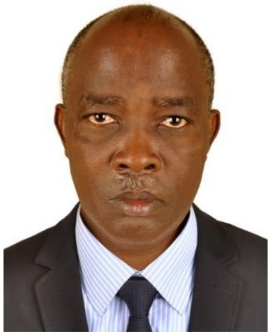

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Coordination in plants

Coordination is a process of linking up process in the body of an organism such that the various process occurs in organized manner.

Plants responses to the environment are controlled by chemicals or hormones. Responses in plants occur in different ways including

1. Tropisms
2. Tactic movements
3. Nastic responses
4. Flowering responding to day length

1. Tropisms

Tropic movements are growth responses towards directional stimuli.

Types of tropisms

Tropisms are classified based on type of stimulant.

1. Phototropism (light)
2. Hydrotropism (water)
3. Geotropism (gravity)
4. Thigmotropism (touch)
5. Chemotropism (chemical)

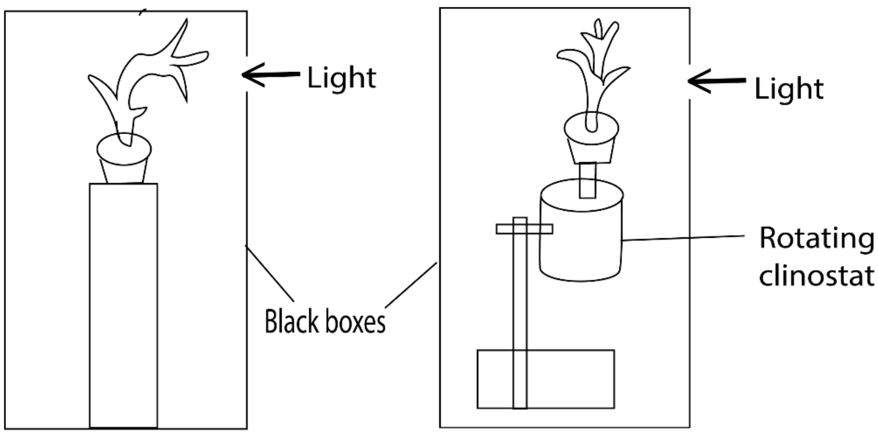
Phototropism

The a growth response towards light from one direction. Shoots grow towards unidirectional light and are said to be positively phototropic. Most root o not respond to light.

Experiment to demonstrate effect of unidirectional light on the growth of shoot

1. Select two potted seedlings of bean of equal age and size and water them.
2. Place one of the seedlings in a box painted black on each side. The box should have a hole on one side to allow in light.
3. Subject the second seedling to the same conditions as the first one except that the pot is mounted on a slowly rotating clinostat.
4. Leave the experiment to stand for 3 days

Note that each seedling should be growing straight at the beginning of the experiment.



Observation

The seedlings on the clinostat grew straight while the other bent toward light

NB. Slowly rotating clinostat ensures uniform exposure of the shoot from all direction.

The significance of phototropism, allow shoot to grow towards and receive light for photosynthesis.

Importance of phototropism

Positive **phototropism** causes the stems of **plants** to grow towards a light source causing the leaves of the **plant** to be pointing towards the light source; this allows the leaves to absorb more light which maximizes photosynthesis.

2. **Taxes:-** is a movement of an entire cell or organism (i.e. locomation) in response to, and directed by an external stimulus. Tactic responses can be described as positive or negative, and can be further classified according to the nature of stimulus

   Types of tactic responses

   There are many types of tactic movements including
   - Phototaxis (stimulation by light)
   - aerotaxis (stimulation by oxygen)
   - anemotaxis (by wind)
   - barotaxis (by pressure)
   - chemotaxis (by chemicals)
   - durotaxis (by stiffness)
   - electrotaxis or galvanotaxis (by electric current)
   - gravitaxis (by gravity)
   - hydrotaxis (by moisture)

3. **Nasties:-** is a non-directional movement of part of a plant is response to an external stimulus.

   For example, " sensitive plant" **Mimosa pudica** is sensitive to touch as well as a variety of other stimuli. It exhibits normal normal sleep movement but responds very rapidly to shock (seismonasty) such as a sharp blow, injury or sudden change in temperature or light intensity. If leaflets at the tip are shocked, they fold upwards in seconds. If the stimulus is strong or sustained, successive pairs of leaflets fold up and stimulus eventually passes through the whole leaf, resulting in the petiole drooping. The stimulus will pass in the reverse direction if the stem is stimulated.

