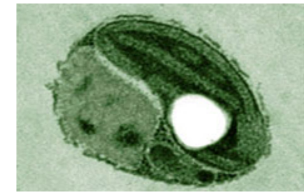
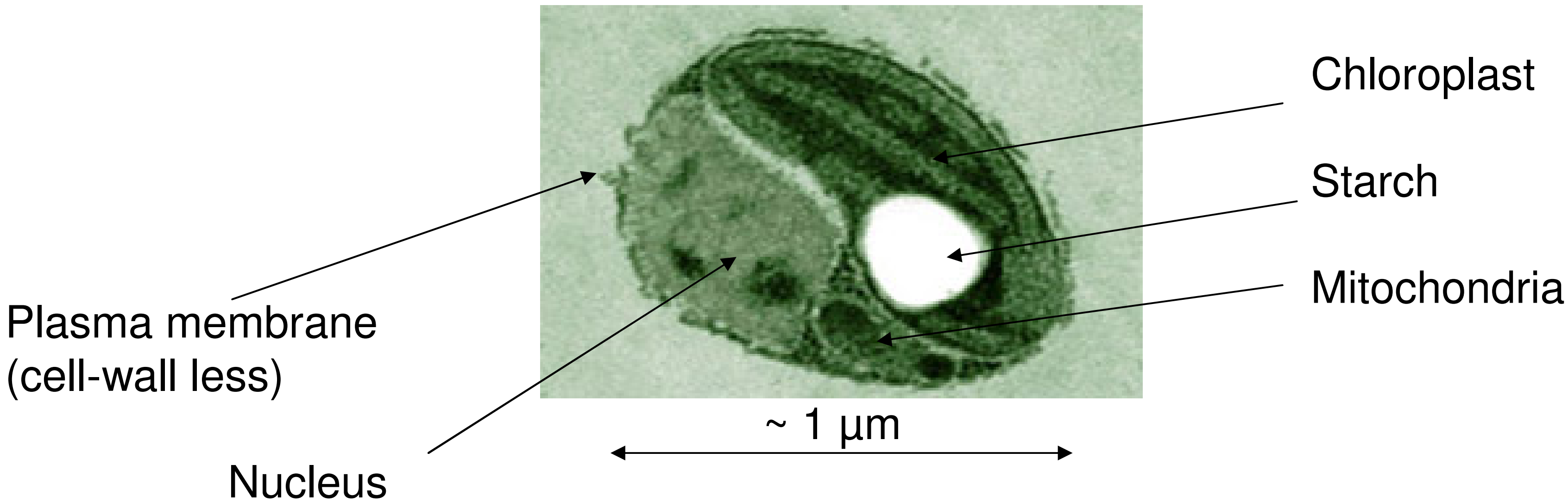
Photosynthesis in the smallest free-living eukaryotic organism: light utilisation and capture in the picoeukaryote Ostreococcus





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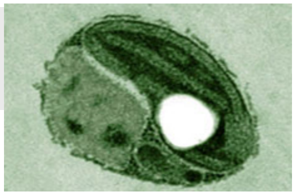
PS07, Glasgow 22-27 july 2007

Ostreococcus : pigments and LHCP antenna



Order of Mamiellales :
Ostreococcus , Micromonas, Bathycoccus

Photosynthetic Antennae of *Ostreococcus tauri* 2225

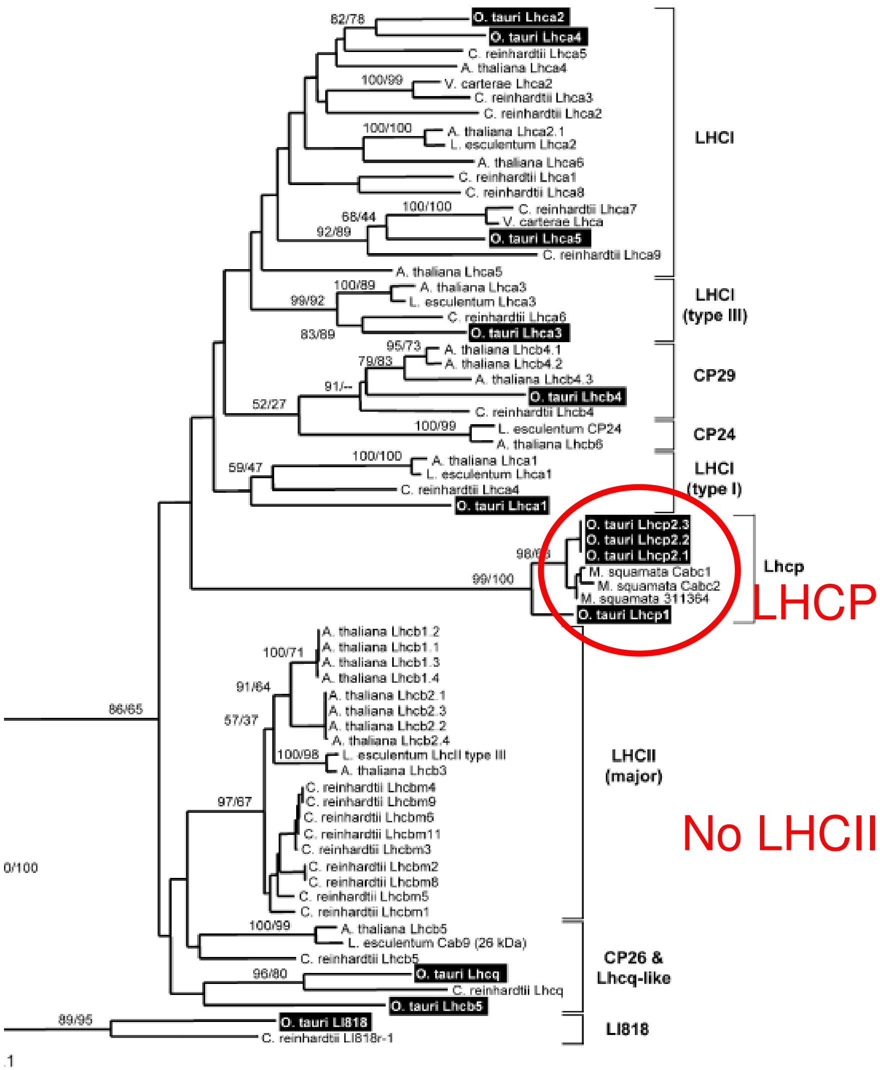
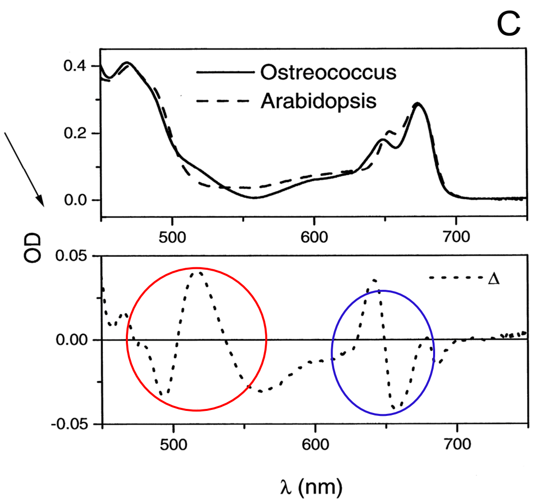
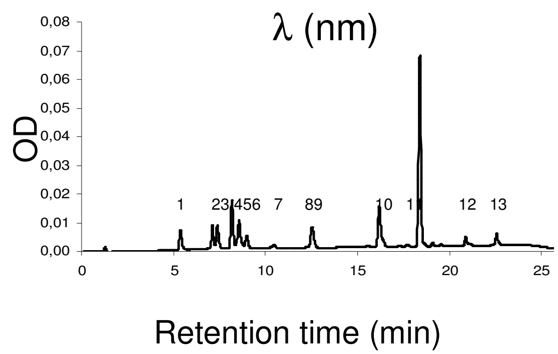


