Investigation into transpiration using a simple potometer

Specification reference: **2.4**

Adaptations for transport

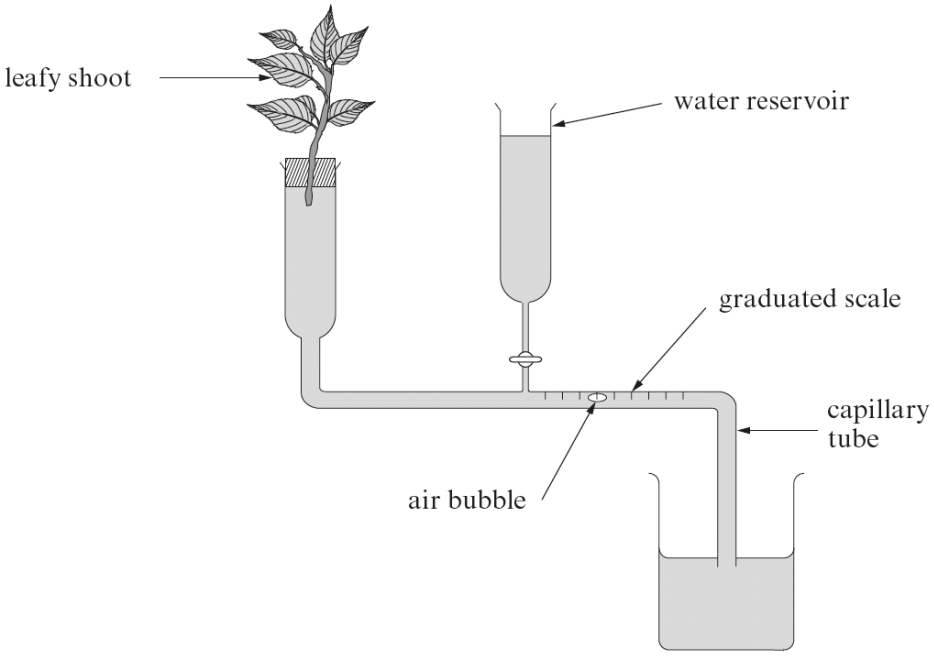
Introduction

The loss of water from the leaves of a plant causes water to be absorbed by the plant and moved through the xylem vessels to the leaves. This upward movement of water through the plant is called the transpiration stream. The evaporation of water from the leaves (mainly through the stomata) to the atmosphere is called transpiration. The assumption is made that the rate of evaporation from the leaf is equal to the rate of uptake. Although, a very small volume of water is used in physiological processes (e.g. photosynthesis typically uses less than 1% of total water as a reactant), the assumption is broadly true and this method gives a reasonable approximation of the transpiration rate.

The rate of transpiration is affected by temperature, light, humidity, wind and atmospheric pressure.

Apparatus

Potometer
Freshly cut plant stems (cut end in water)
Scissors/sharp knife
Vaseline
Bowl of water
Small beaker of water
Clamp stand
Stopclock
Paper towel



Method

1. Immerse the potometer completely under water and assemble it under water to prevent any air bubbles entering.
2. Put the cut end of the stalk (not the leaves) of your plant under water and cut off the last centimetre of the stalk diagonally underwater.
3. With the potometer and stalk still underwater push the stalk into the potometer as shown in the diagram of the apparatus. The stalk should fit tightly into the potometer. It is important that there are no air bubbles in the system and that no air can be sucked into the apparatus around the stalk.
4. Remove the plant and potometer from the water.
5. Apply Vaseline to the joints to prevent air entering.
6. Gently dab the leaves with a paper towel to remove excess water.
7. Clamp the potometer in an upright position with the end of the capillary tube under the water in the beaker.
8. Remove the capillary tube from the water and let an air bubble form.
9. Replace the end of the capillary tube under water.
10. When the air bubble reaches the scale record how far the air bubble travels in a known time.
11. Repeat stages 8, 9 and 10 twice.
12. Record your results in a table.
13. You should record the internal diameter of the capillary tube so that results can be expressed in the form of cm^3 water lost per minute.
    Volume in mm^3 is $\pi r^2 h$
    π= 3.14
    r = radius
    h = distance moved by air bubble.
14. Remove the leaves, place onto graph paper, draw around the edge of each leaf and calculate the total surface area of the leaves.
15. Express your final rate of transpiration as the volume of water lost per cm^2 per minute.

Risk assessment

Hazard	Risk	Control measure
Scissors/ knife are sharp	Cutting hand when cutting shoot	Take care and cut away from hand

Teacher/ Technicians notes

There are various forms of simple potometers available, all of which would be suitable for this investigation. This could be carried out in large groups or as a demonstration as it is often difficult to set up. Further information is available on the link below.

http://www.nuffieldfoundation.org/practical-biology/measuring-rate-water-uptake-plant-shoot-using-potometer

There are numerous simulations available which could be used to generate results. The link for one is given below.

http://www.reading.ac.uk/virtualexperiments/ves/preloader-transpiration.html

An alternative method for determining the surface area of the leaves is:

1. On a white tile cut a 1 cm^2 square from the lamina of a leaf.
2. Weigh this 1 cm^2 of leaf.
3. Remove all the leaves from the shoot used in the experiment and weigh them.
4. Divide the weight of the leaves by the weight of 1 cm^2 of leaf. The value will be the surface area of the leaves in cm^2.

Expected results

The transpiration rate of bean plants was measured in the following conditions.

Conditions	Water loss by transpiration / m^2 / cm^3 min^{-1}			
	1	2	3	Mean
Laboratory conditions at 20 °C.	4.4	4.0	4.3	4.2
Laboratory conditions at 30 °C	10.8	10.6	10.4	10.6
Laboratory conditions at 20 °C in moving air.	9.8	9.4	9.2	9.5
Laboratory conditions at 20 °C but plant misted to give high humidity.	1.9	2.0	2.1	2.0

Further work

- Investigate the effect on transpiration rate of temperature, light, wind or humidity.
- Compare the transpiration rates of different plant species.

Practical Techniques

- use appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)
- use appropriate instrumentation to record quantitative measurements, such as a colorimeter or photometer
- safely and ethically use organisms to measure
  - plant or animal responses
  - physiological functions
- use ICT such as computer modelling, or data logger to collect data, or use software to process data