Topic 9 – Practical 1

Measuring the rate of transpiration in a leafy shoot

Safety

- Care should be taken to avoid cuts to the skin when cutting the leafy shoot.
- If a needle is used to connect the syringe to the rubber tubing, care should be taken not to puncture the skin. This can be avoided by using a three-way tap as a substitute, as described below.

Apparatus and materials

- potometer (see diagram below):
  - conical flask
  - short rubber tubing
  - rubber bung
  - syringe and needle or three-way tap
  - graduated capillary tube
- black plastic bag
- larger container of water in which to assemble and fill the potometer
- transparent plastic bag
- small fan
- retort stand and clamp
- stopwatch
- thermometer
- petroleum jelly
- fresh leafy shoot
- sharp knife to cut shoot

Introduction

A potometer enables scientists to measure the rate of water uptake by a cut shoot. It does not measure transpiration directly but as water is lost from the shoot by transpiration water uptake and transpiration rates are closely correlated. Other potometers are available from scientific suppliers and can be used as an alternative to the one described here.

Procedure

1 Cut a leafy shoot from a suitable plant and immediately immerse the end in water. The stem must have a suitable diameter to fit into the hole in the bung of the conical flask.

2 Fill the conical flask completely with water by submerging it in a large container of water. Transfer the shoot to this container and make a fresh, diagonal cut through the stem. Now push the cut end of the shoot through the hole in the bung, under water. Press the bung into the conical flask and ensure there is a tight seal. Petroleum jelly can be used to make sure the seal is watertight.

3 Completely fill the capillary tubing, rubber tubing and syringe with water. This can also be done by submerging them in water.

4 Set up the apparatus as shown in the diagram below. A needle can be used to connect the syringe to the rubber tubing, or a three-way tap can be used to make this connection. The syringe should be held in an upright position using a clamp stand.

As the shoot takes up water, the water in the capillary tube will move and readings can be taken. The apparatus can be reset by pressing more water from the syringe into the capillary tubing.

5 Using the stopwatch, measure the time taken for the water to move a certain distance along the capillary tubing (for example, 5 cm or 10 cm). On separate paper, note the results in a suitable table, expressing them in appropriate units, such as cm min^{-1}.

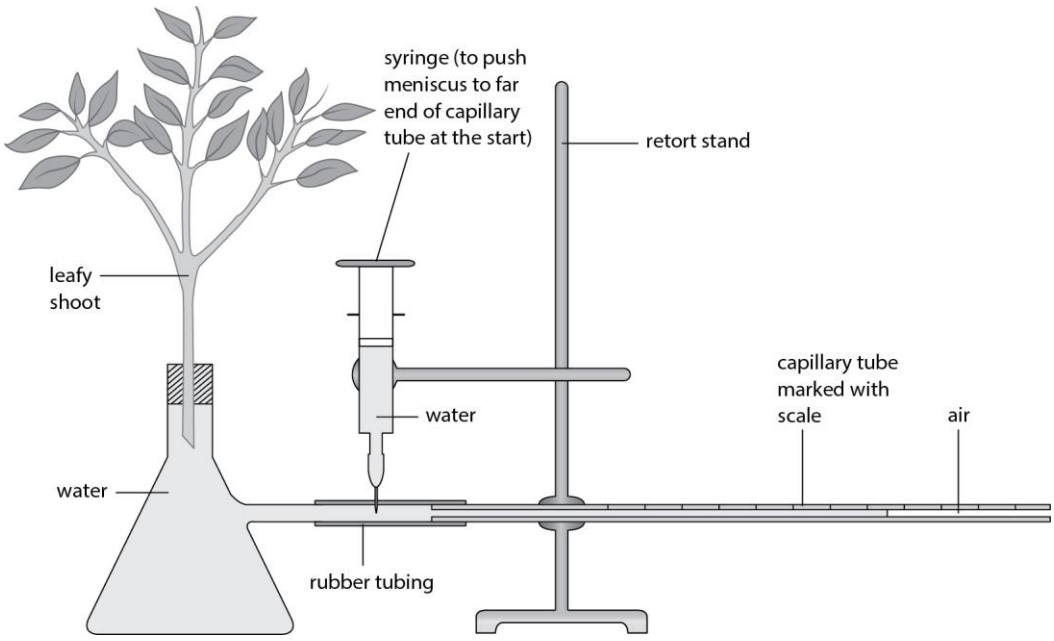
6 Repeat the procedure a number of times to obtain consistent results and calculate an average.

7 Note the temperature of the air in the room in which the experiment is conducted.

8 The potometer can now be used to investigate factors that might affect the rate of transpiration.

- Humidity can be increased by enclosing the shoot in a clear plastic bag.
- The effect of wind can be investigated by using the fan on a low setting, which simulates a breeze but does not damage the leaves.
- Light can be investigated by enclosing the shoot in a black plastic bag.

In each case the plant should be left to equilibrate in the new conditions before readings are taken. In each case a number of results should be collected for consistency, as in step **6**.



Questions and further work

For questions **1** and **2**, use separate paper for your working.

1 If the diameter of the bore of the graduated capillary tube is known, convert the results for each set of conditions you investigated into the actual volume of water taken up per unit time. Possible units might be $cm^3\,h^{-1}$, depending on the conditions and transpiration rate.

2 Since most of the water is lost through the leaves, estimate the rate of water loss per unit area of leaf, for each set of conditions you investigated. Use your calculations of water uptake volume (from **1** above) with measurements of the total surface area of the leaves. Carefully remove all the leaves from the shoot, place each one on graph paper, draw round the leaf and estimate its area. Sum the estimates for all the leaves to obtain a value for the total leaf surface area. Tabulate your results using suitable units for the rate of water loss per unit area of leaf, such as $cm^3\,h^{-1}\,m^{-2}$.

3 How could you use this experiment to show that stomata are situated on the underside of the leaves?