CELL DIVISION

Reproduction involves the division of cells in order to multiply.

Cell division involves two types

i. Mitotic cell division (mitosis)
ii. Meiotic cell division (meiosis)

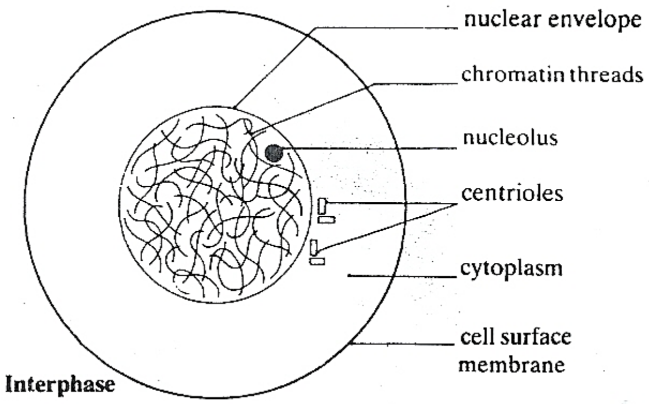
MITOSIS

This is the type of cell division in which the parent cell divides into two daughter cells each having the same number of chromosomes as the parent cell. This type of division involves four stages Prophase, Metaphase, Anaphase and Telophase with a main growth and resting phase, Interphase. The whole process of cell division can take an hour or two roughly

Interphase (replication)

The main process / appearance of the cell

- Chromosomes not visible (are thread like)
- Chromatins present
- Centrioles replicate
- Replication of DNA (double)
- Production of ATP (energy)
- Formation of new organelles (mitochondria, ribosome, chloroplast), duplication

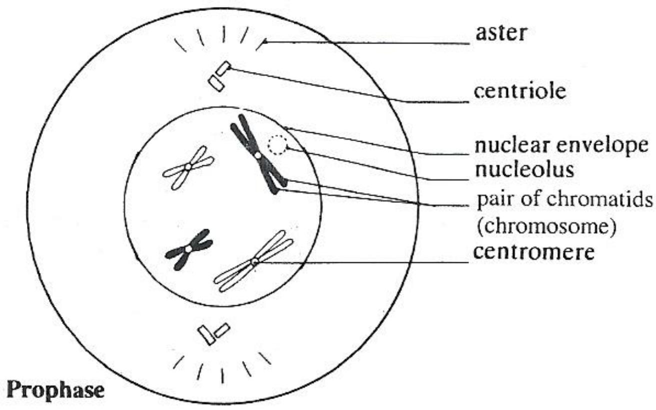


Prophase (thickening)

The main process / appearance of the cell

- Chromatin threads condense to form distinct chromosomes (chromosomes formed from the chromatids are joined at the centromere)
- Centrioles at opposite sides of the nucleus
- Spindle fibers start to form
- Nucleolus disappears
- Nuclear membrane breaks down

Drawing showing prophase

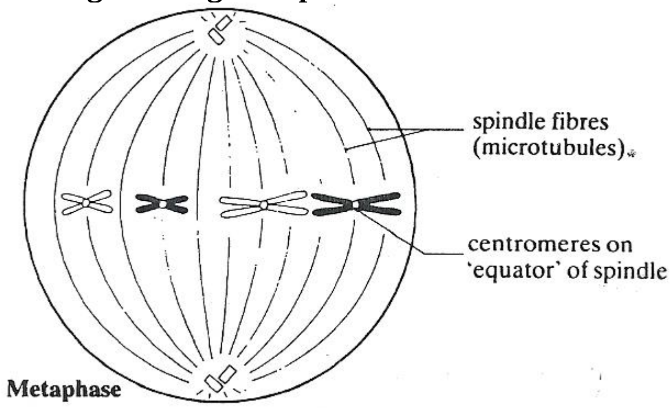


Metaphase (arrangement)

The main process / appearance of the cell.

- Chromosomes arrange themselves on equator of spindle/ Chromosomes migrate at the equator
- Chromatids draw apart at the centromere towards opposite poles.

Drawing showing metaphase

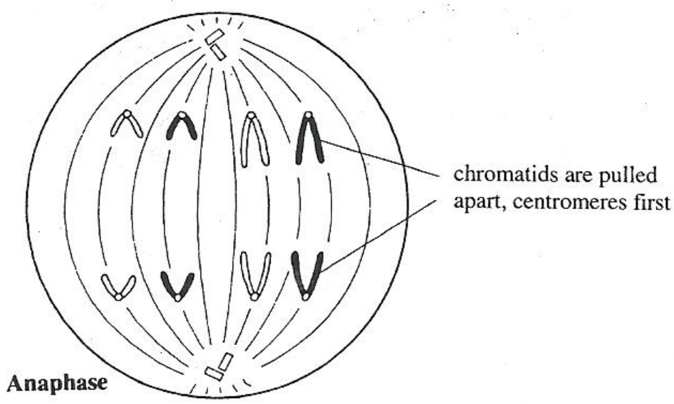


Anaphase (migration)

The main process / appearance of the cell.

- Spindle fibers contract and shorten
- Sister Chromatids part company and migrate to opposite poles of the cell with the centromeres leading
- Chromosomes reach their destination
- Spindle fires begin to break down.

Drawing showing Anaphase

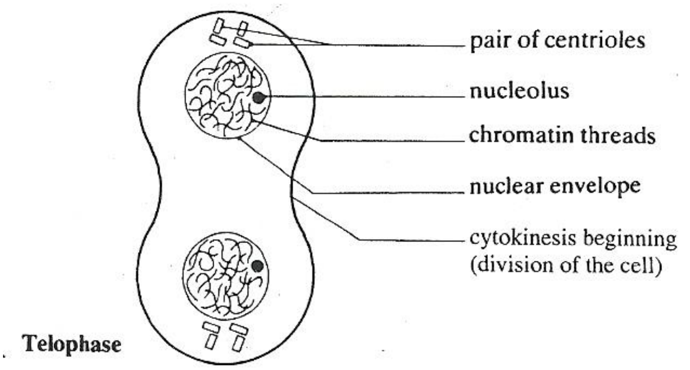


Telophase (cell constrict)

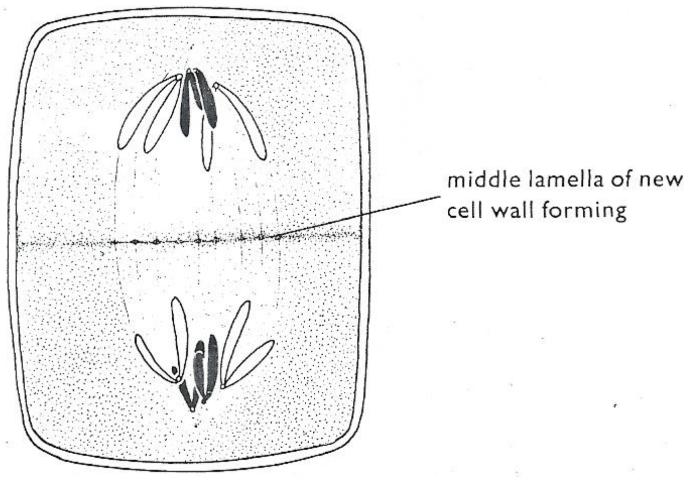
The main process / appearance of the cell.

- Cell membrane starts to constrict across the middle
- Nuclear membrane reforms
- Nucleolus reform
- Spindle apparatus degenerates
- Cytoplasm divides into two new daughter cells with exact number of chromosomes as the parent cell. In plans telophase involves formation of a cell plate.
- Chromosomes uncoil, become thread like

Drawing showing Telophase in animal cells.



Drawing showing Telophase in plants cells.



There are two features in mitosis that ensure that the chromosome constitution is preserved

- Replication of chromosomes before cell division.
- Arrangement of the chromosome on the spindle.

Roles of mitosis

- Growth of an organisms e.g. development of fertilized egg into adult
- Asexual reproduction e.g. protest with binary fission
- Genetic stability (no variation)
- Cell replacement e.g. skin cells
- Regeneration of e.g. legs in crustacean and arms in star fish

Differences between mitosis in plants and animal cells

Plant	**Animal**
No	Centrioles present
No	Aster form
Cell division involves formation of a cell plate	Cell division involves cleavage of cytoplasm
Occurs mainly at meristems	Occurs in tissue throughout the body

Note: Species in which there are two sets of chromosomes are referred to as diploid (2n) organisms. Those with one set of chromosomes are referred to as haploid (n). Some plants are polyploidy with many sets of chromosomes.

MEIOSIS

This is the type of cell division in which diploid parent cell divides into four daughter cells each having half the number of chromosomes as the parent cell.

Contrary to mitosis, meiosis consists of two successive divisions 1^{st} meiotic division were the parent divides into two and the 2^{nd} meiotic division were the products divide to produce four daughter cells. The process involves the four stages Prophase, Metaphase, Anaphase and Telophase but distinguish by I or II for the first and second meiotic division respectively

Interphase

The main process / appearance of the cell.

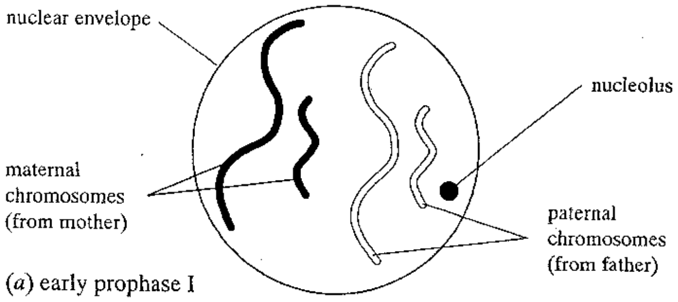
- Chromosomes not visible are thread like
- Chromatins present
- Replication of DNA
- Production of ATP
- Formation of new organelles

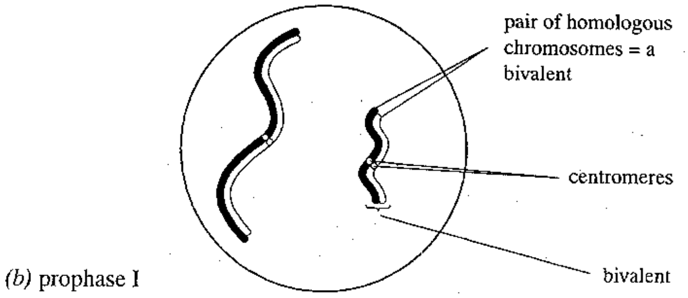
Prophase I

The main process / appearance of the cell.

- Nucleolus disappears
- Centrioles arranged on opposite sides of nucleus
- Spindles form
- Chromosomes condense
- Homologous chromosomes come together (synapsis) forming a bivalent
- Crossing over takes place. i.e exchange of portions of chromosomes between chromatids of homologous chromosomes

Drawing showing prophase I



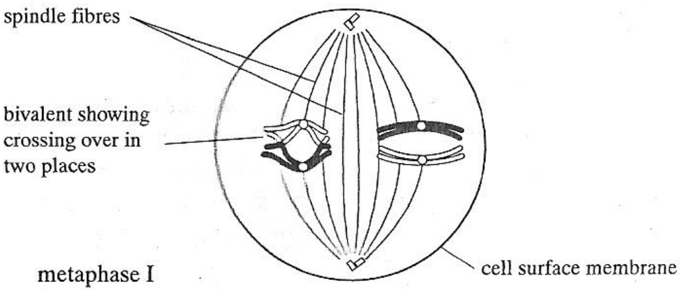


Metaphase I

The main process / appearance of the cell.

- Homologous chromosomes move to the equator of the spindle together (behave as a unit)

Drawing showing metaphase I

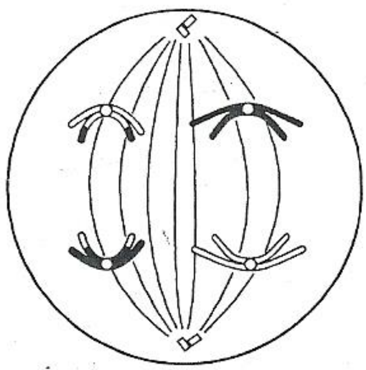


Anaphase I

The main process / appearance of the cell.

- Homologous chromosomes part company move towards opposite poles of the spindle.

Drawing showing Anaphase I

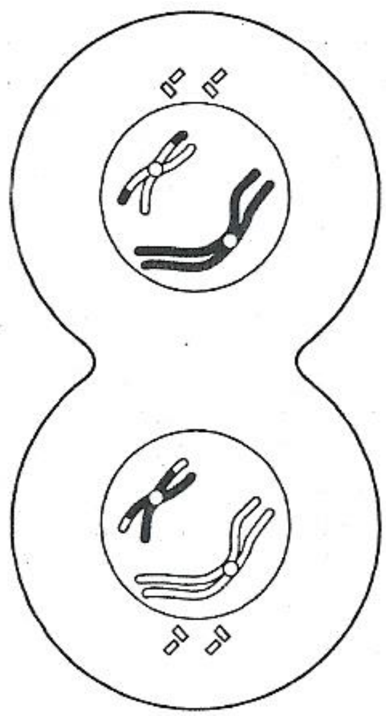


Telophase I

The main process / appearance of the cell.

- The chromosomes have reached their destination and the cell constricts across the middle as in mitosis.

