CELL BIOLOGY

THE CELL - BASIC UNIT OF LIFE

- A cell is a structural and functional unit of all living organisms.
- Organisms contain organs, organs composed of tissues, tissues are made up of cells; and cells are formed of organelles and organelles are made up of molecules.
- Loewy and Siekevitz defined cell as a unit of an organism delimited by a plasma membrane in animal cells and cell wall and plasma membrane in plant cells. Thus cell forms the basic unit of life.
- Anton van Leewenhoek (1632-1723) studied the structure of bacteria, protozoa spermatozoa, red blood cells under the simple microscope which he examined under a simple microscope.
- The word cell was first coined by Robert Hooke in 1665 to designate the empty honey-comb like structures viewed in a thin section of bottle cork which he examined.
- In 1838, the German botanist Schleiden proposed that all plants are made up of plant cells.
- Theodore Schwann studied and concluded that all animals are also composed of cells.
- Cell theory was again rewritten by Rudolf Virchow in 1858.
- Robert Brown in 1831 discovered the presence of nucleus in the cells of orchid roots.
- Purkinje coined the term protoplasm for the slimy substance that is found inside the cells.
- On the basis of the structure, the cells are classified into prokaryotic and eukaryotic cells.
- The smallest cells are found among bacteria (0.2 to 0.5 microns). The largest plant cell is the ovule of Cycas.
- The DNA is constantly read out into a particular set of mRNA (transcription) which specify a particular set of proteins (translation).
- As these proteins function they are being degraded and replaced by new ones and the system is so balanced that the cell neither grows, shrinks, nor changes its function.

DIFFERENCES BETWEEN PLANT AND ANIMAL CELL

Plant cell	Animal cell
Plant cell has outer rigid cell wall, made up of cellulose	Cellwall is absent. Plasma membrane is the outermost covering.
Plant cell has a distinct, definite shape because of the rigid cell wall. So, the shape of cell in permanent.	The shape of the animal cell is not so definite. It can change its shape.
Plant cell contains plastids. Most important of this is the green chloroplast.	Plastids are absent.
Vacuoles are fewer and larger.	Vacuoles are either absent or very small in number and size.
Centrosome is present only in the cells of some lower plants.	All the animal cells have centrosomes
Dictyosome (Golgi complex) is dispersed through out the cytoplasm. It comprises stacks of single membranous lamellar discs.	Golgi complex is organized in the cytoplasm. It appears as shallow saucer shaped body or narrow neck bowl - like form. It consists of interconnecting tubules in distal region.
Lysosomes are found only in the eukaryotic plant cells.	Found in all cells.
Plant cell is larger than the animal cell.	Animal cell is small in size.
Mostly, starch is the storage material.	Glycogen is the storage material
During cytoplasmic division a cell plate is formed in the centre of the cell.	During cytoplasmic division a furrow appears from the periphery to the centre of the cell.

- In the cell cycle DNA is duplicated during synthesis (S) Phase and the copies are distributed to daughter cells during mitotic (M) phase.
- Programmed Cell Death (PCD) plays a very important role by balancing cell growth and multiplication. In addition, cell death also eliminates unecessary cells.

CELL THEORY

- In the year (1839) Schleiden and Schwann have jointly proposed the "Cell Theory"

The important aspects of cell theory are:

1. All living organisms are made up of minute units, the cells which are the smallest entities that can be called living.
2. Each cell is made up of protoplasm with a nucleus and bounded by plasma membrane with or without a cell wall.
3. All cells are basically alike in their structure and metabolic activities.
4. Function of an organism is the sum total of activities and interaction of its constituent cells.

Exception to cell Theory

1. Viruses are biologists' puzzle. They are an exception to cell theory. They lack protoplasm, the essential part of the cell.
2. Bacteria and cyanobacteria (Blue Green algae) lack well organized nucleus.
3. Some of the protozons are acellular.
4. The coenocytic hyphae of some fungi eg. Rhizopus have undivided mass of protoplasm, in which many nuclei remain scattered.
5. Red Blood Corpuscles (RBC) and mature sieve tubes are without nuclei.

Cell Principle or Cell Doctrine

The important features of cell doctrine are:

1. All organisms are made up of cells.
2. New cells are produced from the pre-existing cells.
3. Cell is a structural and functional unit of all living organisms.
4. A cell contains hereditary information which is passed on from cell to cell during cell division.
5. All the cells are basically the same in chemical composition and metabolic activities.
6. The structure and function of the cell are controlled by DNA.
7. Sometimes the dead cells may remain functional as tracheids and vessels in plants and horny cells in animals.

PROKARYOTIC AND EUKARYOTIC CELL (PLANT CELLS)

- These plasmids are very much used in genetic engineering where the plasmids are separated and reincorporated, genes (specific pieces of DNA) can be inserted into plasmids, which are then transplanted into bacteria using the techniques of genetic engineering. peroxysomes, in which fatty acids and amino acids are degraded.
- The cytosol of eukaryotic cells contains an array of fibrous proteins collectively called the cytoskeleton.

The differences between Prokaryotes and Eukaryotes

Size	Prokaryotes	Eukaryotes
General	Most of them are very small. Some are larger than 50 μ m.	Most are large cells (10-100μm). Some are larger than 1 mm.
Characteristics	All are microbes. Unicellular or colonial. The nucleoid is not membrane bound.	Some are microbes; most are large organisms. All possess a membranebound nucleus.
Cell Division	No mitosis or meiosis. Mainly by binary fission or budding.	Mitosis and meiosis types of cell division occur.
Sexual system	Absent in most forms, when present unidirectional altrans fero genetic material from donor to recipient.	Present in most forms, equal male and female participation in fertilization.
Development	No multi-cellular development from diploid zygotes. No extensive tissue differentiation.	Haplo id forms are produced by meiosis and diploid from zygotes. Multicellular organisms show extensive tissue differentiation.
Flagella Type	Some have simple bacterial flagella composed of only one fibril.	Flagella are of 9 + 2 type
Cell Wall	Madeup of peptidoglycan (mucopeptide). Cellulose is absent.	Cell wall is madeup of cellulose in plants and chitin in fungi.
Organelles	Membrane bound organelles such as endoplasmic reticulum, golgi complex, mitochondria, chloroplasts and vacuoles are	Membrane bound organelles such as endoplasmic reticu lum, golgi complex, mitochondria,

	absent.	chloroplastsand vacuoles are present.
Ribosomes	Ribosomes are smaller made of 70s units (s refers to Svedberg unit, these dimentation coefficient of a particle in the ultra centrifuge).	Ribosomes are larger and made of 80s units.
DNA	Genetic material (DNA) is not found in well-organized chromosomes.	Genetic material is found in well organized chromosomes.

CELL WALL

1. The cells of all plants, bacteria and fungi have a rigid, protective covering outside the plasma membrane called cell wall.
2. Among the vascular Plants ,only certain cells connected with the reproductive processes, are naked, all other cells have walls.

Chemical Composition

- In bacteria the cell wall is composed of peptidoglycan, in Fungi it is made up of chitin.
- The plant cell wall is made up of cellulose. Besides cellulose certain other chemicals such as hemicellulose, pectin, lignin, cutin, suberin, silica may also be seen deposited on the wall.

Functions of cell wall

1. It gives definite shape to the cell.
2. It protects the internal protoplasm against injury.
3. It gives rigidity to the cell
4. It prevents the bursting of plant cells due to endosmosis.
5. The walls of xylem vessels, tracheids and sieve tubes are specialized for long distance transport.
6. In many cases, the cell wall takes part in offense and defencse.

CELL MEMBRANE

- All the prokaryotic and eukaryotic cells are enclosed by an elastic thin covering called plasma membrane.

- ❖ It is selectively permeable since it allows only certain substances to enter or leave the cell through it.
- ❖ In addition to this eukaryotic cells possess intracellular membranes collectively called cytoplasmic membrane system, that surround the vacuole and cell organelles.
- ❖ Plasma membrane and the sub-cellular membranes are together known as biological membranes.

Structure of cell Membrane

1. About 75 A thick
2. The Outer and inner layers are formed of protein molecules where as the middle one is composed of two layers of phospholipid molecules.

Fluid Mosaic Model

- ❖ It explains the molecular structure of plasma membrane.

Functions of plasma membrane

- ❖ Transporting nutrients into and metabolic wastes out of the cell. Preventing unwanted materials from entering the cell. In short, the intercellular and intra cellular transport is regulated by plasma membrane.
- ❖ The plasma membrane maintains the proper ionic composition pH(~7.2) and osmotic pressure of the cytosol.

Membrane Transport:

Substances are transported across the membrane either by:

1. Passive Transport or
2. Active Transport

PASSIVE TRANSPORT

Physical processes

- ❖ Passive Transport of materials across the membrane requires no energy by the cell and it is unaided by the transport proteins.
- ❖ The physical processes through which substances get into the cell are
  1. Diffusion 2. Osmosis

Diffusion

- Diffusion is the movement of molecules of any substance from a region of it's higher to a region of it's lower concentration.
- This can be described as 'down hill transport'. Diffusion through the bio membrane takes place in two ways.

Osmosis

- It is the special type of diffusion where the water or solvent diffuses through a selectively permeable membrane from a region of high solvent concentration to a region of low solvent concentration.

Role of Osmosis

1. It helps in absorption of water from the soil by root hairs.
2. Osmosis helps in cell to cell movement of water.
3. Osmosis helps to develop the turgor pressure which helps in opening and closing of stomata. (For more about Osmosis see unit 5.4)

Active transport

- It is vital process. It is the movement of molecules or ions against the concentration gradient. i.e the molecules or ions move from the region of lower concentration towards the region of higher concentration.
- The movement of molecules can be compared with the uphill movement of water.

Endocytosis and exocytosis

- Endocytosis and exocytosis are active processes involving bulk transport of materials through membranes, either into cells(endocytosis) or out of cells (exocytosis).

CELL ORGANELLES

- All eukaryotic cells contain a membrane bound nucleus and numerous other organelles in their cytosol.
- A Typical plant cell contains the following organelles and parts:

Mitochondria

1. They are bounded by two membranes with the inner one extensively folded.
2. Enzymes in the inner mitochondrial membrane and central matrix carry out terminal stages of sugar and lipid oxidation coupled with ATP synthesis.

Plastids

- Plastids are the largest cytoplasmic organelles bounded by double membrane. These are found in most of the plant cells and in some photosynthetic protists. These are absent in prokaryotes and in animal cells. Plastids are of three types namely **chloroplasts, Chromoplasts** and **leucoplasts.**

Chloroplasts

- Chloroplasts can be as long as 10mm and are typically 0.5-0.2mm thick but they vary in size and shape in different cells, especially among the algae.
- They are the sites of Photosynthesis. They are found only in plant cells. They are surrounded by an inner and outer membrane, a complex system of thylakoid membranes in their interior contains the pigments and enzymes that absorb light and produce ATP.
- Chromoplasts are coloured plastids other than green. They are found in coloured parts of plants such as petals of the flower, pericarp of the fruits etc.

Leucoplasts

- Leucoplasts are the colourless plastids. These colourless plastids are involved in the storage of carbohydrates, fats and oils and proteins. The plastids which store carbohydrates are called amyloplasts. The plastids storing fats and oils are called elaioplasts. The plastids storing protein are called proteinoplasts.

Nucleus

- It is surrounded by an inner and outer membrane. These contain numerous pores through which materials pass between the nucleus and cytosol.
- The outer nuclear membrane is continuous with the rough endoplasmic reticulum.
- The nuclear membrane resembles the plasma membrane in its function. The nucleus mainly contains DNA organized into linear structures called chromosomes.

Endoplasmic reticulum

- These are a network of inter connected membranes. Two types of Endoplasmic Reticulum are recognised.
  1. Rough E.R
  2. Smooth E.R

Rough ER

- The endoplasmic reticulum is responsible for protein synthesis in a cell. Ribosomes are sub organelles in which the amino acids are actually bound together to form proteins.
- There are spaces within the folds of ER membrane and they are known as Cisternae.

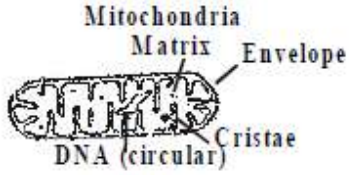
Smooth ER

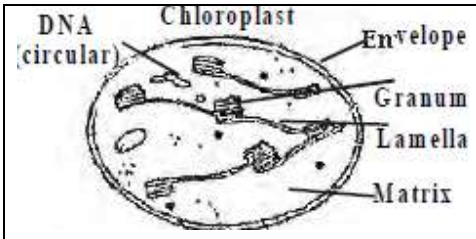
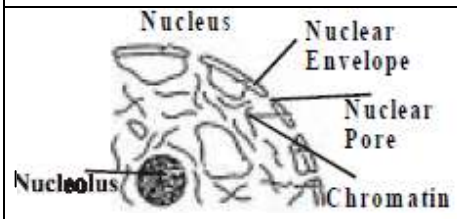
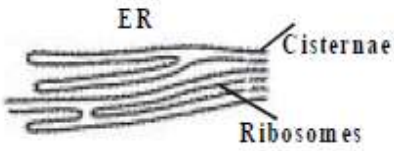
- This type of ER does not have ribosomes.

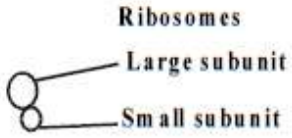
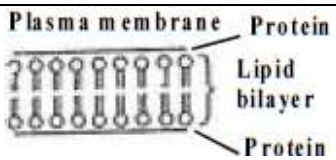
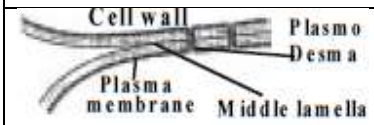
Three researchers, who made the crystal structure of the ribosomes received the Nobel Prize for chemistry in the year 2009. Venkatraman Ramakrishnan, an Indian born U.S.A scientist. Thomas Steitz U.S.A and Ada Yoath of Isrel.

