TOPIC 1- CLASSIFICATION 2

- Classification is the orderly arrangement of organisms into groups based on their similarities.
- Those organisms with similar characteristics are put into the same group or taxon (plural-taxa).
- The science of classification is called **taxonomy.**
- The modern method of classification was devised by ***Carolus linnaeus.***
- Organisms are given are given two names in a scientific system called **binomial nomenclature.**

Significance/ importance / necessity of classification.

1. It groups together living organisms with similar characteristics but separates those with different features.
2. Helps in placing living organisms into their correct groups for easy reference.
3. Helps to arrange the information about living organisms in an orderly manner to avoid chaos and confusion.
4. Helps to understand the evolutionary relationships between different organisms.

BINOMIAL NOMENCLATURE

- This is a scientific system of giving organisms two names, generic/ genus name and specific/ species name.

Rules of binomial nomenclature.

1. The generic/genus name always starts with a capital letter/upper case letter while the specific/species name is written in letter/lower case letter.
2. When hand written/typed the names are underlined separately and when printed they are *italicized.*

- Examples:

i. Maize- Zea mays
ii. Lion – Felis leo

The taxa of classification.

- The taxa of classification include:
    1. Kingdom
    2. Phylum/Division.
    3. Class
    4. Order
    5. Family
    6. Genus
    7. Species

SPECIES.

- **Species** refer to a group of organisms that freely and naturally interbreed to give rise to a viable offspring.

Characteristics of species.

i. Are morphologically similar.
ii. Freely interbreed.
iii. Give rise to a fertile/viable offspring.

KINGDOMS OF CLASSIFICATION

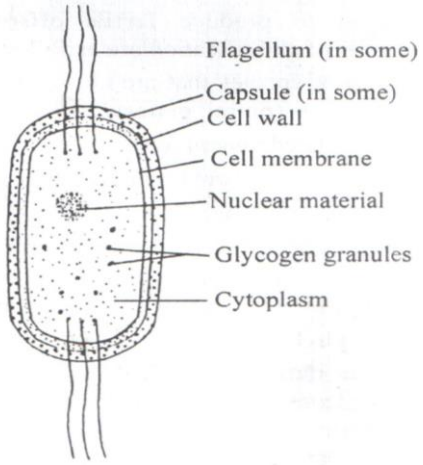
1. Monera
2. Protoctista/protista
3. Fungi
4. Plantae
5. Animalia

1. KINGDOM- MONERA

- Consists of blue green algae and bacteria.

General characteristics.

i. They are microscopic.
ii. They are unicellular.
iii. They lack membrane bound cell organelles e.g. mitochondria and chloroplasts.
iv. Their nuclear material is not surrounded by a nuclear membrane hence they are called **prokaryotes.**
v. They have a cell wall made of **proteins and sugars** instead of **cellulose.**
vi. Most of them are heterotrophic i.e. depend on already manufactured food materials.
vii. Others are autotrophic e.g. blue green bacteria/algae.
viii. Some are saprophytic while others are symbiotic e.g. nitrogen fixing bacteria and others parasitic.
ix. Most of them are mobile.
x. They are found in most habitats.
xi. They appear in different shapes e.g. spherical, rod shaped.
xii. They reproduce through binary fission.



Structure of bacteria

Economic importance of monera/ prokaryotes.

1. Used to manufacture of antibiotics. Production of vitamins B_{12} and K.
2. Used in silage formation.
3. Manufacture of butter and cheese.
4. Fermentation of milk to make yoghurt.
5. Curing of tea and tobacco.
6. Retting flax.
7. Manufacture of enzymes e.g. amylase and invertase and hormones e.g. insulin.
8. Formation of vinegar, acetic acid and lactic acid.
9. Septic tanks/ modern sewage works make use of bacteria in treatment of sewage.
10. Some are parasites that cause diseases e.g. *Salmonella typhi* causes typhoid and *Vibrio cholera* causes cholera.
11. Production of biogas.
12. Nitrogen fixing and nitrifying bacteria increase soil fertility by making nitrates available to plants.
13. Symbiotic bacteria in herbivores help the digestion process by producing the cellulose enzyme.
14. Some cause decay/ spoilage of food.
15. Denitrifying bacteria reduce soil fertility by converting nitrates to free nitrogen.

2. KINGDOM- PROTOCTISTA

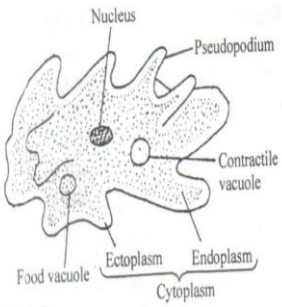
- It consists of:

A. Protozoa e.g. amoeba, paramecium and trypanosoma.
B. Algae e.g. spirogyra, euglena and chlamydomonas.

General characteristics of protoctista.

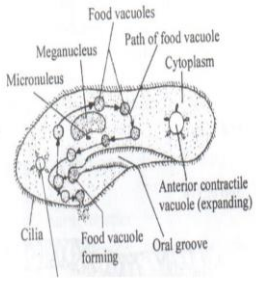
i. They are **eukaryotes** i.e. their nucleus is surrounded by a nuclear membrane.
ii. They are either unicellular or multicellular e.g. spirogyra.
iii. They reproduce asexually.
iv. They are heterotrophic e.g. protozoa or autotrophic e.g. algae.
v. Most protozoa and unicellular algae are mobile moving by pseudopodia, cilia or flagella while multicellular algae are sessile/immobile.

Amoeba

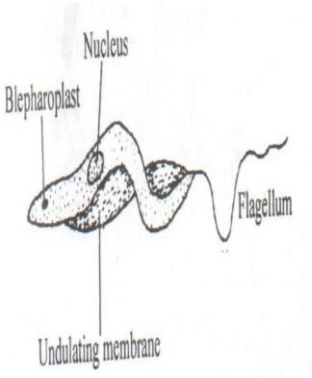


Amoeba

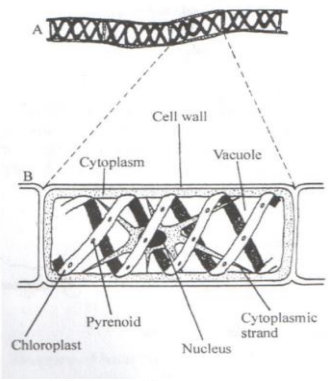
Paramecium



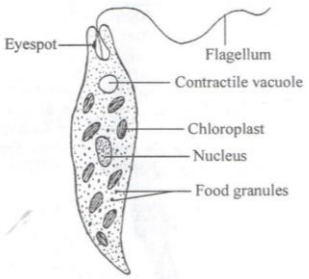
Trypanosome



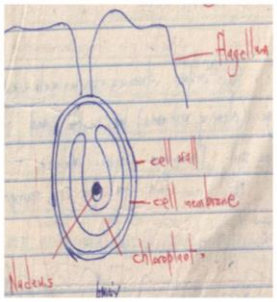
Spirogyra



Euglena



Chlamydomonas



3. KINGDOM- FUNGI.

- It consists of:

i. Mushrooms.
ii. Toad stools.
iii. Moulds e.g.Rhizopus.
iv. Yeast.
v. Smut.
vi. Penicillin.

General characteristics of Fungi

i. They are multicellular.
ii. They are heterotrophic i.e. parasitic or saprophytic.
iii. They store carbohydrates in form of glycogen and lipids in form of oil droplets.
iv. Most of them have cell wall made up of chitin or cellulose.
v. They have a network of hyphae/mycelia.
vi. They reproduce asexually by means of spores (sporulation) and budding in yeast.

Similarities between fungi and plants.

i. The cells of both are enclosed by a cell wall.
ii. Both have vacuoles and granules that contain stored food.

General characteristics of moulds.

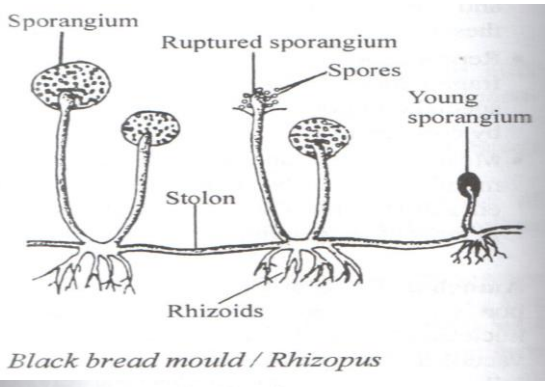
i. They consist of long filamentous structures called **hyphae** and the whole structure is called **mycelium.**
ii. The hyphae are enclosed by a cell wall made of **chitin/fungal cellulose.**
iii. Hyphae that lie on the surface are called **stolons.**
iv. Hyphae that support the mycelium to the surface of the substrate are called **rhizoids (parasitic fungi have haustoria).**
v. Hyphae that grow vertically are called **sporangiosphores** and form reproductive structures called **sporangia (singular-sporangium)** that bear/carry spores.

Functions of rhizoids

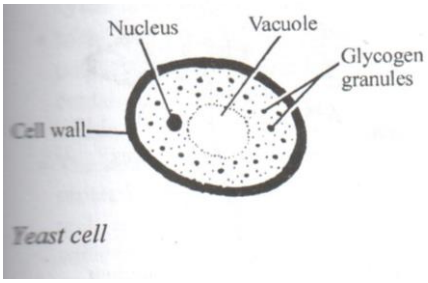
i. Provide anchorage/support.
ii. Absorption of soluble substances.
iii. Produce enzymes which digest organic materials in the substrate.

N/B

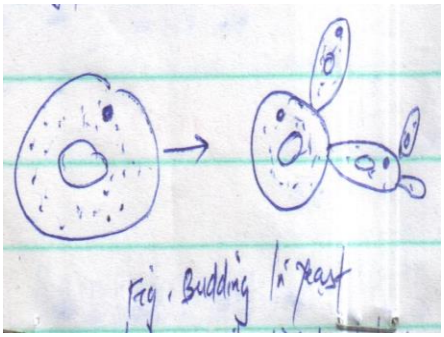
- Rhizoids differ from plant roots in that they lack vascular bundles.



Black bread mould / Rhizopus



Yeast cell



Study question

- A student left a piece of bread on an open place accidentally. 3 days later he observed some black substance developing. Explain how the black substance was formed.

Answer.

- Spores of bread mould deposited on the damp bread which germinated into **hyphae.** When mature the **hyphae** grew into **sporangiosphores. Sporangia** developed on the tip of the **sporangiosphores. Spores** formed in the sporangia which turned black as they matured and dried up.

Economic importance of fungi.

1. Saprophytes_decompose dead matter increasing soil fertility and contributes to recycling of nutrients.
2. Cause decay or spoilage of food.
3. Some cause diseases e.g. ring worm in human beings cause athlete's foot disease.
4. Some cause plant diseases e.g. wheat rust, soft rot and potato blight thus reducing the productivity of plants.
5. Yeast is a source of vitamin B.
6. Yeast is used in brewing and baking industries.
7. Some are used in the production of antibiotics e.g. chloromycin and streptomycin, penicillin from penicillium fungus.
8. Some are used as food for humans e.g. mushrooms.
9. Mycorrhizal associations help plants in the intake/ absorption minerals from the soil.
10. Some are used in the production of organic acids.
11. Some e.g. mildew can ruin clothing, books and other materials.

4. KINGDOM PLANTAE.

General characteristics.

1. They are multicellular organisms
2. They have eukaryotic cells.
3. The plant body is differentiated into leaves, stems and roots/root-like structures.
4. They are autotrophic/contain chlorophyll.
5. Their cells have cellulose cell walls that give them a definite shape.
6. They reproduce sexually and asexually.

PLANT DIVISIONS.

- They include:

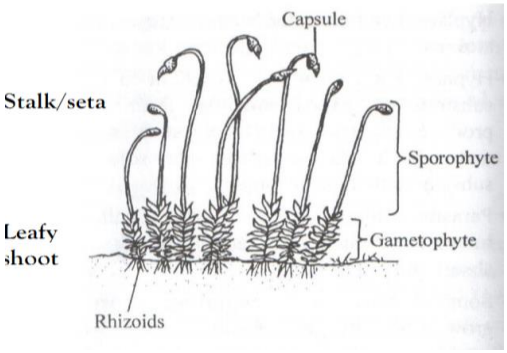
A. Bryophyta.
B. Pteridophyta.
C. Spermatophyta.

A. BRYOPHYTA.

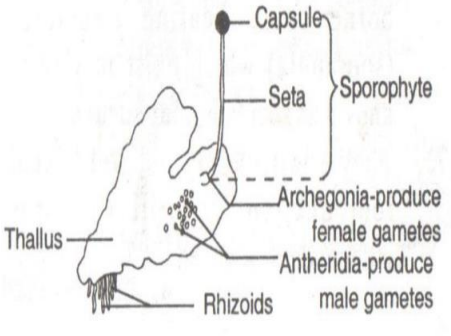
It consists of smallest form of plants which are tiny and green in colour. They grow on damp surfaces of walls and on back of trees.

- They include:
  - Mosses.
  - Liverworts.

Moss



Liverwort



General characteristics of bryophyta.

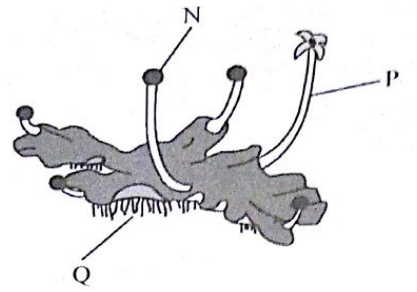
1. They are thin and green in colour.
2. They are autotrophic/contain chlorophyll.
3. They lack vascular bundles.
4. They are **thaloid i.e have undifferented body** as in liverworts or differentiated into simple leaf-like, stem-like and root-like structures (rhizoids).
5. They are terrestrial growing on damp places.
6. They show alternation of generation.
7. They reproduce sexually and asexually.

Alternation of generation/ Process of fertilization in Bryophyta.

- ✓ Fertilization depends on water. The sporophyte/capsule produces spores which germinate to form a gametophyte.
- ✓ The gametophyte has **antheridia** which produces male gametes and **archegonia** which produces female gametes.
- ✓ The mobile sperms/male gametes swim in water to fertilize the egg in the **archegonia** to form a **zygote.**
- ✓ The zygote develops into a young **sporophyte** which grow upwards while still attached to the gametophyte.
- ✓ The sporophyte is the dormant stage while gametophyte is dominant stage.

Study question

The photograph below represents a plant in a certain division.



1. (i) Name the Division to which the plant belongs. (1mk)

✓ Bryophyta

(ii) With reference to the photograph, state three observable features of the Division named in (a) (i) above. (3mks)

✓ Has capsule (for enclosing spores).
✓ Has long setae (for supporting the capsules).
✓ Has rhizoids (for anchorage and absorption of water and mineral salts.
✓ It is thalloid/ thallus/ undifferentiated.

2. Name the parts labeled N and P. (2mks)

N- Capsule.
P- Seta.

3. Explain how the part labeled Q is adapted to its functions. (2mks)

✓ It is numerous / hair-like to increase the surface area for absorption of water and anchorage.

B. PTERIDOPHYTA.

➢ It consists of more advanced plants than bryophytes because:
   i. They show greater ability to inhabit land.
   ii. They show clearly defined sexual reproduction.
   iii. Fertilization does not depend on water.
➢ It includes:
- Ferns
- Horse tails

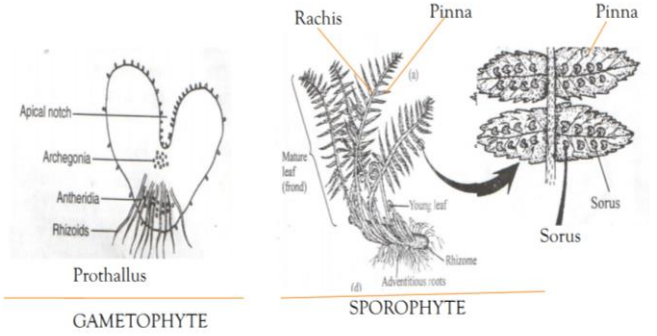
General characteristics of ferns.

1. Plant body is differentiated into roots, stems and leaves but no flowers
2. Have large compound leaves called **fronds.** Fronds have leaf stalk called **rachis.** Attached to the rachis are called **pinna.** On the underside of the pinna there are structures called **sori (singular-sorus)** which carry **sporangia** that contain **spores.**
3. Have chlorophyll/are autotrophic.
4. A sporophyte has underground stem called **Rhizome** from which leaves and roots arise.
5. Have clearly defined vascular system.
6. They reproduce sexually and asexually.
7. They show alternation of generation (where the sporophyte is a dominant stage).

Process of fertilization /Alternation of generation in ferns.

✓ A sporophyte produces spores in the **sori.**
✓ The spores later germinate in the ground into a thin gametophyte (prothallus).
✓ The prothallus/gametophyte has **Antheridia(**which produces male gametes/sperms) and **Archegonia (**which produces eggs/ova/female gametes).
✓ The gametes fuse to form a **zygote** which grows to form a **sporophyte** after which the **gametophyte** dies.

Diagram of a fern.



C. SPERMATOPHYTA.

☐ It consists of:
- Herbs e.g. grasses
- Shrubs e.g. hibiscus
- Trees.

General characteristics of spermatophyta.

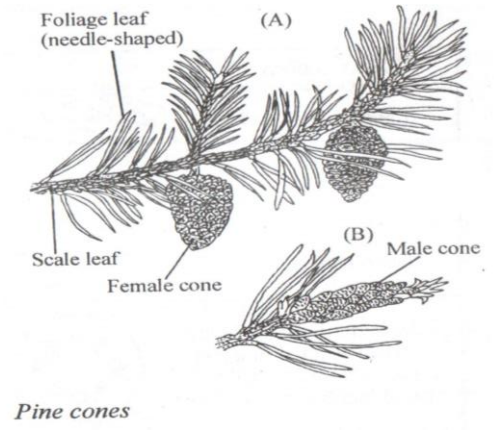
1. They produce seeds.
2. Have well developed vascular bundles.
3. Plant body differentiated into roots, stems, leaves and seed producing structures/flowers.
4. Reproduce sexually and asexually.
5. They are heterospores i.e. produce two types of gametes, female gamete enclosed in the ovule and male gametes in the pollen sac.
6. Have support tissues (collenchyma, sclerenchyma, and xylem).

Sub-divisions of spermatophyta.

➢ They include:
A. Gymnospermae e.g. Pines and Cypress.
B. Angiospermae e.g. Maize, Beans, Jacaranda.

A. General characteristics of gymnospermae.

1. Seeds are not enclosed in the ovary/ seeds are naked.
2. They do not produce flowers.
3. They produce seed bearing structures called **cones.**
4. They produce two types of cones i.e. small male cones that produce pollen grains and larger female cones where seeds are formed.
5. They have xerophytic characteristics e.g. needle shaped leaves, waxy cuticle, sunken stomata.
6. Xylem consists of tracheids only.
7. Phloem does not have companion cells.



Pine cones

General characteristics of angiospermae.

1. Seeds are enclosed in the ovary.
2. They produce bisexual flowers.
3. Their xylem consists of tracheids and vessels.
4. They show double fertilization.
5. The phloem has companion cells.

Differences between gymonspermae and angiospermae.

Gymnospermae	**Angiospermae**
i. Seeds are naked.	i. Seeds are enclosed.
ii. Bear cones where gametes develop.	ii. They bear flowers where gametes develop.
iii. Xylem vessels absent.	iii. Xylem has both vessels and tracheids.
iv. Phloem lack companion cells.	iv. Phloem has companion cells.

CLASSES OF ANGIOSPERMAE.

- They include:

A. Dicotyledonae.
B. Monocotyledonae.

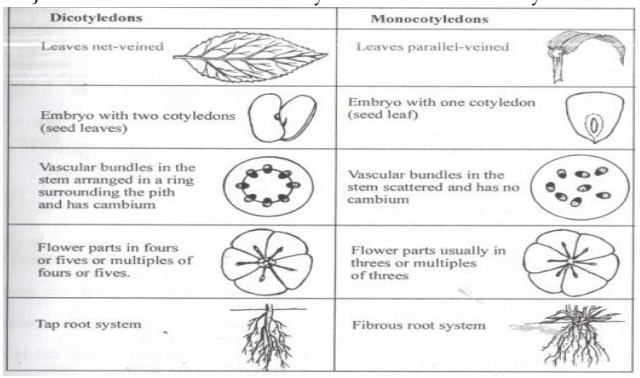
General characteristics of dicotyledonae.

1. The seed has two cotyledons.
2. The leaves are broad.
3. Have taproot system.
4. The leaves has network of veins.
5. Vascular bundles in the stem are arranged in a ring.
6. Have vascular cambium.
7. Xylem in the roots is star shaped and located at the centre with phloem within the arms.
8. Floral parts are arranged in fours or fives or in their multiples.
9. Leaves have a petiole/leaf stalk.

General characteristics of monocotyledonae.

1. Seeds have one cotyledon.
2. Have fibrous root system.
3. Leaves have parallel veins.
4. Vascular bundles are scattered within the cortex of the stem.
5. Roots have a pith.
6. They lack vascular cambium.
7. Floral parts are in threes or multiple of threes.
8. The leaf petiole is modified into a sheath.
9. In the root, vascular bundles are arranged in a ring with xylem alternating with a phloem.

Major differences between dicotyledonae and monocotyledonae.



5. KINGDOM ANIMALIA.

General characteristics of animalia.

i. They are multicellular.
ii. Have eukaryotic cells.
iii. Their cells lack a cell wall.
iv. They are heterotrophic.
v. Reproduce asexually and sexually.
vi. Most of them locomote but a few are sessile.

PHYLA OF ANIMALIA

A. Arthropoda.
B. Chordata/vertebrata.

A. ARTHROPODA

- It is the largest phylum whose members live in water, soil and on land.
- Members in this phylum are called **arthropods.**

Economic importance of arthropods.

1. Some are ectoparasites.
2. Some act as pollinators.
3. Some are used as food.
4. Some are disease vectors.
5. Some are crop pests.

General characteristics of Arthropoda.

1. Have jointed appendages.
2. Their body is covered with **exoskeleton/cuticle** made of chitin.
3. They have segmented bodies.
4. They have open circulatory system.
5. Their bodies are divided into three parts i.e. head, thorax and abdomen but in some the head and thorax are fused to form **cephalothorax.**
6. Gaseous exchange is through tracheal system, gills or book lungs.
7. They have bilateral symmetry i.e. the body can be divided into two parts only.

CLASSES OF ARTHROPODA.

- They include:

A. Diplopoda.
B. Chilopoda.
C. Insecta.
D. Crustacea.
E. Arachnida.

Characteristics/ features that are used to group Arthropoda into classes.

1. The number of legs/legs
2. Presence or absence of antennae.
3. Number of antennae.
4. Number of body parts.
5. Type of eyes.

A. DIPLOPODA- It consists of millipedes.

General characteristics

1. Cylindrical body.
2. Has many simple eyes.
3. Two pairs of legs per segment
4. Head has short antennae.
5. No/lacks poison claws.
6. Has 9-100 segments.
7. Has three body parts (head, thorax and trunk).
8. Has anterior genital aperture.
9. Gaseous exchange is through tracheal system.

Millipede

B. CHILOPODA-it consists of centipedes.

General characteristics

1. Flattened body.
2. Has one pair of simple eyes.
3. One pair of legs per segment.
4. Head has long antennae.
5. Has poison claws.
6. Has 15-21segments.
7. Has two body parts (head and trunk).
8. Has posterior genital aperture.
9. Gaseous exchange is through the tracheal system.

Centipede

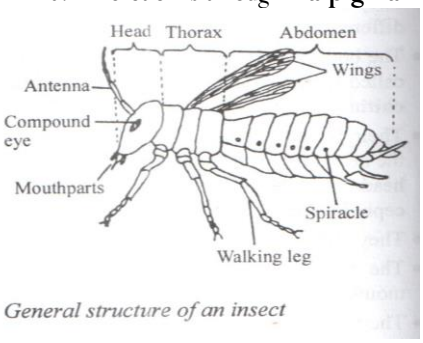
Differences between chilopoda/ centipede and diplopoda/ millipede.

CENTIPEDE/CHILOPODA	MILLIPEDE/DIPLOPODA
1. Flattened body.	1. Cylindrical body.
2. Has one pair of simple eyes.	2. Has many simple eyes.
3. One pair of legs per segment.	3. Two pairs of legs per segment.
4. Head has long antennae.	4. Head has short antennae.
5. Has poison claws.	5. No poison claws.
6. Has 15-21segments.	6. Has 9-100 segments.
7. Has two body parts (head and trunk).	7. Has three body parts (head, thorax and trunk).
8. Has posterior genital aperture.	8. Has anterior genital aperture.

C. **INSECTA** -it consists of insects.

General characteristics

1. Body divided into three parts i.e. head, thorax and abdomen.
2. Have one pair of antennae.
3. Have one pair of compound eyes and several simple eyes.
4. Have three pairs of legs.
5. They breathe through spiracles.
6. The exoskeleton has a layer of wax making it water proof.
7. Mouth parts modified to feeding habits.
8. Have one or two pairs of wings arising from the thorax.
9. Gaseous exchange is through tracheal system.
10. Excretion is through **malpighian tubules.**



General structure of an insect

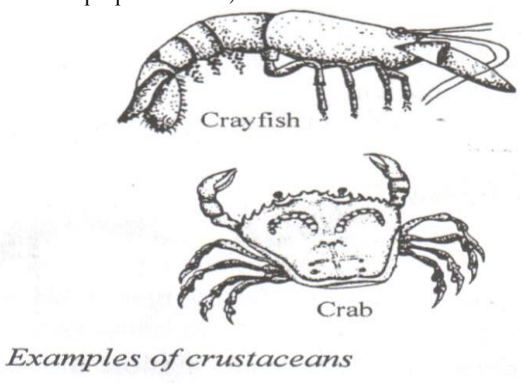
Reasons why insects are adapted to many habitats.

1. Hard exoskeleton which supports the insect above the ground.
2. Water proof layer on the exoskeleton which reduces evaporation hence conserving water.
3. Excretion of uric acid which reduces water loss.
4. Efficient tracheal system for gaseous exchange.
5. Internal fertilization, which eliminates the need for water to achieve successful reproduction.
6. Ability to fly.

D. **CRUSTACEA-** It includes arthropods found in water/aquatic habitat e.g. Crabs, Cray fish, Lobsters, Prawns, Shrimps

General characteristics.

1. The cephalothorax is covered/ protected by carapace.
2. Gaseous exchange through gills.
3. Has two pairs of antennae.
4. Has five or more pairs of limbs/five to twenty pairs of limbs.
5. Has a pair of compound eyes.
6. First pair of limbs modified for defence or holding prey.
7. Has three pairs of mouth parts (consisting of labial pulps/maxillae).

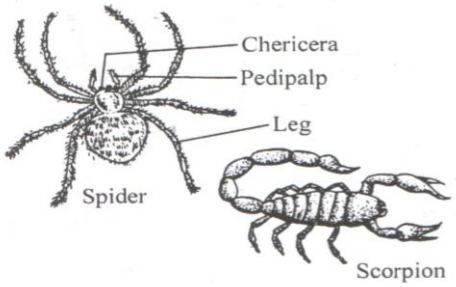


Examples of crustaceans

E. **ARACHNIDA-** It consists of Scorpions, Spiders, Ticks.

General characteristics.

1. The body is divided into 2 parts (**cephalothorax and abdomen).**
2. Have four pairs of walking legs and each leg ends with toothed claws.
3. They lack antennae.
4. Has 8 simple eyes.
5. Gaseous exchange through **book lungs** or **tracheal system.**
6. Has chelicerae to produce poison to paralyze the prey/ are carnivorous.



Examples of arachnids

B. PHYLUM CHORDATA/ VERTEBRATA.

General characteristics.

1. Have a notochord.
2. Have endo or internal skeleton.
3. Have bilateral symmetry.
4. Have a nervous system (brain and spinal cord).
5. The brain is enclosed by a skull.
6. Have a muscular heart to pump blood.
7. Have closed circulatory system.
8. Have a tail or remains of a tail.

Classes of chordata

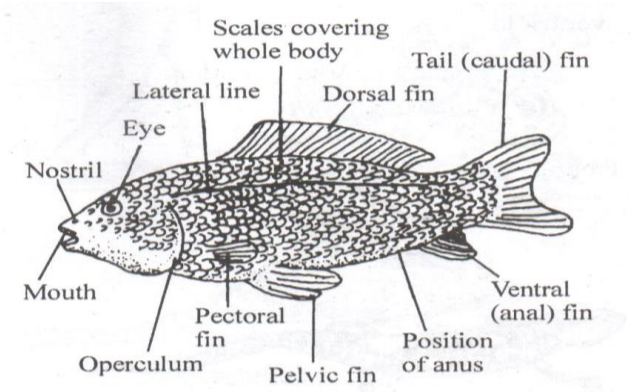
- They include:

A. Pisces.
B. Amphibia.
C. Reptilia.
D. Aves.
E. Mammalia.

A. **PISCES.-**It consists of fish.

General characteristics

1. Have gills for gaseous exchange.
2. Their bodies are covered with scales.
3. They move by means of fins.
4. Are poikilothers/ectotherms.
5. Have external fertilization.
6. Have a lateral line for sensitivity.
7. Have single circulatory system with 2 heart chambers (auricle and ventricle).
8. Have a streamlined body.
9. Their eyes are covered with nictating membrane.



General structure of a fish

B. **AMPHIBIA-** It consists of amphibians that live on both land and water e.g. frogs, toads, newts and salamanders.

General characteristics.

1. Their bodies lack scales.
2. Gaseous exchange is through moist skin, mouth/buccal cavity, lungs and gills (for young amphibians).
3. Have external fertilization.
4. Have double circulatory system.
5. Have 3 chambered heart (2 atria and one ventricle).
6. Live partly in water and partly on land.
7. Have four limbs for movement.
8. Has 2 eyes and ear drum.
9. Are poikilotherms/ectotherms.

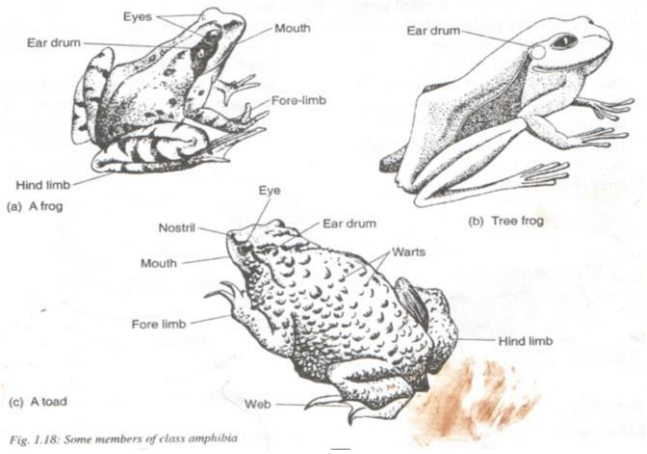


Fig. 1.18: Some members of class amphibia

C. **REPTILIA.** It consists of reptiles e.g. Snakes, Tortoises, Turtles, Crocodiles, Lizards, Chamelions.

General characteristics

1. Have dry scaly skin.
2. Lack external ear.
3. Show internal fertilization with eggs enclosed in a shell.
4. Gaseous exchange is through the lungs.
5. Have double circulatory system.
6. They are poikilotherms/ectotherms.
7. Some have limbs while others crawl on the ground.
8. Some are aquatic and others are terrestrial.
9. They are homodonts (have teeth of the same shape and size).

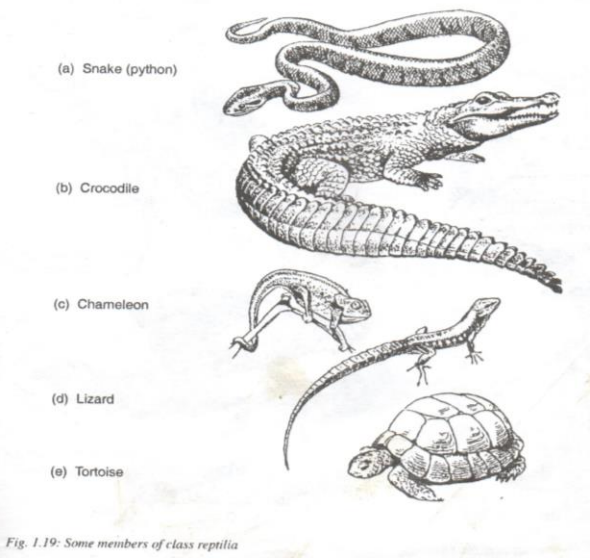
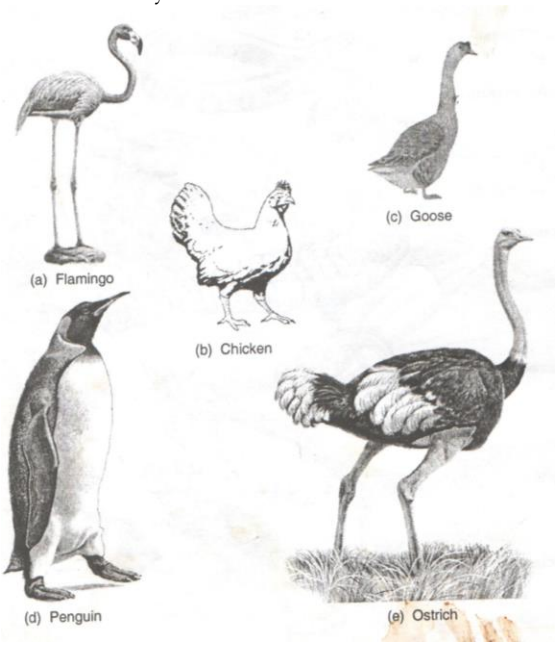


Fig. 1.19: Some members of class reptilia

D. AVES.

General characteristics

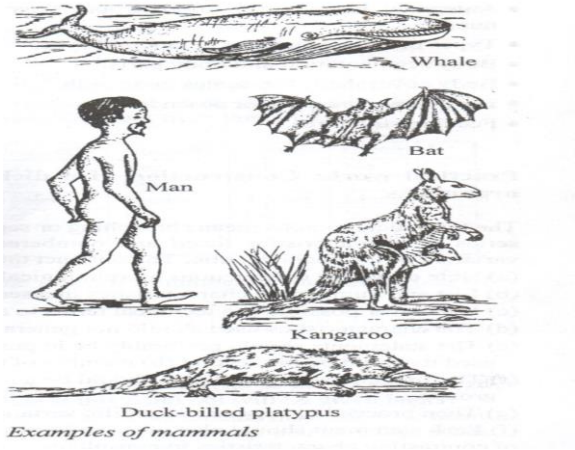
1. Bodies are covered with feathers for insulation and flight.
2. Have beaks for feeding.
3. Legs/hind limbs are covered with scales.
4. Forelimbs are modified to form wings.
5. The sternum/breast bone is modified to form keel for attachment of flight muscles.
6. Gaseous exchange is through lungs.
7. Have double circulation with a four chambered heart.
8. Are endothermic/homoithermic.
9. Fertilization is internal.
10. Have hollow bones.
11. Are **terrestrial (**live on land), **arboreal** (live on trees) and others are **aquatic (**live in water).
12. Have air sacs which store air used to lower the body density.



E. **MAMMALIA.** -It consists of mammals e.g. Bat Man,Cows, Apes, Dolphines, Whales, Lions, Elephants.

General characteristics

1. The skin is covered with fur, hair/wool.
2. Have mammary glands.
3. Have 2 external ears (pinnae).
4. Show internal fertilization.
5. Are homoithermic/endothermic.
6. They use lungs for gaseous exchange.
7. Their brain is highly developed. They give birth to young ones/ does not lay eggs.
8. Have double circulation with four chambered heart.
9. Have sweat glands.
10. Have four limbs.
11. They are heterodont/ have four types of teeth.
12. Have 7 cervical vertebrae.



Examples of mammals

DICHOTOMOUS KEY.

- ✓ This is a set of instructions used to identify unknown organisms by using description of observable features.

Rules used in the construction of a dichotomous key.

