# GROWTH AND DEVELOPMENT

## Objectives:

## You should be able to;

- Define growth and cell division
- Describe the internal and external structure of a seed
- Draw and label the internal and external parts of a seed
- Explain seed dormancy
- List the factors /conditions necessary for seed germination
- Conduct experiments on conditions necessary for seed germination
- Name the types of seed germination in monocots and dicots
- List the causes of seed dormancy
- Explain how seed dormancy can be broken
- State the importance of seed dormancy
- Explain the importance of seed dormancy
- Explain the importance of meristems in plants
- Identify regions of greatest cell elongation in roots and shoots

- Explain the growth patterns in insects, amphibians, and mammals
- Explain how growth is brought about by cell division and cell enlargement in organisms
- Conduct experiments on plant growth over time and plot a growth time graph on the growth observed.
- Explain the increase in complexity and form in plants and animals
- Explain the development of a simple seed into a huge plant

- List the differences between endospermic seeds and non-endospermic seeds
- Describe epigeal and hypogeal germination
- Explain the process of secondary growth of stem in dicot plants
- Define the term metamorphosis
- Explain the difference between complete and incomplete metamorphosis
- Describe the stages of development in an amphibian and a mammal
- Explain metamorphosis in a frog
- Conduct experiments on growth of a frog
- Record observations of human baby by weight for a period of 4 month using a health card

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

### I. Cell division

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

### II. Cell expansion

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

### III. Cell differentiation

This involves specialization of cells to suit particular functions. Growth is usually accompanied by an increase in the complexity of an organism which is also called **development.**

**Development** is the increase in complexity and change of form of an organism.

## Growth and development in plants

Growth is a continuous processes in plants which occurs mainly at the tips of the root and shoot systems. These regions are called **meristems.**
**A meristem** is a group of undifferentiated plant cells which are capable of dividing repeatedly by mitosis.

## Types of meristems

### i) Apical meristems

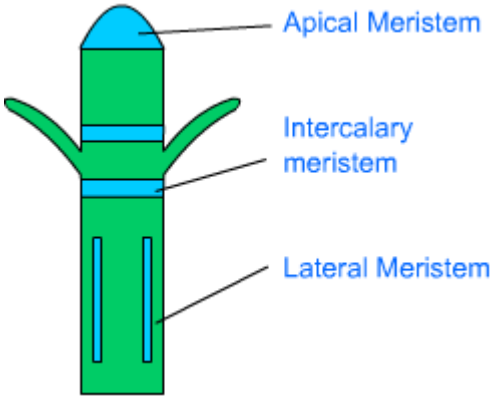
They are located at the tip of roots and shoot. They bring about increase in length or height of the plant. This type of growth which involves increase in length or height of a plant is known as **primary growth.**

### ii) Lateral meristems

These are laterally situated in the stems and roots of the dicot plants. It brings about **secondary growth** after primary growth. Secondary growth or secondary thickening involves increase in thickness in 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.




## GERMINATION

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

**Task.**

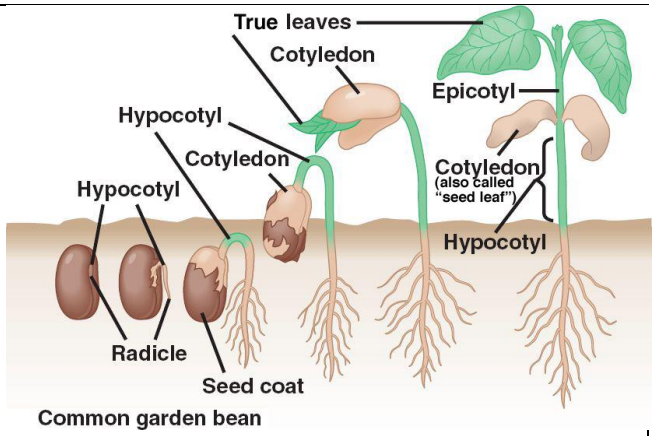
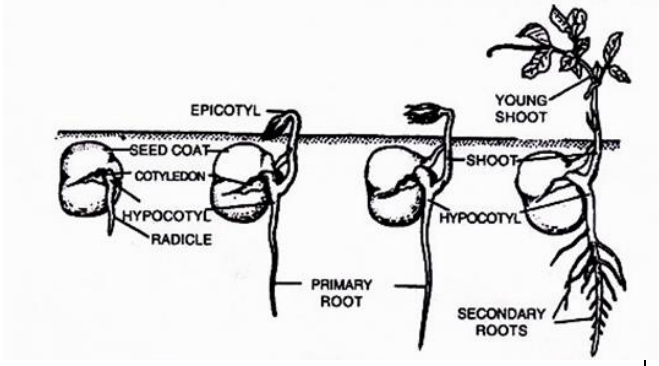
**Describe the process of germination**

During germination, a seed absorbs water from the soil by imbibition through the micropyle which makes the cotyledons swell and split the testa.

