GROWTH AND DEVELOPMENT

Growth is defined as the permanent, quantitative 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 helps 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 gets sufficient nutrients grow 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.**

Thyroxin controls the rate of growth.

***Diseases.**

Some diseases retard growth.

Other factors include Oxygen, water, 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 (imbibitions)

CONDITIONS NECESSARY FOR GERMINATON

Environmental conditions

Water, air/oxygen, suitable temperature, light

Internal factors

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

-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 and transporting them to the growing parts of the shoot and roots.

The process by which seeds take up water is referred to as imbibitions. The seed swells and bursts. This allows oxygen and to enter the seed and carbon dioxide produced to escape

-Oxygen is needed for respiration to yield energy.

-Suitable temperature is needed for proper functioning of enzymes

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

-Viable seeds have mature embryos and all seed parts are present in the seed.

If there are no food reserves, the embryo does not germinate.

-Enzymes regulate the uses of stored food

in the seeds.

Changes during germination

The following changes occur during germination:

-the seed absorbs water through the micropyle

-the seed swells and the tests (seed coat) rupture

-enzymes become activated and begin to hydrolyse stored food

-the rate of respiration increases rapidly

-the radical emerges first and grows downwards to form the root system

-starch in the cotyledons or endosperm is hydrolysed to disaccharides and monosaccharide and is taken to the growing points for respiration

-the radicle develops root hairs and begins to absorb water and mineral salts

-the shoot develops foliage leaves and starts to photosynthesise

-the cotyledons, their food reserves exhausted wither away.

TYPES OF GERMINATION

Hypogeal germination e.g. 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 row straight out of the ground. The sheath, coleoptile protects the plumule.

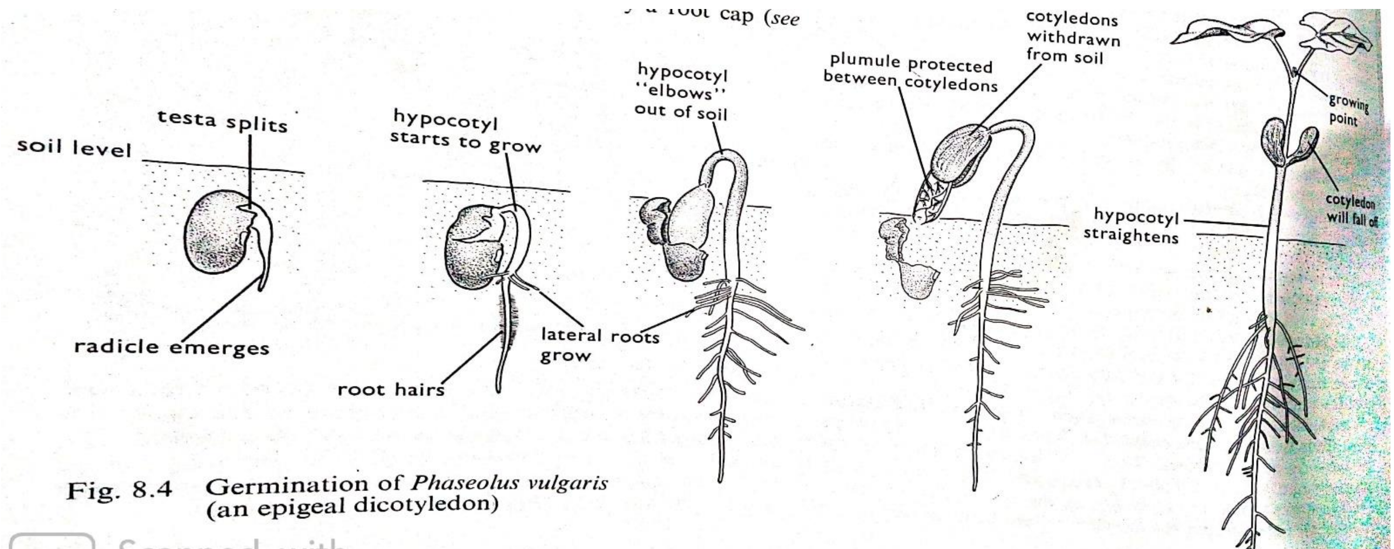


Fig. 8.4 Germination of *Phaseolus vulgaris* (an epigeal dicotyledon)

