Revision Notes for Class 11 Biology

Chapter 13 – Plant Growth and Development

All cells of the plant develop from the zygote. The development of a mature plant from the zygote follows a precise and highly ordered succession of events. It is actually the sum total of growth and differentiation. A complex body organization is formed during this process. The body produces roots, leaves, branches, flowers, and seeds, and after that, the plant dies.

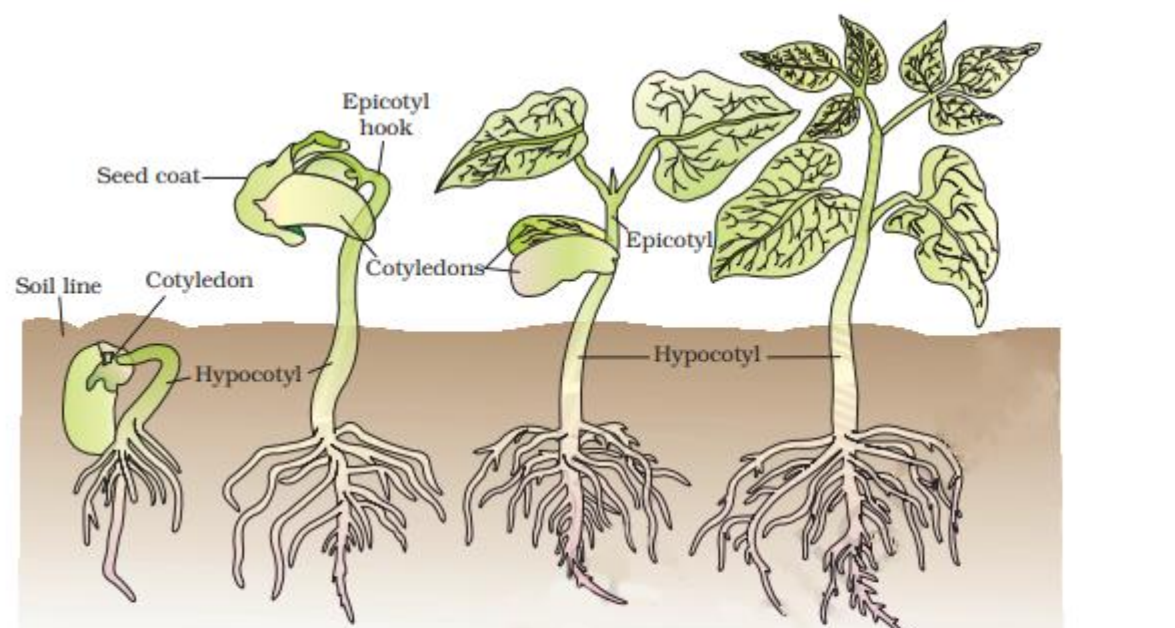


Figure 13.1 Germination and seedling development in bean

Growth

- The stems, roots, leaves, flowers, fruits, and seeds of the plants arise naturally. The order of the growth is in the following manner:

- The plants begin their reproductive phase, where the flowers and fruits are produced to continue the plants' life cycle after completing their vegetative phase.
- Development is the sum of two processes which are growth and differentiation. Few internal and external factors control development and growth.
- Growth is an irreversible increase in dry weight, size, mass, or volume of cells, organs, or organisms which is permanent. It is usually internal in living organisms.
- Growth is achieved by cell division, which increases cell number and cell enlargement in plants. Hence, growth is a quantitative aspect which can be measured according to time.

Plant Growth Generally is Indeterminate

- Plant growth is generally indeterminate because of the capacity of unlimited growth in their lifespan. Meristem tissues are there at certain parts of the plant body.
- **The Open Form of Growth -** The plant growth in which there is an addition of new cells to the plant body due to meristem.
- **Root Apical Meristem and Shoot Apical -** Meristem leads to elongation and the primary growth of the plant body along with the axis.

Growth is Measurable

- At the cellular level, growth refers to the increase in the amount of protoplasm. It is often difficult to measure this increase. However, we can measure the increase in the cell, cell number, and cell size.
- The growth measure is checked by the increase in fresh weight, length, dry weight, area, volume, and cell number. Some can be measured for measuring some kinds of growth.

Phases of Growth

- The phase of cell division or cell formation is called the formative phase. It takes place at the shoot apex, root apex, and other regions having meristematic tissue. The rate of respiration is usually very high in the cells undergoing mitosis division in the formative phase.

