

Plant-A-Plant Photosynthesis & Respiration Laboratory Guide

Task

Determine the rate of photosynthesis and respiration of maize plants based on a gravimetric method (for more information, see Appendix).

Prepare and Perform the Experiment

Materials and Tools (*per replicate*)

- 15 maize leaves (secondary leaves are preferable)
- 2 Petri dishes at least 35 cm in diameter
- 3 very small Beakers
- Small fan (optional, but recommended)
- Aluminium foil
- Portable lamp(s)
- Black cloth
- Filter paper
- Permanent marker and pencil
- Lab scales (accurate to 0.01 g)

** Note: At least two replicates are recommended for this experiment.

** Note: kiln or drying oven is also necessary

Preparation (See Figure 1)

1. Cover the bottom of a Petri dish with filter paper and dampen it with water.
2. Place beakers upside down on top of the filter paper, around the inner edge of the Petri dish – your leaves will be added to this dish later. (A second Petri dish filled with water will sit on top of the beakers.)
3. Set up one or two lamps to shine directly into the Petri dish.
4. Set up the fan to circulate air around the Petri dish, which will help to prevent the experiment from overheating.
5. Prepare 3 aluminium foil squares. Label each of the foil squares - G₀, G_P, or G_R.
6. Weigh the foil squares and record the weight on your data sheet.

Prepare Leaves

1. After seed germination (follow the protocol in the *Seed Germination Laboratory Guide*), monitor the growth of plants. You will ignore the first leaf on each seedling and will consider the second leaf fully developed when the third leaf appears.
2. When 15 seedlings have fully developed their secondary leaves, carefully cut the secondary leaves off the seedling stems.
3. Separate leaves into 3 groups of 5 leaves. Spread them out so they do not overlap. Then measure the leaf surface area of each group using a computer program (ImageJ, Lucia) or other method.

- a. Example: Place 5 leaves in a transparent sheet so that they do not overlap and scan into your computer. Use ImageJ or another computer program to measure the area, and record the value on your data table.
4. Record Leaf Surface Area (sum of the 5 leaves) in m^2 on your data sheet (label SA_O , SA_P , and SA_R to correspond to the different treatments). Be sure to keep track of which 5 leaves go with each area measurement.

Perform Experiment

1. Place the 5 leaves with the SA_O measurement into the foil square labelled G_O and put into the drying oven at $90^\circ C$ overnight.
2. Place the other two groups of leaves into the Petri dish being careful to keep the two groups separate and each leaf non-overlapping.
3. Cover the 5 SA_R leaves with black cloth to block out the light.
4. Fill the second Petri dish with water (several cm deep) and place on top of the beakers in the first Petri dish.
5. Turn on the lamp(s) and fan.
6. Allow the experiment to run for 6 hours.
7. After 6 hours, remove the leaves and place them into the prepared foil squares (place leaves covered with cloth – SA_R into the square labelled G_R , and uncovered leaves – SA_P into the square labelled G_P).
8. Put foil packets into the drying oven at $90^\circ C$ overnight.

Calculate and Report Results

1. Remove the foil packets and weigh individually on the scale. Record your packet dry weight value on your data sheet.
2. Subtract the foil weight from the packet weight to find the dry weight of the leaves. Record the value on your data sheet.
3. Use the formulas below to calculate net photosynthesis, gross photosynthesis and respiration.

$$P_n = \frac{G_P - G_O}{((SA_O + SA_P) / 2) \times t}$$

$$R = \frac{G_O - G_R}{((SA_O + SA_R) / 2) \times t}$$

$$P_G = P_n + R$$

P_n = the rate of net photosynthesis ($g/m^2/sec$)

R = the rate of respiration ($g/m^2/sec$)

P_G = the rate of gross photosynthesis ($g/m^2/sec$)

G_O, G_P, G_R = dry weight of different treatments

SA = surface of leaves in m^2

t = time of experiment in seconds (6 hours = 21600 seconds)

Conclusions

1. Revise answers to questions posed at the beginning of the experiment in your science notebook or on Student Laboratory Questions sheet. Does the experimental outcome provide the answers or at least a clue?
2. Evaluate validity of your hypotheses. Were they supported or rejected? What was your evidence?
3. Did you encounter any issues/difficulties while performing the experiment? What were potential sources of error in the experiment? Are there ways the procedure could be improved?
4. Record any remaining questions about the experiment or its outcomes. How would you design an experiment to test one of these questions?
5. All scientists, once they have completed their investigation, share their findings with peers in their community. Follow the instructions provided by your teacher to share your work.