Epigeal germination e.g. beans

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

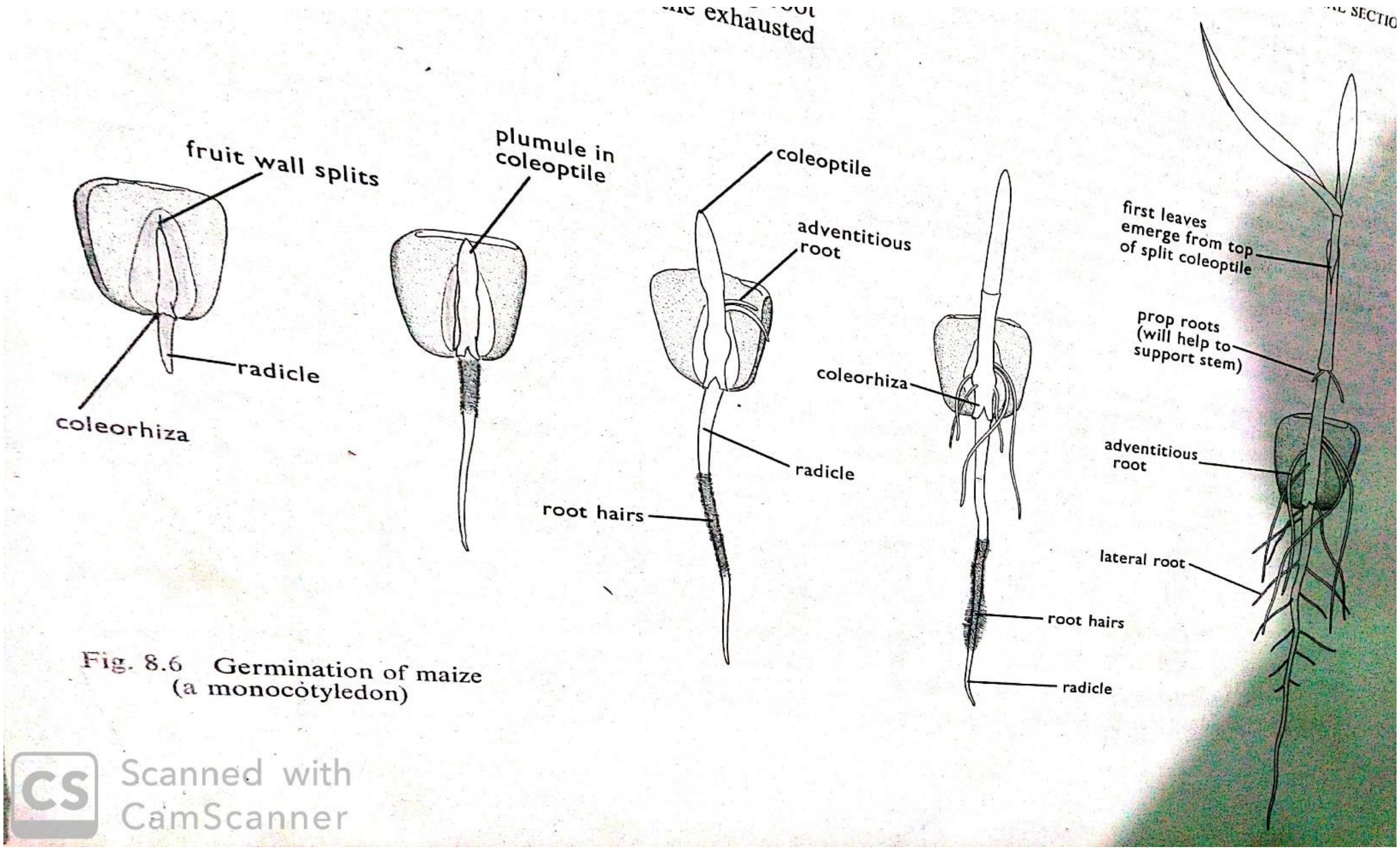
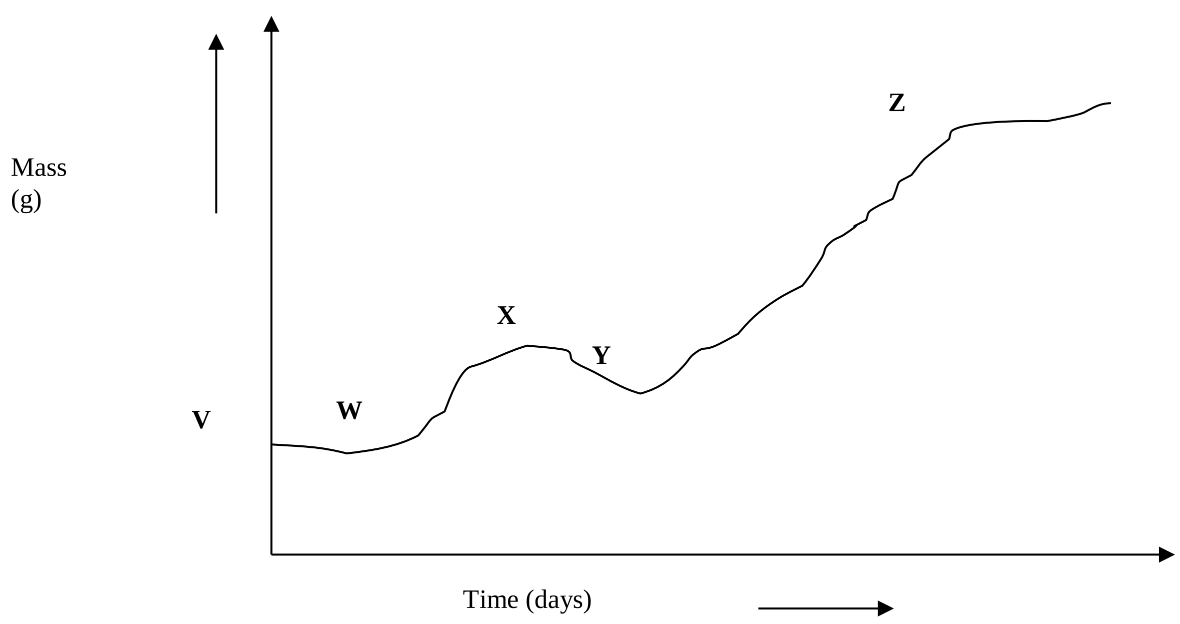


