BIOLOGY FORM 3 NOTES

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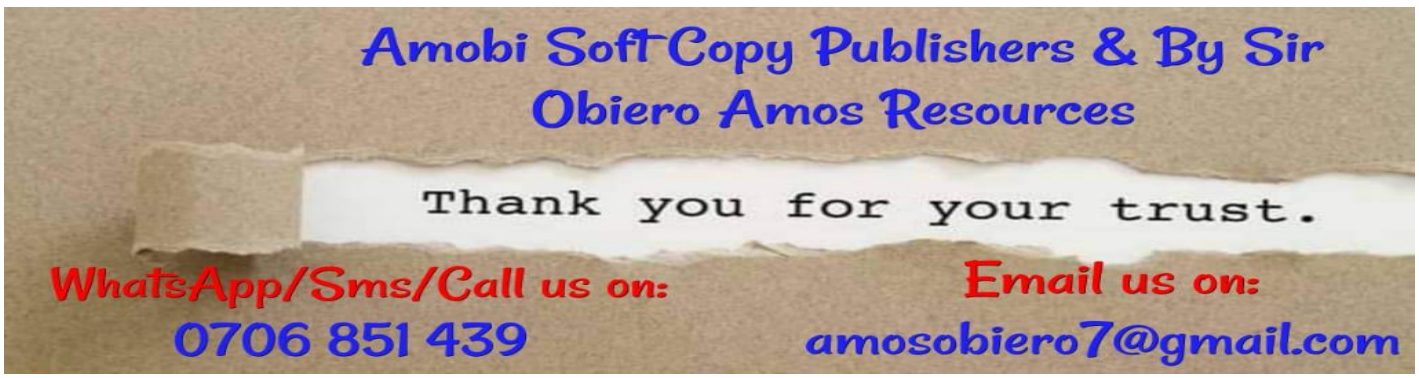

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Classification II

General Principles of Classification

- Classification is the science that puts organisms into distinct groups to make their study easy and systematic.
- Modern scientific classification is based on structure and functions.
- Organisms with similar anatomical and morphological characteristics are placed in one group while those with different structures are grouped separately.
- Modern studies in genetics and cell biochemistry are used to give additional help in classifying organisms.
- There are seven major taxonomic groups.
- The kingdom is the largest group.
- Others are phylum (division for plants) class, order, family, genus and species, the smallest.

Binomial Nomenclature

- Living organisms are named using Latin or Latinised names.
- Every organism has two names.
- This double naming is called ***binomial nomenclature.***
- This system of naming was devised by Carolus Linnaeus in the 18th Century.
- The first name is the generic name - the name of the genus.
- The second name is the name of the species.
- The generic name starts with a capital letter while that of the species starts with a small letter.
- The names are written in italics or are underlined in manuscripts.

Examples:

Bean =*Phaseolus vulgaris.*

- *Phaseolus* is the generic name,
- *vulgaris* is specific name.

Dog =*Canis familiaris.*

- *Canis* is the generic *name*
- *,familiaris* the specific name.

General Characteristics of Kingdoms

Organisms are classified into five kingdoms.

- ***Monera,***
- ***Protoctista,***
- ***Fungi,***
- ***Plantae***
- ***Animalia.***

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Viruses do not fit neatly into any of the above kingdoms.

- They are simple and not cellular.
- They are metabolically inactive outside the host cell.
- Most of them can be crystallised like chemical molecules.
- Therefore they do not exhibit the characteristics of living organisms.

Characteristic	*Monera*	*Protoctista*	*Fungi*	*Plantae*	*Animalia*
Cell type	Prokaryotic	Eucaryotic	Eucaryotic	Eucaryotic	Eucaryotic
U nicellularl Multicellular	Unicellular	Unicellular and multicellular	Unicellular and multicellular	Multicellular	Multicellular
Mode of Feeding	Autotrophic or heterotrophic by absorption	Autotrophic or heterotrophic by absorption or phagocytosis	Heterotrophis by absorption	Autotrophis	Heterotrophic by ingestion
Reproduction	Asexual by binary fission	Asexual binary fission, fragmentation, Sporulation	Asexual fission Fragmentation, sporulation	Asexual by sporulation and fragmentatio Sexual	Sexual

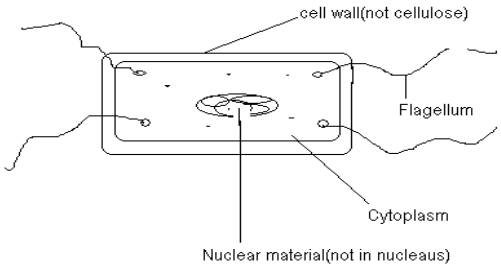
Examples of Organisms in Each Kingdom and Their Economic Importance

Kingdom Monera

General Characteristics

- Unicellular and microscopic
- Some single cells ,others colonial
- Nuclear material not enclosed within nuclear membrane-prokaryotic
- Have cell wall but not of cellulose.
- Have few organelles which are not membrane bound
- Mitochondria absent
- Mostly heterotrophic, feeding saprotrophically or parasitically,some are autotrophic.
- Reproduction mostly asexual through binary fission
- Most of them are anaerobes but others are aerobes
- Most move by flagella

A generalised drawing of a bacterium



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- Examples include ***Escherichia coli, Vibrio cholerae*** and ***Clostridium tetani.***
- Spherical known as Cocci.

- Rod shaped - e.g. *Clostridium tetani*
- Spiral shaped e.g. sprilla
- Coma shaped- Vibrios -e.g., *Vibrio cholerae.*

Economic importance of bacteria Benefits to man include:

- They are used in food processing e.g., *Lactobacillus* used in processing of cheese, yoghurt.
- Involved in synthesis of vitamin Band K, in humans and breakdown of cellulose in herbivores.

Genetic Engineering

- Bacteria are easily cultured and are being used for making antibiotics, aminoacids and enzymes e.g. amylase, and invertase e.g., ***Escherichia coli.***

Nutrient cycling:

- Saprophytes
- They are involved in decomposition of dead organic matter.
- They are useful in the nitrogen cycle.
- Nitrogen fixing and nitrifying bacteria.
- They increase soil fertility.
- Modem sewage works use bacteria in treatment of sewage.
- Cleaning oil spills in oceans and lakes.

Harmful Effects

- Bacteria cause disease:
- To humans (e.g. Cholera).
- To animals (e.g. Anthrax).
- Bacteria cause food spoilage.
- Others cause food poisoning e.g. *Salmonella.*
- Denitrifying bacteria reduce soil fertility e.g., *Pseudomonas denitrificans.*

Kingdom Protoctista

Examples include ;

- Algae such as spirogyra, Chlamydomonas, euglena, Sargassum
- And protozoa such as amoeba, paramecium and Trypanosoma.

General Characteristics

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- They are said to be eukaryotic since their nucleus is bound by a membrane
- Most are mobile, and use flagella, cilia and pseudopodia.
- Some are sessile.
- They reproduce mainly asexually, by binary fission, fragmentation and sporulation.
- Some reproduce sexually by conjugation.
- Some are heterotrophic e.g. paramecium.
- Others are autotrophic e.g. spirogyra.

Economic importance of protoctista

- Algae are the primary producers in aquatic food chains.
- They release a lot of oxygen to the atmosphere.
- Some cause human diseases like malaria and amoebic dysentry ,sleeping sickness
- Some are source of food for humans e.g. sargassum is a source of iodine
- Skeletons of diatoms used in paint making.

Spirogyra: They have spiral chloroplast.

- They are green, thread-like filaments

Chlamydomonas:

- This is a unicellular green algae and has a cup shaped chloroplast.
- They move towards light using the flagella
- Cilia assist the organism to move.
- The shape is due to the presence of a thin flexible pellicle.

Kingdom Fungi

- Multicellular fungi are made of thread-like structures called hyphae (singular hyphae) that form a mycelium.
- .e.g.Saccharomyces cereviseae(bread yeast).
- Others include Penicillium, Rhizopus, and edible mushroom

Economic Importance of Fungi

Beneficial Effects

- Some fungi are used as food e.g. mushrooms.
- Some are decomposers which enhance decay to improve soil fertility - recycling of nutrients e.g., toadstools.
- Some are useful in brewing and bread making e.g., yeast. Yeast is used as food - a rich source of Vitamin B.
- Some are useful in production of antibiotics e.g., *Penicillium griseofulvin.*
- Used in sewage treatment e.g., *Fusarium spp.*

Harmful Effects

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- Some cause food poisoning by producing toxic compounds e.g. *Aspergillus flavus* which produces aflatoxins.
- Some cause food spoilage, fabric and wood spoilage through decomposition.
- Some cause diseases to humans e.g., athlete's foot and ringworms.
- Others cause diseases to plants e.g., potato blight (Irish potatoes) rust in tomatoes and smuts in cereals.

Kingdom Plantae

General Characteristics

- They are multicellular and eukaryotic.
- They are photosynthetic and have a pigment chlorophyll.
- Their cells have cellulose cell walls.
- They reproduce sexually, others asexually.
- Kingdom Plantae has three major divisions:
  - Bryophyta,
  - Pteridophyta
  - Spermatophyta.

Division Bryophyta

These include mosses and liverworts.

- Plant body is not differentiated into root, stem and leaves.
- They have simple structures which resemble leaves and stems.
- They have rhizoids for absorbing water and anchoring the plant to substratum.
- Life cycle consists of two morphologically different plants, the gametophyte and sporophyte.
- The two alternate.
- They show alternation of generations.
- The gamete producing gametophyte is the persistent plant.
- The sporophyte is attached to the gametophyte and is nutritionally dependent on it.
- They lack vascular system.
- Sexual reproduction is dependent on water.

Division Pteridophyta:

These include ferns and horsetails.

General Characteristics

- They have root and shoot system.
- Leaves are compound known as fronds, they have a vascular system.
- They show alternation of generations whereby the spore bearing sporophyte is the main plant.
- Spores are borne in clusters on the underside of leaves making sari.
- The gametophyte is an independent minute structure called prothallus which is short lived.
- Sexual reproduction is dependent on water.

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Division Spermatophyta

- These are the seed bearing plants.

General Characteristics

- Plant body is differentiated into root, stem and leaves.
- Vascular tissue consists of xylem and phloem.
- Sexual reproduction is independent of water.
- Male gametophyte (pollen grain) germinates and grows to reach female gametophyte.
- They are divided into two sub-divisions:
  - Gymnosperms
  - Angiosperms.

Gymnosperms

- These are cone-bearing plants.
- Naked seeds.
- They are trees and shrubs.
- Xylem consists of tracheids only.
- Examples; pine, cypress and spruce.
- They show xerophytic characteristics like having needle-like leaves.

Angiosperms

- Seeds are enclosed within a fruit.
- They comprise trees, shrubs and herbs.
- Xylem consists of vessels of tracheids.
- These are the most advanced plants.
- Angiosperms has two classes;
  - Monocotyledonae
  - Dicotyledonae.

Comparison of Dicotyledonae and Monocotyledonae

Dicotyledonae	*Monocotyledonae*
• Embryo has two cotyledons.	• Embryo has one cotyledon.
• Leaves are broad and have network of veins.	• Leaves are long with parallel veins (have leaf sheath)
• T.S. of root has no pith.	• T.S. of root has pith.
• Have tap root system.	• Have fibrous root system.
• Cross section of stem reveals vascular bundles arranged in a ring.	• Cross section of stem reveals vascular bundles scattered all over.
• Vascular cambium present and have secondary growth.	• Vascular cambium absent and do not have secondary growth.

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• Flower parts in four, five or multiples of these.	• Flower parts in three or multiples of three.
Examples: herbs e.g. tomatoe; shrubs e.g. tea, hibiscus, lantana.	Examples: grass, wheat, sugar-cane.

Economic Importance of Spermatophyta

- They are a source of food for humans and other animals.
- Source of fue1- wood fuel and charcoal.
- Source of timber for building and for paper.
- Ornamental plants.
- Useful in textile industry.

Kingdom Animalia

- Most animals move from place to place in search of food.

Major phyla are:

- Platyhelminthes (Tapeworm).
- Nematoda (Ascaris).
- Annelida (Earthworm).
- Mollusca (Snails).
- Arthropoda
- chordata

Phylum Arthropoda

Distinguishing Characteristics

- They have jointed appendages, which are specialised for various functions.
- Their body is covered by a hardened exoskeleton made of chitin.
- It is shed at intervals to allow for growth.
- They have jointed body parts.
- Most are divided into head, thorax and abdomen.
- Some have two body parts,

General Characteristics

- Body is segmented.
- They have bilateral symmetry.
- Gaseous exchange is through tracheal system, book lungs or gills which opens to the outside through spiracles.
- Aquatic forms use gills.
- Reproduction is mainly sexual.

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- They have an open circulatory system.

Phylum Arthropoda divided into five classes;

- Crustacea,
- Arachnida,
- Chilopoda,
- Diplopoda
- Insecta

This division is based on:

- The number of limbs.
- Presence and number of antennae.
- Number of body parts.

Class Crustacea

- Most of them are aquatic, a few are terrestrial found in moist places e.g., woodlouse.

Distinguishing Characteristics

- Two body parts head and thorax are fused to form cephalothorax and an abdomen .
- They have two pairs of antennae; one is small and branched, the other is long.
- They have five or more parts of limbs.
- Some of these are modified for other functions e.g., locomotion, feeding and defence.
- Exoskeleton hardened with deposits of calcium carbonate i.e. carapace.

Other Characteristics

- Mouthparts include a pair of mandibles and two pairs of maxillae.
- Gaseous exchange is through gills.
- They have a pair of compound eyes.
- Most crustaceans are free-living but a few are parasitic e.g., barnacles.
- Examples are cray-fish and crab.

Class Arachnida

- Members are carnivorous and paralyse prey using poison produced from poison claws.

Distinguishing Characteristics

- The body has two parts: cephalothorax and abdomen.
- Cephalothorax is head fused to thorax.
- A pair of chelicerae, on ventral side of cephalothorax.
- They have four pairs of walking legs.
- They have no antennae.
- Instead they have a pair of short pedipalps which are sensitive to touch.
- Most arachnids use book lungs for gaseous exchange.
- Other characteristics include simple eyes.
- Examples include garden spider, ticks, scorpions.

Class Chilopoda

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e.g. Centipede

Distinguishing Characteristics

- The body has 2 body parts, a head and trunk.
- The body is elongate, and has 15 or more segments.
- Has a pair of legs on each segment.
- The body is dorso-ventrally flattened.

Other characteristics include:

- Head has a pair of antennae.
- Gaseous exchange through tracheal system.
- Are carnivorous.

Class Diplopoda e.g. Millipede

Distinguishing Characteristics

- Has two parts: head, short thorax and a trunk .
- Body elongate with 9-100 segments.
- Has two pairs of legs on each segment.
- They have a cylindrical body.
- Gaseous exchange is by tracheal system.

Other characteristics:

- Head has a pair of antennae.
- Are herbivorous.

Class Insecta

Distinguishing Characteristics

- Body is divided into three body parts head, thorax and abdomen.
- They have three pairs of legs ..
- Most insects have a pair or two of wings.

Other characteristics include:

- A pair of antennae.
- They breathe through spiracles, and gaseous exchange is through tracheal system.

The class is divided into several orders based on:

- Mouth parts- - type e.g. biting or piercing.
- Position of mouthparts - ventral or anterior.
- Wings - presence or absence; number of wing types, structure, texture.
- Size of legs.

Order Orthoptera

- Have biting and chewing mouthparts.
- Hind legs longer than other legs e.g. fore wings, leathery and longer than hind legs .
- e.g. locusts and grasshoppers .

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- Swarming - locusts are a menace to farmers and the environment as they destroy crops and vegetation.

Order Diptera –

- True flies e.g. houseflies, and mosquitoes have sucking and piercing mouthparts, 1 pair of wings.
- The second pair is vestigial- acts as balancer.
- Mouthparts are ventral.
- These are disease vectors e.g., female anopheles mosquito transmits malaria.

Order Lepidoptera –

- Butterflies and moths have sucking mouthparts,
- Two pairs of wings covered by scales.
- This group is important to farmers in pollination.

Order Hymenoptera –

- Bees ,wasps, ants.
- They have sucking mouthparts, two pairs of wings which are membranous.
- Some are non-winged e.g. some ants.
- Bees are important in pollination i.e. in production of honey.

Order Isoptera - Termites

- They have biting mouthparts which are anterior.
- Most are wingless,
- Those with wings they are membranous and of the same size.
- They are important in nutrient cycling as they feed on cellulose.

Order Coleoptera - Beetles

- Have biting mouthparts,
- Two pairs of wings,
- Fore wing hardened enclosing membranous wings.
- Destruction of stored grains and legumes (pulses)

Phylum Chordata

- This name is derived from the term notochord.
- This is a long flexible rod-like structure.
- The more familiar chordates are known as vertebrates.
- In vertebrates the notochord exists only in embryonic stages of development which in later stages is replaced by a vertebral column.

