Dr. Bbosa Science

Growth and development.

Growth is a permanent increase in size of an organism by addition of more body substance. The pattern of growth differs in different organisms. In animals, it is described as being d**iffuse**, with growth occurring in almost all parts of the body. For plants however, have particular regions where they grow, called **meristems**.

Apical meristems are responsible for increase in length while secondary meristems are responsible for increase in girth or diameter of the stem. Three distinct process of contribute to growth; cell division, assimilation, and cell expansion.

Development; involve both an increase in size and differentiation of cell so that they become specialized.

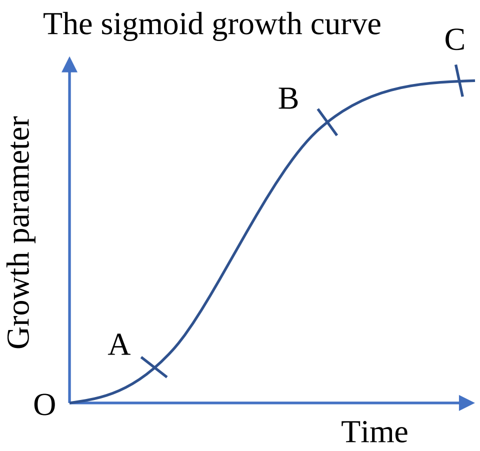
Measuring growth

Growth can be quantified by measuring some features of the organism at suitable interval such as

1. Length: this is easy to do and does not damage the organism but results may be misleading it takes no account of growth in other direction.
2. Area and volume are more accurate than measuring length but are impractical to measure.
3. Fresh mass: this is easy to measure but may be inaccurate due to temporary fluctuation in water content
4. Dry mass: this involves removing all water by drying before weighing. It is accurate but difficult to carry out and kills the organism

Growth curves

When any parameter is measured against set intervals of time, a growth curve is produced. Form many populations, organism or organs, the curve is S-shaped or **sigmoid curve**. It represents a slow growth at first, because there are so few cells initially that even when they are dividing rapidly the actual increase in size is small.



OA
Slow growth due very dividing cells

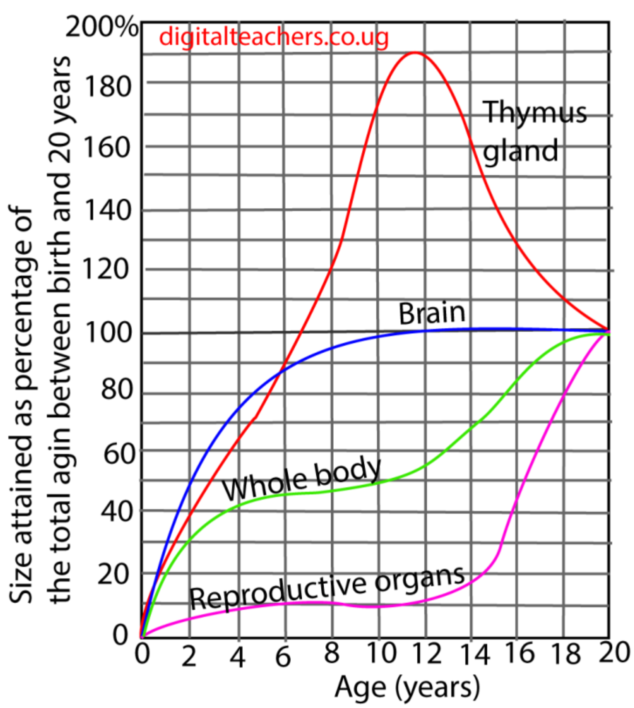
AB
Exponential growth due to presence of big number of dividing cell

BC
Growth slows down and finally stops due rate of cell division equal to rate of cell death or cell division limited by the genotype of the animal.

Allometric growth

This is growth where the different parts the organism may grow at different rates and stop growing at different times. This one problem of measuring growth rate.
For example, in human the head grows rapidly at first and then slows down, virtually stopping altogether soon after the age of about five years. However, the legs and arms continue to grow for another 15 years or so, as do most of the other organs given in figure below

Growth rate of different parts of the human body between 0 and 20 years



NB

- The head and hence the brain mature rapidly to take over the overall control of the body system

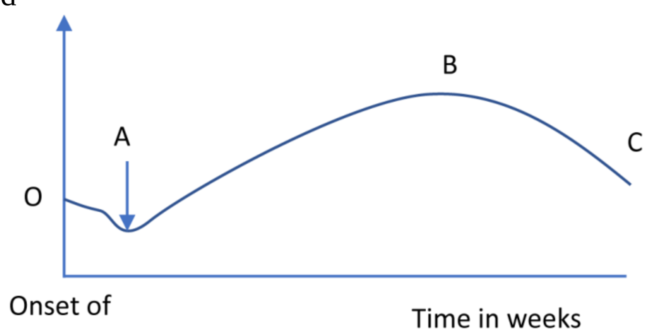
- Lymph tissue which produce white blood cells to fight infections, grows rapidly in early life when the risk of disease is greater as the immunity has not been acquired.

- The reproductive organs grow slowly such that they are mature when the organism is body is ready to support the fetus and to take care of the offspring.

Limited and unlimited growth

Growth in plant and animal show two basic of growth i.e. limited [definite or determinate] growth and un limited [indefinite or indeterminate] growth

Growth in annual plant is limited and after a period of maximum growth, during which the plant matures and reproduce, there is a period of negative growth or senescence before the death of the plant. If the dry mass of the annual plant is plotted against time then sigmoid curve given below as obtained



Explanation of the graph

-The negative growth in the first week is due to respiration of food reserves in the seed

-At A, the green leaves have now grown and opened above ground.

-Along AB dry mass increases because photosynthesis is greater than respiration

-Along BC, dry mass decreases due to dispersal of fruits and seed, loss of leaves / chlorophyll and high respiration as compared photosynthesis.

Several organs show limited growth but do not undergo a period of negative growth e.g., leaves and stem internodes. Animals that show limited growth include insects, birds and mammals.

Unlimited growth is seen in woody perennial plants and some invertebrates, fishes and some reptiles

In plants growth only occurs in group of immature cells called **meristems**.

