CO-ORDINATION AND CONTROL

Coordination is the ability of an organism to detect and respond to changes in their internal and external environment.

Definitions of important terms

1. **Irritability**; this is the ability of an organism to detect and responds to a stimulus in the environment.
2. **Stimulus**; this is a change in the external or internal environment to which an organism responds.
3. **Response**; this is a change in activity of an organism in reaction to a stimulus
4. **Impulse**; this is an electrical message transmitted along nerves in a nervous system.
5. **Effectors**; these are cells or organs in an organism that carry out a response to a stimulus.
6. **Receptors**; these are cells or organs that receive or detect a stimulus.
7. **Internal environment**; this is the immediate surroundings of cells. In animals the internal environment is the blood and tissue fluid.
8. **External environment**; this is the surrounding of the entire organism.

RESPONSES IN ORGANISMS

1. **Nastic responses.**

   This is the movement of part of the plant in response to a non-directional stimulus. This can be observed in the closing of the leaves of *mimosa pudica* when touched (thigmonasty), leaf movements in carnivorous plants
2. **Tactic responses**

   This is a type of response where the whole organism moves towards or away from a unidirectional stimulus. This response is common in lower organisms such as chlamydomonas, chlorella, and antheroziods of moss.
3. **Tropisms**

This is a growth movement of part of a plant in response to a unidirectional stimulus e.g. growth of a plant shoot towards unidirectional light

Note;

Tactic responses and tropisms can be described as negative if movement is away from the stimulus or positive if the movement is towards the stimulus.

The responses are of different types depending on the nature of the stimulus.

COORDINATION AND IRRITABILITY IN PLANTS

Coordination and control in plants is carried out by plant hormones. Plants don't have a nervous system and information is carried by hormones especially ***auxins.***
Since plants do not move from one place to another, their response involves growth movements of part of the plant or the entire plant and turgor changes within cells. Parts of the plant move towards or away from a stimulus due to changes in auxin concentration in the parts concerned.
Plant responses are divided into the following.

1. **Nastic responses.**
2. **Tactic responses**
3. **Tropisms**

TROPISMS

A tropism is the growth movement of a plant part in response to unidirectional stimulus. The direction of response is related to that of the stimulus and the plants move towards or away from it.

Characteristics of tropisms

1. Involve growth
2. Response is slow
3. Occur at the shoot and root tips
4. Related to the direction of stimulus
5. Induced by directional stimulus

Importance of tropisms to plants

1. It enables plants leaves to trap maximum sunlight by enabling plant shoots to grow upright.
2. It enables plants to become firmly anchored in the soil by the roots growing towards gravity.
3. It enables plant roots to absorb or obtain water which is necessary for plant growth.
4. It enhances fertilization in plants since the pollen tubes grow towards the chemicals of the embryo sac.
5. It enables climbing plants to gain support by twinning around the support.
6. Tropisms allow plant parts to alter direction in response to changing conditions in the environment.

TYPES OF TROPISMS

Tropisms are divided into different types depending on the nature of the stimulus. The table below shows the name of tropism and corresponding stimulus

Name of tropism	Stimulus
1. Hydrotropism	Water
2. Thigmotropism/haptotropism	Touch
3. Chemotropism	Chemicals
4. Geotropism	Gravity
5. Phototropism	Light
6. Aerotropism	Air

Hydrotropism; this is the growth movement of part of a plant towards or away from water.

Thigmotropism; this is the growth movement of part of a plant in response to touch.

Chemotropism; this is the growth movement of part of a plant towards or away from a particular chemical e.g. pollen tube grows towards the embryo sac through the style during fertilization by responding to the source of chemicals produced by the embryo sac.

Geotropism; this is the growth movement of part of a plant in response to gravity.

Aerotropism; this is the growth movement of part of a plant towards or away from air.

