COORDINATION IN PLANTS

All organisms have the ability to detect changes in their environment and respond appropriately in order to survive.

Some common terms

The change of activity by the organism is called the **response**
Irritability is the ability of an organism to detect and respond to stimuli.
A stimulus is any change in the environment of an organism. Stimuli may be internal or external.
Stimuli can be categorized as,

- ***Chemical stimulus*** e.g smell & taste
- ***physical stimulus/mechanical*** e.g light, pressure, gravity, touch,& heat
- ***External stimulus*** i.e change in the conditions in the external environment of an organism, to which an organism responds. e.g sound, light, temperature, touch , smell etc.
- ***Internal stimulus*** i.e change in all conditions in fluids surrounding the living cells e.g. internal body temperature, salt concentration, carbon dioxide concentration and blood sugar.

Response; change in activity of part or whole of an organism body as a result of the presence of a stimulus.

Can either be towards the direction of stimulus (***Positive response***) or away from the direction of stimulus (**negative stimulus**).

Reception and response in plants

Plant responses include;

- Nasty / nastic response
- Tropism/ tropic response

(i). **Nastic response;**

Is a non-directional movement of part of a plant in response to some diffused stimulus. i.e response does not depend on the direction from which stimulus is coming from.

Examples of nastic responses include.

thigmonastic/haptonastic nastic movement in response to touch E.g. Folding and drooping of leaves of *Mimosa pudica* on slight touch and closing of leaves in insectivorous plants such as venus fly trap, on landing of insects between its lobes.

Photonasty: Nastic movement in response to differences in light intensity e.g. flower of morning glory opening in response to light and closing in the dark.

Thermonasty: Nastic movement in response to differences in temperature e.g. flowers opening and closing with changes in temperature.

Importance of nastic responses

- It protects the inner delicate parts of the flower.
- It reduces transpiration.
- It regulates temperature.

Revision exercise one

1. *Explain the terms irritability,Stimulus,and response.*
2. *Name the different types of stimuli and corresponding receptor organ.*
3. *Explain what a nastic response is and its importance in organisms.*

Tropism/ tropic response

Growth movement of parts of a plant in response to unidirectional stimuli. A unidirectional stimulus is a stimulus coming from a single direction.

Most tropic responses are slow, and are usually caused by plant growth substances.

Growth of plant parts can be away from the stimulus (***negative tropism***) or towards the stimulus (***positive tropism***).

Types of tropisms

Classified according to the type of external stimulus involved

External stimulus	**Type of response**	Examples
light	Phototropism, growth movement of part of plant in response to a unidirectional light	Plant shoots grow towards the direction of light(positively phototropic) Plant roots grow away from the direction of light. (negatively phototrophic
Water	Hydrotropism , growth movement of part of a plant in response to a unidirectional source of water	• Plant roots grow towards a water source (positivity hydrotropic)
gravity	Geotropism/gravitropism, growth movement of part of a plant in response to gravity.	• Plant roots grow downwards towards the gravitational pull (positively geotropic). • Plant shoots grows away from gravitational pull(negatively
chemicals	Chemotropism, growth movement of part of a plant in response to a unidirectional source of chemical.	• Pollen tubes grow towards the micropyle, where chemicals are secreted(positively chemotropic) • Hyphae of some fungi grow away from their products of metabolism(negatively
touch	Thigmotropism/haptotropism; is the growth movement part of plant in response to unidirectional touch.	• Tendrils of young passion fruits, and pumpkins twine around support.(positively haptotropic).

		• Root tips grow away from stones and other obstacles.(negatively haptotropic

IMPORTANCE OF TROPISM TO PLANTS

- ❖ Positive phototropism of shoots exposes the leaves in the right position absorb sunlight for photosynthesis
- ❖ Positive phototropism allows shoots to be spread out holding flowers and fruits in best positions, enhancing pollination and dispersal respectively.
- ❖ Positive geotropism of roots enables the roots of plants to get water and mineral salts.
- ❖ Positive geotropism of roots also provides firm anchorage to the plant in the soil, preventing physical destruction by wind.
- ❖ Negative geotropism of shoots enables them to grow upwards to ensure the leaves are exposed to sun light for photosynthesis.
- ❖ Negative geotropism of shoots exposes flowers to agents of pollination
- ❖ Positive hydrotropism of roots, allows plants to absorb water and mineral salts for photosynthesis.
- ❖ Thigmotropism enables plants with weak stems to obtain support.
- ❖ Positive chemotropism allows for growth of pollen tube, enhancing the process of fertilization in flowering plants