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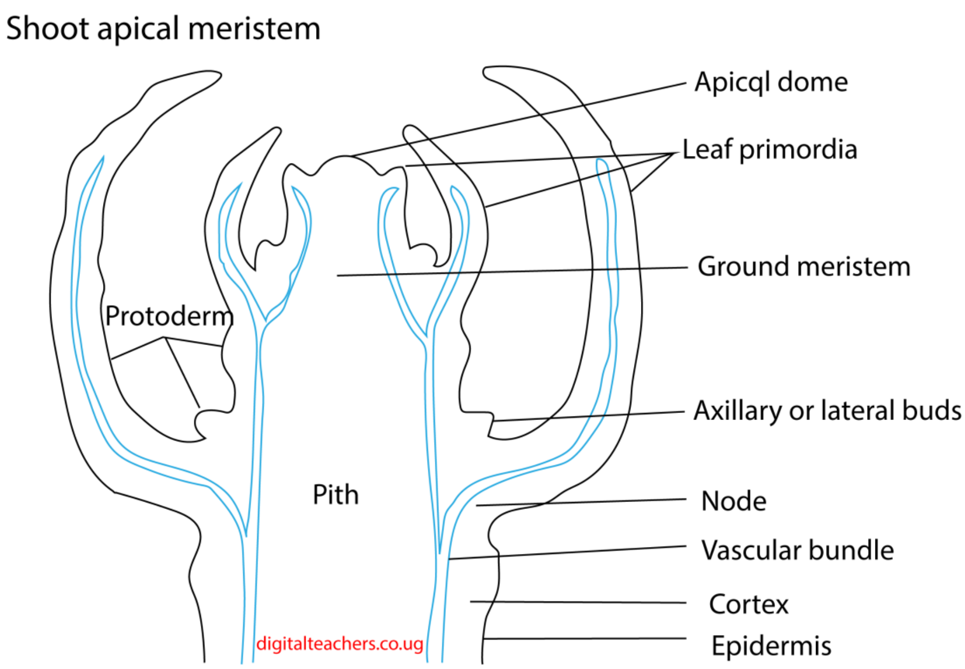
The meristem has a number of defining **features**, including small cells, thin cell walls, large cell nuclei, absent or small vacuoles, and no intercellular spaces. It is divided into three zones.

(i) The zone of cell division is closest to the tip and is made up of the actively-dividing cells of the root meristem, which contains the undifferentiated cells.
(ii) The zone of elongation is where the newly-formed cells increase in length, thereby lengthening the root and shoot
(iii) The zone of cell maturation where the elongated cells differentiate into specialized cell types

There are three types of meristems: -

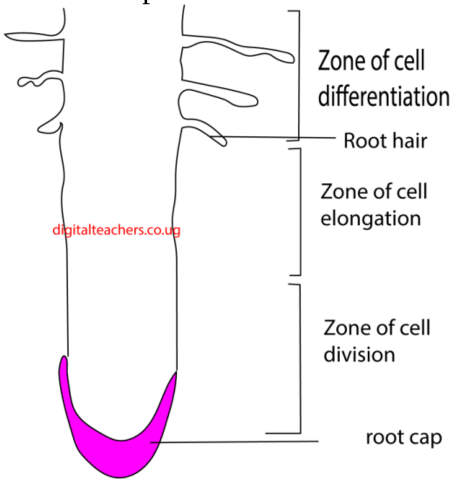
1. **Apical meristems:** these are found at the tips of roots and shoots and are responsible for primary growth of the plants i.e., increase in length.



Role of apical meristem in growth

- Cell division and elongation causes increase in length
- Bud primodium give rise to bud which can develop gives rise to branches
- Pro-cambium gives rise to vascular tissue

Root cap meristem



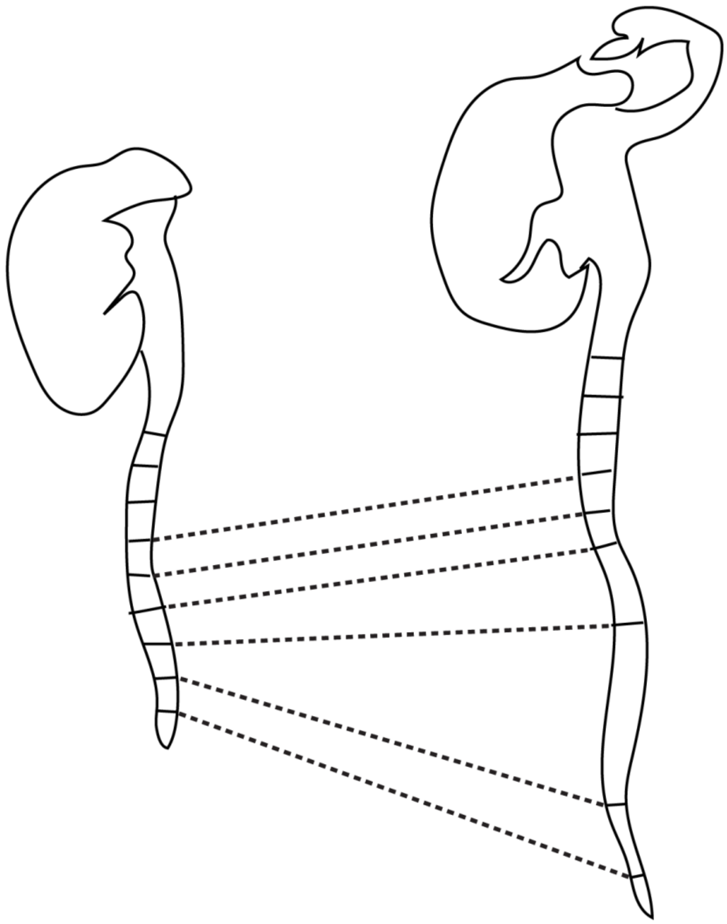
Role of root cap meristem

- Root cap protects the delicate root tip
- Cell division and expansion leads to increase in leangth
- Cell differentiation leads to formation of differents tissues

2. **Lateral meristems:** these are found in a cylinder towards the outside of the stem and roots. They are responsible for secondary growth and cause increase in girth.
3. **Intercalary meristems:** these are found at the nodes in monocotyledonous plants. They allow an increase in length in positions other than the tip.

Experiments to determine the region of growth in a root

1. Take a freshly-germinated bean with a root about 2.5cm long. Mark the root every 2mm with line in permanent black ink.
2. Pin the bean to the underside of a cork, with the root hanging downwards, and put the cork into the moist cotton wool
3. After 2-3 days, the region of growth is indicated by the part where the black line are linger than 2mm.



