認知單元（16）

植物學特論-(1)

植物的光合作用及光感應

Shih-Long Tu
涂世隆

Institute of Plant and Microbial Biology
Academia Sinica, Taipei, Taiwan.
中央研究院植物暨微生物學研究所

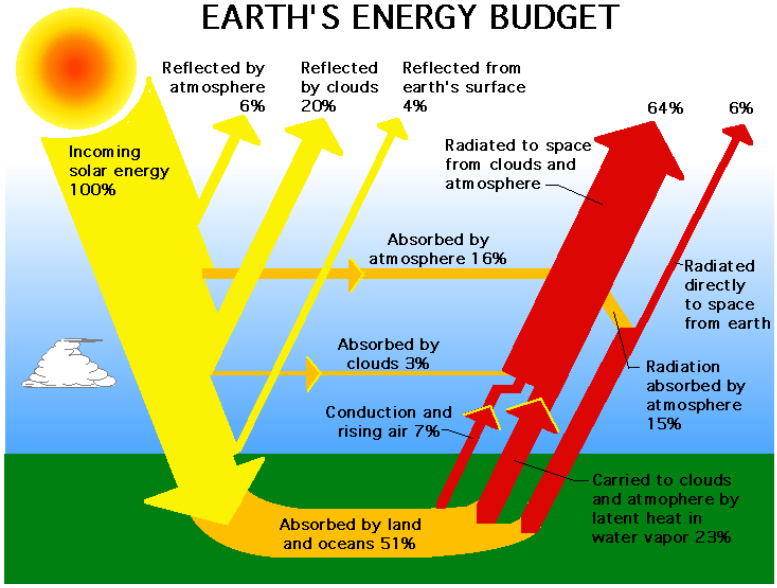
1

大綱

- 光合作用的重要性
- 光合作用發生的位置
- 光線的特性及參與光合作用的色素
- Light reaction (光反應)
- Calvin cycle (卡爾文循環; 碳反應)
- C3, C4, CAM 植物
- 植物的光感應及光型態調控

2

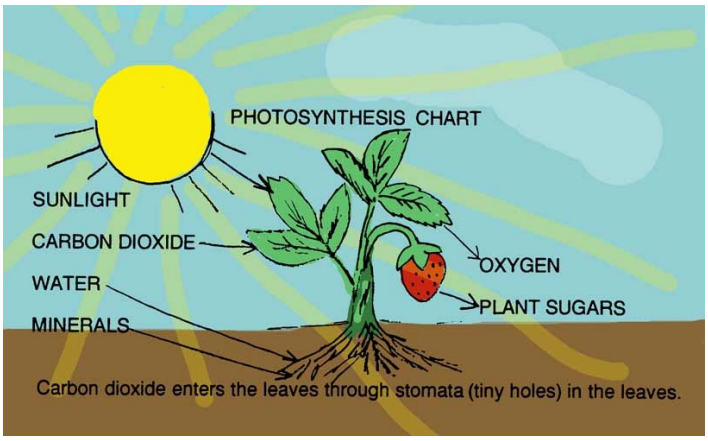
地表對太陽能的折射及吸收



Adapted from http://solarenergyfactsblog.com/solar-energy-diagram/

3

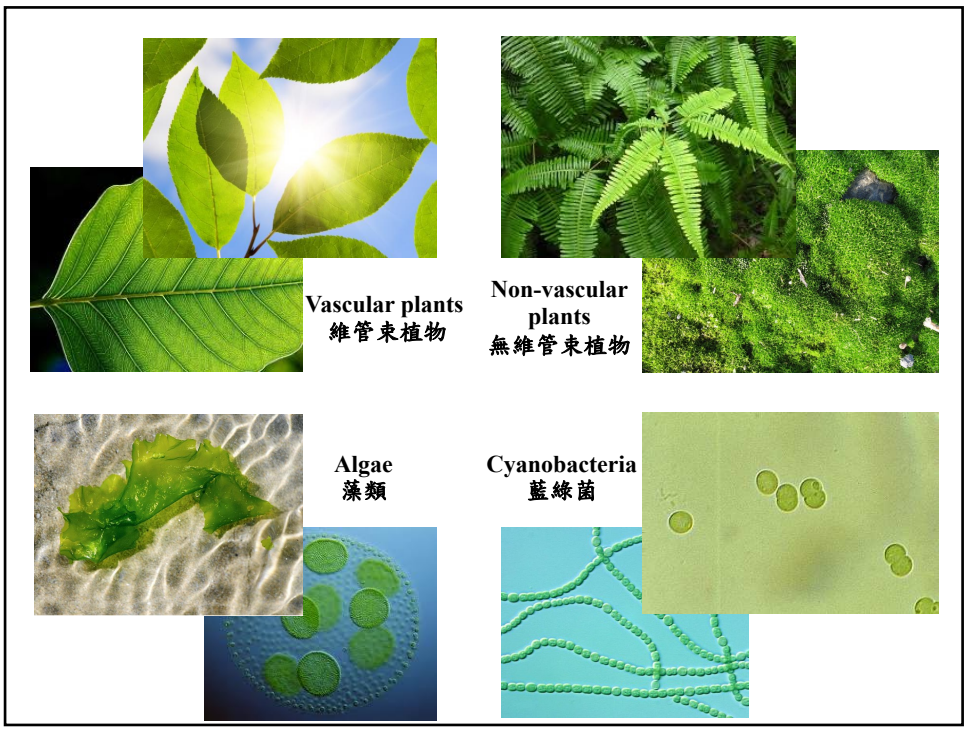
光合作用的重要性



$6\ CO_2 + 12\ H_2O +$ 光子 $\rightarrow C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$

Adapted from http://www.homestead-farm.net/KidsLinks/Photosynthesis.html

4



5

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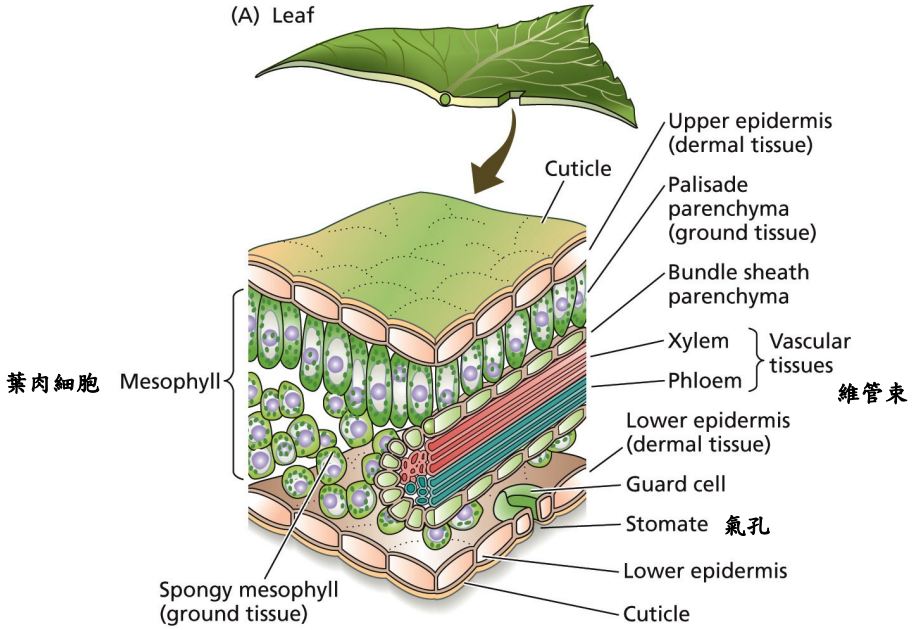
6

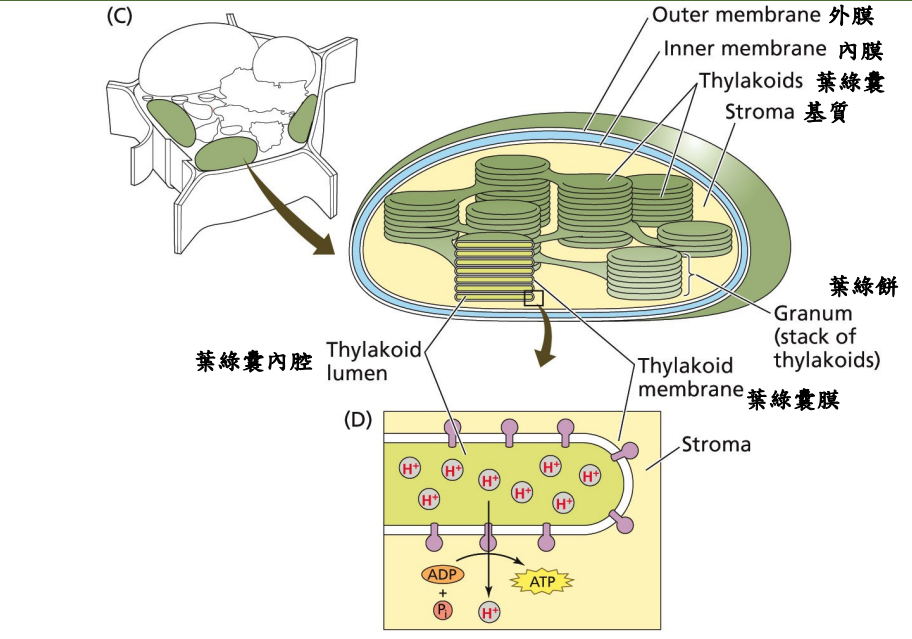
植物的葉片組織



PLANT PHYSIOLOGY, 5e, Figure 1.1 (Part 2)