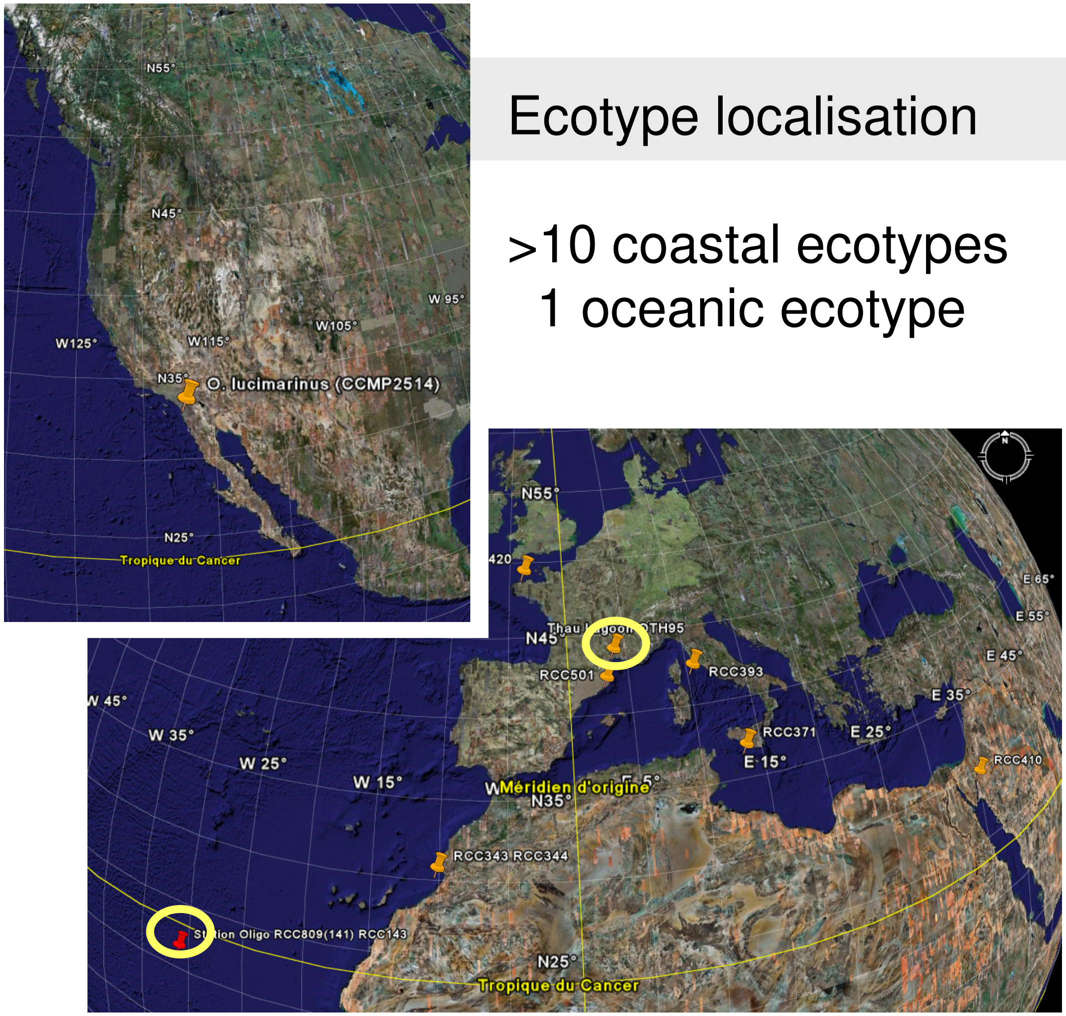
FIG. 6.—Phylogenetic analysis of Lhc protein sequences from *Ostreococcus tauri* (indicated with a black background), higher plants, and selected chlorophyll *a/b*–containing algae (green algae) inferred by NJ and maximum likelihood methods. The analysis includes both PSI (Lhca)- and PSII (Lhcb)-related antennae complexes. The distance tree is shown with corresponding bootstrap values on the internal branches obtained from both maximum likelihood and NJ methods. Bootstrap values (percentage of 100 replicates) are shown in the order NJ-distance/ML. Sequence alignment details are given in Supplementary Material online.



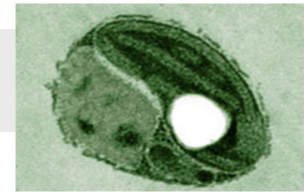


1. Mg-DVP
2. Uriolide
3. Neoxanthophyll
4. Prasinoxanthin
5. Violaxanthin
6. Micromonal
7. Antheraxanthin
8. Zeaxanthin
9. Dihydrolutein
10. Chlorophyll b
11. Chlorophyll a
12. Carotene
13. β-Carotene

(Six *et al.*, 2005 Mol. Biol. Evol. 22, 2217-2230)



Ecotype localisation



>10 coastal ecotypes
1 oceanic ecotype

<u>Strains used in this work</u>

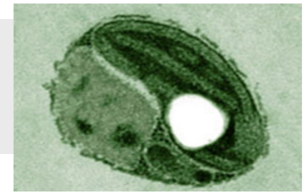
O. tauri **(OTH95)**
Courties et al. 1994 Nature 370, 255.
-Coastal strain
-Surface
-**Fluctuating irradiance**

RCC809
Rodriguez, et al. 2005. Environ. Microbiol. 7, 853-859.
-Oceanic (tropical Atlantic)
-Isolated at 100 m depth
-low light
-Nutrient starvation ?

