- promotes vascular differentiation
- retards leaf abscission

**Gibberellins**

- stimulate stem elongation
- stimulate pollen development
- stimulate pollen tube growth
- stimulate fruit growth
- stimulate seed development and germination
- regulate sex determination and transition from juvenile to adult phase

**Cytokinins**

- regulate cell division in shoots and roots
- modify apical dominance and promote lateral bud growth
- promote movement of nutrients into sink tissues
- stimulate seed germination
- delay leaf senescence

**Abscisic acid**

- inhibits growth
- promotes stomatal closure during drought stress
- promotes seed dormancy and inhibits early germination
- promotes leaf senescence
- promote desiccation tolerance

**Ethylene**

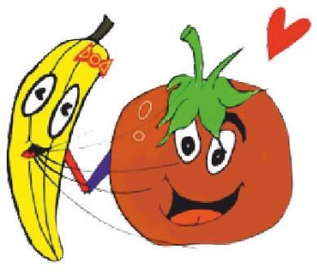
- promotes ripening of many types of fruit
- promote leaf abscission
- promote triple response in seedlings (inhibition of
- stem elongation, promotion of lateral expansion, and
- horizontal growth)
- enhance the rate of senescence
- promote roots and root hair formation
- promotes flowering in the pineapple family

**3. Write short notes on tropic movements of plants**

**Answer**

1. A growth movement
2. of a part of plant
3. in response to an external stimulus
4. in a direction dictated by the direction of stimulus.
5. Can be described as + ve or—ve,
   Several types of movements eg.
6. Phototropism - movement in response to light shown
7. by most plant shoots (sterns),
8. Geotropism - movement in response to gravity
9. shown by most plant roots,
10. Thigmotropism - movement in response to contact,
11. shown by plant tendrils,
12. *Hydrotropism - movement in response to water,*
13. *shown by most plant roots,*
14. *Chemotropism - movement in response to chemicals,*
15. *shown by plant pollen tubes/ fungal hyphae.*
16. The mechanism of tropic movement involves auxin.
17. Differential distribution of auxin in stem apex in response to light,
18. *Differential distribution in roots influenced by statoliths (starch grains)*
19. and cell elongation.

ETHYLENE





# Biology

ENGLISH MEDIUM

Live Biology



UNIT 04

## Plant form and Function

**4.5.0. Plant responses to internal and external Signals**

MEMORY MAXIMIZING PROGRAM Live Biology

# Biology

New Syllabus

SAMPATH LANKADHEERA

Unit 04 **Plant form and Function**

**4.5.0. Plant responses to internal and external Signals**

ADVANCED LEVEL

# Biology

**Unit - 04**

## Plant Responses

Print 2024 August



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**1. Describe Plant responses to light.**

1. Key events in the growth and development of plants that are trigged by light are collectively known as Photomorphogenesis.
2. Action spectrum reveals that the red and blue lights are the most important colours in the regulating plant photomorphogenesis.
3. Photomorphogenesis occurs with the involvement of two major classes of photoreceptors, namely cryptochromes and phytochromes.
4. Cryptochromes are blue light photoreceptors and phytochromes are red light photorephtors.
5. Phytochromes are major type of photoreceptors involving in seed germination.
6. Shade avoidance,
7. flowering,
8. light induced slowing down of hypocotyl elongation during the seedling development are some examples for photomorphogenesis.
9. As the nutrient reserves are limited, many types of seeds (especially small ones germinate only when the light environment and other conditions are nearly optimal.
10. Red light of wavelength of 660nm increase percentage of seed germination
11. Far-red light wavelength (730nm) inhibit seed germination
12. This is due to the effects on phytochromes.
13. During seed germination when a seedling breaks ground, light induced slowing of hypocotyl elongation is due to the responses of blue light photoreceptors.
14. Such seeds often remain dormant for years until light conditions change.
15. eg.- Plowing a field or a death of a shady tree may create a favorable light environment for germination
16. Phytochromes provide the plant with information about the quality of light
17. which enables the plant to get adapted to changes in outside light conditions.
18. eg. “Shade Avoidance” response of a forest tree (below the canopy) that requires relatively high light intensity.
19. As the forest canopy absorbs more red light allowing only far red light to pass through,
20. the tree below the canopy will allocate more of its resources to grow taller.
21. In contrast, exposure to direct sunlight increases the proportion of red: far red light and thereby stimulates branching and inhibits vertical growth.
22. Photoperiod is the interval in a 24 hour period in which the plant gets exposed to light.
23. Photoperiod controls flowering in many types of plants.
24. Controlled by phytochromes (with far-red light wavelength ratios).
25. The growth of a shoot towards light (positive)
26. or away from it (negative) is called phototropism.
27. Positive phototropism strengthen photosynthesis
28. This response results from a differential growth of cells on opposite sides of the shoot;
29. The cells in the darker side elongate faster than the cells on the brighter side.
30. Blue light photoreceptors involve.

