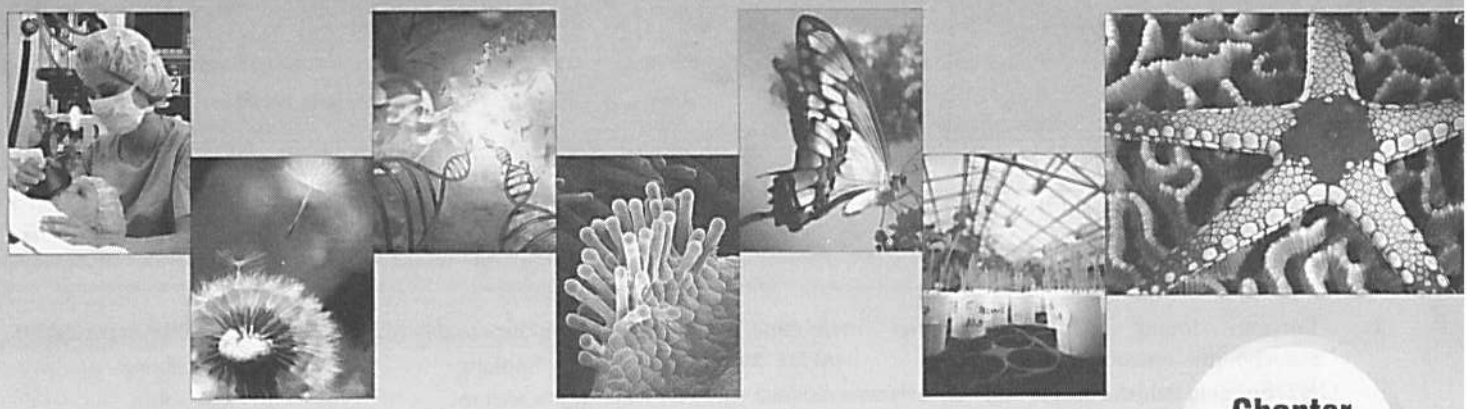


Chapter

4.5

Plant Growth and Development

Growth can be defined as a vital process which brings about irreversible permanent change in any plant or its part with respect to its size, form, weight and volume.

Regions of growth : In unicellular plants there is overall growth and not confined to any specific region but in multicellular plants growth is restricted to specific regions having meristematic cells. On the basis of their position in the plant body (higher plants) meristems are divided into three main categories.

(1) **Apical meristems :** These meristems are found at shoot and root apex. As a result of activity of these meristems plant increases in length. In angiosperms and gymnosperms there is a group of meristematic cells but in bryophytes and pteridophytes there is a single tetrahedral cell found at the shoot apex.

(2) **Intercalary meristems :** These meristems are found above the nodes. As a result of the activity of these meristems increase in length takes place. *e.g.*, *Bambusa*.

(3) **Lateral meristems. :** These meristems are made up of cells which divide in radial direction only. They form laterally placed new cells towards the centre and periphery. Cork cambium (phellogen) and vascular cambium are the examples of lateral meristems. Increase in girth of shoots and roots take place because of the activity of this cambium.

Phases of growth

(1) **Cell division (Formative phase) :** Growth is based on mitotic cell division.

(2) **Cell enlargement :** Cell division is followed by cell enlargement. The cell increases in size due to vacuolation (by absorption of water). The cell enlargement has been explained in two different ways. According to the first view, the turgor of the cell is responsible for cell enlargement. The other view considers that as a result of growth of the cell wall the volume of the cell increases.

(3) **Cell maturation (Differentiation) :** Cell differentiation followed by cell division and cell enlargement leads to the development of specialized mature tissue cell. *e.g.*, xylem tracheids and trachea, sieve tubes and companion cells.

Growth curve : The rate of growth varies in different species and different organs. The young leaf sheath of banana grows for a time at the rate of almost three inches per hour. Growth begins slowly, then enters a period of rapid enlargement, following which it gradually decreases till no further enlargement occurs. The mathematical curve which represents this variation in growth rate is some what flattened S-shaped curve or sigmoid curve. Time in which growth takes place has been called grand period of growth. This term was coined by Sachs. The analysis of growth curve shows that it can be differentiated into three phases :

(1) **Lag phase :** The rate of growth is very slow in lag phase. More time is needed for little growth in this phase.

(2) **Log phase (Exponential phase) :** The growth rate becomes maximum and more rapid. Physiological activities of cells are at their maximum. The log phase is also referred to as grand period of growth.

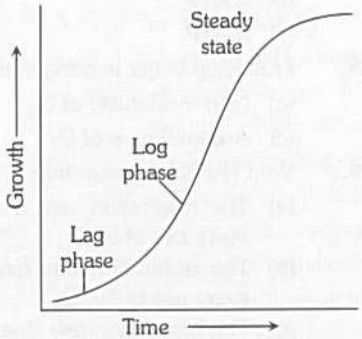


Fig : 4.5-1 A typical S-shaped grand period of growth curve

(3) **Final steady state (Stationary phase) or Adult phase :** When the nutrients become limiting, growth slows down, so physiological activities of cells also slows down. This phase indicates maturity of growth system. The rate of growth can be measured by an increase in size or area of an organ of plant like leaf, flower, fruit etc. The rate of growth is called efficiency index.

In many plants another phase is also evident in their growth curve. This is called linear phase or phase of maximum growth rate. Sachs called it as grand phase.

Measurement of growth

The following methods are designed to measure growth in length :

(1) **Direct method :** Measurement is done between two marked points by a scale at regular intervals.

(2) **Horizontal microscope (Travelling microscope)**

(3) **Auxanometer :** Several kinds of auxanometers have been devised to measure the growth in length of a plant. Two of them are :

(i) **Arch auxanometer**

(ii) **Pfeffer's auxanometer (Automatic auxanometer)**

(4) **Bose's crescograph :** The crescograph invented by Sir Jagdish Chandra Bose is a more delicate instrument and gives magnification upto 10,000 times. The rate of growth of root can be measured by the use of a root auxanometer.

Factors influencing rate of growth : Growth is affected by the factors which affect the activity of protoplasm. It is affected by a large number of factors both environmental and physiological. Physiological factors such as absorption of water, minerals, photosynthesis, respiration etc, and environmental factors including climatic and edaphic both. The effect on these factors on one region of plant are also transmitted to other region of the plant.

Since growth is a resultant of many metabolic processes, it is affected by many external and internal factors, which are as follows :

External factors

(1) **Light :** Light affects variously *e.g.*, light intensity, quality and periodicity.

(i) **Intensity of light :** In general, light retards growth in plants. High light intensities induce dwarfing of the plant. Plants at hill tops are short whereas those of a valley are quite tall. Very weak light induces the rate of overall growth and also photosynthesis. Development of chlorophyll is dependent on light and in its absence etiolin compounds are formed which gives yellow colour to the plant. The phenomenon is called etiolation. Similarly high light intensity affects indirectly and increases the rate of water loss and reduces the rate of water growth.

(ii) **Quality of light :** The different colours (different wavelengths) affect the growth of plant. In blue-violet colour light internodal growth is pronounced while green colour light reduces the expansion of leaves as compared to complete spectrum of visible light. The red colour light favours elongation but they resemble etiolated plants. Infrared and ultraviolet are detrimental to growth. However, ultraviolet rays are necessary for the development of anthocyanin pigments in the flowers. Blue and violet colour increases size of lamina of leaf.

(iii) **Duration of light :** There is remarkable effect on duration of light on the growth of vegetative as well as reproductive structures. The induction and suppresion of flowering are dependent on duration. The phenomenon is termed photoperiodism.

(2) **Temperature :** Temperature has pronounced effect on the growth of plant. The temperature cardinals for growth vary according to temperature zones. The minimum, optimum and maximum temperatures are usually 5°C (arctic), 20 – 30°C (temperate) and 35 – 40°C (tropical). The optimum temperature needed for the growth of a plant is much dependent on the stages of development.

(3) **Water :** As water is an essential constituent of the living cell, a deficiency of water causes stunted growth.

(4) **Oxygen :** In poorly aerated soil there is low concentration of oxygen and a high concentration of CO_2. Under such conditions plants usually show stunted growth. Normal growth of most plants occurs only when abundant oxygen is present since O_2 is important for respiration. It has been reported that oxygen plays some important role during G_1 stage of cell division.

(5) **Mineral salt :** Absence of essential mineral salts results in abnormal growth. For example, the absence of nitrogen prevents protein-synthesis, while the absence of iron prevents chlorophyll formation and thus leads to pale and sickly growth of plants, known as chlorotic condition.

(6) **Pollutants :** Several pollutants such as automobile exhaust, peroxyacetyl nitrate (PAN), pesticides etc have detrimental effect on plant growth. Citrus and Gladiolus are very sensitive to fluorides. Poor growth of tobacco is observed in regions where ozone concentration is high. White pine cannot survive under high O_3 concentration. Cotton plants are similarly very sensitive to ethylene.

(7) **Carbon dioxide :** CO_2 is essential for photosynthesis and hence nutrition. Due to change in photosynthetic rate, with the increase or decrease in CO_2 concentration, the plant growth is also affected.

Internal factors

(1) **Nutrition :** It provides raw material for growth and differentiation as well as source of energy. C/N (Carbohydrate/Nitrogen) ratio determines the type of growth. High C/N ratio stimulates wall thickening. Less protoplasm is formed. Low C/N ratio favours more protoplasm producing thin walled soft cells. According to law of mass growth, the initial rate of growth depends upon the size of germinating structure (seed, tubes, rhizome, bulb, etc.)

(2) **Growth regulators :** These are manufactured by living protoplasm and are important internal growth regulators which are essential for growth and development. These growth regulators include several phytohormones and some synthetic substances.

Differentiation, Dedifferentiation and Redifferentiation

The cells derived from root apical and shoot-apical meristems and cambium differentiate and mature to perform specific functions. This act leading to maturation is termed as **differentiation.** During differentiation, cells undergo few to major structural changes both in their cell walls and protoplasm. For example, to form a tracheary element, the cells would lose their protoplasm. They also develops a very strong, elastic, lignocellulosic secondary cell walls, to carry water to long distances even under extreme tension.

Plants show another interesting phenomenon. The living differentiated cells, that by now have lost the capacity to divide can regain the capacity of division under certain conditions. This phenomenon is termed as **dedifferentiation.** For example, formation of meristems – interfascicular cambium and cork cambium from fully differentiated parenchyma cells. While doing so, such meristems/tissues are able to divide and produce cells that once again lose the capacity to divide but mature to perform specific functions, i.e., get **redifferentiated.**

Growth hormones and Growth regulators

The term hormone was first used by Starling (1906). He called it stimulatory substance. The growth and development in plants is controlled by a special class of chemical substances called hormones. They are needed in small quantities at very low concentrations as compared to enzyme. They are rarely effective at the site of their synthesis.

Thus, growth hormones are also called phytohormones term given by Thimann (1948), it can be defined as 'the 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'. A group of plant hormones including auxins, gibberellins, cytokinins, ethylene and abscisic acid are presently known to regulate growth.

Auxins : Auxins (Gk. *auxein* = to grow) are weakly acidic growth hormones having an unsaturated ring structure and capable of promoting cell elongation, especially of shoots (more pronounced in decapitated shoots and shoot segments) at a concentration of less than 100 *ppm* which is inhibitory to the roots. Among the growth regulators, auxins were the first to be discovered.

Discovery : Julius Von Sachs was the first to indicate the presence of organ forming substances in plants. The existence of first plant growth hormone came from the work of Darwin and Darwin (1881). Darwin described the effects of light and gravity in his book, "Power of movements in plants". Darwin and his son found that bending movement of coleoptile of Canary grass (*Phalasis canariensis*) was due to exposure of tip to unilateral light. Boysen-Jensen (1910; 1913) found that the tip produces a chemical which was later named auxin. Paal (1914, 1919) removed coleoptile tip and replaced it asymmetrically to find a curvature. Auxin was first collected by Went (1928) from coleoptile tip of *Avena*. Went also developed *Avena* curvature test for bioassay of auxin.

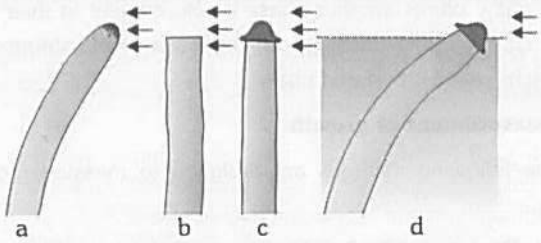
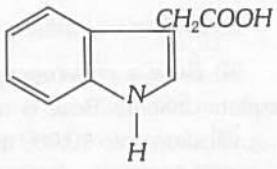


Fig : 4.5-2 Experiment used to demonstrate that tip of the coleoptile is the source of auxin. Arrows indicate direction of light

Types of auxins : There are two major categories of auxins natural auxins and synthetic auxins.

(1) **Natural auxins :** These are naturally occurring auxins in plants and therefore, regarded as phytohormones. Indole 3-acetic acid (IAA) is the best known and universal auxin. It is found in all plants and fungi.



Indole acetic acid (IAA)

The first naturally occurring auxin was isolated by Kogl and Haagen-Smith (1931) from human urine. It was identified as auxin-a (auxenotriolic acid, $C_{18}H_{32}O_5$). Later, in 1934 Kogl, Haagen-Smith and Erxleben obtained another auxin, called auxin-b (auxenolonic acid, $C_{18}H_{30}O_4$) from corn germ oil (extracted from germinating corn seeds), and heteroauxin from human urine. Heteroauxin ($C_{10}H_9O_2N$) also known as indole-3-acetic acid (IAA), is the best known natural auxin. Besides IAA, indole-3-acetaldehyde, indole-3-pyruvic acid, indole ethanol, 4-chloro-idole acetic acid (4-chloro-IAA) etc., are some other natural auxins.

Natural auxins are synthesized (Young) in physiologically active parts of plants such as shoot apices, leaf primordia and developing seeds, buds (apex), embryos, from amino acid tryptophan. In root apices, they are synthesized in relatively very small amount. Auxins show polar movement. It is basipetal (from apex to base) in stem but acropetal (from root tip towards shoot) in the root. Auxins move slowly by diffusion from cell to cell and not through the vascular tissues. Auxins help in the elongation of both roots and shoots. However, the optimum concentration for the two is quite different.

It is 10 *ppm* for stem and 0.0001 *ppm* for the root. Higher concentration of auxins show inhibitory effect on growth.

(2) **Synthetic auxins :** These are synthetic compounds which cause various physiological responses common to IAA. Some of the important synthetic auxins are 2, 4-D (2, 4-dichlorophenoxy acetic acid) is a weedicide, 2, 4, 5-T (2, 4, 5-trichlorophenoxy acetic acid), IBA (indole 3-butyric acid), NAA (naphthalene acetic acid, PAA (Phenyl acetic acid), IPA (Indole 3-propionic acid). IBA is both natural and synthetic auxin. Certain compounds inhibit action of auxin and compete with auxins for active sites and are called antiauxins. *e.g.*, PCIB (p- chlorophenoxy isobutyric acid), TIBA (2, 3, 5-tri iodobenzoic acid). TIBA is used in picking cotton balls.

Bioassay of Auxins : Testing of biological activity (growth) of a substance (auxin) by employing living material is called bioassay.

(1) **Avena coleoptile curvature test :** *Avena* curvature test carried out by F.W. Went (1928) demonstrated the effect of auxins on plant growth by performing some experiments with the oat (*Avena sativa*) coleoptile.

(2) **Split pea stem curvature test :** This test was also discovered by Went, 1934.

(3) **Root growth inhibition test (Cress root inhibition test)**

Functions of auxins : Auxins control several kinds of plant growth processes. These are as follows :

(1) **Cell elongation :** Auxins promote elongations and growth of stems and roots and enlargement of many fruits by stimulating elongation of cells in all directions.

The auxins cause cell enlargement by solubilisation of carbohydrates, loosening of microfibrils, synthesis of more wall materials, increased membrane permeability and respiration.

(2) **Apical dominance :** In many plants, the apical bud grows and the lower axillary buds are suppressed. Removal of apical bud results in the growth of lower buds. The auxin (IAA) of the terminal bud inhibits the growth of lateral buds. This phenomenon is known as apical dominance.

This property of auxins has found use in agriculture. Sprouting of lateral buds (eyes) of the potato tuber is checked by applying synthetic auxin (NAA).

Moving on a grass lawn facilitates better maintenance primarily owing to removal of apical dominance.

(3) **Control of abscission layer :** Auxin inhibits abscission of leaves and fruits. Abscission layer is produced when the auxin content falls below a minimum.

Premature drop of fruits such as apple, pear and citrus can be prevented to a great extent by spraying the trees with a dilute solution of IAA, NAA or some other auxin.

(4) **Weed control :** By the spray of 2, 4-D, broad-leaved weeds can be destroyed but 2, 4-D does not affect mature monocotyledonous plants.

(5) **Root differentiation :** Many new plants are usually propagated by stem cutting *e.g.*, Rose, *Bougainvillea*. If we dip the lower cut end of a cutting in dilute solution of auxins (specially IBA gives very good results) very soon large number of roots are developed on the cut ends due to which these cuttings develop into successful plants.

(6) **Parthenocarpy :** Parthenocarpy can be induced by application of IAA in a paste form to the stigma of a flower or by spraying the flowers with a dilute solution of IAA. Banana, oranges and grapes are now-a-days grown parthenocarpically on commercial scale. Auxins are applied in lanolin paste on stigma for inducing parthenocarpy.

(7) **Control of lodging :** In some plants when the crop is ripe and there is heavy rain accompanied by strong winds, the plants bend as a result of which the ear (inflorescence) gets submerged in water and decays. If a dilute solution of any auxin is sprayed upon young plants the possibility of bending of plants is reduced as the stem becomes stronger by the application of auxins.

(8) **Flowering :** In pineapple, NAA promotes flowering. In lettuce, auxins help in delaying the flowering. In cotton plants, the use of auxins increases the cotton seeds production.

(9) **Differentiation of vascular tissues :** Auxins induce the differentiation of xylem and phloem in intact plants and also in callus produced *in vitro* during tissue culture experiments.