Revision questions Two

1. *Define a tropism*
2. *List the types of tropisms*
3. *Explain phototropism, geotropism and hydrotropism using real life examples*
4. *Describe the importance of the different types of tropisms in plants.*

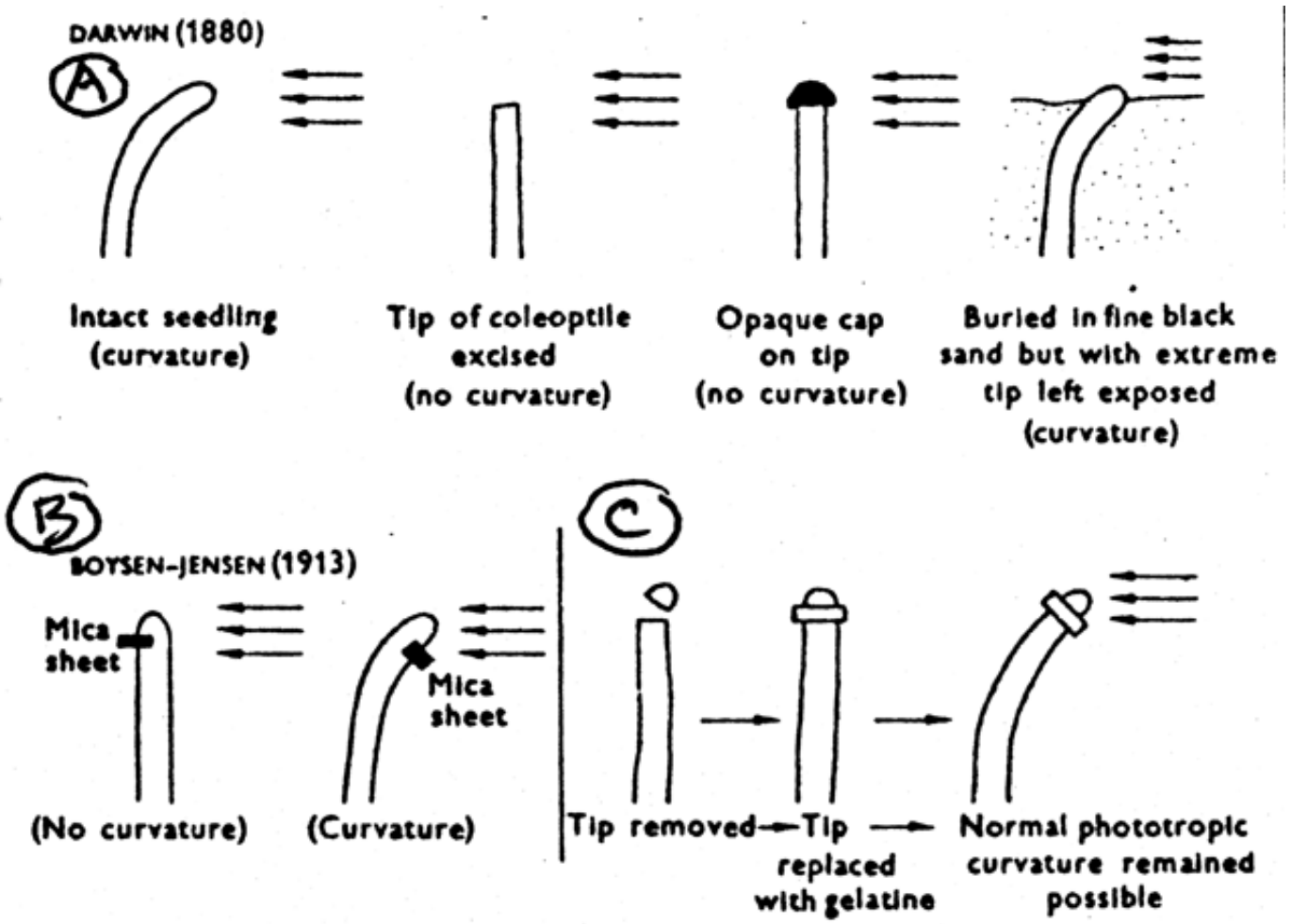
CHEMICAL CONTROL OF PLANT RESPONSES

- Upward growth of shoots and down ward growth of roots in plants is controlled by **plant growth substances i.e** auxins, gibberellins, abscisic acid, cytokinins, and ethene.
- Growth substances in plants are made in one part of plant, and then transported to another part where they cause an effect on growth.
- Movement of these growth substances from cell to cell is by **diffusion**, so it takes time for them to reach their target cell, thus response in plants is slower than in animals.
- **(a)** Auxins;
- Are produced in the shoot and root tips.
- Example of auxin is Indole -acetic acid (IAA).
  Auxins control plant growth by;
    - Causing cell elongation
    - Simulating the development of adventitious roots
    - Inhibiting growth of lateral buds (apical dominance)
    - Inducing parthenocarpy (formation of fruits without fertilisation
    - Inhibiting abscission/ falling of fruits, young leaves and flowers before maturity.
    - Promoting mature leaf fall(abscission)
    - Initiating secondary growth by stimulating cell division in the cambium.
    - Stimulating translocation of organic substances in the phloem.

A series of classic experiments were conducted by biologists trying to understand the positive phototropic response of plant shoots. These experiments were all conducted with oat coleoptiles.

The experiments conducted by Charles Darwin, Peter Boysen –Jensen and others led to the conclusion that phototropism was the result of a chemical produced in the tip of the oat coleoptile that moved to the growing region where it stimulated growth.

Study the diagrams below and explain the different observations.



AUXIN AND PHOTOTROPISM

