Theme: Transport in plants and animals

S2 New Curriculum Biology-Chapter 6– Transport in plants

Transport in plants

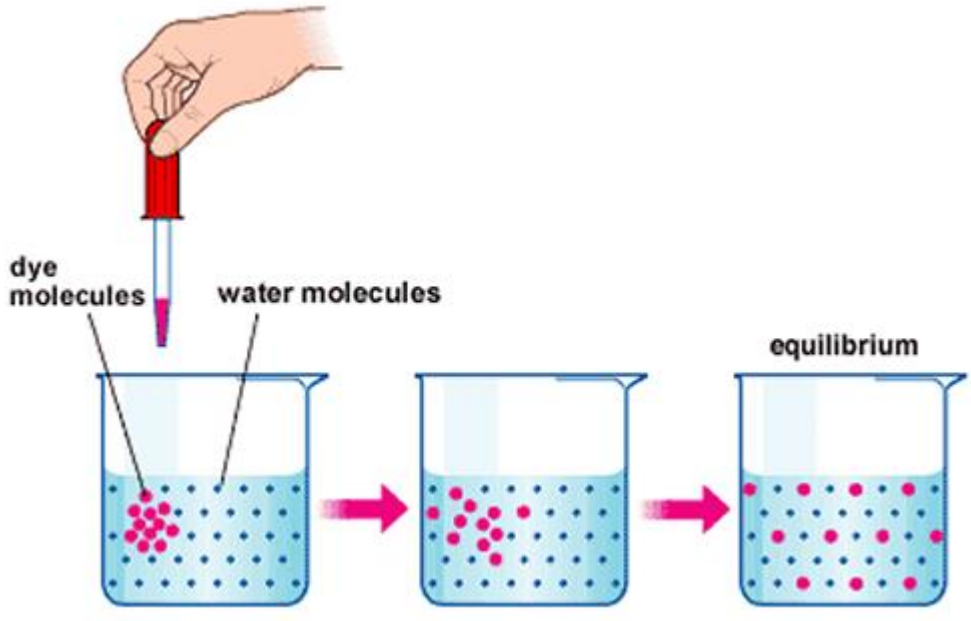
It involves absorption and transport of water from roots to the leaves and transport of food from leaves to other parts of the plants.

Processes by which substances move in and out of the cells

(a) Diffusion

It is the movement of particles (molecules or ions) from a region where they are comparatively concentrated to a region where they are at lower concentration. The difference in the concentration between two regions is called concentration gradient or diffusion gradient. Diffusion will always take place whenever such a gradient exist; and it will continue until eventually the particles are uniformly distributed throughout the system. It is a passive process which takes place by random thermal motion.

An experiment to demonstrate diffusion



When a drop of a dye is placed at one point in a beaker of still water it quickly spread out to the whole water until the colour of water in the beaker is uniform.

Functions of diffusion

1. Gaseous exchange at the lungs
2. Absorption of glucose and amino acids from intestine
3. Absorption of water from colon
4. Uptake of glucose by cells from blood: Glucose does not diffuse freely through the cell membrane because it is insoluble in lipids. It passes through the cell membrane is facilitated by proteins. Therefore, diffusion of glucose through the cell membrane is called facilitated diffusion.
5. Gaseous exchange for photosynthesis
6. Loss of water during transpiration
7. Diffusion of flower scent to attract insect pollinators.
8. Absorption of ions from the soil

Factors that affect the rate of diffusion

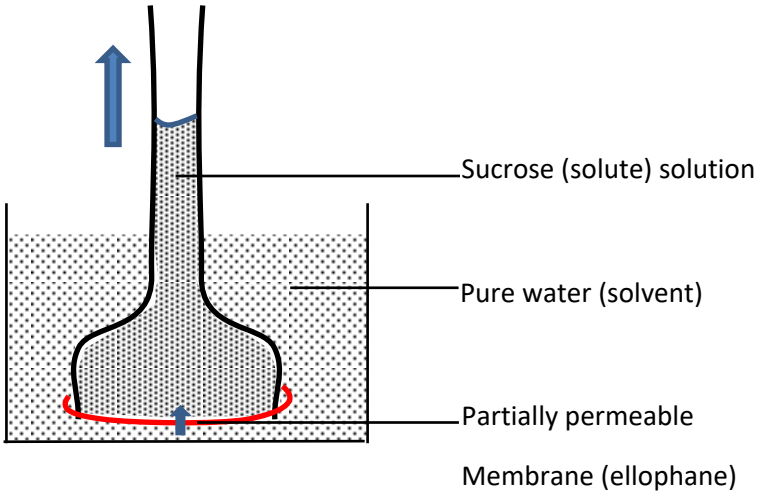
- Temperature
- Diffusion/concentration gradient
- Distance over which diffusion occurs
- Surface area over which diffusion occurs.

