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BIOLOGY**

7 Transport in flowering plants

Relate the structure of root hair cells to their function of water and ion uptake.

In a region above the root tip, the cells of the outer layer produce tiny tube like out-growths called root hairs. They are single-celled extensions of epidermis cells in the root. These look like a white furry layer on the roots of seedlings if you grow them in moist air. Root hair cells are adapted for the efficient uptake of water by osmosis and mineral ions by active transport in following ways.

Long, Thin Projections.

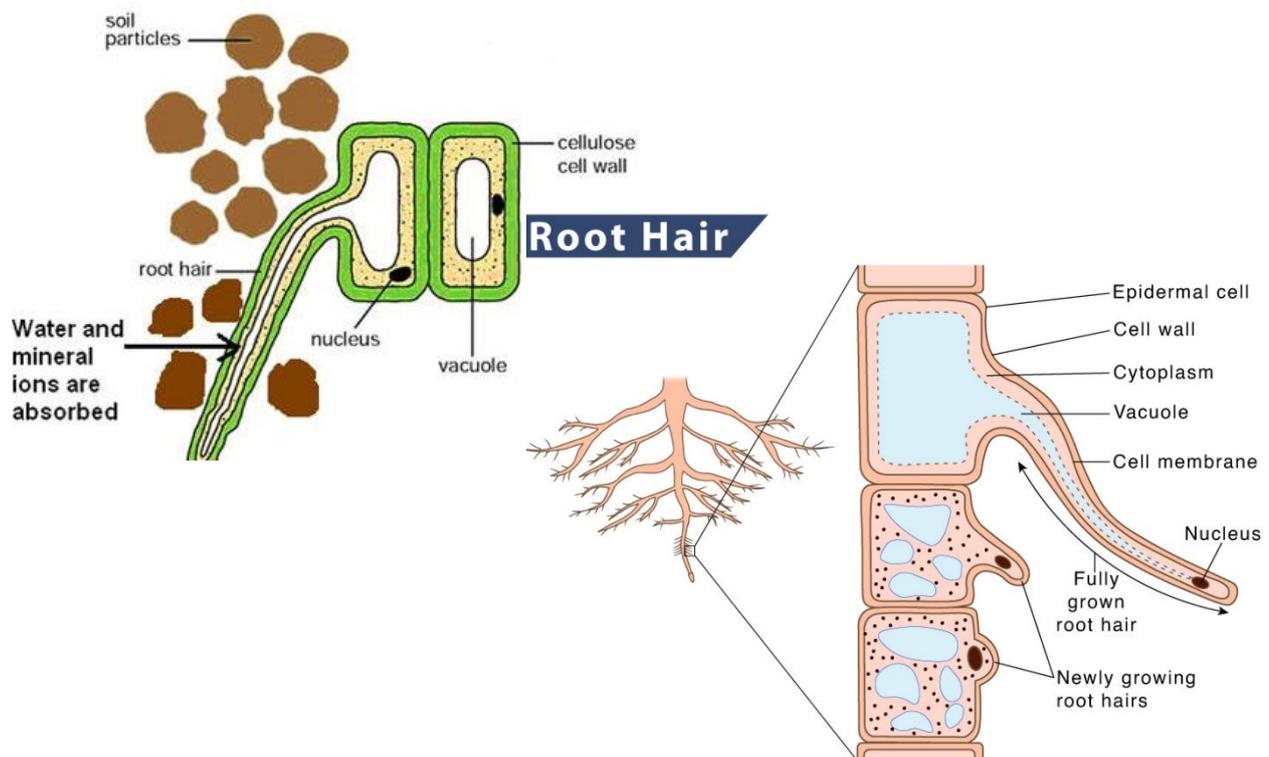
Root hair cells are long, slender, and elongated structures that extend from the surface of the root into the surrounding soil for the absorption of water and mineral ions.

Cell Wall and Cell Membrane.

Root hair cells have a semi-permeable cell membrane that allows for selective uptake of water and ions. The cell wall provides structural support for the turgidity and osmotic pressure. It prevents the cell from bursting.

Vacuole and Cytoplasm.