The absorbed water activates enzymes, thus leads to breaking of food materials e.g. starch and protein which are stored in the cotyledons or endosperm.
The soluble food materials are trapped to the growing points of the embryo where they are used to provide energy and making of new cells.
The radical is the first to emerge, it grows down wards between soil particles, and root hairs develop a short distance from the root cap and start absorbing water and mineral salts.
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**

**There are two types of** Germination;

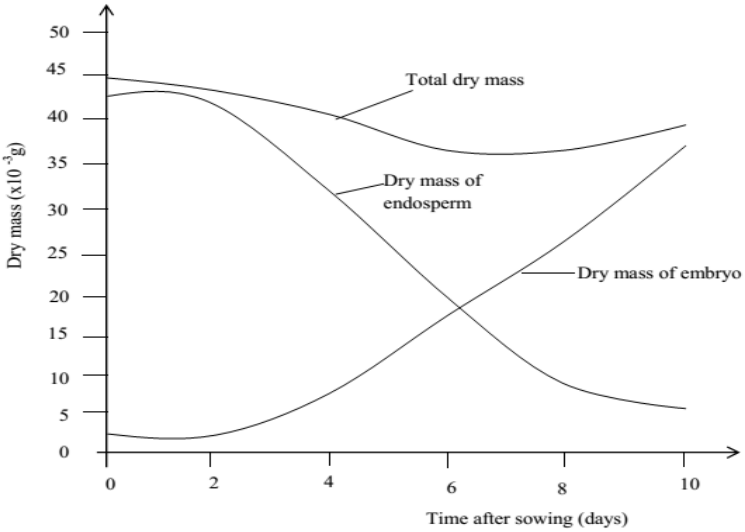
| | |
|---|---|
| **i) Epigeal germination**<br><br>This is where the cotyledons appear above the ground due to rapid elongation of the **<u>hypocotyl</u>**. E.g. beans, tomato, cotton, mangoes, etc. The cotyledons on exposure to sun light turn green and become photosynthetic. This is because they contain chlorophyll. This is when they assume the function of making food. |  <br>Common garden bean |
| **ii) Hypogeal germination**<br><br>The cotyledons remain underground due to the **<u>epicotyls</u>** growing faster than hypocotyls. Seeds showing hypogeal germination are endospermic. Examples include maize and G nuts. |  |

**Question:**

**Discuss the conditions necessary for germination**

| Condition | Required for |
|---|---|
| **Water** | • It activates the enzymes within the seed to hydrolyze the stored food.<br>• It makes the seed swell, soft and the testa to bursts.<br>• It dissolves the stored food.<br>• It is a medium in which all the chemical and enzymatic reactions proceed.<br>• It is a medium of transport of the dissolved food substances to the developing shoot and root of the new plant.<br>• Water is needed for the development of cell vacuoles. Large cell vacuoles contribute to increase in size of cells. |
| **Oxygen** | **Oxygen** is used in aerobic respiration, the main source of the seedling's energy until it grows leaves. |
| **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.<br>Germination will require an optimum temperature which varies from 10̊C-50C̊ for most tropical seeds. |
| | |

**Relative changes in dry mass of endosperm and embryo during germination of barley**



***Question:*** the table below shows the changes observed in dry weight in mg of a barley seedling, its embryo and endosperm during the first ten days after onset of germination.

| Time/days | Embryo | Endosperm | Whole seedling |
|---|---|---|---|
| 0 | 2 | 41 | 45 |
| 2 | 2 | 39 | 43 |
| 4 | 7 | 32 | 41 |
| 6 | 15 | 21 | 38 |
| 8 | 22 | 11 | 35 |
| 10 | 35 | 6 | 43 |

a) Suggest how the experiment was carried out
b) Using a suitable scale and on the same set of axes plot graphs of dry weight of embryo, endosperm and whole seedling against time.
c) Describe and account for the changes in weight shown by:
   i) The embryo
   ii) The endosperm
   iii) Whole seedling during the period of the experiment.
d) Explain how you would expect the weight of the whole seedling to change if the experiment was carried out in the dark.