(b) Osmosis

This is the passage of solvent molecules from a region of their high concentration to a region of their low concentration through a partially permeable membrane. The solvent in biological system is water.

Simple demonstration of osmosis

Osmometer



The solid arrows indicate the net flow of water (solvent) into the solution. The membrane being partially permeable, allows water molecules to pass into the thistle funnel from the beaker. As a result of net flow of water into the funnel, the solution rises up the tube as indicated by the arrow.

Terms relating to the concentration of solution with that of body fluids

(i) Hypotonic solution: is a solution with lower concentration compared to body fluid
(ii) Isotonic solution has the same concentration as body fluid
(iii) Hypertonic solution has higher concentration as body fluid

Functions of osmosis

- Maintains the right balance of fluids in the blood and tissues.
- Provides structural support in plants by regulating water intake for turgor pressure, keeping them upright.
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(c) Active transport

It is energy-consuming transport of molecules or ions across a membrane against a concentration gradient. Substances usually transported across cell membrane by active transport include Na^+, K+, ureate ion and amino acids

Functions of active transport

(i) Absorption of minerals in the stomach
(ii) Absorption of minerals in ascending loop of Henle
(iii) Absorption of mineral in the root hair from the soil
(iv) Entry of water into the guard cell leads to their opening

(d) Endocytosis and exocytosis

These are process by which larger objects are taken into or expelled from the cells

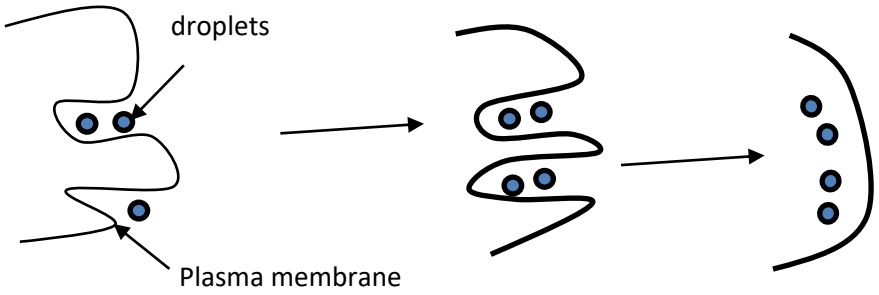
Exocytosis

This provide a means by which enzymes, hormones, antibodies and cell wall precursors are released from the cells. Here a vesicle containing the material moves towards the surface of the cell and fuse with the plasma membrane. The vesicle the opens to the exterior and its contents leave the cells

Endocytosis

This provide a means by which big objects are taken by the cell. First the plasma membrane invaginates to form a flask-shaped depression which envelops the material. The neck of the flask then closes, and the invagination becomes sealed off to form a vesicle which moves into the cell. When a liquid like substance is taken in by the cell the process is referred to as **pinocytosis**. And solid particles are taken in by **phagocytosis**.

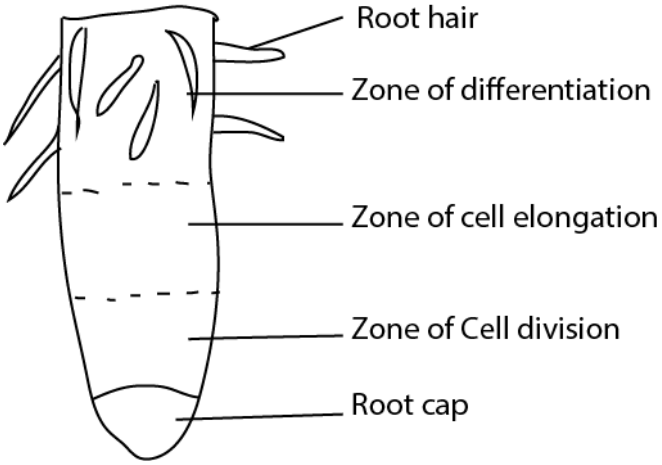
Stages in endocytosis are shown in the diagram below



Absorption of water in plants

It occurs through the root hairs located on the young part of root.

