Biology 1305 – Modern Concepts in Bioscience – ICB Textbook
Week of November 9th, 2020
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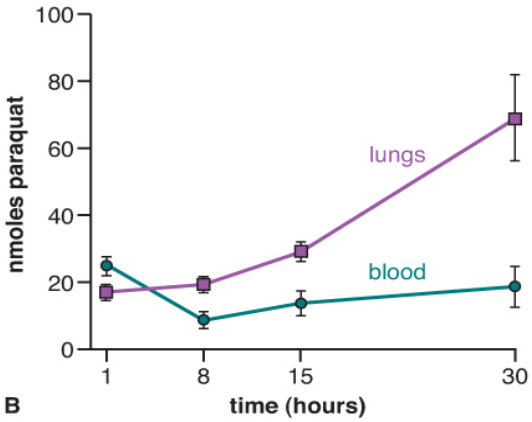
Hello everyone!! I hope you are all enjoying the Biology ICB class. We are a few weeks away from finals and hopefully everyone is in good standing and ready to tackle the material that's left in the class. If you need an extra hand, remember that we continue to have group tutoring for this class each week. If you cannot make it to Group Tutoring, also know that these resources are available to you in the tutoring center website. If you wish to attend group tutoring, make sure you reserve a spot via the tutoring center website.

Our Group Tutoring sessions will be every Tuesday from 6:00 – 7:00 PM. You can reserve a spot at https://baylor.edu/tutoring. I hope to see you there!

Last week, we went over chapter 10 and explored how molecules carry energy and how food is converted to molecular energy. That resource can be found here:
https://www.baylor.edu/support_programs/index.php?id=967950

This week, we will jump into chapter 11 and review the most important concepts related to **light harvesting and photosynthesis**, two major biological processes for plants. We will also use the example of Paraquat, a herbicide that inhibits these processes.

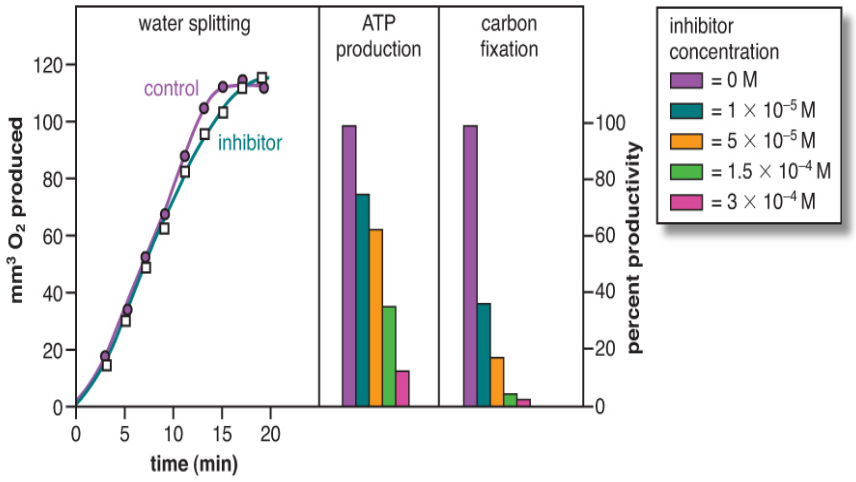
Let's begin with **Paraquat** – a herbicide that is banned in Europe but still used in the American continent. **Here, it is important for us to not only to know what paraquat does, but to understand its effects in both plants and animals. That means to know which biological systems may be at risk upon exposure to paraquat.** Think that herbicides are meant to harm plants, but are the cell and molecular composition of plants really that different from that of animals? Hint: understand enzymes involved in cellular respiration and photosynthesis.



This figure shows the paraquat levels in the blood (per mL) and lungs (per gram) of rats fed with it. Error bars are standard error; n = 5 rats per time point. To understand how this herbicide works and how it might affect animals, we need to fully understand photosynthesis.

