The MultiSpeQ: Measuring Photosynthesis in the Classroom
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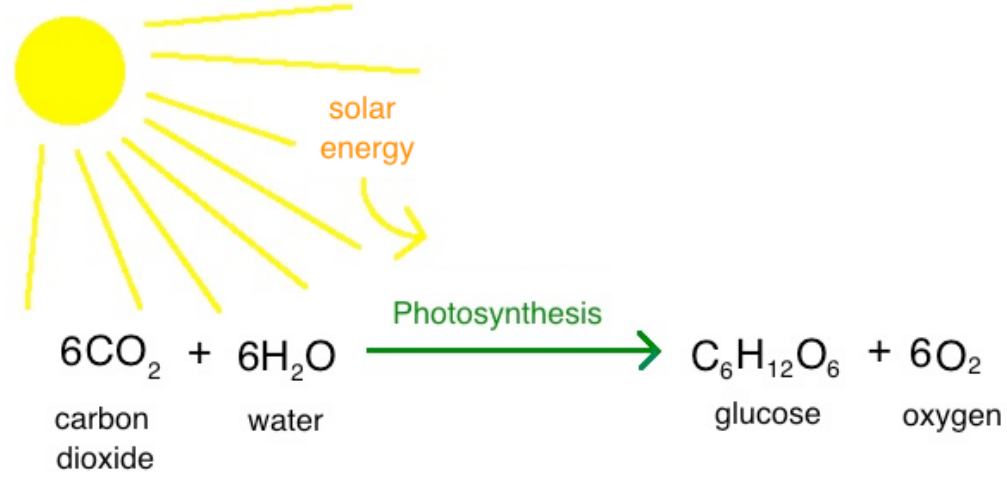
Photosynthesis is a core part of many biology curricula, yet it is very difficult to teach. Students find it hard to engage with the formula or to engage with plants.

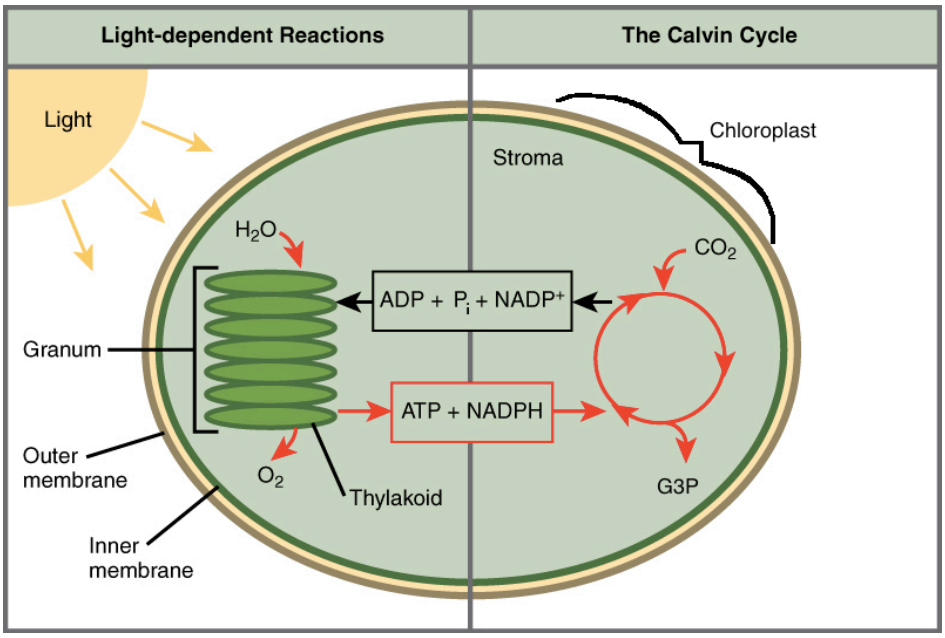
Many teachers have found creative ways to introduce photosynthesis, including submerged leaf experiments, measuring gas exchange in leaves, or doing light/dark experiments.

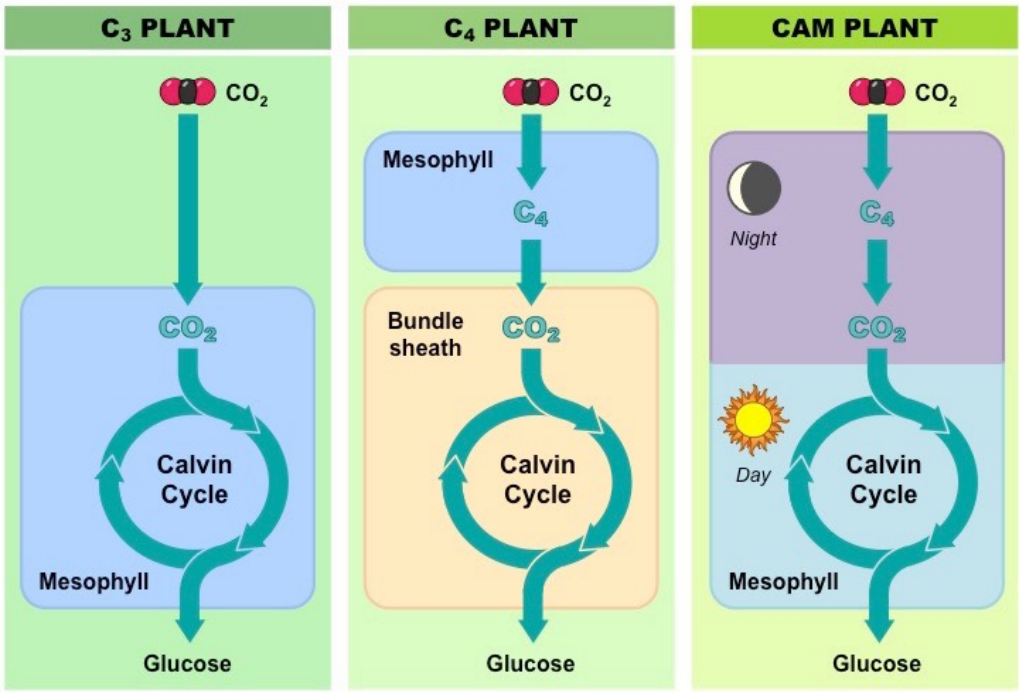
The MultiSpeQ is a handheld device that enables teachers and students to take measurements of photosynthesis in real time under ambient conditions. It has a relatively easy user interface, and connects either to Android apps or to an app on a computer. Being handheld, the device can be taken outside, into a greenhouse or lab, and can be easily learned and used by multiple students.