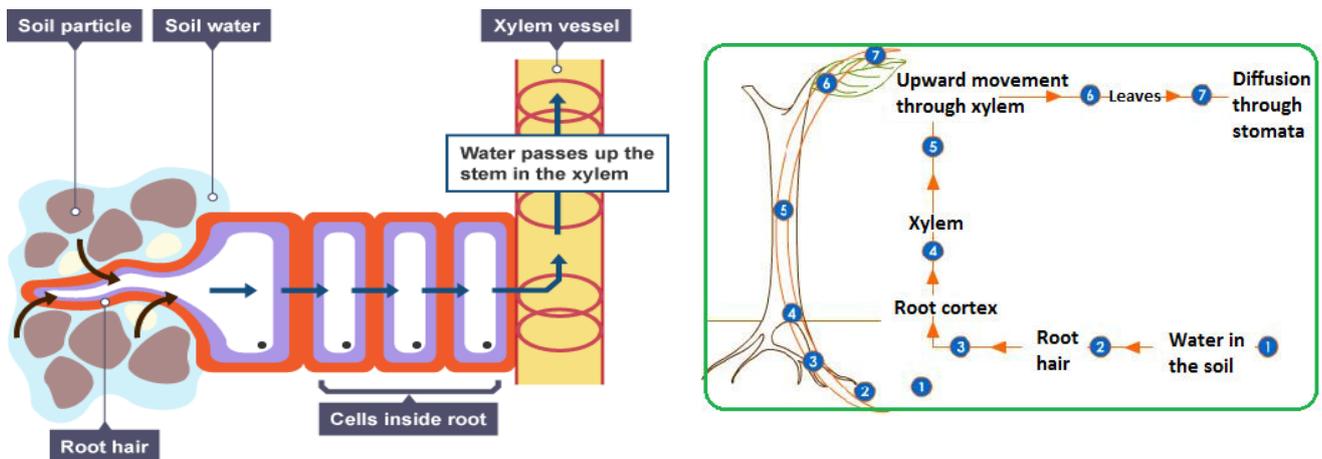
The large Central vacuole stores various solutes, creating a concentration gradient that drives the movement of water and ions into the cell. The cytoplasm contains essential nutrients and proteins that are required for active transport and growth of plant.



Outline the pathway taken by water through the root, stem and leaf, limited to: root hair cells, root cortex cells, xylem and mesophyll cells.

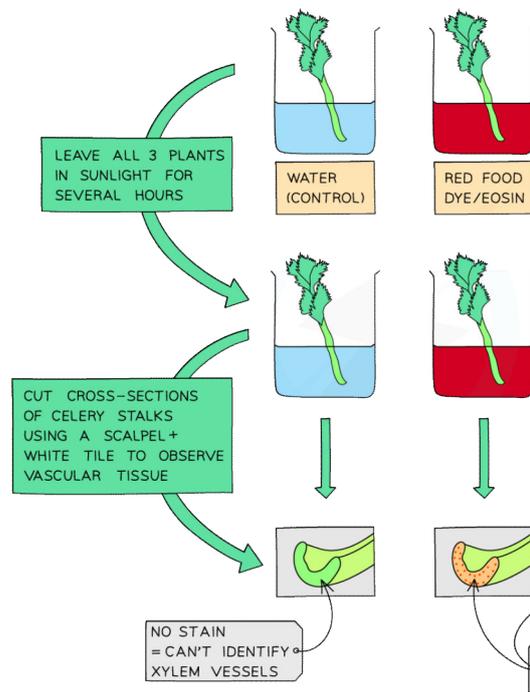
Investigate, using a suitable stain, the pathway of water in a cut stem.

Water enters the roots by diffusion and osmosis which increases water potential in the roots whereas water is lost from the leaves through stomata by transpiration. It decreases water potential in the leaves. Water is followed to the leaves through xylem in the stem down the water potential gradient. Water first diffuses into the root hair by osmosis, it then diffuses from cell to cell or cell wall to cell wall through the root cortex, where it eventually reaches the xylem. Water is taken up through the xylem until it reaches a leaf, where it diffuses out into the surrounding mesophyll cells. Water diffuses from the mesophyll cells to the surrounding inter cellular air spaces as water vapor, and finally, out of the leaf through the stomata.



Investigation

- Cut the base of a stalk of celery (the non-leafy end) under water.
- Place the stalk in a beaker of water that has been stained with red food dye, the base end down, and place it in room temperature conditions, under a bright light and a slight breeze.
- You may observe red lines travelling up the stalk, and then through the leaves.
- If you cut the stalk halfway, only certain areas of the stalk is stained the colour of the water, showing that the water is being carried in specific vessels through the stem - these are the xylem vessels.

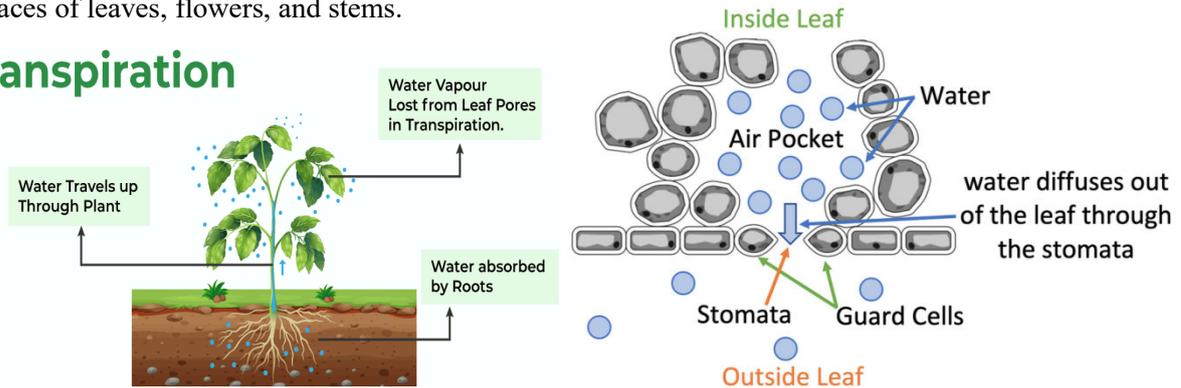


Describe transpiration as the loss of water vapors from leaves.

Understand that water evaporates from the surfaces of the mesophyll cells into air spaces and then diffuses out of the leaves through the stomata as water vapor.

Transpiration is the process by which water is lost from the aerial parts of a plant, primarily from the leaves, in the form of water vapor. Transpiration is defined as the physiological loss of water in the form of water vapor, mainly from the stomata in leaves, but also through evaporation from the surfaces of leaves, flowers, and stems.

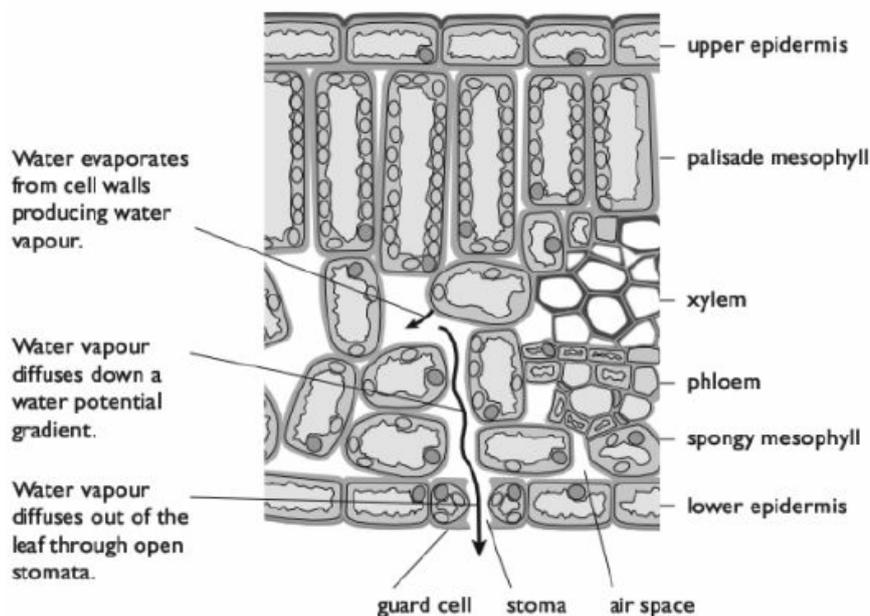
Transpiration



Water evaporates from the cell surfaces of the leaf mesophyll cells, into the air spaces between as water vapor and out through the stomata.

Evaporation leads to a high concentration of water vapor in the leaf's air spaces. Subsequently, the water vapor diffuses out of the leaf through the stomata, which are small pores on the leaf's surface.

The driving force for this diffusion is the concentration gradient, with water vapor moving from the higher concentration inside the leaf to the lower concentration in the atmosphere.



Explain:

(a) the effects of wind speed, and the variation of temperature, humidity and light intensity on transpiration rate (b) how wilting occurs.

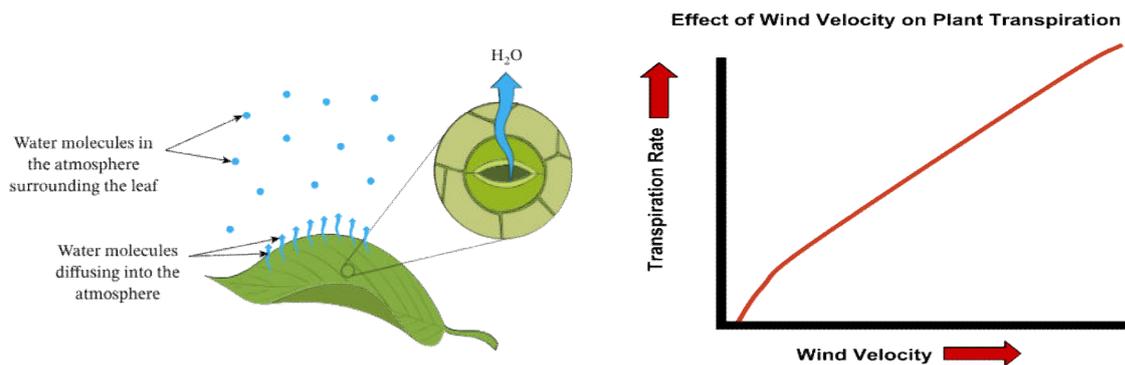
Transpiration rate in plants refer to the speed at which water vapor is lost from the aerial parts of the plant, primarily through the stomata in the leaves.

Following are the factors affecting transpiration.

- Wind Speed.
- Temperature.
- Humidity.
- Light Intensity.

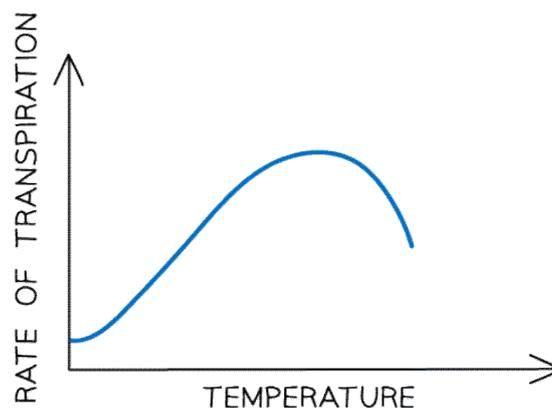
Effect of Wind Speed.

In still air the region around a transpiring leaf will become saturated with water vapors so that no more water can escape from the leaf. In these conditions transpiration would slow down. In moving air the water vapor will be swept away from the leaf as fast as it diffuses out. This will speed up transpiration.



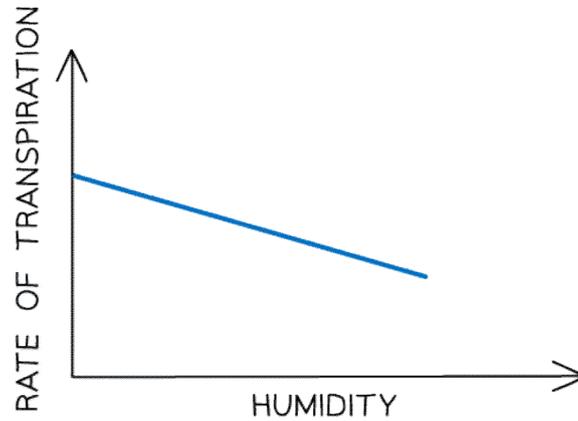
Effect of Temperature.

As temperature rises, transpiration rate generally increases. Warmer temperatures lead to an increase in the kinetic energy of water molecules inside the leaf, hence increasing transpiration rate. Warm air can hold more water vapor than cold air. So, transpiration will take place more rapidly into warm air. Higher the temperature, higher the rate of evaporation as well as the rate of movement of water vapor and thus higher the rate of transpiration.



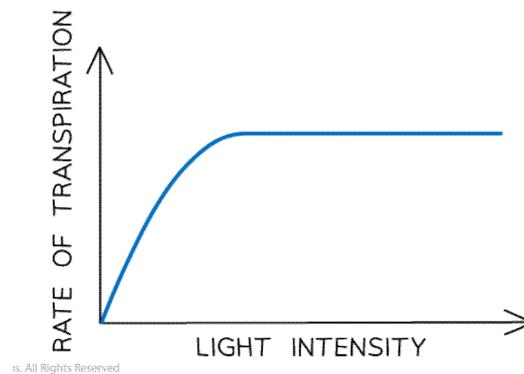
Effect of Humidity.

Higher humidity in the surrounding atmosphere creates a reduced water vapor concentration gradient between the leaf and the air. As a result, the movement of water vapor out of the leaf slows down, leading to a lower transpiration rate. Higher the humidity, higher the concentration of water vapor in the external air. The diffusion gradient is less steep so the rate of transpiration is lowered.



Effect of Light Intensity.

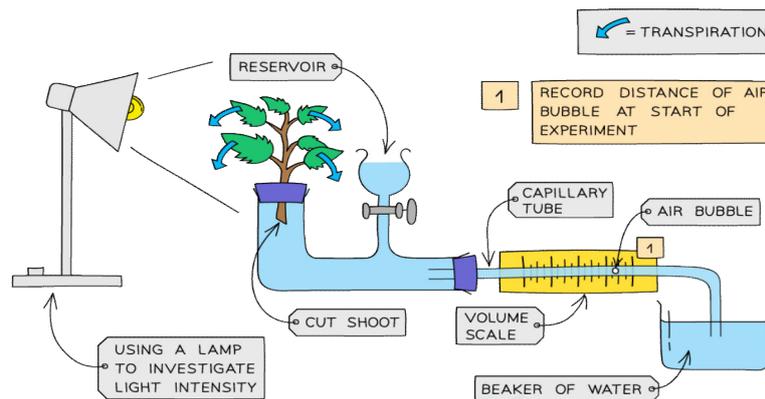
Light Intensity affects the opening and closing of stomata, consequently affecting the transpiration rate. In the presence of sunlight as stomata open for gas exchange, water vapor also escapes, increasing transpiration. Thus, higher light intensity generally leads to increased transpiration rates.



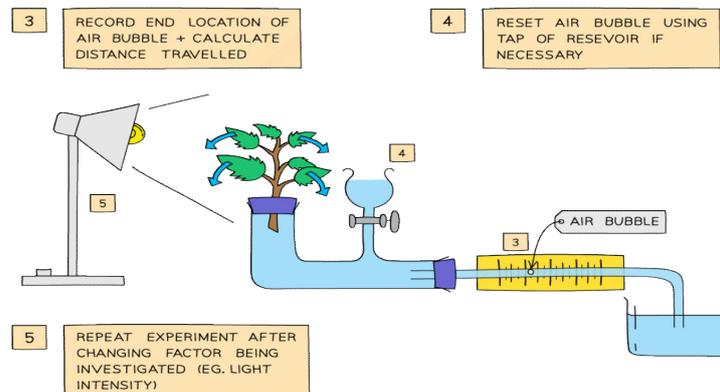
Investigate the effects of wind speed, light intensity and temperature variation on transpiration rate.

Investigate the effect of Wind Speed.

- Cut a shoot underwater to prevent air entering the xylem and place in tube.
- Set up the apparatus as shown in the diagram and make sure it is airtight, using vaseline to seal any gaps. Dry the leaves of the shoot, wet leaves will affect the results
- Remove the capillary tube from the beaker of water to allow a single air bubble to form and place the tube back into the water. Let the plant sit for 10 minutes and record the result.



- Now reset the air bubble at start position by releasing water from reservoir by opening the reservoir tap. Place a fan and turn it on to increase the wind speed.
- Record the starting location of the air bubble. Leave for 10 minutes.
- Record the end location of air bubble. Repeat the experiment for more reliability at different wind speeds.



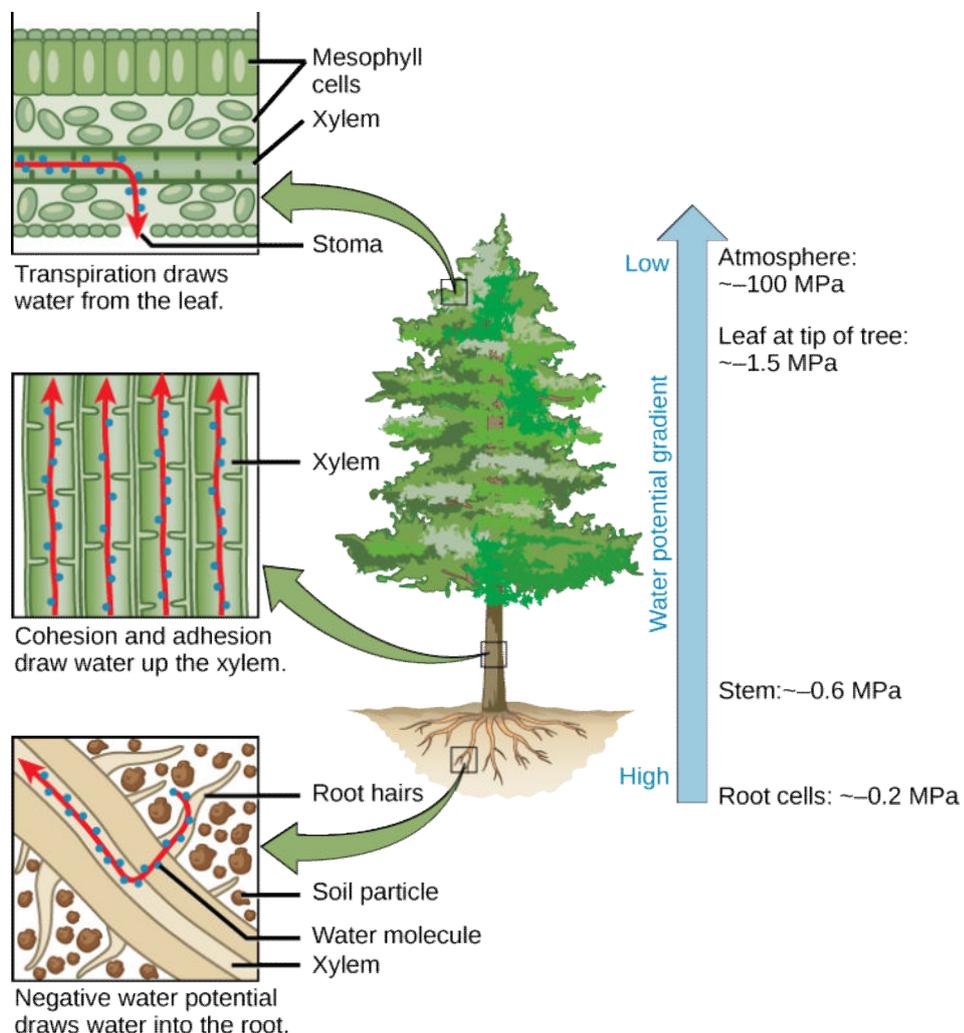
Investigate the effect of Light Intensity and Temperature.

The effect of Light Intensity and Temperature can be studied with the same above mentioned method with some additions:

- While investigating the effect of light intensity place a lamp and vary its distance after some intervals and recording the results.
- For Temperature use a Bunsen burner to change the temperature of water after a fixed time interval and record your results.

Explain the mechanism by which water moves upwards in the xylem in terms of a transpiration pull that draws up a column of water molecules, held together by forces of attraction between water molecules.

- The movement of water upwards in the xylem of plants is primarily driven by a process called transpiration pull. The mass flow of water in a plant is helped by the polar nature of water.
- Hydrogen bonds (H-bonds) form between water molecules which results in cohesion between water molecules and adhesion between the cellulose in the cell walls and the water molecules.
- Water moves from roots to the leaves due to the potential difference of water. The low osmotic pressure in leaves drives this movement.
- When water evaporates from the leaves into the air spaces, it creates tension within the xylem tissue. This tension is effectively transmitted throughout the plant due to the cohesive properties of water molecules, allowing a continuous column of water to move from the roots to the leaves.



Describe translocation as the movement of sucrose and amino acids in the phloem from parts of plants that produce or release them (sources) to parts of plants that use or store them (sinks).

Translocation.

The movement of sucrose and amino acids from a source to a sink through phloem by mass flow is called translocation.

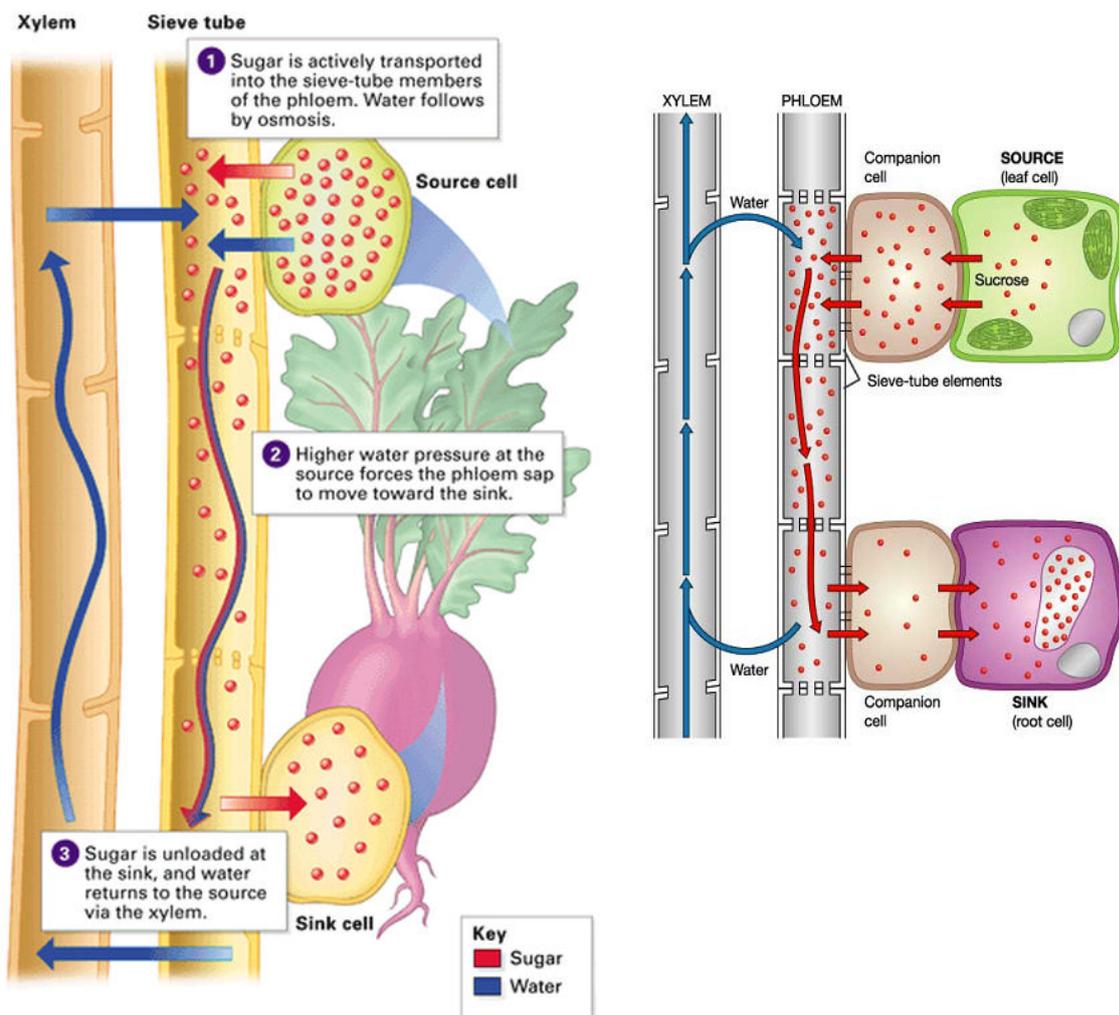
The movement of water and mineral ions in xylem is always upwards from soil to leaf. However, the solutes in the phloem may be traveling up or down the stem.

Source.

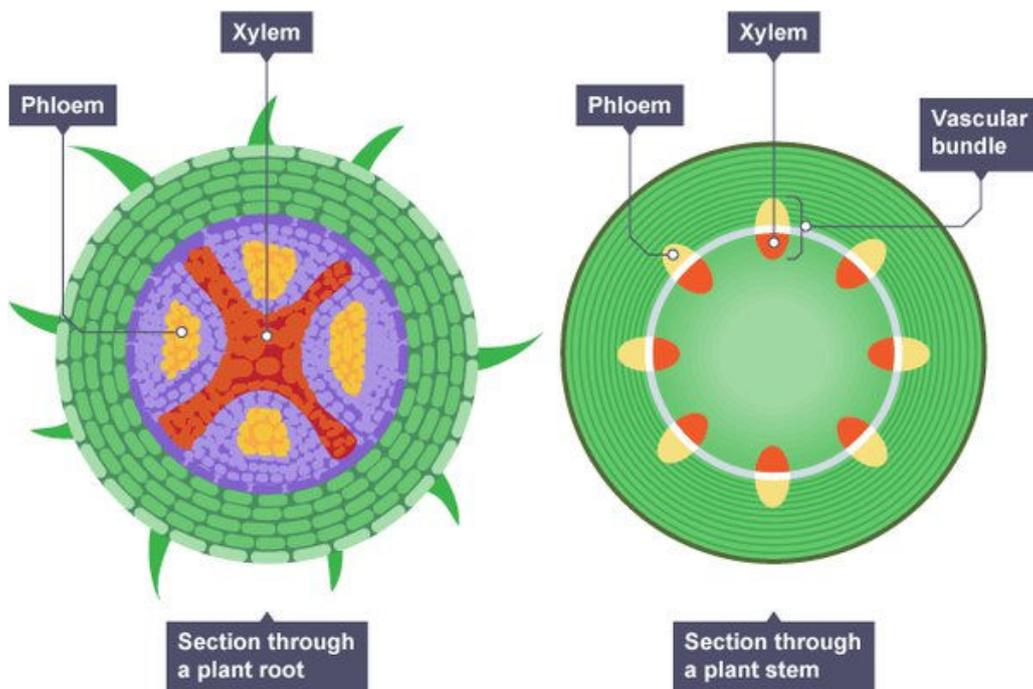
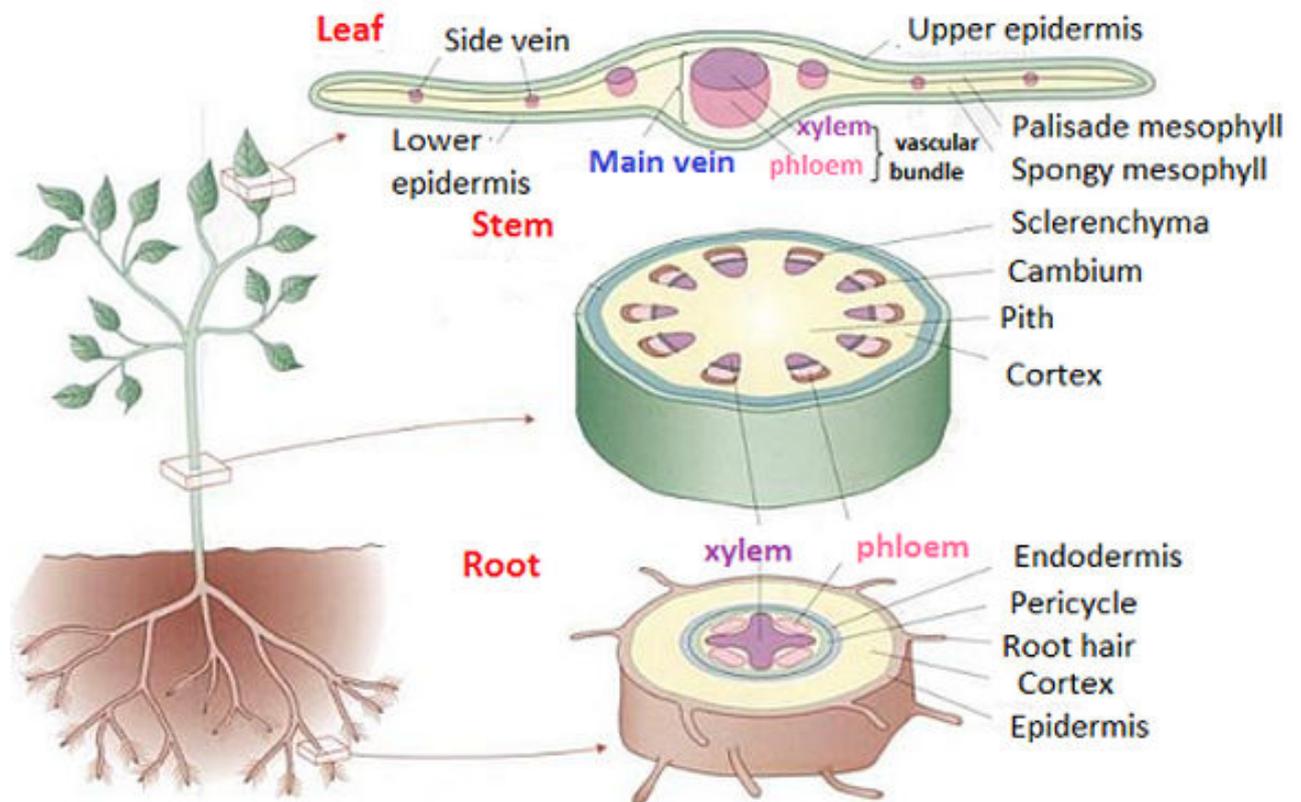
An organ is called a source where sucrose and carbohydrates are produced or released to be carried to other parts of a plant.

Sink.

An organ is called a sink where sucrose and amino acids are stored.



Identify the positions of tissues as seen in transverse sections of non-woody dicotyledonous roots and stems, limited to: xylem, phloem and cortex.



State the functions of xylem as transport of water and mineral ions, and support.

Relate the structure of xylem vessels to their function, limited to: (a) thick walls with lignin (details of lignification are not required) (b) no cell contents (c) cells joined end-to-end with no cross walls to form a long continuous tube.

Xylem is a vital plant tissue that has two main jobs.

- It carries water and minerals from the roots to the rest of the plant, including the leaves. This process is called the ascent of sap.
- It provides support to the plant, helping it stay upright and not wilt under its own weight.

The structure of xylem is well adapted to their functions.

Thick walls with lignin

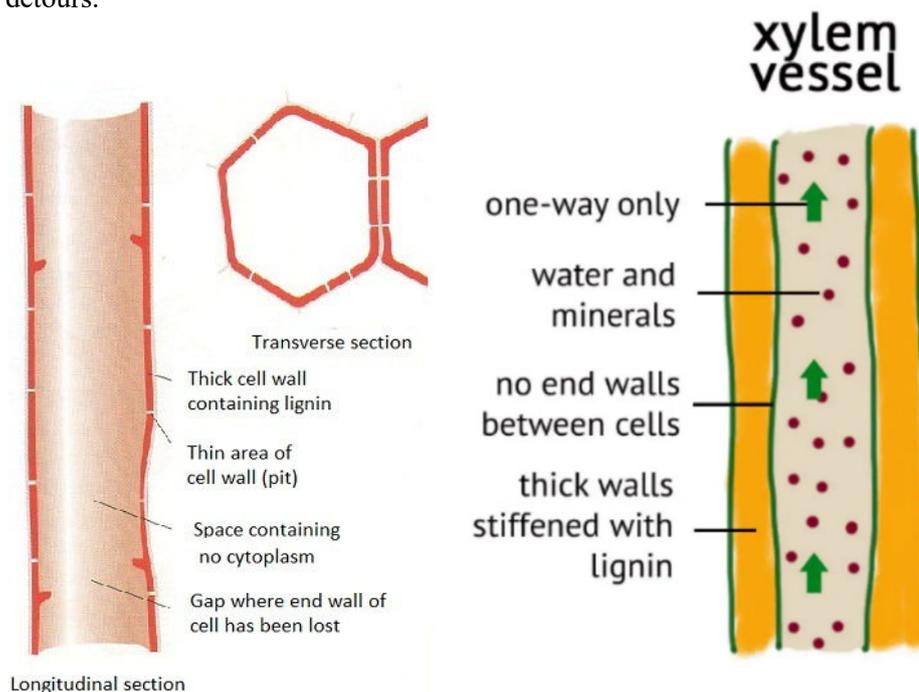
The xylem vessels have thick walls strengthened by lignin, which is a tough and water-resistant material. This lignification gives them mechanical support and prevents collapse when water moves under tension. Additionally, the lignin makes the xylem vessels impermeable, ensuring that water flows only upward from the roots to the rest of the plant in a one-way direction.

No cell contents.

Xylem vessels are composed of dead cells that lack cytoplasm and cell contents. Xylem vessels are hollow tube-like structure. The empty lumen facilitates the movement of water and mineral ions.

Cells joined end-to-end with no cross walls to form a long continuous tube.

Xylem cells are joined end to end with no cross walls to form a long continuous tube. The absence of cross walls ensures that water can flow seamlessly through the entire length of the xylem vessel without detours.





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