農学国際特論1
DGAS Special Lecture 1
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Plant growth #1. Photosynthesis

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Fig. 1. Chloroplasts

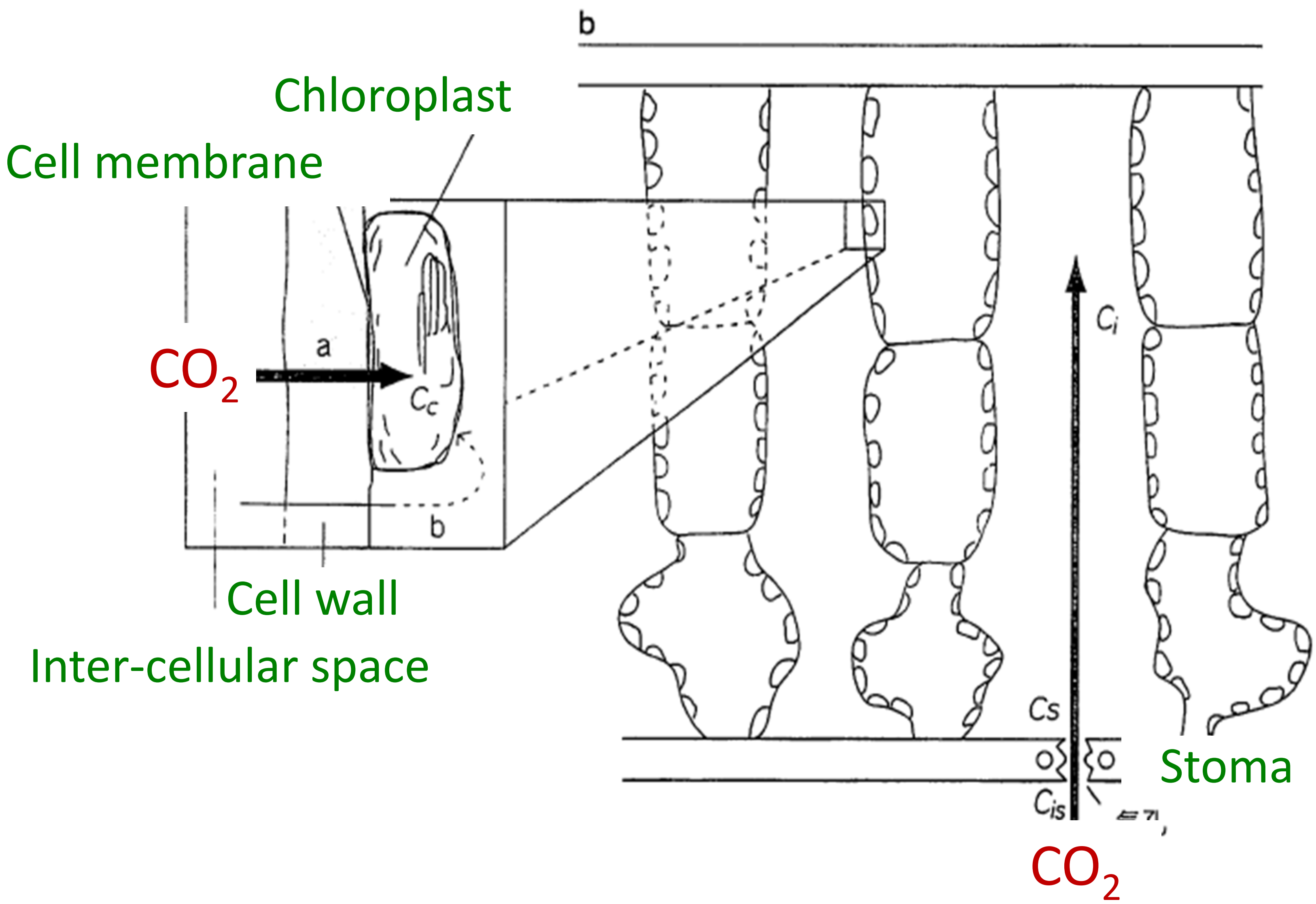
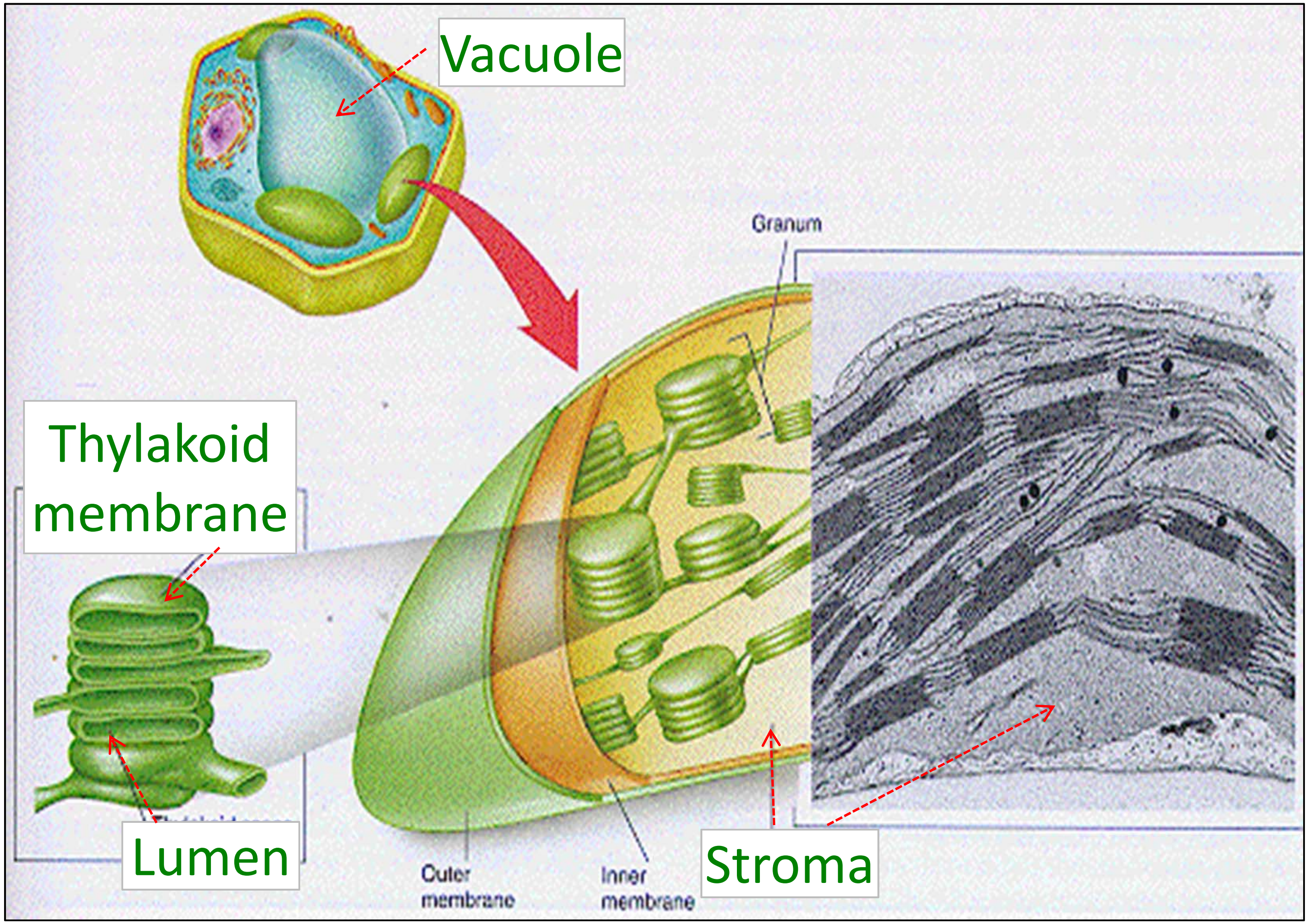
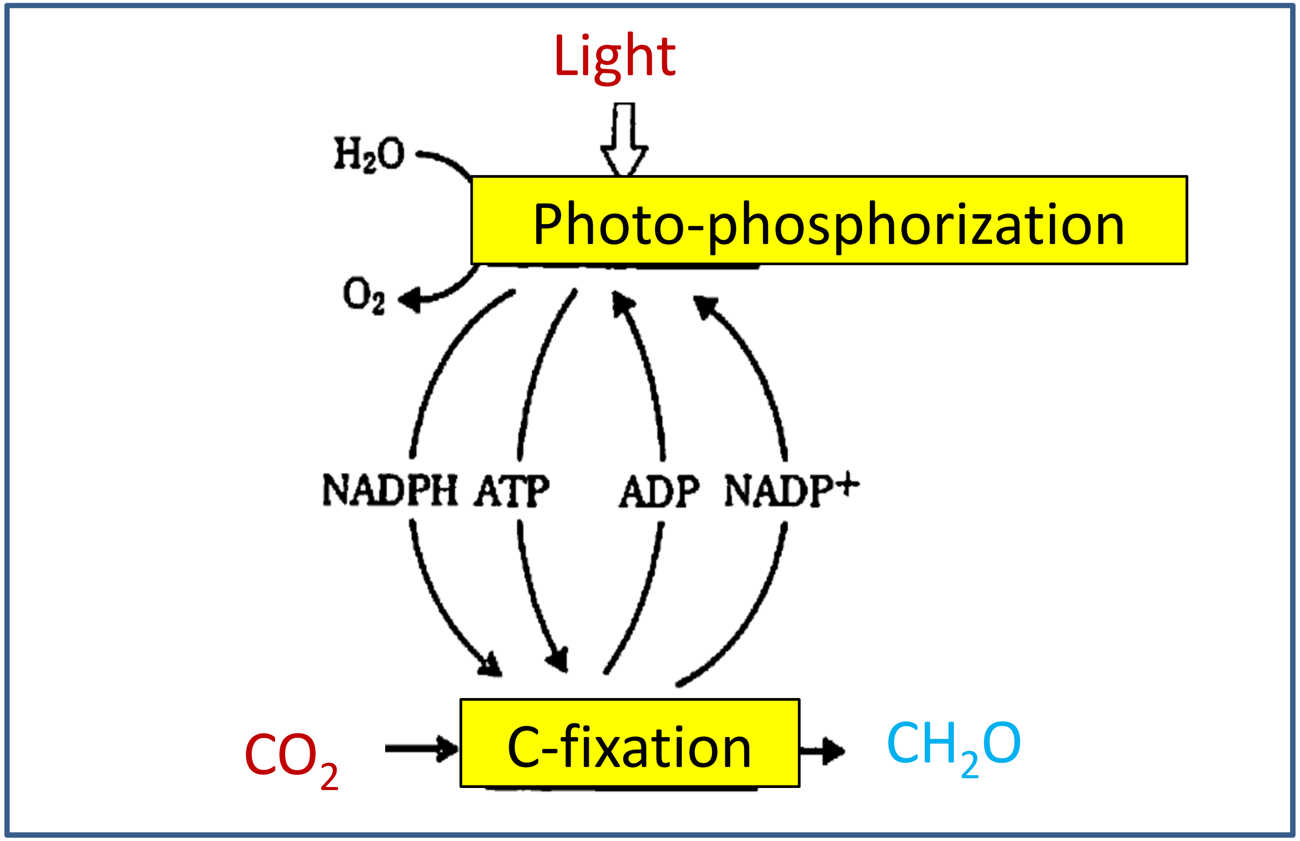


Fig. 2. Inside a chloroplast



http://www.wellesley.edu/Biology/Courses/Plant/images/chloroplast.gif

Fig. 3. Photosynthesis



Oxidation ⟷ Reduction (-O⁻, +2H⁺)

Fig. 4. Radiation spectra of black bodies at 6000 K and 300K

Why you can see the Earth?

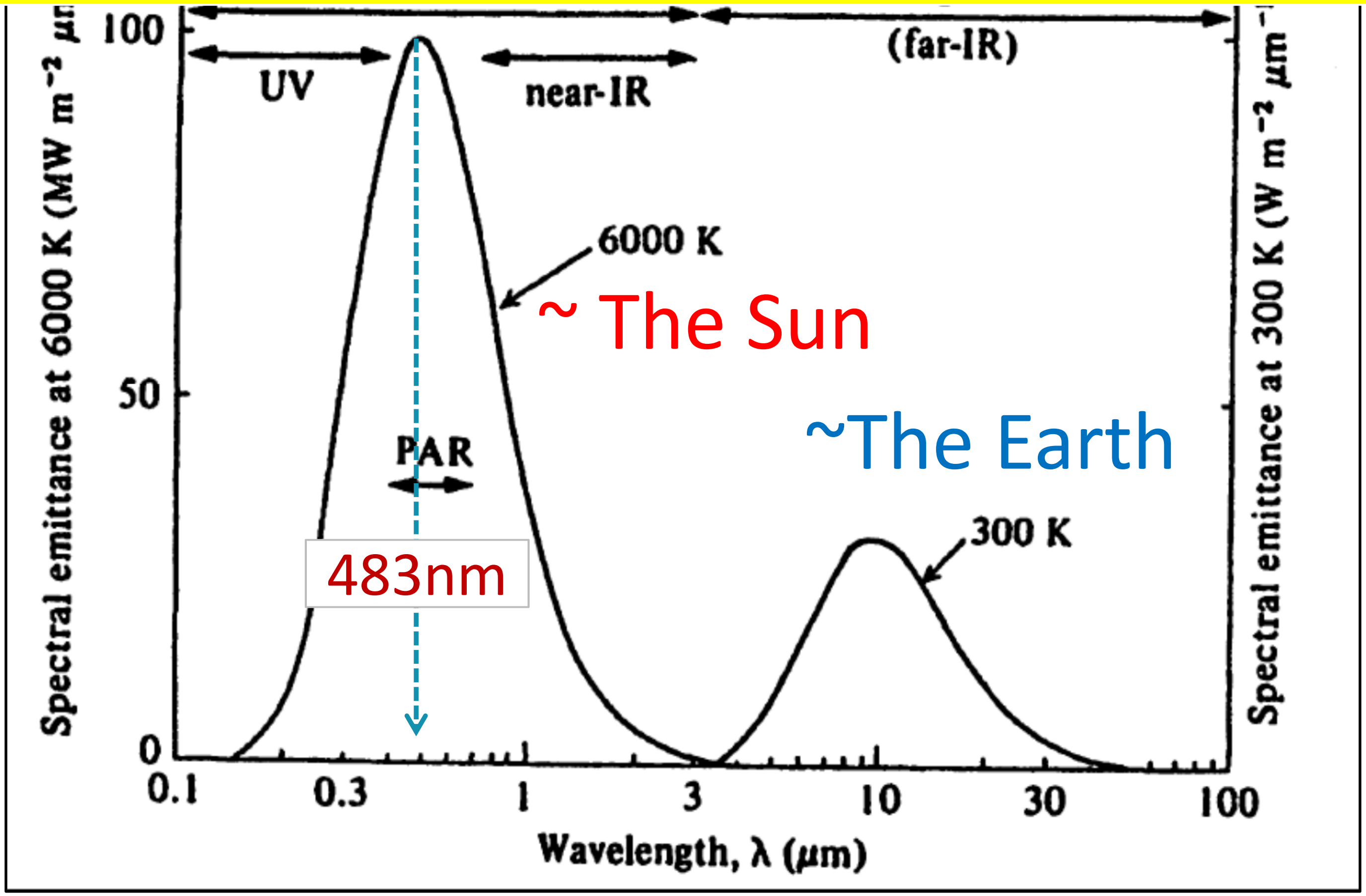


Fig. 4b. Radiation spectrum of the Sun

(Fig2-1. presented by Prof. Okada)