1. Note down the morphological characteristics of the organisms to be identified.
2. Number the characteristics starting with the one showing major variation and proceed progressively with characteristics that show lesser variations e.g.

i. Type of leaf.
ii. Leaf venation
iii. Leaf margin

3. Following the order of numbers, for each of the characteristic construct two contrasting statements that enable you to separate the organisms into two groups.
4. For each of the statements, use identical forms of words. The two statements should be positive and where a negative statement cannot be avoided the first statement should be in positive form e.g.

a) Animal without wings.
b) Animal without wings.

Points to note.

1. Avoid generalizations e.g.

a) Tall plants.
b) Short plants

EXTERNAL FEATURES OF PLANTS

A. Leaves

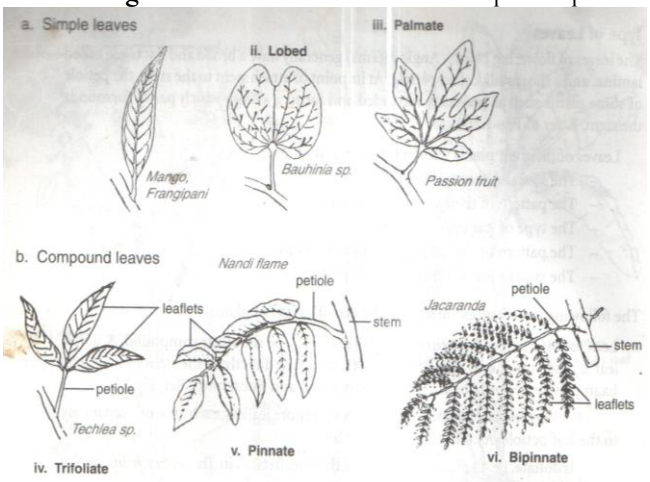
1. Leaf type.

- The leaf can either be simple or compound.
- **In simple leaves**, the lamina is not divided and is attached directly to the petiole.
- A simple leaf can either be palmate (with 5 tip sections) and lobed/bilobed (with 2 tip sections)

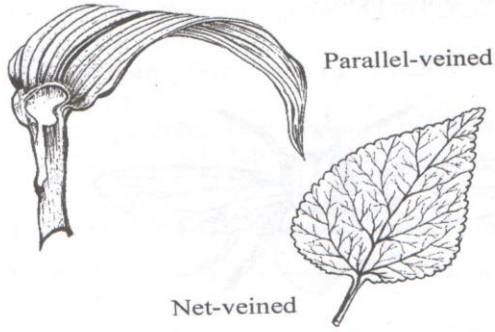
- A compound leaf may be:

i. **Trifoliate-** the leaf is made up of three leaflets.

ii. **Pinnate-** leaf with several leaflets arranged along the petiole.
iii. **Bipinnate-** each leaflet is further subdivided.
iv. **Digitate-** the leaflets all arise from the tip of the petiole.

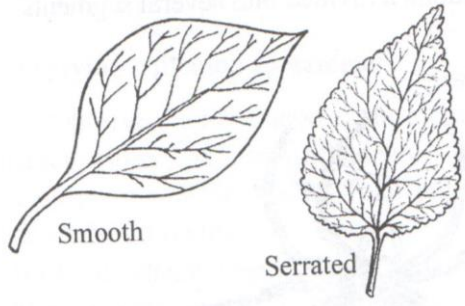


2. Leaf venation.
✓ This is the arrangement of veins in a leaf.
✓ Monocotyledons have **parallel venation** meaning that veins are arranged in a parallel fashion e.g. maize plant, grass etc.
✓ Dicots have network venation e.g. bean plant

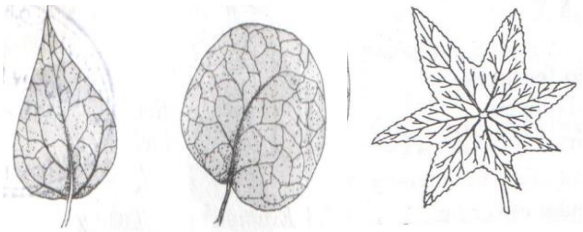


Parallel and net venation

3. Leaf margin.
- The leaf margin is either **smooth**/ **entire** or **serrated.**

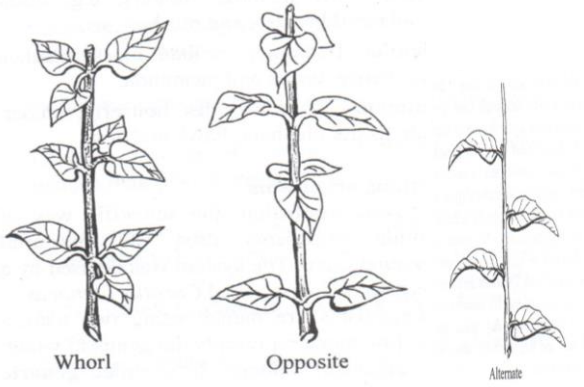


4. Leaf tip/apex.
- The tip/apex can either be **round or pointed.**



Pointed tip Rounded tip **Pointed but lobed**

5. Arrangement of leaves around the stem (leaf phyllotaxy).
- The point where a leaf or leaves are attached to the stem is called **node.**
- Arrangement of the leaves can be:
i. **Whorl:** Three or more leaves arise at the same node around the stem.
ii. **Opposite:** Two leaves are attached opposite to each other on the same node.
iii. **Alternate:** A single leaf arises from each node while the leaf in the next node arises on the opposite side.

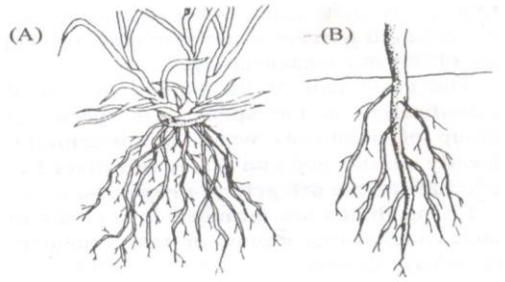


6. Leaf attachment on the stem.
i. **Petiolate-** the leaves have a petiole/leaf stalk.
ii. **Sessile-** the leaves do not have a leaf stalk/petiole/ have leaf sheath.
7. Presence of leaf sheath/ petiole
8. Leaf texture- rough or smooth.
9. Leaf colour- green or variegated.

B. ROOT SYSTEMS.
- There are two major types of root systems:
i. **Fibrous root system-** which consists of several main roots of about the same size.
- This type is mainly seen in monocotyledons.
ii. **The tap root system-** which consists of one main root from which smaller branches arise.
- This is found in dicotyledons.

C. STEMS.
- Stems are classified as either **horizontal** (growing along the ground) or **vertical** (growing upwards).
- They may also be classified as **herbaceous** (non-woody) or **woody.**

D. FLOWERS.
- Flowers are classified on the following basis:
i. **Colour of the flowers:** In some plants, the flowers are brightly coloured while in others they are dull.
ii. **Single flowers or inflorescence:** In some plants flowers occur singly while in others many flowers are borne on the same branch forming an inflorescence.



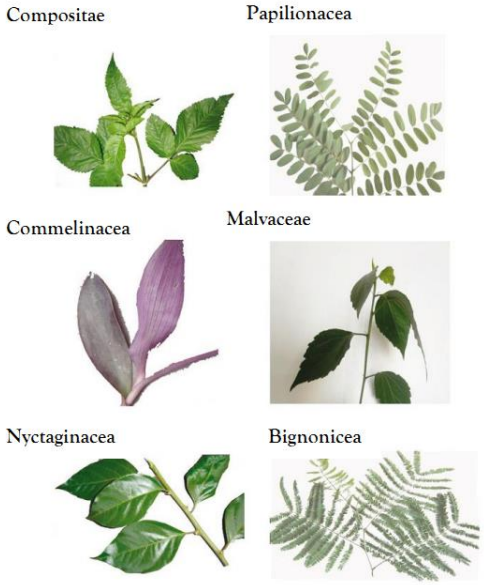
(A) Fibrous root system of grass and (B) Taproot system of bean plant

EXTERNAL FEATURES OF ANIMALS.

i. **Body shape and size-** small/ simple or large.
ii. **Body symmetry-** Most animals are **bilaterally symmetrical** i.e. they can be divided into similar right and left halves but in one plane only.
- Other animals are **radially symmetrical** i.e. they can be divided into right and left halves along several vertical planes.
iii. **Body covering-** e.g. scales, feathers, hair/fur, and shell.
iv. **Locomotory organs** e.g. legs, fins, wings.
v. **Body support structures-** endoskeleton, exoskeleton or hydroskeleton.

EXAMPLE 1

- Below are photographs showing some observable features of leaves.



- Using the features in the order given below, construct a dichotomous key that can be used to identify the specimens.

i. Simple or compound leaves;
ii. Leaf venation;
iii. Leaf margin;
iv. Arrangement of leaves on the stem;
v. Pinnate or trifoliate nature of leaves.

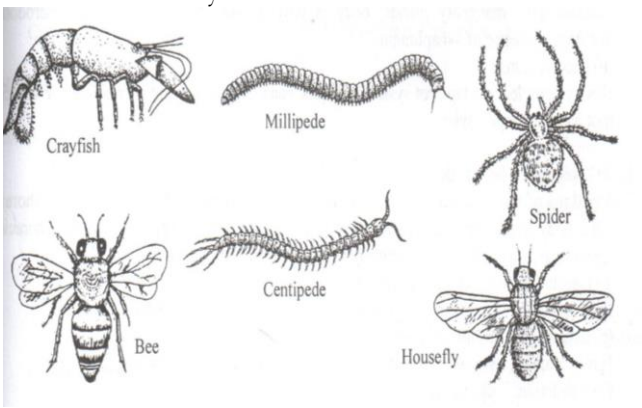
1a. Simple leaf
b. compound leaf
2a. Leaf with parallel venation
b. Leaf with network venation
3a. Leaf with smooth margin
b. Leaf with serrated margin
4a. Alternate arrangement of leaves
b. Opposite arrangement of leaves
5a. Pinnate leaf
b. Trifoliate leaf

Answer

1a. Simple leaf ……***go to 2***
b. compound leaf……***go to 2***
2a. Leaf with parallel venation…..***Commelinaceae***
b. Leaf with network venation……***go to 3***
3a. Leaf with smooth margin..***Nystaginaceae***
b. Leaf with serrated margin……***go to 4***
4a. Alternate arrangement of leaves……***Malvaceae***
b. Opposite arrangement of leaves…..***go to 5***
5a. Pinnate leaf……***papilionaceae***
b. Trifoliate leaf……***compositae***

EXAMPLE 2

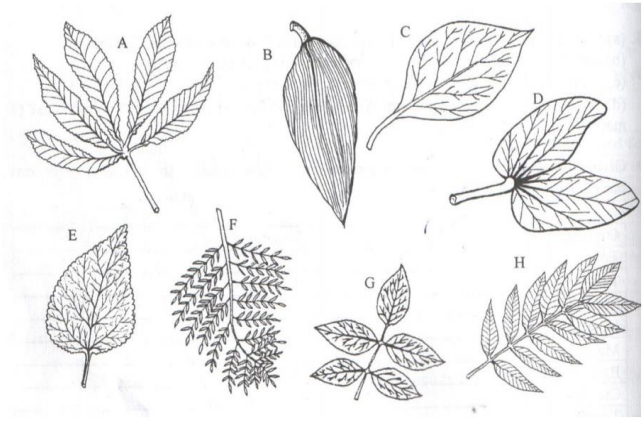
- Examine the drawing of the organisms shown below. Using features that are clearly visible, construct a dichotomous key that can be used to identify them.



1a) Animal with wings……go to 2
b) Animal without wings……go to 3
2a) With one pair of wings……Housefly
b) With two pairs of wings……Bee
3a) With four pairs of walking legs..go to 4
b) With more than four pairs of walking legs……go to 5
4a) With antennae……Crayfish
b) Without antennae……Spider
5a) One pair of legs in each body segment……Centipede
b) Two pairs of legs in each body segment……Millipede

EXAMPLE 3

- Examine the drawings of the leaves and the dichotomous key shown below. Using the key, identify each of the leaves A-H into their respective families. In each case, give the sequence of steps followed to arrive at the identity and fill the table below.



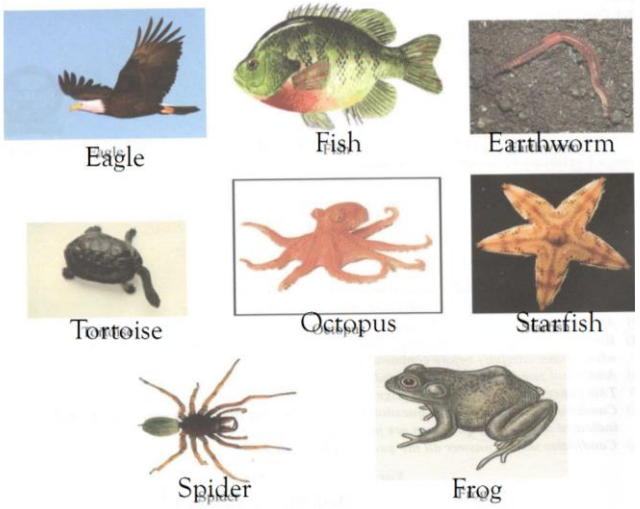
Key

1a) Leaf simple……go to 2
b) Leaf compound……go to 5
2a) Leaf parallel-veined……Commelinaceae
b) Leaf network-veined…..go to 3
3a) Leaf margin smooth……go to 4
b) Leaf margin serrated……Verbenaceae
4a) Leaf apex acute…Nyctaginaceae
b) Leaf apex emarginated……Fabaceae
5a) Palmately compound leaf……Malvaceae
b) Pinnately compound leaf……go to 6
6a) Bipinnate compound leaf……Bignoniaceae
b) Unipinnate compound leaf……go to 7
7a) Leaf with terminal leaflet……Rosaceae
b) Leaf without terminal leaflet……Papillionaceae

	Steps followed	Identity
A	1b, 5a	Malvaceae
B	1a, 2a	Commelinaceae
C	1a, 2b, 3a, 4a	Nyctaginaceae
D	1a, 2b, 3a, 4b	Fabaceae
E	1a, 2b, 3b	Verbenaceae
F	1b, 5b, 6a	Bignoniaceae
G	1b, 5b, 6b, 7a	Rosaceae
H	1b, 5b, 6b, 7b	Papillionaceae

EXAMPLE 4

- Using the pictures of animals provided below, complete the construction of the dichotomous key by filling the blank spaces.



1. a) Animal with a backbone…go to 2
b) Animal without backbone…
2. a) Animal with wings……
b) Animal without wings……
3. a) Animals which live in water all the time……
b) Animal which live in water some time……
4. a) Animal with scales……
b) Animals without scales……
5. a) Animal with legs……
b)Animal without legs…….go to 7
6. a) Animals with six legs……Butterfly
b) Animals with eight legs……
7. a) Animals with a shell……Snail.
b) Animals without a shell……
8. a) Animals with a jelly-like body……
b) Animals without a jell-like body…..
9. a) Animals with a segmented body……
b) Animals without a segmented body……Octopus

Answer

1. a) Animal with a backbone……go to 2
b) Animal without backbone…….. go to 5
2. a) Animal with wings……Eagle
b) Animal without wings……go to 3
3. a) Animals which live in water all the time……Fish
b) Animal which live in water some time……go to 4
4. a) Animal with scales…..Tortoise
b) Animals without scales…….Frog
5. a) Animal with legs……go to 6
b) Animal without legs……go to 7
6. a) Animals with six legs……Butterfly
b) Animals with eight legs…Spider
7. a) Animals with a shell….Snail.
b) Animals without a shell…go to 8
8. a) Animals with a jelly-like body…go to 9
b) Animals without a jell-like body……Starfish
9. a) Animals with a segmented body……Earthworm
b) Animals without a segmented body……Octopus

TOPIC 2- ECOLOGY

Definition of terms.

1. **Ecology** is the study of interrelationships of organisms to each other and with their environment.
2. **Environment** constitutes the surroundings of the organisms both living (biotic) and non-living (abiotic or physical)
3. **Autecology** is the study of single species. It involves studying the relationship of the species with both biotic and abiotic components of ecosystem.
4. **Synecology** is the study of many/different species. It involves studying the relationship of the species with both biotic and abiotic components of the ecosystem.
5. **Habitat -** this is a specific place/locality with a particular set of conditions where an organism lives. They are generally categorized as **aquatic** (water) **and terrestrial** (land) **habitats.**
6. **Biosphere/ ecosphere-** this is the part of the earth and the atmosphere inhabited by living organisms.
7. **Ecological niche-** this is the position/ physical space where the organism lives and the role it plays (feeding relationships and other interactions with other species).
8. **Population-** refers to all members of a particular species in a particular habitat at a particular time e.g. population of lions in Tsavo national park.
9. **Community-** refers to all organisms belonging to different species that interact in the same habitat. It therefore consists of populations.
10. **Ecosystem-** it is a natural unit composed of abiotic and biotic factors whose interactions lead to a self-sustaining system e.g. a pond.
11. **Biomass-** this is the total dry weight of living organisms at a particular feeding/ trophic level e.g. total dry weight of maize crop per hectare or zebras in a park.
12. **Carrying capacity-** refers to maximum number of organisms an area can comfortably support without depletion of available resources e.g. maximum number of cattle a paddock can hold without getting overgrazed.

Application of knowledge gained from ecology

i. Sustainable food production.
ii. Conservation of natural resources.
iii. Pollution control.
iv. Control of pests and diseases.
v. Prediction of climate change.
vi. Population control.
vii. Ecotourism- tourism to exotic or threatened ecosystems to observe wildlife or help to conserve nature.

FACTORS IN AN ECOSYSYEM.

A. Abiotic/Physical/non-living factors.

1. **Light.** It is obtained from the sun as the main source of energy. It is measured by **a photographic light meter.**

Effects.

i. It affects photosynthesis, flowering/ photoperiodism, germination (e.g. in lettuce seeds), opening and closing of stomata; gaseous exchange in plants.
ii. It affects hibernation, synthesis of vitamin D, migration, reproduction and vision in animals.

2. Temperature- It is measured by use of thermometer.

Effects.

i. It affects biochemical reactions because they are controlled by enzymes/ affects enzymatic activities.
   - ✓ Low temperature inactivate enzymes while high temperature denature the enzymes.
ii. It affects the rate of transpiration; evaporation, sweating, photosynthesis, hibernation/ aestivation.

3. Wind- this is moving air. Measured by a wind vane (for direction) and wind sock (for strength).

Effects.

i. It affects evaporation and transpiration.
ii. It facilitates spore, fruit and seed dispersal.
iii. It is an agent of pollination.
iv. Strong wind may break/ uproot trees.
v. Wind may blow away/ bring rain-bearing clouds.
vi. It influences migration of animals.
vii. It influences predation through wafting of the scent.
viii. It causes formation of waves in aquatic habitats facilitating aeration.

4. **Atmospheric pressure-** this is the pressure exerted by the air in the atmosphere. It is measured by a **barometer.**

Effects.

i. Variation in atmospheric pressure affects the amount of oxygen available for respiration and carbon (IV) oxide in the atmosphere for photosynthesis.
ii. Decreased atmospheric pressure increases the rate of transpiration.

5. **Humidity-** this is the volume of water vapor in the atmosphere. When humidity is high there is much water vapor in the atmosphere and when it is low, there is less water vapor in the atmosphere. It is measured by:

i. Paper hygrometer.
ii. Blue anhydrous cobalt (II) chloride paper which turns pink when hydrated. It turns pink faster in humid atmosphere than in relatively dry atmosphere.

Effects of humidity

i. Affects the rate of evaporation, sweating and transpiration hence affecting their distribution.

6. **pH (hydrogen ion concentration)**- Refers to the degree of alkalinity or acidity in aquatic habitats/soil solution. It is measured by use of BDH universal indicator paper/pH meter.

Effects.

i. Affects the distribution plants and animals in soil and fresh water ponds.
ii. Affects the degree of soil fertility.

7. **Salinity- r**efers to the degree of salt concentration in aquatic habitats/ water.

- Based on salt concentration, the aquatic environment is divided into:

i. **Fresh water habitats-** have no salt e.g. rivers, lakes, ponds and wells.
ii. **Marine habitats-** have high salt concentration e.g. oceans.
iii. **Estuarine habitats**- with fluctuating salt concentration.

- ✓ Influences the maintenance of osmotic pressure/ osmoregulation in aquatic animals hence distribution of animals.
- ✓ It is determined by calculating the percentage of salts in water or by acid base titration method.

8. Rainfall/ water
- ✓ The main source of water is rain and the amount of rainfall is measured by use of **rain gauge.**

Effects
- i. It is required for germination.
- ii. It is a raw material for photosynthesis.
- iii. It acts as universal solvent.
- iv. It acts as a medium of transport of substances.
- v. It provides turgidity to cells/ support in herbaceous plants.
- vi. It is an agent of fruit and seed dispersal.
- vii. It is an agent of pollination in some aquatic plants.
- viii. It is required for fertilization in Pteridophytes and Bryophytes;

9. **Topography**-this is the slope of land;
- i. It affects distribution of crops.
- ✓ Wind ward side receives more rainfall hence more and healthy crops/ plants grow.
- ✓ The leeward side receives less rainfall hence fewer and stunted crops/ plants grow.
- ii. North facing slopes in the southern hemisphere have more plants.
- iii. It affects the rate of soil erosion.

B. BIOTIC INTER-RELATIONSHIPS/ INTERACTIONS.

1. PREDATION/ PREDATOR-PREY RELATIONSHIP/ INTERACTION.
- ✓ A predator is an animal that hunts/ kills another (prey) for food e.g. a dog and a hare.
- ✓ Preys have survival mechanisms in their habitats not to be eaten/ killed.
- ✓ Predators have survival mechanisms to enable them survive and reproduce/ propagate their lineage.

Adaptations of the prey.
- i) They run faster/ have strong hind muscles (to escape the predator).
- ii) They camouflage with the environment (i.e. resemble the environment) hence not easily noticed by the predators.
- iii) Some mimic the predators (i.e. they resemble the predators).
- iv) Some emit some chemicals/ smell that turn off predators.
- v) Some have good sense of smell and sight to detect predators.
- vi) Some (e.g. porcupines) have quills/ spines, others (e.g. grasshoppers) have spikes to fight off predators.
- vii) Some have a wider vision/ view to locate the predator.

Adaptations of the predator.
- i) They run faster so as to capture the prey.
- ii) They camouflage with the environment hence not easily noticed by the prey.
- iii) Some mimic the preys.
- iv) They have sharp eyesight to locate the prey.
- v) They have strong sense of smell and sight to locate and identify the prey.
- vi) Some produce venom/ poison that paralyze/ kill prey.
- vii) Some have strong jaws/ claws/ sharp canines/ hawks (for hawks) to capture prey.

Effects/ economic importance of predation.

1. It brings about the biological control especially to destroy disadvantageous prey.
- ▪ **Biological control-** refers to the use of natural enemies to regulate the population of unwanted species.

2. Helps to control the population size of the predator and prey e.g. an increase in the number of gazelles leads to an increase in number of lions.
- \- As lion number increases, they feed on the gazelles whose members will decrease to such a low level that the lions will start to starve and die or migrate.

2. PARASITISM (ANTAGONISTIC/ ANTIPATHETIC SYMBIOSIS).
- \- This is a kind of interspecific relationship/ association where one member/ organism (parasite) benefits while the other (the host) is harmed/ loses.
- ✓ There are two types of parasites, endo/ internal parasites (found inside the body of organism) e.g. liverfluke, roundworm, tapeworm) and ecto/ external parasites (found outside the body of organism) e.g. ticks, fleas, mites).
- ✓ For example a tick (parasite) sucks blood/ nutrients from a cow (host) causing the cow to be anaemic, transmit diseases, destroying the skin, causing it to be malnourished.

Differences between predation and parasitism.
- i. In predation the whole organism/large parts are used as food while in parasitism, tiny parts/tissues are used as food.
- ii. In predation the whole organism dies while in parasitism organism does not die.
- iii. In predation, one predator feeds on many preys while in parasitism many parasites feed on one.

Similarities between predation and parasitism.
- i. In both, one organism uses another organism as food.
- ii. In both, one benefits and the other suffers.

3. **SYMBIOSIS-** this is a close relationship between two organisms of different species where the two mutually benefit from each other.
- ✓ Examples include:
- a) **Bacteria in the rumen/ gut of herbivores-** the bacteria help the herbivores to digest cellulose and herbivores provide shelter to the bacteria.
- b) **The bacteria found in human digestive system/ gut/ colon-** the human beings provide shelter to bacteria while bacteria help to synthesize/ manufacture vitamin K and B12 (or ensures microbial balance).
- c) **The nitrogen fixing bacteria (Rhizobium sp) on root nodules of leguminous plants-** plants provide food and shelter to bacteria while bacteria convert/ fix atmospheric nitrogen into nitrates/ ammonium compounds which are absorbed by plants.
- d) **Mycorrhiza (association between fungus and roots of coniferous/ forest trees-** Mycorrhiza absorbs mineral salts for plant use while trees provide food/ organic materials to fungi)
- e) **Lichen (association between blue green algae and fungus)-** blue green algae provides nutrients/ carries out photosynthesis while the fungus absorbs water and provides a point of attachment for algae.

4. **COMPETITION-** This is an association where two/ more organisms depend on the same limited resources e.g. food, light, water, mates and shelter.
- ✓ Example zebra and gazelle competing for grass.

- ✓ In competition organisms which are poorly adapted die or migrate while the organisms which are well adapted survive hence the species increases competition can be interspecific; or intraspecific.

Types of competition.

a. **Intraspecific competition-** Competition among members of the same species

Signs of intraspecific competition in plants.

i. Thin and tall plants.
ii. Yellow and pale green plants.
iii. Low yield.

b. **Interspecific competition-** Competition among members/organisms of different species.

- If two different species occupy the same ecological niche, sooner or later one will outdo/ eliminate the other. This is called **competition exclusion principle.**
- The organism that outdoes/ eliminates the other has better structural and behavioral adaptations e.g. high rate of multiplication. Organisms without such adaptations migrate or die.
- To avoid competition exclusion principle the organisms **need to occupy different ecological niches.**
- Competition helps to regulate/control population size of organisms.

Study question.

- Explain why the carrying capacity of wild animals is higher than that of cattle in a given area.
- ✓ Wild animals have different feeding habits e.g. some are grazers while others are browsers hence there is minimum competition for food and space.
- ✓ Cattle have the same feeding habits (all are grazers) hence there is competition for food hence fewer cattle can be supported in a given area.

5. SAPROPHYTISM.

- This is a relationship where organisms obtain nutrients from dead organic matter causing decomposition. These organisms are called **saprophytes e.g. bacteria and fungi.**
- They release enzymes that digest the dead decaying matter and the products are directly absorbed into the tissue of the saprophyte.

Importance/ role of saprophytism/ saprophytes/ decomposers in the ecosystem.

Beneficial roles

i) They break down dead organic matter facilitating recycling of nutrients/ improve soil fertility.
ii) Some e.g. *Rhizobium and Azotobacter* are involved in nitrogen fixation/ convert nitrogen to nitrates for plant use.
iii) Treatment of sewage and production of biogas.
iv) Are used in food processing industries for production of yoghurt, cheese, vinegar.
v) Used in curing tea and tobacco and making silage.
vi) Genetically engineered bacteria are used as a source of proteins, for production of enzymes in detergents and for manufacture of hormones e.g. insulin.
vii) Symbiotic bacteria in ruminants and rodents, secrete cellulose enzyme that digests cellulose.

Harmful effects

i. They cause decay hence spoilage of food leading to food poisoning.
ii. Parasitic bacteria e.g. *Streptococcus sp, Pneumoniae sp, Vibrio cholera* cause plant and animal diseases.
iii. Denitrifying bacteria reduce soil nitrates to free nitrogen thus reducing soil fertility.

NITROGEN CYCLE.

- ✓ This is the cycling of nitrogen and its compounds in nature. Nitrogen is used in manufacture of proteins.

Steps/cycle

A. **Nitrogen fixation-** atmospheric nitrogen converted into nitrates/ ammonia for plant use/absorption through biological and non-biological nitrogen fixation.

i. **Biological-** Nitrogen fixation by **symbiotic bacteria** e.g. ***Rhizobium*** in the root nodules of the legumes (which convert nitrogen gas into ammonia which are then converted into ammonium compounds).
ii. Biological- Nitrogen fixation by non-symbiotic bacteria and free living micro-organisms found in the soil e.g. *Azotobacter sp, Clostridium sp, and some algae e.g. Nostoc, blue green algae, chlorella, Anabaena* (which fix nitrogen into ammonia which is then converted into nitrates).
iii. **Non- biological/ Lightning-** During thunderstorm the lightning energy combines atmospheric nitrogen with oxygen to form Nitrogen (IV) oxide. Nitrogen (IV) oxide later dissolves in rain water to form weak nitric acid and nitrous acid. The nitric acid combines with metal ions in the soil to form nitrates.

B. **Absorption by plants-** plants absorb nitrate ions or ammonium ions directly from the soil and them to make amino acids/plant proteins through the process of photosynthesis (hence nitrogen is incorporated into the plant protein).

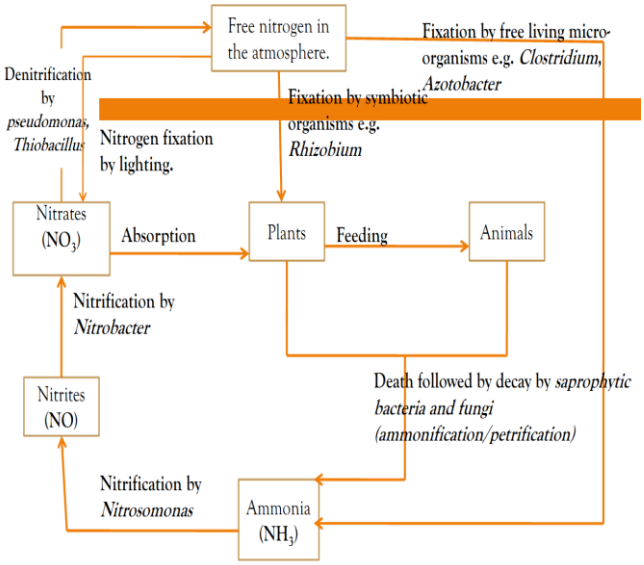
C. **Feeding-** by animals on plant proteins and assimilate them to form animal proteins.

D. **Ammonification/petrification/death and decay-** When animal and plants die they and their wastes and droppings are acted upon by *saprophytic bacteria and fungi* to form **ammonium compounds.**

E. Nitrification- Ammonium compounds are converted into nitrites by nitrifying bacteria e.g. *Nitrosomonas* and *Nitrococcus* . Nitrites are then converted into nitrates by nitrifying bacteria e.g. Nitrobacter. Nitrification enriches the soil with nutrients.

F. Denitrification- Nitrates in the soil are converted into nitrites, ammonia or free nitrogen gas by denitrifying bacteria e.g. *Pseudomonas denitrificans and Thiobacillus denitrificans.*

- Denitrification deprives soil of fixed nitrogen gas and releasing free nitrogen into the air.



Role of nitrogen cycle- Helps to regulate the atmospheric nitrogen.

i. It acts as a source of energy for decomposers.
ii. It allows free nitrogen in the atmosphere to be incorporated into the tissues of organisms.
iii. It enriches the soil with nitrogen for plant use.

Role of decomposers/saprophytes in nitrogen cycle.

i. Their action results into release of nutrients into the soil.

ENERGY FLOW IN THE ECOSYSTEM.

- ✓ The sun is the main source of this energy which is contained in food eaten.
- ✓ Energy flow is the flow of chemical energy in feeding relationship/from one feeding level to the other.
- ✓ Plants absorb the light energy from the sun and use it in manufacture of food for themselves and consumers hence it is incorporated into the plant tissues hence plants are called ***primary producers.***

N/B-The role of producers is to manufacture food to be used by themselves and all other organisms in the ecosystem.

- ✓ Primary consumers obtain the energy from plants/primary producers e.g. **plants,**
- ✓ *Secondary consumers* e.g. herbivores obtain the energy from the primary consumers,
- ✓ *Tertiary consumers* e.g. leopard obtain energy from the secondary consumer.
- ✓ *Quaternary consumers* (scavengers) e.g. **vulture** obtain energy from the tertiary consumer.
- ✓ When living organisms die they are broken down/decomposed by **decomposers (saprophytes) e.g. bacteria and fungi.**
- ✓ The feeding level (producers to consumers) is called **feeding/trophic level.**
- ✓ A small portions of energy is passed from one trophic level to the next therefore the number of organisms in a given trophic level must be more than the succeeding trophic level.
- ✓ This is because some energy is lost through:

i. Respiration,
ii. Excretion,
iii. Excreation/defecation/egestion,
iv. Decomposition,
v. Unedible materials not consumed.

FOOD CHAINS

- ✓ A food chain is a linear representation of the flow of energy from the **producers** to **consumers** and to the **decomposers.**
- ✓ Examples include:

a) Grass → Grasshopper → Bird
b) Napier grass → Goat → Man

- ✓ The arrow points to the eater.

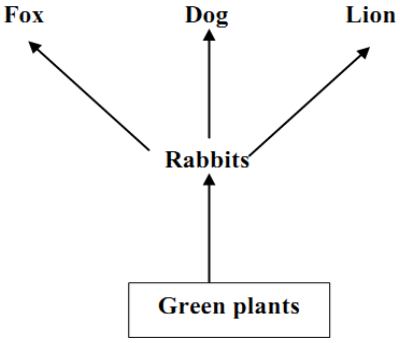
Methods of determining the type of diet of organisms.

a) Dissecting the organism and analyzing the contents of the digestive system/gut.
b) Observations as they feed.
c) Examining the droppings.
d) Studying their dentition/beaks.

FOOD WEBS

- ✓ A food web consists of many food chains.

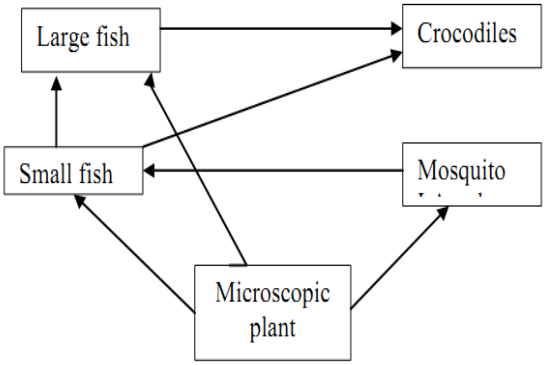
Example 1



a) a. Name the food relationship above.
- ✓ Food web

b) How many trophic levels are shown in the diagram above?
- ✓ Three

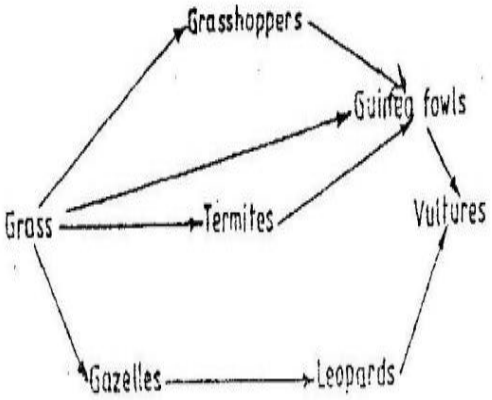
Example 2



a) Construct a food chain ending with crocodile as a quaternary consumer.
- ✓ Microscopic plants → mosquito larvae → small fish → large fish → crocodiles

b) Name the organism in the food web that has only one predator.
- ✓ Large fish
- ✓ Mosquito larvae

Example 3



a) Write down the food chains in which the guinea fowls are secondary consumers.

✓ Grass → Grasshoppers → Guinea fowls

✓ Grass → Termites → Guinea fowls

b) What would be the short term effects on the ecosystem if lions invaded the area?