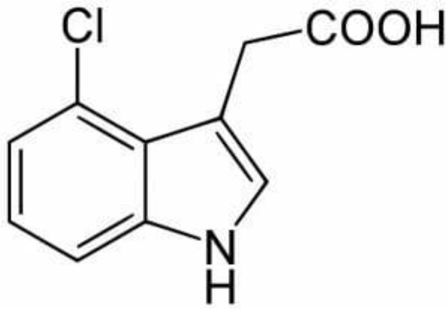
4. **Kinesis:-** This is a type of locomotory response. Since this is virtually confined to the animal kingdom it will be discussed with animal behavior plant growth substances.

Plant hormones

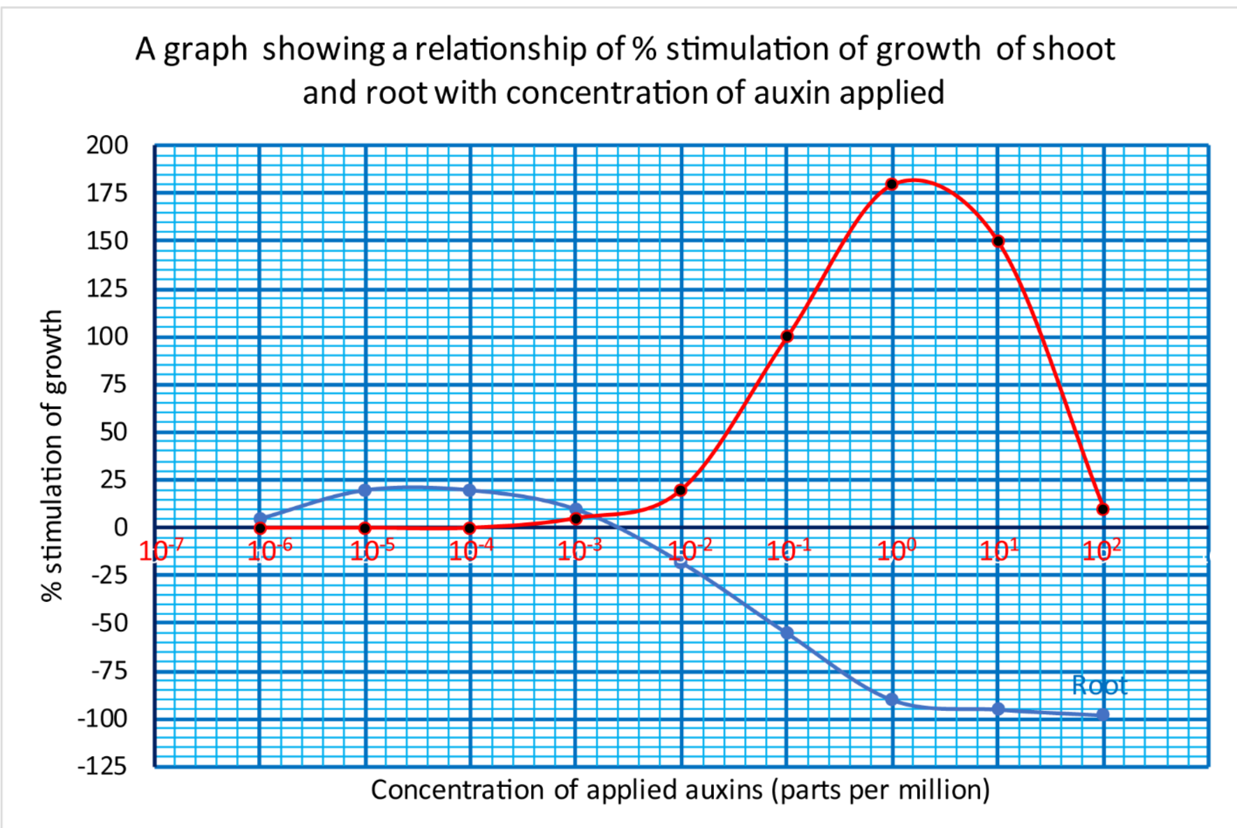
There are chemicals substances that control co-ordination in plant growth

(a) Auxins

Auxin, any of a group of plant hormones that regulate or modify growth of plants, especially root formation, bud growth, and fruit and leaf drop. They include indole acetic acid (IAA)



Auxins are produced at the shoot and root tips and concentrates on the side opposite the stimuli. In stem high concentration of auxins stimulates growth while high concentration of auxins in roots inhibits growth as shown in the graph below



