Fotosintesis

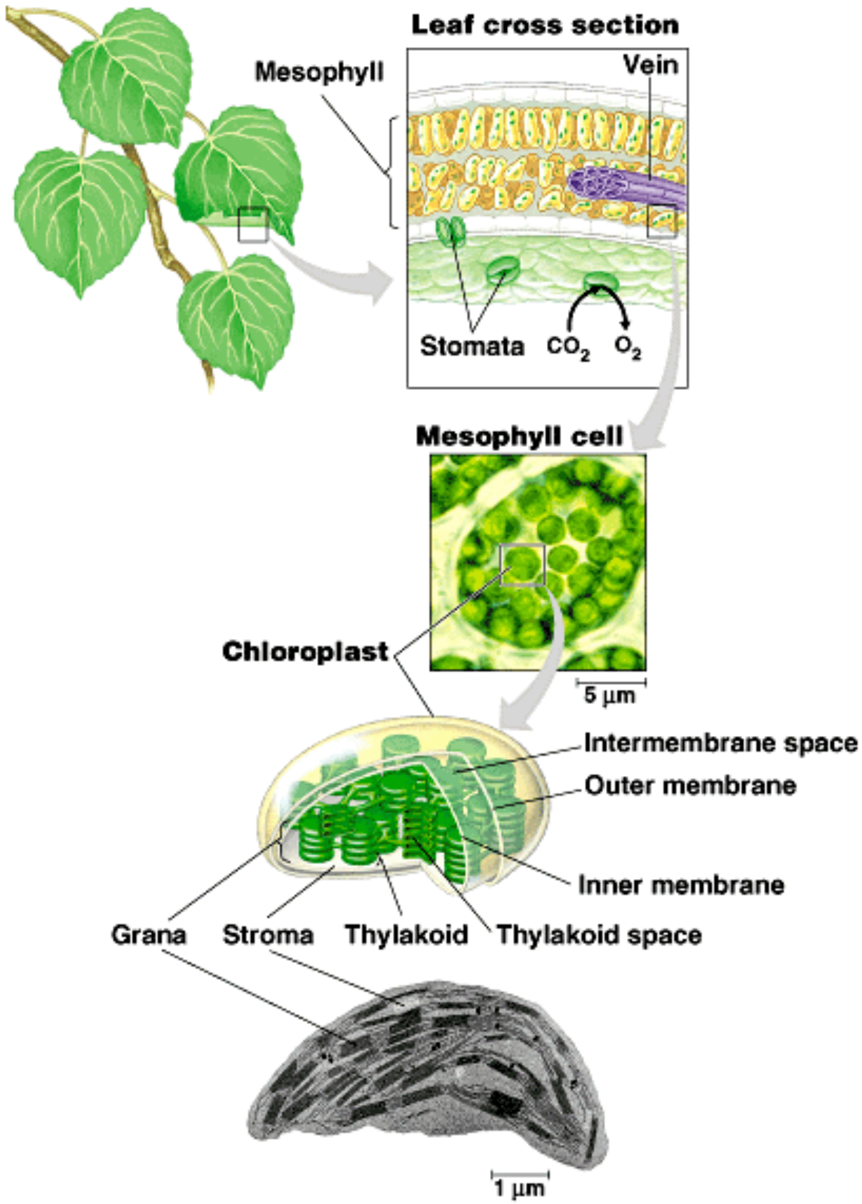
Oleh

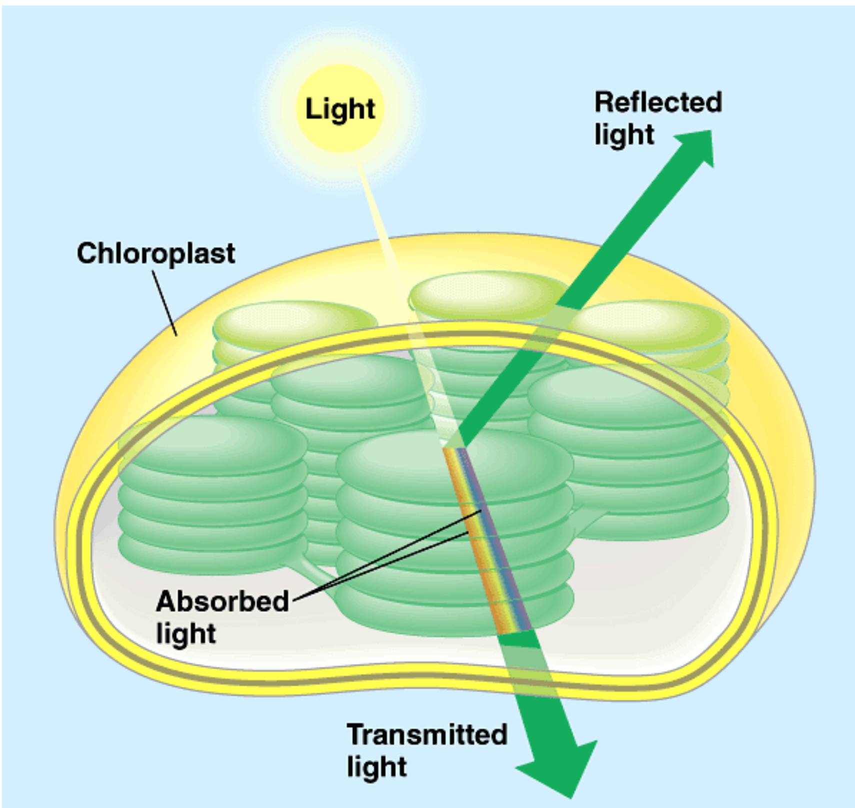
Novri Youla Kandowangko

Internal Factor

- Kandungan pigmen daun (mis. Klorofil)
- Protoplasmik
- Enzim fotosintesis
- Tahanan daun
- Kebutuhan fotosintat
- Hormon
- Pengendalian genetik
- Umur daun

Kandungan klorofil daun





Protoplasmik

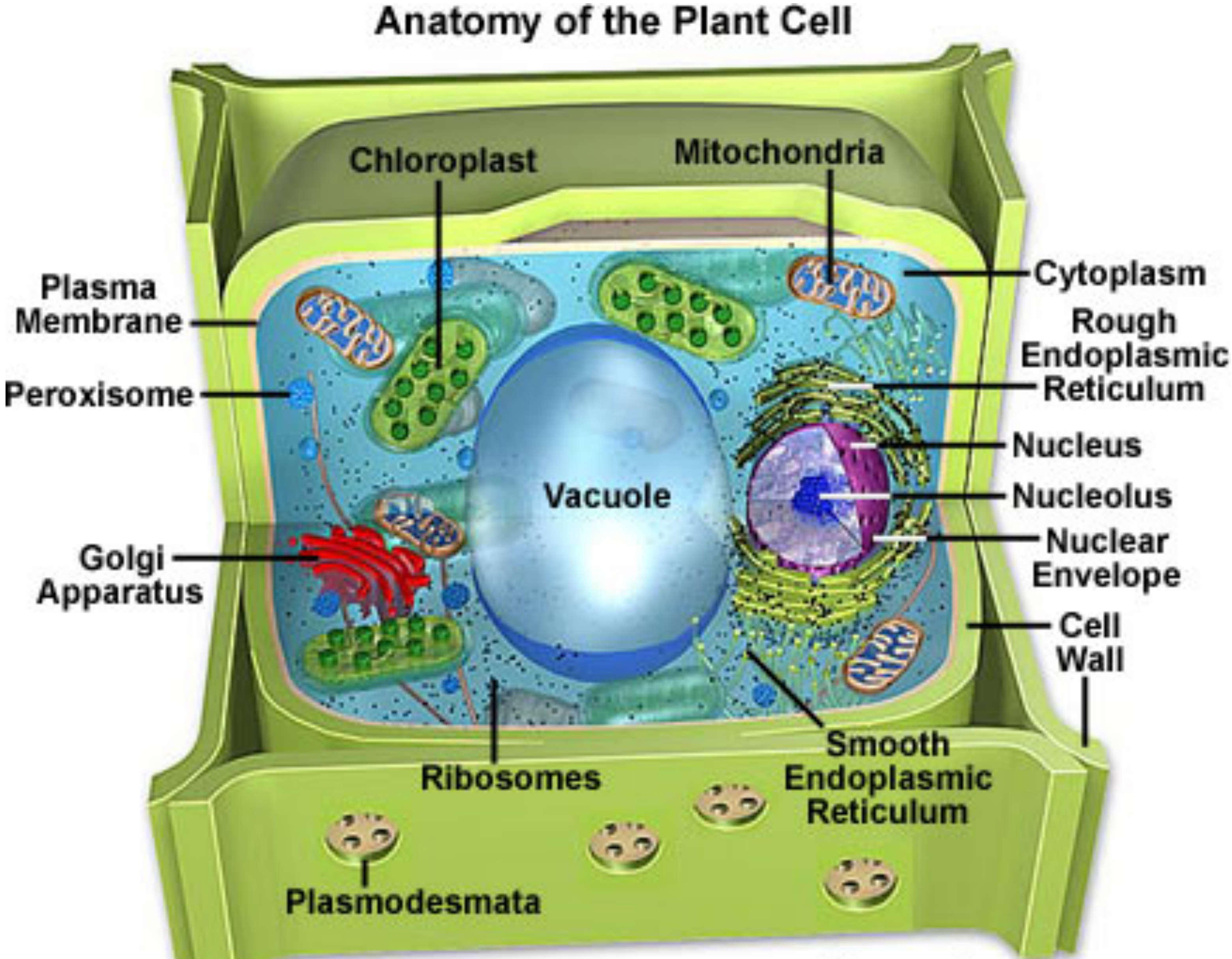
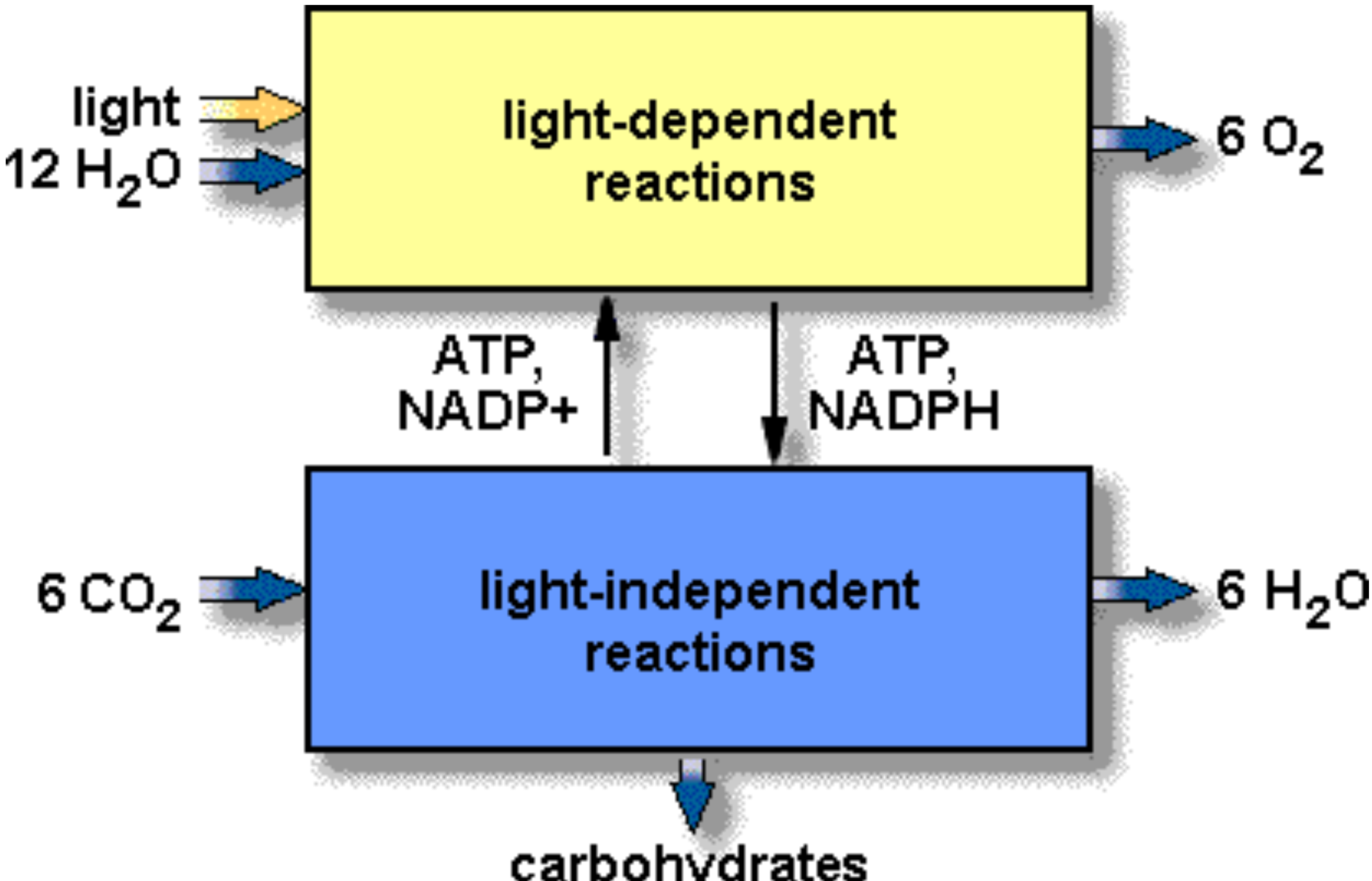
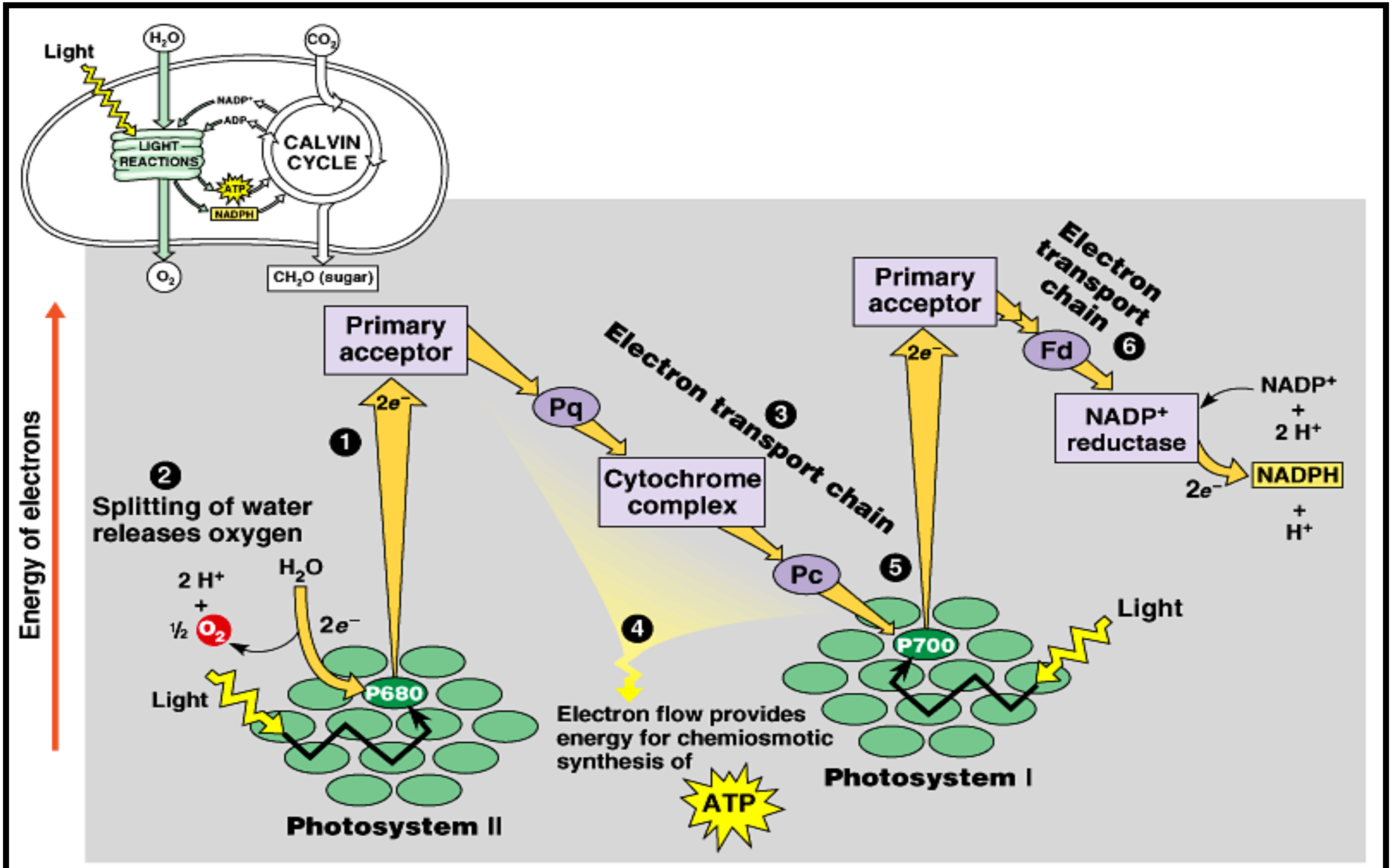


