① CLASSIFICATION II

Meaning of classification

- Classification is the placing of organisms or living things in a series of increasingly specialised groups based on their similarities and differences in structure and origin that indicate a common biological relationship.
- The study of grouping organisms according to their relationships or the science of classification of living things is called taxonomy.

General principles of classification

- Modern classification is based on structural similarities and differences among organisms.
- closely related organisms which share common features and evolutionary history are placed in same group whereas distantly related organisms are placed in different groups.
- Based on similarities and differences in structure seven major taxonomic units are used to classify organisms ie Kingdom, phylum or division, class, order, family, Genus, and finally species. The kingdom is the largest taxon/group whereas the species is the smallest taxon. Similarities along the hierarchy increase down to the lower rank whereas differences decrease accordingly.
- Organisms that resemble in nearly all aspects and which can freely/naturally interbreed to give rise to fertile/viable offsprings are placed in the same species
- Closely related organisms in structure but which do not interbreed to give rise

rise to viable offsprings are placed in the same genus eg horse, donkey, zebra. For example, if horse and donkey interbreed the resultant Mule is infertile. so is the zedonk if donkey and zebra interbreed.

— Distantly related organisms are then placed in the same family, then order, then class, then phylum or division and finally kingdom.

— Scientific names given to organisms are always in Latin or Latinised.

— Every organism is assigned two scientific names, genus and species name. This system of giving an organism genus and species name is called **binomial nomenclature**.

NB - physical differences among members of the same species leads to subspecies eg races in human beings, breeds in cattle and varieties in plants.

Binomial Nomenclature

— system of giving an organism genus and species name. It was first pioneered by the swedish naturalist Carolus Linnaeus.

— has the following principles

1. The first name, genus or generic name must be written starting with a capital letter and the rest in small letters.
2. The second name, species or specific name must be written in small letters.

3. The two scientific names, genus and species must be underlined seperately if handwritten or typed or written in italics if printed.
4. species name may be written with the initials of the scientist who first adequetly described the organism eg Balanus balanoides, L. (L. is initial for Linnaeus who first described the organism.).
5. Biologists may produce Latin or Latinised names for newly discovered plant or animal or any other organism eg Aloe kilifiensis, Meladogyne kikuyuensis

The Five Kingdoms of classification

— Living things are divided into five kingdoms, namely

① Kingdom Monera
② Kingdom Protoctista
③ Kingdom Fungi
④ Kingdom Plantae
⑤ Kingdom Animalia.

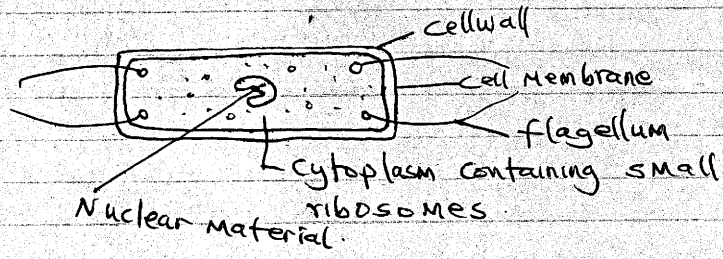
Kingdom Monera

— Comprises mainly bacteria eg Vibrio cholerae, Nitrobacter, Azotobacter, Rhizobium, Salmonella typhi etc. (NB - other books call the kingdom PROKARYOTAE).

General charcterisfics of Kingdom Monera

1. Are unicellular and microscopic organisms. Some are single cells, others are colonial.
2. They are prokaryotic ie nuclear membrane is not enclosed within nuclear membrane.

3. Have cellwall made of sugars and proteins not cellulose.
4. Have very few organelles which are also not membrane-bound. Mitochondria are absent.
5. Most of them are heterotrophic, feeding saprophytically or parasitically whereas others are autotrophic.
6. Reproduction is by binary fission.
7. Most of them are anaerobes but some respire aerobically.
8. Most of them move by means of flagella.

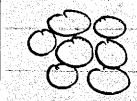


- Bacteria are grouped into three classes based on their cell shapes namely i, cocci
  ii, Bacilli
  iii, spiral forms

1. Cocci

- Are spherical in shape. some exist as long filaments hence called streptococci, others in clusters hence staphylococci and others in pairs hence called diplococci.

○○○○○ streptococci eg Streptococcus faecalis

 staphylococci eg Staphylococcus aureus

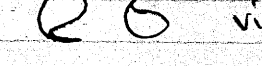
○○ diplococci eg diplococcus pneumoniae

2. Bacilli

- Are rod-shaped which can be straight resembling cigarettes whereas others have tapering ends. Example is Bacillus anthracis

3. Spiral forms

- Consists of a wide variety of bacteria that are convoluted or coiled to varying degrees. Some resemble commas hence vibrios, others resemble spirals hence spirilla eg.

 vibrio eg Vibrio cholerae

 spirilla eg Treponema pallidum

Economic importance of bacteria.

(a) Harmful bacteria / pathogenic bacteria

1. cause diseases in plants and animals eg Tuberculosis, Tetanus, Pneumonia, Leprosy, cholera, typhoid,

diphtheria, anthrax etc.

2. Cause food spoilage and poisoning eg Clostridium botulinum which causes botulism or food poisoning - other harmful bacteria spoil foods like milk, meat, etc causing rotting.

(b) Benefitial bacteria

① Saprophytic bacteria decompose organic matter in the soil into humus and thus release simple inorganic compounds eg water, nitrates, CO_2, NH_3, SO_4^{2-} which are absorbed by plants.

② Saprophytic bacteria help to release simple compounds and molecules from organic matter hence playing a role in carbon, nitrogen and other biogeochemical cycles.

③ Symbiotic bacteria living in the alimentary canals eg rumen of ruminants and caecum and appendix of non-ruminants secrete enzyme cellulase which digests cellulose to glucose. Some intestinal bacteria synthesize vitamins K and B_{12} in the colon which is absorbed by the host. Nitrogen fixing bacteria Rhizobium fixes nitrogen in root nodules of the leguminous plants.

④ Nitrifying bacteria in the soil eg Nitrobacter and Azotobacter, convert N_2 to NH_3 and NH_3 to nitrites and nitrites to nitrates

which plants absorb

⑤ Some bacteria are used in the manufacturing of yoghurt, cheese and sour-milk during fermentation of milk.

⑥ Other bacteria are used for industrial production of enzymes and organic acids and solvents eg acetic acid, lactic acid, citric acid, butanol, ethanol etc.

⑦ Other bacteria are used in treatment of sewage and in biogas production.

⑧ - Other bacteria like streptomyces are used in manufacture of antibiotics such as streptomycins.

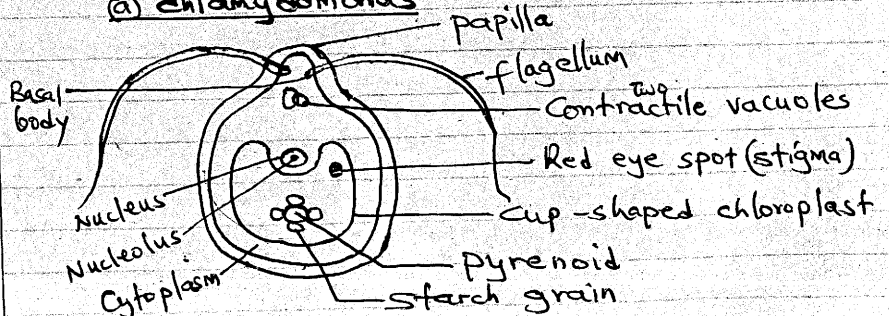
⑨ - Other bacteria are used in genetic engineering to produce enzymes and hormones and other proteins eg insulin.

⑩ - Other bacteria are used in curing of tobacco, fermentation of tea & silage and retting of flax.

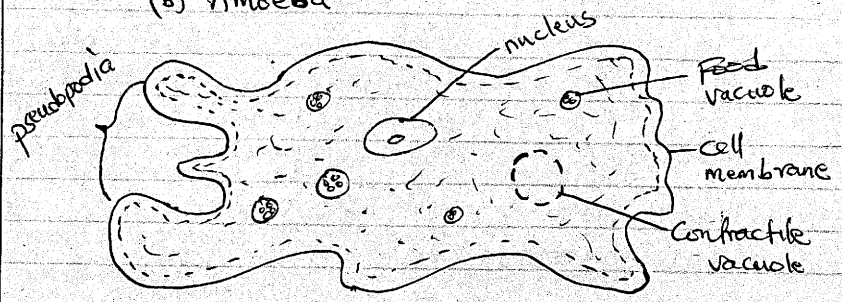
2. Kingdom Protoctista

- Examples include amoeba, paramecium, plasmodium, trypanosomes, chlamydomonas, euglena, spirogyra, diatoms and seaweeds.

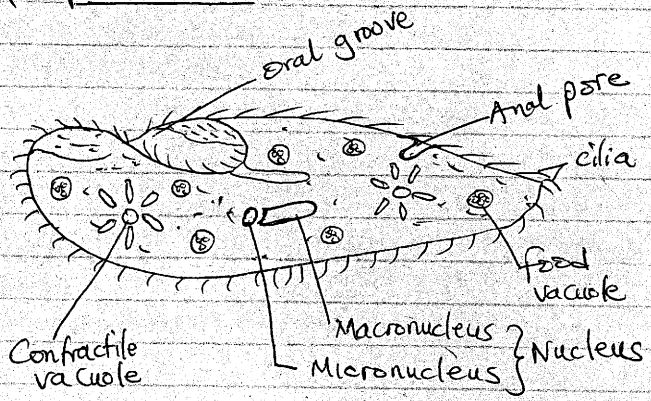
(a) chlamydomonas



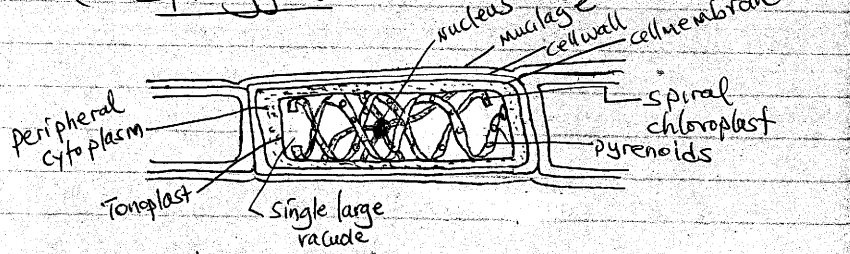
(b) Amoeba



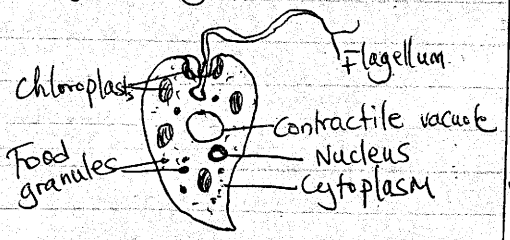
(c) Paramecium



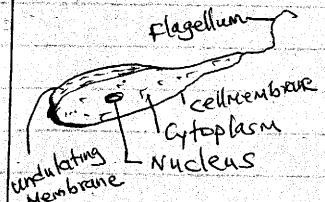
(d) Spirogyra



(e) Euglena



(f) Trypanosome



General characteristics of kingdom Protoctista.

① The organisms have varied body forms — some are microscopic unicellular or colonial while some are multicellular thalloid.
② They are eukaryotic ie their nuclei are bound with a nuclear membrane.
③ They have many membrane-bound organelles including mitochondria.
④ Some are heterotrophic whereas others are autotrophic.
⑤ Reproduction is mainly asexual by binary fission, fragmentation, or sporulation. Under special conditions some reproduce sexually by conjugation.
⑥ Most of them are mobile, moving by means of specialised structures eg pseudopodia for amoeba, cilia for Paramecium and flagella for euglena.
⑦ Some may have specialised structures for performing specific functions eg contractile vacuole for osmoregulation and excretion.

Economic importance of Protoctista.

(a) Algae

① Aquatic algae are the major producers of food in the ecosystem.
② Some seaweeds are a source of food to human beings.
③ Through photosynthesis, algae eg spirogyra, diatoms etc add oxygen to aquatic environments.

④ Seaweeds are a source of agar used in culturing micro-organisms in laboratories.

⑤ Fossil diatom deposists are used in the making of fine abrassive tooth brushes, water filters and insulators.

(b) Protozoa eg amoeba, Paramecium, tryparosomes etc.

① Cause diseases to humans and other animals eg

i, Entamoeba histolytica - Amoebic dysentry in man.

ii, Tryparosomes - sleeping sickness or nagana

iii, Plasmodium - Cause Malaria

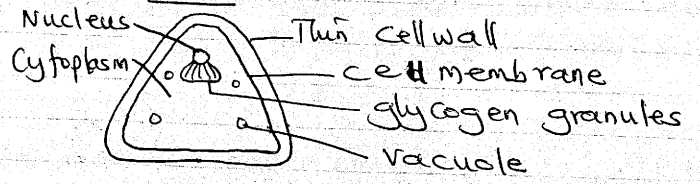
iv, Leishmania, spp - Cause Leishmaniasis in man.

② Some symbiotic protozoa in rumens of ruminants and gut of termites help to produce enzymes which break down complex organic matter to simple organic matter which the host absorbs.

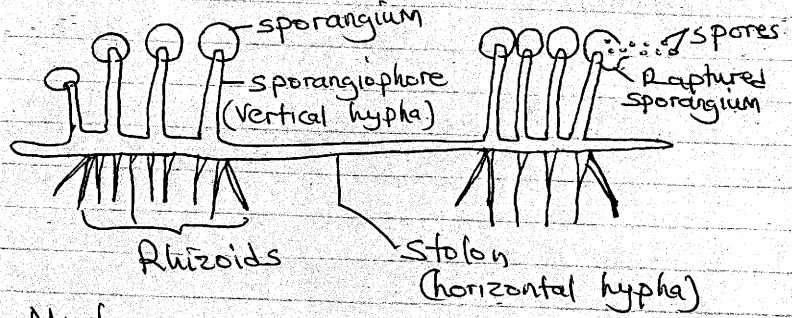
Kingdom Fungi.

- Includes common saprophytes such as yeast, penicillia, Breadmoulds, toadstools, and mushrooms, puffballs and bracket fungi, and parasitic forms such as ringworm (Microsporium Corpolis), athletes foot, potato blight, tomato blight and wheat rust.

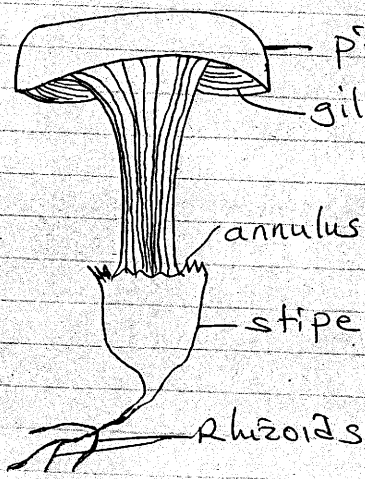
(a) Yeast



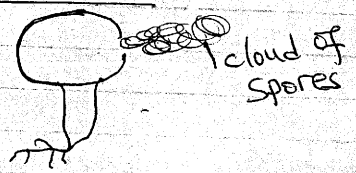
(b) Breadmould (Rhizopus spp)



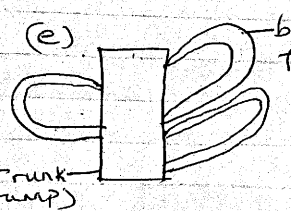
(c) Mushroom



(d) Puffballs



(e)



General characteristics of Kingdom fungi

① Body structure consists of basic units called hyphae (singular = hypha). Hypha consists of a cellwall enclosing cytoplasm containing several nuclei. The hyphae appear as filaments. Collectively hyphae make up the vegetative structure called mycelium

② Fungi are eukaryotic from the simplest unicellular yeast to multicellular toadstools and mushrooms.

③ Fungi have neither chloroplasts nor chlorophyll hence are heterotrophic. They absorb food using specialised hyphae known as rhizoids in saprophytes and haustoria in parasitic fungi

④ Most fungi have cellwalls containing chitin while a few have cellwalls made of cellulose

⑤ The food particles stored in cytoplasm are either glycogen or oil droplets but not starch.

⑥ Fungi reproduce both sexually and asexually. Asexual reproduction is by sporulation as in moulds, mushrooms or by budding as in yeast. Sexual reproduction is by fusion of hyphal branches.

Economic importance of fungi

(a) Benefitial Fungi

① Saprophytic fungi such as mushrooms ~~moulds~~ and toadstools breakdown dead organic matter into humus resulting in decay and recycling of nutrients.

② Certain fungi eg penicillium spp are used in production of antibiotics eg penicillin.

③ Symbiotic fungi eg Mycorrhiza help in absorption of mineral salts such as Ca^{2+}, PO_4^{3-}, K^+ from the soil which benefit the trees on whose roots they grow. In turn the fungus obtain products of photosynthesis from the plant.

④ Fermentation of sugar by yeast is used in manufacture of alcoholic drinks and leavened/raised bread.

⑤ Other fungi eg mushrooms are edible as food by man.

(b) Harmful Fungi

① Cause diseases in plants and animals eg tomato and potato blights, smuts in maize and ringworms in man.

② Cause food spoillage eg maize smuts potato and tomato blights, fruit and bread spoillage.

③ Cause food poisoning eg Aspergillus flavus which grows on moist maize grains produce a toxic substances known as aflatoxin which causes aflatoxicosis. Poisonous mushrooms also produce highly potent poisons which kill human beings.

Kingdom Plantae

Includes all common plants eg beans, maize, grasses, pine, moss, ferns, Hibiscus, cypress etc.

General characteristics

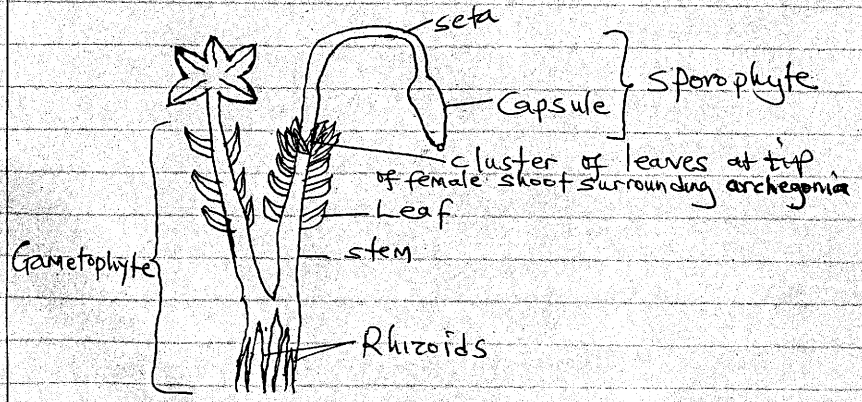
1. They are eukaryotic and Multicellular
2. In most of them, the body is differentiated into leaves, stem and roots.
3. Their cells have cellulose cellwall.
4. Majority have a transport or vascular system.
5. Have photosynthetic pigment known as chlorophyll hence are autotrophic.
6. Reproduction is bot sexual and asexual.
7. They show alternation of generations.

The kingdom is divided into three divisions, namely :-

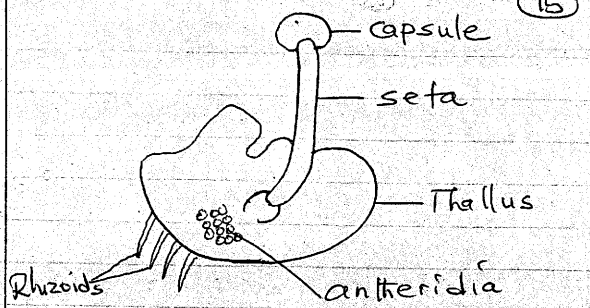
① Division Bryophyta
② Division pteridophyta
③ Division spermatophyta.

Division Bryophyta

- Includes the Mosses (singular Moss) and Liverworts.



Moss (Funaria spp).



Liverwort (Merchantia spp)

General characteristics of Bryophyta

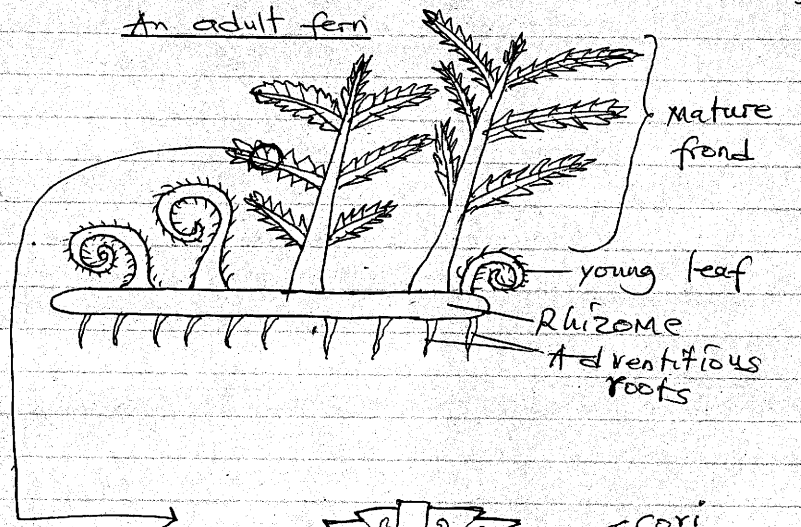
1. They are thalloid as in liverworts or plant body differentiated into simple leaf-like and stem-like structures as in Mosses.
2. They lack vascular tissue. Depend on diffusion
3. Contain chlorophyll hence autotrophic & photosynthetic
4. They have developed rhizoids for anchorage and absorption of water and mineral salts. Lack true roots, true stems and true leaves.
5. They show alternation of generations. The gamete producing gametophyte is the persistent plant. The spore-producing sporophyte is born on the gametophyte and depends on the ~~former~~ latter.
6. Male gametes (antherizoids) are produced by antheridia and female gametes are produced by archegonia. Fertilisation depends on availability of water.
7. They are terrestrial growing on dump substratum eg rocks, walls, Marshes etc.
8. They lack supportive tissues since they grow to a maximum of 2-3 cm.

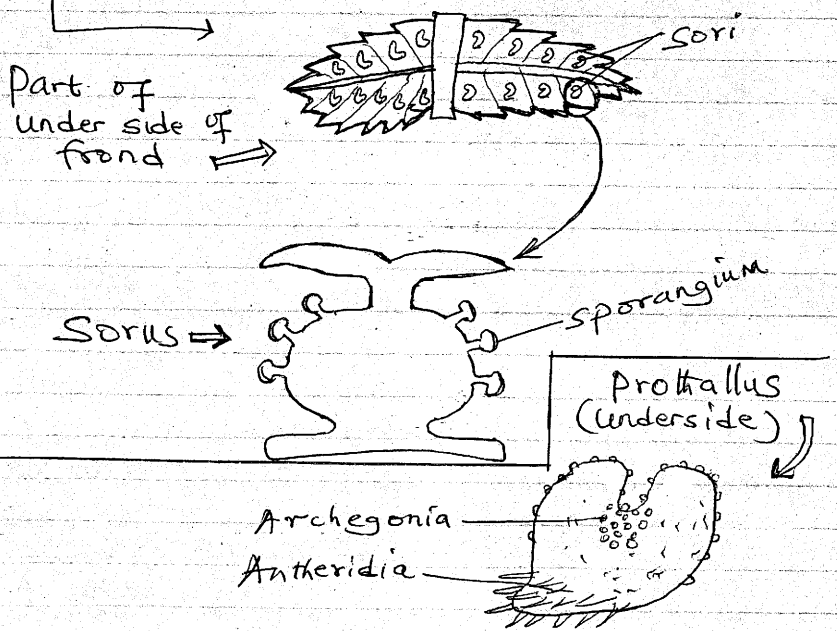
Division Pteridophyta

Includes the ferns and horsetails. The ferns range from small ferns to giant ferns which grow up to 10 m tall. They show greater ability to inhabit land than bryophytes.

(N.B: SOME BOOKS CALL THE DIVISION FILICINOPHYTA)

An adult fern





General characteristics

1. They have roots, stems, leaves but no flowers.
2. Leaves are compound and are known as fronds. The frond has leaflets called pinnae
3. They posses clearly defined vascular system consisting of xylem and phloem. Xylem is mainly tracheids
4. Posses chlorophyll hence are photosynthetic.
5. They show alternation of generations where the sporophyte normally referred as the fern plant is the dominant one. The gametophyte is an independent minute heart-shaped structure called prothallus.
6. On the lower side of mature leaves are spore-producing or spore-bearing structures known as **sporangia** (singular = sporangium) arranged in groups known as sori (singular = sorus)
7. They show clearly defined sexual reproduction. Fertilisation is dependent on water ie external water.
8. Normally inhabit wet environments because fertilisation depends on external water.

Division Spermatophyta

This division comprises all the seed-bearing plants. Their general characteristics include:-

1. Plant body differentiated into roots, stems, leaves and seed-bearing structures - flowers or cones.
2. Vascular tissue is highly developed with xylem consisting of both xylem vessels and tracheids
3. Sexual reproduction is well defined

Fertilisation is preceeded by growth of pollen tube into embryo sac and does not depend on availability of water.

(4) Seeds are produced after fertilisation
(5) They show alternation of generations whereby the sporophyte is the dominant generation and the gametophyte is greatly reduced and enclosed within the sporophyte.
(6) Contain chlorophyll hence are photosynthetic.

The division is divided into two subdivisions

(a) Subdivision Angiospermaphyta/Angiospermae
(b) Subdivision gymnospermaphyta/Gymnospermae

Subdivision Gymnospermaphyta/Gymnospermae

General characteristics

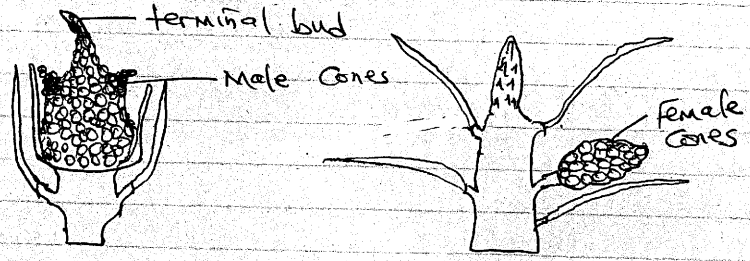
(1) Bear cones of two types - male and female cones.
(2) After fertilisation, seeds are borne on female cones. The seeds are not enclosed in a fruitwall ie are naked seeds.
(3) They show some xerophytic characteristics such as needle-like leaves, thick waxy cuticle, sunken stomata, rolled leaves etc; so as to conserve water and retain their leaves throughout the year even under frozen conditions of winter when water is not available.
(4) Reproduction is sexual.
(5) Have highly developed strengthening

tissues that enable them to grow to large sizes.

- The subdivision is subdivided into five classes, the first three being the commonest and the last two being less common:-
  (i) class Coniferales
  (ii) class Cycadales
  (iii) class Ginkgoales
  (iv) Class Gnetales } Less common.
  (v) Class Taxales }

Class Coniferales

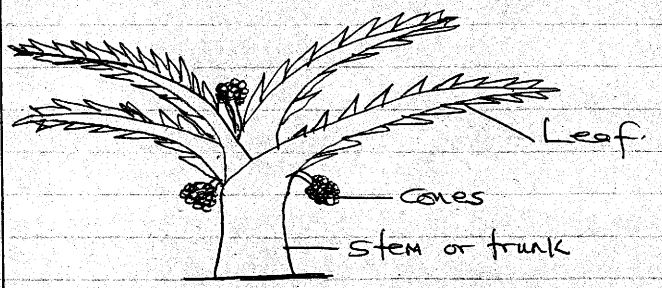
- Are evergreen and bear cones.
- Have small needle-shaped leaves with a thick waxy cuticle.
- Female cones are borne on lateral buds whereas male cones form clusters around the base of terminal buds like in pinus.
- Cones grow only at an altitude of approximately 2000 m above sea level.
- Examples are pines, cedars, firs and cypresses.



Class Cycadales

- Have long compound leaves which are clustered at the apex of a usually thick and unbranched stem.

- Bear cones at the apex of the trunk among leaves.
- They resemble palms superficially
- Example is the cycad.



Class Ginkgoales

- Desduous with fan-like leaves.
- Example is Ginkgo biloba a native of China.

Sub-division Angiospermaphyta (Angiospermae)

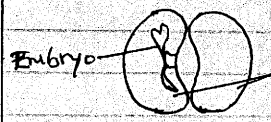
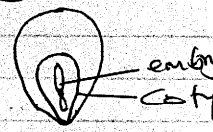
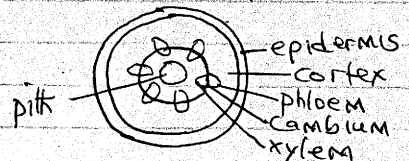
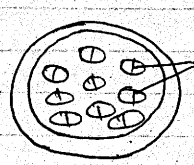
- Are the most advanced plants.
- Include herbs, shrubs, grasses and trees.
- General characteristics include :-

1. Flower-bearing and usually bisexual
2. Seeds are enclosed in the ovary. which develops into a fruit.
3. Xylem has tracheids and vessels while phloem has companion cells.
4. They exhibit double-fertilisation.

The group is divided into two distinct classes :-

(a) class Dicotyledonae
(b) class Monocotyledonae

- Below are the comparative features for each class.

class Dicotyledonae	class Monocotyledonae
① Have net-work vennation on leaves / leaves net veined 	Have parallel-veined leaves / parallel veined. 
② Embryo with two Cotyledons (Seed leaves) 	Embryo with one Cotyledon (Seedleaf) 
③ Vascular bundles in the stem are arranged in a ring around the pith. 	Vascular bundles in the stem are scattered. 
④ Stem has Cambium	Stem Lacks Cambium
⑤ Pith present in stem	Pith absent in stem.
⑥ Flower parts in fours or fives or Multiples of four or five.	Flower parts in threes or Multiples of three.
⑦ Taproot system ⑧ Has Cortex in stem Examples are tea, Coffee, beans, Hibiscus, bougainvillea etc	Fibrous root system. Lacks Cortex in stem Examples are maize, wheat, rice, Sorghum, Millet, bananas etc

Kingdom Animalia

General characteristics

1. Eukaryotic and Multicellular
2. Their cells lack cellwalls
3. All are heterotrophic
4. Most reproduce sexually while a few reproduce asexually
5. Most show locomotion but a few are sessile
6. Are either vertebrates or invertebrates.

- The kingdom is divided into 9 phyla but the two most important phyla are phylum arthropoda and phylum chordata.

Phylum Arthropoda

- Includes all animals with jointed appendages eg insects, arachnids, centipedes, millipedes crabs, prawns, scorpions etc

Main characteristics of phylum Arthropoda

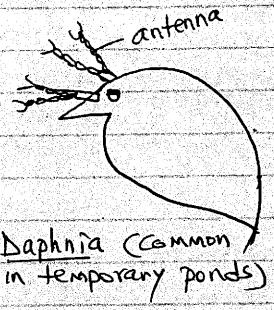
1. Jointed appendages
2. Bodies covered with chitinous exoskeleton. This allows muscle attachment attachment of internal organs, protection of inner parts from mechanical injury etc. It is shed periodically to allow growth. This process is known as moulting or ecdysis.
3. Their bodies are segmented.
4. Are bilaterally symetrical.
5. Have open circulatory system.
6. In most of them the body is divided into three parts - head, thorax and abdomen. In others the body is divided into two parts - Cephalothorax and abdomen.

7. Show cephalisation ie head is well developed with eyes, sensory structures like feelers/antennae, and a fairly developed brain.
8. Gaseous exchange is through tracheal system which opens out through spiracles. Some aquatic forms use gills.
9. Reproduction is mainly sexual with internal fertilisation. sexes are seperate.

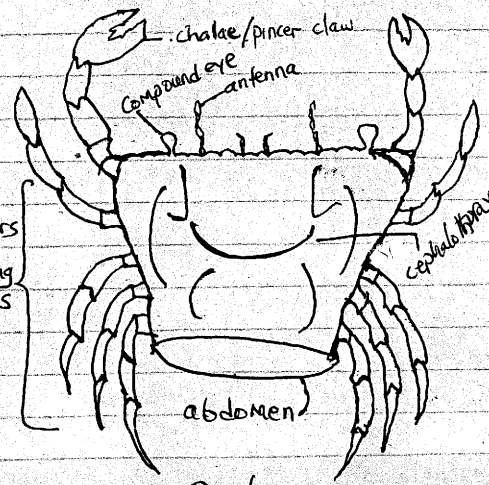
- The phylum arthropoda is divided into 5 main classes ie class Crustacea, chilopoda, diplopoda, arachnida and insecta. The classification is based on:-
  - (i) Number of limbs
  - (ii) Presence and number of antennae
  - (iii) Number of body parts.
  - (iv) Types of eyes

(a) Class Crustacea

- Includes crabs, crayfish, prawn, Daphnia Lobsters, shrimps, woodlice and water fleas.

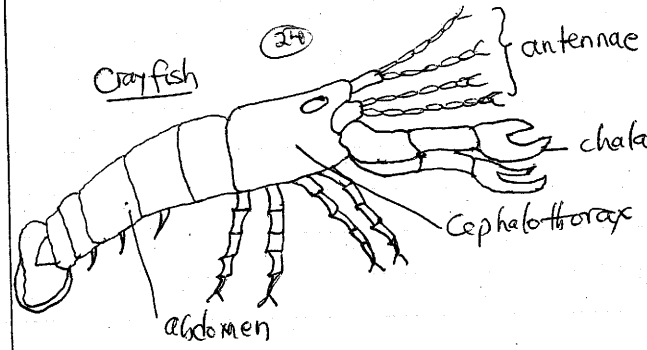


Daphnia (Common in temporary ponds)

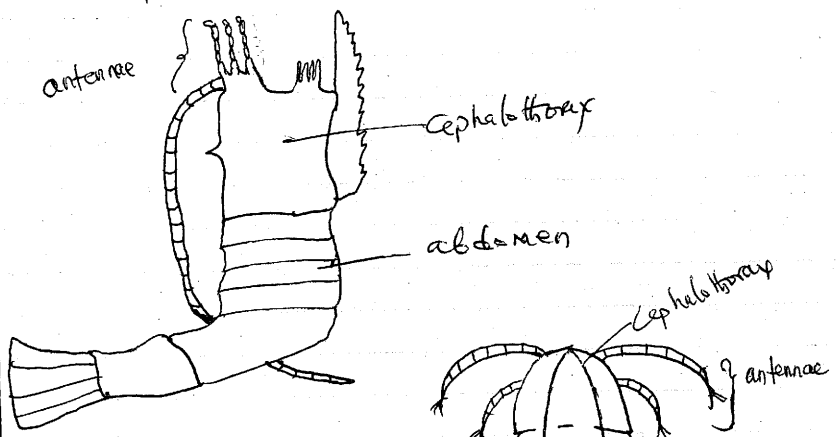


Crab

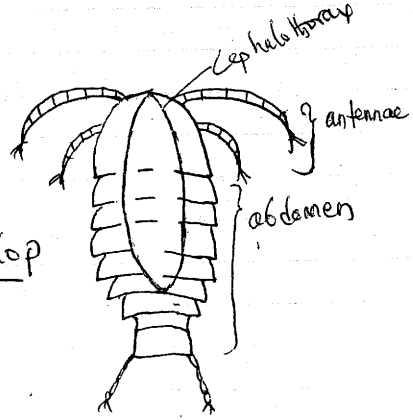
Crayfish



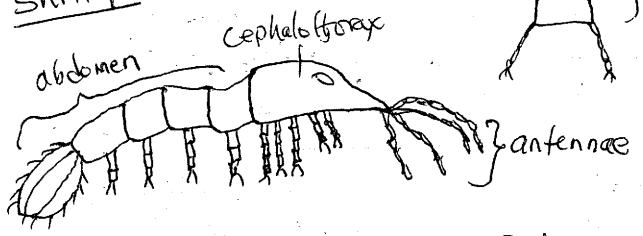
prawn



Cyclop



Shrimp



General characteristics of class Crustacea

1. Two body divisions - Cephalothorax and abdomen. In most of the members, the

Cephalothorax is protected by a carapace
2. Have two pairs of antennae.
3. Have between 5 and 20 pairs of limbs modified for different functions – locomotion, feeding, defence. The limbs are on the cephalothorax and abdomen.
4. Have a pair of compound eyes.
5. Have three pairs of mouthparts – one pair of mandibles and two pairs of maxillae.
6. Gaseous exchange is through gills.
7. Have forked appendages

– other general characteristics include:-

1. Habitat: Most crustaceans are marine but a few live in freshwater and a few on moist soils / land along shores, water rocks, water plants and open waters.
2. Majority are free-living in terms of habit but a few barnacles are parasitic.

Economic importance of Crustaceans

1. source of food to man eg Crabs, Crayfish, lobsters
2. Are the main primary consumers in aquatic ecosystem.

(b) class Chilopoda

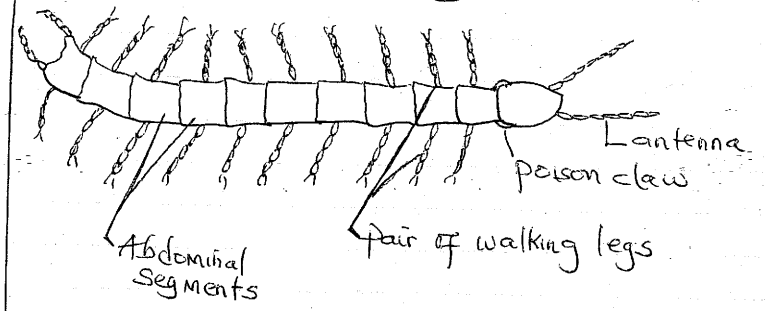
– Comprises the centipedes.

General characteristics

1. Bodies are dorso-ventrally flattened.
2. Body divided into two parts – head and trunk
3. Body consists of up to 15 segments or more.
4. Each segment has a pair of walking legs.
5. The head has a pair of simple eyes.
6. The head has a pair of long antennae
7. Have poison claws on the head which secrete a poisonous substance to paralyse prey
8. Gaseous exchange is through tracheal system.

9. Sexes are seperate. ⑮ Has posterior genital aperture

NB - Centipedes are Carnivorous and Nocturnal. They are mainly terrestrial living in moist places. They are common in ant hills where they feed on larvae



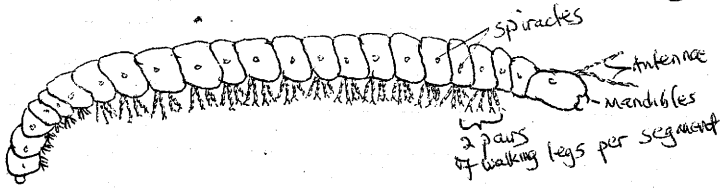
(c) class Diplopoda

- Includes the millipedes

General characteristics

1. Bodies are cylindrical with between 9-100 segments.
2. Have three body parts - head, thorax with 4 segments and a long abdomen.
3. Each segment has two pairs of walking legs except for the first thoracic segment.
4. Head with a pair of short antennae and Mandibles.
5. Have two clumps of many simple eyes.
6. Each segment has a pair of spiracles hence use tracheal system for gaseous exchange.
7. Lack poison claws. ⑧ Has anterior genital aperture;

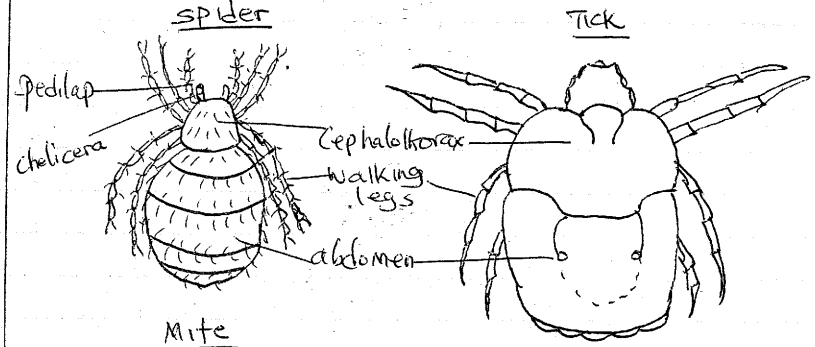
NB. Some authorities combine class chilopoda with diplopoda into one class - Myriapoda - because they have many legs.