Role of auxins in plants

- Stimulates cell elongation
- Stimulates cell division in the cambium and, in combination with cytokinins in tissue culture
- Stimulates differentiation of phloem and xylem
- Stimulates root initiation on stem cuttings and lateral root development in tissue culture
- Mediates the tropistic response of bending in response to gravity and light
- The auxin supply from the apical bud suppresses growth of lateral buds
- Delays leaf senescence
- Can inhibit or promote (via ethylene stimulation) leaf and fruit abscission
- Can induce fruit setting and growth in some plants
- Involved in assimilate movement toward auxin possibly by an effect on phloem transport
- Delays fruit ripening
- Promotes flowering in Bromeliads
- Stimulates growth of flower parts
- Promotes (via ethylene production) femaleness in dioecious flowers
- Stimulates the production of ethylene at high concentrations

(b) Gibberellins

This is another class of growth promoters produced particularly in young epical leaves (possibly in chloroplasts), buds, seeds and root tips. They fall in group of chemical compound called **terpenes.**

Role of gibberellins in plants

1. Promotes stem and root elongation thus, genetically dwarf varieties of peas and maize are restored to normal growth and dwarf beans can be converted into runners by application of gibberellins.
2. Mobilize enzymes that release nutrient reserves in grass seeds.
3. they **stimulate** the growth of side branches from axillary buds
4. they break dormancy and promotes germination of seeds
5. promotes bolting and flowering in long day plants
6. promotes growth of lateral buds
7. promotes development of seedless fruits (parthenocarpy)
8. delays senescence

(c) Cytokinins

This is a class of growth substances that promote cell division. They do so, however in the presence of anxins. Gibberellins may also play a role, as in the cambium.

Roles of cytokinins

1. Promotes cell division
2. Promotes morphogenesis
3. Promotes development of lateral roots
4. Delays senescence
5. Promotes stomata opening

(d) Abscisic acid (ABA)

Abscisic acid is a major inhibitor in plants and is artagonistic to all the three classes of growth promoters.

Role of abscisic acid

1. Maintains leaf dormancy
2. Causes stomata closure
3. Causes seed dormancy
4. Promotes fall of leaves and fruits

(e) Ethene

1. Promotes fruit ripening by promotes the conversion of starch to soluble sugars and trigger a sudden and dramatic increase in the respiration rate which leads to ripening.
2. Promote wound healing.
3. Promotes etiolation of in plants
4. Promotes leaf and fruit fall
5. In plants whose stems grow under water it causes the formation or aerenchyma tissue parechyma tissue with large air filled spaces between the cells: it helps to make the plant buoyant.

Phytochrome and effects of light on plant development

Phytochromes are a class of photoreceptor in plants, bacteria and fungi used to detect light.

In plants, the phyochrome molecules are found in small amounts, in the tips of growing shoot.

The compound consists of a pigment portion attached to a protein and exits in two forms inter-convertible forms. One form **Pfr** or **P730** absorbs far red light and the other **Pr** or **P660** absorbs red light. Absorption of light by one form converts it rapidly and reversibly to the other form.

In natural sunlight Pr (inactive) is converted into Pfr (active), and Pfr into Pr. However, the former predominates because sunlight contains more red than far-red light and in any case, less energy is needed to convert Pr into Pfr than **vice versa.** So Pfr tends to accumulate during day light hours, whilst at night is converted slowly back into Pr.

Besides flowering, phytochrome system regulates the germination of seeds (photoblasty), the synthesis of chlorophyll, the elongation of seedlings, the size, shape and number and movement of leaves and the timing of flowering in adult plants.

The control of flowering photopenodism & flowering

Flowering and many other responses shown by both plants and animals are regulated by day length, i.e. the duration of the **photo-period.** The general term for this phenomenon is **photoperiodism.**

In order to respond to day length, the plant must be able to : measure" the duration of the light period or dark period or both. It is now known that the critical factor is the duration of the **dark period,** in other words the time that elapse between two consecutive light periods. Experiments have indicated that photoperiodic control flowering is achieved through the pytochrome system.

On the basis of their flowering responses to the photoperiods, flowering plants can be divided into three groups.

- **Short day plants** e.g. Chrysanthemums, poinsetias and orchids. Only flower if the period of uninterrupted darkness is more than a certain length each day. Short day plants can be induced to flower by lights period that are longer than the critical lengths. Conversely, they can be prevented from flowering by nights that are shorter than the critical length. On the basis of phytochrome system, short day plants flowering is of promoted by absence of **Pfr**, which is converted into Pr during the long nights.

