Growth and Development

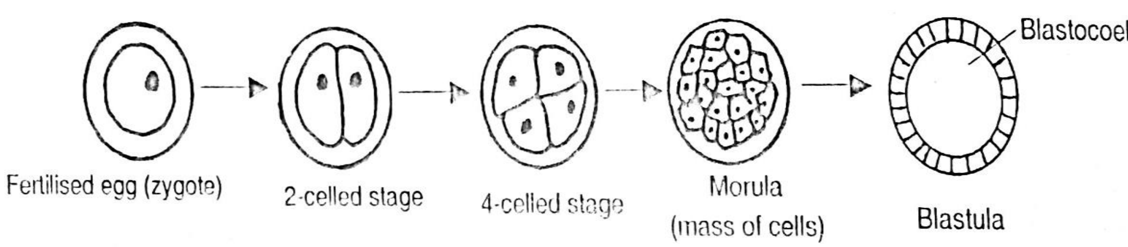
Growth – *refers to the quantitative permanent increase in size of an organism.*

Aspects of growth.

1. Cells of organisms assimilate nutrients hence increase in mass.
2. Cell division (mitosis) that lead to the increase in number of cells.
3. Cell expansion that leads to enlargement of an organism.

Development – *Is the quantitative aspect of growth which involves differentiation of cells and formation of various tissues in the body of an organism.*
-This is to enables the tissues to be able to perform specialized functions.
-Development can only be assessed in terms of increase in complexity of the organism i.e. development of leaves and flowers.

-After fertilization, the zygote undergoes a series of cell division (cleavages) until a mass of cells called **Morula** is formed.
-Morula develops a hollow part and form **blastula.**Later the blastula differentiates into an inner layer (endoderm) and the outer layer(ectoderm)
-The two layered embryo implants into uterine wall and by obtaining nutrients from the maternal blood, it starts to grow and develop.



- Growth requires continuous supply of *food substances, oxygen, water and a means of waste removal.*

- Growth in animals occurs all over the body while plants experiences two types of growth only.

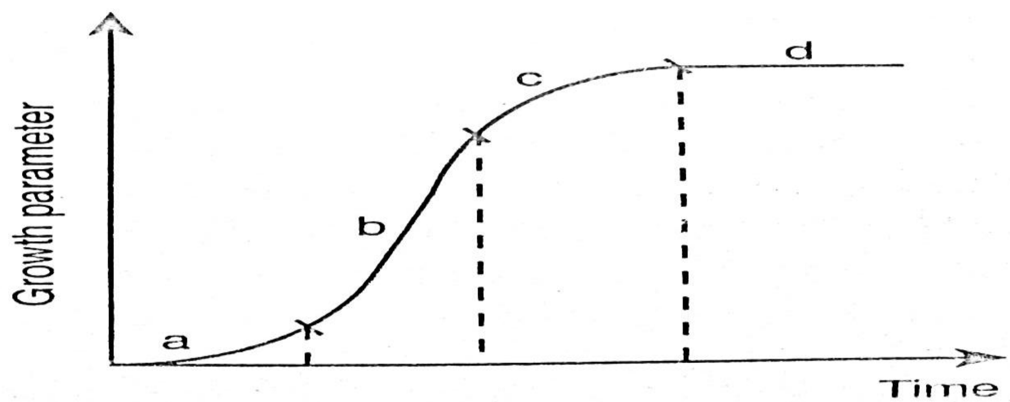
  These include;

(i)Primary (Apical) growth – growth and cells division mostly taking place at the root tip and stem apex. It leads to the lengthening of the plant.
(ii)Secondary growth – this is the side way growth of a plant that leads to an increase in width (girth) due to the activities of the cambium cells.

Measurement of growth.

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

For most organisms, this plotting gives an **S**-shaped graph called **sigmoid curve.**



- The sigmoid curve is divided into 4 parts.

(a)Lag phase (slow growth)
-This is the initial phase during which little growth occurs.
-The growth rate is slow due to various factors namely;

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

(b)Exponential phase (log phase).
-This is second phase in which growth is rapid.
-During this phase, the rate of growth is at its maximum.

-At this point the rate of growth is proportional to the amount of material or numbers of cells of the organism already present.

- This rapid growth is due to;

i. An increase in the number of cells dividing.
ii. Cells have adjusted to the new environment.
iii. Food and other factors are not limiting hence no competition for resources.
iv. The rate of cell increase being higher that the rate of cell death.

