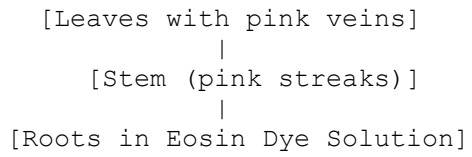
ABSORPTION BY ROOTS

Case-Based & Experimental Questions

Case Study 1: The Balsam Plant Experiment

A student took a well-watered potted Balsam plant, uprooted it carefully to avoid damaging the roots, and washed the root system thoroughly. The roots were then immersed in a beaker containing a diluted **Eosin solution** (a bright pink/red dye). After a few hours, the student observed that the veins of the leaves turned pinkish-red.



- **Question 1:** Name the specific vascular tissue responsible for conducting the pink dye up to the leaves.
  - **Answer: Xylem**.
- **Question 2:** Why did the roots absorb the dye? Explain the mechanism involved.
  - **Answer:** The roots absorbed the dye along with water through **osmosis** and **imbibition**. The cell sap inside the root hair cells has a higher concentration than the surrounding dilute eosin solution, pulling water (and the dye) inward.
- **Question 3:** What would happen if the student coated the roots with thick grease before putting them in the dye?
  - **Answer:** No color change would be observed in the leaves. Grease is hydrophobic (water-repellent) and cuts off contact between the root cells and the water, entirely blocking absorption.

Case Study 2: The Potato Osmoscope

An experiment was set up using a peeled potato tuber. A deep cavity was made in the center, and a concentrated sugar solution was poured inside. The initial level of the sugar solution was marked with a pin. The potato was then placed in a beaker containing pure water. After two hours, the level of liquid inside the cavity rose significantly.

- **Question 1:** Name the phenomenon demonstrated in this experiment.
  - **Answer: Endosmosis** (a type of osmosis where water moves into a system).
- **Question 2:** Why does the potato tissue act as a semi-permeable membrane?
  - **Answer:** The living cell membranes of the potato cells allow only water molecules to pass through while restricting the larger sugar molecules.
- **Question 3:** Predict the outcome if the potato was thoroughly boiled before the experiment.

- **Answer:** The liquid level inside the cavity would **not rise**. Boiling kills the cells and destroys the semi-permeable nature of the cell membrane, making it freely permeable. Consequently, osmosis cannot occur.

Section B: Assertion & Reasoning Questions

Directions: In the following questions, a statement of **Assertion (A)** is followed by a statement of **Reason (R)**. Choose the correct option:

- *(a) Both A and R are true and R is the correct explanation of A.*
- *(b) Both A and R are true but R is not the correct explanation of A.*
- *(c) A is true but R is false.*
- *(d) A is false but R is true.*

Question 1

- **Assertion (A):** Roots absorb mineral ions from the soil even when their concentration is lower in the soil than inside the root cells.
- **Reason (R):** Minerals are always absorbed passively by the process of simple diffusion.
- **Answer: (c) A is true but R is false.**
  - *Explanation:* When mineral concentration is lower in the soil, they are absorbed **actively** against the concentration gradient, which requires the expenditure of metabolic energy (ATP).

Question 2

- **Assertion (A):** Marine plants wilt rapidly if transplanted into a freshwater pond.
- **Reason (R):** Cells of marine plants have cell sap with a very low solute concentration.
- **Answer: (d) A is false but R is true.** (or alternatively: **A is false and R is false** depending on context, let's fix it cleanly).
  - *Correction/Refinement:* Marine plants actually absorb too much water in freshwater and burst or become turgid rather than wilting due to endosmosis, because their cell sap has a *high* solute concentration. Let's look at a standard ICSE variant:
- **Assertion (A):** Over-watering a potted plant can kill it.
- **Reason (R):** Waterlogging drives out air from the soil pores, depriving roots of the oxygen needed for aerobic respiration.
- **Answer: (a) Both A and R are true and R is the correct explanation of A.**

Section C: High-Order Thinking Skills (HOTS)

Question 1: Turgor Pressure vs. Wall Pressure

A cell is placed in pure water. It swells up to a certain point but does not burst, unlike an animal cell (like a Red Blood Cell) which would easily rupture in the same conditions.

