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Activity

Plants, water and nutrients

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Introduction

This worksheet is based on James Dinsley's article 'Plants, water and nutrients: how root systems work'. Use information in this article and your own knowledge to answer the following questions.

Questions

1 Water is vital for plants.

Give **three** properties of water and explain how each is vital for normal plant function. [6 marks]

2 James Dinsley describes the absorption of water and inorganic ions by plant roots as an energy-intensive process.

Explain why this absorption is energy intensive. [4 marks]

3 Water and inorganic ions are taken up by the hydrophilic walls of the root hair cells in the root epidermis. They then pass through the cortex of the root, either by the apoplastic pathway or by the symplastic pathway.

(a) Explain **two** ways in which the root hair cells are adapted for the absorption of water and inorganic ions. [2 marks]

(b) Describe how a root hair cell absorbs inorganic ions. [3 marks]

(c) Give **three** ways in which transport via the apoplastic pathway differs from that via the symplastic pathway. [3 marks]

(d) Suggest **one** further pathway by which water and inorganic ions might cross the cortex of a plant root. [1 mark]

4 The wall of each cell in the root's endodermis has a Casparian strip.

Explain the importance of this Casparian strip. [4 marks]

5 Explain **two** ways in which xylem vessels are adapted to carry water from the root to the leaves of a plant. [2 marks]

6 Some plant species produce root pressure of up to ~0.2 kPa.

Describe how they do it. [3 marks]

7 Increases in temperature and in wind speed cause an increase in the rate of water transport through the stem of a plant.

Explain why. [2 marks]

8 James Dinsley tells us that 80–90% of the world's plant species are involved in a mutualistic relationship with arbuscular mycorrhizal fungi (AMF).

Give **one** way in which a plant might benefit from this relationship and **one** way in which a plant might be damaged by this relationship. [2 marks]

Model answers

1 Mark in pairs to a maximum of three pairs. [6 marks]

Strong cohesion between water molecules.

Supports an unbroken column of water in xylem.

OR

Relatively large latent heat of vaporisation.

Little loss of water through evaporation to cool the plant.

OR

Relatively high heat capacity.

Buffers changes in temperature of plant.

OR

Is a metabolite in many reactions.

Named example of such a reaction (e.g. condensation, hydrolysis, photolysis).

OR

Is a (universal) solvent.

Most metabolic reactions occur in (aqueous) solution.

2 Any four of the following. [4 marks]

Water molecules and inorganic ions must cross the surface membranes of root hair cells.

(Many/most) ions must pass through carrier proteins.

Conformation change / change in tertiary structure of carrier protein requires hydrolysis of ATP.

Absorption of inorganic ions lowers water potential of root hair cell.

Causing water to enter cells by osmosis.

3 (a) Large surface area to volume ratio increases rate of absorption.

Many mitochondria for rapid (aerobic) respiration.

(b) By active transport.

Each (type of) ion by a specific (type of) carrier protein.

In surface membranes of root hairs (of epidermal cells).

(c) Apoplastic occurs through cell walls but symplastic occurs via plasmodesmata.

OR

Apoplastic does not involve cytoplasm but symplastic does.

AND

Apoplastic involves passive transport but symplastic involves active transport.

AND

Apoplastic is unselective but symplastic is selective.

(d) Via tonoplasts / via cell vacuoles / via cell-surface membranes.

4 Passage via symplastic pathway has been selective / occurs via selective carrier proteins.

Casparian strip is impermeable (to water and inorganic ions).

Forces water and inorganic ions into cells of pericycle.

Many ions / many pathogens cannot pass into pericycle (through transport proteins).

OR

Many ions immobilised by chelating agents so cannot leave (cells of) pericycle.

5 Any two of the following. [2 marks]

Hollow tubes with no end walls, so do not impede water flow.

Lignin in cell walls, so vessels withstand internal negative pressures.

Pits in walls allows lateral movement of water, so bypass any blockages.

6 Active transport of inorganic ions (from pericycle) into xylem.

Lower water potential of solution inside xylem (vessels).

So water enters xylem (vessels) by osmosis.

Increased volume within xylem (vessels) causes increase in pressure.

7 Any two of the following. [2 marks]

Both cause an increase in the rate of evaporation of water from the leaves / in the rate of transpiration.

Hydrogen bonding between water molecules prevents breakage in column of water (in xylem vessels).

So more water is pulled up the stem (per unit time).

8 **Benefit**: AMF absorbs inorganic ions which it passes to plant.

Damage: AMF might absorb harmful concentration of toxic ions.