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UPSC – CSE

Civil Services Examinations

Union Public Service Commission

General Studies

Paper 3 – Volume - 3

SCIENCE & TECH

SIERRA INNOVATIONS

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G.S. PAPER – 3 VOLUME – 3

SCIENCE & TECH

1 CHAPTER Biology

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 cells.**

Classification of Organisms

Based on the number of cells	Based on the subcellular structure
● **Single-celled:** Bacteria, archaea, and protists ● **Multicellular:** Animals and Plants	● **Eukaryotes:** Having a well-defined nucleus with genetic material. ● **Prokaryotes:** Without nucleus but possess genetic material in a nucleoid.

Hierarchy of Classification- Groups

Kingdom
↑
Phylum of Division
↑
Class
↑
Order
↑
Family
↑
Genus
↑
Species

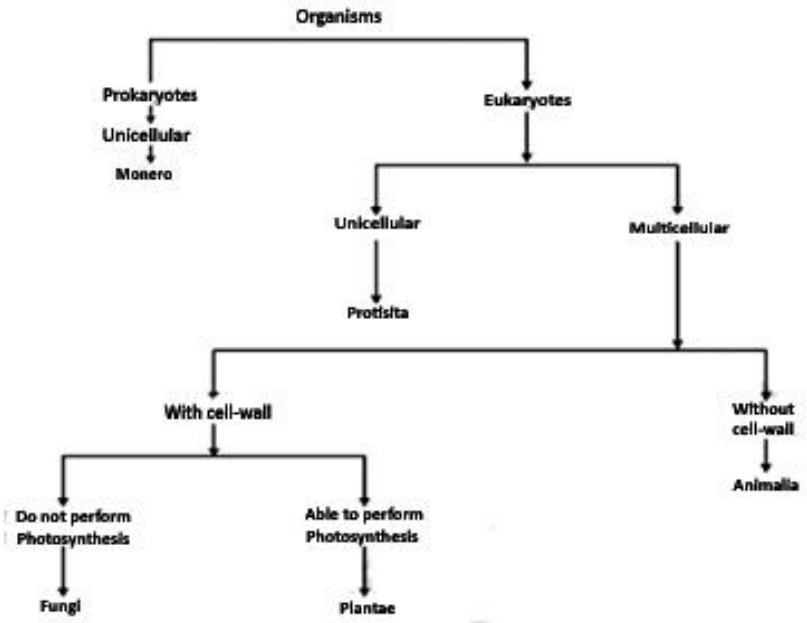
- **Hierarchy - sequence of categories** in a **decreasing** or **increasing order** from kingdom to species and vice versa.
- **Kingdom** (**highest rank**) followed by division, class, order, family, genus and species (**lowest rank**).
  1. **Species:**

- **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.

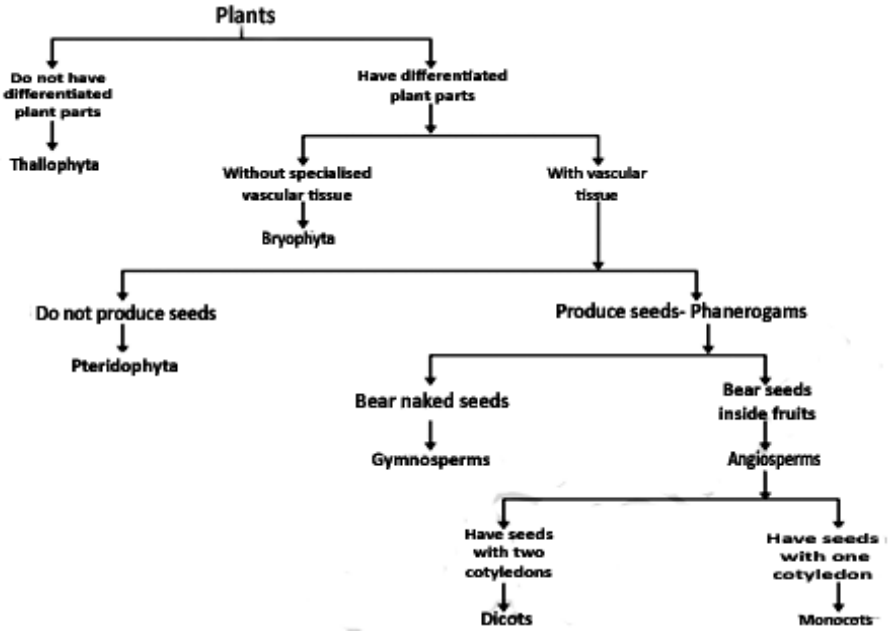
Taxon
Unit that de**notes grouping** of organisms **based on observable features**.