The table below shows some of the tropic movements shown by plants

Type of tropism	Stimulus	Positive response	Negative response
Phototropism	Light	Shoot	Root
Geotropism	Gravity	Root	Shoot
Hydrotropism	Water	Roots	Shoots
Chemotropism	Chemicals	Antherozoids, pollen tube	-
Thigmotropism	Touch	Tendrils of passion fruits	Root tips when in contact with an obstacle
Aerotropism	Air	Roots of red mangrove	Pollen tubes

Control of tropisms by auxins/Indole acetic acid (IAA)

Responses in plants are controlled by a group of plant hormones especially **auxins**. Auxins are also referred to as plant growth substances. *These **auxins** are produced at the **root tip** and **shoot tip.** They move from one cell to the next by **diffusion** and are transported over long distances in the **phloem** together with manufactured food.*

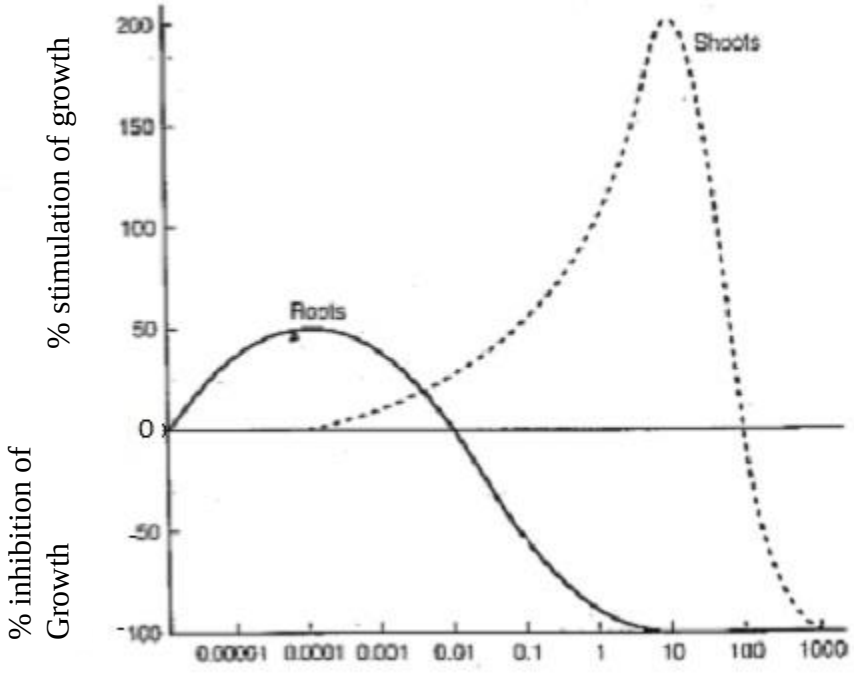
Auxins control responses by controlling growth through stimulation of cell elongation. Here, cells of one side of the shoot are stimulated to grow faster than those on the opposite side which result into differential growth.

Differential growth may also result from cells of one part of a plant such as shoot growing much faster than cells in the root.

Differential growth is brought about by the redistribution of plant of **auxins**.

- In a shoot, a high concentration of auxin increases growth while a low auxin concentration reduces growth.
- In a root, a low auxin concentration stimulates and thus increases growth while a high auxin concentration inhibits growth thus reducing rate of growth

Graph showing the effect of auxins concentration on the growth of roots and shoots.



SHOOT

- At very low auxin concentration, there is no stimulation of shoot growth.
- When auxin concentration increases from 1×10^{-4} parts per million to 1part per million, there is a gradual increase in shoot stimulation of growth.
- Increase in auxin concentration from 1part per million to 10 parts per million results into rapid increase in percentage stimulation of shoot growth to maximum.
- Further increase in auxin concentration from 10 parts per million to 1000 parts per million results into rapid decrease in stimulation of growth and shoot growth is inhibited.

ROOT

- Stimulation of root growth occurs at very low auxin concentration, and increases gradually to peak at auxin concentration of about 1×10^{-4} parts per million.
- Further increase in auxin concentration results into inhibition of root growth.

PHOTOTROPISM

This is the growth movement of part of a plant in response to unidirectional light. Plant shoots are positively phototropic that is, they grow towards the direction of light while the roots are negatively phototropic (they grow away from the direction of light).

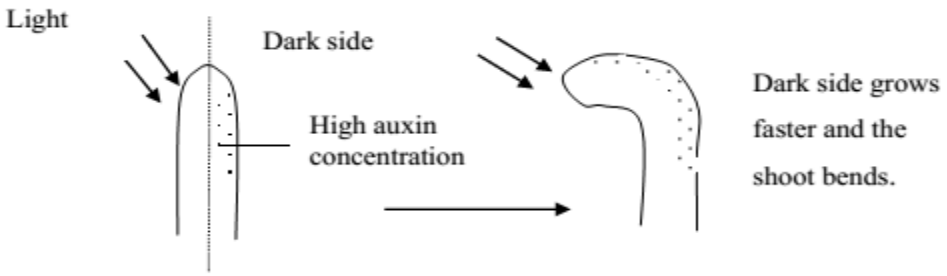
AUXINS AND PHOTOTROPISM

Light from one direction of the shoot causes auxins on that side to diffuse to the opposite side without light.

