

AP Lab 9 - Transpiration

Name _____ Per _____

Purpose: In this lab, you will measure transpiration under various laboratory conditions using a potometer.

Introduction:

The amount of water needed daily by plants for the growth and maintenance of tissues is small in comparison to the amount that is lost through the process of transpiration (and guttation). If this water is not replaced, the plant will wilt and may die.

The transport of water up from the roots in the xylem is governed by differences in water potential (the potential energy of water molecules). These differences account for water movement from cell to cell and over long distances in the plant. Gravity, pressure, and solute concentration all contribute to water potential. Water always moves from an area of high water potential to an area of low water potential. The movement itself is facilitated by osmosis, root pressure, and adhesion and cohesion of water molecules.

The overall process: Minerals actively transported into the root accumulate in the xylem, increase solute concentration and decrease water potential. Water moves in by osmosis. As water enters the xylem, it forces fluid up the xylem due to hydrostatic root pressure. But this pressure can only move fluid a short distance. The most significant force moving the water and dissolved minerals in the xylem is upward pull as a result of transpiration, which creates a negative tension. The "pull" on the water from transpiration is increased as a result of cohesion and adhesion of water molecules.

The details: Transpiration begins with evaporation of water through the stomata, small openings in the leaf surface which open into air spaces that surround the mesophyll cells of the leaf. The moist air in these spaces has a higher water potential than the outside air, and water tends to evaporate from the leaf surface (moving from an area of high water potential to an area of lower water potential). The moisture in the air spaces is replaced by water from the adjacent mesophyll cells, lowering their water potential (since the cytoplasm becomes more concentrated). Water will then move into the mesophyll cells by osmosis from surrounding cells with higher water potentials including the xylem. As each water molecule moves into a mesophyll cell, it exerts a pull on the column of water molecules existing in the xylem all the way from the leaves to the roots. This transpirational pull is caused by (1) the cohesion of water molecules to one another due to hydrogen bond formation, (2) by adhesion of water molecules to the walls of the xylem cells which aids in offsetting the downward pull of gravity.

The upward transpirational pull on the fluid in the xylem causes a tension (negative pressure) to form in the xylem, pulling the xylem walls inward. The tension also contributes to the lowering of the water potential in the xylem. This decrease in water potential, transmitted all the way from the leaf to the roots, causes water to move inward from the soil, across the cortex of the root, and into the xylem.

Evaporation through the open stomata is a major route of water loss in the plant. However, the stomata must open to allow the entry of CO_2 used in photosynthesis. Therefore, a balance must be maintained between the gain of CO_2 and the loss of water by regulating the opening and closing of stomata on the leaf surface. Many environmental conditions influence the opening and closing of the stomata and also affect the rate of transpiration. Temperature, light intensity, air currents, and humidity are some of these factors. Different plants also vary in the rate of transpiration and in the regulation of stomatal opening.

Materials Required:

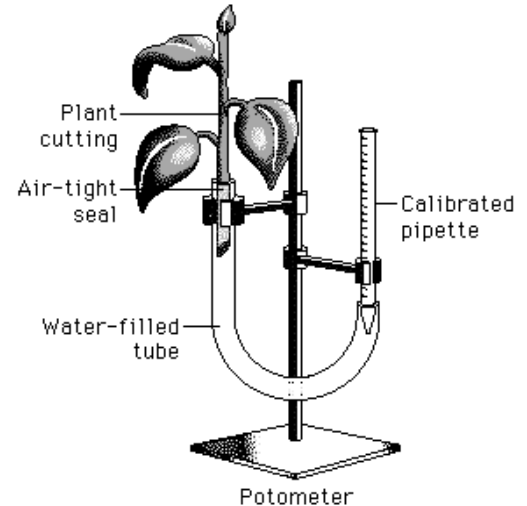
0.1 mL pipette, clear plastic tubing, cup of water dyed with food coloring, syringe, Bean plants (2-3 weeks old), ring-stand and clamp, **Bring your four function calculator to class for lab day

Optional Materials: fan/ lamp/ spray bottle/ plastic bag. .