**2. (a) What are plant growth substances?**
**(b) Give examples of major growth substances and state their sites of productions.**
**(c) Give a brief account of the functions of plant growth substances in plants.**

**Model Answer**

**1. What are plant growth substances?**

- Plant growth substances are plant hormones that are active even at very low concentration.

**2. Give examples of major growth substances and state their sites of productions.**
Auxin (IAA) /Gibberellins/Cytokinins/Abscisic acid/Ethylene

**3. Give a brief account of the functions of plant growth substances in plants.**
**Auxin**

- stimulates stem elongation in low concentration
- promotes the formation of lateral and adventitious roots
- regulates development of fruit
- enhances apical dominance
- functions in phototropism
- functions in gravitropism

ADVANCED LEVEL

# Biology

## THEORY

in English Medium

**New Syllabus**

**Unit 04**

**Plant form and Function**

# Smart Note

**4.5.0. Plant responses to internal and external Signals**

**SAMPATH LANKADHEERA**

B.Sc. Hons. M.Sc. (Biotechnlogy)

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**4.5.1. Responses of plants to different stimuli**

**Response to Light**

**Photomorphogenesis:**

- Key events in the growth and development of plants that are trigged by light are collectively known as Photomorphogenesis.
- Action spectrum reveals that the red and blue lights are the most important colours in the regulating plant **photomorphogenesis.**


- Photomorphogenesis occurs with the involvement of two major classes of photoreceptors, namely cryptochromes and phytochromes.
- Cryptochromes are blue light photoreceptors and phytochromes are red light photorephtors.
- Phytochromes are major type of photoreceptors involving in seed germination Shade avoidance, flowering, light induced slowing down of hypocotyl elongation during the seedling development are some examples for photomorphogenesis.



23. Incorrect statement regarding plant stress responses
(1) When cell membrane cools below a critical temperature it looses its fluidity
(2) Many plants can respond to moderate soil salinity by storing inorganic solutes that are well tolerated at high concentrations
(3) Plants may wilt when water loss by transpiration exceeds water absorption.
(4) Amount and quality of wax and cuticle that cover the epidermal cells is a preexisting structural and chemical defense mechanisms;
(5) Morphological changes in the cell wall is induced structural and chemical defense mechanisms;

**AL 2003**

A. (i) What are the major types of plant hormones involved in growth and development?

.....

.....

(ii) Name the major type of plant hormone that is involved in each of the functions given below.

Breaking of dormancy of seeds .....
Cell division .....
Apical dominance .....
Flower initiation .....
Delaying senescence .....
Stomatal closure .....
Shoot growth .....
Fruit ripening .....
Regulate cell division in shoots .....
Parthenocarpy .....

**Essay**

1. **Describe Plant responses to light.**

2. **(a) What are plant growth substances?**
**(b) Give examples of major growth substances and state their sites of productions.**
**(c) Give a brief account of the functions of plant growth substances in plants.**

3. **Write short notes on tropic movements of plants**

9. Which of the following is the hormone to move nutrients in to sink?
(1) Gibberellins (2) Auxin (3) Cytokinin (4) ABA (5) Etylene

10. Identify the chemical that inhibits sprouting of buds and thus facilitate their long term storage:
(1) Gibberellins (2) Auxin (3) Cytokinin (4) ABA (5) Ethylene

11. Identify the false statement:
(1) Auxins enhance apical dominance (2) Gibberellins induces seed germination.
(3) Gibberellins regulate sex determination
(4) Abscisic acid is a growth promoter. (5) Cytokinin's are anti-senescence hormone.