✓ Lions would compete with leopards for food/prey

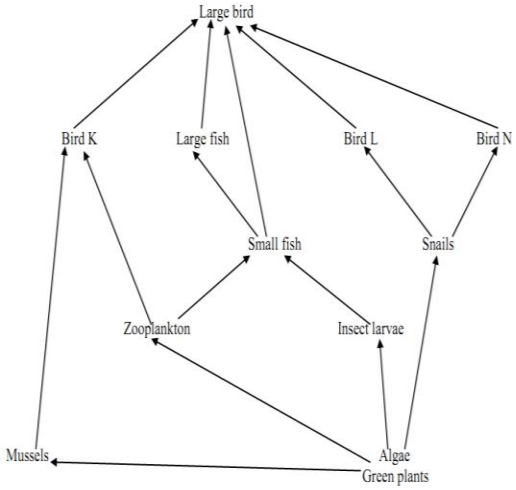
✓ Gazelle numbers would reduce

✓ Grass would increase

c) Name the organism through which energy from the sun enters the food web.

- Grass

Example 4



a) Name the process through which energy from the sun is incorporated into the food web.

✓ Photosynthesis

b) State the mode of feeding of the fish in the food web.

✓ Carnivorous

c) Name the two ecosystems in which the organisms in the food web live.

✓ Terrestrial and aquatic

d) What would happen to the organisms in the food web if bird L migrated?

✓ The number of snails would increase hence more food for bird N whose population would increase. The number of algae and green plants would reduce as they are eaten by the large number of snails.

e) From the information in the food web, construct a food chain with the large fish as the tertiary consumer.

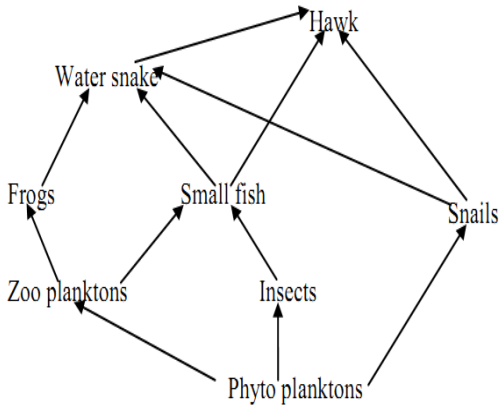
✓ Algae → Insect larvae → Small fish → large fish

✓ Algae → zooplankton → Small fish → large fish

f) The biomass of producers in the ecosystem was found to be greater than that of the primary consumers. Explain.

- So that the producers are able to support the primary consumers. This is because energy is lost through respiration.

Example 5



(i) Name the producers in the ecosystem.

✓ Phytoplanktons

(ii) Name two organisms which are both secondary and tertiary consumers.

✓ Hawk; and water snake

(iii) State **two** short term effects of immigration of insects in the ecosystem.

✓ Decrease in phytoplanktons

✓ Increase in population of small fish

(iv) Which organism has the least Biomass in the food web? Explain.

✓ Hawk;

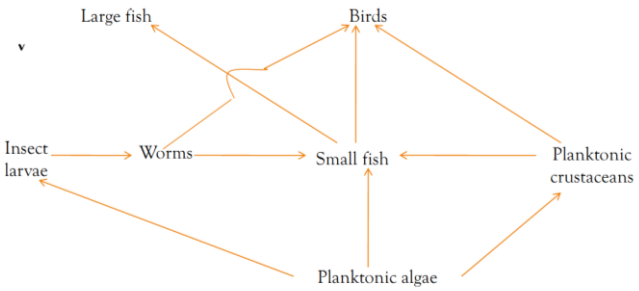
✓ Reason – it is a top predator. Amount of energy decreases in successive trophic levels or energy is lost through respiration; egestion/ excreation, undigested/unconverted food.

Example 6

Given that:

i. Small fish feed on planktonic crustaceans and worms.
ii. Insect larvae feed on planktonic algae.
iii. Large fish feed on small fish.
iv. Birds feed on small fish, planktonic crustaceans and worms.
v. Worms feed on insect larvae.
vi. Planktonic crustaceans feed on planktonic algae.

a) Construct a food web from the above information.



b) Name the organisms that compete for food.

✓ Small fish and birds.

- ✓ Birds and large fish.
- ✓ Planktonic crustaceans, small fish and insect larva.

c) How does man interferes with the above ecosystem?

- ✓ Carrying out fishing.
- ✓ Polluting the water body.
- ✓ Irrigating using the water from the lake.

d) Explain why primary productivity decreases with increase in depth in water /aquatic habitat.

- ✓ Decrease in light intensity.
- ✓ Decrease in temperature.

PYRAMID OF NUMBERS.

- ✓ A pyramid of number is a diagram which represents the total number of organisms at different feeding/trophic levels.
- ✓ It shows the relationship between the number of organisms occupying the trophic levels.
- ✓ Usually the greatest in number are producers followed by consumers in decreasing order.
- ✓ At each trophic level energy is lost in respiration and thus fewer organisms can be supported at a succeeding level.

Constructing pyramid of numbers

i. Use data provided/collected.
ii. From the data identify and draw the most suitable food chain.
iii. Indicate the numbers at each trophic level in the food chain.
iv. Choose a most suitable scale from the data.
v. Using the chosen scale, draw a horizontal rectangular bar to represent the number of producers as the base of the pyramid.
vi.
vii. Progressively draw horizontal bars to represent other trophic levels.

Example.

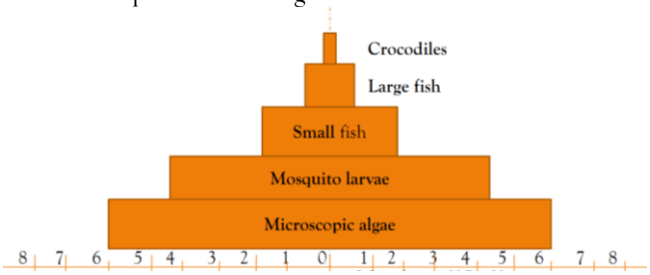
- ✓ The following table shows the estimated number of organisms recorded in a farm.
- ☐ Small fish- 3,500
- ☐ Microscopic algae- 12, 000
- ☐ Crocodiles-100
- ☐ Large fish- 950
- ☐ Mosquito larvae- 8, 900

a) Construct a possible food chain for the dam.

Microscopic algae → mosquito larvae → small fish → large fish → crocodiles

b) Construct a pyramid of numbers from the given data.

Scale: 1cm represents 1000 organisms



c) Explain the shape of the pyramid obtained.

- ✓ The number of organisms decreases up the trophic levels.
- ✓ This is because energy is lost in form of respiration in succeeding trophic levels meaning that fewer numbers can be supported up the trophic levels.

Limitations of pyramid of numbers.

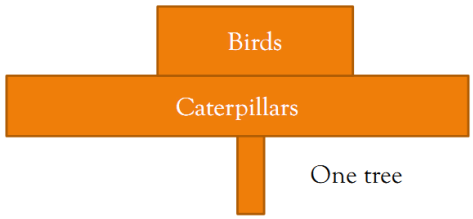
i. Producers vary in size yet they are given the same status.
ii. It is difficult to draw the pyramid of numbers to scale because the numbers vary.
iii. It is difficult to determine the trophic levels of some organisms because some occupy more than one trophic level.

Inverted/irregular pyramid of numbers.

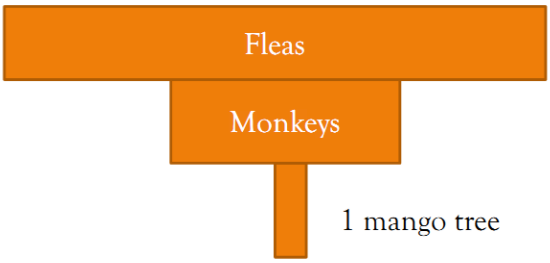
- ✓ It is obtained when the number of organisms does not decrease in succeeding trophic levels e.g.

1. Many caterpillars feeding on one tree which in turn are fed on by birds.
2. Monkeys feeding on one mango tree which are in turn fed on by several fleas/parasites.

Example 1,Partially inverted pyramid of numbers.



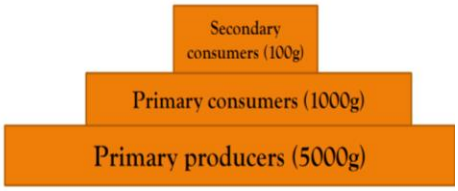
Example 2, Fully/Completely inverted pyramid of numbers.



PYRAMID OF BIOMASS.

- ✓ This is a diagram drawn to represent the dry mass of organisms at different feeding/trophic levels.
- ✓ Primary producers/plants have largest biomass because they are producers i.e. obtain the energy directly from the sun and use it to manufacture food from which other organisms depend on directly or indirectly.
- ✓ Tertiary/Quaternary consumers have the lowest biomass because they occupy the highest trophic levels.
- ✓ As the trophic levels are ascended, most of biomass is lost in form of faeces, urine and as heat during respiration. In a stable ecosystem, the biomass of any trophic level should become more than the successive level in order to support the successive level.
- ✓ The ecosystem should be **ecologically balanced i.e.** the components in the ecosystem are available in a steady manner such that there is no depletion of any of them.
- ✓ In the aquatic ecosystem, the pyramid of biomass is partially/completely inverted because some aquatic organisms have alternative preys.

Example



Example

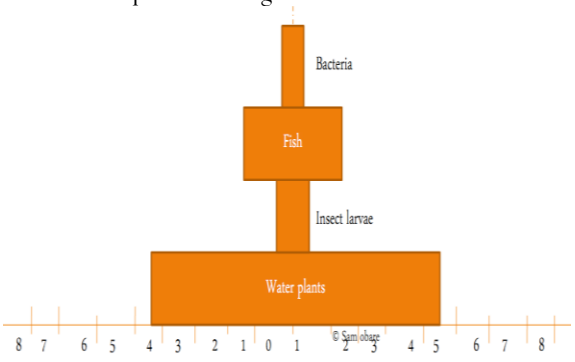
- ✓ The table below gives information about the aquarium which is ecologically balanced.
- ✓ Insect larvae- 500g
- ✓ Fish -1, 200g
- ✓ Water plants- 5, 000g
- ✓ Bacteria – 10g

a) Construct a suitable food chain.

Water plants → insect larvae → fish → bacteria

b) Construct a pyramid of biomass from the given data.

Scale: 1cm represents 500 grams



c) Explain the shape of the pyramid of biomass.

- It is partially inverted because although the insect larvae have less biomass can sustain the fish due to the large number and many eggs laid by the insects.
- Fish will also depend on alternative prey.

d) State two roles of green plants in a fish aquarium other than providing food for fish.

i. Generate oxygen.
ii. Remove carbon (IV) oxide.

POPULATION.

- This is a group of organisms belonging to the same species in a particular habitat e.g. a population of buffalos in a national park.

Characteristics of a population.

1. **Population density-** refers to the number of organisms per unit area.
2. **Population dispersion-** refers to the spread/distribution of organisms.
3. **Population growth rate-** refers to the rate of increase in numbers.

Factors influencing population growth rate.

1. Availability of food.
2. Space.
3. Diseases.
4. Predators
5. Pests.

Population growth.

- When population data is plotted against time, a **sigmoid (s-shaped)** curve is formed.
- It is divided into 4 regions/phases namely:

A. -Lag phase
B. -Log/exponential phase
C. -Decelerating phase
D. -Plateau phase

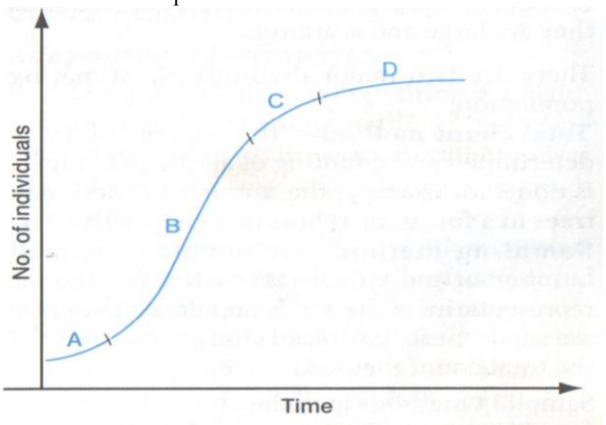


Fig. 9.8 A generalised population growth curve

Phases of sigmoid curve

1. **Lag phase-** The rate of population growth is low/no change in population because:

i. The reproducing individuals are few/have not given birth.
ii. Organisms have not adjusted to the environment.
iii. Organisms still maturing.

2. **B-log/exponential phase-** There is rapid/faster population growth rate because:

i. The organisms have fully adjusted to the environment.
ii. The number of reproducing organisms is high/organisms have sexually matured..
iii. There are enough resources e.g. food and space/no competition.
iv. There are no diseases.
v. Birth rate higher than death rate.

3. **Decelerating phase-** There is reduced growth rate because:

i. Competition as a result of increase in population/overcrowding/space/food limiting.
ii. Accumulation of wastes.
iii. Disease outbreak
iv. Death rate higher than birth rate.

4. **D-plateau phase-** There is no increase/change in population because:

i. Aged/old organisms.
ii. Death rate equal to birth rate.
iii. Limited resources.

- At this point population stops growing and the habitat is said to have attained **carrying capacity.**

Ways through which food regulates population growth.

- More food causes population increase due to high rate of reproduction and immigration leading to competition for food causing death or emigration reducing the population.

METHODS OF POPULATION ESTIMATION.

Reasons for population estimation.

1. To help draw a pyramid of numbers.
2. To establish the population/total number of organisms of a particular species.

- The methods include:

A. Direct counting/head counting/census.
B. Aerial photography count.
C. Sampling methods.

- Sampling methods include:

1. Quadrat method.
2. Line transect.
3. Belt transect.
4. Capture-recapture method.

1. QUADRAT METHOD.

- A **quadrat** is a square frame of 1m x 1m but can be subdivided into smaller squares using a string.
- The method is suitable when estimating the population of small plants e.g. grass, herbs and small slow moving animals.

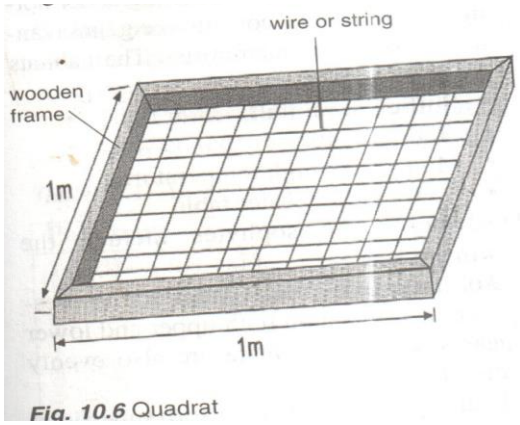


Fig. 10.6 Quadrat

Procedure of using a quadrat.

i. Select the area e.g. play ground.
ii. Estimate the size of the area e.g. 5000m^2 .
iii. Throw the quadrat at random, count the number of organisms of the same species within the quadrat and record
iv. Throw as many times as possible and record.
v. Calculate the average number of organisms in each quadrat.
vi. Use the average to estimate the population in the field/area.

- ✓ 1st -20 organisms
- ✓ 2nd -2 organisms
- ✓ 3rd – 100 organisms
- ✓ 4th – 0 organisms
- ✓ 5th – 50 organisms
- ✓ 6th – 8 organisms

Average

20+2+100+0+50+8 =30
8

- Therefore:

1m2 =30 organisms
5000 m2 =?
= (5000 x 30) organisms
=150,000 organisms

Limitations of quadrat method

1. Randomness is not assured.
2. It is tedious/laborious and time consuming if the area is large.
3. Cannot be used on large plants and most animals.

2. LINE TRANSECT METHOD.

- It involves the use of straight line/rope and a quadrat.
- It is suitable to estimate the population of small plants.

Procedure

i. Identify the area/field to be studied.
ii. Estimate the size in square metres.
iii. Take a long rope/line and stretch across the area/field.
iv. Select equal stations along the rope/line.
v. Place the quadrat at the 1st station ensuring that the line passes though the centre of the quadrat.
vi. Count the number of organisms of the same species in the quadrat and record.
vii. Repeat the procedure in all stations and record.
viii. Calculate the average and estimate the population as in quadrat method.

3. BELT TRANSECT METHOD.

- ✓ It involves the use of two parallel lines/ropes which are 1 m apart.
- ✓ It is used to estimate the population of herbs and shrubs.

Procedure

i. Identify the area/field.
ii. Estimate the size in square metres e.g. 5000m^2
iii. Stretch/lay down 2 ropes of known length parallel to each other **but 1m apart.**
iv. Count the number of organisms of the same species between the ropes and record.
v. Repeat the procedure several times, record and calculate the average.
vi. Use the average to calculate the total number of organisms in the field.

Example

- If the length of the ropes/belts is 20m, then the area of the belts is (20 x 1)= 20 square meters
- If the average number of organisms is 160, then 20 square meters = 160 organisms

- Therefore, 20m2=160 organisms
5000 m2 = ?
= $\frac{5000 \times 160}{20}$
= 40,000 organisms.

4. CAPTURE- RECAPTURE METHOD.

- The method involves capturing, marking, recording, releasing them after marking them.

- It is suitable in estimating the population of highly mobile/constantly moving organisms e.g. crabs, birds, fish, grasshoppers.

Procedure.

1. Select the habitat.
2. Capture as many animals as possible of the same species.
3. Count them, mark using indelible ink and release them **(FCM).**
4. Allow them to mix freely for 24 hours.
5. Recapture the organisms.
6. Record the total number of organisms in the 2nd capture **(SC)** and the number of marked organisms **(SCM).**
7. Use the formula to calculate the total population/number of organisms in the habitat **(TP).**

$$\frac{FCM}{TP} = \frac{SCM}{SC}$$

$$TP \times SCM = SC \times FCM$$

$$TP = \frac{SC \times FCM}{SCM}$$

Where:
TP- Total population
SC- Second capture
FCM- First capture and marked
SCM- Second capture but marked

Materials used to capture the animals

1. Mosquito nets.
2. Fish/seine nets.
3. Sweep nets.
4. Specimen bottles.

Marking techniques/methods and tools

1. Use of light colored paint that is quick to dry e.g. cellulose, colored nail varnish.
2. Use of tags.
3. Tiny brush/ spot marker.

- The marking technique should not harm the animal or alter its behavior.

Example

- A fish farmer wanted to know the number of fish in a pond. He collected **10** fish from the pond and labeled each by a tag label on its fin and returned the ten fish to the pond to mix with other fish. When he later collected **50** fish from the pond, he found only **4** of them had labels. Estimate the total number of fish in the pond (show your working).

- Population $= \frac{FCM \times SC}{SCM}$

$$TP = \frac{10 \times 50}{4} = \frac{500}{4}$$

$$= 125 \text{ fish}$$

ASSUMPTIONS OF CAPTURE-RECAPTURE METHOD.

1. The marked/released organisms mix freely with the rest of the population.
2. The marked/released organisms have enough time to mix freely with the rest.
3. There is no death/ variation/ reproduction in population during the study period/ the population does not vary during the study period.
4. There is no migration in and out of the habitat/study area.
5. The marking technique does not affect the behavior of the organism.
6. There is a uniform/random distribution of animals in the habitat/study area.

ADAPTATIONS OF PLANTS TO VARIOUS HABITATS.

A. XEROPHYTES.

- Xerophytes are plants with adaptations to withstand dry conditions e.g. those found in arid and semi arid areas
- These areas have the following features:

1. Low humidity.
2. Unpredictable and poorly distributed rain.
3. Very high temperatures.
4. Strong winds.

Adaptations.

1. They have ***small and narrow leaves/needle-like leaves and spines*** to reduce the surface area over which transpiration occurs
2. The leaves ***have thick, waxy and shiny cuticle*** to minimize water loss through the cuticle.
3. The leaves have ***sunken stomata*** which accumulate moisture in pits/depressions thus lowering the diffusion gradient reducing the rate of transpiration.
4. Some have ***folded leaves*** hence not exposing stomata to environmental factors thus reducing the rate of transpiration.
5. Some xerophytes show **reversed stomatal rhythm** i.e. they open the stomata during the night and close during the day to prevent excessive water loss through transpiration during the day.
6. Some xerophytes ***shed their leaves*** during drought to reduce the surface area exposed to transpiration.
7. Xerophytes leaves and stems are succulent due to the presence of parenchyma cells to store water which is used during drought.
8. They have ***few/ reduced number of stomata*** that lower the rate of transpiration.
9. Some have ***deep roots*** to absorb water from deep in the soil while some have superficial roots (roots which grow horizontally close to the surface) to absorb water after light or short showers of rain.
10. Some xerophytes have short life cycles to escape drought, hence some survive as seeds or underground storage organs.

B. MESOPHYTES.

- These are plants that grow under normal conditions of well aerated soil and water supply.
- The conditions in those areas include:

i. Adequate rainfall.
ii. Relatively high humidity.
iii. Moderate to high temperature.
iv. Less wind.
v. Shallow water table.

Adaptations

1. The leaves have ***thin cuticle*** to reduce the distance travelled by gases/ for faster diffusion of gases to the

photosynthetic/palisade cells/ and increase the rate of transpiration.

2. The leaves have ***broad lamina*** to increase the surface area for absorption of light and carbon (IV) oxide and transpiration.
3. They have ***mosaic arrangement of leaves*** to avoid overlapping and over shadowing to increase the surface area for absorption of gases and light.
4. They have ***stomata on the upper and lower leaf epidermis*** for efficient gaseous exchange and transpiration.
5. Their ***leaves have transparent cuticle and epidermal cells*** to allow light penetration to the palisade cells and increase the rate of transpiration.
6. Their ***leaves have air spaces in spongy mesophyll*** for gases to diffuse easily into the palisade cells/ for efficient gaseous exchange.
7. Palisade ***cells contain numerous chloroplasts with*** chlorophyll next to the upper epidermis to receive maximum light for photosynthesis.

C. HYDROPHYTES.

- They are plants found in fresh water, marshy/swampy areas.
- They take up excess water and therefore need to lose more water through transpiration.
- Their habitats have the following characteristics:

i. Low O_2 concentration.
ii. Low light intensity.
iii. Low mineral salt concentration content.
iv. A lot of water.
v. Waves and currents.

Types of hydrophtytes

- There are three types of hydrophytes:

i. **<u>Floating hydrophytes-</u>** they float on the surface and the roots are freely hanging in water.
ii. **<u>Emergent hydrophytes-</u>** the root system is anchored to the bottom of the pond but the leaves are above the surface of water.
iii. **<u>Submerged hydrophytes-</u>** they are fully immersed in water.

Adaptations of hydrophytes.

1. ***Emergent and floating hydrophytes have broad leaves with numerous stomata*** on the upper surface to increase the surface area for transpiration and for efficient gaseous exchange.
2. ***Submerged hydrophytes have highly dissected leaves into thread-like straws*** to increase surface area for absorption of maximum light and carbon (IV) oxide for photosynthesis and gaseous exchange.
3. Floating hydrophytes have long fibrous roots to absorb mineral salts.
4. They have poorly developed roots that lack root hairs to reduce absorption of water.
5. They have aerenchyma tissue/ large air filled tissues for buoyancy and for gaseous exchange.
6. Flowers of emergent and floating hydrophytes are raised above the water to allow pollination.
7. The leaves of ***submerged hydrophytes have numerous and sensitive chloroplasts*** that photosynthesize under low light intensities.
8. Leaf lamina is thin for faster diffusion of gases.
9. Leaves lack cuticle to allow for water loss.

D. HALOPHYTES.

- They are plants that are able to tolerate and grow in very salty soils or water. Their habitats are characterized by:

i. High concentration of mineral salts.
ii. Low concentration of dissolved gases.
iii. Low light intensity.
iv. Currents and waves.

How do halophytes suffer from physiological drought?

- The surrounding soil/water medium is hypertonic (contains high salt concentration) as compared to the cell sap of the halophytes. This prevents the absorption of water through osmosis thus plants suffer from physiological drought.

Adaptations of halophytes.

1. Their root cells have high salt concentration to absorb water by osmosis.
2. They have water storage tissues/ succulent tissues that store water to dilute the cell cytoplasm.
3. Some have salt glands on the leaves to get rid/ remove excess salts.
4. They have large air spaces/ aerenchyma tissue in their leaves, stems and fruits to provide buoyancy and for gaseous exchange.
5. Some hydrophytes e.g. mangrove have pneumatophores (breathing roots) for gaseous exchange.
6. They have tissues which are tolerant to dehydration.
7. Submerged halophytes have sensitive chloroplasts which carry out photosynthesis under low light intensity.

Example

- The table below shows stomatal distribution on leaves A and B and their surface area. Use the information to answer the questions that follow.

	Leaf surface	A	B
Number of stomata	Upper surface	20	5
	Lower surface	0	15
Surface area		25 cm square	18 cm square

Identify with reasons the habitats of the plant from which the leaves were obtained:

a) Leaf A

Habitat- Aquatic

Reasons:

i. Stomata are located on the upper surface (to increase the rate of transpiration).
ii. The leaf has a large surface area (to provide a large surface area for transpiration).

b) Leaf B.

<u>Habitat-</u> Terrestrial/ normal dry land.

Reasons.

i. More stomata on the lower surface/ fewer stomata on the upper surface.
ii. Smaller surface area (to reduce the surface area for transpiration).

POLLUTION

- It refers to release of substances of forms of energy into the environment by human activities in such quantities whose effects are either harmful or unpleasant to human and other living organisms.
- Those substances are called **pollutants. A pollutant** is a substance/ a waste that contaminates air, water and soil.

A. AIR POLLUTION.

- Refers to release of substances to the air in amounts that destroy the environment and are harmful to human health and other organisms.

Causes and effects.

1. Release of chemical substances containing Sulphur (IV) oxide, hydrogen sulphide, nitrogen (IV) oxide from volcanic activities-

i) They cause acid rain which;

✓ Alters/ changes/ lowers the soil pH thus affecting plants and other living organisms in the soil.

✓ Causes leaching of minerals/ nutrients.

ii) Sulphur (IV) oxide causes respiratory infections e.g. bronchitis, Pneumonia and heart failure.

iii) Nitrogen (IV) oxide is carcinogenic thus causes cancer.

iv) They interfere with gaseous exchange in animals.

v) Hydrogen sulphide is poisonous when inhaled hence it causes death.

2. **<u>Carbon (IV) oxide and carbon (II) oxide from the combustion of garbage and organic fuels-</u>** they cause greenhouse effect/ global warming which raises the ocean levels resulting in the flooding of lowlands/ interfering with weather patterns/ excessive evaporation from water bodies leading to unexpected heavy rains.

✓ Carbon (II) oxide causes respiratory poisoning / suffocation because it combines with haemoglobin to form stable compound carboxyhaemoglobin which does not dissociate easily reducing the capacity of haemoglobin from carrying oxygen.

3. Smoke and fumes from factories and engines

✓ They reduce visibility on the roads.

✓ They block the stomata of leaves affecting photosynthesis and transpiration.

✓ They cause eye irritation, headaches and breathing difficulties.

✓ Thy contain carbon (IV) oxide which is a respiratory poison.

4. **<u>Dust from cement and lime factories, quarries and road construction-</u>** it blocks the stomata of leaves hence affecting photosynthesis and transpiration.

✓ It can cause respiratory diseases/ affects respiratory system.

✓ It reduces visibility and irritates the eyes.

5. Chlorofluorocarbons (CFCs) from aerosols (e.g. pesticides, herbicides, dry cleaning agents)-they cause irritation to respiratory organs and poisoning of water plants.

✓ They also deplete ozone layer leading to more penetration of ultraviolet (UV) rays which cause skin cancer and affect crops.

6. Lead from combustion/ burning of leaded petrol by motor vehicles.

✓ It enters the blood stream thus damaging the body organs e.g. brain, liver and kidneys.

✓ It affects the nervous system causing mental disorders/ poor mental development.

✓ It blocks the stomata hindering gaseous exchange and photosynthesis causing death of the plant.

7. **<u>Aerosols e.g.</u>** pesticides, insecticides, fungicides, perfumes, air freshener and spray paints.

- The main pollutants of aerosols are copper, lead and chlorofluorocarbons (CFC)

✓ Copper causes irritation of respiratory organs and poisoning of water plants and fish.

✓ Chlorofluorocarbons deplete ozone layer leading to increased penetration of ultra violet (UV) rays that cause skin cancer in humans.

8. Noise from vehicles, machines in factories, aeroplanes.

✓ It interferes with hearing in animals.

✓ It causes stress, headache and abortion.

Control of air pollution

1. Use of CFC free aerosols, perfumes and appliances.
2. Use of unleaded fuels in vehicles.
3. Use of ear muffs in factories and industries.
4. Use of renewable sources of energy e.g. biogas and electricity.
5. Use of biological methods instead of using pesticides and herbicides.
6. Legislation i.e. enforcement of laws on environmental pollution.
7. Exhaust pipes should have filters to remove impurities/ solid particles from the released gas.
8. Educating the public on the need of and how to control air pollution.
9. Scrubbing the gases emitted from factories to remove acidic gases e.g. nitrogen (IV) oxide and Sulphur (IV) oxide.
10. Ban smoking in public places.

B. WATER POLLUTION.

Refers to release of substances to water source in levels that are harmful to organisms.

Causes and effects

1. Release of untreated sewage into water bodies- it contains faeces and nitrogenous wastes.

✓ Sewage contains pathogens that cause water borne diseases e.g. cholera, Typhoid, amoebic dysentery.

✓ Sewage contains nitrogenous wastes/ nitrates that cause eutrophication which reduces oxygen in water thus causing death of aquatic organisms through suffocation.

Eutrophication.

- ✓ This is the enrichment of water bodies by nutrients e.g. phosphates and nitrates from inorganic fertilizers, organic manure and untreated sewage.
- ✓ This promotes excessive growth of algae/ algal bloom.
- ✓ The algal growth leads to reduction of light penetration into the water thus affecting primary productivity causing death of aquatic plants/ autotrophs.
- ✓ As the aquatic plants and algae die, they further increase organic matter increasing the action of decomposers.
- ✓ The decomposers deplete oxygen from water, causing the death of aquatic organisms.

2. **Release of domestic and industrial wastes into water bodies-** they contain poisonous substances/ chemicals that kill the aquatic organisms and enter the food chain and accumulate to toxic levels.
3. **Hot water -**from industries discharged into water bodies.

Effects.

a) Heat reduces the amount of dissolved gases e.g. oxygen and carbon (IV) oxide killing the organisms due to lack of oxygen or lack of photosynthesis.
b) Heat raises the respiratory rate to abnormal levels causing malfunctioning in the organisms.
c) Hot water may kill the living organisms by denaturing enzymes.

4. Oil spillage in water bodies from oil tankers and offshore oil refineries from oil tanker accidents, offshore oil wells and damaged warships.

Effects of oil

i. Oil spreads on the surface of water reducing oxygen supply into the water leading to suffocation and death of aquatic organisms.
ii. Oil also blocks the stomata thus affecting photosynthesis and gaseous exchange of phytoplanktons thus killing them.
iii. Oil layer leads to reduced light penetration thus affecting photosynthesis.
iv. Oil also stick together feathers of aquatic birds making it difficult for the birds to fly.
v. Oil clogs the respiratory surfaces of aquatic animals killing them.

5. **Agro-chemicals-** e.g. fertilizers, herbicides, pesticides. Fertilizers contain nitrates and phosphates while pesticides contain heavy metals e.g. mercury and copper and Chlorofluorocarbon which is not easily broken down/ non-biodegradable.

Effects.

i. The heavy metals affect respiratory activities of aquatic organisms.
ii. The heavy metals accumulate in bodies of organisms and affect functioning of body organs e.g. brain, kidney and liver.
iii. The heavy metals enter the food chains and accumulate along the chains becoming poisonous at higher trophic levels.
iv. Nitrates and phosphates in fertilizers cause eutrophication and change in water pH.

6. Lead from pipes and tanks in domestic water supply systems.
- ✓ Lead affects the physiological functioning of body organs.
- ✓ It also damages the nervous system resulting in mental problems.

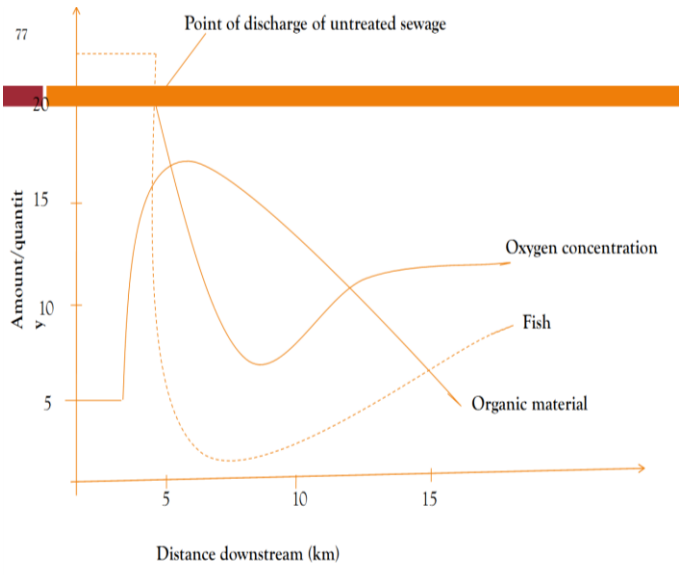
7. Soil erosion.
- ✓ It causes siltation of water bodies making water unfit for human consumption and unsuitable habitation for certain animals.
- ✓ Silt/ soil particles clog the respiratory surfaces of plants and animals thus affecting gaseous exchange.
- ✓ Soil particles/ silt reduce light penetration thus reducing the rate of photosynthesis in aquatic plants.

Control of water pollution.

1. Treatment and proper disposal of sewage.
2. Treatment of industrial waste before disposal and cooling of hot water from the industries before discharging it into water bodies.
3. Caution when transporting oil in ships and when mining petroleum found in ocean deposits.
4. Biological and cultural control of weeds, pests and diseases.
5. Use of organic manure instead of inorganic fertilizers.
6. Prevent soil erosion through terracing, construction of gabions and reaforestation.
7. Disposal of litter/ garbage in designated places but not/ away from water bodies.
8. Use of biodegradable herbicides and pesticides.
9. Educate farmers on the use of correct amounts of agro chemicals.
10. Banning the use of phosphate –based detergents.
11. Replacing lead pipes with plastic pipes.

Study question.

- Sewage contains saprophytic organisms and organic materials. The graph below shows changes occurring in a river for some distance downstream, from a point of untreated sewage discharge.



1) Suggest the reasons for the increase in oxygen after 10 km downstream. (2mks)

- Removal of bacteria by river flow increased plant growth that released more oxygen.

2) Account the relationship between oxygen and fish. (2mks)

- As the concentration of oxygen decreases, the population of fish also decreases and vice versa.
- This is because fish require oxygen for respiration without which they suffocate and die.

3) Explain why there was a gradual fall in the amount of organic matter released into the river shortly after the point of discharge of untreated sewage into the river. (2mks)

- Saprophytes decompose organic matter for food hence they drop.

4) Ammonia is produced by the process taking place in the sewage treatment works and should be removed before released into the river. Explain why this is important. (2mks)

- Ammonia is highly toxic and alkaline which can interfere with the pH.

C. SOIL POLLUTION.

- Refers to release of substances into soil in levels that are harmful to organisms

Causes and effects

1. **Acid rain-**increases the soil pH thus affecting plants and other organisms in the soil.
   - ✓ It causes leaching leading to loss of soil fertility.
2. **Aerosols-** they contain heavy metals (e.g. lead and mercury).
   - ✓ The chemicals kill micro-organisms in the soil thus reducing soil fertility;
   - ✓ The heavy metals enter the food chain and accumulate to high levels causing death.
3. Solid wastes e.g. plastics, glass, rubber, metals and non-biodegradable materials-
   - ✓ They form breeding grounds for mosquitoes, rats and flies which are disease vectors.
   - ✓ They limit soil aeration and microbial activity thus making soil infertile.
   - ✓ Some e.g. glass bottles can injury to animals.
   - ✓ They also destroy the aesthetic value of land.
4. **Inorganic fertilizers-** they reduce the pH of soil thus affecting plants and soil organisms thus reducing microbial activity reducing soil fertility.
5. Oil from overturned oil tankers, burst oil pipelines, garages and oil refineries.
   - ✓ It covers the ground thus affecting soil aeration thus reducing the microbial activities.
6. **Chemicals e.g. acids and strong bases/ alkalis-** they cause changes in soil pH thus affecting plants and soil micro-organisms which thus lowers rate of decomposition/ fertility.
   - ✓ They also cause leaching of nutrients/ mineral salts thus lowering fertility.
7. **Radioactive emissions-** they cause cancer, mutations and death.

