NEET Revision Notes
Biology
Plant Growth and Development

Introduction

- Plants have meristematic cells which help them to grow lifelong.
- A permanent change in physical condition of an organism is defined as growth. Plants grow indefinitely because of cell growth and cell division. This potential is due to the availability of meristems at various parts of the plant body.
- Plants have the ability to grow continuously throughout their lives, so their growth is unique. This ability can be attributed to the presence of meristems having cells with the ability to self-perpetuate and divide, at various locations throughout their body.
- The root and shoot apical meristems are capable for primary plant growth, which contributes to plant elongation along the axis. Lateral meristems, vascular cambium, and cork-cambium occur in gymnosperms and dicotyledonous plants.
- These meristems expand the diameters of active structures, usually resulting in secondary plant growth.
- Growth is an increase in the volume of protoplasm at the cellular level. It is measured using a number of metrics, including dry weight, fresh weight, volume, length, area, and cell number.
- In some plants, growth is demonstrated as an increase in cell number and size, whereas in others, growth is expressed as an increment in pollen tube length, increase in surface area, and so on.

Growth phases in Plants:

- The growth period is divided into three stages:
    1. Meristematic: It includes constantly dividing root and shoot apex cells.
    2. Elongation: It includes transfer of proximal cells to the meristematic region.
    3. Maturation: It includes conversion of proximal cells to the elongation phase cells.

Differentiation, dedifferentiation and redifferentiation:

- Differentiation occurs when cells from the root apical and shoot apical meristems, as well as the cambium, differentiate and mature to carry out special functions.
- Dedifferentiation is the process by which differentiated living cells regain their ability to divide.
- Redifferentiation is the process by which differentiated cells that have exhausted their ability to multiply are reformed from dedifferentiated cells to conduct specific functions.

Types of Growth in Plants:

- The number of cells in organisms grows in a variety of ways. The growth rate is defined as the increased growth per unit time. This can be mathematically expressed.
- Arithmetic and Geometric growth are the two types of growth found in plants.

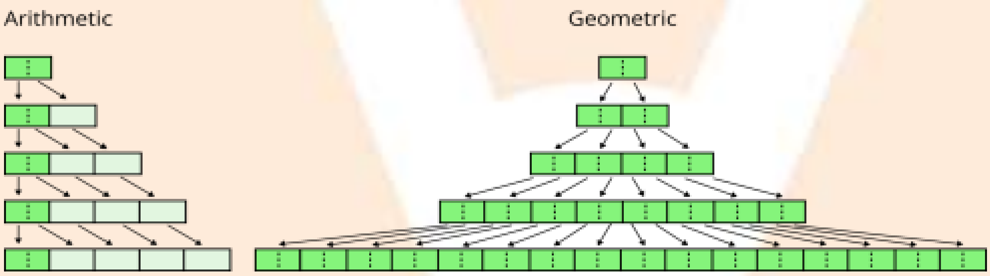

Image: Types of Growth Rates in plants

Arithmetic Growth:

- In terms of arithmetic growth rate, only one of the two daughter cells generated by mitotic division of a cell proceeds to divide while the other differentiates and develops.
- The arithmetic growth curve looks like the one given below:

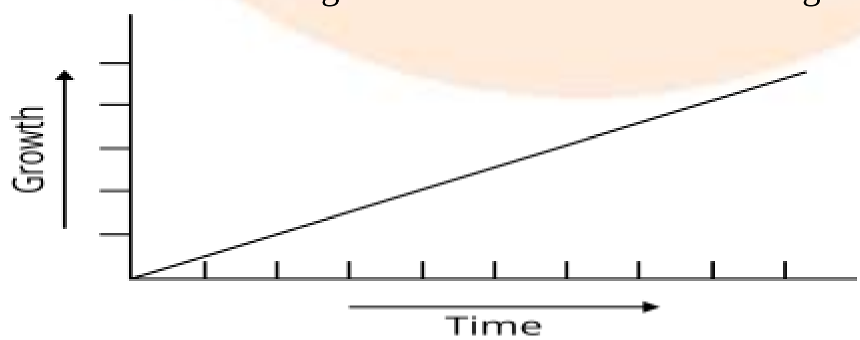

Image: Arithmetic Growth curve

Geometric Growth:

- In the case of geometrical growth, the initial growth is slow and then accelerates at an exponential rate. Both daughter cells maintain their ability to multiply in this case.
- The growth curve analysis reveals that plant growth can be classified into three stages:

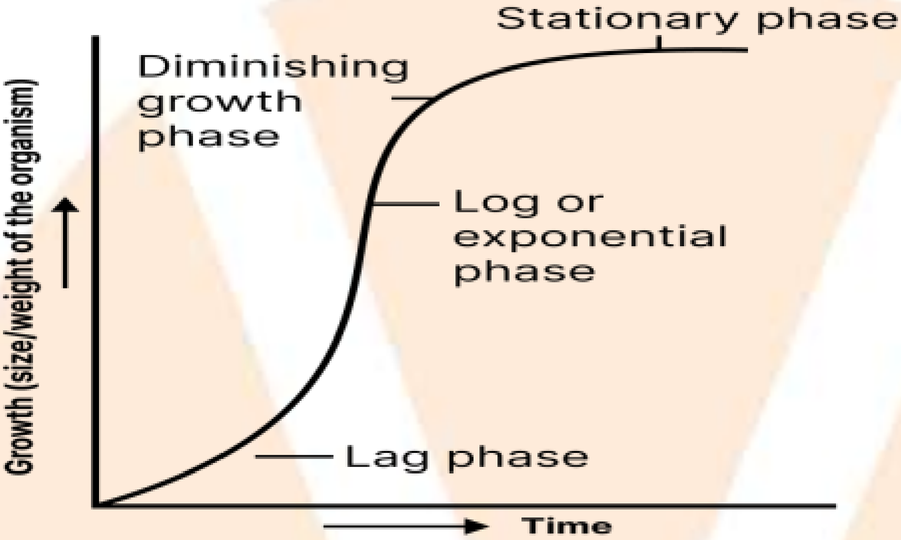

Image: Growth curve

(i) Lag phase: This refers to the early stages of growth. During the lag phase, the growth rate of the plant is extremely slow.

(ii) Log or Exponential phase: The growth rate is highest and faster in this phase than in the lag phase. The log phase is also referred to as the "grand period of growth."

(iii) Stationary phase: When nutrients are scarce, growth slows, and physiological events of cells slow as well. Furthermore, the advancement of the growth mechanism indicates this phase.

The size of a plant-like organ such as a leaf, flower, or fruit can be used to calculate the growth rate.

The **efficiency index** measures the rate of growth.

Phytohormones:

- Growth hormones of plants are also referred to as **phytohormones**.
- **Thimann** (1948) gave the term 'Phytohormones'.
- 'Phytohormones’ can be defined as substances that are produced in trace amounts in one part of the plant body and then translocated to other regions where they control specific physiological processes.

Discovery of Phytohormones:

Though it was by chance, the first steps in the discovery of important plant growth regulators were taken by Charles Darwin and his son, Francis Darwin.
They noticed phototropism in the growth of canary grass coleoptiles toward the light source.
They deduced the participation of a transmittable substance that affects the growth of canary grass towards the light after a series of experiments. That transmittable substance was later identified as auxin, which was isolated by F.W. Went.
Many scientists later discovered and isolated various plant growth regulators. E. Kurosawa discovered gibberellins, also known as gibberellic acid, in uninfected rice seedlings.
F. Skoog and Miller observed kinetin, a growth-promoting substance that is now known as cytokinins.

Growth Hormones and Growth Regulators

Auxins:

- At concentrations less than 100 ppm, auxins are slightly acidic with an unsaturated ring.
- These are used to promote cell elongation, particularly in shoots.
- Among all growth regulators, auxins were the earliest to be discovered.
- Auxins are classified as follows: Auxins are classified into two major groups:

a) Natural Auxins:

- These are the phytohormones that are found naturally in plants.
- Indole 3-acetic acid (IAA), which is found in all plants and fungi, is the most well-known and widely used auxin.

b) Synthetic auxins:

- These are chemically synthesized substances that cause similar physiological reactions to IAA.
- Weedicide called 2, 4-D is one of the crucial synthetic auxins. IBA is both a synthetic and biological auxin.

Functions of auxins: Auxin functions include controlling plant growth processes. These are the following:
(a) Cell elongation: Auxins aid in cell elongation and are also responsible for stem and root growth. It is also in charge of the increase in the size of many fruits.

(b) Apical dominance: Lower axillary buds are suppressed in many plants while the apical bud grows. When the apical bud is removed, lower buds form. The terminal bud's auxin (IAA) inhibits the lateral buds from developing. This procedure is known as apical dominance.

(c) Weed control: Weeds can be seen in a cropped field. 2, 4-D spraying can kill broad-leaved weeds, but it has no effect on mature monocotyledonous plants.

(d) Root differentiation: Auxin is also involved in root differentiation.

(e) Lodging control: Lodging is the dislocation of a plant's stem and roots. As a result, auxin prevents and regulates lodging in plants.

(f) Parthenocarpy: Parthenocarpy can be stimulated by applying IAA paste to a flower's stigma or sprinkling the flowers with a solution containing a low amount of IAA.