## EXPERIMENTS ON GERMINATION

**AIM: An experiment to demonstrate the conditions necessary for germination**

**Apparatus:**

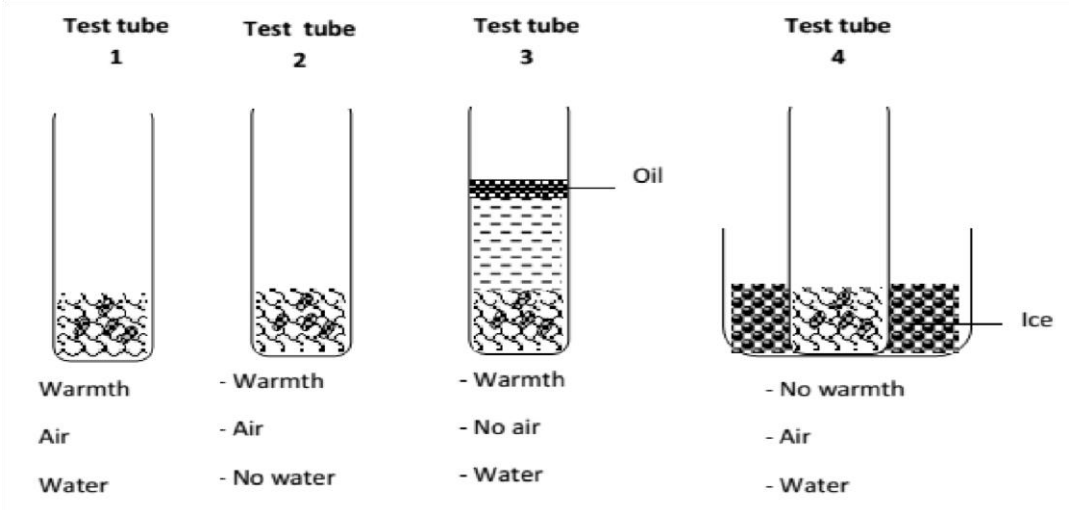
- 4 test tubes,
- Cotton wool,
- Seeds,
- Oil and Water.

**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.

**AIM: Experiment to show that oxygen is necessary for germination**

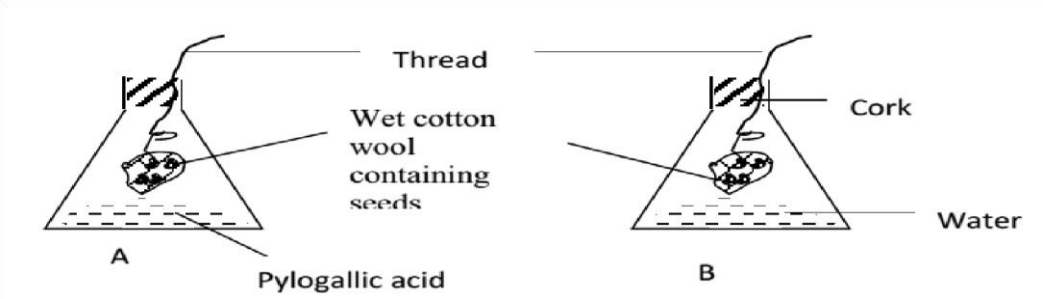
**Apparatus:**

- 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:**

After a few days the 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**

This is a state in which a viable seed will not germinate under favorable conditions. Dormant seeds usually have low metabolic activity, they have low water content and 'Zero' growth rate i.e. the embryos do not grow in any way.

**What is the importance of seed dormancy?**

i) It allows seeds to be dispersed from their parent plants before germinating thus avoiding overcrowding and competition around the parent plants.
ii) It ensures that germination occurs when conditions are favorable for growth. E.g. in many temperate plants, dormancy is broken through exposure of seeds to winter cold. This ensures that seeds are ready for germination in early spring so that they can grow through the rest of spring and summer when temperature is suitable for growth.
iii) It allows the embryo to develop to maturity.

**What are the causes of seed dormancy?**

- ❖ Lack of adequate water supply
- ❖ Lack of adequate oxygen
- ❖ Requirement for suitable temperature range i.e. at high temperature, water is not available and at very low temperature, water is frozen.
- ❖ Hard seed coats mechanically resisting emergency of seedling parts.
- ❖ Hard seed coats impermeable to water and air.
- ❖ Immaturity of the embryo
- ❖ Presence of germination inhibitors like abscisc acid.

- ❖ Absence of germination promoters such as gibberellic acid, cytokines, etc.

How can seed dormancy be broken?

**Breaking of seed dormancy**

1) Clearing vegetation cover. This works for positively photoblastic seeds.
2) By attaining high and low temperature.
   Some seeds in order to break dormancy need to be hydrated at low temperature (between 4-10$^0$C). It also encourages improvement of coat permeability.
3) Hard seeds coats are broken by:
   - ❖ Break down by microorganisms in soil for example bacterial and fungi.
   - ❖ Digestive actions of enzymes of mammals and birds. This works well for seeds of red pepper, passion fruits, etc.
   - ❖ Exposure to alternating high and low temperature
   - ❖ Treatment of seeds using appropriate chemicals e.g. concentrated sulphuric acid and alcohol.
   - ❖ Clipping or breaking off pieces of seed coats.
4) Dormancy due to chemical inhibitors is broken by treatment of seeds using germination stimulators like gibberellic acid and cytokines.
5) Dormancy as a result of embryo immaturity and embryo dormancy is broken by allowing after ripening period and stratification.