7

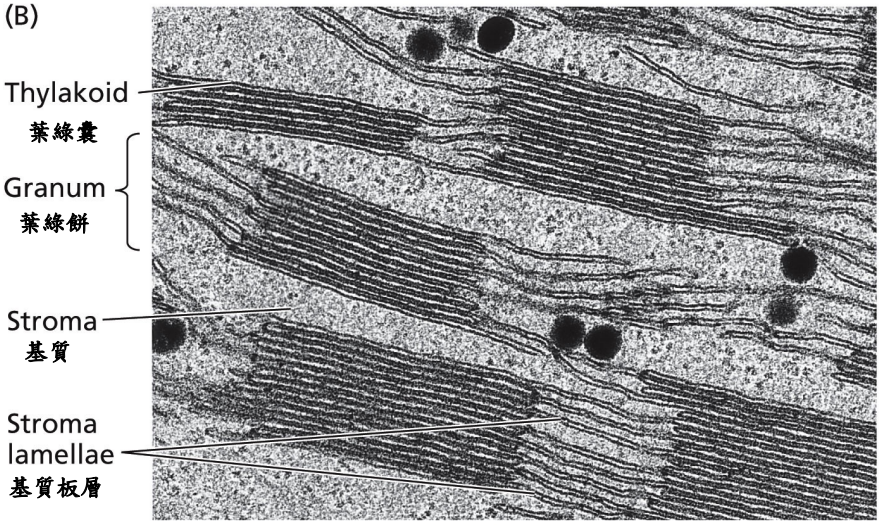
葉綠體的構造



PLANT PHYSIOLOGY, 5e, Figure 1.17 (Part 3)

8

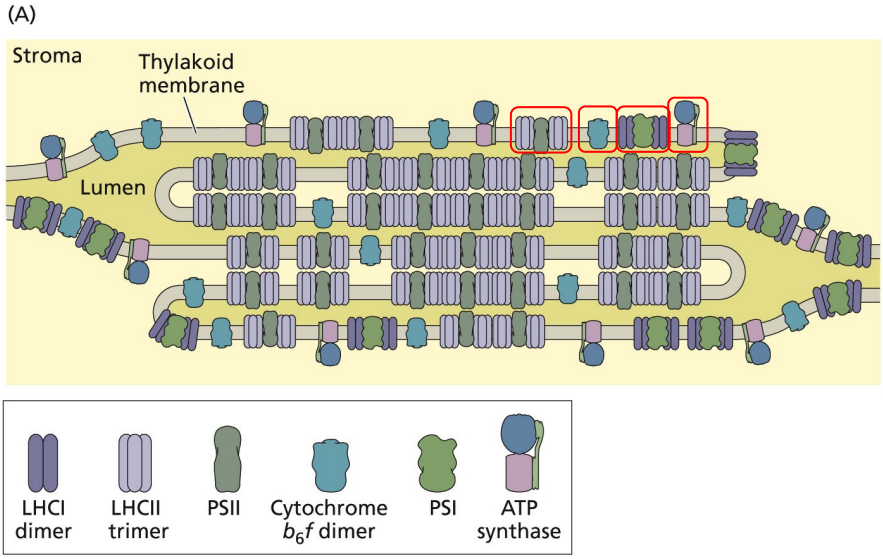
葉綠體的構造：Electron micrograph of a chloroplast



PLANT PHYSIOLOGY, 5e, Figure 1.17 (Part 2)

9

葉綠囊膜上主要的四種蛋白質複合體



PLANT PHYSIOLOGY, 5e, Figure 7.18 (Part 1)

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葉綠囊膜上主要的四種蛋白質複合體

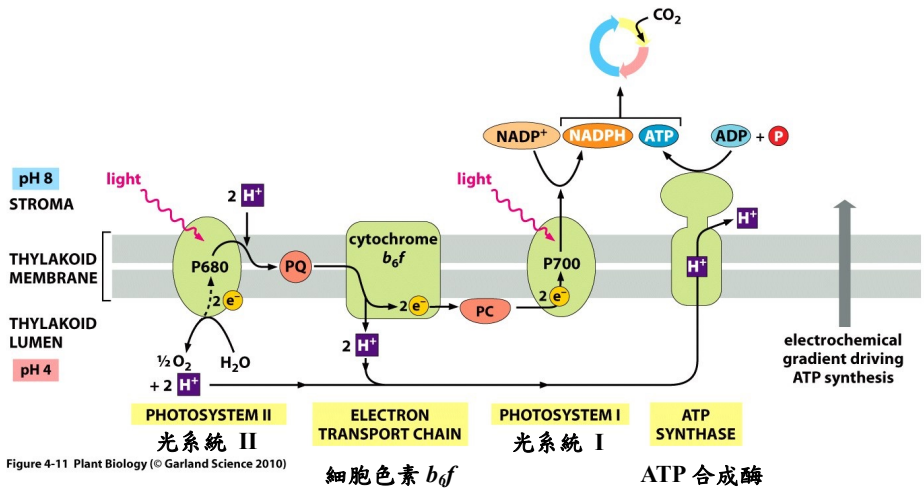

Figure 4-11 Plant Biology (© Garland Science 2010)

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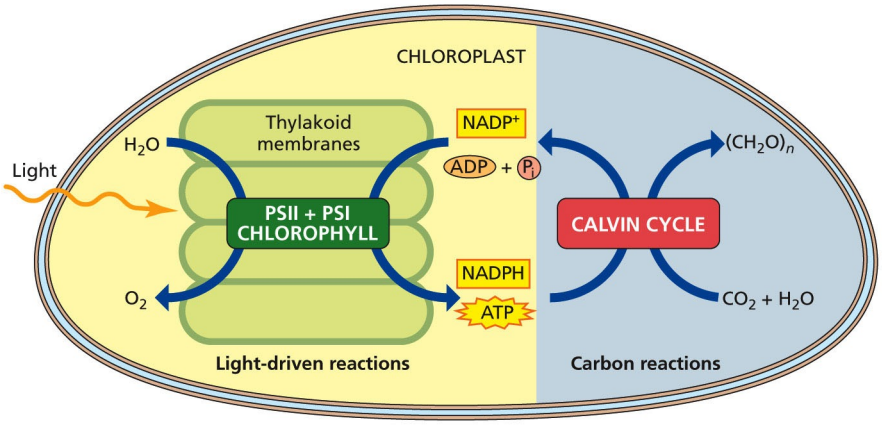
光合作用的光反應 (light reaction) 及卡爾文循環 (Calvin cycle) (或稱碳反應, carbon reaction)



PLANT PHYSIOLOGY, Fourth Edition, Figure 8.1 © 2006 Sinauer Associates, Inc.

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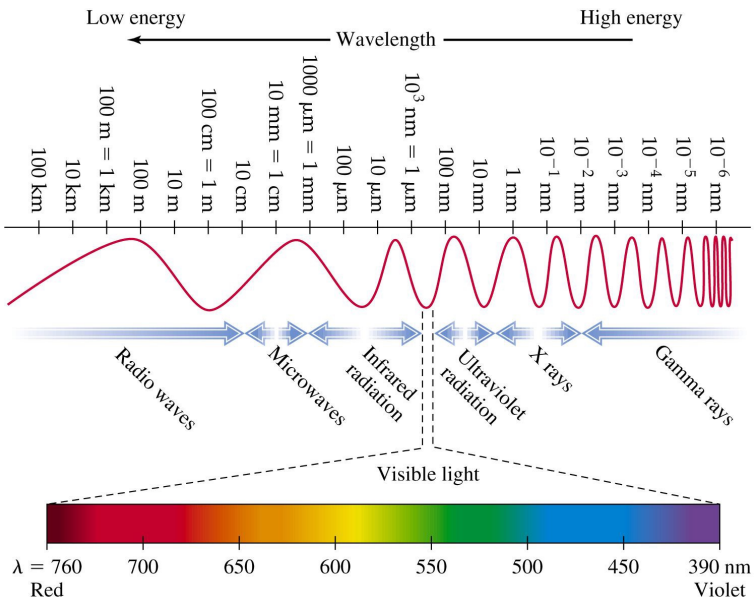
電磁波的波長



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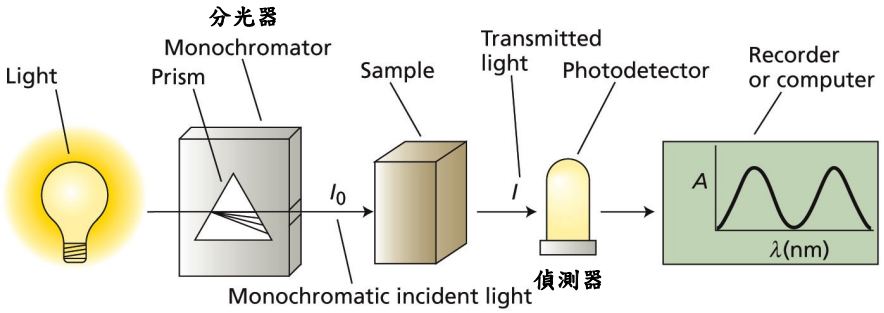
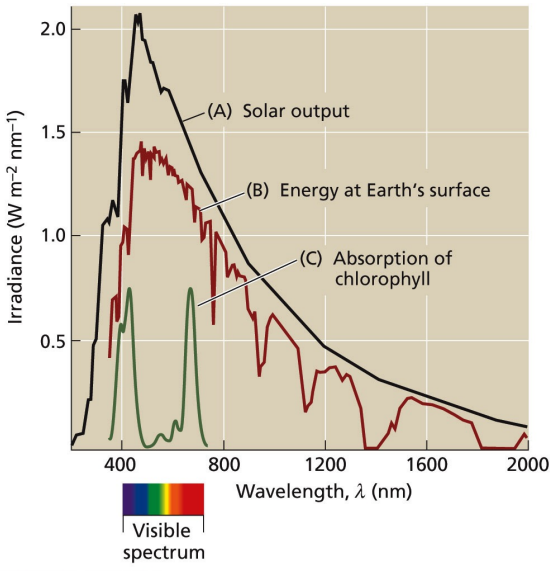
光譜儀 (spectrophotometer) 的原理