(a) If a plant shoot is exposed to light coming from all directions or total darkness,

- ✓ Auxins produced at the shoot tips diffuse uniformly down the shoot,
- ✓ This causes all cells in the zone of cell elongation to elongate uniformly, therefore uniform upward growth of shoot occurs.

(b). if a plant shoot is exposed to a unidirectional light:

- ✓ Light causes the auxins to diffuse to the darker side of the shoot,
- ✓ Higher concentration of auxin on the dark side, causes the cells on the dark side to grow faster than the cells on the light side.

- ✓ Therefore shoot bends towards the unidirectional light.

1. Describe an experiment to show phototropism in plant shoots.

Aim of experiment. To show phototropism in plant shoots.

Requirements

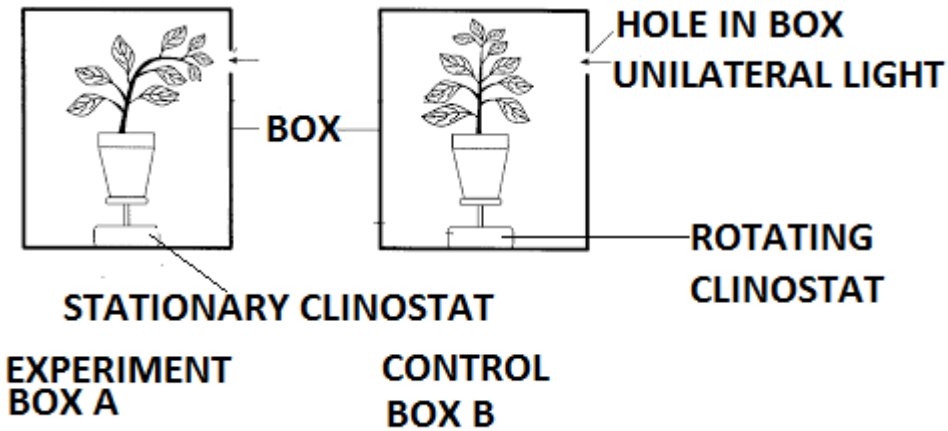
- Two potted bean seedlings, 2 boxes with windows on one side, one clinostat, water.

Procedure

- Two potted bean seedlings are watered.
- One is put on a stationary clinostat then placed in a box with a hole on one side to allow light to reach the shoot from one direction only.**(**Box labelled A)
- The other seeding is placed in another box with the same conditions but on a clinostat rotating slowly so that all the sides of the shoot are equally exposed light. **(**Box labelled B)
- The two experiments are left to stand for 7 days.

Observations

- Shoot of the bean seeding in box A grew bending towards light while the other seedling in box B continued to grow upright.



Conclusion

- Shoots grow towards the direction of light and are positively phototropic.

Explanation

AUXIN AND GEOTROPISM

In a horizontally growing seedling or a seedling with straight radicle, the radicle grows bending downwards, and plumule grows bending upwards because,

- ✓ Auxins produced at the root and shoot tips diffuse to regions of growth,
- ✓ Due to gravity, more auxin accumulates in the lower areas of the root and shoots, i.e. lower regions will have high concentration of auxins.