- **Enlargement Phase -** The newly formed cells produced in the formative phase will undergo enlargement. This enlargement leads to the development of vacuoles that further lead to an increase in cells' volume.

- Cell enlargement takes place from all directions with maximum elongation in conducting tissues and fibres.

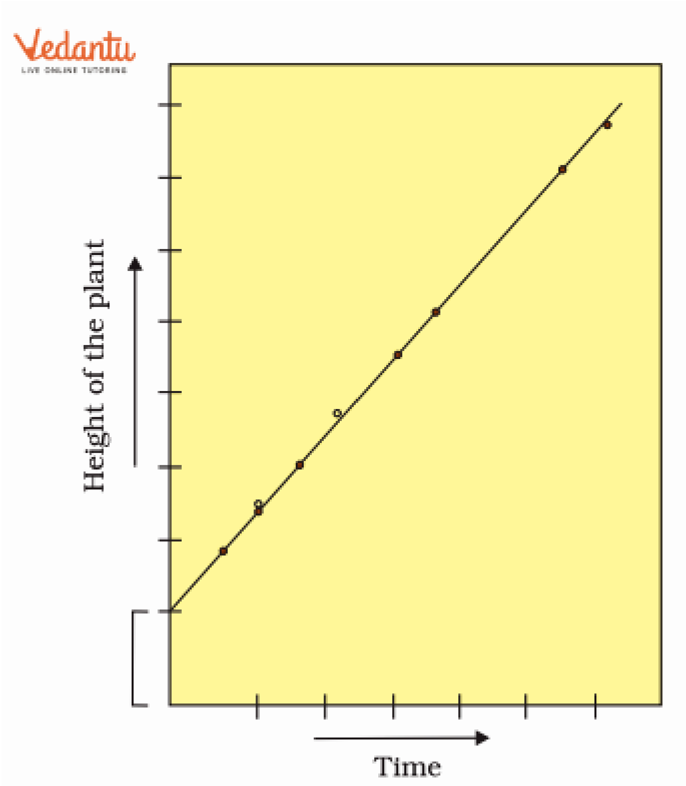
- **The Phase of Maturation -** the cells that have undergone enlargement develop into a specific type of cells by structural and physiological differentiation.

Growth Rate

The growth rate is the increase in growth per unit time. The growth rate may be different in nature. Some are arithmetic or geometric.

- **Arithmetic Growth -** In this type of nature, the rate of growth is constant, and an increase in growth follows an arithmetic progression- 2,4,6,...

It occurs in shoot and root elongation.

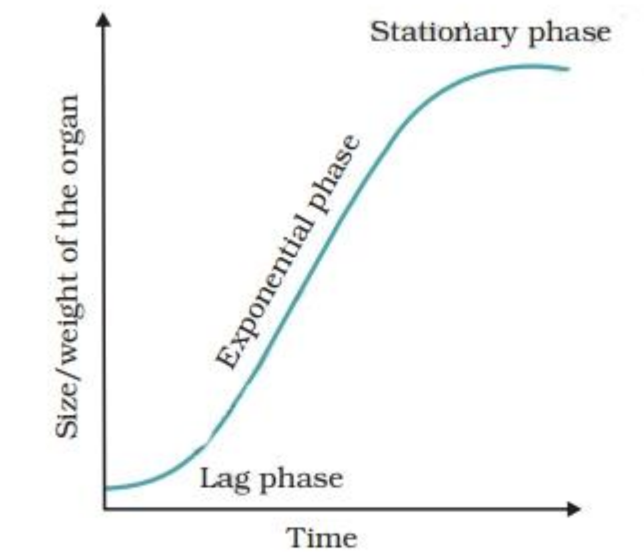


Constant Linear Growth, plot of length L against Time t

$L_t = L_0 + rt$

Length at beginning + growth rate x time = Length after time.

- **Geometric Growth -** In this method, the initial Growth is gradual and then rapidly increases. Each cell divides. The daughter cells divide and grow, and further the granddaughter cells that lead to the exponential growth. It is common in a unicellular organism.
- The sigmoid growth curve includes the stationary phase and fast dividing exponential phase. It is very typical of most living beings in their natural habitat.



Exponential Growth can be represented and can be expressed as follows:

W_0 = initial size, W_1 = final size, $W1 = W_0e^{rt}$., r = growth rate, and the t = time of growth, and e is the base of natural logarithms (2.71828).

