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1878

Measuring Photosynthesis and Respiration with Intact Cells: Integrating Chemistry into Biology in a First-Year Laboratory Environment

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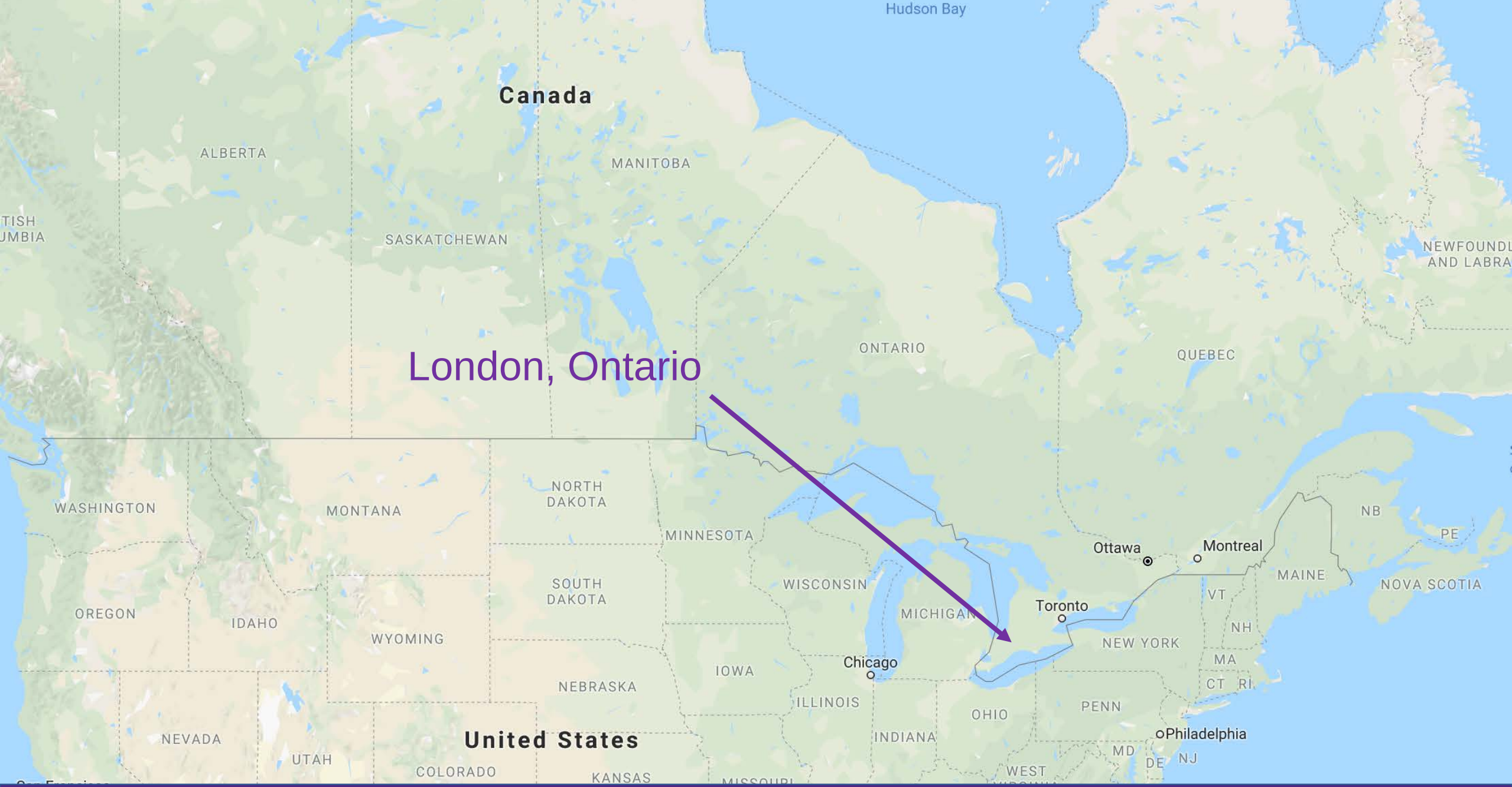
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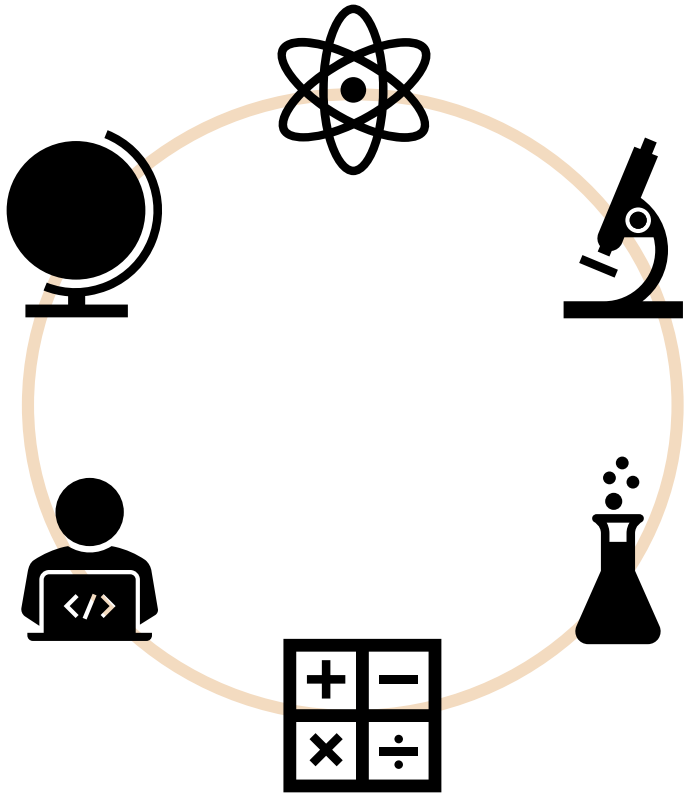
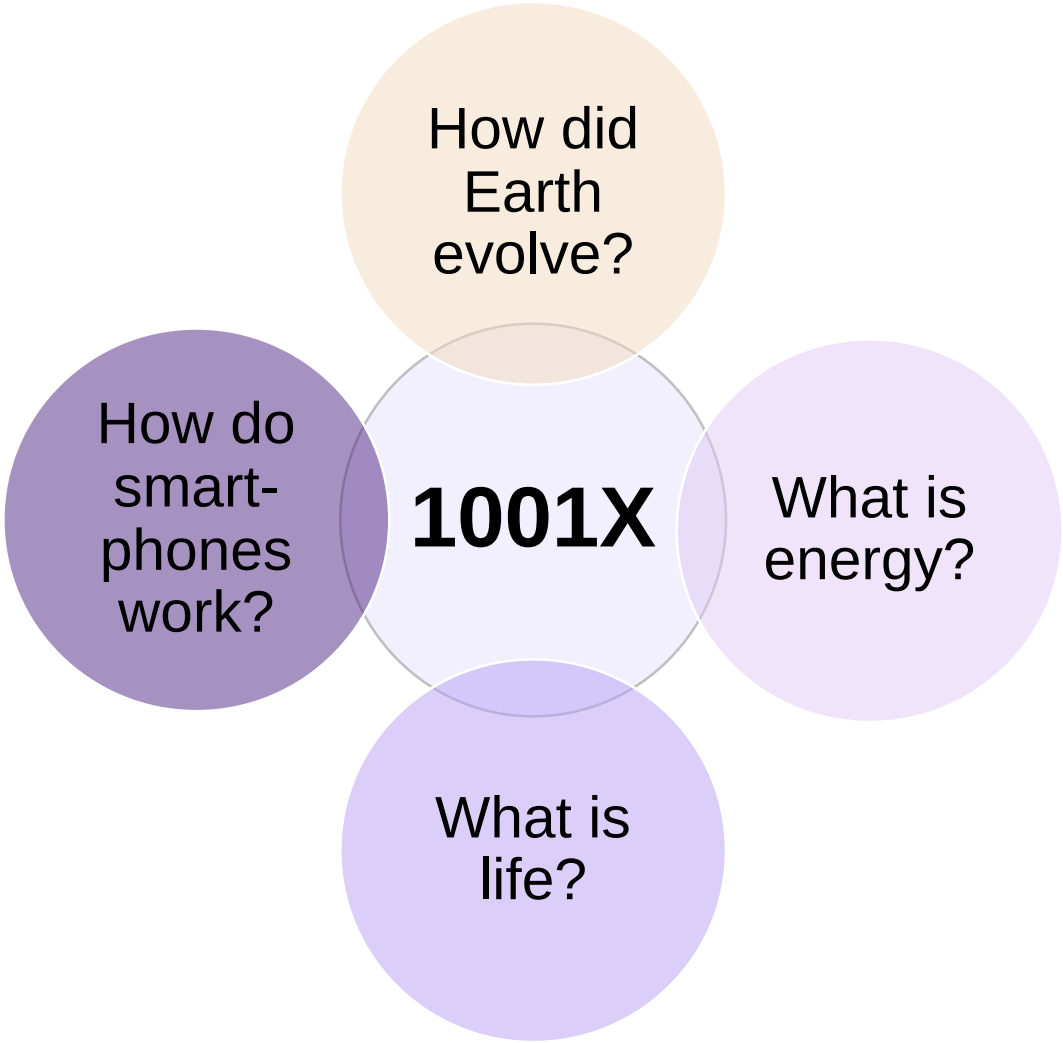
Western Science

