LA LUMIÈRE CHEZ LES ALGUES PHOTOSYNTHÉTIQUES: SOURCE D'INFORMATION ET D'ÉNERGIE OU RISQUE MORTEL ?

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Atelier n°120

13.10.2015

Grenoble, Auditorium de la BU Sciences

2015: International Year of Light

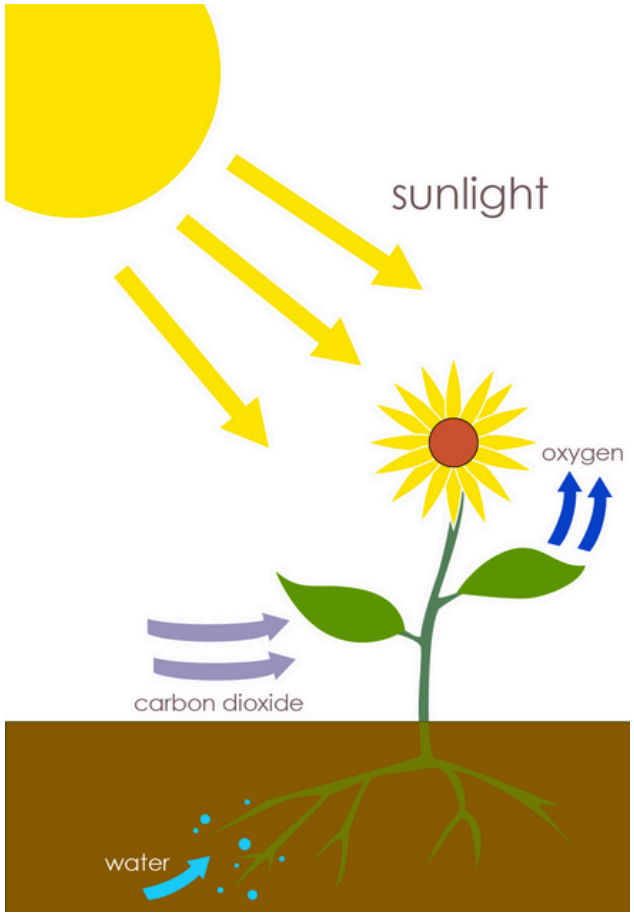
1.5 x 10^{22} kJ of sunlight energy falls on the earth each day

*1000 x (*yearly electricity consumption of the world as of 2008)

http://www.light2015.org/

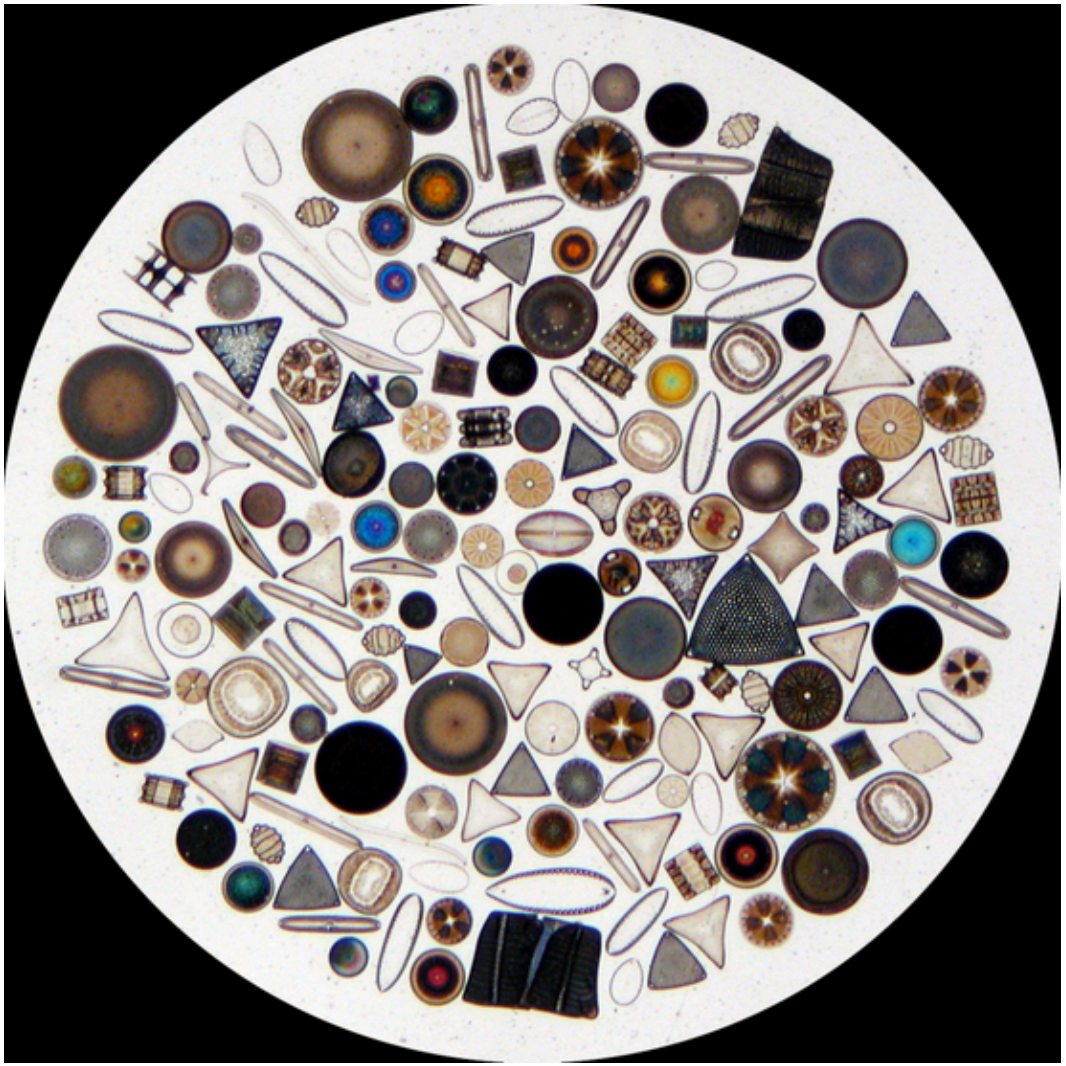
INTRODUCTION

2015: International Year of Light/ Photosynthesis



https://en.wikipedia.org/wiki/Photosynthesis

Algae: an exciting group of microorganisms



Photosynthetic microorganisms

Basis of the trophic chain

O_2 producers (40-50% of the total O_2)

CO_2 fixation

Biotechnological applications

photo: marine diatoms

Green algae: the ancestors of land plants

Leliaert et al (2012)

The unicellular microalga *Chlamydomonas reinhardtii*

Model Photosynthetic organism

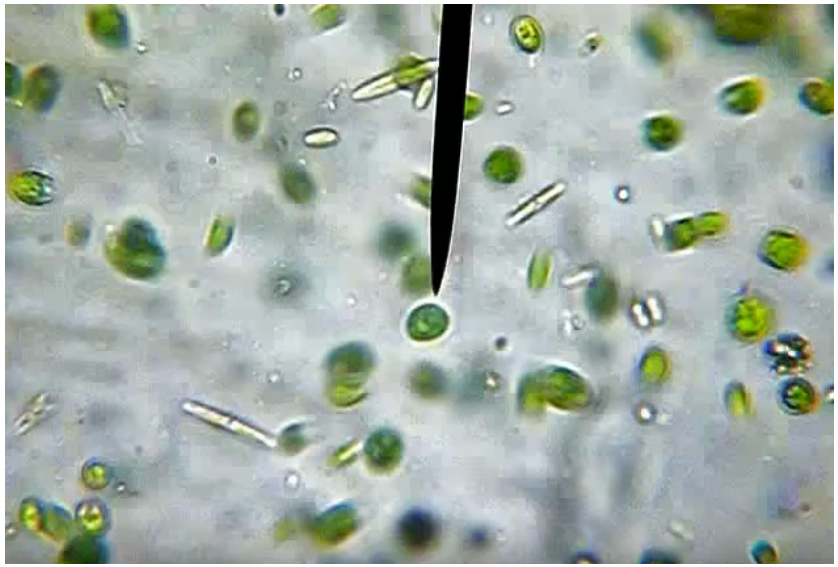
Can grow in the dark in the presence of acetate

Full genome is sequenced (15000 genes)

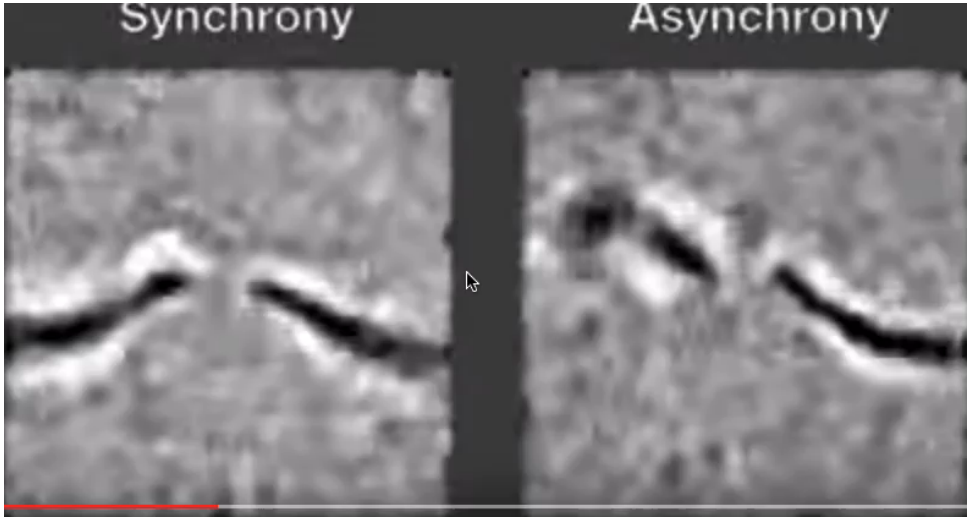
Genetic tools are available

Cell size: 10 µm

The unicellular microalga *Chlamydomonas reinhardtii*



video from Kade Guillory



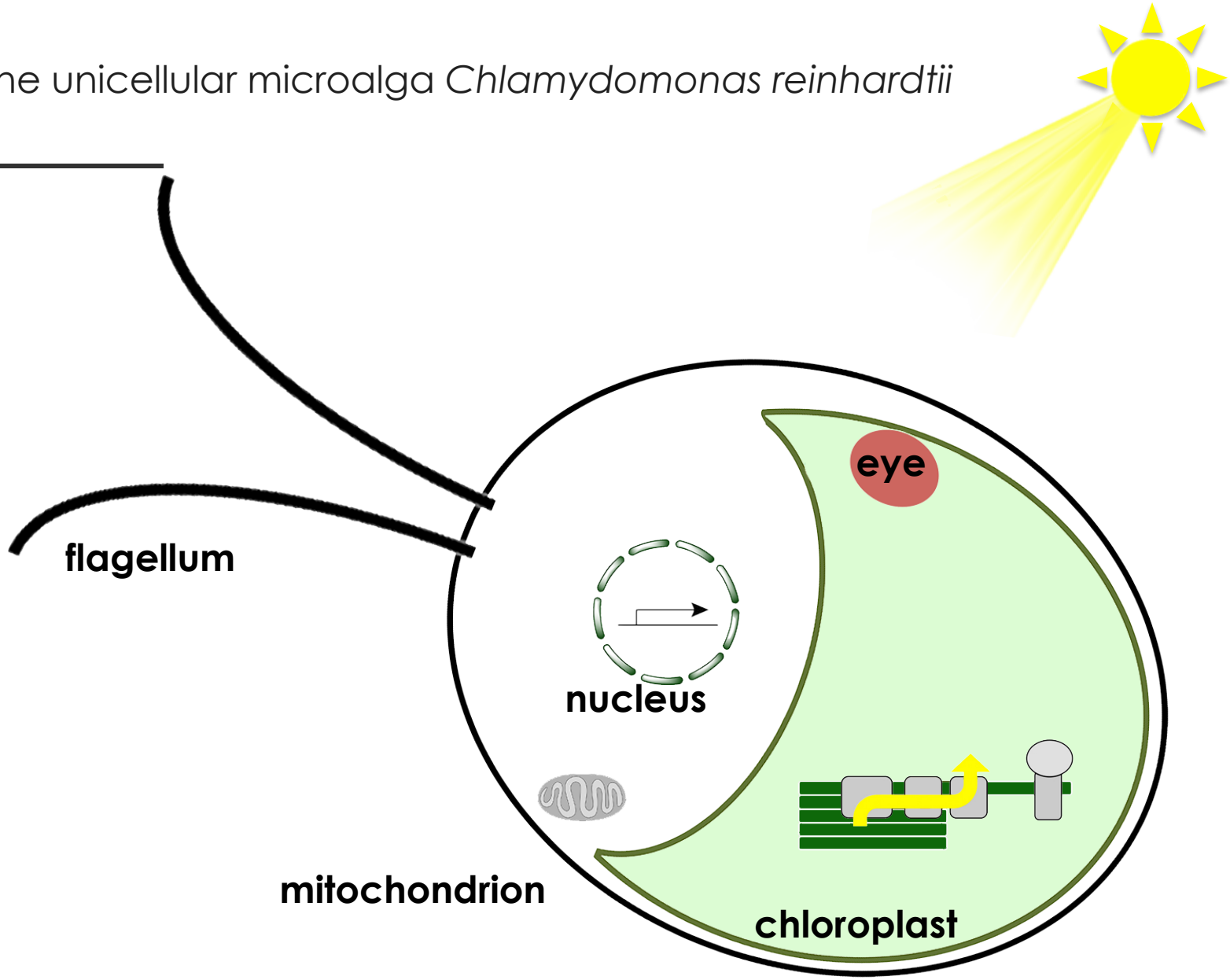
video from
Goldstein lab

The unicellular microalga *Chlamydomonas reinhardtii*

45 km/h 110 km/h 120 km/h

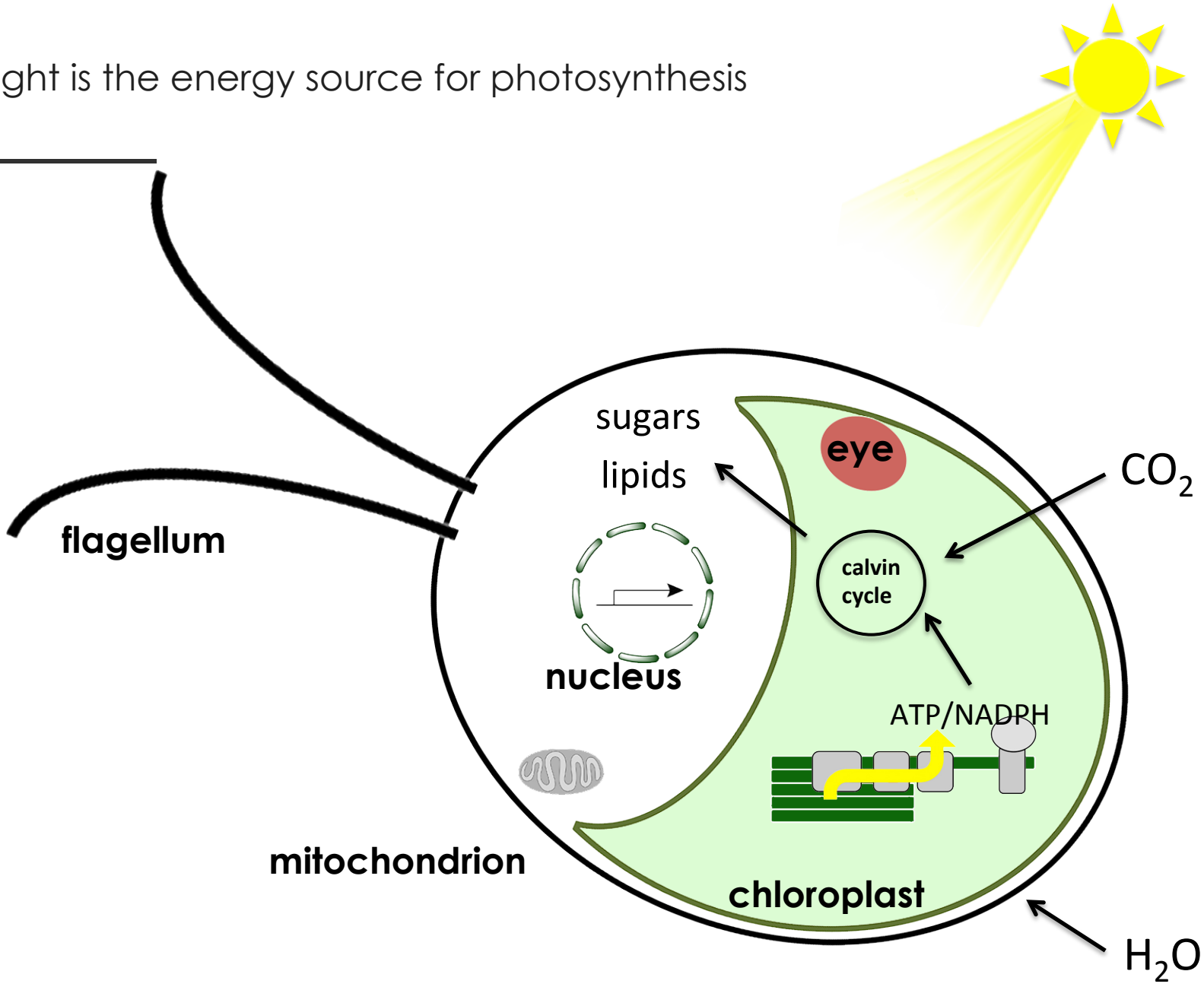
swimming speed: 100-200 µm/sec
size: 10 µm