Figure 1

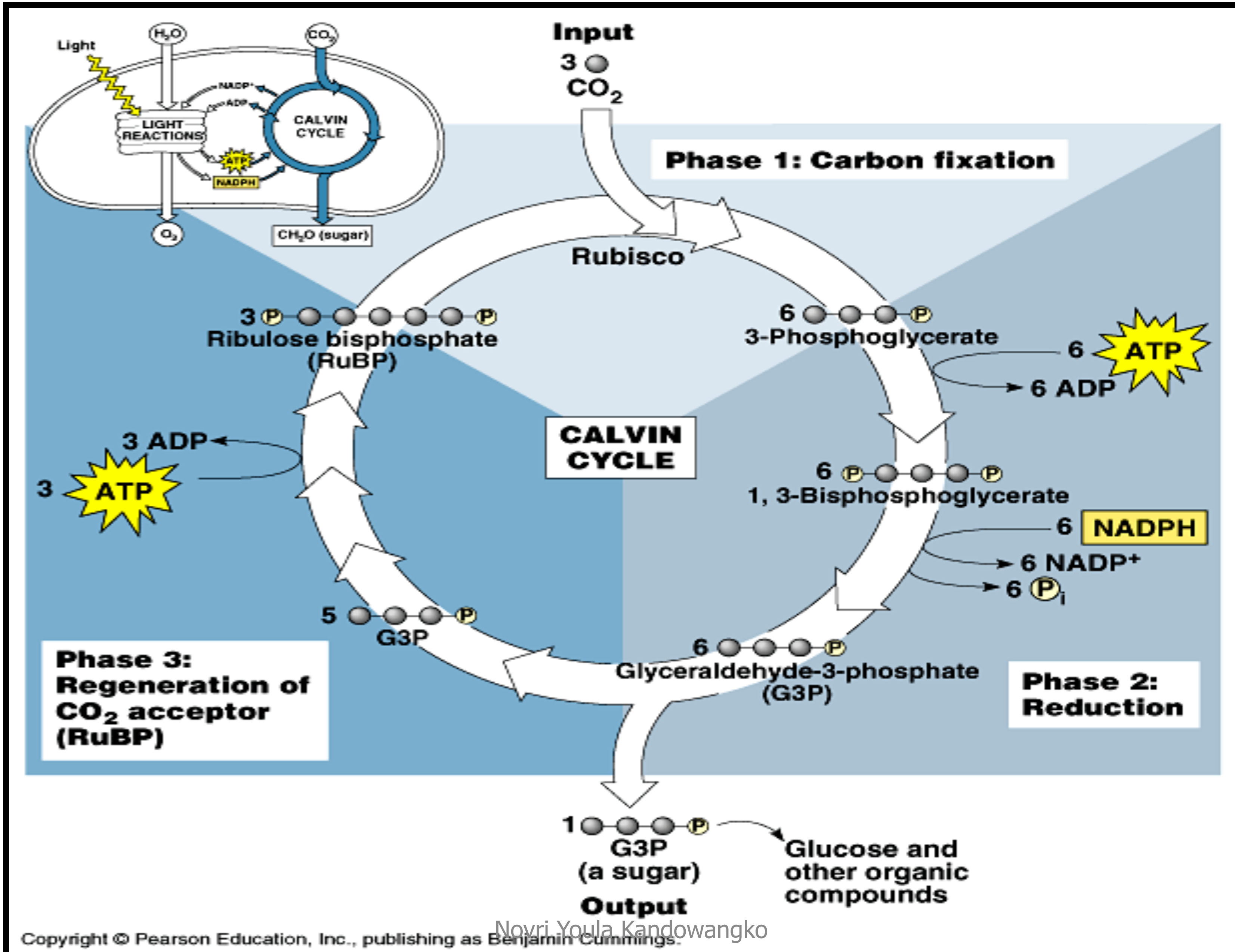
Fotosintesis secara umum



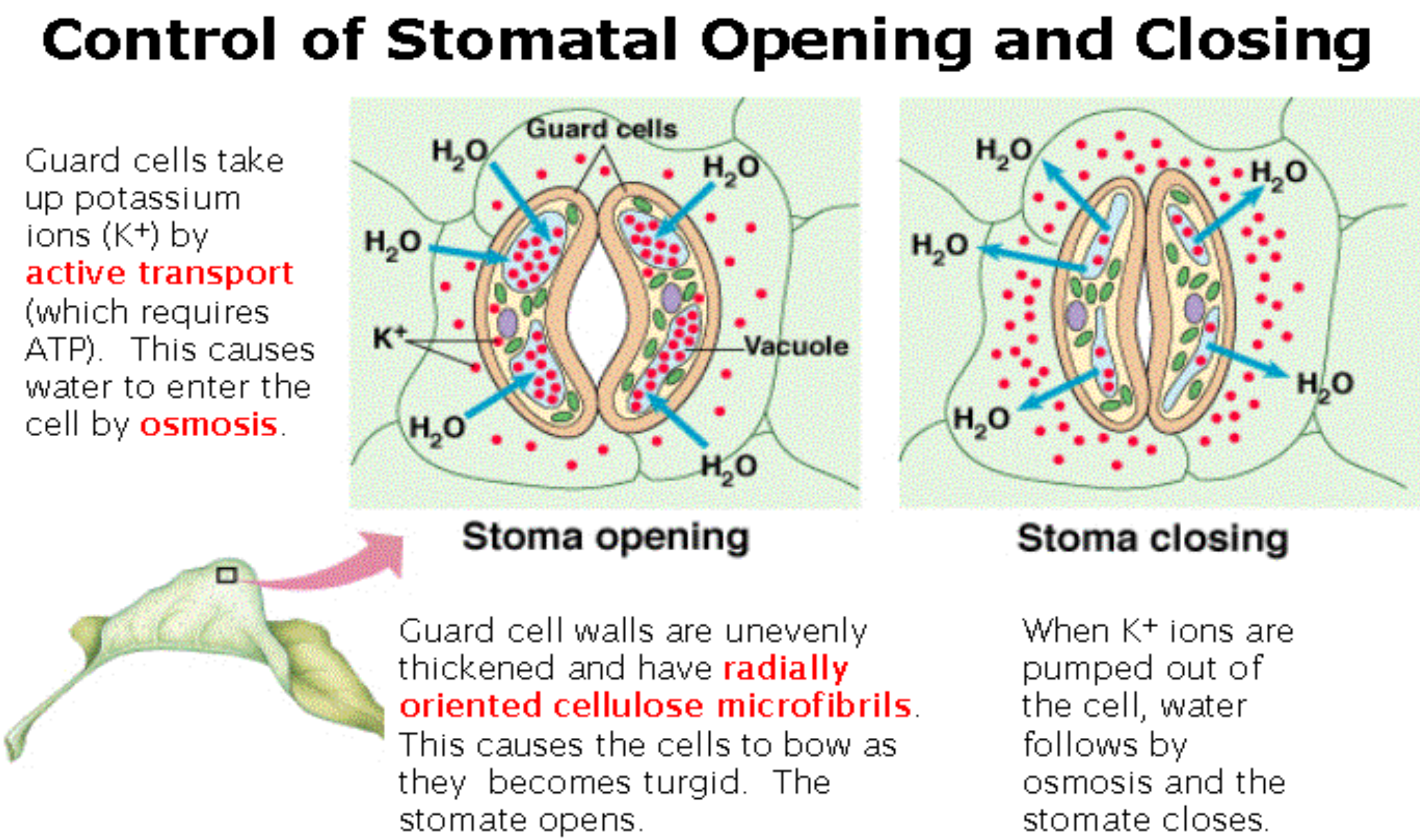
Reaksi terang fotosintesis

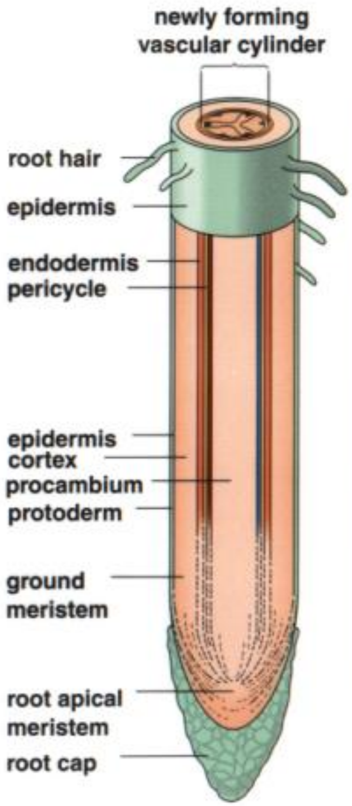


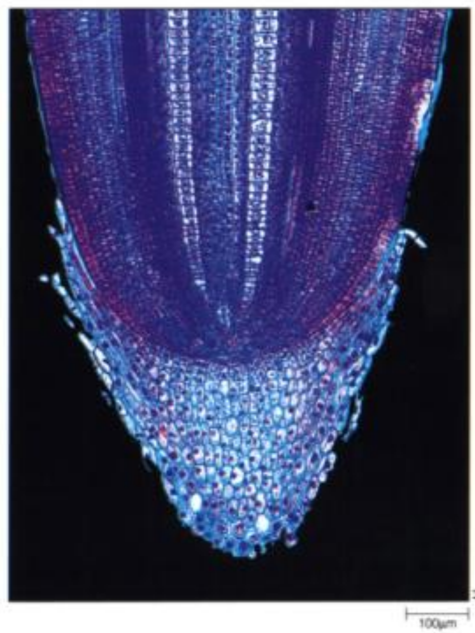
Reaksi Gelap fotosintesis

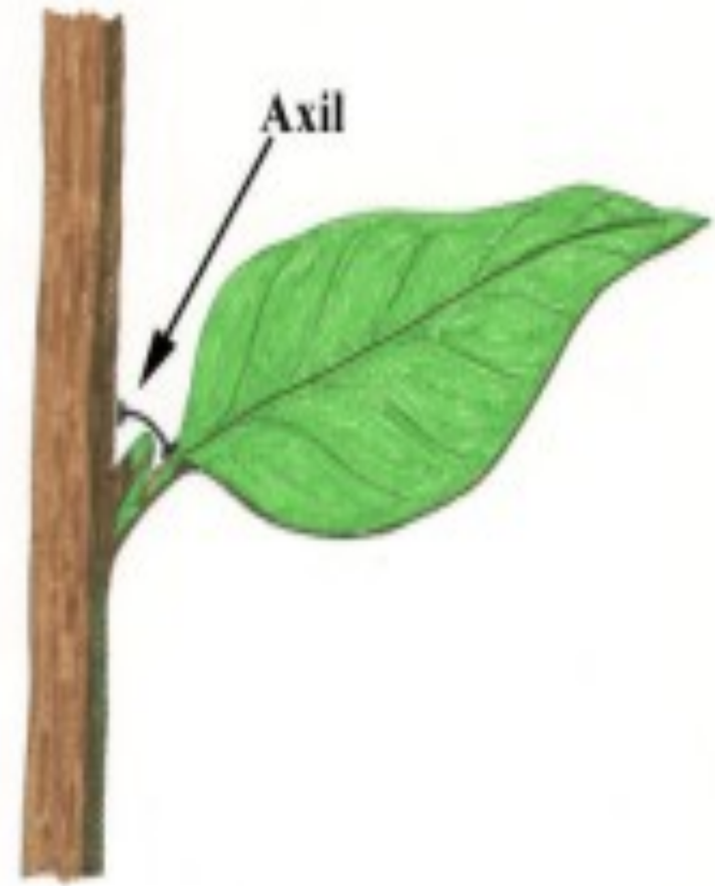


Tahanan daun

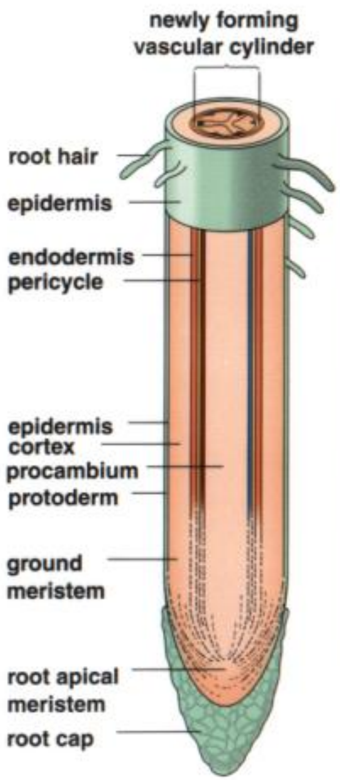


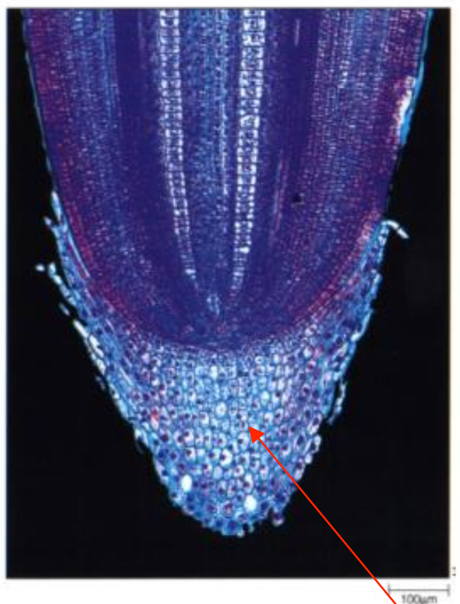

newly forming
vascular cylinder
root hair
epidermis
endodermis
pericycle
epidermis
cortex
procambium
protoderm
ground
meristem
root apical
meristem
root cap

