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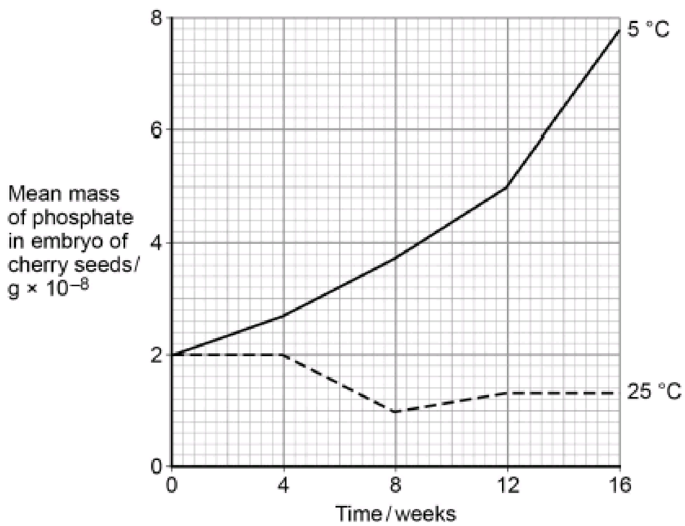
UNDERSTANDING 'A' LEVEL GROWTH & DEVELOPMENT IN ORGANISMS

1. (a) Distinguish between **stratification** and **vernalisation**.

Stratification is the exposure of dormant seeds of temperate plants to period of cold to stimulate germination; while vernalisation is the exposure of certain plants (biennals and perennials) to a period of cold to stimulate flowering;

(b) In an experiment to investigate the effect of chilling on the mass of phosphate in seeds, cherry seeds were exposed to different temperatures and mean mass of the phosphate in their embryos measured over a period of 16weeks.

The graph in figure below shows results of the experiment. Study it carefully and answer the questions that follow.



(i) Describe the changes in the mean mass of phosphate in the embryo at 5℃ over the experimental period.

From 0weeks to 4weeks, mean mass of phosphate increases <u>gradually</u>;
From 4weeks to 12weeks, mean mass of phosphate increases <u>rapidly</u>;
From 12weeks to 16weeks, mean mass of phosphate increases <u>more rapidly</u>; to the <u>highest</u>;

(ii) Compare the changes in the mean mass of phosphate in the embryo of cherry seeds at the two temperatures over the experimental period.

<u>Similarities</u>

At both 5℃ and 25℃, mean mass of phosphate in the embryo of cherry seeds increases from 8weeks to 12weeks;

Mean mass of phosphate at both 5℃ and 25℃, are equal initially;

<u>Differences</u>

Mean mass of phosphate at 5℃	Mean mass of phosphate at 25℃
Higher from 0 weeks to 16weeks	**Lower from 0 weeks to 16weeks**
Increases from 0weeks to 4weeks; and from 12weeks to 16weeks	**Remains constant from 0weeks to 4weeks; and from 12weeks to 16weeks**
Increases from 4weeks to 8weeks	**Decreases from 4weeks to 8weeks**
Increases rapidly from 8weeks to 12weeks	**Increases gradually from 8weeks to 12weeks**
No minimum attained	**Minimum attained**
Increases throughout the experimental period	**Remains constant, decreases and then increases;**

(iii) Account for difference in mean mass of phosphate in the embryo of cherry seeds at the two temperatures.

From 0weeks to 16weeks, mean mass of phosphate at 5℃ is <u>higher</u> than at 25℃; because with <u>lower</u> temperature, abscisic acid content of the seed falls; gibberellic acid concentration in the seed increases; on absorption of water; stimulating the synthesis of hydrolytic enzymes; that catalyze the breakdown of phospholipid molecule in cherry seeds to phosphates; transported to the embryo for growth;

(c) Explain how chilling requirements of certain plant species is important in countries with seasonal changes in environmental conditions.

Allows seeds of certain plant species in countries with seasonal changes in environmental conditions to <u>remain dormant in unfavourable environmental conditions</u>; <u>preventing them from losing all food reserves</u>; by <u>simultaneous germination under temporary suitable conditions</u>; when the seedling will be wiped out by succeeding period of unfavourable conditions e.g. frost during winter;

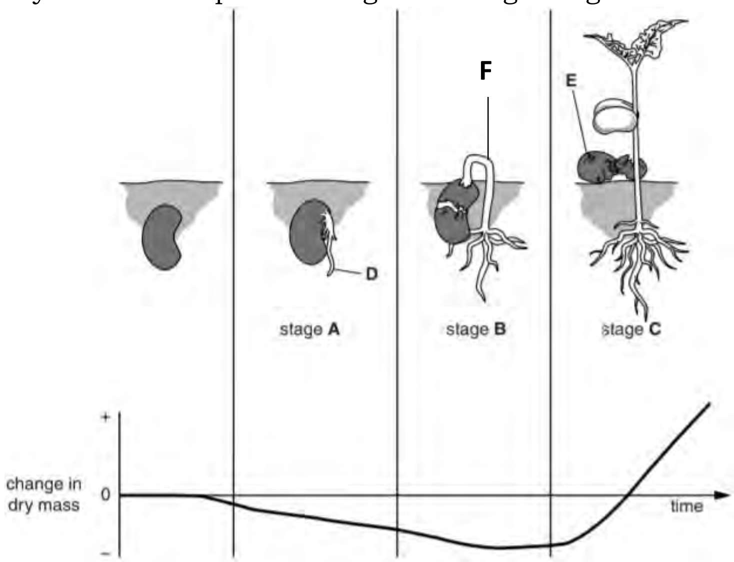
(d) Apart from chilling, describe other methods of breaking named causes of dormancy in seeds.

<u>Hard and impermeable testa</u>; (i) microbial breakdown in the soil e.g. by fungi (ii) digestive action by enzymes of mammals, birds; (iii) exposure to alternating low and high temperatures; allowing expansion and contraction that cracks the testa; (iv) treatment with Sulphuric acid and alcohol that removes a waxy layer of seed coat; facilitating water uptake by imbibition;(v) Physical abrasion of seeds by sandpaper; or pricking a hole in the testa; (vi) action of fire on seeds of certain species, burning away testa;

<u>Immature/premature embryo</u>; by allowing an after-ripening period;
<u>Germination inhibitors;</u> (i) Treatment of seeds with germination stimulators e.g. Gibberellic acid; (ii) prolonged exposure of seeds to moist and cold conditions in presence of oxygen; which allows synthesis of gibberellic acid; and decreased abscisic content of the seed; (iii) Soaking the seed in water; for diffusion of the germination inhibitor out of the seed;

2. (a) What is meant by the term **dry mass** of an organism.
Is the mass of the organism taken after <u>all the water</u> have been evaporated from its tissues;

(b) Figure below shows the stages of germination of a cow pea seed and the changes in dry mass of the plant during these stages of germination.



(i) Name parts labeled **D**, **E** and **F** in the figure.
D: **Radicle/Embryo root**;
E: **Testa/Seed coat**;
F: **Elongating hypocotyl**;

(ii) State the type of germination shown on the figure, and describe how its brought about.
Epigeal germination; cotyledons appear above the ground; owing to <u>rapid elongation of the hypocotyl than epicotyl;</u>

(iii) Explain the advantages of the type of germination in b(ii) above over that observed in broad beans.
Cotyledons protect the <u>delicate plumule</u> as they break the soil particles;
After they (cotyledons) are brought above the ground, they develop <u>photochlorophyll</u>; that absorb sun light energy; photosynthesise; before formation of the foliage leaves; to supplement on the food supply required for growth during germination;
Elongating hypocotyl also breaks through the soil particles; easing the thrusting upwards of the plumule;

(iv) Account for the changes in dry mass shown during each of the stages shown in the figure.
Stage **A:**
Dry mass decreases gradually; because intial uptake of water by imbibition; and osmosis; activates hydrolytic enzymes; that catalyse the breakdown of stored foods into smaller soluble products; translocated to growing points of the embryo; for growth;
Stage **B:**
Dry mass decreases gradually; to a minimum; because of aerobic respiration of small soluble products such as sugars; to provide energy for embryo growth;
Stage **C:**
Dry mass increases rapidly; to the highest; because of emergence of cotyledons; and formation of the first foliage leaves; that carry out photosynthesis;

(c) Outline the **advantages** and **disadvantages** of using dry mass as a measurement of growth in organisms.
<u>Advantages</u>
More accurate result is obtained;
Disadvantages.
-Permanently destroys the organism;
-Requires much preparation of the sample;
-Unethical/undesirable to use in some organisms like humans;
-In some organisms, there is some loss of salts owing to decomposition of some protoplasmic components; thus not catered for in the results obtained.

(d) Other than dry mass, give other parameters used to measure growth in named organisms.
Wet/fresh mass in plants and animals;
Length of stems, roots and internodes in plants; **and height in humans**;

Area/surface area of plant leaves;
Diameter/girth of tree branches;

3. (a) Distinguish between the following growth patterns, giving examples of organisms in each case.

(i) **Allometric growth** and **isometric growth**.

Allometric growth	Isometric growth
-Body organs grow at different rates from the entire body **-Change in size of the organism is accompanied by change in shape/external form of the organism** **-Proportions of organs and whole body differ** **-Exhibited by mammals**	**-Body organs grow at same rate as the rest of body** **-Change in size of the organism is not accompanied by change in shape/external form of the organism** **-Proportions of organs and whole body remain constant** **-Exhibited by fish; and certain insects such as locusts; (except for wings and genitalia)**

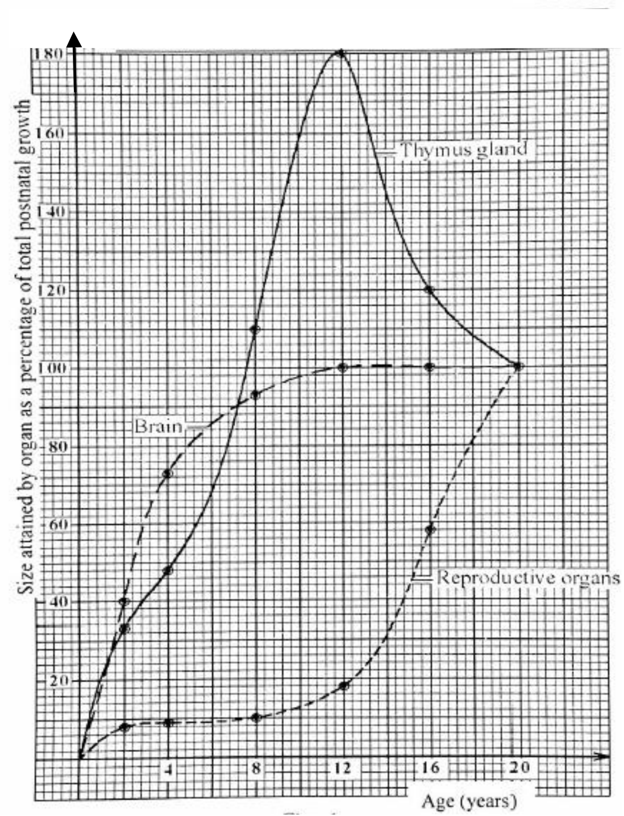
(ii) **Limited growth** and **Unlimited growth.**

Limited/definite/determinate growth	unlimited/indefinite/indeterminate growth
Ceases at maturity **Annual plants and animals such as insects, birds and mammals**	**Continues throughout an organism's life** **Woody perennial plants, fungi, algae, and animals such as fishes, reptiles and non-invertebrates.**

(iii) **Continuous growth** and **intermittent growth**.

Continuous growth	Intermittent/discontinuous growth
Organism continues to grow from birth to maturity, though with changes in growth rate; **Mammals and many other animals**	**Involves periods of extremely rapid growth/spurts; followed by periods of little or no growth;** **Arthropods (insects and crustaceans)**

(b) The graph in the figure below shows the size attained by the human body organs from birth, expressed as a percentage of the total post-natal growth.
Study it carefully and answer the questions that follow.



(i) Describe the growth pattern shown by the;

Thymus gland

From 0years to 2years, size attained increases rapidly;
From 2years to 6years, size attained increases gradually;
From 6years to 12years, size attained increases rapidly; to a peak;
From 12years to 20years, size attained decreases gradually; to almost half its maximum size attained;

Reproductive organs

From 0years to 2years, size attained increases gradually;
From 2years to 8years, size attained remains almost constant;
From 8years to 14years, size attained increases gradually;
From 14years to 20years, size attained increases rapidly; to the highest;

Brain

From 0years to 2years, size attained increases rapidly;
From 2years to 4years, size attained increases gradually;
From 4years to 12years, size attained increases more gradually; to a maximum;
From 12years to 20years, size attained remains constant;

(ii) Explain the growth pattern shown by;

Thymus gland.

From 0years to 12 years, size attained increases to peak to produce white blood cells; that fight

infection in early life when immunity has not been acquired;
From 12years to 20years, size attained decreases to almost half because bone marrow of the long bones is fully developed; thus produce white blood cells for body defence; and more of the thymic tissue is replaced by adipose tissue.

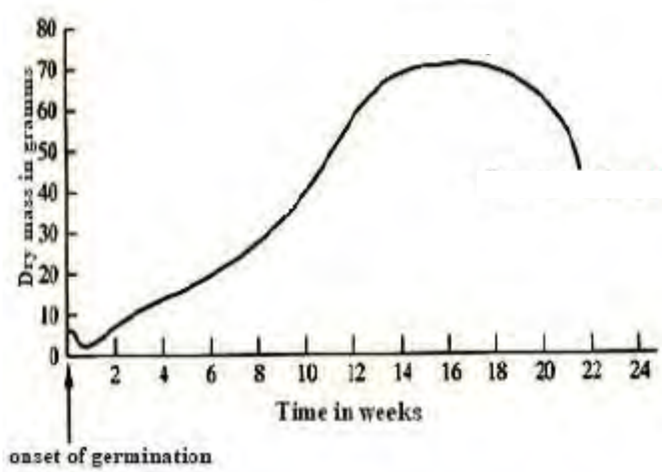
Brain

Size attained increases rapidly for the first two years, then gradually from 2years to 12years, where it reached full maturity; to coordinate growth; development; of different body parts; and learning;

Reproductive organs.

Grows very little in early life up to 14years, as urino-genital organ for excretion;
From 14years to 20years, size attained increases rapidly; owing to sexual maturity; at puberty;

4. The graph in the figure below shows changes in dry mass during the growth of a broad bean, *Vicia faba*. Study it carefully and answer the questions that follow.



(a) Explain the variation in the dry mass of the seed with time.

Initially, dry mass decreases slightly; to a minimum; owing to respiration of stored food reserves; to generate energy for embryo growth;
From 1week to 14weeks, dry mass increases exponentially; to a maximum; because of emergence of cotyledons; and formation of the first foliage leaves; that carry out photosynthesis; Rate of photosynthesis exceeds rate of respiration;
From 14weeks to about 17weeks, dry mass remains almost constant because maturity is attained; rate of photosynthesis equals rate of respiration;
From 17weeks to 21weeks, dry mass decreases rapidly; owing to aging(senescence); dispersal of seeds and fruits;

(b) Giving a reason, state the growth pattern exhibited in the figure above.

Limited/definite/determinate growth; because increase in dry mass/growth stops; on attaining maturity at week 14;

5. (a) Explain the following observations in an investigation on the control of growth and ecdysis in the nymph of the blood-sucking bug, *Rhodinus*.

(i) Blood –sucking bug continues to live for several months but does not moult on decapitation a day after a blood meal.

<u>Insufficient amounts</u> of the brain hormone/prothoracicotropic hormone had been secreted by the neurosecretory cells of the brain; on distention of the abdomen; inhibiting stimulation of the prothoracic gland; to secrete the moulting hormone/ecdysone;

(ii) Moulting occurs on decapitation a week after a blood meal.

