M.Sc. Semester II

MBOTCC-7 Physiology and Biochemistry

Unit 3

Plant Growth and Development, Plant Growth regulators

Definition of Growth

Growth is "an irreversible process of increase in size of cell, tissue or an organ or an individual plant. Growth is the most fundamental and basic characteristics of all living beings and is growth occur as a result of several metabolic processes. These metabolic processes may be catabolic or anabolic. In successive growth stages in plants, seed germinates, develops into seedling and later it takes the shape of an adult plant.

Characteristics of Growth

- **Plant Growth is generally Indeterminate –** Plants possess the ability of growth throughout their life. This is due to the presence of meristems at certain locations in their body and these meristems have the ability to divide and self –perpetuate.

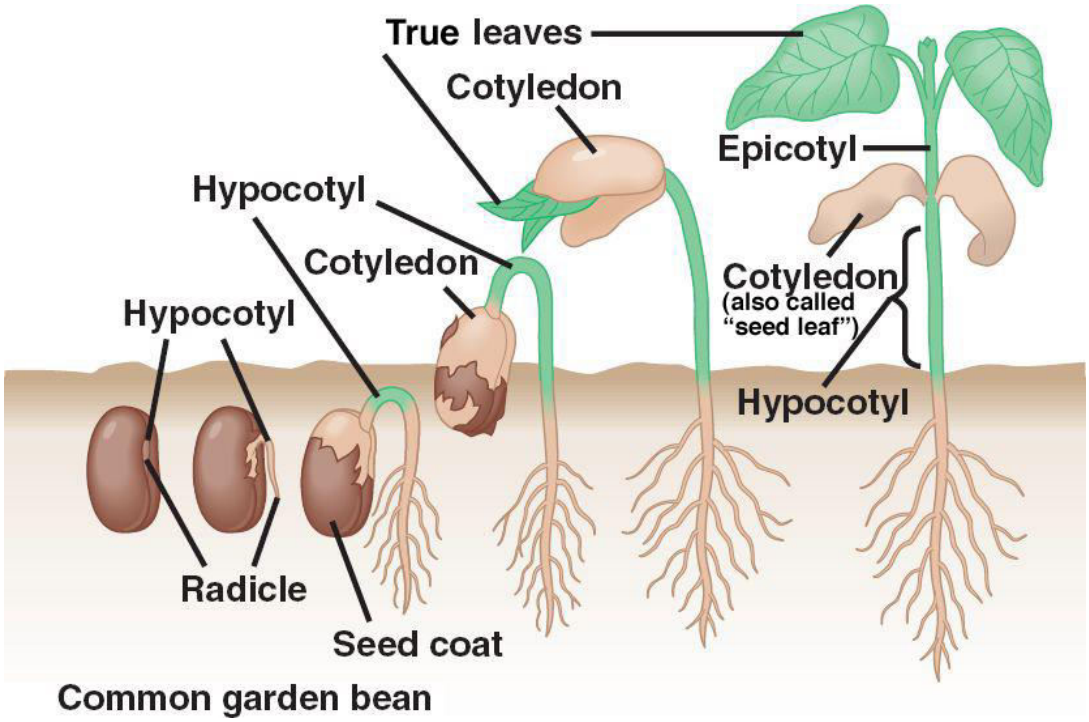
- **Growth is Measurable –** At cellular level, Growth is the consequence of increase in protoplasm but this increase is difficult to measure. Growth, in plants, is measured via different methods like increase in height, fresh weight., dry weight, volume, cell number,

The Growth of Plants has three phases:

- **Formative Phase –** Cell division is the basic event in the growth of plant. All cells are the result of division of pre-existing cells. Mitosis is the type of cell division that happens during growth. This division is carried out in two steps – Division of Nucleus (Karyokinesis) and division of cytoplasm (Cytokinesis). In case of higher plants, an increase of cells is carried out in meristematic region, whereby some daughter cells retain the meristematic activity while some enter in the next phase of growth, i.e. the phase of cell enlargement.
- **Cell Enlargement and Cell Differentiation** – At this stage, the size of tissues and organs is increased and this enlargement occurs by forming Protoplasm, Hydration (absorbing water), developing vacuoles and then adding new cell wall to make it permanent and thicker.
- **Cell Maturation** – At this stage, the enlarged cells acquire specific size and forms as per their location and function. Thus, several cells are differentiated from simple and complex tissues which perform different functions.