Gibberellins: These hormones have a gibbane ring system. These are mildly acidic hormones, influence plants to grow relatively long cells and elongate the internodes of biologically undersized plants, thereby aiding in dwarfism treatment.

Gibberellin Functions: Gibberellin serves many functions and is extremely important and some are mentioned below:

1. Stem lengthening.
2. Leaf enlargement
3. **Dwarfism reversal:** The lengthening of genetic dwarf plants such as corn and pea is one of the most significant implications of gibberellins.
4. **Bolting and flowering:** Gibberellins induce the stems of "rosette plants" like henbane and cabbage to elongate and flower. Such plants are deficient in leaf development as well as internodal growth. Internodes lengthen and stem height increases in these plants soon before they flower or enter the reproductive phase.
5. **Enzyme formation:** The initiation of hydrolytic enzymes inside the aleurone layer of the endosperm of sprouting barley seeds and cereal grains is one of the most significant implications of GA. GA encourages the formation of digestive enzymes such as proteases, a-amylases, and lipases, which aid in the mobilization of stored nutrients.
6. **Breaking of dormancy:** Gibberellins have been thought to be highly effective than auxins in provoking parthenocarpy in fruits such as apples, tomatoes, and pears. As a result of GA, large fruits, as well as long bunches of seedless grapes, have been created.

7. **Parthenocarpy:** Gibberellins regulate sexual expression in certain plants. In general, gibberellin stimulates the production of male flowers in monoecious plants including cucurbits, or in biologically female plants including Cucumis, Cannabis.
8. **Sex expression:** One of the most important effects of GA is its induction of hydrolytic enzymes in the aleurone layer of the endosperm of germinating barley seeds and cereal grains. GA stimulates digestive enzymes biosynthesis including enzymes like lipases, proteases, and α-amylases which help to mobilize stored nutrients.

Cytokinins: Cytokinins are basic (alkaline) plant growth hormones that promote cell division, specifically cytokinesis, either alone or in collaboration with auxin.

Cytokinin Functions:

1. **Cell division:** Cytokinins are involved in cytokinesis and thus encourage cell division. Cytokinins induce cell division even within non-meristematic tissues in the presence of auxin.
2. **Cell Enlargement and Differentiation:** Cytokinins promote the increase of leaf cells in leaf discs as well as cotyledons under certain conditions. These cells are thought mature and do not enlarge under normal conditions.
3. **Senescence delay:** Cytokinin slows the aging of leaves and other organs by limiting protein synthesis and resource mobilization. It's known as the Richmond Lang effect.
4. **Counteraction of apical dominance:** Apical dominance is countered by auxins and cytokinins, which act adversely in the control of apical dominance. Auxins are necessary to stimulate apical bud growth.
5. **Breaking dormancy:** Cytokinins help break dormancy in various types of seeds, allowing them to germinate.

Ethylene: Ethylene is a gaseous hormone that promotes transverse development while inhibiting longitudinal growth.

Functions of ethylene: The following are the functions of ethylene:

1. **Fruit growth and ripening**: Ethylene promotes fruit growth as well as fruit ripening. The hormone is used to accelerate the ripening of climacteric fruits like Apple, Banana, Mango, etc.
2. **Transverse growth inhibition:** Ethylene restricts longitudinal growth but enhances transverse growth, causing the stem to appear swollen.

3. **Epinasty (leaf bending):** Epinasty is characterized by more growth on the upper leaf surface than on the lower. Ethylene is thought to control epinasty in various plants.
4. **Abscission:** Ethylene contributes to the creation of an abscission zone in leaves, flowers, as well as fruits.
5. **Apical dominance:** It is caused by ethylene, which prevents the growth of lateral buds, resulting in apical dominance such as in pea. It is thought that auxin, in part, causes apical dominance through the formation of ethylene.
6. **Root initiation:** Ethylene enhances root initiation and the expansion of lateral roots as well as root hair at low concentrations.
7. **Flowering:** Ethylene enhances flowering in pineapple and similar plants, but in some cases, the hormone causes flower fading.

ABA (abscisic acid): Abscisic acid is a slightly acidic growth hormone that acts as a general growth inhibitor by opposing other hormones including auxin, gibberellins, cytokinins, or hormone-mediated reactions.

Functions of ABA: The following are abscisic acid's functions:

1. Control: Control: It inhibits growth by blocking the effects of growth hormones such as auxins, cytokinins, as well as gibberellins.
2. Dormancy: Abscisic acid behaves as a growth inhibitor and stimulates dormancy in buds as winter approaches.
3. Abscission: ABA promotes the abscission of plant leaves, flowers, and fruits.
4. Senescence: Abscisic acid promotes leaf senescence by destroying chlorophyll and preventing protein and RNA synthesis.

