

# The ecophysiological consequences of light variability

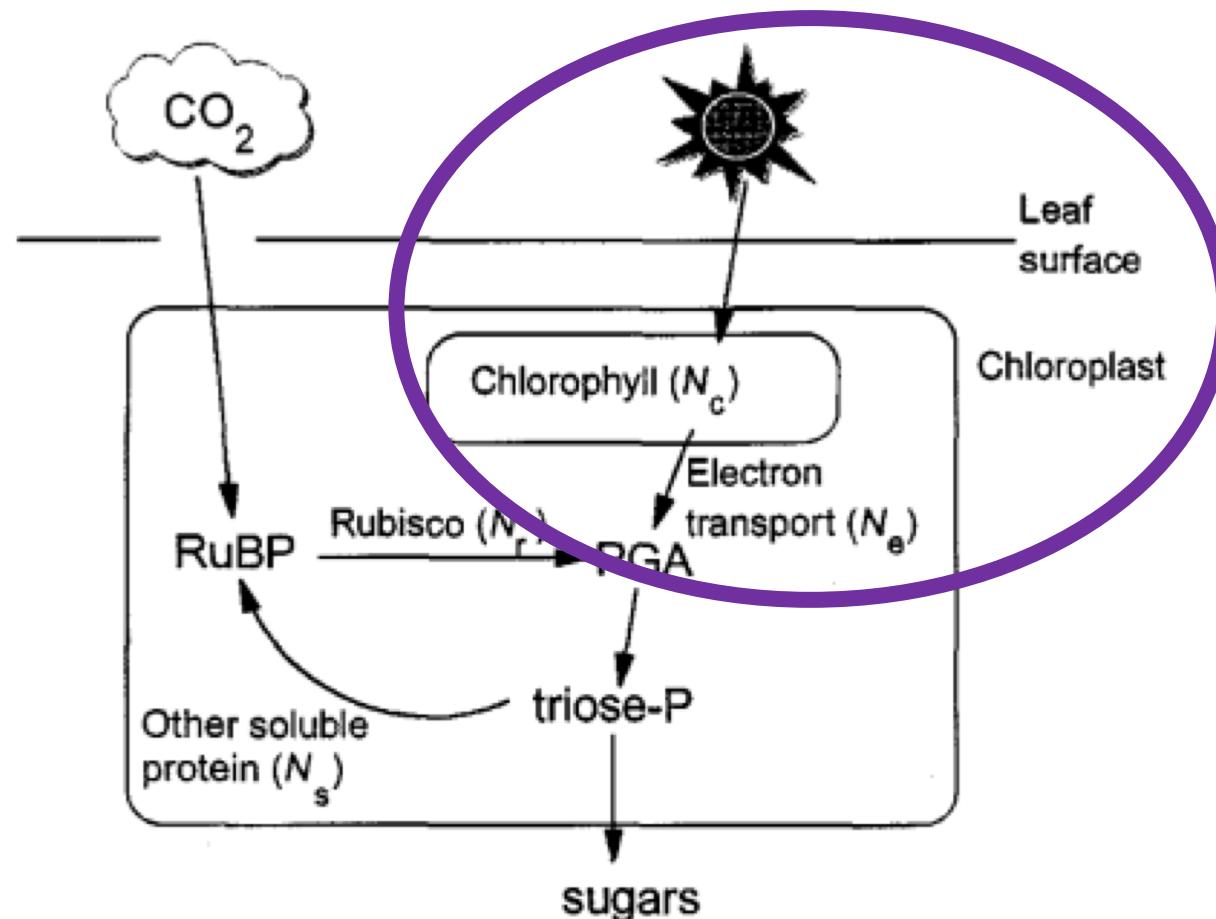
January 31, 2023

# How does light availability to plants vary over space and time?



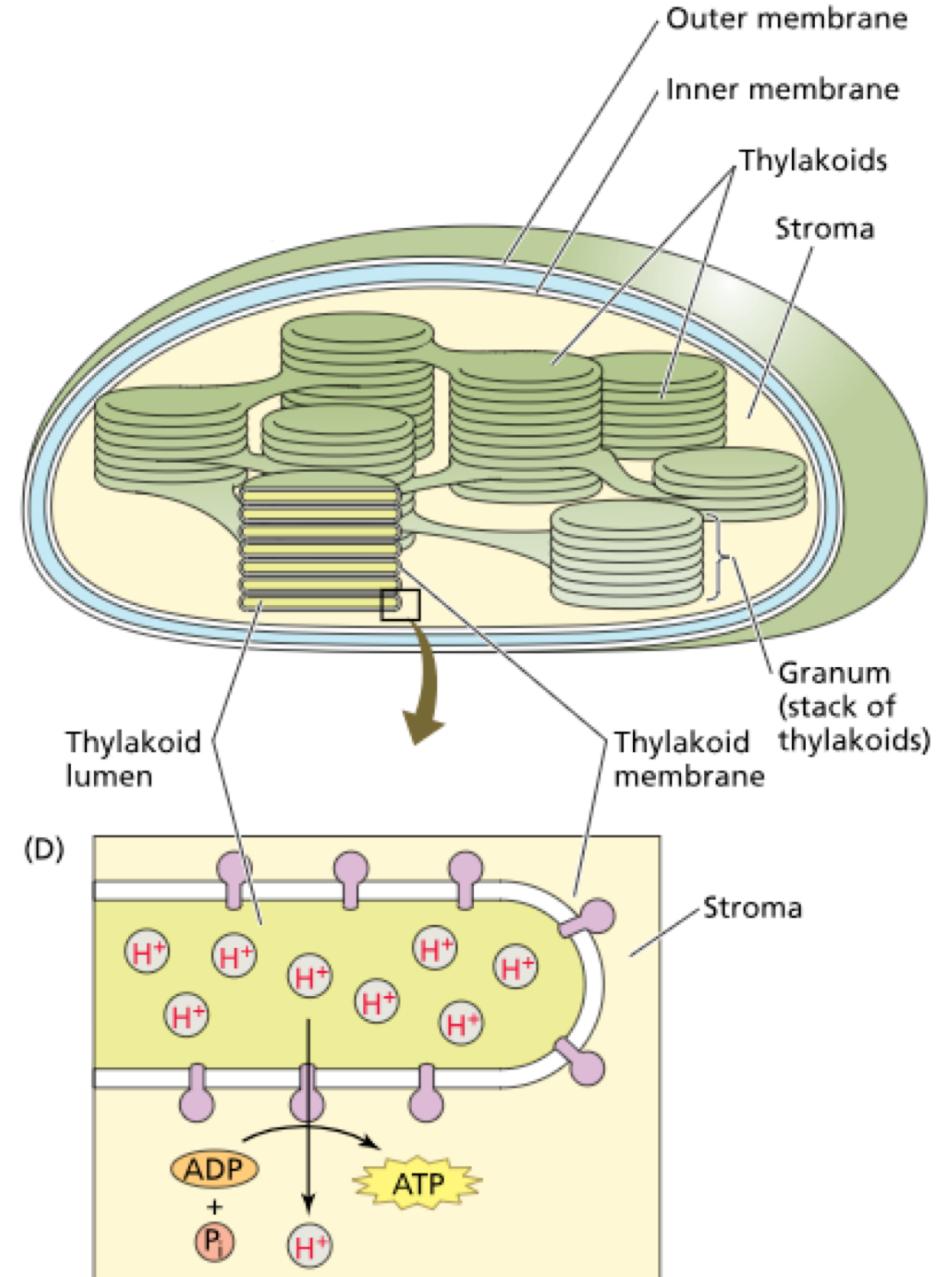
Light effects on short-term plant functioning