- **Question:** Identify the two opposing forces acting within the plant cell at maximum turgidity and explain why the plant cell stays intact.
- **Answer:** The two forces are **Turgor Pressure (TP)** and **Wall Pressure (WP)**.
    - **Turgor Pressure:** The pressure exerted by the swollen cell contents against the cell wall.
    - **Wall Pressure:** The equal and opposite pressure exerted by the rigid cell wall against the cell contents.
    - *Why it doesn't burst:* Because the cell wall is thick and rigid. When **Turgor Pressure = Wall Pressure**, no further net movement of water occurs, protecting the cell from rupturing.

Question 2: Plasmolysis Mechanics

Look at the tabular comparison below representing three different states of a cortical root cell:

Condition	Cytoplasm State	Turgor Pressure	Water Movement
Cell A	Plasmolyzed	Zero / Negative	Outward (Exosmosis)
Cell B	Flaccid	Low	Dynamic Equilibrium
Cell C	Turgid	Maximum	Inward (Endosmosis)

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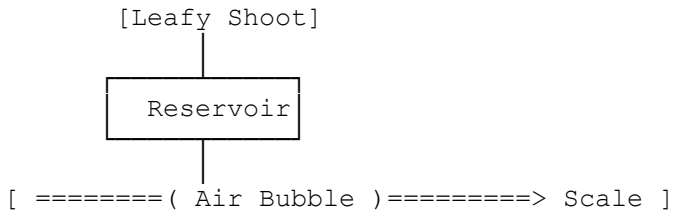
- **Question:** If a person salts a slice of cucumber, it loses its crispness and releases water. Which cell state from the table does the cucumber slice mimic, and why?
- **Answer: Cell A (Plasmolyzed / Flaccid conversion)**. Salting creates a hypertonic environment outside the cucumber cells. Water moves out via **exosmosis**, causing the cells to lose turgor pressure and become limp/soft.

TRANSPIRATION:

Experimental & Diagram-Based Questions

Case Study 1: The Ganong's Potometer Experiment

A student sets up a **Ganong's potometer** to measure the rate of transpiration in a leafy shoot. After setting up the apparatus, they introduce an air bubble into the capillary tube and record its movement over time.



- **Question 1:** What does a potometer actually measure? Does it measure transpiration directly?
    - **Answer:** A potometer measures the **rate of water intake (absorption)** by the shoot. It does not measure transpiration directly, as a small fraction of the absorbed water (<2%) is used by the plant for photosynthesis and maintaining cell turgidity. However, the volume of water absorbed is roughly equal to the water transpired.
- **Question 2:** What is the purpose of the reservoir in this apparatus?
    - **Answer:** The reservoir allows water to be released back into the capillary tube, pushing the air bubble back to its initial zero-mark position so that multiple readings can be taken.
- **Question 3:** Predict what will happen to the speed of the air bubble if the entire setup is placed under a fast-moving ceiling fan. Explain why.
    - **Answer:** The air bubble will move **much faster**. High wind velocity blows away the water vapor accumulating around the leaves, lowering the external humidity and increasing the diffusion gradient, which accelerates the rate of transpiration.

Case Study 2: The Cobalt Chloride Paper Test

A dry strip of blue **Cobalt Chloride ($CoCl_2$) paper** is attached to the upper surface of a dorsiventral leaf, and another strip is attached to the lower surface. Both strips are secured tightly with glass slides and clips.

- **Question 1:** What color change do you expect to see on the strips, and which surface will show this change faster?
    - **Answer:** The cobalt chloride paper turns from **blue to pink** when exposed to moisture. This color change occurs **faster on the lower surface** of a dorsiventral leaf.
- **Question 2:** Give a structural reason for the difference in the rate of color change between the two surfaces.
    - **Answer:** In a dorsiventral leaf, the **lower epidermis contains significantly more stomata** than the upper epidermis. Consequently, stomatal transpiration is much higher on the lower surface, releasing more moisture quickly.