<u>Sufficient amounts</u> of the brain hormone had been secreted by the neurosecretory cells of the brain; on distention of the abdomen; stimulating the prothoracic gland to secrete the moulting hormone;

(iii) Moulting of bug in (i) occurs once connected by a capillary tube to bug in (ii)

<u>Sufficient amounts</u> of the brain hormone secreted by the neurosecretory cells of brain of nymph in (ii) is transported in blood through the capillary tube to prothoracic gland of nymph in (i); stimulating it to secrete moulting hormone;

(b) Suggest **one** piece of evidence supporting the action of the moulting hormone.

On exposure to the hormone, certain regions of chromosomes swell up forming chromosome puffs/sites of RNA synthesis; suggesting switching on of genes needed for synthesis of enzymes; necessary for growth;

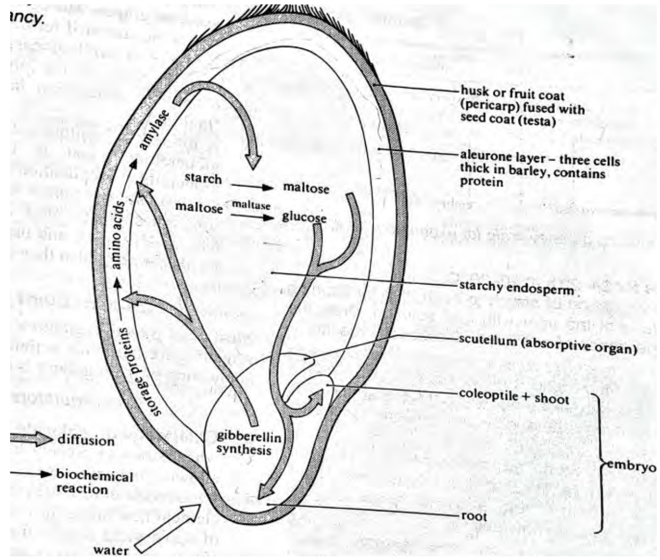
(c) With suitable examples, describe the significance of larval forms of organisms.

Small and motile larvae allow <u>distribution/dispersal of species of animals having restricted movement (slow moving, sessile or parasitic)</u>; e.g. ciliated miracidium of parasitic flukes allowing the flukes get from host to host; ciliated dipleura larva of the slow moving star fish; ciliated planula of the sessile sea anemones; planktonic larva of the mussels and bernacles living on rocky shores;
<u>Asexual reproduction</u>; rapidly increasing the number of new offsprings produced; e.g. larva of the parasitic fluke; and <u>allowing parasite to get from host to host/ infecting new hosts</u>;
<u>Feeding prior to formation of adult</u>; e.g. caterpillar with well-developed mandibles for chewing plant

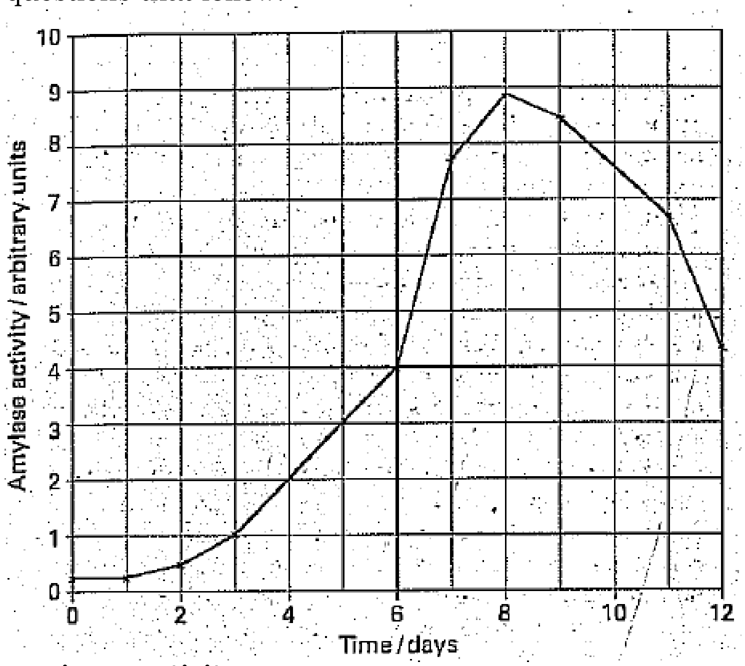
food and thus growth;
Feeding on different foods from adults <u>reduces intraspecific competition for food</u>; e.g. adult butterflies and moths feed on nectar while their larva/caterpillar feed on plant material;

6. (a) Explain the role of gibberellins in the germination of barley.

On absorption of water by the seed; by imbibition; then osmosis; embryo produces gibberellin; which diffuses into the aleurone layer surrounding the endosperm; activates/switches on transcription genes; that code for hydrolytic enzymes; storage proteins are broken down into amino acids; used for synthesis of α-amylase enzyme; and other hydrolytic enzymes; which diffuse into the endosperm;
α-amylase enzyme catalyses the hydrolysis of starch to maltose; further hydrolysed by maltase enzyme to glucose; which diffuses into the embryo; oxidized; providing energy for embryo growth;



(b) The graph in the figure below shows changes in the amylase activity in barley seeds soaked in water and allowed to germinate. Study it carefully and answer the questions that follow.



(i) Calculate the rate of increase of amylase activity in these germinating barley grains between day **2** and day **6**. Show your working.

Rate of increase in amylase activity $=\frac{4-0.5}{6-2}=\frac{3.5}{4}$

$=0.875 \cong 0.9$ arbitrary units/day

(ii) Describe the changes in the amylase activity over the 12-days period.

From day 0 to day 1, amylase activity is low; and remains constant;
From day 1 to day 3, amylase activity increases gradually;
From day 3 to day 6, amylase activity increases rapidly;
From day 6 to day 8, amylase activity increases more rapidly; to a peak;
From day 8 to day 11, amylase activity decreases gradually;
From day 11 to day 12, amylase activity decreases rapidly; to almost half its; maximum activity;

(iii) Explain the changes in the amylase activity over the 12-days period.

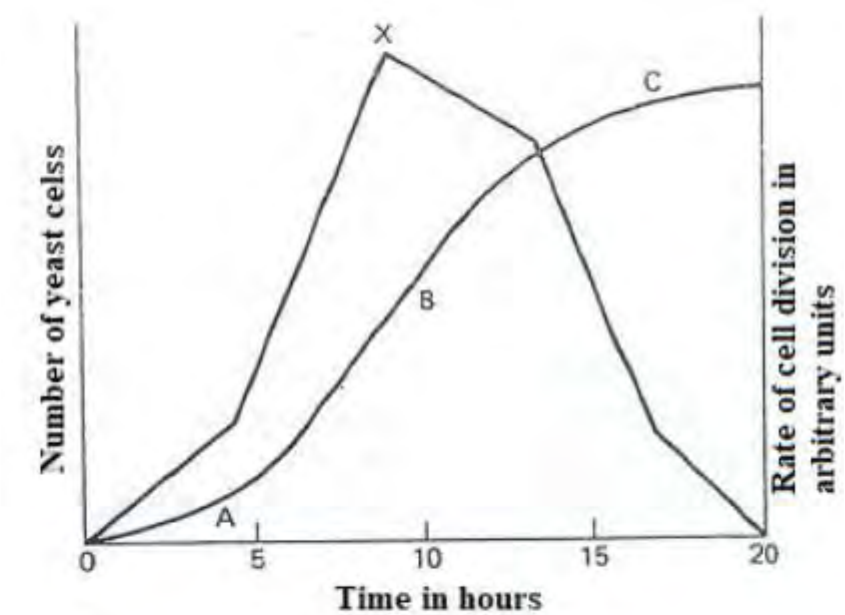
From day 0 to day 1, amylase activity is low and remains constant, because no water absorbed by the seed yet; already existing amylase in the endosperm are inactive;
From day 1 to day 3, amylase activity increases gradually because <u>little</u> water absorbed by the seed by <u>imbibition</u>; only stimulates <u>little</u> embryonic production of gibberellin by the embryo; diffuses to aleurone layer; stimulating synthesis of <u>few</u> amylase;
From day 3 to day 8, amylase activity increases rapidly to a peak because absorption of <u>much</u> water by <u>imbibition</u>; and <u>osmosis</u>; stimulates <u>much</u> embryonic production of gibberellin; diffuses to aleurone layer; stimulating synthesis of <u>more</u> amylase enzymes; which on diffusion into the endosperm, catalyses the breakdown of <u>much</u> starch to maltose;
From day 8 to day 12, amylase activity decreases because all the stored starch is depleted; photosynthesis by the first foliage leaves; can now produce carbohydrates;

(c) Describe **two** ways by which amylase activity in barley seeds can be determined.

- **Samples of barley grains at different times of germination; are ground in water; filtered; and centrifuged; to obtain a clear extract; whose activity is tested on starch solution**;
- **Place an embryo half of a cut barley seed on a <u>moist</u> surface of agar containing starch. Amylase diffusing from the seed into the agar, breaks down starch to maltose; Addition of few drops of iodine solution to the agar stains remaining starch blue-black; with size of the stained zone indicating quantity of amylase present;**

(d) Explain the role of amylase in a germinating barley seed.
Catalyses hydrolysis of stored starch; to maltose; more soluble than starch; so can be transported to growing parts of the embryo; for use as a respiratory substrate;

7. The following results expressed graphically relate to a yeast population grown in a suitable medium. One of the vertical axes relate to the growth curve and the other to the growth rate curve.



(a)Explain the difference between a **growth curve** and a **growth rate curve.**
Growth curve measures the <u>actual size</u> of yeast colony at <u>fixed time intervals</u>; while growth rate curve measures <u>increase in number yeast cells during successive time intervals;</u>
If for example the actual yeast cell numbers at 5-hourly intervals during the experiment were 10, 30, 70,90, and 100 for 25days are plotted, a growth curve similar to curve ABC is obtained;
If for example increase in yeast cells during each 5-hourly interval is calculated, and plotted, growth rate curve similar to X is obtained.

(b) Explain the shape of the growth curve in regions **A**, **B** and **C**.
A: **Number of yeast cells increases slowly; because <u>number of budding cells is small</u>; and yeasts are <u>adjusting/adapting to their new environment</u>; e.g. synthesis of new enzymes to breakdown a wide range of nutrients available in the culture medium;**
B**: Number of yeast cells increases rapidly; because number of budding individual is high; <u>no limiting factors</u> (there is plenty of nutrients and breeding space); yeast cells <u>reproduce at their maximum rate</u>;**
C: **Number of yeast cells increases slowly; because one or more <u>nutrients are getting depleted</u>; and <u>accumulation of toxic wastes, ethanol;</u>**

(c) Suggest **two** factors which may cause a reduction in the growth rate after point **X.**

- **Depletion in available food e.g. sucrose; slowing reproduction; as less energy is available for budding;**
- **Some essential minerals such as nitrogen or phosphorus may be used up; synthesis of proteins stops;**
- **Build-up of waste products such as ethanol; inhibiting further budding;**

8. (a) Describe the characteristics of apical meristematic cells in plants.
Are relatively small in size; cuboidal in shape; large nucleus; thin cellulose cell walls; few small vacuoles; dense cytoplasmic contents; tightly packed with no air spaces between them; cytoplasm contains small undifferentiated plastids/proplastids;

(b) Distinguish between **apical** and **lateral** meristems.

Apical meristems	Lateral meristems
Located at the shoot and root tips	**Located on the outer parts of stems & roots**
Cause increase in height/length of plant	**Cause increase in diameter/girth of the stem & root**
Lead to formation of primary tissues	**Lead to formation of secondary tissues**

(c) Explain the role of the following apical meristematic tissues in plant development.

(i) Procambium

Are meristematic cells; that form long strands extending backwards from the apex;
Gives rise to the vascular tissues; including pericycle; phloem; xylem and vascular cambium;
In stems/shoots, innermost cells of procambial strands differentiate into protoxylem/primary xylem; coupled with loss of protoplast; breakdown of the end walls of adjacent cells; and secretion of lignified secondary wall as annular; or spiral bands;
Outer most cells of the procambial strands differentiate into protophloem/primary phloem; consisting of sieve tube elements; and companion cells;
Procambial cells immediately inside the protophloem differentiates into metaphloem sieve tubes; and companion cells; with procambial cells immediately inside the protoxylem differentiating into metaxylem cells; coupled with loss of end walls; and primary cell walls internally covered by scalariform; reticulate and pitted secondary wall;
Both protoxylem and protophloem become crushed; by formation and enlargement of a more robust metaphloem and metaxylem;
In roots, protophloem and protoxylem form from a single central procambial strand; with protophloem first, then protoxylem; in turn forming metaphloem; and metaxylem respectively;
Outer procambial strand become the pericycle;

(ii) Ground tissue

Cells of much of the ground tissue, the cortex and pith; differentiate into parenchyma; coupled with the development of thin cellulose cell wall; extensive vacuolation of the cytoplasm;
Cortical cells immediately around each vascular bundle become elongated; with tapering end wall; primary cellulose cell wall heavily impregnated with lignin; forming sclerenchyma fibres;
Outer cortical cells become elongated; with tapering end wall; its corners having extra deposits of cellulose; forming collenchyma;
In roots, inner most cortical cells; form endodermis; with suberised radial wall;

(iii) Protoderm

Produces cells that differentiate into epidermis of roots and shoots (leaves and stems);
Stem epidermal cells secrete a waxy material, cutin; over their outer surface; with some differentiating into guard cells of the stomata;
Root epidermal cells develop tubular extensions/root hairs;

(d) Outline the differences between primary growth in roots and shoots.

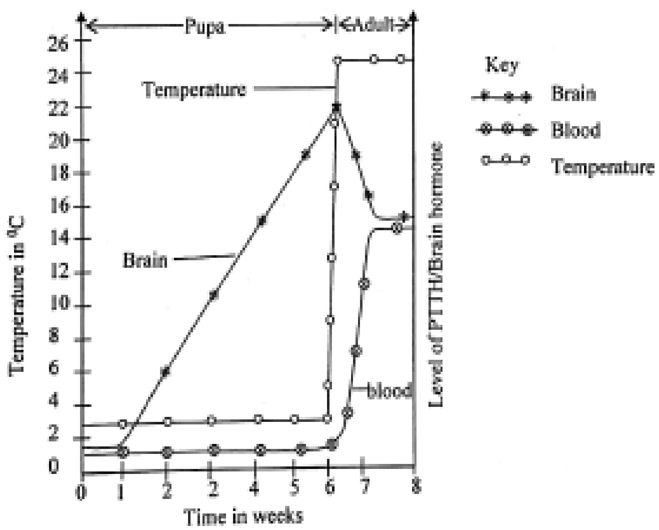
Primary growth in shoots	Primary growth in roots
Form cortical cells(parenchyma and collenchyma) with chloroplasts	**Forms cortical cells(parenchyma and collenchyma)that lack chloroplasts**
Forms epidermis with waxy cuticle	**Forms epidermis that lack cuticle**
Xylem vessels differentiate from inside outwards/endarch xylem	**Xylem vessels differentiate from outside inwards/exarch xylem**
Lateral shoots arise near the shoot apex/apical meristem	**Lateral roots arise at a considerable distance from the root apex/apical meristem**
Superficial origin of lateral shoots/Lateral shoots are exogenous in origin	**Deep-seated origin of lateral roots/Lateral roots are endogenous in origin;**
Does not involve calyptrogen/additional meristematic layer	**Involves calyptrogen/additional meristematic layer in some roots**
No endodermis formed	**Forms endodermis**
Protoxylem and protophloem develop from more than one procambial strand	**Protoxylem and protophloem develop from one central procambial strand**

(e) Describe the role of root apical meristem in plant growth.

