Unit V: Plant Physiology (Functional Organisation)

Chapter 15

Plant Growth and Development

Learning Objectives

The learner will be able to,

- *Define growth.*
- *List out and differentiate the phases of growth.*
- *Explain the structure, precursor, bioassay and physiological effects of plant growth regulators.*

Chapter Outline

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The Banyan tree continues to grow for thousands of years and some others particularly annual plants cease growth within a season or within a year. Can you understand the reasons? How does a zygote give rise to an embryo and an embryo to a seedling? How does a new plant structure arise from the pre-existing structure? Growth is defined as an irreversible permanent increase in size, shape, number,volume and dry weight. Plant growth occurs by cell division, cell enlargement, differentiation and maturation.

DO YOU KNOW?

Growth is measurable, it is amazing to know that one single maize root apical meristem can give rise to more than 17,500 new cells per hour and cells in a watermelon may increase in size upto 3,50,000 times.

DO YOU KNOW?

Bamboos are evergreen grasses and certain species of it can grow at the rate of growth 91 cm per day. The Saguaro Cactus is a tree like cactus and is a slow growing plant. The rate of growth is one inch in the first ten years and it does not begin to flower until it is about 60 years old. It's lifespan exceeds 150 years and takes 75–100 years to grow a side arm.

15.1 Characteristics of Growth

- Growth increases in protoplasm at cellular level.
- Stem and roots are indeterminate in growth due to continuous cell division and is called **open form of growth**.
- The primary growth of the plant is due to the activity of apical meristem where, new cells are added to root and shoot apex causing linear growth of plant body.
- The secondary vascular cambium and cork cambium add new cells to cause increase in girth.
- Leaves, flowers and fruits are limited in growth or determinate or **closed form growth.**
- Monocarpic annual plants produce flowers only once during lifetime and dies. Example: Paddy and Bean

- Monocarpic perennials produce flowers only once during life time but the plants survive for many years. Example: Bamboo.
- Polycarpic perennials produce flowers every year during life time. Example: Coconut.

15.1.1 Kinetics of growth

It is an analysis of the motion of cells or expansion.

1. Stages in Growth rate

The total period from initial to the final stage of growth is called the **grand period of growth.** The total growth is plotted against time and 'S' shaped sigmoid curve (Grand period curve) is obtained. It consists of four phases.

They are:

i. Lag phase
ii. Log phase
iii. Decelerating phase
iv. Maturation phase

i. Lag phase

In this phase new cells are formed from pre-existing cells slowly. It is found in the tip of the stem, root and branches. It is the initial stage of growth. In other words, growth starts from this period.

ii. Log phase or exponential growth

Here, the newly formed cell increases in size rapidly by deposition of cell wall material. Growth rate is maximum and reaches top because of cell division and physiological processes are quite fast. The volume of protoplasm also increases. It results in rapid growth and causes elongation of internode in the stem.

iii. Decelerating phase or Decline phase or slow growth phase

The rate of growth decreases and becomes limited owing to internal and external or both the factors because the metabolic process becomes slow.

iv. Steady state period or maturation phase

In this phase cell wall thickening due to new particle deposition on the inner surface of the cell wall takes place. The overall growth ceases and becomes constant. The growth rate becomes zero.

2. Types of growth rate

The increased growth per unit time is termed as growth rate. An organism or part of an organism can produce more cells through arithmetic growth or geometric growth or both.

i. Arithmetic Growth Rate

If the length of a plant organ is plotted against time, it shows a linear curve and this growth is called **arithmetic growth**.

- The rate of growth is constant and it increases in an arithmetic manner.
- Only one cell is allowed to divide between the two-resulting progeny cell.
- One continues to divide but the other undergoes cell cycle arrest and begins to develop, differentiate and mature.
- After each round of cell division, only a single cell remains capable of division and one new body cell forms.

For example, starting with a single cell after round 1 of cell division there is one dividing cell and one body cell. After round 2 there are two body cells, after round 3 there are three and so on (Figure 15.1).

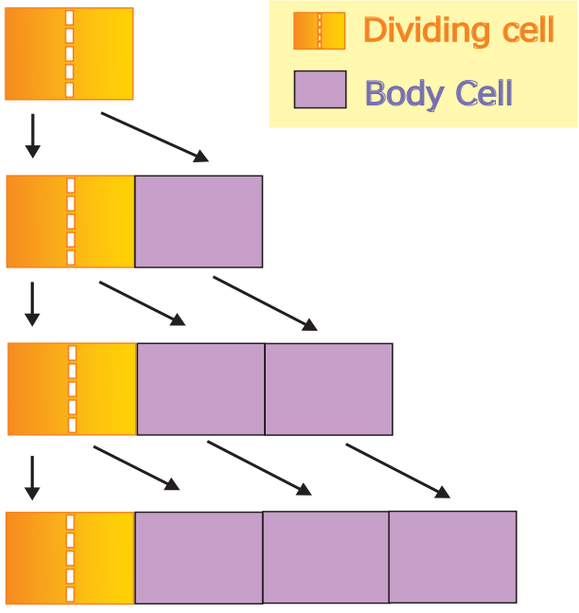

Figure 15.1: Arithmetic Growth Rate

The plants single dividing cell would undergo one million rounds of nuclear and

cellular division. If each round requires one day, this type of arithmetic increase would require one million days or 2739.7 years. This arithmetic rate is capable of producing small number of cells present in very small parts of plants. For example the hair on many leaves and stems consists of just a single row of cells produced by the division of the basal cell, the cell at the bottom of the hair next to other epidermal cells. Hair may contain 5 to 10 cells by the division of the basal cell. So, all its cells could be produced in just five to ten days. In the figure 15.2, on plotting the hight of the plant against time a linear curve is obtained. Mathematically it is expressed as:

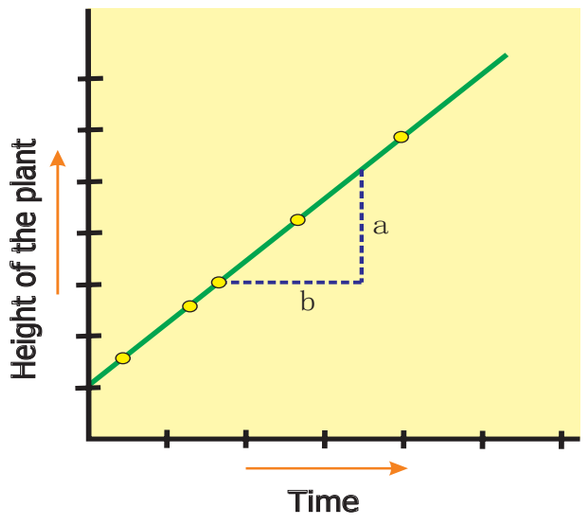

Figure 15.2: Constant Linear Growth

$L_t = L_o + rt$

L_t = length at time 't'

L_o = length at time zero

r = growth rate of elongation per unit

ii. Geometric growth rate:

This growth occurs in many higher plants and plant organs and is measured in size or weight. In plant growth, geometric cell division results if all cells of an organism or tissue are active mitotically. Example: Round three in the given figure 15.3, produces 8 cells as $2^3 = 8$ and after round 20 there are 2^{20} = 1,048,576 cells.

The large plant or animal parts are produced this way. In fact, it is common in animals but rare in plants except when they are young and small. Exponential growth curve can be expressed as,

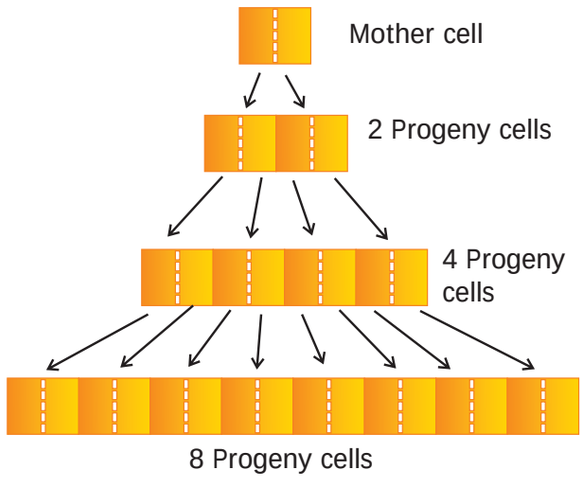

Figure 15.3: Geometric growth

$W_1 = W_0 e^{rt}$

W_1 = Final size (weight, height and number)

W_0 = Initial size at the beginning of the period

r = Growth rate

t = Time of growth

e = Base of the natural logarithms

Here 'r' is the relative growth rate and also a 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 on the initial size W_0.

iii. Arithmetic and Geometric Growth of Embryo

Plants often grow by a combination of arithmetic and geometric growth patterns. A young embryonic plant grows geometrically and cell division becomes restricted to certain cells at the tips of roots and shoots. After this point, growth is of the slower arithmetic type, but some of the new cells that are produced can develop into their mature condition and begin carrying

out specialized types of metabolism (Figure 15.4). Plants are thus a mixture of older, mature cells and young, dividing cells.

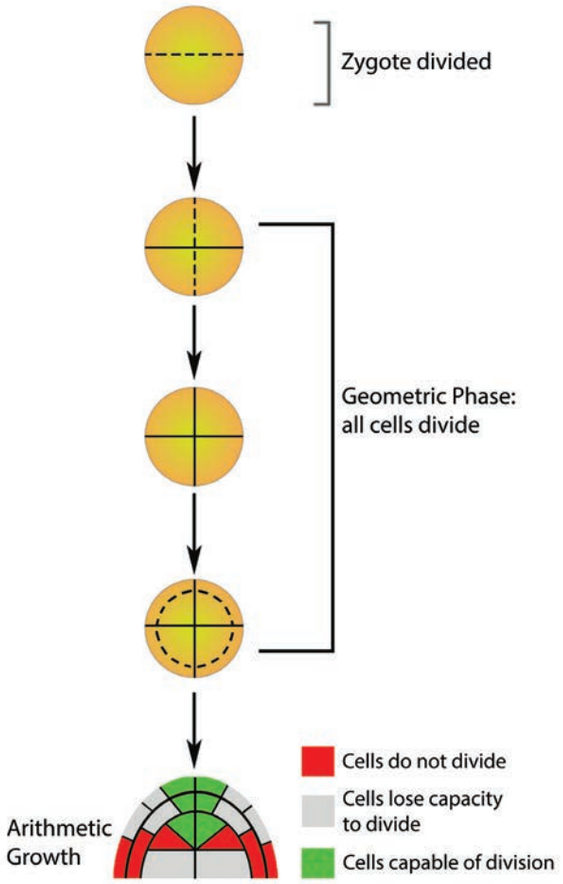

Figure 15.4: Arithmetic and geometric growth of embryo

Quantitative comparisons between the growth of living system can also be made in two ways and is explained in the table 1.

In figure 15.5, two leaves A and B are drawn at a particular time. Then $A^1$and B^1 are drawn after a given time. A and B = Area of leaves at a particular time. A^1 and B^1 = Area of leaves after a given time. (A^1-A) and (B^1-B) represents an absolute increase in area in the given time. Leaf A increases from 5 cm^2 to 10 cm^2; 5 cm^2 in a given time. Leaf B increases from 50 cm^2 to 55 cm^2 ; 5 cm^2 in a given time. Hence, both leaves A and B increase their area by 5 cm^2 in a given time. This is absolute growth. Relative growth is faster in leaf A because of initial small size. It decreases with time.

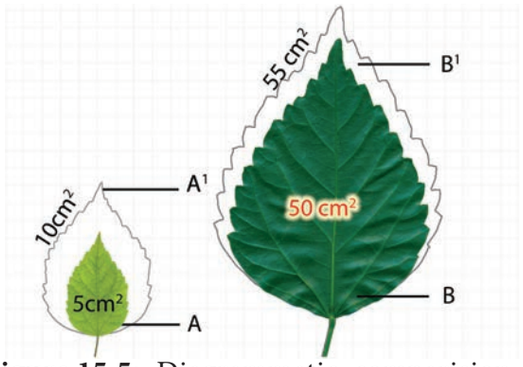

Figure 15.5: Diagrammatic comparision of absolute and relative growth rates

Measurement of Growth

Experiment: 1. Arc auxanometer:

The increase in the length of the stem tip can easily be measured by an arc auxanometer which consists of a small pulley to the axis of which is attached a long pointer sliding over a graduated arc. A thread one end of which is tied to the stem tip and another end to a weight passes over the pulley tightly. As soon as the stem tip increases in length, the pulley moves and the pointer slide over the graduated arc (Figure 15.6). The reading is taken. The actual increase in the length of the stem is then calculated by knowing the length of the pointer and the radius of the pulley. If the distance travelled by the pointer is 10 and the radius of the pulley is 4 inches and the length of the pint is 20 inches, the actual grown is measured as follows:

Actual growth in length = (Distance travelled by the pointer × radius of the pulley) / Length of the pointer.

For example,
actual growth in length =
(10 × 4 inches)/ 20 inches = 2 inches

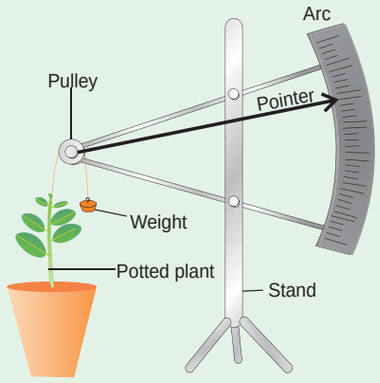

Figure 15.6: Arc auxanometer

15.2 Plant Growth Regulators

Plant Growth Regulators (chemical messenger) are defined as organic substances which are synthesized in minute quantities in one part of the plant body and transported to another part where they influence specific physiological processes. Five major groups of hormones *viz.*, auxins, gibberellins, cytokinins, ethylene and abscisic acid are presently known to coordinate and regulate growth and development in plants. The term **phytohormones** is implied to those chemical substances which are synthesized by plants and thus, naturally occurring. On the other hand, there are several manufactured chemicals which often resemble the hormones in physiological action and even in molecular structure. Recently, another two groups, the brassinosteroids and polyamines were also known to behave like hormones.

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1. Plant growth regulators – classification

Plant Growth Regulators are classified as natural and synthetic based on their source and a detailed flow diagram is given in Figure 15.7.