- ✓ In the root, a high concentration of auxin slows down growth therefore the lower side grows slowly while the upper side grows faster due to more cell elongation, causing the bending of the root downwards.
- ✓ In the shoot, a high concentration of auxin stimulates faster growth on the lower side which makes it longer than the upper side and the shoot bends upwards away from gravity.

3. **Describe an experiment to show geotropism in plant shoots**

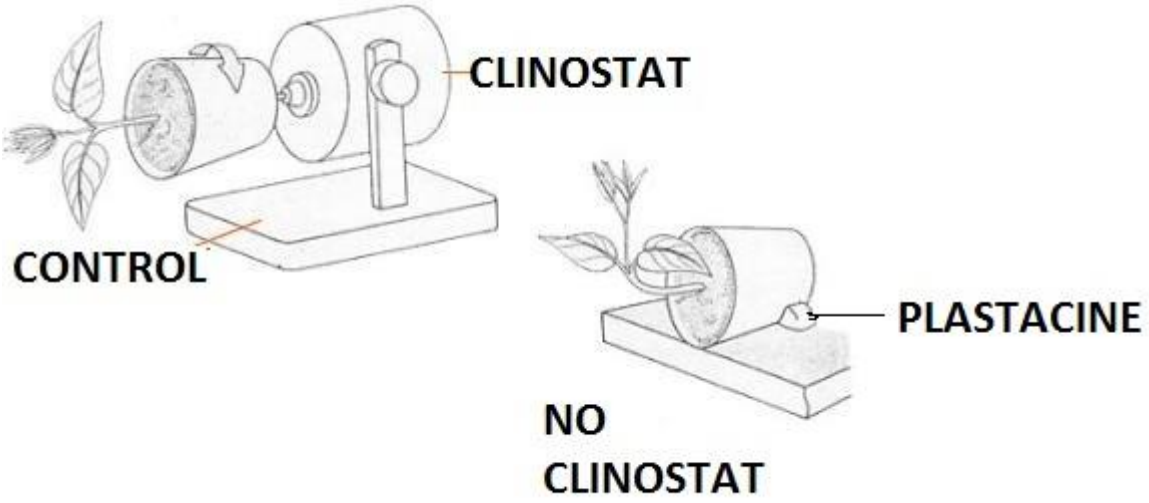
Aim of experiment; To show geotropism in plant shoots.
Requirements. 2 potted seedlings which have grown straight, clinostat, water, plastacine, cardboard.

Procedure

- A shoot of potted plant is laid horizontally in a jar fixed in position by plastacine.
- Second potted seedling is placed in a slowly rotating clinostat, so as to expose all the sides equally to the pull of gravity.
- Both experiments are covered with card board to cut off the effect of light, and experiment left to stand for 48hours.

Observation;

- Shoot of stationary seedling changes direction, growing upwards, while the one in the clinostat continues growing horizontally.



Conclusion

- Shoots grow away from direction of gravity, therefore are negatively geotropic

Explanation

- In the slowly rotating clinostat, plant shoot experiences gravity equally on all sides ; therefore no specific direction of gravity, shoot continues to grow horizontally.
- Shoot of seedling laid horizontally experiences a specific source of gravity, causing un even distribution of auxins in plant shoot with much concentration on lower side; therefore grows faster and bends upwards.

4. **Describe an experiment to show geotropism in plant roots**

Aim of experiment; To show geotropism in plant roots

Requirements ; Young bean seedling with straight radicles, moist cotton wool, 2 petri dishes, one clinostat, pins.

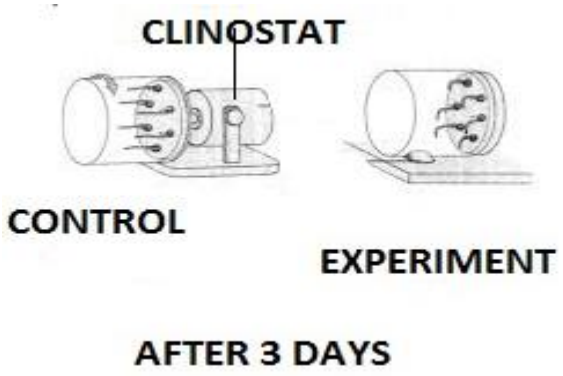
Procedure;

- Two petri dishes are tightly packed with moist cotton wool.
- Bean seedlings with straight radicles are pinned, with one radicle vertically upwards, second with radicle horizontal, and the other radicle vertically downwards.