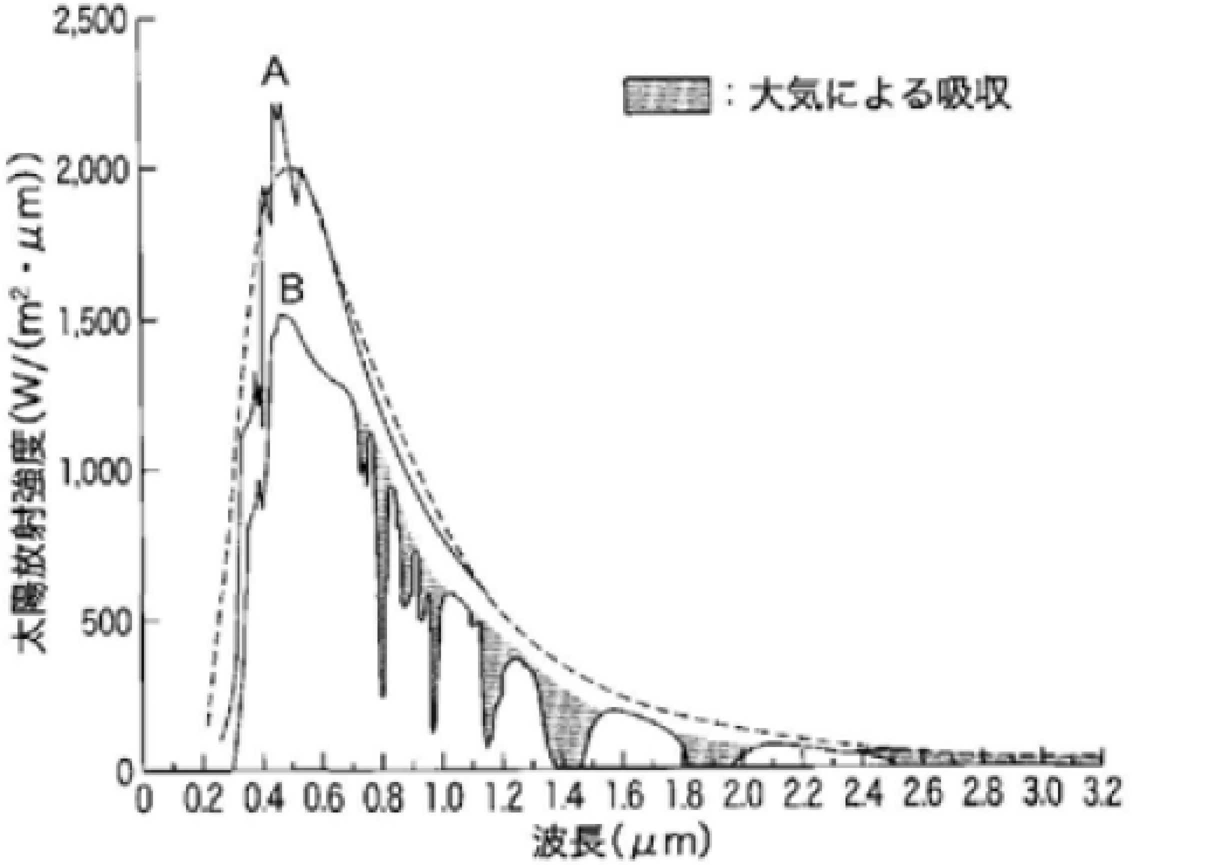


図2-1 波長ごとに見た太陽放射強度

大気圏上面への入射量(A)，地表面への入射量と大気による吸収帯(B)．(Arya, S. P.：Introduction to Micrometeorology, Academic Press, 1988)（浦野ら2009「生物環境気象学」）

Fig. 5. Action spectra of plants

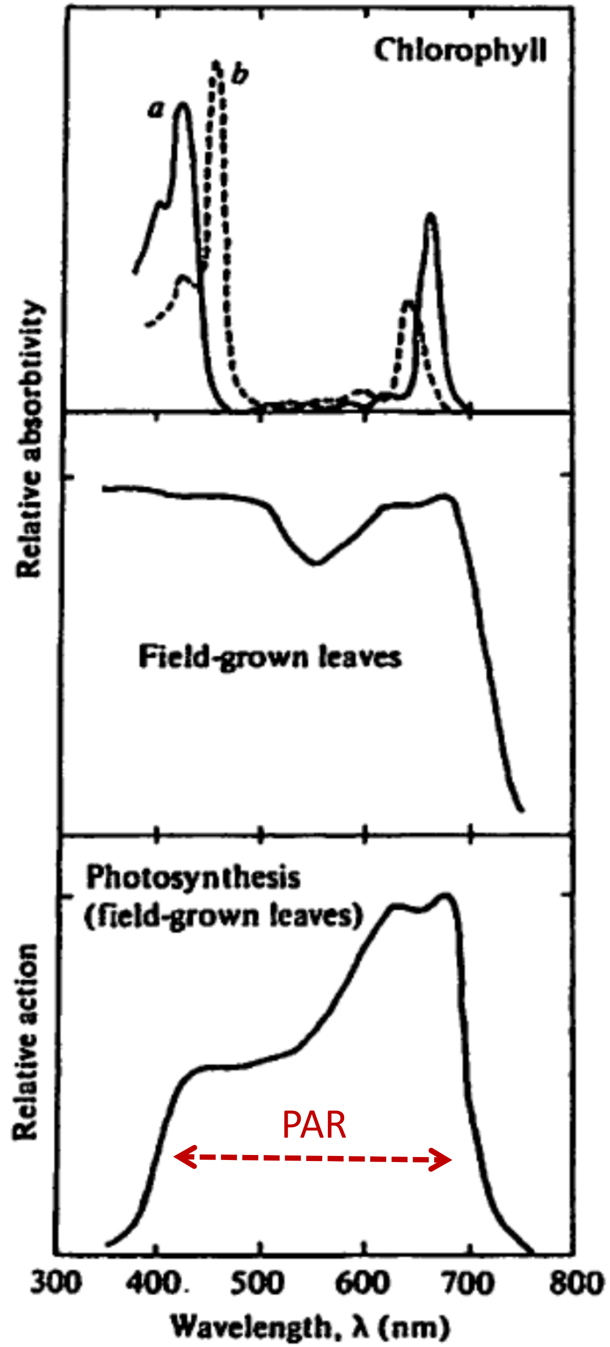


Fig. 6. Capture of light energy

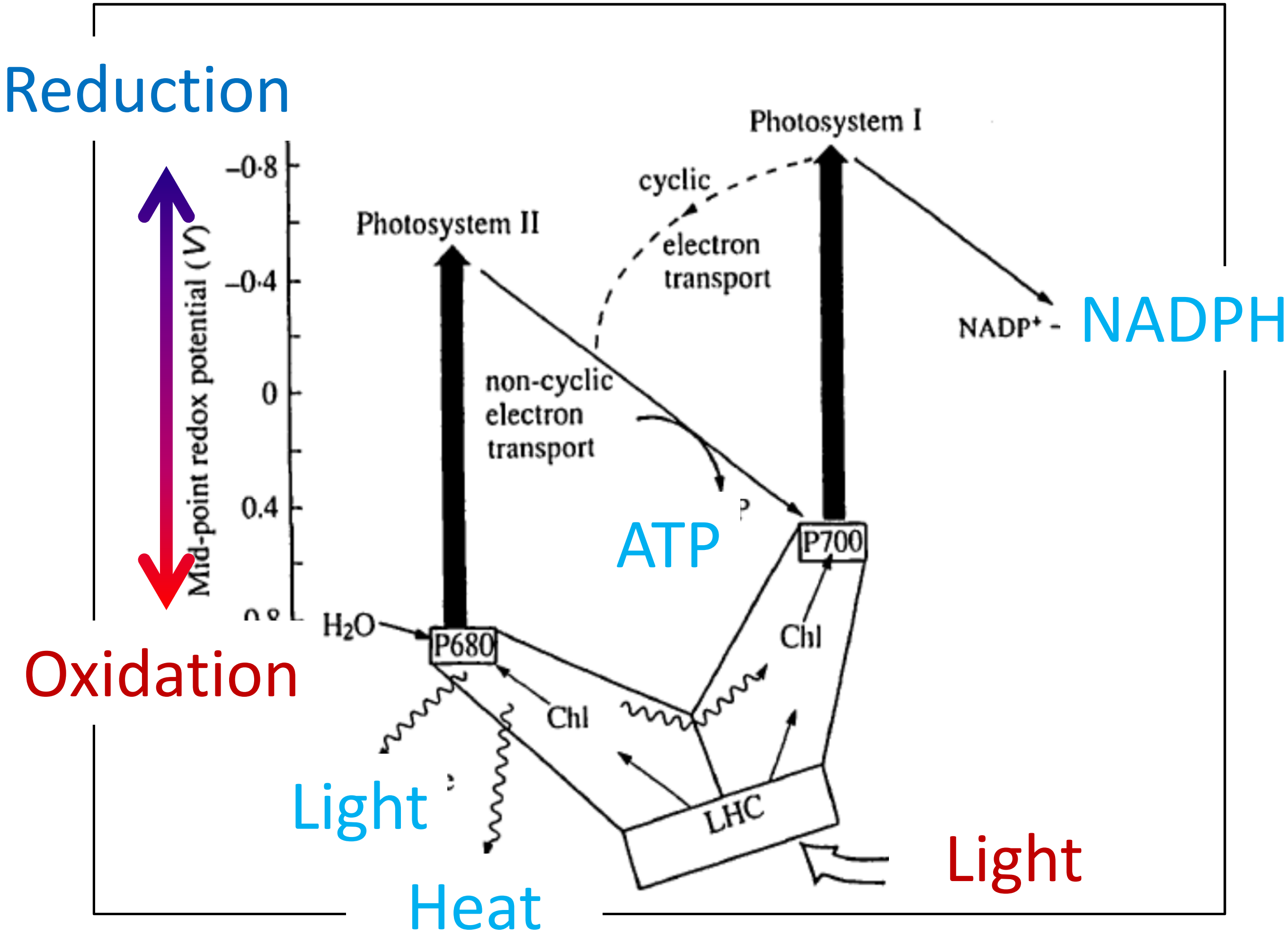


Fig. 7. Generating chemical energy: ATP and NADPH (refer to Fig. 2)

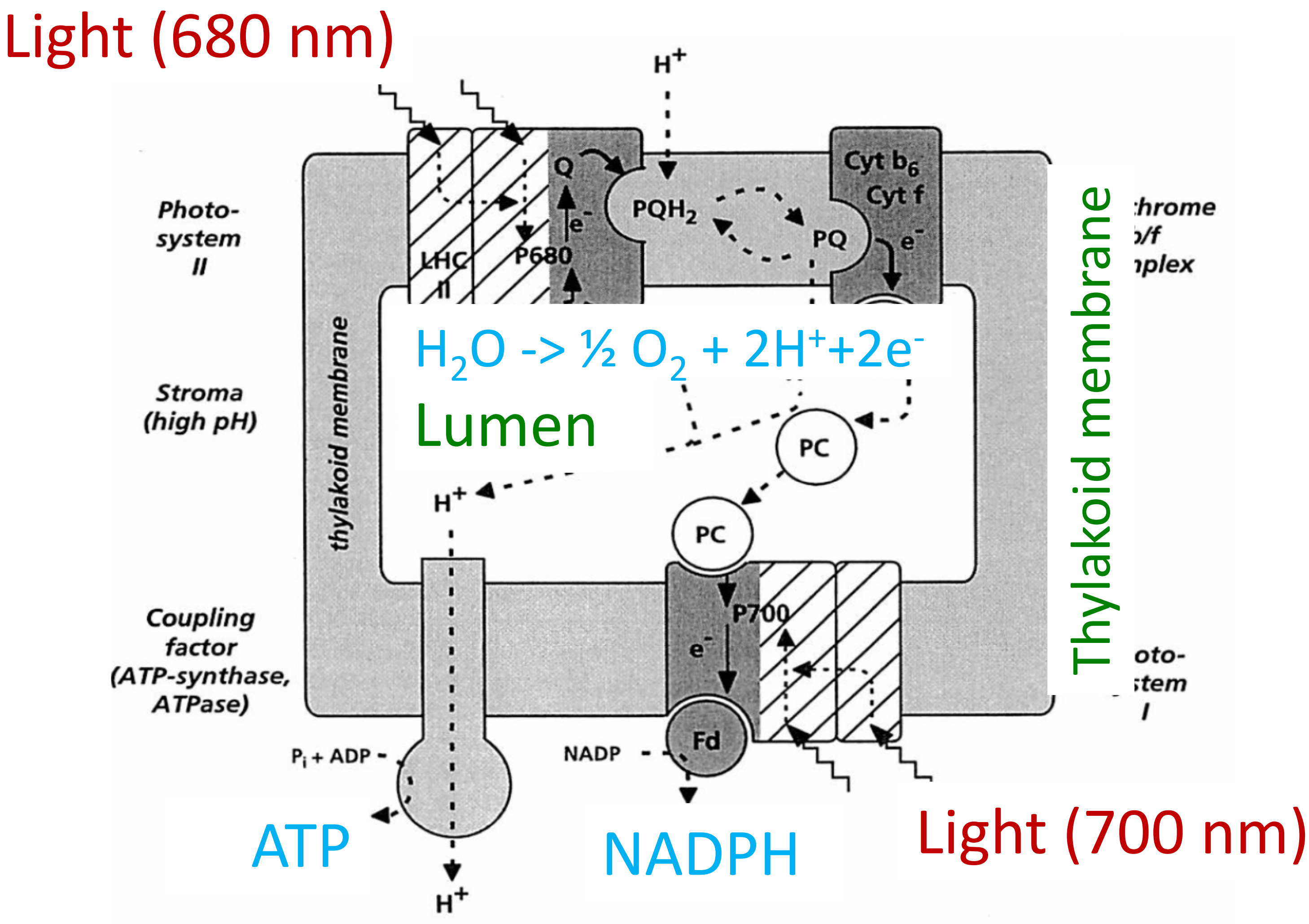


Fig. 8. Carbon fixation

(count the number of C at each step)