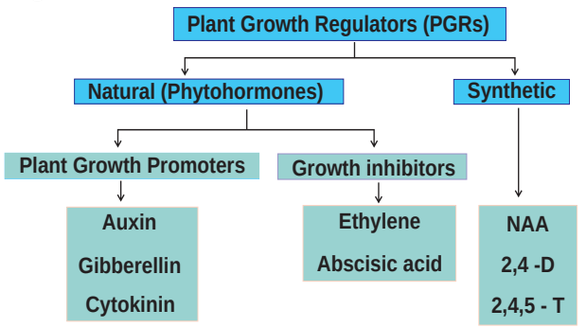


Figure 15.7: Classification of Plant Growth Regulators

2. Characteristics of phytohormones

i. Usually produced in tips of roots, stems and leaves.
ii. Transfer of hormones from one place to another takes part through conductive systems.
iii. They are required in trace quantities.
iv. All hormones are organic in nature.
v. There are no specialized cells or organs for their secretion.
vi. They are capable of influencing physiological activities leading to promotion, inhibition and modification of growth.

3. Synergistic and Antagonistic effects

i. **Synergistic effects**: The effect of one or more substance in such a way that both promote each others activity. Example: Activity of auxin and gibberellins or cytokinins.
ii. **Antagonistic effects**: The effect of two substances in such a way that they have opposite effects on the same process. One accelerates and other inhibits. Example: ABA and gibberellins during seed or bud dormancy. ABA induces dormancy and gibberellins break it.

15.2.1 Auxins

1. Discovery

During 1880, **Charles Darwin** noted the unilateral growth and curvature of Canary grass (*Phalaris canariensis*) coleoptile to light.

The term auxin (*Greek*: Auxin – to Grow) was first used by **F. W. Went** in 1926 using Oats (*Avena*) coleoptile and isolated the auxin. F. W. Went in 1928 collected auxin in agar jelly. **Kogl** and **Haugen Smith** (1931) isolated Auxin from human urine, and called it as **Auxin A**. Later on in 1934, similar active substances was isolated from corn grain oil and was named as **Auxin B**. Kogl *et al.*, (1934) found heteroauxin in the plant and chemically called it as **Indole Acetic Acid** (IAA)

2. Occurrence

Auxin is generally produced by the growing tips of the stem and root, from where they migrate to the region of the action.

3. Types of Auxin

Auxins are divided into two categories Natural auxins and Synthetic auxins.

Anti-auxins

Anti-auxin compounds when applied to the plant inhibit the effect of auxin. Example: 2, 4, 5-Tri Iodine Benzoic Acid (TIBA) and Napthylpthalamine.

Types of Auxin

Natural	Synthetic
Auxin occuring in plants are called "Natural auxin"	These are synthesized artificially and have properties like Auxin.
1. Indole Acetic Acid (IAA)	1. 2,4-Dichloro Phenoxy Acetic Acid (2,4-D)
2. Indole Propionic Acid (IPA)	2. 2,4,5-Trichloro Phenoxy Acetic Acid (2,4,5-T)
3. Indole Butyric Acid (IBA)	3. Napthalene Acetic Acid (NAA)
4. Phenyl Acetic Acid (PAA)	

(i) Free auxin

They move out of tissues as they are easily diffusible. Example: IAA.

(ii) Bound Auxin

They are not diffusible. Example: IAA.

4. Precursor

The amino acid Tryptophan is the precursor of IAA and zinc is required for its synthesis.

5. Chemical structure

Auxin has similar chemical structure of IAA.

6. Transport in Plants

Auxin is polar in transport. It includes basipetal and acropetal transport. Basipetal means transport through phloem from shoot to root and acropetal means transport through xylem from root to shoot.

7. Bioassay (Avena Curvature Test / Went Experiment)

Bioassay means testing of substances for their activity in causing a growth response in a living plant or its part.

The procedure involves the following steps:

When the *Avena* seedlings have attained a height of 15 to 30 mm, about 1mm of the coleoptile tip is removed. This apical part is the source of natural auxin. The tip is now placed on agar blocks for few hours. During this period, the auxin diffuses out of these tips into the agar. The auxin containing agar block is now placed on one side of the decapitated stump of *Avena* coleoptile. The auxin from the agar blocks diffuses down through coleoptile along the side to which the auxin agar block is placed. An agar block without auxin is placed on another decapitated coleoptile. Within an hour, the coleoptiles with auxin agar block bends on the opposite side where the agar block is placed. This curvature can be measured (Figure 15.8).

8. Physiological Effects

- They promote cell elongation in stem and coleoptile.
- At higher concentrations auxins inhibit the elongation of roots but extermely lower concentrations promotes growth of root.
- Suppression of growth in lateral bud by apical bud due to auxin produced by apical bud is termed as **apical dominance**.
- Auxin prevents abscission.
- It is used to eradicate weeds. Example: 2,4-D and 2,4,5-T.
- Synthetic auxins are used in the formation of seedless fruits (Parthenocarpic fruit).
- It is used to break the dormancy in seeds.

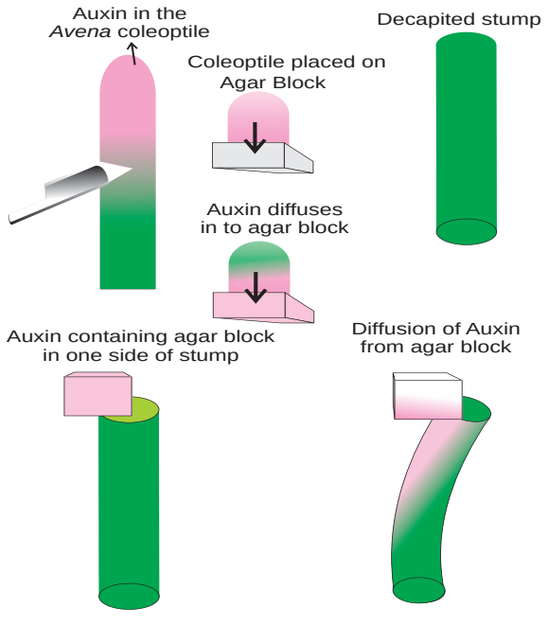


Figure 15.8: *Avena* Curvature Test

15.2.2 Gibberellins

1. Discovery

The effect of gibberellins had been known in Japan since early 1800 where certain rice plants were found to suffer from '**Bakanae**' or foolish seedling disease. This disease was found by **Kurosawa** (1926) to be caused by a fungus *Gibberella fujikuroi*. The active substance was separated from fungus and named as

gibberellin by **Yabuta** (1935). These are more than 100 gibberellins reported from both fungi and higher plants. They are noted as GA_1, GA_2, GA_3 and so on. GA_3 is the first discovered gibberellin. In 1938, **Yabuta** and **Sumiki** isolated gibberellin in crystalline form. In1955, **Brain** *et al.,* gave the name **gibberellic acid**. In 1961, Cross *et al.,* established its structure.

Agent Orange
Mixture of two phenoxy herbicides 2,4-D and 2,4,5-T is given the name 'Agent orange' which was used by USA in Vietnam war for defoliation of forest (chemical warfare).

In botanical gardens and tea gardens, gardeners trim the plants regularly so that they remain bushy. Does this practice have any scientific explanation?

Yes, trimming of plants removes apical buds and hence apical dominance. The lateral buds sprout and make the plants bushy.

2. Occurrence
The major site of gibberellin production in plants is parts like embryo, roots and young leaves near the tip. Immature seeds are rich in gibberellins.

3. Precursors
The gibberellins are chemically related to terpenoids (natural rubber, carotenoids and steroids) formed by 5-C precursor, an Isoprenoid unit called Iso Pentenyl Pyrophosphate (IPP) through a number of intermediates. The primary precursor is acetate.

4. Chemical structure
All gibberellins have gibbane ring structure.

5. Transport in plants
The transport of gibberellins in plants is non-polar. Gibberellins are translocated through phloem and also occur in xylem due to lateral movement between vascular bundles.

6. Bioassay (Dwarf Pea assay)
Seeds of dwarf pea are allowed to germinate till the formation of the coleoptile. GA solution is applied to some seedlings. Others are kept under control. Epicotyl length is measured and as such, GA stimulating epicotyl growth can be seen.

7. Physiological Effects
- It produces extraordinary elongation of stem caused by cell division and cell elongation.
- Rosette plants (genetic dwarfism) exhibit excessive internodal growth when they are treated with gibberellins. This sudden elongation of stem followed by flowering by the application of gibberellin is called bolting (Figure 15.9).
- Gibberellin breaks dormancy in potato tubers.
- Many biennials usually flower during second year of their growth. For flowering in the first year it self these plants should be treated with gibberellins.
- Formation of seedless fruits without fertilization is induced by gibberellins Example: Seedless tomato, apple and cucumber.
- Promotes elongation of inter-node in sugarcane without decreasing sugar content.
- Promotion of flowering in long day plants even under short day conditions.
- It stimulates the seed germination.

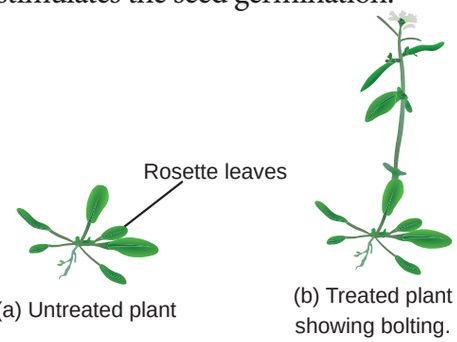


Figure 15.9: Bolting

15.2.3 Cytokinins (Cytos – cell, Kinesis – division)

1. Discovery
The presence of cell division inducing substances in plants was first demonstrated by **Haberlandt** in 1913 in Coconut milk (liquid

endosperm of coconut) which contains cell division inducing substances. In 1954, Skoog and Miller discovered that autoclaved DNA from herring sperm stimulated cell division in tobacco pith cells. They called this cell division inducing principle as kinetin (chemical structure: 6-Furfuryl Amino Acid). This does not occur in plants. In 1963, Letham introduced the term cytokinin. In 1964, Letham and Miller isolated and identified a new cytokinin called **Zeatin** from unripe grains of maize. The most widely occurring cytokinin in plants is Iso Pentenyl adenine (IPA).

2. Occurrence

Cytokinin is formed in root apex, shoot apex, buds and young fruits.

3. Precursor

Cytokinins are derivatives of the purine adenine.

4. Bioassay (Neem Cotyledon Assay)

Neem cotyledons are measured and placed in cytokinin solution as well as in ordinary water. Enlargement of cotyledons is an indication of cytokinin activity.

5. Transport in plants

The distribution of cytokinin in plants is not as wide as those of auxin and gibberellins but found mostly in roots. Cytokinins appear to be translocated through xylem.

6. Physiological effect

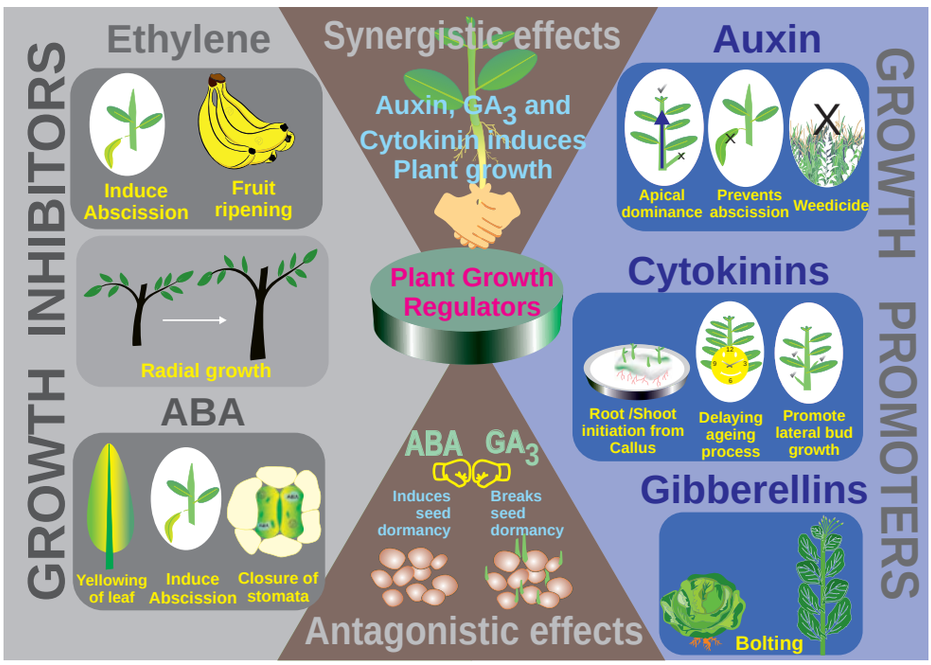
- Cytokinin promotes cell division in the presence of auxin (IAA).
- Cytokinin induces cell enlargement associated with IAA and gibberellins
- Cytokinin can break the dormancy of certain light-sensitive seeds like tobacco and induces seed germination.
- Cytokinin promotes the growth of lateral bud in the presence of apical bud.
- Application of cytokinin delays the process of aging by nutrient mobilization. It is known as Richmond Lang effect.
- Cytokinin (i) increases rate protein synthesis (ii) induces the formation of inter-fascicular cambium (iii) overcomes apical dominance (iv) induces formation of new leaves, chloroplast and lateral shoots.
- Plants accumulate solutes very actively with the help of cytokinins.

15.2.4 Ethylene (Gaseous Phytohormone)

Almost all plant tissues produce ethylene gas in minute quantities.

1. Discovery

In 1924, **Denny** found that ethylene stimulates the ripening of lemons. In 1934, **R. Gane** found that ripe bananas contain abundant ethylene. In 1935, **Cocken** *et al.,* identified ethylene as a natural plant hormone.



2. Occurrence
Maximum synthesis occurs during climacteric ripening of fruits (*see* Box info) and tissues undergoing senescence. It is formed in almost all plant parts like roots, leaves, flowers, fruits and seeds.

3. Transport in plants
Ethylene can easily diffuse inside the plant through intercellular spaces.

4. Precursor
It is a derivative of amino acid methionine, linolenic acid and fumaric acid.

5. Bioassay (Gas Chromatography)
Ethylene can be measured by gas chromatography. This technique helps in the detection of exact amount of ethylene from different plant tissues like lemon and orange.

6. Physiological Effects
- Ethylene stimulates respiration and ripening in fruits.
- It breaks the dormancy of buds, seeds and storage organs.
- It stimulates formation of abscission zone in leaves, flowers and fruits. This makes the leaves to shed prematurely.
- Inhibition of stem elongation (shortening the internode).
- Growth of lateral roots and root hairs. This increases the absorption surface of the plant roots.
- Ethylene normally reduces flowering in plants except in Pine apple and Mango.

