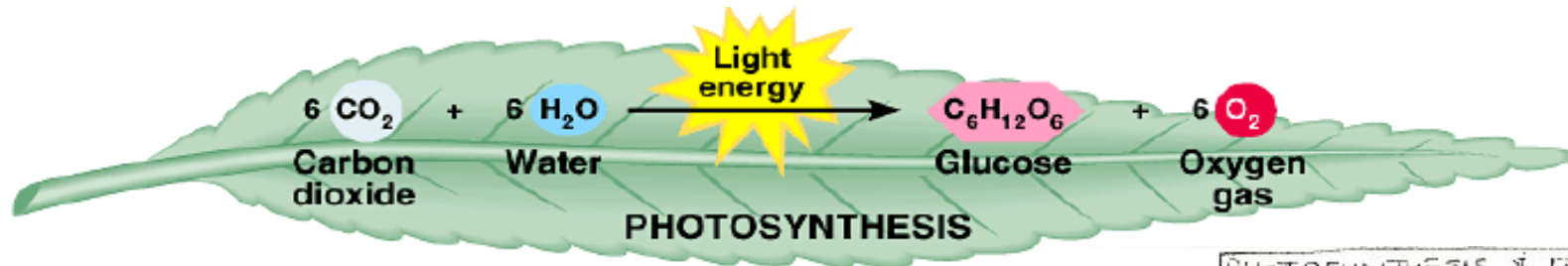
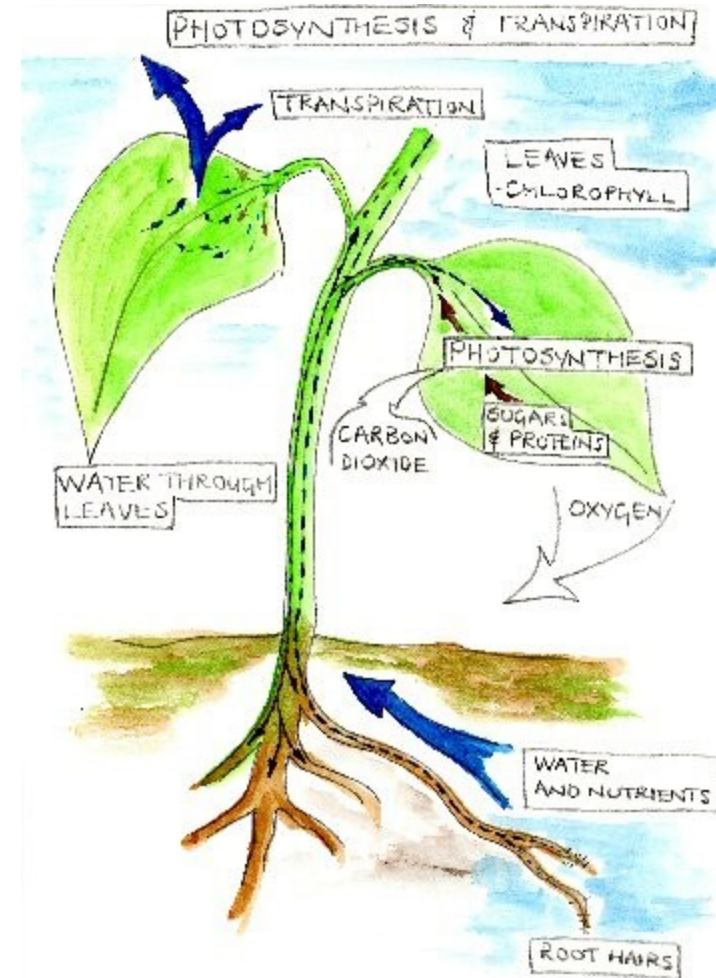
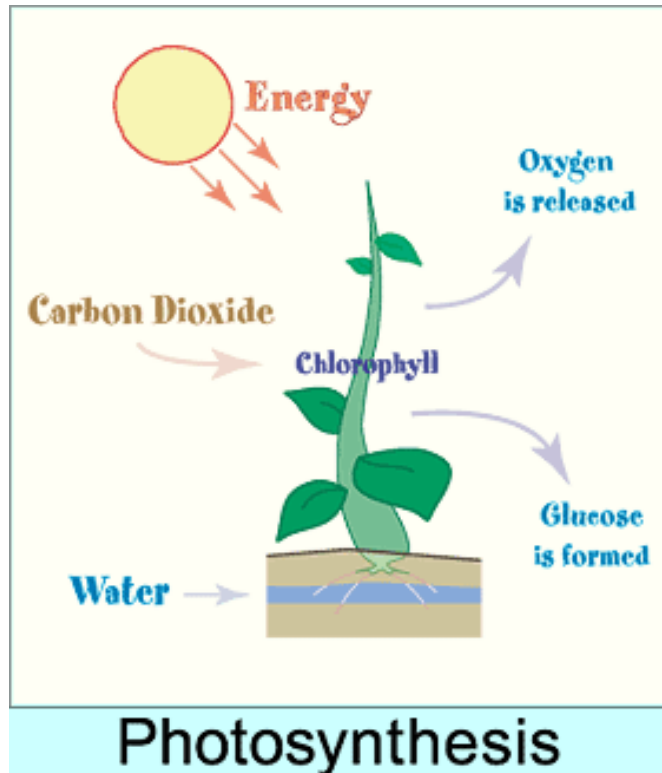


A fotossíntese

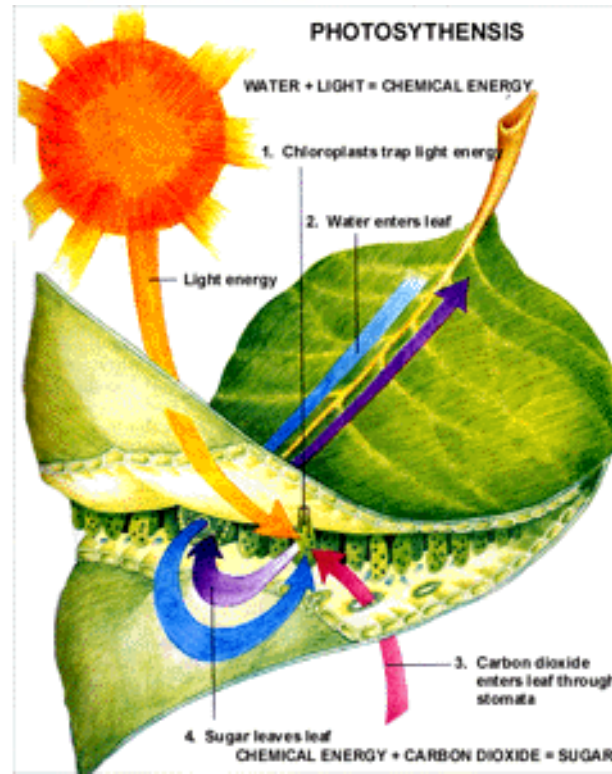
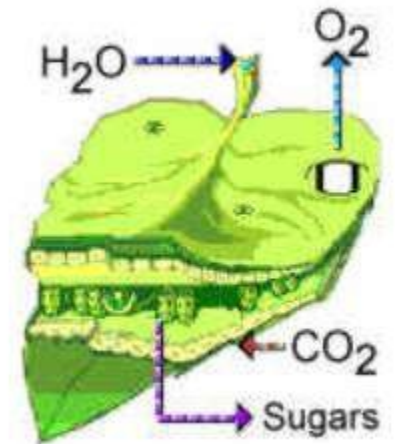
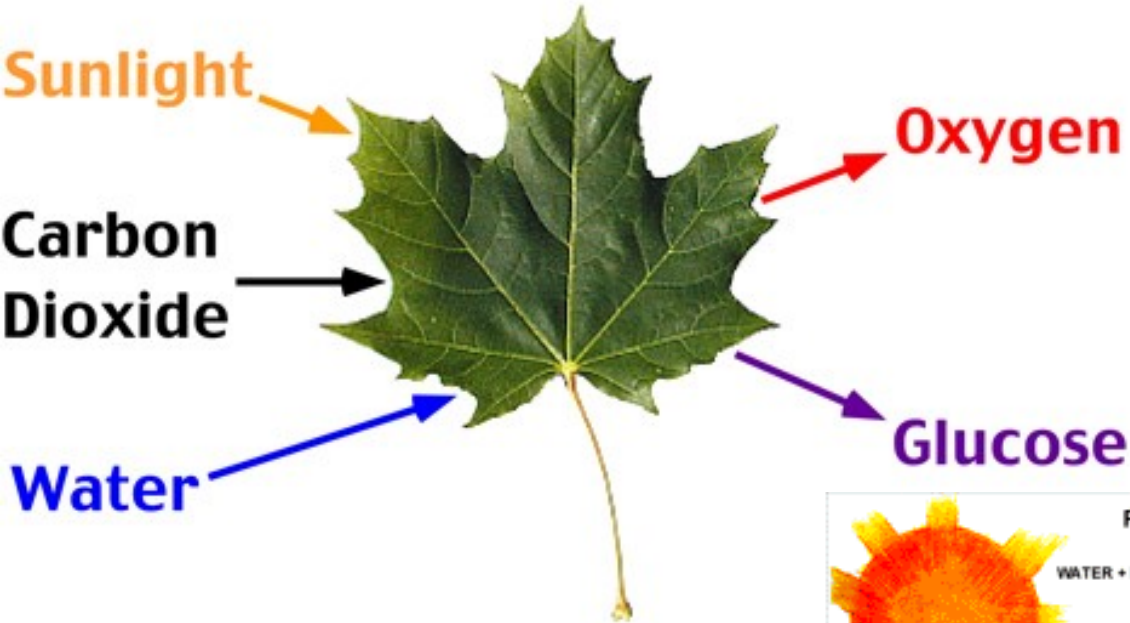
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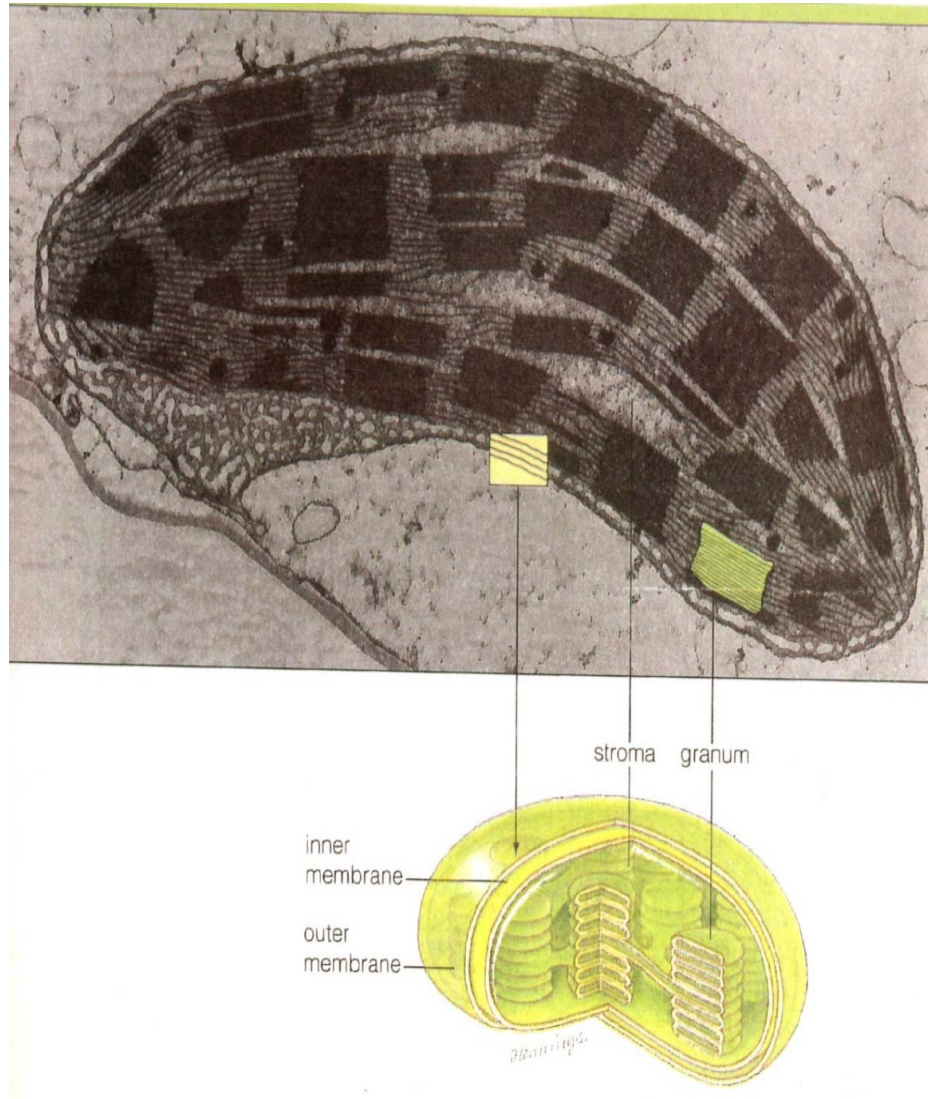
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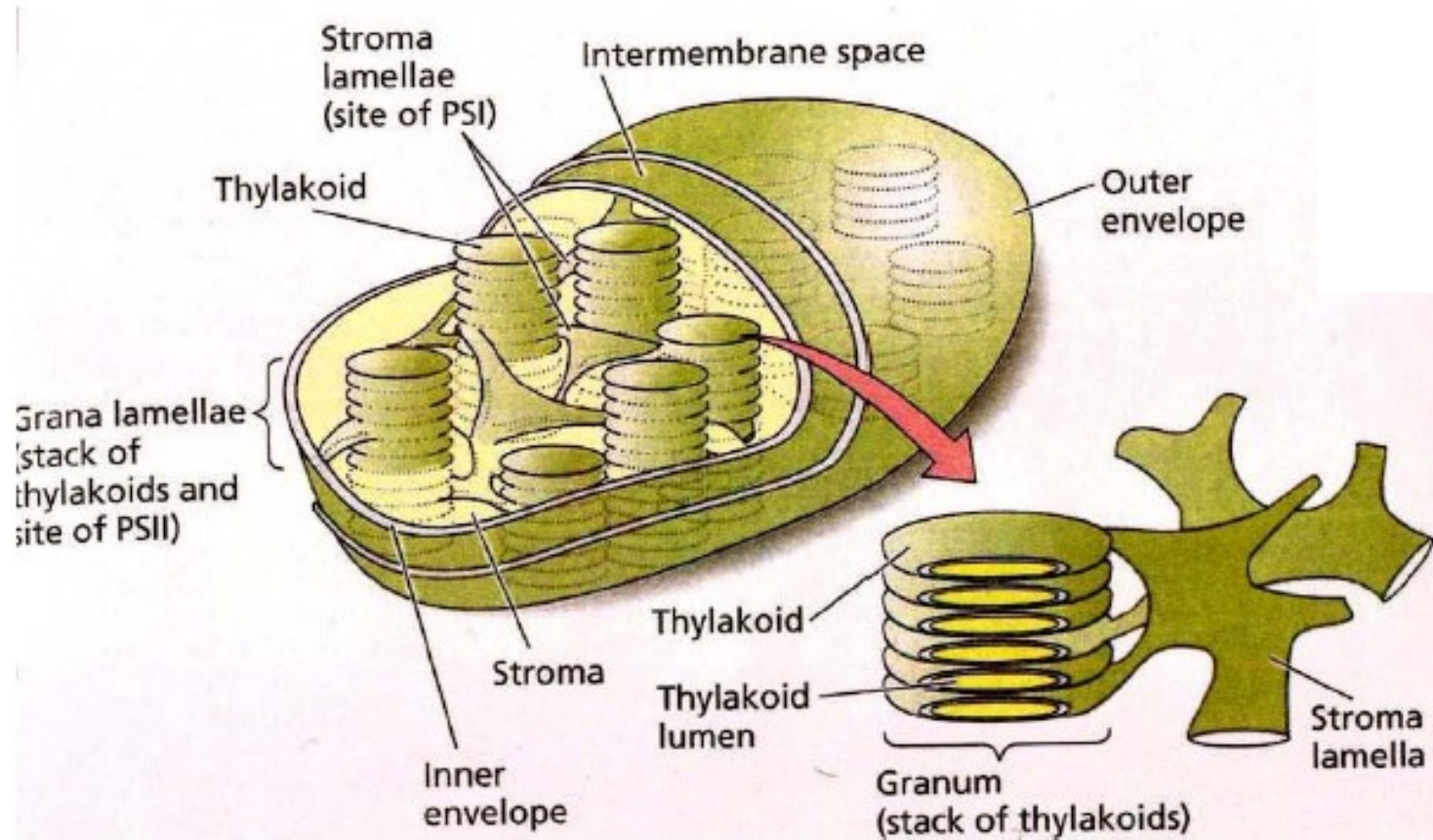
A fotossíntese



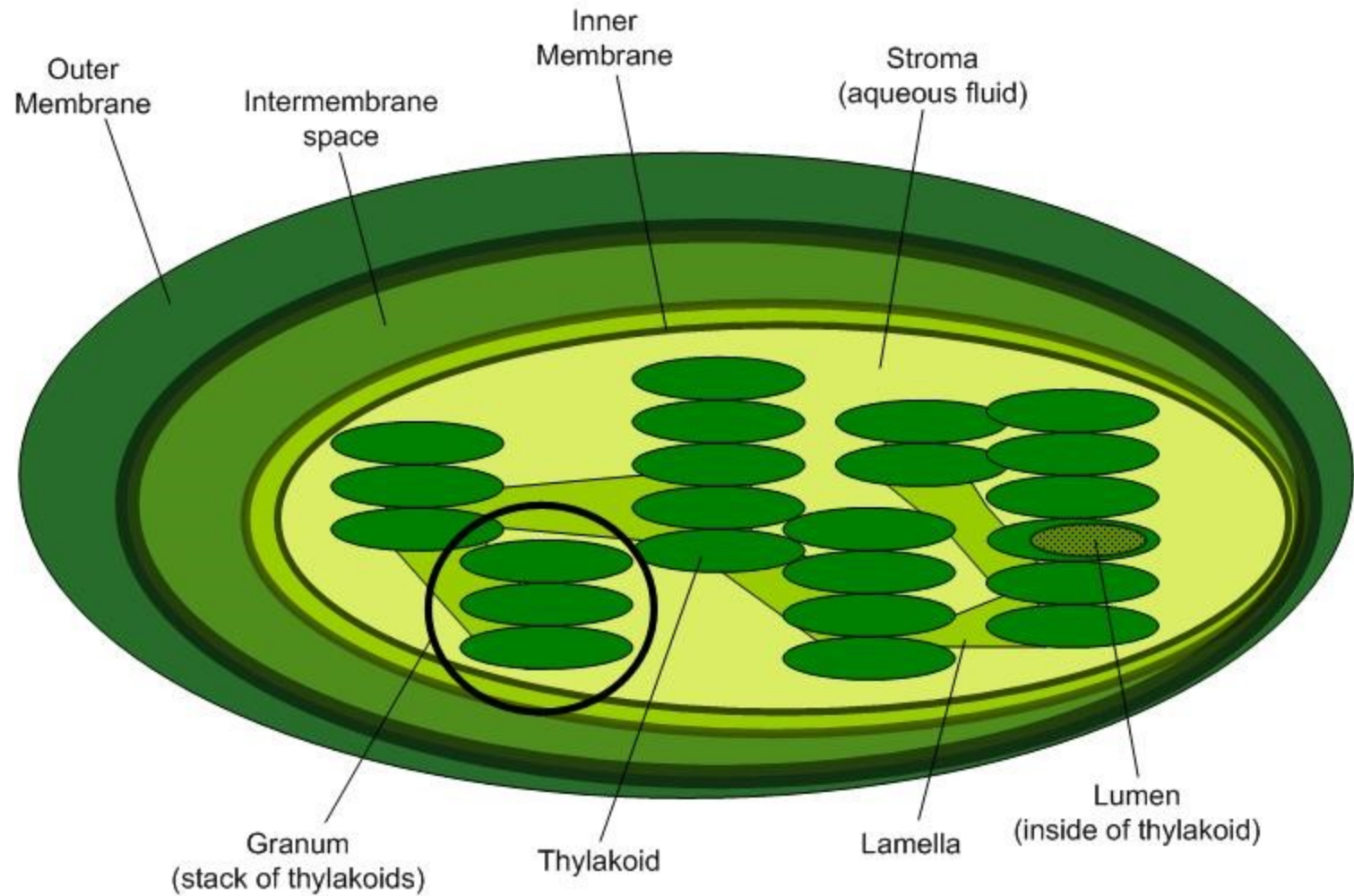
O cloroplasto: estrutura e tipos de reacções bioquímicas