Western Integrated Science Program (WISc)

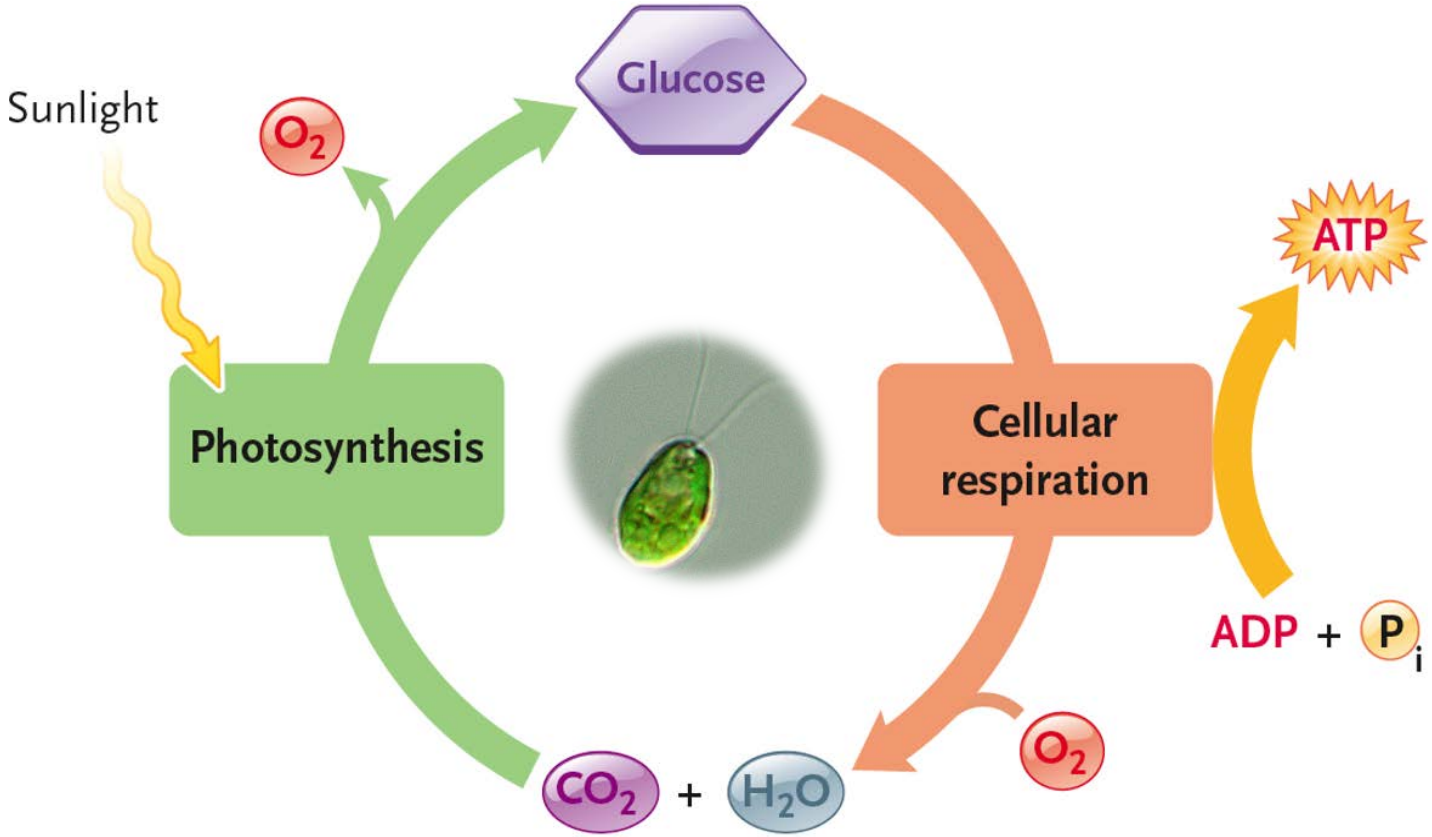
- Limited-enrollment program
- Broad questions-based approach





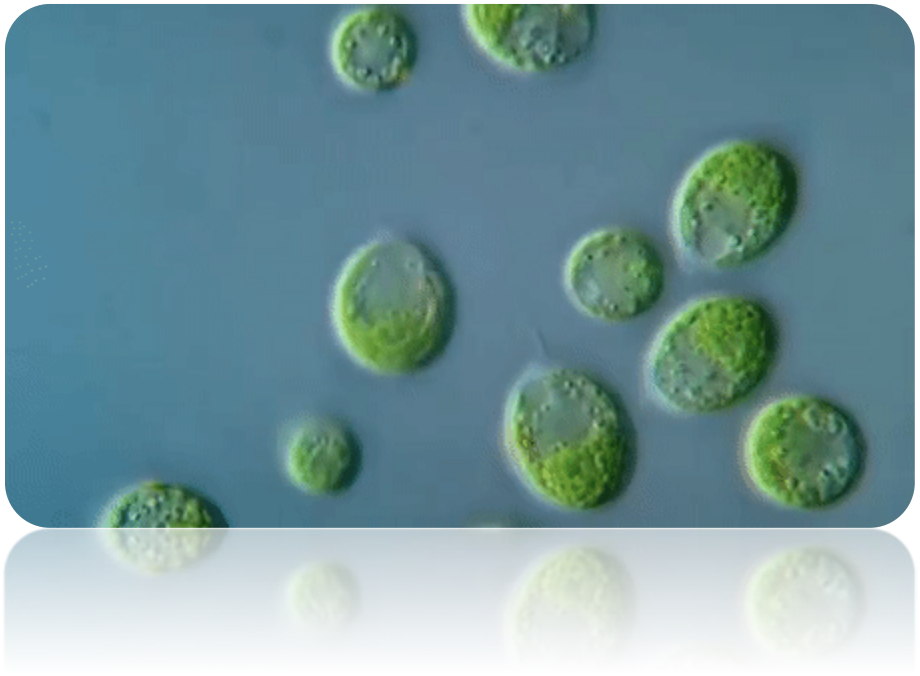
Integrated Metabolism Lab

- Measure change in O_2 evolution in *Chlamydomonas reinhardtii* cell cultures
- Determine impact of environmental stresses on the rate of photosynthesis and cellular respiration



