COORDINATION continuation…

CONCEPTS OF RECEPTION AND RESPONSE IN PLANTS

The ability of plants to respond to stimuli is called **irritability**. These responses are mainly growth responses. The plant responses are of three types.

- Tropism
- Nastism.
- photoperiodic responses

A. TROPISM.

These are growth movements of parts of plant in response to and directed by an external unidirectional stimulus.

TYPES OF TROPISMS AND EXPERIMENTS TO DEMONSTRATE TROPISMS.

The different types of tropisms include,

- phototropism
- Geotropism.
- Hydrotropism.
- Thigmotropism.
- Aerotropism.
- Chemotropism.

(a) PHOTOTROPISM.

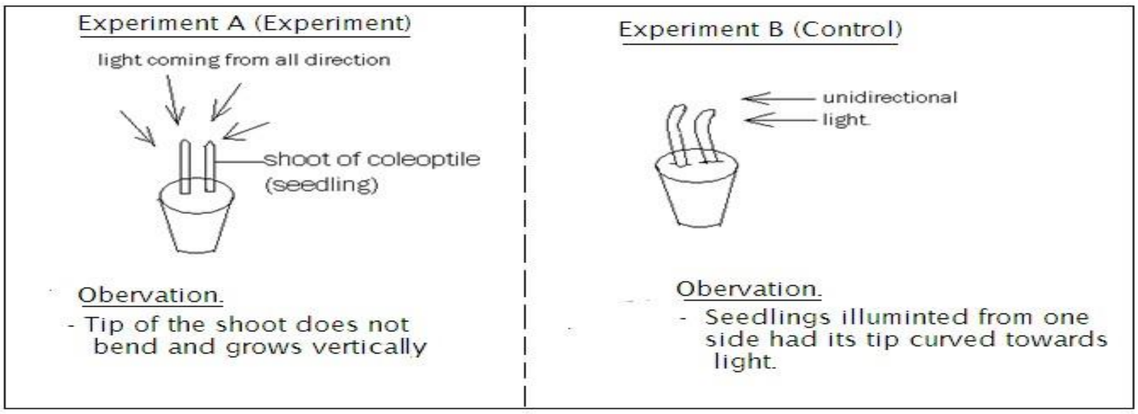
This is the growth movement of the plant part in response to unidirectional light. The shoot is said to be positively phototropic as it grows towards light. This enables the shoot of plants bearing green leaves to reach out for light, ensuring maximum absorption of sun light which is used in for photosynthesis.

Experiment to show the effect of light on the shoot of a plant

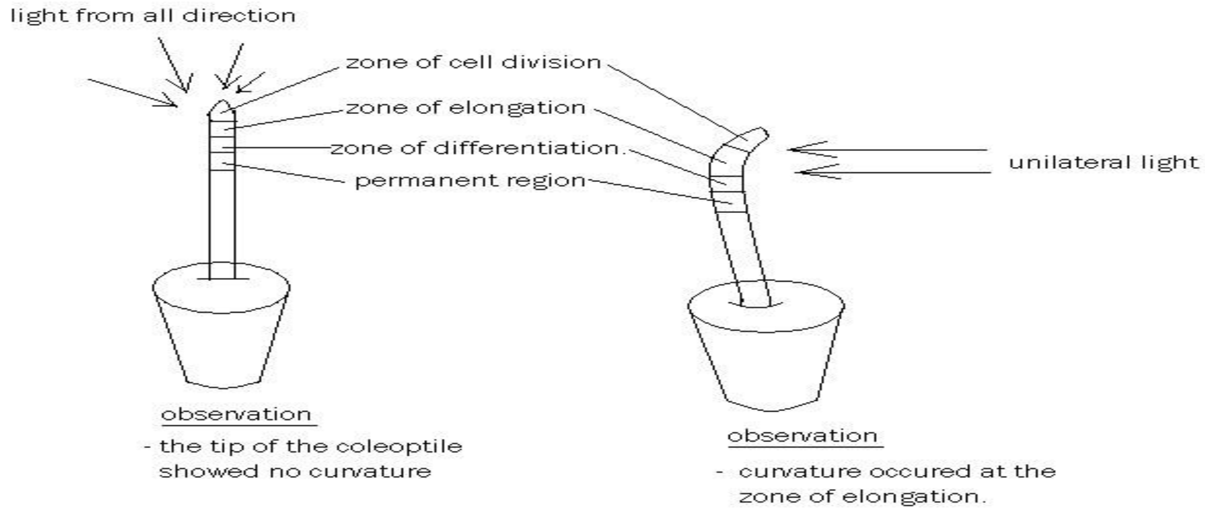
Two seedlings are exposed to light, one seedling exposed to light coming from all direction, while the other illuminated from one side.

In one other experiment, the growing tip of the two seedlings were marked into four zones, which include, zone of cell division, elongation, differentiation and permanent region. The two seedlings again exposed to light, one seedling exposed to light coming from all direction, while the other illuminated from one side.

EXPERIMENT ONE (1)



EXPERIMENT TWO (2)



EXPLANATIONS

The growth response (curvature) towards light is caused by high concentration of the plant hormone called **Auxin** also referred to as **Indole Acetic acid (IAA**). The light stimulus distributes the hormone auxin more on the none-illuminated side (shaded side) of the tip of the seedling. High concentration of Auxin stimulated rapid growth and the none illuminated side experiences more growth than the illuminated side of the tip of the seedling. The tip then curves towards the illuminated side i.e. curves towards light.

Auxin diffuses at high concentration into the region of the cell elongation causing rapid growth in the cells in that region than in the cells in the other regions. The cells in these region are more sensitive to the effect of auxin and so curvature (bending) occurs at the region of cell elongation.