The unicellular microalga *Chlamydomonas reinhardtii*

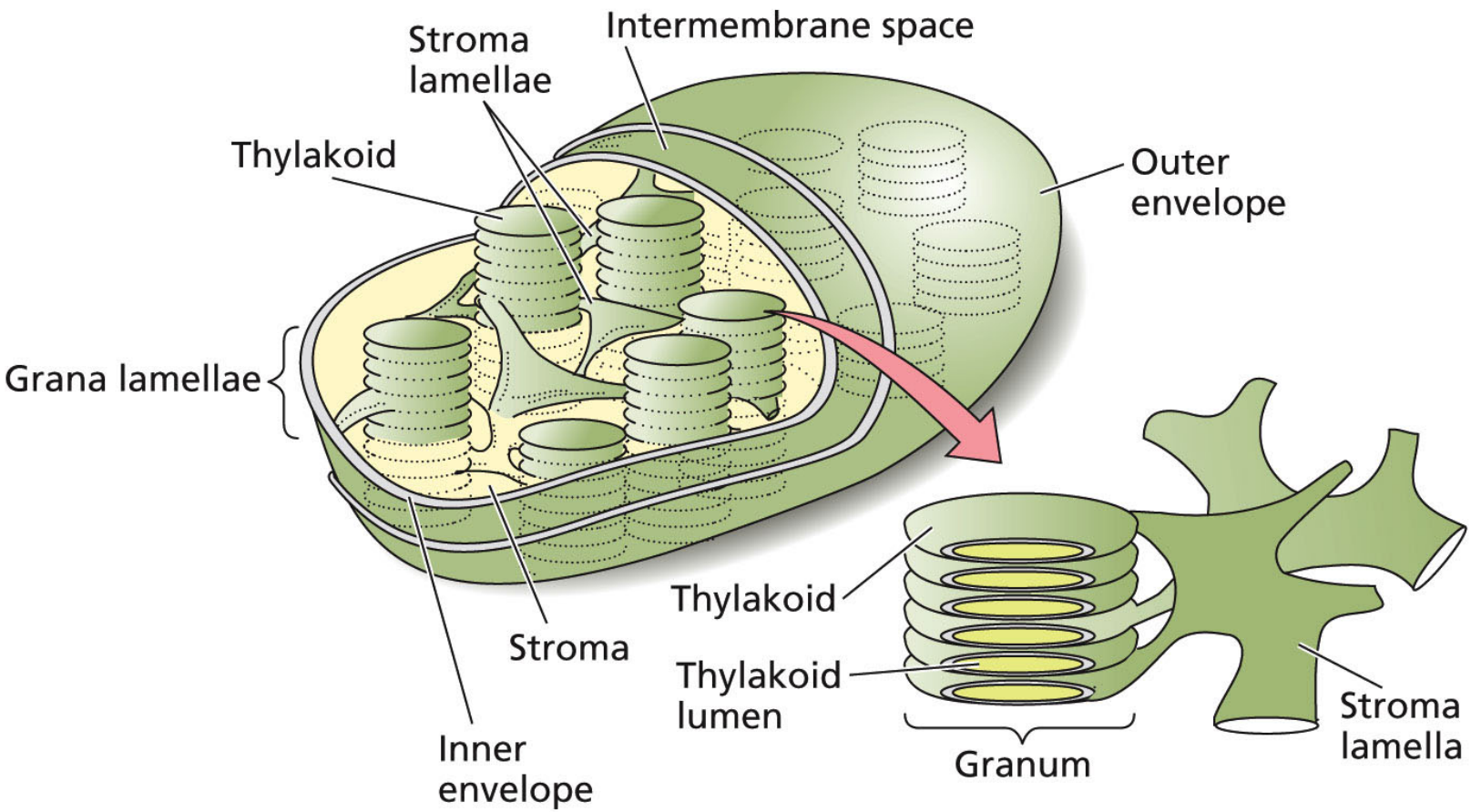


A schematic of the model photosynthetic algae Chlamydomonas

Light is the energy source for photosynthesis



The chloroplast is the site of photosynthesis



INTRODUCTION

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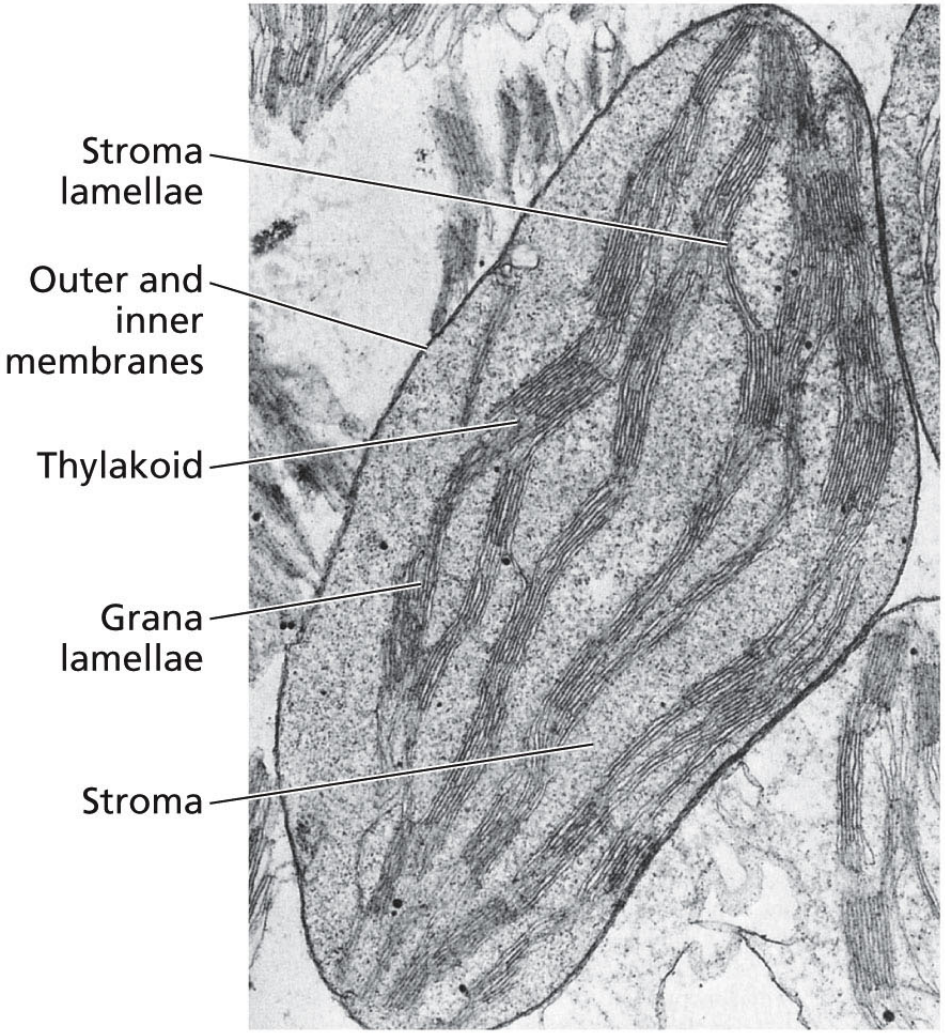
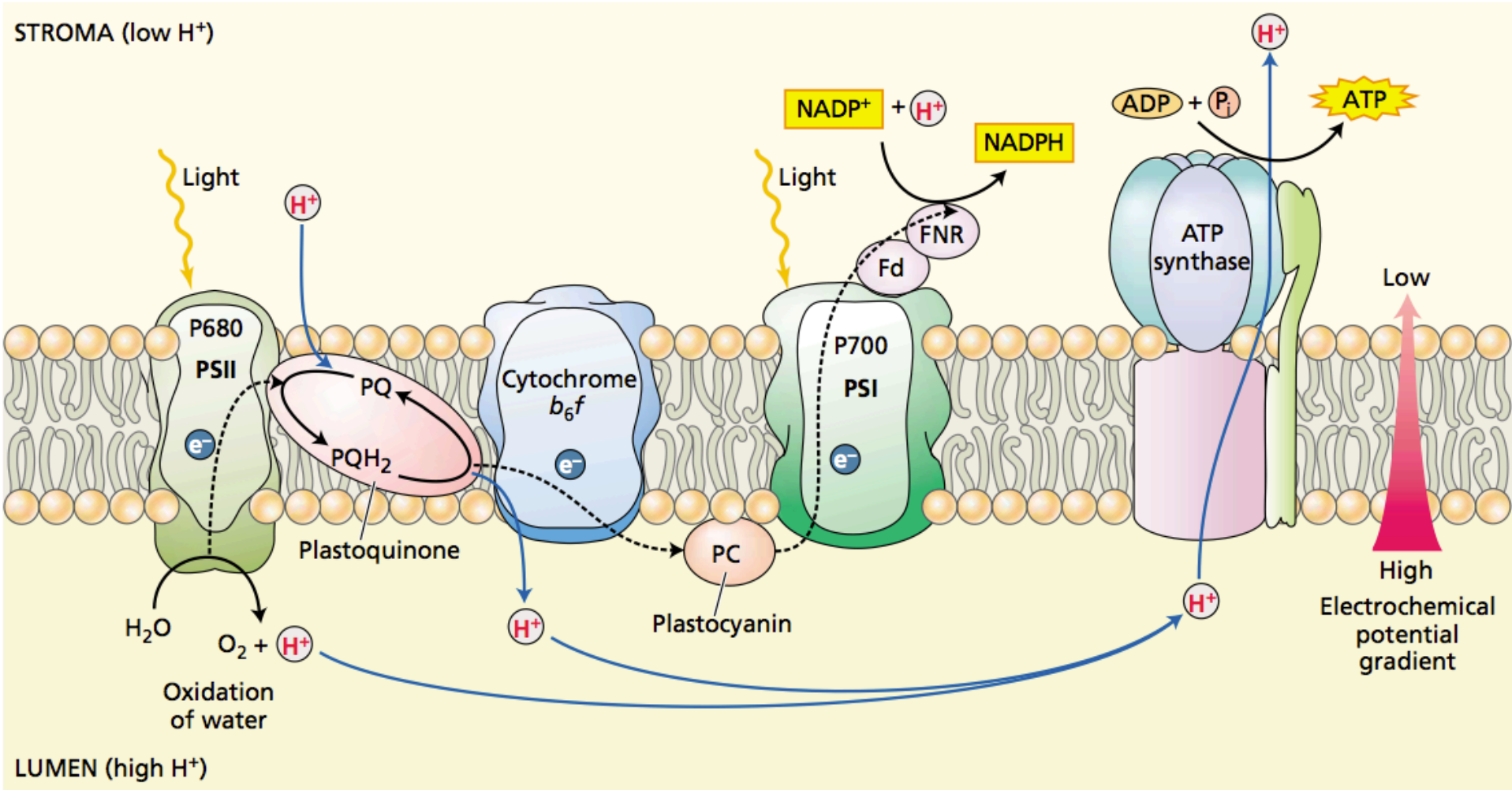


The photosynthetic electron chain



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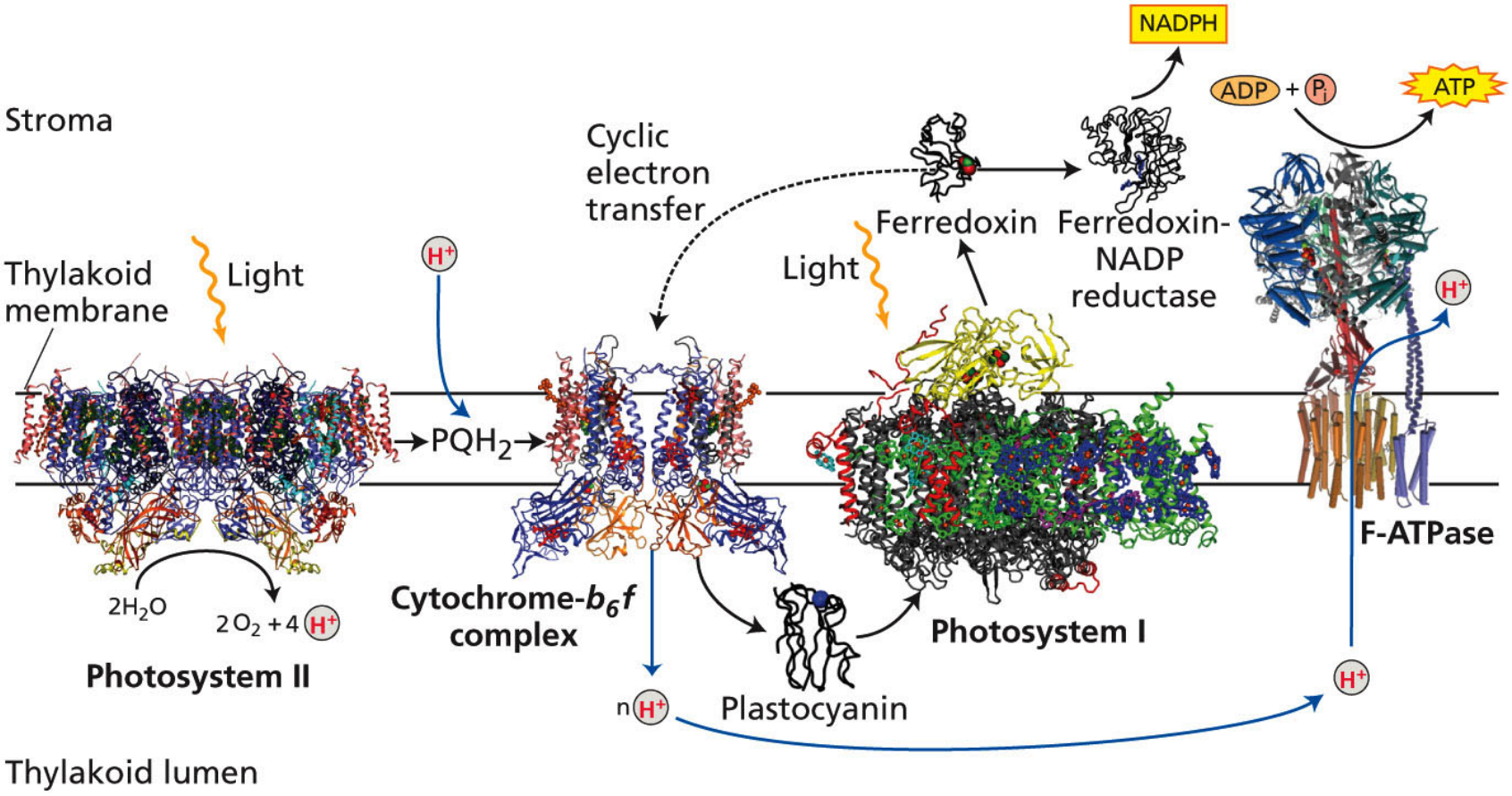
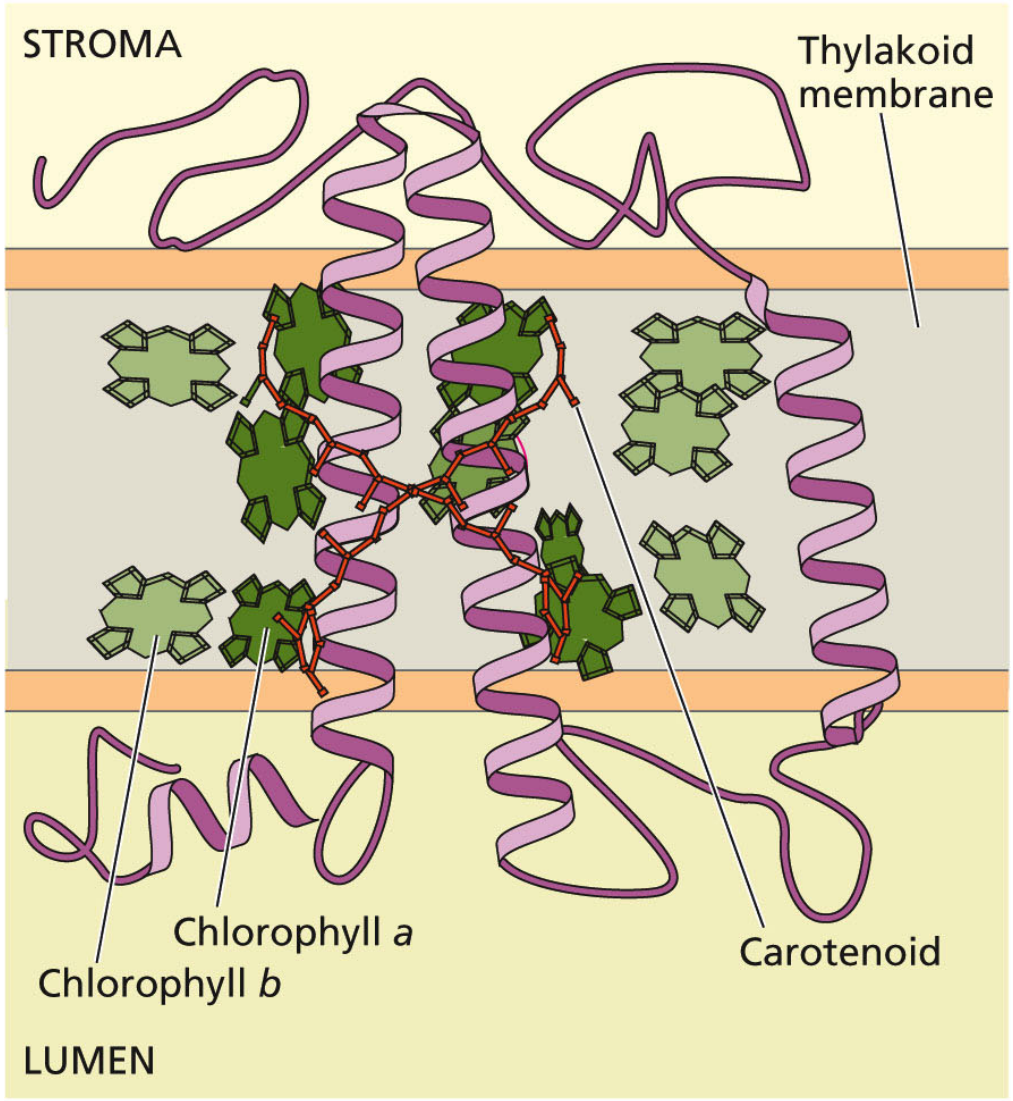
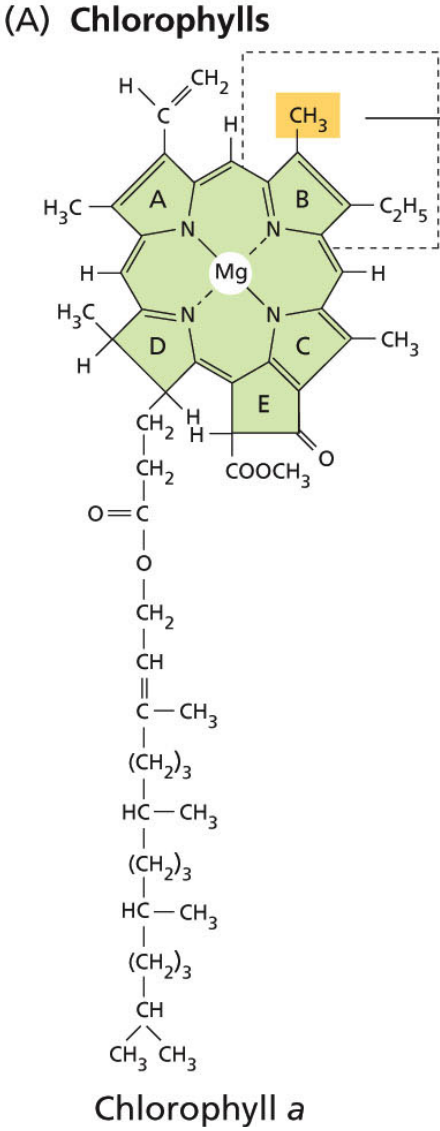
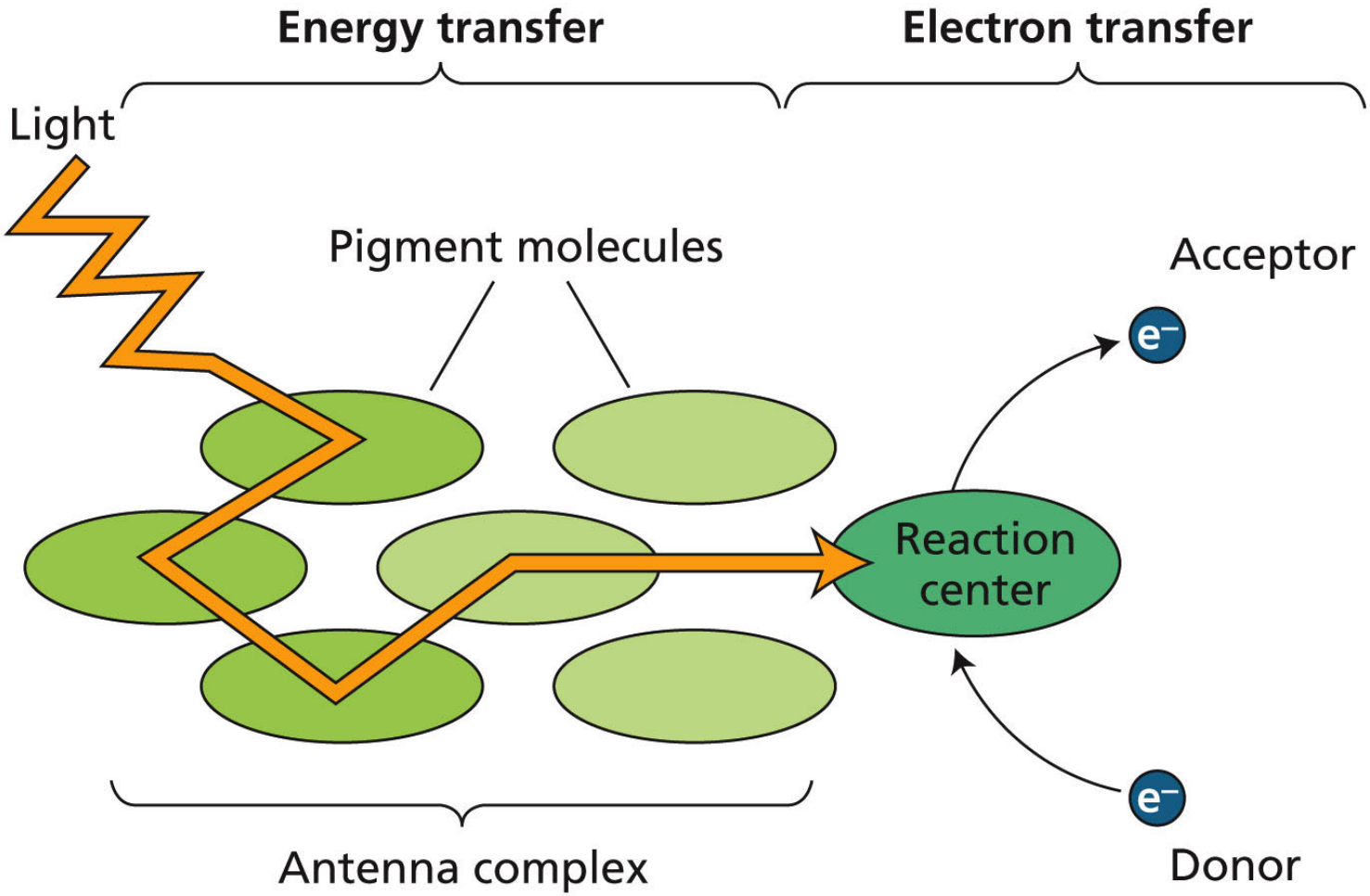