(c) **Decelerating phase**.

-This is the third phase during which growth becomes limited as a result of some internal or external factors.

- The slow growth is due to the fact that;

i. Most cells have fully differentiated.
ii. Fewer cells dividing.
iii. Environmental (factors external and internal) such as;
    - Shortage of oxygen and nutrients due to increased demand.
    - Limited space due to high number of cells.
    - Accumulation of metabolic waste products which inhibits growth.

(d)Plateau (stationary) phase.

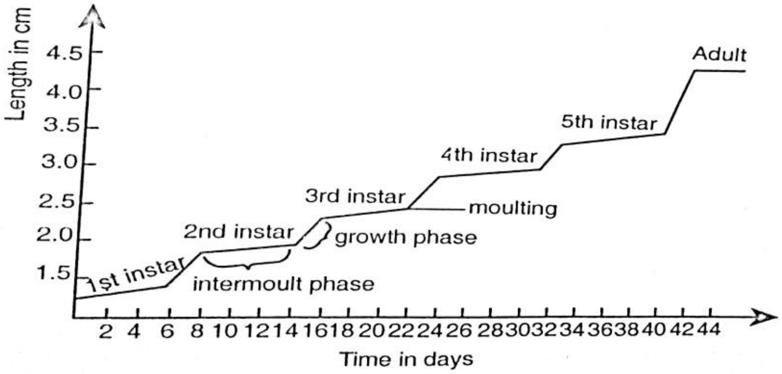
-This is the phase which marks the period where overall growth has ceased (stopped) and the parameters under consideration remain constant.

- This is due to fact that;

i. The rate of cell division equals the rate of cell death.
ii. Nearly all cells and tissues are fully differentiated therefore there is no further increase in the number of cells.

N/B –however the sigmoid curve does not apply to some groups of animals as **arthropods**.

This is because growth takes place at intervals. If volume changes are plotted against time, an **intermittent growth curve** is obtained.



Intermittent growth curve

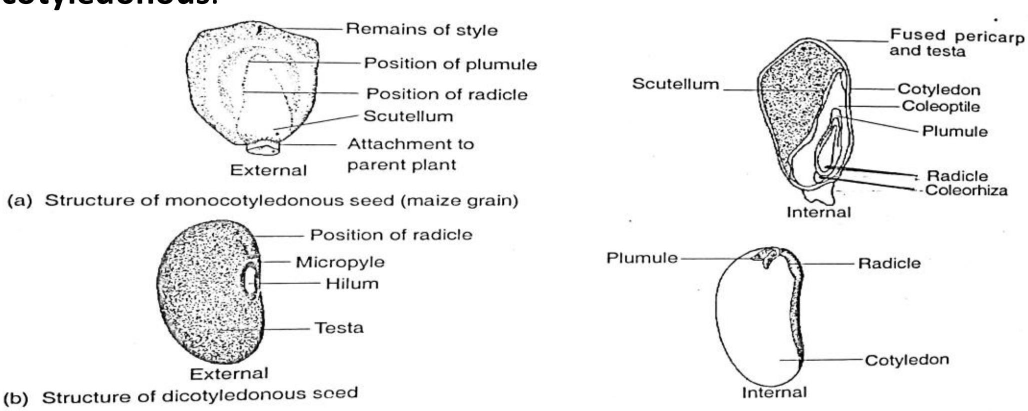
N/B- the intermittent growth curve in insects is due to the fact that they have an **exoskeleton** and hence growth is only possible only when its is shed.

-This shedding process is called **moulting or ecdysis**.

Growth And Development In Plants.

-Growth and development in plants begins with germination of a mature seed.

-The seeds are usually of two major kinds. Those with one cotyledon are called **monocotyledonous** while those with two cotyledons are called **dicotyledonous**.



Structure of the seed.

-A typical seed has a single scar and consist of a seed coat enclosing an embryo.

Differences between fruit and seed

Fruit	Seed
1.Has two scars	1.Has one scar
2.Enclosed by fruit wall(pericarp)	2.Enclosed by seed coat

Parts of a seed and their function.

	Parts	Functions.
i	Testa (seed coat)	-protect the inner of the seed from mechanical damage and entry of microbes
ii	Micropyle	- allows water into the seed during germination.
iii	Hilum	- Point of attachment of seed to fruit.
iv	Endosperm /cotyledon	- Store food for the seed.
v	Plumule	- develops to form the shoot.
Vi	Radicle	- develops to form the root.
vii	Hypocotyl	- attaches radicle to the cotyledon stalk
viii	Epicotyl	- attaches the plumule to cotyledon stalk
ix	Coleorhiza	- protects the tip of the radicle
x	Coleoptile	- protect the tip of the plumule

Dormancy in seeds.