Location of root hairs on the root tip



Functions of parts of the root

a. Root cap protects the root tip
b. Zone of cell division: cells divide to allow for growth.
c. Zone of cell elongation: cells become bigger and longer to elongate the root.
d. Zone of differentiation: cells specialise to perform different functions.

Adaptations of root hairs to absorption of water

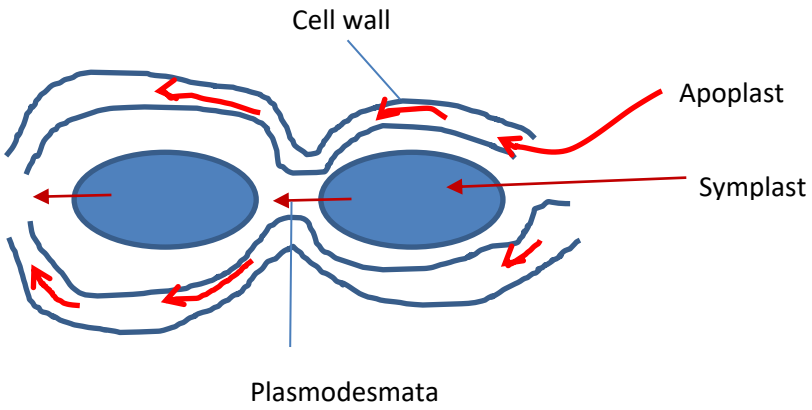
Water is absorbed by osmosis; the root hairs have the following adaptation for efficient absorption of water.

(i) Numerous to increase the surface area for water absorption.
(ii) Have thin epithelium to reduce the absorption barrier
(iii) Have high salt concentration to aid osmosis.

Routes followed by water from root hairs to the xylem

From the root hairs water follow three routes

1. Through spaces in the cell wall: the route is called **apoplast pathway.** This is the major route.
2. Through the plasmodesmata and then vacuole: this is called Symplast pathway.



Plasmodesmata are living connection in plant cells

From the roots to the leaves

Water passes through the xylem.

Three forces aid water to ascend a tall tree.

1. Root pressure: This is hydrostatic pressure that develops into the roots due to higher solute potential than the surrounding soil. Continued absorption of water forces water into the xylem.
2. Capillarity: water ascends by cohesion and adhesion forces.
3. Transpiration pull: loss of water by leaves causes more water to rise in the xylem.

Transpiration

This is the loss of water from the leaves through evaporation.

Factors affecting the rate of evaporation

1. Temperature
   The higher the temperature, the higher the rate of water loss because high temperature provides heat of evaporation.
2. Wind:
   - gentle wind increases the rate of evaporation because it blows away water vapour around the stomata which promotes water loss.
   - Strong wind reduces the rate of transpiration because it causes the stomata to close.
3. Humidity: this is the amount of water vapour in air. High humidity lowers the rate of evaporation and thus transpiration.

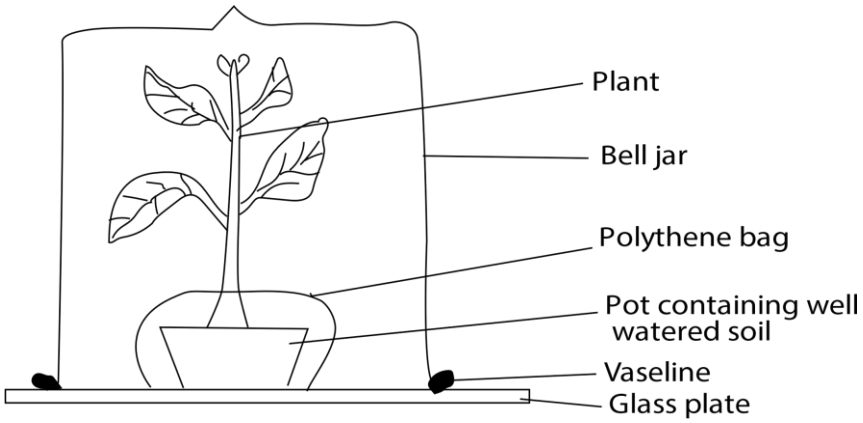
4. Light: light increases the rate of evaporation because it causes the stomata to open.