Main Characteristics of Vertebrates

- Members of the phylum have a notochord in early stages of development.
- They have visceral clefts - which are slits perforating the body wall at the pharynx.

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- In fish these slits become gills while in higher chordates these slits are only present in embryo.
- They have a dorsal, hollow nerve cord.
- It develops into a brain at the anterior and spinal cord at the posterior end.
- The spinal cord is enclosed within the vertebral column.
- They have segmented muscle blocks known as myotomes on either side of the body.
- They possess a post-anal tail although rudimentary in some.
- They have a closed circulatory system.
- The heart is ventrally located.
- They possess an internal skeleton.

The main classes of phylum chordata are;

- Pisces,
- Amphibia,
- Reptilia,
- Aves
- Mammalia.

Class Pisces

- These are the fishes.
- Some fish have a skeleton made of cartilage e.g. the shark.
- Others like Tilapia have a bony skeleton.

Distinguishing Characteristics

- They are aquatic.
- Movement is by means of fins.
- They have a streamlined body.
- They have a lateral line for sensitivity.
- Their heart has two chambers, the auricle and ventricle - simple circulatory system.

Other Characteristics

- Their body temperature changes according to the temperature of the environment.
- They are ectothermic (poikilothermic).
- Body covered with scales.
- They have gills for gaseous exchange.
- Exhibit external fertilisation.

Class Amphibia

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- Larval forms are aquatic while adults are terrestrial.
- Adults return to water for breeding e.g. frogs, toads, newts, salamanders.

Distinguishing Characteristics

- Skin is soft and without scales.
- They have four well developed limbs.
- The hind limbs are longer and more muscular than forelimbs.
- The limb can be used for walking, jumping and swimming
- Gaseous exchange is through the skin, gills and lungs.
- Middle ear is present.

Other Characteristics

- They have a three-chambered heart with two atria and one ventricle.
- Fertilisation is external.
- They are ectothermic (poikilotherms).

Class Reptilia

- Examples are snakes, crocodiles, lizards, chameleons, tortoises and turtles.

Distinguishing Characteristics

- The skin is dry and is covered by horny scales.
- Fertilisation is internal.
- Some species eggs contain a lot of yolk and have either leathery or calcareous shells.
- They have a double circulatory system.
- The heart has three chambers - two atria and a partly divided ventricle.
- However crocodiles have a four chamber heart.

Other Characteristics

- They are ectothermic (poikilothermic).
- Have 2 pairs of limbs.
- They use lungs for gaseous exchange.

Class Aves

- These are birds.
- They are terrestrial and arboreal and others are aquatic
- e.g. flamingo, goose, ostrich, penguin, hawk, dove.

Distinguishing Characteristics

- Body is covered by feathers and legs with horny scales.
- They have two pairs of limbs.
- Fore limbs modified to form wings for flight.
- Hind limbs are for walking or swimming.
- The mouth is a protruding beak.
- They have hollow bones.

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- They have double circulation with a four-chambered heart (2 atria, 2 ventricles).
- They have lungs for gaseous exchange.
- Lungs are connected to air sacs in bones.
- Fertilisation is internal.
- They lay eggs with calcareous brittle shell.
- They have constant body temperatures hence are homoiotherms (endothermic).

Class Mammalia

- They are arboreal e.g. tree-squirrels,
- Others terrestrial e.g. humans
- Others are aquatic e.g. dolphins and whales.

Distinguishing Characteristics

- They have mammary glands hence name of the class.
- Body is covered with fur or hair.
- Their teeth are differentiated into four types (heterodont dentition).
- They have external ear-pinna.
- Most have sweat glands.
- They have a diaphragm that separates the body cavity into thoracic and abdominal.

Other Characteristics

- Internal fertilisation - most give birth.
- They have a double circulatory system with a four-chambered heart.
- They are endothermic (homoiotherms) .

Eg Duck-billed Platypus (egg-laying mammal)

Eg.Kangaroo (pouched mammal)

- The young are born immature and are nourished in a pouch with milk from mammary glands.

Placental Mammals

- They give birth to fully developed young ones which are fed on milk from mammary glands.
- Some are aquatic. e.g. dolphins, whale,
- Others are flying e.g, bat;
- Most are terrestrial e.g. rabbits, elephants, buffalo, giraffe, antelope, cow, human being.

Placental mammals are divided into various orders:

- Rodentia: e.g. rats, mice - have one pair 9f upper incisors.
- Insectivora: e.g. mole-they are like rodents:
- Carnivora: e.g. dog; lion - flesh eaters, they have long pointed canines.
- Cetacea: e.g. whales and dolphins Aquatic mammals. Forelimbs are flippers.
- Chiroptera: e.g. bats - Forelimbs form wings.
- Artiodactyla: e.g. antelopes, cattle - they are even toed with split hooves.
- Perissodactyla: e.g. horse, donkey - they are odd toed with hooves.
- Proboscidea: e.g. elephant - upper lip and nose elongated to form trunk.

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- Lagomorpha: e.g. rabbit, hare - mammals with upper and lower incisors. Have larger hind legs than forelegs.
- Primata: e.g. gorilla, orang utang, chimpanzee, monkeys - some are arboreal, with hand and foot for grasping.
- Human - *Homo sapiens* - upright gait, *opposable* thumb hence use of tools.

Construction and Use of Dichotomous Keys

- Biological keys are sets of statements that act as clues leading to the identification of an organism.
- By following the keys we can be able to place an organism in its group.
- The most common key is the dichotomous key.
- This is a biological tool for identification of unknown organisms.
- The word dichotomous means branching into two.
- A single characteristic is considered at a time.
- Two contrasting statements are put forward to describe the characteristics in such a way as to separate the organisms.
- This continues until all the organisms have been identified.

Rules Used to Construct a Dichotomous Key

- Use morphological characteristics as far as possible e.g. type of leaf - simple or compound.
- Select a single characteristic at a time and identify it by number. 1. Type of leaf. .
- Use identical forms of words for two contrasting statements e.g.:
  a) Flowers scented.
  b) Flowers not scented.
- Start with a major characteristic that divide the organisms into two large groups then proceed to lesser variations that would separate the organisms further into smaller groups.
- Use positive statements especially the first one.
- Avoid generalizations e.g. short plants. Be specific in your description e.g.:
  a) plants above 1m tall.
  b) plants below 1m tall.

Some Common Features Used for Identification In Plants

Leaves

1. ***Type of leaf*** **Leaf**
   (a) Compound leaves. (b) Type of venation.

-
- Simple leaf

- Trifoliate
- Pinnate

- Type ofleaf margin.
- Type ofleaf arrangement on stem.

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- The colour of leaf.
- The texture ofleaf; whether hairy or smooth.
- Shape of the leaf e.g. palmate.

Stem

- Type of stem - woody or herbaceous.
- Shape of stem - cylindrical or rectangular.
- Texture of stem smooth or spiny.

Infloresence

- Are flowers terminal or lateral
- For each flower:
- Is the flower regular or irregular?
- Number of floral parts for each whorl.
- Are floral parts free or fused?

Roots

- Type of root system- Taproot or fibrous?
- Function of the root.

In Animals

Features used to identify animals:

- Type of mouthparts.
- Type of skeleton.
- Presence or absence of antennae.
- Body segmentation.
- Body covering: scales, fur, hair or feathers.
- Number of body parts.
- Locomotory structures: legs, wings and fins.
- Presence or absence of vertebral column.
- Presence and type of eves.

Practical Activities

To examine Bryophyta

- A mature moss plant is obtained.
- The specimen is observed using a hand -lens.
- A labelled drawing showing structures is made: rhizoids, set a capsule, gametophyte, sporophyte ..

To examine Pteridophyta

- A mature fern plant is obtained.
- **It** is observed using a hand lens.
- Sori can be seen on the lower side of fronds.
- A labelled drawing showing: frond, pinna, sorus, rhizome and adventitious roots.

To examine Spermatophyta

A mature twig of either cypress or pinus with cones is obtained.

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- Observation of Male and female is made using a hand-lens.
- The naked seeds are noted.
- The leaves show xerophytic characteristics e.g. they are rolled, or needle-like.

A mature bean plant with pods is obtained,

- Observation of the leaves, stem and roots is made.
- **Leaves are compound, broad arid** have network of veins.
- The leaf-has a leaf stalk.
- They have a tap root system.
- Floral parts are in five e.g. 5 petals.
- A bean seed has two cotyledons.

A mature maize plant is obtained.

- Observation of the leaves, stems and roots is made.
- Leaves are simple, narrow and long with parallel veins ..
- The petiole is modified to form a leaf sheath.
- They have a-fibrous root system.
- Floral parts are in threes.
- A maize gram has one cotyledon,

Examination of Arthropoda

- Specimens of crayfish, millipede, centipede grasshopper and spider are obtained.
- Where specimens are not available photographs are used.
- External features of the specimens are observed.

The differences in the following are noted:

- Body parts.
- Antennae.
- Other appendages.
- Eyes.

Examination of Chordata

- The following specimens are obtained:
- Tilapia, frog, Lizard, bird and rabbit.
- Using observable features each specimen is placed into its class.

Features used include:

- Body covering.
- Limbs.
- Type of teeth.

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ECOLOGY

Introduction

- Ecology is the study of organisms and their environment.
- All organisms show interdependence on one another.
- Organisms are affected by their environment, and they in turn affect the environment.
- Green plants manufacture food by photosynthesis which other organisms obtain directly or indirectly.
- Growth of plants is mainly affected by environmental factors such as soil and climatic factors.
- On the other hand, organisms modify the environment through various activities.
- This interrelationship comprises the study of ecology.
- The study of ecology is important in several fields of study such as agriculture and environmental studies.

Concepts and Terms Used in Ecology

- ***Habitat:***
  - This is the place or "home" that an organism lives or is found,
  - e.g., forest or grassland.
- ***Niche:***
  - A niche is the functional unit in the habitat.
  - It includes not only the specific place in which an organism lives but also how the organism functions.
  - To avoid or reduce competition, organisms are separated or segregated by their niches,
  - for example, different species of birds make their nest on one tree, some at tips of terminal branches, and others feed on leaves, some on flowers and yet others on fruits of the same tree, i.e., food niche.

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- Yet others feed on same food, e.g., worms in the same place but at different times - time niche.

- ***Population:***
  - The term population refers to the total number of individuals of a species living in a given area at a particular time.
  - ***Density*** is the number of ***individuals*** of a population found in a ***unit area***, i.e.,

$$= \frac{\text{Number of individuals}}{\text{Area}}$$

- ***Dispersion:***
  - This is the distribution of individuals in the available space.
  - Dispersion may be uniform as in maize plants in a plantation;
  - random as in cactus plants in the savannah ecosystem or clumped together as in human population in cities.
- ***Community:***
  - This is the term used to describe all the organisms living together in an area.
  - During the development of an ecosystem, the species composition of a community changes progressively through stages.
  - Finally a steady state is reached and this is described as the ***climax community.***
  - This development of an ecosystem is termed succession.
  - Each stage in development of an ecosystem is a sere.
  - Succession is ***primary*** when it starts with bare ground, and ***secondary*** when it starts in a previously inhabited area e.g. after clearing a forest.
- **The Ecosystem:**
  - The community and the abiotic or non-living environment together make up an ecosystem or ***ecological system***.
  - In this system ***energy*** flow is clearly defined from producers to consumers and nutrient cycling takes place in paths that links all the organisms and the non-living environment.
- ***Biomass:***
  - This is the mass of all the organisms in a given area.
  - Ideally, it is the dry mass that should be compared.
- ***Carrying capacity:***
  - This is the maximum sustainable density in a given area e.g. the number of herbivores a given area can support without overgrazing.

Factors in an Ecosystem

- **Abiotic factors (environmental factors)**

Temperature

- Is the hotness or coldness of an area or habitat.
- It directly affects the distribution and productivity (yield) of populations and communities.
- Most organisms are found in areas where temperature is moderate.

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- However, certain plants and animals have adaptations that enable them to live in areas where temperatures are in the extremes such as the hot deserts and the cold polar regions.
- Temperatures not only influence distribution of organisms but also determine the activities of animals.
- High temperature usually accelerates the rates of photosynthesis, transpiration, evaporation and the decomposition and recycling of organic matter in the ecosystem.

Light –

- Light is required by green plants for photosynthesis.
- Light intensity, duration and quality affect organisms in one way or another.

Atmospheric Pressure

- The force per unit area of atmospheric air that is exerted on organisms at different altitudes.
- Growth of plants and activity of animals is affected by atmospheric pressure
- e.g., rate of transpiration in plants and breathing in animals.

Salinity

- This is the salt content of soil or water.
- Animals and plants living in saline conditions have special adaptations.

Humidity

- This describes the amount of moisture (water vapour) in the air.
- Humidity affects the rate of transpiration in plants and evaporation in animals.

pH

- Is the measure of acidity or alkalinity of soil solution or water.
- pH is very important to organisms living in water and soil.
- Most prefer a neutral pH.

Wind:

- Is moving air currents and it influences the dispersion of certain plants by effecting the dispersal of spores, seeds and fruits.
- Air currents also modify the temperature and humidity of the surroundings.

Topography:

- These are surface features of a place.
- The topographical factors considered include altitudes, gradient (slope), depressions and hills.
- All these characteristics affect the distribution of organisms in an area
- e.g., the leeward and windward sides of a hill.

Biotic factors:

- These are the living components in an ecosystem,

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- competition
- predation,
- symbiosis,
- parasitism,
- human activities.

Inter-relationships Between Organisms

- The relationships between organisms in a given ecosystem is primarily a feeding one.
- Organisms in a particular habitat have different feeding levels referred to as trophic levels.
- ***There are two main trophic levels:***

Producers:

- These organisms that occupy the first trophic level.
- They manufacture their own food hence are autotrophic.

Consumers:

- These are the organisms that feed on organic substances manufactured by green plants.

They occupy different trophic levels as follows:

- ***Primary consumers:***
  - These are herbivores and feed on green plants.
- ***Secondary consumers:***
  - These are carnivores and feed on flesh.
  - First order carnivores feed on herbivores while second order carnivores feed on other carnivores, i.e., tertiary consumers.
- ***Omnivores:***
  - These are animals that feed on both plant and animal material.
  - They can be primary, secondary or tertiary consumers.

Competition:

- This describes the situation where two or more organisms in the same habitat require or depend on the same resources.
- Organisms in an ecosystem compete for resources like food, space, light, water and mineral nutrients.
- Competition takes place when the environmental resource is not adequate for all.

Intraspecific competition.

- This is competition between organisms of the same species.
- For example, maize plants in a field compete for water and nutrients among themselves.

Interspecific competition.

- **This refers to** competition between organisms of different species, e.g., different species of predators can compete for water and prey among themselves.

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Predation

- It is a relationship whereby one animal (the predator) feeds on another (the prey).

Saprophytism

- Saprophytism is the mode of nutrition common in certain species of fungi and bacteria.
- Such organisms feed on dead organic material and release nutrients through the process of decomposition or decay.
- Saprophytes produce enzymes, which digest the substrates externally.
- The simpler substances are then absorbed.
- Saprophytes help in reducing the accumulation of dead bodies of plants and animals.
- Harmful saprophytes cause rapid decay of foods such as fruits, vegetables, milk and meat.
- Others damage buildings by causing wood rot.
- Some fungi produce poisonous substances called aflatoxins.
- These substances are associated with cereal crops which are stored under warm, moist conditions.
- If the infected grain is eaten, it may cause serious illness, and death.

Parasitism

- This is an association between members of different species.
- The parasite lives on or in the body of another organism, the host.
- The parasite derives benefits such as food and shelter from the host but the heist suffers harm as a result.

Symbiosis

- This is an association in which organisms of different species derive mutual benefit from one another.
- Some symbiotic associations are loose and the two partners gain very little from each other.
- Other symbiotic associations are more intimate and the organisms show a high degree of interdependence.

Nitrogen cycle –

- Is the interdependence of organisms on one another and the physical environment as nitrogen is traced from and back into the atmosphere
- Although nitrogen is abundant in the atmosphere, most organisms are not able to utilise it directly.
- Some bacteria are capable of converting atmospheric nitrogen into forms which can be used by other living organisms.
- These bacteria are referred to as **nitrogen fIxing bacteria.**

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- **Symbiotic nitrogen** fixing **bacteria** live in the root nodules of leguminous plants such as beans and peas.
- Non-symbiotic nitrogen fixing bacteria live in the soil.
- **Nitrifying' bacteria** convert ammonia into nitrites and nitrates.
- **Denitrifying bacteria** convert nitrates into **atmospheric** nitrogen.