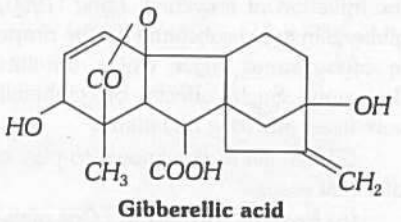
(10) **Sex expression :** The spray of auxins increases the number of female flowers in cucurbits. In maize, application of NAA during the period of inflorescence differentiation can induce formation of hermaphrodite or female flowers in a male inflorescence. Thus auxins cause femaleness in plants.

(11) **Healing :** Healing of injury is effected through auxin induced division in the cells around the injured area. The chemical was formerly named traumatic acid or traumatin.

(12) **Nodule formation :** In legumes, IAA is known to stimulate nodule formation.

(13) **Respiration :** According to French and Beevers (1953) the auxin may increase the rate of respiration indirectly through increased supply of ADP by rapidly utilizing the ATP in the expanding cells.

Gibberellins : Gibberellins are weakly acidic hormones having gibbane ring structure which cause cell elongation of intact plants in general and increased internodal length of genetically dwarfed plants (*i.e.*, corn, pea) in particular.



Gibberellic acid

Discovery : Gibberellins were first isolated from the fungus *Gibberella fujikuroi* (*Fusarium moniliforme*) the causal organism of Bakanae disease or foolish seedling disease of rice plants in Japan by Kurosawa in 1926.

In 1939, Yabuta and Sumiki and coworkers working in Tokyo isolated an active substance from the fungus and called it Gibberellin A. This gibberellin preparation was probably a mixture of several gibberellins. The first gibberellin to be obtained was Gibberellin A-3. Cross *et al.* (1961) explained the detailed structure of gibberellic acid. Now 60 gibberellins have been identified from different groups of plants.

Many of them occur naturally in plants. *Gibberella fujikuroi* has as many as 15 gibberellins. All the different types of gibberellins, known so far, have gibbane skeleton and are acidic in nature. Anti-gibberellins like malic hydrazide, phosphon D, Alar and chorocholine cheoride (CCC) or cycocel are also called antiretardants (stimulates flowering and inhibits the growth of nodes). Commercial production of GA is still carried out by culturing this fungus in large vats.

Bioassay of gibberellin : Gibberellin bioassay is performed through dwarf maize/pea test and cereal endosperm test.

Functions of gibberellin

(1) **Stem elongation :** The gibberellins induce elongation of the internodes. The elongation of stem results due to rapid cell division and cell elongation induced by gibberellins.

(2) **Leaf expansion :** In many plants leaves become broader and elongated when treated with gibberellic acid. This leads to increase in photosynthetic area which finally increases the height of the plant. Interestingly, gibberellins show no effect on roots.

(3) **Reversal of dwarfism :** One of the most striking effects of gibberellins is the elongation of genetic dwarf (mutant) varieties of plants like corn and pea. It is believed that dwarfism in the mutant variety of plant is due to blocking of the capacity for normal gibberellin production (deficiency of gibberellin). When gibberellin is applied to single gene dwarf mutants *e.g.*, *Pisum sativam*, *Vicia faba* and *Phaseolus multiflorus*, they grow to their normal heights. It is further interesting to note that application of gibberellins to normal plants fail to show any remarkable effects.

(4) **Bolting :** Gibberellins induce stem elongation in 'rosette plants' *e.g.*, cabbage, henbane, etc. Such plants show retarded internodal growth and profuse leaf development. In these plants just prior to the reproductive phase, the internodes elongate enormously causing a marked increase in stem height. This is called bolting.

Bolting needs long days or cold nights. It has been further noticed that if cabbage head is kept under warm nights, it remains vegetative. The exogenous application of gibberellins induced bolting in first year itself in plants like cabbage (normally bolting occurs next year due to effect of endogenous gibberellins).

(5) **Flowering :** Gibberellins also play an important role in the initiation of flowering. Lang (1960) demonstrated that added gibberellin could substitute for the proper environmental conditions in *Hyoscyamus niger* which requires long day treatment for flowering. Such effects of gibberellin are common among vernalised and long day plants.

Gibberellin is also known to play essential role in germination of cereal seeds.

(6) **Enzyme formation :** One of the most dramatic effects of GA is its induction of hydrolytic enzymes in the aleurone layer of endosperm of germinating barley seeds and cereal grains. GA stimulates the production of digestive enzymes like proteases, α-amylases, lipases which help to mobilise stored nutrients. GA treatment stimulates a substantial synthesis of new mRNA. Thus GA acts to uncover or depress specific genes, which then cause the synthesis of these enzymes. It is assumed that GA acts on the DNA of the nucleus.

(7) **Breaking of dormancy :** Gibberellins overcome the natural dormancy of buds, tubers, seeds, etc. and allow them to grow. Sprouting of potato in cold storage occur due to GA. In this function gibberellins act antagonistically to abscisic acid (ABA).

(8) **Parthenocarpy :** Gibberellins have been considered to be more effective than auxins for inducing parthenocarpy in fruits like apple, tomato and pear. GA application has also resulted in the production of large fruits and bunch length in seedless grapes.

(9) **Sex expression :** Gibberellins control sex expression in certain plants. In general, gibberellin promote the formation of male flowers either in place of female flowers in monoecious plants such as cucurbits or in genetically female plants like *Cannabis, Cucumis*.

(10) **Substitution for vernalization :** Vernalization is the low temperature requirement of certain plant (*i.e.*, biennials) to induce flowering. The low temperature requirement of biennials for flowering can be replaced by gibberellins.

(11) **Malt yield :** There is increased malt production when gibberellins are provided to germinating barley grains (due to greater production of α-amylase).

(12) **Delayed ripening :** Ripening of citrus fruits can be delayed with the help of gibberellins. It is useful in safe and prolonged storage of fruits.

(13) **Seed germination :** Gibberellins induce germination of positively photo-blastic seeds of lettuce and tobacco in complete darkness.

Cytokinins (Phytokinins) : Cytokinins are plant growth hormones which are basic in nature, either aminopurine or phenyl urea derivatives that promote cell division (cytokinesis) either alone or in conjugation with auxin.

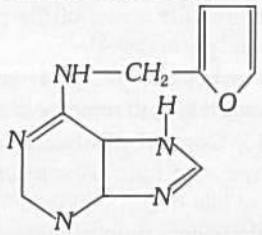
Discovery : The first cytokinin was discovered by Miller, Skoog and Strong (1955) during callus tissue culture of *Nicotiana tobaccum* (tobacco).

It was synthetic product formed by autoclaving Herring sperm (fish sperm) DNA. This synthetic product was identified as 6-furfuryl amino-purine and named as kinetin. He found that normal cell division induced by adding yeast extract.

Various terms such as kinetenoid (Burstran, 1961), phytokinin (Dendolph *et al.* 1963) phytocytomine (Pilet 1965) have been used for kinetin like substances but the term cytokinin proposed by Letham (1963) has been widely accepted. Letham *et al.* (1964) discovered first natural, cytokinin in unripe maize grain (*Zea mays*). It was named as zeatin (6 hydroxy 3 methyl trans 2-butenyl amino purine).

About 18 cytokinins have been discovered, *e.g.*, dihydrozeatin, IPA (Isopentenyl adenine), benzyl adenine. The most widely occurring cytokinin in plant is IPA. It has been isolated from *Pseudomonas tumefaciens*. Many are found as constituents of tRNAs. Cytokinins are synthesized in roots as well as endosperm of seeds. Coconut milk and Apple fruit extract are rich in cytokinins. Cytokinins in coconut milk are called coconut milk factor.

Kinetin (6 furfuryl amino purine) is a derivative of the nitrogen base adenine. Cytokinins are produced in actively growing tissues such as embryos, developing fruits and roots.



Kinetin (6-furfuryl aminopurine)

Cytokinin is transported to different parts of the plant through xylem elements. According to Osborne and Black (1964), the movement of cytokinin is polar and basipetal.

Bioassay of cytokinins : Bioassay is done through retention of chlorophyll by leaf discs, gains of weight of a tissue in culture, excised radish cotyledon expansion, root inhibition test etc.

Functions of cytokinins

(1) **Cell division :** Cytokinins are essential for cytokinesis and thus promote cell division. In presence of auxin, cytokinins stimulate cell division even in non-meristematic tissues. In tissue cultures, cell division of callus (undifferentiated mass of parenchyma tissue) is enhanced when both auxin and cytokinin are present. But no response occurs with auxin or cytokinin alone.

(2) **Cell enlargement and Differentiation :** Under some conditions cytokinins enhance the expansion of leaf cells in leaf discs and cotyledons. These cells considered to be mature and under normal conditions do not expand. Cytokinins play a vital role in morphogenesis and differentiation in plants. It is now known that kinetin-auxin interaction control the morphogenetic differentiation of shoot and root meristems.

(3) **Delay in senescence :** Cytokinin delay the senescence (ageing) of leaves and other organs by controlling protein synthesis and mobilization of resources (Disappearance of chlorophyll). It is called Richmond Lang effect. It was reported by Richmond and Lang (1957) while working on detached leaves of *Xanthium*.

(4) **Counteraction of apical dominance :** Auxins and cytokinins act antagonistically in the control of apical dominance. Auxins are responsible for stimulating growth of apical bud. On the other hand, cytokinins promote the growth of lateral buds. Thus exogenous application of cytokinin has been found to counteract the usual dominance of apical buds.

(5) **Breaking of dormancy :** Cytokinins break seeds dormancy of various types and thus help in their germination. They also induce germination of positively photoplastic seed like lettuce and tobacco even in darkness.

(6) **Accumulation and Translocation of solutes :** Cytokinins induce accumulation of salts inside the cells. They also help solute translocation in phloem.

(7) **Sex expression :** Cytokinins promote formation of female flowers in some plants.

(8) **Enzyme activity :** Cytokinins stimulate the activity of enzymes especially those concerned with photosynthesis.

(9) **Parthenocarpy :** Development of parthenocarpic fruits through cytokinin treatment has been reported by Crane (1965).

(10) **Pomalin :** A combination of cytokinin (6-benzladenine) and gibberellin (GA_4, GA_7) called pomalin is particularly effective in increasing apple size.

(11) **Initiation of interfasicular cambium :** Cytokinins induce the formation of interfasicular cambium in plants *e.g.*, *Pinus radiata*.

(12) **Nucleic acid metabolism :** Guttman (1957) found a quick increase in the amount of RNA in the nuclei of onion root after kinetin treatment.

(13) **Protein synthesis :** Osborne (1962) demonstrated the increased rate of protein synthesis on kinetin treatment.

(14) **Short day plants :** Cytokinins promote flowering in some short-day plants like *Lemna* and *Wolffia*.

Ethylene : Ethylene is a gaseous hormone which stimulates transverse growth but retards the longitudinal one.

Discovery : The effect of ethylene had been known since long. Kerosene lamps and hay have been used by fruit merchants to hasten colour development (ripening) in fruits. These effects are due to ethylene. Neljubow (1901) observed that ethylene gas alters the tropic responses of roots. Denny (1924) reported that ethylene induces ripening of fruits. Crocker *et al.* (1935) identified ethylene as gaseous plant hormone.

Ethylene is produced in plants from the amino acid methionine. It is synthesized in almost all plant parts-roots, leaves, flowers, fruits, seeds. It is more synthesized in nodal regions. Maximum synthesis of ethylene occurs during climacteric ripening of fruits. High concentration of auxin induce ethylene formation. When a fruit ripens, its respiration rate gradually decreases, but when it is reversed by a sharp increase called climacteric. Some of the inhibitory effects earlier attributed to auxin are known to be caused by ethylene.

The commercial product for providing ethylene is ethaphon (2-chloroethyl phosphoric acid). Ethaphon is a liquid from which ethylene gas is released, hence this substance is used for artificial ripening of fruits.

Bioassay of ethylene : It is done on the principle of triple response which includes three characteristic effects of ethylene on etiolated seedlings of pea-viz.

- Swelling of nodes.
- Inhibition of elongation of internodes of stem.
- Induction of horizontal growth of stem against gravity.

Functions of ethylene

(1) **Fruit growth and Ripening :** Ethylene promotes fruit growth and its ripening. The hormone is used in the artificial ripening of climacteric fruits (*e.g.*, Apple, Banana, Mango).

Suitable combination of gases in atmosphere for fruit ripening is 80% ethylene (C_2H_4) and 20% CO_2.

(2) **Transverse growth :** Ethylene inhibits longitudinal growth but stimulates transverse growth so that stem looks swollen.

(3) **Epinasty (leaf bending) :** Epinasty represents more growth on upper surface of leaf than on lower surface. Epinasty is said to be controlled by ethylene in many plants.

(4) **Abscission :** Ethylene stimulates formation of abscission zone in leaves, flowers and fruits.

(5) **Apical dominance :** Ethylene inhibits the growth of lateral buds and thus cause apical dominance (in pea). It is believed that auxin might be functioning partly through synthesis of ethylene in causing apical dominance.

(6) **Root initiation :** In low concentration, ethylene stimulates root initiation and growth of lateral roots and root hair.

(7) **Flowering :** Ethylene stimulates flowering in pineapple and related plants though in other cases, the hormone causes fading of flowers. Fading flowers of *Vanda* are known to release ethylene. Sleep disease (inrolling of petals in blossomed flowers) in due to ethylene.

(8) **Sex expression :** Ethylene application increases the number of female flowers and fruits in cucumber plants.

(9) **Dormancy :** It breaks dormancy of different plant organs but not of lateral buds.

Abscisic acid (ABA) : Abscisic acid is a mildly acidic growth hormone, which functions as a general growth inhibitor by counteracting other hormones (auxin, gibberellins, cytokinins) or reactions mediated by them.

Discovery : The hormone was first isolated by Addicott *et al.* (1963) from cotton balls. They named it as abscisin II. Simultaneously, Wareing and Cornforth isolated a substance that can induce bud dormancy. They named the substance as dormin. Later, both these substances were found to be the same and were named as abscisic acid. It is produced in many parts of the plants but more abundantly inside the chloroplasts of green cells. The synthesis of abscisic acid is stimulated by drought, water logging and other adverse environmental conditions. Therefore, it is also called stress hormone. The hormone is formed from mevalonic acid or xanthophylls. Chemically it is dextro-rotatory cis sesquiterpene. The hormone is transported to all parts of the plant through diffusion as well as through conductive channels.

In some plant tissues (especially in young shoots) occur a related compound called xanthoxine.

Whether xanthoxine is an intermediate of the ABA-biosynthesis or whether it is an independent product remains unknown. The structure indicates that both ABA and xanthoxine are terpene derivatives.

Bioassay of abscisic acid

(1) **Rice seedling growth inhibition test :** Mohanty, Anjaneyulu and Sridhar (1979) used rice growth inhibition method to measure ABA like activity. The length of second leaf sheath after six days of growth is measured.

(2) **Inhibition of α-amylase synthesis in barley endosperm test :** ABA inhibits the synthesis of α-amylase in the aleurone layers which is triggered by gibberellins. Goldschmidt and Monselise (1968) developed the bioassay method to estimate ABA activity by determining the extent of inhibition of α-amylase synthesis induced by treating barley seed endosperm with GA.

Functions of abscisic acid

(1) **Control :** It keeps growth under check by counteracting the effect of growth promoting hormones, *i.e.*, auxins, cytokinins and gibberellins. As growth is primarily controlled by gibberellins, abscisic acid is popularly called antigibberellic hormone. It will inhibit seed germination, growth of excised embryos, growth of Duckweed and other plants.

(2) **Dormancy :** Abscisic acid acts as growth inhibitor and induces dormancy of buds towards the approach of winter. Dormancy of seeds is mainly caused by abscisic acid. Because of its action in inducing dormancy abscisic acid (ABA) is also called dormin. The buds as well as seeds sprout only when abscisic acid is overcome by gibberellins.

(3) **Abscission :** ABA promotes the abscission of leaves, flowers and fruits in plants.

(4) **Senescence :** Abscisic acid stimulates senescence of leaves by causing destruction of chlorophyll (an effect opposite to that of cytokinins) and inhibition of protein and RNA synthesis. The effect, however, can be reversed by application of cytokinins in *Lemna*.

(5) **Antitranspirant :** Abscisic acid can be used as antitranspirant. Application of minute quantity of ABA to leaves reduces transpiration to a great extent through partial closure of stomata. It thus conserves water and reduces the requirement of irrigation.

(6) **Hardiness :** Abscisic acid promotes cold hardiness and inhibits growth of pathogens.

(7) **Flowering :** ABA delays flowering in long day plants. However, in some short day plants (*e.g.*, strawberry, black current) it promotes flowering.

(8) **Rooting :** Abscisic acid can be used to promote rooting in many stem cuttings.

Wound hormone or Traumatic acid or Necrohormone : Haberlandt (1913) reported that injured plants cells release a chemical substance (wound hormone), which stimulate the adjacent cells to divide rapidly in order to heal up the wound. English *et al.* (1939) finally isolated and crystallized this wound hormone and named it as Traumatic acid. Although traumatic acid has been found to be very active in inducing meristematic activity in uninjured green bean pods, but it is not effective in most of the plant tissues including tobacco pith tissues.

Morphactins : Morphactins are synthetic growth regulators which act in variety of ways on the natural regulation mechanisms of plants. The important ones are phenoxyalkancarboxylic acid (synthetic auxin), substituted benzoic acids, Malic acid hydrazide, Fluorene-9 carboxylic acids and their derivatives, Chloroflurenol, Chloroflurun, Flurenol, Methylbenzilate, Dichloroflurenol, etc. Morphactins have fundamental action on morphogenesis of plants and this characteristic designation (morphactins) is derived from morphologically active substances.

The actions of these substances are systematic and after their uptake they are transported and distributed not polarly (as seen by IAA) but basi- and acropetally. Generally these are growth inhibitors. These contain 'fluorene ring' in their structure.

Functions

(1) **Seed germination :** In general, morphactins inhibit seeds germination particularly the emergence of the radicle from the seed shell. This property can be counteracted with GA_3 and almost completely by cytokinins. The germination of fern spores is also delayed by morphactins.