The results show that the plants response to a unidirectional light is a growth response. Once the growing plant has well established leaves the phototropic response is shown by the leaves. This is called **sun tracking** or **heliotropism**. Once the stem has passed the seedling stage, it grows in natural condition responding to gravity rather than the unidirectional light.

(b) GEOTROPISM.

This is the growth movement of plant shoot or root in response to unidirectional gravitational force.

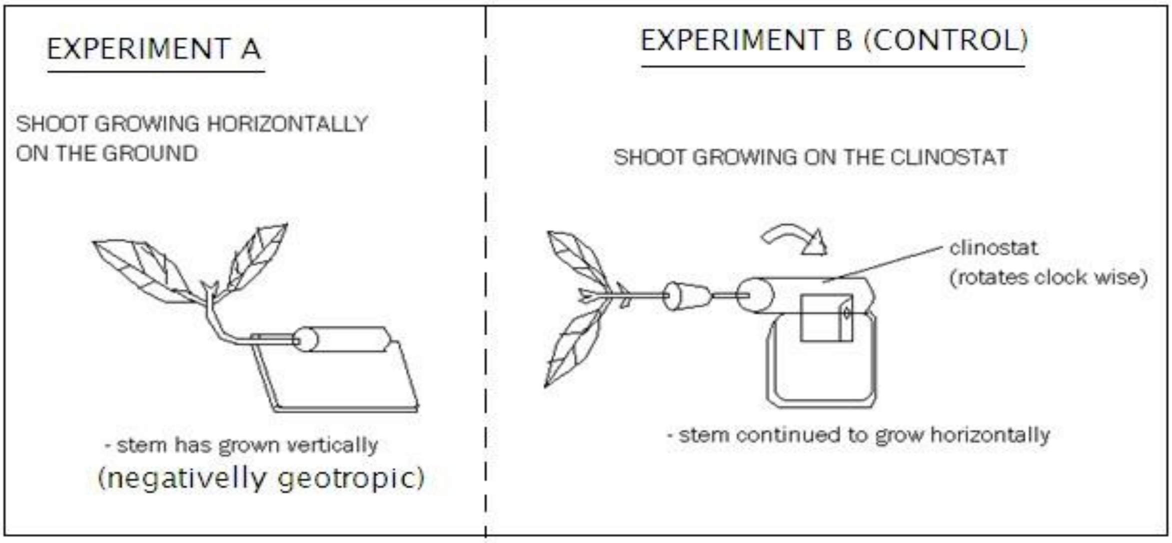
The tip of plant (shoot) grows away from the pull of the gravity thus showing negative geotropism and root grows towards the force of the gravity and thus shows positive geotropism. Lateral roots and stems grow at an angle to the direction of gravitation, this is referred to as **plagiotropism.**

Roots of plants are positively geotropic these enable roots of plants to grow deep into the soil for firm anchorage and proper support of the aerial parts. The roots also reach soil water while the shoots are negatively geotropic enabling the shoots to continue growing vertically to as to reach out the leaves to absorb sun light for photosynthesis.

Experiment to show response to gravity.

Procedure

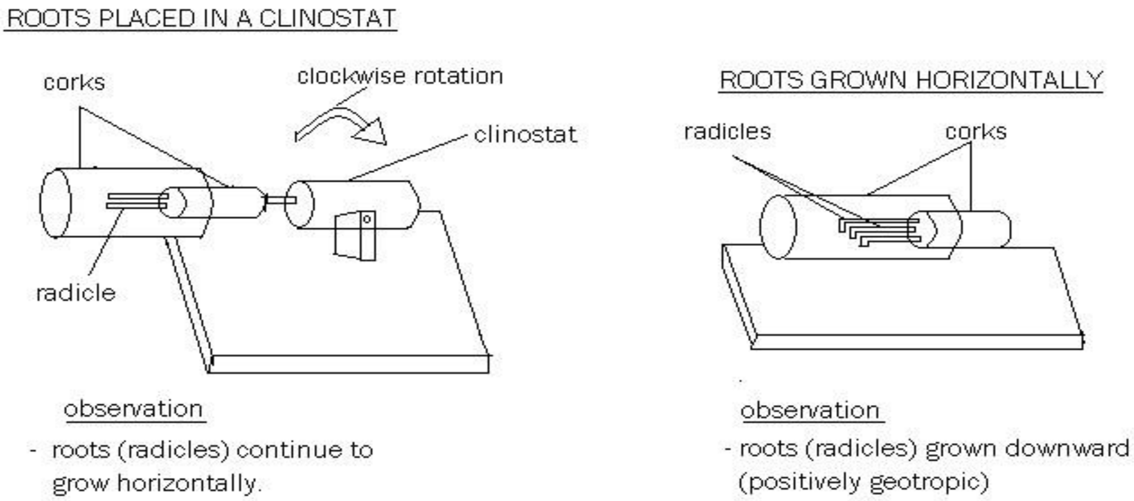
Two potted plants are got, one is inserted in a clinostat while the other plant is placed on the ground on its pot. The one in the clinostat is also placed horizontally on the ground but the clinostat makes it move clockwise, this is to have the effect of gravity equally distributed throughout the shoot. This is used as a control experiment. The two set ups are left in the same environment for a week.



EFFECT OF GRAVITY ON THE ROOT (EXPT USING RADICLES)

Two corks are got and growing seeds are pinned in each of them and allowed to develop. One cork is placed in a clinostat while the other is fixed in a jar like structure and laid horizontally to ground. The same experiment is left within the same conditions for four days.

Illustrations



OBSERVATIONS

The shoot in the clinostat showed no curvature after sometime while the shoot which was left stationary and horizontal to the ground grew upwards showing a negative response to gravity. Hence negatively geotropic.

