

The ecophysiological consequences of light variability

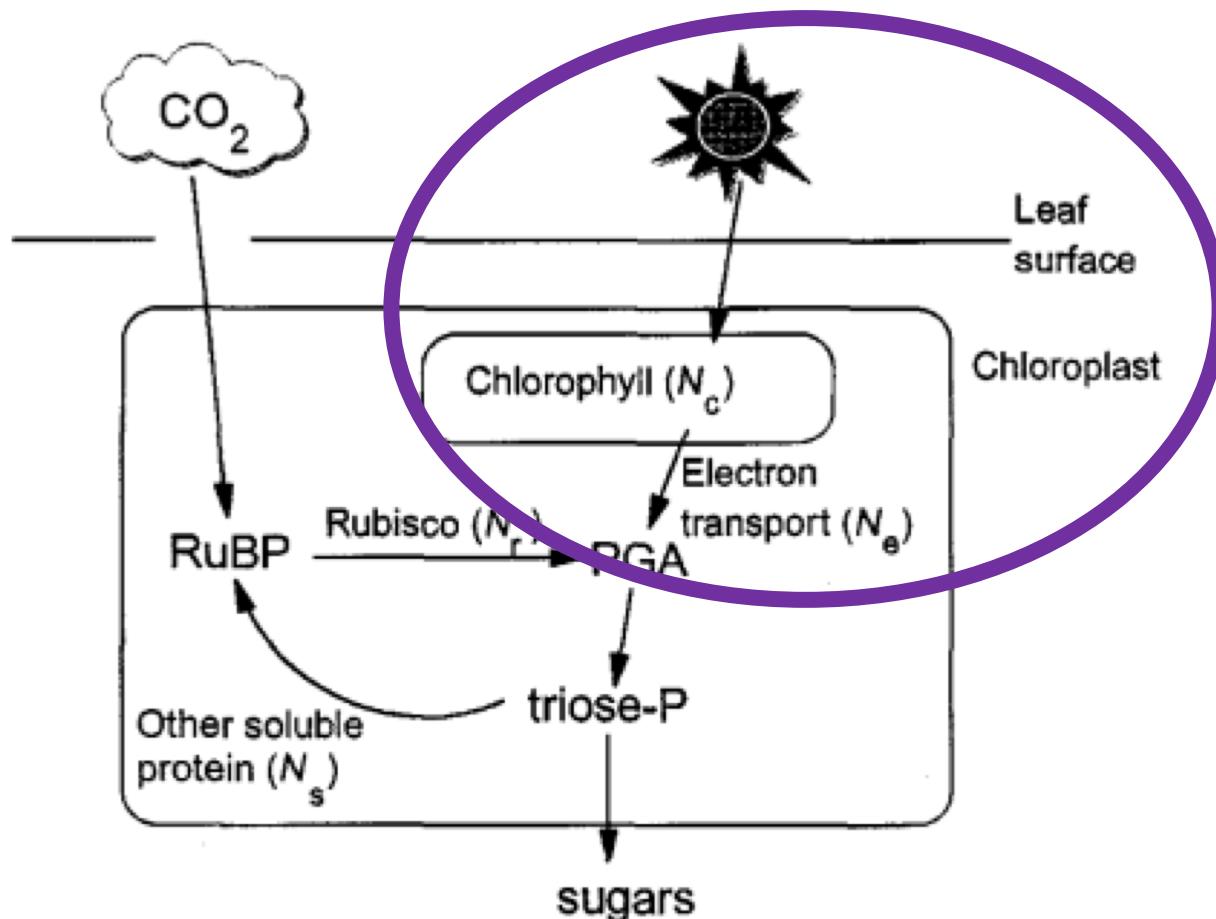
February 9, 2021

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



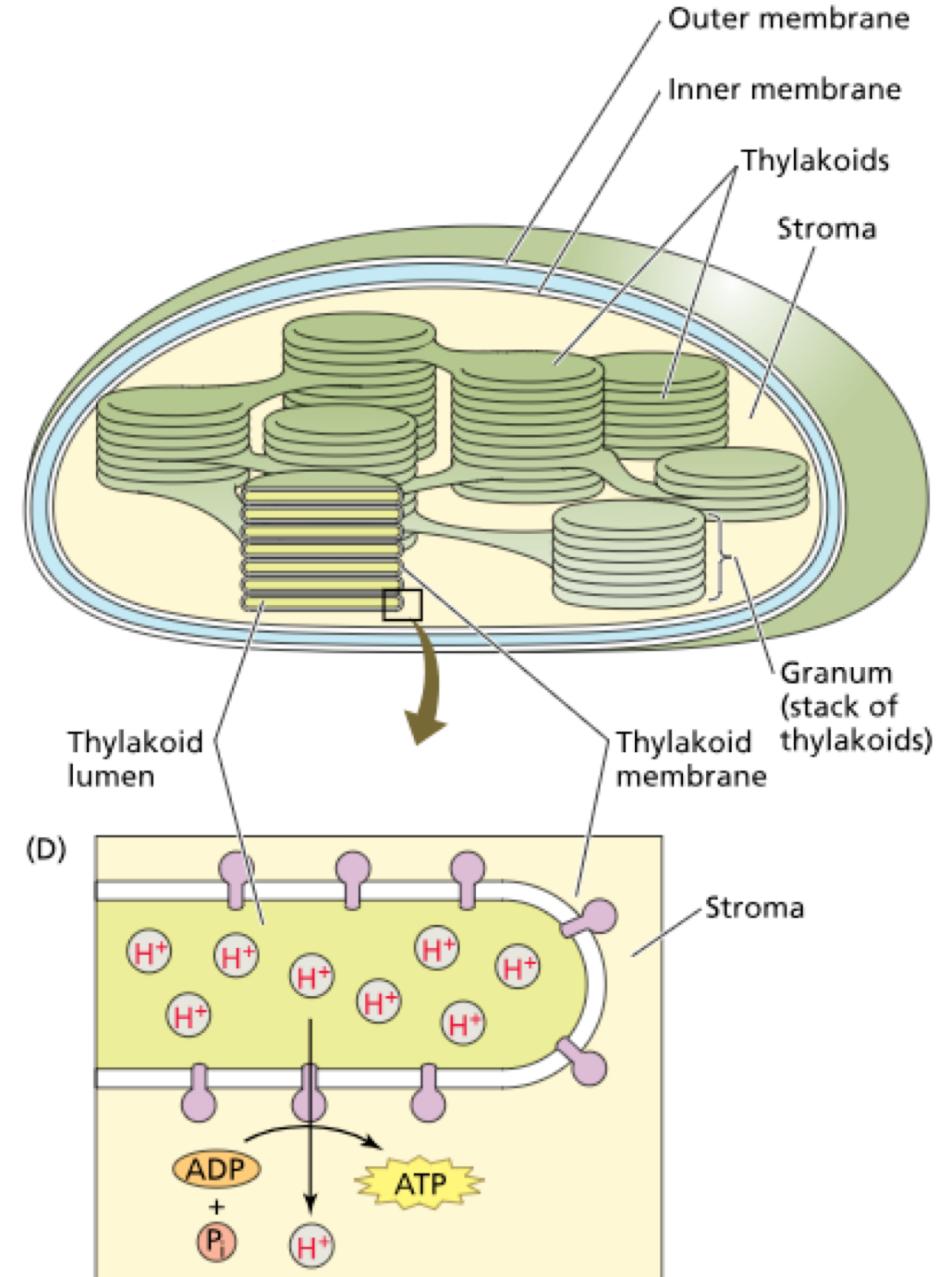
Light effects on short-term plant functioning