- **Produces longitudinal growth of the root; through cell division; and subsequently elongation/expansion;**
- **Gives rise to all primary tissues in a root; through cell differentiation; for example,**
  -Root epidermis; without cuticle; thus permeable to water and mineral salts from the soil;
  -Root hairs just behind root apex of epidermis; increase surface area for absorption of water; and mineral salts from the soil for plant growth;
  -Parenchyma for storage of food manufactured by leaves during photosynthesis;
  -Pericycle which gives rise to lateral roots; increasing surface area for water and mineral salts uptake by plant roots; and form cork cambium responsible for producing protective

covering of old roots;
-<u>Vascular cambium</u>; that increase the diameter/width/girth of the plant; during secondary growth;
-<u>Endodermis</u>; with suberised radial walls; thus control passage of absorbed water and mineral salts from the cortex into root vascular tissues;
-<u>Primary xylem/protoxylem</u>; that transports water and mineral salts to all parts of the plant; including growing root apex;
-<u>Primary phloem/protophloem</u>; transports organic substances in solution to all parts of the plant;
-<u>Root cap</u>; that protects the root tip from mechanical damage as it grows through the soil; and stores large starch grains, acting as gravity sensors; allowing plant roots grow into the soil; absorbing water and mineral salts;

9. The graph in the figure below shows the relationship between the levels of prothoracicotropic hormone (PTTH) or brain hormone in the brain and in blood of the mulberry silk worm, *Bombyx mori* first at 3℃ and later transferred to a temperature of 25℃ with time of its development from pupa to adult. Study the figure carefully and answer the questions that follow.



(a) Compare the levels of brain hormone in the brain and blood of silkworm during the study period.

<u>Similarities</u>

In both the brain and blood, levels of brain hormone remain constant from week 0 to week 1; and week 7 to week 8;

<u>Differences</u>

Level of brain hormone in the brain	Level of brain hormone in blood
Higher from week 0 to week 8	**Lower from week 0 to week 8**
Increases(rapidly) from week 1 to week 6	**Remains constant from week 1 to week 6**
Decreases (rapidly) from week 6 to week 7	**Increases (rapidly) from week 6 to week 7**
Peak attained	**Maximum attained**

(b) Explain the relationship between the levels of brain hormone in the brain and blood of the silk worm during its development from pupa to adult.

Level of brain hormone in both the brain and blood is low and remains constant between week 0 and week 1, because of <u>no secretion of brain hormone by the neurosecretory cells</u> of the brain; owing to <u>young age</u>; and thus <u>no brain hormone is released into blood</u>; at low temperature;

As level of brain hormone in the brain increases between week 1 and week 6, blood brain hormone level is low and remains constant because with neurosecretory cells <u>well developed;</u> secretes <u>large quantities of brain hormone</u>; and <u>stored in corpus cardiacum/ not released into blood at low temperature;</u>

As level of brain hormone in the brain decreases between week 6 and week 7, blood brain hormone level increases because <u>increased temperature</u>; causes release of brain hormone into blood; which on <u>accumulation</u>; inhibits further secretion of brain hormone by neurosecretory cells; but <u>stimulate the prothoracic gland to secrete moulting hormone/ecdysone;</u> <u>dormancy/diapause is broken</u>; pupa metamorphoses into adult;

Level of brain hormone in both the brain and blood remains constant between week 7 and week 8, because with the <u>formation of adult</u>; further <u>secretion of brain hormone by the neurosecretory cells</u> of the brain is inhibited;

(c) Suggest any changes that occur in the silkworm during its pupa stage of development.

Larval organs such as abdominal pro-legs/pseudo legs; anal horn; and mouth parts are lost;

Adult organs such as antenna; wings; and copulatory apparatus develop;

(d) State **two** other environmental factors which affect secretion of brain hormone in insects.

Changes in food supply;
Changes in light;

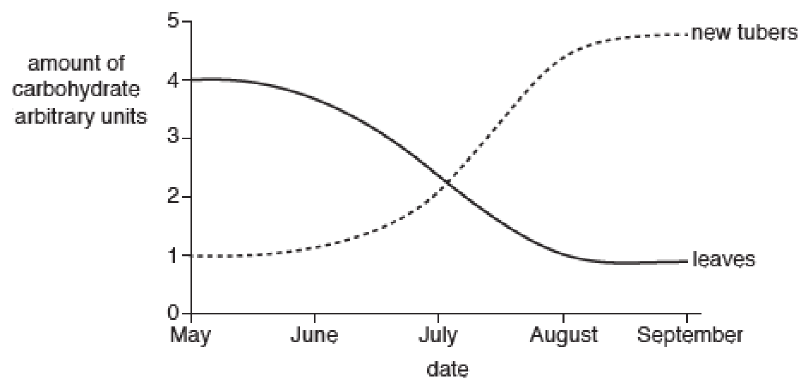
10. (a) (i) Distinguish between **dormancy** and **hibernation**.

Dormancy is a state when organisms are in unfavourable conditions, ceasing growth and development; coupled with fall in their metabolic rates; while hibernation is a form of dormancy in <u>animals</u> during <u>low environmental temperatures in early winter;</u>

(ii) Of what significance is dormancy to organisms?

- **Enables organisms to withstand unfavourable conditions, such as drought, food shortage and winter cold;**
- **Allows time for distribution by dispersal agents such as wind and water; thus colonization of new habitats;**
- **Allows any necessary internal changes to take place for example embryo of seeds to attain full maturity;**

(b) Figure below shows the amount of carbohydrate stored in the leaves and new tubers of Irish potato plants grown in south western part of Uganda between May and September.



(i)Compare the amounts of carbohydrates in tubers and leaves between May and September.

<u>Similarities</u>

Both tubers and leaves have equal amounts of carbohydrate in July;

<u>Differences</u>

-Amount of carbohydrate in new tubers increases while amount of carbohydrate in the leaves decreases from May to September;

-Amount of carbohydrate in tubers is lower than that in the leaves from May to July;

-Amount of carbohydrate in leaves is lower than that in tuber from July to September;

(ii) Explain the difference in amounts of carbohydrates in tubers and leaves in May and September.

In May, amount of carbohydrate in leaves is <u>higher</u> than in new tubers, because with <u>no sprouting/growth</u> of tubers; leaves are carrying out photosynthesis;
In September, amount of carbohydrate in leaves is <u>lower</u> than in new tubers; sugars manufactured during photosynthesis by leaves; are translocated to the new tubers; stored as starch; or aging of leaves coupled with their abscission reduces the rate of photosynthesis;

(iii) How important are the changes in the amount of carbohydrate in leaves and tubers to a potato farmer in temperate region?

New tubers formed store soluble food materials from photosynthesizing leaves; as starch; remaining dormant/undergo period of suspended growth in the soil; with stored food only mobilized, and translocated to the growing plant regions of the plant the following year; allowing the farmer's potato plants to survive frost during winter from one growing season to another; without exhausting food reserves;

(c) Describe the photoperiodic control of tuber formation in potatoes.

Photoperiodic stimulus, longer nights/short days; is detected by leaves; phytochrome far red is slowly converted to phytochrome red; which on <u>accumulation</u>; inactive tuberigen is converted to active tuberigen; translocated to the tips of stolon/site of tuber formation in a plant; longitudinal growth of stolon is suppressed; with radial growth initiated at subapical stolon region; to form tuber;

(d) Other than tuber formation in potatoes, give other photoperiodic responses of plants.

- **Seed germination;**
- **On set of bud dormancy;**
- **Leaf abscission;**
- **Cambium activity;**
- **Bulb formation;**
- **Etiolation (Growth of abnormally long internodes);**

(e) Give the adaptations of potato tubers to survive in their habitats.

Swollen; to store food; ensuring survival during harsh conditions;
Axillary buds/lateral buds; for vegetative propagation; ensuring continuity of life;
Numerous adventitious roots; increasing surface area for absorption of water and mineral salts;

11. (a) Define the following terms.

(i) Growth:

Permanent and irreversible increase in size/dry mass of an organism;

(ii) Development:

Increase in complexity accompanying growth;

(iii) Morphogenesis:

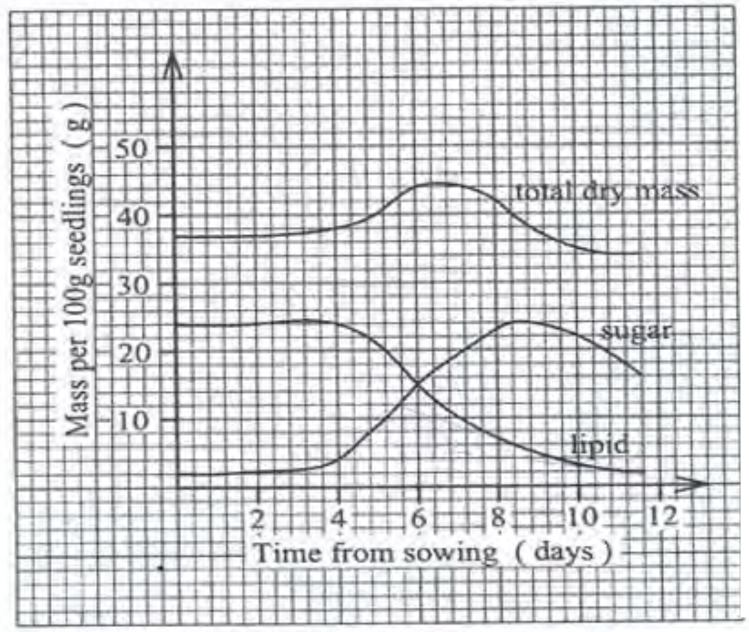
Overall change in form; and structure of an organism; due to growth and development;

(b) Give an account of the factors that affect growth and development of organisms.

Factors	Effect on growth and development
External	
Oxygen	**Aerobic respiration; providing energy for cell division during growth/germination.**
Temperature	**Suitable temperature allow enzyme controlled reactions to proceed efficiently such as in photosynthesis; germination and respiration;** **Low temperature is essential for breaking dormancy of perennating organs; and winter buds; stimulate flowering in biennals and perennial plants;** **Chilling reduces concentration of germination inhibitors in seeds;**
Water	**Vacuolation in plant cells; causing elongation of cells; during primary growth of roots and shoots;** **Raw material for photosynthesis;** **Maintenance of turgidity of young growing organs;** **Essential in germination;** **Uptake and transport of sugars and minerals within organisms;** **Affects direction of root growth/hydrotropic response;**
Light	**Photolysis of water during photosynthesis; building up carbohydrates; from which fats, proteins for growth are synthesized;** **Germination in some seeds e.g. lettuce;** **Synthesis of vitamin D in human skin; increasing calcium ion uptake from the gut; essential for bone formation;** **Length of light period affects time of flowering; leaf fall; bud dormancy; formation of storage organs (bulbs, tubers, corms) and tap roots by herbaceous perennials;** **Affects direction of shoot and root growth by altering the distribution of auxins;** **Total darkness causes etiolation;**
Nutrients	**Plants carry out autotrophism; supplementing with mineral uptake from the soil; e.g. <u>Magnesium</u> for chlorophyll synthesis; used in sun light absorption; for photosynthesis; <u>nitrates</u> for protein synthesis;** **Animals carry out heterotrophism; to obtain nutrients such as <u>proteins</u> for maintenance and repair of tissues; <u>sugars</u> oxidized producing energy for growth**
Carbon dioxide	**Raw material for photosynthesis**
Pollutants	**High concentration of Sulphur dioxide is toxic to higher plants**
Internal	
Hormones	**<u>Growth hormone/somatotropin</u>; in mammals stimulates protein synthesis; by stimulating the liver to secrete somatomedins (insulin-like growth factor); increased respiration of fats; promotes growth of skeleton and muscles during child hood and adolescence; increasing amino acid intake into cells;** **<u>Thyroxine/Tetraiodothyronine(T_4)</u> in mammals regulates rate of tissue metabolism (basal metabolic rate); stimulates respiration of fats and glucose; stimulates growth of skeleton in children;** **<u>Auxins</u> regulate cell elongation and differentiation of vascular tissues; inhibits growth of lateral buds; stimulates growth of adventitious roots; affects phototropic and geotropic responses of roots and shoots; promote fruit formation; secondary thickening by promoting cell division of cambium;** **Inhibits abscission of fruits, young leaves, and flowers before maturity;** **<u>Gibberellins</u>; breaks dormancy of seeds of cereals; promote flowering in long-day plants; fruit growth; growth of lateral buds; stimulates growth of stems of dwarf plants; stimulates cell division at the apical meristem and cambium;**
Genotype	**Directs the synthesis of proteins(enzymes) within cells; through transcription; and translation; thus controls metabolism within cells;** **Controls cell growth and division in the cell cycle;**
	Selection pressure alter gene frequency; with changing environmental conditions favoring genes with selective advantage; increasing their frequency in the gene pool; Stable environment allows expression of a variety of genes

A discerning candidate may also include factors such as parasites, and diseases;

12. The graph in the below shows changes in content of lipids and sugar in castor oil seeds during germination in the dark. Study it carefully and answer the questions that follow.



(a) Explain the changes in each of the following during germination of castor oil seeds.

(i) Lipid content

From 0day to 4days, lipid content is high; and remains constant; because no activation of hydrolytic enzymes; no conversion of lipid to sugars; for translocation to the embryo;
From 4days to 7days, lipid content decreases rapidly; <u>much</u> conversion of lipids to sugars; translocated to the growing parts of the embryo;
From 7days to 11.6days lipid content decreases gradually; to the lowest; because depletion of lipids from the reserves/conversion of <u>little remaining lipids to sugars</u>; for growth of the embryo;

(ii) Sugar content

From 0day to 2.8days, mass of sugars is low and remains constant; because lipids have not been converted to sugars; for translocation to the growing parts of the embryo.
From 2.8days to 4days, mass of sugars increases gradually; because of <u>little</u> conversion of lipids to sugars; for translocation to the growing parts of the embryo;
From 4days to 8.4days, mass of sugars increases rapidly; to a peak; because of <u>much</u> conversion of lipids to sugars; for the translocation to the growing parts of the embryo;
From 8.4days to 11.6days, mass of sugars decreases gradually; because of depletion of lipid reserves; and respiration of sugars in the embryo;

(iii) Total dry mass

From 0day to 2.4days, total dry mass remains constant; because lipids have not been converted to sugars;
From 2.4days to 6days, total dry mass increases gradually; to a maximum; because lipids are converted to sugars; for translocation to the growing parts of the embryo;
From 6days to 7.2days, total dry mass remains almost constant; because rate of conversion of lipids to sugars is equal to rate of respiration of the sugars;
From 7.2days to 11.6, total dry mass decreases gradually; to the lowest; because of depletion of lipid reserves; and respiration of sugars in the embryo;

(b) When the respiratory quotient (RQ) of the castor oil seedling was measured on the fifth day, the embryo was found to have an RQ of about 1.0, while the cotyledons had an RQ of about 0.4– 0.5. Suggest an explanation for these results.

At day 5, RQ of embryo is 1.0 because embryo is <u>aerobically respiring</u>; <u>sugars/carbohydrates derived from lipids;</u>
RQ of remaining cotyledons (0.4-0.5) because cotyledons are gaining energy from <u>conversion of lipids to sugars</u>; and possibly <u>oxidation of both sugars and fatty acids</u>;

(c) What would you expect the respiratory quotient to be on day 11? Explain briefly.