Drawing showing Telophase I in an animal cell



Second Meiotic

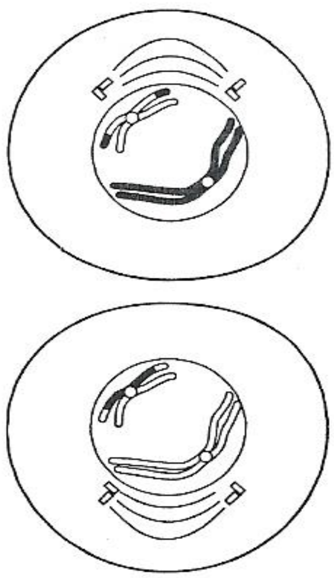
2nd meiotic division aims at separating Chromatids

Prophase II

The main process / appearance of the cell.

- Two daughter cells prepare for the 2nd division
- Centrioles replicated
- New spindles are formed

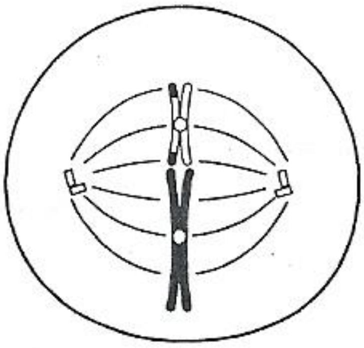
Drawing showing prophase II

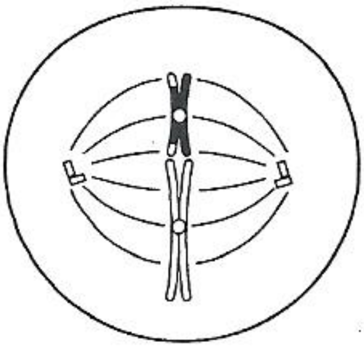


Metaphase II

- Chromosomes arrange themselves on the equator of the spindle in the usual way.

Drawing showing metaphase II

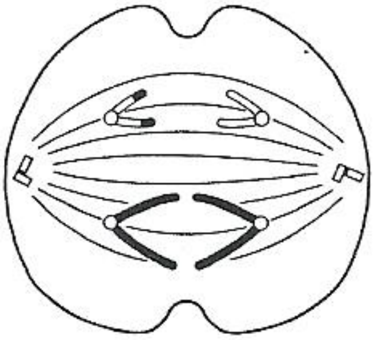


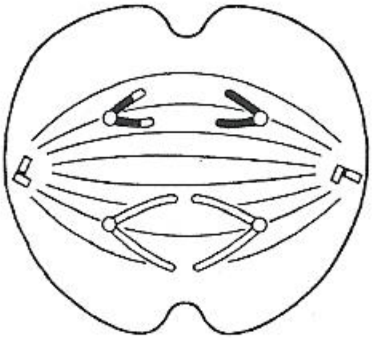


Anaphase II

Chromatids part company and arrange to opposite poles of the cell

Drawing showing anaphase II



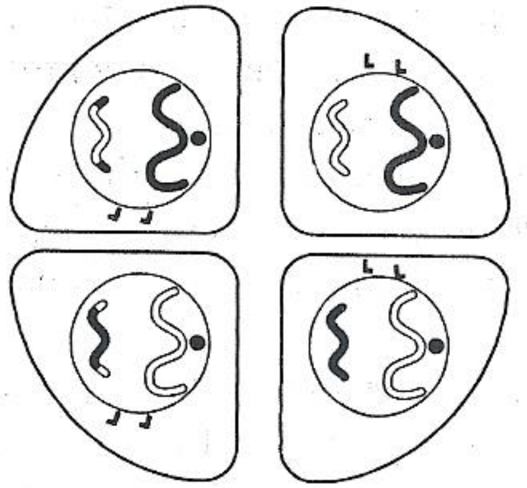


Telophase II

The main process / appearance of the cell.

- Cells constrict across the middle
- The nuclear membrane and nuclei reform
- Four daughter cells are formed

Drawing showing Telophase II



Significance of meiosis

- Sexual reproduction which involves production of gametes
- Genetic variation: provides opportunity for new combinations of genes to occur in the formation of gametes through crossing over and independent assortment
  1. Independent assortment
     Orientation of bivalents at the equator of the spindle in metaphase I is random. The bivalents line up independently and therefore the chromosomes in each bivalent separate (assort) independently of these in other bivalents during anaphase I.
  2. Crossing over
     As a result of chiasmata, crossover of segments of Chromatids occurs between homologous chromosomes during prophase I leading to the formation of new combinations of genes on the chromosomes of the gametes.
     Note: Genetic variation has other advantages which will be discussed later.

Diploid cells give rise to haploid cells during meiosis. The **somatic** (body) cells of animals and higher plants are diploid cells. Each chromosome in a diploid cell has a partner chromosome. The partners are called **homologous chromosomes**. One member of each pair cames from the father (paternal homolog), and one from the mother (maternal homolog).

Thus, for humans, the 46 chromosomes are in 23 pairs.

Sex chromosomes aren't strictly homologous (an X chromosome has different genes compared to a Y chromosome), but they act as if they are homologous during meiosis

A set of chromosomes (***n***) has one member for each homologous pair; a **diploid** cell has two complete sets (***2n***), while a **haploid** cell has one set.

Meiosis reduces chromosome number, producing up to 4 haploid cells from one diploid cell.

Similarities between mitosis and meiosis

- Both begin with a diploid nucleus
- In both there is spindle formation
- In both chromosome arrange at the equator

Differences between mitosis and meiosis

STAGE	MITOSIS	MEIOSIS
Prophase	Homologous chromosomes remain separate. No formation of chiasmata. No crossing over.	Homologous chromosomes pair up. Chiasmata form. Crossing over may occur.
Metaphase	Pairs of Chromatids lineup on the equator of spindle.	Pairs of chromosomes lineup on the equator of spindle
Anaphase	Centromeres divide. Chromatids separate. Separating Chromatids identical.	Centromeres do not divide. Whole chromosomes separate. Separating chromosomes and their Chromatids may not be identical due to crossing over.
Telophase	Same number of chromosomes in daughter cells as parent cells. Both homologous chromosomes present in daughter cells if diploid.	Half the number of chromosomes in daughter cells as parent cells. Only one of each pair
Occurrence	May occur in haploid, diploid or polyploidy cells. Occurs during formation of somatic cells and some spores Formation of gametes.	Only occurs in diploid or polyploidy cells Occurs during formation of gametes or spores

REPRODUCTION

It is the ability of organisms to multiply and give rise to new organisms with the same basic characteristics as their parents. It involves the transmission of genetic material from one generation to the next.

IMPORTANCE OF REPRODUCTION

- Leads to increase in population since the number of offspring is usually more than that of the parent stock.
- Leads to survival of a species through genetic variation.
- Leads to replacement of individuals that die due to disease, starvation, predation etc.
- Leads to transformation and renewal of genetic material in organisms.

TYPES OF REPRODUCTION

- Asexual reproduction
- Sexual reproduction

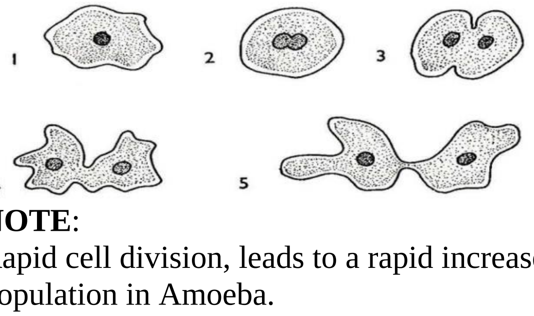
ASEXUAL REPRODUCTION

This is the reproduction of offspring without fusion of gametes. Only one organism is involved.
No gametes (reproductive cells) are formed. Mitosis forms the basis of this type of reproduction.
Genetically identical offspring are produced (any genetic variation would be due to mutation in individuals)
There is rapid multiplication leading to a high population growth e.g. in bacteria.
It is common among lower plants and animals.

METHODS OF ASEXUAL REPRODUCTION.

Binary fission e.g. amoeba

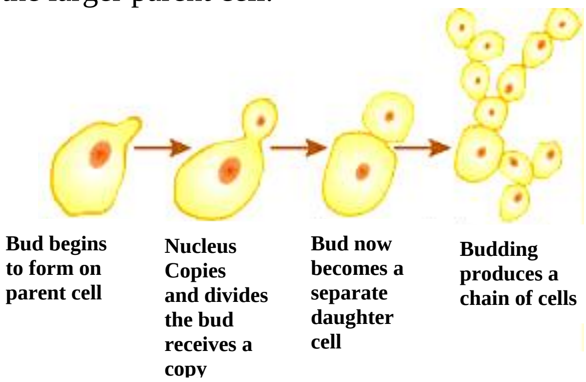
This is the division of a cell into two daughter cells, identical to the parent cell.
Under favourable conditions an amoeba that has reached maturity or maximum size becomes rounded in shape. Its nucleus starts to divide by mitosis. Two daughter nuclei form and the cytoplasm constricts. Two new daughter's cells that are genetically identical are produced and they begin independent lives.



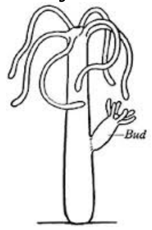
NOTE:

Rapid cell division, leads to a rapid increase in population in Amoeba.
Binary fission also occurs in the bacteria and other single –celled organisms e.g. paramecium.

Budding e.g. yeast:
In favourable conditions, an outgrowth develops on the parent. The cell nucleus in the parent divides into two by mitosis. One nucleus passes into the bud and the other nucleus remains in the parent.
Later, the bud becomes detached from the parent and becomes an independent organism. Unlike in binary fission in which the daughter cells have equal volume, in budding, the buds, (now cells) are smaller than the larger parent cell.



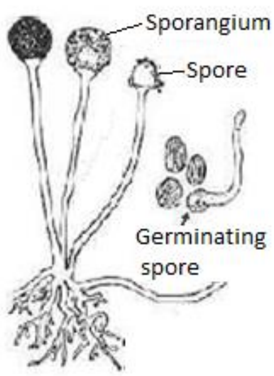
In yeast, buds still attached to the parent cell produce another bud eventually forming a chain cells.
As the bud increases in size, a wall forms between it and the parent. Finally the bud separates from the parent, beginning independent life.
Budding also occurs in Hydra.



Fragmentation: e.g. spirogyra.
This is when the parent breaks into smaller fragments, each of which grows into a separate individual. In favourable conditions when the spirogyra has reached a suitable length, it breaks into fragments spontaneously. Fragmentation occurs in sponges, flat worms and algae.

Sporulation (spore formation) e.g. fungi.
Spores are small and single celled organisms capable of giving rise to new individual organisms. Spores are produced by organisms such as fungi, mosses and ferns.

Drawing of a rhizopus showing spores

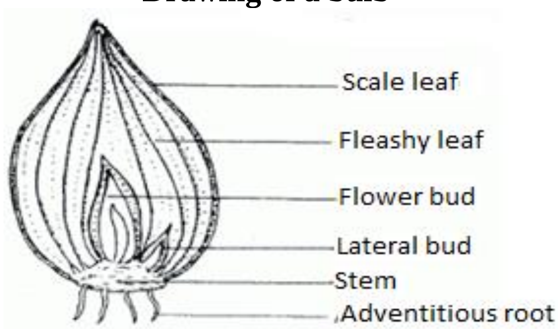


The cytoplasm in the sporangium is multi-nucleated (made up of many nuclei) each nucleus undergoes mitosis and each nucleus develops a mass of cytoplasm around it forming a spore.
The spores develop and finally become mature .The sporangium also matures and eventually bursts releasing spores which are light and small and therefore easily blown by the wind.
If the spores land on suitable substance, they germinate and grow into mycelium.

VEGETATIVE PROPAGATION IN PLANTS.
A new plant grows from parts that are not associated with vegetative reproduction e.g. stems, leaves, roots, and buds. It can occur in two ways: i.e. artificially or naturally.

Forms of natural vegetative propagation.
(i) BULBS e.g. Onions and Garlic.
A bulb is a modified shoot with a short vertical stem bearing fleshly leaves surrounded by dry scale leaves. Buds develop in the axils of fleshly leaves

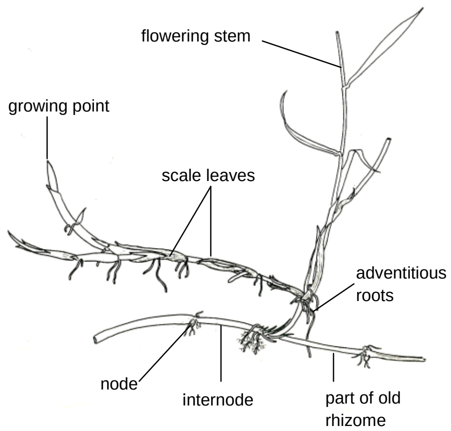
Drawing of a bulb



Under favorable conditions it grows in to a new aerial shoot and when it begins to manufacture its own food, the food is sent to the lateral buds. These enlarge to forms two or more new bulbs within the older ones

(ii) RHIZOMES e.g. Ginger, Canalily
A rhizomes is a horizontal underground stem which posses scalely leaves and buds e.g. Rhizome of the couch grass.

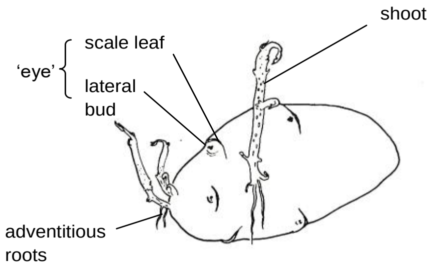
Drawing of the Rhizome of couch grass.