Control of soil pollution

1. Famers to use organic manures instead of inorganic fertilizers.
2. Use of biological methods to control pests and diseases.
3. Recycling of solid wastes e.g. plastics.
4. Biodegradable wastes e.g. plant materials and food remains should be disposed in a compost pit.
5. Transporting petroleum products using pipeline to prevent spillage.
6. Enactment of laws on land pollution.
7. Proper handling and deposition of non-biodegradable wastes e.g. controlled burning, burying deep in the soil.
8. Wastes e.g. clothes and papers should be burned in incinerators.
9. Control of radioactive emissions.

HUMAN DISEASES

- A disease is a disorder in a tissue, organ, organ system during which its functions are not carried out normally.

A. BACTERIAL DISEASES

- They include:

1. Cholera.
2. Typhoid.

1. Cholera.

- It is caused by ***Salmonella typhi.***

Mode of transmission.

- Ingestion of water or food contaminated with faeces/urine of infected people.

Incubation period- 2 weeks

Symptoms.

i. Fever and headache.
ii. Diarrhoea.
iii. Abdominal pain.
iv. Vomiting.
v. Loss of appetite
vi. Dry cough and dehydration.

Prevention and treatment

i. Proper disposal of urine and faeces.
ii. Treatment/chlorination/boiling of drinking water.
iii. Proper storage and cooking of food.
iv. Proper treatment of sewage.
v. Personal and environmental hygiene.
vi. Washing of fruits before eating them.
vii. Treatment of infected people.
viii. Vaccination.

Study questioin

Why is flooding likely to lead to cholera outbreak?

ix. Flood water may mix with human waste contaminated with cholera bacteria *Vibrio cholerae* **.** The flood water may then contaminate food and water and the contaminated water/food is ingested causing cholera infection.

B. PROTOZOAN DISEASES

- They include:

1. Malaria.
2. Amoebic dysentery.

1. MALARIA

- It is caused by ***plasmodium.***
- There are 4 species of plasmodium and each cause different type of malaria. They include:

i. Plasmodium vivax
ii. Plasmodium ovale
iii. Plasmodium falciparum

Mode of transmission- Plasmodium is transmitted from infected person through a vector called ***female anopheles mosquito.***

Incubation period- 7-10 days.

Symptoms

i. High fevers.
ii. Profuse sweating.
iii. Frequent chills and shivers.
iv. Headache, muscle and joint pains.
v. Lack of appetite.
vi. Vomiting.
vii. Anaemia.
viii. Convulsions and death in severe cases.

Prevention/control and treatment.
i. Taking prevention medicine before travelling to malaria prone areas.
ii. Sleeping under treated mosquito nets.
iii. Use of mosquito repellants e.g. creams and mosquito coils and insecticides.
iv. Draining of stagnant water to destroy the breeding grounds of mosquitoes.
v. Clearing bushes around the houses where mosquitoes hide.
vi. Pouring of oil on stagnant water to prevent oxygen penetration hence killing mosquito larvae.
vii. Use of biological method e.g. using fish to feed on mosquito larvae.
viii. Treatment by use of malaria drugs.
ix. Destruction of plastic containers that hold water.

Reasons why it is difficult to eradicate malaria.
i. The plasmodium parasite and Anopheles mosquito can undergo mutation and with time develop resistance to the drugs and insecticides.
ii. The warm tropical conditions provide extremely suitable breeding conditions for multiplication of mosquito.
iii. There are large reservoirs of parasites present in other animals/hosts e.g. birds and monkeys.
iv. Individual countries face financial constraints.

2. AMOEBIC DYSENTERY
- It is caused by Entamoeba histolytica.

Mode of transmission.
- Through ingestion of contaminated water and food.

Symptoms
i. Formation of ulcers by producing a tissue dissolving enzyme **hystolysin** in the colon leading to diarrhoea.
ii. Faeces contain blood.
iii. Dehydration.
iv. Abdominal pain.
v. Severe pain when passing stool.
vi. Fever.

Control/prevention
i. Personal and environmental hygiene.
ii. Proper disposal of faeces.
iii. Drinking water should be treated/ chlorinated/ boiled.
iv. Proper treatment using amoebicides.

C. PARASITIC WORMS.

They include:
1. Round worms (Ascaris lumbricoides).
2. Schistosoma.

1. **Round worm** ***(Ascaris lumbricoides)***- It infects the small intestines in pigs and man.
- It causes ascariasis disease.

Mode of transmission.
- The adult lays eggs in the small intestines of the pigs and human beings that are passed out with faeces and may be swallowed by a new host through contaminated water and food.
- Also direct infection from faeces to mouth in children.

Symptoms/effects of parasite on host
i. General malnourishment of the host.
ii. They feed on blood causing anaemia.
iii. Heavy infestation can cause intestinal blockage.
iv. Interference with digestion by entering the bile duct, pancreatic duct and appendix
v. Abdominal discomfort.
vi. They may cause irritation in the trachea and may damage the lungs.

Adaptive characteristics of round worms *(Ascaris lumbricoides).*

A. Physiological adaptations of *Ascaris lumbricoides.*
1. It has two hosts (i.e. pigs and human beings) hence increasing the chances of survival.
2. They have tissues tolerant to low oxygen concentration characteristics in the gut.

B. Reproductive adaptations of *Ascaris lumbricoides.*
1. They produce large number of eggs to increase the chances of survival even when some are destroyed.
2. The eggs have a protective shell to survive harsh environmental conditions.

C. Structural adaptations of *Ascaris lumbricoides.*
1. They have a thick elastic cuticle to protect them against digestion by digestive enzymes of the host enabling them survive in the alimentary canal.
2. They have muscular pharynx through which they suck digested food from the host's intestines.

Prevention/control and treatment of round worm.
i. Proper sewage disposal.
ii. Personal and environmental hygiene e.g. washing hands after visiting the toilet.
iii. Treatment/chlorination/boiling of drinking water.
iv. Proper cooking of food.
v. Treatment by use of drugs.

2. Schistosoma.
- This is a parasitic flat worm and causes ***schistosomiasis disease.***
- It is found in fresh water e.g. lakes, rivers, dams and rice growing fields.
- Snails are vectors for Schistosoma

Mode of transmission.
- Ingestion of water containing the larvae/ infective stage called **cercaria**.
- The parasite can also penetrate through the skin into the blood stream where it goes to the liver where it matures to an adult worm.

Effects on the host.

i. Damage and irritation to the skin as it penetrates causing itching.
ii. Once in blood the adult releases a chemical which cause fever.
iii. Adult worms have spines which tear the blood vessels, intestines and urinary bladder causing blood to appear on urine/faeces and finally leading to anaemia.
iv. Damage to the liver and kidney.
v. Abdominal pain and Diarrhoea.
vi. Death if untreated.

Adaptive characteristics of *schistosoma*

1. The parasite has suckers for attachment onto the host hence not easily dislodged.
2. Has two hosts (i.e. snail as secondary host and man as final host) to increase chances of transfer to different hosts.
3. The cercaria larvae and eggs have glands that secrete lytic enzymes which soften the tissue to allow for penetration into the hosts.
4. Some larval forms e.g. cercaria are encysted and can remain dormant and viable until they come into contact with human beings.
5. The parasite reproduces through larval forms (i.e. miracidia, cercaria, and rediae in snails) making it difficult to eradicate the parasite and also increases the chances of transmission and survival.
6. The adult worm in blood producers a chemical substances which protect it against the host's defense mechanism.
7. The male forms a groove/canal/ gynecophoric canal in which it carries the female. This ensures that the eggs produced by females are fertilized before they are shed into blood vessels.

Prevention/control and treatment of schistosoma.

i. Proper disposal of faeces and urine in latrines/ flush toilets (but not into rivers, dams and water bodies).
ii. Chemically treating/ boiled drinking water to kill eggs and larval forms.
iii. Avoid swimming, bathing in water infested with snails.
iv. People should wear protective shoes and clothes and avoid waking bare footed in swampy areas.
v. Spray fresh water bodies with molluscides to kill snails.
vi. Proper treatment using de-wormers.

TOPIC 3- REPRODUCTION

- ✓ **Reproduction.-**This is the process by which organisms give rise to offspring of their kind/species.

Importance of reproduction.

1. Procreation- It increases the number of organisms in a species.
2. Quality improvement- It increases genetic variety and therefore helps the species to adapt to changing environmental conditions.
3. It brings about formation of seeds, spores and larvae which reduce intra specific competition.
4. It is involved in development of resistant stages in the lifecycle of some organisms.

Types of reproduction.

A. **Asexual reproduction-** in this type an already existing individual develops into a new free existing individual and does not involve the fusion of male and female gametes.

Advantages of asexual reproduction.

i. Good qualities of the parent plant are retained.
ii. Plants mature faster.
iii. It does not depend on pollination, fertilization and seed and fruit dispersal.
iv. The new plants obtain nourishment from the parent plants therefore can survive temporarily under unsuitable environmental conditions.

Disadvantages of asexual reproduction.

i. The undesirable qualities can be passed on to the offspring.
ii. There is no genetic variation hence offspring may not be able to withstand changing environmental conditions.
iii. Faster growth and development may result in overcrowding and competition where only a few members survive.
iv. It reduces the strength and vigour gradually.

B. **Sexual reproduction-** it involves the fusion of male and female gametes (reproductive cells) to form a **zygote (fertilized egg).**

- The fusion of male and female gametes is called **fertilization.**

Advantages of sexual reproduction.

1. It leads to variation due to crossing over which leads to hybrid vigor and better adaptations of organisms to the environment.
2. Introduction of useful traits/ characteristics.

Disadvantages of sexual reproduction.

1. It takes a long time.
2. Harmful characteristics can be passed from parents to offspring.
3. Fewer offspring are produced at a time.
4. It involves two organisms that must mate.

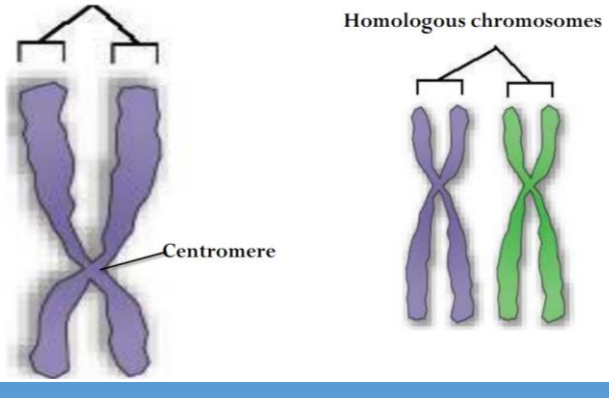
CELL DIVISION.

- ☐ This refers to the division or multiplication of the cells. Cell division leads to growth and formation of reproductive cells/gametes.
- ☐ The cell is able to do all these because it contains **chromosomes found within the nucleus.**

CHROMOSOMES.

- ✓ They are thread like structures found in the nucleus of animal and plant cells.
- ✓ It is made up of two parallel strands called chromatids.
- ✓ The two chromatids (pair of chromatids) are connected at a point called centromere.
- ✓ In the body/somatic cells chromosomes occur in pairs hence called **homologous chromosomes** (which have the same shape and size.
- ✓ Along the length of the chromatid there are structures called genes.
- ✓ Genes are found in the protein molecules called DNA (deoxy ribonucleic acid)
- ✓ Chromosomes are able to form exact copies of themselves. This is called **duplication**
- ✓ There are two types of cells in the human body, namely:

i. Body/somatic cells.
ii. Reproductive cells/gametes.



Types of cell division

- ☐ There are two types of cell division namely:

A. Mitosis.
B. Meiosis.
C. MITOSIS.

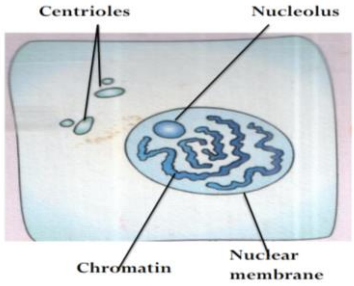
- ☐ This is the process in which a cell divides into two daughter cell each having the same number of chromosomes as parent cell.
- ☐ It takes place in somatic/body cells.

Stages of mitosis

1. Interphase (I)
2. Prophase (P)
3. Metaphase (M)
4. Anaphase (A)
5. Telophase (T)

1. Interphase.

- ✓ This is a resting stage and chromosomes are not visible but appear as threads called **chromatin.**
- ✓ Chromosomes duplicate to produce two sister chromatids.
- ✓ There is synthesis of new organelles e.g. golgi apparatus, centrioles, mitochondria, ribosomes.
- ✓ There is buildup of energy to use in cell division.



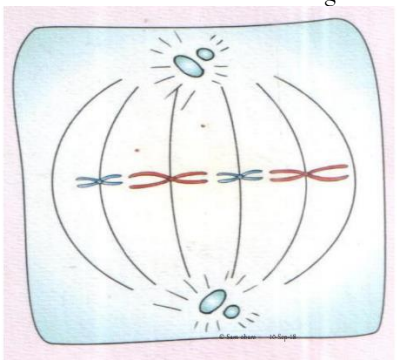
2. Prophase.

- The two chromatids shorten and thicken, join at the centromere hence appear as visible chromosomes.
- Homologous chromosome pair up.
- The centrioles move to the opposite sides/ends of the- animal cell and spindle fibres begin to form.
- The nuclear membrane begins to break down while the nucleolus disappears.

3. Metaphase.

- The nuclear membrane disappears hence chromosomes are free in the cytoplasm.
- The chromosomes arrange themselves at the centre/equator of the cell.
- The chromosomes are attached to spindle fibres at the centromere.

- This is important to ensure even distribution of chromosomes between the daughter cells.



4. Anaphase.

- Chromatids separate at the centromere and migrate to the opposite poles of the cell due to shortening of the spindle fibres.
- The spindle fibres begin to disappear.
- In animal cells the cell membrane begins to constrict.

5. Telophase.

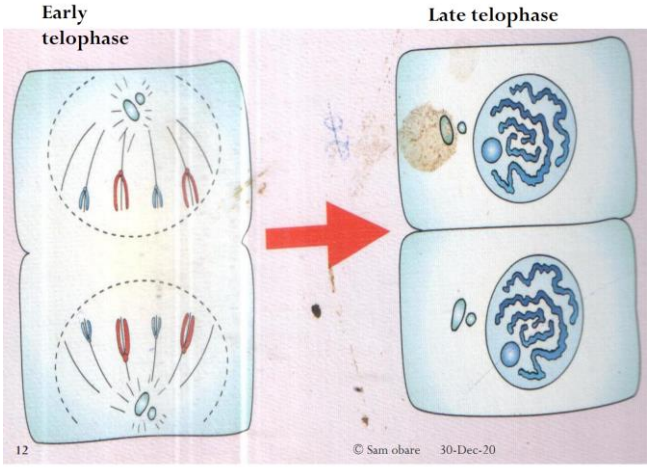
✓ The chromatids collect together at the ends of the cell and duplicate to form chromosomes.

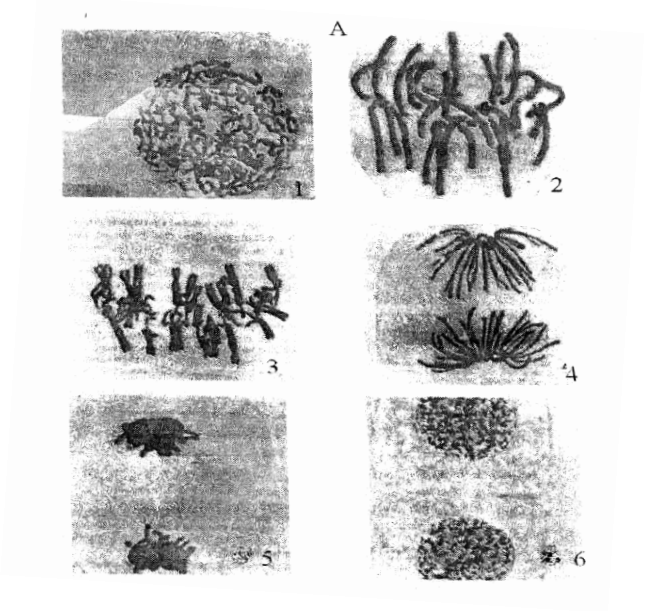
✓ The nuclear membrane forms around each set of chromosomes.

✓ The cytoplasm divides into two leading to the formation of two daughter cells.

✓ The chromosomes become less distinct and regain their threadlike (chromatin) appearance.

N/B. In animal cells, division of cytoplasm is by constriction of cell membrane while in plant cells a cell plate forms within the cytoplasm and grows to separate the two cells.





Significance/ importance of mitosis.

1. It leads to growth of an organism.
2. It is the basis of asexual reproduction/it is involved in asexual reproduction.
3. It ensures that the genetic/ chromosomal constitution of the offspring remains the same as that of the parent.
4. It leads to replacement of damaged or dead cells.

B. MEIOSIS

- This is the process of cell division which reduces the number of chromosomes in a cell by half.
- This forms gametes/reproductive cells.
- It involves two divisions resulting into four daughter cells.
- It takes place in reproductive organs e.g. testes, ovaries, anther e.t.c.

Principle of meiosis.

☐ It consists of 2 successive divisions:

i. 1st meiotic division- homologous chromosomes separate from each other.

ii. 2nd meiotic division- chromatids separate.

1ST MEIOTIC DIVISION.

☐ It leads to separation of homologous chromosomes.

☐ The stages include:

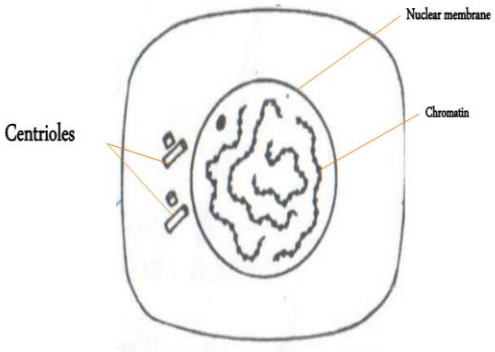
1. Interphase I.
2. Prophase I.
3. Metaphase I.
4. Anaphase I.
5. Telophase I.

1. Interphase 1

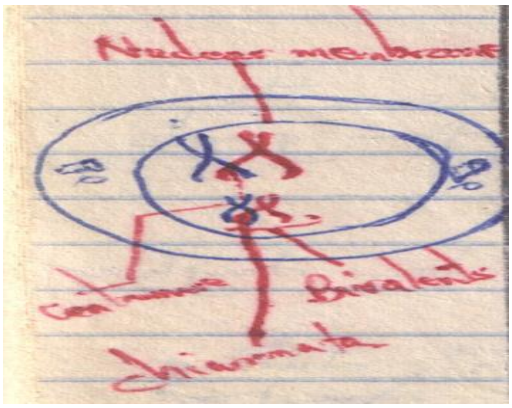
☐ Chromosomes appear as chromatin and replicate/duplicate.

☐ The cell builds up the energy used in meiosis.

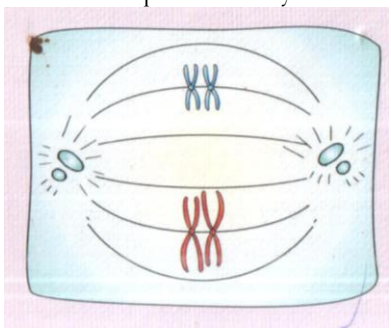
☐ There is synthesis of new organelles.



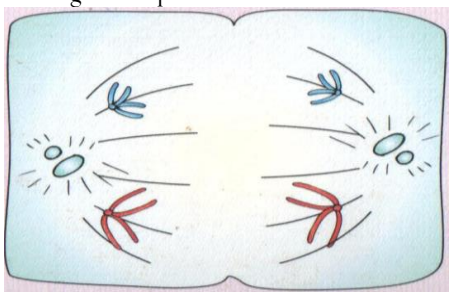
2. Prophase 1
- ☐ The nucleolus disappears.
- ☐ Centrioles become arranged at the opposite sides of the cell.
- ☐ Chromosome condense and shorten hence become visible.
- ☐ Spindle fibres begin to form.
- ☐ Homologous chromosomes lie side by side in the process called **synapsis** and forming pairs called **bivalent.**
- ☐ As prophase continues, chromatids of the two homologous chromosomes coil around each other and remain contact at points called **chiasmata (singular-chiasma).** This is called **chiasma formation.**
- ☐ During separation of homologous chromosomes, the chromatids separate at chiasmata and exchange the genetic materials. This is called **crossing over** which leads to variation.



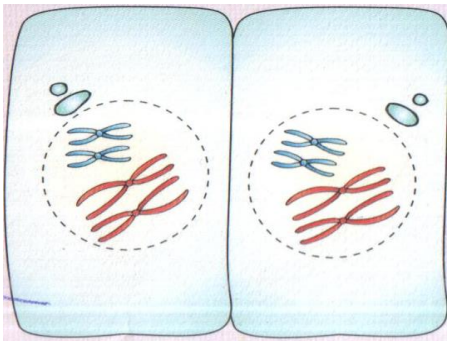
iii. Metaphase I.
- ☐ The nuclear membrane has disappeared and spindle fibres are fully formed.
- ☐ The homologous chromosomes still as bivalents arrange themselves at the centre/ equator of the cell.
- ☐ They attach to the spindle fibres by their centromeres.



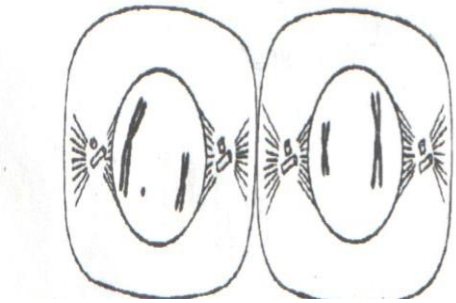
iv. Anaphase I
- ☐ Homologous chromosomes separate.
- ☐ They move to the opposite sides of the cell due to shortening of the spindle fibres.



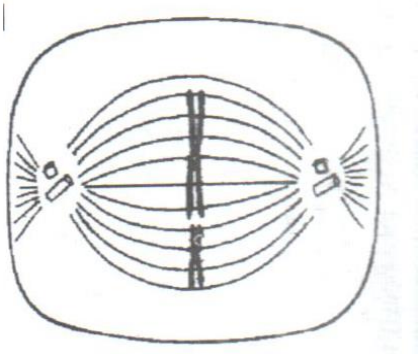
v. Telophase I.
- ☐ The spindle fibres disappear.
- ☐ The cell divides into two.
- ☐ Each cell goes into a short resting stage (interphase II) directly goes into prophase II.



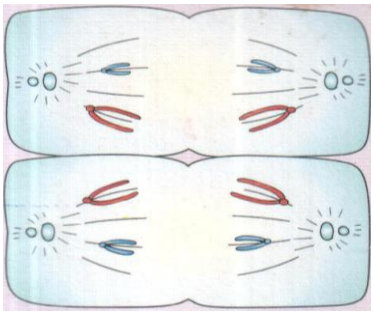
i. Prophase II.
- ☐ The new spindle fibres are formed.
- ☐ Chromosomes become visible.
- ☐ There is no crossing over.



ii. Metaphase II.
- ☐ The chromosomes arrange at the centre of the cell.
- ☐ They attach to the spindle fibres by their centromeres.

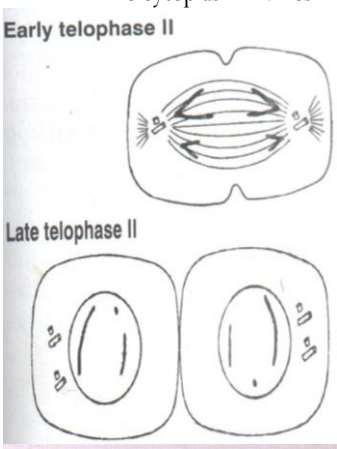


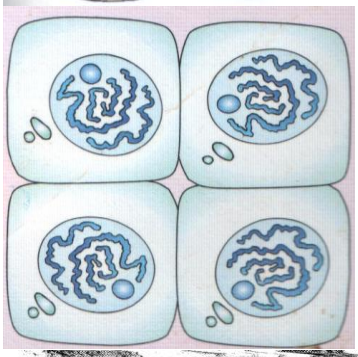
iii. Anaphase II
- ☐ The sister chromatids separate from each other and move to the opposite sides of the poles.
- ☐ This is due to shortening of the spindle fibres.

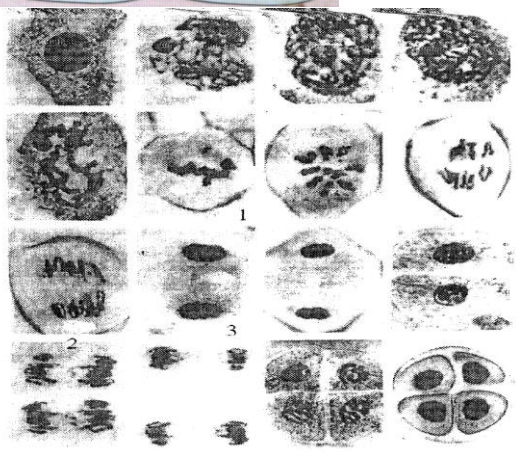


iv. Telophase II.

- ☐ The spindle fibres disappear.
- ☐ The nucleolus reappears and the nuclear membrane is formed around each set off chromosomes.
- ☐ The sister chromatids duplicate and form chromosomes. They uncoil and regain their thread like form.
- ☐ The cytoplasm divides







Significance of meiosis.

1. It leads to gamete formation.
2. It ensures that each gamete has half the number of chromosomes as those found in the original cell/ it helps to restore a constant diploid chromosomal constitution in a species after fertilization.
3. It leads to new combinations of genes in gamete cells. This leads to variation due to crossing over.

Similarities between mitosis and meiosis.

1. Both take place in plant and animal cells.
2. Both involve division/ multiplication.

DIFFERENCES BETWEEN MITOSIS AND MEIOSIS.

Mitosis	Meiosis
1. Two daughter cells are formed which are identical to the parent cell and each diploid.	1. Four daughter cells are formed which are not identical to the parent cell and each haploid.
2. Homologous chromosomes do not associate with each other.	2. Homologous chromosomes associate with each other.
3. There is no chiasma formation hence no crossing over/variation.	3. There is chiasma formation hence crossing over/variation.
4. Occurs in somatic cells leading to growth.	4. Occurs in reproductive cells leading to gamete formation.
5. Takes place in only one nuclear division of four stages.	5. Takes place in two nuclear divisions each with four stages.

ASEXUAL REPRODUCTION

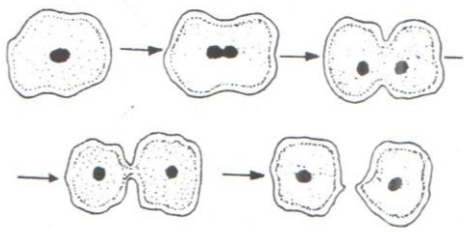
- ☐ Asexual reproduction is the production of offspring from a single organism without the fusion of gametes.

Types of asexual reproduction.

1. Binary fission.
2. Spore formation/sporulation.
3. Budding in yeast.

1. Binary fission in amoeba, plasmodium and bacteria.

- ✓ The first step in binary fission is molecular division where there is internal reorganization of the molecules necessary for structural construction.
- ✓ The molecules are re-aggregated and utilized in the formation of the new cell.
- ✓ The nucleus undergoes mitotic division to give rise to two nuclei with the same number of chromosomes.
- ✓ The cytoplasm then starts dividing into two cells which separate from each other.



Binary fission in amoeba

2. Spore formation /sporulation.

- ✓ **A spore** is a small reproductive unit which is usually microscopic and unicellular.
- ✓ When detached from the parent organism and under favorable conditions, a spore germinates and grows into new individuals.
- ✓ It occurs in bacteria, fungi (e.g. Rhizopus/ Mucor/Mould, yeast, mushroom), mosses and ferns.

Note- Spores are produced in large numbers to increase the chances of survival and growth.

a) Rhizopus/ Mucor/ Mould.

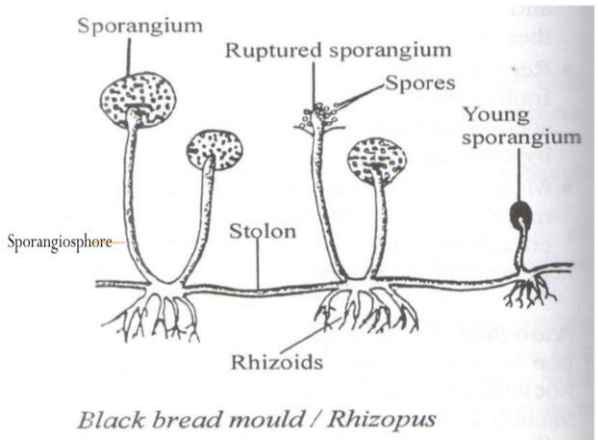
- ✓ *Rhizopus* is a saprophytic fungus which grows on a substrate e.g. bread, rotting fruits and other decaying matter.
- ✓ The vegetative body/ whole organism is called **mycelium** which consists of many branched threads called **hyphae.**
- ✓ The horizontal hyphae are called **stolons** and the vertical hyphae are called **sporangiosphores.**
- ✓ The tips of sporangiosphores swell to form **sporangia (singular- sporangium).**
- ✓ Sporangium contains many spores and as the sporangium matures and ripens it turns black.
- ✓ When the sporangium is fully mature, it bursts and releases the spores which are dispersed and grows into new mycelium.
- ✓ Spores are dispersed by wind, insects and animals.

Process of reproduction in Rhizopus/ Mould/ Mucor

- ✓ The fungus reproduces asexually by sporulation/ producing spores.
- ✓ Spores develop from a single cell in the sporangium, which bursts on maturity releasing spores.
- ✓ Spores are dispersed by air currents/ wind, falling on suitable medium they germinate to form new generation forming a mycelium.

Process of reproduction in mushroom.

- ✓ The fungus reproduces asexually by sporulation/ producing spores.
- ✓ Spores develop in the gill which bursts on maturity releasing spores.
- ✓ Spores are dispersed by air currents/ wind, falling on suitable medium they germinate to form new generation.



Black bread mould / Rhizopus

Study question.

A student left a piece of bread on an open place accidentally. 3 days later he observed some black substance developing.

a) Suggest the identity of the black substance that grew on the bread.

- ✓ Rhizopus.

b) Explain how the black substance was formed.

- ✓ Spores of bread mould deposited on the damp bread which germinated into hyphae. When mature the hyphae grew into sporangiosphores. Sporangia developed on the tip of the sporangiosphores containing the spores. The sporangia matured and dried up and turned black.

c) State the mode of reproduction exhibited by the organism named above.

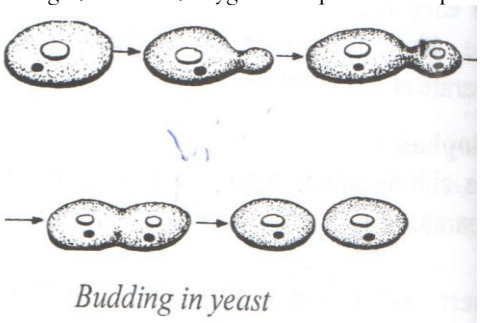
- ✓ Sporulation/ spore formation.

d) State the kingdom to which the organism belongs.

- ✓ Fungi

3. Budding in yeast.

- Yeast is an example of a fungus
- This is a form of asexual reproduction in which a new individual is produced as an outgrowth (bud) of the parent cell and is later released as self-supporting individual and identical copy of the parent plant
- It occurs in yeast under favorable conditions e.g. plenty of sugar, moisture, oxygen and optimum temperature.



Budding in yeast

Process of budding/ reproduction in yeast.

- ✓ Yeast reproduces asexually by budding.
- ✓ The parent cell forms an outgrowth/ projection/ bud followed by division of nucleus into two.
- ✓ One of the nuclei moves into the new bud which grows and develops into a new cell.

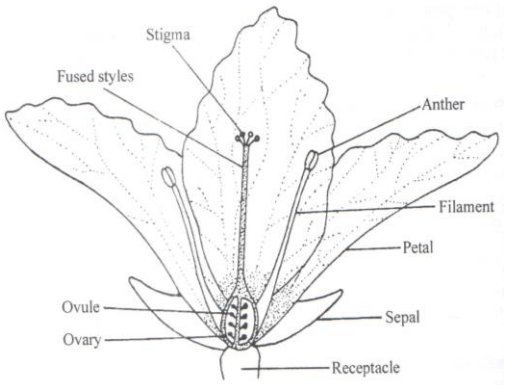
SEXUAL REPRODUCTION IN PLANTS.

- ☐ It involves the formation of male and female gametes which fuse to form a fertilized egg called **zygote.**
- ☐ Gametes are produced in reproductive structures called **flowers.**

Parts of a flower.

- ☐ It is attached to the stem of a plant through the **pedicel/flower stalk.** The top part of the pedicel is called **receptacle.** All the floral/flower parts are attached to the receptacle.
- ☐ The flower/floral parts are divided into four groups namely:

i. Calyx/sepals.
ii. Petals/corolla.
iii. Stamens/androecium.
iv. Carpels/pistil/gynoecium.



Structure of a generalized flower

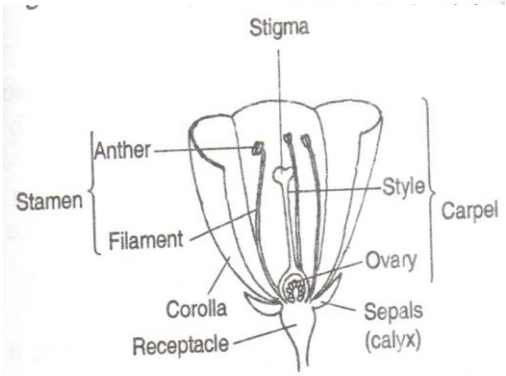


Fig. 3.11: Longitudinal section of a generalised flower

FUNCTIONS OF DIFFERENT PARTS OF A FLOWER.

1. **Sepals/Calyx-** Sepals collectively form **calyx** which are leaf-like structures.
- ✓ Sepals **protect the inner** parts of the flower in the bud/before the flower opens from pest attack and from drying.
- ✓ Some flowers e.g. hibiscus have sepal-like structures below the sepals that are called **epicalyx.**

2. **Stamen/androecium-** They form the male part of the flower. Stamen consists of **anther and filament.** Stamens collectively form **Androecium.**
- ✓ The anther produces pollen grains which contain male gametes and the filament holds the anther in position.
- ✓ One stamen consists of 4 pollen containing sacs which are fused to form **anther.**

3. C**arpels/pistil/gynoecium-** This is the female part of the flower. Carpel consists of **stigma, style and ovary.** Carpels collectively make up **pistil (gynoecium).**
- ✓ Inside the ovary, there are several ovules. The egg cell or female gamete is formed within the ovule.
- ✓ The stigma receives the pollen grains. The style holds the stigma in position.
- ✓ Note: Calyx(sepals) and corolla(petals) are called non-essential parts while androecium (stamens) and pistil/ gynoecium are called essential parts of the flower.

4. **Petals/corolla-** Petals collectively form the **corolla.**
- ✓ They are large and brightly colored and conspicuous to attract insects for pollination.