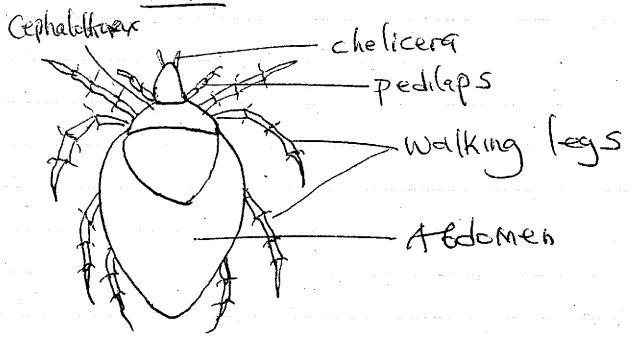


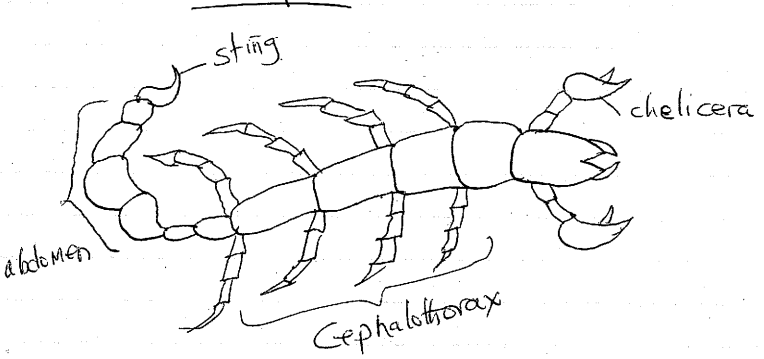
(d) class Arachnida

- Includes spiders, scorpions, ticks and mites.

General characteristics







1. Body divided into two parts - cephalothorax and abdomen
2. Ventral side of Cephalothorax has two chelicerae that produce poison to paralyse the prey.

3. Cephalothorax has 4 pairs of legs each with seven segments.
4. Each leg ends with two toothed margins
5. Lack antennae. Instead have pedipalps which act as sensory organs, for squeezing prey or food or for transfer of semen as in mites.
6. Cephalothorax has 8 simple eyes.
7. In most arachnids gaseous exchange is by means of lungbooks. Some use gillbooks and others the tracheal system.

NB- Members of class arachnida are all carnivorous and paralyse their prey using poison from poison claws.

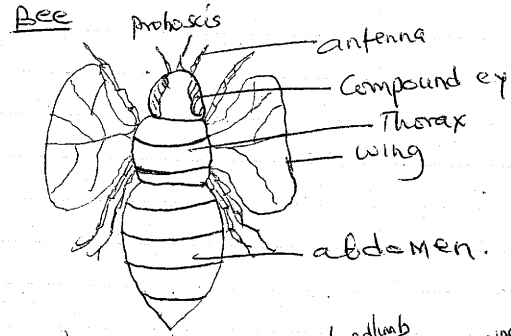
(e) class Insecta

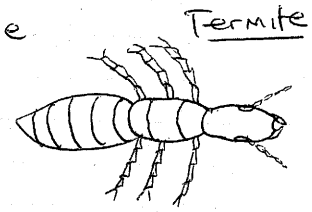
- Constitute the insects. Members of class insecta form the largest population of animals on earth, half the world animal population. They occupy all habitats - air, water, land - in all climatic regions of earth.
- They feed on a variety of foods - plant and animal tissues, animal fluids, dead animals and plants and their excretory products.
- The science of insects is known as Entomology

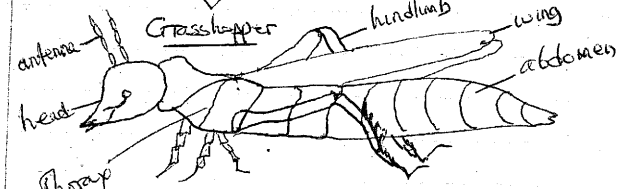
General characteristics

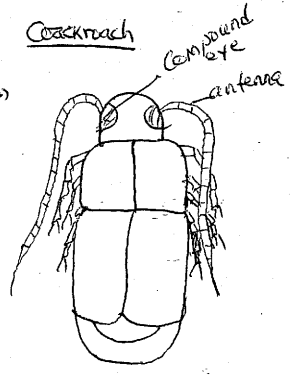
1. Body divided into three parts - head, thorax and abdomen.
2. Have three pairs of legs arising from the three thoracic segments.
3. Have a pair of antennae.
4. Head has a pair of compound eyes and several simple eyes.
5. Gaseous exchange is by means of tracheal system which opens out to spiracles.
6. Mouthparts consists of mandibles, maxillae, labium with and labrum modified according to feeding habits.
7. Abdomen is made up of eleven or fewer segments.
8. Excretion is through Malpighian tubules which remove uric acid.
9. Undergo either complete metamorphosis (Holometabolous) or incomplete metamorphosis (Hemimetabolous).
10. Some have wings and others do not.

Examples include beetles, cockroaches, ants, weevils, grasshoppers, locusts, butterflies, termites houseflies, bees, etc.

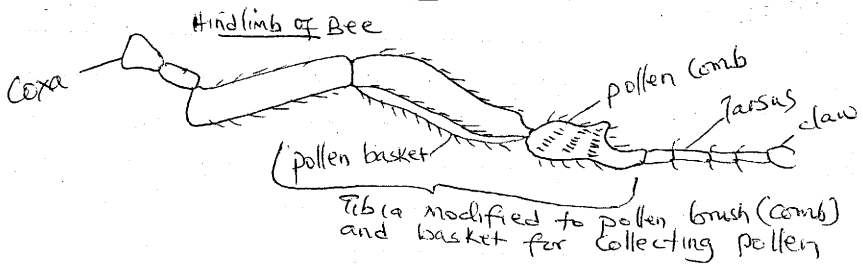




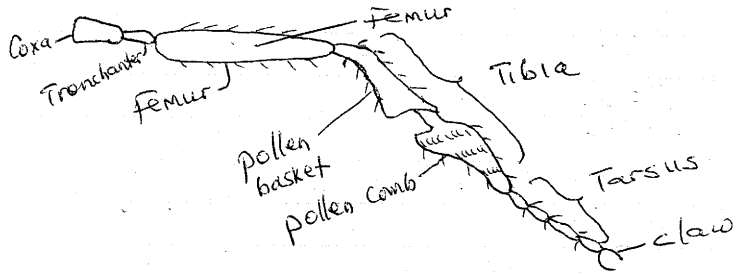




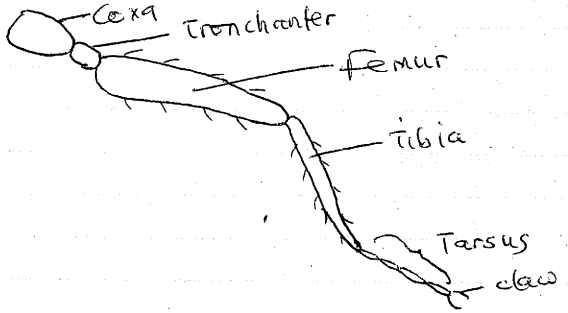
Limbs of insects



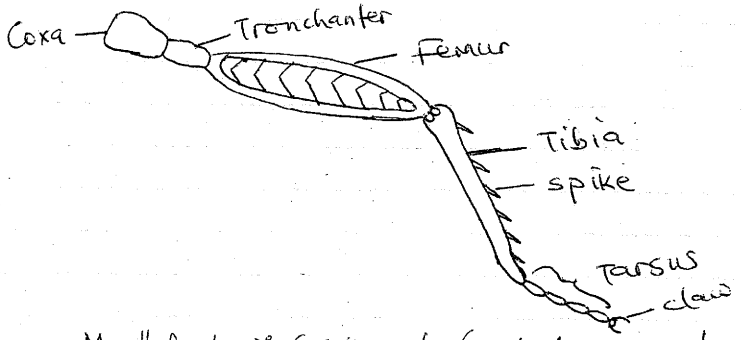
Foreleg of bee



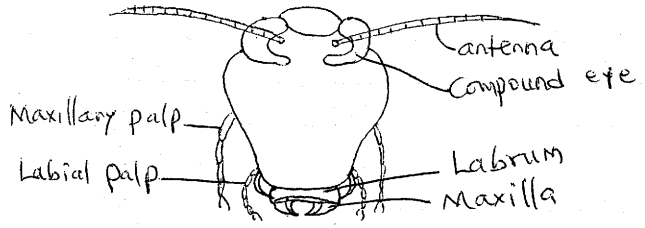
Generalised leg of an insect

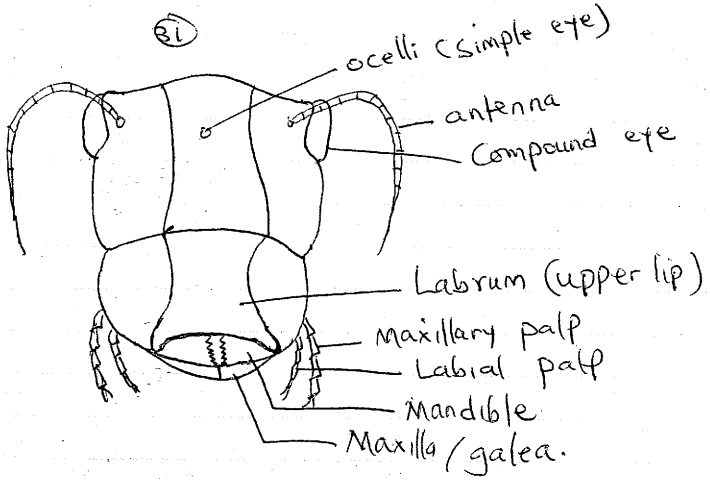


Hindlimb of a Grasshopper

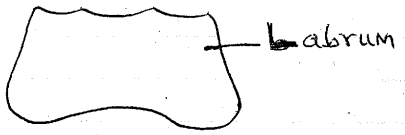


Mouthparts of Cockroach (Ventral view of head)



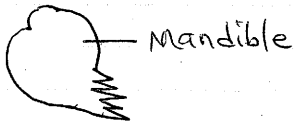


Isolated Mouthparts of grasshopper

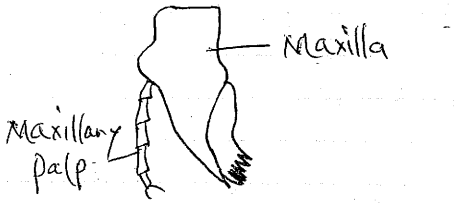


Functions

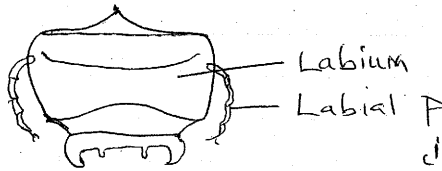
i, Holding/pushing food into the mouth
ii, Tasting food



i, For biting and chewing food.



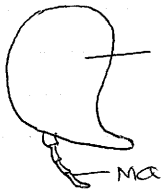
i, Assists mandibles in cutting food
ii, Holding and directing food into the mouth.



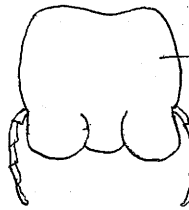
i, Tasting food
ii, Holding and pushing food into the mouth.

Isolated mouth parts of Cockroach

Mandible — for biting and chewing food.



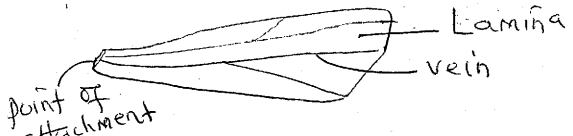
Maxilla
Maxillary palp
} Holding food



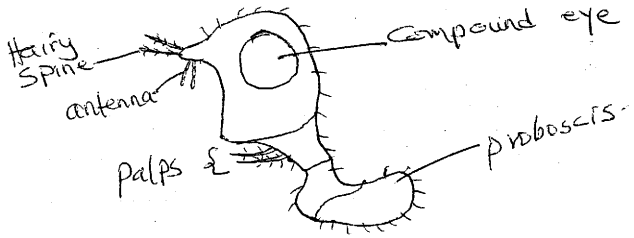
Labium
Labial palp
} Tasting food

Labrum — Prevents food from falling from the mouth.

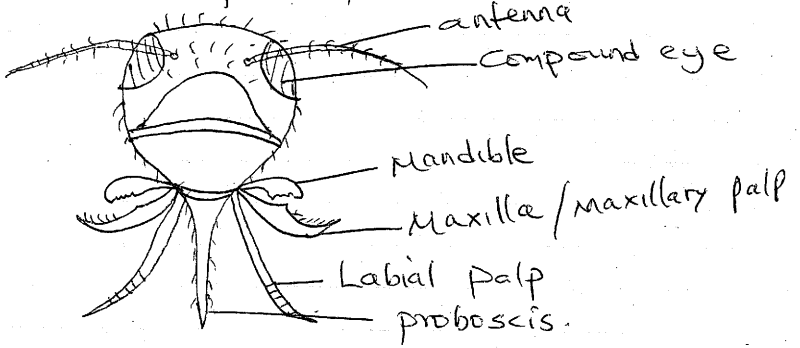
Wing of an insect



Mouthpart of Housefly



Mouthparts of Honey bee



phylum chordata

- Includes fishes, amphibians, reptiles, birds and mammals. They inhabit both terrestrial habitats (including burrowers, aboreal etc) and aquatic (both fresh water and marine).

Main characteristics

1. Have a notochord in atleast some stage of development. This may persist as in Amphioxus or may be replaced by vertebral column.
2. Are bilaterally symmetrical.
3. Have a single dorsal tubular nervecord. This develops anteriorly in higher mammals into the brain and posteriorly into spinal cord.
4. Have visceral clefts - slits perforating the pharynx. This may persist to form gills as in fish or disappear as in other groups.
5. The heart is ventrally located. Blood flows to the heart through ventrally placed veins and from the heart through dorsally placed arteries.
6. Have closed circulatory system.
7. Have segmented muscle blocks called myotomes on either side of the body
8. Possess post-anal tail; although vestigial in some.

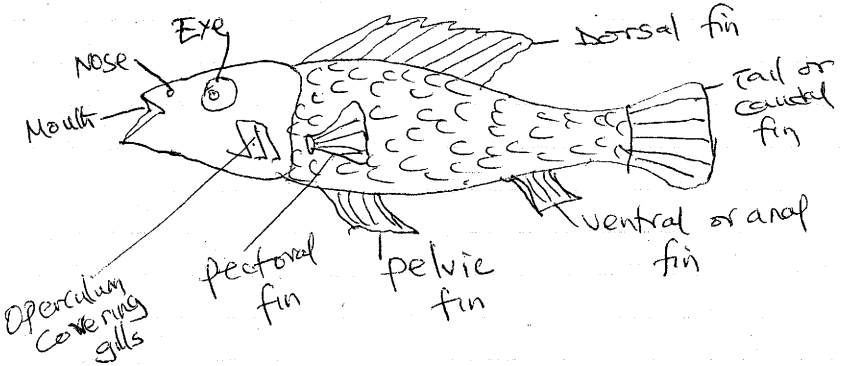
9. Pisces an internal skeleton (endoskeleton).
The phylum is divided into 5 classes, namely Pisces; Amphibia; Reptilia; Aves; Mammalia.

(a) class Pisces

- Includes fishes. They are two sub-classes
i, subclass Osteichthyes – bony fishes such as tilapia, Nile perch, codfish, eel, etc.
ii, Subclass Chondrichthyes or elasmobranchs eg shark, dogfish, lungfish, rayfish. These are fish whose skeleton is made of cartilage.

General characteristics of Pisces

1. Have gills for gaseous exchange
2. Have fins for movement and balance
3. Bodies covered with scales
4. Have stream-lined bodies
5. Operculum covers the gills
6. Lack middle and external ear
7. Have single circulatory system with heart divided into one ventricle and one atria/auricle.
8. Pisses lateral line for sensitivity/detecting vibrations in water.
9. Are poikilothermic/exothermic
10. Eyes covered with nictating membrane.



(b) class Amphibia

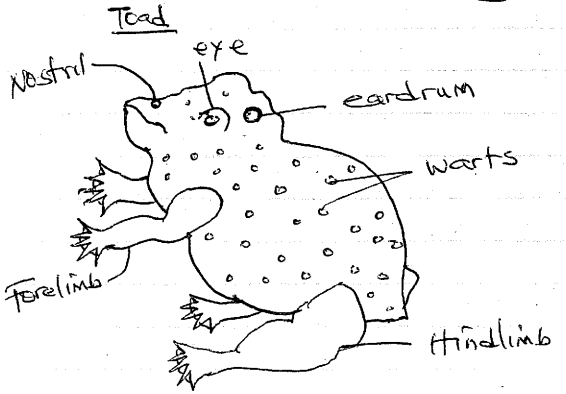
- Includes Toads, frogs, newts and salamanders.
- They are partly aquatic and partly terrestrial.

General characteristics

1. Are quadripedal ie with four legs whereby hindlimbs are longer and more muscular than forelegs; for jumping or hopping.
2. Have a double circulatory system with heart having three chambers – two atria and one ventricle.
3. Breed in water and fertilisation is external.
4. Gaseous exchange is by skin, lungs and buccal cavity in adults and gills in tadpoles.
5. Have two eyes with an eardrum behind the eyes
6. Poikilothermic or exothermic.

The toad is the most advanced of the amphibians. It stays longer on land and goes back to water for breeding. Its skin is less moist and covered with warts. It thus uses lungs more for gaseous exchange.

Toad

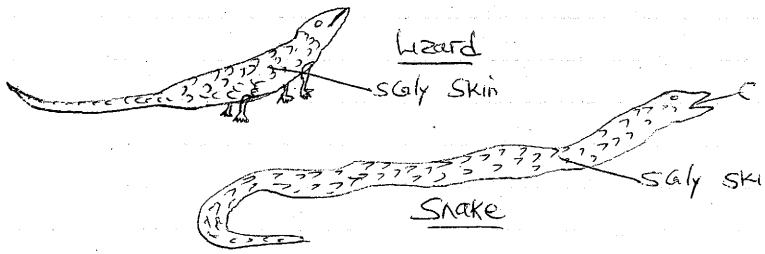


(c) class Reptilia

- Includes turtles, tortoises, lizards, snakes, crocodiles, chamelions, geckos, etc.
- Reptiles are more adapted to live on land than amphibians.

General characteristics

1. Bodies are covered with dry scaly skin meant to reduce desiccation.
2. Are either quadripedal like lizards or limbless like snakes.
3. Fertilisation is internal and lay fertilised eggs covered with a leathery shell to reduce desiccation. However some chameleons retain the eggs in the oviduct and give birth to youngones.
4. Have double circulatory system with a three-chambered heart ie two atria and a partially divided ventricle. But crocodiles have a four-chambered heart.
5. Have well developed lungs for gaseous exchange.
6. Are exothermic/ poikilothermic



(d) class Aves

- Comprises all kinds of birds - domestic fowls, doves, weaverbirds, eagles, turkeys, ostrich, Penguins, hawks, sunbirds etc.

General characteristics

1. Bodies covered with feathers for insulation and flight.
2. Have beaks
3. Most have hollow bones without bone marrow to reduce density and increase buoyancy (for flight).
4. The sternum (breastbone) is enlarged to form a keel for attachment of flight muscles.

5. Have hindlimbs for walking or swimming and forelimbs modified to form wings for flight. However some birds such ostrich do not fly.
6. Hindlimbs have dry scaly skin.
7. Have a double circulatory system with a four-chambered heart.
8. Have lungs for gaseous exchange. Their lungs have numerous airsacs to store air to reduce density and for use during flight.
9. Are homoiothermic/ endothermic.
10. Fertilisation is internal and they lay eggs with calicified / calcareous shells.
11. They have an internal auditory meatus.

(e) class Mammalia

- Examples include human beings, apes, gorillas, monkeys, lions, dogs, cattle, bats, kangaroos, hedgehog, porcupines, elephants, sheep, goats, cats, rats, mice, Duck-billed platypus etc.
- They inhabit various habitats both aquatic (ie fresh water and marine) and terrestrial (including tunnels by burrowers, on trees by the aboreal forms etc).
- Aquatic forms have streamlined bodies and fin-like structures (flippers) for swimming. Examples include whales and dolphins

General characteristics

1. Have mammary glands hence the name mammals.
2. Bodies covered with hair or fur.
3. Have heterodont teeth ie four kinds of teeth modified in relation to habit of feeding - incisor, canine, premolar and molar.
4. Have pinnae / external ear.

5. Have sweat glands
6. Use lungs for gaseous exchange.
7. Have a double circulatory system with a four-chambered heart. Their systemic arch is on the left.
8. Have four limbs hence quadripedal.
9. Have a diaphragm seperating thoracic cavity from abdominal cavity.
10. Brain is highly developed.
11. Have seven cervical bones/ cervical vertebrae in the neck region.
12. Are homoiotherms/endotherms.

NB: All mammals except the egglaying Monotremes give birth to youngones. All the mammals feed their youngones with milk from the mammary glands.

Summary Table on characteristics of Kingdoms

Kingdom	cell type	Nuclear envelope	Mitochondria	chloroplast	Cell wall	Mode of Nutrition
MONERA	prokaryotic	Absent	Absent	Absent	Made of proteins & sugars	Both autotrophic & heterotrophic
PROTOCTISTA	Eukaryotic	Present	present or absent	present in some	present in some	Autotrophic or heterotrophic
FUNGI	Eukaryotic	present	present or absent	Absent	made of chitin & cellulose polysaccharides	Heterotrophic
ANIMALIA	Eukaryotic	present	Present	absent	Absent	Heterotrophic
PLANTAE	Eukaryotic	present	present	present	present. made of cellulose	Autotrophic

Summary table on characteristics of phylum chordata

Characteristic	Pisces	Amphibia	Reptilia	Aves	Mammalia
Body Cover	scales	warts (for toads)	scales	-feathers -scales on hind-limbs	fur or hairs
Locomotory structures	fins	Legs	-Legs -Tail	-Legs -wings	-Legs -fins or flippers
Tail	present	Absent in some, present in others	present in some, absent in others	present in some, absent in others	present in some, absent or vestigal in others
Eyes	Two present	Two present	Two present	Two present	Two present
Ears	Lacks middle and external ear	Eardrum behind eyes	present	present	present with pinna

Assignment

On the table below Summarise the characteristics of phylum Arthropods (30 MKS)

Characteristic	Crustacea	Chilopoda	Diplopoda	Arachnida	Insecta
Body parts					
Number of legs					
Segments					
Antennae					
Means of gaseous exchange					
Pedilaps					
Poison claws					
Wings					
Type of appendages					
Sexes					
Symmetry					
Body cover (Type of skeleton)					

The Dichotomous key

-Dichotomous key is a biological tool for identifying unknown organisms up to some taxonomic level. Dichotomous means seperating or branching into two.

-The key is constructed in a series of couplet statements describing contrasting forms of the same characteristic. A choice is then made from the statement which best fits the specimen. This progresses from broad characteristics until only a single choice remains which gives the identity of the unknown organism.

Rules of Constructing Dichotomous Key

① Use morphological characteristics as far as possible eg leaf form ie simple or compound. body symmetry, segmentation, body parts etc.

② Start with a major characteristic that would seperate the organisms to two major groups. Then proceed to lesser variations that would seperate the organisms into smaller groups until individual identities are made.

③ Select a single characteristic at a time and identify it by a number eg :-
1. Leaf form
2. Type of leaf vernation.

④ Use identical forms of words for two contrasting statements for a characteristic eg for leafform
1a. Leaves simple -go to 2
b. Leaves compound -go to 3
2a. Leaves net-veined — Bougainvillea
b. Leaves Parallel veined — Tradescantia

3a. Leaves pinnate — Cassia
b. Leaves bi-pinnate — Jacaranda.

5. Statements must always be written in positive form. However where negation can not be avoided, the first statement must be in the positive eg
1a. Animal with wings
b. Animal without wings

6. Avoid generalisations or overlapping statements or variations eg
1a. plant tall
b. plant short
Instead
1a. plant 1M tall and above
b plant below 1M tall

Common features used in identification of organisms.

(a) Animals

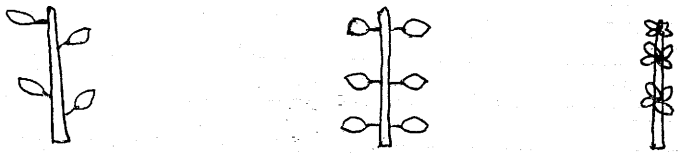
(i) Locomotory structures — legs, wings, fins
(ii) Antennae presence and number
(iii) Presence and types of eyes
(iv) Number of body parts
(v) segments
(vi) structures on body surface / body covered hairs, fur, scales, feathers
(vii) Feeding structures eg beaks
(viii) Type of skeleton eg exoskeleton.

(b) Plants

- Leaves

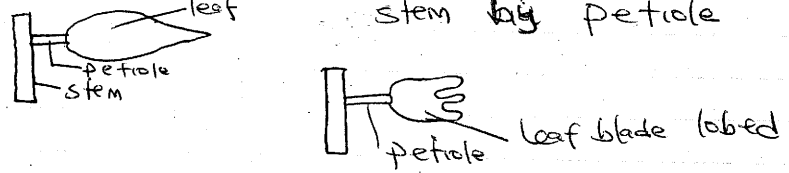
1. Phylotaxy — Leaf arrangement on stems

i) Alternate ii) Opposite iii) Whorled



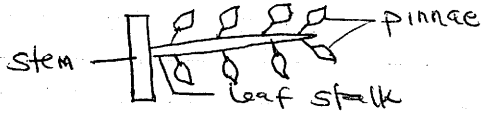
2. Leaf forms

i) Simple – One leaf blade attached to stem by petiole

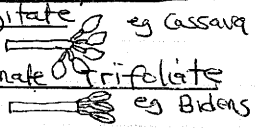


ii) Compound – several leaflets (pinnae) attached to stem by petiole or leafstalk

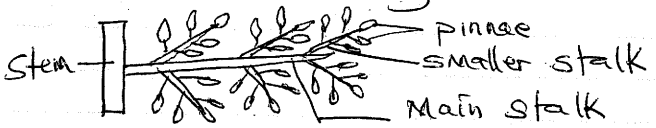
(a) Compound pinnate



- pinnate palmate or digitate eg Cassava
- Pinnate trifoliate eg Bidens



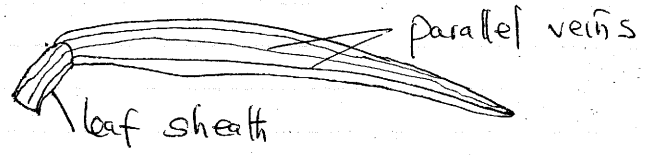
(b) Compound bi-pinnate – several leaflets attached to small stalks which join to Main stalk connecting to stem.



4. Leaf vennation

i) Network vennation / Net-veined / Reticulate

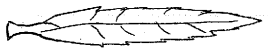
ii) Parallel vennation / Parallel veined



5. Leaf Margins

i) Entire / smooth

ii) serrated

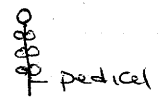


6. Lamina
7. Leaf colour – green, purple, variegated
8. Leaf textures – rough, smooth
9. Leaf succulence – succulent or not succulent

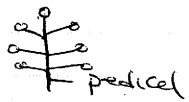
• Flowers

1. Inflorescence type

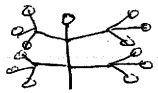
(a) spike



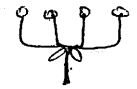
(b) Raceme



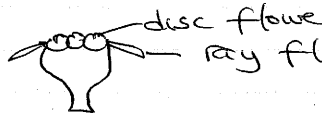
(c) panicle



(d) Umbel



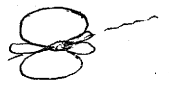
(e) Head



2. Flower shape

(a) Regular / actinomorphic – divisible into half along many plane

(b) Irregular / zygomorphic – divisible into half along one plane only



3. Number of floral parts

i) Fours or fives or their multiples as in dicotyledonous plants

ii) Threes or multiples of three as in Monocotyledonous plants.

Stem

i) Type of stem eg woody or herbaceous/fleshy

ii) Shape of stem eg Cylindrical or rectangular

iii) Texture of stem

Roots

i) Root systems - Taproot or fibrous root system

ii) Storage roots - Taproot tuber or fibrous root tubers.

Worked Examples on Dichotomous Key

Example 1 - Construction of dichotomous key using leaves of plants.

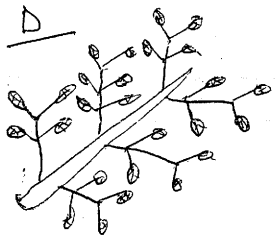
You are provided with specimens labelled A, B, C, D and E. Using external features only, construct a dichotomous key to identify them.

A

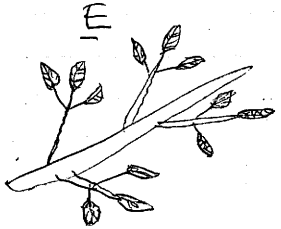
B

C

D



E



Dichotomous Key

1a. leaf simple - go to 2
b. leaf compound - go to 3
2a. leaf blade lobed - A (Bauhnia)
b. leaf blade not lobed - C (Mango)
3a. Leaf pinnate - B (Cassia)
b Leaf bi-pinnate - go to 4
4a. leaflets rounded at apex - D (Flamboyant)
b Leaflets pointed at apex - E (Acacia)

NB To prove that the number of steps is correct use the formula n-1 where n = no. of specimens to get no of steps eg in the key above n-1 = 5-1 = 4 steps ✓

Example 2. Using a constructed key to identify specimens

You are provided with specimen labelled A, B, C, D and E. (Refer Q1 above). Using the dichotomous key, identify the specimens. For each identify, state the steps you followed to arrive at your answer in sequence eg 1a, 2b, 3a etc.

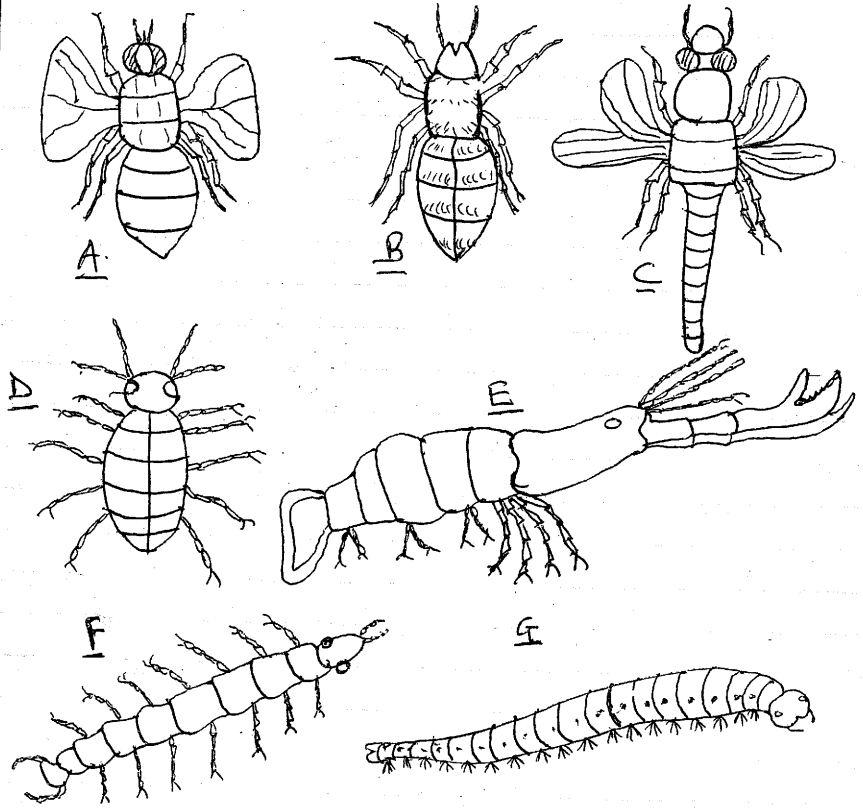
Dichotomous Key

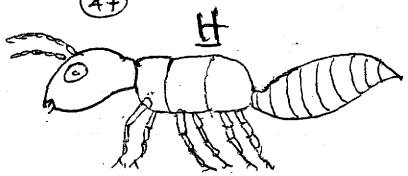
1a. Leaf Simple - go to 2
b. Leaf Compound - go to 3
2a. Leaf blade lobed - Bauhnia spp
b. Leaf blade not lobed - Mangifera indica
3a. Leaf pinnate - Cassia spp
b. Leaf bi-pinnate - go to 4
4a. Leaflets rounded at apex - Flamboyant spp
b Leaflets pointed at apex - Jacaranda mimosifolia

Specimen	steps followed	Identity
A	1a, 2a;	Bauhnia spp
B	1b, 3b;	cassia
C	1a, 3a;	Mangifera indica
D	1b, 3b, 4a;	Flamboyant
E	1b, 3b, 4b;	Jacaranda mimosifolia

Example 3- Construction of dichotomous key using arthropods.

You are provided with specimens labelled A (housefly), B (spider), C (Dragonfly), D (water slatter), E (freshwater shrimp), F (centipede), G (millipede) and H (wingless ant). Construct a dichotomous key to identify them.





Dichotomous key

1a. Animal with wings -- Go to 2
b. Animal without wings - Go to 3
2a. Animal with one pair of wings - A (housefly)
b. Animal with two pairs of wings - C (Dragonfly)
3a. Animal with three pairs of legs - H (ant)
b Animal with more than three pairs of legs - go to 4
4a. Animal with four pairs of legs - B (Spider)
b. Animal with more than four pairs of legs - go to 5.
5a. Animal with two pairs of antennae - go to 6
b. Animal with one pair of antennae - go to 7
6a. Animal with five pairs of legs - D (water slatter)
b. Animal with ten pairs of legs E (freshwater shrimp)
7a. Animal with cylindrical body - G (millipede)
b. Animal with dorso ventrally flattened body - F (centipede)

Example 4 - Using a Constructed dichotomous key to identify given arthropods.

You are provided with specimens, labelled A, B, C, D, E, F, G and H which are the "photographs" in example 3 above. Using the dichotomous key below identify the specimens. For each identity, state in sequence the steps followed eg 1b, 2a, 3b etc.

Dichotomous key

1a. Animal with wings - Go to 2
b. Animal without wings - Go to 3
2a. Animal with a pair of wings - DIPTERA
b. Animal with two pairs of wings - ODONATA

3a. Animal with three pairs of legs - HYMENOPTERA
b. Animal with more than three pairs of legs - go to 4
4a. Animal with four pairs of legs - ARACHNIDA
b. Animal with more than four pairs of legs - go to 5
5a. Animal with two pairs of antennae - go to 6
b. Animals with one pair of antennae - go to 7
6a. Animal with five pairs of legs - SLATE
b. Animal with ten pairs of legs - SHRIMP
7a. Animal with cylindrical body - DIPLOPODA
b. Animal with dorso-ventrally flattened body
—— CHILOPODA

Specimen	steps followed	Identity
A	1a, 2a;	DIPTERA;
B	1b, 3b, 4a;	ARACHNIDA;
C	1a, 2b;	ODONATA;
D	1b, 3b, 4b, 5a, 6a;	SLATE;
E	1b, 3b, 4b, 5a, 6b;	SHRIMP;
F	1b, 3b, 4b, 5b, 7b;	CHILOPODA;
G	1b, 3b, 4b, 5b, 7a;	DIPLOPODA;
H	1b, 3a;	HYMENOPTERA;

2. ECOLOGY

- Ecology is the study of the inter-relationships of organisms to each other and to their environment.
- Environment is the sum total of all the biotic (living) factors and abiotic (non-living) factors surrounding an organism.

Branches of Ecology

① **Autecology** – study of a single species in an ecosystem eg study of Lions in a National park.

② **Synecology** – study of different species of organisms interacting among themselves within an ecosystem.
OR – is the study of all communities / Natural communities of organisms in an ecosystem eg study all animals in Tsavo National park.

Application of Ecology

i. Sustainable food production
ii. Conservation of natural resources
iii. Pollution control
iv. Control of diseases and pests
v. Prediction and Management of adverse weather patterns
vi. Population control
vii. Ecotourism.

Concepts of Ecology

① **Biosphere / Ecosphere**
- Part of earth and atmosphere occupied by organisms.

② **Habitat**
- Specific locality with a particular set of environmental conditions where an organism lives. This can be in water (aquatic habitat) or on land (terrestrial habitat).

③ **Ecological niche**
- Is the position that an organism occupies in the habitat in terms of physical space and its role in terms of feeding relationships eg grass is a producer in a Savannah ecosystem.

④ **Population**
- All members of the same species in a particular habitat at a particular time eg population of Nandi flame trees on Mount Kenya.

⑤ **Community**
- All organisms belonging to different species that co-exist in the same habitat or ecosystem or environment eg all animals in Maasai Mara.

⑥ **Ecosystem.**
- Natural unit composed of biotic and abiotic factors whose interactions leads to a self-sustaining unit eg a small pond, a forest, fresh-water lake, river, ocean etc.

⑦ **Biomass**
- Total dry weight of living organisms at a particular trophic level per unit area eg total dry weight of bean crop per hectare.

⑧ **Carrying capacity**
- Maximum number of organisms of a given species/population comfortably support without depletion of available resources eg maximum number of goats a paddock can support without overgrazing.

⑨ **Biomes.**
- Major world climatic regions named according to dominant vegetation eg Tundra, Savannah, Desert etc.

⑩ **Primary productivity**
- The rate of food production by autotrophs per unit area per year. This can be Gross primary productivity or Net primary productivity. Measured in kilocalories per m^2 per year ($kcal\ m^{-2}\ yr^{-1}$)

Factors in an ecosystem

- An ecosystem comprises of biotic and abiotic factors.

Abiotic factors in an ecosystem

① Light

- Aspects of light that affect livingthings are light intensity, wavelength / quality of light / colour of light and light duration.

EFFECT ON PLANTS - Green plants need light for photosynthesis. Some plants need light for flowering. Some seeds like of lettuce require certain wavelengths of light for germination. Light also affects opening and closing of stomata.

EFFECTS ON ANIMALS - Light affects migrations, hibernations and breeding / reproduction in some animals.

Light intensity is measured using a photographic light meter. Light penetration in water is measured using Seechi disc.

② Temperature

- Affects all biochemical / enzymatic / metabolic processes such as photosynthesis; respiration, germination etc.
- It also affects physical processes such as transpiration; evaporation; decomposition and recycling of organic matter.
- Temperature also influences precipitation and photoperiodism.
- Livingthings develop physiological and behavioural adaptations to cope with temperature extremes since too low temperature inactivates enzymes and too high temperature denatures enzymes and destroys the protoplasm.
- Temperature is measured using a thermometer. Temperature range of day and night ie diurnal range is measured using maximum and minimum thermometer.

③ Atmospheric pressure

- Variation in atmospheric pressure affects availability of carbon(IV) oxide and oxygen which affect photosynthesis and respiration respectively.
- Low atmospheric pressure increases the rate of transpiration in plants.
- At low atmospheri pressure, the gases are less and at high atmospheric pressure the gases are more in terms of quantity.
- Atmospheric pressure is measured using a barometer

④ Humidity

- Refers to the amount of water vapour in the atmosphere.
- Affects transpiration in plants (ie at low atmospheric pressure transpiration rate is higher and vice versa. It also affects rate of evaporation of water from animal and plant surfaces.
- Humidity is measured by the wet and dry bulb hygrometer or by using anhydrous cobalt (II) chloride or copper(II) sulphate coated papers.

⑤ Rainfall

- Affects availability of water for living organisms hence affecting their distribution on earth eg more plants and hence more animals are found in places with more rainfall than in deserts where water is less.
- Water is used in plants for germination, as a raw material for photosynthesis, for

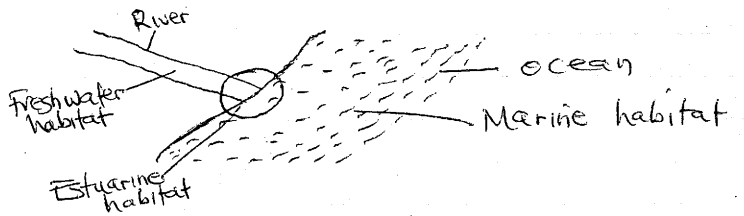
dissolving mineral salts and for turgidity to herbaceous plants conferring support.
- Rainfall is measured using a rain gauge

⑥ Wind

- Wind affects the rate of water loss from organisms hence affecting their distribution. Wind affects rain formation and hence distribution of plants and animals. Wind causes wave formation hence aeration of water bodies providing oxygen for respiration and carbon (IV) oxide for photosynthesis to aquatic organisms and plants respectively.
- Wind disperses fruits and seeds. Rate of transpiration is faster in windy conditions. Wind is an agent of pollination.
- Wind wafts scent hence determining the positioning of hunting animals with respect to their prey in an habitat.
- Wind direction is measured using wind vane or wind-sock. Speed of wind is measured using anemometer.