Internal factors

1. Number of stomata: the higher the number of stomata the higher the rate of loss of water

An experiment to show that a plant transpires

Setup



Potted plant enclosed in a bell jar. Vaseline prevents escape or entry of water vapour and a polythene bag prevent evaporation from the soil

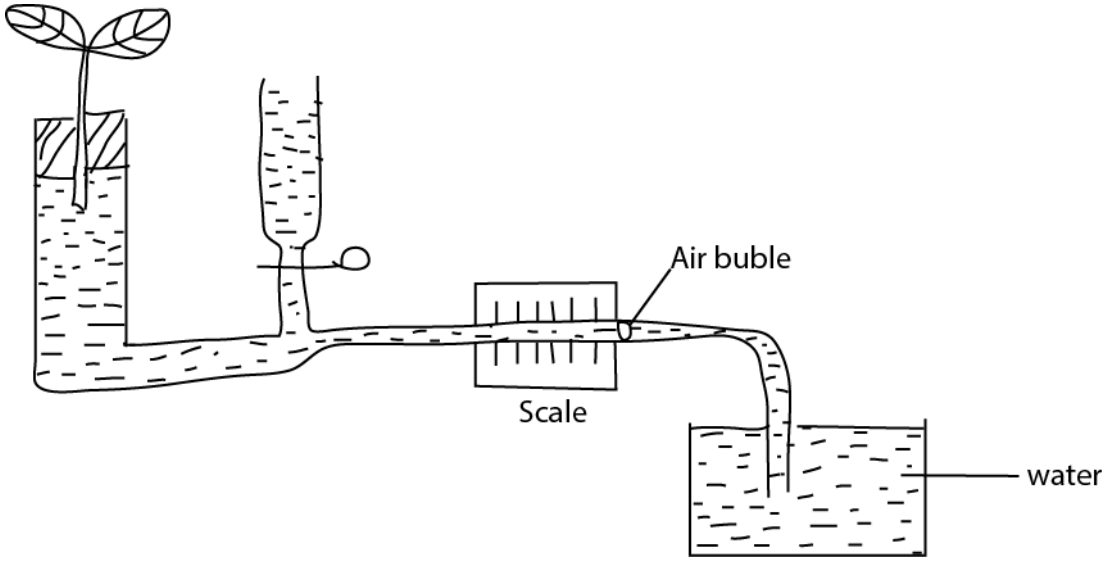
Observations

After sometime water droplets are seen on the walls of bell jar due to transpiration from the plant.

Experiment to demonstrate transpiration

If a leaf is covered by a polythene bag for some time, droplets of water are seen inside the bag.

Measuring the rate of transpiration



1. Fill the photometer with water
2. Allow air bubble into the capillary tube and insert capillary tube in water beaker.
3. The rate of movement of the air bubble in the capillary tube is the measure of the rate transport.

Precautions

1. The plant is cut in water to prevent air entering the xylem.
2. Measurement should begin when leaves are dry.
3. Caution should be taken when preparing holes in rubber bungs, pushing the glass tube, the cutting and the syringe into the bung. It is crucial to avoid air bubbles in the assembled potometer.

Importance of transpiration

(i) helps in absorption of water
(ii) absorption of mineral salts
(iii) cooling of the plant.

Adaptation of plant to live in dry area

1. Extremely long **vertical roots** absorb water deep in the soil e.g. Acacia.
2. **Superficial** roots have an advantage of absorbing water quickly before it has a chance of evaporation e.g. cacti.
3. Some plants have got succulent leaves and/or stem to store water e.g. giant saguaro cactus of North America.
4. Stomata are more on the lower shaded epidermis than upper epidermis to reduce the rate of transpiration

5. plants have sunken stomata. these create small pockets of humid air that reduce the rate of transpiration.
6. Thick cuticle reduce water loss.
7. Lamina is hairy.
8. reduced size of the leaves to reduce surface area over which transpiration occurs
9. rolling of leaves. Rolled leaves trap water vapour to create a humid environment to reduce the rate of transpiration
10. vertical arrangement of leaves such that upper leaves shield lower leaves form sunlight and heat.

Wilting

This is the loss of rigidity of non woody plant due to excess loss of water than can be replaced from the soil.