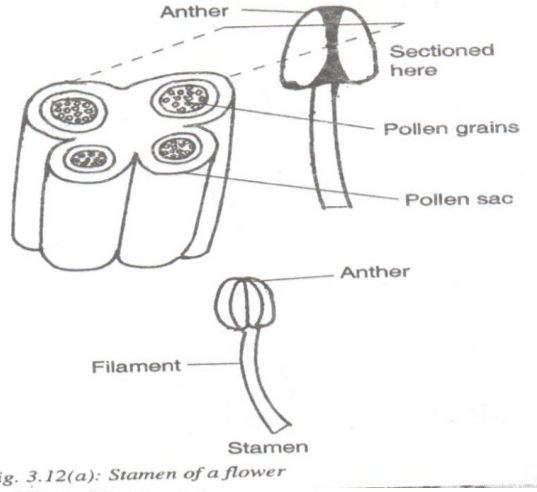


Fig. 3.12(a): Stamen of a flower

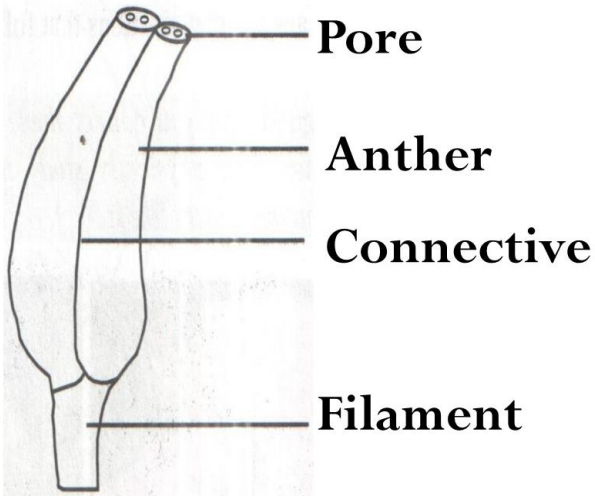
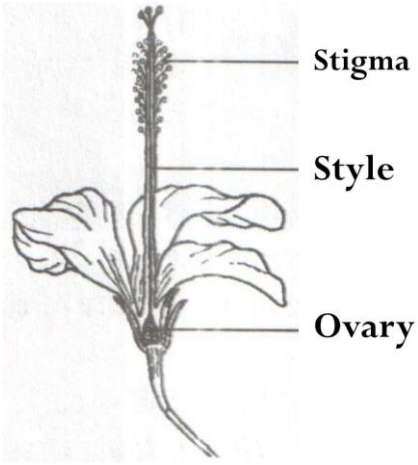


Fig. Pistil



TYPES OF FLOWERS

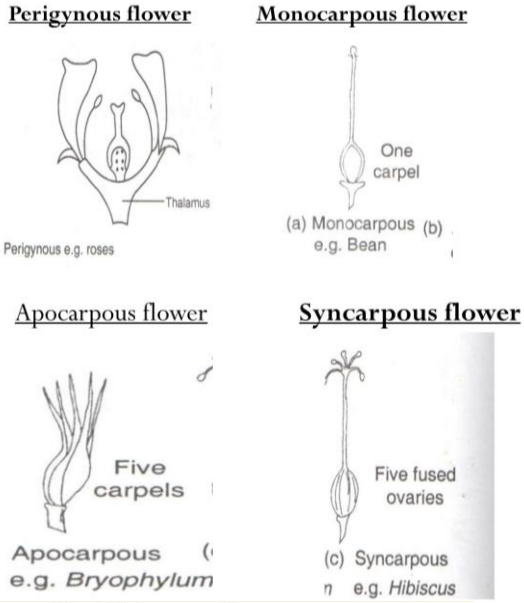
1. **Gamepetalous flower-** the corolla/petals are fused.
2. **Polypetalous-** the corolla/petals are separate.

3. Complete flower/ bisexual flower/hermaphrodite flower- a flower with all floral parts.
4. **Unisexual flower/ incomplete flower-** this is a flower with either male or female parts only.

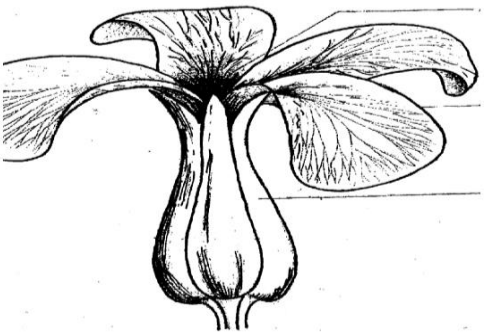
Types of unisexual/ incomplete flowers.

a) **Staminate flower-**has only stamens/androecium/male parts only.
b) **Pistillate/carpellate flower-** has only pistil/carpels/female parts.
c) **Dioecious plant-** plant with unisexual flower separately but on different individual plants e.g. pawpaw plant.
d) **Monoecious plant -**plant with unisexual flower separately but on the same plant e.g. maize plant.

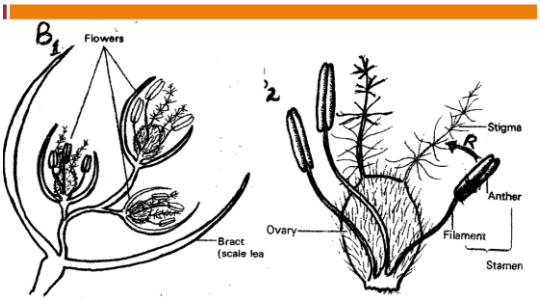
5. **Epigynous/inferior ovary/flower-** the ovary is located below other floral parts e.g. apple flower.
6. **Hypogynous/superior ovary/flower-** ovary is located above other floral parts e.g. hibiscus flower.
7. **Perigynous ovary/flower-** all floral parts are located at the same level e.g. rose flower.
8. Monocarpous gynoecium/ pistil- the pistil has one carpel.
9. **Solitary flower-** flower which occurs singly.
10. **Inflorescence-** consists of flowers that grow in clusters.
11. **Polycarpous gynoecium/ pistil-** the pistil has two or more carpels.
12. **Apocarpous gynoecium/ pistil-** refers to polycarpous pistil with free carpels e.g. rose flower.
13. **Syncarpous gynoecuim/ pistil-** polycarpous pistil with fused carpels e.g. hibiscus flower**.**
14. **Actinomorphic/regular flower-** a radially symmetrical flower and can be divided into two equal halves by any vertical section through the centre.
15. **Zygomorphic/irregular flower –** bilaterally symmetrical flower and can only be divided into two equal halve only in one particular plane.



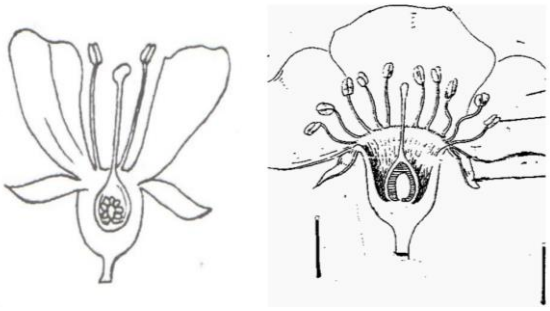
Solitary flower



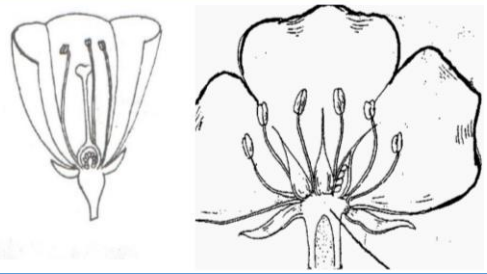
Inflorescence



Epigynous flower/inferior ovary



Hypogynous flower /superior ovary



POLLINATION

- ✓ This is the transfer of pollen grains from the anther to the stigma of a flower on the same or on a different plant of the same species.

Types of pollination.

1. **Self-pollination-** transfer of pollen grains from the anther to the stigma of the same flower or from the anther of one flower to the stigma of another flower on the same plant. This leads to self-fertilization.

Disadvantages of self-pollination.

i. Lack of variation.

ii. Loss of hybrid vigor.
iii. Undesirable characteristics are retained/ transmitted to the offspring.

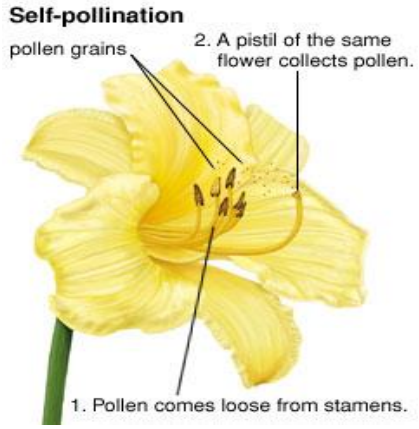
2. **Cross pollination-** transfer of pollen grains from the anther to the stigma of another flower of different plant but of the same species. This leads to cross fertilization.

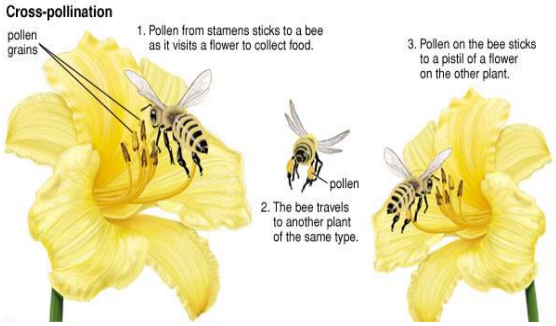
Advantages of cross pollination.

i. It causes genetic variation hence better adaptations of organisms to harsh environmental conditions.

✓ Pollination is brought about by agents which include:

1. Insects.
2. Wind.





Adaptations of insect pollinated (entomophilous) flowers.

1. The flowers are large, conspicuous with brightly colored petals, inflorescence or bracts (modified leaf e.g. in ***bougainvillea***) to attract insects.
2. They have nectary guides that direct insects into nectaries which secrete nectar.
3. They are scented and produce nectar to attract insects.
4. Anther are located inside the flowers to ensure that they get into contact with insect.
5. Anthers produce pollen grains which are large, spiky/ sticky to attach/ stick to the insect's body.
6. The stigmas are small, sticky and occur inside the flower so that pollen grains from the body of insect stick onto them.
7. They have special shaped corolla tube to enable insects land.

Adaptations of wind pollinated (anemophilous) flowers e.g. maize.

1. The flowers are small with inconspicuous petals,dull coloured bracts or inflorescence.
2. They lack nectaries and are not sweet scented, lacking the scent bait to attract insects.
3. Have stigma which are large, long, and feathery and hang outside the flowers to increase the surface area for trapping pollen grains in air.
4. Pollen grains are small, light and smooth and hence can easily be blown by air currents without sticking together.
5. The pollen grains are dry so that they are easily picked up and blown over greater distances by wind.
6. Flowers are irregular in shape with male parts exposed for easy transfer of pollen grains by wind.
7. Anthers are large and loosely attached to the filament so that the slightest air movement can shake them to disperse the pollen grains.

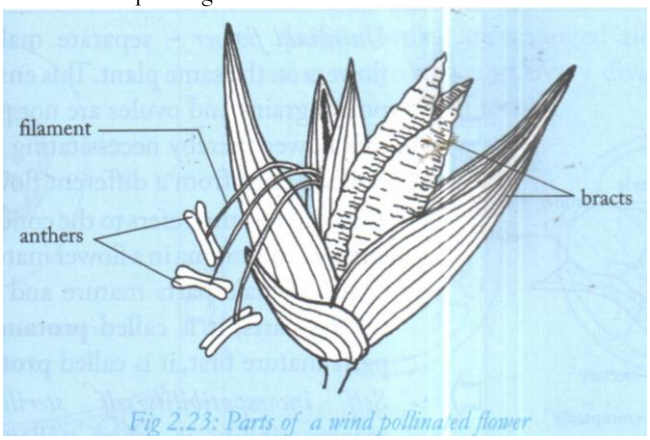


Fig 2.23: Parts of a wind pollinated flower

DIFFERENCES BETWEEN INSECT AND WIND POLLINATED FLOWERS.

Insect pollinated	Wind pollinated
1. Flowers are large with brightly colored petals/corolla.	1. Flowers have dull petals.
2. They are usually scented.	2. They are unscented.
3. They produce nectar.	3. They do not produce nectar
4. They have small and sticky stigma found inside the flower.	4. They have large and feathery stigma hanging outside the flower.
5. Anthers are small and firmly attached to filament.	5. Anthers are large and loosely attached to the filament.
6. Few pollen grains are produced.	6. Many pollen grains are produced.
7. Pollen grains are large, heavy and sticky so that they stick to insects.	7. Pollen grains are small, smooth and light so that they float in air.

Features and mechanisms that promote cross pollination/ hinder self-pollination and fertilization.

1. **Monoecism**- plants have the male and female flower parts at different parts of the same plant e.g. maize plant.

✓ There are risks of self-pollination but they have natural mechanisms of preventing self-pollination.

2. **Protandry-** this is a situation where the **male parts/ stamens** mature earlier and anthers release pollen grains before the **stigma** is mature enough to receive them e.g. in sunflower.
3. **Protogny-** this is a situation where the stigma matures earlier and is ready to receive pollen grains before the anthers are ripe enough to shed the pollen grains e.g. maize.
4. **Self - sterility or incompatibility** - This is where pollen grains from the anthers fail to germinate on the stigma of the same plant e.g. maize. This ensures that self-fertilization does not occur.
5. **Dioecism**- plants have male and female flowers on different plants e.g. pawpaw plant.
6. **Heterostyly-** this is where the stigma is above the anthers so that pollen grains do not reach them.

Ways in which plants promote self-pollination.

1. Having both male and female parts on the same flower.
2. Anthers and stigma mature at the same time.
3. Flowers remain closed and open after fertilization.

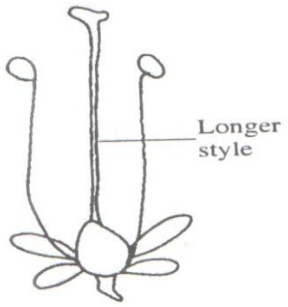
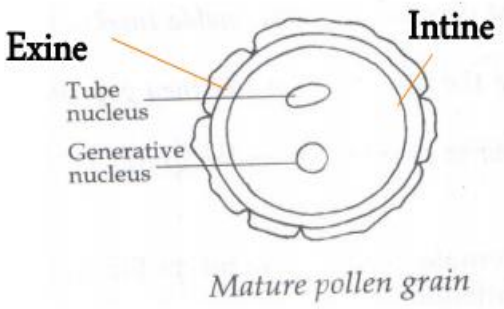


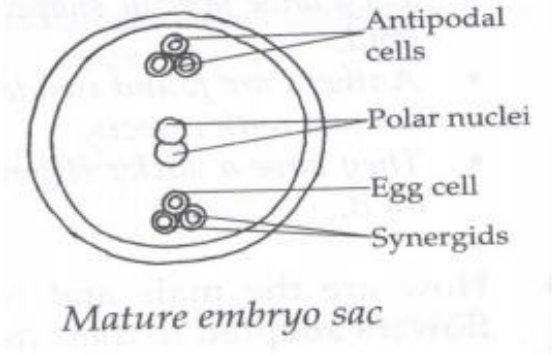
Fig. 3.18: Heterostyly

Fertilization in plants.

- ✓ ***Fertilization*** is the fusion of a male nucleus and female nucleus to form a ***zygote.***
- ✓ In the male gamete is contained in the pollen grain produced in the anther while the female gamete (egg cell) is found in the ovules found within the embryo sac.
- ✓ The **synergids** provide nourishment to the egg cell.



Mature pollen grain



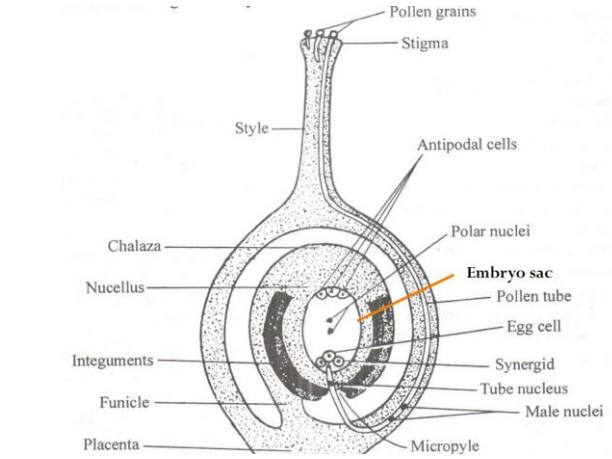
Mature embryo sac

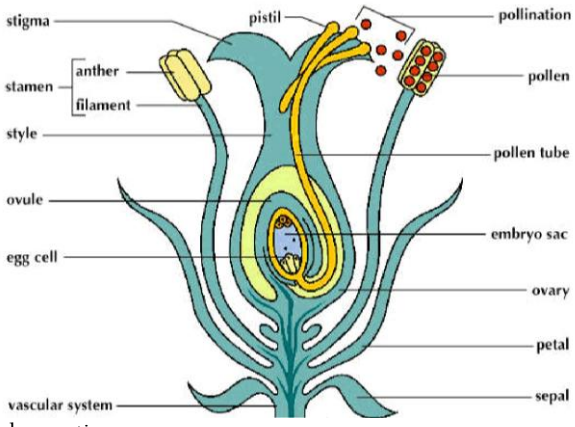
The process of fertilization in flowering plants.

- ✓ Pollen grain lands and sticks onto the stigma.
- ✓ The surface of the stigma produces a sticky chemical substance which stimulates the pollen grains to germinate and form a pollen tube.
- ✓ The pollen grain also absorbs nutrients from the stigma forming a pollen tube.
- ✓ The pollen tube grows down the style, carrying with it the male gametes (tube nucleus and generative nucleus) and it gets nutrients from the surrounding tissues.
- ✓ As the pollen tube germinates, the tube nucleus occupies a position at the tip of growing pollen tube while the generative nucleus follows behind the tube nucleus.
- ✓ As the pollen tube continues to grow downwards, the generative nucleus divides mitotically into two **male gamete nuclei.**
- ✓ The pollen tube grows through the ovary wall, reaches the ovules and enters the embryo sac through the micropyle.
- ✓ At this stage, the tip of the pollen tube bursts open and the tube nucleus disintegrates to release the ***two male nuclei*** which enter embryo sac.
- ✓ One male nucleus / one of the male nuclei fuses with the egg cell nucleus and forms the diploid zygote. The other male gamete nucleus fuses with the two polar nuclei to form a triploid endosperm nucleus. The process is called double fertilization.

Changes /events that take place after fertilization.

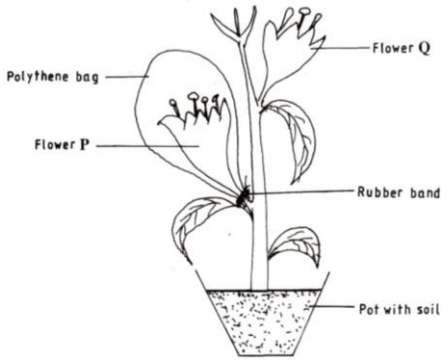
- ✓ The zygote undergoes mitotic division to from the **embryo** which differentiates into the **plumule (which grows to from a shoot)** and **radicle (which grows to form a root)**.
- ✓ The **triploid primary nucleus** undergoes mitosis to form **endosperm** tissue for storage of food.
- ✓ The fertilized **ovary** develops into a **fruit**, the ovary wall becomes the fruit wall (pericarp).
- ✓ The **ovules** develop into **seeds**.
- ✓ The integuments form the testa/seed coat.
- ✓ **Style**, **stigma** and **stamens** dry up and fall off.
- ✓ The **calyx persists** or it may dry up and fall off.
- ✓ The **style** leaves a scar on the fruit wall.





Study question.

- ✓ The diagram below represents an experimental set-up used by students to investigate a certain process.



- ☐ Flower Q produced seeds while P did not. Account for the results.
- ✓ The flower/plant is self-sterile/not successfully self-pollinated.
- ✓ The covering prevents pollination in flower P while flower Q received pollen grains from other plants/ cross pollination leading to fertilization.

FRUIT AND SEED FORMATION.

a) Development of the seed

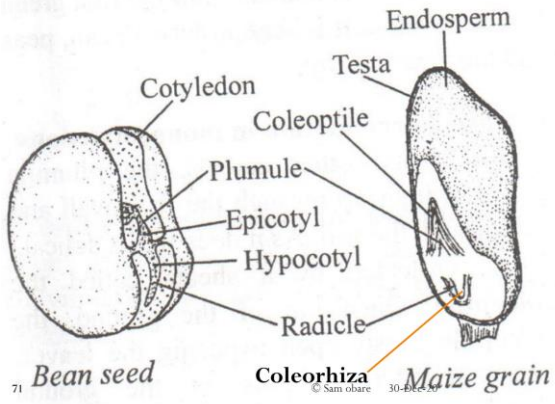
- ✓ The haploid zygote undergoes mitosis to form an embryo. The embryo has three parts: ***plumule (young shoot), radicle (young root) and one or two cotyledons.***
- ✓ The triploid primary endosperm nucleus undergoes mitosis to form the endosperm tissue.
- ✓ The ovule becomes a seed and the ovary becomes the fruit.
- ✓ The integuments form a testa/seed coat which surround the cotyledons.
- ✓ The testa has a scar called **hilum** which is the point of attachment to the placenta
- ✓ The embryo then completely separates from the endosperm by a membrane leaving an opening called **micropyle** which allows entry of water into the seed.
- ✓ It loses water, dries and hardens ready for dispersal.

b) Development of fruit.

- ✓ The ovary forms the fruit.
- ✓ The ovary wall develops to form the pericarp which differentiates into ***epicarp/exocarp, mesocarp and endocarp.***
- ✓ Some fruits e.g. pineapples and bananas develop without fertilization. This is called **parthenocarpy**
- ✓ A true fruit is formed from the ovary e.g. mangoes and beans.
- ✓ A false fruit is formed when other flower parts e.g. receptacle enlarges and encloses the ovary or ovaries e.g. apple, pineapple, straw berry.

Differences between a seed and fruit.

1. A seed is covered by a testa/seed coat while a fruit is covered with pericarp.
2. A seed has one scar/hilum while a fruit has two scars (where it was attached to the fruit stalk and style.
3. A seed is formed from ovule while the fruit is formed from ovary.



Study questions.

1. Name other four changes that occur in the flower after fertilization.
- ✓ Ovary form a fruit.
- ✓ Ovule develops into a seed.
- ✓ Ovary wall forms pericarp.
- ✓ Integuments form a seed coat/ testa.
- ✓ Zygote forms embryo.
- ✓ Primary endosperm nucleus develops into endosperm.

2. Name three structures that wither off after fertilization.
- ✓ Petals.
- ✓ Stamens.
- ✓ Style.

CLASSIFICATION OF FRUITS.

- ☐ They are broadly classified as succulent fruits and dry fruits.

1. **SUCCULENT FRUITS-** They are juicy/flesh. They include:

a) **Berry-**Has fleshy/ succulent pericarp (epicarp, mesocarp and endocarp) with many seeds e.g. tomatoes and oranges.

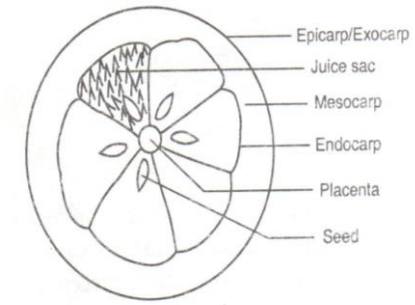
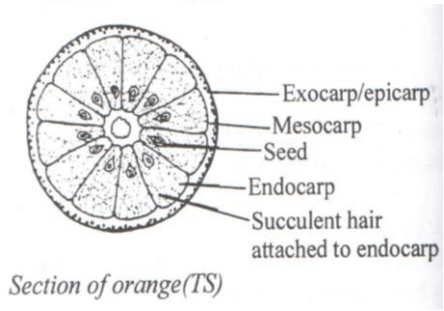


Fig. 3.23: T.S. of an orange (Berry)



Section of orange(TS)

b) **Drupe-** Has thin epicarp, fleshy and fibrous mesocarp, hard stony endocarp enclosing seeds for example mangoes, coconut and avocados.

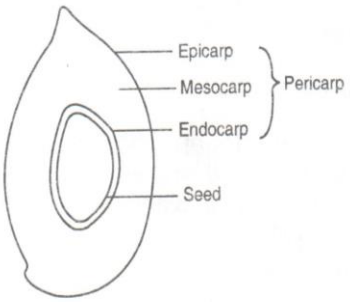
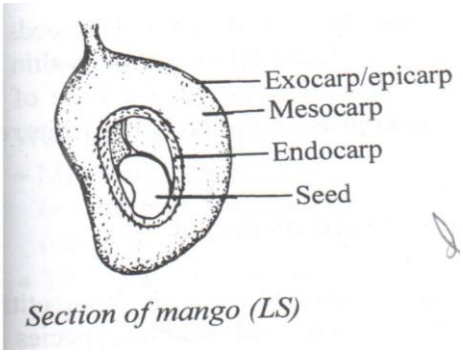


Fig. 3.24: The mango (drupe)



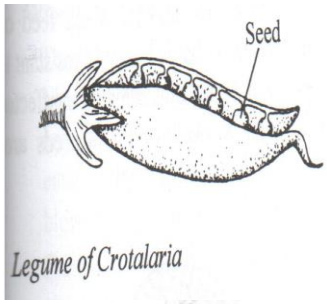
Section of mango (LS)

2. **DRY FRUITS-** They have low moisture content. They are further classified into Dehiscent fruits and Indehiscent fruits.

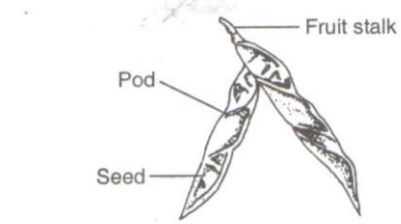
a) **Dehiscent fruits-** They are dry fruits that split open and release seeds when mature.

Types of dehiscent fruits.

1. **Legumes/pod**- Has two lines of weaknesses/sutures hence split and open into two halves e.g. beans, peas, crotalaria.



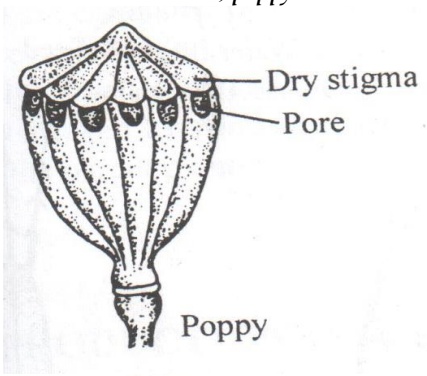
Legume of Crotalaria

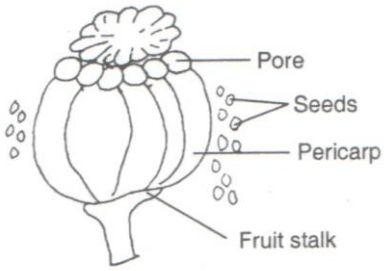


(b) Dehisced fruit

Fig. 3.25: Legume e.g. bean

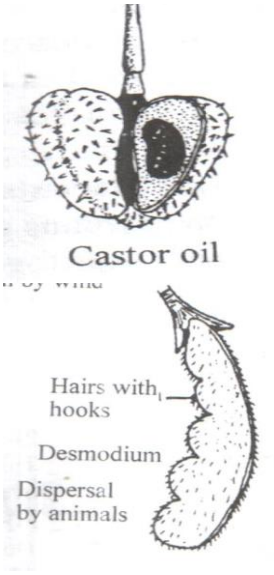
2. **Capsules-** Has a dry pericarp and dehisces along many lines of weaknesses/sutures e.g. **Cotton, *Datura stramoniun, poppy.***





: A capsule of poppy

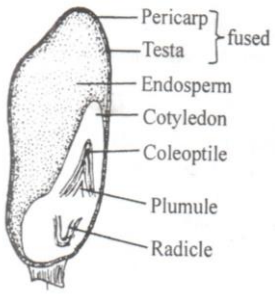
3. **Schizocarp-** A ripe fruit breaks up into small one seeded parts/fragments called mericarps e.g. castor oil and desmodium.



b) **Indehiscent fruits-**They do not split open and release the seeds even if they are dry.

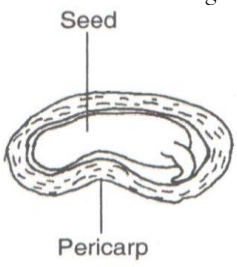
Types of indehiscent fruits

1. **Caryopsis-** In this the seed coat and the pericarp are fused to form the testa e.g. maize grain wheat grain, rice grain e.t.c.



Section of maize grain

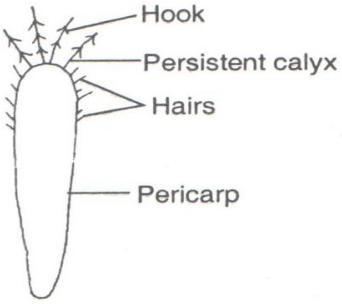
2. **Nuts-** A nut is one seeded fruit whose pericarp is stony/hard and separate from seed coat e.g. cashew nuts.



): Nut e.g. macadamia

3. **Cypsela-** It is one seeded fruit where the seed is free from the pericarp e.g. Black jack (*Bidens pilosa).*

- It is produced by many composite flowers.
- The calyx persists in form of spines or hairs that help in animal dispersal.



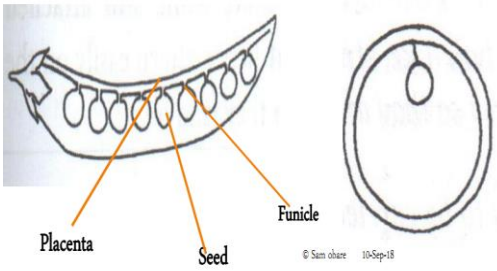
Cypsela of Bidens

PLACENTATION.

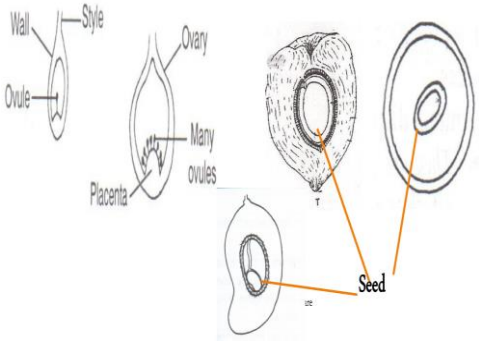
✓ This is the arrangement of seeds/ovules in the ovary/seed.

Types of placentation.

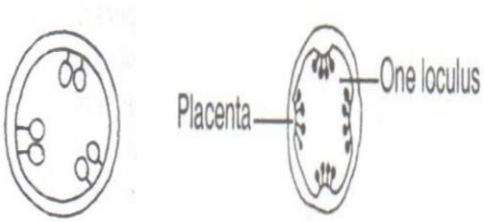
1. **Marginal placentation-** The placenta appears as one ridge/ridge and the seeds/ovules are arranged in one row e.g. beans in a pod.



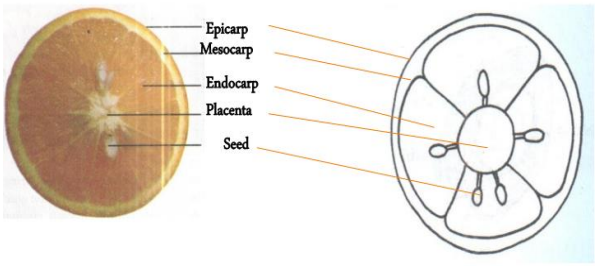
2. **Basal placentation-** In this the placenta is formed at the base of the ovary and seeds attached to it e.g. in sunflower.



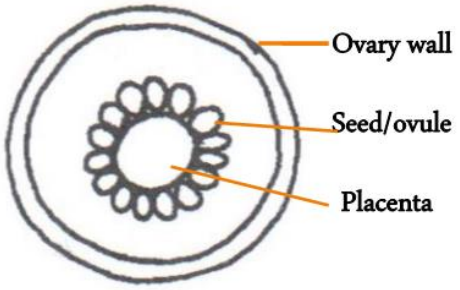
3. **Parietal placentation-** Seeds are attached to the placenta on the periphery of the fruit wall e.g. pawpaw, passion fruits.



4. **Axial/ axile placentation-** In this the seeds/ovules are attached to the placenta located at the centre.



5. **Free placentation-** In this, seeds/ovules are almost free in the fruit.



FRUIT AND SEED DISPERSAL.

- Dispersal is the process by which seeds and fruits are spread from parent plant to a new location.

Advantages of dispersal.

i. It prevents overcrowding that leads to competition for resources.
ii. It ensures that seeds reach new environments which may be suitable for their growth.

Disadvantages of dispersal.

- Some seeds/fruits may be dispersed to areas unsuitable for germination.

Methods of fruit and seed dispersal.

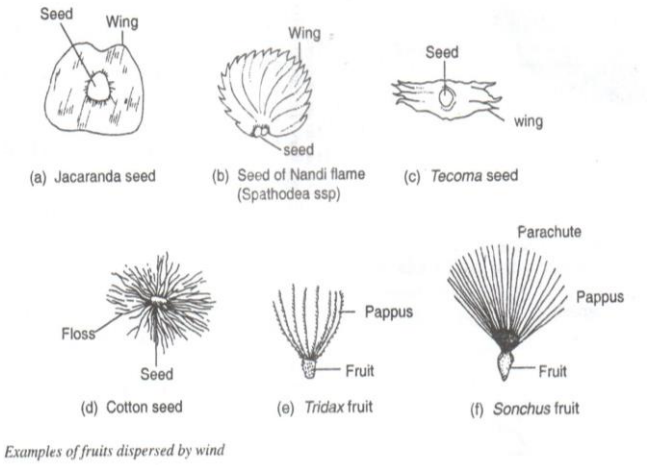
- They include:
  A. Wind dispersal.
  B. Water dispersal.
  C. Animal dispersal.
  D. Self-mechanism/self-explosive mechanism.

A. **Wind dispersal.**

- In this, wind acts as an agent of fruit and seed dispersal.

Adaptations of seeds and fruits to wind dispersal.

1. Some seeds have developed hairy structures, feather-like projections, wing-like structures which increase their surface area to be carried away by wind/ to be blown about by wind.
2. Seeds and fruits are light/small to be carried by air currents.
3. Some fruits have open/perforated capsules attached on long stalks which are swayed by wind scattering the seeds.



Examples of fruits dispersed by wind

g. Milk weed seed

h. Sycamore seed

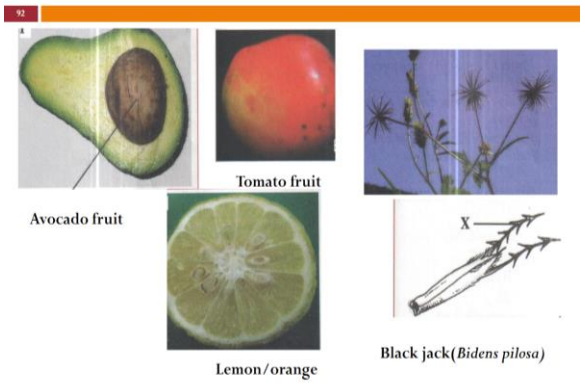
B. **ANIMAL DISPERSAL-**

- Animals are used as agents of dispersal.

Adaptations of fruits/seeds to animal dispersal.

1. Some fruits have **hooks/spikes** to stick/attach to the animal's body.
2. Some fruits are **succulent/fleshy/juicy** hence they attract animals which eat them and carry them away from the parent plant.
3. Some fruits are **in clusters/large/conspicuous** attract/be easily seen by animals.
4. Some fruits are **brightly colored to** attract/be easily seen by animals.
5. Some seeds have **a hard/ tough testa (seed coat)** with sticky/ mucoid/ slimy secretions making them resistant to digestive enzymes hence pass out through the gut undigested/pass out with faeces.
6. Some fruits have sweet smell/aroma/are scented to attract animals.

Examples of fruits/seeds dispersed by animals.

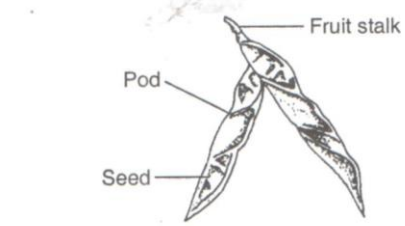


C. **WATER DISPERSAL-**

- Water acts as an agent of dispersal.

Adaptations of seeds/fruits to water dispersal.

1. Some fruits and seeds are light to float on water.
2. Some fruits (e.g. coconut) have fibrous spongy mesocarps to accumulate/trap air making them buoyant or for floating on water.
3. Some fruits (e.g. water lily) produce seeds whose seed coats trap air bubbles making them float on water.
4. Fruits and seeds have water proof pericarp and seed testa respectively hence remain afloat without sinking/soaking.
5. **D. SELF DISPERSAL MECHANISM-** Some fruits (e.g. legumes/pods) **have lines of weakness (sutures)** which split open when dry scattering/ throwing away the seeds.



(b) Dehisced fruit

Fig. 3.25: Legume e.g. bean

SEXUAL REPRODUCTION IN ANIMALS.

