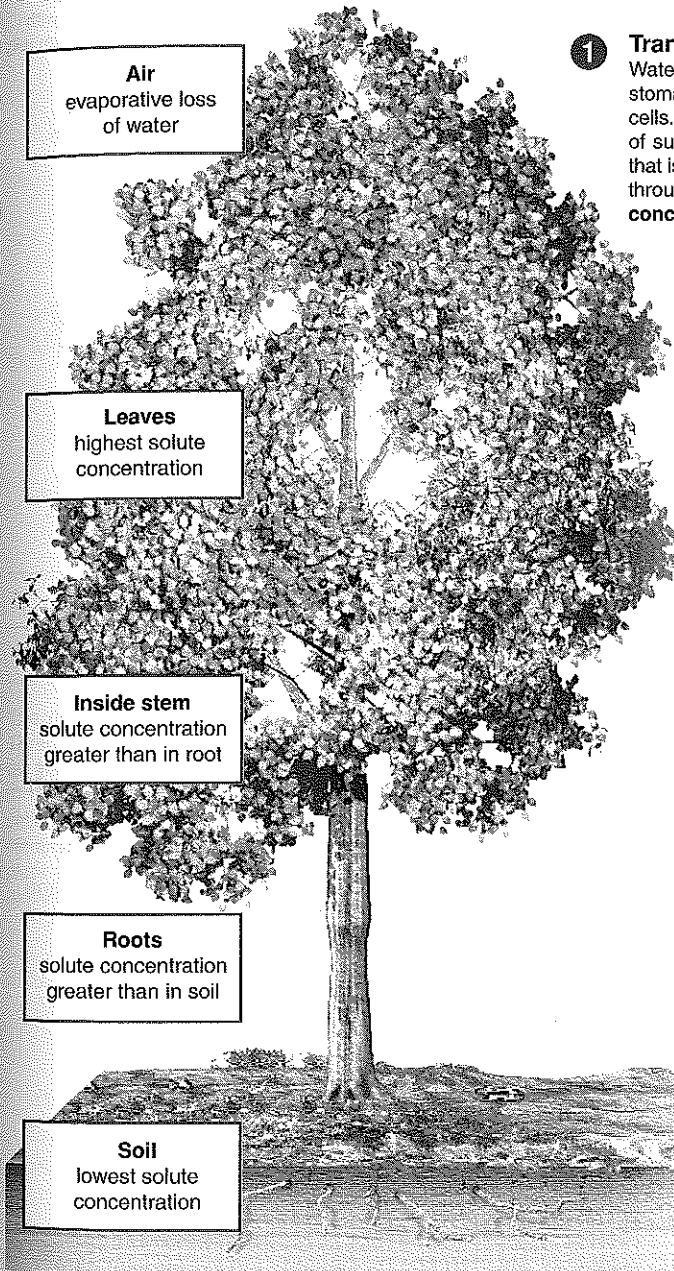


Transpiration

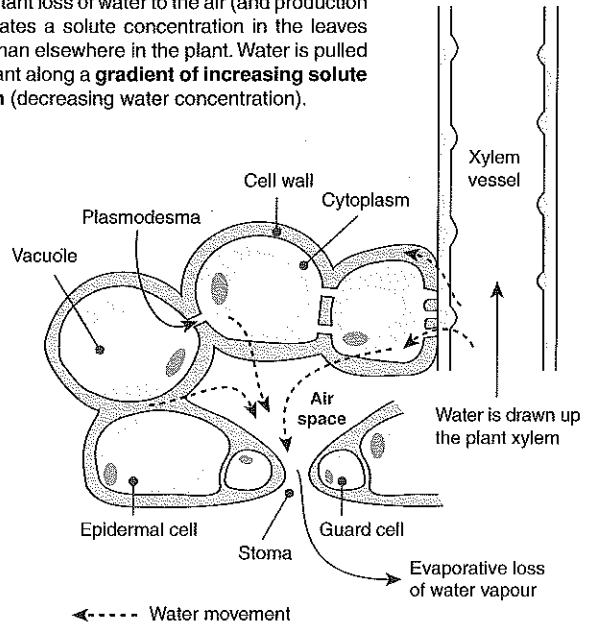
Plants lose water all the time, despite the adaptations they have to help prevent it (e.g. waxy leaf cuticle). Approximately 99% of the water a plant absorbs from the soil is lost by evaporation from the leaves and stem. This loss, mostly through stomata, is called **transpiration** and the flow of water through the plant is called the **transpiration stream**. Plants rely on a gradient in solute concentration from the roots to the air to move water through their cells. Water flows passively from soil to air along a

gradient of increasing solute (decreasing water) concentration. This gradient is the driving force in the ascent of water up a plant. A number of processes contribute to water movement up the plant: **transpiration pull**, **cohesion**, and **root pressure**. Transpiration may seem wasteful, but it has benefits; evaporative water loss cools the plant and the transpiration stream helps the plant to maintain an adequate mineral uptake, as many essential minerals occur in low concentrations in the soil.



1 Transpiration pull

Water is lost from the air spaces by evaporation through stomata and is replaced by water from the mesophyll cells. The constant loss of water to the air (and production of sugars) creates a solute concentration in the leaves that is higher than elsewhere in the plant. Water is pulled through the plant along a **gradient of increasing solute concentration** (decreasing water concentration).



2 Cohesion-tension

The transpiration pull is assisted by the special **cohesive** properties of water. Water molecules cling together as they are pulled through the plant. They also **adhere** to the walls of the xylem (**adhesion**). This creates one **unbroken column of water** through the plant. The upward pull on the cohesive sap creates a tension (a negative pressure). This helps water uptake and movement up the plant.

3 Root pressure

Water entering the stele from the soil creates a **root pressure**; a weak 'push' effect for the water's upward movement through the plant. Root pressure can force water droplets from some small plants under certain conditions (**guttation**), but generally it plays a minor part in the ascent of water.

1. (a) How do plants compensate for the constant loss of water by transpiration? _____
- (b) Describe one benefit of the transpiration stream for a plant: _____
2. Describe three processes that assist the transport of water from the roots of the plant upward:
 - (a) _____
 - (b) _____
 - (c) _____

Transpiration & Adaptation in Plants

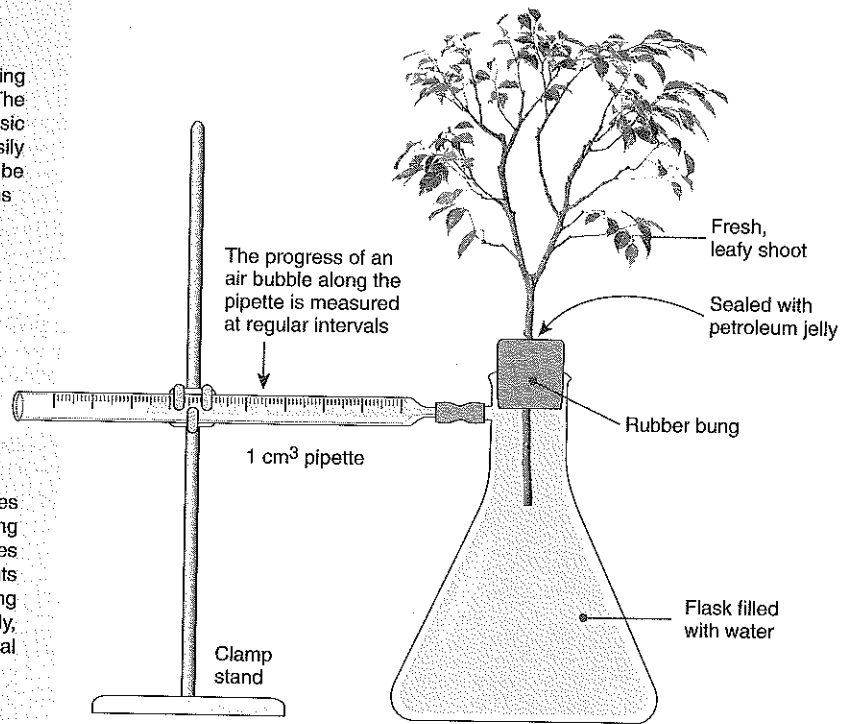
The Potometer

A potometer is a simple instrument for investigating transpiration rate (water loss per unit time). The equipment is simple and easy to obtain. A basic potometer, such as the one shown right, can easily be moved around so that transpiration rate can be measured under different environmental conditions

Some of the physical conditions investigated are:

- Humidity or vapour pressure (high or low)
- Temperature (high or low)
- Air movement (still or windy)
- Light level (high or low)
- Water supply

It is also possible to compare the transpiration rates of plants with different adaptations e.g. comparing transpiration rates in plants with rolled leaves vs rates in plants with broad leaves. If possible, experiments like these should be conducted simultaneously using replicate equipment. If conducted sequentially, care should be taken to keep the environmental conditions the same for all plants used.



3. Describe three environmental conditions that increase the rate of transpiration in plants, explaining how they operate:

- (a) _____
- (b) _____
- (c) _____

4. The potometer (above) is an instrument used to measure transpiration rate. Briefly explain how it works:

5. An experiment was conducted on transpiration from a hydrangea shoot in a potometer. The experiment was set up and the plant left to stabilise (environmental conditions: still air, light shade, 20°C). The plant was then subjected to different environmental conditions and the water loss was measured each hour. Finally, the plant was returned to original conditions, allowed to stabilise and transpiration rate measured again. The data are presented below:

Experimental conditions	Temperature (°C)	Humidity (%)	Transpiration rate (g h ⁻¹)
(a) Still air, light shade, room temperature	20°C	70	1.20
(b) Moving air, light shade	20°C	70	1.60
(c) Still air, bright sunlight	23°C	70	3.75
(d) Still air and dark, moist chamber	19.5°C	100	0.05

(a) Identify the control in this experiment: _____

(b) State which factors increased transpiration rate, explaining how each has its effect: _____

(c) Why did the plant have such a low transpiration rate in humid, dark conditions? _____