Vaculoes

1. The vacuoles form about 75% of the plant cell. In the vacuole the plant stores nutrients as well as toxic wastes.
2. If pressure increases within the vacuole it can increase the sing of the cell. In this case the cell will become swollen. If the pressure increases further the cell will get destroyed.

Diagram	Structure	Functions
	It has an envelope made up of two membranes; the inner is folded to form cristae. Matrix with ribosomes is present. A circular DNA is also there.	Cristae are the sties of oxidative phosphorylation and electron transport, Matrix is the site of Krebs' cycle reactions.

	It has an envelope made up of two membranes. Contains gel like stroma and a system of membranes called grana. Ribosomes and a circular DNA are present in the stroma.	Photosynthesis takes place here. It is a process in which light energy is converted into chemical energy.
	It has an envelope made up of two membranes. They have nuclear pores. It contains nucleolus and chromantin.	Nuclear division is the basis of cell replication and thus reproduction. Chromosomes contain DNA, the molecule responsible for inheritance.
	Structure: Consists of membrane – bounded sacs called cisternae.	Smooth ER, (no ribosomes) is the site of lipid synthesis. Rough ER (with ribosomes) transports proteins made by the ribosomes through the cisternae.
	It is formed by a stack of flattened membrane bound sacs, called cisternae.	Often involved in secretion.
Vacuoles	It is bounded by a single membrane called the tonoplast. It contains cell sap.	Stores various substances including waste products. It helps in the osmotic properties of the cell.

	It consists of a large and a small sub unit. They are made of protein and RNA. Ribosome are found in mitochondria and chloroplasts also. They may form polysomes i.e. collection of ribosomes strung along messenger RNA.	They are the sites of protein synthesis.
	Two layers of lipid (bilayer) sandwiched between two protein layers.	Being a differentially permeable membrane it controls the exchange of substances between the cell and its environment
	Spherical organelle bound by a single membrane	They are the sites of glyoxylate cycle in plants.
	It consists of cellulose microfibrils in a matrix of hemicellulose and pectic substances. Secondary thicking may be seen.	It provides mechanical support and protection.

Golgi Apparatus

The electron microscopic observation of Golgi bodies reveals the presence of three membranous components, namely,

1. Disc shaped group of flattened sacs or cisternae
2. Small vesicles
3. Large vacuoles.

Functions

1. It produces secretory vesicles like zymogen granules that may have enzymes inside.
2. It forms the certain yolk substances in the developing oocytes.
3. It helps in retinal pigment formation in the retinal cells.
4. It helps in the formation of acrosome in sperm cells.

Lysosomes

- Lysosomes are kind of waste disposal system of the cell.
- Lysosomes originate either from the Golgi apparatus or directly from the endoplasmic reticulum. Each lysosome is a round structure. It is filled with a dense material.

Functions

1. Lysosomes help to keep the cell clean by digesting any foreign material as well as worn out cell organelles.
2. When the cell gets damaged lysosomes may burst and the enzymes digest their own cell.
3. Therefore lysosomes are also known as suicidal bags of a cell.

Mitochondria

- In the cytoplasm of most cells, large size filamentous, rounded or rodlike structure known as mitochondria may be seen. The mitochondria are bounded by two membranes made of proteins.
- The outer membrane forms a bag like structure around the inner membrane which gives out many finger like folds on the lumen of the mitochondria. The folds of inner mitochondrial membrane are known as cristae.
- Are self perpetuating semi-autonomous bodies.

Function

1. Mitochondria are considered to be the power houses of the cell because they are the seat of cellular respiration.
2. They also synthesize the energy rich compound ATP- Adinosine Tri Phosphate.

Ribosomes

- Ribosomes are found in all cells, both prokaryotic and eukaryotic except in mature sperm cells and RBCs.
- In eukaryotic cells they occur freely in the cytoplasm and also found attached to the outer surface of rough ER.
- Ribosomes are the sites of protein synthesis.

Centrioles

- Centrioles were first described by Henneguy and Leuhossek in 1897.
- The Centrioles are micro tubular structures, found in two shapes-rod shaped and granules located near the nucleus of animal cell.
- At the time of cell division, the centrioles produce the spindle fibres and astral bodies. They also decide the plan of cell division.

Nucleus

- Nucleus is the most obvious sub cellular organelle. It is round or oval in outline and possesses four parts. They are :
  1. Nuclear Membrane
  2. Nucleoplasm
  3. Chromatin Reticulum
  4. Nucleolus
- The nuclear membrane is the outer delicate covering of the nucleus.
- It contains pores of different dimensions.
- The nucleoplasm is the protoplasmic substance of the nucleus. It is also known as nuclear sap.
- Chromatin Reticulum is composed of a network with highly elongated chromatin threads which overlap one another and are embedded in the nucleoplasm.
- At the time of the cell division, the chromosomes become clearly visible.
- The nucleolus is generally present in the nucleus of most of the cells.
- The nucleolus become enlarged during active period of cell division and are less developed in quiescent stage. It is often called as cell organizer

Functions

1. It controls all metabolic processes and hereditary activities of the cell.
2. The nuclear membrane allows exchange of ions between nucleoplasm and cytoplasm.

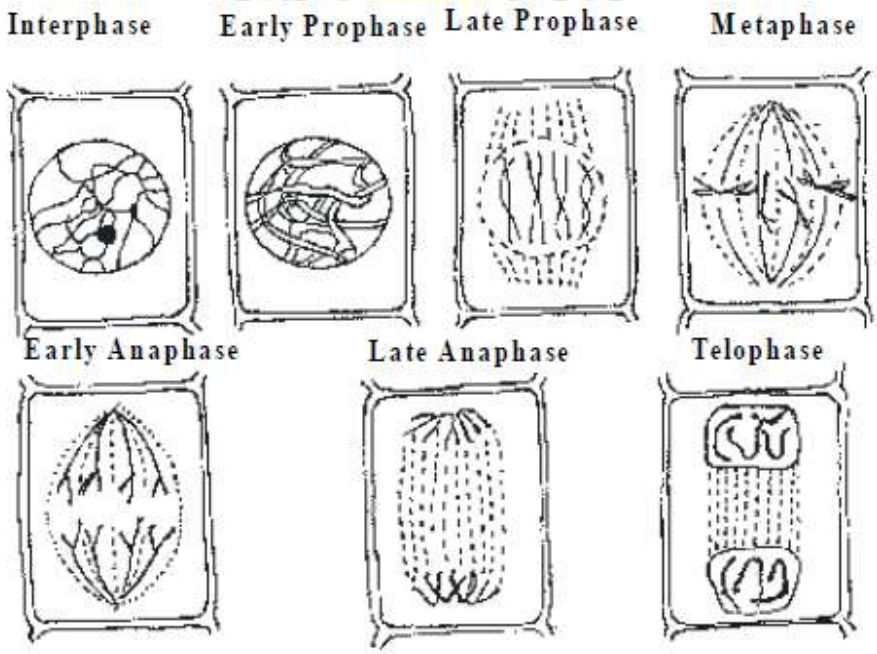
CELL DIVISION

- A matured cell divides into two daughter cells. Unicellular animalcules like amoeba, undergo binary fission without any change in the chromatin reticulum by a type of cell division called Amitosis.
- Body cells of all animals and plants undergo a cell division called Mitosis, involving changes in the structure of chromosomes, but without any change in the chromosomal number.
- The germinal epithelial cells of animals undergo Meiosis cell division, involving changes in the structure and number of chromosomes.

Mitosis

Mitosis is divided into the following 4 sub stages.

1. **Prophase** **2. Metaphase** **3. Anaphase** **4. Telophase**



Mitosis – Equational Cell Division

Prophase

- The chromatin network begins to coil and each chromosome becomes distinct as long thread like structure. Each chromosome at this stage has two chromatids that lie side by side and held together by centromere. The nucleus gradually disappears. The nuclear membrane also starts disappearing.

Metaphase

- The disappearance of nuclear membrane and nucleolus marks the beginning of metaphase. The chromosomes become shorter by further coiling. Finally, the chromosomes become distinct and visible under the compound microscope. The chromosomes orient themselves in the equator of the cell in such a way that all the **centromeres** are arranged in the equator forming metaphase plate or equatorial plate. Out of the two chromatids of each chromosome, one faces one pole and the other one faces the opposite pole. At the same time spindle fibres arising from the opposite poles are seen attached to the centromeres. The fibres are made up of proteins rich in sulphur containing amino acids.
- At late metaphase, the **centromeres divide** and now the chromatids of each chromosome are ready to be separated.

Anaphase

- Division of centromere marks the beginning of anaphase. The spindle fibres start contracting and this contraction pulls the two groups of chromosomes towards the opposite poles. As the chromosomes move toward opposite poles they assume **V or J** or **I** shaped configuration with the centromere proceeding towards the poles with chromosome arms trailing behind. Such variable shapes of the chromosomes are due to the variable position of centromere.

Telophase

- At the end of anaphase, chromosomes reach the opposite poles and they uncoil, elongate and become thin and invisible. The nuclear membrane and the nucleolus reappear. Thus, two daughter nuclei are formed, one at each pole.

Cytokinesis

- The division of the cytoplasm is called cytokinesis and it follows the nuclear division by the formation of cell wall between the two daughter nuclei. The formation of cell wall begins as a cell plate also known as **phragmoplast** formed by the aggregation of vesicles produced by Golgi bodies. These vesicles which contain cell wall materials fuse with one another to form cell membranes and cell walls. Thus, at the end of mitosis, **two identical** daughter cells are formed.

Significance of Mitosis

1. As a result of mitosis two daughter cells which are identical to each other and identical to the mother cell are formed.
2. Mitotic cell division ensures that the daughter cells possess a genetical identity, both quantitatively and qualitatively.
3. Mitosis forms the basis of continuation of organisms.
4. Asexual reproduction of lower plants is possible only by mitosis.
5. Vegetative reproduction in higher plants by grafting, tissue culture method are also a consequence of mitosis.
6. Mitosis is the common method of multiplication of cells that helps in the growth and development of multi- cellular organism.
7. Mitosis helps in the regeneration of lost or damaged tissue and in wound healing.
8. The chromosomal number is maintained constant by mitosis for each species.

Meiosis

- Meiosis is a kind of cell division, which occurs in the germinal epithelial cells of the gonads to form the gametes.
- Meiosis takes place in the specialized diploid cells of gonads and produces four haploid gametes, each having half the number of chromosomes as compared to the parent cell.
- Meiosis is completed in two successive divisions – Meiosis-I and Meiosis-II. In Meiosis-I, as the chromosomal number is reduced to half, it is called Reduction division. Meiosis-II is similar to Mitosis.

Meiosis - I

- The various events of Meiosis-I are studied under four substages namely Prophase-I, Metaphase-I, Anaphase-I and Telophase-I.

Prophase - I

- The chromatin reticulum unwebs and individual chromosomes are liberated from one another.
- The nuclear membrane dissolves. The chromosomes undergo, marked differences in their shape and structure.
- Based on the shape of the chromosomes, this stage is studied under five sub-divisions as Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.

Leptotene

- The chromosomes condense and appear like threads. Each chromosome splits up longitudinally, except at the centromere.

Zygotene

- The homologous chromosomes come closer and start pairing. (A homologous pair of chromosomes consist of a paternal chromosome and maternal chromosome with similar genes).
- The pairing starts from the tip or from the middle and get attached laterally throughout the length.
- This pairing is called Synapsis, the paired chromosomes are called Bivalents.

Pachytene

- The paired chromosomes become shorter and thicker. Each bivalent appears to have four strands called as, tetrads or quadrivalents.
- The point of contact between the homologous pair of chromosomes are called, Chiasmata.
- At the point of chiasmata, exchange of chromosomal segment takes place, between the chromatids of the homologous pairs.
- This exchange of segments of chromatids between homologous chromosomes, is called crossing over.

Diplotene

- After the crossing over is completed, the homologous chromosomes separate and this separation is called terminalization.
- Terminalization may begin in chiasmata and move to the terminal end of the chromosomes.

Diakinesis

- The nuclear membrane and the nucleolus disappear. The spindle apparatus is formed in the cytoplasm.

Metaphase - I

- The chromosomes get condensed. Bivalents now appear on the equator of the spindle with their chromatids, pointing towards the equatorial plate and the centromere pointing towards the poles.

Anaphase - I

- The spindle fibres contract pulling the chromosomes, towards the opposite poles.
- The entire chromosome, with the two chromatids move to the opposite poles. This involves, a reduction in the number of chromosomes. Now two groups of chromosomes are produced, one at each pole with half the number of chromosomes.

Telophase - I

- At the poles, around the group of chromosomes, a nuclear membrane develops. Thus two daughter nuclei each with half the number of chromosomes, are formed at the poles. The spindle fibres disappear.
- At the end of Meiosis-I at right angle to the position of the nuclei, the cytoplasmic constriction takes place leading to the division of the cell. The cytoplasmic division is called Cytokinesis.

Meiosis - II

- Meiosis-II is similar to Mitosis and so it is called Meiotic Mitosis. The events of Meiosis-II are studied in four sub-divisions as, Prophase-II, Metaphase-II, Anaphase- II and Telophase-II.

Prophase - II

- The bivalent chromosomes gets shortened. The centrioles form asters and move to the poles. The nucleolus and nuclear membrane disappear.

Metaphase - II

- Chromosomes, each consisting of two chromatids held together by a centromere are arranged at the equator of the spindle fibres. The centromeres are attached with the spindle fibres.