Germination

Seed germination may be defined as the fundamental process by which different plant species grow from a single seed into a plant

Conditions necessary for germination

1. Water

   The role of water in seed germination may be

- Dissolve and leak away germination inhibitors
- Soften and rapture seed coat to allow in water and oxygen
- hydrate vital activities of protoplasm
- converts the insoluble food into soluble form for its translocation to the embryo

2. Oxygen is necessary for aerobic respiration
3. Temperature; moderate temperature (25 – 300C) activates enzymes.

Others

4. Light: some seed require exposure to sunlight before they germinate

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Experiment to demonstrate conditions necessary germination

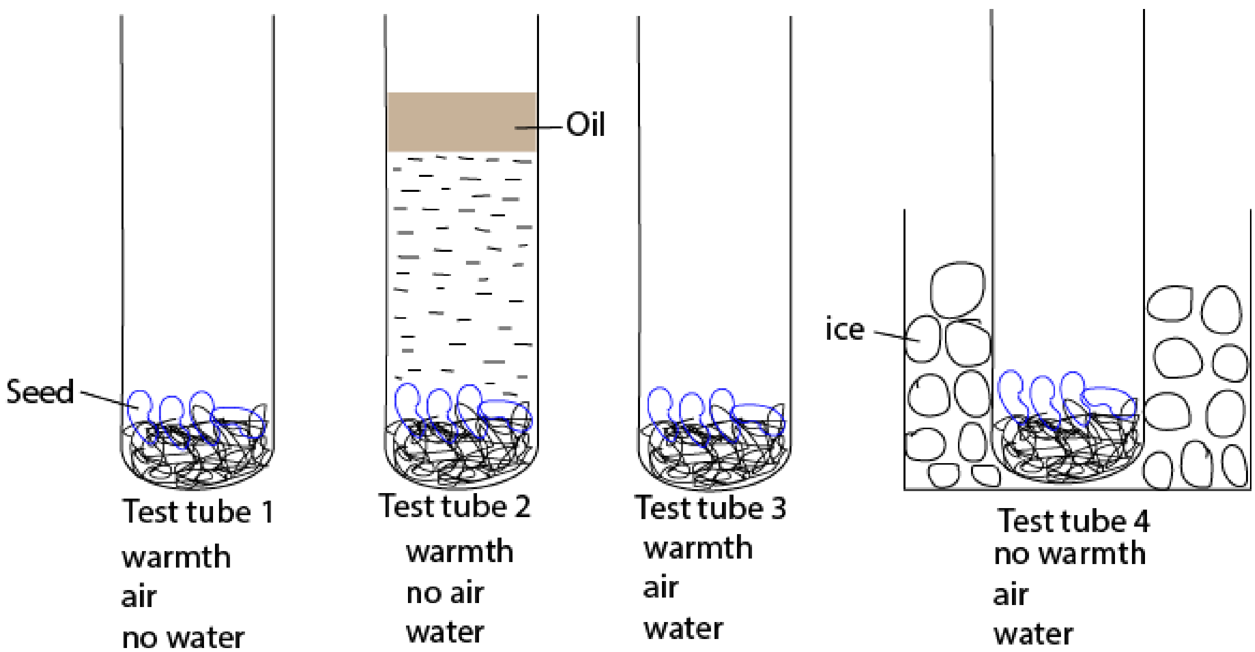
Prepare 4 test tubes as follow

Test tube 1: place dry seeds on cotton and place in a test tube in a warm place such that seed are provided with air and warmth but no water

Test tube 2: seeds on a cotton wool are placed in a test tube full of freshly boiled and cooled water and then covered with oil to prevent entry of air.

Test tube 3: seeds in soaked cotton wool are placed in an open test tube and placed in a warm place. These seed have warmth, oxygen and water

Test tube4: seeds in soaked cotton wool are placed in an open test tube and test tube placed in a a beaker if ice



The setup is left for a few days

Observations

Seeds in test tube 3 germinated because they were provided with warmth, oxygen and water

Physiology of germination

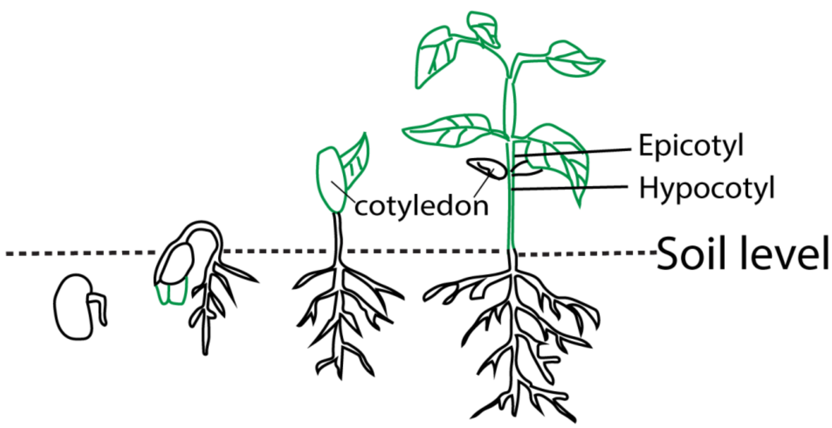
- Germination starts with the rapid uptake of water by the seed through the micropyle by a process called ambition. Water then moves from cell by osmosis.
- The water causes swelling of the embryonic tissue thereby rapturing the seed coat and also activates gibberellins.

- Gibberellins diffuse to the aleurone layer (a special layer which one cell thick **that surrounds the endosperm).** Here gibberellins cause the synthesis and activation of hydrolytic enzymes such as amylase and proteases.
- Amylase catalyzes the breakdown of starch to glucose while proteases catalyze hydrolysis of proteins to amino acids.
- Glucose and amino acids are translocated from the storage centre (endosperm or cotyledon) of the seed to the growing regions of the embryo.
- Here glucose is used in respiration and in the formation of cellulose and other cell wall materials. Amino acids are used to make proteins, which are enzymes and structural components of protoplasm.
- Cell division, elongation and differentiation leads to immergence of a seedling from a seed.

Types of germination

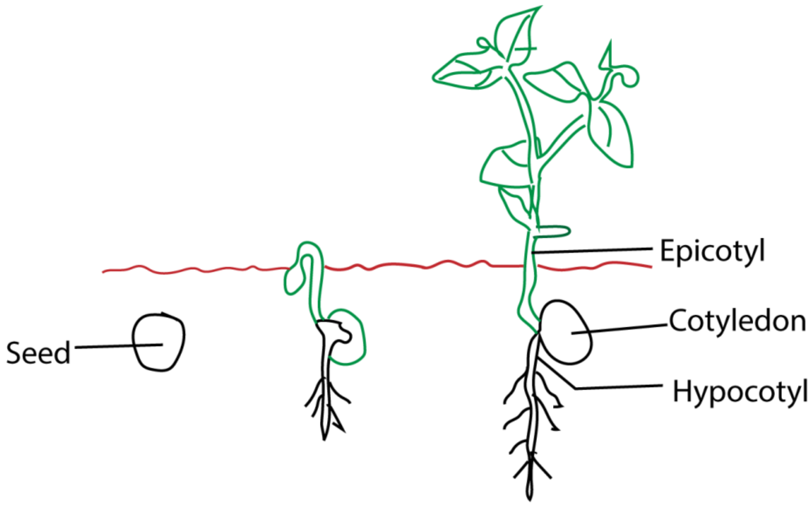
1. Epigeal germination

   Here hypocotyl grows faster than epicotyl causing the cotyledon to grow above ground



2. Hypogeal germination

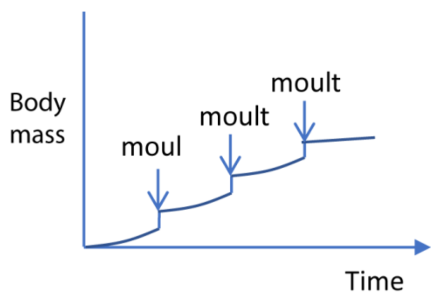
   Here epicotyl grows faster than hypocotyl that the cotyledons remain under the soil.