The photosynthetic proteins bind pigments (e.g. chlorophylls)





Basic concept of energy transfer during photosynthesis



INTRODUCTION

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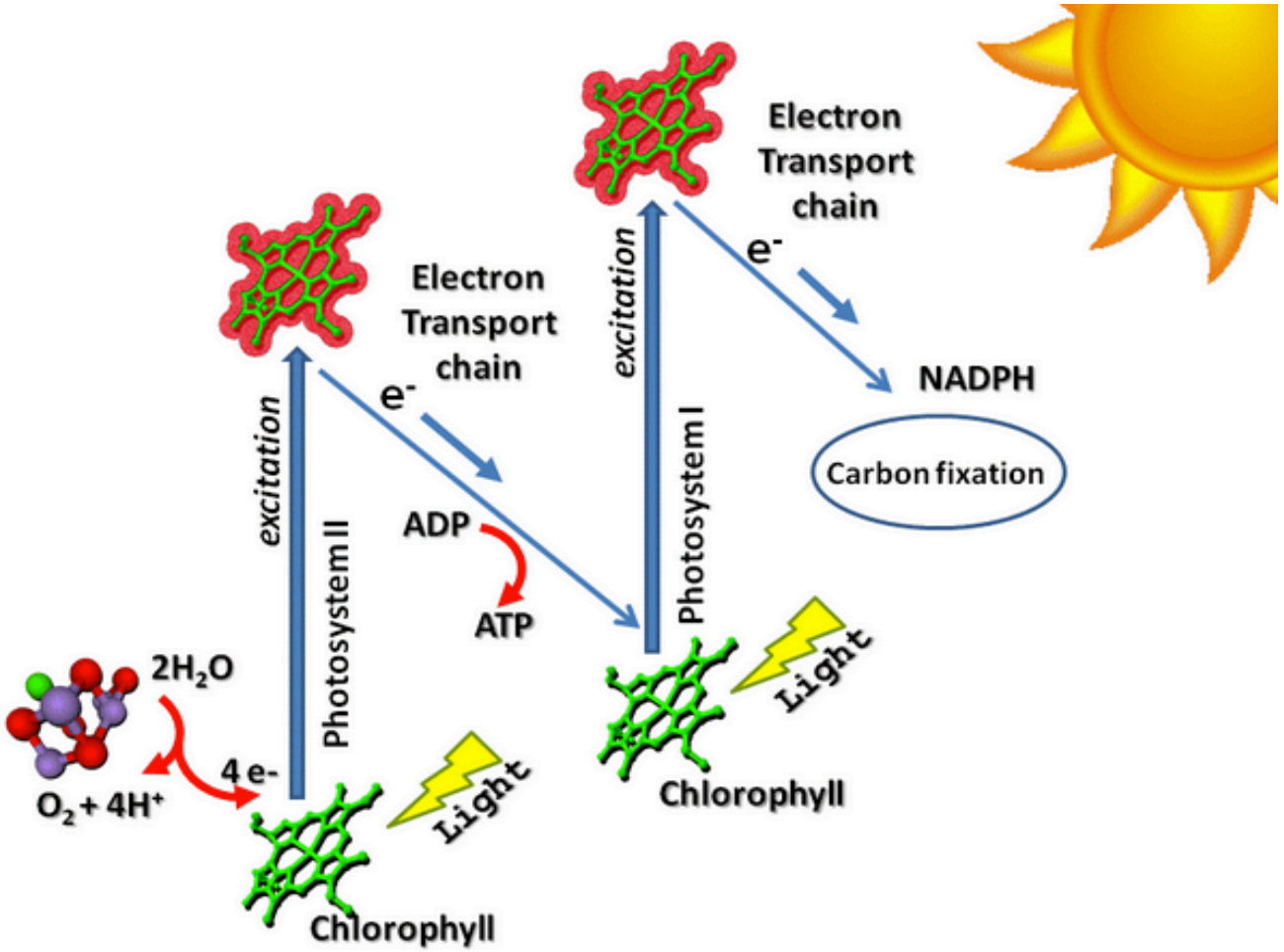

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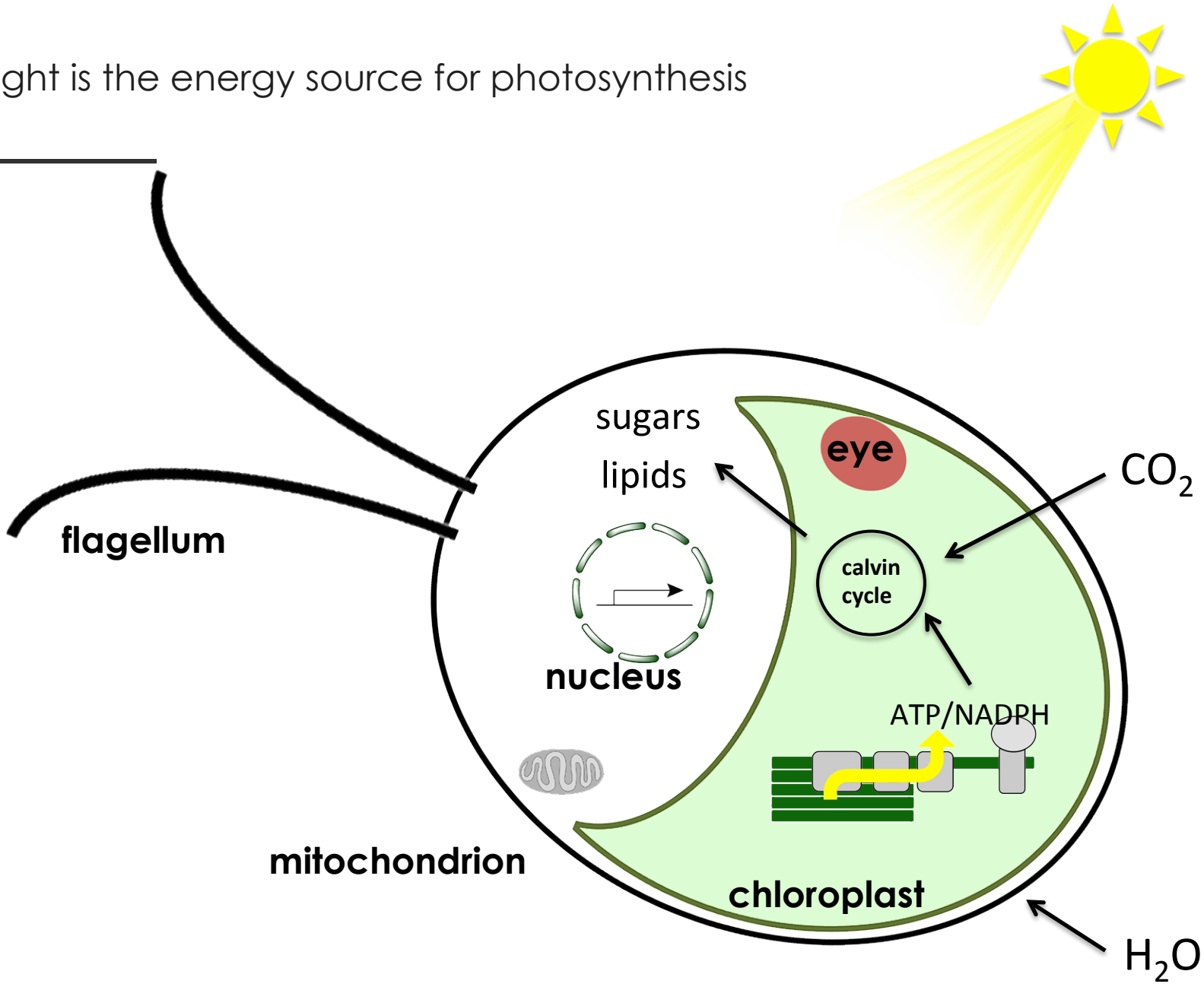
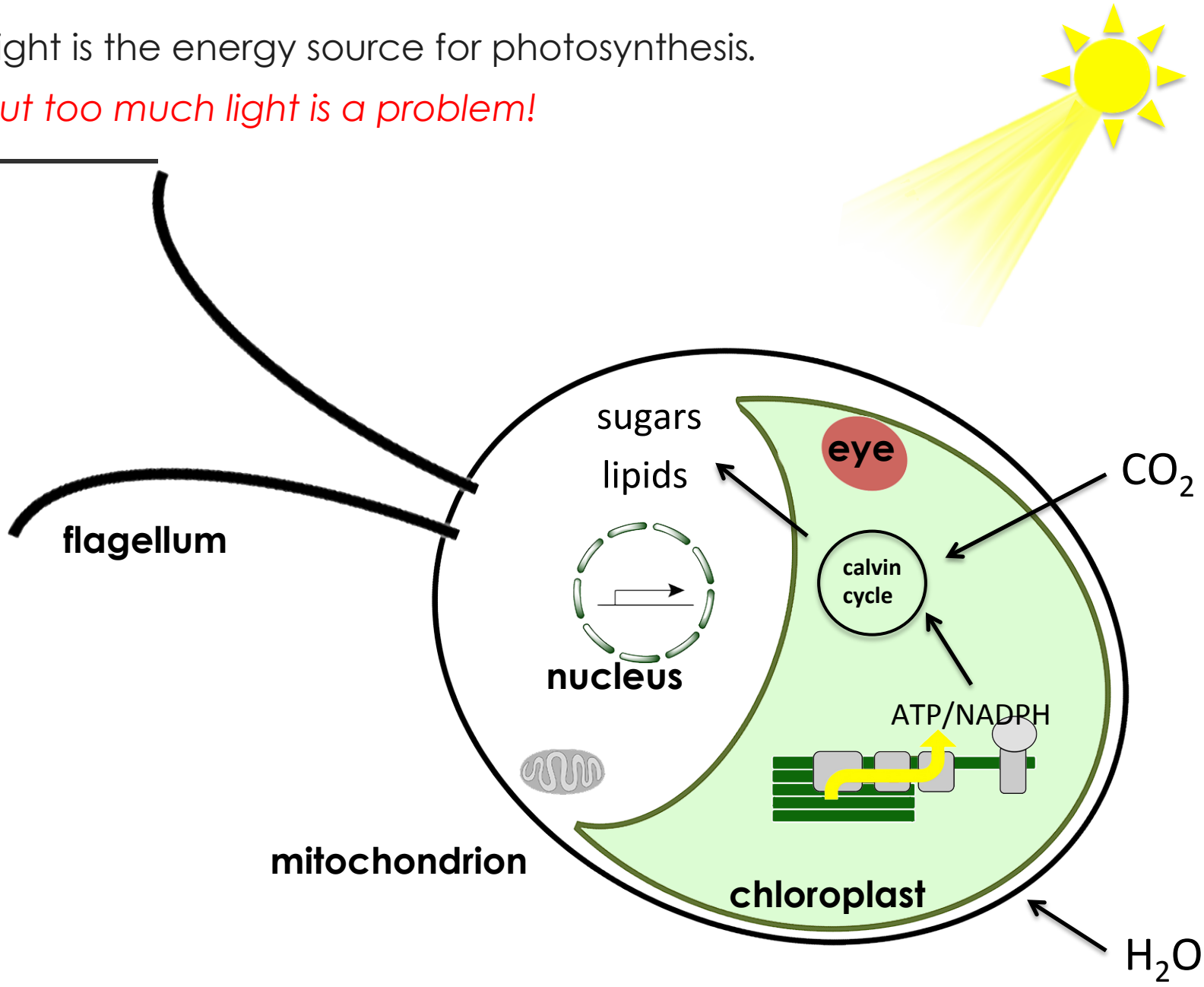


Light is the energy source for photosynthesis.

But too much light is a problem!



