

TRANSPIRATION

LAB PLP 3.CALC

From *Biology with Calculators*, Vernier Software & Technology, 2000.

INTRODUCTION

Water is transported in plants, from the roots to the leaves, following a decreasing water potential gradient. *Transpiration*, or loss of water from the leaves, helps to create a lower osmotic potential in the leaf. The resulting transpirational pull is responsible for the movement of water from the xylem to the mesophyll cells into the air spaces in the leaves. The rate of evaporation of water from the air spaces of the leaf to the outside air depends on the water potential gradient between the leaf and the outside air.

Various environmental factors, including those conditions that directly influence the opening and closing of the stomata, will affect a plant's transpiration rate. This experiment will measure transpiration rates under different conditions of light, humidity, temperature, and air movement. The data will be collected by measuring pressure changes as the plant takes up water into the stem.

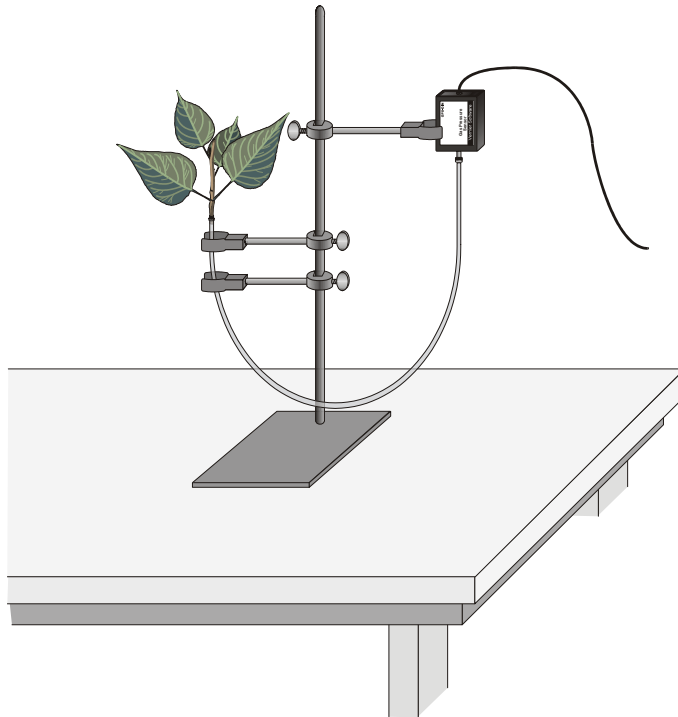


Figure 1

PURPOSE

The purpose of this experiment is to study the environmental conditions that affect transpiration rates by measuring changes in the pressure as the plant takes water into the stem.

MATERIALS/EQUIPMENT

LabPro interface	metric ruler
TI Graphing Calculator	masking tape
DataMate program	100-watt light source
Vernier Gas Pressure Sensor	plastic gallon size bag with twist tie
utility clamps	heater, small electric
ring stand	fan with slow speed
plant cuttings	aerosol spray container or plant mister
plastic tubing clamps	razor blade or scalpel
20 mL syringe	

SAFETY

- Always wear goggles and an apron in lab.
- Use caution when using the scalpel.

PROCEDURE

1. Position the ring stand, utility clamps, and Gas Pressure Sensor as shown in Figure 1.
2. Slip a plastic tubing clamp onto a 36-42 cm piece of plastic tubing as shown in Figure 2.
3. Bend the tubing into a U shape and have another student use the 20 mL syringe that comes with the pressure sensor to fill the tube with water. Add water to the tube until it is nearly full. Tap the tubing to expel any air bubbles that form inside the tube.
4. Select a plant that has a stem roughly the same diameter as the opening of the plastic tubing. Using a scalpel or razor blade, carefully cut the plant one inch above the soil.
5. Place the plant under water against a hard surface and make a new cut at a 45° angle near the base of the stem.

