



UPSC - IAS

Civil Services Examinations

Union Public Service Commission

General Studies

Paper 3 – Volume 3

Science and Tech



UPSC CSE - IAS

Science and Tech

Paper – 3 Volume 3

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1 CHAPTER

Biology



| Year | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Pre | Mains | - | - | - | - | 1 | - | - | - | 4 | - | 2 |

Organisms

- A living thing with an **organized structure** that can:
 - React to **stimuli**
 - **Reproduce**
 - **Grow**

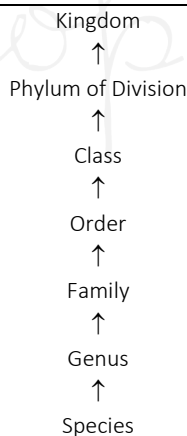


- **Adapt**
- **Maintain homeostasis.**
- **Classified by taxonomy into groups:**
 - Multicellular animals, plants, and fungi or unicellular microorganisms
 - Eg. protists, bacteria, and archaea.
- **All organisms made of ce**

Classification of Organisms

| Based on the number of cells | Based on the subcellular structure |
|---|--|
| <ul style="list-style-type: none"> • Single-celled: Bacteria, archaea, and protists • Multicellular: Animals and Plants | <ul style="list-style-type: none"> • Eukaryotes: Having a well-defined nucleus with genetic material. • Prokaryotes: Without nucleus but possess genetic material in a nucleoid. |

Hierarchy of Classification- Groups



- **Hierarchy - sequence of categories** in a **decreasing** or **increasing order** from kingdom to species and vice versa.
- **Kingdom (highest rank)** followed by division, class, order, family, genus and species (**lowest rank**).
 1. **Species:**
 - **Group of population similar** in form, shape and **reproductive features** so that **fertile sibling** can be **produced**.

2. **Genus:**
 - A **group of similar species**.
 - **Genera** having **only one species - monotypic**.
 - **Genera** having **more than one species - polytypic**.
 - **Eg.** Lion & tiger are quite similar species placed under genus Panthera.
3. **Family:**
 - **Collection of similar genera**.
 - **Separated from genera by reproductive and vegetative features**.
 - **Eg. cats** and leopard - family Felidae.
4. **Order:**
 - **One or more than one similar families** constitute order.
 - **Eg. Family** Felidae are included in the order Carnivora.
5. **Class:**
 - **One or more than one order makes a class**.
 - **Eg.** Class Mammalia includes all mammals - bats, rodents, kangaroos, whales, great apes and man.

6. Phylum:

- Collection of similar classes.
- Eg. Phylum chordata of animals has class Mammalia along with birds, reptiles and amphibians.

7. Kingdom:

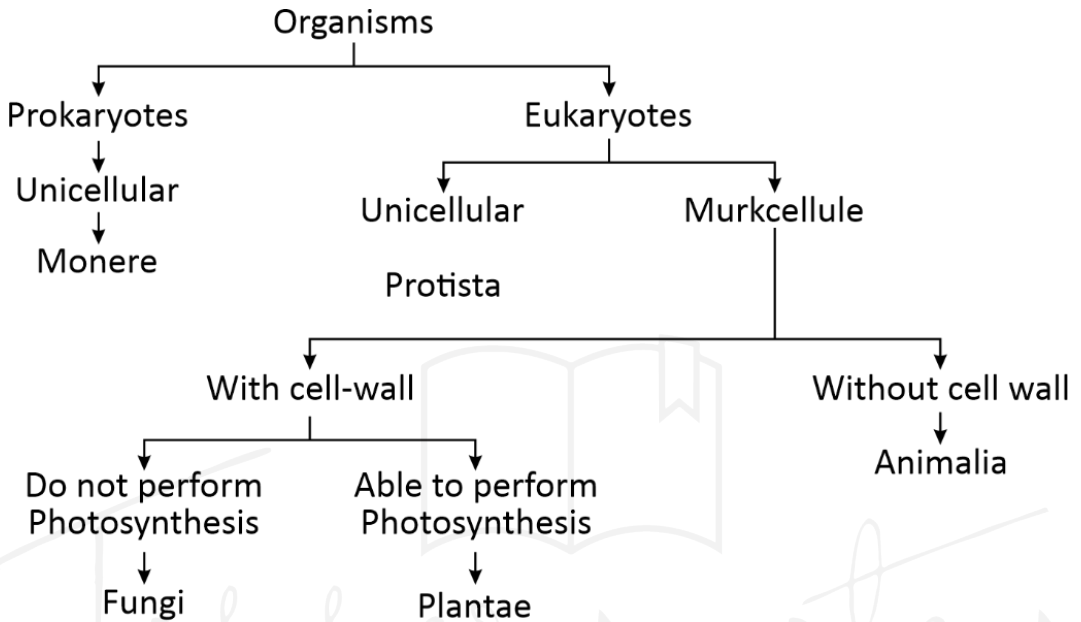
- Top most taxonomic category.

- Eg. all animals are included in Kingdom Animalia.

Taxon

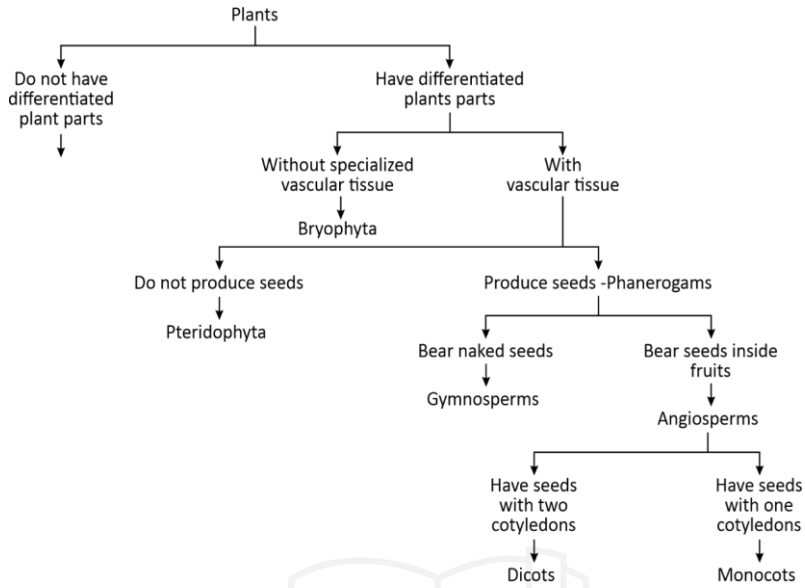
Unit that denotes **grouping** of organisms **based on observable features**.

5 Kingdom classification



| Comparison of Five Kingdom | | | | | |
|----------------------------|---|---|--|---|--|
| Criteria | Monera | Protista | Fungi | Plantae | Animalia |
| Cell Type | Prokaryotic | Eukaryotic | Eukaryotic | Eukaryotic | Eukaryotic |
| Level of organisation | Unicellular | Unicellular | Multicellular and unicellular | Tissue/organ | Tissue / organ/ organ system |
| Cell wall | Present (made up of peptidoglycan and mucopeptides) | Present in some (made up of cellulose, absent in other) | Present (made up of chitin or cellulose) | Present (made up of cellulose) | Absent |
| UPSC PRE 2021 | | | | | |
| Nutrition | Autotrophic (Phototrophic, Chemoautotrophic) Heterotrophic parastic and saprophytic) | Autotrophic photosynthetic Heterotrophic | Heterotrophic, Parastic or saprophytic | Autrophic (photosynthetic) | Heterotrophic (holozoic) |
| Motility | Motile or non-motile | Motile or non-motile | Non-motile | Mostly Non-motile | Mostly motile |
| Organisms | Archaeobacteria, Eubacteria, Cyanobacteria, Actinomycetes and mycoplasma | Chrysophytes, Dinoflagellates, Euglanoids, Slime molds, Amoeba, Plasmodium, Trypanosoma, Paramecium | Yeast, Mushrooms, and molds | Algae, Bryophytes, Pteridophytes, Gymnosperm and Angiosperm | Sponges, Invertebrates and vertebrates |