5 Kingdom classification

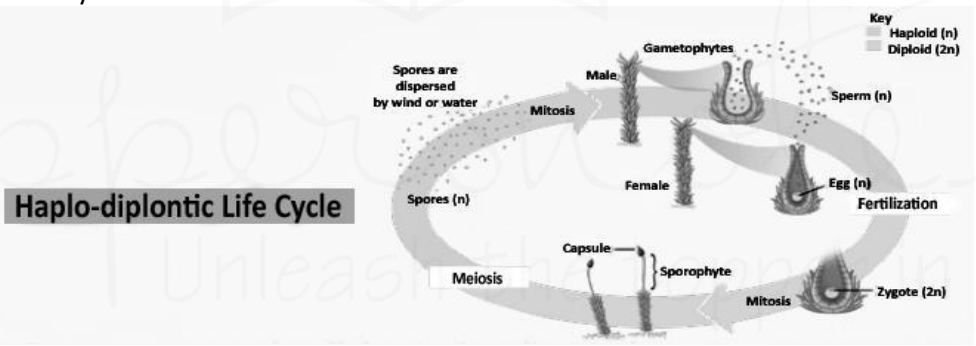
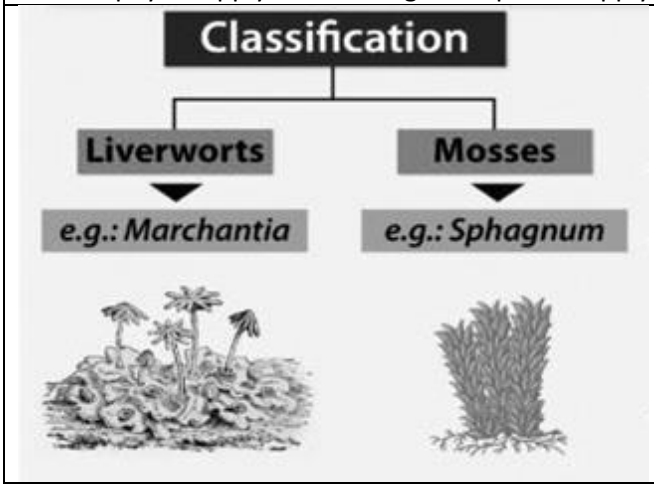


Comparison of Five Kingdom					
Criteria	**Monera**	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell Type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Leval of organisation	Unicellular	Unicellular	Multicellular and unicellular	Tissue/organ	Tissue organ/ organ system
Cell wall	Present (made 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
Nutrition	Autotrophic (Phototrophic, Chemoautrophic) Hetetrophic parastic and saprophytic)	Autotrophic photosynthetic Hetetrophic	Hetetrophic, Parastic or saprophytic	Autrophic (photosynthetic)	Heterotrophic (holozoic)
Motility	Motile or non-motile	Motile or non-motile	Non-motile	Mostly Non-motile	Mostly motile
Organisms	Archaebacteria, Eubacteria, Cyanbacteria, 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**.
     - Predominantly **aquatic**.
     - **Eg.** Spirogyra, Ulothrix, Cladophora, Ulva and Chara.
   - Reproduction : **No specialised reproduction** process
2. **Bryophyta**

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 • 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 (i) Antherozoid released in water come in contact with archegonium (ii) Male & female gametes fuse to form zygote which remains in archegonium for some time. (iii) Mitosis of zygote forms embryonic sporopyte that is covered & proteced by calyptra (iv) Meiosis occurs in sporophyte to produce haploid spores which germinate to produce gametophyte Gametophyte supply nutrient & gametophore supply water & minerals to embryo
 **Importance** • Have the ability to initiate soil formation in barren lands as they survive on bare rocks. • Maintain soil moisture & replenism nutrients in fores tvegetation • Peat mosses act as biofuel & are economically useful  • Used as packing material for shipment of living material as they can retain water.