- **Long day plants:-** e.g. petumas, spanich, radishes and lettuce, on flower if the period of uninterrupted darkness is **less** than a certain critical length each day. Long day plants can be induced to flower by nights that are longer than the critical length. These plants will flower due to accumulation of **Pfr** resulting from long exposure to light.

- **Day neutral plants:-** e.g. geranium, tomato, cucumber and snapdragon are indifferent to day length and will flower irrespective of the relative durations of light and dark which they receive each day. If follows therefore, that flowering in these plants will occur of whether Pfr or Pr are present.

Short day and day neutral plants on the other hand, tend to live nearer the equator where days and nights are about the same length all the year, but in the temperature zone long day tend to flower in summer and short day plants flower in the autumn.

As regards to the phytochrome system, the photoperiodic stimulus is detected by leaves. From the leaves the message is transmitted to the buds, some of which respond by changing into flower buds. The latter, instead of giving rise to vegetative structure such as side branches and leaves, develop into flowers. In other words, on receipt of the message, a potentially vegetative apex is turned into a floral apex. The message itself takes the form of a chemical substance and this hypothetical flowering hormone has been named **florigen.**

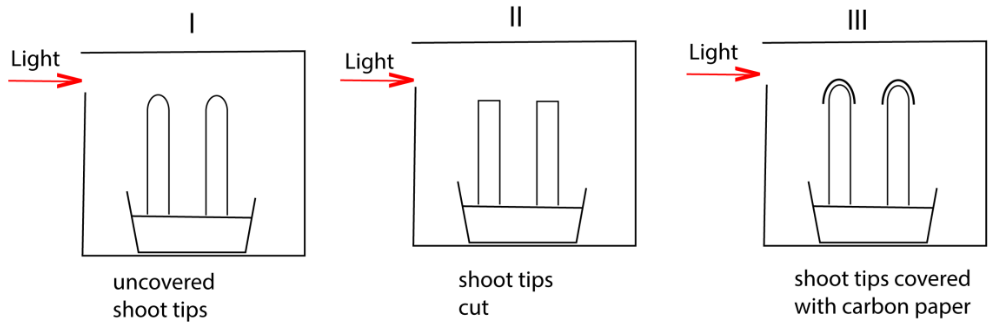
Vernalization and flowering

This is the promotion of flowering by a period of low temperature.

Exercise

1. The importance of phototropism in plants is to enable
   A. Plants to grow towards mineral salts and water
   B. Climbing plants to get grip on their support
   C. Plants in shade grow faster and get exposed to light
   D. Plant roots gain anchorage
2. The movement of maggots to dark areas when exposed to light is an example of
   A. Phototaxis
   B. Reflex action
   C. Phototropism
   D. Conditioned reflex
3. When the tip of a maize coleoptile is covered with an aluminium foil and then illuminated on one side, it grows straight because
   A. The foil kills the hormones in the coleoptile
   B. The tip does not receive the light stimulus
   C. Hormones in the coleoptile move to the zone of elongation
   D. The foil activates the hormones in the coleoptile
4. When a seedling is fixed on a rotating clinostat and placed in a horizontal position, the shoot continues to grow in a horizontal position because
   A. Auxins accumulate on the lower side of the shoot
   B. Production auxins stops
   C. Auxins are uniformly distributed in the shoot
   D. Auxins accumulate on the upper side of the shoot
5. The growth of a plant shoot towards light is induced by
   A. Lack of auxins on the dark side
   B. A higher concentration of auxins on the light side
   C. A high concentration of auxins at the tip of the shoot
   D. A higher distribution of auxins on the dark side
6. A radicle of a seedling grows downwards because he concentration of auxins is
   A. higher on the lower side, promoting growth on that side
   B. lower on its lower side, promoting growth on that side
   C. higher on its upper side, promoting growth on that side
   D. lower on its upper side, promoting growth on that side
7. Which one of the following is a nastic response?
   A. Bending of shoot towards light
   B. Folding of plant leaflets when touched
   C. Growing of plant roots towards water
   D. Bending of plant root towards gravity

8. The figure below is a setup of an experiment to show the effect of unilateral lighting on plant shoots



In which experiments would the shoot grow straight?

A. I and II
B. I and III
C. II and III
D. III only

9. Which of the following is directional growth response
A. Taxis
B. Reflex
C. Tropic
D. Nastic

10. If a long-day plant has a critical night length of 10 hours, which one of the following conditions would allow flowering in the plant?