Plantae Kingdom



1. Thallophyta

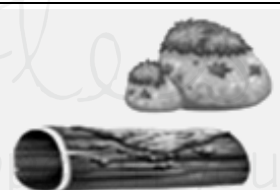
- Unique features:
 - Plants that **do not have well-differentiated body design.**
 - **Commonly called algae.**

2. Bryophyta

- Predominantly **aquatic.**
- **Eg.** Spirogyra, Ulothrix, Cladophora, Ulva and Chara.
- Reproduction : **No specialised reproduction process**

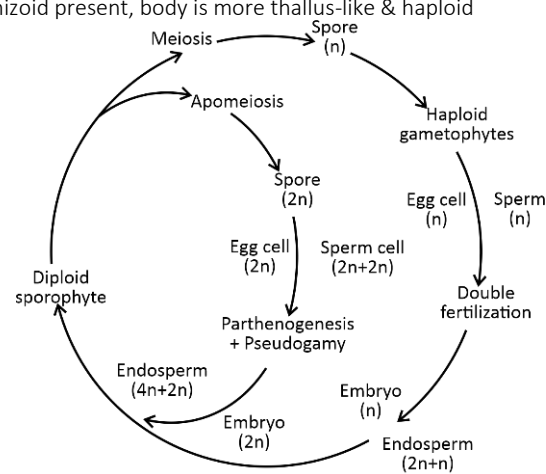
Bryophyta

- Amphibians of plant kingdom
- Grow in terrestrial environment but depend on water for reproduction
- Grow in moist & shady areas
- Responsible for plant succession on bare rocks
- Habitat: Arid forests, rainforests, apart from the alpine habitats
- Grow on rocks, soil, tree trunks, bones, rotting wood etc.





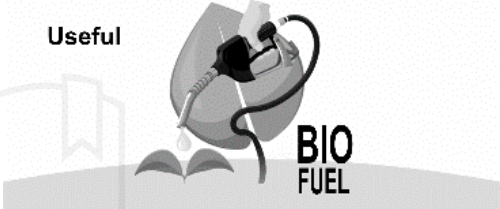
Unique Bryophyta

- Length: Few millimetre to 1 m
- Partially differentiated body, lacking true roots, leaves & stem
- Root-like structure called rhizoid present, body is more thallus-like & haploid







Haplo-diplontic Life Cycle

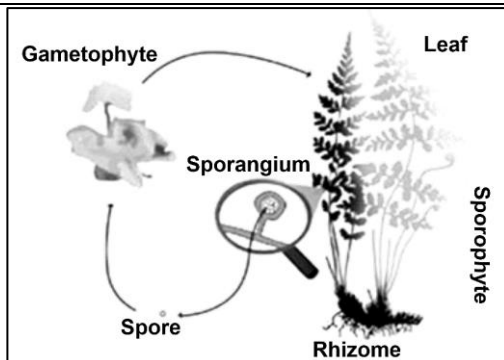
- Spore producing, non-vascular plants
 - Exhibit haplo-diplontic life cycle
 - Reproduction: Sex organs are multicellular. Antheridium is the male sex organ while archegonium is the female sex organ → Antheridium produces antherozoids with 2 flagella & archegonium produces single
 - Antherozoid released in water come in contact with archegonium
 - Male & female gametes fuse to form zygote which remains in archegonium for some time.
 - Mitosis of zygote forms embryonic sporophyte that is covered & protected by calyptra
 - Meiosis occurs in sporophyte to produce haploid spores which germinate to produce gametophyte
- Gametophyte supply nutrient & gametophore supply water & minerals to embryo

| | |
|--|---|
| <h3 style="text-align: center;">Classification</h3> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>Liverworts</p> <p>e.g.: Marchantia</p>  </div> <div style="text-align: center;"> <p>Mosses</p> <p>e.g.: Sphagnum</p>  </div> </div> | <h3>Importance</h3> <ul style="list-style-type: none"> • Have the ability to initiate soil formation in barren lands as they survive on bare rocks. • Maintain soil moisture & replenish nutrients in forest vegetation • Peat mosses act as biofuel & are economically useful • Used as packing material for shipment of living material as they can retain water. <p>Useful</p>  |
|--|---|

3. Pteridophyta

| | |
|--|--|
| <h4>Pteridophyta</h4> <ul style="list-style-type: none"> • Family of ferns & horsetails • Called cryptogams as they don't bear flowers & seeds. • First group of terrestrial vascular plants. • Found in damp and shady places. • Ferns are grown as ornamental plants. |  <p style="display: flex; justify-content: space-around;">Horsetails Fern</p> |
|--|--|

| | |
|--|---|
| <h4>Unique Features</h4> <ul style="list-style-type: none"> • LENGTH : MOSTLY SHORT BUT FEW GROW TALL UP TO FEW METRES. • PLANT BODY IS DIFFERENTIATED INTO TRUE ROOTS, LEAVES & STEMS. • LEAVES CAN BE SMALL (MICROPHYLLS) OR LARGE (MEGAPHYLLS) • SPORANGIA BEAR LEAF-LIKE APPENDAGES – SPOROPHYLL • SPOROPHYLLS FORM COMPACT STRUCTURE CALLED CONES OR STROBILI IN SOME PLANTS. • REPRODUCTION : SHOW TRUE ALTERNATION OF GENERATION. | <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Sellaginella (Microphylls)</p> </div> <div style="text-align: center;">  <p>Ferns (Megaphylls)</p> </div> </div> <div style="text-align: center; margin-top: 20px;">  <p>Cone of Equisetum</p> </div> |
|--|---|

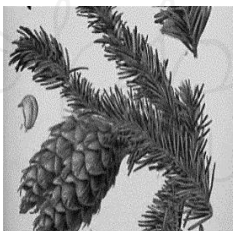


- Dominant sporophyte produce spores by meiosis & gametophyte produces gametes by mitosis.
- Sporangia produce spores in the spore mother cells that germinate to give gametophytes.
- Gametophytes are free-living, multicellular, photosynthetic – Prothallus
- Male sex organ anteridia produce antherozoids & female sex organ is archegonia.
- **Reproduction procedure.**
 - Antherozoids are released in water and come in contact with archegonia.
 - Gametes fuse in the archegonium to produce zygote
 - Zygote produces sporophyte after division.
- Spores : Homosporous or heterosporous
- In heterosporous plants, microspore & megaspore give rise to male & female gametophyte respectively.

4. Gymnosperms

Gymnosperm :

- Consist of pines & deodar
- Gymno-naked: sperma – seed
- Plants with naked seeds that do not bear flower & fruits
- Seeds are visible as cones & develop on surface of reproductive structure.



Cone



Pine



Cycas

Unique Features

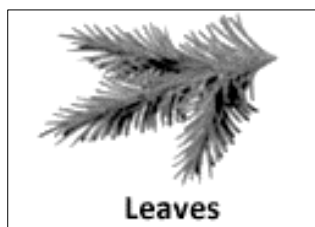
- Wind is the major source of pollination.
- Length : Medium to large tree & few are shrubs
- Vascular & Complete differentiation into leaves, stem & roots
- Leaves: Needle-like with thick cuticle & sunken stomata.