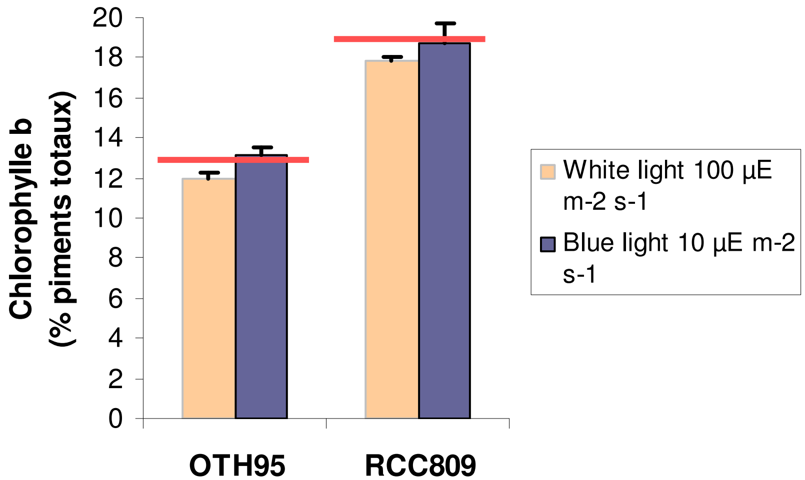
Aim : compare light harvesting and electron transfer capacity to reveal adaptation to nutrient and light shortage

10 $\mu E.m^{-2}.s^{-1}$ blue light vs 100 $\mu E.m^{-2}.s^{-1}$ white light

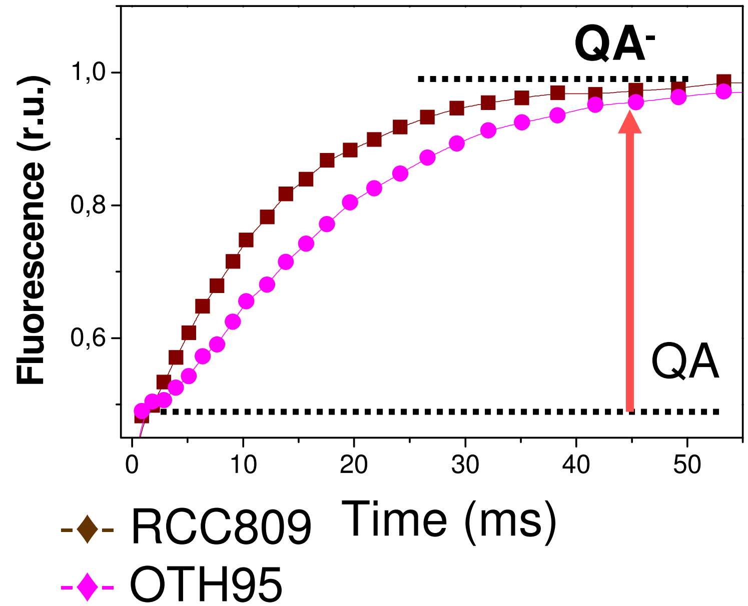
1. Light availability and changes in the absorption properties of Photosystem LHC



Chlorophyll b

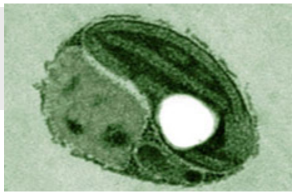


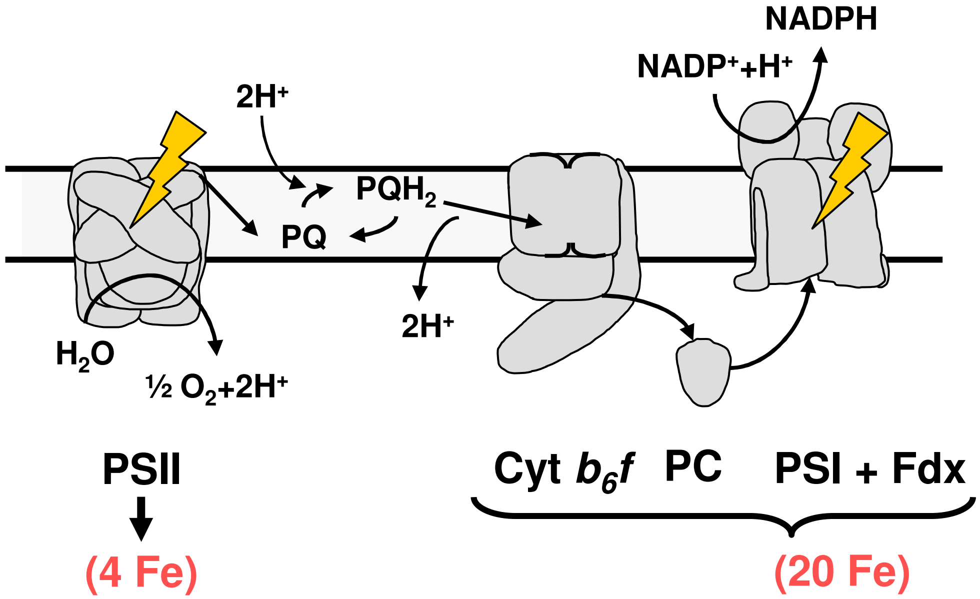
PSII antenna size (Low light + DCMU)



Increased absorption capacity of photosystem II
Constitutive adaptation of RCC809 to low light environment