- Quantitative comparison between the Growth of the living system can be made by

1. The absolute rate means the measurement and comparison of total Growth per unit time.

2. The relative growth rate is the growth of a given system per unit of time, which is expressed on a common basis.

Condition for Growth

- Water, oxygen, and essential elements are the essential conditions for growth. Water is highly required for all cell enlargement and controls turgidity. Water also acts as a medium for enzymatic conditions.

- Water is required for the formation of Protoplasm, while the micro and macronutrients act as a source of energy.

Differentiation, Dedifferentiation, and Redifferentiation in Plants

1. **Differentiation**: This is the process by which unspecialised cells develop into specialised cells with distinct functions. During differentiation, cells undergo changes in gene expression, leading them to form specific tissues and organs, such as roots, stems, or leaves. Differentiated cells have unique structures and functions tailored to their roles within the plant.

2. **Dedifferentiation**: In contrast, dedifferentiation involves the reversal of differentiation. Specialized cells regain their ability to divide and become more like the original, unspecialized cells. This process can occur in response to injury or stress, allowing the plant to form new tissues or regenerate lost parts. Dedifferentiation is a crucial aspect of plant healing and regeneration.

3. **Redifferentiation**: Following dedifferentiation, redifferentiation is the process where the newly undifferentiated cells specialize again, but into different types of cells or tissues than before. This allows plants to adapt and form new structures based on their needs or environmental conditions. Redifferentiation is essential for the formation of new organs or tissues during development and repair.

These processes are vital for plant growth, development, and regeneration, enabling plants to adapt to their environment and repair damage.

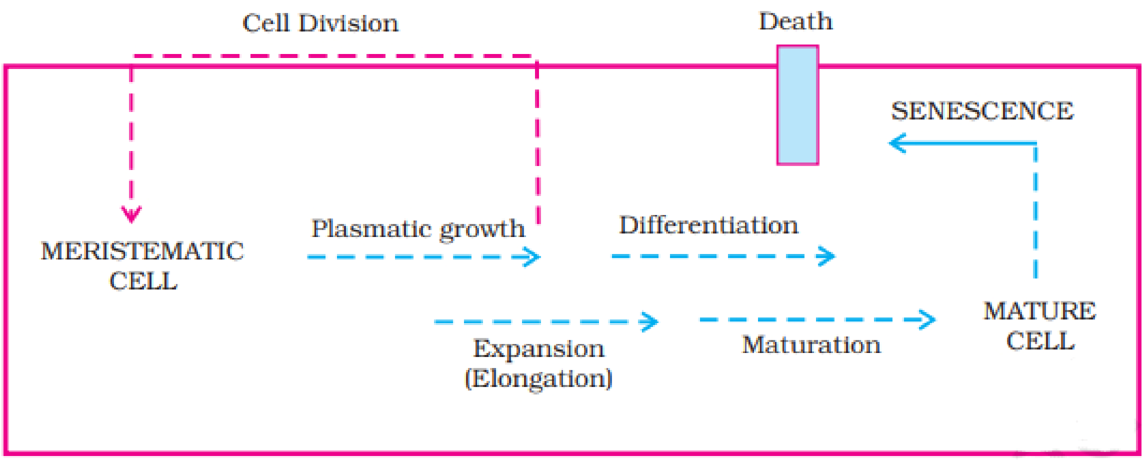


Figure 13.8 Sequence of the developmental process in a plant cell

Development

It is the order of the events in the life span of a cell, organ, or organism, including growth differentiation, seed germination, growth, flowering, senescence, and seed formation.

The sequence of the development process in plant cells:

- Different structures of plants develop in different stages of growth, also as in response to the environment. Plasticity is the ability to change under the influence of internal or external stimuli - for example, Heterophylly in cotton plants.

Plant Growth Regulators

Plant growth regulators (PGRs) are chemical substances that influence various aspects of plant growth and development. They are crucial for regulating processes such as cell division, elongation, differentiation, and responses to environmental stimuli.

Characteristics of Plant Growth Regulators

- **Specific Effects**: Each plant growth regulator (PGR) affects different plant processes. For example, auxins help plants grow longer, while gibberellins help seeds sprout.
- **Dependence on Amount**: The impact of PGRs changes with their concentration. Small amounts can boost growth, while too much can slow it down or change the effect.
- **Interaction with Other Regulators**: PGRs can work together or against each other. For instance, auxins and cytokinins often need to be balanced to promote healthy growth.
- **Timing Matters**: The effects of PGRs depend on when and how long they are used, and they can vary throughout a plant's life.
- **Local or Transported Action**: PGRs can act where they are applied or be moved to different plant parts to work.
- **Reversible Effects**: Some effects of PGRs can be changed by adjusting their amount or using other regulators.
- **Natural and Synthetic**: PGRs can be natural (made by plants) or synthetic (artificially created). Both types can help control plant growth.
- **Growth and Stress Response**: PGRs are important for normal growth, like sprouting and flowering, and help plants deal with stress like drought or disease.