PLANT PHYSIOLOGY, 5e, Figure 7.4

15

太陽光的光譜 (spectrum) 及葉綠素 (chlorophyll) 的吸收光譜 (absorption spectrum)



PLANT PHYSIOLOGY, 5e, Figure 7.3

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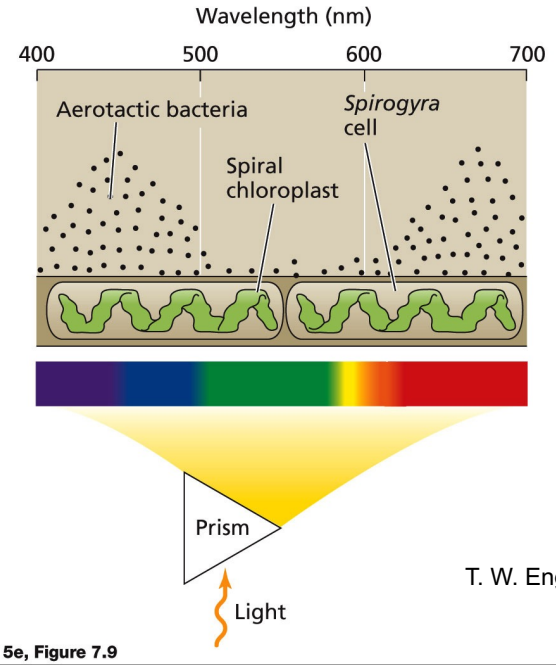
不同波長光線的光合作用效率



PLANT PHYSIOLOGY, 5e, Figure 7.9

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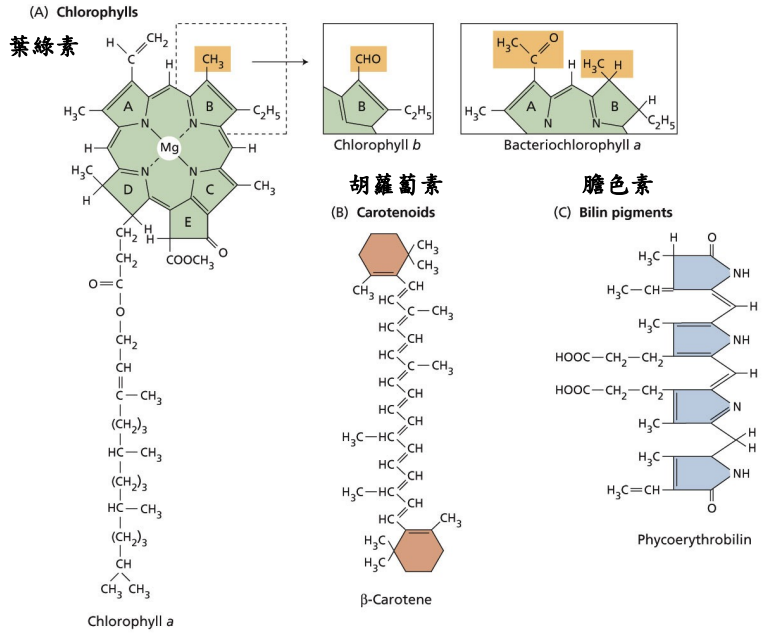
光合作用色素的化學結構



PLANT PHYSIOLOGY, 5e, Figure 7.6

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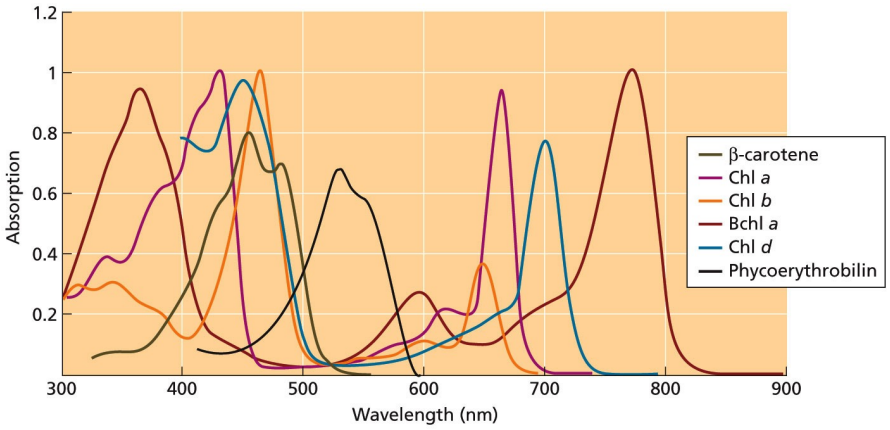
光合作用色素的吸收光譜



PLANT PHYSIOLOGY, 5e, Figure 7.7

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20

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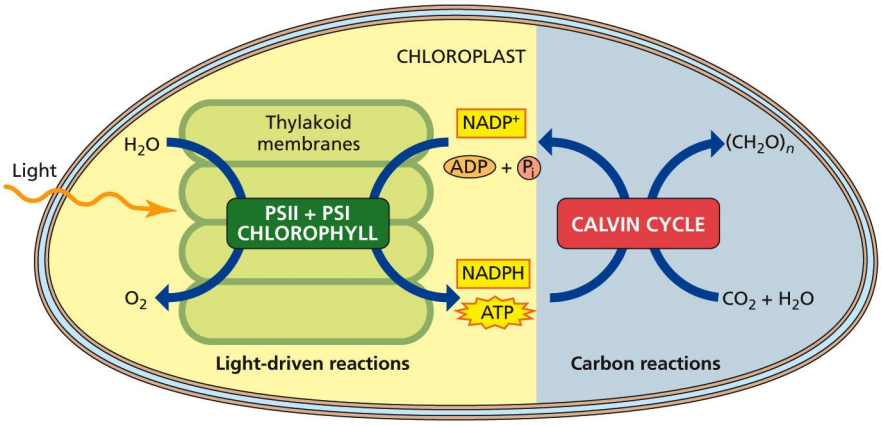

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葉綠囊膜上主要的四種蛋白質複合體

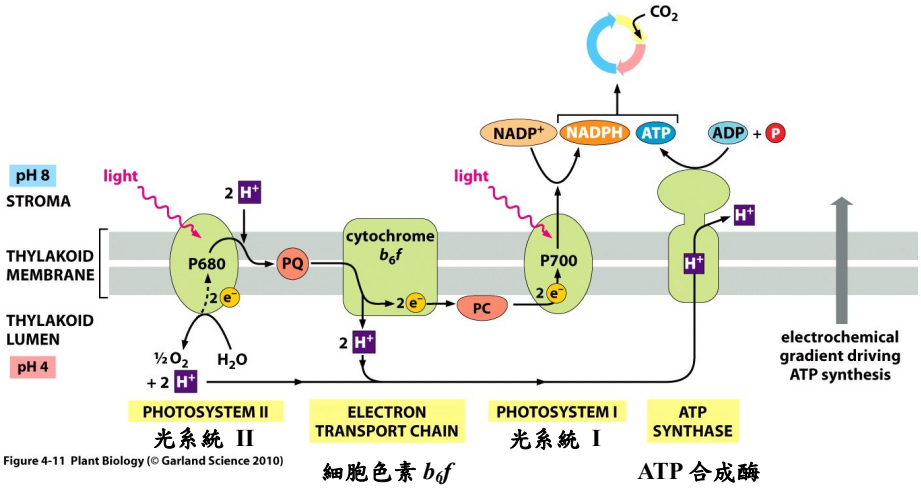

Figure 4-11 Plant Biology (© Garland Science 2010)

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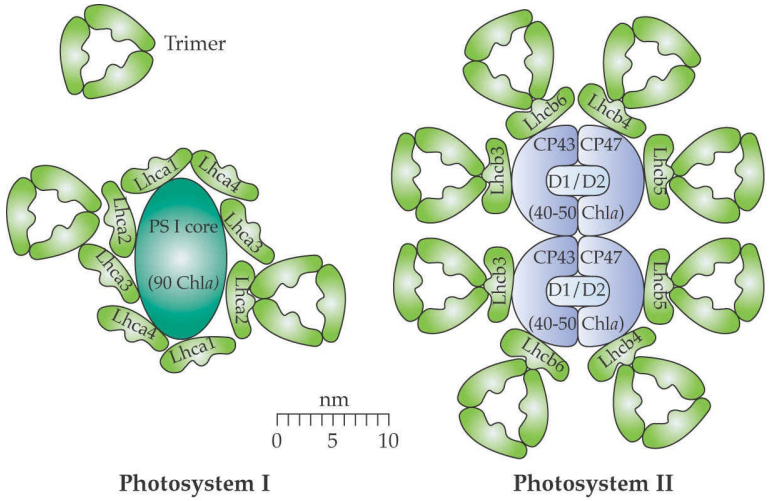
光系統 I 及 II 上的光吸收蛋白