Respiratory quotient of the whole seedling would be slightly less than 0; because of <u>aerobic respiration of sugars</u>, RQ=1; and some <u>little conversion of lipids to sugars</u>, RQ=0.4-0.5;

$$C_{18}H_{34}O_2 + 13O_2 \longrightarrow C_{12}H_{22}O_{11} + 6CO_2 + 6H_2O + \text{energy}$$

Ricinoleic acid (fatty acid derivative from lipid)   **Sucrose**

$$C_{12}H_{22}O_{11} + 12O_2 \longrightarrow 12CO_2 + 11H_2O + \text{energy}$$

$$25O_2 \longrightarrow 18CO_2$$

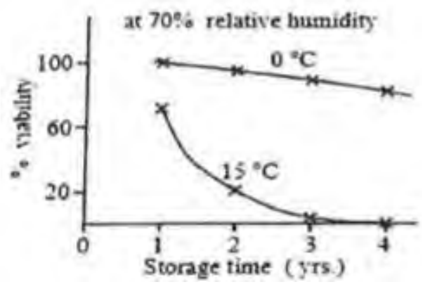
$$RQ = \frac{18}{25} = 0.72$$

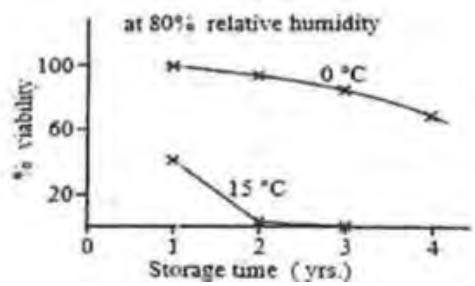
(d) Why was the experiment carried in the dark?
To prevent occurrence of photosynthesis; which would form new sugars; thus interfering with the experimental results;

(e) Suggest differences in changes of lipids, sugar and total dry mass of castor oil seedlings if they were introduced to a well illuminated environment on the sixth day. Explain each difference suggested.
In presence of light, mass of sugar would increase; because photosynthesis would commensurate; producing more sugars;
Lipid content would decrease gradually; because of the utilization of sugars from photosynthesis by the embryo; during respiration;
Total dry mass would continue to increase; because with formation of first foliage leaves; photosynthesis occurs; rate of photosynthesis exceeds rate of respiration;

13. (a) Distinguish between **seed viability** and **seed longevity**.
Seed viability is a measure of the percentage of seeds that are alive after storage time while seed longevity is the period over which a seed remains viable and capable of germination;

(b) The graphs in the figures below show viability of Fescue grass seed at different conditions. Study them carefully and answer the questions that follow.





(i) From the figures, state the factors that affect viability of Fescue grass seeds.
Temperature; Storage time; Relative humidity/moisture content

(ii) Describe the effect of each factor in b(i) above on the viability of the seed.
Increase in storage time decreases viability of the seed;
Increase in relative humidity decreases more viability of the seed (vice versa)
Increase in temperature decreases more viability of the seed (vice versa)

(iii) Explain the effect of each factor in b(i) on the viability of the seed.
Longer storage time results into <u>depletion of food reserves</u>; and <u>accumulation of toxic substances</u>; which reduces seed viability;
Both high temperature and relative humidity <u>increase metabolism</u>; resulting into <u>faster</u> depletion of food reserves; and <u>faster</u> accumulation of toxic wastes;

14. Two plant seedlings **X** and **Y** of different species had their respiratory quotients measured during their early development. The results are given in the Table below.

Number of days from start of germination	X	Y
1	0.61	0.65
5	0.41	0.91
9	0.71	0.99
13	0.70	1.02

(a) What is meant by 'respiratory quotient'
Ratio of volume of carbon dioxide produced to volume of oxygen consumed during <u>respiration</u> over a <u>given period</u>;

(b) Using the results of the experiment, discuss the possible nature of the respiratory substrates being used by **X** and **Y**

<u>Species X</u>:
In the early stages of germination, RQ is 0.61 probably due to the <u>complete metabolism of stored lipid</u> (RQ=0.7); and <u>little conversion of stored lipid to carbohydrates</u> (RQ=0.35);
After 5days from start of germination, <u>more conversion of stored lipids to carbohydrates</u> occurs;
Between day 9 and day 13 after the start of germination, <u>some stored lipids are still being converted to carbohydrates</u> (RQ=0.35); and <u>aerobic respiration of the formed carbohydrates</u>(RQ=1.0); causing R.Q of 0.71/0.7;

<u>Species Y</u>
In the early stages of germination, R.Q is 0.65 probably due to the <u>complete metabolism of lipid</u> (R. Q=0.7); and <u>little conversion of stored lipid to carbohydrates</u> (R. Q=0.35);
After 5days from start of germination, much aerobic respiration of stored or derived carbohydrate from lipids occurs; with metabolism of <u>little</u> remaining lipids in the stores; giving an R.Q of 0.91.
Between day 5 and day 13 after the start of germination, R.Q increases gradually; because <u>only aerobic respiration of carbohydrates occurs;</u>

(c) Describe **two** circumstances in which respiratory quotient of germinating seeds is greater than1.0

- **At start of germination, (first 24-48hours of germination); testa of some seeds is relatively impermeable; insufficient amounts of oxygen diffuse into the seed; much anaerobic respiration than aerobic respiration occurs;**
- **Large and bulky seeds such as broad bean have a small surface area to volume ratio; resulting into inadequate supply of oxygen to respiring cells; much anaerobic respiration than aerobic respiration occurs;**

15. (a) Explain the following observations.

(i) Dormancy of seeds of some lettuce varieties is broken by light after water uptake.
Red light stimulates lettuce seed germination; but far-red light inhibits it; In presence of red light; phytochrome red is converted to phytochrome far- red; which on <u>accumulation</u>; production of gibberellic acid is stimulated; which stimulate the synthesis of hydrolytic enzymes in the seed; catalyzing hydrolysis of stored food into simple soluble products; translocated to the embryo for growth;

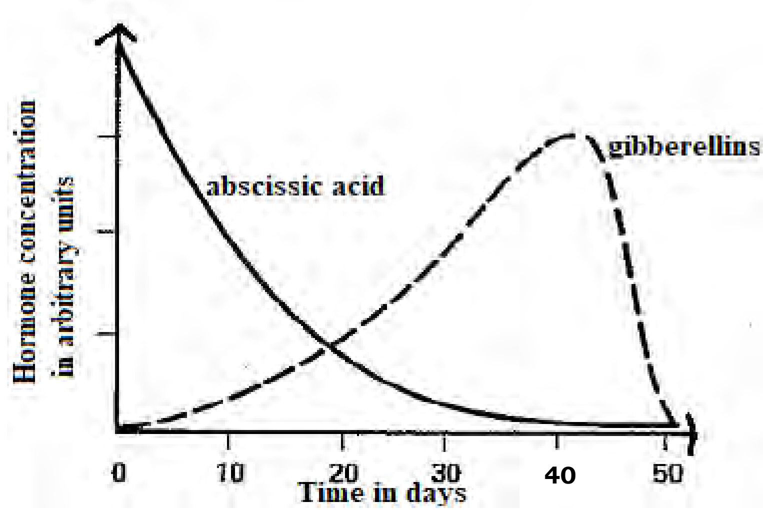
(ii) Many light-dependent seeds are small.
Small seeds have relatively small food reserves; light-dependence allows their embryonic shoot system to quickly reach at/near the soil surface; so that photosynthesis can start before the food reserves are depleted;

(iii) Lettuce seeds do not germinate under canopy grounds.
Canopy of leaves on trees absorb much red light; light reaching canopy ground is thus enriched in far-red; seeds accumulate phytochrome red; which inhibits germination;

(iv) Many weeds start to sprout in freshly ploughed soils.
Ploughing brings the light dependent seeds of weeds to the soil surface; where their dormancy is broken;

(v) Trying to germinate seeds in space is very difficult.
In space, gravity is 0; thus no geotropic responses; radicles and plumule grow in all directions; soil/growth medium/water cannot be kept in one position/place. In space, oxygen is very insufficient; thus seeds must be grown in air-tight containers;

(b) The graph in the figure below shows the effects of chilling on the concentrations of two different hormones in the seeds of sugar maple. Study it carefully and answer the questions that follow.



(i) State any differences observed in the concentrations of the two hormones in the seeds of sugar maple.

Abscisic acid concentration	Gibberellin concentration
Initially higher	**Initially no gibberellin present**
Decreases from day 0 to day 50;	**Increases first, then decreases**
Does not peak	**Peaks**
Higher from day 0 to day 20	**Lower from day 0 to day 20**
Lower from day 20 to day 50	**Higher from day 20 to day 50**

(ii) Explain the variation in the concentrations of gibberellins for the first 40 days.

Gibberellin concentration increases; because chilling stimulates its synthesis by the embryo; for synthesis of α-amylase enzyme; and other hydrolytic enzymes; which diffuse into the endosperm; α-amylase enzyme catalyses the hydrolysis of starch to maltose; further hydrolysed by maltase enzyme to glucose; which diffuses into the embryo; oxidized; providing energy for embryo growth;

(iii) Of what advantage is the difference in the concentration of the two hormones in seeds of sugar maple to a farmer in temperate regions?
Temperate regions are characterized by changes in seasons; thus with chilling, concentration of abscisic acid decreases; while concentration of gibberellins increases towards the end of dormancy; allowing growth only when more suitable weather conditions of spring and summer are about to follow;

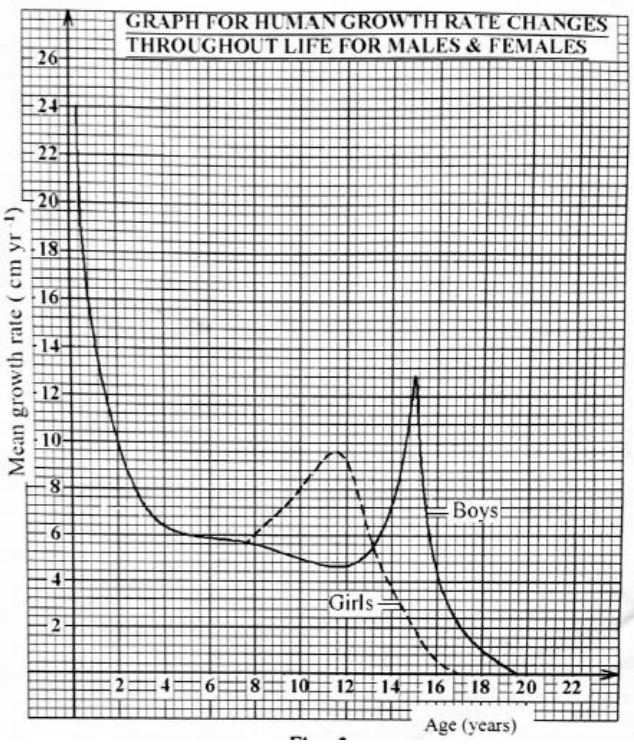
(iv) Apart from seed germination, give **two** other instances where low temperature treatment have been used to initiate development following dormancy.

- **Breaking dormancy of winter buds in deciduous shrubs and trees;**
- **Breaking dormancy of perennating organs such as bulbs, corms, tubers and rhizomes;**
- **Stimulate flowering in biennals and perennial plants;**

16. (a) Distinguish between **absolute growth rate** and **relative growth rate**.

Absolute growth rate(AGR) is the increase in size of an organism per unit of time; while relative growth rate(RGR) is the increase in growth over a period of time expressed as a percentage of the already existing amount of matter/rate of increase in size per unit of already existing size of the organism;

(b) The graph in the figure below shows the mean growth rate changes in centimetres per year, in boys and girls, from birth to maturity. Study it carefully and answer the questions that follow.



(i) Compare the mean growth rate in boys and girls.

Similarities.

Mean growth rate in both boys and girls,

- **Decreases from 1year to 7.6years;**
- **Spurts/attain peak;**
- **Decreases to zero after peak**
- **Is equal at 7.6years; and 13.2 years;**

Differences

Mean growth rate in boys	Mean growth rate in girls
Attains higher peak/spurt	**Attains lower peak/spurt**
Spurt later/peaks later	**Spurt earlier/peaks earlier**
Stops later	**Stops earlier**
Decreases rapidly after peak	**Decreases gradually after peak**
Decreases gradually from 7.6years to 11.6years	**Increases gradually from 7.6years to 11.6years**
Increases rapidly from 12yrs to 15years	**Decreases rapidly from 12years to 15years**
Lower from 7.6years to13.2 years	**Higher from 7.6years to13.2 years**

Mean growth rate in boys is higher than that in girls from 13.2 years to 16.8years;

(ii) Explain the relationship between the size attained by reproductive organs in boys and girls and the mean growth rate at puberty.

Onset of puberty/adolescence is from 11years to 20years;
In girls, mean growth rate spurts earlier than in boys; because of early secretion of oestrogen hormone; that stimulate development of secondary sexual characteristics; and reproductive organs;
In boys, from 12years to 15years, mean growth rate increases rapidly because of secretion of testosterone hormone; that maintains and enlarges the testes;
Mean growth rate of both boys and girls, decreases after a peak because reproductive organs have attained maximum size; level of sex hormones thus lowers;

(iii) Outline **three** main factors that affect growth rate in humans.

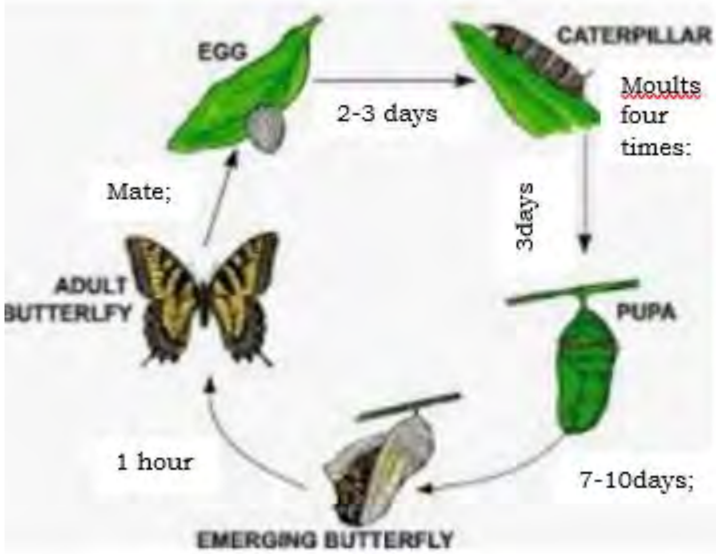
- **Genotype;**
- **Concentration of growth hormones such as Human Growth hormone, Thyroxine in blood;**
- **Dietary factors e.g. vitamins and inorganic salts;**

Main factors affecting growth pattern *Acc Diseases*

(c) Outline **four** differences in plants and animals.

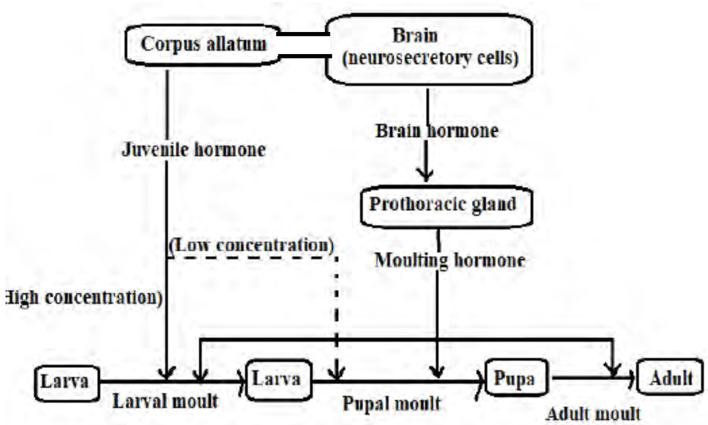
Growth in animals	Growth in plants
Occurs all over the body	**Occurs in meristems**
Stops at adulthood/Limited	**Continues throughout plant life/unlimited e.g. in perennial plants**
Tissues and organs are more adapted and specialized.	**Tissues and organs are less adapted and specialized.**
Growth control factors not sensitive to environmental factors such as sun light.	**Growth control factors not sensitive to environmental factors such as sun light.**

17. (a) Give a brief account of the growth and development from egg to adult of a named insect.



Adult male and female <u>butterfly</u> mate; eggs are <u>fertilized internally</u> in the female's body; Female butterfly lays eggs <u>singly</u>; on the underside of young leaves; After about <u>2days to 3days</u>; eggs hatch into larvae/caterpillars; which feed on plant leaves using their mandibles and grow quickly; After <u>3days</u>; caterpillars moults <u>four</u> times; changing into pupa/chrysalis; After <u>7days to 10 days</u>; tissue reorganization occurs; pupal skin splits; adult butterfly emerges; Small and crumpled wings expand, dry and harden; and after an <u>hour</u>; adult butterfly is ready to fly away, feed , mate and lay more eggs.; Such life cycle is called <u>complete metamorphosis; /Holometabolous</u>

(b) Describe the hormonal control of larval development for the above named insect into adult.