Dormancy – A period rest (after ripening) undergone by the embryo of a dry fully developed seed.

***Factors that cause dormancy*.**

1) Embryo may not yet be fully developed.
2) Presence of chemical inhibitors that inhibit germination in seeds e.g. abscisic acid.
3) Very low concentrations of hormones e.g. **gibberellins.**
4) Hard and impermeable seed coat prevents entry of air and water in some seeds e.g. wattle.
5) In some seeds, absence of certain wavelengths the light makes them remain dormant e.g.**lettuce**.
6) Freezing seeds (especially during winter) lowers their enzymatic actions making them dormant.

***Ways of breaking seed dormancy*.**

1) Allowing seed embryo to mature.
2) Increase in concentration of hormones e.g**. cytokinins** and **gibberellins**.

3) Providing favorable environmental factors such as water, oxygen and suitable temperature.
4) Providing wavelength of light trigger production of hormones like gibberellins.
5) Scarification – weakening of testa in seeds with hard seed coat so that the seed can germinate.

-Scarification is achieved :-
Naturally – Decomposition by saprophytic bacteria and fungi.
-Passing through the gut of animals.
Artificially- In agriculture by boiling, roasting and cracking.

Seed germination .

Germination – Is the process by which a seed develops into a seedling.
It takes place into 3 major steps.

1) **Imbibition** – Is a process by which water is absorbed into the seed. This causes the seed to swell.
   The cells of the cotyledon become turgid and active.
2) **Hydrolysis** – Water is the seed is used to dissolve and break down the complex food substance stored in the cotyledon into simple soluble substances.
3) **Translocation** – The soluble food is transported to the growing plumule and radicle.

N/B- The plumule grows into a shoot while the radicle grows into a root.
- The radicle emerges from the seed through the micropyle bursting the seed coat.

Conditions necessary for germination.

a)External conditions.

i. Water

-A non-germinating seed contain very little water.
-In a germinating seed, water performs the following roles:

I. Activates and provide a medium for enzyme to break down the stored food into soluble form.
II. Hydrolyses and dissolve food material.

III. Act as a medium of transport for dissolved food.
IV. Soften the testa for the emergence of the radicle.

ii. Oxygen

-Germinating seeds requires energy for cell division and growth.
-The energy is obtained from the oxidation of stored food substances in the seed.

N/B: Therefore seed in water logged soil or buried deep in the soil will not germinate due to lack of oxygen.

iii. Temperature

-The optimum temperature for seed to germinate is around 30^0C.
-Very high temperature will denature the enzymes and kill the protoplasm in the seed.
-Very low temperatures will inactivate the enzymes.

b) <u>Internal conditions</u>.

i. Enzymes

-They convert insoluble food to soluble form.
-For example:

- **Diastase enzyme**- breaks down carbohydrates to glucose.
- **Protease-** converts proteins to amino acids.
- **Lipase-** converts lipids to fatty acid and glycerol.

-Enzymes also convert hydrolysed products to new plant tissues.

ii. Hormones

-Hormones as gibberellins and cytokinins act as growth stimulators.
-These hormones also counteract the effect of germination inhibitors (act as of growth stimulators.)

iii. Viability

-This is the ability of a seed to germinate.
-Only seeds whose embryos are alive are viable.
-A seed can lose viability if:

- It’s stored for a long time thus depleting its food reserves.
- It’s embryo is destroyed by pests and diseases.

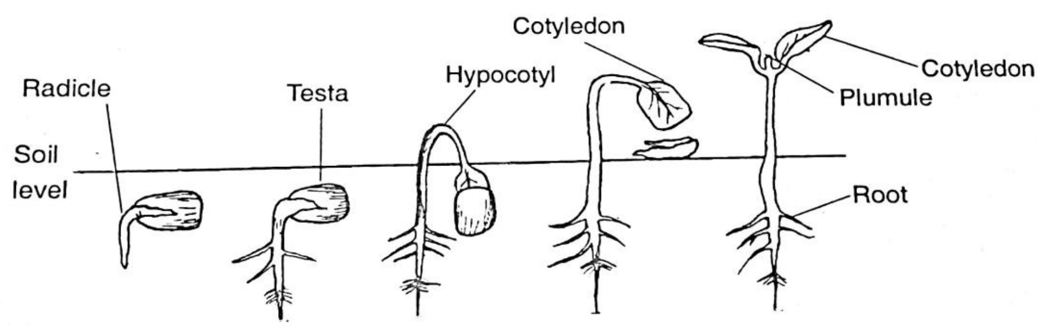
Types of germination

Are of two types:

1) Epigeal
2) Hypogeal

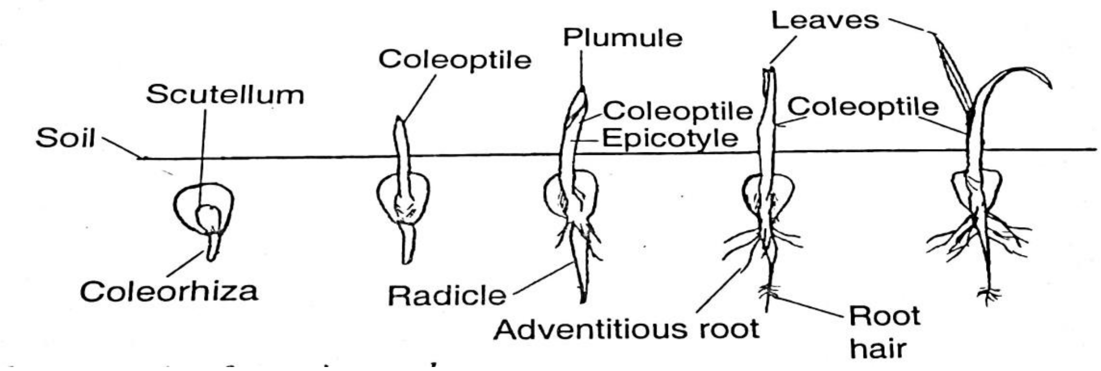
1) Epigeal germination

-This is a type of germination in which the cotyledons are brought above the soil surface.
-In this type of germination, the radicle grows out through the micropyle downwards into the soil as a primary root.
-The **hypocotyl** (part of the embryo between the cotyledon and the radicle) curves and pushes upwards through the soil protecting the delicate shoot tip.
-The hypocotyl then straighten and elongate carrying with it the two cotyledons which turns green and starts photosynthesizing.
-The plumule then begins to grow into first foliage leaves.



2) Hypogeal germination

-It's a type of germination in which the cotyledons remains below the ground.
-The radicle along with the protective covering (coleorhiza) grows out of the seed.
-The **epicotyl** (the parts of the embryo between the cotyledon and the plumule) elongate and plumule grows out of the coleoptile then forms the first foliage leaves.
-The seedling begins to photosynthesize as the cotyledon shrivels (shrinks).



Primary and secondary growth

-Region of growth in plants is found in the meristems.
-**A meristem –** is a group of undifferentiated cells in plants which are responsible for continous mitotic division.

Main regions of the plants where meristems occur.

- At the root and shoot tips (Apical meristems) and are responsible for primary growth.
- At the vascular cambium and cork cambium**-** Responsible for secondary growth.

a) Primary growth

-Occurs at the tips of the root and shoots due to the activity of apical meristems.
-There are 3 distinct regions in this type of growth:

I. *Regions of cell division.*
II. *Region of cell elongation.*
III. *Region of cell differentiation.*

1) Region of cell division

It's an area of actively dividing meristems cells.

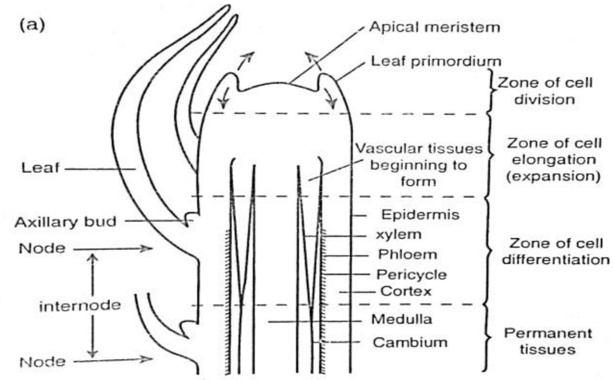
Characteristics of meristematic cells

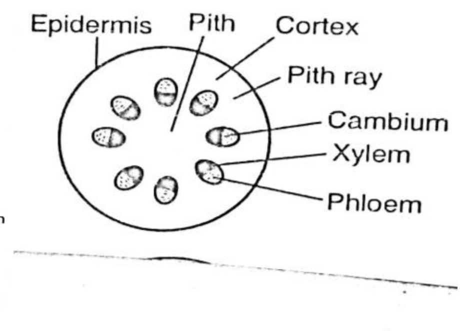
- Have thin cell walls.
- They have a dense cytoplasm.
- They divide actively.
- They have no vacuole.