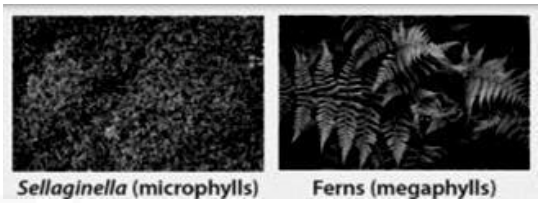
3. Pteridophyta

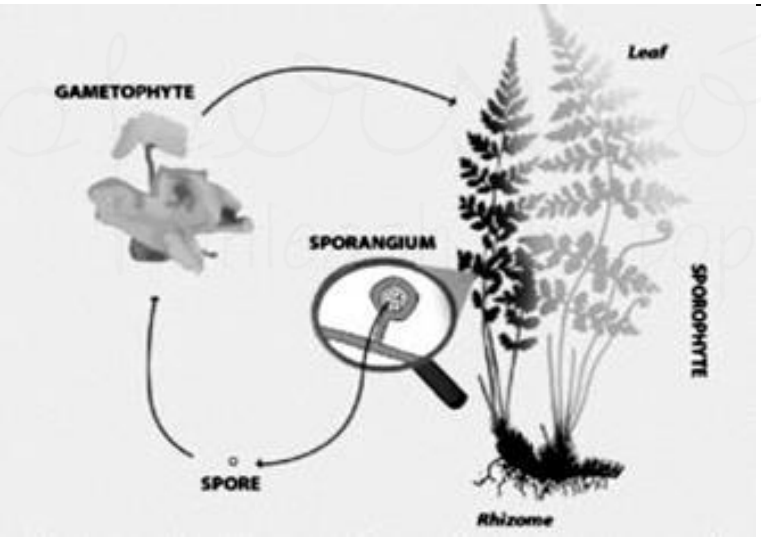
Pteridophyta

- 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.

Unique Featuers

- **Length :** Mostly short but few grow tall upto few metres.
- Plant body is differentiated into true roots, leaves & steams.
- Leaves can be small (microphylls) or large (megaphylls)
- Sporangia bear leaf-like appendages – **sporophyll**
- Sporophylls form compact structure called cones or strobili in som plants.
- Reproduction : Show true alternation of generation.

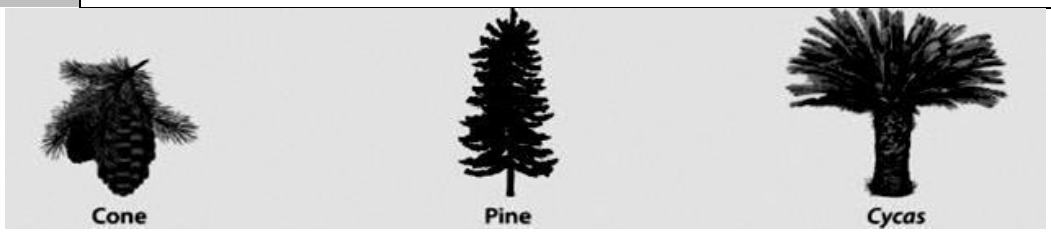




- Dominant sporophyte produce spores by meiosis & gametophyte produces gametes by mitosis.
- Sporangia produce spores in the spore mother cells that germinate to give gametophytes.
- Gametophytes are free-living, multicellular, photosynthetic – Prothallus
- Male sex organ anteridia produce antherozoids & 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 gametephyte respectively.

4. Gymnosperms

Gymnosprem :	• 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.