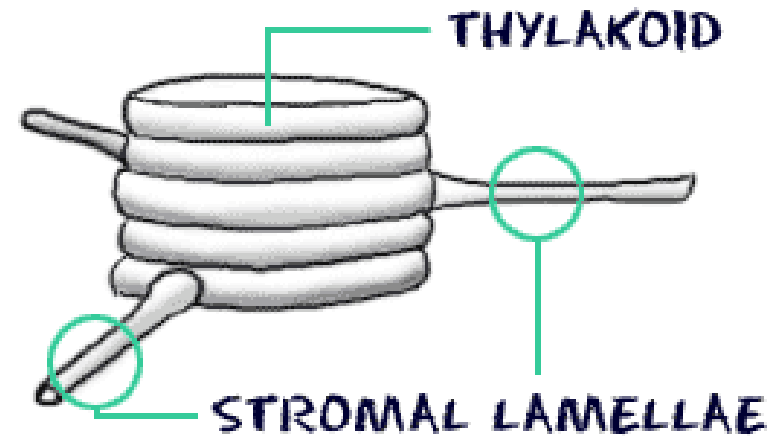
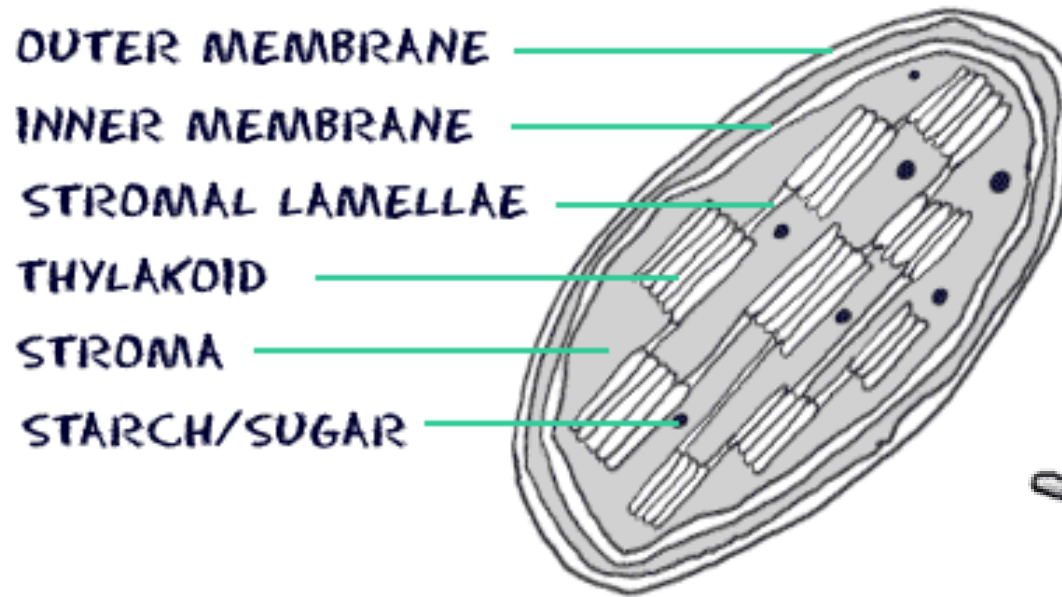
O cloroplasto: estrutura e tipos de reacções bioquímicas



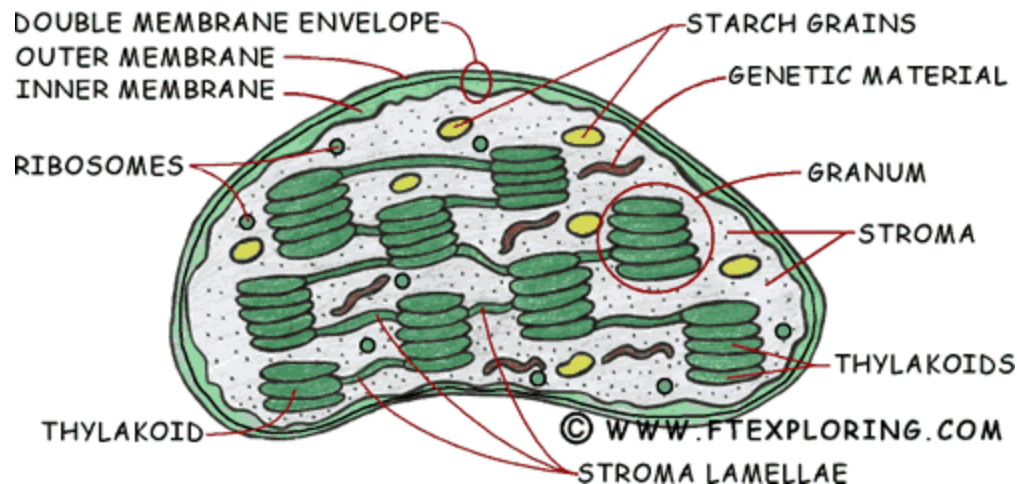
O cloroplasto: estrutura e tipos de reacções bioquímicas



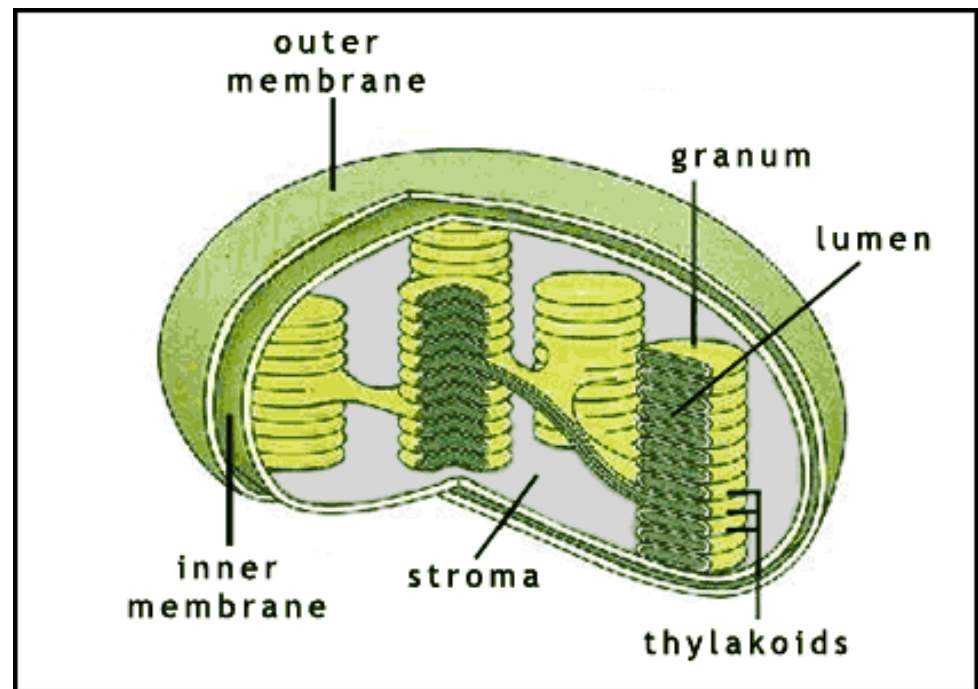
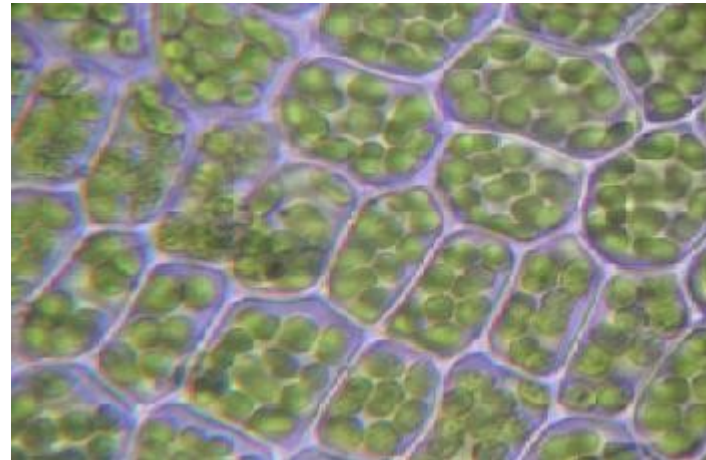
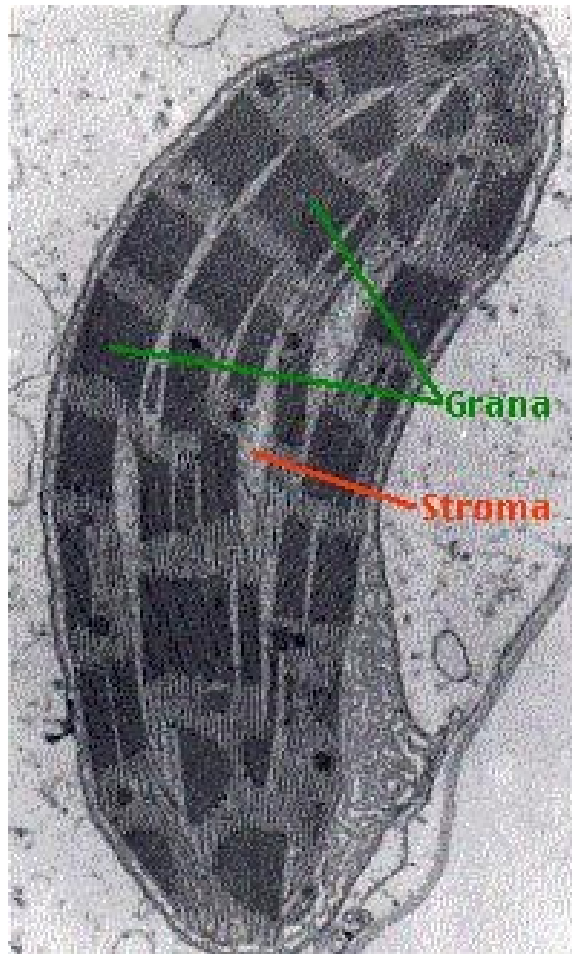
O cloroplasto: estrutura e tipos de reacções bioquímicas



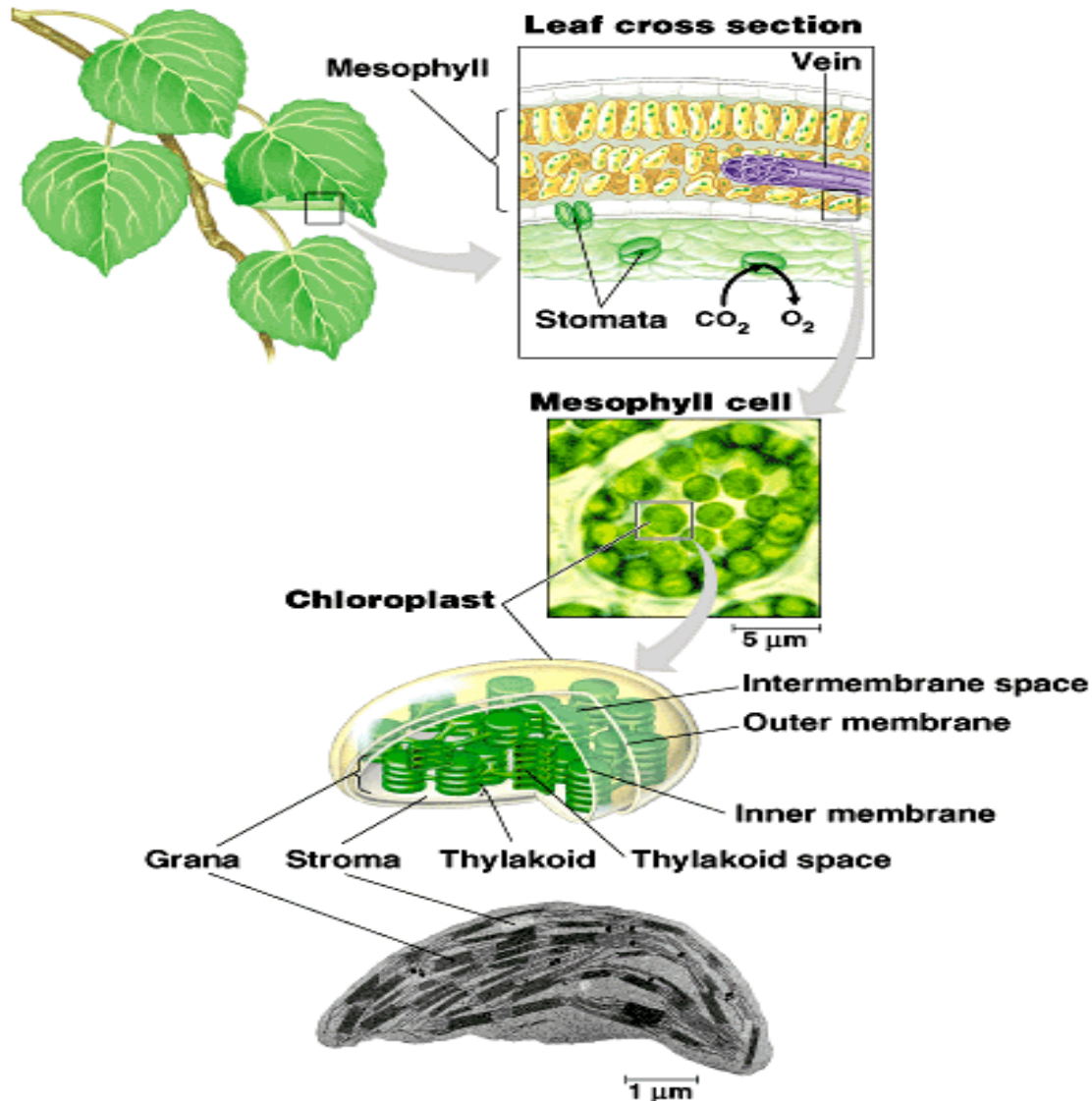
CHLOROPLAST



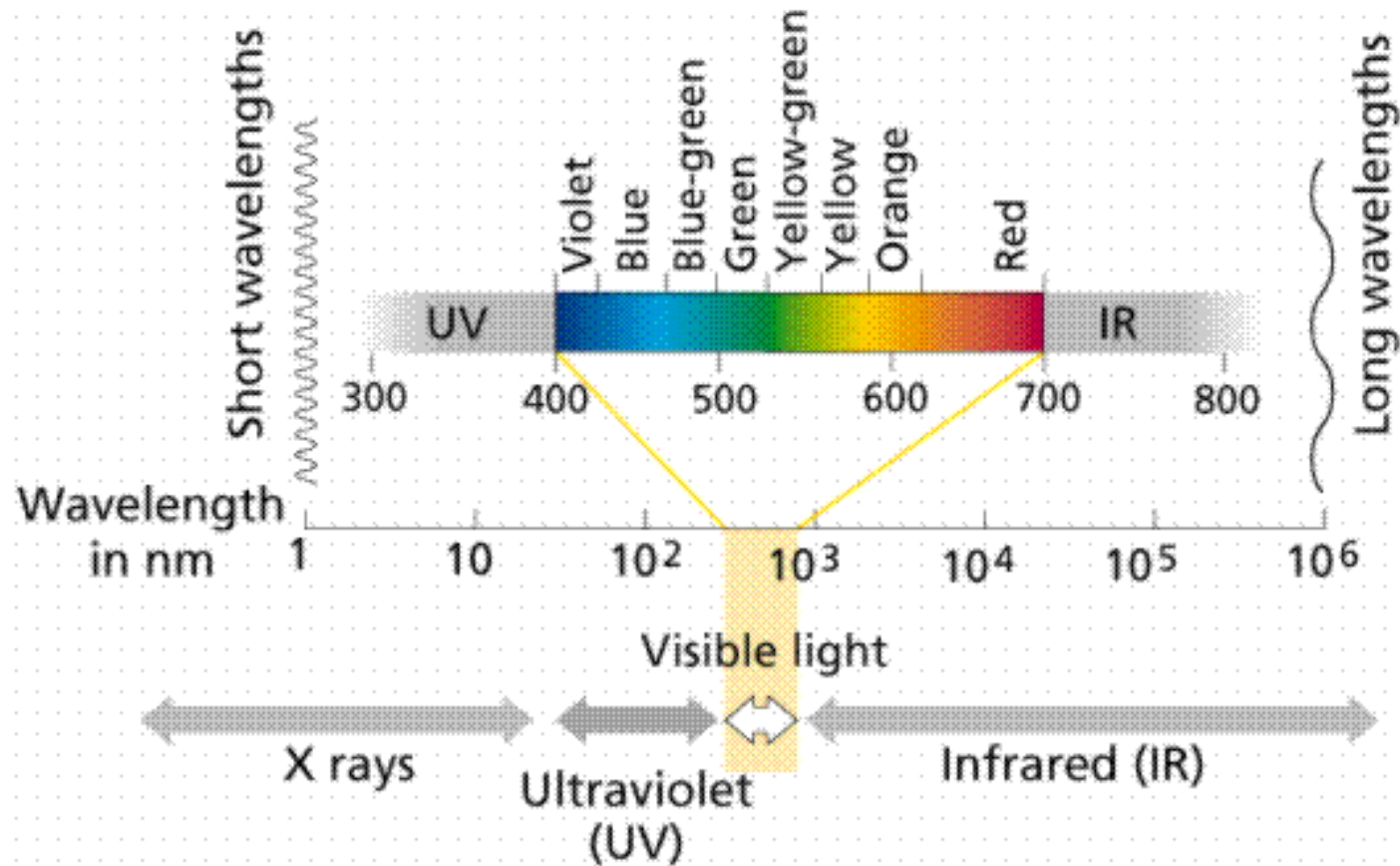
O cloroplasto: estrutura e tipos de reacções bioquímicas



O cloroplasto: estrutura e tipos de reacções bioquímicas



A luz e os pigmentos fotossintéticos



A luz e os pigmentos fotossintéticos

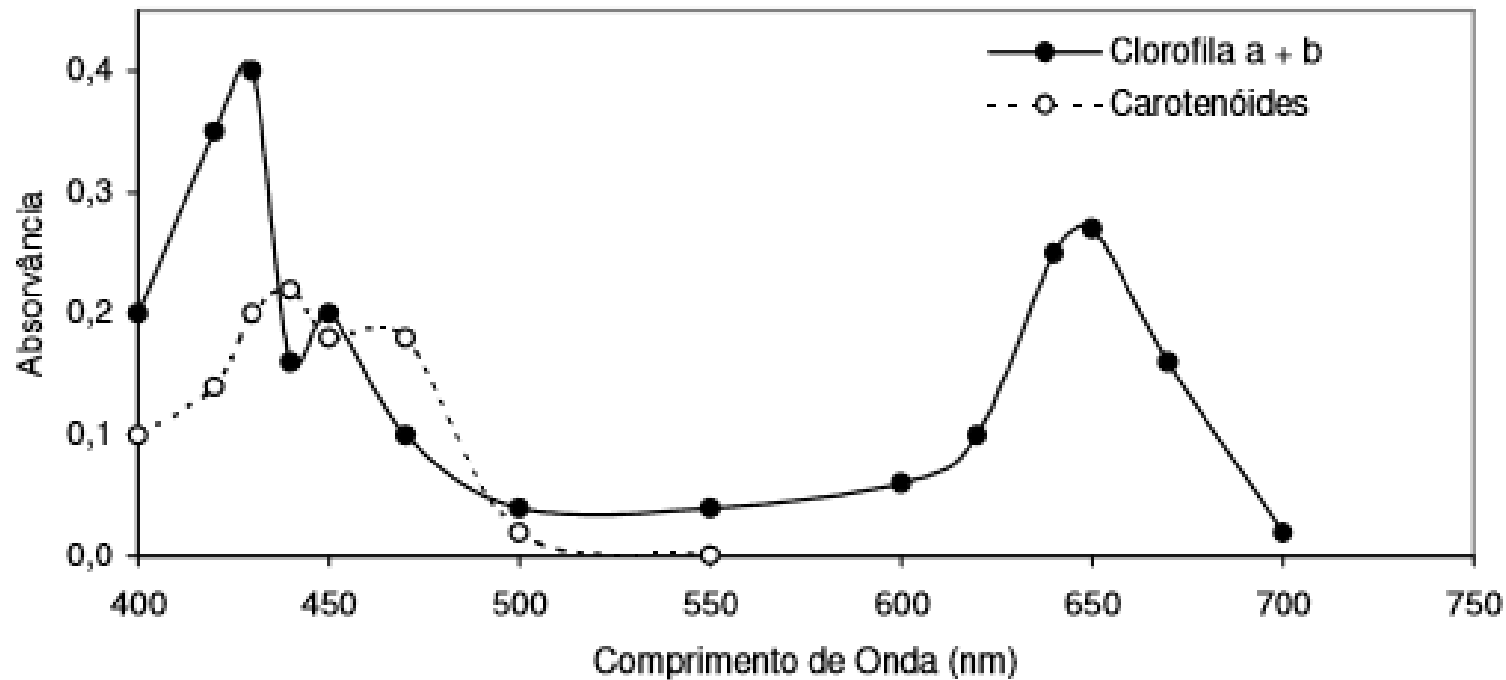
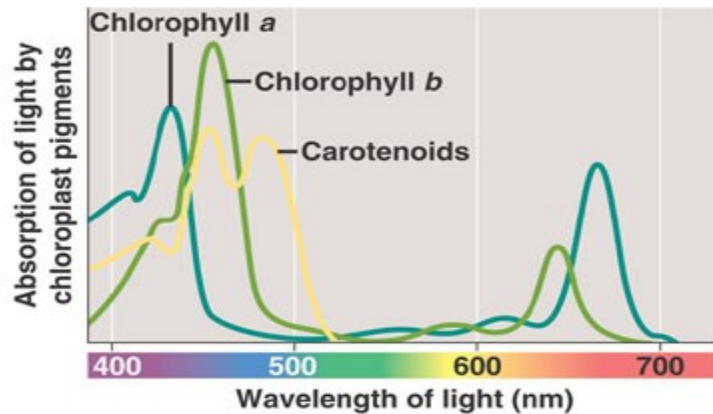
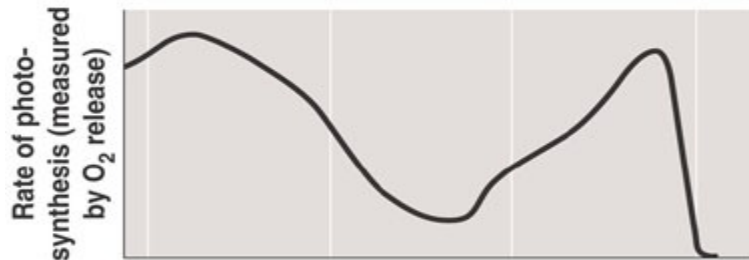


Figura 3 - Espectro de absorção das clorofilas (a + b) e dos carotenóides.