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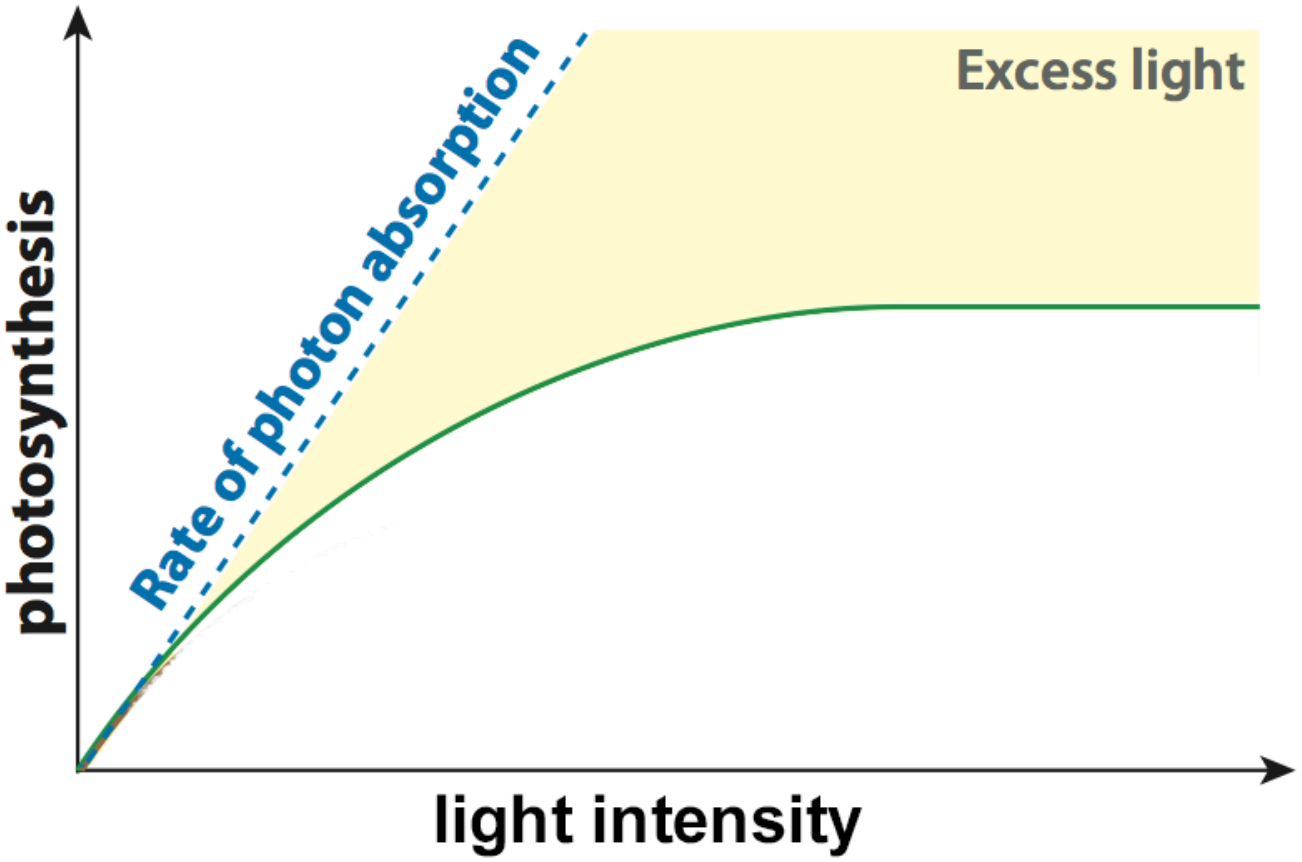
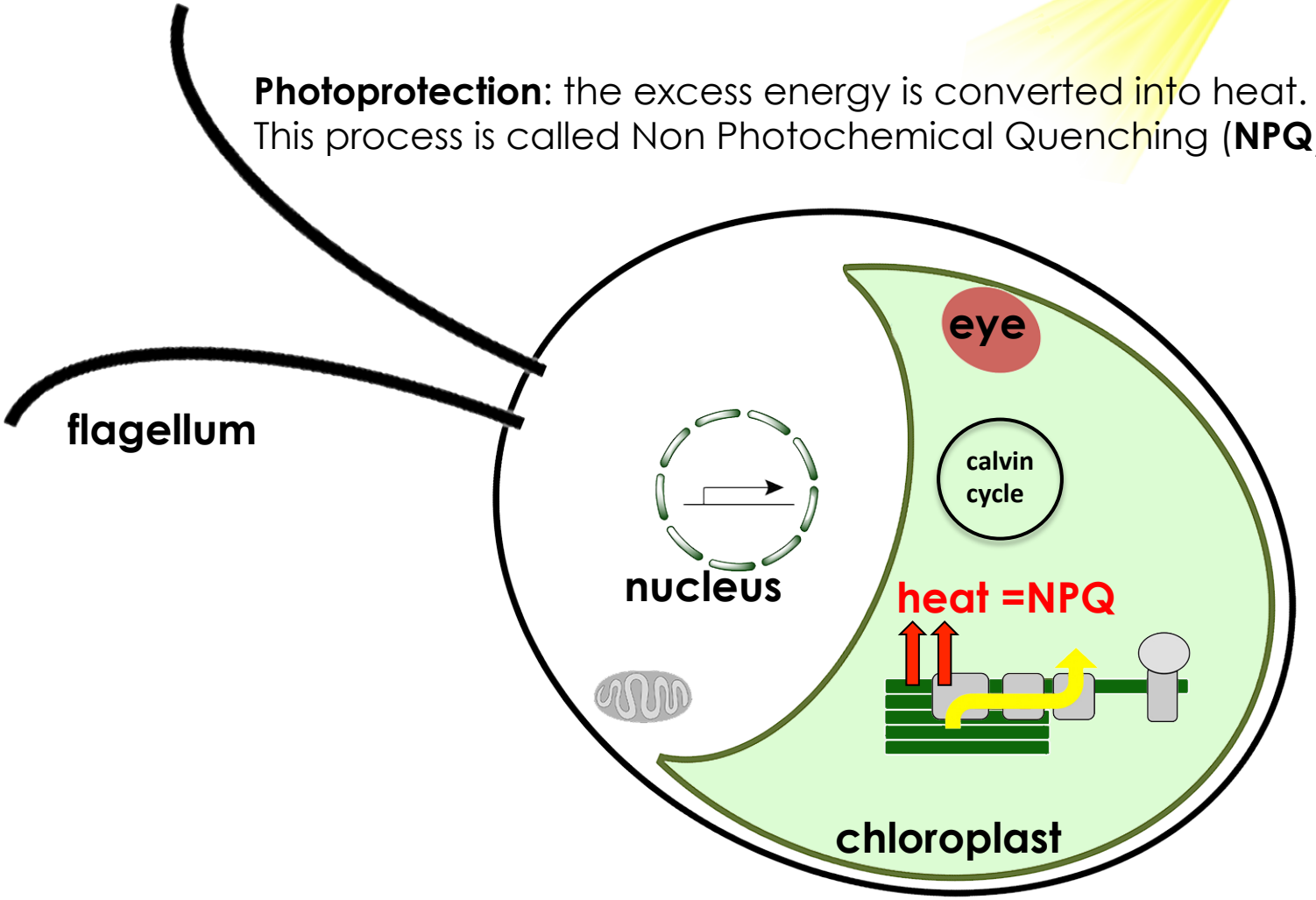


Li et al 2009

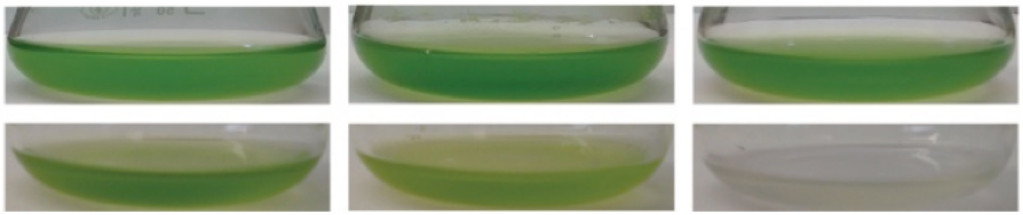
Excess light causes oxidative stress and cell death

Photoprotection: the excess energy is converted into heat.
This process is called Non Photochemical Quenching (**NPQ**)



DATA FROM OUR LAB

Excess light is lethal if the cells have no NPQ (photoprotection)



light intensity in a room: 10
fully sunny day: 1000-2000

µmol photons m^{-2} s^{-1}

In green algae NPQ requires the protein LHCSR3

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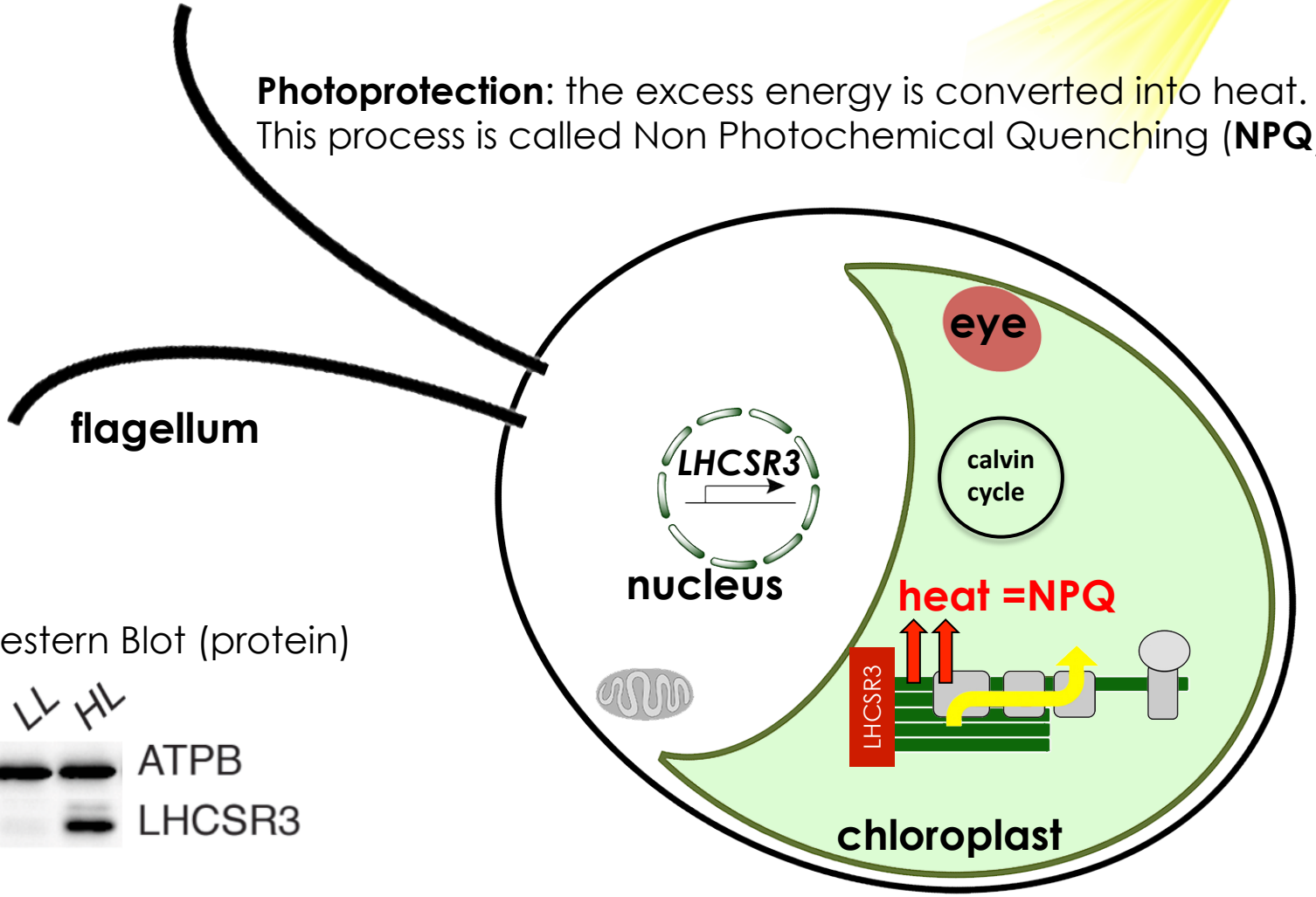
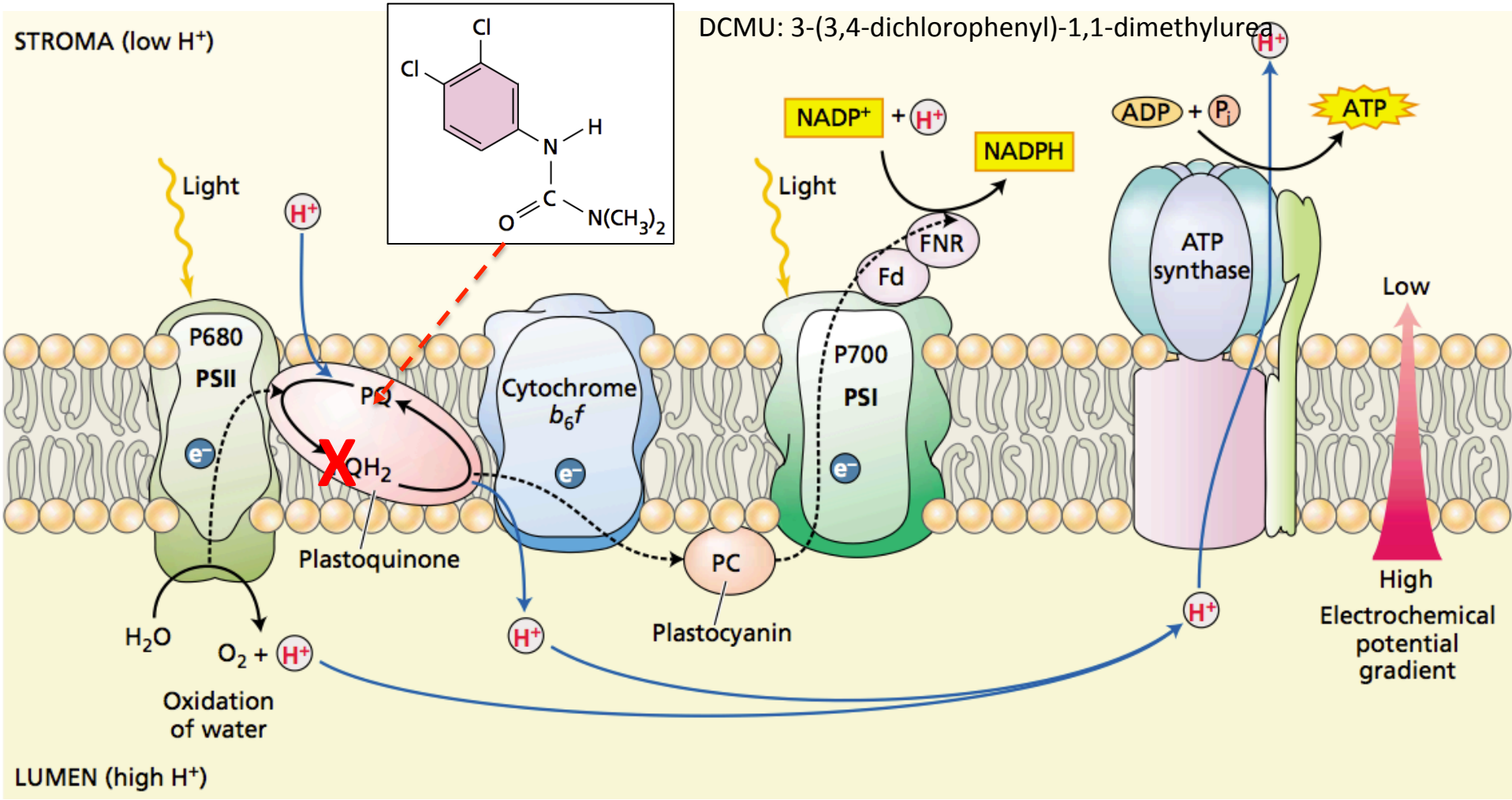


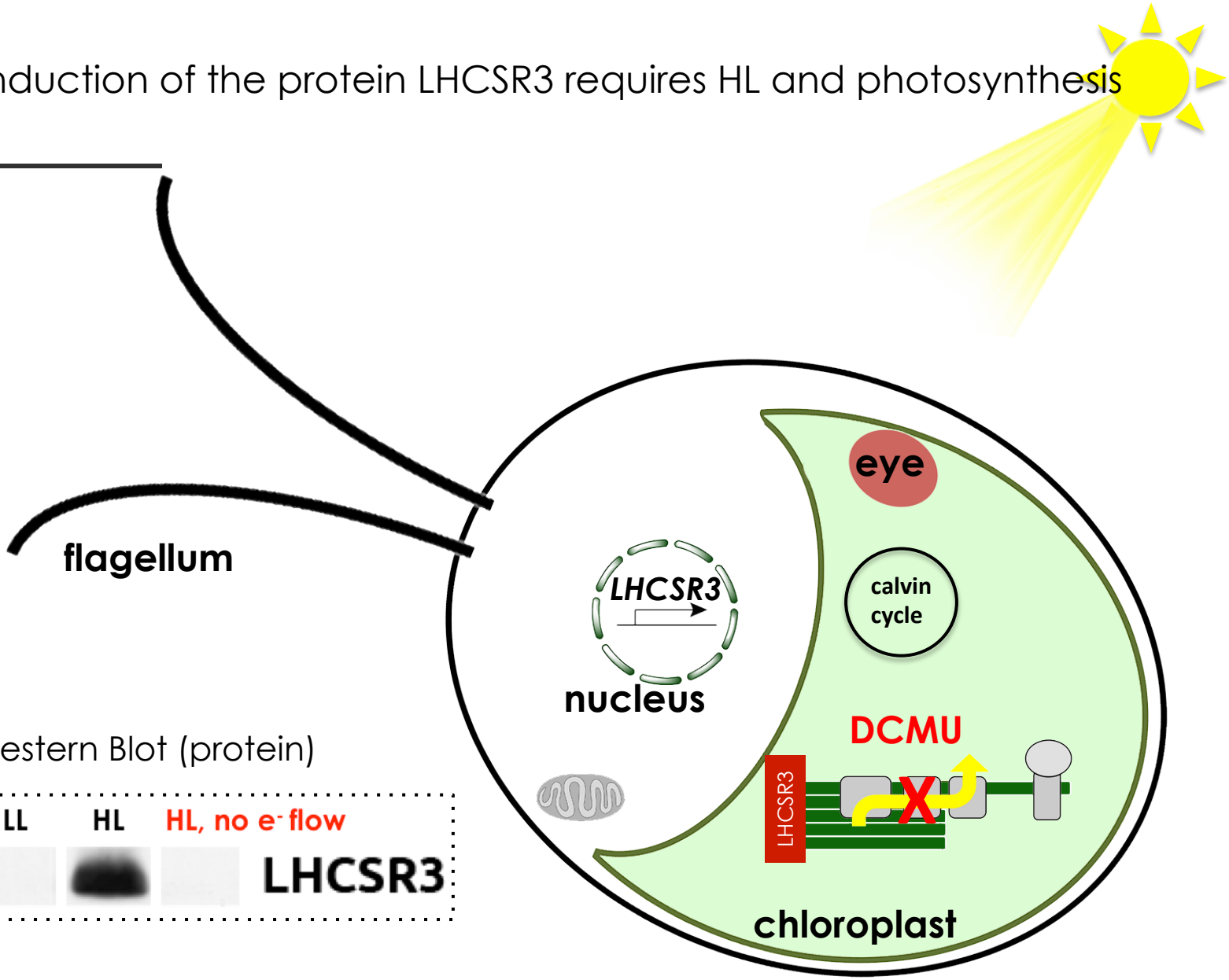
Western Blot (protein)