Distention of the insect abdomen after feeding/swallowing; stretch receptors here are stimulated; impulses fired along afferent neurones to the brain; stimulating the neurosecretory cells in the brain to secrete a brain hormone prothoracicotropic hormone; which flows in blood to the thorax; and on <u>accumulation</u>; stimulates the prothoracic gland to secrete moulting hormone/ecdysone; During the <u>early</u> larval stages, (instars); high concentration of juvenile hormone/neotonin is secreted by a gland, corpus allatum in the brain; maintains larval characteristics/larval moults occur; under the influence of ecdysone; As larva <u>matures</u>, secretion of neotonin by the brain is inhibited; blood neotonin level falls; larva metamorphoses into pupa; and in complete absence of neotonin, pupa metamorphoses into adult;
Ecdysone switches on genes needed to produce enzymes necessary for ecdysis; and thus growth;

(c) Discuss the stages in a moulting process during insect metamorphosis.
Epidermal cells separate from the old cuticle; begin to divide laterally producing a folded surface; <u>At the same time</u>, epidermal cells secrete a moulting fluid; containing enzymes, protease; and chitinase; only activated when new layer of epicuticle is secreted by epidermal cells;
Old endocuticle/soft inner part of the old cuticle is completely digested; leaving hard outer part (old epicuticle and old exocuticle) with the new epicuticle protected from enzyme action by substances in its waxy layer; products of digestion are absorbed back into the epidermis via pore canals; used to build new cuticle;
Expansion of the insect on swallowing water or air; and stretching of the new cuticle; outer part of new cuticle is hardened by impregnation of chitin with tanned(hardened) protein from the epidermis;
Deposition of wax at surface of cuticle makes it waterproof;

(d) Outline **three** basic features common to all larval forms of organisms.
- **Markedly different in structure from the adult;**
- **Self-supporting and lead an independent life; having different ways of fending from the adults;**
- **Incapable of sexual reproduction; only reproducing asexually in specialized instances;**

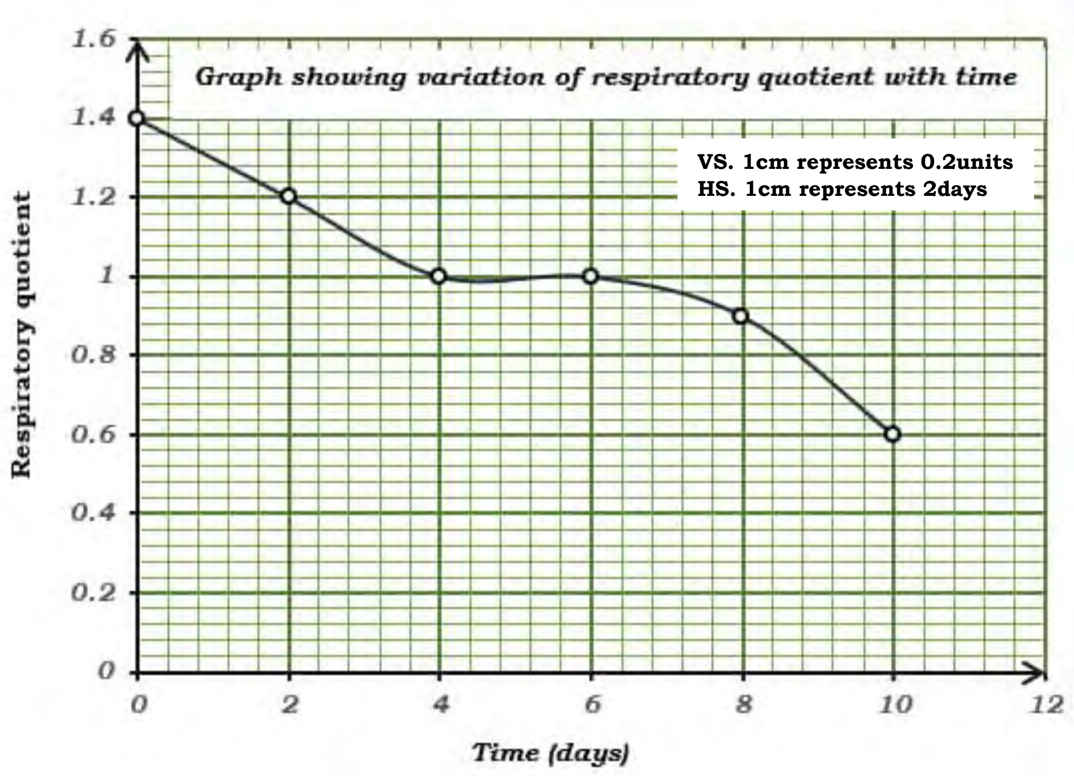
(e) To what extent is metamorphosis in the life cycle described in (a) above different from metamorphosis in the frog?
Gradual adjustments in size and structure occur between tadpole and adult frog while

abrupt restructuring occurs during pupation in butterfly metamorphosis;

18. During germination of maize seeds, the volume of carbon dioxide evolved and oxygen consumed by the seed embryo were established with time and recorded in the table below.

Time(days)	0	2	4	6	8	10
Volume of carbon dioxide(cm³)	8.4	7.2	8.0	8.5	9.4	6.8
Volume of oxygen(cm³	6.0	6.0	8.0	8.49	10.4	11.3
Respiratory Quotient(R.Q)	**1.4**	**1.2**	**1.0**	**1.0**	**0.9**	**0.6**

(a) Calculate the respiratory quotients and fill the values in the Table above.
(b) Draw a graph to show the variation of respiratory quotient with time



(c) Describe the variation of the respiratory quotient of seedlings with time.
Initially at day 0, R.Q was high; and above 1.0;
From day 0 to day 4, R.Q decreases rapidly;
From day 4 to day 6, R.Q remains constant;
From day 6 to day 8, R.Q decreases gradually;
From day 8 to day 10, R.Q decreases rapidly;

(d) Account for the variation of the respiratory quotient with time.
At the start of germination, R.Q was high; and above 1.0 because the embryo respired both aerobically and anaerobically; hard and impermeable testa, prevents entry of sufficient oxygen into the seed;
From day 0 to day 4, R.Q decreases rapidly to 1.0 because imbibition of water softens the testa; thus sufficient oxygen enters the seed; more aerobic respiration of stored carbohydrates occurs than anaerobic respiration;
From day 4 to day 6, R.Q remains constant at 1.0; because with fully ruptured testa, sufficient oxygen enters the seed; allowing complete aerobiosis of stored carbohydrates;
From day 6 to day 10, R.Q decreases because the seedling had developed the first foliage leaves; thus carry out photosynthesis; thus consuming some carbon dioxide from respiration;

19. (a) How is secondary thickening brought about in stems of dicotyledonous plants?
Results from mitotic division of vascular cambium; and cork cambium (Phellogen);
Tangential mitotic division of narrow elongated cambial cells, fusiform initials; produces secondary xylem; to the inside; and secondary phloem; to the outside; with more secondary xylem produced; and more lignified than secondary phloem;
Tangential mitotic division of spherical shaped cambial cells, Ray initials; produces rays of parenchyma cells/medullary rays; running radially between secondary xylem and secondary phloem;

Increased girth ruptures the surface tissues; thus tangential mitotic division of cork cambium occurs; forming cork cells/phellem; on the outside; and secondary cortex; on the inside;
Walls of cork cells are impregnated with suberin; and at intervals, cork cells are loosely packed; forming lenticels;

(b) (i) Describe the role of vascular cambium in the formation of annual rings in temperate trees.
In wet spring, mitotic division of the cambium produces thin walled secondary xylem vessel; with large lumens/diameter; constituting spring wood;
In dry summer, narrow; thick walled secondary xylem vessels; and more sclerenchyma fibres are formed; constituting summer wood; harder; and denser; than the spring wood;
Alternate bands of spring wood and summer wood form the concentric annual rings;

(ii) How is the formation of annual rings an important scientific phenomenon?
Used in dendroclimatology; to study present climate; reconstructing and analysis of past climate variability; with favourable climatic conditions such as warm and wet; producing more wood; and wider tree-rings than poor climatic conditions;
Used in dendrochronology; dating of wood by recognizing patterns of annual rings; with the pattern giving the time during which the wood was growing;

(c) Describe the structure, distribution and functions of the following in plant development.

(i) Sapwood
Lighter in colour; consist of living parenchyma cells; and partially lignified younger xylem cells; are found at the periphery of the stem;
Transports water; and mineral salts from the roots to the leaves;

(ii) Heartwood
Darker in colour; owing to deposition of tannins, resins and dyes;
Consists of old; completely dead xylem cells; found at the centre of the stem;
Offers support to the plant;

(d) Explain the following observations.

(i) Few annual plants need secondary growth
Most annual plants do not grow sufficiently large; to warrant the development of the more robust support; provided by secondary thickening;

(ii) Virtually there are no monocotyledonous trees.
With lack of vascular cambium in monocotyledonous plants, no secondary thickening occurs; secondary xylem thus not produced; to offer much support to the large mass of trees;

(iii) Most conifers and dicotyledonous angiosperms need secondary growth.
Conifers and dicotyledonous angiosperms are perennial plants; growing in length each year; their mass thus increases beyond limits supported by their primary tissues only; calling for secondary growth to produce more supportive secondary tissues;

(iv) Grass shoots regenerate rapidly even after being cut at their tips by grazing animals.
Grass plants possess intercalary meristems; at their internodes/ between leaf nodes; which promote longitudinal growth of the shoot; due to its mitotic division even on removal of the apical meristem by grazing animals;

(e) Of what significance is secondary thickening to plants?

- **Produces considerable secondary xylem that are heavily lignified; giving extra support to the plant;**
- **Impregnation of cork cells with suberin serves to reduce water loss, prevents infection; and mechanical injury to plants;**
- **Increased number of xylem and phloem improves transport of water, mineral salts and food substances respectively in plants;**
- **Lenticels formed improves gaseous exchange by higher plants; and provides space in the heartwood for deposition of wastes;**
- **Medullary rays transport water and mineral salts from the xylem; and food substances from the phloem; radially across the stem;**
- **Medullary rays also store food during periods of dormancy in winter within some plants**

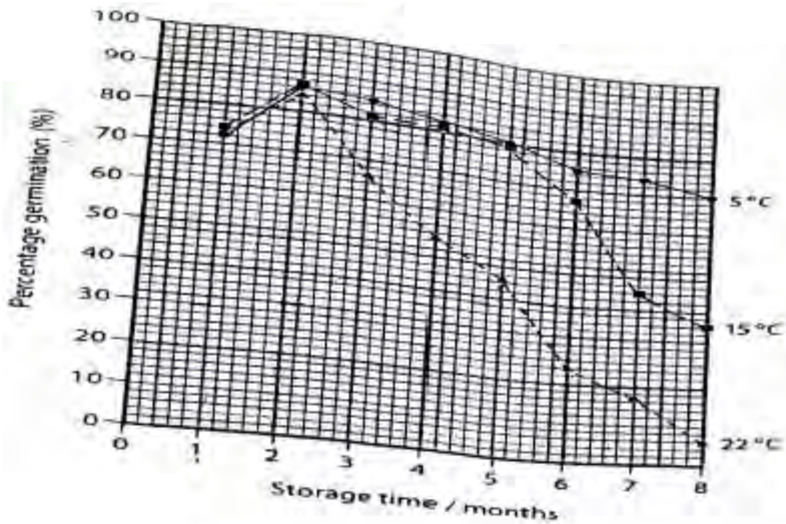
(f) Distinguish between **primary growth** and **secondary growth**.

- **Primary growth increases length of a plant while secondary growth increases girth/width/diameter of a plant.**
- **Primary growth results from cell division in apical meristem and intercalary meristem; while**

secondary results from cell division in lateral meristem;

- **Primary growth occurs in monocotyledonous plants and herbaceous(non-woody) ones while secondary growth occurs in woody perennial plants (shrubs and trees);**
- **Occurs at the onset of plant growth; while secondary growth occurs later in plant life after primary growth**;

20. Seeds were stored at 5℃, 15℃ and 22℃ for eight months. Samples of seeds were germinated every month and percentage of seeds that germinated were recorded. Graph below shows the results of this investigation.



(a) Using information on the graph, describe the effect of storage time and temperature on the percentage germination of seeds.

Increase in storage time from 1month to 2months, rapidly increased percentage germination of seeds stored at all temperatures;

Increase in storage time from 2months to 8months, decreased percentage germination of stored seeds gradually at 5℃, moderately at 15℃ and rapidly at 22℃;

(b) Explain the effect of storage temperature on the percentage germination of stored seeds.

Increase in storage temperature from 5℃ to 22℃, rapidly decreased percentage seed germination because of <u>rapid metabolism</u>; resulting into <u>rapid depletion of food reserves</u>; and <u>rapid accumulation of metabolic toxins</u>;

(c) Explain why seeds are dried before they are stored in a seed bank.

- **To reduce seed water/moisture content; reducing on metabolism; consequently, <u>low rate</u> of depletion of food reserves; and accumulation of toxic wastes; thus maintaining its viability; and vigor during storage;**
- **Increase dormancy of seeds; and after-ripening effect;**
- **Prevents growth and harmful effects of fungi on seed viability;**

(d) In predicting the drying period of seeds, 1000g of seeds with 12% moisture content were dried to 5% content. Determine the;

(i) Weight of these seeds after drying.

Final seed weight= Initial seed weight X $\frac{100-\text{initial \% moisture content}}{100-\text{final \% moisture content}}$

Final seed weight= 1000X$\frac{100-12}{100-5}$

Final seed weight=926.315≅ 926.3g

(ii) Loss in weight of these seeds during drying.

Weight loss= Initial weight -Final weight

Weight loss= 1000-926.3

=73.7g

21. The Table below shows the changes in RQ as a soaked seed germinates. Study it and use it to answer the following questions.

	Treatment	R.Q
1	4h soaking in water	6.0
2	4h soaking +4h in air	1.8
3	4h soaking +24h in air	1.0

(a)Suggest an explanation for the:

(i)High RQ value obtained in treatment 1.

<u>Less dissolved oxygen</u> diffused into the seed; <u>more</u> anaerobic respiration of stored food occurs than aerobic respiration;

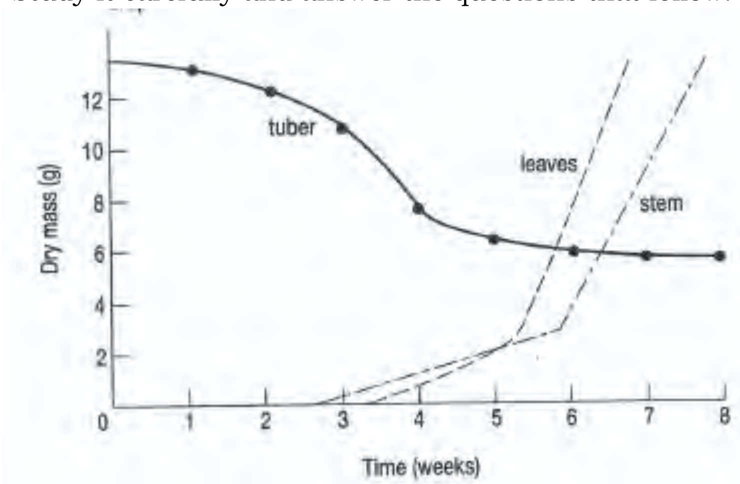
(ii) fall in the RQ value in treatment 2.

<u>Relatively sufficient</u> amounts of oxygen in air, diffuses into the seed; <u>more aerobic respiration than anaerobic respiration</u> of stored food occurs;

(ii) R.Q obtained in treatment 3.