2) **Region of cell elongation-** The cells become enlarged to their maximum size by stretching of their walls.
   -Vacuoles start forming and enlarging.

3) **Region of cell differentiation**

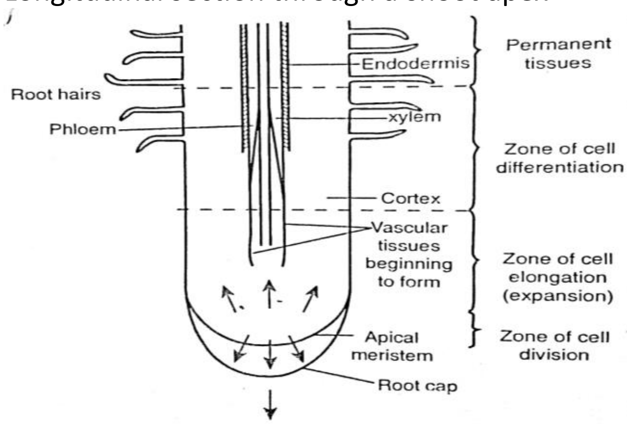
-Their cells attain their permanent size.
-They have large vacuoles and thickened cell walls.
-The cells also differentiate into tissues specialised for specific functions.

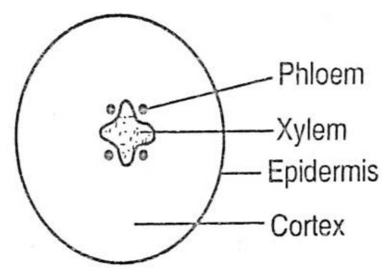




Longitudinal section through a shoot apex

Transverse section of stem.





(zone of permanent tissues)

Longitudinal section through a root tip

Transverse section of root.
(Zone of permanent tissues)

Region of growth in a root

Procedure

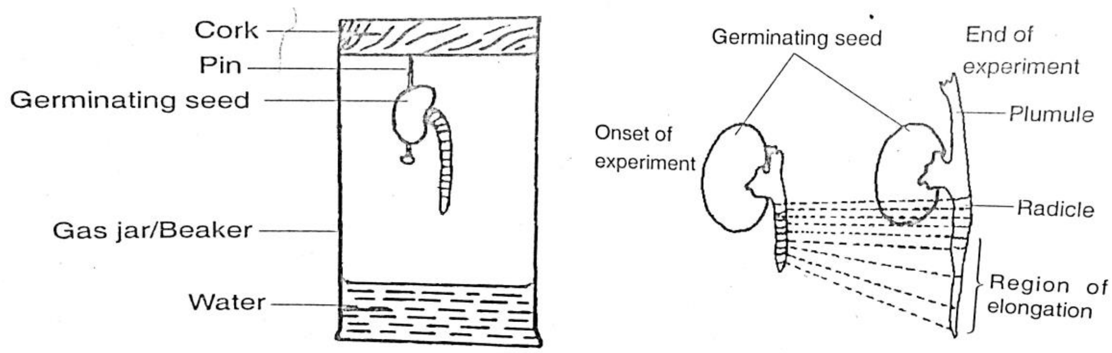
-This is determined by taking a young germinating seedling whose radicle is then marked with the Indian ink at intervals of 2mm.
-The seedling is left to grow for sometimes (24 hours or overnight) and then the ink marks are examined

Result

-It is found that the first few ink marks especially between 2nd and 3rd marks above the root tip have increased significantly.

Conclusion

- This shows that growth has occurred in the region just behind the tip of the root.