⑦ Salinity

- Is the concentration of mineral salts in water. This divides the aquatic environment into marine, freshwater and estuarine habitats.



- It affects the osmoregulatory mechanisms of organisms affecting their distribution eg plants with salt tolerant tissues like Mangroves grow in saline areas whereas plants in estuarine habitats as well as the animals adjust to salt fluctuations.

⑧ pH (hydrogen ion concentration)

- Each plant requires a specific pH to grow well - acidic or neutral or alkaline. This in turn affects distribution of animals.
- pH is measured using universal indicator and pH scale.

⑨ Topography.

- Refers to the configuration of the earth's surface.
- North facing slopes in south temperate lands have more organisms than south facing slopes.
- Leeward sides have stunted vegetation and fewer animals whereas windward slopes have more vegetation and animals.
- This is because topography affects rainfall patterns, light, humidity, wind direction, surface run offs and hence distribution of organisms. For example, at high altitudes temperature is low, atmospheric pressure decreases, rainfall increases; and at the plains, drainage is poor.

⑩ Edaphic/Soil factors

(a) Mineral salts and Trace elements - affects distribution of various plants in the soil. They thrive well where there is no deficit. Where there is deficit, the plants develop adaptive methods eg harbouring nitrogen fixing bacteria or becoming insectivorous.

(b) Soil texture - Affects drainage and aeration hence determining distribution of plants and animals.

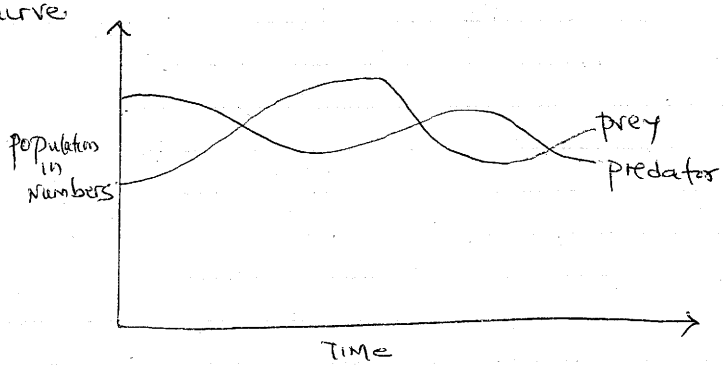
Biotic factors and biotic inter-relationships in an Ecosystem.

① Competition

- Is the struggle for a common resource which is in limited supply between two or more individuals of the same or different species.
- Such resources include water, light, space, mates, food, mineral salts etc.
- If the competition is between members of the same species it is said to be intraspecific competition eg Male lions competing for mates.
- If the competition is between members of different species, it is said to be interspecific competition eg lions and leopards competing for gazelles.
- Competition results in the following
  (i) Migration ie emigration or displacement
  (ii) Death of the poorly adapted competitor
  (iii) Co-existence.
- Competition is more severe when ecological niches of competing organisms are close eg when Paramecium aurelia and Paramecium caudatum are grown in the same culture, severe competition occurs and P. caudatum is eliminated. But when Paramecium caudatum and paramecium bursoria are grown in the same culture medium, each occupies a different part of the nutrient culture feeding on bacteria without any competition. In like manner grazers and browsers co-exist in the same habitat. Even among grazers eg zebra, wildebeest and gazelles, none is eliminated as zebra feeds on tender shoots, followed by wildebeest and gazelles feed on the fibrous remnants of the same grass.

② Predation

- Is the feeding relationship in which one organism, the predator, kills another, the prey, and feeds on it either wholly or in part.
- Predators have various adaptive features to increase their efficiency eg praying mantis have enlarged forelimbs to capture insects; hawks/eagles/kites have sharp eyesight, fast flight and modified beaks and talons to seize prey; Lions have strong jaws, strong muscular forelimbs, fast movements, colour camouflage and instinctive behavioural response for efficient hunting.
- The prey also have adaptive features to minimise predation eg colour camouflage, fast running eg for antelopes, deer etc; confrontational display eg porcupines; mimicry eg stick insects; large eyes on sides of head to increase visual field eg zebra.
- The distribution of prey and predator are related in what is called prey-predator relationship. When the prey population is high, that of predators also increase. When the population of predators increase that of prey decreases thus decreasing the predator population. Below is a prey-predator curve



- for example in a game reserve a high population for zebra will cause lion population to increase. The high number of lions causes a decrease in zebra

population. Hence population of lions begins to decrease due to starvation, deaths or migrations. In turn the population of zebra begins to increase due to reduced predation.

NB → Prey population always starts at high number because as primary consumers they must be able to sustain the secondary consumers.

③ Parasitism

- Parasitism is a relationship in which one organism, the parasite, obtains nutrients from another, the host, without necessarily killing it but often causing harm to the host.
- Parasites which live on hosts' bodies to obtain nutrients are called ecto parasites eg ticks whereas those that live in host tissues or body to obtain nutrients are called endoparasites eg roundworms; plasmodium spp.
- Parasites obtain nutrients/food from the host and shelter. They in turn weaken the host, damage host tissues, cause diseases and death thus reducing population of the host and affecting its distribution.

④ Symbiosis/Mutualism

- Is an association between organisms of different species in which both benefit; eg Rhizobium bacteria in root nodules of Leguminous plants. Both organisms called Symbionts enhance each others populations.

⑤ Saprophytism

- A type of nutrition in which an organism obtains nutrients from dead organic matter causing decomposition. Decomposition releases nutrients into the ecosystem making them available for other organisms. This helps in nutrient cycling in biogeochemical cycles.

⑥ Commensalism.

- Relationship between two organisms of different species in which one, the commensal, obtains nutrients or benefits from the other, the host, without harming it, the host eg epiphytic ferns and orchids which grow on trees obtaining nutrients from humus deposited on the host by birds etc.

Other factors that affect distribution of organisms and their populations.

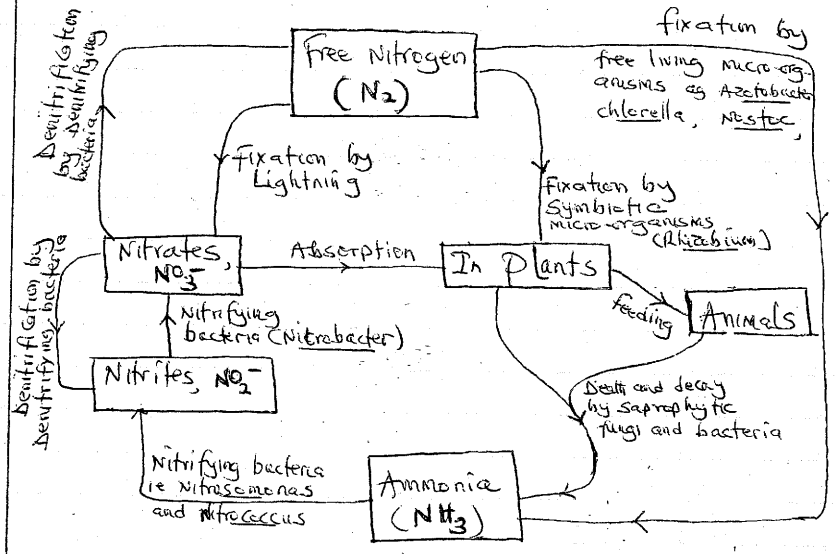
① Diseases – reduce populations
② Social stress – reduce reproduction and population
③ Availability of food – Abundance of food increases population and vice versa.
④ Availability of space – The more the space, the more likely the population growth and spread.
⑤ Natural Calamities eg floods, famine, earthquakes, landslides, volcanicity, Tsunamis etc reduce populations.

Revision Questions.

① KNEC 2004/No.19 → Describe how various abiotic factors affect plants (20 mks)
② Describe how various factors affect distribution of organisms in space (20 mks)
③ Describe how various biotic factors affect organisms (20 mks).
④ What is meant by the following ecological terms? (a) population (b) community (c) Ecosystem (d) Habitat (e) ecological niche (f) Carrying Capacity (g) Biomass (h) Biomes (i) primary productivity.

The Nitrogen cycle

- Nitrogen cycle refers to the cycling of nitrogen and its compounds in nature as illustrated below:-



- Nitrogen is essentially used in protein synthesis by organisms. However organisms can not utilize the molecular atmospheric nitrogen, N_2. Instead it has to be converted to nitrates before it is absorbed and assimilated by plants. Animals obtain the nitrogen in form of proteins from plants or other animals.
- The following are the processes through which atmospheric nitrogen is fixed into nitrates in the soil :-

① Nitrogen fixation by symbiotic bacteria – Rhizobium

- Rhizobium bacteria in root nodules of Leguminous plants fix nitrogen into ammonia, then nitrites and finally nitrates which the plants absorb and then assimilate to form proteins.

② Nitrogen fixation by free-living micro-organisms in the soil.

- Free-living bacteria in the soil ie Azotobacter and clostridium and algae ie chlorella and Nostoc fix atmospheric nitrogen into ammonia which is then oxidised to nitrates which plants absorb.

③ Non-biological fixation by lightning / Thunderstorms

- Lightning energy combines atmospheric nitrogen with oxygen to form nitrogen (IV) oxide which then dissolves in water to form nitric and nitrous acids.

$$NO_2 + 2O_2 \xrightarrow{\text{lightning}} 2NO_2$$

$$2NO_2 + H_2O \longrightarrow HNO_3 + HNO_2$$

- The acids are then chemically converted to nitrates in the soil eg KNO_3, $Ca(NO_3)_2$, $NaNO_3$ which are then absorbed and assimilated by plants to form proteins
- The herbivores or primary consumers feed on plants they obtain proteins which are then digested into amino acids and absorbed and assimilated to form the animal proteins.
- When secondary consumers and other carnivores feed on primary consumers, they obtain proteins which are then digested, absorbed and assimilated as amino acids to form proteins.

④ Excretion

- When plants and animals excrete or animals do egestion or when they die, saprophytic bacteria and fungi decompose the organic matter/proteins releasing ammonia, a process called ammonification
- Ammonia is then oxidised to nitrites by nitrifying bacteria Nitrosomonas and Nitrococcus.
- Nitrites are further oxidised by Nitrobacter into nitrates which are absorbed by plants.

Removal of nitrogen from the soil back to the atmosphere – Denitrification.

- Some anaerobic bacteria breakdown nitrates into nitrites and nitrites into ammonia and eventually to nitrogen a process called denitrification

-This process removes nitrogen from the soil to the atmosphere making it available for recycling. Examples of such denitrifying bacteria include Pseudomonas denitrificans and Thiobacillus denitrificans.

Revision quiz

1. Describe the nitrogen cycle (20mks) KNEC-2008.
2. Describe how atmospheric nitrogen is made available for plants in the soil and how it eventually reaches secondary consumers in an ecosystem. (20mks).

Energy Flow in an Ecosystem

-The natural source of energy in an ecosystem is the sun. Green plants trap light energy during photosynthesis and store the potential energy in form of chemical energy in food such as glucose. Hence green plants are the producers of food in any ecosystem.
-When herbivores feed on green plants, they thus obtain the energy stored in the food from producers. The herbivores are primary consumers
-When carnivores feed on herbivores/primary consumers such as buffaloes, antelopes, goats, zebra etc they obtain energy from them. Such carnivores feeding on herbivores are secondary consumers such as dogs, lions, leopards, cats etc.
-Other carnivores feed on secondary consumers and thus obtain energy from them eg hyena feeding on a dog. Such carnivores feeding on secondary consumers are called tertiary consumers.
-Other carnivores feed on tertiary consumers to obtain energy eg vultures feeding on a dead hyena. Such carnivores that feed on tertiary consumers are called quarternary consumers.
-The feeding levels through which energy is passed from producers to the last consumer are called trophic levels.
-When living things die, they are decomposed by saprophytic fungi and bacteria which thus obtain energy from the dead organic matter. These saprophytic organisms are called decomposers. Decomposers release nutrients into the ecosystem allowing material cycling.
-In the process of energy transfer from one trophic level to another, there is energy loss through the following processes:-
  i) Respiration
  ii) Excretion
  iii) Defecation.
-When all organic matter is fully decomposed, all the energy is lost into the environment mainly in form of heat. Hence energy is not cyclic ie does not go back to its source - the sun.

Material Cycling in An Ecosystem

-The food materials manufactured during photosynthesis such as carbohydrates, proteins and lipids are passed along the trophic levels from producer to primary consumers to secondary consumers to tertiary consumers to quarternary consumers during feeding and finally to decomposers through death and excretion.
-Decomposers (saprophytic fungi and bacteria) break down these complex organic matter into simple substances during decomposition/decay/putrefaction. Finally, simple inorganic compounds such as CO_2, NH_3, H_2O, N_2, NO_3^- are made available in

the ecosystem for reuse during photosynthesis. to manufacture food materials such as proteins, lipids and carbohydrates.
- Thus food materials are recycled in an ecosystem.
- The rate of decomposition depends on the following factors :- (i) The substrate - faster in animals than plants
(ii) Temperature - faster in higher temp.
(iii) Water - faster in moist/ wet conditions than in dry conditions.

Food chains

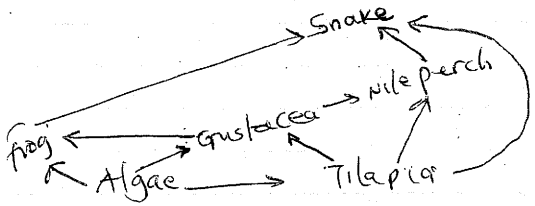
- A food chain is a linear representation of energy flow along trophic levels from producer to consumers and finally to decomposers.
- There are two types of food chains
(a) Grazing food chain - starts with green plants
eg 1. Grass → Grasshoppers → Hen → Mongoose → Hyena → → Vulture
2. Napier grass → Goat → humans
3. Kikuyu grass → Mouse → Snake → Hawk → Bacteria
(b) Detritus food chain. - starts with dead organic matter (debris) eg
1. Plant Debris → Bacteria → Protozoa → Mosquito larvae → fish → humans
2. Animal debris → Bacteria → Protozoa → Mosquito larva → Tilapia → Kingfisher.

NB - The arrow must point to the direction of energy flow ie the eater.

Food webs

- A food web is an association of several food chains in an ecosystem. This is because one organism feeds on several others and is fed on by several others too. eg

(a) Aquatic food web



Exercise

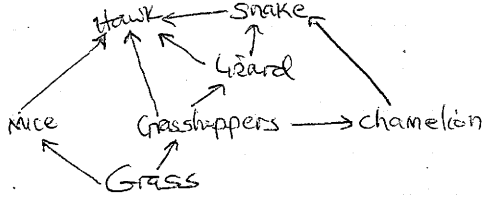
1. From the food web above isolate and write down all the food chains (6mks)
(i)
(ii)
(iii)
(iv)
(v)
(vi)

2. Which organisms occupy the following trophic levels ? (5 mks)
(i) producer/ First trophic level -
(ii) Primary consumers/ Second trophic level -
(iii) Secondary consumers/ Third trophic level -
(iv) Tertiary consumers/ fourth trophic level -
(v) Quarternary consumers/ Fifth trophic level -

3. Name the organism with the
(a) Least biomass and energy
organism -
Reasons -

(b) highest biomass and energy
organism -
Reasons -

(b) Terrestrial food web



Exercise

1. write down a food chain with five organisms (1MK)

2. write down a food chain where hawk is a
i) secondary consumer (1MK)

ii) quarternary consumer (1MK)

3. What would be the effect of
i) introducing rats in this ecosystem (3MKS)

ii) removing lizards from this ecosystem (3MKS)

4. Why is biomass of a primary consumer greater than that of secondary consumers ? (2MKS)

5. i) Name the source of energy in this ecosystem. _____ (1MK)
ii) Name the process by which energy enters the ecosystem (1MK)
iii) Name the initial product of the process named in ii. above. (1MK)

Ecological pyramids.

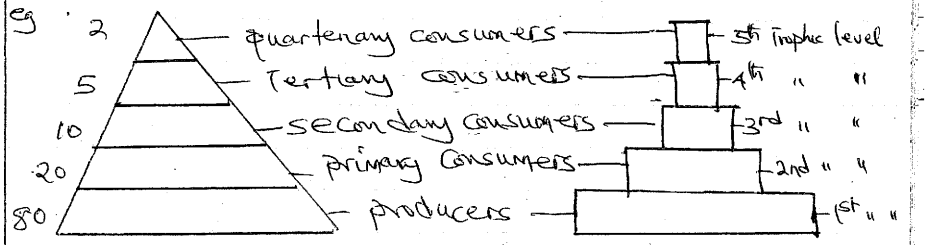
- Ecological pyramids are graphic representations showing the number of organisms or biomass or energy at each trophic level in a food chain in an ecosystem.
- These include — pyramids of numbers; pyramids of biomass and pyramids of energy.

(a) pyramids of Numbers.

- Are graphic representations of numbers of organisms at each trophic level using bars/histograms/pictograms proportional to the numbers, in a food chain.
- The data collected or provided is used to construct a food chain. Numbers of organisms are indicated at each trophic level. Using a suitable scale horizontal rectangular bars are drawn from producers progressively to the last consumers. The width of the bars must be uniform.
- There are two types of pyramids of Numbers:-

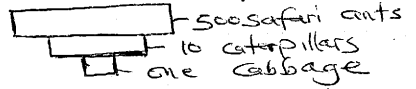
i) Normal pyramids of Numbers

- Here the number of organisms in preceeding trophic levels outnumber those in succeeding higher levels eg



ii) Inverted pyramids of Numbers.

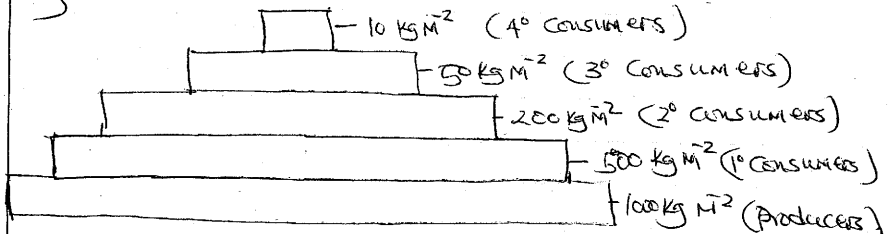
- Formed when one large consumer in one trophic level supports many small organisms in the succeeding trophic level(s) eg one cabbage supporting many caterpillars.



Ants → 2° consumers ; Caterpillars — primary consumers ; Cabbage → producer

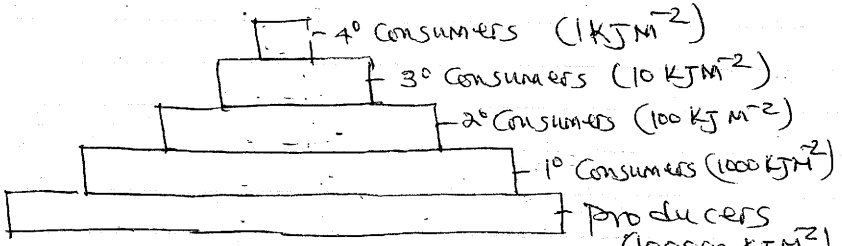
(b) Pyramids of Biomass

- Are graphic representations of the total dry mass of organisms at each trophic level in a food chain. The producers have the highest biomass because they need to sustain themselves and support the consumers. There is also less energy loss at this level.
- Organisms in the highest trophic levels have the least biomass because :-
  i) Up the trophic levels there loss of biomass through excretion, respiration and defecation.
  ii) There is inefficient utilization of food resource OR not all organisms in the preceeding trophic levels are fed on by organisms in the succeeding trophic levels.
- The biomass of an organism is represented as either dry biomass or fresh weight of an organism or standing crop harvested per unit area per habitat eg



(c) Pyramids of energy

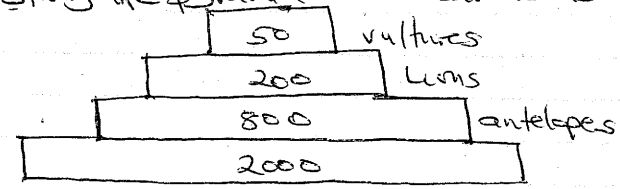
- The pyramids are constructed by considering the amount of energy at each trophic level.
- These are the most reliable since they give the amount of energy present at each trophic level, and the efficiency of energy transfer in a community eg



Efficiency of Energy tanfer:- worked example

Eqn2.

Study the pyramid below. Biomass is in g/M².



Given that only 10% of energy is transferred from one trophic level to another, and the total energy in grass is 1000 KJM², Calculate :-

i) Energy contained in antelopes

$\frac{10}{100} \times 1000 = 100\ KJM^{-2}$

ii) Energy contained in vultures

Lions $= \frac{10}{100} \times 100 = 10\ KJM^{-2}$

vultures $= \frac{10}{100} \times 10 = 1\ KJM^{-2}$

Population

- Is a group of organisms belonging to the same species in a particular habitat eg - population of Lions in Tsavo National Park.

Characteristics of a population

① Density — Total number of organisms of a species per square unit or volume of a locality. It is influenced by changes in seasons, rainfall, food supply, diseases and predators.

Density = $\frac{\text{Number of organisms of a species}}{\text{Area in unit square.}}$

② Dispersion - Is the spread or distribution of organisms in the habitat. This can be uniform or random or clumped depending on environmental factors or resources.

③ Population growth - Refers to rate of increase in a population. It is determined by mortality and natality rates.

Factors regulating population growth and distribution of organisms in habitat.

Ⓐ Physical factors/Density independent factors
1. Light
2. Temperature
3. Water availability/rainfall.
4. Salinity
5. Wind
6. Topography
7. Atmospheric pressure
8. Soil factors/edaphic factors

Ⓑ Biotic factors/Density dependent factors
1. Predation
2. Competition
3. Parasitism
4. Migrations
5. Social stress
6. Diseases.

Ⓒ Other factors
1. Availability of food
2. Availability of space
3. Sex-ratio (male : females)
4. Age structure
5. Natural calamities.

Factors in human populations

① Age structure - Is the proportion of different age groups in a population ie young; adolescents and middle/reproductive age; old age; OR infancy, childhood, youth, adulthood and senile. A population has a potential of increasing faster if the young are more than the old.

② Sex-ratio - Is the proportion of males to females in a population. Population growth is bound to be faster where females are more.

③ Birth rate or Natality - Is the measure of how many children are born per year. Depends on:-
(i) Age at which sexual maturity is attained
(ii) Sex-ratio.
(iii) Environmental factors eg food, shelter, diseases
(iv) Fertility rate
(v) Fecundity - number of individuals a female produces at birth.

NB - In other animals/plants/organisms:-
(i) Reproductive season
(ii) Method of reproduction - faster if asexual
(iii) Gestation period.

④ Death rate/~~Mortality~~ Mortality rate
← Rate of loss of individuals in a population per year. Depends on:-
(i) Life expectancy/Longevity
(ii) Environmental factors eg diseases, natural calamities, availability of food etc.

Causes of Rapid human population growth
(i) Advances in medicine reducing death rates
(ii) Advances in Agriculture hence more food
(iii) Cultural factors eg polygamy and need for sons
(iv) Political stability hence absence of wars.

Effects of Rapid human population growth

1. Pressure on land leading to deforestation,
2. Dependency ratio increases
3. Rapid urbanisation and uncontrolled settlements eg slums.
4. Inadequate provision of social amenities eg schools, hospitals, housing, recreation etc
5. Shortage of water and electricity
6. Land fragmentation hence reducing agricultural land.
7. Rise in social crimes — prostitution, robbery, mob-justice, burglary, social diseases etc.

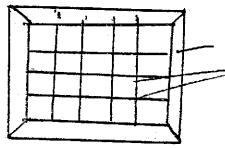
Methods of population Measurement

① Total body counts/Actual body counts/Head Counts/Direct Counts.

- Includes physical counts of every individual of a species within a given habitat; eg census in human beings, counting large mammals or wild animals in a game park/National park. The latter can be done using a low-flying aircraft. This is called aerial counting. This may involve taking of photographs for counting hence aerial photography. Another example is counting of bacteria/microbes using a light microscope. This is called Coulter counting
- Advantages of Total body counts — accurate and reliable.
- Disadvantages — Laborious and expensive if a large area is to be covered. Some animals being counted may be dangerous.

② Quadrat Method

- A quadrat is a square frame of known area made of wood or metal. A standard quadrat is $1M^2$. This can further be subdivided into smaller squares by wires or thread/string.



- In using a quadrat, the following procedure is followed :-

(i) Select a suitable area of study eg grassland.
(ii) Mark and measure the area of study.
(iii) Standing in the middle of area of study, throw the quadrat randomly.
(iv) Count, record and identify the names and numbers of various species enclosed in the quadrat.
(v) Make several throws of the quadrat to get a large sample while repeating the procedure of identifying, counting and recording as in the table below :-

Throws / Number species	1	2	3	4	5	6	7	8	9	10	Total	AV.
A												
B												
C												
D												
E												
F												

(vi) Sum up the total number per species and record.
(vi) Average population is also calculated by dividing Total population by the number of throws for each species
(vii) Density per species is calculated by dividing the average population by area in square metres.

③ Line Transect Method

- Select the area of study and measure its area.
- A line transect is taken by running a rope or tape across the area of study marked at equidistant points.
- A surveyor moves along counting and recording the number and type of species at each station. Only those plants along the line are identified, counted and recorded. A large number of transects is made to obtain more accurate results.
- The total population of each species is calculated.
- The average population per species is then calculated by dividing the total population in each transect by the number of transects.
- Quadrats may be used at each station along the line eg 3 M apart, to determine the number and type of species of plants.
- A line transect best reveals the profile/distribution of a species when studying transition of a species in habitats.

④ Belt transect

- Select the area of study and measure its area.
- A belt is taken by running two ropes one metre apart along the length of area of study.
- Stations are then marked equally along the belt and at each station, the number and types of species of plants and animals are counted, identified and recorded.
- Total population per species in each transect is calculated. Average population per species is then calculated by dividing total population for each species by number of belts.
- Abiotic factors such as soil pH, temperature of soil and air, humidity and direction of wind
- Fewer belts are required to build up the realistic picture of a species compared to line transect.

⑤ Capture – recapture Method

- The technique is used to estimate population of organisms that are highly mobile eg fish, grasshoppers, crabs, birds, rats, butterflies and other insects.
- Select the area of study and measure the area.
- An appropriate technique is selected for capturing the organisms eg use of sweep nets for insects; traps nets for fish or crabs or birds etc.
- The organisms are captured, counted, marked and released into the habitat. Marking involves use of indelible ink to mark the organisms eg grasshoppers, tagging or use of tags or other recognisable marks for birds or fish or rats; eg paint, Nail vanish.
- A large sample should be made to increase accuracy and reliability of results.
- After 24 hours or sometime, the procedure is repeated and the number of recaptured and number in second capture is recorded.
- Now:-

$$\text{Total population} = \frac{\text{Number caught is first Catch} \times \text{Number in 2nd Catch}}{\text{Number Marked recaptured in second Catch}}$$

$$P = \frac{Fc \times Sc}{MR}$$ Where :-

- Fc – Number in first catch
- Sc – Number in second catch
- MR – Number Marked recaptured
- P – Total population.

- The technique has the following limitations:-
  - The marks may disappear

- The technique has the following assumptions :-
  (i) The number of organisms captured represent an index relationship to the number that escapes the capture.
  (ii) No migrations or deaths occur eg through predation.

Analysis of Results

① Percentage Cover

- The ground space covered by a certain species in a habitat is determined and expressed in percentage using results from quadrats etc

② Density of a species

- Can be calculated by dividing the number of a species by the area of study

③ Frequency

- This helps to determine the number of times a species occurs in the habitat. This can be worked out by determining the number of times a species is included or excluded in the quadrat throws or number of stations.

Adaptations of Plants to Various habitats

- Adaptations are the structural or physiological or behavioural changes of an organism that increase its chances of survival in a specific environment.

① Adaptations of Xerophytes to their habitat

- Xerophytes are plants that are adapted to growing in dry or arid / desert or semi desert / semi-arid areas.
- The habitat is characterised by the following environmental conditions :-
  (i) Unpredictable and poorly distributed rainfall between 250 mm – 350 mm per annum.
  (ii) Very high temperatures with high diurnal ranges
  (iii) Very windy.
  (iv) Low humidity

Adaptations of the xerophytes

LEAVES

① Some have leaves with reduced surface area / in size or leaf surface reduced to scales or spines or thorns reduce surface area over which transpiration takes place to conserve water, as in Whistling Pine (Casuarina spp) with needle-like leaves or Cactus (with spines) or Acacia (with small leaves of small surface area).

② Some have leaves with thick waxy cuticle to minimise rate of cuticular transpiration eg Bryophylum

③ Some have sunken stomata which accumulate moisture in the substomatal spaces leading to low diffusion gradient thus reducing transpiration rate.

④ Most of them have reduced number of stomata that lowers rate of transpiration.

⑤ Some xerophytes experience reversed stomatal rythm (ie opening at night and closing during day) to reduce rate of transpiration.

⑥ Some have succulent leaves to store water for use during prolonged drought. The water is stored in large parenchyma cells / tissues.

⑦ Some have hairy leaves. The hairs trap escaping water vapour from stomata hence saturating the leaf surface with moisture and reducing diffusion gradient and rate of transpiration.

⑧ Some have leaves with thick mucilage to trap water in cells thus reducing rate of transpiration eg Tradescantia

⑨ Some fold their leaves or shed leaves during drought. Folding of leaves reduces rate of transpiration by hiding stomata from direct sunlight. shedding of leaves reduces the surface of for transpiration.

⑩ Xerophytes have stomata with small opening or aperture to reduce rate of transpiration.

ROOTS

① Some xerophytes have deep roots to reach underground water whereas others have superficially extensive roots horizontally close to the surface to absorb run off water during the short rains or light shower of rain.

② Some have succulent roots which store water in parenchyma cells for use during drought.

STEMS

① Some have succulent stems which store water in large parenchyma cells for use during drought and to reduce rate of transpiration.

OTHER FEATURES

① Some xerophytes have a very short life cycles to evade drought. These are drought evaders. They hence survive through seeds or underground perenating organs eg Corms and bulbs.

NB → Those with features to withstand drought are called drought resistors.

② Mesophytes

- Are plants which grow in ~~normal~~ soils with normal conditions of water supply such as forests and grasslands / savannah grasslands.

- The habitat of mesophytes has the following characteristics :-

1. Adequate rainfall between 950 mm – 1800 mm per anum well distributed throughout the year
2. Relatively high humidity
3. Clouds are common
4. Moderate to high temperatures with low diurnal ranges.
5. Less windy
6. Shallow water tables.

Adaptations of Mesophytes

LEAVES

① The plants forming undergrowth have numerous chloroplasts to be sensitive to dim light or light of low intensity for photosynthesis.

② Mesophytes which grow in ample water supply have broader leaves with thin cuticle and many stomata on both leaf surfaces to encourage loss of excess water.

③ Mesophytes in drier areas have narrower leaves with thick cuticle and more stomata on lower leaf surface to reduce rate of transpiration.

④ Some have waxy and shiny/glossy leaf surfaces eg Mango to reflect away excessive sun rays to prevent overheating to reduce rate rate of transpiration; and to allow rain water to drip away.

STEMS

① Most of them grow tall to reach light for photosynthesis; climbers and lianas support themselves to tall stems to reach light. Epiphytes grow on other trees to reach light for photosynthesis.

ROOTS

① Mesophytes in drier areas develop deep roots to absorb water from deep the soil and for

Support. Those with shallow roots develop buttress or prop roots for extra support eg. Ficus natalensis.

③ Hydraphytes.

- Are plants which grow wholly or partially in fresh water or wet areas with fresh water.
- The habitat has the following characteristics:-
  - (I) Low concentration of dissolved gases eg oxygen.
  - (II) Low density water medium.
  - (III) Water currents and waves are common.
  - (IV) Low light intensity under water; ie light intensity decreases with increase in water depth. Temperature also decreases with increase in water depth.

Adaptations of hydraphytes to their habitats

LEAVES

① Most emergent and floating hydraphytes have broad leaves; with maximum number of stomata on upper leaf surface only; to provide a large surface area for gaseous exchange; and to encourage quick loss of excess water by transpiration;

② Some sub-merged hydraphytes have leaves which are deeply dissected into straws to provide a large surface area for absorption of light for photosynthesis.

③ Have leaves with numerous chloroplasts sensitive to light of low intensity so as to photosynthesise even in dim light.

ROOTS

① Have poorly developed roots lacking root hairs to reduce absorption of water.

② Floating hydraphytes have extensively developed roots to maximise absorption of mineral salts from water

Other general adaptations

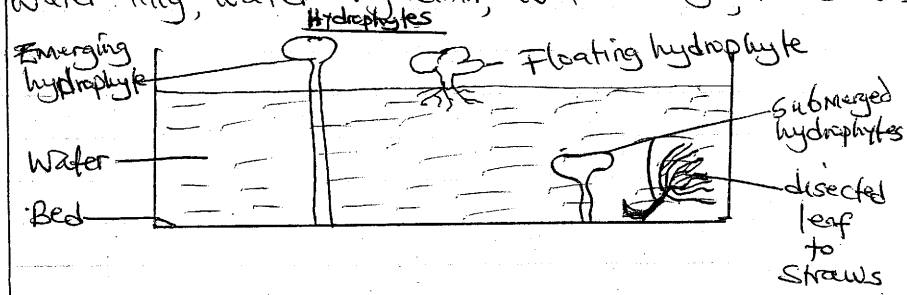
① Have large-air-filled tissues called aerenchyma to increase bouyancy and assist in gaseous exchange. The aerenchyma tissue are thin-walled for faster diffusion of the gases; and have large airspaces for storage and circulation of air.

② Other floating hydraphytes have hydathode glands to excrete excess water by guttation when humidity is high.

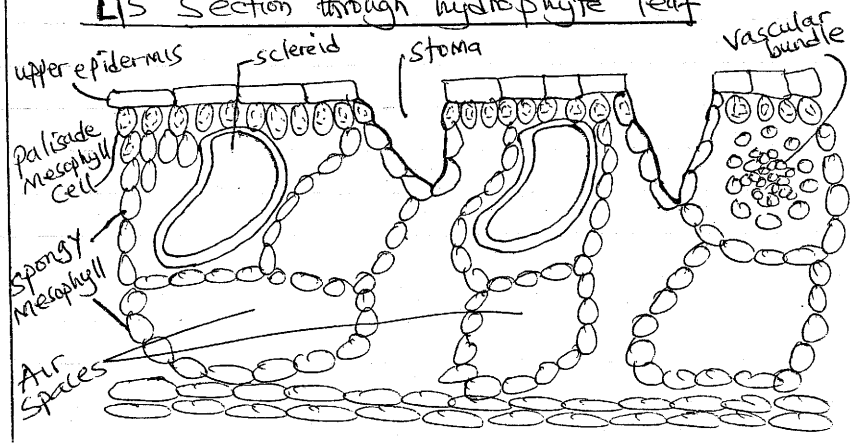
③ Have poorly developed vascular tissues or xylem as they absorb water by diffusion

④ Flowers are above water surface to enhance pollination.

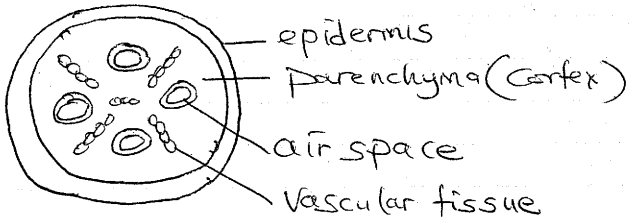
⑤ Some floating hydraphytes eg water hyacinth have floaters / air bladders for bouyancy. Other examples of hydraphytes include salvinia, water lilly, water hyacinth, water sedge, reeds etc.



L/s Section through hydraphyte leaf



T/s through a hydrophyte stem



④ Halophytes

- Are plants adapted to grow in saline soils or marine water.

- Their habitat is characterised by :-
  (i) High mineral salt concentration.
  (ii) Low concentration of dissolved gases especially in marine water.
  (iii) Low light intensity in marine water.
  (iv) Currents and waves are common.

NB - Marine temperatures are generally stable.

Adaptations of halophytes to their habitat

① Root hair cells concentrate alot of salts in their cytoplasms or vacuoles by active transport to enable them absorb water from the highly concentrated medium by osmosis. This helps them to overcome the physiological drought they face.
② Other halophytes have succulent tissues to store water.
③ Other halophytes like mangroves have pneumatophores or breathing roots for gaseous exchange.
④ Most submerged halophytes are found close to water surface for photosynthesis. They also have numerous chloroplasts sensitive to light for photosynthesis
⑤ Some have holdfasts for attachment to substratum eg Sargassum.
⑥ Floating halophytes have floaters or air bladders to facilitate buoyancy.
⑦ Halophytes growing in mudflats eg Mangrove have buttress roots for extra anchorage or support.
⑧ Have reproductive adaptations such as fruits with aerenchymatous tissue to facilitate buoyancy.

Revision questions

1. KNEC → Describe how the following plants are adapted to their habitats
   (a) Xeroplytes (8 Marks)
   (b) Hydroplytes (7 Marks)
2. Describe the adaptations of each of the following to their habitats
   (a) Mesoplytes (10 MKS)
   (b) Haloplytes (10 MKS)
3. How are leaves of mesoplytes adapted to photosynthesis ? [KNEC] (20 MKS)
4. The table below shows stomata distribution on leaves A and B and their surface areas
   Use the information to answer questions that follow :-

	Leaf surface	A	B
Number of stomata	Upper surface	20	5
	Lower Surface	0	15
Surface area		$25cm^2$	$18cm^2$

(a) Identify with reasons the habitats of the plants from which the leaves were obtained.

Leaf A: Habitat _
Reasons i,
ii

Leaf B: Habitat _
Reasons i,
ii, (2mks)

(b) Account for the surface area for specimens A & B.

4. How are aerenchyma tissue adapted to their functions. (2 mks)

5. Explain two abiotic factors which affect primary productivity in aquatic ecosystem (2mks)

EFFECTS OF POLLUTION ON HUMAN BEINGS AND OTHER ORGANISMS.

1. AIR POLLUTION

Causes and effects of air pollution

(i) Sulphur-based chemicals such as sulphur (IV) oxide (SO_2) and hydrogen sulphide (H_2S).

- These are produced by food preserving industries, during manufacture of Sulphuric acid (H_2SO_4) and burning of sulphur-based petroleum products.
- H_2S is also produced from mineral extraction mines, volcanic activities and geothermal emissions or power stations. These also emit Carbon (IV) oxide (CO_2) and carbon (II) oxide (CO).

Effects

- High concentrations of SO_2 causes respiratory diseases such as bronchitis, pneumonia and heart failure.
- slows down ciliary activities in respiratory tracts, hence solids reach lungs interfering with gaseous exchange.
- SO_2 blocks stomata interfering with photosynthesis and gaseous exchange.
- SO_2 dissolves in rain water causing acid rain which lowers soil pH hence lowering yield; corrodes metal surfaces thus contaminating drinking water; leaches Ca^{2+} and Mg^{2+} ions from the soil.
- Hydrogen sulphide is poisonous to organisms as it contaminates blood and causes suffocation.

(ii) Oxides of nitrogen such as Nitrogen (IV) oxide (NO_2) and Nitrogen (II) oxide (NO)

- produced by burning of petroleum products or fuels in industries, and from emissions of exhaust gases or fumes in Motor Vehicles.
- Also released during industrial manufacture of nitric acid.

Effects

- Dissolves in rain water causing acid-rain with similar effects as above.
- They are poisonous to animals as they affect the respiratory system when inhaled.
- NO_2 is carcinogenic - initiates cancers.
- when trapped near the ground due to thermal inversion, the gases diminish visibility on roads.

(iii) Smoke and fumes containing CO_2, CO and Carbon Solids.

- Produced from industries which burn coal, petroleum products and wood fuel.
- Also produced from combustion of natural gases such as biogas.
- Smoke and fumes contain carbon (IV) oxide and carbon (II) oxide and Carbon particles.

Effects

- Smoke and fumes affect visibility due to formation of "smog" on roads.
- Settle on leaves blocking stomata thus limiting photosynthesis

—Smog also causes intense irritation of eyes, headaches and breathing difficulties.
—Carbon(II) oxide causes respiratory poisoning by forming carboxyhaemoglobin in blood.
—Carbon(IV) oxide prevents layers of warm air from escaping into the upper atmosphere causing green house effect thus leading to global warming

(iv) Dust

— Produced from cement and lime processing industries; quarries, road construction and from dusty dry weather roads.