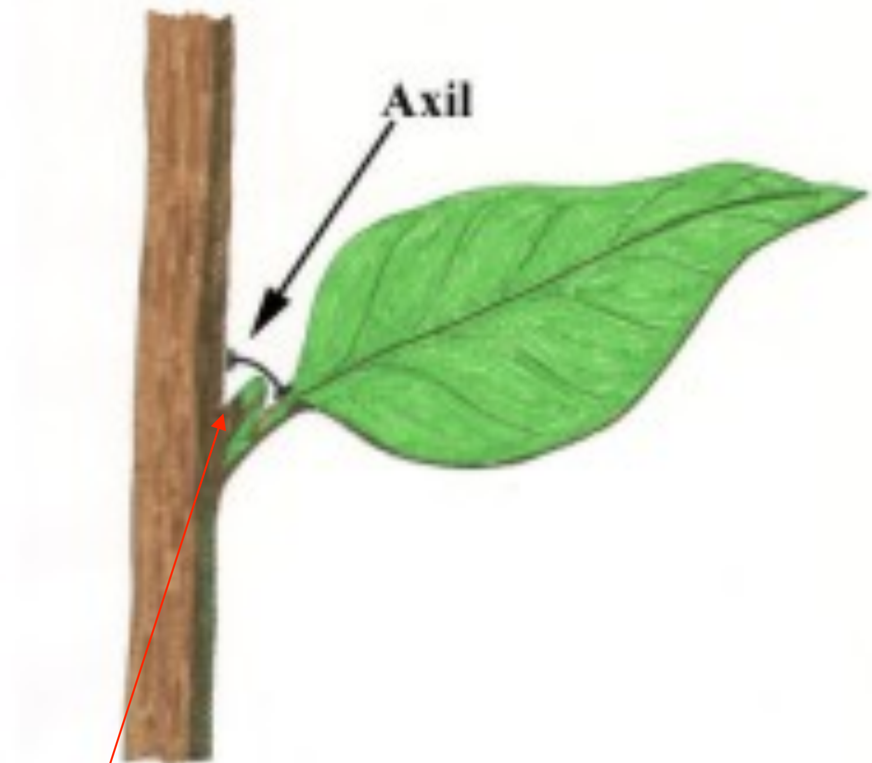

100µm


Axil

Hormon

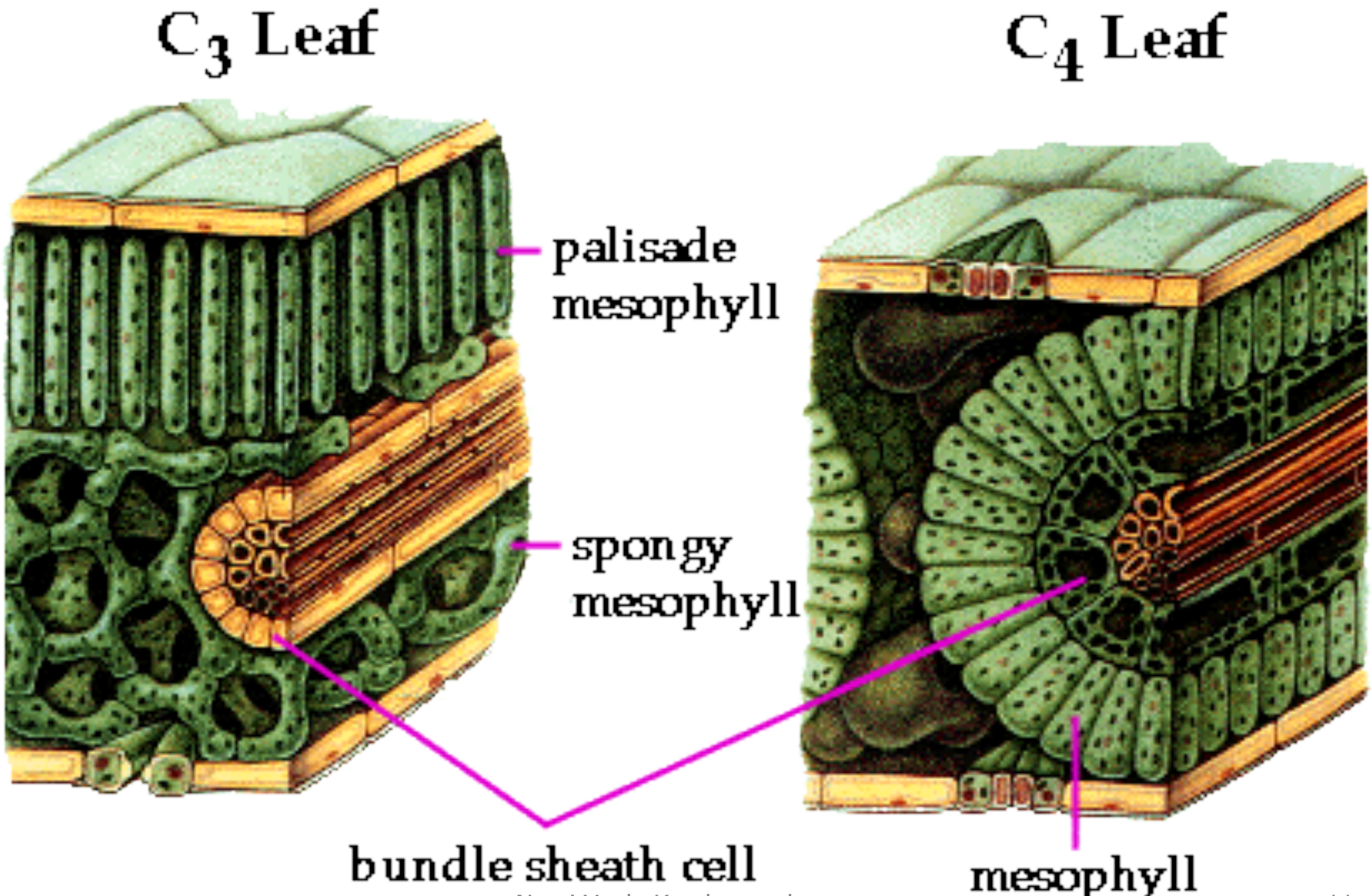


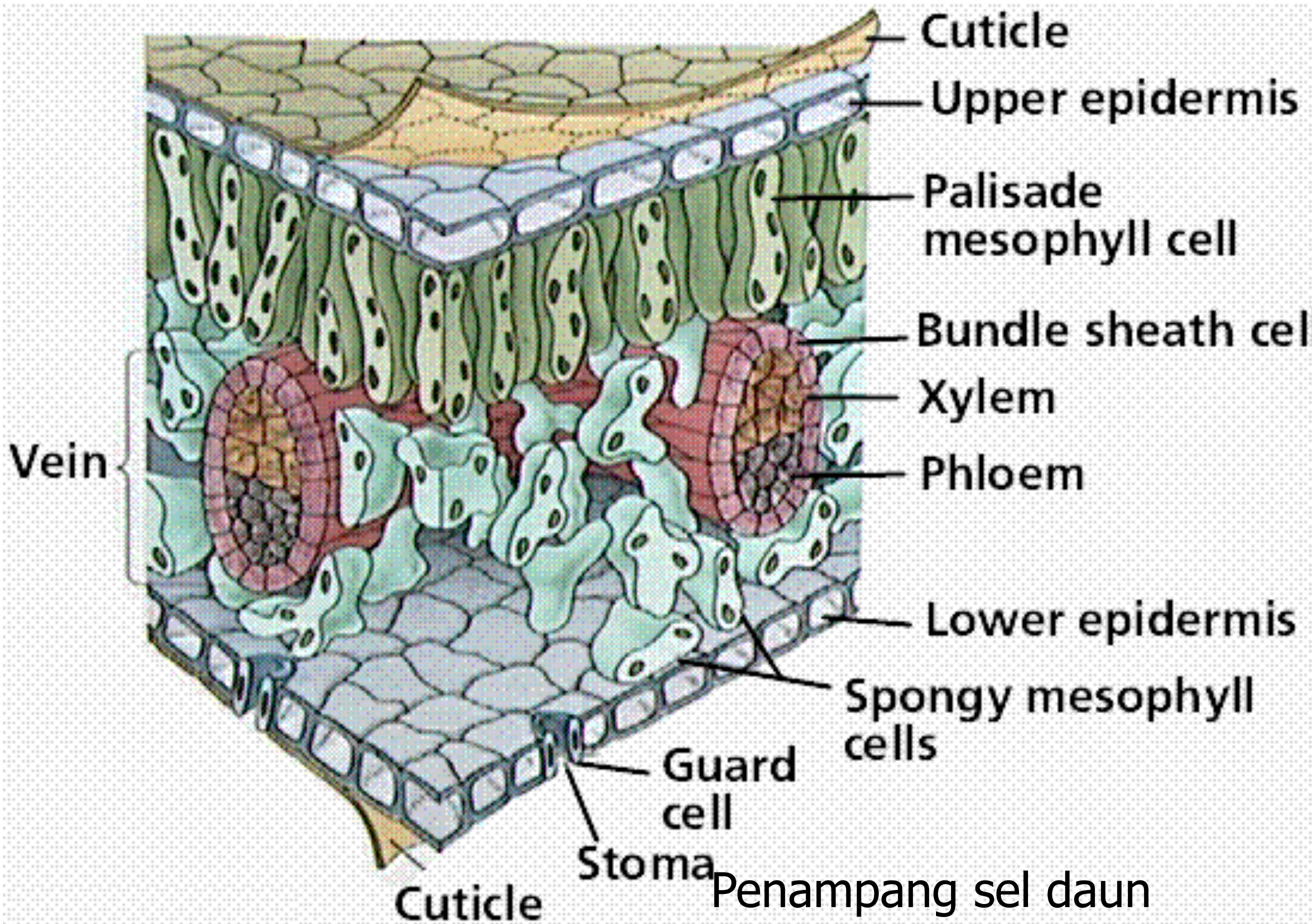




GA3, Kinetin, Sitokinin

Pengendalian genetik



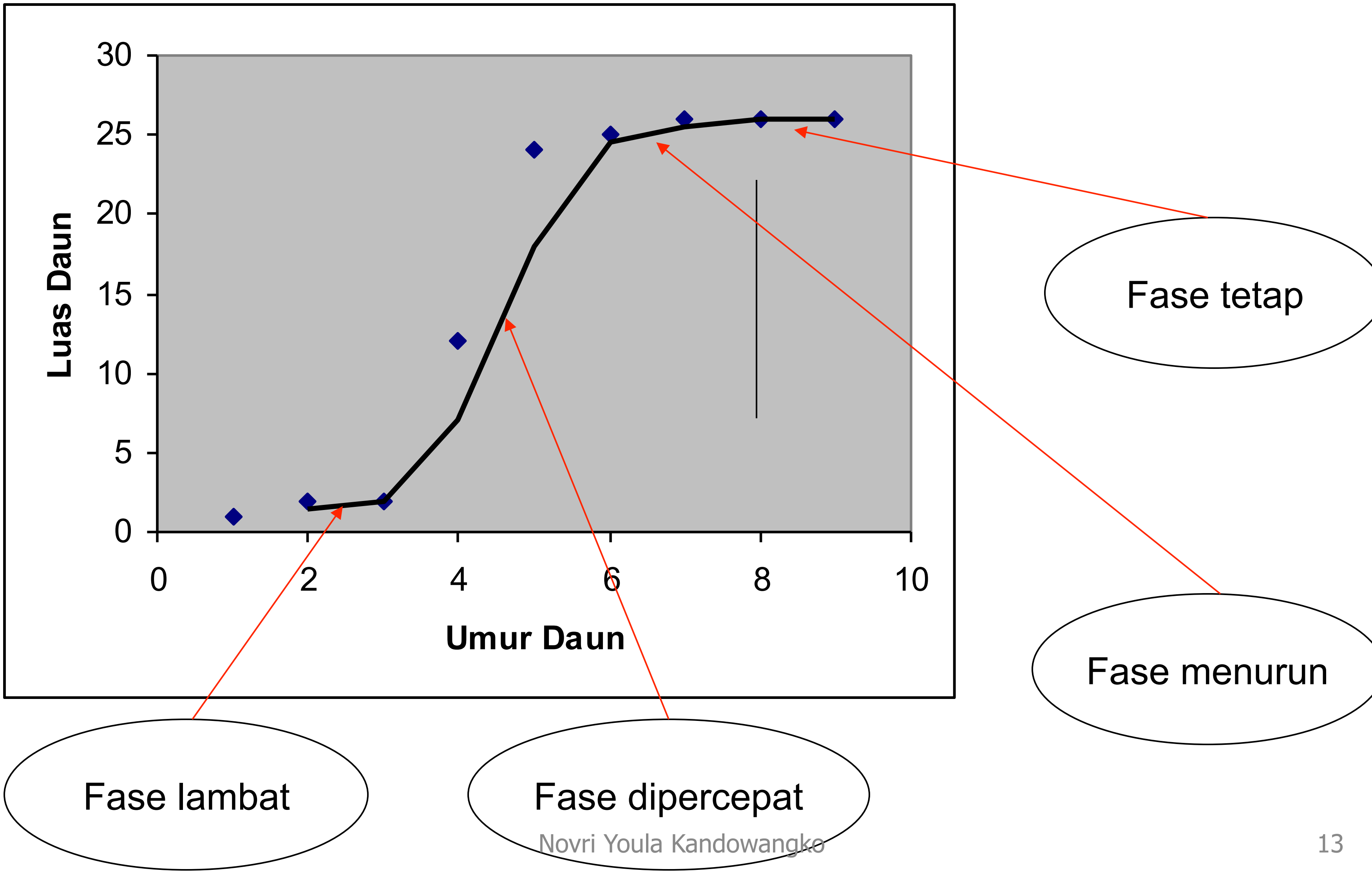


Penampang sel daun

Yang penting untuk fotosintesis

Stomata, guard cell (sel penjaga), sel mesofil dan vein

Umur daun