The side without light has a higher concentration of while the side that receives more light has a lower auxin concentration.

A high concentration of auxins on the side with little or no light increases the rate of cell division and elongation on that side.

This causes the shoot to bend towards the direction of light (positive phototropism)



However, high auxins concentration limits growth in plant roots

EXPERIMENT TO SHOW THE EFFECT OF UNIDIRECTIONAL LIGHT ON GROWTH OF THE PLANT SHOOT

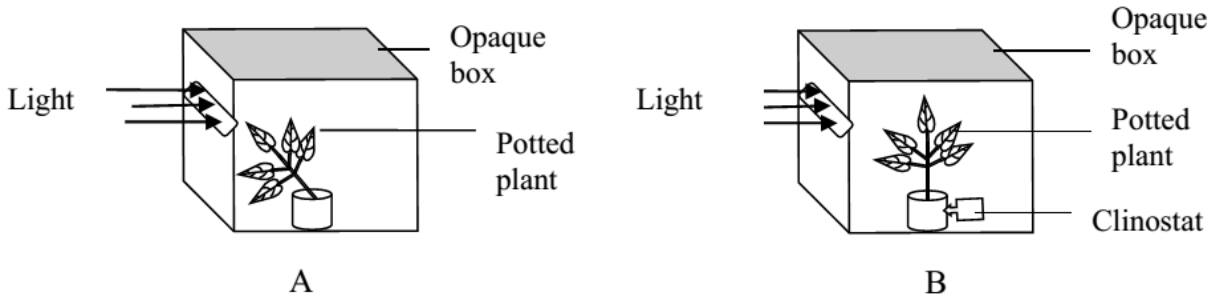
Materials

2 Potted plant seedlings, 2 opaque boxes, klinostat and Razor blade

Procedure

a) Get two opaque boxes and using a razor blade cut a small hole on one side of each. Label one box A and another one B
b) Get two potted plants of equivalent size.
c) Place one in box A and another in box B but fixed on a klinostat to serve as the control experiment.
d) Place both boxes in light such that plants receive light only through the small hole.
e) Start the klinostat to rotate the plant seedling in box B.
f) Leave the experiment for 4 days.

Setup



Observation:

The shoot in A bent towards the direction of light while that in B continued to grow straight.

Explanation:

Light coming from one direction in A made the stationary shoot to bend towards the direction of light. There was no effect on direction of growth for shoot in B because of rotating clinostat ensuring that all of its sides received equal amounts of light.

Conclusion:

The shoot responds positively towards light.

GEOTROPISM

This is the growth movement of the plant part in response to the direction of the force of gravity. Roots grow towards the direction of force of gravity hence positive geotropism while shoots are negatively geotropic

HOW AUXINS CONTROL GEOTROPISM IN ROOTS

Gravity also affects the distribution of auxins.

- If a seedling is lying horizontally, more auxins will diffuse on the lower side of the root and shoot due to gravity.
- In roots, the high concentration of auxins inhibits growth causing the lower side to grow slowly, while the upper side grows faster.
- This results in the roots bending towards gravity.

Experiment to demonstrate geotropism in plant roots (the effect of gravity on roots)

Apparatus

Petri dish, Cotton wool, Cupboard

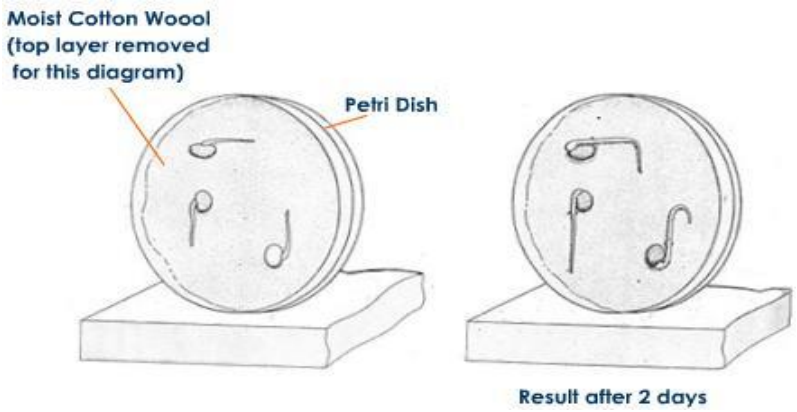
Procedure

i) Bean seeds are allowed to germinate and three seeds with straight radicles are selected.