Plants use light to make energy for photosynthesis



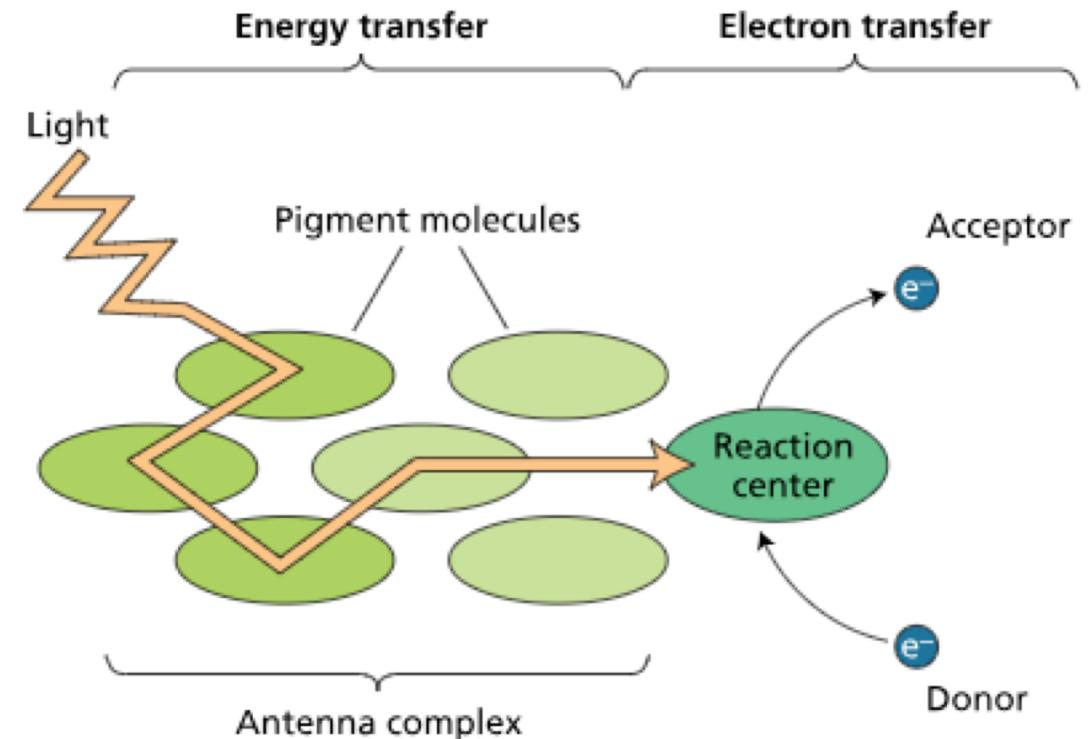
Chloroplasts

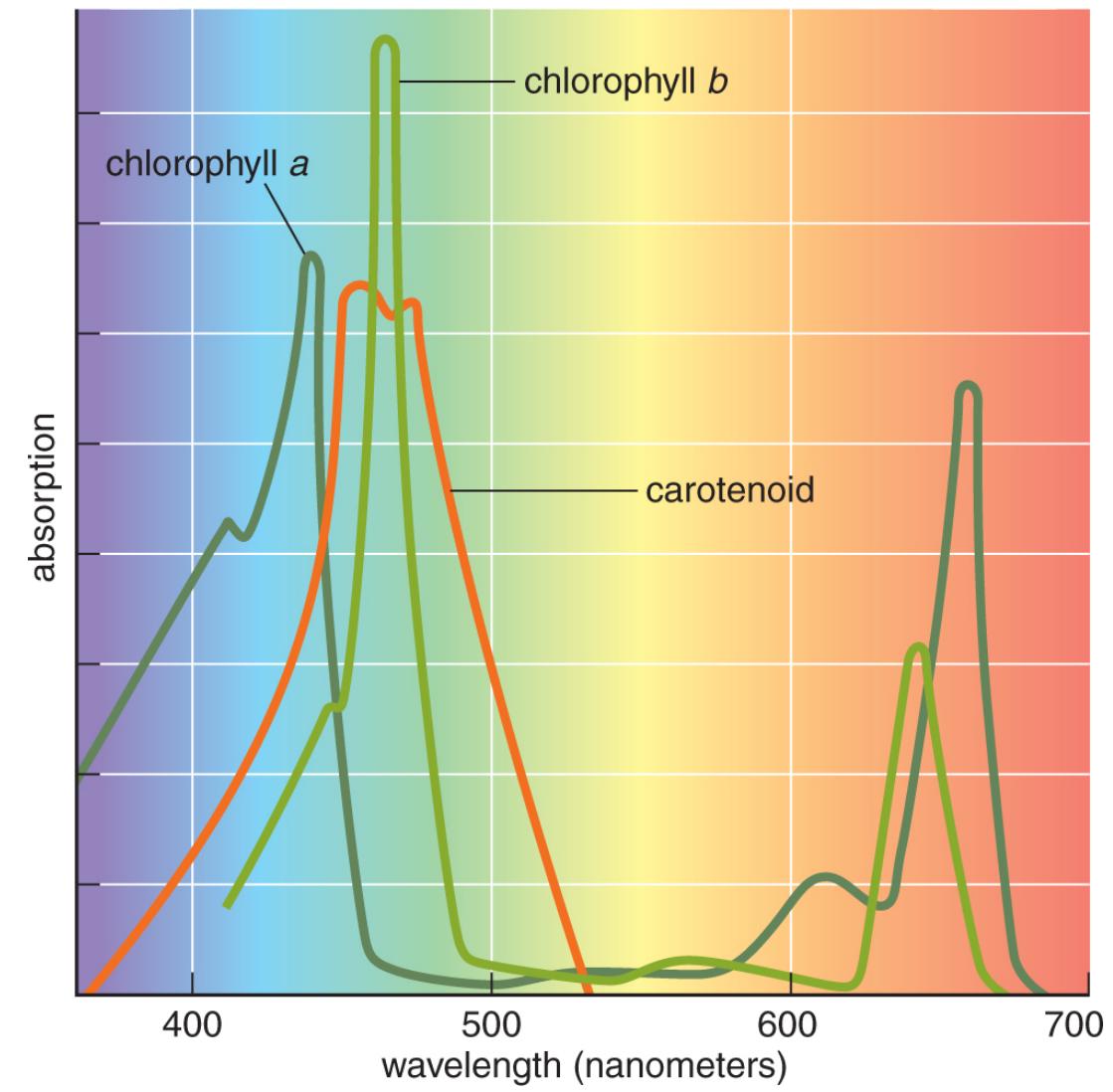
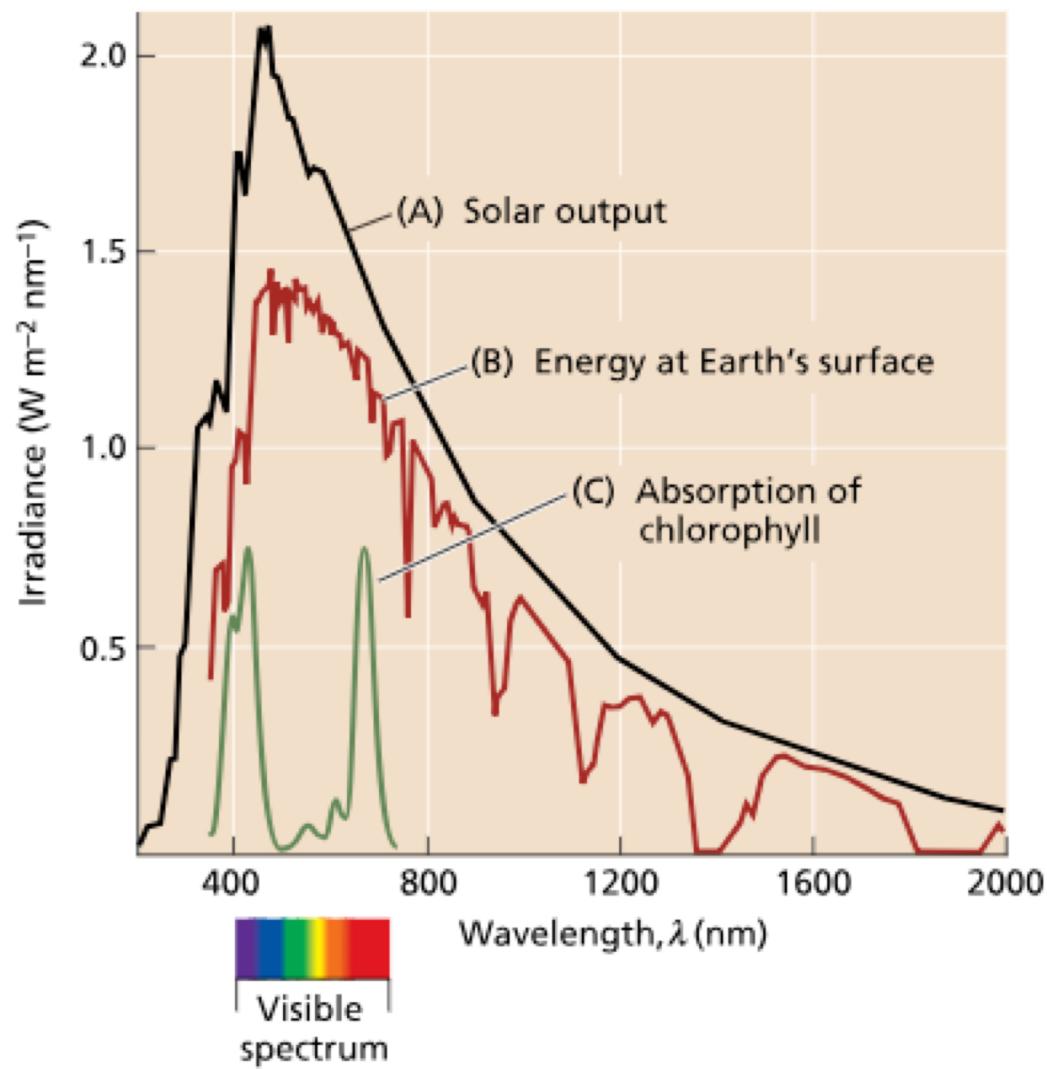
Light reaction proteins and pigments are embedded in the thylakoid membrane