# Plants use light to make energy for photosynthesis



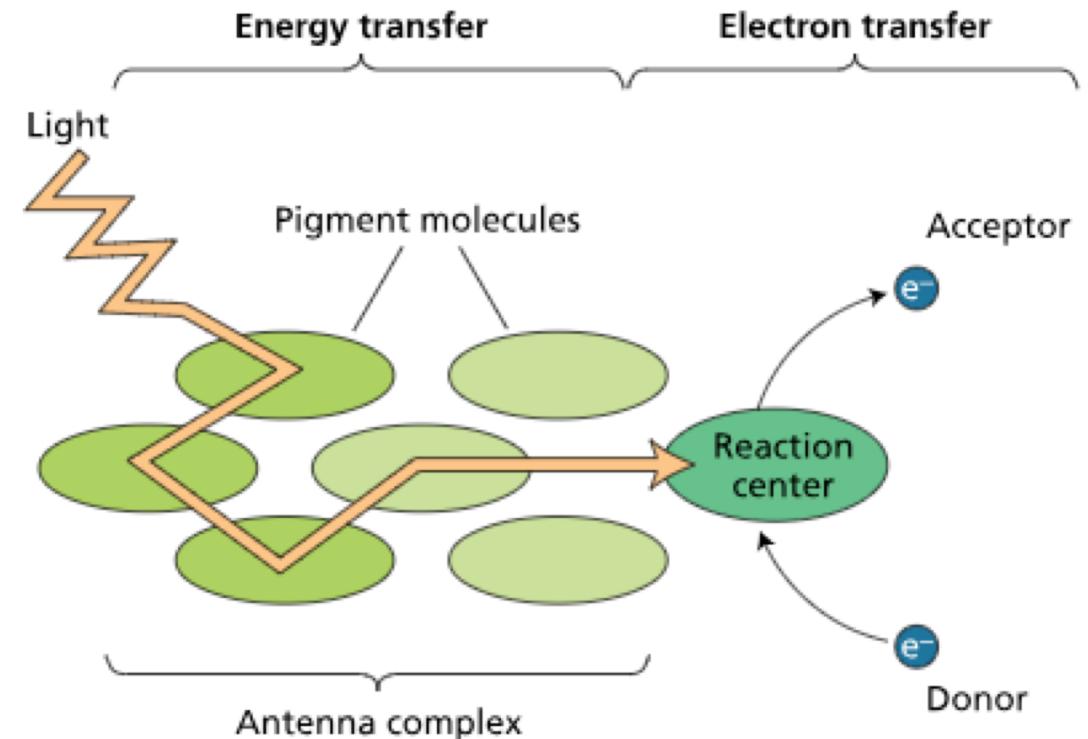
# Chloroplasts

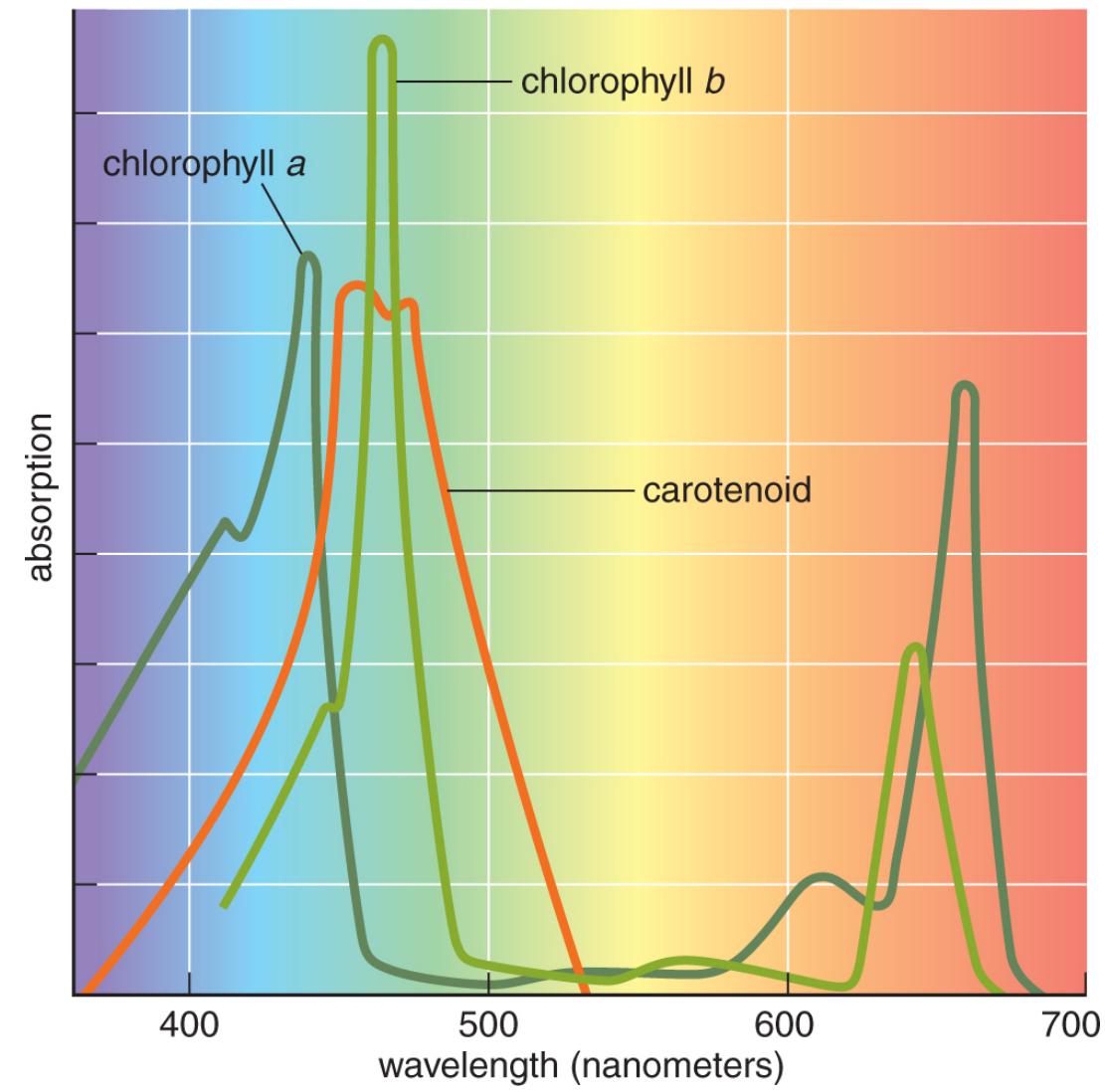
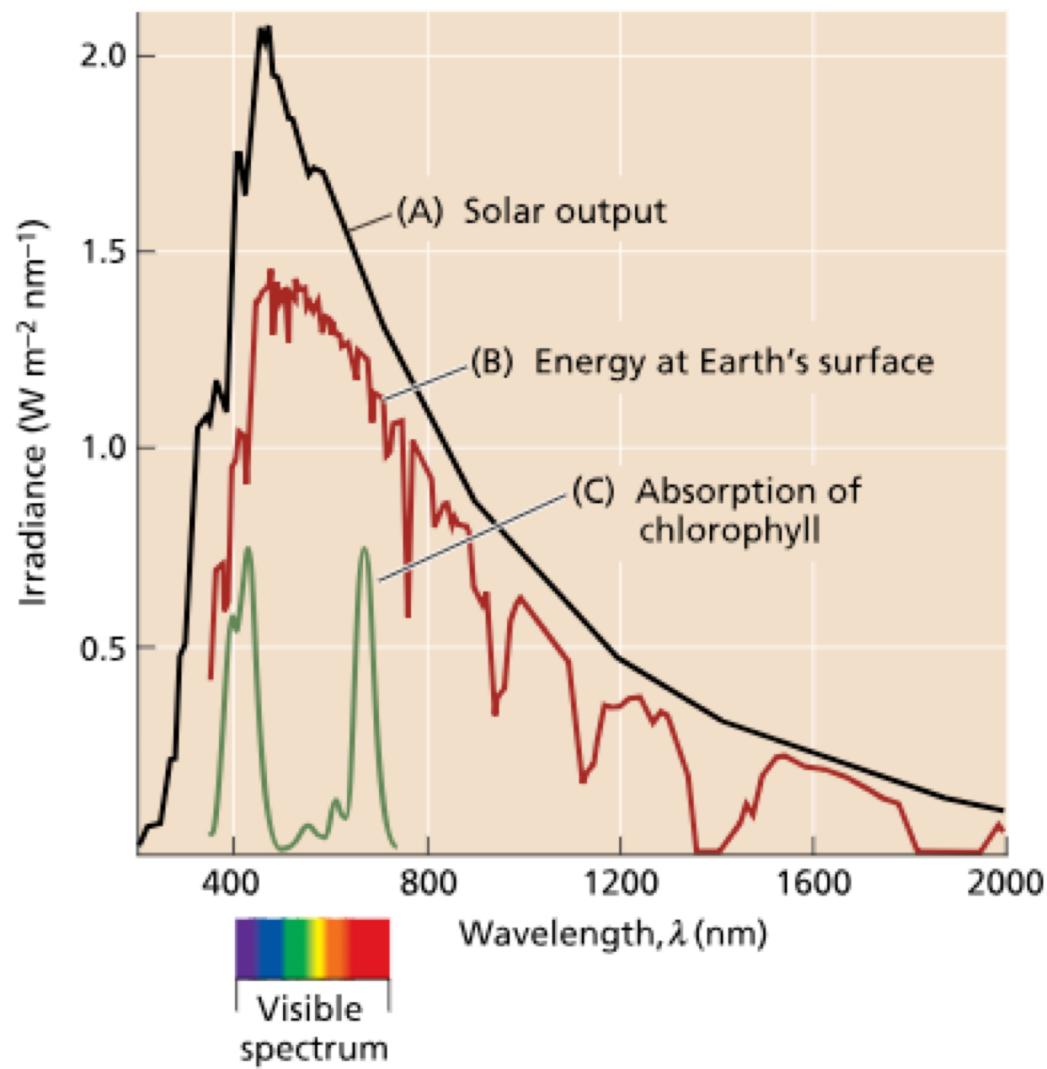
Light reaction proteins and pigments are embedded in the thylakoid membrane



# Chlorophyll

Chlorophyll pigments absorb light and create usable energy in the form of NADPH and ATP