15.2.5 Abscisic Acid (ABA) (Stress Phyto hormone)

1. Discovery
In 1963, the hormone was first isolated by **Addicott *et al.,*** from young cotton bolls and named as **Abscission II**. Eagles and Wareing during 1963–64 isolated a dormancy inducing substance from leaves of *Betula* and called it as dormin. In 1965, it was found by Cornsforth *et al.*, that both dormin and abscission are chemically same compounds and called **Abscisic Acid (ABA)**.

2. Occurrence
This hormone is found abundantly inside the chloroplast of green cells.

3. Precursors
The hormone is formed from mevalonic acid pathway or xanthophylls.

4. Transport in plants
Abscisic acid is transported to all parts of the plant through diffusion as well as through phloem and xylem.

5. Chemical structure
It has carotenoid structure.

6. Bioassay (Rice Coleoptile)
The inhibition of IAA induces straight growth of rice seedling coleoptiles.

7. Physiological effects
- It helps in reducing transpiration rate by closing stomata.
- ABA is a powerful growth inhibitor. It causes 50% inhibition of growth in Oat coleoptile.
- It induces bud and seed dormancy.
- It promotes the abscission of leaves, flowers and fruits by forming abscission layers.
- ABA plays an important role in plants during water stress and during drought conditions. It results in loss of turgor and closure of stomata.
- In Cannabis sativa, induces male flower formation on female plants.
- It promotes sprouting in storage organs like Potato.
- It inhibits the shoot growth and promotes growth of root system. This character protect the plants from water stress. Hence, ABA is called as **stress hormone.**

15.3 Photoperiodism

Trees take several years for initiation of flowering whereas an annual herb flowers within few months. Each plant requires a specific time period to complete their vegetative phase which will be followed by reproductive phase as per their internal control points through Biological Clock.

The physiological mechanisms in relation to flowering are controlled by (i) light period (Photoperiodism) and (ii) temperature (Vernalization). The physiological change on flowering due to relative length of light and darkness (photoperiod) is called **Photoperiodism**. The term photoperiodism was coined by **Garner** and **Allard** (1920) when they observed this in 'Biloxi' variety of soybean (*Glycine max*) and 'Maryland mammoth' variety of tobacco (*Nicotiana tabacum*). The photoperiod required to induce flowering is called **critical day length**. Maryland mammoth (tobacco variety) requires 12 hours of light and cocklebur (*Xanthium pensylvanicum*) requires 15.05 hours of light for flowering.

1. Classification of plants based on Photoperiodism

i. **Long day plants**: The plants that require long critical day length for flowering are called long day plants or short night plants. Example: Pea, Barley and Oats.

ii. **Short day plants**: The plants that require a short critical day length for flowering are called short day plants or long night plants. Example: Tobacco, Cocklebur, Soybean, Rice and *Chrysanthemum*.

iii. **Day neutral plants**: There are a number of plants which can flower in all possible photoperiods. They are also called **photo neutrals** or **indeterminate plants**. Example: Potato, *Rhododendron*, Tomato and Cotton.

2. Photoperiodic induction

An appropriate photoperiod in 24 hours' cycle constitutes one inductive cycle. Plants may require one or more inductive cycles for flowering. The phenomenon of conversion of leaf primordia into flower primordia under the influence of suitable inductive cycles is called **photoperiodic induction**. Example: *Xanthium* (SDP) – 1 inductive cycle and *Plantago* (LDP) – 25 inductive cycles.

3. Site of Photoinductive perception

Photoperiodic stimulus is perceived by the leaves. Floral hormone is synthesised in leaves and translocated to the apical tip to promote flowering. This can be explained by a simple experiment on Cocklebur (*Xanthium pensylvanicum*), a short day plant. Usually *Xanthium* will flower under short day conditions. If the plant is defoliated and kept under short day conditions it will not flower. Flowering will occur even when all the leaves are removed except one leaf. If a cocklebur plant is defoliated and kept under long day conditions, it will not flower. If one of its leaves is exposed to short day condition and rest are in long day condition, flowering will occur (Figure 15.10).

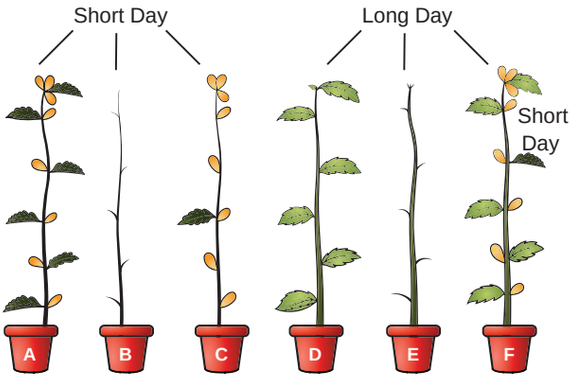
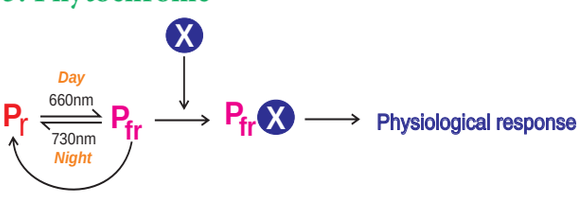


Figure 15.10: Experiment on Cocklebur plant showing photoperiodic stimulus

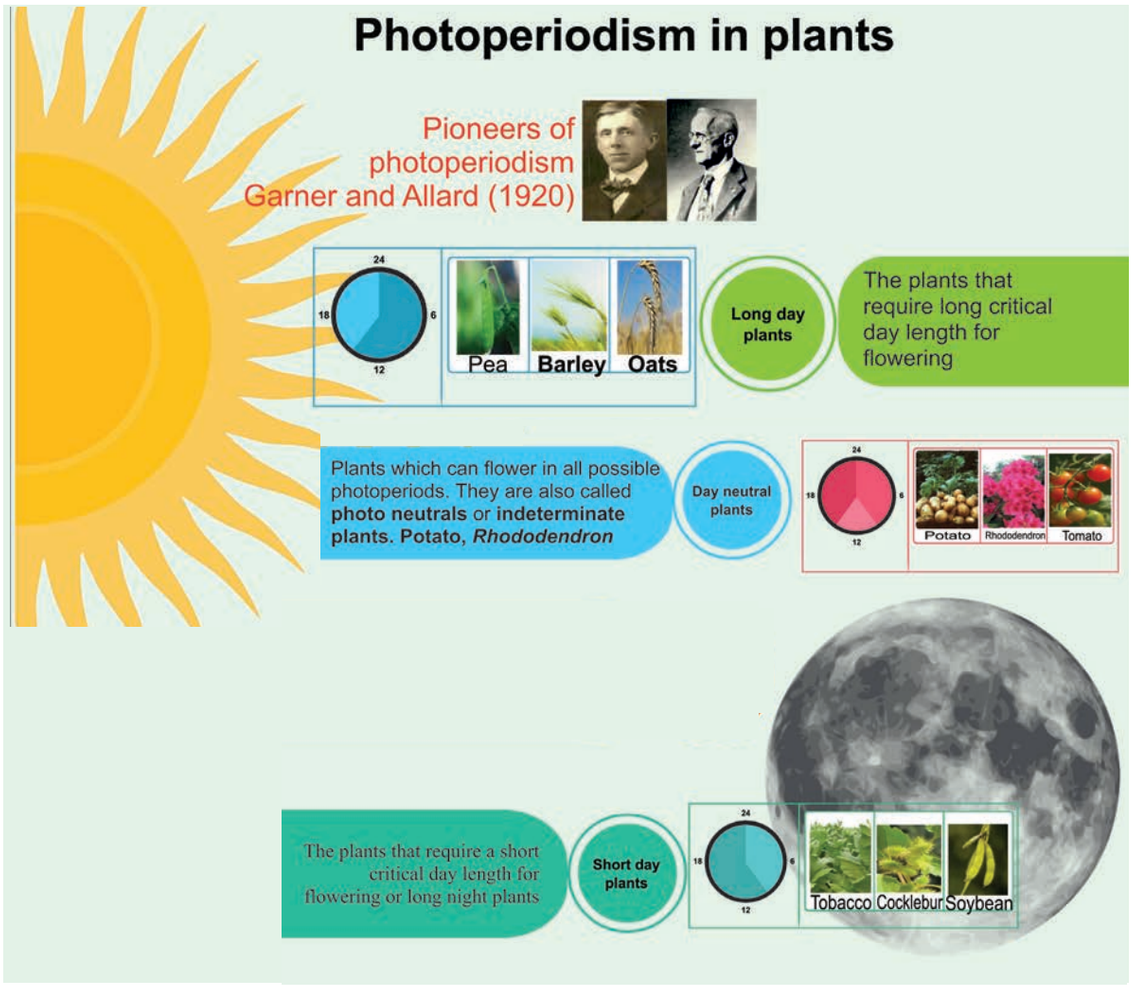
4. Importance of photoperiodism

1. The knowledge of photoperiodism plays an important role in hybridisation experiments.
2. Photoperiodism is an excellent example of physiological pre-conditioning that is using an external factor to induce physiological changes in the plant.

5. Phytochrome



Phytochrome is a bluish biliprotein pigment responsible for the perception of light in photo physiological process. **Butler *et al.*,**



(1959) named this pigment and it exists in two interconvertible forms: (i) red light absorbing pigment which is designated as P_r and (ii) far red light absorbing pigment which is designated as P_{fr}. The P_r form absorbs red light in 660nm and changes to P_{fr}. The P_{fr} form absorbs far red light in 730nm and changes to P_r. The P_r form is biologically inactive and it is stable whereas P_{fr} form is biologically active and it is very unstable. In short day plants, P_r promotes flowering and P_{fr} inhibits the flowering whereas in long day plants flowering is promoted by P_{fr} and inhibited by P_r form. P_{fr} is always associated with hydrophobic area of membrane systems while P_r is found in diffused state in the cytoplasm. The interconversion of the two forms of phytochrome is mainly involved in flower induction and also additionally plays a role in seed germination and changes in membrane conformation.

15.4 Vernalization (*Vernal* – Spring Like)

Besides photoperiod certain plants require a low temperature exposure in their earlier stages for flowering. Many species of biennials and perennials are induced to flower by low temperature exposure (0°C to 5°C). This process is called **Vernalization.** The term Vernalization was first used by **T. D. Lysenko** (1938).

1. Mechanism of Vernalization:

Two main theories to explain the mechanism of vernalization are:

i. Hypothesis of phasic development
ii. Hypothesis of hormonal involvement

i. Hypothesis of phasic development

According to Lysenko, development of an annual seed plant consists of two phases. First phase is **thermostage**, which is vegetative phase requiring low temperature and suitable moisture. Next phase is **photo stage** which requires high temperature for synthesis of florigen (flowering hormone).

ii. Hypothesis of hormonal involvement

According to **Purvis** (1961), formation of a substance A from its precursor, is converted into B after chilling. The substance B is unstable. At suitable temperature B is converted into stable compound D called **Vernalin**. Vernalin is converted to F (Florigen). Florigen induces flower formation. At high temperature B is converted to C and devernalization occurs (Figure 15.11).

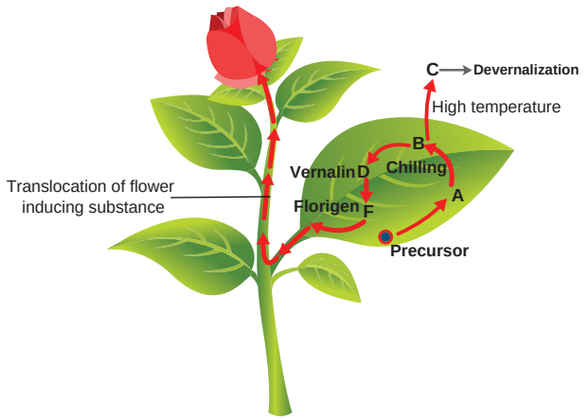


Figure 15.11: Vernalization and Flowering

2. Technique of Vernalization:

The seeds are first soaked in water and allowed to germinate at 10° C to 12° C. Then seeds are transferred to low temperature (3°C to 5°C) from few days to 30 days. Germinated seeds after this treatment are allowed to dry and then sown. The plants will show quick flowering when compared to untreated control plants.

3. Devernalization

Reversal of the effect of vernalization is called **devernalization**.

4. Practical applications

1. Vernalization shortens the vegetative period and induces the plant to flower earlier.
2. It increases the cold resistance of the plants.
3. It increases the resistance of plants to fungal disease.
4. Plant breeding can be accelerated.

15.5 Seed Germination and Dormancy

I. Seed Germination

The activation and growth of embryo from seed into seedling during favourable conditions is called **seed germination**.

1. Types of germination

There are two methods of seed germination. Epigeal and hypogeal.

i. Epigeal germination

During epigeal germination cotyledons are pushed out of the soil. This happens due to the elongation of the hypocotyl. Example: Castor and Bean.

ii. Hypogeal germination

During hypogeal germination cotyledons remain below the soil due to rapid elongation of epicotyls (Figure 15.12). Example: Maize, Pea.

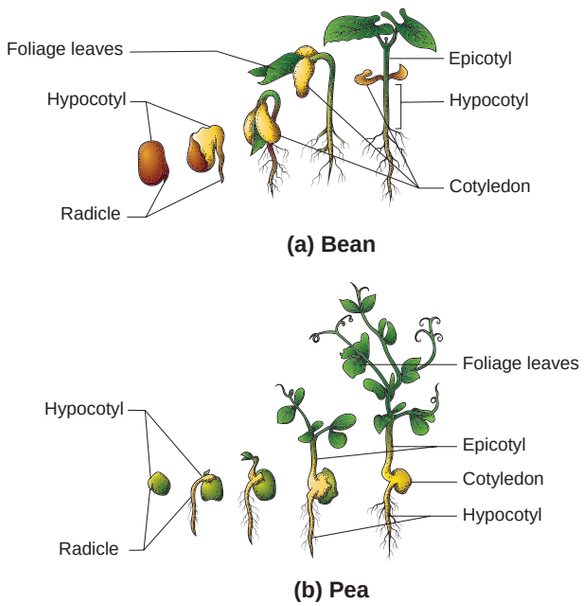


Figure 15.12: (a) Epigeal Germination
(b) Hypogeal Germination

2. Factors affecting germination

Seed germination is directly affected by external and internal factors:

i. External factors

a. **Water**: It activates the enzymes which digest the complex reserve foods of the

seed. If the water content of the seed goes below a critical level, seeds fail to germinate.

b. **Temperature**: Seeds fails to germinate at very low and high temperature. The optimum temperature is 25°C to 35°C for most tropic species.

c. **Oxygen**: It is necessary for germination. Since aerobic respiration is a physiological requirement for germination most will germinate well in air containing 20% oxygen.

d. **Light**: There are many seeds which respond to light for germination and these seeds said to be photoblastic.

e. **Soil conditions**: Germination of seed in its natural habit is influenced by soil conditions such as water holding capacity, mineral composition and aeration of the soil.

ii. Internal factors

a. **Maturity of embryo**: The seeds of some plants, when shed will contain immature embryo. Such seeds germinate only after maturation of embryo.

b. **Viability**: Usually seeds remain viable or living only for a particular period. Viability of seeds range from a few days (Example: *Oxalis*) to more than hundred years. Maximum viability (1000 years) has been recorded in lotus seeds. Seeds germinate only within the period of viability.

c. **Dormancy**: Seeds of many plants are dormant at the time of shedding. A detailed treatment is given below.