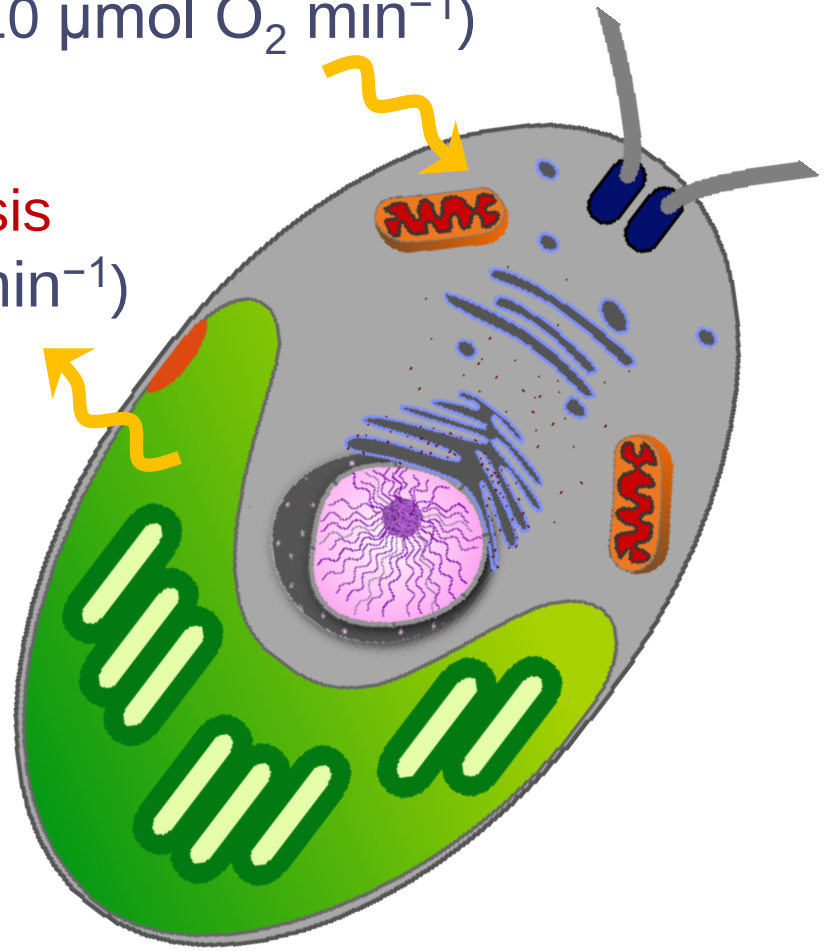
Chlamydomonas reinhardtii

- Green unicellular flagellated eukaryotic alga

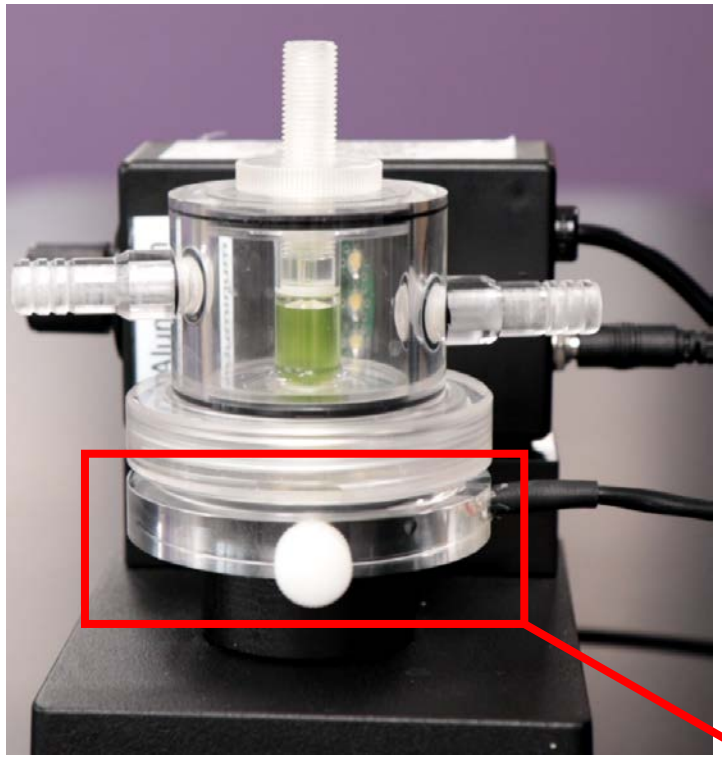


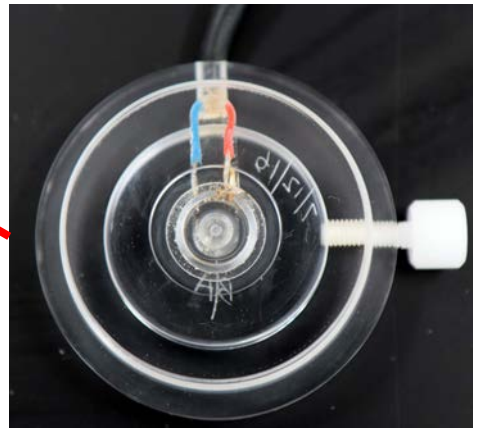
Respiration
(10 µmol O_2 min^{-1})

Photosynthesis
(100 µmol O_2 min^{-1})