- Control experiment is set up, all seedlings pinned with their radicles horizontal, and petridish placed in a clinostat.
- Both experiments are left to stand for about two days in darkness to avoid the effect of light.

Observation

- Radicles of seedlings pinned in the petridish placed in slowly rotating clinostat continued growing horizontally, without bending.
- All radicles of seedling pinned in the first petri dish grew bending vertically downwards.



Conclusion

- Roots grow towards the direction of gravity, therefore are positively geotropic.

5. **Describe an experiment to show hydrotropism in plant roots**

Aim of experiment ; To show hydrotropism in plant roots

Requirements;

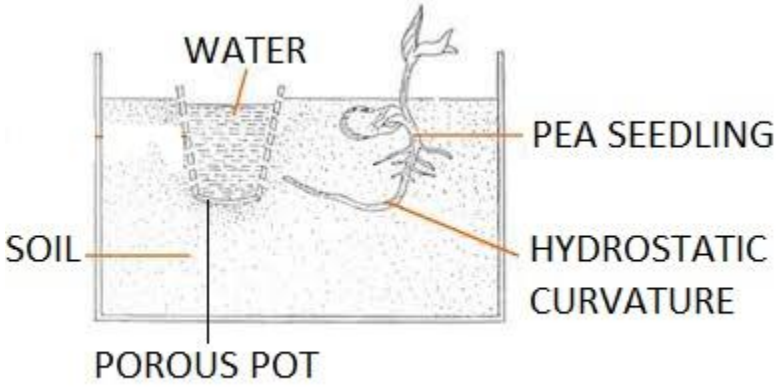
porous pot, dry soil, water, glass trough, bean seeds

Procedure;

- A porous pot is placed at the centre of the trough.
- Pot is filled with water
- Dry soil is is placed all around the pot in the trough.
- Germinated seeds are placed 5cm from the porous pot.
- Set up is left to stand for 3 days.

Observation

- Radicles grow downwards towards the water source as the shoots continue growing vertically upwards.



Conclusion

- Roots grow towards water, therefore positively hydrotropic.

Revision questions Three

1. Explain the effect of
   a) light reaching the shoot of a plant from only one direction.
   b) gravity on shoots and roots .
2. Describe an experiment that would be carried out to show that a plant shoot is negatively geotropic.(13mks)
3. Compare tropic and nastic responses in plants (10marks**)**