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光吸收蛋白上的葉綠素及胡蘿蔔素

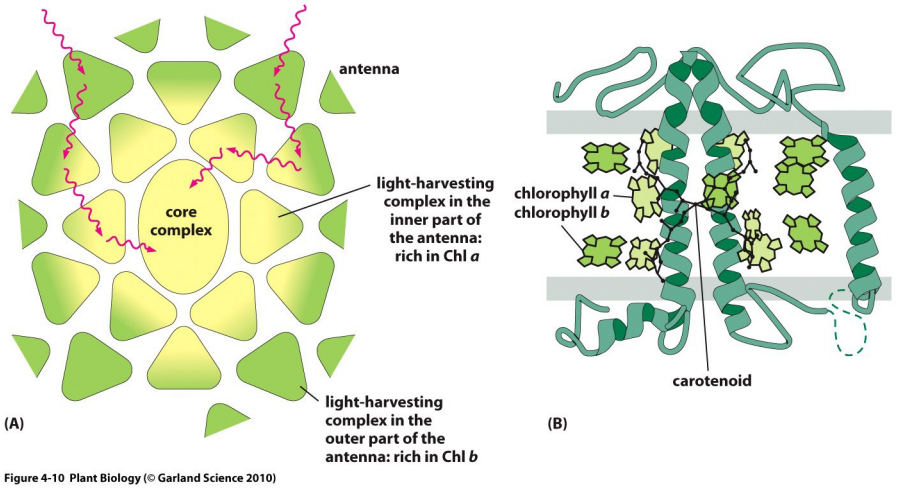

Figure 4-10 Plant Biology (© Garland Science 2010)

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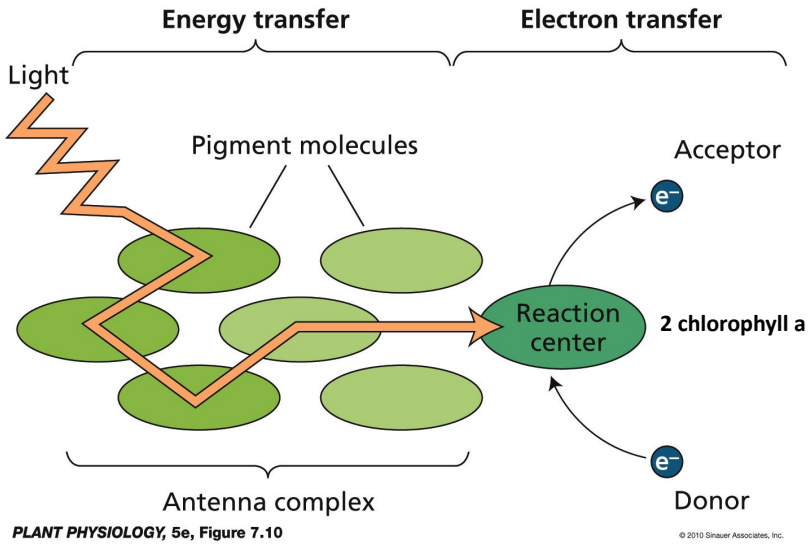
光吸收蛋白上的能量傳遞及反應中心的電子生成



25

水分子裂解及電子生成

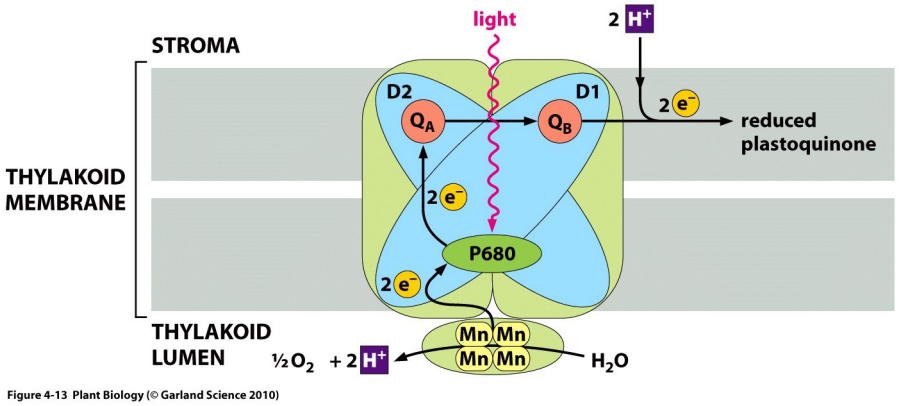


Figure 4-13 Plant Biology (© Garland Science 2010)

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光系統 I 上的電子傳遞及 NADPH 生合成

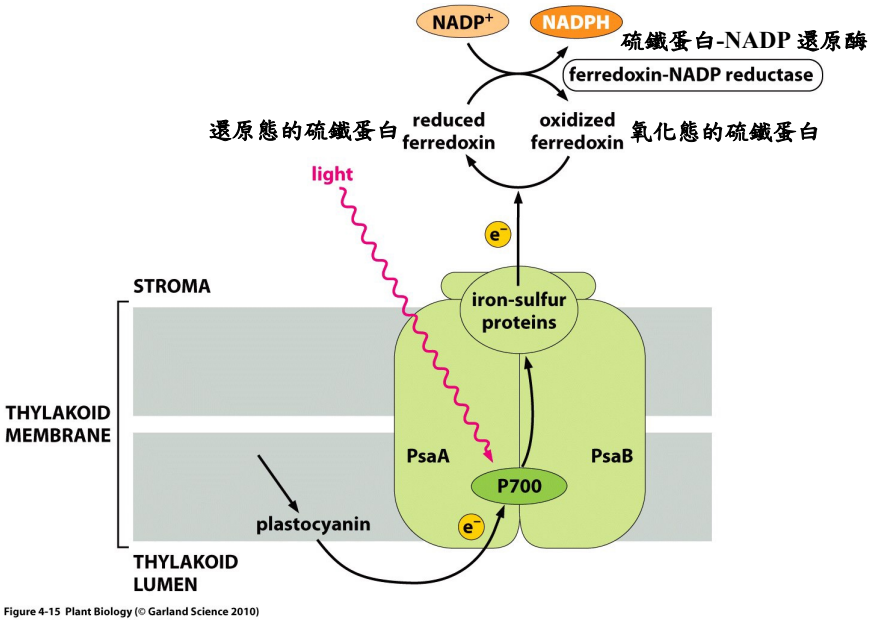

Figure 4-15 Plant Biology (© Garland Science 2010)

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電子傳遞鏈及氫離子梯度

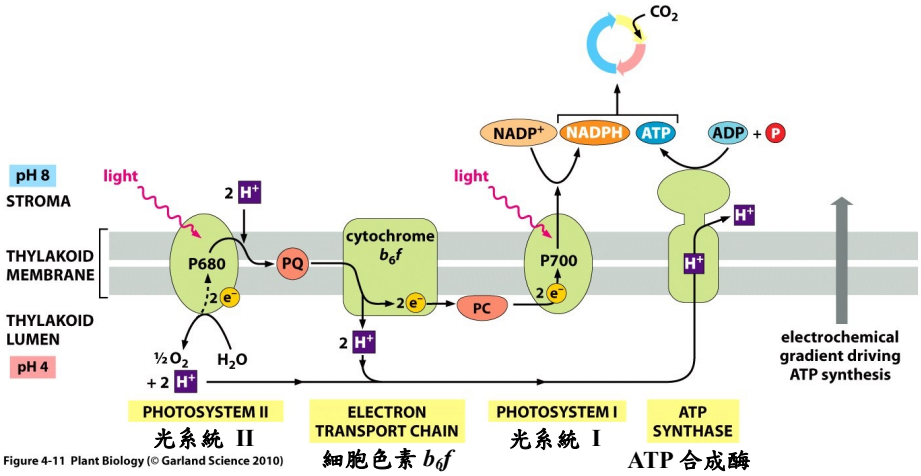

Figure 4-11 Plant Biology (© Garland Science 2010)

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ATP 合成酶 (F_1F_o ATP synthase) 的作用機制及結構

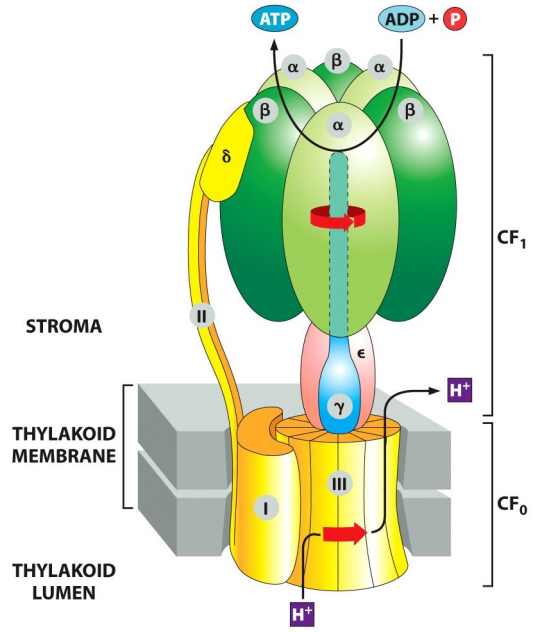

Figure 4-17 Plant Biology (© Garland Science 2010)