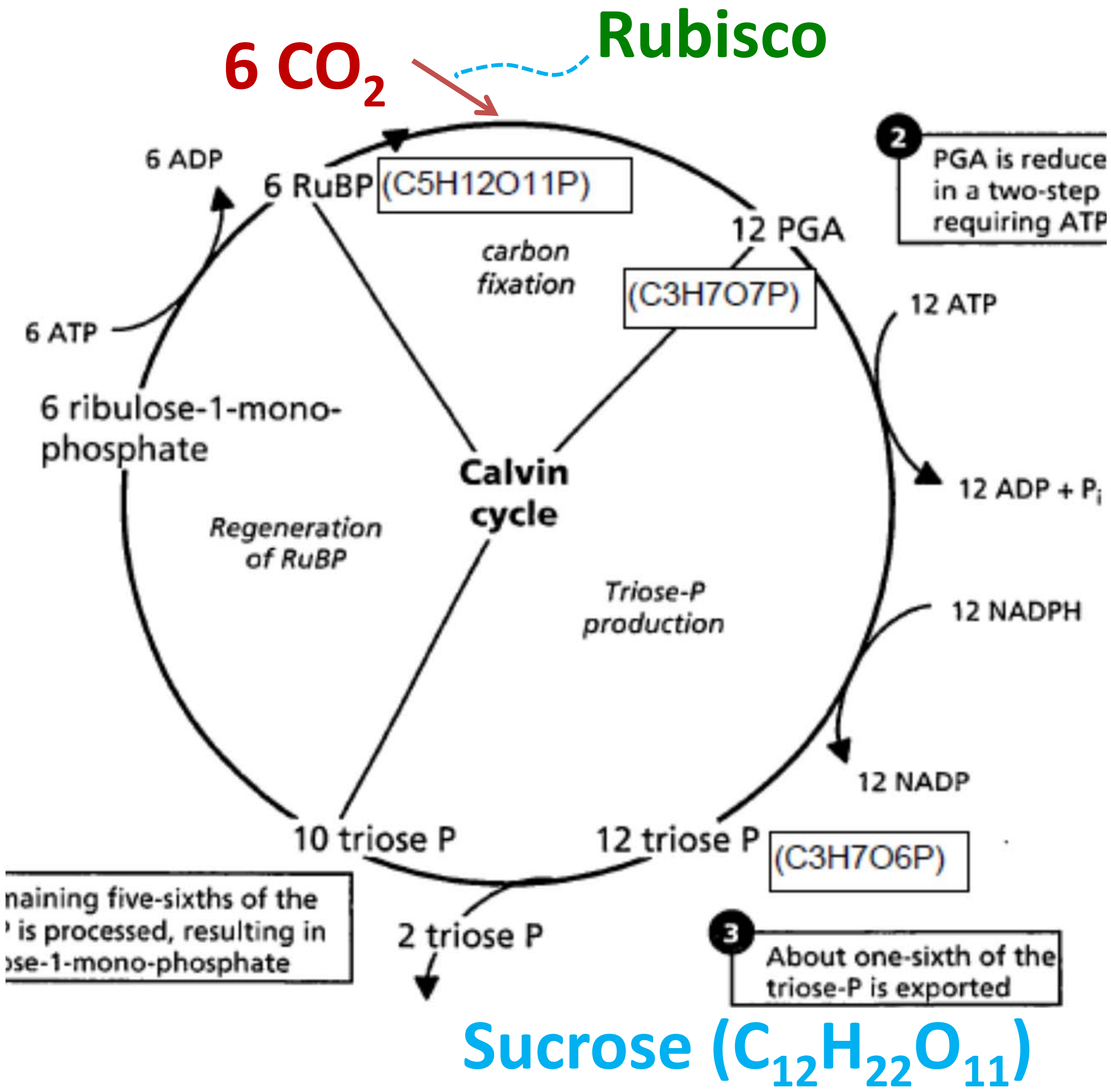
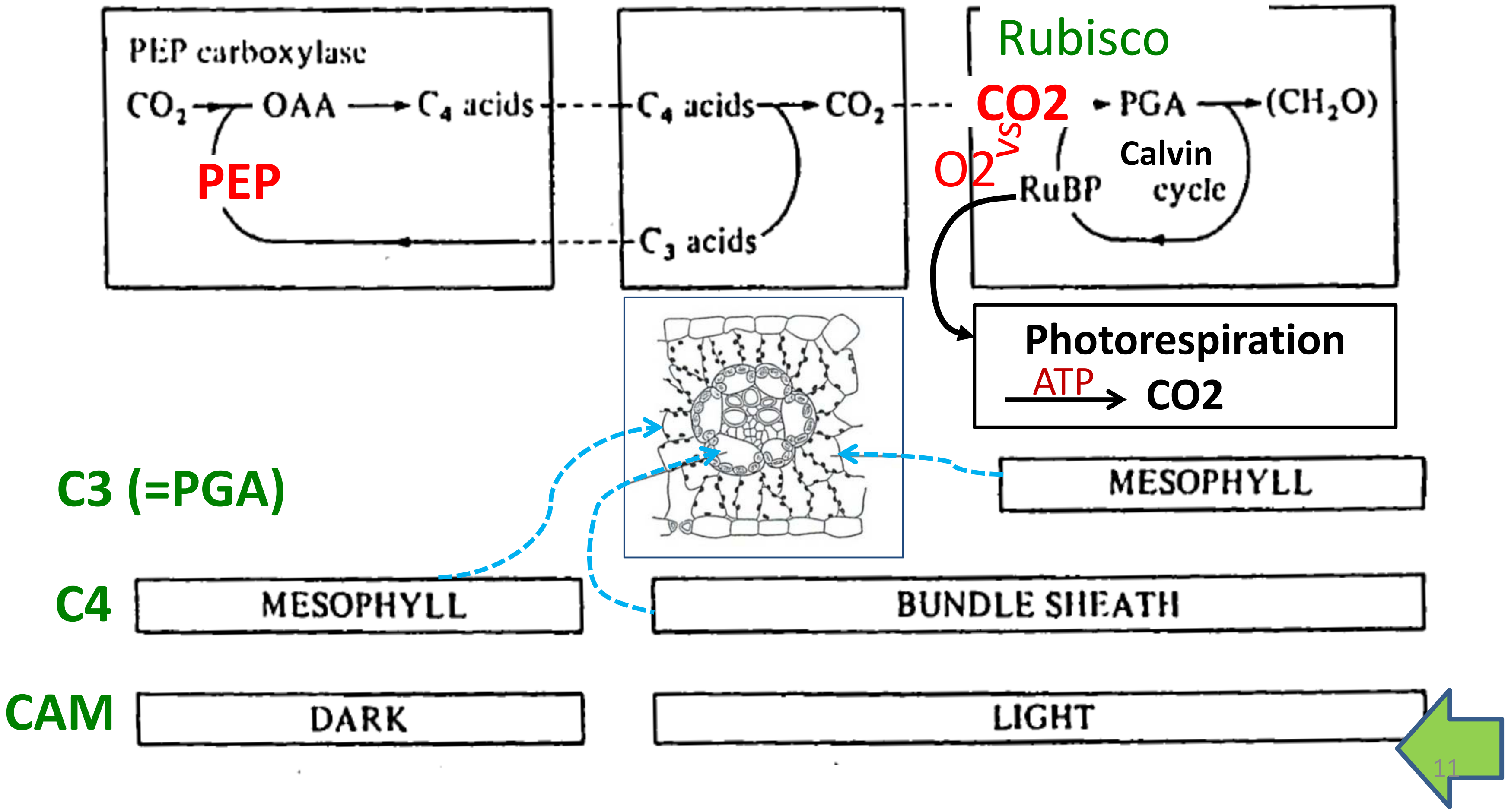
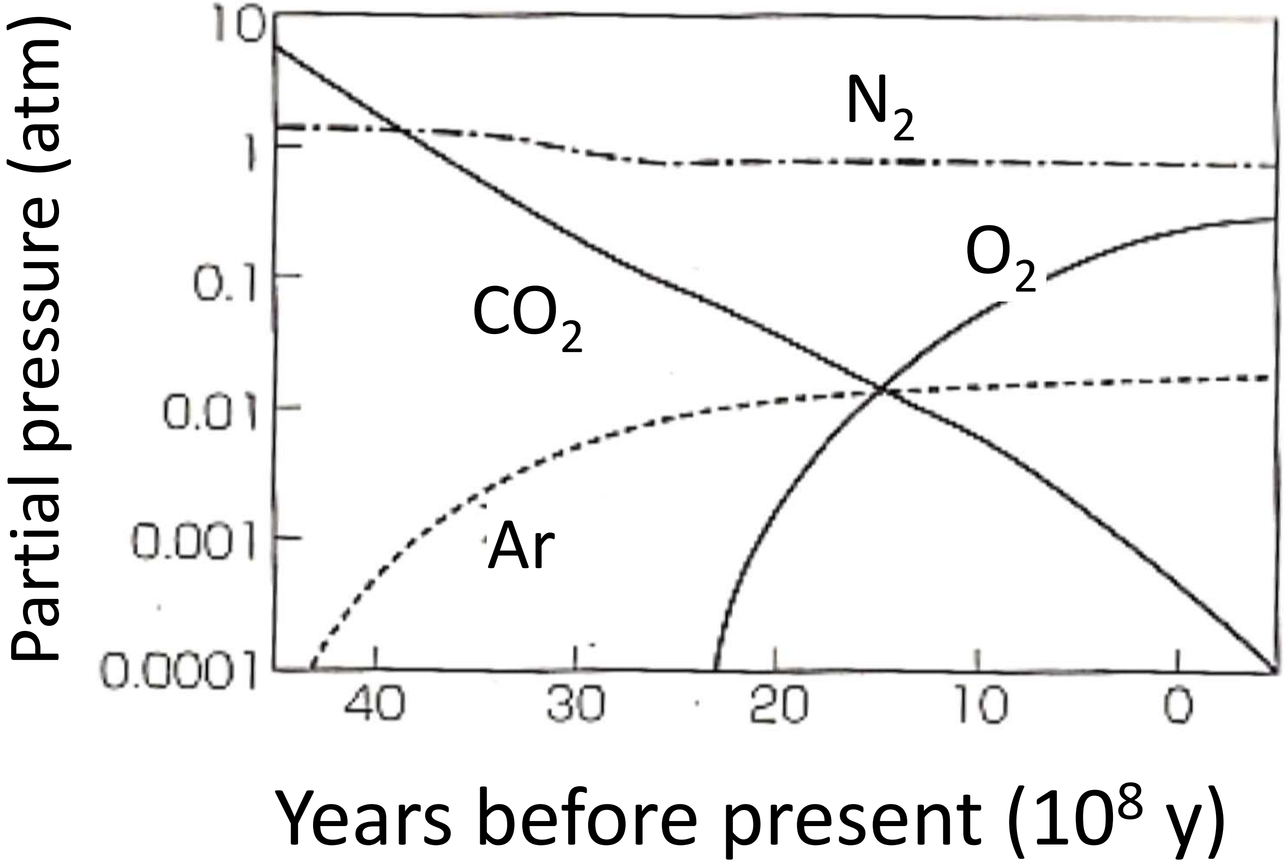


Fig. 9. Extra pathway for higher efficiency of carbon fixation by Rubisco

Why there is photorespiration?



The earth's atmosphere when photosynthesis was invented…



Source: 藤岡（2013）「海はどうしてできたのか」

Fig. 10. Light-leaf photosynthesis relationship

See Fig. 3 for light capture and C fixation.

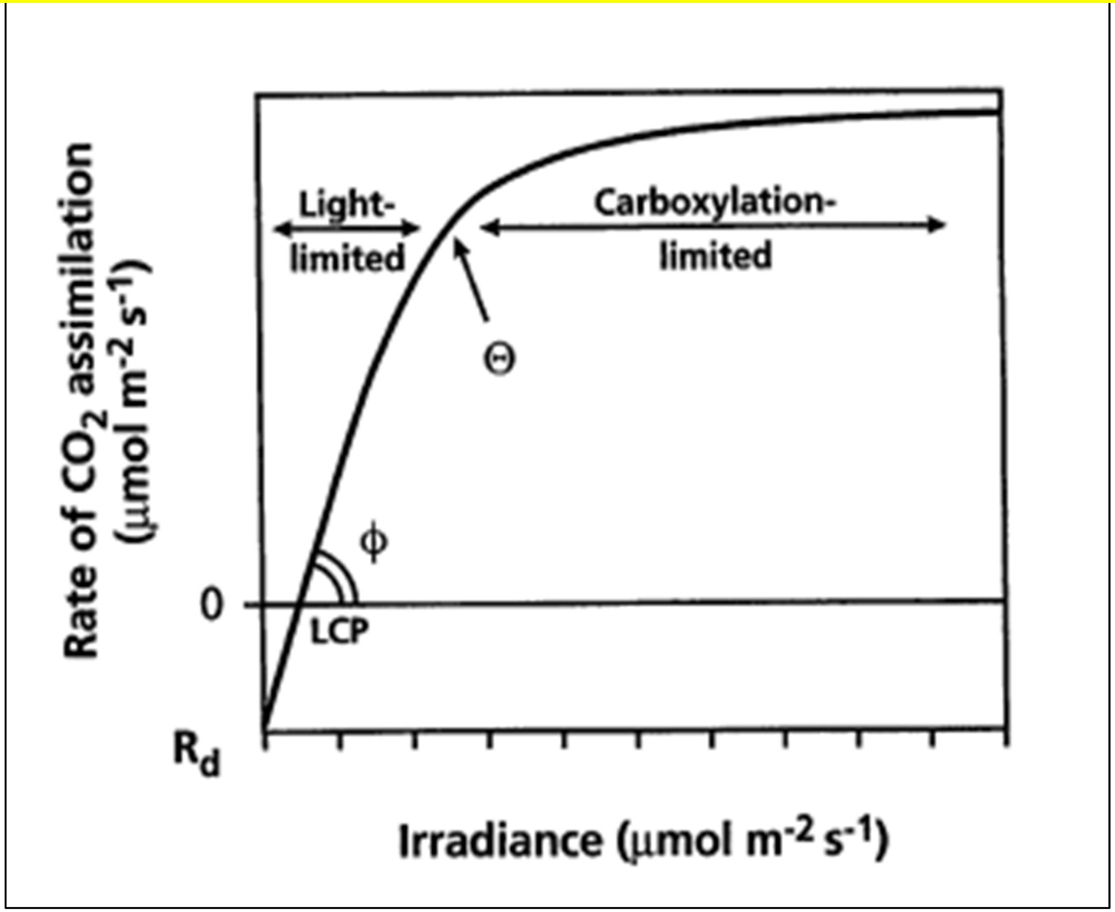


Fig. 11. Light-leaf photosynthesis relationship in various species.