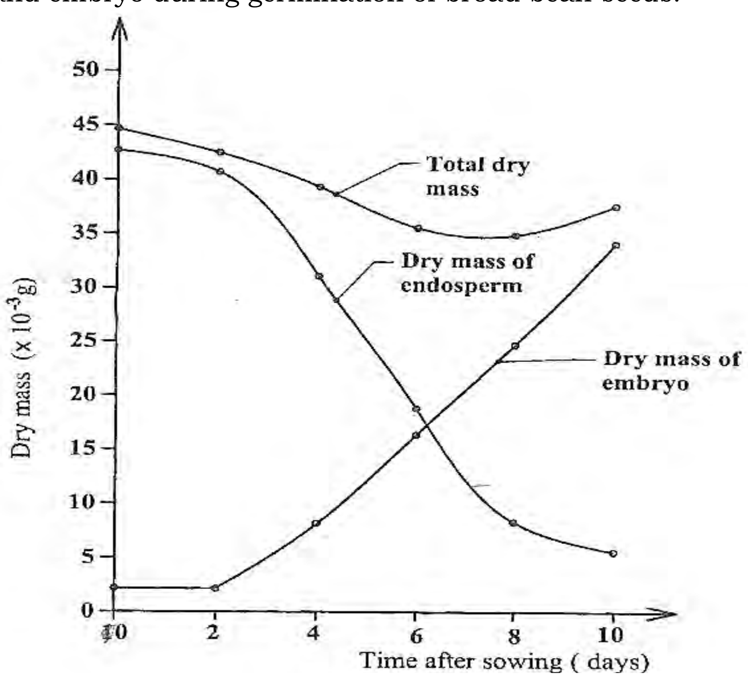
R.Q value is 1.0 ; because <u>sufficient</u> amounts of oxygen diffuses into the seed; <u>complete aerobic respiration of stored carohyrdate occurs</u>;

22. The graph below shows growth curve for a potato plant grown from a tuber. Study it carefully and answer the questions that follow.



(a) Suggest one reason for the choice of the unit of growth shown in the graph.
Amount of water in these plant organs is variable; fresh mass would thus give a poor indication of growth;
It is easy with plant organs to take samples; and dry to constant weight;
(b) Describe the phases of growth for the stem of the potato plant.
From 2.6weeks to 5.8weeks, dry mass increases gradually;
From 5.8weeks to 7.8weeks, dry mass increases rapidly; to the highest;
(c) Account for the shape of the curve for the tuber of the potato plant.
Initially, dry mass of the tuber is high; because the tuber is probably under period of suspended growth/dormancy; thus no mobilization of stored food;
From 0weeks to 4weeks, dry mass decreases rapidly; because of mobilization of stored foods; translocated to the leaves and stem; for growth;
From 4weeks to 8weeks, dry mass decreases slowly; to the lowest; because the leaves begin to photosynthesise; and stop using stores from the tuber;

23. The graph in the figure below shows the relative changes in dry mass of endosperm and embryo during germination of broad bean seeds.



(a) Explain the changes which occur, during the 10day germination period, in the dry mass of;
(i) the endosperm
From 0day to 2days, dry mass decreases gradually; because initial uptake of water by imbibition occurs; few hydrolytic enzymes are activated; little hydrolysis of stored food reserves into simple soluble products occurs; for translocation to the growing points of the embryo for growth;
From 2days to 8days, dry mass decreases rapidly; because more hydrolytic enzymes are activated; much hydrolysis of stored food reserves into simple soluble products occur; such as starch to sugars/maltose; proteins to amino acids; lipids to fatty acid and glycerol; which are translocated to the growing points of the embryo;
From 8days to 10days, dry mass decreases gradually; to the lowest; because all the stored food is almost depleted;
(ii) the embryo
From 0day to 2days, dry mass is low; and remains constant; because stored foods are being hydrolysed in the endosperm; little/no translocation of simple soluble products from the endosperm to the embryo;
From 2days to 10days, dry mass increases rapidly; to the highest; because of formation of the first foliage leaves; that carry out photosynthesis; adding new material to the embryo;
(iii) the seed.
From 0day to days, dry mass decreases gradually; because of aerobic respiration/oxidation of glucose in both endosperm and embryo; for energy production;
From 0days to 8days, dry mass remains almost constant because rate of respiration balances the rate of photosynthesis/anabolism balances catabolism;
From 8days to 10days, dry mass increases gradually; to the highest; because first foliage leaves

emerge; and start to photosynthesise; rate of photosynthesis exceeds rate of respiration;

(b) Suggest with reasons, what would happen;

(i) to the total dry mass of the seedlings if the seeds were germinated in the dark.
Total dry mass would decrease; absence of sun light; no photosynthesis; rate of respiration outweighs rate of photosynthesis;

(ii) if the experiment continued for another 10 days.
Dry mass of the endosperm would decrease to zero; owing to exhaustion of food reserves; and the total dry mass increases rapidly; due to increase in number of photosynthetic tissues;

(c) The results of an experiment on germinating peas showed that in the first three days of germination, there was a 43% decrease in total dry mass. 40% of the initial total mass of the peas was found to be due to water content. The initial total mass of the pea was 450g.
Calculate the,

(i) Initial total dry mass of the peas. Show your working.
Initial total dry mass % =100-40=60;
Initial total dry mass= $\frac{60}{100}$ **X 450;**
Initial total dry mass=270g;

(ii) Mass of dry matter remaining after the first three days of germination. Show your working.
Decrease in dry mass= $\frac{43}{100}$ **X 270; =116.1g;**
Mass of dry matter remaining= 270-116.1
=153.9g;

24. In an investigation, a nutrient broth containing glucose, amino acids and vitamins was inoculated with a small number of *Escherichia coli* in a conical flask. The culture was sampled at intervals and the living cell concentration for the culture was determined at this sampling times for 2days.
The results of the measurements of the growth of an *Escherichia coli* population is shown in the Table below. Study it carefully and answer the questions that follow.

Time (hours)	0	2	4	6	8	10	12	15	20	30	35	40	45
Population/cell number X $10^{-6}cm^{-3}$	0	0	0	1	30	420	512	513	511	513	164	9	1

(a) Calculate the growth rate of the bacteria population over the experimental period.

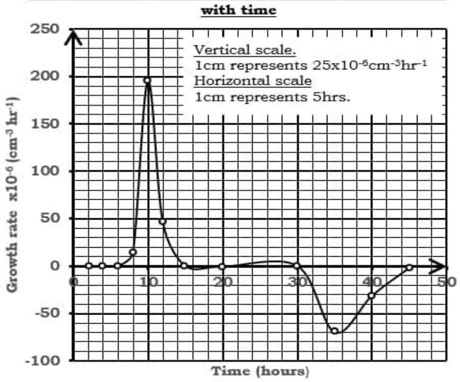
Time (hours)	0	2	4	6	8	10	12	15	20	30	35	40	45
Increase in population/cell number X $10^{-6}cm^{-3}$		***0***	***0***	***1***	***29***	***390***	***92***	***1***	***-2***	***2***	***-349***	***-155***	***-8***

Time (hours)	0	2	4	6	8	10	12	15	20	30	35	40	45
Growth rate/increase in cell number X $10^{-6}cm^{-3}$ hr^{-1}		***0***	***0***	***0.5***	***14.5***	***195***	***46***	***0.3***	***-0.4***	***0.2***	***-69.8***	***-31***	***-1.6***

Growth rate = $\frac{\textit{Increase in cell number}}{\textit{Time between two samples}}$

(b) Use the information in (a) above to plot a growth rate curve of a culture of *Escherichia coli*.

Graph showing variation of growth rate/ cell number with time



c) Describe the shape of the graph plotted in (b).
From 2hours to 6hours, growth rate remains constant; at zero;
From 6hours to 8hours, growth rate increases gradually;
From 8hours to 10hours, growth rate increases rapidly; to a peak;
From 10hours to 12hours, growth rate decreases rapidly;
From 12hours to 15hours, growth rate decreases gradually; to zero;
From 15hours to 30hours, growth rate remains constant at zero;
From 30hours to 35hours, growth rate decreases gradually; to a minimum;
From 35hours to 45hours, growth rate increases gradually*;*

(d)Account for shape of the graph in the following periods.

(i) 2-6hours

environment; e.g. by synthesizing new enzymes to break down a wide range of nutrients available in the culture medium;

(ii) 8-10hours

Growth rate increases rapidly to a peak because with plenty of nutrients; and breeding space; bacteria reproduce at their maximum rate;

(iii) 10-15hours.

Growth rate decreases; because one or more nutrients are getting depleted; and accumulation of toxic wastes;

(iv) 15-30hrs

Growth rate remains constant at zero; because cell death is equivalent to new cells formed;

(v) 30-35hours

Growth rate decreases gradually to a minimum because of exhaustion of nutrients; and accumulation of wastes; cell death number outweighing number of new cells produced;

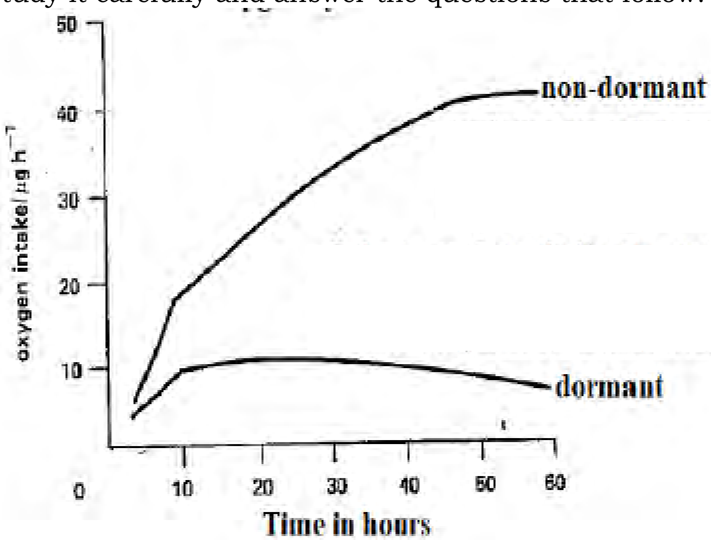
(e) (i) Using the information, given above state the method used by the experimenter to measure the population growth of E. coli.

Viable counting; in which only living bacteria cells in the culture are counted using either spread plates or pour plates;

(ii) Apart from the method given above, briefly describe one other method could have used to measure population growth of E. coli.

Turbidimetry;/measuring cloudiness or turbidity of a solution(suspension); in which the more cells there are in the solution(suspension), the greater the turbidity;

25. The graph in the figure below shows changes in oxygen intake by dormant and non-dormant seeds soaked in water for some time.
Study it carefully and answer the questions that follow.



(a) Describe the variation in the oxygen intake by non-dormant seeds over the experimental period.

From 4hours to 10hours, oxygen intake increases rapidly;
From 4hours to 46hours, oxygen intake increases gradually; to a maximum;
From 46hours to 60hours, oxygen intake remains almost constant;

(b) Compare the variation in the oxygen intake by the two groups of seeds over the experimental period.

Similarities

In both dormant and non-dormant seeds;
-oxygen intake increases from 4hours to 10hours;

Oxygen intake is low initially/at 4hours;

Differences.

Oxygen intake by non-dormant seeds	Oxygen intake by dormant seeds
Higher throughout the experimental period	**Lower throughout the experimental period**
Increases rapidly from 4hours to 10hours	**Increases gradually from 4hours to 10hours**
Increases gradually from 10hours to 46hours	**Decreases gradually from 10hours to 46hours**
Remains almost constant from 46hours to 60hours	**Decreases gradually from 46hours to 60hours**
Maximum attained	**Peak attained**

(c) Account for the difference in the oxygen intake by non-dormant and dormant seeds.

From 10hours to 60hours, oxygen intake by non-dormant seeds continues to increase while oxygen intake by dormant seeds decreases; because with onset of germination of embryo of non-dormant seeds; involving synthesis of new cellular components at the radicle and plumule apices; requiring much metabolic energy; stored food reserves such as carbohydrates and lipids are hydrolysed into simple soluble products; oxidized during aerobic respiration; producing sufficient energy; for growth; calling for continued increase in oxygen intake;

(d) Suggest how the information provided in the graph may be useful to a farmer during seed storage.

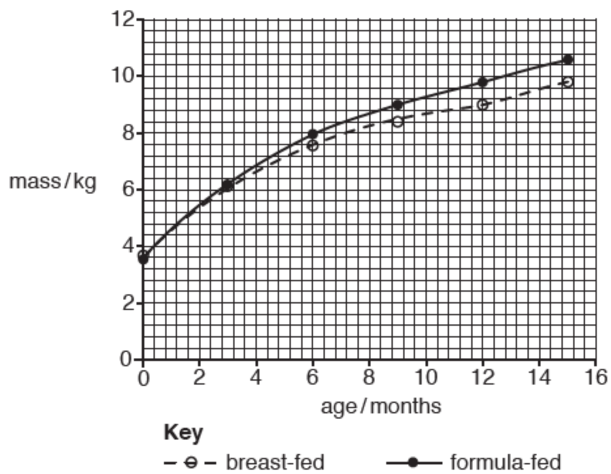
Drying of seeds before storage; preventing their germination in moist conditions; that would release heat energy; resulting into self-heating; enzyme denaturation occurs; killing the embryo; and with

depletion of food reserves, seed viability is lost;

(e) Why should farmers soak seeds before planting?

- **Softening the testa; making it permeable to oxygen; and its easy rupture; allowing emergence of the radicle and plumule;**
- **Allowing diffusion of the germination inhibitors out of the seed;**
- **Increasing seed water/moisture level; activating the respiratory enzymes in the seeds; subsequently increasing germination rate;**
- **With increased germination rate, seeds overcome drainage problems associated with excessively sandy or clay soils;**

26. Table below shows the nutritional components in breast-fed milk and bottle-fed formula milk and volumes of breast-fed milk and bottle-fed formula milk taken per day. The graph in the figure below shows the growth (measured in mass) of the babies fed with breast milk and babies fed with formula milk from birth for 15months. Study the table and graph carefully and answer the questions that follow.



	Breast milk	Formula milk
Lipid(gdm^{-3})	37	38
Lactose(gdm^{-3})	73	72
Protein(gdm^{-3})	8.7	12.9
Energy($KJdm^{-3}$)	680	690
Volume of milk taken($gday^{-1}$)	448	732

(a) State the similarities and differences between the nutritional value of breast milk and formula milk.

<u>Similarities.</u>

Both breast milk and formula milk have approximately equal amounts of lipids, lactose and energy;

<u>Differences</u>

Formula milk has a higher protein content than breast milk;

(b) Using information in the table and graph, explain the difference in the mass of the babies that were breast-fed and babies that were bottle-fed with formula milk.

From 3months to 15months, mass of babies breast-fed is <u>lower</u> than mass of babies bottle-fed with formula milk; owing to <u>lower volume of milk</u> drunk by breast-fed babies; with <u>lower content of protein</u>; and slighter <u>lower energy content</u> than formula milk; both required for <u>growth</u>;

(c) Outline the advantages and disadvantages of breast-feeding.

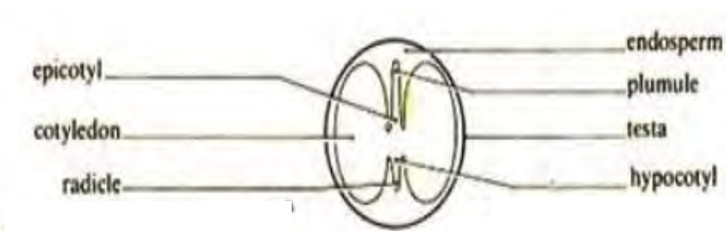
<u>Advantages</u>.

-Easy to digest; reducing risks of colic;
-No additives; reducing risks of allergies;
-Contains antibodies/provides passive immunity against pathogenic microbes;
-Strengthens bond between mother and baby;
-Is at body/correct temperature;
-Sterile; thus less risk of infection;
-No preparation required;
-It is cheap;

<u>Disadvantages</u>.

-Viruses such as HIV and hepatitis B can be transmitted to the baby;
-Mother may not be able to produce enough milk;
-Drugs such as alcohol can be passed to the baby;
-Task cannot be shared with another parent;
-Difficult to know amount consumed by baby;
-Painful/sore nipples/mastitis;

27. (a) Describe the general structure of a seed.



Consists of an <u>embryonic plant</u>; differentiated into an immature embryo shoot, <u>plumule</u>; and undeveloped embryo root, <u>radicle</u>; and is attached on either <u>one seed leaf/cotyledon</u>; in monocotyledonous plants; or <u>two seed leaves</u> in dicotyledonous plants; with internode just above the cotyledon, <u>epicotyl</u>; and internode just below the cotyledon, <u>hypocotyl</u>;
Food is stored either in swollen <u>cotyledons</u>; or <u>endosperms</u>;
Whole seed structure is encased in a tough <u>seed coat/testa;</u> pierced by a small aperture, the <u>micropyle;</u>

(b) Describe the physiological changes that occur in a seed during germination.