Intermittent growth in arthropods

Due to inelastic nature of their exoskeletons, they appear to grow only in spurts interrupted by a series of moults. Significant growth is only possible when the new cuticle is still soft enough to allow the body to expand

Arthropod growth curve

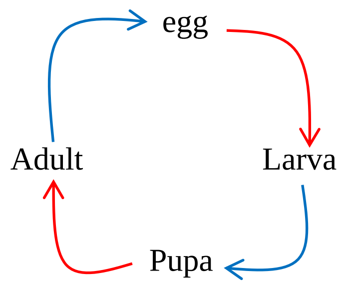


Moulting is controlled two main hormones: **moulting hormones (ecdysone)** and **juvenile hormone**. Moulting hormone is produced by gland in the first thoracic segment called **prothoracic gland**. Juvenile hormone is produced by a region behind the brain known as the **corpus allatum**. The production of both hormones is controlled by neurosecretory cells in the brain. All moults require moulting hormone. If juvenile hormone is present in high concentration larval moults occur, which means the insect remains as a larva.

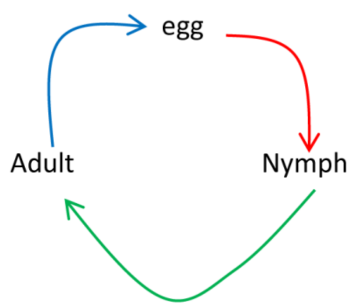
Metamorphosis

Applies to those changes which occurs during the transition from larval to adult forms. It is very common in insect, frog and other amphibian's metamorphosis enable the different stage organism develops to fill different ecological niches which reduces competition.

Complete metamorphosis
E.g. in butterfly



Incomplete metamorphosis
E.g. in cockroach



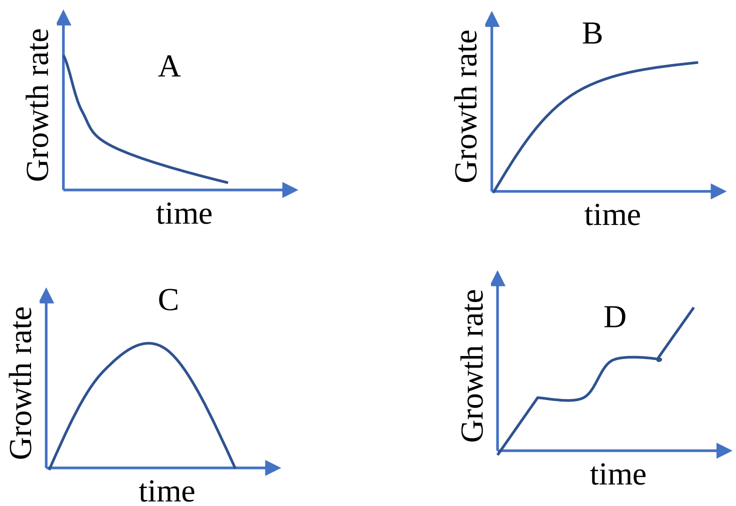
Senescence
Senescence refers to the body changes that lead to a decreasing life expectancy with age.
These changes include:

- Mental senility i.e. mental deterioration
- Atherosclerosis and arteriosclerosis which lead to hardening of arteries.
- The speed of impulse conduction in nerves decreases and so does sensitivity.
- Shrinking in body size
- Osteoporosis
- Hair becomes grey etc.
- Decrease in body sensitivity

Exercise

1. The following occur during senescence except
   A. Hardening of arteries
   B. Shrinking body size
   C. Increased sensitivity
   D. Mental senility

2. Which one of the following graphs in the figure below correctly represents the growth rate of multicellular organism?



3. Which one of the following is not a role of the larval stage in animal's development?
   A. Dispersal
   B. Asexual reproduction
   C. Feeding
   D. Sexual reproduction

4. Worker bees and queen bee are polymorphic forms which differ in fertility as a result of
   A. Feeding on different diet
   B. Worker's eggs not being fertilized
   C. Workers being produced parthenogenetically
   D. The queen having diploid cells while workers have haploid cells
5. Worker bees are
   A. Sterile females developed from fertilized eggs
   B. Fertile male developed from unfertilized eggs
   C. Sterile females developed from unfertilized eggs
   D. Fertile female developed from unfertilized eggs

5. Which one of the following is **not** a role of larval stage in animal development?
   A. Dispersal
   B. Feeding

C. Asexual reproduction
D. Sexual reproduction

6. Primary growth in plants is mainly the activity of

A. lateral meristems.

B. apical meristems.

C. primary meristems.

D. intercalary meristems.

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7. When are gibberellins formed in the germinating starchy seed?

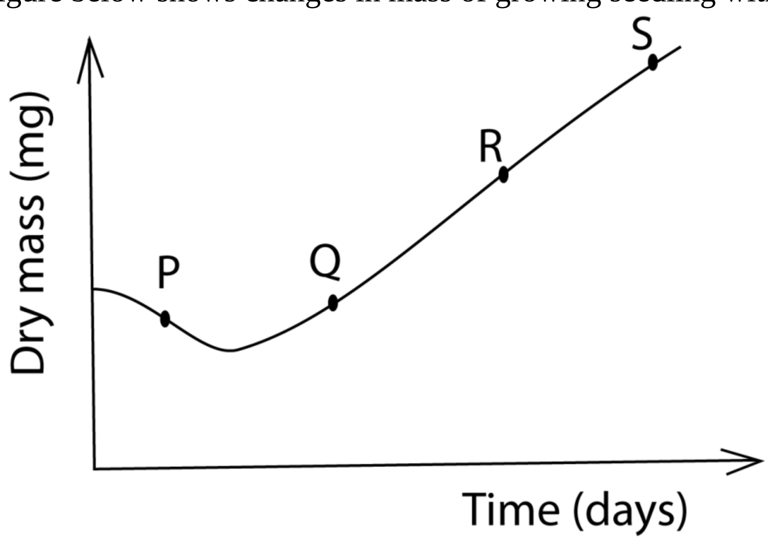
A. After water absorption.