Significance of wilting

- Stomata lose turgidity and close which reduces water loss from the plant.
- the surface of the leaves over which transpiration occurs reduces.

Guttation

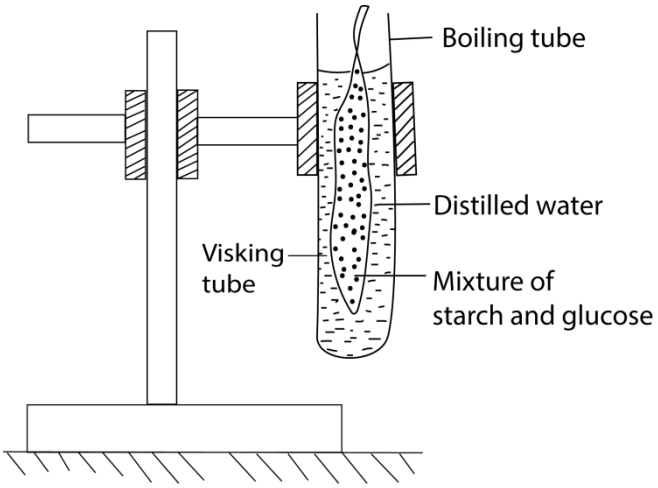
It is the oozing out of drops of water from leaf margins and tips in cool, humid conditions. it occurs when the rate of absorption of water is higher than the rate of transpiration

Translocation

Translocation is the transport of food in the plant. It occurs in the sieve /phloem.

Revision questions

1. A solution containing starch and glucose was put in a visking tube in the set up shown in the figure below and left to stand for 30 minutes



After 30 minutes, samples were drawn from the contents of the visking tube and boiling tube, then iodine and Benedict's test carrier out on each of them.

(a) Describe what was observed with iodine test on

(i) Visking tube content (½ mark)

(ii) Boiling tube content (½ mark)

(b) Explain your answer in (a) (02marks)

(c) Describe what was observed with iodine test on

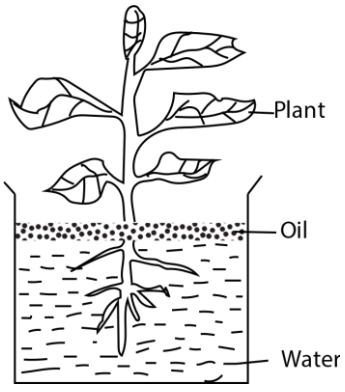
(i) Visking tube content (1mark)

(ii) Boiling tube content (1 mark)

(d) Explain your answer in (a) (03marks)

(e) Giving reasons, state the nature of the visking tube (02marks)

2. The figure below shows a set up used in an investigation on water loss and uptake in a green plant

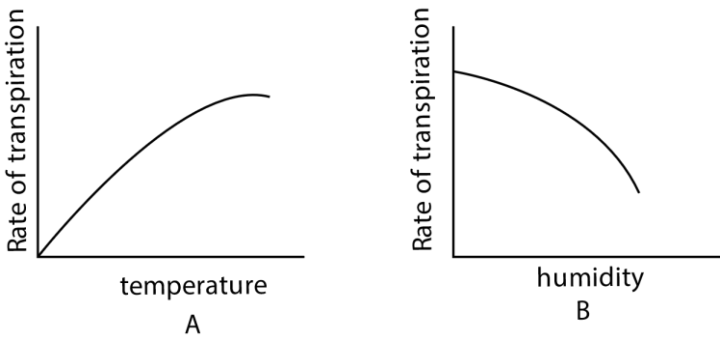


The set up was left in the open and the mass of the plant together with the beaker were recorded every 2hour for 14 hours. The result are shown in table below. Use the information to answer the questions that follow.

Time	Mass of plant and beaker (g)
8.00 a.m	368
10.00 a.m	363
12.00 noon	358
2.00 p.m	353
4.00 p.m	347
6.00 p.m	344
8.00 p.m	342
10.00 p.m	341

(a) Why was oil used in the experiment? (01mark)
(b) Plot a graph in the space below to represent the formation in Table above (07mark)
(c) From the graph, determine what the mass of the plant at 1.00pm (01mark)
(d) Calculate the volume of water lost by the plant during the period of the experiment (02marks)
(e) (i) Using your graph, state the time of the highest rate of transpiration. Give a reason for your answer. (02marks)
(ii) Give two reasons why the time in €(i) had the highest rate of transpiration (02mark)
(f) Suggest two ways that this plant could benefit from the transpiration. (02marks)
(g) Suggest three ways that this plant may reduce water loss. (03marks)

3. (a) what is transpiration?
(b) Figures A and B show how temperature and humidity affect the rate of transpiration.