Effects

—Dust settles on plant leaves hence limiting photosynthesis.
—It clogs respiratory surfaces resulting in breathing difficulties and respiratory diseases.
—Irritates eyes and impairs visibility.

v, Lead (Pb) fumes.

— Produced from combustion of leaded petrol by motor vehicles. (The lead is added to petrol to prevent "knocking" of engines/ as anti-knock compound).

Effects

— When inhaled, it is absorbed into blood stream and accumulates affecting the liver, kidneys, bones and brain causing mental development retardation in children. This is lead poisoning.
—Blocks stomatal pores interfering with gaseous exchange and photosynthesis.

vi, Aerosols

—An aerosol is a substance containing very small fine particles of solid or ~~gas~~ liquid suspended fungicides, perfumes, air fresheners and spray paints.
—These contain copper, lead and CFCs ie chlorofluorocarbons or organofluorocarbon compounds.

Effects

—Copper-based chemicals cause irritation of respiratory organs of animals when inhaled.
—Also poison fish and water plants.
—Copper-based chemicals are **non-biodegradable** and accumulate to poisonous levels in the ecosystem or in the soil.
—CFCs deplete ozone layer leading to ~~incr~~ increased penetration of ultra-violet rays that cause skin cancer and affect crops.

vii, Noise

— Loud sound/noise incessantly produced by machines, aeroplanes, heavy industries, heavy vehicles, loud music speakers, concords and jua-kali workshops.

Effect

— Noise affects hearing in animals. It also irritates and causes stress in animals.

viii, Radioactive emissions.

— Radioactive emissions from nuclear reactors, mines, bombs, which utilise uranium, radium, germanium, plutonium and hydrosonium (heavy water).

Effects

—Increases mutations/mutation rates leading to genetic disorders or abnormalities.
—causes cancer such as bone tumours and leukemia.
—In excessive doses, it causes deaths.

Control of Air pollution

① Legislation – government to enforce legislative laws or acts on environmental pollution
② Encourage use of lead-free fuels in motor vehicles.
③ Develope and encourage use of renewable energy sources eg solar, wind and H.E.P.
④ Use of CFC free aerosols and appliances.
⑤ Use of biological control methods to control pests, diseases and weeds.
⑥ Filtration of waste gases to remove waste gases or dissolution of waste gases or use of tall chimney to remove waste gass.
⑦ Factories to be erected far away from residential areas.
⑧ Concords/ jet-fighters and other aeroplanes to fly high to reduce noise or high intensity sounds.
⑨ Mass education on sustainable environmental management.
⑩ Banning on public smoking of cigarettes.
⑪ Use of ear muffs in factories and workshops.
⑫ Government to be signatory to global treaties on environmental conservation.
⑬ Encourage use of public transport means more than private cars to minimise emission of gas pollutants.

Revision questions

1. KNEC QN → Discuss the various activities of man that have caused air pollution. (20MKS)
2(a) List the causes of air pollution (8MKS)
(b) State one effect of each of the pollutants named in 2(a) above (8MKS)
(c) State four ways of controlling air pollution (4MKS)

2. WATER POLLUTION.

Sources and effects of water pollution:

1. Domestic effluents.

– Untreated sewage from urban centres discharged into water bodies eg rivers, lakes, contains disease-causing micro-organisms such as bacteria (eg salmonella typhi), viruses and protozoa eg Entamoeba histolytica; which cause water-borne diseases such as cholera, typhoid and amoebic dysentry.
– Also contains detergents which add alot of phosphates to water which cause algal blooms, eutrophication and increased biological oxygen demand (B.O.D) in aquatic ecosystems.

2. Industrial effluents.

– Industrial discharges into rivers, dams, marshes, lakes, oceans etc contain toxic metallic compounds such as mercury, arsenic, cadmium, acids and other chemicals. These kill aquatic organisms such as fish directly or cause eutrophication and increased B.O.D thus indirectly killing fish and other organisms.
– The compounds also enter the food chain and accumulate to lethal levels in higher organisms such as man.

3. Hot water or heat

– Hot water discharged directly into water bodies from factories; reduce the amount of dissolved gases such as oxygen for respiration and CO_2 for photosynthesis thus limiting gaseous exchange and photosynthesis.
– The heat may also directly kill aquatic organisms due to high temperatures. Heat also

raises respiratory rates to abnormal levels causing malfunctioning in organisms.

4. Oil spillage

—Oil spillage from oil-tankers, accidents, offshore oil wells and refineries and damaged warships, forms oil layer on water surfaces reducing oxygen supply thus leading to death of aquatic organisms; clogs respiratory surfaces of the aquatic organisms; Coats and blocks stomata of plants limiting photosynthesis; reduces light penetration into water limiting photosynthesis;

5. Agrochemicals

—Inorganic fertilizers, herbicides, pesticides, insecticides, acaricides and fungicides from farms are agrochemicals.
—Inorganic fertilizers contain phosphates and nitrates which cause eutrophication and increased biological oxygen demand in aquatic ecosystems. Pesticides contain heavy metals like Copper and Mercury that affect respiratory activities of aquatic organisms. These chemicals such as DDT (Dichlorodiphenyltrichloroethane), an insecticide, and heavy metals in pesticides contain non-biodegradable CFCs which accumulate along the food chains becoming toxic at higher trophic levels.

6. Lead

—A pollutant from pipes and tanks. When ingested by animals, it accumulates in kidneys, liver, bones and brain causing malfunctioning. It also blocks stomata limiting photosynthesis in plants.

7. Mercury

—Mercury from industries manufacturing chlorine NaOH, ores and vinyl plastics, from combustion of coal and petroleum oils; from cosmetics and fungicides.
—Methane producing bacteria convert the mercury to Methyl mercury. Methyl mercury poisons and kills organisms such as wood pigeons. It also accumulates along the food chain eventually reaching man and accumulating in the liver, kidneys and brain affecting physiological functioning resulting in mental retardation in children and death. Mercury also interferes with melanin formation leading to light skins, blindness, paralysis and death.

8. Soil erosion

—Makes water unclean and unfit for human consumption.
—Silt reduces light penetration limiting photosynthesis.
—Silt also clogs respiratory surfaces interfering with gaseous exchange and photosynthesis in plants.

Control of water pollution

① Legislations — laws by parliament to protect water bodies
② Treatment of industrial effluents before discharging into water bodies.
③ Proper treatment and disposal of sewage
④ Use of unleaded petrol.
⑤ Mass education to public on water conservation.
⑥ Use of biological control methods to replace pesticides and herbicides eg cats to control rats and mice in store of cereals; Chameleons to control insects in farms; fish to control mosquito larvae in ponds; Goats to control weeds in coffee farms; Beetles to feed on water hyacinths. Biological control is the use of a living organism to control or check and maintain the population of another organism naturally.
⑦ Avoiding oil spillages
⑧ Controlling soil erosion.
⑨ Avoiding hot water discharges into water bodies.

(iv) Avoiding introducing of detergents into water bodies.

NB - Eutrophication is the increase of nutrients in water, causing excessive growth of algae / algal blooms, which causes depletion of oxygen from water due to increased Biological oxygen demand.

- Eutrophication causes death of aquatic animals; causes reduction of dissolved oxygen in water; Reduction of light penetration in water thus affecting rate of photosynthesis.

Revision questions

1. Discuss the various activities of man that have caused water pollution. (20 marks)

2(a) List the factors that cause water pollution (8 MKS)

(b) State the effects of each of the factors listed in 2(a) above (8 MKS)

(c) state four ways of controlling water pollution. (4 MKS)

3. KNEC 2010. (a) (i) What is eutrophication (3MKS)

(ii) What are the effects of eutrophication ? (3 MKS)

(b) (i) What is meant by biological control (1MK)

(ii) Give an example of biological control (1MK)

(c) Name a substance that is responsible for acid rain. (1MK).

-

3. SOIL OR LAND POLLUTION

Causes and effects of land pollution

(i) Oxides of sulphur - eg sulphur(IV) oxide.

- Oxides of sulphur such as SO_2 enter the soil as acid rain through precipitation. Acid rain alters soil pH affecting plants and animals that can not tolerate acid pH. It also causes leaching of mineral salts / ions causing loss of soil fertility.

(ii) Aerosols

- Aerosols such as herbicides, insecticides, acaricides, fungicides; sprayed to control pests, insects and diseases; contain heavy metals such as Mercury and Copper.
- These chemicals are absorbed by plants and accumulate along the food chains eventually poisoning and killing animals. The chemicals also kill nitrogen-fixing bacteria thus lowering soil fertility.

(iii) Petroleum products

- Petroleum products like oil spilled on land clog soil thus soil organisms fail to obtain oxygen and die; coating of plant leaves or respiratory surfaces interferes with gaseous exchange and limits photosynthesis.

(iv) Inorganic fertilizers

- Agricultural inorganic fertilizers contain phosphates and nitrates. These increase acidity in the soil killing soil micro-organisms. Hence formation of soil organic matter due to decomposition slows down then stops. Soil becomes exhausted hence plant and animal life ceases. In addition soil structure is changed causing soil erosion.

(v) Solid wastes.

-community household wastes and industrial wastes that are non-biodegradable eg rubber polythene bags, clothing, plastics, scrape metals glass bottles are a nuisance and may be injurious. They destroy aesthetic value of the environment and offer breeding sites for pests, rodents and insect vectors. They also limit aeration inhibiting microbial activities.

Control of soil pollution

① Recycling of solid wastes eg polythene bags, plastic containers, glass bottles, scrape metals, paper.
② Biodegradable wastes to be disposed in composit pits to form manure.
③ Combustible solid wastes eg old clothes, sanitary towels, hair to be burned in incinerators
④ Discourage excessive use of agrochemicals
⑤ Biological control of pests and diseases to be encouraged.
⑥ Encourage pipeline transportation of petroleum products to minimise spillage risks.
⑦ Enforce appropriate legislations to conserve land and for proper solid waste management.

Revision Questions

1. (KNEC) Discuss the various activities of man that have caused land pollution. (20MKS)
2. Explain how excessive use of agrochemicals such as inorganic fertilisers affect the ecosystem (3MKS)

HUMAN DISEASES

A disease is a disordered state of a tissue, organ, organ system or organism, during which its functions are not carried out normally.

Causes of Diseases or ill-health

① Injuries - burns, scalds, cuts, raptures etc.
② Harmful drugs.
③ Pathogens and parasites
④ Lack of balanced diet.
⑤ Genetic / heritable disorders.
⑥ Pollutants eg smoke, poisonous gases, dust
⑦ Ageing or degeneration of biological functions.

Means by which disease-causing microorganisms enter our bodies

① Orally through contaminated food/water
② Inhaling - air borne diseases.
③ Bites by disease vectors eg tsetseflies and mosquitoes.
④ Boring through the skin eg schistomes.
⑤ Blood transfusion eg HIV/AIDS, Hepatitis B.
⑥ Sexual intercourse eg HIV/AIDS, Syphylis.

Some Bacterial diseases

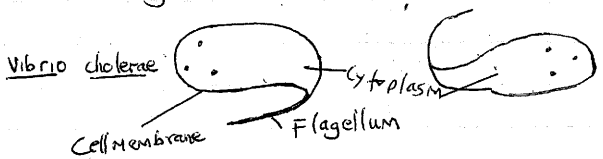
① Cholera

- Caused by a bacterium Vibrio cholerae.
- Mode of transmission is through ingesting contaminated food or water. Hence is a water-borne disease.
- Incubation period varies between one to six days depending on the severity of the infection.
- The bacteria reaches the intestines and secretes an enzyme known as mucinase which digests lining of the ~~sto~~ intestines. Exposed intestinal lining becomes irritated by bacterial toxins resulting in the following symptoms:-
  ① violent diarrhoea
  ② vomiting

(iii) Severe abdominal pains
(iv) General body dehydration due to high frequency of diarrhoea.
- Death by cholera can occur within 24 hours in severe infection.

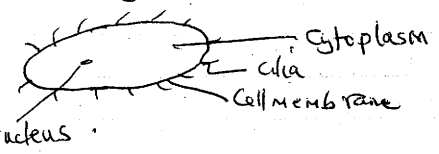
Prevention and control

① Sanitary disposal of faeces and refuse eg use of deep and well-covered pit latrines.
② Good personal hygiene.
③ Boiling or treatment of ~~boiling~~ water to kill the bacterial spores.
④ Isolation and treatment of cholera patients using antibiotics eg tetracycline, streptomycins and rehydration solutions.



2. Typhoid

- Caused by a bacterium Salmonella typhi



- The mode of transmission is through infected food and water hence it is a water-borne disease.
- The bacteria can be found in saliva and sweat of the patients hence clothings and beddings of patients can be a source of infection.
- The incubation period lasts for about two weeks after which symptoms begin to appear.
- The bacteria attacks and multiplys in the intestinal wall and causes patches of sores which in severe infection may burst and cause perforations of intestines causing death.
- The bacteria may invade the lymph glands around the intestines and then pass into blood stream and attack and perforate other internal organs including the liver, kidney, skin and therefore be present in sweat and saliva.

Symptoms

(i) Sever rash and fever
(ii) Severe diarrhea
(iii) Abdominal pains and general body pains
(iv) Headaches, fever and chills.

Prevention and Control

(i) Proper sanitary disposal of faeces and urine
(ii) Treatment and or boiling of water for drinking.
(iii) Personal hygiene eg washing of hands before eating and after visiting toilets; washing and drying of utensils and cutlerly; washing of fruits and vegetables etc; regular Medical check-ups for food handlers
(iv) Vaccination using attenuated / weakened typhoid bacteria vaccine
(v) Treatment using antibiotics eg chloramphenicol, etc

Protozoan Diseases - selected Examples

① Amoebic Dysentry / Amoebiasis.

- Caused by a protozoan, Entamoeba histolytica.
- Mode of transmission is through infected food or water, hence is a water-borne disease.
- When the protozoan cysts are ingested, the cysts membranes are digested and the protozoan are released and multiply in the intestines.

- when in the lumen, they feed on bacteria without harming the host. But finally they invade the intestinal wall and secrete an enzyme histolyn which digests intestinal wall and mucosa causing ulcers. They then begin feeding on RBCs at the ulcerated regions resulting in the following symptoms :-
  (i) Blood-stained and mucoid diarrhoea
  (ii) Dehydration.
  (iii) Fever.
  (iv) Abdominal pains
  (v) Severe pains when passing out stool.
- In severe conditions, the protozoan may get into the bloodstream and invade other organs causing abscesses in the liver, lungs etc, which then becomes fatal.

Prevention & Control

(i) Boiling and treatment of drinking water.
(ii) Proper disposal of faeces and wastes
(iii) Avoiding contaminated and/or poorly cooked food with cysts / Proper cooking of food,
(iv) Personal hygiene and Sanitation.
(v) ~~Proper sanit~~

2. Malaria

- Is caused by a protozoan, plasmodium spp
- The genus has the following species :-
  (i) plasmodium falciparum
  (ii) plasmodium vivax
  (iii) plasmodium ovale
  (iv) plasmodium malarae
- Mode of transmission is through bites of the female anopheles mosquito which is the vector.
- Upon biting an infected person, the mosquito sucks blood containing the parasites called sporozoites The sporozoites multiply in the salivary glands of the mosquito and upon biting another person, the infective plasmodium sporozoites get into the bloodstream and then migrate into the liver cells.
- In the liver cells, they multiply and transform into merozoites. The merozoites then pass into the blood stream where they attack, feed in and multiply in the RBCs thus destroying them.

Symptoms

(i) High regular fevers accompanied by profuse sweating punctuated by chills and shivers.
(ii) Headaches
(iii) Muscle and joint pains.
(iv) Lack of appetite.
(v) Vomiting.
(vi) Enlargement of liver and spleen - splenomegally.
(vii) Anaemia.
(viii) Convulsions in severe attacks in serious infections.
- Malaria is a major killer-disease among children in the tropics.

Prevention and Control

(i) Sleeping under treated mosquito nets.
(ii) Use of mosquito coils and repellants.
(iii) Spraying with insecticides to kill adult mosquitoes preferably biodegradable pyrethrins
(iv) Drainage of stagnant water which are breeding sites of mosquitoes.
(v) Disposal of plastic containers, tins, polythene bags which collect water and act

(vi) Biological control by introducing fish in ponds to feed on mosquito larvae.
(vii) Biological control by introducing genetically modified sterile male mosquitoes to mate with females hence reducing mosquito populations.
(viii) Use of antimalarial drugs for prophylaxis and treatment eg quinines, artemisinins.
(ix) Vaccinations. Currently under research and trial.

Limitations and challenges to Malarial Control and fight.

i) Presence of large reservoirs of the parasites in other hosts eg monkeys.
ii) Warm tropical conditions favour breeding and multiplication of the vectors.
iii) Development of resistance to insecticides by mosquitoes.
iv) Financial constraints among poor countries
v) Regional conflicts diverting money to purchase weapons instead of malarial control.

NB - Oil can be applied on stagnant water to control mosquitoes and hence Malaria. The oil forms a layer on water preventing penetration of oxygen thus killing the mosquito larvae. But the practice should be discouraged as it pollutes water killing non-target organisms such as fish.

Parastic Worms — Helminths

1. Ascaris lumbricoides — Large Roundworm.

- Is a parasitic roundworm which belongs to the phylum Nematoda.

- It infects the small intestines of pigs and human beings. But may also occur in other organs in form of the larval stages.
- This is the largest parasitic roundworm of the genus Ascaris. It is brownish yellow in colour and its mouth has three lips.
- The male is about 25cm long and 0.4cm in diameter. The female is about 35cm long and 0.5 cm in diameter. The female is larger to accomodate the large ovaries to produce many eggs.

Life cycle and Mode of Transmission

- Mode of transmission is through ingesting eggs of the Ascaris in contaminated food or water.
- The eggs are passed out with faeces swallowed in contaminated food or water or vegetables and fruits or through direct infection from faeces to mouth by hands especially in children.
- Ingested eggs reach intestines and their egg shells dissolve, releasing the larvae.
- The larvae penetrate intestinal wall and enter the bloodstream. They then move to the liver, then heart and lungs. In the alveoli of the lungs, they moult twice. The larvae then migrate up to the trachea where they cause irritation and are then coughed out and may be swallowed down the oesophagus into the stomach and finally into the small intestines where they mature into adult worms, mate and lay fertilised eggs which come out in faeces.

Effects of Ascaris on the host

i) Irritation in the trachea may cause lung damage and infection with other diseases.
ii) Malnutrition among children with heavy infections as the parasites consume alot of food which

has been digested.
(iii) Anaemia as the larvae feed on blood tissue and RBCs during migration.
(iv) Intestinal blockage and distended stomach in heavy infections.
(v) Obstructions of pancreatic ducts, bileducts and appendix causing further complications.

Adaptations of Ascaris lumbricoides to their parasitic mode of life

(i) Ascaris lumbricoides has two hosts, human beings and pigs to ensure it has a ready host for survival.
(ii) It lays many eggs to increase chances of survival and infection.
(iii) The eggs have a protective shell to survive harsh environmental conditions; and host enzyme attack.
(iv) They have a thick elastic cuticle to protect the larvae and adults from host enzyme attack
(v) It has tissues tolerant to low oxygen concentration in intestines.
(vi) Has a muscular pharynx with which it sucks digested food from the hosts' intestines its its gut since its digestive system is not well developed.
(vii) Its body is narrow to fit in the host intestines
(viii) The eggs are viable for a long period of time outside the hosts to increase chances of infection.
(ix) Its gut has valves to prevent regurgitation of swallowed food, and villi with microvilli to secrete digestive enzymes and for absorption of digested food.

Prevention & Control

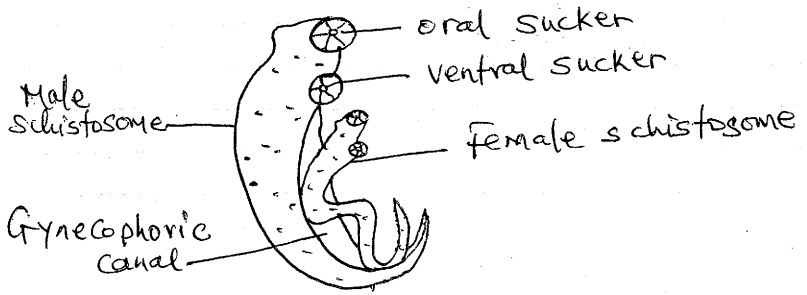
(i) Proper sanitary disposal of faeces eg use of deep covered pit latrines.
(ii) High standards of personal hygiene eg washing of hands before eating, washing of fruits and vegetables before eating.
(iii) Drinking boiled water.
(iv) Patients to be treated with anti-helmenthic drugs eg Nebendazole and albendazoles. children to be dewormed regularly.

Ascaris

Ascaris egg

2. Schistosomiasis / Bilharzia

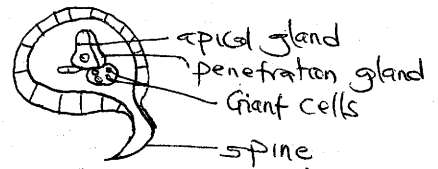
- Is a parasitic disease of blood caused by a flatworm of genus schistosoma; which belongs to the phylum platyhelminthes.
- There are three different types of the species of genus schistosoma which infect man, viz:-
  (i) Schistosoma mansoni
  (ii) Schistosoma haematobium
  (iii) Schistosoma japonicum.



Mode of transmission — The schistosomes pore or drill through the skin from contaminated water in fresh water. Canals, lakes, dams, rice-growing fields. OR through drinking contaminated water containing larval forms called **Cercariae**.

Life cycle of schistosomes

- From the stagnant water, the **cercariae** penetrates into the human skin or is swallowed in drinking water into the intestines.
- The larvae then get into the blood stream and migrate to the liver where they mature into adults.
- The adults then move to the blood vessels of the intestines and urinary bladder and some remaining in the liver. Here in they pair up, male and female and lay fertilized eggs. The male carries the female in the gynecophoric canal.
- The motile eggs tear blood vessels by their spines and enzymes and enter urine and faeces.



- The eggs are then passed into water where they hatch into larvae known as **Miracidia**. Miracidia then infect the secondary host — water snail eg Bulinus, Limnea natalensis and Biomphalaria
- In the snail, they transform into **sporocysts** or **redia** which then transforms into **Cercariae**. Cercariae then are shed into water from where they infect man.

Symptoms of infection

1. Itching at point of penetration.
2. Fever, when the larvae are in blood.
3. Anaemia, because larvae feed on RBCs.
4. Rash on the skin.
5. Blood-stained urine or stool.
6. Abdominal pains.
7. Diarrhoea.

Effects of parasite on its host.

1. Damages host's skin when penetrating thus causing itching.
2. Once in blood, the parasites release toxins which cause fever.
3. The adult worms and their eggs have sharp spines which they use to tear blood vessels hence causing damage of the tissues resulting in blood-stained stool or urine.
4. Anaemia due to loss of blood.
5. Abdominal pains and diarrhoea.
6. If untreated, death results due to exhaustion or secondary infections.

Adaptive characteristics of schistosomes.

1. Have suckers for attachment to host tissues to avoid being dislodged.
2. The parasite has two hosts, man, the primary host and snail, the secondary host, to increase chances of survival and infection.
3. The larvae cercariae have glands that secrete lytic enzymes which soften tissue to allow penetration into the host.
4. Some larval forms are encysted to remain dormant and viable for long outside the hosts' bodies to increase chances of survival and infection.
5. The parasite reproduces through larval forms eg miracidia, sporocyst or redia and cercariae to increase chances of transmission and survival.
6. The adult worms in blood produce chemical substances which protect it against the hosts' defence mechanism..

7. The worms are of seperate sexes and the male forms a gynecophoric canal in which it carries the female in a prolonged association to ensure fertilization of the eggs.
8. The eggs have a hook-like structure or spine which raptures walls of intestines or bladder.
9. Lays large number of eggs to ensure survival.
10. Larva has a tail for swimming in search of a host in water.
11. It can tolerate low oxygen concentration in animal tissues.

Prevention and Control

1. Proper sanitary disposal of faeces and urine eg in deep pit latrines or flush toilets.
2. Boiling or treatment of drinking water to kill the larvae or destroy their eggs.
3. Avoid bathing, wading, swimming in snail-infested waters.
4. Putting on protective shoes or clothes and gloves when working in swampy areas.
5. Spraying with Molluscides to kill water snails.
6. Infected people to seek Medical treatment

3. REPRODUCTION IN PLANTS & ANIMALS

Introduction

- Reproduction is the process by which new individuals are produced by existing mature individuals.

Types of Reproduction

① Asexual Reproduction.

- Is a type of reproduction where parts of mature organisms develop into new individuals without involving use of gametes eg budding, vegetative propagation, binary fission.

② Sexual Reproduction.

- A type of reproduction which involves the fusion of the nucleus of a male gamete with the female gamete to form a zygote which then transforms into a new offspring.

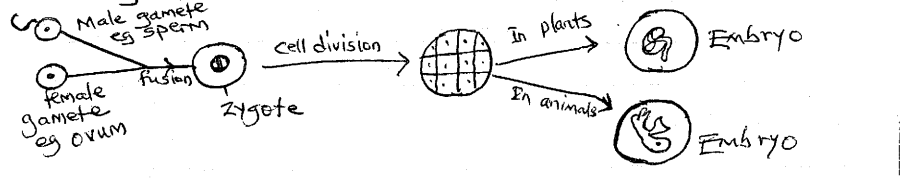
Importance of Reproduction.

1. Procreation – perpetuation of life of a species
2. Improvement of genetic qualities of a species through sexual reproduction. Mixing of genes from different genetic backgrounds causes variations which adapt organisms to changing environment.

Cell Division.

- Cell division is the basis of reproduction. Life starts as a single cell – zygote or spore which must undergo cell division to produce new cells, which differentiate, specialise to tissues, then organs and finally a multicellular organism; or a single cell divides by binary fission to give rise to daughter cells as in asexual reproduction, such as binary fission in amoeba. These are illustrated below:-

(a)



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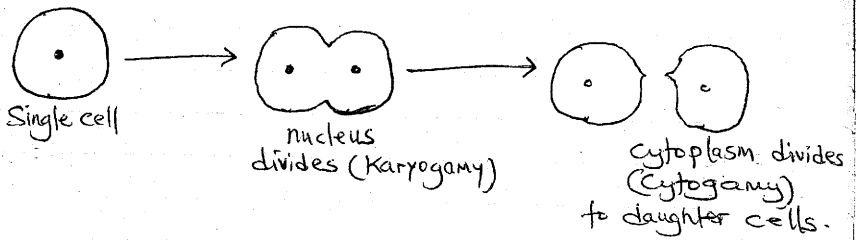
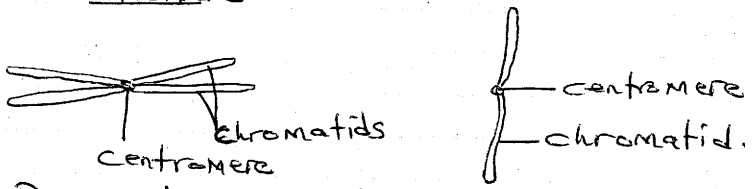


- Cell division starts with the nucleus and later the cytoplasm.
- Within the nucleus are structures called chromosomes which bear hereditary structures called genes

Chromosomes

- Chromosomes are thread-like structures found in the nucleus.
- Each cell has a fixed number of chromosomes eg 46 chromosomes in each body cell in humans.
- Each chromosome is made up of two parellel strands called **chromatids** attached to a centre called **centromere**.



Properties of chromosomes

1. Present in the cell at all times but **visible** under the light microscope only during cell division.
2. In body cells, they occur in pairs called **homologous pairs** or homologues / homologous chromosomes. This occurrence of chromosomes in pairs in somatic cells is called **diploidy** or diploid condition or 2n.
3. Each homologous pair is made of **same characteristic appearance** eg shape, size but **different genetic** constitution. During sexual reproduction each parent contributes a member of the pair.
4. Chromosomes have a series of hereditary factors along their lengths known as **genes**. Genes are too small to be seen even using the most powerful microscope. Genes determine the characteristics of livingthings.
- Each gene consists of a nucleic acid molecule known as **DNA** (Deoxyribonucleic acid). DNA consists of coded information which dictates the characteristics of an offspring.
5. The **number** of chromosomes is **definate and constant** in every species eg 46 in humans.
- Examples of actively dividing regions in mammals include - Malpighian layer of the skin, Germinal epithelium of ovary and **seminiferous** tubules of testis.
In plants - Meristematic apical regions of roots and shoot tips, Cambium, bases of young leaves, bases of internodes, tips of lateral buds.

Types of cell division

- Includes Mitosis and Meiosis.

MITOSIS.

- Is a type of cell division in which one cell divides into two daughter cells each having the same number of chromosomes as the parent cell.
- It occurs in the following rapid and successive stages :-

① Interphase

- During interphase, the cell undergoes intense internal activities in preparation for cell division; namely :
(i) Multiplication of the genetic material (DNA) to avail enough so that daughter cells will have ~~enough~~ the same number of chromosomes as parent cells.
(ii) Synthesis of new cell organelles such as golgi apparatus, centrioles, Mitochondria etc for daughter cells.

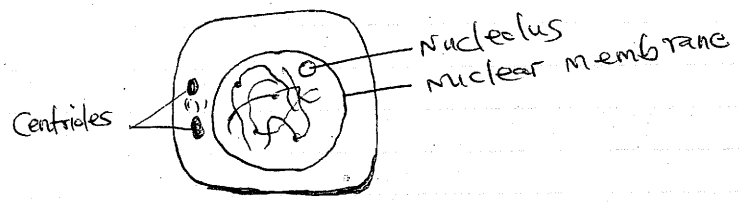
iii, Build up enough energy stores (ATP) to drive the cell through the entire process of cell division.

- Interphase is characterised by the following features :-

i, chromosomes are less distinct, seen as long, thin, coiled thread-like structures.

ii, Nuclear membrane and nucleolus are intact.

iii, Centrioles replicate and start moving to opposite poles of the nucleus.



② Prophase

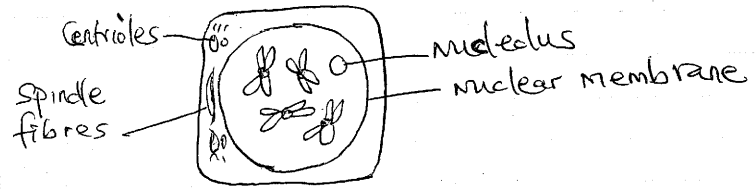
- has following features

i, chromosomes split into chromatids except at the centromeres.

ii, chromosomes appear shortened and thickened and take up stains easily hence distinct.

iii, The duplicated centrioles in animal cells seperate and move to opposite poles of the cell.

iv, The nuclear membrane and nucleolus begin to breakdown or disfergrate.



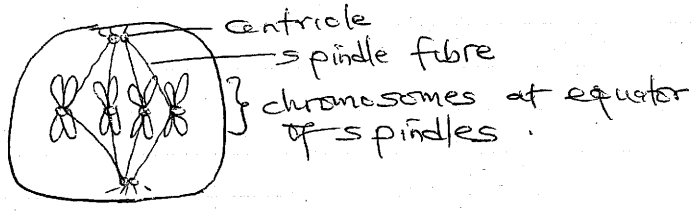
③ Metaphase

- Characterised by the following features :-

i, nuclear membrane and nucleolus disintergrate and disappears hence chromosomes are free in Cytoplasm

ii, spindle fibres lengthen and in animal cells attach to centrioles at both poles.

iii, chromosomes allign themselves at the equator of the spindles and are attached to spindle fibres by their centromeres.



④ Anaphase

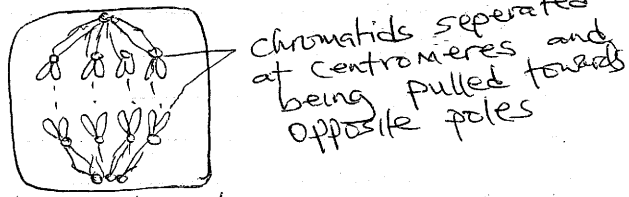
- characterised by the following features

i, chromatids seperate at the centromeres and migrate to opposite poles. The movement is believed to be brought about by shortening of the spindle fibres.

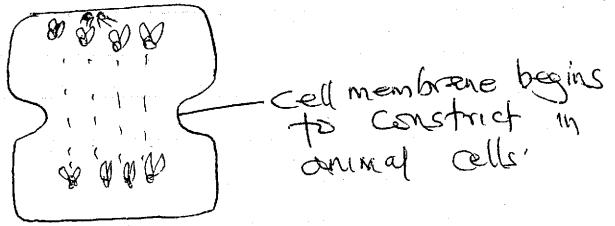
ii, spindle fibres begin to disappear at late anaphase.

iii, The cell membrane in animal cells begins to constrict at late anaphase.

Early Anaphase



LATE Anaphase



5. Telophase

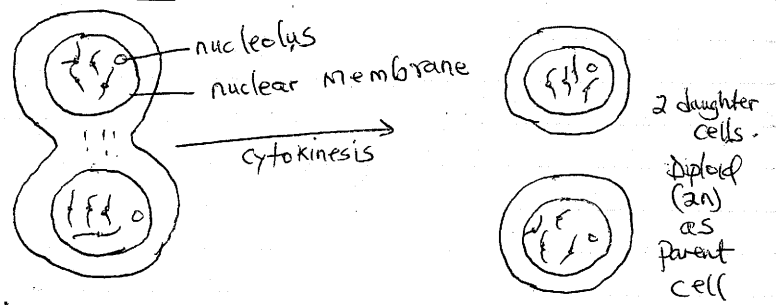
- This is the final phase of mitosis. Has the following features :-

(i) chromatids collect together at the two opposite poles / ends of the spindle fibres.

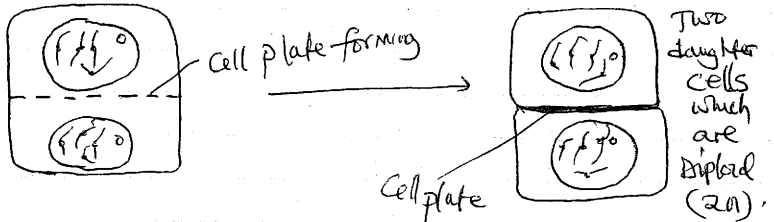
(ii) Nuclear membrane forms around each set of chromatids (now called chromosomes). Nucleolus also reappears.

(iii) The cytoplasm divides into two leading to formation of two daughter cells in animal cells. In plant cells, a cell plate forms within the cytoplasm and grows to seperate the two daughter cells.

Animal cell



Plant cell



Significance of Mitosis.

(i) Leads to increase in number of body / somatic cells with the same number of chromosomes as parent cells enabling growth to take place.

(ii) Leads to retention of chromosome number in a species.

(iii) Is the basis of asexual reproduction such as binary fission / multiple fission; budding etc.

(iv) Produces new cells for repair of damaged tissues.

Meiosis

- Is a type of cell division that occurs in the reproductive organs (gonads) during gametogenesis, resulting in one diploid parent cell giving rise to four haploid daughter cells.

Principle underlying Meiosis

- Meiosis occurs in two successive nuclear divisions.
- In the first Meiosis / Meiotic division, homologous chromosomes seperate from each other into different daughter cells. Hence there is halving of chromosome number in the daughter cells. This is called reductive division.
- In the second Meiotic division, the chromatids in each daughter cell seperate as in mitosis resulting in four haploid daughter cells. Hence this is Mitotic / Multiplication division.

First Meiotic division / Meiosis I

- occurs in the following stages

① Interphase I

- characterised by :-

(i) Synthesis of cell organelles
(ii) synthesis of more DNA
(iii) synthesis of ATP in preparation for cell division.

② Prophase I

- characterised by the following :-

(i) The homologous chromosomes shorten and

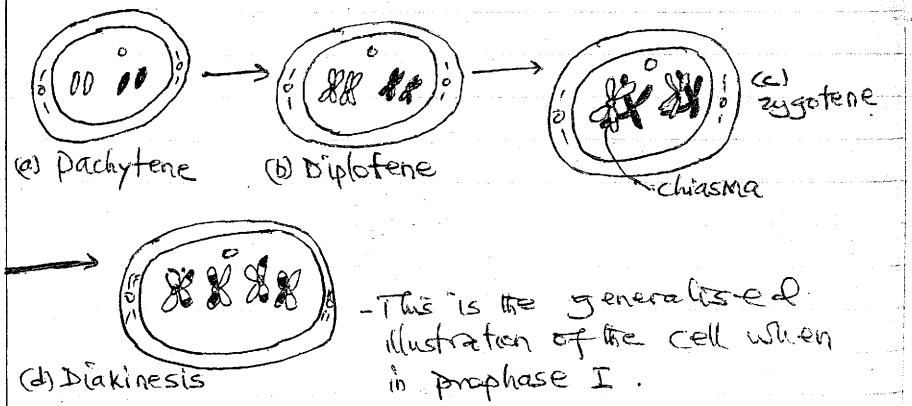
thicken, due to synthesis of new genetic material. This substage is described as **pachytene**.

(ii) chromosomes split into chromatids except at the centromeres. This substage is **diplotene**.

(iii) Homologous chromosomes pair up to form bivalents, a process called **synapsis**.

(iv) Chiasmata (singular = chiasma) form at points of attachment of chromosomes when they coil around each other. This coiling of bivalents around each other is known as **zygotene**.

(v) There is breakage and reunion of chromatids portions at chiasmata. In the process **crossing over** occurs leading to exchange of genetic information between the homologous chromosomes. This leads to **variation**. This substage is called **diakinesis**.



- This is the generalised illustration of the cell when in prophase I.

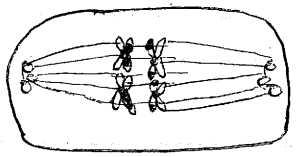
(3) Metaphase I

characterised by :-

(i) Nuclear membrane and nucleolus disappear or disintegrate.

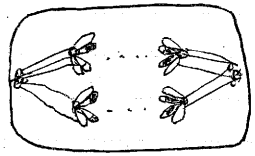
(ii) The spindle fibres are fully formed.

(iii) The bivalent chromosomes allign at the equator of spindle fibres.



(4) Anaphase I

- Homologous chromosomes seperate and migrate to opposite poles with their centromeres leading. This happens by shortening of spindle fibres.

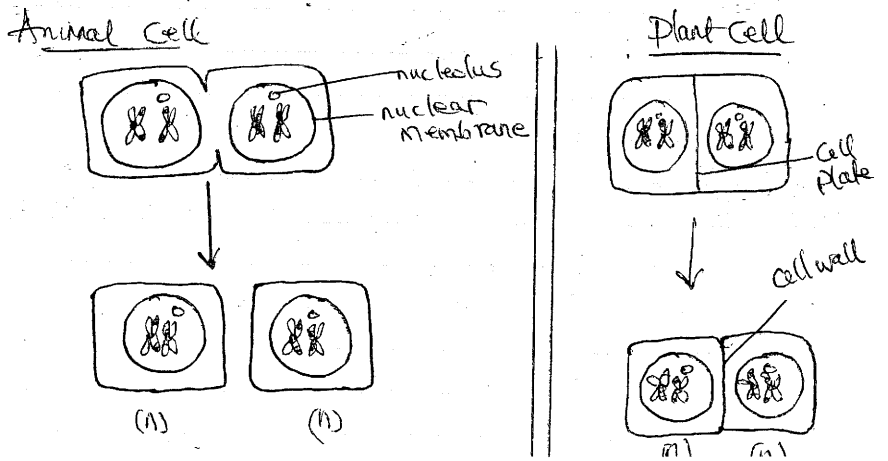


(5) Telophase I

(i) Cytoplasm divides to seperate the daughter cells in animal cells. In plant cells, a cell plate forms between the daughter cells

(ii) Nuclear membrane and nucleolus reappear.

(iii) Spindle fibres disappear.



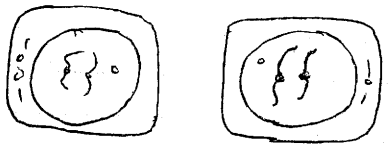
- Hence, at the end of meiosis I, separation of homologous chromosomes has been achieved and resulting daughter cells are haploid (n) in genetic constitution ie having half the number of chromosomes compared to parent cells.

Second Meiotic Division / Meiosis II

- The purpose of second meiosis is to separate the chromatids from one another. Occurs in the following stages:-

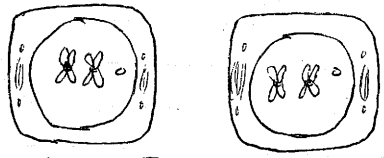
① Interphase II

- The resultant daughter cells undergo a short interphase in which new DNA, organelles and ATP are synthesized. But sometimes, the chromosomes may remain condensed and the cell moves straight to prophase II.