Fig. 8.6 Germination of maize (a monocotyledon)

VARIATION OF SEED MASS DURING SEED GERMINATION.

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

A graph showing change in mass with time during seed germination



V-W The seed is still dormant and has not yet started germinating.

W-X The weight of the seed increases sharply because it has absorbed water and germination has started.

X-Y The weight of the seed decreases because the stored food is used up to provide energy for growth.

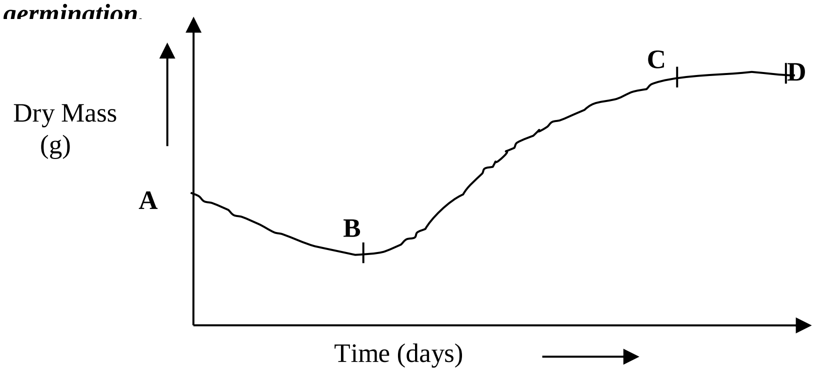
Y-Z The weight increases rapidly because the embryo has grown into seedling. Seedling builds up new cells and at the same photosynthesis is occurring hence producing more food than one being used up.

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 until all the water init evaporates. The changes in dry weight of seedling during germination are illustrated in the graph in the figure below.

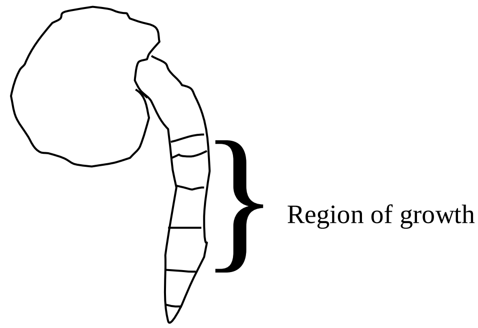
A graph showing changes in dry mass of seedlings with time during seed germination.



A-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.

B-C Between B and C, the dry weight begins to increase steadily or sharply 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 **apical meristem** 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 primordium is another meristematic area, the bud **primordium.** 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

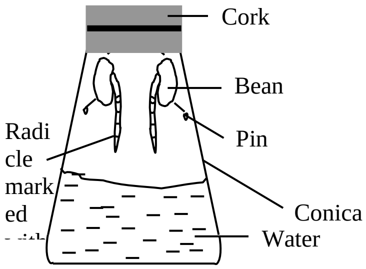
AIM: To find out the region of growth in radicle.

MATERIALS

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

PROCEDURE/METHOD

- Bean seedlings with straight radicles after few 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 short distance between the markings at the tips of radicles and at its tops 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.