Oxygen Electrode



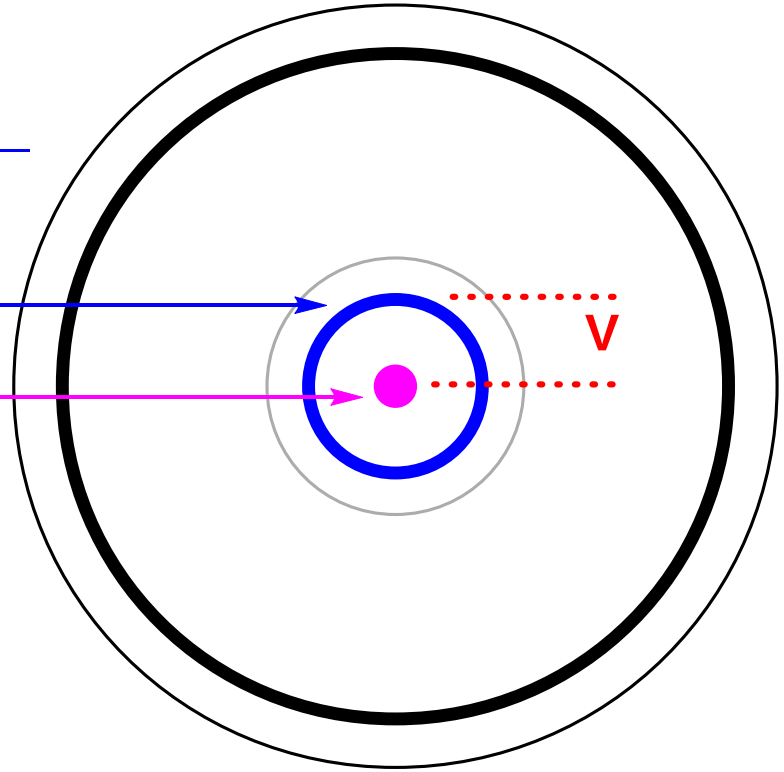


$$4\,Ag + 4\,Cl^- \rightarrow 4\,AgCl + 4\,e^-$$

Ag anode

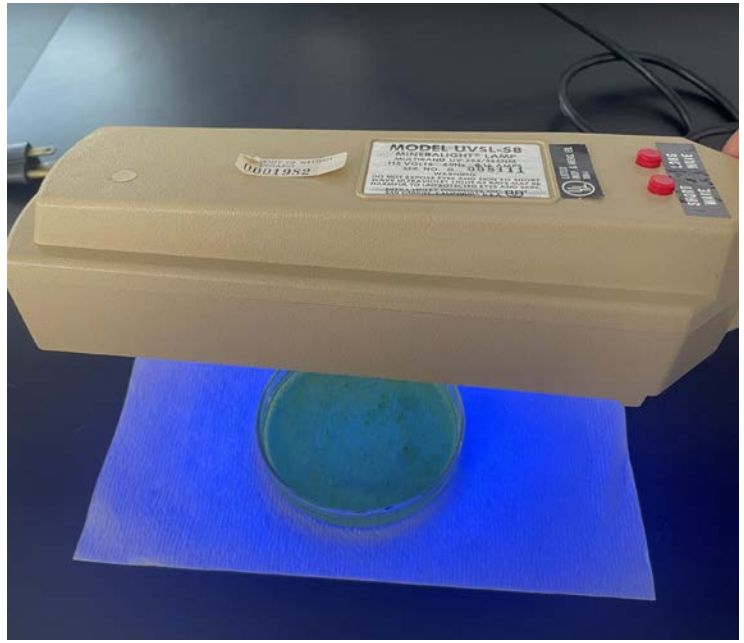
Pt cathode

$$4\,e^- + O_2 + 4\,H_+ \rightarrow 2\,H_2O$$

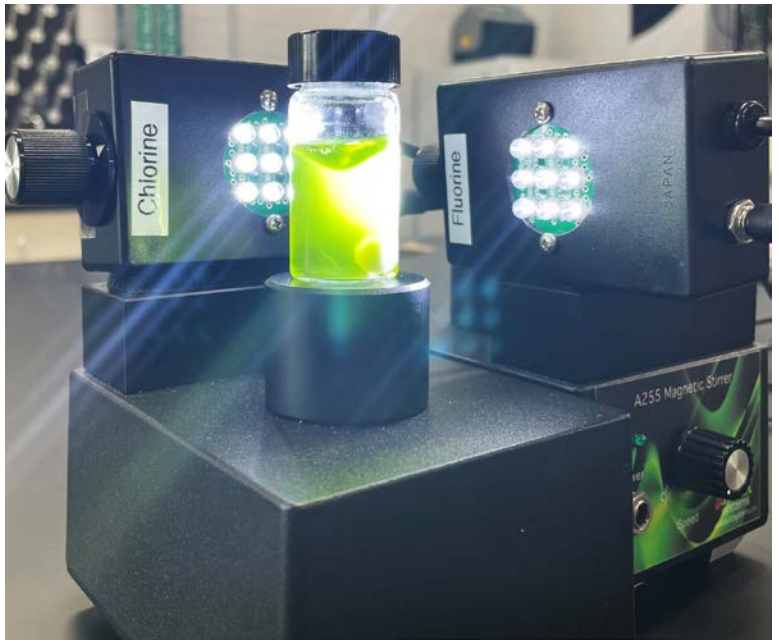


Environmental Stresses

UV light

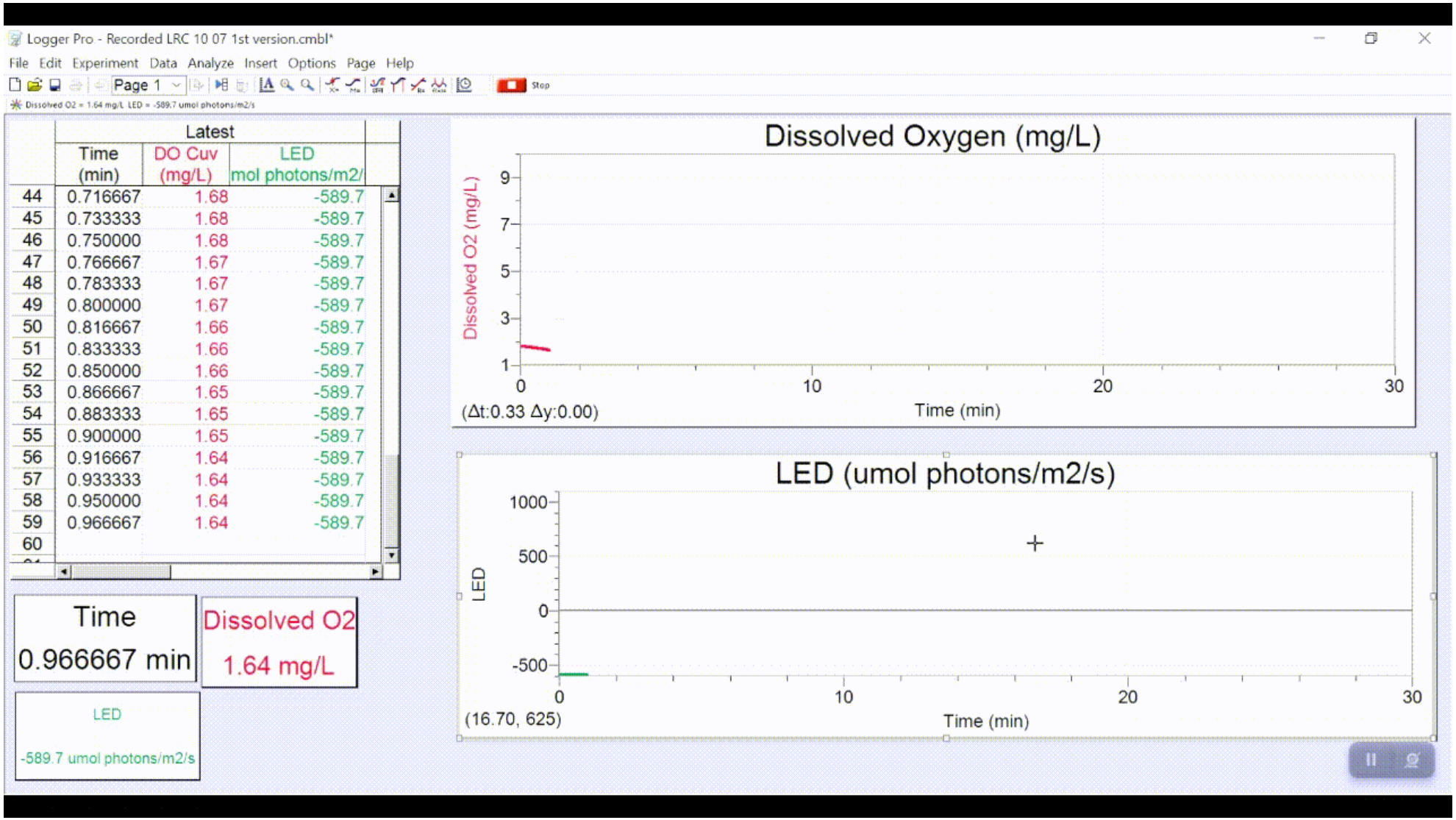


Bright light



High temp

Measuring O_2 Concentration



Change in light intensities

Rate of Change in O_2 Concentration

Logger Pro - Chlamy day 2 control#2 - Copy.cmbl*

File Edit Experiment Data Analyze Insert Options Page Help

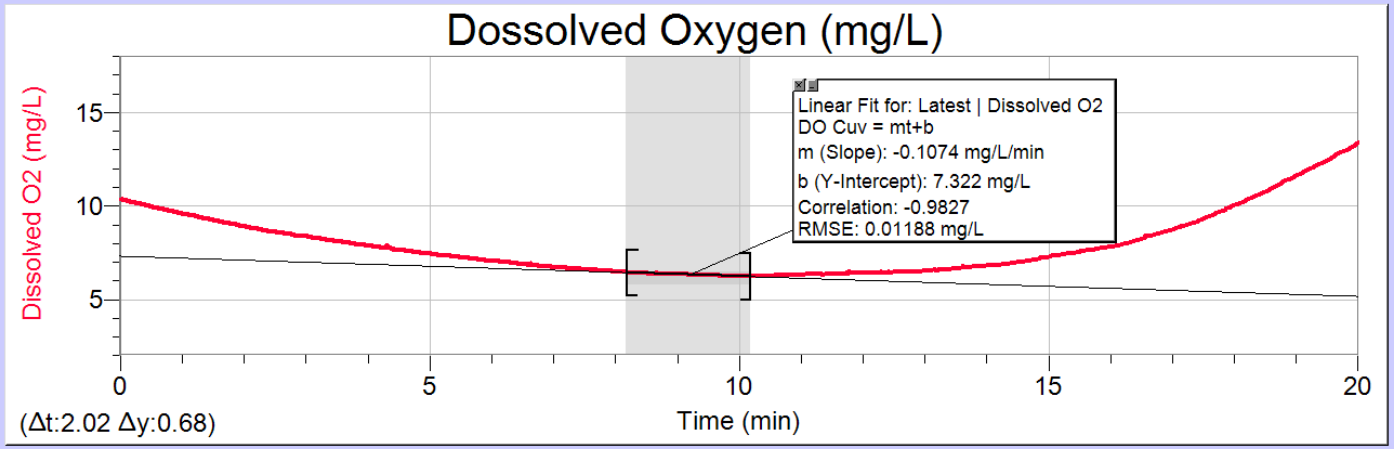
No device connected.

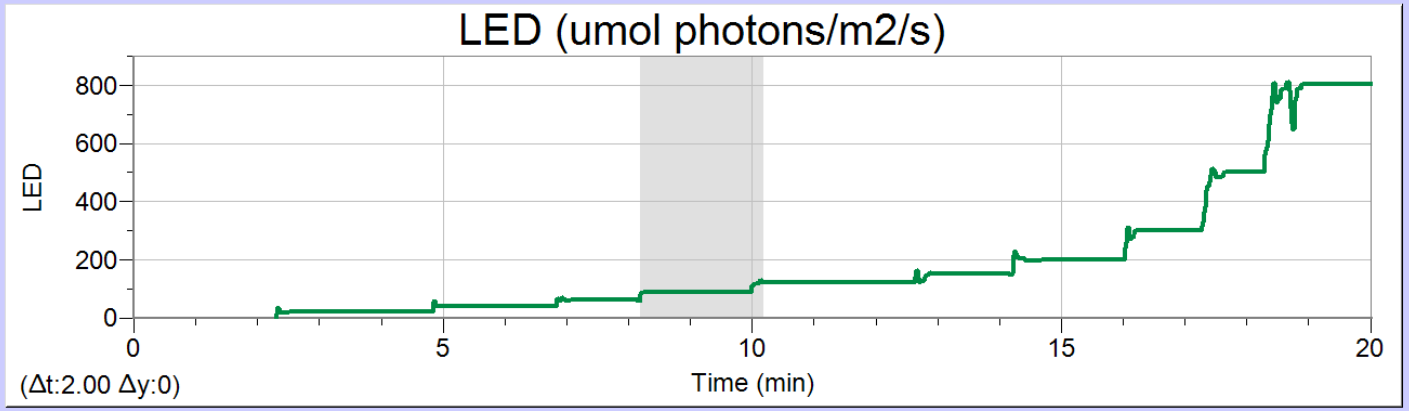
	Latest		
	Time (min)	DO Cuv (mg/L)	LED mol photons/m2/
478	7.950000	6.51	61
479	7.966667	6.51	61
480	7.983333	6.51	61
481	8.000000	6.51	61
482	8.016667	6.48	61
483	8.033333	6.48	61
484	8.050000	6.48	61
485	8.066667	6.47	61
486	8.083333	6.47	61
487	8.100000	6.47	61
488	8.116667	6.47	61
489	8.133333	6.46	61
490	8.150000	6.46	59
491	8.166667	6.46	59
492	8.183333	6.48	59
493	8.200000	6.45	85
494	8.216667	6.44	85