(2) **Growth seedling :** Morphactins inhibit the growth of seedling affecting the shoot and often also root. With this property they show a similarity with cytokinin. The inhibitory effect of seedling shoot growth can be partly counteracted with GA_3 but not the inhibition of root growth.

(3) **Stem elongation :** They have inhibitory effect on the stem elongation. Increased concentration produces dwarfing in the plants.

(4) **Polarity of cell division :** Denffer and others (1969) observed in the dividing cells of the root tips of *Allium* that treatment of morphactin (CFI) results in random orientation of the mitotic spindle and plane of cell division, *i.e.*, they exercise depolarisation during cell division.

Jasmonic acid (Jasmonates) : According to Parthier (1991), jasmonic acid and its methyl esters are ubiquitous in plants. They have hormone properties, help regulating plant growth, development and they seem to participate in leaf senescence and in the defense mechanism against fungi.

Just like ABA jasmonates inhibit a premature germination of the oil-containing seeds of *Brassica* and *Linum*. After germination they induce the synthesis of the seed storage proteins Napin and Cruciferin as well as that of several more elaiosome-associated proteins.

Calines (Formative hormones) : Certain other natural growth hormones in plants called as calines or formative hormone which are through to be essential for the effect of auxin an root, stem and leaf growth they are :

(1) **Rhizocaline or Root forming hormone :** It is produced by the leaves and translocated in a polar manner down the stem.

(2) **Caulocaline or Stem forming hormone :** It is produced by the roots and is transported upward in the stem.

(3) **Phyllocaline or Self forming hormone :** It is produced probably by the cotyledons. It stimulates mesophyll development in the leaves and is synthesized only in the presence of light.

Physiology of flowering plant

Flowering in a plant occurs at a particular time of the year and controlled by many morphological and environmental conditions. Two important controlling factors are photoperiod or light period, *i.e.*, photoperiodism, low temperature *i.e.*, vernalization.

(1) **Photoperiodism (Light period) :** The effects of photoperiods or daily duration of light periods (and dark periods) on the growth and development of plants, especially flowering is called photoperiodism.

The role of photoperiodism in the control of flowering was demonstrated for the first time by W.W Garner and H.A. Allard (1920). They observed that Maryland mammoth variety of tobacco could be made to flower in summer by reducing the light hours with artificial darkening. It could be made to remain vegetative in winter by providing extra light. On the basis of length of photoperiod requirements of plants, the plants have been classified into following categories.

(i) **Short day plants (SDP) :** These plants initiate flowering when the day length (Photoperiod) become shorter than a certain critical period. Most of winter flowering plants belong to this category *e.g.*, cocklebur (*Xanthium*), *Chrysanthemum*, sugarcane, tobacco (Mutant Maryland mammoth), soybean, strawberry, *Dahlia* etc.

(ii) **Long day plants (LDP) :** These plants begin flowering when the day length exceeds a critical length. This length too differs from species to species. The long day plants fail to flower, if the day length is shorter than the critical period. *e.g.*, spinach (*Spinacea oleracea*), henbane (*Hyoscymus niger*), radish, sugar-beet, wheat, lattuce, poppy, larkspur, maize etc.

(iii) **Day neutral plants :** These plants can flower in all possible photoperiods. The day neutral plants can blossom throughout the year. *e.g.*, cucumber, cotton, sunflower, tomato, some varieties of pea, etc.

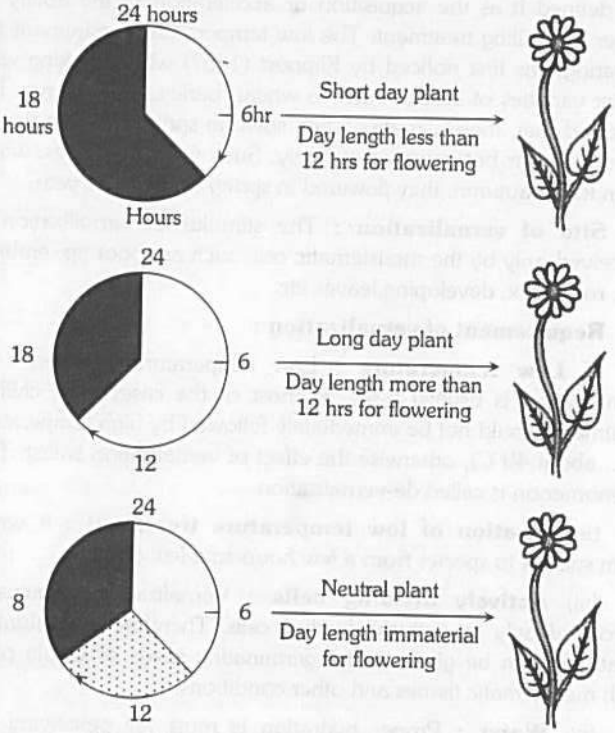


Fig : 4.5-3 The day-length requirements for flowering in three catagories of plants

(iv) **Intermediate plants :** These plants flower only under day lengths within a certain range usually between 12-16 hours of light but fail to flower under either longer or shorter photoperiods. *e.g.*, *Mikania scandens*, *Eupatorium hyssopifolium* and *Phaseolous polystacous*.

(a) **Amphiphotoperiodic plants :** Such plants remain vegetative on intermediate days length and flower only on shorter or longer day lengths. *e.g.*, *Media elegans*.

(b) **Short long day plants :** These plants require short photoperiods for initiation of flowering and long photoperiods for blossoming. *e.g.*, *Triticum vulgare*, *Secale cereale*.

(c) **Long short day plants :** These plants require long photoperiods for initiation of flowering and short photoperiods for blossoming. *e.g.*, *Bryophyllum*, *Cestrum*.

Critical period : Critical photoperiod is that continuous duration of light, which must not be exceeded in short day plants and should always be exceeded in long days plant in order to bring them to flower. There is no relation with the total day length. Thus, the real distinction between a SDP and LDP is whether flowering is induced by photoperiods shorter or longer than the critical period. The critical day length for *Xanthium* (a short day plant) is 5 – 6 hours and that for *Hyoscymus niger* (a long day plant) is about 11 hours, yet the former is SDP as it flowers in photoperiods shorter than its critical value, whereas the latter is LDP requiring photoperiods longer than its critical value. Both *Xanthium* and *Hyoscymus niger* flower with 14 hours of light per day. Thus, day length in which a plant flowers is no indication of its response class in the absence of further information.

Skotoperiodism (Dark period) : When photoperiodism was discovered, the duration of the light period was thought to be critical for flowering. Subsequently, it was found that when the long night period was interrupted by a brief exposure to light, the short day plants, failed to flower. Thus, for flowering, these plants require a long night or critical dark period rather than a short day length. Similarly, long day plants respond to nights shorter than the critical dark period. Curiously, they do not need an uninterrupted dark period. Therefore, a short day plant is also called long night plant and a long day plant as a short night plant.

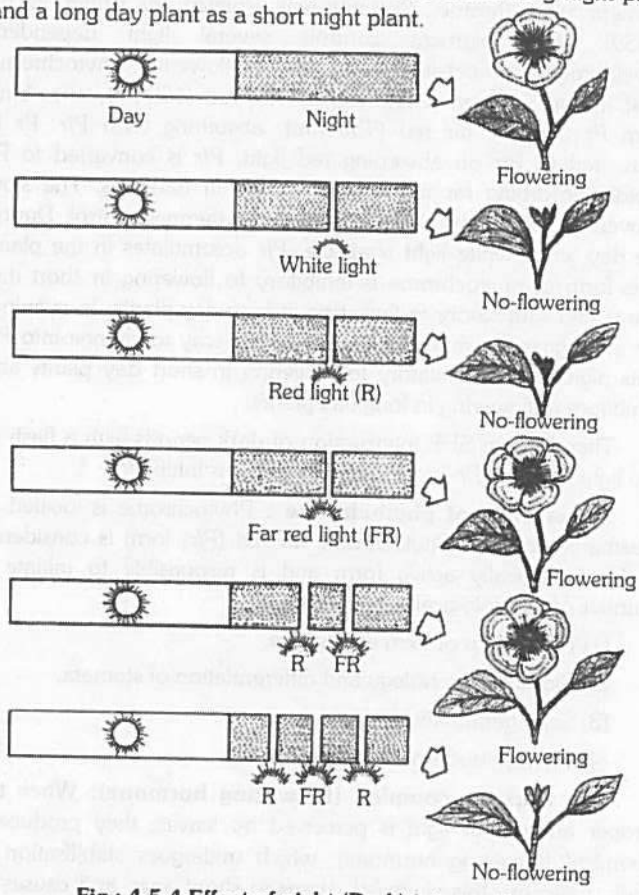


Fig : 4.5-4 Effect of night (Dark) interruption on flowering in a short-day plant

In the night interruption experiments, when the short day plants were exposed to a flash of light before achieving a critical dark period, flowering was prevented. It is called light break reaction.

Mechanism of photoperiodism

Photoreceptor : The chemical which perceives the photoperiodic stimulus in leaves is phytochrome. The wavelengths of light are absorbed by the leaves. This becomes evident by the fact that defoliated (leaves removed) plant does not flower. Presence of even a single leaf is sufficient to receive required amount of photoperiod. Partially mature leaves are more senstitive to light while very young or mature leaves are much less sensitive to photoperiodic induction.

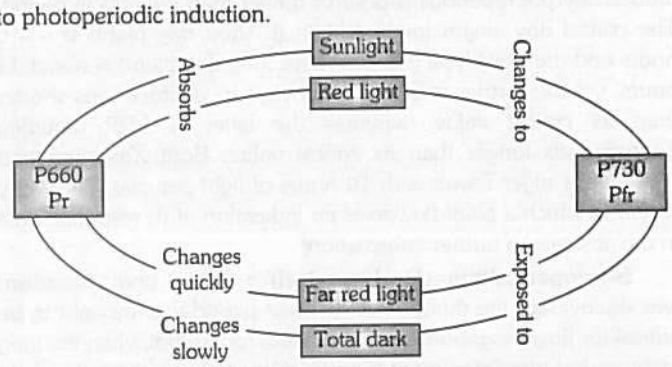


Fig : 4.5-5 The phytochrome concept

Garner and Allard's early work led to the discovery, isolation and much of the characterization of the pigment responsible for absorbing light involved in photoperiodic phenomenon of plants. Borthwick, Hendricks and their colleagues later termed this pigment phytochrome. Pigment was isolated by Butter *et al.* (1959). This pigment controls several light dependent developmental processes in plants besides flowering, Phytochrome exist in two interconvertible forms. The red (660*nm*), absorbing form *Pr* and the far red (730 *nm*), absorbing form *Pfr*. Pr is converted to *Pfr* on absorbing red light. *Pfr* is converted to Pr rapidly absorbing far red light or slowly in darkness. The slow conversion to red absorbing form is under thermal control. During the day when white light available, *Pfr* accumulates in the plant. This form of phytochrome is inhibitory to flowering in short day plants and stimulatory to flowering in long day plants. In evening, *Pfr* undergoes thermal and spontaneous decay to change into Pr. This pigment is stimulatory to flowering in short day plants and inhibitory to flowering in long day plants.

Therefore, in SDP interruption of dark periods with a flash of red light converts *Pr* into *Pfr* and flowering is inhibited.

Importance of phytochrome : Phytochrome is located in plasmamembrane. Phytochrome far red (*Pfr*) form is considered to be biologically active form and is responsible to initiate a number of physiological process such as.

(1) Elongation of stem and leaves.

(2) Plastids morphology and differentiation of stomata.

(3) Seed germination.

(4) Photoperiodism and transpiration.

The florigen complex (Flowering hormone): When the proper amount of light is perceived by leaves, they produce a chemical (flowering hormone), which undergoes stabilisation in dark. Later on, this chemical passes to shoot apex and causes its differentiation into flowering shoot.

Chailakhyan (1936) a Russian investigator on photoperiodism, proposed that it be called 'florigen'. According to him (1958) the "Florigen complex", the true flowering hormone includes two groups of substances formed in leaves :

Gibberellins : Which are necessary for formation and growth of stem.

Anthesins : Substances which are necessary for flower formation.

Photomorphogenesis : When plants are grown in continuous darkness they become etiolated *i.e.*, such plants are longer, weaker, having yellowish half opened leaves, while light grown plants do not show such conditions. When etiolated plants are kept in light they gradually develop green colour and become normal. The effect of light in reversing etiolation involves two kinds of action; one at the biochemical level for the synthesis of the chlorophyll and secondly at the level of morphogenesis light acts to promote expansion of the leaves and inhibits elongation of the internodes. This phenomenon is called photomorphogenesis and is independent of the direction of light.

The action spectrum of photomorphogenesis reveals that plants are most sensitive to red light, but blue light is ineffective.

(2) **Vernalization :** Russian agronomist Lysenko coined the term vernalization (1929-30). According to him vernalization may be defined as the method of inducing early flowering in plants by pretreatment of their seeds at low temperatures. Chourad (1960) has defined it as the acquisition or acceleration of the ability to flower by chilling treatment. The low temperature requirement for flowering was first noticed by Klipport (1857) while working with winter varieties of cereals such as wheat, barley, oat and rye. He observed that, these varieties when sown in spring failed to flower the same year but grow vegetatively. Such winter varieties, when sown in the autumn, they flowered in spring of the same year.

Site of vernalization : The stimulus of vernalization is perceived only by the meristematic cells such as shoot tip, embryo tips, root apex, developing leaves etc.

Requirement of vernalization :

(i) **Low temperature :** Low temperature required for vernalization is usually 0-4°C is most of the cases. The chilling treatment should not be immediately followed by high temperature (*i.e.*, about 40°C), otherwise the effect of vernalization is lost. This phenomenon is called de-vernalization.

(ii) **Duration of low temperature treatment :** It varies from species to species from a few hours to a few days.

(iii) **Actively dividing cells :** Vernalization stimulus is perceived only by actively dividing cells. Therefore, vernalization treatment can be given to the germinating seeds or whole plant with meristematic tissues and other conditions.

(iv) **Water :** Proper hydration is must for perceiving the stimulus of vernalization.

(v) **Oxygen :** Aerobic respiration is also a requirement for vernalization. The stimulus has been named as vernalin (reported by Mechlers).

Process of vernalization : Usually vernalization treatment is given to the germinating seeds. The seeds are moistened sufficiently to allow their germination. They are then exposed to a temperature of 0-4°C for a few weeks and sown to the fields. Lysenko developed the process of vernalization. It is completed in two stages.

(i) **Thermostage :** Germinating seeds are treated with 0-5°C in presence of oxygen and slight moisture. The seed dormancy is broken.

(ii) **Photostage :** This stage is very essential to initiate the reproductive phase. After vernalization plants must be subjected to a correct photoperiod in order that they may produce flowers.

Importance of vernalization

(i) Vernalization is believed to overcome some inhibitor and induce synthesis of growth hormones like gibberellins.

(ii) It reduces the vegetative period of plant.

(iii) It prepares the plant for flowering.

(iv) It increases yield, resistance to cold and diseases.

(v) Vernalization can remove kernel wrinkles in wheat.

(vi) Vernalization is beneficial in reducing the period between germination and flowering. Thus more than one crop can be obtained during a year.

Senescence and Death

Plant and their parts develop continuously from germination until death. The production of flowers, fruits and seeds in annuals and biennials leads to senescence. The latter part of the developmental process, which leads from maturity to the ultimate complete loss of organization and function is termed senescence. Several workers equate ageing and senescence as same process. Ageing is a sum total of changes in the total plant or its constituents while senescence represents degenerative and irreversible changes in a plant. The study of plant senescence is called phytogerontology.

Types of senescence : Plant senescence is of four types- whole plant senescence, shoot senescence, sequential senescence and simultaneous senescence. The last three are also called organ senescence.

(1) **Whole plant senescence** : It is found in monocarpic plants which flower and fruit only once in their life cycle. The plants may be annual (*e.g.*, rice, wheat, gram, mustard etc.), biennials (*e.g.*, cabbage, henbane) or perennials (*e.g.*, certain bamboos). The plant dies soon after ripening of seeds.

(2) **Shoot senescence :** This type of senescence is found in certain perennial plants which possess underground perennating structures like rhizomes, bulbs, corm etc. The above ground part of the shoot dies each year after flowering and fruiting, but the underground part (stem and root) survives and puts out new shoots again next year. *e.g.*, banana, gladiolus, ginger etc.

(3) **Sequential senescence** : This is found in many perennial plants in which the tips of main shoot and branches remain in a meristematic state and continue to produce new buds and leaves. The older leaves and lateral organs like branches show senescence and die. Sequential senescence is apparent in evergreen plants *e.g.*, *Eucalyptus*, *Pinus*, Mango.

(4) **Simultaneous or synchronous senescence :** It is found in temperate deciduous trees such as elm and maple. These plants shed all their leaves in autumn and develop new leaves in spring. Because of this shedding of leaves, autumn season is also called fall. *e.g.*, Dalbergia, Elm, Mulberry, Poplar.

Theories of senescence

(1) **Wear and tear :** According to this theory, senescence occurs due to loss of activity and cells undergo wear and tear due to disintegration of organelles.

(2) **Toxicity :** It is viewed that senescence takes place due to accumulation of toxic and deleterious substances in all.

(3) **Loss of metabolites** : It is assumed that senescence leads to gradual depletion of essential metabolites in a cell.

(4) **Genetic damage**

Characteristics of ageing and senescence

(1) There is general decline in metabolic activities, decline in ATP synthesis and also decreased potency of chloroplast.

(2) Decrease in RNA and DNA.

(3) Decrease in semipermeability of cytoplasmic membranes.

(4) Decrease in the capacity to repair and replace wornout cells.

(5) There may be accumulation of chromosomal aberrations and gene mutations with advancing age. As a result of these changes protein synthesis becomes defective.

(6) Increased production of hydrolytic enzymes such as proteases and nucleases.

(7) Deteriorative change in cell organelles and membranes.

(8) Decrease in the internal content of auxin and cytokinins and increase in the production of abscisic acid or ethylene.