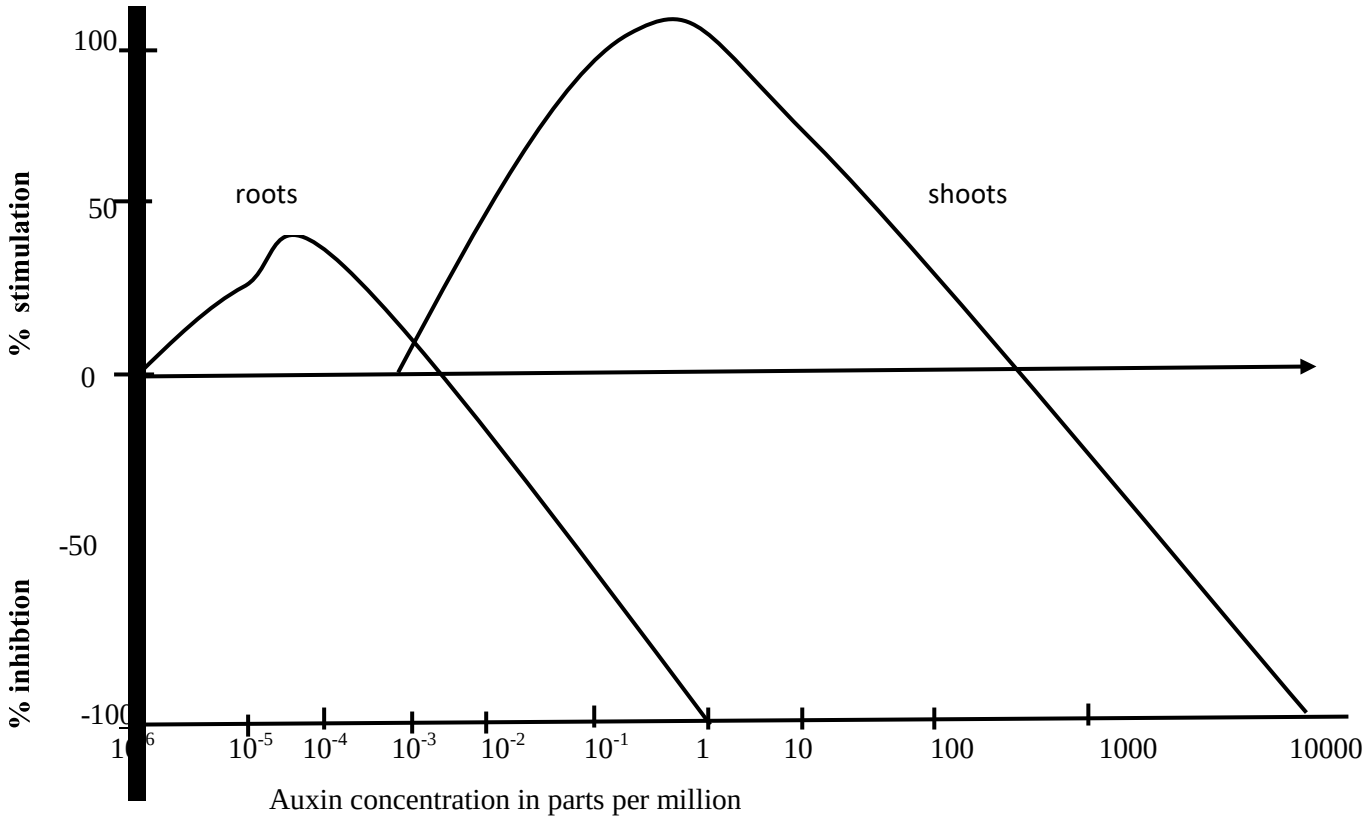
Sample question

- *How does auxin concentration affect the growth of plant roots?*

Solution

Low auxin concentration stimulates root growth and high auxin concentration retards root growth.

Graph showing effect of auxin concentration on growth responses of roots and shoots.



Interpretation

(a) In roots;

- Increase in auxin concentration from 10^{-6} to 10^{-4} ppm, increases the stimulation in growth of roots
- Maximum stimulation of growth in roots is at auxin concentration, 10^{-4} ppm
- Increase in auxin concentration from 10^{-4} to 10^{-2} ppm, decreases the stimulation of growth in roots
- Auxin concentration greater than 10^{-2} ppm, does not stimulate growth of roots, but produces increasing inhibition of roots as the concentration increases.
- Concentration of auxin greater than 1ppm inhibits growth of roots.

(b) In shoots ;

- Auxin concentration from 10^{-6} to 10^{-4} ppm, produces no stimulation of growth in shoots
- Increase in auxin concentration from 10^{-4} to 1 ppm, increases stimulation of growth in shoots, reaching a maximum stimulation of growth at concentration 1ppm.
- At concentration of auxin greater than 1ppm there is decreasing stimulation in growth in shoots .

- Auxin concentration of 10000ppm produces total inhibition of growth in shoots.

(b) **other important plant growth substances, and their effects in plant growth**

Growth substance	**Site of production**	**Effect on plant growth**
Gibberelins	Young leaves, root tips, embryo seeds	▪ Breaks seed dormancy ▪ Elongation of internodes of dwarf plants ▪ Stimulates germination of seeds by synthesis of amylase which hydrolyses starch to maltose for respiration. ▪ Simulate flowering in some plants ▪ Inhibits growth of adventitious roots ▪ Promotes growth of side branches
cytokinins	Fruits, seeds, and carried to other plant parts	▪ Slows down ageing of leaves ▪ Breaks dormancy in both buds and seeds ▪ Stimulates bud development ▪ Enlargement of cotyledons ▪ Stimulate formation of callus tissue that heals damaged tissues in plants
Ethene/ ethylene	Nodes of stems, ageing leaves, flowers, outer covering of fruits	▪ Promotes ripening of fruits ▪ Breaks bud dormancy ▪ Stimulates abscission of leaves ▪ Induces flowering in pineapples ▪ Inhibits root growth
Abscissic acid	Buds, base of leaves, fruits, seeds, tubers	▪ Stimulates leaf fall ▪ Inhibits germination in seeds by prolonging dormancy ▪ Stimulates closure of stomata in leaves under water stress ▪ Promotes ageing

Revision Exercise Six

1. *Compare the effects of auxins and gibberellins (7marks)*
2. *Explain how auxins are used in agriculture (5marks)*

Reception, response and behavior in animals

Tactic responses /taxis(plural, taxes)

Is the movement of a whole organism in response to a unidirectional stimulus.