DCMU is a specific inhibitor of photosynthesis



DATA FROM OUR LAB

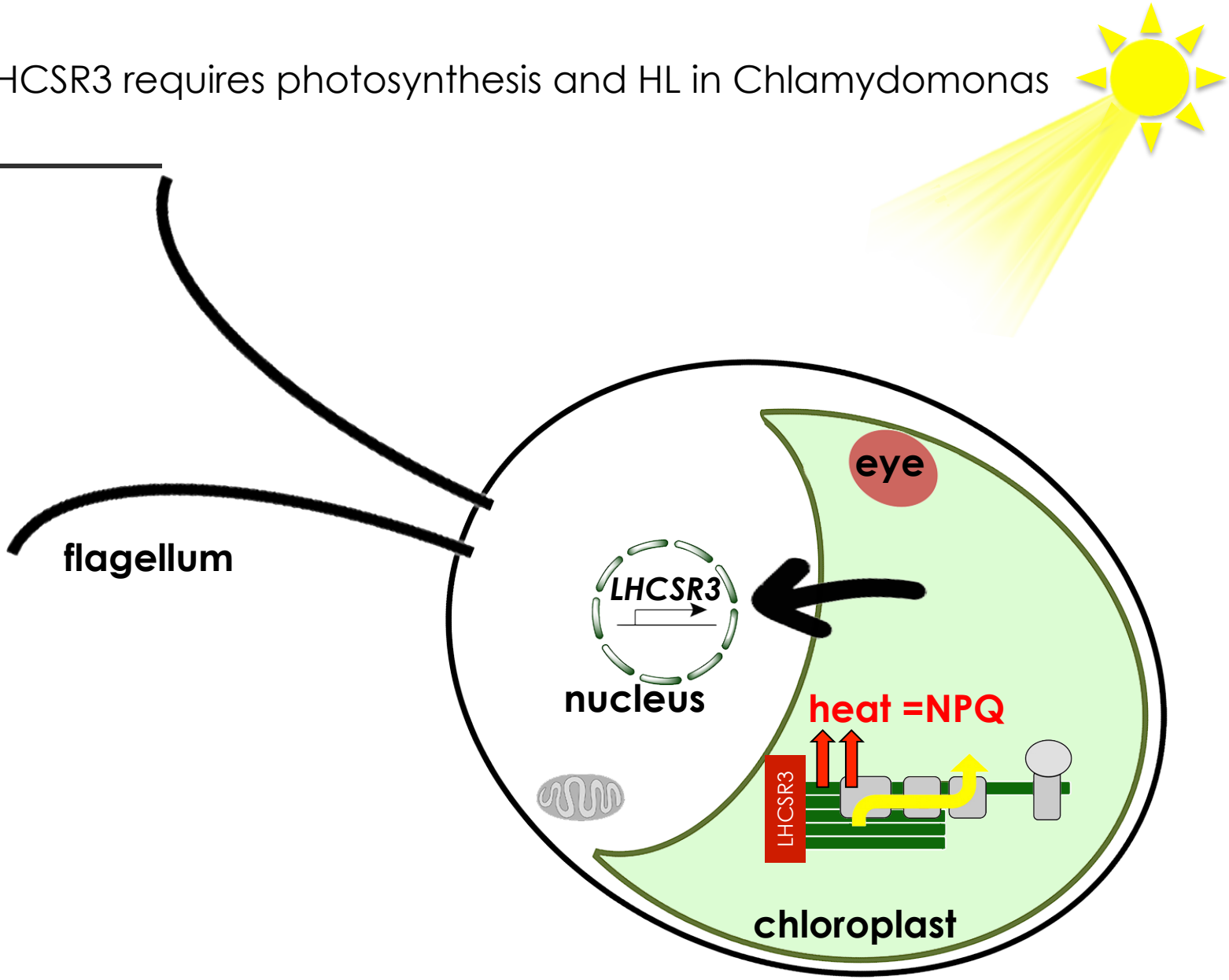
Induction of the protein LHCSR3 requires HL and photosynthesis



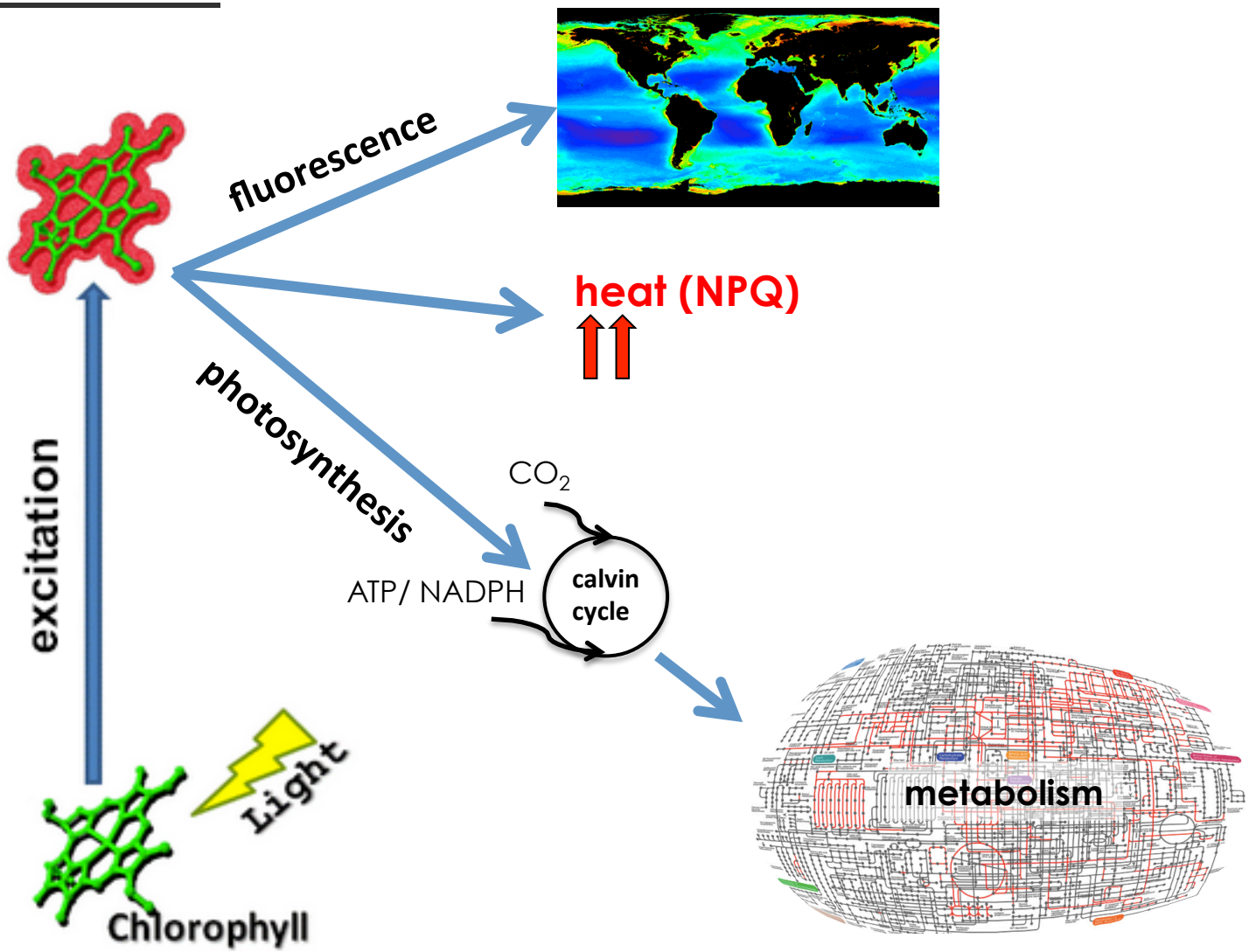
Western Blot (protein)

CONCLUSIONS (I)

LHCSR3 requires photosynthesis and HL in Chlamydomonas



We can measure photosynthesis *in vivo* using chlorophyll fluorescence



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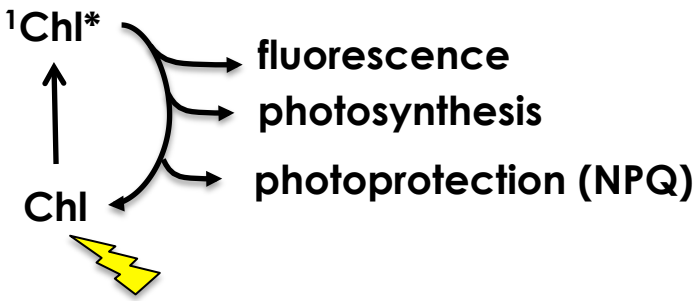

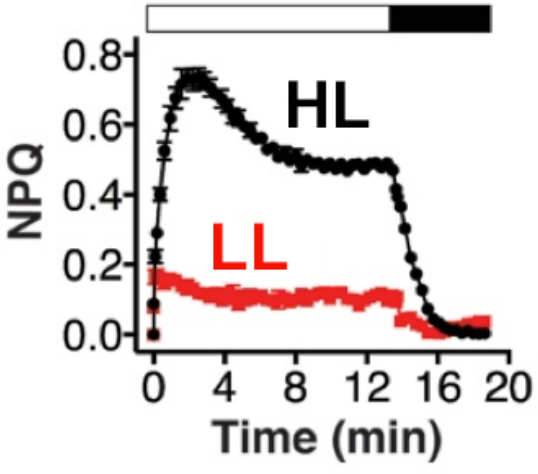

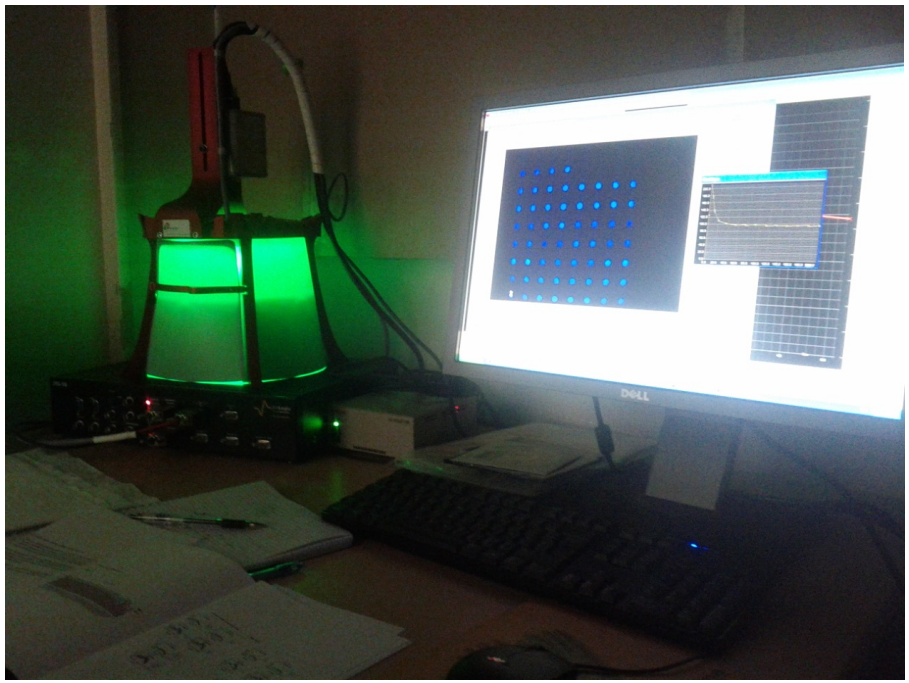

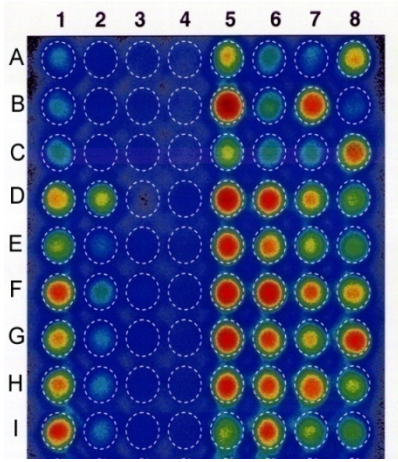

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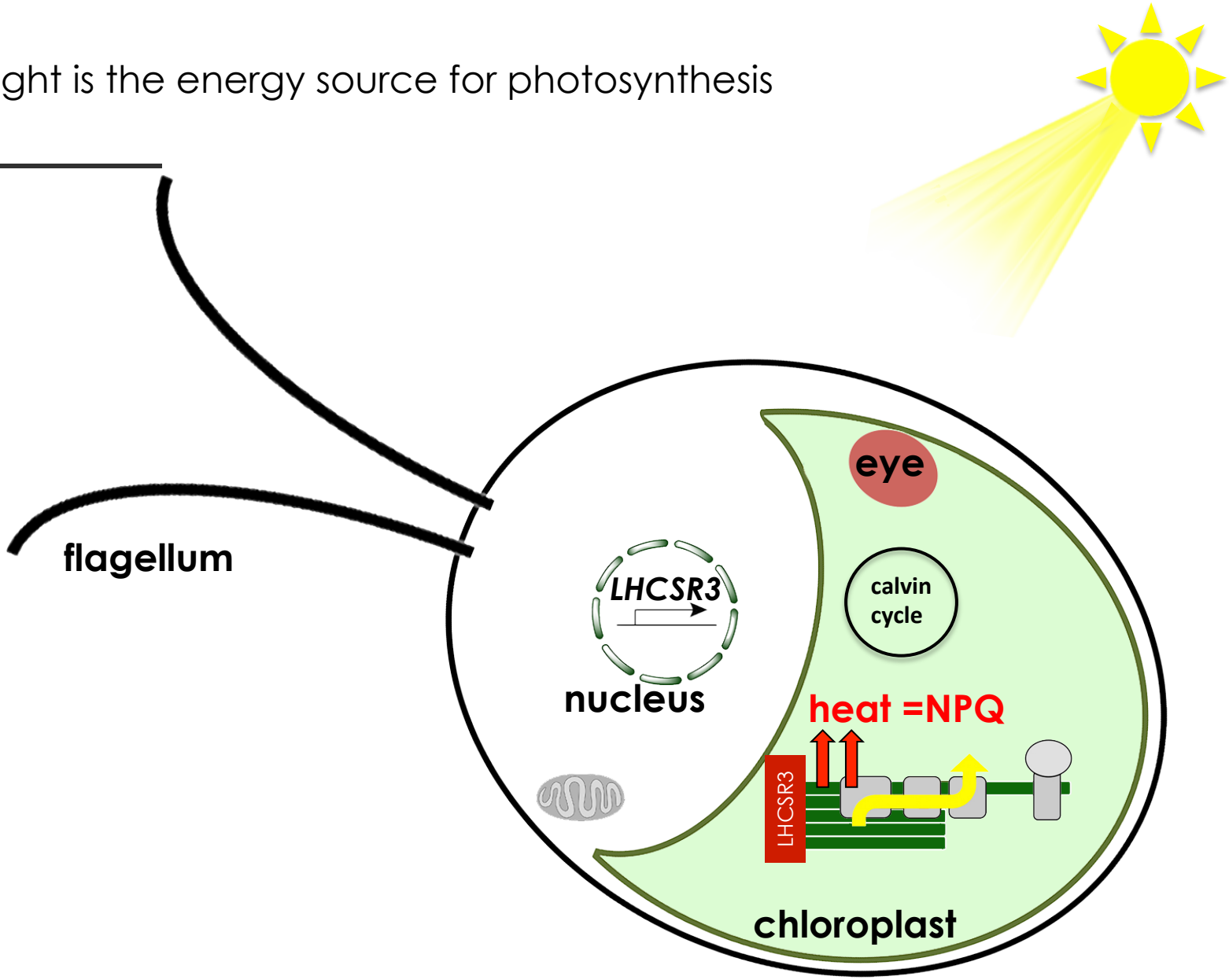
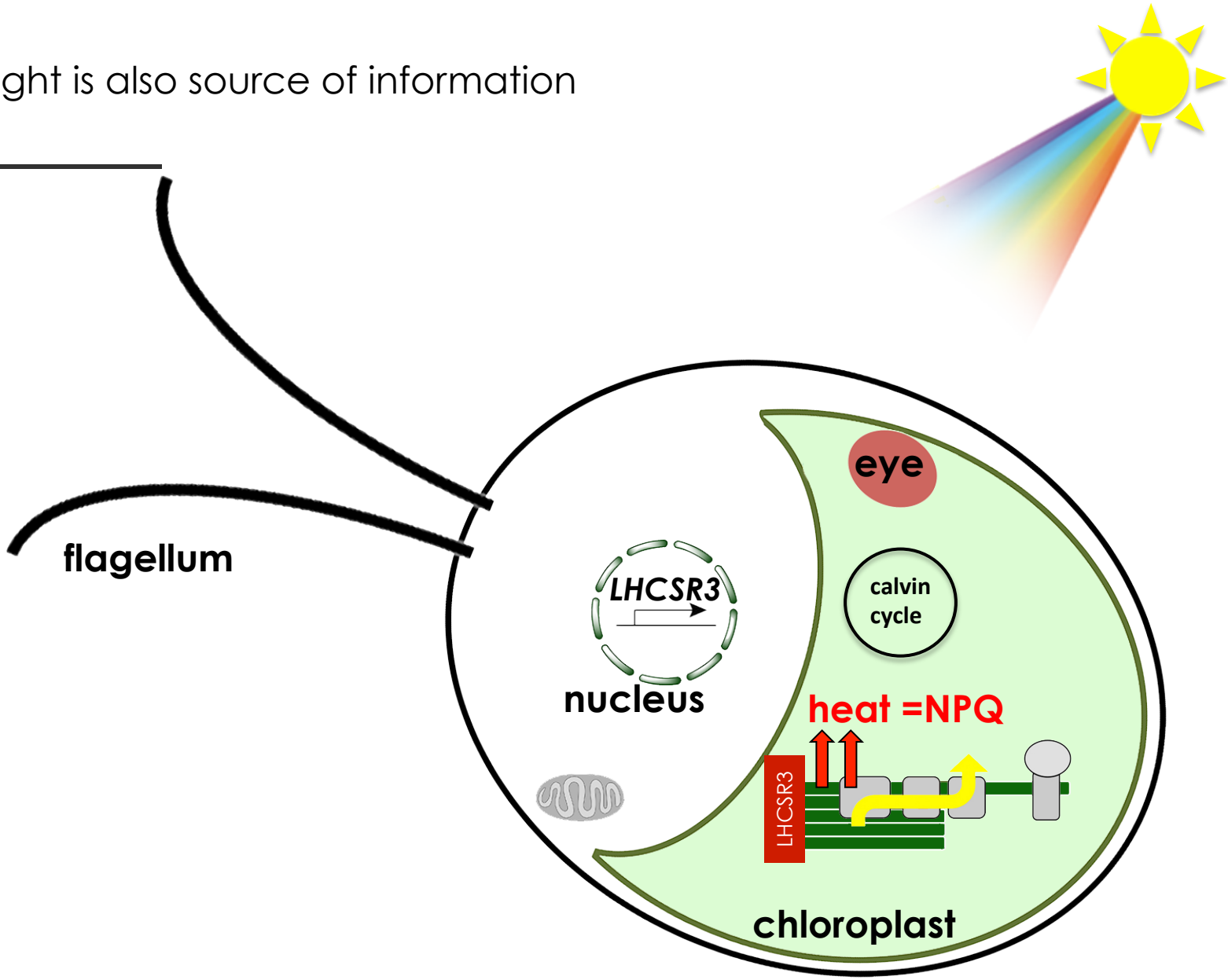
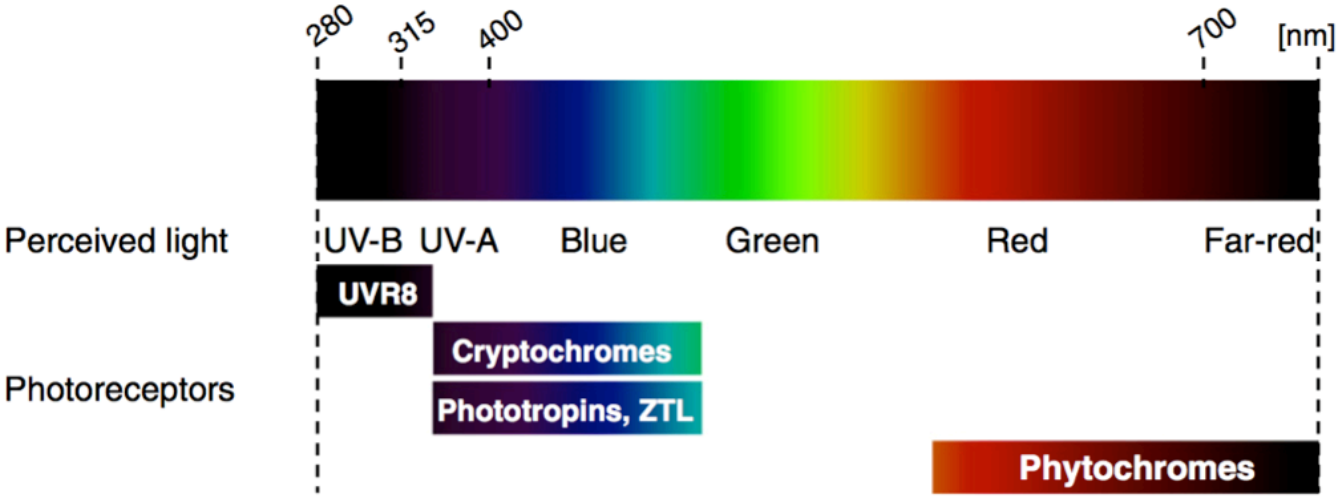