II. Seed Dormancy

The seeds of most plants germinate under favourable environmental conditions but some seeds do not germinate when suitable conditions like water, oxygen and favourable temperature are not available. Germination of such seeds may be delayed for days, months or years. The condition of a seed when it fails to germinate even in suitable environmental condition is called **seed dormancy**. There are two main reasons for the development of dormancy: Imposed dormancy and innate dormancy. Imposed dormancy is due to low moisture and low temperature. Innate dormancy is related to the properties of seed itself.

1. Factors causing dormancy of seeds:

i. Hard, tough seed coat causes barrier effect as impermeability of water, gas and restriction of the expansion of embryo prevents seed germination.

ii. Many species of seeds produce imperfectly developed embryos called **rudimentary embryos** which promotes dormancy.

iii. Lack of specific light requirement leads to seed dormancy.

iv. A range of temperatures either higher or lower cause dormancy.

v. The presence of inhibitors like phenolic compounds which inhibits seed germination cause dormancy.

2. Methods of breaking dormancy:

The dormancy of seeds can be broken by different methods. These are:

i. **Scarification**: Mechanical and chemical treatments like cutting or chipping of hard tough seed coat and use of organic solvents to remove waxy or fatty compounds are called as **Scarification**.

ii. **Impaction**: In some seeds water and oxygen are unable to penetrate micropyle due to blockage by cork cells. These seeds are shaken vigorously to remove the plug which is called **Impaction**.

iii. **Stratification**: Seeds of rosaceous plants (Apple, Plum, Peach and Cherry) will not germinate until they have been exposed to well aerated, moist condition under low temperature (0°C to 10°C) for weeks to months. Such treatment is called **Stratification**.

iv. **Alternating temperatures**: Germination of some seeds is strongly promoted by alternating daily temperatures. An alternation of low and high temperature improves the germination of seeds.

v. **Light**: The dormancy of photoblastic seeds can be broken by exposing them to red light.

15.6 Senescence

Plant life comprises some sequential events, *viz*: germination, juvenile stage, maturation, old age and death. Old age is called **senescence** in plants. Senescence refers to all collective, progressive and deteriorative processes which ultimately lead to complete loss of organization and function. Unlike animals, plants continuously form new organs and older organs undergo a highly regulated senescence program to maximize nutrient export.

The branch of botany which deals with ageing, abscission and senescence is called **Phytogerontology**

1. Types of Senescence

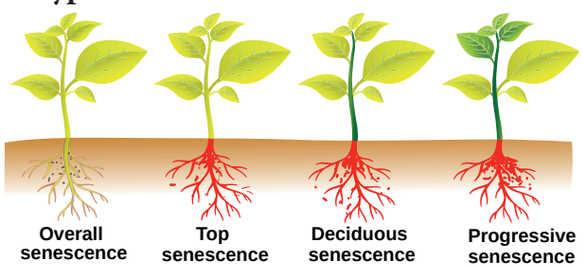


Figure 15.13: Different types of senescence in plants

Leopold (1961) has recognised four types of senescence:

i. Overall senescence
ii. Top senescence
iii. Deciduous senescence
iv. Progressive senescence

i. **Overall senescence**: This kind of senescence occurs in annual plants when entire plant gets affected and dies. Example: Wheat and Soybean. It also occurs in few perennials also. Example: *Agave* and Bamboo.

ii. **Top senescence**: It occurs in aerial parts of plants. It is common in perennials, underground and root system remains viable. Example: Banana and *Gladiolus*.

iii. **Deciduous senescence**: It is common in deciduous plants and occurs only in leaves of plants, bulk of the stem and root system remains alive. Example: Elm and Maple.

iv. **Progressive senescence**: This kind of senescence is gradual. First it occurs in old leaves followed by new leaves then stem and finally root system. It is common in annuals (Figure 15.13).

2. Physiology of Senescence

- Cells undergo changes in structure.
- Vacuole of the cell acts as lysosome and secretes hydrolytic enzymes.
- The starch content is decreased in the cells.
- Photosynthesis is reduced due to loss of chlorophyll accompanied by synthesis and accumulation of anthocyanin pigments, therefore the leaf becomes red.
- There is a marked decrease in protein content in the senescing organ.
- RNA content of the leaf particularly rRNA level is decreased in the cells due to increased activity of the enzyme RNAase.
- DNA molecules in senescencing leaves degenerate by the increased activity of enzyme DNAase.

3. Factors affecting Senescence:

- ABA and ethylene accelerate senescence while auxin and cytokinin retard senescence.
- Nitrogen deficiency increases senescence whereas nitrogen supply retards senescence.
- High temperature accelerates senescence but low temperature retards senescence.
- Senescence is rapid in dark than in light.
- Water stress leads to accumulation of ABA leading to senescence.

4. Programmed cell death (PCD)

Senescence is controlled by plants own genetic programme and death of the plant or plant part consequent to senescence is called **Programmed Cell Death**. In short senescence of an individual cell is called **PCD**. The proteolytic enzymes involving PCD in plants are **phytaspases** and in animals are **caspases**. The nutrients and other substrates from senescing cells and tissues are remobilized and reallocated to other parts of the plant that survives. The protoplasts of developing xylem vessels and tracheids die and disappear at maturity to make them functionally efficient

to conduct water for transport. In aquatic plants, aerenchyma is normally formed in different parts of the plant such as roots and stems which encloses large air spaces that are created through PCD. In the development of unisexual flowers, male and female flowers are present in earlier stages, but only one of these two completes its development while other aborts through PCD (Figure 15.14).

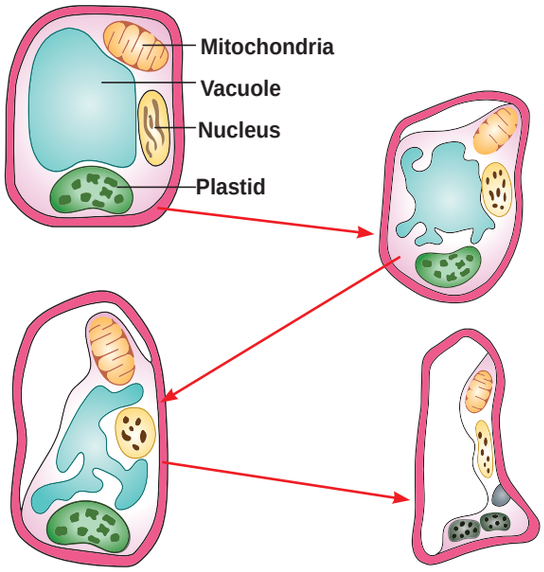


Figure 15.14: Programmed cell death

5. Abscission

Abscission is a physiological process of shedding of organs like leaves, flowers, fruits and seeds from the parent plant body. When these parts are removed the plant seals off its vascular system to prevent loss of water and nutrients. Final stage of senescence is abscission. In temperate regions all the leaves of deciduous plants fall in autumn and give rise to naked appearance, then the new leaves are developed in the subsequent spring season. But in evergreen plants there is gradual abscission of leaves, the older leaves fall while new leaves are developed continuously throughout the year.

6. Morphological and Anatomical changes during abscission

Leaf abscission takes place at the base of petiole which is marked internally by a distinct zone of few layers of thin walled cells arranged transversely. This zone is called **abscission zone or abscission layer**. An abscission layer is greenish-grey in colour and is formed by rows of cells of 2 to 15 cells thick. The cells of abscission layer separate due to dissolution of middle lamella and primary wall of cells by the activity of enzymes **pectinase** and **cellulase** resulting in loosening of cells. Tyloses are also formed blocking the conducting vessels. Degrading of chlorophyll occur leading to the change in the colour of leaves, leaf detachment from the plant and leaf fall. After abscission, outer layer of cells becomes suberized by the development of periderm (Figure 15.15).

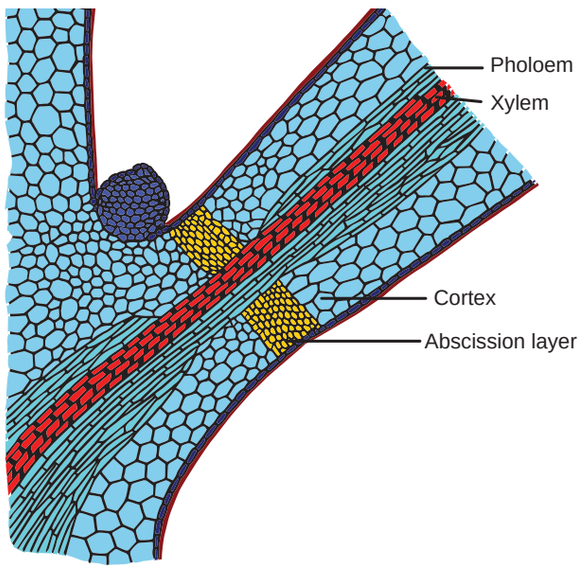


Figure 15.15: L.S of petiolar base showing abscission layer

7. Hormones influencing abscission

All naturally occurring hormones influence the process of abscission. Auxins and cytokinins retard abscission, while abscisic acid (ABA) and ethylene induce it.

8. Significance of abscission

1. Abscission separates dead parts of the plant, like old leaves and ripe fruits.
2. It helps in dispersal of fruits and continuing the life cycle of the plant.
3. Abscission of leaves in deciduous plants helps in water conservation during summer.
4. In lower plants, shedding of vegetative parts like gemmae or plantlets help in vegetative reproduction.

Summary

Growth occurs by cell division, cell elongation and cell maturation. The first phase is lag phase, the second is log phase and the final phase is steady state phase. The log phase is otherwise known as **exponential phase**. The three phases are collectively called Grand period of growth. Plant growth and development are controlled by both internal and external factors. The internal factors are chemical substances called Plant Growth Regulators (PGRs). The hormones are classified into five groups: Auxins, gibberellins, cytokinins, abscisic acid and ethylene. These PGRs are synthesized in various parts of the plant. PGRs may act synergistically or antagonistically. Mechanism of flowering is controlled by light period (photoperiodism) and temperature (vernalization). The physiological changes on flowering with effect from relative length of light and darkness (photoperiodism) are called photoperiodism. A bluish biliprotein responsible for the perception of light in photophysiological process (induction and inhibition of flowering) is called **Phytochrome**. Besides photoperiod certain plants require a low temperature in the earlier stages for flowering. Many biennial and perennial plants are induced to flower by low temperature (0°C to 5°C). This process is called **vernalization** and the reversal effect of vernalization is called **devernalization**. The condition of a seed when it fails to germinate even in suitable environmental condition is called **seed dormancy**. Thus, dormancy can be overcome by following methods such as scarification, impaction, stratification, alternating temperatures and light. Senescence refers to all collective, progressive and deteriorative processes which ultimately lead to complete loss of organization and function. Senescence is of four types and they are overall, top, deciduous and progressive. Senescence is controlled by plant's own genetic programme. Death of the plant or its parts consequent to senescence is called **Programmed Cell Death** (PCD). The final stage of senescence is abscission. Abscission is a physiological process of shedding of organs from the parent plant body.

Evaluation

1. Select the wrong statement from the following:
   a. Formative phase of the cells retain the capability of cell division.
   b. In elongation phase development of central vacuole takes place.
   c. In maturation phase thickening and differentiation takes place.
   d. In maturation phase, the cells grow further.

2. If the diameter of the pulley is 6 inches, length of pointer is 10 inches and distance travelled by pointer is 5 inches. Calculate the actual growth in length of plant.
   a. 1.5inches b. 6 inches
   c. 12 inches d. 30 inches

3. _____ is the powerful growth inhibitor
   a. Ethanol b. Cytokinins
   c. ABA d. Auxin

4. Select the correctly matched one

A) Human urine	i) Auxin –B
B) Corn gram oil	ii) GA_3
C) Fungus	iii) Abscisic acid II
D) Herring fish sperm	iv) Kinitin
E) Unripe maize grains	v) Auxin A
F) Young cotton bolls	vi) Zeatin

   a) A-iii, B-iv, C-v, D-vi, E-i, F-ii,
   b) A-v, B-i, C-ii, D-iv, E-vi, F-iii,
   c) A-iii, B-v, C-vi, D-i, E-ii, F-iv,
   d) A-ii, B-iii, C-v, D-vi, E-iv, F-i

5. Seed dormancy allows the plants to
   a. overcome unfavourable climatic conditions
   b. develop healthy seeds
   c. reduce viability
   d. prevent deterioration of seeds
6. Which one of the following method are used to break the seed dormancy?
   a) Scarification b) Impaction
   c) Stratification d) All the above.
7. Write the physiological effects of Cytokinins.
8. Describe the mechanism of photoperiodic induction of flowering.
9. Give a brief account on Programmed Cell Death (PCD)

ICT Corner

How do Plants respond to different stimuli?

Let's Stimulate **the Plants.**

Steps
- Scan the QR code
- Click Exploring plant responses
- Select items and complete the check list
- Follow the procedure – 1 to 10 steps
- Record your prediction and not your observation in lab note – Right top

Activity
- Observe the movements of plant seedlings and plant parts.
- Conclude your observations.