2. Nutrient availability and changes in stoichiometries of photosynthetic complexes

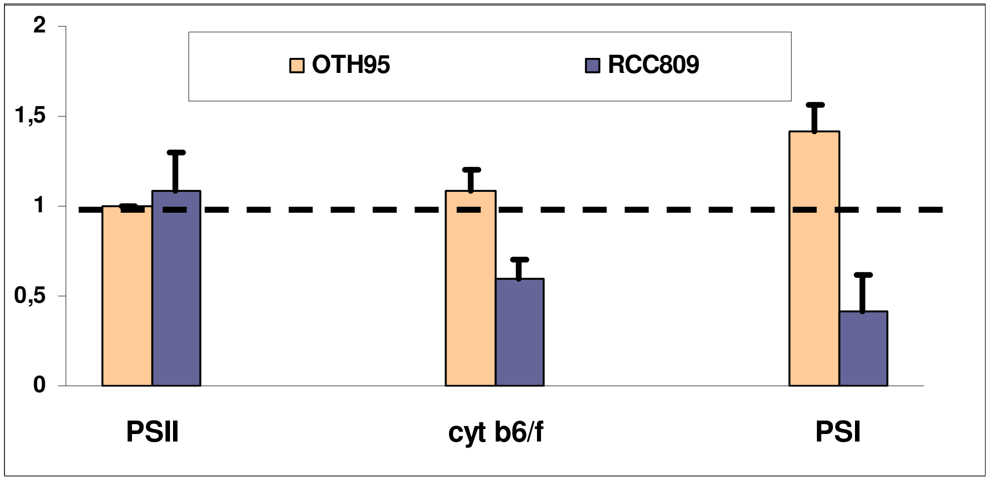




Diatoms
(Strzepek and Harrison, Nature 2004 431, 689-692)

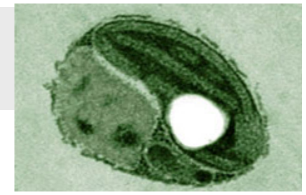
Cyanobacteria
(Boekema et al. Nature 412: 745 (2001))

Oceanic photosynthetic organisms cope with iron limitation by decreasing iron-rich photosynthetic pathway

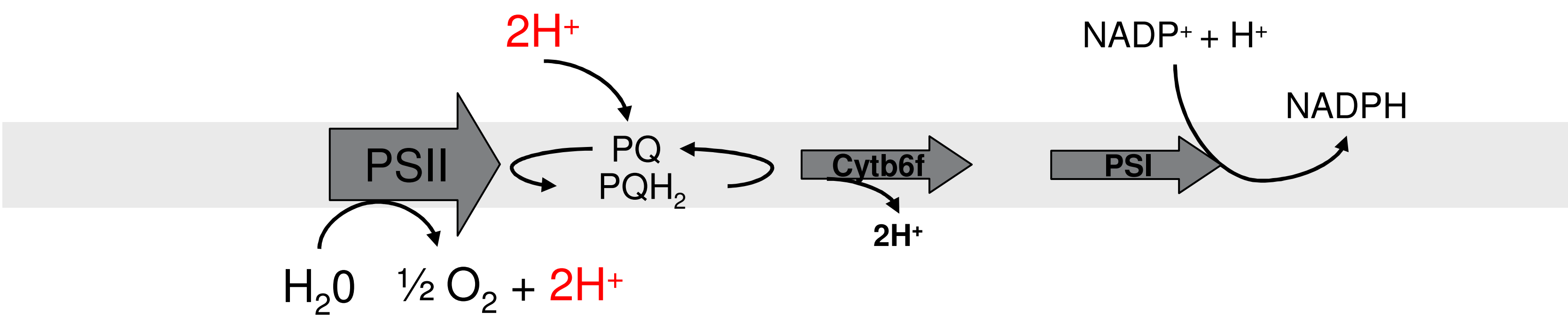


RCC809 constitutively shows a Fe starvation-like phenotype

RCC809

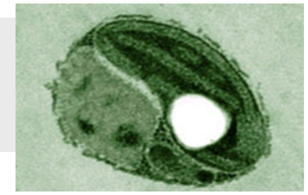


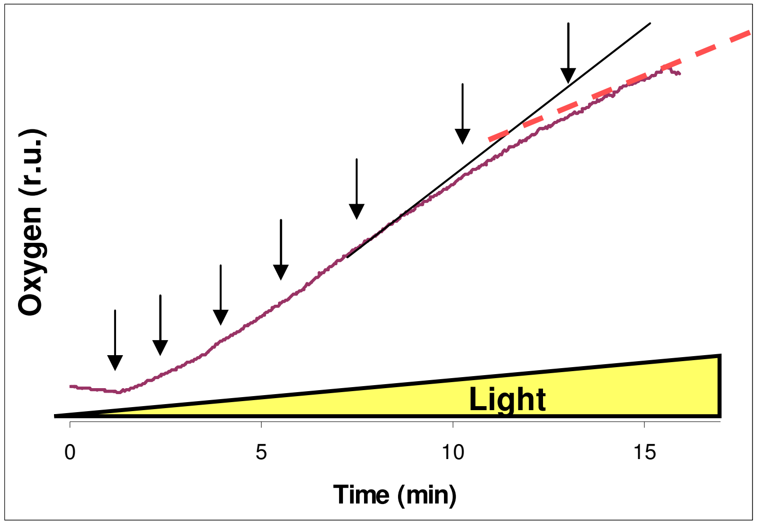
PSII Light absorption increases
PSI/cytb6f decreases

