GROWTH AND DEVELOPMENT

Growth is an irreversible or permanent increase in the size and dry weight of an organism. Growth in multicellular organisms is divided into 3 phases.

1. Cell division

This involves increase in the number of cells mainly as a result of mitosis.

2. Cell expansion

It is the permanent increase in the cell size as a result of uptake of water or synthesis of living materials.

3. Cell differentiation

This involves specialization of cells to suit particular functions.

Growth is usually accompanied by development**. Development** is an increase in complexity and change in form of an organism.

FACTORS AFFECTING GROWTH

A. External factors

i) Nutrients

Growth of an organism increases if nutrients are available and decreases when nutrients are in short supply. This is because nutrients are used in the buildup of new tissues. They are also oxidized to provide energy required for growth.

ii) Accumulation of the byproducts of metabolism (excretory substances):

Growth may be inhibited by metabolic waste products which are toxic to the body cells. Fortunately most plants and animals are not affected much because they can convert these substances to less toxic ones.

iii) Temperature:

Growth depends on bio-chemical reactions which are catalyzed by enzymes. Temperature affects growth by affecting enzymes which catalyzes the chemical reactions in the body. Increase in temperature to the optimum increases the rate of growth, beyond which a decrease in growth occurs due to denaturation of enzymes.

iv) Light:

In plants, light affects the rate of photosynthesis which adds more organic matter to the plant. Therefore increase in light intensity in green plants increases the rate of growth and decrease in light intensity decreases the rate of growth.

v) PH:

PH affects the activity of enzymes which catalyzes reactions in the body. This can result into decrease in growth of an organism.

vi) Carbon dioxide:

In animals, carbon dioxide is a waste product of metabolism. If allowed to accumulate, it can lead to a decrease in the rate of growth while in plants carbon dioxide is a raw material for photosynthesis therefore increase in carbon dioxide concentration increases the rate of growth.

B. Internal factors

i) Hormones:

In animals, the presence of growth hormones and thyroxin hormone in blood increases the rate of growth while in plants the presence of auxins also increases the rate of growth.

ii) Hereditary factors:

Growth is under the control of genes which determine the particular size of an organism.

GROWTH AND DEVELOPMENT IN PLANTS

In plants, growth is continuous processes which occurs mainly at the tips of the root and shoot. These regions are called **meristems.** ***A meristem*** *is a part of the plant with cells that are capable of actively dividing by mitosis.*

Types of meristems

i) Apical meristems

These are located at the tip of roots and shoots. They bring about increase in length or height of the plant. This type of growth which involves increase in length or height of a plant is known as **primary growth.**

ii) Lateral meristems

These are laterally situated in the stems and roots of the dicot plants. They bring about **secondary growth** after primary growth. Secondary growth (secondary thickening) involves increase in girth/thickness of a plant.

Lateral meristems are of 2 types namely:

a) Cork cambium; which forms the secondary cortex
b) Vascular cambium; which gives rise to the secondary phloem and xylem tissues.

SEED GERMINATION

This is defined as the emergence and development of an embryo into a seedling capable of existing as a new and independent plant under favourable conditions.

The process of germination

- During germination, a seed absorbs water from the soil by imbibition mainly through the micropyle which makes the cotyledons swell and split the testa.
- The water activates the enzymes in the cotyledons to hydrolyze / breakdown the stored foods like starch, lipids and proteins into soluble products which are later used by the germinating seed. The enzymes involved in hydrolysis include diastase / amylase, protease and lipase.
- The soluble food substances are transported to the embryo where they are used. eg Simple sugars and fats are oxidized to produce energy. Amino acids are used to make new cells and tissues.
- Absorption of water from the soil results into increase in the size of the seed and growth of the radicles and plumule which brings about rapturing of the seed coat and an embryo emerges.

TYPES OF GERMINATION

1. Epigeal germination:

In this type of germination, the ***cotyledons appear above the ground due to the rapid elongation of the hypocotyl*** (i.e. the portion of the stem below the cotyledons) e.g. in tomatoes, beans, cotton, lettuce.

-During epigeal germination the seed absorbs water through the micropyle, a process called imbibition. This softens the testa and makes the cotyledons to swell.

-The testa splits to allow the radicle and plumule to emerge.