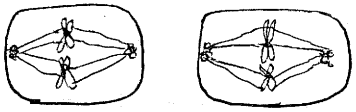
② Prophase II

i. New spindle fibres are formed.
ii. Each chromosome already split into chromatids



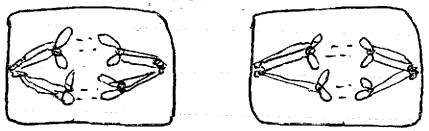
③ Metaphase II

i) The chromosomes move to the equator of the spindles and attach to the spindle fibres at their centromeres.
ii) The chromosomes orientate themselves towards the opposite poles.



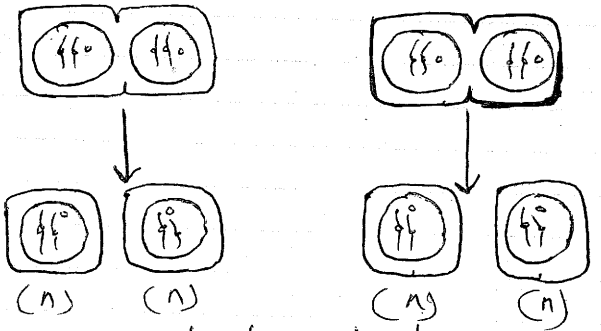
④ Anaphase II

i) chromosomes completely seperate at the centromeres to form chromatids.
ii) Chromatids are pulled to the opposite poles by shortening of spindle fibres.

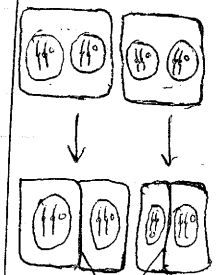


⑤ Telophase II

i. spindle fibres begin to disappear.
ii. Nucleolus and nuclear membrane reappear.
iii. The chromatids reach the opposite poles and are now called chromosomes. They become more thread like due to uncoiling and they become surrounded by nuclear membrane.
iv. The cytoplasm divides hence four daughter cells (tetrads) which are haploid are produced, in animal cells. In plant cells cellplates seperate the daughter cells.



4 haploid daughter cells in Animal cells



Cell plate
4 haploid daughter cells in plant cells

Significance of Meiosis

① Formation of gametes / sex-cells which are haploid.
② Haploid chromosomes ensure a diploid number of chromosomes after fertilization hence avoiding doubling of chromosome number in successive generations.
③ Leads to crossing-over and variations which are essential in improvement of genetic qualities and in evolution.

Similarities between Mitosis & Meiosis

① Both take place in plants and animals.
② Both involve cell division and increase in number of cells.

Differences between mitosis & Meiosis

Mitosis	Meiosis
1. Diploid number of chromosomes in daughter cells / Retention of chromosome number in daughter cells.	- Haploid number of chromosomes / halving of chromosome number in daughter cells.
2. Takes place in somatic or body cells.	- Takes place in reproductive cells or organs or gonads.
3- Two daughter cells produced	- Four daughter cells are produced.
4- No crossing over, no variation, no chiasma formation.	- There is crossing-over, variation and chiasma formation
5- No pairing of homologous chromosomes / No synapsis	- There is pairing of homologous chromosomes / There is synapsis.
6- One nuclear division process	- Two nuclear division process.

ASEXUAL REPRODUCTION

- Asexual reproduction is the production of an offspring or single organism from existing mature parts of organisms without fusion of nuclei of gametes. Meiosis is not involved and offsprings are identical to the parents.

Types of Asexual Reproduction

① Binary fission as in amoeba.
② Sporulation / Spore formation as in Rhizopus spp
③ Budding as in yeast
④ Fragmentation as in spirogyra
⑤ Vegetative propagation in higher plants.

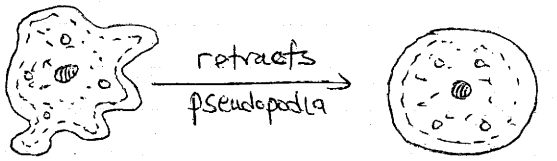
① Binary fission.

- Binary fission / splitting involves the splitting of the parent cell of a single-celled organism into two similar daughter cells.
- Binary fission involves the following processes:
  (i) Internal re-organisation of organelles
  (ii) Division of the nucleus ie karyogamy
  (iii) Division of the cytoplasm ie cytogamy.
- occurs in amoeba, paramecium, plasmodium, and bacteria.

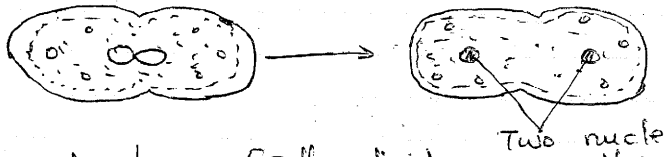
Binary fission in Amoeba.

- occurs when conditions are favourable eg enough food, optimum temperature and pH.
- The first step involves molecular division. This includes synthesis and re-organisation of molecules necessary in cell division, and formation of new cell structures.
- A mature amoeba having attained maximum size retracts the pseudopodia and attains

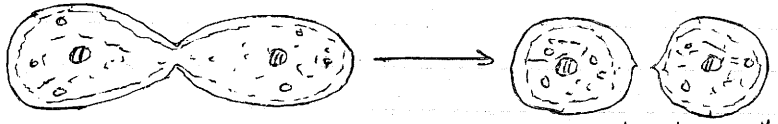
an oval shape; ready to start cell division.



- The nucleus then divides mitotically giving rise to two nuclei which are diploid.

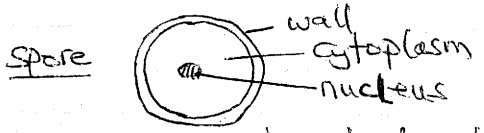


- The cytoplasm finally divides resulting in two daughter cells which seperate.



② sporulation / spore formation

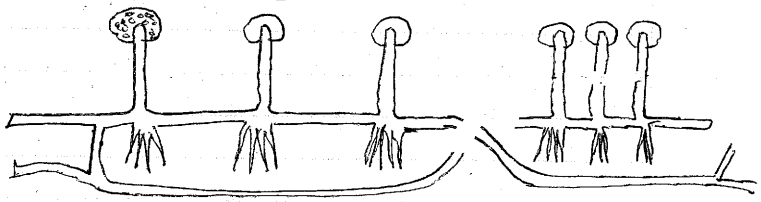
- Asexual type of reproduction involving use of spores.
- Spores are small reproductive units each of which is microscopic and unicellular containing a small amount of cytoplasm and a nucleus.



- Spores are produced by bacteria, most fungi, ferns and bryophytes eg Moss.

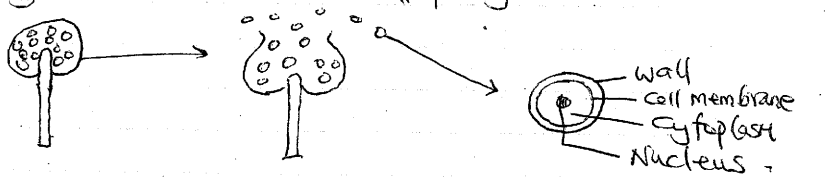
Sporulation in Breadmould (Rhizopus spp)

- Breadmould (Rhizopus), grows on decaying moist substrates such as bread, ugali, rotting fruits and other decaying organic matter. It is a saprophyte.
- The vegetative body of the fungus is known as **mycelium** and consists of many branched thread-like structures called **hyphae** (singular = hypha)
- The horizontal hyphae are called **stolons**.
- The vertical hyphae are known as **sporangiophores**
- The tips of sporangiophores swell up to form spore-producing structures called **sporangia** (singular = sporangium).



Spore formation

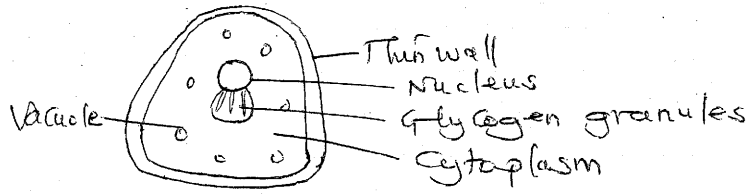
- Inside a mature sporangium, the nuclei divide meiotically producing daughter nuclei that contain a haploid number of chromosomes (n). Each nuclei is then enclosed by a cytoplasm and a cellwall thus forming a spore. As spores form in the sporangium, it turns black. When fully mature, the sporangium raptures/bursts open dispersing the spores - either by wind, insect or other animal. On landing on appropriate medium, they germinate into new offsprings.



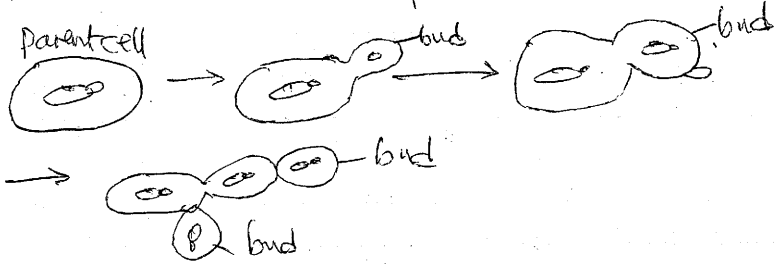
③ Budding as in yeast

- Budding is a form of sexual reproduction in which a new individual is produced as an outgrowth (bud) of a parent which then drops off to grow into a new offspring.

- occurs in unicellular fungi such as yeast.
- Yeast is a single-celled organism in the kingdom Fungi whose structure is shown below:-



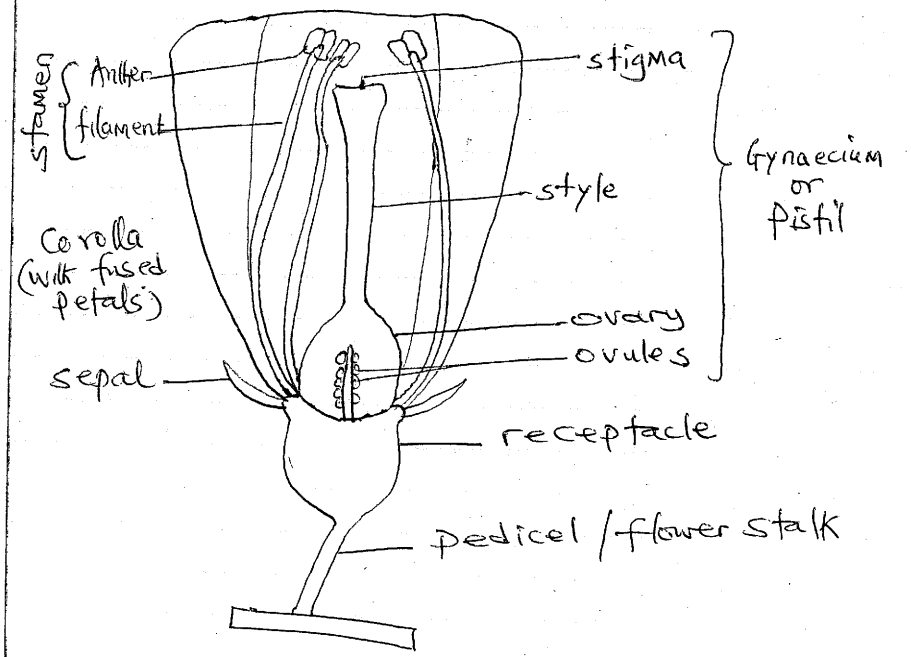
- Under favourable conditions, ie plenty of sugar, moisture, oxygen and optimum temperature, yeast cells reproduce asexually by budding.
- In budding, a small area of the cellwall softens and forms a projection of a bud which bulges outwards
- The nucleus then mitotically divides into two and one of the nuclei moves into the bud.
- As the bud grows in size new cell organelles are then formed. After this, the bud seperates off to become independant. But since budding process is very fast another bud starts to grow/form before seperation from the parent cell. This results in a chain of cells.



SEXUAL REPRODUCTION IN PLANTS

- The reproductive structure in higher plants is the flower. A flower is a modified shoot consisting of a modified stem (pedicel and receptacle) and modified leaves (sepals, petals, gynaecium and androecium).

structure & functions of a flower.



① Pedicel / flower stalk

- Supports the whole flower and positions it for pollination.

② Receptacle

- Apex of the pedicel. It is the point of attachment for androecium, gynaecium, corolla and calyx (sepals).

③ Sepals

- Green leaflets at the base of the flower. Protects the inner parts of the flower especially before it opens up. Sepals collectively are known as calyx.

④ Petals - Brightly coloured and usually large and conspicuous to attract insect pollinators. Petals collectively form the corolla.
⑤ Androecium / Stamens - Male part of the flower. Consists of :-
(a) Filaments - stalks supporting anthers and positioning them for pollination.
(b) Anthers - swollen tips of filaments which contain pollen grains in pollen sacs. Upon dehiscence, the pollen is carried to the pistil for pollination. Pollen grains are also manufactured in the anthers.
⑥ Gynoecium / Pistil - female part of the flower. consists of :-
(a) ovary - contains ovules. Develops into fruit wall after fertilisation.
(b) Ovules - contain embryo sac with female nuclei in which fertilization occurs. Develops into seed after fertilization.
(c) Style - stalk of stigma holding it in position for reception of pollen. pollen tube grows down the style to reach the embryo sac for fertilisation.
(d) Stigma - sticky tip of style that receives pollen grains during pollination and fertilization.
⑦ Epicalyx - In some flowers these are sepal-like structures beneath the calyx. for protection of flower before it opens up.

Description of a flower and its floral parts

(a) Description of a flower.
1(a) Complete flower - flower with all the four essential parts ie Calyx, Corolla, Pistil and stamens.
(b) Incomplete flower - a flower lacking one or more of the floral parts.
2(a) Unisexual flower - Flower with only one of the reproductive organs - Pistil / stamens.
(b) Bisexual flower - Flower with both the reproductive organs, pistil and stamens. This is also known as hermaphroditic flower.
3(a) staminate flower - flower with stamens only and lacking gynoecium.
(b) Pistillate flower - flower with pistil only and lacking stamens.
4(a) Essential parts of a flower - Includes Pistil / gynoecium and stamens / androecium.
(b) Non-essential parts of a flower - Includes calyx and corolla.
5(a) Solitary flower - Flower occuring singly ie one flower to one flower stalk.
(b) Inflorescence / Composite / Compound flower - Flower consisting of many florets attached to one flowerstalk.
6. Pedicillate flower - flower with flowerstalk
7(a) Irregular / zygomorphic flower. - Flower which can be divided into two equal halves in one particular plane only eg crotalaria.
(b) Regular / Actinomorphic flower - Flower that can be divided into two equal halves along many planes eg Morning glory.

Description of floral parts.

① Sepals / Calyx.

(a) Arrangement – when sepals are fused, they are described as gamosepalous; when they are free, they are described as polysepalous.

(b) Numbers – Usually threes or their multiples in Monocots and fives or fours or their multiples in dicot flowers

② petals / Corolla.

(a) Arrangement – when petals are fused, they are described as gamopetalous, and if free, polypetalous.

(b) Numbers – As in sepals above ie (b) above

③ Stamens / Androecium

(a) Arrangement – Either free or with filaments fused to form a staminal tube as in Hibiscus.

(b) Numbers – Three / Multiples of three in Monocot flowers OR fives / fours or multiples of five or four as in dicot flowers.

④ Gynoecium / pistil

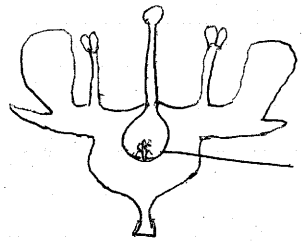
(a) Stigma – May be one as in many flowers or florets or more as in Hibiscus. The shape also varies eg some club-shaped, others lobed etc.

(b) Style – Usually one per flower or floret. May be long and slender or stout / short and thick.

(c) Ovary

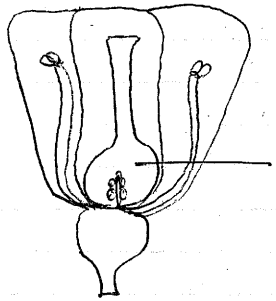
i, Epigynous ovary.

– An ovary with floral parts above it. It is also described as inferior eg apples.



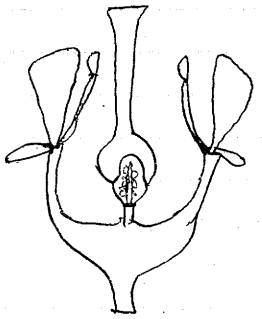
inferior ovary.

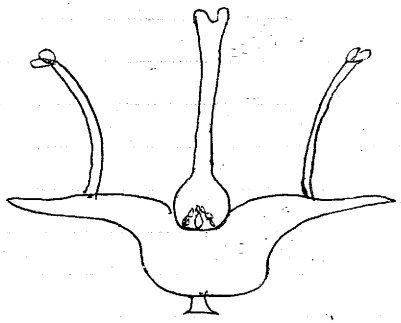
ii, Hypogynous ovary – ovary with floral parts below it ie ovary above other floral parts. Also described as superior ovary as in Hibiscus.



superior ovary.

iii, Perigynous ovary – ovary with the other floral parts arising around the ovary ie ovary at the same level of origin as the other floral parts eg roses.

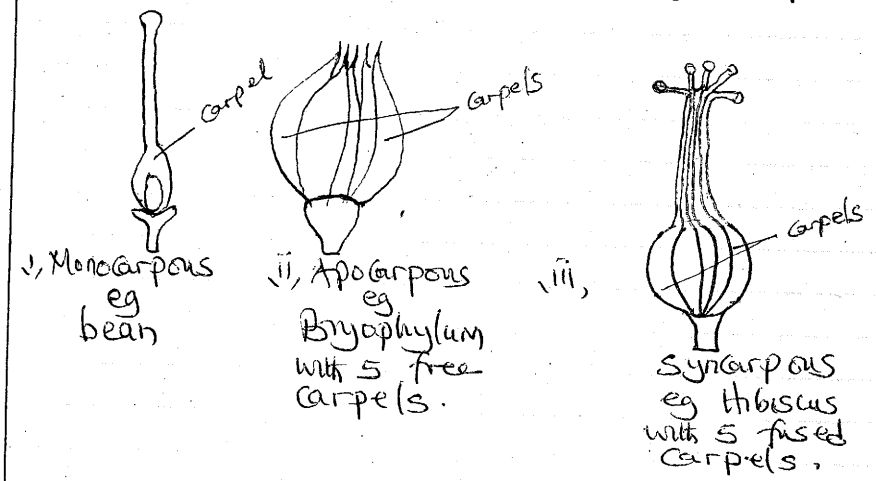




– A gynoecium (pistil) consists of carpels that form the female reproductive organ of the flower.

– A carpel consists of the ovary, the style and the stigma.

-If a gynoecium consists of a single carpel eg beans, it is described as **Monocarpous**.
-If a gynoecium consists of more than one carpel, it is described as **polycarpous**.
-If the polycarpous gynoecium consists of free carpels as in Bryophylum, it is described as **apocarpous**. Roses is another example.
-If the polycarpous gynoecium consists of fused carpels as in Hibiscus, orange, lemon, etc it is described as **syncarpous**



i, Monocarpous eg bean

ii, Apocarpous eg Bryophylum with 5 free carpels.

iii, Syncarpous eg Hibiscus with 5 fused carpels.

Description of plants in terms of flowers

(a) Monoecious plants
-Plants with both male and female flowers borne on the same plant eg Maize, oil palm.

(b) Dioecious plants
-Plants bearing male and female flowers on seperate plants eg pawpaw.

POLLINATION

-Is the transfer of pollen grains from anthers to stigma of the same species.

Types of pollination.

① Self-pollination
-Transfer of pollen grains from anther to stigma of the same flower or plant.

② Cross-pollination.
-Transfer of pollen grains from anthers to stigma of another flower of a plant of same species.

Disadvantages of self pollination.

-Leads to recombination of similar genes hence no variations. The plants which are offsprings can not adapt well to the changing environment

Advantages of cross pollination.

-Leads to recombination or mixing of genes from different genetic backgrounds leading to variation and hence ability of offsprings to adapt to changing environmental conditions. This also forms the basis of major evolutionary changes.

Agents of pollination.

① Wind - hence anemophilous pollination.
② Insects - hence entomophilous pollination
-Flowers of different plants are structured in ways to adapt them to either of the pollination agents.

Adaptations of flowers to pollination

(a) Insect-pollinated flowers.
i) The flower is large or conspicuous to be seen easily hence attract insects for pollination.
ii) Have brightly coloured petals/sepals/perianth/inflorescence/bracts to attract insects.
iii) Are scented to attract insects.
iv) Have sticky stigma for pollen grains to stick on.
v) Presence of nectar guides to guide insects to nectaries.

(vi) Have nectar to attract insects.
(vii) Have nectaries to secrete nectar.
(viii) stigma or anthers are located inside the flower and flower has funnel-shaped corolla or is tubular to increase chances of contact by insects.
(ix) has sticky or sping or spiky pollen grains which stick or adhere to the insect body; and on stigma;
(x) Anthers are firmly attached to filaments to rub against insects.
(xi) Have landing platforms to ensure the insects come into contact with anthers and stigma.
(xii) Some have mimicking body forms ~~of~~ female insects to attract male insects.

(b) Wind-pollinated flowers / Entomophilous flowers :- Adaptations to pollination

(i) The filament and style are long to expose anthers and stigma for pollination.
(ii) stigma is hairy, branched or feathery to increase surface area over which pollen grains land / to trap pollen grains in air.
(iii) pollen grains are smooth, dry and small to be easily carried by wind.
(iv) Large amounts of pollen grains produced per anther to increase chances of pollination.
(v) Anthers are loosely attached to filaments to enable them sway to release the pollen grains.
(vi) pollen grains may have structures which contain air to increase buoyancy.
(vii) Flowers have long stalks holding them out in the wind.
(viii) Anthers and stigma hang outside the flower to increase chances of pollination. The petals/sepals/bracts/inflorescence are small and inconspicuous.

Differences between wind-pollinated (anemophilous) and insect-pollinated entomophilous flowers

	Wind-pollinated flowers	Insect-pollinated flowers
1.	Flower small and inconspicuous	- Flower large and conspicuous
2.	petals with dull colour	- petals brightly coloured.
3.	Not scented.	- scented.
4.	Lacks nectar	- Nectar present.
5.	Feathery stigma	- Compact sticky stigma.
6.	small, smooth and light pollen grains	- large, rough/spiky, heavier pollen grains.
7	Many pollen grains per anther	- few pollen grains per anther.
8	Stamens with long, thin filaments.	- stamens with short, stout filaments
9.	Anthers versatile	- Anthers fixed.

Factors that Encourage Cross-pollination and fertilization / factors that discourage self-pollination and self fertilization in flowering plants.

① Monoecious condition - male and female flowers borne on the same plant eg maize but with developed mechanisms such as herkogamy, brightly coloured petals etc to attract insects.
② Dioecious condition - male and female flowers borne on different plants eg pawpaw.
③ Dichogamy / Dichogamous condition - Male and female parts of the flower mature at

(a) Protandry / protandrous condition. eg Sunflower.
- Male parts/stamens mature earlier than pistil

(b) Protogyny / protogynous condition.
- Female parts/pistil matures earlier than stamens. eg maize

④ Self-sterility and incompatibility
- pollen grains of the same plant can not germinate on stigma of the same plant (self-sterility).
- Even if pollination and germination of pollen grain occurs, fertilization can not take place as in passion fruits (incompatibility).

⑤ Herkogamy / herkogamous condition
- Existence of a physical barrier (eg space in maize) between male and female parts of the flower or the flowers.

⑥ Heterostyly / heterostylous condition.
- Male and female parts are of different lengths eg long style and short stamens.

⑦ Stamens or whole inflorescence hanging down to disperse pollen grains.

⑧ Anthers borne on long flexible filaments to disperse pollen grains away from same plant.

⑨ Brightly coloured petals/sepals/perianth/bracts/inflorescence to attract insects.

⑩ Scented to attract insects.

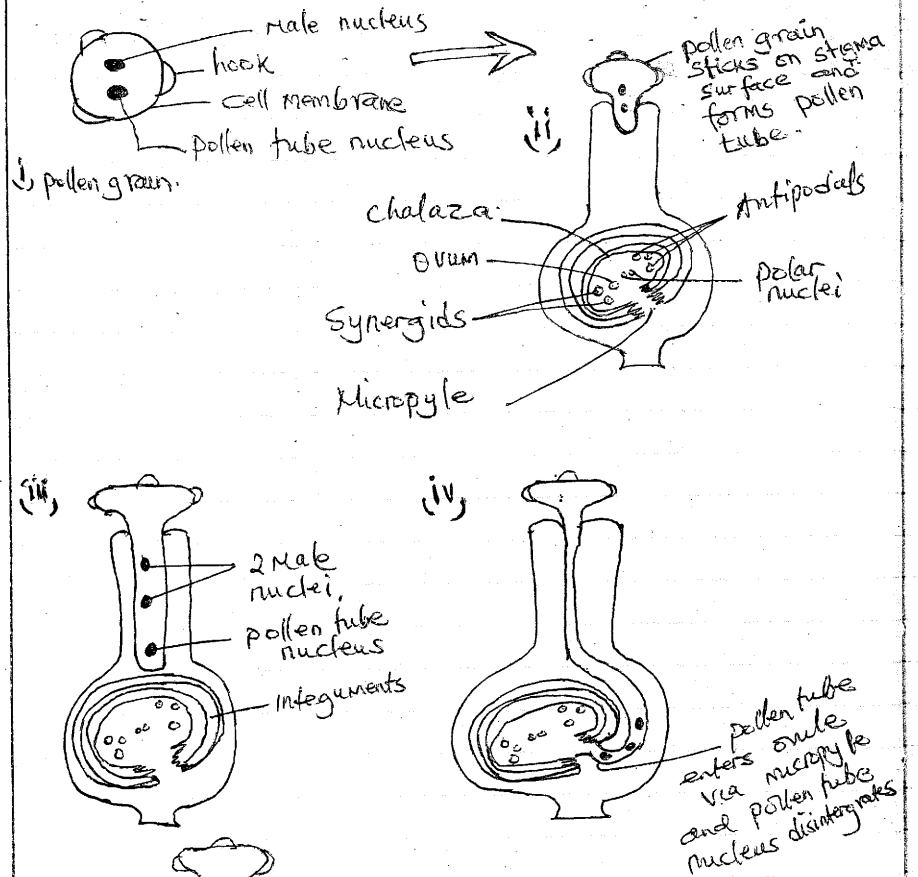
⑪ presence of nectaries which secrete nectar to attract insects.

⑫ presence of nectar guides to guide insects to base of flower where there is nectar thus making insect leave pollen grains on stigma or pollen grains to adhere to its hairy body.

⑬ presence of sticky stigma and sticky pollen grains for pollen to adhere and for adhering to insect body respectively.

THE PROCESS OF FERTILIZATION IN FLOWERING PLANTS

- Fertilization is the fusion of male and female nuclei in the embryo sac.
- After pollination, pollen grains stick on the stigma surface due to the chemical substances stigma cells secrete.
- The surface of the stigma also produces chemical substances which activate germination of pollen grains to produce pollen tubes.
- The pollen tube grows down the style from which it obtains nutrients ie from style cells.
- As this continues the generative/male nucleus of the pollen divides mitotically to give rise to two male nuclei.
- As the pollen tube grows down the style, the pollen tube nucleus occupies the position of the tip while the two male nuclei follow behind.
- Meanwhile in the embryo sac in the ovule, the female nucleus divides into eight nuclei which form two synergids; one egg cell/ovum; two polar nuclei and three antipodals or antipodal cells.
- When the pollen tube reaches the micropyle, of the ovule, the pollen tube nucleus/vegetative nucleus disintergrates. One of the male nuclei then fuses with the egg cell/ovum to form a diploid zygote which later forms the embryo. The other male nucleus fuses with the two polar nuclei to form a triploid nucleus (primary endosperm nucleus which later forms the endosperm.
- This process involves double fertilization which is unique in all flowering plants.



Changes in the flower after fertilization.

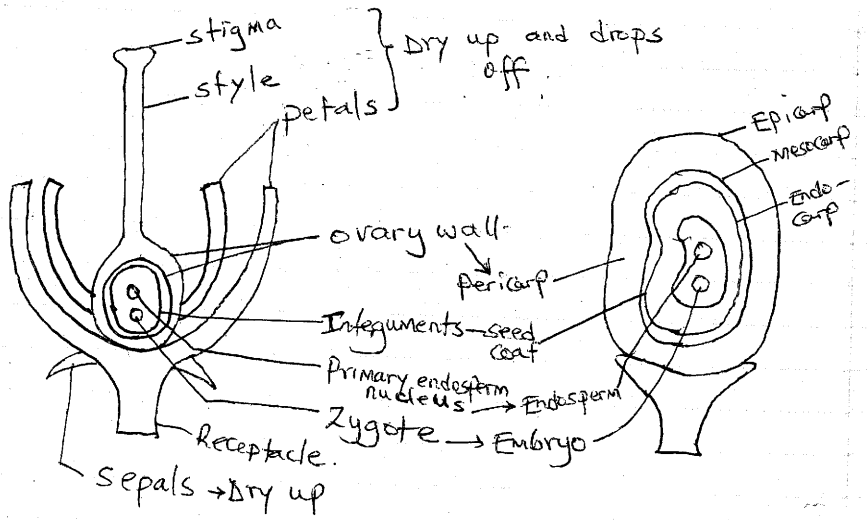
① The integuments form seed coat / testa.
② The zygote forms the embryo.
③ The triploid nucleus forms endosperm.
④ The ovule forms the seed
⑤ Ovary wall forms the fruitwall / pericarp.
⑥ The ovary forms the fruit.
⑦ The style dries up and falls leaving a scar.
⑧ Corolla dries up and falls off.
⑨ Calyx becomes very dry and persists or drops off.
⑩ Stamens dry up.

Seed and fruit formation.

(a) Development of a seed

- After fertilization, the zygote divides mitotically to form the embryo.
- The embryo differentiates into the radicle (young root) and plumule (young shoot) and one or two cotyledons (seed leaves).
- The embryo is attached to the wall of the embryo sac by a suspensor for obtaining nutrients.
- The primary endosperm nucleus undergoes mitosis and gets enclosed with cytoplasm to form a semi-fluid storage tissue called endosperm.
- The embryo sac expands crashing out the nucelles (other cells of ovule) thus reaching the integuments. The embryo then completely seperates from the endosperm by a membrane leaving an opening called micropyle; through which water enters the seed.

-The integuments are modified to form the outer seed coat - testa and inner seed coat - tegmen.
-The water content of the seed so formed is withdrawn from 80% to 15% thus remaining dormant awaiting dispersal. In this form it withstands adverse environmental conditions.



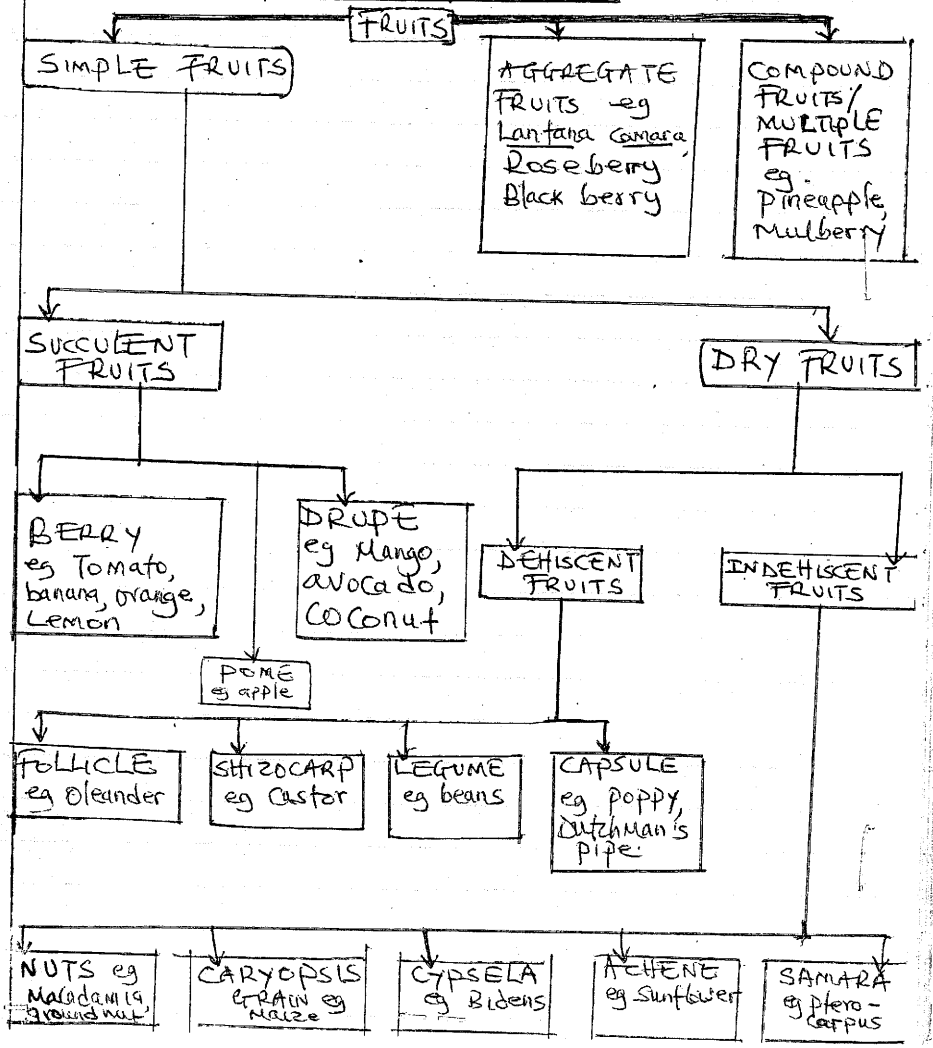
(b) Development of fruits

-Fruit development begins immediately after fertilization. This is brought about by a plant hormone known as gibberellins, which causes increase in size.
-During fruit formation, the ovary wall becomes the fruitwall or pericarp. The pericarp is usually made of three layers - epicarp / exocarp (outer layer), Mesocarp (middle layer) and endocarp (inner layer).
-Therefore a fruit is a fully developed fertilized ovary containing fully developed seeds.
-However, some fruits such as pineapples develop from the flower without fertilization. This process is known as parthenocarpy.

Differences between fruit and seed.

1. A fruit has two scars, the point of attachment to the receptacle and remains of style; whereas a seed has one scar, the point of attachment to the funicle.
2. A fruit has fruitwall / pericarp whereas the seed is covered with testa.

classification of fruits.



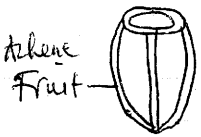
(A) SIMPLE FRUITS

- Fruit formed from a single flower ovary with one or several carpels fused. Simple fruits include

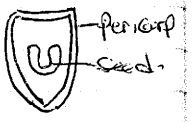
1. DRY FRUITS

i. DRY – INDEHISCENT FRUITS

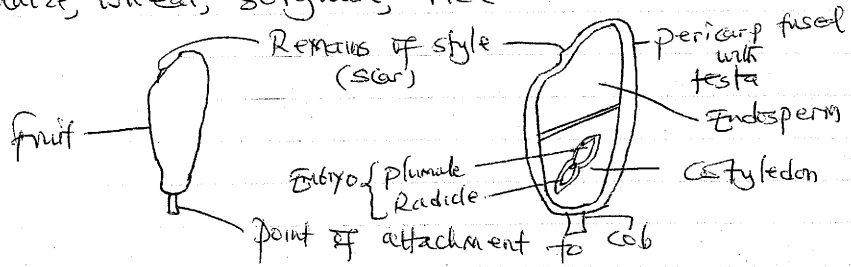
(a) Achene – simplest fruit consisting of one seed surrounded by a dry indehiscent pericarp eg Sunflower, strawberry, buckwheat etc.



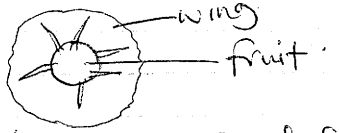
L/s of achene fruit →



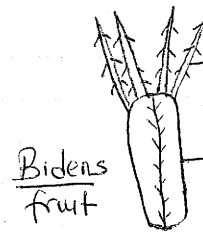
(b) Grain/Caryopsis – Fruit of the grass family in which the pericarp is fused with testa eg Maize, wheat, sorghum, rice.

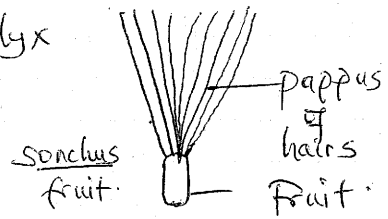


(c) Samara – one or two-seeded fruit with wings eg pterocarpus. Pericarp is extended to form wings.

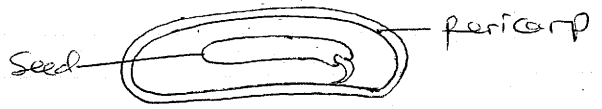


(d) Cypsela – one seeded fruit whose calyx persists to form parachute of hairs/pappus of hairs or persistent calyx with hooks eg Sonchus and Bidens and Tridax



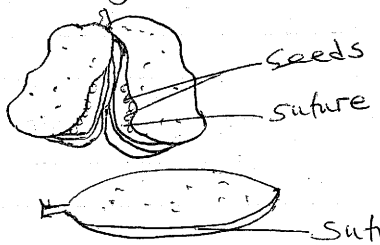


(e) Nuts – A fruit where the pericarp becomes hard and woody and seperate from seed coat eg Macadamia, groundnuts/peanuts

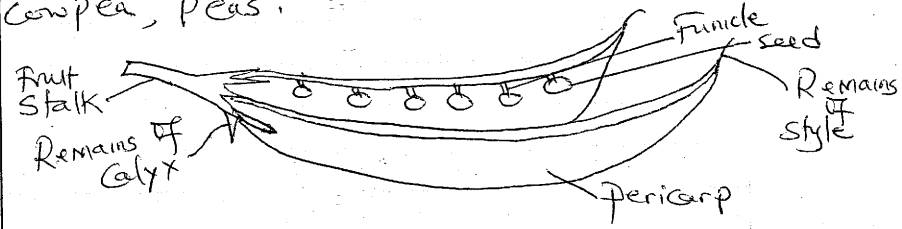


ii. DRY-DEHISCENT FRUITS

(a) Follicle – Fruit with one line of weakness or suture eg Oleander.

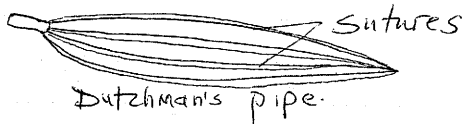


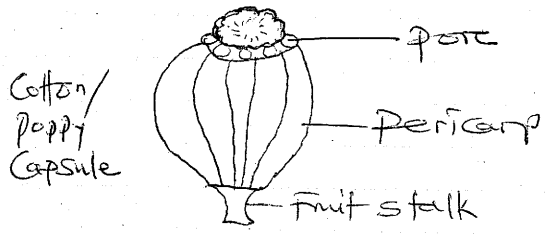
(b) Legume/pod – Fruit with two lines of weakness or two sutures eg beans, Crotalaria, Cassia, cowpea, peas.



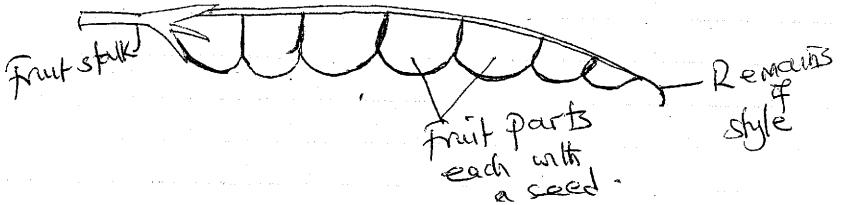
(c) Capsule

- Fruit with many lines of weakness/many sutures eg Dutchman's pipe, poppy etc. Others eg Cotton dehisce by a ring of pores.