Importance of senescence : Biologically, senescence and death have following advantages :

(1) It maintains efficiency since the old and inefficient organs are replaced by young efficient part like leaves, buds, flowers and fruits. etc.

(2) During senescence, the cellular breakdown results in release of many nutrients including amino acids, amides, nucleotides, simple sugars and minerals. The same are withdrawn from the senescing organs into the main trunk and later utilised in the growth and developed of new parts.

(3) Shoot senescence is a mechanism to help the plants perennate during the unfavourable periods.

(4) Simultaneous or synchronous leaf fall occurs in autumn prior to winter. It reduces transpiration, which is essential for survival in winter, when the soil in frozen and roots can not absorb water.

(5) Litter of fallen leaves and twigs is an important source of humus and mineral replenishment for the soil.

Abscission

The process of shedding of leaves, fruits or flowers by a plant is called abscission. The shedding of plant parts takes place by the formation of a special layer of cells called abscission layer, within the region of attachment. The middle lamella between certain cells in this layer in often digested by polysaccharide hydrolyzing enzymes such as cellulase and pectinases.

Tips & Tricks

- The double sigmoid growth curve occurs in some fruits *e.g.*, Grapes, plum.
- Measurement of growth in young root by making it at 1mm intervals with Indian Ink was first done by Strasburger
- The development of shoot and root is determined by cytokinin and auxin ratio.
- Mixture of 2, 4-D and 2, 4, 5-T (dioxin) is given the name 'Agent orange' which was used by USA in Vietnam war for defoliation of forests (*i.e.*, in chemical warfare).
- In glass houses when plants are kept on artificial light and temperature, then this method is called phytotron and is applicable in agriculture, horticulture and tissue culture.
- Phytotron is a method in which plants are grown in controlled environment.
- When each meristem influences other meristems then this phenomenon is called growth correction.
- ABA is used in dryfarming.
- Malic hydrazide is a growth retardant which checks cell division. So during seed storage this is applied for checking sprouting of potato tubers so that the importance of potato may be lowered down.
- Auxin and Cytokinin in combined form shows synergistic effect (affects development of physical structure).
- SDP's contain anthesins and synthesize gibberellic acid for flowering. Whereas LDP's contain GA and synthesize anthesins for flowering.
- Leaves show maximum expansion in violet light.
- Knott (1934) found that the locus of photoperiodic induction is the leaves.
- Wellensick (1964) found that the locus for perception of cold treatment is the meristmatic cells (at all places) especially the shoot apex .
- Reduced availability of auxin stimulates leaf fall while presence of auxin slows down leaf fall. Cytokinin prevent senescence through stimulating anabolic activity. They are called antiageing hormones Florigen hormone synthesized in the leaves.
- Geotropic stimulus is perceived by root cap in case of root by stem apex in case of stem.

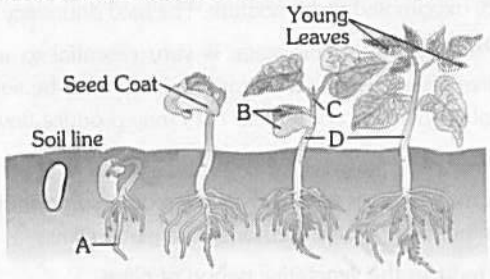
Ordinary Thinking

Objective Questions

Growth

1. Maximum growth in roots occurs
(a) At apex (b) In presence of light
(c) Behind the apex (d) In presence of soil

2. The given figure indicates the stages of seed germination



Identify A, B, C and D respectively **[NCERT]**
(a) Root hair, Cotyledons, Epicotyl and Hypocotyl
(b) Mesocotyl, Cotyledons, Epicotyl and Hypocotyl
(c) Radicle, Cotyledons, Epicotyl and Hypocotyl
(d) Plumule, Cotyledons, Epicotyl and Hypocotyl

3. Which of the following instrument can be used to record plant growth by seconds *i.e.* in fraction of a minute
(a) Arc auxanometer (b) Arc indicator
(c) Space marker disc (d) Crescograph

4. Which two factors primarily affect the developmental phase of growth of plants
(a) Light and temperature
(b) Rainfall and temperature
(c) Light and wind
(d) Temperature and relative humidity

5. Evergreen trees remain green throughout the year on account of
(a) Absence of leaf fall
(b) Leaves falling in small numbers at intervals
(c) Supply of the moisture throughout the year
(d) Cold climate

6. The growth involves
(a) Cell division (b) Cell enlargement
(c) Cell maturation (d) All the above

7. Where would you look for active cell division in plants
(a) In the pith cells
(b) In the cells of cortex
(c) In the internodal region
(d) At the tip of root and shoot

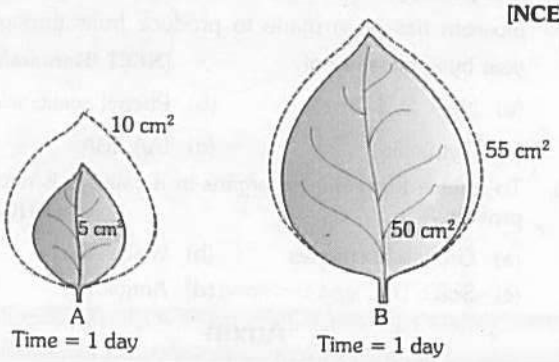
8. Plant growth in length is increased by **[MP PMT 1998]**
(a) Apical meristem (b) Lateral meristem
(c) Dermatogen (d) Periblem

9. Growth is
(a) Unidirectional backward (b) Reversible
(c) Unidirectional forward (d) None of the above

10. Phytotron is a device by which **[CPMT 1995; AIIMS 1998; MH CET 2001]**
(a) Electrons are bombarded
(b) Protons are liberated
(c) Plants are grown in controlled environment
(d) Mutation are produced in plants

11. The *S*–shaped growth curve and 'grand period of growth' may change with
(a) Sudden fluctuation in light intensity
(b) Change in temperature
(c) Fluctuation in humidity
(d) It remains unaffected

12. See the figure and choose the correct option from table **[NCERT]**



	A - Leaf		B - Leaf	
	AGR	RGR	AGR	RGR
(a)	0.5	100%	1.5	100%
(b)	5	100%	5	10%
(c)	100%	5	10%	5
(d)	1%	1	2%	2

13. Deeply sown seeds do not germinate and do not come up over due to the deficiency of
(a) Light (b) Water
(c) Oxygen (d) Nutrients

14. The rate of growth of any organism follows **[MP PMT 1998]**
Or
Typical growth curve in plants is **[AIPMT (Cancelled) 2015]**
(a) Hyperbola curve (b) J–shaped curve
(c) Sigmoid curve (d) Parabola curve

15. Exponential growth occurs in **[Odisha JEE 2009]**
(a) Yeast (b) Asexual reproduction
(c) Bacterial (d) All of these

16. Dendrochronology is **[Kerala CET 2003]**
(a) Secondary growth
(b) Apical growth
(c) Seasonal variation
(d) Determination of age of tree

17. In vascular plants, light promotes
(a) Growth (b) Development
(c) Differentiation (d) De–differentiation

18. In lag phase, the growth is
(a) Slowest (b) Fastest
(c) Intermediate (d) No growth at all

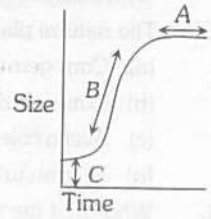
19. To remove seed dormancy by mechanical removing of seed coat is called **[DPMT 2003; J & K CET 2008]**
(a) Stratification (b) Scarification
(c) Vernalization (d) Photoperiodism

20. Highest growth is found in **[NCERT; Pb. PMT 1999; RPMT 1999; CBSE PMT 2004]**
(a) Static phase (b) Exponential phase
(c) Descending phase (d) Lag phase

21. The growth in plants is **[MP PMT 1999]**
(a) Limited (b) Unlimited
(c) Unlocalised (d) None of these

22. Which of the following is the primary motive force responsible for growth
(a) Root pressure (b) Turgor pressure
(c) Osmotic pressure (d) DPD

23. Given below is a graph drawn on the parameters of growth versus time *A*, *B*, *C* respectively represent **[NCERT; Kerala PMT 2007; AIIMS 2011]**
(a) Exponential phase, log phase and steady state phase
(b) Steady state phase, log phase and lag phase
(c) Slow growing phase, lag phase and steady state phase
(d) Lag phase, steady state phase and logarithmic phase
(e) Lag phase, log phase and steady state phase



24. "*Traumatin*" is present in
(a) Old leaves (b) Cork
(c) Wood (d) Injured portion

25. Seeds of parasitic plants like *Orobanche* germinate in the presence of
(a) Auxin produced by the roots of the host
(b) GA_3 produced by the roots of the parasite
(c) Exudates of the host plant
(d) Exudates of the parasite

26. Growth is maximum in the zone of **[AFMC 1994]**
(a) Cell division (b) Cell elongation
(c) Cell maturation (d) All of these

27. The instrument by which the rate of growth of stem is accurately measured is **[CPMT 1995, 2002; Kerala CET 2003; J & K CET 2005; Odisha JEE 2012]**
Or
Growth in length of a plant can be measured by **[Pb. PMT 2004; AMU (Med) 2005; RPMT 2005; HP PMT 2005; AFMC 2010]**
(a) Hydrometer (b) Auxanometer
(c) Osmometer (d) Potometer

28. Several horticultural techniques are followed for the production of 'bonsai' plants. One of them is drastic pruning of root system. Which of the following physiological factor is involved in that method **[CBSE PMT 1990]**
(a) Inadequacy of mineral nutrients
(b) Deficiency of auxins
(c) Impairment of water absorption
(d) Deficiency of cytokinins

29. Distribution of growth in a root by marking it at equal intervals with Indian ink was originally studied by
(a) Wellensick (b) Strasburger
(c) Went (d) Nitsch

30. Classical experiments on growth were performed by
(a) Lamarck and Boysen–Jennsen
(b) Boysen–Jennsen and Darwin
(c) Darwin and Lamarck
(d) De Vries and Paul

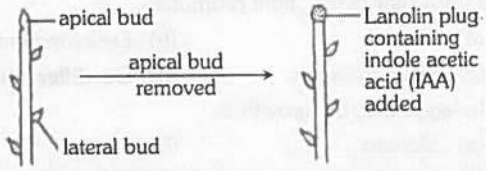
31. The type of growth of bands in conifers is
(a) Lateral (b) Delinquent
(c) Caudex (d) Excurrent

Growth Hormones

1. Among plants 'pheromones' are secreted by the cells of following plants for the given function **[BHU 1994]**
   (a) All plants for growth and development
   (b) Yeast for facilitating mating
   (c) All fungi for sexual reproduction
   (d) *Rhizopus* for the formation of zygospore
2. The natural plant hormones were first isolated from
   (a) Corn germ oil and human urine
   (b) Cotton fruits, spinach leaves and rice plants
   (c) Avena coleoptile spinach leaves and the fungus gibberella
   (d) Human urine and rice seedlings
3. Who used the term '*phytohormones*' for plant hormone
   (a) Balis (b) Morgan
   (c) Went (d) Thimann
4. Phytohormones control **[CBSE PMT 1990]**
   (a) Growth (b) Physiological functions
   (c) Rooting (d) Flowering
5. Legume seeds exhibit dormancy because of
   (a) Undeveloped embryo (b) Hard seed coat
   (c) Absence of cytokinin (d) Absence of GA_3
6. By hormone application it is possible to obtain seedless fruits. In which of the following it is undesirable to obtain seedless fruits
   (a) Tomato (b) Orange
   (c) Watermelon (d) Pomegranate (Anar)
7. In which of the following respect, the plant hormones differ from enzymes **[BVP 2003]**
   (a) Required in less quantity
   (b) They are expended in the process
   (c) They release some energy
   (d) None of the above
8. Plant hormones are usually
   (a) Proteins (b) Lipids
   (c) Carbohydrates (d) Aromatic compounds
9. Whose technique is employed for the extraction and elimination of hormones
   (a) Beck (b) Beer
   (c) Garner (d) Allard
10. Who for the first time speculated the presence of organ forming substances in plant now called hormones **[MP PMT 2001]**
    (a) Darwin (b) Went
    (c) Yabuta (d) Sachs
11. Rhizocalin is a additional hormonal substance which is secreted by
    (a) Cotyledons (b) Roots
    (c) Leaves (d) Stem
12. Certain chemical substances having profound effect on growth, are called **[MP PMT 1997]**
    (a) Catalytic agents (b) Phytohormones
    (c) Enzymes (d) Compost
13. The pineapple which under natural conditions is difficult to blossom has been made to produce fruits throughout the year by application of **[NEET (Karnataka) 2013]**
    (a) NAA, 2, 4-D (b) Phenyl acetic acid
    (c) Cytokinin (d) IAA, IBA
14. To induce formation of organs in a callus it is necessary to provide **[MHCET 2015]**
    (a) Growth hormones (b) Water
    (c) Soil (d) Antibiotics

Auxin

1. Leaf fall occurs as abscission layer is formed when the content of **[MP PMT 1996]**
   (a) Auxin increases (b) Auxin decreases
   (c) Abscisic acid decreases (d) Gibberellic acid decreases
2. Dr. F. Went noted that if coleoptile tips were removed and placed on agar for one hour, the agar would produce a bending when placed on one side of freshly cut coleoptile stumps. Of what significance is this experiment **[CBSE PMT 2014]**
   (a) It supports the hypothesis that IAA is auxin
   (b) It demonstrated polar movement of auxins
   (c) It made possible the isolation and exact identification of auxin
   (d) It is the basis for quantitative determination of small amounts of growth-promoting substances
3. Apical dominance in higher plants is due to **[NCERT]**
   (a) Balance between auxin and cytokinin
   (b) Enzyme activity and metabolism
   (c) Carbohydrates
   (d) Photoperiodism
4. See the following diagram



After two weeks the appearance of the shoot would be **[NCERT]**

(a) 
(b) 
(c) 
(d) 

5. Which one of the following plant function is not generally governed or controlled by auxin **[AMU (Med.) 2010]**
(a) Apical dominance (b) Phototropism
(c) Photosynthesis (d) Growth

6. Which of the following movements is not related to change in auxin levels **[CBSE PMT 1990]**
(a) Nyctinastic leaf movement
(b) Movement of roots towards soil
(c) Movement of sunflower tracking the direction of the sun
(d) Movement of shoot towards light

7. Parthenocarpy is induced by **[KCET 1994]**
(a) ABA (b) Auxins
(c) Zeatin (d) Cytokinin

8. Who among the following discovered the Avena curvature test to find out the concentration of auxins **[NCERT]**
(a) F.W. Went (b) L.J. Audus
(c) K.V. Thimman (d) F. Skoog

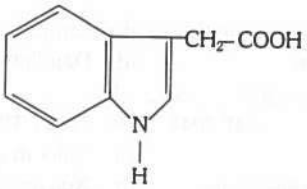
9. One of the synthetic auxin is **[CBSE PMT 2009]**
Or
Flowering in pineapple is promoted by
(a) NAA (b) IAA
(c) GA (d) IBA

10. Which of the following is not naturally occurring plant hormone **[MP PMT 1996; CPMT 1999; JIPMER 2001; BVP 2002; KCET 2009]**
(a) 2, 4–D (b) GA_2
(c) Gibberellin (d) IAA

11. Highest concentration of auxins exist in **[CBSE PMT 1990; MP PMT 2000]**
(a) At the base of various plant organs
(b) Growing tip of plants
(c) In leaves
(d) In xylem and phloem cells only

12. A well known naturally occuring auxin is **or** A natural growth regulator (hormone) is
(a) 2, 4–D (b) Indole acetic acid
(c) NAA (d) Maleic hydrazide

13. See the following



Above structure is of an auxin, that is
(a) *IAA* (b) Auxin *b*
(c) Auxin *a* (d) None of the above

14. Which one among the following chemical is used for causing defoliation of forest trees **[CBSE PMT 1998]**
(a) Amo–1618 (b) Phosphon–*D*
(c) Maleic hydrazide (d) 2, 4-*D*

15. Auxins inhibits the growth of
(a) Apical bud
(b) Lateral axillary buds
(c) Roots on stem cuttings
(d) Parthenocarpic development of fruits

16. Phototropism in shoots is attributed to **[NCERT]**
(a) Auxin (b) Gibberellins
(c) Cytokinins (d) Abscisic acid

17. Differentiation of shoot is controlled by **[CBSE PMT 1999]**
(a) High gibberellin : cytokinin ratio
(b) High cytokinin : auxin ratio
(c) High auxin : cytokinin ratio
(d) High gibberellin : auxin ratio

18. How does pruning help in making the hedge dense **[CBSE PMT 2006]**
(a) The apical shoots grows faster after pruning
(b) It releases wound hormones
(c) It induces the differentiation of new shoots from the rootstock
(d) It frees axillary buds from apical dominance

19. Both in callus and suspension cultures commonly used auxin is **[Kerala CET 2005; Odisha JEE 2012]**
(a) NAA
(b) IBA
(c) 2, 4-D
(d) 2, 4, 5-Trichlorophenoxy acetic acid
(e) Abscisic acid

20. Levitt performed experiments. He observed that auxin treated cells were able to absorb water even when kept in hypertonic solution. Which explains this observation best **[Manipal 2005]**
(a) Auxin treated cells lose selective permeability
(b) ATP production increases and therefore much energy is available for active absorption
(c) Auxin lowers the water potential of cells
(d) Auxin increases the solute potential of cells

21. Which of the following ion is pulled out in apoplast by the auxin during growth **[CPMT 1999]**
(a) Na^+ (b) K^+
(c) Mg^{2+} (d) H^+

22. Pruning of plants promotes branching because the axillary buds get sensitized to **[AIIMS 2004]**
(a) Ethylene (b) Gibberellin
(c) Cytokinin (d) Indole acetic acid

23. One of the commonly used plant growth hormone in tea plantations is **[CBSE PMT (Mains) 2010]**
(a) Ethylene (b) Abscisic acid
(c) Zeatin (d) Indole-3-acetic acid

24. Auxin–*B* was first isolated by
(a) Kogl and Erxlaben
(b) Kogl, Erxlaben and Haagen-Smith
(c) Miller and Skoog
(d) Yabuta and Sumiki