B. After production of amylase.

C. When the radicle emerges.

D. During the production of amylase.

8. The figure below shows changes in mass of growing seedling with time



Which part of the curve indicates growth where respiration is higher than photosynthesis?
A. R
B. S
C. P
D. Q

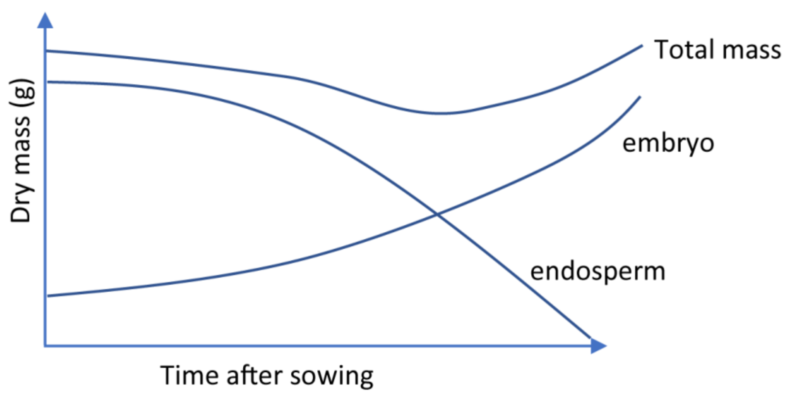
9. The significance of Etiolation in germinating seed in the soil is that is
A. Leads to rapid elongation of the hypocotyl in monocotyledonous plant
B. Allows maximum growth in length with minimum use of food reserves
C. Allows seedlings to grow in the dark
D. Ensure leaves remain small to break through the soil.

10. The primary meristematic tissues in plant which gives rise to the cortex is the
    A. Ground meristem
    B. Procambium
    C. Protoderm
    D. Protoxylem
11. In higher plants, the lateral roots originate from the
    A. Endodermis
    B. Epidermis
    C. Pericycle
    D. Cambium.

Structural questions

12. (a) What is the role of apical meristem in root growth? (7marks)
    (b) Describe the formation of secondary tissues in dicotyledonous plant. (13marks)

13. Figure 5 shows change in dry mass of the embryo, endosperm and total mass of maize seeds germinating in light condition.



(a) Explain the changes in relative dry mass of the

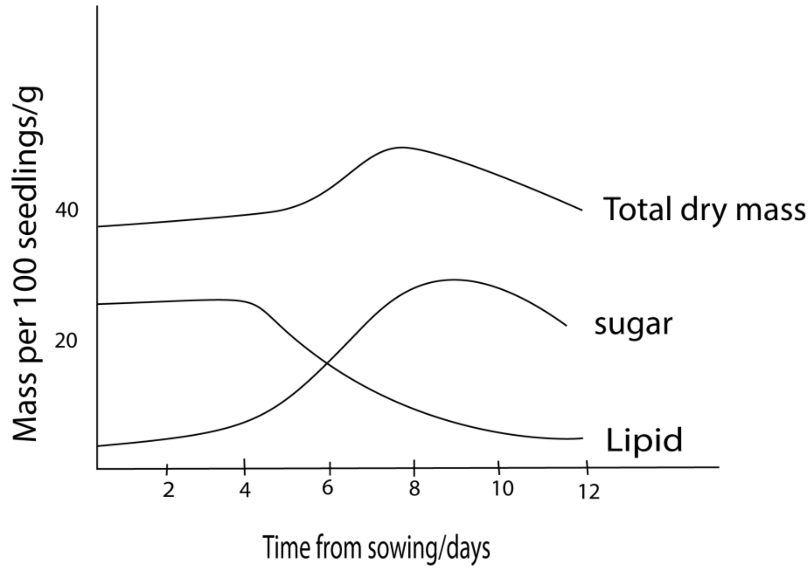
(i) endosperm

(ii) embryo

(b) Explain why the total dry mass of the seedling initially decreases then later increases

(c) Suggest with reason, what would happen to the total dry mass of seedling if the seeds were germinated in the dark

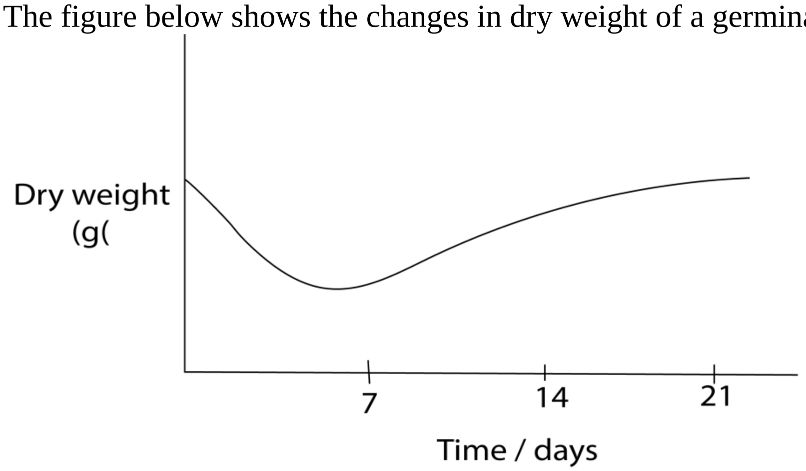
14. The graph below shows changes in lipids and sugar content of castor oil seeds during germination in the dark



(a) Explain the changes in lipid and sugar content and total dry mass during the experimental period.
(b) On the same graph indicate the shape of the curves if the seeds were to germinate in light (2marks)

15. (a) describe how the following tissues bring about growth in higher plants
(i) Apical meristem
(ii) Vascular meristems
(b) How does growth in mammals differ from that in flowering plants?

16. The figure below shows the changes in dry weight of a germinating bean seed



(a) explain the changes
(i) in the first seven (7) days
(ii) between the seventh and 21 day
(b) Give the major factors that cause seed dormancy

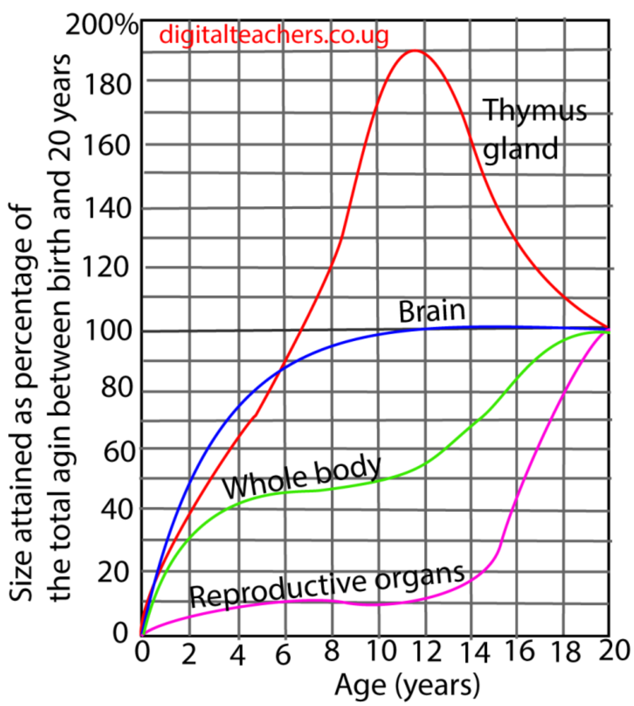
17. (a) Describe the physiological changes that occur in a seed during germination (10 marks)

