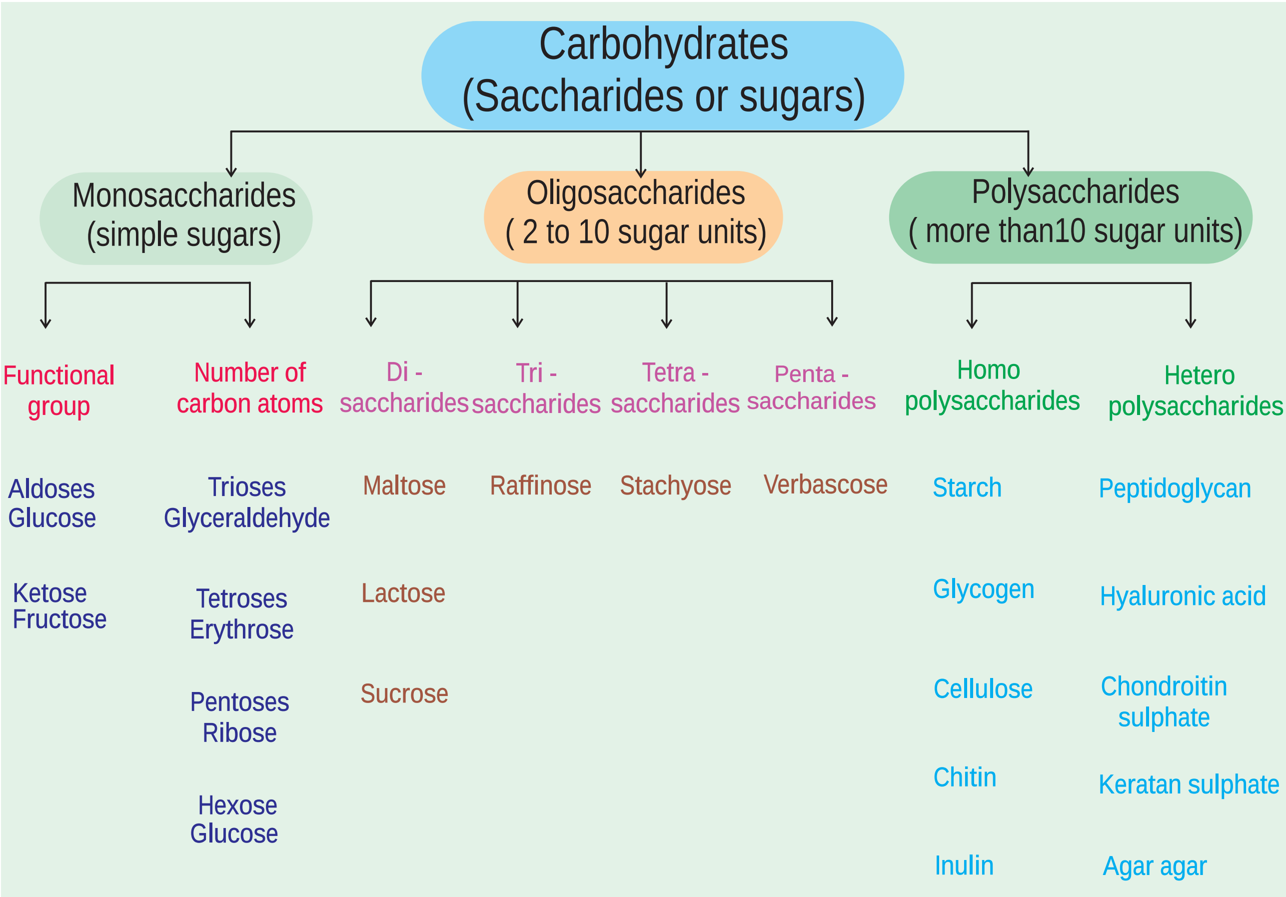
Morphine is the first alkaloid to be found. It comes from the plant Opium poppy (*Papaver somniferum*). It is used as a pain reliever in patients with severe pain levels and cough suppressant.

8.2.1 Organic Molecules

Organic molecules may be small and simple. These simple molecules assemble and form large and complex molecules called **macromolecules**. These include four main classes – carbohydrates, lipids, proteins and nucleic acids. All macromolecules except lipids are formed by the process of polymerisation, a process in which repeating subunits termed monomers are bound into chains of different lengths. These chains of monomers are called **polymers**.

8.3 Carbohydrates

Carbohydrates are organic compounds made of carbon and water. Thus one molecule of water combines with a carbon atom to form CH_2O and is repeated several (n) times to form $\mathbf{(CH_2O)_n}$ where n is an integer ranging from 3–7. These are also called as **saccharides**. The common term sugar refers to a simple carbohydrate such as a monosaccharide or disaccharide that tastes sweet are soluble in water (Figure 8.7).



8.3.1 Monosaccharides – The Simple Sugars

Monosaccharides are relatively small molecules constituting single sugar unit. Glucose has a chemical formula of $C_6H_{12}O_6$. It is a six carbon molecule and hence is called as **hexose** (Figure 8.6).

All monosaccharides contain one of two functional groups. Some are aldehydes, like glucose and are referred as **aldoses**; other are ketones, like fructose and are referred as **ketoses**.

> **DO YOU KNOW?**
>
> Glucose is one of the most well-known molecules due to its nature as an essential nutrient for human health. You ingest glucose in your food, and then your body uses blood to carry the glucose to the cells of every organ for the purpose of energy production.

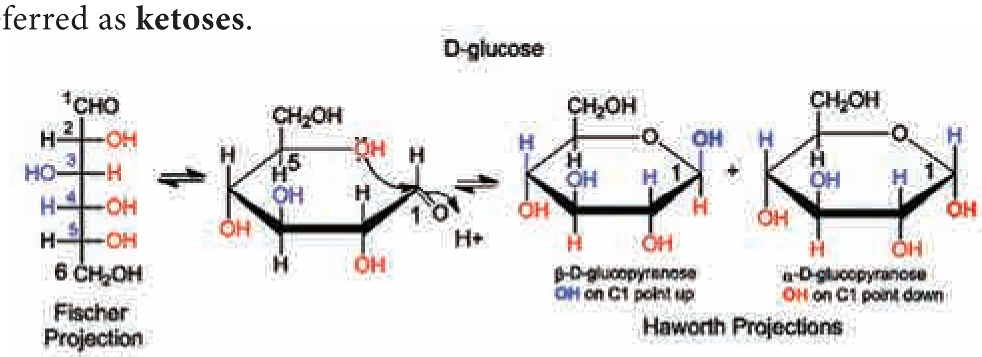


Figure 8.6: Structure of Glucose

8.3.2 Disaccharides

Disaccharides are formed when **two monosaccharides** join together. An example is **sucrose**. Sucrose is formed from a molecule of α-glucose and a molecule of fructose. This is a condensation reaction releasing water. The bond formed between the glucose and fructose molecule by removal of water is called **glycosidic bond**. This is another example of strong, covalent bond.

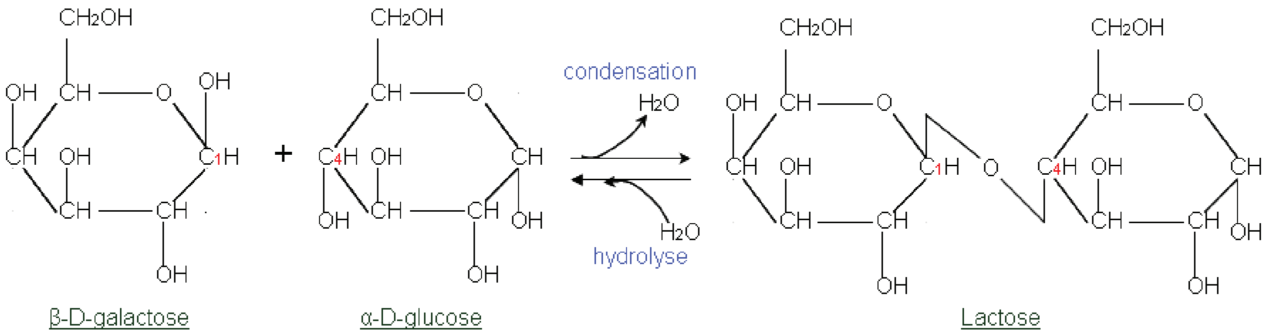


Figure 8.7: structure of carbohydrates

In the reverse process, a disaccharide is digested to the component monosaccharide in a hydrolysis reaction. This reaction involves addition of a water (hydro) molecule and splitting (lysis) of the glycosidic bond.

8.3.3 Polysaccharides

These are made of **hundreds of monosaccharide units**. Polysaccharides also called "**Glycans**". Long chain of branched or unbranched monosaccharides are held together by glycosidic bonds. Polysaccharide is an example of giant molecule, a macromolecule and consists of only one type of monomer. Polysaccharides are insoluble in water and are sweetless. **Cellulose** is an example built from repeated units of glucose monomer.

Depending on the function, polysaccharides are of two types - **storage polysaccharide and structural polysaccharide** (Figure 8.8).

8.3.4 Starch

Starch is a storage polysaccharides made up of repeated units of **amylose and amylopectin**. Starch grains are made up of successive layers of amylose and amylopectin, which can be seen as growth rings. Amylose is a linear, unbranched polymer which makes up 80% of starch. Amylopectin is a polymer with some 1, 6 linkages that gives it a branched structure.

Figure 8.8: Branched and linear polysaccharides

8.3.5 Test for Starch

We test the presence of starch by adding a solution of iodine in potassium iodide. Iodine molecules fit nearly into the starch helix, creating a **blue-black colour** (Figure 8.9).

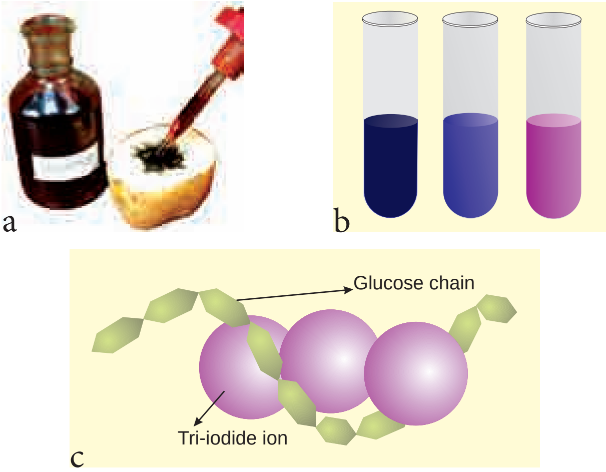


Figure 8.9: Test for starch

a. Test on potato; b. test on starch at varied concentrations; c. starch – iodine reaction

8.3.6 Glycogen

Glycogen is also a storage polysaccharide otherwise called as **animal starch**. It is the only carbohydrate stored in animals and fungi. Like amylopectin glycogen is a polymer of glucose with (α1-6) linked branches. Glycogen is seen in liver cells, skeletal muscle fibre and throughout the human body except brain (Figure 8.10).

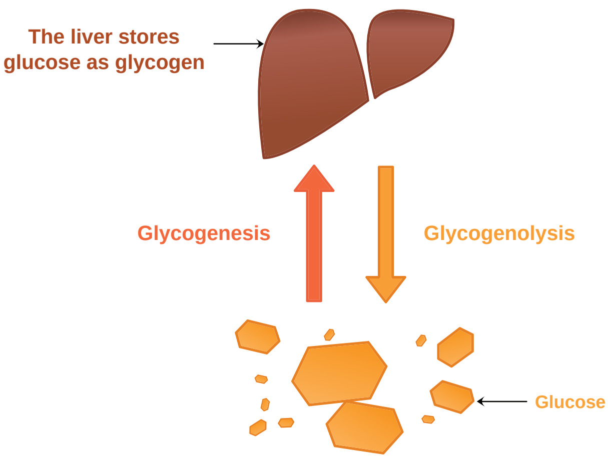


Figure 8.10: Glycogen: Glycogen in liver

8.3.7 Celluloses

Cellulose is a structural polysaccharide made up of thousands of glucose units. In this case, β-glucose units are held together by 1,4 glycosidic linkage, forming long unbranched chains. Cellulose fibres are straight and uncoiled. It has many industrial uses which include cellulose fibres as cotton, nitrocellulose for explosives, cellulose acetate for fibres of multiple uses and cellophane for packing (Figure 8.11).

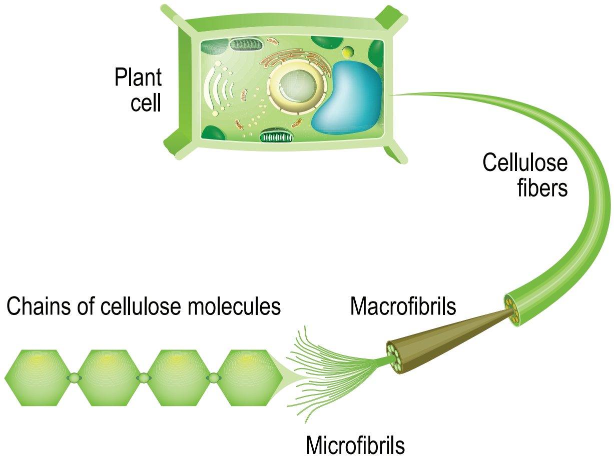


Figure 8.11: Cellulose molecule

Most herbivores have a problem:

- Cellulose is one of the most abundant organic compound in the biosphere.
- eat grass: principle component is cellulose
- cannot produce cellulase

Solution: Mutualistic bacteria in digestive system produce cellulases.

8.3.8 Chitin

Chitin is a homo polysaccharide with amino acids added to form **mucopolysaccharide.** The basic unit is a nitrogen containing glucose derivative known as **N-acetyl glucosamine.** It forms the exoskeleton of insects and other arthropods. It is also present in the cell walls of fungi (Figure 8.12).