Energy Flow in an Ecosystem

- Most of the energy used in an ecosystem is derived from the sun.
- Solar energy is trapped by photosynthetic plants.
- It flows through different trophic levels .
- At each level energy is lost as heat to space and also through respiration.
- Besides animals lose energy through excretion and defecation.
- The amount of energy passed on as food from one trophic level to another decreases progressively.
- The energy in the organisms is recycled back to plants through the various nutrient or material cycles.

Food Chains

- A food chain is a linear relationship between producers and consumers.
- It represents the transfer of food energy from green plants through repeated stages of eating and being eaten.

Types of Food Chain

- Grazing food chain - starts with green plants.
- Detritus food chain - starts with dead organic material (debris or detritus).

Detritivores:

- Detritivores feed on organic wastes and dead matter derived from the grazing food chain.
- Many different types of organisms feed on detritus.
- They include fungi, protozoa, insects, mites annelids and nematodes.

Examples of Food Chains

Green plants~ aphids ~ lady-bird beetle
Green plants ~antelope -lion
Algae ~Tilapia ~ kingfisher
Plant debris ~bacteria -eprotozoa ~ mosquito larva
Phytoplankron-eZooplankton ~ Tilapia
~ Nile perch ~ Human

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Food Web

- In a natural community, several food chains are interlinked to form a food web.
- Several herbivores may feed on one plant .
- Similarly, a given herbivore may feed on different plants and may in turn be eaten by different carnivores.

Decomposers

- These are mainly bacteria and fungi.
- These organisms feed on dead organic matter thereby causing decomposition and decay and releasing nutrients for plants.
- They form a link between the biotic and the abiotic components.

Pyramid of Numbers

- Refers to the number of organisms in each trophic level presented in a graphic form and a pyramid shape is obtained.
- The length of each bar is drawn proportional to the number of organisms represented at that level.
- This is because a herbivore feeds on many green plants.
- One carnivore also feeds on many herbivores.

- In a forest the shape of the pyramid is not perfect.
- This is because very many small animals such as insects, rodents and birds feed on one tree.

Pyramid of Biomass

- This is the mass of the producers and consumers at each trophic level drawn graphically.

Population Estimation Methods

- It is important to find or estimate the sizes of the different populations in a habitat.
- Direct counting or head count which involves the counting of every individual, is not always applicable for all organisms .
- e.g., it is impossible to count directly the numbers of grasshoppers in an area.
- Different sampling methods are thus used.
- A sample acts as a representative of the whole population. .

Sampling Methods

Quadrat Method

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- A Quadrat is a square, made of woos metal/hard plastic.
- It can also be established on the ground using pegs, rope/permanent coloured ink, using metre rule or measuring tape.
- The size is usually one square metre ($1M^2$), in grassland.
- In wooded or forest habitat it is usually larger, and can reach upto 20 m^2 depending on particular species under investigation.
- The number of each species found within the quadrat is counted and recorded.
- Total number of organisms is then calculated by, finding the average quadrats and multiplying it with the total area of the whole habitat.
- The number of quadrats and their positions is determined by the type of vegetation studied.
- In a grassland, the quadrat frame can be thrown at random.
- In other habitats of forest, random numbers that determine the locus at which to establish a quadrat are used.

Line Transect

- A line transect is a string or rope that is stretched along across the area in which all the plants that are touched are counted.
- It is tied on to a pole or tent peg.
- It is particularly useful where there is change of populations traversing through grassland, to woodland to forest land.
- This method can also be used in studying the changes in growth patterns in plants over a period of time.

Belt Transect

- Two line transects are set parallel to each other to enclose a strip through the habitat to be studied.
- The width is determined by the type of habitat, i.e., grass or forest and by the nature of investigation.
- In grassland it can be 0.5 m or 1 m.
- Sometimes it can be 20 metres or more especially when counting large herbivores.
- The number of organisms within the belt is counted and recorded.

Capture-recapture method

- This is used for animals such as fish, rodents, arthropods and birds.
- The animals are caught, marked, counted and released.
- For example, grasshoppers can be caught with a net and marked using permanent ink.
- After sometime, the same area is sampled again, i.e., the grasshoppers are caught again.
- The total number caught during the second catch is recorded.

The number of marked ones is also recorded:

- Let the number caught and marked be *a.*
- The total number in the second catch be *b.*
- The number of marked ones in the second catch be c.

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- The total number of grasshoppers in the area be *T*.

The total number *T* can be estimated using the following formula:
Total Number =

$$\frac{\text{Number caught during the first catch} \times \text{number caught in the second catch}}{\text{Number marked in second catch}}$$

$$\text{OR } T = \frac{a \times b}{c}$$

The following assumptions are made:

- No migration, i.e., no movement in and out of the study area.
- There is even distribution of the organisms in the study area.
- There is random distribution of the organisms after the first capture.
- No births or deaths during the activity.
- ***After the estimation, the results can be used to show anyone of the following population characteristics:***

Density:

- Density is calculated by dividing the number of organisms by the size of the area studied.

Frequency:

- Frequency is the number of times that a species occurs in the area being studied.

Percentage Cover:

- This is the proportion of the area covered by a particular species.
- For example, a given plant species may cover the whole. of a given area.
- In this case the plant is said to have 100% cover.

Dominance:

- This is the term used to describe a species that exerts the most effect on others.
- The dominance may be in terms of high frequency or high density.

Adaptations of Plants to Various Habitats

- Organisms have developed structural features that enable them to live successfully in their particular habitats.
- Plants found beneath the canopies of trees are adapted to low light intensities by having broad leaves.

Xerophytes

- These are plants that grow in dry habitats,
- i.e., in deserts and semi-deserts.
- They have adaptations to reduce the rate of transpiration in order to save on water consumption.

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- Others have water storage structures.

Adaptations include:

- Reduction of leaf surface area by having needle-like leaves, rolling up of leaves and shedding of leaves during drought to reduce water loss or transpiration.
- Thick cuticle; epidermis consisting of several layers of cells;
- leaves covered with wax or resin to reduce evaporation.
- Sunken stomata, creating spaces with humid still air to reduce water holes.
- Few, small stomata, on lower epidermis to reduce water loss.
- Stomata open at night (reversed stomatal rhythm) to reduce water loss .
- Deep and extensive root systems for absorption of water.
- Development of flattened shoots and succulent tissue for water storage e.g. ***Opuntia.***

Mesophytes

- These are the ordinary land plants which grow in well-watered habitats.
- They have no special adaptations.
- Stomata are found on both upper and lower leaf surfaces for efficient gaseous exchange and transpiration.
- However, those found in constantly wet places e.g. tropical rain forests, have features that increase transpiration.
- These plants are called hygrophytes.
- The leaves are broad to increase surface areas for transpiration and thin to ensure short distance for carbon (IV) oxide to reach photosynthetic cells and for light penetration.
- The stomata are raised above the epidermis to increase the rate of transpiration.
- They have grandular hairs or byhathodes that expel water into the saturated atmosphere.
- This phenomenon is called guttation.

Hydrophytes (Water plants)

- Water plants are either submerged, emergent or floating.

Submerged Plants

- The leaves have an epidermis with very thin walls and a delicate cuticle.
- They have no stomata.
- Water is excreted from special glands and pores at the tips.
- Other adaptations include the following:
- Presence of large air spaces and canals (aerenchyma) for gaseous exchange and buoyancy.
- Some plants have filamentous leaves In order to increase the surface area for absorption of light, gases and mineral salts.
- Some plants are rootless, hence support provided by water.

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- Mineral salts and water absorbed by all plant surfaces.
- In some plants, the stem and leaves are covered with a waxy substance to reduce absorption of water. e.g. *Ceratophyllum* and *Elodea* sp.

Floating Plants

- Their structure is similar to that of mesophytes.
- The leaves are broad to increase the surface area for water loss.
- They have more stomata on the upper surface than on the lower surface to increase rate of water loss.
- Examples are *Pistia* sp. (water lettuce), *Salvinia* and *Nymphea.*

Halophytes (Salt plants)

- These are plants that grow in salt marshes and on coastlines.
- They have root cells that concentrate salts and enable them to take in water by osmosis.
- They have salt glands which excrete salts.
- Fruits have large aerenchymatous tissues for air storage that makes them float.
- Some have shiny leaves to reduce water loss.
- The mangrove plants have roots that spread horizontally, and send some branches into the air.
- These aerial roots are known as breathing roots ***or pneumatophores***.
- They have lenticel-like openings called ***pneumatothodes*** through which gaseous exchange takes place.

Pollution

Effect of Pollution on Human Beings and other Organisms

Pollution

- This is the introduction of foreign material, poisonous compounds and excess nutrients or energy to the environment in harmful proportions.
- Any such substance is called a pollutant.

Effects and Control of causes of Pollutants in Air, Water and Soil

- Industrialisation and urbanisation are the main causes of pollution.
- As human beings exploit natural resources the delicate balance in the biosphere gets disturbed.

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- The disturbance leads to the creation of conditions that are un-favourable to humans and other organisms.

Sources of Pollutants

- Motor vehicles release carbon (II) oxide, sulphur (IV) oxide, and nitrogen oxides and hydrocarbons.
- Agricultural chemicals, fertilisers and pesticides.
- Factories, manufacturing and metal processing industries.
- They release toxic substances and gases as well as synthetic compounds that are bio-undegradable.
- They release solid particles or droplets of poisonous substances e.g. arsenic, beryllium, lead and cadmium.
- Radioactive waste: Leakages from nuclear power stations and testing sites release radioactive elements like strontium-90 which can eventually reach man through the food chain.
- Domestic waste and sewage are released raw into water bodies.
- Oil spills from accidents in the seas and leakage of oil tankers as well as from offshore drilling and storage and processing.

Water Pollution.

- In most cases, chex,pical wastes from industries are discharged into water.
- Toxic chemicals such as mercury compounds may be ingested by organisms.
- Insecticides like DDT, and weedkillers eventually get into the water and contaminate it.
- Oil and detergents also pollute water.
- Excess nitrates and phosphates from sewage and fertilisers cause overgrowth of algae and bacteria in water.
- This is called ***eutrophication.***
- As a result there is insufficient oxygen which causes the deaths of animals in the water.

Air pollution:

- Smoke from industries and motor vehicles contains poisonous chemicals like carbon (II) oxide, carbon (IV) oxide, sulphur (IV) oxide and oxides of nitrogen.
- When sulphur (IV) oxide and oxides of nitrogen dissolve in rain, they fall as acid rain.
- Accumulation of carbon (IV) oxide in the atmosphere causes the infrared light to be confined within the atmosphere, the earth's temperature rises.
- This is called the greenhouse effect.
- Carbon particles in smoke coat the leaves of plants and hinder gaseous exchange and photosynthesis.
- The particles also form smog in the air.
- Lead compounds are from vehicle exhaust pipes.
- All these have negative effects on man and the environment.

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Soil/Land pollution:

- Plastics and other man-made materials are biologically non-degradable i.e they are not acted upon by micro-organisms.
- Scrap metal and slag from mines also pollute land.
- Failure to rehabilitate mines and quarries also pollute land.

Effects of Pollutants to Humans and other organisms

- Chemical pollutants e.g. nitrogen oxides, fluorides, mercury and lead cause physiological and metabolic disorders to humans and domestic animals.
- Some hydrocarbons as well as radioactive pollutants acts as mutagens (cause mutations) and carcinogens induce cancer.
- Radioactive pollutants like strontium, caesium and lithium are absorbed into body surface and cause harm to bone marrow and the thyroid gland.
- Communicable diseases like cholera are spread through water polluted with sewage.
- Thermal pollution result in death of some fish due to decreased oxygen in the water.
- Oil spills disrupt normal functioning of coastal ecosystems.
- Birds that eat fish die due to inability to fly as feathers get covered by oil.
- Molluscs and crustaceans on rocky shores also die.

Control of Air Pollution

- Use of lead-free petrol and low sulphur diesel in vehicles.
- Use of smokeless fuels e.g electricity or solar.
- Filtration of waste gases to remove harmful gases.
- Liquid dissolution of waste gases.
- In Kenya, factories are subjected to thorough audits to ensure that they do not pollute the environment.
- Factories should be erected far away from residential areas.
- Reduce volume or intensity of sound.
- Use of ear muffs.
- Vehicle exhaust systems should be fitted with catalytic oxidisers.
- Regular servicing of vehicles to ensure complete combustion of fuel.

Water Pollution

- Treatment of sewage.
- Treatment of industrial waste before discharge into water.
- Use of controlled amounts of agrochemicals.
- Organic farming and biological control.
- Avoid spillage of oils and other chemicals into water.

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- Good water management.
- Stiff penalties for oil spillage.
- Use of *Pseudomonas* bacteria that naturally feed on oil and break it up.

Soil Pollution

- Addition of lime to farms to counteract the effect of agrochemicals.
- Recycling of solid waste.
- Compacting and incineration of solid waste.
- Use of biodegradable materials and chemicals.
- Good soil management to avoid soil erosion.

Human Diseases

- The term disease denotes any condition or disorder that disrupts the steady state of well being of the body.
- Health is a state of physical, mental and emotional well being in the internal environment of the body.
- Some of the causes of diseases are due to entry of pathogens and parasites.
- Pathogens include bacteria, viruses, protozoa and fungi.
- Parasites are organisms which live on or in the body of another organisms.
- Vectors are animals that carry the pathogen from are person to another.
- Most are ectoparasites that transmit the disease as they feed.

Bacterial Diseases

Cholera

- Causative agent a bacterium *Vibrio cholerae.*
- Transmission - It is spread through water and food contaminated by human faeces containing the bacteria.

The bacteria produce a powerful toxin, enterotoxin, that causes inflammation of the wall of the intestine leading to:

- Severe diarrhoea that leads to excessive water loss from body.
- Abdominal pain
- Vomiting
- Dehydration which may lead to death.

Prevention and Control

- Adequate sanitation such as water purification sewage treatment and proper disposal of human faeces.
- Public and personal hygiene e.g washing hands before meals and washing fruits and vegetables, boiling drinking water.

Vaccination

- Carriers should be identified, isolated and treated during outbreaks.

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Treatment
- Use of appropriate antibiotics.
- Correcting fluid loss by injecting fluids or by administration of oral rehydration solutions.

Typhoid
- Causative agent.
- The disease is caused by *Salmonella typhi.*
- Transmission is through contaminated water and food.
- It is also transmitted by certain 'e.g foods, e.g. oysters, mussels and shell fish.

Symptoms
- Fever
- Muscle pains
- Headache
- Spots on the trunk of the body
- Diarrhoea
- In severe cases mental confusion may result and death.

Prevention
- Boil drinking water.
- Proper sewage treatnient.
- Proper disposal of faeces, if not flushed use deep pit latrines.
- Observe personal hygiene e.g. washing hands before meals.
- Washing fruits and vegetables.

Treatment
- Use of appropriate antibiotics.

Protozoa
Malaria
- Malaria is caused by the protozoan plasmodium.
- The most common species of plasmodium are *P. falciparum, P. vivax, P. rnalariae* and *P. ovale* with varying degree of severity.

Transmission
- Is by female anopheles mosquito as it gets a blood meal.

Symptoms
- Headache, sweating, shivering, high temperature *(40-41* 0C) chills and joint pains.
- The abdomen becomes tender due to destruction of red blood cells by the parasites .

Prevention
- Destroy breeding grounds for mosquitoes by clearing bushes and draining stagnant water.
- Kill mosquito larvae by spraying water surfaces with oil.
- Use insecticides to kill adult mosquitoes
- Sleeping under a mosquito net.
- Take preventive drugs.

Treatment
- Use appropriate anti-malarial drugs.

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Amoebic dysentry (Amoebiasis)

Cause

- This disease is caused by *Entamoeba histolytica.*
- The parasites live in the intestinal tract but may occasionally spread to the liver.
- Transmission - They are transmitted through contaminated water and food especially salads.

Symptoms –

- Abdominal pain, nausea and diarrhoea.
- The parasites cause ulceration of the intestinal tract, which results in diarrhoea.

Prevention and control

- Proper disposal of human faeces.
- Boiling water before drinking.
- Personal hygiene e.g. washing hands before meals.
- Washing vegetables and steaming particularly salads and fruits before eating.

Treatment

- Treatment of infected people with appropriate drugs.

Parasitic Diseases

Ascaris lumbricoides

- *Ascaris lumbricoides* lives in the intestines of a man or pig, feeding on the digested food of the host.
- The body of the worm is tapered at both ends.
- The female is longer than the male.

Mode of transmission

- The host eats food contaminated with the eggs, the embryo worms hatch out in the intestine.
- The embryo worms then bore into the blood vessels of the intestine.
- They are carried in the bloodstream to the heart and then into the lungs.
- As they travel through the bloodstream, they grow in size.
- After sometime, the worms are coughed out from the air passages and into the oesophagus.
- They are then swallowed, eventually finding their way into the intestines where they grow into mature worms.