- ✓ It involves fusion of male gamete/sperm and female gamete/egg/ovum forming a zygote/fertilized egg.
- ✓ Male gametes/sperms are formed in the **testes** while **female gametes/ova** are formed in the ovaries.
- ✓ The nucleus of sperm fuse with the nucleus of ovum to form a diploid zygote. This process is called fertilization.

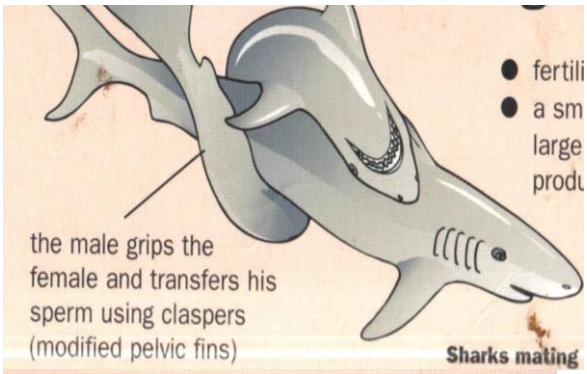
Types of fertilization.

A. External fertilization in amphibians and fish.
B. Internal fertilization.

A. **EXTERNAL FERTILIZATION.**

- ✓ It occurs in amphibians (e.g. frogs/ toads) and fish
- ✓ It takes place in water. The female lays eggs and the male sheds sperms on the eggs as they are laid to fertilize them. This leads to fertilization outside the body.
- ✓ Many/ large number of eggs are laid to increase the chances of survival because some eggs could be eaten by animals of attacked by bacteria.
- ✓ During mating season in frogs and toads, the males croak at night to attract the females.
- ✓ While mating the males mount on female and sheds sperms as female lays eggs. This is to increase the chances of fertilization.
- ✓ The eggs are laid in a jelly like substance which:

i) Protects the eggs.
ii) Prevents the predators from feeding on the eggs.
iii) Separates the eggs from each other allowing good aeration.
iv) Attaches the eggs to water plant and makes them buoyant.



B. **Internal fertilization.**

- ✓ It takes place in reptiles, birds and mammals.
- ✓ Male and female gametes fuse/ fertilization takes place inside the body of female.
- ✓ The female produces fewer number of eggs than males because there are higher chances of fertilization as the sperms are deposited into the female body and protection of gametes and fertilized eggs/ zygotes are higher.

Disadvantages of internal fertilization.

1. Pregnant mother are susceptible to predators
2. Mothers may die during giving birth
3. The disease affecting the mother may be transmitted to the young ones
4. Young ones may deplete the mother's nutrients

Study questions.

1. **Explain why a female frog lays many eggs.**
   - ✓ This is to increase the chances of survival because many eggs may die through predation, drying. Some eggs may rot due to bacterial attack and others fail to be fertilized.
2. **Give reasons why frog eggs have the jelly-like substance.**
   - ✓ For protection.
   - ✓ Prevents the predators from feeding on the eggs.
   - ✓ Separates the eggs from each other allowing good aeration.
   - ✓ Attaches the eggs to water plant and makes them buoyant.

Differences between external and internal fertilization.

External fertilization	Internal fertilization
1. It occurs outside the body.	1. It occurs inside the body of female animals.
2. Many eggs are laid.	2. Fewer eggs are released.
3. There is usually less contact between males and females.	3. There is close contact between males and females through copulation.
4. Both fertilized and unfertilized eggs are exposed to danger e.g. predation, desiccation.	4. Fertilized and unfertilized eggs are enclosed hence highly protected inside the body of females.

REPRODUCTION IN MAMMALS.

- ✓ Fertilization occurs internally and the egg is either laid or develops within the female's body in the uterus/ womb.

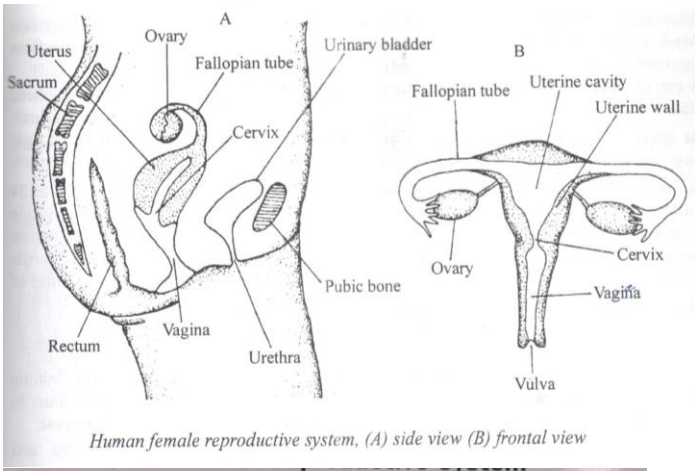
a) **Oviparity-** the embryo develops outside the body of females e.g. in duck-billed platypus.

b) **Oviviparity-** the embryo develops within the female's body and is nourished by the egg yolk. The young ones are born alive e.g. some fish and reptiles.

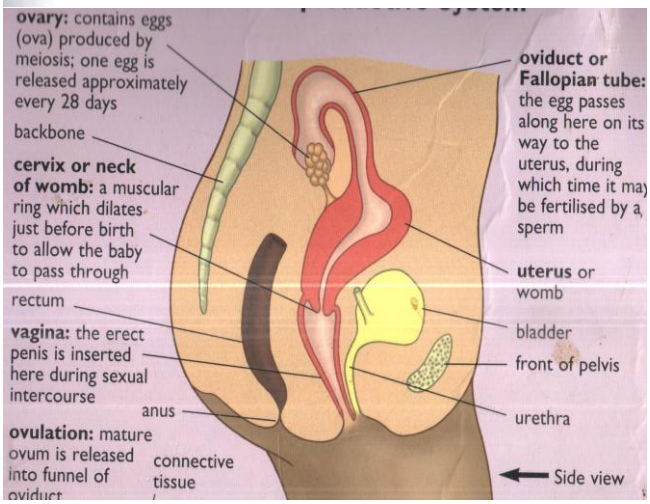
c) **Viviparity-** the embryo develops within the mother and obtains nourishment directly from the mother's body. The young ones are born alive e.g. human beings.

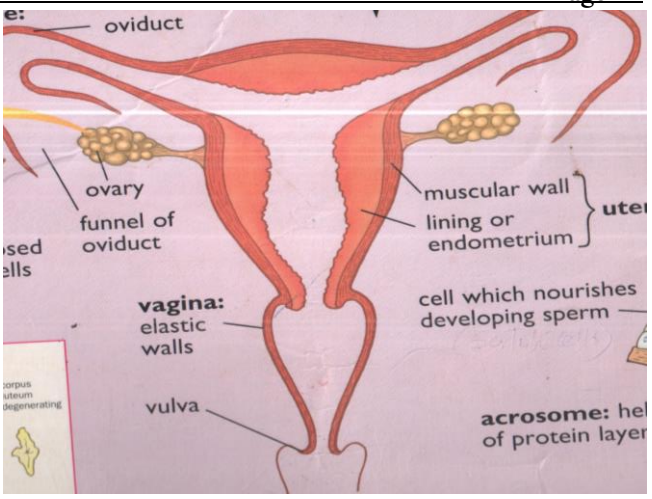
- In some mammals, embryo develops to a certain stage and then released into a structure called a pouch where it develops fully e.g. in kangaroo.

STRUCTURE AND FUNCTION OF FEMALE REPRODUCTIVE SYSTEM.



Human female reproductive system, (A) side view (B) frontal view





Adaptations of parts of female reproductive system.

1. **Ovary-** it has secretory cells that secrete female sex hormones e.g. oestrogen and progesterone.
   - ✓ It has a germinal epithelium which produces the eggs/ ova.
2. **Fallopian tube/ oviduct-** this is where fertilization takes place.
   - ✓ It is funnel shaped to receive the ovum after ovulation.
   - ✓ It has cilia which waft the ovum moving it towards the uterus.
   - ✓ It has smooth muscles which contract to help in movement of the ovum.
3. **Uterus/womb-** It has muscular walls (myometrium) that contract facilitating parturition.
   - ✓ The muscular walls are also able to expand as the embryo develops and return to its original size after birth.
   - ✓ It has endometrium/inner wall with dense network of capillaries to facilitate implantation and nourishment of the embryo.
4. **Cervix-** It is a muscular ring which close to keep the fetus within the womb.
   - ✓ It secretes a plug of mucus which prevents entry of pathogens into the uterus during pregnancy.
5. **Vagina/birth canal and vulva-** the vagina is tubular/ hollow thus allows passage of the foetus during parturition.
   - ✓ The walls of vulva have **vestibular glands (Bartholin's glands)** that secrete mucus when the female is sexually for lubrication of vagina during copulation.

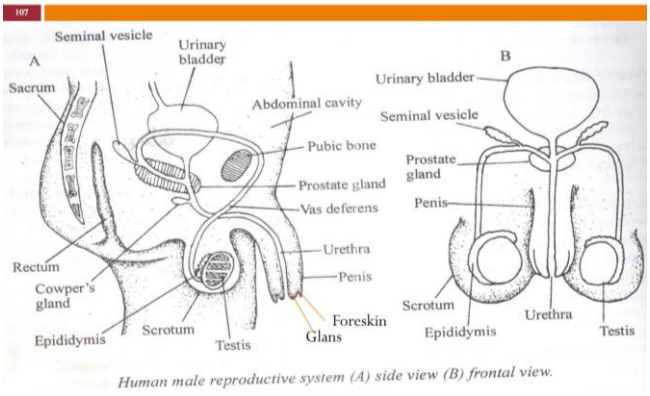
Ways in which sperms move within the female reproductive system.

i. By help of a tail in the fluid medium of the female reproductive system.
ii. They are attracted by the chemical produced by the ovum.
iii. Muscular/peristaltic contraction of uterine walls.

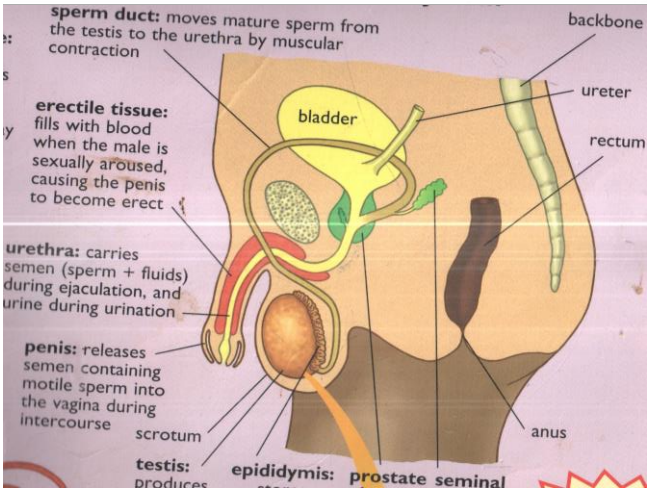
Ways in which the ovum moves within the fallopian tube.

i. The cilia beats/wafts the egg facilitating movement.
ii. By contraction of smooth muscles of the fallopian tube.

MALE REPRODUCTIVE SYSTEM



Human male reproductive system (A) side view (B) frontal view.



Adaptations of parts of male reproductive system

1. The **penis** is made up of spongy tissue and blood vessels which fill with blood causing it to erect to facilitate copulation.
2. **The testes** are protected by **scrotum** and are made up of several and highly coiled **seminiferous tubules** which provide a large surface area for sperm production.

✓ **The testes** have **sertoli cells** that nourish the sperms. The testes are located to hang outside the body to provide a cooler environment for sperm production.

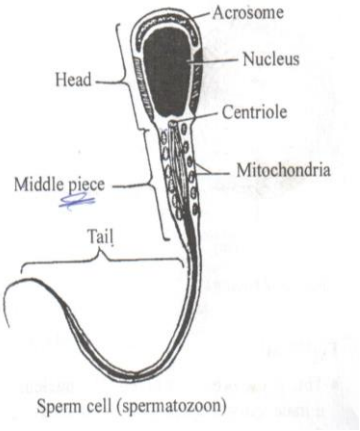
✓ The testes also have **interstitial cells** which produce male hormones called **androgens.** The main androgen is **testosterone.**

3. The **Epididymis** is highly coiled to provide a large surface area for storage of sperms.
4. The **Seminal vesicle** (connected to the sperm duct a short distance from where the sperm duct enters the urethra) secretes an alkaline fluid which contains nutrients for the sperms.
5. The **Prostate gland (**is located at the junction between the sperm duct and urethra) secretes an alkaline fluid to neutralize the vaginal fluids and activate the sperms.
6. The **Cowper's gland** (located below the prostate gland) secretes an alkaline fluid to neutralize the acidity along the urethra (caused by pH variations of urine).

✓ The alkaline fluid and sperms form semen.

7. The **Sperm duct/ vas deferens** is tubular connecting the epididymis and urethra and is used for passage of sperms/ acts as ejaculatory duct.
8. The **Urethra** is tubular to expel urine and semen (hence said to have urino-genital role).

SPERMATOZOA (SPERMS)

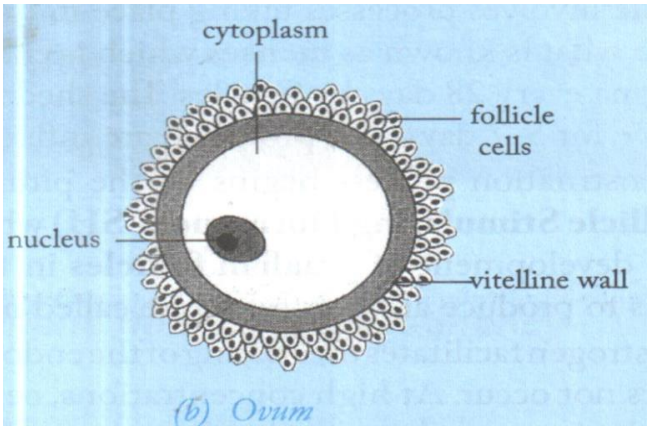


Sperm cell (spermatozoon)

ADAPTATIONS OF THE SPERM CELL.

1. The head contains a large **haploid nucleus which** carries genetic material.
2. Acrosome contains lytic enzymes, which digest the membranes of the egg for the sperm to penetrate and effect fertilization.
3. The **middle piece** contains **numerous mitochondria** which provide energy for the propulsion of the sperm to reach the egg.
4. The long **tail** which lashes side by side to propel the sperm forward.
5. The shot neck has centrioles for controlling axial filaments

OVUM/EGG CELL/FEMALE GAMETE.



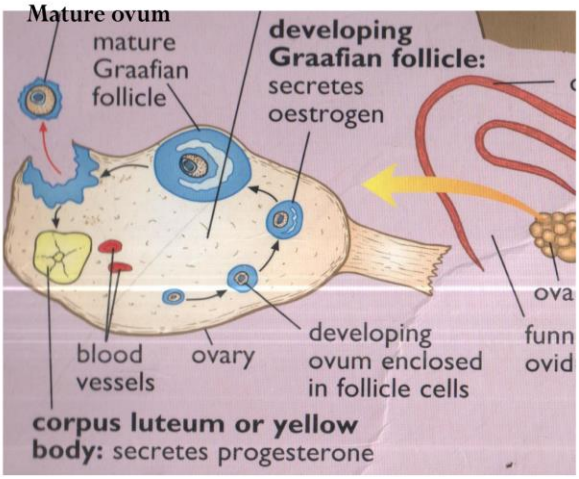
ADAPTATION OF AN OVUM/EGG CELL.

1. **It has follicle cells** to nourish the ovum.
2. **It has vitelline membrane** which thickens after penetration of the first sperm preventing entry of other sperms.
3. **It has nucleus** which contains genetic material and fuses with the nucleus of sperm to form zygote.
4. **It has large cytoplasm** which contains stored food substances that nourish the embryo before implantation.
5. **It has cell membrane** which encloses contents of the egg and allows selective movement of substances in and out of ovum.

Development of the ovum.

✓ Egg formation in the ovary is called **oogenesis.**

- ✓ Egg formation begins in the ovary of the foetus before birth. At birth, there are about 70,000 potential eggs in the ovary of a baby girl but only 500 ova eventually develop after puberty.
- ✓ At birth eggs are enclosed by a layer of primary follicles which provide nourishment.
- ✓ During puberty primary follicles develop into **Graafian follicle** that contains mature ovum.
- ✓ Ova are at different levels of development such that one Graafian follicle matures every month.
- ✓ At ovulation the Graafian follicle bursts to release the mature egg surrounded by a layer of follicle cells.



DIFFERENCES BETWEEN THE SPERM AND OVUM.

Sperm	Ovum/ egg
1. It has a tail and acrosome.	1. It lacks a tail and acrosome.
2. It is smaller in size.	2. It is relatively larger in size.
3. It has less food reserve.	3. Has more food reserve.
4. It is motile/mobile	4. It is immotile/non-motile
5. Has prominent nucleus and negligible cytoplasm	5. Has large amount of cytoplasm

The process of fertilization in man.

- ✓ Fertilization is the fusion of male and female gametes and it occurs in the oviduct/fallopian tube.
- ✓ When the sperm comes into contact with the egg, the acrosome bursts open and releases lytic enzymes, which dissolve the vitelline/ egg membrane and also disperse the follicle cells surrounding the egg cell.
- ✓ The acrosome forms a fine filament that is used to penetrate the egg hence head of the sperm enters the ovum and the tail is left outside the ovum.
- ✓ The vitelline membrane then undergoes a change which stops any other sperm from entering the ovum.
- ✓ Once the head is in the cytoplasm, it bursts to release the male nucleus which fuses with the female nucleus to form a diploid zygote.
- ✓ After ovulation, the ovum can remain viable for 8-24 hours before it dies while the sperms can remain viable for 2-3 days within the female reproductive system before they die.

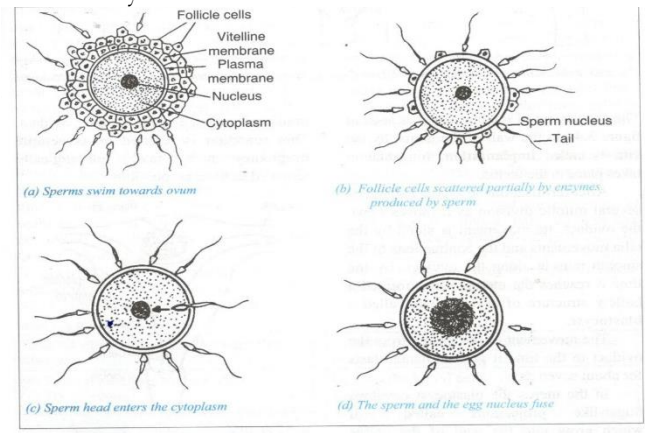


Fig. 3.42: The process of fertilisation

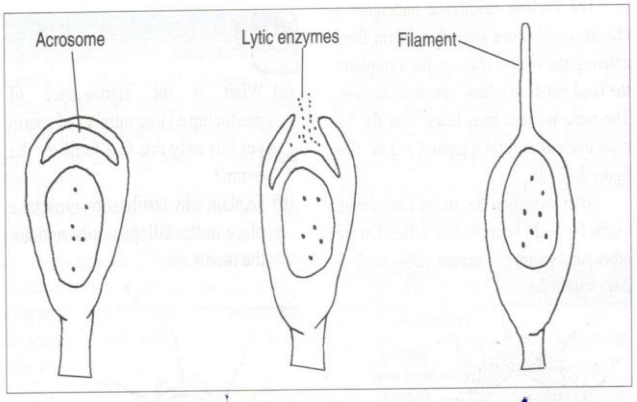


Fig. 3.43: Reliease of acrosome enzymes and formation of filament that help sperms penetrate the eggImplantation

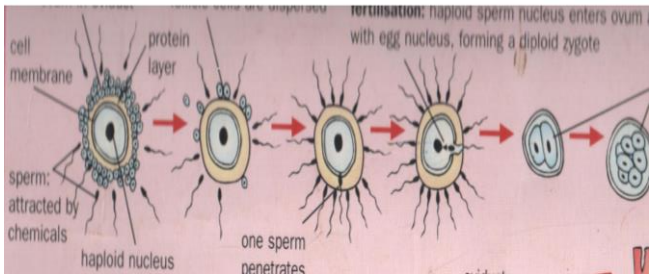
The significance of producing a large number of sperms yet it is only one that fertilizes the ovum.

- ✓ This is because many die before reaching the ovum due to:

1. Inappropriate temperature for production in the testes and storage in the epididymis.
2. Inappropriate pH (e.g. acidity) in the female reproductive tract.
3. Others deplete their energy before reaching the ovum because the distance between the vagina and oviduct is long.
4. The egg produces a chemical that inactivates the sperms.

Reason why fertilization must take place in the fallopian tube/ oviduct but not in the uterus.

- ✓ The ovum can take up to 7 days to travel through the oviduct to the uterus. By then it would be dead because it survives for 8-24 hours after release from the ovary.



Changes that take place after fertilization.

(a) **Zygote.**

- ✓ It moves along the oviduct to the uterus by help of cilia and contraction of the oviduct smooth muscles.

- ✓ It undergoes mitotic division forming a hollow structure with several cells called **blastocyst**.
- ✓ The **blastocyst** develops fingerlike projections called **villi** which attach it to the **endometrium**.
- ✓ The attachment of the blastocyst to the wall of the uterus/endometrium is called **implantation.**
- ✓ After implantation the **blastocyst** develops into **embryo.**
- ✓ The embryo uses the villi to absorb nutrients from the endometrium.
- ✓ The villi and endometrium develop into **placenta.**
- ✓ The movement of the zygote from the oviduct until it is implanted lasts for about 7 days.
- ✓ Sometimes the zygote fails to move down the oviduct to the uterus but instead gets implanted into the walls of the oviduct. This is called **ectopic pregnancy** which is deadly if it is not surgically removed as soon as possible.

(b) Uterus

- ✓ The uterus lining/ endometrium thickens.
- ✓ There is increased blood supply.

FORMATION OF PLACENTA.

- ✓ During implantation, the blastocyst differentiates into 3 layers;

1. **Chorion-** the outermost membrane which develops chorionic villi which grow into the endometrium.

- ✓ During early stages of embryo development the villi form sites for exchange of materials between the embryo and maternal blood vessels in the uterine lining.

2. **Amnion-** which surrounds the embryo forming amniotic cavity in which the embryo lies.

- ✓ The amnion secretes amniotic fluid which fills the amniotic cavity.

3. **Allantois-** together with chorionic villi and endometrium it forms the **placenta** which is connected to foetus by **umbilical cord.**

- ✓ The umbilical cord has:

a) **Umbilical vein**- which carries blood into the foetus rich in oxygen and nutrients.

b) **Umbilical artery** – which brings blood to the placenta from the foetus with high amount carbon (IV) oxide and nitrogenous wastes e.g. urea but low nutrients and oxygen.

- Carbon (IV) oxide in the foetal blood diffuses across the placenta into maternal blood, it accumulates in the uterine vein which transports it away from the uterus.

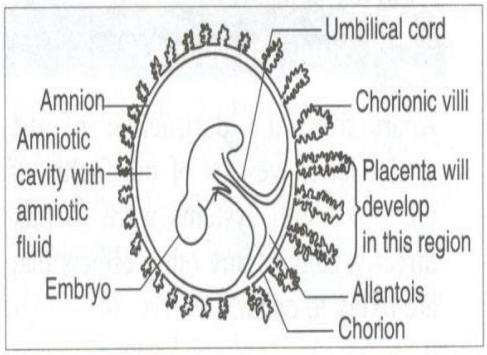


Fig. 3.45: Diagram illustrating relationship between the human embryo and its embryonic membranes

Role of amniotic fluid.

1. Protects the foetus against mechanical damage/ injury/acts as a shock absorber.
2. Provides a medium for foetus to move about/ suspends the embryo providing it with support.
3. It is a source of nourishment for the foetus within the first 3 months of pregnancy.
4. Prevents the foetus from drying.
5. It ensures constant temperature within the womb.
6. Equalize pressure around the foetus.

Materials that are not allowed to pass through the placenta.

1. All blood cells.
2. Plasma proteins.
3. Most bacteria.

Materials that pass from foetus to mother.

1. Carbon (IV) oxide.
2. Nitrogenous waste products/ urea.

Materials that pass from mother to foetus.

1. Oxygen
2. Digested food substances (glucose, amino acids, fatty acids, glycerol)
3. Vitamins.
4. Mineral salts.
5. Hormones.
6. Water.
7. Antibodies and antigens.
8. Drugs, alcohol and some chemicals from cigarette.

Role of the placenta

1. It allows passage of nutrients from the mother to the foetus for growth and development.
2. It allows diffusion of gases between the mother and foetus.
3. It secretes hormones e.g. progesterone, oestrogen, human chorionic gonadotrophin (HCG)
4. Prevents destruction of delicate blood vessels of the foetus and prevents entry of pathogens into the foetus.

Adaptations of the placenta to its function. / How is the placenta suited to its functions?

1. Has numerous capillaries/highly vascularized to increase concentration gradient for efficient exchange of materials.
2. It has a thin membrane for faster diffusion of materials/reduce the distance travelled by substances.
3. It has numerous (chorionic) villi to increase the surface area of diffusion of substances.
4. It has selective membrane which allows selective diffusion of substances.
5. It is glandular to secrete hormones e.g. progesterone, oestrogen.
6. Has counter current flow of maternal and foetal blood to maintain steep concentrated gradient hence efficient diffusion of substances.

Note.

- ✓ The foetal blood does not mix with maternal blood in the placenta because there is no direct connection between the foetal blood system and that of the mother. This is important because:

1. It ensures that no agglutination occurs in foetal red blood cells due to incompatible blood groups of the mother and foetus, both ABO and Rhesus antigens.

2. It ensures that the foetus delicate blood vessels are not destroyed/do not burst by the high pressure in the mother's/ maternal circulatory system.
3. It prevents the transfer of pathogens from mother into foetus.
4. It prevents the transfer of waste products from maternal blood into the foetus

TERMS RELATED TO REPRODUCTION.

1. **Gestation period:** this is a period between conception and birth.
2. **Miscarriage:** This is natural termination of pregnancy before completion of six months. The baby will not survive.
3. **Abortion:** Intentional termination of pregnancy either chemically or physically.
4. **Premature birth:** If birth occurs after 7 months but before the full term, the birth is called **premature birth.**

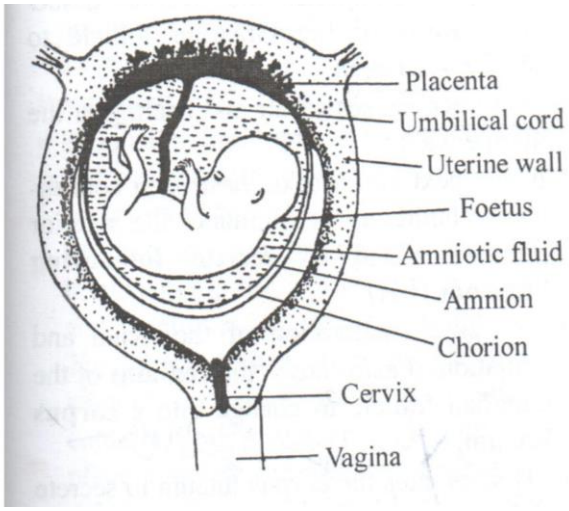
✓ The baby can survive if it has attained a certain weight or else it will be cared for in incubators.

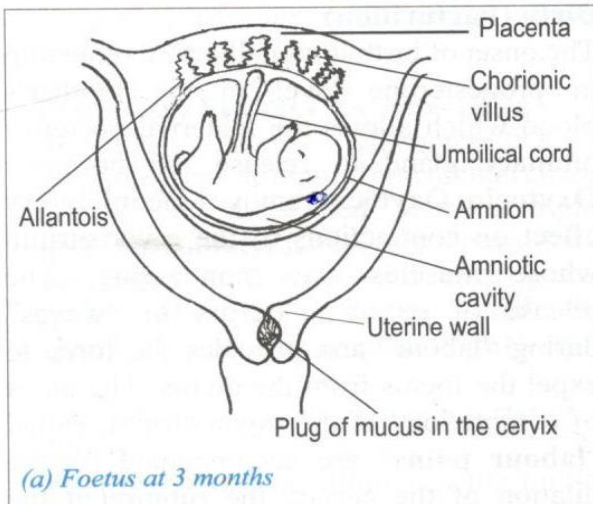
5. **Monozygotic or identical twins:** These are as a result of a fertilized egg that divides into two independent parts in the early stages of development, which proceed to develop into two separate embryos.

✓ Such twins are of the same sex. They are genetically identical and are completely alike.

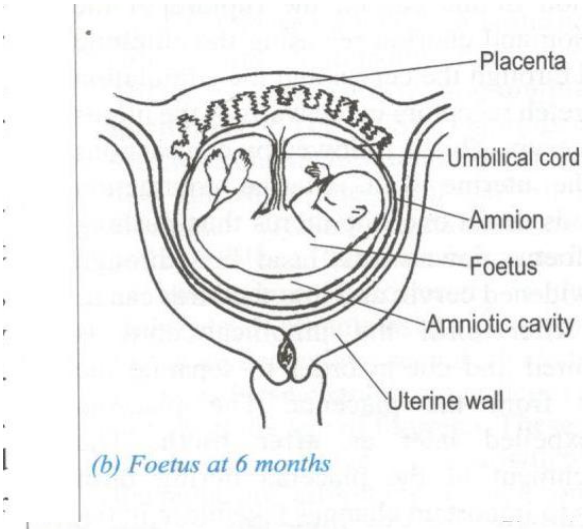
6. **Siamese twins:** these are identical twins who develop without separating completely so that they are born with some parts fused
7. **Dizygotic or fraternal twins:** These are as a result of simultaneous release of two or more ova, which are fertilized independently.

- Such twins may be of the same or of different sex. They are genetically different and have the same degree of resemblance as that of other brothers and sisters born at different times.

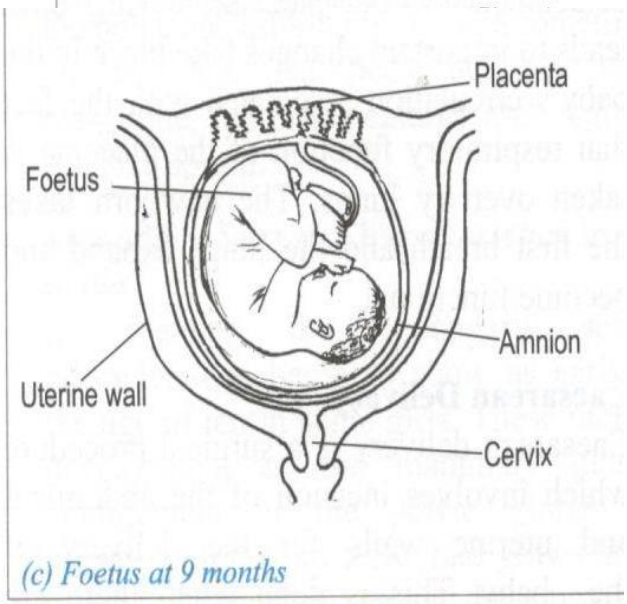




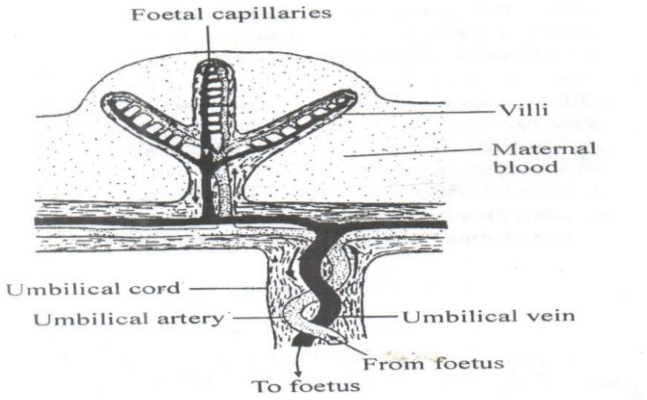
(a) Foetus at 3 months



(b) Foetus at 6 months



(c) Foetus at 9 months



Structure of placenta

PREGNANCY/GESTATION PERIOD.

- ✓ This is a period between conception and birth. It lasts for 9 months (38-40 weeks).
- ✓ During this time, the **zygote** develops into an **embryo** and further into **foetus (at 3 months when all organs and tissues are fully developed),** the **foetus** then develops into a **baby** ready to be born.
- ✓ The heart and blood vessels are among the first organs to form in the embryo because blood is needed in all the developing body parts to supply oxygen, nutrients and also remove metabolic wastes.
- ✓ The **corpus luteum (yellow body)** in the ovary persists and continues to secrete **progesterone** during the early months of pregnancy**.**
- ✓ After 4 months, the placenta takes over producing the hormone. Therefore even if the ovaries are removed after 4 months, there would be no effect on pregnancy.
- ✓ At 9 months, the head is directly above the cervix/facing downwards and dilation of cervix hence a sign of near parturition.
- ✓ **Progesterone** keeps pregnancy by maintaining a thickened and highly vascularized inner lining (endometrium) hence providing nourishment to the foetus.
- ✓ Menstruation should stop during pregnancy to ensure that the inner wall (endometrium) remains intact which is essential for the development of the foetus.
- ✓ If menstruation occurs it will lead to **miscarriage.**
- ✓ The pregnant mother should have a balanced diet with plenty of **proteins** for growth and development of embryo, **calcium and phosphorus** for bone formation and **iron** for formation of haemoglobin.
- ✓ At delivery the pituitary glands also secrete **prolactin hormone** which stimulates the secretion of milk by the secretory cells of the mammary glands.

PARTURITION/BIRTH.

- ✓ It is brought about by **Dilation of cervix and strong contractions of the uterus and abdominal walls.**
- ✓ Towards the end of pregnancy, the level of progesterone falls. This causes the **pituitary gland** to secrete **oxytocin hormone.**
- ✓ **Oxytocin** stimulates the myometrium to contract providing the force to expel the foetus from the uterus.
- ✓ This is accompanied by some pains hence called **labour pains.**
- ✓ Oxytocin also stimulates milk let down by the mammary glands.
- ✓ The contraction of the myometrium is accompanied by dilation of the cervix, rapture of amnion and chorion releasing the amniotic fluid.
- ✓ The contraction of uterus pushes the foetus downwards, head first through the widened cervix into the birth canal.
- ✓ After birth the umbilical cord is tied and cut to separate the baby from the placenta. The placenta is later expelled as **after birth.**
- ✓ The placenta secretes **Relaxin hormone** prior to labour which causes the ligaments within the pelvic girdle to loosen, providing a more flexible passage for the baby during delivery.
- ✓ In case of difficult in normal delivery, surgical operation is done on the abdominal and uterine walls for delivery of the baby. This is called **caesarean delivery.**
- ✓ After birth, the baby cries immediately because of fall in body temperature. Crying is important because it stimulates the breathing system and expands the lungs so that the baby starts breathing.

PARENTAL CARE.

- ✓ It is the attention given to the new born by providing food/ milk protection and providing favourable conditions for growth.
- ✓ At delivery the pituitary glands also secrete **prolactin hormone** which stimulates the secretion of milk by the secretory cells of the mammary glands.
- ✓ Mother's milk is the best food for the offspring because:

1. It does not require mechanical breakdown for it is in a liquid form that is easy to swallow.
2. It contains all nutrients required for growth and in the right amounts.
3. It contains antibodies which provide passive immunity to the foetus.
4. Reduces chances of infections since no preparation is needed.

- Various stimuli e.g. cry of the baby, smell, suckling and sight of the baby stimulates hypothalamus of the mother to send impulse to the pituitary gland which secretes **oxytocin hormone.**
- **Oxytocin hormone** stimulates contraction of muscles of mammary glands allowing milk let-down to the nipple where the baby sucks from.
- Milk let-down is inhibited by distraction, embarrassment, anxiety of fatigue.

ROLE OF HORMONES IN DEVELOPMENT OF SECONDARY SEXUAL CHARACTERISTICS.

- ✓ The presence of vagina and penis is used to differentiate between a baby boy or girl. These physical characteristics are called **primary sexual characteristics.**
- ✓ At puberty (at age of 12 years in girls and 14 years in boys), other features develop that distinguish males and females.
- ✓ They are controlled by oestrogen hormone in females and androgens in males hence called **secondary sexual characteristics.**

Secondary sexual characteristics in males.