Chlorophyll

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





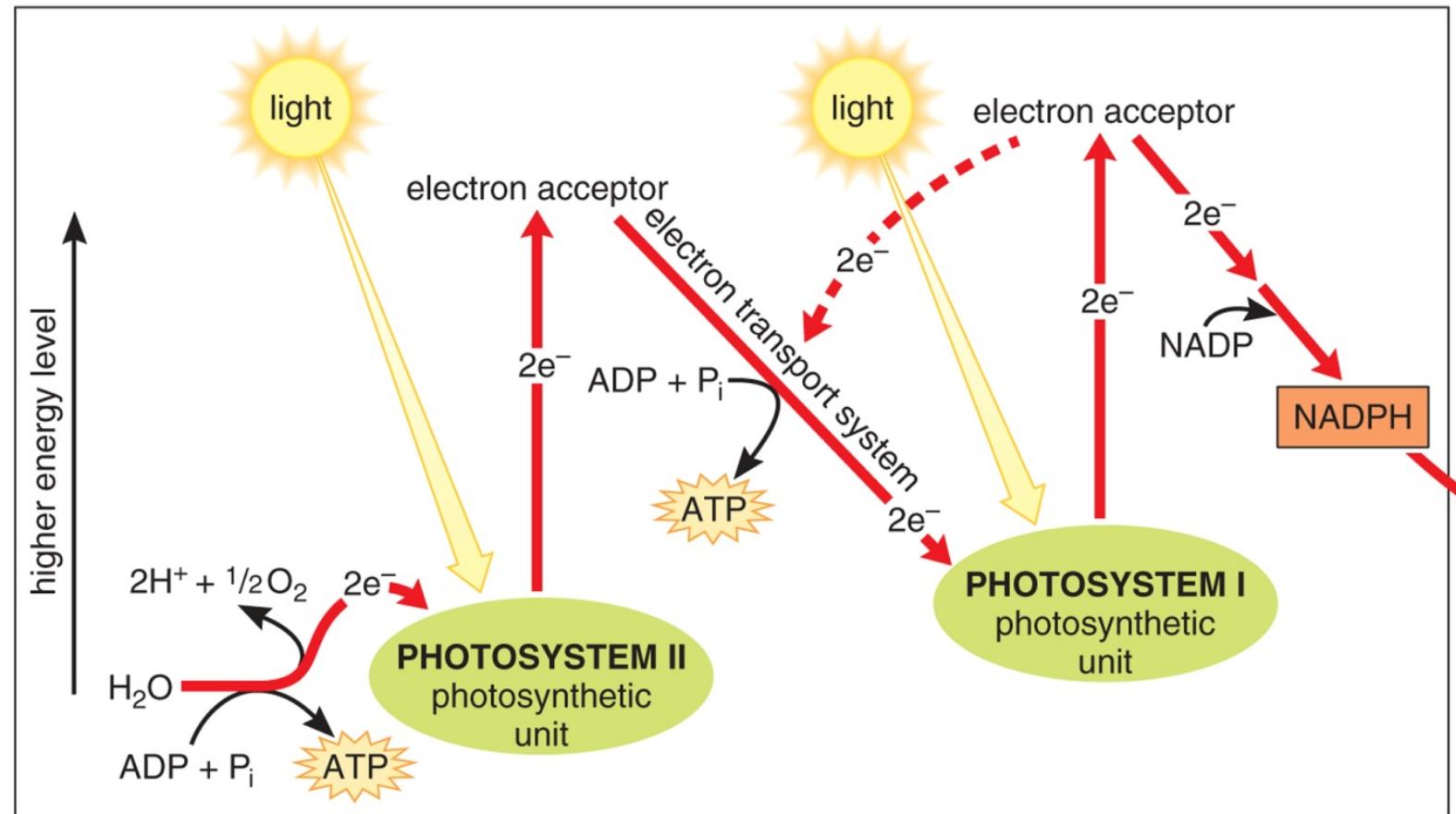
Light-dependent reactions

1. Ingredients

- Light
- H₂O
- NADP⁺
- ADP
- P

2. Outcomes

- ATP
- NADPH
- O₂
- H⁺



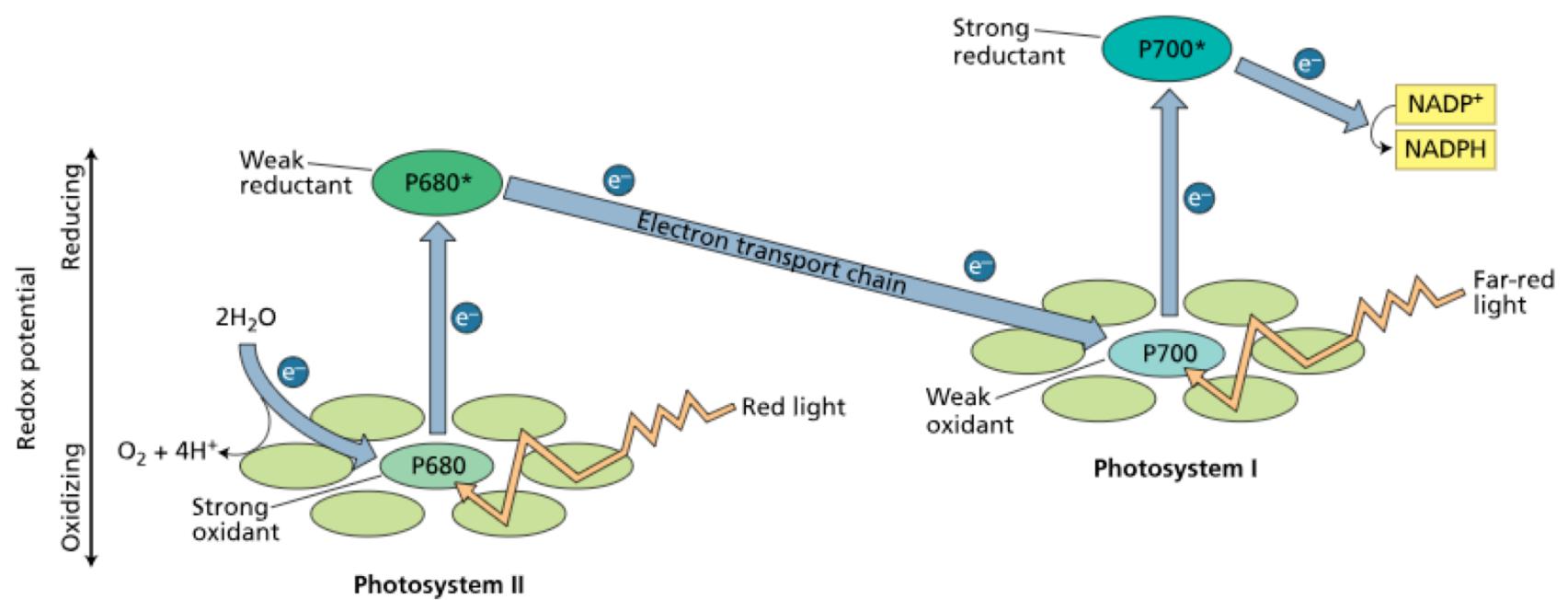
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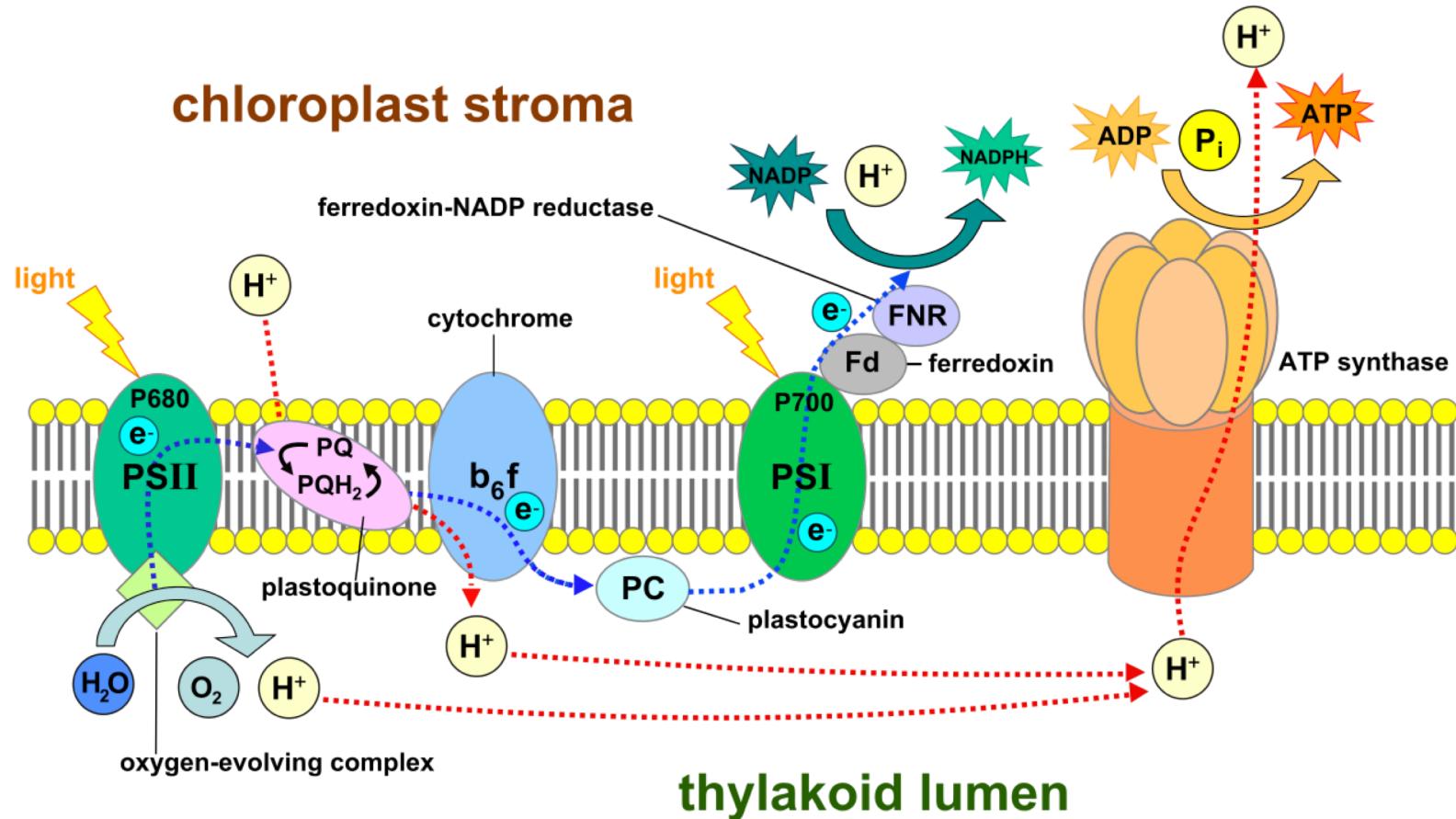
Light-dependent reactions