Currently the commercial cost of a MultiSpeQ device is $600. This is prohibitive for most teacher budgets, so we are working on putting together a kit of MultiSpeQ devices and Android phones that can be sent around to different schools so that teachers can use them for a specific module and then pass them on.
For some useful tutorials, see: http://www.photosynq.org/tutorials

We will be conducting a "pilot study" of the effectiveness of such a kit soon. If you are interested in being part of this pilot study, please contact Klara Scharnagl: scharnag@msu.edu







Photosynthesis: Common Misconceptions

* Plants get their mass from soil, rather than carbon dioxide

* When plants “breathe,” they take in CO2 and exhale O2
* Plants are static; they cannot adapt their photosynthesis to different light levels

To address the first two misconceptions, it is useful to use the Stomata Exercise, outlined below.

To address the third misconception, you can use the MultiSpeQ!

Possible Questions to Address with the MultiSpeQ

* Do different species (eg. different types of beans) have different photosynthetic rates?
* Does a plant have different photosynthetic rates under different colored lights (red, blue, green and white)?
* Do plants with different photosynthetic pathways (C3, C4, CAM) have different photosynthetic rates?
* Does a plant have different photosynthetic rates throughout the day (compare morning, midday and afternoon sun)?
* Do plants under stress (less water or nutrients) have different photosynthetic rates from non-stressed plants?
* Do plants with different colored leaves have different rates of photosynthesis (green versus purple leaves)?

Data from the MultiSpeQ: interpretations

The MultiSpeQ has the capacity to measure and return a lot of data. Let’s focus on five main measurements, three of which we discuss in our presentation.

Phi2: this measures the amount of incoming light that the plant actually uses for photosynthesis

PhiNPQ: this can be thought of as “sunblock” - it measures the amount of incoming light that is dissipated as heat or other energy so that the plant does not get damaged

PhiNO: this can be thought of as “sunburn” - it measures the amount of incoming light that is neither used for photosynthesis nor is dissipated, effectively causing potential damage to the leaf

LEF (linear electron flow): this can be considered a proximate measurement of photosynthesis; basically, how much energy is being moved around in the chloroplasts following exposure to light.

PQ SPAD: this measures relative chlorophyll content and can be used as an indicator of plant nitrogen content as well as an indicator of plant stress.

You can also look at chlorophyll fluorescence directly, which is the “greenness” of your plants,

Module for Teachers from GK12 Workshop on 4/18/2017

Set up a project on photosynq.org

This project uses a basic measurement module of photosynthesis, and includes two questions to include with each measurement: Morning or Afternoon session? Inside or Outside?

Open the PhotosynQ app on an Android phone. Connect it via bluetooth to your MultiSpeQ device. Open your project on the phone app.

Click Take Measurement or New Measurement

Answer the two questions, then click Measure.

Using the button on top of the MultiSpeQ, open it, and clamp down on a leaf. Make sure the whole measurement area is occupied by leaf tissue. Make sure it is not over a thick leaf vein or other odd textures.

Measurement can take up to 30 seconds to complete. Once complete, you can un-clamp the device from the plant, and click Accept on the phone app.

Take multiple measurements inside. Then take the plants outside, give them a few minutes to acclimate, then take multiple measurements. Be sure not to shade the device or leaf while taking the measurement.

We found in our workshop that leaves inside have a higher Phi2 than leaves outside. This means that leaves inside are using more of the amount of available light inside when doing photosynthesis. In the bright sunshine, plants need a much smaller available percentage of the available light in order to do photosynthesis.

To compare actual photosynthetic rates, we used LEF as a proxy measurement, and found that even though plants outside were using a much smaller percentage of the available light, they had a much higher LEF (rate of photosynthesis).

The Stomata Exercise

For this, you can use a live plant if it has relatively large and thick leaves. Plants with small or thin leaves will not do well.
Alternatively, you can use spinach leaves or leaves freshly collected from a live plant. If just using leaves, tape them onto a paper or paper towel so that as they dry they will not curl.

Use clear nail polish or liquid nail.

On the underside of a leaf, make two thick brush strokes with the nail polish. This makes about a 1cm squared area of nail polish. You can make it as large as 2cm squared.

Allow the nail polish to dry. Depending on thickness of how much nail polish you applied, this could take between 15-40 minutes.

Using forceps/tweezers, gently grab a corner of the nail polish and peel it away from the underside of the leaf.

Place the nail polish on a glass slide. Make sure the surface that was connected to the leaf is facing up. You can use the back of the tweezers to gently flatten the nail polish onto the slide.

Place the slide on a compound microscope. Stomate can already be visible at 40X, and can be seen in more detail at 100X. They look like little mouths.

Students can count stomata or compare sizes. This is not only a fun and relatively simple exercise, but allows students to think about gas exchange and respiration in plants.

Some questions:
Compare a nail polish peel from the underside of the leaf versus the top.

Compare nail polish peels from different types of plants.

Compare nail polish peels from stressed versus healthy plants.