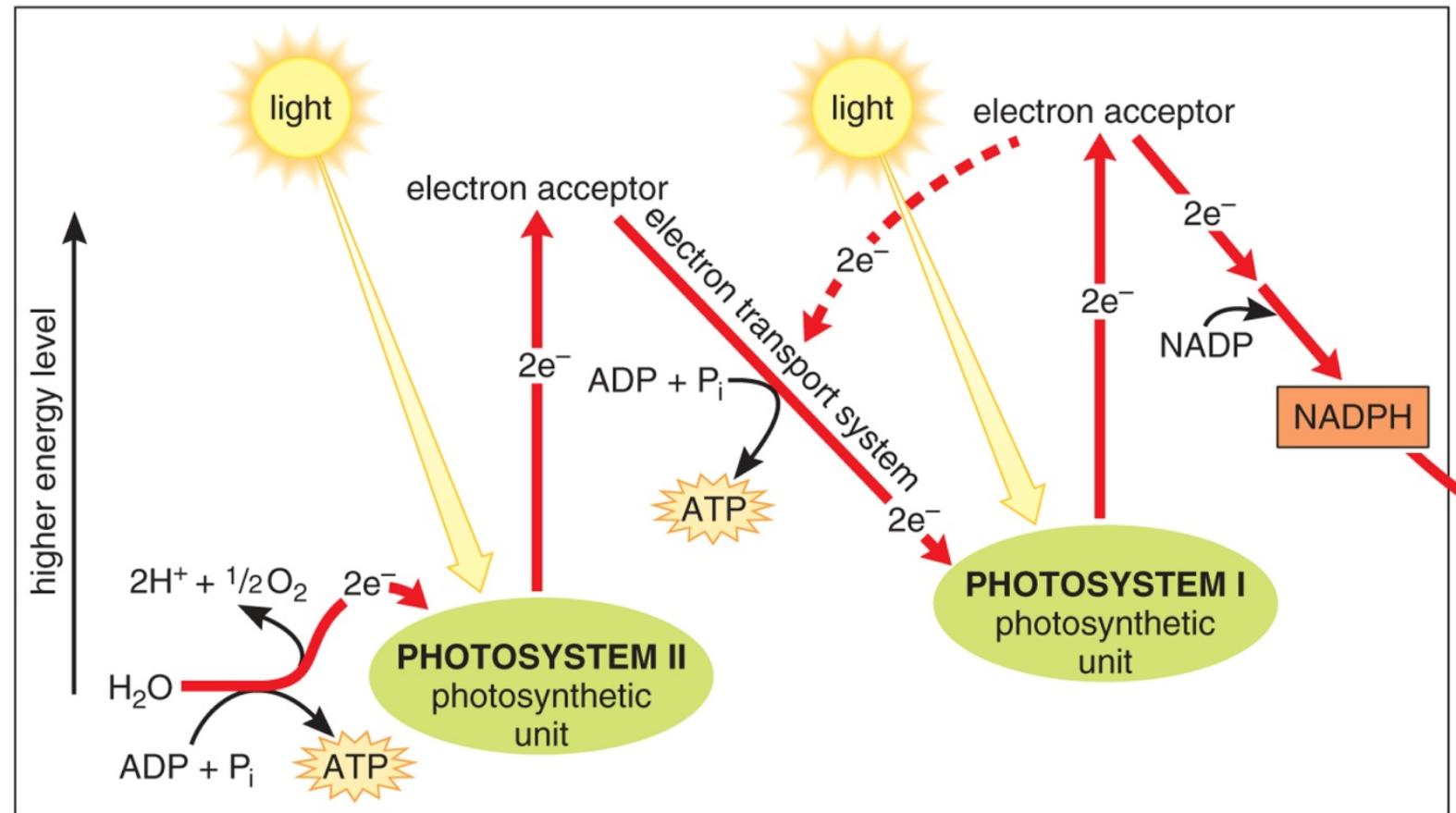
# Light-dependent reactions

## 1. Ingredients

- Light
- H<sub>2</sub>O
- NADP<sup>+</sup>
- ADP
- P

## 2. Outcomes

- ATP
- NADPH
- O<sub>2</sub>
- H<sup>+</sup>



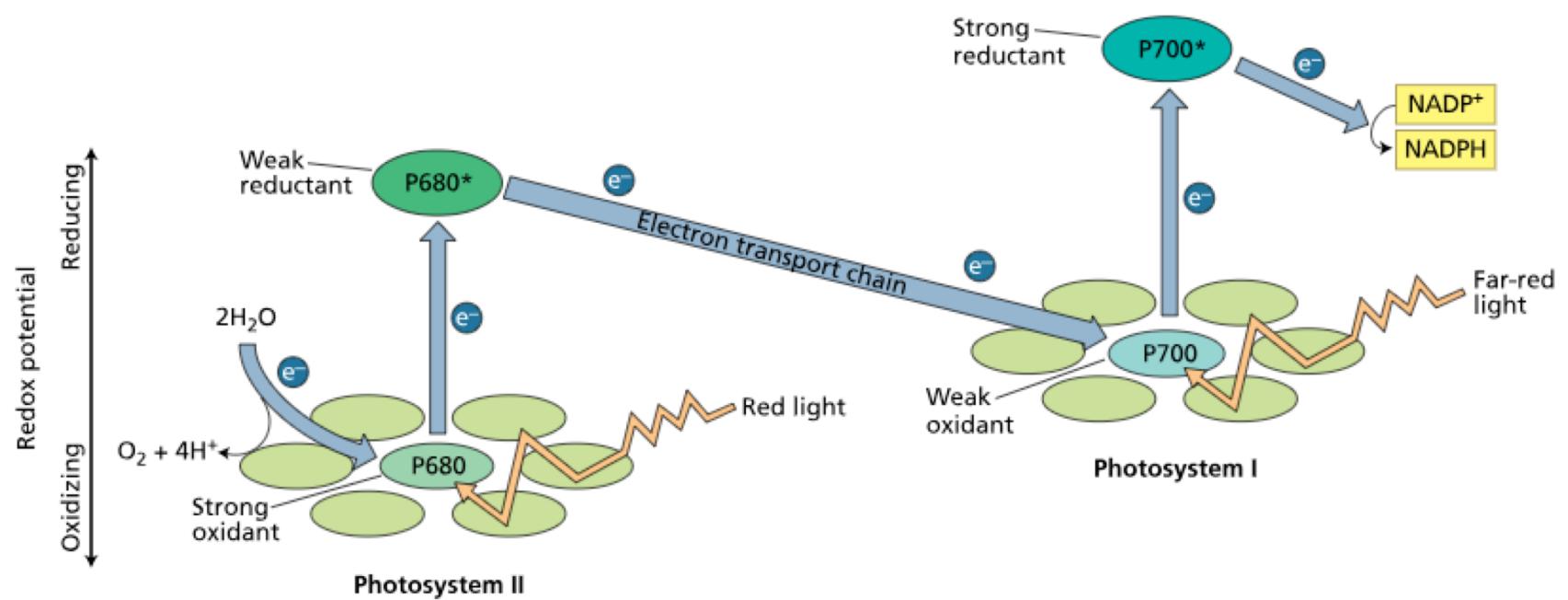
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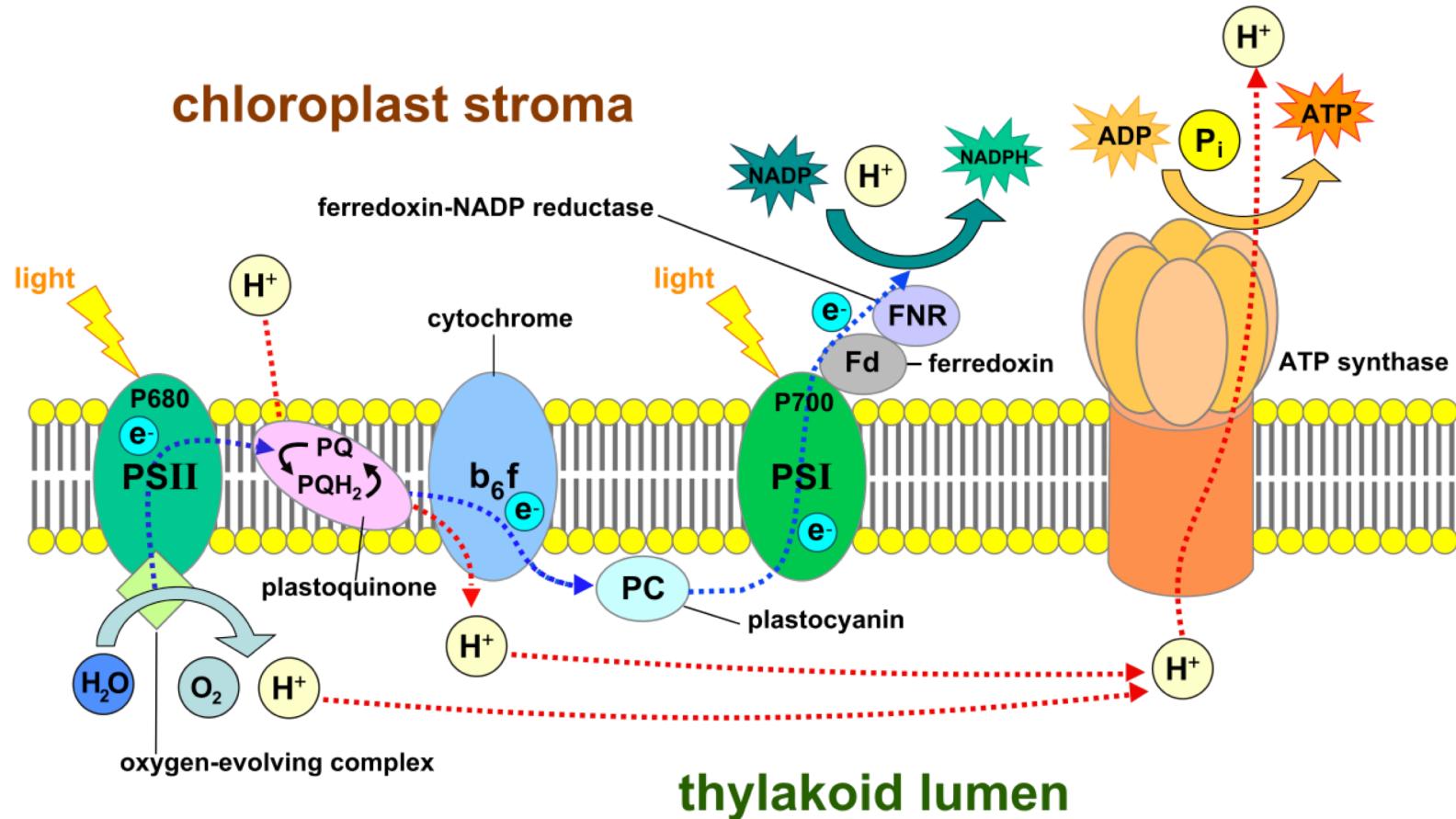
# Light-dependent reactions