Anaphase - II

- The centromere divides into two and the two chromatids separate and now they are called as daughter chromosomes or new chromosomes. The daughter chromosomes move towards the opposite poles.

Telophase - II

- The haploid set at the two poles coil to form chromatin material. The nuclear membrane and nucleolus reappear. Thus two daughter nuclei are formed.

Cytokinesis

- The cytoplasmic division takes place at right angles to the position of the nuclei, resulting in the formation of four gametes.

Significance of Meiosis

1. Haploid sex cells are produced, in order to maintain the constancy in the number of chromosomes of a species.
2. Crossing over results in variation of genetic traits in the offspring.
3. Variations form the raw material for evolution.

CLASSIFICATION OF LIVING ORGANISM

SYSTEMATICS

- The branch of biology dealing with identification, naming and classifying the living organisms is known as Taxonomy.
- Taxonomy in Greek means rendering of order. The word Systematics means to put together.
- It was Carolus Linnaeus who used this word first in his book 'Systema Naturae'. Systematic s may be defined as the systematic placing of organisms into groups or taxa on the basis of certain relationships between organisms.

History of Classification

- Hippocrates (460-377 BC), the Father of Medicine listed organisms with medicinal value. Aristotle and his student Theophrastus (370-282 BC) made the first attempt to classify organisms without stressing their medicinal value.
- They tried to classify the plants and animals on the basis of their form and habitat.
- It was followed by Pliny the Elder (23-79 AD) who introduced the first artificial system of classification in his book 'Historia Naturalis'.
- John Ray an English naturalist introduced the term species for the first time for any kind of living things.
- It was then Carolus Linnaeus the Swedish naturalist of 18th century now known as Father of Taxonomy developed the Binomial System of nomenclature which is the current scientific system of naming the species.

- In his famous book 'Species Plantarum'(1753) he described 5,900 species of plants and in "systema Naturae'(1758) he described 4200 species of animals.
- Augustin- Pyramus de Candolle(1778-1841) who coined the word Taxonomy

The seven main categories used in any plan of classification are given below:

1. Kingdom
2. Phylum or Division
3. Class
4. Order
5. Family
6. Genus
7. Species

Two Kingdom System of Classification

- Carolus Linnaeus (1758) divided all the living organisms into two kingdoms.
  1. Kingdom Plantae
  2. Kingdom Animalia

Kingdom Plantae:

This kingdom includes bacteria (Prokaryotes), photosynthetic plants and non - photosynthetic fungi. The characteristic features of this kingdom are:

1. Plants have branches, asymmetrical body with green leaves.
2. Plants are non motile and fixed in a place.
3. During the day time plants more actively involve in photosynthesis than in respiration and hence take more of CO_2 and liberate O_2 & during night O_2 is taken in and CO_2 is liberated.
4. They are autotrophic in their mode of nutrition since they synthesize their own food.
5. Plants have growing points which have unlimited growth.
6. Excretory system and nervous system are absent.
7. Reserve food material is starch.
8. Cells have a cell wall. Cells have a lager vacuole. Plant cells lack centrosome and they may have inorganic crystals.
9. Reproduction takes place with the help of agents such as air, water and insects. Asexual and vegetative method of reproduction is also not uncommon.

Kingdom Animalia

This kingdom includes unicellular protozoans and multi-cellular animals or metazoans. They are characterized by

1. Definite shape of the body and absence of branches.
2. Ability to move from place to place.
3. During day and night take in O_2 and release CO_2 i.e only respiration takes place and there is no photosynthesis.
4. Holozoic mode of nutrition since no chlorophylls present and hence they are heterotrophs.
5. Growth is limited in animals. Growth stops after attaining a particular size and age.
6. Excretory system and nervous system are well developed.
7. Reserve food material is glycogen.
8. Lacks cell wall. They have small vacuoles. Centrosomes are present. Cells do not have inorganic crystals.
9. Animals do not depend on any external agents for sexual reproduction. Regeneration of body parts and asexual reproduction is found only in lower organisms.

The Five Kingdom System of Classification

- In order to suggest a better system of classification of living organisms, R.H. Whittaker (1969) an American Taxonomist divided all the organisms into 5 kingdoms based on their phylogenetic relationships. This classification takes into account the following important criteria.

1. Complexity of Cell structure – prokaryote to Eukaryote
2. Mode of nutrition – autotrophs and heterotrophs
3. Body organization -unicellular or multi-cellular
4. Phylogenetic or evolutionary relationship
5. The Five kingdoms are Monera, Protista, Fungi, Plantae and Animalia.

Comparison of Five Kindgoms					
	Kingdom				
Criteria	**Monera**	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Level of Organization	Unicellular	Unicellular	Multicellular and unicellular	Tissue / Organ	Tissue/organ/ Organ system
Cell wall	Present (made up of Peplidoglycan and Mucopeptides)	Present in some (made up of cellulose), absent in others	Present (made up of chitin or cellulose)	Present (made up of cellulose)	absent
Nutrition	Autotrophic (Photorrophic, Chemoautotrophic) Heterotrophic (parasitic and saprophytic)	Autitriphic Photosynthetic. Heterotrophic	Autotrophic - parasitic or Saprophytic	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic)
Motility	Motile or non-motile	Motile or non-motile	non-motile	Motile or non-motile	Motile motile
Organisms	Archaebacteria, Eubacteria, Cyanobacteria, Actinomycetes and Mycoplasma	Chrysophytes, Dinoflagellates, Eugleoids, Slime molds, Amoeba, Plasmodium, Trypanosoma, Paramecium	Yeast, Mushrooms and Molds	Algae, Bryophytes, Gymnoserms and Angiosperms	Sponges, Invertabrates and Vertebrates

Kingdom of Monera

- This kingdom includes all prokaryotic organisms i.e. mycoplasma, bacteria, actinomycetes (filamentous bacteria) and cyanobacteria (blue green Algae).
- They are microscopic. They do not possess a true nucleus. They lack membrane bound organelles.
- Their mode of nutrition is autotrophic
- Many other bacteria like Rhizobium, Azotobacter and Clostridium can fix atmospheric nitrogen into ammonia. This phenomenon is called Biological Nitrogen Fixation.
- Some bacteria are parasites and others live as symbionts.
- Some monerans like Archaebacteria can live in extreme environmental conditions like absence of oxygen (anaerobic), high salt condition, high temperature like 800c or above and highly acidic soils.

Kingdom of Protista

- This kingdom includes eukaryotic unicellular mostly aquatic cells. They show the following characters.
- They have a typical Eukaryotic cell organization.
- They often bear cilia or flagella for locomotion. Most of them are photosynthetic autotrophs.
- They form the chief producers of food in oceans and in fresh water. All unicellular plants are collectively called as phytoplanktons and unicellular animals as zooplanktons. Phytoplanktons are photosynthetically active and have cell wall.
- Zooplanktons are mostly predatory. They lack cell wall and show holozoic mode of nutrition as in Amoeba.
- Some protists are parasitic. Some are symbionts while others are decomposers.

Kingdom of Fungi

- This kingdom includes moulds, mushrooms, toad stools, puffballs and bracket fungi. They have eukaryotic cell organization. They show the following characteristics.
- They are either unicellular or multi-cellular organisms.
- Their mode of nutrition is heterotrophic since they lack the green pigment

chlorophyll. Some fungi like Puccinia are parasites while others like Rhizopus are saprotrophic and feed on dead organic matter.

- Their body is made up of numerous filamentous structures called hyphae.
- Their cell wall is made up of chitin.

Kingdom of Plantae

- It includes all multi-cellular plants of land and water. Major groups of Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms belong to this kingdom.
- The cells have a rigid cell wall made up of cellulose.
- Most of them are autotrophs since they have chlorophyll. Some plants are heterotrophs. For eg. Cuscuta is a parasite. Nepenthes and Drosera are insectivorous plants.

Kingdom Animalia

- This kingdom includes all multi-cellular eukaryotic organisms. They are also referred to as metazoans.
- All animals show heterotrophic mode of nutrition. They form the consumers of an ecosystem.
- They have contractibility of the muscle cells.
- They can transmit impulses due to the presence of nerve cells.
- Some groups of animals are parasites eg. tapeworms and roundworms.

Merits of the Five Kingdom Classification

- It shows the phylogenetic relationships among the organisms.
- It is based on the complexity of the cell structure from prokaryotic to eukaryotic cell organization.
- It is based on the complexity of body organization from unicellular to multicellular.
- It is based on the modes of nutrition: autotrophic or heterotrophic mode of nutrition.

Demerits of Five Kingdom Classification

- Chlamydomonas and Chlorella are included under the kingdom Plantae. They should have been included under kingdom Protista since they are unicellular.
- Animal protozoans are not included along with animals.
- Animal protozoans are included under the kingdom Protista which include unicellular plants. They show different modes of nutrition.
- Yeasts, though unicellular eukaryotes, are not placed in the kingdom Protista.

Bentham and Hooker's Classification of Plants

It was proposed by two English botanists George Bentham (1800-1884) and Sir Joseph Dalton Hooker (1817-1911). Their system of classification was published in 'Genera Plantarum' in three volumes and they had described 97,205 species of seeded plants in 202 orders (now referred to as families).

Merits of Bentham and Hooker's classification of plants

1. Bentham and Hooker's classification is the most natural system, based on actual examination of specimens.
2. The description of plants is quite accurate and reliable.
3. Although this system is natural, most of the aspects of this system show affinity to modern concepts of evolution. For example, the order Ranales, which is the first order in the arrangement of plants, has been given a primitive position in this system. Recent taxonomic findings also indicate that the members of Ranales are the most primitive living angiosperms.
4. The placement of monocotyledonae after the dicotyledonae also appears to be in accordance with the evolutionary trends.

Demerits of Bentham and Hooker's classification of plants

1. The placement of Gymnospermae in between dicotyledonae and monocotyledonae is an error.
2. Advanced family Orchidaceae has been considered as primitive among monocotyledons and it is placed in the beginning of the system.
3. In this system, some closely related families have been separated and placed under different groups. For example, all the families of series Curvembryeae of Monochlamydeae are related to Caryophyllaceae of series Thalamiflorae of Polypetalae, but they are separated.

4. Unrelated families have been grouped nearer. For example, Podostemaceae of series Multiovulatae aquaticae of Monochlamydeae deserves a place in Rosales of the series Calyciflorae of Polypetalae. Similarly Laurineae of series Daphnales of Monochlamydeae deserves a place in Ranales of the series Thalamiflorae of polypetalae. Thus, two unrelated families Podostemaceae and Laurineae are grouped nearer.

VIRUSES

- The word virus is derived from Latin meaning 'poison',
- Viruses have both living and non-living characters, Hence viruses are regarded as a separate entity.
- It is excluded in Whittaker's five kingdom classification
- Viruses are now defined as Ultramicroscopic, disease causing intra cellular obligate parasites

Have you heard of the terms EBOLA, ZIKA, AIDS, SARS, H1N1 etc? There are serious entities which are considered as "Biological Puzzle" and cause disease in man. They are called viruses. (BOX)

Tobacco Mosaic Virus (TMV) cause severe damage to commercially important tobacco crop

Evolution in Virology

W.M. Stanley (1904-1971) An American Scientist obtained virus in crystallised form from infected tobacco juice in the year 1935. He was jointly awarded "Nobel Prize" in Chemistry in 1946 with J.H. Northrop.

1796 Edward Jenner used vaccination for small pox

1886 Adolf Mayer demonstrated the infectious nature of Tobacco mosaic virus using sap of mosaic leaves

1892 Dimitry Ivanowsky proved that viruses are smaller than bacteria

1898 M.W. Beijierink defined the infectious agent in tobacco leaves as 'Contagium vivum fluidum'

1915 F.W.Twort identified Viral infection in Bacteria

1917 d'Herelle coined the term 'Bacteriophage'

1984 Luc Montagnier and Robert Gallo discovered HIV (Human Immuno Deficiency Virus).

Living Characters :

- Presence of nucleic acid and protein.
- Capable of mutation
- Ability to multiply within living cells.
- Able to infect and cause diseases in living beings.
- Show irritability.
- Host –specific

Non-living Characters

- Can be crystallized.
- Absence of metabolism.
- Inactive outside the host.
- Do not show functional autonomy.
- Energy producing enzyme system is absent.

Size and Shape:

- Can be seen only under electron microscope.
- Measured in nanometers (1 nm = 10-9metre or 1 meter = 109 nm)
- Generally from 20 nm to 300 nm in size
- Very small size and ability to pass through bacterial filters are classic attributes of viruses.

The methods to determine the size of the viruses:

- Direct observation
- Filtration through membranes of graded porosity
- Sedimentation by ultra centrifugation
- Comparative measurements

    1. Staphylococcus - Dia 1000 nm
    2. Bacteriophage - 10 - 100 nm

Shapes:

1. Cubic symmetry: polyhedral or spherical. eg: Adeno virus, HIV
2. Helical symmetry: e.g: Tobacco Mosaic virus (TMV), Influenza virus
3. Complex or atypical e.g: Bacteriophage, Pox virus

Structure of a virus

1. Capsid (the protein coat)
2. Nucleic acid.

- The capsid is the outer protein coat. It is protective in function. Composed of many identical sub units called capsomeres.
- Some of the viruses have an outer covering called envelope eg: HIV. They are called enveloped viruses. Others are called naked viruses or non-enveloped viruses.
- The capsid is in close contact with the nucleic acid and hence known as nucleocapsid.
- Unlike any living cell a virus contains either DNA or RNA, but never both.
- The Infective nature of the virus is attributed to the nucleic acid while host specificity is attributed to the protein coat.

Virion

An intact, infective virus particle which is non-replicating outside a host cell is called virion.

Viroids

A viroid is a circular molecule of RNA without a capsid. viroids cause several economically important plant diseaes, including Citrus exocortis.