1. Ingredients

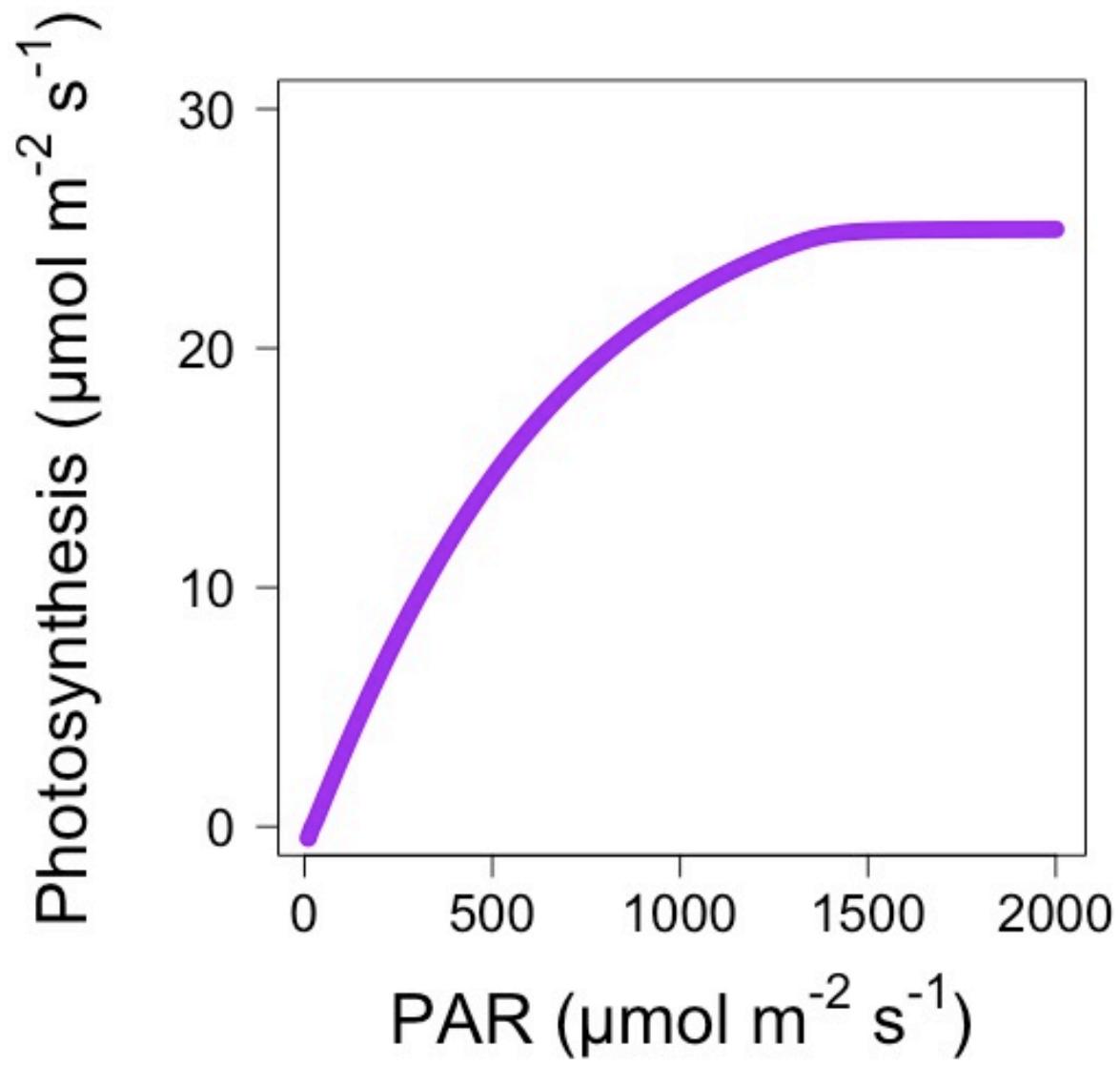
- Light
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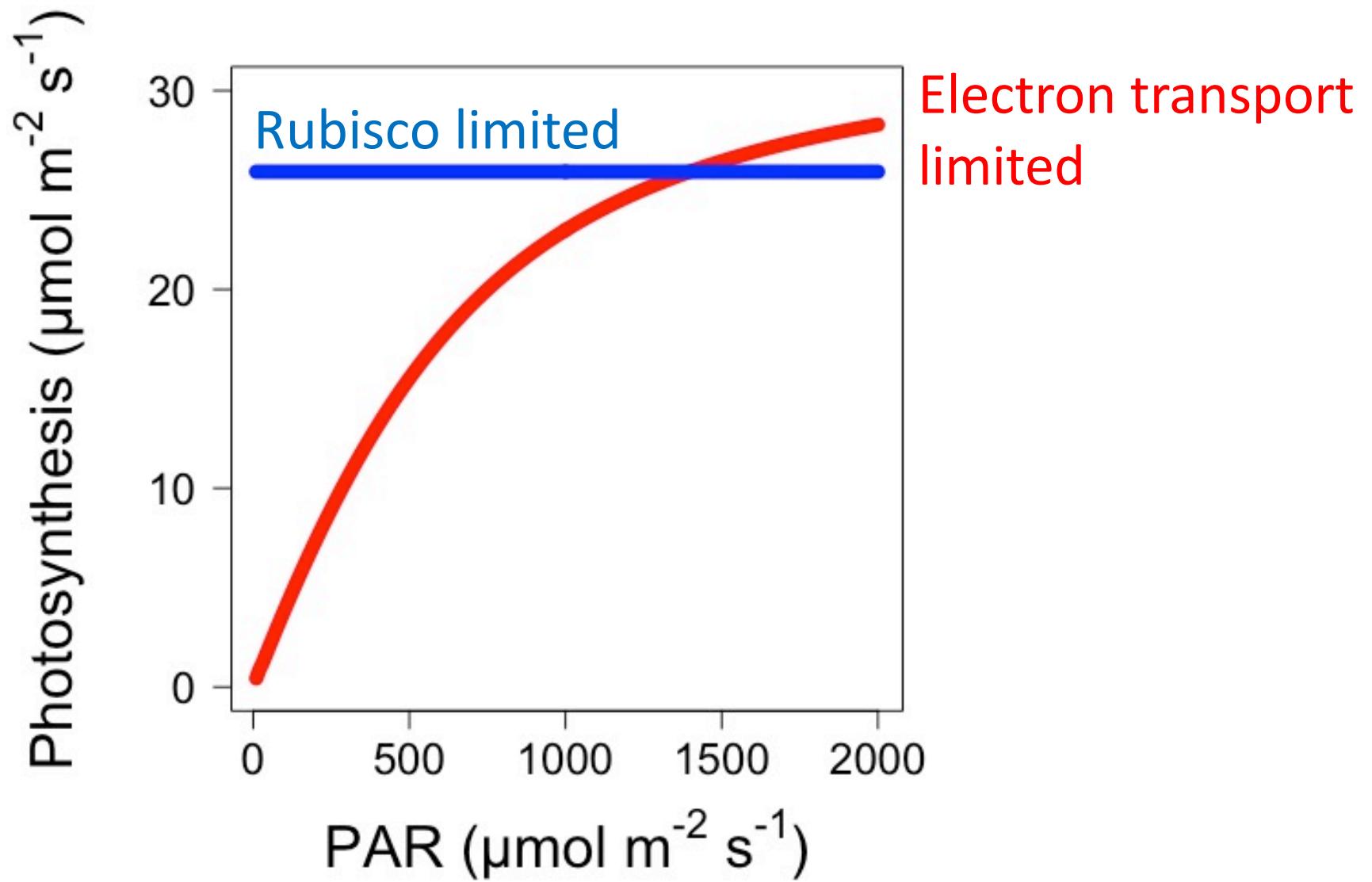
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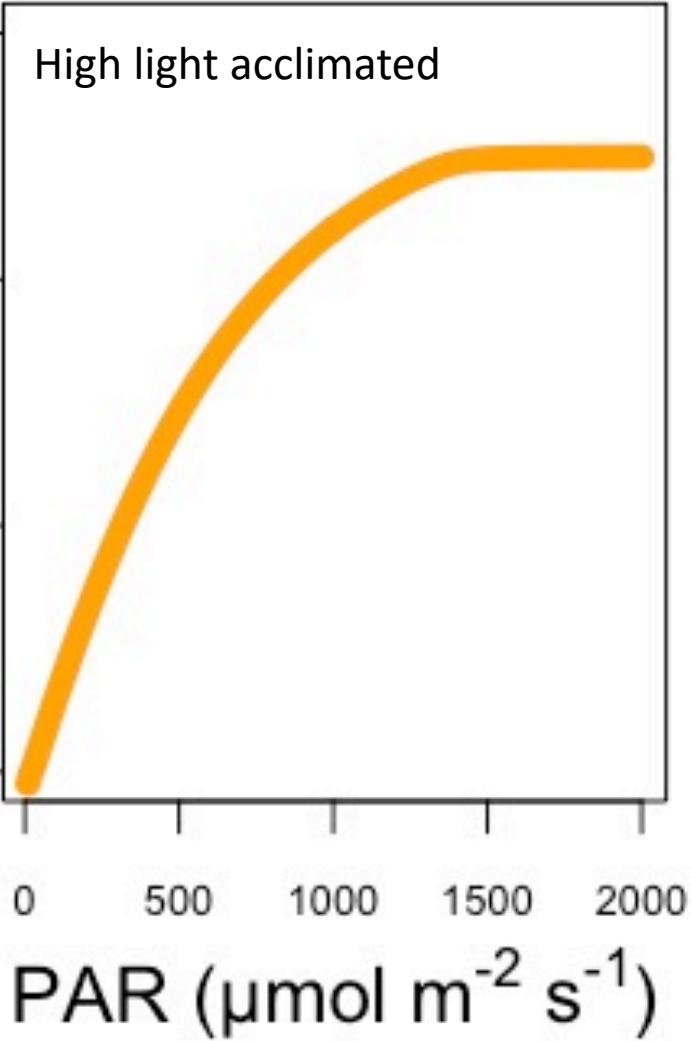
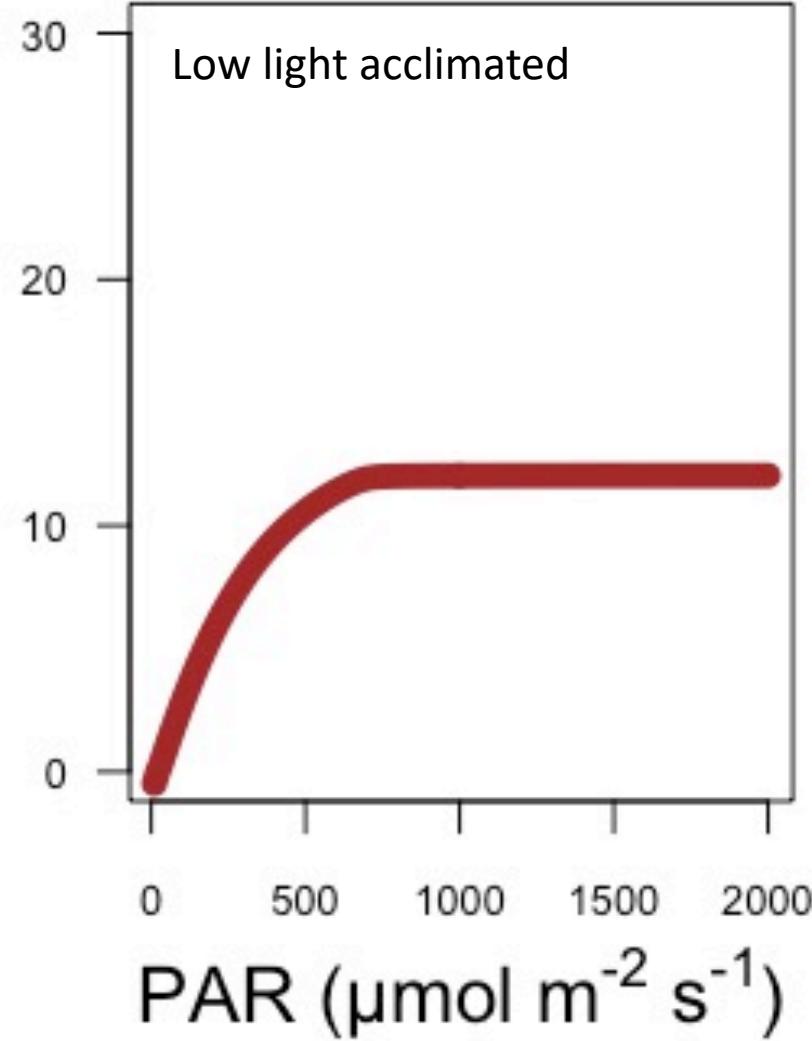
The light response of
photosynthesis





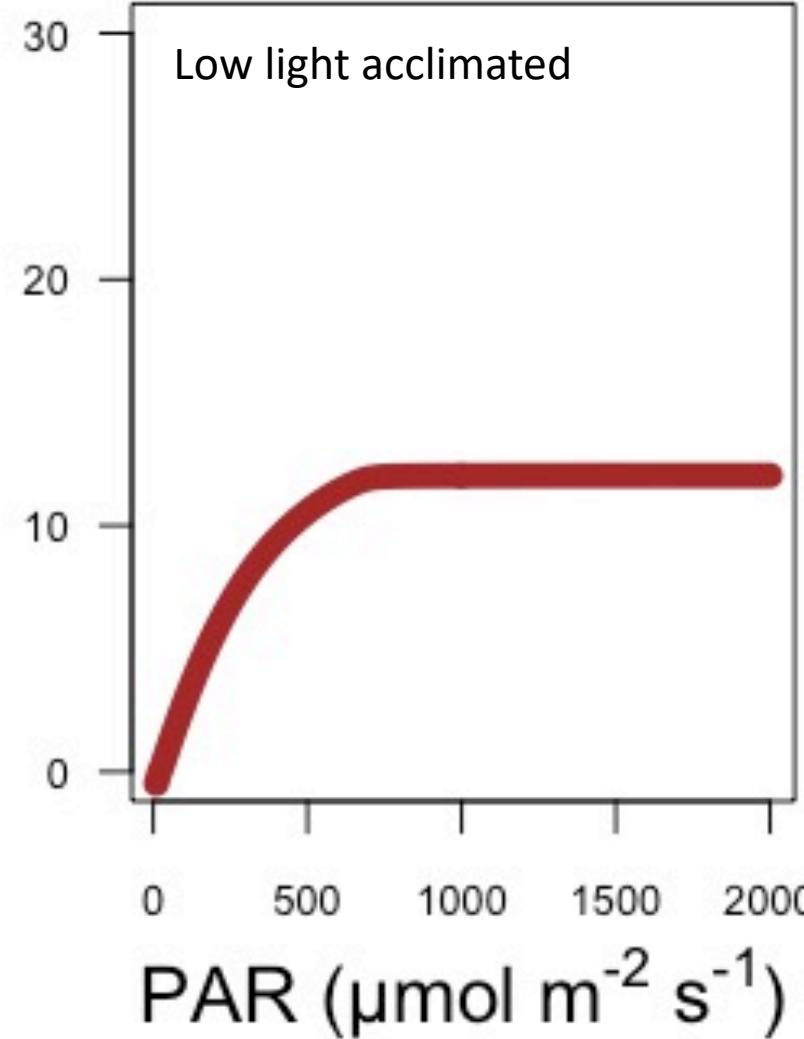
Light effects on long-term plant
functioning - acclimation