## 1. Ingredients

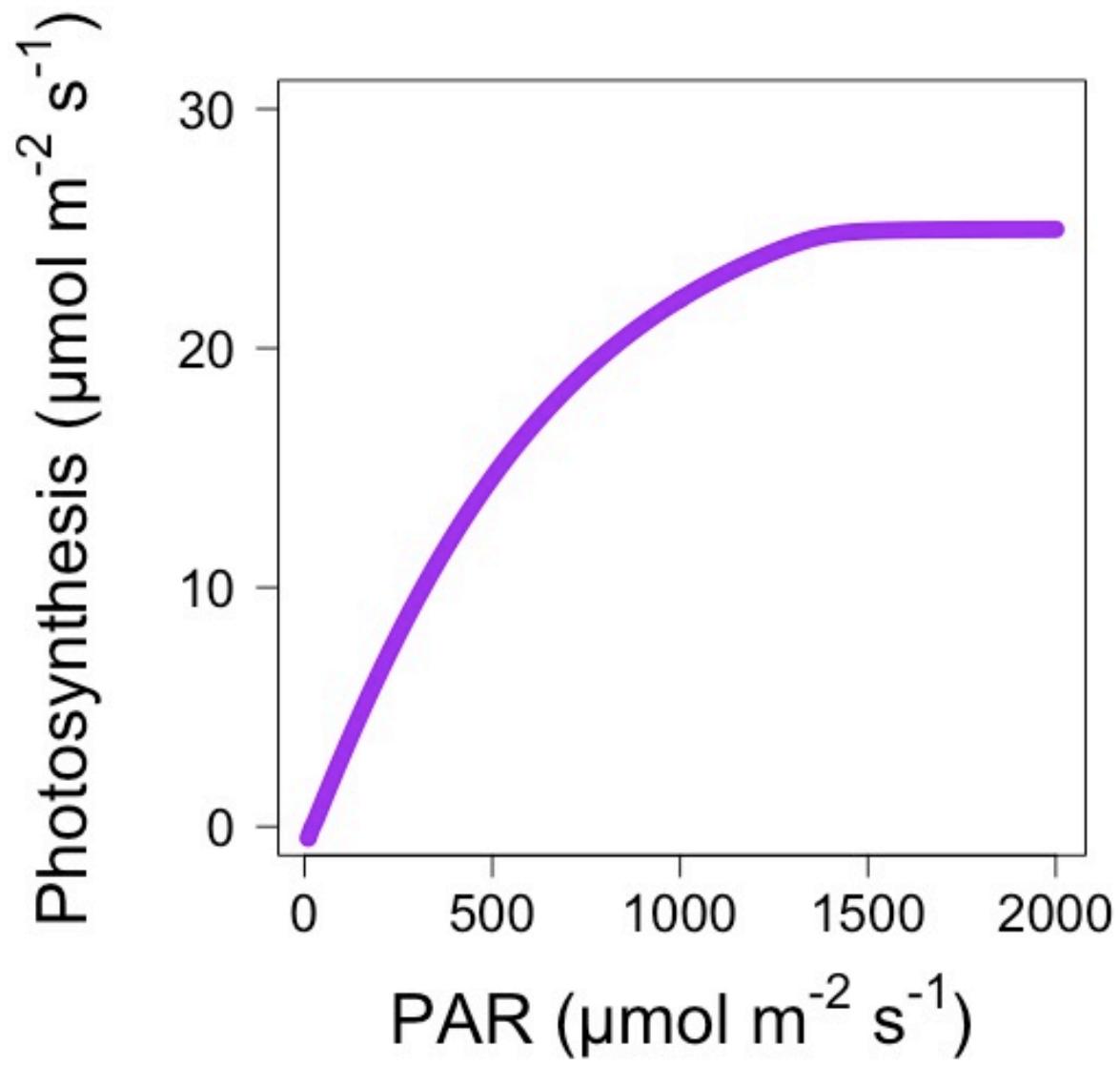
- Light
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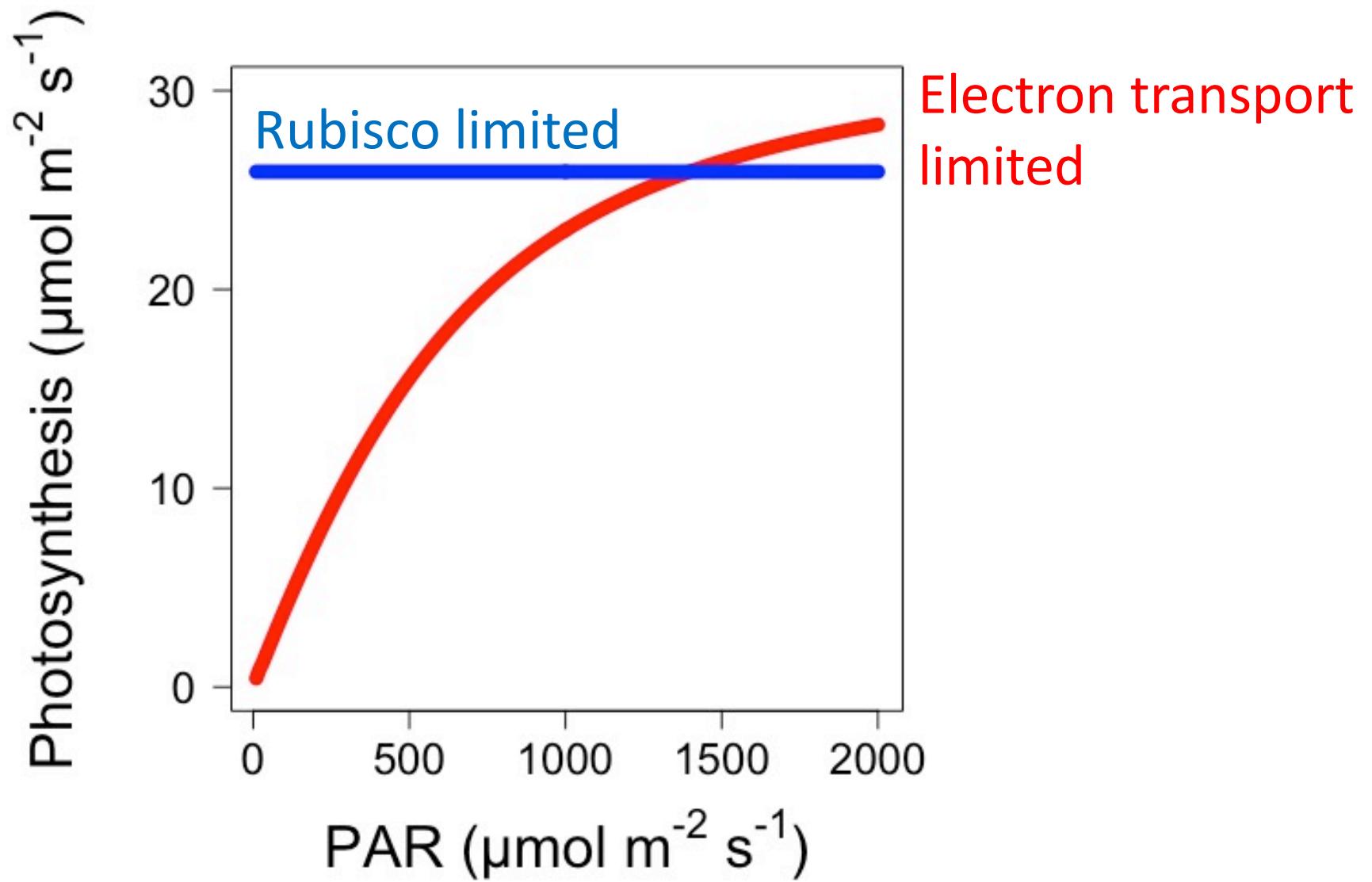
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- ATP
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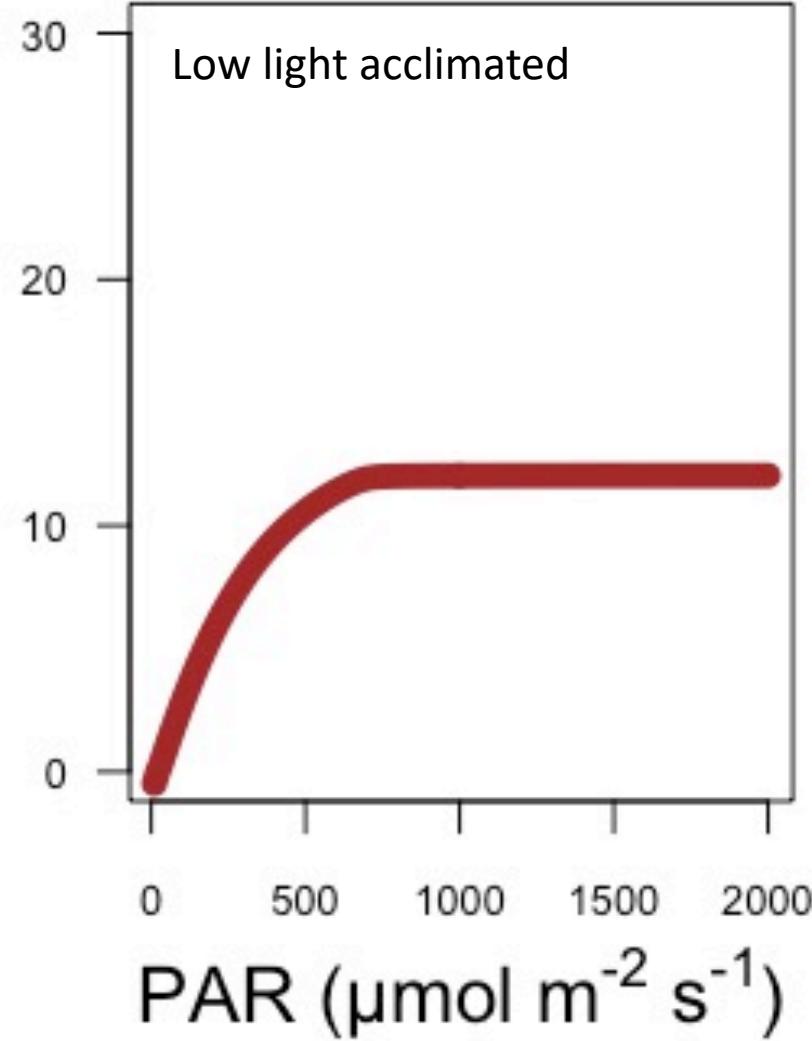
The light response of  
photosynthesis



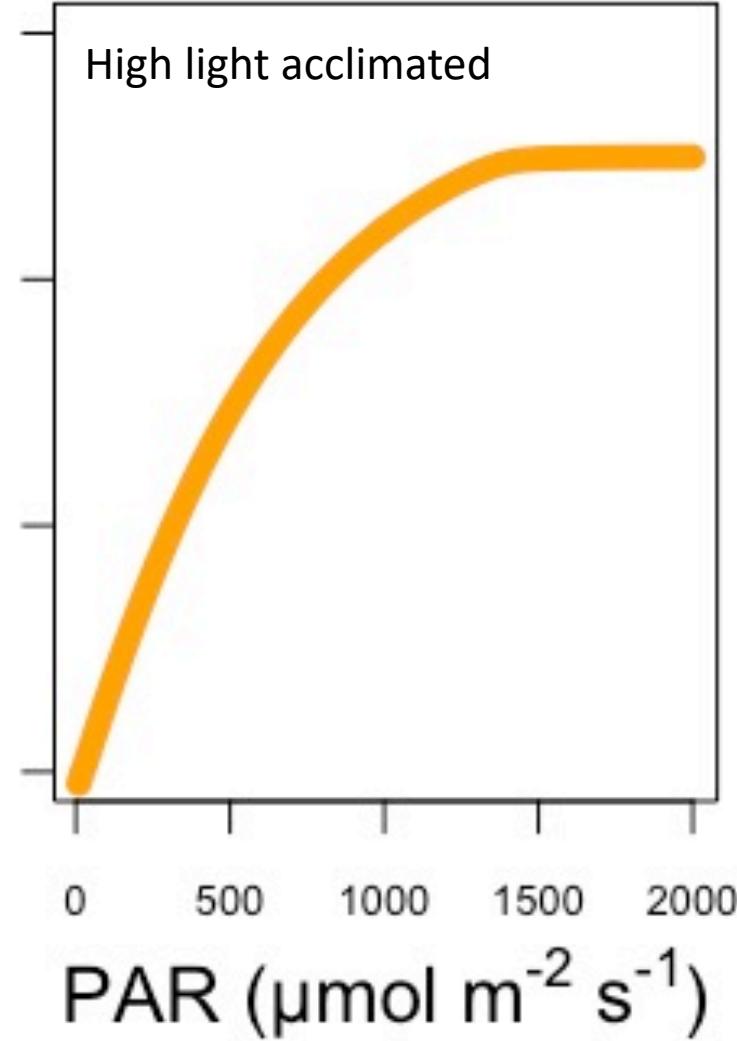


Light effects on long-term plant  
functioning - acclimation

Photosynthesis ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ )

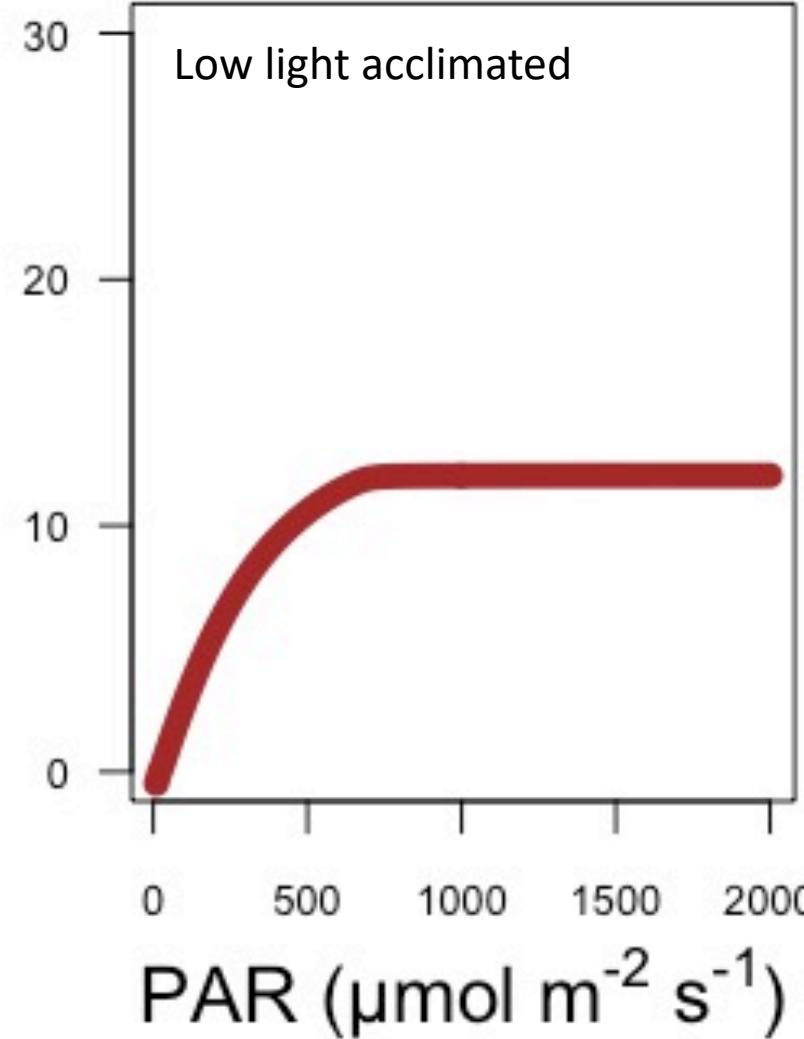


High light acclimated

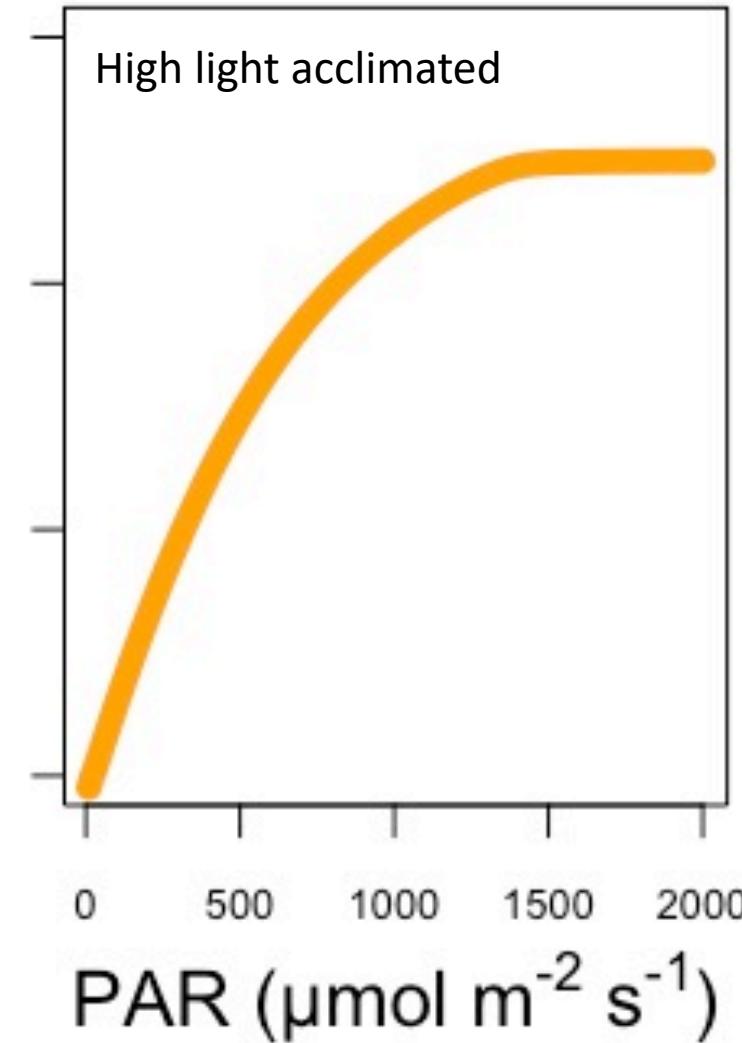


What's happening here?

Photosynthesis ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ )

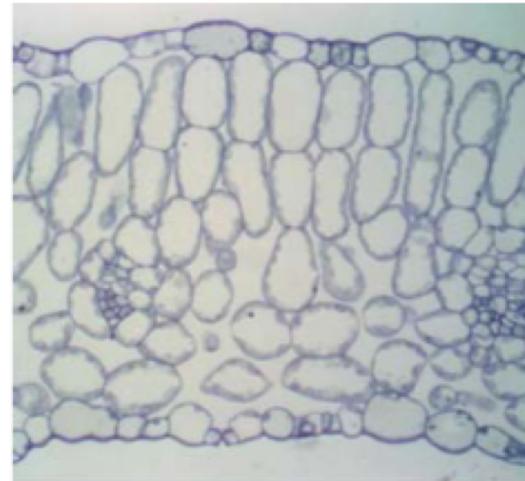


High light acclimated

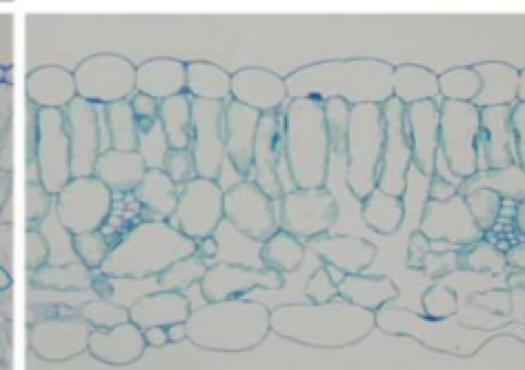
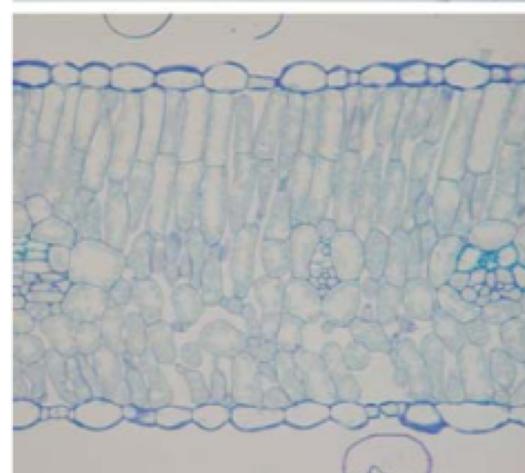
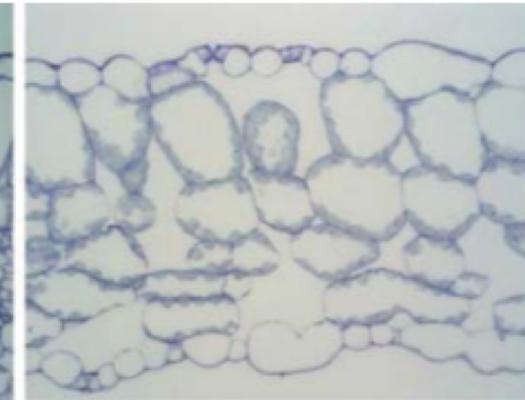


# Sun leaves are thicker

Sun

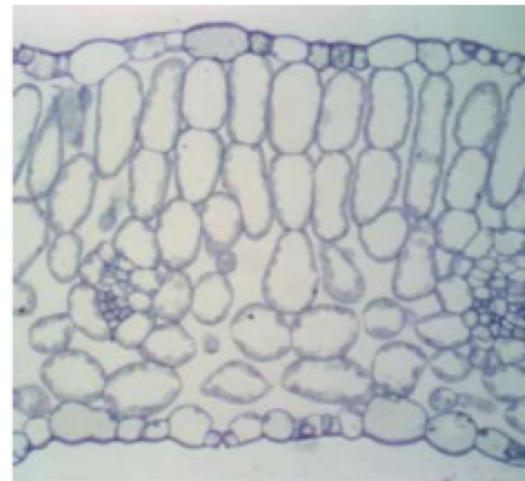


Shade

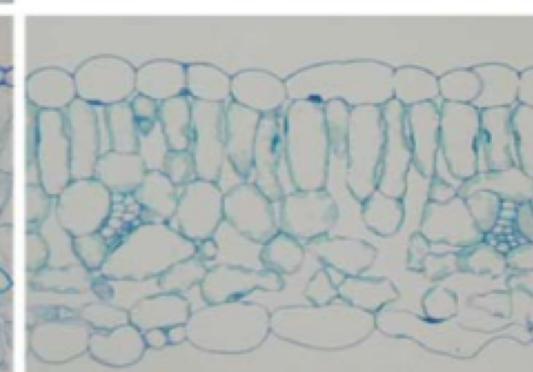
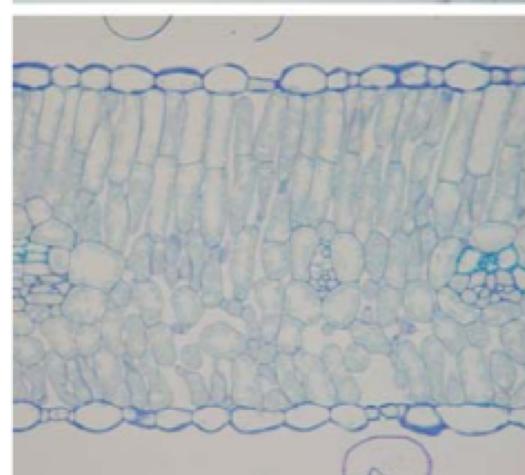
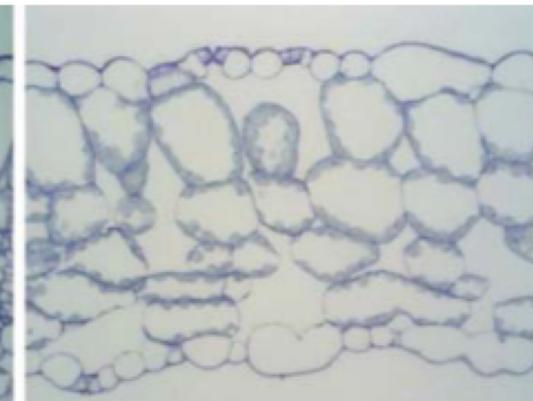