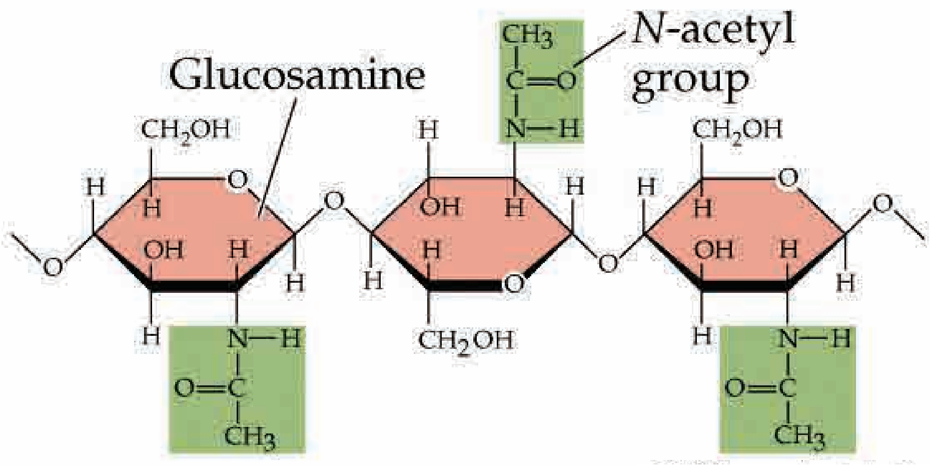


Figure 8.12: Structure of Chitin molecule

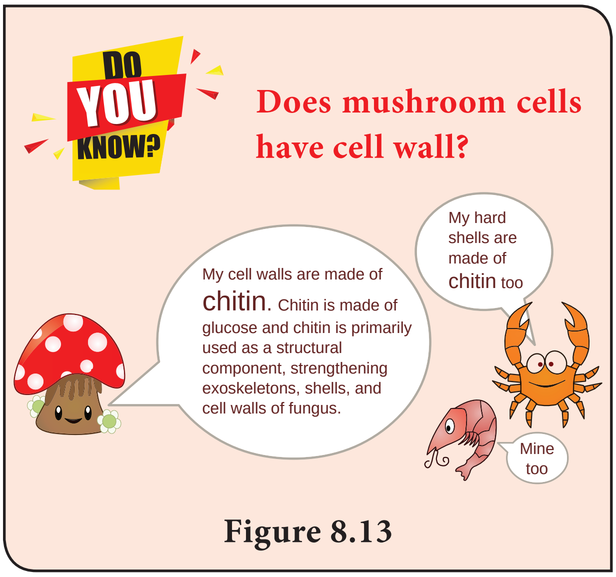


Figure 8.13

8.3.9 Test for Reducing Sugars

Aldoses and ketoses are reducing sugars. This means that, when heated with an alkaline solution of copper (II) sulphate (a blue solution called **benedict's solution**), the aldehyde or ketone group reduces Cu^{2+} ions to Cu^{+} ions forming brick red precipitate of copper(I) oxide. In the process, the aldehyde or ketone group is oxidised to a carboxyl group (–COOH). This reaction is used as test for reducing sugar and is known as **Benedict's test.** The results of benedict's test depends on concentration of the sugar. If there is no reducing sugar it remains blue (Figure 8.14).

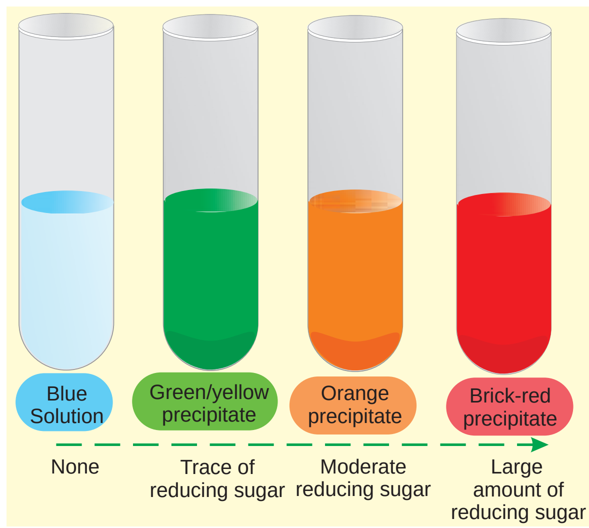


Figure 8.14: Test for sugar

- Sucrose is not a reducing sugar
- The greater the concentration of reducing sugar, the more is the precipitate formed and greater is the colour change.

Other Sugar Compounds

Other Polysaccharides	Structure	Functions
Inulin	Polymer of fructose	It is not metabolised in the human body and is readily filtered through the kidney
Hyaluronic acid	Heteropolymer of d glucuronic acid and D-N acetyl glucosamine	It accounts for the toughness and flexibility of cartilage and tendon
Agar	Mucopolysaccharide from red algae	Used as solidifying agent in culture medium in laboratory
Heparin	Glycosamino glycan contains variably sulphated disaccharide unit present in liver	Used as an anticoagulant
Chondroitin sulphate	Sulphated glycosaminoglycan composed of altering sugars (N-acetylglucosamine and glucuronic acid)	Dietery supplement for treatment of osteoarthritis
Keratan sulphate	Sulphated glycosaminoglycan and is a structural carbohydrate	Acts as cushion to absorb mechanical shock

DO YOU KNOW?

Human can't digest cellulose but herbivores can digest them with the help of bacteria present in the gut which produces enzyme **cellulase.** This is an example of **mutualism.**

8.4 Lipids

The term lipid is derived from *greek* word lipos, meaning fat. These substances are not soluble in polar solvent such as water but dissolve in non-polar solvents such as benzene, ether, chloroform. This is because they contain long hydrocarbon chains that are non-polar and thus hydrophobic. The main groups of compounds classified as lipids are triglycerides, phospholipids, steroids and waxes.

8.4.1 Triglycerides

Triglycerides are composed of single molecule of glycerol bound to 3 fatty acids. These include fats and oils. Fatty acids are long chain hydrocarbons with a carboxyl group at one end which binds to one of the hydroxyl groups of glycerol, thus forming an ester bond. Fatty acids are structural unit of lipids and are carboxylic acid of long chain hydrocarbons. The hydrocarbon can vary in length from 4 – 24 carbons and the fat may be saturated or unsaturated. In saturated fatty acids the hydrocarbon chain is single bonded (Eg. palmitic acid, stearic acid) and in unsaturated fatty acids (Eg. Oleic acid, linoleic acid) the hydrocarbon chain is double bonded (one/two/three). In general solid fats are saturated and oils are unsaturated, in which most are globules.

8.4.2 Membrane Lipids

A class of lipids that serves as major structural component of cell membrane is **phospholipids**. These contain only 2 fatty acids attached to the glycerol, while the third glycerol binding site holds a phosphate group. This phosphate group is in turn bonded to an alcohol. These lipids have both hydrophobic and hydrophilic regions. The structure of lipid bilayer helps the membrane in function such as selective permeability and fluid nature (Figure 8.15).

8.4.3 Steroids

These are complex compounds commonly found in cell membrane and animal hormones. Eg. Cholesterol which reinforces the structure of the cell membrane in animal cells and in an unusual group of cell wall deficient bacteria – Mycoplasma.

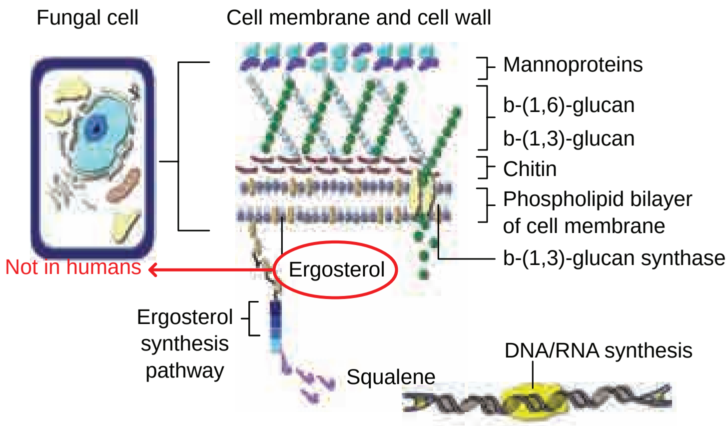


Figure 8.15: Complex molecules in cell wall

8.4.4 Waxes

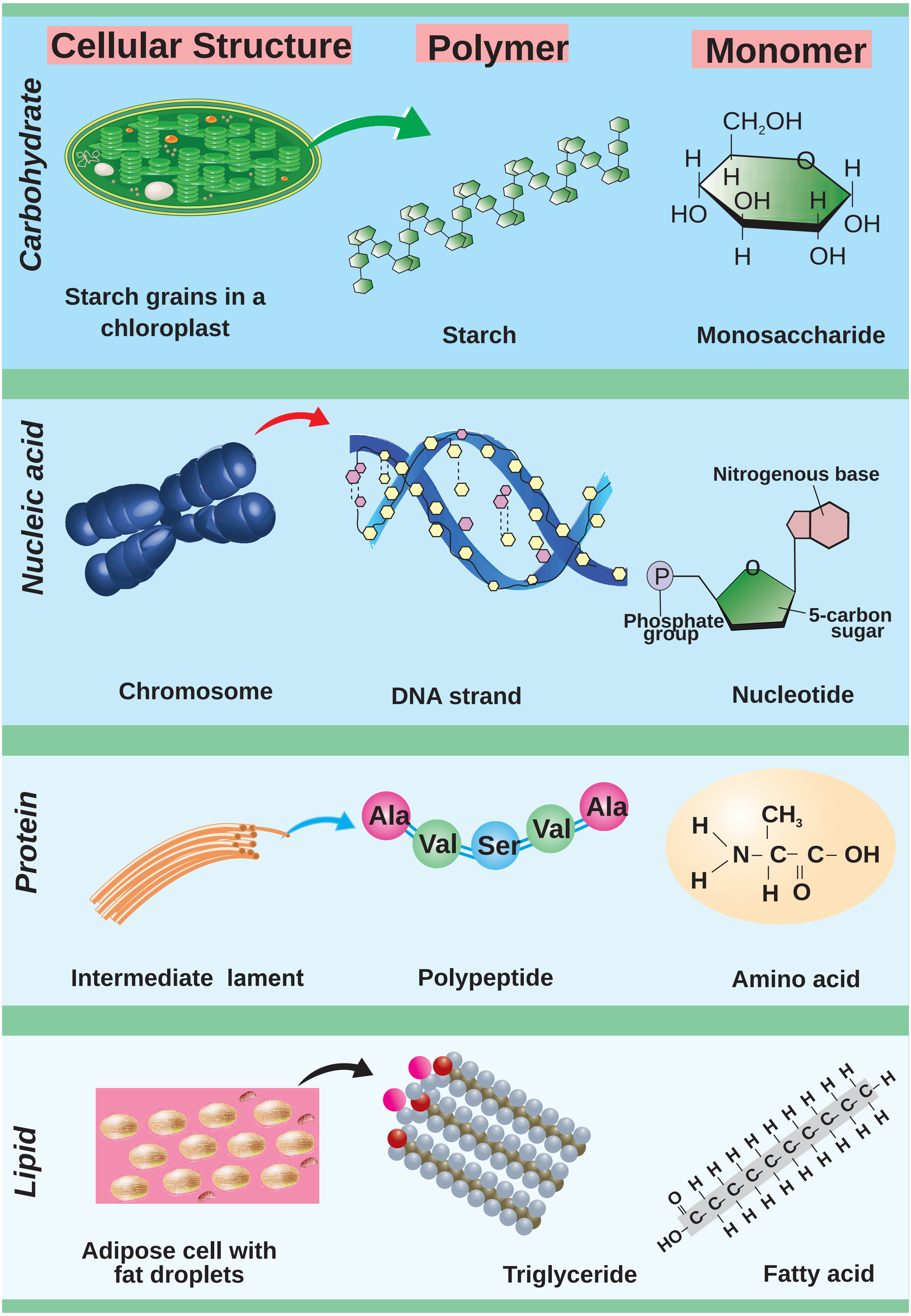
These are esters formed between a long chain alcohol and saturated fatty acids.

Figure 8.16: Lecithin

Lecithin is a food additive and dietery supplement

Fur, feathers, fruits, leaves, skin and insect exoskeleton are naturally waterproofed with a coating of wax (Figure 8.16 and 8.17).

Figure 8.17: Wax D present in cell wall of TB and Leprosy causing bacteria is infectious



Cellular Structure
Polymer
Monomer
Carbohydrate
Starch grains in a chloroplast
Starch
Monosaccharide
Nucleic acid
Nitrogenous base
P
Phosphate group
5-carbon sugar
Chromosome
DNA strand
Nucleotide
Protein
Ala
Val
Ser
Val
Ala
Intermediate lament
Polypeptide
Amino acid
Lipid
Adipose cell with fat droplets
Triglyceride
Fatty acid

8.5 Proteins

Proteins are the most diverse of all macromolecule. Proteins make up 2/3 of total dry mass of a cell. The term protein was coined by **Gerardus Johannes Mulder** and is derived form a *greek* word proteos which means of the first rank.