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

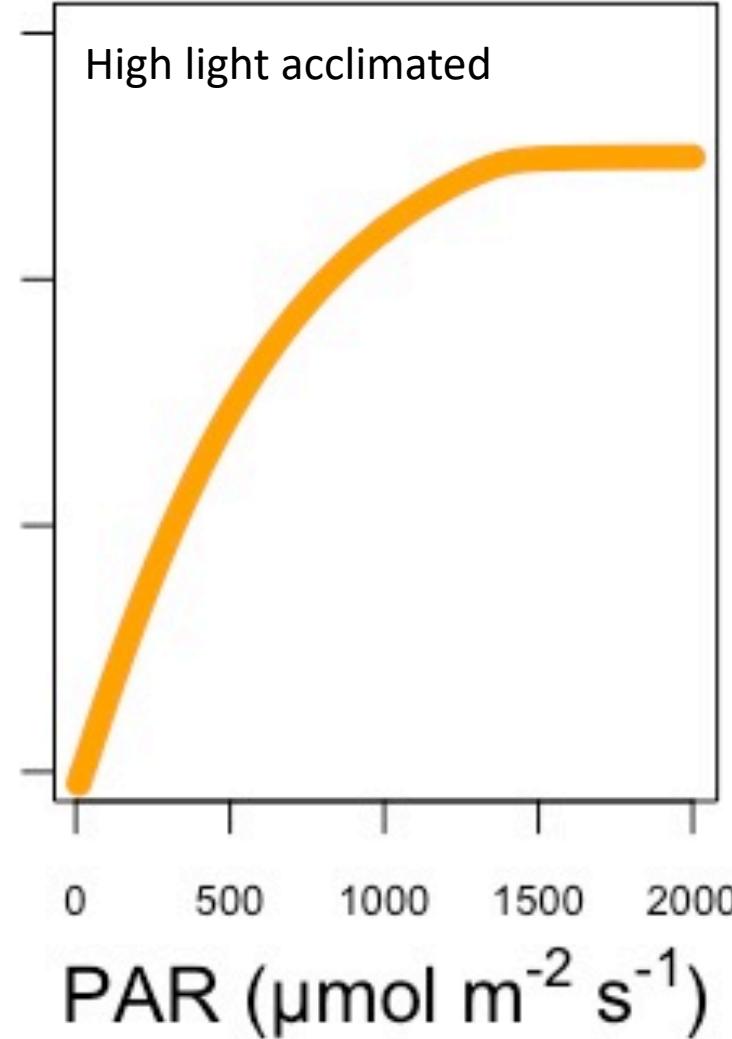


What's happening here?

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

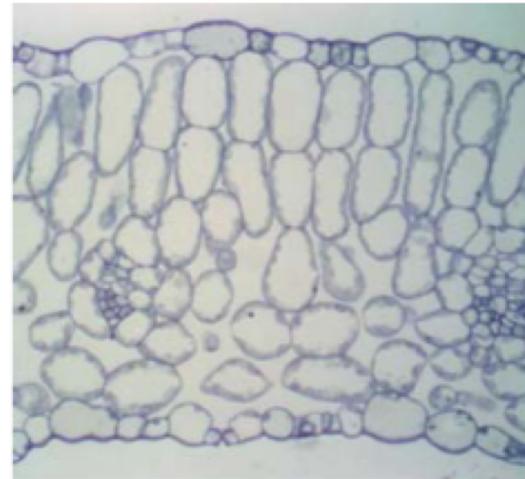


High light acclimated

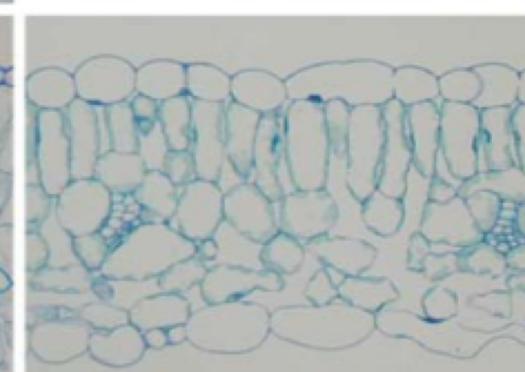
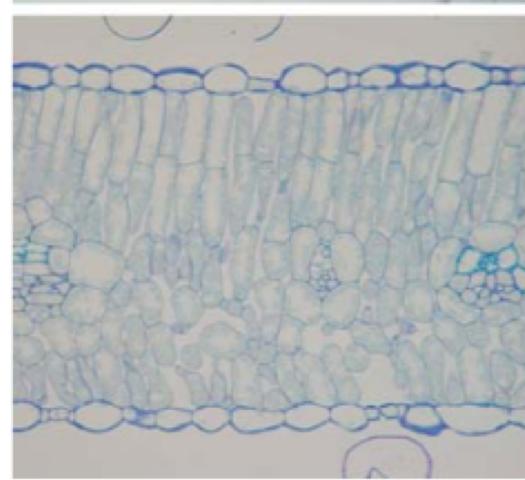
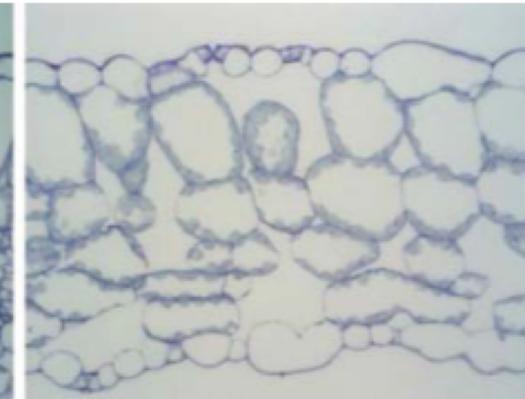


Sun leaves are thicker

Sun

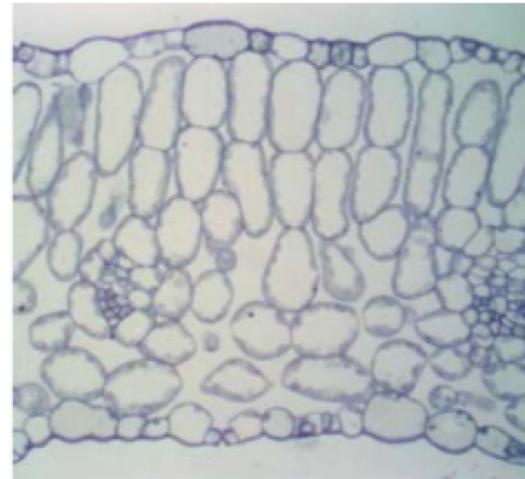


Shade

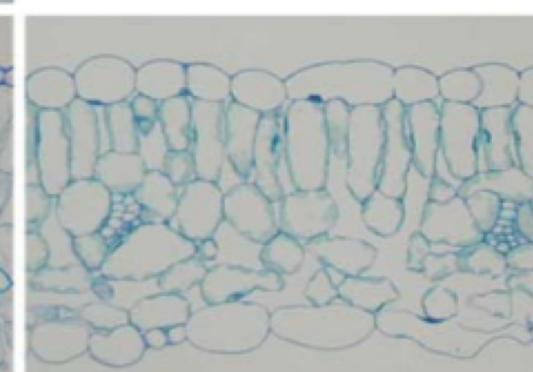
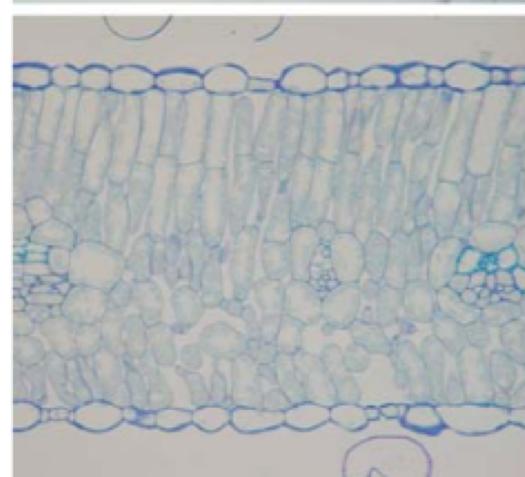
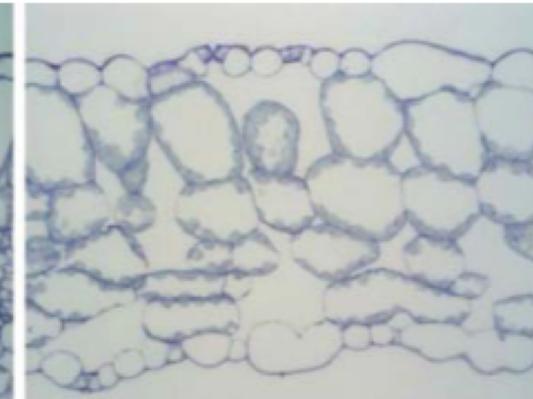


Sun leaves are thicker – why?

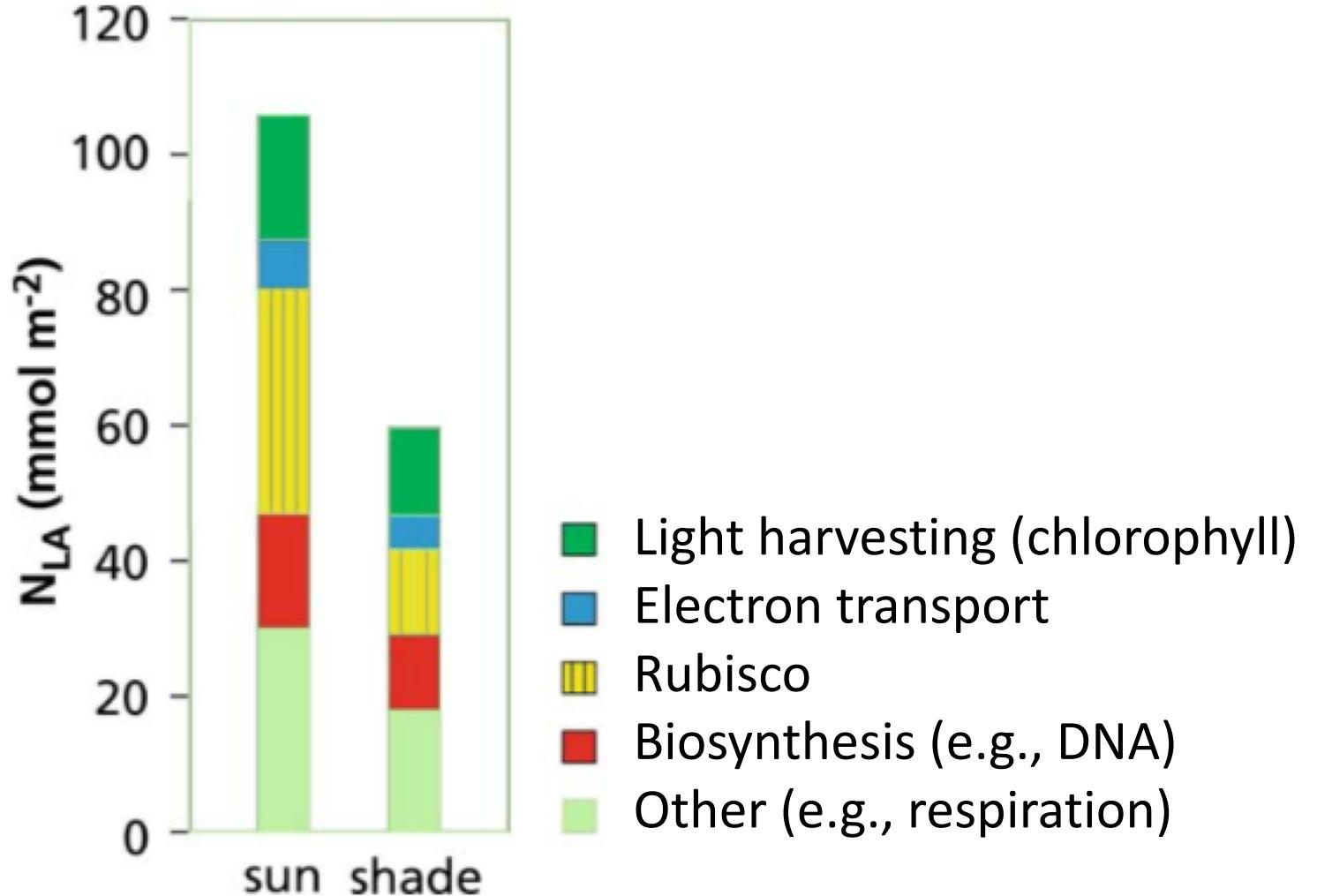
Sun



Shade



Sun leaves have more N invested in photosynthesis



Sun leaves have more N invested in photosynthesis – why?