# Sun leaves are thicker – why?

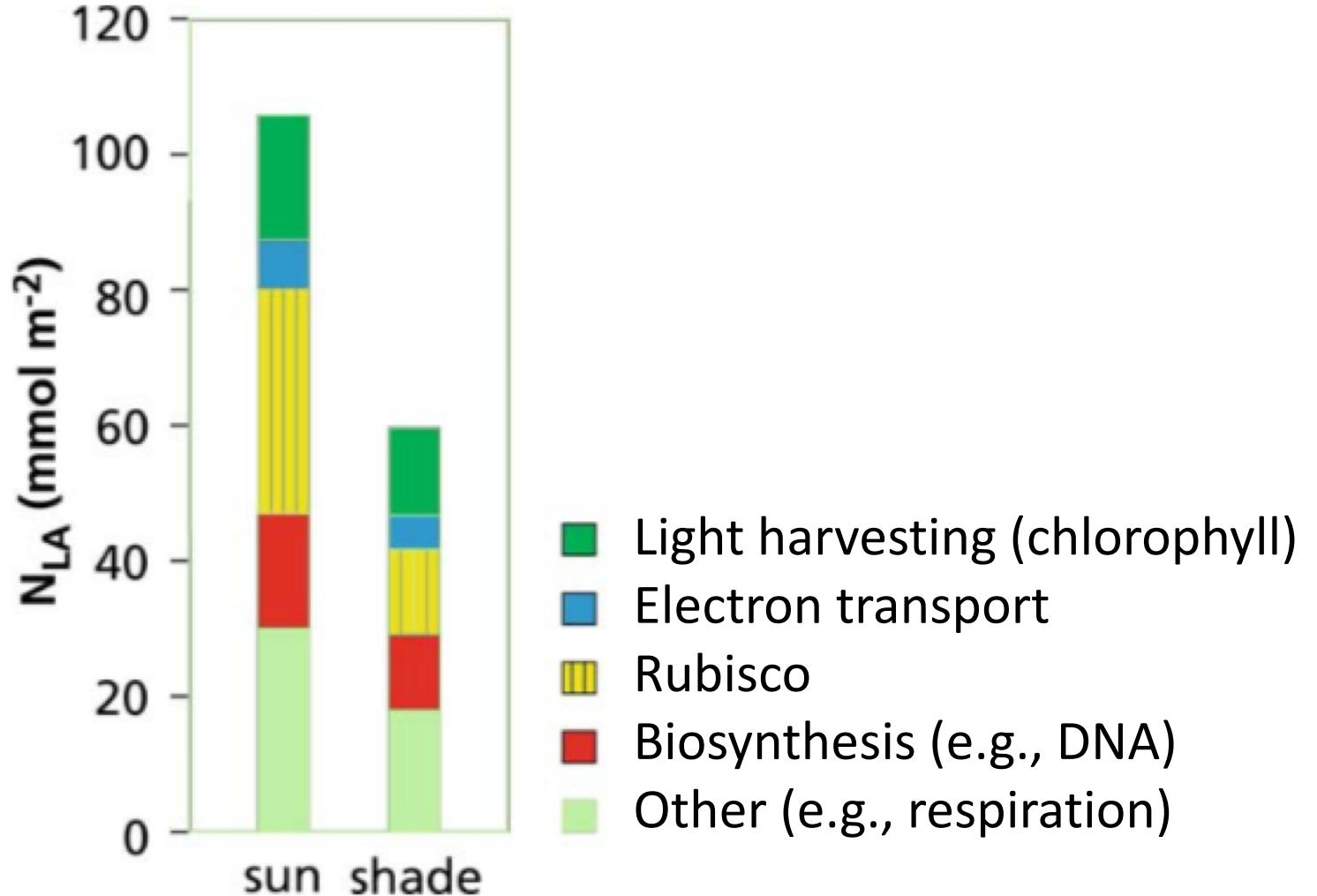
Sun



Shade



# Sun leaves have more N invested in photosynthesis



# Sun leaves have more N invested in photosynthesis – why?

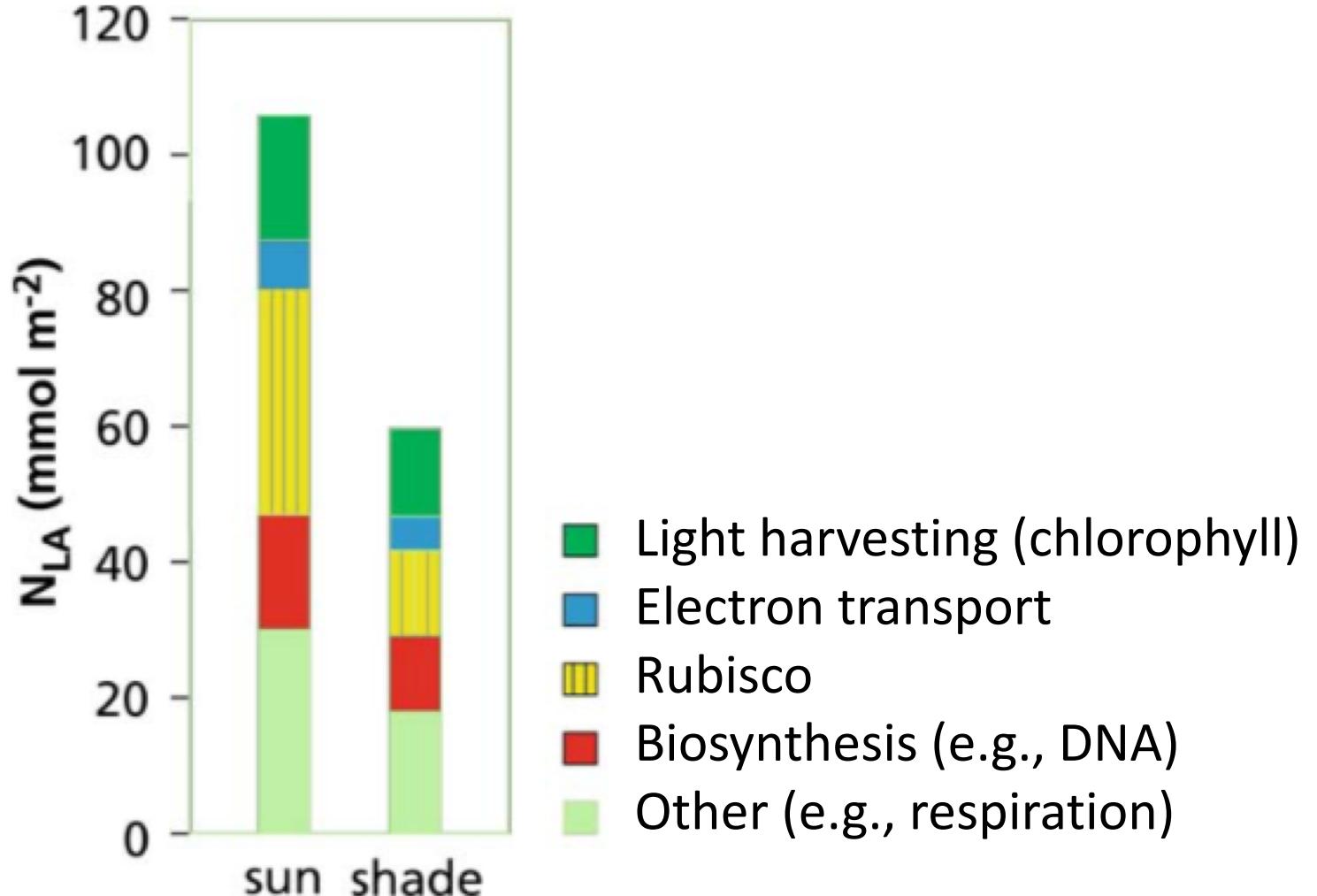


TABLE 2. Overview of generalized differences in characteristics between shade- and sun-acclimated leaves.

	Sun	Shade
<b>Structural</b>		
Leaf dry mass per area	High	Low
Leaf thickness	Thick	Thin
Palisade parenchyma thickness	Thick	Thin
Spongy parenchyma thickness	Similar	Similar
Stomatal density	High	Low
Chloroplast per area	Many	Few
Thylakoids per stroma volume	Low	High
Thylakoids per granum	Few	Many
<b>Biochemical</b>		
Chlorophyll per chloroplast	low	high
Chlorophyll per area	similar	similar
Chlorophyll per dry mass	low	high
Chlorophyll a/b ratio	high	low
Light-harvesting complex per area	low	high
Electron transport components per area	high	low
Coupling factor (ATPase) per area	high	low
Rubisco per area	high	low
Nitrogen per area	high	low
Xanthophylls per area	high	low
<b>Gas exchange</b>		
Photosynthetic capacity per area	high	low
Dark respiration per area	high	low
Photosynthetic capacity per dry mass	similar	similar
Dark respiration per dry mass	similar	similar
Carboxylation capacity per area	high	low
Electron transport capacity per area	high	low
Quantum yield	similar	similar
Curvature of light-response curve	gradual	acute

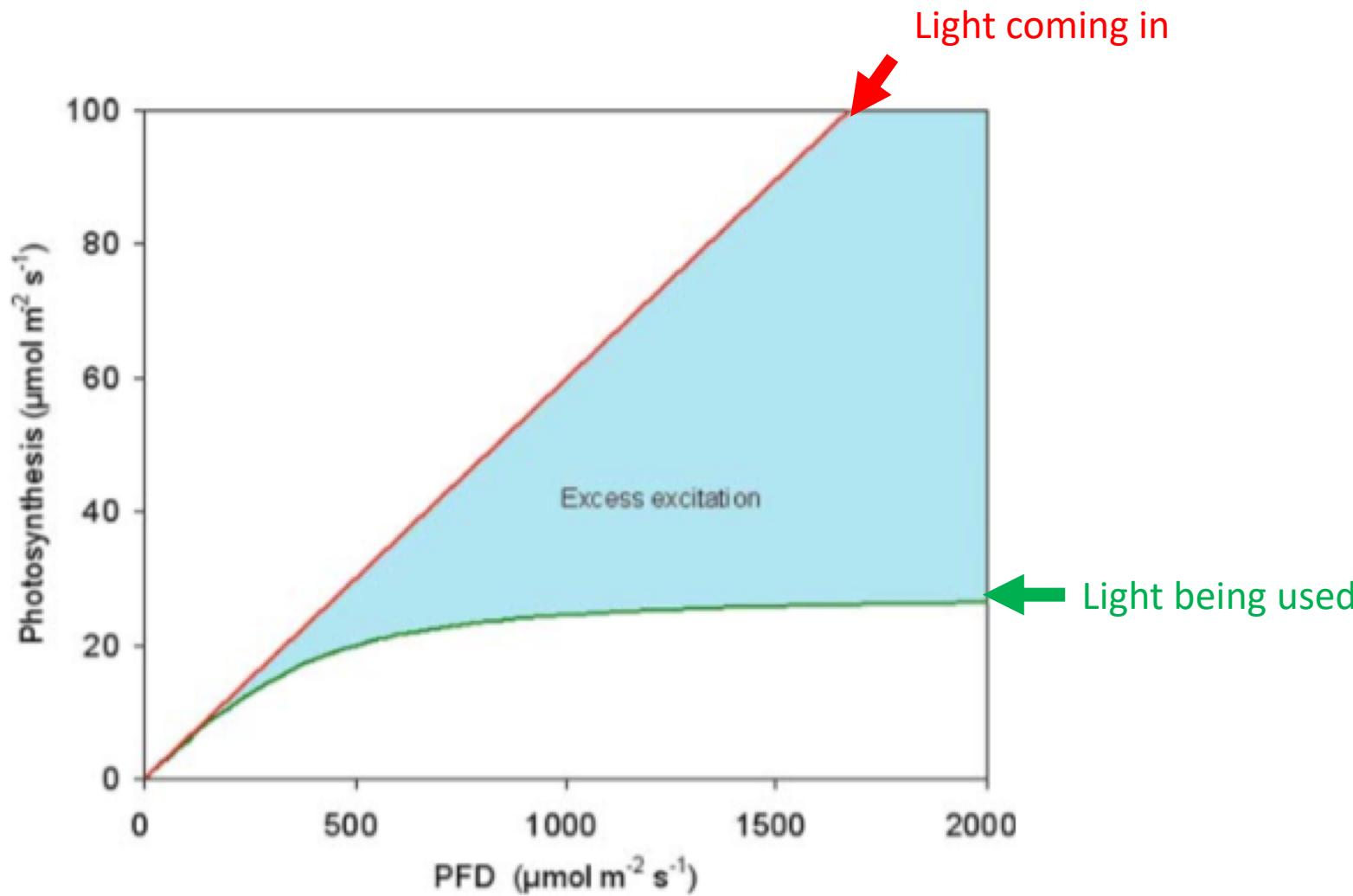
## Other differences

Why??