12. Ripening of fruit can be facilitated by keeping them in an atmosphere rich in:
(1) Oxygen (2) Carbon dioxide (3) Ethylene (4) Nitrous oxide (5) $N_2$

13. Retarding leaf abscission and promoting leaf abscission is done by:
(1) Cytokinin and ABA (2) Auxin and Ethylene (3) Cytokinin and Ethylene (4) Gibbrelline and ABA
(5) Auxin and Cytokinin

14. Abscisic acid promotes
(1) Premature ripening of fruit (2) Seed formation (3) Formation of small sized flowers
(4) Closure of stomata. (5) Parthenocarpy

15. Plant secrete substances that regulate growth and effect physiological mechanisms, these are called
(1) Cytochromes (2) Photoreceptors (3) Phytochromes (4) Pigments (5) Plant growth regulators

16. Auxin stimulate:
(1) Protein synthesis (2) Photosynthesis (3) Cell elongation (4) Transpiration (5) Vascular differentiation

17. Which of the following classes of plant hormones play a major role in cell division?
(1) Auxins (2) Gibberellins (3) Abscisic acid (4) Cytokinin (5) Ethylene **(AL 2000)**

18. Which one of the following substances is **incorrectly** paired with its function?
(1) Auxin — root elongation (2) Cytokinin — induction of senescence in plants
(3) Gibberellins — seed germination (4) Abscisic acid — seed dormancy
(5) Ethylene — Triple response in seedling **(AL 2001)**

19. Auxins stimulate
(1) cell division of stem apex. (2) rooting of stem cuttings. (3) growth of lateral buds.
(4) ripening of fruits. (5) breaking of seed dormancy. **(AL 2002)**

20. Which of the following statement regarding plant growth substance is incorrect?
(1) Ethylene promotes ripening of fruits. (2) Auxins promote root initiation.
(3) Gibberellins break seed dormancy. (4) Cytokinin's delay aging of leaves.
(5) Abscisic acid breaks seed dormancy **(AL 2005)**

21. Which of the following is not a plant stress..
(1) Drought stress (2) Cold stress (3) Salt stress (4) Light stress (5) Biotic stress

22. Find correct statement
(1) Water deficit stimulates increased synthesis and release of abscisic acid (ABA), which acts on guard cell membrane, closing stomata to reduce transpiration.
(2) In grasses the leaves roll in to a tube-like shape which reduces the surface area to reduce transpiration. Some plants shed their leaves during seasonal drought.
(3) They increase the proportion of unsaturated fatty acids which keeps the membranes more fluid at low temperature.
(4) Water in the cell wall and intercellular spaces freezes before freezing the solute-rich water in the cytosol.
(5) Before the onset of winter, the cell of frost-tolerant plants increases cytoplasmic levels of specific solutes such as sugars that help to reduce the loss of water from the cell preventing dehydration.



**Seed germination** **Effect of light on:**

- .....
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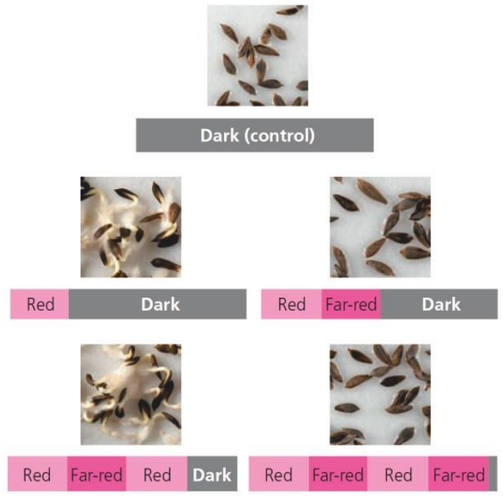
- Red light of wavelength of 660nm increase percentage of seed germination.
- Far-red light wavelength (730nm) inhibit seed germination. This is due to the effects on phytochromes.
- During seed germination when a seedling breaks ground, light induced slowing of hypocotyl elongation is due to the responses of blue light photoreceptors.
- Such seeds often remain dormant for years until light conditions change. (Eg: Plowing a field or a death of a shady tree may create a favorable light environment for germination)