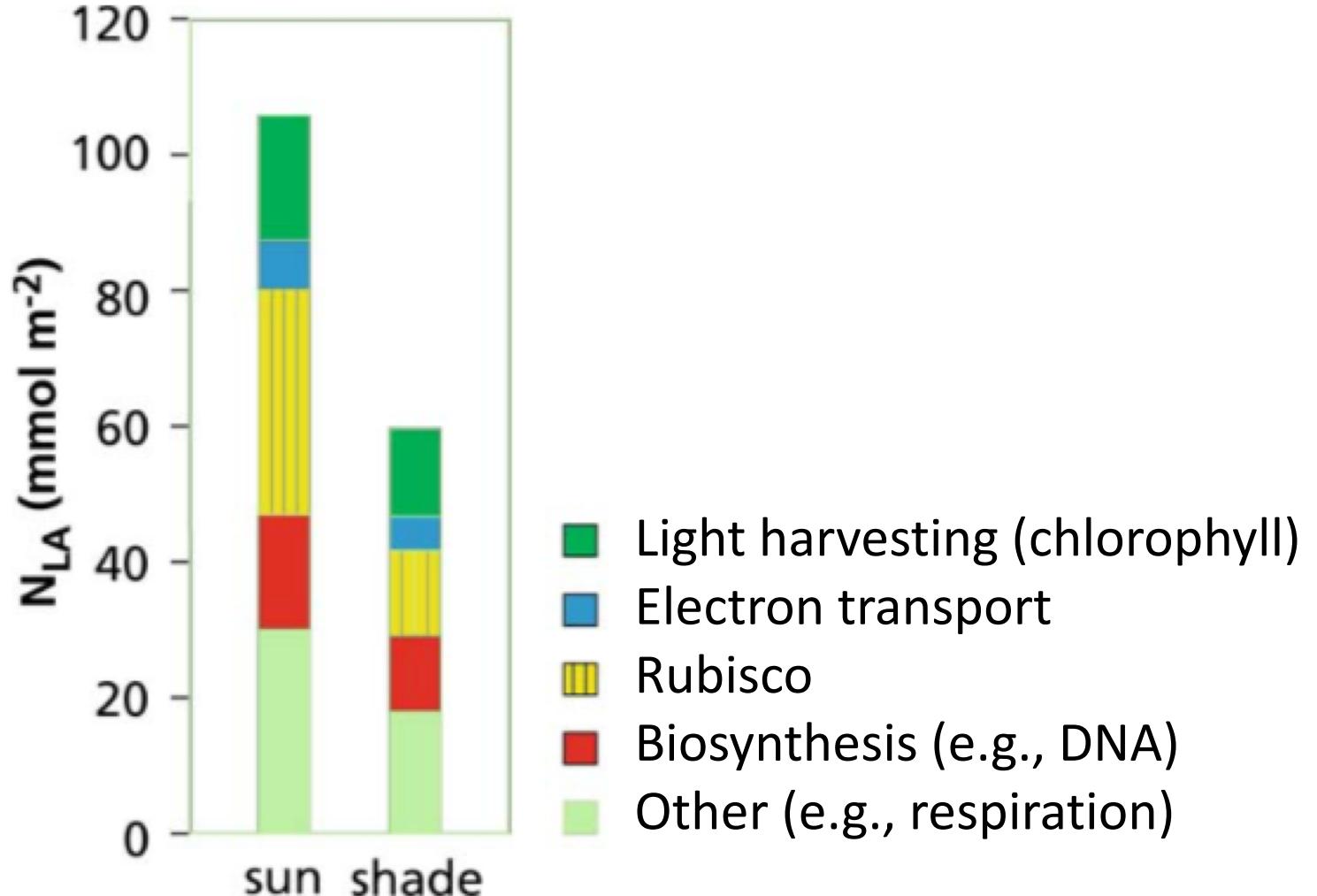


TABLE 2. Overview of generalized differences in characteristics between shade- and sun-acclimated leaves.

	Sun	Shade
Structural		
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
Biochemical		
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
Gas exchange		
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

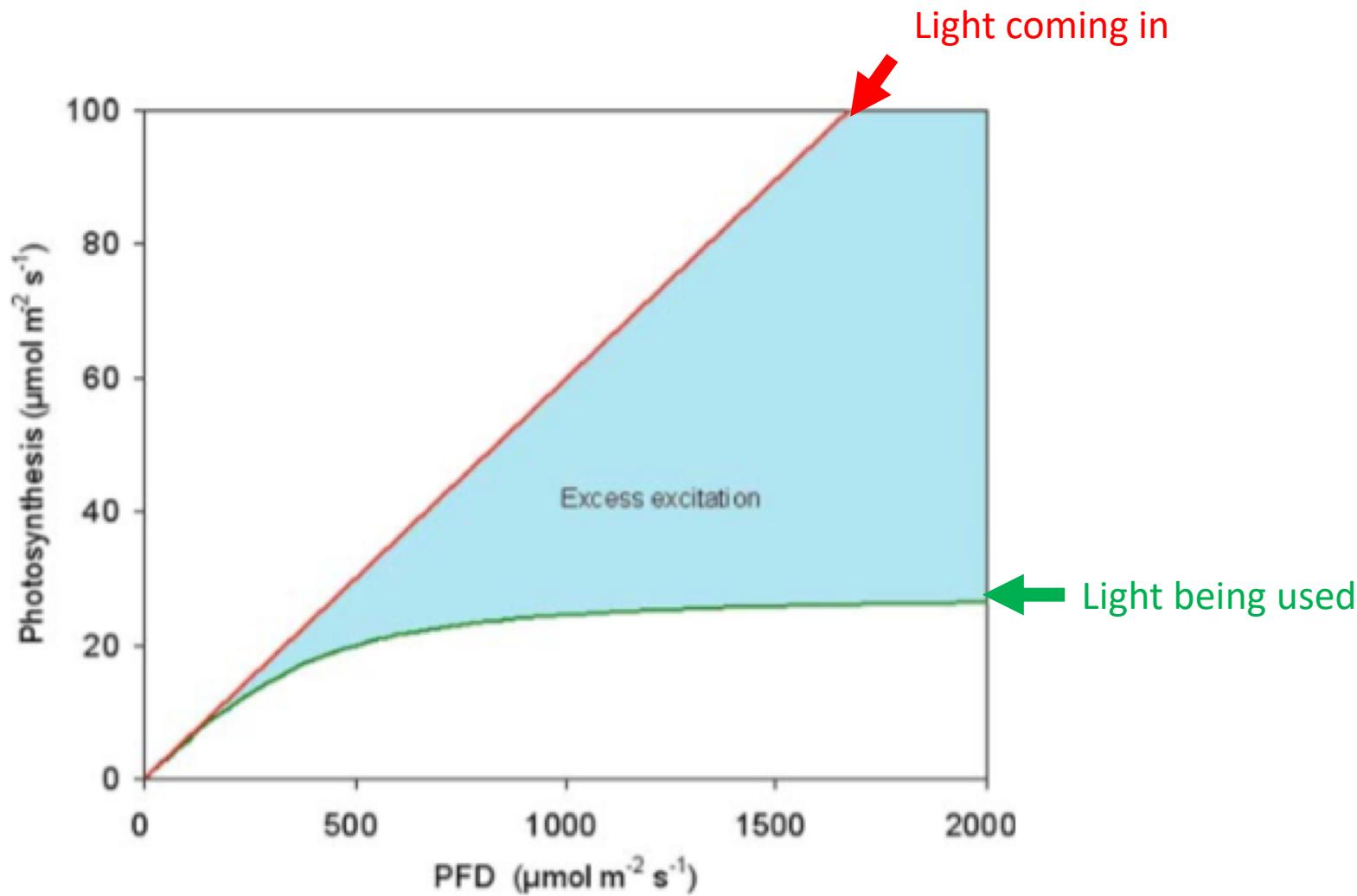
Other differences

Why??

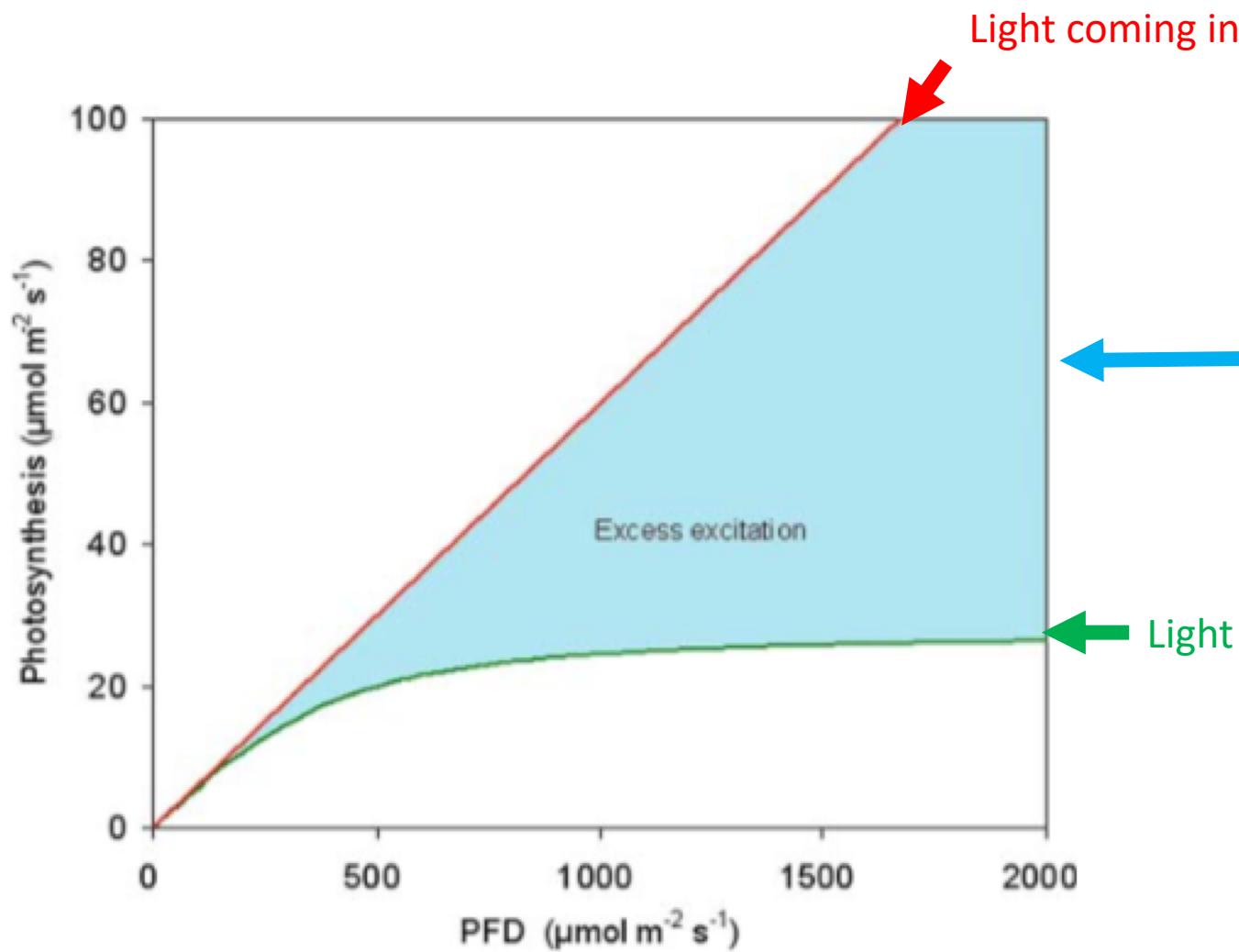
Activity: pick a trait and formulate a hypothesis to explain the observed response

Photoinhibition

Photoinhibition



Photoinhibition



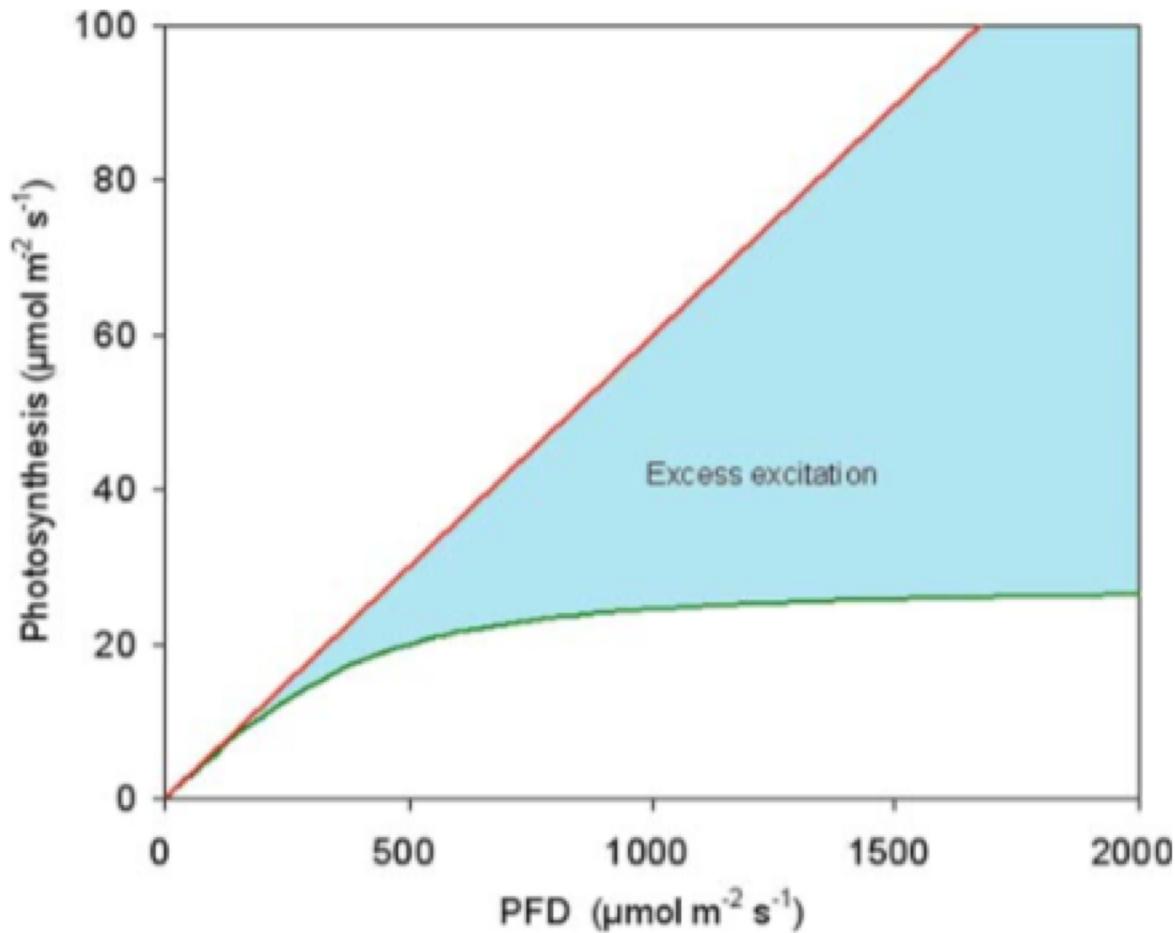
Light coming in

Too much excitement!

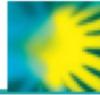
Light being used



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 CO₂ assimilation in the Arctic

Alistair Rogers¹, Shawn P. Serbin¹, Kim S. Ely¹, Victoria L. Sloan² and Stan D. Wullschleger²

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

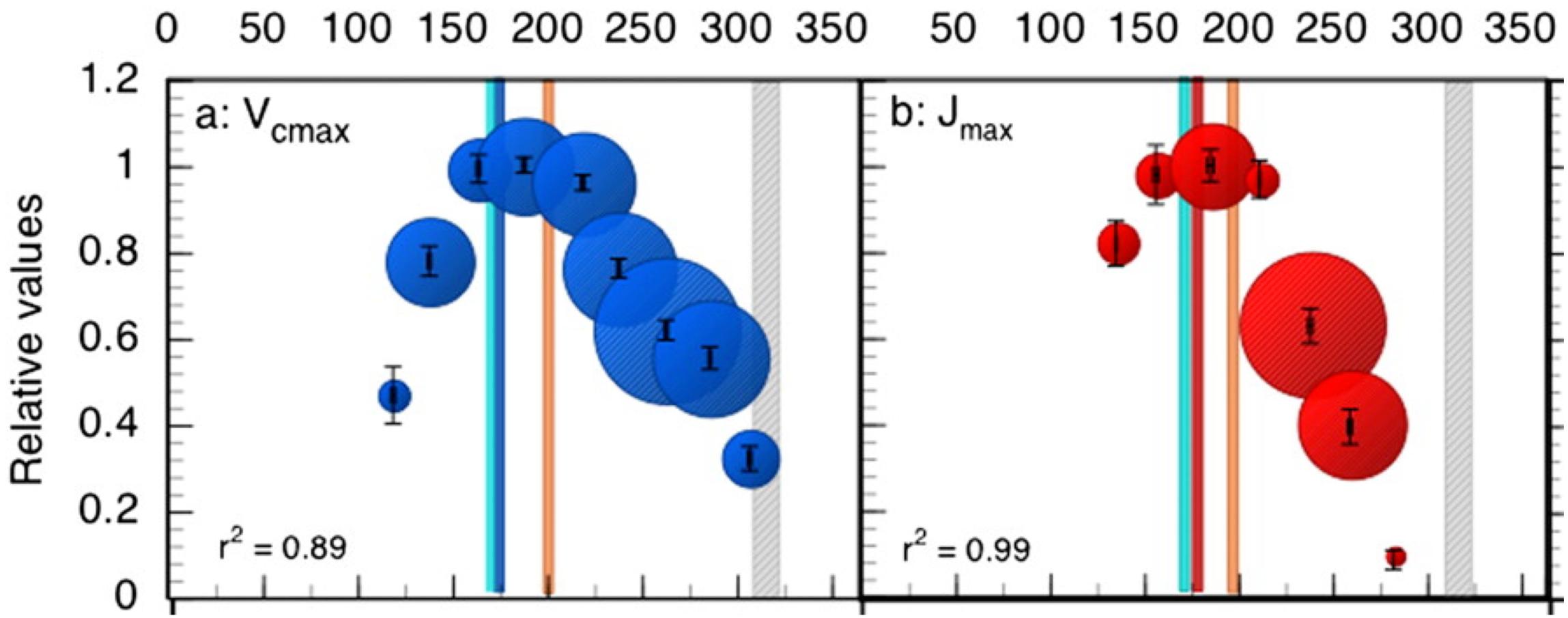
Translation: lots of Rubisco in the arctic!!
Why might this be the case?