Procedure: *Each lab pair will expose one plant to the control treatment and a second plant to an experimental treatment.*

Setting Up the Control

1. Obtain a potometer. (The potometer is a 0.1 mL pipette connected to a 16 -inch piece of clear plastic tubing.)
2. Gently arrange your plants leaves on the grid of your lab write up (p3). Trace the edge pattern of the leaves directly on to the grid. This information will be used to estimate your plants leaf surface area in step 13 below.
3. Set up the photometer (tubing attached to pipette) as shown (without a plant) into a "U" configuration. Secure the photometer upright using the ring stand and clamp. Stand your photometer (without a plant) in a sink or white tub. Arrange the photometer so the end of the tubing lines up horizontally with the 0mL mark on the pipette (The pipette will stand taller than the tubing end).
4. Use colored water and a 30cc syringe to fill the tubing with colored water. The colored water will make reading the pipette and checking for air bubbles much easier.
5. When you are ready to insert the plant stem into the rubber tubing, use the scissors to cut the plant stem just above the soil then submerge the plant stem quickly in water. Carefully cut your plant stem a second time just above your first cut while this section of the stem is under water so that no air is introduced into the xylem.
6. While a drip of water is protecting the end of your plant stem, gently insert the freshly cut stem into the open end of the tubing. You may practice this step by cutting a small section of stem and placing it in the tubing (remove before adding your plant).
7. Adjust the sides of the "U" so that the stem remains submerged and the water falls into the marked range of the pipette. (Near "0" –does not have to be exact because we are measuring change.)
8. Check that the leaves of your plant are dry, if not blot off any excess water on your leaves with a paper towel. (Omit this step for mist experiment.)
9. Let the potometer equilibrate for 5-10 minutes before recording the time zero reading.
10. Using the two leaf outlines on your grids, count all of the blocks that are completely within the tracing and estimate the number of blocks that lie partially within the tracing. The grid has been constructed so that a square of four blocks equals 1 cm². The total surface area (in cm²) can be calculated by dividing the total number of blocks covered by 4. Convert the surface area to m². (Remember 1 m² = 10,000 cm².) **Record the value in your data table.**
11. Read the level of water in the pipette at the beginning of your experiment (time zero) and **record your finding in Table 9.1.**
12. Continue to record the water level in the pipette every 3 minutes for 30 minutes. **Record the data (numbers directly off pipette) in Table 9.1.** Between readings complete the calculations required for table 9.2 using the information in step 13 below and the scaffolding provided in the results section.



Experimental Plant

13. Repeat steps 1-12 to expose the second plant to an experimental treatment, while simultaneously collecting data on the control plant.

Calculations and Results

1. Determine the cumulative water loss (from time zero) for each time point, and **record the value in Table 9.2.**
2. To calculate the water lost per square meter of leaf surface for each time point, divide the cumulative water loss at each time point by the leaf surface area you calculated for your plants two leaves. **Record these values in Table 9.2.**
3. Record your group's results from Table 9.2 in the class data table.
4. Record the compiled class average of the class data for each treatment in **Table 9.3.**
5. On page 4, graph the average of the class data for each time interval.

Transpiration Lab: Pre-Lab

Name: _____

Date: _____

Per: _____

Question: _____

Hypothesis: _____

Constants: _____

What data will you collect? _____

Data:

Treatment:	
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Reading on pipette
after 3 min.

Table 9.1: Potometer Readings (taken directly off potometer)

Time (min)	0	3	6	9	12	15	18	21	24	27	30
Reading (mL)											
Example	0.01	0.03	0.04	0.04	0.05	0.07	0.08	0.08	0.1	0.11	0.11

Table 9.2: Cumulative Water Loss in mL / m² (values will be increasing →)

	Time (minutes)										
	0	3	6	9	12	15	18	21	24	27	30
Total water loss (mL)	0										
Example (mL)	0	0.02	0.03								
Water loss per m ² (mL/m ²)	0										
Example (mL / m ²)	0	0.02 0.015									

Results:

How to calculate cumulative water loss (mL/m²)

Leaf 1 SA = _____ blocks + Leaf 2 SA = _____ blocks

Total plant leaf SA = _____ blocks / 4 = _____ cm²

Convert cm² to m²

Total plant leaf SA = _____ cm² $\left| \frac{1\text{m}^2}{10,000\text{cm}^2} \right|$ = _____ m²

Example: Total plant leaf SA = 600 blocks (2 leaves)
 Therefore total plant leaf SA = **0.015 m²**

****After conducting the experiment, attach your graph before turning in this paper with your data and Post-Lab Analysis questions complete.**