Time min

Dissolved O2 mg/L

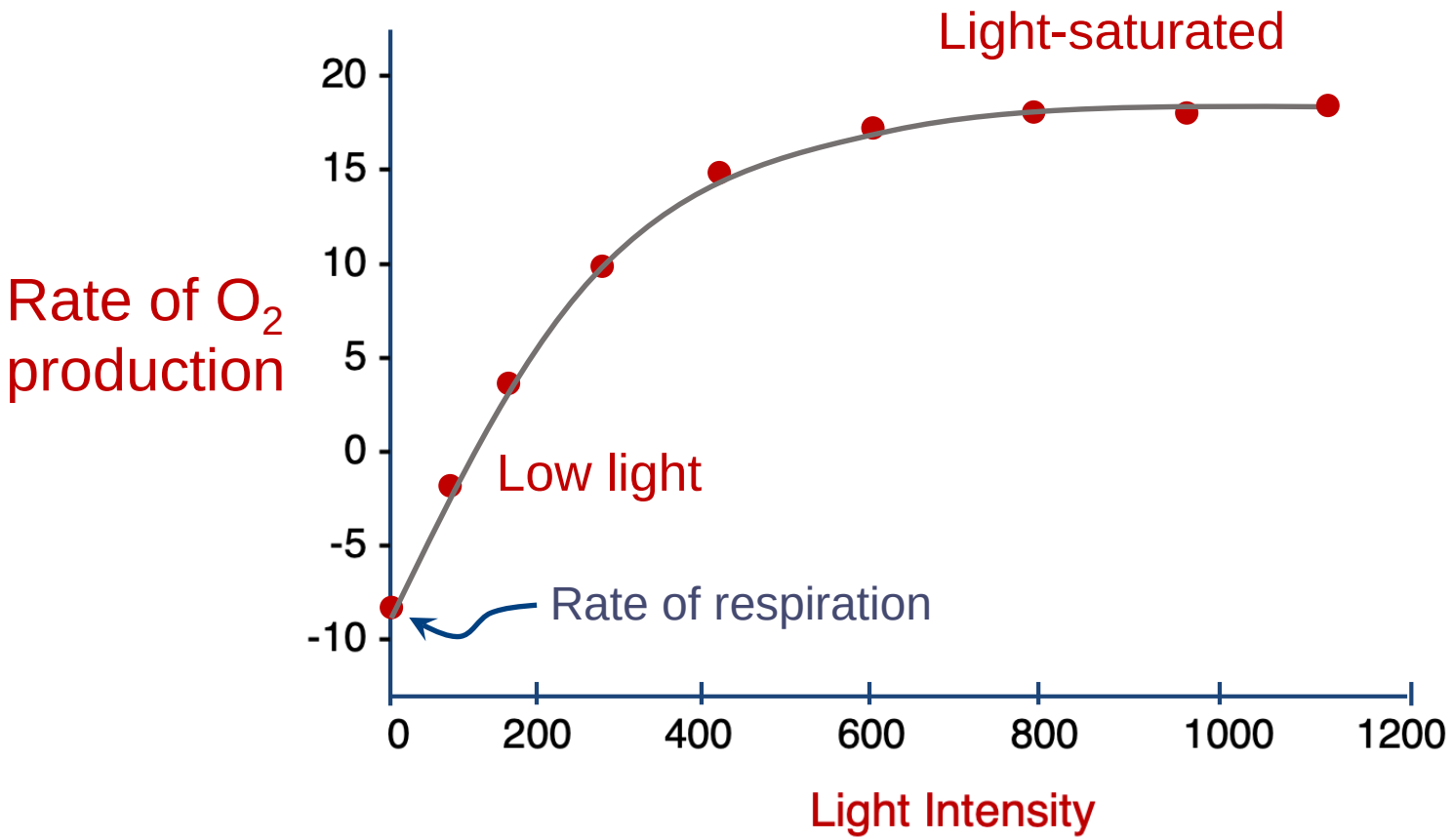
LED umol photons/m2/s

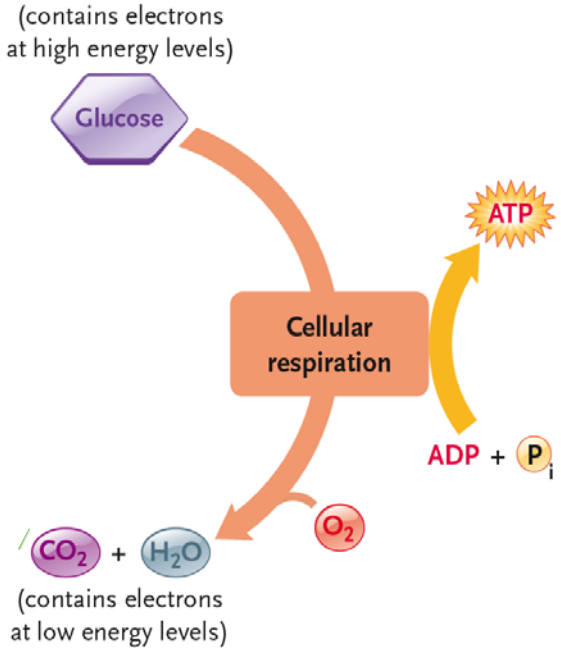




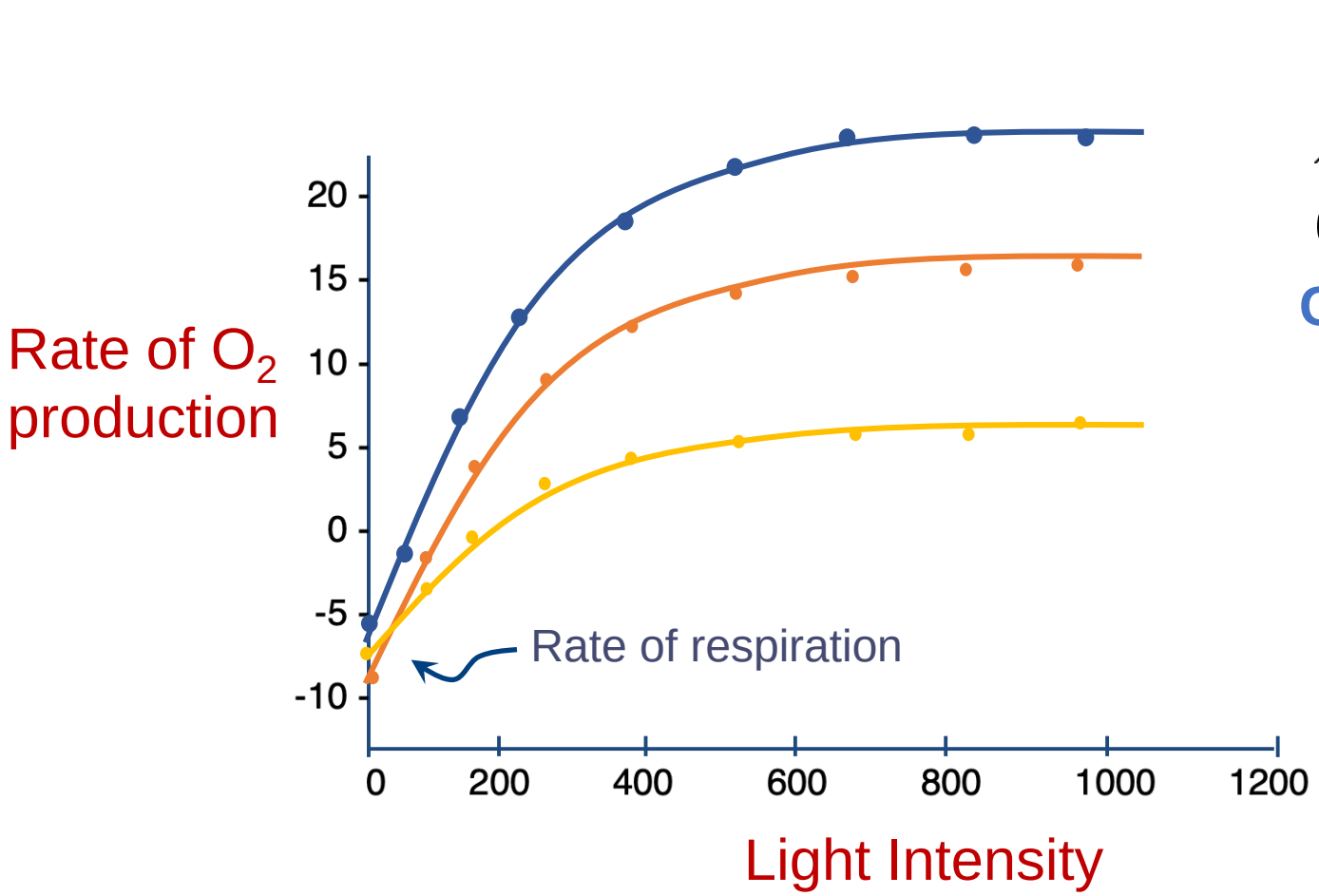
Light Response Curve

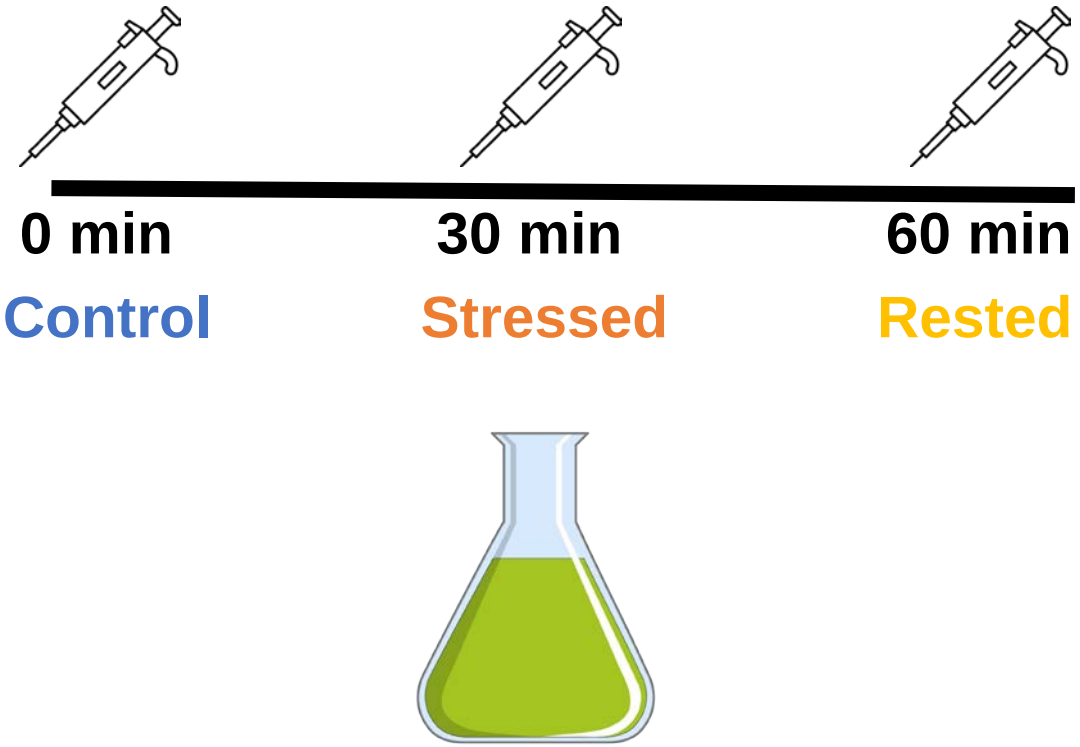
- Plot shows rate of respiration and photosynthesis at different light intensities