Roots

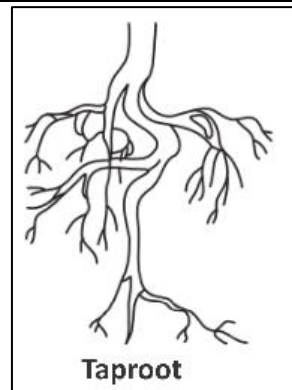
- Taproot system
- Some form mycorrhiza (e.g. pinus)
- Some form specialized roots called coralloids roots (e.g. *Cycas*)

Reproduction:

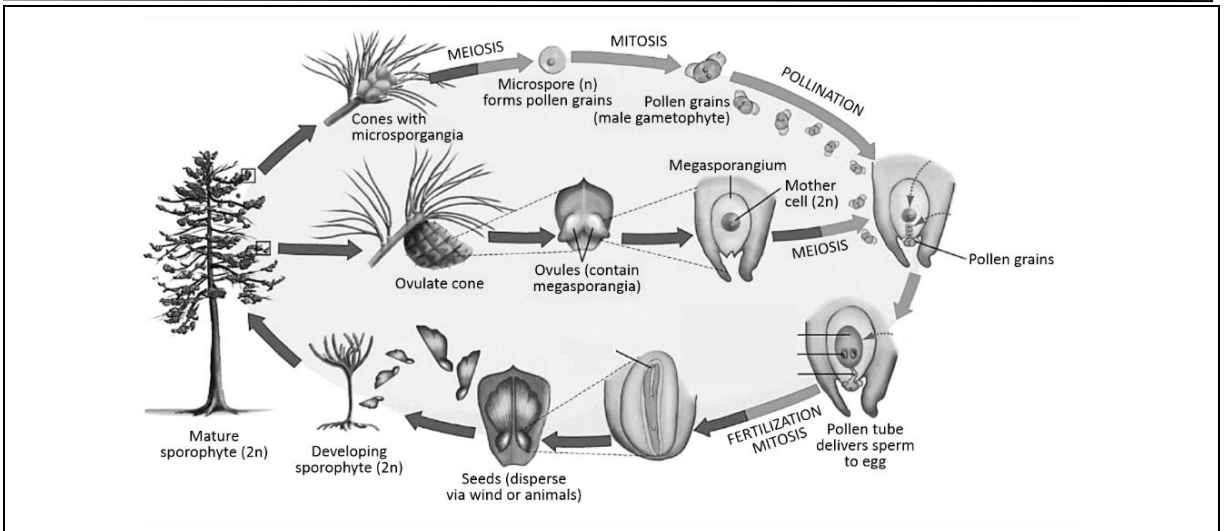
- Male & female cones can be same (e.g. Pinus) or different (e.g. : cycas) plants.
- Heterosporous plants that produce haploid microspores & megaspores.
- Male cones: Contain microsporophyll, few of which develop into pollen grains & rest degenerate.
- Female Cones: Several megasporophyll cluster to form female cone.
- Female cone bears ovule with megasporangium & give rise to haploid megaspores & a megaspore mother cell.



Leaves

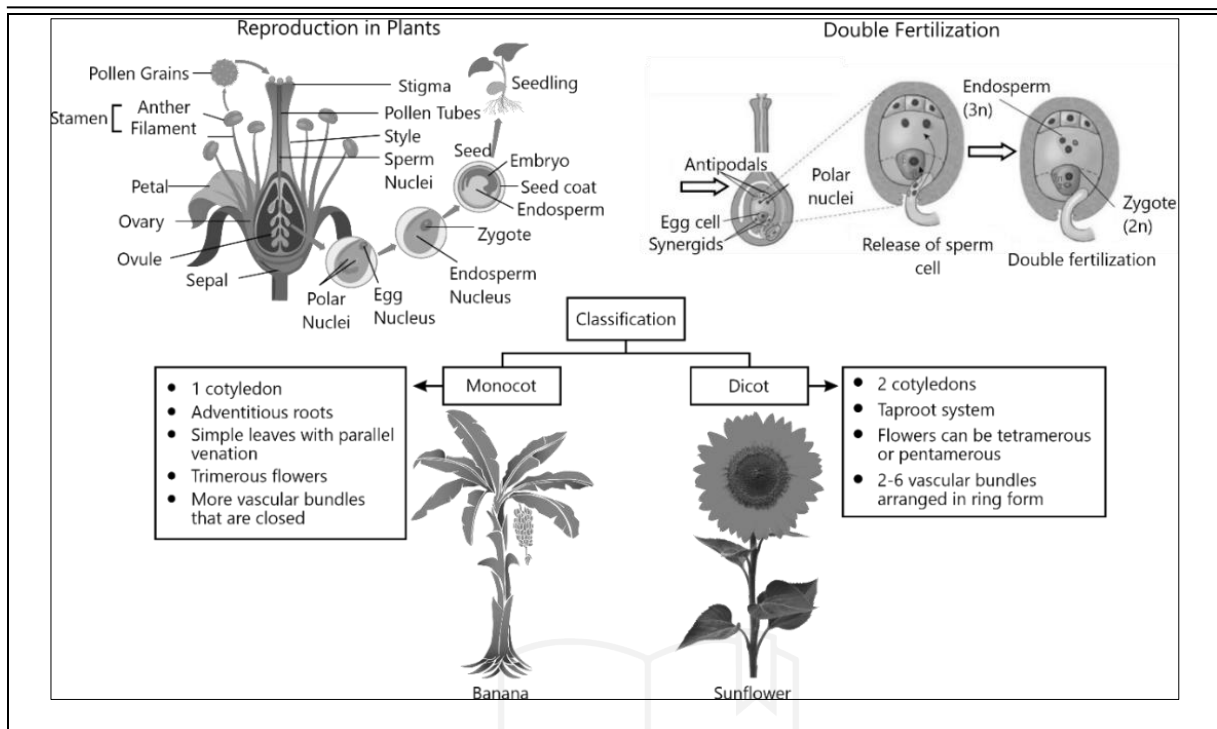


Taproot



5. Angiosperms

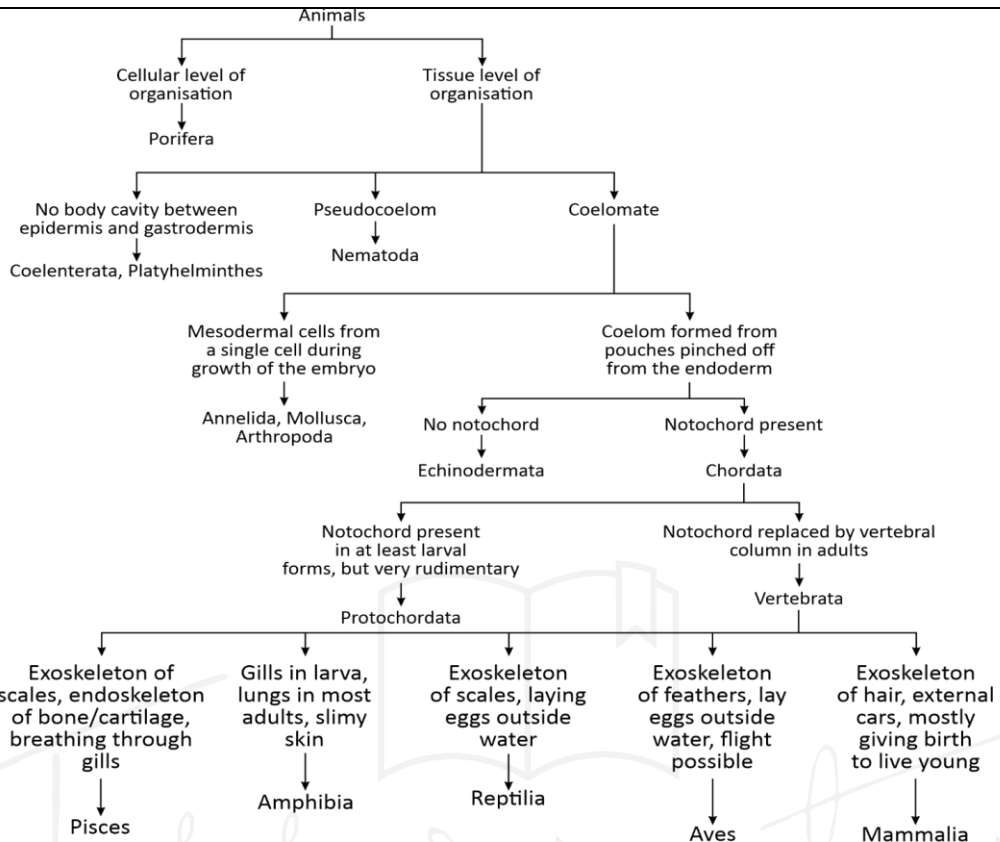
| | | |
|---|--|---|
| <p>Angiosperms</p> <ul style="list-style-type: none"> The family of flowering plants. Vascular fauna dominating across the globe. Called phanerogams due to the presence of flowers Seeds (ovules) are enclosed inside hollow ovary (which forms the fruit) | | |
| <p>Unique Features</p> <ul style="list-style-type: none"> Well differentiated plant body with fully developed root & shoot system. Survive in various habitats. Length : Microscopic <i>Wolffia</i> to > 100 m tall <i>Eucalyptus</i> Vast diversity including woody trees, shrubs & herbs. Leaves, stem & roots are adapted as per habitat | | <p style="text-align: center;">Herb Shrub Tree</p> |
| <p>Reproduction:</p> <ul style="list-style-type: none"> Flower is the reproductive structure can be unisexual or bisexual] Alternation of generation – haploid gametophyte alternates with the diploid sporophyte. Double fertilization is characteristic to Angiosperms – Syngamy & triple fusion. Post-fertilization ovary forms the fruit & ovules form the seeds & remaining parts with off. | | <p style="text-align: center;">Structure of an idealized flower</p> |