25. 6-furfuryl amino purine, 2, 4-dichlorophenoxy acetic acid and indole-3-acetic acid are examples respectively for **[Kerala PMT 2007]**

(a) Synthetic auxin, kinetin and natural auxin
(b) Gibberellin, natural auxin and kinetin
(c) Natural auxin, kinetin and synthetic auxin
(d) Kinetin, synthetic auxin and natural auxin
(e) Natural auxin, gibberellin and kinetin

26. Apical dominance in plant is caused by **[NCERT; BHU 1995, 99; MP PMT 2000; AIEEE Pharmacy 2004; DPMT 2005, 07; J & K CET 2010; Odisha JEE 2010]**

(a) High concentration of auxins in the terminal bud
(b) High concentration of gibberellins in the apical bud
(c) High concentration of auxins in the lateral bud
(d) Absence of auxins and gibberellins in the apical bud

27. Auxin in plant is not meant for **[NCERT; BHU 2003]**

Or

Cell elongation in plants is caused by **[CPMT 1994, 95]**

(a) Cell elongation (b) Fruit ripening
(c) Cell division (d) Inhibit the root growth

28. Synthetic auxins are used for **[Kerala CET 2003]**

(a) Killing weeds
(b) Ripening fruits
(c) Increasing the size of the fruits
(d) Stimulating growth of cells in tissue culture

29. Which of the following prevents falling of fruits **[KCET 1998; CBSE PMT 2001]**

Or

Fruit and leaf drop at early stages can be prevented by the application of **[NEET 2017]**

(a) GA_3 (b) *NAA* / Auxin
(c) Ethylene (d) Zeatin

30. Which of the following is not a physiological effect/an influence of auxin **[KCET 2006; Kerala PMT 2012]**

(a) Initiates rooting in stem cuttings
(b) Promotes flowering
(c) Prevents fruit and leaf drop at early stages
(d) Inhibits the growth of lateral buds
(e) Promotes bolting

31. The substances which have proved very effective to induce rooting from cut end of the stem is **[EAMCET 1995; BHU 1999; Pb. PMT 2000]**

Or

Abscission of fruits is prevented by **[Pb. PMT 1999; RPMT 1999]**

(a) Phenyl acetic acid (b) α–naphthalene acetic acid
(c) Indole acetic acid (d) Indole butyric acid

32. Auxins originates at the tip of the stem and controls growth elsewhere. The movement of auxin is largely **[CBSE PMT 2000; KCET 2007]**

(a) Basipetal (b) Acropetal
(c) Acropetal and basipetal (d) Centropetal

33. Which of the following effects of auxins on plants is the basis for commercial application

(a) Callus formation
(b) Curvature of stem
(c) Induction of root formation in stem cuttings
(d) All of the above

34. 2, 4–D is a **[CPMT 1996; BHU 2002; Manipal 2005; WB JEE 2016]**

(a) Insecticide (b) Weedicide
(c) Nematicide (d) Rodenticide

35. During germination, stem grows upward and root goes downward because **[CPMT 1995]**

Or

Phototropic curvature is the result of uneven distribution **[CBSE PMT (Pre.) 2010]**

(a) It depends upon light
(b) Of auxin
(c) It does not depend on light
(d) Of epinasty and hyponasty

36. IAA and serotonin are derived (formed) from which of the following **[DPMT 2007]**

(a) Tryptophan (b) Tyrosine
(c) Phenylalanine (d) None of these

37. Bioassay for auxin is **[RPMT 1999; BHU 2005; AIPMT 2015]**

(a) Avena curvature test (b) Green leaf test
(c) Dwarf maize test (d) Cell division test

38. Substances which originate at the tip of the stem and control growth elsewhere are **[CPMT 1993]**

(a) Food material (b) Auxins or hormones
(c) Vitamins (d) Enzymes

39. *Avena coleoptile test* detects the presence of **[RPMT 1999; JIPMER 2002; NEET (Phase-I) 2016]**

(a) *IAA* (b) *GA*
(c) *NAA* (d) *BA*

40. Auxins are abundantly produced in **[CBSE PMT 1990; BHU 2008]**

(a) Root
(b) Meristematic region of the root
(c) Shoot
(d) Meristematic region of the shoot

41. The presence of auxins in a solution could be tested by **[MP PMT 1999]**

(a) *Avena sativa* stem tip test (b) Carbon tetrachloride test
(c) Iodine test (d) Defoliation test

42. In plants auxin synthesis occurs in **[MP PMT 1994; CPMT 1999; KCET 2000]**

(a) Cortex (b) Phloem cells
(c) Root and shoot tips (d) Xylem cells

43. 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 (Phase-II) 2016]**

(a) Gibberellin and abscisic acid
(b) IAA and gibberellin
(c) Auxin and cytokinin
(d) Auxin and abscisis acid

Gibberellins

1. Gibberellin was first extracted from **[CPMT 1993, 94, 96, 98, 2003; AFMC 2006]**
(a) *Gibberella fujikuroi* (b) Algae
(c) Bacteria (d) Roots of higher plants

2. Specific property attributed to gibberellins is **[KCET 2004]**
(a) Shortening of genetically tall plants
(b) Elongation of genetically dwarf plant
(c) Promotion of rooting
(d) Yellowing of young leaves

3. The hormone involved in metabolism of food material in cereal grain during germination is **[DPMT 2003; BVP 2004]**
(a) Auxin (b) *CKN*
(c) *GA* (d) None of these

4. Cell elongation in internodal region takes place due to **[MP PMT 1999; CBSE PMT 2004; DPMT 2007; J & K CET 2012]**
(a) Gibberellins (b) Ethylene
(c) Cytokinins (d) Indole acetic acid

5. Which of the following plant hormone substitutes for long photoperiods in flowering plants **[BHU 2004]**
(a) Auxins (b) Gibberellins
(c) Cytokinins (d) Ethylene

6. Gibberellic acid induces flowering **[CBSE PMT 1997]**
(a) In some gymnospermic plants only
(b) In long day plants under short day conditions
(c) In short day plants under long day conditions
(d) In day neutral plants under dark conditions

7. Which one of the following pairs, is not correctly matched **[CBSE PMT 2007]**
(a) Abscissic acid – Stomatal closure
(b) Gibberellic acid – Leaf fall
(c) Cytokinin – Cell division
(d) IAA – Cell wall elongation

8. Parthenocarpic tomato fruites can be produced by **[CBSE PMT 2006]**
(a) Raising the plants from vernalized seeds
(b) Treating the plants with phenylmercuric acetate
(c) Removing androecium of flowers before pollen grains are released
(d) Treating the plants with low concentrations of gibberellic acid and auxins

9. Gibberellins can promote seed germination because of their influence on **[AIIMS 2005; NEET 2013]**
(a) Rate of cell division
(b) Production of hydrolyzing enzymes
(c) Synthesis of abscisic acid
(d) Absorption of water through hard seed coat

10. Dormancy of seed is broken by **[RPMT 2002; Pb. PMT 2004; WB JEE 2016]**
(a) Auxin and Cytokinin (b) Gibberellins and ethylene
(c) Ethylene and auxin (d) Cytokinin and auxin

11. Apical dominance is not affected by **[MP PMT 2001]**
(a) Indole acetic acid (b) Gibberellic acid
(c) Indole acetaldehyde (d) Indole butyric acid

12. The hormone which was discovered through 'foolish seedling' disease of rice is **[AIIMS 1994; CBSE PMT 2007; BHU 2008]**
Or
Bakane disease in paddy is caused by **[VITEEE 2006; WB JEE 2009]**
(a) Indole–3–acetic acid (b) Ethylene
(c) Gibberellic acid (d) Kinetin

13. Gibberellins were first discovered in fungal genus **[MP PMT 1999]**
(a) *Mucor* (b) *Rhizopus*
(c) *Agaricus* (d) *Fusarium*

14. The rosette habit of cabbage can be changed by application of **[KCET 2011]**
(a) IAA (b) GA
(c) ABA (d) Ethaphon

15. At the onset of seed germination, the digestive enzymes amylase are produced by the action of **[BHU 2005; AMU (Med.) 2006]**
Or
The activity of α amylase in the endosperm of barley geminating seed is induced by **[MP PMT 2002]**
(a) Auxins (b) Gibberellins
(c) Cytokinins (d) Ethylene

16. The chemical nature of gibberellins is that they are **[KCET 2006]**
(a) Acidic (b) Alkaline
(c) Proteinaceous (d) Amines

17. The gibberellins are plant growth hormones. They cause elongation of stems. Gibberellin was first isolated by Japanese workers from **[CPMT 1993, 94, 2003; AIEEE Pharmacy 2003; DPMT 2004]**
(a) Endosperm of barley (b) Sporophyte of moss
(c) A parasitic fungus (d) Scutellum of rice

Cytokinin

1. Cytokinin is a hormone whose main function is **[AFMC 1997, 2000, 12; CPMT 2000, 10; AIIMS 2001; BHU 2004; Odisha JEE 2004]**
(a) Induction of cell division and delay in senescence
(b) To take part in cell division
(c) Refers to cell movements
(d) To cause dormancy

2. Richmond Lang effect can be observed in plants by the treatment of **[MP PMT 1993; Odisha JEE 2012]**
(a) Cytokinin (b) Ethylene
(c) Abscisic acid (d) Gibberellins

3. A plant hormone used for inducing morphogenesis in plant tissue culture is **[CBSE PMT 1998]**
Or
For plant tissue culture among the following which one is required
(a) Abscisic acid (b) Gibberellins
(c) Cytokinins (d) Ethylene

4. Cytokinesis refers to **[KCET 1994]**
(a) Division of chromosomes (b) Division of cytoplasm
(c) Division of nucleus (d) None of these

5. Leaf fall can be prevented by
(a) Florigen (b) Auxin
(c) Cytokinins (d) Abscisic acid

6. Which of the following induces flowering in short day plant **[AFMC 1997]**
(a) Gibberellins (b) Cytokinin
(c) Auxins (d) Ethylene

7. All the cytokinins are **[MP PMT 1996]**
(a) Acidic (b) Aminopurines
(c) Phenol (d) Glucosides

8. Pick out the correct statements
(A) Cytokinins specially help in delaying senescence
(B) Auxins are involved in regulating apical dominance
(C) Ethylene is especially useful in enhancing seed germination
(D) Gibberellins are responsible for immature falling of leaves **[Kerala PMT 2008]**
(a) A and C only (b) A and D only
(c) B and C only (d) A and B only
(e) B and D only

9. Which of the following is a coconut milk factor **[NCERT; CBSE PMT 2000, 03; Manipal 2005; J & K CET 2008; AFMC 2009]**
(a) Auxin (b) Cytokinin
(c) Morphactin (d) None of the above

10. Match the following and choose the correct combination

Column I	Column II
A. Zeatin	1. Flowering hormone
B. Florigen	2. Synthetic auxin
C. IBA	3. Cytokinin
D. NAA	4. Natural auxin

[Kerala PMT 2009]
(a) A — 3, B — 4, C — 1, D — 2
(b) A — 2, B — 1, C — 4, D — 3
(c) A — 1, B — 2, C — 3, D — 4
(d) A — 4, B — 1, C — 2, D — 3
(e) A — 3, B — 1, C — 4, D — 2

11. Farmers in a particular region were concerned that premature yellowing of leaves of a pulse crop might cause decrease in the yield. Which treatment could be most beneficial to obtain maximum seed yield **[CBSE PMT 2006; AIIMS 2007]**
(a) Removal of all yellow leaves and spraying the remaining green leaves with 2, 4, 5-trichlorophenoxy acetic acid
(b) Application of iron and magnesium to promote synthesis of chlorophyll
(c) Frequent irrigaion of the crop
(d) Treatment of the plants with cytokinins alongwith a small does of nitrogenous fertilizer

12. Cytokinins are formed in **[NCERT; BVP 2004]**
(a) Roots (b) Leaves
(c) Fruits (d) Stems

13. An excised leaf does not turn yellow if it is induced to root. This is attributed to synthesis in root of **or** Leaf aging is retarded by **[BHU 2003]**

Or

The cut flowers and vegetables can be kept fresh a long period by this plant hormone **[Kerala PMT 2004; KCET 2012]**
(a) Ethylene (b) Cytokinins
(c) Gibberellins (d) Auxins

14. Which of the following is indispensable in all culture
(a) Gibberellin (b) Kinetin
(c) Ethylene (d) Auxin

15. Cambial tissue of *Pinus radiata* contains
(a) Auxins (b) Gibberellins
(c) Cytokinin (d) None of the above

16. Guttman (1957) found a quick increase in the amount of RNA in the nuclei on onion root after
(a) Auxin treatment (b) Kinetin treatment
(c) Gibberellin treatment (d) All the above

17. RNA formation is induced by
(a) Phyllocalins (b) All calins
(c) Kinetins (d) Florigens

18. Cytokinin was first synthesized by **[RPMT 1995; BVP 2003]**

Or

Name '*zeatin*' was given by **[RPMT 1995; J & K CET 2002; BVP 2003]**
(a) Skoog and Miller (b) Letham
(c) Bensan and Calvin (d) Thimman and Went

19. The natural plant hormone isolated from corn kernels and coconut milk is **[Kerala PMT 2007]**
(a) Florigen (b) GA_3
(c) Free auxins (d) Zeatin
(e) Indole acetic acid

Ethylene

1. Pineapple can be made to flower in off season by **[NCERT]**
(a) Ethylene/*NAA* (b) Zeatin
(c) Short day (d) Temperature

2. Ethylene gas **[BHU 1994]**
(a) Is a saturated hydrocarbon
(b) Slows down the ripening of apples
(c) Retards ripening of tomatoes
(d) Speeds up maturation of fruits and early ripening of some fruits

3. The phytohormone which induces triple response is **[J & K CET 2008]**
(a) *IAA* (b) *ABA*
(c) GA_3 (d) C_2H_4

4. Ethylene is a **[BHU 1994; Bihar MDAT 1995; RPMT 1999; BVP 2000; Pb. PMT 2004; HP PMT 2005; WB JEE 2009]**
(a) Gaseous hormone (b) Gaseous enzyme
(c) Liquid–gas mixture (d) Solid hormone

5. A higher proportion of ethylene is found in
(a) Ripening banana (b) Green banana
(c) Green apple (d) Fresh potato tuber

6. The most efficient precursor of ethylene is
(a) Adenine (b) Thiocarbamate
(c) Zeation (d) Methionine

7. The ripening of fruits can be hastened by treatment with **[NCERT; CPMT 1994, 2001, 03, 09; MP PMT 1994, 2005; BHU 1995, 2000; KCET 2000; Odisha JEE 2004; HP PMT 2005; AMU (Med.) 2006; Kerala PMT 2009]**
(a) Gibberellic acid (b) Indole acetic acid
(c) Florigen (d) Ethylene gas

8. Which of the following is called as *phytogerontological hormone*
(a) Ethylene (b) Auxin
(c) Gibberellin (d) Cytokinin

9. Which one of the following responses of plants to growth hormones is true for ethylene **[MP PMT 1995]**
(a) Increase in cell elongation
(b) Decrease in the formation of female flowers
(c) Increase in ripening of fruits
(d) Decrease in abscission of flowers

10. Artificial ripening of which of the following fruits is useless **[CBSE PMT 1992]**
(a) Mango (b) Banana
(c) Grapes (d) Pomegranate/Coconut

11. Root development is promoted by **[CBSE PMT (Mains) 2010]**
(a) Abscisic acid (b) Auxin
(c) Gibberellin (d) Ethylene

12. Which combination of gases is suitable for fruit ripening **[CBSE PMT 1998]**
(a) 80% C_2H_4 and 20% CO_2 (b) 80% CO_2 and 20% CH_2
(c) 80% CH_4 and 20% CO_2 (d) 80% CO_2 and 20% O_2

13. Which hormone causes stunted growth in pea **[MHCET 2003]**
(a) Gibberellic acid (b) Auxin
(c) Cytokinin (d) Ethylene

ABA and Other growth regulators

1. Abscisic acid controls **[CBSE PMT 1990, 99; EAMCET 1995]**
(a) Shoot elongation
(b) Cell elongation and cell wall formation
(c) Cell division
(d) Leaf fall and dormancy

2. The following is a naturally occuring growth inhibitors **[CPMT 1996; AFMC 2010]**
(a) *IAA* (b) *ABA*
(c) *NAA* (d) *GA*

3. Which one of the following acids is a derivative of carotenoids **[CBSE PMT 2009]**

Or

One of the most commonly detected inhibitor of germination is **[JIPMER 2002]**
(a) Indole butyric acid (b) Indole-3-acetic acid
(c) Gibberellic acid (d) Abscisic acid

4. Wound hormone is called
(a) Necrohormone (b) Hormone only
(c) Auxins (d) Phyllocaline

5. Maleic hydrazide is used to
(a) To prolong dormancy (b) To break dormancy
(c) Both (a) and (b) (d) None of the above

6. Match List I and List II and select the correct option

List I		List II	
A.	Auxin	1.	Herring sperm DNA
B.	Cytokinin	2.	Inhibitor of growth
C.	Gibberellin	3.	Apical dominance
D.	Ethylene	4.	Epinasty
E.	Abscisic acid	5.	Induces amylase synthesis

[Kerala PMT 2008]
(a) A – 3, B – 1, C – 5, D – 4, E – 2
(b) A – 4, B – 5, C – 1, D – 3, E – 2
(c) A – 2, B – 1, C – 5, D – 3, E – 4
(d) A – 3, B – 1, C – 5, D – 2, E – 4
(e) A – 4, B – 1, C – 5, D – 3, E – 2

7. "*Morphactins*" are
(a) Synthetic growth regulators (b) Synthetic auxins
(c) Synthetic gibberellins (d) None of the above

8. Elongation of internodes is inhibited by
(a) Gibberellins (b) Morphactins
(c) Both (a) and (b) (d) None of the above

9. One hormone helps in ripening of fruits while the other stimulates closure of stomata. These are respectively **[Kerala PMT 2008]**
(a) Abscisic acid and auxin
(b) Ethylene and abscisic acid
(c) Abscisic acid and ethylene
(d) Ethylene and gibberellic acid
(e) Gibberellic acid and abscisic acid