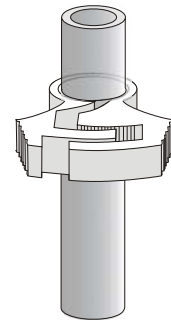


Figure 2

6. Connect the plant to the tubing.
 - a. The plastic tubing has a white plastic connector at one end that allows you to connect it to the Gas Pressure Sensor. Raise the end of the tubing with the connector until you see water beginning to drip out of the other end.
 - b. Carefully push the cut stem of the plant down into the end of the tubing where the water is dripping out. Be careful not to allow any air bubbles to form between the cut portion of the stem and the water in the tube.
 - c. Push the plant down as far as it will go without damaging the plant. At least one centimeter of the plant stem should fit into the tubing. If the stem is too large for the tubing, cut the stem at a higher point where it is smaller.
 - d. Squeeze the tubing clamp shut as tight as possible as shown in Figure 3.

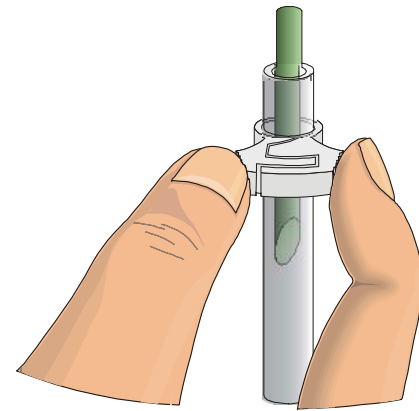


Figure 3

7. When the tubing clamp is shut tight, invert your plant cutting to check for any leaks. If water does leak out, turn the plant right side up and try tightening the clamp further.

Important: Be sure the tubing is filled completely with water. The water column must be flush with the stem. There should be no air visible at the base of the stem. If water moves down the tube away from the stem after it has been inserted, check for a leak in the system.

8. Connect the plastic tubing to the sensor valve. If your sensor has a blue plastic valve on it, place the valve in the position shown in Figure 4.

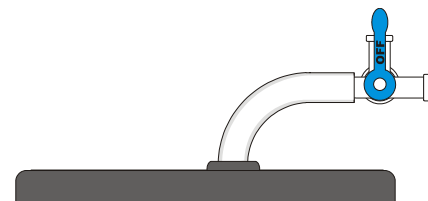


Figure 4

Caution: Do not allow water to enter the valve of the Gas Pressure Sensor.

9. Secure the plant in an upright position with the utility clamps as shown in Figure 1. It should be positioned so that the cut stem is about 8 cm below the water level at the other end of the tubing, as shown in Figure 1.
10. Place a mark on the tube at the starting water level to allow you to refill the tube to the proper level in Step 21.
11. Place your plant setup in an area where the wind, humidity, and temperature are reasonably constant. **This will be your control setup.**

12. Allow the system 5 minutes to adjust to the environment. While the system is adjusting, set up the calculator and interface.
13. Plug the Gas Pressure Sensor into Channel 1 of the LabPro interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.
14. Turn on the calculator and start the DATAMATE program. Press **CLEAR** to reset the program.
15. Set up the calculator and interface for a Gas Pressure Sensor.
 - a. Select 1:SETUP from the main screen.
 - b. Press **ENTER** to select CH 1.
 - c. Select 4:MORE.
 - d. Select 4:PRESSURE from the SELECT SENSOR menu.
 - e. Select 1:GAS PRESSURE SENSOR.
 - f. Select 1:GAS PRESSURE (KPA).
 - g. Select OK to return to the main screen.
16. Check the base of the plant stem in the water tube to make sure that no air bubbles or air pockets have formed that will prevent the plant from taking up water. If an air pocket has formed, refit the plant in the tubing before initiating data collection in Step 17.
17. After the plant has equilibrated for 5 minutes, select START on the calculator to begin data collection. Data will be collected for 15 minutes. During that time, if it is necessary to quit data collection early, you can press **STO▶** to stop data collection. Press **ENTER** to return to the main screen.
18. When data collection has stopped, perform a linear regression to calculate the rate of transpiration.
 - a. Select 4:ANALYZE from the main screen.
 - b. Select 2:CURVE FIT from the ANALYZE OPTIONS menu.
 - c. Select 1:LINEAR (CH 1 VS TIME) from the CURVE FIT menu.
 - d. The linear-regression statistics for these two lists are displayed for the equation in the form:
$$Y=A*X+B$$
 - e. Enter the absolute value of the slope, A, as the rate of transpiration in Table 1.
 - f. Press **ENTER** to view a graph of the data and the regression line.
 - g. Press **ENTER** to return to the ANALYZE menu.
 - h. Select 1:RETURN TO MAIN SCREEN from the ANALYZE menu.