Vascular and Nonvascular Plants

| | Vascular Plants | Non - Vascular Plants |
|---------------------------|--|--|
| Definition | <ul style="list-style-type: none"> • Possess vascular system to conduct food and water throughout the plant | <ul style="list-style-type: none"> • Lack vascular systems |
| Diversity | <ul style="list-style-type: none"> • Higher | <ul style="list-style-type: none"> • Low |
| Vascular System | <ul style="list-style-type: none"> • Present | <ul style="list-style-type: none"> • Absent |
| True stem, Roots & Leaves | <ul style="list-style-type: none"> • Yes | <ul style="list-style-type: none"> • No; a stem and leaf-like structures and rhizoids, instead of true structures. |
| Plant Strength | <ul style="list-style-type: none"> • Xylem tissues contain lignified tissues - provide support and rigidity to the plant. | <ul style="list-style-type: none"> • No water conducting tissues • Tender and shorter than vascular plants |
| Reproduction | <ul style="list-style-type: none"> • Sporophytes | <ul style="list-style-type: none"> • Gametophytes |
| Examples | <ul style="list-style-type: none"> • Ferns, conifers, and flowering plants. | <ul style="list-style-type: none"> • Bryophytes, including liverworts, mosses, and hornworts. |
| Drought Resistance | <ul style="list-style-type: none"> • Almost all are drought resistant | <ul style="list-style-type: none"> • Susceptible to drought. • Associated with swamps |

| Sporophytes | Gametophytes |
|-------------------------------------|---|
| Use the process of meiosis | Use the process of mitosis |
| Results- formation of spores | Results - production of gametes |
| Diploid plants | Haploid plants |
| Have two sets of chromosomes | Have a single set of chromosomes |
| Reproduce asexually | Reproduce sexually |



1. Porifera

- Non mobile animals attached to some solid support.
- Holes or pores all over the body.
- A canal system circulating water throughout body to bring in food and O₂.
- Mainly found in marine habitats.
- Commonly k/a sponges

2. Coelenterata

- Animals living in water.
- Diploblastic: body is made up of two layers of cells.
- Some live in colonies while others have a solitary life
- Eg. span (Hydra) jellyfish .

3. Platyhelminthes

- Triploblastic: 3 layers of cells from which different tissues can be made.
- Some degree of tissues formation.
- Either free living or parasitic.
- Eg. Planarians, liver flukes.

4. Nematode

- Bilaterally symmetrical and triploblastic.
- Body is cylindrical rather than flattened.
- Tissues, but no real organs,
- A sort of body cavity or a pseudocoelom, is present.
- K/a parasitic worms causing diseases, such as worms causing elephantiasis (filarial worms) or worms in the intestines (roundworm or pinworms).

5. Annelida

- Have true body cavity.
- Allows true organs to be packaged in body structure.
- Extensive organ differentiation.
- Eg- Earthworms, leeches.

6. Arthropods

- Open circulatory system and so the blood does not flow in well-defined blood vessels.
- Have joint legs.
- Eg- prawns, butterflies, houseflies, spiders, scorpions and crabs.

7. Mollusca

- Have an **open circulatory system** and **kidney like organs** for excretion.
- **Little segmentation.**
- A **foot** is used for **moving around.**
- **Eg-** snails, and mussels, octopus.

8. Echinodermate

- **Spiny skinned** organisms.
- **Exclusively free living marine animals.**
- Have a **water driven tube system** that they use for moving around.
- Have **hard calcium carbonate structure** that they use as skeleton.
- **Eg-** starfish, sea cucumber.

9. Protochordats

- **Marine animals.**
- **Eg.** balanoglossus, hardemania and amphioxus.

10. Vertebrata

- Have a **true vertebral column & internal skeleton.**
- **Bilaterally symmetrical**
- **Triploblastic**
- **Coelomic and segmented**
- **Complex differentiation** of body tissues and organs.
- All **chordates** possess the following features:
 - have a **notochord**
 - have a **dorsal nerve cord**
 - **Triploblastic**
 - Paired **gill pouches**
 - **Coelomate.**
- Grouped into **six classes**:
 - A. Cyclostomes**
 - **Jawless vertebrates.**
 - Have an **elongated eel-like body, circular mouth, slimy skin**
 - **Scaleless.**
 - **Ectoparasites** or borers of other vertebrates.
 - **Eg.** Petromyzon (Lamprey) and Myxine (Hagfish)
 - B. Pisces**
 - **Exclusively aquatic** animals.
 - **Skin** is covered with **scales/ plates.**
 - **Obtain oxygen** dissolved in water by using **gills.**

- **Body is streamlined,** and a **muscular tail** for movement. T
- **Cold-blooded**
- **Hearts** have only **two chambers.**
- **Lay eggs.**
- **Eg.** sharks, tuna or rohu

C. Amphibia

- **No scales**
- Have **mucus glands** in the skin,
- **3 chambered heart.**
- **Respiration** through **either gills** or **lungs.**
- **Lay eggs.**
- Found both in **water** and **on land.**
- **Eg.** Frogs, toads and salamanders

D. Reptilia

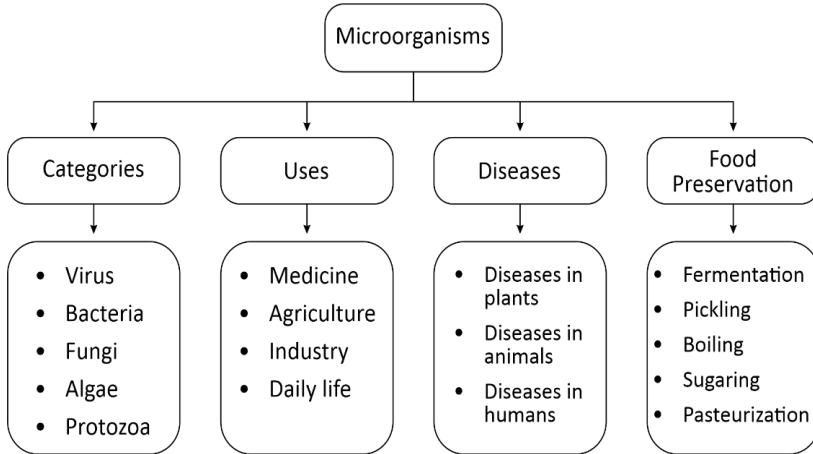
- **Cold-blooded**
- Have **scales** and **breathe through lungs.**
- Most have a **three-chambered heart**
- **Exception:** crocodiles- 4 heart chambers.
- **Lay eggs** with **tough coverings.**
- **Do not need to lay their eggs** in **water,** unlike amphibians.
- **Eg.** Snakes, turtles, lizards and crocodiles

E. Aves

- **Warm-blooded** animals
- **4-chambered heart.**
- **Lay eggs.**
- An **outside covering** of **feathers;** 2 **forelimbs** modified for **flight.**
- **Breathe** through **lungs.**
- **Eg.** All birds

F. Mammalia

- **Warm-blooded** animals with **four-chambered hearts.**
- Have **mammary glands** for **production of milk.**
- **Skin** has **hairs& sweat** and **oil glands.**
- **Produce live young ones.**
- Few like **platypus** and **echidna** lay egg
- **Kangaroos** give **birth** to **very poorly developed** young ones.
- **Eg.** human, monkeys, whale etc



- Very small in size & cannot be seen with naked eye.
- Can be seen only with the help of a microscope.
- aka microbes.