Proteins and cell wall components (hemicelluloses and pectic substances) in the seed causes rapid micropylar uptake of water into seed by imbibition; hydrating the seed tissues; and with dissolution of soluble substances in the seed, water potential/solute potential of the tissues is lowered; water thus moves from cell to cell by osmosis;

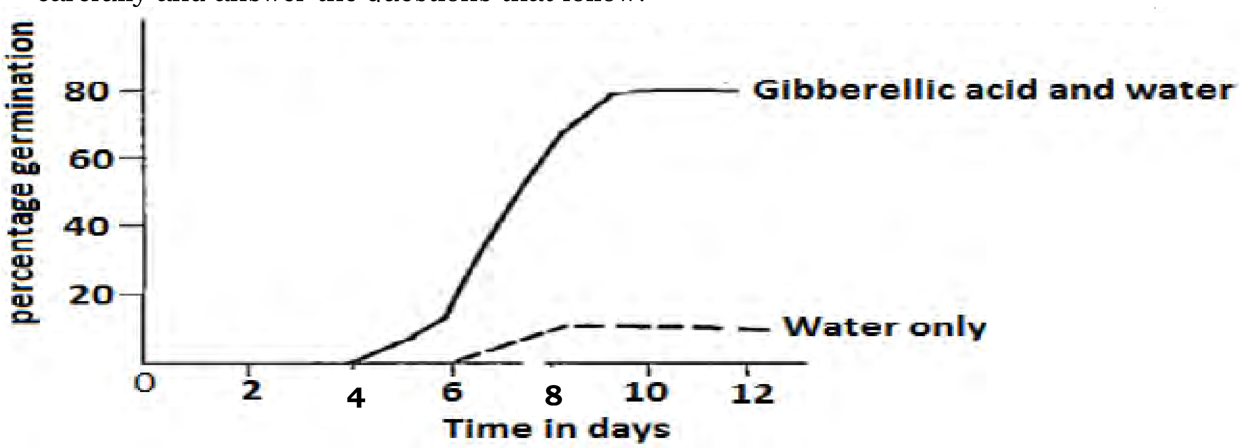
Uptake of water by the embryonic tissue by imbibition and osmosis causes swelling of the embryo; seed coat ruptures; allowing the growing plumule and radicle to emerge; activates respiratory enzymes; and some already existing hydrolytic enzymes; stimulates gibberellic acid synthesis by the embryo for synthesis of $\alpha -$ amylase and other hydrolytic enzymes;

Stored food materials are hydrolysed into relatively simple soluble substances; dissolved in water; and translocated to the growing apices of the plumule and radicle such as stored starch is hydrolysed by amylase enzymes into maltose; further hydrolysed by maltase enzyme into glucose; converted to sucrose; translocated to the growing parts of the embryo; used for synthesis of cell wall components (cellulose, hemicellulose and pectic compounds); and can also be oxidized providing energy for cell division during embryo growth;

Lipids are hydrolysed into fatty acids; and glycerol; by lipase enzyme; Fatty acids may be oxidized releasing energy; or converted to sucrose for membrane synthesis; Glycerol is converted to sucrose; oxidized releasing energy;

Proteins are hydrolysed to amino acids by protease enzymes; some transported in solution to the embryo; and most amino acids transported as amides to the growing parts of the embryo; deaminated; and the amino acids used for synthesis of structural proteins and enzymes;

(c) In an experiment to investigate the effect of gibberellic acid on dormant seeds of hazel, *Corylus avellana L*, two groups of 20 dry hazel seeds each were treated separately as follows.
First batch of seeds were soaked in water only while the second batch were soaked in a solution of water and gibberellic acid.
Both treatments were left to stand for 12days and percentage germination of seeds determined. The results of this investigation are shown in figure the below. Study it carefully and answer the questions that follow.



(i) Compare the percentage germination of hazel seeds in the two treatments shown on the graph.

Similarities.

In both treatments, percentage germination of seeds,

- **Increases from 6days to 8.4days;**
- **Attain maximum;**
- **Remain constant from 9.4days to 12days**;

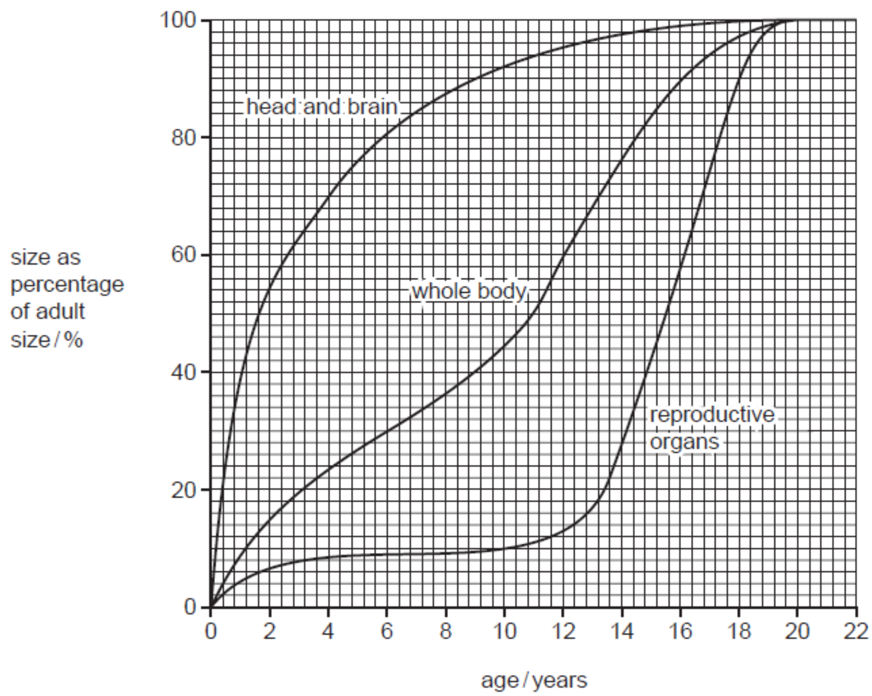
Differences

Percentage germination in water only	Percentage germination in water + Gibberellic acid
Lower maximum attained	**Higher maximum attained**
Maximum attained earlier	**Maximum attained later**
Lower from 6days to 12days	**Higher from 6days to 12days**
Germination starts later	**Germination starts earlier**
Increases gradually from 6days to 8.4days	**Increases rapidly from 6days to 8.4days**
Remains constant from 8.4days to 9.4days	**Increases gradually from 8.4days to 9.4days**

(ii) Account for the difference in percentage germination of seeds between the two treatments.

Percentage germination of seeds soaked in solution of gibberellic acid and water is higher than those soaked in water only; because with imbibition of water, synthesis of endogenous gibberellin by the embryo occurs; which together with exogenous gibberellin; gibberellic acid content in the former treatment is higher than that in the latter; rapidly increasing lipase activity; much hydrolysis of stored lipids/oils into fatty acids; and glycerol occurs; both rapidly converted into much sugars(sucrose) by citrate lyase enzymes; translocated to the growing parts of the embryo; oxidized; releasing much energy; causing much higher germination of seeds soaked in solution of gibberellic acid and water than those soaked in water only;

28. Figure below shows the growth of different parts of the human body.



(a) Using the information on the figure, state the type of growth exhibited.

Allometric growth; because body organs grow at a different rate from the whole body; with head and brain developing rapidly early in life; and reproductive organs developing last;

(b) Suggest **one** reason for the choice of the unit of growth shown in the graph.

Individual parts of the body start off at different sizes;

(c) Why is the growth of the brain so rapid in the early years of life?

In order to coordinate growth; development; of different body parts; and learning;

(d) (i) Between which two ages does the rapid increase in the size of the reproductive organs occur?

13.6years to 20years;

(ii) Give reasons for the choice of the age range in d(i) above.

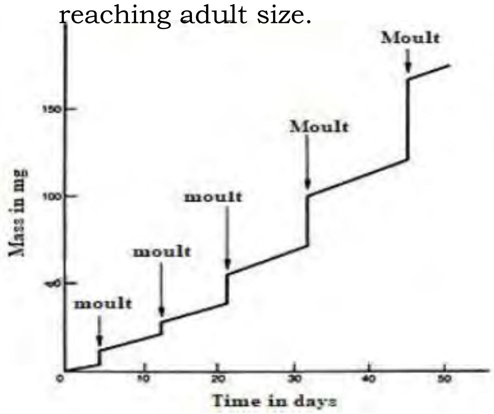
Onset of puberty/adolescence; sexual maturity attained; coupled with secretion of sex hormones, oestrogen in females; and testosterone in males; that stimulate development of secondary sexual characteristics; and reproductive organs;

(e) If the ratio of brain size to body size is 1:24 in the human adult, estimate from the graph the ratio in a 10-year old child.

At 10years old, the brain size is 92%, almost adult size; and body size is 44%, about 50% of adult size, the ratio is thus 1: 12;

(f) Many insects increase in mass rapidly at the time of moulting, but show little change between moults.

(i) Sketch a graph you would expect for an insect which moulted five times before reaching adult size.



(i) State the type of growth exhibited by insects.

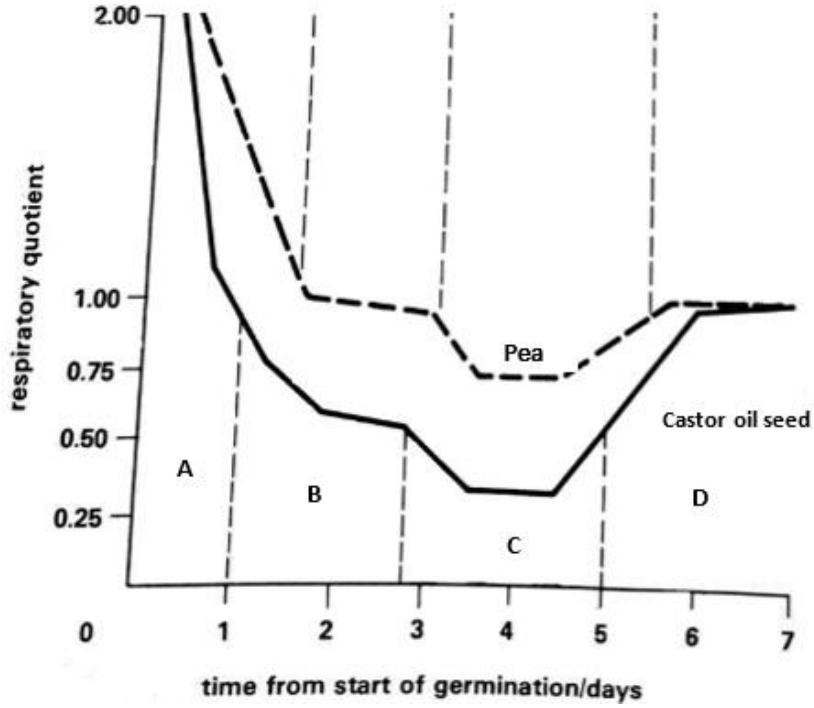
Discontinuous growth/Intermittent growth;

(ii) Account for the shape of the graph sketched in f(i).

Growth is discontinuous; with periods of extremely rapid growth/growth spurts; followed by periods of very little growth; owing to hardened exoskeleton; that limits body growth;

At moulting/ecdysis, hardened exoskeleton is shed; new soft cuticle is formed underneath; insect swallows water or air; rapidly expanding the body; before its cuticle hardens again; subsequently increasing mass;

29. The figure below shows the respiratory quotients of two types of seeds at various stages of germination. Study it carefully and answer the questions that follow.

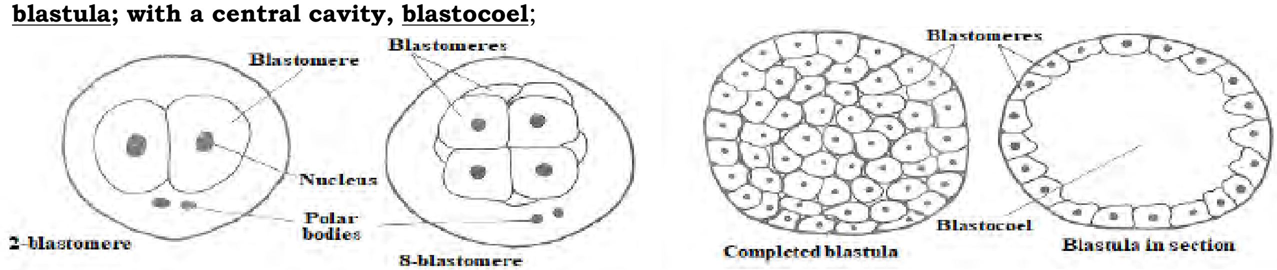


Account for the changes in respiratory quotients for both types of seeds in regions **A**, **B, C** and **D**

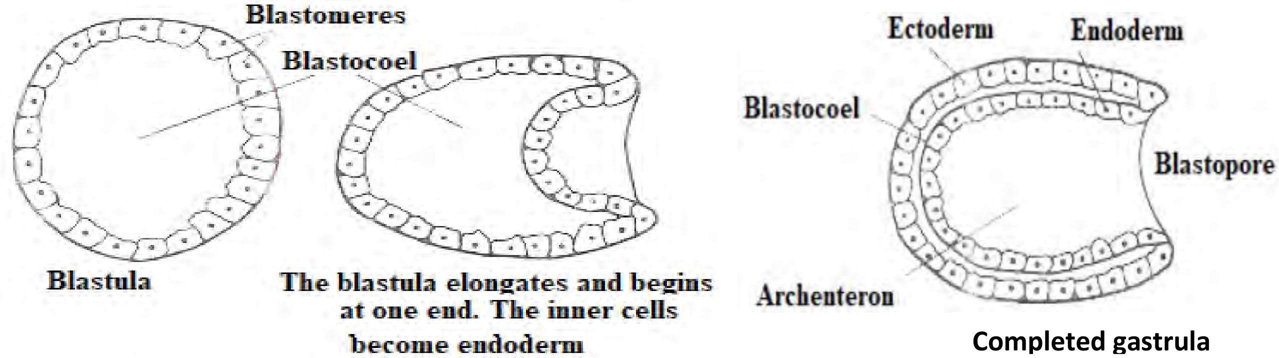
Region	Type of seed	
	Pea seed	Castor oil seed
A	**R.Q is above 1.0; because relatively impermeable testa; allows diffusion of <u>inadequate amounts</u> of oxygen; <u>more</u> anaerobic respiration than aerobic respiration occurs;**	**R.Q is above 1.0; because relatively impermeable testa; allows diffusion of <u>inadequate amounts</u> of oxygen; <u>more</u> anaerobic respiration than aerobic respiration occurs**
B	**R.Q remains almost constant at 1.0; because <u>adequate</u> oxygen diffuses into the seed; <u>aerobic respiration of stored carbohydrate</u> occurs;**	**R.Q is slightly lower than 0.75, owing to <u>aerobic respiration of stored lipids</u>;**
C	**R.Q decreases and remained constant at about 0.75 owing to <u>aerobic respiration</u> of some stored <u>lipids</u>; and <u>remaining carbohydrates;</u>**	**R.Q decreases and remains constant at about 0.35, owing to <u>conversion of some stored lipids to carbohydrates</u>;**
D	**R.Q increases and remains constant at 1.0; because <u>aerobic respiration of formed carbohydrates from photosynthesis;</u>**	**R.Q increase rapidly to 1.0; because of <u>aerobic respiration of carbohydrates from lipid conversion</u>;**

30. (a) Describe using labeled diagrams, the main sequence of events in development from fertilization to the establishment of the primary germ layers of the embryo in a named chordate.