Can be positive (towards the stimulus) or negative(away from stimulus)

Classified according to the nature of stimulus e.g

s**timulus**	**Response**	**example**s

light	Phototaxis, movement of whole organism towards a unidirectional light.	▪ Maggots move away from light(negative phototactic) ▪ Grasshoppers fly towards light at night(show positive phototaxis)
Chemical	Chemotaxis, movement of whole organism inresponse to chemical concentration.	▪ Movement of bees towards flowers following scent from them.(shows positive chemotaxis) ▪ Male moths fly towards a pheromone(shows positive chemotaxis)
water	Hydrotaxis , movement of whole organism in response to moisture.	▪ Earthworms move to moist areas of soil(shows positive hydrotaxis). ▪ Wood louse seeks moist area.(shows positive hydrotaxis)

1. **Describe an experiment to demonstrate hydrotaxis in using a named invertebrate.**

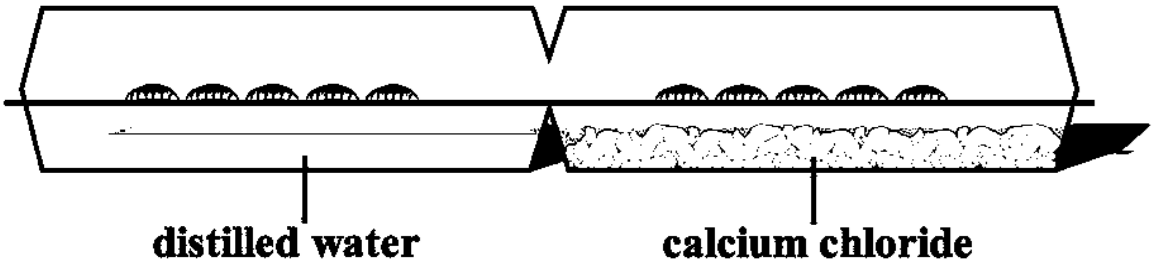
Aim; To demonstrate hydrotaxis in wood lice.

Requirements*:* choice chamber, wood lice, anhydrous calcium chloride, water and wire mesh

Procedure

- ✓ Anhydrous calcium chloride is placed in one half a choice chamber and water is put in the other half.
- ✓ A mesh is placed above each half
- ✓ Wood lice are placed on the mesh in the choice chamber and the choice chamber is closed.
- ✓ Experiment is left to stand for about 3 hours.

The choice chamber consisted of *two halves*, with distilled water introduced into one side and *calcium chloride* (a drying agent) into the other



In this investigation, *tactic responses* are being observed as the woodlice demonstrate their *preference* for a particular environment by *movement* towards or away from a stimulus (level of humidity)

Observation

All the woodlice moved to the moist cotton wool

Conclusion

Wood lice are positively hydrotactic

2. **Describe an experiment to demonstrate phototaxis using a named invertebrate**

Aim ; To demonstrate phototaxis in blow fly larvae/ maggot

Requirements; Glass tube, black paper, cotton wool and water.

Procedure

- soaked cotton wool is spread at the base of the glass tube.
- one side of the glass is wrapped with black paper.
- blow fly larvae are introduced in the middle of the glass tube and experiment left for about 3 hours **observation**

Most of the blowfly larvae move and settle on the dark side of the glass tube.

Conclusion

Blow fly larvae are negatively phototactic.

Revision questions seven

1. *Describe an experiment to demonstrate chemotaxis in sugar ants. (7marks).*
2. *Describe experiments to demonstrate phototaxis and hydrotaxis using a named invertebrate. (10 marks).*

IMPORTANCE OF TACTIC RESPONSES

- Tactic response enables the organisms to move to areas with favorable conditions for their survival e.g. earthworms move to moist soils to avoid loss of water and death.
- Tactic responses enable organisms to escape from danger
- It enables organisms move to areas where they can locate and obtain food.
- It enables organisms to locate to mates during the breeding season, enhancing production of off springs