- **Microbiology-** Branch of science dealing with study of microorganisms.
- Found in : air, water (ponds, lakes, rivers and oceans), soil and even inside our bodies.

5 categories

| | | |
|----------|---|----------------------|
| Virus | <ul style="list-style-type: none"> ● A tiny particle made up of genetic material and protein. ● Intermediate between living and nonliving things. ● Intracellular obligatory parasites. ● Virology- study of viruses. ● 10,000 times smaller than bacteria. ● Can be rod shaped, spherical or of other shapes. ● Contains a core DNA or RNA. ● Core surrounded with a protein coat ● Protein coat is sometimes covered by an envelope of proteins, lipids, and carbohydrates. ● Causes diseases to plants, animals and human beings. ● viruses cannot and require living host cells for propagation | UPSC PRE 2021 |
| Bacteria | <ul style="list-style-type: none"> ● Single-celled prokaryotes(cells without nuclei). ● Considered 1st living organisms on earth. ● Grouped under the kingdom Monera. ● Bacteriology- study of bacteria. ● Size - 1µm to 5µm(micrometer). ● 2 types based on respiration : <ul style="list-style-type: none"> ○ Aerobic bacteria (requires oxygen), ○ Anaerobic bacteria (does not require oxygen). ● An outer covering k/a cell wall. ● Other cell organelles (mitochondria, golgi body, endoplasmic reticulum etc..) are absent. ● Eg : E.coli, Bacillus anthracis, Vibrio cholera etc. ● processing plants and can contaminate food products. ● known to exhibit antibiotic resistance, which can make them difficult to treat. upsc prelims 2022 ● IT CAN BE CULTURED ARTIFICIALLY. | UPSC PRE 2021 |
| Fungi | <ul style="list-style-type: none"> ● Eukaryotic organisms that lack chlorophyll. ● Grow in dark environments. ● Either unicellular (like Yeast) or multicellular (like Penicillium). ● Found in all kinds of habitats. ● Included under kingdom Fungi. ● Mycology- study of fungi. | |

| | | |
|-----------------|---|----------------------|
| | <ul style="list-style-type: none"> Some are macroscopic (Eg. Mushroom). Around 70,000 species of fungi in the world. IT CAN BE CULTURED ARTIFICIALLY | UPSC PRE 2021 |
| Algae | <ul style="list-style-type: none"> Very simple plants like eukaryotic organisms. Found in moist habitats. Rich in chlorophyll Seen as thin film on surface of lakes and ponds. <ul style="list-style-type: none"> aka 'grass of water'. Autotrophic and produce their own food(with help of chloroplast). Algology/ phycology- study of algae. Size - 1 micron to 50 meter. Eg : Chlamydomonas, Volvox, Ulothrix, Fristschiella etc. | |
| Protozoa | <ul style="list-style-type: none"> Single celled eukaryote. Included under the kingdom Protista. Protozoology- Study of protozoa. Found in ponds, ocean, in moist soil, and in the cells and tissues of plants and animals - causing diseases. Range - 2 to 200 microns. Eg : Paramecium, Euglena, Amoeba, Plasmodium etc. Probiotics are live microorganisms that are intended to have health benefits when consumed. Some probiotics, particularly those in the Lactobacillus and Bifidobacterium families, are able to break down lactose, the sugar found in milk. Probiotic organisms are not just found in the foods we eat, but also occur naturally in our gut microbiota. | UPSC PRE 2022 |

Animals

- Any **eukaryotic multicellular organism** of kingdom Animalia.

- Heterotrophic, motile & with specialized sensory organs**,
 - Lacking a cell wall & growing from a blastula** during embryonic development.

Characteristics

| | |
|------------------------------------|---|
| Multicellular | <ul style="list-style-type: none"> Body composed of several cells performing specific functions. <ul style="list-style-type: none"> Cells organized into various animal tissues, Eg: Epithelial tissues, connective tissues, etc. |
| Eukaryotic | <ul style="list-style-type: none"> Contain a membrane-bound nucleus. Nucleus -organelle containing chromosomes that bear genes. <ul style="list-style-type: none"> Other organelles suspended in the cytoplasm of an animal cell, Eg. Golgi apparatus, endoplasmic reticulum, lysosomes, and peroxisomes, |
| Heterotrophic | <ul style="list-style-type: none"> Depend on other organisms for food. |
| Motile | <ul style="list-style-type: none"> Capacity to move at will. By muscles and locomotory structures (e.g. arms, legs, wings, fins, tails, etc.) |
| Specialized sensory organs: | <ul style="list-style-type: none"> Eg: eyes, ears, nose, skin, and tongue. Vital in recognizing and responding to stimuli in environment. Contains common and specialized receptors. |
| Reproduce sexually | <ul style="list-style-type: none"> Produce a haploid sperm cell (a male sex cell) & a haploid ovum (a female sex cell) <ul style="list-style-type: none"> Unite at fertilization to form a diploid zygote. Capable of asexual reproduction. Eg: some cnidarians produce a genetic clone by budding. |
| Aerobic Respiration | <ul style="list-style-type: none"> Inhale oxygen and release carbon dioxide. Oxygen important to cell respiration for synthesis of energy. |

Cell

- Simplest and most basic unit of life.
- **Discovered:** Robert Hooke (1665)
- All living things made up of cells-
- **structural, functional, and biological unit of life.**



- Has the **ability to duplicate itself** on its own.
- aka "building blocks of life."

Cell Structure and its components

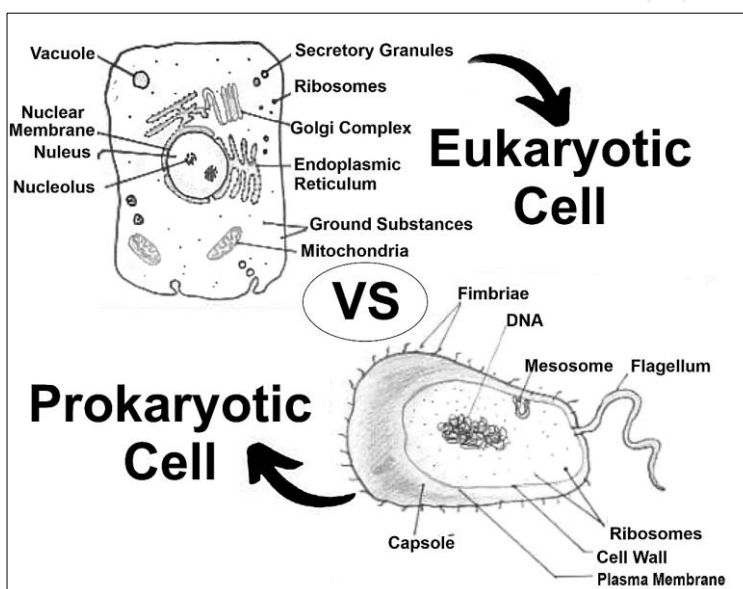
Cell Organelles

- Present within a cell & **perform certain specific functions to carry out life's processes.**