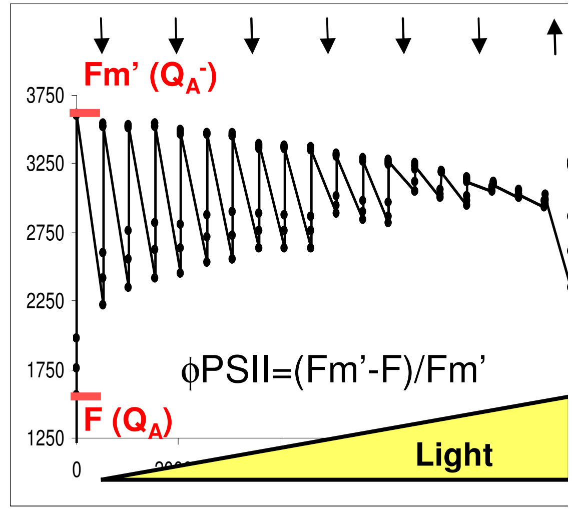


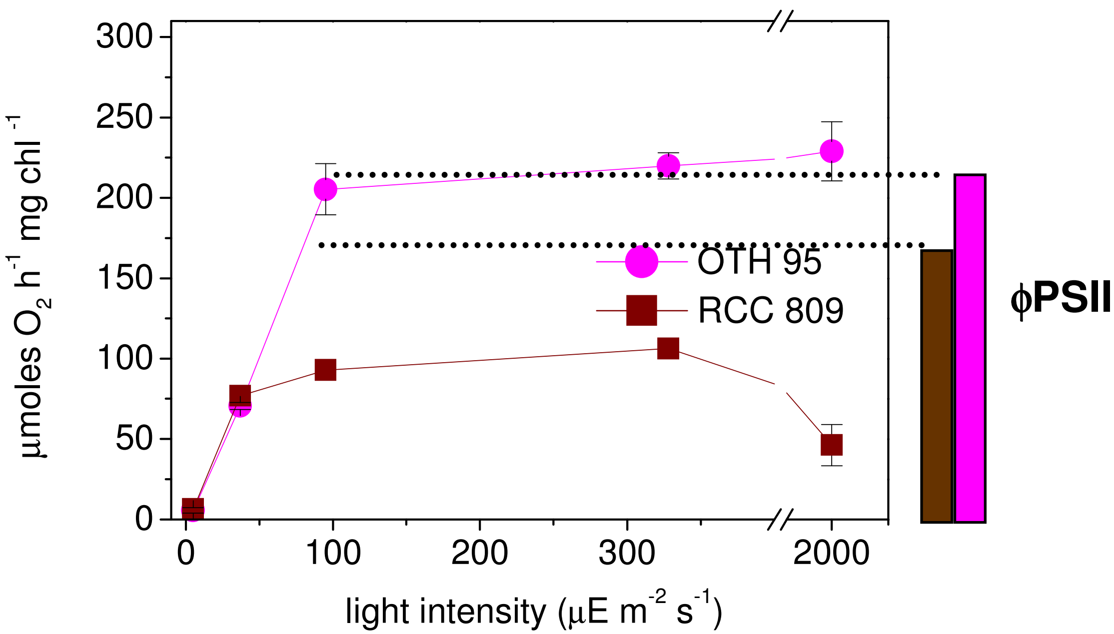
→Impact on photosynthesis?

Consequences of reduced PSI and cyt b6f complexes
Oxygen Evolution and Photosystem II activity



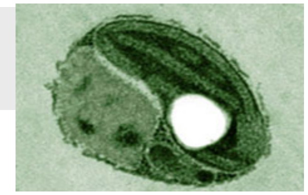




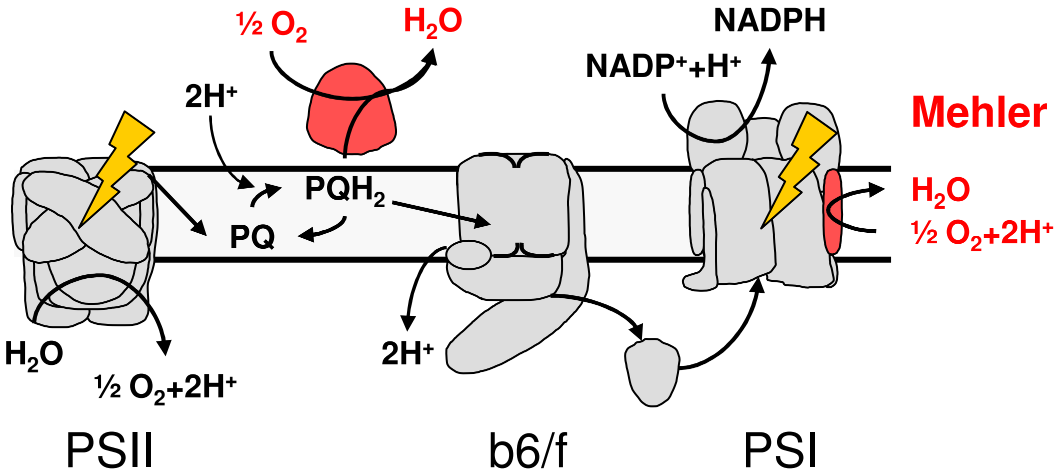


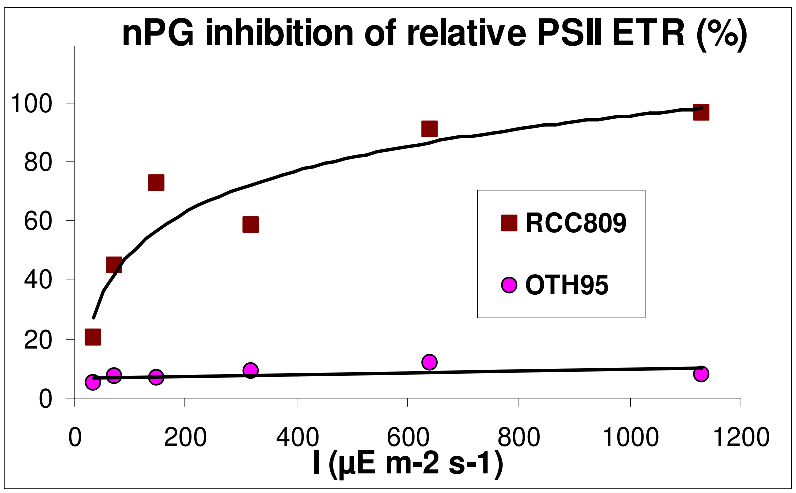
→PSII might transfer electrons to another acceptor : oxygen ?

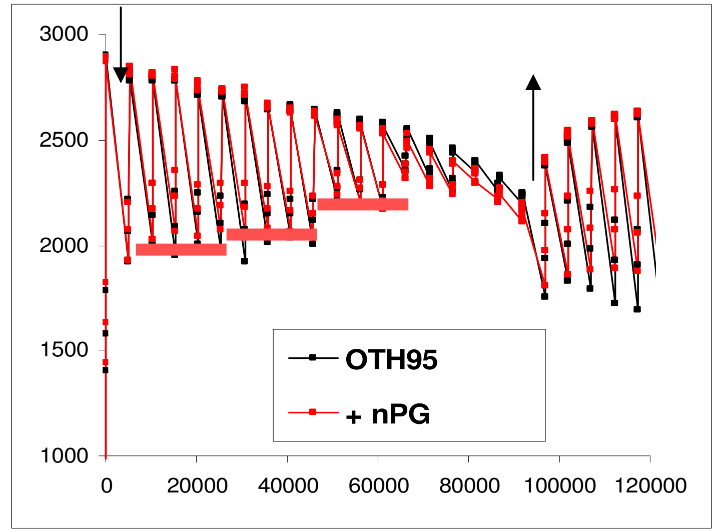
Impact of n-propylgallate on PSII electron Transport rate