(b) Giving reasons, suggest suitable conditions under which seeds for planting should be stored (06 marks)

(c). Even when supplied with suitable conditions for germination, some seeds remain dormant, explain the importance of dormancy in seeds. (04 marks)

18. The figure below shows growth of the brain, thymus gland, reproductive organs and whole body of human. The size attained is expressed as percentage of total gain between birth and maturity (20 years)

(a) Explain the different growth rates of the brain, thymus gland, reproductive organs and the whole body

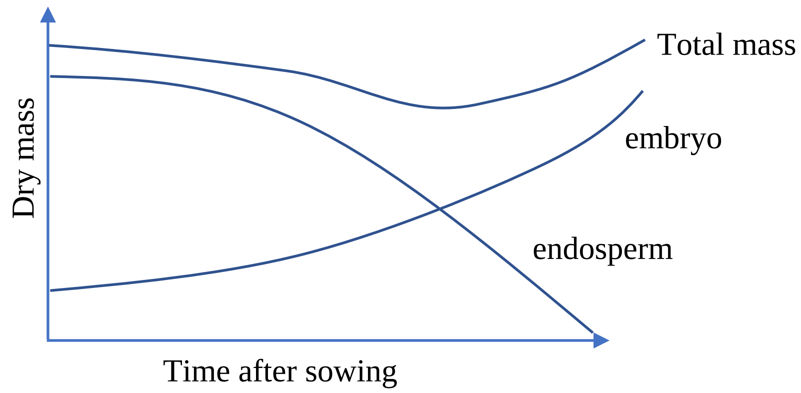


(i) Brain (2marks)
(ii) Thymus gland (3marks)
(iii) Reproductive organs (2marks)
(iv) Whole body (2marks)

(b) what type of growth is exhibited in the figure? (1marks)

19. Explain how organism have overcome the challenges of being multicellular (12 marks)

20. Figure 5 shows change in dry mass of the embryo, endosperm and total mass of maize seeds germinating in light condition.



(a) Explain the changes in relative dry mass of the

(i) endosperm

(ii) embryo

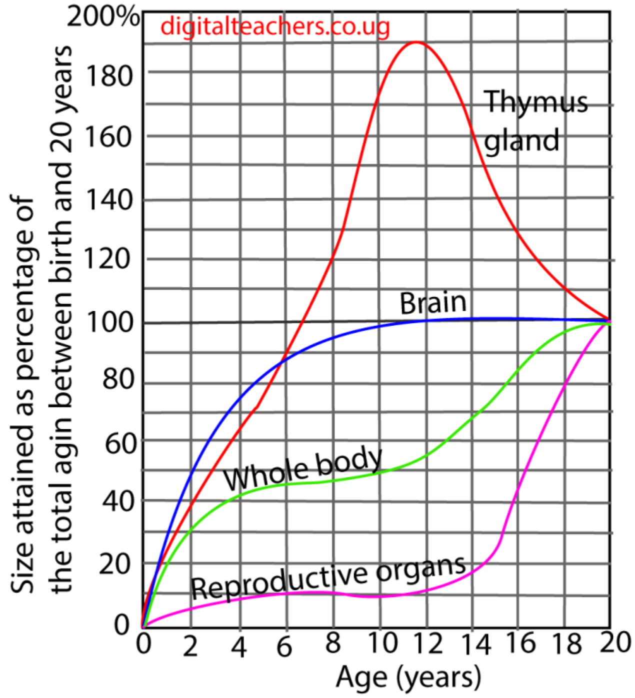
(b) Explain why the total dry mass of the seedling initially decreases then later increases

(c) Suggest with reason, what would happen to the total dry mass of seedling if the seeds were germinated in the dark

21. (a) Describe structural characteristic of cells of meristematic tissues. (03 marks)
    (b) Distinguish between apical and lateral meristems. (03 marks)
    (c) Describe structural adaptation of vascular tissues for support. (14marks)

22. Figure A and B shows growth pattern of organs in human and the mean growth mean growth rates in different sex respectively. Figure A represents the sizes attained by human body organs from birth, expressed as percentage of the total post natal growth. Figure B represents the mean growth rate changes in centimeters per year, in boys and girls, from birth to maturity. Study the figures and answer the questions that follow

Figure A: a graph showing the size attained by body organs as a percentage of total post natal growth against time



200%
180
160
140
120
100
80
60
40
20
0
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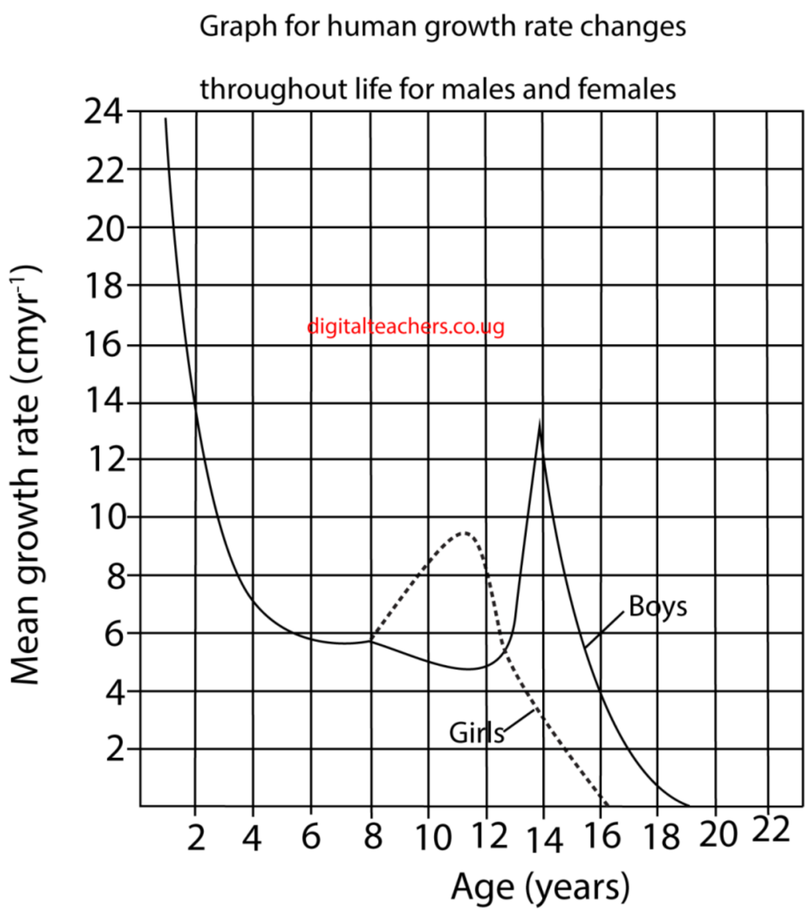
Thymus gland
Brain
Whole body
Reproductive organs
0 2 4 6 8 10 12 14 16 18 20
Age (years)
Size attained as percentage of the total agin between birth and 20 years