Similarly, the root in the clinostat showed no curvature, while the root left stationary and horizontally grew downwards towards the force of gravity, and therefore positively geotropic.

CONCLUSION.

Roots of plants are positively geotropic while the shoots are negatively geotropic.

EXPLAINATION.

Low concentration of auxin does not stimulate growth in shoots but stimulate growth in the roots and High concentrations of auxin stimulate rapid growth in shoots but inhibit growth in roots. But at a very high concentration of auxin growth is inhibited in both roots and shoots of plants.

Auxins accumulated to higher concentrations on the lower side than the upper side of the shoot which was horizontally placed. Higher concentrations of auxin on the lower side of the shoot stimulated faster growth on the lower side than the upper side and shoot bent upwards.

In the roots, auxins still accumulated to higher concentrations on the lower side than the upper side of the roots (Radicles) which were horizontally placed. But in the roots, higher concentrations of auxin on the lower side inhibited growth on the lower side. There fore the upper side experienced faster growth than the lower side and root (Radicles) bent downwards.

(c) CHEMOTROPISM

This is a growth movement of part of plant in response to unidirectional chemical.eg the growth of pollen tube towards chemicals produced by the micropyle of the ovule, therefore, pollen tube is positively chemotropic.

(d) HYDROTROPISM

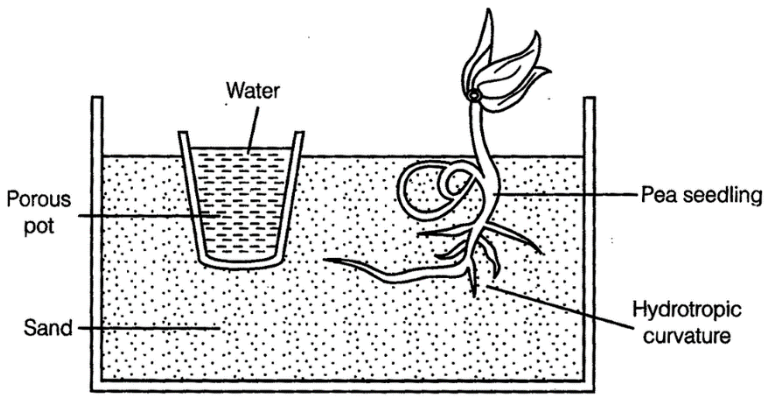
This is the growth movement of parts of the plant in response to unilateral water source . The roots are positively hydrotropic which enables the roots to grow towards the soil water where they can absorb water and mineral salts needed for plant growth. While the shoots are negatively hydrotropic.

Experiment to show the response of roots and shoots to water.

A trough is filled with soil and a porous pot is placed in the Centre, some seedlings are grown near the pot, the soil watered until after the plumule appear, then the watering is stopped. The porous pot is filled partly with water.

Leave the experiment for some days and dig out the seedlings without damaging the roots.

Illustration



OBSERVATIONS

The plant roots grew towards the porous pot,while the shoot grew away from the pot.

CONCLUSIONS.

Plant roots are positively hydrotropic, while the shoots are negatively hydrotropic.

(e) THIGMOTROPISM (HAPTOTROPISM)

This is a growth movement of part of plant in response to touch in a given direction. Plants that show positive thigmotropism are yams, morning glory, passion fruits etc. Tendrils and other climbing organs of climbing plants are positively thigmotropic. Plants with weak stems use tendrils to obtain extra support.

B. NASTIC RESPONSES OF PLANTS.

This is the growth movement of part of plant in response to a non-directional stimulus. In such response the direction of the response of the plant organ is not determined by the direction of the stimulus.

TYPES OF NASTIC RESPONSES AND THEIR SIGNIFICANCE TO PLANTS.

They include,

- Photonastism.
- Thermonastism.
- Thigmonastism.

(a) PHOTONASTISM.

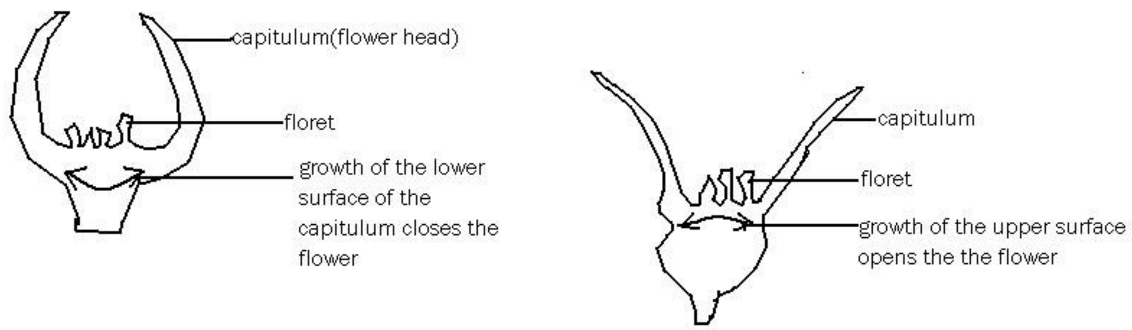
This is the growth movement of part of a plant in response toa non-directional light stimulus. For example, the dandelion flower head opens up in the light and closes up in the dark (low light). This enable cross fertilisation to take place by any of the agents of pollination.

(b) THERMONASTISM.

This is a growth movement of a plant organ such as flowers in response to non-directional heat. For example the opening and closure of flowers of tulip and the crococcus are stimulated by changes in temperatures, such responses are referred to as thermonastic.

The opening and the closure of flowers for such responses is due to localized growth in particular part of the flower or inflorescence. During the day the upper surface of the capitulum of the dandelion flower grows more than the lower one and the flower head opens. While at night the lower surface of the capitulum grows more than the upper one and the flower head closes.