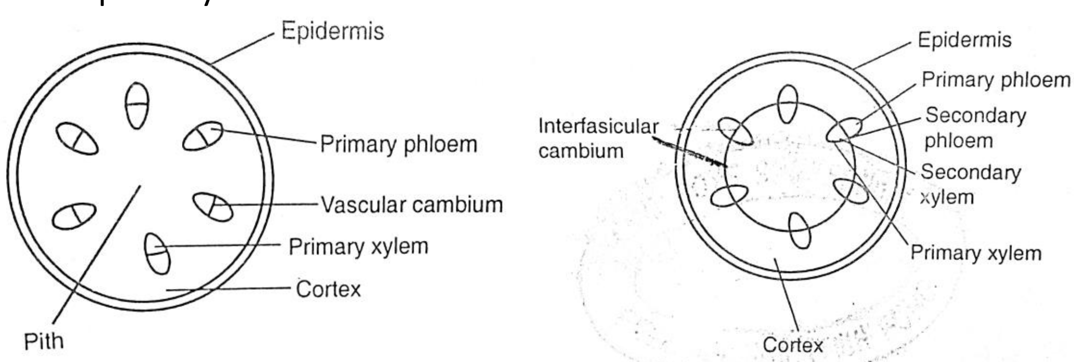
Marking of a root tip

b) Secondary growth

-Secondary growth results in an increase in width or girth due to activity of the cambium. It takes place in dicotyledonous plants.

-In secondary growth, new tissues are formed by the <u>vascular cambium</u> and <u>cork cambium</u>.

- **Vascular cambium** - gives rise to new vascular tissues.
- This is a meristematic tissue found between the primary phloem and secondary xylem.
- It becomes active soon after the primary growth is complete.
- In early stage of secondary growth, a typical dicotyledonous stem has the primary structure as shown below.

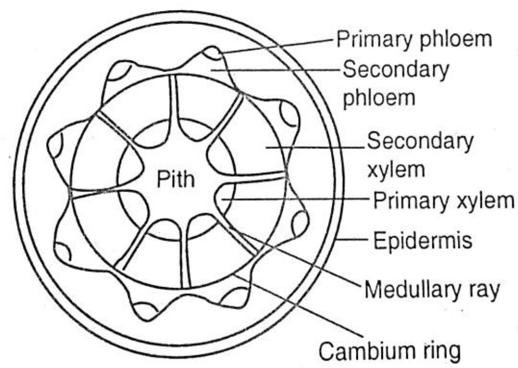


Transverse section of a dicot stem *Beginning of secondary growth in a dicot stem*

- The cells of the vascular cambium divide actively to form a complete ring of cambium.
- Continued activity of the cambium produces secondary xylem to the inside and secondary phloem to the outside.
- The interfascular cambium also cuts off parenchymatous cells which forms secondary medullary rays.

N/B: The medullary rays provide horizontal pathway:-

- For the passage of water and solutes across the stem.
- Also for gaseous exchange by diffusion
- May also be used for food shortage.



- **Cork cambium** (phellogen) -this meristematic tissue arises later to replace the ruptured epidermis of the expanding in plant tissue.

- As the secondary xylem increases and pushes outwards it raptures the delicate epidermis.
- The epidermis is replaced by activity of the cork cambium beneath it.
- The cells of the cork cambium divide to form cork cells to the outside and secondary cortex to the inside.
- This enables the stem to cope with the expansion from activity of the vascular cambium.
- The cork cells are then covered with a substance known as **suberin** and eventually the cells die.
- Accumulation of the dead cells from the bark of the tree.

<u>Functions of the bark</u>

i. Prevent excessive loss of water.

ii. Prevent infection from fungi, bacteria and insects.
iii. Protect the tree from mechanical injury and from fires.

N/B:

- At random interval, the loosely packed cork cells from structures known as **lenticels.**
- These openings allow gaseous exchange between the inside and the outside of the stem.
- The rate of secondary growth in a stem varies with seasonal changes.
- During rainy season, light textured wood with thin walled cells are formed.
- During dry season, dark textured wood with thick walled cells form.
- This leads to the development of two distinctive layers of within secondary xylem in a year called **annual rings.**

Significance of annual rings

i. Determination of the age of a tree by counting the number of the annual rings.
ii. The past climatic changes of the past years can be inferred from the size of the ring.