Light is also source of information



Light is an informational signal perceived by photoreceptor proteins

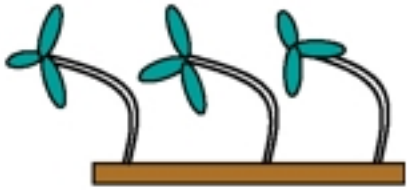


Control of developmental processes, photoorientation, circadian clock

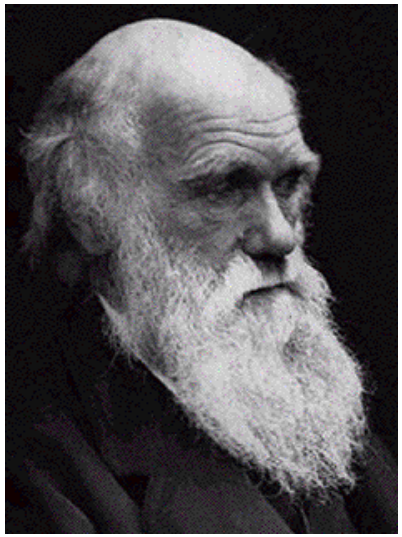
Heijde and Ulm 2012, Trends in Plant Science

The phototropic response of plants

Sun Light

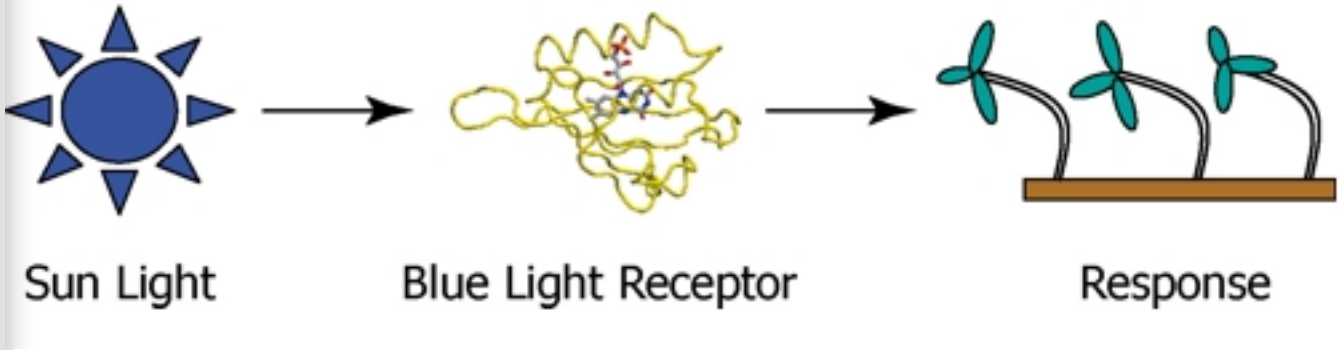


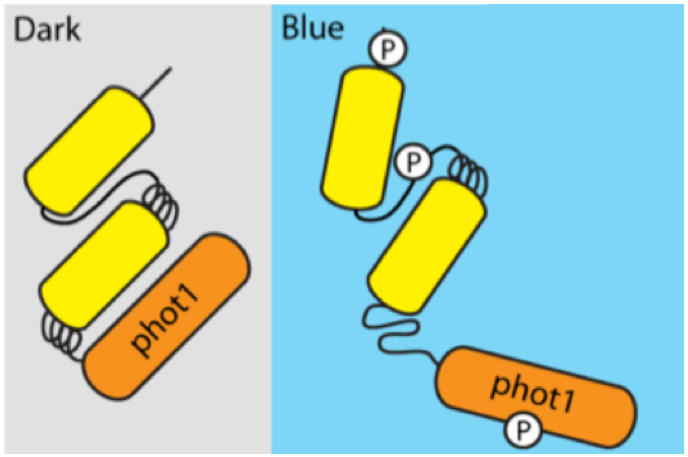
Response



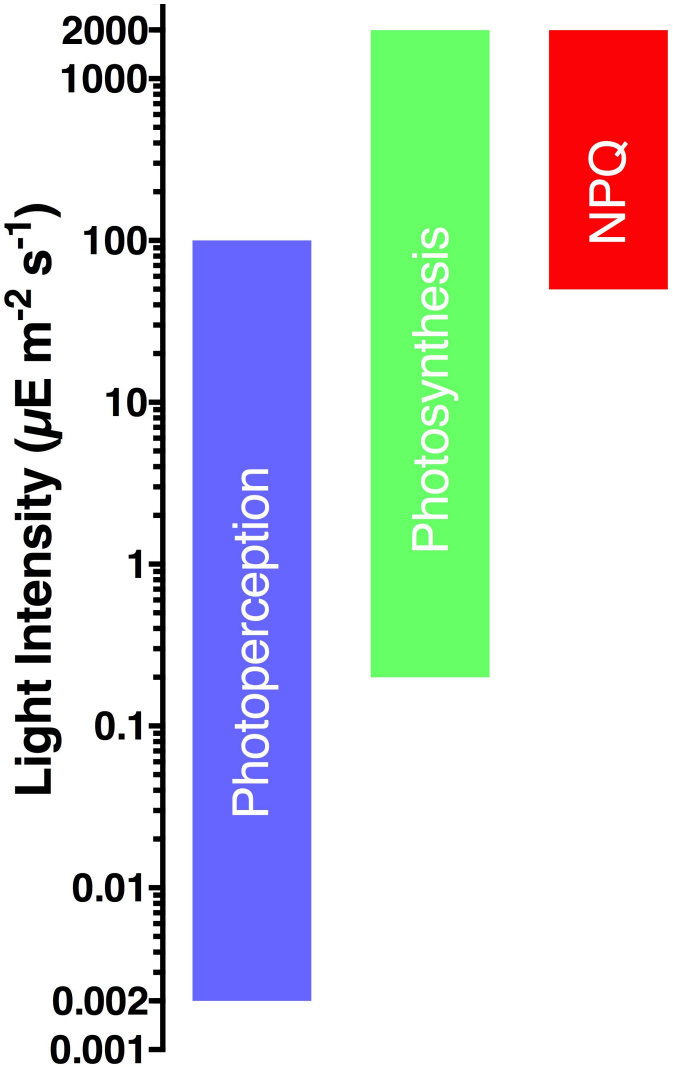
Charles Darwin 1881, Darwin C (1881)
The Power of Movement in Plants

The phototropic response of plants is mediated by the blue light photoreceptor phototropin





Photoperception, photosynthesis and NPQ are activated at very different light intensities



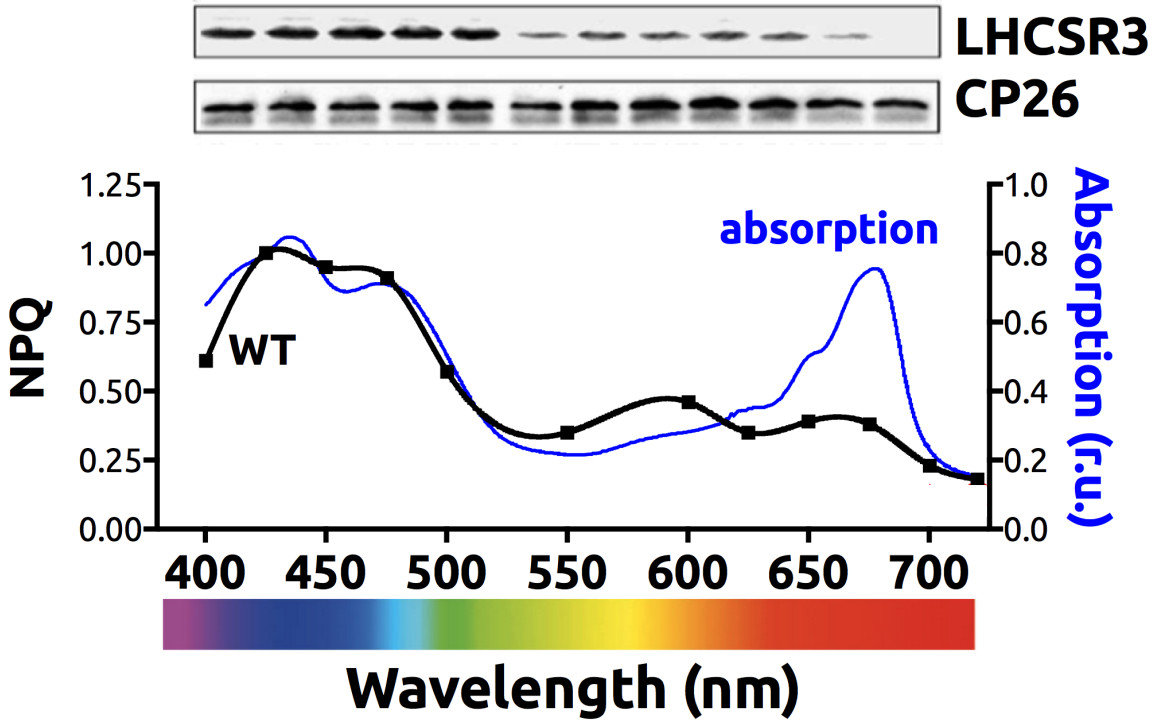
RESEARCH QUESTION

Is LHCSR3 under control of a photoreceptor?

Okazaki Large Spectrograph

DATA FROM OUR LAB

Blue light has a prominent role in inducing LHCSR3 and NPQ



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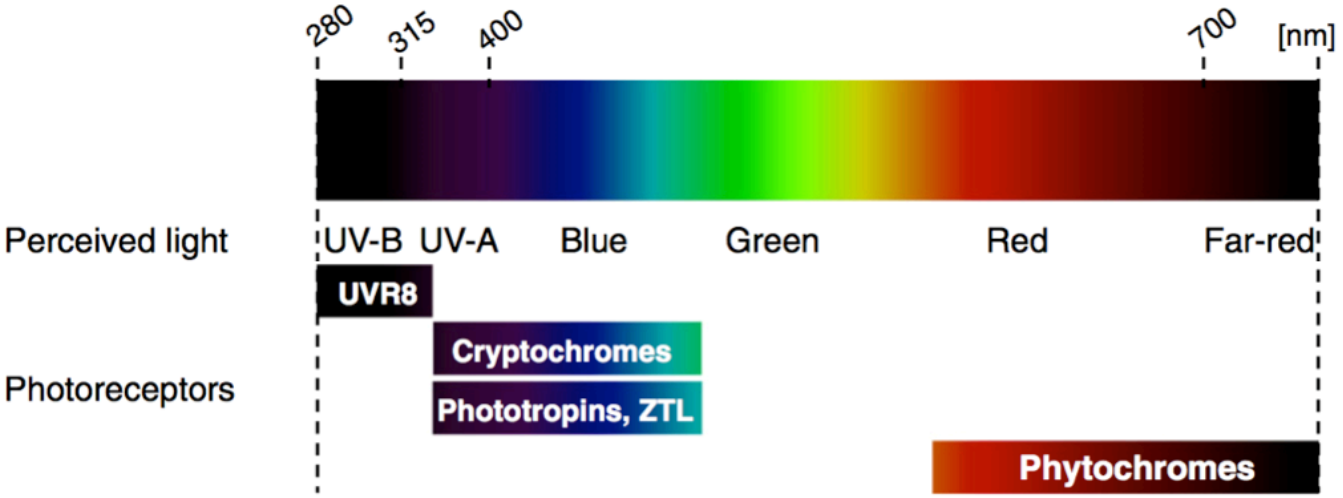
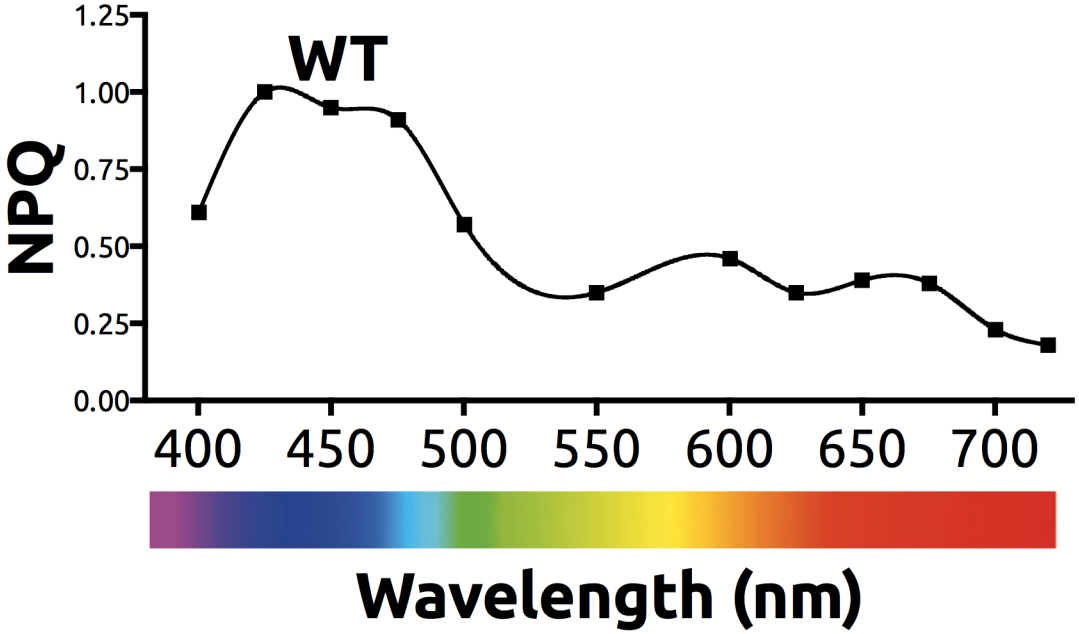


Heijde and Ulm 2012, Trends in Plant Science

DATA FROM OUR LAB

Hunting the blue light photoreceptor that controls LHCSR3 and NPQ induction

LHCSR3 in WT



DATA FROM OUR LAB

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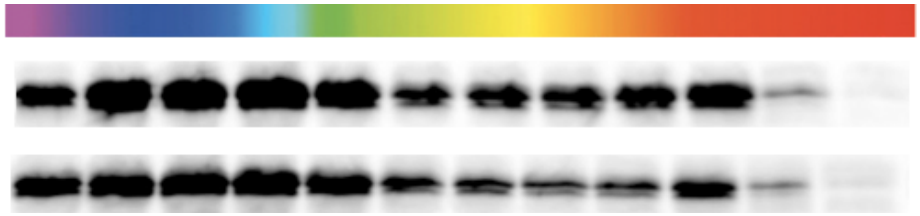
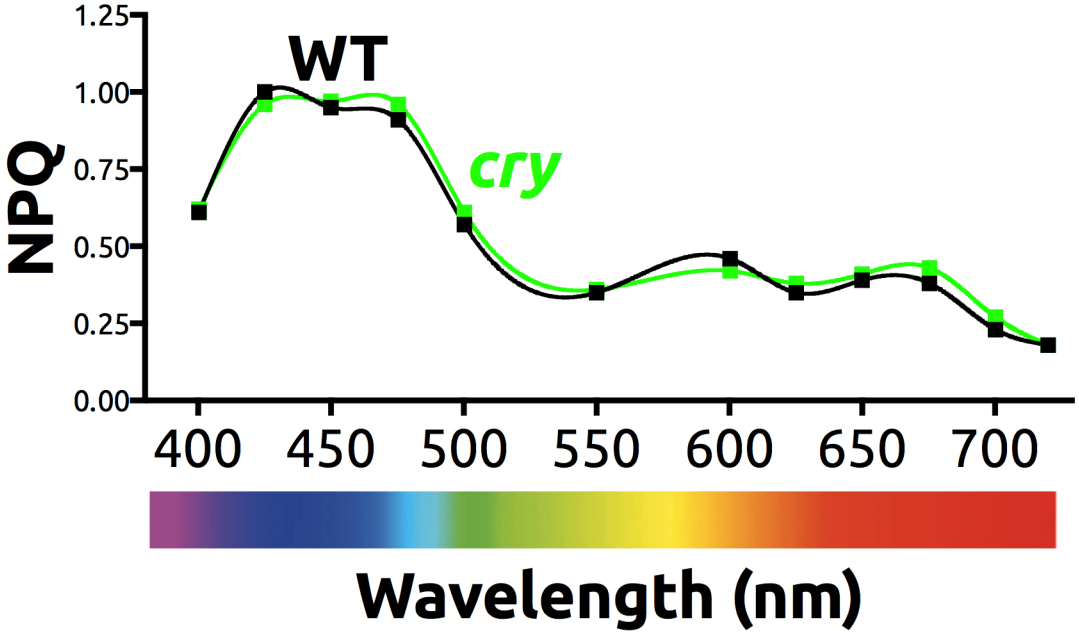