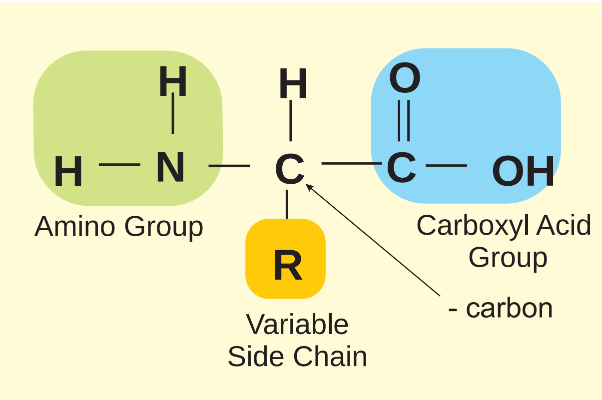


Figure 8.18: Structure of basic amino acid

Amino acids are building blocks of proteins. There are about 20 different amino acids exist naturally. All amino acids have a basic skeleton consisting of a carbon (a-carbon) linked to a basic amino group.

(NH_2), an acidic carboxylic group (COOH) and a hydrogen atom (H) and side chain or variable R group. The amino acid is both an acid and a base and is called **amphoteric**.

A **zwitterion** also called as **dipolar ion**, is a molecule with two or more functional groups, of which at least one has a positive and other has a negative electrical charge and the net charge of the entire molecule is zero. The pH at which this happens is known as the **isoelectric point** (Figure 8.19).

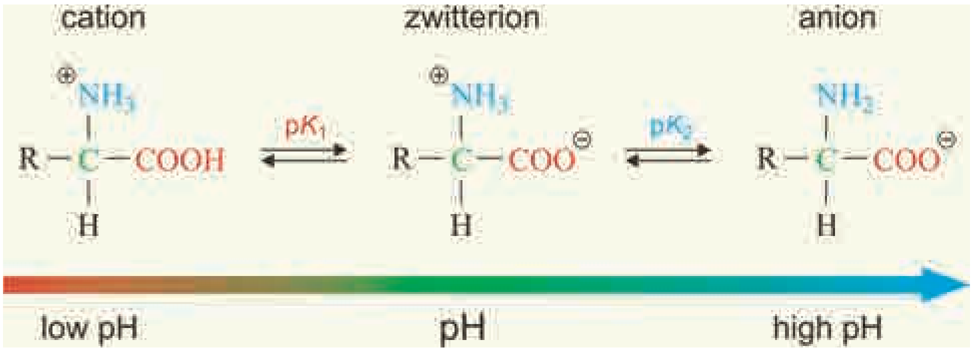


Figure 8.19: Structure of amino acid

8.5.1 Classification of Amino acids

Based on the R group amino acids are classified as acidic, basic, polar, non-polar.

The amino group of one amino acid reacts with carboxyl group of other amino acid, forming a **peptide bond**. Two amino acids can react together with the loss of water to form a **dipeptide**. Long strings of amino acids linked by peptide bonds are called **polypeptides**. In 1953 Fred Sanger first sequenced the Insulin protein (Figure 8.18 and 8.20 a and b).

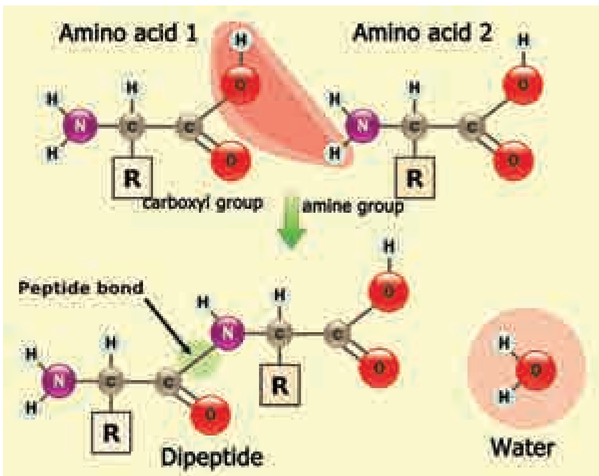


Figure 8.20(a): Amino acid reaction

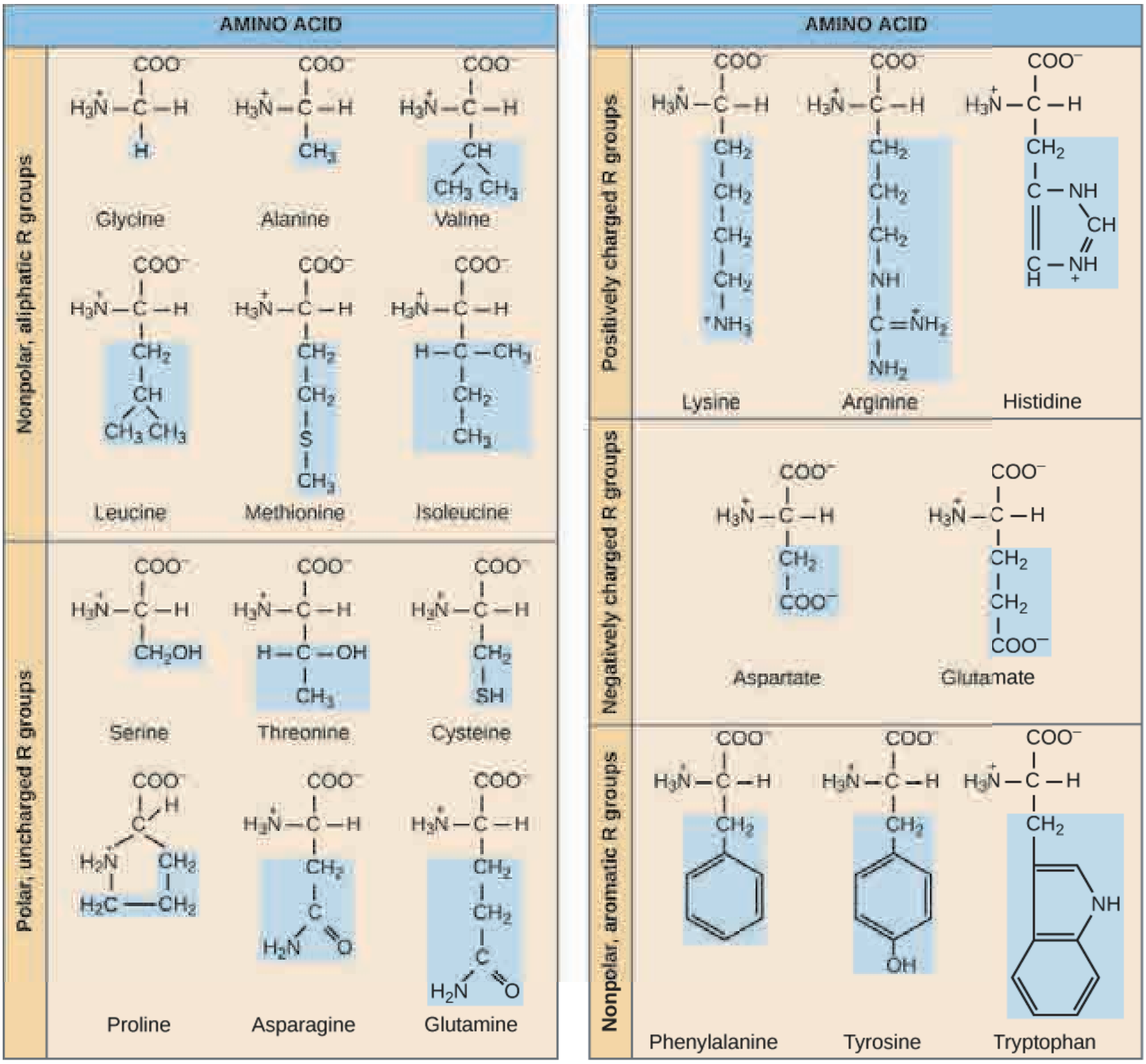


Figure 8.20(b): Classification of Amino Acids

DO YOU KNOW?

First protein Insulin was sequenced by Fred Sanger

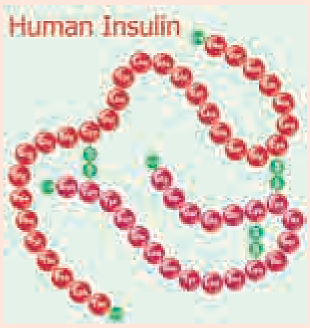


Figure 8.21

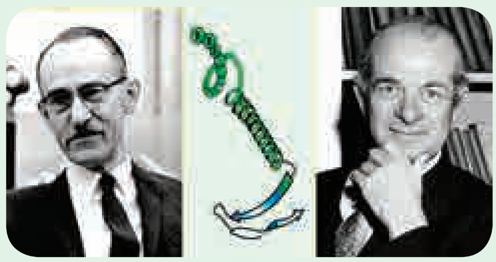


Figure 8.22

Linus Pauling and Robert Corey in 1951 proposed the α-helix and β sheet secondary structures of proteins. They were awarded nobel prize in 1954

8.5.2 Structure of Protein

Protein is synthesised on the ribosome as a linear sequence of amino acids which are held together by peptide bonds. After synthesis, the protein attains conformational change into a specific 3D form for proper functioning. According to the mode of folding, four levels of protein organisation have been recognised namely primary, secondary, tertiary and quaternary (Figure 8.23).

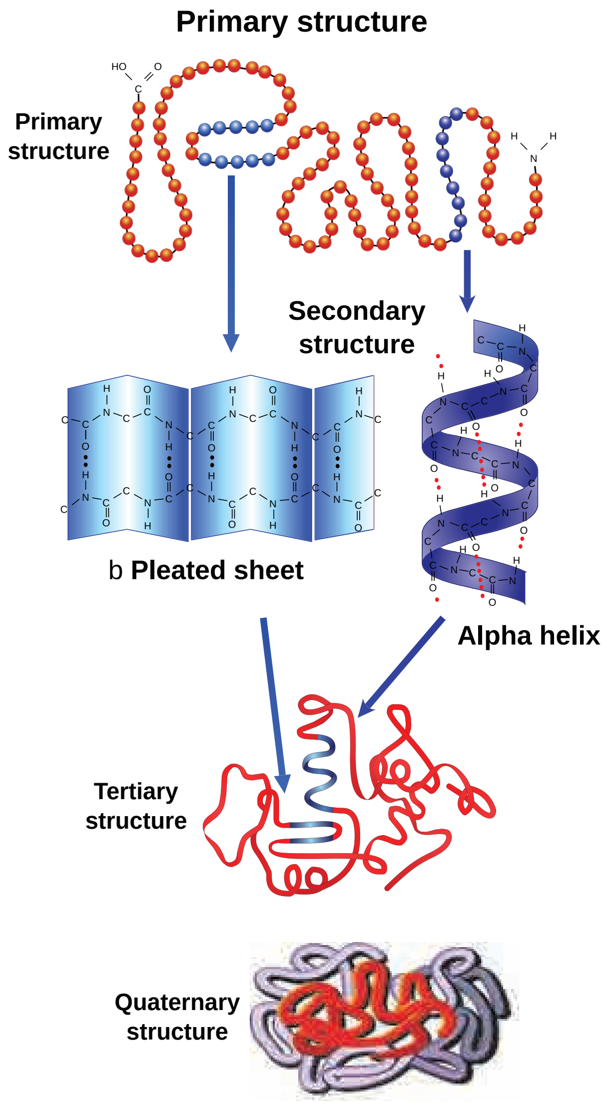


Figure 8.23: Structure of Protein

- The **primary structure** is linear arrangement of amino acids in a polypeptide chain.
- **Secondary structure** arises when various functional groups are exposed on outer surface of the molecular interaction by forming hydrogen bonds. This causes the aminoacid chain to twist into coiled configuration called α-**helix** or to fold into a flat β-pleated sheets.
- **Tertiary protein structure** arises when the secondary level proteins fold into globular structure called domains.
- **Quaternary protein structure** may be assumed by some complex proteins in which more than one polypeptide forms a large multiunit protein. The individual polypeptide chains of the protein are called **subunits** and the active protein itself is called a **multimer.**

For example: Enzymes serve as catalyst for chemical reactions in cell and are non-specific. Antibodies are complex glycoproteins with specific regions of attachment for various organisms.

8.5.3 Protein Denaturation

Denaturation is the loss of 3D structure of protein. Exposure to heat causes atoms to vibrate violently, and this disrupts the hydrogen and ionic bonds. Under these conditions, protein molecules become elongated, disorganised strands. Agents such as soap, detergents, acid, alcohol and some disinfectants disrupt the interchain bond and cause the molecule to be non-functional (Figure 8.25).

Christian Anfinsen explained denaturation of proteins by heat treatment leading to breakage of non-covalent bond.

Figure 8.24

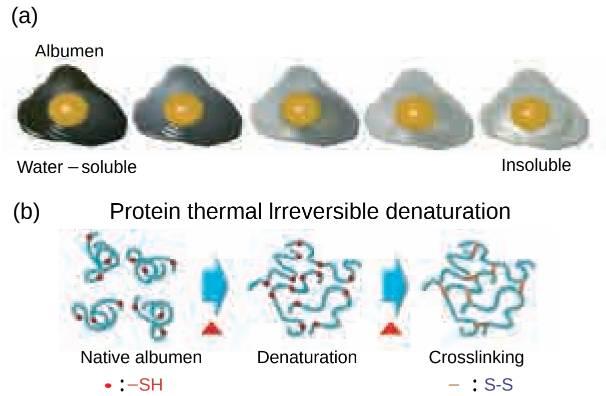


Figure 8.25: Protein denaturation

8.5.4 Protein Bonding

There are three types of chemical bonding

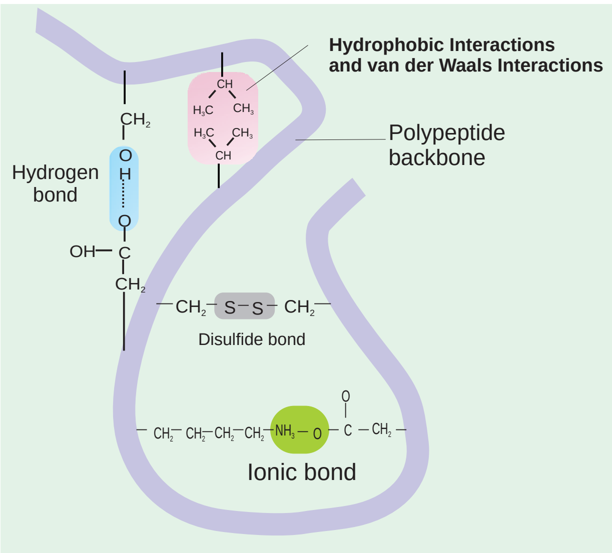


Figure 8.26: Protein bonding

Hydrogen Bond

It is formed between some hydrogen atoms of oxygen and nitrogen in polypeptide chain. The hydrogen atoms have a small positive charge and oxygen and nitrogen have small negative charge. Opposite charges attract to form hydrogen bonds.