| | |
|------------------------|---|
| Plasma / Cell Membrane | <ul style="list-style-type: none">• Outermost covering of the cell• Separates contents of cell from its external environment.• A selectively permeable membrane as it allows entry and exit of some materials in and out of the cell. |
| Cell Wall | <ul style="list-style-type: none">• ONLY in plants• Outside the plasma membrane.• Mainly composed of cellulose.<ul style="list-style-type: none">◦ Cellulose: A complex substance - provides structural strength to plants. |
| Cytoplasm | <ul style="list-style-type: none">• Jelly-like substance present between cell membrane & nucleus.• Fluid content inside plasma membrane.• Contains many specialised cell organelles (mitochondria, golgi bodies, ribosomes, etc) |
| Nucleus | <ul style="list-style-type: none">• Contains chromosomes that contain information for inheritance of features from parents to next generation in form of DNA• Plays a central role in cellular reproduction.• Nuclear membrane- a double-layered covering on nucleus.<ul style="list-style-type: none">◦ Allows transfer of material from inside nucleus to its outside, i.e., to cytoplasm. |
| Nucleolus | <ul style="list-style-type: none">• Ribosome synthesis site regulating cellular activity and reproduction. |
| Gene | <ul style="list-style-type: none">• Unit of inheritance in living organisms. |
| Protoplasm | <ul style="list-style-type: none">• Entire content of a living cell [cytoplasm + nucleus].• aka living substance of the cell. |
| Chromosomes | <ul style="list-style-type: none">• Rod-shaped structures• Visible only when the cell is about to divide.• Contain information for inheritance of features from parents to next generation in the form of DNA (deoxyribo nucleic acid)• Composed of DNA and Protein. |
| DNA molecules | <ul style="list-style-type: none">• Contains information necessary for constructing and organising cells.• Functional segments of DNA - genes. |
| Vacuoles | <ul style="list-style-type: none">• Empty structure in cytoplasm• Act as storage sacs for solid or liquid contents.• Common in plant cells.• Smaller in animal cells.• Substances stored- amino acids, sugars, various organic acids and some proteins. |
| Endoplasmic Reticulum | <ul style="list-style-type: none">• A large network of membrane-bound tubes and sheets.• 2 types :<ol style="list-style-type: none">1. Rough endoplasmic reticulum [RER]<ul style="list-style-type: none">◦ Has ribosomes attached to its surface.◦ Ribosomes - sites of protein manufacture.2. Smooth endoplasmic reticulum<ul style="list-style-type: none">◦ Helps in the manufacture of fat molecules, or lipids, important for cell function.◦ Some of these proteins and lipids help in building the cell membrane k/a membrane biogenesis.• Serve as channels for transport of materials between various regions of cytoplasm or between the cytoplasm and the nucleus. |

| | |
|----------------------------------|--|
| | <ul style="list-style-type: none"> Also functions as a cytoplasmic framework providing a surface for some biochemical activities of cells. |
| Golgi Apparatus/ Complex | <ul style="list-style-type: none"> A system of membrane-bound vesicles arranged parallel to each other in stacks called cisterns. Packages and dispatches material synthesised near ER to various targets inside and outside the cell. Stores, modifies and packages products in vesicles. Involved in the formation of lysosomes. <ul style="list-style-type: none"> Membrane-bound sacs filled with digestive enzymes. Kind of waste disposal system of the cell. Help to keep the cell clean by digesting any foreign material as well as worn-out cell organelles. |
| Mitochondria | <ul style="list-style-type: none"> Aka powerhouse of the cell. Energy required for various chemical activities is released by mitochondria in the form of ATP (Adenosine Triphosphate) molecules. 2 membranes: <ul style="list-style-type: none"> Outer membrane- porous Inner membrane - deeply folded. <ul style="list-style-type: none"> Folds create a large surface area for ATP-generating chemical reactions. |
| ATP | <ul style="list-style-type: none"> aka energy currency of the cell. Body uses energy stored in ATP for making new chemical compounds and for mechanical work. |
| Ribosomes | <ul style="list-style-type: none"> Site of protein synthesis. Polyribosomes or Polysomes: Several ribosomes may attach to a single mRNA and form a chain. Prokaryotes- ribosomes are associated with the plasma membrane of the cell. |
| Cilia and Flagella | <ul style="list-style-type: none"> Hair-like outgrowths of the cell membrane. Cilia - small structures which work like oars, causing the movement of either the cell or the surrounding fluid. Flagella - comparatively longer and responsible for cell movement. Prokaryotic bacteria have flagella but structurally different from eukaryotic flagella. |
| Centrosome and Centrioles | <ul style="list-style-type: none"> Centrosome- an organelle usually containing 2 cylindrical structures called centrioles. Surrounded by amorphous pericentriolar materials. Both the centrioles in a centrosome lie perpendicular to each other |

Types of Cells



| Prokaryotic Cell | Eukaryotic Cell |
|--|--|
| <ul style="list-style-type: none"> Primitive/undeveloped nucleus. | <ul style="list-style-type: none"> Has true or developed nucleus |
| <ul style="list-style-type: none"> Size - 0.2 - 2.0 micrometers | <ul style="list-style-type: none"> Size- 10- 100 micrometers. |
| <ul style="list-style-type: none"> Simpler in structure | <ul style="list-style-type: none"> More complex |
| <ul style="list-style-type: none"> Organelles not membrane-bound | <ul style="list-style-type: none"> Organelles membrane bound & specific in function. |
| <ul style="list-style-type: none"> DNA arranged in circular shape | <ul style="list-style-type: none"> DNA linear in shape |
| <ul style="list-style-type: none"> Cytoplasm present, but lacks in most cell organelles. | <ul style="list-style-type: none"> Consists of both cytoplasm and organelles |
| <ul style="list-style-type: none"> Cell wall present. Made of mucopeptide or peptidoglycan | <ul style="list-style-type: none"> Usually, absence of cell wall here. Made of cellulose |
| <ul style="list-style-type: none"> Cell division - binary fission, transduction, conjugation, and transformation | <ul style="list-style-type: none"> Cell division - mitosis |
| <ul style="list-style-type: none"> Mitochondria absent | <ul style="list-style-type: none"> Mitochondria present. |
| <ul style="list-style-type: none"> Endoplasmic reticulum not present. | <ul style="list-style-type: none"> Endoplasmic reticulum present. |
| <ul style="list-style-type: none"> Ribosome present | <ul style="list-style-type: none"> Ribosome present |
| <ul style="list-style-type: none"> Plasmids commonly found. <ul style="list-style-type: none"> A small, circular, double-stranded DNA molecule distinct from a cell's chromosomal DNA. Naturally exist in bacterial cells. | <ul style="list-style-type: none"> Plasmids very rarely found |
| <ul style="list-style-type: none"> Only asexual reproduction. | <ul style="list-style-type: none"> Both sexual and asexual reproduction. |
| <ul style="list-style-type: none"> Have a single origin of replication | <ul style="list-style-type: none"> Have multiple origins of replication |
| <ul style="list-style-type: none"> Only 1 chromosome. | <ul style="list-style-type: none"> Many chromosomes present |
| <ul style="list-style-type: none"> Eg. Bacteria and Archaea. | <ul style="list-style-type: none"> Eg. Plant and animal cells. |