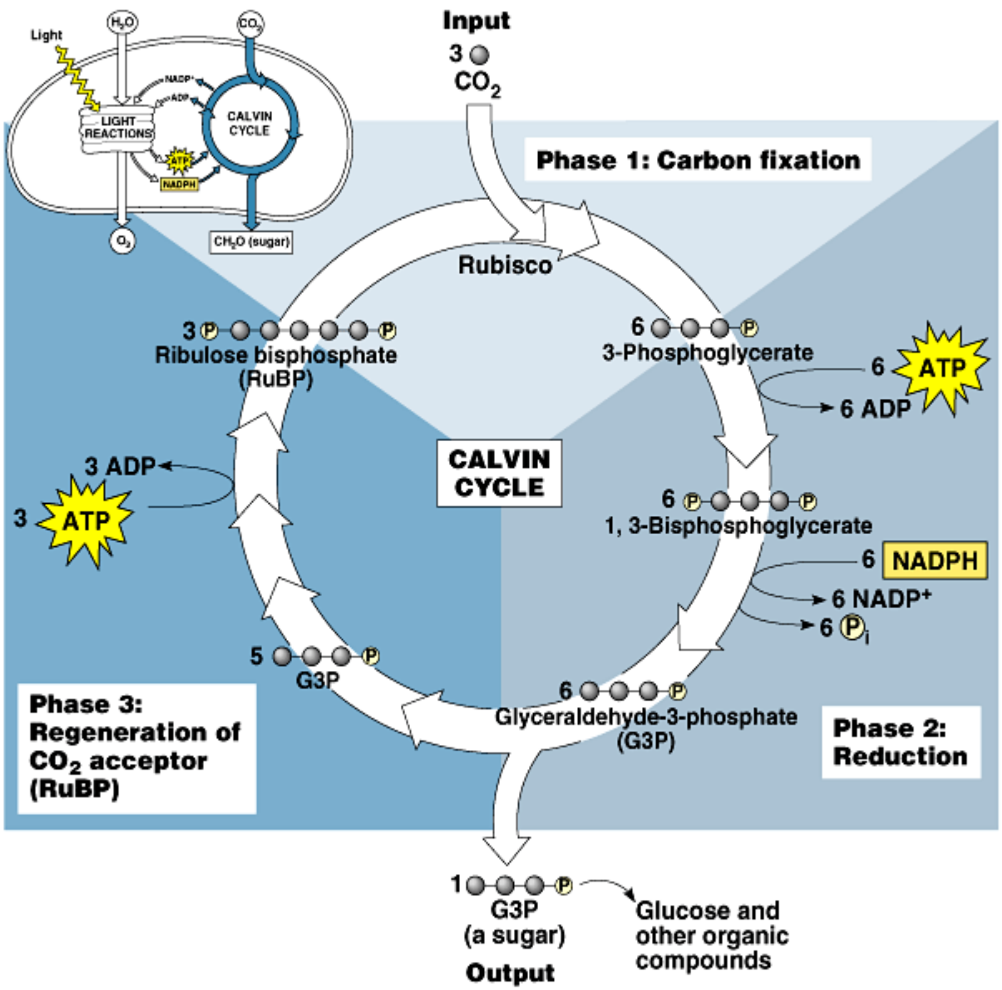


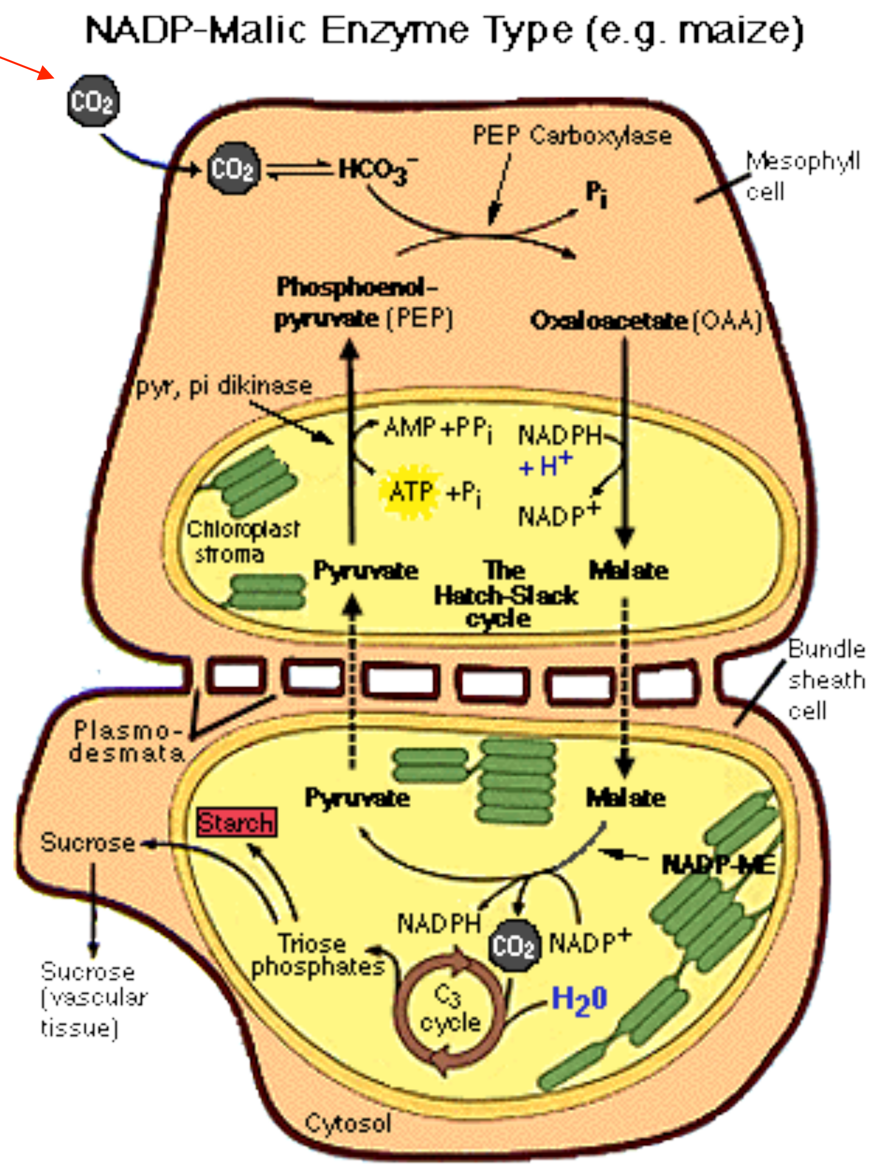
30
25
20
15
10
5
0
Luas Daun
0
2
4
6
8
10
Umur Daun
Fase tetap
Fase menurun
Fase lambat
Fase dipercepat

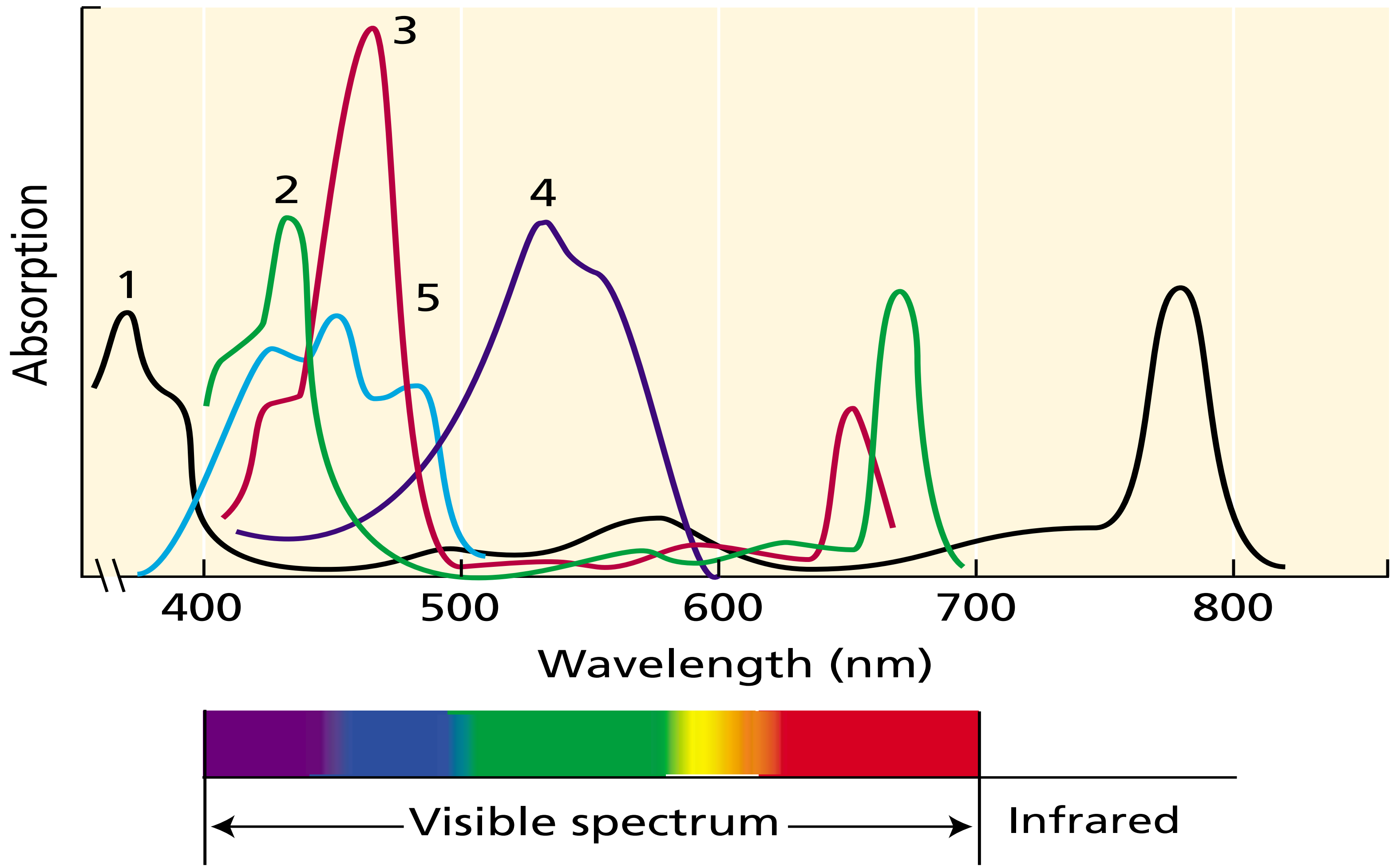
Faktor eksternal

- CO_2 lingkungan
- Cahaya: intensitas cahaya, panjang gelombang, fotoperiodisitas
- Suhu
- Air
- Oksigen
- Nutrisi