10. Match the items in Column – I with Column – II and choose the correct option

Column – I		Column – II	
A.	Human urine	1.	Cytokinin
B.	*Gibberella fujikuroi*	2.	Auxin
C.	Herring fish DNA	3.	Ethylene
D.	Ripening fruits	4.	Abscisic acid
E.	Aged leaves of plants	5.	Gibberellins

[Kerala PMT 2007]
(a) A – 2, B – 5, C – 1, D – 3, E – 4
(b) A – 2, B – 3, C – 4, D – 5, E – 1
(c) A – 1, B – 5, C – 2, D – 4, E – 3
(d) A – 5, B – 4, C – 3, D – 2, E – 1
(e) A – 3, B – 2, C – 1, D – 5, E – 4

11. Which one of the following generally acts as an antagonist to gibberellins **[NCERT; CBSE PMT (Mains) 2012; BHU 2012]**
(a) Zeatin (b) Ethylene
(c) ABA (d) IAA

12. Abscisic acid treatment results in **[CBSE PMT 1991; Odisha JEE 2005; GUJCET 2007; J & K CET 2010]**
(a) Leaf expansion (b) Stem elongation
(c) Stomatal closure (d) Root elongation

13. Which plant hormone promotes seed, bud dormancy and causes stomatal closure **[CBSE PMT 1999; AIIMS 1999, 2002; DPMT 2006; WB JEE 2008]**

Or

Presence of which of the following in seed is associated with dormancy **[CBSE PMT 1999; BVP 2002]**

Or

Leaf abscission, fruit fall, bud dormancy occurs by which Phytohormone **[CPMT 1998; AFMC 2004; BHU 2006; J & K CET 2010]**

(a) *IAA* (b) Abscisic acid
(c) GA_1 (d) Cytokinin

14. In the extreme drought condition which of the following plant hormone is produced due to which stomata closes **[AMU (Med.) 2005; J & K CET 2012]**

(a) *ABA* (b) *I.A.A*
(c) Gibberellin (d) Ascorbic acid

15. Choose the wrongly matched pair from the following **[Kerala PMT 2006]**

(a) Auxins – "to grow"
(b) Gibberellins – *Gibberella fujikurai*
(c) Cytokinins – Herring sperm DNA
(d) Abscissic acid – Flowering hormone
(e) Ethylene – Gas hormone

16. Phytotron is **[CPMT 2003]**

(a) Fish culture (b) Plant hormone
(c) Animal hormone (d) None of these

17. The shedding of leaves, flowers or fruits due to change in the hormonal balance in plant is referred as **[J & K CET 2005]**

(a) Senescence (b) Abscission
(c) Photoperiodism (d) Vernalisation

18. Which one of the following plant hormones (Phytohormone) is known as a stress hormone **[NCERT; MHCET 2000; MP PMT 2006; WB JEE 2008; AIIMS 2012; CBSE PMT 2014]**

(a) Gibberellins (b) Kinetin
(c) Auxin (d) Abscisic acid

19. Which of the following hormone is responsible for senescence **[CBSE PMT 2001]**

(a) *GA* (b) *ABA*
(c) Auxin (d) Cytokinin

Photoperiodism and Vernalization

1. The response of different organisms to the environmental rhythms of light and darkness is called **[CBSE PMT 1998; Kerala PMT 2009]**

Or

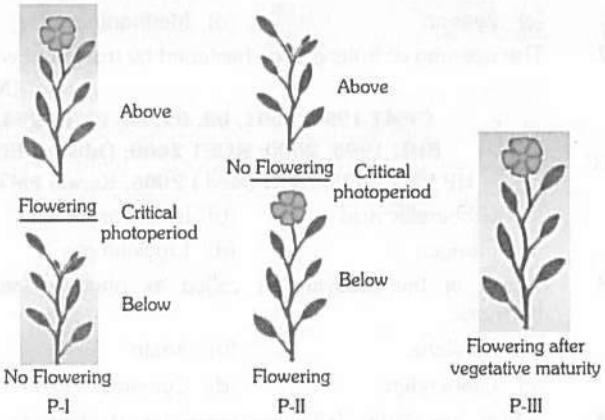
The effect of daily light period on flowering is called **[CPMT 1999]**

(a) Phototaxis (b) Phototropism
(c) Vernalization (d) Photoperiodism

2. With which of the following process *Cholodny–Went theory* is concerned **[Odisha JEE 2008]**

(a) Phototropism (b) Photomorphogenesis
(c) Photorespiration (d) Photoperiodism

3. See the following experiment and observe the result



Now identify plants (P - I, II and III) **[NCERT]**

(a) P - I = Long day plant; P - II = Long day plant; P - III Day neutral plant
(b) P - I = Short day plant; P – II = Short day plant; P - III = Day neutral plant
(c) P - I = Short day plant; P - II = Long day plant; P - III Day neutral plant
(d) P - I = Long day plant; P - II = Short day plant; P - III = Day neutral plant

4. The red absorbing form of phytochrome gets converted to the far–red absorbing form after getting irradiated at **[BHU 1994]**

(a) 660 *nm* (b) 730 *nm*
(c) 530 *nm* (d) 660 *nm* to 730 *nm*

5. The pigment involved in red–far red light interconversion is **[CPMT 1994; CBSE PMT 1995, 2002]**

Or

The pigment involved in photomorphogenetic movements is **[BHU 2000]**

Or

Pigment involved in photo–perception in flowering is

(a) Cytochrome (b) Xanthophyll
(c) Lycopen (d) Phytochrome

6. Importance of day length (Photoperiodism) in flowering of plants was first shown in **[CBSE PMT 2008; CBSE PMT (Pre.) 2010]**

(a) Cotton (b) *Petunia*
(c) *Lemna* (Photoperiodism) (d) Tobacco

7. *Nicotiana* sylvestris flowers only during long days and *N. tobacum* flowers only during short days.If raised in the laboratory under different photoperiods, they can be induced to flower at the same time and can be cross fertilized to produce self–fertile offspring. What is the best reason for considering *N. sylvestris* and *N.tobacum* to be separate species **[AIIMS 2007]**

(a) They are physiologically distinct
(b) They are morphologically distinct
(c) They cannot interbreed in nature
(d) They are reproductively distinct

8. Phytochrome is found in [MP PMT 2007]
(a) Algae (b) Fungi
(c) Vascular cryptogams (d) Flowering plants

9. Effect of length of day (light duration) on flowering is called [JIPMER 2001]
(a) Phototropism (b) Photoperiodism
(c) Photorespiration (d) None of the above

10. *Saccharum officinarum* grows well in [Odisha JEE 2008]
(a) Low temperature (b) Swampy area
(c) Dry and arid condition (d) Moist condition

11. When the dark period of short day plants is interrupted by a brief exposure of light, then the plant [CBSE PMT 1994]
(a) Will not flower at all
(b) Flower immediately
(c) Give more flowers
(d) Turn into a long day plant

12. Which of the following hormones can replace vernalization [BHU 1994]
Or
Genetic dwarfness can be overcome by treating with [MHCET 2003]
(a) Auxin (b) Ethylene
(c) Gibberellins (d) Cytokinins

13. Which of the following is a short day plant [HP PMT 2005]
(a) Wheat (b) Barley
(c) Larkspur (d) *Dahlia*

14. What helps in flowering [DPMT 2006; Odisha JEE 2012]
(a) Cytochrome (b) *ABA*
(c) C-phytochrome (d) Ethylene

15. Vernalisation stimulates flowering in [NCERT; CBSE PMT (Mains) 2012]
(a) Zamikand (b) Turmeric
(c) Carrot (d) Ginger

16. Photoperiodic stimulus is received by [MP PMT 1999]
(a) Leaves (b) Buds
(c) Meristem (d) Flowers

17. Biological clock in plants is controlled by [BHU 2012]
(a) Phytochrome (b) Cryptochrome
(c) Both (a) and (b) (d) Gibberellin

18. The period of suspended growth due to exogenous condition is termed as [J & K CET 2005]
(a) Quiescence (b) Dormancy
(c) Perennation (d) Hibernation

19. Short day plant is [Odisha JEE 2005]
(a) *Xanthium* (b) *Pisum*
(c) *Cucumis* (d) *Avena*

20. Through their effect on plant growth regulators, what do the temperature and light control in the plants [NCERT; CBSE PMT (Mains) 2012]
(a) Apical dominance (b) Flowering
(c) Closure of stomata (d) Fruit elongation

21. Photoperiodism is substituted by [MP PMT 2005]
(a) Temperature (b) Mineral nutrient
(c) Vit. (d) Iron

22. If plants are given only visible light it's growth will [MP PMT 2005]
(a) Increase (b) Decrease
(c) Unusual form (d) None of these

23. Phytochrome occurs in two forms. In which form it promotes the germination of seeds of some species [CPMT 1995, 2004]
(a) P_{fr} forms (b) P_r forms
(c) Both forms (d) None of these

24. When flowering is regulated by length of day and night, it is called [Odisha JEE 2004; MP PMT 2012]
(a) Photoperiodism (b) Phototropism
(c) Nyctinasty (d) None of these

25. Most of the plants are seasonal due to [MP PMT 1997]
(a) Photoperiodism (b) Phototropism
(c) Photosynthesis (d) Photolysis

26. Name '*phytochrome*' was given by [MP PMT 2001]
(a) Mothes (b) Borthwick and Hendrick
(c) Sorokin *et al* (d) Wickson and Thimman

27. One set of a plant was grown at 12 hours day and 12 hours night period cycles and it flowered while in the other set night phase was interrupted by flash of light and it did not produce flower. Under which one of the following categories will you place this plant [CBSE PMT 2004]
(a) Day neutral (b) Short day
(c) Long day (d) Darkness neutral

28. The low temperature treatment that reduces the period between sowing and flowering is called [BHU 1999, 2006; CPMT 2000; DPMT 2003, 04; BVP 2004; AMU (Med.) 2005, 06; HP PMT 2005; Kerala PMT 2006]
Or
The practice of subjecting seeds to low temperatures for a period of time in order to cause growth and flowering during summer season is called [CBSE PMT 1992; WB JEE 2016]
(a) Chemotaxis (b) Vernalization
(c) Freezing injury (d) None of the above

29. Phytochrome is closely related to [RPMT 1999]
(a) Chlorophyll '*e*' (b) Bacterio chlorophyll
(c) Phycocyanin '*c*' (d) Carotinoid

30. Treatment of seed at low temperature under moist conditions to break its dormancy is called [CBSE PMT 2006]
(a) Chelation (b) Stratification
(c) Scarification (d) Vernalization

31. In SDP flowering does not occur [BHU 2003]
(a) When intermediate light is given red → far red → red
(b) Interrupted by a flash of far light
(c) Interrupted by a flash red → far light
(d) All of these

32. The term "*photoperiodism*" was proposed by **or** The phenomenon of photoperiodism in plants was discovered by **[MP PMT 1994, 98, 2002, 12]**
(a) Lysenko and Thimman
(b) Blackman and Skoog
(c) Garner and Allard
(d) Chailakhyan and Borthwick

33. A hypothetical chemical involved in the flowering of plants is **or** Chemical agent which has important role in flowering is **[CBSE PMT 1991]**
(a) Gibberellin (b) Kinetin
(c) Indole acetic acid (d) Florigen

34. Phytochrome is used in **[RPMT 1992; Kerala CET 2001, 03]**
(a) Flowering only
(b) Seed germination only
(c) Transpiration only
(d) All physiological processes exhibited by the plants such as seed germination, flowering (photoperiodism), stem elongation and transpiration

35. In short day plants (SDP) flowering is induced by **[CBSE PMT 1992]**
(a) Long night
(b) Photoperiod less than 12 hours
(c) Photoperiod shorter than initial value and uninterrupted long night
(d) Short photoperiod and interrupted long night

36. If a tree flowers thrice in a year (October, January and July) in Northern India, it is said to be **[CBSE PMT 1997]**
(a) Photosensitive but thermo-insensitive
(b) Thermosensitive but photo-insensitive
(c) Photo and thermo-insensitive
(d) Photo and thermosensitive

37. For germination of seed, which light is necessary **[AFMC 1996]**

Or

Which wavelength of light is responsible for best flowering **[MP PMT 2011]**
(a) Red light (b) Green light
(c) Far–red light (d) Blue light

38. Phytochrome becomes active in **[MP PMT 1998; CBSE PMT 1998]**
(a) Green light (b) Blue light
(c) Red light (d) None of these

39. Phytochrome is **[MP PMT 1993]**
(a) Absorption of blue light by leaves
(b) Absorption of *PR* and *PFR* in reversible manner
(c) Absorption of red light with wavelength 660$m\mu$
(d) Absorption of far–red light with wavelength 740$m\mu$

40. A pigment concerned with both floral induction and seed germination is **[MP PMT 2002; CPMT 2010]**
(a) Florigen (b) Chlorophyll
(c) Plastocyanin (d) Phytochrome

41. Photoperiodism affects **[MP PMT 2001]**
(a) Vegetative growth (b) Internode elongation
(c) Seed germination (d) All of these

42. Florigen is synthesized in **[RPMT 1995]**
(a) Stem (b) Leaves
(c) Root (d) Fruits

43. With respect to photoperiodism, these are long day plant **[MP PMT 2007; GUJCET 2007]**
(a) Wheat, oat, soyabean
(b) Wheat, *Xanthium*, paddy
(c) Wheat, poppy, soyabean
(d) Wheat, poppy, beet

44. Which of the following is a long day plant **[CBSE PMT 2001; AFMC 2010]**
(a) *Mirabilis*
(b) *Glycine max*
(c) *Mirabilis jalapa*
(d) *Spinacia oleracea* (Spinach)

45. What is the action spectrum of photoperiodism
(a) 430 and 660 *nm* (b) 640 and 660 *nm*
(c) 660 and 730 *nm* (d) 700 and 900 *nm*

46. Proteinaceous pigment which is the centre of activities concerned with light is **[CBSE PMT 2001]**
(a) Phytochrome (b) Chlorophyll
(c) Anthocyanin (d) Carotenoids

47. A few normal seedlings of tomato were kept in a dark room. After a few days they were found to have become white-coloured like albinos. Which of the following terms will you use to describe them **[Bihar MDAT 1995; DUMET 2009; CBSE PMT 2014]**
(a) Etiolated (b) Defoliated
(c) Mutated (d) Embolised

48. The wavelength of light absorbed by Pr form of phytochrome is **[CBSE PMT 2007]**
(a) 640 *nm* (b) 680 *nm*
(c) 720 *nm* (d) 620 *nm*

49. Phytochrome is sensitive to **[BHU 2001; Pb. PMT 2004]**
(a) Red light (b) Far red light
(c) Green light (d) Both (a) and (b)

50. *Chrysanthemum* flowers either in winter season or in evening because it is a **[J & K CET 2008]**
(a) Short–day plant (b) Long–day plant
(c) Day–neutral plant (d) Mid–day plant

51. Phytochrome is a **[NEET (Phase-II) 2016]**
(a) Chromoprotein (b) Flavoprotein
(c) Glycoprotein (d) Lipoprotein

52. Plants which disregard the requirement of a definite day length for the flowering are called **[WB JEE 2016]**
(a) Short day plants (b) Long day plants
(c) Day neutral plants (d) Long short-day plants

NCERT Exemplar Questions

1. The photoperiod in plants is perceived at **[NCERT]**
(a) Meristem (b) Flower
(c) Floral buds (d) Leaves

2. The affect of apical dominance can be overcome by which of the following hormone **[NCERT]**
(a) IAA (b) Ethylene
(c) Gibberellin (d) Cytokinin

3. Match the following

A. IAA	i. Herring sperm DNA
B. ABA	ii. Bolting
C. Ethylene	iii. Stomatal closure
D. GA	iv. Weed-free lawns
E. Cytokinins	v. Ripening of fruits

Options **[NCERT]**
(a) A-iv, B-iii, C-v, D-ii, E-i
(b) A-v, B-iii, C-iv, D-ii, E-i
(c) A-iv, B-i, C-v, D-iii, E-ii
(d) A-v, B-iii, C-ii, D-i, E-iv

4. Apples are generally wrapped in waxed paper to **[NCERT]**
(a) Prevent sunlight for changing its colour
(b) Prevent aerobic respiration by checking the entry of O_2
(c) Prevent ethylene formation due to injury
(d) Make the apples look attractive

5. Growth can be measured in various ways. Which of these can be used as parameters to measure growth **[NCERT]**
(a) Increase in cell number
(b) Increase in cell size
(c) Increase in length and weight
(d) All the above

6. The term synergistic action of hormones refers to **[NCERT]**
(a) When two hormones act together but bring about opposite effects
(b) When two hormones act together and contribute to the same function
(c) When one hormone affects more than one function
(d) When many hormones bring about any one function

7. Plasticity in plant growth means that **[NCERT]**
(a) Plant roots are extensible
(b) Plant growth is dependent on the environment
(c) Stems can extend
(d) None of the above

8. To increase sugar production in sugarcanes, they are sprayed with **[NCERT]**
(a) IAA (b) Cytokinin
(c) Gibberellin (d) Ethylene

9. Monocarpic plants are those which **[NCERT]**
(a) Bear flowers with one ovary
(b) Flower once and die
(c) Bear only one flower
(d) All of the above

Critical Thinking Objective Questions

1. During cell enlargement phase of growth, molecules of new cell wall material are inserted between the original molecules of stretched wall. This process is known as
(a) Intussusception (b) Apposition
(c) Integration (d) None of the above

2. Senescence as an active developmental cellular process in the growth and functioning of a flowering plant, is indicated in **[CBSE PMT 2008]**
(a) Annual plants
(b) Floral parts
(c) Vessels and tracheid differentiation
(d) Leaf abscission

3. Phytohormones are **[CBSE PMT 1990; AFMC 2006]**
(a) Hormones regulating growth from seed to adulthood
(b) Growth regulators synthesised by plants and influencing physiological processes
(c) Hormones regulating flowering
(d) Hormones regulating secondary growth