Effects of Ascaris lumbricoides on the host

- The parasites feed on the host's digested food.
- This results in malnutrition especially in children.
- If the worms are too many, they may block the intestine and interfere with digestion.
- The worms sometimes wander along the alimentary canal and may pass through the nose or mouth.
- In this way, they interfere with breathing and may cause serious illness.

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- The larvae may cause severe internal bleeding as they penetrate the wall of the intestine.

Adaptive Characteristics

- The female lays as many as 25 million eggs.
- This ensures the continuation of the species.
- Eggs are covered by a protective cuticle that prevents them from dehydration.
- The adult worms tolerate low oxygen concentration.
- Have mouth parts for sucking food and other fluids in the intestines.
- Has a thick cuticle or pellicle to protect it from digestive enzymes produced by the host.

Control and Prevention

- Personal hygiene e.g. washing hands before eating.
- Proper disposal of faeces.
- Washing of fruits and vegetables.

Treatment

- Deworm using appropriate drugs ant-helmintics.

Schistosoma

- Schistosoma or bilharzia worm is a flat worm, parasitic on human beings and fresh water snails. (Biomphalaria and Bulinus.)
- The snail act as intermediate host.

Mode of Transmission

- Schistosomiasis also known as a bilharsiasis is caused by several species of the genus schistosoma.
- *Schistosoma haematobium* infects the urinary system mainly the bladder
- S. *japonicum* and S. *mansoni* both infect the intestines.
- *Schistosoma haemotobium* is common in East Africa where irrigation is practised and where slow moving fresh water streams harbour snails.
- It is spread through contamination of water by faeces and urine from infected persons.
- The embryo (miracidium) that hatch in water penetrates into snails of the species *Biompharahia* and *Bulinus.*
- Inside the snail's body, the miracidium undergoes development and multiple fission to produce rediae.
- The rediae are released into the water and develop to form cercariae which infect human through:
  - Drinking the water
  - Wading in water;
  - Bathing in snail-infested water.
- The cercaria burrows through the skin and enters blood vessel.

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Effects on the host

- Inflammation of tissues where egg lodge.
- Ulceration where eggs calcify.
- Egg block small arteries in lungs leading to less aeration of blood.
- The body turns blue - a condition known as cyanosis.
- If eggs lodge in heart or brain, lesions formed can lead to death.
- Bleeding occurs as the worms burrow into blood vessels (faeces or urine has blood).
- Pain and difficulty in passing out urine.
- Nausea and vomiting.
- When eggs lodge in liver ulceration results in liver cirrhosis.
- Death eventually occurs.

Adaptive Characteristics

- The female has a thin body and fits into small blood vessels to lay eggs.
- Eggs are able to burrow out of blood vessel into intestine lumen.
- Many eggs are laid to ensure the survival of the parasite.
- Large numbers of cercariae are released by snail.
- The miracidia and cercariae larvae have glands that secrete lytic enzymes which soften the tissue to allow for penetration into host.
- The male has a gynecophoric canal that carries the female to ensure that eggs are fertilised before being shed.
- Has suckers for attachment.

Prevention and Control

- Drain all stagnant water
- Boil drinking water.
- Do not wade bare feet in water.
- Wear long rubber boots and gloves (for those who work in rice fields).
- Eliminate snails, by spraying with molluscides.
- Reporting to doctor early when symptoms appear for early treatment.

Practical Activities

- Ecology is best studied outdoors.
- Students identify a habitat within or near the school compound, e.g. a flower bed.
- The quadrat method is used.
- Observation and recording of the various animals as well as their feeding habits is done.
- Birds that feed on the plants or arthropods in the area studied are noted through observation of habitat at various times of the day.

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- Food chains are constructed e.g green plants ~ caterpillar ~ lizard and many others involving all organisms in the area.
- The numbers of animals in 1 m^2 is counted directly or estimated e.g small arthropods like black ants.
- The number of plants is easily counted and recorded and ratio of consumers to producers calculated.
- It will be noted that in terms of numbers where invertebrates are involved, there are very many consumers of one plant.
- Several other quadrats are established and studied and averages calculated.

Adaptions to Habitat

Hydrophytes

- Specimen of hydrophytes e.g water lily is observed.
- Students should note the poorly developed root systems and broad leaves.
- Stomata distribution on leaf surface is studied through microscopy or by emersing a leaf in hot water and counting number of bubbles evolved.

Mesophytes –

- Ordinary plants e.g bean hibiscus and zebrina can be studied.
- Size of leaves is noted and stomata distribution studied.

Xerophytes

- Specimen include *Euphorbia,* cactus and sisal which are easily available.
- The root system e.g in sisal is noted as shallow but extensive.
- It will be noted that sisal has fleshy leaves and stem while cactus and *Euphorbia* have fleshy stem but leaves are reduced to small hair-like structures.

Comparison of Root nodules from fertile and poor soils

Root nodules –

- Are swellings on roots of leguminous plants.
- Soil fertility determines number of root nodules per plant.
- Bean plants are best used in this study.
- One plot can be manured while the other is not.
- Similar seeds are planted in the two plots.
- The plants are uprooted when fully mature (vegetatively) i.e any time after flowering and before drying.
- The number of nodules per plant is counted.
- An average for each plot is calculated.
- It is noted that the beans from fertile soil have more and large nodules than those grown in poor soils.

Estimation of Population using Sampling Methods

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- The number of organisms both producers and the various consumers is recorded in each area studied e.g. using a quadrat.
- The total area of the habitat studied is measured.
- The average number of organisms per quadrat (1 m^2) is calculated after establishing as many quadrats as are necessary to cover the area adequately.
- Total population of organisms is calculated from the area.
- Abiotic environment is studied within the area sampled.
- Air temperature soil surface temperature are taken and recorded.
- This is best done at different times of day, i.e., morning afternoon and evening.
- Any variations are noted.
- pH of the soil is measured using pH distilled water to make a solution.
- Litmus papers can be used to indicate if soil is acidic or alkaline, but pH paper or meter gives more precise pH values.
- Humidity is measured using anhydrous blue cobalt chloride paper which gives a mere indication of level of humidity.
- A windsock is used to give an indication of direction of wind.
- As all the abiotic factors are recorded observations are made to find the relationships between behaviour of organism and the environmental factors for example:
  - The temperature affects the behaviour of animals.
  - The direction of wind will affect growth of plants.
  - The level of humidity determines the type, number and distribution of organisms in an area.

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REPRODUCTION IN PLANTS AND ANIMALS

Introduction

- The process by which mature individuals produce offspring is called reproduction.
- Reproduction is a characteristic of all living organisms and prevents extinction of a species.
- There are two types of reproduction: sexual and asexual reproduction.
- Sexual reproduction involves the fusion of male and female gametes to form a zygote.
- Asexual reproduction does not involve gametes.

Cell Division

- Cell division starts with division of nucleus.
- In the nucleus are a number of thread-like structures called chromosomes, which occur in pairs known as homologous chromosomes.
- Each chromosome contains-genes that determine the characteristics of an organism.
- The cells in each organism contains a specific number of chromosomes.

There are two types of cell division:

Mitosis –

- This takes place in all body cells of an organism to bring about increase in number of cells, resulting in growth and repair.
- The number of chromosomes in daughter cells remain the same as that in the mother cell.

Meiosis –

- This type of cell division takes place in reproductive organs (gonads) to produce gametes.
- The number of chromosomes in the gamete is half that in the mother cell.

Mitosis

- Mitosis is divided into four main stages.
- Prophase, Metaphase, Anaphase and Telophase.
- These stages of cell division occur in a smooth and continuous pattern.

Interphase

- The term interphase is used to describe the state of the nucleus when the cell is just about to divide.
- During this time the following take place:
- Replication of genetic material so that daughter cells will have the same number of chromosomes as the parent cell.
- Division of cell organelles such as mitochondria, ribosomes and centrioles.
- Energy for cell division is synthesised and stored in form of Adenosine Triphosphate (ATP) to drive the cell through the entire process.
- During. interphase, the following observations can be made:
- Chromosomes are seen as long, thin, coiled thread-like structures.

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- Nuclear membrane and nucleolus are intact.

Prophase

- The chromosomes shorten and thicken.
- Each chromosome is seen to consist of a pair of chromatids joined at a point called centromere.
- Centrioles (in animal cells) separate and move to opposite poles of the cell.
- The centre of the nucleus is referred to as the equator.
- Spindle fibres begin to form, and connect the centriole pairs to the opposite poles.
- The nucleolus and nuclear membrane disintegrate and disappear.

Metaphase

- Spindle fibres lengthen.
- In animal cells they attach to the centrioles at both poles.
- Each chromosome moves to the equatorial plane and is attached to the spindle fibres by the centromeres.
- Chromatids begin to separate at the centromere.

Anaphase

- Chromatids separate and migrate to the opposite poles due to the shortening of spindle fibres .
- Chromatids becomes a chromosome.
- In animal cell, the cell membrane starts to constrict.

Telophase

- The cell divides into two.
- In animal cells it occurs through cleavage of cell membrane.
- In plants cells, it is due to deposition of cellulose along the equator of the cell.(Cell plate formation).
- A nuclear membrane forms around each set of chromosome.
- Chromosomes later become less distinct.

Significance of Mitosis

- It brings about the growth of an organism:
- It brings about asexual reproduction.
- Ensures that the chromosome number is retained.
- Ensures that the chromosomal constitution of the offspring is the same as the parents.

Meiosis

- Meiosis involves two divisions of the parental cell resulting into four daughter cells.
- The mother cell has the diploid number of chromosomes.

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- The four cells (gametes) have half the number of chromosomes (haploid) that the mother cell had.
- In the first meiotic division there is a reduction in the chromosome number because homologous chromosomes and not chromatids separate.
- Each division has four stages ***Prophase, Metaphase, Anaphase and Telophase.***

Interphase

- As in mitosis the cell prepares for division.
- This involves replication of chromosomes, organelles and build up of energy to be used during the meiotic division.

First Meiotic division

Prophase I

- Homologous chromosomes lie side by side in the process of synapsis forming pairs called bivalents.
- Chromosomes shorten and thicken hence become more visible.
- Chromosomes may become coiled around each other and the chromatids may remain in contact at points called chiasmata (singular chiasma).
- Chromatids cross-over at the chiasmata exchanging chromatid portions.
  Important genetic changes usually result.

Metaphase I

- Spindle fibres are fully formed and attached to the centromeres.
- The bivalents move to the equator of the spindles.

Anaphase I

- Homologous chromosomes separate and migrate to opposite poles.
- This is brought about by shortening of spindle fibres hence pulling the chromosomes.
- The number of chromosomes at each pole is half the number in the mother cell.

Telophase I

- Cytoplasm divides to separate the two daughter cells.

Second Meiotic Division

- Usually the two daughter cells go into a short resting stage (interphase)

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- but sometimes the chromosomes remain condensed and the daughter cells go straight into metaphase of second meiotic division.
- The second meiotic division takes place just like mitosis.

Prophase II

- Each chromosome is seen as a pair of chromatids.

Metaphase II

- Spindle forms and are attached to the chromatids at the centromeres.
- Chromatids move to the equator.

Anaphase II

- Sister chromatids separate from each other
- Then move to opposite poles, pulled by the shortening of the spindle fibres.

Telophase II

- The spindle apparatus disappears.
- The nucleolus reappears and nuclear membrane is formed around each set of chromatids.
- The chromatids become chromosomes.
- Cytoplasm divides and four daughter cells are formed.
- Each has a haploid number of chromosomes.

Significance of Meiosis

- Meiosis brings about formation of gametes that contain half the number of chromosomes as the parent cells.
- It helps to restore the diploid chromosomal constitution in a species at fertilisation.
- It brings about new gene combinations that lead to genetic variation in the offsprings.

Asexual Reproduction

- Asexual reproduction is the formation of offspring from a single parent.
- The offspring are identical to the parent.

Types of asexual reproduction.

- Binary fission in amoeba.
- Spore formation in *Rhizopus.*
- Budding in yeast.

Binary fission

- This involves the division of the parent organism into two daughter cells.
- The nucleus first divides into two and then the cytoplasm separates into two portions

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- Binary fission also occurs in bacteria, *Paramecium, Trypanosoma* and *Euglena.*

Spore formation in Rhizopus

- *Rhizopus* is a saprophytic fungus which grows on various substrate such as bread, rotting fruits or other decaying organic matter.
- The vegetative body is called mycelium which has many branched threads called hyphae.
- Horizontal hyphae are called stolons.
- Vertical hyphae are called sporangiophore.
- The tips of sporangiophore become swollen to form sporangia, the spore bearing structure.
- Each sporangium contains many spores.
- As it matures and ripens, it turns black in colour.
- When fully mature the sporangium wall burst and release spores which are dispersed by wind or insects.
- When spores land on moist substratum, they germinate and grow into a new *Rhizopus* and start another generation.

Spore formation in ferns

- The fern plant is called a sporophyte.
- On the lower side of the mature leaves are sari (Singular: sorus) which bear spores.

Budding in Yeast

- Budding involves the formation of a protrusion called a bud from the body of the organism.
- The bud separates from the parent cell, in yeast budding goes on so fast and the first bud starts to form another bud before the separation.
- A short chain or mass of cells is formed.

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Sexual Reproduction in Plants

- In flowering plants, the flower is the reproductive organ which is a specialised shoot consisting of a modified stem and leaves.
- The stem-like part is the pedicel and receptacle, while modified leaves form corolla and calyx.

Structure of a flower

- A typical flower consists of the following parts:

Calyx –

- made up of sepals.
- They enclose and protect the flower when it is in a bud. Some flowers have an outer whorl made of sepal-like structures called epicalyx.

Corolla –

- consists of petals. The petals are brightly coloured in insect - pollinated flowers.

Androecium –

- Is the male part of the flower. It consists of stamens.
- Each stamen consists of a filament whose end has an anther.
- Inside the anther are pollen sacs which contain pollen grains.

Gynoecium (pistil) –

- Is the female part of the flower.
- It consists of one or more carpels.
- Each carpel consists of an ovary, a sty le and a stigma.
- The ovary contains ovules which become seeds after fertilisation.
- A ***monocarpous pistil*** has one carpel e.g. beans.
- ***A polycarpous pistil*** has many carpels.
- If the carpes are free, it is called ***apocarpous*** as in rose and *Bryophyllum,*
- In carpels that are fused it is called ***syncarpous*** as in *Hibiscus.*
- ***A complete flower*** has all the four floral parts.
- A regular flower can be divided into two halves by any vertical section passing through the centre. e.g. morning glory.
- Irregular flower can be divided into two halves in only one plane e.g. crotalaria.

Pollination

- This is the transfer of pollen grains from the anther to the stigma.

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Types of pollination

- ***Self pollination*** is the transfer of pollen grains from the anther of one flower to the stigma of the same flower.
- ***Cross-pollination*** is the transfer of pollen grains from the anther of one flower to the stigma of a different flower, of the same species.

Agents of pollination

- Agents of pollination include wind, insects, birds and mammals.
- Insect pollinators include bees, butterflies and mosquitoes.

Mechanisms that hinder self-pollination

- Stamens ripen early and release their pollen grains before the stigma, mature. This is called protandry e.g. in sunflower.
- The stigma matures earlier and dries before the anthers release the pollen grains.
- This is called protogyny and is common in grasses.
- Self sterility or incompatibility
- Pollen grains are sterile to the stigma of the same flower, e.g. in maize flower.
- Shorter stamens than pistils.

Fertilisation in Plants

- The pollen grain contains the generative nucleus and a tube nucleus.
- When the pollen grain lands on the stigma, it absorbs nutrient and germinates forming a pollen tube.
- This pollen tube grows through the style pushing its way between the cells.
- It gets nourishment from these cells.
- The tube nucleus occupies the position at the tip of the growing pollen tube.
- The generative nucleus follows behind the tube nucleus, and divides to form two male gamete nuclei.
- The pollen tube enters the ovule through the micropyle.
- When the pollen tube penetrates the ovule disintegrates and the pollen tube bursts open leaving a clear way for the male nuclei.
- One male nucleus fuses with the egg cell nucleus to form a diploid zygote which develops into an embryo.
- The other male gamete nucleus fuses with the polar nucleus to form a triploid nucleus which forms the primary endosperm.
- This is called double fertilisation.

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After fertilisation the following changes take place in a flower:

- The integuments develops into seed coat (testa).
- The zygote develops into an embryo.
- The triploid nucleus develops into an endosperm.
- The ovules become seeds.
- The ovary develops into a fruit.
- The ovary wall develops into pericarp.
- The style, dries up and falls off leaving a scar.
- The corolla, calyx and stamens dry up and fall off.
- In some the calyx persists.