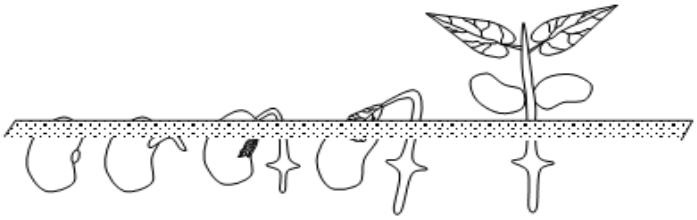
-The water also activates enzymes that hydrolyse the stored food and the products are passed from the cotyledons to the radicle and plumule where they are used for growth.

-The radicle emerges first and the hypocotyls elongate faster pushing the cotyledons upwards.

-The cotyledons may turn green in some plants to carry out photosynthesis. The cotyledons open to allow out the plumule.

-The leaves are formed and they start to photosynthesize.

Diagrammatic illustration of epigeal germination



2. Hypogeal germination:

In this type of germination, the ***cotyledon remains below the ground due to the rapid elongation of the epicotyl*** (i.e. the portion of the stem above the cotyledons) e.g. in beans, peas and maize.

-During hypogeal germination, the seed absorbs water by imbibition.

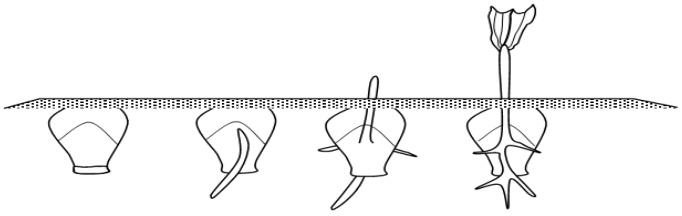
The water activates the enzymes that hydrolyse the stored food and the products are passed to the radicle and plumules.

-The radicle appears first bursting its protective sheath called coleorhiza. The radicle produces fibrous roots, which absorb water and anchor the plant.

-The protective plumule sheath (coleoptile) opens to allow the plumule out.

-The epicotyls elongate faster leaving the cotyledons below the ground.

Diagrammatic illustration of hypogeal germination



Conditions necessary for seed germination

1. Water

Water is needed for the following:

- It activates the enzymes within the seed to hydrolyze the stored food.

- It makes the seed swell, soft and the testa to bursts.
- It dissolves the stored food.
- It is a medium in which all the chemical and enzymatic reactions occur.
- It is a medium of transport of the dissolved food substances to the developing shoot and root of the new plant.
- Water is needed for the development of cell vacuoles. Large cell vacuoles contribute to increase in size of cells.

2. Oxygen

Oxygen is necessary for the process of respiration, ie the oxidation of food to provide energy required for growth.

3. Warmth

Suitable temperature is important for the enzyme controlled reactions in the cotyledon of the germinating seed. At low temperatures, the enzymes are inactive and at high temperatures, they are denatured hence no germination. Germination requires an optimum temperature.

EXPERIMENTS ON GERMINATION

An experiment to demonstrate the conditions necessary for germination

Apparatus:

4 test tubes, Cotton wool, Seeds, Oil and Water.

Procedure:

-Arrange four test tubes labeled 1-4

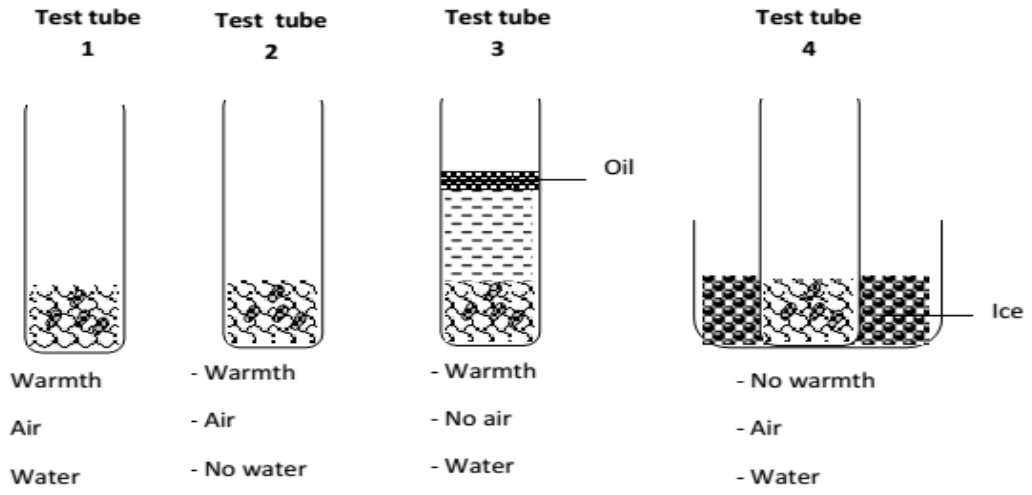
-To test tube 1 add moist cotton wool, seeds and leave test tube open.