ii) They are arranged so that the radicle of one is horizontal, the second radicle points vertically upwards and the third radicle points vertically downwards (A).

iii) The seeds are placed on moist cotton wool in a petri dish.

iv) The whole set up is placed in a dark cupboard for two days.



A **B**

Observation:

The horizontal radicle curves downwards towards the pull of gravity. The radicle that was pointing vertically upwards also curves downwards. The radicle that was pointing vertically downwards continues to grow downwards (B).

Conclusion: Roots are **positively geotropic**.

QUESTION: Explain why shoots are negatively geotropic

HYDROTROPISM

This is the growth movement of a plant and part in response to a unidirectional source of water. The roots grow towards the source of water hence show positive hydrotropism. The shoots grow away from the source hence negatively hydrotropic.

Experiment to show hydrotropism in roots

Materials:

Porous pot, Viable seeds, water

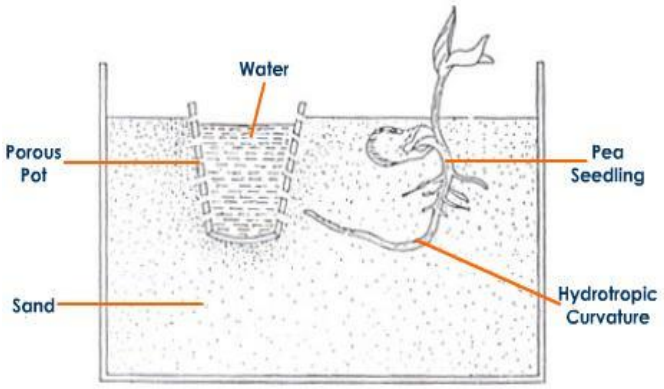
Procedure:

Viable seeds are planted in a large pot, 6 cm from a porous pot.

They are watered adequately until the radicles and Plumule appear.

The porous pot is partially filled with water.

Set up:



Observation: The roots grow inwards towards the water.

Conclusion: Roots are **positively hydrotropic**.

Explanation of auxin control of Hydrotropism

When the plant root is provided with water, auxins move from the side without water to the side with water. Because growth in roots is favoured by a low auxin concentration, the side with a low auxin concentration grows faster than the side with high concentration. This causes the bending.

PLANT GROWTH SUBSTANCES

1. Indole Ascetic Acid (IAA) or Auxins

It is a naturally occurring growth substance in higher plants. It influences cell elongation and root initiation. It has a powerful effect on growth. It also brings about development of parthenocarpic fruits. It also checks formation of branches from side buds. If IAA is applied to the cut end of the main stem, the side buds don't develop into branches.

Importance of auxins

- ✓ Causes apical dominance
- ✓ Leads to parthenocarpy
- ✓ Causes tropic response such as phototropism. Shoots obtain adequate light
- ✓ Causes rooting of the stem cutting.
- ✓ Inhibits leaf abscission
- ✓ Inhibits fruit abscission
- ✓ Used as herbicides**; explanation:-** A high concentration of auxins inhibits growth of both root and shoot system thus synthetic auxins at high concentrations are used to kill weeds