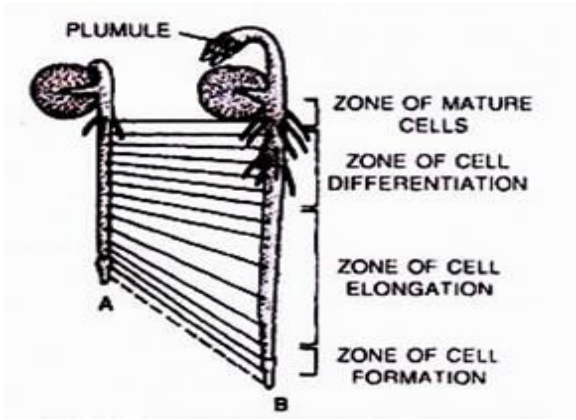
Experiment to Study Phases of Growth

In order to study the phases of Growth, germinate few seeds of peas in moist cotton bed in petri plate. Select the couple of seedlings with 2 – 3 cm of length, wash them and blot the surface water. Then, mark the radicles from tip to base with 10 – 15 point at interval of 2 mm via water proof ink. After drying of ink, place those seedlings on moist blotting paper and allow them to grow for 1 – 2 days. Finally measure the intervals between the marks and we can clearly observe the different phases of growth.



Ist stage in seed, II nd stage seed germination and the marked radicle of seedling at the beginning of experiment and next condition is after 48 hours. We can clearly identify hypoctyl region. Zone of hypoctyl at maturity form shoot region and radicle form roots.

Different zones of cell growth i.e., zone of cell formation, cell elongation, cell differentiation and zone of matured cells is described in picture given below



Types of Growth

Primary and Secondary Growth:

The mitotic divisions of meristematic cells (undifferentiated cell capable of cell division) present at the root and shoot apex increases the length of the plant body. This is referred as Primary Growth. Secondary meristem results in an increase in diameter of the body of plant.i.e., stem girth

Unlimited (Indeterminate) Growth: This is the stage, when root and shoot of plant continuously grow from germination stage to death and throughout the entire lifespan.

Limited Growth: This is the stage, when fruits, leaves and flowers stop growing after attaining certain size. It is also called determinate type of Growth.

Vegetative Growth: The Growth of Plant before flowering in called Vegetative Growth. This Growth includes producing of stems, leaves and branches.

Reproductive Growth: At this stage, plants start flowering, which is the reproductive part of the plant.

Factors Affecting Plant Growth

External Factors: Oxygen, Water and Nutrients, Temperature and Light.

Temperature:

Temperature plays important role in the growth of plants. The minimum, optimum and maximum temperature varies and from species to species. As the temperature increases above minimum, growth is accelerated until the optimum temperature is attained, when the growth gets slower and is completely retarded. Effect of duration for which a plant is exposed to certain temperature also varies amongst different species. For Example: The plant shows good growth when it is exposed to 86°F for a short duration and the same temperature has negative impact if maintained for longer duration.

Light

Light also affect the growth and development of plant. Several factors of light like light intensity, duration of light and quality of light influences several physiological processes like movement of stomata, chlorophyll synthesis, temperature of aerial organs, formation of anthocyanin, absorption of minerals streaming of protoplasm and rate of transpiration. Intensity of light also influences plant growth and the variation in intensity has significant

impact on growth pattern. Most ornamental plants and crops, such as Peas, Corn, Tobacco and Peas makes stocky and vigorous growth will full sun and thus, is also called “Sun Plant.”

Difference in wave length of light also effects the growth of plant. Several experiments have proved that plants that has full spectrum of visible light shows proper development and increase in dry weight. Plants grown in violet and blue light tend to dwarf, while plants in red light are taller and spindly.

Duration of light also affects the plant growth as it affects the rate of photosynthesis. For instance, during winters when days are short, the growth is very slow, while, it increases during summers when the days are longer.

Oxygen:

The plants with lesser availability of oxygen show retarded growth while it is vice versa in the presence of ample of oxygen. It is important to note that plants in flooded areas, results in deficiency of soil aeration which on the other hand, results in poor plant growth.

Water

Water is very important for plants and inadequate water results in poor growth. Plants grow well only in the presence of optimum water. Plants respond to deficiency of moisture as well. For instance, peppers, spinach and radishes wilt and cease to grow when the percentage of water in soil is lower.