CONCLUSION

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

An experiment to investigate whether water is necessary for germination

Apparatus / materials

4petri dishes

Cotton wool

Been seeds

Water

Procedure

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

Setup

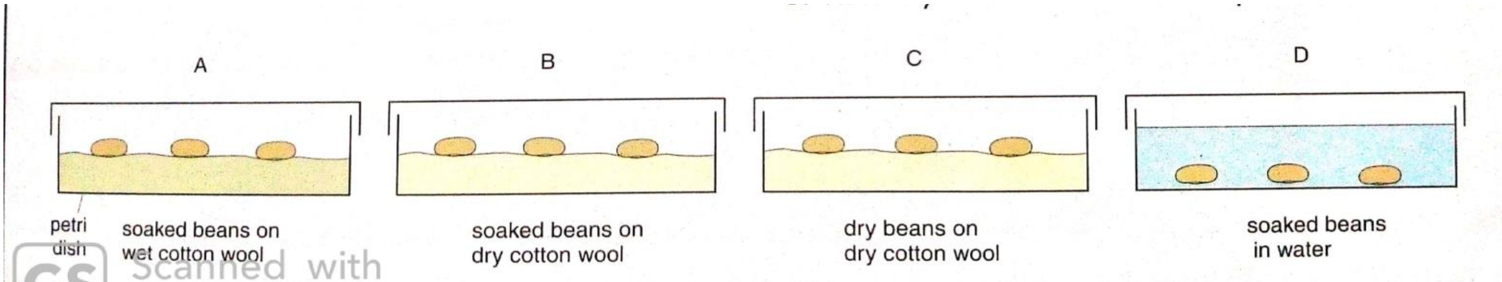


Fig 25.9 Experiment to investigate whether water is necessary for germination

Observation

Explanation

An experiment to investigate whether oxygen is needed for germination

Apparatus

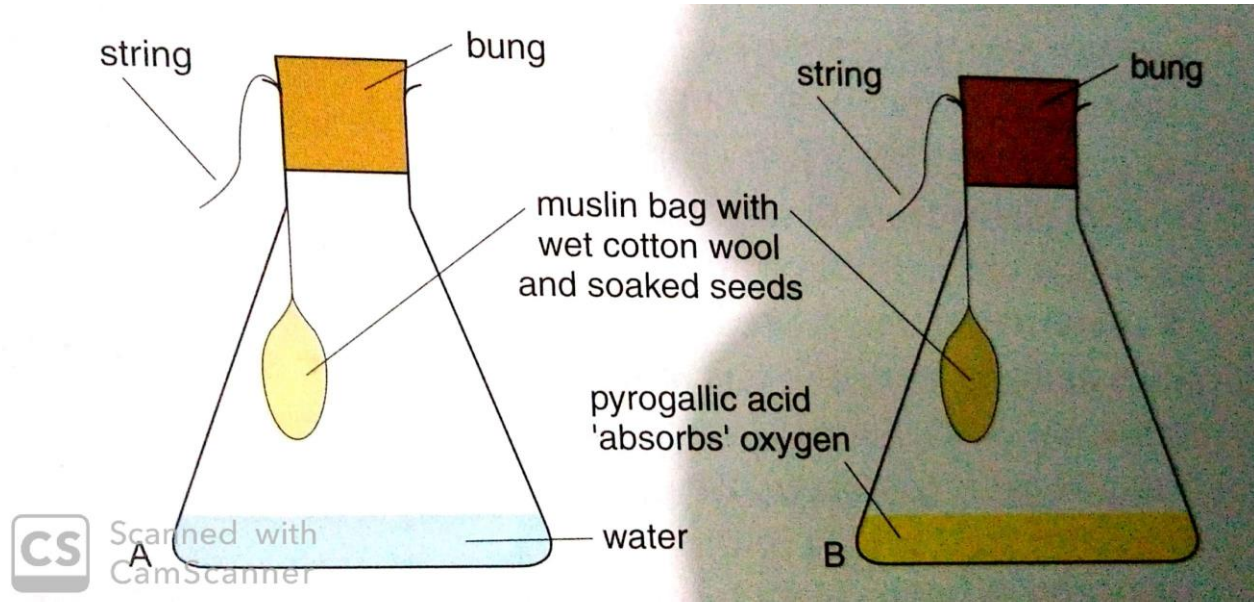
2 conical flasks, 2pieces of muslin, string, soaked been seeds

Cotton wool, 2 corks, pyrogallic acid, water

Procedure

- Label one conical flask A and the other B
- Place water in the flask marked A and pyrogallic acid in the flask marked B to depth of about 1cm
- 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 flask
- Seal the flasks with the corks
- Leave the experiment s for one week

Setup



Observation

Explanation

3. An experiment to investigate whether water is necessary for germination

Apparatus/ materials

3 Petri dishes, soaked beans, cotton wool, water, incubator, fridge

Procedure

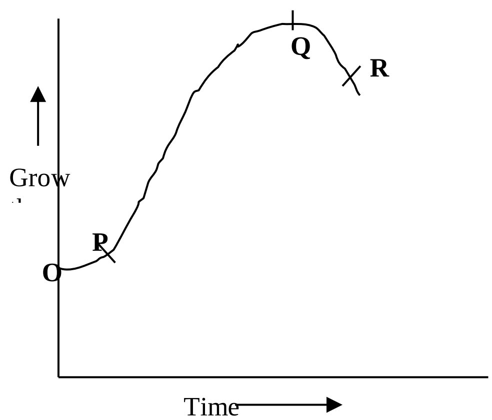
- Label Petri dishes A,B and C
- Place dump cotton wool in each Petri dish
- Place ten soaked bean seeds in each dish
- Leave dish A at normal room temperature
- Place dish B in a fridge at low temperature
- Place dish C in an incubator at a temperature of 40oc
- Leave the setup for a week

Observation

Explanation

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 which growth slows down as shown in the figure below.



O-P Growth rate is slow i.e. is not rapid.

P-Q Period of rapid growth.