4. Identify two physiological processes induced by two different phytohormones having a common precursar which is formed due to the catalytic activity of pyruvic dehydrogenase complex
(I) More female flowers in cucumber
(II) α-amylase production in barley grain
(III) Acceleration of fruit ripening in tomato
(IV) Delay in sprouting of potato tubers
The correct combination is **[EAMCET 2009]**
(a) I, II (b) I, III
(c) II, IV (d) III, IV

5. Choose the correct sequence of stages of growth curve for bacteria **[AIIMS 2007]**
(a) Lag, log, stationary, decline phase
(b) lag, log, stationary phase
(c) Stationary, lag, log, decline phase
(d) Decline, lag, log phase

6. Which of the following is more essential for the breaking of seed dormancy **[Odisha JEE 2008; MHCET 2011]**
(a) Light (b) Heat
(c) Cold (d) Moisture

7. Moving on a grass lawn facilitates better maintenance primarily owing to **[JIPMER 1994]**
(a) Removal of apical dominance and promotion of lateral meristem
(b) Removal of apical dominance
(c) Wounding which stimulate rapid regeneration
(d) None of the above

8. Apical dominance means
   (a) Suppression of growth of apical bud by axillary buds
   (b) Suppression of growth of axillary buds by presence of apical bud
   (c) Stimulation of growth of apical bud by removal of axillary buds
   (d) Inhibition of growth of axillary buds by removal of apical bud

9. Clinostat is the apparatus used to
   (a) Measure the rate of growth in plant
   (b) Measure the quantity of auxin in plant
   (c) Measure the effect of light on plant
   (d) Eliminate the effect of gravity on plant

10. Which of the following statement is false with respect to application of auxins
   (a) Control direction of growth of plants
   (b) Inhibits lateral bud growth
   (c) Initiate and promote cell division actively particularly in tissue culture
   (d) Produce hyperelongation effect

11. A green plant bends towards the source of light when exposed to the light on only one side, it bends towards the source of light as it grows. Which of the following is the best explanation of the phenomenon **[AIPMT (Cancelled) 2015]**
   (a) The apices of their stems are attracted by light
   (b) They need light for photosynthesis
   (c) Some auxins accumulates on the shaded side to induce greater cell elongation on that side
   (d) Light stimulates the cells on the illuminated side to increase in length

12. What will be the effect on phytochrome in a plant subjected to continuous red light **[CBSE PMT 1997]**
   (a) Level of phytochrome will decrease
   (b) Phytochrome will be destroyed
   (c) Phytochrome synthesis will increase
   (d) None of these

13. Exogenous application of gibberellins induces male flower formation on genetically female plants in
   (a) *Carica* (b) *Cucumis*
   (c) *Coccinia* (d) *Cucurbita*

14. A genetically dwarf plant can be converted into a tall plant by the use of **[MP PMT 1996]**
   (a) Kinetin (b) GA_3
   (c) *IAA*/X-rays (d) 2, 4–*D*

15. One hormone is used to speed up the malting process in barley, another is used to promote flowering in pineapple, while the third helps in the delay of leaf senescence. These are respectively **[Kerala PMT 2012; AMU (Med) 2012]**
   (a) Auxin, gibberellin and cytokinin
   (b) Gibberellin, cytokinin and auxin
   (c) Gibberellin, auxin and cytokinin
   (d) Cytokinin, auxin and gibberellin
   (e) Auxin, cytokinin and gibberellin

16. The ripening of fruits can be accelerated by
   (a) Reducing the supply of water to plant when fruits are maturing
   (b) Increasing the supply of nitrogen to the atmosphere surrounding them
   (c) Warming up the surroundings artificially
   (d) Artificially adding ethylene gas to the atmosphere surrounding them

17. Which one of the following statements is true for the phytochrome **[MP PMT 1995]**
   (a) Phytochrome is a phytohormone
   (b) Phytochrome is a photosynthetic pigment
   (c) Phytochrome is a pigment that controls growth, photomorphogenesis and development of many plants
   (d) Phytochrome is a regulatory protein that controls several dark–dependent developmental processes

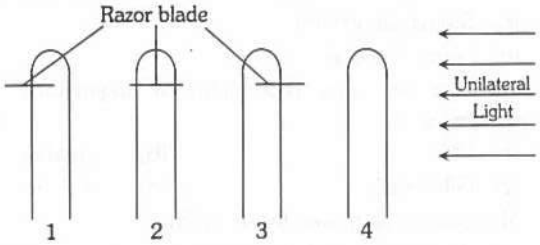
18. Which one of the following synthetic growth regulators is used to promote synchronized flowering in pineapple **[KCET 2010]**
   (a) Benzyl aminopurine
   (b) Phenylmercuric acetate
   (c) Indolebutyric acid
   (d) 2-chloroethylphosphoric acid

19. Which one of the following pairs is incorrectly matched **[NCERT; Kerala PMT 2011]**

(a)	Adenine derivative	-	Kinetin
(b)	Carotenoid derivative	-	ABA
(c)	Terpenes	-	IAA
(d)	Indole compounds	-	IBA
(e)	Gas	-	Ethylene

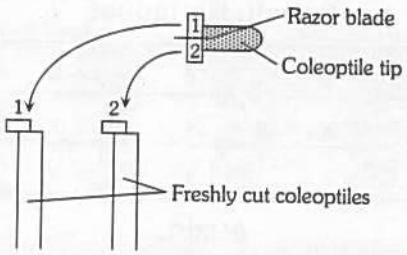
20. The viability of seeds is tested by **[NEET (Karnataka) 2013]**
   (a) 2, 6 dichlorophenol indophenols
   (b) 2, 3, 5 triphenyl tetrazolium chloride
   (c) DMSO
   (d) Safranine

21. The given figure shows four coleoptiles set up at the start of an experiment

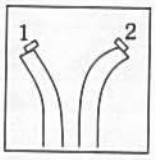


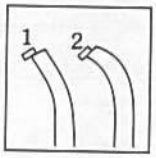
Which two coleoptiles will bend towards the light source **[NCERT]**
   (a) 3 and 4 (b) 2 and 3
   (c) 1 and 4 (d) 1 and 2

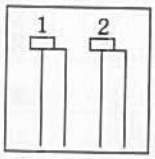
22. Two blocks of Agar 1 and 2 were kept in the positions shown in the diagram below for several hours and then transferred into two freshly cut coleoptiles

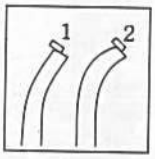


After two days of growth which of the following would result **[NCERT]**

(a) 

(b) 

(c) 

(d) 

23. One hormone hastens maturity period in juvenile conifers, a second hormone controls xylem differentiation, while the third increases the tolerance of plants to various stresses they are respectively **[KCET 2015]**

(a) Gibberellin, Auxin, Cytokinin
(b) Auxin, Gibberellins, Cytokinin
(c) Gibberellin, Auxin, ABA
(d) Auxin, Gibberellins, ABA

24. Which of the following enhances or induces fusion of protoplasts **[AIPMT (Cancelled) 2015]**

(a) Polyethylene glycol and sodium nitrate
(b) IAA and kinetin
(c) IAA and gibberellins
(d) Sodium chloride and potassium chloride

25. Seed dormancy can be broken by the following combination of chemicals **[WB JEE 2016]**

(a) GA_3, *IAA* and *ABA*
(b) KNO_3, GA_3 and Ethylene chlorohydrin
(c) *NAA*, 2,4,5 – *T* and *IAA*
(d) *ABA*, *BAP* and GA_3

26. Seedless fruits can be induced by **[WB JEE 2016]**

(a) ABA and IAA
(b) ABA and Zeatin
(c) IAA and GA_3
(d) Ethylene and ABA

AR Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Gibberellins induce flowering in long day plants.
Reason : Genetically tall plantbecome dwarf by application of Gibberellin. **[AIIMS 1994]**

2. Assertion : Agent orange is a mixture of 2,4-D and 2,4,5-T, used during Vietnam War.
Reason : 2,4-D and 2,4,5-T are used as herbicides.

3. Assertion : Auxins promote apical dominance by suppressing the activity of lateral buds.
Reason : In moriculture, periodic pruning of shoot tips is done to make mulberry plants bushy. **[KCET 2009]**

4. Assertion : "Touch" responses in *Mimosa* is an example of such movement.
Reason : Nastic movements occur in the direction of stimulus.

5. Assertion : Photomodulation of flowering is phytochrome-regulated process.
Reason : Active form of phytochrome (Pfr) directly induces floral induction in shoot buds. **[AIIMS 2004]**

6. Assertion : Secondary roots and shoots are plagiogeotropic.
Reason : Plagiogeotropic roots are those which develop at an angle of 45° from the vertical axis.

7. Assertion : The apical bud is the only source of auxins.
Reason : Removal of apical bud promotes lateral bud growth.

8. Assertion : Cytokinin are antisenescent.
Reason : Effects of cytokinins is antagonistic to ethylene.

9. Assertion : Ethylene cause climacteric ripening of fruits.
Reason : Climacteric fruits show a rise in respiration at the time of ripening.

10. Assertion : *Stratification* of seeds may promote their germination.
Reason : *Stratification* promote gibberellin and cytokinins.

11. Assertion : Sigmoid growth curve consists of four parts.
Reason : Lag phase is called as grand phase of growth.

12. Assertion : Dark period play more important part in flowering than light period.
Reason : Flowering occurs in short-day plant if the dark period is interrupted by light break.

13. Assertion : Phototropism is a directional growth movement.
Reason : Phototrophic movement occur in the direction of light.

14. Assertion : Phytochrome exists in two form P_r and P_{fr}.
Reason : P_r form stimulates and P_{fr} form inhibit flowering.

15. Assertion : Floral initiation is done by florigen.
Reason : Florigen is translocated from flowers to leaves.

16. Assertion : Vernalization is a treatment to plant given artifically.
Reason : Vernalization is perceived by whole plant.

17. Assertion : Plant growth as a whole is indefinite.
Reason : Plants retain the capacity of continuous growth throughout their life. **[AIIMS 2011]**

Answers

Growth

1	c	2	c	3	d	4	a	5	b
6	d	7	d	8	a	9	c	10	c
11	d	12	b	13	c	14	c	15	b
16	d	17	c	18	a	19	b	20	b
21	b	22	b	23	b	24	d	25	c
26	b	27	b	28	c	29	b	30	b
31	a								

Growth Hormones

1	d	2	a	3	d	4	b	5	b
6	d	7	a	8	d	9	c	10	d
11	c	12	b	13	a	14	a		

Auxin

1	b	2	c	3	a	4	d	5	c
6	a	7	b	8	a	9	a	10	a
11	b	12	b	13	a	14	d	15	b
16	a	17	c	18	d	19	c	20	c
21	b	22	d	23	d	24	b	25	d
26	a	27	b	28	a	29	b	30	e
31	d	32	a	33	d	34	b	35	b
36	a	37	a	38	b	39	a	40	d
41	a	42	c	43	c				

Gibberellins

1	a	2	b	3	c	4	a	5	b
6	b	7	b	8	d	9	b	10	b
11	b	12	c	13	d	14	b	15	b
16	a	17	c						

Cytokinin

1	a	2	a	3	c	4	b	5	c
6	b	7	b	8	d	9	b	10	e
11	d	12	a	13	b	14	b	15	c
16	b	17	c	18	b	19	d		

Ethylene

1	a	2	d	3	d	4	a	5	a
6	d	7	d	8	a	9	c	10	d
11	d	12	a	13	d				

ABA and Other growth regulators

1	d	2	b	3	d	4	a	5	a
6	a	7	a	8	b	9	b	10	a
11	c	12	c	13	b	14	a	15	d
16	d	17	b	18	d	19	b		

Photoperiodism and Vernalization

1	d	2	a	3	d	4	a	5	d
6	d	7	c	8	d	9	b	10	a
11	a	12	c	13	d	14	c	15	c
16	a	17	c	18	b	19	a	20	b
21	a	22	b	23	a	24	a	25	a
26	b	27	b	28	b	29	c	30	b
31	a	32	c	33	d	34	d	35	c
36	b	37	a	38	c	39	b	40	d
41	d	42	b	43	d	44	d	45	c
46	a	47	a	48	a	49	d	50	a
51	a	52	c						

NCERT Exemplar Questions

1	d	2	d	3	a	4	b	5	d
6	b	7	b	8	c	9	b		

Critical Thinking Questions

1	a	2	d	3	b	4	d	5	a
6	d	7	b	8	b	9	d	10	c
11	c	12	d	13	b	14	b	15	c
16	d	17	c	18	d	19	c	20	b
21	a	22	d	23	c	24	a	25	b
26	c								

Assertion and Reason

1	c	2	b	3	a	4	c	5	c
6	a	7	e	8	b	9	b	10	b
11	c	12	c	13	a	14	c	15	c
16	b	17	a						

AS Answers and Solutions

Growth

1. (c) Apex portion of root is made up of protective tissue 'root cap' and region of cell division is situated below the root cap.

4. (a) Differential length of light and temperature influence the developmental phase of plant. Photoperiodism and vernalization are the two important factors responsible for the flowering of plants.

6. (d) First phase of growth is cell division, second phase is cell enlargement and third phase is cell maturation.

7. (d) In apical meristem, tissue actively dividing cells are present.

8. (a) Apical meristem are found at shoot and root apex. As a result of activity of these meristems plants increases in length.

9. (c) Because growth is a irreversible process.

10. (c) In glass houses when plants are kept on artificial light and temperature, then this method is called phytotron and is applicable in agriculture, horticulture and tissue culture.

13. (c) Most plants require oxygen for seed germination. That is why soil is ploughed before sowing the seeds.

14. (c) The growth of an organism/organ passes through different phases. If the growth rate of a plant part is plotted against time on a graph paper, a sigmoid/S-shaped growth curve is obtained.

18. (a) It represents intial stage of growth. The rate of growth is very slow in lag phase.

19. (b) Scarification is mechanical or chemical method to soften/weaken hard seed coat by chipping, filing or machine threshing, hot water, fat solvent, H_2SO_4.

20. (b) Log phase is the rapid growing phase of plants between lag and stationary phase.

27. (b) Auxanometer can register total growth, rate of growth at specific time and overall pattern of growth. In arc auxanometer actual growth in length of a plant is measured as

$$\text{Actual growth} = \frac{\text{distance travelled by pointer} \times \text{radius of pulley}}{\text{Length of pointer from centre of pulley}}$$

29. (b) Measurement of growth in young root by marking it at 1*mm* intervals with Indian ink was first done by Strasburger.

30. (b) The existence of first plant growth hormone came from the work of Darwin and Darwin. They found that bending movement of coleoptile of canary grass was due to exposure of tip to unilateral light. Boysen-Jenson found that the tip produces a chemical which was later named auxin.

Growth Hormones

3. (d) Growth hormones are also called phytohormomes term given by Thimann (1948).

5. (b) Seed of many plants including the leguminosae, Malvaceae. Chenopodiaceae, Convolvulaceae and Solanceae have very hard seed coats. Such seed coats are impermeable to water.

6. (d) By parthenogenesis, seedless fruits are produced but in pomegranate, this process is inapplicable because in it seeds are important.

7. (a) Growth of the plant is very much regulated by certain chemical substances (hormones), which are synthesized by the plant in very small quantities. They are needed in small quantities at very low concentrations as compared to enzyme.

11. (c) Rhizocaline is also called as root forming hormone and it is produced by the leaves and translocated in a polar manner down the stem.

Auxins

1. (b) Auxin inhibits abscission of leaves and fruits. Abscission layer is produced when the auxin content falls below a minimum.
2. (c) F.W. went isolated auxin from *Avena* coleoptile tip.
3. (a) Presence of auxin causes apical dominance in plants and cytokinins are responsible for breaking of apical dominance.
5. (c) Because photosynthesis is enzymatic reaction and it is anabolic process.
7. (b) In presence of auxins unfertilized ovary get changed into fruit.
10. (a) 2, 4–D (2, 4-dichlorophenoxy acetic acid) is a artificial auxin.
14. (d) 2, 4 dichlorophenory acetic acid is used as a defoliant for broad leaved plants.
23. (d) Auxins are commonly use in hedge making.
27. (b) Because ethylene is responsible for ripening of fruits. Auxins promote elongations and growth of stems and roots and enlargement of many fruits by stimulating elongation of cells in all direction.
28. (a) Weeds are undesirable in a field with a crop that causes poor yeild. 2, 4-D is a famous herbicide or weedicide by which broad-leaved weeds can be destroyed but does not affect mature monocotyledonous plants.
29. (b) Abscission layer is produced when the auxin content falls below a minimum. Application of auxin retards the abscission of leaves, fruits, branches, etc.
31. (d) Many new plants are usually propagated by stem cutting. If we dip to the lower cut end of a cutting in dilute solution of auxins (especially IBA) very soon large number of roots are developed on the cut ends due to which these cutting develop into successful plants.
32. (a) Auxin show polar movement. It is basipetal (from apex to base) in stem but acropetal (from root tip towards shoot) in the root.
34. (b) 2, 4-*D* is a selective weedkiller. It is highly toxic to broad-leaved plants. It increases carbohydrate metabolism to such an extent that the plants burn themselves to death in dicots.
36. (a) Natural auxins are synthesized in physiologically active parts of plants such as shoot apices, leaf primordial and developing seeds, bud, embryos from amino acid tryptophan
38. (b) Hormones are secreted by cells in one part of the plant and produce their effect in other part of the plant.
39. (a) Avena curvature test carried out by F.W. Went demonstrated the effect of auxins on plant growth by performing some experiments with the oat (*Avena sativa*) coleoptile. IAA is the natural auxin.
43. (c) Auxins and cytokinin induce development of root and shoot in a culture medium (respectively)

Gibberellins

1. (a) Gibberellins was extracted from rice seedling suffering from 'bakanae disease' which is caused by *Gibberella fujikuroi* fungus.
2. (b) Gibberellins are weakly acidic hormones having gibbane ring structure which cause cell elongation of intact plants in general and increased internodal length of genetically dwarfed plants (*i.e.*, corn, pea) in particular.
3. (c) GA hormone promotes RNA, protein and enzyme synthesis. They helps in germination process.
4. (a) The gibberellins induce elongation of the internodes. The elongation of stem results due to rapid cell division and cell elongation induced by gibberellins.
5. (b) The GA induced bolting in rosettes is exploited commercially to induce early production of seeds.
6. (b) When long day plant are grown under short day conditions the gibberellins are produced in insufficient quantities and flowering does not occur. However if the plant is transferred to long day conditions or gibberellin solution is applied to leaves flowering occurs.
7. (b) Gibberellic acid is mainly related with elongation of plant.
9. (b) Aleurone layer of endosperm releases α-amylase and protease hydrolytic enzyme, which promotes seed germination.
10. (b) Aleurone layered α-amylase promotes breaking of seed dormancy.
11. (b) GA promote only plant elongation but the apical dominance by auxins.
12. (c) In 19th century, Japanese farmers observed that the seedlings of rice were abnormally elongated due to infection of fungus *Gibberella fujikuroi*. This effect is called as foolish seedling disease.
13. (d) GA Ist discovered from *Gibberella fujikuroi* (*Fusarium moniliforme*) which is of ascomycetous fungus.
15. (b) GA enhances seed germination by enhancing α-amylase synthesis and thus overcomes dormancy.
17. (c) *Gibberella fujikuroi* is the ascomycetous fungus, which is parasitic in nature.

