PLANT GROWTH AND DEVELOPMENT

GROWTH

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- Growth can be defined as an irreversible permanent increase in size of an organ or its parts or even of an individual cell.
- Growth is accompained by metabolic processes (both anabolic and catabolic), that occur at the expense of energy. e.g., expansion of a leaf is growth.

CHARACTERSTICS OF PLANT GROWTH

1. Plant growth is generally indeterminate because plants retain the capacity for unlimited growth throughout their life.
   This ability of plants is due to the presence of meristems at certain locations in their body. The cells of such meristems have the capacity to divide and self-perpetuate. The product however, soon loses the capacity to divide and such cells make up the plant body.
2. Plant growth is localised.
   Reason : Plant growth is restricted to certain locations (apical meristems, intercalaxy meristems, lateral meristems) within plant body.
3. Plant growth is open. In this form of growth new cells are always being added to the plant body by the activity of the meristem.

PLANTS SHOW TWO TYPES OF GROWTH

Primary growth	Secondary growth
Root apical meristem and the shoot apical meristem are responsible for the primary growth of the plants and principally	In dicotyledonous plants and gymnosperms, the lateral meristems, vascular cambium and cork-cambium appear later in life. These are the meristems that cause the increase in the

contribute to the elongation of the plants along their axis.	girth of the organs in which they are active. This is known as secondary growth of the plant.

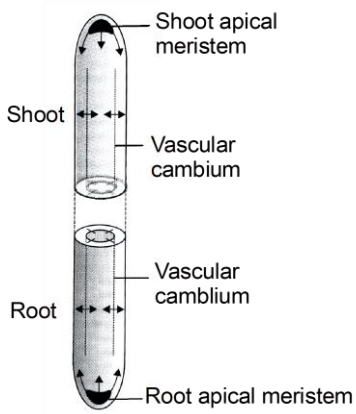


Fig : Diagrammatic representation of locations of root apical meristem, shoot aplical meristem and vascular cambium. Arrows exhibit the direction of growth of cells and organ

GROWTH IS MEASURABLE

1. Growth is measured by a variety of parameters some of which are: increase in fresh weight, dry weight, length, area, volume and cell number.
2. You may find it amazing to know that one single maize root apical mersitem can give rise to more than 17,500 new cells per hour, whereas cells in a watermelon may increase in size by upto 3,50,000 times. In the former, growth is expressed as increase in cell number; the latter expresses growth as increase in size of the cell.
3. The growth of a pollen tube is measured in terms of its length, an increase in surface area denotes the growth in a dorsiventral leaf.

METHODS OF GROWTH MEASUREMENT

(a) By direct observation **(b)** By auxanometer

(c) By crescograph : This apparatus was developed by J.C. Bose.

PHASES OF GROWTH

The period of growth is generally divided into three phases. namely :

(i) Meristematic phase
(ii) Elongation phase
(iii) Maturation phase

(i) Meristematic phase : The constantly dividing cells, both at the root apex and the shootapex, represent the meristematic phase of growth. The cells in this region are characterised by :

(a) Cells are small in size with abundant plasmodesmal connections.

(b) Intercellular spaces are absent, if present then very small.

(c) Cell walls are primary in nature, thin and cellulosic.

(d) Cells are rich in protoplasm, possess large conspicuous nuclei.

(ii) Elongation phase : The cells proximal to the meristematic zone represent the phase of elongation. Cells in this region are characterized by :
(a) Increased vacuolation (b) Cell enlargement (c) New cell wall deposition

(iii) Maturation phase : The cells more proximal to the phase of elongation represent the phase of maturation. Cells of this zone, attain their maximal size in terms or wall thickening and protoplasm modifications.

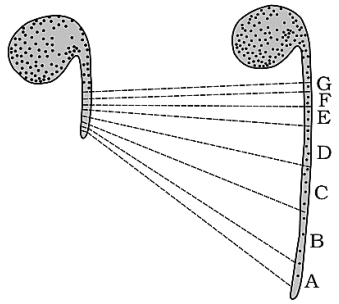


Figure: Detection of zones of elongation by the parallel line technique. Zones A, B, C, D immediately behind the apex have elongated most.