-To test tube 2 add dry cotton wool, seeds and leave test tube open.

-To test tube 3 add seeds, boiled cooled water and a layer of oil.

-To 4 add seeds, moist cotton wool, ice and leave test tube open. Leave all test tubes for 3 days.

Setup:



Observations

Seeds germinated in only test tube 1 and those in 2, 3 and 4 did not germinate.

Conclusion:

Air, water and warmth are necessary for germination.

Experiment to show that oxygen is necessary for germination

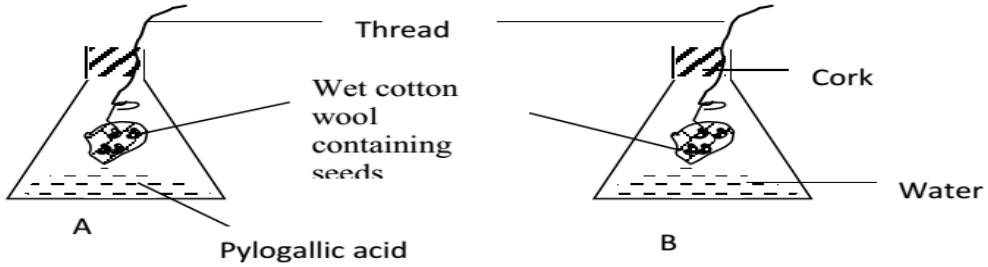
Apparatus:

2 conical flasks, 2 corks, Water, Cotton wool, Seeds and Pyrogallic acid.

Procedure:

- ✓ Pour some water in one conical flask and some alkaline pyrogallol in another conical flask.
- ✓ Tie some seeds in wet cotton wool and suspend the cotton wool in the flasks using a thread.
- ✓ Fix the threads using a cork.
- ✓ Leave the set up for three days

Set up:



Observation:

Seeds in B germinated while those in A did not germinate.

Conclusion:

Oxygen is necessary for germination.

Explanation:

Alkaline pyrogallol absorbs oxygen from air in flask A thereby preventing germination.

SEED DORMANCY

Seed dormancy is the condition where by viable seeds fail to germinate under certain conditions or resting stage.

Causes of seed dormancy

1. **Immature embryo of the seed**

Germination cannot occur if the embryo is immature since there will be no development of the plumules and radicle.

2. **Presence of germination inhibitors**

Some chemical substances like acids do not promote germination of seeds when present. They destroy the enzymes.

3. **Extreme temperatures**

High temperatures denature enzymes while low temperatures inactivate them.

4. **Presence of hard impermeable seed coat**

This does not allow water and gases to enter the seeds. Without water and gases, germination will not take place.

5. **lack of sufficient oxygen enough for seeds.**

If oxygen is absent, seed respire anaerobically and obtain less energy. This will not allow seeds to germinate.

Ways of breaking seed dormancy

1. Harvesting mature seeds. This allows embryos in seeds to develop up to maturity for a certain period called ***after-ripening period.*** This allows the seed to develop fully.
2. By providing growth promoters which deactivate germination inhibitors. These are chemical substances that can make inhibitors less acive. They contain nutrients or hormones for proper growth.
3. By exposing seeds to a cool period or chilling to initiate germination. This is common method of breaking seed dormancy in cereals.
4. By providing suitable conditions of oxygen, temperature and moisture which favour germination.
5. Removing the hard seed coat by:
   - Soaking seeds in water to soften it.
   - Action of fire to burn away the seed coat.
   - Passing seeds through animal gut.
   - Churning seed coat in concentrated acids.
   - Physical removal of the seed coat by using the hand or pricking or by action of bacteria in the soil.
   -

Importance of seed dormancy

i) It promotes germination of seeds during favourable conditions e.g. seeds dispersed in winter remain dormant in summer.
ii) It improves the chances of seedlings to grow to maturity during favourable conditions.
iii) Dormant seeds can be stored for a long time. This helps in their transportation.
iv) It reduces the risk of seeds being frozen to death during unfavorable conditions.