Unique Features

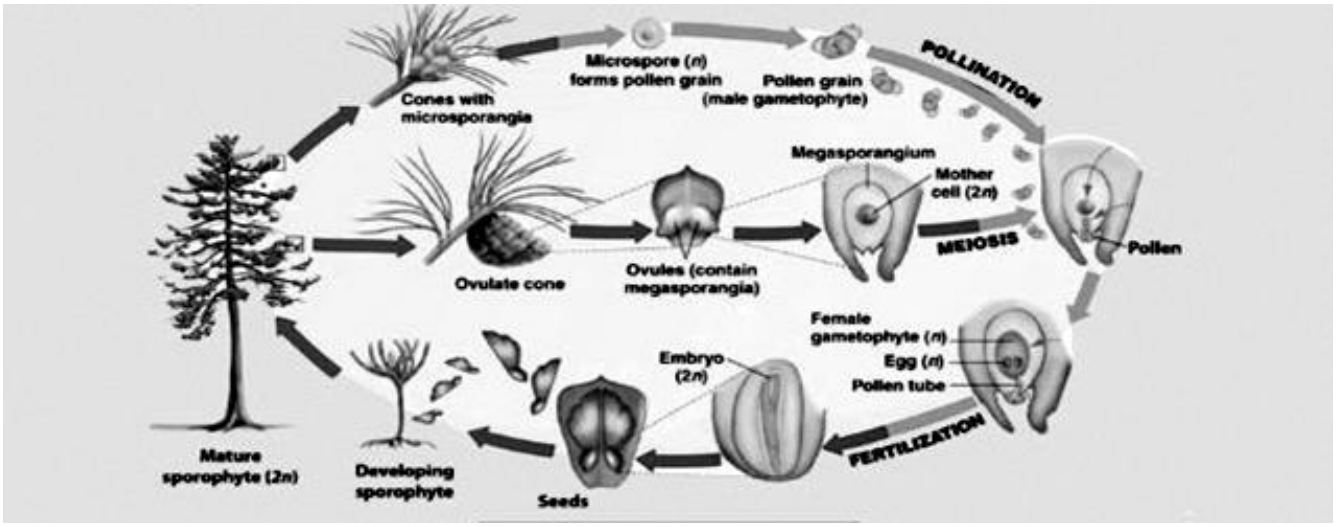
- Wind is the major source of pollination.
- Leangth : Medium to large tree & few are shrubs
- Vascular & Complete differentiation into leaves, steam & roots
- Leaves: Needle-like with thick cuticle & sunken stomata.

Roots

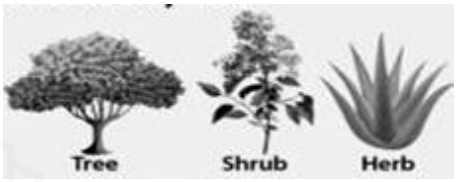
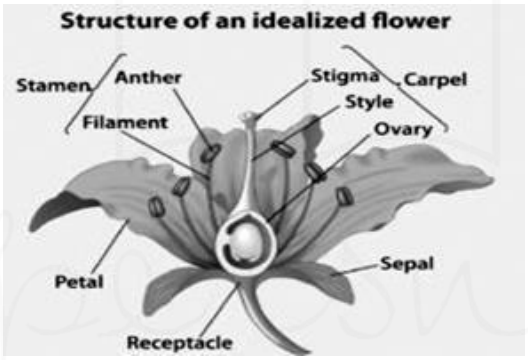
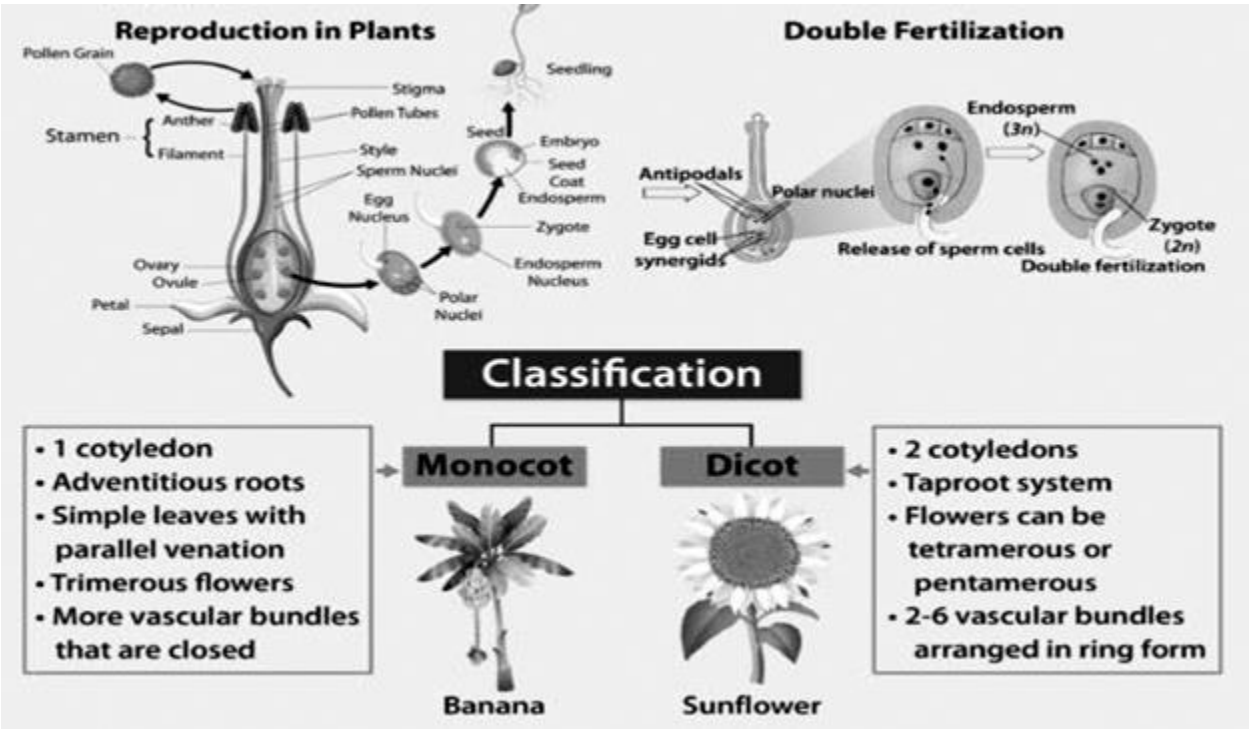
- Taproot system
- Some from mycorrhiza (e.g. pinus)
- Some form specialized roots called coralloids roots (e.g. *Cycas*)