Prions (pronounced "preeons")

- They are proteinaceous infectious particles, causative agents for about a dozen fatal degenerative disorders of the central nervous systems of humans and other animals. eg: M.Creutzfeldt-Jacob Disease (CJD), Bovine Spongiform Encephalopathy (BSE)Commonly known as mad cow disease, etc.
- ***Stanley Prusiner*** did research work on prions and was ***awarded Nobel Prize.***

Classification of virus:

- Viruses are not classified as members of the five kingdoms
- The type of the host they infect, viruses are classified mainly into the following four types.

  1. Plant viruses includings, algal viruses-RNA/DNA
  2. Animal viruses including human viruses-DNA/RNA

3. Fungal viruses (Mycoviruses) - ds RNA
4. Bacterial viruses (Bacteriophages) including cyanophages-DNA

1. Plant Viruses:

They infect plants and cause diseases. Some common plant viral diseases are:

1. Mospic diseases of tobacco (TMV), cucumber (CMV), cauliflower.
2. Bunchy top of banana
3. Leaf-roll of potato
4. Spotted wilt of tomato

- Plant viruses have RNA with the exception of some viruses such as cauliflower mosaic virus which has DNA.

2. Animal viruses:

- They infect animals and cause diseases. The nucleic acid is either DNA, or RNA. Some of the diseases caused by viruses in human beings are common cold, polio, measles, small pox, Jaundice, herpes, hapatitis A,B,C,D,E,G, influenza, mumps, rabies, AIDS and SARS.
- Viruses cause disease in cattle. eg: Foot and mouth disease: (FMD) in cattle, encephalomyelitis of horse, distemper of dog, rabbies etc.,

3. Diseases in Fungi:

- Diseases in fungi are called mycophages and viruses that attack blue green algae/ cyanobacteria and cause diseases called cyanophages.

4. Bacteriophages

- Virus that infects bacteria is called bacteriophage or simply phage, tadpole like nucleic acid is DNA eg. T2, T4, T6 bacteriophages.

Life cycle of a phage

- Phages exhibit two different types of life cycle.

1. Virulent or lytic cycle
2. Temperate or lysogenic cycle.

1. Virulent or lytic cycle

- Intra cellular multiplication ends in the lysis of the host bacterium and the release of progeny virions. Replication of a virulent phage takes place in the following

stages.

1. Absorption,
2. Penetration,
3. Synthesis of phage components
4. Assembly
5. Maturation
6. Release of progeny phage particles

Absorption

- The attachment of the phage to the surface of a susceptible bacterium by means of its tail is called adsorption.
- The infection of a bacterium by the naked phage nucleic acid is known as transfection.

Penetration

The process of penetration resembles injection through a syringe. The phage DNA is injected into the bacterial cell through the hollow core.

Synthesis of phage components

- Synthesis of bacterial protein, DNA, and RNA ceases. The DNA is compactly 'packaged' inside, the polyhedron head and finally the tail structures are added.
- The assembly of phage components into mature infectious phage particle is known as (5) Maturation.

Release of phages:

Release of phages typically takes place by the lysis of the bacterial cell. During the replication of phages, the bacterial cell wall is weakened and it assumes a spherical shape and finally burst or lyse.

Lysogenic cycle

- The temperate phages enter into a symbiotic relationship with the host cells.
- There is no death or lysis of the host cells
- The integrated phage nucleic acid is called a prophage..
- The prophage behaves like a segment of the host chromosome and replicates along with it. This phenomenon is called lysogeny.

- The bacterium that caries prophage within its genome is called lysogenic bacterium.
- The prophage confers certain new properties on the bacterium. This is called lysogenic conversion or phage conversion. An example is toxin production by the Diptheria bacillus which is determined by the presence of prophage beta. The elimination of prophage abolishes the toxigenicity of the bacillus.

PLANT VIRAL DISEASE

Bunchy top of banana

- Banana bunchy top virus causes this disease. The infected plant shows extremely stunted growth.
- Leaves become short and narrow. Affected leaves are crowded in a rosette like fashion (bunch of leaves) at the top of the plant. Chlorosis and curling of the leaves also occur.

Emerging viral infection(in human beings)

- Recent examples of merging viral infections in different regions of the world include ebola virus, HIV, dengue, hemorrhagic fever, lassa fever. Rift valley fever, SARS
- ***AIDS: (Acquired Immuno Deficiency Syndrome)*** is a recently discovered sexually transmitted Virus disease.
- It is caused by Human Immuno Deficiency Virus (HIV).
- HIV belong to a group of viruses called retroviruses. It infects the T4 lymphocytes known as helper cells.
- HIV kills the T4 lymphocytes and the resulting depletion of T4 cell population creates an immune deficiency.
- This paves way for many opportunistic pathogens to attack. May also have headache, fatigue, persistent diarrhoea, dry cough, lymphomas and damage of the central nervous system.
- Appearance of thrush in the mouth and throat and night sweats. Changes in behavior and mental illness may also occur.

Mode of infection:

- Primarily HIV is sexually transmitted. It is predominant among homosexuals.
- Persons with veneral diseases, persons who have many sexual parents.
- During blood transfusion, tissue or organ donation of HIV infected persons to healthy persons
- AIDS can spread from infected mother to the child during pregnancy or through breast feeding.

Prevention

- Since there is no cure for AIDS the best approach to control AIDS is prevention. Reduction of sexual promiscuity and adoptions of measures.
- Drugs like AZT (azidothymidine) only help to increase the life span of the victim by few months and do not offer complete cure for the disease.

Viruses and cancer:

- Cancer is an uncontrollable and unorganized growth of cells causing malignant tumour.
- Cancer is caused by the DNA virus called Simian virus (SV-40) and a group of RNA viruses called retroviruses.
- The cancer causing Viruses are oncogenic viruses, some viruses are involved leukemia, sarcoma and some kind of breast cancer also.

A new disease called SARS: SARS is a respiratory illness

Symptoms:

- It begins with high fever. Other symptoms include headache, discomfort and body aches. Patient may develop dry cough and have trouble in breathing.
- SARS is caused by a group of viruses called Corona viruses which are enveloped viruses.
- Their genome is single stranded RNA. The nucleocapsid is helical. These viruses have petal shaped surface projections arranged in a fringe like a solar corona.

Viral vaccines

- The purpose of viral vaccine is to utilize the immune response of the host to prevent viral diseases.
- Vaccination is the most cost effective method of prevention of serious viral infection.

Interferons (IFN8):

- Host coded proteins of cytokine family that inhibit viral replication. They are produced by intact animal or cultured cells in response to viral infection or other inducers.

Significance of Viruses:

1. Viruses are a kind of biological puzzle to biologists since they are at the threshold of living and non-living things showing the characteristics of both.
2. Viruses are very much used as biological research tools due to their simplicity of structure and rapid multiplication. They are widely used in research especially in the field of molecular biology, genetic engineering, medicine etc.
3. Viruses are used in eradicating harmful pests like insects. Thus they are used in Biological Control Programmes.
4. Plant viruses cause great concern to agriculturists. Bacteriophages attack the N2 fixing bacteria of soil and are responsible for reducing the fertility of soil.
5. In industry, viruses are used in preparation of sera and vaccines.

BACTERIA

- ***Anton Van Leeuwenhoek*** (1676) discovered ***simple microscope.***
- ***Robert Hooke (1820)*** – discovered ***compound microscope – BACTERIA*** named as ***'Infusorial animalcules"***
- ***Louis Pasteur*** (1822-95) made a detailed study of Bacteria and proposed ***Germ theory of disease.***
- ***Robert Koch*** proves the cause & effect relationship between ***microbes*** and animal ***diseases.***
- ***Ehrenberg*** (1829) – First use the ***term Bacterium.***
- ***Bacteriology – Study of Bacteria***

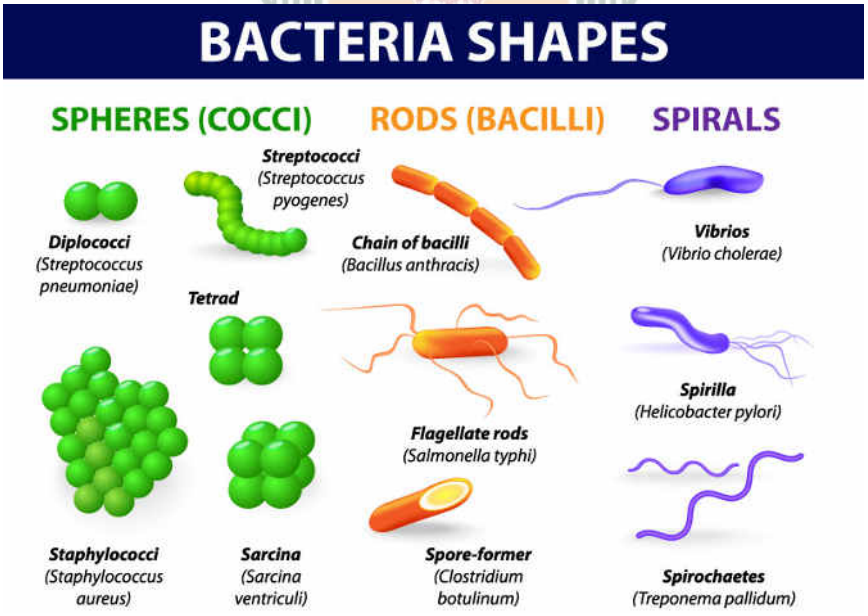
Bacterial Cell:

1. Prokaryote – Cell wall & cell membrane, granular cytoplasm filled with ribosomes, clumps of genetic material are present
2. Membrane bound organelles (Mitocondria, ER, Golgi bodies), nuclear membrane are absent.
3. Single stand of DNA – bacterial chromosome present – termed incipient nucleus or nucleoid. (Ecoli – extra choromosomal circular DNA called plasmid)
4. Bacterial Cell wall: Peptidoglycan – a complex of protein & polysaccharides. Cell wall protects the cell and maintain its shape.
5. Mesosomes – Synthesis of DNA.
6. Mitocondria absent, instead the metabolic functions are carried out by the enzymes present in the plasma membrane.

Occurrence: Bacteria are omni present (air, water, soil, saprophytes, parasites).

- Commensals – Association between members of different species – One species benefited without any effect on the other. Ex. colis
- Symbionts – Both species derive benefit – ***nitrogen fixation of bacteria. Ex. Rhizobium.***
- Size: Diameter 0.5 – 1 micron, Length 3 – 5 microns.

Classification of Bacteria based on the shape and arrangement:



1. Coccus – spherical shape
2. Bacilli – Straight rod
3. Spirilla – Helically curved
4. Vibrio – Comma shaped
5. Spirochete – Spiral shape
6. Sarcina – cluster – Cuboidal arrangement
7. Pleomorphic – Variety of Shapes – Ex: Arthrobacter

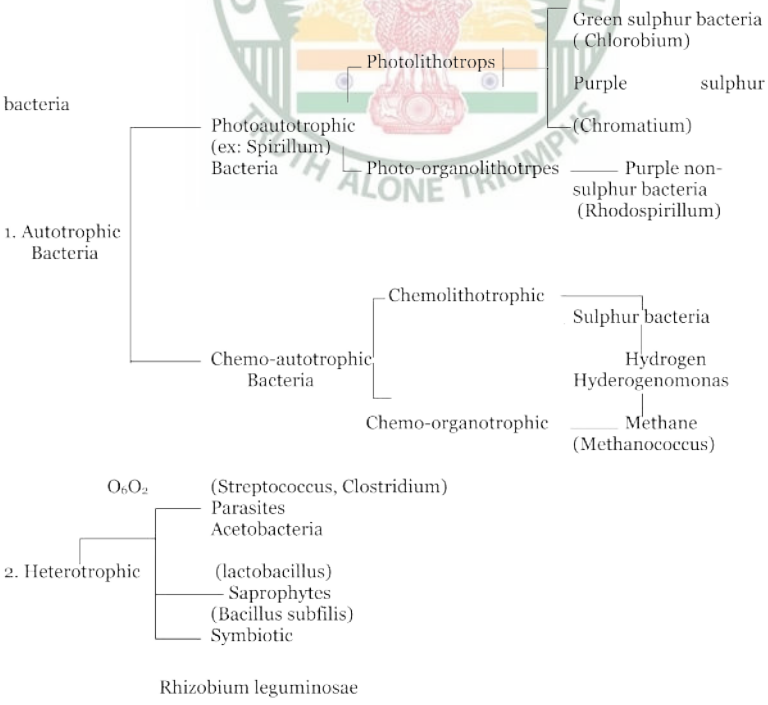
- Diplococooi: Cells divide in one plane
- Streptococci – Cells divide in one plane and remain attached to form chains.
- Tetracocci – Cells divide in two planes and form group of four cells.
- Staphylococci – Cells divide in three planes – irregular pattern produces bunches of cocci.

FLAGELLATION IN BACTERIA:

1. Polar arrangement:

a) Monotrichous – Single flagellum
b) Lophotrichous – bunches attached at one end.
c) Amphitrichous – with flagella at both poles of the cell

MODES OF NUTRITION IN BACTERIA:



2. Peritrichous – dispersed randomly over the surface of the cell

3. Atrichous lack flagellum

Flagellar – Functions can detect chemical signals called as chemotaxis. Positive chemotaxis – moment of cell in the direction of favourable chemical. Negative chemotaxis – move away from harmful compound.

Respiration in Bacteria:

1. Aerobic: Require oxygen to grow.
2. Anaeorbic Bacteria: Fermentation – Clostridium Species.
3. Capnophilic: Require CO2 for growth
4. Facultative anaerobes: Respire either using oxygen or through fermentation.
   Ex: E-Coli

Reproduction:

Binary fission.