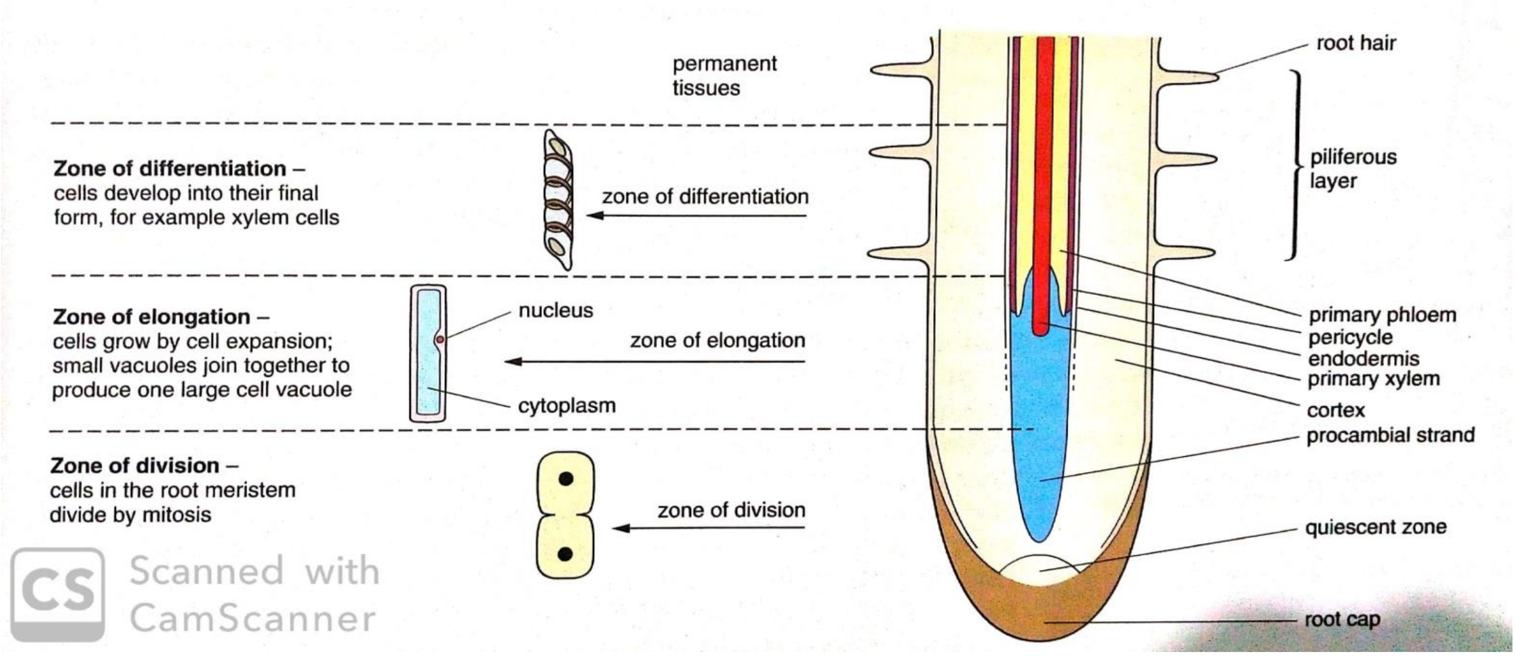
Q-R Period of slow growth.

The graph above shows that growth starts slowly then accelerates and is followed by deceleration.

SECONDARY GROWTH IN PLANTS

In plants there are regions where growth takes place called meristems. Meristems are a group of plant cells that divide rapidly by mitosis. The root meristems consist of a group of unspecialised cells. The cells divide and, only then, become specialised for particular functions a process called differentiation

Other meristems near the tip of the shoot control the growth of the stem. These two groups of cells are called primary meristems. They are concerned mainly with increasing the height of plants.