Diagram showing photonastic response in flower.



(c) THIGMONASTISM.

This is the growth movement of plant organ in response to non-directional touch.

The leaves of the plant known *as Mimosa pudica* fold their leaves when touched. This is because depolarization occurs across the membrane of the cells of the leaflet touched, action potential is developed and transmitted via the phloem and across the plasmodesmata to reach the group of parenchyma cells called motor cells, found at the base of the leaflets called pulvinus. Potassium ions are actively transmitted out the of the cells, the water potential in the cell is increased and the cells lose water by osmosis to the surrounding region, the cells become flaccid and the leaflets are pulled forward and upwards and leaflets close. The leaflets open when the motor cells gain water and become turgid, the leaflets are pulled downwards and outwards and leaflets open. This type of response due touch is referred to as thigmonastic. It is partly for defense against predators or browzers and grazers but also when the leaves close they are less exposed to direct heat for that period and water loses due to evaporation are minimized.

COMPARISON BETWEEN TROPISM AND NASTIC RESPONSE.

DIFFERENCES.

Tropic response	**nastic response**
1. Direction of the response is determined by the that of the stimulus.	1. Direction of response is not determined by that of the stimulus
2. Stimulus direction is specific (unidirectional)	2. Stimulus direction is not specific (non-directional)
3. Response is slower	3. Response is faster
4. Mainly chemical in nature.	4. Electrical and mechanical in nature.

Similarities.

- Both are growth response.
- Both occur in a part of plant or plant organ.
- Both responses are triggered by stimuli.

EXPERIMENTS TO DISCOVER PLANT HORMONES (GROWTH SUBSTANCES)

The experiments done to find the substances responsible for growth include;

i) Darwin's experiment.
ii) Boysen-jensen experiment.
iii) Paal's experiment
iv) Went's experiment.

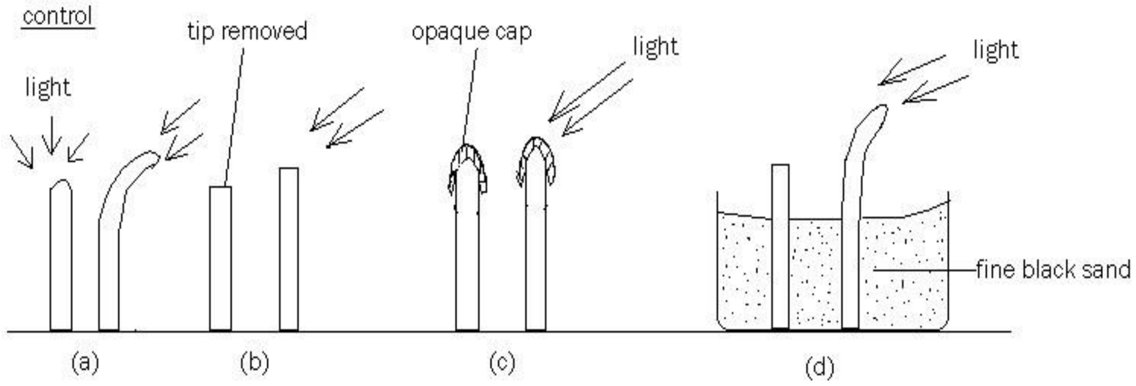
(i) DARWIN'S EXPERIMENT.

This experiment is to discover the position of the substance responsible for growth. This substance is auxin. In his experiment he used a metal cap to find the position of the growth substance.

1. Light was allowed to strike coleoptile shoot from one direction as in **A** after some time he found that the shoot bent towards light.
2. He cut tip of the coleoptile shoot and allowed the shoot to grow in the same condition as in **B**. He found that there was no curvature(bending). This suggested that the tip is the region of the perception of the stimulus.
3. He covered the tip with an opaque cap and allowed the plants to grow in the same condition as in **C**. He found that no curvature took place. This confirmed that the stimulus is perceived at the tip of the shoot but not at region of the response.

4. He buried the seedlings within the sand with only the tip exposed as in **D**. He found that the plant shoot bends towards light proving that the lower part of the same plant has no links with the response.

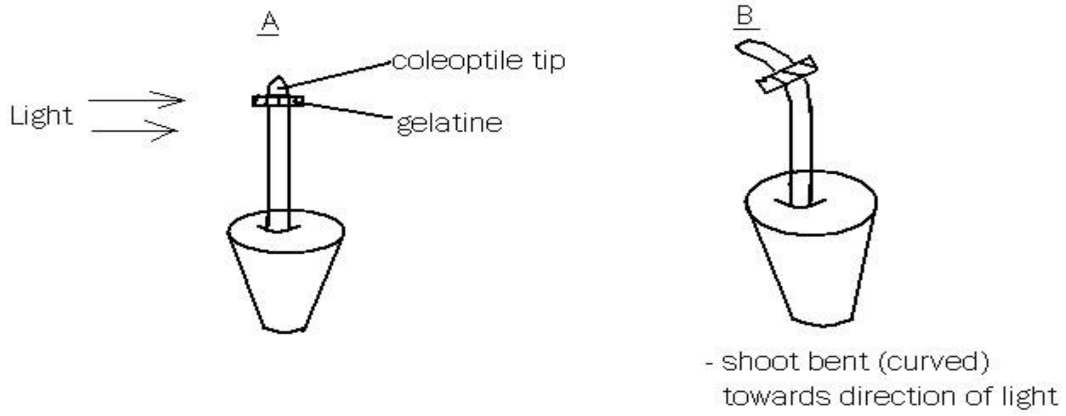
Illustrations



(ii) BOYSEN-JENSEN EXPERIMENT.