- Bacteria reproduces asexually by Binary fission.
- Under favourable conditions the cell divides into two daughter cells. The nuclear material divides first and it is followed by the formation of a simple median constriction which finally results in the separation of two cells.

Endospores

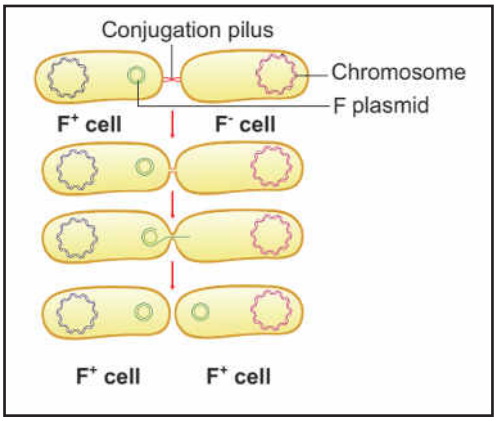
During unfavourable condition bacteria produce endospores. Endospores are produced in Bacillus megaterium, Bacillus sphaericus and Clostridium tetani. Endospores are thick walled resting spores. During favourable condition, they germinate and form bacteria

Sexual Reproduction: Gene recombination can occur in bacteria by three ways:

1. Conjugation
2. Transduction
3. Transformation

1. Conjugation:

- The donor cell get attached to the recipient cell with the help of pili.
- The plasmid of donor cell undergoes replication. One strand of DNA is transferred to recipient cell.
- The recipient completes the structure of double stranded DNA



2. Transduction:

Zinder and Lederberg (1952) discovered Transduction in Salmonella typhimurum. Phage mediated DNA transfer is called Transduction.

3. Transformation:

- Donor DNA is transferred to recipient through forced or natural methods.
- In the Lab, many bacteria treated with high salt and temperature and make render for assimilation of extra-cellular plasmids.
- This is fundamental principle used in genetic engineering.
- Economic Importance of Bacteria:

Harmful activities:

1. Diseases caused by bacteria in plants:

Name of the host	Name of the disease	Name of the pathogen
Citrus	Citrus Canker	Xanthomonas Citri
Rice	Bacterial blight	Xanthomonas oryzae
Cotton	Angular leaf spot	Xanthomonas malvacearum
Pears	Fire blight	Pseudomonas solanacearum
Carrot	Soft rot	Erwinia caratovora
Potato	Ring rot	Clavibacter michiganensis subsp. sepedonicus

2. Diseases caused by bacteria in animals:

Name of the host	Name of the disease	Name of the pathogen
Sheep	Anthrax	Bacillus anthracis
Cattle	Brucellosis	Brucella abortus
Sheep-goat	Brucellosis	Brucella melitensis

3. Diseases caused by bacteria in human beings:

Name of the disease	Name of the pathogen
Cholera	Vibrio cholerae
Typhoid	Salmonella typhi
Tuberculosis	Mycobacterium tuberculosis
Leprosy	M. leprae
Bubonic plague	Pasturellapestis
Bacterial influenza	Hemophilous influenza
Whooping cough	H. pertusis
Diarrhoea	Bacillus coli
Pneumonia	Diplococcus pneumonia
Syphilis	Treponemapallidum
Gonorrhoea	Neisseria gonorrhoeae
Tetanus	Clostridium tetani
Bacterial dysentery	Shigelladysentariae
Corditis	Streptococcus spp,
Diphtheria	Corynebactrium diphtheria
Jaundice	Leptospiraicetero-haemorrhagiate
Meningitis	Nessieria meningitides
Ptomanine poisoning (Food poisoning)	Clostridium botulinum
Streptococcus sp.	Rheumatic fever

Benefits Activities of Bacteria:

1. Sewage disposal: Saprotrophic bacteria – ex: Bacillus subtilis

2. Decomposition of plant and animals

3. Soil fertility:

- Ammonifying bacteria – Bacillus ramosus, B. mycoides – ammonia to ammonium salts

- Nitrifying bacteria such as Nitrobacter, Nitrosomonas – convert ammonium salts into nitrites and nitrates.
- Nitrogen fixing bacteria such as Azotobacter and Clostridium and Rhizobium (a symbiotic bacterium) are capable of converting atmospheric nitrogen into organic nitrogen.
- The nitrogenous compounds are also oxidized to nitrogen by denitrifying bacteria. Ex: Bacillus denitrificans

4. Dairy industry: Lactic acid bacteria – ex: Streptococcus lactis, Yoghurt (Lactobacillus bulgaricus), cheese (Lactobacillus acidophobus).

5. Vinegar: Acidic acid bacteria – Ex: Acetobactor aceti.

6. Alcohols and Acetone: Ex: Clostridium acetobutylicum

7. Retting of fibres: Clostridium

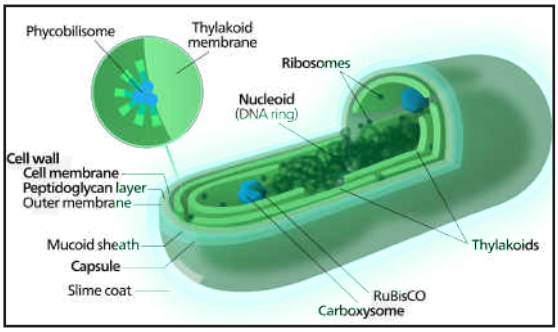
8. Genetic engineering: E-coli

9. Biological control: B. thuringiensis

10. In Medicine:

Antibiotics	Name of Bacteria	Range of action
Bacitracin	Bacillus subtilis	Gram positive bacteria
Chloromycetin (Chloramphenicol)	Streptomyces venezuelae	Broad spectrum
Aureomycin (Chlorotetracycline)	Arewpromyxwaaurofaciens	Broad spectrum
Erythromycin etc.	Streptomyces erythraeus and others	Gram positive bacteria and Gram negative bacteria
Neomycin	Streptomyces griesus	Gram positive and Gram negative bacteria
Streptomycin	Streptomyces griesus	Gram positive and Gram negative bacteria
Terramycin	Streptomyces ramosus	Broad spectrum
Tetracycline	Streptomyces aureofaciens	Broad spectrum
Griesofulvin	Streptomyces griesus	Fungi
Kanamycin	Streptomyces kanamyceticus	Mycobacterium tuberculosis

CYNOBACTERIA



Cynobacteria –Oxygenic phototrophic bacteria

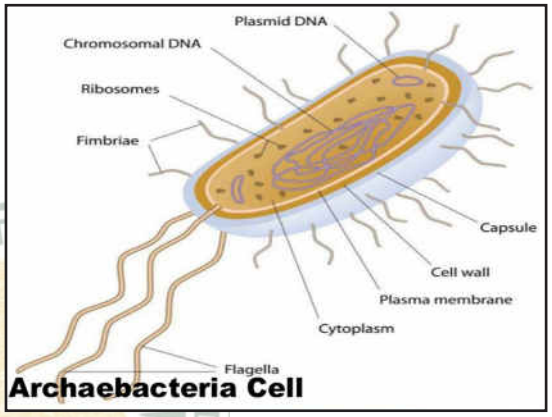
The cell walls of cyanobacteria show some chemical similarity to those of bacteria. Certain cyanobacteria may be infected with viruses which resemble bacteriophages.

Characteristic Features:

- Are omnipresent
- The pigments found in this group are-chlorophyll α, β-carotene, Antheraxanthin, Aphanicin, Aphanizophyll, Flavacin, Lutein. Myxoxanthophyll, Oscilloxantin, Zeaxanthin, Allophycocyanin, Phycocyanin, Phycoerythrin.
- The storage products are cyanophycean starch and protein
- Flagella are absent.
- May be unicellular (e.g. Chroococcus, Tetrapedia, Gloeocapsa), colonial (e.g., AphanocapsaNostoc, Aphanothece) and filamentous (e.g. Oscillatoria).
- Filaments are called trichomes, which are generally surrounded by a sheath,
- Cyanobacteria live in symbiotic association with other organisms.
- Fix the atmospheric nitrogen in the soil.
- Form a thick stratum on the surface of slaineusuar soils in the reclamation of usur lands.
- In many cases thick walled, spherical heterocysts are found.
- The cells of filamentous genera accumulate much of food. Thick walled and called the akinetes which face the adverse conditions.

- They may reproduce asexually by endospores (e.g., Dermocapsa) and exospores (e.g. Chamaesiphon)
- The trichomes of Oscillatoria show oscillating movement.
- Example for Cyanobacteria – Nostoc, Oscillatoria, Anabanea, Gloeocapsa, Chroococcus, Cylndrospermum, Gloeotrichia, Rivularia and several others.

ARCHAEBACTERIA:



- They tolerate the extremes of heat and pH.
- First group: The archaebacteria of this group are strict anaerobes which produce methane (CH_4) from carbon dioxide or formic acid. Such bacteria are called methanogens. e.g, methane producers.
- The methanogens are capable to produce methane in biogas fermenters.
- The archaebacteria that live in extremely strong salt soulutions are called halophiles or salt living.
- Second group: The archaebacteria of this group are found in hot sulphur springs. Sulphur dependent are called thermoacedophiles. They supposed to be ancient.

FUNGI

Fungi have included in plant kingdom

Salient Features:

- Non-chlorophyllous, eukaryotic organisms
- They are universal in their distribution.
- They resemble plants in that they have cell walls. But lack chlorophyll (most important attribute of plants)
- Mushrooms, moulds and yeasts are the common fungi
- The study of fungi is known as ***Mycology.***

Distinguishing Features of Fungi:

1. They have definite cell wall made up of chitin - a biopolymer made up of n-acetyl glucosamine units.
2. They are without chlorophyll, hence they exhibit heterotrophic mode of nutrition. They may be saprotrophic in their mode of nutrition or parasitic or symbiotic.
3. Usually non-molite (Except the subdivision of Mastigomycotina)
4. Storage product is not starch but glycogen and oil
5. They reproduce mostly by spore formation. However sexual reproduction also takes place.

Structure:

- The body structure of fungi is unique. The somatic body of the fungus is unicellular or multi-cellular or coenocytic.
- Multi cellular is composed of profusely branched interwoven, delicate, thread like structures called hyphae, whole mass collectively called ***mycelium.***
- Protoplasm is either continuous or is interrupted at intervals by cross walls called septa which divide the hyphae.
- The hyphae may be aseptate (hyphae without cross walls) or septate (hyphae with cross walls).
- Aseptate they are coenocytic containing many nuclei. Each hypha has chief component called chitin, a nitrogen containing polysaccharide also found in the exoskeleton of arthropods.

Nutrition:

Fungi are heterotrophic in their mode of nutrition that is they require an organic source of carbon. Nutrition of fungi can be described as absorptive because they absorb nutrients directly from outside their bodies. Fungi obtain their nutrients as saprotrophs, parasites or symbionts

Saprotrophs:

- An organism that obtains its food from dead and decaying matter.
- It secretes enzymes on to the organic matter
- Saprotrophic fungi and bacteria constitute the decomposers and are essential in bringing about decay and recycling of nutrients.
- They produce humus from animal and plant remains.

Parasites:

- An organism that lives in or on another organism, the host from which it obtains its food and shelter.
- Parasites which cause diseases are called pathogens
- Some parasites can survive and grow only in living cells and are called biotrophs or Obligate parasites
- Fungi parasites more commonly attack plants than animals.
- Obligate parasites posses specialized penetration and absorption devices called haustoria

Symbiosis:

Two important types of symbiotic union are made by fungi:

Lichens

- Symbiotic association found between algae and fungi. The algae is usually green alga or blue green alga.
- The fungus is an ascomycete or basidiomycete. Alga contributes organic food from photosynthesis and the fungus is able to absorb water and mineral salts.

Mycorrhizae:

- These are symbiotic association between a fungus partner and roots of higher plants. Most land plants enter into this kind of relationship with soil fungi.
- The fungus may form a sheath around the center of the root (an ectotrophic mycorrhiza) is found in many forest trees such as conifers, beech and oak and involve in the fungi of the division basidiomycetes or which penetrate the host issue (an endotrophic mycorrhiza)

Classification of Fungi:

- Modification of the scheme of classification of fungi proposed by Ainsworth (1973) and adopted by ***Webster (1980)***
- ***Division Myxomycota:*** They lack cell wall and are quite unusual organisms. Posses either a plasmodium, a mass of naked, multinucleate protoplasm, which feeds by ingesting particulate matter. They are also called 'Slime moulds'
- ***Division Eumycota:*** called true fungi, all with cell wall.

A. Mastigomycotina: These are zoosporic fungi, solely aquatic

B. Zygomycotina: Vegetative body haplophase.

- Fungi of this group are also known as conjugation fungi.
- Cell wall is made up of chitin and chitosan.

➤ The classes: Common black, bread moulds Rhizopus and Mucor,belong to this group

C. Ascomycotina: Hyphae are septate, vegetative body is haplophase. It has five classes:

➤ Includes Yeasts, brown moulds, green moulds, pink moulds, cup fungi and edible morels.

➤ Sexual reproduction takes place by means of gametangial copulation (yeasts)

➤ The ascomycetes or sac fungi are characterized by the development of spores called ascospores

➤ The ascospores are enclosed in a sac like structure, the ascus.

➤ Groups of asci get aggregated to form campact fruiting bodies called the ascocarps. The ascocarps are of three types:

1. ***Cleistothecium:*** Closed and spherical ascocarps.
2. ***Perithecium:*** Flask shape ascocarps.eg: Neurospora
3. ***Apothecium:*** Cup shaped ascocarps. eg: Peziza

D. Basidiomycotina:

➤ Three classes, hyphae are septate, vegetative.

➤ From the basidium the club shaped structure formed at the tip of the reproductive hypha.

➤ Large reproductive structures or fruiting bodies called basidiocarps. Common example for basidiomycetes include mushrooms, toadstools, puffballs and bracket fungi.

➤ Distinct sex organs absent.

➤ Advance forms of basidiomycetes produce fruiting bodies called basidiocarps.

E. Deuteromycotina:

Called Fungi Imperfecti. Their sexual (perfect or teleomorphic) states are either unknown or may possibly be lacking altogether.

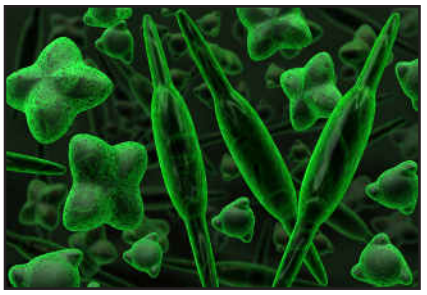
Economic importance of Fungi:

- Antibiotic pencillin was discovered in 1928 by Alexander Fleming of Britain from the fungus Penicillium Notatum.
- 'Wonder drug' for the treatment of bacterial diseases.
- 'Niche' to fungi in the realm of biological sciences as producers of antibiotics.
- Other important antibiotics are produced by moulds.
- Many fungi such as yeast, mushrooms, truffles, morels etc., are edible. Edible mushrooms contain proteins and vitamins.
- Agaricus such as A. Bisporus, A. arvensis are edible. Volvariella volvacea and V. dispora are also edible mushrooms cultivated commercially.
- Brewing and baking industries rely heavily on the uses of yeast (saccharomyces).
- Yeasts ferment sugar solution into alcohol and carbon-di-oxide. Alcohol is used in brewing industry and CO2 in baking industry.
- The 'biochemical genetics' which later developed into the fascinating 'molecular biology' was founded by studies with Neurospora crassa a fungus which even dethroned Drosophila.
- Neurospora and Aspergillus continue to be important organisms studied in genetics.
- "Without fungi even death will be imcomplete" said Pasteur.
- The dead cellulosic vegetation is decomposed into carbon and minerals by the saprotrophic fungi.
- Thus fungi maintain the carbon and mineral cycles in nature.

Harmful aspects of Fungi:

- LSD (d-lysergic acid diethylamide) produced from the fungus ergot. (Clavicepspurpurea) produces hallucinations. Fungus is called hallucinogenic fungus.
- The devasting disease called 'late flight of potato' caused by the fungus (one million people died of sarvation)
- Plant pathology - science deals with diseases of plants caused not only by fungi but also by bacteria, viruses.

ALGAE



- Autotrophic organisms. Have chlorophyll.
- Study of Algae is known as ***Algology or phycology***
- Plant body is called ***thallus,*** no vascular tissues.
- Most of the algae are aquatic either fresh water or marine.
- The free floating and free swimming minute algae are known as phytoplanktons.
- Some species of algae and fungi are found in association with each other and they are called Lichens.
- Some species are epiphytes (ie., they live on another plant or another algae) and some of them are lithophytes (ie., they grow attached to rocks)
- ***Chlamydomonas*** Example for unicellular and motile
- ***Chlorella*** - non motile

Reproduction:

Three common methods of reproduction found in Algae are

1. Vegetative
2. Asexual
3. Sexual reproduction

Vegetative reproduction:

It lakes place by fragmentation or by the formation of adventitious branches.

Asexual reproduction:

- It takes place by means of different kinds of spores like Zoospores, Aplanopores and Akinetes.
- Zoospores are naked, flagellated and motile. eg: (Chlamydomonas) Aplanospores are thin walled and non motile (egChlorellaya) Akineties are thick walled and non motile spores (eg. Pithophora)

Sexual Reproduction

- Sexual reproduction involves fusion of two gametes. If fusing gametes belong to the same thallus it is called homothallic and if they belong to different thalli it is heterothallic. Fusing gametes may be isogametes or heterogametes.

1. **Isogamy:** It is the fusion of two morphologically and physiologically similar gametes.eg. Spirogyra and some species of Chlamydomonas.
2. **Heterogamy:**
   - This refers to the fusion of dissimilar gametes.
   - It is of two types
     1. Anisogamy
     2. Oogamy

Anisogamy :

Anisogamy is the fusion of two gametes which are morphologically dissimilar but physiologically similar (both motile or both non-motile)

Oogamy :

- Oogamy refers to the fusion of gametes which are both morphologically and physiologically dissimilar.
- In this type of fusion the male gamete is usually referred to as antherozoids which is usually motile and smaller in size and the female gamete which is usually non-motile and bigger in size is referred to as egg.
- The sex organ which produces the antherozoids is called antheridium and the egg is produced in oogonium.
- The fusion product of antherozoid and egg is called Zygote. The zygote may germinate directly after meiosis or may produce meiospores which in turn will germinate.

Classification

F.E. Fritsch (1944-45) classified algae into 11 classes in his book ***"Structure and Reproduction of Algae"*** based on the following characteristics.

1. Pigmentation
2. Reserve food
3. Flagellar arrangement
4. Thailus organization
5.Reproduction.

The 11 classes of algae are:

1. Chlorophyceae
2. Xanthophyceae
3. Chrysophyce
4. acillariophyceae
5. Cryptophyceae
6. Dinophyceae
7. Chlromonodinear
8. Euglenophyceae
9. Phaeophyceae
10. Rhodophyceae
11. Myxophyceae

Economic Importance of Algae:

- **Algae as Food:** Algae are important as a source of food for human beings, domestic animals and fishes.
- Species of Porphyra are eaten in Japan, England and U.S.A, Ulva, Laminaria, Sargassum and Chlorella are also used as food in several countries. Sea weeds (Laminaria, Fucus, Ascophyllum) are used as fodder for domestic animals.

Algae in Agriculture:

- Various blue green algae such as Oscillatoria, Anabaena, Nostoc, Aulosira increase the soil fertility by fixing the atmospheric nitrogen.
- In view of the increasing energy demands and rising costs of chemical making nitrogenous fertilizers, much attention is now being given to nitrogen fixing bacteria and blue green algae. Many species of sea weeds are used as fertilizers in China and Japan.

Algae in Industry:

- ***Agar - agar:*** This substance is used as a culture medium while growing bacteria and fungi in the laboratory. It is also used in the preparations of some medicines and cosmetics. It is obtained from the red algae Gelidium and Gracilaria.
- A phycocolloid Alginic acid is obtained from brown algae. Algin is used as emulisifier in ice creams, tooth pastes and cosmetics.
- ***Iodine:*** It is obtained from kelps (brown algae) especially from speicies of Laminaria
- ***Diatomite:*** It is a rock like deposit formed on the siliceous walls of diatoms (algae of Chrysophyceae).

- When they die they sediment, so that on the seabed and lake bottom extensive deposits can be built up over periods of time. The resulting 'diatomaceous earth' has a high proportion of silica. Diatomite is used as a fire proof material and also as an absorbent.

Characteristics of Major Groups of Algae

Class	Pigments	Flagella	Reserve food
Chlorophyceae (green algae)	Chlorophyll-a,b Carotene Xanthophyll	Two identical flagella per cell	Starch
Xanthophyceae	Chlorophyll-a, b Carotene Xanthophyll	Heterokont type. one whiplash type and other tinsel	Fats and Leucosin
Chrysophyceae (diatoms, golden algae)	Chlorophyll-a, b Carotenoids	One, two or more unequal flagella	Oils and Leucosin
Bacillario, phyceae	Chlorophyll-a, c Carotenes	Very rare	Leucosin and fats
Cryptophyceae	Chlorophyll-a, c Carotenes and xanthophylls	Heterokont typeone tinsel and other whiplash	Starch
Dinophyceae (Di noflagellates)	Chlorophyll-a. c Carotenoids Xanthophyll	Two unequal lateral flagella in different plane.	Starch and oil
Chloromonodineae	Chlorophyll-a, b Carotenes Xanthophyll	Isokont type	Oil
Euglenophyceae (Euglenoids)	Chlorophyll-a, b	One,two or three anterior flagella.	Fats and paramylon
Phaeophyceae (brown algae)	Chlorophyll-a Xanthophyll	Two dissimilar lateral flagella	Laminarin, fats

Rhodophyceae (Red algae)	Chlorophyll-a, Phycocyanin Phycoerythrin	Non-motile	Starch
Myxophyceae	Chlorophyll-a. carotene, phycocyanin, phycoerythrin	Non-motile	Cyanophycean starch

It is used in sound and fire proof rooms. It is also used in packing of corrosive materials and also in the manufacture of dynamite.

Algae in space travel:

Chlorella pyrenoidosa is used in space travel to get rid of CO_2 and liberate O_2 during photosynthesis. It decomposes human urine and faeces to get N_2 for protein synthesis.

Single cell protein (SCP):

- Chlorella and Spirulina which are unicellular algae are rich in protein and they are used as protein source.
- Besides Chlorella is a source of vitamin also. The rich protein and amino acid content of chlorella Spirulina make them ideal for single cell protein production. An antibiotic Chlorellin is extracted from Chlorella.

Sewage Disposal:

- Algae like Chlorella are grown in large shallow tanks containing sewage. These algae produce abundant oxygen by rapid photosynthesis.
- Microorganisms like aerobic bacteria use these oxygen and decompose the organic matter and thus the sewage gets purified.

Harmful effects of Algae

- Under certain conditions algae produce B that is dense masses material.
- This is especially true in relatively warm conditions when there is high nutrient availability, which sometimes is induced by man as and when sewage is added to water or inorganic fertilizers run off from agricultural land into rivers and lakes.
- As a result of this a sudden and explosive growth of these primary producers (algae) occurs.

- They are produced in such a huge quantity that they die before being eaten. The process of decomposition is carried out by aerobic bacteria which in turn multiply rapidly and deplete the water of oxygen. The lack of oxygen leads to the death of fish and other animals and plants in the lakes.
- The increase of nutrients which starts off the entire process is called eutrophication and if rapid it constitutes a major problem of pollution. The toxins produced by algal bloom can also lead to mortality.
- This can be a serious problem in lakes and oceans. Sometimes the toxins may be stored by shellfish feeding on the algae and be passed on to man causing the disease called paralytic shellfish feeding on the algae and be passed on to man causing the disease called paralytic shellfish poisoning.
- Algae also cause problems in water storage reservoirs where they may taint the water and block the beds of sand used as filters.

Mycoplasma

- PPLO – Pleuropneumonia like organisms and L-forms.
- The smallest cell. It is not a bacterium.

BRYOPHYTES

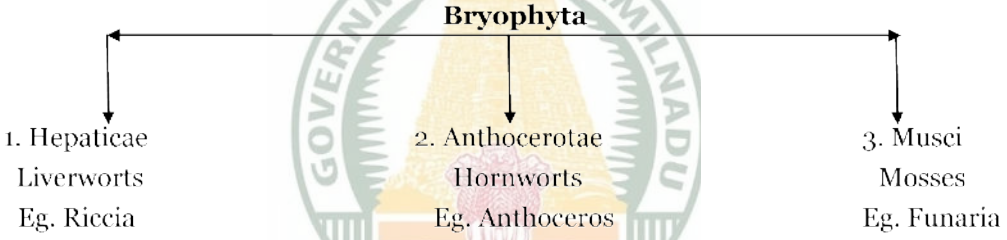
Salient features of Bryophyta

- Bryophyta are the simplest group of land plants. They are relatively poorly adapted to life on land, so they are mainly confined to damp,shady places.
- These are terrestrial non-vascular plants(no vascular tissue namely xylem and phloem) which still require moist environment to complete their life-cycle. Hence these are called amphibians of plant kingdom.
- The male sex organ is called antheridium and the female sex organ is called archegonium.
- Bryophytes show distinct alternation of generation in their life cycles. Bryophytes include mosses, liverworts and hornworts.
- Water and mineral salts can be absorbed by the whole surface of the plant body, including the rhizoids. So the main function of rhizoids is anchorage, unlike true roots (true roots also possess vascular tissues, as do true stems and leaves). Thus the “stems” and “leaves” found in some Bryophytes are not homologous with stems and leaves of vascular plants. The plant body is called thallus.
- Sex organs are multi-cellular and they have a protective jacket layer of sterile cells.

Alternation of Generations

- In common with all land plants and some advanced algae such as Laminaria, bryophytes exhibit alternation of generations.
- The haploid generation is called the gametophyte because it undergoes sexual reproduction to produce gametes. Production of gametes involves mitosis, so the gametes are also haploid.
- The gametes fuse to form a diploid zygote which grows into the next generation, the diploid sporophyte generation. It is called sporophyte because it undergoes asexual reproduction to produce spores.
- Production of spores involves meiosis, so that there is a return to the haploid condition. The haploid spores give rise to the gametophyte generation.
- In all other land plants the sporophyte generation is dominant.

Classification Bryophyta is divided into three major classes.



Economic Importance

- Bryophytes form dense mat over the soil and prevent soil erosion.
- Sphagnum can absorb large amount of water. It is extensively used by gardeners in nursery to keep seedlings and cut plant parts moist during propagation.
- Peat is a valuable fuel like coal. Mosses like Sphagnum which got compacted and fossilized over the past thousands of years have become peat.
- Mosses are good sources of animal food in rocky areas.

PTERIDOPHYTES

- Tracheophyta includes pteridophytes and the more advanced spermatophytes (seed bearing plants) as two subdivisions.
- The occurrence of vascular tissue in the the sporophyte is one reason why sporophyte generation has become the dominant one in all vascular plants.

- The xylem of pteridophytes contains only tracheids rather than vessels and the phloem contains sieve cells rather than sieve tubes.
- These plants are mostly small and herbaceous. They grow well in moist, cool and shady places where water is available.
- Vascular tissue i.e xylem and phloem are present. Xylem lacks vessels but tracheids are present. In phloem sieve tubes and companion cells are absent.
- Asexual reproduction takes place by spores. Most pteridophytes are homosporous i.e they produce one type of spores A few show heterospory i.e they produce two types of spores microspores and megaspores.
- Sporangia bearing leaves are called sporophylls. Some common examples of microphyllous pteridophytes are Psilotum, Lycopodium, Selaginella, Isoetes, Equisetum etc.
- Common examples of ferns are Nephrolepis, Ophioglossum, Osmunda, Pteris, Adiantum, Marsilea, Azolla, Salvinia etc.

Characteristics of Pteridophytes

There are two types of spore and the plants are therefore described as heterosporous.

Economic importance of pteridophytes

- Ferns are grown as ornamental plants for their beautiful fronds. The rhizomes and petioles of the fern Dryopteris yield a vermifuge drug.
- The sporocarps of Marsilea (a water fern) are used as food by certain tribal people.

SPERMATOPHYTES (GYMNOSPERMS)

- The most successful and advanced group of land plants are the spermatophytes (sperma – seed).
- One of the main problems that had to be faced by plants living on land was the vulnarability of their gametophyte generation.
- For example in ferns the gametophyte is a delicate prothallus and it produces the male gametes (sperms) which are dependent on water for swimming to reach the female gamete in archegonia.

- In seed plants, however, the gametophyte generation is protected and very much reduced.
- Three important developments have been made by seed plants.

1. The development of heterospory.
2. The development of seeds.
3. The development of non-swimming male gametes.

Class Gymnospermae (Cycads Conifers, and Ginkgos)	Class Angiospermae (flowering plants)
No vessels in xylem, only tracheids(except Gnetales) no companion cells in phloem.	xylem has vessels, phloem contains companion cells
Usually have cones on which sporangia and spores develop.	Produce flowers in which sporangia and spores develop
Seeds are naked that is the seeds are exposed; they are not enclosed in ovary.	Seeds are enclosed in ovary.
No fruit because no ovary	After fertilization ovary develops into fruit.

- Water is not needed for sexual reproduction because male gametes do not swim, complex vascular tissues in roots, stem and leaves are present. It includes two classes namely Gymnospermae and angiospermae.
- Gymnosperms represent a primitive group of seed bearing plants (Spermotophytes) in which the seeds are naked (The word Gymnos means naked and spermos means seed) This is because in Gymnosperms the ovules are exposed and they are not covered by ovary.

- They are found in the form of coniferous forests in the Himalayas in the Indian sub-continent.
- The common conifers are species of pine, fir, spruce,Cedar,Cupressus, Sequoia gigantia.
- The life cycle of gymnosperms shows heteromorphic alternation of generations.
- The plant body is the sporophyte (diploid) mostly a tree with well developed roots, stem and leaves.
- Ovules are naked.
- Pollination is mostly by wind (anemophilous).
- Vessels are absent in xylem (except Gnetales)

Chamberlain has classified gymnosperms into two classes

1. Class Cycadophyta
2. Class Coniferophyta

Economic importance of Gymnosperms

- Woods of many conifers is used in the manufacture of paper. eg. Pinus.
- Conifers are the source of soft wood for construction, packing and ply wood industry eg. Cedrus, Agathis
- Turpentine is obtained from the resin of Pinus. It is used as solvent in paint and polishes. It is also used medicinally for pain, bronchitis etc.
- Seeds of Pinus gerardiana are edible.
- Ephedrine is an alkaloid obtained from Ephedra. It is used in curing asthma and respiratory problems.
- Saw dust of conifers is used in making linoleum and plastics.
- Pinus species yield a resin called rosin which is used in water proofing and sealing joints.
- Araucaria is an ornamental plant.

NUTRITION AND DIETETICS

NUTRITION

- The mode of taking food by an organism and utilizing it by the body is called **nutrition.**

Modes of Nutrition in Plants

- There are two modes of nutrition in organisms. They are
  1. Autotrophic nutrition
  2. Heterotrophic nutrition.

1. Autotrophic Nutrition (Auto = self; trophos = nourishment)

- Green plants are the only organisms which can synthesize food for themselves and also for other organisms including us.
- The mode of nutrition in which organisms make their own food is called **Autotrophic Nutrition** and such organisms are called **autotrophs.**
  eg : Green plants, Euglena.

2. Heterotrophic nutrition: (Hetero = other; trophos = nourishment)

- Non-green plants and most animals (like us) take in ready made food from plants and other animals.
- The mode of nutrition in which organisms depend on others for their food is called **Heterotrophic Nutrition.**
  eg : All animals, including human beings.

Other Modes of Nutrition in Plants

- There are some non-green plants which cannot prepare the food. They take readymade food prepared by other plants.
- They follow heterotrophic nutrition. They may be **saprophytes, parasites, insectivorous** plants etc.

Saprophytes

- Fungi grow on dead organic matter.
- They produce digestive enzymes on the dead matter and change it into simple nutrients.
- They absorb the nutrients in dissolved form (solution) and utilize it.
- Such a mode of nutrition is called **saprotrophic** nutrition and those plants are called **saprotrophs**.
  eg: mushroom, bread mould.

Parasites

- Cuscuta cannot synthesize food.

- As it lacks chlorophyll, it depends on the tree on which it is climbing for food.
- The plant which provides food is called **host** and the plants which consumes it is called **parasite**.

Symbiotic Plants

- There is yet another mode of nutrition in which two different types of organisms live together and mutually help each other for nutrition.
- Lichens are organisms that consist of a fungus and alga.
- The algae gives food to the fungus and the fungus absorbs water and minerals and gives to algae. Here, both the organisms help mutually.
- The phenomenon by which two different organisms live together for mutual help is called **symbiosis.** The organisms are called **symbionts.**

Chemosynthetic autotrophs

- Organisms which use sunlight energy for synthesis of food materials are called photosynthetic organisms or photoautotrophs.

- Those organisms which use chemical energy for the synthesis of carbon compounds are called chemosynthetic organisms.
- Examples for chemosynthetic autotrophs are Nitrosomonas, Beggiatoa. Nitrosomonas oxidizes ammonia into nitrite.
- The energy liberated during this process is used for the synthesis of carbohydrates.

  $2NH_3 + 3O_2 \rightarrow 2NO2^- + 2H_2O + 2H^+ + ENERGY$
- Beggiatoa oxidises H2S to sulphur and water. During this, energy is released and used for its growth.

  $H_2S + [O] \rightarrow H_2O + S + ENERGY$
- Sulphur is stored as granules inside cell.

Chemosynthetic heterotrophs

- Examples for chemosynthetic heterotrophs are fungi, most bacteria, animals and man.

Nutrition includes five steps

Ingestion

- The process of taking food into the body is called **ingestion**.
- The mode of intake of food differs in different organisms. eg: Butterflies and bees suck the nectar of the flowers. Snakes (Python) and frogs swallow their food.
- Aquatic animals (Blue Whale) filter feed.

Digestion

- The process of breaking down of complex food into simple food with the help of enzymes is called **digestion**.

Absorption

- The process by which the digested food passes into the blood vessels of the wall of the intestine is called **absorption**.

Assimilation

- The ways in which the absorbed food is utilized in cells is called **assimilation**.

Egestion

- The removal of undigested food through anus is called **egestion**.

Nutrition Comprises Organic & Inorganic Components.

- Organic - Contain Carbon in their Structure.
  (eg) Carbohydrates, Proteins, Lipids, Vitamins.
- Inorganic - Don't contain Carbon.

Carbohydrates :- [Poly-hydroxyaldehydes (or) Ketones.]

$(CH_2O)_n$ $[CHOH]_n$.

Ratio = C : H : O

1 : 2 : 1

THREE TYPES

Monosacchrides

- Comprised of single organic molecule. Depends upon number of Carbon atoms, they are classified into

Trioses ($C_3H_6O_3$)

- Intermediary products of Carbohydrate metabolic process.
- Important role in interconversion of Biomolecules.
  Example : glyceraldehyde.
  1. Pentoses ($C_5H_{10}O_5$) eg. ribose & deoxyribose
  2. Hexoses ($C_6H_{12}O_6$) Each gram of Carbohydrate yields 4.1 calories
     Example : Glucose, Fructose, Galactose.

Disacchrides

1. Formed by Condensation of
2. Monosacchride.
   eg. Milk & Sugar

Mineral Nutrition

Woodward (1699) Observation

- Plants grow better in muddy water than rain water. Characteristics of a Mineral element:-

1. Normal growth and reproduction must be dependent on particular mineral elements.
2. An essential element must have direct influence on plant.
3. Essential elements must be indispensable and their substitution by other elements must be impossible.
4. Some elements are required in very low quantities and status of essentiality (or) non-essentiality is doubtful (eg) silicon.

Functions of Minerals

1. Calcium - found in middle lamella
2. Nitrogen and Sulphur - in Proteins
3. Phosphorous - in nucleic acids.
4. Minerals influence Osmotic pressure of plant cell.
5. It absorbed from soil, affects pH of cell sap.
6. Elements like Fe, Cu, Mn and Zn acts as catalyst.
7. Elements like Ca, Mg, Na, K - Neutralize the toxic effects of other elements.
8. Elements like As, Cu, Hg show toxic effects at plants.
9. Deposition of ions like K^+ and Ca^{++} on cell membrane changes its permeability.

Hydroponics

- Growth of plants in water and sand culture.
- Also known as soil-less agriculture, test-tube farming, tank farming (or) chemical gardening.

Uses

- To know which mineral essential for growth and development of plant.
- Increase yield of ornamentals such as gladioli, snapdragon, roses and vegetables such as carrot, radish, potatoes, tomatoes & lettuce.

Advantages

1. Provide desired nutrient environment.
2. Acid-base balance can easily maintained.
3. Mulching, changing of soil and weeding are eliminated.
4. Proper aeration of nutrition solution is possible.
5. Labour for watering of plants can be avoided
6. Tilling is not necessary.

Disadvantages

1. Production is limited.
2. Technical skill is required to design equipment.

Macro Nutrients

Elements	Physiological Role	Deficiency Symptoms
C, H, O	General metabolism of plants	Affects normal growth of plants.
Nitrogen	Constituent of Protein, Nucleic Acids, Vitamins, **Chlorophyll,** ATP	1. Stunted growth. 2. Chlorosis 3. Reduction in fruit size and flowering and protein contents. 4. Change in Pigmentation pattern.
Phosphorous	1. Constituent of Plasma membrane, nucleic acids, nucleotides. 2. Promotes root growth and fruit ripening	1. Increase in Phosphatase enzyme activity. 2. Reduction in growth.
Potassium	1. Required in region of cell differentiation 2. Involved in stomatal opening and closing. 3. Protein and Carbohydrate metabolism	1. Causes mottled chlorosis 2. Shortening of internodes.
Sulphur	1. Constituent of thiamine and Biotin and Co-enzyme A - important role in respiration 2. Constituent of amino acids such as cystine, cysteine and methionie	1. inhibition of protein synthesis 2. Chlorosis.
Magnesium	1. Chorophyll can't formed without magnesium 2. activates enzymes PEP carboxylase and RuBP carboxylase	1. Interveinal chlorasis. 2. Appearance of Necrotic spots
Calcium	1. Formation of Plasmamembrane 2. Constituent of enzymes like phospholipase and adenyl kinase	1. Affects respiration 2. Cell wall become brittle.

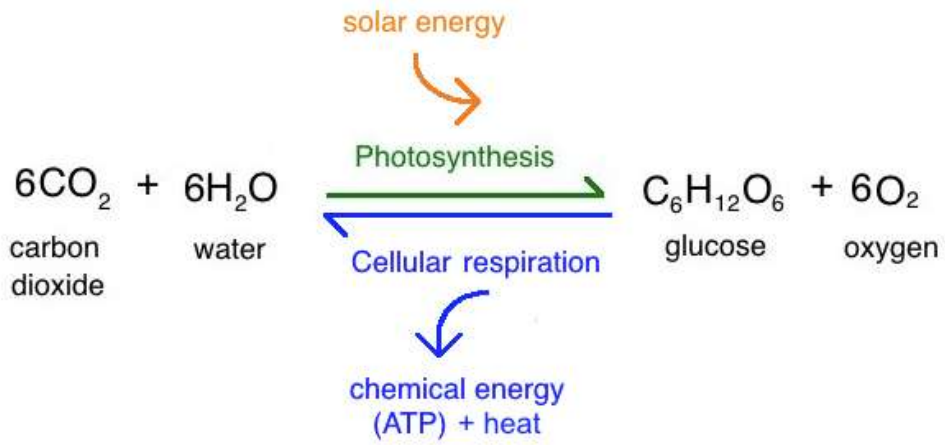
Micronutrients

Iron	1. constituent of enzymes such as catalases, peroxidases and cytochromes 2. Important role in electron - transport system of Photosynthesis.	Impairs aerobic respiration.
Boron	Necessary for Pollen germination, cell differentiation and translocation of **Carbohydrates**.	1. Brown rot disease in beetroots. 2. Premature tall of fruits and flowers.
Manganese	activator of enzymes likes carboxylase, oxidases, dehydrogenses, kinases.	Grey Spot disease in Oats.
Copper	1. Constituent of Plastocyanin plays a role in Photophosphoxylation 2. Maintains Carbohydrate - nitrogen balance	1. die back of shoots in citrus. 2. exanthema disease - Producing gums on spark. 3. Reclamation disease - affecting seed formation.
Zinc	1. Synthesis of Indole-Acetic Acid (IAA) by activating enzyme **tryptophan Synthetase.** 2. Important role in Protein Synthesis.	little leaf disease.
Molybdenum	1. role in nitrogen metabolism. 2. Affects Synthesis of ascorbic acid.	1. Yellow spot disease of citrus. 2. Whiptail disease in cauliflower.

RESPIRATION

PHOTOSYNTHESIS

- Photosynthesis is referred as photochemical oxidation and reduction reactions carried out with help of light, converting solar energy into Chemical energy.
- It is the most important anabolic process.
- The overall chemical equation for photosynthesis is:



HISTORY OF PHOTOSYNTHESIS

- **1727 Stephen Hales** recognised the importance of light and air in the nourishment of plants.
- **1779 Jan Ingen-Housz** discovered that the green parts of the plant purify the polluted air in the presence of light.
- **1782 Senebier** showed that as the concentration of CO_2 increases, the rate of O_2 evolution also increases.
- **1845 Von Mayer** recognised that green plants convert solar energy into chemical energy of organic matter.
- **1845 Liebig** pointed out that the organic matter was derived from CO_2 and water.
- **1920 Warburg** introduced the unicellular green alga Chlorella as a suitable material to study photosynthesis.

- **1932 Emerson** and Arnold showed that the existence of light and dark reactions in photosynthesis.
- **1937 Hill** demonstrated photolysis of water by isolated chloroplasts in the presence of suitable electron acceptor.
- **1941 Ruben and Kamen** Used ^{18}O radioactive Oxygen to prove that oxygen evolves from water
- **1954 Arnon, Allen** and Whatley used $14CO_2$ to show fixation of CO_2 by isolated chloroplasts.
- **1954 Calvin** traced the path of carbon in photosynthesis and gave C_3 cycle (Calvin cycle) and was awarded Noble prize in 1960.
- **1965 Hatch and Slack** reported the C_4 pathway for CO_2 fixation in certain tropical grasses.

SIGNIFICANCE OF PHOTOSYNTHESIS

1. Photosynthetic organisms provide food for all living organisms on earth either directly or indirectly.
2. It is the only natural process that liberates oxygen in the atmosphere and balances the oxygen level.
3. Photosynthesis balances the oxygen and carbon cycle in nature.
4. Fuels such as coal, petroleum and other fossil fuels are from preserved photosynthetic plants.
5. Photosynthetic organisms are the primary producers on which all consumers depend for energy.
6. Plants provide fodder, fibre, fire wood, timber, useful medicinal products and these sources come by the act of photosynthesis.

SITE OF PHOTOSYNTHESIS

- Chloroplasts are the actual sites for photosynthesis.
- All green parts of a plant are involved in photosynthesis.
- Leaves are the most important organs of photosynthesis.

Difference between C_3 and C_4 photosynthetic pathways

C_3 pathway	C_4 pathway
Photosynthesis occurs in mesophyll cells.	Photosynthesis occurs in mesophyll and bundle sheath cells
The CO_2 molecule acceptor is RuBP	The CO_2 acceptor molecule is phosphoenol pyruvate.
The first stable product is a 3° C compound called 3 - PGA	The first stable product is a 4C compound called OAA.
Photorespiration rate is high and leads to loss of fixed CO_2 It decreases CO_2 fixation rate	Photorespiration is negligible and it is almost absent. Hence, it increases CO_2 fixation rate.
Optimum temperature is 20°C to 25°C.	Optimum temperature is 30 to 45°C.
Examples of C_3 plants are rice, wheat and potato.	Examples of C_4 plants are maize, sugarcane, Tribulus and Amaranthus

Difference between photorespiration and dark respiration

Photorespiration	Dark respiration
It takes place only in photosynthetic cells in the presence of light.	It takes place in all living cells in the mitochondria.
It is light dependent	It takes place in the presence and in the absence of light.
It is the function of chloroplast, peroxisomes and mitochondria	It is the function of mitochondria alone.

RESPIRATION

A process in living organisms involving the production of energy, typically with the intake of oxygen and the release of carbon dioxide from the oxidation of complex organic substances is called Respiration.

The term respiration was coined by Pepys (1966).

- Respiration is a biological process in which oxidation of various food substances like carbohydrates, proteins and fats take place and as a result of this, energy is produced where O2 is taken in and CO2 is liberated.
- The compounds that are oxidised during this process are known as respiratory substrates.
- Carbohydrate is the common respiratory substrate.
- Breaking of C-C bonds of complex organic compounds through oxidation within the cells leads to energy release.
- During respiration, the whole energy contained in the respiratory substrate is not released all at once.
- In respiration, oxygen is utilized and carbondioxide, water and energy are released.
- Respiration is an exothermic reaction and the oxidation of glucose is given in the following equation.
  $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ + Energy (2900kJ)
- The energy released during this process is transformed into usable form of energy as adenosine triphosphate (ATP).
- ATP molecules act as carriers of free energy between energy yielding and energy requiring reactions of the cell.
- ATP is described as energy currency of the cell.
- It is a nucleotide consisting of adenine, ribose sugar and three phosphate groups.
- It is an energy rich compound and contains two high energy terminal bonds.
- A large amount of free energy is liberated, when these bonds are broken by hydrolysis

Types of Respiration

Respiration is classified into two types as aerobic and anaerobic respiration

AEROBIC RESPIRATION

- Respiration occurring in the presence of oxygen is called **aerobic respiration.**

- During aerobic respiration, food materials like carbohydrates, fats and proteins are completely oxidised into CO_2, H_2O and energy is released.
- Aerobic respiration is a very complex process and is completed in four major steps:
  1. Glycolysis
  2. Pyruvate oxidation (Link reaction)
  3. Krebs cycle (TCA cycle)
  4. Electron Transport Chain
  (Terminal oxidation).

Glycolysis

- The process by which the glucose (6C compound) is split into two molecules of pyruvic acid (3C compound) is called glycolysis.
- Three German Microbiologists – Embden, Meyerhof and Parnas, first demonstrated this process in yeast cell.
- Hence, it is otherwise known as EMP pathway. **It occurs in cytoplasm**. It is common in all organisms.
- In glycolysis, 4ATP and $2NADH_2$ molecules are formed and 2ATP molecules are consumed in hexose phase. Hence, the net gain is 2ATP and $2NADH_2$.
- The two molecules of pyruvic acid formed from a glucose molecule move into mitochondria and are oxidized, decarboxylated to two molecules of acetyl coenzyme A (acetyl Co~A).
- These 2 carbon compounds are formed by decarboxylation and dehydrogenation.
- This reaction is catalyzed by pyruvic dehydrogenase and two molecules of NAD+ are reduced to $NADH_2$.
- During this reaction two molecules of CO_2 are released.
- Oxidative decarboxylation of pyruvic acid occurs only under aerobic condition. Under anaerobic conditions, the pyruvic acid is reduced either to lactic acid or ethyl alcohol depending on the nature of the organism.

$$2 \text{ Pyruvic acid} + 2NAD^{+} \xrightarrow[\text{Dehydrogenase}]{\text{Pyruvic}} 2 \text{ Acetyl Co A} + 2NADH2+2CO_2$$

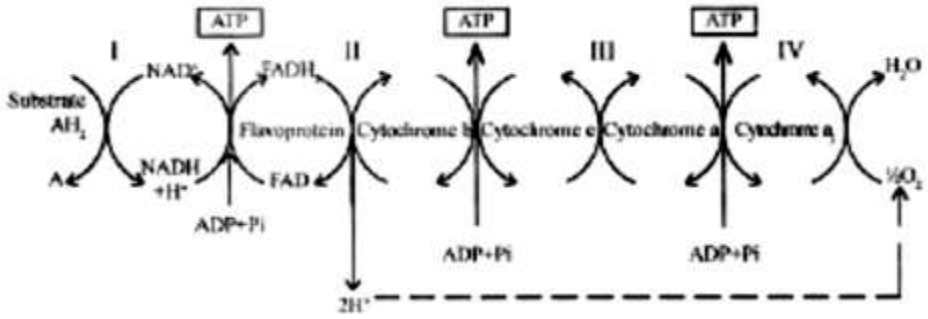
- In 1937, Sir Hans Adolf Krebs described the catalytic role of pyruvic acid for the production of energy in the cell.
- The series of cyclic reactions involved in converting pyruvic acid to carbondioxide and water in mitochondria is called Krebs cycle.
- It is also known as citric acid cycle or tricarboxylic acid cycle – TCA cycle.

Significance of Krebs cycle

- 2 molecules of acetyl CoA enter into Krebs cycle which on subsequent oxidation generate $6NADH_2$, $2FADH_2$.
- When $6NADH_2$, $2FADH_2$ enter into the electron transport system generate 22ATP molecules. In one step, there is substrate level phosphorylation which directly yield 2ATP molecules.
- So, during Krebs cycle, every 2 molecules of acetyl CoA enter into Krebs cycle 24 ATP molecules are generated. So, primarily it is a energy producing system.
- Since, Krebs cycle involves with both anabolic and catabolic processes, it is also described as amphibolic process.

Electron transport chain

- Electron transport system (ETS) is a chain of electron carriers consisting of NAD+, FAD+, CoQ and cytochromes (cyt. b, cyt. c, cyt. a and cyt.a3).
- The glucose molecule is completely oxidized by the end of the citric acid cycle.
- But, energy is not released, unless NADH2 and FADH2 are oxidized through electron transport system.
- Transfer of electrons and protons from NADH2 and FADH2 to oxygen through a series of components like flavoprotein, cytochrome is called electron transport chain.
- This process leads to coupling of electrons to form high-energy phosphate bonds in the form of ATP from ADP is called oxidative phosphorylation.
- The electron transport components are arranged in the inner membrane of mitochondria.



Energy yield

- Complete oxidation of one glucose molecule yields a net gain of 38ATP.
- Out of 38ATP molecules, 4ATP are obtained by direct substrate level phosphorylation, 30ATP through oxidation of $NADH_2$ and 4ATP through oxidation of $FADH_2$.
- Since, a large number of ATP molecules are produced in the mitochondria, they are called the 'power houses of the cell'.

No.	Stages of respiration	Number of molecules of			Total number of ATP ATP NADH obtained
		ATP	$NADH_2$	$FADH_2$	
1.	Glycolysis	2	2	-	8
2.	Oxidative decarboxylation of pyruvic acid	-	2	-	6
3.	Krebs cycle	2	6	4	24
	total	4	30 ATP	4 ATP	38

Significance of pentose phosphate pathway

- It provides alternative route for carbohydrate breakdown.
- It generates $NADPH_2$ molecules which are used as reductants in biosynthetic processes. Production of $NADPH_2$ is not linked to ATP generation in pentose phosphate pathway.
- It provides ribose sugar for the synthesis of nucleic acids.
- It provides erythrose phosphate required for the synthesis of aromatic compounds.
- It plays an important role in fixation of CO_2 in photosynthesis through Ru5P.

Anaerobic respiration

- Anaerobiosis means life in the absence of oxygen. Certain organisms can survive in the absence of oxygen.
- The respiration which takes place in the absence of free oxygen molecules is called anaerobic respiration.
- It occurs in yeast and some bacteria. Hence, they are known as anaerobes.
- Glycolysis alone occurs in these organisms.
- The splitting of glucose into two molecules of pyruvic acid is given in the following equation.

$$C_6H_{12}O_6 + 2NAD^+ \rightarrow 2C_3H_4O_3 + 2NADH_3$$

Respiratory quotient

- Respiratory quotient may be defined as "the ratio between the volume of carbondioxide given out and oxygen consumed during respiration".
- This value depends upon the nature of the respiratory substrate and its rate of oxidation.

Respiratory quotient = $\frac{Volume\ of\ co_2\ evolved}{Volume\ of\ o_2\ consumed}$

Respiratory quotient of a carbohydrate

$c_6\ H_{12}O_6 + 60_2 \longrightarrow 6C0_2 + 6H_2o +$ Energy

$Glucose$

Respiratory quotient of glucose = $\frac{6\ moles\ of\ co_2}{6\ moles\ of\ o_2} = 1$

Respiratory quotient of an organic acid

$C_4H_6O_5 + 30_2 \longrightarrow 4CO_2 + 3H_2o +$ Energy

Malic acid

Respiratory quotient of malic acid = $\frac{4\ moles\ of\ co_2}{3\ moles\ of\ o_2} = 1.33$

(more than one)

Respiratory quotient of fatty acid

$C_{16}H_{32}O_2 + 110_2 \longrightarrow C_{12}H_{22}\ O_{11} + 4CO_2 + 5H_2o +$ Energy

Palmitic acid Sucrose

Respiratory quotient of palmitic acid = $\frac{4\ moles\ of\ co_2}{11\ moles\ of\ o_2} = 0.36$ (less than one)

Respiratory quotient for anaerobic respiration

- In anaerobic respiration, carbondioxide is evolved but oxygen is not consumed.

- Therefore, the respiratory quotient in such case is infinity. For example,

$$c_6H_{12}O_6 \xrightarrow{\text{Zymase}} 2c_2H_5OH + 2CO_2 + \text{Energy}$$

Glucose — Ethanol

Respiratory quotient of glucose in anaerobic respiration $= \frac{2\ moles\ of\ co_2}{zero\ moles\ of\ o_2} = \infty$ (infinity)

Fermentation

- Fermentation literally means a chemical change accompanied by effervescence.
- The anaerobic breakdown of glucose to carbondioxide and ethanol is a form of respiration referred to fermentation.
- It is normally carried by yeast cells and accounts for the production of alcohol in alcoholic beverages.

$C_6H_{12}O + \text{yeast} \rightarrow 2CH_3CH_2OH + 2CO_2 + \text{Energy}$

$C_6H_{12}O_6 \xrightarrow{\text{Bacillus acidi-lacti}} 2CH_3\,CHOHCOOH + \text{Energy}$

Glucose ⟶ Lactic acid

- When glucose is converted into organic acids such as lactic acid, then this type of fermentation is known as lactic acid fermentation.
- It is carried out by the bacterium Bacillus acidilacti.