A. 8 hours light and 16 hours darkness.

B. 16 hours light and 8 hours darkness.

C. 12 hours light and 12 hours darkness.

D. 10 hours light and 14 hours darkness.

11. Interruption of the period of darkness by a brief red light prevents flowering in a short day plant because

A. florigen is produced rapidly.

B. the concentration of Pfr lowers.

C. the concentration of Pfr increases.

D. Pr is converted to Pfr.

In a short day plant, pr promotes flowing while Pfr inhibits it. Now, red light promotes the conversion of Pr to Pfr and therefore a brief flash of red light would prevent flowering in short day plants.

12. The ripening of raw tomatoes when mixed with ripe ones occurs because ripe tomatoes produce.

A. warmth.
B. cytokinins.
C. ethene.
D. gibberellins

13. The hormone which enables plants to respond to drought is

A. gibberellins.

B. abscisic acid.

C. auxins.

D. cytokinin.

14. Which one of the following would occur to a plant requiring at least 14 hours of dark period daily in order to flower?

A. No flowering occurs if the dark period is interrupted with a flash of light.

B. Flowering occurs if the days are 14hours long.

C. No flowering occurs if the dark period is more than 14 days.

D. Flowering occurs if the dark period is interrupted with a flash of light.

15. Ripening of unripe fruits is facilitated when they are enclosed with ripe ones because

A. IAA is produced by the ripe fruits to initiate ripening of others.

B. ripe fruits produce ethene which facilitates ripening of others

C. ripe fruits increase the temperature which enhances ripening.

D. the unripe fruits absorb moisture from ripe fruits which speeds up ripening.

16. When the shoot apex of a growing plant is removed, lateral growth is encouraged because

A. auxins are activated in buds.

B. growth of lateral buds is stimulated by gibberellins.

C. more abscisic acid is produced to promote lateral growth.

D. cytokinins are activated in the absence of auxins at the apex.

17. When are gibberellins formed in the germinating starchy seed

A. After absorption of water

B. after production of amylase

C. when the radicle immerge

D. during production of amylase

18. Which one of the following pairs of responses in plants is caused by unequal distribution of auxins?

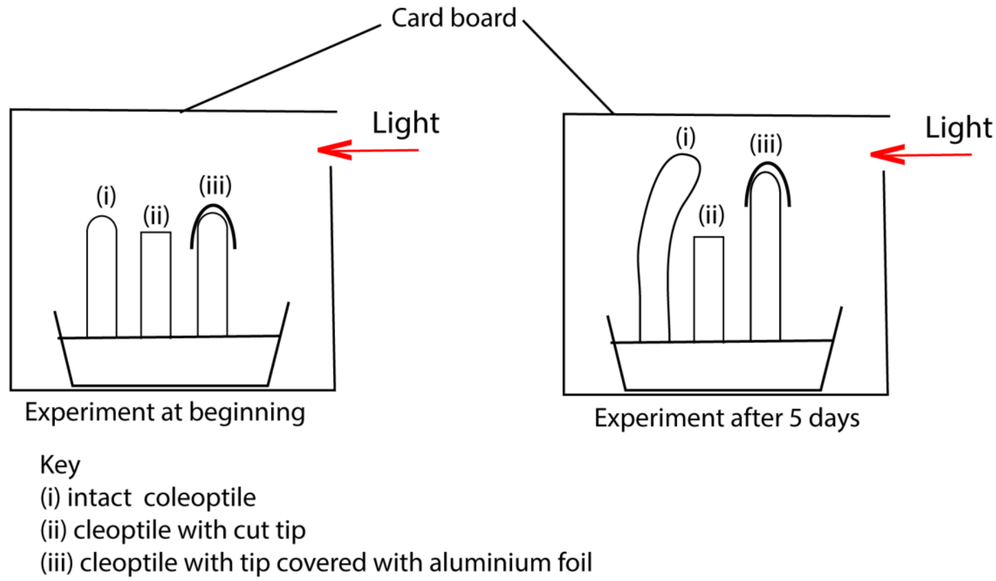
A. Photoperiodism and phototropism.

B. Geotropism *and* phototropism.

C. Nastic movement and geotropism.

D. Photoperiodism and abscission.

19. The figure below shows the effect of unilateral light on the growth of plant shoots. Study the figure and answer the questions that follow;



(a) Explain why each coleoptile appear as shown after 5 days.

(i)

(ii)

(iii)

(b) What is the importance of the response shown in the figure to the plants. (3marks)

20. (a) What is meant by tropism? (02marks)

(b) Describe the importance of different types of tropisms in plants (13marks)

21. (a) Define

(i) phototropism

(ii) geotropism

(b) Describe an experiment you would carry out to determine the effects of gravity on the root of a dicotyledonous plant.