In <u>Amphioxus</u> (primitive chordate); during <u>cleavage</u>; nucleus of the zygote divides <u>mitotically</u>; into smaller cells, <u>blastomeres</u>; forming a solid spherical mass, <u>morula</u>; which with successive mitotic division, form a hollow fluid-filled ball of cells, <u>blastula</u>; with a central cavity, <u>blastocoel</u>;



During gastrulation; wall of the blastula invaginates at one end; forming an opening, blastopore; to the exterior; coupled with formation of two-layered cup-shaped structure, gastrula; outer layer of cells forming the ectoderm; and inner layer of cells forming the endoderm; between them is a mass of cells, forming the mesoderm; Blastocoel is obliterated; and replaced by a new cavity, archenteron/primitive gut;



Completed gastrula

(b) Complete the table below with a germ layer in a chordate embryo that gives rise to the given structures.

Structure	Germ layer
Skin epidermis	**Ectoderm**
Epithelium of the intestine	**Endoderm**
Muscles	**Mesoderm**
Brain	**Ectoderm**

31. (a) Describe the functions of the following parts of a seed.

(i) Testa.

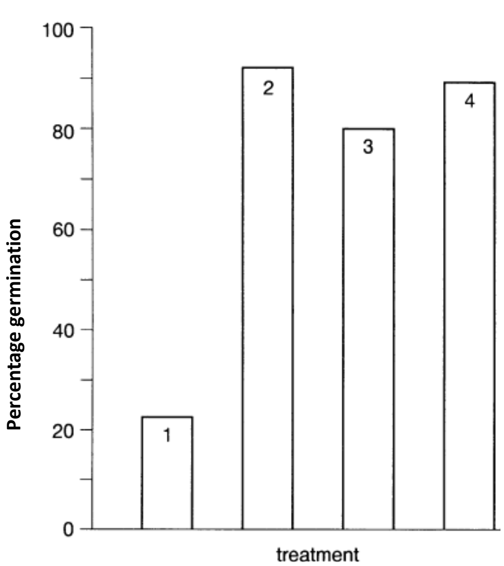
Protects the embryo of seeds; from mechanical damage; and attack by microorganisms;
Restricts entry of oxygen into a seed; owing to its hardness and impermeability; making the seed dormant;

(ii) Cotyledon

Store food reserves; such as proteins; and lipids; which are mobilized; for early growth of embryo; before photosynthesis starts;

(b) In an investigation, seeds of the 'Grand Rapids' variety of lettuce were subjected to four different treatments as shown in the Table. In each treatment, 100 seeds were placed on moist filter paper in a petri dish and left for 30hours to allow germination to take place.
After 30hours, the percentage of germination in each batch of seeds was determined. The results are as shown in figure below. Study the table and figure carefully and answer the following questions.

Treatment	Pre-treatment	Experimental conditions	
		Temperature(℃)	Light/dark
I	None	25	Dark
II	None	25	Light
III	None	2 for 0-4 hours 25 for 4- 30hours	Dark
IV	Testa scratched	25	Dark



With reference to the Table and graph,

(i) Describe the effect of light on the germination of Grand Rapids lettuce seeds.

Light increases percentage germination;

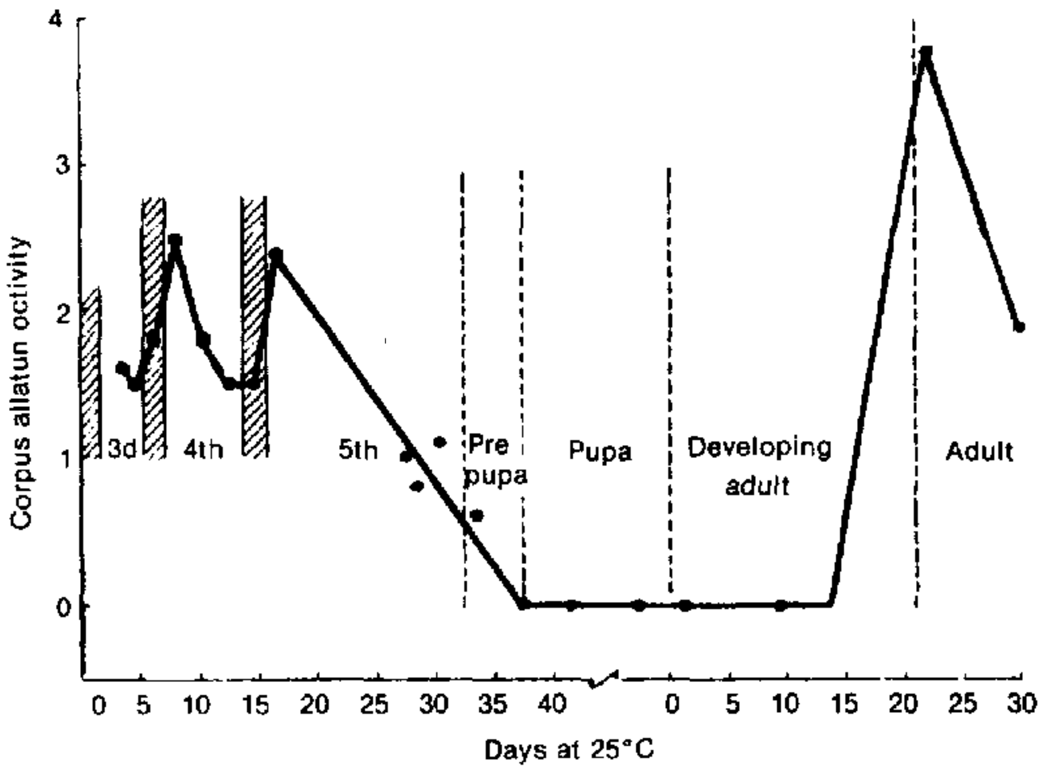
(ii) Suggest an explanation for the difference between germination rates in,

- Treatment I and III.

Germination rate is higher in treatment III than I; because on exposure to low temperature/chilling first; abscisic acid content of the seeds fall; gibberellic acid concentration in the seed increases; stimulating synthesis of hydrolytic enzymes; stored foods are mobilized for embryo growth; increasing more, germination rate in treatment III than I

- Treatment I and IV
  Germination rate is <u>higher</u> in treatment IV than I; because scratching the testa, makes it <u>more permeable to oxygen; and water</u>; and allows <u>expanding embryo to break through;</u>

32. The graph in the figure below shows changes in the endocrine activity of the corpora allata of the cercropia silkworm. The activity was assayed by transplanting corpora allata from cercropia at each stage into last Polyphemus pupa. The break in the time scale represents the storage of the donor pupa at 6℃ for 10-20weeks. The cross-hatched zones represents larval moulting.
    Study the graph and answer the questions that follow.



(a) Why was the donor pupae stored at 6℃ for 10-20weeks before being transplanted corpora allata from the cercropia?
To break diapause/dormancy of the pupa;

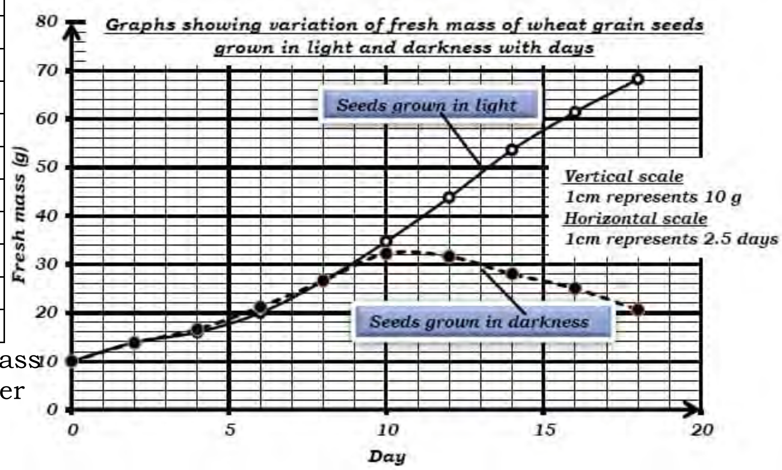
(b) Describe the trend in the corpus allatum activity exhibited in the graph.
At the third and fourth larval moults, corpus allatum activity increases rapidly; to a peak;
From fifth instar larva to early pupa stage, corpus allatum activity decreases rapidly; to zero;
From early pupa stage to mid developing adult stage, corpus allatum activity ceases/remains constant at zero;
From mid developing adult stage to adult stage, corpus allatum activity increases rapidly; to a peak;
At adult stage, corpus activity decreases rapidly; to almost half its maximum activity;

(c) Account for the trend in the corpus allatum activity exhibited in the graph.
At the third and fourth larval moults, corpus allatum activity increases to rapidly secrete <u>large quantities</u> of Juvenile hormone/neotonin into blood; which under the influence of ecdysone, causes <u>retention of larval characteristics</u>; as the <u>larva grows to full size;</u>
At fifth larval stage, corpus allatum activity decreases rapidly to zero; secreting <u>low</u> quantities of juvenile hormone; <u>larva metamorphoses into pupa</u>;
From early pupa stage to (mid) developing adult stage, corpus allatum activity ceases; <u>no more</u> secretion of Juvenile hormone; <u>pupa metamorphoses into developing adult</u>;
From (mid) developing adult stage to adult stage, corpus allatum activity increases to rapidly secrete <u>large quantities</u> of Juvenile hormone/neotonin into blood; for <u>retention of adult characteristics</u>; as the developing <u>adult grows to full size;</u>
With complete development of adult stage, activity of corpus allatum is inhibited;

33. A 10-gram sample of wheat grains was germinated on moist filter paper. Half of the sample was grown in normal day light and the other half in permanent darkness. Samples from each group were weighed every 48hours. The fresh mass was found in each case and the results are as shown in the Table below.

Day	Fresh mass of seeds grown (g)	
	In light	In darkness
0	10.0	10.0
2	13.9	13.8
4	16.0	16.6
6	20.0	21.2
8	26.6	26.6
10	34.7	32.2
12	43.8	31.6
14	53.6	28.0
16	61.4	25.0
18	68.2	20.6

(a) On the same axes, plot graphs of the fresh mass against time.



(b) Compare the variation in the fresh mass of seeds grown in light and darkness over the period of study.

Similarities

In both seeds grown in light and darkness, fresh mass;

- **Is equal initially; and at day 8;**
- **Increases from day 0 to day 10;**

Differences.

Fresh mass of seeds grown in darkness	Fresh mass of seeds grown in light
Increases then decreases during the study period	**Increases throughout the study period**
Decreases from 10days to 18days	**Increases from 10days to 18days**
Lower from 8days to 18days	**Higher from 8days to 18days**
Higher from 4days to 8days	**Lower from 4days to 8days**
Maximum attained	**Highest attained**

(c) Explain the differences between the fresh mass of seeds grown in darkness and light over period of study.

From 10days to 18days, fresh mass of seeds grown in light continues to increase; and is higher than fresh mass of seeds grown in darkness because in light, with continued photosynthesis; rate of photosynthesis exceeds rate of respiration/anabolism exceeds catabolism;

(d) Suggest an explanation for the difference in the results if the dry mass and not fresh mass was obtained for the seedlings grown in the dark and in the light.

In the dark, dry mass would decrease immediately; no photosynthesis occurs;
In the light, dry mass would decrease first; because rate of respiration exceeds rate of photosynthesis, as no foliage leaves have been developed yet; Dry mass then increases due to formation of first foliage leaves which photosynthesise; rate of photosynthesis thus exceeds rate of respiration;

(e) Seedlings grown in the dark become etiolated.

(i) State **three** characteristics of etiolated plants.

- **Elongated internodes;**
- **Weak stems;**
- **Leaves lack chlorophyll/is chlorotic; thus appears pale yellow;**
- **Leaves of dicotyledonous plants remain small; and unexpanded;**
- **Leaves of monocotyledonous plants remain rolled up;**

(ii) Of what significance is etiolation to plants?

Allows maximum growth in length; with minimal use of food reserves; which in absence of light, the plant can not obtain by photosynthesis;

(iii) How does the morphology of an etiolated plant suit it for growing through soil?

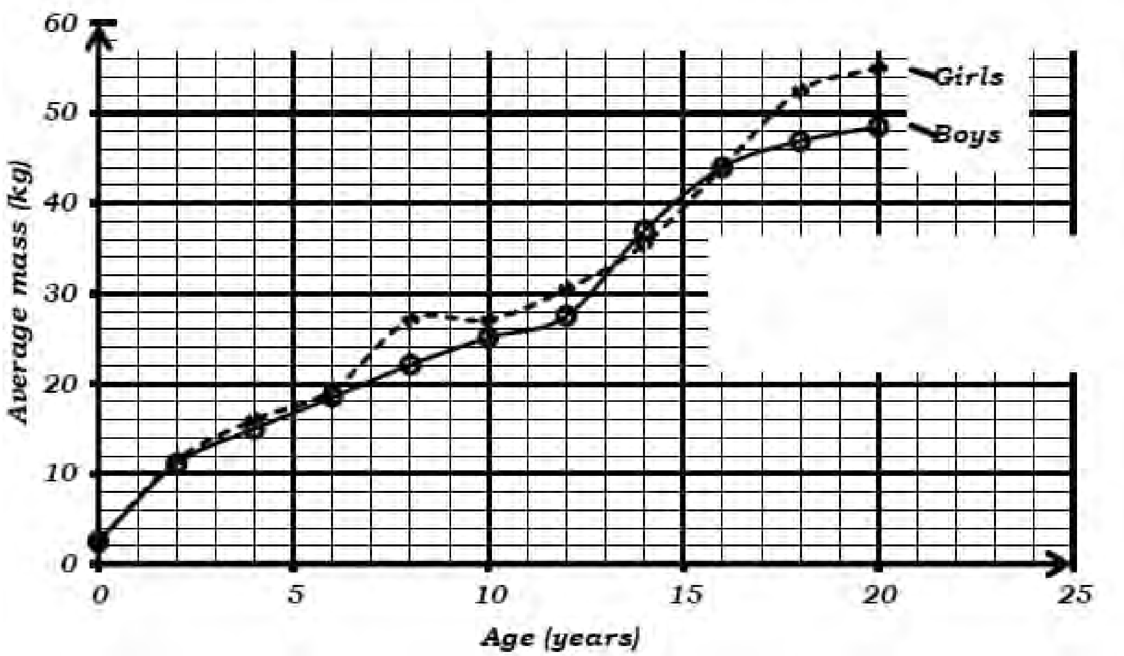
Small leaves offer less resistance to passage through the soil;
Hooked plumule of dicotyledonous plants protects the delicate apical meristem from soil particles;
Elongated internodes ensure maximum chance of reaching light;

(iv) Describe how exposure of a seedling to red light can prevent etiolation.

In presence of red light, inactive form of phytochrome red is converted to the active form, phytochrome far- red; which on accumulation; promotes leaf expansion; and inhibits

internode elongation; thus restoring normal growth pattern of the shoot;

34. The figure below shows average mass in kilograms for some boys and girls over a period of 20years. Study it and answer the questions that follow.



(a) From the graph, determine the growth rate in girls between ages 13 and 15.

Growth rate= $\frac{\text{change in mass}}{\text{change in time}} = \frac{(40-32)}{(15-13)} = \frac{8}{2}$ **= 4.0kg/year.**

(b) Account for your answer in (a) above.

13 to15 years represents onset of puberty/adolescence; secretion of estrogen hormone occurs, stimulate development of secondary sexual characteristics; and reproductive organs; resulting into fast growth.

(c) Give **two** differences in the trend of average mass for both girls and boys over period of 20 years.

Average mass of girls	Average mass of boys
Higher from 2years to13.5years, and 16years to 20years	**Lower from 2years to13.5years, and 16years to 20years**
Lower from 13.5years to 16years	**Higher from 13.5years to 16years;**

(d) Why do girls above 10years require intake of food richer in iron than boys of the same age?

Onset of menstruation cycle; thus need more iron to replace the lost blood during menstruation;

(e) Other than diet, mention **two** other factors that affect rate of growth in boys and girls.

- **<u>Genetic factors</u>; <u>Level of hormones</u> in blood such as growth hormones, sex hormones; <u>Health status</u>;**

'Education is not the learning of facts but it's rather the 'training of the mind to think'