Photoperiodism:

- "Photoperiodism is the reaction of plants and animals to the duration of the day and night."
- Photoperiod refers to the difference in length between day and night.
- Some plants require a specific amount of sunlight exposure to induce flowering. This is the reason why flowers bloom seasonally.
- In the year 1880, Charles Darwin and his son Francis discovered and recognised this form of natural phenomenon.
- Photoperiodism is used by most angiosperms or flowering plants to determine when to flower. They accomplish this by utilising one of the

photoreceptor proteins found in their bodies, including cryptochrome or phytochrome.

- The critical duration is well defined. This critical duration varies depending on the plant.
- Plants are classified into three types based on their duration:

1. Long-day Plants: Long-day plants are those that require more light exposure such as radish, sugar beet, spinach, and so on.
2. Short-day Plants: Short-day plants are those that require less light exposure including sunflower, rice, tobacco, soybeans, and other crops are examples.
3. Day Neutral Plants: Plants that flower regardless of the length of the day are referred to as day-neutral plants. Roses, tomatoes, cucumbers, and other day-neutral plants are examples. After reaching a certain developmental stage, day-neutral plants flower.

- Flowering is not dependent on photoperiodism.

Vernalization:

- The term "vernalization" is derived from the Latin word "vernus," which means "spring" thus, vernalization means "spring-like."
- It is the initiation of the plant's flowering phase by long intervals of cold winter or similar conditions.
- Plants develop the ability to flower once this process is completed. They may, however, require additional seasonal weeks of growth before flowering.
- Flowering is aided by a cold treatment given to an entirely hydrated seed or a growing plant during the vernalization process.
- The vegetative stage of the plant is limited as a result of the vernalization process, resulting in early flowering.
- Plants that require vernalization show delayed flowering or remain vegetative in the absence of cold treatment.

Seed Dormancy:

- Seed dormancy is the condition or state in which seeds are avoided from germinating even when the environmental conditions for germination are favourable, such as water, light, temperature, gas, seed coats, and other mechanical constraints.

- The primary reason for these situations is that they need a period of rest before they can germinate. These conditions can last for days, months, or even years. Light, water, seed coats, gases, heat and hormone structures are all present in these conditions.
- There are several major causes of seed dormancy. The following are a few of the causes of seed dormancy:
    1. Germination inhibitors
    2. Light
    3. Temperature
    4. Hard Seed Coat
    5. Period After Ripening
    6. Seed embryo's immaturity
    7. Seed coat water impermeability
    8. Seed coat oxygen impermeability
    9. Seed coat with mechanical resistance
    10. Solutes with high concentrations are present.

Points to remember:

- Growth is amongst the most visible aspects of any living organism.
- Growth is a permanent increase manifested in parameters including size, area, height, length, volume, cell number, and so on. It has a noticeable increase in protoplasmic material.
- Meristems are the locations of growth in plants. Root and shoot apical meristems, as well as intercalary meristems, contribute to the elongation of plant axes.
- In higher plants, growth is indeterminate. Cell division in shoot and root apical meristem cells can result in arithmetic or geometric growth.
- Growth may or may not occur at a rapid rate throughout the life of a cell/ tissue/ organ/ organism.
- There are three main stages of growth: the lag, the log, and the senescent phase.
- When a cell loses its ability to divide, it differentiates. Differentiation results in the formation of structures that are appropriate for the function that the cells must eventually perform.
- The general principles for cell, tissue, and organ differentiation are similar.
- Dedifferentiation and redifferentiation can occur in differentiated cells.

- Because plant differentiation is open, development may also be flexible, i.e., development is the sum of differentiation and growth. Plants are malleable during development.
- Both extrinsic and intrinsic factors influence plant growth and development.
- Plant growth regulators (PGRs) are the chemical substances that act as intercellular intrinsic factors.
- Plants contain a variety of PGRs, the most common of which are auxins, gibberellins, abscisic acid, cytokinins, and ethylene.
- These PGRs are produced in various parts of the plant and regulate various differentiation and developmental activities.
- Plants respond physiologically to PGRs in a variety of ways. Diverse PGRs exhibit similar effects. PGRs can work together or against each other.
- Light, temperature, oxygen level, nutrition, gravity, and other environmental factors all influence plant growth and development.
- Flowering in certain plants is only induced when they are exposed to a specific photoperiod.
- Plants are classified as short day plants, long day plants, or day-neutral plants based on their photoperiod requirements.
- Certain plants must also be subjected to low temperatures in order to flower later in life. This is referred to as vernalisation.