**Plant spacing**

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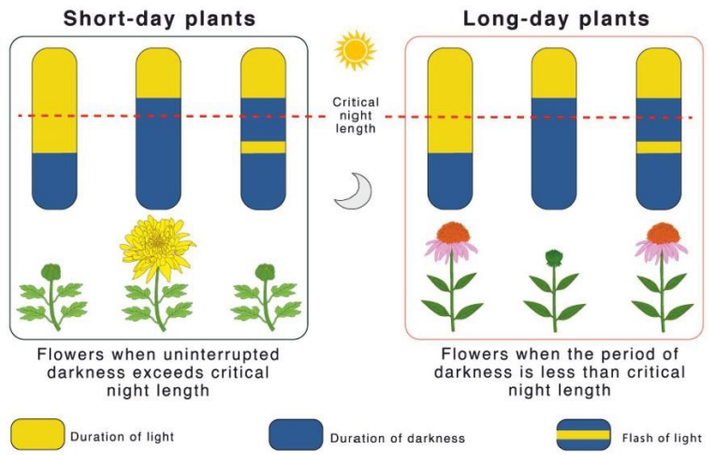
- Eg: "Shade Avoidance" response of a forest tree (below the canopy) that requires relatively high light intensity. As the forest canopy absorbs more red light allowing only far red light to pass through, the tree below the canopy will allocate more of its resources to grow taller. In contrast, exposure to direct sunlight increases the proportion of far red: red light and thereby stimulates branching and inhibits vertical growth.


**Flowering**

- Photoperiod is the interval in a 24 hour period in which the plant gets exposed to light.
- Photoperiod controls flowering in many types of plants.
- Controlled by phytochromes (with far-red light wavelength ratios).






**MCQ**

1. Which of the following is incorrect.
   (1) Light triggers many key events in plant growth and development, collectively known as photomorphogenesis.
   (2) Light reception also allows plants to measure the passage of days and seasons.
   (3) Plants detect not only light signals, but also the direction, intensity and wave length
   (4) A graph called an action spectrum depicts the relative amount of light absorbed in carrying out photosynthesis.
   (5) Action spectrum reveals that red and blue light are the most important colors in regulating plant's photomorphogenesis.

2. Find correct statement
   (1) The two major classes of light receptors in plants are the blue light photoreceptors and cytochrome
   (2) Far red photo receptors initiates a variety of responses in plants, including phototropism, the light induced opening of stomata
   (3) The light induced slowing of epicotyl elongation that occurs when a seedling breaks ground.
   (4) Phytochrome photoreceptors regulate many plant responses to light, including seed germination and shade avoidance.
   (5) Far red is the wave length above 760nm.

3. Incorrect about seed germination.
   (1) As the nutrient reserves are limited, many types of seeds germinate only when the light environment and other conditions are nearly optimal.
   (2) Some seeds often remain dormant for years until light conditions change.
   (3) Plowing a field or a death of a shady tree may create a favorable light environment for germination
   plant spacing
   (4) Seed dormancy occur due to some plant hormones.
   (5) Far red stimulates germination.

4. Select incorrect statement.
   (1) Phytochromes provide the plant with information about the quality of light
   (2) Light quality enables the plant to get adapted to changes in outside light conditions.
   (3) "Shade Avoidance" response of a forest tree (below the canopy) that requires relatively high light intensity.
   (4) As the forest canopy absorbs more red light allowing only far red light to pass through the tree below the canopy will allocate more of its resources to grow taller.
   (5) Exposure to direct sunlight increases the initiate vertical growth.

5. Which of the following statement is incorrect about gravitropism
   (1)Shoot of the plant grows upwards while root grows downwards, due to their response to gravity or gravitropism.
   (2)Gravitropism can be either positive or negative.
   (3)Gravitropism occurs as soon as a seed germinates. This ensure that the root grows into the soil and shoot grows towards sunlight.
   (4)Plants may detect gravity by the settling of statoliths.
   (5)Statolith of vascular plants are specialized plastids containing dense starch grains to detect gravity.

6. Trees grow in windy environment normally have shorter stockier trunks than same species growing in normal environmental conditions. Which of the following shows the reason
   (1) This exhibits the sensitivity of mechanical stress of plants. (2) High wind reduces ability of photosynthesis.
   (3) Plant increase transpiration to result shorter trunk. (4) Due to lack of temperature for photosynthesis
   (5) Production of more $CO_2$ by cellular respiration.