GROWTH RATES:

- The increased in growth per unit time is called growth rate. It is due to arithmetic or geometric growth.

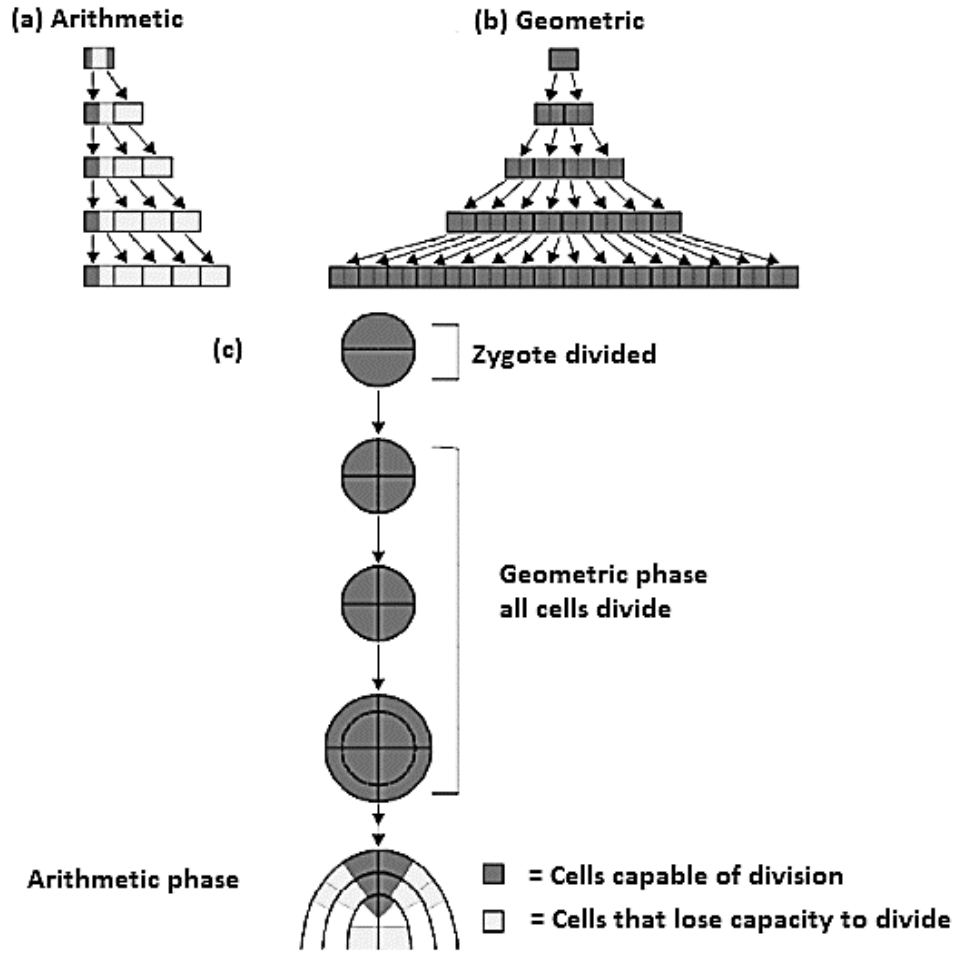


Fig. Diagrammatic representation of (a) Arithmetic (b) Geometric growth and (c) Stages during embryo development showing geometric and arithematic phases

(a) **Arithmetic growth :** In arithmetic growth cell undergoes mitotic cell division and produce two daughter cells. Only one daughter cell continue to divide while the other differentiates and matures.

- The simplest expression of arithmetic growth is examplified by a root elongating at a constant rate.

- Mathematically, it is expressed as :

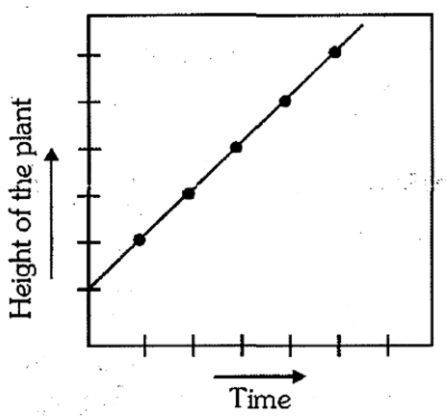
  $L_t = L_0 + rt$

  L_t = Length at time 't'

  L_0 = Length at time 'zero'

  r = Growth rate/elongation per unit time

- On plotting the length of the root against time, a linear curve is obtained.