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光反應合成 ATP 及NADPH

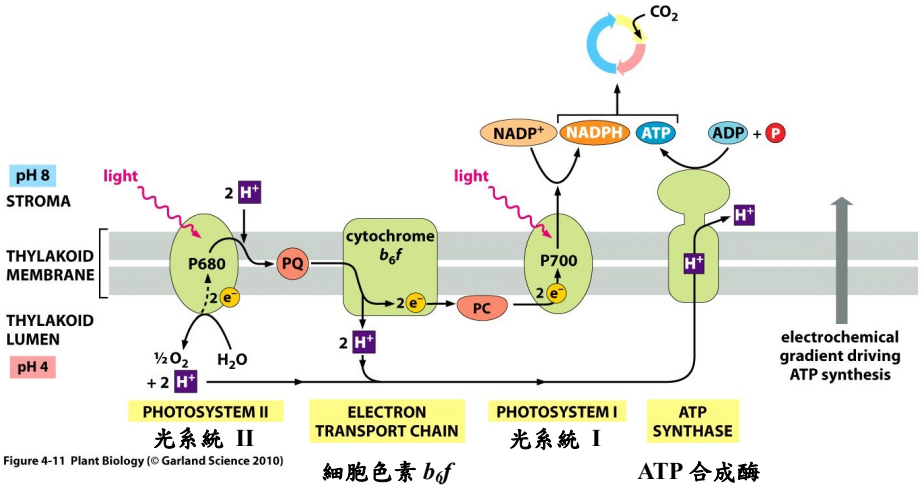

Figure 4-11 Plant Biology (© Garland Science 2010)

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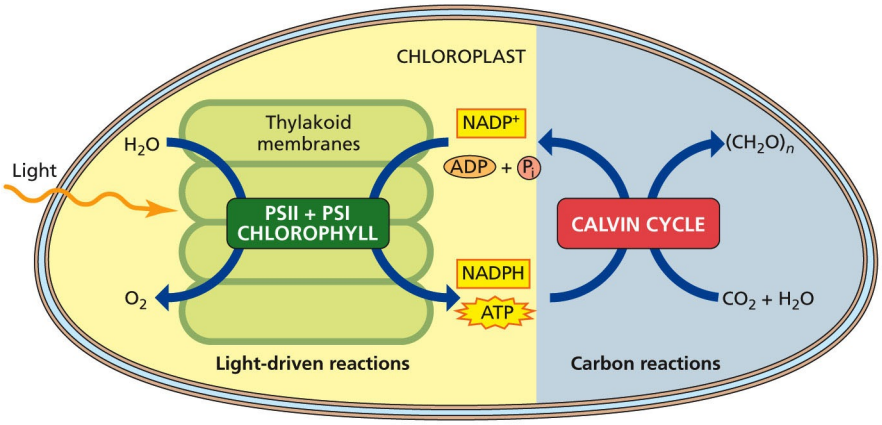

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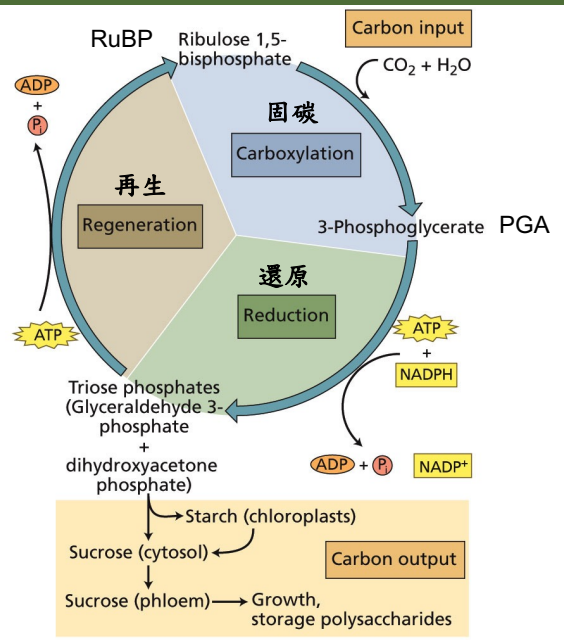
卡爾文循環的三個主要階段



PLANT PHYSIOLOGY, 5e, Figure 8.2

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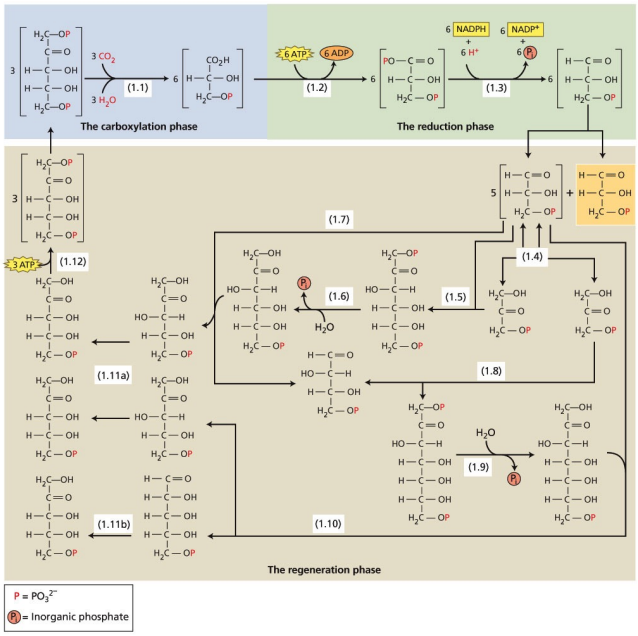
卡爾文循環



PLANT PHYSIOLOGY, 5e, Figure 8.3

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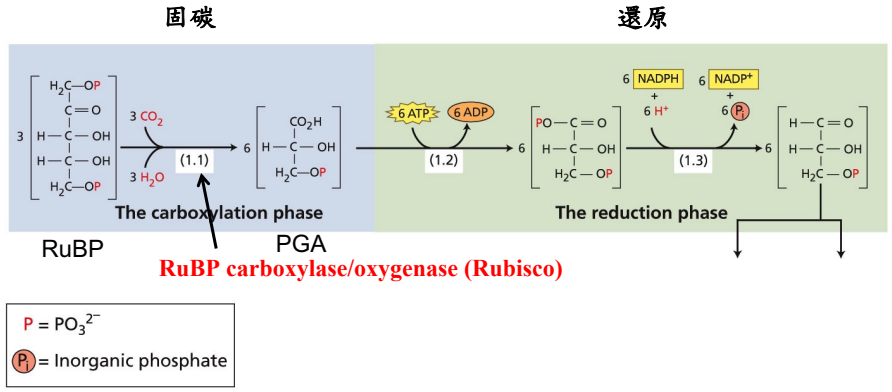
卡爾文循環中的固碳及還原反應



PLANT PHYSIOLOGY, 5e, Figure 8.3 (Part 1)

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RuBP carboxylase/oxygenase (Rubisco) 的組成

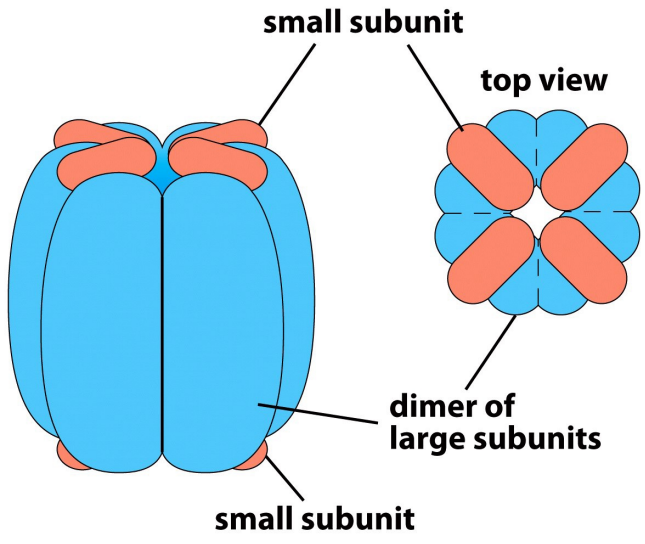

Figure 4-22 Plant Biology (© Garland Science 2010)

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醣類的生合成

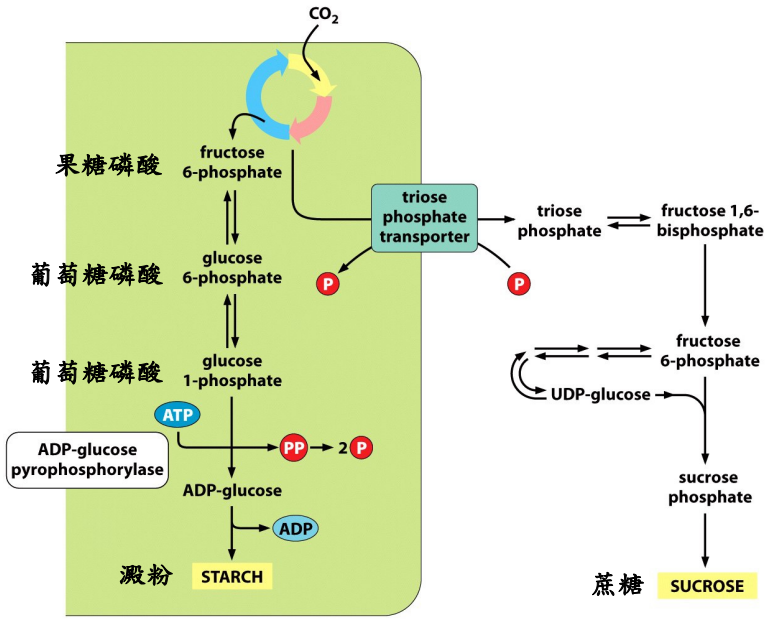

Figure 4-29a Plant Biology (© Garland Science 2010)