CO2 lingkungan

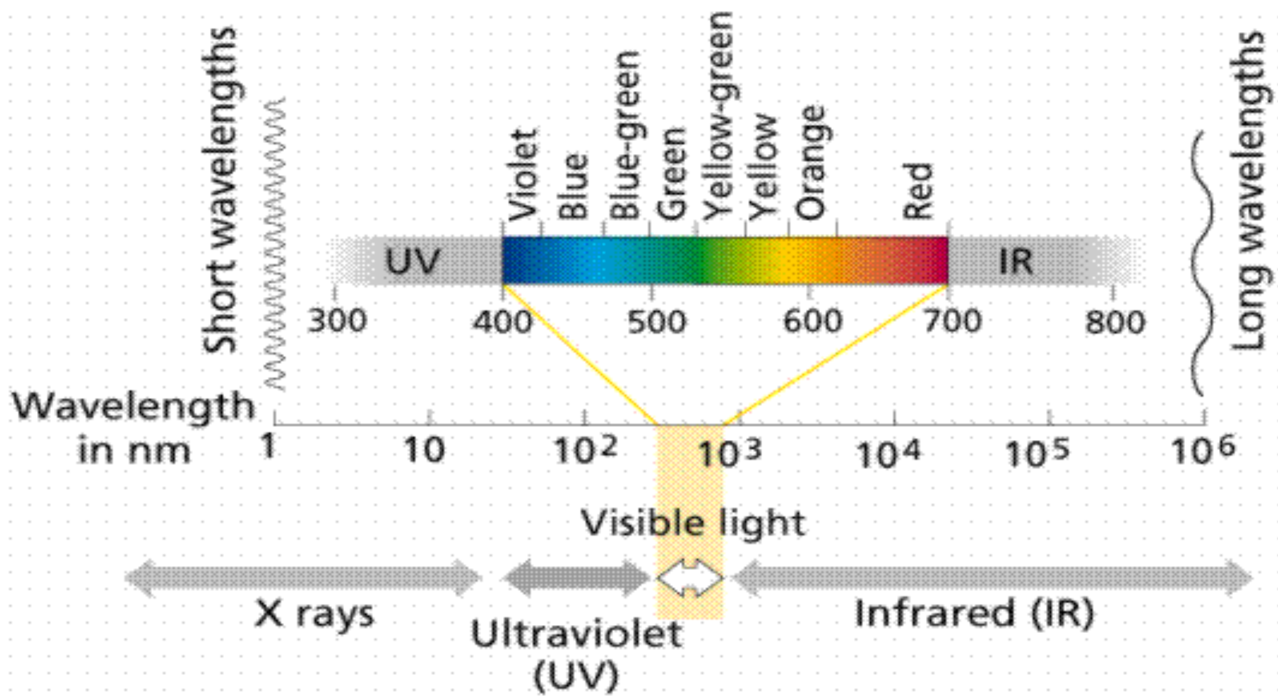




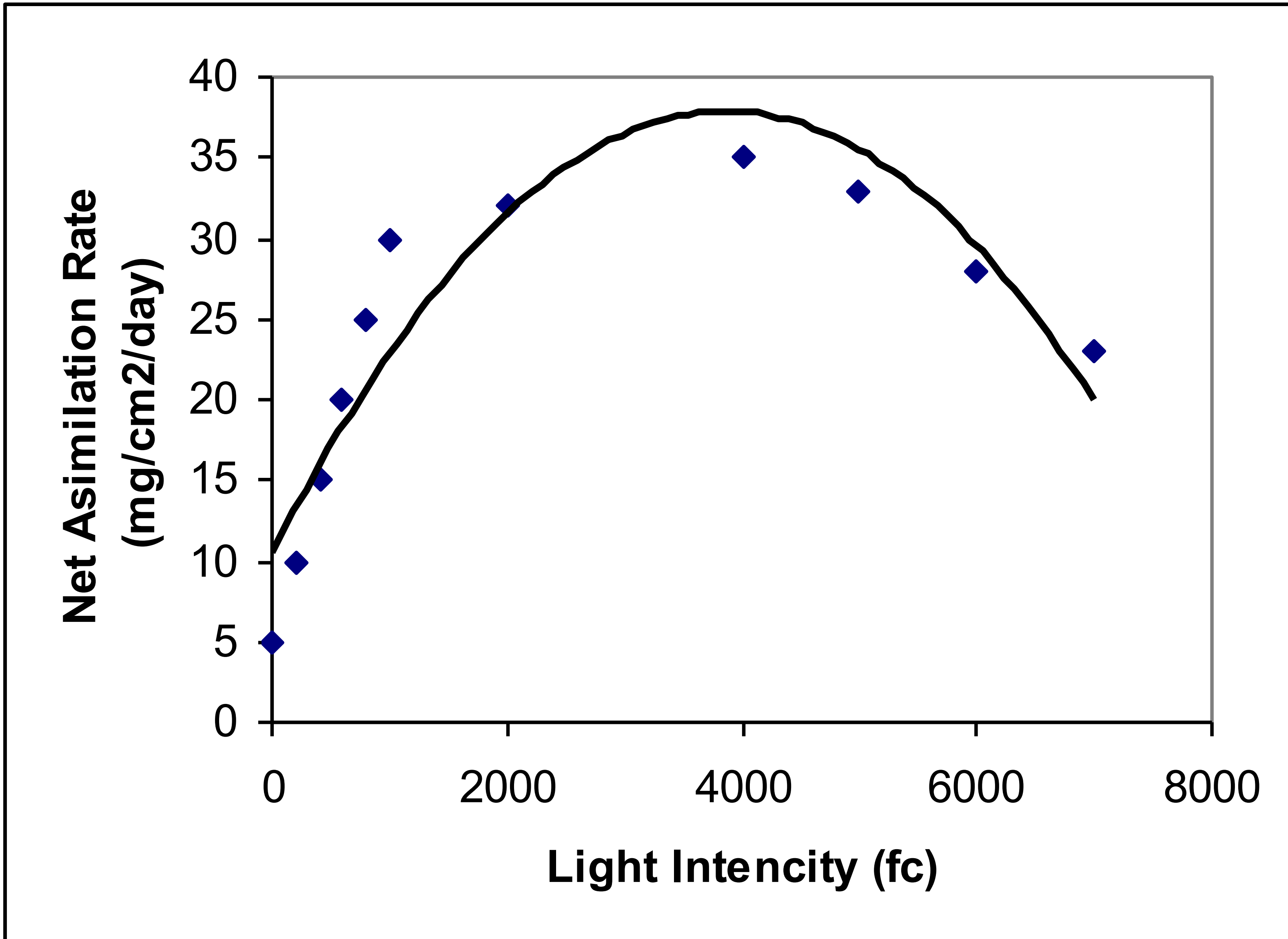


Spektrum penyerapan beberapa pigmen fotosintesis. Kurva 1, bakterioklorofil a; kurva 2, klorofil a; kurva 3, klorofil b; kurva 4, phycoerythrobilin; kurva 5, β-karoten (Lincoln Taiz, 2006)

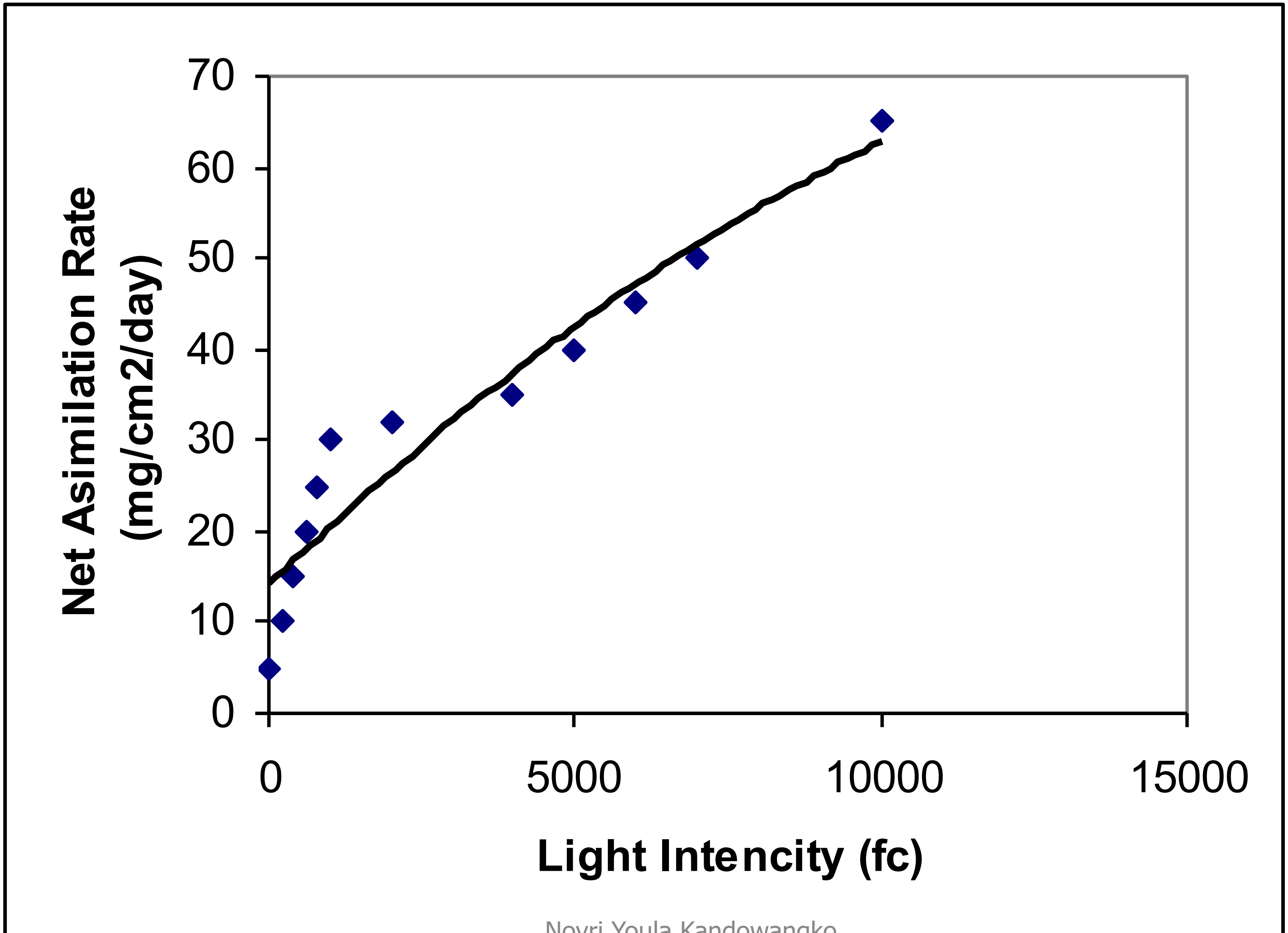
Urutan warna ditentukan oleh panjang gelombang cahaya. Cahaya yang dapat terlihat merupakan sebahagian kecil **spektrum elektromagnetik**. Semakin panjang gelombang maka warnanya semakin merah. Sehingga yang terpendek adalah jinga/violet. Yang memiliki panjang gelombang lebih panjang dari merah disebut dengan Infra Merah, sedangkan yang lebih pendek dari jinga/unggu disebut ultraviolet



Intensitas cahaya (Tipe C3)



Intensitas cahaya (Tipe C4)

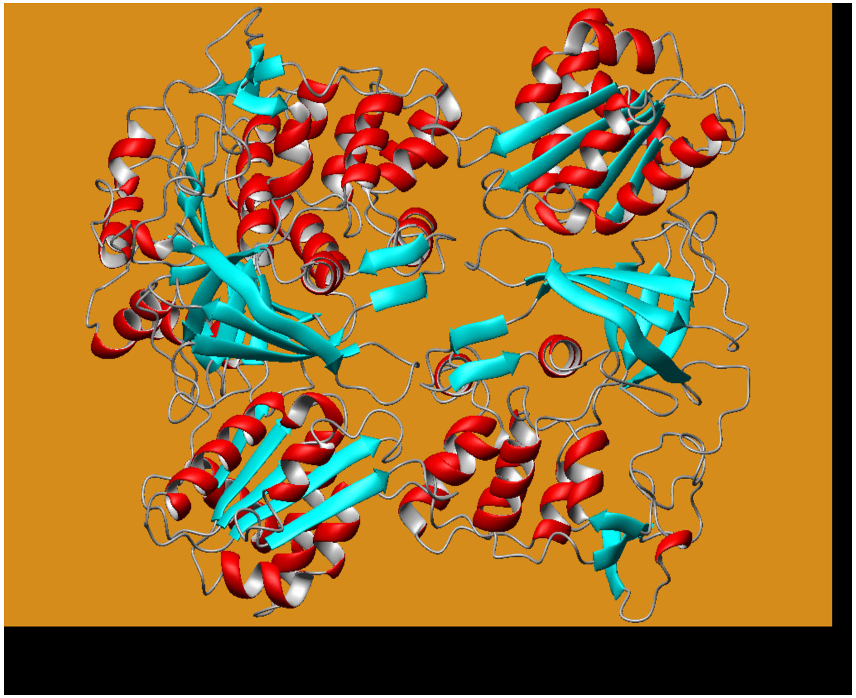


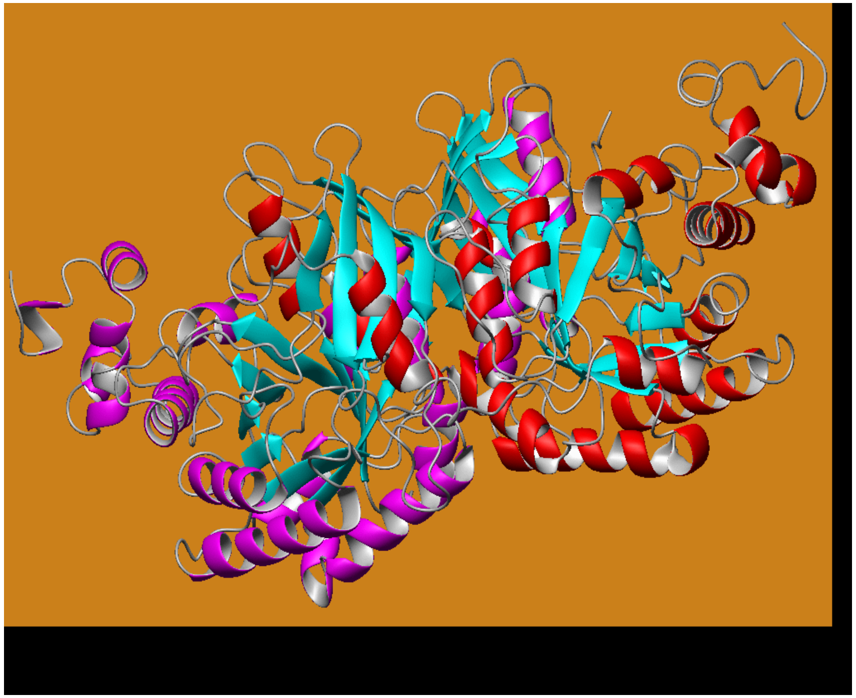
Kenapa belajar fotosintesis ?