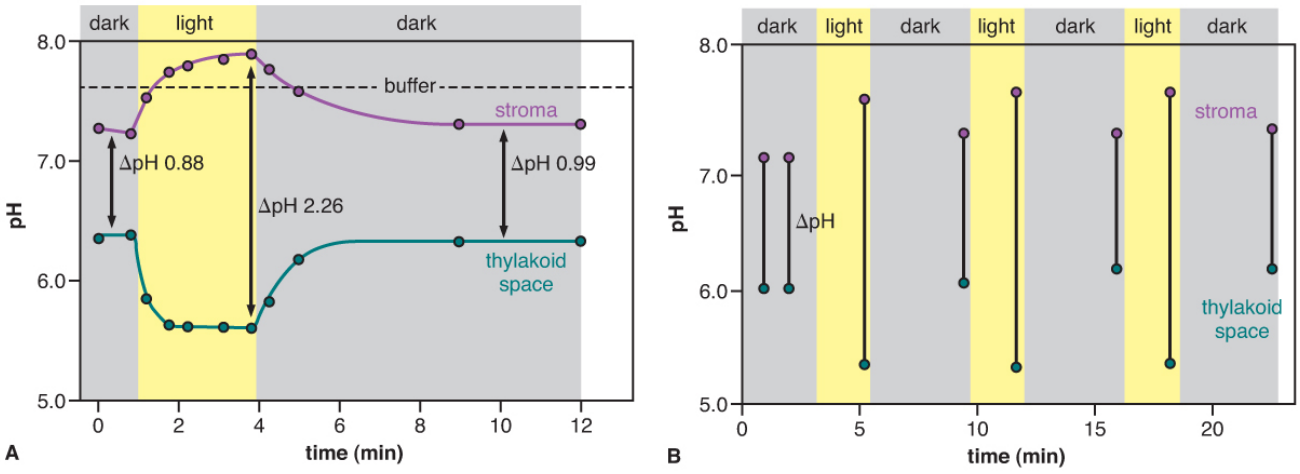
Let's start by refreshing the concepts of **excitation of chlorophyll by light and the parts of a photosystem** The following videos are a great resource to refresh our minds:

https://www.youtube.com/watch?v=nPt4zKt6lMk&list=PLYjFOc4FIyikoVfco6z-axMx5_CDDHj2m&index=25
https://www.youtube.com/watch?v=GoUpxy_zkds&list=PLYjFOc4FIyikoVfco6z-axMx5_CDDHj2m&index=27



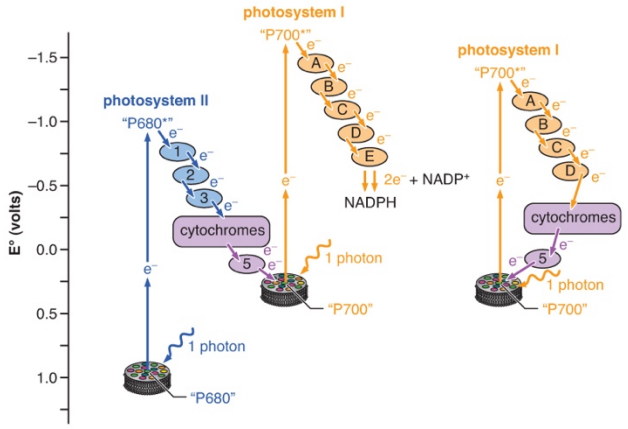
Photosynthesis is a summation of three parts: water splitting, ATP production and carbon fixation. The graphs to the right, represent the results of experiments using an enzyme inhibitor. In this case, botanists dissected photosynthesis by measuring the production of oxygen (+/- 10^{-5} M inhibitor), ATP, and carbon fixation (at the indicated inhibitor concentrations).

In the experiment above, it was clear that plants could **split (or consume) water,** produce adenosine triphosphate (ATP), and convert CO_2 into multicarbon sugars **(carbon fixation).** Daniel Arnon, a pioneer in photosynthesis, measured the rate of all three processes when they were exposed to different concentrations of an enzymatic inhibitor. He placed chloroplasts in a solution containing a concentration of 1.5×10^{-5} M of the inhibitor and compared the rate of water splitting by chloroplasts without any inhibitor. For the remaining two experiments, Arnon measured the rate of ATP production and the rate of CO_2 fixation when exposed to a range of inhibitor concentrations. By testing the ability of chloroplasts to perform all three functions in the presence a photosynthesis inhibitor, Arnon made an important discovery about the overall process of photosynthesis.



How does pH vary between the stroma and the thylakoid space in the chloroplasts? To answer this, botanists measured the pH of a single chloroplast exposed to dark or light, as indicated (A), and repeated exposures of a chloroplast to light and dark cycles within minutes of each other (B). Make sure to explain the results from both panels.