MEASUREMENTS OF GROWTH

Measurement of growth involves the use of fresh weight and dry weight of a seedling.

1. Fresh weight/mass:

This is the total amount of organic matter and water in an organism.

Advantages of measuring growth by using the fresh weight of an organism

- It does not involve the killing of the organism.
- It is a very easy method of determining growth.
- It is the most suitable method of determining growth of seedlings.

Disadvantages of measuring growth by measuring the fresh weight of an organism

- It is less accurate since the biggest part of an organism is water.
- It is not reliable because the mass keeps on fluctuating due to water loss by transpiration and evaporation.

2. Dry weight/mass

This is the total amount of organic matter making up the body of an organism after removing water. It involves heating of an organism in an oven to a constant weight.

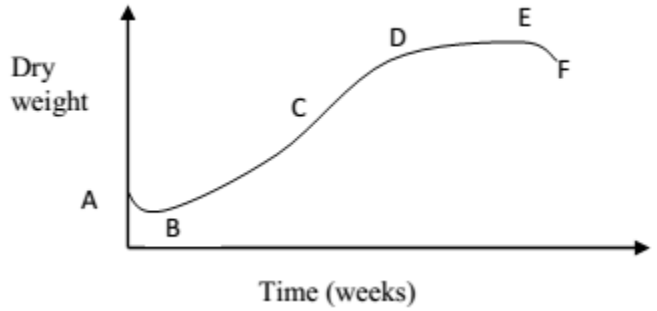
Advantages

- ✓ It is a more accurate method of determining growth.
- ✓ It is reliable because constant results are obtained.

Disadvantages

- It involves killing of an organism.
- The volatile tissues may decompose before removing all the water.

CHANGES IN DRY WEIGHT OF A GERMINATING SEED



Description and explanation of the graph:

From point **A to B**, the dry weight of the seed decreases. This is because the stored food reserves are hydrolyzed (broken down) to produce energy for germination.

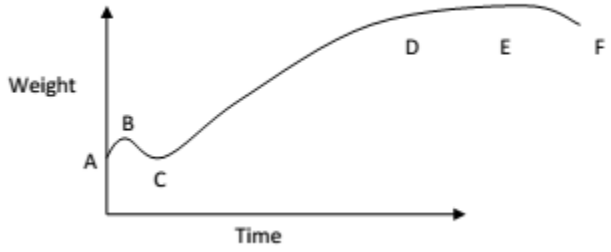
From point **B to C**, the dry weight increases rapidly. This is because the seedling has developed leaves, which carry out photosynthesis. It makes food, which causes its dry weight to increase.

From points **C to D**, the growth rate increases gradually.. This is because the plant has matured and preparing for flowering and fruiting.

From points **D to E**, the dry weight remains constant. The plant has produced fruits and no more growth takes place.

From point **E to F**, dry weight decreases gradually because the seeds are dispersed, the plant leaves dry and fall off.

CHANGE IN FRESH WEIGHT OF A GERMINATING SEED.



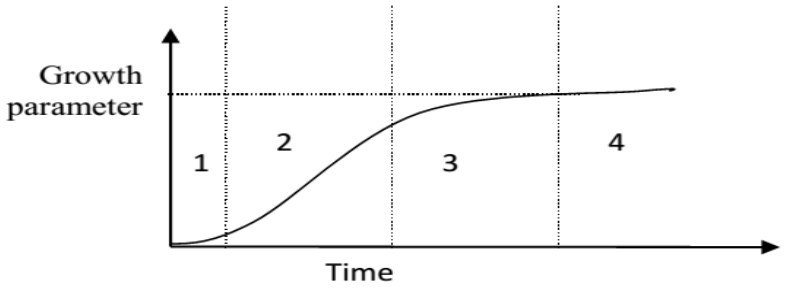
Explanation of the graph:

Most of the changes are similar to those in the graph showing changes of dry weight with time in a germinating seed except that for dry weight, the weight of water in the seed is not considered. For the total weight of the seed during germination, water is put into consideration.