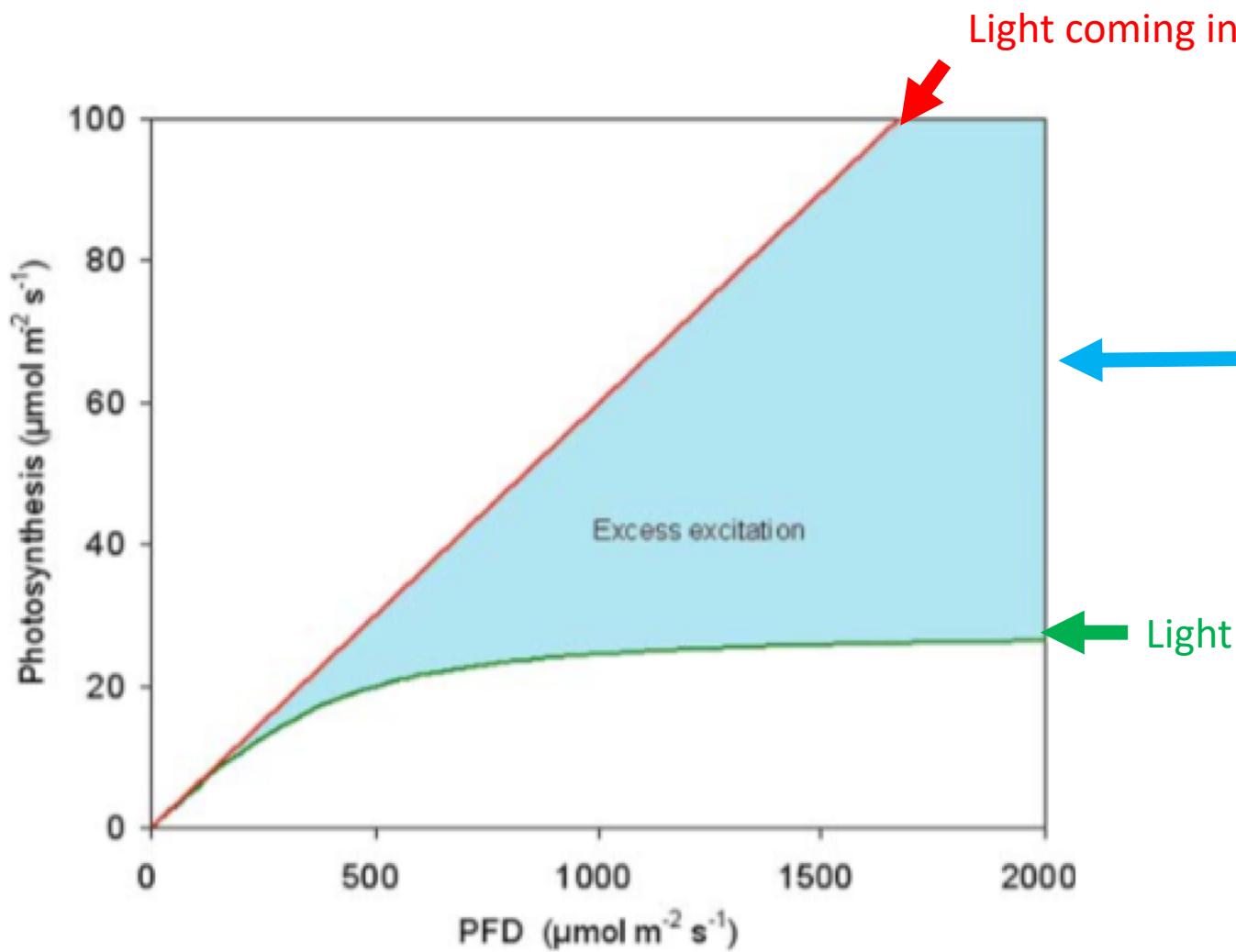
Activity: pick a trait and formulate a hypothesis to explain the observed response

# Photoinhibition

# Photoinhibition



# Photoinhibition



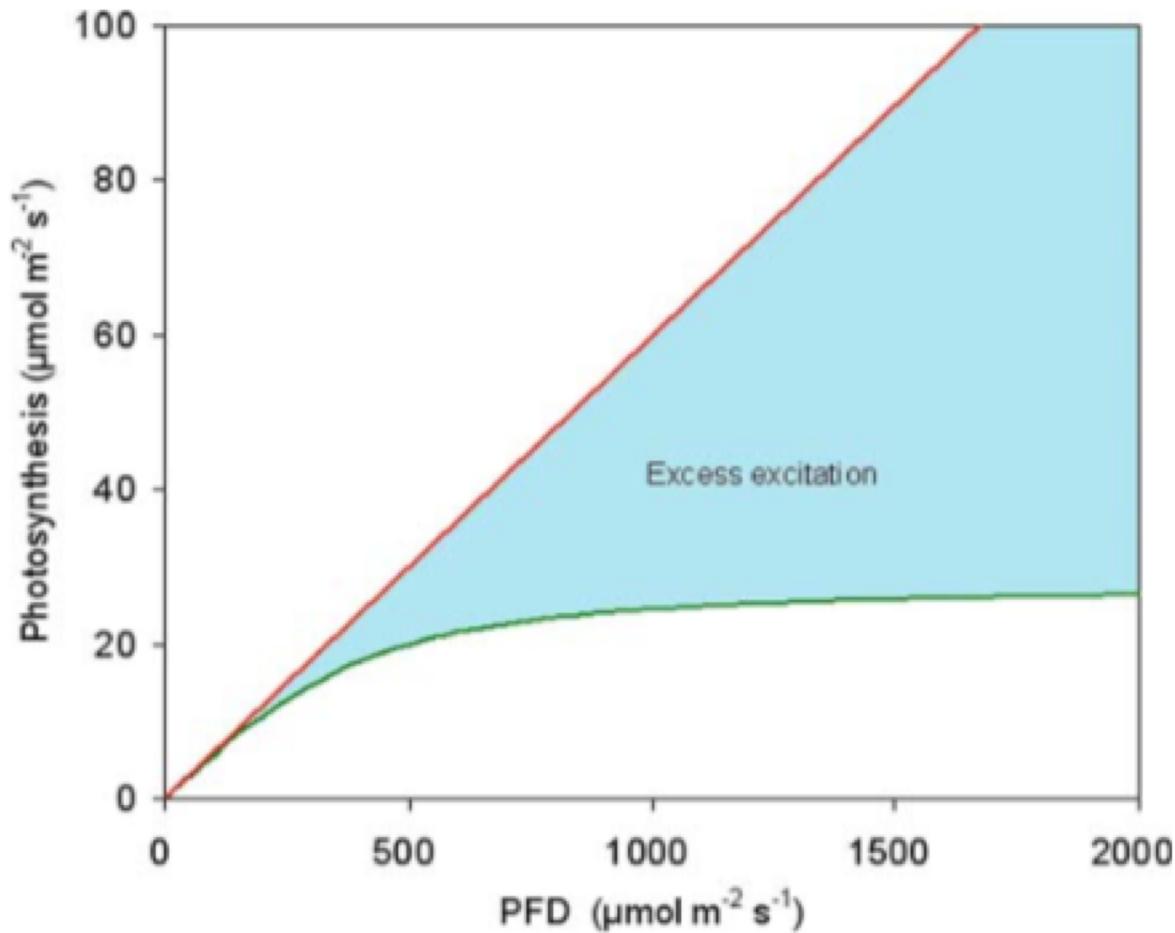
Light coming in

Too much excitement!

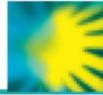
Light being used



# Photoinhibition



Excess energy is not dissipated, leading to the creation of ROS that damage photosynthetic complexes, reducing photosynthesis



# Terrestrial biosphere models underestimate photosynthetic capacity and CO<sub>2</sub> assimilation in the Arctic

Alistair Rogers<sup>1</sup>, Shawn P. Serbin<sup>1</sup>, Kim S. Ely<sup>1</sup>, Victoria L. Sloan<sup>2</sup> and Stan D. Wullschleger<sup>2</sup>

<sup>1</sup>Environmental and Climate Sciences Department, Brookhaven National Laboratory, Upton, NY 11973-5000, USA; <sup>2</sup>Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6301, USA

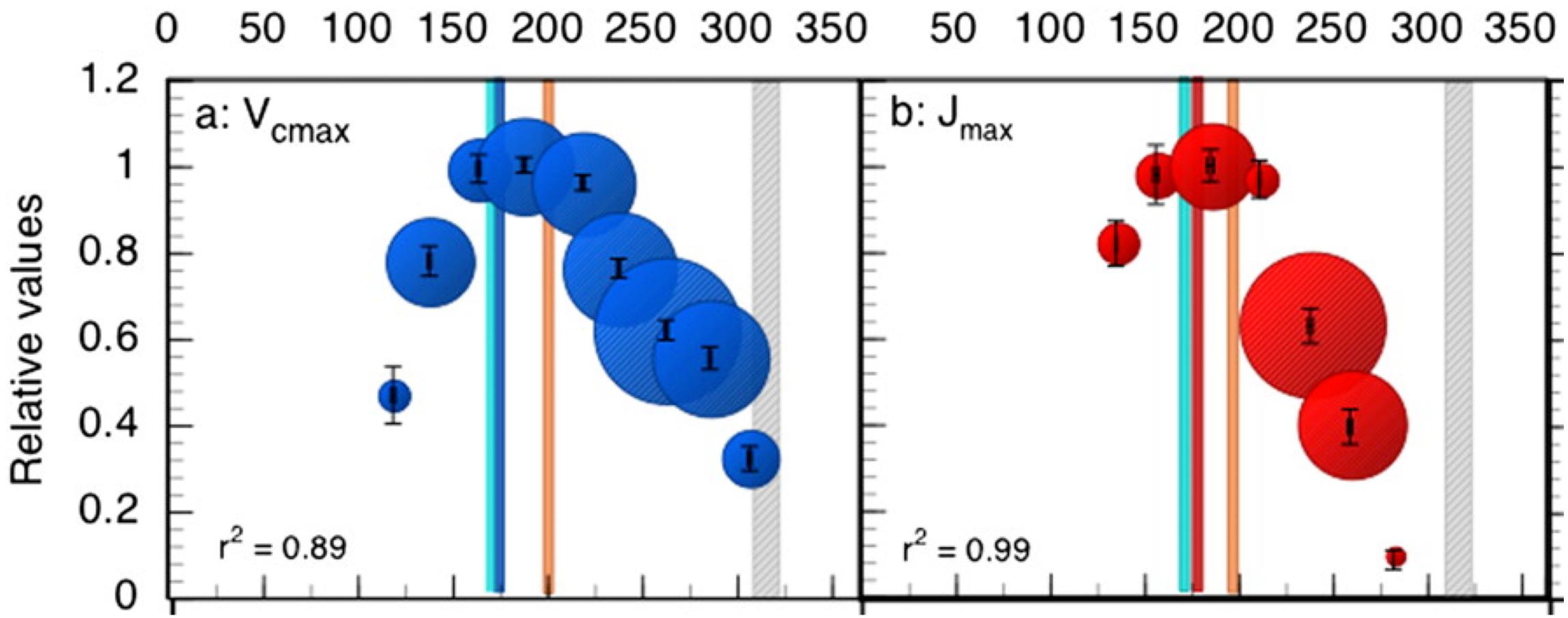
Translation: lots of Rubisco in the arctic!!  
Why might this be the case?