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.



5. Angiosperms

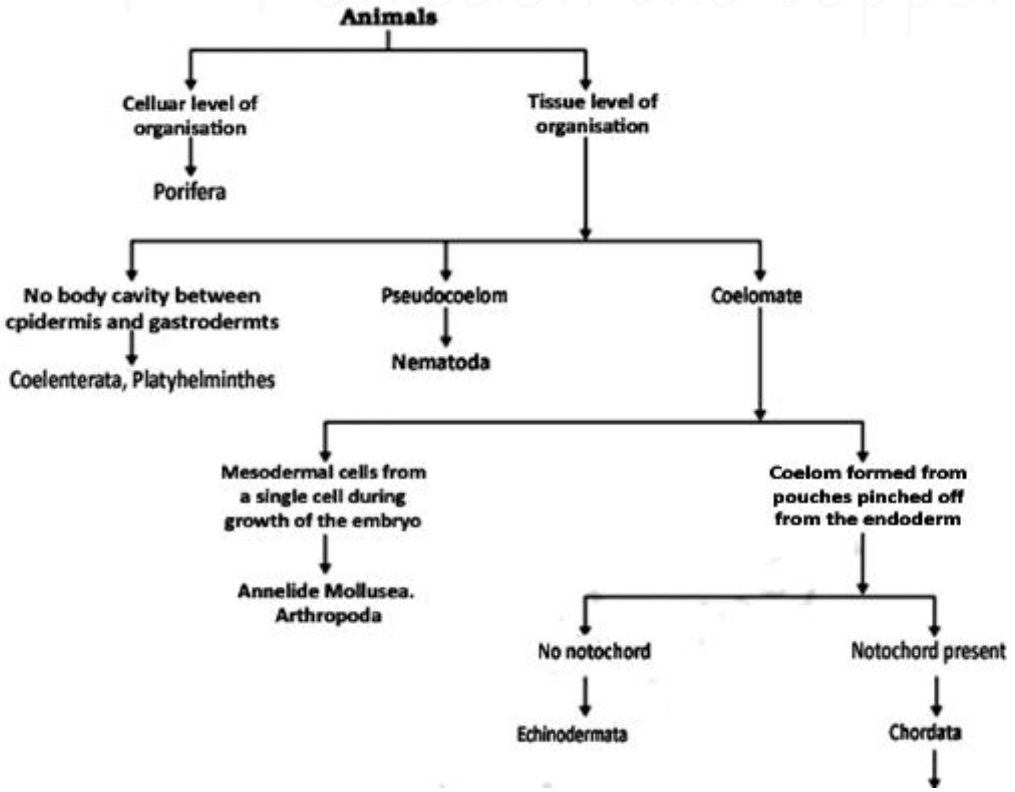
Angiosperms
• The family of flowering platns. • Vascular fauna dominating across the globe. • Called phanerogams due to the presence of flowers • Seeds (ovules) are enclosed inside hollow ovary (which forms the fruit) 
Unique Features
• Well differentiated plant body with fully developed root & shoot system. • Survive in various habitats. • Length : Microscopic Wolfia to > 100 m tall Eucalphytus • Vast diversity including woody trees, shrubs & herbs. • Leaves, steam & roots are adapted as per habitat  **Reproduction:** • Flower is the reproductive structure can be unisexual or bisexual  • Alternation of genetation – haploid gametophyte alternates with the diploid sporophyte. • Double fertilization is characteristic to Angiosperms – Syngamy & triple fusion. • Post-fertilziation ovary forms the fruit & ovules form the seeds & remaining parts with off. 