Though these bonds are weak, large number of them maintains the molecule in 3D shape (Figure 8.26).

Ionic Bond

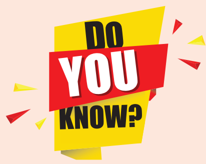
It is formed between any charged groups that are not joined together by peptide bond. It is stronger than hydrogen bond and can be broken by changes in pH and temperature.

Disulfide Bond

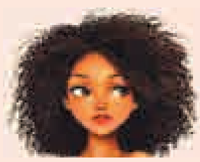
Some amino acids like cysteine and methionine have sulphur. These form disulphide bridge between sulphur atoms and amino acids.

Hydrophobic Bond

This bond helps some protein to maintain structure. When globular proteins are in solution, their hydrophobic groups point inwards away from water.



The more the distance between the sulphur atoms, the more the proteins bend; the more the hair curls.



8.5.5 Test for Proteins

The biuret test is used as an indicator of the presence of protein because it gives a purple colour in the presence of peptide bonds (–C–N–). To a protein solution an equal quantity of sodium hydroxide solution is added and mixed. Then a few drops of 0.5% copper (II) sulphate is added with gentle mixing. A distinct purple colour develops without heating (Figure 8.27 a and b).

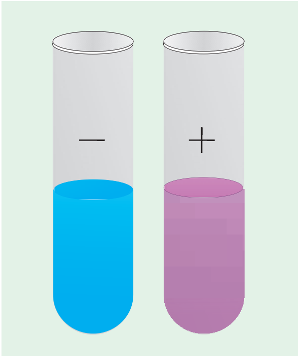


Figure 8.27(a): Biuret test

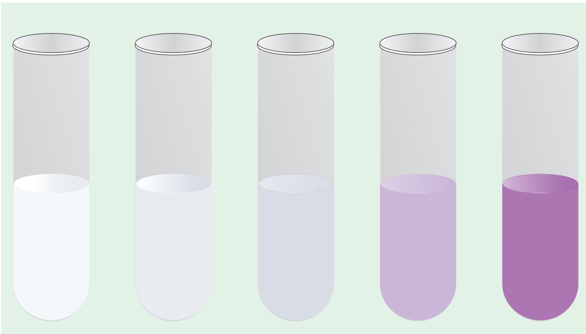


Figure 8.27(b): Colour intensity increases with increase in concentration

8.6 Enzymes

Enzymes are globular proteins that catalyse the many thousands of metabolic reactions taking place within cells and organism. The molecules involved in such reactions are metabolites. Metabolism consists of chains and cycles of enzyme-catalysed reactions, such as respiration, photosynthesis, protein synthesis and other pathways. These reactions are classified as

- **anabolic** (building up of organic molecules). Synthesis of proteins from amino acids and synthesis of polysaccharides from simple sugars are examples of anabolic reactions.
- **catabolic** (breaking down of larger molecules). Digestion of complex foods and the breaking down of sugar in respiration are examples of catabolic reactions (Figure 8.28).

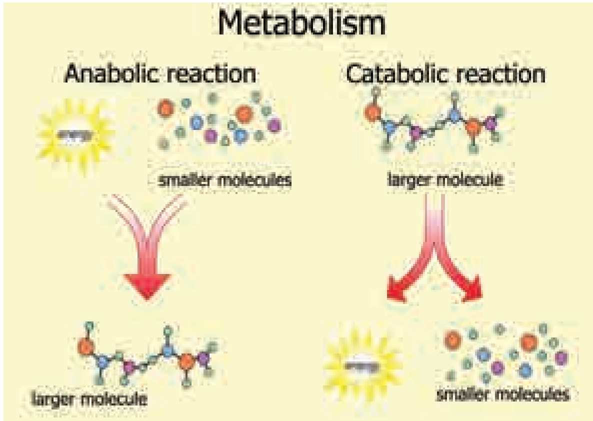


Figure 8.28: Enzyme reaction

Enzymes can be **extracellular enzyme** as secreted and work externally exported from cells. Eg. digestive enzymes; or **intracellular enzymes** that remain within cells and work there. These are found inside organelles or within cells. Eg. insulin

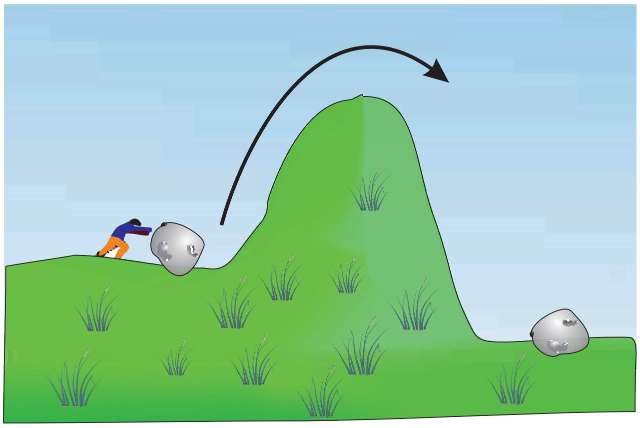
8.6.1 Properties of Enzyme

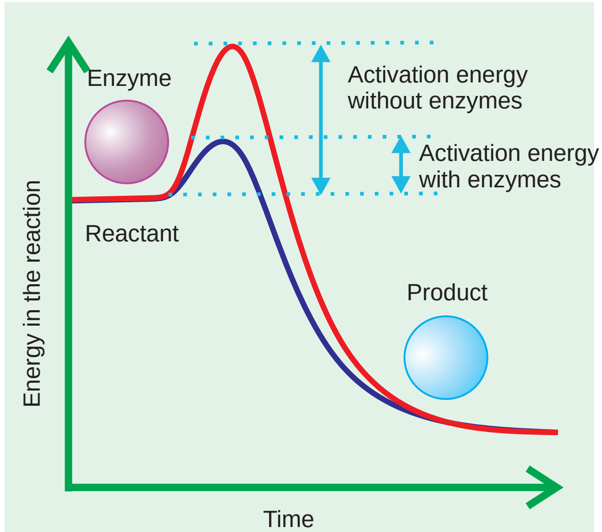
- All are globular proteins.
- They act as catalysts and effective even in small quantity.
- They remain unchanged at the end of the reaction.
- They are highly specific.
- They have an active site where the reaction takes place.
- Enzymes lower activation energy of the reaction they catalyse.

DO YOU KNOW?

RUBISCO is the abundant protein in the whole biosphere

As molecules react they become unstable, high energy intermediates, but they are in this transition state only momentarily. Energy is required to raise molecules to this transition state and this minimum energy needed is called the **activation energy**. This could be explained schematically by 'boulder on hillside' model of activation energy (Figure 8.29).





This graph shows the activation energies of a reaction with and without enzymes

Figure 8.29: Activation energy

8.6.2 Lock and Key Mechanism of Enzyme

In a enzyme catalysed reaction, the starting substance is the substrate. It is converted to the product. The substrate binds to the specially formed pocket in the enzyme – **the active site**, this is called **lock and key mechanism** of enzyme action. As the enzyme and substrate form a **ES complex**, the substrate is raised in energy to a transition state and then breaks down into products plus unchanged enzyme (Figure 8.30).

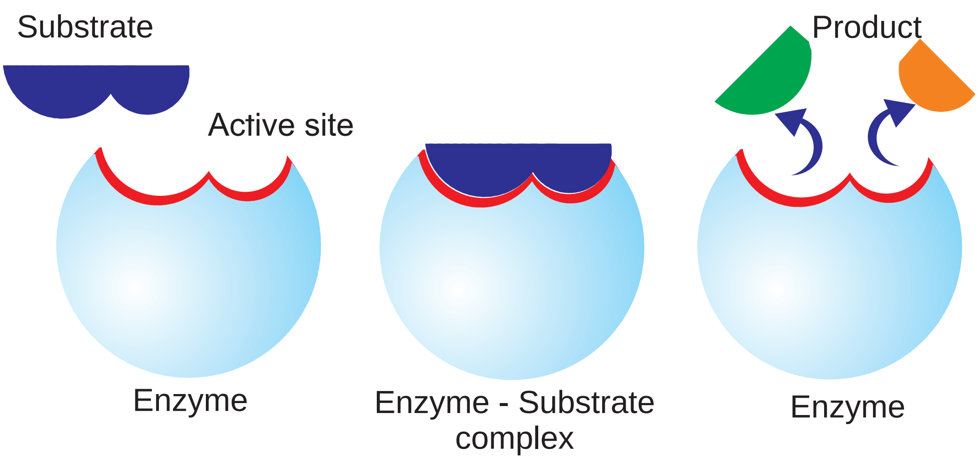


Figure 8.30: Enzyme mechanism

8.6.3 Factors Affecting the Rate of Enzyme Reactions

Enzymes are sensitive to environmental condition. It could be affected by temperature, pH, substrate concentration and enzyme concentration.

The rate of enzyme reaction is measured by the amount of substrate changed or amount of product formed, during a period of time.

8.6.4 Temperature

Heating increases molecular motion. Thus the molecules of the substrate and enzyme move more quickly resulting in a greater probability of occurence of the reaction. The temperature that promotes maximum activity is referred to as optimum temperature (Figure 8.31a).

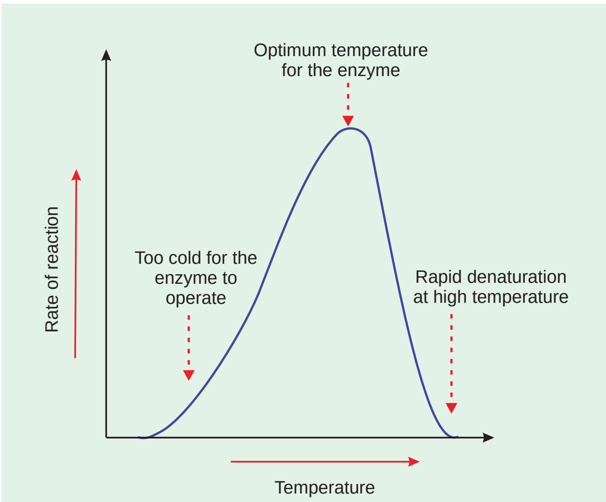


Figure 8.31(a): Temperature

8.6.5 pH

The optimum pH is that at which the maximum rate of reaction occurs. Thus the pH change leads to an alteration of enzyme shape, including the active site. If extremes of pH are encountered by an enzyme, then it will be denatured (Figure 8.31b).

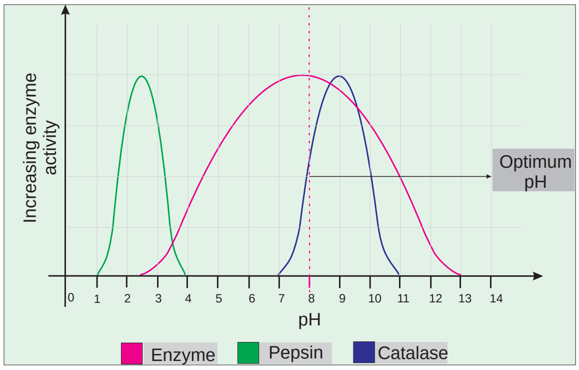


Figure 8.31(b): pH

8.6.6 Substrate Concentration

For a given enzyme concentration, the rate of an enzyme reaction increases with increasing substrate concentration (Figure 8.32).

8.6.7 Enzyme Concentration

The rate of reaction is directly proportional to the enzyme concentration.

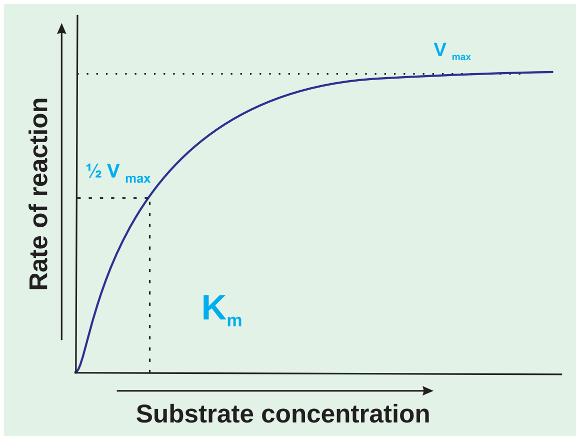


Figure 8.32: Rate of enzyme reaction

8.6.8 Introducing the Michaelis-Menton Constant (Km) and Its Significance

When the initial rate of reaction of an enzyme is measured over a range of substrate concentrations (with a fixed amount of enzyme) and the results plotted on a graph. With increasing substrate concentration, the velocity increases – rapidly at lower substrate concentration.

However the rate increases progressively, above a certain concentration of the substrate the curve flattened out. No further increase in rate occurs.

This shows that the enzyme is working at maximum velocity at this point. On the graph, this point of maximum velocity is shown as V_{max}.

8.6.9 Inhibitors of Enzyme

Certain substances present in the cells may react with the enzyme and lower the rate of reaction. These substances are called **inhibitors**. It is of two types **competitive and non-competitive** (Figure 8.33).