Experimental Runs





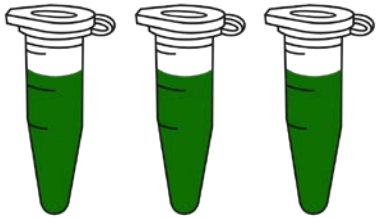
Chlorophyll Extraction

Rate from slope

$mg\ O_2 \bullet L^{-1} \bullet min^{-1}$

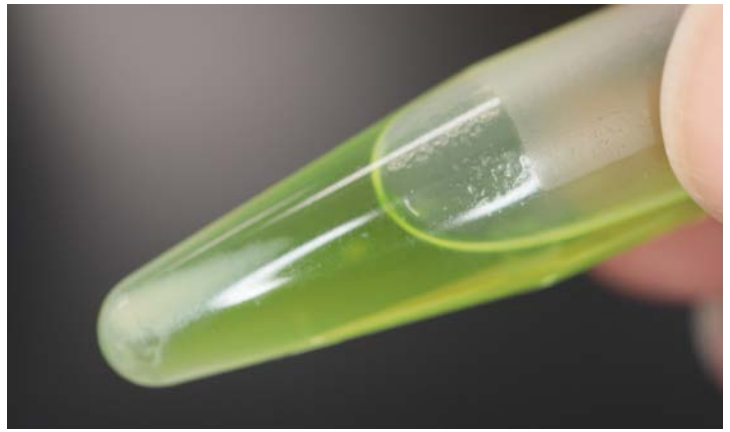
Adjusted for amount

$\mu mol\ O_2 \bullet mg^{-1}\ Chl \bullet hr^{-1}$

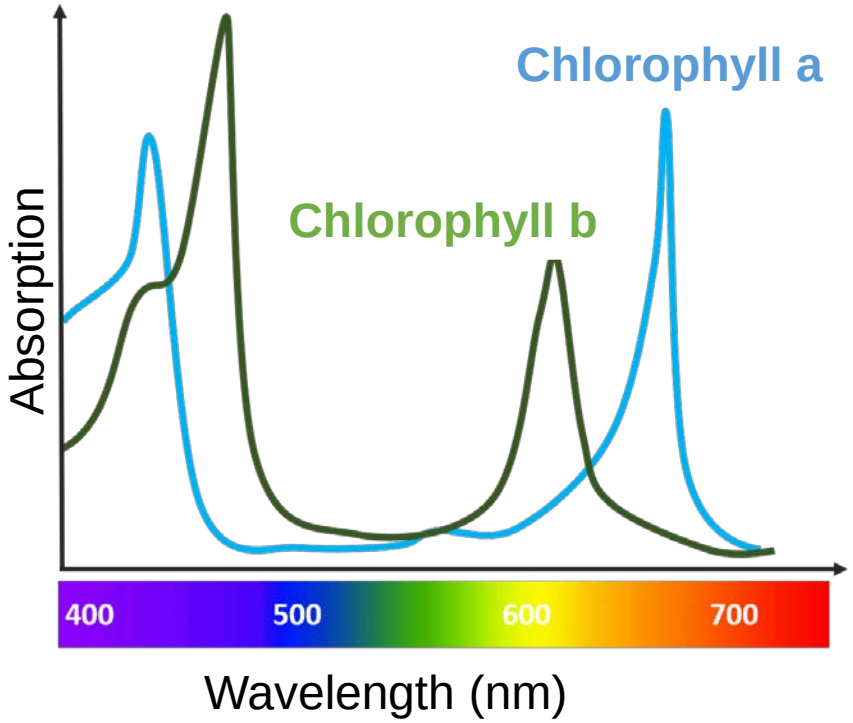


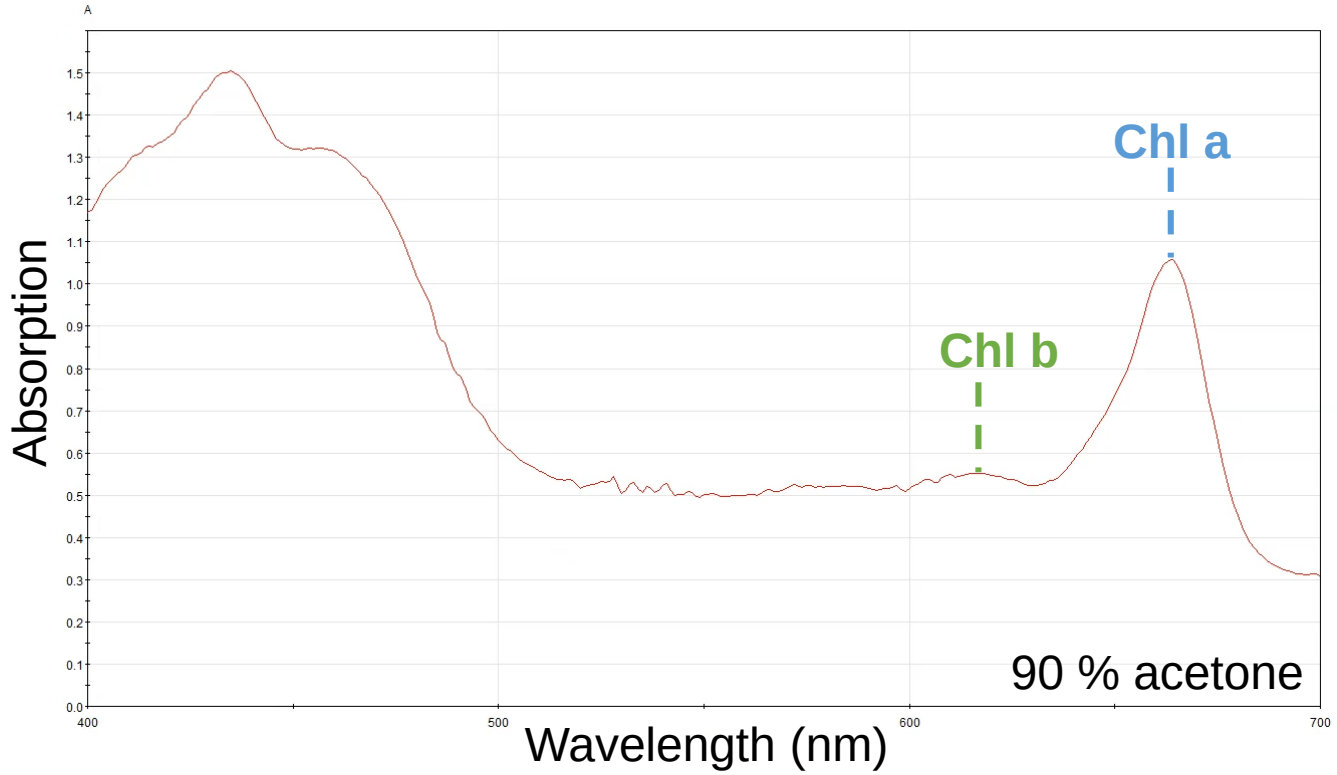
Day 1

Day 2



Chlorophyll Quantification



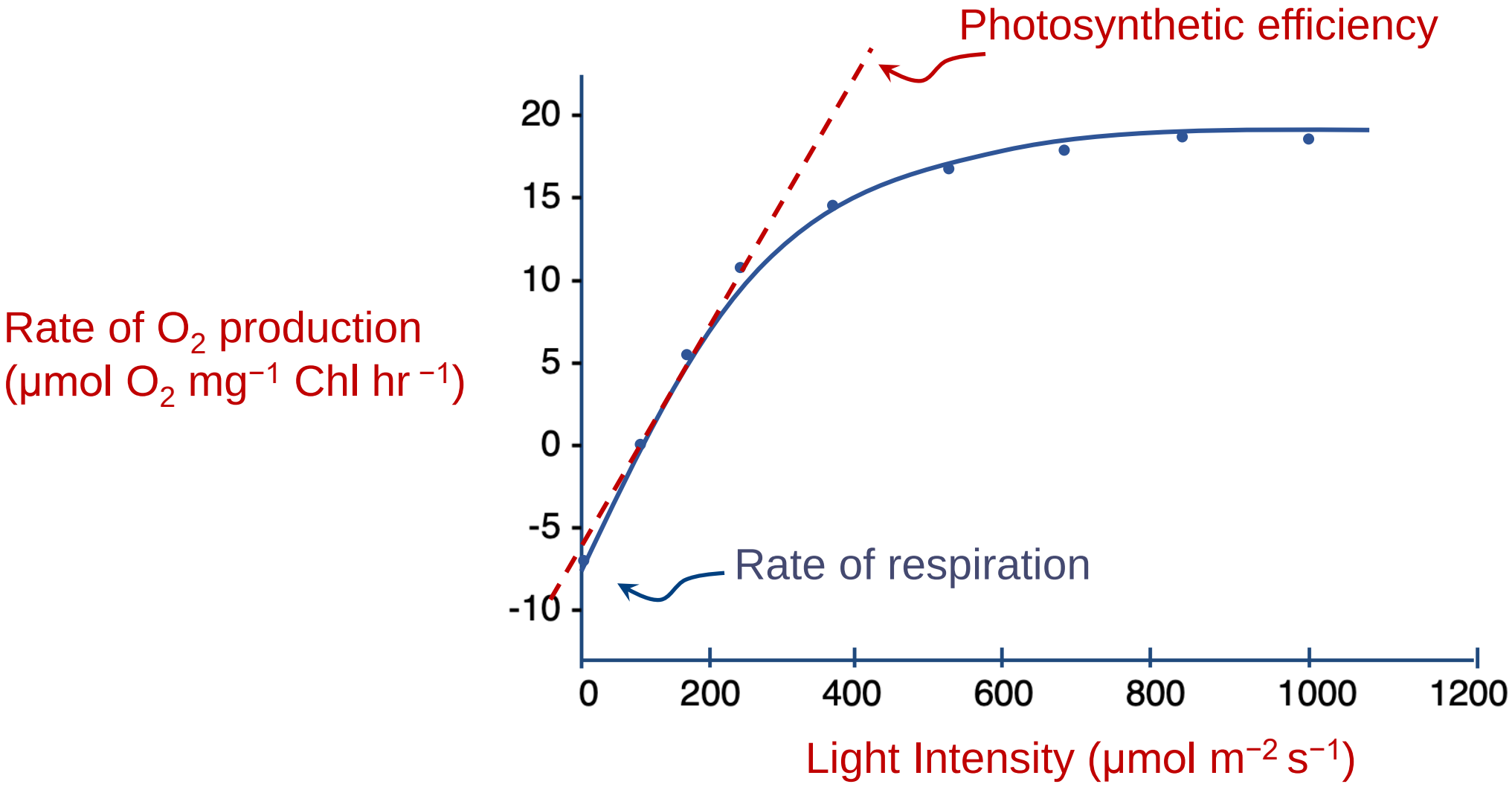


$$\text{Chlorophyll a } (\mu g\ mL^{-1}) = 11.93(A_{664}) - 1.93(A_{647})$$