Fruit formation

- Fruit development without fertilisation is called parthenocarpy
- e.g. as in pineapples and bananas.
- Such fruits do not have seeds.

Classification of fruits

- False fruits develops from other parts such as calyx, corolla and receptacle,
- e.g. apple and pineapple which develops from an inflorescence.
- True fruits develop from the ovary, e.g. bean fruit (pod).
- True fruits can be divided into fleshy or succulent fruits e.g. berries and drupes and dry fruits.
- The dry ones can be divided into Dehiscent which split open to release seeds and indehiscent which do not open.

Types of fruits

Type of fruit	*Structure*	*Example*
Berry Fleshy-	Ovary fleshy, thin skinned juicy with many	Tomato, orange, Sodom
Drupe fleshy-	Outer layer fleshy, inner layer hard, endosing more seeds	Mango, plum
Pod Dehiscent (dry)	Ovary wall thin, contains many seeds. Splits	Bean, pea
Schizocarp (dry)	The ripe fruit breaks up into small one seeded	Castor oil
Caryopsil Dry	Pericarp and seed coat are fused to form thin covering	Maize grain
Cypsela Dry indehiscent	One seeded fruit. The calyx persists	Bidens, Tridax
Pome	Outer fleshy layer develops from calyx and	Pear, apple

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Multiple fruit	Formed from several flowers in a cluster	Pineapple
Achene	Ovary wall separated from seed	Sunflower

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Placentation

- This is the arrangement of the ovules in an ovary.

Marginal placentation:

- The placenta appears as one ridge on the ovary wall e.g. bean.

Parietal placentation:

- The placenta is on the ridges on ovary wall.
- Ovules are in them e.g. pawpaw.

Axile placentation:

- The placenta is in the centre.
- Ovary is divided into a number of loculi. e.g. orange.

Basal placentation.

- The placenta is formed at the base of the ovary e.g. sunflower.

Free Central placentation.

- Placenta is in the centre of the ovary.
- There are no loculi e.g. in primrose.

Methods of fruit and seed dispersal

Animal dispersal

- Fleshy fruits are eaten by animals.
- Animals are attracted to the fruits by the bright colour, scent or the fact that it is edible.
- The seeds pass through the digestive tract undamaged and are passed out with faeces. E.g. tomatoes and guavas.
- Such seeds have hard, resistant seed coats.
- Others have fruits with hooks or spines that stick on animal fur or on clothes.
- Later the seeds are brushed of or fall off on their own e.g. *Bidens pilosa* (Black jack).

Wind dispersal

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- Fruits and seeds are small and light in order to be carried by air currents.
- A fruit that is a capsule e.g. tobacco split or has pores at the top e.g. Mexican poppy.
- The capsule is attached to along stalk when swayed by wind the seeds are released and scattered.
- Some seeds have hairy or feather-like structures which increase their surface area so that they can be blown off by the wind e.g. *Sonchus.*
- Others have wing-like structures e.g. Jacaranda and Nandi Flame.
- These extensions increase the surface area of fruits and seeds such that they are carried by the wind.

Water dispersal

- Fruits like coconut have fibrous mescocarp which is spongy to trap air, the trapped air make the fruit light and buoyant to float on water.
- Plants like water lily produce seeds whose seed coats trap air bubbles.
- The air bubbles make the seeds float on water and are carried away.
- The pericarp and seed coat are waterproof.

Self dispersal (explosive) Mechanism

- This is seen in pods like bean and pea.
- Pressure inside the pod forces it to open along lines of weakness throwing seeds away from parent plant.

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Reproduction in Animals

- Sexual reproduction involves the fusion of gametes.
- In animals two individuals are involved, a male and a female.
- Special organs known as gonads produce gametes.
- In males testes produce sperms while in females ovaries produce ova.

- The fusion of male gamete and female gamete to form a zygote is called fertilisation.

There are two types of fertilisation. External and internal.

External fertillsation

- Example in amphibians takes place in water.
- The male mounts the female and shed sperms on the eggs as they are laid.
- Eggs are covered by slippery jelly-like substance which provides protection.
- Many eggs are released to increase the chances of survival.

Internal fertilisation

- This occurs in reptiles, birds and mammals.
- Fertilisation occurs within the body of the female.
- Fewer eggs are produced because there are higher chances of fertilisation since sperms are released into the female body.

Reproduction in Humans

Structure of female reproduction system

The female reproduction system consist of the following:

Ovaries

- Are two oval cream coloured structures found in lower abdomen below the kidneys.

Oviducts.

- They produce the ova.
- Are tubes which conduct the ova produced by the ovaries to the uterus.
- Fertilisation occurs in the upper part of the oviduct.

Uterus

- The uterus is a hollow muscular organ found in the lower abdomen.

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- The embryo develops inside the uterus.
- The inner lining endometrium supplies nutrients to embryo.
- The embryo is implanted into the inner uterine wall- the endometrium which nourishes the embryo.
- The thick muscles of the uterus assist in parturition.

Cervix

- Has a ring of muscles that separates the uterus from the vagina.
- It forms the opening to the uterus

Vagina

- Is a tube that opens to the outside and it acts as the copulatory and birth canal through the vulva.

Structure of male reproductive system

The male reproductive system consists of the following:

Testis:

- Each testis is a mass of numerous coiled tubes called semniferous tubules.
- Each is enclosed within a scrotal sac that suspends them between the thighs.
- This ensures that sperms are maintained at a temperature lower than that of the main body.

Seminiferous tubules

- The lining of seminiferous tubules consists of actively dividing cells which give rise to sperms.
- Between the seminiferous tubules are interstitial cells which produce the male hormones called androgens e.g. testosterone.
- The seminiferous tubules unite to form the epididymis, which is a coiled tube where sperms are stored temporarily .
- Vas deferens (sperm duct) is the tube through which sperms are carried from testis to urethra.
- Seminal vesicle produces an alkaline secretion which nourishes the spermatozoa.

Prostate gland

- Produces an alkaline secretion to neutralise vaginal fluids.

Cowpers' gland

- Secretes an alkaline fluid.
- All these fluids together with spermatozoa form semen.

Urethra

- Is a long tube through which the semen is conducted during copulation.
- It also removes urine from the bladder.

Penis

- Is an intro-mittent organ which is inserted into the vagina during copulation .

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Fertilisation in Animals

- Fertilisation is preceded by copulation in which the erect penis is inserted into the vagina.
- This leads to ejaculation of semen.
- The sperms swim through the female's genital tract to the upper part of the oviduct.
- The head of the sperm penetrates the egg after the acrosome_ releases lytic enzymes t dissolve the egg membrane.
- The tail is left behind.
- Sperm nucleus fuses with that of the ovum and a zygote is formed.
- A fertilisation membrane forms around the zygote which prevents other sperms from penetrating the zygote.

Implantation:

- After fertilisation the zygote begins to divide mitoticaly as it moves towards the uterus.
- It becomes embedded in the wall of the uterus a process called implantation.
- By this time the zygote is a hollow ball of cells called blastocyst or embryo.
- In the uterus the embryo develops villi which project into uterus for nourishment later the villi and endometrium develop into placenta.

Embryonic membranes

- Embryonic membranes develop around the embryo.
- The outermost membrane is the chorion which forms the finger-like projections (chorionic villi) which supply nutrients to the embryo.
- The amnion surrounds the embryo forming a fluid filled cavity within which the embryo lies.
- Amniotic cavity is filled with amniotic fluid.
- This fluid acts as a shock absorber and protects the foetus against mechanical injury.
- It also regutates temperature.
- The chorionic villi, allantois together with the endometrium from the placenta.
- The embryo is attached to the placenta by a tube called umbilical cord which has umbilical vein and artery.
- The maternal blood in the placenta flows in the spaces lacuna and surrounds capillaries from umbilical vein and artery.
- The umbilical cord increase in length as the embryo develops.

Role of placenta

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Protection

- Maternal blood and foetal blood do not mix.
- This ensures that the pathogens and toxins from maternal blood do not reach the foetus.
- The placenta allows maternal antibodies to pass into the foetus, providing the foetus with immunity.

Nutrition

- The placenta facilitates the transfer of nutrients from maternal blood to foetus.

Excretion

- Placenta facilitates the removal of nitrogenous wastes from the foetus' blood to maternal blood.

Gaseous exchange

- Oxygen from the maternal blood diffuses into the foetal blood while carbon (IV) oxide from foetal blood diffuse into maternal blood.

Production of hormones

- Placenta produces progesterone and oestrogen.

Gestation period

- The period between conception and birth is called gestation.
- In humans gestation takes nine months (40 weeks).
- The embryo differentiates into tissues and organs during this period.

Week 1 to 3:

- Zygote divides to form blastocyst.
- Implantation takes place.
- The three germ layers form endoderm, mesoderm and ectoderm.
- Nervous system starts to form.

Week 4 to 7:

- Development of circulating and digestive systems.
- Further development of nervous system, formation of sensory organs,
- All major internal organs are developed.
- At week 5, heartbeat starts .

Week 8 to 24:

- All organs well developed including sex organs.
- Hair, finger and toe nails grow.
- Foetus move and eyelids open.

Week 25- 30:

- The fully developed foetus responds to touch and noises and moves vigorously.
- The head turns and faces downwards ready for birth.

Week 31-40:

- Foetus increases in size.

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- Birth occurs.

Reproductive Hormones

Hormone	*Source*	*Functions*
Follicle Stimulating Hormone (FSH)	Pituitary gland	Development of ovarian follicle; stimulates secretion of oestrogen by the ovary
Luteinising Hormone	Pituitary gland	Causes ovulation; causes development of Graafian follicle into the corpus luteurn; causes secretion of progesterone by the ovary
Prolactin	Pituitary gland	Initiates production and secretion of milk by the mammary glands
Oxytocin	Pituitary gland	Causes contraction of the uterus during parturition (birth)
Progesterone	Corpus luteum in the ovary	Causes contraction of wall of the uterus to thicken after ovulation
Oestrogen	Ovary	Causes changes in the uterine wall in preparation for implantation; initiates development of secondary sexual characteristics
Androgens-Testosterone	Interstitial cells of testis	Stimulates the development of secondary sexual characteristics
Interstitial Cell Hormone (ICSH)	Pituitary gland	Stimulates the interstitial cells of testis to release androgens
Human Chorionic Gonadotrophin (HCG)	Chorionic villi	Stops the degeneration of the corpus luteum for production of oestrogen and progesterone

Secondary Sexual Characteristics

Male

- Testerone is the main androgen that stimulates the development of secondary sexual characteristics.
- Broadening of the shoulders.
- Deepening of the voice due to enlargement of larynx.
- Hair at the pubic area, armpit and chin regions.
- Penis and testis enlarge and produce sperms.

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- Body becomes more masculine.

Female

- Enlargement of mammary glands.
- Hair grows around pubic and armpit regions.
- Widening of the hips.
- Ovaries mature and start producing ova.
- Menstruation starts.
- Oestrogen triggers the onset of secondary sexual characteristics.

Sexually transmitted infections (STI)

Disease	*Causative*	*Method of transmission*	*Symptoms*	*Prevention/control*
Gonorrhoea	Bacterium Neiseeria Gonorrhoea	-Sexual contact - during birth for infants -Sharing towels	-Itching of urethra -yellowish discharge pain as males urinate, vaginal discharge. with odour in females	A void indiscriminate sex. Treat both partners infected A void sharing linen
Syphilis	Bacterium Treponema Palladium	-Sexual contact - During birth for infants. - Sharing towels and linen	Solitary painless ulcer-on genital or mucous -Rashes, muscles and papules on hands, feet lips, genital areas	Treat at primary infection stage -Avoid indiscriminate sex. - A void sharing linen
Trichomoniasi	Protozoan Trichomonas Vaginalis	-Sexual contact -contaminated linen, underwear and toilet seats	Itching of urethra or vagina in females, smelly, yellow discharge	A void sharing linen -Avoid indiscriminate sex -personal hygiene
Hepatitis	Virus Hepatitis B	-Sexual contact -blood contaminated needles and syringes	Fever, nausea, jaundice, loss of appetite, yellow urine	-Avoid indiscriminate sex -use disposable needles and syringes - strict personal hygiene
Candidiasis	Fungus Albicans	-spread through sexual contact - sharing linen and towels	Itching and burning sensation and white discharge from genitals	-Avoid indiscriminate sex - Treat both partners
Herpes (Simplex)	Virus Herpes	-sexual contact kissing, contaminated needles	Lesions on skin and mucous membranes of buccal cavity vagina or head of penis	- A void indiscriminate sex and contaminated needles and syringes.
HIV and Aids	Virus	-sexual contact	-chronic diarrhoea	-Avoid indiscriminate

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	Human Deficiency	-blood -contaminated instruments -Through breast milk and body fluids. -Through birth canal for infants	-weight loss (more than 10% body weight lost in a month) - constant, persistent cough, skin infectious (herpes zoster)	sex. -Use screened blood - No sharing of tooth brushes, razors - Use disposable needles

Menstrual Cycle

- This is characterized by discharge of blood and tissue debris (menses) from the uterus every 28 days.
- This is due to the breakdown of the endometrium which occurs when the level of progesterone falls and the girl starts to menstruate.
- The follicle stimulating hormone (FSH) causes the Graafian follicle to develop and also stimulate the ovary to release oestrogen.
- Oestrogen hormone triggers the onset of secondary sexual characteristics.
- Luteinising hormone (L.H) causes the mature ovum to be released from the Graafian follicle - a process called ovulation.
- After ovulation progesterone hormone is produced.
- After menstruation, the anterior lobe of the pituitary gland starts secreting the follicle stimulating hormone (FS.H) which causes the Graafian follicle to develop in the ovary.
- It also stimulates the ovary tissues to secrete oestrogen.
- Oestrogen brings about the repair and healing of the inner lining of the uterus (endometrium) which had been destroyed during menstruation.
- Oestrogen level stimulates the pituitary gland to produce (Luteinising Hormone (L.H).
- This hormone makes the mature Graafian follicle to release the ovum into the funnel of oviduct, a process called ovulation.
- After releasing the ovum, the Graafian follicle changes into a yellow body called corpus luteum.
- The luteinising hormone stimulates the corpus luteum to secrete a hormone called progesterone which stimulates the thickening and vascularisation of endometrium.
- This prepares the uterine wall for implantation of the blastocyst.
- If fertilisation takes place, the level of progesterone increases and thus inhibits FSH from stimulating the maturation of another Graafian follicle.
- If fertilisation does not occur, the corpus luteum disintegrates and the level of progesterone goes down.
- The endometrium, sloughs off and menstruation occurs.

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Advantages of Reproduction Asexual

- Good qualities from parents are retained in the offspring without variation.
- New individuals produced asexually mature faster.
- Process does not depend on external factors which may fail such as pollination.
- New individuals obtain nourishment from parent and so are able to survive temporarily under unsuitable conditions.
- No indiscriminate spreading of individuals which can result in wastage of offspring.
- Takes a shorter time and leads to rapid colonization.

Disadvantages of asexual reproduction

- New offspring may carry undesirable qualities from parents.
- Offspring may be unable to withstand changing environmental conditions.
- Faster maturity can cause overcrowding and stiff competition.
- Reduced strength and vigour of successive generations.

Advantages of sexual reproduction

- Leads to variations.
- Variations which are desirable often show hybrid vigour.
- High adaptability of individuals to changing environmental conditions.
- Variations provide a basis for evolutionary changes.

Disadvantages of sexual reproduction

- Fusion is difficult if two individuals are isolated.
- Some variations may have undesirable qualities.
- Population growth is slow.

Practical Activities

Examining the stages of mitosis

- About 2 mm of a root tip of onion bulb is cut off and placed on a microscope slide.
- A stain e.g. aceto-orcein is added and the root tip macerated using a scapel.
- A cover slip is added and observations made.
- Different stages of mitosis can be observed.

Examining the stages of meiosis

- An unopened bud of *Tradescantia* is obtained
- The anther is removed and placed on a microscope slide.
- A few drops of hydrochloric acid and acetic-orcein stain are added.

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- A cover slip is placed on the anther.
- Pressing the cover slip gives a thin squash, which is observed under the microscope.
- Different stages of meiosis are observed.

To observe the structure of Rhizopus

- *Rhizopus* grow on moist bread left under suitable temperature
- A piece of moist bread is placed on a petri-dish or enclosed in a plastic bag and observe daily for four days.
- Under a low power microscope the sporangia and stolons can be observed.

To examine spores on sori of ferns

- Obtain the fern plant.
- Detach a frond from the plant and observe the under-side using a hand lens to see the raised brown patches - the sori.
- Open up the sorus to observe the sporangia.