The terminal bud uses food stored in the rhizome to form aerial shoots. Food made from the aerial leaves is passed on to the rhizomes and to the lateral buds. The lateral buds produce new rhizomes which branch to from the parent stem. The terminal buds of the branches grow upwards and produce new leafy shoot

(iii) STEM TUBER; e.g. Irish potato

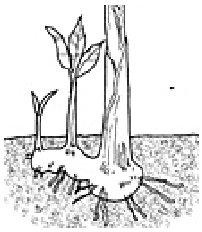
It is a swollen stem bearing scale leaves and buds underground



The buds grow into aerial shoots and adventitious roots grow at their bases. Excess food in the new aerial shoot is transported down to the underground stem where it is stored in the tips. The tips swell to new tubers

(iv) SUCKERS

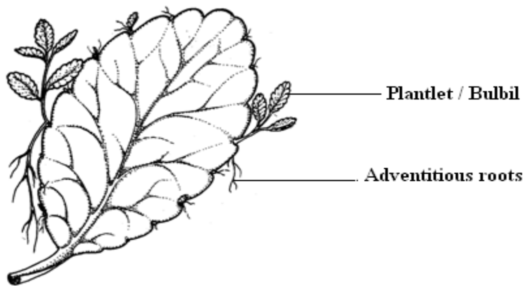
The terminal bud of the sucker grows upwards through the soil and form leaves above the surface Suckers are produced by plants such as bananas, pineapple and sisal.



(v) PROPAGATION BY USE OF A LEAF e.g. the leaf of bryophyllum.

When a Brayophylum leaf or part of it with a notch is placed on damp soil or a surface with favourable conditions, adventitious roots and buds easily develop along its margin in the notches. The buds sprout into new Brayophyllum plants.

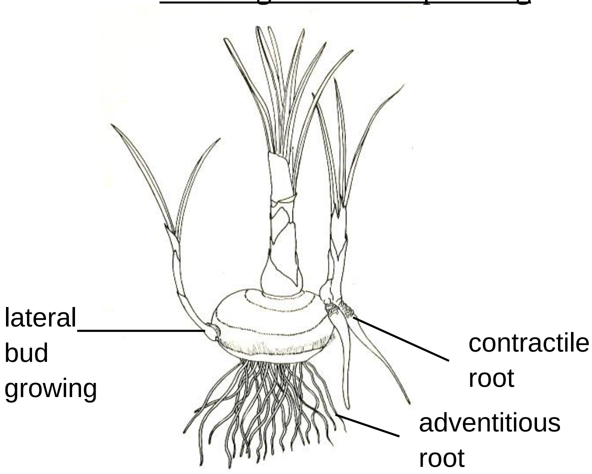
Drawing of a Bryophylum leaf sprouting



(vi) CORMS

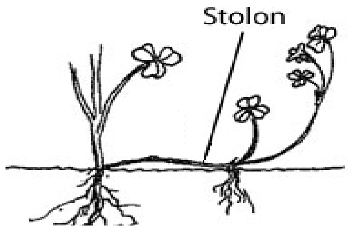
Under favorable conditions, adventitious roots develop from the base of the corm. The buds use the food stored in the corm to grow into a new shoot. The food eventually gets used up from the old corm and shrivels (dies). The new leaves manufacture food by photosynthesis. Excess food not used by the plant is passed down and stored in the base of the new stem which is underground. Gradually, the stem swells to form a new corm on top of the old one.

Drawing of a corm sprouting



(vii) CREEPING STEM OR RUNNER.

Plants like the sweet potato have a creeping stem or runner which generally develop roots at the nodes. whenever these (nodes) touch the ground. New plants usually develop when the internodes die.



ADVANTAGES OF VEGETATIVE PRODUCTION.

- It takes a short time. Food stored in the storage organs in the parent enables rapid growth of buds into daughter plants.
- New plants are able to obtain food from the parent plant until they are well established.
- The daughter plants are exactly similar to the parent and so the new plant passes desirable characteristics present in the parent plant.
- The plant does not have to depend on any agent for dispersal of fruits and seeds.
- It leads to rapid colonization of an area e.g. where plants produce runners. Vegetative propagation often takes place when conditions are more suitable for growth.
- It ensures early growth of the new plant and enables it to mature faster before other plants therefore avoid competition.

Benefits of propagation by vegetative methods to a farmer.

- Varieties which have good features are produced exactly.
- Plants grown form seeds take longer time to bear fruits while those obtained from grafting or budding take a shorter time.
- Once plants produced from grafting are established they require less care and attention than those grown from seeds.
- Some plants do not produce seeds so new plants may only be grown by vegetative method.

Disadvantages of vegetative propagation

- Lack of any dispersal mechanism may lead to overcrowding and new plants may suffer due to competition for food and light.
- The new plants are less varied than those produced by seeds thus less adapted to change in the environment.
- Colonization of new areas is unlikely as the offspring are always produced close to the parent.

ARTIFICIAL VEGETATIVE PROPAGATION.

It is where by new plants with desirable characteristics are produced artificially from a parent plant by farmers. Clones i.e. plants genetically identical with each other and their parent are produced.

Methods of artificial vegetative propagation.

Cuttings

The stems of a healthy plant are cut just below the node. The stem cutting is planted in suitable soil rich in organic manure and mineral salts so that the node can develop adventitious roots to form a new plant e.g. cassava, sugarcane, and sweet potatoes.
Precaution: Remove most of the leaves from the cutting to prevent excessive loss of water.

Grafting

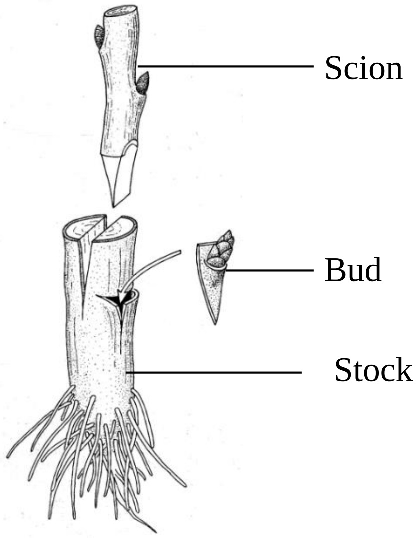
Stem grafting

This is a similar technique to cutting though in this case the cutting (a young shoot referred to a scion) is inserted into a stem of another plant (referred to as the stock).
Both plants are bound together with tape and the joint covered with wax to prevent evaporation and infection.

Bud grafting

A piece of the bark with a bud is cut off from the scion, a T- shaped cut is made in the stock. The bud is held in place with tape and the joint covered with wax to prevent evaporation and infection.

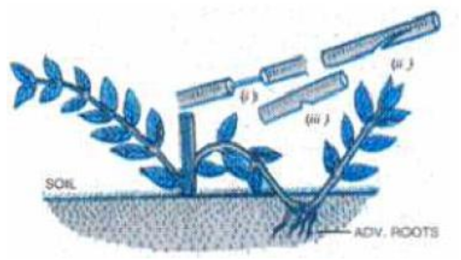
Drawing showing bud and stem grafting



Layering

A low branch with a node is bent to the ground without breaking it. A ring of bark, about 5cm is removed from the node where it touches the ground or soil.
The ringed section is completely covered with soil rich in organic manure and mineral salts.
Pegs are placed on the branch to prevent it from being lifted off the ground.

Drawing showing layering

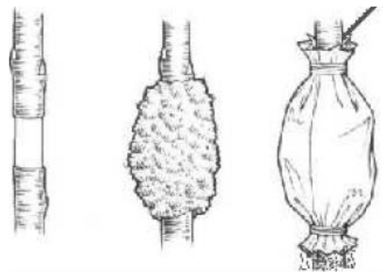


A new shoot develops from a bud. When roots are fully established, the branch is cut off from the parent plant.

Marcotting / Air layering

This involves inducing a branch to produce roots while still attached to the aerial part of the plant.
A healthy shoot is selected. Two rings, 5cm a part are made through the bark. A strip of bark is removed from around this portion. Organic manure rich in mineral salts is tied around the ring. It is moistened regularly.
After developing many roots, the marcot is separated from the parent plant and planted in a suitable place.

Drawings showing marcotting



SEXUAL REPRODUCTION

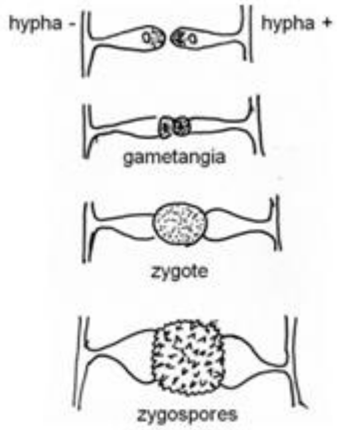
This is the type of reproduction where an organism arises from two parents, a male and female.
The male and female parent produce gametes.
Gametes are reproductive cells produced by meiosis and therefore haploid.
The male gamete is called a sperm (or spermatozoa).
The female gamete is called an egg/ovum.
Sexual reproduction involves the fusion of the sperm with the ovum in a process known as fertilization.
The fertilized egg is called a zygote. The zygote develops into an embryo. The embryo develops into an adult. The offspring are not genetically identical to their parents, this genetic recombination may render the offspring better adapted to the environment than either parent, or it may be more poorly adapted than either parent. Sexual reproduction must contain a mechanism to half the number of chromosomes at some point, halving the chromosome number is accomplished through **meiosis**

SEXUAL REPRODUCTION IN LOWER ORGANISMS.

In Rhizopus or mucor.

Suexual reproduction in mucor occurs when conditions are unfavourable.
Hyphae of different strains adjacent to each other grow towards each other. The tips swell and touch other. Cross walls form at the bases of the swellings, enclosing several nuclei in the swollen tips. Walls touching each other dissolve and allow nuclei (positive and negative strains) to fuse in pairs hence forming a zygote. A thick outer wall forms around the zygote to form a zygospore which germinates when conditions are favourable.

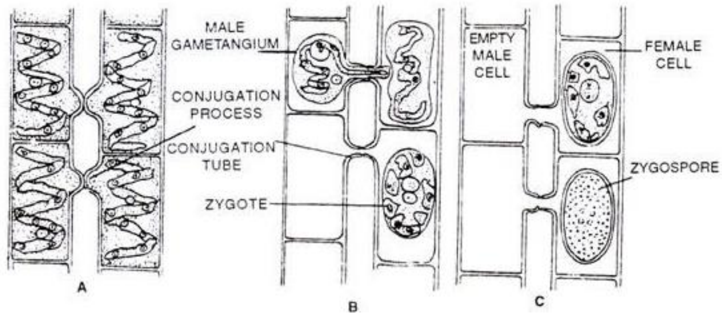
Drawings showing sexual reproduction in Rhizopus



In Spirogyra

Reproduce sexually by conjunction. Short tubes grow from two parallel filaments that lie side by side. The tubes become attached to each other. Through the tubes formed, the contents of one cell move into the other and their nuclei combine or fuse. The cytoplasm then round off to form a zygote which develops a thick wall becoming a zygospore. When the cell walls break open the zygospore sink to the bottom of the pond.
When conditions improve, the zygospore bursts open and new filaments grow out.

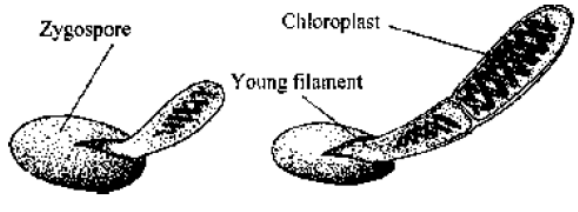
Drawings showing sexual reproduction in spirogyra



Major stages

1. Growth of conjugation tubes between adjacent cells
2. Cells contents shrink and cytoplasm disintegrates
3. Contents of the plus cells pass into the minus cell nucleus fuse to form a zygote.
4. Zygote develops into a zygospore with a protective wall.

Drawings showing a germinating zygospore



Sexual reproduction in higher plants e.g. flowering plants.

Flowers are the reproductive organs of plants. The male and female gametes are found in the flower.

The female gametes are found in the ovules inside the ovary.
Pollens grains are transferred to the stigma in a process known as pollination.

POLLINATION
Pollination is the transfer of pollen grains from the anthers to a mature stigmas of a flower of the same species.

Types of pollination

- Cross pollination.
- Self pollination.

Self pollination
Self pollination is the transfer of pollen grains from the anthers to the stigma of the same flower or to the stigma of a different flower on the same plant.

Cross pollination
Cross pollination is the transfer of pollen grains from the anther of a flowers to the stigma of another flower on another plant of the same species.

Adaptations to cross pollination
(methods of preventing self pollination)

1. Some plants have **monoecious** flowers e.g. maize which has separate male and female flowers.
2. Some plants are **dioecious** e.g. the pawpaw, individual plants have either all male or all female flowers.
3. In plants with bisexual flowers, the anthers and stigma may mature at different times. When the stamens ripen before the stigma, this called **protandry**. When stigma and ovules ripen before the stamens, this is known as **protogyny**.
4. **Heterostyly**. Whereby the style is longer than the filaments so that the stigma is positioned above the anthers
5. Some flowers exhibit **self sterility** or incompatibility so that the pollen grains cannot grow on the stigma of the same flower and even if they do, fertilization cannot take place.