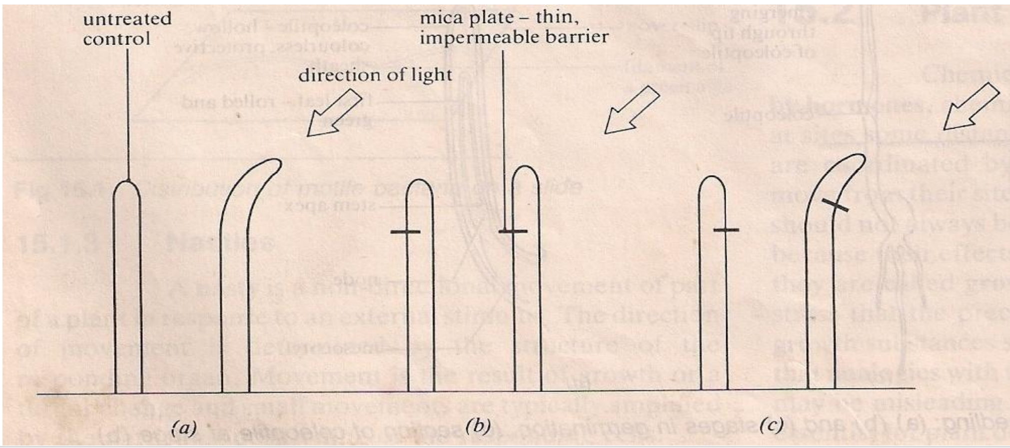
He investigated the transmission of the growth substances from the tip of the shoot to the zone of elongation (region of response).

1. He cut a coleoptile tip and inserted a slice of gelatin between the decapitated tip and the lower part. The lower part curved towards the unilateral light in the same way as the normal coleoptile.



2. He inserted a mica plate on the shaded part of coleoptile, this prevented curvature in a unilateral light. He then inserted the mica plate on the illuminated side and curvature took place. This proved that the chemical substance (auxin) diffused from the illuminated the shaded part of the shoot and the shaded part experienced greater growth and hence curved.

DIAGRAMS



(iii) PAAL'S EXPERIMENT.

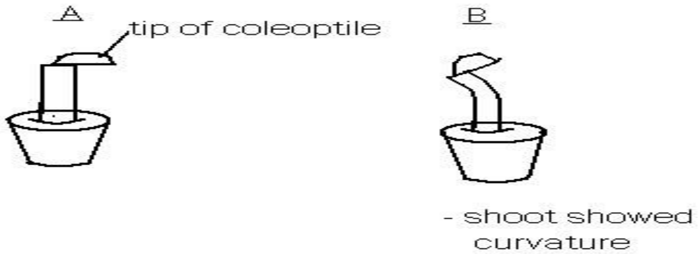
He tried to prove that hormones are responsible for the growth response but not light.

He performed the experiment by removing the coleoptile tip and replaced it but displaced to one side and placed in the dark.

OBSERVATION:

Coleoptile tip bends towards the side where no tip is present.

Illustrations



EXPLANATION.

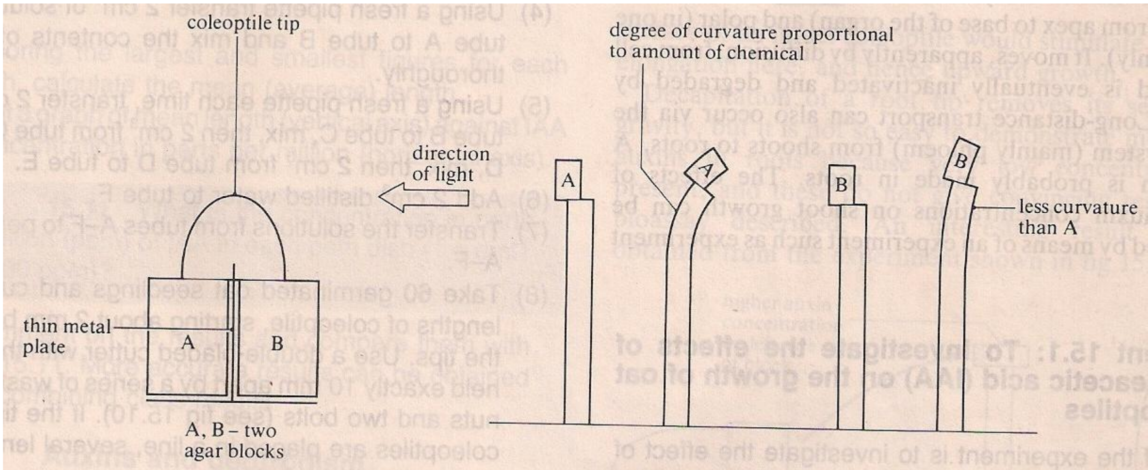
Displacement of the coleoptile tip on one side means that the growth substance (auxin) diffused downwards on only one side where the tip was placed. Rapid cell elongation occurred on that side, this side grew more rapidly causing bending.

(iv) WENT'S EXPERIMENT

In this experiment, he cut the coleoptile tip and placed it on an agar block, allowed it to stand on the agar block for 1-2 days to allow the chemical to penetrate.

The agar block is placed on one side of decapitated coleoptile.

Illustrations



OBSERVATION:

Coleoptile bends towards side where no a gar block is present.

EXPLANATION.

The growth substance (auxin) from the coleoptile tip penetrated into the agar block. When the agar was placed on decapitated coleoptile to one side, the hormone auxin moved downwards that side, increasing growth and causing bending. The degree of curvature is proportional to the amount of auxin.

3. **PHOTOPERIODISM IN PLANTS.**

Photoperiodism is the response of organisms to the changing lengths of the days and the night periods (light periods). In plants is where the activity in the plants such as flowering is influenced by the changing lengths of the days and the night periods.