7. During evolution, some plant species have become 'touch specialists'. Which of the flowing is not an example of touch response.
   (1) Tendrils coil rapidly around support. (2) Rapid leaf movements of *Mimosa pudica*
   (3) A wine grow around a support (4) Bend of glandular tentacles of Sundews.
   (5) Close of Nepenthes lid when touched by an insect.

8. What is the hormone to retard leaf abscission?
   (1) Ethylene (2) Gibebrellins (3) Auxin (4) ABA (5) Cytokinins

**3. Salt stress**

- An excess of salts (high salinity) in soil lowers the water potential of soil resulting reduced water potential gradient from soil to root. This leads to reduction of water uptake by roots.
- In general too high salinity in soil is toxic to plants.
- Many plants can respond to moderate soil salinity by producing solutes that are well tolerated at high concentrations. These are organic compounds that keep the water potential of cell more negative than that of the soil solution.
- A few plants that are salt-tolerant (halophytes) have developed salt glands, which secrete excess salts out of the plant across leaf surfaces. e.g. many mangrove plants

**Biotic stress**

- How plants defend themselves against pest and pathogens attack; In plant defense mechanisms, some compounds and structures are already existed whilst some others are formed after infection or pest attack.
- Therefore, two categories of defense mechanisms called

1. Preexisting
2. Induced mechanisms can be identified.

**Pre-existing structural and chemical defense mechanisms**

1. Amount and quality of wax and cuticle that cover the epidermal cells.
2. The structure of the epidermal cell walls and thickness.
3. The size, location and shapes of stomata.
4. Thorns, pricks, trichromes
5. Chemical defense mechanisms include plants producing secondary metabolites namely toxic compounds such as cyanogenic glycosides, Alkaloids such as nicotine, phenolics such as flavanoids, lignin and tannins. Terpenoids such as Azadirachtin and Lectin.

**Induced structural and chemical defense mechanisms**

1. Morphological changes in the cell wall
2. Formation of cork and abscission layers
3. Production of phenolic compounds
4. Production of toxic compounds
5. Production of enzymes that can degrade fungal cell walls or damage insect organs



**Shoot elongation and Phototropism**

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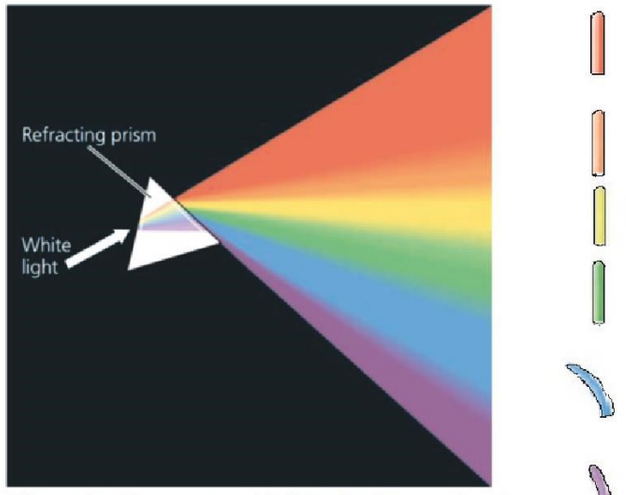
- This response results from a differential growth of cells on opposite sides of the shoot; the cells in the darker side elongate faster than the cells on the brighter side.
- Involvement of phytochromes/blue light photoreceptors.




When coleoptiles are exposed to light of various wavelengths as shown here, violet light induces slight curvature toward the light and blue light induces the most curvature. The other colors do not induce any curvature.