EXPERIMENTS ON AUXINS

1. Experiment to show that auxins from shoot tip are responsible for growth

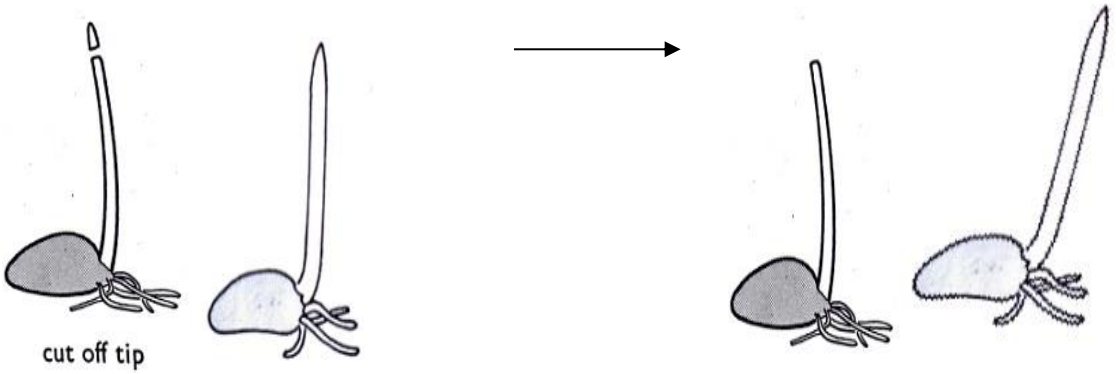
Materials

2 Coleoptiles (plant seedling) and razor blade

Procedure

Using a razor blade cut off the tip of one coleoptile while the tip of the second coleoptile is left intact and leave it to stand for 3-6 days.

Setup



Observations

Growth stops taking place on coleoptile with cut tip, but continues in coleoptile whose tip was left intact.**Explanation**

The coleoptile tip produces a growth-promoting chemical which stimulate cell division as new cells are formed. When the tip is cut off, growth stops because growth promoting chemicals are not produced.

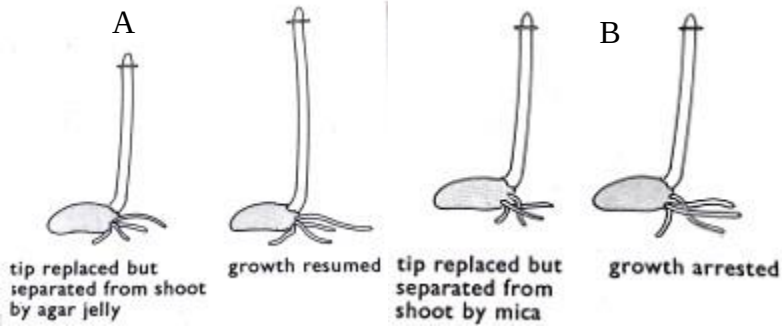
Experiment to show that auxins are diffusible substances

Apparatus / Material.

- ❖ Agar block (gelatinous substance through which auxins can diffuse)
- ❖ Maize seedlings with coleoptiles.
- ❖ Mica plate
- ❖ Clock.
- ❖ Ruler

Procedure

- Take two maize seedlings with coleoptiles at least 2cm long. Expose the coleoptiles to light for at least 4 hours.
- Cut the coleoptiles tips
- Replace tips, with one tip separated from shoot by agar block, A while the second tip separated from shoot by mica plate, B.
- Leave shoots in open light for 3 days



Observation

Shoot A continues to grow, shown by increase in length while growth in B is arrested shown by no increase in length of shoot

Explanation

Auxin diffuses from shoot tip to stimulate growth of shoot A. Mica plate prevented diffusion of auxin to shoot, thus no growth occurred.

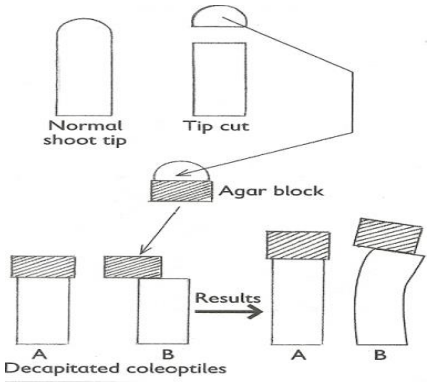
Experiment to show the effect of unequal distribution of auxins.

Apparatus / Material.

- ❖ Maize seedlings with coleoptiles.
- ❖ Agar block (gelatinous substance through which auxins diffuse).
- ❖ Clock.
- ❖ Ruler

Procedure

- Take two maize seedlings with coleoptiles at least 2cm long. Expose the coleoptiles to light for at least 4 hours.
- Cut the coleoptiles tips and transfer them (each) on to an agar block and leave them for 24 hours.
- Remove the coleoptile tips and place the agar blocks on fresh decapitated shoot tips so that in set up A, the agar block is uniformly placed on the seedling while in et B, it is placed on one half of the seedling as shown below.



Observation

Shoot A grew straight upright while shoot B grew bending away from the side with agar block.