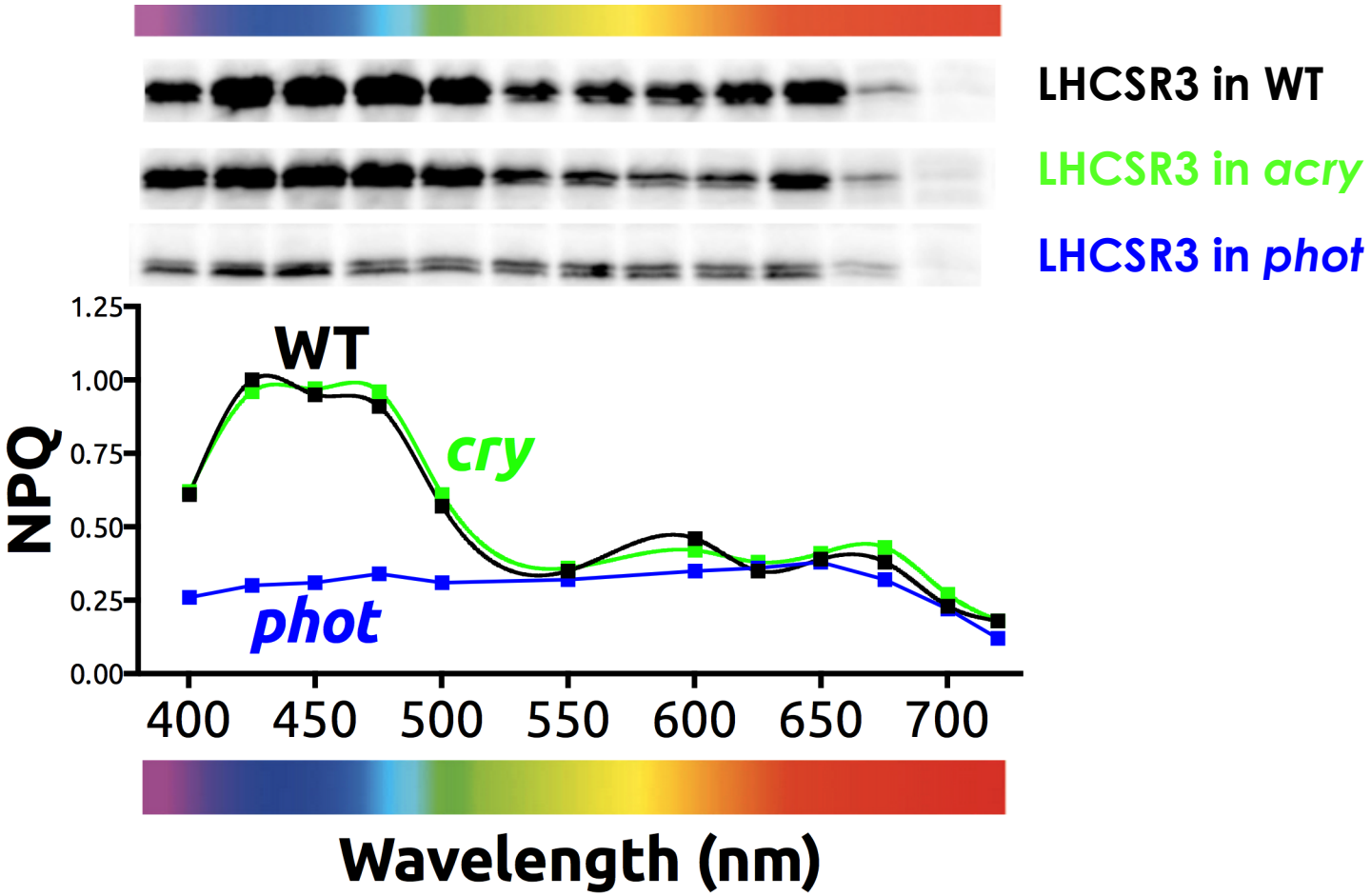
LHCSR3 in WT

LHCSR3 in *acry*



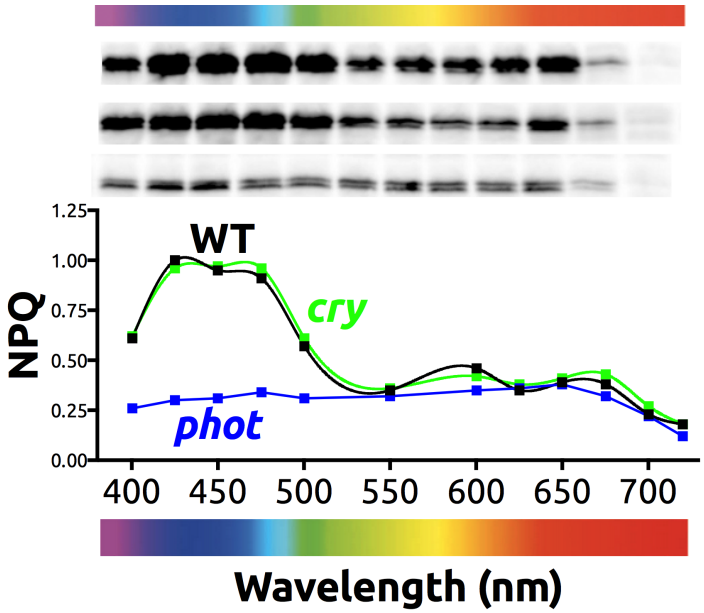
DATA FROM OUR LAB

PHOTOTROPIN is the blue light photoreceptor that controls LHCSR3 and NPQ in Chlamydomonas

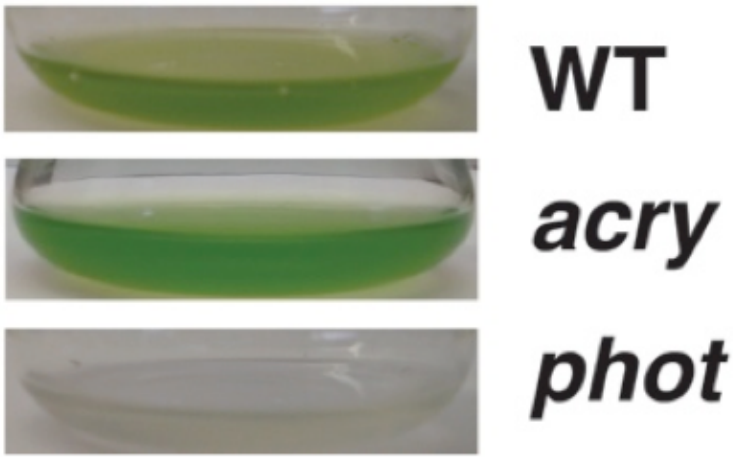


DATA FROM OUR LAB

The *phot* mutant is highly photosensitive

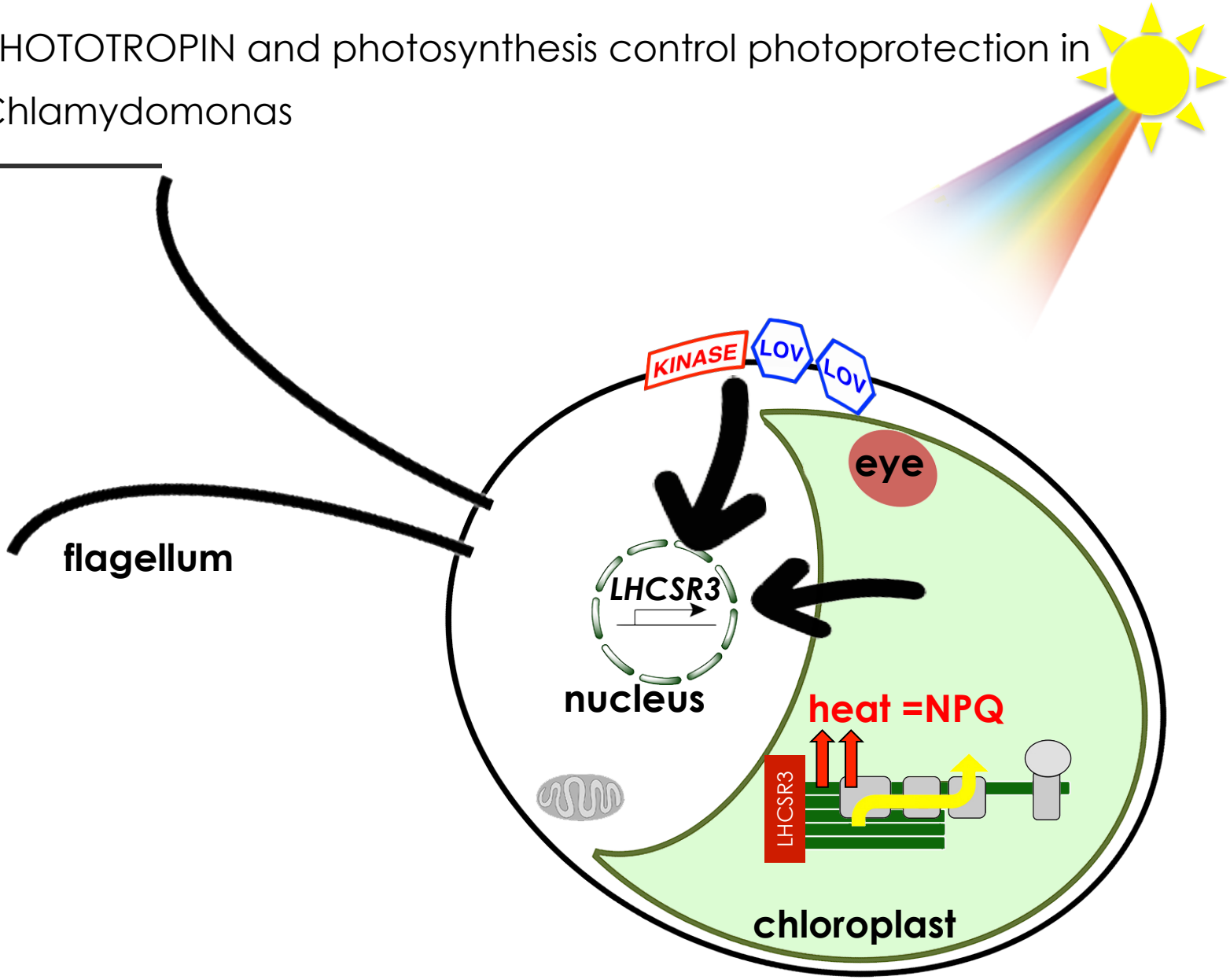


LHCSR3 in WT
LHCSR3 in *acry*
LHCSR3 in *phot*

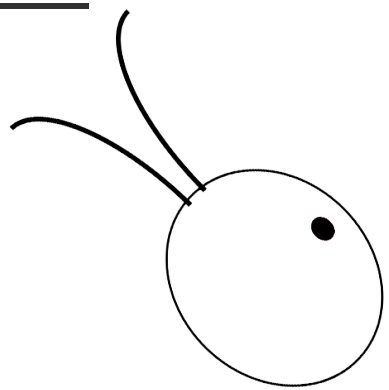


CONCLUSIONS (II)

PHOTOTROPIN and photosynthesis control photoprotection in Chlamydomonas



PHOTOTROPIN is localized in plasma membrane, in the and in the eye



engineered PHOTOTROPIN fused
to GFP: green fluorescent protein

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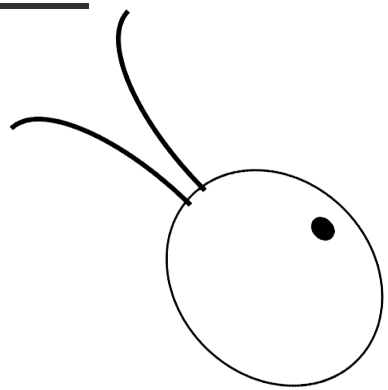

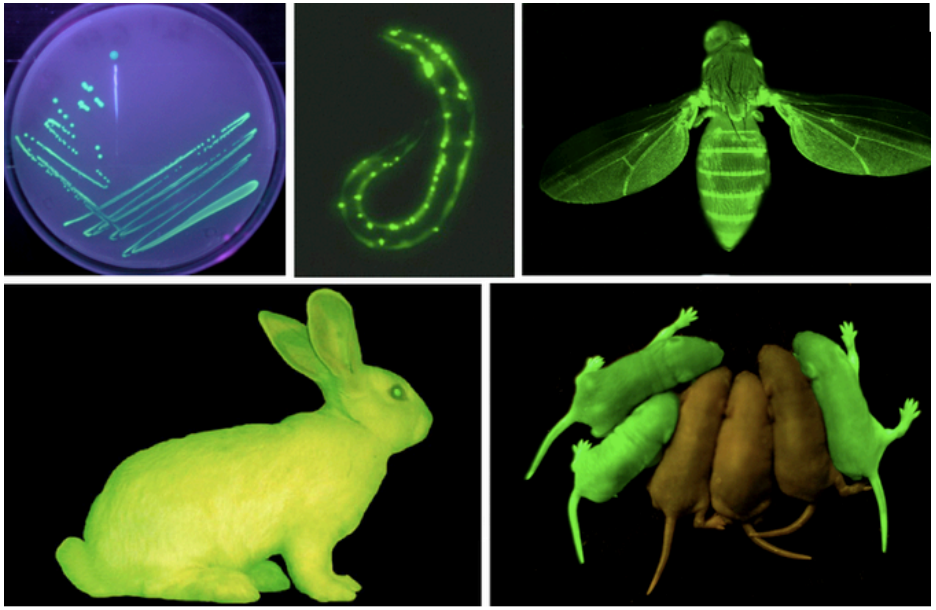

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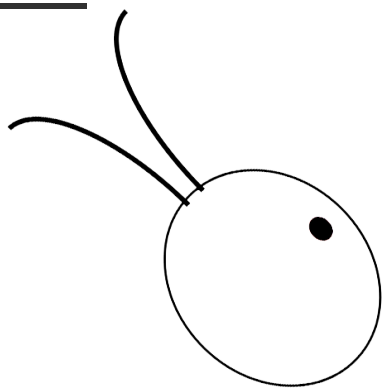

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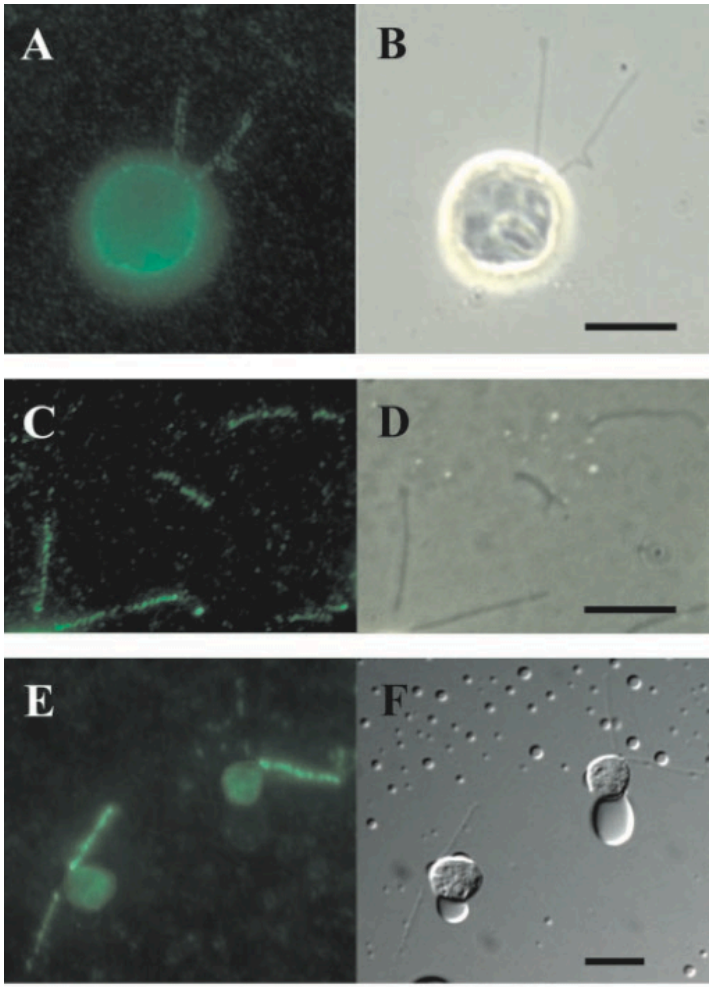
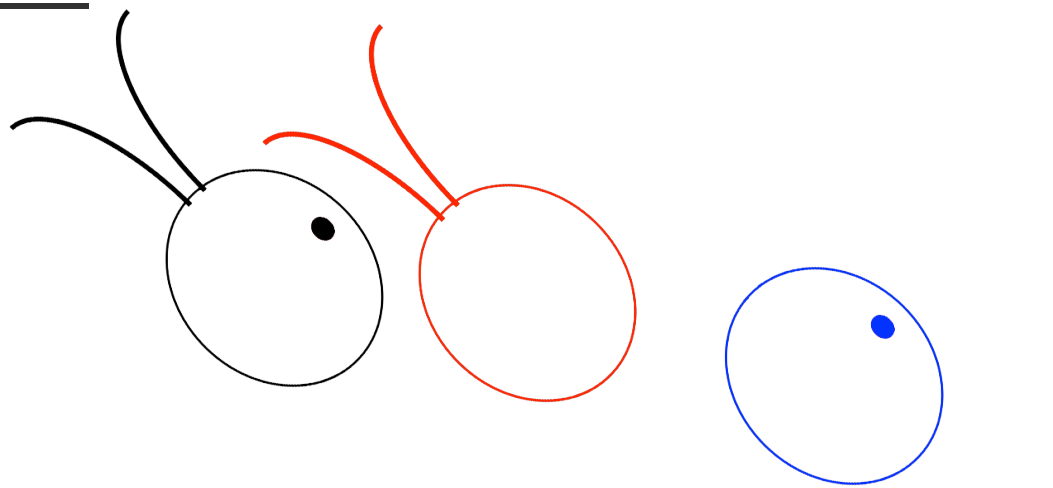


Huang et al. 2004

RESEARCH QUESTION

Is the different localization of PHOTOTROPIN important for the regulation of LHCSR3?