Karena fotosintesis merupakan reaksi biokimia (C,H,O --> reaksi hidup) penting ---yang menghasilkan "makanan" (selulosa, karbohidrat dll)

Dipelajari PENTING karena "harus meningkatkan efisiensi fotosintesis"-contoh pada tanaman jagung dari energi yang diterima hanya sekitar 1-2% energi matahari tsb yang dirubah menjadi "produk (karbohidrat, selulosa dll)" , pada tanaman yang tidak dibudidayakan hanya sekitar 0.2%, tanaman tebu yang termasuk paling efisienpun hanya mampu merubah 8% dari total energi yang dia terima menjadi makanan

Suhu: aktivitas enzim fotosintesis

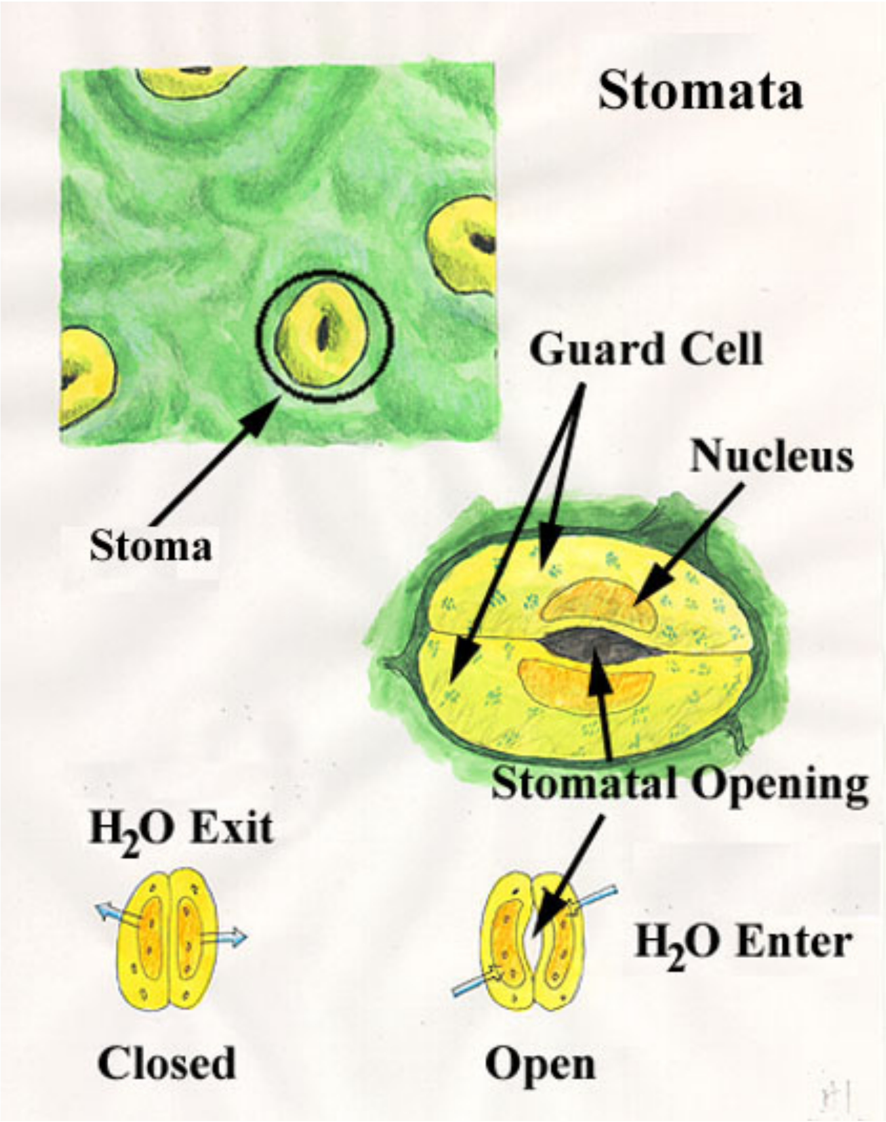


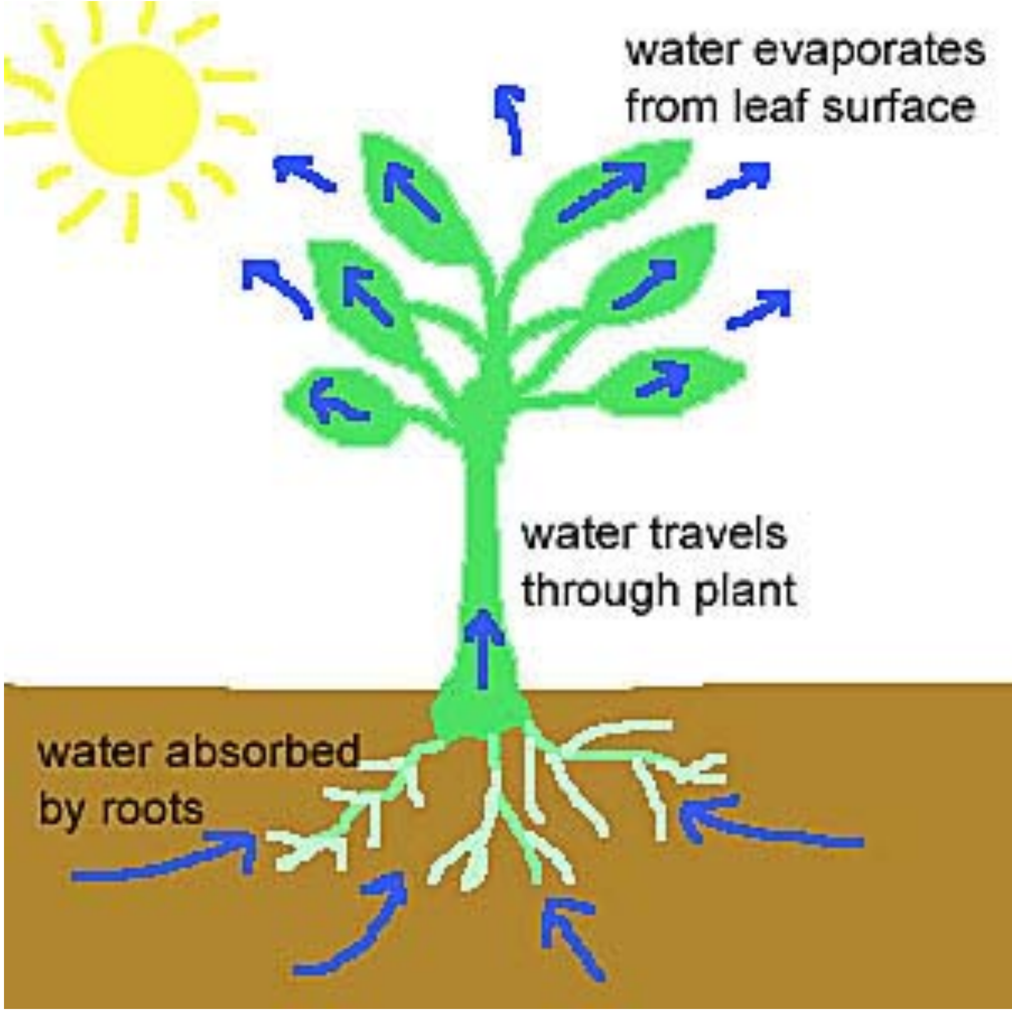


Cytochrom

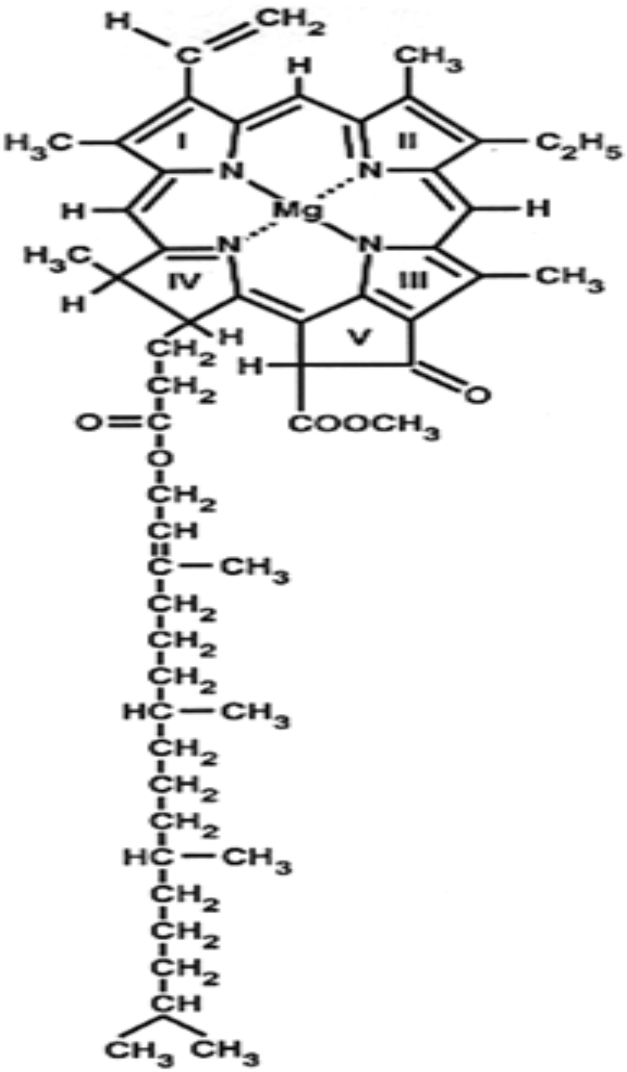
rubisco

Air


Stomata
Guard Cell
Nucleus
Stoma
Stomatal Opening
H_2O Exit
H_2O Enter
Closed
Open


water evaporates from leaf surface
water travels through plant
water absorbed by roots

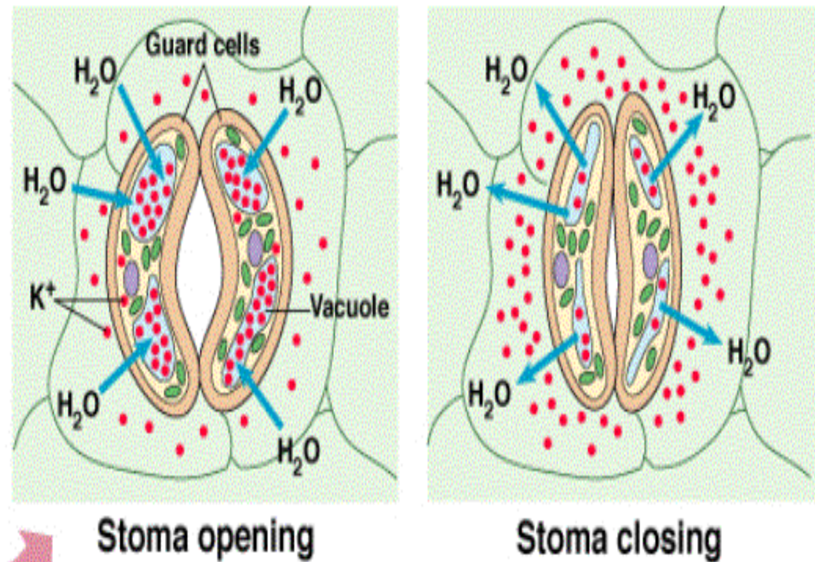
Nutrisi

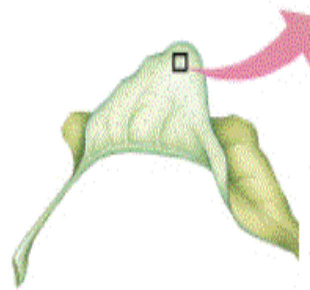


Chlorophyll *a*

Control of Stomatal Opening and Closing

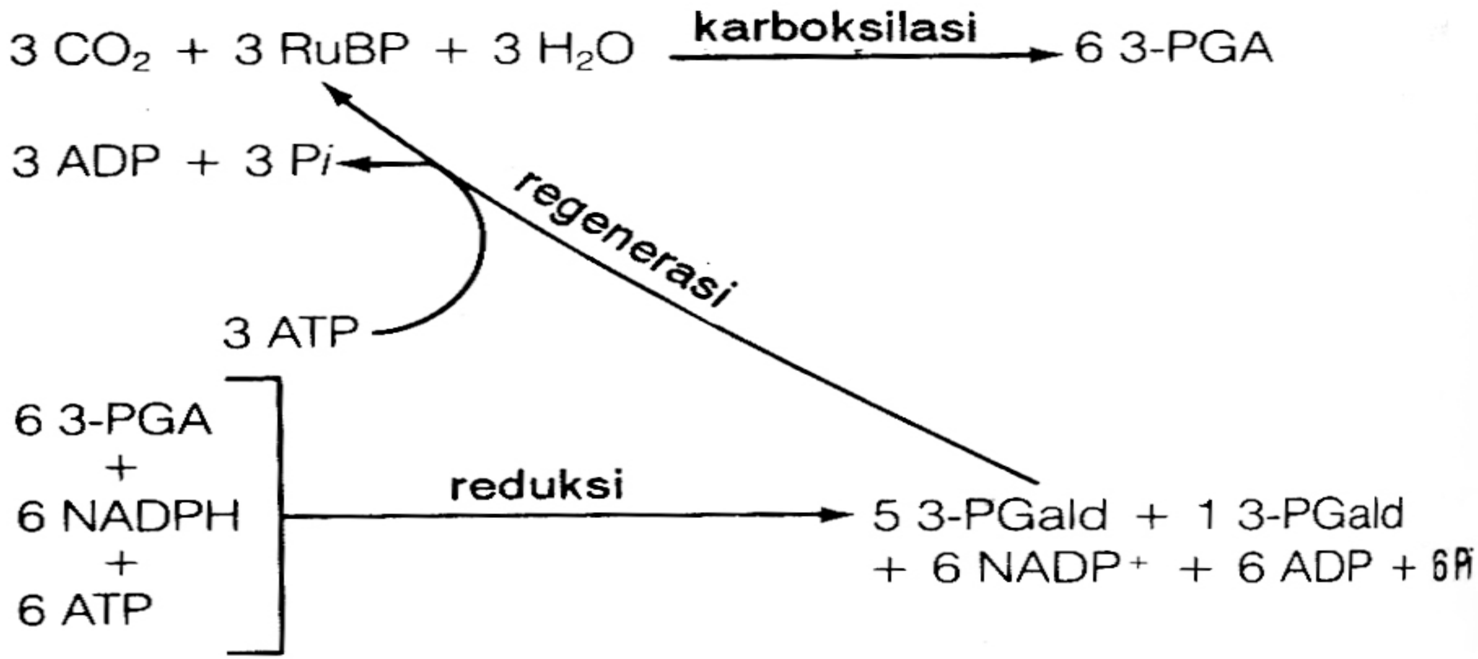
Guard cells take up potassium ions (K^+) by **active transport** (which requires ATP). This causes water to enter the cell by **osmosis**.





Guard cell walls are unevenly thickened and have **radially oriented cellulose microfibrils**. This causes the cells to bow as they becomes turgid. The stomate opens.