Explanation

Auxins diffused from the coleoptile tips into the agar block. Thus auxins are evenly distributed on the agar block.

In shoot A- Auxins diffuse from the agar block into the decapitated shoot. All sides receive same concentrations of auxins. Cell elongation occurred and growth took place evenly with the shoot growing up right.

In shoot B- Auxins diffused on one side of the shoot. I.e. the side covered with agar block. There was faster cell elongation and hence faster growth on the side compared to the uncovered side. This resulted to the growth curvature observed.

OR

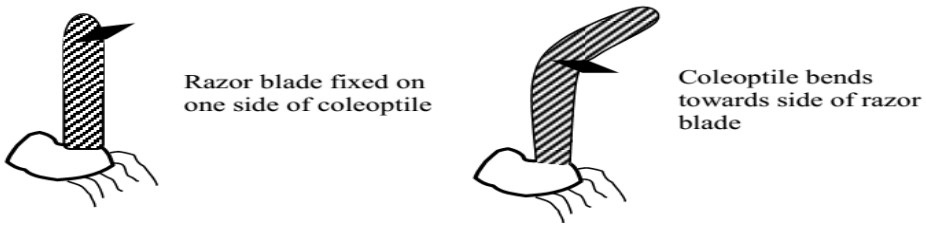
Experiment to investigate the effect of auxin distribution on plant growth

Materials:

Coleoptile and Razor blade

Procedure:

Insert a razor blade on one side of the coleoptile tip and leave it to grow.



Observation:

The coleoptile continues to grow bending towards the side with the razor blade.

Conclusion:

The side without a razor blade grows faster than the one with a razor blade causing the coleoptile to bend towards the side with a razor blade.

Explanation:

In equal illumination, auxins are equally distributed in the shoot. The insertion of a razor blade on one side prevents auxins from moving down on that side. Unequal distribution of auxins causes uneven growth of the shoot.

OTHER PLANT GROWTH SUBSTANCES

2. Gibberellins

They are produced by plants in varying amounts in seeds and young plants.

Effects of gibberellins on a plant

- Cause increase in length of stems due to increased cell elongation
- Promote cell division
- Promote cell differentiation
- Stimulate fruit development
- Prevent formation of adventitious roots
- Break seed dormancy
- Break seed buds
- Affect flowering in plants

3. Cytokinins

These promote cell division in the presence of auxins and are mostly found in actively dividing tissues like fruits and in seeds.

Effects of cytokinins

- Promote cell division
- Delay aging and falling of leaves

4. Abscisic acid (ABA)

This inhibits growth. Its effects are opposite to those of auxins, gibberellins and cytokinins.

Effects of abscisic acid

- Inhibit growth
- Promote aging and falling of leaves, fruits
- Induce seed dormancy
- Induce bud dormancy

5. **Ethene;** this is another plant hormone with the following effects; promotes ripening of fruits**,** breaks bud dormancy

NASTIC RESPONSE (NASTIC)

This is the movement of a plant part in response to a non-directional stimulus or it is a response in which plant movements are not related to the direction of stimulus but to its intensity.

Nastic response are named depending on the type of stimulus i.e.

- ❖ Photo nastic if the stimulus is light.
- ❖ Hydro nasty if the stimulus is water
- ❖ Thigmonasty if the stimulus is touch

Note: Nastic movements do not involve growth.

Characteristics of nastic

1) It involves changes of turgidity of plant cells.
2) It is a rapid response.
3) It occurs in any part of a plant
4) The response is not related to the direction of the stimulus
5) It is induced by non-directional stimulus.

Examples of nastic response

1) Opening and closing of flowers in response to light e.g. morning glory.
2) Sudden closer of leaf lets of *Mimosa pudica* in response to touch.
3) Closures of leaves of insectivorous plants e.g. butter walt and pitcher plant when an insect lands on the leaf. Such plants are found in nitrogen deficient soil.

Similarities between nastic and tropic movement

- ✓ Both are brought about by external stimuli.
- ✓ Both occur in plants
- ✓ Both involve movement of plant parts.

Differences between tropisms and nastic responses

Nastic response	Tropism
i) Does not depend on the direction of the stimulus.	It depends on the direction of the stimulus
ii) It occurs in any part of the plant.	It occurs in growing tips of plants
iii) It does not involve auxins	It involves auxins
iv) Are usually faster	Are usually slower
v) It involves turgor changes	It involves growth only.