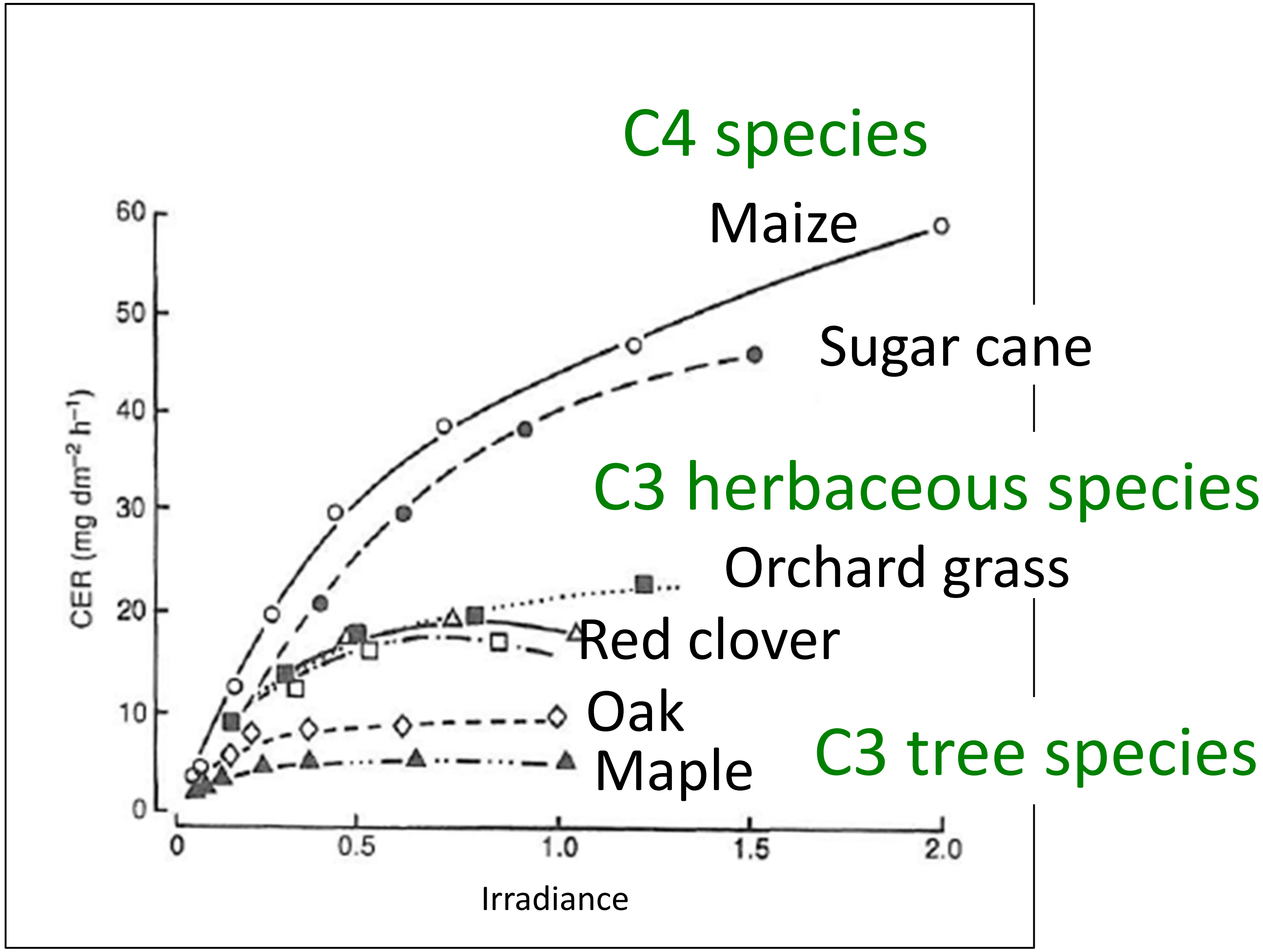
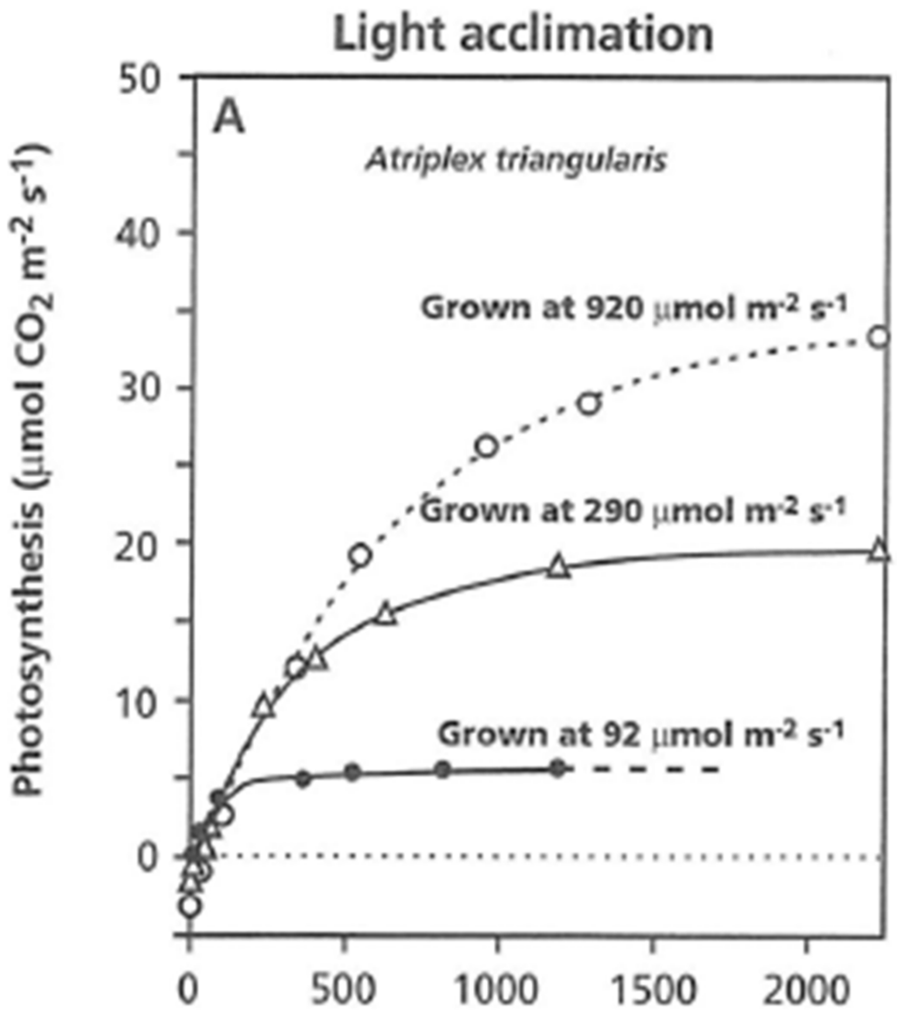


Fig. 12. Light-photosynthesis relationship for leaves developed in various light regimes.



Q: Why do the species in drier climate have to avoid light absorption?

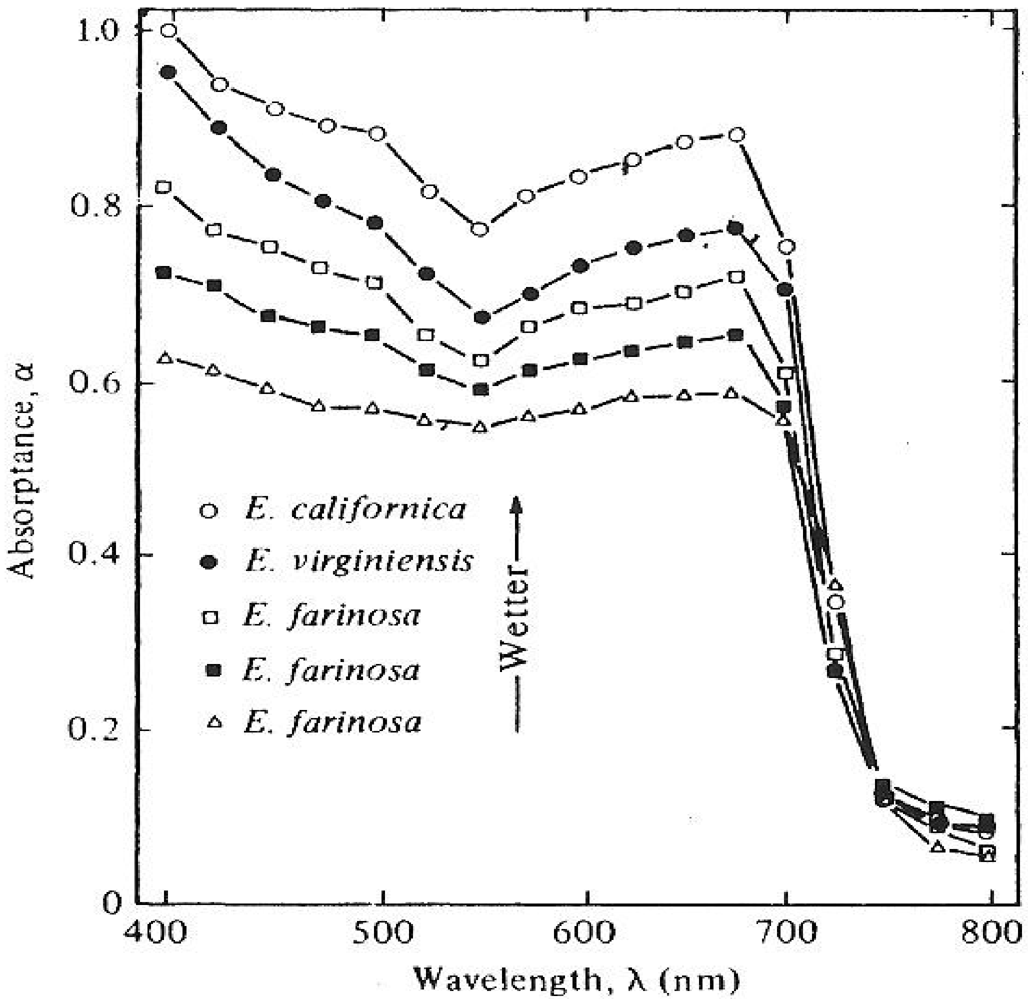
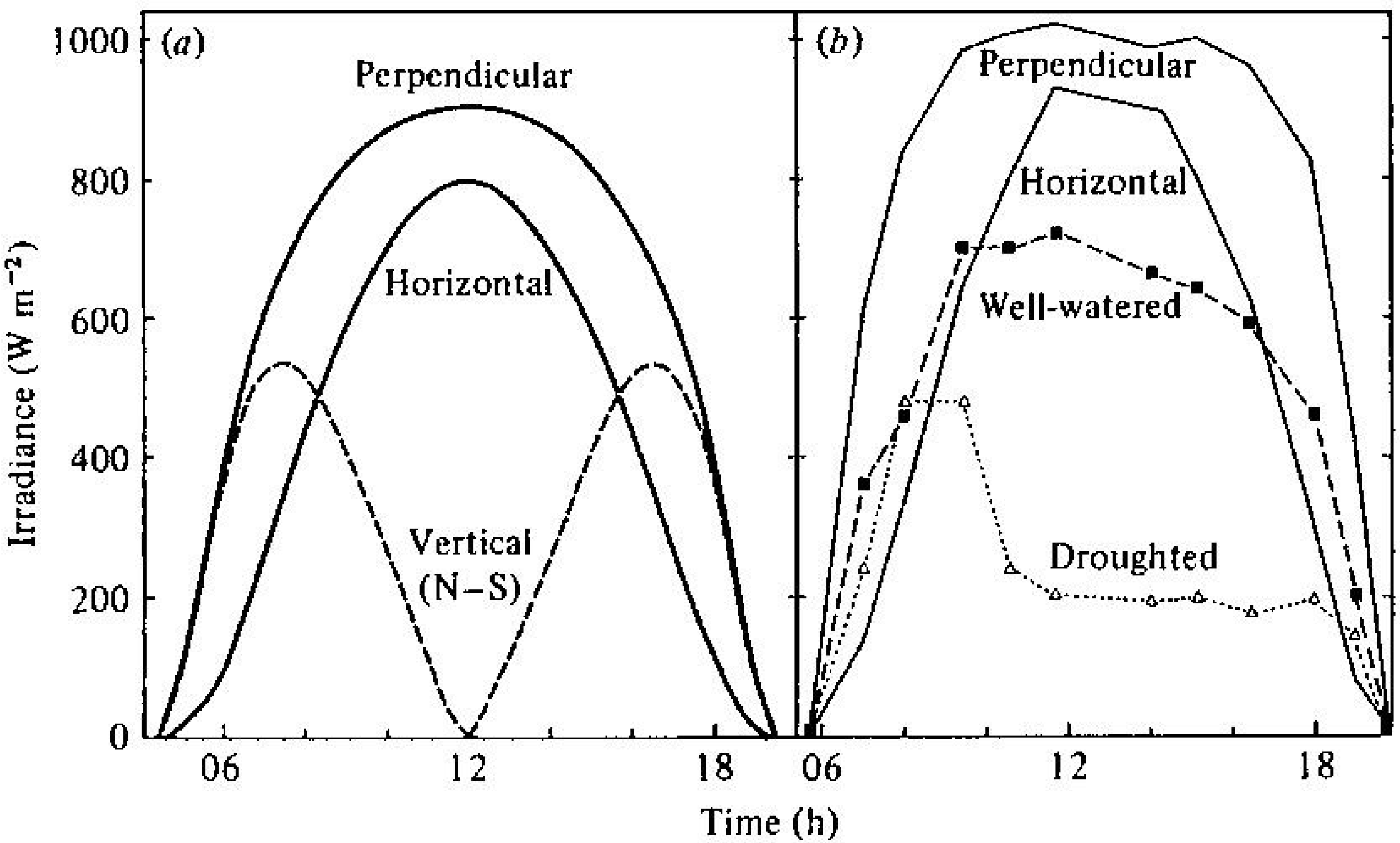


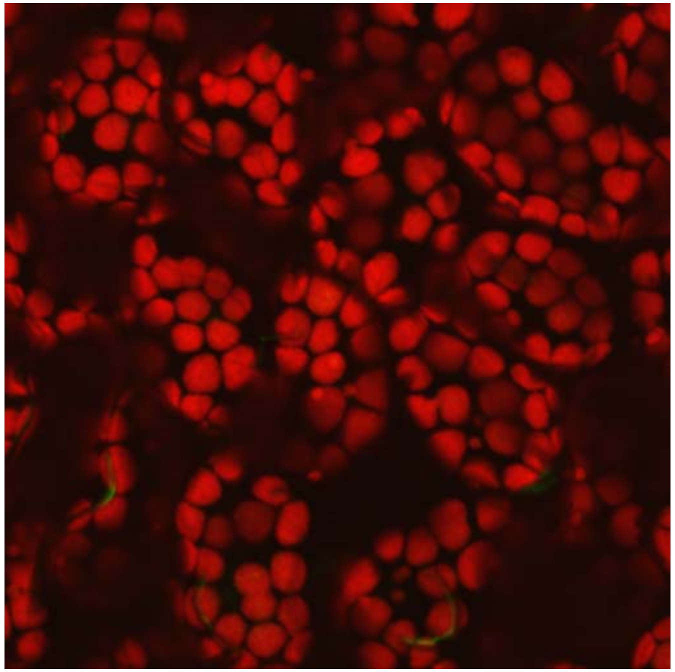
Fig. 14. Diurnal course of leaf irradiance for theoretical leaves of various angles (a), and actual leaves of well-watered and water-stressed bean plants (b).