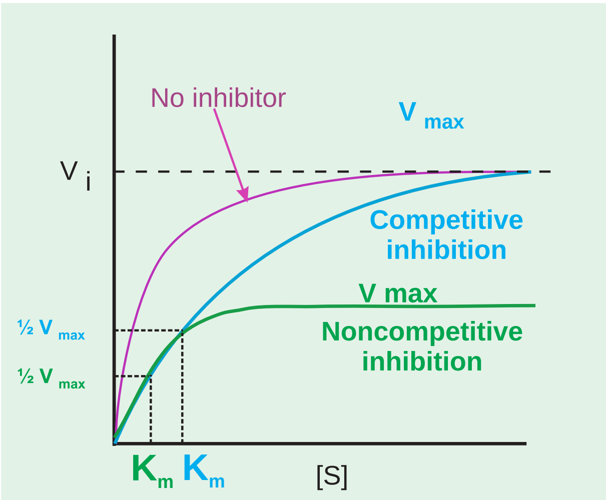


Figure 8.33: Enzyme inhibitors

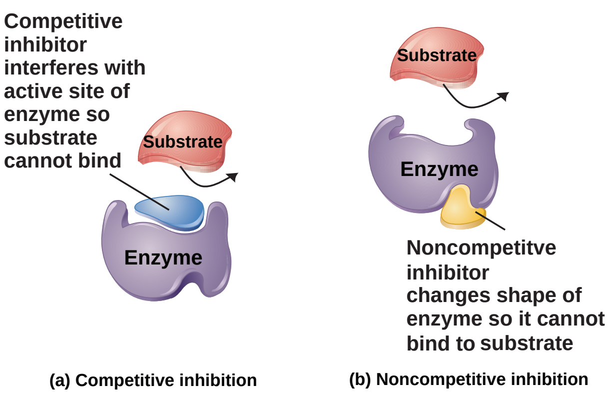


Figure 8.34: Action of Enzyme inhibitors

8.6.10 Competitive Inhibitor

Molecules that resemble the shape of the substrate and may compete to occupy the active site of enzyme are known as **competitive inhibitors**. For Example: the enzyme that catalyses the reaction between carbon di oxide and the CO_2 acceptor molecule in photosynthesis, known as **ribulose biphosphate carboxylase oxygenase (RUBISCO)** is competitively inhibited by **oxygen/carbon-di-oxide** in the chloroplast. The competitive inhibitor is **malonate** for **succinic dehydrogenase** (Figure 8.34).

8.6.11 Non-competitive Inhibitors

There are certain inhibitors which may be unlike the substrate molecule but still combines with the enzyme. This either blocks the attachment of the substrate to active site or change the shape so that it is unable to accept the substrate. For example the effect of the amino acids alanine on the enzyme pyruvate kinase in the final step of glycolysis.

Certain **non-reversible/irreversible inhibitors** bind tightly and permanently to an enzyme and destroy its catalytic properties entirely. These could also be termed as **poisons**. Example – **cyanide ions** which blocks **cytochrome oxidase** in terminal oxidation in cell aerobic respiration, the **nerve gas sarin** blocks a neurotransmitter in synapse transmission.

8.6.12 Allosteric Enzymes

They modify enzyme activity by causing a reversible change in the structure of the enzyme active site. This in turn affects the ability of the substrate to bind to the enzyme. Such compounds are called

allosteric inhibitors. Eg. The enzyme hexokinase which catalysis glucose to glucose-6 phosphate in glycolysis is inhibited by glucose 6 phosphate. This is an example for **feedback allosteric inhibitor**.

8.6.13 End Product Inhibition (Negative Feedback Inhibition)

When the end product of a metabolic pathway begins to accumulate, it may act as an allosteric inhibitor of the enzyme controlling the first step of the pathway. Thus the product starts to switch off its own production as it builds up. The process is self – regulatory. As the product is used up, its production is switched on once again. This is called **end-product inhibition** (Figure 8.35).

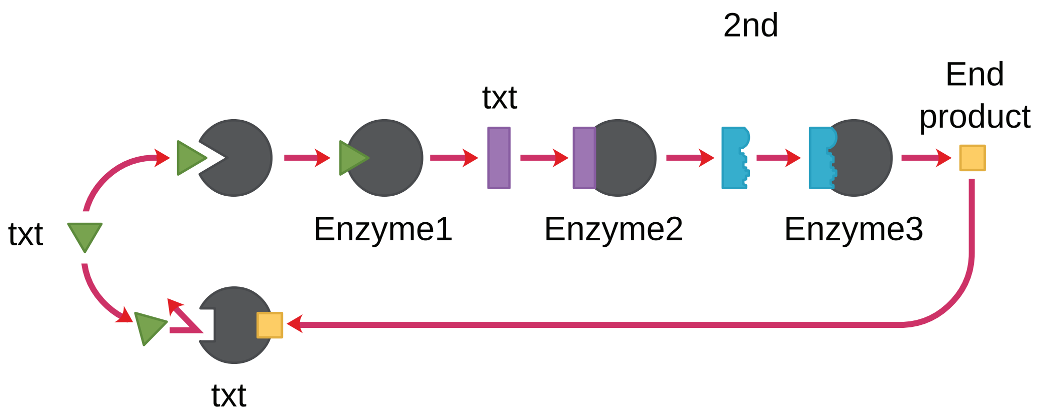


Figure 8.35: Negative feedback inhibition of enzyme

8.6.14 Enzyme Cofactors

Many enzymes require non-protein components called **cofactors** for their efficient activity. Cofactors may vary from simple inorganic ions to complex organic molecules. They are of three types: **inorganic ions, prosthetic groups and coenzymes** (Figure 8.36).

- **Holoenzyme** – active enzyme with its non protein component.

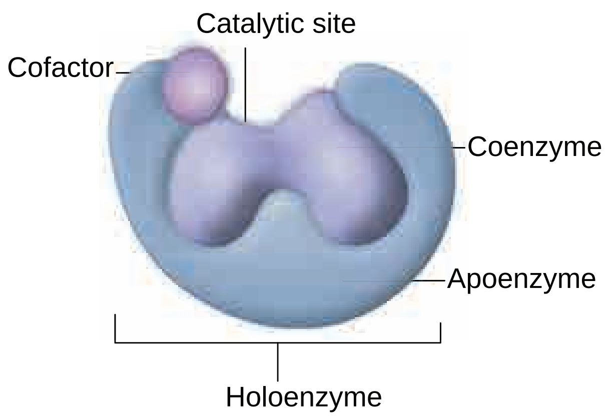


Figure 8.36: Enzyme components

- **Apoenzyme** – the inactive enzyme without its non protein component.
- **Inorganic ions** help to increase the rate of reaction catalysed by enzymes. Example: Salivary amylase activity is increased in the presence of chloride ions.
- **Prosthetic groups** are organic molecules that assist in catalytic function of an enzyme. Flavin adenine dinucleotide (FAD) contains riboflavin (vit B2), the function of which is to accept hydrogen. 'Haem' is an iron-containing prosthetic group with an iron atom at its centre.
- **Coenzymes** are organic compounds which act as cofactors but do not remain attached to the enzyme. The essential chemical components of many coenzymes are vitamins. Eg. NAD, NADP, Coenzyme A, ATP

DO YOU KNOW?

Ribozyme – Non Protein Enzyme

A Ribozyme, also called as **catalytic RNA**; is a ribonucleic acid that acts as enzyme. It is found in ribosomes.

8.6.15 Nomenclature of Enzymes

Most of the enzymes have a name based on their substrate with the ending **–ase**. For example lactase hydrolyses lactose and amylase hydrolyses amylose. Other enzymes like renin, trypsin do not depict any relation with their function.

8.6.16 Classification of Enzymes

Enzymes are classified into six groups based on their mode of action**.**

Enzymes	Mode of action	General scheme of reaction	Example
Oxidoreductase	Oxidation and reduction (redox) reactions	$A_{red} + B_{ox} \longrightarrow A_{ox} + B_{red}$	Dehydrogenase
Transferase	Transfer a group of atoms from one molecule to another	$A - B + C \longrightarrow A + C - B$	Transaminase, phosphotransferase
Hydrolases	Hydrolysis of substrate by addition of water molecule	$A - B + H_2O \longrightarrow A - H + B - OH$	Digestive enzymes
Isomerase	Control the conversion of one isomer to another by transferring a group of atoms from one molecule to another	$A - B - C \longrightarrow A - C - B$	Isomerase

(Continued)

Enzymes	Mode of action	General scheme of reaction	Example
Lyase	Break chemical bond without addition of water	$A - B \longrightarrow A + B$	Decarboxylase
Ligase	Formation of new chemical bonds using ATP as a source of energy	$A + B + ATP \longrightarrow A - B + ADP + Pi$	DNA ligase

DO YOU KNOW?

Telomerase – A Ribonucleo Protein

Telomere protects the end of the chromosome from damage. Telomerase is a ribonucleo protein also called as *terminal transferase.*

8.6.17 Uses of Enzymes

Enzyme	Source	Application
Bacterial protease	Bacillus	Biological detergents
Bacterial glucose isomerase	Bacillus	Fructose syrup manufacture
Fungal lactase	Kluyveromyces	Breaking down of lactose to glucose and galactose
Amylases	Aspergillus	Removal of starch in woven cloth production

8.7 Nucleic Acids

As we know DNA and RNA are the two kinds of nucleic acids. These were originally isolated from cell nucleus. They are present in all known **cells** and **viruses** with special coded genetic programme with detailed and specific instructions for each organism heredity.

DO YOU KNOW?

Friedrich Miescher *was the first to isolate a non-protein substance in nuclei of pus cells and named it as* '**Nuclein**'.

DNA and RNA are polymers of monomers called **nucleotides**, each of which is composed of a nitrogen base, a pentose sugar and a phosphate. A purine or a pyrimidine and a ribose or deoxyribose sugar is called **nucleoside**. A nitrogenous base is linked to pentose sugar through n-glycosidic linkage and forms a nucleoside. When a phosphate group is attached to a nucleoside it is called a **nucleotide**. The nitrogen base is a heterocyclic compound that can be either a **purine** (two rings) or a **pyrimidine** (one ring). There are **2 types of purines – adenine** (A) **and guanine** (G) **and 3 types of pyrimidines – cytosine** (C), **thymine** (T) **and uracil** (U) (Figure 8.38).