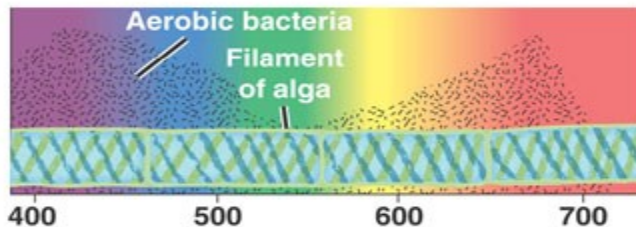
A luz e os pigmentos fotossintéticos



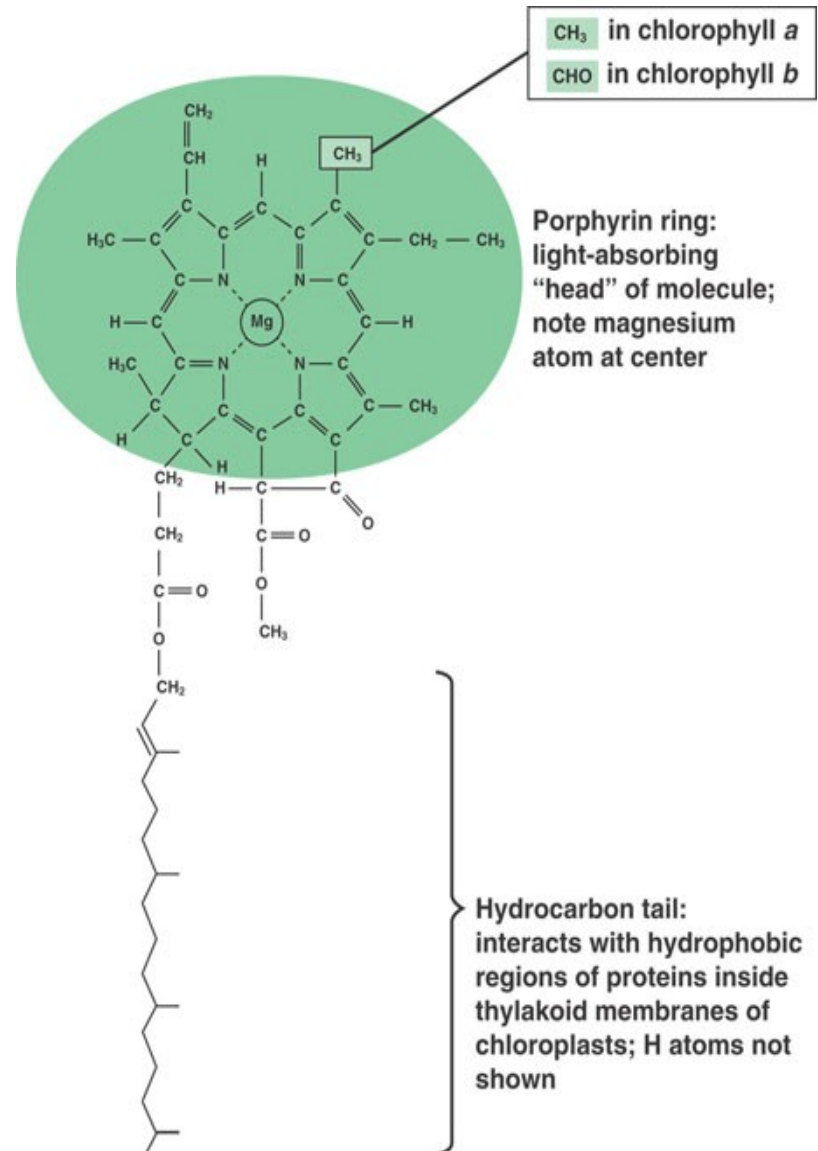
(a) Absorption spectra



(b) Action spectrum



(c) Engelmann's experiment



A fotossíntese

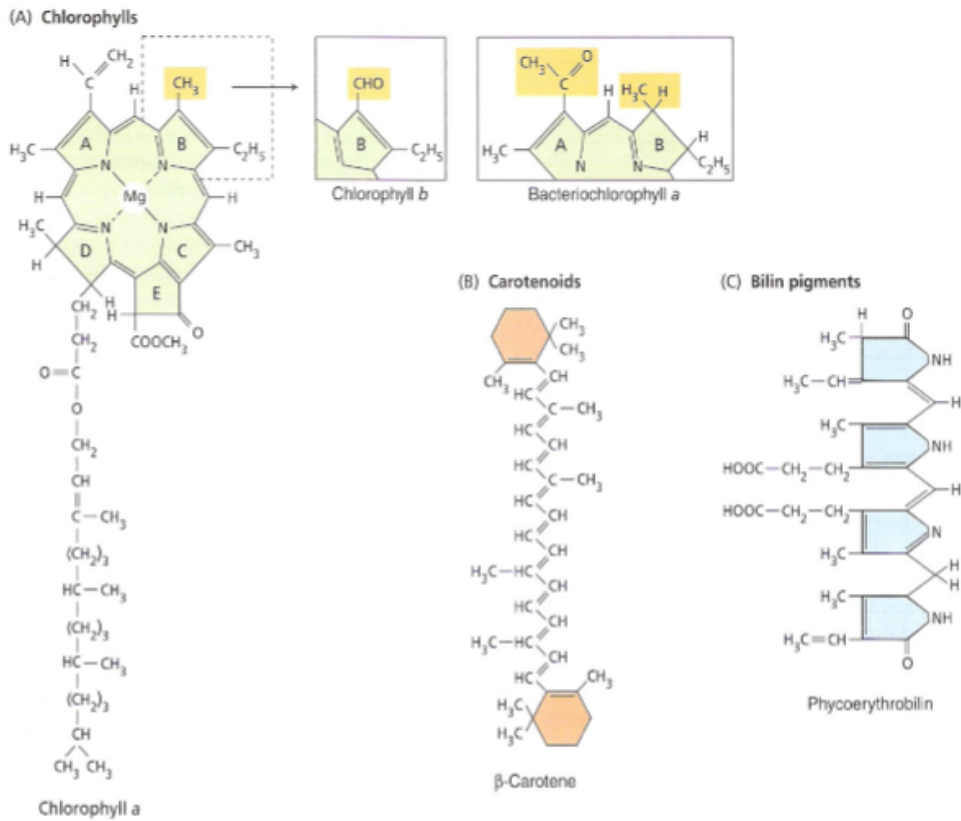
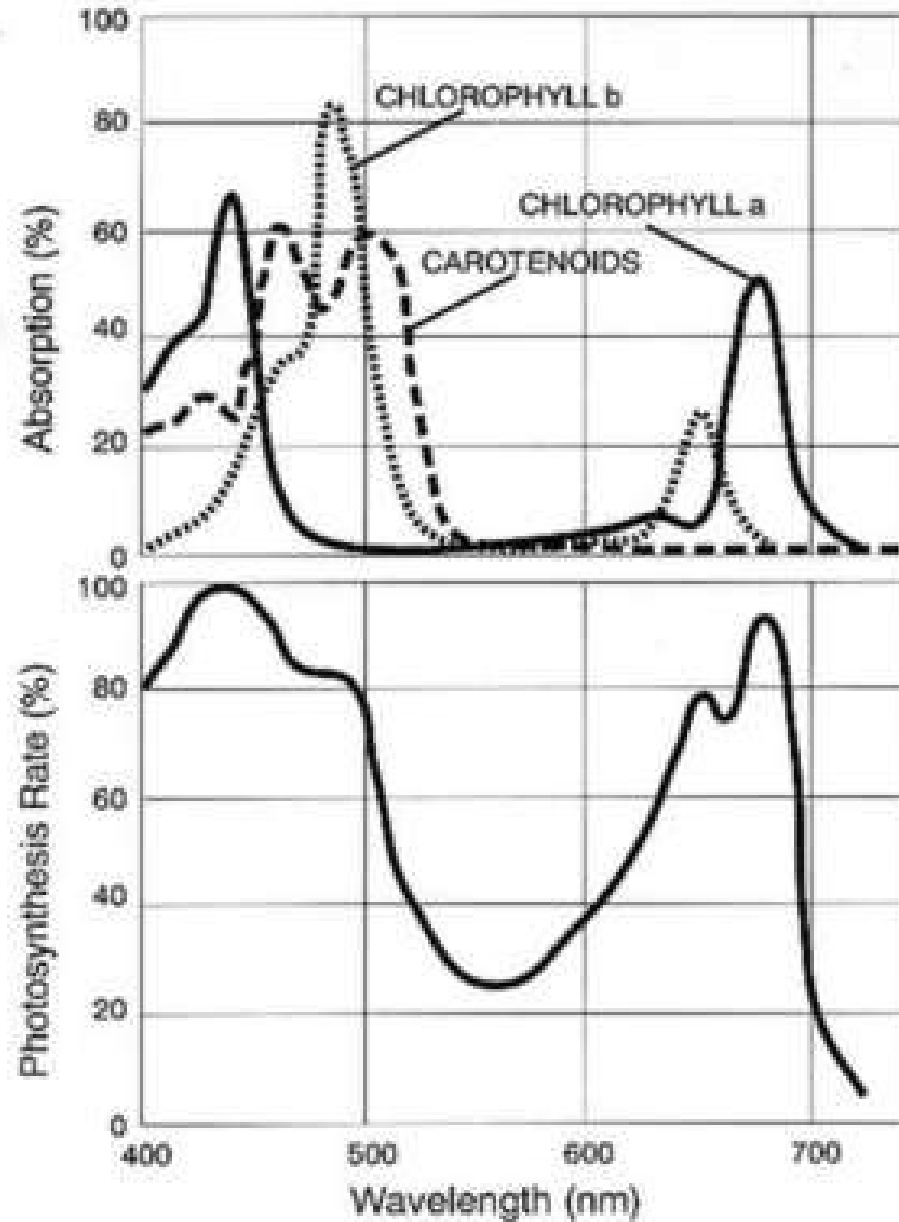
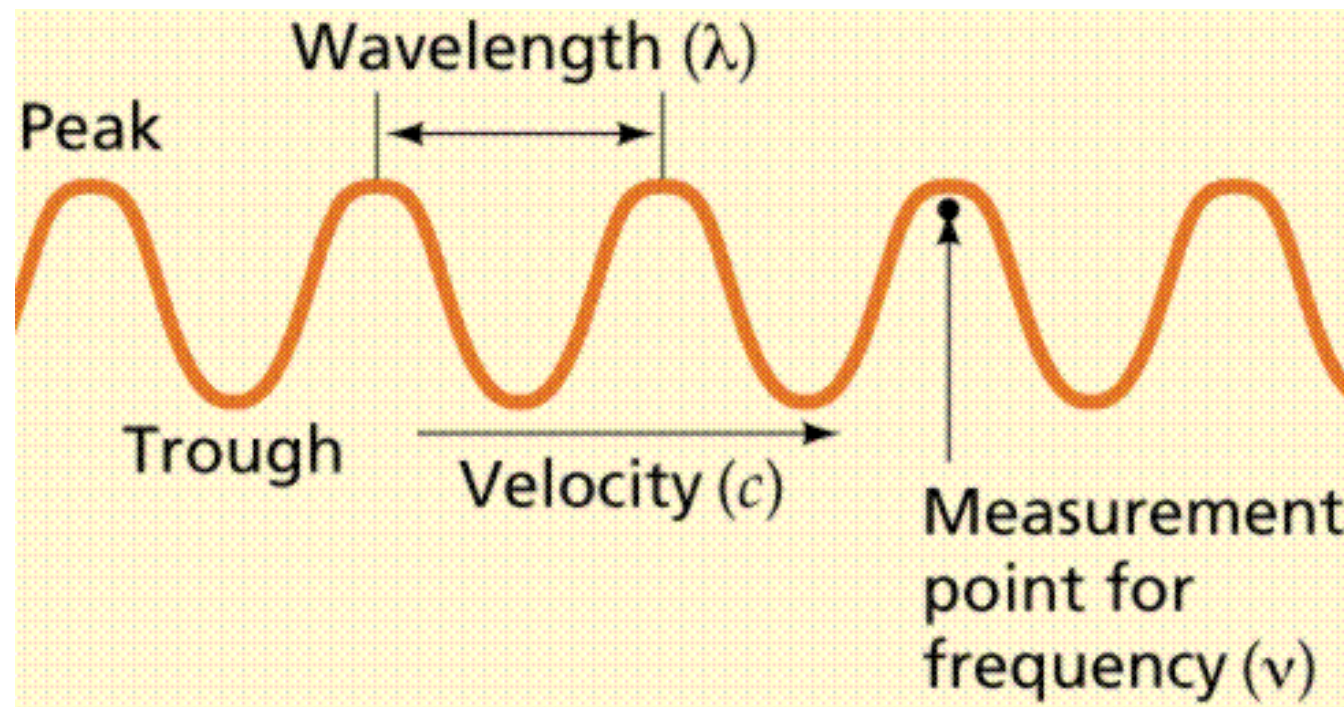


Figura 6 – Estrutura molecular de pigmentos fotossintéticos (Taiz & Zeiger, 1998)

A fotossíntese



A luz e os pigmentos fotossintéticos



$$c = \lambda \cdot \nu$$

$$E = h\nu$$

$$E = (h \cdot c) / \lambda$$

Velocidade da luz – $C = 3 \times 10^8 \text{ ms}^{-1}$

Energia de um fóton (E)
h- cont. de Planck $6,62 \times 10^{-34} \text{ J.s}$
 ν - frequência (nº de ondas por segundo)

A energia de cada fóton é inversamente proporcional ao c.d.o. da luz.

A luz e os pigmentos fotossintéticos

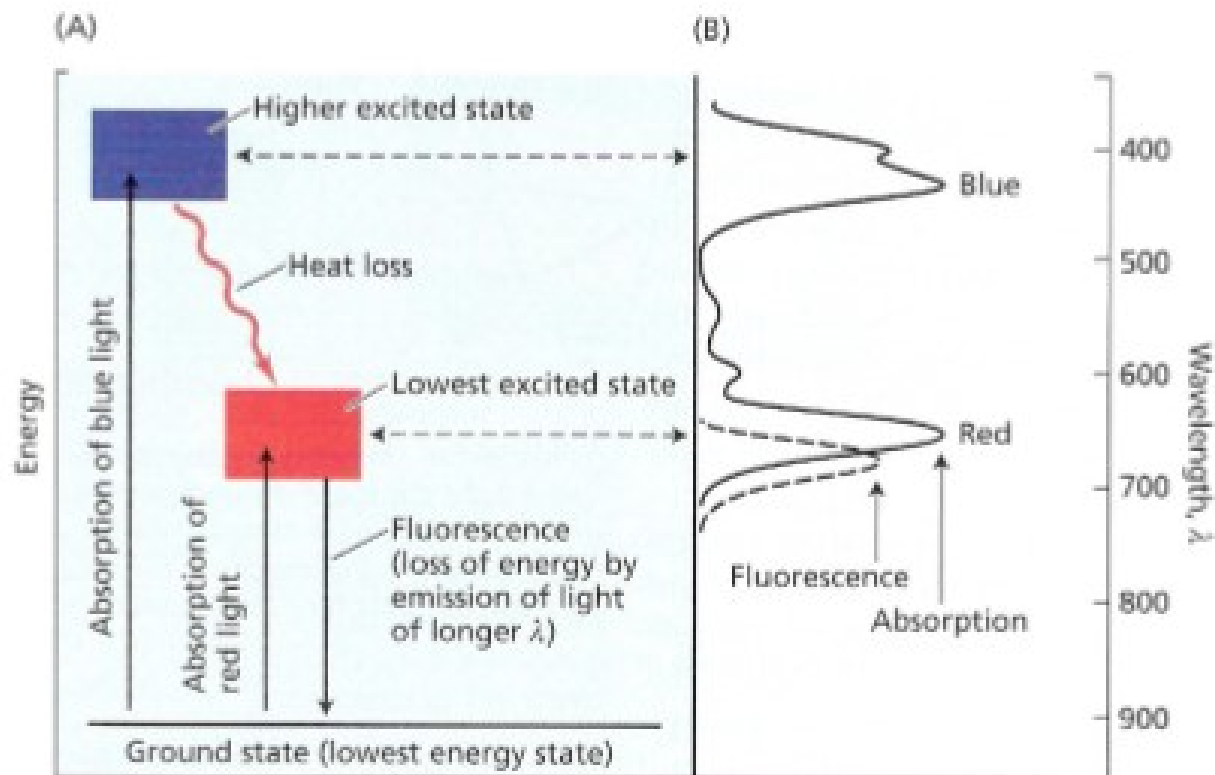


Figura 5 – A excitação da molécula de clorofila pela luz (Taiz & Zeiger, 1998)

A luz e os pigmentos fotossintéticos

Fluorescência

Neste processo, a molécula de clorofila reemite um fóton de luz e retorna para o seu estado fundamental.

Ocorre perda de energia na forma de calor e o comprimento de onda fluorescente é sempre maior do que o da luz absorvida.

A molécula pode converter a energia na forma de calor, sem nenhuma emissão de fótons.

Transferência de energia

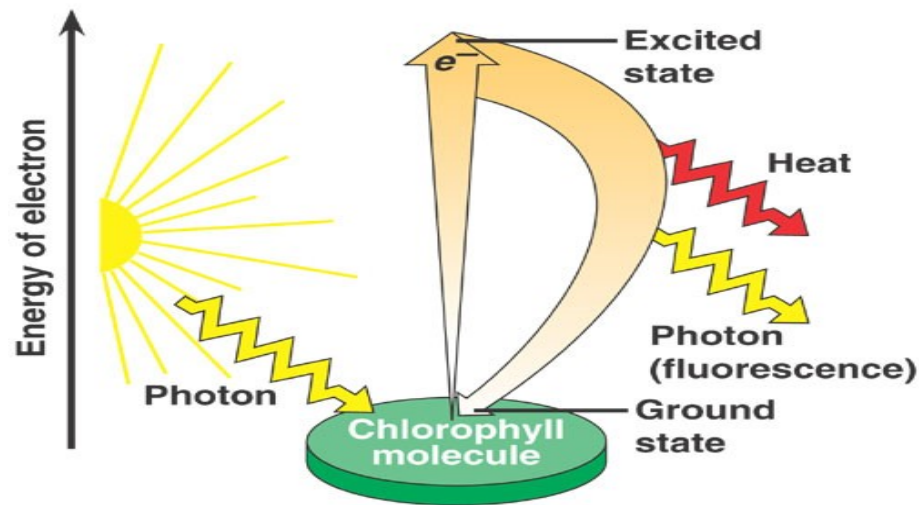
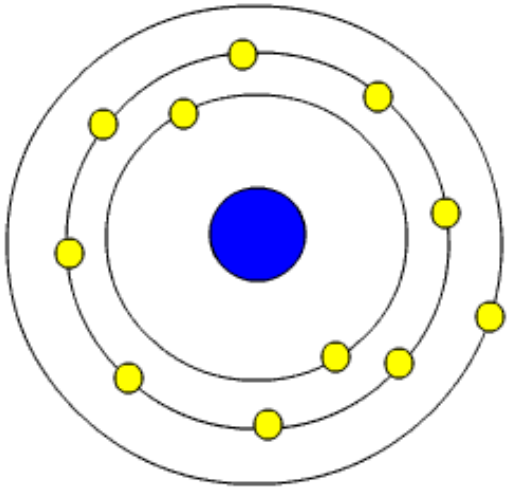
A molécula excitada transfere sua energia para outra molécula por ressonância induzida.

A luz e os pigmentos fotossintéticos

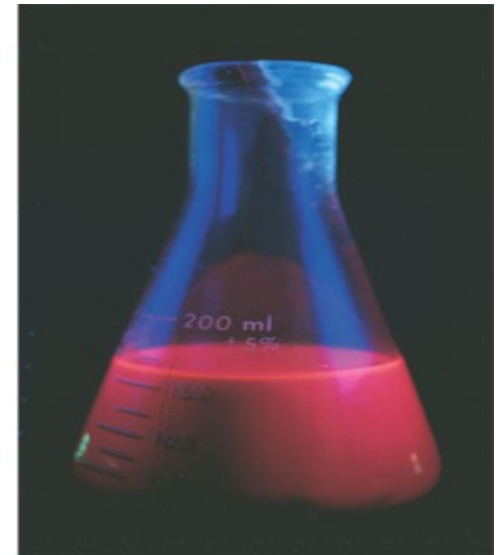
Reacção Fotoquímica

A energia do estado excitado é usada para impulsionar uma transferência de electrões.