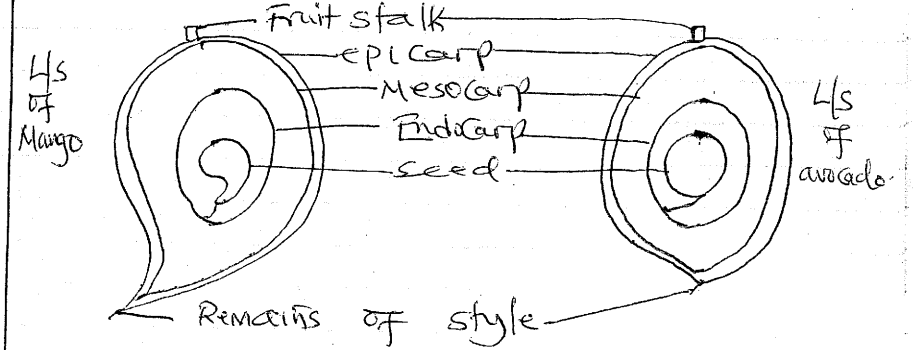
(d) **Schizocarp** — several-seeded fruit which breaks into several parts each with one seed eg Desmodium



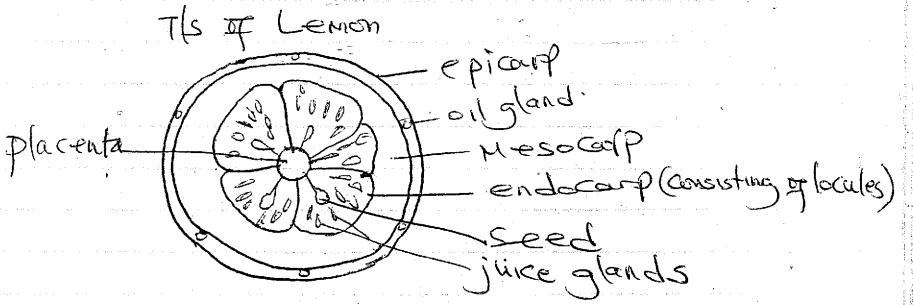
2. SUCCULENT FRUITS

— Are fruits which are fleshy or with fleshy Mesocarp and or endocarp. Include

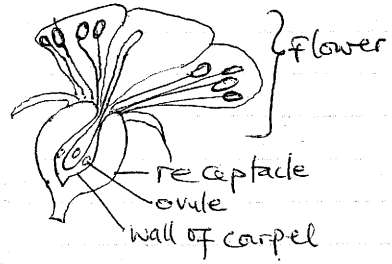
i, Drupe - one seeded fruit with fleshy Mesocarp, skiny epicarp and hard/stony endocarp. eg Mango, avocado, plum, coconut.

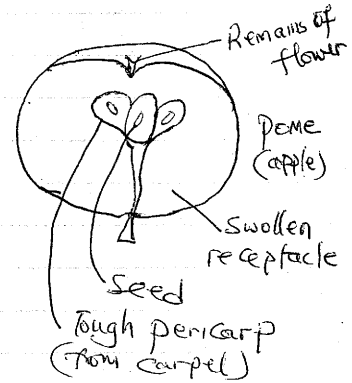


ii, Berry — Succulent fruit with skiny epicarp/ exocarp/ ectocarp and succulent/ fleshy Mesocarp and endocarp. It is derived from a compound ovary consisting of several carpels which are fused eg tomato, orange, lemon, guava, grapes, pumpkin, pawpaw, banana etc.



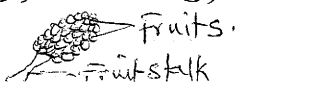
iii, Pome — consists of swollen receptacle as the succulent part with pericarp and seeds. The ovary forms only the core. Also known as false fruit eg apple.





B. AGGREGATE FRUITS

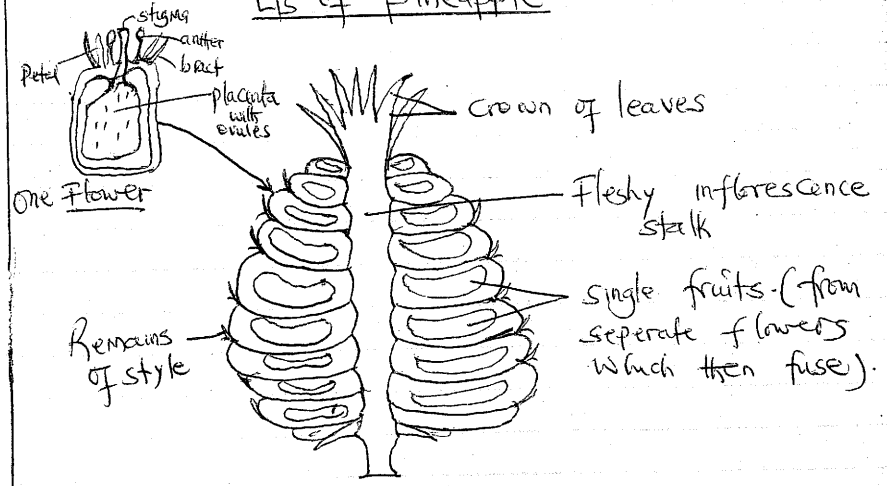
— Many small fruits which develop from a single flower with many free carpels attached to one stalk eg blackberry, roseberry, Lantana camara, strawberry



C. COMPOUND / MULTIPLE FRUITS

- These fruits form from an inflorescence whose carpels fuse to form one fruit such as pineapple, mulberry.

Ls of pineapple

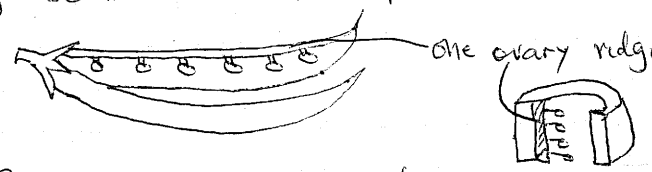


Placentation

- This is the arrangement of ovules in the ovary. It depends on the nature of gynaecium eg Monocarpous gynaecium eg legume; placentation is either Marginal or basal; In syncarpous gynaecium placentation is either axile or Parietal or central or free central.

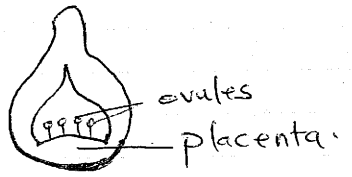
① Marginal placentation

- placenta appears as one ridge on the ovary wall and ovules are attached to the placenta in a row eg beans and other pods.



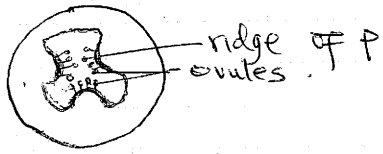
② Basal placentation

- Placenta formed at the base of the ovary with numerous ovules attached to it eg sunflower, mango etc.



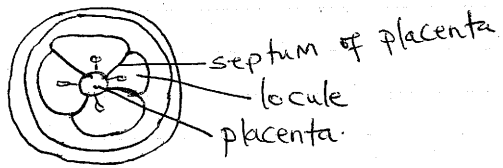
③ Parietal placentation

- placenta in seperate ridges on the ovary with numerous ovules on them eg pawpaw.



④ Axile placentation

- In this type the edges of the carpels fuse together to form central placenta in the axil formed by carpels. Ovules are arranged on the placenta. The ovary is divided into a number of loculi by walls of the carpel eg orange, lemon, tomato, banana, guava etc.



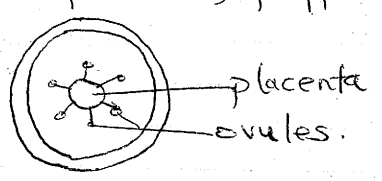
⑤ Central placentation

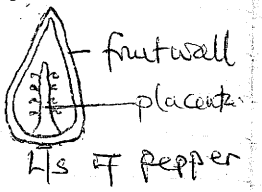
- Placenta at the centre of the ovary/fruit but not free ie connects to both poles of the ovary eg lemon, orange.

⑥ Free-central placentation

- The placenta appears at the centre of the ovary or fruit in one locule and has many ovules attached to it. It is homologous

with basal placentation of apocarpous ovaries. Example is primrose, pepper etc.





FRUIT & SEED DISPERSAL

Importance of fruit and seed dispersal

1. Helps to avoid overcrowding and hence competition for resources such as light, water, nutrients.
2. Leads to colonization of new habitats.
3. Reduces risks of disease epidemics.
4. Enhances survival chances of a species.

Adaptations of fruits and seeds to various Agents of dispersal.

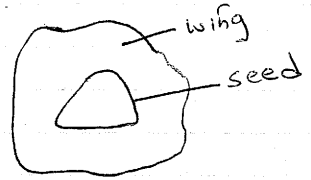
(A) Adaptations to wind dispersal

(i) censor- Mechanism.
- An open or split or perforated capsule is usually loosely attached to the fruitstalk. The long fruitstalk is swayed by wind scattering the seeds eg simsim, tobacco (Nicotina spp) and Mexican poppy (Argemone spp).

(ii) Presence of pappus of hairs or floss which increase surface area for buoyancy making it easy for fruits/seeds to be blown away.

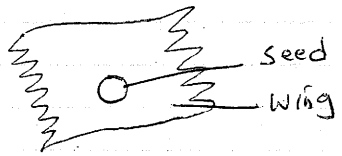
(iii) Presence of wing-like structures to increase surface area for buoyancy to enable seeds or fruits to be blown away. eg Nandi flame Jacaranda, Makhania Lutea etc.

(iv) Fruits/seeds are light due to small size and dry therefore easily carried away by wind.

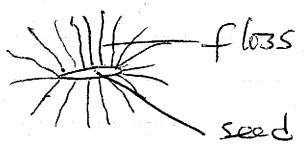


Jacaranda seed

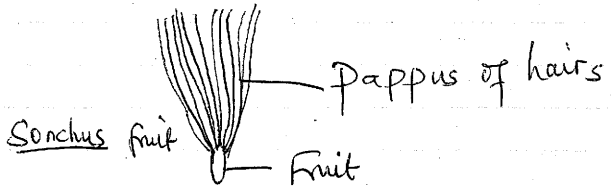
Seed of Nandi flame (Spathodea) spp



Tecoma seed



Cotton seed



(B) Adaptations to water Dispersal.

(i) Seeds and mesocarps of fruits have air spaces thus making them light and buoyant to float and therefore carried away by water.

(ii) The fruits and seeds are protected from soaking by waterproof pericarps and testa respectively.

(iii) The fruits and seeds are light to float on water hence to be carried away.

(iv) Some fruits such as coconuts have fibrous and spongy mesocarps to trap air thus making them buoyant to be carried in water.

© Adaptations to Animal dispersal

i, Presence of hooks in some fruits for attachment to animal body/hair/fur, thus carried to other places eg blackjack (Bidens pilosa), Desmodium, Triflax etc

ii, Fruits brightly coloured in some plants; succulent/fleshy; aromatic/scented; to attract animals which feed on them.

iii, Some have hard seedcoats or slimy seedcoats hence resistant to digestive enzymes, thus remain unaffected. The seeds are dropped away from parent plant in faeces/droppings.

(D) Adaptations to self-dispersal Mechanism (Self-Explosive Mechanism)

- The dry pods or fruits split along lines of weakness/dehiscence/sutures; scattering away seeds from the parent plant; eg beans, peas, Cassia, Crotalaria etc.
- The splitting is due to loss of water and pressure from within due to detached seeds from the placenta.

Quiz - Describe how various fruits and seeds are adapted to their modes of dispersal (2 Marks)

SEXUAL REPRODUCTION IN ANIMALS

- Sexual reproduction involves fusion of nuclei of Male and female gametes to form a zygote.
- The gametes (sperms in Males and ova in females) are produced in gonads ie testes in Males and ovaries in females.
- Fusion of the nuclei of Male and female gametes to form a zygote is called fertilization
- The gametes are haploid whereas the zygote is diploid - fertilization may be external or internal.

External fertilization in fishes and amphibians

- External fertilization involves fusion of Male and female gametes' nuclei outside the body of the female.
- External fertilization is only possible in water where the sperms swim to reach the eggs for fertilization. A female lays eggs in water. A Male sheds sperms in the water on the eggs resulting in fertilization.
- To increase chances of fertilization, the an amphibian eg toad, frog, mounts on the female and sheds sperms into the eggs as they are being laied by the female. The Male also croaks to attract females.
- The eggs are laid in long strands of slippery jelly-like substance which protects the eggs from predation and also spreads them out to aerate them and also for attachment to substratum eg water plants.
- In external fertilization, eggs are laid in large numbers to increase chances of survival and fertilization.

Internal fertilization in reptiles, birds, Mammals

- Fusion and nuclei of Male and female gametes occurs in the body of the Male ie in oviduct
- The eggs laid are fewer since chances of fertilization are higher due to protection, security of the gametes and fertilized eggs.
- In most Mammals, some chameleons and some snakes, the fertilized eggs develop

within the bodies of the females (mainly in the uterus or in chameleons, in the oviduct) and young ones are given birth to.

Differences between External and Internal Fertilizations in animals

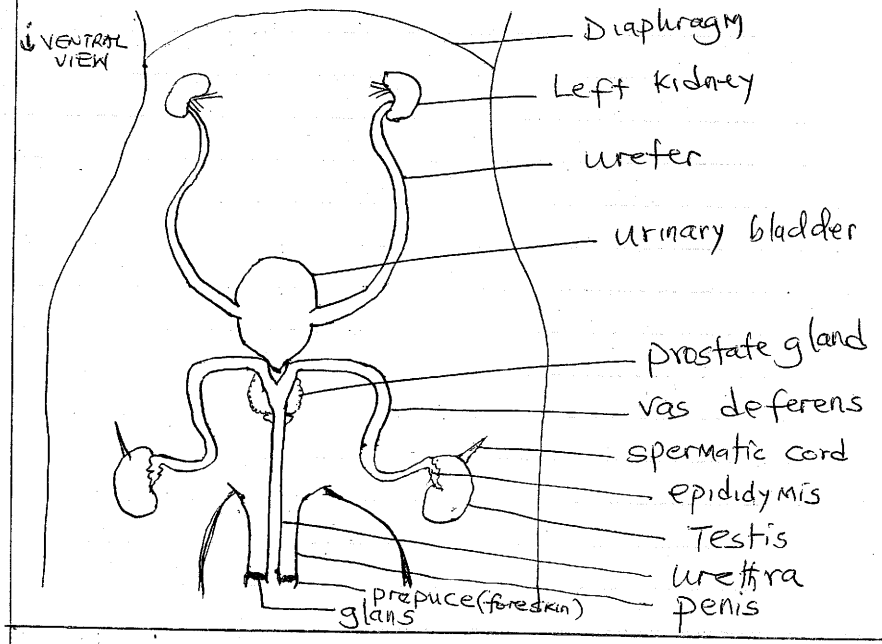
External fertilization	Internal fertilization
① Occurs outside the body of female ie in water	Occurs inside the body of the female (oviduct).
② Many eggs produced	Fewer eggs produced.
③ Less security for the gametes (eggs) and the fertilised egg.	More security for the eggs and the fertilized egg.
④ Occurs mostly among aquatic animals	occurs among terrestrial animals
⑤ Sex organ which sheds sperms onto eggs in water	Sex organs specialised to introduce sperms into female reproductive system

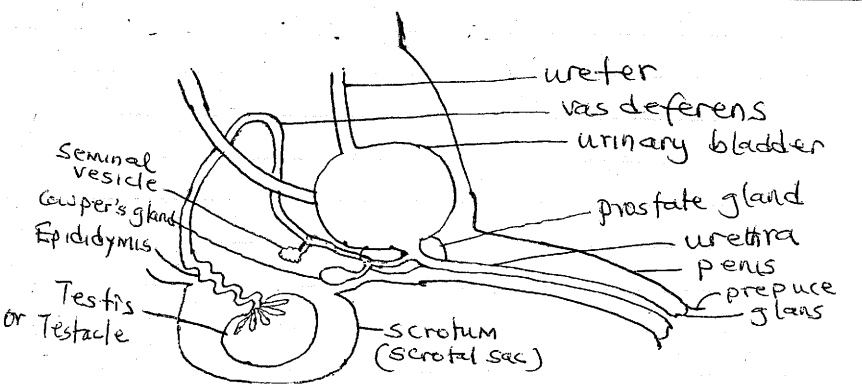
Reproduction in Mammals

- After internal fertilization, the fertilized egg is laid or may develop into foetus in the uterus of the female.
- The egg-laying mammals (monotremes) such as Duck-billed platypus are said to be oviparous.
- Oviparity refers to the condition of a mammalian embryo developing outside the body of the female after being laid.
- Development of a mammalian embryo inside the body of the female (ie uterus) into a foetus viviparity.
- In viviparity or viviparous mammals;
  i) the zygote may develop into embryo and foetus within the uterus but after birth, the immature youngone continues to develop in a special pouch as in kangaroos.
  ii) the fully developed foetus is given birth to forming a young one as in humans and other mammals.
- Mammals which give birth to youngones are called placental mammals.
- placental mammals have mammary glands which produce milk for youngones; and show highly developed parental care.

Reproduction in Human beings

(a) Structure and functions of the Male Reproductive system.





① **The penis** – Is highly vascularised and spongy; consisting of erectile tissue to become erect when blood supply is increased to it upon stimulation; hence allowing entry into the vagina during copulation. It also has urethra to conduct urine and sperms;

② **scrotum / scrotal sac** – The sac contains testes / testacles outside the body to offer lower temperature or cool temperature for sperm development.

③ **Testes / testacles** – contains numerous seminiferous tubules, on whose walls spermatogenesis occurs. Its lining consists of actively dividing cells which give rise to sperms. This process is favoured by the lower temperature.

– Testes also contain Sertoli cells or nurse cells which nourish spermatids until they mature into sperms.

– Between seminiferous tubules are the interstitial cells which produce male hormones (androgens) such as testosterone.

④ **Epididymis** – Is a long and coiled tube for storage of sperms.

⑤ **vas deferens / sperm ducts**

– Are muscular tubes that upon contraction push out sperms to allow ejaculation.

⑥ **Seminal vesicle**

– Blind ending sac opening into the urethra. It secretes semen an alkaline fluid which contains nutrients for spermatozoa and also provides medium for swimming of the sperms.

⑦ **Prostate gland**

– secretes an alkaline fluid which neutralises vaginal fluids and activates sperms.

⑧ **Cowper's gland**

– secretes an alkaline fluid which neutralises the acidity along the urethra caused by urine.

– All the fluids from the seminal vesicle, Cowper's gland and prostate gland combine with spermatozoa from the vas efferentia to form semen.

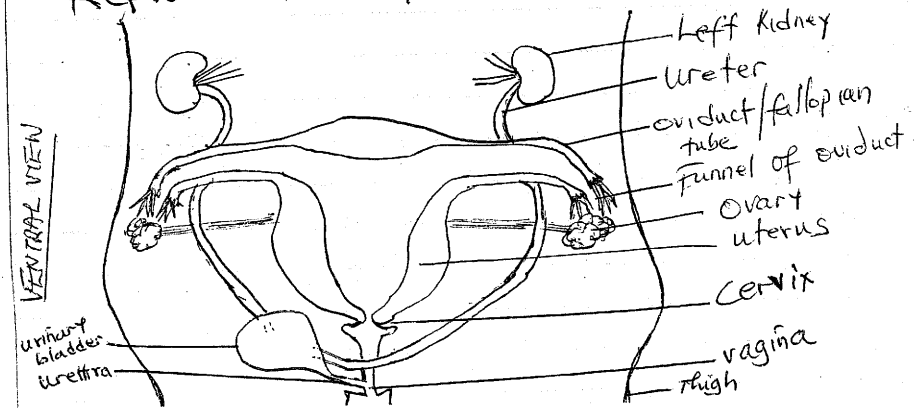
⑨ **Urethra**

– Is a long tube for expulsion of urine and sperms; hence it is a urinogenital organ.

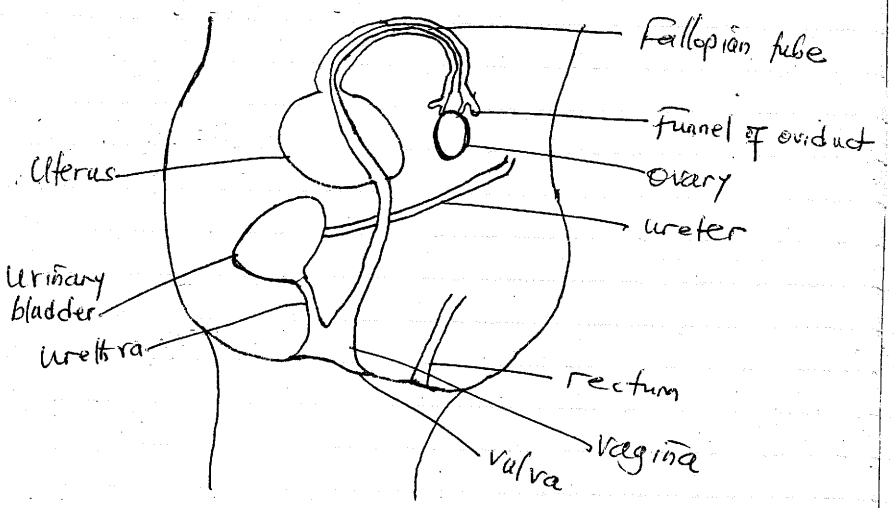
⑩ **sperms**

– Are the male gametes and are produced in large numbers to increase chances of fertilisation. They have tails for swimming to reach the eggs in the oviduct. They also have a high density of mitochondria to provide energy for swimming.

(b) The structure and functions of the female Reproductive System.



SIDE VIEW



The female reproductive system consists of:-

① Ovaries

- A female human being has two ovaries which are small cream-coloured oval bodies 3-4 cm long on the lower part of the abdomen below the kidneys.
- The ovaries are supplied with blood by the ovarian artery and removed by the ovarian vein.
- Adaptations:- Wall of ovary consists of the germinal epithelium which undergoes oogenesis to produce the ova.
- Ovary tissues also produce female hormones Oestrogen and progesterone. Progesterone maintains pregnancy. Oestrogen causes healing and repair of endometrium after menestruation.

② Oviducts / fallopian tubes

- Are muscular tubes which have an expanded funnel-shaped opening (fimbrated end of fallopian tube) which sucks the eggs from the ovaries upon ovulation.
- It is lined with cilia that wafts the eggs/ova along the tube to the uterus.
- Has smooth muscles whose contractions aid in movement of the fertilized ovum to the uterus for implantation.
- Fertilization occurs in the oviduct.

③ Uterus / Womb.

- Is an elastic & muscular structure in which implantation and growth and development of the embryo and foetus take place.
- The elasticity allows it to expand so as to accomodate the full size of the foetus and upon birth, it contracts to its original size of 8cm length.
- The contractions of the muscles during labour pains facilitates the birth process.
- The uterine wall is also lined with endometrium which proliferates to allow implantation to take place and also for nourishment of the embryo at the initial stages.
- The uterus is held in its position by ligaments and supported by the bladder and muscular floor of the pelvis.

④ Cervix

- Is the lower narrow end of the uterus leading to the vagina.
- It consists of a ring of muscles which dilate prior to birth allowing passage of the foetus.
- It secretes a plug of mucus which prevents

entry of pathogens and other harmful substances to the uterus during pregnancy.
- Its contractions creates suction pressure which sucks sperms from the vagina into the uterus.

⑤ **Vagina**

- Is the copulatory anal. Together with the urethra, they open into the vulva.
- The vaginal orifice is encircled by the major and minor labia (muscular regions) of external genitalia. The external genitalia has a sensitive clitoris
- Vaginal wall consists of or is lined with vestibular glands which secrete mucus and vaginal fluids (smegen) which lubricate the vagina during copulation.

⑥ **The ova / The eggs.**

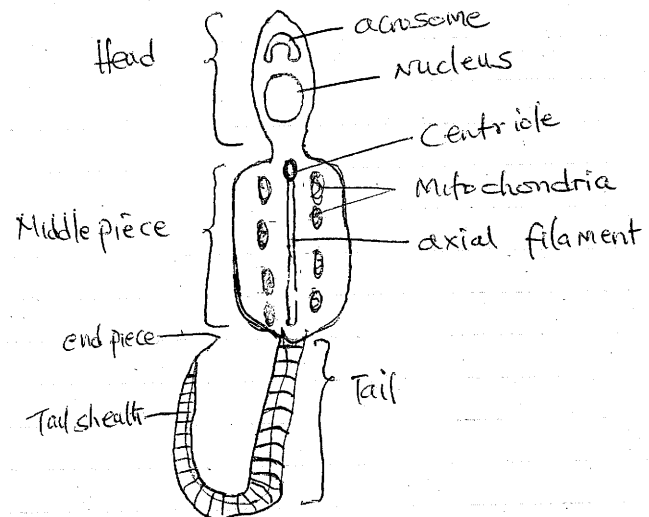
- They are motile and contain the female nucleus; with maternal chromosomes. The nucleus of the sperm fuses with that of the ovum resulting in fertilization and formation of the zygote.

FERTILIZATION

(a) Structure of Gametes

Human sperms

- Sperms are produced in the walls of the seminiferous tubules of the testes by meiosis. The spermatids so formed then get nourishment by sertoli or nurse cells where they undergo differentiation and maturation to form sperms.
- This occurs at puberty.
- A mature sperm consists of an ovoid head, short neck, middle piece and a tail.

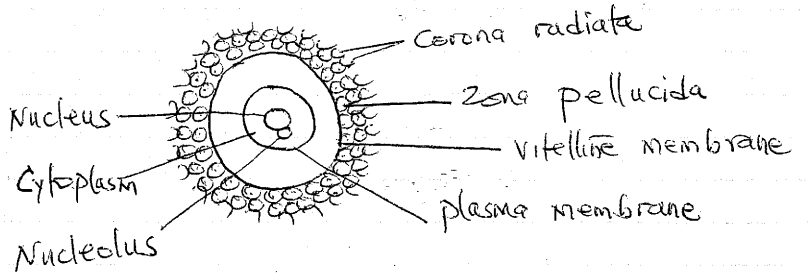


- The nucleus in the head carries the genetic material (DNA). The nucleus is haploid.
- Acrosome contains lytic enzymes which digest the membrane of the egg for sperm to penetrate; causing fertilization.
- The high density of mitochondria in the middle piece provides energy for propulsion of the sperms to reach the eggs.
- The tail propels the sperm forward by side lashing action aiding it to swim to reach the eggs.

Human ovum.

- The process of egg formation begins in the ovary of the foetus before birth. At birth a baby girl has 70,000 potential ova enclosed by a layer of ovary cells called primary follicles which provide nourishment. Of these, 500 of them may develop into ova as from puberty. This occurs by meiosis.

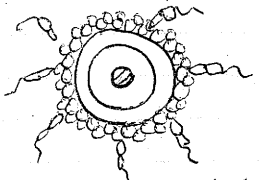
-During puberty, primary follicles undergo growth and become mature Graafian follicles. At ovulation Graafian follicles burst releasing the ovum.



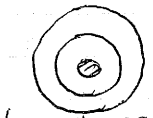
-A mature ovum of a human consists of a large haploid nucleus surrounded by the nuclear membrane. The nucleus is within the cytoplasm and enclosed by the plasma membrane, vitelline membrane, zona pellucida and corona radiata respectively. The corona radiata and zona pellucida consists of follicle cells.
-A human ovum is about 0.2mm in diameter.

(b) The process of fertilization.

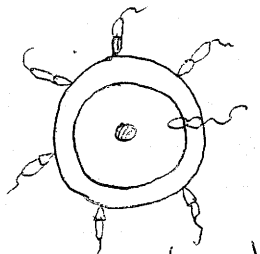
- process that involves fusion of the nuclei of male gamete and female gamete to form the zygote.
- It occurs in the upper part of the oviduct after copulation/sexual intercourse/coitus.
- sperms introduced into the vaginal canal are drawn up by suction pressure through the cervix into the uterus from where they swim up to the oviduct using their tails.
- As the ovum moves down the oviduct, it releases chemical substances which have to be neutralised by the sperm's acrosomes before a sperm can penetrate the ovum.
- Several sperms coming into contact with the ovum rapture their acrosomes hence releasing their lytic enzymes which dissolves the corona radiata and softens the zona pellucida and vitelline membrane.
- species specific receptors in the zona pellucida bind with only one spermatozoon ie the fastest.
- The acrosome of the sperm turns inside out forming a fine filament that the sperm uses to penetrate the cytoplasm leaving out the tail.
- The ovum responds to this invasion by undergoing second meiosis to form a mature ovum. The vitelline membrane then undergoes a chemical change to prevent entry by any other sperm.
- Once in the cytoplasm, the head of the sperm bursts open releasing the nucleus which then fuses with the ovum nucleus forming a diploid zygote.
- The zygote then begins to undergo repeated cell divisions by mitosis or cleavage to form the blastula or blastocyst as it moves down the oviduct and gets implanted in the uterus by the 7th day.



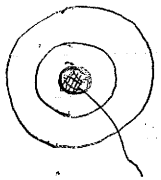
(a) sperms swim towards ovum, release lytic enzymes



(b) Follicle cells scattered by lytic enzymes; zona pellucida and vitelline membrane softened.



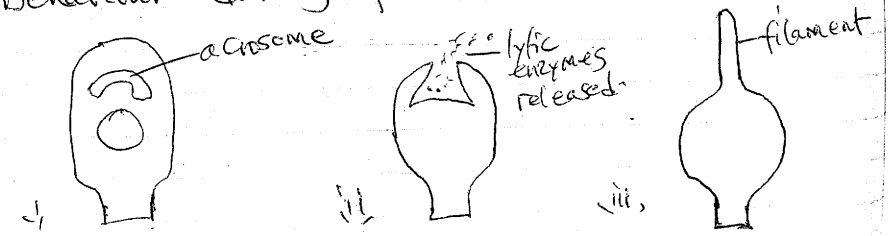
(c) Sperm head enters cytoplasm of ovum, vitelline membrane changes to prevent any more penetration



(d) Sperm and ovum nuclei fuse. Zygote formed.

NB :-

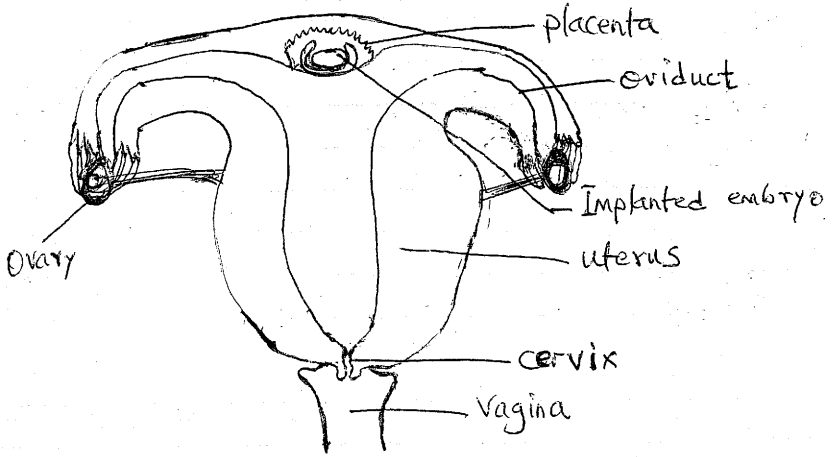
① Sperms remain viable within the female reproductive system for between 2-3 days.
② The ovum remains viable for between 8-24 hours.
③ Fertilization is possible latest by the 3rd day after ovulation.
④ A normal man produces 15 million sperms per mm^3 semen.
⑤ Below is an illustration of acrosome behaviour during fertilization.



Implantation

- Is the attachment of the blastocyst/blastula into the proliferated wall of uterus (endometrium) with help of villi. This occurs by the 7th day after fertilization.

- After fertilization, the zygote undergoes several mitotic divisions/cleavages as it moves down the oviduct. This movement is aided by cilia movements and muscular contractions of the oviduct.
- By the time it reaches the uterus, it would have formed a hollow mass of cells called blastocyst or blastula.
- In the uterus, the blastocyst forms finger-like projections called villi which grow into the endometrium thus implanting the blastocyst
- The villi, also called trophoblastic villi together with the endometrium form the placenta.
- Upon implantation, the zygote develops into the embryo.
- Occasionally, the zygote may fail to be implanted in the uterus wall and it is implanted in the wall of the oviduct resulting in an **ectopic pregnancy**. This can be fatal hence it has to be removed surgically.



Formation of placenta and other Extra-embryonic structures.

- During implantation, some cells of the developing embryo and the uterus form the following extra-embryonic structures :- chorion, amnion, allantois and later on, placenta and umblical cord.

(a) chorion

- This is the outermost membrane. It :-
  i) Encloses and protects the inner membranes and embryo.
  ii) forms placenta together with uterine tissue.
- The membrane is highly vascularised and sends finger-like projections (chorionic villi) with chorionic capillaries which are in close contact (but not direct contact) with maternal capillaries in the uterus allowing exchange of materials between embryo and mother

(b) Amnion

- It is a sac that contains a liquid known as amniotic fluid. Its functions include :-
  i) Provides a moist/aquatic environment suitable for the development of the foetus. Hence it prevents the foetus from desiccation.
  ii) Absorption of shock and prevention of the foetus from mechanical injury.

(c) Allantois

- Acts as a temporary store for metabolic wastes in other animals. It does not feature prominently in human beings.

(d) Yolk sac

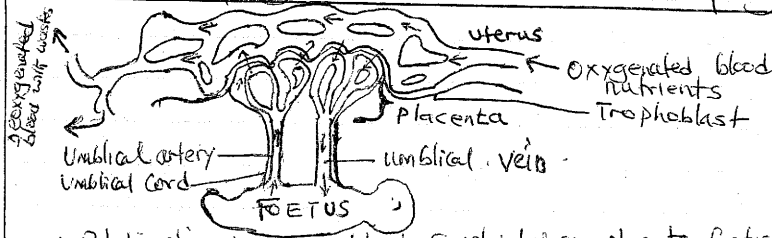
- Stores food for the developing foetus in other animals especially the egg-laying.

(e) Umblical Cord

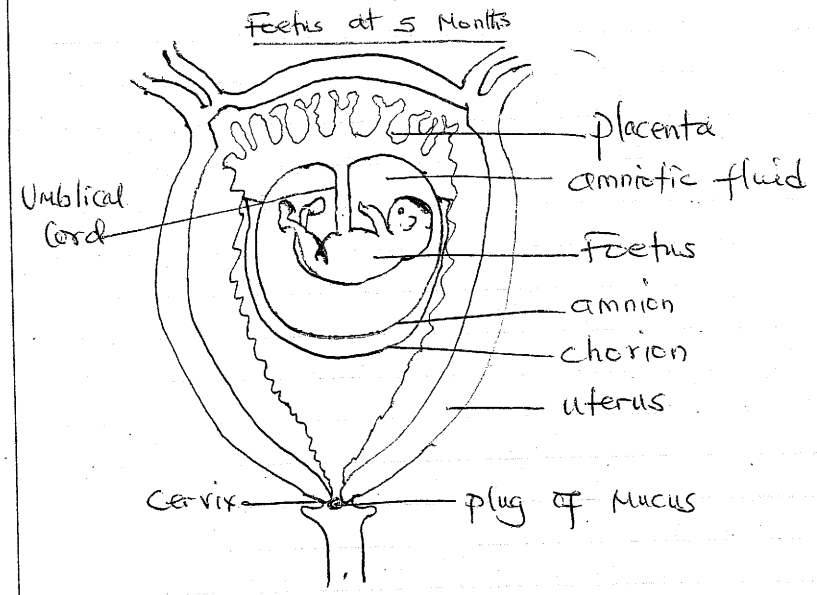
- Contains umblical artery and umblical vein. It is highly vascularised. Its roles are
  i) Supplies nutrients and oxygen from Mother to foetus, and removes metabolic wastes from foetus to Mother via the Umblical vein and umblical artery respectively.
  ii) Attaches embryo or foetus to the placenta.

(f) placenta

i) Gaseous exchange. Allows diffusion of oxygen from maternal capillaries in uterus to foetus and diffusion of CO_2 from the foetus to the maternal capillaries.
ii) Nutrition / nourishment. Allows diffusion of nutrients from maternal capillaries to the foetus; across the sinuses.
iii) Excretion. Allows diffusion of metabolic wastes such as nitrogenous wastes from foetus to maternal capillaries in uterus.
iv) Produces hormones eg progesterone, oestrogen and human chorilk gonadotrophic hormone etc. During the first trimester the hormones eg progesterone are secreted by the ovaries. Progesterone maintains the pregnancy.



* Relationship between blood supply between placenta, foetus & uterus



Gestation Period

- Is the period between conception or implantation and birth.
- It varies from animal to animal eg 22 days in mice; 30 days in rabbits; 9 Months in humans and 18 months in large Mammals like elephants.
- By the second week after implantation extra-embryonic membranes begin to form mainly chorion and amnion. They form from the outer layer of cells of the blastocyt. The inner layer develops into embryo. Embryo appears as a pump on the uterine wall.
- The placenta also forms from the chorionic villi and part of uterine tissue. Umblical cord also forms. Amnion gets filled with amniotic fluid.
- The embryo then differentiates into tissues and organs forming the foetus.
- By the 3rd month, the heart and blood vessels form and foetal circulatory and cardiac activity are demonstrated. The head region is well developed ie cephalisation is represented, hence foetus is at cephalic presentation.
- Spinal cord and tail also form. Limbs begin to appear.
- By the sixth month, limbs are developed, alveoli and nostrils. foetal movements are demonstrated.
- By the 9th month, all organs are formed and head of foetus is directly above the cervix, ready for birth.

NB

① Miscarriage – birth before completion of 6 months. The baby does not survive.

② Abortion – Expulsion of foetus by chemical or physical inducement thus interfering with its development.

③ Premature birth – Birth occuring after 7 months but before full term. A premature baby has large surface area to volume ratio hence loses more heat to the surrounding which can lead to desiccation and death. Hence they are kept in incubators until they attain the required weight.

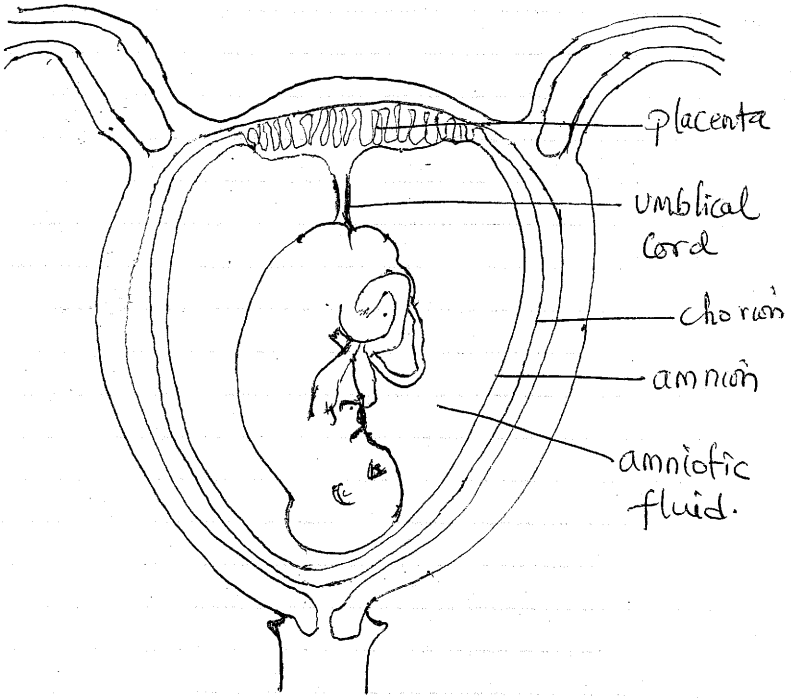
④ Pregnant/expectant mothers must:-
(a) feed on balanced diet rich in proteins for growth and development of the foetus; calcium and phosphorous for bone development; iron for haemoglobin formation.
(b) attend ante-natal ~~pre-natal~~ clinics for

vaccinations / immunisations; weight monitoring, Urinalysis, bloodpressure monitoring, heart beat albumen level check-ups etc.

Birth or Parturition

- As birth nears, the level of progesterone in blood declines. This stimulates the posterior lobe of the pituitary gland to secrete the hormone oxytocin.
- Oxytocin removes the inhibitory effect on contractions of myometrium. The myometrium starts contracting.
- Release of oxytocin is in "waves" thus initiating "labour pains" which are accompanied with dilation of cervix, rapture of amnion and chorion releasing the amniotic fluid through the cervix; and stimulation of the stretch receptors in the walls of the uterus and cervix.
- Contractions of the uterus follows which spreads downwards the uterus pushing the foetus downwards and outwards, head first through the widened cervix and birth canal (vagina) resulting in birth.
- After birth, the umbilical cord is ligatured and cut to seperate the baby from the placenta.
- The placenta is later expelled as "afterbirth"
- After birth, important changes take place in the circulatory system of the foetus ie closing of foramen ovale and ductus arteriosus - shunt systems which help to by-pass pulmonary circulation since the lungs are still fluid-filled and non-functional.
- Upon birth, the baby takes first breath, lungs expand and become functional.