The initial slight increase in weight from point A to B is due to imbibition (absorption) of water into the seed. The other changes that follow in the subsequent points on the curve are similar to those in the change of dry weight with time.

GROWTH CURVE

This is a graph which shows the change of a given growth parameter with time. This graph is S-shaped in most living organisms and it is called the sigmoid curve.



The curve shows 4 phases.

1. Lag phase.

This is a period of slow growth. It is the first phase of growth where there are very few cells dividing and the organism is getting used to the environment.

2. The exponential phase.

This is a phase of rapid growth. It is the second phase where the cells dividing are many and the organism is used to the environment.

3. Decelerating growth phase.

This is a period where growth slows down. The deceleration in growth may be due to;

1. Competition for food, space and other resources.
2. The organism is preparing for reproduction.
3. The organism is aging.

4. Stationary phase.

This is a period where there is no change in the growth parameter under investigation. At this point the number of cells which die is equal to those produced.

After the stationary phase, growth decelerates in some organisms due to aging and dispersal. In perennial organisms, growth increases continuously.

GROWTH AND DEVELOPMENT IN ANIMALS

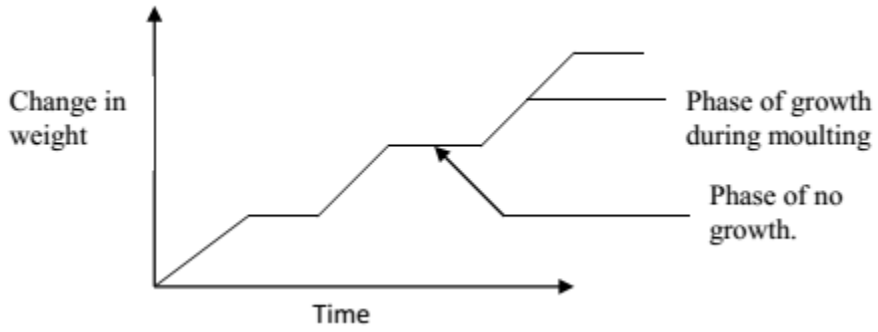
In animals growth occurs throughout the body of the organism unlike in plants where growth is localized in specific areas called meristems. Most animals grow continuously until they reach maturity. This is called continuous growth. In Arthropods like insects growth is discontinuous, i.e. there are periods of growth and no growth.

GROWTH AND DEVELOPMENT IN INSECTS

Insects have an exoskeleton which is rigid and prevents expansion of the insect during growth. Before the insect grows, it sheds the exoskeleton in a process called moulting (ecdysis).

Without the exoskeleton, the insect expands and grows. A new exoskeleton then forms and growth ceases. This kind of growth is referred to as intermittent growth or discontinuous growth. Successive moults result into formation of a new forms of the insect. This is called metamorphosis

A graph showing intermittent growth in insects



GROWTH AND DEVELOPMENT IN VERTEBRATES

After fertilization, the zygote undergoes three changes during its growth and development. These changes are;

1. Cleavage:

This is the mitotic division of the zygote to form a mass of cells. The zygote at this stage is called a **blastocyst**.

2. Gastrulation.

This is the rearrangement of the cells into distinct layers. The outer cells make up a layer called ectoderm. The cells in the middle make up a layer called mesoderm and the inner cells make up the endoderm. From these layers the various organs and systems are formed.

3. Organogenesis:

This is the formation of organs and organ systems.

EXPERIMENT TO FIND OUT THE REGION OF ELONGATION IN A ROOT

Materials:

- ✓ Water
- ✓ Ink
- ✓ Cock
- ✓ Seedlings
- ✓ Conical flask
- ✓ Dark cup board
- ✓ Pin

Procedure:

-Take bean seedlings with straight radicles.
-On each seedling mark the radicle every 2mm with lines in black ink.
-Pin the seedlings to the under side of the cork with the radicles hanging down wards.
-Insert the cork into the neck of the flask containing little water.
-Put the flask in the dark cup board for 3-4 days.

Experimental set up:

Leave 7 lines for a drawing

Observation:

Some lines on the radicle are 2mm apart while others are more than 2mm apart.

Conclusion:

The region where the lines are further apart is the zone of elongation (region of growth).