A luz e os pigmentos fotossintéticos

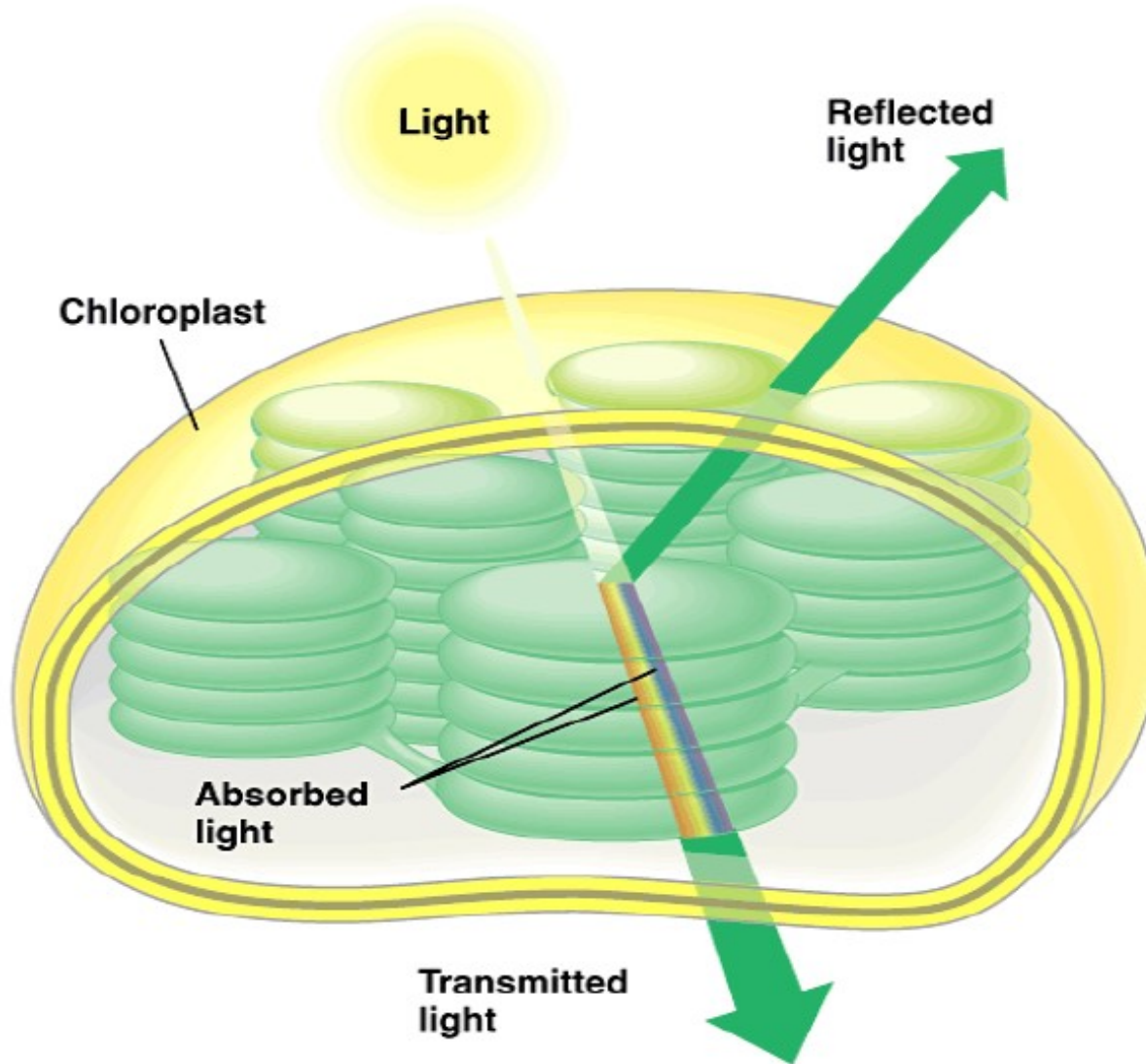


(a) Excitation of isolated chlorophyll molecule

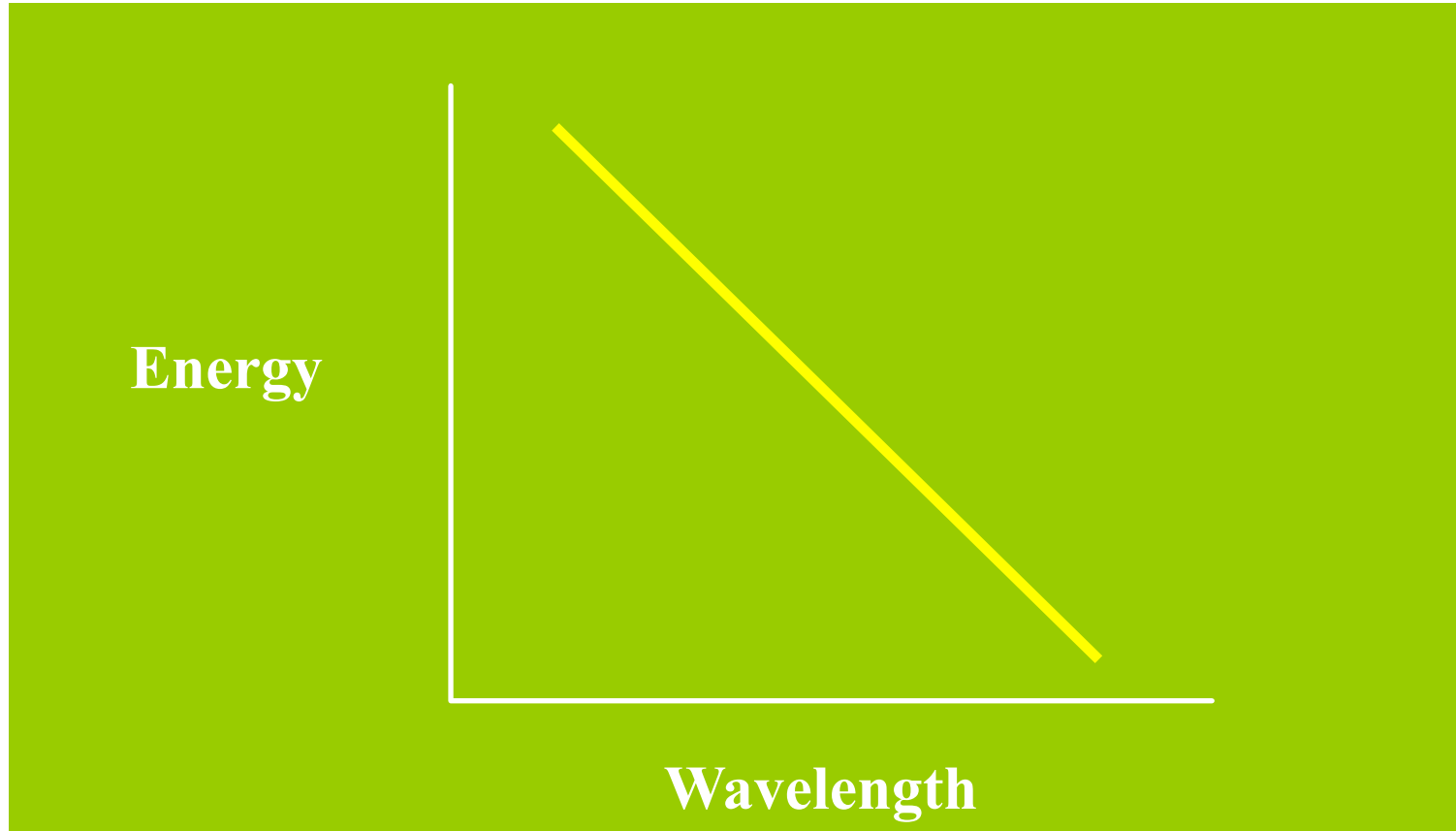


(b) Fluorescence

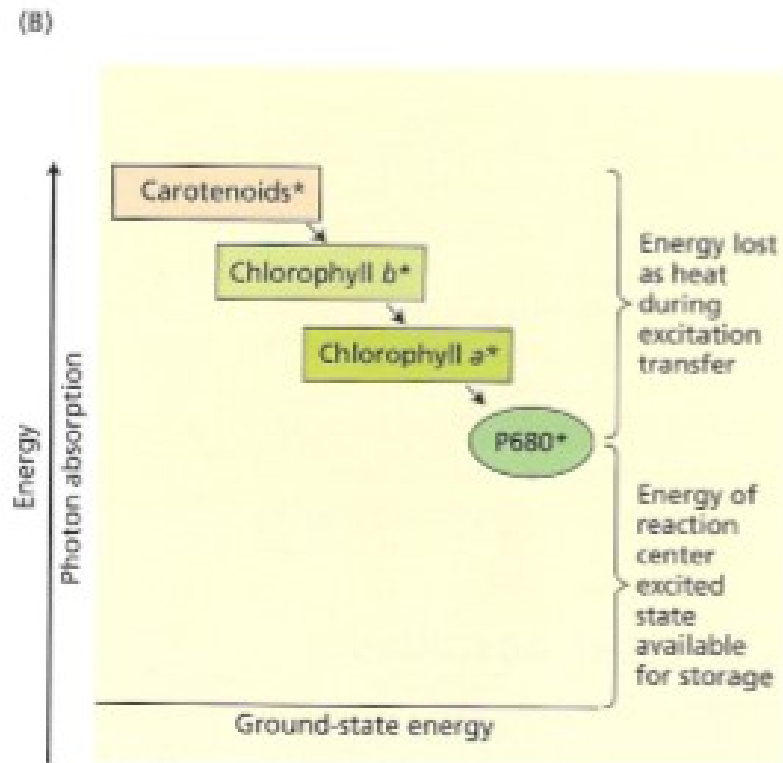
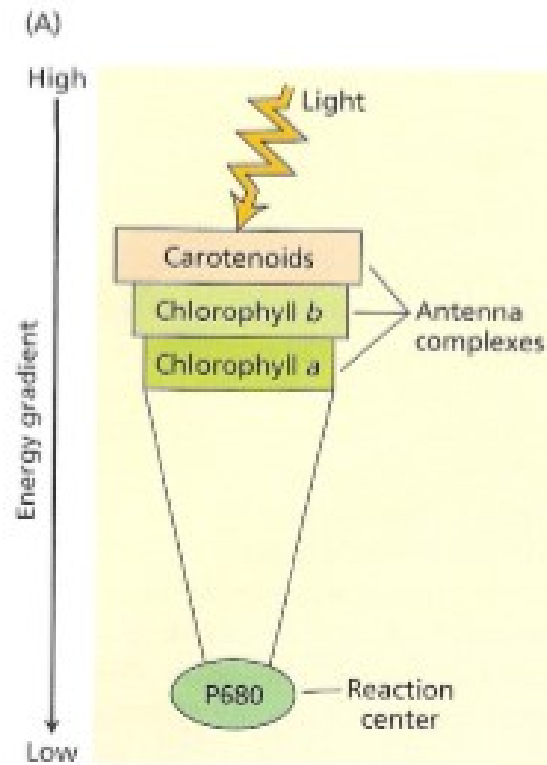
A luz e os pigmentos fotossintéticos



A fotossíntese

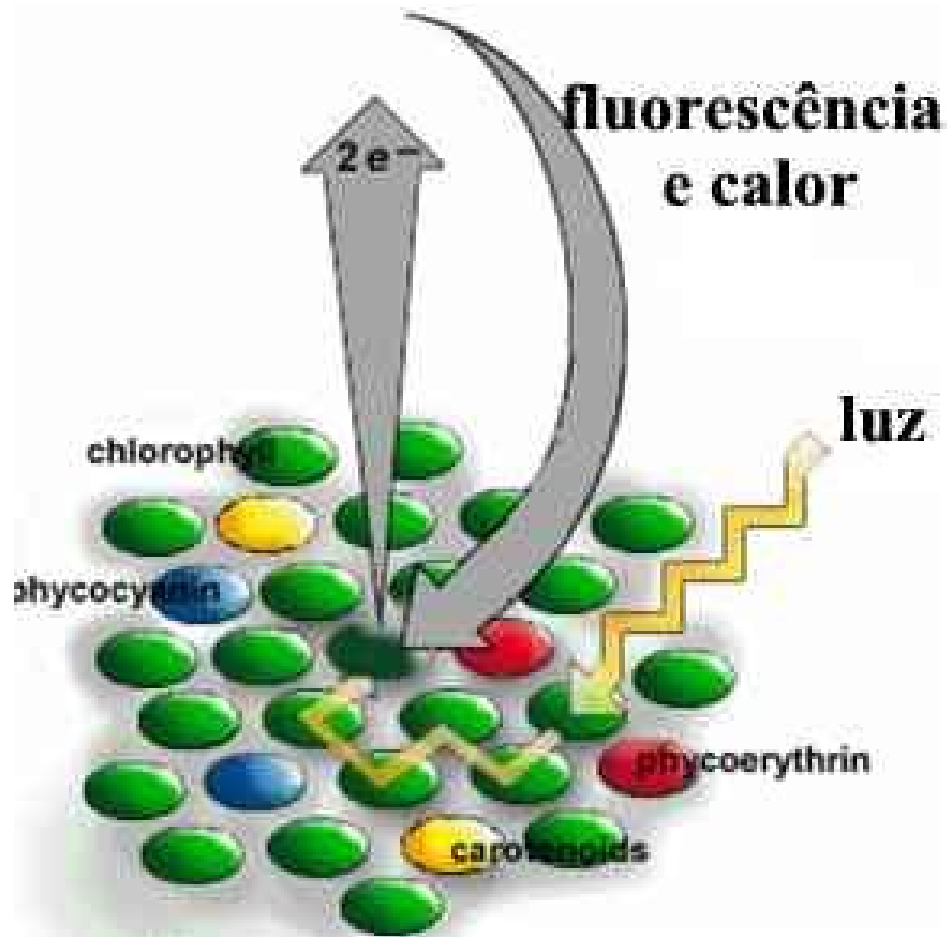


A luz e os pigmentos fotossintéticos



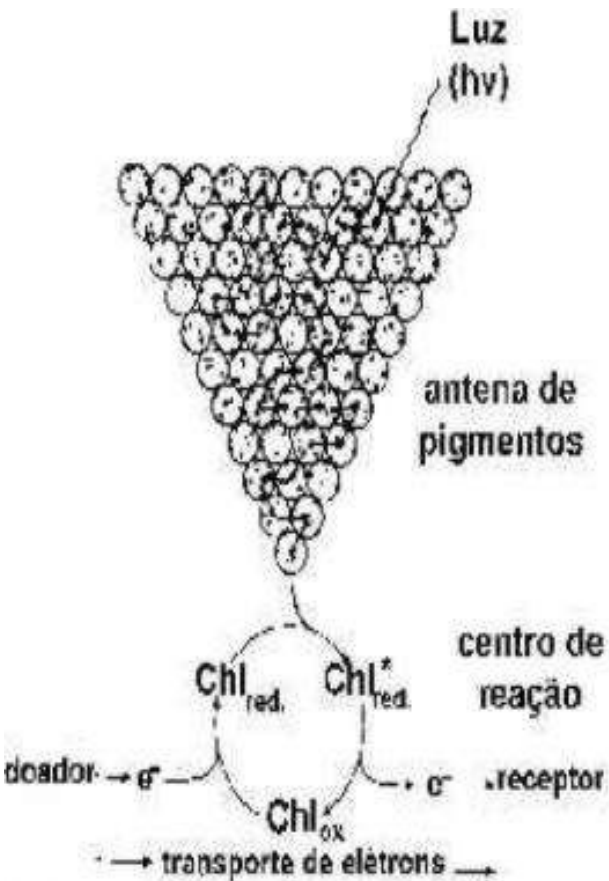
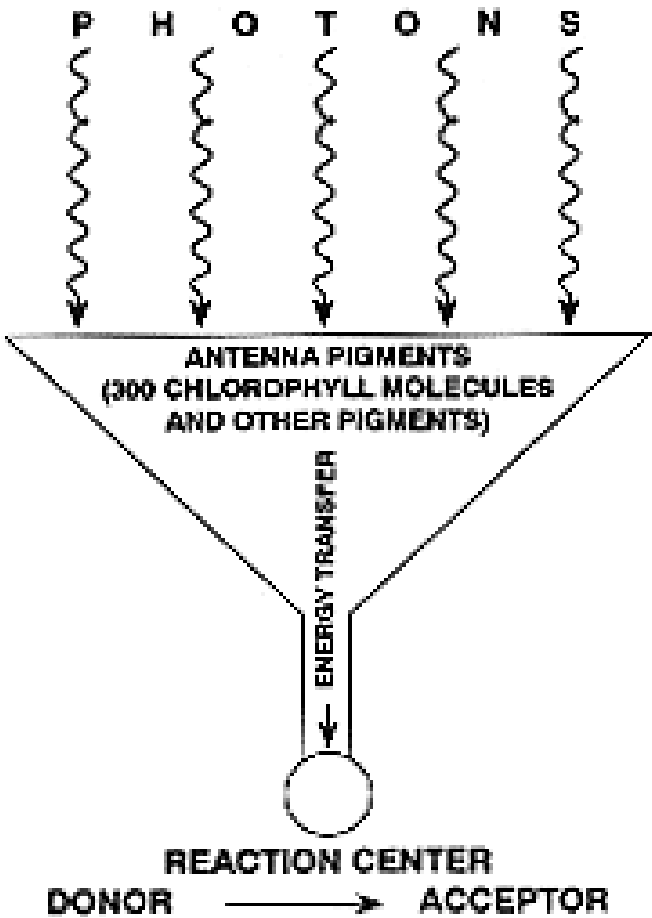
O cloroplasto: estrutura e tipos de reacções bioquímicas

Conceito de fotossistema, fotossistema I e fotossistema II



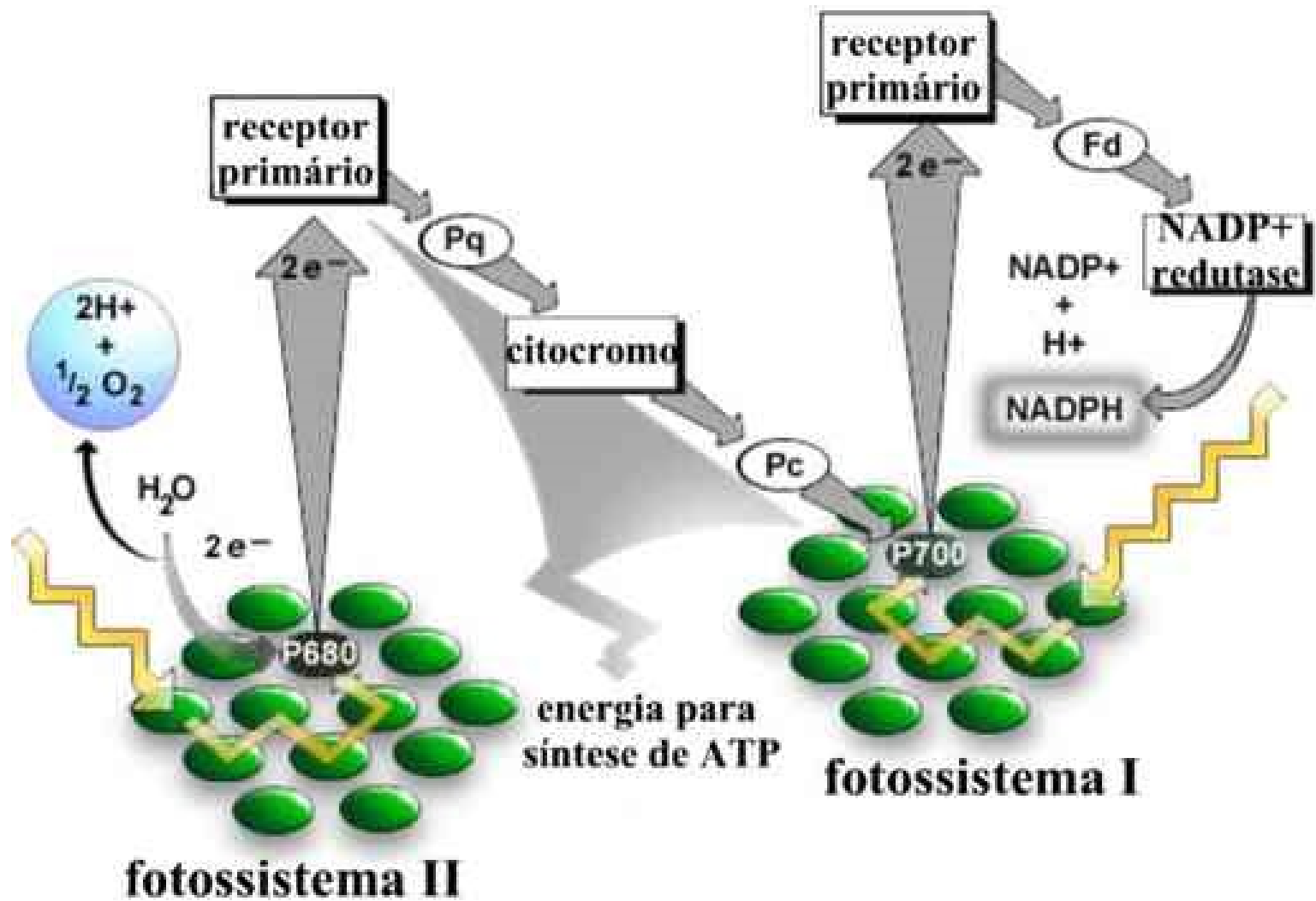
O cloroplasto: estrutura e tipos de reacções bioquímicas