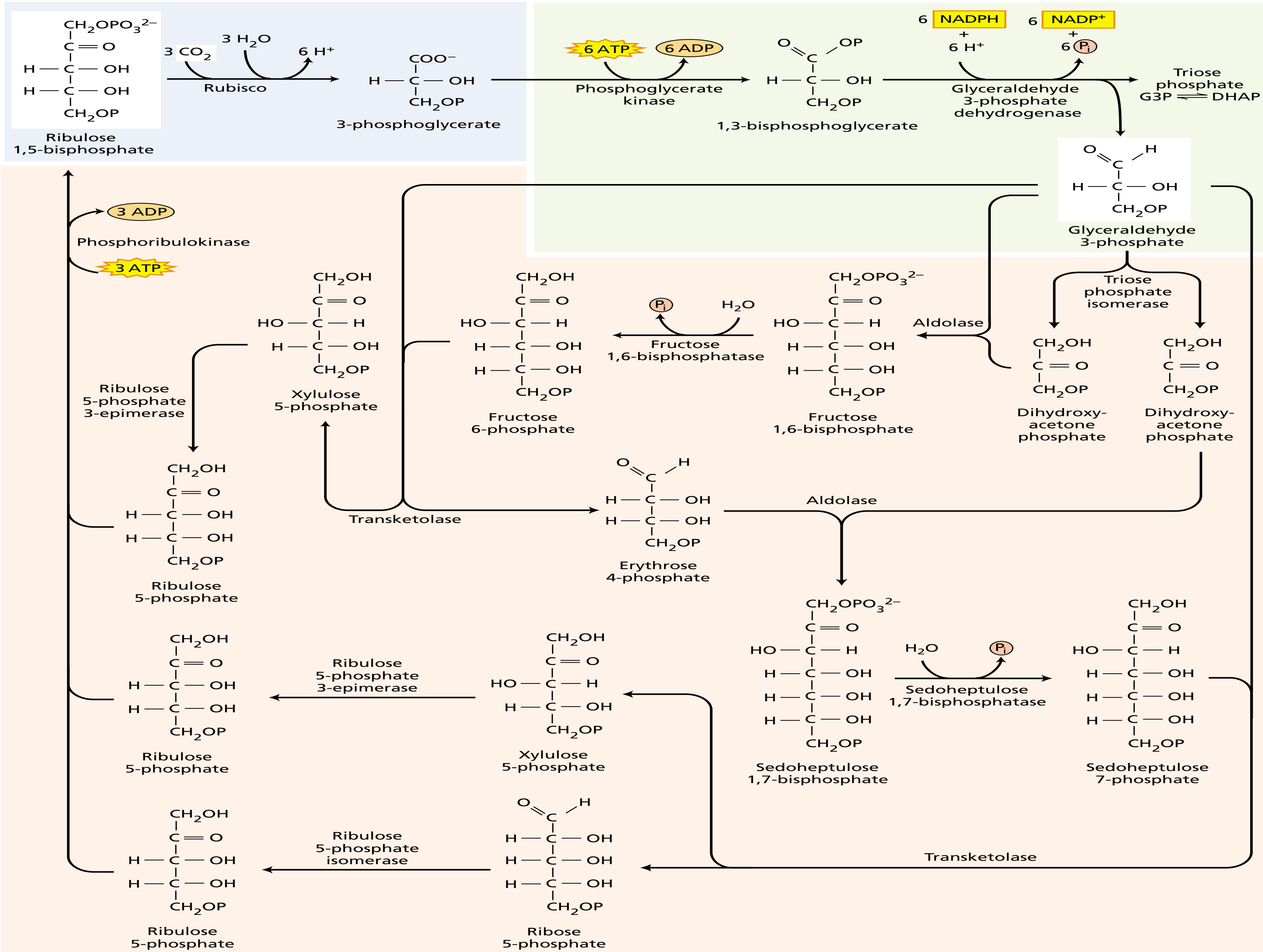
When K^+ ions are pumped out of the cell, water follows by osmosis and the stomate closes.



ringkasan:

$$3\ CO_2 + 3\ H_2O + 3\ RuBP + 9\ ATP + 6\ NADPH \longrightarrow 1\ 3\text{-}PGald + 6\ NADP^+ + 9\ ADP + 9\ P_i$$

Gambar 11.2 Rangkuman daur Calvin, ditekankan pada fase karboksilasi, reduksi, dan regenerasi



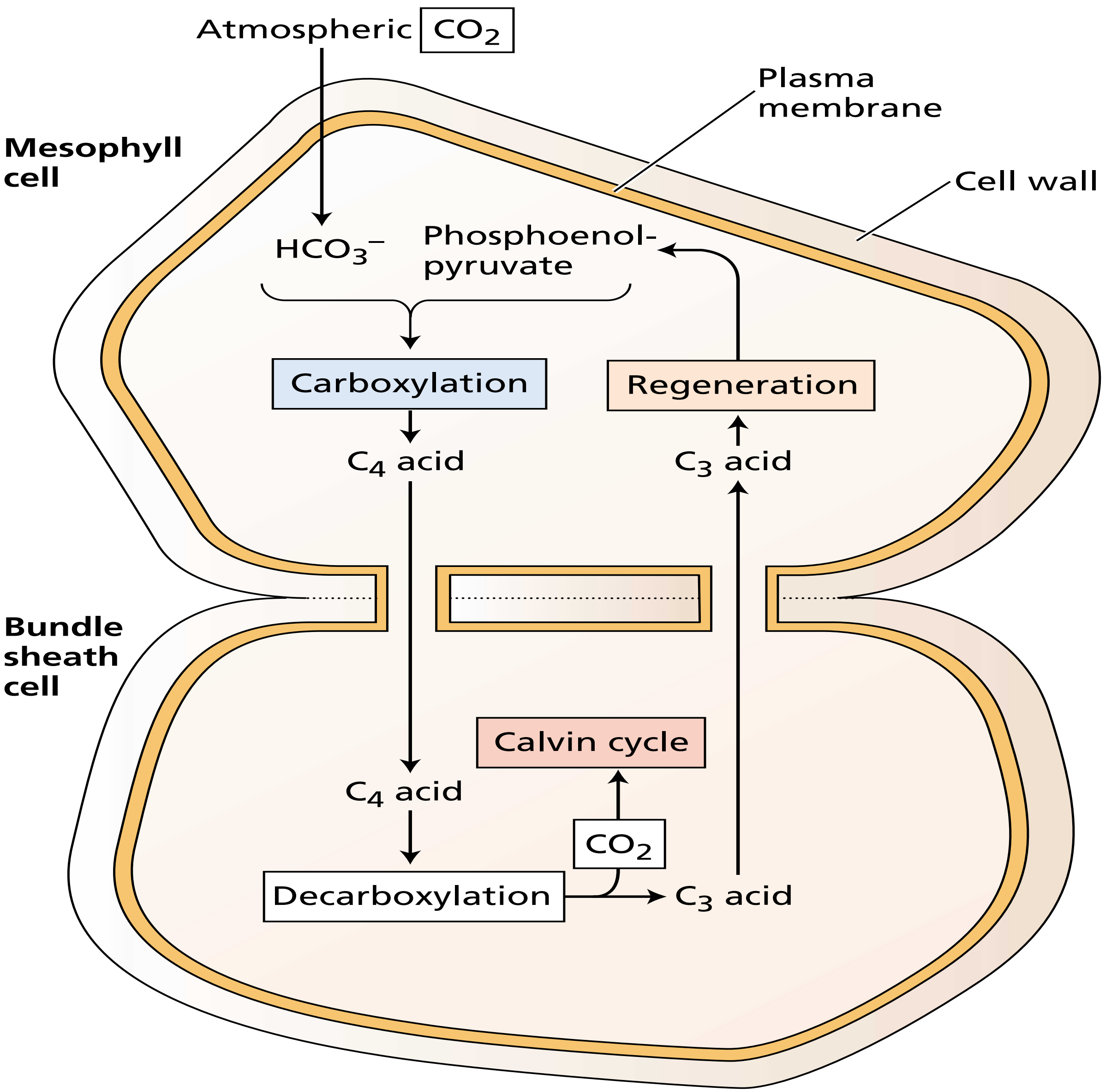
Gambar 1. Siklus Calvin

Enzim yang berperan dalam Reaksi yang terjadi dalam siklus Calvin

TABLE 8.1
Reactions of the Calvin cycle

Enzyme	Reaction
1. Ribulose-1,5-bisphosphate carboxylase/oxygenase	6 Ribulose-1,5-bisphosphate + 6 CO_2 + 6 H_2O → 12 (3-phosphoglycerate) + 12 H^+
2. 3-Phosphoglycerate kinase	12 (3-Phosphoglycerate) + 12 ATP → 12 (1,3-bisphosphoglycerate) + 12 ADP
3. NADP:glyceraldehyde-3-phosphate dehydrogenase	12 (1,3-Bisphosphoglycerate) + 12 NADPH + 12 H^+ → 12 glyceraldehye-3-phosphate + 12 $NADP^+$ + 12 P_i
4. Triose phosphate isomerase	5 Glyceraldehyde-3-phosphate → 5 dihydroxyacetone-3-phosphate
5. Aldolase	3 Glyceraldehyde-3-phosphate + 3 dihydroxyacetone-3-phosphate → 3 fructose-1,6-bisphosphate
6. Fructose-1,6-bisphosphatase	3 Fructose-1,6-bisphosphate + 3 H_2O → 3 fructose-6-phosphate + 3 P_i
7. Transketolase	2 Fructose-6-phosphate + 2 glyceraldehyde-3-phosphate → 2 erythrose-4-phosphate + 2 xylulose-5-phosphate
8. Aldolase	2 Erythrose-4-phosphate + 2 dihydroxyacetone-3-phosphate → 2 sedoheptulose-1,7-bisphosphate
9. Sedoheptulose-1,7,bisphosphatase	2 Sedoheptulose-1,7-bisphosphate + 2 H_2O → 2 sedoheptulose-7-phosphate + 2 P_i
10. Transketolase	2 Sedoheptulose-7-phosphate + 2 glyceraldehyde-3-phosphate → 2 ribose-5-phosphate + 2 xylulose-5-phosphate
11a. Ribulose-5-phosphate epimerase	4 Xylulose-5-phosphate → 4 ribulose-5-phosphate
11b. Ribose-5-phosphate isomerase	2 Ribose-5-phosphate → 2 ribulose-5-phosphate
12. Ribulose-5-phosphate kinase	6 Ribulose-5-phosphate + 6 ATP → 6 ribulose-1,5-bisphosphate + 6 ADP + 6 H^+
Net: 6 CO_2 + 11 H_2O + 12 NADPH + 18 ATP → Fructose-6-phosphate + 12 $NADP^+$ + 6 H^+ + 18 ADP + 17 P_i	

Note: P_i stands for inorganic phosphate.



Gambar 1. Proses fotosintetik tumbuhan C4 yang melibatkan empat tahap dalam dua jenis sel yang berbeda: (1) Fiksasi CO_2 menjadi 4 atom C pada sel selubung didalam sel mesofil; (2) Pengangkutan 4 C dari sel mesofil ke sel selubung bundel; (3) Dekarboksilasi 4 asam Carbon, dan pembangkitan konsentrasi CO_2 tinggi dalam sel selubung pembuluh. CO_2 yang dikeluarkan diperbaiki oleh rubisco dan diubah menjadi karbohidrat oleh siklus Calvin. (4) Pengangkutan asam karbon tiga residu kembali ke sel mesofil, di mana akseptor CO_2 asli, diregenerasi.

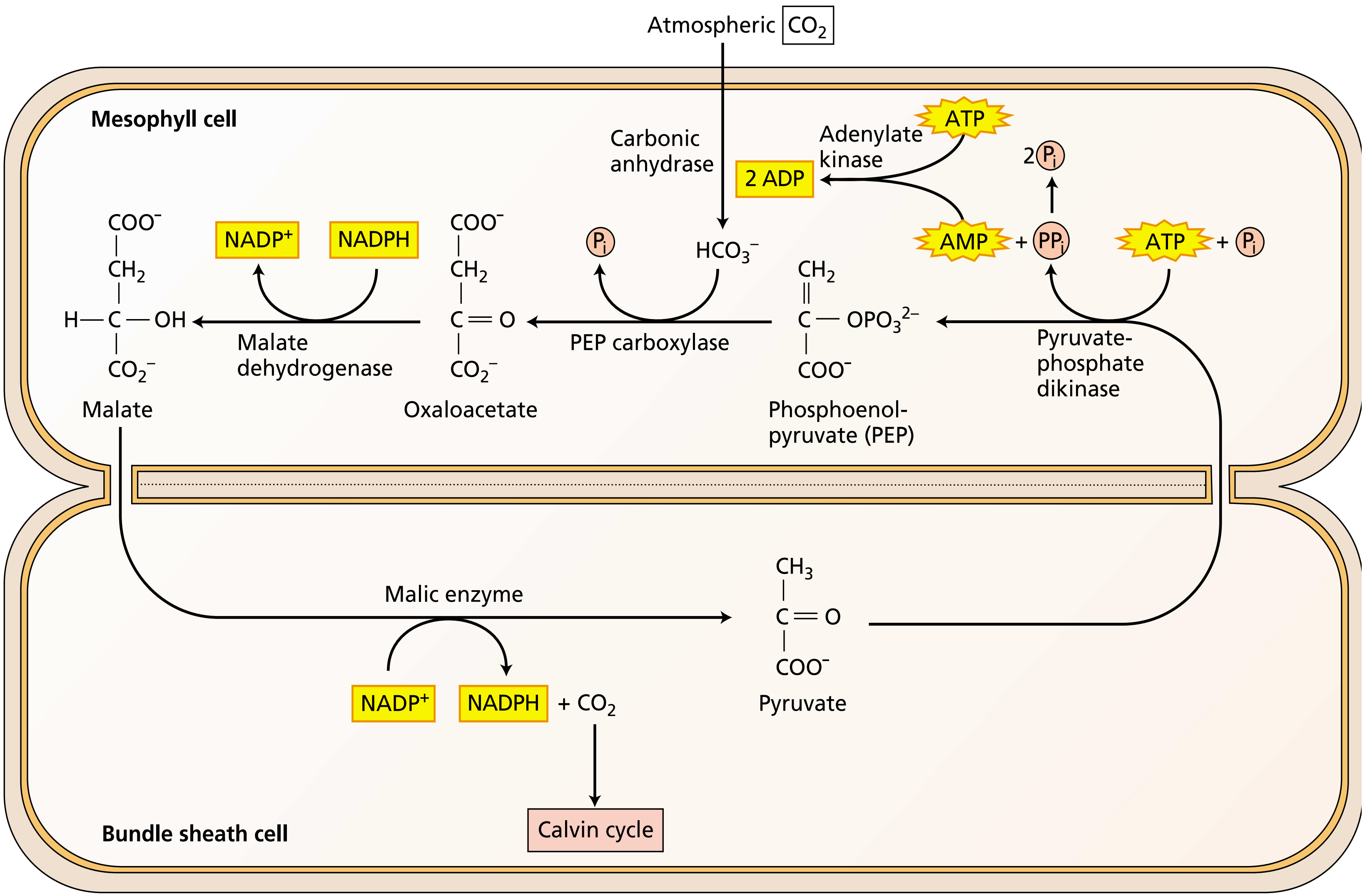
Enzim yang berperan dalam reaksi fotosintesis tumbuhan C4