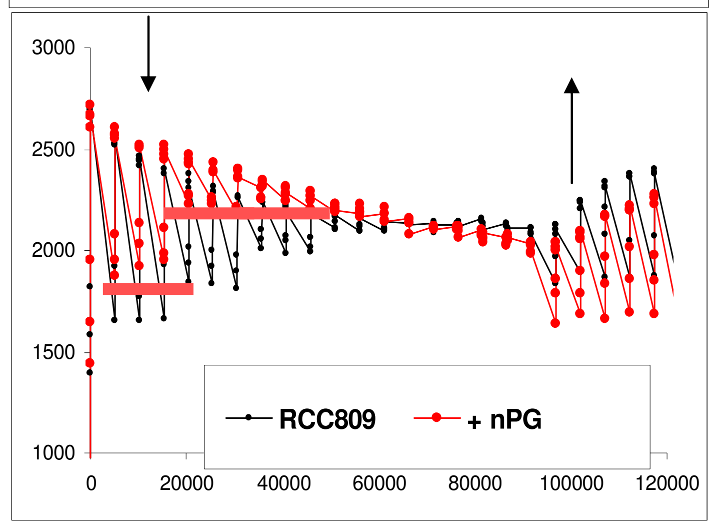


Plastid terminal oxidase (PTOX)





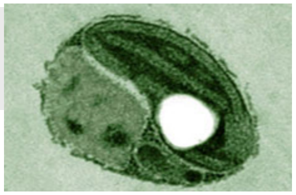




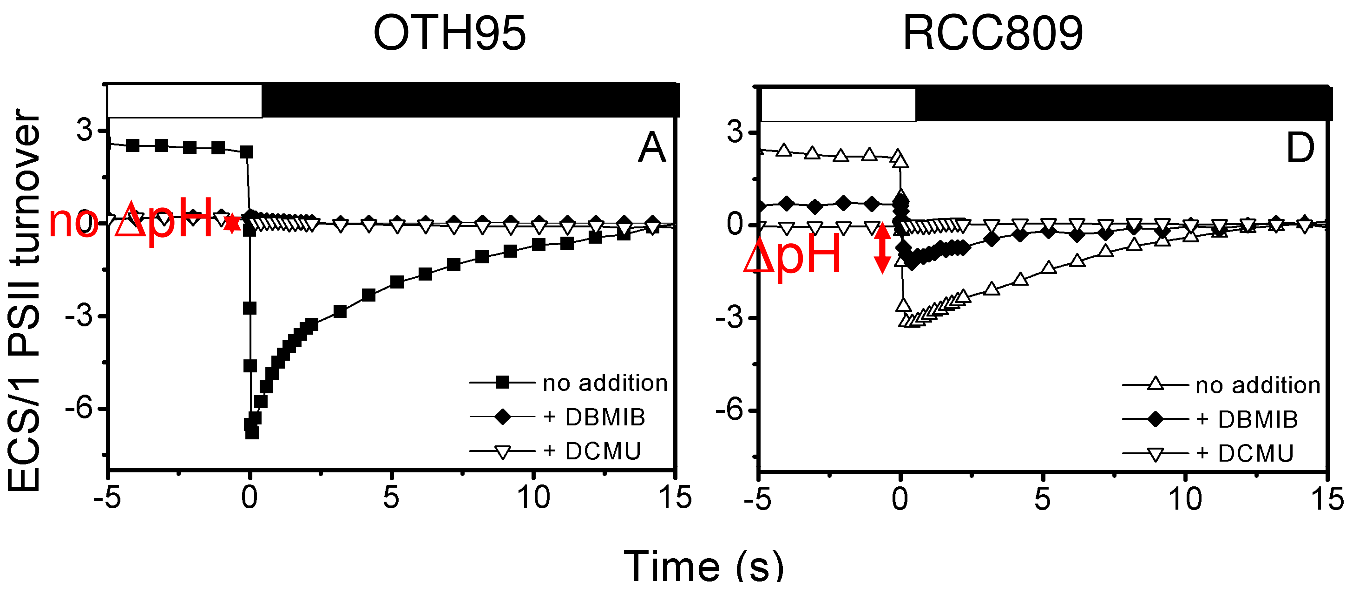
→PTOX acts as a valve

→possible role in ΔpH homeostasis

Estimation of $\Delta\mu H+$ (ΔpH and ΔΨ) in the light :



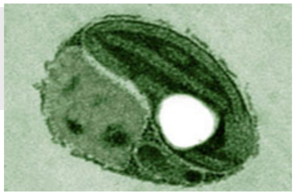
Relaxation of the electrochromic shift (ECS) signal at steady state

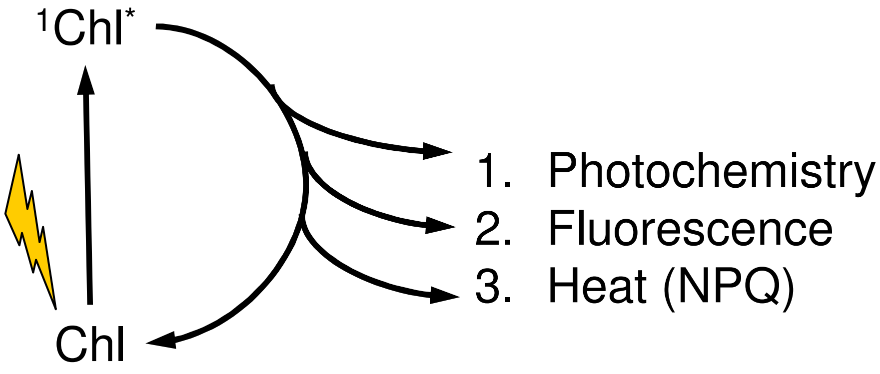


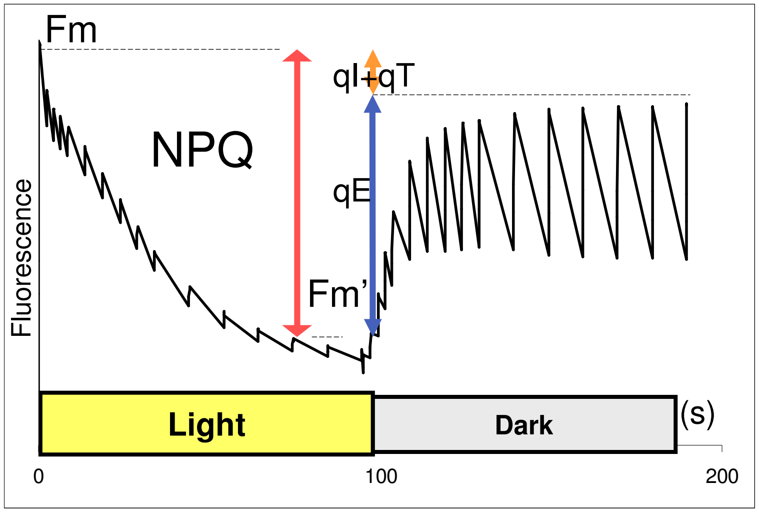
1. Lower ΔpH in RCC809

2. "water to water" electron flow via PSII-PTOX activity supports ΔpH homeostatis in RCC809