Examine insect and wind pollinated flowers

- Obtain insect pollinated flowers e.g. crotalaria, hibiscus/Ipomea, Solanum, incunum.
- Note the scent, colour and nectar guides.
- A description of the calyx, corolla, androecium and gynoecium is made.
- Obtain a wmd pollinated flower e.g,' maize, star-grass, sugar-cane, Kikuyu grass.
- Observe the glumes, spikes and spikelet.
- Examine a single floret, and identify the androecium and gynoecium.

Classifying fruits

- Obtain different fruits - oranges, mangoes, maize, castor oil, bean pod, black jack .
- Observe the fruits, classify them into succulent, dry-dehiscent or indehiscent.

Dissection of Fruits

- Obtain an orange and a mango fruit.
- Make a transverse section.
- Observe the cut surface and draw and label the parts.
- Note that the fruit is differentiated into epicarp, mesocarp and endocarp.
- Obtain a pod of a legume.
- Open up the pod and observe the exposed surface.
- Draw and label the parts.
- Note that the fruit wall is not differentiated.

Dispersal of fruits and seeds

- Obtain animal dispersal fruits, like oranges, tomatoes, black jack, sodom apple.

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- Identify the way by which each is adapted to dispersal by animals.
- Obtain wind dispersed fruit/seed

e.g. Nandi flame, Jacaranda *Sonchus,* cotton seed, *Tecoma.*

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GROWTH AND DEVELOPMENT

Concept of Growth and Development

- Growth is a characteristic feature of all living organisms.
- Most multicellular organisms start life as a single cell and gradually grow into complex organisms with many cells.
- This involves multiplication of cells through the process of cell division.
- This quantitative permanent increase in size of an organism is referred to as growth. **For growth to take place the following aspects occur**
- Cells of organisms assimilate nutrients hence increase in mass.
- Cell division (mitosis) that lead to increase in the number of cells.
- Cell expansion that leads to enlargement an increase in the volume and size of the organism. It is therefore possible to measure growth using such parameters as mass, volume, length, height, surface area.
- On the other hand development is the qualitative aspect of growth which involves differentiation of cells and formation of various tissues in the body of the organism in order for tissues to be able to perform special functions.
- It is not possible to measure ac aspects of development quantitative.
- Therefore development can be assessed terms of increase in complexity of organism e.g. development of leaves, flowers and roots.
- A mature human being has millions of cells in the body yet he or she started from; single cell, that is, a fertilised egg.
- During sexual reproduction mammals an ovum fuses with a sperm form a zygote.
- The zygote divides rapidly without increasing in size, first into 2, 4, 8, 16,32, 64 and so on, till it forms a mass cells called morula.
- These first cell division is called cleavages.
- The morula develops a hollow part, resulting into a structure known as a blastula (blastocyst).
- Later, blastocyst cells differentiate into an inner layer (endoderm) and the outer layer (ectoderm).
- The two-layered embryo implants into the uterine wall and, by obtaining nutrients from the maternal blood, starts to grow and develop.

Blastocoel

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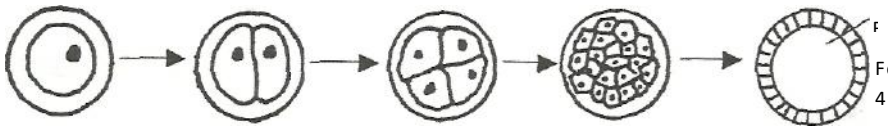

- As the embryo grows and develops, changes occur in cell sizes and cell -types.
- Such changes are referred to as growth and development respectively.
- These processes lead to morphological and physiological changes in the developing young organism resulting into an adult that is more complex and efficient.

- In the early stages, all the cells of the embryo look alike, but as the development process continues the cells begin to differentiate and become specialised into different tissues to perform different functions.

- Growth involves the synthesis of new material and protoplasm.
- This requires a continuous supply of food, oxygen, water, warmth and means of removing waste products.

- In animals, growth takes place all over the body but the rates differ in the various parts of the body and at different times.
- In plants however, growth and cell division mostly take place at the root tip just behind the root cap and stem apex.
- This is referred to as **apical growth** which leads to the lengthening of the plant.
- However, plants do not only grow upwards and downwards but sideways as well.
- This growth leads to an increase in width (girth) by the activity of cambium **cells.**
- The increase in girth is termed as **secondary growth.**

Study Question 1-State two major differences between growth and development

Measurement of growth

- Growth can be estimated by measuring some aspect of the organism such as height, weight, volume and length over a specified period of time.
- The measurements so obtained if plotted against time result into a growth curve.

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Study Question 2

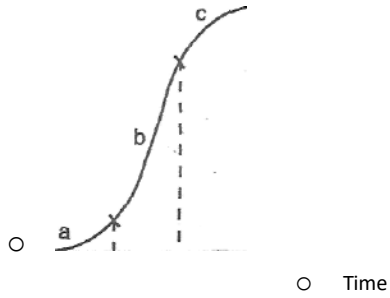
- The following results were obtained from a study of germination and early growth of maize.
- The grains were sown in soil in a greenhouse and.at two-day intervals. Samples were taken, oven dried and weighed. See table .

Table

Time after sowing	*Drymass of embryo (g)*
0	0.002
2	0.002;
4	0.008
6	0.016
8	0.024
10	0.034
. -12-	0.034

- Plot a graph of dry mass of embryo against time after sowing.
- Describe the shape of the graph.

For most organisms when the measurements are plotted they give an S-shaped graph called a **sigmoid curve** such as in figure .



- Fig. *4.2: TSie sigmoid growth curve*

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- This pattern is due to the fact that growth tends to be slow at first and then speeds up

and finally slows down as adult size is reached.

A sigmoid curve may therefore be divided into four parts.

Lag phase (slow growth)

- This is the initial phase during which little growth occurs.
- The growth rate is slow due to various factors namely:
  (i) The number of cells dividing are few.

  (ii) The cells have not yet adjusted to the surrounding environmental factors.

Exponential phase (log phase)

- This is the second phase during which growth is rapid or proceeds exponentially.
- During this phase the rate of growth is at its maximum and at any point, the rate of growth is proportional to the amount of material or numbers of cells of the organism already present.
- This rapid growth is due to:
  (i) An increase in number of cells dividing,2-4-8-16-32-64 following a geometric progression,

  (ii) Cells having adjusted to the new environment,

  (iii) Food and other factors are not limiting hence cells are not competing for resources,

  (iv) The rate of cell increase being higher than the rate of cell death.

Decelerating Phase

- This is the third phase during which time growth becomes limited as a result of the effect of some internal or external factors, or the interaction of both.
- The slow growth is due to: (
  i) The fact that most cells are fully differentiated.

  (ii) Fewer ceils still dividing,

  (iii) Environmental factors (external and internal) such as:

- shortage of oxygen and nutrients due to high demand by the increased number of cells.

- space is limited due to high number of cells.

- accumulation of metabolic waste products inhibits growth.
  limited acquisition of carbon (IV) oxide as in the case of plants.

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Plateau (stationary) **phase**

- This is the phase which marks the period where overall growth has ceased and the parameters under consideration remain constant.

This is due to the fact that:

- The rate of cell division equals the rate of cell death.
- Nearly *all* cells and tissues are fully differentiated, therefore there is *no* further increase in the number of cells.
- The nature of the curve during this phase may vary depending on the nature of the parameter, the species and the interns! factors.
- In some cases, the curve continue to increase slightly until organism dies as is the case monocotyledonous plants, man invertebrates, fish and certain reptiles. indicates positive growth.
- In some ot cases the curve flattens out indicating change in growth while other growth curv may tail off indicating a period of negat growth rate.
- This negative pattern characteristic of many mammals includi humans and is a sign of physical senesee associated with increasing age.

- **Study Question 3**

- What happens during the following; log and stationary phases of growth?

- However, the sigmoid curve does not to all organisms, for example, arthropods.
- I insects, growth takes place at intervals-volume changes are plotted against time., different curve is obtained.
- This is cal intermittent growth curve. See figure 43,
- The intermittent growth in insects is due to the fact that they have an exoskeleton and hence growth is possible only when it is shed.
- This shedding process is known as **moulting** or **ecdysis.**
- However, cell division continues to take place during the inter-moult phase but the expansion of tissues is limited by the unshed exoskeleton.

Practical Activity I: Project

To measure the growth of a plant

Requirements

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- *Small plots/boxes, meter rule and seeds of beans (or green grams, peas, maize),*

Procedure

- *Place some soil in the box or prepare a small plot outside the laboratory.*
- . *Plant some seeds in the box and place it in a suitable place outside the laboratory (or plant the seeds in your plot).*
- *Water the seeds daily.*
- *Observe the box/plot daily and note the day the seedlings emerge out of the soil.*
- *.Measure the height of the shoot from the soil level up to the tip of the shoot. Repeat this with four other seedlings. Work out the average height of the shoots for this day.*
- *Repeat procedure 5 every three days for at least three weeks.*
- *Record the results in a table form.*
- *On the same seedlings measure the length of one leaf from each of the five seedlings (from leaf apex to itsattachment on the stem).*
- *Calculate the average length of the leaves and record in the table.*
- *Plot a graph of the height of the shoot against time. On the same axes plot length of leaf against time.*
- *Compare the two graphs drawn.*

4.2 Growth and Development in Plants

- *The main growth and development phase in plants begins with the germination of the mature seed.*
- *Seeds are of two kinds depending on the number of cotyledons or embryo leaves.*
- 

Practical Activity 2

To investigate structural differences between monocotyledonous and dicotyledonous seeds

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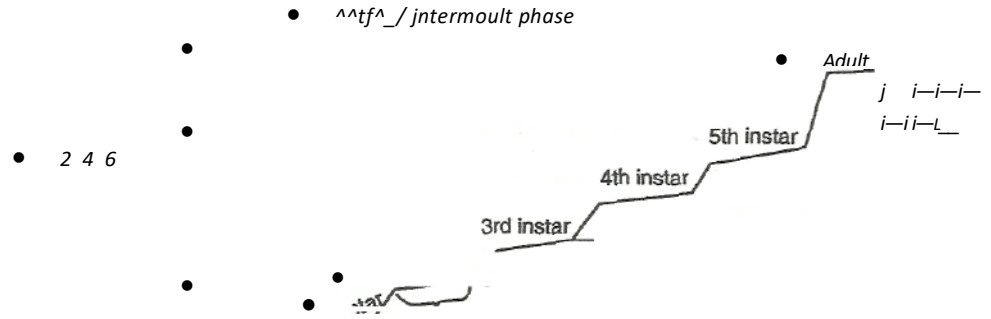


Time in days Fig. 4.3: Growth curve showing increase in length of the short homed grasshopper

Requirements

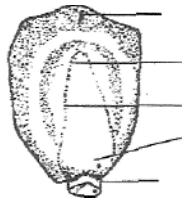
- Bean seeds and maize grains which have been soaked overnight. Scalpel or razor blades, iodine solution, Petri-dish and hand lens.

Procedure

- Using a scalpel or razor blade make longitudinal sections (LS) of both the bean seed and the maize grain.
- Observe the LS of the specimens using a hand lens.
- Note any structural difference between the specimens.
- Draw the LS of each specimen and label.
- Puta drop of iodine solution on the cut surfaces of both specimens.
- Note any differences in colouration with iodine on the surfaces of the two specimens.
- On your diagrams indicate the distribution of the stain.
- Account for the difference in distribution of the colouration with iodine in the two specimens.

Structure of the Seed

- A typical seed consists of a seed coat enclosing an embryo.
- The seed coat is the outer covering which, in most seeds, is made



-Remains of style

Position of radicle Scutellum

Attachment to External Parent plant

Position of plumule

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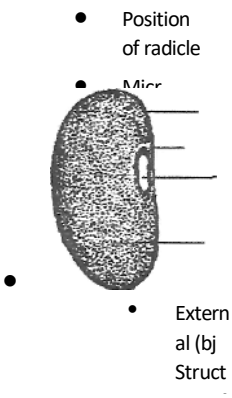
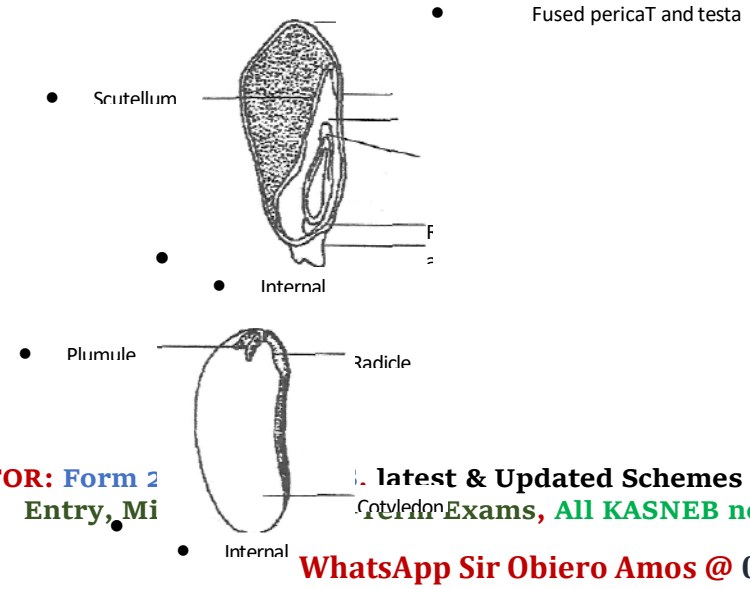
- Structure of monocotyledonous seed (maize grain)



- up of the two layers, an outer testa and inner one, the legmen.
- The testa is thick; the tegmen is a transparent membrane tissue.
- The two layers protect the seed bacteria, fungi and other organisms whk may damage it.
- There is a scar called **hilurn** on one part of the seed.
- This is point where the seed had been attached the seed stalk or funicle.
- Near one end of 1 hilum is a tiny pore, the **micropyle.**
- This allows water and air into the embryo, embryo is made up of one or two seed leavi or cotyledons, a **plumule** (embryonic sh(and a **radicle** (the embryonic root).
- The of the radicle is opposite the micropyle.
- In some seeds the cotyledons swollen as they contain stored food for growing plumule and radicle. Such seeds, called non-endospermic seeds.
- In ot cases, the seeds have their food stored in: endosperm.
- Such seeds are call endospermic seeds. Seeds with one cotyk are referred to as **monocotyledonous** wi those with two are referred to **dicotyledonous.**
- This is the major basis i differentiation between the two large cb of plants, the monocotyledonae aa dicotyledonae.



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Dormancy in Seeds

- The embiyo of a dry, fully developed seed usually passes through a period of rest after ripening period.
- During this time the seed performs all its life (physiological) processes very slowly and uses up little food. This is a period of dormancy.
- Even if all the favourable environmental conditions for germination are provided to the seed during this period of dormancy, the seed will not germinate.
- This is due to the fact that the seed embryo may need to undergo further development before germination.
- Some seeds can germinate immediately after being_shed from the parent plant (e.g. most tropical plants) while others must pass through dormancy period, lasting for weeks, months or even years before the seed can germinate.
- Dormancy provides the seeds with enough time for dispersal so that they can germinate in a suitable environment.
- It also enables seeds to survive during adverse environmental conditions without depleting their food reserves.
- The embryo has time to develop until favourable conditions are available e.g. availability of water.

Factors that Cause Dormancy

- Embryo may not yet be fully developed.
- Presence of chemical inhibitors that inhibit germination in seeds e.g. abscisic acid.
- Very low concentrations of hormones e.g. gibberellins and enzymes reduces the ability of seeds to germinate.
- Hard and impermeable seed coats prevent entry of air and water in some seeds e.g. wattle.
- In some seeds the absence of certain wavelengths of light make them remain dormant e.g. in some lettuce plants.
- Freezing of seeds during winter lowers their enzymatic activities rendering them dormant.

Ways of Breaking Dormancy

- When the seed embryos are mature then the seed embryos can break dormancy and germinate.

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- Increase in concentration of hormones e.g. cytokinins and gibberellins stimulate germination.
- Favourable environmental factors such as water, oxygen and suitable temperature.
- Some wavelengths of light trigger the production of hormones like gibberellins leading to breaking of dormancy.
- Scarification i.e. weakening of the testa is needed before seeds with hard impermeable seed coats can germinate.
- This is achieved naturally by saprophytic bacteria and fungi or by passing through the gut of animals.
- In agriculture the seeds of some plants are weakened by boiling, roasting and cracking e.g. wattle.

Seed Germination

- The process by which the seed develops into a seedling is known as germination.
- It refers to all the changes that take place when a seed becomes a seedling.
- At the beginning of germination water is absorbed into the seed through the micropyle in a process known as imbibition and causes the seed to swell.
- The cells of the cotyledons become turgid and active.
- They begin to make use of the water to dissolve and break down the food substances stored in the cotyledons.
- The soluble food is transported to the growing plumule and radicle.
- The plumule grows into a shoot while the radicle grows into a root.
- The radical emerges from the seed through micropyle, bursting the seed coat as it does so.