Conceito de fotossistema, fotossistema I e fotossistema II

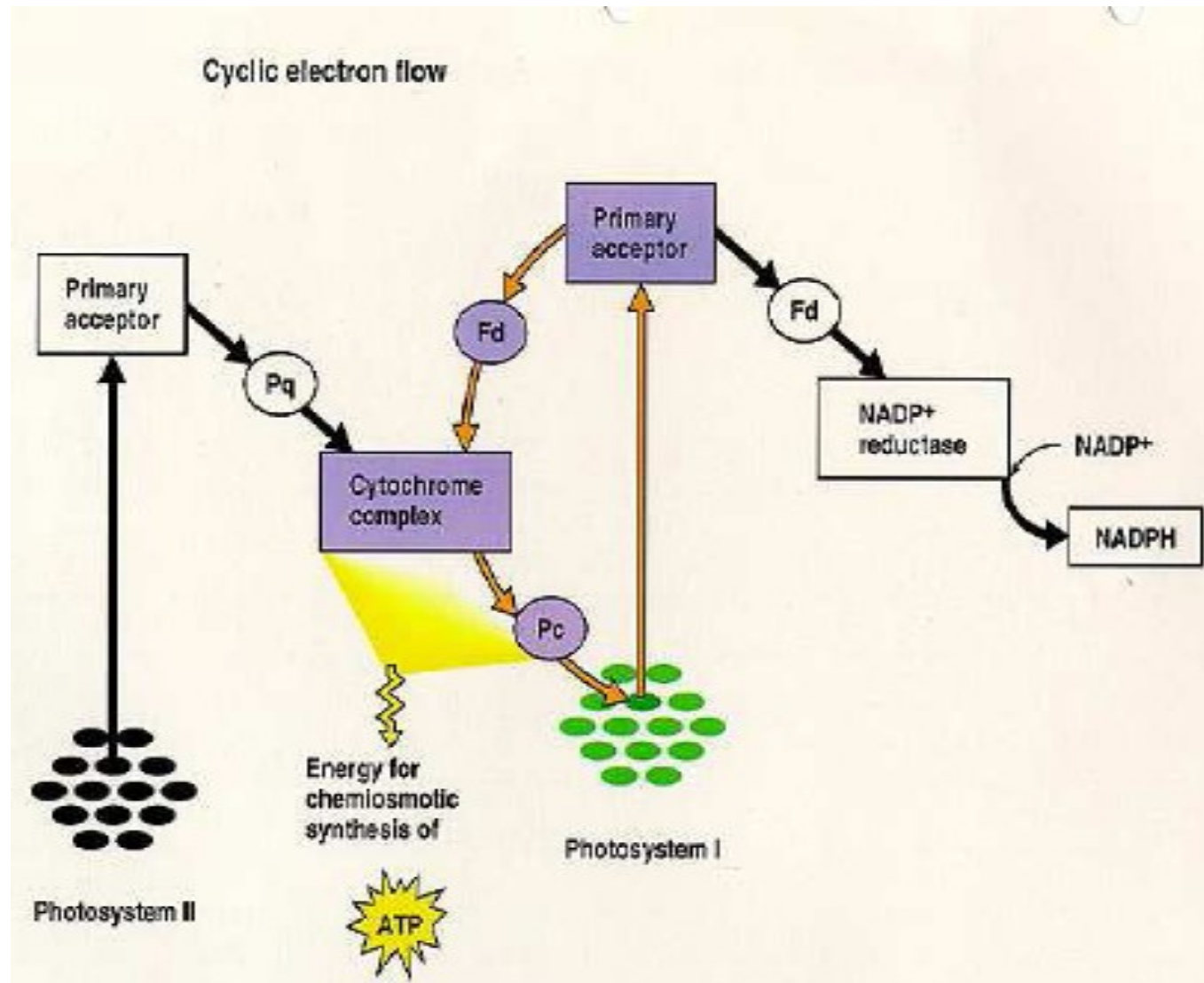


Fosforilação

Transporte de electrões cíclico e não cíclico

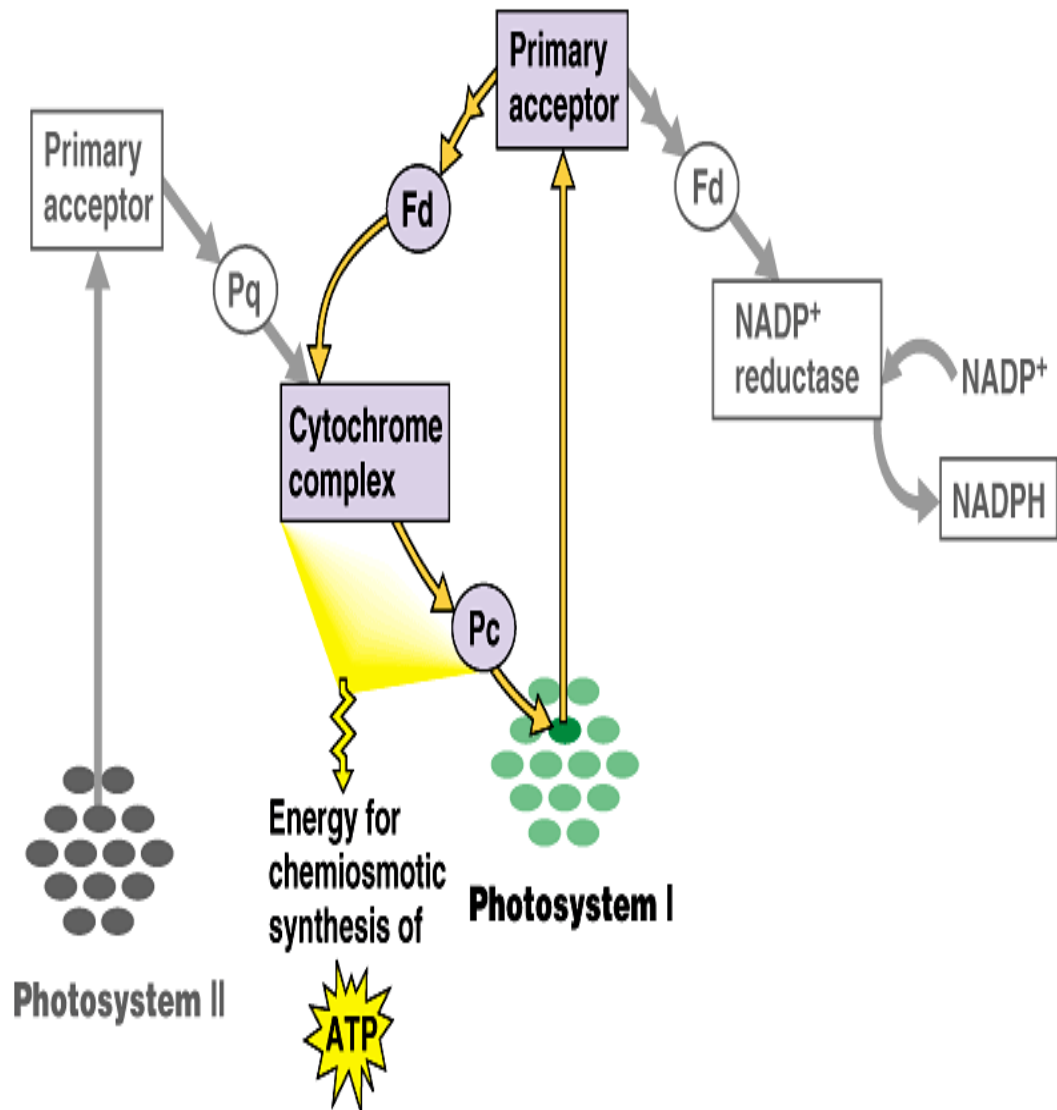


Transporte de electrões cíclico e não cíclico



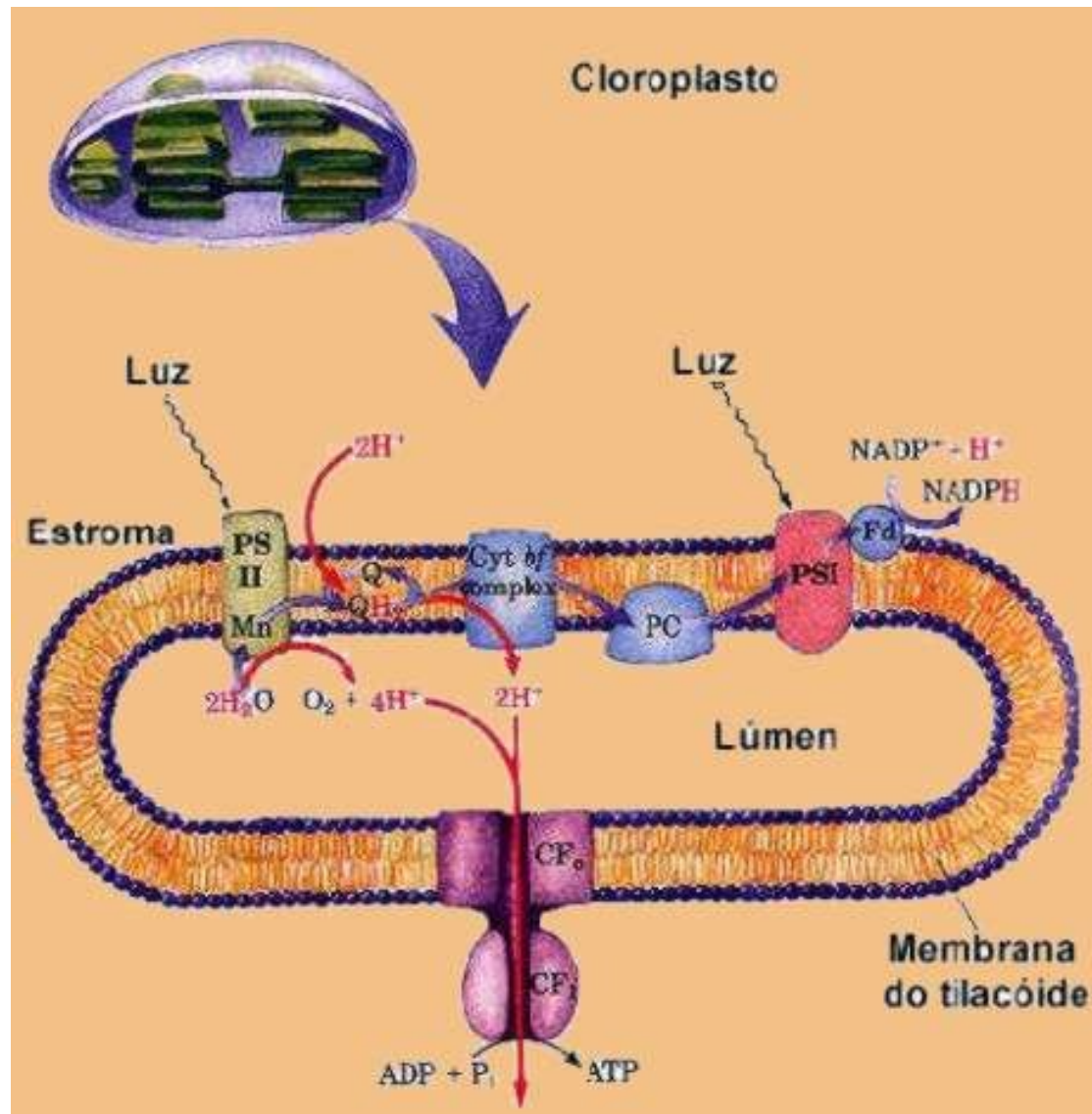
Fosforilação

Transporte de electrões cíclico e não cíclico



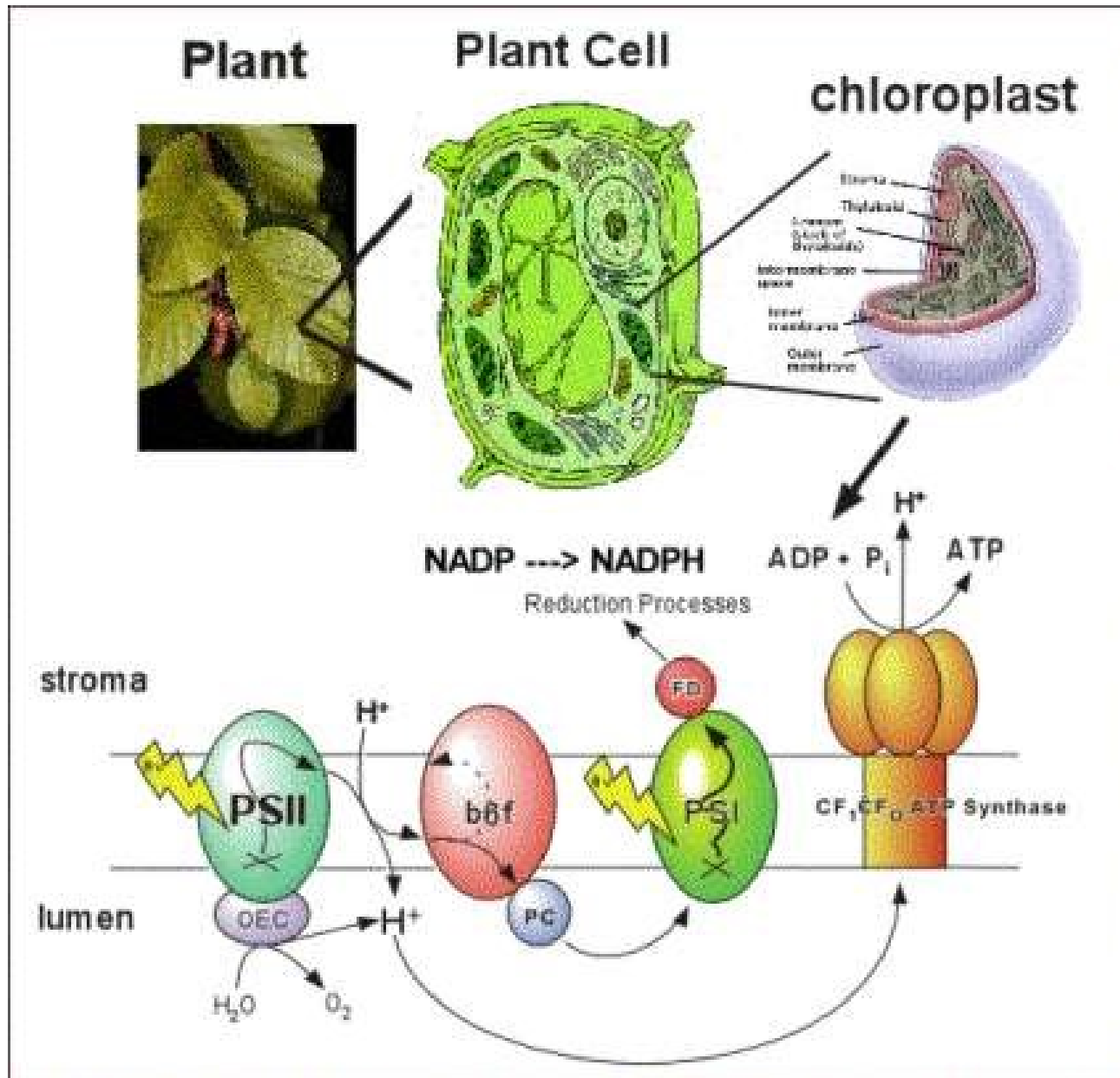
Fosforilação

Transporte de electrões cíclico e não cíclico



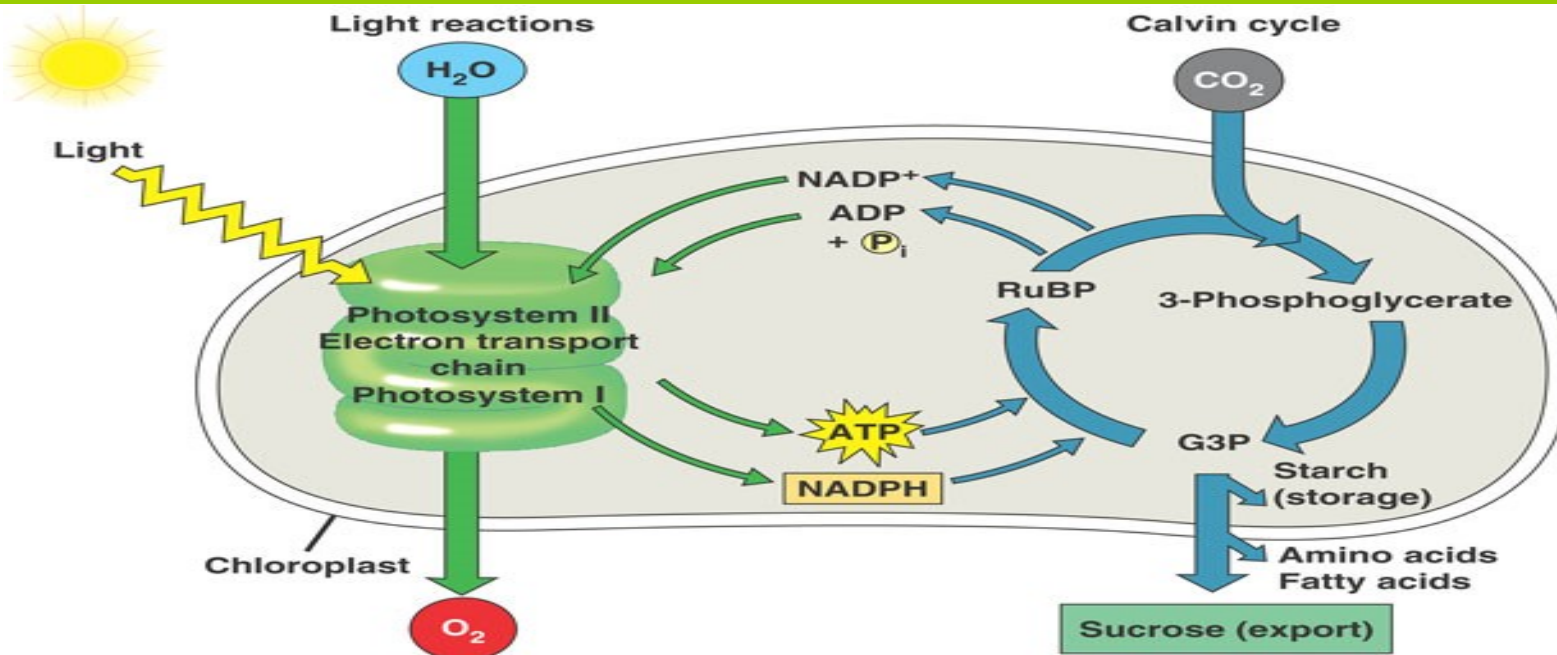
Fosforilação

Transporte de electrões cíclico e não cíclico



O metabolismo do carbono

O ciclo redutor dos fosfatos de pentose (ciclo de Calvin): activação e regulação do ciclo

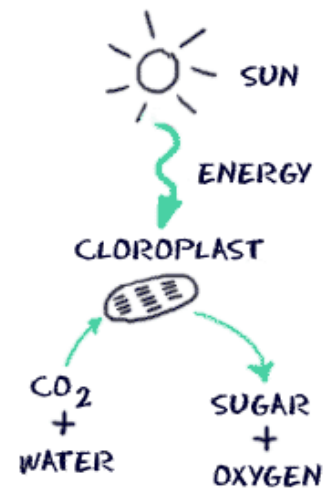


Light reactions:

- Are carried out by molecules in the thylakoid membranes
- Convert light energy to the chemical energy of ATP and NADPH
- Split H_2O and release O_2 to the atmosphere

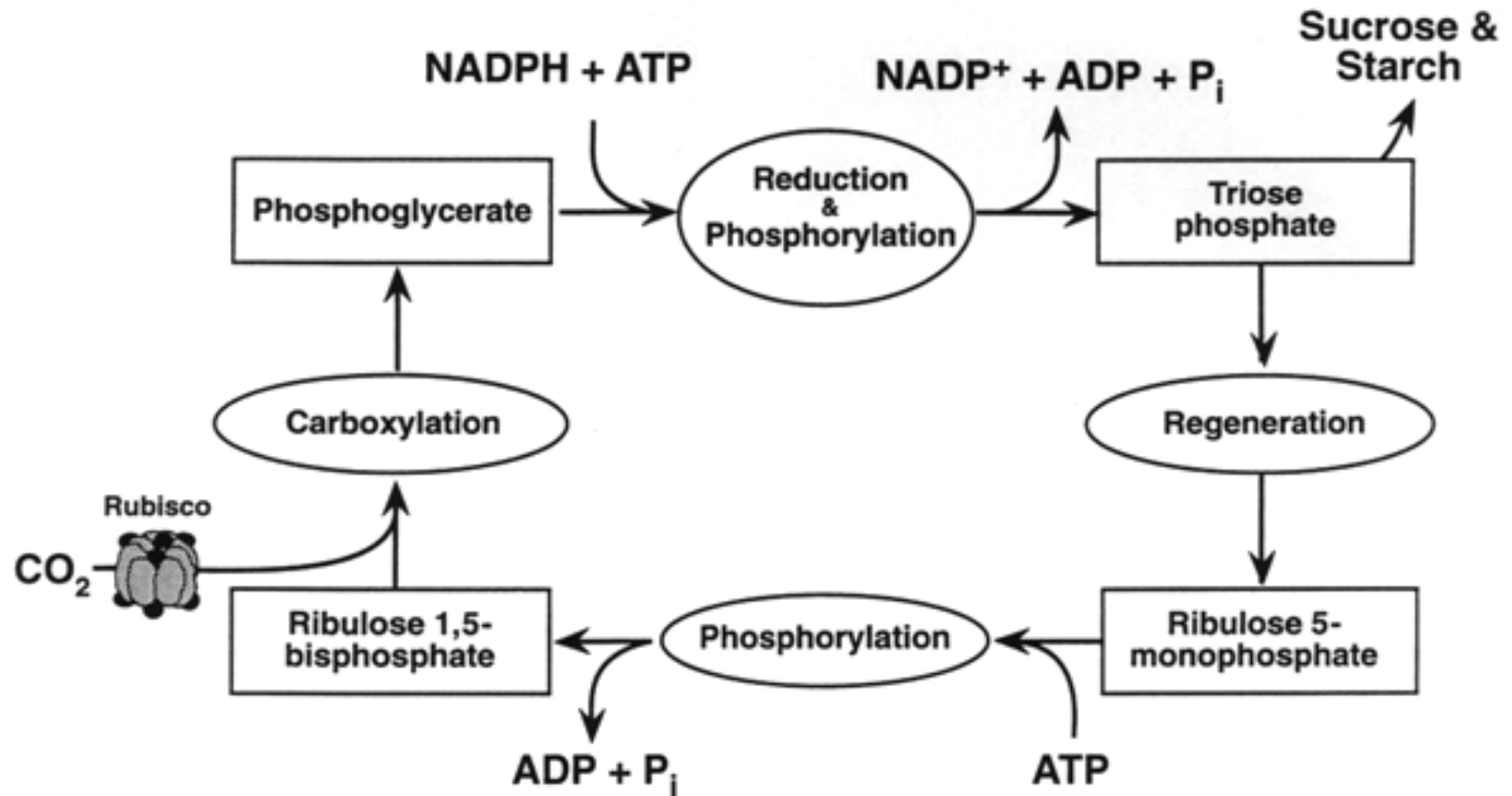
Calvin cycle reactions:

- Take place in the stroma
- Use ATP and NADPH to convert CO_2 to the sugar G3P
- Return ADP, inorganic phosphate, and $NADP^+$ to the light reactions



O metabolismo do carbono

A assimilação fotossintética do dióxido de carbono

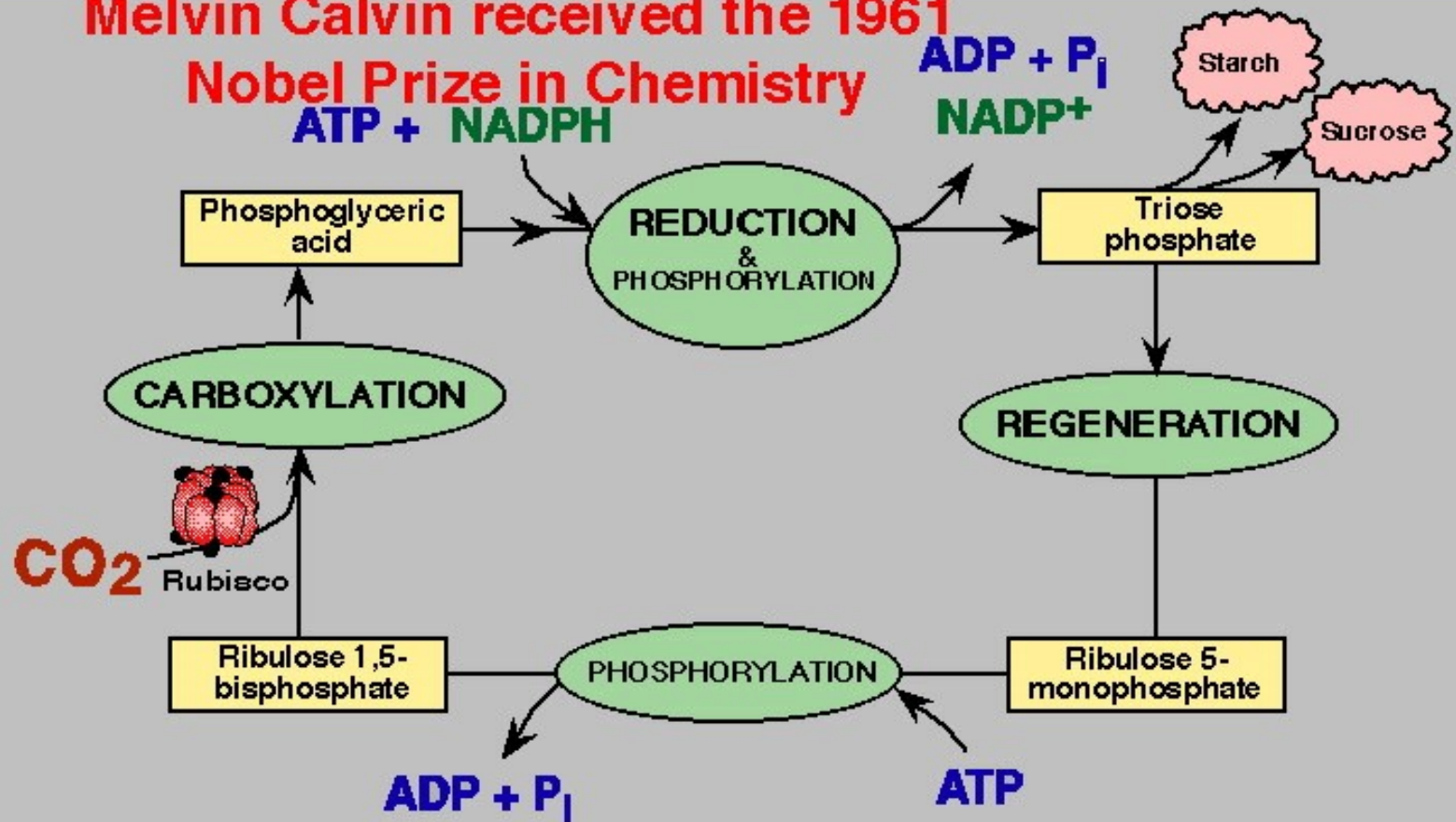


O metabolismo do carbono

A assimilação fotossintética do dióxido de carbono

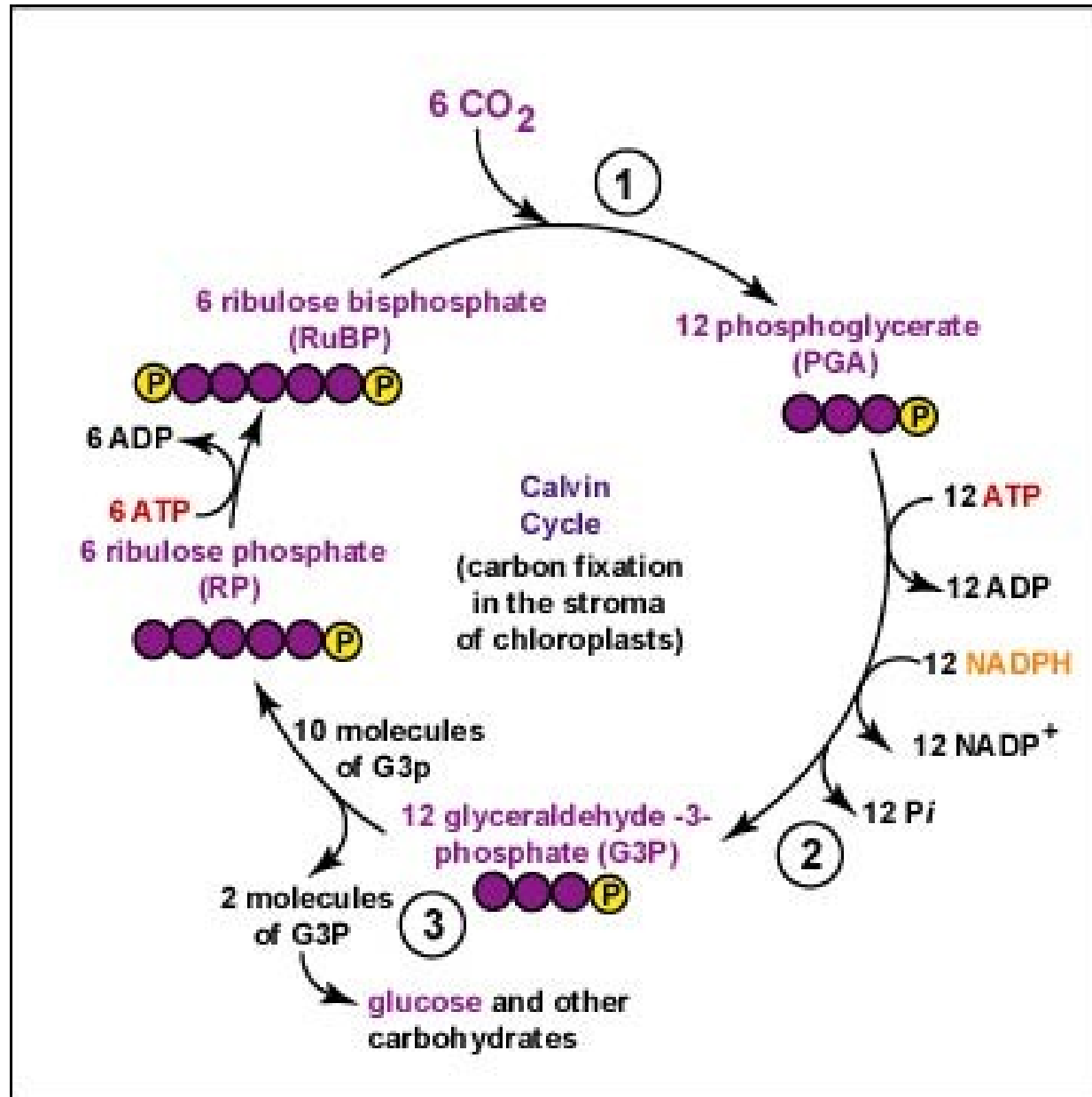
Fig.6.2, p. 57, handbook

**Melvin Calvin received the 1961
Nobel Prize in Chemistry**



O metabolismo do carbono

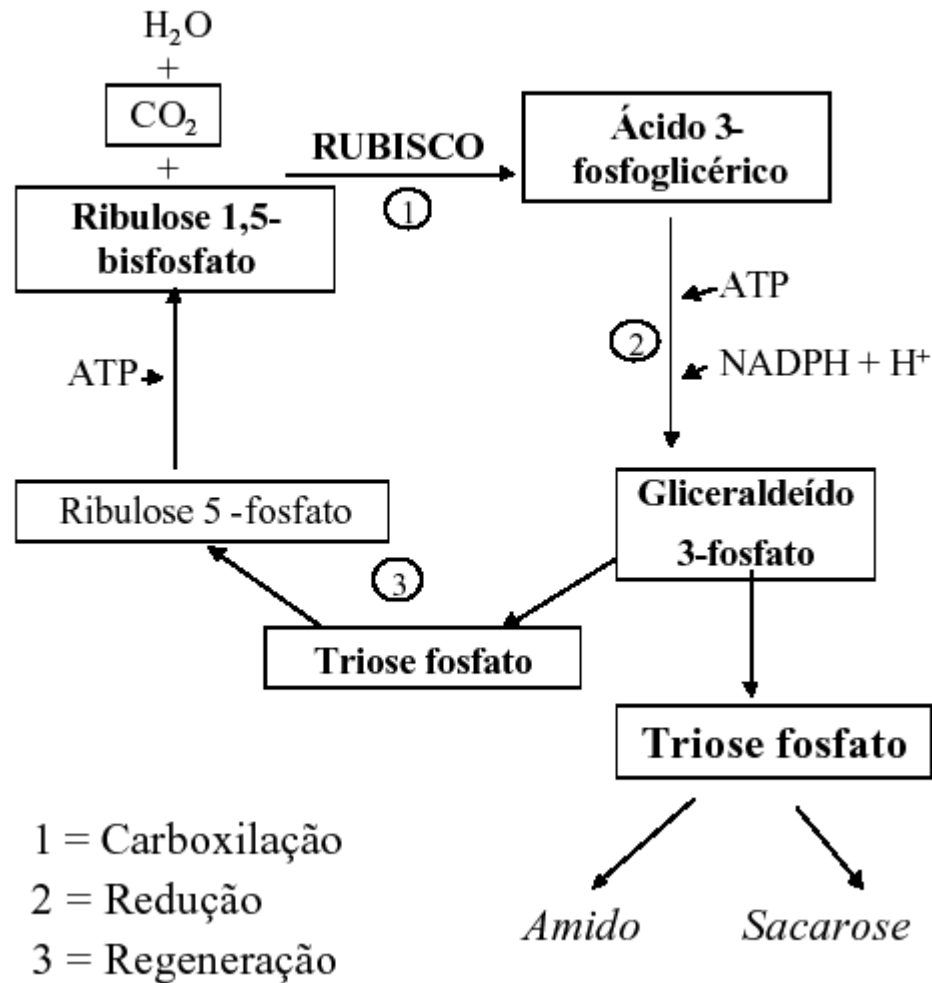
A assimilação fotossintética do dióxido de carbono

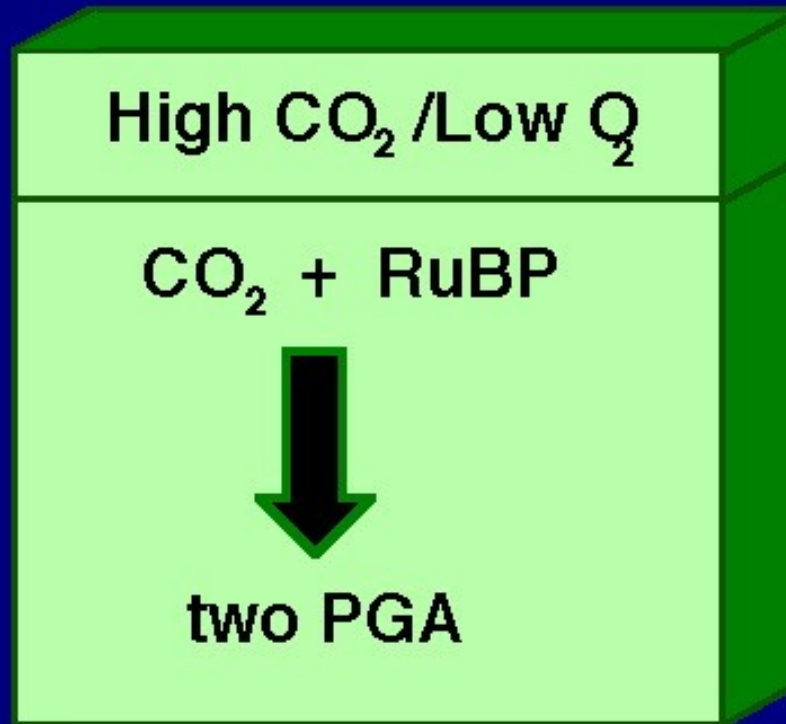


O metabolismo do carbono

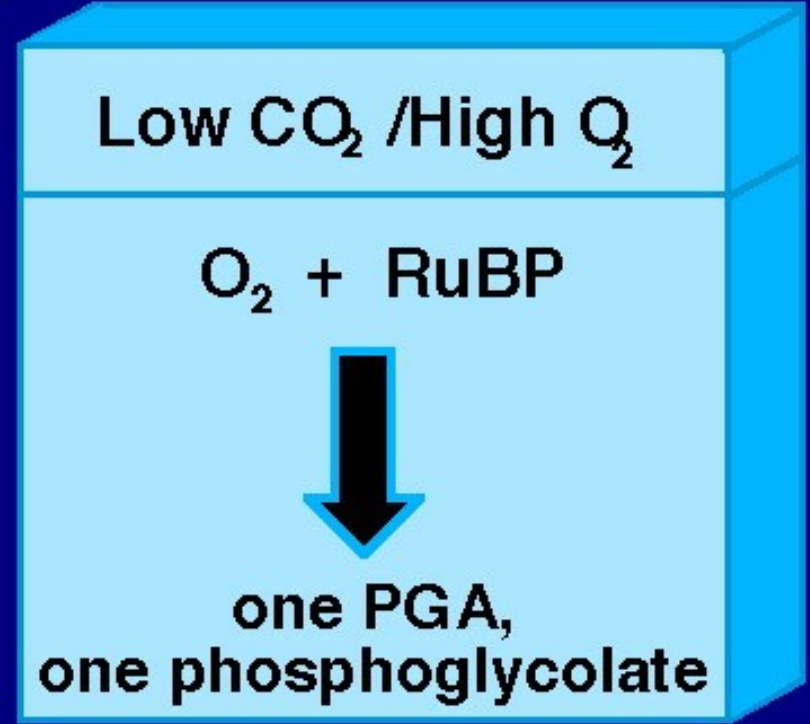
A assimilação fotossintética do dióxido de carbono

Ciclo de Calvin-Benson



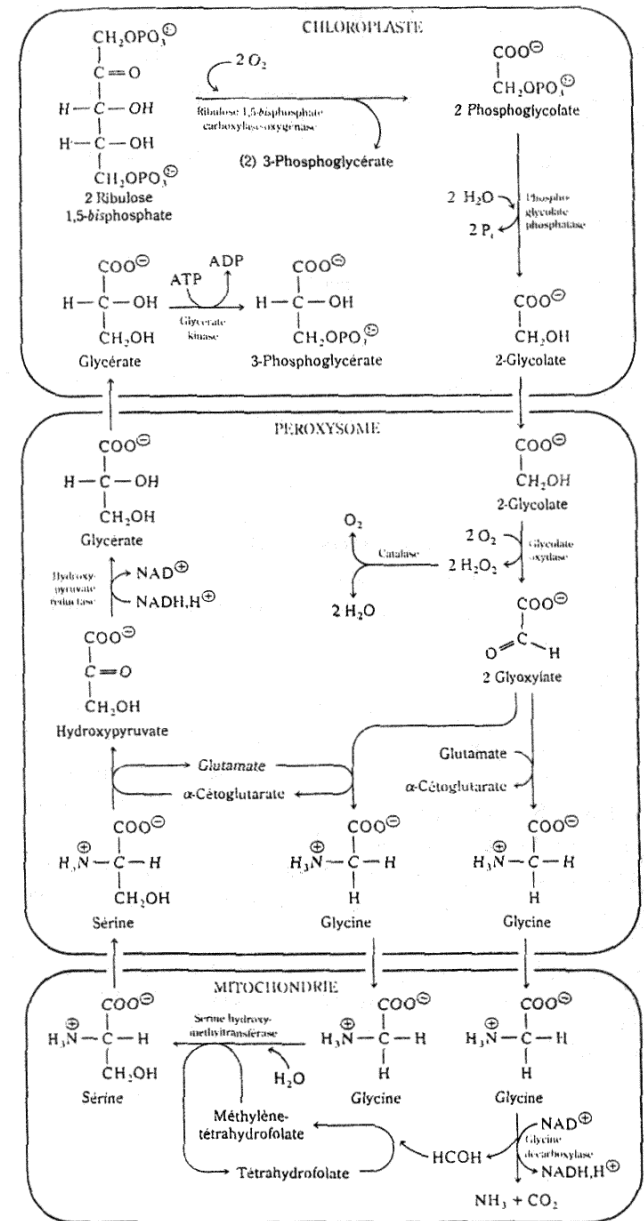
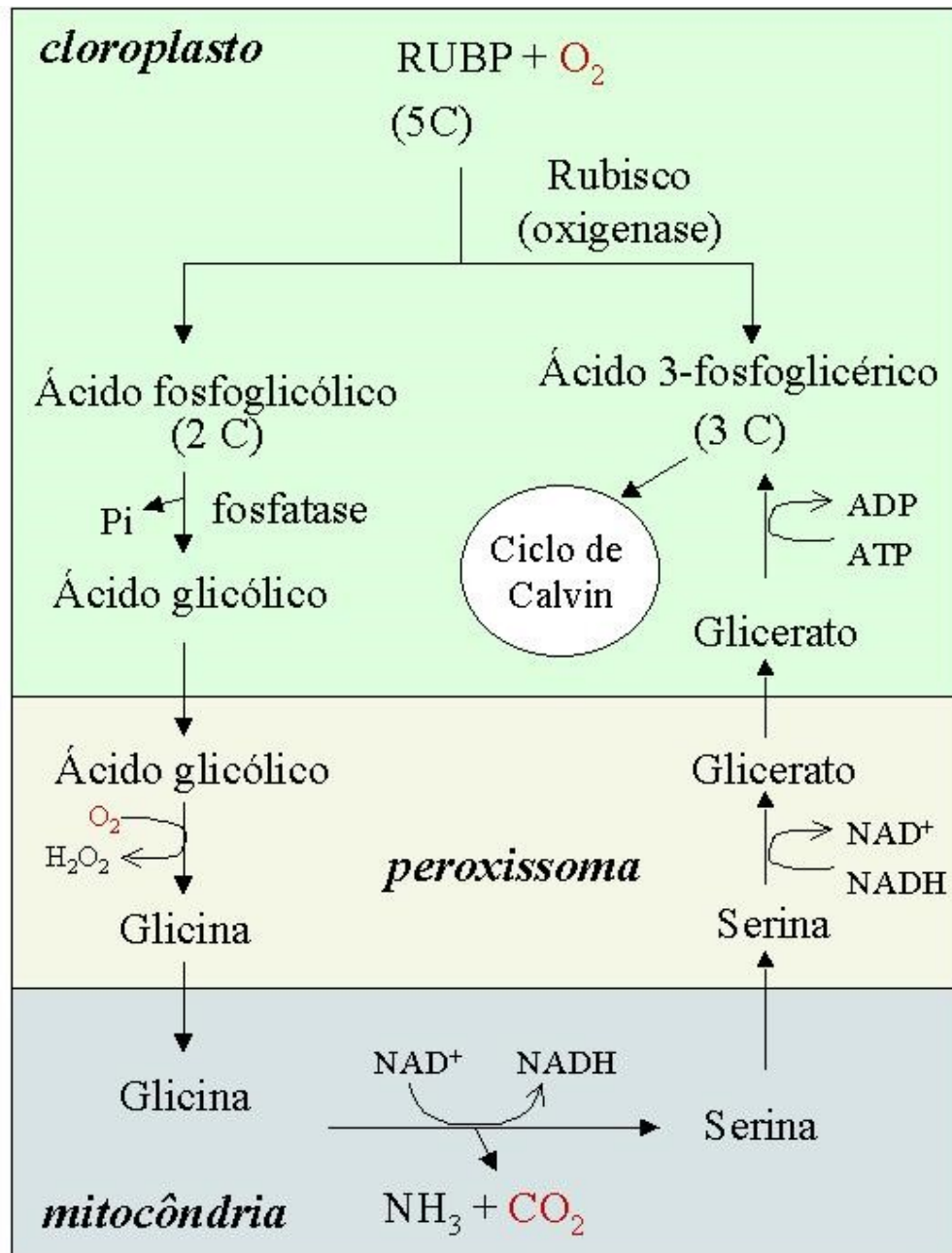