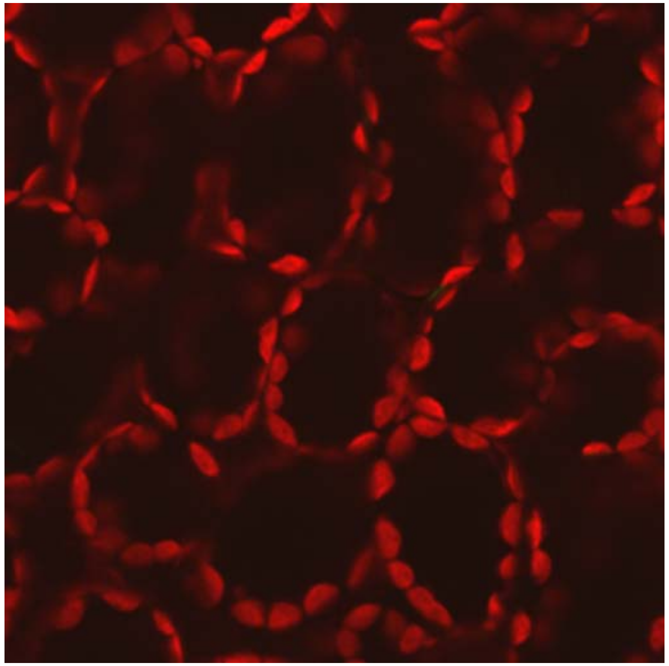


Young and mature leaves of *Cinnamomum tenuifolium*

Alignment of chloroplasts under weak light (L) and strong light (R) intensities.

Cells are viewed from the top.

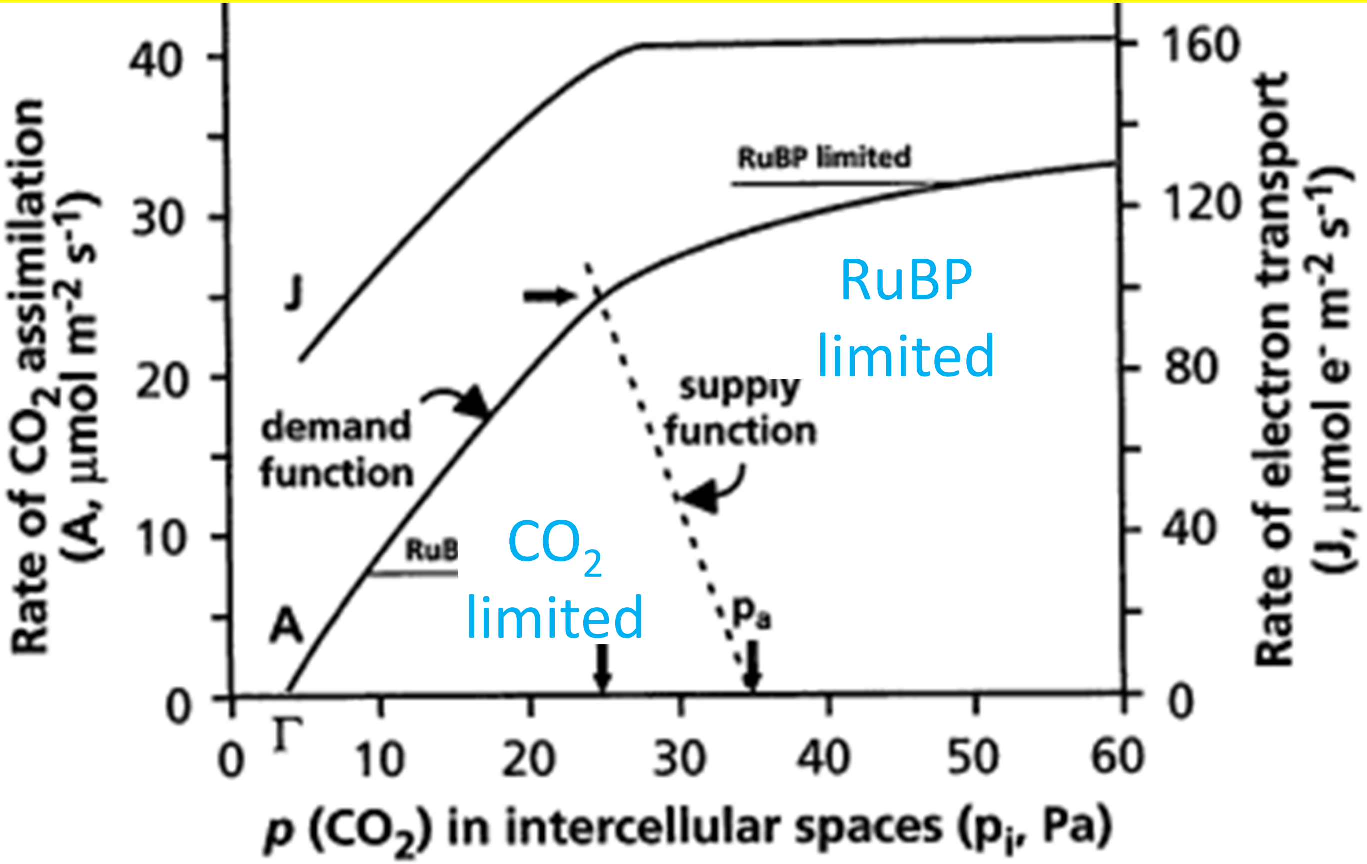




Source: http://podb.nibb.ac.jp/

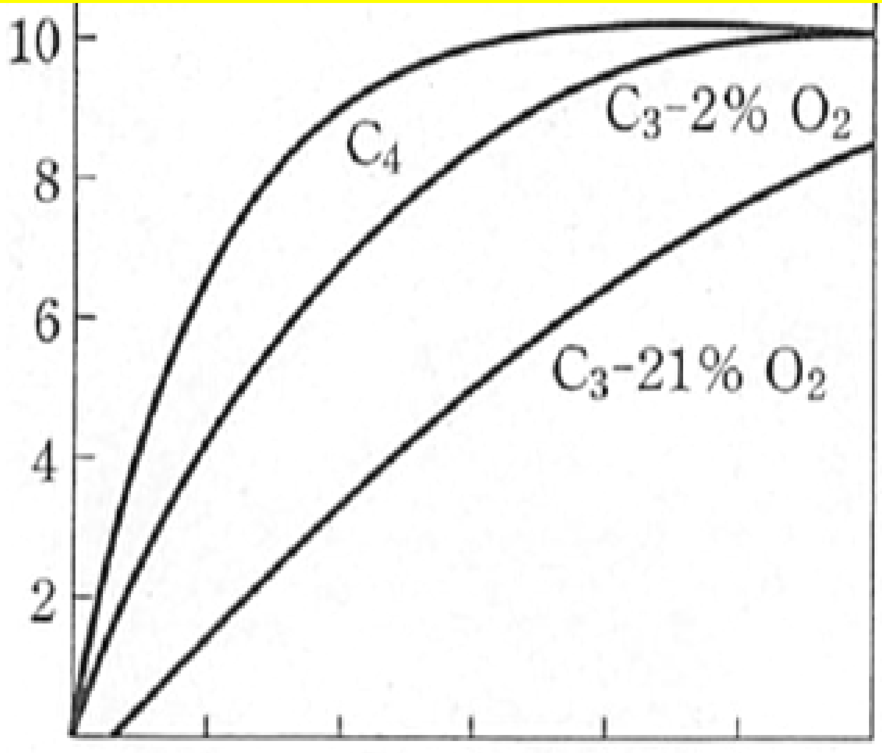
Fig. 15. CO_2 in intercellular space and leaf photosynthesis rate.

See Fig. 8 for C fixation and RuBP regeneration.



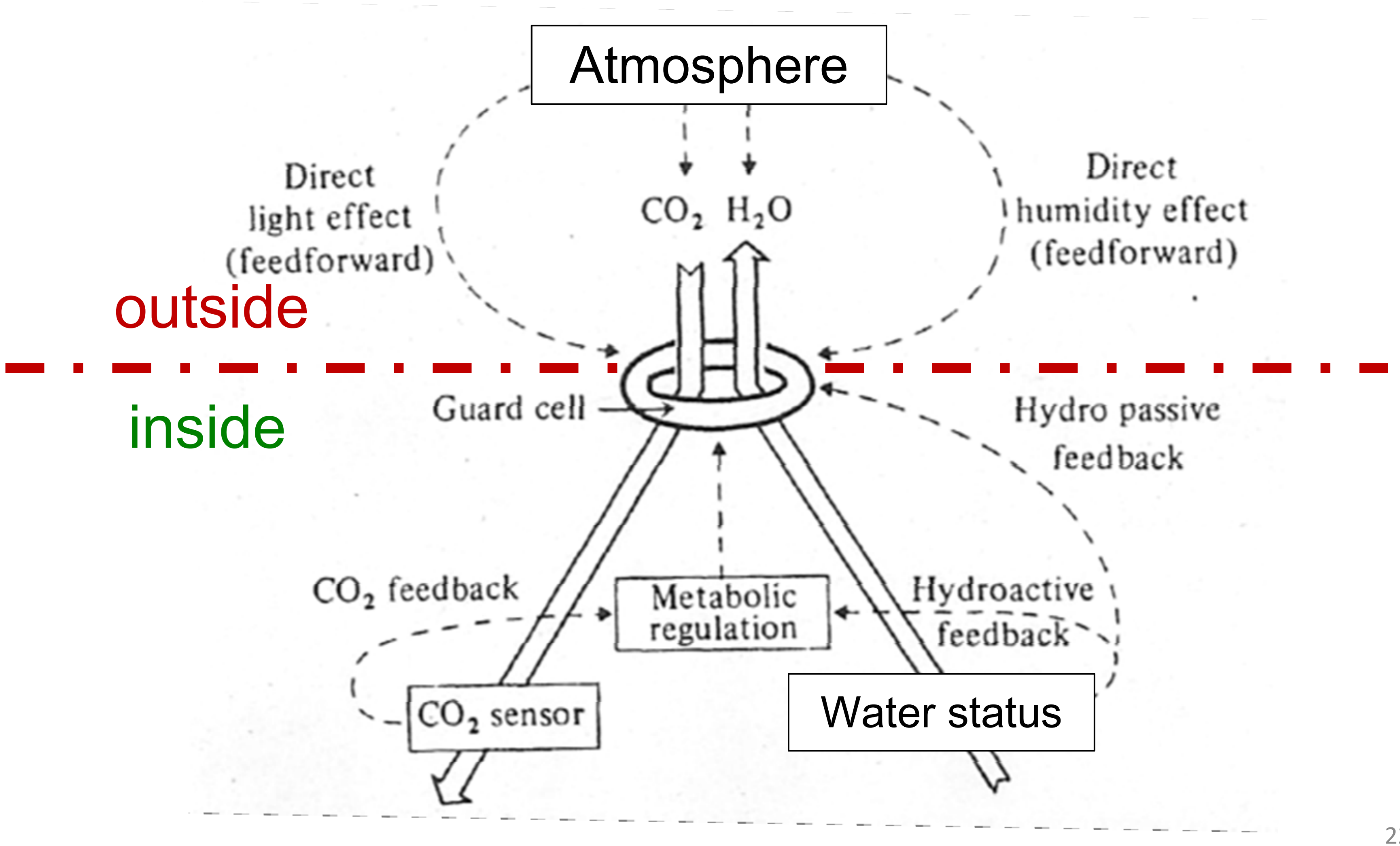
Q: Why do the C_3 species performs better in lower O_2 concentration?

See Fig. 9 for the C_3 – C_4 contrast.