22. Three healthy, unrelated species of flowering plants A, B and C were subjected to a range different light and dark treatments. The results are shown in the table below.

	Treatments					
	1	2	3	4	5	6
Hour of light	15	14	13	12	11	10
Hour of darkness	9	10	11	12	13	14
Species A	+	+	+	+	-	-
B	-	-	-	-	+	+
C	+	+	+	+	+	+

Key: + = flowering, - = no flowering

(a) State the photoperiodic group to which each species belong, giving a reason in each case

(i) A

(ii) B

(iii) C

(b) Describe how the phytochrome controls flowering response exhibited in species A and B

(i) Species A

(ii) Species B

(c) What would be the effect of flashing light during darkness, on each of the specimens?

(i) A

(ii) B

(iii) C

23. (a) What is meant by apical dominance?

(b) State the causes of each of the following

(i) Apical dominance

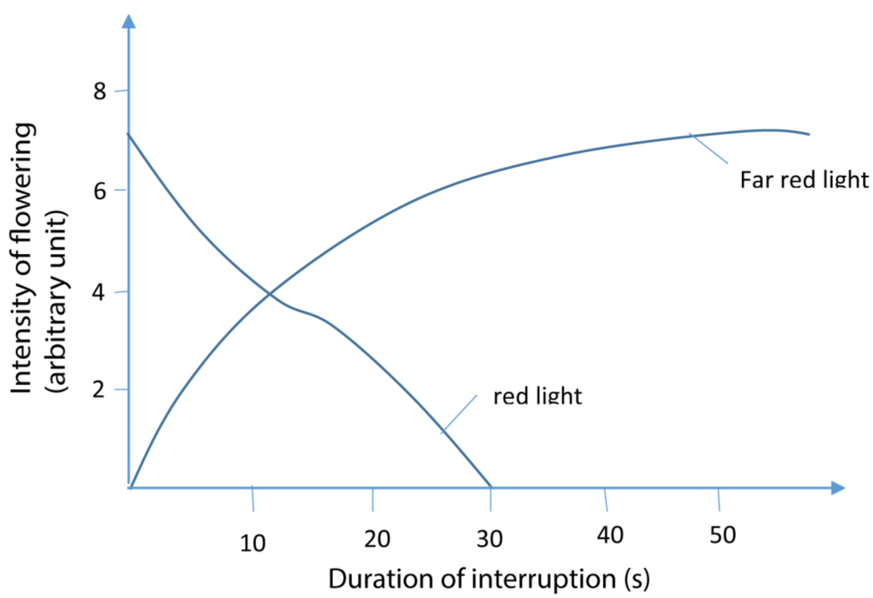
(ii) Seed dormancy

(c) what is the ecological importance of

(i) Apical dominance

(ii) Seed dormancy

24. Figure 2 show the effect of red light interruption of night period, on flowering of a plant.



(a) What is the effect of interruption of the night period by each type of light?

(i) Red light

(ii) Far-red light

(b) Suggest the type of plant that would exhibit responses to light treatments as show in figure 2.

(c) How can the knowledge of the effect of red light and far-red light on flowering be utilized in commercial growing of flowers?

25. An investigation was carried out on the effect of applying different concentrations of auxin on roots and shoots of oat seedlings. The results in table 1 obtained. Were expressed as percentage stimulation (+) or inhibition (-) of growth, compared with untreated controls. Use the information to answer the questions that follow.

Table 1

		Concentration of applied auxins (parts per million)								
% simulation of growth.		10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}	10^{2}
	Root	+5	+20	+20	+10	-18	-55	-90	-95	-98
	Shoot	0	0	0	+5	+20	100	180	150	10

(a) (i) Present the results in a suitable graphical form. (07 mark)

(ii) Using your graph, describe the effect of different concentrations of auxin on root and shoot growth. (06 marks)

(iii) From your graph and table 1, point out the difference between the responses of the roots and shoots to the different concentrations of auxin. (04 marks)

(b) In another experiment, groups of pea seedlings were treated as shown in table 2.

Table 2

Group of seedlings	Treatment done
A	Apical buds removed
B	Apical buds removed and auxin placed on cut stumps.
C	Apical buds removed and Gibberellic acid placed on cut stumps
D	Apical buds removed and cytokinin placed on cut stumps
E	Seedlings left intact

At intervals after treatment, the length of the axillary shots were determined and the results obtained were recorded as shown in table 3.