TABLE 8.3
Reactions of the C_4 photosynthetic carbon cycle

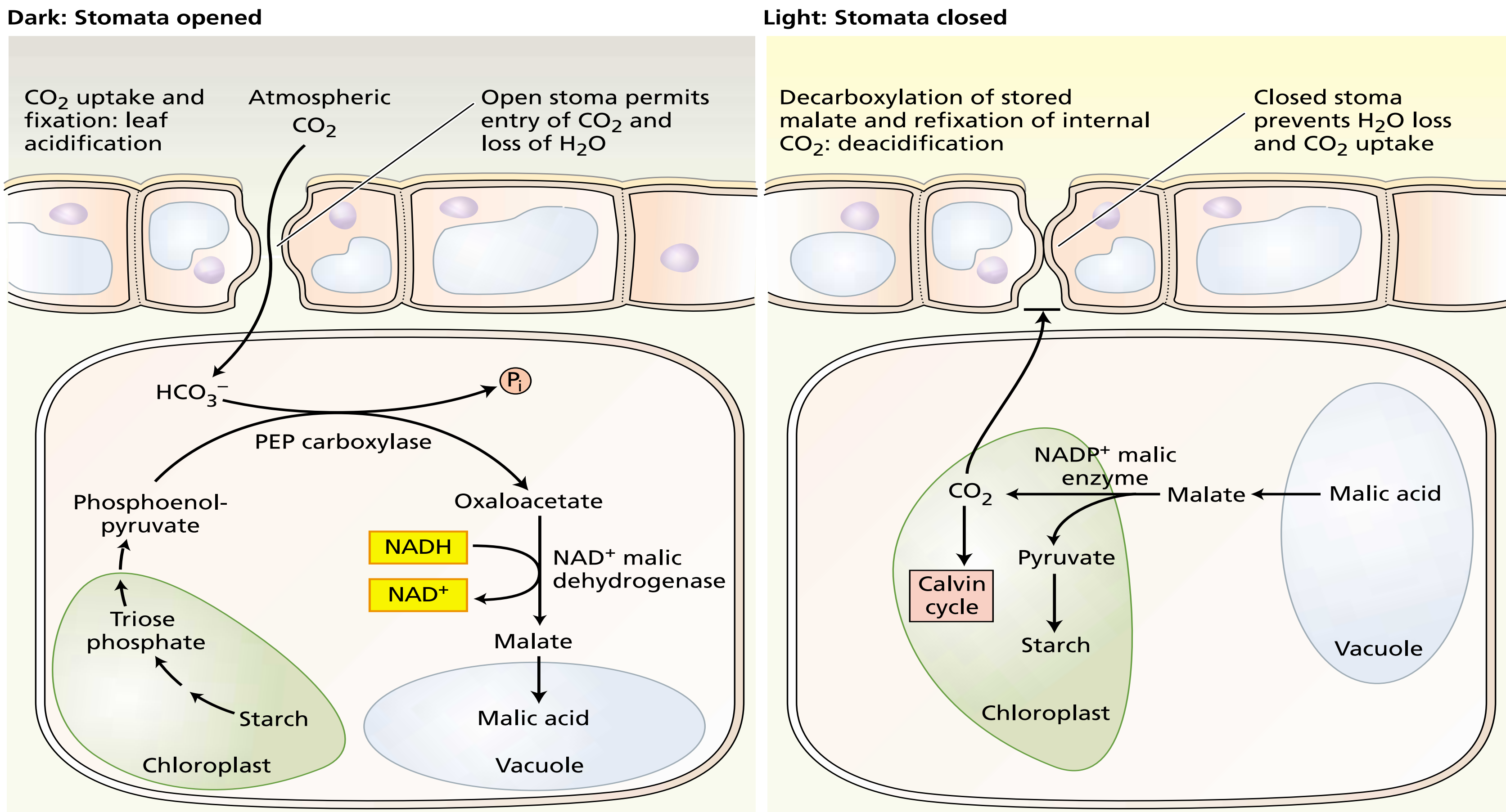
Enzyme	Reaction
1. Phosphoenolpyruvate (PEP) carboxylase	Phosphoenolpyruvate + HCO_3^- → oxaloacetate + P_i
2. NADP:malate dehydrogenase	Oxaloacetate + NADPH + H^+ → malate + $NADP^+$
3. Aspartate aminotransferase	Oxaloacetate + glutamate → aspartate + α-ketoglutarate
4. NAD(P) malic enzyme	Malate + $NAD(P)^+$ → pyruvate + CO_2 + NAD(P)H + H^+
5. Phosphoenolpyruvate carboxykinase	Oxaloacetate + ATP → phosphoenolpyruvate + CO_2 + ADP
6. Alanine aminotransferase	Pyruvate + glutamate ↔ alanine + α-ketoglutarate
7. Adenylate kinase	AMP + ATP → 2 ADP
8. Pyruvate–orthophosphate dikinase	Pyruvate + P_i + ATP → phosphoenolpyruvate + AMP + PP_i
9. Pyrophosphatase	PP_i + H_2O → 2 P_i

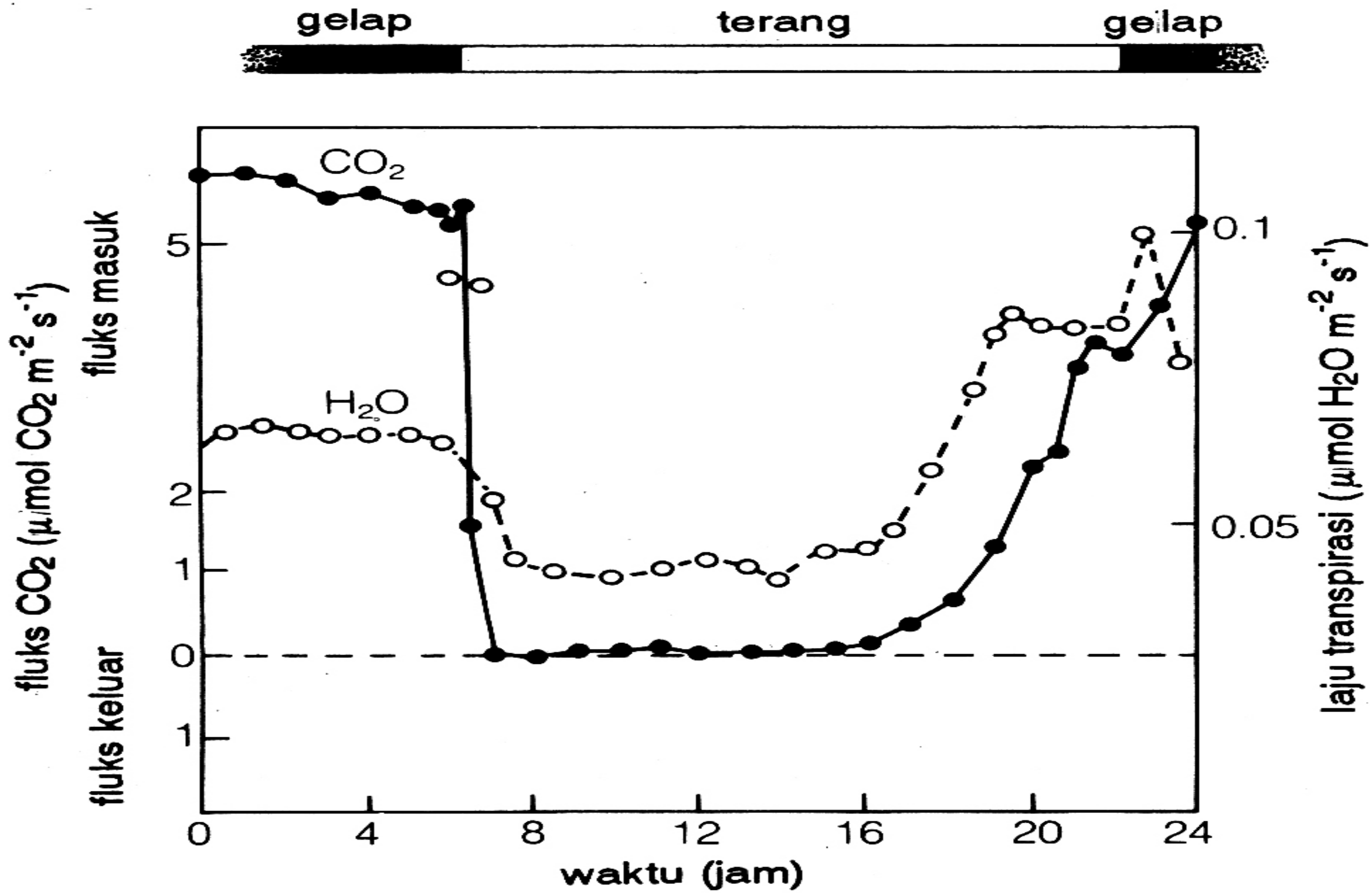
Note: P_i and PP_i stand for inorganic phosphate and pyrophosphate, respectively.

The C4 photosynthetic pathway. The hydrolysis of two ATP drives the cycle in the direction of the arrows, thus pumping CO2 from the atmosphere to the Calvin cycle of the chloroplasts from bundle sheath cells.

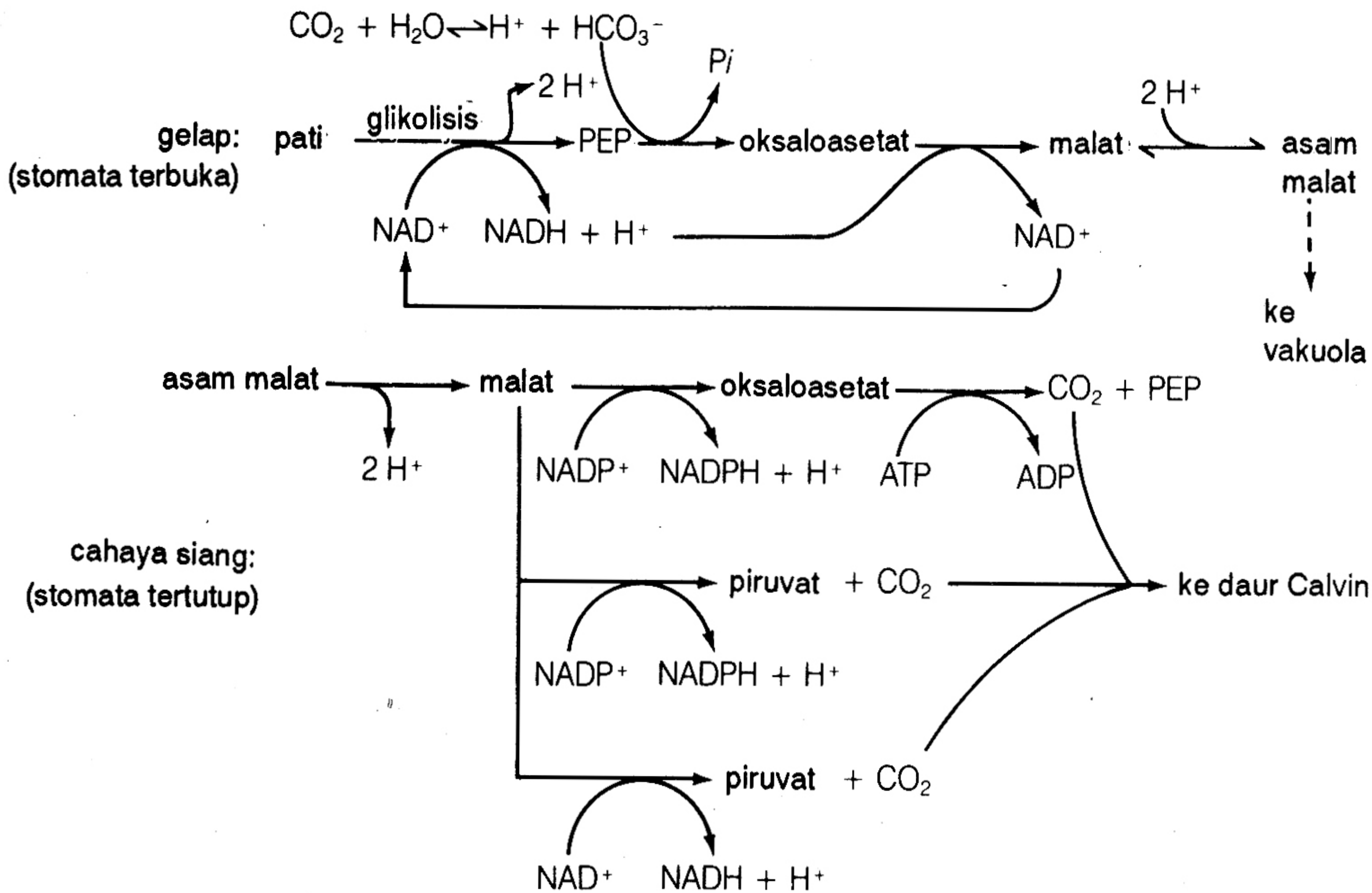


Crassulacean acid metabolism (CAM). Temporal separation of CO_2 uptake from photosynthetic reactions: CO_2 uptake and fixation take place at night, and decar- boxylation and refixation of the internally released CO_2 occur during the day. The adap- tive advantage of CAM is the reduction of water loss by transpiration, achieved by the stomatal opening during the night.





Gambar 11.13 Laju penambatan CO_2 dan laju transpirasi tumbuhan CAM *Agave americana*, menuruti perubahan periode cahaya dan gelap. (Dari Neales dkk, 1968)



Gambar 11.14 Rangkuman penambatan CO_2 pada tumbuhan CAM