Measuring photosynthetic rates in C3 & C4 plants

Demonstrations and data provided by Dr. Asaph Cousins and his lab members

15 September 2014

Goals:

- To understand how photosynthesis is measured
- To understand how rates of photosynthesis change with CO_2 concentrations in C3 & C4 plants
- To practice summarizing and graphing data

You will recall that photosynthesis uses light energy (energetic photons) to "fix" CO_2 into sugars. In outline,

$$6H_2O + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6O_2.$$

The H_2O comes from the roots and CO_2 is diffused into the leaves from the atmosphere. As the light independent-reaction of photosynthesis uses CO_2, concentrations of this gas in the intercellular spaces (C_i) decline. You should remember that C3 and C4 plants have different physiological "strategies" which lead to differences in how efficiently they use CO_2 and H_2O. In C3 plants, the enzyme Rubisco uses atmospheric CO_2 directly, converting it into sugars (with the energy from the light reaction). Rubisco can use O_2 as a substrate, too, in the process known as photorespiration. As much as 1/3 of the reactions of Rubisco maybe photorespiration in C3 plants. The problem gets worse when concentrations of O_2 increase relative to CO_2 (when would this happen?), and when temperatures are high. The leaf can let in more CO_2 from the atmosphere (measured as C_a) by opening its stomata, but of course it loses water by doing so.

C4 plants convert atmospheric CO_2 into a 4-Carbon intermediate in the mesophyll and then transport this into the bundle sheath cells, where the 4-Carbon intermediate releases the CO_2, thus increasing the concentration of CO_2 in the bundle sheath cells where Rubisco is involved in the light-independent reaction. C4 plants are very good at using low levels of CO_2, but this comes at the cost of extra energy involved in converting CO_2 into the 4-Carbon intermediate.

In the laboratory one can measure the rate of photosynthesis by looking for fluxes or changes in the concentrations of O_2 or CO_2, as well as water use efficiency by measuring water vapor directly or indirectly. During this week's lab, student's in Dr. Asaph Cousin's laboratory will demonstrate how they collect data on gas exchange and isotopic ratios to measure photosynthetic rates, water use efficiency, and perhaps other quantities. They use very delicate and

expensive equipment, so please be very careful around their lab! The are also being very generous with their time and facilities, so please be gracious, polite, and attentive!

At the end of the demonstrations you will receive some data that the Cousins lab has collected. Your task is to summarize these data into two nicely constructed figures that illustrate how C3 and C4 plants respond to changes in atmospheric and intercellular concentrations of CO_2.

- You will receive data on several replicate plants across a range of CO_2 concentrations (so called "biological replicates", as opposed to multiple measurements on the same plant at a given concentration). You'll need to average these before proceeding.
- You need to calculate the CO_2 compensation point—the concentration of CO_2 where the amount of carbon dioxide fixed by photosynthesis balances the amount of CO_2 produced by the metabolism of the leaf's machinery. Include these values in the captions.
- Make sure to explain what the graph is showing. Is one line saturating earlier? If so, why?

Points will be assigned according to this rubric:

	Points	Possible
Correct axis labels (with units)		/3 pts
Clear, concise, and adequate presentation of data		/4 pts
Clear, descriptive caption		/3 pts