**Response to Gravity**

**Gravitropism**

- **Shoot of the plant grows upwards while root grows downwards, due to their response to gravity or gravitropism.**
- **Gravitropism can be either positive or negative.**
- **Eg: Roots display positive gravitropism while shoot display negative gravitropism.**
- **Gravitropism occurs as soon as a seed germinates. This ensure that the root grows into the soil and shoot grows towards sunlight.**
- **Plants may detect gravity by the settling of statoliths.**
- .....
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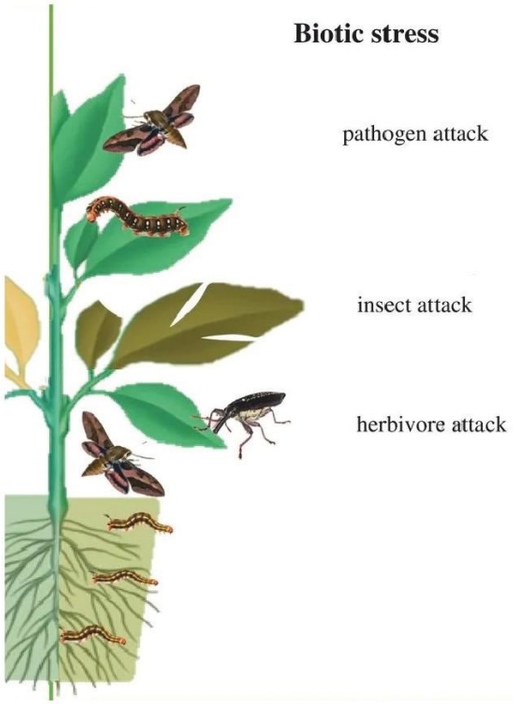
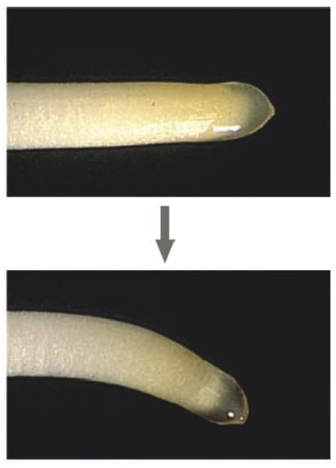
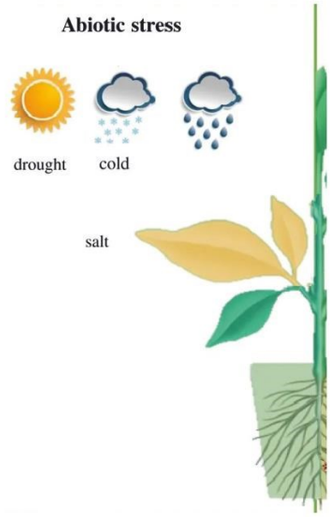
**The Statolith hypothesis:**

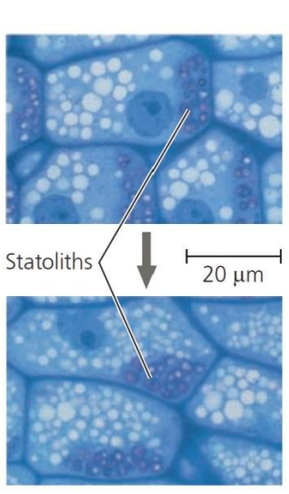
- **The aggregation of statoliths at the low points of root cap cells triggers re-distribution of Ca2+ which cause lateral transport of auxin within the root.**
- **As a result, Ca and auxin get accumulated at lower side of elongation zone of root.**
- **At high concentration of auxin, cell elongation is inhibited resulting slow growth on lower side and more rapid elongation on upper side. Consequently, the root grows downwards.**



**(a)** Over the course of hours, a horizontally oriented primary root of maize bends gravitropically until its growing tip becomes vertically oriented (LMs).



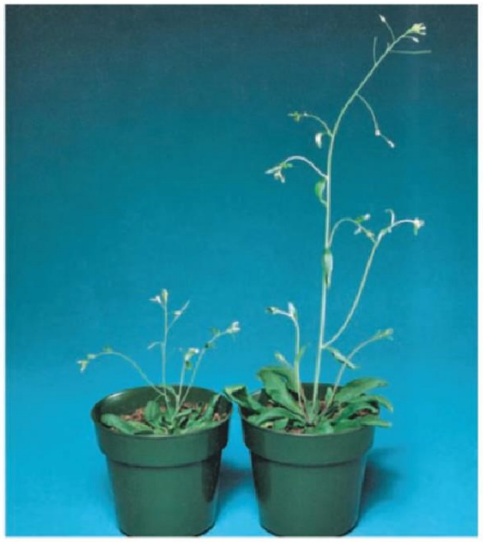

**(b)** Within minutes after the root is placed horizontally, plastids called statoliths begin settling to the lowest sides of root cap cells. This settling may be the gravity-sensing mechanism that leads to redistribution of auxin and differing rates of elongation by cells on opposite sides of the root (LMs).