**Calvin cycle
dominates**

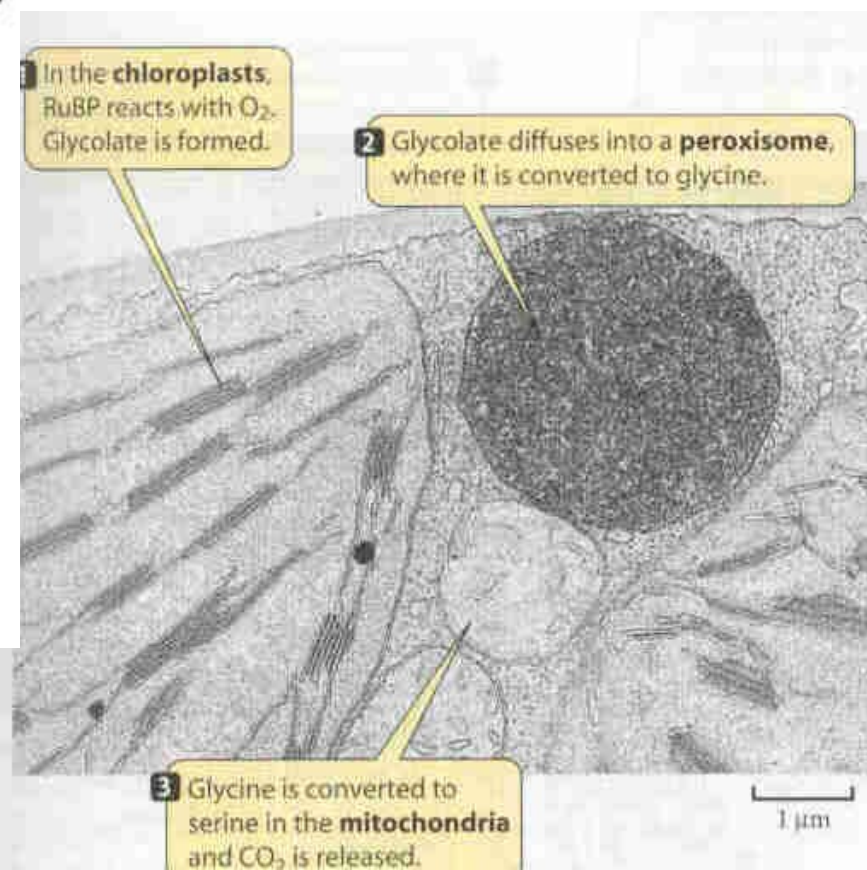
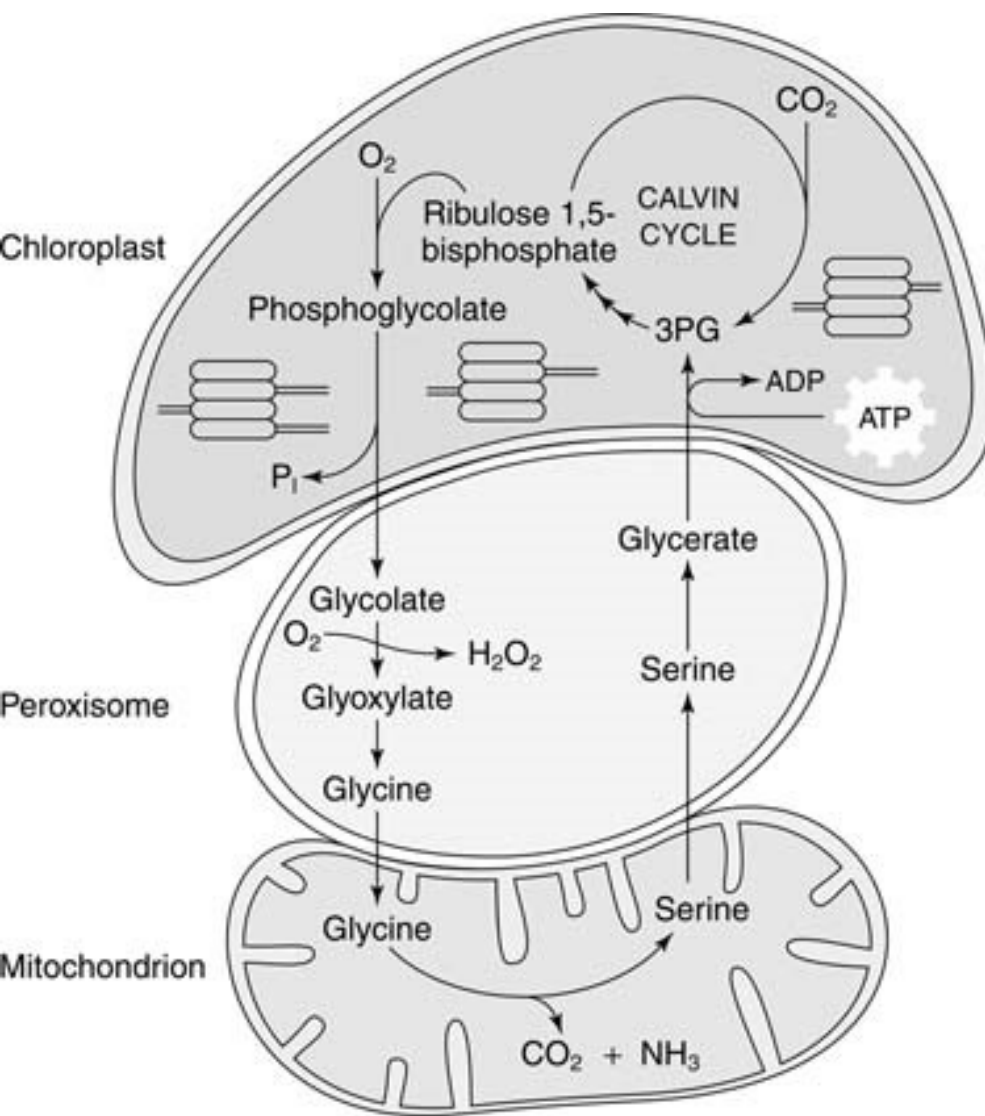


***Photorespiration*
dominates**

A fotorespiração – função e importância



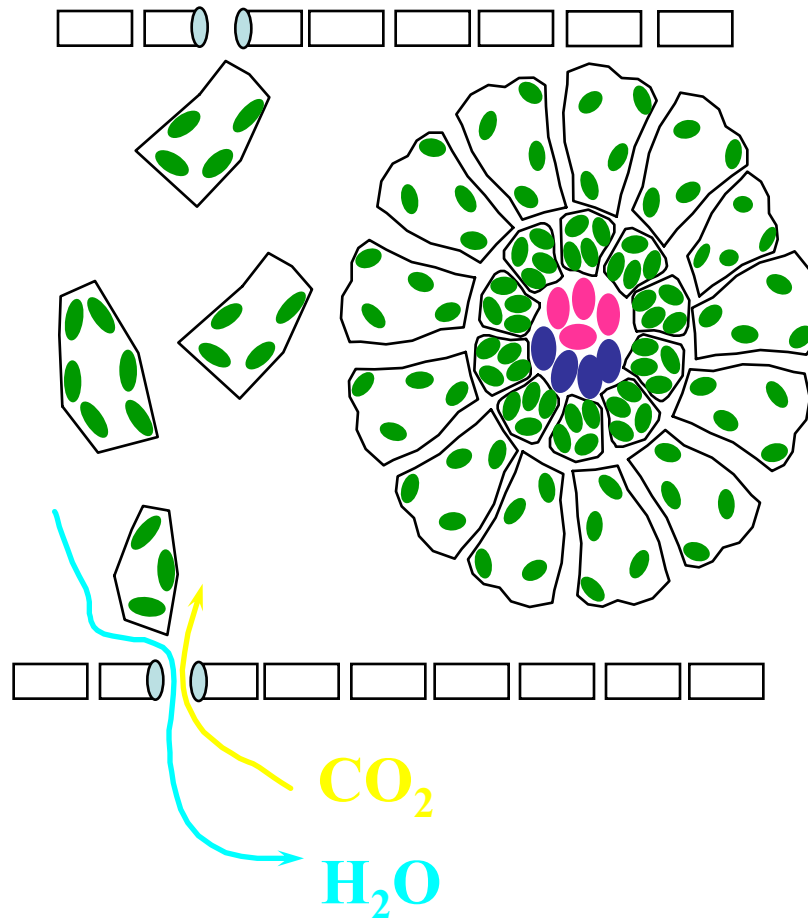
A fotorespiração – função e importância



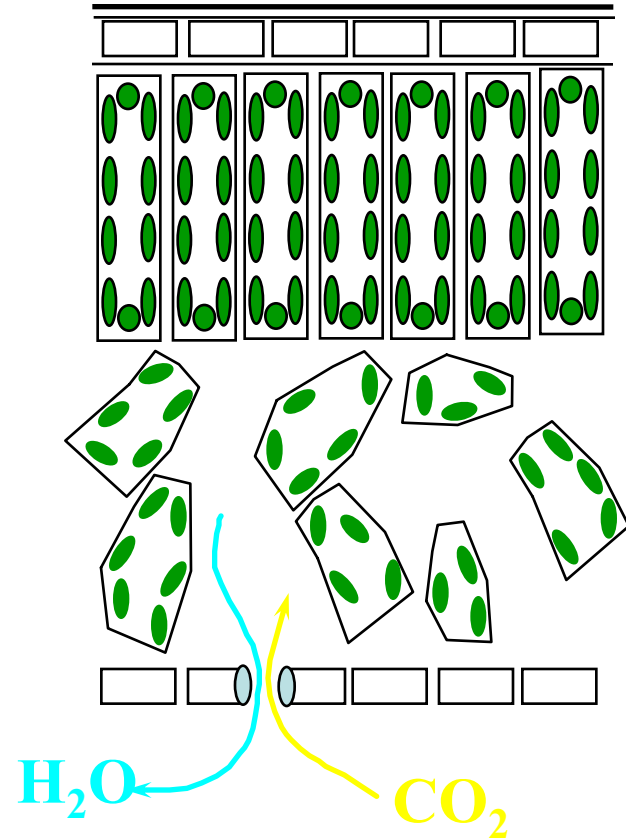


As plantas C3, as plantas C4 e as plantas CAM

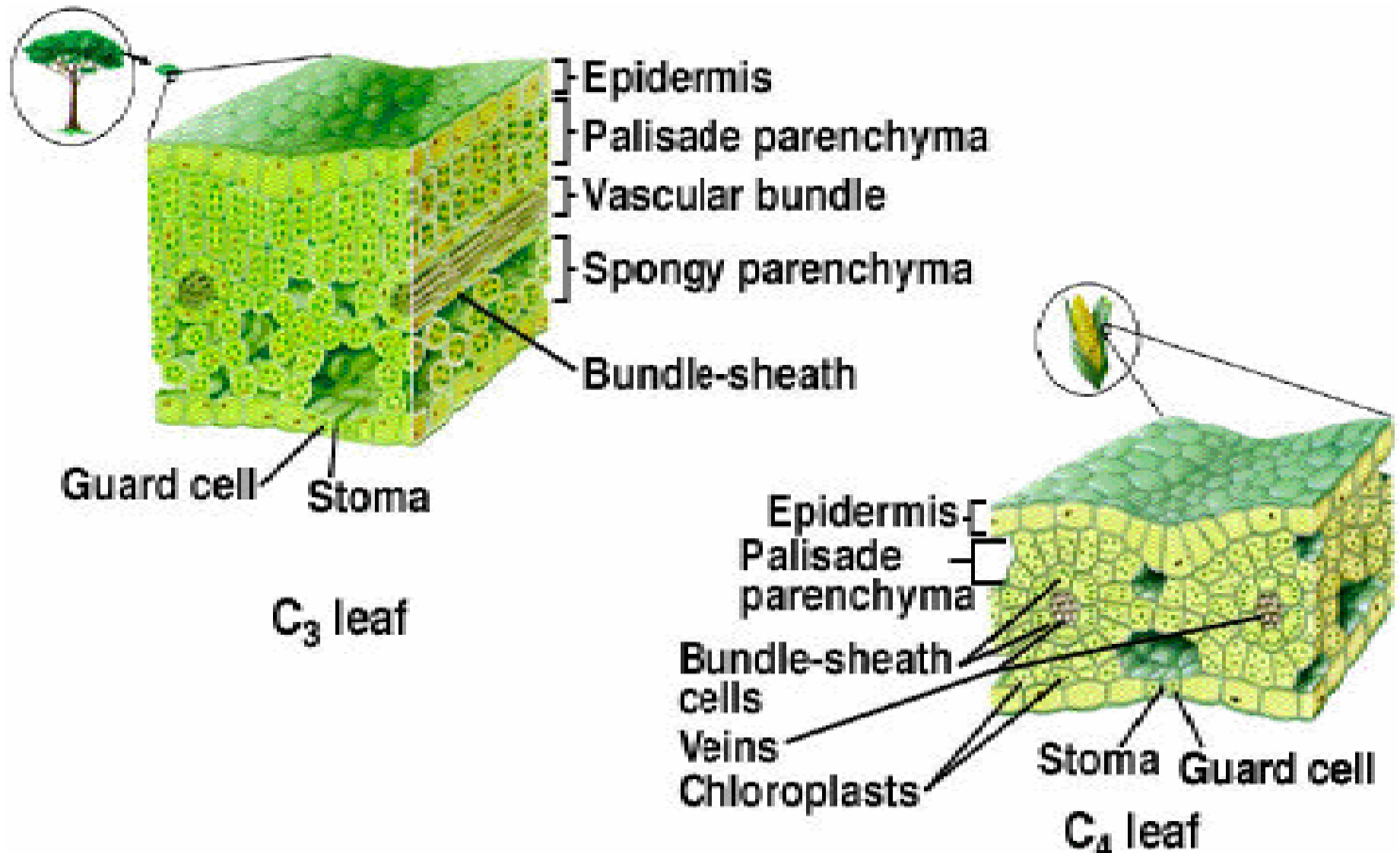
C₄ - Kranz Anatomy



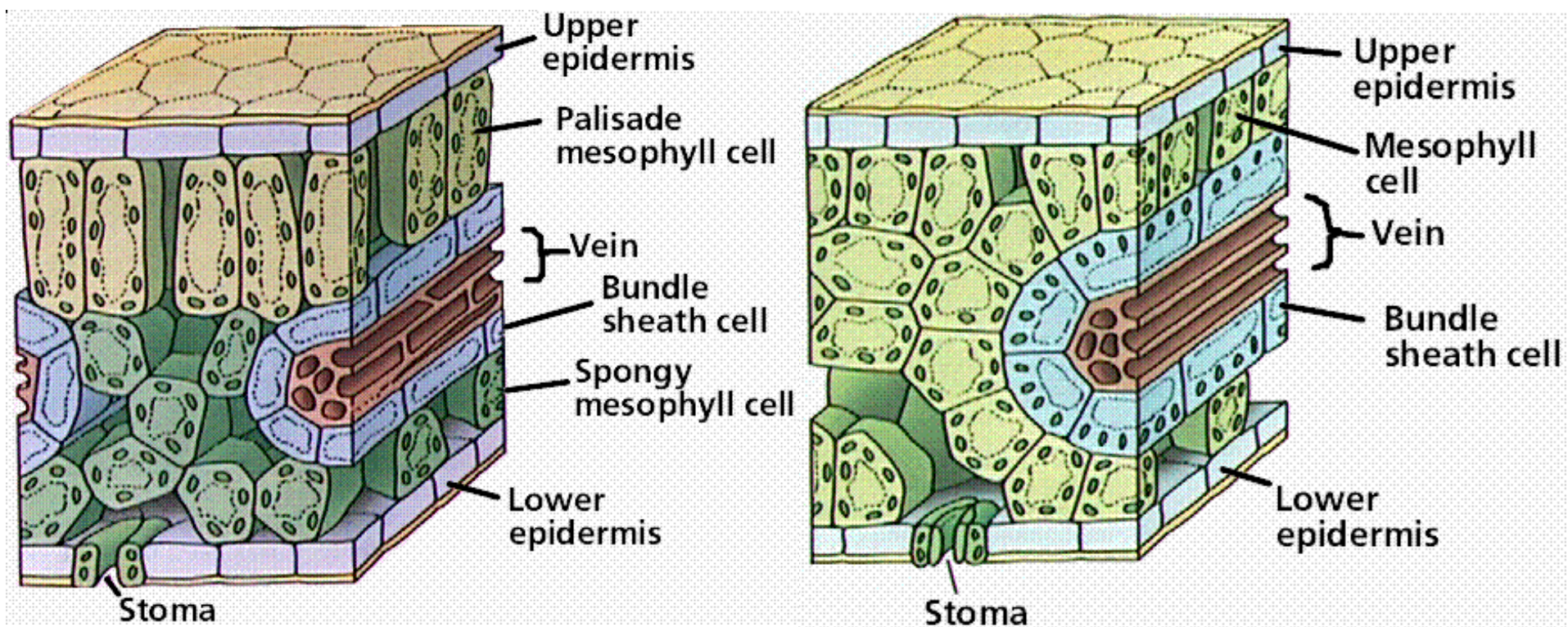
C₃



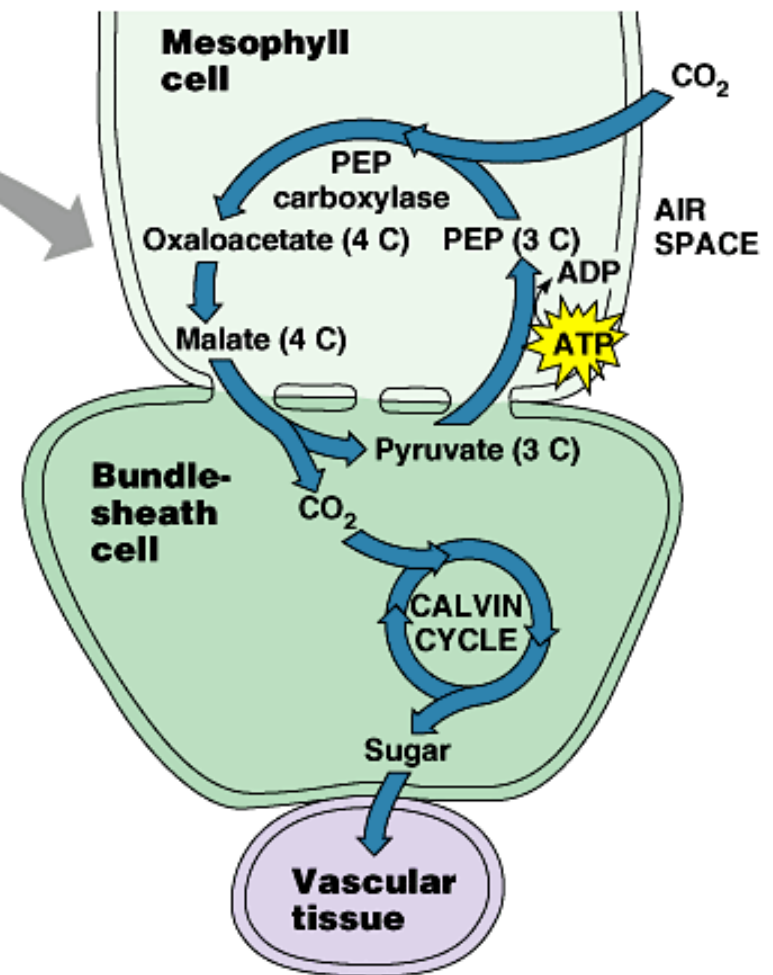
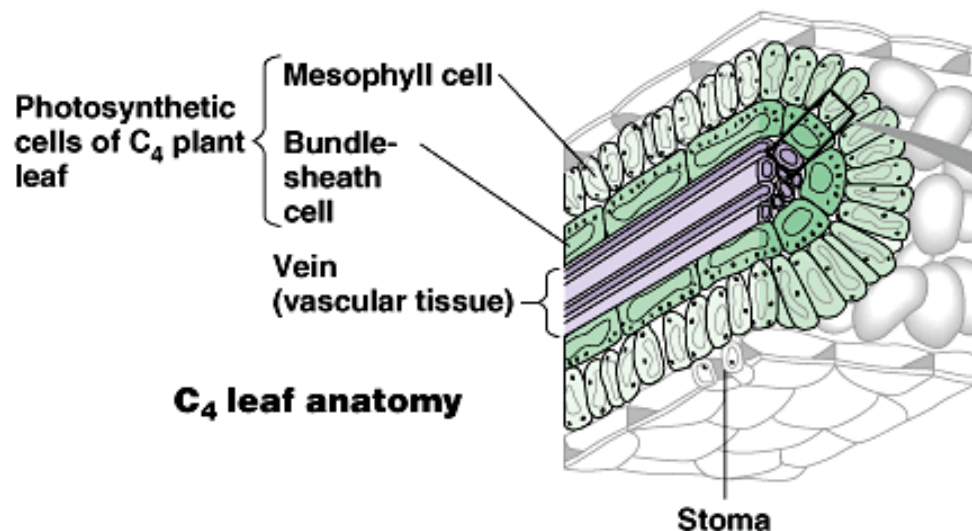
As plantas C₃, as plantas C₄ e as plantas CAM



