



Transpiration in Plants

Objectives

This activity provides an excellent opportunity for students to explore the following topics:

- Detection of water loss through the plant leaf
- Dependence of transpiration on plant ecotype and environmental conditions
- Dependence of transpiration on the width and expanse of the stomata

Materials

- Ohaus® Scout® Pro [SPE123](#) or [SPE202](#) (minimum readability 0.001 g or 0.01 g)*
- Erlenmeyer Flasks with Narrow Neck, 100 or 200 mL
- One-Hole Stopper
- Cotton Wool
- Paraffin Oil (possibly colored with a lipophilic dyestuff)
- Table Lamp
- Hair Dryer
- Scissors
- Pipet
- Plant Material**

*With sensitive balances, and if short measuring intervals are desired, we recommend using a draftshield to protect the balance from drafts that could affect measurements. If you don't have a draftshield, you can construct one from Plexiglas® or some other suitable material.

**At a minimum, you'll need a branch from a plant in a warm, dry location and one from a plant in a moist location. The following plants are readily available throughout the year from gardens or parks:

- Yew (other conifers are also suitable)
- Evergreen snowball species (e.g., *Viburnum rhytidophyllum*, *V. fragrans*)
- Evergreen *Cotoneaster* species (e.g., *C. salicifolius*)
- Laurel (e.g., *Prunus laurocerasus*; easily sliced into thin sections for microscopy)
- Holly
- Oleander

Procedure

1. Fill the Erlenmeyer flask with water.
2. Condition the branch by cutting the stem at an angle under water. Insert the freshly cut branch into the flask.
3. Using the pipet, carefully add a little paraffin oil to the water surface (to prevent direct evaporation).
4. Secure the branch in an upright position with the one-hole stopper or cotton wool.
5. Place the flask on the balance.
6. Weigh the flask at suitable intervals (depending on the sensitivity of the balance and the size and type of the branch) and record your measurements.
7. Create a table of your experimental data using time, weight of flask, and weight difference (subtract current reading from previous reading).
8. Calculate the transpiration rate using the data from the table.

Analysis

The loss in weight of the flask and branch represents the loss of water from the leaves. Water loss is primarily dependent on leaf area, time, and the relative atmospheric humidity. The rate of loss in mg per min is the transpiration rate. We want to calculate the amount of water transpired per cm^2 leaf area per minute. Keep in mind that leaf area is proportional to leaf mass. So let's first determine the leaf area as follows:

1. Lay the leaves on a sheet of paper and trace their outlines with a pencil.
2. Cut out and weigh the paper leaves, which serve as a substitute for the real leaves. The weight of a sample area of 100 cm^2 is also determined and used to calculate the density of the sheet of paper (g cm^{-2}).
3. Use the equations in the example below to determine the surface area of the leaves and transpiration rate.

Example data and calculations

<i>Pelargonium</i> Branch Data Table		
Time (in min)	Weight of Flask and Branch (in g)	Difference (in mg)
0	108.187	0
5	108.135	52
65	107.685	550

Weight of paper leaf area: 2.93 g

Weight of 100 cm^2 paper sample: 1.17 g

$$\text{Leaf area in cm}^2 : \frac{\text{Weight of paper leaf (g)}}{\text{Density of paper (g cm}^{-2}\text{)}}$$

$$\text{Leaf area in cm}^2: \quad \frac{2.93 \text{ g} \times 100 \text{ cm}^2}{1.17 \text{ g}} = 250 \text{ cm}^2$$

Specific transpiration = Weight loss per cm^2 per min

$$\begin{aligned} \text{Total weight loss} & \quad 602 \\ = \frac{\text{Time in min} \times \text{Leaf area}}{65 \times 250} & \quad = \frac{602}{65 \times 250} \\ & \quad = 0.037 \text{ mg/cm}^2/\text{min}^{-1} \end{aligned}$$

Extensions

- Rapidly weigh branches kept in the dark; an increase in transpiration occurs when the stomata open.
- Determine the specific transpiration for different plants. Microscopic leaf sections can be combined with this.
- Change the environmental conditions using the same plants. Try the following: moist air (create a moist-air chamber using a glass bell lined with blotting paper), dry air (room), warm air (with heating lamp), and moving air (with hair dryer).

Notes

- Place the branches in water immediately after cutting and possibly nick again under water.
- Collect branches when the plant is well supplied with water; otherwise, they will take up water (but not transpire) at the outset when the stomata are closed. The weight loss is then very small. This difficulty can be circumvented by conditioning the plants for a few hours before the start of the experiment.
- Use your highest resolution balance for more dramatic results.

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