- **Question 3:** Why is it necessary to clamp glass slides over the paper strips during the experiment?
    - **Answer:** The glass slides prevent atmospheric moisture from coming into contact with the dry cobalt chloride paper, ensuring that the color change is caused solely by water vapor transpired by the leaf.

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Question 1

- **Assertion (A):** Transpiration rates drop drastically during rainy or highly humid days.
- **Reason (R):** High atmospheric humidity saturates the air outside the leaf, reducing the water vapor concentration gradient between the leaf interior and the outside atmosphere.
- **Answer: (a) Both A and R are true and R is the correct explanation of A.**

Question 2

- **Assertion (A):** Transpiration is often described as a "necessary evil" for plants.
- **Reason (R):** While it causes unavoidable water loss that can lead to wilting, it is critical for creating the transpirational pull needed to ascend sap and cool the plant body.
- **Answer: (a) Both A and R are true and R is the correct explanation of A.**

Section C: High-Order Thinking Skills (HOTS) & Applications

Question 1: Guttation vs. Transpiration

A student walks into a garden early in the morning and notices tiny droplets of water neatly aligned along the margins of grass leaves. They conclude that this is due to heavy morning condensation (dew).

- **Question 1:** Correct the student's conceptual error. Name the actual physiological process and the specific structures involved.
    - **Answer:** The process is **Guttation** (not dew or transpiration). It occurs through specialized pores located at the tips or margins of the leaves called **hydathodes**.
- **Question 2:** Distinguish between the liquid lost in this process versus the liquid lost during transpiration.
    - **Answer: * Transpiration:** Water is lost as pure **water vapor** (gas), leaving solutes behind.
        - **Guttation:** Water is lost as a **liquid solution** containing dissolved organic and inorganic substances (salts, sugars).

Question 2: Adaptation & Survival

Look at the structural comparison of three different plants below:

Plant Type	Stomata Placement / Structure	Cuticle Profile	Special Features
Plant X (Nerium)	Sunken stomata in pits	Extremely thick, waxy	Leaves modified or narrow
Plant Y (Hydrilla)	Absent or non-functional	Absent	Submerged aquatic
Plant Z (Sunflower)	More on lower surface	Normal, thin	Typical mesophyte

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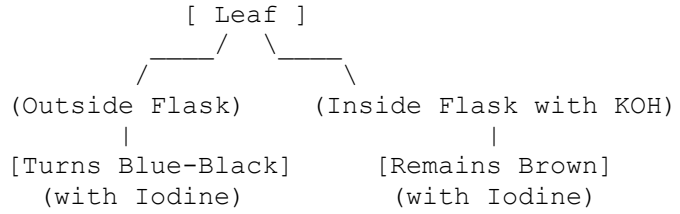
- **Question:** If a severe drought hits an agricultural zone, which plant's structural adaptations (from the table) mimic the mechanism used by desert plants to prevent excessive water loss? Explain how those features help.
- **Answer: Plant X (Nerium/Xerophytic profile)**.
    - **Sunken Stomata:** By being buried deep in pits, stomata escape direct wind currents, trapping a pocket of humid air that reduces the rate of transpiration.
    - **Thick Cuticle:** Acts as a mechanical barrier preventing cuticular evaporation, minimizing non-stomatal water loss during peak heat.

PHOTOSYNTHESIS

Experimental & Diagram-Based Questions

Case Study 1: Moll’s Half-Leaf Experiment

A student sets up an experiment to prove that a certain external factor is necessary for photosynthesis. A part of a leaf of a destarched plant is inserted into a conical flask containing a cotton plug soaked in **Potassium Hydroxide (KOH)**. The remaining half of the leaf is left outside in the open air. The setup is then placed in sunlight for a few hours.



- **Question 1:** What is the specific purpose of introducing potassium hydroxide (KOH) into the flask?
    - **Answer:** KOH is used to absorb all the carbon dioxide (CO2) present inside the air of the conical flask.
- **Question 2:** If the leaf is plucked and tested with iodine solution at the end of the experiment, what changes will be observed in both halves of the leaf?
    - **Answer:** * The half of the leaf **outside the flask** will turn **blue-black**, confirming the presence of starch.
        - The half of the leaf **inside the flask** will turn **clear brown**, showing a negative test for starch.
- **Question 3:** What is the ultimate conclusion derived from this experiment?
    - **Answer:** It proves conclusively that **Carbon Dioxide (CO2) is absolutely essential** for the process of photosynthesis.