Cytokinin

1. (a) The cytokinin is a true cell division factor, promotes meristematic tissue regions. The cytokinin prevents distruction of chlorophyll in leaves. In presence of kinin the rate of mitotic cell division gets increased. Under this effect when green leaves are kept in cytokinin solution then they become green for long time. So this effect of cytokinin is called as Richmond–Lang effect of senescence.

2. (a) Cytokinins delay the senescence of leaves and other organs by controlling protein synthesis and mobilization. Reported by "Richmond and Lang" in 1957 working on "Xanthium leaves"

3. (c) Cytokinin is a plant hormone which plays a part in organ formation (morphogenesis) with auxin.

4. (b) Cytokinesis – formation of cell after the karyokinesis in the cytoplasm of cell.

5. (c) Cytokinins help in delaying senescence.

6. (b) Cytokinin promotes flowering in some SDP like *Lemna*, *Wolffia*.

7. (b) Bio chemically the cytokinin is aminopurines.

9. (b) In liquid endosperm of coconut kinetin (cytokinins) are present.

12. (a) Cytokinin concentration are highest in meristematic regions and area of continuous growth such as root, young leaves, developing fruits and seed.

13. (b) Cytokinin prevents decolouration of chlorophyll study under Richmond – lang effects. Cytokinin increase shelf life of vegetables and cut flowers and keep them fresh for longer time by preventing deterioration of protein chlorophyll.

14. (b) Kinetin induces cell division.

16. (b) Cytokinin promotes RNA synthesis in nuclei after treatment.

18. (b) Letham first synthesized cytokinin from corn milk.

Ethylene

1. (a) Ethylene retards the flowering in most of the plants but increase flowering in pineapple in off season.

4. (a) Ethylene is gaseous hormone which stimulates transverse or isodiamteric growth but retards the longitudinal one.

7. (d) Ethylene is a gaseous plant hormone and it is responsible for fruit ripening.

11. (d) Root development and root hair formation C_2H_4.

12. (a) Suitable combination of gases in atmosphere for fruit ripening is 80% ethylene (C_2H_4) and 20% CO_2.

13. (d) As ethylene inhibits longitudinal growth but stimulates transverse growth.

ABA and Other growth regulators

1. (d) Spray of abscisic acid causes very fast abscission of leaves, and also causes dormancy of buds and seeds.

2. (b) Because IAA, NAA and GA are growth promoters and ABA is growth inhibitor.

3. (d) Seed germination is limited and hence abscisic acid induces dormancy of seeds and buds.

4. (a) Wound hormone is also called as traumatic acid or necrohormone.

5. (a) Maleic hydrazide is a growth retardant which checks cell division.

7. (a) Morphactins are synthetic growth regulators which act in variety of ways on the natural regulation mechanism of plants.

8. (b) Morphactins have inhibitory efficient on the stem elongation. Increased concentration produces dwarfing in the plants.

11. (c) Gibberellins and *ABA* are antagonistic with each other.

12. (c) *ABA* inhibits the $H^+|K^+$ exchange and promotes the leakage of maleic acid. The reduction of osmotically active solutes would render the guard cells flaccid and keep the stomatal pore closed.

13. (b) Abscisic acid (also called stress hormone) is a mildly acidic growth hormone which function as a general growth inhibitor by counteracting other hormones (auxin, gibberellin, cytokinin) or the reactions mediated by them. ABA induced bud dormancy, seed dormancy closure of stomata and stopage of cabial activity.

18. (d) The synthesis of abscisic acid is stimulated by drought, water logging and other adverse environmental condition. Therefore, it is also called as stress hormone.

19. (b) Abscisic acid stimulates senescence of leaves by causing destruction of chlorophyll and inhibition of protein and RNA synthesis.

Photoperiodism and Vernalization

1. (d) Photoperiodism is the term to denote a biological response to changes in the ratio of light and darkness in a 24 hour cycle.

2. (a) In phototropism according to Cholodny Went theory, unilateral light produces more auxin and hence more growth on the shaded side resulting in bending.

4. (a) Phytochrome exists in two interconvertible forms. The red (660 *nm*), absorbing form *Pr* and far red (740 *nm*), absorbing from *Pfr*.

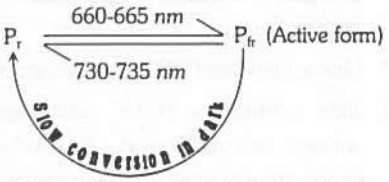
5. (d) Phytochrome is responsible for absorption of red and far red light and it is involved in red–far red light interconversion. According to Buttler in 1959, light absorbing pigment are called as phytochrome. These are proteinaceous substances in which coloured pigment is chromatophore.

8. (d) Phytochrome is chromoprotein (Photosensitive) photoreceptor, blue pigment protein complex, found in almost all flowering plants (angiosperms).

11. (a) If dark period of SDP is interrupted, the plant will not have flower because in SDP, dark period is critical and necessary for flowering.

12. (c) The stimulus of vernalization in known as vernalin. The stimulus of vernalization that induce flowering could be a particular gibberellin or a mixture of gibberellins. If GA is sprayed on the single gene dwarf plants, genetic dwarfism is overcome and plants become long *e.g.*, maize, pea, etc.

14. (c) Phytochrome is an amorphous photoreceptor protein pigment. It exists in two states, *i.e.*, phytochrome Red (P_r) and phytochrome far-red (P_{fr}).



It is considered that during the day P_{fr} form of the phytochrome is accumulated in the plant which is inhibitory to flowering in short-day plants but is stimulatory in long day plants.

16. (a) Photoperiodic stimulus is perceived by mature/old leaves.

20. (b) Flowering is induced by light temperature.

28. (b) Because in vernalized plant 'vernalin' substance is produced which is responsible for flowering.

29. (c) Phytochrome is bright blue or bluigh green pigment which is similar to phycocyanin.

30. (b) In stratification apple, plum, seeds, are exposed in well areated, moist condition under low temperature of 0 – 10° *C* for weeks of months.

32. (c) The effect of photoperiod on flowering was discovered by Garners and Allard at USA in 1920 in case of Maryland mammoth variety of Tobacco which is an SDP.

33. (d) *Florigen* : In the process of flowering, this hypothetical hormone is applied which is gibberellin in nature.

34. (d) In photoperiodism, photoreceptor pigment called phytochrome are in fully developed mature leaves which receive the stimulus of light.

35. (c) In SDP the dark period is critical and must be continuous. If this dark period is interrupted even with a brief exposure of red light, the short day plant will not flower.

36. (b) Since flowering can take place during any part of the year therefore the plant is not senstitive to photoperiod.

37. (a) Red light of 660 nm stimulates germination in positively photoblastic seeds.

38. (c) Phytochrome occurs in two *i.e.*, *Pr.* (Red light) and *Pfr.* (far red light) and both are interconvertible. It is considered that during day time *Pfr* form accumulates in plants which is inhibitory to flowering in SDP During night *Pr* form accumulates in plants which is stimulatory to flowering.

43. (d) Long-day plant will be induced to flower only when the period of available light exceeds a given critical or limiting period. Wheat, poppy, oat, beet etc. are longday plants.

45. (c) Because two types of phytochrome is present in plants *i.e.*, P_{660} and P_{730}.

47. (a) Etiolation is depigmentation in leaf when plant is placed in dark for more than 36 hrs. Plants get etiolated in dark, because chlorophyll is not synthesized in darkness.

48. (a) Actual absorption spectrum of P_R is 660 which is not in answer so answer may be 640 *nm*.

52. (c) Day neutral plants – flowering in plants is not affected due to variation in photoperiod. (Day length and night length)

Critical Thinking Questions

1. (a) During enlargement phase of growth new particles of cellulose are deposited between particles of the old wall, is known as intussusception.

3. (b) Phytohormones are biochemical substances which regulates physiology of the plants.

7. (b) Sometimes apical bud inhibits the growth of lateral buds, it is called apical dominance. By moving on a grass lawn apical buds are removed and apical dominance of grass is breaked.

8. (b) The apex inhibits the growth of axillary bud is called apical dominance.

9. (d) Clinostat (= klinostat) is an instrument which can eliminate the effect of gravity and allow a plant to grow horizontally by slowly rotating it.

10. (c) Because cytokinins initiate and promote cell division actively in plants tissue and tissue culture.

11. (c) Accumulation of auxin at the apex of the plant, which is responsible for the phototropism movement so that plant cells are elongated.

12. (d) If phytochrome P_{660} is exposed to red-light, it changes to P_{730} and if P_{730} is exposed to far-red light, it changes quickly back to P_{660} because both are in interconvertible form.

14. (b) GA is sprayed on these single gene dwarf plants, genetic dwarfism is overcome and plants become long *e.g.*, maize, pea.

16. (d) Ethylene is unique in that it found only in gaseous form, and accelerates ripening of fruits, leaves abscission and promotes senescence.

17. (c) Phytochrome is pigment which regulates growth and development like, photoperiodism, chloroplast development, leaf abscission and senescence etc.

Assertion and Reason

1. (c) Application of GA can induce flowering in long day plants. It has no favourable effect on size of flower and fruit in certain plants. The genetically dwarf plants can be made tall by application of GA.
2. (b) The first selective herbicides to be discovered and used widely were 2,4-D and its derivatives. These compounds are very potent auxins. 2,4-D and 2,4,5-T destroy dicots weeds. They block their seive elements and disturb mitosis. The plant is ultimately destroyed. Agent orange, which was used in the war in Vietnam as a defoliant is an effective mixture of free 2,4-D and the N-butyl ester of 2,4,5-T.
3. (a) Auxin is produced by shoot tip and acts as a growth promoter for apical bud and inhibit the growth of lateral buds. When a terminal bud is removed, the nearest axillary buds begin to grow and the plant branches rapidly. In case of mulberry plants, pruning is done to remove apical dominance and causes more branching of the main body of the plant.
4. (c) Nastic movements are non-directional movements in which the response is determined by the structure of the responsive organ and not the direction of the stimulus. "Touch" responses in *Mimosa* are an example of movements that do not necessarily occur towards or away from the stimulus. The movement is produced due to turgor changes in the cells of pulvinus or swollen area lying at the base of the petiole, pinnae and pinnules.
5. (c) Phytochrome is a receptor pigment present in leaves. They are responsible for flowering in plants. Phytochrome are two types P_r (Red light) and P_{fr}(far-red light) P_{fr} are responsible for flowering in LDP.
6. (a) Secondary roots and shoots are plagiogeotropic that is, they grow to a position at an oblique angle (45°) to the gravitational force. Root and stem branches lie at an angle other than 90° to the direction of gravity.
7. (e) The apical bud is not the only source of auxins. Young developing leaves also produce auxins and it has been shown that auxins from this source may inhibit lateral bud growth. When the apical bud is removed, the lateral buds sprout. However, if a paste of auxin is painted on the cut end of the decapitated shoot, the lateral buds remain inhibited, as if the apical bud is present.
8. (b) When cytokinins are added directly to the abscission layer, senescence of the zone is retarded. This delayes the degradation of protein and chlorophyll of the plant parts and hence delays senescence. As they act as antisenescent, they act as antagonistic to ethylene which accelerate senescence.
9. (b) In most fruits the rate of respiration will undergo a sharp rise and then fall near the end of ripening. Kidd and West termed this phenomenon "climacteric rise". The climacteric acts as a trigger that sets in progress those changes that rapidly transform the fruit from an unripe to a ripe condition. Finally, application of ethylene to unripe fruit will bring on a premature climacteric and accelerate ripening.
10. (b) Stratification of seeds may affect the disappearance of inhibitors and the buildup of germination promoters such as the gibberellins and cytokinins. Natural stratification occurs when seeds shed in the fall are covered with cold soil, debris and snow. In artificial stratification, layers of seeds are alternated with layers of moistened *Sphagnum* sand or some other appropriate material are stored at low temperatures.
11. (c) If total growth is plotted against time, an S-shaped or sigmoid curve is obtained. It consists of four parts-lag phase, log phase, phase of diminishing growth and stationary phase. Growth is slow in the lag phase, rapid during log or exponential phase, slow again during the phase of diminishing growth. Growth stops completely during the stationary phase. Log phase is also called as grand phase of growth due to fast growth in this phase.
12. (c) It has been demonstrated that flowering in plant is more of a response to the dark period than to the light period. In short day plants, plants can flower in complete darkness if supplied with exogenous nutrients. Flowering is prevented in them if dark period below the critical level is interrupted by a flash of light. Interruption of light by dark inhibits flowering under normal photoperiods.
13. (a) Phototropism is a paratonic directional growth movement of curvature which is induced and determined by the direction of light stimulus. Shoots grow towards the source of light hence called positively phototropic while roots grow away from the source of light hence called negatively phototropic.
14. (c) Light energy become effective when it is absorbed by a pigment. These pigments are called phytochromes. It occurs in two forms namely P_r and P_{fr}. The two forms are interconvertible. The P_r form absorbs red light of 660 *nm* and changed to P_{fr}. The P_{fr} form absorb far red light of 730 *nm* and changed to P_r. The P_r form stimulates whereas P_{fr} form inhibit flowering. P_{fr} form of phytochrome is the active form. The P_r form is not considered to be active.
15. (c) Cajlakhjan, working on floral initiation, coined the term florigen for the flowering hormone thought to be present in photoinduced leaves and plants. It is supposed that leaf prepare a special compound A on receiving CO_2. *A* on turn produces *B* in dark and is followed by formation of *C* (florigen). The florigen translocates from vegetative meristems to floral initiation.
16. (b) Many plants do not come to flower before they experience a low temperature. These plants remain vegetative during the warm season, receive low temperature during winter, grow further and then bear flowers and fruits. Vernalization is, therefore, a process of shortening of the juvenile or vegetative phase and hastening flowering by a previous cold treatment. The stimulus of vernalization is perceived only by the meristematic cells, *e.g.*, shoot tip, embryo tips, root apex, developing leaves etc.
17. (a)

Plant Growth and Development

SET Self Evaluation Test

1. Cold treatment of seeds is called **[RPMT 2006]**

Or

Seeds of winter varieties are benefited by this method **[J & K CET 2010]**

(a) Vernalization (b) Stratification
(c) Devernalization (d) Photophosphorylation

2. Crescograph was prepared by **[BHU 2000, 01]**

(a) Bose (b) Strasburger
(c) Went (d) None of the above

3. In callus culture, roots can be induced by the supply of **[MP PMT 2013]**

(a) Auxin and no cytokinin
(b) Higher amounts of auxin and lower amounts of cytokinin
(c) Higher amounts of cytokinin and lower amounts of auxin
(d) Auxin and cytokinin in equal amounts

4. Which of the following plant material is widely used in the preparation of culture medium

(a) *Pinus longifolia* (b) *Cocos nucifera*
(c) *Borassus flabellifer* (d) *Cycas revoluta*

5. Exponential growth in plants can be expressed as **[Kerala PMT 2011]**

(a) $L_t = L_0 + rt$ (b) $L_e = L_t rt$
(c) $W_1 = W_0 e^{rt}$ (d) $W_1 = W_0 ert$

6. Which Hormone is responsible for vernalization **[MP PMT 2011]**

(a) Florigen (b) Colchicine
(c) Abscission (d) Vernalin

7. Antiauxin used in picking cotton balls is

(a) NPA (b) 2- 4D
(c) TIBA (d) Both (a) and (c)

8. A substance which is used to stimulate the increase in size of the apple fruit is **[NCERT]**

(a) Morphactin (b) Promalin
(c) Ethylene (d) Ethapone

9. Storage sprouting of potato can be prevented by

(a) *IAA* (b) Maleic hydrazide
(c) Cytokinins (d) Gibberellins

10. A substance isolated from herring sperm DNA and named as '*kinetin*' by **[NCERT]**

(a) Miller (b) Skoog
(c) Saltza and Strong (d) All the above

AS Answers and Solutions

1	a	2	a	3	b	4	b	5	c
6	d	7	d	8	b	9	b	10	a

1. (a) The term vernalisation was coined by Lysenko to the method of accelerating the flowering ability of biennials or winter annuals, by exposing their soaked seeds to low temperatures for a few weeks.

2. (a) It is more delicate instrument and gives magnification upto 10,000 times. It uses as a root auxanometer.

4. (b) Because liquid endosperm of *Cocos nucifera* possesses kinetin (cytokinin) growth hormone which is responsible for rapid cell division in culture medium.

8. (b) Promalin is a mixture of cytokinin–6–benzaldenine, GA_4 and GA_7. It is very active in stimulating increase in apple size particularly in red delicious apples.

9. (b) Maleic hydrazide : It is a growth retardant which checks cell division. So during seed storage this is applied for checking sprouting of potato tubers so that the importance of potato may not be lowered down.

10. (a) Isolation and identification of kinetin, (6-furfurylaminoprine) from nucleic acid preparations, was first reported by Miller (1956).

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