Roles of growth hormones in plants

a) <u>Auxins</u>

i. Promote cells division and elongation leading to primary growth.
ii. Causes tropic responses.
iii. Stimulates growth of adventitious roots.
iv. Induces parthenocarpy-the growth of an ovary into fruit without fertilisation.
v. Enhances apical dominance by inhibitors growth and development of side branches, from lateral buds.
vi. Causes formation of abscission layer that leads to leaf fall (at low concentration).
vii. Auxins (in association with cytokinins) induce the formation of callus tissue which causes the healing of wounds.
viii. Synthetic auxin (2, 4 - D) induces distorted growth and excessive respiration leading to death of a plant handle used as a selective weed killer.

b) Gibberellins

i. Stimulates rapid cell division and elongation in dwarf varieties.
ii. Are important in fruit formation ie growth of ovaries into fruits after fertilization.
iii. They induce parthenocarpy.
iv. Promote formation of side branches from lateral buds.
v. Inhibits sprouting of adventitious rots from stem cuttings.
vi. Retards formation of abscission layer hence reduce leaf fall.
vii. Breaks seed dormancy.

c) Cytikinins(kinetins)

In the presence of auxins

viii. they stimulate cell division thereby bringing about growth of roots, leaves and buds.
ix. They stimulate the formation of callus tissues in plants.(callus tissues are used in the repair of wounds in plants)
x. Promote flowering.
xi. Promote the breaking of seed dormancy in some plant species.
xii. Promote formation of adventitious roots from stems.
xiii. Stimulate lateral bud development in shoots.
xiv. When in high concentration,cytokinins induce cell enlargement of leaves
xv. In low concentration they encourage leaf senescence and leaf fall.

b) Ethylene

Is a growth substance produced in gaseous form.

i. Its major effect in plants is that it causes ripening and falling of fruits.
ii. It stimulates formation of abscission layer leading to leaf fall.
iii. Induces thickening of stems by promoting cell division and differentiation at the cambium meristem.
iv. It inhibits stem elongation.
v. It promotes breaking of seed dormancy in some seeds.
vi. Promotes flower formation mostly in pineapples.

c) Abscisic acid

A plant hormone whose effects are inhibitory in nature.

i. It inhibits seed germination leading to seed dormancy
ii. It inhibits the sprouting of buds from stems.

iii. It retards stem elongation
iv. In high concentration, it causes closing of stomata(enabling a plant to reduce water loss)
v. Promotes leaf fall and fruit fall.

d) <u>Florigen</u>

Promotes flowering.

Apical Dominance.

- *This is the failure of the lateral buds to sprout in the presence of apical bud due to diffusion of auxins from shoot apex downwards in concentrations higher than that promoting lateral bud development.*

-If the apical bud is removed, it is observed that the lateral bud sprouts producing many branches. This forms the basis of pruning in agriculture.

Growth And Development In Animals.

-In most animals, growth occurs throughout their life till they die. This type of growth is called **continuous growth**
-Arthropods e.g. Insects show rapid growth immediately after moulting with long periods when no growth increase occurs. This is called **discontinuous (intermittent) growth**
-Most insects undergo sexual reproduction; however in some insects as black and green aphids, the eggs are usually produced without being fertilized and are able to hatch into adult insects. This type of asexual reproduction is referred to as **parthenogenesis.**

Growth and development in insects

-*The developmental changes undergone by an insect from egg to adult is referred to as **metamorphosis.***

a) <u>Complete metamorphosis</u>

-Majority of insects undergo all stages of development ie
egg→larva→pupa→adult

-The **larva** sometimes referred as a grub, a maggot or a caterpillar;

- Eats a lot

- Grows rapidly
- Sheds its cuticle several times(until it reaches full size to become pupa)

-The **pupa** is;

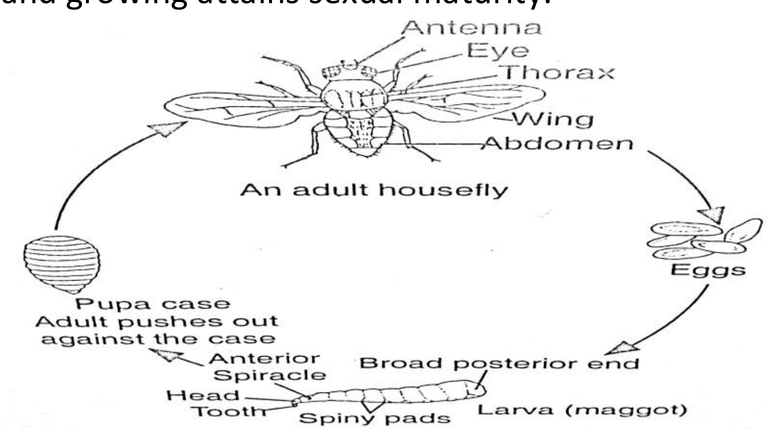
- Inactive
- Non-feeding
- Where extensive breakdown and re-organisation of body tissues occur.