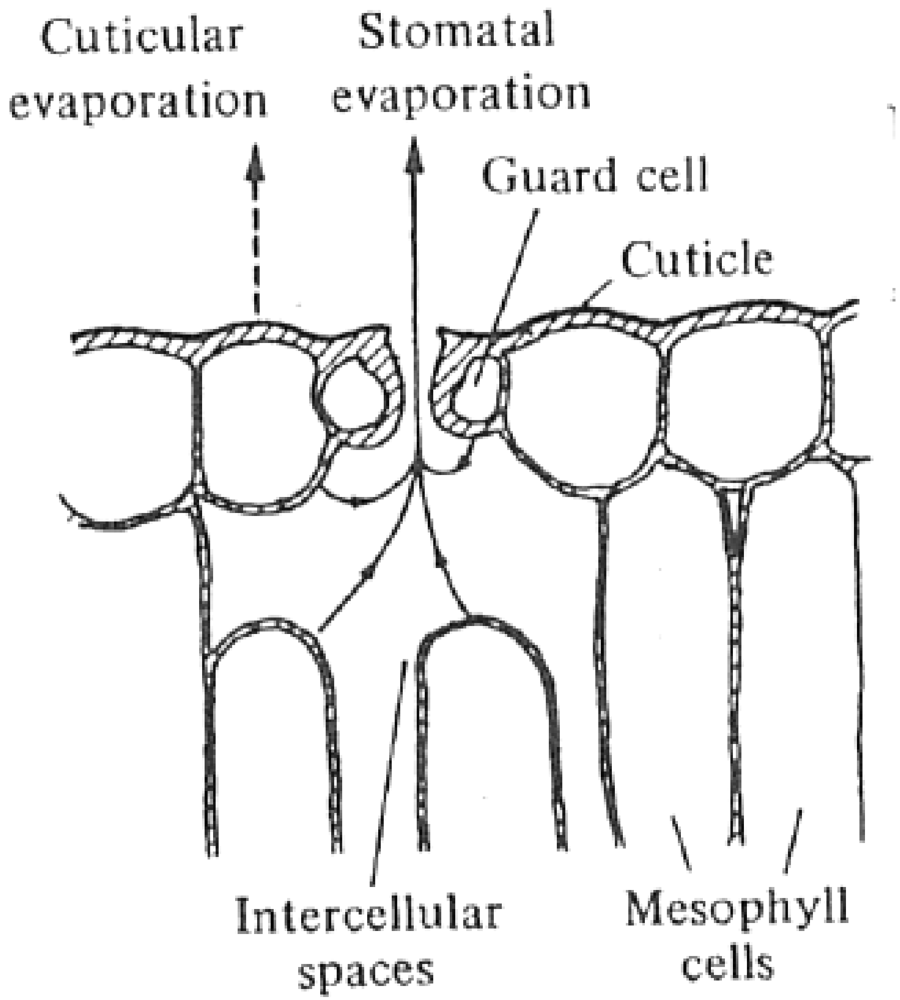


CO2 concentration (in 100 ppm)

Fig. 17. Stomatal control of CO_2 and water vapor transfer.



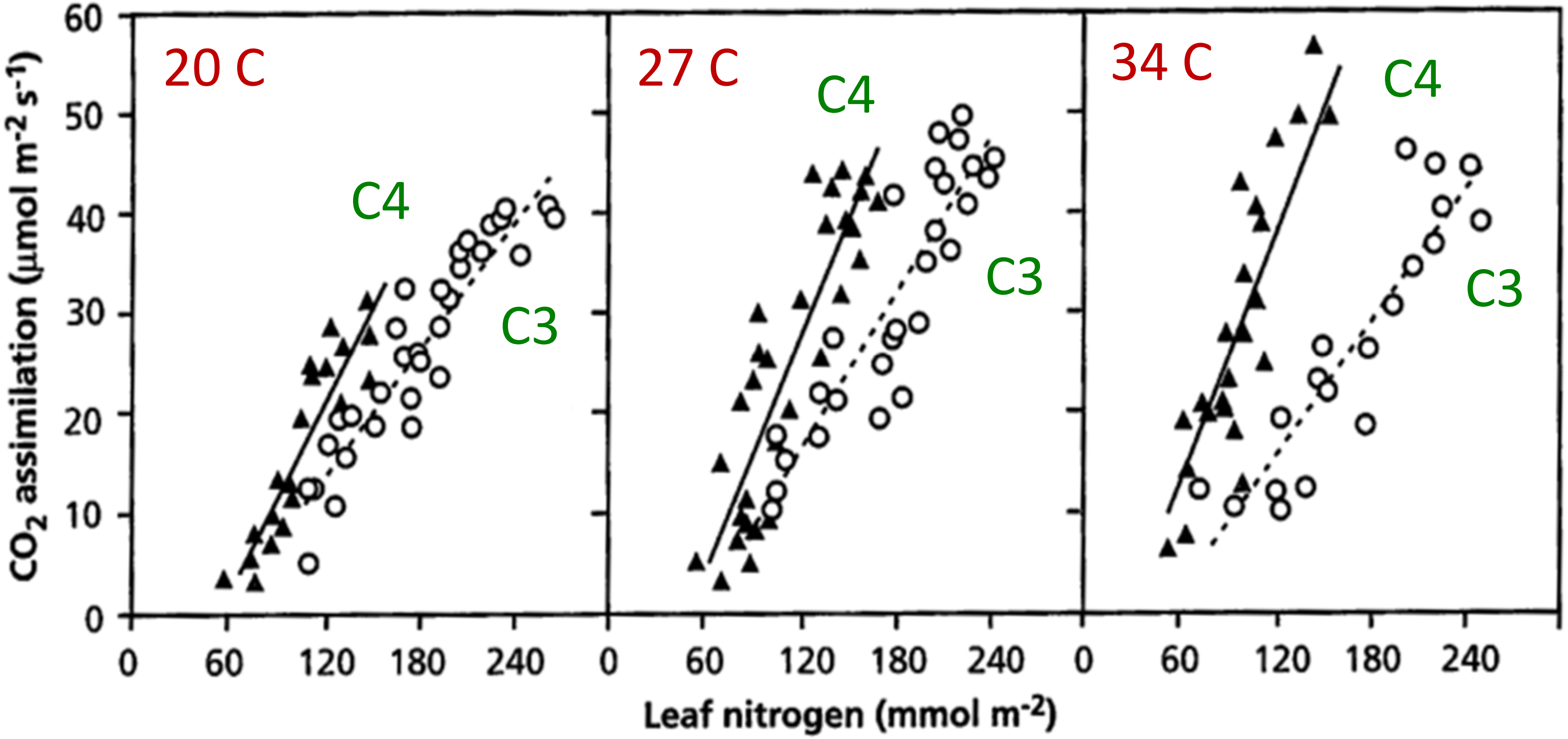
Q: What drives the diffusion of water and CO_2 via stomata?



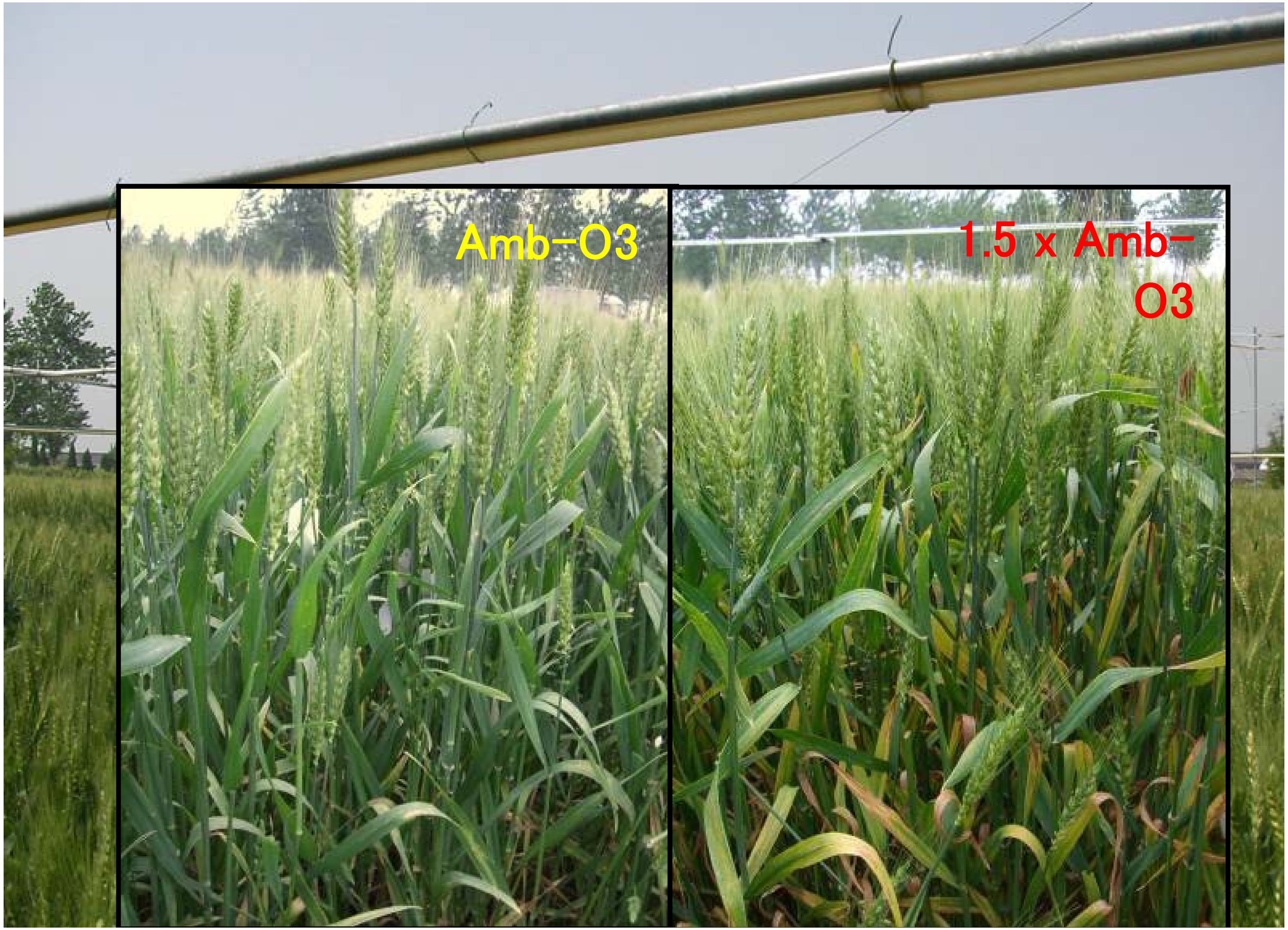
Q: Why do the C_3 species performs poorer in higher temperature?

See Fig. 9 for the C_3 – C_4 contrast.

species.



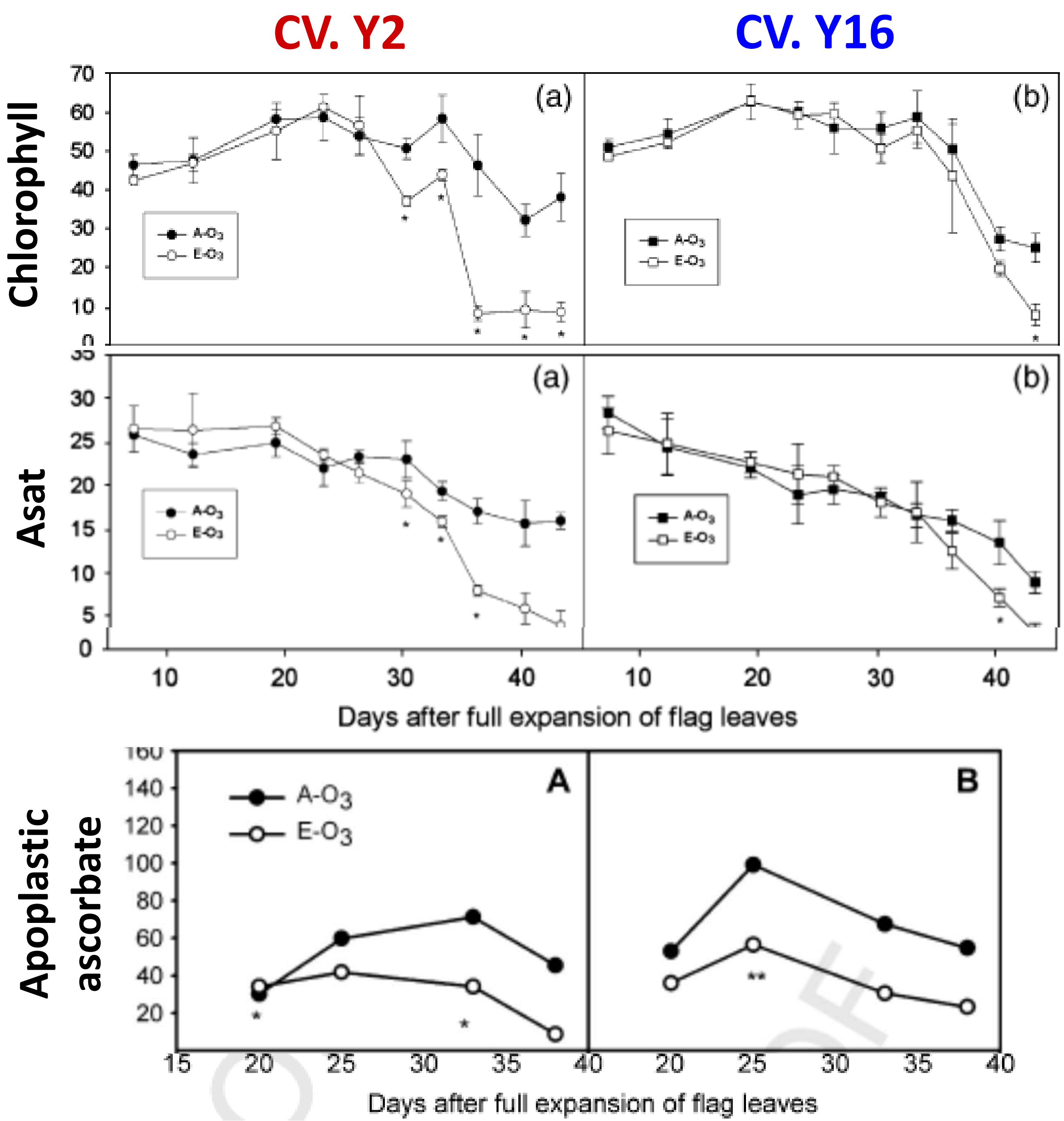
FACE — Ozone in China



Wheat leaf photosynthesis (top) and apoplastic ascorbate (bottom).

●: control,

○: elev. O3.