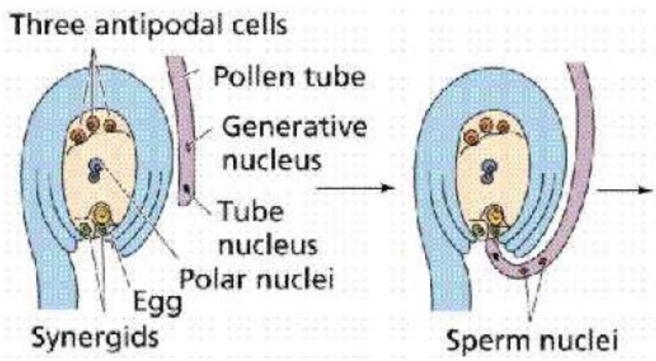
ADAPTIONS PROMOTING SELF POLLINATION

1. Plants have bisexual flowers.
2. Anthers and stigma ripen at the same time.
3. The flowers remain closed until fertilization has occurred e.g. garden pea flowers.
4. The flowers are buried in the ground e.g. G. nuts.
5. Plants with bisexual flowers, the anthers and stigma grow at the same time.
6. The stigma and anthers are at the same levels.

Differences between wind pollinated flowers and insect pollination flowers.

Wind pollinated	Insect pollinated
Flowers are often unisexual	Flowers are often bisexual
No scent or nectar is produced	Scent and nectar is produced
Petals are dull and small	Petals are large and brightly coloured
Stigmas hangout of the flower on long styles.	Stigma lie deep within the flower
Stigmas often feathery	Stigmas relatively small.
Anthers dangle out of the flower on long filaments	Anthers lie inside the corolla
Enormous amounts of pollen produced.	Less pollen is produced
Pollen is smooth, light dry, small.	Pollen is sticky, large, and heavy.

STRUCTURE OF THE OVULE



The ovule consists of a mass of cells called the **nucellus** carried on a stock known as the **funicle**. Integuments surround and protect the nucellus except for a narrow channel of the tip known as the **micropyle**. The embryo sac consists of;

- Three cells near the micropyle one of which is the egg cell and the other two called synergids.
- Two polar nuclei.
- Three antipodal cells found opposite the egg cell.

FERTILISATION IN PLANTS.
This is the fusion of male and female nuclei to form a zygote. Therefore, in flowering plants, fertilization takes place inside the ovule.
When a mature pollen grain lands on a mature stigma, the stigma releases substances which induce the growth (germination) of a pollen tube from the pollen grain. The pollen tube grows towards the ovule. The pollen tube contains three nuclei (two male nuclei and one pollen tube nucleus). The pollen tube nucleus which is near the tip of the pollen tube bursts open near the micropyle. The pollen tube nucleus disintegrates and the two male nuclei enter the ovule. One of the male nuclei fuses with the egg nucleus to form a zygote.

The second nucleus fuses the polar nuclei to form a triploid nucleus which develops into a primary endosperm. This is known as **double fertilization**.

Summary the events which take place before and after ferlisation.

Before fertilization	After fertilization
Polar nuclei	Triploid endosperm (may act as food store)
Integuments	Testa (thin protective layer)
Micropyle	Micropyle (remains as a pore in the testa)
Ovary wall	Pericarp
Ovary	fruit

Advantages of sexual reproduction in plants.

a. There is variation among the offspring which creates stability or resistance against diseases.
b. The embryo is protected by the seed.
c. Seeds can be dispersed so as to colonize new areas.
d. Seeds can remain dormant for a long time hence in harsh conditions, they are not destroyed.

Disadvantages of sexual reproduction in plants.

a. The seeds may be eaten by animals.
b. Compared to vegetative propagation, food reserves in seeds are low.
c. Seeds rely on external agents for dispersal.

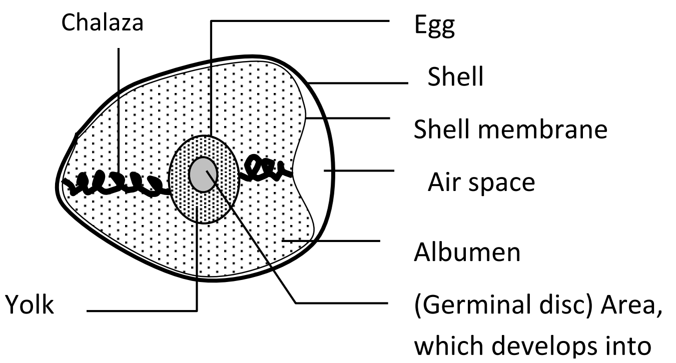
REPRODUCTION IN ANIMALS.

Sexual Reproduction in Vertebrates

Birds:

After courtship displays such as singing and nest building, the birds pair up and mate.
The bird's eggs are laid soon after they are formed.

Drawings showing the internal structure of an egg



Functions of the parts of an egg.

Shell: Permeable to gases; allows exchange of carbon dioxide and oxygen with atmosphere.
Yolk: Source of proteins and fats for embryo.
Albumen: Source of protein and water for embryo.
Airspace; this stores air for gaseous exchange of the embryo.
Chalaza; this holds the yolk in position.
Germinal disc; this develops into an embryo.

Once the eggs are laid, they are incubated in the nest by the parent maintaining a suitable temperature for development.
When the chicks hatch, the parents continue to brood (sit on) the chicks until their feathers are formed.
The chicks are then fed in the nest by the parents, protected against predators and taught to fly and sing.

Fertilization in birds is internal with the male bird introducing sperms into the cloacae of the hen. Sperms swim to the oviduct where fertilization occurs.

Sexual Reproduction in Fish

During breeding season, fish gather in large schools and deposit sperms and ova into the water, where fertilization takes `place. This is called external fertilization.
To induce the release of sperm or egg, some species of fish engage in courtship behavior which include visual colour displays and nest building.
Though most fish do not care for their young, the tilapia does. The female sucks the fertilized eggs in her mouth and keeps them there until they hatch. After hatching, the fry stays in the mouth or close to the mother.

Sexual Reproduction in Amphibians.

Amphibians return to water to breed. Fertilization is external. The males croak to attract the females. The female lays her eggs as the male sheds sperms on them.
Fertilization occurs externally in the water.
The eggs are laid in a string of jelly usually fixed on a plant or a rock.
The jelly has the following roles:
-Keeps the eggs apart so that each egg can get sufficient oxygen.
-Prevents the eggs from drying up.
Despite these strategies, mortality is high though the female toad lays many eggs, surviving eggs hatch into tadpoles.

Sexual Reproduction in Insects

The male insect attracts the female insect using smells, sounds or colours. After a brief courtship, mating occurs. Fertilization is internal.
Sperms are passed into the reproductive tract and are stored in a sperm sac in the female's body. When her eggs have matured, each may be fertilized by a sperm as they pass out.

In bees, the unfertilized eggs become fertile drones. The fertilized eggs become female workers if fed on honey and pollen or a queen if fed on royal jelly.
In grasshoppers, after laying eggs, the female digs a hole into the soft soil using the tip of her abdomen. The entrance is then blocked by a frothy secretion. The eggs will later hatch into nymph.

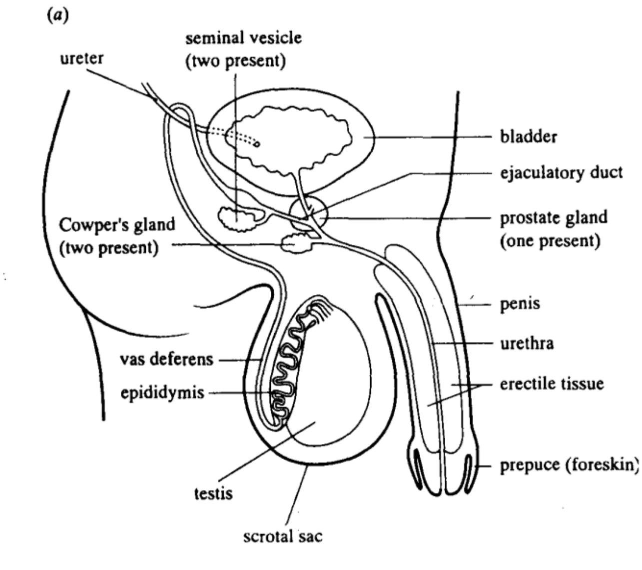
Advantages of external fertilization
- No time wasted on raising the offspring.
- Many gametes released means many offspring produced.

Disadvantages of external fertilization
- Gametes and offspring vulnerable to environmental hazards and predation.
- Low chances of fusion of gametes.
- Survival rate is low.
- Wastage of gametes.
- Offspring do not learn from parents.

Qn. State the differences between internal and external fertilization.

REPRODUCTION IN MAN

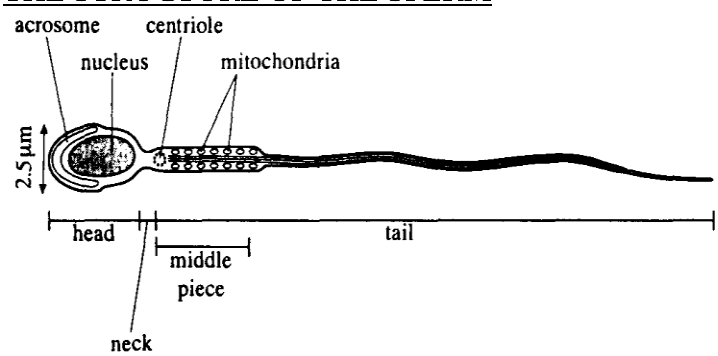
The male reproductive part system



The male reproductive organs are responsible for;
- Production of sperms
- Production of sex hormones
- Transfer of sperms to female organs

Part	**Function**
Scrotal sac (scrotum)	Holds and protects the testes
Epididymis	Stores sperm
Sperm duct (vans deferens)	Conducts sperms from epididymis to the urethra
Seminal vesicle	Produces fluid that contains sugars (fructose) which provide sperm with energy for motility.
Prostate gland	Produce fluid that neutralizes the acidity of urine which remains in the urethra.
Cowper's gland	Produce fluid that cleans the urethra. Produces mucus for lubrication of both the male and female urethra to ease copulation. N.B: This fluid is collectively known as semen.
Urethra	It is the passage of urine and semen
Penis	It is the organ for copulation. It introduces sperms into the female tract near the cervix.
Glans	It is the head of the penis and sensitive part to the penis.
Foreskin	It protects the glans in an uncircumcised penis
Testis	Produce sperm and testosterone hormone. Testosterone does the following: i. Stimulates the development of sperms. ii. Activates the seminal vesicles, prostate gland and Cowper's glands. iii. Causes primary and secondary sexual characteristics.

THE STRUCTURE OF THE SPERM



Functions of the parts of a sperm cell
Nucleus: contains haploid number of chromosomes from male parents.
Mitochondria: produce energy for beating movement of sperm tail.
Tail: Uses whip-like movement to propel the sperm.

Acrosome: contains lytic enzymes which digest the wall of the ovum for the sperm to penetrate through.

Secondary sexual characteristics in males

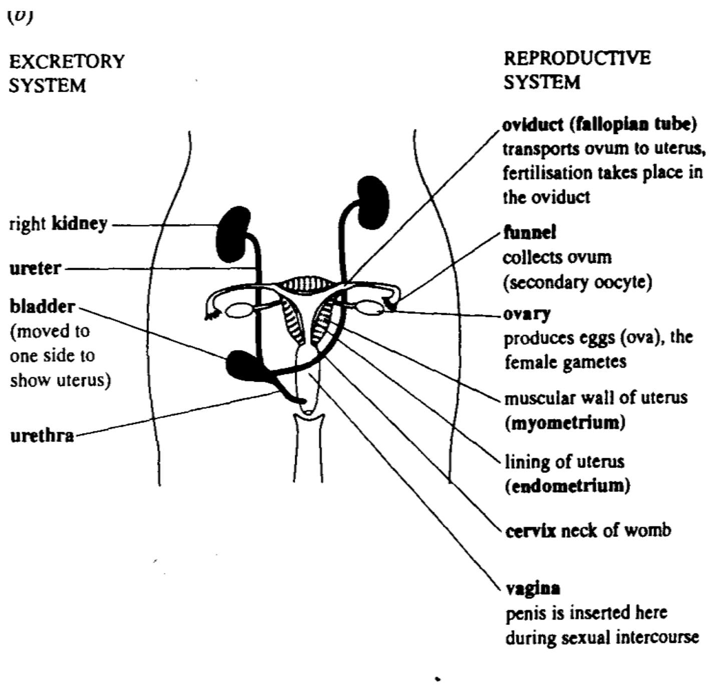
- Increase in muscle development.
- Development and enlargement of the testes and penis.
- deepening of the voice.
- Increase in body height.
- Growth of beards and hair in the arm pits.
- Onset of wet dreams.

MALE HORMONES

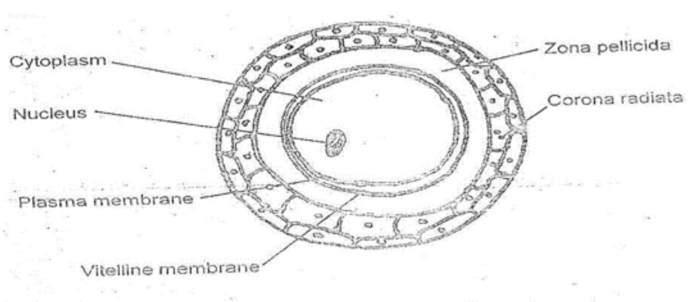
At puberty, the hypothalamus stimulates the anterior part of the pituitary to release two hormones.

i. **The follicle stimulating hormone (F.S.H)** which stimulates sperm production.
ii. **The Luteinizing hormone (LH)** also known as the interstitial cell stimulating hormone (ICSH) which stimulates the interstitial cells of the testis to release another hormone testosterone which stimulates the development of the male secondary sexual characters.

FEMALE REPRODUCTIVE SYSTEM



Structure of an ovum



Functions of the parts of the female reproductive system

Part	Function
Ovaries	Produce eggs / ova. Store and release mature eggs during ovulation. Produce progesterone and oestrogen.
Oviducts (fallopian tubes)	It provides suitable place for fertilization. After fertilization in the oviduct, the zygote is pulled downwards to the uterus by peristaltic contractions of the oviduct wall muscles. The lining of the oviduct is ciliated and the cilia play role in propelling the zygote to the uterus.
Uterus	Receives the zygote Encloses and protects the developing foetus. Has myometrium with muscular walls which contract to expel the foetus at birth
Cervix	It controls the entry to the uterus
Vagina	It receives the penis during copulation. It is a birth canal, passage of the foetus out of the uterus. Passage for menstrual blood

Qn. Describe the adaptations of the of the female reproductive system.

FEMALE HORMONES AND THE MENSTRUAL CYCLE

If the ovum is not fertilized, the new layer of cells breaks down and the unwanted cells, mucus and some blood pass out through the cervix and vagina. This is called menstruation. It takes place once about 28 days, 12-14 days after the release of the ovum.

The menstrual cycle

The menstrual cycle is controlled by four hormones of which two are secreted from **the interior lobe of pituitary gland and the other two from the ovaries.** The pituitary gland secretes **Follicle stimulating hormone (FSH) and Luteinizing hormone (LH)** and the ovary secretes **progesterone and oestrogen**. The four hormones are secreted in the following sequences.

FSH ⟶ Oestrogen ⟶ LH ⟶ Progesterone

1. **Follicle stimulating hormone (FSH)**
   - ✓ Causes the development of the graafian follicles in the ovaries.
   - ✓ It stimulates the follicles to produce oestrogen.

2. **Oestrogen.**

- ✓ This stimulates the repair of the uterine wall after menstruation.
  - ✓ When in high levels, it stimulates the pituitary gland to produce luteinizing hormone (LH)
  - ✓ It inhibits the production of FSH from the pituitary gland.

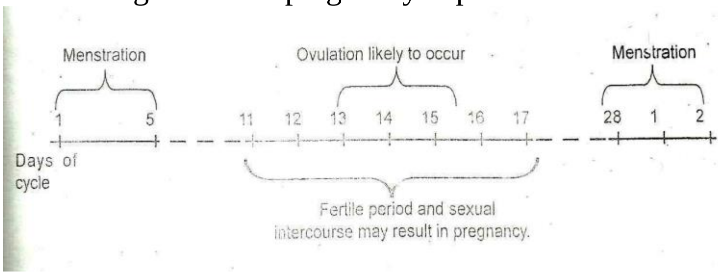
3. **Luteinizing hormone (LH)**
   - ✓ This cause ovulation.
   - ✓ It also stimulates the ovary to produce progesterone from the corpus luteum.

4. **Progesterone**.
   - ✓ This maintains the uterine lining in preparation for implantation.
   - ✓ It inhibits production of FSH and LH if its level is high.

If the ovum is not fertilized the corpus luteum continues to secrete progesterone for the next 14 days. When production of progesterone stops, the endometrium breaks leading to the flow of blood a process called menstruation.

If fertilization occurs, the placenta produces the progesterone which prevents menstruation and maintains pregnancy.

Menstruation stops at around the age of 45 years on average and one is said to have reached menopause. At this stage no more pregnancy is possible.



Graph illustrating the hormonal changes in blood during a menstrual cycle.

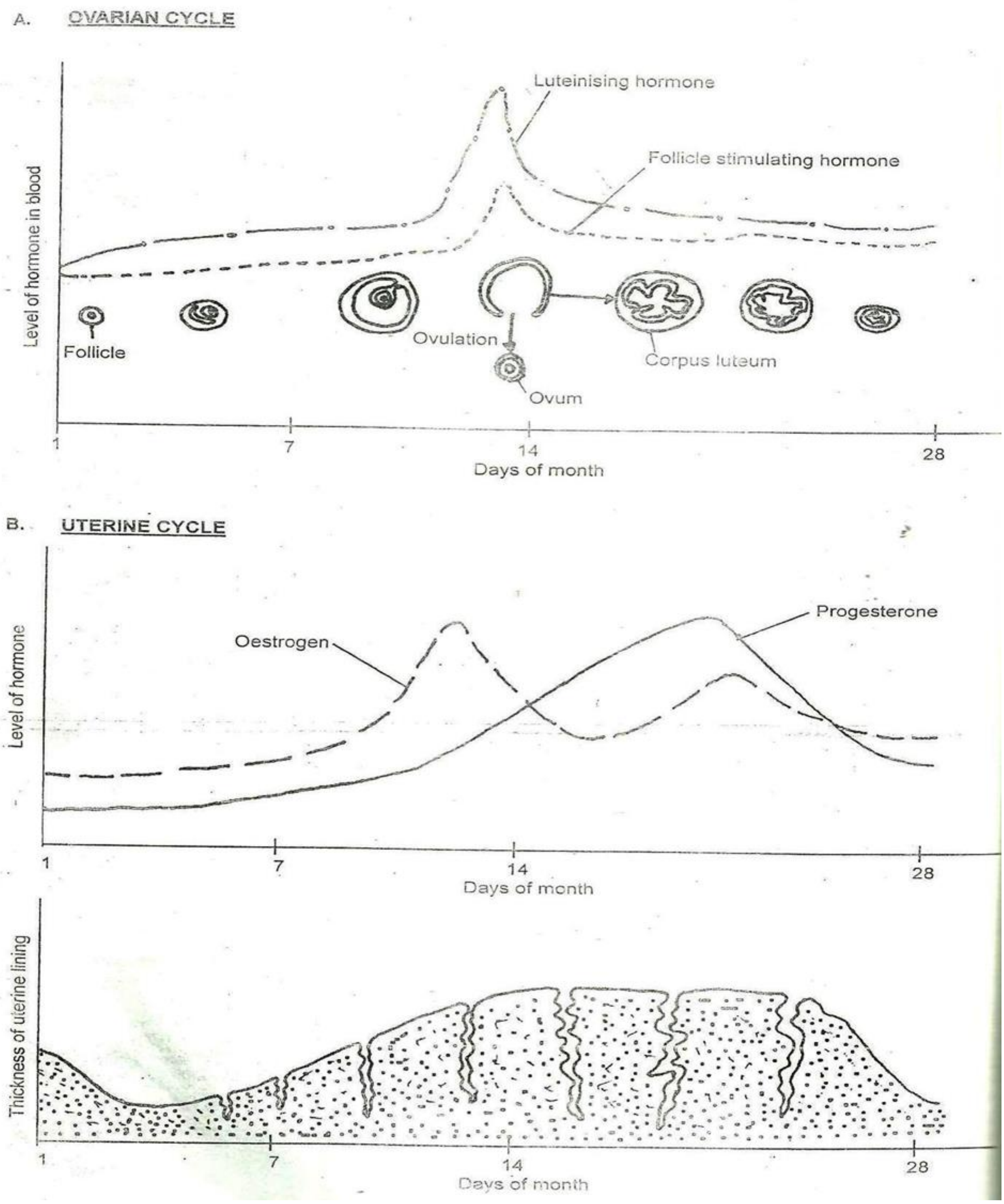
SAFE PERIODS

It refers to the days within the menstrual cycle when there is no mature ovum in the reproductive system so a female can have sexual intercourse without getting pregnant.

During the first safe period, there is development of a graafian follicle and takes about 10 days from the end of menstruation.

A female should abstain from sex for 2 days before ovulation and 2 days after ovulation because the sperm cannot survive for more than 2 days.

The 2nd safe period starts from around the 18th day up to the 28th day. Thus a mature egg dies after waiting for a sperm in vain.


A. OVARIAN CYCLE
Luteinising hormone
Follicle stimulating hormone
Level of hormone in blood
Follicle
Ovulation
Ovum
Corpus luteum
1
7
14
28
Days of month
B. UTERINE CYCLE
Oestrogen
Progesterone
Level of hormone
1
7
14
28
Days of month
Thickness of uterine lining
1
7
14
28
Days of month

Copulation and Fertilization
During copulation or sexual intercourse semen is deposited in the vagina near the cervix by an erect penis.
Sperms swim through the uterus to the oviduct using their tail. Also waves of muscular contraction through the walls of the uterus and the oviduct draws sperms to the site of fertilization.
NB: 1.5cc of semen contain about 100,000,000 sperms. Only a few of these will make it up to the oviduct and one sperm will fertilize the ovum in the oviduct.
For the sperm head to penetrate the ovum, the acrosome releases enzymes to break down the corona radiator and disperse the follicle cells.
As soon as the sperm head has entered the egg, the vitelline membrane (outer wall) swells and thickness so that no other sperm can enter.
Fusion of the sperm nucleus with egg nucleus takes place forming the zygote.
This process is called fertilization which in humans is internal. The remaining sperms that don't fertilise the egg eventually die.

Multiple Births.

- Identical twins
- Fraternal twins

Identical twins;
They are produced by one fertilized egg. The fertilized egg or zygote divides into two parts at the early stage of mitosis.
Each cell develops separately to become a baby. These twins have the same sex, same genes and are identical in almost every physical aspect since they are derived from one fertilized egg.
Conjoined (Siamese) twins are as a result of the fertilized egg dividing but not separating completely.

Fraternal twins;
In women, mature eggs may be released into the oviduct at the same time. The two eggs are fertilized by different sperms. The two zygote formed don't contain the same genetic materials and the twins formed are not identical and may be of different sex.

PREGNANCY
Six to nine days after fertilization, implantation occurs in which the zygote attaches itself onto the lining of the uterus.
The embryo develops finger like projection called villi which usually grow into the uterus wall. The embryo obtains its requirements, nutrients, oxygen through the villi.
As the embryo develops, two membranes form;

- The chorion membrane
- Amnion membrane

The placenta develops from the
The allantois has a respiratory, excretory and nutritive function. It fuses with the chorion to give rise to the placenta.
The Amnion contains amnionic fluid which acts as a shock absorber and protects the baby from mechanical shock.
It also lubricates the birth canal during delivery.

Drawing of an embryo in the uterus

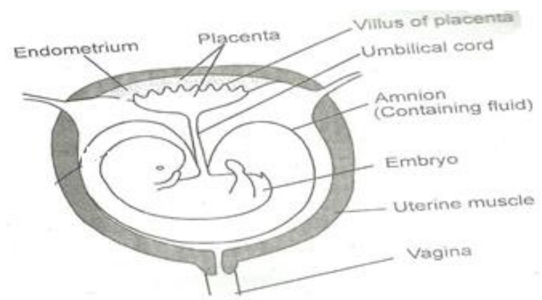
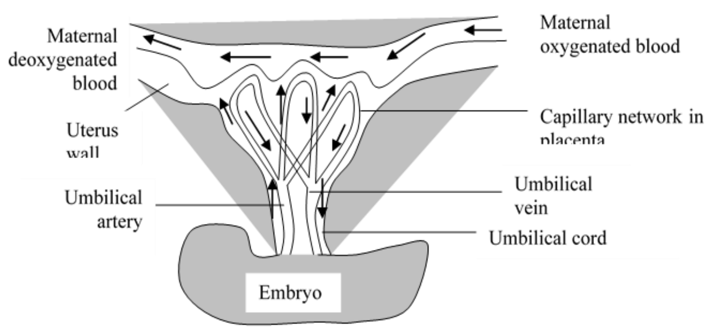


Diagram showing blood circulation to and from the fetus



Functions of the Placenta

- It allows the exchange of glucose, amino acids, water, salts, vitamins and oxygen from the mother's blood to the foetus blood.
- It allows the metabolic waste products i.e. urea and carbon dioxide to diffuse from the foetus' blood capillaries into the mother's blood.
- It allows the anti bodies to diffuse from the mother's blood into the foetus' blood. These would protect the embryo against certain diseases.
- It acts as a barrier by preventing disease causing organisms e.g. HIV, bacteria and some chemicals in the mother's blood from reaching the foetus. But the placenta is not an effective barrier to alcohol, carbon monoxide, Nicotine from cigarette smoke,

cocaine, Heroine can pass from the mother's blood into the baby's blood causing birth defects or even death.

- As pregnancy progresses, the placenta takes over the role of producing oestrogen and progesterone. Progesterone makes the uterine lining to remain thick and well supplied with blood vessels. It also prevents the uterus from contracting until the baby is born.

Birth.

At the end of gestation period, oxytocin which is secreted by the pituitary gland causes the uterus to contract. The amnion bursts and the amniotic fluid passes out through the vagina. vigorous contractions of the uterine wall push the baby through the cervix and vagina, head first.

The umbilical cord is clamped and cut. Further contractions of the uterus expel the placenta with the remainder of the umbilical cord. After birth, the pituitary of the mother provides prolactin and oxytocin. Prolactin stimulates the production of milk from the breast while oxytocin will cause the uterus to contract to its normal size.

<u>Parental Care</u>

It involves provision of food i.e. breast milk, shelter or protection.

<u>Advantages of breast milk.</u>

It is free from harmful bacteria
Easier than cow milk to digest
Cause bonding between mother and child.
Rarely gives allergic reactions.
Contains antibodies for the baby's immune system.

<u>Contraception/Birth Control Methods</u>

These are methods that prevent pregnancy or ovulation. The aim of using birth control is to either;
Prevent the fertilization of an ovum by a sperm.
Make conditions unsuitable for importation of the fertilized ovum in the uterus

Methods of birth control may include;

Mechanical methods, chemical methods, sterilization methods and rhythm methods.

Method	Basis of action	Note on use	Advantage	Disadvantage
Condom	Prevents sperm entering the vagina by collecting semen	Rubber sheath placed on erect penis.	Cheap, easy, protection from STDs	May tear or slip off
Diaphragm (cervical cap)	Prevents sperms from entering the uterus	Rubber dome that fits over cervix. Use spermicidal	Insert hours before intercourse	May cause abdominal pain. Needs training how to fit on cervix
Intra-Uterine device	Prevents implantation	Copper, plastic or stainless steel device inserted into uterus	Can be left in place for 5 years	May cause bleeding
Hormonal a)Oval contraceptive b) Injectable contraceptive	Contain oestrogen and progesterone which -prevents development of eggs -ovulation	One taken every day orally Hormone preparation injected into blood stream	Reliable	Side effects like Nausea, weight gain, clotting
Natural a)Abstinence	No sexual intercourse		Effective	
b)Rhythm method	No sexual intercourse around the time of ovulation			Requires self-discipline
c) Coitus interruptus	Withdraw of a penis before ejaculation.	Sperms do not reach eggs	unreliable	Requires self-discipline
Sterilisation a)Vasectomy	Sperm duct are cut and tied	Sperms do not get in semen	Reliable	Difficult to reverse
b)Tubal ligation	Oviduct cut and tied	Sperms do not reach eggs	Reliable	Difficult to reverse

SEXUALLY TRANSMITTED DISEASES

These are diseases spread by sexual intercourse or very close contact;

Gonorrhea;

It is caused by bacteria Neiserra. In men, it invades the urethra and in females the vagina. Transmission is sexual or from mother to child during birth.

Symptoms in males

Yellow pus like discharge with a fowl smell.
Burning sensation during urination.
Dripping or retention of urine.

In Females; Infection is less obvious and so infections may spread to the uterus, fallopian tube, rectum, throat, to the conjunction, untested.

Prevention:

Use condoms
Stick to one partner.
Don't share towels.
Visit a medical doctor for antibiotics.

Syphilis

Caused by Treponema bacteria which invades the reproductive system.

Symptoms in males.

Sores on penis especially the glans and may not be painful.
Females; sores on the vagina may not be painful.
Later spread of the bacteria could cause mild fever and rushes.
Six months without treatment will cause sores on lips, mouth and genital area.
Fifteen years of infection would lead to blindness, Deritium (mental instability)
Teeth have rugged edges.
Finally death may set in.

Prevention;

Use condoms
Screen blood before transfusion.
Treat infected pregnant women to reduce mother to child transmission.

Candidiosis (thrush)

It is a yeast (fungal) infection. It may grow on the tongue, infects the valve in females and the penis in males. Appears as white flatty patches on the tongue or as red inflamed (swollen) skin.

Symptoms;

Females produce a thick white discharge.
Itches of the vulva due to irritation.
In males inflammation of the glans.

Prevention;

Use condoms.
Get proper complete treatment.
Clean bathrooms and toilets thoroughly.
Don't share towels and basins.

HIV/AIDS

It is caused by the Human Immunodeficiency Virus. HIV destroys the immune system and makes the individual vulnerable to opportunistic infection e.g. TB, pneumonia, cervical and cancer, Herpes Zoster.

Preventions

Use condoms
One sexual partner.
Do not share sharp objects e.g. razor blades.
Screen blood during transfusion.
Use anti-Retroviral Drugs and therapy for HIV pregnant mothers to prevent mother to child transmission.

Questions

1. (a) In what ways will the composition of blood in umbilical cord vein different from that in the umbilical artery?
   (a) State the adaptations of the female reproductive system to its functions.
2. What is vegetative reproduction in flowering plants?
3. (a) Define the term menstruation.
   (b) Describe the menstrual cycle in females
4. (a) What are the causes of infertility in males
   (c) Describe the process of fertilization in man
5. (a) Describe the different forms of asexual reproduction in flowering plants.

GROWTH AND DEVELOPMENT.

Growth is defined as the permanent increase in size or dry weight of an organism. It is accompanied by an increase in the amount of protoplasm.

Growth is brought about by cell division, cell elongation or enlargement. Cell division results in the increase of body (somatic) cells. Cell differentiation makes cells to perform specific functions well.

Development is the process by which body cells of organisms grow to advanced stages and become complex. Development of an organism involves growth, cell differentiation and organization of cells into various structures.

Factors that affect growth of oranisms

Amount of nutrients available for organisms.

An organism which gets sufficient nutrients grows faster than one with a deficiency of nutrients.

- **Temperature** Bodily functions are controlled by enzymes which work well within certain temperature ranges.
- **Light** This affects growth of plants mainly. Light affects the formation of chlorophyll, photosynthesis, opening and closing of stomata, flowering, and phototropic responses.
- **pH** This greatly affects microbes and other lower animals which live in environments with water.
- **Hereditary factors.** The ability of an organism to grow is inherited from parents through genes.
- **Hormones** like growth hormone and thyroxin control the rate of growth.
- **Diseases** Some diseases retard growth.
  Other factors include Oxygen, water and excretory products.

GROWTH IN PLANTS

Germination

This is the growth and development of an embryo of a seed into a young plant or seedling under favourable conditions. Seeds can either be endospermic or non endospermic. Germination starts with absorption of water(imbibition)

Conditions necessary for germination.

Environmental conditions

Water, air/oxygen, suitable temperature and some seeds need light

Internal factors

Viability of seeds, food stored in seeds, enzymes, absence of germination inhibitors.

Importance of the conditions

Water is necessary in germination of seeds for;

- Activation of enzymes in seeds
- Providing necessary medium for enzyme activity
- Dissolving and hydrolyzing stored food materials
- Transporting them to the growing parts of the shoot and roots.

The process by which seeds take up water is referred to as **imbibition**. The seed swells and the test bursts.

Oxygen

The micropyle allows air containing oxygen to enter the seed and carbon dioxide produced to escape Oxygen is needed for respiration to yield energy.

Suitable temperature / warmth

Suitable temperature is needed to activate enzymes used in the hydrolysis of stored food and respiration.

Photoblastic seeds require a certain amount of light exposed to them before they can germinate.

Changes during germination

The following changes occur during germination:

i. The seed absorbs water through the micropyle
ii. The seed swells and the testa (seed coat) ruptures
iii. Enzymes become activated and begin to hydrolyse stored food
iv. The rate of respiration increases rapidly
v. The radical emerges first and grows downwards to form the root system.
vi. Starch in the cotyledons or endosperm is hydrolysed to disaccharides and monosaccharide and is taken to the growing points for respiration
vii. The radicle develops root hairs and begins to absorb water and mineral salts
viii. The shoot develops foliage leaves and starts to photosynthesise

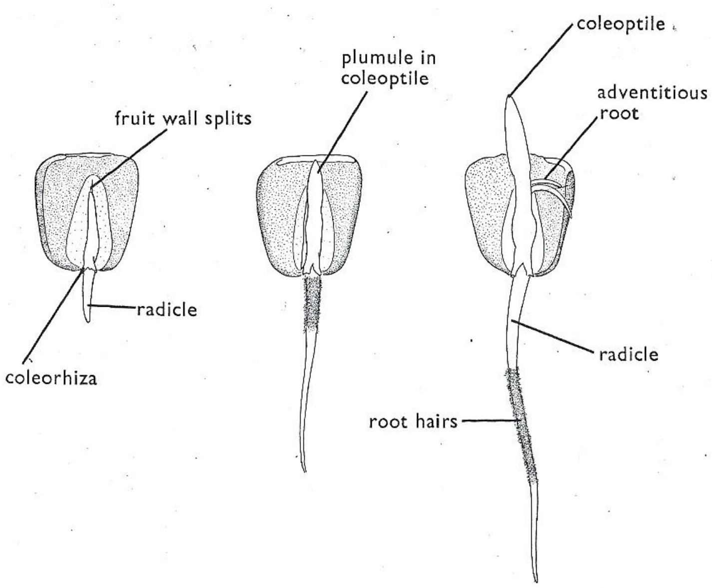
ix. When food reserves in the cotyledons are exhausted, the cotyledons wither away.

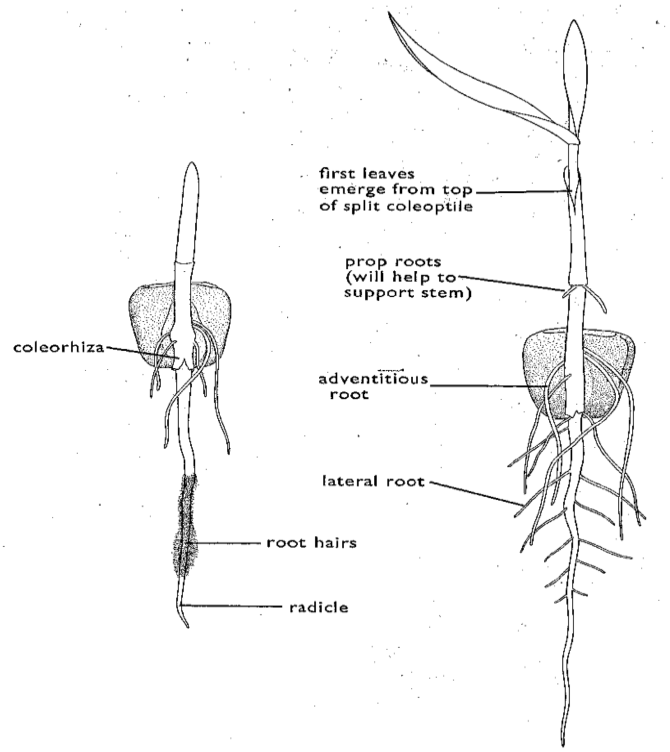
TYPES OF GERMINATION

Hypogeal germination e.g. in maize

Cotyledons of the seeds remain below the ground. This is brought about by the rapid elongation of the epicotyl which causes the plumule to grow straight out of the ground. The sheath protects the plumule.

Drawings showing Hypogeal germination

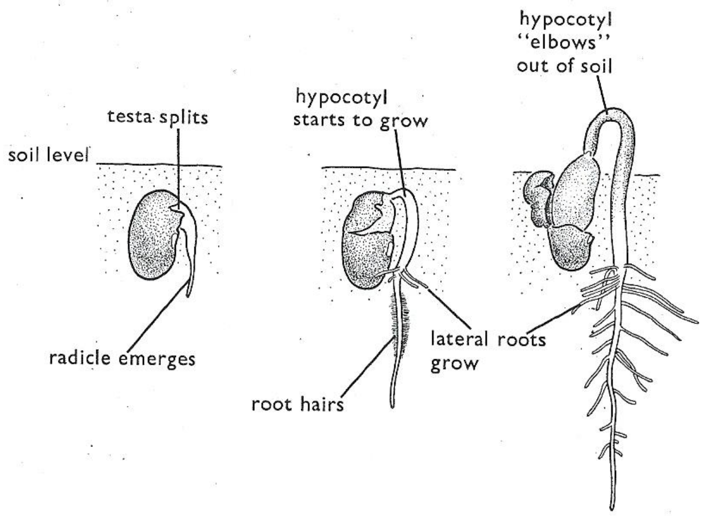


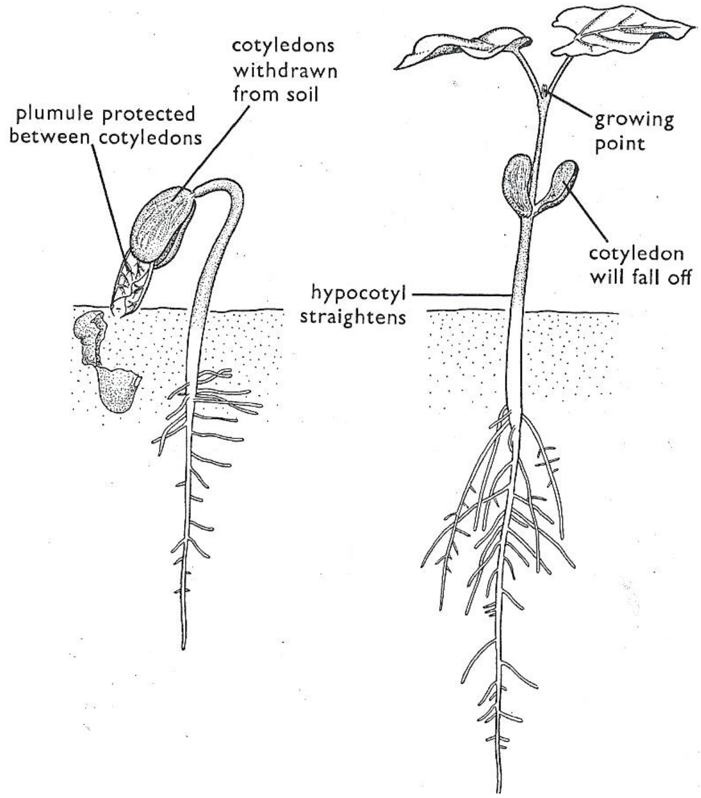


Epigeal germination e.g. beans

The cotyledons are carried above the ground due to the rapid elongation of the hypocotyl upwards. Once exposed to the surface, the cotyledons separate exposing the plumule. The cotyledons develop chlorophyll and start carrying out photosynthesis

Drawings showing epiogeal germination.

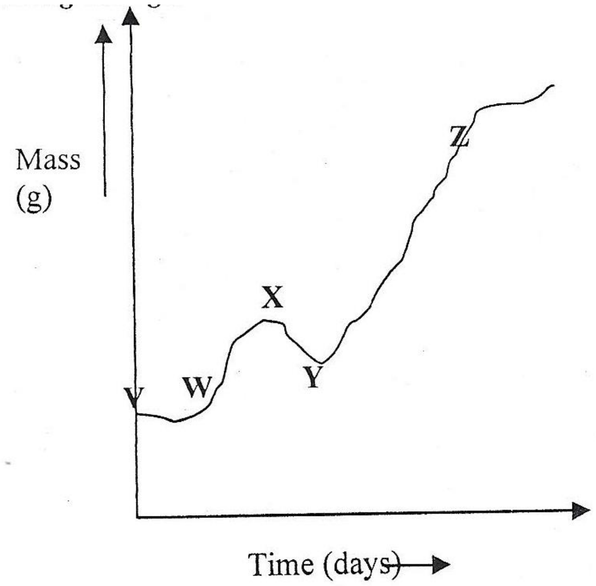




VARIATION OF SEED MASS DURING SEED GERMINATION.

The mass of seeds remains the same in the first day or second day. It then rapidly increases for the next few days of germination and then slightly reduces. After this period, the mass of seeds rapidly increases before slowing down.

A graph showing variaton in mass with time during seed germination

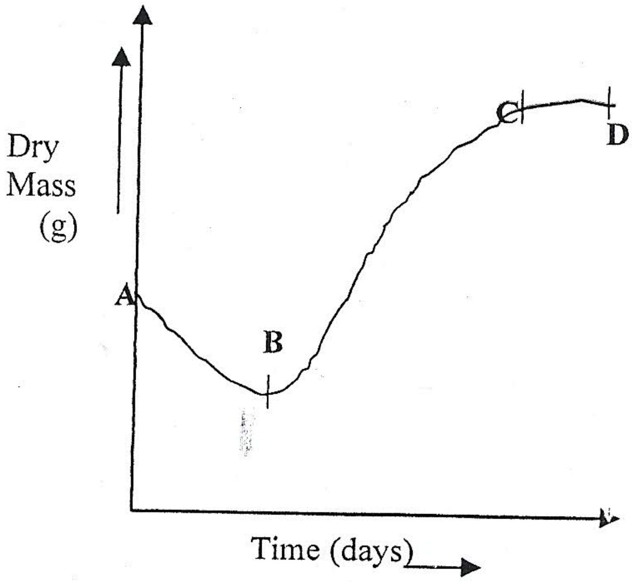


From V to W the seed is still dormant and has not yet started germinating.
From W to X the weight of the seed increases rapidly because it has absorbed water and germination has started.
From X to Y the weight of the seed decreases because the stored food is used up to provide energy for growth and the rate of tissue formation is lower than the rate of hydrolysis of stored food.
From Y to Z the weight increases rapidly because the embryo has grown into seedling. Seedling builds up new cells and at the same photosynthesis is occurring hence producing more food than one being used up.
Beyond point **Z** the plant weight may remain constant and then start to decrease due to production of seeds, fruit which are later dispersed.

CHANGES IN DRY WEIGHT OF SEEDLING DURING GERMINATION

The dry mass or weight of a seedling is the weight of seedling after the water content has been removed. This is normally done by placing the seedlings in an oven at moderate temperature(100°C).
Change in dry weight of a seedling during germination is illustrated in the graph in the figure below.

A graph showing changes in dry mass of seedlings with time during seed germination.



From A to B, the dry weight decreases because the stored food is used up in respiration for cell growth. There is little or no growth. This phase of growth is called lag phase.
From B to C, the dry weight begins to increase rapidly because the seedling has reached a stage of producing more food by photosynthesis than it can use up during respiration. The number of cells also increases which increases the dry weight.
Various structures may arise from a shoot (leaves, flowers, stem branches and roots) so that the apical meristem rises to various kinds of meristem or **primordial. Leaf primordial arise** from the stem in a pattern and sequence that determines the arrangement of leaves (singly or in pairs and in one or more planes). In the axil of each leaf primodium is another meristematic area, the bud primoridium. The node remains a site of meristematic potential.

REGION OF GROWTH

Growth in plants occurs at the tip of shoot and root by cell division and cell elongation i.e. when the new cells expand. Measurement of region of growth in a seedling e.g. bean seedling is best done by measuring length of radicle at regular intervals of time.

EXPERIMENT I

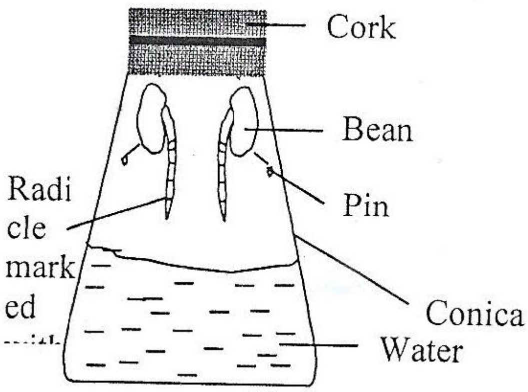
AIM: To find out the region of growth in radicle.

MATERIALS

- Cork	- Conical flask
- Water	- Indian water proof ink
- Pin	- Bean seedling
- Ruler	

PROCEDURE/METHOD

- Straight radicles of bean seedlings of 3 days germination are marked with Indian water proof ink at 2mm intervals.
- The seedlings are then pinned to the bottom of the cork, which is then fixed in the mouth of conical flask with little water as shown in the figure below.
- The flask is placed in a dark place to allow the radicle continue to grow for about 2 days.
- The gaps on radicle are then measured again using a ruler.

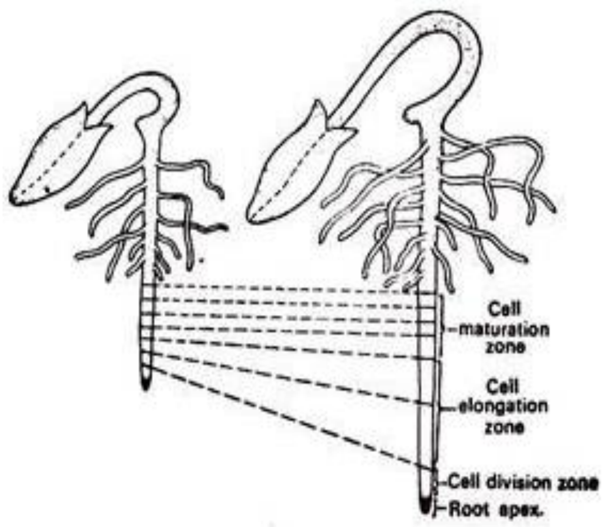


OBSERVATION

There is a shorter distance between the markings at the tip of a radicle and at its top than in the middle. i.e. there is no change in length of gaps at furthest back and tips.

In between these two areas, there is an increase in length of gaps as shown in the figure below.

Region of growth



CONCLUSION

Region of growth in a root is a short distance located behind the tip of the root.

An experiment to show that water is necessary for germination

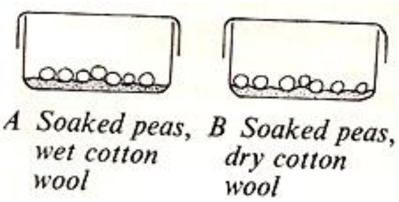
Apparatus *I* materials

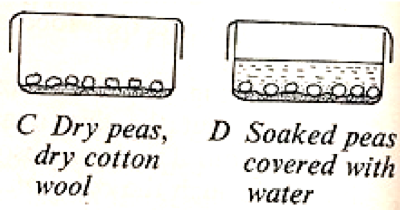
4 petri dishes, Cotton wool, pea seeds

Water

Procedure

- Label four Petri dishes A, B, C and D.
- In petro dish A, place soaked pea seeds on wet cotton wool and cover.
- In Petri dish B, place soaked pea seeds on dry cotton wool and cover.
- In Petri dish C place dry pea seeds on dry cotton wool and cover.
- In Petri dish D fill with water and place socked pea in water then cover.
- Leave the dishes for one week and then observe





Observation.

Only in petri dish A do the seeds germinate properly. The seeds in B started to germinate and then shriveled and die. The seeds in D died and rotted

Conclusion.

Adequate water is required for germination.

An experiment to show that oxygen is needed for germination

Apparatus

2 conical flasks, 2 pieces of muslin cloth, string, soaked been seeds

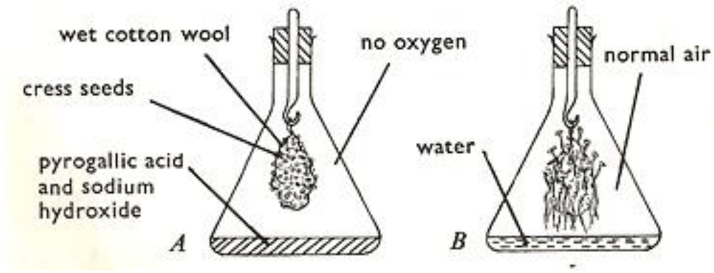
Cotton wool, 2 corks, pyrogallic acid, water

Procedure

- Label one conical flask A and the other B
- Place pyrogallic acid in the flask marked A and water in the flask marked B to depth of about 1 cm.
- Soak the cotton wool in water and divide it into two. Place soaked bean seeds on each piece of cotton wool

- Wrap each piece of cotton wool and the seeds in muslin and tie to form a bag
- Using a piece of string, suspend each bag in one of the conical flasks
- Seal the flasks with the corks
- Leave the experiment s for one week

Setup

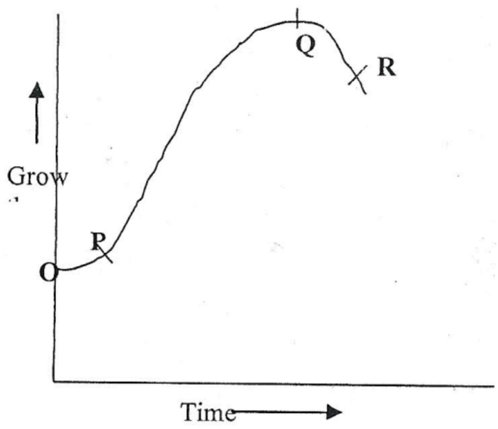


Observation
Only seeds in flask B germinated.
Conclusion.
Oxygen is required for germination.

Explanation
Pyrogallic acid absorbed oxygen from conical flask A hence no germination took place in flask A.
Flask B had oxygen hence germination took place.

Experiment to show that optimum temperature is required for germination.
Apparatusl materials
3 Petri dishes, soaked beans, cotton wool, water, incubator, refrigerator.
Take three Petri dishes and label them A, B and C. Place equal numbers of soaked seeds on moist cotton wool in the petri dishes.
Keep Petri dish A in an incubator at 60ºC, dish B in a refrigerator at 4ºC and C in a cupboard in the laboratory at room temperature. \Observe the seed after a week and the seeds are compared.
Observation
Only seeds in the cupboard germinated
Conclusion.
Optimum temperature is required for germination.

GROWTH IN PLANTS
Young plants grow faster than older ones. The growth of a plant is slow at first stages because of less photosynthesis hence more assimilation. The growth then gradually increases until it reaches a maximum after growth slows down as shown in the figure below.

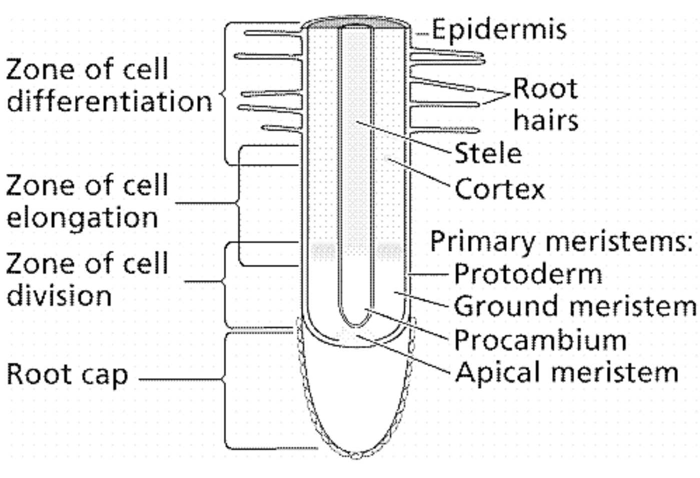


The graph above shows that growth starts slowly then accelerates and is followed by deceleration due to senescence and loss of some plant parts.

Regions of growth in Plants.
In plants there are regions where growth takes place called **meristems.**
A meristem gives rise to all other cells of plant. It is composed of small, unspecialized cells that divide continually and after division one cell remains meristematic the other cell becomes part of plant body and may or may not go through more mitosis before differentiating. Meristems cause primary and secondary growth.

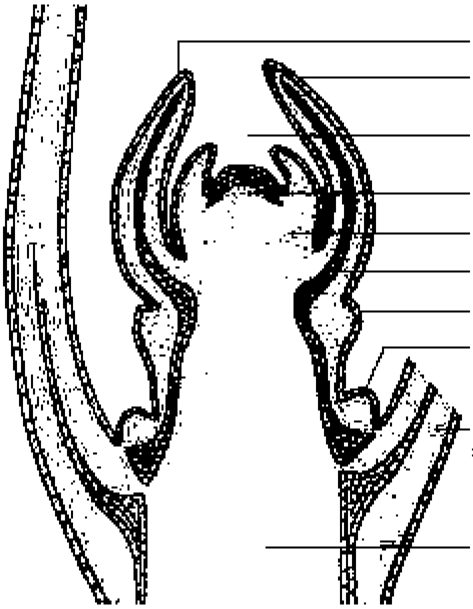
Primary growth
Primary growth is initiated by **apical meristems** near tips of roots, shoots and results in increase in length of primary plant body.
The following are the meristems in a plant root.
- **ground meristem** – produces ground tissue
- **protoderm** – produces epidermis
- **procambium** – produces primary vascular tissue

Drawing showing primary meristems in a root.



Note. Differentiation is the process by which a **cell** becomes specialized in order to perform a specific function.

Drawing showing primary meristems in a shoot.

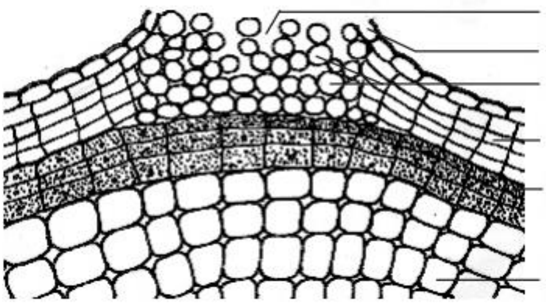


Secondary growth.

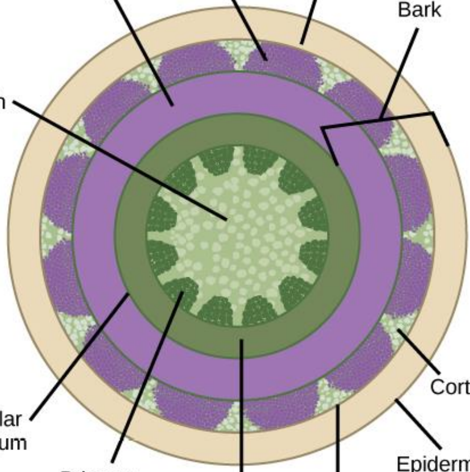
It is initiated by **lateral meristems** – internal meristematic cylinders, which expand the girth of a plant (thickening of plant body). Lateral meristems include;

- **cork cambium** – cork cells in bark of woody plants (outer bark)
- **vascular cambium**: secondary vascular tissue which gives rise to
    - secondary phloem – closest to cork
    - secondary xylem – internal; main component of wood

Drawing showing Cork cambium.



Drawing of the transverse section of a stem showing secondary growth.



Methods used to measure growth

- Use of linear dimension such as length of height or circumference e.g child growth
- Measurement of the mass e.g in babies

- Measurement of dry mass in plants.
  Dry mass is the amount of organic material in an organism minus the water in its cytoplasm. This is done by drying an organism in an oven at about 100^oc. The water evapourates but the carbohydrates, lipids and proteins do not burn. Organisms are constantly weighed until a constant dry mass is measured.
  Disadvantages of measurements of dry mass
  - It kills the organism so growth is not followed individuals.
  - large number of organisms are used.

SEED DORMANCY

This is a condition whereby viable seeds fail to germinate even under environmental conditions normally favorable for germination.

CAUSES OF SEED DORMANCY

- **Immature embryo of seed:** This may cause dormancy in seed germination since the embryo may need to undergo development before germination occurs
- Presence of germination **inhibitors**: Substances like abscissic acid prevent germination of seeds when present
- **Extremes of temperatures:** These greatly affect the functioning of enzymes in seeds. High temperatures denature enzymes and low temperatures inactivate

them.
- Presence of hard, **impermeable seed coat:** Such a seed coat does not allow water and gases to enter seeds.
- some seeds may require light to germinate.

WAYS OF BREAKING SEED DORMANCY

i. **Harvesting mature seeds:** This involves allowing embryos in seeds to develop up to maturity for a certain period called **after ripening.**

ii. By providing **growth promoters** which inactivates the germination inhibitors.

iii. By exposing seeds to a cold period (**chilling**) to initiate germination. This is a common method of breaking seed dormancy in cereals.

iv. **Treatment with light,**Some seeds do not germinate in dark thus continuous or periodic exposure of light is essential e. g. Lettuce

v. Removing the hard seed coat (**scarification**) by:
- Soaking seeds in water to soften it.
- Physical removal (scarification) by action of bacteria in soil.
- Action of fire to burn away seed coat.
- Passing seeds through animal guts.
- Filing the seed coat to make it soft or thin.
- Churning seed coat in concentrated sulphuric acid

IMPORTANCE OF SEED DORMANCY

1. It improves the chances of a seedling to grow to maturity.
2. It reduces the risk of seeds being frozen to death during unfavourable conditions.
3. It promotes germination of seeds during favourable conditions.
4. An extended period of dormancy gives seeds a greater opportunity to be removed away from the parent plant hence useful in seed dispersal.

PLANT GROWTH AND HORMONES

Plant growth is controlled by auxins. Other plant hormones important in plants include

1. Gibberellins:

-These promote extensive growth of intact plants by stimulating stem elongantion.

-They promote seed germination in some cereal grasses.

-They are also sprayed onto fruits to produce seedless fruit such as grapes.

2. Cytokinins:

-Atimulate cellular division, enlargement of cotyledons and development of lateral buds

3. Abscissic acid:

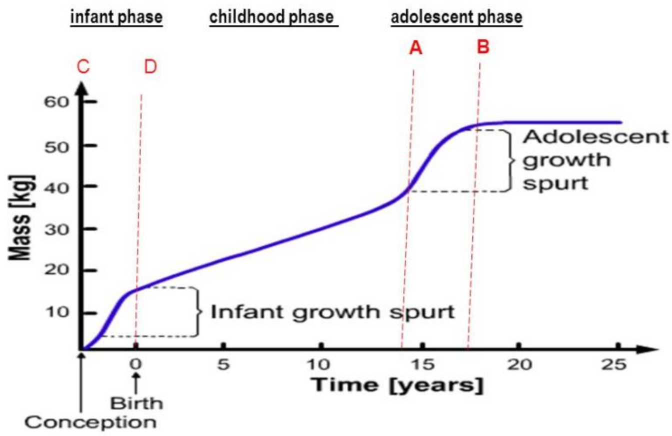
-Acts mainly as a growth inhibitor.
It is presents in large quantities in dormant buds.

-It also influences dormancy in some seeds.

GROWTH IN ANIMALS

Unlike plants, growth in animals is not localized to certain parts. It occurs throughout the body parts and is controlled by hormones. However, there is variation in growth of animals. Mammals and many other animals exhibit **continuous growth** i.e. do not stop growing from birth to maturity even though their growth rate changes. The growth of humans and other mammals ceases at maturity.

Graph showing the human growth curve



Growth in arthropods.

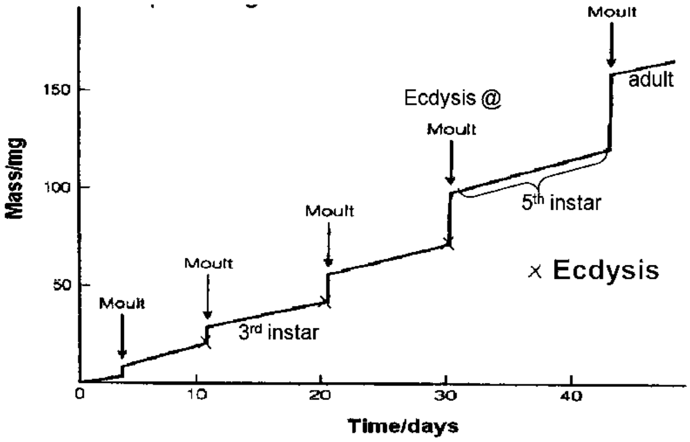
Arthropods on the other hand, usually have a number of periods of extremely rapid growth followed by a long period in which there is little or no growth. This growth pattern is termed as **discontinuous growth or intermittent growth .**

Insects just like other arthropods have an exoskeleton which is not capable of expansion. In order to grow, insects shed off the exoskeleton, a process called moulting. This is followed by rapid growth before a new exoskeleton becomes fully developed and hardened. This is done by insects taking in much water.

In most animals, moulting is triggered by secretions of the thyroid gland or pituitary gland. Many mammals shed their hair in spring, and some even moult and regenerate parts of their bodies; deers, for example, grow new antlers. Birds usually moult in the late summer without effect on their ability to fly, and snakes and amphibians cast off their skins several times a year. The moulting of hard exoskeleton or

cuticle occurs in crustaceans and insects.
During moulting (ecdysis) the exoskeleton splits longitudinally and the next stage or form, nymph, pupa and imago emerges out of it. This kind of transformation is termed as metamorphosis

A graph showing intermittent growth of arthropods like insects.



METAMORPHOSIS IN INSECTS
Metamorphosis is the transformation from the larval to adult form that occurs in life cycle of some organisms e.g. insects and amphibians. It is controlled by some hormones.

TYPES OF METAMORPHOSIS
There are two types of metamorphosis namely:
(i) Incomplete metamorphosis or hemimetabolous

(ii) Complete metamorphosis or holometabolous

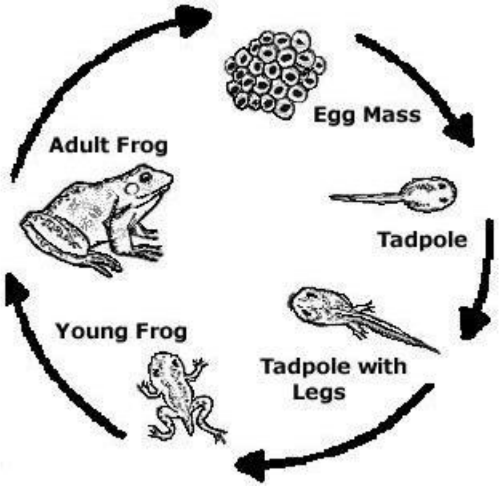
INCOMPLETE METAMORPHOSIS
It occurs in some insects like cockroaches, crickets, aphids, etc. in this type of metamorphosis the eggs hatch into nymphs which resemble adults except that they are smaller, lack wings and sexually immature. Repeated moulting occurs before the nymph becomes an adult. In incomplete metamorphosis, the young resembles the adult. The animal's form gradually changes through moulting, or shedding.

COMPLETE METAMORPHOSIS
This occurs in some insects like moths, butterflies, houseflies, bees, mosquitoes etc. Here, eggs hatch into larvae which differ from adults. Each larva Undergoes a series of moults and considerable feeding to become a pupa. A pupa is dormant since it doesn't feed. It undergoes considerable tissue breakdown and reorganisation internally to become an adult (imago). In complete metamorphosis, a clear distinction exists between the various stages of the animal's development. In the first phase, an embryo forms inside an egg. When the egg hatches, the animal is called a larva. During the next period, the larva changes into a pupa. At the end of the pupal stage, the adult emerges.

IMPORTANCE OF METAMORPHOSIS
Metamorphosis helps insects and other animals to prepare for adult life in a new environment. This increases on chances of exploiting space and food resources in different environments.
It also minimizes competition between young ones and adults. Since the two may be in a different environment.

GROWTH AND DEVELOPMENT OF AMPHIBIANS
Just like insects, amphibians undergo metamorphosis. The fertilized egg undergoes **cleavage** (series of cell division) and **gastrulation** (re-arrangement of cells into distinct layers) during the first two days. By the third day, the embryo develops into a young **tadpole**
Just after hatching, the tadpole is a tiny short- bodied creature with a disc-like mouth. It clings to plant vegetation and nourishes on yolk in its body until it starts to feed. Soon after hatching, the body lengthens, and two pairs of external gills appear at the sides of the head. The tail lengthens and develops a caudal fin. The mouth opens and the tadpole begins to feed on microscopic water plants such as algae by scrapping the leaves with horny lips.
At this stage, the operculum grows and the tadpole begins to develop internal gills. In about 20-35 days, from hatching, internal gills fully mature. In this state, the tadpole becomes a free swimmer and horny lips disappear.
A long coiled digestive tract develops and the tadpole starts living on aquatic vegetation scums. At this stage, the tadpole is a fish-like animal with two chambered heart; and transforms into an adult.
Soon after the appearance of the front legs, the tadpole then starts re-absorbing its tail. Late in metamorphosis, the tadpole's mouth broadens and teeth develop.
As those external changes occur, the internal changes also occur. A sac-like chamber forms in back of the throat. This divides into two sacs becoming the lungs. The heart becomes three-chambered and gill arteries turn into carotid, aortic aches and pulmonary cutaneous arteries. The gills stop functioning and the tadpole comes to the surface frequently to gulp air. Even before the tail is totally reabsorbed the tadpole leaves water and comes to land as young frog or toad. The young frog or toad undergoes Continuous development to become mature.

Drawing of the life cycle of an amphibian like a toad.



References
1. Introduction to Biology by D.G.Mackean
2. Biology for East African Schools by Soper and Smith
3. Tropical Biology by Cozens

Miscellaneous questions

1. Describe the events that occur in a germinating seed.

2. Outline the use of water in a germinating seed.
3. What type of cell division is responsible for growth? Reason?
4. How is growth in plants different to growth in animals?
5. Describe the external and internal changes that occur in a germinating maize grain.
6. State the differences between complete and incomplete metamorphosis.
7. What is the importance of the caterpillar being markedly different from the butterfly?
8. What is the use of Intercalary meristems?
9. How do you measure rate of growth in seedlings using dry mass.

☺ **END OF TOPIC**