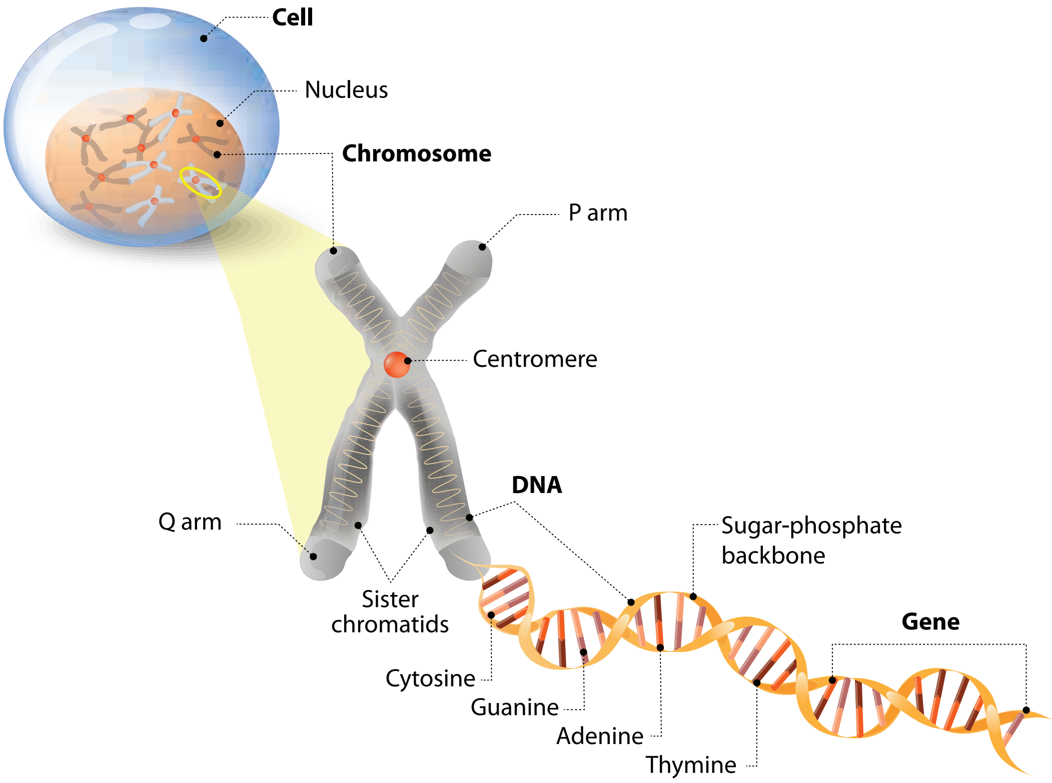


Figure 8.37: Position of DNA in the cell

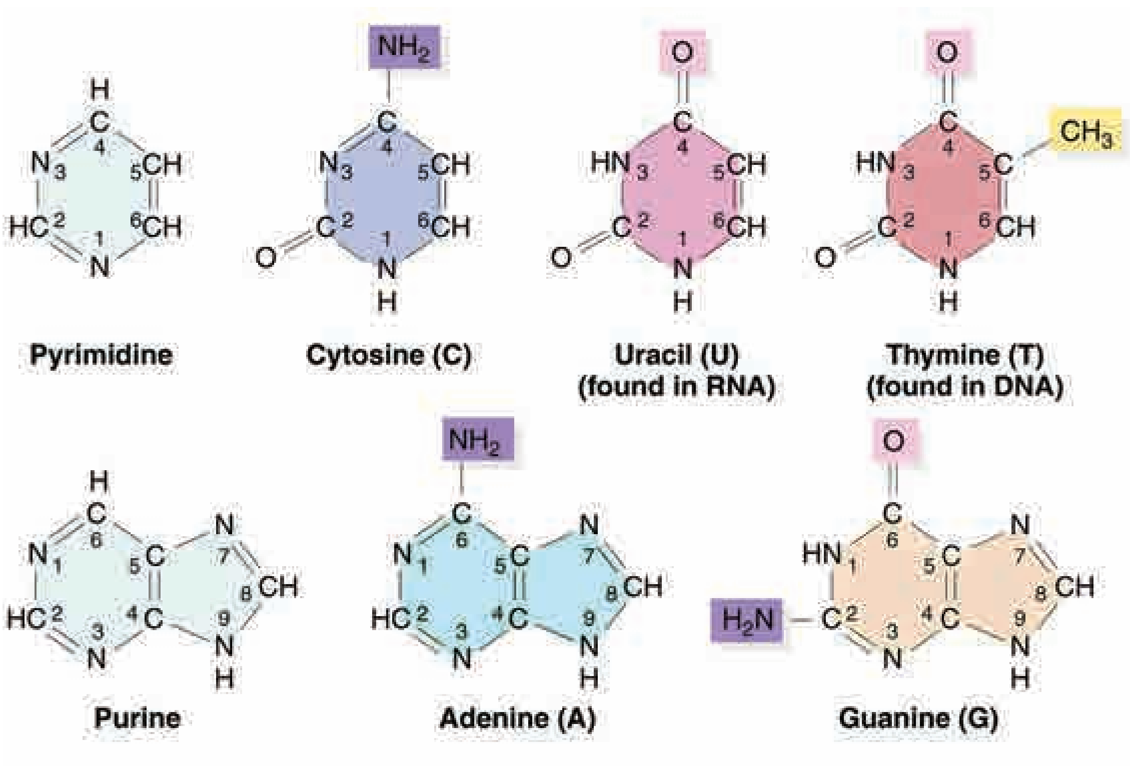


Figure 8.38: Structure of nucleic acid component

A characteristic feature that differentiates DNA from RNA is that DNA contains nitrogen bases such as Adenine, guanine, thymine (5-methyl uracil) and cytosine and the RNA contains nitrogen bases such as adenine, guanine, cytosine and uracil instead of thymine. The nitrogen base is covalently bonded to the sugar ribose in RNA and to deoxyribose (ribose with one oxygen removed from C_2) in DNA. Phosphate group is a derivative of (PO_4^{3-}) phosphoric acid, and forms phosphodiester linkages with sugar molecule (Figure 8.39).

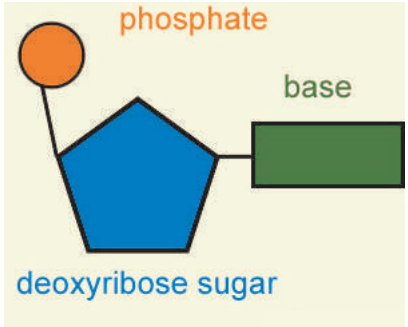


Figure 8.39: Basic component of DNA and RNA

8.7.1 Formation of Dinucleotide and Polynucleotide

Two nucleotides join to form **dinucleotide** that are linked through 3′-5′ phosphodiester linkage by condensation between phosphate groups of one with sugar of other. This is repeated many times to make **polynucleotide**.

Nucleoside	Nucleotide
It is a combination of base and sugar.	It is a combination of nucleoside and phosphoric acid.
Examples	**Examples**
Adenosine = Adenine + Ribose	Adenylic acid = Adenosine + Phosphoric acid
Guanosine = Guanine + Ribose	Guanylic acid = Guanosine + Phosphoric acid
Cytidine = Cytosine + Ribose	Cytidylic acid = Cytidine + Phosphoric acid
Deoxythymidine = Thymine + Deoxyribose	Uridylic acid = Uridine + Phosphoric acid

8.7.2 Structure of DNA

Watson and Crick shared the **Nobel Prize** in **1962** for their discovery, along with **Maurice Wilkins**, who had produced the crystallographic data supporting the model. **Rosalind Franklin** (1920–1958) had earlier produced the first clear crystallographic evidence for a helical structure. **James Watson** and **Francis Crick** (Figure 8.40) of Cavendish laboratory in Cambridge built a scale model of double helical structure of DNA which is the most prevalent form of DNA, the **B-DNA**. This is the secondary structure of DNA.

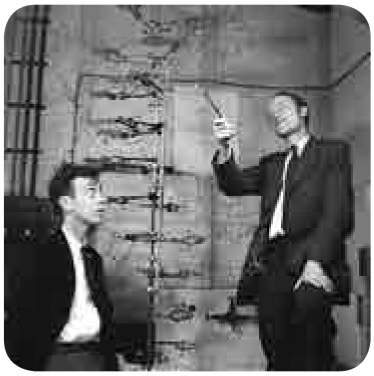


Figure 8.40: Watson and Crick

As proposed by **James Watson and Francis Crick**, DNA consists of right handed double helix with 2 helical polynucleotide chains that are coiled around a common axis to form right handed B form of DNA. The coils are held together by hydrogen bonds which occur between complementary pairs of nitrogenous bases. The sugar is called **2′-deoxyribose** because there is no hydroxyl at position 2′. Adenine and thiamine base pairs has two hydrogen bonds while guanine and cytosine base pairs have three hydrogen bonds.

Chargaff's Rule:

- A = T; G ≡ C
- A + G = T + C
- A : T = G : C = 1

As published by **Erwin Chargaff** in 1949, a purine pairs with pyrimidine and vice versa**.** Adenine (A) always pairs with Thymine (T) by double bond and Guanine (G) always pairs with Cytosine (C) by triple bond.

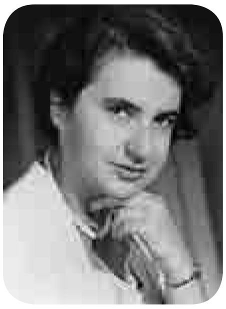


Figure 8.41: Rosalind franklin

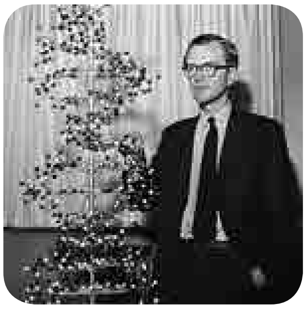


Figure 8.42: Erwin Chargaff

DO YOU KNOW?

In 1950s, ***Maurice Wilkins and Rosalind Franklin*** *of Kings College, London studied the X-ray crystallography and revealed experimental data on the structure of DNA*

8.7.3 Features of DNA

- If one strand runs in the 5′-3′ direction, the other runs in 3′-5′ direction and thus are antiparallel (they run in opposite direction). The 5′ end has the phosphate group and 3'end has the OH group.
- The angle at which the two sugars protrude from the base pairs is about 120°, for the narrow angle and 240° for the wide angle. The narrow angle between the sugars generates a **minor groove** and the large angle on the other edge generates **major groove.**
- Each base is 0.34 nm apart and a complete turn of the helix comprises 3.4 nm or 10 base pairs per turn in the predominant B form of DNA.
- DNA helical structure has a diameter of 20 A° and a pitch of about 34 A°. X-ray crystal study of DNA takes a stack of about 10 bp to go completely around the helix (360°).
- Thermodynamic stability of the helix and specificity of base pairing includes (i) the hydrogen bonds between the complementary bases of the double helix (ii) stacking interaction between bases tend to stack about each other perpendicular to the direction of helical axis. Electron cloud interactions ($\Pi - \Pi$) between the bases in the helical stacks contribute to the stability of the double helix.
- The phosphodiester linkages gives an inherent polarity to the DNA helix. They form strong covalent bonds, gives the strength and stability to the polynucleotide chain (Figure 8.43).

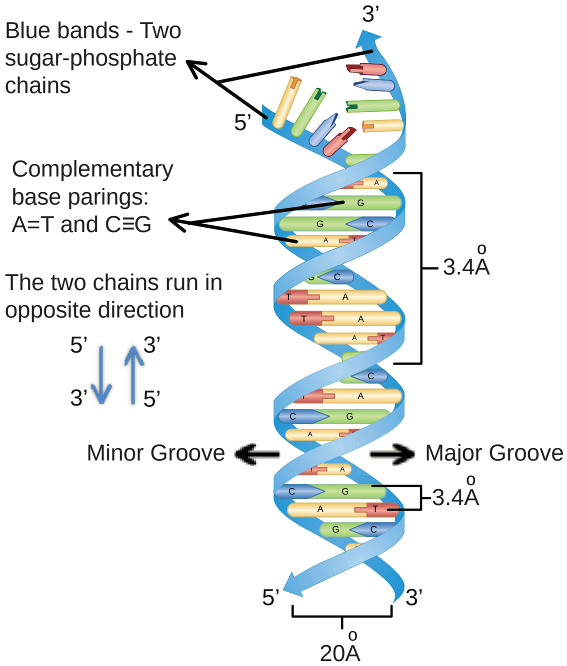


Figure 8.43: Structure of DNA

- Plectonemic coiling - the two strands of the DNA are wrapped around each other in a helix, making it impossible to simply move them apart without breaking the entire structure. Whereas in paranemic coiling the two strands simply lie alongside one another, making them easier to pull apart.
- Based on the helix and the distance between each turns, the DNA is of three forms – **A DNA, B DNA and Z DNA** (Figure 8.43) .

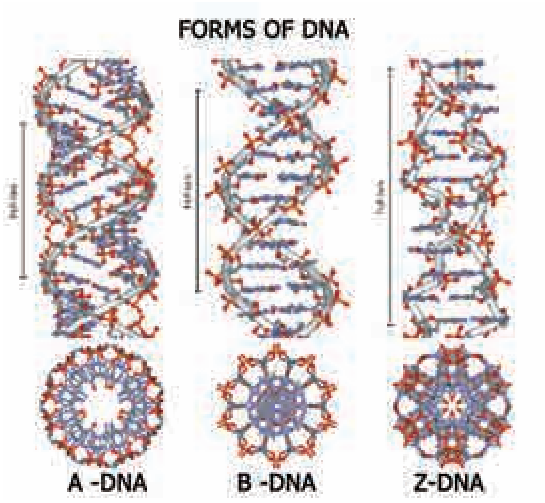


Figure 8.44: Forms of DNA

Feature	B-DNA	A-DNA	Z-DNA
Type of helix	Right-handed	Right-handed	Left-handed
Helical diameter (nm)	2.37	2.55	1.84
Rise per base pair (nm)	0.34	0.29	0.37
Distance per complete turn (pitch) (nm)	3.4	3.2	4.5
Number of base pairs per complete turn	10	11	12
Topology of major groove	Wide, deep	Narrow, deep	Flat
Topology of minor groove	Narrow, shallow	Broad, shallow	Narrow, deep

8.7.4 Ribonucleic Acid (RNA)

Ribonucleic acid (**RNA**) is a polymeric molecule essential in various biological roles in coding, decoding, regulation and expression of genes. RNA is single stranded and is unstable when compared to DNA (Figure 8.45).

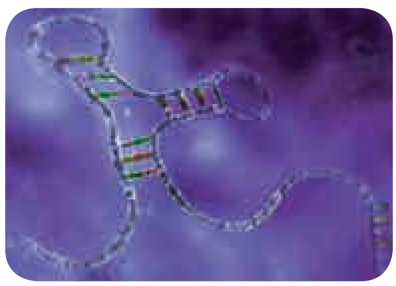
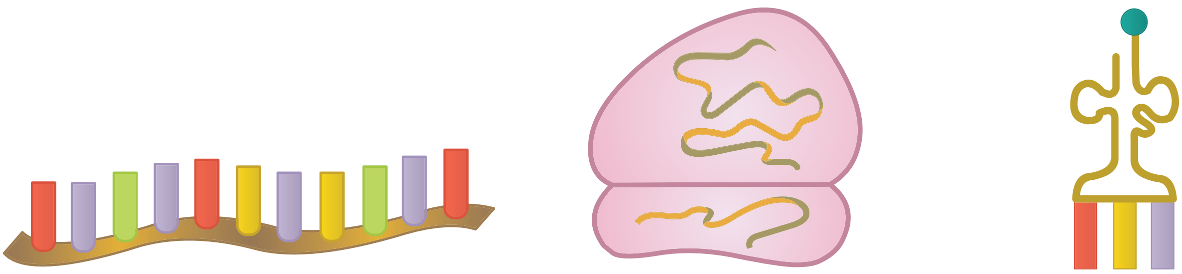


Figure 8.45: Structure of RNA

8.7.5 Types of RNA

- **mRNA (messenger RNA):** Single stranded, carries a copy of instructions for assembling amino acids into proteins. It is very unstable and comprises 5% of total RNA polymer. Prokaryotic mRNA (Polycistronic) carry coding sequences for many polypeptides. Eukaryotic mRNA (Monocistronic) contains information for only one polypeptide.
- **tRNA (transfer RNA):** Translates the code from mRNA and transfers amino acids to the ribosome to build proteins. It is highly folded into an elaborate 3D structure and comprises about 15% of total RNA. It is also called as **soluble RNA**.
- **rRNA (ribosomal RNA):** Single stranded, metabolically stable, make up the two subunits of ribosomes. It constitutes 80% of the total RNA. It is a polymer with varied length from 120–3000 nucleotides and gives ribosomes their shape. Genes for rRNA are highly conserved and employed for phylogenetic studies (Figure 8.46).