Photoperiods refers to lengths of the day or the light periods.

Flowering plants are divided into three groups on the basis of their response to the photoperiods.

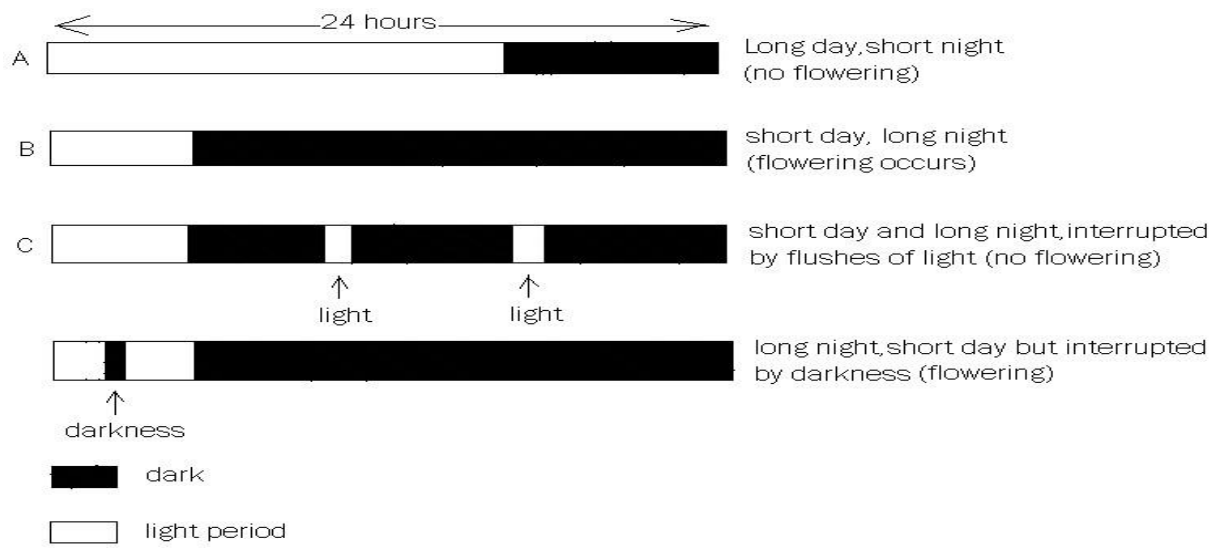
i) Short day plants.
ii) Long day plants.
iii) Day neutral plants.

(i) SHORT DAY PLANTS

These are plants which only flower when day periods become shorter than the critical length of the day. Examples of such plants include, sugarcane, soya-beans etc. They have the following characteristics: -

- They require short days and long nights.
- They flower only when the days become shorter than the critical length of the day.
- They need an uninterrupted long night for flowering.
- The longer nights are more essential for flowering than the short periods of the day.
- They don't flower when exposed to short day and long nights interrupted by some flashes of lights at intervals.
- They flower when exposed to short days interrupted by intervals of darkness but the long night remained uninterrupted with flashes of lights.
- They flower during autumn and winter when the nights become longer and the days shorter.
- Flowering is promoted when all the phytochrome far red are converted to phytochrome red.

DIAGRAM SHOWING THE EFFECT OF DAY AND NIGHT PERIODS ON FLOWERING OF SHORT-DAY PLANTS.

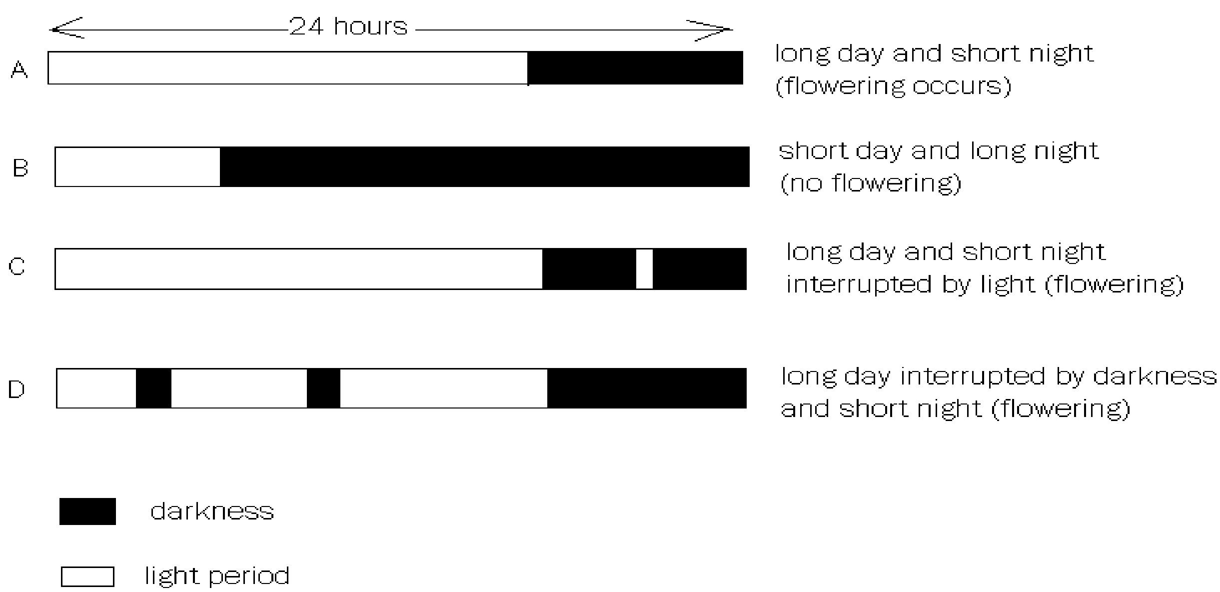


(ii) LONG DAY PLANTS.