Feng et al. (2010a)

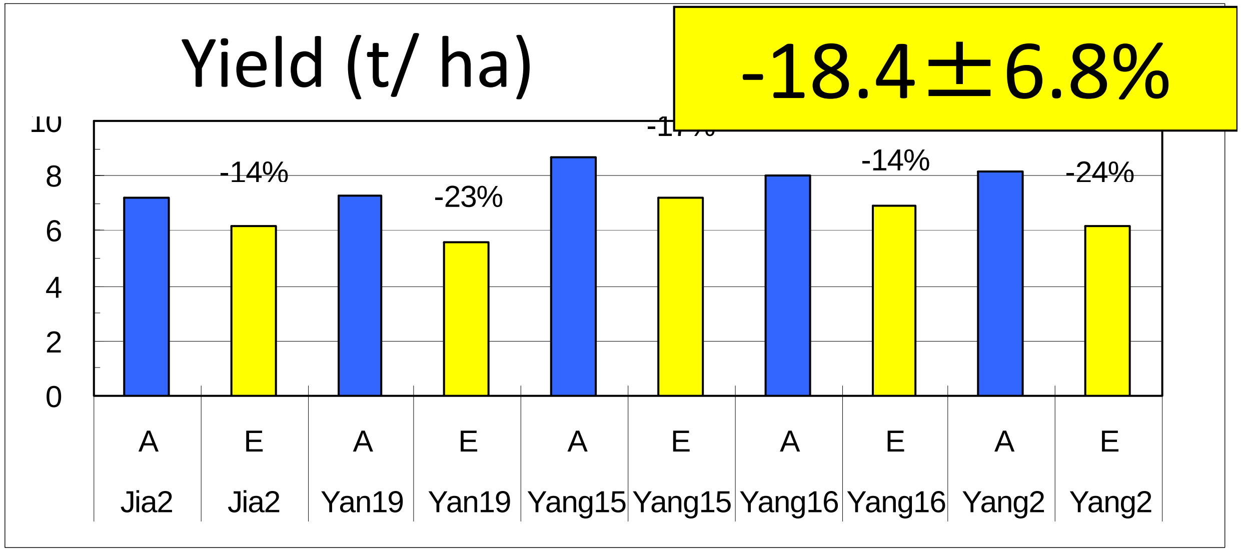
Feng et al. (2010b)

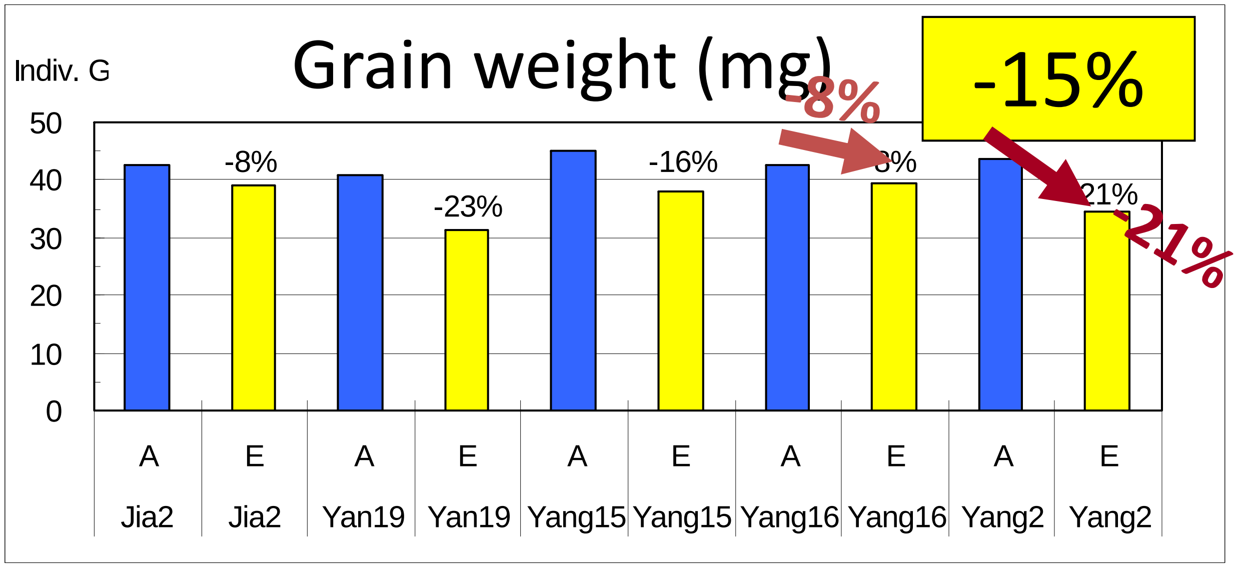
Wheat 5 varieties x 3 years

Yield declined by 18%

due mostly to the reduction in grain weight

Varietal difference

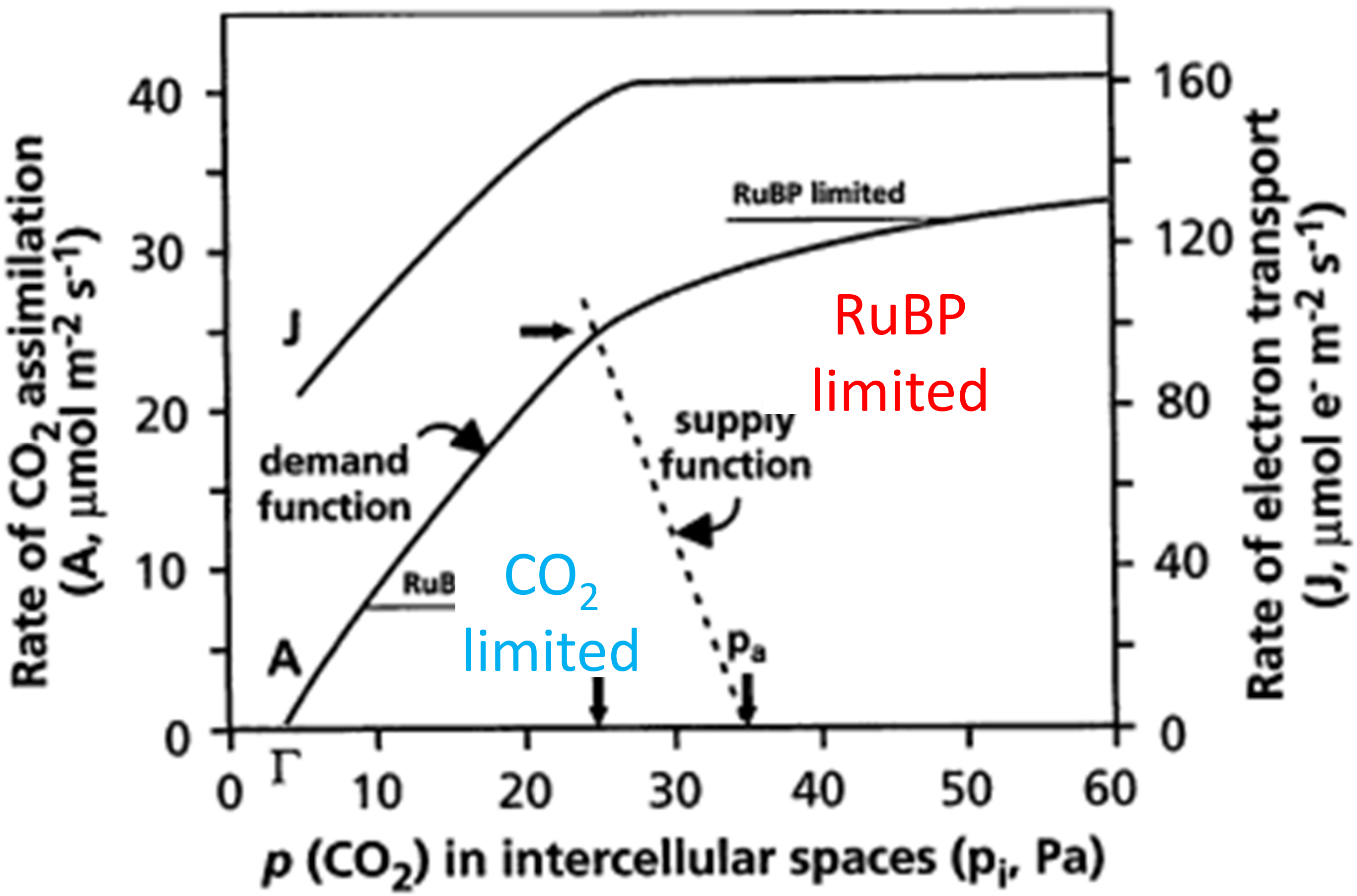




Zhu et al. (2011). GCB 17, 2697-

Question:

Explain, <u>in plain words</u> in either English or Japanese, what the demand line, the supply line, and the intersection between them mean in Fig. 15. Also explain the merit for the leaf to operate photosynthesis near the break points of the CO_2-limited and energy (RuBP-regenration)-limited lines as in the case of the water-stressed bean plants as shown in the figure at the bottom.



Rate of CO_2 assimilation (A, μmol m^{-2} s^{-1})
40
30
20
10
0
J
A
demand function
RuB
CO_2 limited
supply function
p_a
RuBP limited
RuBP limited
Γ
0
10
20
30
40
50
60
p (CO_2) in intercellular spaces (p_i, Pa)
160
120
80
40
0
Rate of electron transport (J, μmol e^- m^{-2} s^{-1})

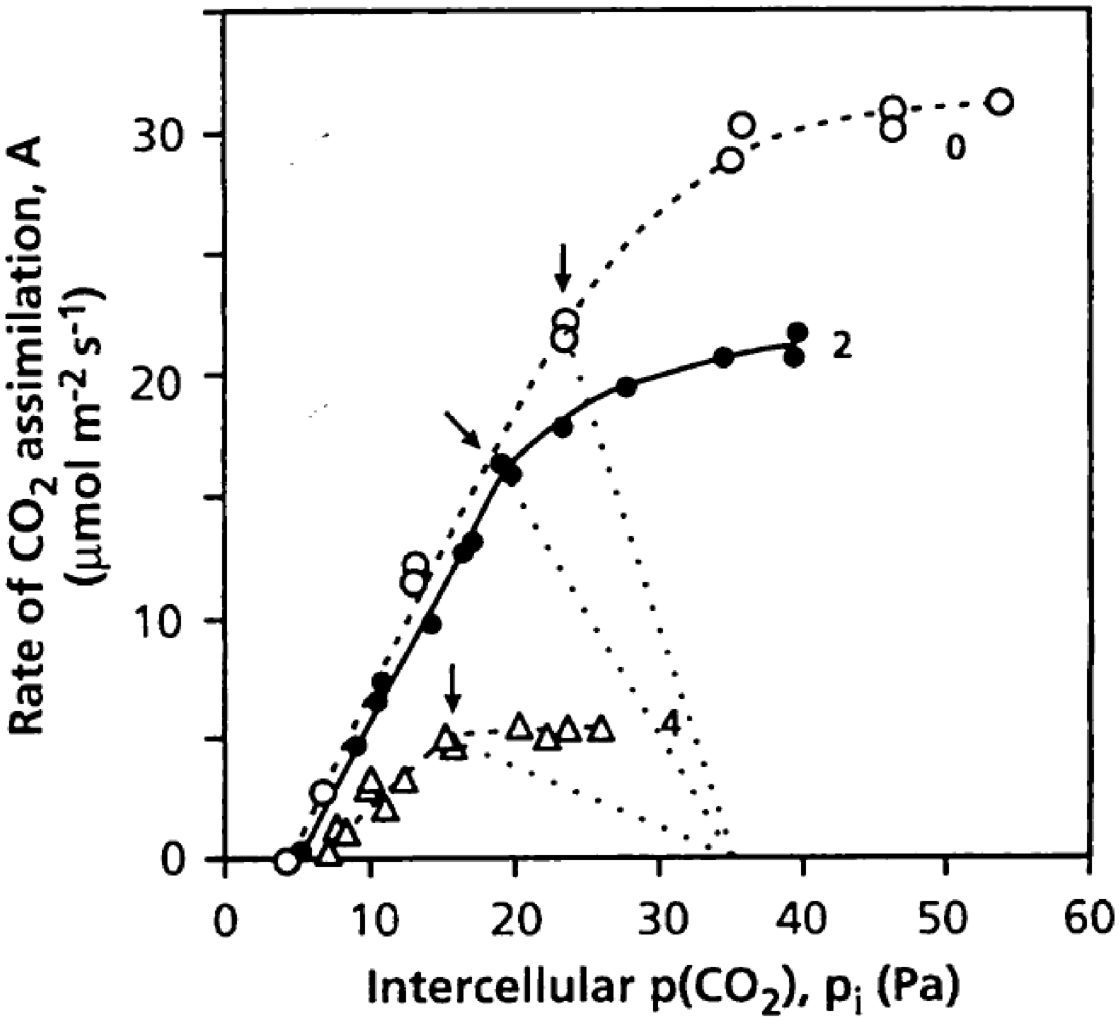
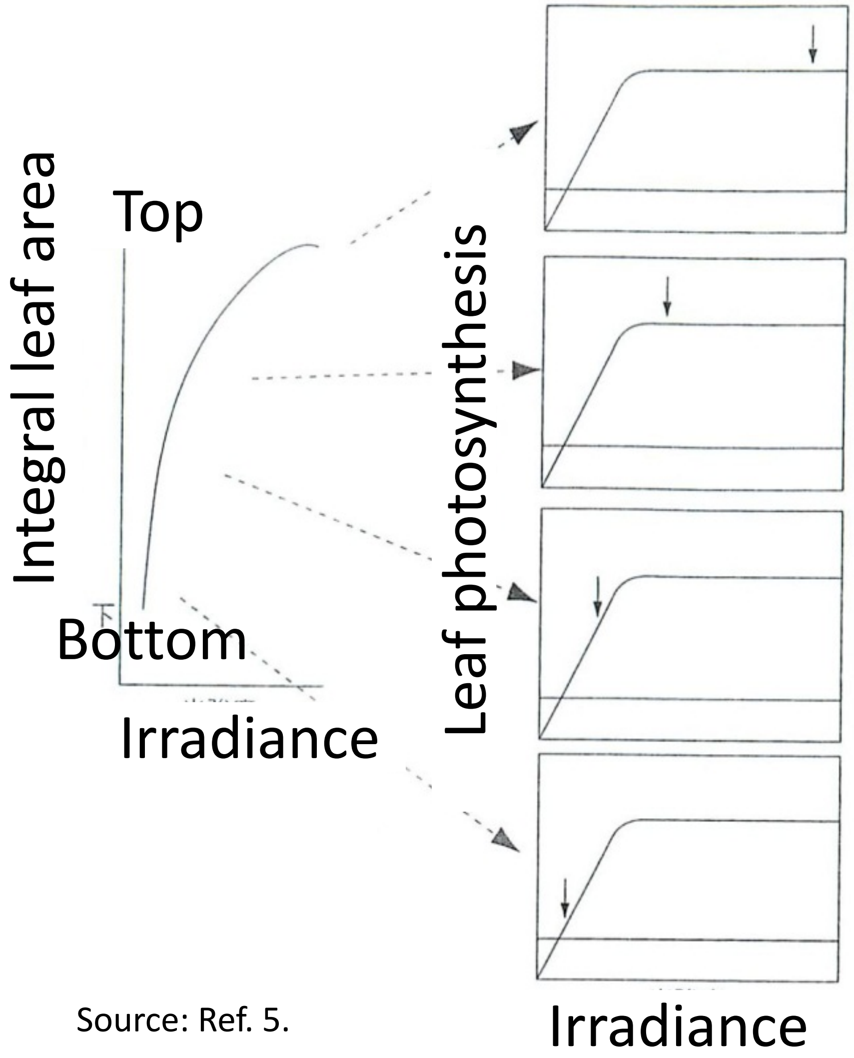

Rate of CO_2 assimilation, A
(μmol m^{-2} s^{-1})
30
20
10
0
0
10
20
30
40
50
60
Intercellular $p(CO_2)$, p_i (Pa)
0
2
4

Fig. 20. Monsi-Saeki Model of canopy photo-synthesis.