Messenger **RNA** (m**RNA**) Ribosomal **RNA** (r**RNA**) Transfer **RNA** (t**RNA**)

Figure 8.46: Types of RNA

Summary

- ❖ **Cells** are composed of water, inorganic compounds and organic molecules. The biomolecules of the cells include carbohydrates, lipids, proteins, enzymes and nucleic acids.
- ❖ **Carbohydrates** include simple sugars (monosaccharides) and polysaccharides. Polysaccharide serve as storage forms of sugar and structural components of cell.
- ❖ **Lipids** are the principle components of cell membrane, and they serve as energy storage and signalling molecules.
- ❖ **Proteins** are polymers of 20 different amino acids, each of which has a distinct side chain with specific chemical properties. Each protein has a unique aminoacid sequence which determines its 3D structure.
- ❖ **Nucleic acids** are the principle information molecules of the cell. Both DNA and RNA are polymers of purine and pyrimidine nucleotides. Hydrogen bonding between complementary base pairs allows nucleic acids to direct their self replication.

Evaluation

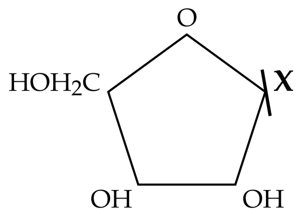
1. The most basic amino acid is
   a. Arginine
   b. Histidine
   c. Glycine
   d. Glutamine

2. An example of feedback inhibition is
   a. Cyanide action on cytochrome
   b. Sulpha drug on folic acid synthesiser bacteria
   c. Allosteric inhibition of hexokinase by glucose-6-phosphate
   d. The inhibition of succinic dehydrogenase by malonate

3. Enzymes that catalyse interconversion of optical, geometrical or positional isomers are
   a. Ligases
   b. Lyases
   c. Hydrolases
   d. Isomerases

4. Proteins perform many physiological functions. For example some functions as enzymes. One of the following represents an additional function that some proteins discharge:
   a. Antibiotics
   b. Pigment conferring colour to skin
   c. Pigments making colours of flowers
   d. Hormones

5. Given below is the diagrammatic representation of one of the categories of small molecular weight organic compounds in the living tissues. Identify the category shown & one blank component " X" in it



Category	**Compound**
Cholesterol	Guanine
Amino acid	NH_2
Nucleotide	Adenine
Nucleoside	Uracil

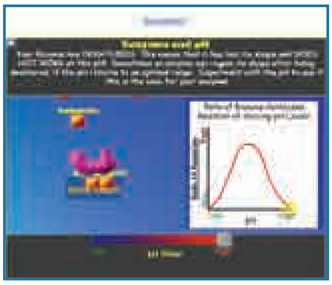
6. Distinguish between nitrogenous base and a base found in inorganic chemistry.
7. What are the factors affecting the rate of enzyme reaction?
8. Briefly outline the classification of enzymes
9. Write the characteristic feature of DNA
10. Explain the structure and function of different types of RNA

5TEKP3

ICT Corner

ENZYMES

Bio Catalyst →

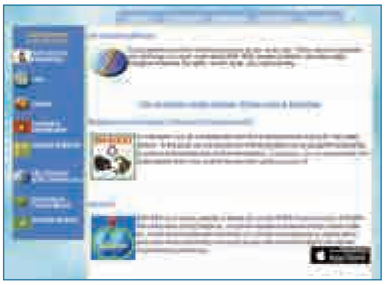


Steps

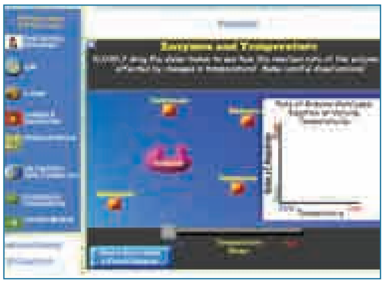
- Scan the QR code
- Click Enzymatic
- Start a new game
- Select yes if you using touch screen mobile / tablet
- Tap or click here
- Click experiments

Activity

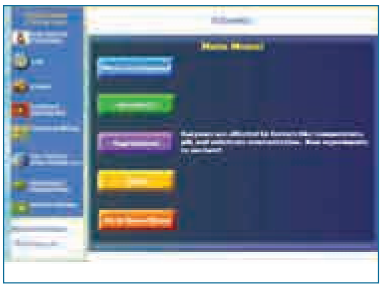
- Move the slide to change temperature
- Go to next concept
- Try Quiz after experiments



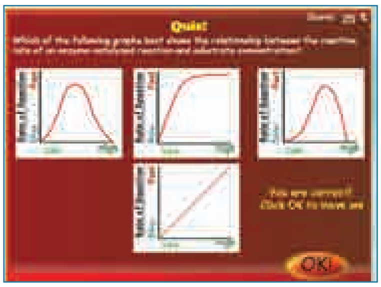
Step 1



Step 3



Step 2



Step 4

URL:

https://www.biomanbio.com/HTML5GamesandLabs/LifeChemgames/lifechem.html

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* Pictures are indicative only

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Glossary

Acetyl CoA	Small, water-soluble metabolite comprising an acetyl group linked to coenzyme A (CoA).
Active site	Region of an enzyme molecule where the substrate binds and undergoes a catalyzed reaction.
Akinetes	Thick walled, dormant, non motile asexual spores.
Aleurone	Outer layer of the endosperm
Anamorph	Asexual or imperfect state of fungi
Anisogamy	Fusion of morphologically and physiologically dissimilar gametes
Apogamy	Formation of sporophyte from the gametophytic tissue without the fusion of gametes.
Apospory	Development of the gametophyte from the sporophyte without the formation of spores
Balausto	Fleshy in dehiscent fruit
Basal body	Structure at the base of cilia and flagella from which microtubules forming the axoneme radiate
Biosphere	The region of earth on which life exist
Buffer	A solution of the acid and base form of a compound that undergoes little change in pH when small quantities of strong acid or base are added.
Carcinogen	Any chemical or physical agent that can cause cancer when cells or organism s are exposed to it.
Chemotaxonomy	Classification based on the biochemical constituents of plants
Clades	Group of species comprising common ancestor and its descendants
Cladistics	Methodology used to classify organisms into monophyletic group
Codon	Sequence of three nucleotides in DNA or mRNA that specifies a particular amino acid during protein synthesis; also called triplet
Coenocytic condition	Aseptate, multinucleate condition
Dalton	Unit of molecular mass approximately equal to the mass of a hydrogen atom (1.66 × 10–24 g)
Endosperm	Nutritive tissue for the embryo
Endospore	Thick walled, resting spores
Eusporangiate	Sporangium formed from a group of initials
Fossil	The remains or impression of plant or animal of the past geological age
Gametophyte	The haploid plant body
Genome	Complete set of genes in an organism
Germ	Protein rich embryo

Heterospory	Production of spores of different sizes: megaspores and microspores
Karyogamy	Fusion of nucleus
Karyotype	Number, sizes, and shapes of the entire set of metaphase chromosomes of a eukaryotic cell.
Km	A parameter that describes the affinity of an enzyme for its substrate and equals the substrate concentration that yields the half-maximal reaction rate;
Leptosporangiate	Sporangium formed from a single initial
Merosity	Number of parts per whorls
Microgreens	Young vegetable greens add flavour in culinary
Monograph	Complete account of a taxon of any rank
Monosulcate	Pollen grain with single furrow or pores
Mycobank	Online database documenting new mycological names
Nucleoid	Genetic material of bacterium
Oogamy	Fusion of morphologically and physiologically dissimilar gametes
Parthenocarphy	Fruit developed without fertilization
Pendulous	Hanging downward loosely or freely (like catkin)
Petrifaction	A process of fossil formation through infiltration of minerals over a long period
pH	A measure of the acidity or alkalinity of a solution defined as the negative logarithm of the hydrogen ion concentration in moles per liter
Phylogeny	Evolution of group of organisms
Pistillode	Sterile pistil
Plasmogamy	Fusion of cytoplasm
Pluriocular	An ovary with two or more locus
Prophage	The integrated phage DNA with host DNA
Protologue	Set of information associated with the scientific name of a taxon at its first valid publication containing the entire original material regarding the taxon
Rachilla	Central axis of a spikelet
Sporophyte	Diploid plant body
Telomorph	Sexual or perfect state of the fungi
Thallospores	Asedual spores formed due to the fragmentation of hyphae
Triplicate	Pollen grain with three furrows or pores
X-Ray crystallography	Most commonly used technique for determining the three-dimensional structure of macromolecules (particularly proteins and nucleic acids) by passing x-rays
Zoospore	Motile, asexual spores
Zygospore	Thick walled diploid resting spores

English – Tamil Terminology

Acropetal succession (arrangement)	நுனி நோக்கிய வரிசை
Aggregatte fruit	திரள் கனி
Akinetes	உறக்க நகராவித்து
Anamorph	பாலிலாநிலை
Anisogamy	சமமற்ற கேமீட்களின் இணைவு
Anthrophytes	பூக்கும் தாவரங்களின் முன்னோடிகள்
Apogamy	பாலிணைவின்மை
Apospory	குன்றலில்லா வித்துத்தன்மை
Arbitary marker	தன்னிச்சையான குறிப்பான்
Basipetal succession	அடி நோக்கிய வரிசை
Biosphere	உயிர்க்கோளம்
Buttress root	பலகை வேர்
Centrifugal	மையம் விலகியது
Centripetal	மையம் நோக்கியது
Cladogram	கிளை வரைபடம்
Coenocytic	பல்உட்கரு நிலை
Conjugation	இணைவு
Cotyledons	விதையிலைகள்
Dry dehiscent fruit	உலர் வெடிகனி
Dry indehiscent fruit	உலர் வெடியாக்கனி
Embryo	கரு
Endosperm	கருவூண்திசு
Endospores	அகவித்துகள்
Eukaryote	உண்மை உட்கரு உயிரி
Eusporangiate	உண்மை வித்தகத்தன்மை
Fossil	தொல்லுயிரெச்சம்
Funicle	சூல்காம்பு
Gametophyte	கேமீட்டக தாவரம்
Gene marker	மரபணு குறிப்பான்
Genome	மரபணுத் தொகுப்பு
Geocarpic fruit	புவிபுதை கனி/நிலத்தகத்துக் கனி
Geophytes	நிலத்தகத்துத் தூண்சேர் தாவரம்
Gynobasic	சூற்பை அடி சூலகத்தண்டு
Heterospory	மாற்று வித்தகத்தன்மை
Homeostasis	சமசீர் நிலை
Hydrochory	நீர்மூலம் பரவுதல்
Indeterminate	வரம்பற்ற வளர்ச்சி
Irritability	உறுத்துணர்ச்சி
Isogamy	ஒத்த கேமீட்களின் இணைவு
Karyogamy	உட்கரு இணைவு
Karyokinesis	காரியோகைனசிஸ்
Leaf primodium	இலைத்தோற்றுவி
Legume / Pod	விதைப்பை

Leptosporangiate	மெலி வித்தகத்தன்மை
Maturation promoting factor (MPF)	முதிர்ச்சியை ஊக்கப்படுத்தும் காரணி
Merosity	எண்ணிக்கை அமைவு
Metabolism	வளர்சிதைமாற்றம்
Middle Lamella	இடைமென் அடுக்கு
Monograph	தனிக்கட்டுரை
Multiple fruit	கூட்டுக்கனி
Mycobank	பூஞ்சை வங்கி
Nuclear envelope	நியூக்ளியர் உறை
Nuclear organizer	நியுக்ளியோலார் அமைப்பான்கள்
Nucleoid	உட்கரு ஒத்த அமைப்பு
Oogamy	முட்டை கருவுறுதல்
Pendulous	தொங்குகின்ற
Pericarp	கனி உறை
Petrification	கல்லாதல்
Pili or Fimbriae	நுண் சிலும்புகள்
Pistillode	மலட்டு சூலகம்
Plasmogamy	சைட்டோபிளாச இணைவு
Plumule	முளைக்குருத்து
Plurilocular	பல்லறை சூற்பை
Polymorphism	பலபடிவுடமை
Primary adapter	முதன்மை மாற்றி
Probe	ஆய்வி
Prokaryote	தொல்லுட்கரு உயிரி
Prophage	ஃபாஜ் முன்னோடி
Rachilla	சிறுகதிரின் மையஅச்சு
Radicle	முளை வேர்
Restriction site	வரையறு தளம்
Seed	விதை
Seed coat	விதை உறை
Serotaxonomy	ஊநீர் வகைப்பாட்டியல்
Sporophyte	வித்தகத்தாவரம்
Synaptonemal complex	சைனாப்டினிமல் தொகுதி
Systematics	முறைப்பாட்டு தாவரவியல்
Tandem repeat	ஒருசெயல நிகழும் மாறிகள்
Taxon	வகைப்பாட்டுத் தொகுதி
Teleomorph	பால்நிலை
Thallospores	உடல வித்துகள்
Transduction	மரபணு ஊடுகடத்தல்
Transformation	மரபணு மாற்றம்
True fruit	மெய்க்கனி
Zoospore	இயங்கு வித்து
Zygospore	உறக்க கருமுட்டை

Competitive Examination Questions

Unit – 1 Diversity of Living World

1. Which of the following are found in extreme saline conditions? (NEET-2017)
   a. Archaebacteria
   b. Eubacteria
   c. Cyanobacteria
   d. Mycobacteria

2. Select the mismatch (NEET – 2017)
   a. *Frankia* *Alnus*
   b. *Rhodospirillum* *Mycorrhiza*
   c. *Anabaena* *Nitrogen fixer*
   d. *Rhizobium* *Alfalfa*

3. Which among the following are the smallest living cells, known without a definite cell wall, pathogenic to plants as well as animals and can survive without oxygen? (NEET – 2017)
   a. *Bacillus* b. *Pseudomonas*
   c. Mycoplasma d. *Nostoc*