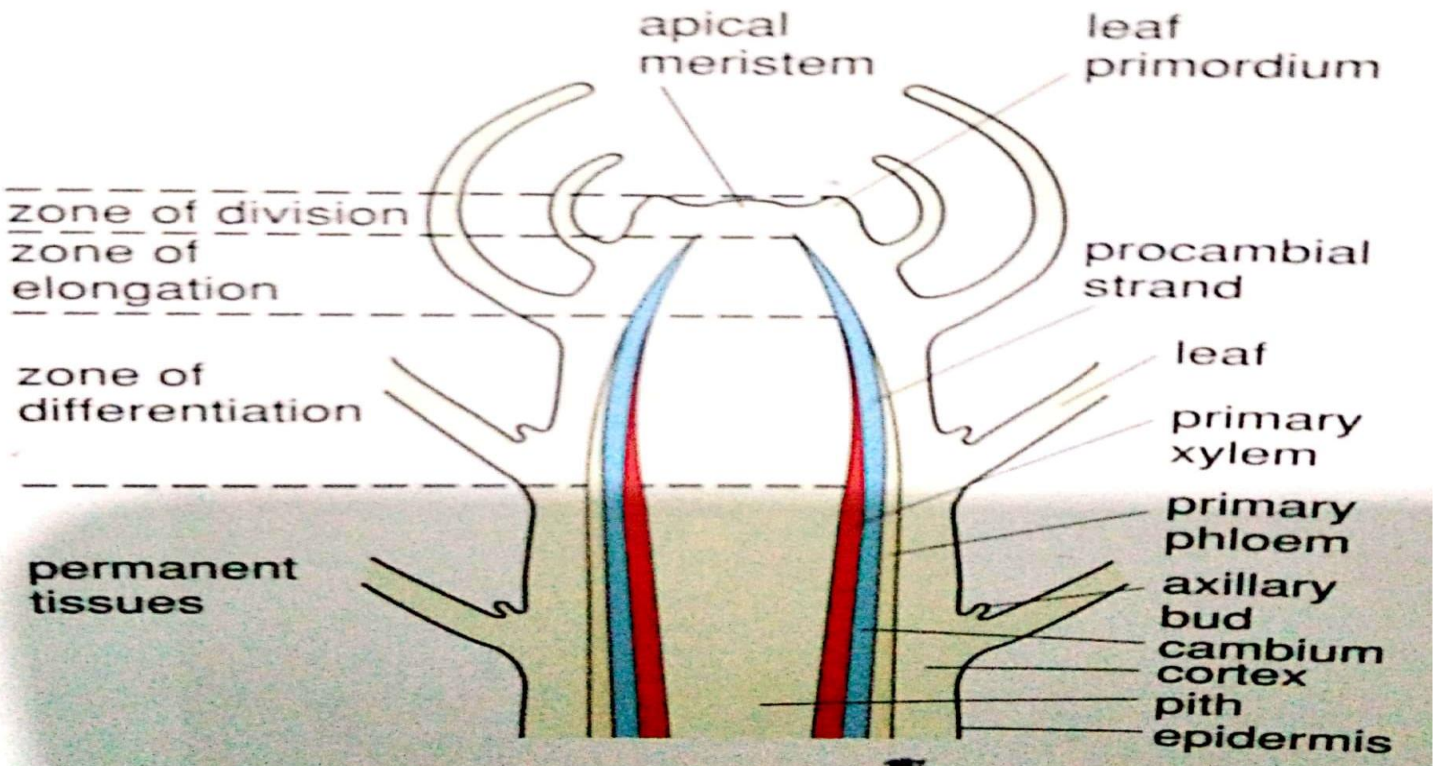


Fig. 25.12 Longitudinal section of a plant stem to show the sub-apical meristem and axillary buds

Secondary growth refers to increase in thickness (girth) of plant shoots and roots. It occurs in all dicotyledonous plants except herbaceous dicotyledonous plants. It also occurs in gymnosperms. However, monocotyledons don't undergo secondary growth. Secondary growth results in the formation of permanent tissues and is also termed as **secondary thickening**

Secondary growth is brought about by the division of cambium (secondary meristems) ring and cork cambium. When the cambium ring (vascular cambium) divides, it forms secondary xylem on the inside and secondary phloem on the outside. The cork cambium is responsible for the formation of wood (bark) in dicotyledonous plants

Note

Primary growth in plants results from cell division and elongation of apical meristems in root and hoot

Secondary growth results from division of lateral meristems such as cambium to increase diameter

IMPORTANCE OF SECONDARY GROWTH

- It increases the girth of stems and roots to provide extra support for other plant parts above.
- It helps in regeneration of plants parts.
- used in healing of wounds by forming callus tissue on shoots and roots.

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.

Dry mass is the amount of organic material i an organism minus the water in its cytoplasm. This is done by drying an organism in an oven at about 80oc. The water evapourates but the carbohydrates, lipids and proteins donot burn. Organisms ar constantly weighed until a constant dry mass is measured.

Disadvantages of the method

-It kills the organism so growth is not followed individuals.

-large number of organisms are used and needed

SEED DORMANCY

This is a condition whereby viable seeds fail to germinate under certain conditions. It is caused by several factors

CAUSES OF SEED DORMANCY

- Immature embryo of seed: This may cause dormancy in seed germination since the embryo may undergo development before germination occurs

- Presence of germination inhibitors: Substances like abscissic acid do not promote 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.

- **Lack of sufficient oxygen available for seeds:** If oxygen is absent, seeds respire anaerobically and obtain less energy.

- - **Dryness** of soil which does not allow germination of see**ds**

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) By providing suitable conditions of oxygen, temperature, moisture etc which favour germination.

(v) Removing the hard seed coat 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 grassesnad bolting of biennials such as lettuce.

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

2. Cytokinins:

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

3. Abscisic acid:

-acts mainly as a growth inhibitor.