The Discovery of Plant Growth Regulators

The discovery of plant growth regulators (PGRs) marked a significant advancement in understanding plant biology. Here’s a brief overview suitable for Class 11 Biology:

1. **Early Observations**: Scientists first observed that plants respond to various stimuli, such as light and gravity, and that these responses were controlled by internal substances.

2. **Discovery of Auxins**: The first plant growth regulator, auxin, was discovered in the early 20th century. Scientists like Frits Went and Peter Boysen-Jensen conducted experiments showing that a substance in the plant tips (later identified as auxin) promotes cell elongation and growth. Auxins were found to be crucial for processes such as root development and fruit growth.

3. **Gibberellins**: In the 1920s, Japanese scientist Eiichi Kurosawa discovered gibberellins while studying a fungal disease in rice plants. He found that these substances could induce abnormal growth patterns, such as excessive stem elongation.

4. **Cytokinins**: Cytokinins were identified in the 1950s by scientists like Folke Skoog and Carlos Miller. They discovered that cytokinins promote cell division and growth in plant tissues. This was observed through experiments where these substances stimulated cell proliferation in tissue cultures.

5. **Abscisic Acid**: In the 1960s, researchers identified abscisic acid, a growth regulator that inhibits growth and helps plants respond to stress, such as drought. It was found to play a key role in seed dormancy and abscission (the shedding of leaves).

6. **Ethylene**: Ethylene was discovered in the early 20th century as a gas that affects fruit ripening and other growth processes. It was later recognized as a plant hormone that regulates various aspects of plant growth and development.

Physiological Effects of Plant Growth Regulators

1. Auxin - It is commonly known as indole-3-acetic acid (IAA). It is produced at the stem and root apex and often migrates to the site of action.

It serves the following functions:

1. Cell enlargement.

2. Cell division.

3. Apical dominance.

4. Induce Parthenocarpy.
5. Inhibition of abscission.

2. Gibberellins: Gibberellins are promotery PGR seen in more than 100 forms. They are denoted as GA1, GA2, GA3 and so on. Gibberellic Acid is the most common one.

It serves the following functions:

1. Cell elongation.
2. Early maturity.
3. Seed germination.
4. Breaking of dormancy.

3. Cytokinins - Cytokinins have specific effects on cytokinesis and were discovered as kinetin (a modified form of adenine, a purine) from the autoclaved herring sperm DNA. The most common forms are zeatin, kinetin, etc. They are mainly made in the roots.

Some of the Functions:

1. Cell division and cell differentiation.
2. Overcome apical dominance.
3. Promote nutrient mobilization.
4. Essential for tissue culture.

4. Ethylene - It is called a gaseous hormone that stimulates isodiametric or transverse growth; however, it retards the longitudinal one.

It serves the following functions:

1. Inhibition of longitudinal Growth.
2. Senescence.
3. Promote apical dominance.
4. Fruit ripening.

5. Abscisic Acid - It is also referred to as stress hormone or dormin. It works like a general plant growth inhibitor. Abscisic acid is formed at the terminal buds of the top of the plant or in the roots of the plants.

It can serve the following functions:

1. Bud dormancy.
2. Induce Parthenocarpy.
3. Seed development and maturation.
4. Leaf senescence.

Photoperiodism - Photoperiodism is the effect of photoperiods or day duration of light hours on the plant's growth and development, especially flowering. The flowering plants have been divided into the following categories based on photoperiodic response:

1. **Short Day Plants -** The flowers which need exposure to light for a period less than this critical duration before the flowering is initiated. For example - Xanthium, Sugarcane, and Potato Rice.

2. **Long Day Plants -** The plant flowers when they need a long photoperiod of light, greater than the critical period. Example - Barley, Radish, Lettuce.

3. **Day Neutral Plants -** These plants can blossom throughout the year - for example - Wild Kidney, and Bean.

Vernalisation - is the process of reducing the juvenile or vegetative phase and fastening the flowering procedure by cold treatment. Meristematic cells help in perceiving the stimulus of vernalization.

- Vernalisation reduces the vegetative period of plants and leads to early flowering.
- It applies to temperate plants like Rice, Wheat, Millets, etc..