APPENDIX

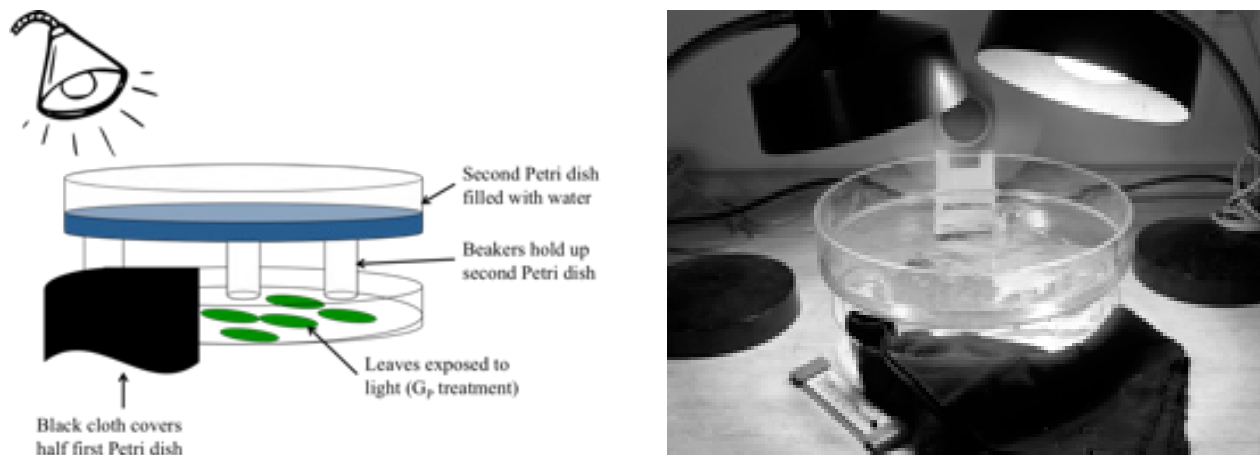


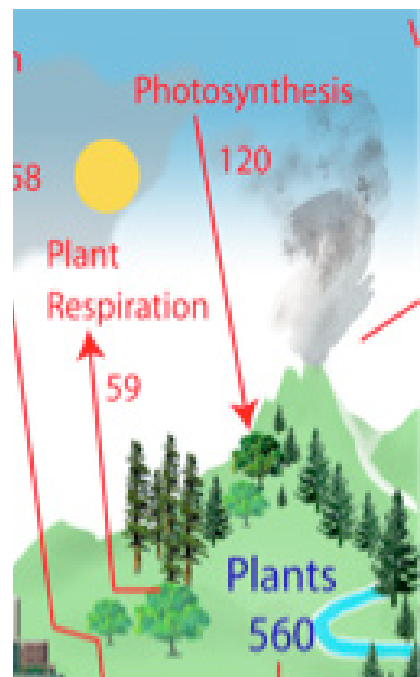
Figure 1. Experimental Set-up

Background Information

At a global scale, the plant carbon pool gains carbon from the atmosphere through photosynthesis and loses carbon to the atmosphere through respiration (see Figure on right). The same processes also occur at the individual leaf level.

During the daytime, leaves are continuously *both* respiring (giving off CO_2) and photosynthesizing (taking up CO_2). At night, when there is no sunlight, they continue to respire (release CO_2 as a by product of the citric acid or Krebs cycle in order to generate the energy they need to transport water, etc.), but do not photosynthesize. In this experiment we simulate plants in the daylight by placing leaves under a lamp (G_P treatment), and plants at night by covering leaves by a cloth to block the light (G_R treatment).

When plants photosynthesize or respire they are gaining or losing (respectively) the mass of the carbon and oxygen molecules. This is why we are able to measure photosynthesis and respiration by determining the difference in mass of the leaves at the start (G_O treatment) and end (G_P and G_R treatments) of the experiment. – Remember that biomass is 50% carbon.



In the G_R treatment, we only measure the loss of mass due to respiration, however in the G_P treatment the leaves are both gaining mass due to photosynthesis and losing mass due to respiration. This treatment, therefore, tells us our *net photosynthesis* (aka the carbon the plant gains - and stores - after accounting for the losses of carbon due to respiration). If we want to calculate *gross photosynthesis* (all the carbon taken up by the plant, before accounting for respiration), we can simply add the net photosynthesis to the respiration.