Conditions Necessary for Germination

- Seeds can easily be destroyed by unfavourable conditions such as excessive heat, cold or animals.
- Seeds need certain conditions to germinate and grow.
- Some of these conditions are external, for example water, oxygen and suitable temperature while others are internal such as enzymes, hormones and viability of the seeds themselves.

Water

- A non-germinating seed contains very little water.
- Without water a seed cannot germinate.
- Water activates the enzymes and provides the medium for enzymes to act and break down the stored food into soluble form.
- Water hydrolyses and dissolves the food materials and is also the medium of transport of dissolved food substances through the various cells to the growing region of the radical and plumule.
- Besides, water softens the seed coat which can subsequently burst and facilitate the emergence of the radicle.

Oxygen

- Germinating seeds require energy for cell division and growth.

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- This energy is obtained from the oxidation of food substances stored in the seed through respiration thus making oxygen an important factor in seed germination.
- Seed in water logged soil or seed buried deep into the soil will not germinate due to lack of oxygen.

Temperature

- Most seeds require suitable temperature before they can germinate.
- Seeds will not germinate below 0°C or above 47° C.
- The optimum temperature for seeds to germinate is 30°C.
- At higher temperature the protoplasm is killed and the enzymes in the seed are denatured.
- At very low temperatures the enzymes become inactive.
- Therefore, the protoplasm and the enzymes work best within the optimum temperature range.
- The rate of germination increases with temperature until it reaches an optimum.
- This varies from plant to plant.

Enzymes

- Enzymes play a vital role during germination in the breakdown and subsequent oxidation of food.
- Food is stored in seeds in form of carbohydrates, fats and proteins which are in insoluble form.
- The insoluble food is converted into a soluble form by the enzymes.
- Carbohydrates are broken down into glucose by the **diastase enzyme,** fats into fatty acids and glycerol by **lipase,** and proteins into amino acids by **protease.**
- Enzymes are also necessary for the conversion of hydrolysed products to new plant tissues.

Hormones

- Several hormones play a vital role in germination since they act as growth stimulators.
- These include gibberellins and cytokinins.
- These hormones also counteract the effect of germination inhibitors.

Viability

- Only seeds whose embryos are alive and healthy will be able to germinate and grow.
- Seeds stored for long periods usually lose their viability due to depletion of their food reserves and destruction of their embryo by pests and diseases.

Study Question 4

- In an experiment to investigate the effect of neat on germination of seeds, ten bags each containing 60 pea seeds were placed in a water-bath maintained at 85°C .

- After every two minutes a bag was removed and seeds contained in it planted.

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- The number that germinated was recorded.
- The procedure used for pea seeds was repeated for wattle seeds.

The results obtained were as shown in the table 4,2,

	Number of seeds that	
Time (Min)	*Pea seeds*	*Wattle seeds*
0	60	0
2	60	0
4	48	0
6	42	2
8	34	28
10	10	36
12	2	40
14	0	44
16	0	46
18	0	48
20	0	49
22	0	49

- (a)Using a suitable scale and on the same axes, draw graphs of time in hot water against number of seeds that germinated for each plant. Use horizontal axis for time and the vertical axis for the seeds that germinated.
    - Explain why the ability of pea seeds to germinate declined with time of exposure to heat.
    - Explain why the ability of the wattle seeds to germinate improved with time of exposure to heat.

Practical Activity 3

To investigate conditions necessary for seed germination

Requirements

- Cotton wool, seeds, water, six fiat bottomed flasks, 2 corks, 2 test-tubes, blotting paper, incubator,

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refrigerator, thermometer, pyrogallic acid and sodium hydroxide.

Procedure

- Prepare three set-ups as shown in figure 4.5.
- Leave the set-ups to stand for five days.
- Record all the observable changes that have taken place in the flasks hi each set up in a table form as shown

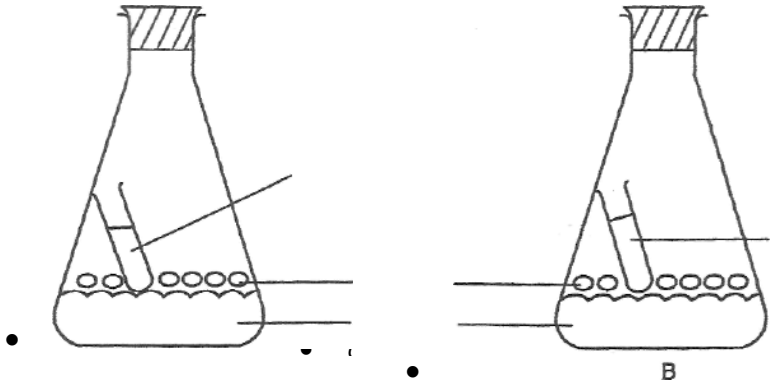
etup	*Observations*	
	In flask	In flask B
I II iii		

Study Question 5

- Which condition was being investigated in set-up I, II and III?
- For each set-up explain the results obtained.
- What was the role of flask B in each set-up?

Types of Germination

- The nature of germination varies in different seeds.
- During germination the cotyledons may be brought above the soil surface.
- This type of germination is called epigeal germination.
- If during germination the cotyledons remain underground the type of germination is known as **hypogeal.**
  - *SET UP 1*



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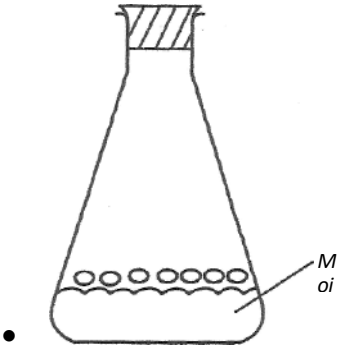
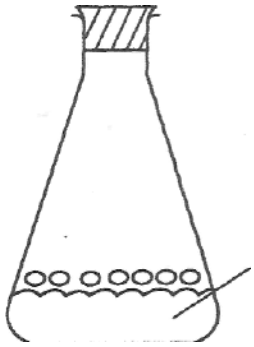
- *Seeds*
- *Moist*
- *Water*

- *SET UP 2*





- *Dry cotton wool*

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- *SETUPS*

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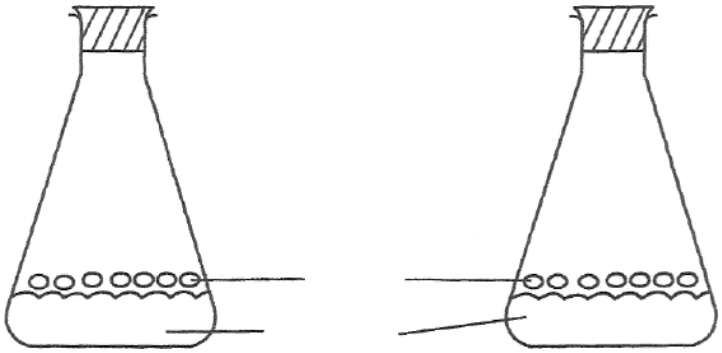

- Fig. 4.5: Set-up for investigating conditions necessary for germination

Epigeal Germination

- During the germination of a bean seed, the radicle grows out through the micropyle.
- It grows downwards into the soil as a primary root from which other roots arise.
- The part of the embryo between the cotyledon and the radicle is called the **hypocotyl.**
- This part curves and pushes upwards through the soil protecting the delicate shoot tip.
- The hypocotyls then straightens and elongates carrying with it the two cotyledons which turn green and leafy.
- They start manufacturing food for the growing seedling.
- The plumule which is lying between two cotyledons, begins to grow into first foliage leaves which start manufacturing food.

Hyopgeal Germination

- In maize, the endosperm provides food to the embryo which begins to grow.
- The radicle along with a protective covering(c(?/eorfci2a) grows out of the seed.
- The epicotyl is the part of the embryo between the cotyledon and the plumule.
- The epicotyl elongates and the plumule grows out of the coleoptile and forms the first foliage leaves.
- The seedling now begins to produce its own food and the endosperm soon shrivels.
- This type of germination in which the cotyledon remains below the ground is known as hypogeal germination.

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Practical Activity 4

To investigate epigeal and hypogeal germination

Requirements

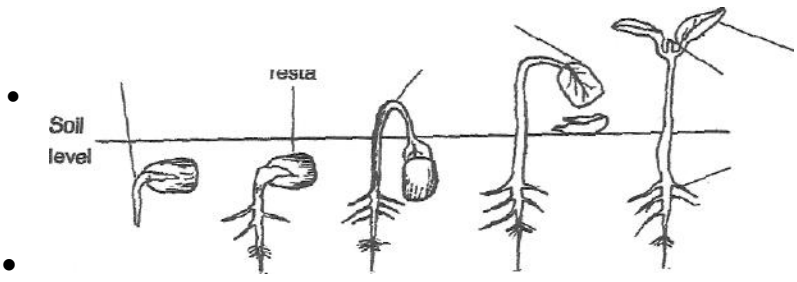
- Tin or box, soil, water, maize grains and bean seeds.

Procedure

- Place equal amounts of soil into two containers labelled A and B.
- In A, plant a few maize grains.In B, plant a few bean seeds.
- Water the seeds and continue watering daily until they germinate.
- Place your set-ups on the laboratory bench.
- Observe daily for germination.
- On the first day the seedlings emerge from the soil, observe them carefully with regard to the soil level.

Carefully uproot one or two seedlings from each set.

- Observe and draw the seedlings from each set Label the parts and indicate the soil level on your diagram.
- On the fifth day since emergence, again uproot another seedling.
- Observe and draw.
- Indicate the soil level on your diagram..
- Tabulate the differences between the two types of germination studied.



- Cotyle don

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Hypoc

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- *Fig. 4.6 (a): Epigeal germination for castor seeds*
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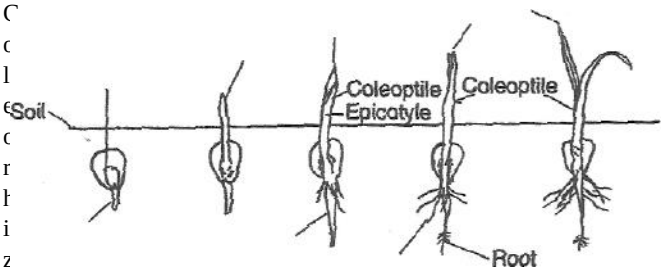

Primary and Secondary Growth

- The region of growth in plants is found in localised areas called meristems as shown .
- A meristem is a group of undifferentiated cells in plants which are capable of continuous mitotic cell division.
- The main meristems in flowering plants are found at the tips of shoots and roots, in

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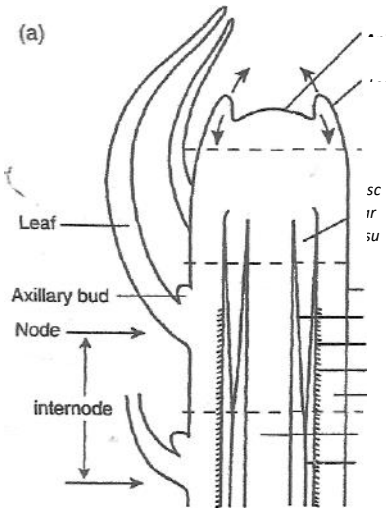
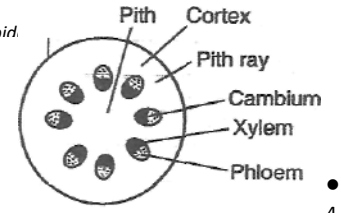
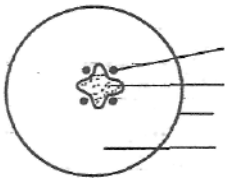
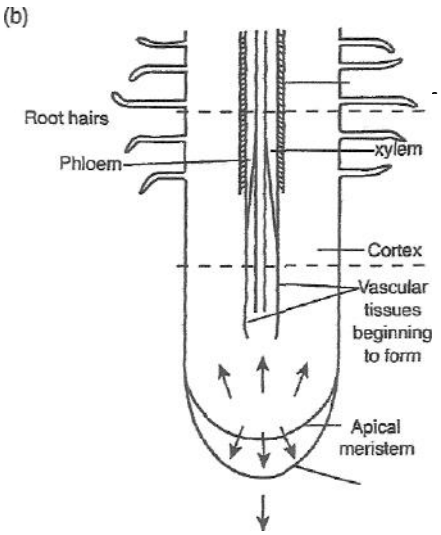
young leaves, at the bases of the inter-nodes, and in



- ***Zone of cell division***
- *Zone of cell elongation (expansion)*
- *Zone Trf cell*
- ***differentiation***
- ***Permanent tissues***







- *Fig.* 4.7(a) and (b): Longitudinal section of the root tip and apex Fig. 4.7(c) and (d): Transverse section of the stem and rooi

- z o n e

- vascular cambium and cork cambium. T
- he meristems at the tips of the shoots and the roots are known as apical meristems and are responsible for primary **growth.** The cambium meristems are responsible for secondary growth.

- ## Primary Growth
- Primary growth occurs at the tips of roots and shoots due to the activity of apical

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meristems. These meristems originate from the embryonic tissues. In this growth there are three distinctive regions, the region of cell division, cell ejpngarion and eel] differentiation. See figure 4.7.

- The regipn of cell division is an area of actively dividing meristematic cells. These cells have thin cell walls, dense cytoplasm and no vacuoles. In the region of cell elongation, the cells become enlarged to their maximum size by the stretching of their walls. Vacuoles start forming and enlarging. In the region of ceH differentiation the cells attain their permanent size, have large vacuoles and thickened watt cells. The cells also differentiate into tissues specialised for specific functions.
- Primary growth results into an increase in the length of shoots and roots.

- **Study Question**

- ;:Mgure;4-S indkate the appearance of cells at different regions at the apical meristems.Nudeus -Cytoplasm
- *Fig. 4.8*
- Rearrange them into three regions:
- Zone of cell *division.*
- Zone of cell elongation.; *-,*
- Zone of cell differentiation. (jb) Name specialised tissues formed at tl
- zone of cell differentiation.

- **Region of** Growth in a root
- This is determined by taking a young germinating seedling whose radicle is then marked with the Indian ink at intervals of 2 mm. The seedling is left to grow for sometime (about 24 hours or overnight) and then the ink marks are examined. When the distance between successive ink marks are measured, it is found that the first few ink marks, especially between the 2nd and 3"1 mark above tip of root have increased significantly. This shows that growth has occurred in the region just behind the tip of the root. The difference between the length of each new interval and the initial interval of 2 mm gives the increase in the length of that interval during that period of time. From this the rate of growth of the root region can be calculated. See figure 4.9.
- „ Increase in length . „_
- Growth = ^—— ^— X 100
    - Original length

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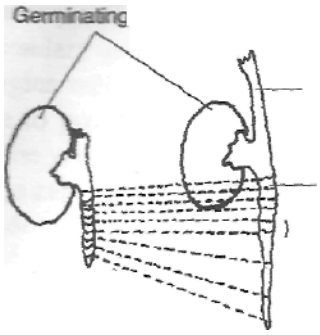
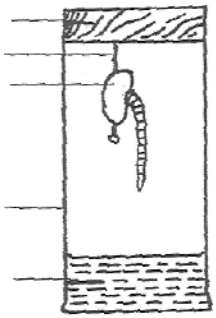
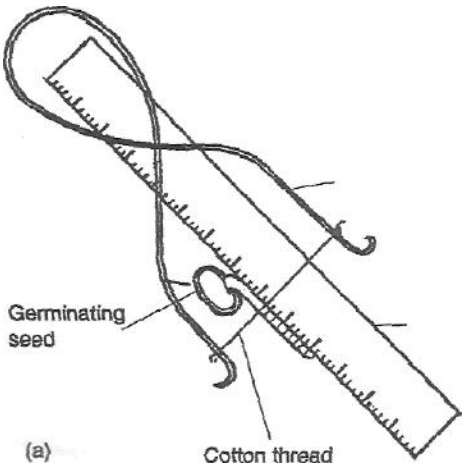




- **Practical Activity 5 To determine the region of growth in roots**

- **Requirements**
- Germinating bean seeds with radicle of about 1cm in length, cork, pin, beaker or gas jar, water, Indian ink, blotting paper or filter paper, marker and ruler marked in mm.

- **Procedure**
- Take the germinating been seed, and using a blotting paper, dry the radical taking care not to damage the root.
- Using a marker and ruler make light ink marks 2mm apart along the length of



the root. See figure 4.10(a).

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- Make a drawing of the marked root. Pin the seedling onto the cork and place it in the beaker containing a little water. See figure 4.10(b). Leave it overnight. Take out the seedling and examine the ink marks.
- 6. • Measure the distances between the successive ink marks and record.
- 5 Make a well labelled drawing of the seedling at the end of the experiment and
- 7. compare with the drawing of the. seedling at the start of the experiment.