✓ In males secondary sexual characteristics begin to show at the age of 14 years. The sex hormones / gonadotrophins produced are:

1. **Follicle stimulating hormone (FSH)-** which stimulates synthesis and maturation of sperms.
2. **Luteinizing hormone (LH)/interstitial cell stimulating hormone (ICSH)-** stimulates the interstitial cells to produce male hormones called **androgens** and the main androgen is **Testosterone. Testosterone** stimulates the development of secondary sexual characteristics which include:

a) Deepening of voice.
b) Growth of beards and hair in pubic area
c) Enlargement of testes and penis.
d) Broadening of shoulders.
e) Enlargement of muscles around the chest and shoulders.
f) Production of sperms.

Secondary sexual characteristics in females.

✓ In females secondary sexual characteristics begin to show at the age of 10-12 years. The hypothalamus stimulates the pituitary gland to release gonadotrophins which include:

a) **Luteinizing hormone (LH)-** which stimulates mature Graafian follicle to release a mature ovum in the process called **ovulation.**
b) **Follicle stimulating hormone (FSH)-** which stimulates the ovary to release the hormone oestrogen. Oestrogen stimulates the development of Graafian follicle in the ovary and development of secondary sexual characteristics.

✓ Secondary sexual characteristics in females include:

i) Enlargement of pelvic girdle.
ii) Widening of hips.
iii) Growth of hair in pubic and armpit regions.
iv) The ovaries mature and start releasing eggs and the girls begin to menstruate.

B. ROLE OF HORMONES IN MENSTRUATION IN FEMALES.

- Gamete production in females is cyclical after every 28 days hence called menstrual cycle.
- It begins with **menses i.e.** discharge of blood and tissue debris from the uterus which takes place for 5-7 days. Before menses the females experience abdominal pain, back pains and nausea.
- The events of menstrual cycle involves the ovaries (ovarian cycle) and in the uterus (uterine cycle) controlled by pituitary gonadotrophins.

Role in menstrual cycle.

✓ After/ at the onset of menstruation, (the anterior lobe of) pituitary gland secretes **Follicle Stimulating Hormone (FSH)** which:

1) Causes/ stimulates the Graafian follicle to develop in the ovary. The graafian follicle contains the ovum.
2) Stimulates the ovary tissues to secrete **Oestrogen hormone.**

✓ Oestrogen hormone has the following effects:

1) Brings about/ causes/ stimulates repair and healing of endometrium/ uterine lining (after menstruation).
2) Its concentration increases to a level which stimulates the (anterior lobe of the) pituitary gland to secrete Luteinizing hormone.
3) Its concentration increases to a level which stops further secretion of Follicle stimulating hormone.

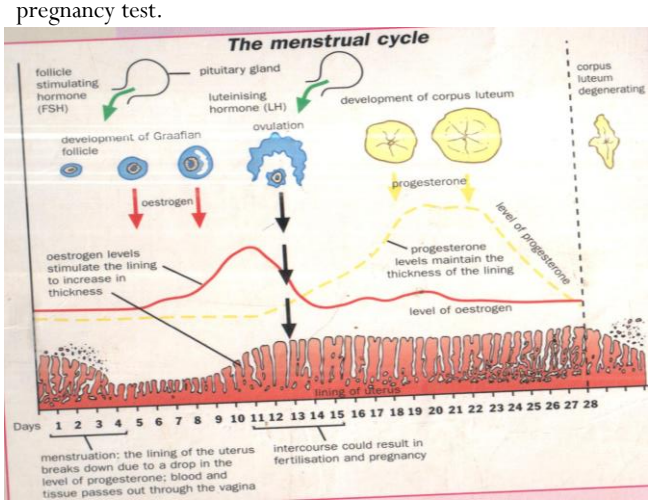
✓ Luteinising hormone has the following effects:

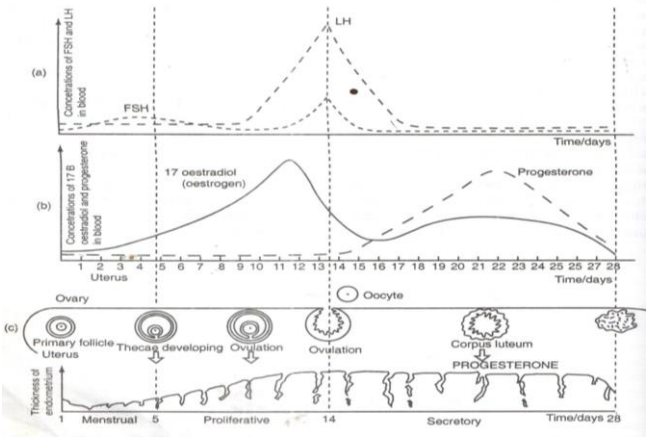
1) It stimulates the maturation of Graafian follicle.
2) It stimulates or causes ovulation/stimulates the Graafian follicle to burst releasing the ovum.
3) It stimulates the remains of Graafian follicle to form a yellow body (Corpus luteum) in the ovary.
4) It stimulates the corpus luteum to secrete progesterone.

✓ Progesterone has the following effects:

1) It stimulates thickening of endometrium/ inner lining of uterine wall in readiness for implantation.
2) As the level of progesterone increases it inhibits the pituitary gland from secreting follicle stimulating hormone.
3) Further increase in progesterone level inhibits the pituitary gland from secreting Luteinizing hormone.
4) Further increase in progesterone level causes the corpus luteum to degenerate.

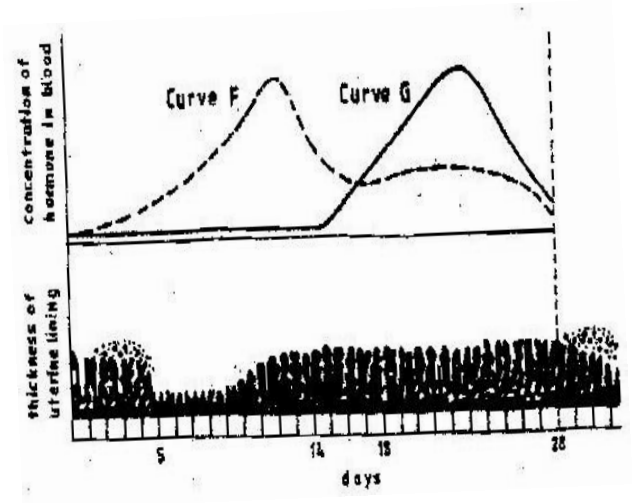
- Degeneration of corpus luteum reduces the amount of progesterone.
- The sudden drop in secretion of progesterone causes the endometrium to slough off/ menstruation occurs. The cycle is then repeated.
- ***Ovulation and hormonal imbalance causes a rise in temperature during menstruation.***
- During pregnancy the implanted embryo produce another hormone called **human chorion gonadotropic hormone (HCG)** which is sent to ovary to sustain corpus luteum.
- The hormone is excreted through urine. The presence of this hormone in urine is used to **confirm pregnancy** during a pregnancy test.





Study question

✓ The figure shows changes that take place during menstrual cycle in humans.



a) Name the hormone whose concentrations are represented by curves F and G.

✓ ***F- Oestrogen.***

✓ ***G- Progesterone.***

b) State the effects of the hormones named in (a) above on the lining of the uterus.

✓ ***Oestrogen-Promotes healing and repair.***

✓ ***Progesterone -Causes thickening and increased blood supply /vascularisation.***

c) (i) Name the hormone which is released by the pituitary gland in high concentration on the 14th day of the menstrual cycle.

✓ ***Luteinizing hormone.***

(ii) State two functions of the hormone named in (c) (i) above.

✓ ***Causes / stimulates ovulation.***

✓ ***Stimulates Graafian follicle to become corpus luteum.***

✓ ***Stimulates corpus luteum to release progesterone.***

d) State the fertile period during the menstrual cycle.

✓ ***12th-16th.***

e) State the dietary requirements that maintain the menstrual cycle.

✓ **Iron** for the formation of haemoglobin.

✓ **Vitamin K** for blood clotting to prevent prolonged bleeding.

✓ **Vitamin C** to heal the uterine wall and absorption of iron.

f) State the factors that change the menstrual cycle.

✓ Change in diet.

✓ Stress.

✓ Disease infection.

✓ Emotions.

Menopause

✓ This is the permanent end of menstruation and fertility. It may begin between the age of 40 and 50.

✓ It is a gradual process signified by :

i) Decrease in number of Graafian follicles,

ii) The follicles become less sensitive to follicle stimulating hormone,

iii) Secretion of oestrogen declines.

Symptoms

1. Night sweat.
2. Random hot flashes during the day.
3. Changes in mood that shows depression.
4. Fatigue.
5. Vaginal dryness.
6. Loss of minerals e.g. Calcium. This leads to softening of bone, a condition called **osteoporosis.**

SEXUALLY TRANSMITTED DISEASES.

1. HIV AND AIDS (ACQUIRED IMMUNE DEFICIENCY SYNDROME)

a) **Cause.** Caused by the HIV (Human Immunodeficiency Virus).

b) **Mode of transmission.**

✓ Sexual intercourse with an infected person.

✓ Sharing of contaminated needles with infected people.

✓ Blood transfusion with infected blood.

✓ From infected mother to child during birth or through breast milk.

c) **Symptoms.**

i. Swollen lymph glands.
ii. Diarrhoea, fever, sweating and body fatigue.
iii. Sudden weight loss.
iv. Persistent cough.
v. Generalized skin infections.

Prevention and control of HIV and AIDS

1. Abstaining from sexual intercourse before marriage.
2. Correct and consistent use of male and female condoms.
3. Have one faithful sexual partner/ avoid multiple sexual partners.
4. Screening of blood before transfusion.
5. Use of antiretroviral (ARV) drugs by those affected.
6. Sex education to enlighten the public on socio-economic effects HIV/ AIDS.
7. Public health interventions to curb/ stop the spread of HIV.
8. Avoid risky cultural practices e.g. female genital mutilation, traditional male circumcision and wife inheritance.
9. Use of bottle feeding instead of breast feeding for babies.
10. Enforce laws that make it an offence to spread HIV intentionally. Avoid sharing surgical and piercing instruments e.g. ear piercing and sharing of needles by drug users.

11. Promote male circumcision to reduce the risk of contracting HIV.
12. Encourage people to know their HIV status hence minimize the spread.

Study question

a) **Give the possible reasons why HIV/AIDS is still rampant despite a lot of awareness creation.**

1. *Many adolescents engage in sexual activity through excitement, wrong advice, peer pressure, or ignorance.*
2. *Many people especially youths misuse their leisure time through engaging in erotic dances, reading and watching pornography.*
3. *Lack of strict policy on drug abuse.*
4. *Commercial sex/ prostitution due to unemployment.*
5. *Pervasive behavior e.g. homosexuality and rape.*
6. *Long incubation behavior of HIV makes people complacent.*
7. *Many traditionalists have opted not to believe HIV hence continuation of wife inheritance, traditional circumcision tattooing etc.*
8. *Presence of quack, bush doctors and conmen/ women who cheat people about cure drugs or miracle cures of HIV/AIDS condition.*

b) **Offer possible solutions to these problems.**

1. *Avoid bad company.*
2. *Proper use of leisure time by avoiding reading erotic magazines, watching pornography and not attending night clubs.*
3. *Abstain from misuse of drugs/ drug addiction.*
4. *Public awareness of HIV/AIDS e.g. lack of cure, no miracle cure of the disease.*
5. *Abstaining from commercial/ indiscriminate sexual behavior.*
6. *Avoiding risky behaviors e.g. wife inheritance.*
7. **A child born of a HIV positive mother tested HIV positive after birth. However, after a few months the child tested HIV negative. Explain.**
8. *At birth, the child tested HIV positive because of the presence of HIV antibodies which passed through the placenta. After a few months the antibodies are removed from the blood hence the child tested HIV negative.*

2. Syphilis.

✓ It affects the genital organs of both males and females.
✓ Caused by the bacterium *Treponema pallidum.*

Transmission.

1. Through sexual intercourse with infected person.
2. Transfusion with infected blood.
3. Transmission from infected mother to the child during birth or through the placenta before 7th month of delivery

Symptoms.

1. Painless sore appearing on or around the sex organs.
2. Skin rashes.
3. Flu like symptom i.e. Fever, sore throat, bone and joints pain.
4. Headache.
5. Insanity.

Prevention.

i. Avoid indiscriminate sex.
ii. Use of condoms.

3. GONORRHOEA.

✓ It is a disease affecting genital organs caused by the bacterium *Neisseria gonorrhoea.*

Transmission

1. Sexual intercourse with infected person.
2. During birth when a mother is infected.

Symptoms.

1. Pain when passing urine.
2. Bleeding in between the periods in women.
3. Females have unusual vaginal discharge which is watery, yellow or greenish in color.
4. Yellow or green discharge in males.
5. Tenderness and pain in the testicles in males.
6. Inflammation of the foreskin in males

Control and prevention

1. Public education on dangers of indiscriminate sex.
2. Use of condoms during sexual intercourse.
3. Treatment using antibiotics.

4. GENITAL HERPES.

✓ It is caused by the virus *Herpes simplex.*

Transmission.

1. Sexual intercourse with an infected person.
2. Kissing infected person.
3. Sharing of contaminated needles and syringes.

Symptoms.

1. Lesions on the skin and mucous membrane of the mouth/ buccal cavity, vaginal canal and conjunctiva in females.
2. Painless lesions on the head of the penis

Control and prevention.

1. Avoid indiscriminate sex and contaminated needles and syringes.

5. HEPATITIS B.

✓ It is a condition that describes inflammation of the liver.
✓ It is caused by a virus which attacks liver cells eventually causing damage in the liver.

Transmission.

i. Sexual contact with an infected person.
ii. Sharing contaminated instruments used by barbers and dentists.
iii. Sharing contaminated syringes and needles (by drug addicts).
iv. Blood transfusion with infected blood.
v. Kissing an infected person.
vi. Infected mother to unborn child.

Symptoms.

i. Loss of appetite.
ii. Jaundice.
iii. Headache and muscle ache.
iv. Vomiting.
v. Dark urine.

Prevention.

i. Screening of blood before transfusion.
ii. Avoiding indiscriminate sex.
iii. Avoiding sharing needles.
iv. Using condoms during sexual intercourse.

6. TRICHOMONIASIS.

✓ Caused by a protozoa called *Trichomoniasis vaginalis.*

Transmission

i. Through sexual intercourse.
ii. Contaminated clothes or beddings.

Symptoms.

1. Yellow smelly discharge in females.
2. Burning sensation when urinating.
3. Itching in the urethra and vagina.

Control and prevention.

1. Use protective methods during sexual intercourse/ avoid indiscriminate sex.
2. Avoid sharing linen/ clothes.
3. High personal hygiene in the genitals.

7. CANDIDIASIS.

✓ Caused by a fungus, *Candida albicans.*

Transmission.

✓ Through sexual contact with infected person.

Symptoms.

i. Itching and burning sensation in the genital area.
ii. White discharge from the vagina which does not smell.

Control and prevention.

i. Avoid indiscriminate sex.
ii. Using condoms during sex.
iii. Proper hygiene (e.g. wiping oneself from front to back after using the toilet, use of pure cotton and loose pants in females).
iv. Proper treatment using antibiotics.

TOPIC 4- GROWTH AND DEVELOPMENT

Definition of terms.

1. **Growth-** this is the irreversible/permanent quantitative increase in the size of an organism. It is brought about by multiplication and elongation of cells in the process of cell division.
- It is measurable e.g. increase in height, length, width e.t.c.
2. **Development-** this is the qualitative growth which involves differentiation of cells and formation of new tissues to be able to perform specialized functions.
- It is not measurable but can be assessed through complexity e.g. development of leaves, flowers and roots.
3. **Differentiation –** It refers to modifications of cells to perform specific functions.
- Differentiation is important because cells become specialized to enable the organism perform specific functions.
4. **Morphology** refers to the body form of an organism. Morphology is as result of growth and development.
- In animals, growth takes place all over the body but in plants it takes place in specialized/localized regions called **meristems.**

Differences between growth and development.

✓ Growth is quantitative while development is qualitative.
✓ Growth is measurable while development can only be assessed through increased complexity.

Processes involved in growth.

1. **Assimilation** -Cells of organisms make/synthesize new cellular substances from food nutrients hence increase in mass.
2. **Cell division (mitosis) -** that lead to increase in the number of cells.
3. **Cell expansion -** that leads to enlargement an increase in the volume and size of the organism.

Differences in growth between plants and animals.

Plants	Animals
i. Growth occurs at specific/localized parts.	i. Growth occurs throughout the animal body.
ii. Growth takes place throughout the life cycle.	i. Growth takes place in early stages and stops at maturity.
iii. Growth is mainly influenced by environmental factors.	i. Growth is mainly influenced by hormones.

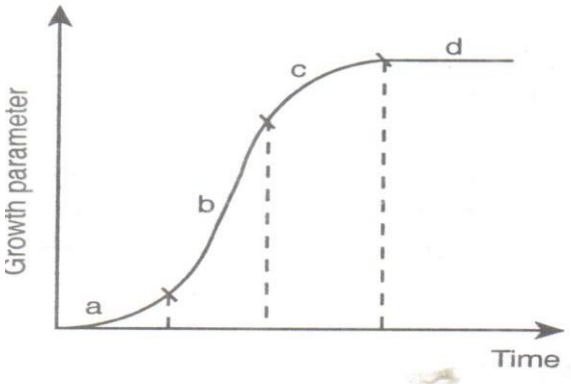
Measurement of growth.

✓ Growth can be estimated by measuring some aspect of an organism e.g. ***volume, height and mass and in unicellular organisms, the number of cells*** over a period of time.
✓ Dry mass is the best indicator of growth because it gives the actual amount of living matter in an organism.
✓ Fresh mass is dependent on the amount of water present in an organism hence it is not the best indicator of growth.

- ✓ Dry mass has **limitation** in estimating growth because it kills the organism hence cannot be used over a period of time to estimate growth.
- ✓ If the measurements so obtained are plotted against time, the curve obtained is a **growth curve (**S-shaped curve /sigmoid curve).

Limitations of measuring growth using the above parameters.

1. Difficulty in choosing the right growth parameter.
2. The use of a single growth parameter does not take into account growth in other directions.
3. Volume cannot be used for those organisms with irregular shape.
4. Mass of an organism is usually affected by variation in the fluid content of the organism.
5. Use of dry mass involved killing the organism.
6. The use of mass or size may be inaccurate because different parts of an organism mature at different times.
7. Irregularities in the growth of an organism due to fluctuation in the environment / diet.



The sigmoid growth curve

PARTS OF A SIGMOID CURVE.

a) **Lag phase - region A.**

- ✓ Growth is slow because:

i. The number of cells dividing are few.
ii. The cells have not yet adjusted to the surrounding environmental factors.

b) **Exponential phase (or log phase) - Region B.**

- ▪ There is rapid/ exponential growth because:

i. There is increase in the number of dividing cells.
ii. Cells have adjusted to the new environment.
iii. Food and other factors are not limiting hence cells are not competing for resources.
iv. The rate of cell increase is higher than the rate of cell death.

c) **Decelerating phase - Region C.**

- ✓ Growth is slow because of the following:

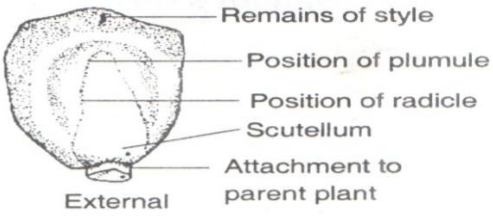
i. Most cells are fully differentiated.
ii. Fewer cells are still dividing.
iii. Shortage of oxygen and nutrients due to high demand by increased number of cells.
iv. Space is limited due to high number of cells.
v. Accumulation of metabolic waste products which inhibit growth.
vi. Limited acquisition of carbon (IV) oxide in plants.

d) **Stationary (plateau) phase - Region D.**

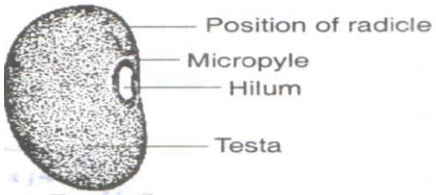
- ✓ There is no growth/ growth is constant because:

i. The rate of cell division equals the rate of cell death.
ii. Cells have fully differentiated hence no increase in number of cells.

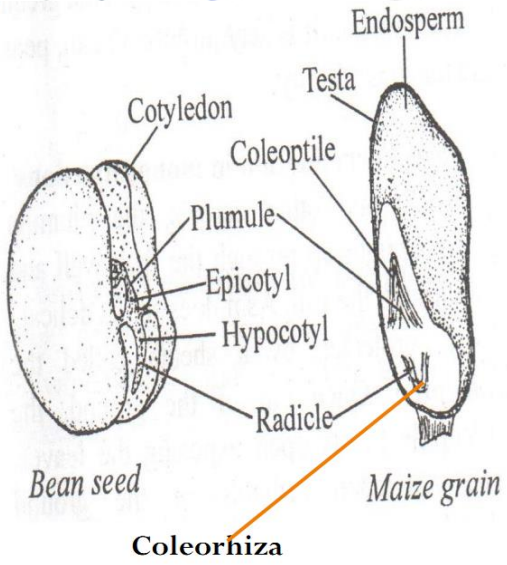
STRUCTURE OF A SEED.



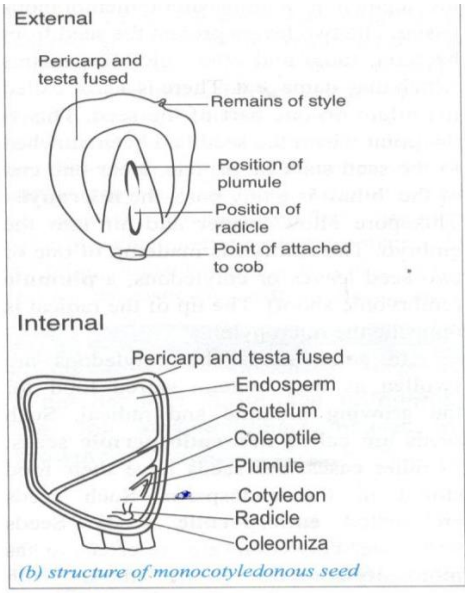
monocotyledonous seed (maize grain)



dicotyledonous seed

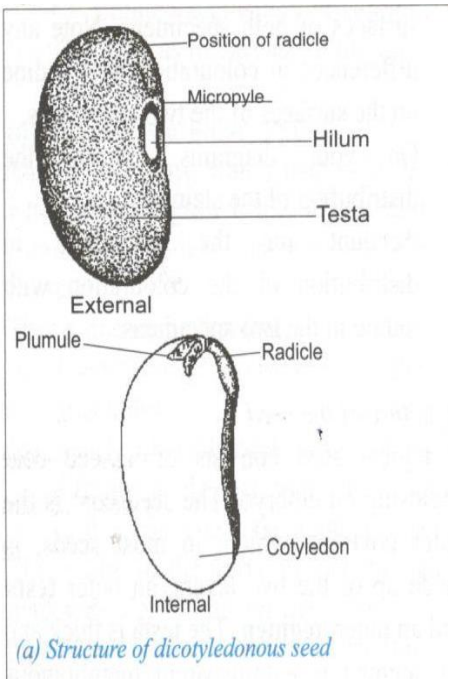


Coleorhiza



(b) structure of monocotyledonous seed

Fig. 4.4: Structure of seeds



(a) Structure of dicotyledonous seed

PARTS OF A SEED.

1. **Seed coat-** This is the outer covering of the seed formed from the integuments of embryo sac.

✓ It consists of :

i. **Testa-** thick outer layer.

ii. **Tegmen-** inner transparent membranous layer.

Role/ function of seed coat (testa and tegmen)

✓ Protect the seed from bacteria, fungi and other organisms which may damage it.

2. **Hilum -** This is the point where the seed had been attached to the seed stalk or **funicle.**
3. **Micropyle.** This is a pore which allows water and air into the embryo.
4. **Endosperm-** this is the swollen part of the seed **which stores food for growing radicle and plumule.** It is prominent in **monocot seeds.**

✓ Some seeds store food in the cotyledons e.g. **dicot seeds** hence are called **non- endospermic seeds.**

✓ Seeds that store food in the endosperm are called **endospermic seeds e.g. monocot seeds like maize, wheat, rice e.t.c.**

5. **Embryo-** it is made up of:

i. **One** or **two** seed leaves (cotyledons) - they store food for the growing plumule and radicle (in dicots). **Dicot seeds** have **2 cotyledons** while **monocot seeds** have **1 cotyledon.**

ii. **Plumule** (embryonic shoot) - it grows to form a shoot.

- It is connected to the cotyledon by the **epicotyl.**
- The tip of the plumule is protected by the **coleoptile.**

iii. **Radicle** (the embryonic root) - it grows to form a root.

- It is connected to the cotyledons by the **hypocotyl.**
- The tip of the radicle is protected by the **coleorhiza.**

SEED DORMANCY.

✓ This is a period when seeds fail to germinate even if all the favorable environmental conditions for germination are provided.

✓ This is because the embryo may not undergo further development before germination.

✓ The seed performs its physiological processes slowly and utilizes little food.

Importance/significance of seed dormancy.

1. It provides the seeds with enough time for dispersal so that they can germinate in a suitable environment.
2. It enables seeds to survive during adverse environmental conditions without depleting their food reserves.
3. Provides time for the embryo to develop until favorable conditions are available e.g. availability of water.

CAUSES OF SEED DORMANCY.

a) **Internal conditions in a seed.**

1. Underdeveloped embryo/ embryo not fully developed.
2. Hard/impermeable seed coat/testa which prevent entry of air and water e.g. wattle seeds.
3. Presence of chemical/growth inhibitors which inhibit germination in seeds e.g. abscisic acid.
4. Very low concentration of hormones and enzymes.

b) **External/environmental conditions/ conditions outside a seed.**

i. Absence/ lack of certain light wavelength e.g. lettuce seeds.

ii. Low/freezing temperature which lowers their enzymatic activities.

WAYS OF BREAKING SEED DORMANCY.

1. Allowing time for the embryo to mature.
2. Increasing concentration of hormones e.g. cytokinins and gibberellins which stimulate germination.
3. Soaking in water.
4. Providing favorable environmental conditions, e.g. water, oxygen and optimum temperature.
5. Providing the light wavelength that stimulate production of hormones (e.g. gibberellins).
6. Scarification (physical breaking/ weakening of the seed coat) through boiling, roasting and cracking e.g. wattle seeds.
7. Removal of mucilage.

✓ Scarification can also be achieved naturally by saprophytic bacteria and fungi or by passing through the gut of animals.

✓ Some seeds e.g. wattle seeds are exposed to heat for a long time before germination ***because they have hard seed coat.***

SEED VIABILITY.

- This is the ability of the seed to survive and develop into a new plant.
- Seed viability is lost due to denatured enzymes.

Factors affecting seed viability

1. Maturity of the seed- only mature seeds can germinate.
2. Storage conditions- if seeds are exposed to unfavourable conditions e.g. high temperatures, enzymes are denatured affecting viability.
3. Storage time- some seeds, if kept for a long time they lose viability.

SEED GERMINATION.

✓ This is the process by which the seed develops and grows into a seedling.

The process of germination.

✓ At the beginning of germination water is absorbed into the seed through the micropyle in the process called **imbibition** causing the seed to swell.

✓ The cells of the cotyledons become turgid and active.

SEED GERMINATION.

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The process of germination.

- ✓ At the beginning of germination water is absorbed into the seed through the micropyle in the process called **imbibition** causing the seed to swell.
- ✓ The cells of the cotyledons become turgid and active.
- ✓ The radicle grows into a root and plumule into a shoot.
- ✓ The **radicle** is the first to emerge from the seed through the **micropyle, it bursts the seed coat** and grows to form **a root.**
- ✓ It grows downwards between soil particles with its tip protected by a root cap.
- ✓ Root hairs develop behind the root cap.
- ✓ The **plumule** then breaks through the surface and develops into a **shoot**.

Reasons why the radicle develops first before the plumule.

i. To provide anchorage to the seedling.
ii. To provide the seedling with water and mineral salts.

CONDITIONS NECESSARY FOR GERMINATION.

- They include:

A. Environmental factors e.g. **water, oxygen and optimum temperature.**
B. Internal/physiological factors e.g. **enzymes and hormones.**

A. WATER.

1. Water activates enzymes involved in germination.
2. Provides a medium for enzymes to act and breakdown stored food into soluble form.
3. It hydrolyzes and dissolves the stored food substances.
4. It softens the seed coat which swells and bursts to facilitate emergence of radicle.
5. It acts as a medium of transport of dissolved food substances to the growing regions of radicle and plumule.

B. OXYGEN.

- ✓ It is required for oxidation of food substances in respiration to provide energy for cell division and growth.
- ✓ Seeds in waterlogged soil or seeds buried deep into the soil will not germinate due to lack of oxygen.

C. TEMPERATURE.

- ✓ Seeds require optimum temperature for germination. The optimum temperature is usually 30°C.
- ✓ At very low temperature (below 0°C) the temperatures are inactivated hence there is no germination.
- ✓ At very high temperatures (above 47°C) the enzymes in seeds are denatured/ destroyed hence there is no germination.

D. ENZYMES.

i. They catalyze hydrolysis if stored/ insoluble food into soluble substances.

- Food is stored in seeds in form of ***carbohydrates, fats and proteins*** which are in insoluble form.
- Carbohydrates are broken down into ***glucose*** by the **diastase enzyme,** fats into fatty acids and glycerol by **lipase,** and proteins into amino acids by **protease.**

ii. Enzymes are also necessary for the conversion of hydrolyzed products to new plant tissues.

E. HORMONES.

- ✓ These include gibberellins and cytokinins.
- ✓ They act as growth regulators and also counteract the effect of germination inhibitors.

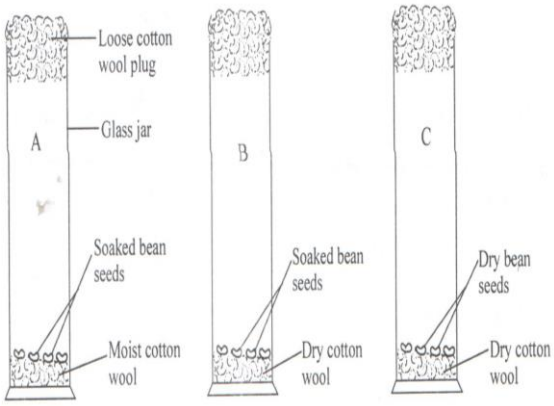
EXPERIMENT 1.

Aim

- ✓ To show that water is necessary for germination.

Procedure

- ✓ Set the apparatus as shown below.
- ✓ Keep the jars in room temperature for 5 days.



Observation and explanation.

- ✓ In A, the seeds germinated because water was available.
- ✓ In B, the seeds may start to germinate then dry up due to lack of water.
- ✓ In C, the seeds do not germinate due to lack of water.

Note

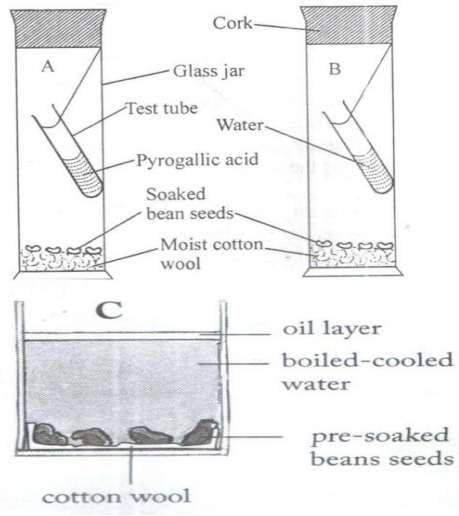
- The loose cotton wool plug ensures free circulation of air.

EXPERIMENT 2.

Aim: To show that oxygen is necessary for germination.

Procedure

- ✓ The experimental setup is as shown below.
- ✓ In Jar A, the test tube contains pyrogallic.
- ✓ In Jar B, the test tube contains water.
- ✓ The jars are left at room temperature for five days.



Observation and explanation.

- ✓ There was no germination in jar A because pyrogallic acid absorbed oxygen necessary for germination. The seeds could not respire thus did not germinate.
- ✓ The seeds in jar B germinated because oxygen necessary for germination was available.
- ✓ The seeds in C did not germinate due to the absence of oxygen. This is because boiling drives out oxygen, oil layer prevents entry of oxygen from the surrounding atmosphere.

EXPERIMENT 3.

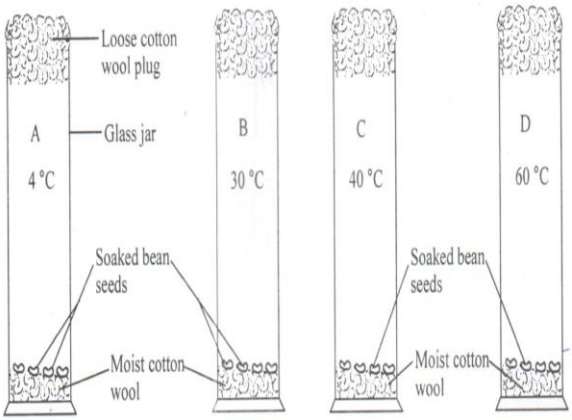
Aim: To show that seeds require optimum temperature to germinate.

Procedure.

- Set up the experiment as follows:

i. Jar A is placed in a refrigerator set at 4 °C.
ii. Jar B is placed in a water bath set at 30 °C.
iii. Jar C is placed in a water bath set at 40 °C.
iv. Jar D is placed in an oven set at 60 °C.

- The jars are left for five days.



Observation and explanation.

- ✓ There was no germination in jars A and D. This is because in jar A temperature was low which inactivated the enzymes.
- ✓ There was germination in jar B and C because temperature was optimum for germination.

STUDY QUESTION 1.

- In an experiment to investigate the effect of heat on germination of seeds, eleven bags each containing 50 bean seeds was placed in a water bath maintained at 90oC. After 2 minutes, a bag was removed and the seeds contained were planted. The number that germinated was recorded. The procedure used for the beans was repeated for Acacia/wattle seeds. The results obtained were as shown in the table below.

Time (min)	Beans seeds	Acacia seeds
0	50	0
2	50	0
4	46	1
6	35	2
8	10	28
10	1	36
12	0	41
14	0	44
16	0	47
18	0	48
20	0	50

QUESTIONS

1. Which one of the two types of seeds was more sensitive to heat influence on germination? Give reasons for your answer.

✓ **Bean seeds. This is because more seeds germinating on exposure to hot water for a short time.**

2. Explain why the ability for the:

(i) Beans seeds to germinate declined with time of exposure to heat.

- **The bean seeds have a weak testa which quickly soaked and allows water into the seed.**
- **Since water was hot the high temperature denatured the enzymes.**
- **The longer the seeds were exposed to this temperature the more the enzymes were denatured. The bean seeds exposed for 12 minutes have all enzymes denatured, the cells die and no germination took place.**

ii) Acacia seeds to germinate improved with time of exposure to heat.

✓ **Acacia seeds have a tough testa which requires a longer time of contact with water to be softened. The hot water hastened the softening process.**

✓ **The seeds exposed in hot water for 20 minutes had the most optimum time for softening of testa hence leading to best germination percentage.**

3. Explain the results that would be expected if the temperature of water was maintained at:

i. 100°C.

At 100°C comparatively fewer/no bean seeds will germinate but more/all acacia seeds will germinate. This is because enzymes in bean seeds could be denatured and the seed coat in acacia softened.

ii. 5°C.

At 5°C no acacia seeds will germinate and all or most of bean seed will germinate. This is because the seed coat of acacia could not be softened.

STUDY QUESTION 2.

✓ An experiment was carried out to determine the growth rates of bamboo and a variety of maize plants in two adjacent plots. The average height and average dry weight of plants from the two populations were determined over a period of twenty weeks. The data is as shown in the table below.

	Bamboo		Maize	
Age in weeks	Average height (Metres)	Average weight (Grams)	Average height (Metres)	Average weight (Grams)
2	1.3	52	0.3	20
4	4.0	182	0.5	29
6	8.2	445	0.8	57
8	12.1	682	1.2	78
10	13.9	801	1.7	172
12	14.1	957	1.9	420
14	14.3	1025	2.1	704
16	14.4	1062	2.1	895
18	14.6	1127	2.1	926
20	14.6	1229	2.1	908

a) Between which two weeks did the greatest increase in weight occur in:

i. Bamboo plants.