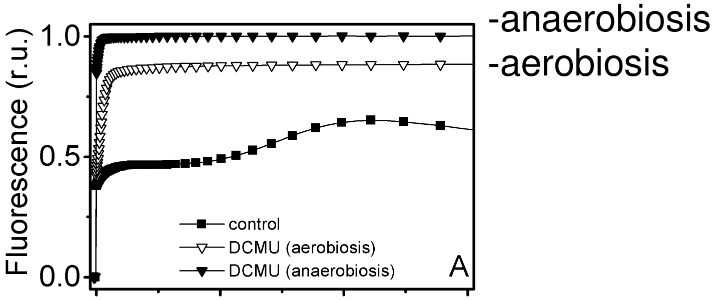
Photoprotection Mechanisms



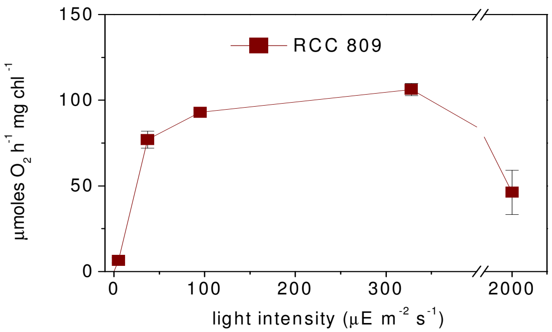




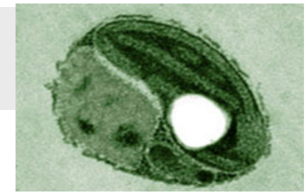
i . qT : State transitions
→No Fluorescence decrease during an aerobiosis to anaerobiosis transition



ii . qI : Photoinhibition
→ occurs in RCC809
(indicated by the decrease in PMAX)



Photoprotection Mechanisms



iii. qE :

thermal dissipation of energy at the antenna level

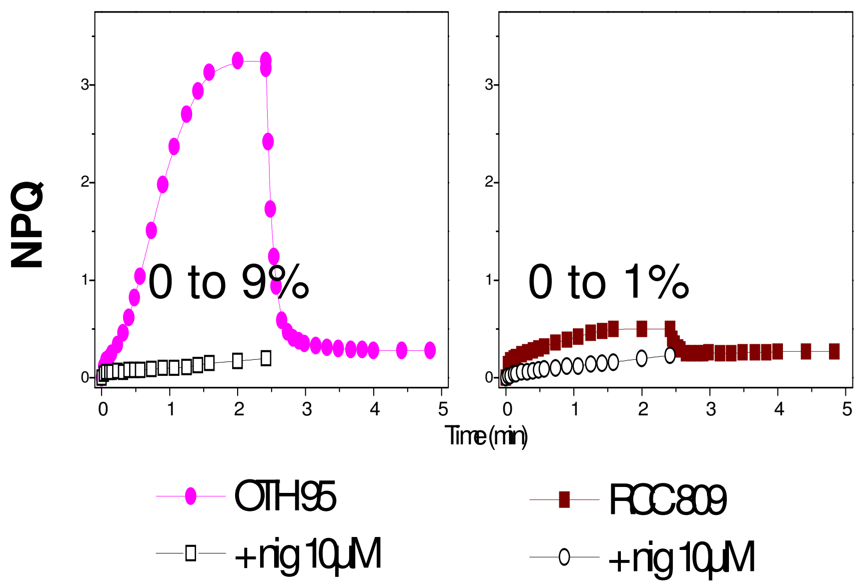
LI818, CP26, PSBS

Induced by lumen acidification

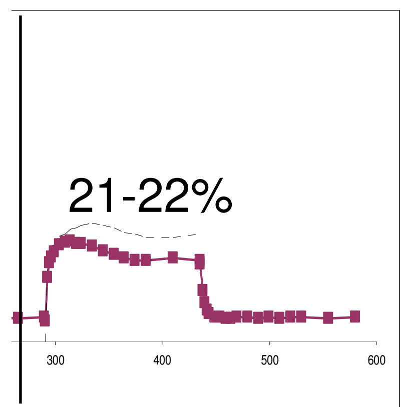
Psbs Protonation

Activation of Violaxanthin deepoxidase (Vx to Ax)

Dark-adapted

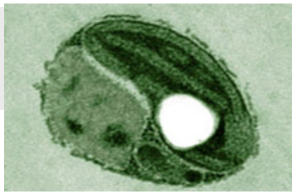


>12 hours 100 µE



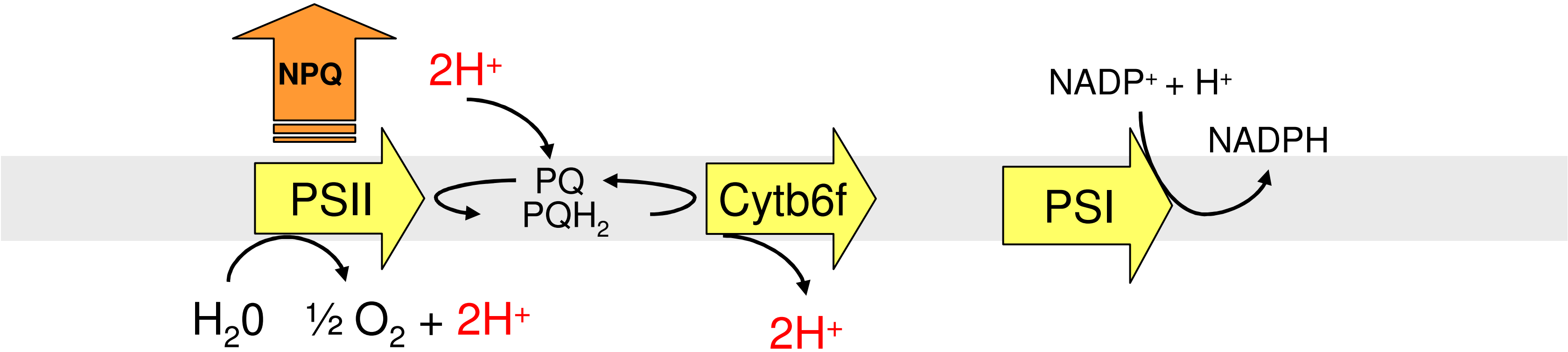
→NPQ machinery present in RCC809 but not quickly activated