Foetus at 9 months ready for birth ↓



Caesarean delivery

- Surgical incision of abdominal and uterine walls for delivery of the offspring or baby.
- It is done when there are complications which can not allow the foetus to pass through the birth canal normally.

Abortion

- The premature termination of pregnancy before the foetus is capable of surviving on its own; either by chemical or physical means eg suction.
- It is illegal unless it posses a healthy risk to the mother.

NB:-

① Placental Exchanges

Materials allowed to cross placenta to foetus

- oxygen; digested food; vitamins; mineral salts; mineral hormones; water; antibodies; antigens.

Materials allowed to cross placenta from foetus

- Carbon(IV) oxide; nitrogenous wastes.

Materials not allowed to cross placenta

- All blood cells; plasma proteins; bacteria.

② Twinning

(a) Monozygotic twins / identical twins

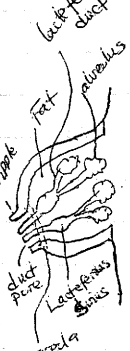
- Arise due to same fertilised ovum/zygote dividing into two independent parts each of which is implanted and develops into foetus. Identical twins are genetically identical. If however seperation does not fully occur, then siamese twins arise.

(b) Dizygotic twins / Fraternal twins.

- Arise when the two ovaries simultaneously release ova both of which are fertilised and develop into foetuses. Fraternal twins are not genetically identical.

Parental care

- Is the attention given to the newborn eg food provision and security/protection.
- Mother's milk is the best food for the baby because it contains nutrients needed for its growth and development.
- From the first to the third day mammary glands produce Colostrum - yellow fluid containing proteins, lactose, antibodies, calcium and other mineral salts (but not iron), fats.
- Colostrum is later replaced with white



Milk has has all the above contents except antibodies. Milk lacks iron and the baby relies on iron stored in the liver during gestation.

Milk Letdown / Secretion

- Milk secretion is a reflex action which is affected by prevailing environmental conditions.
- When the breast is stimulated by touch or by crying of the baby or smell or sight of the baby, impulse is conveyed to the hypothalamus which in turn relays impulse to Pituitary gland. Pituitary gland secretes the hormone Oxytocin. Oxytocin is carried in blood and stimulates the lobules containing alveoli of the Mammary glands to contract forcing milk into the lacteferous ducts and then into the reservoirs (lacteferous sinus) behind the areola; from which the baby suckles the milk.
- Milk letdown requires a positive environment. Negative environment such as fatigue, embarassment etc inhibit milk secretion.

child labour

- Employment of under-age children to engage in activities such as baby-sitting, house help etc
- It is illegal as it interferes with schooling and skill development for better life.

Role of Hormones in human Reproduction

(a) Role of hormones in secondary sexual characteristics

- Secondary sexual characteristics are physiological,

structural and mental changes which are associated with feminity and masculinity in humans. occur as from puberty.

(i) secondary sexual characteristics in Males

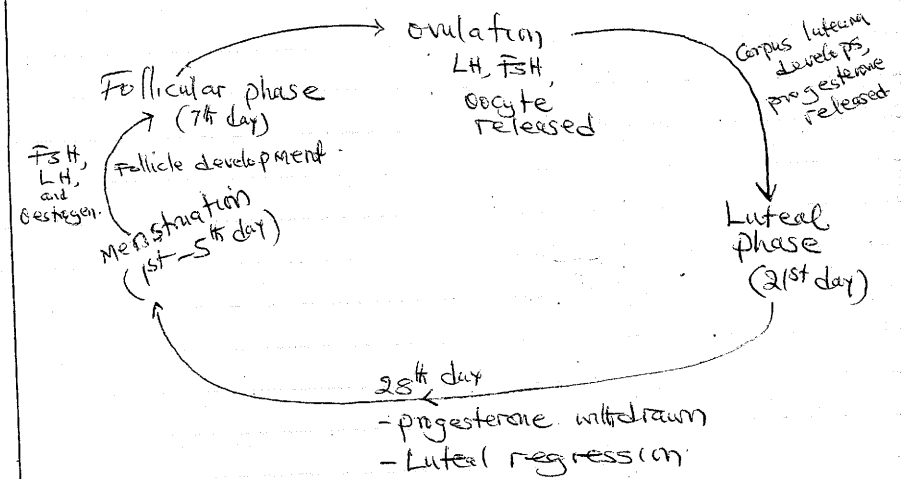
- As from puberty, the hypothalamus stimulates the pituitary gland to release the Follicle Stimulating Hormone (FSH) and luteinizing Hormone (LH). These are known as gonadotrophic hormones.
- FSH stimulates Synthesis of sperms and their maturation.
- LH also known as Interstitial cell stimulating hormone (ICSH) stimulates interstitial cells to release the male hormones known as the androgens eg Testosterone.
- Testosterone stimulates development of secondary sexual characteristics eg growth of the beard, armpit hairs, pubic hairs, enlargement of tetestes, sperm production, breaking of voice, widening of shoulders and general Masculinity.

(ii) Secondary sexual characteristics in females

- Puberty can start earlier in females eg at age of 10 years.
- Hypothalamus stimulates pituitary gland to release gonadotrophic hormones - Follicle stimulating hormone and Luteinizing hormone.
- FSH stimulates ovary to release a hormone known as oestrogen and triggers development of the Graafian follicles in the ovaries.
- As the level of oestrogen increases it triggers the onset of secondary sexual characteristics ie growth of armpit and pubic hairs, development of the mammary glands in breast, enlargement of hips or pelvic girdle, onset of Menstruation, ovulation and general feminity.
- In females the hormones are released periodically unlike in males.
- At a certain level, oestrogen triggers or stimulates pituitary gland to release the Luteinizing hormone. LH causes ovulation.
- After ovulation a hormone known as progesterone causes thickening and vascularisation of endometrium in readiness for implantation.

(b) Role of hormones in human Menstrual cycle.

- In human females, gamete production is a cyclic activity with an average periodicity of about 28 days. This is called menstrual cycle which can be divided into :-
  (i) Menstrual phase (about 1st – 5th day)
  (ii) Follicular phase (about 7th day)
  (iii) Ovulation phase (about 14th day ie 12th – 16th day)
  (iv) Luteal phase (around 21st day).
- The events of the menestrual cycle involves the ovaries (ie ovarian cycle) and the uterus (uterine cycle). These events are regulated by hormones secreted by the ovary which in turn is regulated by the gonadotrophic hormones from the pituitary gland.



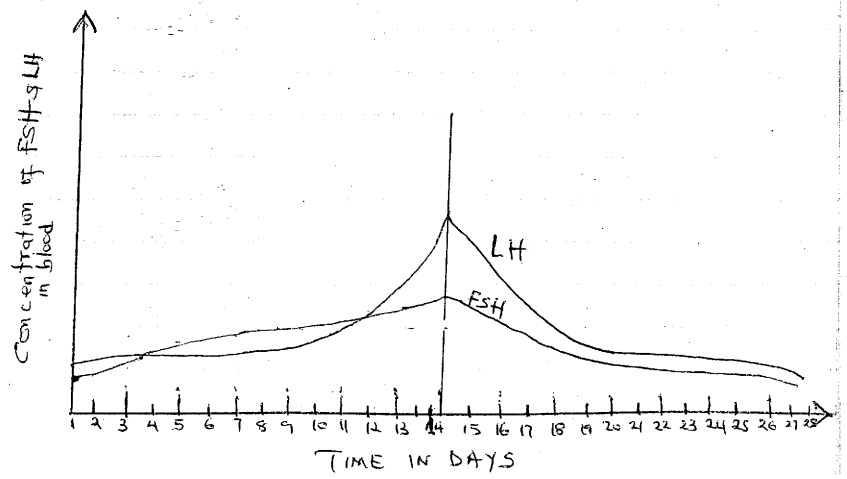
- The cycle begins with discharge of blood and debris (menses) from the uterus. Just before these, the female experiences backpains, nausea and abdominal pains.

ROLE OF HORMONES

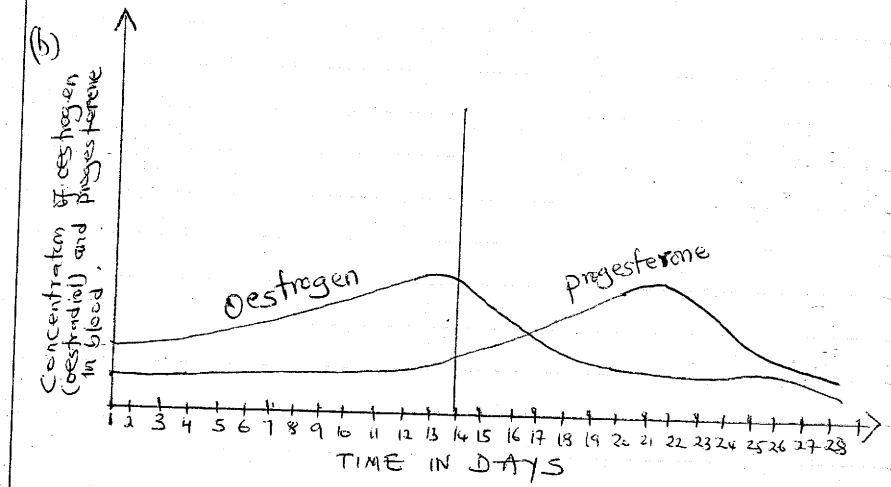
→ Just before menestruation, the anterior lobe of the pituitary gland secretes Follicle stimulating hormone (FSH). FSH causes or stimulates development of Graafian follicles in the ovary. It also causes/stimulates the wall of the follicles or theca to secrete another hormone known as oestrogen.

- Oestrogen causes healing and repair of the uterine wall which was destroyed during menestruation. Oestrogen also stimulates the anterior lobe of the pituitary gland to secrete another hormone known as Luteinizing hormone (LH).
- LH causes maturation of the Graafian follicles which then burst releasing the ovum, a process known as ovulation.
- After ovulation, the Graafian follicles are stimulated by LH and change to a yellow Mass of cells known as Corpus luteum. LH stimulates corpus to secrete another hormone known as Progesterone
- Progesterone causes thickening and increased blood supply to the endometrium ie proliferation of the endometrium, in readiness for implantation of the blastocyst. Progesterone also inhibits the anterior lobe of the pituitary gland from secreting FSH; thus no more follicles develop in the ovary and level of oestrogen reduces.
- In the next two weeks, progesterone level rises in blood and inhibits the anterior lobe of the pituitary gland from secreting LH. Hence corpus luteum degenerates and secretion of progestrone stops. This leads to menstriation. The anterior lobe of the pituitary gland secretes FSH again and the cycle is repeated. The whole cycle lasts for 28 days on average.

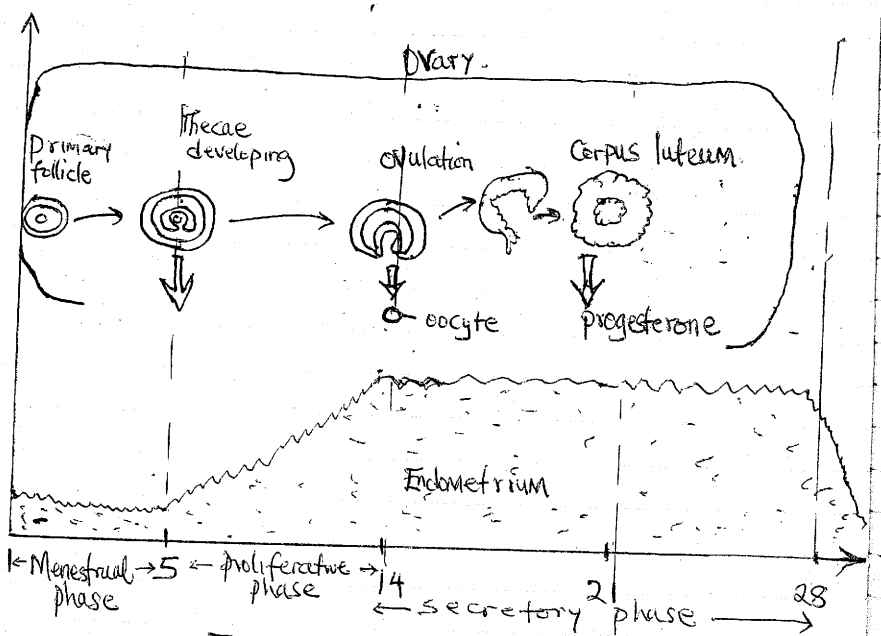
(a)



(b)



(c) Size of uterus wall (endometrium) during the Menestrual Cycle and events in the ovary.



Sanitary Health

- Women and girls have a right to proper sanitary health during menestruation. They have to use clean sanitary towels/pads and maintain personal hygiene. Hence sanitary pads/towels are zero-rated on VAT to increase accessibility to the towels.

Menopause

- Most women stop ovulating at the age of 45. This is called menopause. But men continue to produce sperms which are viable up to the age of 75.

Other emerging issues in human Reproduction.

① Contraception

- Knowledge of sex hormones and menestrual cycle has helped in manufacture of contraceptives for family planning eg condoms, pills, IUCDs, etc.

② Solving problems of infertility in Males

- Infertility problems due to low sperm counts in men can be solved by "in vitro" fertilization; where sperms are made to fuse with the ovum in a test-tube before implanted in uterus.

③ Sperm banks.

- Men who are far from their wives or are not ready for children can have their sperms stored in sperm banks for future use.

Sexually Transmitted infections (STIs)

Include:-

i, Gonorrhea
ii, Syphylis
iii, Trichomoniasis
iv, Candidiasis
v, Hepatitis B
vi, Herpes
vii, HIV & AIDS.

① Gonorrhea

- Caused by bacteria Neisseria gonorrhoeae which affects the urethra in males and vaginal tract in females.

Mode of Transmission :-

i, sexual intercourse with infected person.
ii, Mother to foetus at birth.

Incubation period — 2 to 4 days.

Symptoms

i, Itching of urethra or vaginal wall
ii, yellowish discharge
iii, Pain when urinating in males
iv, Unusual vaginal odour.

Control & Treatment:

i, Public education against indiscriminate sexual contacts
ii, Regular screening and treatment with antibiotics
iii, Use of Condoms.

- If left untreated, the disease affects other organs like spinal cord and urinary bladder and results in infertility / sterility in Males.

② Herpes simplex

- Caused by a virus Herpes Simplex virus.
- Mode of transmission is through sexual intercourse.
- Symptoms include :-

i, Vaginal and urethral ulcerations and itchy pains
ii, Urethral and vaginal discharges.

Prevention and Control

i, Creating public awareness against indiscriminate sexual intercourse.
ii, Abstenance from sexual intercourse
iii, Broad spectrum antibiotics

③ syphylis

- Caused by bacteria Treponema pallidium.
- Mode of transmission is through :-

i, Sexual intercourse with infected person.
ii, Blood transfusion from infected donar
iii, Mother to foetus.

- If untreated, the disease advances in three phases :-

(a) primary phase

- characterised by a solitary painless sore around sex organs / genitals and around anus. The sore may heal or go unnoticed. The phase gives no serological positive test (ie VDRL Test). Lasts for 10 - 90 days.

(b) secondary phase

- characterised by rash (Macules = discoloured spots and papules = pimples on skin) on body skin, hips, genitals and mouth; flue-like symptoms ie fever, headaches and body pains. Lasts for 2 - 6 weeks.

(c) Tertiary phase.

- Attacks other internal or visceral organs eg heart, liver, and CNS resulting in insanity.
- occurs 10 or more years of contact with the disease.

Treatment and Control.

i, Abstenance from sexual intercourse.
ii, Public education against indiscriminate sexual contacts and risky behaviour.
iii, Treatment of infected persons using antibiotics. Complicated cases require specialised medical attention

④ Trichomoniasis

—Caused by a protozoan Trichomonas vaginalis which thrives well in vaginal canal which is less acidic.

—Mode of transmission is through:-

(i) Sexual intercourse with infected person.

(ii) sharing contaminated underwears.

Symptoms

(i) Urethral and vaginal itching and pain.

(ii) Vaginal and urethral discharges.

—This may be associated with secondary bacterial infections complicating the disease.

Control and Treatment.

(i) Avoid sharing underwears

(ii) Abstenance from sexual intercourse.

(iii) Use of condoms.

(iv) Treatment using broad spectrum antibiotics.

⑤ Candidiasis.

—Caused by a fungus known as Candida albicans which resembles yeast.

—Mode of transmission is through sexual intercourse with infected people.

Symptoms

(i) Itching and burning sensation of genitals

(ii) White discharge which does not smell from the vagina.

—The fungus is normally present in vaginal canal and is infective when its population rises above normal due to change in vaginal pH or use of antibiotics which kill the bacteria that control the fungal populations.

Treatment and control.

(i) Use of anti-fungal drugs and creams to treat patients.

(ii) Avoid using strong-scented soaps/medicated soaps which alter vaginal pH.

(iii) Avoid back-to-front wiping after using toilet

(iv) Proper aeration of genitals eg using pure cotton and loose pants.

—The disease is opportunistic in women suffering from diabetes mellitus hence necessity of regular medical check-ups.

⑥ Hepatitis B.

—Caused by a virus known as Hepatitis B.

—Mode of transmission is through:-

(i) Sexual intercourse with infected person.

(ii) Blood transfusion from infected donar.

(iii) sharing of unsterilised syringes, needles and surgical blades; barber's instruments/impliments.

(iv) Kissing and sharing of dentist's impliments

(v) Transplacental mode ie mother to foetus.

—The virus is present in body fluids eg blood, milk, semen, vaginal mucosa, saliva, sweat, urine.

—Incubation period is 2-6 months.

—The DNA containing virus affects the liver causing jaundice, sever loss of appetite, nausea and fever.

Treatment and control.

(i) Vaccination — the best method.

(ii) High standards of personal hygiene.

(iii) Avoiding sexual contacts with infected people.

⑦ HIV & AIDS.

- AIDS in an acronym for Acquired immunodeficiency Syndrome.
- It is caused by the Human immunodeficiency Virus (HIV) type 1 (HIV I) and or type 2 (HIV II).

Mode of transmission

(i) Sexual intercourse with infected person.
(ii) Blood transfusion from infected donar.
(iii) Sharing of infected surgical and piercing instruments; eg needles, scopels, syringes.
(iv) Mother to foetus at birth.
(v) Mother to baby through breast feeding.

- The virus is found in body fluids eg blood, semen, vaginal mucosa/fluids, milk.
- The virus attacks T-helper cells or T lymphocytes and consequently impairs the immune system paving way for opportunistic diseases such as Tuberculosis, Diarrhoea, Meningitis, Kaposi's sarcoma etc.

Symptoms

(i) Recurrent oral thrushes.
(ii) Skin infections / Kaposi's sarcoma.
(iii) Drastic weight loss, >10% per month.
(iv) Chronic diarrhoea.
(v) Herpes zoaster/shingles / zona
(vi) Herpes simplex
(vii) Generalised inflammed lymph nodes.

Although the body develops antibodies against the virus, the rate of multiplication of the virus and its mutation are too high.

Prevention & Control

(i) Avoidance of indiscriminate sexual contacts or sex.
(ii) Avoidance of pre-dispesing factors such as excessive consumption of alcohol, wife inheritance, female genital Mutilation (FGM) traditional Circumcision methods, intravenous drug abuse etc.
(iv) screening of blood before transfusion.
(v) Avoid sharing of toothbrushes, razors and other piercing and surgical impliments.
(vi) Visting VCTs (Voluntary Counselling and Testing Centres).
(vii) Use of ARVs (Anti Retroviral drugs to reduce viral load.
(viii) Avoid pregnancy if HIV-positive / Avoid breastfeeding baby if HIV-positive.
(ix) Use of Condoms to reduce chances of infection.

Social and Economic Effects of HIV & AIDS

① Deaths affect the country's demographic Prozess thus lowering economic growth due to loss of manpower.
② Increased number of orphans who are a burden to extended family or state.
③ Gross Domestic product (GDP) of a nation (ie ability of a nation to exploit its resources) will be affected.
④ High cost of drugs and expenditure on drugs and medical services hence loss of investments, increase in poverty, decreased productivity due to lack of motivation.
⑤ Disrupted family life.
⑥ Psychological torture and feelings of suicide.

Advantages & Disadvantages of sexual and asexual Reproduction.

Advantages of Asexual Reproduction.

(i) Allows retention of useful characteristics of parents in the offspring.
(ii) There is abundant food for the offsprings hence they can survive temporarily under unsuitable conditions.
(iii) Does not result in indiscriminate and wide-spread dispersal which can be wasteful.
(iv) The offsprings establish faster and show early maturity.
(v) Independent of pollination, fertilization and dispersal.
(vi) Gives rise to a dense clump of plants which do not encourage competitors.

Disadvantages of asexual Reproduction.

(i) Undesired parental qualities are retained in the offspring.
(ii) Lack of variation leads to inability of offsprings to withstand changes with the environmental conditions.
(iii) Can result to overcrowding and hence stiff competition for resources.
(iv) Asexual reproduction gradually reduces in vigour and strength in successive generations.

Advantages of sexual Reproduction.

(i) Fertilization brings about mixing of genetic material from different genetic lines and hence recombination of characteristics which lead to desirable variations.
(ii) Desirable variations show hybrid vigour among offsprings eg increased yield, resistance to diseases, resistance to pests, resistance to drought; and hence high adaptability to environmental conditions.
(iii) As a source of variations, it provides basis for major evolutionary changes leading to formation of new strains or varieties.

Disadvantages of sexual Reproduction

(i) Impossible or difficult where males and females of same species are isolated.
(ii) May produce individuals with undesired qualities which may soon or later be eliminated.

4. GROWTH AND DEVELOPMENT

concepts of Growth & Development.

Growth

- Growth is the quantitative increase in the amount of protoplasm which is accompanied with permanent increase in the size and weight of an organism.
- For growth to occur, the following aspects are required:-
  i, Assimilation of nutrients by cells hence increase in mass.
  ii, Cell division by Mitosis that leads to increase in number of cells.
  iii, Cell expansion or elongation that leads to enlargement and increase in size of organism.
- Growth can be measured using parameters like mass, weight, length, height, mass and surface area against time.

Development

- Refers to changes in the complexity of an organism from the time it was a zygote or spore or single cell to the time of formation of adult body. It involves cell differentiation and formation of various tissues and organs specialised for different functions.
- Development involves :-
  i, cell differentiation.
  ii, cell specialisation and formation of various structures ie morphogenesis.
  iii, Growth.
- Development is a qualitative aspect

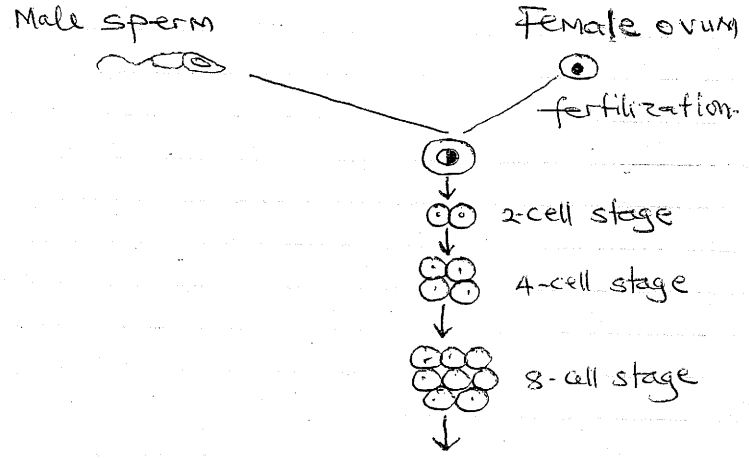
of growth and therefore can not be measured quantitatively. Development can be assessed in terms of increase in complexity of an organism eg development of leaves, flowers, fruits, roots in plants or growth of breasts, beard, armpit and pubic hairs, breaking of voice, widening of hips etc in humans

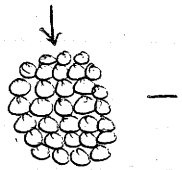
Growth and development in Animals

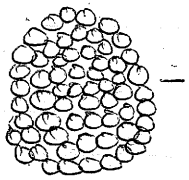
- Growth and development in animals starts from the time a zygote is formed after fertilization.
- The zygote undergoes cell division by mitosis or cleavage to form the embryo.
- The development of the fertilised ovum to form an embryo with all the characteristics of an adult is known as embryogenesis
- Growth and development in animals involves the following stages :-

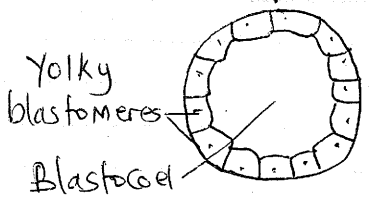
(a) cleavage

- Is the progressive mitotic division of the zygote in a geometric series as illustrated below :-




— 32 cell-stage

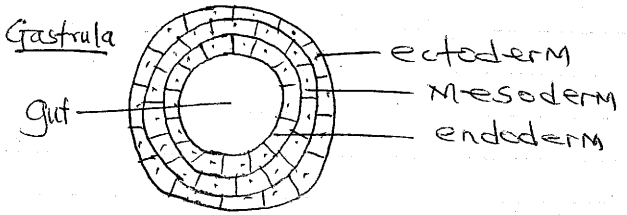

— 64-cell stage. A mass of cells known as Morulla



Vertical section of Blastula (blastocyst)

(b) Gastrulation

- Differentiation of the mass of cells ie Morulla into germ-layers - ectoderm, mesoderm and endoderm; with a gut or archenteron.



(c) Organogenesis.

- Formation of organs and organ systems from the germ layers. They arise as follows:-

(i) Ectoderm — epidermis of skin, nervous system, eyes, ears, nose.

(ii) Mesoderm — gut wall, visceral organs like

muscles, skeleton, circulatory system etc
iii, Endoderm - Inner gut lining, liver, Pancreas, lungs, heart etc.

(d) Development of extra-embryonic structures

- Cells of the developing embryo and uterus form extra-embryonic structures or membranes such as chorion, amnion, amniotic fluid, placenta, allantois, yolk sac and umbilical cord.
- some organs develop earlier than others eg heart and circulatory system.
- After birth, growth and development continues under the influence of the growth hormone or somatotrophin and later at puberty by gonadotrophic hormones such as oestrogen and testosterone.
- The lifespan of a human being can therefore be divided into infancy, juvenile, adolescence, adulthood and senescence.

Patterns of Growth

① Allometric and isometric growth.

- Allometric pattern of growth is one in animals where different organs/parts grow at different rates. This brings out much changes in shape of the organism as in birds and mammals.
- Isometric growth is a pattern of growth as in fish where different parts grow at the same rate. This results in no or little change in shape of the organism.

② Limited and unlimited growth.

- Limited growth is one in which an organism grows to an average maximum size beyond which growth stops eg in humans.
- Unlimited growth is one in which an organism grows continuously year after year until death eg woody perenial plants.

③ Intermittent growth / Discontinuous growth

- Exhibited in arthropods where growth occurs when exoskeleton is shed and stops when exoskeleton thickens. This occurs periodically and follows every moulting.

Types of Growth in plants.

① Primary or apical growth.

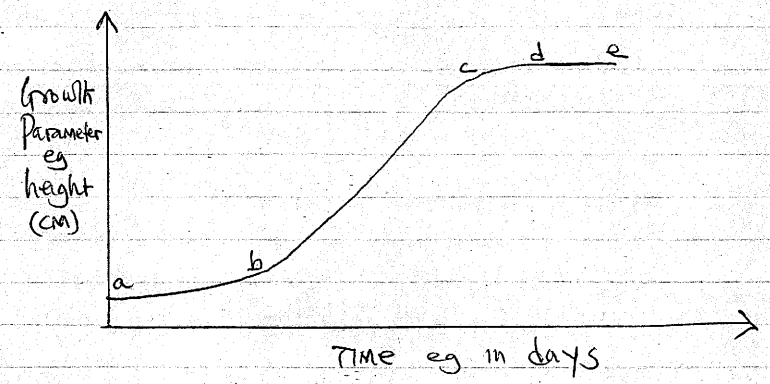
- occurs at the apical meristems resulting in increase in height.

② secondary growth or thickening.

- occurs due to division of cambium cells resulting in increase in width or girth of the stem or root.

Measurement of Growth

- Growth can be estimated by measuring some aspects of the organism such as height, weight, volume, length or surface area over a specified period of time.
- The measurements so obtained are plotted against time resulting into a growth curve.
- For most organisms, when the measurements are plotted against time, they give an S-shaped curve known as Sigmoid curve



Key

ab – Lag phase
bc – Exponential phase
cd – Decelerating phase.
de – plateau or stationary phase

– A sigmoid curve is due to the fact that the growth is initially rapid, then tends to slow as adult size is attained. The curve is divided into four phases :-

(a) Lag phase

– characterised by slow growth and occurs during initial stages. The growth is slow due to :-

i) Number of cells dividing are few.
ii) The cells have not yet fully adjusted to the environmental conditions / factors.

(b) Exponential or logarithmic phase

– characterised by rapid growth due to :-

i) An increase in number of dividing cells
ii) Cells have already adjusted to the environmental conditions.
iii) Environmental factors or resources are not limiting ie there is abundant food, space, light, oxygen etc.
iv) Rate of cell increase is faster than rate of cell death.

(c) Decelerating phase.

– characterised by slow and decelerating or declining growth due to :-

i) The fact that most cells are fully differentiated.
ii) Fewer cells are still dividing.
iii) Environmental factors become limiting eg shortage of food, accumulation of metabolic wastes, limited acquisition of CO_2 in plants, shortage of oxygen etc.

(d) plateau or stationary phase.

– Is the phase where overall growth has ceased and parameter under consideration remains constant. Due to :-

i) Rate of cell division is equal to rate of cell death.
ii) Nearly all the cells are fully differentiated

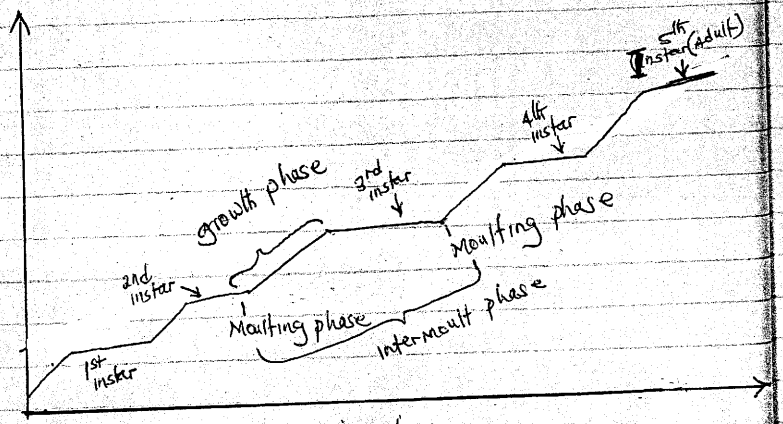
– The nature of the curve in this phase depends on the type of organism, nature of the parameter under consideration and internal factors; hence may result in varying shapes as follows :-

i) positive growth – Curve may continue to increase slightly until death eg Monocot leaves, reptiles and fish.
ii) No further change / flattens.

(c) Negative growth as in humans due to senescence.

Intermittent growth curve.

- In arthropods eg insects, growth is intermittent due to presence and shedding of exoskeleton.
- When the exoskeleton thickens cell expansion and hence growth stops. When moulting occurs, the young cuticle / exoskeleton formed is elastic and can allow cell expansion hence growth occurs. When the exoskeleton thickens cell elongation stops hence growth also stops. This leads to a stair-case like or step-wise like pattern of growth known as intermittent growth and hence intermittent growth curve, as in grasshoppers, shown below :-



i, Moulting phase

- When exoskeleton is shed Also known as ecdysis. This allows cell expansion to commence since the young cuticle secreted can allow this expansion and hence growth.

ii, Growth phase

- Due to absence of the old thick cuticle due to ecdysis, there is rapid cell elongation and hence growth.

iii, Intermoult phase

- Is the phase between one moulting and another. When exoskeleton is thick and intact, growth stops. only cell division can occur but no cell elongation. When the old cuticle is shed, cell elongation and growth occurs.

Measurement of Growth.

- Measurement of growth can be done using the following materials :-

i, metre rule / tape measure or graduated thread with ink marks - for measurement of height or length changes.

ii, Weighing machine and means of heating for measurement of weight and biomass or dry weight.

iii, Grid paper / graph paper for measurement of surface area eg of a leaf.

- The most accurate method of determining growth is by measurement of dry weight or biomass of an organism, ie mass obtained after drying to remove water. This is the best indicator of increase in protoplasm.
- On the other hand, fresh weight of an organism is unreliable because water content of an organism fluctuates with environmental conditions or seasons.
- Although dry weight is reliable, accurate and shows increase in protoplasm, it has the

following drawbacks / shortcomings / limitations :-
(i) Kills the whole organism / standing crop.
(ii) Is convenient to small organisms where samples can be taken.
- once results are obtained, they are recorded over a specified period and then analysed eg working out average growth rate, graphical analysis etc.

Examples of Measurement of Growth

(1) Growth Rate of a single leaf on a plant.

(a) Measurement using length of the leaf.

- Choose or identify a young leaf on a plant which has just unfolded.
- Use the same leaf throughout the experiment.
- Measure the total length of the whole leaf using a ruler.
- Record the length and repeat the procedure at regular intervals; until no more changes in length occur on the leaf; ie constant length is obtained.
- Determine the average growth rate by dividing the total increase in length by the period taken to achieve the final length ie

$$\text{Average growth Rate} = \frac{\text{Total increase in length}}{\text{Time taken to achieve final length.}}$$

(b) Measurement using area of the leaf.

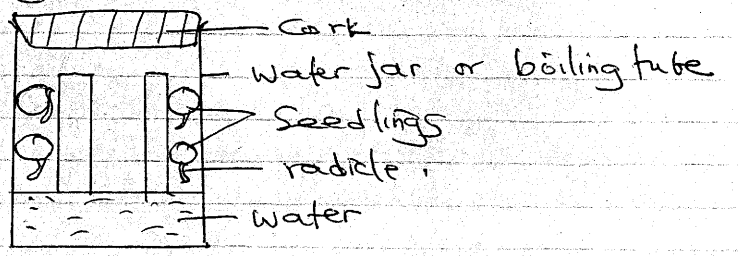
- Choose or identify a young leaf on a plant which has just unfolded.
- Use the same leaf through out the experimental period.
- Trace the outline of the leaf on a graph paper and work out the surface area by totalling the numbers of full squares and the half squares divided by two.
- Record the results. Repeat at regular intervals until constant area is achieved.

$$\text{Average growth Rate} = \frac{\text{Total increase in area}}{\text{Time taken to achieve the final area.}}$$

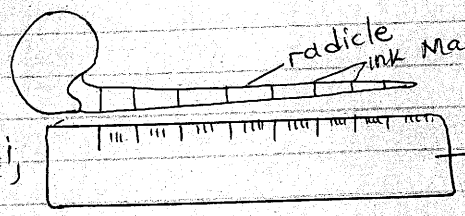
(2) Measurement of Growth Rate of a seedling using the radicle and determination of growth region of the radicle.

- place water in a waterjar to a depth of 5cm. Line the inside of the jar with a roll of blotting paper.
- Take several bean seeds which have been soaked in water overnight and place them between the blotting paper and wall of the jar 10cm from the bottom.
- Leave the beans until the radicle emerges to a length of about 1cm.

(i)

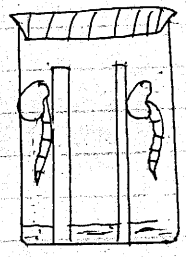


- Remove the seedlings from the jar and select those whose radicles have grown straight.
- Mark the radicles at 2mm intervals with indian ink and a graduated thread.

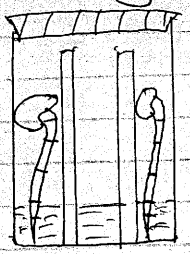


(i)

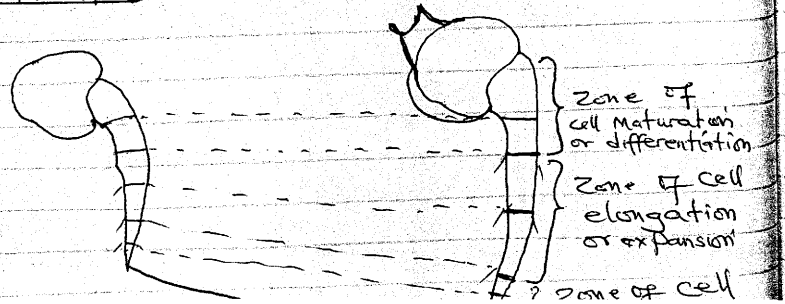
- Replace the seedlings into the water jar or boiling tube as before.
- At set regular time intervals, remove the seedlings and measure the lengths of the radicles as well as the length of each division for about 5 days.
- Analyse the results and plot a growth curve of the seedling.



(iii)



(iv)



(v)

- It is observed that the greatest increase in length of the ink marks occurs at the area 2cm above the root tip. This is the growth area of the seedling.

$$\text{Growth Rate} = \frac{\text{Total increase in length (mm)}}{\text{Time taken in days.}}$$

$$\text{Percentage growth Rate} = \frac{\text{Total increase in length (mm)}}{\text{Time taken in days}} \times 100\%$$

- The region or area of growth of a radicle of a seedling is the zone of cell elongation or expansion. The region is found to be about 2cm above the root tip. Below the region of cell elongation is the region of cell division where cells actively divide before elongating in the region of cell elongation. Above the region of cell elongation is the region of cell differentiation or cell maturation where different tissues begin to form.

Growth and development in plants.

- Growth in plants starts with germination of the seed to a seedling or sprouting of the bud.

Physiology of germination of a seed to a seedling.

- The seed absorbs water by imbibition via the micropyle.
- The water stimulates the cotyledons

or embryo tissues to secrete hormones such as auxins, cytokinins and gibberellins.
- The plant hormones stimulate the Cotyledons to secrete hydrolytic enzymes thereby promoting digestion of complex food materials to simple soluble food materials; eg:-

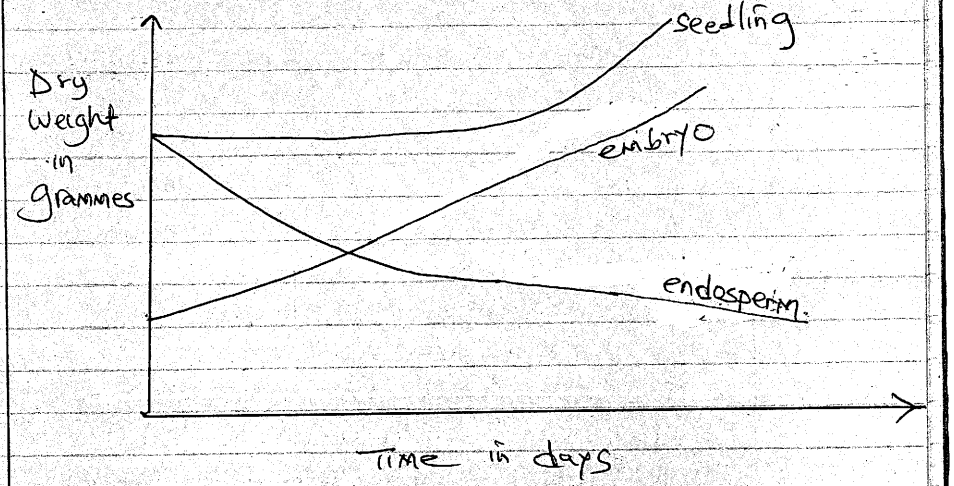
(i) Starch $\xrightarrow[\text{or diastase}]{\text{amylase}}$ Maltose $\xrightarrow{\text{Maltase}}$ Glucose

(ii) Sucrose $\xrightarrow[\text{or invertase}]{\text{sucrase}}$ Glucose + fructose

(iii) Proteins $\xrightarrow{\text{Proteases}}$ amino acids

(iv) Lipids $\xrightarrow{\text{Lipases}}$ fatty acids + glycerol.