**Response to Mechanical Stimuli**

- **Trees grow in windy environment normally have shorter stockier trunks than same species growing in normal environmental conditions.**
- **Advantage of this is that the tree could stand high winds.**
- **This exhibits the sensitivity of mechanical stress of plants.**

**Thigmo-morphogenesis**

- **The changes in plant form due to mechanical disturbances is called thigmo-morphogenesis.**



**Thigmorphogenesis in *Arabidopsis*.** The shorter plant on the left was rubbed twice a day. The untouched plant (right) grew much taller.

Plant movements

| Tropic Movement | Nastic Movement | Taxic Movement |
|---|---|---|
| | | |
| | | |
| | | |



**4.5.3. Response of plants to some biotic and abiotic stresses**

**Stress**

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**Abiotic Stress**

- Among several common abiotic stresses. Following three stresses are discussed.
  1. Drought stress 2. Cold stress 3. Salt stress

**1. Drought stress**

- Plants may wilt when water loss by transpiration exceeds water absorption.
- Prolonged drought may even kill a plant.
- Plants have control systems that enable them to cope with the drought/water deficit conditions.
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**2. Cold stress**

- When cell membrane cools below a critical temperature it looses its fluidity due to the lipids become locked in to crystalline structure. This blocks the transport across the membrane and affects the function of the cell.
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- The reduction of liquid water in the cell wall lowers the extracellular water potential causing water in the cytosol to leave.
- This results high concentration of solutes in the cytoplasm which is harmful and may lead to cell death.
- Before the onset of winter, the cell of frost-tolerant plants increases cytoplasmic levels of specific solutes such as sugars that help to reduce the loss of water from the cell preventing dehydration.

**4.5.2: Investigates the role of plant growth substances/regulators/hormones in response to different stimuli**

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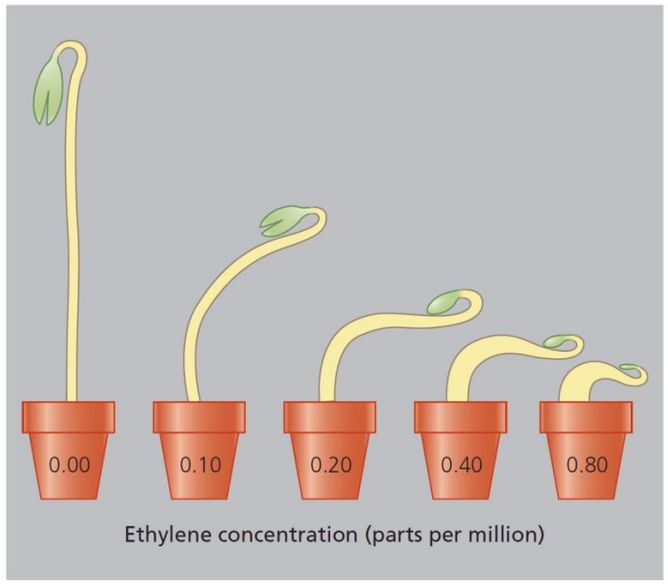
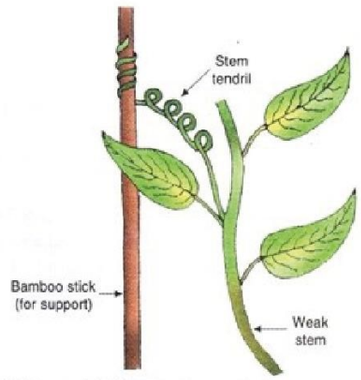
- **With this definition, its hard to explain some physiological processes in plants.**
- **In addition, some signaling molecules that are considered as plant hormones act locally. Thus the broader term plant growth regulators seem more appropriate.**
- **Plant growth regulators are natural or synthetic organic compounds which modify or control specific physiological process in plants.**
- **Plant biologists prefer to use the term plant growth regulators rather than plant hormones, as there are certain differences in plant hormones and animal hormones.**
- **Therefore, plant hormones and plant growth substances are considered as equal. But plant hormones are active even at very low concentration.**
- **Major types of plant hormones/growth regulators are auxins, gibberellins, cytokinin, abscisic acid, ethylene and Jasmonate (jasmonic acid).**