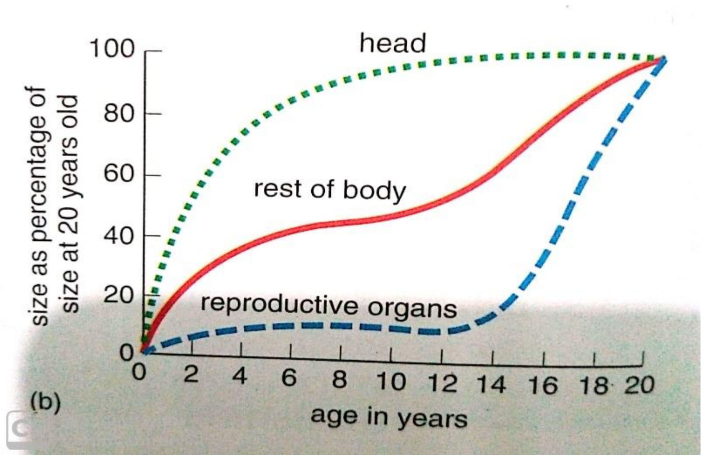
-It is presents in large quanties in dormant buds.

-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 of curves in humans


head
rest of body
reproductive organs
size as percentage of size at 20 years old
100
80
60
40
20
0
0 2 4 6 8 10 12 14 16 18 20
age in years
(b)