These are plants which flower only when the light periods exceed the critical period of the night. Examples of such plants include, wheat, barley, lettuce, clover and radish. They have the following characteristics,

- They require long days and short nights.
- They flower only when the light periods exceed a critical period of the night.
- Shorter nights are more essential for flowering than the length of the day.
- They flower even when the short nights are interrupted by flashes of lights but the day remained uninterrupted.
- They show flowering when the long day is interrupted by just brief periods.
- They flower during summer when the days are longer than the night periods.
- Flowering is promoted by high levels of phytochrome far red.

DIAGRAM OF EFFECT OF DAY AND NIGHT PERIODS ON FLOWERING OF LONG DAY PLANTS.



(iii) DAY NEUTRAL PLANTS

These are plants which flower after a period of vegetative growth regardless of the changing length of day and the nights. Examples include tomatoes, cotton, and garden pea.

DIFFERENCES BETWEEN SHORT DAY AND LONG DAY PLANTS.

SHORT DAY PLANTS	LONG DAY PLANTS
1.Flowering is induced by longer nights	1.Flowering is induced by short nights
2.Flowering is inhibited by interruption of the night periods.	2.Flowering is not inhibited by the interruption of the night periods.
3. Uninterrupted longer nights is critical for flowering.	3. Shorter nights are critical for flowering.
4. They flower in winter.	4.They flower in summer.
5. Flowering is promoted absence of Pfr and presence of Pr.	5. Flowering is promoted in higher concentration of Pfr than Pr.

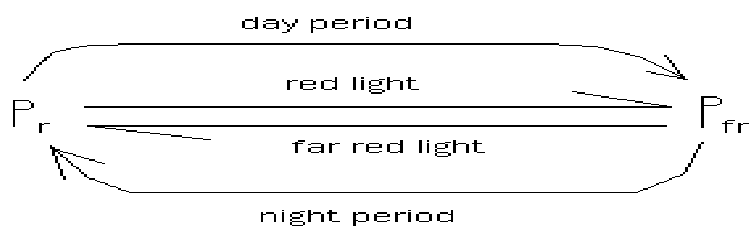
THE MECHANISM OF FLOWERING IN PLANTS.

This is controlled by the protein pigments called phytochromes present in the leaves. There are two types of phytochromes. Phytochrome red **(Pr) or** P_{660} and phytochrome far red **(Pfr) or** P_{730}. These phytochromes are interconvertible.

During the day, phytochrome red absorbs red light within the wave length of P_{660} nm and it is converted into phytochrome far red (Pfr).

During the night, phytochromes far red absorbs far red light within the wave length of P_{730} and are converted to phytochrome red (Pr).

DIAGRAM SHOWING INERCONVERTION OF PHYTTOCHROM SYSTEMS



In short day plants, the phytochrome far red in the leaves absorbs the far red light during the long night periods and they are all rapidly converted into phytochrome red. The absence of the phytochrome far red causes the florigen precursor to be converted to florigen. The hormone is then transported to the buds and it stimulates the buds to develop into flowers.

In long day plants, the phytochrome red in the leaves absorbs red light during the long day periods and it is rapidly converted into phytochrome far red (Pfr) which is chemically active. The phytochrome far red stimulates the conversion of florigen precursor to florigen which is then transported to buds to induce flowering.

Note:

- Pfr is the chemically active form of the protein molecule, whereas the Pr is the in-active form. The absence of Pfr induces flowering in the short-day plants, while its presence in higher concentrations induces flowering in long day plants.

❖ Gibberellin, auxins, cytokinin, and ethene can also stimulate release of the hormone florigen in the same way phytochromes do.

DIFFERENCES BETWEEN THE EFFECTS OF Pr AND Pfr ON DIFFERENT PHYSIOLOGICAL PROCESSES.

PHYTOCHROME RED (Pr)	**PHYTOCHROME FAR RED (Pfr)**
1. Inhibits germination of small seeds.	1. Promotes germination of small seeds.
2. Promotes growth of internodes.	2. Inhibits growth of internodes.
3. Inhibits chloroplast development.	3. Promotes chloroplast development.
4. Inhibits chlorophyll synthesis.	4. Promotes chlorophyll synthesis.
5. Inhibits leaf expansion.	5. Promotes leaf expansion.
6. Promotes lateral root growth.	6. Inhibits lateral root growth.
7. Inhibits flowering in long day plants.	7. Promotes flowering in long day plants.
8. Promotes flowering in short day plants.	8. Inhibits flowering in short day plants.

VERNALISATION

This is the exposure of a plant to very low temperature requirements to induce flowering. In some plants like perennial and the biennials, the treatment to cold temperatures like 0oC to $4^{O}C$ from 4 days to 3 months inducing flowering depending on the plant. Vernalization is also given to meristem and seeds to make their plants flower quickly. During Vernalization the whole stimulus is received by the shoot apex in mature plants and by embryos in seeds but not by leaves as in Photoperiodism. Vernalization induces flowering by increasing the gibberellins level.

DIFFERENCES BETWEEN PHOTOPERIOODISM AND VERNALISATION

PHOTOPERIODISM	**VERNALISAION**
1**.** Responses of plants to changing length of days and nights.	1. Responses of plants or seeds to low temperature requirements.
2. Perceived by leaves.	2. Perceived by shoot apex in plants and embryo in seeds.
3. Hormone involved is florigen	3. Hormone involved is vernalin.
4. can induce flowering	4. Cann ot induce flowering but prepares the plant for flowering.
5. Essential for short and long day plants.	5. Essential for short day, long day and day neutral plants.

SENESCENCE AND DEATH.

Senescence is the gradual decline in the normal functioning of an organism leading to it’s death.