Conclusions

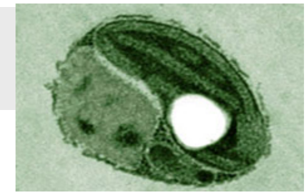


Ostreococcus tauri (coastal strain OTH95)

- Behavior similar to that of land plants
- Equimolar PSI/Cytb$_6$f/PSII ratio
- Fast and sustained photoprotective response



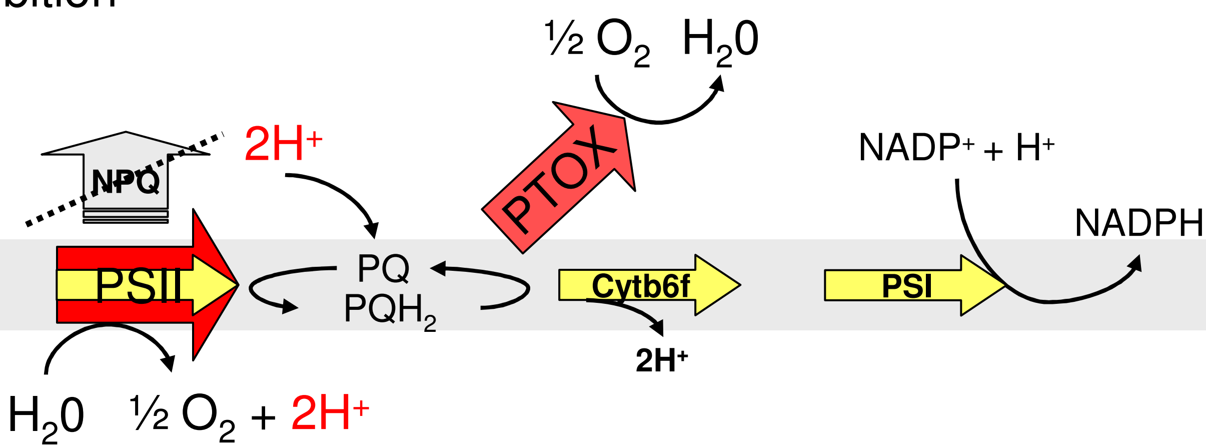
Conclusions



Deep oceanic ecotype (RCC809)

- Constitutive iron starvation phenotype:
  - Low b_6f and PSI content
  - Plastid terminal oxidase alleviate PSII excitation and provides “extra” ΔpH

- Constitutive adaptation to low light intensities
  - Larger PSII antenna size
  - No rapid photoprotective response (ΔpH not optimum)
  - photoinhibition



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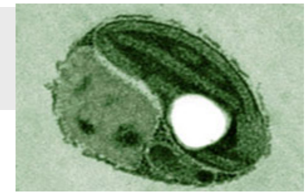
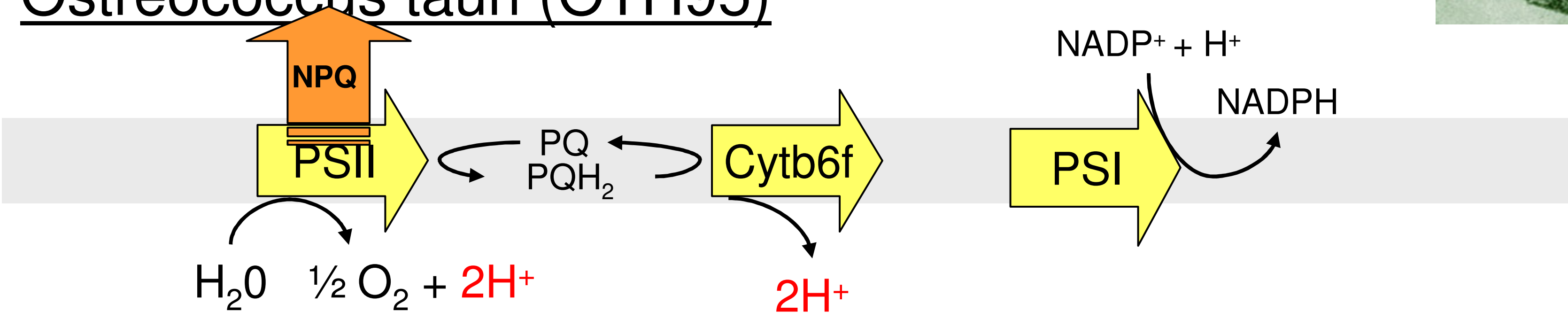
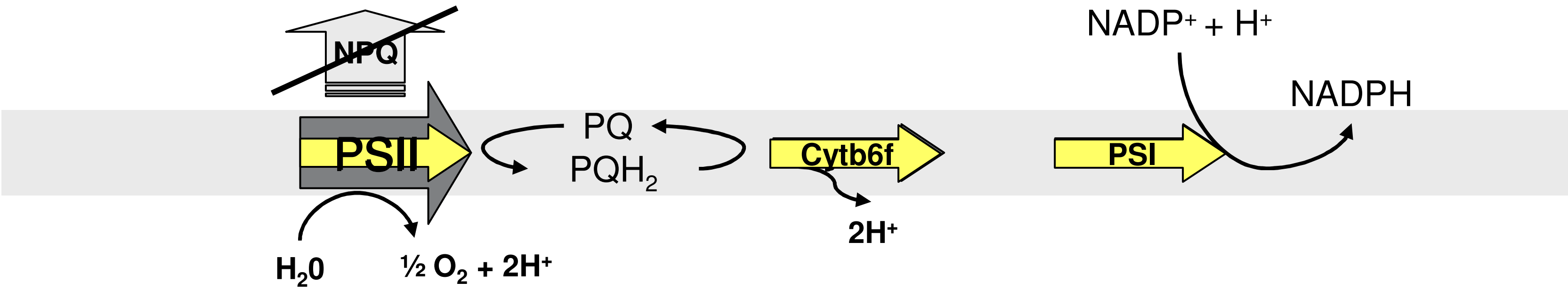
Summary



Ostreococcus tauri (OTH95)



RCC809 at low light



RCC809 at high light