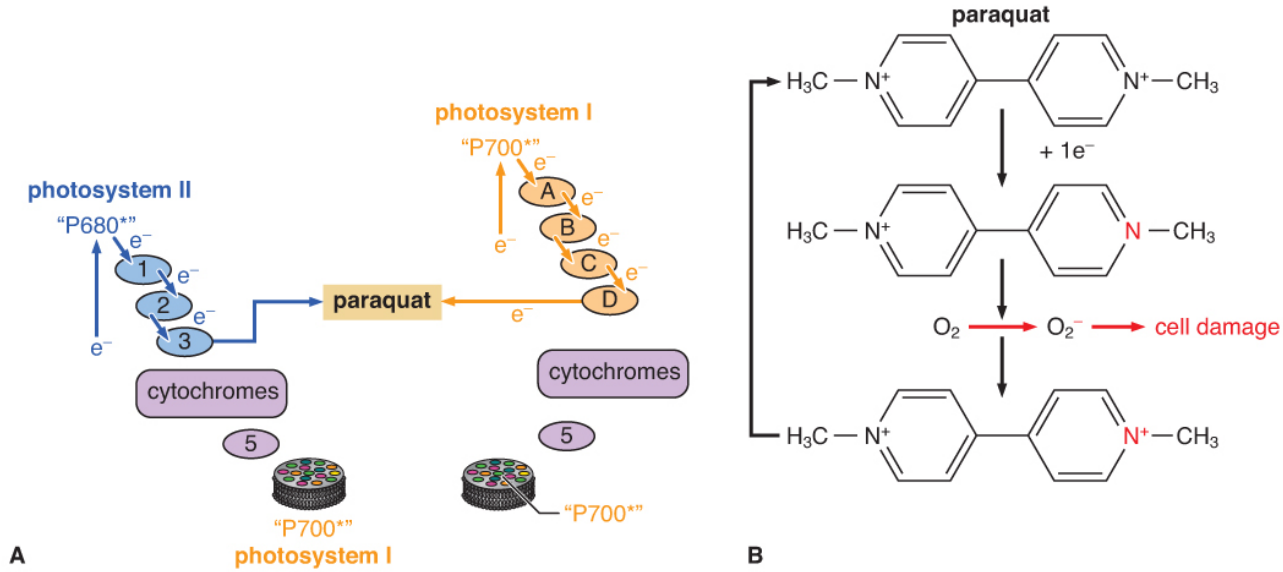
Now, how do electrons flow in the different photosystems?



Flow of electrons energized by light. **In the figure to the right, Photosystems I (orange) and II (blue) absorb two photons and use electron carrier molecules to pass excited electrons that eventually form a new covalent bond in nicotinamide adenine dinucleotide phosphate-oxidase (NADPH) formed in the stroma.**

When working alone, photosystem I (PSI) has the ability to pass its electrons back to its own reaction center via the shared components of PSI and PSII (pink).

Now that we saw the main experiments that led to the discovery of photosynthesis, let's get back to Paraquat. So, **how does paraquat affect photosynthesis and how is it toxic to animals and humans?**



If you review the structure of paraquat, you will see that it contains two positive charges, which makes it very electronegative. In plants, **Paraquat's structure allows it to bind very closely to the electron binding site on PSI and PSII cytochromes. Paraquat's strong electronegativity draws the electrons away from the cytochromes, therefore interrupting the normal cycle of electron flow and stopping the production of glucose.**

In animals and humans however, the mode of toxicity is the production of oxygen radicals (O_2^-), which are highly reactive molecules. **In this case, we define damage by oxygen radicals as Oxidative Stress.**

Let's check your understanding!!

1. What's the name of the organelle where photosynthesis takes place?
2. What is chlorophyll?
3. What three major processes compose photosynthesis?
4. What is special about Paraquat's structure in relation to its toxicity?
5. What is the main type of damage by Paraquat in humans and animals?

Answers!!

1. Chloroplasts
2. The main pigment in plant cells that captures sunlight for photosynthesis
3. Water splitting, ATP production and carbon fixation.
4. It allows Paraquat to bind very closely to the electron binding site on PSI and PSII cytochromes.
5. Oxidative stress

That's it this week. Please reach out if you have any questions and don't forget to visit the Tutoring Center website for further information.