Soil nutrients

Soil nutrients, their quantity and nature also affect the growth of plant. For Luxuriant Growth, it is important to have adequate amount of nutrients.

Important terminologies:

Differentiation, Dedifferentiation and Redifferentiation

Differentiation: The cells derived from root apical and shoot – apical meristems and cambium differentiate and mature to perform specific function and this act leading to maturation is termed as differentiation.” During this process, **several** structural changes are carried out in cells and protoplasm. For instance, In order to form a tracheary element, cells would lose protoplasm and develop elastic, strong and lignocellulosic secondary cell walls in order to transport water even in extreme tensions.

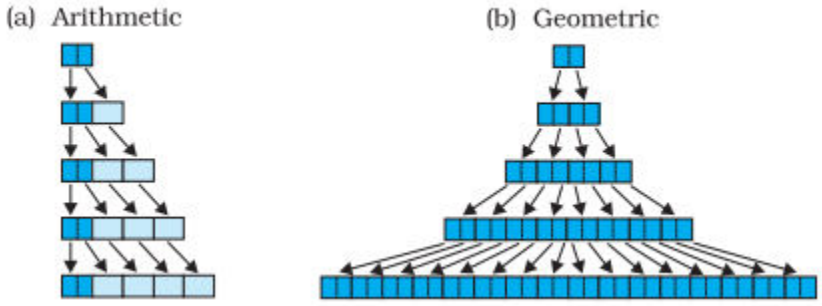
Dedifferentiation: An undividable differentiated cell sometimes regains the power of division. This process is called dedifferentiation. Dedifferentiation is a common process in

plants during secondary growth and in wound healing mechanisms. A dedifferentiated cell can divide and produce new cells.. **For Example:** Formation of Meristems – cork cambium and interfascicular cambium form fully differentiated parenchyma cells and in such condition, tissues and meristems are able to divide and produce cells even after losing the capacity to divide.

Redifferentiation: produced new cells of dedifferentiated cell again loose the power of division and become a part of permanent tissue. This process is called "redifferentiation'. Tumour cells form good example for redifferentiated cells.

Growth pattern in plants:

The increased growth per unit time is termed as **Growth Rate**. An organism can produce cells in several ways and display **Geometric** as well as **Arithmetic Growth.** Following diagram shows both types of growth in plants:



The following diagram displays the various stages of embryo development showing both **Geometric** and **Arithmetic Phases**. Here dark blue blocks **represent** the cells capable of division while light blue blocks represents the cells that have lost the capacity to divide:

Thus, in **Arithmetic Growth**, only one daughter cell continues to divide while other differentiates and matures. The following graph represents the length of an organ against time, whereby a linear curve is obtained. We can clearly observe the constant linear growth against time t.

Geometrical Growth: In majority of cases, Initial Growth is slow and is referred as lag phase. Then, it increases rapidly at an exponential rate referred as log phase or exponential phase. The growth of plant slows down in cases of limited nutrient supply and results in stationery phase. When we plot the growth against time, it results in **S-Curve** or **Sigmoid Curve**. Following graph represents an idealized sigmoid growth curve typical of cells in culture and many higher plants and plant organs.

It is an ‘S’ shaped curve obtained when we plot growth against time (Fig. 15.2). It is also called ‘sigmoid ‘curve. This curve mainly shows four phases of growth- 1.initial slow growth (Lag phase), 2. the rapid period of growth (log phase/grand period of growth/exponential phase) where maximum growth is seen in a short period and 3. The diminishing phase where growth will be slow and 4. Stationary / steady phase where finally growth stops.

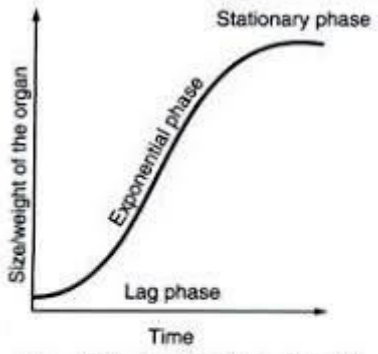


Fig. 15.4. An idealised sigmoid growth curve typical of cells in culture, and many higher plants and plant organs

Plant embryonic cell showing arithmetic and Geometric growth is presented below