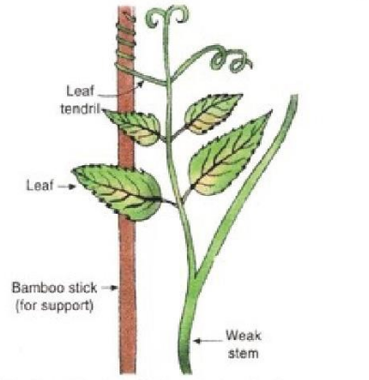



**Thigmotropism**

- **During evolution, some plant species have become 'touch specialists'. Climbing plants have tendrils that coil rapidly around support. Tendril usually grows straight until it touches a support.**
- **The contact stimulates differential growth on opposite sides of the tendril. The directional growth of tendril towards support is called Thigmotropism.**



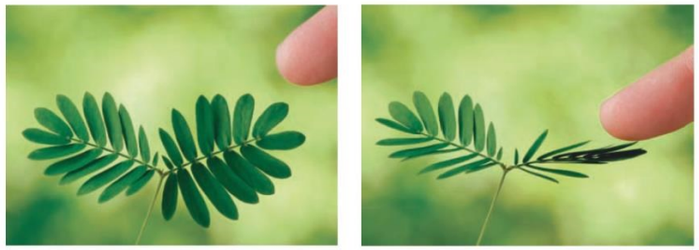

(*a*) Stem tendrils help the plant to climb up a support



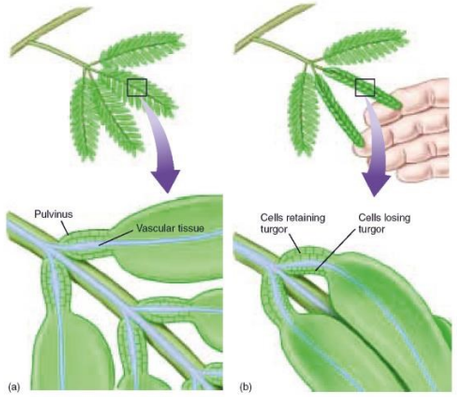

(*b*) Leaf tendrils also help the plant to climb up a support

**Thigmonasty**

- **Other touch specialists, respond to touch by rapid leaf movements.**
- ***Eg: Mimosa pudica* collapses its leaflets when touched.**
- **Touching results in a sudden loss of turgor of cells in a specialized motor organ called pulvini, causing the leaflets to collapse.**
- **This response is called Thigmonaty.**



**(a) Unstimulated state (leaflets spread apart) (b) Stimulated state (leaflets folded)**



| Auxin | Gibberellins | Cytokinins s | Abscisic acid | Ethylene |
|---|---|---|---|---|
| • Stimulates stem elongation in low concentration<br>• Promotes the formation of lateral and adventitious roots<br>• Regulates development of fruit<br>• Enhances apical dominance<br>• Functions in phototropism<br>• Functions in gavitotropism<br>• Promotes vascular differentiation<br>• Retards leaf abscission | • Stimulate stem elongation<br>• Stimulate pollen development<br>• Stimulate pollen tube growth<br>• Stimulate fruit growth<br>• Stimulate seed development and germination<br>• Regulate sex determination and transition from juvenile to adult phase | • Regulate cell divivision in shoots and roots<br>• Modify apical do ominance and promote lateral ll bud growth<br>• Promote movemment of nutrients into sinink tissues<br>• Stimulate seed ggermination<br>• Delay leaf senesscence | • Inhibits growth<br>• Promotes stomatal-closure during drought stress<br>• Promotes seed dormancy and inhibits early germination<br>• Promotes leaf senescence<br>• Promote desiccation tolerance | • Promotes ripening of many types of fruit<br>• Promote leaf abscission<br>• Promote triple response in seedlings (inhibition of stem elongation, promotion of lateral expansion, and horizontal growth)<br>• Enhance the rate of senescence<br>• Promote roots and root hair formation<br>• Promotes flowering in the pineapple family |