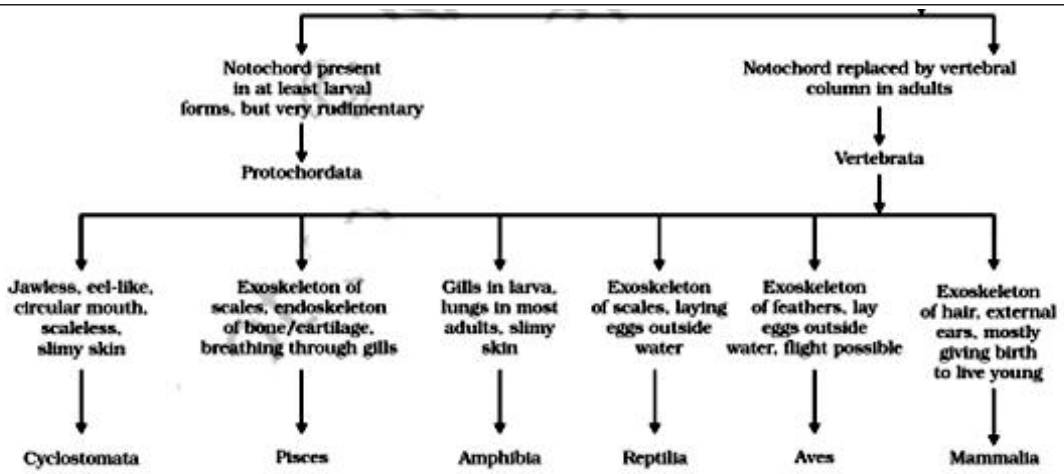
Vascular and Nonvascular Plants

	Vascular Plants	Non - Vascular Plants
Definition	● **Possess vascular system to conduct food and water** throughout the plant	● L**ack vascular systems**
Diversity	● **Higher**	● **Low**
Vascular System	● **Present**	● **Absent**
True stem, Roots & Leaves	● **Yes**	● **No;** a **stem and leaf-like structures and rhizoids, i**nstead of true structures.
Plant Strength	● **Xylem** tissues **contain lignified tissues** - **provide support and rigidity** to the plant.	● No water conducting tissues ● **Tender and shorter** than vascular plants
Reproduction	● **Sporophytes**	● **Gametophytes**
Examples	● **Ferns**, **conifers**, and flowering plants.	● **Bryophytes**, including liverworts, **mosses**, and **hornworts**.
Drought Resistance	● **Almost all** are **drought resistant**	● **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 **sexaully**

Animalia:





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. **Vertebratia**
    - 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