Case Study 2: Light and Dark Chemical Phases

A researcher tags water molecules supplied to a plant with a radioactive isotope of oxygen (18O). Later, they track the products of photosynthesis to locate where this radioactive isotope ends up.

- **Question 1:** In which of the final products—Glucose (C6H12O6), Water (H2O), or Oxygen (O2) gas—will the radioactive isotope be detected?
    - **Answer:** The radioactive isotope 18O will be detected exclusively in the **Oxygen (O2) gas** released by the plant.
- **Question 2:** Name and explain the exact photochemical step responsible for this outcome.
    - **Answer: Photolysis of water**. During the light-dependent reaction, absorbed light energy splits water molecules inside the thylakoid lumen into hydrogen ions (H+), electrons (e−), and molecular oxygen (O2). The equation is:

      $$2H_2O \xrightarrow{\text{Light / Chlorophyll}} 4H^+ + 4e^- + O_2\uparrow$$

- **Question 3:** Why does the production of sugar (glucose) continue for a brief period even after the light source is completely switched off?
    - **Answer:** Because the **Dark Reaction (Calvin Cycle)** does not require light directly. It relies on the chemical assimilatory power (ATP and NADPH)

generated during the preceding Light Reaction. It continues until these stored energy reserves are entirely exhausted.

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Question 1

- **Assertion (A):** The rate of photosynthesis drops drastically if a plant is exposed to green light only.
- **Reason (R):** Chlorophyll pigments absorb green light most efficiently compared to blue and red wavelengths.
- **Answer: (c) A is true but R is false.**
    - *Explanation:* Chlorophyll **reflects** green light (which is why leaves look green) and absorbs it poorly. It absorbs maximum light in the blue and red regions of the spectrum.

Question 2

- **Assertion (A):** Destarching a plant by keeping it in absolute darkness for 24–48 hours is mandatory before starting any photosynthesis experiment.
- **Reason (R):** This ensures that any starch detected at the end of the experiment is synthesized purely during the experimental period, eliminating false positives.
- **Answer: (a) Both A and R are true and R is the correct explanation of A.**

Section C: High-Order Thinking Skills (HOTS) & Application

Question 1: Marine Plant Depth Zoning

An oceanographer observes that green algae are found mostly near the surface of the ocean, while brown and red algae can survive in significantly deeper layers of water.

- **Question:** Explain this observation based on the properties of light penetration and photosynthetic pigments.
- **Answer:** Sunlight is a composite spectrum. Red and blue light wavelengths (powering green chlorophyll) are easily absorbed and scattered in the shallow upper layers of water.
    - Deeper water layers are penetrated primarily by shorter, high-energy **blue-green light wavelengths**.
    - Brown and red algae possess specialized **accessory pigments** (like phycoerythrin and fucoxanthin) capable of capturing these specific deep-penetrating blue-green wavelengths, allowing them to perform photosynthesis at depths where green plants cannot survive.

Question 2: Starch vs. Glucose Conversion

A student notes that while glucose is the direct chemical product synthesized during the Calvin cycle, it is immediately converted into starch inside the leaf tissue for storage.

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[ Glucose Synthesized ] ⟶ ( Converted to Insoluble Starch ) ⟶ [ Safe Storage ]
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- **Question:** Why don't plants simply store the sugar as glucose inside their leaf cells? What is the physiological advantage of starch?
- **Answer:** Glucose is highly **soluble in water** and chemically active. If stored as glucose, it would massively increase the solute concentration inside the cytoplasm, triggering heavy **endosmosis** and dangerously increasing the turgor pressure of the cell.
    - **Starch is completely insoluble** and osmotically inactive. Storing carbohydrates as starch exerts zero osmotic pressure on the cell, allowing safe storage without disrupting the cell's water balance.