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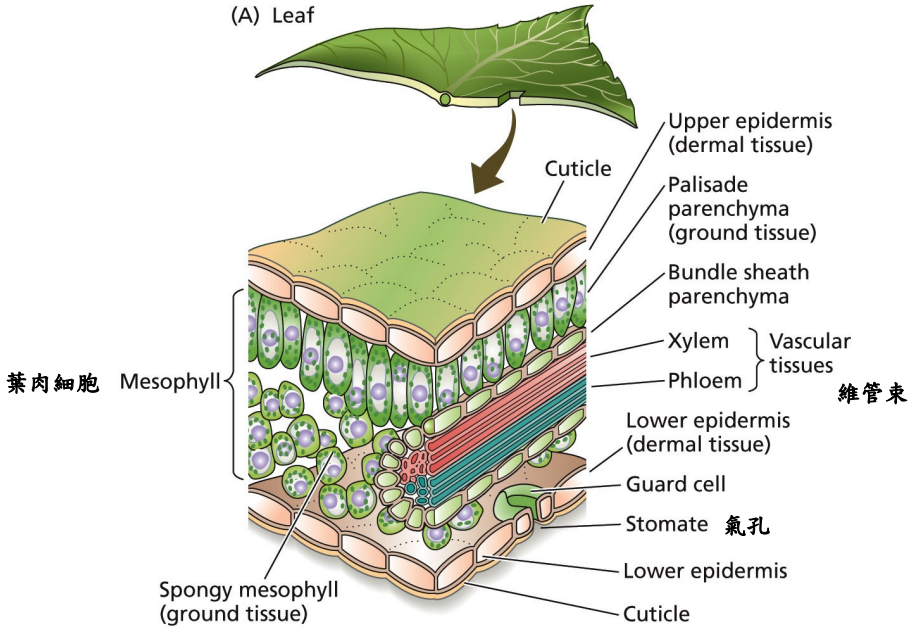
植物的葉片組織



PLANT PHYSIOLOGY, 5e, Figure 1.1 (Part 2)

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C4 及C3 植物葉片切面的比較

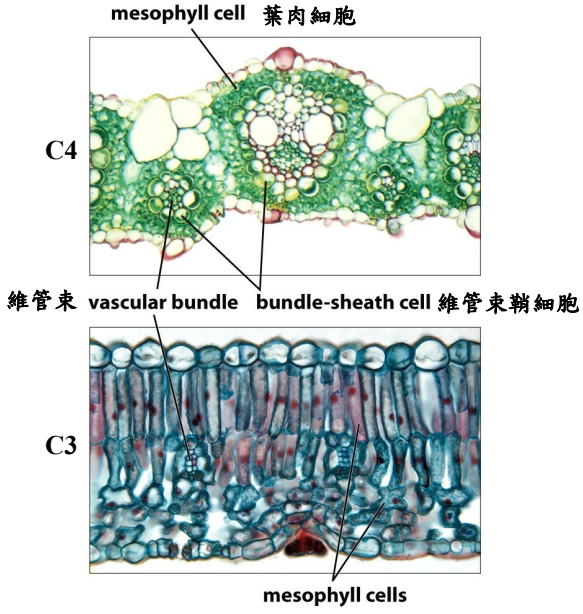

Figure 4-38c Plant Biology (© Garland Science 2010)

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C4 植物葉片切面

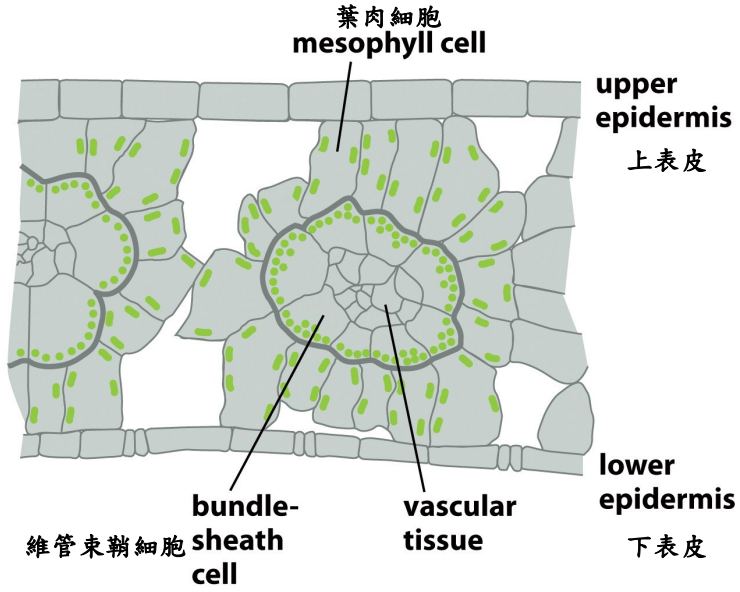

Figure 4-38b Plant Biology (© Garland Science 2010)

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C4 植物的碳反應

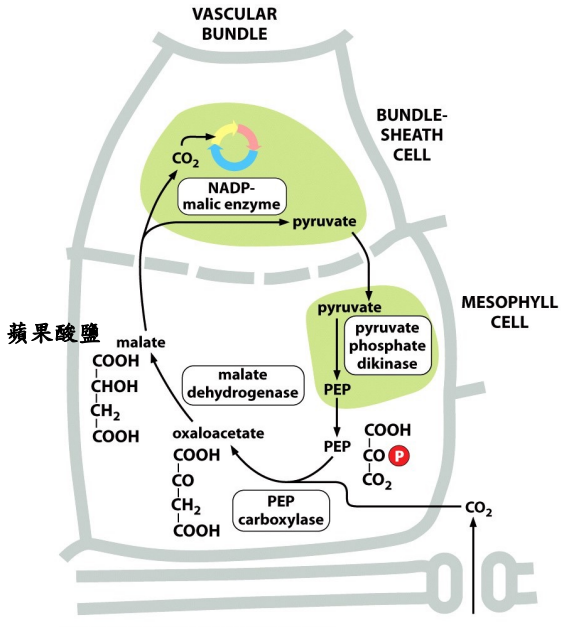

Figure 4-38d Plant Biology (© Garland Science 2010)

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代表性的 C4 植物

(A) 玉米 (B) 甘蔗 (C) 高粱

Figure 4-41 Plant Biology (© Garland Science 2010)

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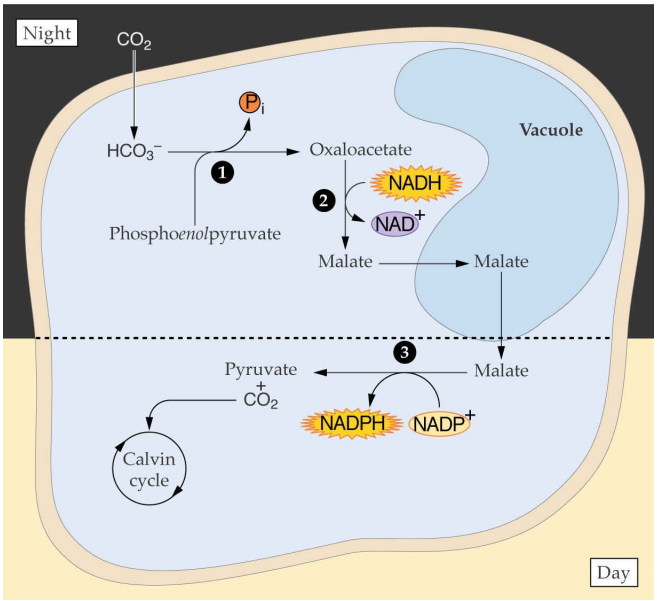
CAM 植物的碳反應