Plant and Animal Cells

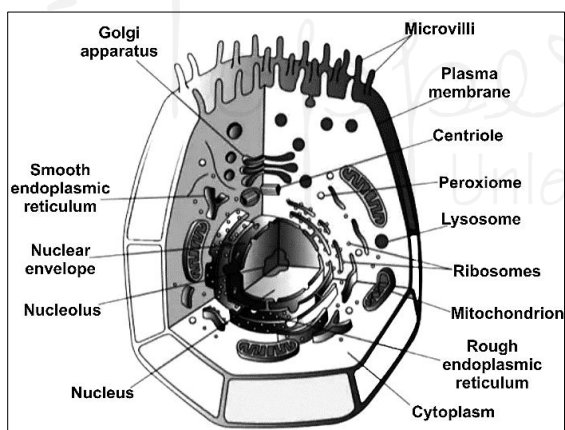


Fig : Animal Cell

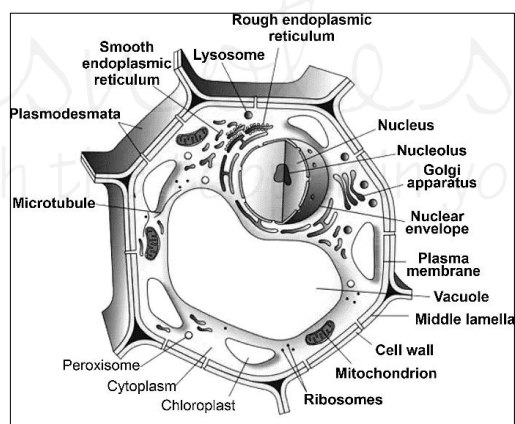


Fig : Plant Cell

| | Animal Cell | Plant Cell |
|-----------------------|---|---|
| Nucleus | Present | Present |
| Cilia | Present | Very rare |
| Shape | Round (irregular shape) | Rectangular (fixed shape) |
| Chloroplast | NO chloroplasts | Chloroplasts present |
| Cytoplasm | Present | Present |
| Endoplasmic Reticulum | Present | Present |
| Ribosomes | Present | Present |
| Mitochondria | Present | Present |
| Vacuole | One or more small vacuoles (much smaller than plant cells). | One large central vacuole taking up 90% of cell volume. |

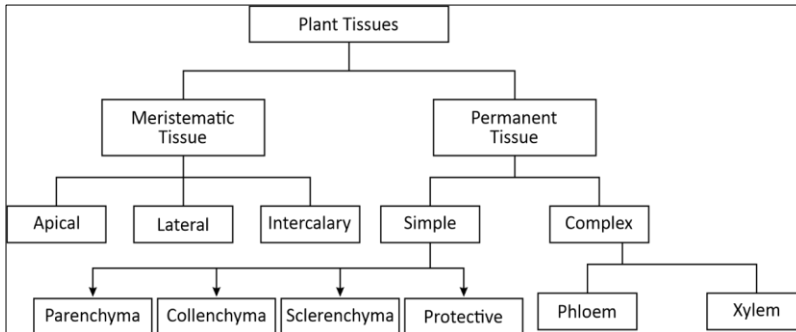
Tissues

- A group of cells with similar shape and function.

- **Group of** (cells → Tissues → Organs → Organ systems).
- **Histology:** study of tissues

Types of Tissues

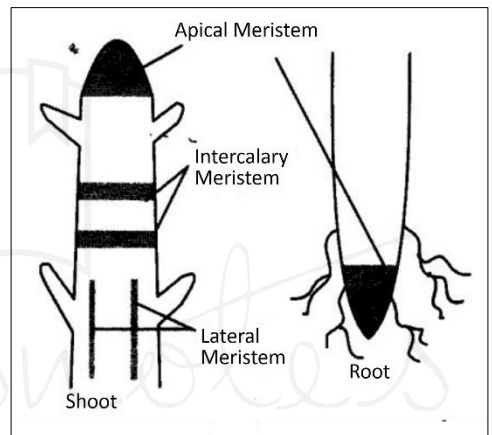
1. Plant Tissues



On the basis of the dividing capacity, plant tissues are of two types:

A. Meristematic tissues

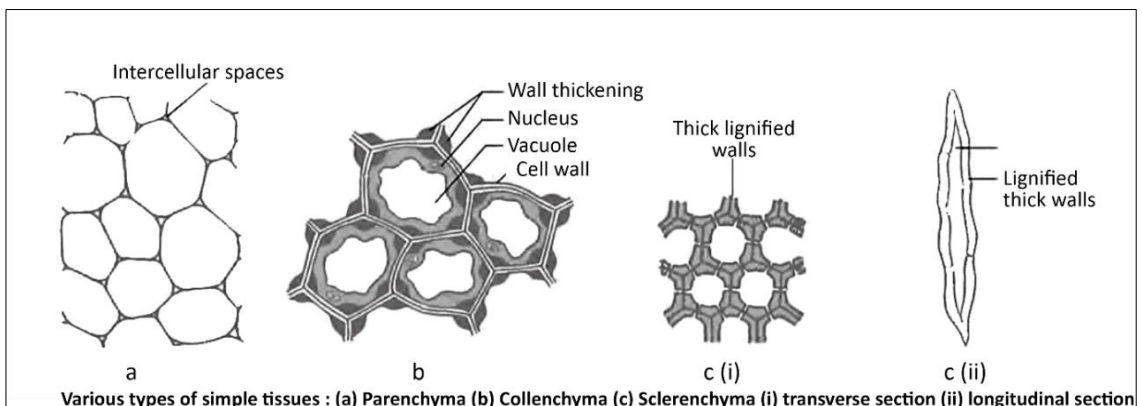
- Consist of **actively-dividing cells**.
- **3 types:**
 - Apical meristem:**
 - Present at the **growing tips of stems and roots**.
 - **Increases the length of stems and roots**.
 - Intercalary meristem:**
 - Present at the **base of leaves or internodes**.
 - **Longitudinal growth** of plants.
 - Lateral meristem:**
 - Present on the **lateral sides of the stems and roots**.
 - **Increases thickness** of stems and roots.



B. Permanent Tissues

- **Formed when cells from meristematic tissues lose the ability to divide.**
- **2 types:**
 - Simple permanent tissue:**
 - Consist of **only one type of cells**.

Types:



Various types of simple tissues : (a) Parenchyma (b) Collenchyma (c) Sclerenchyma (i) transverse section (ii) longitudinal section

b. Parenchyma:

- Composed of **unspecialised living cells** with **relatively thin cell walls**, intercellular space.
- Present in **soft parts of the plant**.
- **Main function** - storage.

c. Collenchyma:

- Composed of **living** and **elongated cells** with cell walls **irregularly thickened** at the corners.
- **No intercellular space**.
- Provides **mechanical support** and **elasticity** to plant - helps in **bending of leaves and stems**.

d. Sclerenchyma:

- Composed of **long, narrow, and thick-walled cells**.
- Made up of **dead cells**.
- **No intercellular spaces**.
- Present in **seeds, nuts, the husk of a coconut, fibres of jute** etc.

e. Protective tissues:

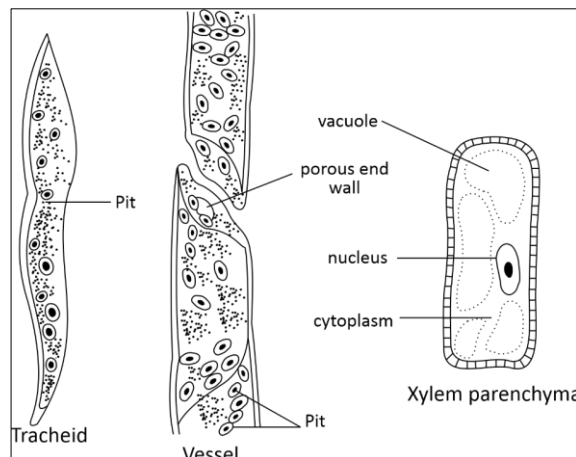
- **Protect the plant body by forming an outer layer.**
- 2 types:
 - a. Epidermis:**
 - **Covers the entire body of plant.**
 - **Protect plants** from injury, germs and water loss.
 - **Cells form a continuous layer without intercellular spaces.**
 - b. Cork Simple Tissues:**
 - **Consist dead cells with no intercellular spaces.**
 - **Form the outer layer** of old tree trunks.
 - **Cells have a chemical - suberin** in their walls that makes them **impervious to gases and water.**
 - **Protects plants** from injuries, germs and water loss.
 - **Lightweight** - used for making several products like bottle stoppers and shuttlecock.