4. Read the following statements (A to E) and select the option with all correct statements (AIPMT – 2015)
   A. Mosses and Lichens are the first organisms to colonise a bare rock.
   B. *Selaginella* is a homosporous pteridophyte.
   C. Coralloid roots in *Cycas* have VAM.
   D. Main plant body in bryophytes is gametophytic, whereas in pteridophytes it is sporophytic.
   E. In gymnosperms, male and female gametophytes are present within sporangia located on sporophyte.
   a. B, C and E
   b. A, C and D
   c. B, C and D
   d. A, D and E

5. An example of colonial alga is (NEET – 2017)
   a. *Chlorella* **b. Volvox**
   c. *Ulothrix* d. *Spirogyra*

6. Five kingdom system of classification suggested by R.H. Whittaker is not based on (AIPMT – 2014)
   a. Presence or absence of a well defined nucleus
   b. Mode of reproduction
   c. Mode of nutrition
   d. Complexity of body organisation

7. Mycorrhizae are the example of (NEET – 2017)
   ` a. Fungitasis c. Amensalism
   b. Antibiosis **d. Mutualism**

8. Which of the following shows coiled RNA strand and capsomeres? (AIPMT – 2014)
   a. Polio virus
   b. Tobacco mosaic virus
   c. Measles virus
   d. Retrovirus

9. Viroids differ from viruses in having : (NEET – 2017)
   a. DNA molecules with protein coat
   b. DNA molecules without protein coat
   c. RNA molecules with protein coat
   d. RNA molecules without protein coat

10. Select the mismatch (NEET – 2017)
    a. *Pinus* — Dioecious
    b. Cycas — Dioecious
    c. *Salvinia* — Heterosporous
    d. *Equisetum* — Homosporous

11. Life cycle of *Ectocarpus* and *Fucus* respectively are (NEET – 2017)
    a. Haplontic, Diplontic
    b. Diplontic, Haplodiplontic
    c. Haplodiplontic, Diplontic
    d. Haplodiplontic, Halplontic

12. Zygote meiosis is characterisitic of (NEET – 2017)
    a. *Marchantia* b. *Fucus*
    c. *Funaria* **d. *Chlamydomonas***

13. Which of the following is correctly matched for the product produced by them? (NEET – 2017)
    a. *Acetobacter acetic* : Antibiotics
    b. *Methanobacterium* : Lactic acid
    c. *Penicillium notatum* : Acetic acid
    d. *Saccharomyces cerevisiae* : Ethanol

14. Which of the following components provides sticky character to the bacterial cell? (NEET – 2017)
    a. Cell wall b. Nuclear membrane
    c. Plasma membrane **d. Glycocalyx**

15. Which of the following statements is wrong for viroids? (NEET – 2016)
    a. They lack a protein coat
    b. They are smaller than viruses
    c. They causes infections
    d. Their RNA is a high molecular weight

16. In bryophytes and pteridophytes, transport of male gametes require (NEET – 2016)
    a. Wind b. Insects
    c. Birds **d. Water**

17. How many organisms in the list below are autotrophs? (AIPMT Mains 2012)
    Lactobacillus, Nostoc, Chara, Nitrosomonas, Nitrobacter, Streptomyces, Saccharomyces, Trypanosoma, Porphyra, Wolffia
    a. Four b. Five
    c. Six d. Three

18. Which of the following would appear as the pioneer organisms on bare rocks? (NEET – 2016)
    a. Lichens b. Liverworts
    c. Mosses d. Green algae

19. Monoecious plant of *Chara* shows occurrence of (NEET-2013)
    a. Stamen and carpel on the same plant
    b. Upper antheridium and lower oogonium on the same plant
    c. Upper oogonium and lower antheridium on the same plant
    d. Antheridiophore and archegoniophore on the same plant

20. Read the following five statement (A-E) and answer as asked next to them (AIPMT Prelims – 2012)
    a. In *Equisetum*, the female gametophyte is retained on the parent sporophyte
    b. In *Ginkgo*, male gametophyte is not independent
    c. The sporophyte in *Riccia* is more developed than that in *Polytrichum*
    d. Sexual reproduction in *Volvox* is isogamous
    e. The spores of slime moulds lack cell walls

    How many of the above statement are correct? (AIPMT Prelims – 2012)
    a. Two b. Three
    c. Four **d. One**

21 One of the major components of cell wall of most fungi is (NEET – 2016)
    a. Chitin b. Peptidoglycan
    c. Cellulose d. Hemicellulose

22. Which one of the following statements is wrong? (NEET – 2016)
    a. Cyanobacteria are also called blue-green algae
    b. Golden algae are also called desmids
    c. Eubacteria are also called false bacteria
    d. Phycomycetes are also called algal fungi

23. Flagellated male gametes are present in all the three of which one of the following sets? (AIPMT Prelims – 2007
    a. *Riccia, Dryopteris* and *Cycas*
    b. *Anthoceros, Funaria* and *Spirogyra*
    c. *Zygnema, Saprolegnia* and *Hydrilla*
    d. *Fucus, Marsilea* and *Calotropis*

24. Ectophloic siphonostele is found in (AIPMT Prelims – 2005)
    a. *Adiantum* and Cucurbitaceae
    b. *Osmunda* and *Equisetum*
    c. *Marsilea* and *Botrychium*
    d. *Dicksonia* and maiden hair fern

25. Which part of the tobacco plant is infected by *Meloidogyne incognita*? (NEET – 2016)
    a. Flower b. Leaf
    c. Stem **d. Root**

26. Select the correct statement (NEET – 2016)
    a. Gymnosperms are both homosporous and heterosporous
    b *Salvinia, Ginkgo* and *Pinus* all are gymnosperms
    c. *Sequoia* is one of the tallest trees
    d. The leaves of gymnosperms are not well adapted to extremes of climate

27. Seed formation without fertilization in flowering plants involves the process of (NEET – 2016)
    a. Sporulation
    b. Budding
    c. Somatic hybridization
    d. Apomixis

28. Chrysophytes, Euglenoids, Dinoflagellates and Slime moulds are included in the kingdom (NEET – 2016)
    a. Animalia **b, Monera**
    c. Protista d. Fungi

29. The primitive prokaryotes responsible for the production of biogas from the dung of ruminant animals, include the (NEET – 2016)
    a. Halophiles b. Thermoacidophiles
    c. Methanogens d. Eubacteria

Unit – 2 Plant Morphology and Taxonomy of Angiosperm

1. Leaves become modified into spines in [AIPMT-2015]
   a. Silk Cotton **b. *Opuntia***
   c. Pea d. Onion

2. Keel is the characteristic feature of flower of [AIPMT-2015]
   a. Tomato b. Tulip
   c. *Indigofera* d. *Aloe*

3. Perigynous flowers are found in [AIPMT-2015]
   a. Rose b. Guava
   c. Cucumber d. China rose

4. Which one of the following statements is correct [AIPMT-2014]
   a. The seed in grasses is not endospermic
   b. Mango is a parthenocarpic fruit

c. A proteinaceous aleurone layer is present in maize grain
d. A sterile pistil is called a staminode

5. An example of edible underground stem is [AIPMT-2014]
a. Carrot b. Groundnut
c. Sweet potato **d. Potato**

6. Placenta and pericarp are both edible portions in [AIPMT-2014]
a. Apple b. Banana
c. Tomato d. Potato

7. When the margins of sepals or petals overlap one another without any particular direction, the condition is termed as [AIPMT-2014]
a. Vexillary **b. Imbricate**
c. Twisted d. Valvate

8. An aggregate fruit is one which develops from [AIPMT-2014]
a. Multicarpellary syncarpous gynoecium
b. Multicarpellary apocarpous gynoecium
c. Complete inflorescence
d. Multicarpellary superior ovary

9. Non-albuminous seed is produced in [AIPMT-2014]
a. Maize b. Castor
c. Wheat **d. Pea**

10. Seed coat is not thin, membranous in [NEET-2013]
a. Coconut b. Groundnut
c. Gram d. Maize

11. In china rose the flower are [NEET-2013]
a. Actinomorphic. Epigynous with valvate aestivation
b. Zygomorphic, hypogynous with imbricate aestivation
c. Zygomorphic, epigynous with twisted aestivation
d. Actinomorphic, hypogynous with twisted aestivation

12. Placentation in tomato and lemon is [AIPMT Prelims-2012]
a. Marginal **b. Axile**
c. Parietal d. Free central

13. Vexillary aestivation is characteristic of the family [AIPMT Prelims-2012]
a. Solanaceae b. Brassicaceae
c. Fabaceae d. Asteraceae

14. Phyllode is present in [AIPMT Prelims-2012]
a. Australian *Acacia* b. *Opuntia*
c. *Asparagus* d. *Euphorbia*

15. How many plants in the list given below have composite fruits that develop from an inflorescence? Walnut, poppy, radish, pineapple, apple, tomato. [AIPMT Prelims-2012]
a. Two **b. Three**
c. Four d. Five

16. Cymose inflorescence is present in [AIPMT Prelims-2012]
a. *Trifolium* b. *Brassica*
c. *Solanum* d. *Sesbania*

17. Which one of the following organism is correctly matched with its three characteristics? [AIPMT Mains -2012]
a. Pea : C3 pathway, Endospermic seed, Vexillary aestivation
b. Tomato : Twisted aestivation, Axile placentation, Berry
c. Onion: Bulb, Imbricate aestivation, Axile placentation
d. Maize : C3 pathway, Closed vascular bundles, scutellum

18. How many plants in the list given below have marginal placentation?
Mustard, Gram, Tulip, *Asparagus*, Arhar, sun hemp, Chilli, *Colchicine*, Onion, Moong, Pea, Tobacco, Lupin [AIPMT Mains -2012]
a. Four b. Five
c. Six d. Three

19. The Eyes of the potato tuber are [AIPMT Prelims-2011]
a. Axillary buds b. Root buds
c. Flower buds d. Shoot buds

20. Which one of the following statements is correct? [AIPMT Prelims-2011]
a. Flower of tulip is a modified shoot
b. In tomato, fruit is a capsule
c. Seeds of orchids have oil – rich endosperm
d. Placentation in primrose is basal

21. A drup develops in [AIPMT Prelims-2011]
a. Tomato **b. Mango**
c. Wheat d. Pea

Unit 3 Cell biology and Biomolecules

1. Who invented electron microscope? (2010 AIIMS, 2008 JIPMER)
a. Janssen b. Edison
c. Knoll and Ruska d. Landsteiner

2. Specific proteins responsible for the flow of materials and information into the cell are called (2009 AIIMS)
a. Membrane receptors
b. carrier proteins
c. integeral proteins
d. none of these

3. Omnis-cellula-e-cellula was given by (2007 AIIMS)
a. Virchow b. Hooke
c. Leeuwenhoek d. Robert Brown

4. Which of the following is responsible for the mechanical support, protein synthesis and enzyme transport (2007 AIIMS)
a. cell membrane
b. mitochondria
c. dictyosomes
d. endoplasmic reticulum

5. Genes present in the cytoplasm of eukaryotic cells are found in (2006 AIIMS)
a. mitochondria and inherited via egg cytoplasm
b. lysosomes and peroxisomes
c. Golgi bodies and smooth endoplasmic reticulum
d. Plastids inherited via male gametes

6. In which one the following would you expect to find glyoxysomes(2005 AIIMS)
a. Endosperm of wheat
b. endosperm of castor
c. Palisade cells in leaf
d. Root hairs

7. A quantosome is present in (JIPMER 2012)
a. Mitochondria **b. Chloroplast**
c. Golgi bodies d. ER

8. In mitochondria the enzyme cytochrome oxidase is present in (2012 JIPMER)
a. Outer mitochondrial membrane
b. inner mitochondrial membrane
c. Stroma d. Grana

9. Which organelle is present in higher number in secretory cell (2008 JIPMER)
a. Mitochondria b. Chloroplast
c. Nucleus **d. Dictyosomes**

10. Major site for the synthesis of lipids (2013 NEET)
a. Rough ER **b. smooth ER**
c. Centriole d. Lysosome

11. Golgi complex plays a major role in. (2013 NEET)
    a. post translational modification of proteins and glycosidation of lipids
    b. translation of proteins
    c. Transcription of proteins
    d. Synthesis of lipid

12. Main arena of various types of activities of a cell is (2010 AIPMT)
    a. Nucleus b. Mitochondria
    c. Cytoplasm d. Chloroplast

13. The thylakoids in chloroplast are arranged in (2005 JIPMER)
    a. regular rings b. linear array
    c. diagonal direction **d. stacked discs**

14. Sequences of which of the following is used to know the phylogeny (2002 JIPMER)
    a. mRNA **b. rRNA** c. tRNA d. Hn RNA

15. Structures between two adjacent cells which is an effective transport pathway- (2010 AIPMT)
    a. Plasmodesmata
    b. Middle lamella
    c. Secondary wall layer
    d. Primary wall layer

16. In active transport carrier proteins are used, which use energy in the form of ATP to
    a. transport molecules against concentration gradient of cell wall
    b. transport molecules along concentration gradient of cell membrane
    c. transport molecules against concentration gradient of cell membrane
    d. transport molecules along concentration gradient of cell wall

17. The main organelle involved in modification and routing of newly synthesised protein to their destinations is (AIPMT 2005)
    a. Mitochondria
    b. Glyoxysomes
    c. Spherosomes
    d. Endoplasmic reticulum

18. Algae have cell wall made up of (AIPMT 2010)
    a. Cellulose, galactans and mannans
    b. Cellulose, chitin and glucan
    c. Cellulose, Mannan and peptidoglycan
    d. Muramic acid and galactans

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This book has been printed on 80 G.S.M.
Elegant Maplitho paper.

Printed by offset at: