Classification of Living Organism

6th Term I

Unit 4 – The Living World of Plants

Plant forms and functions:

- Our body is made up of many organs. Similarly the plant body is also made up of several organs such as root, stem leaves and flowers. Plants are of many forms and many colours, yet they are alike in some manner. That is, they all have stems and leaves above the ground which we can see easily and roots below the ground.

As shown in the picture, a flowering plant consists of two main parts. They are,

- Root system.
- Shoot system

Root system

Root

- The underground part of the main axis of a plant is known as root. It lies below the surface of the soil. Root has no nodes and internodes. It has a root cap at the tip. A tuft of root hairs is found just above the root tip. Roots are positively geotropic in nature. Plants root system is classified into two types.

- Tap root system
- Fibrous root system

Tap Root System

- It consists of a single root, called taproot, which grows straight down into the ground. Smaller roots, called lateral roots arise from the taproot. They are seen in dicotyledonous plants.

Example: Bean, Mango, Neem.

Fibrous root system

- It consists of a cluster of roots arising from the base of the stem. They are thin and uniform in size.

- It is generally seen in monocotyledonous plants. Example: Grass, Paddy, Maize.

Functions of the Root

- Fixes the plant to the soil.

- Absorbs water and minerals from the soil.

- Stores food in some plants like Carrot and beet root.

Shoot system

Stem

- The aerial part of the plant body above the ground is known as the shoot system. Main axis of the shoot system is called the stem. The shoot system consists of stem, leaves, flowers and fruits. Stem grows above the soil, and it grows towards the sunlight. It has nodes and internodes. Nodes are the parts of stem, where leaf arises. The part of the stem between two successive nodes is called internode. The bud at the tip of the stem is known as apical or terminal bud, and the buds at the axils of the leaves are called auxiliary buds.

Functions of the stem

The stem,

- supports the branches, leaves, flowers and fruits
- transports water and minerals from roots to upper aerial plant parts.
- transports the prepared food from leaves to other parts through stem.
- stores food as in the case of sugarcane.

Structure of a leaf

- The leaf is a green, flat expanded structure borne on the stem at the node
- A leaf has a stalk called petiole. The flat portion of the leaf is called leaf lamina or leaf blade. On the lamina, there is a main vein called midrib. Other veins are branchout from mid rib. The portion of the leaf connected in the nodal region of the stem is known as the leaf base. Leaves of some plants possess a pair of lateral outgrowth on the base, on either side of auxiliary bud. These are called stipules.
- The green colour of the leaf is due to the presence of green coloured pigment called chlorophyll. On the lower side of the leaf there are tiny pores or openings known as stomata.

Functions of the leaf

The green leaves

- Prepare food by the process of photosynthesis.
- Helps in respiration.

- Carry out transpiration

Victoria amazonica, the leaves of this plant grow up to 3 metres across. A mature Victoria leaf can support an evenly distributed Load of 45 Kilograms or apparently young person.

Habitat

- Each and every organism needs a place to live and reproduce. Such a dwelling place is called habitat. From the depths of the ocean to the top of the highest mountain, habitats are places where plants and animals live.

Types of Habitat

Aquatic habitat:- When we visit a pond, we see some plants appear to float on water. One of the common plants is the lotus plant. Its leaves float on the water. There is a small frog sitting on a leaf. It is ready to catch the insects flying/fluttering around the flowers. The stem of the plant is seen to be inside (submerged) the water. Its roots are found within the muddy floor of the pond. As this plant grows in water.

- Aquatic habitat includes areas that are permanently covered by water and surrounding areas that are occasionally covered by water. There are two types namely Fresh water habitat and Marine water habitat.

- Nile is the longest river in the world. It is 6650 Km long. The Longest river in India is Ganges River. It is 2525 Km long.

Fresh water Habitat :-

- Rivers, lakes, ponds and pools are the fresh water habitat. Water hyacinth, water lily and lotus are seen in the fresh water habitat. In these plants roots are very much reduced in size. Stem and leaves have air chambers that allow aquatic plants to float in water.

Air spaces in stems and petioles of lotus are useful for floating in water

Marine water habitat:-

- From outer space earth looks like an awesome blue marble, That's because most of earth's surface, more than 70% is covered by oceans. Oceans also support the growth of plants. Marine plants perform about 40% of all photosynthesis that occurs on the planet.

Example: Marine Algae, Sea grasses, Marsh grass, Phytoplanktons.

Terrestrial habitat:

- Terrestrial habitats are the ones that are found on land like forest, grassland and desert. It also includes man-made habitats like farms, towns and cities. They can be as big as a continent or as small as an island. They make up about 28% of the entire world habitat.

Example : Rubber tree, teak tree and Neem tree

- The first land plants appeared around 470 million years ago. They were mosses and liverworts.
- The Amazon Rain Forest in South America produces half of the world's oxygen supply.

Terrestrial habitat is classified into three types such as
a. Desert b. Grassland c. Forest

a. **Desert habitat**
b. **Grassland**
c. **Forest**

- A habitat without much water is called deserts. Deserts are the driest place on earth, They get fewer than 25cm of rainfall annually. Deserts cover atleast 20% of the earth. The plants which grows in this habitat have thick leaves that store water and minerals. The plants like cactus store water in their stem and the leaves are reduced to spines. They have long roots that go very deep in the soil in the search of water.

- Types: (i) Hot dry deserts, (ii) Semi arid deserts, (iii) Coastal deserts, (iv) Cold deserts. Example: Cactus, Agave, Aloe, Bryophyllum

Thar Desert, also called Great Indian Desert, is an arid region of rolling sand hills on the Indian subcontinent. It is located partly in Rajasthan state, north-western India, and partly in Punjab and Sindh (Sind) provinces, eastern Pakistan

Grassland habitat

- Grassland is an area where the Vegetation is dominated by grasses. Grasses ranges from short to tall. eg. Savanna Grassland

Forest habitat

- Forest is a large area dominated by trees. There are three types of forests and are:- tropical forests, temperate forests and mountain forest. Annual rain fall ranges from 25-200 cm.

World habitat day is observed on 1st Monday of October

Plant Adaptations and Modifications.

- Adaptations are special features in plants which help them to survive in the habitats they live in over a long period. Plants in a specific environment have developed special features which help them to grow and live in that particular habitat. In this chapter, Let us study some adaptations like tendril, twiners and thorns. These adaptations are seen in plants which live in terrestrial and desert habitat.

Tendril Climber:- Tendril is a twining climbing organ of some weak stemmed plants like peas and bitter gourd. Tendril coils round a support and help the plant to climb. Example

Sweet Peas ⟹ Leaflets are modified into tendrils.

Bitter Gourd ⟹ Axillary buds are modified into tendril which helps the plant to climb.

Bamboo is one of the fast growing plants, during active growth phase.

Twiners:- Some plants have weak stems. They cannot stand straight on their own. They must climb on any support to survive.
Example: Clitoria and Jasmine.

Thorns:- Leaves of some plants become wholly or partially modified into sharp pointed structures called "thorns or spines" for defensive purpose.

Example:

- Agave - the leaf apex and margins are modified into thorns
- Opuntia - the leaves are modified into spines.
- bougainvillea – the stem has sharp thorns.

6th std
Unit 5 – Living World of Animals

Biodiversity

- In the living world, a lot of diversity is seen both in animals and plants. Every plant and animal is unique. The term biodiversity refers to the totality of species, populations, communities and ecosystems, both wild and domestic. It may also be defined as the variety and variability among living organisms and the habitats in which they live.

- Biodiversity includes a variety of ecosystems such as those that occur in deserts, forests, mountains, lakes, rivers and agricultural fields. In each ecosystem, living creatures, including humans, form a community interacting with one another and with other animals, plants, air, water and soil around them. The living things form biotic community and non-living things form abiotic community.

Habitat

- Fishes and crabs grow only in water while many animals like elephants, tigers and camels live on land. The geographical features and environmental conditions on earth differ from one place to another. Though camel can live anywhere it is able to live in deserts more comfortably. Polar Bear and Penguins dwell in cold regions. Living in such harsh conditions requires special features in these animals which help these organisms to live, breed and excel well in that particular place. Living or dwelling place of an organism is known as habitat.

In Jurong Birds Park, Singapore, Penguins are kept in a big glass case with ice bergs and temperature is maintained at 0° C and below.

Unicellular and Multicellular Organisms

- Living things are made of small units called cells. All the functions and processes in the body of living things are brought about with the help of these microscopic cells

- Some organisms are made up of a single cell and these are called unicellular organisms, whereas, the organisms that are made of many cells are called multicellular organisms.

- Amoeba, Paramecium and Euglena are unicellular while, fish, frog, lizard, bird and man are multicellular.

Unicellular organism

- Unicellular organisms are small, usually microscopic, cannot be seen with naked eye. They are aquatic, simplest and most primitive of all animals. They perform all their physiological activities by the special structures present inside the body called organelles

- We know Amoeba is an unicellular organism It does all the activities like digestion, locomotion, respiration and reproduction.

- It swallows food from the water and the food is digested in the food vacuole. Contractile vacuoles help in excretion. Respiration is by simple diffusion through the body surface. They have finger-like structures called Pseudopodia, (false foot) which help in movement or locomotion.

Paramecium

- Paramecium is also a unicellular organism which lives in water and move with the help of cilia.

Euglena

- Euglena is an unicellular animal which moves with a flagellum

Differences between Unicellular and Multicellular Organisms

Unicellular Organisms	Multicellular Organisms
• They are made up of Single Cell • The single cell of the organism can perform all the functions of life. • These organisms are generally very small (microscopic) in size. • They lack tissues, organs and organ systems. • Growth occurs by an increase in the size of the cell. Eg. Amoeba, Paramecium and Euglena	• They are organisms are made up of many cells. • Division of labour exists among cells. • Different cells are specialized to perform different functions. • They are mostly large in size. • They are composed of tissues, organs and organ systems • Growth occurs by an increase in the number of cells by cell division. Eg. Earthworms, Fish, Frogs, Lizard and Human beings.

Multicellular organisms:

- Majority of organisms we see around us, including animals are multicellular. In such organisms, different functions are carried out by different groups of cells or organs in their body. E.g. Jelly fish, Earth worm, snails, fish, frog, snakes, pigeon, tiger, monkey and man.

Animals vary in size, shape and behaviour

- A Living thing can survive in a particular habitat if its body is adapted to the conditions of that habitat. Plants and animals develop special characteristics or features in their body in order to survive in their habitat (the surroundings). The presence of specific body features for certain habits which enable a plant or an animal to live in a particular habitat is called adaptation.

- The fish lives in either freshwater or marine water.

Fish

- The head, trunk and tail of a fish merge to form a streamlined shape. The streamlined body shape helps the fish to move through the water easily.

- The fish has special organs called "Gills" which is a respiratory organ helps to absorb oxygen dissolved in water for breathing. It is adapted to breathe in water.

- Most of the fishes have slippery scales all over the body which protect the body.

- The fish has fins for swimming.

- The fish has strong tail which acts as rudder to change direction and keep its body balance in water.

Lizard

- Lizards are scaly-skinned reptiles that are usually distinguished from snakes by the possession of legs, movable eyelids, and external ear openings.

- They mostly inhabit warm regions. Most lizards are quadripedal (walk with four legs) and have a powerful limb.

- Some lizards have the capacity to rotate the head around the head joint.

- They breathe through lungs. Some lizards are able to run bipedally with two legs. In this the tail is held out backward and upward and acts as a counterweight.

- Most lizards eat a variety of insects like mosquitoes and Cockroaches with sharp, tricuspid, teeth adapted for grabbing and holding

- Some lizards (Dinosaurs) have web in the toes, and few lizards are able to glide or parachute the air and make soft landings.

Birds

- They have streamlined body covered with feathers.
- This body shape provides minimum resistance to air.
- They have beak instead of mouth.
- They breathe through lungs.
- They have a pair of wings that are modified forelimbs.
- They have hollow and light bones.
- Usually we see birds fly, however they can also hop, move, run, etc., on the ground and they perch well on the branches of tree with the help of a pair of clawed feet.
- The tail of the bird helps it to control the direction of the movements.
- They have strong chest muscles which help them withstand the pressure of the air while flapping their wings during flight.
- At a time, birds can see one object with one eye and another object with the other eye. (Binocular vision).

When an animal moves its location as the season changes it is said to be Migration. In Tamil Nadu Bird Sanctuaries are located at Vedanthangal, Kodiyakkarai and Koondhankulam. There are many birds from foreign countries like Siberia and Russia migrate to our Vedanthaangal. Likewise during summer and drought conditions birds from our country migrate to foreign countries. These birds are called Migratory Birds

Adaptation in Camel:

- Camel lives in hot desert where water is scarce. The body structure of a camel helps it to survive in desert because of its following special features which are listed below:

- The camel has long legs which help it to keep its body away from the hot sand in the desert.

- A camel can drink large amount of water (when it is available) and store it in the body.

- A camel's body is adapted to save water in the dry desert as follows: A Camel passes small amount of urine; its dung is dry and it does not sweat. Since a camel loses very little water from its body, it can live for many days without drinking water.

- A camel's hump has fat stored in it. In case of emergency a camel can break down stored fat for nourshment.

- A camel has large and flat padded feet which help it to walk easily on soft sand. Thus it is called "The ship of the desert".

- Camel has long eye lashes and hairs to protect its eyes and ears from the blowing dust.

- It can keep its nostrils closed to avoid dust.

Kangaroo rat does not drink water at all. Whatever food it eats and oxygen it gets from air combine together to form water inside the body.

Adaptive Features of Animals from different Habitats

S.No	Name of the Animal	Habitat	Adaptive Features
1	Polar Bear	Polar region	Thick skin for protection, white fur
2	Penguin	Polar region	Paddle to swin, walk with two leg.
3	Mountain Goat	Mountains	Strong hooves for running, long hair to protect from cold
4	Lion	Forest	Strong and fast runner has sharp claws to catch prey.

The mountain goat namely Nilgri Tahr can find small spaces on rock to climb with ease and keep its balance as it feeds

7th Term II

Unit 5 – Basis of Classification

Features of dichotomous key

- A single feature that differentiate a group easily.
- One character selected to separate the group, as present or absent.
- Continue the 2nd step until only one item will remain at the end.

Dichotomy of Animals

- Using a dichotomy pattern, classify the given list of animals: Ostrich, peacock, monkey, frog, toad, turtle, snake, shark, goldfish, ant, tapeworm, earthworm and leech.
    - Presence or absence of back bone, we can classify them into two groups.
    - Animals with back bone can be divided into its subgroup based on its body temperature.
    - Further classification can be done based on its difference like presence of feather or hair, scales etc.

Basics of Classification:

- Living organisms are so large in number that they need to be classified into smaller groups. Classification of living organisms is made on the basis of their characteristics, similarities and differences Based on the, special features and characters, the students identify each button, according to its size, hole and colour. This is known as identification. Then teacher shall ask students to separate the buttons according to the size, hole and colours. This is known as assortment. After assorting the buttons the teacher ask the students to gather the buttons according to their, size, hole and colours. This is termed as

grouping. Identification, assortment and grouping, which results in classification.

Aristotle was a Greek philosopher and thinker who lived about 2400 years ago. Aristotle came up with the following grouping system that was used for almost 2000 years after his death!

- He classified all organisms into either animals or plants.
- Then he classified into those 'with blood' and those 'without blood'.
- Then the animals are classified into three groups based on their method of movement: walkers, flyers or swimmers.

Need for Classification

- Classification is needed to identify an organism correctly.
- It helps to know the origin and evolution of an organism.
- To establish the relationship among different organisms.
- It provides the information about living things in different geographical regions
- It helps in understanding how complex organisms must have evolved from simpler ones.

- Scientists have been able to discover and classify more than 2 million organisms on the earth ranging from tiny bacteria to the largest blue whales. Each organism has been classified in a category based on its evolutionary relationship with other group of organisms. We can define hierarchy of organisms as:

- "The system of arranging taxonomic categories in a descending order based on their relationships with other group of organism is called hierarchy of categories". This system was introduced by Linnaeus and is called Linnaean hierarchy. There are seven main categories of hierarchies namely, Kingdom, Phylum, Class, Order, Family, Genus and Species. Species is the basic unit of classification.

Classification of Plants

- Based on dichotomy, plants also can be classified into two main groups – Flowering and Non – flowering. Non – flowering plants do not produce seeds and flowering plants produce seeds. Based on their nature of plant body, Non – flowering plants are classified into three types: algae, mosses and ferns. Based on their fruit body, flowering plants are classified into two types: gymnosperms and angiosperms

Algae

- Plant is thallus, not well-differentiated into root, stem, and leaves.
- They are predominantly aquatic.
- They are unicellular or multicellular - filamentous. Example – Chara

Mosses

- Plant body is not differentiated into true root, stem and leaves.
- They are water living plants, needs moisture to complete its life cycle. Hence they are referred to as amphibious plants.
- They do not have any specialized vascular tissues for conduction of water and food.

Examples: Funaria

Ferns

- Plant body is well-differentiated into root, stem, and leaves. Leaves may be large or small.
- Specialized vascular tissues are found for the conduction of water and food.
- Basically they are the first land plants which grows well in shady, moist, and cool places.

(Examples: Adiantum)

Gymnosperms

- Plants are perennial, woody, evergreen with true root, stem and leaves.
- They possess vascular tissues, xylem without vessels and phloem without companion Cells.
- Ovules are naked, without ovary. Hence they do not produce fruits. Seed are naked.

(Examples: Pinus, Cycas)

Angiosperms

- Plant body is well differentiated into true root, stem, and leaves.
- They produce flower with four whorls (calyx, corolla, androecium and gynoecium), hence known as flowering plants.
- Female reproductive organ, ovary is present inside the flower which develops into fruit and ovule develops into seed.
- Plant possess well developed vascular system with xylem vessels and phloem –companion cells.

- Angiosperms are the dominant plant forms of present day. Based on the number of cotyledons, angiosperms are broadly divided into two groups. a) monocotyledons b) dicotyledons. Plant seeds which have only one cotyledon are said to be monocots. Plant seeds which have two cotyledons are known as dicots.

Example- Paddy (monocot), tamarind (dicot).

The Five Kingdom Classification

- The five kingdom classification was proposed by R.H. Whittaker in 1969. Five kingdoms were formed on the basis of characteristics such as cell structure, mode of nutrition, source of nutrition and body organization.

Monera

Kingdom Monera – Bacteria

- All prokaryotes belong to the Kingdom Monera, which do not posses true nucleus. Cells of prokaryotes do not have a nuclear membrane and any membrane bound organelles. Most of the bacteria are heterotrophic, but some are autotrophs. Bacteria and Blue green algae are examples for monera

Kingdom Protista:

- The Kingdom Protista includes unicellular and a few simple multicellular eukaryotes. There are two main groups of protists. The plant like protists are photosynthetic and are commonly called algae. Algae include unicellular and multicellular types. Animals like protists are often called protozoans. They include amoeba and paramecium.

Kingdom Fungi:

- Fungi are eukaryotic, and mostly are multicellular. They secrete enzymes to digest the food and absorb the food after digested by the enzymes. Fungi saprophytes as decomposers (decay –causing organisms) or as parasites. Kingdom Fungi includes molds, mildews, mushrooms and yeast.

Kingdom Plantae:

- Planatae (plants) are multicellular eukaryotes that carry out photosynthesis. Reserve food materials are starch and lipids in the

form of oil or fat. Plant cells have cell wall and specialized functions, such as photosynthesis, transport of materials and support. Kingdom Plantae includes ferns, cone bearing plants and flowering plants.

Kingdom Animalia:

- Animalia (animals) are multicellular, eukaryotic and heterotrophic animals. Cells have no cell wall. Most members of the animal kingdom can move from place to place. Eg. Invertebrates like sponges, hydra, flatworms round worms, insects, snails, starfishes. Vertebrates like Fish, amphibians, reptiles, birds, and mammals including human beings belong to the kingdom Animalia.

Characteristics	**Monera**	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell Type	Unicellular, Prokaryotic	Unicellular, Eukaryotic	Multicellular, Non-green and Eukaryotic	Multi Cellular, Eukaryotic	Multi Cellular, Eukaryotic
Nucleus	Absent	Present	Present	Present	Present
Body Organisation	Cellular level of organization	Cellular level of organizations	Multi Cellular with loose tissue.	Tissue level and organ level.	Tissue, organ and organ system
Mode of Nutrition	Auto (or) Heterotrophic	Auto (or) Heterotrophic	Saprophytic, parasitic sometime symbiotic	Autotrophic	Heterotrophic
Example	Bacteria and Blue green algae	Spirogyra and Chlamydomonas	Rhizopus and Agaricus	Herb, Shrub and Trees.	Fish, frog, crocodile, Birds and human being

Merits of five Kingdom Classification

- This system of classification is more scientific and natural.
- This system of classification clearly indicates the cellular organization, mode of nutrition,
- and characters for early evolution of life.
- It is the most accepted system of modern classification as the different groups of organisms are placed phylogenetically
- It indicates gradual evolution of complex organisms from simpler one.

Demerits of five Kingdom Classifications

- In this system of classification of viruses have not been given a proper place.
- Multicellular organisms have originated several times from protists.
- This type of classification has drawn back with reference to the lower forms of life.
- Some organisms included under Protista are not eukaryotic

Binomial Nomenclature

- Gaspard Bauhin in 1623, introduced naming of organisms with two names which is known as Binomial nomenclature, and it was implemented by Carolus Linnaeas in 1753. He is known as 'Father of Modern Taxonomy'.
- Binomial nomenclature is an universal system of naming organisms. As per this system, each organism has two names – the first is the Genus name and the second is the Species name. Genus name begins with a capital letter and Species name begins with a small letter.

Example: The nomenclature for onion is Allium sativam. Genus name is Allium, species name is sativam.

- Vernacular name is a local name that is familiar for a particular place. Binomial name is an universal name which never changes. Binomial nomenclature and classification helps scientists to identify any organisms and to place them at a particular hierarchy.

8th Term I
Unit 6 – Microorganisms

Introduction

- Microorganisms are too small in size that they cannot be seen through naked eye. These organisms can be seen only with the help of a microscope, therefore they are also known as microbes. The science that deals with the study of microorganisms is known as microbiology.

- Microorganisms occur everywhere. They are found in air, water (ponds, lakes, rivers and oceans), soil and even inside our bodies. Some of them can even survive in severely adverse conditions, such as hot springs, deserts, snow and deep oceans. They remain inactive under unfavourable conditions and become active during favourable conditions.

Microorganisms can be studied under five categories. They are:

- **Virus**
- **Fungi**
- **Protozoa**
- **Bacteria**
- **Algae**

Virus

- A virus is a tiny, particle made up of genetic material and protein. They are intermediate between living and non living things. Virus means 'poison' in Latin. Viruses are intracellular obligatory parasites. The study of virus is called 'virology'. Viruses are 10,000 times

smaller than bacteria. Viruses have different shapes. They can be rod shaped, spherical or of other shapes.

Virus structure

- A virus contains a core DNA or RNA. Surrounding that core is a protein coat. In some viruses, the protein coat is covered by an envelope made of proteins, lipids, and carbohydrates. The envelope has spikes that help the virus particles attach to the host cells.

Virus shows both living and non living characters:

Living characters

- They respond to heat, chemicals and radiations.
- They reproduce inside the host cells and produce copies of themselves.
- They show irritability

Non-Living characters:

- They are inactive when present freely in the environment.
- They can be crystallized and stored for a very long time, like other non-living things.
- The metabolic machinery, cytoplasm is absent.

Viruses cause many diseases to plants, animals and human beings.

Bacteria

- Bacteria are single-celled prokaryotes (cells without nuclei). They are considered to be the first living organisms on earth. Bacteria are grouped under the kingdom Monera. The study of Bacteria is called Bacteriology. The size of bacteria range from 1µm to 5µm (micrometer). Bacteria are of two types based on respiration.

- Aerobic bacteria (requires oxygen).
- Anaerobic bacteria (Does not requires oxygen).

Cell structure:

- A bacterium has an outer covering known as the cell wall. Nuclear material is represented by a nucleoid without nuclear membrane. An extra chromosomal DNA called plasmid is present in the cytoplasm. Protein synthesis is carried out by 70S ribosomes. Other cell organelles (mitochondria, Golgi body endoplasmic reticulum etc.,) are absent. Flagella aids in locomotion.
- Bacteria are described according to the shape of their cells. They are:
  - Bacilli - Rod shaped bacteria. Eg. Bacillus anthracis
  - Spirilla - Spiral shaped bacteria. Eg. Helicobacter pylori
  - Cocci - Spherical or ball shaped bacteria. They can stick together in pairs (diplococcus); form a chain (streptococcus) eg. Streptococcuspneumoniae or occur in bunches (staphylococcus).
  - Vibrio - comma shaped bacteria. Eg. Vibrio cholera
- Bacteria are also classified according to the number and arrangement of flagella, which are as follows:
  - Monotrichous - Single flagella at one end. Eg. Vibrio cholera
  - Lophotrichous - Tuft of flagella at one end. Eg. Pseudomonas.
  - Amphitrichous - Tuft of flagella at both ends. Eg. Rhodospirillum rubrum.
  - Peritrichous - Flagella all around. Eg. E.coli.

- Atrichous - Without any flagella. Eg. Corynebacterium diptherae

- Bacteria get their food in many ways. Photosynthetic bacteria make their own food. (Eg. Cyanobacteria). Bacteria that live in harsh environment use chemicals (Ammonia, hydrogen sulphide) to produce their food instead of utilizing energy from the sun. This process is called chemosynthesis. Some bacteria exhibit symbiotic relationship (eg. E.coli lives in the intestine of man). Bacteria reproduces by fission (binary and multiple fission).

Fungi

- Fungi are group of eukaryotic organisms that lack chlorophyll. They grow in dark environments. They may be either unicellular (eg. Yeast) or multicellular (eg. Penicillium). They are found in all kinds of habitats. They are included under kingdom Fungi. The study of fungi is called mycology. Some fungi are macroscopic (eg. Mushroom). There are around 70,000 species of fungi, living in the world.

Cell structure:

Unicellular fungi (eg. Yeast)

- Yeasts are found freely in the atmosphere. Yeast grows in all kinds of media containing sugar. The cell is ovoid in shape, containing cell wall and a nucleus. The cytoplasm is granular, and has vacuoles, organelles, glycogen an oil globules. Yeast aids in fermentation with the help of the enzyme zymase. Yeast respires anaerobically. Yeast reproduces by budding.

Multicellular fungi (eg. Mushroom)

- Mushrooms are found growing on wet soil in shaded places during the rainy season, such as at the roots of the trees. The umbrella shaped structure that grows above the soil is known as the fruiting body. There are small slit like structures under the umbrella which are known as gills. The gills contain spores.

- The mycelium is located underneath the fruiting body, in the top layer of the soil. Mycelium in turn is made up of thread-like structures called hyphae. Walls of the hyphae are made up of chitin and cellulose. Hyphae help in transport of nutrients for the growth of mushroom. Reproduction is by the method of fragmentation and spore formation.

- Fungi are either saprophytes (i.e., derives nutrition from the remains of dead and decomposing plants and animals) eg. Rhizopus, Penicillium, Agaricus, or parasites (ie. derives nutrition from the living cells of the host) eg. Puccina, Albugo, Ustilago, or symbionts (ie., fungus in the roots of vascular plant) eg. Mycorrhiza.

Algae

- Algae are very simple plant like eukaryotic organisms. Algae are found in moist habitats. Algae are rich in chlorophyll and can be seen as thin film on the surface of lakes and ponds, therefore they are known as 'grass of water'. They are autotrophic and manufacture their own food with the help of chloroplast. Chloroplast contain chlorophyll (green) pigments for photosynthesis. The study of algae is called algology (phycology).

- Their size varies from 1 micron to 50 meter. Algae may be unicellular, microscopic (eg. Chlamydomonas) or multicellular and macroscopic (eg. Sargassum). Unicellular algae exhibits variety of shapes (i.e., spherical, rod, spindle), where as multicellular algae are in the form of filaments and branches.

Cell structure
(Eg. Chlamydomonas)

- Chlamydomonas is a simple, unicellular, motile fresh water algae. They are oval, spherical or pyriform in shape. The pyriform (pear shape) is a common one found in ponds, ditches and water tanks. They have a narrow anterior end and a broad posterior end.

- The cell is surrounded by a thin and firm cell wall made of cellulose. The cytoplasm is seen in between the cell membrane and the chloroplast. The cell contains large dark nucleus lying inside the cavity of the cup shaped chloroplast. The anterior part of the cell bears two flagella which helps in locomotion. Two contractile vacuoles are seen at the base of each flagellum. The anterior side of the chloroplast contains a tiny red coloured eyespot. Chlamydomonas exhibits sexual and asexual modes of reproduction.

Some algae have other photosynthetic pigments like fucoxanthin (brown), xanthophylls (yellow), phycoerythrin (red), phycocyanin (blue).

Protozoan

- A protozoan (in Greek protos = first and zoon = animal) is a single-celled eukaryote. They are included under the kingdom Protista. The study of protozoa is called Protozoology. They are found in ponds, ocean, in moist soil, and in the cells and tissues of plants and animals causing diseases. They range from 2-200 microns. Protozoans have specialized organelles. These organelles are used for movement, feeding, and other functions. The types of protozoans are as follows

- Ciliates - presence of cilia for locomotion (eg. Paramecium)
- Flagellates - presence of flagella for locomotion (eg. Euglena)
- Pseudopods - presence of pseudopodia for locomotion (eg. Amoeba)
- Sporozoans - parasites(eg. Plasmodium)

Cell structure (Eg. Amoeba)

- Amoeba is a unicellular microscopic organism. It is found in ponds. Amoeba is irregular in shape. It has cell membrane, cytoplasm and nucleus. It is a protozoan that move by means of pseudopodia (in Latin, "false feet.") Pseudopodia are the extended part of cell membrane. It helps to catch its prey (algae). The body 'flows' around

the food particle and engulfs it forming food vacuoles. Contractile vacuoles are seen in the cytoplasm that help in excretion. Amoeba reproduces by means of fission and sporulation.

Uses of Microorganisms in Medicine, Agriculture, Industry and Daily Life

Medicine

We obtain antibiotics and vaccines from microbes.

Antibiotics

- The word 'Anti' means 'against'. Antibiotic is a substance produced by living organisms which is toxic for other organisms. Sir Alexander Fleming was the first person to discover the antibiotic Penicillin in the year 1928. The antibiotic Penicillin was obtained from the fungi Penicillium chrysogenum. It is used to treat diseases such as tetanus, diphtheria. Antibiotic Streptomycin is obtained from Streptomyces bacteria to cure various bacterial infections eg. Plague.

Vaccines

- Vaccines are prepared from dead or weakened microbes. Edward Jenner was the first person to discover small pox vaccine. He coined the term vaccination. When the vaccine is injected to the body of a patient, the body produces antibodies to fight against the germs. These antibodies remain inside the body and protects from future invasion of the germs. Therefore vaccination is otherwise called as immunization.

Eg. MMR vaccine for Measles, Mumps, Rubella. BCG (Bacille Calmette Guerin) vaccine for Tuberculosis

Agriculture

Natural Fertilizer

- Microorganisms are called as decomposers because they act upon degradable wastes. During the process, nitrates and other inorganic nutrients are released into the soil, making the soil fertile. This compost is called as natural fertilizer.

Nitrogen Fixation:

- Rhizobium bacteria living in the root nodules of leguminous plants enrich the soil by fixing the atmospheric nitrogen as nitrates which are essential for the growth of plants. Some free living bacteria in soil, cyanobacteria Nostoc can also fix nitrogen biologically.

Biocontrol Agents:

Microbes are used to protect the crops from pests. For example,

- Bacillus thuringiensis (Bt cotton) helps to control insects.
- Trichoderma (Fungi) helps to protect roots and control plant pathogens.
- Baculoviruses (Virus) attack insects and other arthropods.

Industry

Sewage Treatment

- Aerobic microbes are allowed to grow in the primary effluent during the secondary stage of waste water treatment. These microbes consume the major part of the organic matter in the effluent eg. Nitrobacter sps. In the anaerobic treatment of sewage Methanobacterium is used.

Production of Biogas

- Human and animal faecal matter and plant wastes are broken down by anaerobic bacteria to produce methane (biogas) along with carbon dioxide and hydrogen. These bacteria are called as methanogens.

Production of Alcohol and Wine

- Alcoholic drinks are prepared by fermentation process using yeast. Sugars in grapes are fermented by using yeast. Beer is produced by the fermentation of sugars in rice and barley.

Microbes in Retting and Tanning Process

Retting

- Flax plants are tied in bundles and kept in water. Bacteria loosen the supporting fibres of the stem by acting on the stem tissues. This process is known as retting. Linen thread is made from these fibres eg. Pseudomonas aeruginosa.

Tanning

- In Tanning industry bacteria act upon the skin of animals and makes it soft and therefore it becomes pliable.

In Daily Life

Making of Bread

- Yeast is used in bakeries to make bread and cakes. They are added to the dough to produce carbon dioxide which makes the dough rise. Bread and cakes are soft due to carbon dioxide gas. Chlorella (green algae) is rich in proteins and vitamins is added to the dough which enrich the bread with nutrients.

Preparation of Curd and Cottage Cheese

- Lactose in the milk gets turned into Lactic acid by the action of Lactobacillus (bacteria). Therefore the milk becomes thick (curd). It gives the sour taste. When curd is processed cottage cheese (panneer) is obtained.

In Human Intestine

- Lactobacillus acidophilus that lives in the human intestine helps in digestion of food and fight against harmful disease causing organisms.

- E.coli bacteria in human intestine help in synthesizing vitamin K and vitamin B complex.

Harmful Microorganisms

- A few microorganisms are harmful to humans, animals and plants. They cause diseases and hence they are called as pathogens. Pathogens enter into the body through cuts and wounds in the skin, mouth or nose and cause diseases. Viruses causing 'flu' are spread through air. When the patient sneezes droplets containing viruses spread in air and it gets entered to another person when he breathes.

Diseases Caused By Microorganisms In Humans

S.NO	Human Diseases	Causative microorganisms	Mode of Transmission	Symptoms	Preventive measures/Treatment
1	Tuberculosis	Mycobacterium tuberculosis (Bacteria)	Through air and sputum of infected person	Persistent cough, blood mucus, loss of weight, breathlessness	BCG Vaccine
2	Choler	Vibrio	By flies	Water	Anticholera

	a	Cholera (Bacteria)	and by contaminated food and water	diarrhea, vomiting, rapid dehydration.	vaccine, maintaining personal hygiene.
3	Common Cold	Influenza (virus)	Through Air	Running nose, sneezing	Isolation of patient.
4	Rabies	Rhabdo viridae (virus)	Animal bite	Fever, hallucination, Paralysis inability to swallow	Anti – rabies vaccine.
5	Amoebic dysentery	Entamoeba histolytica (protozoa)	Food water and flies	Severe diarrhea and blood in stool	Proper sanitation to be followed and metronidazole antibiotic to be administered
6	Malaria	Plasmodium (protozoa)	Female Anopheles mosquito	Nausea, vomiting High Fever	Antimalarial drugs like quinine, chloroquine to be taken and also usage of mosquito repellents and nets.

Diseases Caused By Microorganisms in Animals

Animal Diseases	**Causative microorganisms**	**Mode of transmission**	**Symptoms**	**Preventive measures / Treatment**
Anthrax (Cattle) also	Bacillus anthracis (Bacteria)	Through contaminated soil and	Difficulty in breathing, unconsciousness	Anthrax Vaccine

affects humans		food.	, loss of appetite	
Food and mouth disease	Aphthovirus (virus)	Through air and animal vectors	Fever, blisters in mouth, weight loss, decreased milk produced.	FMD Vaccine

Diseases Caused By Microorganisms in Plants

Plant Diseases	**Causative microorganisms**	**Mode of transmission**	**Symptoms**	**Preventive measures / Treatment**
Citrus Canker	Xanthomonas axonopodis (Bacteria)	Air, water	Lesions on leaves, stems and fruit	Copper based bactericides can be used.
Potato blight disease	Phytophthora infestans (Fungi)	Air	Brown lesions on the surface of tubers	Fungicides are used

MICROBES IN FOOD PROCESS

- For food processing, commonly used microorganisms are yeast, bacteria, and moulds. Fermentation process which is carried out by microorganisms results in the production of organic acids, alcohol and esters. They help to preserve food and generate distinctive new food products.

Food Preservation:

Two techniques are followed in food preservation. They are;

- Traditional techniques
- Modern techniques

Traditional techniques:

- Fermentation**:** Fermentation is the microbial conversion of starch and sugars into alcohol. It makes foods more nutritious and palatable.

- **Pickling:** Pickling is a method of preserving food in an edible antimicrobial liquid. It is of two types:

- **Chemical pickling:** Food is placed in an edible liquid that kills bacteria and other microorganisms. Eg. Vinegar, alcohol, vegetable oil. (pickling agents)

- **Fermentation pickling:** Bacteria in the liquid produce organic acid as preservation agent that produces lactic acid due to the presence of Lactobacillus.

- **Boiling:** Boiling liquid food items kill all the microbes. Eg. Milk and Water.

- **Sugaring:** Sugar is used to preserve fruits in an antimicrobial syrup with fruit such as apples, pears, peaches, plums or in a crystallized form, therefore the product is stored in dry condition.

Modern techniques:

- **Pasteurization:** It is a process for preservation of liquid food. This method was invented by Louis Pasteur in 1862. Milk is heated up to 70^{o}c to kill the bacteria and it is cooled to 10^{o}c to prevent the growth of remaining bacteria. Then milk is stored in sterilized bottles in cold places.

Food Production:

- **Probiotics:** Probiotics are live food supplements used in yoghurt and other fermented milk products. Eg. Lactobacillus acidophilus and Bifidobacterium bifidum. These bacteria improve the microbial spectrum in the gut and thus contribute to the following effects:

- Decrease the risk of colon cancer
- Decrease cholesterol absorption
- Prevent diarrheal diseases by increasing the immunity power

RELATIONSHIP BETWEEN MAN AND MICROBES-BALANCES, IMBALANCES AND USES

- Thousands of bacteria, fungi and other microbes that live in our gut are essential contributors to a good health. They break down toxins, manufacture some vitamins and essential amino acids and form a barrier against invaders. Gut microbes are the bacteria in human gut. It is one of the most important allies in our overall health and well being. Gut ensures that the body is absorbing all the important nutrients, to function at its highest level. Many different aspects of health are attached to it.

PRIONS

- The word prion is derived from "protinaceous infectious particle". Prions have neither DNA or RNA to transmit infection. A prion is a mutted form of a usually harmless protein. Prions cause diseases by affecting brain or neural tissue. Eg. Creutzfeldt-Jackob disease. Another example is Kuru- associated with cannibalism.

VIRIONS

- Virion is an entire virus particle consisting of an outer protein shell called a capsid and an inner core of nucleic acid (RNA or DNA). If the virus is found outside the cell (extracellular) it is known as virion. Virion has the capacity to infect the living tissue.

8th std
Unit: 7. Plant Kingdom

Introduction

- The living organisms found on the earth are different in their structures, habit, habitat, mode of nutrition and physiology. The estimated number of species on the earth is 8.7 million. Among them 6.5 million (1 million =10 lacks) species are living on land, 2.2 million species in the ocean. In these 4,00,000 species are flowering plants. The living organisms show lot of similarities and differences so that they can be arranged into many groups systematically. The plant kingdom includes thallophytes, bryophytes, pteridophytes, gymnosperms and angiosperms.

Taxonomy

- Taxonomy is the branch of biology that deals with the study of identification, classification, description and nomenclature of living organisms. The word taxonomy is derived from two Greek words (**Taxis:** arrangement and **Nomos**: laws.) The word 'Taxonomy' was first coined by Augustin-Pyramus de Candolle.

Classification:

- Plants are arranged into different groups and categories on the basis of similarities and differences are called classification.

Types of classification:

There are four types of classification.

1. Artificial system of classification

2. Natural system of classification

3. Phylogenetic system of classification

4. Modern system of classification

Artificial system of classification

- This is the earliest system of classification in plants. Plants are classified on the basis of one or few morphological characters. The most famous artificial system of classification is Linnaeus classification which was proposed by Carolus Linnaeus in Species plantarum.

Natural system of classification

- In this system, plants are classified on the basis of several characters. Bentham and Hooker's classification is an example of Natural System of Classification. This system of classification is based on morphological and reproductive characters of the seeded plants.

- This classification is widely used in many Herbaria (herbarium is defined as the collection of pressed, dried plants pasted on a sheet and arranged according to any one of the accepted systems of classification) and botanical gardens all over the world.

Bentham and **Hooker** published their Natural system of Classification in their book named Genera Plantarum in 3 volumes.

OUTLINE OF BEtrf5NTHAM AND HOOKER'S SYSTEM OF CLASSIFICATION

The division spermatophyta are divided into 3 classes:

- **Dicotyledonae**
- **Gymnospermae**
- **Monocotyledonae**

Class I - Dicotyledonae

- **Seed has two cotyledons.**
- **Leaves have reticulate venation**
- **Tap root system is present.**
- **Flowers are tetramerous or pentamerous.**

Class II - Gymnospermae (Naked seed plants)

- Plants of this class have no fruit.
- It has three families, they are

1. Cycadaceae
2. Coniferae
3. Gnetaceae

Class III - Monocotyledonae

- Seed has single cotyledon.
- Leaves have parallel venation.
- Fibrous root system is present
- Flowers are Trimerous

Binomial Nomenclature

- The naming of an organisms with two words are known as Binomial Nomenclature. For example, the binomial name of mango is Mangifera indica. Here the first word Mangifera refers to the genus name and the second word indica to the species name.

- Binomial system had been properly made used by Linnaeus in his book, "Species Plantarum."

- The system of naming the plants on scientific basis is known as Botanical nomenclature. Binomial name was first introduced by Gaspard Bauhin in the year of 1623.

Salient features of Algae

- Algae are chlorophyll bearing simple, primitive plants and are autotrophs.
- Algae belongs to thallophyta, and the plant body of algae are called thallus. i.e. the plant body is not differentiated into root, stem and leaf.
- Most of the algae are living in aquatic region. It may be fresh water or marine water. Very few algae can survive in terrestrial conditions.
- Some algae are very minute and float on the surface of the water. These algae are called Phytoplankton.
- Some of the algae are symbionts (algae living with fungi and they both are mutually benefitted.) e.g. Lichen.
- A few species of them are epiphytes (growing on another plants).

Various forms of Algae:

- Plant body of the algae are unicellular or multicellular
- Unicellular motile (Chlamydomonas), non-motile. (Chlorella)
- Multicellular unbranched filaments (Spirogyra) and branched filaments (Cladophora).
- Some algae are giant kelp – Macrocystis.

- Some algae are living as colonial form – Volvox.
- Alga like Chara resembles largest plant body and it possess well developed sex organs.

Reproduction of Algae:

- Three types of reproduction are seen in algae.
- Vegetative reproduction by fragmentation e.g. Spirogyra.
- Asexual reproduction by spore formation e.g. Chlamydomonos.
- Sexual reproduction by mean of fusion of gametes e.g. Spirogyra, Chara

S. No.	Class	Types of Pigments	Reserve food matrial
1.	Bluegreen algae (Cyanophyceae)	Phycocyanin	Cyanophycean Starch
2.	Green algae (Chlorophyceae)	Chorophyll	Starch
3.	Brown algae (Phaeophyceae)	Fucoxanthin	Laminarian starch and Manitol
4.	Red algae (Rhodophyceae)	Phycoerythirin	Floridian Starch

Economic Importance of algae:

1. Food:

- Algae are consumed as food by the people in Japan, England and also in India. e.g. Ulva, Spirulina, Chlorella etc..
- Some algae are used as a food for domestic animals. e.g. Laminaria, Ascophyllum.

2. Agriculture

- Some of the blue green algae are essential for the fixing of atmospheric nitrogen into the soil, which increases the fertility of the soil. e.g. Nostoc, Anabaena.

3. Agar Agar

- Agar Agar is extracted from some red algae, namely Gelidium, Gracillaria, etc., which is used to prepare growth medium in laboratories.

4. Iodine

Iodine is obtained from brown algae like Laminaria (kelp).

5. Algae in space Travel

- Chlorella pyrenoidosa is used in spacew travel to get rid of CO2 and decompose human wastes.

6. SCP (Single Cell protein)

- Some of the single cell algae and blue green algae are used to produce protein. e.g. Chlorella, Spirulina.

Fungi

General characters of fungi

- Fungi (singular – fungus) belongs to thallophyta because the plant body is not differentiated into root, stem, and leaves.

- The plant body of fungus consists of filament like structures called as hyphae. Several hyphae arranged in the form of network called mycelium. There are two types of mycelium found in fungi, namely septate mycelium and aseptate mycelium. If the cross wall is seen between the cell, it is called septate mycelium. If the cross wall is not

seen, it is called aseptate mycelium. When aseptate mycelium contains many nuclei it is called as coenocytic mycelium.

- The cells of fungi are multicellular and eukaryotic organisation. Some species of fungi like yeast is unicellular and eukaryotic cell. Cell wall of fungi is made up of a chemical substance called chitin. The reserve food materials of fungi are glycogen and oil. They have no starch because they have no chlorophyll pigments. So, they are heterotrophs. Heterotrophs are of three types called parasites, saprophytes and symbionts.

Parasites

- Parasites absorbs food from the living organisms with the help of special root called haustoria. e.g. Cercospora personata. It affects groundnut plants and causeTikka disease.

Saprophytes:

- Saprophytes grow up on the dead and decay matters and get food from them. e.g. Rhizopus.

Symbionts:

- Some species of fungi living with algae and are mutually benefitted. e.g. Lichen.
- Some fungi live symbiotically with higher plants roots called Mycorrhizae

Classification of fungi (W.Martin 1961)

Economic Importance of Fungi:

1. Antibiotic:

Penicillin (Penicillium notatum), Neomycin, Gentamycin, Erythromycin are some antibiotics obtained from fungi, which cure variable diseases.

2. Food:

Mushroom contains rich protein and minerals. The most common edible mushroom is Agaricus. (Button mushroom).

3. Vitamins:

Fungus like Ashbya gospii and E r y mo t h e c i u m ashbyii are used to produce vitamin B2 (riboflavin).

4. Alcohol:

Fungus like yeast contain enzymes invertase and zymase, which ferment the sugar molasses into alcohol.

Harmful Effects of Fungi

Diseases caused by Fungi in Plants

S. No.	Pathogen	Name of the Disease
1.	Fusarium oxispotam	Wilt disease of cotton
2.	Cercospora personata	Tikka disease of ground nut
3.	Colletotrichum	Red rot of sugar cane
4.	Pyricularia oryzae	Blast disease of paddy
5.	Albugo candida	White rust of radish

Bryophytes

General Characters of Bryophytes

- Bryophytes are the primitive and simplest group of land plants.
- These are terrestrial and non-vascular cryptogams (they have no vascular tissues lik xylem, phloem).

Differences between algae and fungi

S. No.	Algae	Fungi
1.	Algae are autotrophs.	Fungi are heterotrophs.
2.	It has pigments.	It has no pigments
3.	Reserve food material is	Reserve food materials are

	starch.	glycogen and oil.
4.	Some algae are prokaryotic in nature eg. Cyanobacteria (Nostac, Anabenae)	All are eukaryotic nature.eg.Agaricus

• Water is essential to complete their life cycle, so these plants are called amphibians of the Plant Kingdom.

• Bryophytes have distinct alternation of generation. gametophytic is domina and sporophytic generation is small and depends on the gametophytic generation.

• The gametophytic plant can be either thalloid (liverworts) or leafy (mosses).

• The plant remains fi xed to the substratum with the help of root like structure called rhizoid.

- Sexual reproduction is oogamous type
- They have well developed sex organs like antheridia and archegonia.
- The male sex organ is antheridium, which produces antherozoid. The female sex organ is archegonium which contains an egg.
- Antherozoid swims and reaches the archegonium, fertilizes the egg and form zygote (2n).
- Zygote is the first cell which develops into sporophytic generation and produce haploid spore (n) by meiosis.
- Spore is the first cell of the gametophytic generation. Class I Hepaticae (e.g. Riccia)
- Protonemal stage is present.
- Sporophytes is differentiated into foot, seta, and capsule

Economic Importance of Bryophytes:

- 1. Bryophytes prevent the soil erosion.

2. Sphagnam can absorb large amount of water. Hence, it is used by the gardeners in nursery.

3. Peat is a valuable fuel like coal obtained from Sphagnum.

Class I Hepaticae (e.g. Riccia)

- These are lower forms of bryophytes. They are simple in structure than moss.
- Protonemal stage is absent. Sporophyte is very simple and short lived.

Class–II Anthocerotae (e.g. Anthoceros)

- Gametophyte is undifferentiated thallus, rhizoids are unicellular and unbranched.
- Protonemal stage is absent. Sporophyte is differentiated into foot and capsule only.

Class-III Musci (e.g. Funaria)

- These are higher forms in which the gametophytes is differentiated into stem like, leaf like parts.
- Protonemal stage is present.
- Sporophytes is differentiated into foot, seta, and capsule

Pteridophytes

General Characters of Pteridophyte:

- Pteridophytes are the first true land plants with xylem and phloem. Hence it is called vascular cryptogams.

Pteridophytes also exhibit alternation of generation. The diploid sporophytic phase

alternates with the haploid gametophytic phase.

- The main plant body is sporophytes, which is the dominant phase, differentiated into true root, stem and leaves.
- Sporophytes reproduce by means of spores. Spores are produced in sporangium.
- The sporangia bearing leaves are called sporophyll.
- Most of the plants produce only one type of spore, it may be either microspore or megaspore (homosporous).
- In some plants two types of spores are produced. They are microspore and megaspore(heterosporous).
- Spores give rise to gametophytic generation called prothallus, which is short lived and independent.
- The gametophytes produce the multicellular sex organs, Antheridium which produces antherozoid (male gamete) and archegonium which contains an egg. (female gamete)
- The antherozoid fertilizes with egg and form diploid zygote. It develops into an
- embryo which grow differentiate into sporophyte.

Economic Importance of Pteridophytes:

- Ferns are used as ornamental plants.

- The rhizome and petioles of the Dryopteris yield the vermifuge drug.

- The sporocarp of Marsilea (water fern) is used as food by tribal people.

Differences between Bryophytes and Pteridophytes

S. No.	Bryophytes	Pteridophytes
1.	Plant body cannot be differentiated into root, stem and leaf	Plant body can be differentiated into root, stem and leaf.
2.	Bryophytes are amphibian	Pteridophytes are land plants.
3.	Vascular tissues are absent.	Vascular tissues are present.
4.	The dominant phase of the plant body is gametophyte.	The dominant phase of the plant body is sporophyte.
5.	Sporophytic generation depends on the gametophytic generation e.g.Riccia	Gametophytic generation does not depend on sporophytic e.g. Selaginella

Gymnosperms

General Characters of Gymnosperms

- Gymnosperm are naked seed plant, i.e. the ovule is not enclosed by ovary.

- Gymnosperms have two phases in its life cycle. (Sporophytic and Gametophytic)

- Plant body is sporophyte dominant which is differentiated into root, stem and leaf.

- They have well developed vascular tissues. (xylem and phloem)

- The water conducting tissue is tracheid. Food conducting tissue is sieve cell.

- They have cone on which sporangia and spores are produced.

Economic Importance of Gymnosperms

- Woods of many conifers are used in the paper industries. e.g. Pinus, Agathis
- Conifers are the sources of soft wood for construction, packing and plywood industry e.g. Cedrus, Agathis
- Turpentine is an essential oil used for paint preparation extracted from the resin of Pinus. It is also used medicinally to get relief from pain and bronchitis etc.,
- Seeds of Pinus gerardiana are edible.
- Ephedrine is an alkaloid extracted from Ephedra. It cures asthma and respiratory problems.
- Araucaria bidwillii is an ornamental plant.

Classification of Gymnosperms

Cycadales e.g Cycas sps	**Ginkgoales eg. Ginko biloba**	**Coniferales eg. Pinus sps**	**Gnetales**
Palm like small plants (erect and unbranched)	Ginko biloba is the only living species in the group.	Evergreen trees with cone like appearance.	Small group plants.
Leaves are pinnately compound forming a crown.	It is a large tree with fan shaped leves.	Needle like leaves or scale leaves.	It posses advanced characters Angiosperm
Tap root system and Coralloid root.	They produce unpleasant smell.	Seeds are winged and produced in female cone.	Ovules naked developed flower shoot.

Angiosperms (Closed seeded plants)

General Characters of Angiosperms

- The term 'Angiosperm 'is derived from two Greek words, i.e. 'Angio' which means box or closed and 'sperma' which means seed.
- Angiosperms are called flowering plants. In this group more than 4,00,000 living species are found.
- They occupy every habitat on earth except extreme environment. (extreme hot and cold conditions).
- Habit of the plants may be herb, (Solanaum melongena) shrub, (Hibiscus rosasinensis) and tree – Mangifera indica (Mango)
- They have well developed conducting tissues. (Vascular bundles)
- Xylem contains vessel, tracheid, xylem parenchyma and xylem fibre.
- Phloem contains sieve tubes, phloem parenchyma, companion cells and phloem fibres.

Classification of Angiosperms

Angiosperms are divided into two classes, They are:

- **Monocotyledons**
- **Dicotyledons**

Characteristic features of monocotyledons

- Seed has only one cotyledon.
- Plants have fibrous root system, leaves with parallel venation.

- Flowers are trimerous and not differentiated in to calyx and corolla.
- Pollination occurs mostly by wind.
- E.g. Grass, Paddy, Banana.

Characteristic features of Dicotyledons

- Seed has two cotyledons.
- Plants have tap root system, leaves with reticulate venation.
- Flowers are tetramerous or pentamerous. Calyx and corolla are well differentiated.
- Pollination occurs mostly by insects.
- E.g. Bean, Mango, Neem

Uses of Medicinal plants

Acalypha indica (Kuppaimeni)

- It belongs to the family Euphorbiaceae.
- The paste obtained from the leaves of this plant is used to cure the burns on the skin.
- The juice of this plant leaves is mixed with lemon juice to cure ringworm

Aegle marmelos (Vilvam)

- It belongs to the family Rutaceae.
- The unripe fruit of this tree is used to treat indigestion.
- It is used to cure chronic, diarrhoea and dysentery.

Solanum trilobatum (Thoodhuvalai)

- It belongs to the family Solanaceae.
- The leaves and fruits of this plant cure cough and cold.
- It is widely used in the treatment of tuberculosis and bronchial asthma.

Phyllanthus amarus (Keezhanelli)

- It belongs to the family Euphorbiaceae.
- The entire plant is used for the treatment of jaundice.
- It gives additional strength to human liver and used to treat other liver disorders.

Aloe vera (Sothu Katrazhai)

- It belongs to the family Liliaceae.
- Leaves of this plant is used to cure piles and inflammations on the skin.
- It cures peptic ulcer

9th std
Unit 17 – Animal Kingdom

Introduction

- The variety of living organisms surrounding us is incomprehensible. Nearly 1.5 million species of organism which have been described are different from one another. The uniqueness is due to the diversity in the life forms whether it is microbes, plants or animals. Every organism exhibits variation in their external appearance, internal structure and behavior, mode of living etc. This versatile nature among the living animals forms the basis of diversity. The diversity among the living organisms can be studied in an effective way by arranging each kind of animals in an orderly and systematic manner. The study of various organisms would be difficult without a suitable method of classification.

- The method of arranging organism into groups on the basis of similarities and differences is called classification. Taxonomy is the science of classification which makes the study of wide variety of organisms easier. It helps us to understand the relationship among different group of animals. The first systematic approach to the classification of living organisms was made by a Swedish botanist, Carolus Linnaeus. He generated the standard system for naming organisms in terms of genus, species and more extensive groupings using Latin terms.

Classification of Living Organisms

- Classification is the ordering of organism into groups on the basis of their similarities, dissimilarities and relationships. The five kingdom classification are Monera, Protista, Fungi, Plantae and Animalia. These groups are formed based on cell structure, mode of nutrition, body organization and reproduction. On the basis of hierarchy of classification, the organisms are separated into smaller and smaller groups which form the basic unit of classification.

- **Species:** It is the lowest taxonomic category. For example, the large Indian parakeet (Psittacula eupatra) and the green parrot (Psittacula krameri) are two different species of birds. They belong to different species eupatra and krameri and cannot interbreed.

- **Genus:** It is a group of closely related species which constitute the next higher category called genus. For example, the Indian wolf (Canis pallipes) and the Indian jackal (Canis aures) are placed in the same genus Canis

- **Family:** A group of genera with several common characters form a family. For example, leopard, tiger and cat share some common characteristics and belong to the larger cat family Felidae.

- **Order:** A number of related families having common characters are placed in an order. Monkeys, baboons, apes and Man although belong to different families, are placed in the same order Primates. Since all these animals possess some common features, they are placed in the same order.

- **Class:** Related or similar orders together form a class. The orders of different animals like those of rabbit, rat, bats, whales, chimpanzee and human share some common features such as the presence of skin and mammary glands. Hence, they are placed in class Mammalia.

- **Phylum:** Classes which are related with one another constitute a phylum. The classes of different animals like mammals, birds, reptiles, frogs and fishes constitute Phylum Chordata which have a notochord or back bone.

- **Kingdom:** It is the highest category and the largest division to which microorganisms, plants and animals belong to. Each kingdom is fundamentally different from one another, but has the same fundamental characteristics in all organisms grouped under that Kingdom.

The taxa of living organisms are in a hierarchy of categories as follows

Basis for Classification

- We can divide the Animal kingdom based on the level of organization (arrangement of cells), body symmetry, germ layers and nature of coelom.

- Level of organization: Animals are grouped as unicellular or multicellular based on cell, tissue, organ and organ system level of organization

- **Symmetry:** It is a plane of arrangement of body parts. Radial symmetry and bilateral symmetry are the two types of symmetry. In radial symmetry the body parts are arranged around the central axis. If the animal is cut through the central axis in any direction, it can be divided into similar halves. e.g. Hydra, jelly fish and star fish. In bilateral symmetry, the body parts are arranged along a central axis. If the animal is cut through the central axis, we get two identical halves e.g. Frog.

- **Germ layers:** Germ layers are formed during the development of an embryo. These layers give rise to different organs, as the embryo becomes an adult. Organisms with two germ layers, the ectoderm and the endoderm are called

- **diploblastic** animals. e.g Hydra. Organisms with three germ layers, ectoderm, mesoderm and endoderm are called **triploblastic** animals. e.g Rabbit

- **Coelom:** It is a fluid-filled body cavity. It separates the digestive tract from the body wall. A true body cavity or coelom is one that is located within the mesoderm. Based on the nature of the coelom, animals are divided into 3 groups.

➢ Acoelomates do not have a body cavity e.g Tapeworm.

➢ Pseudocoelomates have a false body cavity e.g Roundworm.

- Coelomates or Eucoelomates have a true coelom e.g Earthworm, Frog.

- Animal Kingdom is further divided into two groups based on the presence or absence of notochord as below.

- **Invertebrata**
- **Chordata-Prochordata and Vertebrata**

- Animals which do not possess notochord are called as Invertebrates or Non- chordates. Animals which possess notochord or backbone are called as Chordates.

Binomial Nomenclature

- Carolus Linnaeus introduced the method of naming the animals with two names known as binomial nomenclature. The first name is called genus and the first letter of genus is denoted in capital and the second one is the species name denoted in small letter. The binomial names of some of the common animals are as follows

Common Name	**Binominal Name**
Amoeba	Amoeba Proteus
Hydra	Hydra Vulgaris
Tape Worm	Taenia Solium
Round Worm	Ascaris Lumbricoides
Earth Worm	Lampito mauritii/ Perionyx excavatus
Leech	Hirudinaria granulosa
Cockroach	Periplaneta americana
Snail	Pila globosa
Starfish	Asterias rubens
Frog	Rana hexadactyla
Wall lizard	Podarcis muralis
Crow	Corvus splendens
Peacock	Pavo Cristatus
Dog	Canis Familiaris
Cat	Felis Felis
Tiger	Panthera tigria

Man	Homo sapiens.

Invertebrata

Phylum Porifera (Pore bearers)

- These are multicellular, non-motile aquatic organisms, commonly called as sponges. They exhibit cellular grade of organization. Body is perforated with many pores called ostia. Water enters into the body through ostia and leads to a canal system. It circulates water throughout the body and carries food, oxygen. The body wall contains spicules, which form the skeletal framework. Reproduction is by both asexual and sexual methods. e.g- Euplectella, Sycon.

Phylum Coelenterata (Cnidaria)

- Coelenterates are aquatic organisms, mostly marine and few fresh water forms. They are multicellular, radially symmetrical animals, with tissue grade of organization. Body wall is diploblastic with two layers. An outer ectoderm and inner mesoderm are separated by non-cellular jelly like substance called mesoglea. It has a central gastrovascular cavity called coelenteron with mouth surrounded by short tentacles. The tentacles bear stinging cells called cnidoblast or nematocyst.

- Many coelenterates exhibit polymorphism, which is the variation in the structure and function of the individuals of the same species. They reproduce both asexually and sexually. e.g. Hydra, Jellyfish.

Phylum Platyhelminthes (Flat worms)

- They are bilaterally symmetrical, triploblastic, acoelomate (without body cavity) animals. Most of them are parasitic in nature. Suckers and hooks help the animal to attach itself to the body of the host.

- Excretion occurs by specialized cells called flame cells.

- These worms are hermaphrodites having both male and female reproductive organs in a single individual. e.g- Liverfluke, Tapeworm

Phylum Aschelminthes (Round worms)

- Aschelminthes are bilaterally symmetrical, triploblastic animals. The body cavity is a pseudocoelom. They exist as free-living soil forms or as parasites. The body is round and pointed at both the ends. It is unsegmented and covered by thin cuticle. Sexes are separate. The most common diseases caused by nematodes in human beings are elephantiasis and ascariasis. e.g-Ascaris, Wuchereria.

Phylum Annelida (Segmented worms)

- These are bilaterally symmetrical, triploblastic, first true coelomate animals with organ-system grade of organization. Body is externally divided into segments called metameres joined by ring like structures called annuli. It is covered by moist thin cuticle. Setae and parapodia are locomotor organs. Sexes may be separate or united (hermaphrodites). e.g- Nereis, Earthworm, Leech.

Phylum Arthropoda (Animals with jointed legs)

- Arthropoda is the largest phylum of the animal kingdom. They are bilaterally symmetrical, triploblastic and coelomate animals. The body is divisible into head, thorax and abdomen. Each segment bears paired jointed legs. Exoskeleton is made of chitin and is shed periodically as the animal grows. The casting off and regrowing of exoskeleton is called moulting.

- Body cavity is filled with haemolymph (blood). The blood does not flow in blood vessels and circulates throughout the body (open circulatory system). Respiration is through body surface, gills or tracheae (air tubes). Excretion occurs by malphigian tubules or green glands. Sexes are separate. e.g., Prawn, Crab, Cockroach, Millipedes, Centipedes, Spider, Scorpions.

Centipede means 'hundred legs'. But most species have only 30 pairs. Millipedes have two pairs of legs on each segment. This name means 'thousand legs'. But, most millipedes have only about a hundred

Phylum Mollusca (Soft Bodied Animals)

- They are diversified group of animals living in marine, fresh water and terrestrial habitats. Body is bilaterally symmetrical, soft and without segmentation. It is divided into head, muscular foot and visceral mass. The foot helps in locomotion. The entire body is covered with fold of thin skin called mantle, which secretes outer hard calcareous shell. Respiration is through gills (ctenidia) or lungs or both. Sexes are separate with larval stages during development. e.g-Garden snail, Octopus.

Octopus is the only invertebrate that is capable of emotion, empathy, cognitive function, self awareness, personality and even relationships with humans. Some speculate that without humans, octopus would eventually take our place as the dominate life form on earth

Phylum Echinodermata (Spiny Skinned Animals)

- They are exclusively free-living marine animals. These are triploblastic and true coelomates with organ-system grade of organization. Adult animals are radially symmetrical but larvae remain bilaterally symmetrical. A unique feature is the presence of fluid filled water vascular system. Locomotion is affected by tube feet. Body wall is covered with spiny hard calcareous ossicles. e.g-Star fish, Sea urchin.

Phylum Hemichordata

- Hemichordates are marine organisms with soft, vermiform and unsegmented body. They are bilaterally symmetrical, coelomate animals with non-chordate and chordate features. They have gill slits but do not have notochord. They are ciliary feeders and mostly remain as tubiculous forms. e.g- Balanoglossus (Acorn worms).

Chordata

- Chordates are characterized by the presence of notochord, dorsal nerve cord and paired gill pouches. Notochord is a long rod like

support along the back of the animal separating the gut and nervous tissue. All chordates are triploblastic and coelomate animals. Phylum Chordata is divided into two groups: Prochordata and Vertebrata.

Prochordata

- The prochordates are considered as the forerunner of vertebrates. Based on the nature of the notochord, prochordata is classified into subphylum Urochordata and subphylum Cephalochordata.

Subphylum Urochordata

- Notochord is present only in the tail region of free-living larva. Adults are sessile forms and mostly degenerate. The body is covered with a tunic or test. e.g. Ascidian

Subphylum Cephalochordata

- Cephalochordates are small fish like marine chordates with unpaired dorsal fins. The notochord extends throughout the entire length of the body. e.g. Amphioxus

Vertebrata

- This group is characterized by the presence of vertebral column or backbone. Notochord in an embryonic stage gets replaced by the vertebral column, which forms the chief skeletal axis of the body. Vertebrata are grouped into six classes.

Class: Cyclostomata

- Cyclostomes are jawless vertebrates (mouth not bounded by jaws). Body is elongated and eel like. They have circular mouth. Skin is slimy and scaleless. They are ectoparasites of fishes. e.g. Hag fish.

Class: Pisces

- Fishes are poikilothermic (cold-blooded), aquatic vertebrates with jaws. The streamlined

- body is divisible into head, trunk and tail. Locomotion is by paired and median fins. Their body is covered with scales. Respiration is through gills. Th e heart is two chambered with an auricle and a ventricle. There are two main types of fishes.

➢ Cartilaginous fishes, with skeleton made of cartilages e.g. Sharks, Skates.

➢ Bony fishes with skeleton made of bones e.g. Carps, Mullets.

Class: Amphibia (amphi- both; bios- life)

- These are the first four legged (tetrapods) vertebrates with dual adaptation to live in both land and water. Th e body is divisible into head and trunk. Their skin is moist and have mucus gland. Respiration is through gills, lungs, skin or buccopharynx. Th e heart is three chambered with two auricles and one ventricle. Eggs are laid in water. The tadpole larva, transforms into an adult. e.g-Frog, Toad

The Chinese giant salamander Andrias davidians is the largest amphibian in the world. Its length is about five feet and eleven inches. It weighs about 65 kg, found in Central and South China

Class: Reptilia (repere- to crawl or creep)

- These vertebrates are fully adapted to life on land. Their body is covered with horny epidermal scales. Respiration is through lungs. The heart is three chambered with an exemption of crocodiles, which have four-chambered heart. Most of the reptiles lay their eggs with tough outer shell e.g Calotes, Lizard, Snake, Tortoise, Turtle

Class: Aves (avis – bird)

- Birds are homeothermic (warm-blooded) animals with several adaptations to fly. The spindle or boat shaped body is divisible into head, neck, trunk and tail. The body is covered with feathers. Forelimbs are modified into wings for flight. Hindlimbs are adapted for walking, perching or swimming. The respiration is through lungs,

which have air sacs. Bones are filled with air (pneumatic bones), which reduces the body weight. They lay large yolk laden eggs. They are covered by hard calcareous shell. e.g. Parrot, Crow, Eagle, Pigeon, Ostrich

Class: Mammalia (mamma-breast)

- Mammals are warm-blooded animals. The skin is covered with hairs. It also bears sweat and sebaceous (oil) glands. The body is divisible into head, neck, trunk and tail. Females have mammary glands, which secrete milk for feeding the young ones. The external ear or pinnae is present. Heart is four chambered and they breathe through lungs. Except egg laying mammals (Platypus, and Spiny anteater), all other mammals give birth to their young ones (viviparous). Placenta is the unique characteristic feature of mammals.e.g Rat, Rabbit, Man.

10th Book

Unit 17- Reproduction in plants and Animals

Introduction

- "Living organisms cannot survive for an indefinite period on earth. All living organisms have the ability to produce more of its own kind by the process called reproduction. Reproduction is the unfolding of life forms where new individuals are formed. It ensures continuity and survival of the species. This process is to preserve individual species and it is called as self-perpetuation. The time required to reproduce also varies from organism to organism. You may find great variations in period of reproduction in yeast, bacteria, rat, cow, elephant and humans. In sexual reproduction offsprings are produced by the union of male and female gametes (sperm and egg). The male and female gametes contain the genetic material or genes present on the chromosomes which transmit the characteristic traits to the next generation. There are three types of reproduction in plants namely i) Vegetative ii) Asexual and iii)Sexual reproduction. In this unit you willknow more about the types and the process of asexual and sexual reproduction in plants, animals and human.

Vegetative Reproduction

- In this type, new plantlets are formed from vegetative (somatic) cells, buds or organs of plant. The vegetative part of plant (root, stem, leaf or bud) gets detached from the parent body and grows into an independent daughter plant. It has only mitotic division, no gametic fusion and daughter plants are genetically similar to the parent plant.

Vegetative reproduction may take place through

- Leaves**:** In Bryophyllum small plants grow at the leaf notches

- **Stems:** In strawberry aerial weak stems touch the ground and give off adventitious roots and buds. When the connections with the parent plant is broken, the offspring beomes independent

- **Root:** Tuberous roots (Asparagus and Sweet potato) can be used for vegetative propagation.

- Bulbils**:** In some plants the flower bud modifies into globose bulb which are called as bulbils, when these falls on the ground they grow into new plants. e.g. Agave.

- **Fragmentation**: In filamentous algae, breaking of the filament into many fragments is called fragmentation. Each fragment having atleast one cell, may give rise to a new filament of the algae by cell division e.g. Spirogyra

- Fission**:** In this type the parent cell divides into two daughter cells and each cell develops into a new adult organism e.g. Amoeba.

- **Budding:** Formation of a daughter individual from a small projection, the bud, arising on the parent body is called budding. e.g. Yeast.

- **Regeneration:** The ability of the lost body parts of an individual organism to give rise to an whole new organism is called regeneration. It takes place by specialized mass of cells e.g Hydra and Planaria

Asexual Reproduction

- Production of an offspring by a single parent without the formation and fusion of gametes is called asexual reproduction. It involves only mitotic cell divisions and meiosis does not occur. Offspring produced by asexual reproduction are not only identical to parents but are also exact copies of their parent.

- Asexual reproduction occurs by spore formation. This is the most common method of asexual reproduction in fungi and bacteria.

- During spore formation a structure called sporangium develops from the fungal hypha. The nucleus divides several times within the sporangium and each nucleus with small amount of cytoplasm develops into a spore. The spores are liberated and they develop into new hypha after reaching the ground or substratum.

Sexual Reproduction in Plants

- Sexual reproduction is the process in which two gametes (male and female) are fused to produce offspring of their own kind. In such cases both sexes, male and female sex organs are needed to produce gametes. You have already learnt that the flower is a reproductive organ of a flowering plant. To

understand this further we need to study the structure of a flower

Parts of a Typical Flower

- A flower is a modified shoot with limited growth to carry out sexual reproduction. A flower consists of four whorls borne on a thalamus. These whorls are from outside

- **Calyx – consisting of sepals**
- **Corolla – consisting of petals**
- **Androecium – consisting of stamens**
- **Gynoecium or pistil – consisting of carpels**

- The two outermost whorls calyx and corolla are non–essential or accessory whorls as they do not directly take part in the reproduction. The other two whorls androecium and gynoecium are known as the essential whorls, because both take part directly in reproduction.

- **Androecium:** Androecium, the male part of flower is composed of stamens. Each stamen consists of a stalk called the filament and a small bag like structure called anther at the tip. The pollen grains are produced in the anther within the pollen sac.

- **Pollen grain:** Pollen grains are usually spherical in shape. It has two layered wall. The hard-outer layer is known as exine. It has prominent apertures called germpore. The inner thin layer is known

as intine. It is a thin and continuous layer made up of cellulose and pectin. Mature pollen grains contain two cells, the vegetative and the generative cell. Vegetative cell contains a large nucleus. The generative cell divides mitotically to form two male gametes.

Gynoecium: Gynoecium is the female part of the flower and is made up of carpels. It has three parts:

- **Ovary**
- **Style**
- **Stigma**

The ovary contains the ovules.

Structure of the Ovule

- The main part of the ovule is the nucellus which is enclosed by two integuments leaving an opening called as micropyle. The ovule is attached to the ovary wall by a stalk known as funiculus. Chalaza is the basal part.

- The embryo sac contains seven cells and the eighth nuclei located within the nucellus. Three cells at the micropylar end form the egg apparatus and the three cells at the chalaza end are the antipodal cells. The remaining two nuclei are called polar nuclei found in the centre. In the egg apparatus one is the egg cell (female gamete) and the remaining two cells are the synergids.

Process of sexual reproduction in flowering plants. It involves:

- Pollination
- Fertilization

Pollination

- The transfer of pollen grains from anther to stigma of a flower is called as pollination.

Importance of Pollination

- It results in fertilization which leads to the formation of fruits and seed.
- New varieties of plants are formed through new combination of genes in case of cross pollination.

Types of Pollination

- **Self-pollination**
- **Cross pollination**

Self-pollination (Autogamy)

- Self-pollination is also known as autogamy. The transfer of pollen grains from the anther to the stigma of same flower or another flower borne on the same plant is known as self-pollination. e.g. Hibiscus.

Advantages of self-pollination

- Self-pollination is possible in certain bisexual flowers.
- Flowers do not depend on agents for pollination.
- There is no wastage of pollen grains

Disadvantages of self-pollination

- The seeds are less in numbers.
- The endosperm is minute. Therefore, the seeds produce weak plants.
- New varieties of plants cannot be produced

Cross pollination

- Cross-pollination is the transfer of pollen from the anthers of a flower to the stigma of a flower on another plant of the same species e.g. apples, grapes, plum, etc.

Advantages of cross pollination

- The seeds produced as a result of cross pollination, develop and germinate properly and grow into better plants, i.e. cross pollination leads to the production of new varieties.
- More viable seeds are produced.

Disadvantages of cross-pollination

- Pollination may fail due to distance barrier.
- More wastage of pollen grains
- It may introduce some unwanted characters
- Flowers depend on the external agencies for pollination

Agents of Cross Pollination

- In order to bring about cross pollination, it is necessary that the pollen should be carried from one flower to another of a different plant.
- This takes place through the agency of animals, insects, wind and water.

Pollination by wind

- The pollination with the help of wind is called anemophily. The anemophilous flowers produce enormous amount of pollen grains. The pollen grains are small, smooth, dry and light in weight. Pollen of such plants are blown off at a distance of more than 1,000 km. The

stigmas are comparatively large, protruding and sometimes hairy to trap the pollen grains. e.g. Grasses and some cacti.

Pollination by insects

- Pollination with the help of insects like honey bees, flies are called entomophily. To attract insects these flowers are brightly coloured, have smell and nectar. The pollen grains are larger in size, the exine is pitted, spiny etc., so they can be adhered firmly on the sticky stigma. Approximately, 80% of the pollination done by the insects is carried by honey bees.

Pollination by water

- The pollination with the help of water is called hydrophily.This takes place in aquatic plants.

➢ Pollen grains are produced in large numbers.

➢ Pollen grains float on surface of water till they land on the stigma of female flowers e.g. Hydrilla, Vallisneria.

Pollination by Animals

- When pollination takes place with the help of animals, it is called Zoophily. Flowers of such plants attract animals by their bright color, size, scent etc. e.g. sun bird pollinates flowers of Canna, Gladioli etc., Squirrels pollinate flowers of silk cotton tree.

Fertilization in Plants

➢ Pollen grains reach the right stigma and begin to germinate.

➢ Pollen grain forms a small tube-like structure called pollen tube which emerges through the germ pore. The contents of the pollen grain move into the tube.

- Pollen tube grows through the tissues of the stigma and style and finally reaches the ovule through the micropyle.

- Vegetative cell degenerates and the generative cell divides to form two sperms (or male gametes).

- Tip of pollen tube bursts and the two sperms enter the embryo sac.

- One sperm fuses with the egg (syngamy) and forms a diploid zygote. The other sperm fuses with the secondary nucleus (Triple fusion) to form the primary endosperm nucleus which is triploid in nature. Since two types of fusion syngamy and triple fusion take place in an embryo sac the process is termed as double fertilization.

- After triple fusion, primary endosperm nucleus develops into an endosperm.

- Endosperm provides food to the developing embryo.

- Later the synergids and antipodal cells degenerate.

Significance of Fertilization

- It stimulates the ovary to develop into fruit.

- It helps in development of new characters from two different individuals.

Post fertilization changes:

- The ovule develops into a seed.

- The integuments of the ovule develop into the seed coat.

- The ovary enlarges and develops into a fruit.

The seed contains the future plant or embryo which develops into a seedling under appropriate conditions.

Sexual Reproduction in Human

- In human beings the male and female reproductive organs differ anatomically and physiologically. New individuals develop by the fusion of gametes. Sexual reproduction involves the fusion of two haploid gametes (male and the female gametes) to form a diploid individual (zygote).

Organs of the reproductive system are divided into primary and secondary (accessory) sex organs.

- Primary reproductive organs include the gonads (Testes in male and Ovaries in female).

- Accessory sex organs

- **Male:** Vas deferens, epididymis, seminal vesicle, prostate gland and penis.

- **Female:** Fallopian tubes, uterus, cervix and vagina.

The secondary (accessory) sex organs include those structures which are involved in the

- Process of ovulation
- Fusion of the male and female gametes (fertilization)
- Division of the fertilized egg upto the formation of embryo
- Pregnancy
- Development of foetus
- Child birth.

The cells of the primary reproductive organs in human male and female and their role in reproduction.

Male Reproductive Organ - Structure of Testes

- Testes are the reproductive glands of the male that are oval shaped organs which lie outside the abdominal cavity of a man in a sac like structure called scrotum. Now we shall study the various cells which are present in the testes.

- Each testes is covered with a layer of fibrous tissue called tunica albuginea. Many septa from this layer divide the testes into pyramidal lobules, in which lie seminiferous tubules, cells of Sertoli, and the Leydig cells (interstitial cells).

- The process of spermatogenesis takes place in the seminiferous tubules. The Sertoli cells are the supporting cells and provide nutrients to the developing sperms. The Leydig cells are polyhedral in shape and lie between the seminiferous tubules and secrete testosterone. It initiates the process of spermatogenesis.

Female Reproductive Organ - Structure of Ovary

- The ovaries are located on either side of the lower abdomen composed of two almond shaped bodies, each lying near the lateral end of fallopian tube. Each ovary is a compact structure consisting of an outer cortex and an inner medulla. The cortex is composed of a network of connective tissue called as stroma and is lined by the germinal epithelium. The epithelial cells called the granulosa cells surround each ovum in the ovary together forming the primary follicle. As the egg grows larger, the follicle also enlarges and gets filled with the fluid and is called the Graafian follicle.

Gametogenesis

- The formation of the sperm in male and the ovum in female is called gametogenesis. It involves spermatogenesis (formation of spermatozoa) and oogenesis (the formation of ova). Gametes with haploid cells are produced through gametogenesis.

Structure of Human Sperm

- The spermatozoan consists of head, a middle piece and tail. The sperm head is elongated and formed by the condensation of nucleus. The anterior portion has a cap like structure called acrosome. It contains hyaluronidase an enzyme that helps the sperm to enter the ovum during fertilization. A short neck connects the head and middle piece which comprises the centrioles.The middle piece contains the mitochondria which provides energy for the movement of tail. It brings about sperm motility which is essential for fertilization.

Structure of Ovum

- The mature ovum or egg is spherical in shape.The ovum is almost free of yolk. It contains abundant cytoplasm and the nucleus. The ovum is surrounded by three membranes. The plasma membrane is surrounded by inner thin zona pellucida and an outer thick corona radiata. The corona radiata is formed of follicle cells. The membrane forming the surface layer of the ovum is called vitelline membrane. The fluid-filled space between zona pellucida and the surface of the egg is called perivitelline space.

Puberty

- The reproductive system in both males and females becomes functional and an increase in sex hormone production resulting in puberty. This phenomenon tends to start earlier in females than in males. Generally boys attain puberty between the age of 13 to 14 years, while girls reach puberty between 11 to 13 years. In male, the onset of puberty is triggered by the secretion of the hormone testosterone in the testes, in female the secretion of estrogens and progesterone from the ovary. The secretion of both male and female hormones are under the control of the pituitary gonadotropins luteinizing hormone (LH) and follicle stimulating hormone (FSH).

Menstrual Cycle-Process of Ovulation

- The cyclic events that take place in a rhythmic fashion during the reproductive period of a woman's life is called menstrual cycle. In human females the menstrual cycle starts at the age of 11-13 years which marks the onset of puberty and is called menarche, and ceases around 48-50 years of age and this stage is termed menopause. The reproductive period is marked by characteristic events repeated almost every month in physiologically normal women (28 days with minor variation) in the form of a menstrual flow. The menstrual cycle consists of 4 phases.

- Menstrual or Destructive Phase
- Follicular or Proliferative Phase
- Ovulatory Phase
- Luteal or Secretory Phase

- These phases show simultaneous synchrony of events in both ovary and uterus. Changes in the ovary and the uterus are induced by the pituitary hormones (LH and FSH) and ovarian hormones (estrogen and progesterone).

Phase	**Days**	**Changes in Ovary**	**Changes in Uterus**	**Hormonal Changes**
Menstrual Phase	4-5 days	Development of Primary Follicles	Breakdown of Uterine endometrial lining leads to bleeding	Decrease in Progesterone and Oestrogen
Follicular phase	6^{th} – 13^{th} days	Primary follicles grow to become a fully mature Graafian follicle	Endometrium regenerates through Poliferation	FSH and Oestrogen increase
Ovulatory	14^{th} day	The Graafian	Increase in	LH Peak

phase		follicle ruptures, and releases the Ovum (Egg)	endometrial thickness	
Luteal Phase	15th – 28th days	Emptied Graafian follicle develops into corpus luteum	Endometrium is prepared for implantation if fertilization of egg takes place, if fertilization does not occur corpus luteum degenerates, Uterine wall ruptures, bleeding starts and unfertilized egg is expelled	LHS and FSH Decrease, corpus luteum Produces progesterone and its level increases followed by a decline, if menstrual bleeding occurs.

Fertilization to Foetal Development

Fertilization

- Fertilization in human is internal and occurs in the oviduct of the female genital tract. It takes place usually in the ampulla of the fallopian tube. An oocyte is alive for about 24 hours after it is released from the follicle. Fertilisation must take place within 24 hours. The sperm enters into the ovum and fuses with it, resulting in the formation of a 'zygote'. This process is called fertilization. The zygote is a fertilized ovum.

Cleavage and Formation of Blastula

- The first cleavage takes place about 30 hours after fertilization. Cleavage is a series of rapid mitotic divisions of the zygote to form many celled blastula (Blastocyst) which comprises an outer layer of smaller cells and inner mass of larger cells.

Implantation

- The blastocyst (fertilized egg) reaches the uterus and gets implanted in the uterus. The process of attachment of the blastocyst to the uterine wall (endometrium) is called implantation. The fertilized egg becomes implanted in about 6 to 7 days after fertilization

Gastrulation

- The transformation of blastula into gastrula and the formation of primary germ layers (ectoderm, mesoderm and endoderm) by rearrangement of the cells is called gastrulation. This takes place after the process of implantation.

Organogenesis

- The establishment of the germ layers namely ectoderm, mesoderm and endoderm initiates the final phase of embryonic development. During organogenesis the various organs of the foetus are established from the different germ layers attaining a functional state.

Formation of Placenta

- The placenta is a disc shaped structure attached to the uterine wall and is a temporary association between the developing embryo and maternal tissues. It allows the exchange of food materials, diffusion of oxygen, excretion of nitrogenous wastes and elimination of carbon dioxide. A cord containing blood vessels that connects the placenta with the foetus is called the umbilical cord.

Pregnancy (Gestation)

- It is the time period during which the embryo attains its development in the uterus. Normally gestation period of human last for about 280 days. During pregnancy the uterus expands upto 500 times of its normal size.

Parturition (Child Birth)

- Parturition is the expulsion of young one from the mother's uterus at the end of gestation. Oxytocin from the posterior pituitary stimulates the uterine contractions and provides force to expel the baby from the uterus, causing birth.

Sometimes ovaries releases two eggs and each is fertilised by a different sperm, resulting in Non-Identical Twins (Fraternal Twins). If single egg is fertilised and then divides into two foetus, Identical Twins develop.

Lactation

- The process of milk production after child birth from mammary glands of the mother is called lactation. The first fluid which is released from the mammary gland after child birth is called as colostrum. Milk production from alveoli of mammary glands is stimulated by prolactin secreted from the anterior pituitary.

The ejection of milk is stimulated by posterior pituitary hormone oxytocin.

Reproductive Health

- According to World Health Organization (WHO) reproductive health means a total well being in all aspects of reproduction, ability to reproduce and regulate fertility, women's ability to undergo pregnancy and safe child birth, maternal and infant survival and well being.

- Several measures were undertaken by the government to improve the reproductive health of the people by launching National Health Programmes such as the

- Family Welfare Programme
- Reproductive and Child Health Care (RCH) Programme

Family welfare programme: The National Family Welfare Programme is a comprehensive scheme which includes:

- Maternal and child health care (MCH)
- Immunization of mothers, infants and children.
- Nutritional supplement to pregnant women and children.
- Contraception with health education, to motivate couples to accept contraceptive methods and to have small family norms, which improve economic status, living status and the quality of life.

Reproductive and Child Health Care (RCH) Programme:

It has integrated all services which include

- Pregnancy and child birth
- Postnatal care of the mother and child
- Importance of breast feeding
- Prevention of reproductive tract infections and sexually transmitted diseases.

Population Explosion and Family Planning

- Population explosion defined as the sudden and rapid rise in the size of population, especially human population. Realizing the dangers inherent in population growth, the Government of India has taken several measures to check population growth and introduced family planning. India has been one of the first country in the world to launch the nation wide family planning programme in 1952.

- Family planning is a way of living that is adopted voluntarily by couples on the basis of knowledge and responsible decisions to promote the health and welfare of the family group and society. The

WHO (World Health Organisation) has also stressed the importance of family planning as global strategy health for all.

The inverted red triangle is a symbol of family planning in India for family welfare. It is displayed prominently at all hospitals, primary health clinics and family welfare centres where any help or advice about family planning is available free of cost. The symbol is displayed along with a slogan Small Family, Happy Family.

Contraception

- Contraception is one of the best birth control measures. A number of techniques or methods have been developed to prevent pregnancies in women. The devices used for contraception are called contraceptive devices. Common contraceptive methods used to prevent pregnancy are discussed here

- Barrier methods
- Hormonal methods
- Intra-Uterine Devices (IUDs)
- Surgical methods

Barrier Methods

- This method prevents sperms from meeting the ovum. Its entry into the female reproductive tract is prevented by barrier.

- Condom**:** Condom prevents deposition of sperms in the vagina. Condoms are made of thin rubber or latex sheath. Condom also protect against sexually transmitted diseases (STD) like syphilis, AIDS.

- Diaphragm **(Cervical cap):** Vaginal diaphragm fitting into the vagina or a cervical cap fitting over the cervix. This prevents the entry of sperms into the uterus.

Hormonal Methods

- Hormonal preparations are in the form of pills or tablets (contraceptive pills). These hormones stop (interfere with ovulation) the release of egg from the ovary.

Intra-Uterine Devices (IUDs)

- The intrauterine device (IUD)are contraceptive devices inserted into the uterus. There are two synthetic devices commonly used in India are Lippe's Loop and Copper-T made of copper and plastic (non irritant). This can remain for a period of 3 years. This reduces the sperm fertilizing capacity and prevents implantation. This also helps to give adequate time interval between pregnancies.

Surgical Methods

- Surgical contraception or sterilization techniques are terminal methods to prevent any pregnancy. This procedure in males is vasectomy (ligation of vas deferens) and in females it is tubectomy (ligation of fallopian tube). These are methods of permanent birth control.

Urinary Tract Infection (UTI)

- Many diseases affect both women and men, but a few diseases occur at a higher frequency in woman. Woman are susceptible to UTI from the bacteria that are present on skin, rectum or vagina. This will enter the urethra, before moving upwards. The types of UTI are:

Cystitis or Bladder infection

- Bacteria lodged in the urinary bladder thrive and multiply leading to inflammation. It is most common in the age group of 20 to 50.

Kidney Infection

- The bacteria can travel from the urinary bladder and upward to ureter and affect one or both the kidneys. It also infects the blood stream and leads to serious life-threatening complications.

Asymptomatic Bacteriuria

- The bacteria present in the urinary bladder which may not show any symptoms.

Personal Hygiene

- Hygiene is the practice of healthy living and personal cleanliness. Personal hygiene is caring of one's own body and health. Social hygiene is proper care of the surrounding environment. The main aspect of hygiene are body hygiene, food hygiene, sanitary hygiene and hygienic environment.

Body Hygiene

- Washing is vital to all age group of people which maintains our personal hygiene. A daily bath regularly keeps skin clean and free of germs. Hair should be kept clean by frequent washing. Mouth wash should be done after every meal. We should wash our hands many times during the day.

- Cloth towels used to dry our hands or body should be dried after each use and laundered regularly. Clothes, handkerchief, undergarments and socks should be washed daily. Washing prevents body odour, infections and skin irritation.

Toilet Hygiene

- The toilet has a lot to do with personal hygiene and general health as it is a place that cannot be avoided and used regularly. Parents should guide and practice their children on how to use the toilets at home, in schools and other public places so that it will protect the

children from various contagious infections and diseases. The following measures can ensure toilet hygiene

- The floors of the toilet should be maintained clean and dry. This helps to reduce the bad odour and also infection.

- Toilet flush handles, door knobs, faucets, paper towel dispensers, light switches and walls should be cleaned with disinfectants to kill harmful germs and bacteria.

- Hands should be washed thoroughly with soap before and after toilet use.

Menstrual and Napkin Hygiene

- Women's health depends upon the level of cleanliness to keep them free from skin and genitourinary tract infection.

Menstrual hygiene

- Maintaining menstrual hygiene is important for the overall health of women. The basic menstrual hygiene ways are

- Sanitary pads should be changed regularly, to avoid infections due to microbes from vagina and sweat from genitals.

- Use of warm water to clean genitals helps to get rid of menstrual cramps

Wearing loose clothing rather than tight fitting clothes will ensure the airflow around the genitals and prevent sweating.

11th Botany
Chapter 1 – Living World

- Earth was formed some 4.6 billion years ago. It is the life supporting planet with land forms like mountains, plateaus, glaciers, etc., Life on earth exists within a complex structure called biosphere. There exist many mysteries and wonders in the living world some are not visible but the activity of some capture the attention of all. For example the response of sunflower to the sunlight, the twinkling firefly in the dark forest, the rolling water droplets on the surface of lotus leaf, the closure of the leaf of venus fly trap on insect touch and a squid squeezing ink to escape from its predator. From this it is clear that the wonder planet earth harbors both landforms and life forms. Have you thought of DNA molecule? It is essential for the regulation of life and is made up of carbon, hydrogen, oxygen, nitrogen and phosphorus thus nonliving and living things exist together to make our planet unique.

- According to a survey made by Mora et al., 2011 the number of estimated species on earth is 8.7 million. The living world includes microbes, plants, animals and human beings which possess unique and distinct characteristic feature.

Attributes of living organisms

- The attributes of living organisms are given below and is represented.

Growth

- Growth is an intrinsic property of all living organisms through which they can increase cells both in number and mass. Unicellular and multicellular organisms grow by cell division. In plants, growth is indefinite and occurs throughout their life. In animals, growth is definite and occurs for some period. However, cell division occurs in living organisms to repair and heal the worn out tissues. Growth in non-living objects is extrinsic. Mountains, boulders and sand mounds grow by simple aggregation of material on the surface. Living cells

grow by the addition of new protoplasm within the cells. Therefore, growth in living thing is intrinsic. In unicellular organisms like bacteria and amoeba growth occurs by cell division and such cell division also leads to the growth of their population. Hence, growth and reproduction are mutually inclusive events.

Cellular structure

- All living organisms are made up of cells which may be prokaryotic or eukaryotic. Prokaryotes are unicellular, lack membrane bound nuclei and organelles like mitochondria, endoplasmic reticulum, golgi bodies and so on (Example: Bacteria and Blue green algae). In Eukaryotes a definite nucleus and membrane bound organelles are present. Eukaryotes may be unicellular (Amoeba) or multicellular (Oedogonium).

Reproduction

- Reproduction is one of the fundamental characteristic features of living organisms. It is the tendency of a living organism to perpetuate its own species. There are two types of reproduction namely asexual and sexual. Asexual reproduction refers to the production of the progeny possessing features more or less similar to those of parents. The sexual reproduction brings out variation through recombination. Asexual reproduction in living organisms occurs by the production of conidia (Aspergillus, Penicillium), budding (Hydra and Yeast), binary fission (Bacteria and Amoeba) fragmentation (Spirogyra), protonema (Mosses) and regeneration (Planaria). Exceptions are the sterile worker bees and mules.

Response to stimuli

- All organisms are capable of sensing their environment and respond to various physical, chemical and biological stimuli. Animals sense their surroundings by sense organs. This is called Consciousness. Plants also respond to the stimuli. Bending of plants towards sunlight, the closure of leaves in touch-me-not plant to touch are some examples for response to stimuli in plants. This type of response is called Irritability.

Homeostasis

- Property of self-regulation and tendency to maintain a steady state within an external environment which is liable to change is called Homeostasis. It is essential for the living organism to maintain internal condition to survive in the environment.

- Movement, Nutrition, Respiration and Excretion are also considered as the property of living things.

- The levels of organization in living organism begin with atoms and end in Biosphere

Metabolism

- The sum total of all the chemical reactions taking place in a cell of living organism is called metabolism. It is broadly divided into anabolism and catabolism. The difference between anabolism and catabolism

Difference between Anabolism and Catabolism

Anabolism	**Catabolism**
Building up Process	Breaking down process
Smaller Molecules combines together to form larger molecule	Larger molecule break into smaller units
Chemical Energy is formed and stored	The stored chemical energy is released and used.
Example: Synthesis of Proteins from amino acids	Example: Breaking down of glucose to CO_2 and water.

Viruses

There are serious entities which are considered as "Biological Puzzle"

and cause disease in man. They are called viruses. We have learnt about the attributes of living world in the previous chapter. Now we shall discuss about viruses which connect the living and nonliving world.

- The word virus is derived from Latin meaning 'Poison'. Viruses are sub-microscopic, obligate intracellular parasites. They have nucleic acid core surrounded by protein coat. Viruses in their native state contain only a single type of nucleic acid which may be either DNA or RNA. The study of viruses is called 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" with Dr. J.H. Northrop for Chemistry in 1946.

Milestones in Virology

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)

Size and shape

- Viruses are ultramicroscopic particles. They are smaller than bacteria and their diameter range from 20 to 300 nm. (1nm = 10-9metres). Bacteriophage measures about 10-100 nm in size. The size of TMV is 300×20 nm.

Generally viruses are of three types based on shape and symmetry

- Cuboid symmetry – Example: Adenovirus, Herpes virus.
- Helical symmetry – Example: Influenza virus, TMV.

- Complex or Atypical – Example: Bacteriophage, Vaccinia virus.

Characteristic features of Viruses

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.

Classification of Viruses

- Among various classifications proposed for viruses the classification given by David Baltimore in the year 1971 is given below. The classification is based on mechanism of RNA production, the nature of the genome (single stranded –ss or double stranded - ds), RNA or DNA, the use of reverse transcriptase(RT), ss RNA may be (1) sense or (2) antisense.

Viral genome

- Each virus possesses only one type of nucleic acid either DNA or RNA. The nucleic acid may be in a linear or circular form. Generally nucleic acid is present as a single unit but in wound tumour virus and in influenza virus it is found in segments. The viruses possessing DNA are called 'Deoxyviruses' whereas those possessing RNA are called 'Riboviruses'. Majority of animal and bacterial viruses are DNA viruses (HIV is the animal virus which possess RNA). Plant

viruses generally contain RNA (Cauliflower Mosaic virus possess DNA). The nucleic acids may be single stranded or double stranded. On the basis of nature of nucleic acid viruses are classified into four Categories. They are Viruses with ssDNA (Parvoviruses), dsDNA (Bacteriophages), ssRNA (TMV)and dsRNA(wound tumour virus).

Tobacco Mosaic Virus (TMV)

- Tobacco mosaic virus was discovered in 1892 by Dimitry Ivanowsky from the Tobacco plant. Viruses infect healthy plants through vectors like aphids, locusts etc. The first visible symptom of TMV is discoloration of leaf colour along the veins and show typical yellow and green mottling which is the mosaic symptom. The downward curling and distortion of young apical leaves occurs, plant becomes stunted and yield is affected.

Structure

- Electron microscopic studies have revealed that TMV is a rod shaped (Figure 1.4b) helical virus measuring about 280x150µm with a molecular weight of 39x106 Daltons. The virion is made up of two constituents, a protein coat called capsid and a core called nucleic acid. The protein coat is made up of approximately 2130 identical protein subunits called capsomeres which are present around a central single stranded RNA molecule. The genetic information necessary for the formation of a complete TMV particle is contained in its RNA. The RNA consists of 6,500 nucleotides.

Different Classes of Viruses

Class	Example
Class 1 – Viruses with ds DNA	Adeno viruses
Class 2- Viruses with (+) sense ss DNA	Parvo Viruses
Class 3- Viruses with ds RNA	Reo Viruses
Class 4- Viruses with (+) sense ss RNA	Toga Viruses
Class 5 – Viruses with (-) sense ss RNA	Rhabdo viruses

Class 6 – Viruses with (+) sense ss RNA – RT: that replicate With DNA intermediate in life cycle	Retro Viruses
Class 7- Viruses with ds DNA – RT: that replicate with RNA intermediate in life cycle	Hepadna Viruses

or double stranded - ds), RNA or DNA, the use of reverse transcriptase(RT), ss RNA may be (1) sense or (2) antisense. Viruses are classified into seven classes

Bacteriophage

- Viruses infecting bacteria are called Bacteriophages. It literally means 'eaters of bacteria' (Gr: Phagein = to eat). Phages are abundant in soil, sewage water, fruits, vegetables, and milk.

Structure of T_4 bacteriophage

- The T_4 phage is tadpole shaped and consists of head, collar, tail, base plate and fibres (Figure 1.4). The head is hexagonal which consists of about 2000 identical protein subunits. The long helical tail consists of an inner tubular core which is connected to the head by a collar. There is a base plate attached to the end of tail. The base plate contains six spikes and tail fibres. These fibres are used to attach the phage on the cell wall of bacterial host during replication. A dsDNA molecule of about 50 µm is tightly packed inside the head. The DNA is about 1000 times longer than the phage itself.

Multiplication or Life Cycle of Phages

- Phages multiply through two different types of life cycle. a. Lytic or Virulent cycle b. Lysogenic or Avirulent life cycle

Lytic Cycle

- During lytic cycle of phage, disintegration of host bacterial cell occurs and the progeny virions are released (Figure 1.5a). The steps involved in the lytic cycle are as follows:

Adsorption

- Phage (T4) particles interact with cell wall of host (E. coli). The phage tail makes contact between the two, and tail fibres recognize the specific receptor sites present on bacterial cell surface. The lipopolysaccharides of tail fibres act as receptor in phages. The process involving the recognition of phage to bacterium is called landing. Once the contact is established between tail fibres and bacterial cell, tail fibres bend to anchor the pins and base plate to the cell surface. This step is called pinning.

Penetration

- The penetration process involves mechanical and enzymatic digestion of the cell wall of the host. At the recognition site phage digests certain cell wall structure by viral enzyme (lysozyme). After pinning the tail sheath contracts (using ATP) and appears shorter and thicker. After contraction of the base plate enlarges through which DNA is injected into the cell wall without using metabolic energy. The step involving injection of DNA particle alone into the bacterial cell is called Transfection. The empty protein coat leaving outside the cell is known as 'ghost.

Synthesis

- This step involves the degradation of bacterial chromosome, protein synthesis and DNA replication. The phage nucleic acid takes over the host biosynthetic machinery. Host DNA gets inactivated and breaks down. Phage DNA suppresses the synthesis of bacterial protein and directs the metabolism of the cell to synthesis the proteins of the phage particles and simultaneously replication of Phage DNA also takes place.

Assembly and Maturation

- The DNA of the phage and protein coat are synthesized separately and are assembled to form phage particles. The process of assembling

the phage particles is known as maturation. After 20 minutes of infection about 300 new phages are assembled.

Release

- The phage particle gets accumulated inside the host cell and are released by the lysis of host cell wall.

Lysogenic Cycle

- In the lysogenic cycle the phage DNA gets integrated into host DNA and gets multiplied along with nucleic acid of the host. No independent viral particle is formed

- As soon as the phage injects its linear DNA into the host cell, it becomes circular and integrates into the bacterial chromosome by recombination. The integrated phage DNA is now called prophage. The activity of the prophage gene is repressed by two repressor proteins which are synthesized by phage genes. This checks the synthesis of new phages within the host cell. However, each time the bacterial cell divides, the prophage multiplies along with the bacterial chromosome. On exposure to UV radiation and chemicals the excision of phage DNA may occur and results in lytic cycle.

- Virion is an intact infective virus particle which is non-replicating outside a host cell.

- Viroid is a circular molecule of ssRNA without a capsid and was discovered by T.O.Diener in the year 1971. The RNA of viroid has low molecular weight. Viroids cause citrus exocortis and potato spindle tuber disease in plants.

Virusoids were discovered by J.W.Randles and Co-workers in 1981.They are the small circular RNAs which are similar to viroids but they are always linked with larger molecules of the viral RNA.

- Prions were discovered by Stanley B. Prusiner in the year 1982 and are proteinaceous infectious particles. They are the causative agents

for about a dozen fatal degenerative disorders of the central nervous system of humans and other animals. For example Creutzfeldt – Jakob Disease (CJD), Bovine Spongiform Encephalopathy (BSE) – commonly known as mad cow disease and scrapie disease of sheep.

- Viruses infecting blue green algae are called Cyanophages and are first reported by Safferman and Morris in the year 1963(Example LPP1 - Lyngbya, Plectonema and Phormidium). Similarly, Hollings(1962) reported viruses infecting cultivated Mushrooms and causing die back disease. The viruses attacking fungi are called Mycoviruses or Mycophages.

Viral diseases

- Viruses are known to cause disease in plants, animals and Human beings.

Viral Diseases

Plant Diseases	Animal Diseases	Human Diseases
1. Tobacco mosaic 2. Cauliflower mosaic 3. Sugarcane mosaic 4. Potato leaf roll 5. Bunchy top of banana 6. Leaf Curl of papaya 7. Vein clearing of Lady's finger 8. Rice tungro disease 9. Cucumber mosaic	1. Foot and mouth disease of cattle 2. Rabies of dog 3. Encephalomyelitis of horse	1. Common Cold 2. Hepatitis B 3. Cancer 4. SARS (Severe Acute Respiratory Syndrome) 5. AIDS (Acquired Immuno Deficiency syndrome) 6. Rabies 7. Mumps 8. Polio 9. Chikungunya 10. Small pox 11. Measles

10.Tomato mosaic disease		

Streaks on Tulip flowers are due to Tulip breaking Virus which belong to Potyviridae group.

Viruses of Baculoviridae group are commercially exploited as insecticides. Cytoplasmic polyhedrosis Granulo viruses and Entomopox virus were employed as potential insecticides

Classification of Living World

- In our daily life we see several things in and around us. Imagine you are on a trip to Hill station. You are enjoying the beauty of mountains, dazzling colour of the flowers, and melodious sound of the birds. You may be capturing most of the things you come across in the form of photography. Now, from this experience can you mention the objects you came across? Can you record your observations and tabulate them. How will you organize the things? Will you place mountain and flowers together or tall trees and trailing herbs in one category or place it in different category? If you place it in different category, what made you to place them in different category? So classification is essential and could be done only by understanding and comparing the things based on some characters. In this chapter we shall learn about classification of living world. Many attempts have made in the past to classify the organisms on earth.

- Theophrastus, "Father of Botany" used the morphological characters to classify plants into trees, shrubs and herbs. Aristotle classified

animal into two groups. i.e., Enaima (with red blood) and Anaima (without red blood). Carl Linnaeus classified living world into two groups namely Plants and Animals based on morphological characters. His classification faced major setback because prokaryotes and Eukaryotes were grouped together. Similarly fungi, heterotrophic organisms were placed along with the photosynthetic plants. In course of time, the development of tools compelled taxonomists to look for different areas like cytology, anatomy, embryology, molecular biology, phylogeny etc., for classifying organisms on earth. Thus new dimensions to classifications were put forth from time to time.

Need of Classification

Classification is essential to achieve following needs

- To relate things based on common characteristic features.
- To define organisms based on the salient features.
- Helps in knowing the relationship amongst different groups of organisms.
- It helps in understanding the evolutionary relationship between organisms.

Five Kingdom Classification

- R.H.Whittaker, an American taxonomist proposed five kingdom classification in the year 1969. The Kingdoms include Monera, Protista, Fungi, Plantae and Animalia (Figure 1.7). The criteria adopted for the classification include cell structure, thallus organization, mode of nutrition, reproduction and phylogenetic relationship.

Merits

- The classification is based on the complexity of cell structure and organization of thallus.

- It is based on the mode of nutrition

- Separation of fungi from plants
- It shows the phylogeny of the organisms

Demerits

- The kingdom Monera and protista accommodate both autotrophic and heterotrophic organisms, cell wall lacking and cell wall bearing organisms thus making these two groups more heterogeneous.
- Viruses were not included in the system.

- Carl Woese and co-workers in the year 1990 introduced three domains of life viz., Bacteria, Archaea and Eukarya based on the difference in rRNA nucleotide sequence, lipid structure of the cell membrane. A revised six Kingdom classification for living world was proposed by Thomas Cavalier-Smith in the year 1998 and the Kingdom Monera is divided in to Archaebacteria and Eubacteria. Recently Ruggerio et al., 2015 published a seven kingdom classification which is a practical extension of Thomas Cavalier's six kingdom scheme. According to this classification there are two superkingdoms (Prokaryota and Eukaryota) Prokaryota include two kingdoms namely Archaebacteria and Eubacteria. Eukaryota include the Protozoa, chromista, fungi, Plantae and Animalia. A new Kingdom, the Chromista was erected and it included all algae whose chloroplasts contain chlorophyll a and c, as well as various colorless forms that are closely related to them. Diatoms, Brown algae, cryptomonads and Oomycetes were placed under this kingdom.

Red tide is caused by toxic bloom of Dinoflagellates like Gymnodinium breve and Gonyaulax tamarensis. A major red tide incident in west coast of Florida in the year 1982 killed Hundreds and thousands of fishes

Bacteria

- The change is brought by Lactobacillus lactis, a bacterium present in the curd. The sourness is due to the formation of Lactic acid. Have you been a victim of Typhoid? It is a bacterial disease caused by Salmonella typhi, a bacterium. So we can consider this prokaryotic organism as friend and foe, due to their beneficial and harmful activities.

Robert Koch (1843–1910) Robert Heinrich Hermann Koch was a German physician and microbiologist. He is considered as the founder of modern bacteriology. He identified the causal organism for Anthrax, Cholera and Tuberculosis. The experimental evidence for the concept of infection was proved by him (Koch's postulates). He was awarded Nobel prize in Medicine/Physiology in the year 1905

Milestones in Bacteriology

1829 C.G. Ehrenberg coined the term Bacterium
1884 Christian Gram introduced Gram staining method
1923 David H. Bergy published First edition of Bergey's Manual
1928 Fredrick Griffith discovered Bacterial transformation
1952 Joshua Lederberg discovered of Plasmid

- Bacteria are prokaryotic, unicellular, ubiquitous, microscopic organisms. The study of Bacteria is called Bacteriology. Bacteria were first discovered by a Dutch scientist, Anton van Leeuwenhoek in 1676 and were called "animalcules".

General characteristic features of Bacteria

- They are Prokaryotic organisms and lack nuclear membrane and membrane bound organelles.
- The Genetic material is called nucleoid or genophore or incipient nucleus
- The cell wall is made up of Polysaccharides and proteins
- Most of them lack chlorophyll, hence they are heterotrophic (Vibrio cholerae) but some are autotrophic and possess Bacteriochlorophyll (Chromatium)

- They reproduce vegetatively by Binary fission and endospore formation.
- They exhibit variations which are due to genetic recombination and is achieved through conjugation, transformation and transduction.

Ultrastructure of a Bacterial cell

The bacterial cell reveals three layers

- Capsule/Glycocalyx
- Cell wall and
- Cytoplasm

- Duodenal and Gastric ulcers are caused by Helicobacter pylori, a Gram negative bacterium.
- Bt toxin from Bacillus thuringiensis finds application in raising insect resistant crops (Bt Crops)

Capsule/Glycocalyx

- Some bacteria are surrounded by a gelatinous substance which is composed of polysaccharides or polypeptide or both. A thick layer of glycocalyx bound tightly to the cell wall is called capsule. It protects cell from desiccation and antibiotics. The sticky nature helps them to attach to substrates like plant root surfaces, Human teeth and tissues. It helps to retain the nutrients in bacterial cell.

Cell wall

- The bacterial cell wall is granular and is rigid. It provide protection and gives shape to the cell. The chemical composition of cell wall is rather complex and is made up of Peptidoglycan or mucopeptide (N-acetyl glucosamine, N-acetyl muramic acid and peptide chain of 4 or 5 aminoacids). One of the most abundant polypeptide called porin is present and it helps in the diffusion of solutes.

Plasma membrane

- The plasma membrane is made up of lipoprotein. It controls the entry and exit of small molecules and ions. The enzymes involved in the oxidation of metabolites (i.e., the respiratory chain) as well as the photosystems used in photosynthesis are present in the plasma membrane

Cytoplasm

- Cytoplasm is thick and semitransparent. It contains ribosomes and other cell inclusions. Cytoplasmic inclusions like glycogen, poly-β-hydroxybutyrate granules, sulphur granules and gas vesicles are present.

Bacterial chromosome

- The bacterial chromosome is a single circular DNA molecule, tightly coiled and is not enclosed in a membrane as in Eukaryotes. This genetic material is called Nucleoid or Genophore. It is amazing to note that the DNA of E.coli which measures about 1mm long when uncoiled, contains all the genetic information of the organism. The DNA is not bound to histone proteins. The single chromosome or the DNA molecule is circular and at one point it is attached to the plasma membrane and it is believed that this attachment may help in the separation of two chromosomes after DNA replication.

Plasmid

- Plasmids are extrachromosomal double stranded, circular, self-replicating, autonomous elements. They contain genes for fertility, antibiotic resistant and heavy metals. It also help in the production of bacteriocins and toxins which are not found in bacterial chromosome. The size of a plasmid varies from 1 to 500 kb usually plasmids contribute to about 0.5 to 5.0% of the total DNA of bacteria. The number of plasmids per cell varies. Plasmids are classified into different types based on the function. Some of them are F (Fertility) factor, R (Resistance) plasmids, Col (Colicin) plasmids, Ri (Root inducing) plasmids and Ti (Tumour inducing) plasmids.

Mesosomes

- These are localized infoldings of plasma membrane produced into the cell in the form of vesicles, tubules and lamellae. They are clumped and folded together to maximize their surface area and helps in respiration and in binary fission.

Polysomes / Polyribosomes

- The ribosomes are the site of protein synthesis. The number of ribosome per cell varies from 10,000 to 15,000. The ribosomes are 70S type and consists of two subunits (50S and 30S). The ribosomes are held together by mRNA and form polyribosomes or polysomes.

Flagella

- Certain motile bacteria have numerous thin hair like processes of variable length emerge from the cell wall called flagella. It is 20–30 µm in diameter and 15 µm in length. The flagella of Eukaryotic cells contain 9+2 microtubles but each flagellum in bacteria is made up of a single fibril. Flagella are used for locomotion. Based on the number and position of flagella there are different types of bacteria.

Fimbriae or Pili

- Pili or fimbriae are hair like appendages found on surface of cell wall of gram-negative bacteria (Example: Enterobacterium). The pili are 0.2 to 20 µm long with a diameter of about 0.025µm. In addition to normal pili there are special type of pili which help in conjugation called sex pili are also found.

Gram staining procedure

- The Gram staining method to differentiate bacteria was developed by Danish Physician Christian Gram in the year1884. It is a differential staining procedure and it classifies bacteria into two classes - Gram positive and Gram negative. The steps involved in

Gram staining procedure. The Gram positive bacteria retain crystal violet and appear dark violet whereas Gram negative type loose the crystal violet and when counterstained by safranin appear red under a microscope.

- Most of the gram positive cell wall contain considerable amount of teichoic acid and teichuronic acid. In addition, they may contain polysaccharide molecules. The gram negative cell wall contains three components that lie outside the peptidoglycan layer.

- Lipoprotein
- Outer membrane
- Lipopolysaccharide.

- Thus the different results in the gram stain are due to differences in the structure and composition of the cell wall.

Difference between Gram Positive and Gram Negative Bacteria

S.No	Characteristics	Gram Positive Bacteria	Gram Negative Bacteria
1	Cell wall	Single layered with 0.015m – 0.02m	Triple layered with 0.0075 m-0.012m thick
2	Rigidity of cell wall	Rigid due to presence of peptidoglycans	Elastic due to presence of lipoprotein – polysaccharide mixture
3	Chemical composition	Peptidoglycans – 80% Polysaccharide – 20% Teichoic acid Present	Peptidoglycans - 3 to 12 % rest is polysaccharides and lipoproteins. Teichoic acid absent
4	Outer membrane	Absent	Present
5	Periplasmic space	Absent	Present
6	Susceptibility to penicillin	Highly susceptible	Low susceptible

7	Nutritional requirements	Relatively complex	Relatively Simple
8	Flagella	Contain 2 basal body rings	Contain 4 basal body rings
9	Lipid and lipoproteins	Low	High
10	Lipopolysaccharides	Absent	Present

What are Magnetosomes ?

Intracellular chains of 40-50 magnetite (Fe_3O_4) particles are found in bacterium Aquaspirillum magnetotacticum and it helps the bacterium to locate nutrient rich sediments.

Life processes in Bacteria Respiration

- Two types of respiration is found in Bacteria. They are 1. Aerobic respiration 2. Anaerobic respiration

Aerobic respiration

- These bacteria require oxygen as terminal acceptor and will not grow under anaerobic conditions (i.e. in the absence of O_2) Example: Streptococcus

Obligate aerobes

- Some Micrococcus species are obligate aerobes (i.e. they must have oxygen to survive).

Anaerobic respiration

- These bacteria do not use oxygen for growth and metabolism but obtain their energy from fermentation reactions. Example: Clostridium

Facultative anaerobes

- There are bacteria that can grow either using oxygen as a terminal electron acceptor or anaerobically using fermentation reaction to obtain energy. When a facultative anaerobe such as E. coli is present at a site of infection like an abdominal abscess, it can rapidly consume all available O2 and change to anaerobic metabolism producing an anaerobic environment and thus allow the anaerobic bacteria that are present to grow and cause disease.

Example: Escherichia coli and Salmonella

Capnophilic Bacteria

- Bacteria which require CO2 for their growth are called as capnophilic bacteria. Example: Campylobacter

Nutrition

- On the basis of their mode of nutrition bacteria are classified into two types namely Autotrophs and Heterotrophs

Autotrophic Bacteria

- Bacteria which can synthesis their own food are called autotrophic bacteria. They may be further subdivided as

Photoautotrophic bacteria:-
Bacteria use sunlight as their source of energy to synthesize food. They may be

Photolithotrophs:
In Photolithotrophs the hydrogen donor is an inorganic substance.

Green sulphur bacteria: In this type of bacteria the hydrogen donor is H2S and possess pigment called Bacterioviridin. Example: Chlorobium

Purple sulphur bacteria: For bacteria belong to this group the hydrogen donor is Thiosulphate, Bacteriochlorophyll is present. Chlorophyll containing chlorosomes are present Example: Chromatium.

Photoorganotrophs

- They utilize organic acid or alcohol as hydrogen donor. Example: Purple non sulphur bacteria – Rhodospirillum.

Chemoautotrophic bacteria

- They do not have photosynthetic pigment hence they cannot use sunlight energy. These type of bacteria obtain energy from organic or inorganic substance.

Chemolithotrophs

- This type of bacteria oxidize inorganic compound to release energy

Examples
Sulphur bacteria - Thiobacillus thiooxidans
Iron bacteria - Ferrobacillus ferrooxidans
Hydrogen bacteria - Hydrogenomonas
Nitrifying bacteria - Nitrosomonas and Nitrobacter

Chemoorganotrophs

This type of bacteria oxidize organic compounds to release energy.

Examples
Methane bacteria – Methanococcus
Acetic acid bacteria – Acetobacter
Lactic acid bacteria – Lactobacillus

Heterotrophic Bacteria

- They are Parasites (Clostridium, Mycobacterium) Saprophytes (Bacillus mycoides) or Symbiotic (Rhizobium in root nodules of leguminous crops).

Reproduction in Bacteria

- Bacteria reproduces asexually by Binary fission, conidia and endospore formation. Among these Binary fission is the most common one.

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

- Typical sexual reproduction involving the formation and fusion of gametes is absent in bacteria. However gene recombination can occur in bacteria by three different methods they are

- Conjugation
- Transformation
- Transduction

Conjugation

- J. Lederberg and Edward L. Tatum demonstrated conjugation in E. coli. in the year 1946. In this method of gene transfer the donor cell gets attached to the recipient cell with the help of pili. The pilus grows in size and forms the conjugation tube. The plasmid of donor cell which has the F+ (fertility factor) undergoes replication. Only one strand of DNA is transferred to the recipient cell through conjugation

tube. The recipient completes the structure of double stranded DNA by synthesizing the strand that complements the strand acquired from the donor.

Transformation

- Transfer of DNA from one bacterium to another is called transformation. In 1928 the bacteriologist Frederick Griffith demonstrated transformation in Mice using Diplococcus pneumoniae. Two strains of this bacterium are present. One strain produces smooth colonies and are virulent in nature (S type) In addition another strain produced rough colonies and are avirulent (R type). When S-type of cells were injected into the mouse, the mouse died. When R-type of cells were injected, the mouse survived. He injected heat killed S-type cells into the mouse the mouse did not die. When the mixture of heat killed S-type

- Griffith's experiment on Transformation
- Mechanism of Transformation

- cells and R-type cells were injected into the mouse. The mouse died. The avirulent rough strain of Diplococcus had been transformed into S-type cells. The hereditary material of heat killed S-type cells had transformed R-type cell into virulent smooth strains. Thus the phenomenon of changing the character of one strain by transferring the DNA of another strain into the former is called Transformation

Transduction

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

Transduction is of two types

Generalized Transduction (ii) Specialized or Restricted Transduction.

Generalized Transduction

- The ability of a bacteriophage to carry genetic material of any region of bacterial DNA is called Generalised transduction

Specialized or Restricted Transduction

- The ability of the bacteriophage to carry only a specific region of the bacterial DNA is called specialized or restricted transduction.

Economic importance of Bacteria

Bacteria are both beneficial and Harmful.

Beneficial Aspects	**Bacteria**	**Role**
1. Soil Fertility		
Ammonification	1. Bacillus ramosus 2. Bacillus mycoides	Convert complex proteins in the dead bodies of plants and animals into ammonia which is later converted into ammonium salt
Nitrification	1. Nitrobacter 2. Nitrosomonas	Covert ammonium salts into nitrites and nitrates
Nitrogen fixation	1. Azotobacter 2. Clostridium 3. Rhizobium	i. Converting atmospheric nitrogen into organic nitrogen ii. The nitrogenous compounds are also oxidized to nitrogen iii. All these activities of bacteria increase soil fertility.

2. Antibiotics		
1. Streptomycin	Streptomyces griseus	It's cures urinary infections, tuberculosis, meningitis and pneumonia
2. Aureomycin	Streptomyces aureofaciens	It's used as a medicine to treat whooping cough and eye infections.
3. Chloromycetin	Streptomyces venezuelae	It cure typhoid fever
4. Bacitracin	Bacillus licheniformis	It is used to treat syphilis
5. Polymyxin	Bacillus polymyxa	It cure some bacterial diseases.
3. Industrial Uses		
1. Lactic acid	Streptococcus lactis and lactobacillus bulgaricus	Convert milk sugar lactose into lactic acid.
2. Butter	Streptococcus lactis, leuconostoc citrovorum	Convert milk into butter, cheese, curd and Yoghurt.
3. Cheese	Lactobacillus acidophobus, lactobacillus lactis	
4. Curd	Lactobacillus lactis	
5. Yoghurt	Lactobacillus bulgaricus	
6. Vinegar (Acetic Acid)	Acetobacter aceti	This bacteria oxidizes ethyl alcohol obtained from molasses by fermentation to vinegar (Acetic acid)
7. Alcohol and Acetone i. Butyl alcohol ii. Methyl alcohol	Clostridium acetobutylicum	Alcohols and acetones are prepared from molasses by

		fermentation activity of the anaerobic bacterium
8. Retting of fibres	Clostridium tertium	The fibres from the fibre yielding plants are separated by the action of clostridium is called retting of fibres.
9. Vitamins	Escherichia coli	Living in the intestine of human beings produce large quantities of vitamin K and vitamin B complex
	Clostridium acetobutylicum	Vitamin B_2 is prepared by the fermentation of sugar.
10. Curing of Tea and Tobacco	Mycococcus candisans, Bacillus megatherium	The special flavour and aroma of the tea and tobacco are due to fermentation.

Bacteria are known to cause disease in plants, animals and Human beings

S.No	**Name of the Host**	**Name of the disease**	**Name of the pathogen**
1.	Rice	Bacterial blight	Xanthomonas oryzae
2.	Apple	Fire blight	Erwinia amylovora
3.	Carrot	Soft rot	Erwinia caratovora
4.	Citrus	Citrus Canker	Xanthomonas Citri
5.	Cotton	Angular leaf spot	Xanthomonas malvacearum

6.	Potato	Ring rot	Clavibacter michiganensis subsp sepedonicus.
7.	Potato	Scab	Streptomyces scabies.

Animal diseases caused by Bacteria

S.NO	Name of the Animal	Name of the disease	Name of the Pathogen
1	Sheep	Anthrax	Bacillus anthracis
2	Cattle	Brucellosis	Brucella abortus
3	Cattle	Bovine tuberculosis	Mycobacterium bovis
4	Cattle	Black leg	Clostridium chanvei

Human disease caused by Bacteria

S.No	Name of the disease	Name of the Pathogen
1	Cholera	Vibrio cholerae
2	Typhoid	Salmonella typhi
3	Tuberculosis	Mycobacterium tuberculosis
4	Leprosy	Mycobacterium Leprae
5	Pneumonia	Diplococcus pneumonie
6	Plague	Yersinia Pestis
7	Diphtheria	Corynebacterium diptheriae
8	Tetanus	Clostridium tetani
9	Food Poisoning	Clostridium botulinum
10	Syphilis	Treponema pallidum

Have you heard about the word "Probiotics"

Probiotic milk products, tooth paste are available in the Market.

Lactobacillus, Bifidobacterium are used to prepare probiotic yoghurt and tooth paste

Bacteria forms Biofilms and leads to dental caries and Urinary tract infection (UTI)

Ralstonia synthesize PHB (Poly-β- hydroxybutyrate) a microbial plastic which is biodegradable

Archaebacteria

- Archaebacteria are primitive prokaryotes and are adapted to thrive in extreme environments like hot springs, high salinity, low pH and so on. They are mostly chemoautotrophs. The unique feature of this group is the presence of lipids like glycerol & isopropyl ethers in their cell membrane. Due to the unique chemical composition the cell membrane show resistance against cell wall antibiotics and lytic agents. Example: Methanobacterium, Halobacterium, Thermoplasma.

- Pseudomonas putida is a superbug (genetically engineered) which breakdown hydrocarbons.
- "Pruteen" is a single cell protein derived from Methylophilus and Methylotropus.
- Agrobacterium tumefaciens cause crown gall disease in plants but its inherent tumour inducing principle helps to carry the desired gene into the plant through Genetic engineering.
- Thermus aquaticus is a thermophilic gram negative bacteria which produces Taq Polymerase a key enzyme for Polymerase Chain Reaction (PCR).
- Methanobacterium is employed in biogas production. Halobacterium, an extremophilic bacterium grows in high salinity. It is exploited for the production β carotene

Cyanobacteria (Blue Green Algae)

- Stromatolites are deposits formed when colonies of cyanobacteria bind with calcium carbonate. They have a geological age of 2.7 billion years. Their abundance in the fossil record indicates that cyanobacteria helped in raising the level of free oxygen in the atmosphere.

- Cyanobacteria are popularly called as 'Blue green algae' or 'Cyanophyceae'. They are photosynthetic, prokaryotic organisms. According to evolutionary record Cyanobacteria are primitive forms and are found in different habitats. Most of them are fresh water and few are marine (Trichodesmium and Dermacarpa) Trichodesmium erythraeum a cyanobacterium imparts red colour to sea (Red sea). Species of Nostoc, Anabaena lead an endophytic life in the coralloid root of Cycas, leaves of aquatic fern Azolla and thallus of hornworts like Anthoceros by establishing a symbiotic association and fix atmospheric nitrogen. Members like Gloeocapsa, Nostoc, Scytonema are found as phycobionts in lichen thalli.

Salient features

- The members of this group are prokaryotes and lack motile reproductive structures.
- The thallus is unicellular in Chroococcus, Colonial in Gloeocapsa and filamentous trichome in Nostoc.
- Gliding movement is noticed in some species(Oscillatoria).
- The protoplasm is differentiated into central region called centroplasm and peripheral region bearing chromatophore called chromoplasm.
- The photosynthetic pigments include c-phyocyanin and c-phycoerythrin along with myxoxanthin and myxoxanthophyll.
- The reserve food material is Cyanophycean starch.
- In some forms a large colourless cell is found in the terminal or intercalary position called Heterocysts. They are involved in nitrogen fixation.
- They reproduce only through vegetative methods and produce Akinetes (thick wall dormant cell formed from vegetative cell),

Hormogonia (a portion of filament get detached and reproduce by cell division), fission, Endospores.

- The presence of mucilage around the thallus is characteristic feature of this group. Therefore, this group is also called Myxophyceae.

- Sexual reproduction is absent.

- Microcystis aeruginosa, Anabaena flos-aquae cause water blooms and release toxins and affect the aquatic organism. Most of them fix atmospheric nitrogen and are used as biofertilizers (Example: Nostoc, Anabaena). Spirulina is rich in protein hence it is used as single cell protein. The thallus organisation and methods of reproduction.

A prokaryote takes a joy ride on polar bear (Aphanocapsa montana - a cynobacterium grow on the fur of a polar bear).

Mycoplasma or Mollicutes

- The Mycoplasma are very small (0.1–0.5µm), pleomorphic gram negative microorganisms. They are first isolated by Nocard and co-workers in the year 1898 from pleural fluid of cattle affected with bovine pleuropneumonia. They lack cell wall and appears like "Fried Egg" in culture. The DNA contains low Guanine and Cytosine content than true bacteria. They cause disease in animals and plants. Little leaf of brinjal, witches broom of legumes phyllody of cloves, sandal spike are some plant diseases caused by mycoplasma. Pleuropneumonia is caused by Mycoplasma mycoides.

Actinomycetes (Actinobacteria)

- Actinomycetes are also called 'Ray fungi' due to their mycelia like growth They are anaerobic or facultative anaerobic microorganisms and are Gram positive. They do not produce an aerial mycelium. Their DNA contain high guanine and cytosine content (Example: Streptomyces).

- Frankia is a symbiotic actinobacterium which produces root nodules and fixes nitrogen in non – leguminous plants such as Alnus and

Casuarina. They produce multicellular sporangium. Actinomyces bovis grows in oral cavities and cause lumpy jaw.

- Streptomyces is a mycelial forming Actinobacteria which lives in soil, they impart "earthy odor" to soil after rain which is due to the presence of geosmin (volatile organic compound). Some important antibiotics namely, Streptomycin, Chloramphenicol, and Tetracycline are produced from this genus.

Fungi

- Alexander Fleming Discovery of Penicillin in the year 1928 is a serendipity in the world of medicine. The History of World War II recorded the use of Penicillin in the form of yellow powder to save lives of soldiers. For this discovery - The wonderful antibiotic he was awarded Nobel Prize in Medicine in the year 1945.

Milestones in Mycology

1729 P.A.Micheli conducted spore culture experiments
1767 Fontana proved that Fungi could cause disease in plants
1873 C.H. Blackley proved fungi could cause allergy in Human beings
1906 A.F.Blakeslee reported heterothallism in fungi
1952 Pontecarvo and Raper reported Parasexual cycle

- The word 'fungus' is derived from Latin meaning 'mushroom'. Fungi are ubiquitous, eukaryotic, achlorophyllous heterotrophic organisms. They exist in unicellular or multicellular forms. The study of fungi is called mycology (Greek: mykes – mushroom: logos – study). P.A. Micheli is considered as founder of Mycology. Few renowned mycologists include Arthur H.R. Buller, John Webster, D.L.Hawksworth, G.C.Ainsworth, B.B.Mundkur, K.C.Mehta, C.V. Subramanian and T.S. Sadasivan.

E.J. Butler (1874-1943) Father of Indian Mycology. He established Imperial Agricultural Research Institute at Pusa, Bihar. It was later shifted to New Delhi and at present known as Indian Agricultural Research Insitute (IARI) He published a book, 'Fungi and Disease in

Plants' on Indian plant diseases in the year 1918.

General characteristic features

- Majority of fungi are made up of thin, filamentous branched structures called hyphae. A number of hyphae get interwoven to form mycelium. The cell wall of fungi is made up of a polysaccharide called chitin (polymer of N-acetyl glucosamine)
- The fungal mycelium is categorised into two types based on the presence or absence of septa. In lower fungi the hypha is aseptate, multinucleate and is known as coenocytic mycelium (Example: Albugo). In higher fungi a septum is present between the cells of the hyphae. Example: Fusarium

- The mycelium is organised into loosely or compactly interwoven fungal tissues called plectenchyma. It is further divided into two types prosenchyma and pseudoparenchyma. In the former type the hyphae are arranged loosely but parallel to one another In the latter hyphae are compactly arranged and loose their identity.

- In holocarpic forms the entire thallus is converted into reproductive structure whereas in Eucarpic some regions of the thallus are involved in the reproduction other regions remain vegetative. Fungi reproduce both by asexual and sexual methods. The asexual phase is called Anamorph and the sexual phase is called Teleomorph. Fungi having both phases are called Holomorph.

- In general sexual reproduction in fungi includes three steps 1. Fusion of two protoplasts (plasmogamy) 2. Fusion of nuclei (karyogamy) and 3. Production of haploid spores through meiosis. Methods of reproduction in fungi.

Methods of Reproduction in Fungi

Asexual Reproduction

- **Zoospores:** They are flagellate structures produced in zoosporangia (Example: Chytrids)

- **Conidia:** The spores produced on condiophores (Example: Aspergillus)

- **Oidia/Thallospores/Arthrospores:** The hypha divide and develop in to spores called oidia (Example: Erysiphe).

- **Fission:** The vegetative cell divide into 2 daughter cells. (Example: Schizosaccharomyces-yeast).

- **Budding:** A small outgrowth is developed on parent cell, which gets detached and become independent. (Example: Saccharomyces-yeast)

- **Chlamydospore:** Thick walled resting spores are called chlamydospores (Example: Fusarium).

Sexual Reproduction

Planogametic copulation: Fusion of motile gamete is called planogametic copulation.

Isogamy – Fusion of morphologically and physiologicall similar gametes. (Example: Synchytrium).

Anisogamy – Fusion of morphologically or physiologically dissimilar gametes (Example: Allomyces).

Oogamy – Fusion of both morphologically and physiologically dissimilar gametes. (Example: Monoblepharis)

Gametangial contact: During sexual reproduction a contact is established between antheridium and Oogonium (Example: Albugo)

Gametangial copulation: Fusion of gametangia to form zygospore (Example:
Mucor, Rhizopus).

Spermatization: In this method a uninucleate pycniospore/microconidium is transferred to receptive hyphal cell (Example: Puccinia/Neurospora)

Somatogamy: Fusion of two somatic cells of the hyphae (Example: Agaricus)

Classification of Fungi

- Many mycologists have attempted to classify fungi based on vegetative and reproductive characters. Traditional classifications categorise fungi into 4 classes – Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. Among these 'Phycomycetes' include fungal species of Oomycetes, Chytridiomycetes and Zygomycetes which are considered as lower fungi indicating algal origin of fungi. Constantine J. Alexopoulos and Charles W. Mims in the year 1979 proposed the classification of fungi in the book entitled 'Introductory Mycology'. They classified fungi into three divisions namely Gymnomycota, Mastigomycota and Amastigomycota. There are 8 subdivisions, 11 classes, 1 form class and 3 form subclasses in the classification proposed by them. The salient features of some of the classes – Oomycetes, Zygomycetes, Ascomycetes, Basidiomycetes and Form class Deuteromycetes.

- Recently, with the advent of molecular methods myxomycetes and oomycetes were reclassified and treated under chromista.

Oomycetes

- Coenocytic mycelium is present. The cell wall is made up of Glucan and Cellulose. Zoospore with one whiplash and one tinsel flagellum is present. Sexual reproduction is Oogamous. Example: Albugo

Zygomycetes

- Most of the species are saprophytic and live on decaying plant and animal matter in the soil. Some lead parasitic life (Example: Entomophthora on housefly)

- Bread mold fungi (Example: Mucor, Rhizopus) and Coprophilous fungi (Fungi growing on dung Example: Pilobolus) belong to this group.

- The mycelium is branched and coenocytic.
- Asexual reproduction by means of spores produced in sporangia.
- Sexual reproduction is by the fusion of the gametangia which results in thick walled Zygospore. It remains dormant for long periods. The zygospore undergoes meiosis and produce spores.

Ascomycetes

- Ascomycetes include a wide range of fungi such as yeasts, powdery mildews, cup fungi, morels and so on.
- Although majority of the species live in terrestrial environment, some live in aquatic environments both fresh water and marine.
- The mycelium is well developed, branched with simple septum.
- Majority of them are saprophytes but few parasites are also known (Powdery mildew – Erysiphe).
- Asexual reproduction takes place by fission, budding, oidia, conidia, chlamydospore.
- Sexual reproduction takes place by the fusion of two compatible nuclei.
- Plasmogamy is not immediately followed by karyogamy, instead a dikaryotic condition is prolonged for several generations.
- A special hyphae called ascogenous hyphae is formed.
- A crozier is formed when the tip of the ascogenous hyphae recurves forming a hooked cell. The two nuclei in the penultimate cell of the hypha fuse to form a diploid nucleus. This cell form young ascus.
- The diploid nucleus undergo meiotic division to produce four haploid nuclei, which further divide mitotically to form eight nuclei. The nucleus gets organised into 8 ascospores.

- The ascospores are found inside a bag like structure called ascus. Due to the presence of ascus, this group is popularly called "Sac fungi".

- Asci gets surrounded by sterile hyphae forming fruit body called ascocarp.

- There are 4 types of ascocarps namely Cleistothecium (Completely closed),

Perithecium (Flask shaped with ostiole), Apothecium (Cup shaped, open type) and Pseudothecium.

Basidiomycetes

- Basidiomycetes include puff balls, toad stools, Bird's nest fungi, Bracket fungi, stink horns, rusts and smuts.

- The members are terrestrial and lead a saprophytic and parasitic mode of life.

- The mycelium is well developed, septate with dolipore septum(bracket like). Three types of mycelium namely Primary (Monokaryotic), Secondary (Dikaryotic) and tertiary are found.

- Clamp connections are formed to maintain dikaryotic condition.

- Asexual reproduction is by means of conidia, oidia or budding.

- Sexual reproduction is present but sex organs are absent. Somatogamy or spermatisation results in plasmogamy. Karyogamy is delayed and dikaryotic phase is prolonged. Karyogamy takes place in basidium and it is immediately followed by meiotic division.

- The four nuclei thus formed are transformed into basidiospores which are borne on sterigmata outside the basidium (Exogenous). The basidium is club shaped with four basidiospores, thus this group of fungi is popularly called "Club fungi". The fruit body formed is called Basidiocarp.

Deuteromycetes or Fungi Imperfecti

- The fungi belonging to this group lack sexual reproduction and are called imperfect fungi. A large number of species live as saprophytes in soil and many are plant and animal parasites. Asexual reproduction takes place by the production of conidia, chlamydospores, budding, oidia etc., Conidia are also produced in special structures called Pycnidium, Acervulus, Sporodochium and Synnema. Parasexual cycle operates in this group of fungi. This brings genetic variation among the species.

Economic importance

- Fungi provide delicious and nutritious food called mushrooms. They recycle the minerals by decomposing the litter thus adding fertility to the soil. Dairy industry is based on a single celled fungus called yeast. They deteriorate the timber. Fungi cause food poisoning due the production of toxins. The Beneficial and harmful activities of fungi are discussed below:

Beneficial activities

Food

- Mushrooms like Lentinus edodes, Agaricus bisporus, Volvariella volvaceae are consumed for their high nutritive value. Yeasts provide vitamin B and Eremothecium ashbyii is a rich source of Vitamin B12.

Medicine

- Fungi produce antibiotics which arrest the growth or destroy the bacteria. Some of the antibiotics produced by fungi include Penicillin (Penicillium notatum) Cephalosporins (Acremonium chrysogenum) Griseofulvin (Penicillium griseofulvum). Ergot alkaloids (Ergotamine) produced by Claviceps purpurea is used as vasoconstrictors.

Industries

- **Production of Organic acid:** For the commercial production of organic acids fungi are employed in the Industries. Some of the organic acids and fungi which help in the production of organic acids are: Citric acid and Gluconic acid – Aspergillus niger; Itaconic acid – Aspergillus terreus, Kojic acid – Aspergillus oryzae

Bakery and Brewery

- Yeast (Saccharomyces cerevisiae) is used for fermentation of sugars to yield alcohol. Bakeries utilize yeast for the production of Bakery products like Bread, buns, rolls etc., Penicillium roquefortii and Penicillium camemberti were employed in cheese production.

Production of enzymes

- Aspergillus oryzae, Aspergillus niger were employed in the production of enzymes like Amylase, Protease, Lactase etc., 'Rennet' which helps in the coagulation of milk in cheese manufacturing is derived from Mucor spp.

Agriculture

- Mycorrhiza forming fungi like Rhizoctonia, Phallus, Scleroderma helps in absorption of water and minerals.

- Fungi like Beauveria bassiana, Metarhizium anisopliae are used as Biopesticides to eradicate the pests of crops.

- Gibberellin, produced by a fungus Gibberella fujikuroi induce the plant growth and is used as growth promoter.

Harmful activities

- Fungi like Amanita phalloides, Amanita verna, Boletus satanus are highly poisonous due to the production of Toxins. These fungi are commonly referred as "Toad stools".

- Aspergillus, Rhizopus, Mucor and Penicilium are involved in spoilage of food materials. Aspergillus flavus infest dried foods and produce carcinogenic toxin called aflatoxin.

Patulin, ochratoxin A are some of the toxins produced by fungi.

Diseases caused by Fungi

S.NO	Name of the disease	Causal oganism
Plant Diseases		
1	Blast of Paddy	Magnaporthe grisea
2	Red rot of Sugarcane	Collectotrichum falcatum
3	Anthracnose of Beans	Collectotrichum Lindemuthianum
4	White rust of crucifers	Albugo candida
5	Peach leaf Curl	Taphrina deformans
6	Rust of Wheat	Puccinia graminis tritici
Human Diseases		
1	Athlete's Foot	Epidermophyton floccosum
2	Candidiasis	Candida albicans
3	Coccidioidomycosis	Coccidioides immitis
4	Aspergillosis	Aspergillus fumigatus

Dermatophytes are fungi which cause infection in skin. Example: Trichophyton, Tinea, Microsporum and Epidermophyton

The late blight disease of Potato by Phytophthora infestans caused a million deaths, and drove more to emigrate from Ireland (1843-1845). In India Helminthosporium oryzae, Blight of Paddy is also a factor for Bengal famine in 1942-1943

Mycorrhizae

- The Symbiotic association between fungal mycelium and roots of plants is called as mycorrhizae. In this relationship fungi absorbs nutrition from the root and in turn the hyphal network of mycorrhizae forming fungi helps the plant to absorb water and mineral nutrients from the soil Mycorrhizae are classified into three types

Importance of Mycorrhizae

- Helps to derive nutrition in Monotropa, a saprophytic angiosperm,
- Improves the availability of minerals and water to the plants.
- Provides drought resistance to the plants
- Protects roots of higher plants from the attack of plant pathogens

Mycorrhizae

Ectomycorrhizae	Endomycorrhizae	Ectendomycorrhizae
The fungal mycelium forms a dense shealth aroud the root called mantle. The hyphal net – work penetrate the intercellular spaces of the epidermis and cortex to form Hartignet. Example: Pisolithus tinctorius.	The hyphae grows mainly inside the roots, penetrate the outer cortical cells of the plant root. A small portion of the mycelium us found outside the root. This form is also called vesicular Arbuscular mycorrhizal fungi (VAM fungi) due to the presence of vesicle or arbuscle like haistoria. Arbuscular mycorrhizae (VAM) Example: Gigaspora	The fungi forms both mantle and also penetrates the cortical cells.

	Ericoid mycorrhizae - Example: Oidiodendron Orchid mycorrhizae – Example: Rhizoctonia	

Lichens

- The symbiotic association between algae and fungi is called lichens. The algal partner is called Phycobiont or Photobiont and the fungal partner is called Mycobiont. Algae provide nutrition for fungal partner in turn fungi provide protection and also help to fix the thallus to the substratum through rhizinae. Asexual reproduction takes place through fragmentation, Soredia and Isidia. Phycobionts reproduce by akinetes, hormogonia, aplanospore etc., Mycobionts undergo sexual reproduction and produce ascocarps.

Classification

- Based on the habitat lichens are classified into following types: Corticolous(on Bark) Lignicolous(on Wood) Saxicolous(on rocks) Terricolous(on ground) Marine(on siliceous rocks of sea) Fresh water(on siliceous rock of fresh water).

- On the basis of morphology of the thallus they are divided into Leprose (a distinct fungal layer is absent) Crustose-crust like; Foliose-leaf like; Fruticose- branched pendulous shrub

- The distribution of algal cells distinguishes lichens into two forms namely Homoiomerous (Algal cells evenly distributed in the thallus) and Heteromerous (a distinct layer of algae and fungi present)

- If the fungal partner of lichen belongs to ascomycetes, it is called Ascolichen and if it is basidiomycetes it is called Basidiolichen.

- Lichens secrete organic acids like Oxalic acids which corrodes the rock surface and helps in weathering of rocks, thus acting as pioneers in Xerosere. Usnic acid produced from lichens show antibiotic

properties. Lichens are sensitive to air pollutants especially to sulphur-di-oxide. Therefore, they are considered as pollution indicators. The dye present in litmus paper used as acid base indicator in the laboratories is obtained from Roccella montagnei. Cladonia rangiferina (Reindeer moss) is used as food for animals living in Tundra regions.

11th Botany

Chapter 2 – Plant Kingdom

- Traditionally organisms existing on the earth were classified into plants and animals based on nutrition, locomotion and presence or absence of cell wall. Bacteria, Fungi, Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms were included under plant group. Recently, with the aid of molecular characteristics the Bacteria and Fungi were segregated and placed under separate kingdoms. Botany is one of the oldest science in the world because its origin was from time immemorial as early men explored and identified plants for the needs of food, clothing, medicine, shelter etc., Plants are unique living entities as they are endowed with the power to harvest the light energy from the sun and to convert it to chemical energy in the form of food through the astounding reaction, photosynthesis. They not only supply nutrients to all living things on earth but sequester carbon-di-oxide during photosynthesis thus minimizing the effect of one of the major green house gases that increase the global temperature. Plants are diverse in nature, ranging from microscopic algae to macroscopic highly developed angiosperms. There are mysteries and wonders in the plant world in terms of size, shape, habit, habitat, reproduction etc., Although plants are all made up of cells there exists high diversity in form and structure.

Total Number of Plant groups in the World and India

Plants group	**Number of Known species**	
	World	India
Algae	40,000	7,357
Bryophytes	16,236	2,748
Pteridophytes	12,000	1,289
Gymnosperms	1,012	79
Angiosperms	2,68,600	18, 386

Classification of Plants

- Classification widely accepted for plants now include Embryophyta which is divided into Bryophyta and Tracheophyta. The latter is further divided into Pteridophyta and Spermatophyta (Gymnospermae and Angiospermae). An outline Classification of Plant Kingdom.

Life Cycle Patterns in Plants

Alternation of Generation

- Alternation of generation is common in all plants. Alternation of the haploid gametophytic phase (n) with diploid sporophytic phase (2n) during the life cycle is called alternation of generation. Following type of life cycles are found in plants.

Haplontic Life Cycle

- Gametophytic phase is dominant, photosynthetic and independent, whereas sporophytic phase is represented by the zygote. Zygote undergoes meiosis to restore haploid condition. Example: Volvox, Spirogyra.

Diplontic Life Cycle

- Sporophytic phase (2n) is dominant, photosynthetic and independent. The gametophytic phase is represented by the single to few celled gametophyte. The gametes fuse to form Zygote which develops into Sporophyte. Example: Fucus, Gymnosperms and Angiosperms.

Haplodiplontic Life Cycle

- This type of life cycle is found in Bryophytes and pteridophytes which is intermediate between haplontic and diplontic type. Both the phases are multicellular. but they differ in their dominant phase.

- In Bryophytes dominant independent phase is gametophyte and it alternates with short-lived multicellular sporophyte totally or partially dependent on the gametophyte.

- In Pteridophytes sporophyte is the independent phase. It alternates with multicellular saprophytic or autotrophic, independent, short lived gametophyte(n).

Algae

M.O. Parthasarathy (1886-1963) 'Father of Indian Phycology'.
He conducted research on structure, cytology, reproduction and taxonomy of Algae. He published a Monograph on Volvocales. New algal forms like Fritschiella, Ecballocystopsis, Charasiphon and Cylindrocapsopsis. were reported by him.

- Algae are autotrophs, and grow in a wide range of habitats. Majority of them are aquatic, marine (Gracilaria, and Sargassum) and freshwater (Oedogonium, and Ulothrix) and also found in soils (Fritschiella, and Vaucheria). Chlorella lead an endozoic life in Hydra and sponges whereas Cladophora crispata grow on the shells of molluscs. Algae are adapted to thrive in harsh environment too. Dunaliella salina grows in salt pans (Halophytic alga). Algae growing in snow are called Cryophytic algae. Chlamydomonas nivalis grow in snow covered mountains and impart red colour to the snow (Red snow). A few algae grow on the surface of aquatic plants and are called epiphytic algae (Coleochaete, and Rhodymenia). The study of algae is called algology or phycology. Some of the eminent algologists include F.E.Fritsch, F.E. Round, R.E. Lee, M.O. Parthasarathy, M.S. Randhawa, Y. Bharadwaja, V.S. Sundaralingam and T.V.Desikachary.

General Characteristic features

- The algae show a great diversity in size, shape and structure. A wide range of thallus organisation is found in algae. Unicellular motile (Chlamydomonas), unicellular non-motile (Chlorella), Colonial motile (Volvox), Colonial non motile (Hydrodictyon), siphonous (Vaucheria), unbranched filamentous (Spirogyra), branched filamentous (Cladophora), discoid (Coleochaete) heterotrichous

(Fritschiella), Foliaceous (Ulva) to Giant Kelps (Laminaria and Macrocystis).

- Algae are Eukaryotes except blue green algae. The plant body does not show differentiation into tissue systems. The cell wall of algae is made up of cellulose and hemicellulose. Siliceous walls are present in diatoms. In Chara the thallus is encrusted with calcium carbonate. Some algae possess algin, polysulphate esters of polysaccharides which are the sources for the alginate, agar agar and Carrageenan. The cell has a membrane bound nucleus and cell organelles like chloroplast, mitochondria, endoplasmic reticulum, golgi bodies etc., Pyrenoids are present. They are proteinaceous bodies found in chromatophores and assist in the synthesis and storage of starch. The pigmentation, reserve food material and flagellation differ among the algal groups.

- Algae reproduces by vegetative, asexual and sexual methods. Vegetative reproduction includes fission (In unicellular forms the cell divides mitotically to produce two daughter cells Example: Chlamydomonas); Fragmentation (fragments of parent thallus grow into new individual Example: Ulothrix) Budding (A lateral bud is formed in some members like Protosiphon and helps in reproduction) Bulbils, (a wedge shaped modified branch develop in Sphacelaria) Akinetes (Thick walled spores meant for perennation and germinates with the advent of favourable condition Example: Pithophora). Tubers (Structures found on the rhizoids and the lower nodes of Chara which store food materials).

- Asexual reproduction takesplace by the production of zoospores(Ulothrix, Oedogonium) aplanospore(thin walled non motile spores Example: Vaucheria); Autospores (spores which look similar to parent cell Example: Chlorella); Hypnospore (thick walled aplanospore – Example: Chlamydomonas nivalis); Tetraspores (Diploid thallus of Polysiphonia produce haploid spores after meiosis).

- Sexual reproduction in algae are of three type 1. Isogamy (Fusion of morphologically and Physiologically similar gametes Example: Ulothrix) 2. Anisogamy (Fusion of either morphologically or

physiologically dissimilar gametes Example: Pandorina) 3. Oogamy (Fusion of both morphologically and physiologically dissimilar gametes. Example: Sargassum). The life cycle shows distinct alternation of generation.

The Oldest recorded alga is Grypania, which was discovered in the banded iron formations of northern Michigan and dated to approximately 2100Ma

Classification

- F.E. Fritsch proposed a classification for algae based on pigmentation, types of flagella, reserve food materials, thallus structure and reproduction. He published his classification in the book "The structure and reproduction of the Algae"(1935). He classified algae into 11 classes namely Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonodineae, Euglenophyceae, Phaeophyceae, Rhodophyceae, Cyanophyceae.

The salient features of Chlorophyceae, Phaeophyceae and Rhodophyceae are given below.

Chlorophyceae

- The members are commonly called 'Green algae'. Most of the species are aquatic (Fresh water-Spirogyra, Marine -Ulva). A few are terrestrial(Trentipohlia). Variation among the shape of the chloroplast is found in members of algae. It is Cup shaped (Chlamydomonas), Discoid (Chara), Girdle shaped, (Ulothrix), reticulate (Oedogonium), spiral (Spirogyra), stellate (Zygnema), plate like (Mougeoutia). Chlorophyll 'a' and Chlorophyll 'b' are the major photosynthetic pigments. Storage bodies called pyrenoids are present in the chloroplast and store starch. They also contain proteins. The cell wall is made up of inner layer of cellulose and outer layer of Pectin. Vegetative reproduction takes place by means of fragmentation and asexual reproduction is by the production of zoospores, aplanospores and akinetes. Sexual reproduction is present and may be isogamous,

anisogamous or Oogamous. Examples for this group of algae includes Chlorella, Chlamydomonas, Volvox, Spirogyra,Ulothrix, Chara and Ulva.

Phaeophyceae

- The members of this class are called 'Brown algae'. Majority of the forms are found in marine habitats. Pleurocladia is a fresh water form. The thallus is filamentous (Ectocarpus) frond like (Dictyota)or may be giant kelps (Laminaria and Macrocystis). The thallus is differentiated into leaf like photosynthetic part called fronds, a stalk like structure called stipe and a holdfast which attach thallus to the substratum. The Pigments include Chlorophyll a, c, carotenoids and Xanthophylls. A golden brown pigment called fucoxanthin is present and it gives shades of colour from olive green to brown to the algal members of this group. Mannitol and Laminarin are the reserve food materials. Motile reproductive structures are present. Two laterally inserted unequal flagella are present. Among these one is whiplash and another is tinsel. Although sexual reproduction ranges from isogamy to Oogamy, Most of the forms show Oogamous type. Alternation of generation is present (isomorphic, heteromorphic or diplontic). Examples for this group include Sargassum, Laminaria, Fucus and Dictyota.

Rhodophyceae

- Members of this group include 'Red algae' and are mostly marine. The thallus is multicellular, macroscopic and diverse in form. Porphyridium is the unicellular form. Filamentous (Goniotrichum) ribbon like (Porphyra) are also present. Corallina and Lithothamnion are heavily impregnated with lime and form coral reefs. Apart from chlorophyll a, r-phycoerythrin and r-phycocyanin are the photosynthetic pigments. Asexual reproduction takes place by means of monospores, neutral spores and Tetraspores.

- The storage product is floridean starch. Sexual reproduction is Oogamous. Male sex organ is spermatangium which produces spermatium. Female sex organ is called carpogonium. The spermatium is carried by the water currents and fuse with egg

nucleus to form zygote. The zygote develops into carpospores. Meiosis occurs during carpospore formation. Alternation of generation is present. Examples for this group of algae include Ceramium, Polysiphonia, Gelidium, Cryptonemia and Gigartina

A green alga Botryococcus braunii is employed in Biofuel production.

Algae in Health care

- Kelps are the rich source of Iodine
- Chlorella is used as Single cell protein (SCP).
- Dunaliella salina an alga, growing in Salt pan is complement to our health and provide β carotene.

A Productive Cultivation in Sea

Algae like Kappaphycus alvarezii, Gracilaria edulis and Gelidiella acerosa are commercially grown in the sea for harvesting the phycocolloids

Economic Importance of Algae

Name of the Algae	Economic importance
Beneficial activities	
Chlorella, Laminaria, Sargassum, Ulva, Enteromorpha	Food
Gracilaria, Galidiella, Gigartina	Agar Agar – Cell wall material used for media preparation in the microbiology lab. Packing canned food, cosmetic, textile paper industry
Chondrus crispus	Carrageenan – Preparation of tooth paste, pant, blood coagulant
Laminaria, Ascophyllum	Alginate – ice cream, paints, flame proof fabrics.
Laminaria, sargassum, Ascophyllum, focus.	Fodder.
Diatom (Siliceous Frustules)	Diatomaceous earth – water filters, insulation material, reinforcing agent in concrete and rubber.
Lithophyllum, chara, Fucus	Fertilizer.

Chlorella	Chlorellin – Antibiotic
Chlorella, Scenedesmus, chlamydomonas	Sewage treatment, pollution indicators.
Harmful Activity	
Cephaleuros Virescens	Red rust of coffee

Bryophytes

Amphibians of Plant Kingdom

- We noticed a wide range of thallus organization in Algae. Majority of them are aquatic. The development of heterotrichous habit, development of parenchyma tissue, dichotomous branching in some algae supports the view that colonization of plants in land occurred in the past. Bryophytes are simplest and most primitive plant groups descended from alga – like ancestors. They are simple embryophytes. Let us learn about the structure and reproduction of these primitive land plants called Bryophytes in detail.

- Bryophytes are simplest land inhabiting cryptogams and are restricted to moist, shady habitats. They lack vascular tissue and hence called 'Non- vascular cryptogams'. They are also called as 'amphibians of plant kingdom' because they need water for completing their life cycle.

General characteristic features

- The plant body of bryophyte is gametophyte and is not differentiated into root, stem and leaf like structure.

- Most of them are primitive land dwellers. Some of them are aquatic (Riella, Ricciocarpus).

- The gametophyte is conspicuous, long lived phase of the life cycle. Th alloid forms are present in liverworts and Hornworts. In Mosses leaf like, stem like structures are present. In Liverworts thallus grows prostrate on the ground and is attached to the substratum by means of rhizoids. Two types of rhizoids are present namely smooth walled and pegged. Multicellular scales are also present. In Moss the plant

body is erect with central axis bearing leaf like expansions. Multicellular rhizoids are present. Th e structure and reproduction

- Vascular tissue like xylem and phloem are completely absent, hence called 'Non vascular cryptogams'.

- Vegetative reproduction takes place by the formation of adventitious buds (Riccia fl uitans) tubers develop in Anthoceros. In some forms small detachable branches or brood bodies are formed, they help in vegetative reproduction as in Bryopteris fruticulosa. In Marchantia propagative organs called gemmae are formed and help in reproduction.

- Sexual reproduction is Oogamous. Antheridia and Archegonia are produced in a protective covering and are multicellular.

- The antheridia produces biflagellate antherozoids which swims in thin film of water and reach the archegonium and fuse with the egg to form diploid zygote.

- Water is essential for fertilization.

- The zygote is the first cell of the sporophyte generation. It undergoes mitotic division to form multicellular undifferentiated embryo. The embryogeny is exoscopic (the first division of the zygote is transverse and the apex of the embryo develops from the outer cell). The embryo divides and give rise to sporophyte.

- The sporophyte is dependent on gametophyte.

- It is differentiated into three recognizable parts namely foot, seta and capsule. Foot is the basal portion and is embedded in the gametophyte through which water and nutrients are supplied for the sporophyte. The diploid spore mother cells found in the capsule region undergoes meiotic division and give rise to haploid spores. Bryophytes are homosporous. In some sporophytes elaters are present and help in dispersal of spores (Example: Marchantia). The spores germinate to produce gametophyte.

- The zygote, embryo and the sporogonium constitute sporophytic phase. The green long living haploid phase is called gametophytic phase The haploid gametophytic phase alternates with diploid sporophyte and shows heterologous alternation of generation. Proskauer in the year 1957 classified Bryophytes into 3 Classes namely

- Hepaticopsida (Riccia, Marchantia, Porella, Riella) ii) Anthocerotopsida (Anthoceros and Dendroceros) iii) Bryopsida (Funaria, Polytrichum and Sphagnum).

Economic importance

- A large amount of dead thallus of Sphagnum gets accumulated and compressed, hardened to form peat. In northern Europe peat is used as fuel in commercial scale (Netherlands). Apart from this Nitrates, brown dye and tanning materials are derived from peat. Sphagnum and peat are also used in horticulture as packing material because of their water holding capacity. Marchantia polymorpha is used to cure pulmonary tuberculosis. Sphagnum, Bryum and Polytrichum are used as food. Bryophytes play a major role in soil formation through succession and help in Soil conservation.

Buxbaumia aphylla and Cryptothallus mirabilis are saprophytic bryophytes

Pteridophytes

Seedless Vascular Cryptogams

- We are aware of the salient features of amphibious plants called Bryophytes. But there is a plant group called Pteridophytes which are considered as first true land plants. Further, they were the first plants to acquire vascular tissue namely xylem and phloem, hence called vascular cryptogams. Club moss, Horsetails, quill worts, water ferns and Tree ferns belong to this group. This chapter deals with the characteristic features of Pteridophytes.

- Pteridophytes are the vascular cryptogams and were abundant in the Devonian period of Palaeozoic era (400 million years ago). These plants are mostly small herbaceous and grow well in moist, cool and shady places where water is available. Photographs for some pteridophytes are given.

General characteristic features of Pteridophytes:

- Plant body is sporophyte (2n) and it is the dominant phase. It is differentiated into root, stem and leaves.
- Roots are adventitious.
- Stem shows monopodial or dichotomous branching.
- Leaves may be microphyllous or megaphyllous.
- Stele is protostele but in some forms siphonostele is present (Marsilea)
- Tracheids are the major water conducting elements but in Selaginella vessels are found.
- Sporangia, spore bearing bag like structures are borne on special leaves called sporophyll. The sporophylls gets organized to form cone or strobilus. Example: Selaginella, Equisetum .
- They may be homosporous (produce one type of spores- Lycopodium) or Heterosporous (produce two types of spores- Selaginella). Heterospory is the origin for seed habit.
- Development of sporangia may be eusporangiate (development of sporangium from group of initials) or leptosporangiate (development of sporangium from single initial).
- Spore mother cells undergo meiosis and produce spores (n).
- Spore germinates to produce haploid, multicellular green, cordate shaped independent gametophytes called prothallus.

- Fragmentation, Resting buds, root tubers and adventitious buds help in Vegetative reproduction.

- Sexual reproduction is Oogamous. Sex organs, namely antheridium and archegonium are produced on the prothallus.

- Antheridium produces spirally coiled and multiflagellate antherozoids.

- Archegonium is flask shaped with broad venter and elongated narrow neck. The venter possesses egg or ovum and neck contain neck canal cells

- Water is essential for fertilization. After fertilization a diploid zygote is formed and undergoes mitotic division to form embryo.

- Pteridophytes show apogamy and apospory.

- Reimer (1954) proposed a classification for Pteridophytes In this classification, the Pteridophytes are divided into five subdivisions. 1. Psilophytopsida 2. Psilotopsida 3. Lycopsida 4. Sphenopsida 5. Pteropsida. There are 19 orders and 48 families in the classification.

Economic Importance

Economic Importance of Pteridophyte

Pteridophyte	**Uses**
Rumohra adiantiformis (Lather leaf fern)	Cut flower arrangements
Marsilea	Food
Azolla	Biofertilizer
Dryopteria filix - mas	Treatment for tapeworm
Pteris vittata	Removal of heavy metals from soils - Bioremediation
Pteridium sp	Leaves yield green dye
Equisetum sp.	Stems for scouring
Psilotum, Lycopodium, Selaginella, Angiopteris, Marattia.	Ornamental plants.

- The success and dominance of vascular plants is due to the development of,
- Extensive root system.
- Efficient conducting tissues.
- Cuticle to prevent desiccation.
- Stomata for effective gaseous exchange.

Types of Stele

- The term stele refers to the central cylinder of vascular tissues consisting of xylem, phloem, pericycle and sometimes medullary rays with pith.

There are two types of steles

- Protostele
- Siphonostele

Protostele:

- In protostele phloem surrounds xylem. The type includes Haplostele, Actinostele, Plectostele, and mixed protostele.

Haplostele: Xylem surrounded by phloem is known as haplostele. Example: Selaginella.

Actinostele: Star shaped xylem core is surrounded by phloem is known as actinostele. Example: Lycopodium serratum.

Plectostele: Xylem plates alternates with phloem plates. Example: Lycopodium clavatum.

Mixed prototostele: Xylem groups uniformly scattered in the phloem. Example: Lycopodium cernuum.

Siphonostele: In siphonostele xylem is surrounded by phloem with pith at the centre. It includes Ectophloic siphonostele, Amphiphloic siphonostele, Solenostele, Eustele, Atactostele and Polycylic stele.

Ectophloic siphonostele: The phloem is restricted only on the external side of the xylem. Pith is in centre. Example: Osmunda.

Amphiphloic siphonostele: The phloem is present on both the sides of xylem. The pith is in the centre. Example: Marsilea.

Solenostele: The stele is perforated at a place or places corresponding the origin of the leaf trace.

Ectophloic solenostele – Pith is in the centre and the xylem is surrounded by phloem. Example: Osmunda.

Amphiphloic solenostele – Pith is in the centre and the phloem is present on both sides of the xylem. Example: Adiantum pedatum.

Dictyostele – The stele is separated into several vascular strands and each one is called meristele. Example: Adiantum capillus-veneris.

Eustele: The stele is split into distinct collateral vascular bundles around the pith. Example: Dicot stem.

Atactostele: The stele is split into distinct collateral vascular bundles and are scattered in the ground tissue Example: Monocot stem.

Polycyclicstele: The vascular tissues are present in the form of two or more concentric cylinders. Example: Pteridium.

Gymnosperms

Naked Seed producing Plants

- Michael Crichton's Science fiction in a book transformed into a Film of Steven Spielberg (1993) called Jurassic Park.

- Gymnosperms (Gr. Gymnos= naked; sperma= seed) are naked seed producing plants. They were dominant in the Jurassic and cretaceous periods of Mesozoic era. The members are distributed throughout the temperate and tropical region of the world.

General characteristic features

- Most of the gymnosperms are evergreen woody trees or shrubs. Some are lianas (Gnetum)

- The plant body is sporophyte and is differentiated into root, stem and leaves.

- A well developed Tap root system is present. Coralloid Roots of Cycas have symbiotic association with blue green algae. In Pinus the roots have mycorrhizae.

- The stem is aerial, erect and branched or unbranched (Cycas) with leaf scars.

- In conifers two types of branches namely branches of limited growth (Dwarf shoot) and Branches of unlimited growth (Long shoot) is present.

- Leaves are dimorphic, foliage and scale leaves are present. Foliage leaves are green, photosynthetic and borne on branches of limited growth. They show xerophytic features.

- The xylem consists of tracheids but in Gnetum and Ephedra Vessels are present.

- Secondary growth is present. The wood may be Manoxylic (Porous, soft, more parenchyma with wide medullary ray -Cycas) or Pycnoxylic (compact with narrow medullary ray-Pinus).

- They are Heterosporous. The plant may be monoecious (Pinus) or dioecious (Cycas).

- Microsporangia and Megasporangia are produced on Microsporophyll and Megasporophyll respectively.

- Male and female cones are produced.
- Anemophilous pollination is present.

- Fertilization is siphonogamous and pollen tube helps in the transfer of male nuclei.

- Sporne (1965) classified gymnosperms into 3 classes, 9 orders and 31 families. The classes include i) Cycadospsida ii) Coniferopsida iii) Gnetopsida.

Comparison of Gymnosperm with Angiosperms

Gymnosperms resemble with angiosperms in the following features

- Presence of well organised plant body which is differentiated into roots, stem and leaves

- Presence of cambium in gymnosperms as in dicotyledons.

- Flowers in Gnetum resemble to the angiosperm male flower. The Zygote represent the first cell of sporophyte.

- Presence of integument around the ovule

- Both plant groups produce seeds

- Pollen tube helps in the transfer of male nucleus in both.

- Presence of Eustele.

Difference between Gymnosperms and Angiosperms

S.No	Gymnosperms	Angiosperms
1	Vessels are absent (Expect Gnetales)	Vessels are present
2	Phloem lacks companion cells	Companion cells are present
3	Ovules are naked	Ovules are enclosed within the ovary
4	Wind Pollination only	Insects, wind, water, animals etc., act as

		pollinating agents.
5	Double fertilization is absent	Double fertilization is Present.
6	Endosperm is haploid	Endosperm is triploid
7	Fruit formation is absent.	Fruit formation is present.
8	Flowers absent	Flowers present.

Economic importance of Gymnosperms

S.No	Plants	Products	Uses
1	Cycas circinalis, Cyas revoluta	Sago	Starch used as food.
2	Pinus gerardiana	Roasted seed	Used as a food
3	Abies balsamea	Resin (Canada balsam)	Used as mounting medium in permanent slide preparation
4	Pinus insularis, pinus roxburghii	Rosin and Turpentine	Paper sizing and varnishes.
5	Araucaria (monkey's Puzzle), picea and phyllocladus	Tannins	Bark yield tannins and is used in leather industries.
6	Taxus brevifolia	Taxol	Drug used for cancer treatment.
7	Ephedra gerardiana	Ephedrine	For the treatment of asthma, bronchititis.
8	Pinus roxburghii	Oleoresin	Used to make soap, varnishes and Printing ink.
9	Pinus roxburghii, picea smothiana	Wood Pulp	Used to make papers.

10	Cedrus deodara	Wood	Used to make doors, boats and railway sleepers
11	Cedrus atlantica	Oil	Used in Perfumery
12	Thuja, cupressus, Araucaria, and cryptomeria	Whole plant	Ornamental plants/ Floral Decoration

Know about Fossil plants

- The national wood fossil park is situated in Tiruvakkarai, a Village of Villupuram district of Tamil Nadu. The park contains petrified wood fossils approximately 20 million years old. The term 'form genera' is used to name the fossil plants because the whole plant is not recovered as fossils instead organs or parts of the extinct plants are obtained in fragments. Shiwalik fossil park-Himachal Pradesh, Mandla Fossil park-Madhya Pradesh, Rajmahal Hills– Jharkhand, Ariyalur – Tamilnadu are some of the fossil rich sites of India.

Prof. Birbal Sahni (1891-1949)
Father of Indian Palaeobotany. He described Fossil plants from Rajmahal Hills of Eastern Bihar. Pentoxylon sahnii, Nipanioxylon are some of the form genera described by him. Birbal Sahni Institute of Palaebotany is located in Lucknow

Some of the fossil representatives of different plant groups are given below

Fossil algae - Palaeoporella, Dimorphosiphon
Fossil Bryophytes – Naiadita, Hepaticites, Muscites
Fossil Pteridophytes – Cooksonia, Rhynia,, Baragwanthia, Calamites
Fossil Gymnosperms – Medullosa, Lepido- carpon, Williamsonia, Lepidodendron
Fossil Angiosperms – Archaeanthus, Furcula

Angiosperms

- Spermatophytes also include plants bearing ovules enclosed in a protective cover called Ovary, such plants are called Angiosperms. They constitute major plant group of our earth and are adapted to the terrestrial mode of life. This group of plants appeared during the early cretaceous period (140 million years ago) and dominates the vegetation on a world scale. The sporophyte is the dominant phase and gametophyte is highly reduced.

Salient features of Angiosperms

- Vascular tissue (Xylem and Phloem) is well developed.
- Flowers are produced instead of cone
- The embryosac (Ovule) remains enclosed in the ovary.
- Pollen tube helps in fertilization, so water is not essential for fertilization.
- Double fertilization is present. The endosperm is triploid.
- Angiosperms are broadly classified into two classes namely Dicotyledons and Monocotyledons.

Characteristic features of Dicotyledons and Monocotyledons

- Current Angiosperm Phylogeny Group (APG) System of classification doesn't recognize dicots as a monophyletic group. Plants that are traditionally classified under dicots are dispersed in several clades such as early Magnolids and Eudicots

11th Zoology

Chapter 1 – Living World

- All living forms co-exist with each other. There are about 8.7 million species of animals which have been identified, named, described and classified. A study reports that 86% of all species on the land and 91% of those in the seas are yet to be discovered, described and catalogued. Though humans are placed in the top most position on the hierarchy, they have to depend on plants and animals for food. Animals are also used as source of labour, in farming, as pets, and for other economic benefits. Understanding animals and their unique characteristics, habitats, behaviour and evolutionary relationships is very important.

Diversity in the Living World

- Earth has numerous habitats with a wide range of living organisms inhabiting them. Plants and animals are present in almost all of the places, from polar ice caps to volcanic hot springs, from shallow lagoons to the deepest oceans, from tropical rain forests to dry and parched deserts. There are a variety of species that have been adapted successfully to live in diverse ecosystems. Ecosystem is a community of living organisms (plants and animals), non-living environment (including minerals, climate, soil, water, sunlight) and their interrelationships (A.G. Tansley, 1935). The presence of a large number of species in a particular ecosystem is called 'biological diversity' or in short ' biodiversity'. The term biodiversity was first introduced by Walter Rosen (1985), and defined by E.D. Wilson.

Difference between the Living and Non-living

- Living organisms show a variety of unique characters different from non-living matter. The key characters of living organisms are, cellular organization, nutrition, respiration, metabolism, growth, response to stimuli, movement, reproduction, excretion, adaptation and homeostasis. Numerous scientists and taxonomists have made tremendous contribution and documentation in the observation and

study of even minute characters in living organisms. Their keen observations have led to the classification of living organisms and the study of their interrelationships.

Need for classification

- We come across many places where things are arranged in specific categories. In super markets, the shelves can have rows and columns of groceries, cosmetics, toys, stationeries, snacks and utensils. If it is not arranged in a well organized manner, customers and sales persons will waste lot of time in finding an item. In the same way, libraries also organize the books alphabetically or genres-wise into autobiographies, novels, kids stories, science fictions, etc. Likewise it is nearly impossible to study all the living organism hence it becomes necessary to device some means and methods to make this possible and this process is called classification. Classification is a process by which things are grouped in convenient categories, based on easily observable characters. The scientific term used for these categories is taxa (taxon–singular). Taxa indicates categories at different levels, for example Kingdom Animalia, includes multicellular animals such as reptiles, mammals, etc. Based on their characteristics, all living organisms can be classified into different taxa. This science of classification is called taxonomy. External and internal structures along with developmental processes and ecological information of organisms are essential, as they form basis of the taxonomical studies. Hence, characterisation, identification, nomenclature and classification are the scientific stages that are basic to taxonomy.

The basic need for classifications are:

- To identify and differentiate closely related species
- To know the variation among the species
- To understand the evolution of the species
- To create a phylogenetic tree among the different groups
- To conveniently study living organisms

Taxonomy and Systematics

- Taxonomy (G. taxis- arrangement ; nomoslaw) is the science of arrangement of living organisms along with classification, description, identification, and naming of organisms which includes all flora and fauna including microorganisms of the world. The word taxonomy was coined by Augustin Pyramus de Candole (1813). Taxonomy is a theoretical study of classification with well defined principles, rules and procedures. Aristotle is called the father of taxonomy (classical) and Carolus Linnaeus is the father of modern taxonomy.

Systematics (G. System/sequence)

- The objectives of taxonomy and systematics are very similar; their goal is to classify organisms with stipulated rules. The main criteria of systematics is identifying, describing, naming, arranging, preserving and documenting the organisms. Apart from the above said features, evolutionary history of the species and the environmental adaptations and interrelationship between species are also being investigated in systematics.

Carolus Linnaeus is the father of modern taxonomy, which is the system of classifying and naming organisms. One of his contributions was the development of a hierarchical system of classification of nature. Today, this system includes eight taxa: domain, kingdom, phylum, class, order, family, genus, and species.

History of Classification

- Early classification of organisms were based on only two criteria, beneficial or harmful animals. An ancient classification system recognized 5 animal groups - domestic, wild, creeping, flying and sea animals. Initially the classification was based on organism's fundamental characteristics such as the habitat and morphology only.

- Aristotle (384 to 322 BC), was the first to classify all animals in his History of Animals (Historia Animalium in Latin). He attempted a basic classification of all living organisms into Plants and Animals.

Animals were classified based on locomotion; walking (terrestrial), flying (aerial) and swimming (aquatic). Based on the presence or absence of red blood he classified the animals into two as Enaima with blood and those without blood as Anaima.

- Aristotle's classification system had limitations and many organisms were not fitting into his classification. For example, the tadpoles of frogs are born in water and have gills but when they metamorphosed into adult frogs they have lungs and can live both in water and on land. How to classify frogs and where to place them? Aristotle classified organisms based on locomotion, hence, birds, bats, and flying insects were grouped together just by observing one single characteristic feature, the flying ability. On the contrary to the above said example, the ostrich, emu and penguin are all birds but cannot fly. So Aristotle would not have classified them as birds. In spite of these limitations Aristotle's classification system was followed for more than 2000 years upto 1700.

- After Aristotle, his student Theophrastus (372-287 BC) continued his research on the classification of plants, and he was known as the "Father of Botany." There was a huge gap till 16th century, then the English naturalist John Ray (1627–1705) wrote several important works through his life. His most important contribution was the establishment of species as the ultimate unit of taxonomy. In 1682 he published the Methodus Plantarum Nova, which contained about 18,000 plant species, a result of a relatively narrow species concept. His complicated classification was based on many combined characters, as opposed to earlier taxonomists. John Ray also aimed at publishing a complete system of nature, which included works on mammals, reptiles, birds, fishes and insects. The Swedish biologist Carolus Linnaeus (1707 - 1788) father of modern taxonomy and founder of modern systematics developed a scientific system of taxonomy and binomial nomenclature, which is still (with modifications) in use.

- Aristotle to Linnaeus employed easily observable single to few traits for classification of organisms. With increased knowledge of the several biological domains, many characters were considered for classifying organisms. This represented the phase of classical

taxonomy which was based on overall similarities or affinities derived from morphology, anatomy and embryology of organisms. A modification of this system is the numerical taxonomy, which evolved in the 1950s. This system evaluates the resemblances and differences through statistical methods followed by computer analyses to establish the numerical degree of relationship among individuals. Later on biologists initiated studies on the evolutionary and genetic relationships among organisms, which led to the emerge of phylogenetic classification or cladistics.

- It is an evolutionary classification based on how a common ancestry was shared. Cladistic classification summarizes the genetic differences between all species in the 'phylogenetic tree'. Ernst Haeckal introduced the method of representing evolutionary relationships with the help of a tree diagram known as cladogram.

- This system of classification takes into account ancestral characters (traits of basic body design which would be in the entire group) and derived characters (traits whose structure and functions differs from those of ancestral characters). One or more derived characters which appeared during evolution resulted in the formation of new subspecies. In a cladogram each evolutionary step produces a branching and all the members of the branch would possess the derived character which will not be seen in organisms below the particular branch point. Arranging organisms on the basis of their similar or derived characters which differ from the ancestral characters produced a phylogenetic tree or cladogram.

- Depending on the system of classification, organisms were classified into two or three kingdoms. Later into four, five, six and now into seven kingdoms. R.H.Whittaker (1969) proposed the Five kingdom Classification, the Kingdoms defined by him were Monera, Protista, Fungi, Plantae, and Animalia based on the cell structure, mode of nutrition, mode of reproduction and phylogenetic relationships gives a comparative account of different characteristics of the five kingdoms.

- Classification has come a long way and now takes into an account even molecular level DNA and RNA identification. The advancement

in molecular techniques and biochemical assays has led to a new classification - The "Three Domain" classification.

Three Domains of life

- Three domain classification was proposed by Carl Woese (1977) and his co- workers. They classified organisms based on the difference in 16S rRNA genes. The three domain system adds the taxon 'domain' higher than the kingdom. This system emphasizes the separation of Prokaryotes into two domains, Bacteria and Arachaea, and all the eukaryotes are placed into the domain Eukarya. Archaea appears to have more in common with the Eukarya than the Bacteria. Archaea differ from bacteria in cell wall composition and differs from bacteria and eukaryotes in membrane composition and rRNA types.

Thermus aquatics is a bacterium which can tolerate high temperatures. The first DNA polymerase enzyme was isolated from T. aquaticus it is used in PCR (Polymerase Chain Reaction) for DNA amplification

Domain Archaea

- This domain includes single celled organisms, the prokaryotes which have the ability to grow in extreme conditions like volcano vents, hot springs and polar ice caps, hence are also called extremophiles. They are capable of synthesizing their food without sunlight and oxygen by utilizing hydrogen sulphide and other chemicals from the volcanic vents. Some of the them produced methane (methanogens), few live in salty environments (Halophiles) and are thermoacidophiles which thrive in acidic environments and at high temperatures.

Domain Bacteria

- Bacteria are prokaryotic, their cells have no definite nucleus and DNA exists as a circular chromosomes and do not have histones associated with it. They do not possess membrane bound organelles except for ribosome (70S type). Their cell wall contains peptidoglycans. Many are decomposers, some are photo-synthesizers and few cause diseases. There are beneficial probiotic bacteria and

harmful pathogenic bacteria. which are diversely populated. Cyanobacteria are photosynthetic blue green algae which produce oxygen. These had played a key role in the changes of atmospheric oxygen levels from anaerobic to aerobic during the early geologic periods.

Curd is one of the best sources of probiotics, which are friendly bacteria that can improve our health. e.g. Lactobacillus sp.

Domain Eukarya (Eukaryotes)

- Eukaryotes are animals which have true nucleus and membrane bound organelles. DNA in the nucleus is arranged as a linear chromosome with histone proteins, ribsosomes of 80S type in the cytosol and 70S type in the chloroplast and mitochondria. Animals in this domain are classified under kingdoms, namely, Protista, Fungi, Plantae and Animalia.

- In 1987, Cavalier-Smith revised the six kingdom system to Seven Kingdom system. The concept of super kingdom was introduced and revised to seven kingdom classification. The classification is divided

Salient features	KINDS OF KINGDOM				
	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Non-cellular	Present in some	Present	Present	Absent
Body organisation	Cellular	Cellular	Multicelluar Tissue	Tissue Organ	Tissue Organ Organ system
Mode of nutrition	Autotrophic Heterotrophic	Autotrophic Heterotrophic	Heterotrophic	Autotrophic	Heterotrophic

Taxonomic hierarchy

- In biological classification, the taxonomical hierarchy includes seven major categories namely kingdom, phylum, class, order, family, genus and species and other intermediate categories such as subkingdom, grade, division, subdivision, subphylum, superclass, subclass, superorder, suborder, superfamily, subfamily and subspecies.

Species

- Species is the basic unit of classification in the taxonomic hierarchial system. It is a group of animals having similar morphological features (traits) and is reproductively isolated to produce fertile offspring. There are some exceptional animals which can produce sterile offspring because of mating with closely related species.

Crosses between
Male horse and Female Donkey results in Hinny (Sterile).
Male Donkey and Female Horse results in Mule (Sterile)
Male Lion and Female Tiger results in Liger
Male Tiger and Female Lion results in Tigon

Genus: It is a group of closely related species which have evolved from a common ancestor. In some genus there is only one species which is called as monotypic genus (e.g. Red panda is the only species in the genus Ailurus : Ailurus fulgens) . If there are more than one species in the genus it is known as polytypic genus, for example 'cats' come under the Genus Felis, which has a number of closely related species, Felis domestica (domestic cat), Felis margarita (jungle cat). Felis silvestris (wild cat).

Family: It is a taxonomic category which includes a group of related genera with less similarity as compared to genus and species. For example, the family Felidae includes the genus Felis (cats) and the genus Panthera (lions, tigers, leopards).

Order: This category includes an assemblage of one or more related families which show few common features. One or more similar families are grouped together to form an order. For example, family Canidae and Felidae are placed in the order Carnivora.

Class: This category includes one or more related orders with some common characters. For example order Primata comprising monkeys, apes and man is placed in the Class Mammalia, along with the order Carnivora which includes dogs and cats.

Recently Discovered species in South India

Scientists have discovered a new and unusual species of frog in the Western Ghats in India in August 2017. The frog has shiny, purple skin, a light blue ring around its eyes, and a pointy pig-nose. It is named as Bhupathy's purple frog (Nasikabatrachus bhupathi) to honour Dr.Subramaniam Bhupathy, herpetologist who lost his life in the Western Ghats in 2014.

Biological nomenclature derives from the binomial (or binominal) nomenclature that was originally codified in the works of Linnaeus, Species Plantarum (1753) and Systema Naturae, 10th Edition (1758). These publications are the starting points for the modern biological nomenclature in most groups of plants and animals

Phylum: The group of classes with similar distinctive characteristics constitute a phylum. The classes Pisces, Amphibia, Reptilia, Aves and Mammalia constitute the next higher category, phylum Chordata. These classes share some common features like presence of a notochord and a dorsal tubular nerve cord hence included in the phylum Chordata.

Kingdom: All living animals belonging to various phyla are included in the Kingdom Animalia and it is the top most of the taxonomic hierarchy.

In July, 2017, a 9 years old boy discovered a new Freshwater species of Jellyfish in the Kodaikanal lake, Tamilnadu.

Nomenclature

- In all probability these words must be new to you…but they all mean "Human" in different foreign languages! There are presently more than 6000 languages in the world and an animal can be named in more than 6000 ways! Unfortunately it is impossible for anyone to have a good functioning knowledge of most languages and hence there arises a need for a universally accepted scientific naming system for all organisms. The process of assigning scientific names to animals or taxonomic group is called nomenclature. For example, worldwide, the scientific name Homo sapiens denotes human. Classification and grouping were done to facilitate a deeper understanding of the unique characteristics of each organism and its interrelationship among closely related species. It plays a vital role in the arrangement of known species based on their similarities and dissimilarities. Numerous characters such as morphology, genetic information, habitat, feeding pattern, adaptations, evolution, etc., are examined before an organism is named.

- One of the primary responsibilities of systematic biology is the development of biological nomenclature and classification. Nomenclature is not an end to systematics and taxonomy but it is necessary in organizing information about biodiversity. Nomenclature, functions to provide names for all taxa at all levels in the hierarchy of life. Naming of the organisms is done based on the guidelines of the International Code of Zoological Nomenclature (ICZN). The scientific name ensures that each organism has only one name.

A newly discovered Himalayan forest thrush bird was named after the birdman of India, Ornithologist Dr. Salim Ali. The name of the bird is
"Zoothera salimalii". A fruit bat is also named after him "Latidens salimalii"

Binomial Nomenclature

(L. Bi-two; Nomen-Name)

- Biologists follow universally accepted principles to provide scientific names to known organisms. Each name has two components, a generic name and a specific epithet. This system of naming the organism is called Binomial Nomenclature which was popularized by Carolus Linnaeus and practised by biologists all over the world. Example, the National Bird (Indian Peafowl) – Pavo cristatus, the National Animal tiger as Panthera tigris, and the Tamil Nadu State bird is the common Emerald dove Chalcophaps indica.

Trinominal Nomenclature

(Tri – three)

- This naming system was proposed by Huxley and Stricklandt, Trinomen means, three names: generic name, species name and sub-species name. When members of any species which have large variations then trinomial system is used. On the basis of dissimilarities, this species gets classified into subspecies. It is the extension of binominal nomenclature system which has an addition of subspecies. All the three names are set in italics and only the generic name is capitalized, if handwritten then it should be underlined separately E.g.Corvus splendens splendens (Indian house crow)

Tautonymy: The practice of naming the animals in which the generic name and species name are the same, is called Tautonymy. e.g. Naja naja (The Indian Cobra).

Rules of Nomenclature

The scientific name should be italicized in printed form and if handwritten, it should be underlined separately.

- The generic name's (Genus) first alphabet should be in uppercase.

- The specific name (species) should be in lowercase.
- The scientific names of any two organisms are not similar.
- The name or abbreviated name of the scientist who first publishes the scientific name may be written after the species name along with the year of publication. For example Lion-Felis leo Linn., 1758 or Felis leo L., 1758.
- If the species name is framed after any person's name the name of the species shall end with i, ii or ae.

- For example, a new species of a grounddwelling lizard (Cyrtodactylus) has been discovered and named after Scientist Varad Giri, Cyrtodactylus varadgirii.

Concept of species

- Species is the basic unit of classification. The term species was coined by John Ray, and in his book "Historia Generalis Plantarum" (3 volumes) in 1693 described species as a group of morphologically similar organisms arising from a common ancestor. Carolus Linnaeus in his book "Systema naturae" considered species as the basic unit of classification. Species can be defined as a group of organisms that have similar morphology and physiology and can interbreed to produce fertile offsprings. In 1859 Charles Darwin in his book Origin of species explains the evolutionary connection of species by the process of natural selection.

Tools for study of taxonomy

- Tools and taxonomical aids may be different for the study of plants and animals. Herbarium and Botanical garden may be used as tools for the study of plant taxonomy. In the case of animal studies, the classical tools are Museum, Taxonomical Keys and Zoological and Marine parks.

Arignar Anna Zoological Park, also known as the Vandalur Zoo is in the south western part of Chennai, Tamil Nadu, spreads over an area of 1500 acres, is one of the largest zoological parks in India. The zoo houses 2,553 species of both flora and fauna.

- The important components of the taxonomical tools are field visits, survey, identification, classification, preservation and documentation. Many tools are being used for taxonomical studies, amongst them some of the important tools are discussed below:

The classical taxonomical tools

Taxonomical Keys: Keys are based on comparative analysis of the similarities and dissimilarities of organisms. There are separate keys for different taxonomic categories.

Museum: Biological museums have collection of preserved plants and animals for study and ready reference. Specimens of both extinct and living organisms can be studied.

Zoological parks: These are places where wild animals are kept in protected environments under human care. It enables us to study their food habits and behaviour.

Marine parks: Marine organisms are maintained in protected enviroments.
Printed taxonomical tools consist of identification cards, description, field guides and manuals.

Molecular taxonomical tools

- Technological advancement has helped to evolve molecular taxonomical tools from classical tools to molecular tools. The accuracy and authenticity is more significant in the molecular tools. The following methods are being used for taxonomical classification.

- Molecular techniques and approaches such as DNA barcoding (short genetic marker in an organism's DNA to identify it as belonging to a particular species), DNA hybridization (measures the degree of genetic similarity between pools of DNA sequences), DNA fingerprinting (to identify an individual from a sample of DNA by looking at unique patterns in their DNA), Restriction Fragment Length Polymorphisms (RFLP) analysis (difference in homologous DNA sequences that can be detected by the presence of fragments of

different lengths after digestion of the DNA samples), and Polymerase Chain Reaction (PCR) sequencing (to amplify a specific gene, or portion of gene,) are used as taxonomical tools.

Automated species identification tools

It consists of Cyber tools. For example: DAISY, ALIS, ABIS, SPIDA, Draw wing, etc.

ALIS - Automated Leafhopper Identification System.
DAISY - Digital Automated Identification System.
ABIS - Automatic Bee Identification System.
SPIDA - Species Identified Automatically (spiders, wasp and bee wing characters).

Draw wing - Honey bee wing identification

Neo taxonomical tools – This is based on Electron Microscopy images to study the molecular structures of cell organelles.

Ethology of taxonomical tools – Based on the behaviour of the organisms it can be classified. For example sound of birds, bioluminescence, etc.

e-Taxonomic resources – INOTAXA is an electronic resource for digital images and description about the species which was developed by Natural History Museum, London. INOTAXA means Integrated.
Open taxonomic access.

11th Zoology

Chapter 2 - Kingdom Animalia

Basis of classification

- Multicellular organisms are structurally and functionally different but yet they possess certain common fundamental features such as the arrangement of cell layers, the levels of organisation, nature of coelom, the presence or absence of segmentation, notochord and the organisation of the organ system.

Levels of organisation

- All members of Kingdom Animalia are metazoans (multicellular animals) and exhibit different patterns of cellular organisation. Th e cells of the metazoans are not capable of independent existence and exhibit division of labour. Among the metazoans, cells may be functionally isolated or similar kinds of cells may be grouped together to form tissues, organ and organ systems.

Cellular level of organisation

- This basic level of organisation is seen in sponges. The cells in the sponges are arranged as loose aggregates and do not form tissues, i.e. they exhibit cellular level of organisation. Th ere is division of labour among the cells and different types of cells are functionally isolated. In sponges, the outer layer is formed of pinacocytes (platelike cells that maintain the size and structure of the sponge) and the inner layer is formed of choanocytes. These are flagellated collar cells that create and maintain water flow through the sponge thus facilitating respiratory and digestive functions.

Tissue level of organisation

- In some animals, cells that perform similar functions are aggregated to form tissues. The cells of a tissue integrate in a highly coordinated fashion to perform a common function, due to the presence of nerve

cells and sensory cells. Th is tissue level of organisation is exhibited in diploblastic animals like cnidarians. Th e formation of tissues is the first step towards evolution of body plan in animals. (Hydra - Coelenterata).

Organ level of organisation

- Different kinds of tissues aggregate to form an organ to perform a specific function. Organ level of organisation is a further advancement over the tissue level of organisation and appears for the first time in the Phylum Platyhelminthes and seen in other higher phyla.

Organ system level of organisation

- The most efficient and highest level of organisation among the animals is exhibited by flatworms, nematodes, annelids, arthropods, molluscs, echinoderms and chordates. The evolution of mesoderm in these animals has led to their structural complexity. The tissues are organised to form organs and organ systems. Each system is associated with a specific function and show organ system level of organisation. Highly specialized nerve and sensory cells coordinate and integrate the functions of the organ systems, which can be very primitive and simple or complex depending on the individual animal. For example, the digestive system of Platyhelminthes has only a single opening to the exterior which serves as both mouth and anus, and hence called an incomplete digestive system. From Aschelminthes to Chordates, all animals have a complete digestive system with two openings, the mouth and the anus.

- Similarly, the circulatory system is of two types, the open type: in whichthe blood remains filled in tissue spaces due to the absence of blood capillaries.(arthropods, molluscs, echinoderms, and urochordates) and the closed type:in which the blood is circulated through blood vessels of varying diameters(arteries, veins, and capillaries) as in annelids, cephalochordates and vertebrates.

Diploblastic and Triploblastic organisation

- During embryonic development, the tissues and organs of animals originate from two or three embryonic germ layers. On the basis of the origin and development, animals are classified into two categories: Diploblastic and Triploblastic.

- Animals in which the cells are arranged in two embryonic layers, the external ectoderm, and internal endoderm are called diploblastic animals. In these animals the ectoderm gives rise to the epidermis (the outer layer of the body wall) and endoderm gives rise to gas trodermis (tissue lining the gut cavity). An undifferentiated layer present between the ectoderm and endoderm is the mesoglea. (Corals, Jellyfish, Sea anemone)

- Animals in which the developing embryo has three germinal layers are called triploblastic animals and consists of outer ectoderm (skin, hair, neuron, nail, teeth, etc), inner endoderm (gut, lung, liver) and middle mesoderm (muscle, bone, heart). Most of the triploblastic animals show organ system level of organisation (Flat worms to Chordates).

Patterns of symmetry

- Symmetry is the body arrangement in which parts that lie on opposite side of an axis are identical. An animal's body plan results from the animal's pattern of development. The simplest body plan is seen in sponges. They do not display symmetry and are asymmetryical. Such animals lack a definite body plan or are irregular shaped and any plane passing through the centre of the body does not divide them into two equal halves (Sponges). An asymmetrical body plan is also seen in adult gastropods (snails).

- Symmetrical animals have paired body parts that are arranged on either side of a plane passing through the central axis. When any plane passing through the central axis of the body divides an organism into two identical parts, it is called radial symmetry. Such radially symmetrical animals have a top and bottom side but no

dorsal (back) and ventral (abdomen) side, no right and left side. They have a body plan in which the body parts are organised in a circle around an axis. It is the principal symmetry in diploblastic animals. Cnidarians such as sea anemone and corals are radially symmetrical. However, triploblastic animals like echinoderms (e.g., starfish) have five planes of symmetry and show Pentamerous radial symmetry.

- Animals which possess two pairs of symmetrical sides are said to be biradially symmetrical. Biradial symmetry is a combination of radial and bilateral symmetry as seen in ctenophores. There are only two planes of symmetry, one through the longitudinal and sagittal axis and the other through the longitudinal and transverse axis. (e.g., Comb jellyfish – Pleurobrachia)

- Animals which have two similar halves on either side of the central plane. show bilateral symmetry. It is an advantageous type of symmetry in triploblastic animals, which helps in seeking food, locating mates and escaping from predators more efficiently. Animals that have dorsal and ventral sides, anterior and posterior ends, right and left sides are bilaterally symmetrical and exhibit cephalisation, in which the sensory and brain structures are concentrated at the anterior end of the animal.

Coelom

- The presence of body cavity or coelom is important in classifying animals. Most animals possess a body cavity between the body wall and the alimentary canal, and is lined with mesoderm.

- Animals which do not possess a body cavity are called acoelomates. Since there is no body cavity in these animals their body is solid without a perivisceral cavity, this restricts the free movement of internal organs. (e.g., Flatworms).

- In some animals, the body cavity is not fully lined by the mesodermal epithelium, but the mesoderm is formed as scattered pouches between the ectoderm and endoderm. Such a body cavity is called a pseudocoel and is filled with pseudocoelomic fluid. Animals that possess a pseudocoel are called pseudocoelomates e.g., Round

worms. The pseudocoelomic fluid in the pseudocoelom acts as a hydrostatic skeleton and allows free movement of the visceral organs and for circulation of nutrients.

- Eucoelom or true coelom is a fluidfilled cavity that develops within the mesoderm and is lined by mesodermal epithelium called peritoneum. Such animals with a true body cavity are called coelomates or eucoelomates. Based on the mode of formation of coelom, the eucoelomates are classified into two types, Schizocoelomates – in these animals the body cavity is formed by splitting of mesoderm. (e.g., annelids, arthropods, molluscs). In Enterocoelomate animals the body cavity is formed from the mesodermal pouches of archenteron. (e.g., Echinoderms, hemichordates and chordates).

Segmentation and Notochord

- In some animals, the body is externally and internally divided into a series of repeated units called segments with a serial repetition of some organs (Metamerism). The simplest form of segmentation is found in Annelids in which each unit of the body is very similar to the next one. But in arthropods (cockroach), the segments may look different and has different functions.

- Animals which possess notochord at any stage of their development are called chordates. Notochord is a mesodermally derived rod like structure formed on the dorsal side during embryonic development in some animals. Based on the presence Or absence of notochord, animals are classified as chordates (Cephalochordats, Urochordates, pisces to Mammalia) and nonchordates (Porifera to Hemichordata).

Classification of Kingdom Animalia

Animal Kingdom is divided into two sub kingdoms, the parazoa and Eumetazoa based on their organisation.

- **Parazoa:** These include the multicellular sponges and their cells are loosely aggregated and do not form tissues or organs

- **Eumetazoa:** These include multicellular animals with well defined tissues, which are organised as organs and organ systems. Eumetazoans includes two taxonomic levels called grades. They include Radiata and Bilateria.

Division: 1. Protostomia (Proto: first; stomium: mouth)

- Protostomia includes the eumetazoans in which the embryonic blastopore develops into mouth. This division includes three subdivisions namely acoelomata, pseudocoelomata and schizocoelomata.

Division: 2. Deuterostomia (deuteron: secondary; stomium: mouth)

- Eumetazoans in which anus is formed from or near the blastopore and the mouth is formed away from the blastopore. It includes only one subdivision Enterocoelomata. They have a true coelom called enterocoel, formed from the archenteron.

Non Chordates (Invertebrata)

Phylum: Porifera

(L. poros-pore; ferre-to bear)

- These pore bearing animals are commonly called sponges. They are aquatic, mostly marine, asymmetrical and a few species live in freshwaters. They are primitive, multicellular, sessile animals with cellular level of organisation in which the cells are loosely arranged. They are either radially symmetrical or asymmetrical animals.

- They possess a water transport system or canal system where water enters through minute pores called ostia lining the body wall through which the water enters into a central cavity (spongocoel) and goes out through the osculum. This water transport system is helpful in food gathering, circulation, respiration and removal of waste. Choanocytes or collar cells are special flagellated cells lining the spongocoel and the canals. The body is supported by a skeleton made up of calcareous and siliceous spicules or spongin or both. Nutrition

isholozoic and intracellular. All sponges are hermaphrodites (i.e.) the ova and sperms are produced by the same individual. They also reproduce asexually by fragmentation or gemmule formation and sexually by the formation of gametes. Development is indirect with different types of larval stages such as parenchymula and amphiblastula. Examples: Sycon (Scypha), Spongilla (freshwater sponge), Euspongia (bath sponge)Euplectella (Venus flower basket)

The underwater sea bed is the new habitat where the discovery and development of Marine Pharmaceuticals are in peak. Anticancerous, Antimalarial drugs and other bioactive molecules have been isolated and tested successfully.

Phylum: Cnidaria

(G. knode -needle or sting cells)

- Cnidarians (were previously called Coelenterata), are aquatic, sessile or free swimming, solitary or colonial forms with radial symmetry except for sea anemones (bilateral symmetry). The name Cnidaria is derived from cnidocytes or cnidoblasts with stinging cells or nematocyst on tentacles. Cnidoblasts are used for anchorage, defense, and to capture the prey. Cnidarians are the first group of animals to exhibit tissue level organisation and are diploblastic. They have a central vascular cavity or coelenteron (serves both digestion and circulatory function) with a single opening called mouth or hypostome, which serves the process of ingestion and egestion. Digestion is both extracellular and intracellular. The nervous system is primitive and is formed of diffused nerve net. Cnidarians like corals have a skeleton made up of calcium carbonate. Cnidarians exhibit two basic body forms, polyp and medusa. The polyp forms are sessile and cylindrical (e.g. Hydra, Adamsia)

- Whereas the medusa are umbrella shaped and free swimming. Cnidarians which exist in both forms, also exhibit alternation of generations in their life cycle (Metagenesis). The polyp represents the asexual generation and medusa represents the sexual generation. Polyps produce medusa asexually and medusa forms polyps

sexually. Development is indirect and includes a free swimming ciliated planula larva.

Examples: Physalia (Portugese man of war), Adamsia (sea anemone), Pennatula (sea pen), Meandrina (brain coral)

Phylum: Ctenophora

(G. Ktenos -comb; phoros -bearing)

- Ctenophora are exclusively marine, radially symmetrical, diploblastic animals with tissue level of organisation. Though they are diploblastic, their mesoglea is different from that of cnidaria. It contains amoebocytes and smooth muscle cells. They have eight external rows of ciliated comb plates (comb jellies) which help in locomotion, hence commonly called comb jellies or sea walnuts. Bioluminescence (the ability of a living organism to emit light) is well marked in ctenophores. They lack nematocysts but possess special cells called lasso cells or colloblasts which help in food capture. Digestion is both extracellular and intracellular. Sexes are not separate (monoecious). They reproduce only by sexual means. Fertilization is external and development is indirect and includes a larval stage called cydippid larva. e.g., Pleurobrachia

Examples : Pleurobrachia and Ctenoplana.

Phylum: Platyhelminthes

(Flatworms)

- (G. Platy -broad or flat; helmin-worm) They have a dorsoventrally flattened body and hence called flatworms. These animals are bilaterally symmetrical, triploblastic, acoelomate with organ system level of organisation. They show moderate cephalization and unidirectional movement. They are, mostly endoparasites of animals including human beings. Hooks and suckers are present in the parasitic forms and serve as organs of attachment. Their body is not segmented, but some exhibit pseudo segmentation. Some of the parasitic flatworms absorb nutrients directly from the host through their body surface. However, flatworms like liver fluke have an incomplete digestive system. Specialized excretory cells called flame

cells help in osmoregulation and excretion. Sexes are not separate (monoecious); fertilisation is internal and development is through larval stages (miracidium, sporocyst, redia, cercaria). Polyembryony is common in some flatworms (Liver flukes). Some members like Planaria show high regeneration capacity.

Examples: Taenia solium (tape worm), Fasciola hepatica (liver fluke), Schistosoma (blood fluke).

Phylum: Aschelminthes

(Round Worms)

- (G. Askes –cavity; helminths – worms) Previously called Nematoda, this phylum is now named as Aschelminthes. The body of these worms is circular (round) in cross section and hence are called round worms. They are free living or parasitic on aquatic and terrestrial plants and animals. They are bilaterally symmetrical, triploblastic and pseudocoelomate animals with organ system level of organisation. The body is unsegmented and covered by a transparent, tough and protective collagenous layer called cuticle. The alimentary canal is complete with a well developed mouth, muscular pharynx and anus. Excretory system consists of rennet glands. Sexes are separate; and exhibit sexual dimorphism; often females are longer than males. Fertilisation is internal; majority are oviparous (e.g. Ascaris) few are ovoviviparous (Wuchereria). Development may be direct or indirect.

Examples. Ascaris lumbricoides (round worm), Enterobius vermicularis (Pin worm), Wuchereria bancrofti (filarial worm), Ancylostomaa deuodenale (hook worm)

Phylum: Annelida

(Segmented worm)

(L. annulus -a ring, and G. edios- form)

- Annelids were the first segmented animals to evolve. They are aquatic or terrestrial, free living but some are parasitic. They are

triploblastic, bilaterally symmetrical, schizocoelomates and exhibit organ system level of body organisation. The coelom with coelomic fluid creates a hydrostatic skeleton and aids in locomotion. Their elongated body is metamerically segmented and the body surface is divided into segment or metameres. Internally the segments are divided from one another by partitions called septa. This phenomenon is known as metamerism. The longitudinal and circular muscles in the body wall help in locomotion. Aquatic annelids like Nereis have lateral appendages called parapodia, which help in swimming. Chitinous setae in Earthworms, and suckers in Leech help in locomotion. The circulatory system is of closed type and the respiratory pigments are hemoglobin and chlorocruorin. Nervous system consists of paired ganglion connected by the lateral nerves to the double ventral nerve cord. They reproduce sexually. Development is direct or indirect and includes a trochophore larva. Some are monoecious (earthworms) while some are dioecious (Neries and Leech).

Examples: Lampito mauritii (earthworm), Neries (sand worm), Hirudinaria (leech).

Filariasis has been a major public health problem in India next only to malaria. The disease was recorded in India as early as 6th century B.C. by the famous Indian physician, Susruta in his book Susruta Samhita. In 7 th century A.D., Madhavakara described signs and symptoms of the disese in his treatise ' Madhava Nidhana' which holds good even today. In 1709, Clarke identified elephantoid legs in Cochin. The microfilariae in the peripheral blood was first identified by Lewis in 1872 in Calcutta (Kolkata).

Phylum: Arthropoda

(G. arthros- jointed; podes- feet)

- This is the largest phylum of the Kingdom Animalia and includes the largest class called Insecta (total species ranges from 2-10 million). They are bilaterally symmetrical, segmented, triploblastic and schizocoelomate animals with organ system grade of body organisation. They have jointed appendages which are used for locomotion, feeding and are sensory in function. Body is covered by

chitinous exoskeleton for protection and to prevent water loss, It is shed off periodically by a process called moulting or ecdysis. The body consists of a head, thorax, and abdomen with a body cavity called haemocoel. Respiratory organs are gills, book gills, book lungs or trachea. Circulatory system is of open type. Sensory organs like antennae, eyes (compound and simple), statocysts (organs of balance/ equilibrium) are present. Excretion takes place through malpighian tubules, green glands, coxal glands, etc. They are mostly dioecious and oviparous; fertilization is usually internal. Development may be direct or indirect. Life history includes many larval stages followed by metamorphosis.

Examples : Limulus (King crab, a living fossil), Palamnaeus (Scorpion), Eupagarus (Hermit crab), Apis (Honey bee), Musca (House fly), Vectors- Anopheles, Culex, Aedes (mosquitoes), Economically important insects - Apis- (Honey bee), Bombyx (Silk worm), Laccifer (Lac insects), Living fossils Limulus- (King crab), Gregarious pest - Locusta (Locust).

Phylum: Mollusca

(L. molluscs –soft bodied)

- This is the second largest animal phylum. Molluscs are terrestrial or aquatic (marine or fresh water) and exhibit organ system level of body organisation. They are bilaterally symmetrical (except univalves), triploblastic and coelomate animals. Body is covered by a calcareous shell and is unsegmented with a distinct head, muscular foot and a visceral hump or visceral mass. A soft layer of skin forms a mantle over the visceral hump. The space between the visceral mass and mantle (pallium) is called the mantle cavity in which a number of feather like gills (ctenidia) are present, which are respiratory in function. The digestive system is complete and mouth contains a rasping organ called radula with transverse rows of chitinous teeth for feeding (radula is absent in bivalves. The sense organs are tentacles, eyes and ospharidium (to test the purity of water and present in bivalves and gastropods). Excretory organs are nephridia. Open type of circulatory system is seen except for cephalopods such as squids, cuttle fishes and octopuses. Blood contains haemocyanin, a copper containing respiratory pigment. They are dioecious and

oviparous. Development is indirect with a veliger larva (a modified trochophore larva)

Examples: Pila (Apple snail), Lamellidens (Mussel), Pinctada (Pearl oyster), Sepia (Cuttle fish), Loligo (Squid), Octopus (Devil fish).

Spider silk is five times stronger than steel of the same diameter. It has been suggested that a Boeing 747 could be stopped in flight by a single pencilwidth strand and spider silk is almost as strong as Kevlar, the toughest man-made polymer.

Marbled Cone Snail
(Conus marmoreus)

This cone-shaped snail can deliver dangerous venom which may result in vision loss, respiratory failure, muscle paralysis and eventually death. There is no anti-venom available.

Phylum Echinodermata

(G. Echinos – spiny; dermos –skin)

- All Echinoderms are marine animals. The adults are radially symmetrical but the larvae are bilaterally symmetrical. These animals have a mesodermal endoskeleton of calcareous ossicles and hence the name Echinodermata (spiny skin). They are exclusively marine with organ system level of organisation. The most distinctive feature of echinoderms is the presence of the water vascular system or ambulacral system with tube feet or podia, which helps in locomotion, capture and transport of food and respiration. The digestive system is complete with mouth on ventral side and anus on the dorsal side. Excretory organs are absent. The nervous system and sensory organs are poorly developed. The circulatory system is open type without heart and blood vessels. Sexes are separate. Reproduction is sexual and fertilization is external. Development is indirect with free swimming bilaterally symmetrical larval forms. Some echinoderms exhibit autotomy with remarkable powers of regeneration.

Examples: Asterias (Starfish or sea star), Echinus (Sea-urchin), Antedon (Sea-lily), Cucumaria (Sea-cucumber), Ophiura (Brittle star)

Phylum: Hemichordata

(G.hemi –half; chorde-string)

- Hemichordates were earlier treated as a subphylum of Chordata (or Prochordata). They are now regarded to be an independent phylum of invertebrates, close to Echinodermata. The animals of this group possess the characters of invertebrates as well as chordates.

- This phylum consists of a small group of worm-like, soft marine animals, mostly tubiculous and commonly called the 'acorn worms' or 'tongue worms'. They are bilaterally symmetrical, triploblastic and coelomate animals with organ system level of organisation. Their body is cylindrical and is divided into three regions, the anterior proboscis, a short collar and a long trunk. Most hemichordates are ciliary feeders. Their circulatory system is simple and open or lacune type with a dorsal heart. Respiration is through paired gill slits opening into the pharynx. Excretion is by a single proboscis gland or glomerulus situated in the proboscis. Nervous system is primitive. Sexes are separate and exhibit sexual mode of reproduction; Fertilization is external. Development is indirect with a free swimming tornaria larva.

Examples: Balanoglossus, Saccoglossus, Ptychodera flava (Indian Hemichordate found in Kurusadai islands in Tamilnadu)

Phylum: Chordata

(G. Chorda –string)

- Chordata is the largest phylum with most familiar group of animals, such as fishes, amphibians, reptiles, birds and mammals and less known forms such as lancelets (Amphioxus) and tunicates (Ascidian). All chordates possess three fundamental distinct features at some stage of their life cycle, they are:

- Presence of elongated rod like notochord below the nerve cord and above the alimentary canal. It serves as a primitive internal skeleton. It may persist throughout life in lancelets and lampreys. In adult vertebrates, it may be partially or completely replaced by backbone or vertebral column.

- A dorsal hollow or tubular fluid filled nerve cord lies above the notochord and below the dorsal body wall. It serves to integrate and co-ordinate the body functions. In higher chordates, the anterior end of the nerve cord gets enlarged to form the brain and the posterior part becomes the spinal cord, protected inside the vertebral column.

- Presence of pharyngeal gill slits or clefts in all chordates at some stage of their lifecycle. It is a series of gill slits or clefts that perforates the walls of pharynx and appears during the development of every chordate. In aquatic forms, pharyngeal gill slits are vascular, lamellar and form the gills for respiration. In terrestrial chordates, traces of non-functional gill clefts appear during embryonic developmental stages and disappear later. Besides the above said features, chordates are bilaterally symmetrical, triploblastic, coelomates with organ system level of organisation; they possess post anal tail, closed circulatory system with a ventral myogenic heart except in Amphioxus.

Subphylum: Urochordata or Tunicata

(G. Oura – A tail; L. Chord – cord)

- They are exclusively marine and are commonly called sea squirts. Mostly sessile, some pelagic or free swimming, exist as solitary and colonial forms. Body is unsegmented and covered by a test or tunic. Adult forms are sac like. Coelom is absent, but has an atrial cavity surrounding the pharynx. Notochord is present only in the tail region of the larval stage, hence named urochordata. Alimentary canal is complete and circulatory system is of open type. The heart is ventral and tubular. Respiration is through gill slits and clefts. Dorsal tubular nerve cord is present only in the larval stage and a single dorsal ganglion is present in the adults. Mostly hermaphrodites,

development indirect and includes a free swimming tadpole larva with chordate characters. Retrogressive metamorphosis is seen.

Examples: Ascidia, Salpa, Doliolum

Chordates	**Non-chordates**
Notochord is present	Absence of notochord
Dorsal, hollow and single nerve cord	Double ventral solid nerve cord
Pharynx perforated by gill slits	Gill slits absent
Heart is ventrally placed	Heart is dorsal or laterally placed or absent
A post anal tail is present	Post anal tail is absent
Alimentary canal placed ventral to the nerve cord	Alimentary canal is placed dorsal to the nerve cord

Subphylum: Cephalochordata

(L. Cephalo- 'head' ; G. chorda 'cord'.)

- Cephalochordates are marine forms, found in shallow waters, leading a burrowing mode of life. They are small fish like coelomate forms with chordate characters such us notochord, dorsal tubular nerve cord and pharyngeal gill slits throughout their life. Closed type of circulatory system is seen without heart. Excretion is by protonephridia. Sexes are separate, Fertilization is external. Development is indirect and includes a free swimming larva.

Example: Branchiostoma (Amphioxus or lancelet)

Subphylum-Vertebrata

(L. Vertebrus –back bone)

- Vertebrates are also called higher chordates and they possess notochord during embryonic stage only. The notochord is replaced by a cartilaginous or bony vertebral column in the adult. Hence all vertebrates are chordates but all chordates are not vertebrates. Vertebrates possess paired appendages such as fins or limbs. Skin is covered by protective skeleton comprising of scales, feathers, hairs,

claws, nails, etc. Respiration is aerobic through gills, skin, buccopharyngeal cavity and lungs. Vertebrates have a ventral muscular heart with two, three or four chambers and kidneys for excretion and osmoregulation.

- Subphylum Vertebrata is divided into two divisions, Agnatha and Gnathostomata. Agnatha includes jawless fish-like aquatic vertebrates without paired appendages. Notochord persists in the adult. Gnathostomata includes jawed vertebrates with paired appendages. Notochord is replaced partly or wholly by the vertebral column. Agnatha includes one important class – Cyclostomata. Gnathostomata includes jawed fishes (Pisces) and Tetrapoda (amphibia, reptilia, aves and mammals). The superclass Pisces includes all fishes which are essentially aquatic forms with paired fins for swimming and gills for respiration. Pisces includes cartilaginous fishes (Chondrichthyes) and bony fishes (Osteicthyes).

Class: Cyclostomata

(G.cyklos–circle; stomata -mouth)

- All members of cyclostomata are primitive, poikilothermic, jawless aquatic vertebrates and are ectoparasites on some fishes. Body is slender and eel-like bearing six to fifteen pair of gill slits for respiration. Mouth is circular without jaws and suctorial. Heart is two chambered and circulation is of closed type. No paired appendages. Cranium and vertebral column are cartilaginous. Cyclostomes are marine but migrate to fresh waters for spawning (anadromous migration). After spawning within a few days they die. The larvae (ammocoete) after metamorphosis returns to the ocean. Examples: Petromyzon (Lamprey) and Myxine (Hag fish).

Class: Chondrichthyes

(G. chondros –cartilage; ichthys -fish)

- They are marine fishes with cartilaginous endoskeleton. Notochord is persistent throughout life. Skin is tough covered by dermal placoid

scales and the caudal fin is heterocercal (asymmetrical both externally and internally). Mouth is located ventrally and teeth are modified placoid scales which are backwardly directed. Their jaws are very powerful and are predaceous animals. Respiration by lamelliform gills without operculum (gill cover). Excretory organs are mesonephric kidneys. Two chambered heart is present. Cartilaginous fishes are ureotelic and store urea in their blood to maintain osmotic concentration of body fluids. They are poikilothermic and viviparous. Sexes are separate. In males pelvic fins bear claspers to aid in internal fertilisation.

Examples: Scoliodon (Shark), Trygon (Sting ray), Pristis (Saw fish)

Class: Osteichthyes

(G. osteon –bone; ichthys -fish)

- It includes both marine and freshwater fishes with bony endoskeleton and spindle shaped body. Skin is covered by ganoid, cycloid or ctenoid scales. Respiration is by four pairs of fi lamentous gills and is covered by an operculum on either side. Air bladder is present with or without a connection to the gut. It helps in gaseous exchange (lung fishes) and for maintaining buoyancy in most of the ray finned fishes. They have a ventrally placed two chambered heart. Excretory organs are mesonephric kidneys and are ammonotelic. Presence of well developed lateral line sense organ. Sexes are separate, external fertilization is seen and most forms are oviparous.

Examples: Exocoetus (Flying fish), Hippocampus (Sea horse), Labeo (Rohu), Catla (Catla), Echeneis (Sucker fish), Pterophyllum (Angel fish)

Class: Amphibia

(G. amphi-both; bios -life)

- Amphibians are the first vertebrates and tetrapods to live both in aquatic as well as terrestrial habitats. They are poikilothermic. Their body is divisible into the head and trunk and most of them have two pairs of limbs; tail may or may not be present. Their skin is smooth or

rough, moist, pigmented and glandular. Eyes have eyelids and the tympanum represents the ear. Respiration is by gills, lungs and through the skin. Heart is three chambered. Kidneys are mesonephric. Sexes are separate and fertilization is external. They are oviparous and development is indirect. They show hibernation and aestivation.

Examples: Bufo (Toad), Rana (Frog), Hyla (Tree frog), Salamandra (Salamander), lcthyophis (Limbless amphibians).

Class: Reptilia

(L. repere or reptum – to creep or crawl)

- They are mostly terrestrial animals and their body is covered by dry, and cornified skin with epidermal scales or scutes. Reptiles have three chambered heart but four chambered in crocodiles. All are cold blooded amniotes (poikilotherms). Most reptiles lay cleidoic eggs with extraembryonic membranes like amnion, allantois, chorion and yolk sac. Excretion by metanephric kidneys and are uricotelic. They are monoecious. Internal fertilization takes place and all are oviparous.

Examples : Chelone (Turtle), Testudo (tortoise), Hemidactylus (House lizard), Chameleon (Tree lizard), Calotes (Garden lizard), Draco (Flying lizard), Crocodilus (crocodile), Poisonous snakes – Naja (Cobra), Bangarus (Krait), Vipera (Viper)

Class Aves

(L. Avis –bird)

- Aves are commonly known as birds. The characteristic feature of Aves is the presence of feathers and the ability to fly except for flightless birds (Eg. Ostrich, Kiwi, Penguin). The forelimbs are modified into wings, and the hind limbs are adapted for walking, running, swimming and perching. The skin is dry and devoid of glands except the oil gland or preen gland at the base of the tail. The exoskeleton consists of epidermal feathers, scales, claws on legs and

the horny covering on the beak. The endoskeleton is fully ossified (bony) and the long bones are hollow with air cavities (pneumatic bones). The pectoral muscles of flight (pectoralis major and pectoralis minor) are well developed. Respiration is by compact, elastic, spongy lungs that are continuous with air sacs to supplement respiration. The heart is four chambered. Aves are homeothermic. Migration and parental care is well marked. Urinary bladder is absent. Sexes are separate with well marked sexual dimorphism. In males, the testes are paired but in females, only the left ovary is well developed while the right ovary is atrophied. All birds are oviparous. Eggs are megalecithal and cleidoic. Fertilization is internal.

Examples Corvus (Crow), Columba (Pigeon), Psittacula (Parrot), Pavo (Peacock), Aptenodytes (Penguin), Neophron (Vulture), Chalcophaps indica (Tamilnadu state bird, Common Emerald Dove)

Hooded Pitohui
(Pitohui dichrous)
The Hooded Pitohui is a songbird found in the rain forests of New Guinea,
The first poisonous bird to be documented A neurotoxin called Homobatrachotoxin is found in its skin and feathers, causes numbness and tingling in those touching the bird.

Class: Mammalia

(L. Mamma – Breast)

- They are found in a variety of habitats. Their body is covered by hair, a unique feature of mammals. Some of them are adapted to fly or live in water. Presence of mammary glands is the most unique feature of mammals. They have two pairs of limbs adapted for walking, running, climbing, burrowing, swimming and flying. Their skin is glandular in nature, consisting of sweat glands, scent glands and sebaceous glands. Exoskeleton includes horny epidermal horns, spines, scales, claws, nails, hooves and bony dermal plates. Teeth are thecodont, heterodont and diphyodont. External ears or pinnae are present. The heart is four chambered and possess a left systematic arch. Mature RBCs are circular, biconcave and non nucleated.

Mammals have a large brain when compared to other animals They show greatest intelligence among all animals. Their kidneys are metanephric and are ureotelic. All are homeothermic, sexes are separate and fertilization is internal.

- **Examples Oviparous-** Ornithorhynchus (Platypus), Viviparous- Macropus (Kangaroo), Pteropus (Flying fox), Macaca (Monkey), Canis (Dog), Felis (Cat), Elephas (Elephant), Equus (Horse), Delphinus (Common dolphin) Balaenoptera (Blue whale), Panthera tigris (Tiger), Panther leo (Lion), Homo sapiens (Human) Bos (Cattle).