CHARACTERISTICS OF SENESCENCE

- Continued degeneration of cells occur.
- Chemical changes in protein molecules.
- Increase in metabolic failure.
- Frequent mutation leading to mistakes in protein synthesis.
- There is decrease in functional capacity

TYPES OF SENESCENCE.

1. **Whole plant senescence:** This is where the whole plant including the stem, roots die at the same time after seed production.eg rice, beans, and maize etc. Plants like bamboo live for several years but flower only once and then undergoes senescence and death.
2. **Progressive or sequential senescence**: This is common in perennial plants where the older parts undergo senescence followed next aging and then the whole plant dies.
3. **Shoot senescence**: This is where only the part of plant above the ground dies every year and the underground parts surviving and producing a new plant on the onset of favorable conditions e.g. yams, bananas, Irish potatoes.
4. **Deciduous senescence:** Is where the leaves of the plants are shade simultaneously or at same time. It occurs in temperate deciduous trees during autumn.

ADVANTAGES OF SENESCENCE.

❖ It allows old and in-efficient organs to be replaced by new, young and developing organs like leaves, buds, flowers and fruits.

❖ During senescence more nutrients are directed towards developing buds that need energy while the nutrients are withdrawn from the old aging plants.

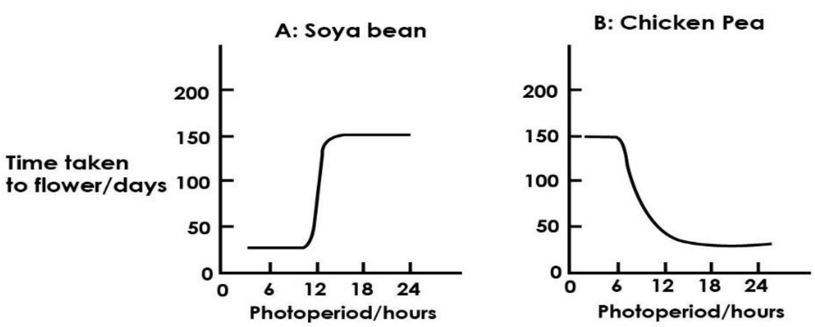
❖ It leads o to bud dormancy, leaf fall which are adaptations to survive unfavourable conditions like cold winter by reducing the metabolic needs and transpiration.

❖ Leaf fall brings about recycling of nutrients necessary to maintain growth and development.

Exercise 1

1. *a) What is meant by **photoperiodism**?* ***(02 marks)***

(b) The graphs in the figure below shows the responses to day length of two flowering plants



(i) *Giving a reason, state which of the two plants will flower under long day conditions.* ***(02 marks)***

(ii) *State* ***two (2)*** *ways the response to phytochrome differ in soya bean and chick pea.*

(02 marks)

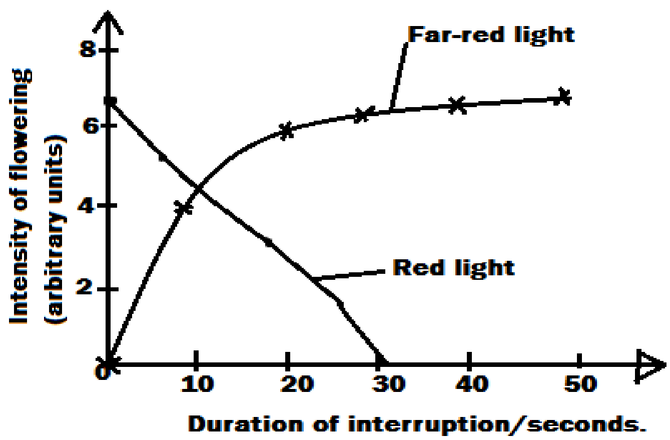
(c) Describe the role of phytochrome in the flowering process. ***(04 marks)***

2. *(a) what is meant by the following terms*
   - *(i) Tactic movements*
   - *(ii) Nastic movements*
   - *(iii) Tropic movements*

   (b) explain the mechanisms involved that result in a shoot of a potted plant on a window sill growing to face the light (10 marks)

   (c) What do you understand by short day plants and long day plants? How is flowering controlled in such plants? (08 marks)

3. *A study was carried out to determine the effect of red and far red light interruptions of long night on the intensity of flowering of a short day denlent. The figure below shows the results obtained from the study.*



In another experiment, three species of the genus of a plant and a hybrid between two of them were tested for their vernalisation requirements.

The sample plants of each strain were subjected to different periods of time at 4°C before being returned to their original conditions.

The number of days which elapsed between the end of cold treatment and the on set of flowering were recorded. The results obtained are shown in the table below.

Weeks at 4°C	***Number of days between end of cold treatment and the onset of flowering.***			
	A	***B***	***C***	***A X B (Hybrid)***
0	*No flowering*	*40*	*25*	*75*
1	*160*	*38*	*25*	*65*
2	*110*	*36*	*25*	*50*
4	*90*	*34*	*25*	*40*
8	*35*	*32*	*25*	*32*
16	*24*	*28*	*25*	*24*

(a)Describe the effect of interruption of the night period on the intensity of flowering by each of the following types of light.

(i) Red light. *(04 marks)*

(ii) Far-red. (04 marks)

(b)Give the explanation for the effects described in (a) above. (10 marks)

(c)Explain how red and far red-light interruptions would have affected the intensity of flowering if they had used a long day plant. (03 marks)

(d)(i) What was the effect of subjecting the sample plants of each strain to different periods of time at 4^oC. (05 marks)

(ii)Explain the results shown in the table. (08 marks)

(e)Predict and explain what would happen if the experiment in the table had been carried out at 1^oC. (03 marks)

(f)What is the significance of the two experiments to an agriculturalist? (03 marks)