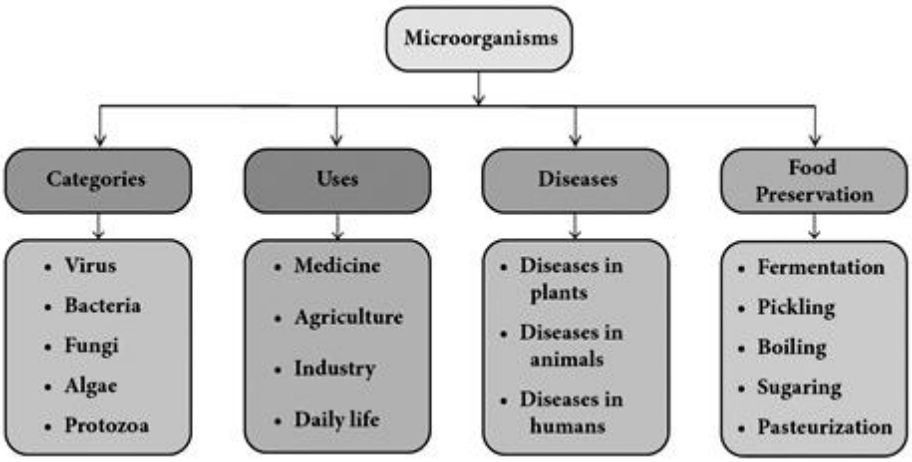
E. Aves

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

F. Mammalia

- W**arm-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

Microorganisms



- **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	● A **tiny particle made up of genetic material and protein.** ● **Intermediate between living and non living 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.**
Bacteria	● **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 **:** ○ **Aerobic** bacteria (requires oxygen), ○ **Anaerobic** bacteria (does not require oxygen). ● **A**n **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.
Fungi	● **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.** ● **Some** are **macroscopic (**Eg. Mushroom**).** ● Around **70,000 species of fungi** in the world.
Algae	● Very simple plants like **eukaryotic organisms.** ● **Found in moist habitats.** ● **Rich in chlorophyll** ● **Seen** as thin film on **surface of lakes and ponds.** ○ 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	● **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.

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	● Body **composed of several cells** performing specific functions. ○ Cells **organized into** various animal **tissues,** ○ **Eg:** Epithelial tissues, connective tissues, etc.
Eukaryotic	● Contain a **membrane-bound nucleus.** ● **Nucleus -organelle containing chromosomes** that bear genes. ■ Other organelles **suspended in the cytoplasm** of an animal cell, ■ **Eg.** Golgi apparatus, endoplasmic reticulum, lysosomes, and peroxisomes,
Heterotrophic	● **Depend on other** organisms **for food.**
Motile	● **Capacity to move** at will. ● by **muscles and locomotory structures**(e.g. arms, legs, wings, fins, tails, etc.)
Specialized sensory organs:	● **Eg:** eyes, ears, nose, skin, and tongue. ● **Vital in recognizing** and **responding to stimuli** in environment. ● Contains **common and specialized receptors.**
Reproduce sexually	● Produce a **haploid sperm cell (**a male sex cell) & **a haploid ovum** (a female sex cell) ○ **Unite at fertilization** to form a diploid zygote. ● Capable **of asexual reproduction.** ● Eg: some cnidarians **produce a genetic clone** by budding.
Aerobic Respiration	● **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	● **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	● **ONLY** in **plants** ● **Outside** the **plasma membrane.** ● Mainly **composed of cellulose.** ○ **Cellulose:** A complex substance - provides structural strength to plants.
Cytoplasm	● **Jelly-like substance** present between **cell membrane & nucleus.** ● **Fluid content inside plasma membrane.** ● **Contains** many specialised **cell organelles** (mitochondria, golgi bodies, ribosomes, etc)
Nucleus	● **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. ○ **Allows transfer** of **material** from **inside** nucleus **to its outside**, i.e., to cytoplasm.
Nucleolus	● **Ribosome synthesis site regulating cellular activity** and **reproduction**.
Gene	● **Unit of inheritance** in living organisms.
Protoplasm	● **Entire content of a living cell** [cytoplasm + nucleus]. ● aka **living substance of the cell.**
Chromosomes	● **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	● Contains **information necessary for constructing and organising cells**. ● Functional segments of DNA - **genes.**
Vacuoles	● **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	● A **large network of membrane-bound tubes and sheets**. ● **2 types :** 1. **Rough endoplasmic reticulum [RER]** ○ **Has ribosomes** attached to its surface. ○ **Ribosomes** - sites of **protein manufacture**. 2. **Smooth endoplasmic reticulum** ○ 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. ● Also functions as **a cytoplasmic framework** providing a **surface for some biochemical activities of cells.**
Golgi Apparatus/ Complex	● 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**. ○ **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	● 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:** ○ **Outer membrane- porous** ○ **Inner membrane - deeply folded.** ■ **Folds** create a **large surface area** for **ATP-generating chemical reactions**.
ATP	● aka **energy currency of the cell.** ● **Body uses energy** stored in **ATP** for **making new chemical compounds** and for mechanical work.
Ribosomes	● **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.**