Difference between parenchyma, collenchyma and sclerenchyma

| Features | Parenchyma | Collenchyma | Sclerenchyma |
|----------------------|---|--|---|
| Cell shape | Isodiametric cells which are oval, spherical or polygonal shape. | Circular, oval or polyhedral | Variable in shape Fibres and sclereids |
| Cell wall | Thin cellulosic cell wall | Uneven thickening on their cell wall | Lignified secondary cell wall present. |
| Cytoplasm | Abundant | Present | Absent |
| Nucleus | Present (Living tissue) | Present (Living tissue) | Absent (Dead tissue) |
| Vacuoles | Large vacuole | Vacuolated | Absent |
| Intercellular spaces | Present | Absent | Absent |
| Occurrence | Basically packing tissue all soft part of plant-path cortex, medullary rays | Dicot stem, petiole and beneath the epidermis Absent in monocot and roots | Dicot hypodermis, bundle sheath, pericyct seed, pulp of fruits. |

● **Complex permanent tissue:**

- Made up of **more than one type of cells** (Conducting tissues.)
- **Types:**
 - **Xylem:**



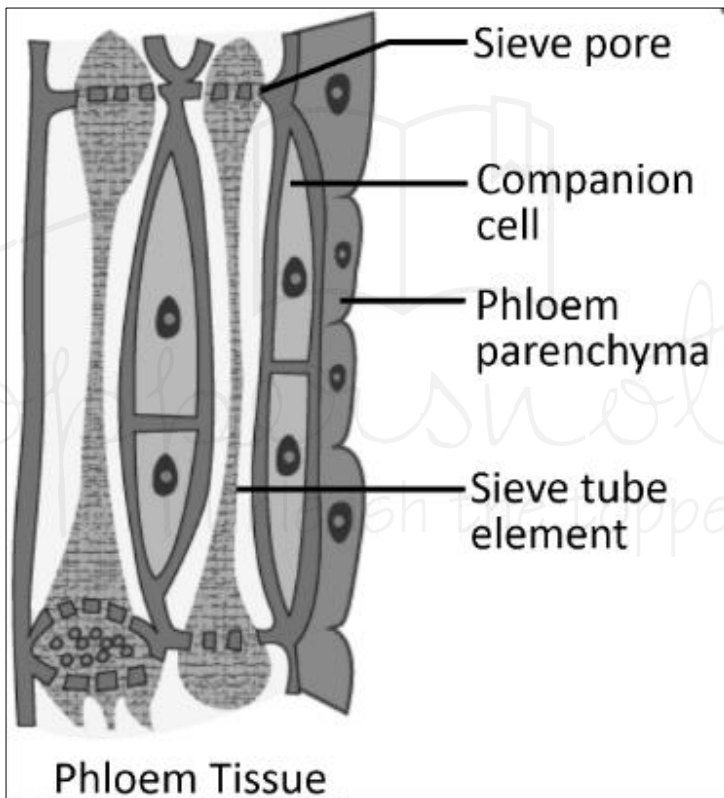
- **Conducts water and minerals** from roots to different parts of plant.
- **4 different types of cells:**
 - ☞ **Tracheids**
 - ✓ **Elongated angular dead cells** mainly involved in **conduction of water and minerals** in **gymnosperms**.
 - ☞ **Vessels**
 - ✓ **Advance element** (generally found in **angiosperms**).
 - ✓ **Cylindrical tube like structures** placed one above other end to end to form a continuous

channel for efficient conduction of water.

- ☞ **Xylem parenchyma** —
 - ✓ **Small & thick walled** parenchymatous cells subjected for **storage of starch** (food).
- ☞ **Xylem sclerenchyma**
 - ✓ **Non-living fibres** with **thick walls** and **narrow cavities** provide mechanical support.

Except xylem parenchyma all other xylem elements are dead.

○ **Phloem:**



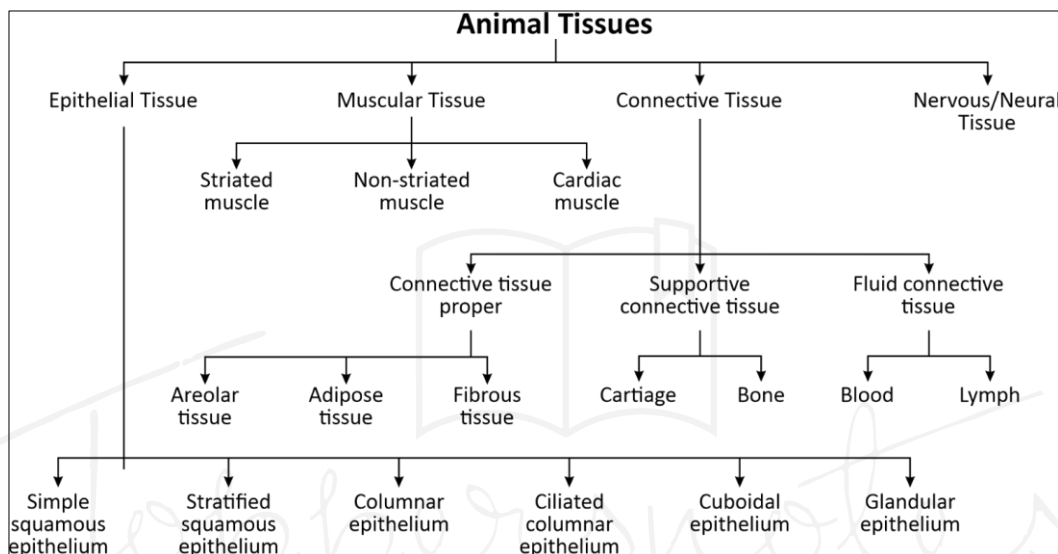
- **Conducts food material** from the leaves to the different parts of the plant.
- **4 types of cells**
 - ☞ **Sieve tubes:**
 - ✓ **Slender tube like structures** made up of elongated, thin walled cells placed end to end.
 - ✓ **End walls perforated** by numerous pores, called as **sieve plates**.
 - ☞ **Companion cells**

- ✓ Have **dense cytoplasm** and **prominent nuclei**.
- ✓ **Sieve cells + companion cells = sister cells** (originate from single mother cell).

- ☞ **Phloem fibre**
 - ✓ **Mechanical support** to sieve tubes.
- ☞ **Phloem parenchyma**
 - ✓ **Store food** and help in **radial conduction** of food.

| Features | Xylem | Phloem |
|-----------------------|-------------------------|-----------------|
| Cells: Living/ dead | Dead | Living |
| Cell walls: Thickness | Thick | Thin |
| Material | Lignin | Cellulose |
| Permeability | Impermeable | Permeable |
| Cross walls | None | Sieve Plates |
| Cytoplasm | None | Yes |
| Function | Carries water and salts | Carries sugar |
| Direction of flow | Upwards | Down and up |
| Special features | Fibres | Companion cells |

Animal Tissues



• 4 types:

A. Epithelial tissues:

- Always **grow on some other types of tissue.**
- **Cells very close to each other and tissue rests on a non-cellular basement membrane.**
- Consists of **single layer of cells.**
- **Blood vessels absent and non-nervous** in nature.
- **Covers all the organs and lines the cavities** of hollow organs like **stomach.**
- **Primarily protective** in function.
- **Types:**
 - a. **Squamous epithelium:**
 - **aka pavement epithelium.**
 - **Single layer of flat cells.**
 - **Location:** Lining of the mouth, oesophagus, lung, alveoli, etc.
 - b. **Cuboidal epithelium:**
 - **Found in kidney tubules, thyroid vesicles & in glands** (salivary glands, sweat glands)

- **Forms germinal epithelium** of gonads (testes & ovaries).
- Involves **absorption, excretion & secretion.**
- Provides **mechanical support**

c. Columnar epithelium:

- Consists of **elongated or column-like cells.**
- **Location:** Inner lining of the intestine and gut.
- **Function:** secretion and absorption.

d. Ciliated epithelium -

- May be **cubical or columnar.**
- **Cilia present** on its free surface
- **Helps in the movement of ova** in the fallopian tube.

B. Connective tissues

- Cells are **loosely spaced and embedded in an intercellular matrix.**
- Specialised to **connect various body organs.**