$$\text{Chlorophyll b } (\mu g\ mL^{-1}) = 20.36(A_{647}) - 5.50(A_{664})$$

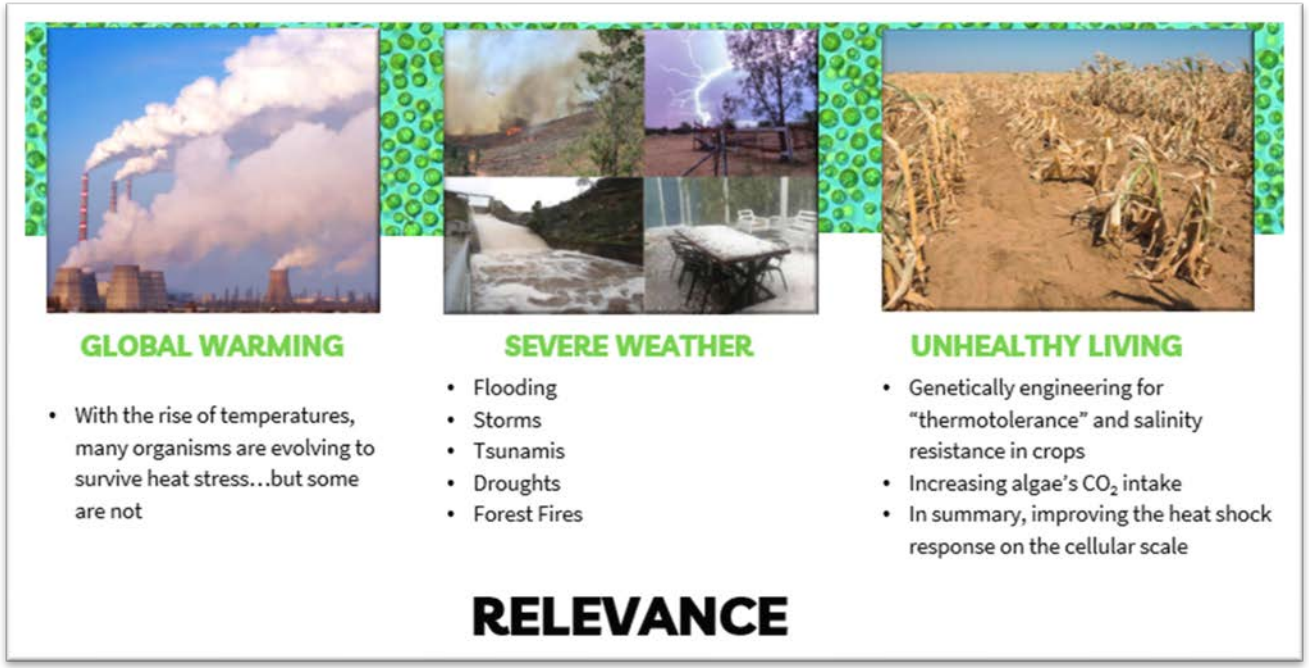
S.W. Jeffrey, and G.R. Humphrey, *Biochem. Physiol. Pflanzen,* 1975, **167**, 191-194

Light Response Curve Analysis



Group Oral Presentation

- Teamwork skills
- Scientific communication
- Constructive feedback



Formal Report

- Use pictures to document the setup of the experiment
- Perform a literature search to help explain the observations
- Show scientific concepts and data using figures