Step 1 Step 2 Step 3 Step 4

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Web URL: https://www.classzone.com/books/hs/ca/sc/bio_07/virtual_labs/virtualLabs.html * Pictures are indicative only

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Glossary

Abscission zone	A region near the base of petiole of leaf which contains abscission layer.
Absorption Spectrum	A curve obtained by plotting the amount of absorption of different wavelengths of light by a pigment is called its absorption spectrum.
Acetyl CoA	Small, water-soluble metabolite comprising an acetyl group linked to coenzyme A (CoA).
Action Spectrum	A graphic representation showing the rate of photosynthesis at different wavelengths of light is called action spectrum
Active site	Region of an enzyme molecule where the substrate binds and undergoes a catalyzed reaction.
Aeroponics	A technique of growing plants suspended over the nutrient solution in a mist chamber. Nutrient sprayed by motor driven rotor on the roots.
Agar	Jelly-like substance, derived from red algae
Akinetes	Thick walled, dormant, non motile asexual spores.
Aleurone	Outer layer of the endosperm
Allelopathy	The chemical substances released by one plant species which affect or benefit another plant
Amphicribal/ Hadrocentric	Xylem in the centre with phloem surrounding it. Example: Ferns (Polypodium)
Amphivasal / Leptocentric	Phloem in the centre with xylem surrounding it. Example: Dragon plant – Dracena and Yucca
Anabolic	It is an enzyme catalyzed reaction in a cell that involves synthesis of complex molecules from simple molecules which uses energy.
Anamorph	Asexual or imperfect state of fungi
Anisogamy	Fusion of morphologically and physiologically dissimilar gametes
Apical cell theory	Single apical cell growing into whole plant
Apogamy	Formation of sporophyte from the gametophytic tissue without the fusion of gametes.
Apospory	Development of the gametophyte from the sporophyte without the formation of spores
Axil Parenchyma	Parenchyma arranged longitudinally along the axis
Balausto	Fleshy in dehiscent fruit
Basal body	Structure at the base of cilia and flagella from which microtubules forming the axoneme radiate
Biosphere	The region of earth on which life exist
Buffer	A solution of the acid and base form of a compound that undergoes little change in pH when small quantities of strong acid or base are added.
Callose	Sieve pores are blocked by substances called callose
Carbonic acid	A weak acidic solution of carbon-di-oxide dissolved in water
Carcinogen	Any chemical or physical agent that can cause cancer when cells or organism s are exposed to it.
Catabolic	It is an enzyme catalyzed reaction in a cell that involves degradation of molecules into simple subunits which release energy.
Chelating agents	A chelate is the soluble product formed when certain atoms in an organic ligand donate electrons to the cation.
Chemotaxonomy	Classification based on the biochemical constituents of plants
Chlorosis	Breakdown of chlorophylls leads to yellowing of leaves
Clades	Group of species comprising common ancestor and its descendants
Cladistics	Methodology used to classify organisms into monophyletic group

Closed vascular bundle	Cambium absent between xylem and phloem Example: Monocot stem
Codon	Sequence of three nucleotides in DNA or mRNA that specifies a particular amino acid during protein synthesis; also called triplet
Coenocytic condition	Aseptate, multinucleate condition
Coenzyme	A non-protein molecule involved in enzyme catalyzed reactions serves as transfer of protons or electrons between various molecules
Colloidal	An evenly distributed mixture of two different particles in a system without losing its own properties.
Dalton	Unit of molecular mass approximately equal to the mass of a hydrogen atom ($1.66 \times 10-24$ g)
Deamination	The enzymatic removal of an amino group from an amino acid to form its corresponding keto acid.
Desiccation tolerance	Ability of plants which can tolerate extreme water stress without being killed.
Drought resistance	Capacity of a plant to limit and control consequences of water deficit.
EDTA	Ethylene Diamine Tetra Acetic acid, chelating agent makes iron uptake possible by forming soluble complex in an alkaline soil.
Endergonic	A chemical reaction with a positive free energy charge or ATP utilizing reactions.
Endosperm	Nutritive tissue for the embryo
Endospore	Thick walled, resting spores
Eusporangiate	Sporangium formed from a group of initials
Exergonic	A chemical reaction with a negative free energy charge or ATP producing reactions.
Extra stellar ground tissue	Tissues outside the stele
Fibre-Tracheids	Transitional form between fibre and tracheids
Fluorescence	Emission of light by a substance that has absorbed light in the form luminescence.
Fossil	The remains or impression of plant or animal of the past geological age
Gametophyte	The haploid plant body
Gelatin	An animal-based product used as a gelling agent.
Genome	Complete set of genes in an organism
Germ	Protein rich embryo
Granum	A stack of thylakoid in a stroma of chloroplast
Hadrome	Xylem-by Haberlandt
Halophytes	Plants native to saline soils and complete their life cycle
Heliophytes	Plants which are adapted to light
Heterospory	Production of spores of different sizes: megaspores and microspores
Histogenesis	Differentiate tissues from undifferentiated cells of meristem
Indeterminate growth	Plants grow throughout their life
Intrastelar ground tissue	Tissues within the stele
Isomerisation	Rearrangement of atomic groups within the same molecule without any loss or gain of atoms.
Karyogamy	Fusion of nucleus
Karyotype	Number, sizes, and shapes of the entire set of metaphase chromosomes of a eukaryotic cell.

Km	A parameter that describes the affinity of an enzyme for its substrate and equals the substrate concentration that yields the half-maximal reaction rate;
Leptome	Phloem – by Haberlandt
Leptosporangiate	Sporangium formed from a single initial
Lumen	Space inside the tracheid/vessel/fibres
Malate Shuttle mechanism	It is a biochemical system for translocating electrons produced from glycolysis across inner membrane of mitochondrion for oxidative phosphorylation.
Mass meristem	Meristem which divides in all planes
Microgreens	Young vegetable greens add flavour in culinary
Monograph	Complete account of a taxon of any rank
Monosulcate	Pollen grain with single furrow or pores
Mycobank	Online database documenting new mycological names
Necrosis	Death of tissue
Non heme iron	An iron porphyrin prosthetic group of heme proteins from plant origin
Nucleoid	Genetic material of bacterium
Nutation	The growing stems of twiner and tendrils show automatic movement
Oogamy	Fusion of morphologically and physiologically dissimilar gametes
Open vascular bundle	Cambium present between xylem and phloem Example: Dicot stem
Oxidation	Water is oxidised into Oxygen (loss of electrons)
PAR	The wavelength at which the rate of photosynthesis is more is called 'Photosynthetically Active Radiations' which falls between 400 to 700 nm.
Parthenocarphy	Fruit developed without fertilization
Pendulous	Hanging downward loosely or freely (like catkin)
Petrifaction	A process of fossil formation through infiltration of minerals over a long period
pH	A measure of the acidity or alkalinity of a solution defined as the negative logarithm of the hydrogen ion concentration in moles per liter
Phosphorescence	Phosphorescence is the delayed emission of absorbed radiations.
Photolysis	Splitting of water molecules by light which generate protons, electrons and oxygen.
Photon	Light is electromagnetic radiant energy and travels as tiny particles called photons. A discrete Physical unit of light energy.
Photoperiodism	The response of plants to the photoperiod expressed in the form of flowering.
Phylogeny	Evolution of group of organisms
Phytochrome	A photo reversible proteinaceous plant pigment in very low concentration that absorbs red and far red light which controls flowering.
Pistillode	Sterile pistil
Pitted thickening	Uniformly thick except at their pits
Plasmogamy	Fusion of cytoplasm
Pluriocular	An ovary with two or more locus
Preparatory phase	First half of glycolysis comprising five enzymatic reactions in which one molecule of glucose splitting into two molecules of glyceraldehyde 3 phosphate with consumption of two ATP molecules.
Prickles	Stiff and sharp outgrowth
Prophage	The integrated phage DNA with host DNA

Protologue	Set of information associated with the scientific name of a taxon at its first valid publication containing the entire original material regarding the taxon
Quantasome	Morphological expression of physiological photosynthetic units, located on the inner membrane of thylakoid lamellae. Act as photosynthetic unit contains 200 to 300 chlorophyll molecules.
Quantum	The energy contained in a photon is represented as quantum
Quantum requirement	The number of photons or quanta required to release one molecule of oxygen during photosynthesis
Quantum yield	The number of oxygen molecules produced per quantum of light absorbed.
Quiescent centre concept	Inactive region of root meristem
Rachilla	Central axis of a spikelet
Radial vascular bundles	Xylem and phloem present on different radii
Ray Parenchyma	Parenchyma cells arranged in radial rows
Redox reactions	Oxidation (loss of electrons) and Reduction (gain of electrons) reactions are called redox reactions.
Reduction	CO2 is reduced into Carbohydrates (gain of electrons)
Rib-meristem	Meristem which divides anticlinally in two planes
RUBISCO	Enzyme responsible for fixation of Carbon dioxide, the most abundant protein (Ribulose 1,5 bisphosphate Carboxylase Oxygenase)
Salt stress	Adverse effects of excess mineral salts on plants
Sap	It is a fluid consist of water and dissolved minerals
Slime body	A special protein (Phloem Protein) in sieve tubes
Sporophyte	Diploid plant body
Stellate hairs	Star shaped hairs
Stratification	A process of breaking the dormancy of some plants resulting from chilling requirements
Subsidiary cells	Surrounding guard cells in the leaf epidermis
Sucrose	Non-reducing disaccharide composed of glucose and fructose
Teloemorph	Sexual or perfect state of the fungi
Thallospores	Asedual spores formed due to the fragmentation of hyphae
Trichoblasts	One type of epidermal cells that is also called short cell
Trichomes	Unicellular or multicellular appendages
Triplicate	Pollen grain with three furrows or pores
Tunica-carpus theory	Two zones of apical meristem Tunica and Carpus
X-Ray crystallography	Most commonly used technique for determining the three-dimensional structure of macromolecules (particularly proteins and nucleic acids) by passing x-rays
Xylos	Wood
Zoospore	Motile, asexual spores
Zygospore	Thick walled diploid resting spores

English – Tamil Terminology

Abscission	உதிர்தல்
Abscission zone	உதிரும் அடுக்கு
Absorption spectrum	ஒளி ஈர்ப்பு நிறமாலை
Acropetal succession (arrangement)	நுனி நோக்கிய வரிசை
Action spectrum	ஒளி செயல்திறன் நிறமாலை
Activated diffusion	மேம்படுத்தப்பட்ட பரவல்
Active transport	ஆற்றல்சார் கடத்தல்
Adhesion	ஒட்டிணைவு
Aeroponics	காற்றூடக வளர்ப்பு
Aggregatte fruit	திரள்கனி
Akinetes	உறக்க நகராவித்து
Anabolic	சேர்க்கைச் செயல்
Anamorph	பாலிலாநிலை
Anisogamy	சமமற்ற கேமீட்களின் இணைவு
Annual rings	ஆண்டு வளையங்கள்
Antenna molecules	ஏற்பி மூலக்கூறுகள்
Anthrophytes	பூக்கும் தாவரங்களின் முன்னோடிகள்
Apical cell theory	நுனி செல் கொள்கை
Apogamy	பாலிணைவின்மை
Apospory	குன்றலில்லா வித்துத்தன்மை
Arbitary marker	தன்னிச்சையான குறிப்பான்
Arithmetic growth	எண் கணித வளர்ச்சி
Ascent of sap	சாறேற்றம்
Assimilatory power	தன்மயமாக்கும் ஆற்றல்
Autonomous movement	தன்னிச்சையான அசைவுகள்
Autumn wood or late wood	குளிர்க்காலக் கட்டை அல்லது பின்பருவக் கட்டை
Axial parenchyma	அச்சு பாரங்கைமா
Basipetal succession	அடி நோக்கிய வரிசை
Bicollateral vascular bundle	இருபக்க ஒருங்கமைந்த வாஸ்குலக் கற்றை
Biosequestration	உயிர்வளி தனிமைப்படுத்துதல்
Biosphere	உயிர்க்கோளம்
Biosynthetic phase	உயிர்மதோற்ற நிலை
Brown heart disease	மைய கருக்கல் நோய்
Buttress root	பலகை வேர்
Callus	திசுத்திரள்
Carbon di oxide compensation point	கார்பன்-டை-ஆக்ஸைட் ஈடு செய்யும் புள்ளி
Carbon fixation	கார்பன் நிலைநிறுத்தம்
Carrier protein	தாங்கிப் புரதம்/கொண்டு செல்லும் புரதம்
Catabolic	சிதைக்கும் செயல்
Catalytic amination	வினையூக்க அமைனோவாக்கம்
Cavitation	குமிழாதல்
Centrifugal	மையம் விலகியது
Centripetal	மையம் நோக்கியது
Channel protein	கால்வாய் புரதம்
Chelating agents	பிணைக்கும் காரணி
Chemiosmotic theory	வேதி சவ்வூடு பரவல் கோட்பாடு
Chlorophyll	பச்சையம்
Chloroplast	பசுங்கணிகம்
Chlorosis	பச்சைய சோகை
Cladogram	கிளை வரைபடம்
Closed collateral vascular bundles	மூடிய ஒருங்கமைந்த வாஸ்குலக் கற்றைகள்
Coenocytic	பல்உட்கரு நிலை
Cohesion	கூட்டிணைவு
Collateral vascular bundles	ஒருங்கமைந்த வாஸ்குலக் கற்றைகள்
Companion cells	துணைச் செல்கள்
Compensation point	ஈடுசெய்யும் புள்ளி
Concentration gradient	செறிவு சரிவு வாட்டம்
Concentric vascular bundles	சூழமைந்த வாஸ்குலக் கற்றைகள்
Conjugation	இணைவு
Core complex	மைய ஆதார கூட்டமைப்பு
Cotyledons	விதையிலைகள்
Critical concentration	தீர்வுக் கட்ட செறிவு
Day neutral plants	நாள் நடுநிலை தாவரங்கள்
Deamination	அமினோ நீக்கம்
Dendrochronology	மர வயதியல்
Deplasmolysis	பிளாஸ்மா சிதைவு மீட்சி
Dicarboxylic acid pathway	டைகார்பாக்சிலிக் அமில சுழற்சி
Die back of shoot	தண்டின் நுனி அடி இறப்பு
Diffusion	பரவல்
Dimorphic chloroplast	இருவடிவ பசுங்கணிகம்
Drought resistance	வறட்சியை எதிர்ப்பவை
Dry dehiscent fruit	உலர் வெடிகனி
Dry indehiscent fruit	உலர் வெடியாக்கனி
Efflux	அயனி வெளிப்புகல்
Electro magnetic spectrum	மின்காந்த நிறமாலை
Electron transport chain	எலக்ட்ரான் கடத்து சங்கிலி
Embryo	கரு
Emerson's enhancement effect	எமர்சனுடைய மேம் படுத்தப்பட்ட விளைவு
Endergonic	ஆற்றல் ஏற்கும் வினை
Endosperm	கருவுண்திசு
Endospores	அகவித்துகள்

Endosymbiotic hypothesis	அக கூட்டுயிர் கோட்பாடு
Eukaryote	உண்மை உட்கரு உயிரி
Eusporangiate	உண்மை வித்தகத்தன்மை
Eutrophication	மிகை ஊட்ட நிலை
Exarch Xylem	வெளிநோக்கு சைலம்
Exergonic	ஆற்றல் வெளியிடும் வினை
Extinction point	அழிவுப் புள்ளி
Fermentation	நொதித்தல்
Fibre Tracheids	நார் டிரக்கீடுகள்
Flourescence	உடன் ஒளிர்தல்
Flux	அயனிபுகல்
Fossil	தொல்லுயிரெச்சம்
Funicle	சூல்காம்பு
Gametophyte	கேமீட்டக தாவரம்
Gene marker	மரபணு குறிப்பான்
Genome	மரபணுத் தொகுப்பு
Geocarpic fruit	புவிபுதை கனி/நிலத்தகத்துக் கனி
Geometric growth	ஜியோமித வளர்ச்சி
Geophytes	நிலத்தகத்துத் தூண்சேர் தாவரம்
Grand period of growth	மொத்த வளர்ச்சிக் காலம்
Growth rate	பெரும வளர்ச்சி வீதம்
Gynobasic	சூற்பை அடி சூலகத்தண்டு
Halophiles	உவர்நாட்டவுயிரிகள்
Halophytes	உவர்நிலை தாவரங்கள்
Heart wood	வைரக்கட்டை
Heliophytes	ஒளியை விரும்பும் தாவரங்கள்
Heterospory	மாற்று வித்தகத்தன்மை
Histogen theory	ஹிஸ்டோஜன் கொள்கை
Histogenesis	ஹிஸ்டோஜெனிசிஸ்
HMP shunt	HMP மாற்றுவழிப் பாதை
Homeostasis	சமச்சீர் நிலை
Hydathode	நீர்கசிவுத் துளை
Hydrochory	நீர்மூலம் பரவுதல்
Hydroponics	நீர் ஊடக வளர்ப்பு
Imbibition	உள்ளீர்த்தல்
Indeterminate	வரம்பற்ற வளர்ச்சி
Influx	அயனி உட்புகல்
Interveinal chlorosis	நரம்பிடை பச்சைய சோகை
Irritability	உறுத்துணர்ச்சி
Isogamy	ஒத்த கேமீட்களின் இணைவு
Isomerisation	மாற்றியமாதல்
Karyogamy	உட்கரு இணைவு
Karyokinesis	காரியோகைனசிஸ்
Lag phase	உருவாக்க நிலை

Leaf primodium	இலைத்தோற்றுவி
Legume / Pod	விதைப்பை
Lenticel	பட்டைத்துளை
Leptosporangiate	மெலி வித்தகத்தன்மை
Light harvesting complex	ஒளி அறுவடை கூட்டமைப்பு
Link reaction	இணைப்பு வினை
Log phase	நீட்சியுறு நிலை
Macro nutrients	பெரும ஊட்ட மூலங்கள்
Malate Shuttle mechanism	மாலேட் திருப்பு செயல்
Mass meristem	பொருண்மை ஆக்குதிசு
Matric potential	ஊடக உட்திறன்
Maturation promoting factor (MPF)	முதிர்ச்சியை ஊக்கப்படுத்தும் காரணி
Merosity	எண்ணிக்கை அமைவு
Metabolism	வளர்சிதைமாற்றம்
Micro nutrients	நுண் ஊட்ட மூலங்கள்
Middle Lamella	இடைமென் அடுக்கு
Mineral Nutrition	கனிம ஊட்டம்
Mitochondrial matrix	மைட்டோகாண்ட்ரிய உட்கூழ்மம்
Monograph	தனிக்கட்டுரை
Multiple fruit	கூட்டுக்கனி
Mycobank	பூஞ்சை வங்கி
Necrosis	நைவுப் புண்கள்
Nitrate Assimilation	நைட்ரேட் தன்மயமாதல்
Nitrogen metabolism	நைட்ரஜன் வளர்சிதை மாற்றம்
Non-porous wood	துளைகளற்ற கட்டை
Nuclear envelope	நியூக்ளியர் உறை
Nuclear organizer	நியுக்ளியோலார் அமைப்பான்கள்
Nucleoid	உட்கரு ஒத்த அமைப்பு
Nutation	சுழலசைவு
Obligate parasite	கட்டாய ஒட்டுண்ணி
Oogamy	முட்டை கருவுறுதல்
Open vascular bundle	திறந்த வாஸ்குலக் கற்றை
Oxygen evolving complex (OEC)	ஆக்ஸிஜன் உருவாக்கும் கூட்டமைப்பு
Paper chromatography	வண்ண பிரிகைதாள் வரைப்படம்
Paratonic movement	தூண்டப்படும் அசைவுகள்
Parthenocarpy	விதையிலாக் கனி
Passive transport	ஆற்றல்சாரா கடத்தல்
Pay off phase	விளை நிலை
Pendulous	தொங்குகின்ற
Pericarp	கனி உறை
Petrification	கல்லாதல்
Phosphorescence	நின்றொளிர்தல் / தாமத மறு ஒளிர்தல்

Photo chemical phase	ஒளி வேதிநிலை
Photo oxidation phase	ஒளி ஆக்ஸிஜனேற்ற நிலை
Photo respiration	ஒளி சுவாசம்
Photolysis	ஒளியின் நீராற் பகுப்பு
Photon	ஒளித்துகள்
Photoperiodic induction	ஒளிக் காலத்துவ தூண்டுதல்
Photoperiodism	ஒளிக்காலத்துவம்
Photophosphorylation	ஒளி பாஸ்பரிகரணம் / ஒளி பாஸ்பரஸ் சேர்க்கை
Photosynthetic carbon reduction cycle	ஒளிச்சேர்கையின் கார்பன் ஒடுக்க சுழற்சி
Photosynthetic unit (Quantasome)	ஒளிச்சேர்க்கை அலகு (குவாண்டோசோம்)
Photosystem	நிறமி அமைப்பு / ஒளி அமைப்பு
Pili or Fimbriae	நுண் சிலும்புகள்
Pistillode	மலட்டு சூலகம்
Plant antitranspirants	நீராவிப்போக்குத் தடுப்பான்கள்
Plasmogamy	சைட்டோபிளாச இணைவு
Plasmolysis	பிளாஸ்மா சிதைவு
Plasticity	உருமாறும் தன்மை
Plumule	முளைக்குருத்து
Plurilocular	பல்லறை சூற்பை
Polymorphism	பலபடிவுடமை
Porous woods	துளைக்கட்டை
Preparatory phase	ஆயத்த நிலை
Pressure potential	அழுத்தயியல் திறன்
Primary adapter	முதன்மை மாற்றி
Primary growth	முதல்நிலை வளர்ச்சி
Probe	ஆய்வி
Programmed cell death	திட்டமிடப்பட்ட செல் இறப்பு
Prokaryote	தொல்லுட்கரு உயிரி
Prophage	ஃபாஜ் முன்னோடி
Proton gradient	புரோட்டான் சரிவு
Pumps	உந்திகள்
Quiescent centre concept	உறக்க மையக் கொள்கை
Rachilla	சிறுகதிரின் மையஅச்சு
Radial vascular bundles	ஆரப்போக்கமைந்த வாஸ்குலக் கற்றைகள்
Radicle	முளை வேர்
Ray parenchyma	கதிர் பாரங்கைமா
Reaction Centre	வினை மையம்
Red drop	சிவப்பு வீழ்ச்சி
Redox reaction	ஆக்ஸிஜனேற்ற ஒடுக்கவினை
Reducing power	ஒடுக்கும் ஆற்றல்
Respiratory quotient	சுவாச ஈவு
Restriction site	வரையறு தளம்
Reverse osmosis	பின்னோக்கிய சவ்வூடு பரவல்
Rib meristem	வரிசை ஆக்குத்திசு
Ring Bark	வளைய பட்டை
Sap wood	சாற்றுக்கட்டை
Scale Bark	செதில் பட்டை
Seed	விதை
Seed coat	விதை உறை
Seed dormancy	விதை உறக்கம்
Semi autonomy	பாதி சுயசார்புதன்மை
Senescence	மூப்படைதல்
Serotaxonomy	ஊநீர் வகைப்பாட்டியல்
Sink	தேங்கிடம்
Slime bodies	ஸ்லைம் உடலங்கள்
Solute potential	கரைபொருள் திறன்
Source	தோற்றுவாய்
Sporophyte	வித்தகத்தாவரம்
Spring wood or early wood	வசந்தக்காலக் கட்டை அல்லது முன்பருவக் கட்டை
Stress escapers	நெருக்கடியை தப்பித்துக் கொள்ளும் தாவரங்கள்
Stress physiology	நெருக்கடி சார் வாழ்வியல்
Substrate phosphorylation	தளப்பொருள் பாஸ்பரிகணம்
Sunken stomata	உட்குழிந்த இலைத்துளை
Synaptonemal complex	சைனாப்டினிமல் தொகுதி
Systematics	முறைப்பாட்டு தாவரவியல்
Tandem repeat	ஒருசெயல நிகழும் மாறிகள்
Taxon	வகைப்பாட்டுத் தொகுதி
Telomorph	பால்நிலை
Terminal oxidation	இறுதி ஆக்ஸிஜனேற்றம்
Thallospores	உடல வித்துகள்
Thermonastic	வெப்ப தூண்டல்
Thigmotactic	தொடு உணர்வு அசைவு
Transamination	அமைனோ மாற்றம்
Transduction	மரபணு ஊடுகடத்தல்
Transformation	மரபணு மாற்றம்
True fruit	மெய்க்கனி
Tunica corpus theory	டூனிகா கார்பஸ் கொள்கை
Vernalization	தட்பப்பதனம்
Water potential	நீரியல் திறன்
Xeric Succession	வறள் தாவர படிநிலை வளர்ச்சி
Zoospore	இயங்கு வித்து
Zygospore	உறக்க கருமுட்டை

Competitive Examination Questions

Unit – 1 Diversity of Living World

1. Which of the following are found in extreme saline conditions? (NEET-2017)
   a. Archaebacteria b. Eubacteria
   c. Cyanobacteria d. Mycobacteria

2. Select the mismatch (NEET – 2017)
   a. *Frankia* *Alnus*
   b. *Rhodospirillum* ***Mycorrhiza***
   c. *Anabaena* *Nitrogen fixer*
   d. *Rhizobium* *Alfalfa*

3. Which among the following are the smallest living cells, known without a definite cell wall, pathogenic to plants as well as animals and can survive without oxygen? (NEET – 2017)
   a. *Bacillus* b. *Pseudomonas*
   c. Mycoplasma d. *Nostoc*

4. Read the following statements (A to E) and select the option with all correct statements (AIPMT – 2015)
   A. Mosses and Lichens are the first organisms to colonise a bare rock.
   B. *Selaginella* is a homosporous pteridophyte.
   C. Coralloid roots in *Cycas* have VAM.
   D. Main plant body in bryophytes is gametophytic, whereas in pteridophytes it is sporophytic.
   E. In gymnosperms, male and female gametophytes are present within sporangia located on sporophyte.
   a. B, C and E b. A, C and D
   c. B, C and D **d. A, D and E**

5. An example of colonial alga is (NEET – 2017)
   a. *Chlorella* **b. *Volvox***
   c. *Ulothrix* d. *Spirogyra*

6. Five kingdom system of classification suggested by R.H. Whittaker is not based on (AIPMT – 2014)
   a. Presence or absence of a well defined nucleus
   b. Mode of reproduction
   c. Mode of nutrition
   d. Complexity of body organisation

7. Mycorrhizae are the example of (NEET – 2017)
   a. Fungitasis c. Amensalism
   b. Antibiosis **d. Mutualism**

8. Which of the following shows coiled RNA strand and capsomeres? (AIPMT – 2014)
   a. Polio virus **b. Tobacco mosaic virus**
   c. Measles virus d. Retrovirus

9. Viroids differ from viruses in having : (NEET – 2017)
   a. DNA molecules with protein coat
   b. DNA molecules without protein coat
   c. RNA molecules with protein coat
   d. RNA molecules without protein coat

10. Select the mismatch (NEET – 2017)
    a. *Pinus* **— Dioecious**
    b. Cycas — Dioecious
    c. *Salvinia* — Heterosporous
    d. *Equisetum* — Homosporous

11. Life cycle of *Ectocarpus* and *Fucus* respectively are (NEET – 2017)
    a. Haplontic, Diplontic
    b. Diplontic, Haplodiplontic
    c. Haplodiplontic, Diplontic
    d. Haplodiplontic, Halplontic

12. Zygote meiosis is characterisitic of (NEET – 2017)
    a. *Marchantia* b. *Fucus*
    c. *Funaria* **d. *Chlamydomonas***

13. Which of the following is correctly matched for the product produced by them? (NEET – 2017)
    a. *Acetobacter acetic* : Antibiotics
    b. *Methanobacterium* : Lactic acid
    c. *Penicillium notatum* : Acetic acid
    d. *Saccharomyces cerevisiae* : Ethanol

14. Which of the following components provides sticky character to the bacterial cell? (NEET – 2017)
    a. Cell wall b. Nuclear membrane
    c. Plasma membrane **d. Glycocalyx**

15. Which of the following statements is wrong for viroids? (NEET – 2016)
    a. They lack a protein coat
    b. They are smaller than viruses
    c. They causes infections
    d. Their RNA is a high molecular weight

16. In bryophytes and pteridophytes, transport of male gametes require (NEET – 2016)
    a. Wind b. Insects
    c. Birds **d. Water**

17. How many organisms in the list below are autotrophs? (AIPMT Mains 2012)

Lactobacillus, Nostoc, Chara, Nitrosomonas, Nitrobacter, Streptomyces, Saccharomyces, Trypanosoma, Porphyra, Wolffia

a. Four b. Five
c. Six d. Three

18. Which of the following would appear as the pioneer organisms on bare rocks? (NEET – 2016)

a. Lichens b. Liverworts
c. Mosses d. Green algae

19. Monoecious plant of *Chara* shows occurrence of (NEET-2013)

a. Stamen and carpel on the same plant
b. Upper antheridium and lower oogonium on the same plant
c. Upper oogonium and lower antheridium on the same plant
d. Antheridiophore and archegoniophore on the same plant

20. Read the following five statement (A-E) and answer as asked next to them (AIPMT Prelims – 2012)

a. In *Equisetum*, the female gametophyte is retained on the parent sporophyte
b. In *Ginkgo*, male gametophyte is not independent
c. The sporophyte in *Riccia* is more developed than that in *Polytrichum*
d. Sexual reproduction in *Volvox* is isogamous
e. The spores of slime moulds lack cell walls

How many of the above statement are correct? (AIPMT Prelims – 2012)

a. Two b. Three
c. Four **d. One**

21 One of the major components of cell wall of most fungi is (NEET – 2016)

a. Chitin b. Peptidoglycan
c. Cellulose d. Hemicellulose

22. Which one of the following statements is wrong? (NEET – 2016)

a. Cyanobacteria are also called blue-green algae
b. Golden algae are also called desmids
c. Eubacteria are also called false bacteria
d. Phycomycetes are also called algal fungi

23. Flagellated male gametes are present in all the three of which one of the following sets? (AIPMT Prelims – 2007

a. *Riccia, Dryopteris* and *Cycas*
b. *Anthoceros, Funaria* and *Spirogyra*
c. *Zygnema, Saprolegnia* and *Hydrilla*
d. *Fucus, Marsilea* and *Calotropis*

24. Ectophloic siphonostele is found in (AIPMT Prelims – 2005)

a. *Adiantum* and Cucurbitaceae
b. *Osmunda* and *Equisetum*
c. *Marsilea* and *Botrychium*
d. *Dicksonia* and maiden hair fern

25. Which part of the tobacco plant is infected by *Meloidogyne incognita*? (NEET – 2016)

a. Flower b. Leaf c. Stem **d. Root**

26. Select the correct statement (NEET – 2016)

a. Gymnosperms are both homosporous and heterosporous
b *Salvinia, Ginkgo* and *Pinus* all are gymnosperms
c. *Sequoia* is one of the tallest trees
d. The leaves of gymnosperms are not well adapted to extremes of climate

27. Seed formation without fertilization in flowering plants involves the process of (NEET – 2016)

a. Sporulation b. Budding
c. Somatic hybridization **d. Apomixis**

28. Chrysophytes, Euglenoids, Dinoflagellates and Slime moulds are included in the kingdom (NEET – 2016)

a. Animalia **b, Monera** c. Protista d. Fungi

29. The primitive prokaryotes responsible for the production of biogas from the dung of ruminant animals, include the (NEET – 2016)

a. Halophiles b. Thermoacidophiles
c. Methanogens d. Eubacteria

Unit – 2 Plant Morphology and Taxonomy of Angiosperm

1. Leaves become modified into spines in [AIPMT-2015]

a. Silk Cotton **b. *Opuntia***
c. Pea d. Onion

2. Keel is the characteristic feature of flower of [AIPMT-2015]

a. Tomato b. Tulip
c. *Indigofera* d. *Aloe*

3. Perigynous flowers are found in [AIPMT-2015]

a. Rose b. Guava
c. Cucumber d. China rose

4. Which one of the following statements is correct [AIPMT-2014]
   a. The seed in grasses is not endospermic
   b. Mango is a parthenocarpic fruit
   c. A proteinaceous aleurone layer is present in maize grain
   d. A sterile pistil is called a staminode

5. An example of edible underground stem is [AIPMT-2014]
   a. Carrot b. Groundnut
   c. Sweet potato **d. Potato**

6. Placenta and pericarp are both edible portions in [AIPMT-2014]
   a. Apple b. Banana **c. Tomato** d. Potato

7. When the margins of sepals or petals overlap one another without any particular direction, the condition is termed as [AIPMT-2014]
   a. Vexillary **b. Imbricate** c. Twisted d. Valvate

8. An aggregate fruit is one which develops from [AIPMT-2014]
   a. Multicarpellary syncarpous gynoecium
   b. Multicarpellary apocarpous gynoecium
   c. Complete inflorescence
   d. Multicarpellary superior ovary

9. Non-albuminous seed is produced in [AIPMT-2014]
   a. Maize b. Castor c. Wheat **d. Pea**

10. Seed coat is not thin, membranous in [NEET-2013]
    a. Coconut b. Groundnut c. Gram d. Maize

11. In china rose the flower are [NEET-2013]
    a. Actinomorphic. Epigynous with valvate aestivation
    b. Zygomorphic, hypogynous with imbricate aestivation
    c. Zygomorphic, epigynous with twisted aestivation
    d. Actinomorphic, hypogynous with twisted aestivation

12. Placentation in tomato and lemon is [AIPMT Prelims-2012]
    a. Marginal **b. Axile**
    c. Parietal d. Free central

13. Vexillary aestivation is characteristic of the family [AIPMT Prelims-2012]
    a. Solanaceae b. Brassicaceae
    c. Fabaceae d. Asteraceae

14. Phyllode is present in [AIPMT Prelims-2012]
    a. Australian Acacia b. *Opuntia*
    c. *Asparagus* d. *Euphorbia*

15. How many plants in the list given below have composite fruits that develop from an inflorescence? Walnut, poppy, radish, pineapple, apple, tomato. [AIPMT Prelims-2012]
    a. Two **b. Three** c. Four d. Five

16. Cymose inflorescence is present in [AIPMT Prelims-2012]
    a. *Trifolium* b. *Brassica*
    c. Solanum d. *Sesbania*

17. Which one of the following organism is correctly matched with its three characteristics? [AIPMT Mains -2012]
    a. Pea : C3 pathway, Endospermic seed, Vexillary aestivation
    b. Tomato : Twisted aestivation, Axile placentation, Berry
    c. Onion: Bulb, Imbricate aestivation, Axile placentation
    d. Maize : C3 pathway, Closed vascular bundles, scutellum

18. How many plants in the list given below have marginal placentation?

    Mustard, Gram, Tulip, *Asparagus,* Arhar, sun hemp, Chilli, *Colchicine,* Onion, Moong, Pea, Tobacco, Lupin [AIPMT Mains -2012]
    a. Four b. Five **c. Six** d. Three

19. The Eyes of the potato tuber are [AIPMT Prelims-2011]
    a. Axillary buds b. Root buds
    c. Flower buds d. Shoot buds

20. Which one of the following statements is correct? [AIPMT Prelims-2011]
    a. Flower of tulip is a modified shoot
    b. In tomato, fruit is a capsule
    c. Seeds of orchids have oil – rich endosperm
    d. Placentation in primrose is basal

21. A drup develops in [AIPMT Prelims-2011]
    a. Tomato **b. Mango** c. Wheat d. Pea

Unit 3 Cell biology and Biomolecules

1. Who invented electron microscope? (2010 AIIMS, 2008 JIPMER)
   a. Janssen b. Edison
   c. Knoll and Ruska d. Landsteiner

2. Specific proteins responsible for the flow of materials and information into the cell are called (2009 AIIMS)
   a. Membrane receptors
   b. carrier proteins
   c. integeral proteins
   d. none of these

3. Omnis-cellula-e-cellula was given by (2007 AIIMS)

a. Virchow b. Hooke

c. Leeuwenhoek d. Robert Brown

4. Which of the following is responsible for the mechanical support, protein synthesis and enzyme transport (2007 AIIMS)

a. cell membrane

b. mitochondria

c. dictyosomes

d. endoplasmic reticulum

5. Genes present in the cytoplasm of eukaryotic cells are found in (2006 AIIMS)

a. mitochondria and inherited via egg cytoplasm

b. lysosomes and peroxisomes

c. Golgi bodies and smooth endoplasmic reticulum

d. Plastids inherited via male gametes

6. In which one the following would you expect to find glyoxysomes(2005 AIIMS)

a. Endosperm of wheat

b. endosperm of castor

c. Palisade cells in leaf

d. Root hairs

7. A quantosome is present in (JIPMER 2012)

a. Mitochondria **b. Chloroplast**

c. Golgi bodies d. ER

8. In mitochondria the enzyme cytochrome oxidase is present in (2012 JIPMER)

a. Outer mitochondrial membrane

b. inner mitochondrial membrane

c. Stroma d. Grana

9. Which organelle is present in higher number in secretory cell (2008 JIPMER)

a. Mitochondria b. Chloroplast

c. Nucleus **d. Dictyosomes**

10. Major site for the synthesis of lipids (2013 NEET)

a. Rough ER **b. smooth ER**

c. Centriole d. Lysosome

11. Golgi complex plays a major role in. (2013 NEET)

a. post translational modification of proteins and glycosidation of lipids

b. translation of proteins

c. Transcription of proteins

d. Synthesis of lipid

12. Main arena of various types of activities of a cell is (2010 AIPMT)

a. Nucleus b. Mitochondria

c. Cytoplasm d. Chloroplast

13. The thylakoids in chloroplast are arranged in (2005 JIPMER)

a. regular rings b. linear array

c. diagonal direction **d. stacked discs**

14. Sequences of which of the following is used to know the phylogeny (2002 JIPMER)

a. mRNA **b. rRNA** c. tRNA d. Hn RNA

15. Structures between two adjacent cells which is an effective transport pathway- (2010 AIPMT)

a. Plasmodesmata

b. Middle lamella

c. Secondary wall layer

d. Primary wall layer

16. In active transport carrier proteins are used, which use energy in the form of ATP to

a. transport molecules against concentration gradient of cell wall

b. transport molecules along concentration gradient of cell membrane

c. transport molecules against concentration gradient of cell membrane

d. transport molecules along concentration gradient of cell wall

17. The main organelle involved in modification and routing of newly synthesised protein to their destinations is (AIPMT 2005)

a. Mitochondria b. Glyoxysomes

c. Spherosomes **d. Endoplasmic reticulum**

18. Algae have cell wall made up of (AIPMT 2010)

a. Cellulose, galactans and mannans

b. Cellulose, chitin and glucan

c. Cellulose, Mannan and peptidoglycan

d. Muramic acid and galactans

Unit -4 – Plant Anatomy

1. The balloon – shaped structures called tyloses (NEET II – 2016)

a. originate in the lumen of vessels

b. characterise the sap wood

c. are extensions of xylem parenchyma cells into vessels

d. are linked to the ascent of sap through xylem vessels

2. Cortex is the region found between (NEET II – 2016)
   a. epidermis and stele
   b. pericycle and endodermis
   c. endodermis and pith
   d. endodermis and vascular bundle

3. Read I – IV and find the correct order of components from outer side to inner side in a woody dicot stem (CBSE -AIPMT – 2015)
   (I) secondary Cortex (II) wood
   (III) secondary phloem (IV) phellem
   a. III, IV, II and I b. I, II, IV and III
   c. IV, I, III and II d. IV, III, I and II

4. You are given a fairly old piece of a dicot stem and a dicot root. Which of the following anatomical structures will you use to distinguish between the two? (CBSE -AIPMT 2014)
   a. secondary xylem
   b. secondary phloem
   c. protoxylem
   d. cortical cells

5. Heart wood differs from sapwood in (CBSE -AIPMT 2010)
   a. the presence of rays and fibres
   b. the absence of vessels and parenchyma
   c. having dead and non-conducting elements
   d. being susceptible to hosts and pathogens

6. The annular and spirally thickened conducting elements generally develop in the protoxylem when the root or stem is (CBSE -AIPMT 2009)
   a. maturing b. elongating
   c. widening d. differentiating

7. Anatomically fairly old dicotyledonous root is distinguished from the dicotyledonous stem by the (CBSE- AIPMT 2009)
   a. absence of secondary xylem
   b. absence of secondary phloem
   c. presence of cortex
   d. position of protoxylem

8. In barley stem, vascular bundles are (CBSE -AIPMT 2009)
   a. open and scattered
   b. closed and scattered
   c. open and in a ring
   d. closed and radial

9. Palisade parenchyma is absent in the leaves of (CBSE- AIPMT 2009)
   a. sorghum b. mustard
   c. soyabean d. gram

10. Sugarcane plant has (AIIMS 2009)
    a. reticulate venation
    b. capsular fruits
    c. pentamerous flowers
    d. dump-bell shaped guard cells

11. Vascular tissues in flowering plants develop from (CBSE- AIPMT 2008 & JIPMER 2012)
    a. phellogen **b. plerome**
    c. periblem d. dermatogen

12. The length of different internodes in a culm of sugarcane is variable because of (CBSE -AIPMT 2008)
    a. short apical meristem
    b. position of axillary buds
    c. size of leaf lamina at the node below each internode
    d. intercalary meristems

13. Passage cells are thin-walled cells found in (CBSE -AIPMT 2007)
    a. endodermis of roots facilitating rapid transport of water from cortex to pericycle
    b. phloem elements that serve as entry points for substances for transport to other plant parts
    c. testa of seeds to enable emergence of growing embryonic axis during seed germination
    d. central region of style through which the pollen tube grows towards the ovary

14. Which one of the following is not a lateral meristem (CBSE -AIPMT 2010)
    a. interfascicular cambium
    b. phellogen
    c. intercalary meristem
    d. intrafascicular cambium

15. A common feature of vessel elements and sieve tube elements is (CBSE- AIPMT 2007)
    a. enucleate condition
    b. presence of P. Protein
    c. thick secondary wall
    d. pores on lateral walls

16. In a longitudinal section of a root, starting from the tip upward, the four zones occur in the following order (CBSE -AIPMT 2004)
    a. root cap, cell division, cell enlargement, cell maturation
    b. root cap, cell division, cell maturation, cell enlargement
    c. cell division, cell enlargement, cell maturation, root cap

d. cell division, cell maturation, cell enlargement, root cap

17. The cells of the quiescent centre are characterized by (CBSE -AIPMT 2003)
    a. having dense cytoplasm and prominent nucleus
    b. having light cytoplasm and small nucleus
    c. dividing regularly to add to the corpus
    d. dividing regularly to add to tunica

18. P. Protein is found in (CBSE- AIPMT 2000)
    a. parenchyma b. collenchyma
    c. sieve tube d. xylem

19. Specialized epidermal cells surrounding the guard cells are called (NEET (I) 2016)
    a. bulliform cells
    b. lenticels
    c. complementary cells
    d. subsidiary cells

Directions:

The following questions 20 & 21 consist of two statements, one labelled **Assertion** and the another labelled **Reason**. Select the correct answer from the codes given below:

a) Both assertion and reason are true and reason is the correct explanation of assertion
b) Both assertion and reason are true, but reason is not the correct explanation of assertion
c) Assertion is true but reason is false
d) Assertion and reason are false

20. **Assertion:** Conducting tissues, especially xylem show greatest reduction in submerged hydrophytes.
    Reason: Hydrophytes live in water. So no need of tissues. (AIIMS – 2010) Ans: c.

21. **Assertion:** Long distance flow of photo assimilates in plants occurs through sieve tubes.
    Reason: Mature sieve tubes have partial cytoplasm and perforated sieve plates (AIIMS – 2012)
    Ans: a.

22. Duramen is present in (JIPMER 2016)
    a. the inner region of secondary wood
    b. a part of sap wood
    c. the outer region of secondary wood
    d. region of pericycle

23. The interxylary phloem is found in the stem of (JIPMER 2013)
    a. Cucurbita b. Salvia
    c. Calotropis d. none of these

24. Wound healing is due to (JIPMER 2013)
    a. ventral meristem
    b. secondary meristem
    c. primary meristem
    d. all of these

25. Which of the following tissues consists of living cells (JIPMER 2012)
    a. vessels b. tracheids
    c. companion cell d. sclerenchyma

26. The Quiescent centre in root meristem serves as a (JIPMER 2011)
    a. site for storage of food, which is utilized during maturation
    b. reservoir of growth hormones
    c. reserve for replenishment of damaged cells of the meristem
    d. region for absorption of water

27. In the sieve elements, which one of the following is the most likely function of P.Proteins? (JIPMER 2011)
    a) Deposition of callose on sieve plates
    b. Providing energy for active translocation
    c. Autolytic enzymes
    d. Sealing-off mechanism on wounding

28 .Which of the following is made up of dead cells? (NEET 2017)
    a. Xylem parenchyma b. Collenchyma
    c. Phellem d. Phloem

29. The vascular cambium normally gives rise to (NEET 2017)
    a. phelloderm b.primary phloem
    c. secondary xylem d. periderm

30. Which of the following plants shows multiple epidermis? (Manipal 2012)
    a. Croton b. Allium
    c. Nerium d. Cucurbita

Unit -5 Plant Physiology

1. The water potential of pure water is (NEET 2017)
    a. Less than zero
    b. More than zero but less than one
    c. More than one
    d. Zero

2. Transpiration and root pressure cause water to rise in plants by (NEET 2015)
    a. pulling it upward
    b. pulling and pushing it, respectively

c. pushing it upward

d. pushing and pulling it, respectively

3. Movement of ions or molecules in a direction opposite to that of prevailing electro-chemical gradient is known as (C.B.S.E. 2000)

a. Active transport

b. Pinocytosis

c. Brownian movement

d. Diffusion

4. Correct sequence of events in wilting? (P.M.T. Kerala 2001)

a. Exosmosis-deplasmolysis-temporary and permanent wilting

b. Exosmosis-plasmolysis-temporary and permanent wilting

c. Endosmosis-plasmolysis-temporary and permanent wilting

d. Endosmosis-deplasmolysis - temporary and permanent wilting

e. Exosmosis-deplasmolysis-plasmolysis - temporary and permanent wilting

5. What will be the direction of net osmotic movement of water if a solution 'A', enclosed in a semi permeable membrane, having an osmotic potential of'- 30' bars and turgor pressure of '5' bars is submerged in a solution 'B' with an osmotic potential of '- 10' bars and '0' turgor pressure ? (C.E.T. Karnataka 2002)

a. Equal movement in both directions

b. 'B' to 'A'

c. No movement

d. 'A' to 'B'

6. The pressure exerted by a swollen vacuole on the cell wall is (C.M.C. Vellore 2002)

a. OP b. WP

c. TP d. DPD

7. Who said that 'transpiration is a necessary evil'? (JIPMER-2006)

a. Curtis b. Steward

c. Anderson d. J.C.Bose

8. Which one gives the most valid and recent explanation for stomatal movements? (NEET 2015)

a. Transpiration

b. Potassium influx and efflux

c. Starch hydrolysis

d. Guard cell photosynthesis

9. Carrier proteins are involved in (PMT-UP-1998)

a. Active transport of ions

b. Passive transport of ions

c. Water transport

d. Water evaporation

10. Active transport of ions in the cell requires (PMT MP 2002)

a. High temperature **b. ATP**

c. Alkaline pH d. Salts

11. Guttated liquid is (AFMC 2002)

a. Pure water

b. Water plus minerals

c. Water plus enzymes

d. All of these

12. Stomata of a plant open due to (CBSE 2003)

a. Influx of potassium ions

b. Efflux of potassium ions

c. Influx of hydrogen ions

d. Influx of calcium ions

13. Potometer works on the principle of (CBSE 2000)

a. Osmotic pressure

b. Amount of water absorbed equals the amount transpired

c. Potential difference between the tip of the tube and then of the plant

d. Root pressure

14. Most suitable theory for ascent of sap is (CBSE 1991, CPMT-UP 1995)

a. Transpirational pull and cohesion theory of Dixon and Jolly

b. Pulsation theory of J.C. Bose

c. Relay pump theory of Godlewski

d. None of these

15. If a cell kept in a solution of unknown concentration gets deplasmolysed, the solution is, (CPMT-UP 1996)

a. Detonic **b. Hypertonic**

c. Isotonic d. Hypotonic

16. Which is essential for the growth of root tip ? (NEET PHASE II 2016)

a. Zn b. Fe

c. Ca d. Mn

17. On the basis of symptoms of chlorosis in leaves, a student inferred that this was due to deficiency of nitrogen. The inference could be correct only if we assume that yellowing of leaves appeared first in (AIIMS 2007)

a. old leaves b. young leaves

c. young leaves followed by mature leaves

d. mature leaves followed by young leaves.

18. Cytochrome oxidase contains (UP CPMT 2006)

a. Iron b. Magnesium

c. Zinc **d. Copper**

19. Which is correct to saprophytic angiosperms? (UP CPMT 2006)

a. They secrete enzyme outside the body and absorb

b. They have mycorrhizae fungi

c. They take food and then digest it

d. They are photosynthetic

20. The ability of the venus fly trap to capture insects is due to (JIPMER 2008)

a. chemical stimulation by the prey

b. a passive process requiring no special ability on the part of the plant.

c. Specialized muscle like cells

d. rapid turgor pressure changes

21. Boron in green plants assists in (RPMT 2007)

a. photosynthesis

b. Sugar transport

c. activation of enzyme

d. acting as enzyme cofactor

22. Which of the following elements is very essential for the uptake of Ca2+ and membrane function? (Kerala CEE 2007)

a. phosphorus b. molybdenum

c. manganese **d. boron**

23. Sulphur is not a constituent of (AMU 2011)

a. cysteine b. methionine

c. ferredoxin **d. pyridoxine**

24. Deficiency symptoms of nitrogen and potassium are visible first in _____ (AIPMT 2014)

a. senescent leaves b. young leaves

c. roots d. buds

25. The first stable product of fixation of atmospheric nitrogen in leguminous plants is _____ (AIPMT 2013)

a. NO^{-3} b. glutamate

c. NO^{-2} **d. ammonia**

26. C4 plants are more efficient in photosynthesis than C3 plants due to (AIPMT 2010)

a. presence of thin cuticle

b. lower rate of photorespiration

c. higher leaf area

d. presence of larger number of chloroplast in the leaf cells.

27. Chlorophyll b is (JIPMER 1980)

a. $C_{54}H_{70}O_6N_4Mg$

b. $C_{55}H_{70}O_6N_4Mg$

c. $C_{55}H_{72}O_5N_4Mg$

d. $C_{45}H_{72}O_5N_4Mg$

28. Synthesis of ADP + Pi → ATP in grana is (AIIMS 1993)

a. phosphorylation

b. photophosphorylation

c. oxidative phosphorylation

d. photolysis

29. In chloroplast, chlorophyll is present in the (AIPMT 2004)

a. stroma b. outer membrane

c. inner membrane **d. thylakoids**

30. Electrons from the excited chlorophyll molecule of photosystem II are accepted first by (AIPMT 2008)

a. quinone b. ferredoxin

c. cytochrome-b d. cytochrome-f

31. Read the following four statements A,B,C and D. Select the right option (AIPMT 2010)

A. Z scheme of light reaction takes place in the presence of PS I only

B. only PS I is functional in cyclic photophosphorylation

C. cyclic photophosphorylation results into synthesis of ATP and NADPH2

D. stroma lamellae lack PS II as well as NADP

a. A and B b. B and C

c. C and D **d. B and D**

32. Photolysis of each water molecule in light reaction will yield ___ (Kerala CEE 2007)

a. 2 electrons and 4 protons

b. 4 electrons and 4 protons

c. 4 electrons and 3 protons

d. 2 electrons and 2 protons

33. Photosynthetic active radiation (PAR) has the following range of wavelength (AIPMT 2005)

a. 400-700 nm b. 450-920 nm

c. 340-450 nm d. 500-600 nm

34. Phosphoenol pyruvate (PEP) is the primary CO_2 acceptor in __ (NEET 2017)

a. C_3 plants **b. C_4 plants**

c. C_2 plants d. C_3 and C_4 plants

35. With reference to factors affecting the rate of photosynthesis, which of the following statements is not correct? (NEET 2017)

a light saturation for CO_2 fixation occurs at 10 % of full sunlight

b. increasing atmospheric CO_2 concentration up to 0.05% can enhance CO_2 fixation rate

c. C_3 plants respond to higher temperature with enhanced photosynthesis while C_4 plants have much lower temperature optimum.

d. tomato is a greenhouse crop which can be grown in CO_2 enriched atmosphere for higher yield

36. A plant in your garden avoids photorespiratory losses, has improved water use efficiency, shows high rates of photosynthesis at high temperatures and has improved efficiency of nitrogen utilization. In which of the following physiological groups would you assign this plant? (NEET PHASE I 2016)

a. C_4 b. CAM

c. Nitrogen fixer d. C_3

37. Emerson's enhancement effect and Red drop have been instrumental in the discovery of (NEET PHASE I 2016)

a. two photosystems operating simultaneously

b. photophosphorylation and cyclic electron transport

c. oxidative phosphorylation

d. photophosphorylation and non-cyclic electron transport

38. The process which makes major difference between C_3 and C_4 plants is (NEET PHASE II 2016)

a. glycolysis b. calvin cycle

c. photorespiration d. respiration

39. In a chloroplast the highest number of protons are found in (NEET PHASE I 2016)

a. lumen of thylakoids

b. inter membrane space

c. antennae complex

d. stroma

40. Oxidative phosphorylation is (NEET 2016)

a. formation of ATP by transfer of phosphate group from a substrate to ADP

b. oxidation of phosphate group in ATP

c. Aaddition of phosphate group to ATP

d. formation of ATP by energy released from electrons during substrate oxidation.

41. Which of the biomolecules is common to respiration-mediated breakdown of fats, carbohydrates and proteins? (NEET 2013, 2016)

a. glucose-6-phosphate

b. fructose1,6-bisphosphate

c. pyruvic acid

d. acetyl CoA

42 Which statement is wrong for Krebs cycle? (NEET 2017)

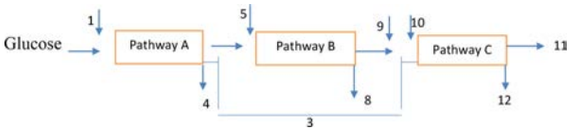
a. there is one point in the cycle where FAD is reduced to $FADH_2$

b. during conversion of succinyl CoA to succinic acid, a molecule of GTP is synthesised.

c. the cycle starts with condensation of acetyl group a.cetyl CoA. with pyruvic acid to yield citric acid

d. there are three points in the cycle where NAD^+ is reduced to $NADH+H^+$

43. The three boxes in this diagram represents the three major biosynthetic pathways in aerobic respiration and arrows represent net reacts or products. (NEET 2013)



Arrows numbered 4, 8 and 12 can be

a. ATP b. H_2O

c. FAD or $FADH_2$ d. NADH

44. The energy released metabolic process in which substrate is oxidised without an external electron acceptor is called (AIPMT 2010)

a. glycolysis **b. fermentation**

c. aerobic respiration d. photorespiration

45. Krebs cycle starts with the formation of six carbon compound by a reaction between (CPMT 1980)

a. malic acid and acetyl coenzyme

b. oxaloacetic acid and acetyl coenzyme

c. succinic acid and pyruvic acid

d. fumaric acid and pyruvic acid

46. Respiration is a process in which (CPMT 1980)

a. energy is used up

b. energy is stored in the form of ADP

c. energy is released and stored in the form of ATP

d. energy is not released at all

47. The common phase between aerobic and anaerobic respiration is called (CPMT 1984)

a. glycolysis

b. krebs cycle

c. tricarboxylic acid cycle

d. oxidative phosphorylation

48. ATP synthesis occurs on/in the (AIIMS 1984)

a. matrix

b. outer membrane of mitochondrion

c. innermembrane of mitochondrion

d. none of the above

49. Which 5-carbon organic acid of the Krebs cycle is a key compound in the N2 metabolism of a cell (AIIMS 1989)

a. citric acid

b. fumaric acid

c. oxalosuccinic acid

d. α-Ketoglutaric acid

50. Which one of the following acts as a hormone involved in ripening of fruits (CBSE PMT 2000)

a. naphthalene acetic acid

b. ethylene

c. indole acetic acid

d. zeatin

51. Coconut milk factor is (PMT 2003)

a. auxin b. gibberellin

c. abscisic acid **d. cytokinin**

52. Banana is seedless because (JIPMER 2004)

a. it produces asexually

b. auxin is sprayed

c. both A and B

d. none of the above

53. Pruning of plants promotes branching due to sensation of axillary buds by (AIIMS 2004)

a. Ethylene b. Gibberellin

c. IAA d. Cytokinin

54 Avena curvature test is bioassay for activity of (AIIMS 2006) (NEET 2016)

a. Auxin b. Ethylene

c. Cytokinin d. Gibberellin

55. One of the synthetic auxin is (AIPMT 2009)

a. IBA **b. NAA**

c. IAA d. GA

56 Which one of the following acids is derivative of carotenoids (AIPMT 2009)

a. Abscisic acid

b. Indole butyric acid

c. Indole – 3 acetic

d. Gibberellic acid

57. Photoperiodism was first characterized in (AIPMT 2010)

a. Cotton **b. Tobacco**

c. Potato d. Tomato

58. One of the commonly used plant growth hormone in tea plantations is (AIPMT 2010)

a. Abscisic acid b. Zeatin

c. Indole – 3 – acetic acid

d. Ethylene

59. Root development is promoted by (AIPMT 2010)

a. Auxin b. Gibberellin

c. Ethylene d. Abscisic acid

60. Senscence as an active developmental cellular process in the growth and functioning of a flowering plant is indicated in (AIPMT 2008)

a. Annual plants

b. Floral plants

c. Vessels and Tracheid differentiation

d. Leaf abscission

61. You are given a tissue with its potential for differentiation in an artificial culture. Which of the following pairs of hormones would you add to the medium to secure shoots as well as roots? (NEET 2016)

a. Gibberellin and abscissic acid

b. IAA and gibberellins

c. Auxin and cytokinin

d. Auxin and abscisic acid

62. Phytochrome is a (NEET 2016)

a. Chromo protein

b. Flavo protein

c. Glyco protein

d. Lipo protein

63. Typical growth curve in plants is (NEET 2016)

a. Linear

b. Stair – steps shaped

c. Parabolic

d. Sigmoid

Biology - Botany - Class XI
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