Crassulacean Acid Metabolism

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代表性的 CAM 植物

仙人掌

鳳梨

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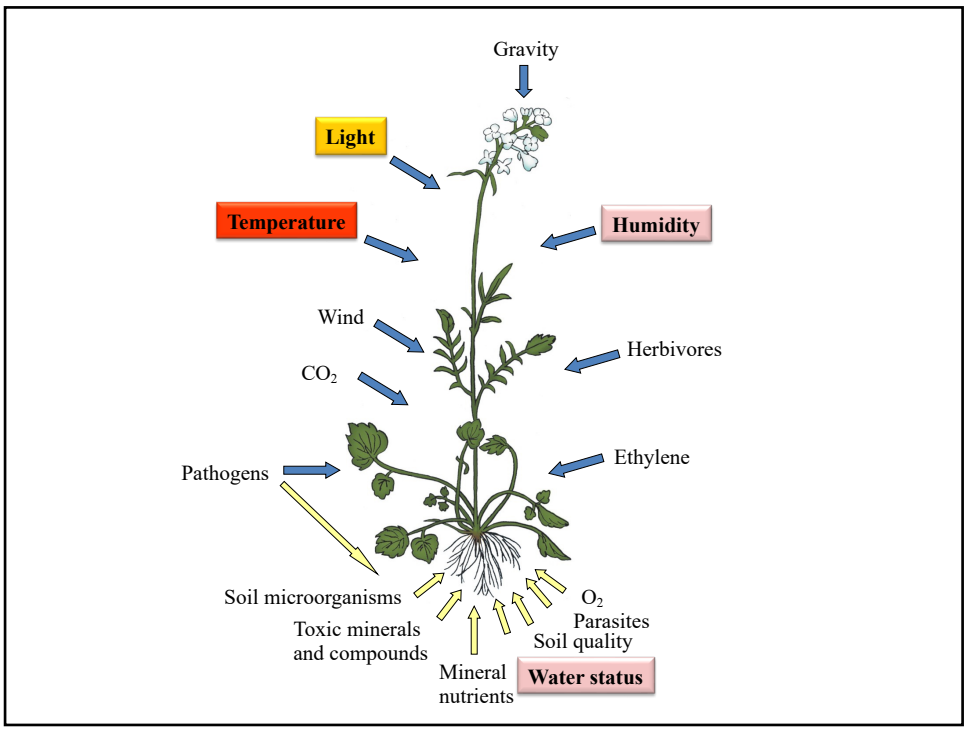
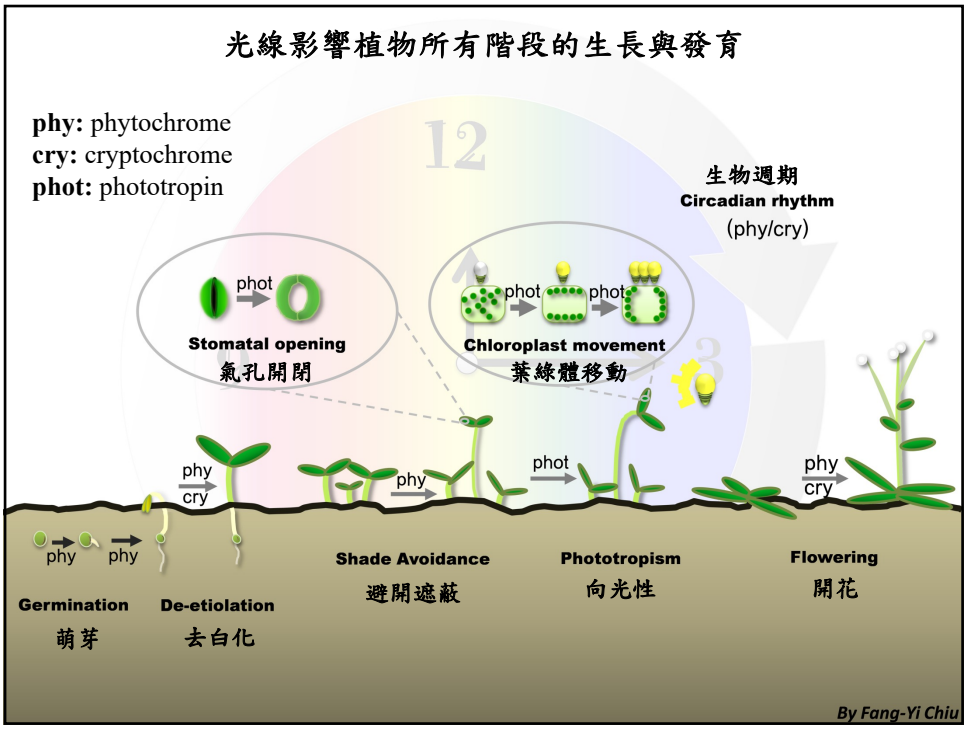

Gravity
Light
Temperature
Humidity
Wind
Herbivores
CO_2
Pathogens
Ethylene
Soil microorganisms
O_2
Parasites
Toxic minerals
and compounds
Soil quality
Mineral
nutrients
Water status

47


光線影響植物所有階段的生長與發育
phy: phytochrome
cry: cryptochrome
phot: phototropin
生物週期
Circadian rhythm
(phy/cry)
phot
Stomatal opening
氣孔開閉
phot
phot
Chloroplast movement
葉綠體移動
phy
cry
phy
phot
phy
cry
phy
phy
Germination
萌芽
De-etiolation
去白化
Shade Avoidance
避開遮蔽
Phototropism
向光性
Flowering
開花
By Fang-Yi Chiu

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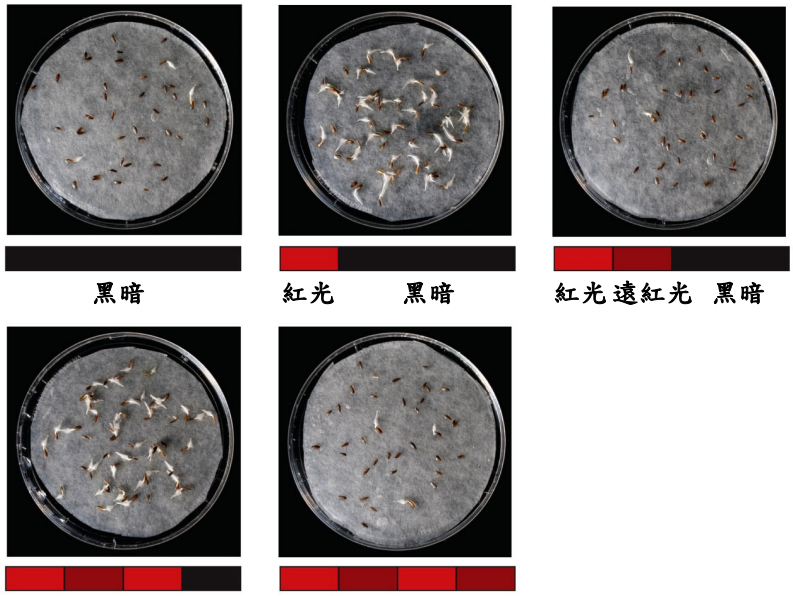
種子萌芽會被光影響



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生長在黑暗中及光線下的植物幼苗

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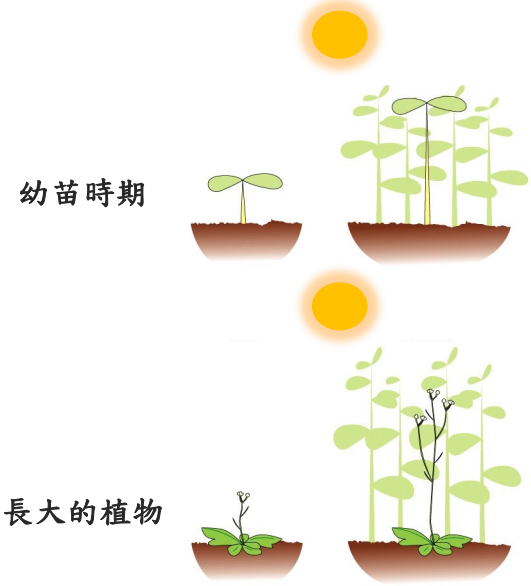
植物被遮蔽下會伸長及提早開花



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植物會往光線方向生長：向光性

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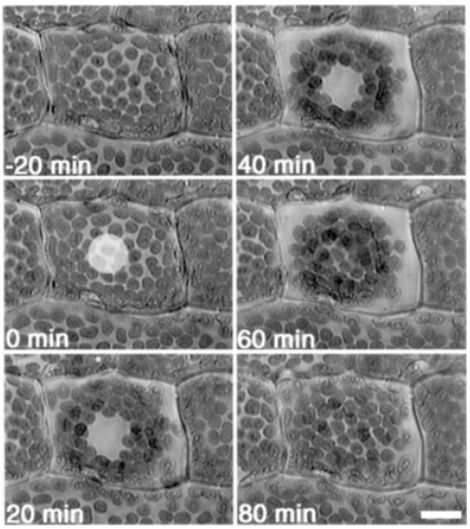
Chloroplast movement (葉綠體移動)

mediated by phototropins

Science 291, 2138–2141 (2001)



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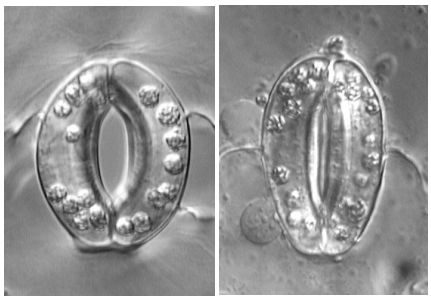
Stomatal opening (氣孔開閉)

mediated by phototropins

氣孔開閉主要由二個因子調節:

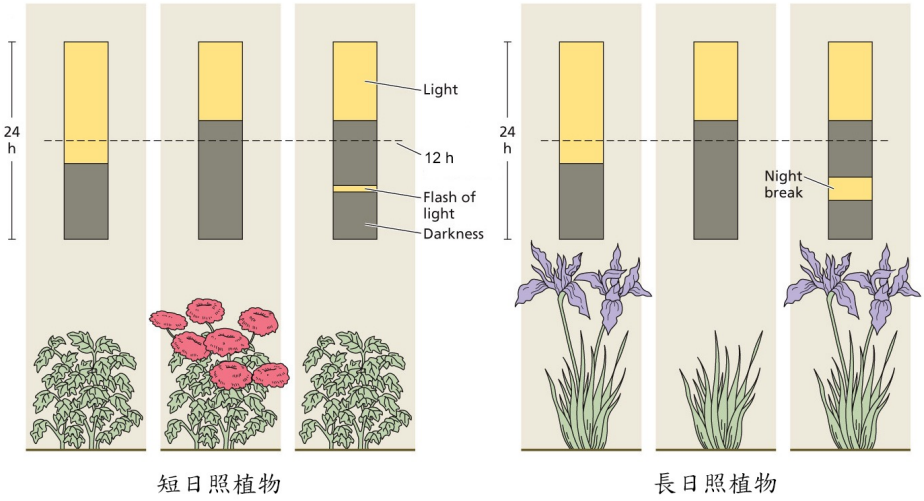
1. CO_2 (二氧化碳)
2. Light



light **dark**

54

日照長短影響植物開花時間



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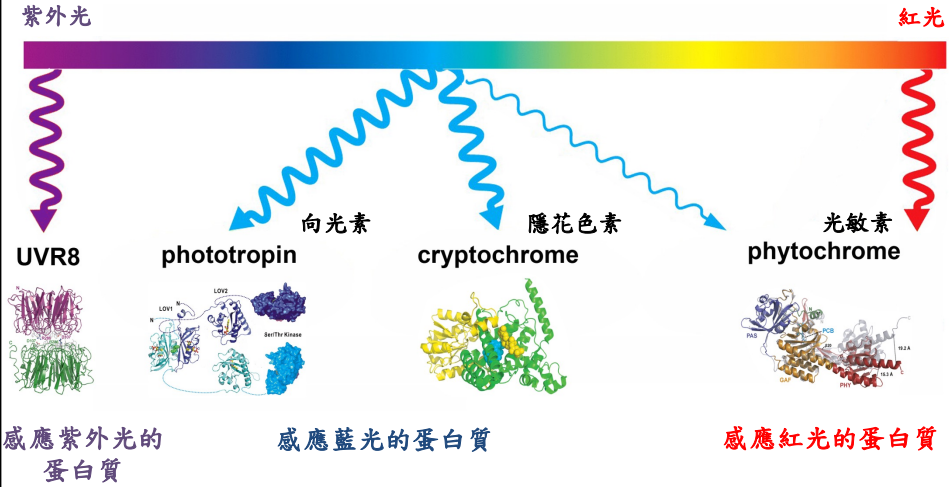
植物也有感應光線的蛋白質



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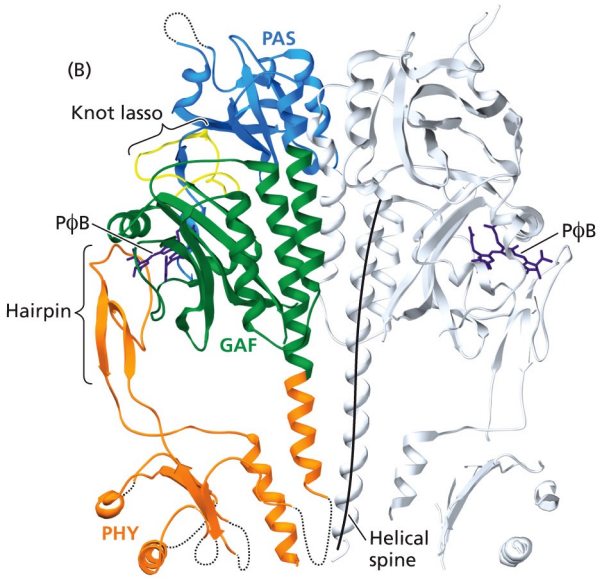
光敏素的蛋白質結構



PLANT PHYSIOLOGY AND DEVELOPMENT 6e, Figure 16.9 (Part 2)

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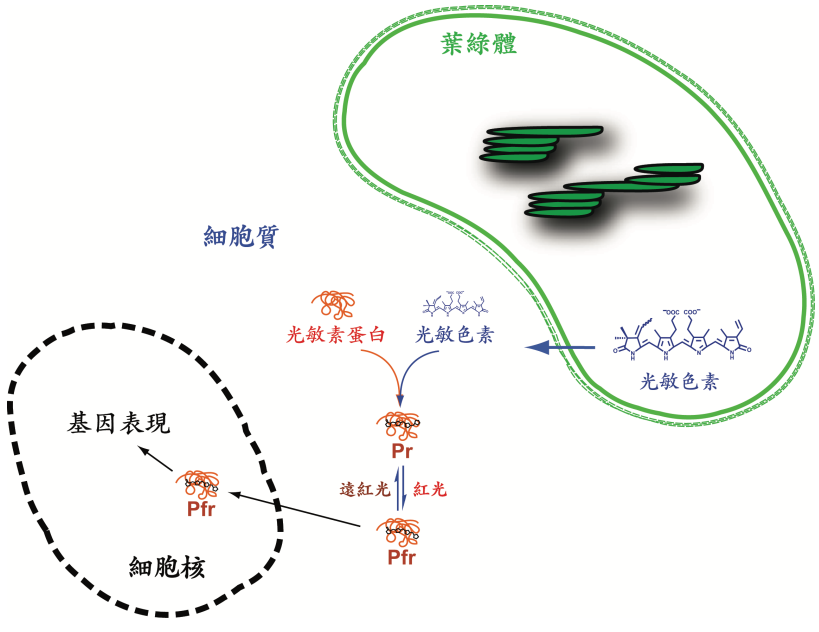
光敏素在細胞中的合成及作用機制



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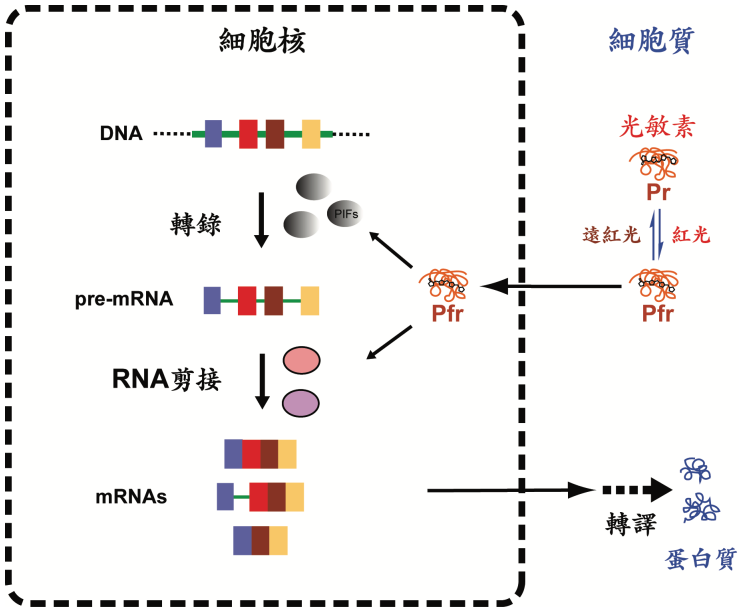
光敏素在細胞核中的基因調控



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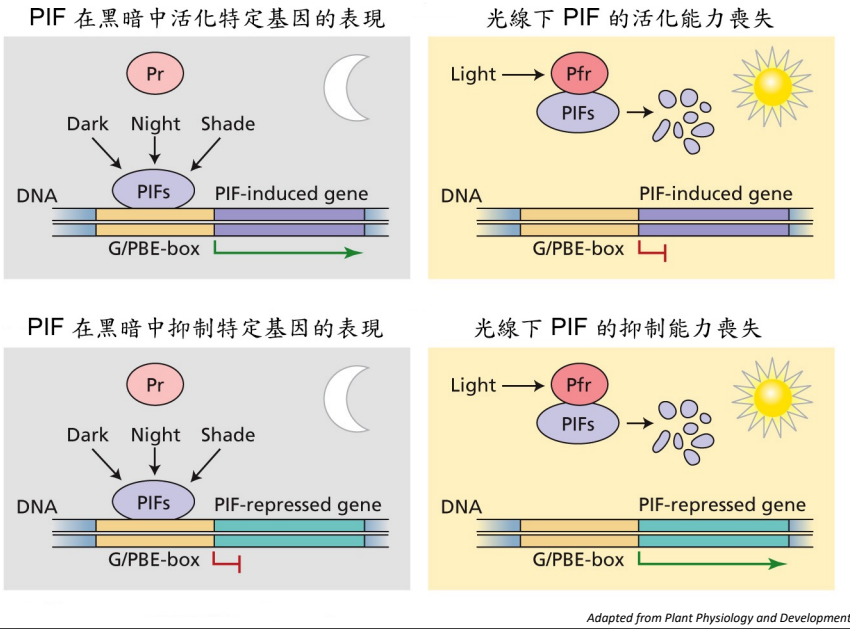
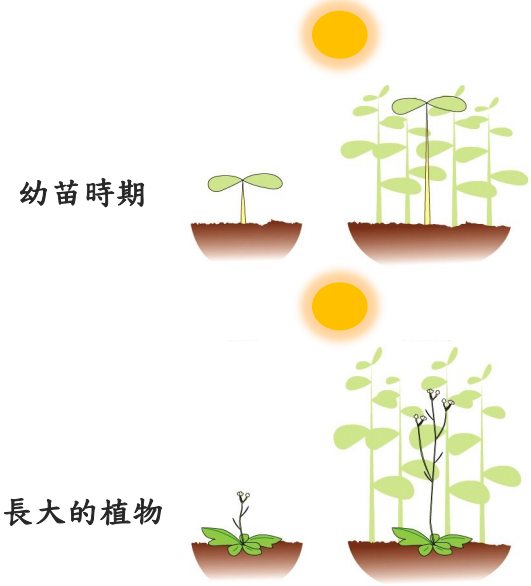
光敏素及 PIF 調控基因轉錄的方式



60

植物被遮蔽下會伸長及提早開花



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光感應機制在農業上的應用之一：
抑制植物避開遮蔽的反應來增加農作物種植密度

PLANT PHYSIOLOGY, 5e, Figure 17.18

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大綱

- 光合作用的重要性
- 光合作用發生的位置
- 光線的特性及參與光合作用的色素
- Light reaction (光反應)
- Calvin cycle (卡爾文循環; 碳反應)
- C3, C4, CAM 植物
- 植物的光感應 及光型態調控

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Taiz & Zeiger, Plant Physiology, 2010
Smith, et al., Plant Biology, 2009

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