Table 3

Time after start of treatment (days)	Mean total axillary shoot length per group of seedlings (mm)				
	A	B	C	D	E
2	3	3	3	3	3
4	10	4	12	9	3
6	30	4	45	32	3
8	50	5	90	47	3
10	78	6	116	80	3
13	118	30	150	119	3

i. What was the effect of the treatment done, on each group of seedlings at the end of the experiment?

ii. Explain the results in table 3.

iii. Outline ways in which auxins have been used in improving agriculture.

1	C	6	D	11	D	16	D		
2	A	7	B	12	C	17	A		
3	B	8	C	13	B	18	B		
4	C	9	C	14	A				
5	D	10	B	15	B				

22. Solution:

(a) (i) A-long-day plant

Reason

Decreasing duration of light inhibits flowering.

(iii) B short –day plant

Reason

Decreasing duration of light favour flowering

(iii). C Day –neutral plant

Reason

Varying duration of light does not affect flowering

(b) (i) Species A

Phytochrome (P_{FR}) promotes while P_R inhibits flowering in this species. Long duration of light promotes conversion of P_R to P_{FR} and thus promotes flowering this species.

(ii).Species B

Phytochrome PFR inhibits P_R promotes flowering in this species. During a long duration of light, P_{FR} predominates and inhibits flowering. In the dark, P_{FR} is sufficiently converted of P_R which promotes flowering in this species in short light duration.

(C) (i) A

A Flash of light during darkness would promote flowering

(ii).B

A flash of light during darkness would inhibits flowering

(iii). C

A flash of light during darkness would have no effect on flowering

23. Solution

(a) Apical dominance is a phenomenon that occurs in plants where the presence of the apical bud inhibits the growth of lower axillary buds, yet when the epical bud is removed, growth of the lower buds resumes.

(b) (i) Causes of apical dominance.

- Auxins produced in the apical bud travel down the stem to the lateral buds and inhibit their growth.

- Presence of the apical bud promotes apical dominance

(ii). Causes of dormancy

- Premature embryo
- Presence of hard impermeable testa/seed coat.
- Presence of germination inhibitors such as abscisic acid.

(c) (i) Importance of apical dominance

- Enable the plant to grow first vertically so as to access sunlight.
- Enable the plant to outcompete other individuals in the vicinity for sunlight.
- In case of damage t0 the apical bud, it ensures continuity of plant species by allowing the lateral buds to grow thereafter.

(ii). Importance of seed dormancy

- Enable the seeds to survive unfavorable conditions like drought.
- Prevents the seeds from developing in the pods
- Allows for seed dispersal, which ensures colonization of new habitants

24. Solution

(a) Generally, exposure to red light inhibits flowering to an extent dependent on the duration of interruption of the night period.
When exposed for 10s or less, red light rapidly reduces intensity of flowering.
Exposed for 10-30s, the intensity of flowering decrease gradually further to zero.

Exposed beyond 30s, flowering occurs.

(ii). interruption with far-red light, becoming fairly constant for duration 5s and above.