## 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 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.

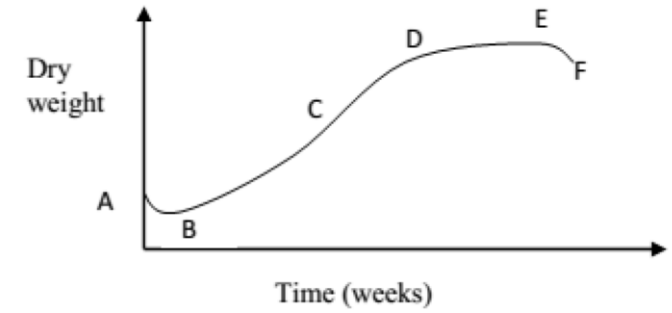
**Advantages**

- ✓ 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-B**, the dry weight of the seed decreases. This is because the stored food in food reserves is hydrolyzed (broken down) to produce energy for germination.

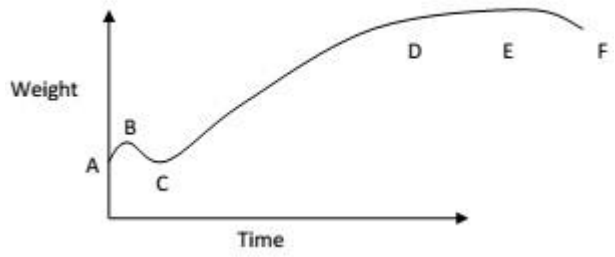
From point **B-C**, the dry weight increases rapidly. This is because the seed has produced leaves, which are carrying out photosynthesis. It makes food, which causes its dry weight to increase.

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

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

From point **E-F**, weight drops because the seed are dispersed, the plant leaves dry and fall off. This causes a reduction in dry weight.

**Change in total 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-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 and development in selected 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.

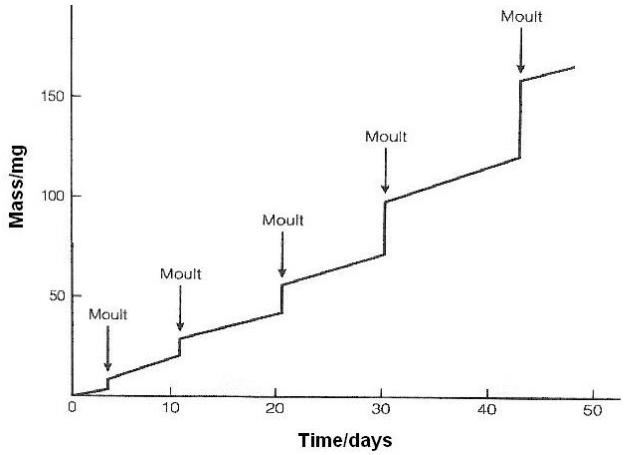
## Growth and development in insects

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 form of the insect. This is called metamorphosis. Metamorphosis has already been discussed under insects.

**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.

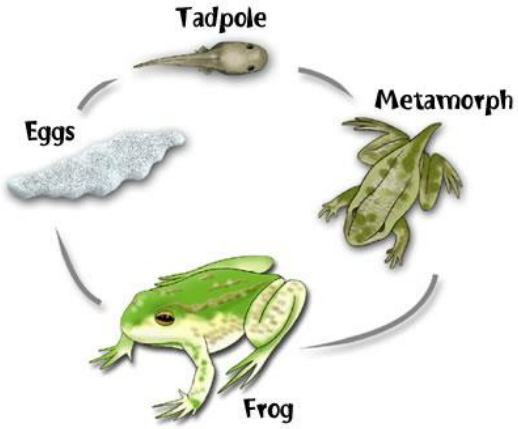
3. **Organogenesis:**

This is the formation of organs and organ systems.

**Growth in amphibians**

Amphibians

They develop in both land and water .This process is studied a lot because scientist still want to establish how some organisms develop in water but are able to develop to live in land .




**Discussion questions**

1. Define the term metamorphosis
2. Explain the difference between complete and incomplete metamorphosis
3. Describe the stages of development in an amphibian and a mammal
4. Explain metamorphosis in a frog
5. Conduct experiments on growth of a frog
6. Record observations of human baby by weight for a period of 4 month using a health card