19. Design an experiment to simulate *one* of the following environmental conditions, as assigned by your teacher:
 - the effect of light intensity
 - the effect of the wind blowing on the plant
 - the effect of humidity
 - the effect of temperature
 - the effect of another self-identified environmental variable
20. Be sure to address the following questions in your design:
 - What is the essential question being addressed?
 - What assumptions are made about the system being measured?
 - Can those assumptions be easily verified?
 - Will the measurements provide the necessary data to answer the question under study?
21. Check your procedure with your teacher, then obtain the materials needed for the experiment and perform the tests. Record your values in Table 1.
22. When you are finished using DataMate, press 6 to QUIT.

PROCESSING THE DATA

1. Identify the environmental condition you tested in the blank provided in Table 1.
2. Determine the surface area of all the leaves on your plant cutting by the following method:
 - Cut all the leaves (not stems) off your plant and weigh them with a balance.
 - Estimate the total leaf surface area in cm^2 for your plant by cutting out a section of leaf $5 \text{ cm} \times 5 \text{ cm}$.
 - Weigh this leaf section and divide by 25 cm^2 to find the weight of 1 cm^2 of leaf.
 - Divide the total weight of the leaves by the weight of 1 cm^2 to find the total leaf surface area.
 - Record the calculated surface area in Table 1.

3. Divide the slope by the surface area for each test and record in the **rate/area** column of Table 1. These rate values should be expressed as kPa/s/cm^2 .

4. Subtract the control (rate/area) value from the experimental value. Record this adjusted rate in the last column of Table 1.

5. Record the adjusted rate for your experimental test on the board to share with the class. Record the class results in Table 2 for each of the environmental conditions tested. If a condition was tested by more than one group, take the average of the values and record in Table 2.

6. Make a bar graph that shows the effect of different environmental conditions on the transpiration of water in plant cuttings. Using the data in Table 2, plot the adjusted rate for each test on the y-axis and the test label on the x-axis.

DATA SHEET

Name _____

Name _____

Period _____ Class _____

Date _____

TRANSPIRATION

DATA TABLES

TABLE 1				
Conditions	Slope (kPa/s)	Surface area (cm ²)	Rate/area (kPa/s/cm ²)	Adjusted rate (kPa/s/cm ²)
Experimental Variable: _____				
Control				-----

TABLE 2	
Class Data	
Variable Conditions	Adjusted rate (kPa/s/cm ²)
Light	
Humidity	
Wind	
Temperature	

QUESTIONS

1. How was the rate of transpiration affected by each of the variable conditions compared to the control?

2. Which variable resulted in the greatest rate of water loss? Explain why this factor might increase water loss when compared to the others.

3. What adaptations enable plants to increase or decrease water loss? How might each adaptation affect transpiration?

EXTENSIONS

1. Test cuttings from a variety of different plant species. How does each compare?

2. Count the number of stoma/cm² for each of the plants in Extension 1. How does this relate to the plant's ability to transpire water?

3. Propose other variables that you can test.

4. Design an experiment to test for the variables in Question 3.