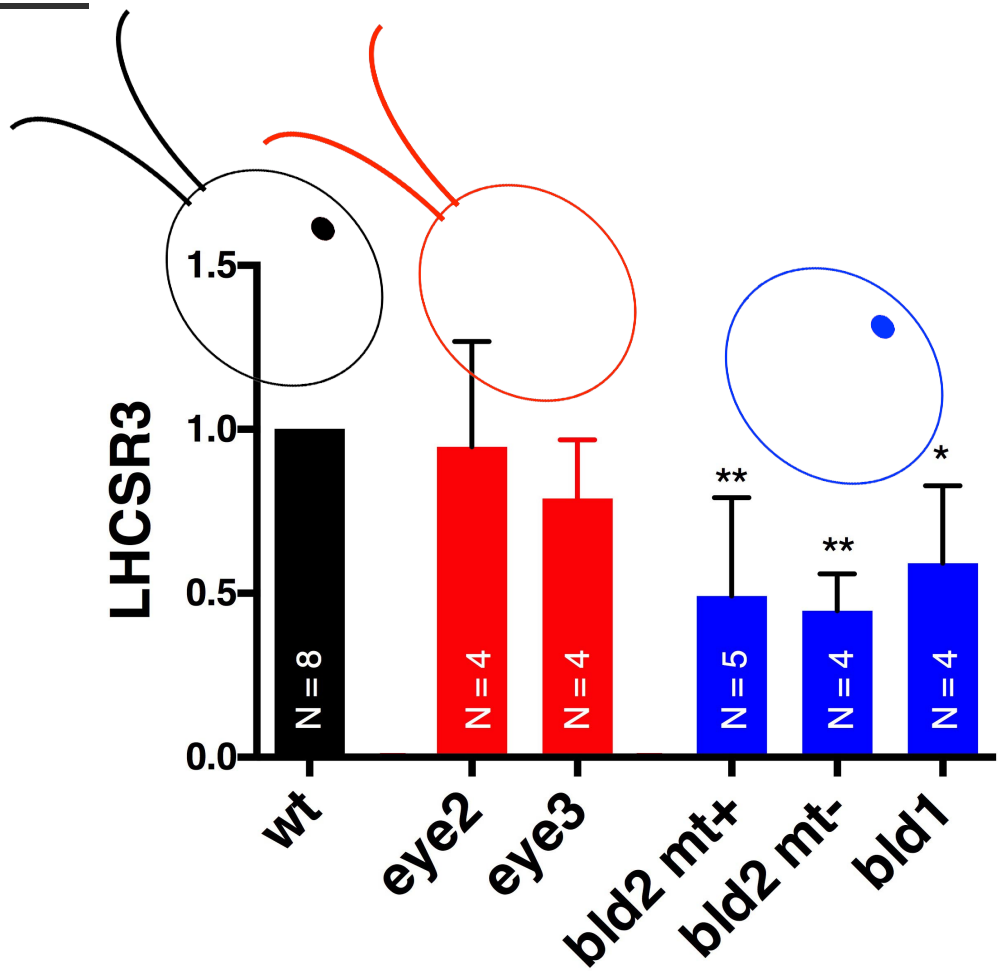
Wild Type

eye-less mutant

flagella-less mutant

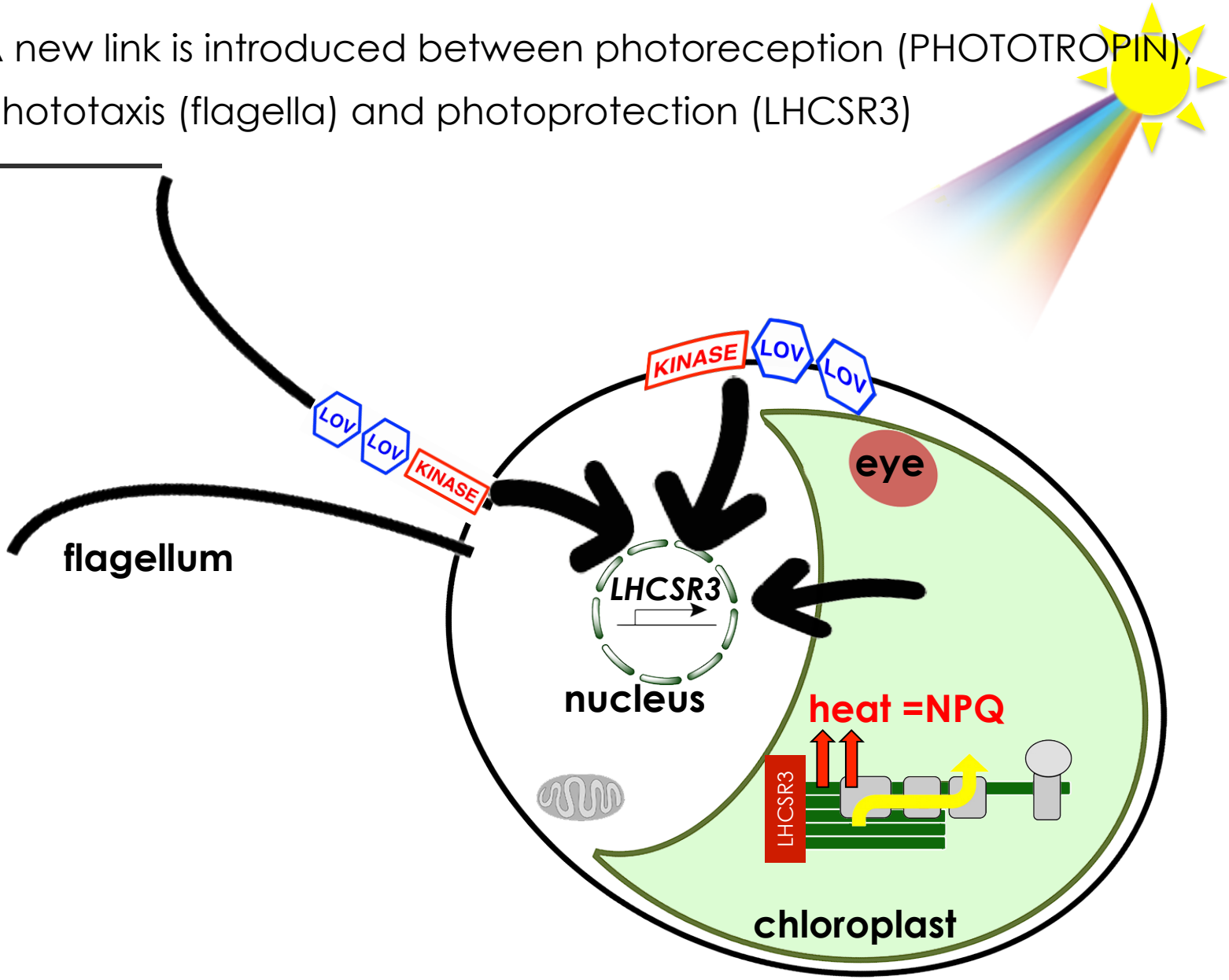
DATA FROM OUR LAB

flagella-localized and plasma-membrane localized PHOTOTROPIN are essential for LHCSR3 regulation



CONCLUSIONS (III)

A new link is introduced between photoreception (PHOTOTROPIN), phototaxis (flagella) and photoprotection (LHCSR3)



DISCUSSION

What is the importance of these new discoveries?

They advance knowledge in basic research

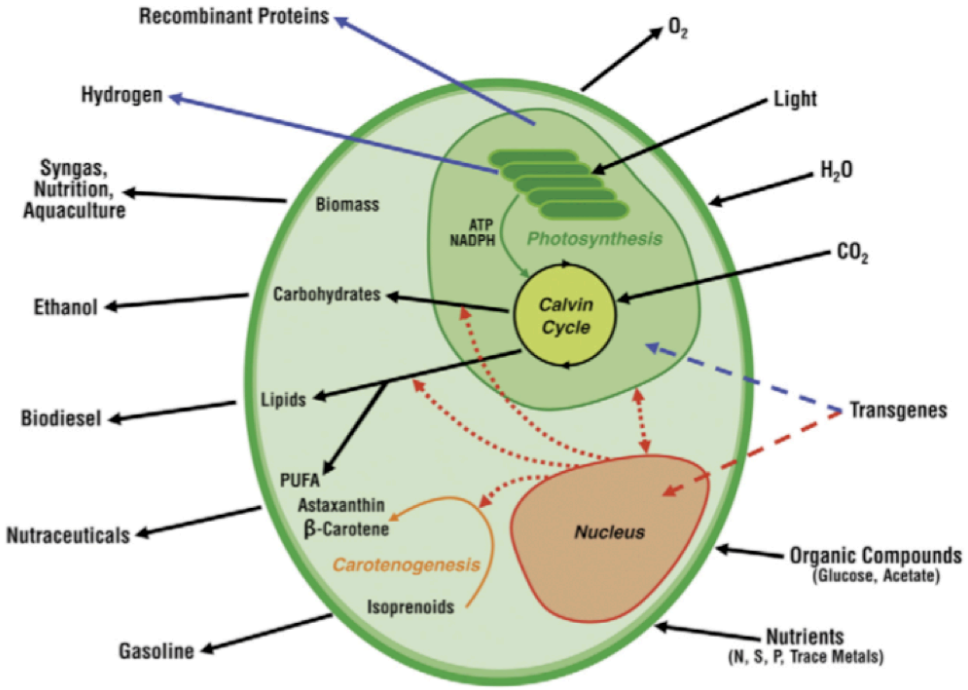
They open new dimensions for research (bringing together photobiology (photoreceptors), photoprotection and phototaxis

Without photoprotection no photosynthesis would take place, so it is important to understand these biological process

Gives rise to ideas for applications and biotechnology

DISCUSSION

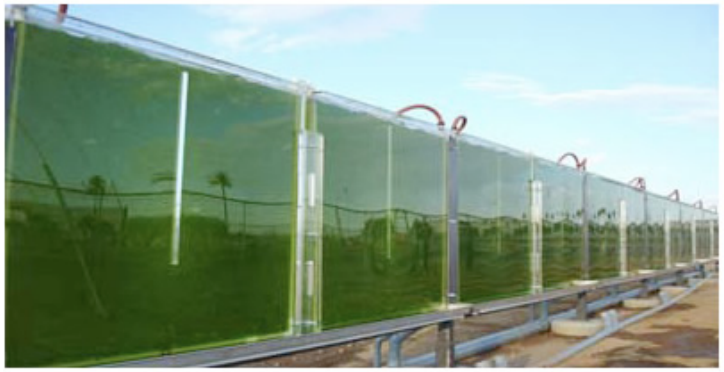
Microalgae are metabolic cell factories

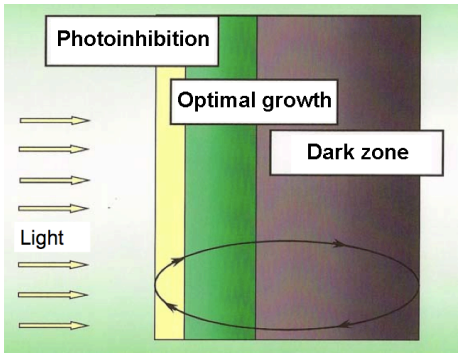


Curr Opin Biotechnol (2008) 19: 430-436

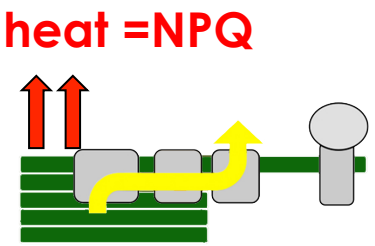
DISCUSSION

NPQ is a crucial biological process with biotechnological importance

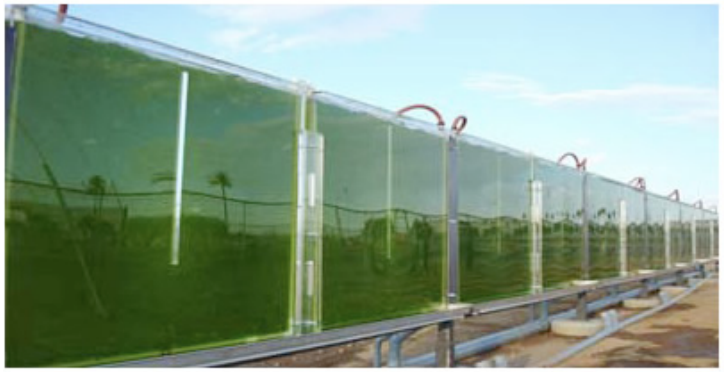


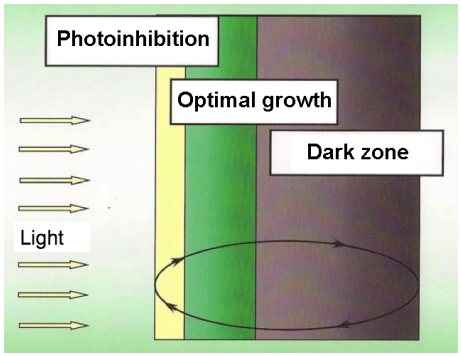


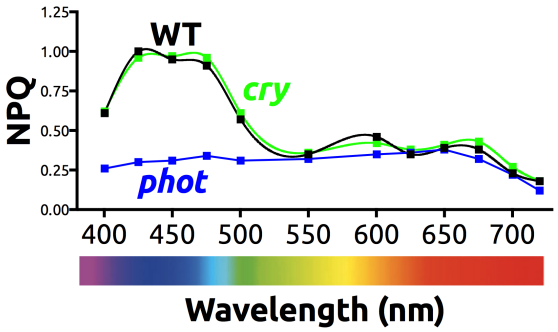
Microalgae: Biomass, Biotechnology, Bioenergy and Biohydrogen: Rüdiger Schulz-Friedrich

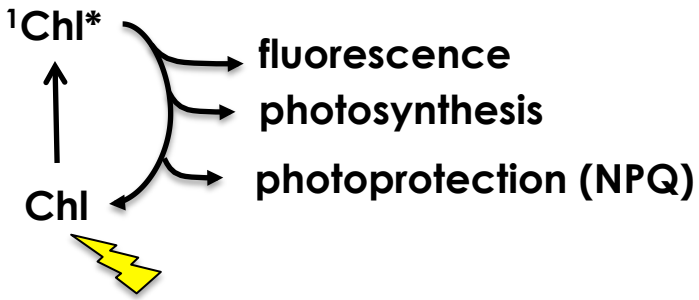


Fine-tuning of NPQ will improve algae biomass yield









DICUSSION

Microalgae: Biomass, Biotechnology, Bioenergy and Biohydrogen:
Rüdiger Schulz-Friedrich

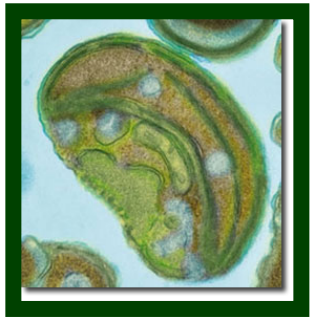
Laboratoire de Physiologie Cellulaire et Végétale, CEA Grenoble

Team: Light, Photosynthesis and Metabolism

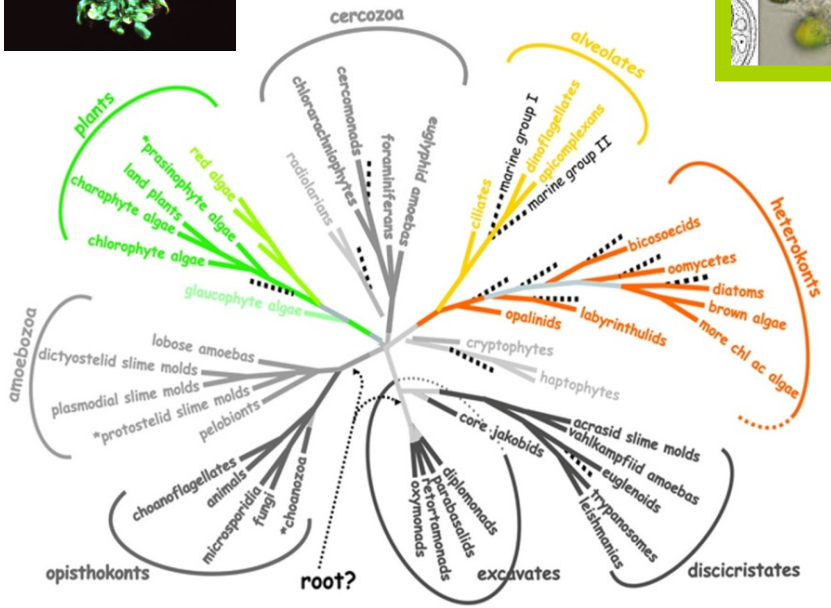
Objectif de recherche: comprendre comment la photosynthèse répond à différents types de stress (Lumière forte, carence en éléments nutritifs)

Arabidopsis

Ostreococcus



Nannochloropsis



Phaeodactylum

Chlamydomonas

CONTACT