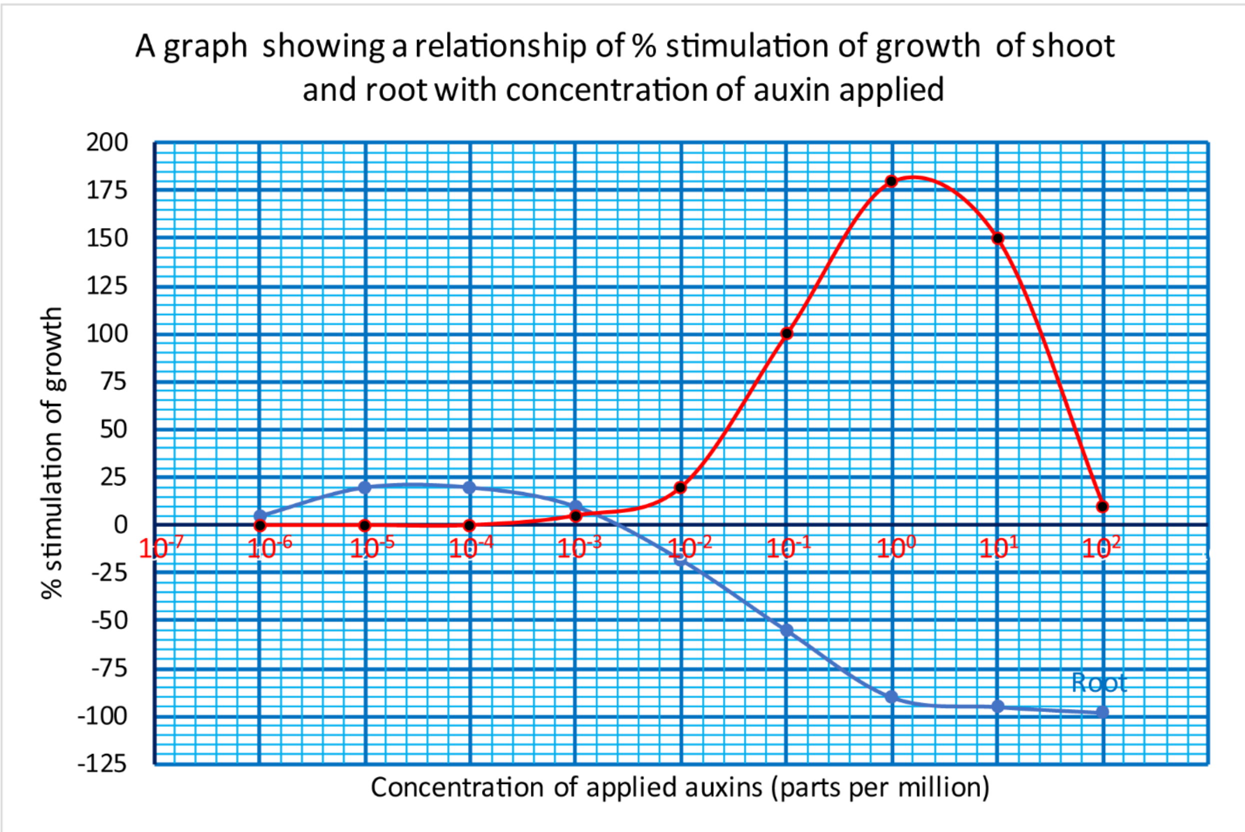
(b) The plant used in the experiment is a long –day plant

(c) Red light and far-red light stimulate flowering in long day short- day plants respectively, thus the two types of lights can be used to enhance flower harvest in different plant types.

Note
Red light inhibits flowering in this plant. Since day light is mainly red light, this plant need long hours of darkness to flower hence a short day plant.

25. Solution

(a) (i)



(ii)Generally, lower auxin concentration stimulates root growth but have no effect on shoot growth. High concentrations inhibit root growth but stimulate shoot growth.

Root growth

- From 10^{-6} to 10^{-5} ppm auxin concentration, root growth is stimulated gradually while it is constant between 10^{-5} to 10^{-4}ppm.
- From 10^{-4} to 10^{-3}ppm auxin concentration, there is gradual inhibition of root growth followed by rapid inhibition from 10^{-0} to 10^{2}ppm.

Shoot growth

- From 10^{-6} to 10^{-4} ppm auxin concentration, there is no effect on shoot growth.
- From 10^{-4} to 10^{-2}ppm auxin concentration, there is gradual stimulation of shoot growth followed by a rapid stimulation to a maximum from 10^{-2} to 10^{0}ppm.
- From 10^{0} to 10^{2}ppm, there is a rapid inhibition of shoot growth.

(iii)

Root growth response	Shoot growth response
From 10^{-6} to 10^{-4} ppm, root growth is stimulated From 10^{-4} to 10^{-3}ppm, there is gradual inhibition of root growth. From 10^{-2} to 10^{0} ppm, there is rapid inhibition of root growth. From 10^{0} to 10^{2}ppm, there is gradual inhibition of root growth	Auxin concentration from 10^{-6} to 10^{-4} ppm have no effect on shoot growth. From 10^{-4} to 10^{-2}ppm, there is gradual stimulation of shoot growth From 10^{-2} to 10^{0} ppm, there is a rapid stimulation of shoot growth to a maximum. From 10^{0} to 10^{2} ppm, there is a rapid inhibition of shoot growth.

(b) (i) group A

There is gradual increase in mean total axillary shoot length with time up to day 10 followed by a rapid increase up to day 13

Group B

There is a very slow increase in mean total axillary shoot length with time up to day 10 followed by a rapid increase up to day 13.

Group C

There is rapid increase in mean total axillary shoot length with time up to day 8 followed by a more rapid increase up to day 13.

Group D.

There is a gradual increase in mean total axillar shoot length with time up to day 4 followed by a rapid increase up to day 10 and a more rapid increase up to day 13.

Group E

Mean total axillary shoot length remains constant over the period of the experiment.