# How does light availability to plants vary over space and time?

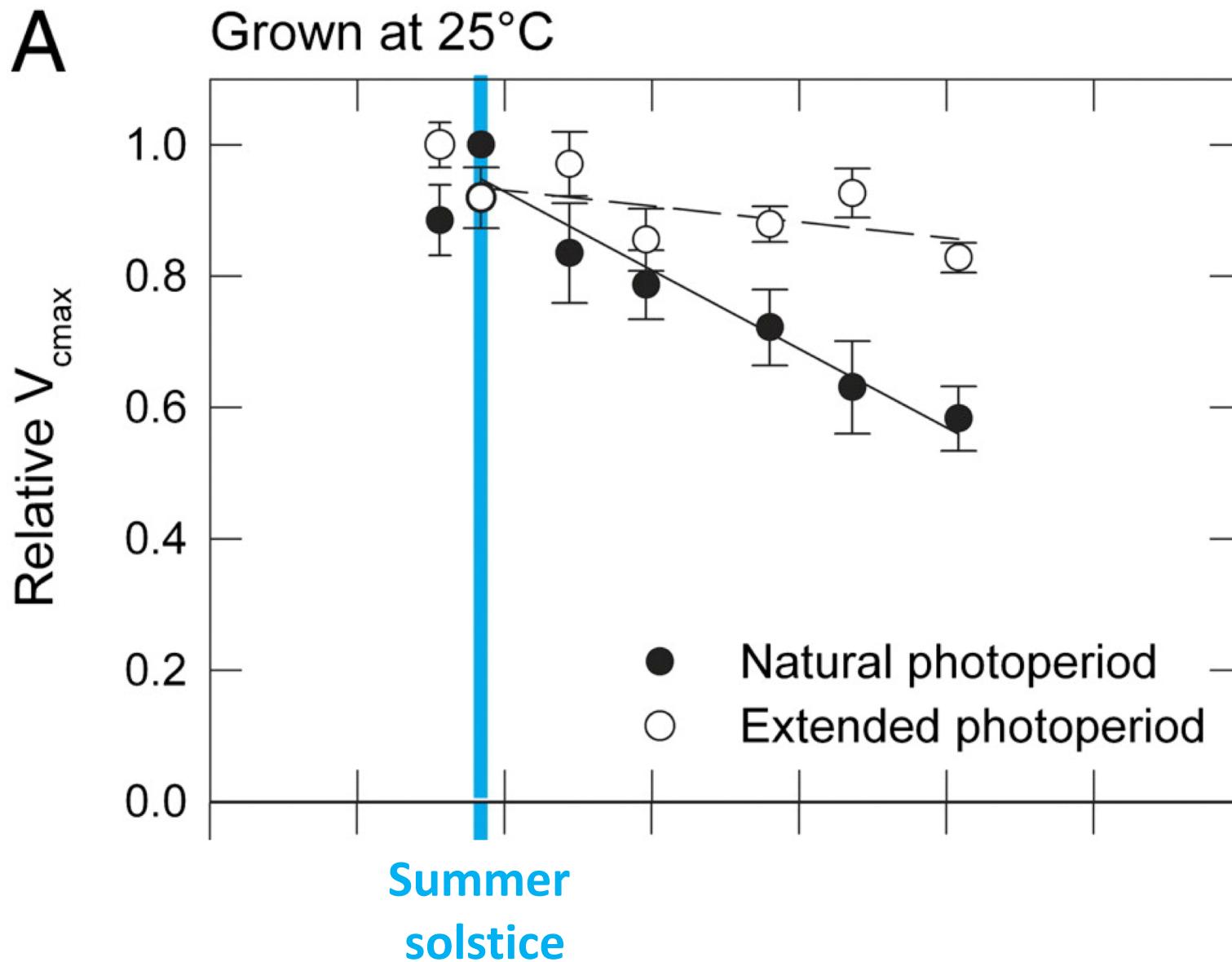


# Seasons

Day of Year (DOY)



A

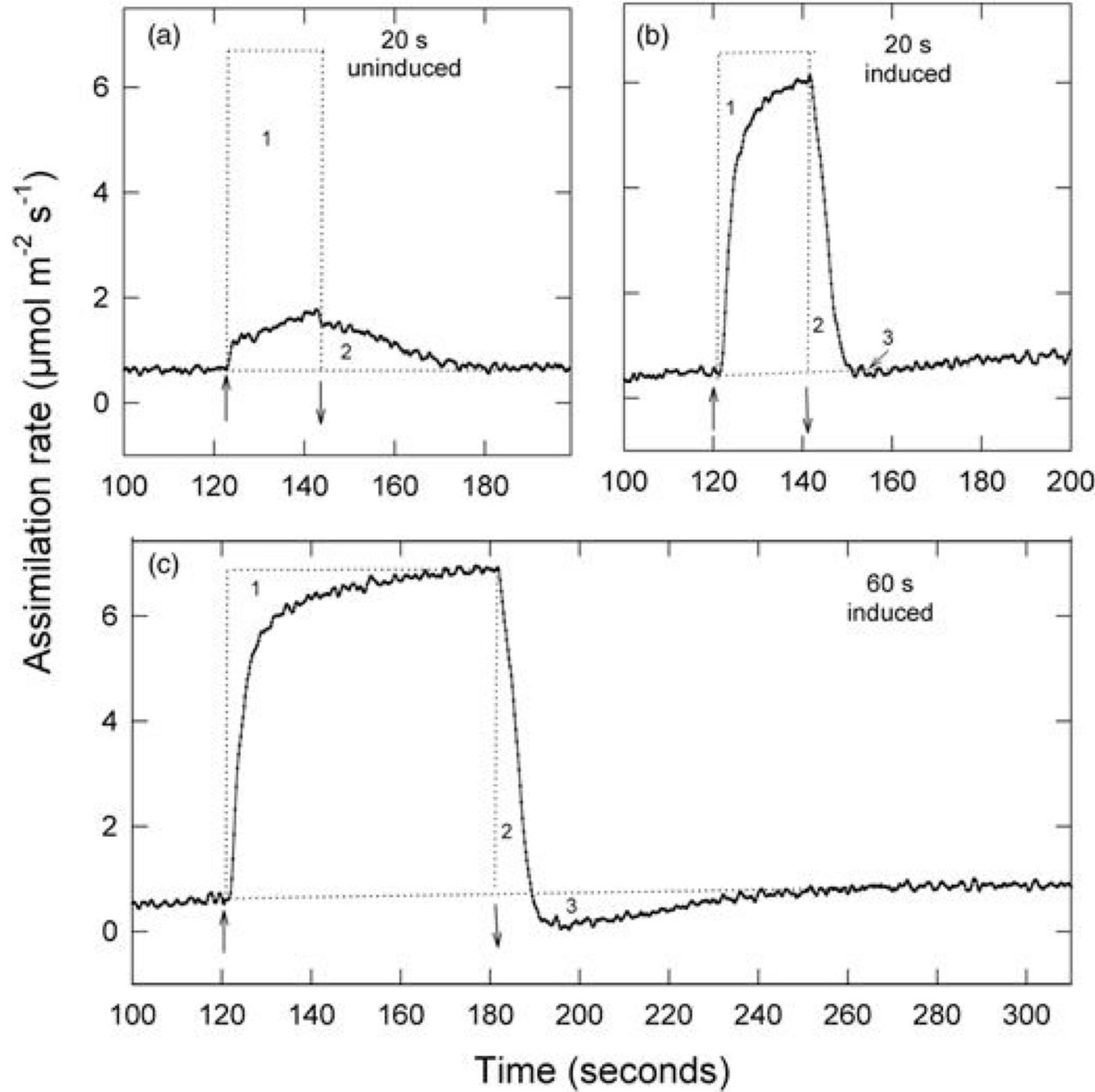


Sunflecks

# Sunflecks



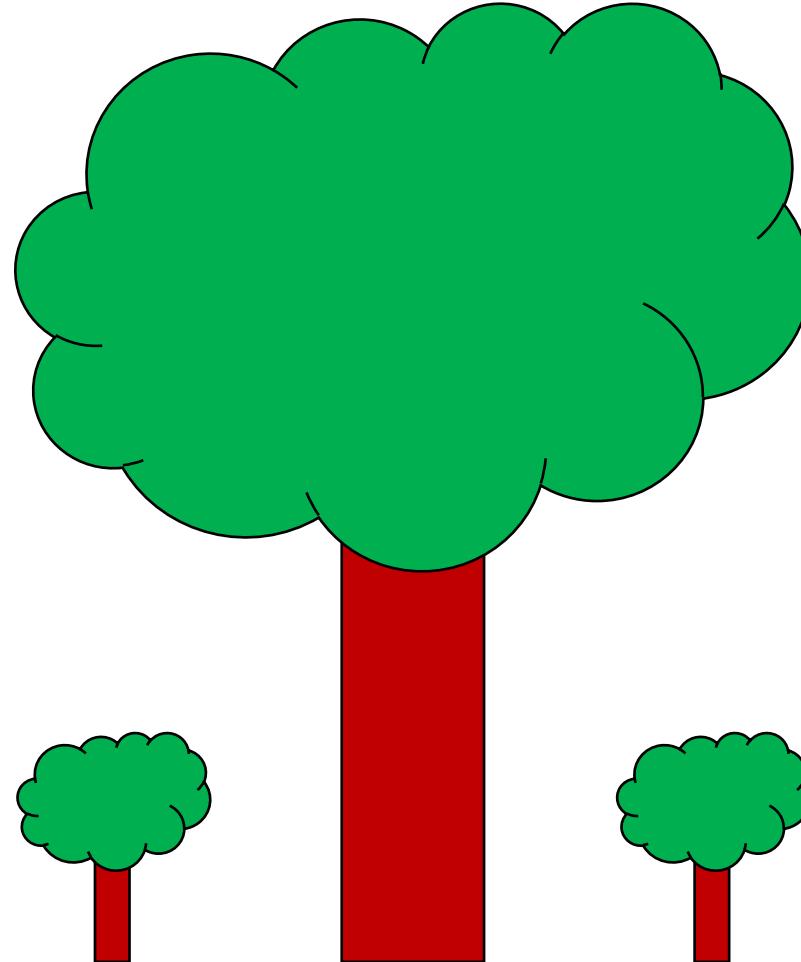
# Sunflecks



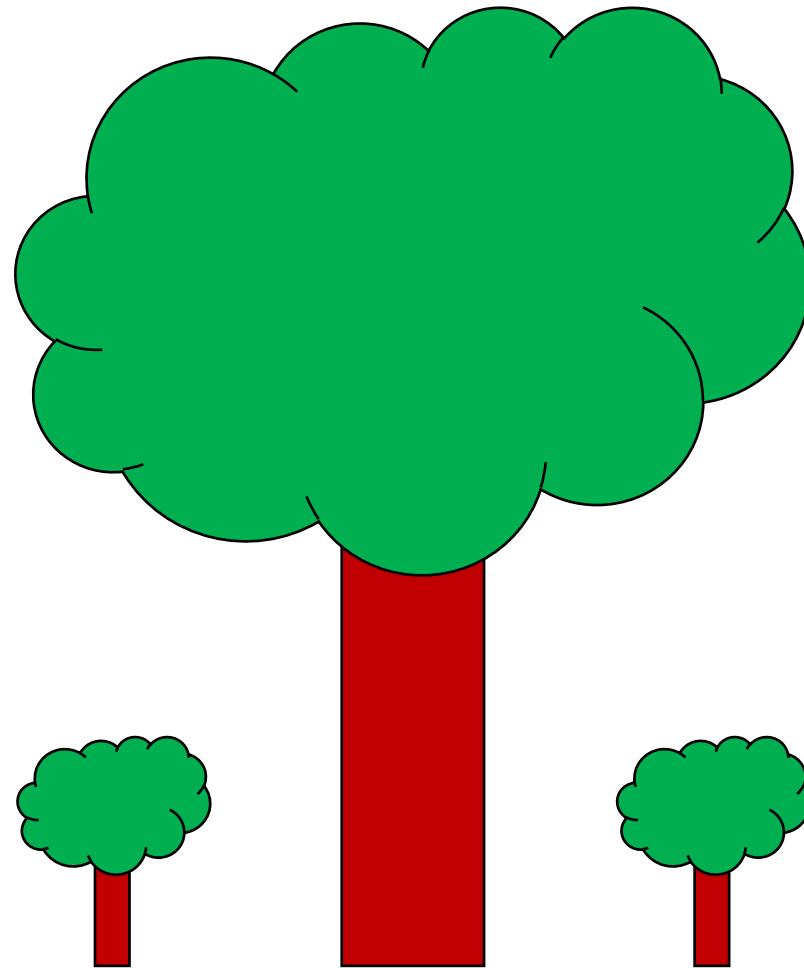
Induced refers to  
prior exposure  
to a sunfleck

Light competition

Light is the most strongly fought-after aboveground resource



So why aren't plants taller?



Can an individual plant be sun  
and shade adapted?