Source: Ref. 5.

Fig. 21. Monsi-Saeki Model as compared with observed canopy and leaf photosynthesis rates.

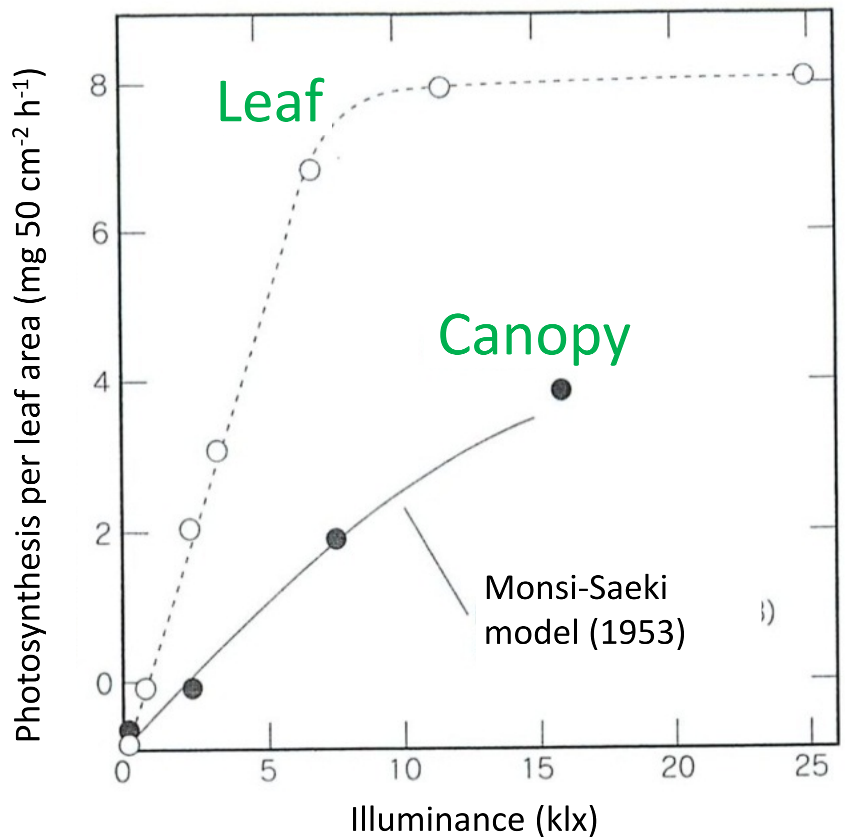


Fig. 22. Hirose-Werger Model for photo-synthesis with N gradient for optimum light use.

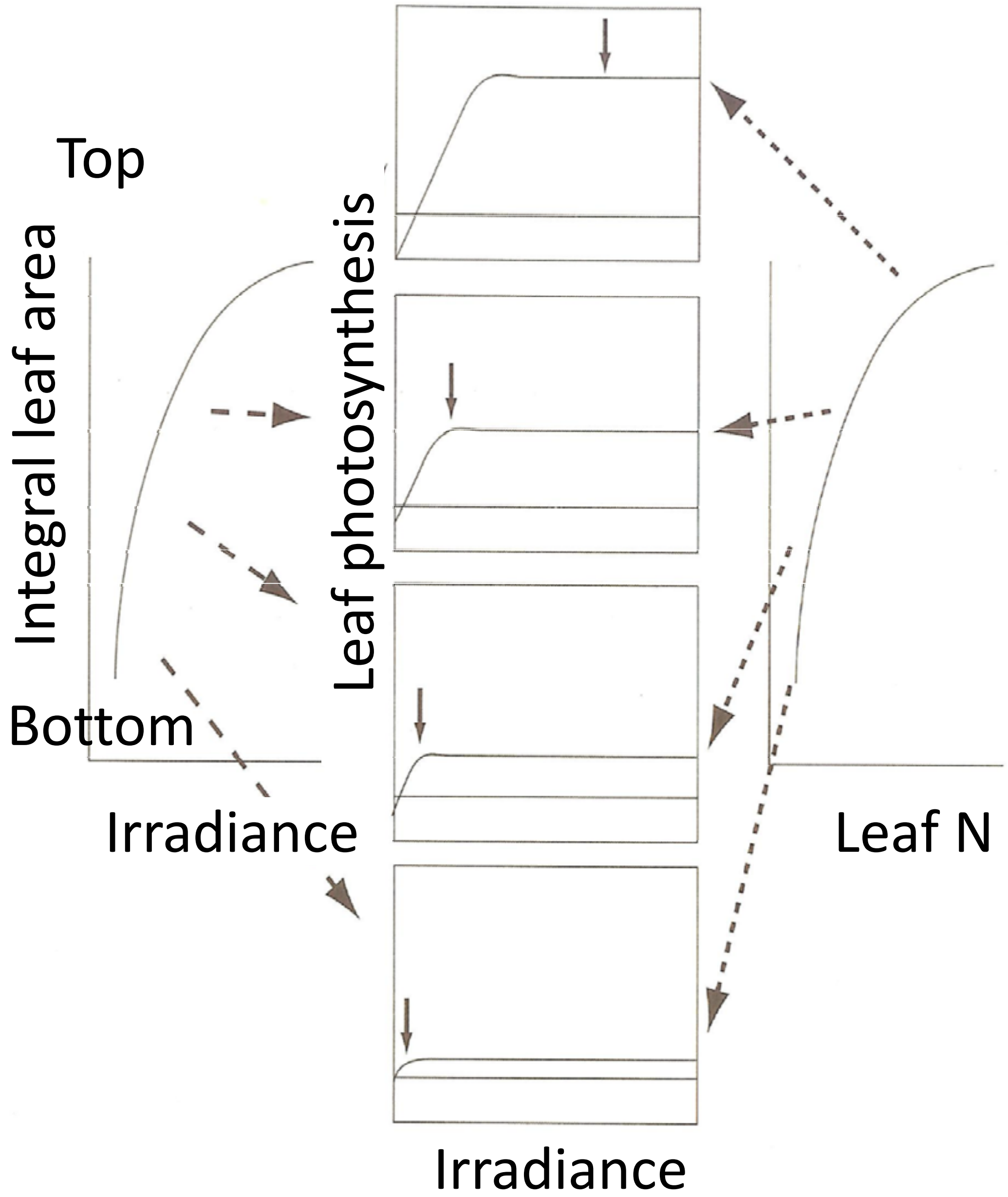


Fig. 23. Effect of leaf N gradient on canopy photosynthesis

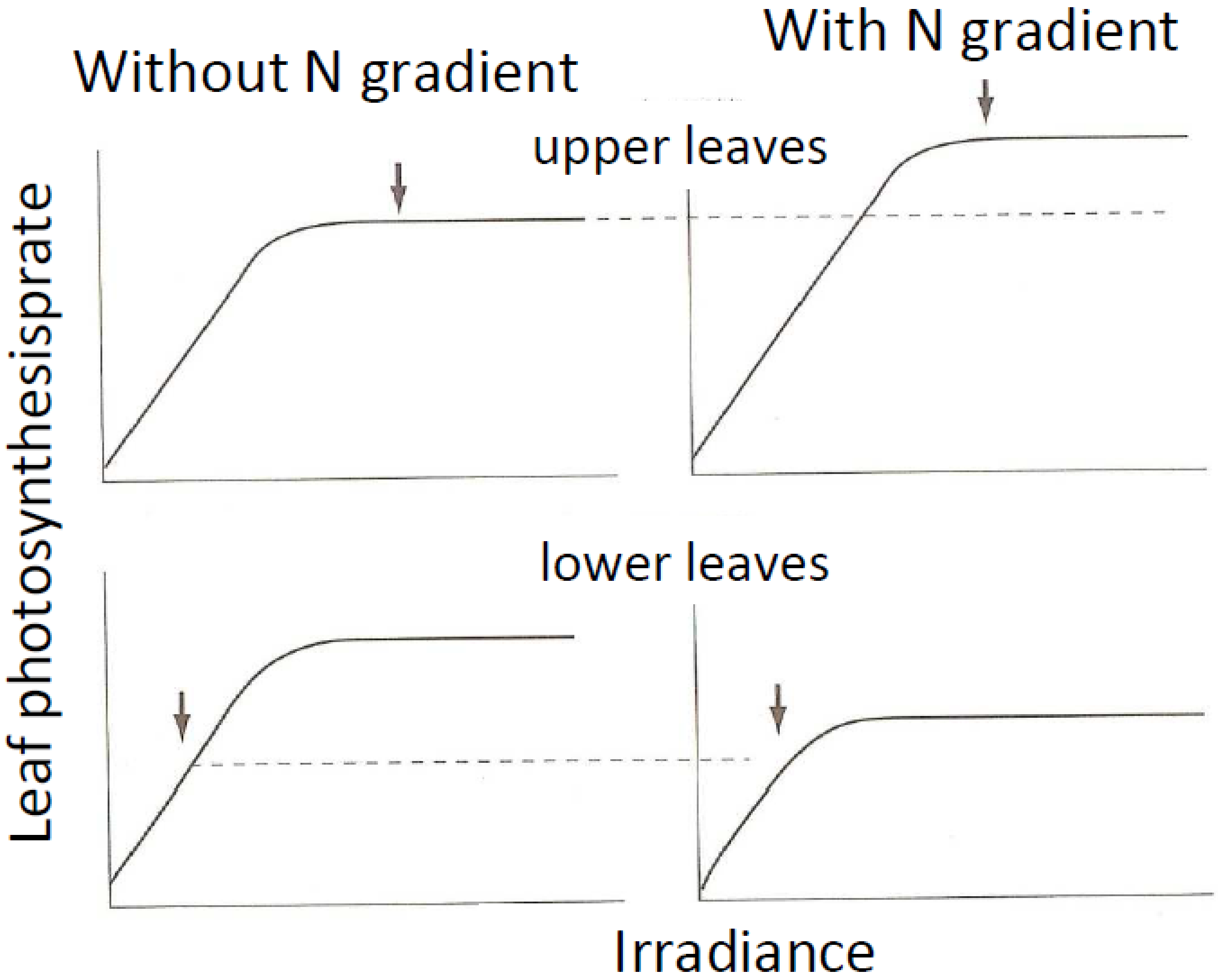
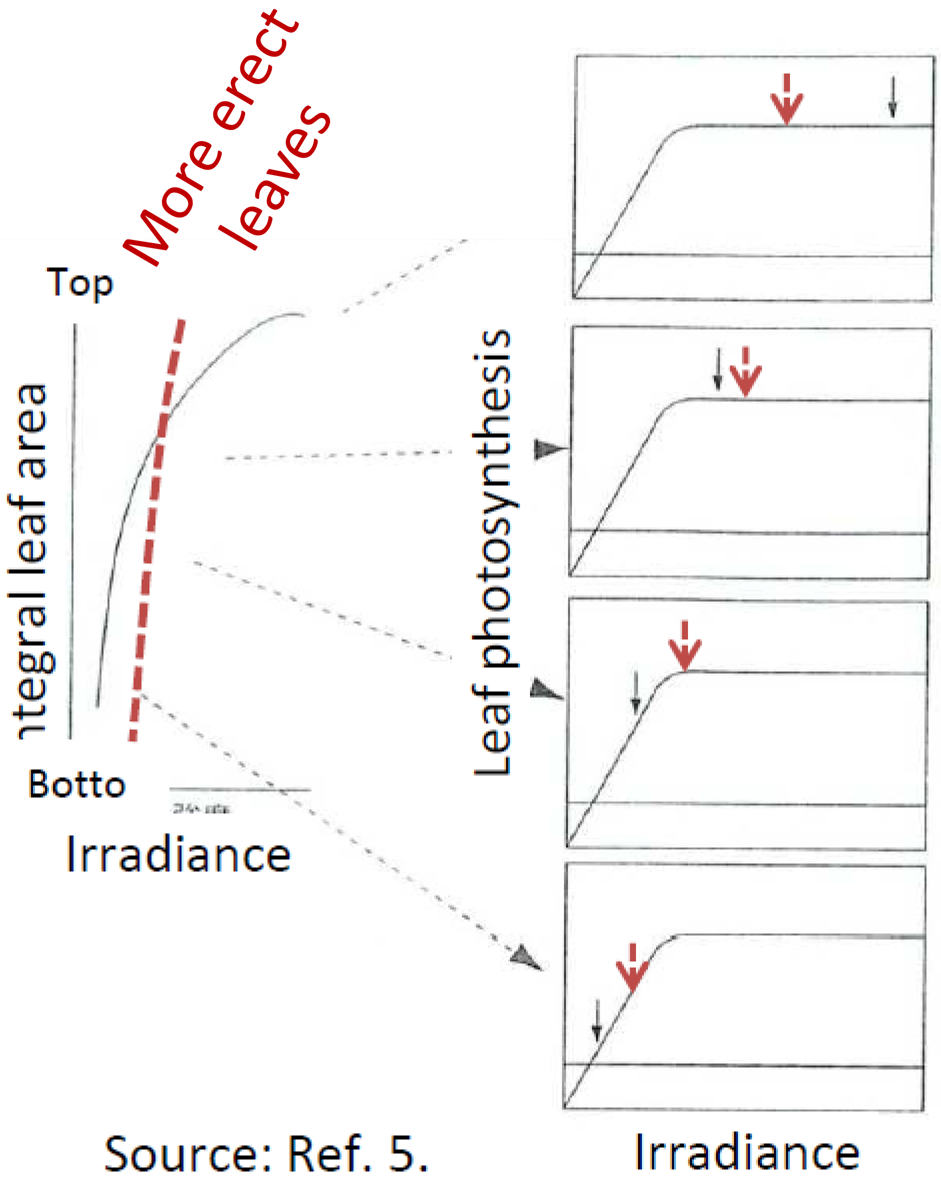


Fig. 24. Effect of altered irradiance profile on canopy photo-synthesis.



Source: Ref. 5.