(i) From fig. A, describe how the rate of transpiration changes with temperature (01mark)

(ii) From fig. B, describe how the rate of transpiration changes with humidity. (01mark)

(c) Explain why:

(i) temperature affect the rate of transpiration as shown in figure A (02marks)

(ii) humidity affects the rate of transpiration a shown in figure B (02mark)

(d) State the importance of transpiration in plant. (02marks)

11. 4. (a) What is transpiration? (02marks)
(b) Explain how a plant benefit from transpiration (06marks)
(c) Explain why some plants may dry out in water logged soil (07 marks)

Solutions

1. (a) (i) starch present

(ii) starch absent

(b) starch molecules are to big to cross the visking tube

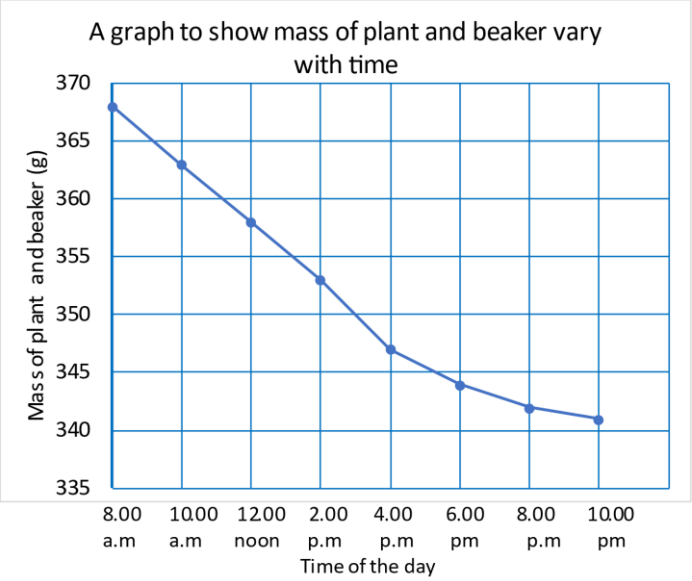
(c)(i) reducing sugar present

(ii) reducing sugar present

(d) glucose molecules crossed the visking tube to the test tube

(e) Visking tube is semi-permeable because it allowed glucose molecules to pass through and retained starch.

. (a) oil prevents evaporation of water from the surface



(c) 342g

(d) mass of water lost = 365 – 341 = 24g

but 1g = $1cm^3$

∴ 24 g = 24 x 1 = cm^3

(e) (i) between 2.00p.m to 4.00pm

(ii) it is the hottest time of the day providing heat for vaporization

there is light causing opening of the stomata

(f) evaporation of water cools the plant

the plant loses excess water

helps absorption of water from the soil

(g) leaves are reduced to spines

having fewer stomata on upper surface of the leaf than on lower part of the leaf

having hairy lamina

having sunken stomata

having thick cuticle

shedding of leaves

rolling of leaves

3. (a) Transpiration is loss of water from the leaves by evaporation

(b) (i) the rate of transpiration increases with temperature

(ii) Rate of transpiration decreases as humidity increases

(c) (i) the rate of transpiration increases as temperature increases because increase in temperature supplies energy required for evaporation to take place.

(ii) the rate of transpiration decreases as humidity increases because increase in humidity reduces the diffusion gradient between the surface of the leaf and the air which reduces the rate of evaporation.

(d) importance of transpiration

- absorption of water
- absorption of mineral salts
- cooling of the plant

4. (a) transpiration is the loss of water through stomata of plant

(b) - evaporation of water cools the plant

- transpiration creates a tension that draws water and mineral salt up the plant
- transpiration helps the plant to lose excess water.
- transpiration maintains water pressure within the cells keeping them rigid to provide support to non woody plants.

(c) (i) a lack of oxygen in a waterlogged soil damages or kills plant roots.

(ii) anaerobic microbes in a waterlogged soil produce toxic waste products that can harm plant roots. For example, in waterlogged soils, nitrate is converted to ammonium, sulfate to sulfide and manganese ion +4 to manganese ion +2.