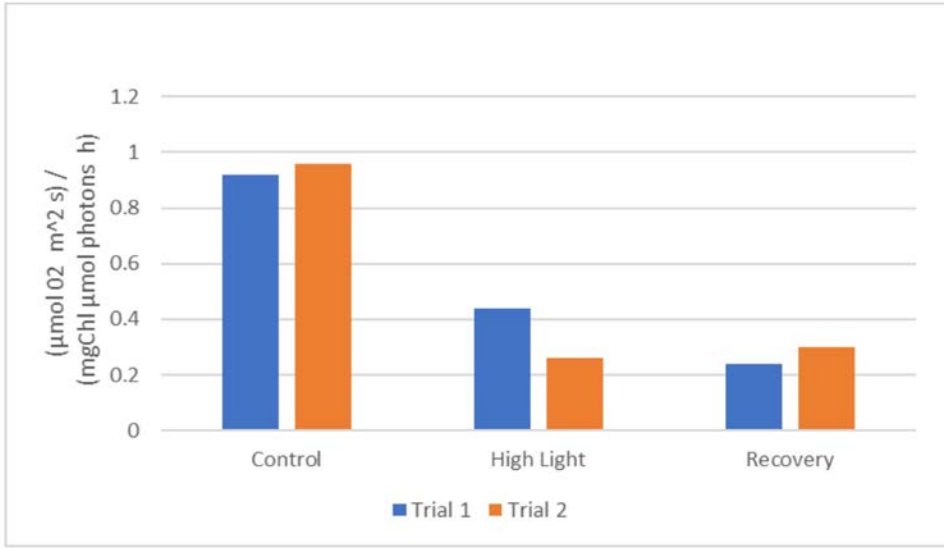


Figure 6: Change in photosynthetic efficiency of *Chlamydomonas reinhardtii* due to high-light.

minutes with the provided increments, please refer to Image 3. Please refer to Images 1-3 to visualize the process of this lab.

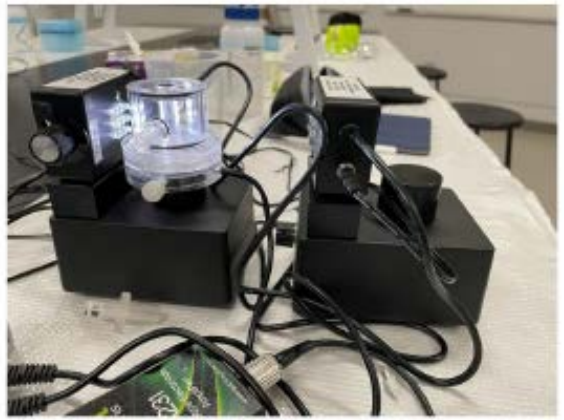


Image 1 showcases the step for the control cells where a light source is directed at the culture. Note that the black cloth used to cover the cells is not shown for visualization purposes.

Formal Report

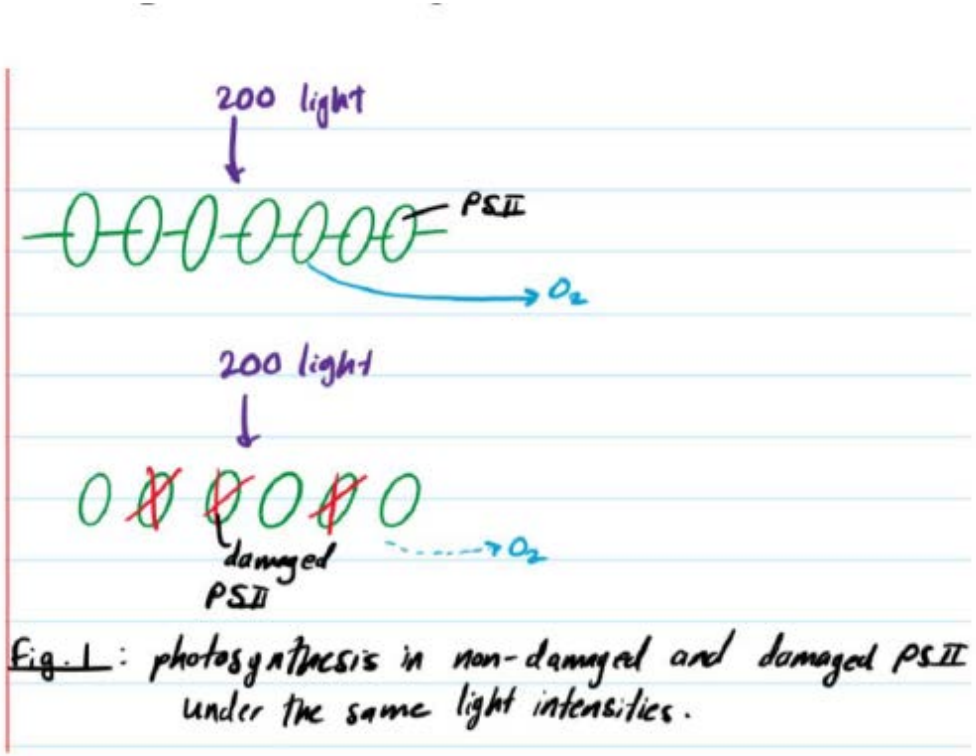


Fig. 1: photosynthesis in non-damaged and damaged PSII under the same light intensities.

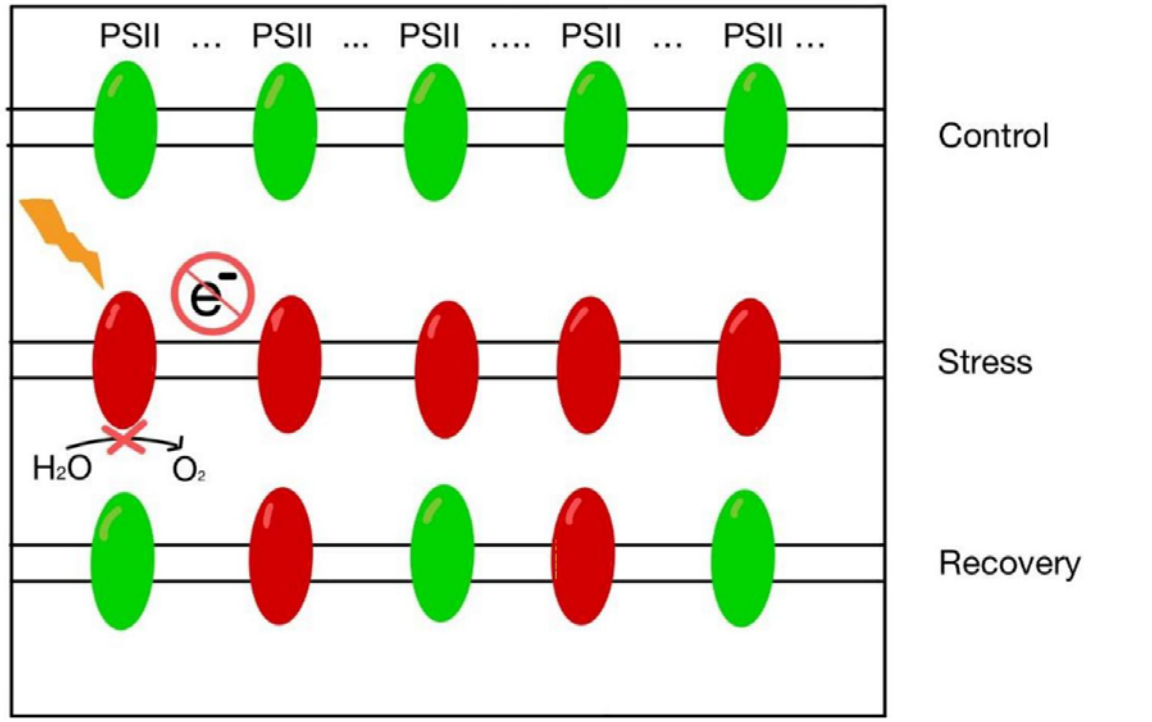


Figure 7: A hand-drawn representation of photoinhibition across cell samples

Learning Outcomes

- Learn chemistry using biology
- Set up, use, and troubleshoot an O_2 electrode
- Use a variety of lab techniques to extract chlorophyll and then quantify it by UV-Vis spectrophotometry
- Use software to collect, assess, and communicate scientific data, and draw conclusions from the data
- Collaboratively create an oral presentation and write a formal lab report

Student Feedback

"I really appreciated the opportunity to utilize lab equipment otherwise not used in general first year labs, like the O_2 electrode, micropipette and the centrifuge. In addition to this, using live *Chlamy* cells and observing their behaviour under a microscope was one of the highlights of the semester. For next steps, I would've appreciated another round of data collection, and a lesson explaining the importance of the lab, and how it can be completed successfully". *Kiera A. Sammut*

"The lab was a super cool and stimulating opportunity! I got to learn and use various laboratory apparatus for the first time and experience the meticulous (albeit tedious) data collection process in microbiology. I just wish we had more time to explore a larger range of UV intensities and complete multiple controls to further corroborate our findings". *Malavika Nair*

Renee Webber

Felix Lee

Denis Maxwell

Acknowledgments

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EuChemS European Chemical Society

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