- **Study Question 7**

- What part of the radicle has the ink marks moved further apart?
- Give an explanation for your answers in (a) above.
- What is the increase in length within each interval?
- Work out the rate of growth for the root

- Secondary **Growth**
- Secondary growth results in an increase in width or girth due to activity of the cambium. In secondary growth new tissues are formed by **vascular cambium** and **cork cambium.** In monocotyledons plants there are no cambium cell in the vascular bundles.The *growth in diameter is due to the enlargement of the primary cells.*
- *Secondary growth in dicotyledonous pjants begins with the division of vascular cambium to produce new cambium cells between the vascular bundles. This forms a continuous **cambium ring.** These cambium cells divide to form the new cells that are added to the older ones. The cambium cells have now become meristematic.*
- *The new cells produced to the outer side of cambium differentiate to become **secondary phloem** and those to the inner side differentiate to become the **secondary xylem.** More secondary xylem is formed than secondary phloem. The interfascuiar cambium a/so cuts orTparenchymatous cells which form secondary medullary rays as seen in figure 4.11 (a), (b) and* (c).
- *As a result of the increase in the volume of the secondary tissues, pressure is exerted on the outer cells of the stem. This results in stretching and rupturing of the epidermal cells. In order to replace the protective outer layer of the stem, a new band of cambium cells are formed in the cortex. These cells, called **cork** cambium **orphellogen** originate* from *the cortical cells. The cork cambium divides to produce new cells on either side. The cells on the inner side of the cork cambium differentiate into **secondary cortex** and those produced on the outer side become **cork** cells. Cork cells are dead with thickened walls. Their walls become coated with a waterproof substance*

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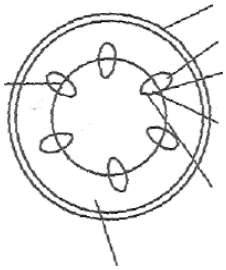
*called **suberin.** The cork cells increase in number and become the bark of the stem. This prevents loss of water, infection from fungi and damage from insects. The corky bark is also resistant to fire and thus acts as an insulatory layer.*

- *The bark is normally impermeable to water and respiratory gases. Periodically the cork cells, instead of being tightly packed, they form a loose mass. This mass is known as **Jenticel.** The lenticles make it possible for*

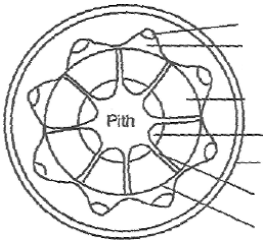
Transverse section of dicotyledonous stem



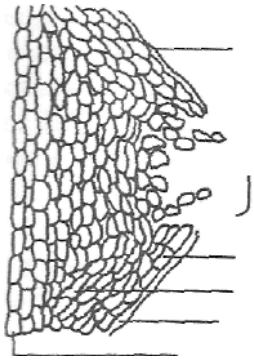
- Epidermis *Primary phloem*
- *Secondary phloem*
- *Secondary xylem*
- *Primary xy/em*
- *Cortex*

Beginning of secondary growth in dicot stem

- *Primary phloem*
- *Secondary ph/oem*
- *Secondary xylem Primary xylem*
- *Epidermis Medullary ray*



- *Cambium ring*
- Cork cell Cork cambium Secondary cortex Primary cortex
- ***Fig. 4.12: Section through a lenticel***



- The rate of secondary growth in a stem varies with seasonal changes. During rainy season, xylem vessels and tracheids are formed In large numbers. These cells are large, have thin walls and the wood has a light texture. In the dry season, the xylem and trancheids formed are few in number. They are small, thick-walled and their wood has a dark texture. This leads to the development of two distinctive layers within the secondary xylem formed m a year, called **annual rings.** See figure 4.13. It is possible to determine the age of a tree by counting

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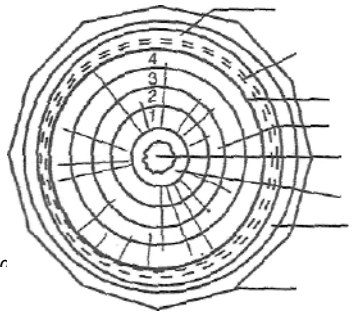
the number of annual rings. Furthermore climatic changes of the past years can be infered from the size of the ring.



- Primary phloem Secondary phloem
- Cambium ring Medullary ray Pith
- Primary xylem Cortex
- Cork

- *Fir*

• Role of Growth Hormones in Plants

- Plant hormones are chemicals produced in very small amounts within the plant body, and play a very important part in regulating plant growth and development. Most growth hormones are produced at the tip of a shoot and transported downwards to the root. The root tip produces very small quantities of the hormones.
- There are many different types of plant hormones and one well-known group is the **auxins. Indoie** acetic **acid (IAA)** is one best known auxin. Auxins are produced at the shoot and root tips. Maximum influence on growth in plants occurs when auxins are produced simultaneously with other plant hormones e.g. gibberellins. Maximum growth response in stems requires more IAA than tn roots.
- Auxins are known to have various effects on the growth and development in plants. They stimulate cell division and cell elongation in stems and roots leading to primary growth. Auxins cause tropic responses, which are growth responses in plants due to external stimuli acting from a given direction.
- On the other hand IAA stimulates the growth of adventitious roots which develop from the stem rather than tbe main root. Cuttings can be encouraged to develop roots with the help of IAA. If the cut end of a stem is dipped into IAA, root sprouting is faster. IAA is also used to induce parthenocarpy. This is the growth of an ovary into a fruit without fertilisation. This is commonly u^ed by horticulturalists to bring about a good crop of fruits particularly pineapples.
- Auxins are known . to inhibit development of side branches from lateral buds. They therefore enhance apical dominance. During secondary growth auxins Play an important role by initiating cell division in the cambium and differentiation of these cambium cells into vascular tissues.
- Auxins in association with other plant hormones such as the cytokinins induce the formation of callus tissue which causes the healing of wounds. When the concentration of auxins falls in the plant, it promotes formation of an abscission layer leading to leaf fall. A synthetic auxin, 2,4-dichlorophenoxyacetic acid (2,4-D) induces distorted growth and excessive respiration leading to death of the plant. Hence it can be used as a selective weed killer.

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- GibbereHins are another important group of plant growth hormone. GibbereHins are a mixture of compounds and have a very high effect on growth. The most important in growth is gibberellic acid. Gibbereilins are distinguished from auxins by their stimulation of rapid cell division and cell elongation in dwarf varieties of certain plants. Dwarf conditions are thought to be caused by a shortage of gibberellins due to a genetic deficiency.
- Gibberellins are important in fruit formation. They induce the growth of ovaries into fruits after fertilisation. They also induce parthenocarpy. Gibberellins also promote formation of side branches from lateral buds and breaks dormancy in buds. This is common in species of temperate plants whose buds become dormant in winter. In addition, this hormone also inhibits sprouting of adventitious roots from stem cuttings, it retards formation of abscission layer hence reduces leaf fall. Gibberellins also break seed dormancy by activating the enzymes involved in the breakdown of food substances during germination.
- Cytokuuns also known as kinetins, are growth substances which promote growth in plants when they interact with auxins. In the presence of auxins, they stimulate cell division thereby bringing about growth of
- roots, leaves and buds. They also stimulate formation of the callus tissues in plants. The callus tissue is used in the repair of wounds in damaged parts of plants.
- Cytokinins promote flowering and breaking of seed dormancy in some plant species. They also promote formation of adventitious roots from stems and stimulate lateral bud development in shoots. When in high concentration cytokinins induce cell enlargement of leaves but in low concentration they encourage leaf senescence and hence leaf fall.
- Ethylene is a growth substance produced in plants in gaseous form. Its major effect in plants is that it causes ripening and falling of fruits. This is widely applied in horticultural farms in ripening and harvesting of fruits. It stimulates formation of abscission layer leading to leaf fall, induces thickening of stems by promoting cell division and differentiation at the cambium meristem. But it inhibits stem elongation. Ethylene promotes breaking of seed dormancy in some seeds and flower formation mostly in pineapples.
- Abscisic acid is a plant hormone whose effects are inhibitory in nature. It inhibits seed germination leading to seed dormancy, inhibits sprouting of buds from stems and retards stem elongation. In high concentration, abscisic acid causes closing of the stomata. This effect is important in that it enables plants to reduce water loss. It also promotes leaf and fruit fall. Another hormone, florigen is produced in plants where it promotes flowering.

- **Apical Dominance**
- Although auxins, particularly IAA are important stem and root elongation, they are known to exert profound effects on other aspects of plant growth and development. If an apical bud which normally contains high concentrations of auxins

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is removed, it is

- observed that more lateral buds lower down the stem sprout, producing many branches. This shows that high concentrations of auxins have an inhibitor}' effect on sprouting of lateral buds and therefore hinders growth of many branches. This forms the basis of pruning in agriculture where more branches are required for increased harvest particularly on crops like coffee and tea.
- The failure of lateral buds to develop in the presence of an apical bud is due to the diffusion of auxins from the shoot apex downwards in concentrations higher than that promoting lateral bud development.

- 

  - **Practical Activity *6***
  - **To investigate apical dominance in plants**

- **Requirements**
- Tomato seedlings growing in a tin.

- **Procedure**

- Cut off the terminal buds from 3 seedlings in the tin, leaving the other seedlings with the terminal buds intact,
- Leave the seedlings to continue growing for five more days.

- **Study Questions 8**

- *list* the differences noticed between the two groups of seedlings? Explain how the differences come about.
- From your observations, explain the basis for pruning tea and coffee.

Growth and Development in Animals

- In higher animals, most cells with the exception of the nerve cells, retain their power of division.
- Thus, there is a continued breakdown and replacement of cells.
- Animal cells undergo rapid cell division and cell differentiation but, unlike plant cells, they undergo very little cell enlargement.
- In most animals growth occurs through: their life till they die.
- This type of growth called **continuous** growth.
- Arthropods e.g. insects show rapid growth immediately after moulting with periods when no growth increase occurs.

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- This is called discontinuous growth.
- Insects exhibit two types of reproducti processes.
- In some insects, the ova in t female are fertilised by the spermatozoa frc the male.
- This is a typical example of sexi reproduction, common in butterflies ai moths.
- In other insects like the black and t green aphids, the eggs are usually product without being fertilised and are able to --- into adult insects.
- This type of asexual reproduction is referred to *;* **parthenogenesis.**

Growth and Development in Insects

- Majority of insects lay eggs that hatch int larvae, which is an immature stage, usual! quite different from the adults in morpholog and behaviour.
- Depending on the insec species a larva is referred to as **a grub, maggot or a caterpillar.**
- Generally the larv eats a lot, grows rapidly and sheds its cuticl several times until it reaches full size t< become a **pupa.**
- The pupa is an inactive, non feeding stage during which extensivi breakdown and re-organisation of body tissui occur, eventually giving rise to the imago o adult form.
- Such changes, callec **metamorphosis,** do occur in butterflies moths, bees, wasps and flies.
- Insects which pass through these stages, namely, egg-larva-pupa, into imago/adult in their developmenl are said to undergo **complete metamorphosis.**

Development in a Housefly(An example of complete metamorphosis)

- When the egg of a housefly is laid, it measures about 1mm in length.
- The eggs are laid in batches of between 100 to 150.
- The larvae which hatch from the eggs grow and feed on decaying matter.
- After several moults and increase in size, a Jarva reaches about 1cm in length.
- This takes about 5 days.
- After this, the larva changes into a pupa encased in a pupal case called die puparium, from which the adult fly later emerges.
- After emergence, the adult tgkes about two weeks of feeding and growing to attain sexual maturity, i.e. the males can mate and the females are able to lay eggs.
- Figure 4.14 summarises the life cycle of a housefly.

Incomplete Metamorphosis

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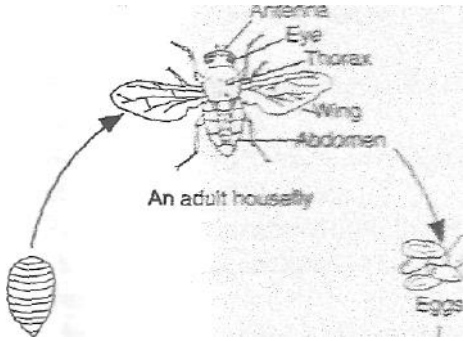
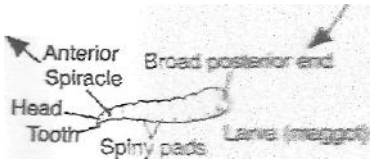
- Development in some insects like the locust and cockroaches, involves the.egg hatching into a nymph which e!cie!y resembles the adult in every form, except for size and lack of sexual maturity.
- For such insects to reach the adult, stages, they undergo a series of moults. before fully acquiring the adult size and



- Pupa case **Adult**



attaining the sexual maturity.

- These insects are said to undergo incomplete metamorphosis.

Development in a Cockroach(An example of incomplete metamorphosis)

- Cockroaches produce eggs enclosed in a case in groups of between 10 - 15.
- The case known as ootheca is made up of cfaitm.
- The ootheca is usually deposited in moist dark and warm places, for example in cracks of furniture or crevices in walls.
- It takes about a month before the small wingless nymphs emerge.

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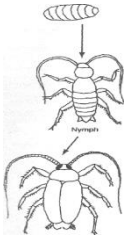
- The nymphs feed, and moult about ten times with the total nymphal period lasting about 16 days for all the adult structure to become fully developed.

- 

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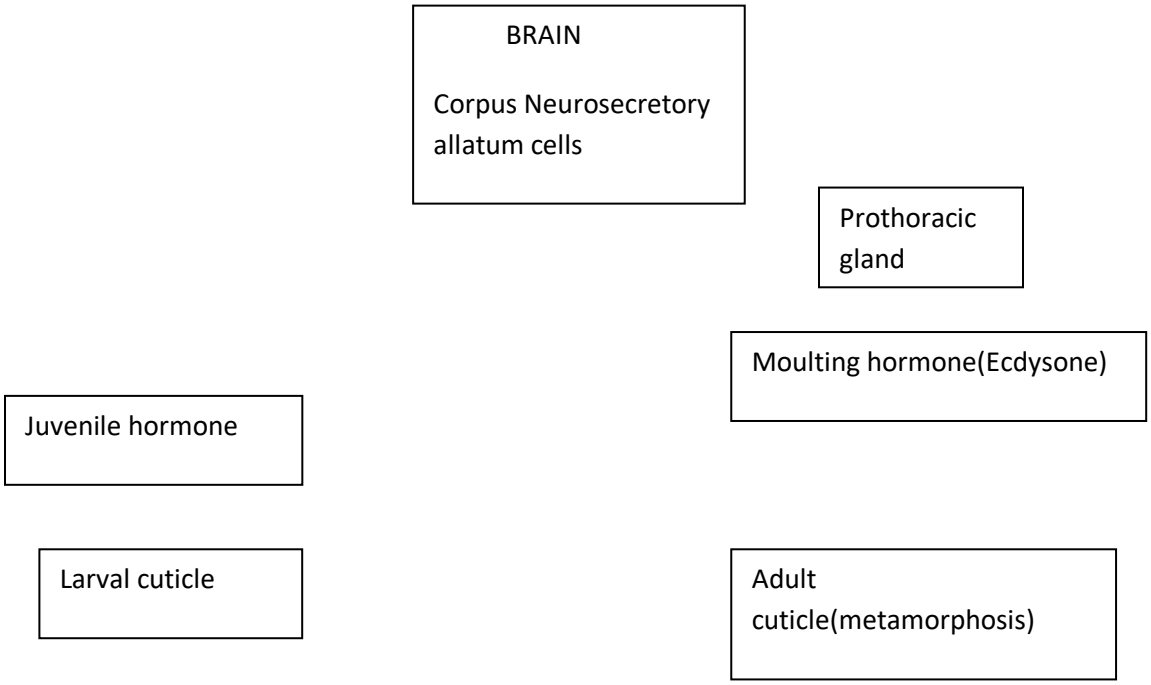
Role of Hormones in InsectMetamorphosis

- In insects metamorphosis is controlled by hormones.
- The hormones are produced in three glands namely;
- Neurosecretory cells in the brain ganglia, a pair of **corpora allata** (singular Corpus allatum) located in the mandibular segment and prothoracic glands in the thorax.
- During larval stages of the insect the corpora ailata produces **juvenile hormone,**
- This leads to formation of larval cuticle., therefore moulting does not go beyond the larval stage.
- When the larva matures, the corpus allatum disintegrates-
- At this time the neurosecretory cells stimulate the prothoracic glands to produce **moulting hormone (ecdysone).**
- Ecdysone is responsible for moulting in insects leading to the laying of the adult cuticle.



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