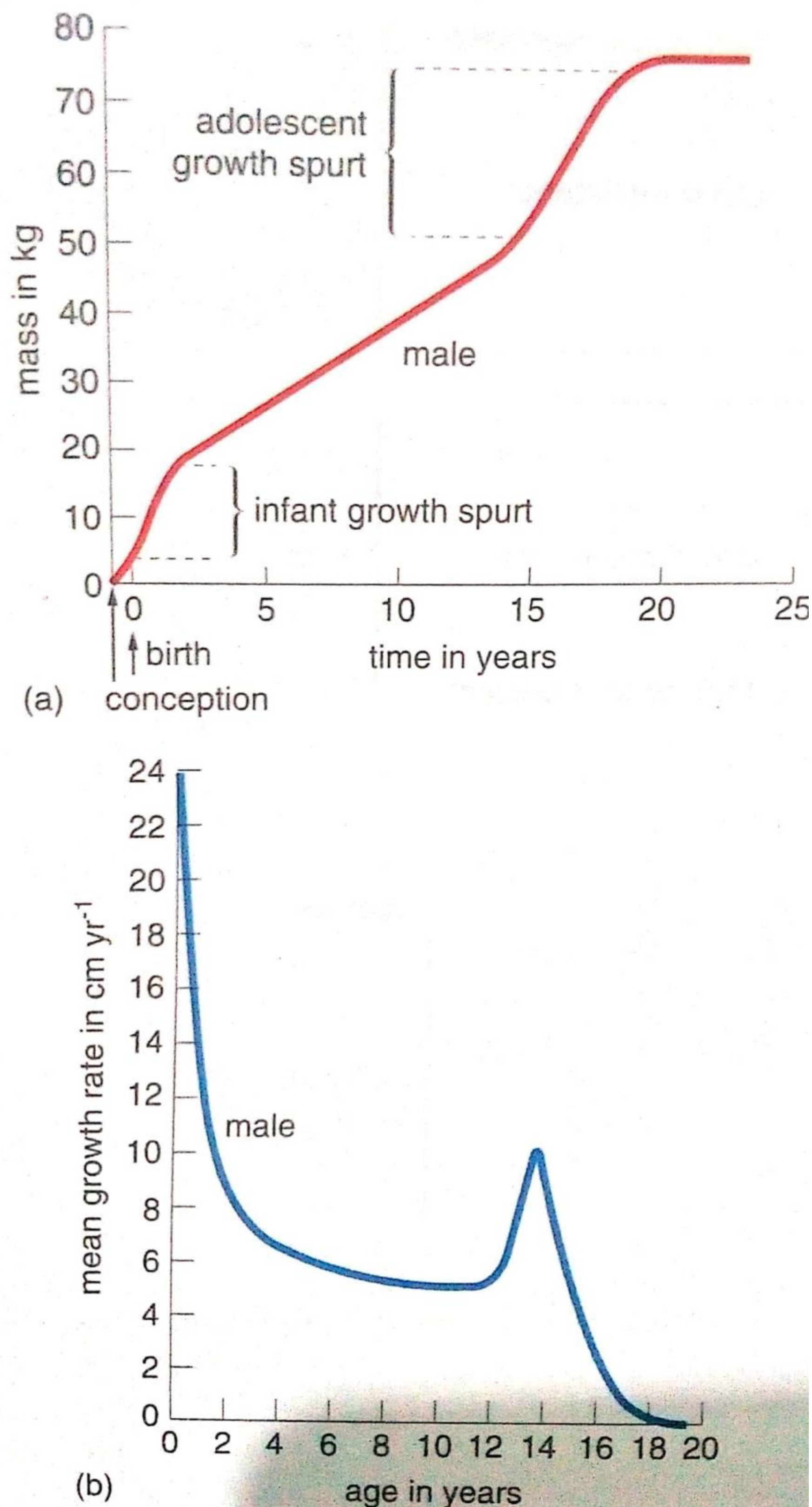


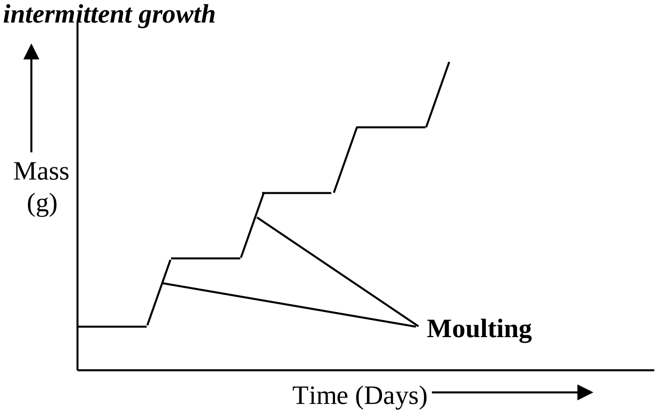
Fig. 25.5 Actual growth and growth rate during the first 18 years for a human male

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**.

GROWTH IN INSECTS

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.

Growth curve of an insect showing discontinuous intermittent growth



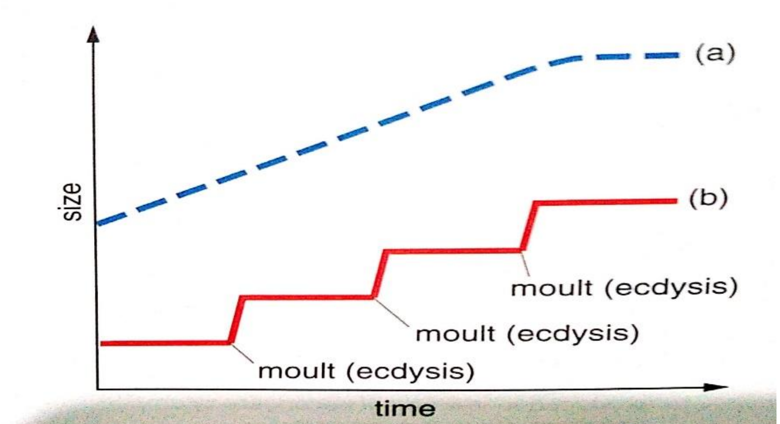


Fig. 25.17 Growth curves to show continuous and discontinuous growth in animals

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; deer, for example, grow new antlers, and the lemming acquires new claws. 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, imago emerges out of it. This kind of transformation is termed as **metamorphosis**

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(or hemimetabolous) metamorphosis

(ii) Complete (or holometabolous) metamorphosis

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 adult life in new environment. This increases on chances of exploiting, space, food resources in different environments.

It also minimizes competition between young ones and adults. Since the two may be in 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 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, equally important, 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.

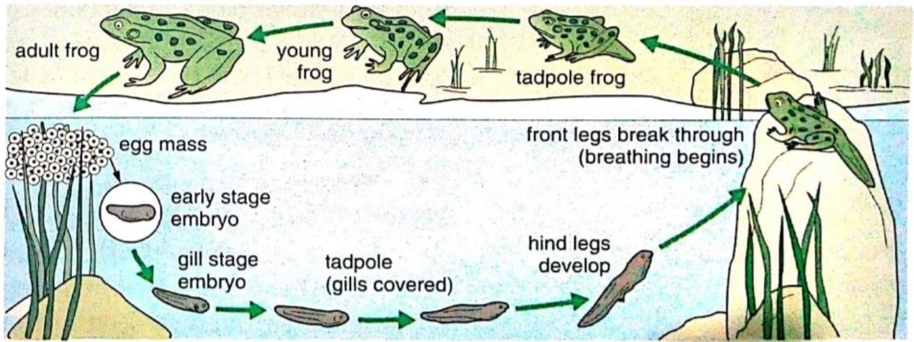


Fig 25.20 Life cycle of an amphibian

References

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

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

Mass of the stored food decreases as it is **hydrolysed** by **enzymes** into **soluble products** which pass to the actively growing regions.

Starch is hydrolysed to glucose by enzyme diastase

Proteins are hydrolysed to amino acids by proteases

What are lipids broken down into?

(Avoid terms such as ‘converted to’)

Glucose may then be oxidised during respiration to produce energy for chemical reactions. Glucose may be used to make cellwalls, cellulose.Amino acids may be built into proteins, enzymes and hormones or to make protoplasm.

Outline the use of water in a germinating seed.

Soften testa, Activate enzymes, dissolve stored food.

Q2. What type of cell division is responsible for growth? Reason?

Q3. How is growth in plants different to growth in animals?

Q4. Describe the external and internal changes that occur in a germinating maize grain.

Q5. State the differences between complete and incomplete metamorphosis.

Q6. What is the importance of the caterpillar being markedly different from the butterfly?

Q7. Intercalary meristems are found in the nodes of monocotyledonous plants. What is the use of lateral meristems?

Q8. How do you measure (i) fresh mass (ii) Dry mass of sample seedlings.