4. GROWTH AND DEVELOPMENT.

Definition of terms.

1. **Growth-** this is the irreversible/permanent quantitative increase in the size of an organism. It is brought about by multiplication and elongation of cells in the process of cell division.

- It is measurable e.g. increase in height, length, width e.t.c.

2. **Development-** this is the qualitative growth which involves differentiation of cells and formation of new tissues to be able to perform specialized functions.

- It is not measurable but can be assessed through complexity e.g. development of leaves, flowers and roots.

3. **Differentiation -** It refers to modifications of cells to perform specific functions.

- Differentiation is important because cells become specialized to enable the organism perform specific functions.

4. **Morphology** refers to the body form of an organism. Morphology is as result of growth and development.

- In animals, growth takes place all over the body but in plants it takes place in specialized/localized regions called **meristems.**

Differences between growth and development.

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

Processes involved in growth.

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

Differences in growth between plants and animals.

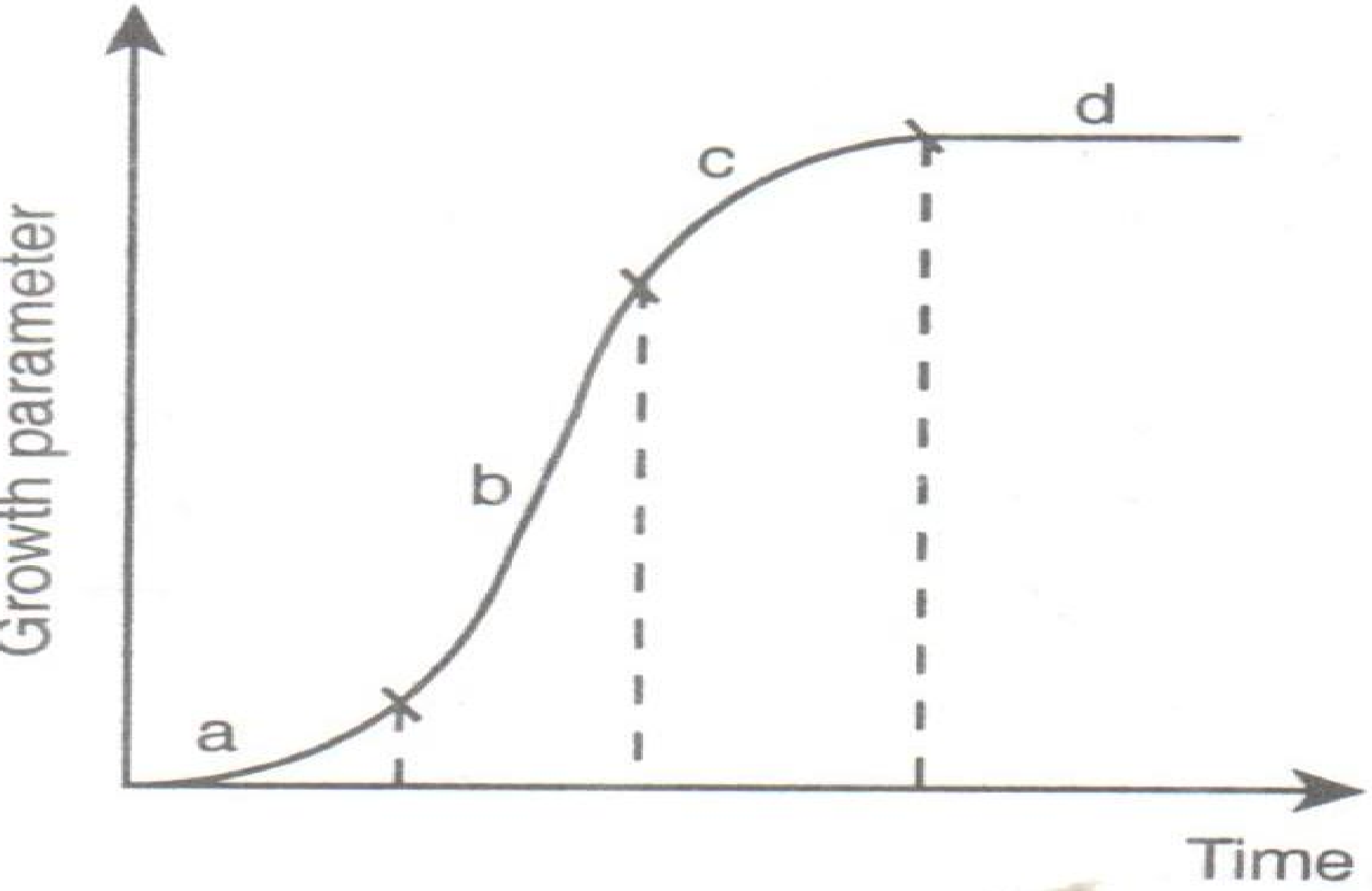
i. Growth occurs at specific/localized parts.	i. Growth occurs throughout the animal body.
ii. Growth takes place throughout the life cycle.	ii. Growth takes place in early stages and stops at maturity.
iii. Growth is mainly influenced by environmental factors.	iii. Growth is mainly influenced by hormones.

Measurement of growth.

- ✓ Growth can be estimated by measuring some aspect of an organism e.g. ***volume, height and mass and in unicellular organisms, the number of cells*** over a period of time.
- ✓ Dry mass is the best indicator of growth because it gives the actual amount of living matter in an organism.
- ✓ Fresh mass is dependent on the amount of water present in an organism hence it is not the best indicator of growth.
- ✓ Dry mass has **limitation** in estimating growth because it kills the organism hence cannot be used over a period of time to estimate growth.
- ✓ If the measurements so obtained are plotted against time, the curve obtained is a **growth curve (**S-shaped curve /sigmoid curve).

Limitations of measuring growth using the above parameters.

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



The sigmoid growth curve

PARTS OF A SIGMOID CURVE.

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

✓ Growth is slow because:

i. The number of cells dividing are few.

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

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

- There is rapid/ exponential growth because:

i. There is increase in the number of dividing cells.

ii. Cells have adjusted to the new environment.

iii. Food and other factors are not limiting hence cells are not competing for resources.

iv. The rate of cell increase is higher than the rate of cell death.

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

✓ Growth is slow because of the following:

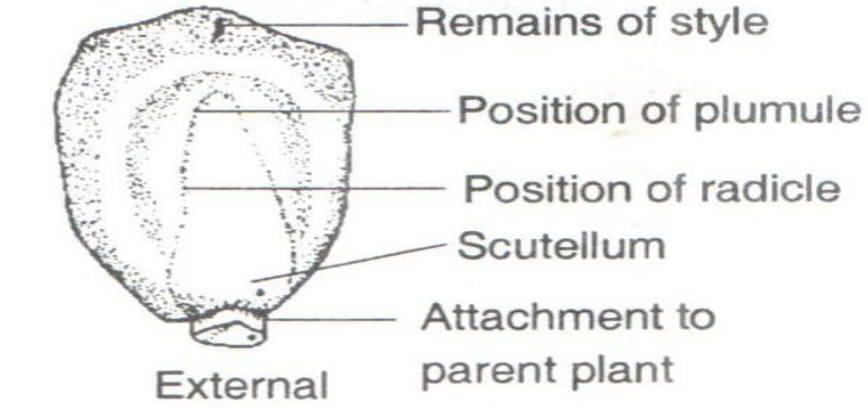
i. Most cells are fully differentiated.
ii. Fewer cells are still dividing.
iii. Shortage of oxygen and nutrients due to high demand by increased number of cells.
iv. Space is limited due to high number of cells.
v. Accumulation of metabolic waste products which inhibit growth.
vi. Limited acquisition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

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

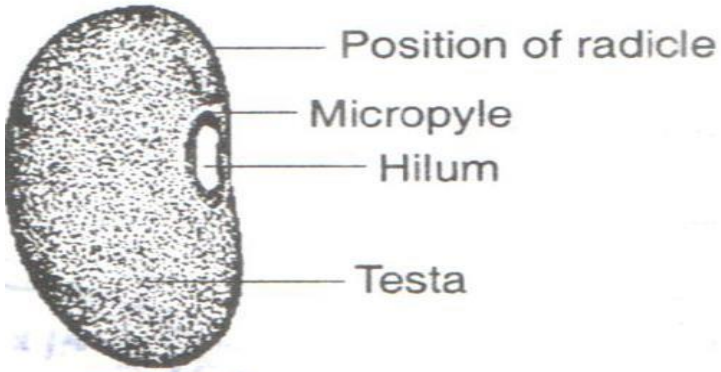
✓ There is no growth/ growth is constant because:

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

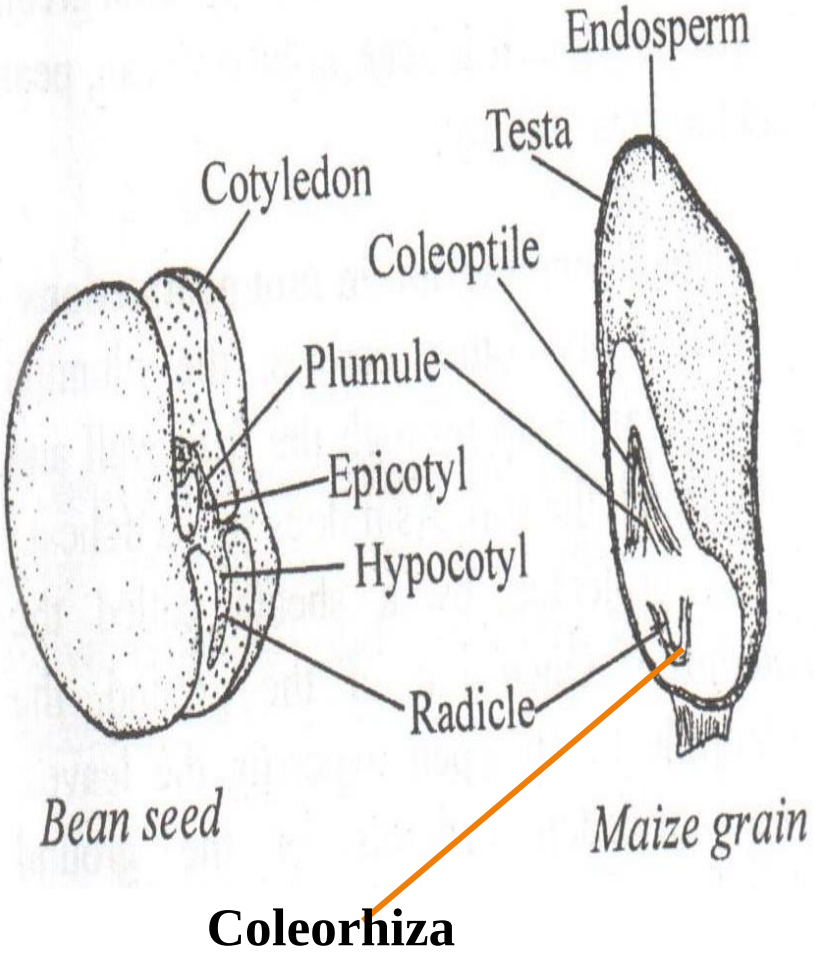
Structure of a seed.



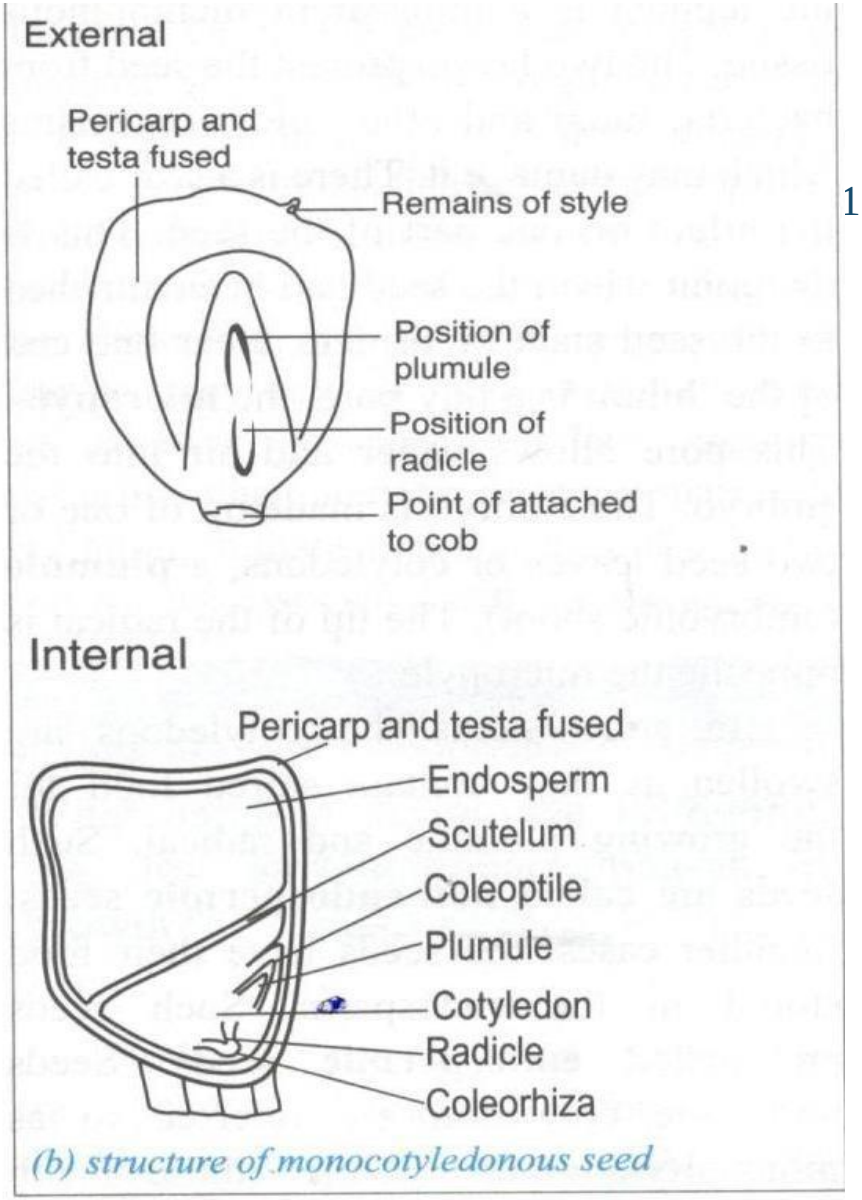
External monocotyledonous seed (maize grain)



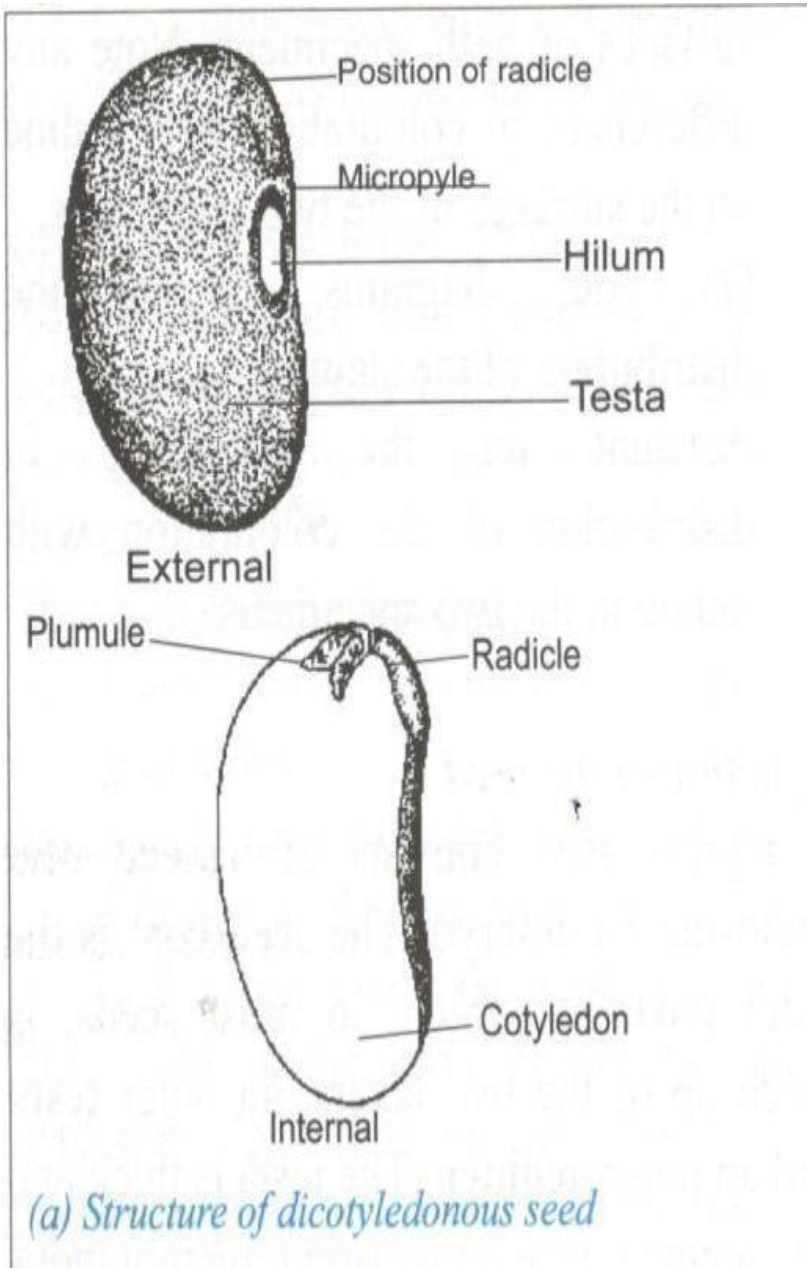
External dicotyledonous seed



Coleorhiza



(b) structure of monocotyledonous seed



(a) Structure of dicotyledonous seed

Fig. 4.4: Structure of seeds

PARTS OF A SEED.

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

✓ It consists of :

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

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

Role/ function of seed coat (testa and tegmen)

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

2. **Hilum -** This is the point where the seed had been attached to the seed stalk or **funicle.**

3. **Micropyle.** This is a pore which allows water and air into the embryo.

4. **Endosperm-** this is the swollen part of the seed **which stores food for growing radicle and plumule.** It is prominent in **monocot seeds.**

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

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

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

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

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

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

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

SEED DORMANCY.

- ✓ This is a period when seeds fail to germinate even if all the favorable environmental conditions for germination are provided.
- ✓ This is because the embryo may not undergo further development before germination.
- ✓ The seed performs its physiological processes slowly and utilizes little food.

Importance/significance of seed dormancy.

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

CAUSES OF SEED DORMANCY.

a) Internal conditions in a seed.

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

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

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

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

WAYS OF BREAKING SEED DORMANCY.

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

- ✓ Scarification can also be achieved naturally by saprophytic bacteria and fungi or by passing through the gut of animals.
- ✓ Some seeds e.g. wattle seeds are exposed to heat for a long time before germination ***because they have hard seed coat.***

SEED VIABILITY.

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

Factors affecting seed viability

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

SEED GERMINATION.

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

The process of germination.

- ✓ At the beginning of germination water is absorbed into the seed through the micropyle in the process called **imbibition** causing the seed to swell.
- ✓ The cells of the cotyledons become turgid and active.

- ✓ Absorbed water activates enzymes, dissolves food and leads to the hydrolysis/ breakdown of stored food materials/ substances stored in the otyledons.
- ✓ The soluble food materials are transported to the growing radicle and plumule of the embryo.
- ✓ At the growing points glucose is used for respiration to provide energy for growth and amino acids are used for synthesis of new cellular materials.
- ✓ The radicle grows into a root and plumule into a shoot.
- ✓ The **radicle** is the first to emerge from the seed through the **micropyle, it bursts the seed coat** and grows to form **a root.**
- ✓ It grows downwards between soil particles with its tip protected by a root cap.
- ✓ Root hairs develop behind the root cap.
- ✓ The **plumule** then breaks through the surface and develops into a **shoot**.

Reasons why the radicle develops first before the plumule.

i. To provide anchorage to the seedling.

ii. To provide the seedling with water and mineral salts.

CONDITIONS NECESSARY FOR GERMINATION.

- They include:

A. Environmental factors e.g. **water, oxygen and optimum temperature.**

B. Internal/physiological factors e.g. **enzymes and hormones .**

A. WATER.

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

B. OXYGEN.

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

C. TEMPERATURE.

- ✓ Optimum temperature is required for optimum enzymatic activity hence facilitating germination.
- ✓ The optimum temperature is usually At very low temperature (below 0^oC) the temperatures are inactivated hence there is no germination.
- ✓ At very high temperatures (above 47^oC) the enzymes in seeds are denatured/ destroyed hence there is no germination.

D. ENZYMES.

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

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

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

E. HORMONES.

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

EXPERIMENT 1.

Aim

- ✓ To show that water is necessary for germination.

Procedure

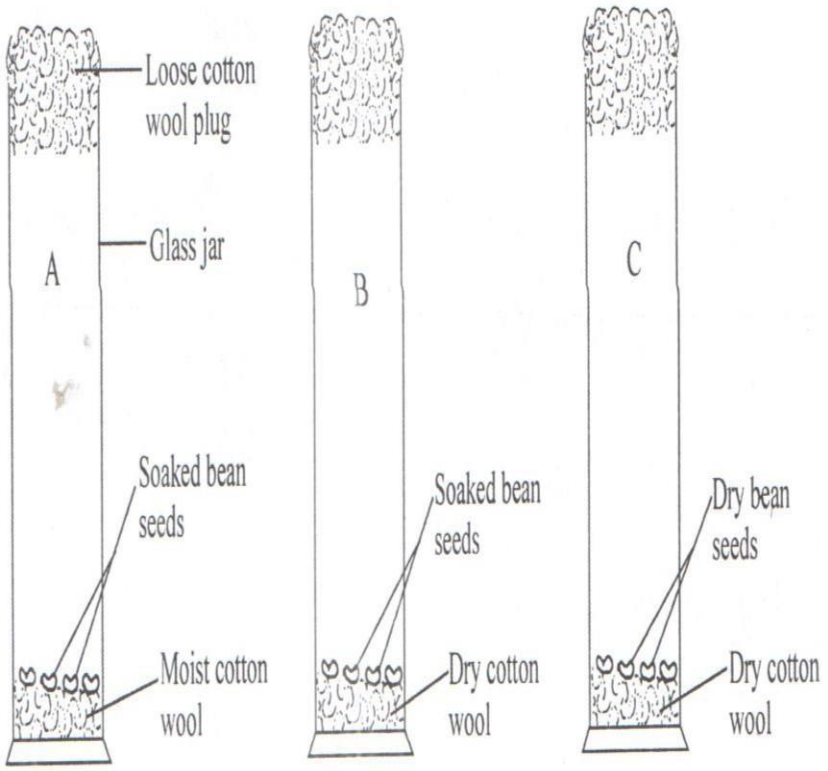
- ✓ Set the apparatus as shown below.
- ✓ Keep the jars in room temperature for 5 days.

Observation and explanation.

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

Note

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



EXPERIMENT 2.

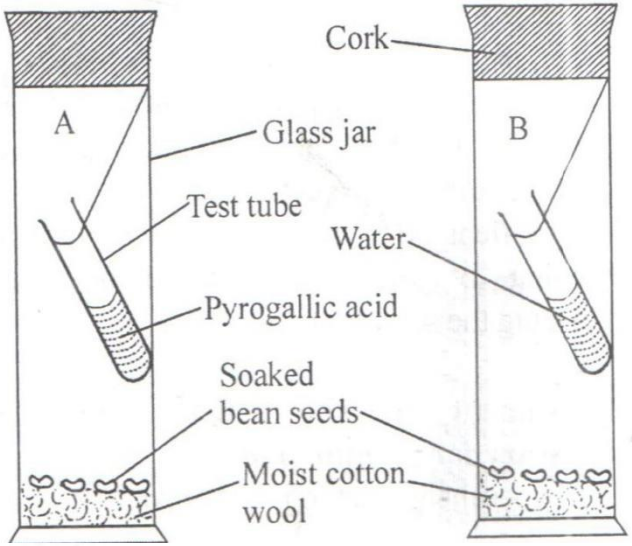
Aim: To show that oxygen is necessary for germination.

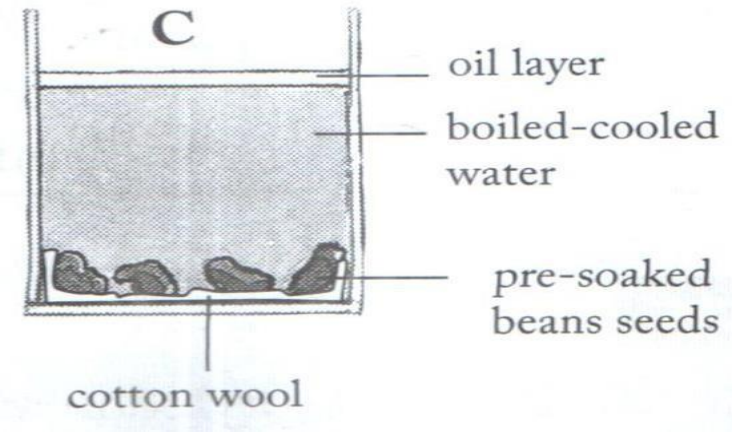
Procedure

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

Observation and explanation.

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





EXPERIMENT 3.

22

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

Procedure.

- Set up the experiment as follows:

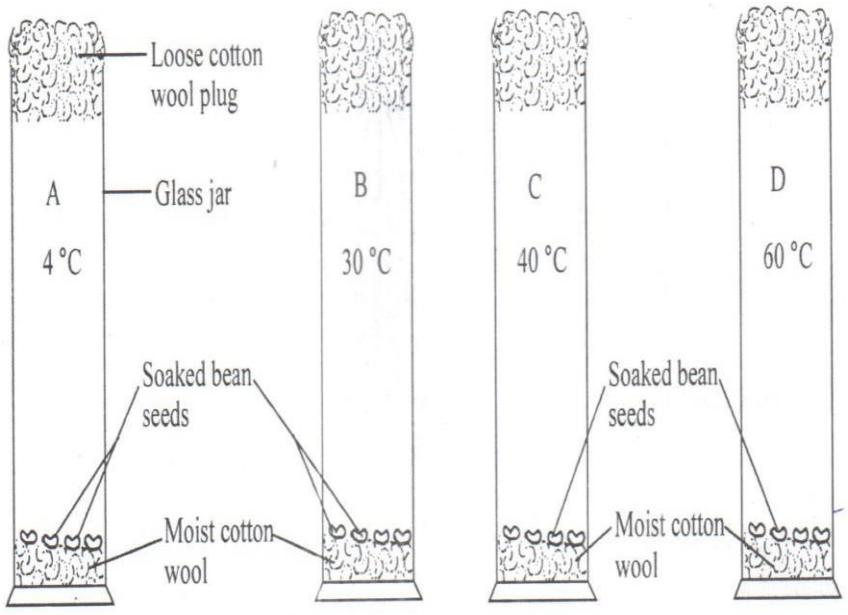
i. Jar A is placed in a refrigerator set at 4 °C.

ii. Jar B is placed in a water bath set at 30 °C.

iii. Jar C is placed in a water bath set at 40 °C.

iv. Jar D is placed in an oven set at 60 °C.

- The jars are left for five days.



Observation and explanation.

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

STUDY QUESTION 1.

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

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

QUESTIONS

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

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

2. Explain why the ability for the:

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

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

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

- **Acacia seeds have a tough testa which requires a longer time of contact with water to be softened.The hot water hastened the softening process.**
- ✓ **The seeds exposed in hot water for 20 minutes had the most optimum time for softening of testa hence leading to best germination percentage.**

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

i. 100^{o}C.

At 100^{0}C comparatively fewer/no bean seeds will germinate but more/all acacia seeds will germinate.This is because enzymes in bean seeds could be denatured and the seed coat in acacia softened.

ii. 5^{o}C.

At 5^{0}C no acacia seeds will germinate and all or most of bean seed will germinate.This is because the seed coat of acacia could not be softened.

STUDY QUESTION 2.

- An experiment was carried out to determine the growth rates of bamboo and a variety of maize plants in two adjacent plots. The average height and average dry weight of plants from the two populations were determined over a period of twenty weeks.The data is as shown in the table below. [26]

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

i. Bamboo plants.

- ***4 and 6.***

ii. Maize plants.

- ***12 and 14.***

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

- ***Bamboo***

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

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

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

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

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

TYPES OF GERMINATION.

A. EPIGEAL GERMINATION.

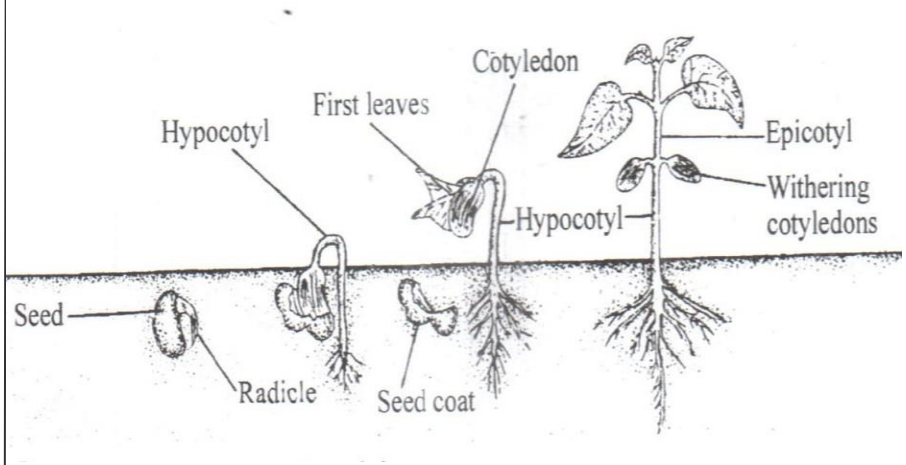
- ✓ The cotyledons are lifted/ brought above the ground and the hypocotyl elongates. It occurs in dicot seeds.

Process of epigeal germination.

- ✓ The radicle grows out through the micropyle and grows downwards into the soil **to provide anchorage to the seedling and absorb water and mineral salts**.
- ✓ The **hypocotyl** curves and pushes upwards through the soil **protecting the delicate shoot tip and pulling cotyledons.**
- ✓ The hypocotyl then straightens and elongates carrying with it the two cotyledons which open and expose the plumule
- ✓ They cotyledons then turn green and leafy and begin to photosynthesize/ manufacturing food for the growing seedling.
- ✓ The plumule which lies between the cotyledons grows into **first foliage leaves** which start manufacturing food.
- ✓ After the foliage leaves start to photosynthesize then the cotyledons wither, shrink and fall.

Functions of cotyledon before development of first foliage leaves.

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



B. HYPOGEAL GERMINATION.

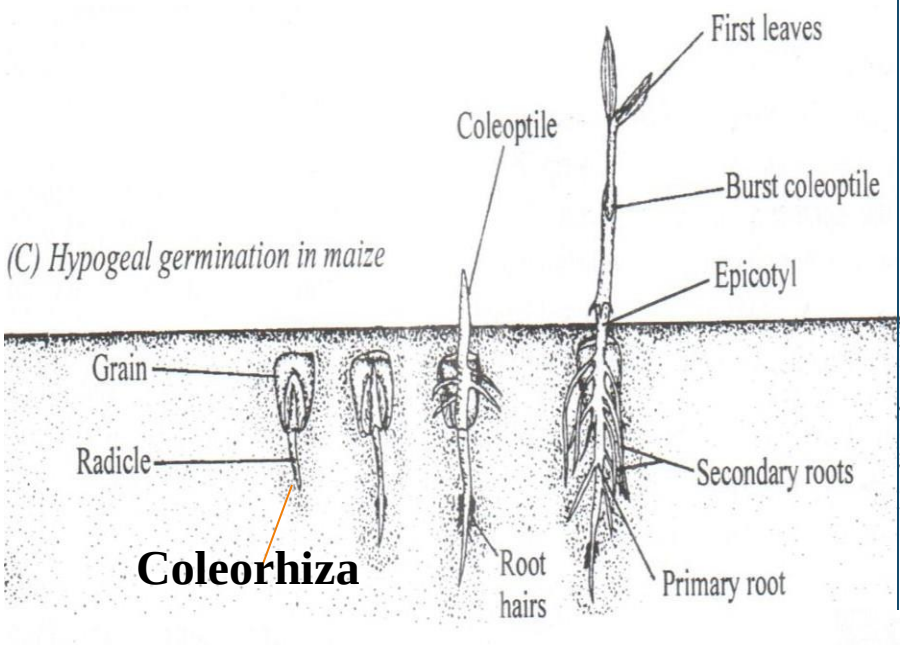
- ✓ The cotyledons remain below the ground.

Process of hypogeal germination.

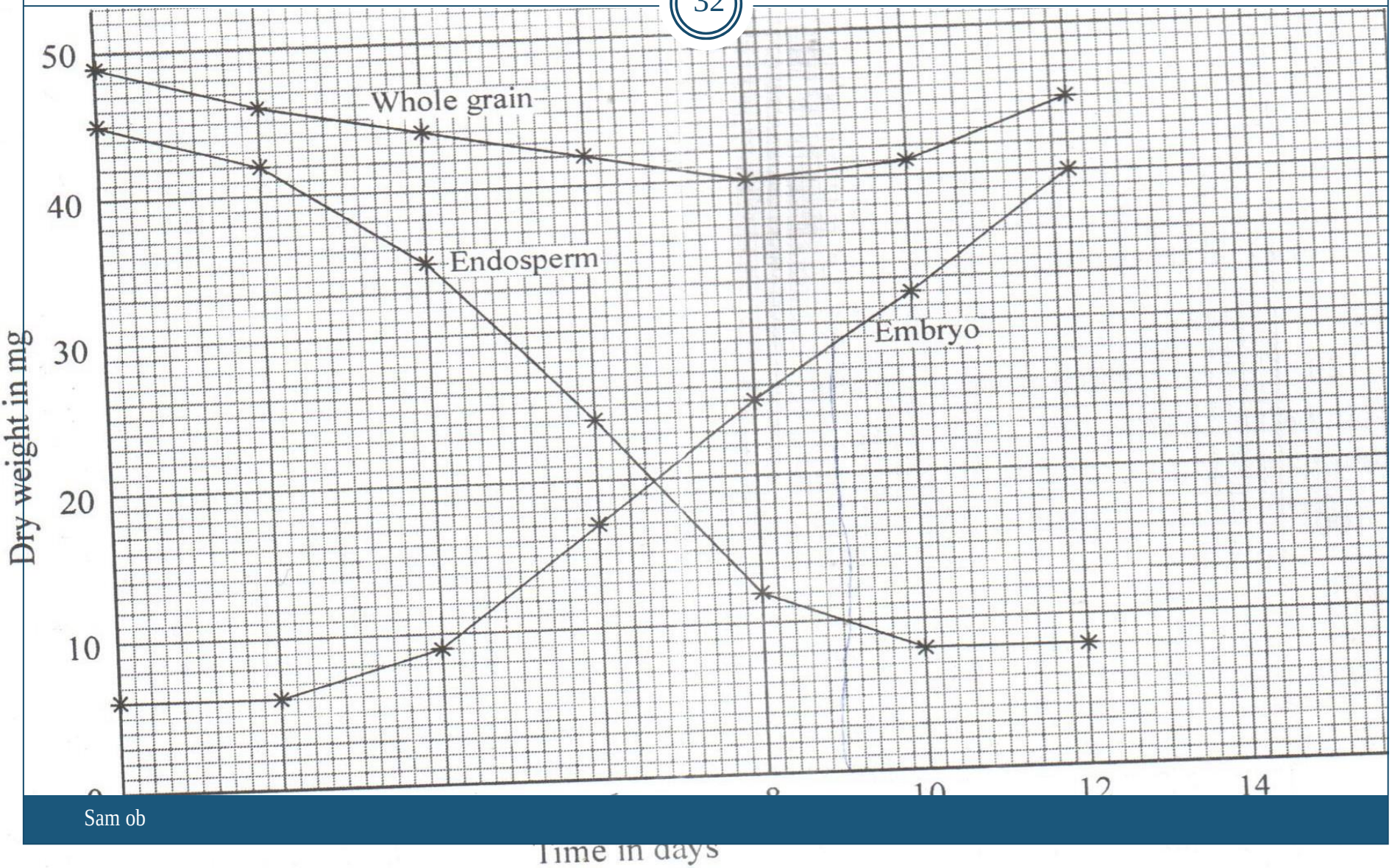
- ✓ The radicle protected by coleorhiza grows down into the soil **to provide anchorage to the seedling and absorb water and mineral salts**.
- ✓ **Epicotyl** elongates carrying the **coleoptile** which pushes the soil and appears above the ground.
- ✓ Coleoptile then breaks to release the plumule which forms the first **foliage leaves** and starts to photosynthesize.
- ✓ After the seedlings begin to photosynthesize, the endosperm begins to shrink.

Differences between epigeal and hypogeal germination.

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



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



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

GROWTH IN PLANTS

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

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

Types of meristems.

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

Primary growth in plants.

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

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

a) **Region of cell division-** consists of meristematic cells that actively divide.

- ✓ Each cell divides into two, one cell remains meristematic while the other moves to the region of cell elongation.

b) **Region of cell elongation-** the cells become enlarged to their maximum size.

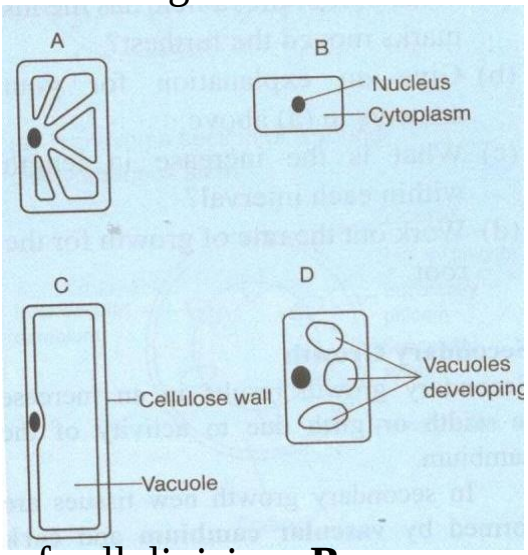
- ✓ Vacuoles start forming and enlarging.

c) **Region of cell differentiation-** the cells attain their permanent size, with large vacuoles and thickened.

- ✓ The cells differentiate into tissues specialized for specific functions.
- ✓ Examples of tissues formed at the region of cell differentiation include epidermis, phloem, xylem, cambium, cortex.
- ✓ Behind the region of cell differentiation there are permanent tissues.

Study question.

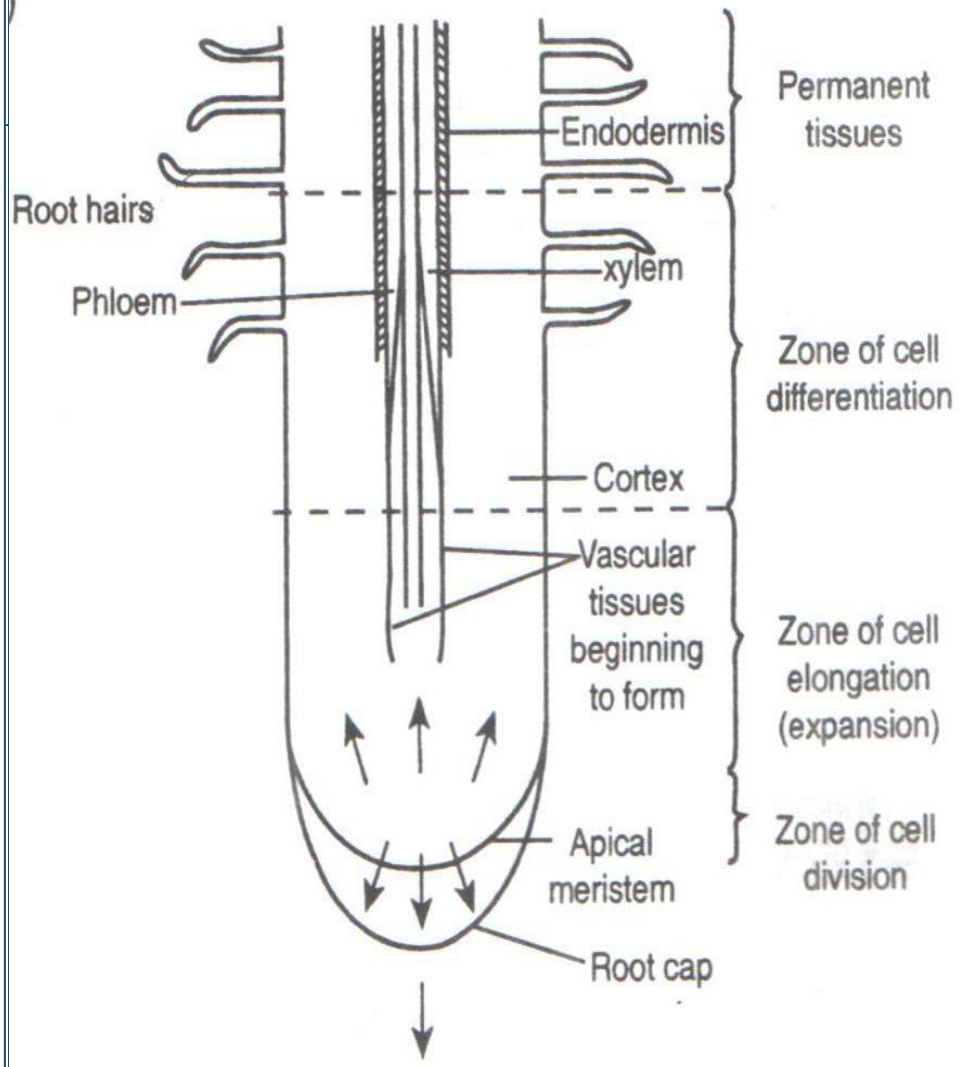
The figures below indicate the appearance of cells at different regions at the apical meristems. Rearrange them into three regions:



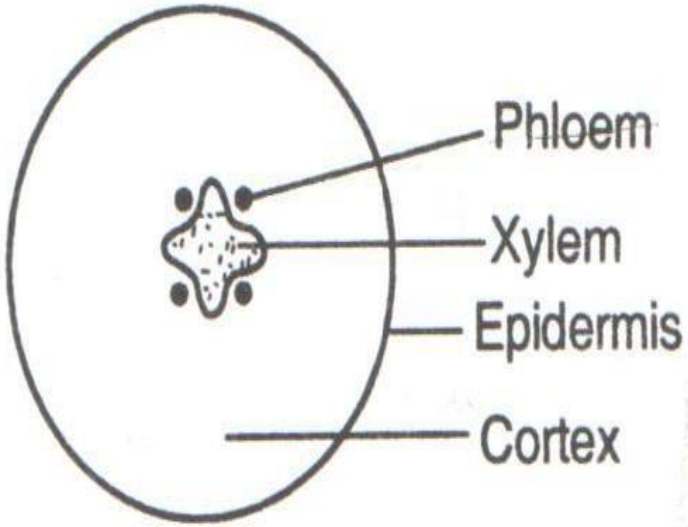
a) Zone of cell division- **B**

b) Zone of cell elongation- **A and D**

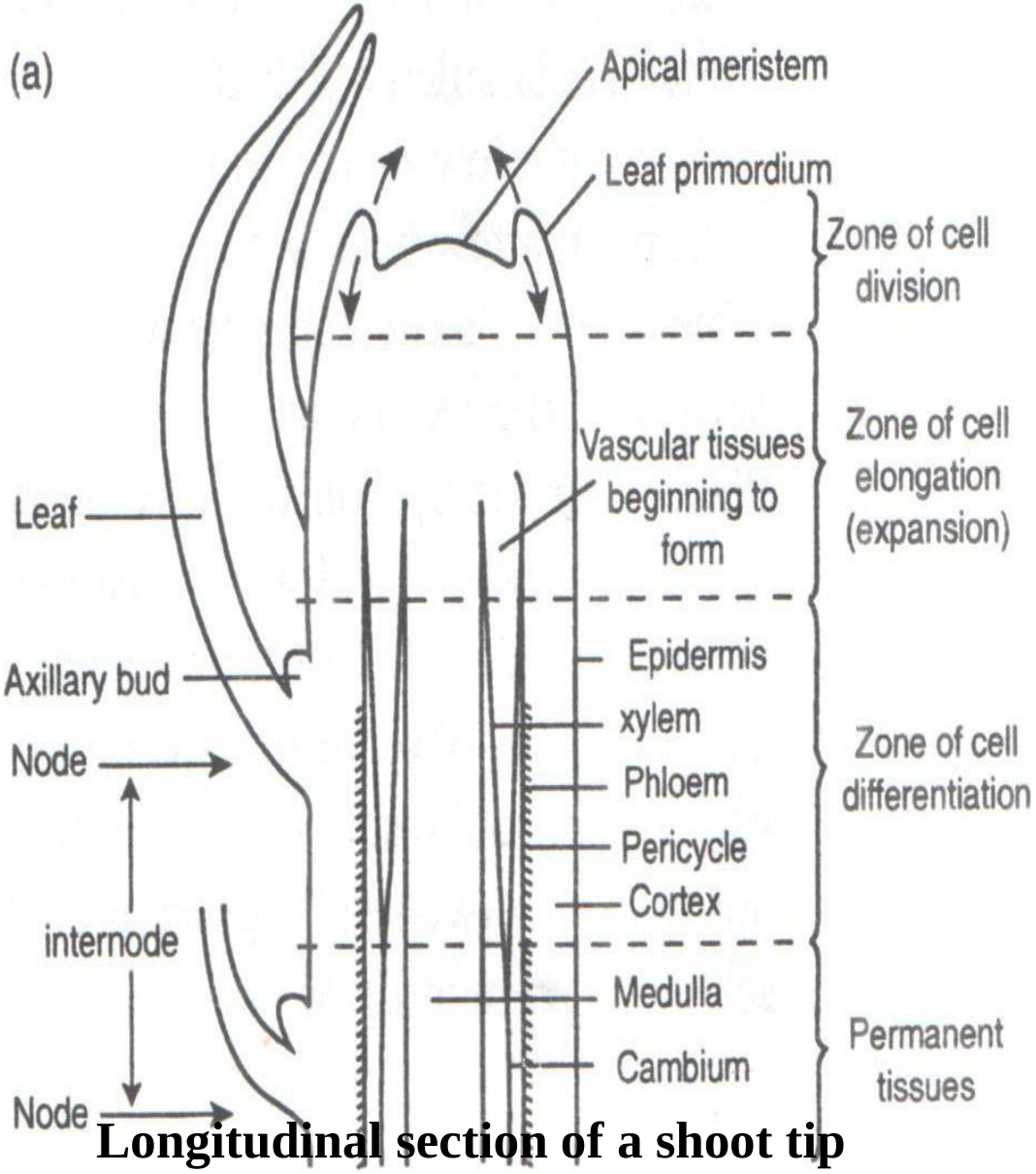
c) Zone of cell differentiation- **C**



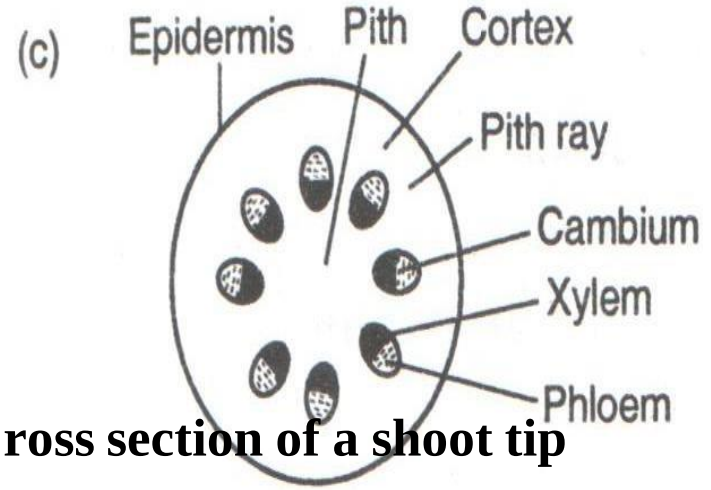
Longitudinal section of a root tip



Cross section of a root



Longitudinal section of a shoot tip



Cross section of a shoot tip

EXPERIMENT.

Aim: To determine the region of growth in a seedling

Equipment

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

Other requirements.

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

Procedure

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

Observations and explanation.

- The widest interval is found at the region just behind the tip.
- This is the region of greater growth/cell elongation and differentiation.
- Cells farthest from the tip undergoes maturation and differentiation.

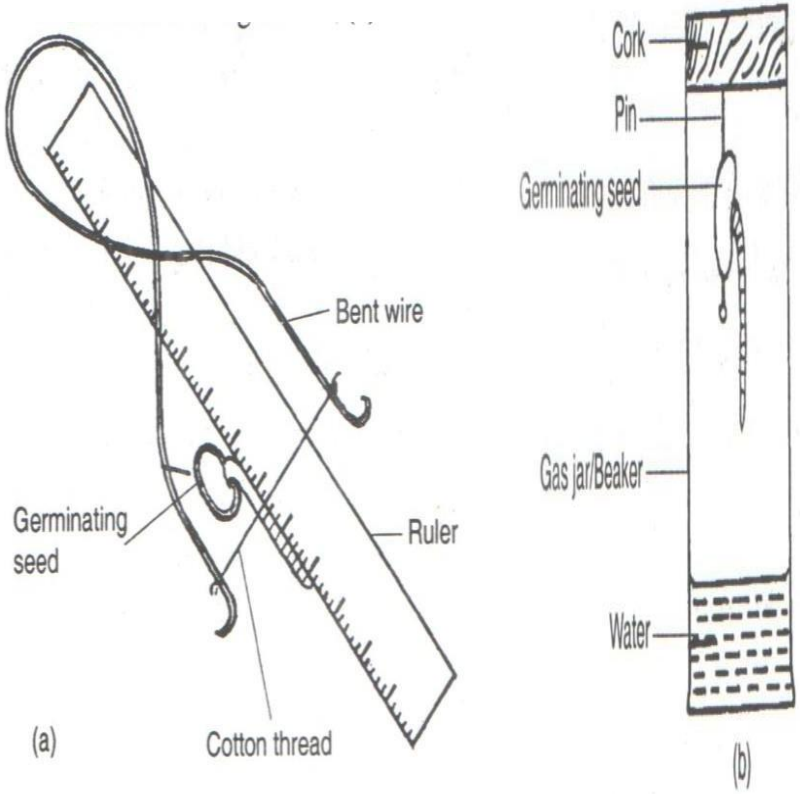
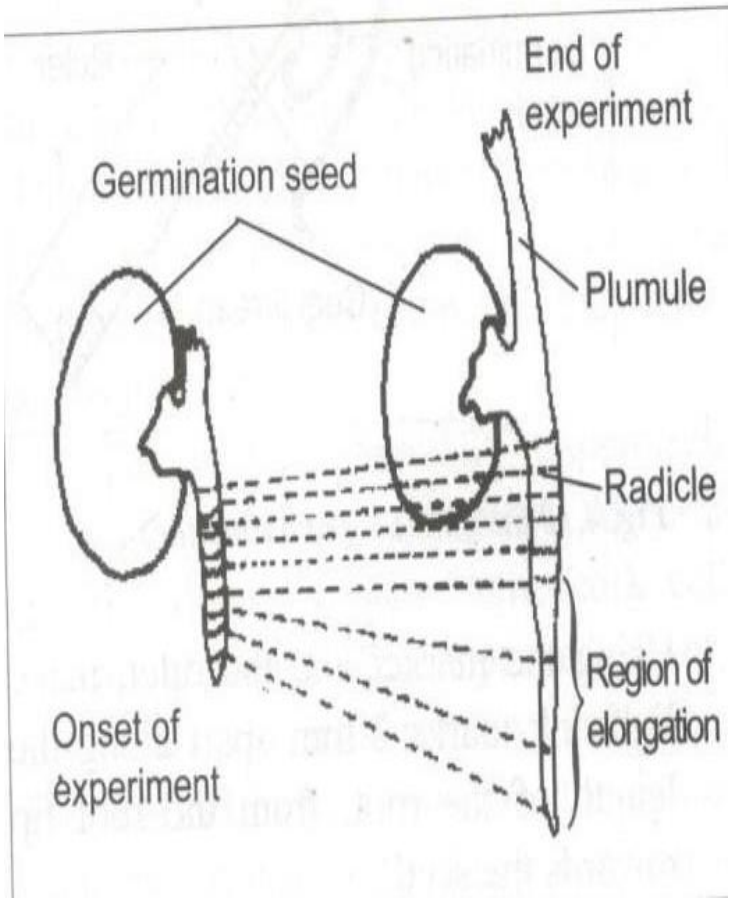


Fig. 4.10: Marking of a root tip



STUDY QUESTION

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

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

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

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

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

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

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

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

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

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

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

SECONDARY GROWTH/ THICKENING IN PLANTS.

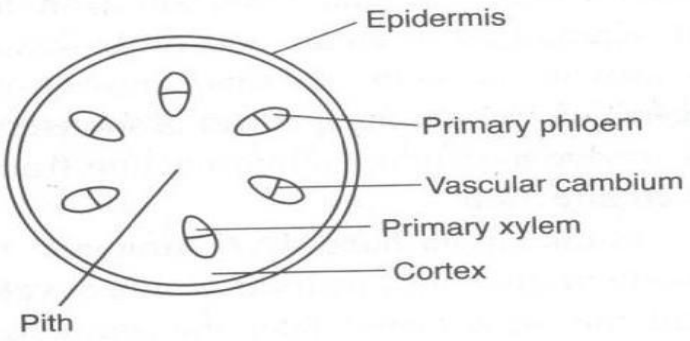
- Secondary growth in dicots results in increase in width/ girth due to the activity of cambium (vascular and cork cambium).
- ✓ Monocot plants lack cambium hence it does not undergo secondary growth.
- ✓ However there is increase in diameter due to enlargement of primary cells.

Process of secondary growth in dicots.

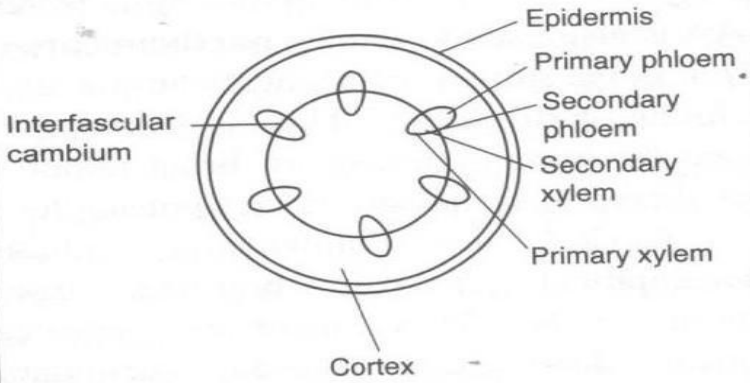
- The vascular cambium divides to produce new cambium cells between the vascular bundle called **intervascular cambium.**
- ✓ The intervascular cambium and vascular cambium form a continuous cambium ring.
- ✓ The new cells obtained on the outer side of cambium differentiate to form **secondary phloem** and those to the outer side differentiate to form **secondary xylem.**
- ✓ More secondary xylem is formed than secondary phloem and intervascular cambium also cuts the parenchymatous cells forming **medullary rays** which allow transport of water and solutes inside the stem.

- As a result of increase in the volume of secondary tissues, pressure is exerted on the outer cells of the stem. This leads to stretching and rapturing of epidermal cells.
- In order to replace the protective outer layer of the stem, a new band of cambium cells are formed in the cortex called **cork cambium/ phellogen**
- The cork cambium divides to produce new cells on either side.The cells on the inner side of the cork cambium differentiate into **secondary cortex** and those on the outer side become **cork cells.**
- Cork cells are dead with thickened walls.Their walls become coated with a waterproof substance called **suberin.**

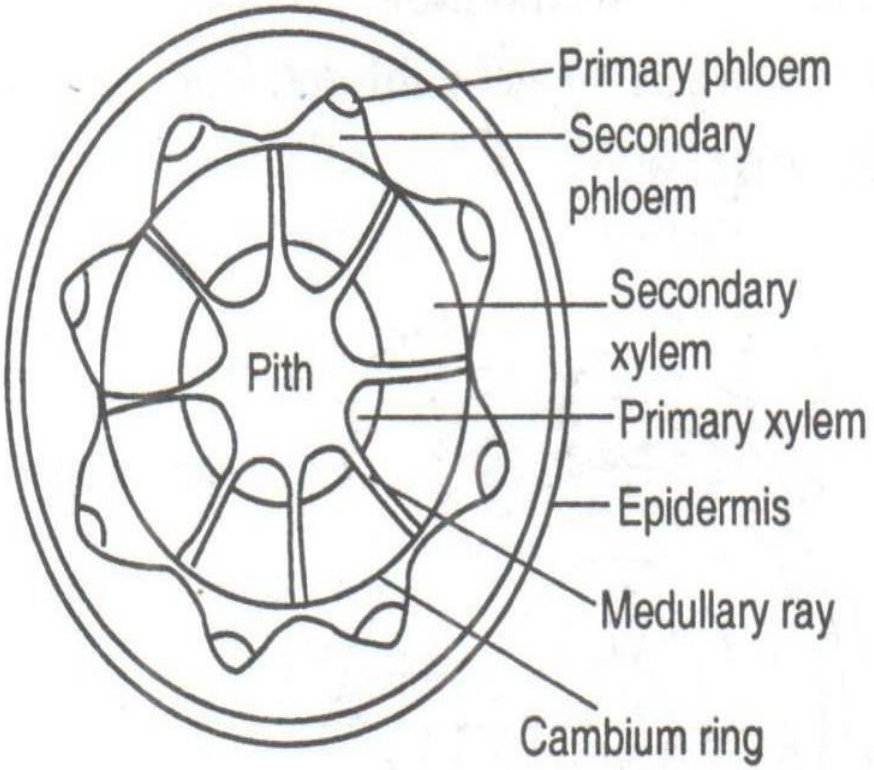
- The cork cells increase in number and become the bark of the stem. This prevents loss of water, infection from fungi, damage from insects and acts as insulatory layer.
- ✓ At certain points along the stem the cork cells become loosely packed forming **lenticels** for gaseous exchange.
- The rate of secondary growth in the stem varies with seasonal changes.
- During rainy season xylem vessels and tracheids are formed in large numbers.The cells are large, have thin walls and the wood has light texture.
- ✓ In the dry season, the xylem and tracheids formed are few in number. They are small, thick walled ad their wood has dark texture.
- This leads to two distinctive layers within the secondary xylem hence called annual rings.
- ✓ It is possible to determine the number age of the tree by counting the number of annual rings.



(a) Transverse section of a young dicotyledonous stem



(b) Beginning of secondary growth in dicotyledonous stem



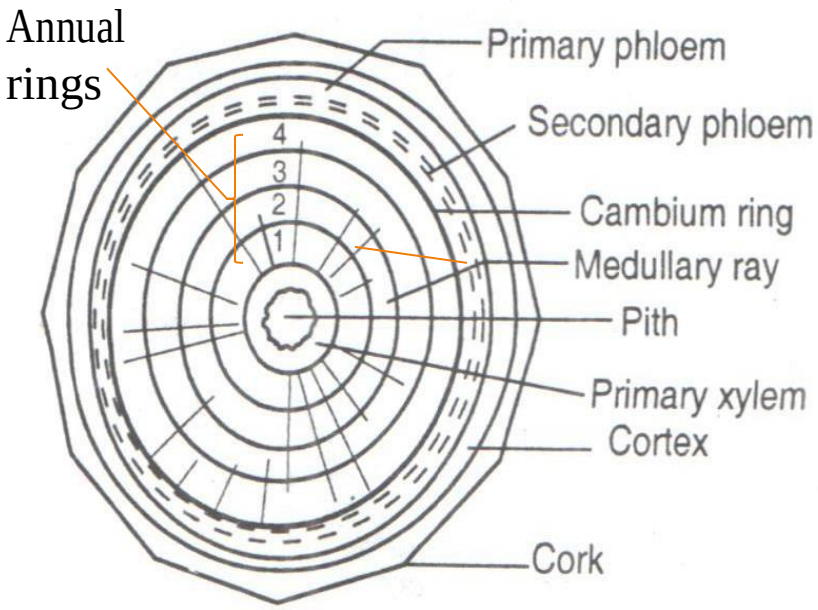
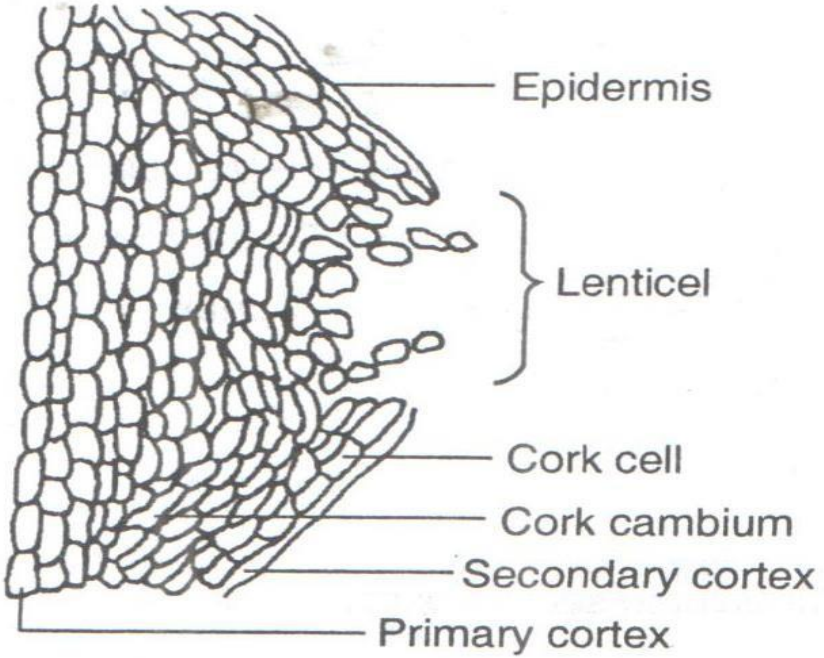


Fig. 4.13: Annual rings



: Section through a lenticel

ROLE OF GROWTH HORMONES IN PLANTS

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

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

STUDY QUESTIONS

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

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

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

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

B. GIBBERELLIC ACID/ GIBBERELLINS.

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

C. CYTOKININS/KINETINS.

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

D. ETHYLENE/ETHENE.

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

E. ABSCISIC ACID.

✓ It's effects are inhibitory in nature.

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

F. FLORIGENS- they promote flowering.

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

PRACTICAL APPLICATIONS OF PLANT GROWTH HORMONES IN AGRICULTURE.

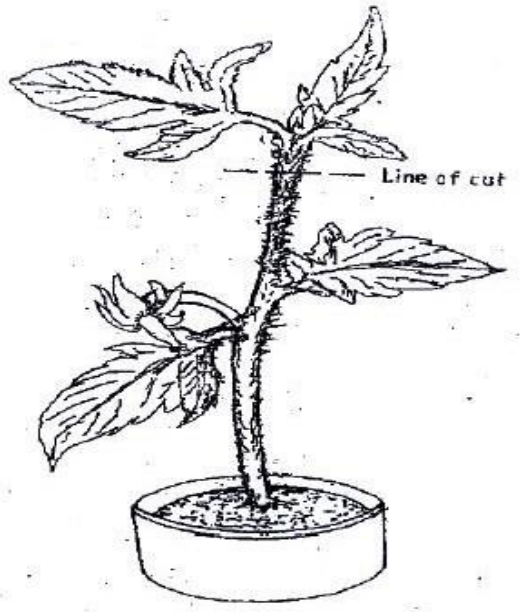
1. Induce root growth in stem cutting.
2. Used as selective weed killers/herbicides.
3. Encourage apical dominance.
4. Encourage sprouting of side branches.
5. Breaking seeds dormancy.
6. Induce parthenocarpy.
7. Promotes flowering.
8. Induce fruit fall.
9. Accelerates ripening of fruits.
10. Synthetic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

APICAL DOMINANCE.

- ✓ This is the inhibition of development of lateral/side branches due to the presence of apical bud.
- ✓ If an apical bud which normally contains high concentrations of auxins is removed, more lateral/side branches develop
- ✓ This shows that high concentrations of inhibit/hinder sprouting of lateral buds and therefore hinders growth of many branches.
- ✓ This forms the basis of pruning in agriculture where more branches are required for increased harvest particularly on crops like coffee and tea.
- ✓ The failure of lateral buds to develop in the presence of an apical bud is due to the diffusion of auxins from the shoot apex downwards inhibiting the development of lateral buds.

Study question 1.

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



a) State the expected results after 2 weeks.

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

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

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

c) Suggest one application of this practice?

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

d) What is the importance of this practice?

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

Study question 2

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

i. Shoot A – Apical bud was removed.

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

iii. Shoot C – Apical bud was left intact.

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

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

a) Account for the results obtained in the experiment.

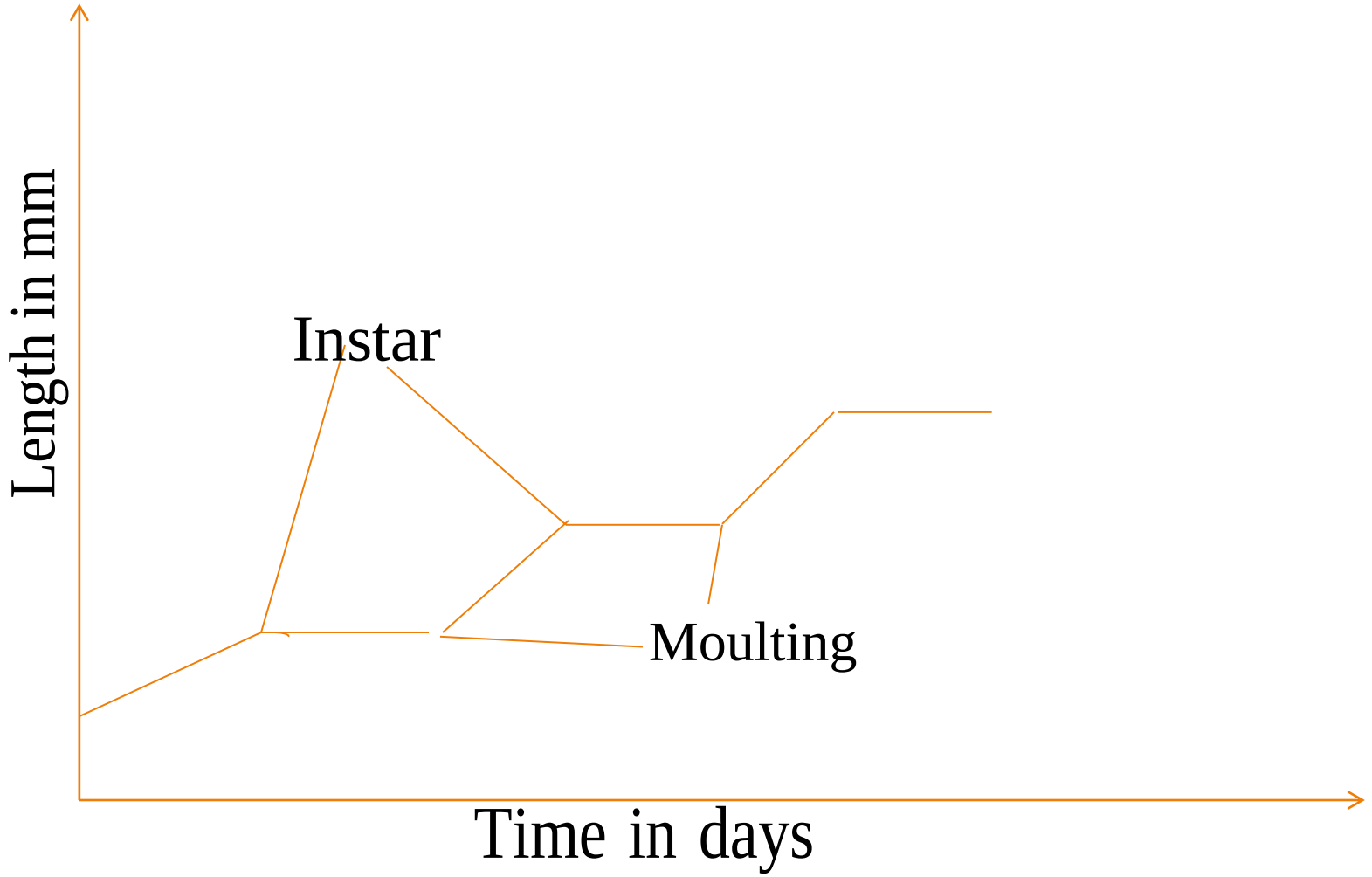
- **Shoot A: The tip of the shoot which was removed contained indole acetic acid (IAA), which causes apical dominance/ inhibits growth/ development of more lateral buds; hence lateral buds sprouted/grew.**
- **Shoot B:The gibberellic acid which was added on the cut promotes formation of lateral branches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

GROWTH AND DEVELOPMENT IN ANIMALS.

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

Process of growth in arthropods

- ✓ Intermittent growth is a result of the shedding of the exoskeleton/ moulting/ecdysis.
- ✓ After moulting growth occurs rapidly leading to increase in size. This is because the tough exoskeleton is shed allowing the larvae to take in air/ water leading to rapid growth thus increasing in size of organism.
- ✓ The growth rate slows down as the new exoskeleton is secreted and it hardens after exposure to air thus limiting growth.


Length in mm
Instar
Moulting
Time in days

GROWTH AND DEVELOPMENT IN INSECTS.

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

Importance of metamorphosis.

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

Types of metamorphosis.

A. Complete metamorphosis.
B. Incomplete metamorphosis.

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

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

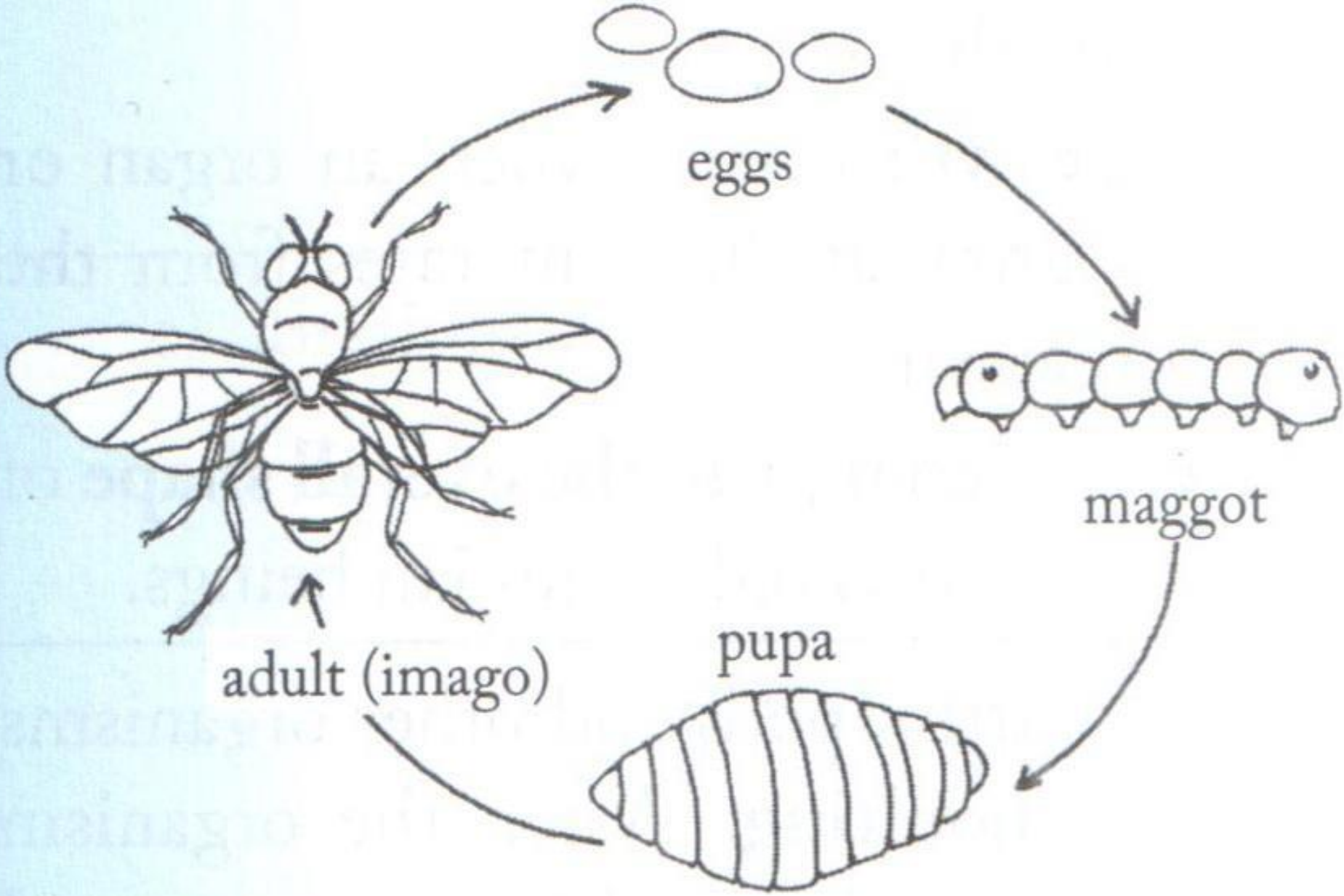
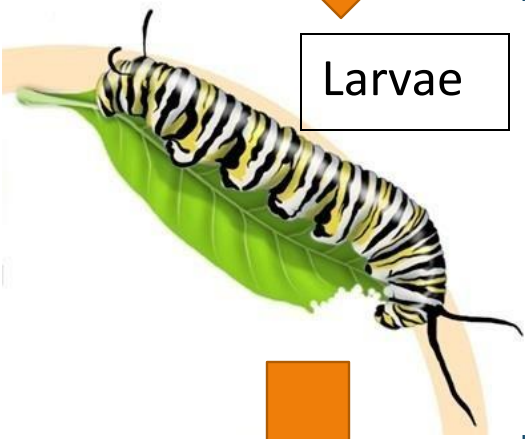
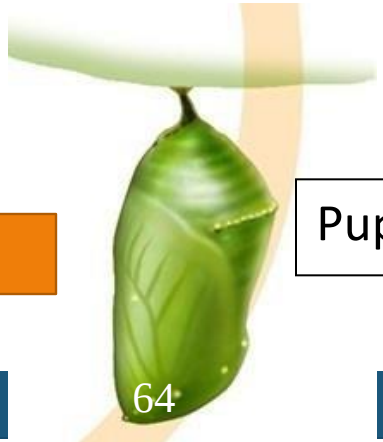


Fig 3.39: Lifecycle of housefly

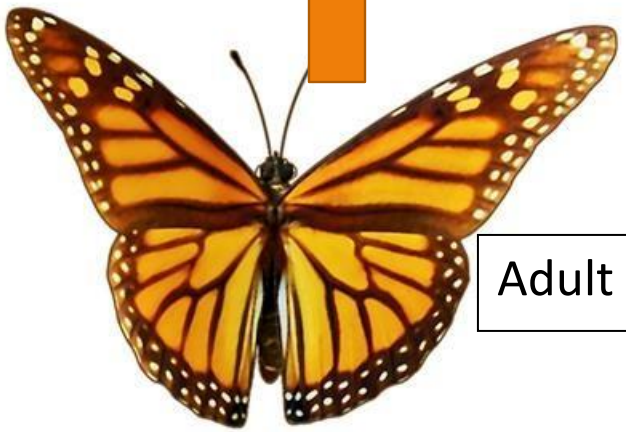
Egg



Larvae



Pupa



Adult

B. INCOMPLETE METAMORPHOSIS e.g. in cockroaches.

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

Advantage of incomplete metamorphosis.

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

Differences between complete and incomplete

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

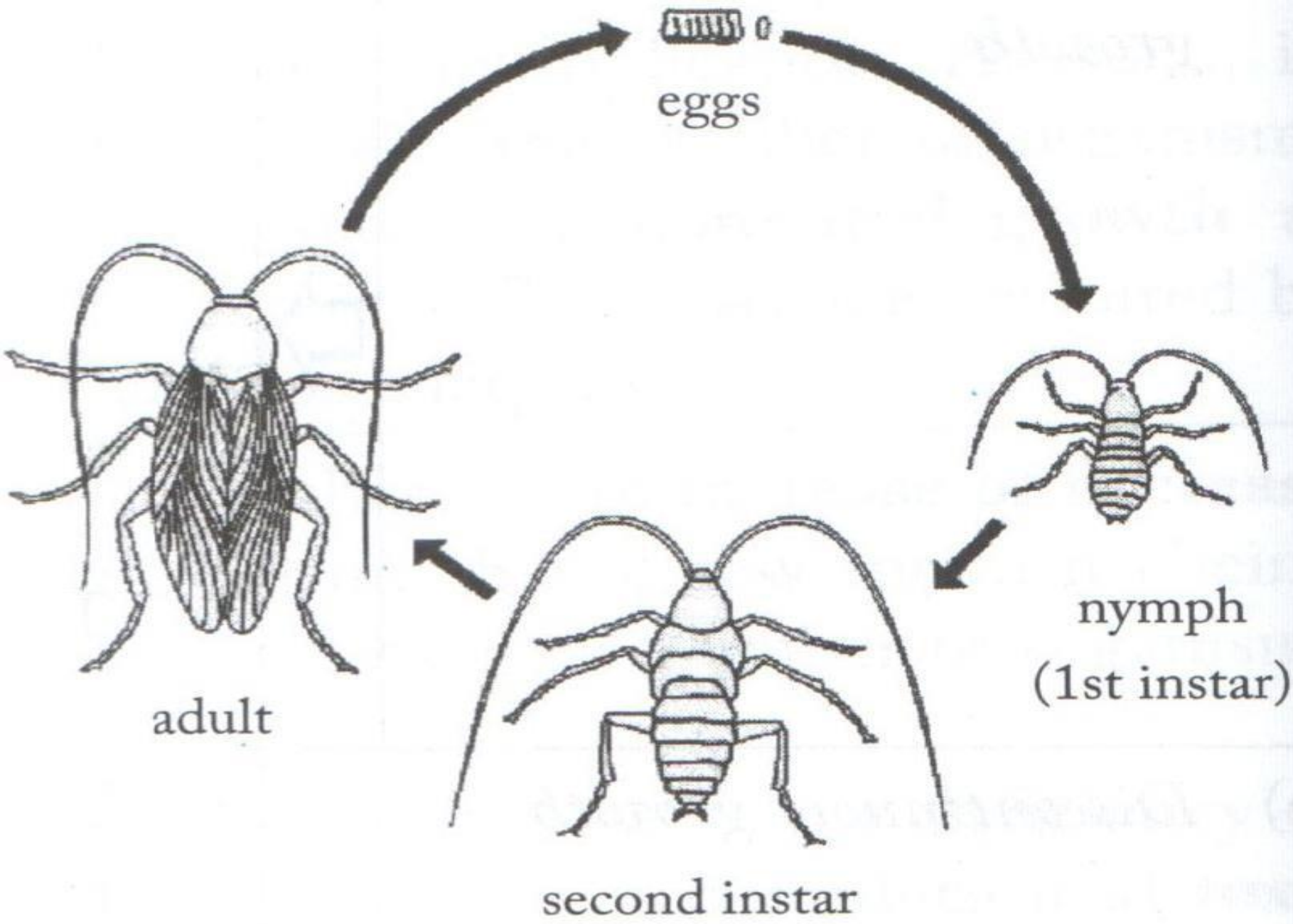


Fig 3.40: Lifecycle of a coakroach

ROLE OF HORMONES IN METAMORPHOSIS.

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

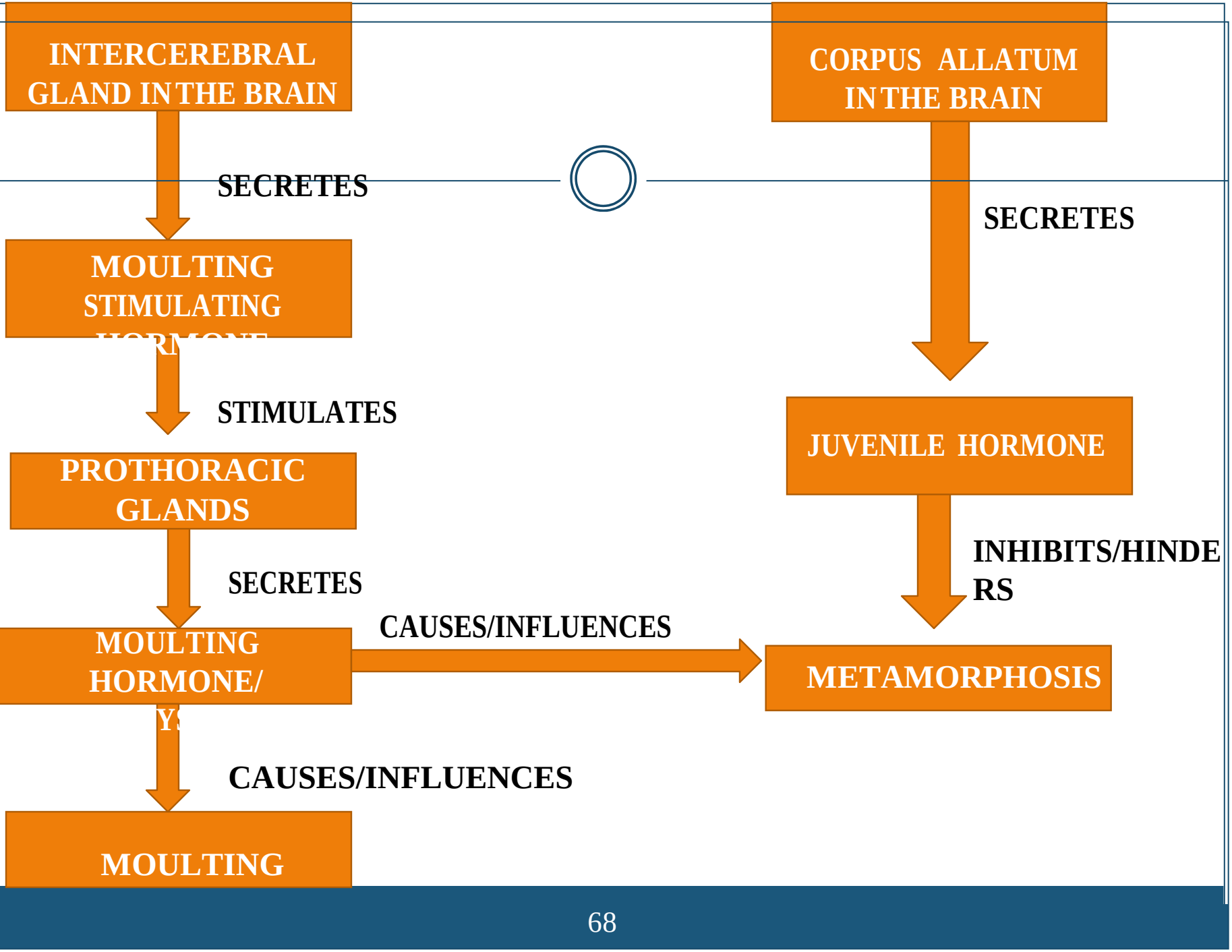
i. **Corpus allata** (singular Corpus allatum) in the brain.

ii. **Intercerebral gland** in the **brain** .

iii. **Prothoracic glands** in the thorax.

- During larval stages of the insect the corpora allata produces **juvenile hormone** which inhibits metamorphosis by stimulating formation of larval cuticle hence moulting does not go beyond the larval stage.

- ✓ When the larva matures, the corpus allatum disintegrates hence the level of juvenile hormone drops.
- ✓ Low level of juvenile hormone stimulates **intercerebral gland** in the **brain** secretes ***moulting stimulating hormone (MSH)***.
- ✓ The moulting stimulating hormone stimulates the prothoracic gland to secrete ***moulting hormone (ecdysone).***
- Ecdysone/ moulting hormone causes metamorphosis/ causes the larval stage to change into pupa and pupa into adult.


INTERCEREBRAL GLAND IN THE BRAIN
SECRETES
MOULTING STIMULATING
STIMULATES
PROTHORACIC GLANDS
SECRETES
MOULTING HORMONE/
CAUSES/INFLUENCES
MOULTING
CORPUS ALLATUM IN THE BRAIN
SECRETES
JUVENILE HORMONE
INHIBITS/HINDERS
METAMORPHOSIS