Figure B



Graph for human growth rate changes throughout life for males and females
24
22
20
18
16
14
12
10
8
6
4
2
digitalteachers.co.ug
Boys
Girls
2 4 6 8 10 12 14 16 18 20 22
Age (years)
Mean growth rate (cmyr-1)

(a) Describe the graph pattern shown by the
  (i) Thymus (04marks)
  (ii) Brain (04 marks)
  (iii) Reproductive organs (04marks)
(b) Explain the growth pattern shown by the
  (i) Thymus (06marks)
  (ii) Brain (04 marks)
  (iii) Reproductive organs (02 marks)

(c) Compare the mean growth rate in boys and girls (08marks)
(d) Explain the relationship between the size attained by reproductive organs and the mean growth rate between 11-20 years.

23. (a) What are problems of large size in animals (10marks)
(c) Explain how the problems of large size in animals have been overcome (10marks)

Suggested answers

1. C 2. C 3. D 4. A 5D 6B 7. A 8. C 9. B 10.A 11. C

12. **Solution**

(a) The apical meristem in the root gives rise to primary tissues of the root.
- (i) The root cap protects the delicate growing tissues in the root tips
- (ii) Cell division and cell expansion in the root apical meristem lead to root elongation
- (iii) Cell differentiation gives rise to different kinds of root tissues
- (iv) Primary vascular tissue growth contributes to increase in the girth of the root.
- (v) Lignification of xylem cells contributes to support.

(b) Secondary tissue formation in dicotyledonous plant is occurs by lateral meristems and leads to secondary growth or thickening

Lateral meristems include

(i) Vascular cambium
This divides into three layers of cells; the inner layer differentiates into secondary xylem; the outer layer into secondary phloem; while the inner layer remain meristematic.

Phloem distributes manufactured food while the xylem transports water and provides mechanical support

(ii) Cork cambium/phellogen
Divides into three layers of cells; the inner differentiates into secondary cortex, the outer cork while the inner remain meristematic.

13 **Solution**

(a) (i) The dry mass of the endosperm first decreases gradually and then rapidly.
As a result of imbibition and osmosis, the endosperm becomes hydrated.
The water activates the enzymes of respiration which oxidize the available glucose, leading to a gradual decrease in dry mass.

Later, there is rapid mobilization of blood reserves. The water also facilities the hydrolysis of stored food material such as starch into soluble products which are then translocated to the growing regions of the embryo. This accounts for the rapid increase in its dry mass.

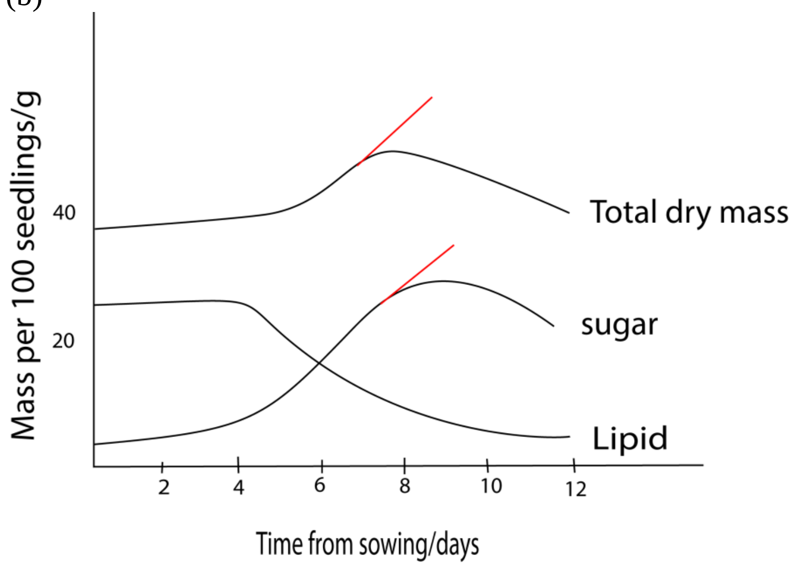
(b) The initial decrease in the total dry mass is due to the aerobic respiration occurring. This consumes sugar in both the embryo and endosperm.
Later, the total dry mass increases as the first foliage leaf emerges and starts to photosynthesize. The carbohydrate formed more than compensate for the respiration losses so that there is a net increase in total dry mass.

(c) The total dry mass of the seedling would continue to decrease gradually with no subsequent increases.
This is because the food store would be depleted by respiration and no photosynthesis would occur in the dark compensate for the loss.

14. (a)

- The main storage food reserve is lipid
- During germination, lipids decrease as they are broken down to fatty acids and glycerol
- The fatty acids are either used directly for respiration or are converted to sugars. The sugar content therefore rises.
- Sugar is translocated to the embryo
- The dry mass at day 6, because of assimilation of sugars to structural materials and growth occurs.
- Dry mass then fall because the lipids are exhausted and sugar decrease due to respiration

(b)



15. **Solution**

(a) (i) Apical meristem

- Are found at the root and shoot apices
- Meristematic cells called, initials, divide by mitosis.
- Some of the cells remain meristematic while others increase in size and differentiate to become permanent tissues.
- Apical meristems increase lengths of root and shoot by increasing the number and size of cells at apices.

(ii) Vascular cambium

- A lateral meristem consist of two types of cells fusiform and ray initials
- Fusiform initials are elongated and divide by mitosis to form secondary phloem to the outside and secondary xylem on the inside. The amount of xylem produced normally exceeds the amount of phloem.
- Ray initials are spherical and divide by mitosis to form parenchyma cells which accumulate to form rays between the neighboring xylem and phloem
- Successive divisions results in increase in the girth of the plant.

(b)

- Growth control factors in plants are sensitive to environmental factors such as sunlight and gravitation pull while that of mammals does not.