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

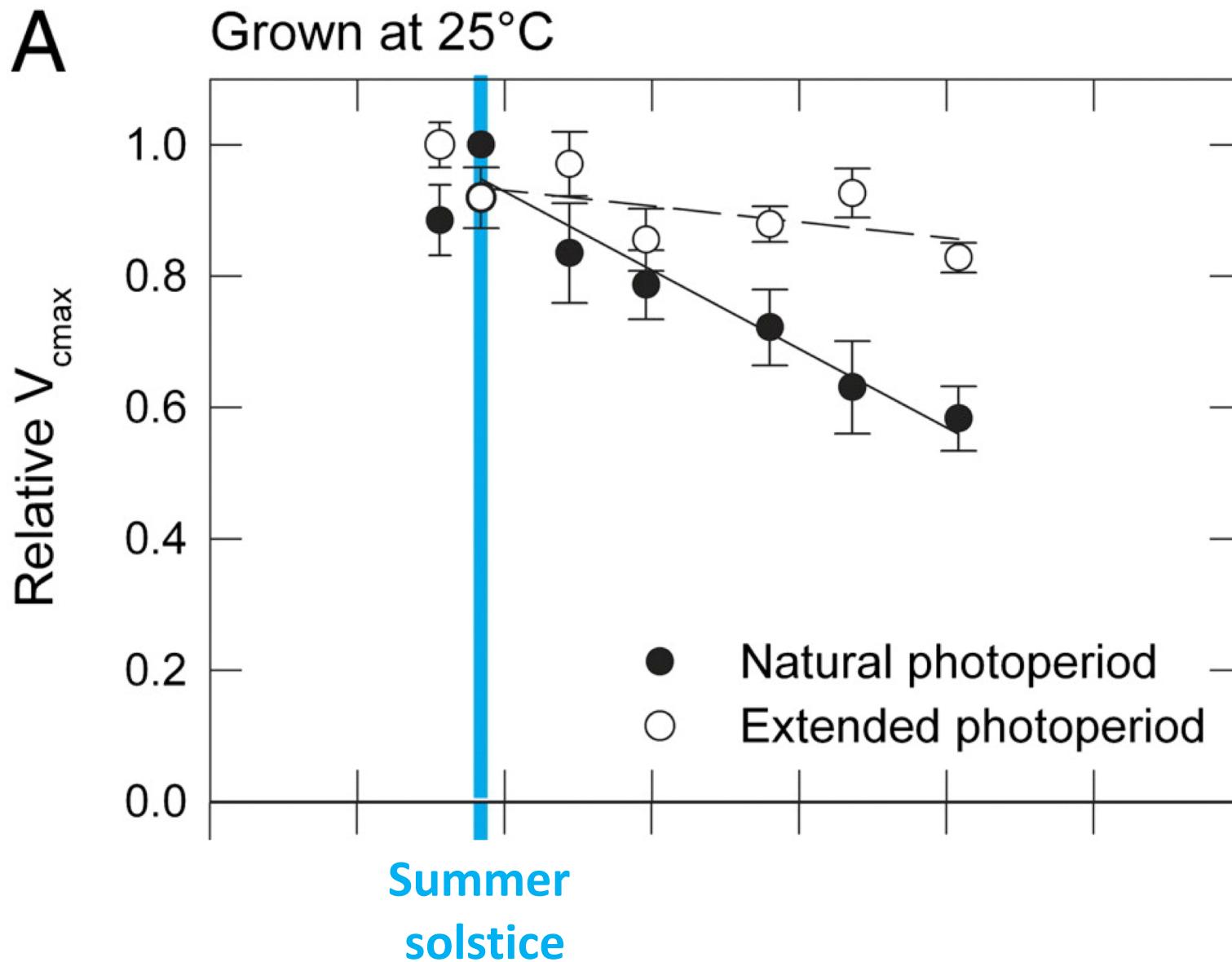


Seasons

Day of Year (DOY)



A

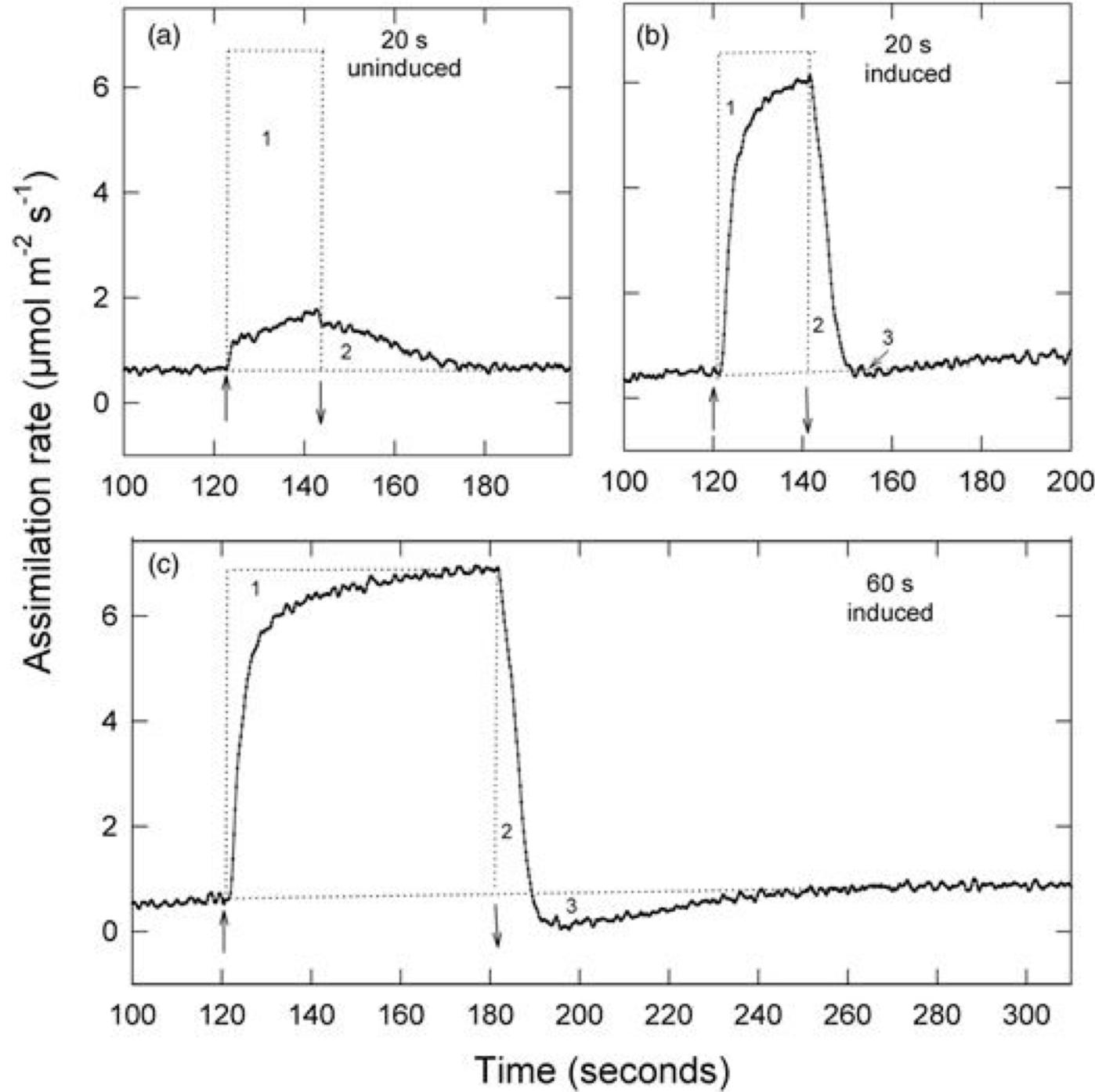


Sunflecks

Sunflecks



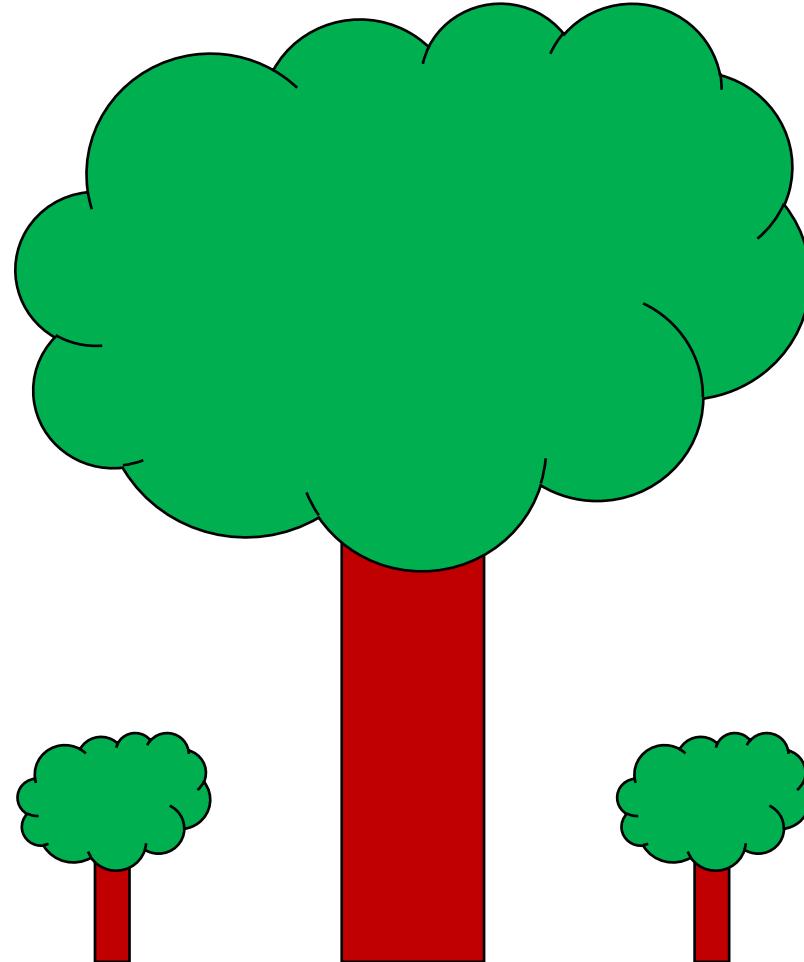
Sunflecks



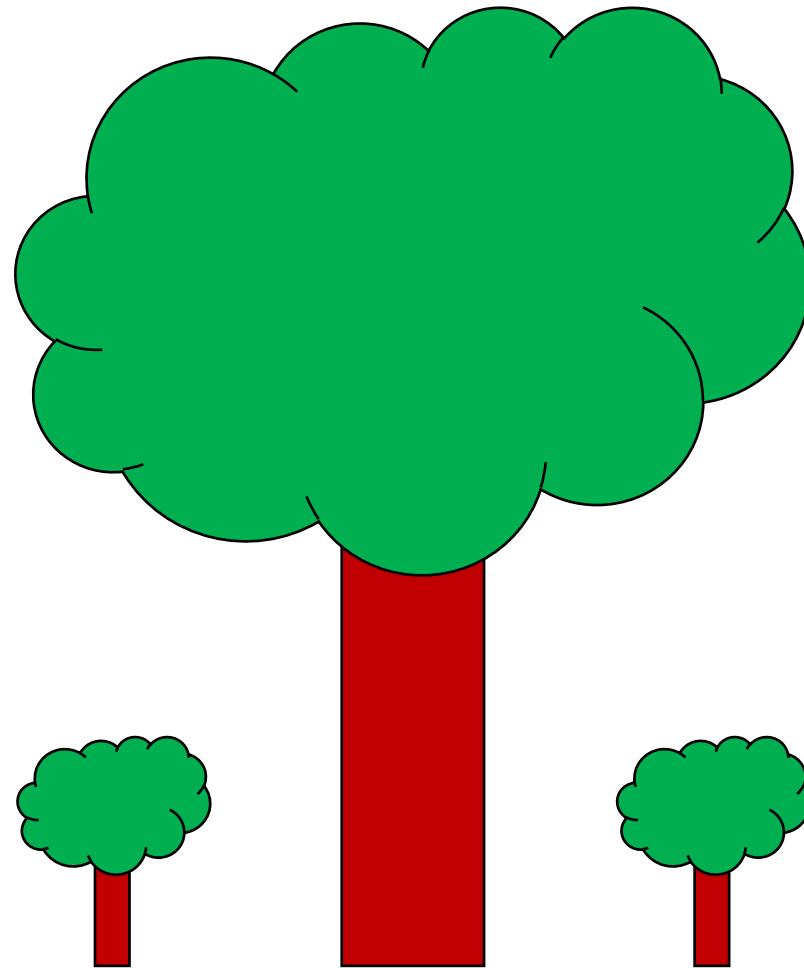
Induced refers to
prior exposure
to a sunfleck

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?