- *4 and 6.*

ii. Maize plants.

- *12 and 14.*

b) Which of the two types of plants had a higher productivity by the end of the experiment?

- ***Bamboo***

c) Give a reason for your answer in (b) above.

- ***It had accumulated more weight and therefore greater dry weight***

d) Between weeks 14 and 18, the average height of the maize plants remained constant while average dry weight increased. Explain this observation.

- ***The cells have fully divided hence no further growth, there is further development resulting into the reproductive parts, hence an increase in the dry weight.***

TYPES OF GERMINATION.

A. **EPIGEAL GERMINATION.**

✓ The cotyledons are lifted/ brought above the ground and the hypocotyl elongates. It occurs in dicot seeds.

Process of epigeal germination.

✓ The radicle grows out through the micropyle and grows downwards into the soil **to provide anchorage to the seedling and absorb water and mineral salts**.

✓ The **hypocotyl** curves and pushes upwards through the soil **protecting the delicate shoot tip and pulling cotyledons.**

✓ The hypocotyl then straightens and elongates carrying with it the two cotyledons which open and expose the plumule

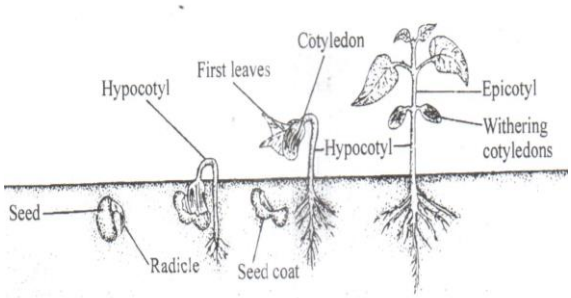
✓ They cotyledons then turn green and leafy and begin to photosynthesize/ manufacturing food for the growing seedling.

✓ The plumule which lies between the cotyledons grows into **first foliage leaves** which start manufacturing food.

✓ After the foliage leaves start to photosynthesize then the cotyledons wither, shrink and fall.

Functions of cotyledon before development of first foliage leaves.

1. Site for hydrolysis of stored food.
2. Site for respiration to provide energy for cell division and formation of new tissues.
3. Protection of the embryo/plumule.
4. Photosynthesis before the first foliage leaves appear.



B. **HYPOGEAL GERMINATION.**

✓ The cotyledons remain below the ground.

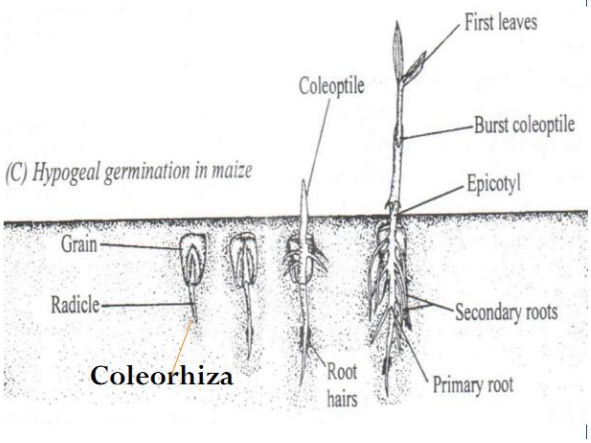
Process of hypogeal germination.

✓ The radicle protected by coleorhiza grows down into the soil **to provide anchorage to the seedling and absorb water and mineral salts**.

✓ **Epicotyl** elongates carrying the **coleoptile** which pushes the soil and appears above the ground.

✓ Coleoptile then breaks to release the plumule which forms the first **foliage leaves** and starts to photosynthesize.

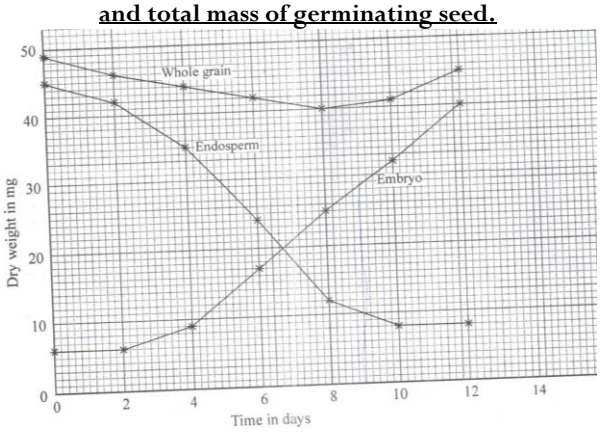
✓ After the seedlings begin to photosynthesize, the endosperm begins to shrink.



Differences between epigeal and hypogeal germination.

Epigeal germination	Hypogeal germination
The cotyledons are brought above the ground.	The cotyledons remain below the ground
The hypocotyl elongates	The epicotyl elongates

Changes in the dry mass of endosperm, embryo and total mass of germinating seed.



- ✓ There is a decrease in the dry mass of the endosperm between day 0 and day 12 because **the stored food in the endosperm is being hydrolyzed / broken down and used by the developing embryo.**
- ✓ There is an increase in dry mass of the embryo between day 0 and day 12 **because the seed absorbs water and the embryo starts to develop.**
- ✓ There is a decrease in the total mass of the seed/whole grain between day 0 and day 8 **because the embryo uses up the food reserves as it grows/ stored food is oxidized to provide energy for germination.**
- ✓ There is an increase in total mass of the whole seed after day 8, **because photosynthesis starts as first foliage leaves appear, providing food for synthesis of new materials.**

GROWTH IN PLANTS

- ✓ In plants, growth takes place in localized parts called meristems.
- ✓ A meristem is group of undifferentiated cells in plants capable of continuously dividing through mitosis.
- ✓ Meristems consist of **meristematic cells** with the following characteristics:

i. Are small in size.
ii. Have thin cell walls.
iii. Have a dense/large cytoplasm.
iv. Have a large central nucleus.
v. Have no vacuoles.

Types of meristems.

1. **Apical meristems-** they are located at the tips of shoots and roots and are responsible for **primary growth.**
2. **Vascular cambium-** located between phloem and xylem in stems and roots and are responsible for **secondary growth/ thickening.**
3. **Cork cambium-** located below the bark.
4. **Lateral buds-** located above the leaf and give rise to lateral/ side branches.

Primary growth in plants.

- ✓ This is growth that takes place at the tips of shoot and root due to active mitotic division of meristematic cells.
- ✓ This leads to increase in length of shoot and root.
- ✓ In primary growth there are three distinctive regions, namely:

a) Region of cell division.
b) Region of cell elongation.
c) Region of cell differentiation.

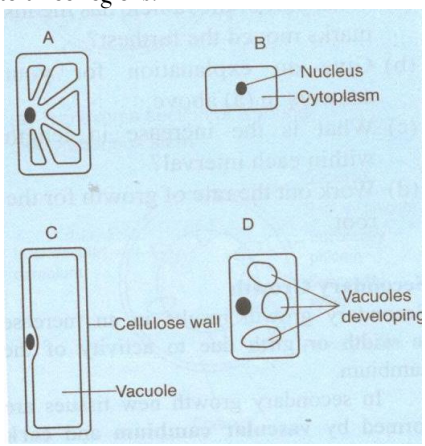
a) **Region of cell division-** consists of meristematic cells that actively divide.
- ✓ Each cell divides into two, one cell remains meristematic while the other moves to the region of cell elongation.

b) **Region of cell elongation-** the cells become enlarged to their maximum size.
- ✓ Vacuoles start forming and enlarging.

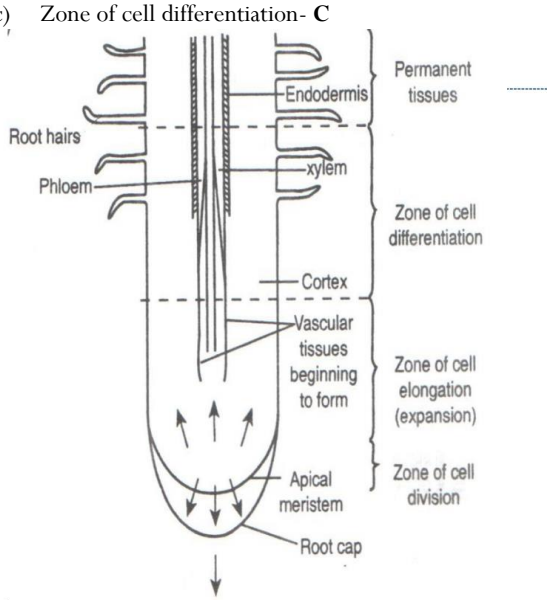
c) **Region of cell differentiation-** the cells attain their permanent size, with large vacuoles and thickened.
- ✓ The cells differentiate into tissues specialized for specific functions.
- ✓ Examples of tissues formed at the region of cell differentiation include epidermis, phloem, xylem, cambium, and cortex.
- ✓ Behind the region of cell differentiation there are permanent tissues.

Study question.

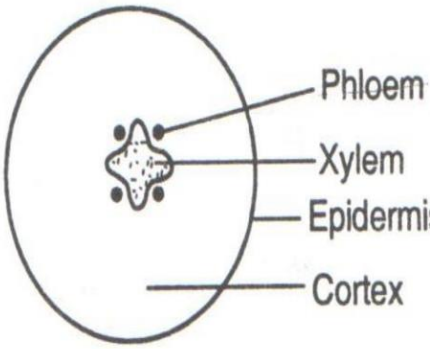
The figures below indicate the appearance of cells at different regions at the apical meristems. Rearrange them into three regions:



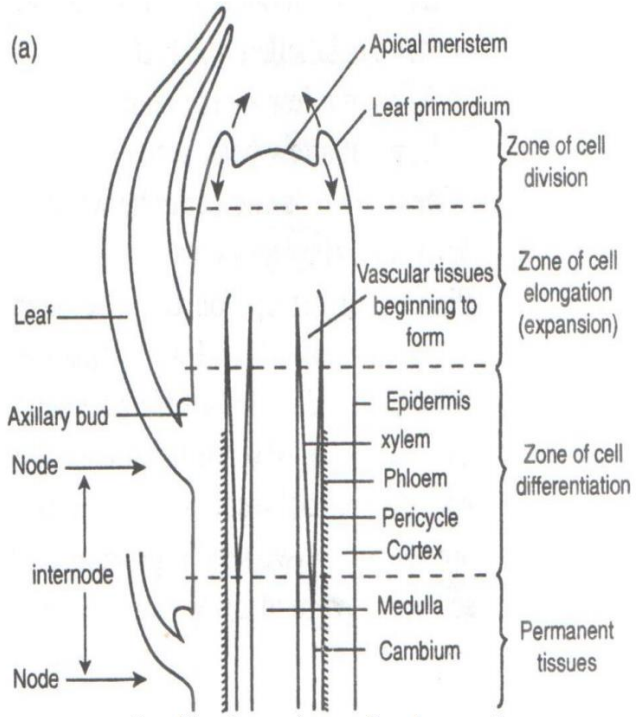
a) Zone of cell division- **B**
b) Zone of cell elongation- **A and D**
c) Zone of cell differentiation- **C**



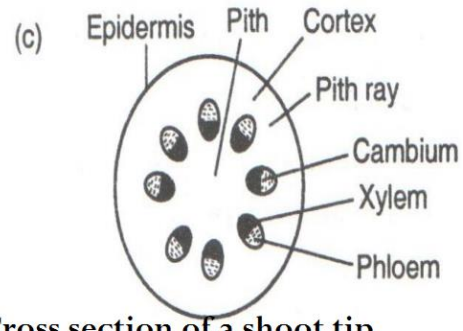
Longitudinal section of a root tip



Cross section of a root



Longitudinal section of a shoot tip



Cross section of a shoot tip

EXPERIMENT.

Aim: To determine the region of growth in a seedling

Equipment

i. Wire/ thread/ string.
ii. Marker pen.
iii. Dye/ water proof ink.
iv. Pen.
v. Book.
vi. Blotting paper.
vii. Tissue paper/ piece of cloth.
viii. Ruler (marked in mm).

Other requirements.

i. Germinating bean seedlings.
ii. Pins.
iii. Cork.
iv. A boiling tube.
v. Moist cotton wool.

Procedure

- ✓ Get a bean seedling with a straight root.
- ✓ Dry the seedling using blotting paper.
- ✓ Place the radicle against the ruler marked in millimetres.
- ✓ Dip the fine thread in waterproof ink.
- ✓ Using the ink-soaked thread, mark the radicle at equal intervals.
- ✓ Pin the seedlings onto a cork and suspend it with the radicle pointing down into **a** boiling tube containing moist cotton wool.
- ✓ Allow the seedling to grow for 2 days and observe the intervals between the marks.
- ✓ Record your observations in a book.

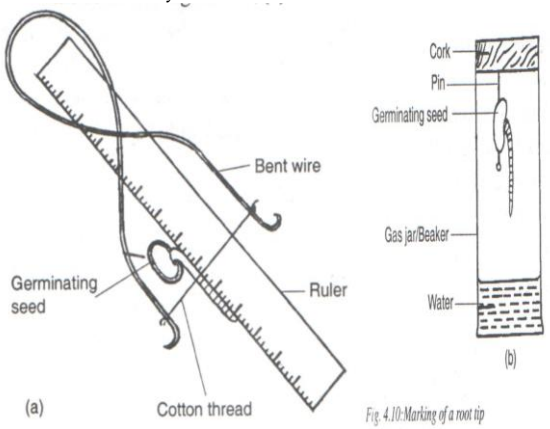
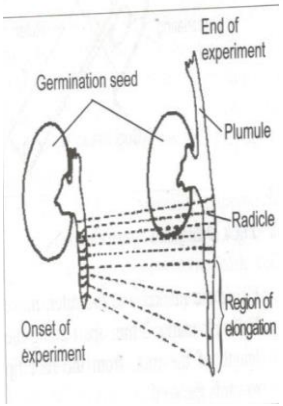


Fig. 4.10: Marking of a root tip



STUDY QUESTION

- In an experiment to investigate the effect of sodium chloride on the growth rate in a spinach seedling, seeds were treated with different concentrations of sodium chloride. The results are as recorded below.

Concentration of sodium chloride (mol/l)	Percentage of spinach seeds which started to grow roots	Mean root length (mm)
0.00	99.98	17.70
0.06	98.20	15.60
0.12	92.0	10.20
0.18	54.0	7.60

a) From the results in the table above, explain the effect of increasing the concentration of sodium chloride. (3mks)

- ***Increased sodium chloride concentration increases osmotic pressure in the surrounding solution/ makes the surrounding solution hypertonic to the cell sap of seedling cells.***
- ***Cells take in less water/ lose water to the surrounding solution through osmosis reducing growth enzymatic activity thus reducing growth.***

b) Apart from a ruler, state two other equipment one would need to determine the rate of growth in roots. (2mks)

- ***Thread/ string /wire.***
- ***Marker pen.***
- ***Book.***
- ***Pen.***
- ***Dye/waterproof ink.***
- ***Blotting paper.***
- ***Tissue paper/ piece of cloth.***

c) With a reason, state one part of the seedling the students would focus on to determine the effect of sodium chloride on growth. (2mks)

✓ ***Rate of growth or increase in length of the shoot tip/ apex.***

✓ ***This is because it is a region of active cell division/ growth.***

d) State the likely on the seedling of increasing the concentration of sodium chloride to 2.20 mol/l (1mk)

- ***The seedling will wither/dry/ die.***

SECONDARY GROWTH/ THICKENING IN PLANTS.

✓ Secondary growth in dicots results in increase in width/ girth due to the activity of cambium (vascular and cork cambium).

✓ Monocot plants lack cambium hence it does not undergo secondary growth.

✓ However there is increase in diameter due to enlargement of primary cells.

Process of secondary growth in dicots.

✓ The vascular cambium divides to produce new cambium cells between the vascular bundle called **intervascular cambium.**

✓ The intervascular cambium and vascular cambium form a continuous cambium ring.

✓ The new cells obtained on the outer side of cambium differentiate to form **secondary phloem** and those to the outer side differentiate to form **secondary xylem.**

✓ More secondary xylem is formed than secondary phloem and intervascular cambium also cuts the parenchymatous cells forming **medullary rays** which allow transport of water and solutes inside the stem.

✓ As a result of increase in the volume of secondary tissues, pressure is exerted on the outer cells of the stem. This leads to stretching and rapturing of epidermal cells.

✓ In order to replace the protective outer layer of the stem, a new band of cambium cells are formed in the cortex called **cork cambium/ phellogen**

✓ The cork cambium divides to produce new cells on either side. The cells on the inner side of the cork cambium differentiate into **secondary cortex** and those on the outer side become **cork cells.**

✓ Cork cells are dead with thickened walls. Their walls become coated with a waterproof substance called **suberin.**

✓ The cork cells increase in number and become the bark of the stem. This prevents loss of water, infection from fungi, and damage from insects and acts as insulatory layer.

✓ At certain points along the stem the cork cells become loosely packed forming **lenticels** for gaseous exchange.

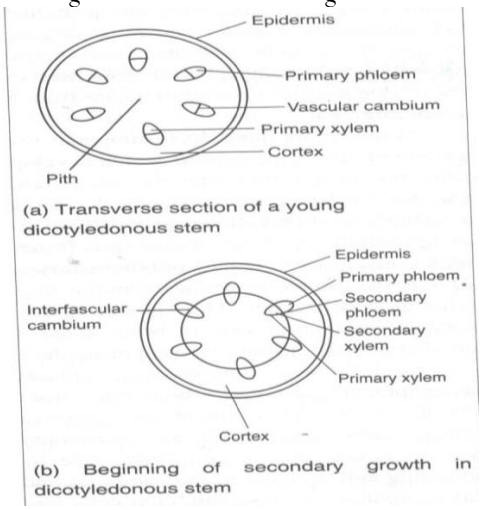
✓ The rate of secondary growth in the stem varies with seasonal changes.

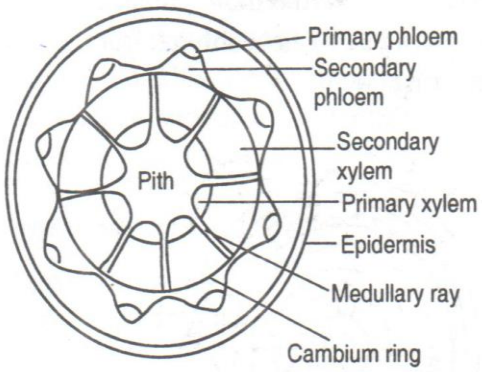
✓ During rainy season xylem vessels and tracheids are formed in large numbers. The cells are large, have thin walls and the wood has light texture.

✓ In the dry season, the xylem and tracheids formed are few in number. They are small, thick walled ad their wood has dark texture.

✓ This leads to two distinctive layers within the secondary xylem hence called annual rings.

✓ It is possible to determine the number age of the tree by counting the number of annual rings.





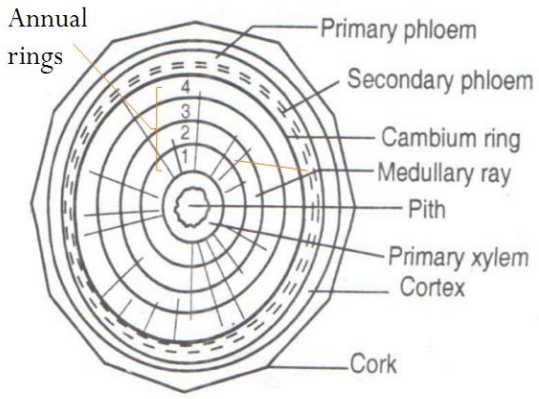
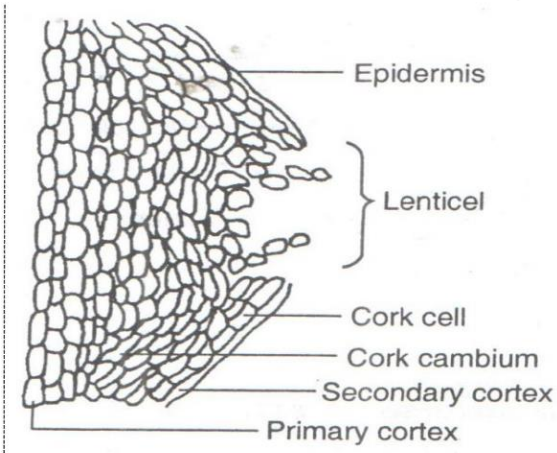


Fig. 4.13: Annual rings



: Section through a lenticel

ROLE OF GROWTH HORMONES IN PLANTS

A. **AUXINS e.g. IAA (Indoleacetic Acid)**

1. They stimulate cell division and elongation (leading to primary growth.
2. They stimulate tropic responses/ growth in plants.
3. They stimulate growth of adventitious roots in stem cuttings
4. They induce parthenocarpy, **i.e. development of fruit from ovary without fertilization**
5. They inhibit growth of lateral/ side branches from lateral buds enhancing apical dominance.
6. They initiate cell division and differentiation in cambium enhancing secondary growth.
7. They stimulate formation of callus tissue which causes healing of wounds (in association with other hormones).
8. Some synthetic auxins are used as selective weed killer/ herbicide (by inducing distorted growth of plants and excessive respiration causing death of the plant).

STUDY QUESTIONS

1. **State three ways in which effects of auxins is applied in flower farming.**

✓ Faster maturity of flower/ earlier flower formation/ earlier flowering.
✓ Prunning/ decapitating shoot tips to allow sprouting of lateral buds hence more yield.
✓ Stimulates formation/development of adventitious roots.
✓ Keeping flowers fresh/ avoid withering.

2. **Explain how auxins are utilised as selective weed killers in agriculture.**

✓ Selective weed killers contain auxins which are absorbed by the weeds more than desirable/ beneficial plants.
✓ This makes the weeds to grow abnormally/ die out ahead of beneficial plants.

B. **GIBBERELLIC ACID/ GIBBERELLINS.**

1. They stimulate rapid cell division and elongation in dwarf plants.
2. They stimulate fruit formation (by inducing the growth of ovaries into fruits after fertilization).
3. They promote formation of side branches from lateral buds and breaks dormancy in buds.
4. They inhibit formation/ sprouting of side branches from stem cuttings.
5. They retard the formation of abscission layer hence reduce leaf fall.
6. They break seed dormancy by activating enzymes involved in breakdown of food substances during germination.

C. **CYTOKININS/KINETINS.**

1. They promote growth when they interact with auxins.
2. They stimulate cell division in the presence of auxins.
3. Break dormancy in some plants.
4. Promote flowering.
5. Promote formation of adventitious roots.
6. Promote stomatal opening hence increased gaseous exchange and transpiration.
7. Stimulate lateral bud development in shoots.
8. Induce cell enlargement in leaves when in high concentration.

D. **ETHYLENE/ETHENE.**

1. Causes ripening of fruits.
2. Stimulates formation of abscission layer leading to leaf and fruit fall.
3. Stimulates lateral bud development.
4. Promotes germination of certain seeds by breaking seed dormancy.
5. Promotes flowering in plants, for example in pineapples.
6. Inhibits plant growth and may cause plant death.

E. **ABSCISIC ACID.**

✓ It's effects are inhibitory in nature.

1. It causes seed dormancy.
2. Inhibits development of lateral buds/branches.
3. Retards stem elongation.
4. High concentration of abscisic acid causes stomatal closure by interfering with potassium ion uptake.
5. Causes formation of an abscission layer that encourages leaf and fruit fall.

F. **FLORIGENS-** they promote flowering.

G. **TRAUMATINS-** they cause healing of wounds in plants.

PRACTICAL APPLICATIONS OF PLANT GROWTH HORMONES IN AGRICULTURE.

1. Induce root growth in stem cutting.
2. Used as selective weed killers/herbicides.
3. Encourage apical dominance.
4. Encourage sprouting of side branches.
5. Breaking seeds dormancy.
6. Induce parthenocarpy.
7. Promotes flowering.
8. Induce fruit fall.
9. Accelerates ripening of fruits.
10. Synthetic auxin 2, 4-D is used as a herbicide.
11. Florigen is sprayed on young flower buds to promote flowering.
12. Ethylene is used to ripen fruits such as oranges, bananas and tomatoes.
13. Abscisic acid is sprayed in mature plantations to promote fruit fall for easy harvesting.
14. Seeds are treated with gibberellins to break seed dormancy.
15. Certain natural dwarf varieties of plants are treated with gibberellins to produce taller varieties.

APICAL DOMINANCE.

✓ This is the inhibition of development of lateral/side branches due to the presence of apical bud.

✓ If an apical bud which normally contains high concentrations of auxins is removed, more lateral/side branches develop

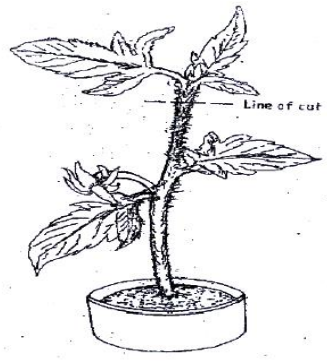
✓ This shows that high concentrations of inhibit/hinder sprouting of lateral buds and therefore hinders growth of many branches.

✓ This forms the basis of pruning in agriculture where more branches are required for increased harvest particularly on crops like coffee and tea.

✓ The failure of lateral buds to develop in the presence of an apical bud is due to the diffusion of auxins from the shoot apex downwards inhibiting the development of lateral buds.

Study question 1.

In an experiment the shoot tip of a young tomato plant was decapitated as shown in the diagram below.



a) State the expected results after 2 weeks.

✓ **Auxiliary / lateral buds sprout / branches will be formed.**

b) Give a reason for your answer in (a) above.

✓ **Decapitation removes the hormone / auxins / IAA which is produced in the terminal bud / the stem tip. The removal of the hormone / auxins / IAA promote development of auxiliary /lateral buds/branches.**

c) Suggest one application of this practice?

✓ **The pruning of coffee/tea/hedge**.

d) What is the importance of this practice?

✓ **More yield/Production/Bushy edge.**

Study question 2

- An experiment was carried out to investigate the effect of hormones on growth of lateral buds of three pea plants. The shoots were treated as follows:

i. Shoot A – Apical bud was removed.

ii. Shoot B – Apical bud was removed and gibberellic acid placed on the cut shoot.

iii. Shoot C – Apical bud was left intact.

- The length of the branches developing from lateral buds were determined at regular intervals. The results obtained are as shown in the table below.

Time in days	Length of branches in millimeters		
	Shoot A	Shoot B	Shoot C
0	3	3	3
2	10	12	3
4	28	48	8
6	50	9	14
8	80	120	20
10	118	152	26

a) Account for the results obtained in the experiment.

- **Shoot A: The tip of the shoot which was removed contained indole acetic acid (IAA), which causes apical dominance/ inhibits growth/ development of more lateral buds; hence lateral buds sprouted/grew.**
- **Shoot B: The gibberellic acid which was added on the cut promotes formation of lateral**

branches of stems, hence the fast growth of branches.

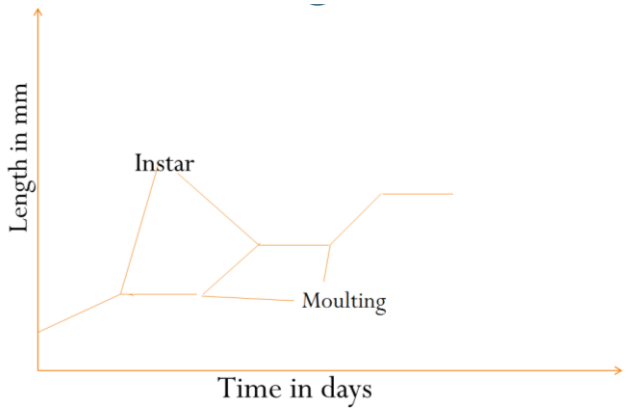
- **Shoot C: The shoot tip which remained intact contains IAA which inhibits growth/ development of lateral buds, hence little change of length of lateral branches.**

GROWTH AND DEVELOPMENT IN ANIMALS.

- ✓ Growth in animals occurs in all parts of the body and stops at maturity. All cells in animals except the nerve cells divide.
- ✓ Animals therefore exhibit c**ontinuous growth** e.g. in **chordates** and **discontinuous/intermittent growth** e.g. in Arthropods.
- ✓ Members of phylum Arthropoda have exoskeletion made of chitin which inhibits growth. To allow growth, exoskeleton has to be shed in the process called **moulting/ecdysis.**
- ✓ A plot of the growth rate at various stages reveals a period of rapid growth and a period of **no growth.**
- ✓ The stages between moults are represented by the flat portions and are known as **instars.**

Process of growth in arthropods

- ✓ Intermittent growth is a result of the shedding of the exoskeleton/moulting/ecdysis. After moulting growth occurs rapidly until the exoskeleton hardens. The growth rate slows down as the exoskeleton hardens.



GROWTH AND DEVELOPMENT IN INSECTS.

- ✓ Growth and development in insects occur in the process called **metamorphosis.**
- ✓ **Metamorphosis** refers to developmental changes that take place in an organism until the adult stage is attained.
- ✓ They exhibit intermittent/ discontinuous growth curve.

Importance of metamorphosis.

i. Helps to allow time for development to take place.
ii. Helps to reduce competition for resources because different stages have different niches.
iii. Helps to avoid and survive unfavourable environmental conditions which would affect life processes.

Types of metamorphosis.

A. Complete metamorphosis.
B. Incomplete metamorphosis.

A. **COMPLETE METAMORPHOSIS e.g. in butterflies, moths, houseflies.**

- ✓ It has four stages i.e. Egg —▶ larva—▶ pupa —▶ adult. Several eggs are laid and are not enclosed in egg case/ ootheca.
- ✓ **Eggs** hatch into **larvae which are different from the adult.**
- ✓ The **larva** feeds on the decaying matter and increases in size hence has rapid growth. At larval stage, rapid cell elongation takes place i.e. it is a growing stage.
- ✓ The larva moults and develops into a **pupa (chrysalis)**. During pupal stage the organism is found in a cocoon which helps it to survive in extreme conditions.
- ✓ During pupal stage, differentiation/development takes place.
- ✓ The pupa develops into **adult** which feeds and grows and attains physical and sexual maturity i.e. males and females can mate and the females are able to lay eggs.

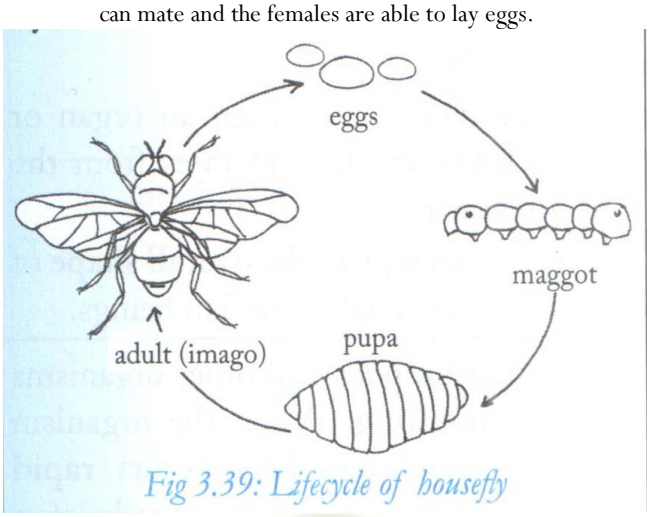
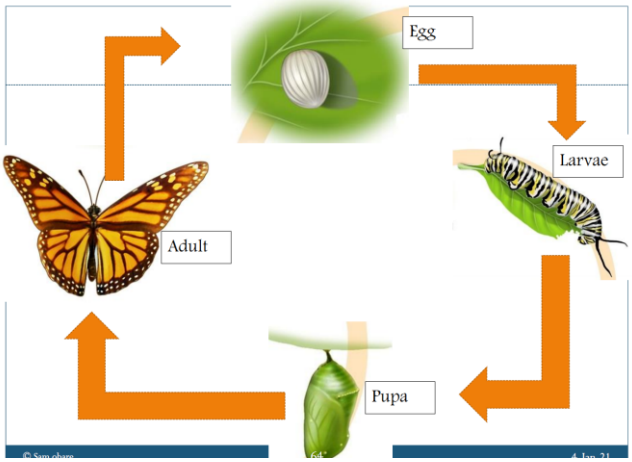


Fig 3.39: Lifecycle of housefly



B. **INCOMPLETE METAMORPHOSIS e.g. in cockroaches.**

- ✓ Has three stages i.e. Egg — **nymph** —adult.
- ✓ Fewer eggs are laid enclosed in egg case/ootheca.
- ✓ The eggs hatch into nymphs ***which are similar to adults but smaller and sexually immature.***
- ✓ **The nymphs and adults feed on the same (occupy the same ecological niche)** leading to competition**.**
- ✓ Nymph **moults** into **adult**.

Advantage of incomplete metamorphosis.

- ✓ Absence of larval and pupal stages shortens the lifecycle of an organism. This helps to avoid adverse environmental conditions that would affect its life processes.

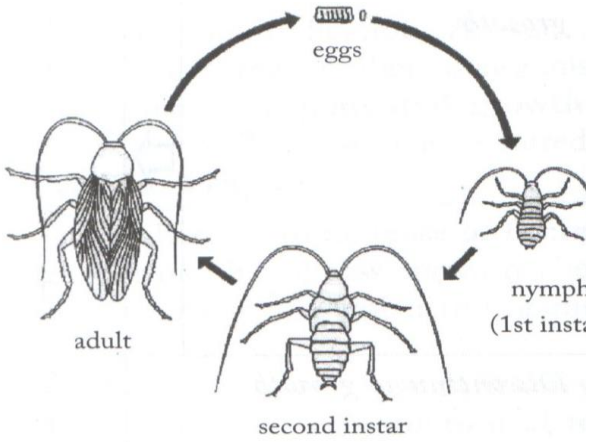
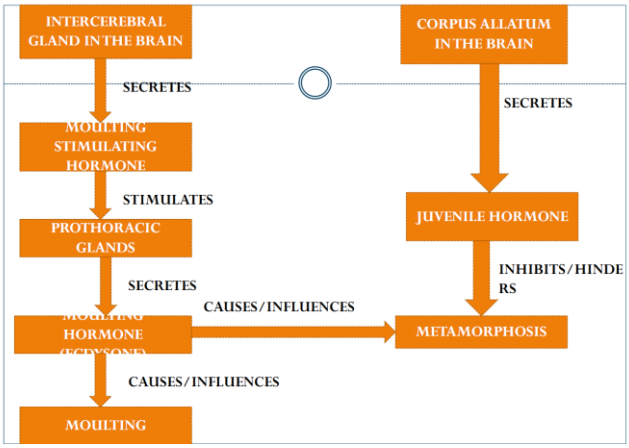


Fig 3.40: Lifecycle of a coakroach



Differences between complete and incomplete metamorphosis.

Complete metamorphosis	Incomplete metamorphosis
1. It has 4 stages i.e. egg, larva, pupa and adult.	1. It has 3 stages i.e. egg, nymph and adult.
2. Eggs do not have egg case/ ootheca.	2. Eggs have egg case/ootheca.
3. Many/ several eggs are laid.	3. Fewer eggs are laid.

ROLE OF HORMONES IN METAMORPHOSIS.

- In insects metamorphosis is controlled by hormones.
- The hormones are produced by three glands namely;

i. **Corpus allata** (singular Corpus allatum) in the brain.
ii. **Intercerebral gland** in the **brain**.
iii. **Prothoracic glands** in the thorax.

- ✓ During larval stages of the insect the corpora allata produces **juvenile hormone** which inhibits metamorphosis by stimulating formation of larval cuticle hence moulting does not go beyond the larval stage.
- ✓ When the larva matures, the corpus allatum disintegrates hence the level of juvenile hormone drops.
- ✓ Low level of juvenile hormone stimulates **intercerebral gland** in the **brain** secretes ***moulting stimulating hormone (MSH)***.
- ✓ The moulting stimulating hormone stimulates the prothoracic gland to secrete ***moulting hormone (ecdysone).***
- ✓ Ecdysone/ moulting hormone stimulates moulting leading to laying of adult cuticle.