Plants, stomata, and water flux

Experiment A –Can you find the stomata?
Experiment B – How much water goes out of leaves through stomata?
Experiment C – What happens to a leaf if the stomata stop working?

Experiment A – Can you find the stomata?

Paint a 1 inch square area on the backside of a leaf with clear nail polish. Set it aside to dry for about 10 min.

While waiting, find a partner and answer the following questions. Discuss each question with your partner and then share with the group.

1. What do plants need to grow?

2. What is photosynthesis?

3. How can plants capture the resources needed for photosynthesis?
   Hint: Think about where photosynthesis happens in the plant.

We are going to look at the stomata of two pant types under a microscope. Let's develop some hypotheses.

Hypothesis A-1: Do you think the stomata from the two plant types will look the same or different?

Hypothesis A-2: Do you think the two plant types will have the same amount of stomata?

Tasks:

1. After the nail polish is dry, place a piece of scotch tape sticky side down on the back of the leaf over the nail polish. Rub the tape down with your fingers, then carefully peel it off the leaf, taking the nail polish with it.
2. Stick the tape down to a microscope slide.
3. Use a permanent marker to write the plant type on the edge of the slide.
4. Set up the slide in the microscope (we can help you get it adjusted).
5. Draw a sketch of what you see in the microscope here:

Plant Type #1: ______________	Plant Type #2: ______________

What do you see in the microscope? Can you find any stomata?

Calculate the density of stomata for each plant type. Do this by counting the number of stomata under the microscope at a magnification of 40X without moving the slide. The area of leaf under the microscope is 0.166 mm^2.

Stomatal density = Number of stomata ÷ Area of leaf under microscope

Write the stomatal density for each plant type in the small box below your drawings.

Discussion Questions - A

1. For each of your hypothesis:
   - Did the experiment support your hypothesis?
   - If yes, does your reason for picking that hypothesis seem correct or did it happen for a different reason?
   - If no, why do you think it turned out differently?

Hy A-1

Hy A-2

2. Do the plant types have different stomatal densities? Why might some plants have less stomata than others? Talk about this with your partner and then compare with other groups.

3. Bonus Question! Look back under the microscope. Are the stomata open or closed? Why might plants be able to open and close stomata?

Experiment B – How much water goes out of leaves through stomata?
Experiment C – What happens to a leaf if the stomata stop working?

Tasks

1. Check and record the water level of each burette. Start your timer for 10 min. When the 10 min is up – record the water levels again.
2. Write down your hypothesis:

Hypothesis B-1: What do you think will happen to the water level in the burette 10 min from now?

Hypothesis B-2: Will the two plant types have the same change in water?

3. Smear Vaseline on the backside of a leaf on a small branch. Make sure to cover the whole leaf!
4. Get help putting your branch into a jar (we have to cut the branch under water).
5. Place your jar in front of a lamp
6. Write down your hypothesis:

Hypothesis C-1: Do you think the temperature of the leaf with Vaseline will be the same as the other leaves after about 10 min?

7. (Make sure 10 min has gone by for Experiment B and that you have recorded the water levels again.)
8. We will move the branch-burette apparatus in front of a lamp for you. Measure and record the water level and set your timer for 10 min. When 10 min is up record the water level again.

9. Write down your hypothesis:

Hypothesis B-3: Will the change in water of the branch with the lamp be the same or different than the branch without the lamp?

10. While you are waiting the 10 min for your branch under the lamp, go back and check the leaf with Vaseline. Measure the temperature of the Vaseline leaf and record it.
11. Measure the temperature of a neighbor leaf with no Vaseline and record it.

Table for Experiment B

Plant Name	0 Min (mL)	10 Min (mL)	Difference (mL)

Table for Experiment C

	Temperature (C) Before the lamp	Temperature (C) After the lamp	Difference (Before – After)
Control Leaf			
Vaseline Leaf			

Discussion Questions - B & C

1. For each of your hypothesis:
   a) Did the experiment support your hypothesis?
   b) If yes, does your reason for picking that hypothesis seem correct or did it happen for a different reason?
   c) If no, why do you think it turned out differently?

Hy B-1: What will happen to the water level in the burette after 10 minutes? a) b) c)

Hy B-2: How did the two types of plant differ in their water use? a) b) c)

Hy B-3: How did the change in branch water use differ with the lamp compared to the branch without the lamp? a) b) c)

Hy C-1: How did temperature of the leaf with Vaseline differ from the control leaf? a) b) c)

2. Bonus calculation! (You can do this later or at home, too.)
Lets calculate the amount of energy the branch got rid of through evaporating all of that water.

Pick your largest change in water over 10 min from the table for Experiment B:

$$\text{Change in } \mathrm{H_2O} = \underline{\hspace{2cm}} \text{ ml water}$$

There is a quantity that describes how much energy it takes to convert a fixed amount of water from a liquid to a gas. It's called the **latent heat of vaporization**, abbreviated $\boldsymbol{L_v}$. It depends slightly on temperature, but for our purposes we can use a constant value:

$$L_v = 2.45 \times 10^6 \mathrm{J/kg}$$

There are 1000ml of water in 1L of water, and 1L of water = 1kg of water. We want to calculate how many kg of water the branch evaporated:

$$\underline{\hspace{2.5cm}} \text{ ml water} \times \frac{1\text{L}}{1000 \text{ ml}} = \underline{\hspace{2cm}} \text{ L water}$$

$$\underline{\hspace{2cm}} \text{ L water} \times \frac{1 \text{ kg water}}{1 \text{ L water}} = \underline{\hspace{2cm}} \text{ kg water}$$

We did the experiment for 10 minutes. We want to calculate how much water left the branch each second, so we convert 10 minutes to seconds:

$$10 \text{ minutes} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = \underline{\hspace{2cm}} \text{ seconds}$$

Now we can calculate how much energy this is, using the latent heat of vaporization ($\boldsymbol{L_v}$) :

$$\frac{\text{amount of water [kg]}}{\text{time [seconds]}} \times L_v[\mathrm{J/kg}] = \text{energy}[\mathrm{J/s}]$$

User the amount of water (in kg) and the length of time (in seconds) that you just calculated to calculate the amount of energy using this equation:

$$\frac{\underline{\hspace{2cm}} \text{ kg water}}{\underline{\hspace{2cm}} \text{ seconds}} \times \left(2.45 \times 10^6 [\mathrm{J/kg}]\right) = \underline{\hspace{2cm}} \text{ J/s} = \underline{\hspace{2cm}} \text{ W}$$

A J/s (Joule per second) is the same as a Watt (W), so now you have the amount of energy in Watts that your plant pumped out through water!

Watts are the same unit that many light bulbs measure energy use in. How does your plant's energy flux compare to a common light blub? (Does the plant use more energy than a light bulb, or less?)