-This eventually give rise to the **imago or adult.**

<u>DEVELOPMENT OF HOUSEFLY</u>

(An example of complete metamorphosis)

-The 1mm long housefly eggs are laid in batches of between 100 and 150.
-The larva which hatch from the eggs grow and feed on decaying matter and after several moults increase in size reaching about 1cm in length in about 5 days.
The larvae then changes into a **pupa** encased in a pupal case called **puparium.**
-The adult later emerges from the puparium and after 2 weeks of feeding and growing attains sexual maturity.



b) ***<u>Incomplete metamorphosis</u>***

-Some insects such as cockroaches and locusts undergo **incomplete metamorphosis** where the eggs hatch into **nymph** which develops into adult insect.

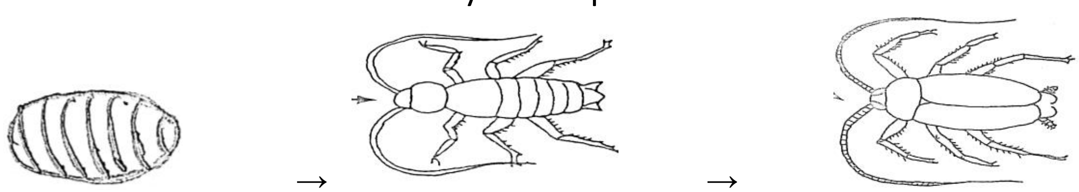
-The nymph closely resembles the adult except that its smaller in size and lacks sexual maturity. Hence to attain adult size it has to undergo several moults.

DEVELOPMENT OF COCKROACH

(An example of incomplete metamorphosis)

-Cockroaches produce eggs enclosed in a chitin case (ootheca) in groups between 10-15.The ootheca is usually deposited in moist dark warm places as cracks of furniture.

-It takes about a month before the small wingless nymphs emerge which feed and moults about ten times in a period of about 16 days for all the adult structures to become fully developed.



Ootheca with eggs → *Nymph* → *Adult insect*

Significance of metamorphosis

1.It enables an insect to evade adverse conditions ie during pupation

2.It minimizes competition between the larval stage and adult as they occupy different ecological niches.

Role of hormones in insect metamorphosis

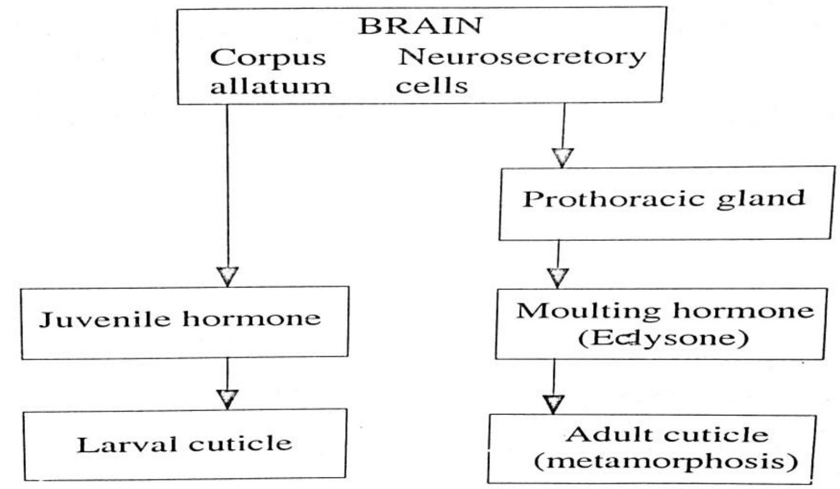
-Metamorphosis in insects is controlled by hormones produced by three glands namely;

- Neurosecretory cells in the brain ganglia.
- A pair of corpora allata in the mandibular segment.
- Prothoracic glands in the thorax.

-During larval stages of the insect, the corpora allata produces the **juvenile hormone.** This leads to the formation of the larval cuticle therefore moulting does not go beyond the larval stage.

When the larva matures, the corpora allata disintegrates. At this time, the neurosecretory cells stimulate the prothoracic glands to produce **ecdysone (moulting hormone)**

-Ecdysone is responsible moulting in insects leading to the laying of the adult cuticle.


BRAIN
Corpus allatum
Neurosecretory cells
Prothoracic gland
Juvenile hormone
Moulting hormone (Ecdysone)
Larval cuticle
Adult cuticle (metamorphosis)

The End