- The simple sugars and fatty acids and glycerol are oxidised to yield energy for germination.
- Amino acids and fatty acids and glycerol and simple carbohydrates are used in formation of new cell structures.
- Auxins and cytokinins stimulate cell division. Auxins also stimulate cell elongation bringing about growth of the plumule and radicle.
- During the early stages of germination food stored in the Cotyledons or endosperm is used. During this time the dry weight of the endosperm and Cotyledons decreases whereas while the dryweight of the embryo increases because the food reserves in the endosperm and Cotyledons are broken down and converted to protoplasm of the embryo. The dry weight of the seedling initally remains constant but when the first foliage leaves form and photosynthesis begins to take place, both the fresh weight and dry weight of the seedling begin to increase. These changes are illustrated in the graph below:-



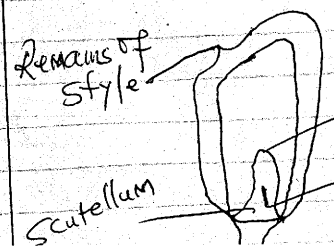
- During germination, the radicle emerges out through the micropyle to form the root and plumule also comes out when seed coat bursts to form the shoot.

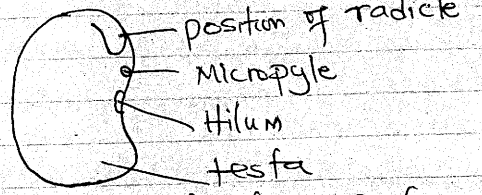
Structure of a Seed and changes that occur during germination.

(a) Structure of a Seed.

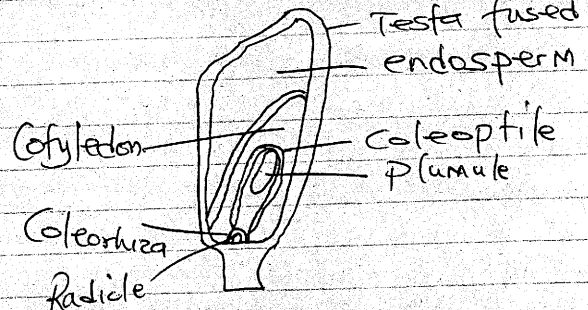
- A typical seed consists of a seedcoat enclosing the embryo.
- The seedcoat in most seeds has the outer layer testa and the inner layer tegmen. The testa is thick whereas tegmen is transparent. The

seed coat protects the inner parts from invasion by bacteria, fungi and other pathogens.
- The scar known as hilum on the concave part of most seeds is the point of attachment to the funicle.
- Near one end of the seed is a tiny opening called micropyle which allows in water into a seed by imbibition, and also air into the embryo.
- The embryo has one or two cotyledons or seedleaves for storage of food. a plumule which grows into a shoot and a radicle which grows into a root The tip of the radicle is opposite to the micropyle.
- In some seeds, cotyledons are swollen and store food for the embryo. Such seeds are described as non-endospermic seeds; eg beans, peas, groundnuts.
- In other seeds, there is only one cotyledon and food for the embryo is mainly stored in the endosperm. Such seeds are described as endospermic seeds.
- Dicotyledonous seeds are mainly non-endospermic whereas monocotyledonous seeds are endospermic.

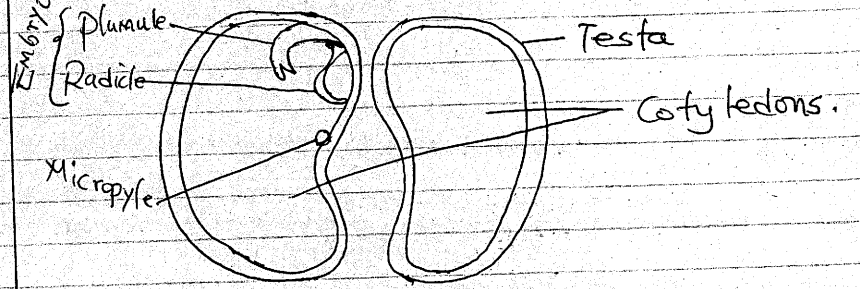




(b) External structure of bean seed.



(c) Internal structure of Maize grain



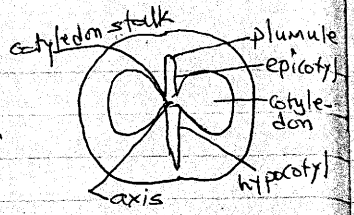
(d) Internal structure of bean seed.

(b) Changes that occur during germination

i) Dicotyledonous seeds eg beans

- Seed coat bursts after softening in water
- hypocotyl elongates upwards pushing out the cotyledons and plumule upwards and the radicle downwards and outwards through the

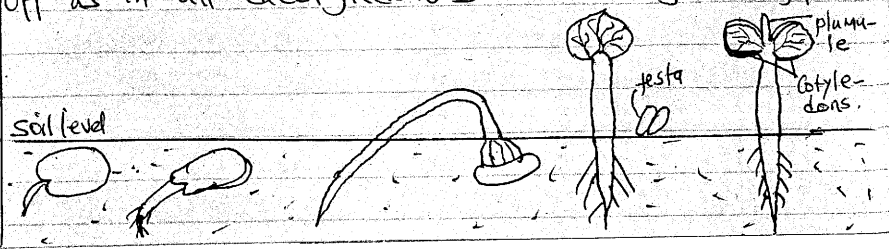
micropyle.
- Radicle forms the root.
- Plumule forms the shoot.



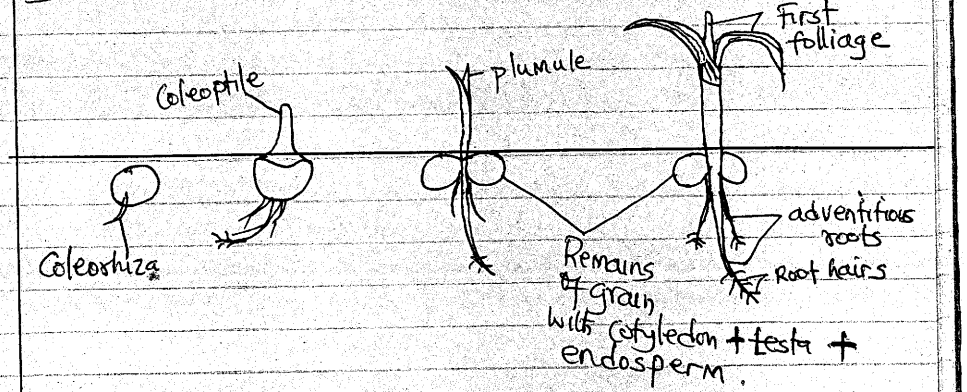
ii, Monocotyledonous seeds
- Testa softens in water and bursts.
- Epicotyl elongates pushing the plumule upwards and outwards. The cotyledon thus remains in the soil ie does not come out with the cotyledons. Endosperm also remains underground.
- The radicle emerges out through the micropyle to form the root whereas the plumule forms the shoot. The radicle is protected by **Coleorhiza** whereas the plumule is protected by the **Coleoptile**. Later the endosperm and cotyledons shrivel here in the soil when the first foliage leaves form and begin to photosynthesise.

Types of Germination.

① Epigeal Germination.
- Germination in which cotyledons are thrust above the ground surface together with the plumule as a result of elongation of the hypocotyl.
- The cotyledons develop chlorophyll and photosynthesise until the first foliage leaves form. After this they shrivel and pluck off as in all dicotyledonous seeds eg beans, Pear.



② Hypogeal germination.
- Germination in which the epicotyl elongates pushing out the plumule above the soil surface but leaving cotyledons and testa below the soil surface.
- The cotyledons and endosperm provide the first food to the seedling until the first foliage leaves develop and begin to photosynthesise. This occurs in all monocots eg Maize, Sorghum, Millet and rice.



NB ① The coleoptile protects the plumule in monocot seedlings whereas coleorhiza protects the radicle
② In dicot seedlings the hypocotyl :-
i, protects the delicate shoot tip by breaking the ground.
ii, pulls the cotyledons and plumule from the ground.

Conditions necessary for Germination.

① Water/Moisture
- Plays the following roles :-

(i) Activates hydrolytic enzymes and provides medium for the enzymes to break down stored food into simple soluble forms.
(ii) Hydrolysis and dissolution of food
(iii) Provides medium for transport of soluble food to growing regions of radicle and plumule.
(iv) Softens seed coat allowing emergency of radicle.

③ Air or Oxygen.
- Required for oxidation of stored food to yield energy for germination during respiration.
- Hence seeds in water logged soils or deeply buried in the soil do not germinate.

② Temperature
- Optimum temperature of about 30°c in most seeds is required to activate the enzymes involved in germination.
- Very high temperature destroys the protoplasm and denatures enzymes.
- Very low temperature inactivates enzymes responsible for germination.

④ Enzymes
- Enzymes are required for:-
(i) Hydrolysis of stored food to simple soluble forms.
(ii) Oxidation of stored food to yield energy.
(iii) Conversion of insoluble food to soluble form which can be transported to growing regions.
(iv) Conversion of simple food materials eg amino acids to new plant tissues.
- Examples of such enzymes include carbohydrases eg amylase / diastase, lipases, maltases, proteases etc.

⑤ Hormones
- Stimulate growth by activating secretion of enzymes from cotyledons eg maltase, diastase, amylase, lipase etc.
- Neutralises germination inhibitors eg Abscisic acid (ABA)
- Examples of plant hormones include auxins, gibberellins, cytokinins etc.

⑥ Viability of seeds.
- Only living seeds can germinate.
- Seeds stored for along time lose viability hence can not germinate. So applies to seeds with immature embryo and those stored in poor environmental conditions.

NB - Water/Moisture, Oxygen/air and temperature are external factors whereas enzymes, hormones and viability of seeds are internal factors of germination.

DORMANCY in seeds

- Dormancy in seeds is a period of rest

in which an embryo of a fully developed seed passes through after ripening during which it can not germinate even if all the conditions for germination are provided.

- During dormancy, seeds perform their physiological processes slowly and use up little stored food.
- During this time, the seed embryo needs to undergo further development before germination occurs.
- Dormancy may be relative as in maize or absolute as in lettuce.
- It may take days, weeks, months or even years.
- Dormancy is more common in the temperate than in the tropical habitats

Importance of Seed Dormancy.

(i) It provides the seeds with enough time for dispersal so that they can germinate in suitable habitats.
(ii) Enables the seeds to survive harsh environmental conditions without depleting food reserves.
(iii) Enables the embryo to develop fully until favourable conditions are available eg availability of water.

Factors that Cause Seed dormancy.

(I) Immaturity of embryo
(II) Presence of germination inhibitors
(III) Absence or low concentrations of hormones and enzymes.
(IV) Hard and impermeable seed coats which do not allow in water and air.
(V) Freezing of seeds during winter conditions which inactivate enzymes.
(VI) In some seeds, absence of certain wavelengths of light eg lettuce.
(VII) Lack of favourable environmental conditions eg water and oxygen.

Ways of breaking Seed Dormancy.

(1) Scarification or weakening of seed coat, for seeds with impermeable seed coats. This is achieved naturally by saprophytic fungi in the soil or when the seeds are passed along guts of animals; by enzymes.
(2) Increasing concentrations of hormones eg cytokinins and gibberellins to stimulate germination.
(3) Providing favourable environmental conditions eg water, temperature, oxygen.
(4) Providing suitable wavelengths of light to trigger secretion of hormones eg gibberellins.
(5) Allowing more time for embryo maturity.
(6) Application of synthetic plant hormones eg gibberellins.
(7) Heat stimulus eg boiling, roasting to some seeds eg Acacia hearnsii (black wattle).

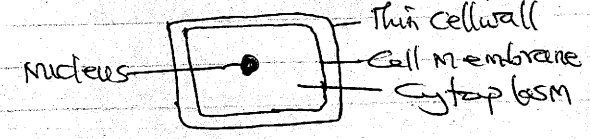
Types of Growth in plants

- Includes :-
  (i) Primary growth
  (ii) Secondary growth.

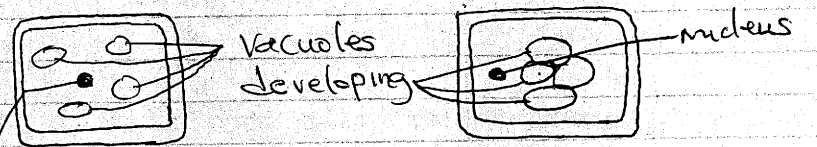
- The regions of growth in plants include:-
(i) apical Meristems of shoot tip.
(ii) apical Meristems of root tip.
(iii) Cambium Meristems in cambium tissue.
(iv) Meristems at base of young leaves
(v) Meristems at bases of internodes
(vi) Cork Cambium.
- Apical Meristems at shoot tip and root tip are responsible for primary growth whereas Cambium Meristems are responsible for secondary growth in flowering plants.
- Meristems are a group of undifferentiated cells in plants which are capable of Mitotic Cell divisions.

Primary Growth

- Primary growth occurs in apical Meristems of roots and shoots causing increase in length or height.
- Meristematic cells are found about 2cm below the tip of the shoot and about 2cm above the tip of the root
- These meristematic cells are:-
(i) small
(ii) thin-walled (have thin cellwalls)
(iii) with dense cytoplasm
(iv) with no vacuoles.

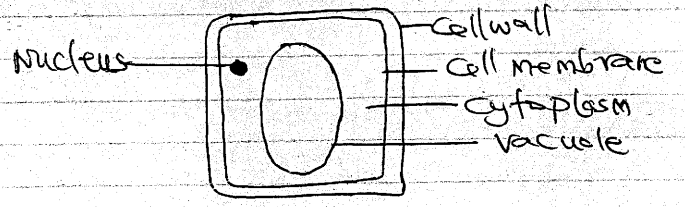


- These Meristematic cells constitute the Zone of cell division; and arise from embryonic tissues.
- As Mitosis occurs, one of the daughter cells remains Meristematic hence forming the zone of cell division; whereas the other daughter cell takes up water by osmosis, develops vacuoles and expands by stretching of the thin cellwalls leading to growth. The cells in this region constitute the Zone of cell elongation or cell expansion which is below the zone of cell division in shoots and above zone of cell division in roots.



Nucleus.

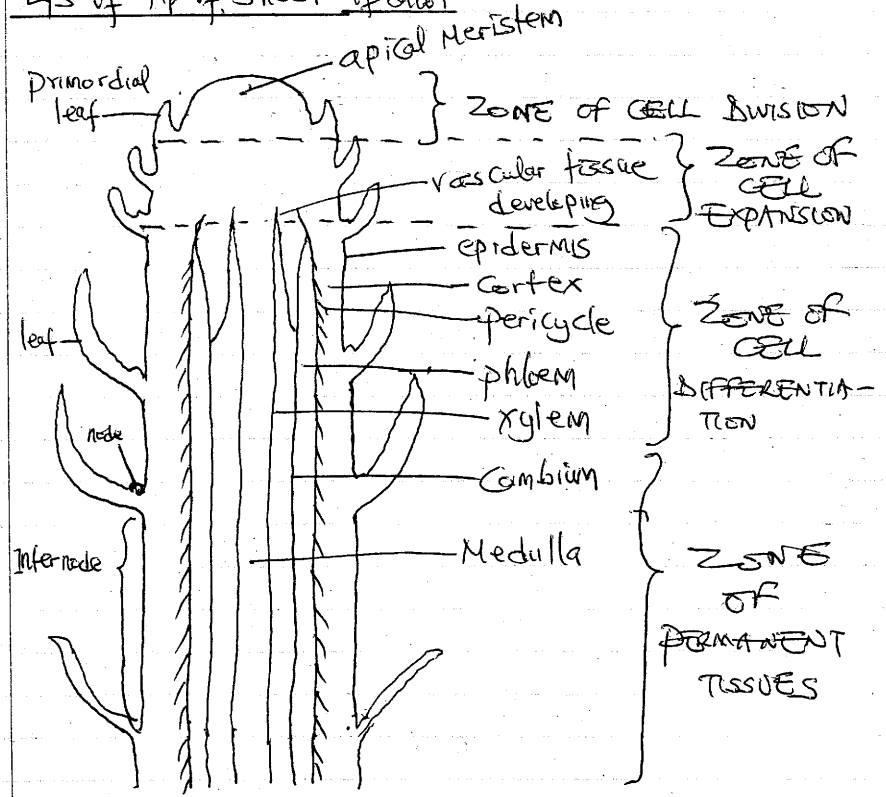
- Further back for the shoots and further above for the roots is the zone of cell differentiation or zone of cell maturation. Here the cells attain Permanent sizes, have large vacuoles and thickened walls



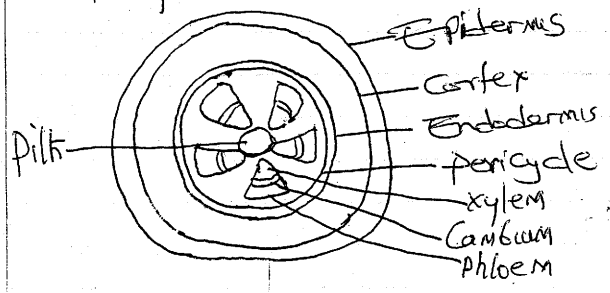
- The cells begin to specialise to carry out their functions. Such include piliferous layer (young epidermis which gives rise to root hairs), primordial leaves, phloem, xylem, Carter, endoderms, pericycle and pith at the centre.

In young root of a dicot, xylem occupies the centre and is star-shaped with the phloem alternating at its arms, followed by pericycle, endodermis, cortex and then the epidermis / piliferous layer.

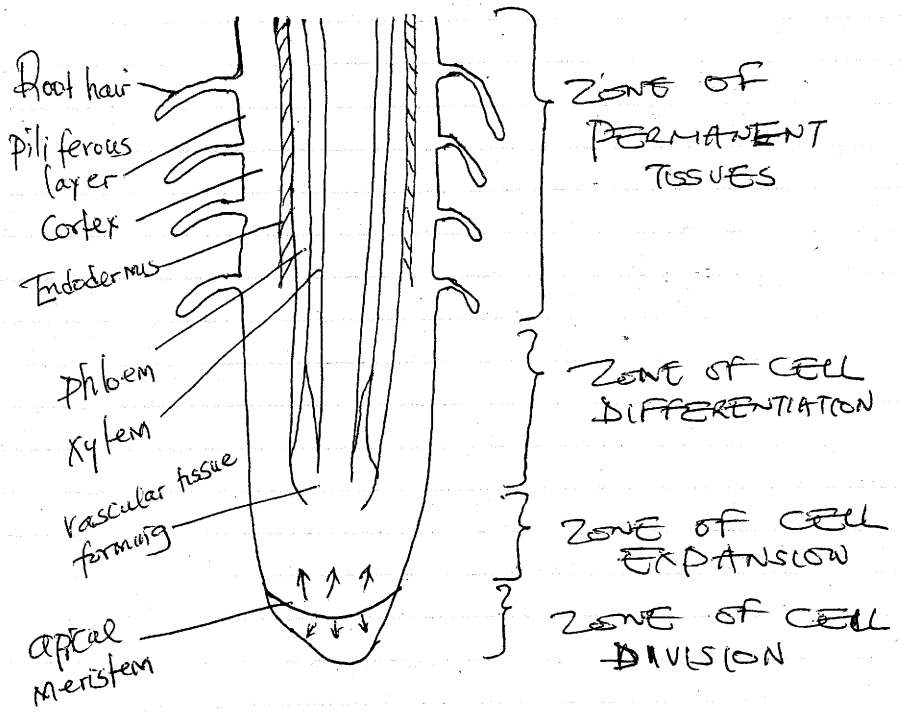
L/s of tip of shoot of dicot



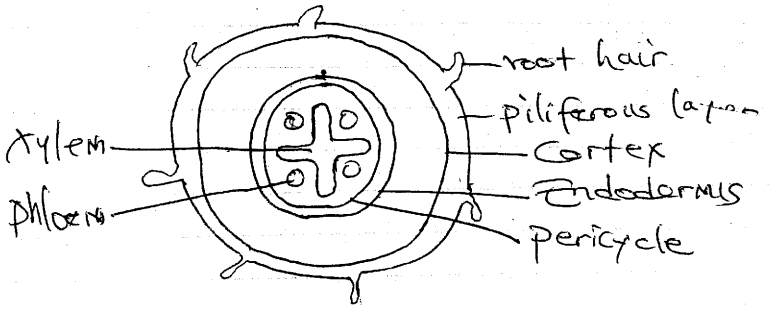
T/s of a dicot shoot



L/s of dicot root



T/s of Dicot root



Secondary growth / secondary thickening
Growth in girth

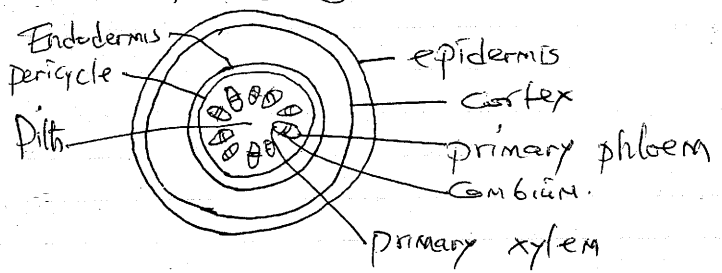
- Is a growth which results in increase in width or girth or diameter of a plant due to activity of Cambium tissue.
- It occurs in dicots. Monocots lack Cambium tissue hence do not undergo secondary thickening. The slight increase in diameter of the plant is due to the enlargement of primary cells.
- Secondary growth in dicots begins with the division of the vascular cambium; to produce new cells.
- These cells differentiate into secondary tissues added to the older primary xylem and primary phloem, as secondary xylem and secondary phloem respectively. This division of Cambium to produce new tissues results in formation of the Cambium ring which is cylindrical.
- More secondary xylem is formed than secondary phloem resulting in the formation of wood. This helps in giving the growing plant support.
- The interascular Cambium also cuts off parenchymatous pith cells which form secondary medullary rays.
- As a result of increase in volume of secondary tissues pressure is exerted on the outer epidermal cells resulting in rapturing of the epidermal cells.
- Hence a new band of Cambium cells called Cork Cambium or phellogen arises or originates in the cortex to replace the protective epidermal layer.
- The Cork Cambium divides and differentiates into secondary cortex (phelloderm) to the inside and Cork cells to the outside.
- Cork cells are dead thick-walled cells which are suberised ie covered with waterproof suberin.
- Cork cells increase in number and form the bark which protects the plant against water loss, infections, insects, damage by fire etc.
- Because cork is impermeable to water and respiratory gases, at certain points it breaks to a loosely packed mass of cells forming lenticels for gaseous exchange.
- During rain season, secondary xylem vessels formed as well as tracheids are large, many and thin-walled hence giving wood a lighter texture.
- During dry season, the secondary xylem vessels are tracheids formed are small, fewer and thick-walled giving wood a darker texture. This results in formation of annual rings.

NB:-

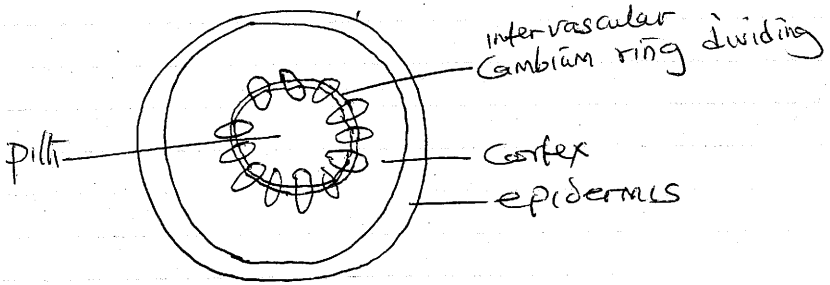
1. It is possible to determine the age of a tree by counting the number of annual rings. Climatic changes of the past years can also be inferred from the sizes of annual rings.
2. Cork (phellem) + secondary cortex (phelloderm) + cork cambium (phellogen) ⟶ periderm.
3. Growth in plants is sigmoid.

Diagramatic illustrations of secondary growth in flowering plants.

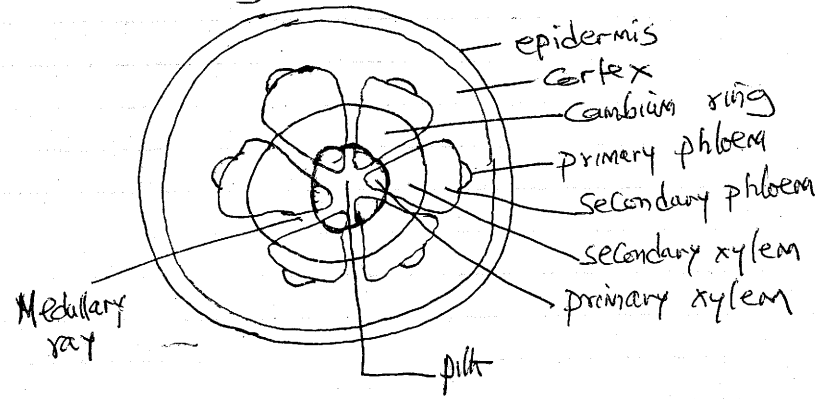
i, T/s of a young dicotyledonous stem:



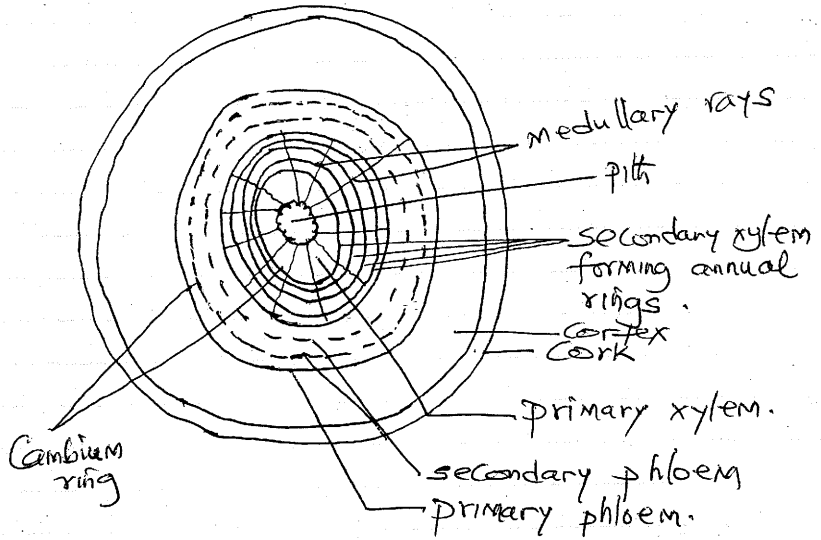
ii, Beginning of secondary growth in dicot stem (layers surrounding vascular bundles omitted in the diagram).



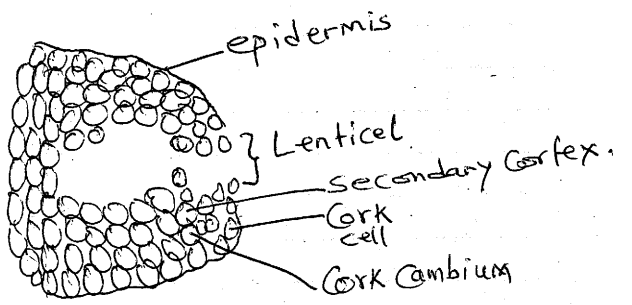
iii, Secondary growth has occured



iv, Annual rings



v, Section through a lenticel



Role of hormones in plant growth and development

- plant hormones are chemicals produced in very small quantities within the plant body and influence plant growth and development.
- Most of the growth hormones in plants are

produced at the tip of the shoot and are transported downwards to the root
- The root tip also produces very small quantities of the hormones.
- The important plant hormones include:-
(i) auxins eg indoleacetic acid.
(ii) Gibberellins
(iii) Cytokinins or kinetins
(iv) Abscisic acid (ABA)
(v) Ethylene (Ethene)
(vi) Florigens
(vii) Traumatins.

(1) Auxins eg Indoleacetic acid

(i) promotes or stimulates cell elongation leading to primary growth.
(ii) causes tropic responses in plants eg phototropism.
(iii) Stimulates growth of adventitious roots which develop from the stem. Hence encourages formation of roots from stem cuttings.
(iv) Induces parthenocarpy ie growth or development of a fruit from a flower without fertilization.
(v) promotes apical dominance in plants by inhibiting growth of lateral branches.
(vi) promotes secondary thickening by stimulating cell division in the Cambium tissue and the differentiation of Cambium cells to vascular tissue.
(vii) In conjuction with cytokinins, auxins induce formation of Callus tissue which causes healing of wounds.
(viii) In low concentrations or when the concentrations of auxins falls, it promotes formation of abscission layer leading to leaf fall.

(2) Gibberellins eg Gibberellic Acid (GA_3)

(i) Promotes cell division and cell elongation in dwarf plants or dwarf varieties of certain plants. Dwarfness in plants is due to shortage of gibberellins due to genetic deficiency.
(ii) Induce parthenocarpy and fruit formation after fertilization.
(iii) Promotes formation of side branches from lateral buds hence ending or breaking apical dominance. Also breaks bud dormancy in temperate lands.
(iv) Inhibits sprouting of adventitious roots from stem cuttings or any stem.
(v) Retards formation of abscission layer hence reduces leaf fall.
(vi) Breaks seed dormancy by activating hydrolytic enzymes involved in breakdown of food during germination. Therefore it promotes seed germination.
(vii) Retards leaf expansion thereby affecting leaf expansion and shape.

(3) Cytokinins / Kinetins

(i) In the presence of auxins, they stimulate cell division thereby bringing about growth of roots, leaves and buds. This is achieved

by stabilising proteins and chlorophyll.
(ii) Stimulate formation of callus tissue, in conjuction with auxins for healing of wounds in damaged plant parts.
(iii) Breaks dormancy in some species.
(iv) Promotes flowering in some species
(v) In high concentrations, it causes cell enlargement in leaves but in low concentrations it encourages leaf senescence and fall.
(vi) It stimulates lateral buds development
(vii) Promotes formation of adventitious roots on stems.

(4) Ethylene / Ethene.

- Produced in gaseous form and has the following effects on plant growth and development:-
(i) Causes uniform ripening of fruits eg bananas.
(ii) Stimulates formation of abscission layer leading to leaf fall and fruit fall.
(iii) Induces thickening of stems by promoting cell division and differentiation in the cambium tissue or meristem. In this way ethylene inhibits stem elongation.
(iv) Breaking of seed domancy in some species.
(v) Promotes flower morphogenesis in some plants eg pineapples.

(5) Abscisic acid (ABA)

- Has inhibitory effects in nature including:-
(i) Inhibits seed germination causing seed dormancy.
(ii) Inhibits sprouting of buds from stems.
(iii) Causes abscission of fruits and leaves; causing leaf fall and fruit fall.
(iv) Induces dormancy in buds.
(v) Inhibits stem elongation or growth when in high concentrations.
(vi) High concentration of ABA causes stomatal closure by interfering with uptake of K^+ ions.

(6) Florigen

- promotes flowering.

(7) Traumatin

- causes healing of wounds by formation of the callus tissue.

Apical Dominance

- Condition in which presence of the apical bud inhibits growth of lateral buds due to high auxin concentration in the apical bud than in the lateral buds.
- If the apical bud is removed / nipped off, lateral buds sprout leading to formation of side branches and a bush. This is because the suppression from the apical bud is removed being the source of the high auxin concentration.
- This shows that a higher auxin concentration from the tip of the shoot and flowing downwards favours growth of apical buds more than the

the lateral buds which have a lower auxin concentration.
- This principal is applied in pruning of tea, coffee, hedges etc which leads to formation of many side branches thus increasing yield and accessibility to harvesting.

NB: ① How to differentiate between auxins and gibberellins.

i, Gibberellins promote stem elongation in dwarf varieties only while auxins promote general stem elongation.
ii, Auxins induce tropic responses whereas gibberellins do not.

② Applications of plant hormones in Agriculture.

① Breaking Seed dormancy eg GA_3 ie Gibberellic acid
② As herbicides eg Synthetic hormone 2,4-Dichlorophenoxyacetic acid (2,4-D). This is a synthetic auxin which causes abnormal growth / distorted growth in weeds due to its ability to cause abnormal respiration in the weeds.
③ Inducing parthenocarpy ie auxins and gibberellins.
④ Fruit ripening (by ethene) and fruit fall or harvest (using ABA and ethene).

Growth and development in insects

- As in other animals, most insects' cells except nerve cells retain their power of cell division. Hence cell division is continuous throughout but unlike plant cells, cell enlargement is very limited.
- Most animals experience continuous growth until death but insects experience discontinuous growth just like other arthropods due to presence of exoskeleton which has to be shed periodically to allow growth.
- Insects have two types of reproduction:-
  ① Sexual reproduction as in butterflies, moths, cockroaches, grasshoppers, etc
  ② Asexual reproduction or parthenogenesis - where eggs which are unfertilised hatch into adult insects as in black and green aphids.

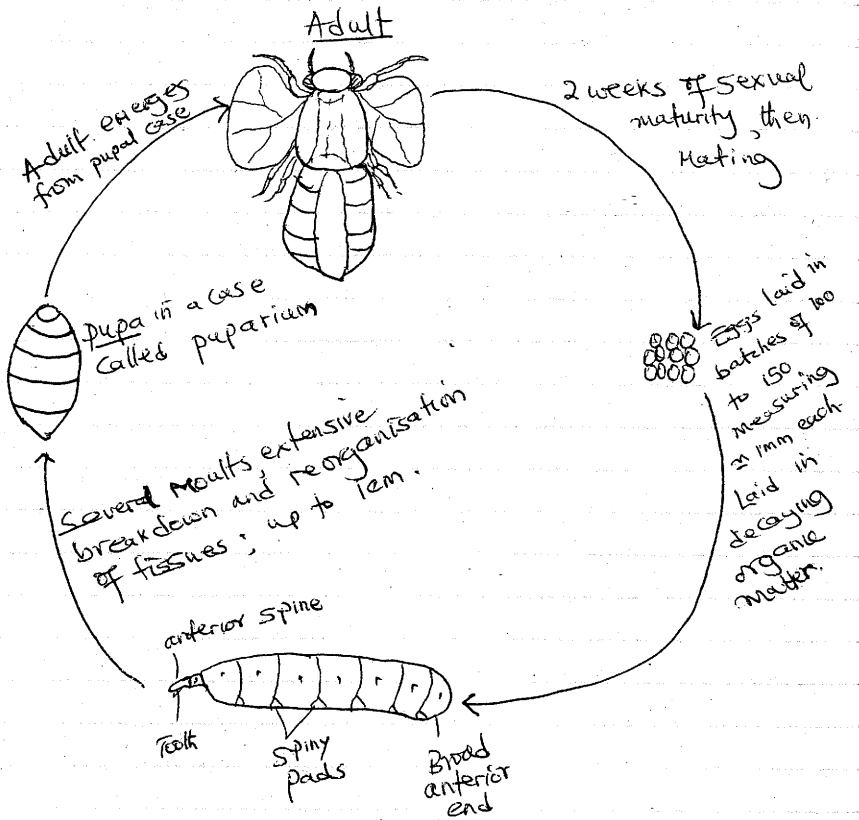
Life history of insects

(a) Complete metamorphosis ie holometabolous insects.

- Involves change of an insect from egg to larva to pupa and finally to adult or imago.
- Larva may have other names eg. grub, maggot, caterpillar etc. Larval stage is the most active phase involving alot of eating and formation of tissues. It also involves moulting of cuticle until it reaches the full size of the pupa.
- Pupal stage is inactive phase involving extensive breakdown of tissues and also reorganisation to form new organs or tissues

until the adult is formed.

(a) An Example of complete Metamorphosis — Housefly (Musca domestica)



(b) Examples of incomplete Metamorphosis ie Hemimetabolous insects

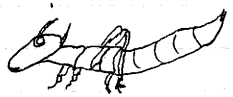
- Incomplete Metamorphosis involves the egg hatching into nymph which then undergoes several moults to transform to an adult.

- A nymph has all the features of the adult but is smaller and sexually immature.

Incomplete Metamorphosis in :-

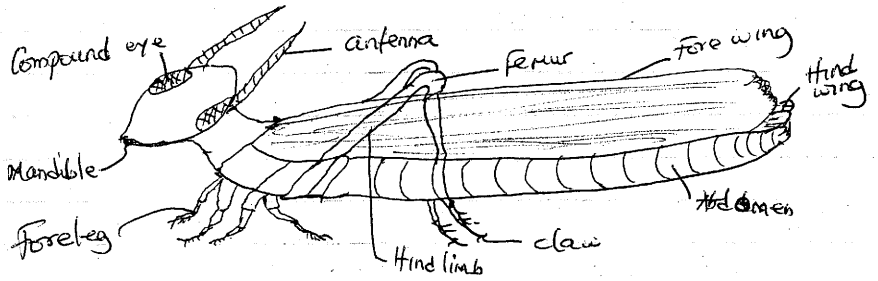
i) Locust & Grasshopper.

Eggs laid in burrow in sand → hatch → nymphs → Moulting → 2nd instar



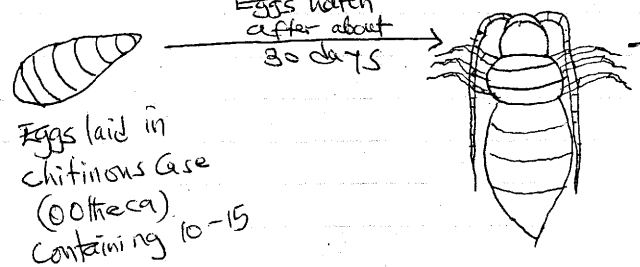
→ Moulting → 3rd instar → Moulting → 4th instar

→ Moulting → 5th instar → last Moulting → Adult.

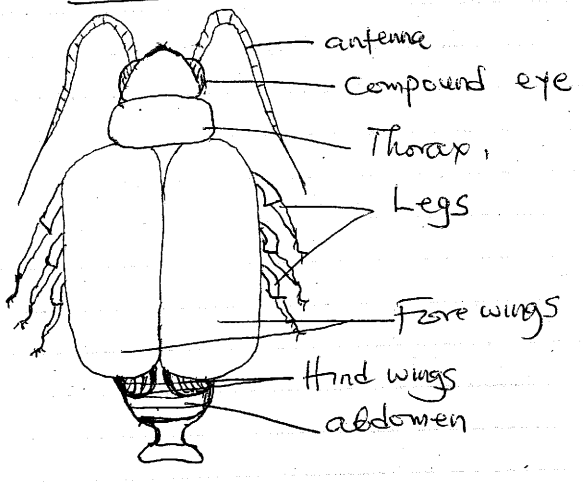


Adult (100 mm).

ii) Cockroach



Adult cockroach



Role of Hormones in insect Metamorphosis

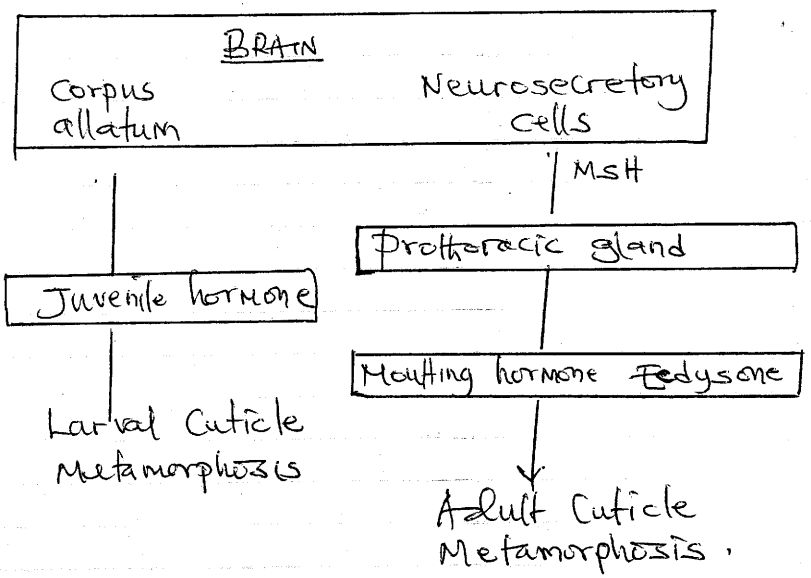
-Metamorphosis is controlled by hormones from three glands :-

(i) Neurosecretory cells in brain ganglia
(ii) Corpora allata (singular = corpora allatum) a pair located in the mandibular segment,
(iii) Prothoracic glands in thorax.

-During larval stages, **corpora allata** secretes the **juvenile hormone** which leads to formation of larval cuticle hence larval characteristics are retained ie moulting does not go beyond larval stage.

-When the larva matures, the corpus allatum disintergrates and **neurosecretory** cells produces **moulting stimulating hormone** (MSH) which is stored in **cocpeca cardiaca** before being carried via blood to the **Prothoracic gland** which is then stimulated to secrete **Ecdysone hormone** or Moulting hormone.

-Ecdysone causes moulting and removal of the old cuticle (exoskeleton to allow growth; and also formation or laying up of the adult cuticle.



Significance of Metamorphosis

-The adult and the larva exploit different food niches thus reducing competition for resources thus increasing chances of survival.