(b) Geometric growth :

In geometric growth cell undergoes mitotic cell division and produce two daughter progeny. Both the progeny cells following mitotic cell division retain the ability-to divide and continue to do so.

Geometric growth has two phases- Lag and Log phase. When nutrients are limited the growth will be logistic which show sigmoid growth curve.

Sigmoid growth curve is divided into following three stages :

(a) Lag phase: It is initial stage, where growth is slow.

(b) Log phase: At this stage growth is rapid at exponential rate.

(c) Stationary phase : At this stage. the growth slows down leading to a stationary phase.

- The exponential growth can be expressed as :

  $w_1 = w_0 e^{rt}$

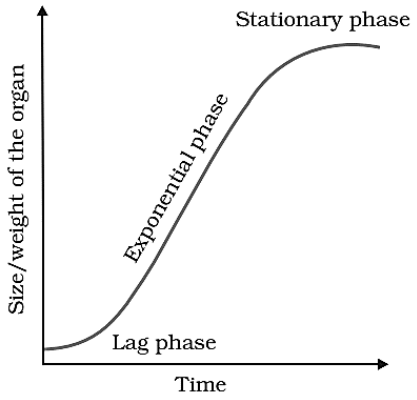
  w_1 = final size (weight. height. number etc.)

  w_0 = Initial size at the beginning of the period.

  r = growth rate

  t = time of growth

  e = base of natural logarithms



Here, 'r' is the relative growth rate and is also the measure of the ability of the plant to produce new plant material, referred to as efficiency index. Hence, the final size of w_1 depends upon the initial size, w_0.

- If we plot the parameter of growth against time, we get a typical sigmoid or s-curve.
- A sigmoid curve is a characteristic of living organism growing in a natural environment (limited resources).
- It is typical for all cells tissues and organs of plant. It is also idealised for cells in culture.

Q. What kind of a curve can you expect in a tree showing seasonal activities ?

Ans. Sigmoid or S-curve

- Quantitative comparisons between growths of various systems can be made by measuring their absolute and relative growth rates.

Absolute Growth rate: The total growth per unit time. It is usually S-shaped

Relative Growth rate: It is growth per unit time per unit initial parameter of growth.

$$\text{Relative Growth rate} = \frac{\text{Growth in Given Time Period}}{\text{Measurement at Start of Time Period}}$$

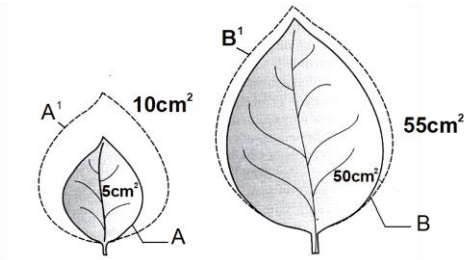


Fig: Diagrammatic comparision of absolute and relative growth rates. Both leaves A and B have increased their area by 5 cm^2 in a given time(one week) to produce A^1, B^1 leaves

Analysis:- Leaf A and B both show equal absolute growth (5 cm^2) but in case of leaf A the relative growth is 100% while in leaf B, the relative growth is 10%.

Conditions for growth : Necessary conditions for growth are :

1. **Water:**

- The plant cells grow in size by cell enlargement which in turn requires water.
- Turgidity of cells help in extension growth. Thus, plant growth and further development is intimately linked to the water status of the plant.
- Water also provides the medium for enzymatic activities needed for growth.

2. Oxygen:- Oxygen helps in releasing metabolic energy essential for growth activities.

3. Nutrients:- Nutrients (macro and micro essential elements) are required by plants for the synthesis of protoplasm and act as source of energy.

4. Temperature:- In addition, every plant organism has an optimum temperature range best suited for its growth. Any deviation from this range could be detrimental to its survival. Environmental signals such as light and gravity also affect certain phases/stages of growth.
   (i) Light : Light is a stimulus for shoot growth. (positive phototropism).
   (ii) Gravity : Gravity is a stimulus for root growth (positive geotropism)