- Growth in plants is limited at the meristems while that of mammal occurs in all parts of the body

16. **Solution**

(a)(i) Explanation of changes in first seven days

There is slow and then rapid decrease in dry weight due to respiration

(ii) There is gradual increase in dry weight due to accumulation of sugars by photosynthesis.

(b) causes of seed dormancy

- hard impenetrable seed coat to water and oxygen
- immaturity of embry0
- presence of germination inhibitors
- unfavorable environment conditions

17. **Solution**

(a) Germination starts with the rapid uptake of water by the seed through the micropyle by a process called ambition. Water then moves from cell by osmosis.

- The water causes swelling of the embryonic tissue thereby rapturing the seed coat and also activates gibberellins.
- Gibberellins diffuse to the aleurone layer whereby they cause the synthesis and activation of hydrolytic enzymes such as amylase and proteases.
- Amylase catalyzes the breakdown of starch to glucose while proteases catalyze hydrolysis of proteins to amino acids.
- Glucose and amino acids are translocated from the storage centre (endosperm or cotyledon) of the seed to the growing regions of the embryo.
- Here glucose is used in respiration and in the formation of cellulose and other cell wall materials. Amino acids are used to make proteins, which are enzymes and structural components of protoplasm.

(b) The suitable temperature for germination in most seeds is 25-30^{0}C. thus seeds should be kept at a temperature below this in order to prevent germination in these seeds.

- Water is necessary for germination. Therefore, keeping seeds in a dry environment prevents germination and keeps the seed viable.

- Light is important for germination in most seeds and therefore keeping them in darkness prevents germination and keeps the seed viable.

(c) Dormancy allows for seed dispersal.

- Seeds are able to survive unfavorable conditions like drought.
- Dormancy prevents seeds from germination in the pods.
- The low metabolic rate during dormancy enables seeds to stay viable for a long time.

18. (a) (i) the brain mature rapidly to take over the overall control of the body system

(ii) Lymph tissue which produces white blood cells to fight infections, grows rapidly in early life when the risk of disease is greater as the immunity has not been acquired.
(iii) The reproductive organs grow slowly such that they are mature when the organism is body is ready to support the fetus and to take care of the offspring.
(iv) Whole body grows fast up to about 7year, gradual growth up to about 11 years and thereafter very rapid growth up to maturity size because there is much tissue formation in the early years and rapid elongation in the latter years

(b) Allometric growth

19. These challenges have been overcome in the following ways;

- There is division of labor, different cells being adapted to perform specific functions. This has improved efficiently in co-ordination of life-sustaining processes.
- Specialized respiratory surfaces have been developed to enhance gaseous exchange. These are usually highly folded to increase surface area for gaseous exchange. For example, lungs and gills.
- A specialized transport system has been developed to move gases and other materials to and from the body cells. For example, in higher animals and plants.
- In some, the body is flattened, thus reducing the distances between the two body surfaces and enhancing the process of diffusion. For example, in flat worms and leaves of plants.
- A specialized supporting system such as a skeleton in most animals has been developed to support, protect and assist locomotion of the organism.
- In some, the body is constructed such that the tissues are thin. This reduces the diffusion distance. For example, in hydra.

- In some, there exists a system by which the external medium is brought is brought into the body so that it comes into intimate contact with all the tissues in order to enhance exchange of materials by diffusion. For example, the tracheal system of insects.

20. **Solution**

(a) (i) The dry mass of the endosperm first decreases gradually and then rapidly.

As a result of imbibition and osmosis, the endosperm becomes hydrated.
The water activates the enzymes of respiration which oxidize the available glucose, leading to a gradual decrease in dry mass.

Later, there is rapid mobilization of blood reserves. The water also facilities the hydrolysis of stored food material such as starch into soluble products which are then translocated to the growing regions of the embryo. This accounts for the rapid increase in its dry mass.

(b) The initial decrease in the total dry mass is due to the aerobic respiration occurring. This consumes sugar in both the embryo and endosperm.
Later, the total dry mass increases as the first foliage leaf emerges and starts to photosynthesize. The carbohydrate formed more than compensate for the respiration losses so that there is a net increase in total dry mass.

(c) The total dry mass of the seedling would continue to decrease gradually with no subsequent increases.
This is because the food store would be depleted by respiration and no photosynthesis would occur in the dark compensate for the loss.

21. (a) Characteristics of meristematic tissues include small cells, thin cell walls, large cell nuclei, absent or small vacuoles, and no intercellular spaces.

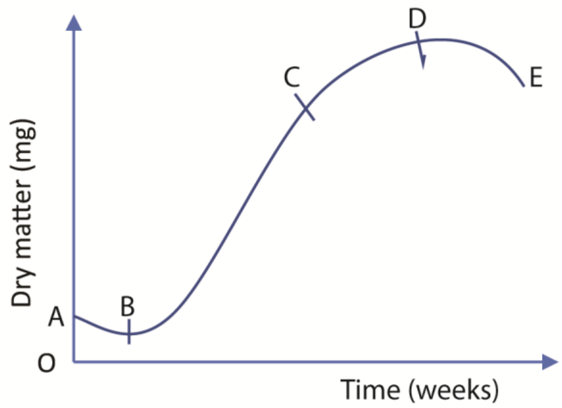
(b) Apical meristem is the **meristematic** tissue at the tip of stem and roots, responsible for the primary growth or increase in length of the plant whereas **lateral meristem** is the **meristematic** tissue at the margins of roots and stems, which is responsible for the secondary growth or increase in girth of the plant.

(c) Structural adaptation of vascular tissues for support

1. Walls are lignified

2. Vessels are circular for additional support.

22. The figure below shows the accumulation of dry matter of bean plant measured at different stages of growth from plating up to harvesting time. Study the figure and answer the questions that follow.



(a) Name the different stages

- (i) A – B: lag phase/establishment stage
- (ii) B – C: logarithmic stage/rapid growth stage
- (iii) C – D: steady stage/maturation stage
- (iv) D – E : decline stage/senescence

(b) State four physiological events that occur between A and B (04marks)

- Hydrolysis of storage food material
- Synthesis of enzymes, nucleic acids, structural proteins
- Respiration to provide energy for cellular activities
- **Glucose** and amino acids are translocated from the storage centre (endosperm or cotyledon) of the seed to the growing regions of the embryo.
- Cell division, elongation and differentiation leads to immergence of a seedling from a seed.

(c) Account for rapid increase in dry matter yield between B and C (02marks)

- Rapid cell multiplication due to presence of many cells
- Absence of diseases and other environmental resistance.
- Absence of pollutants

(d) Suggest two causes of the decline in dry matter yield between A and E

High rate cell death caused

- Accumulation of waste/toxic materials in plant that inhibit growth
- Diseases
- Predators/parasite
- Lack of water towards dry season