As plantas C3, as plantas C4 e as plantas CAM

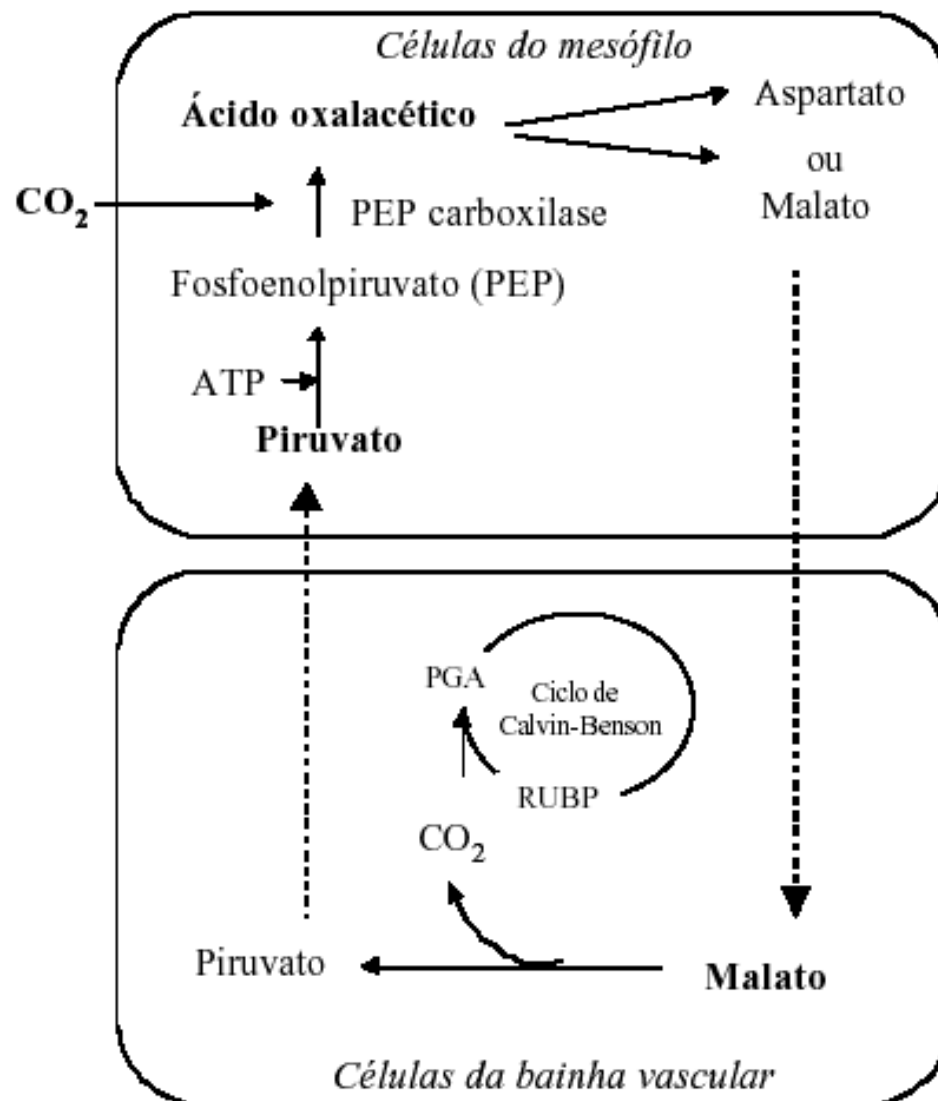


As plantas C3, as plantas C4 e as plantas CAM

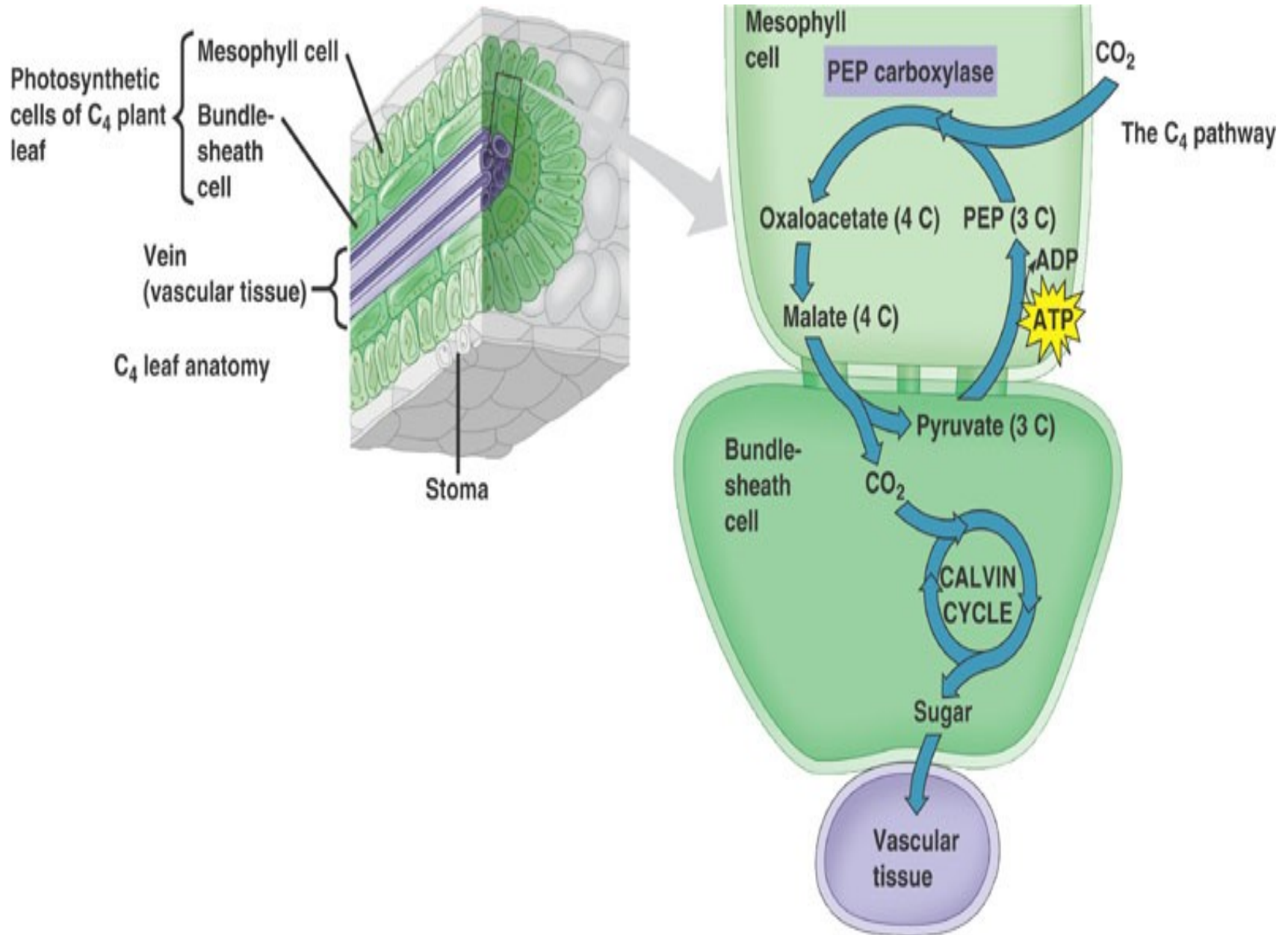


The C₄ pathway

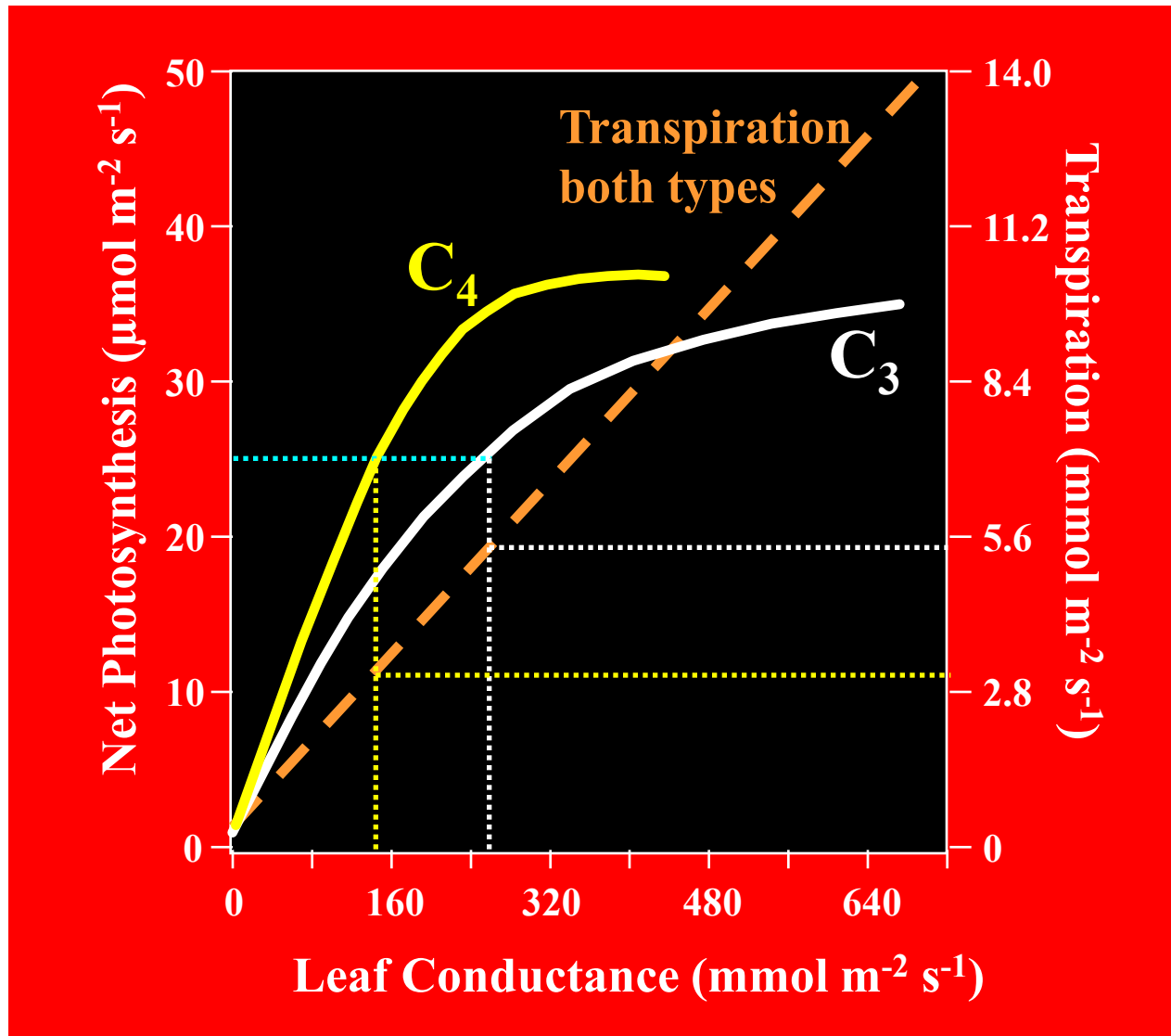
As plantas C3, as plantas C4 e as plantas CAM



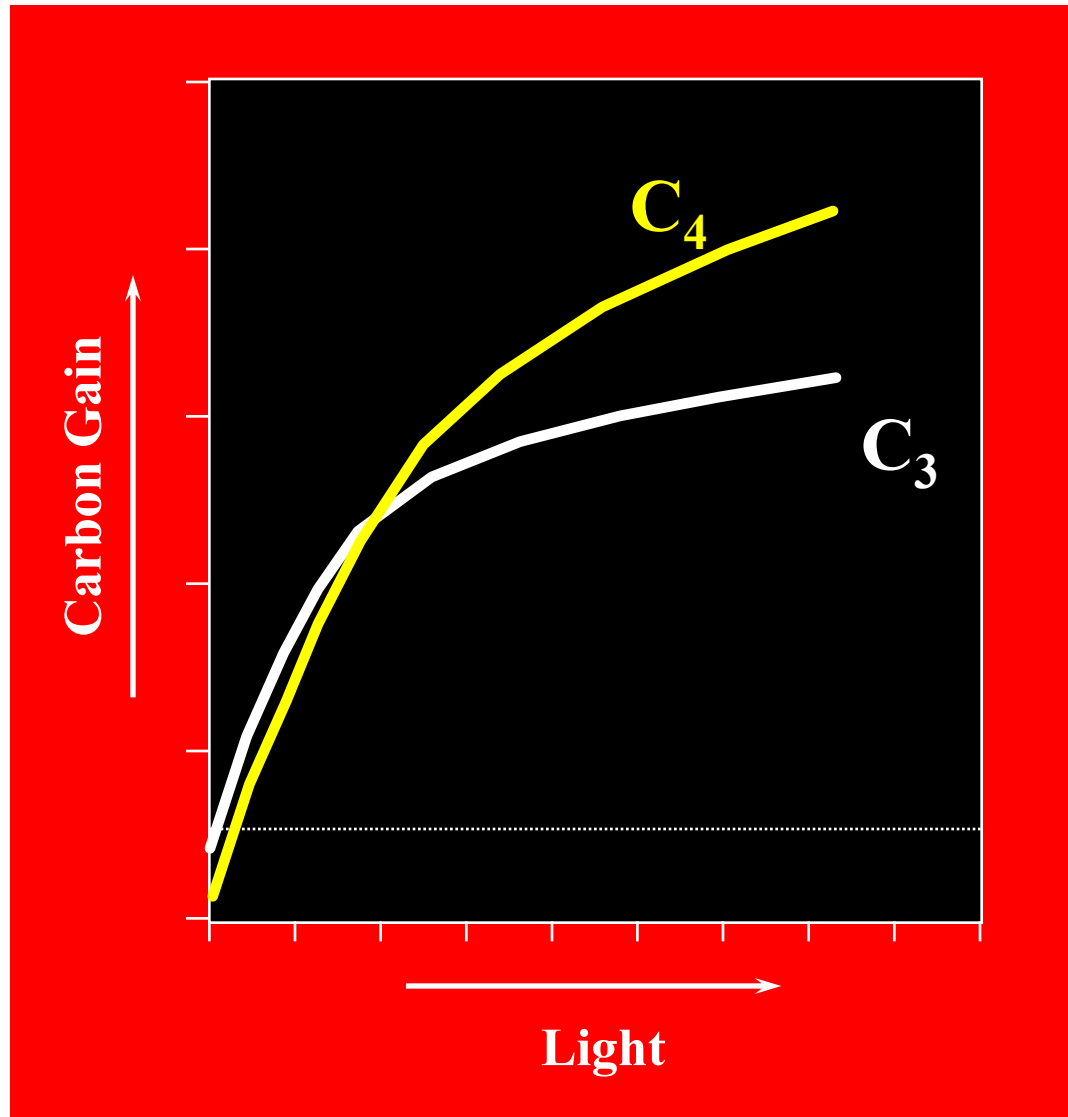
A regulação fotossintética das plantas C₄ e plantas CAM



As plantas C3, as plantas C4 e as plantas CAM

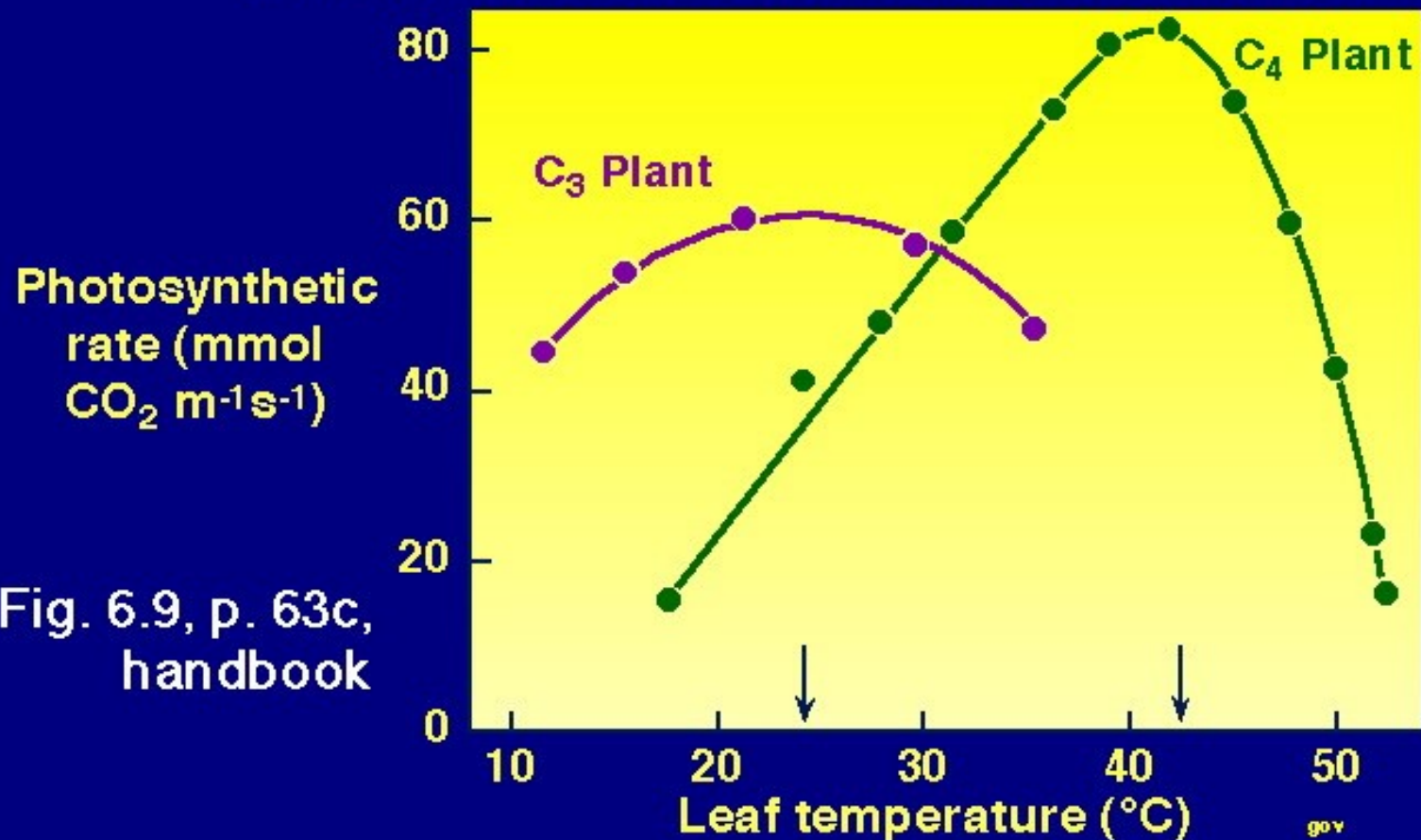


As plantas C3, as plantas C4 e as plantas CAM

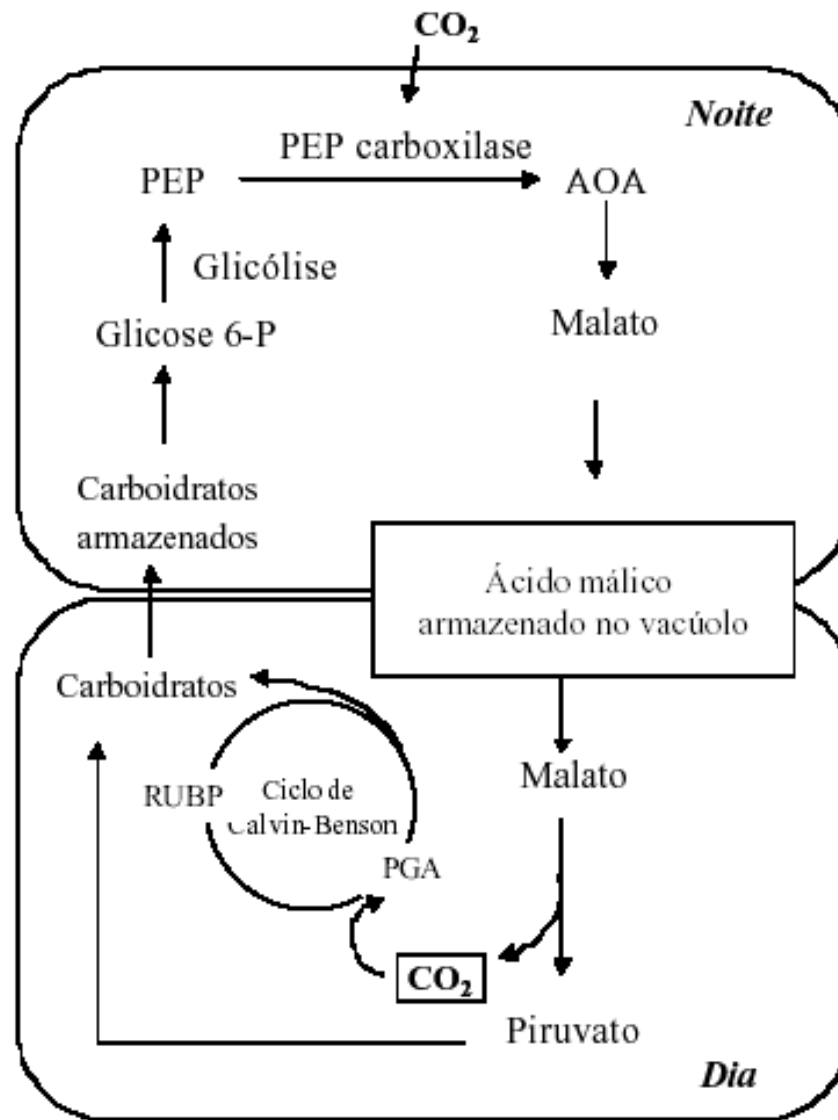


As plantas C3, as plantas C4 e as plantas CAM

The relationship of photosynthetic rate to leaf temperature in two desert ephemerals



O significado ecológico das plantas CAM.



CAM

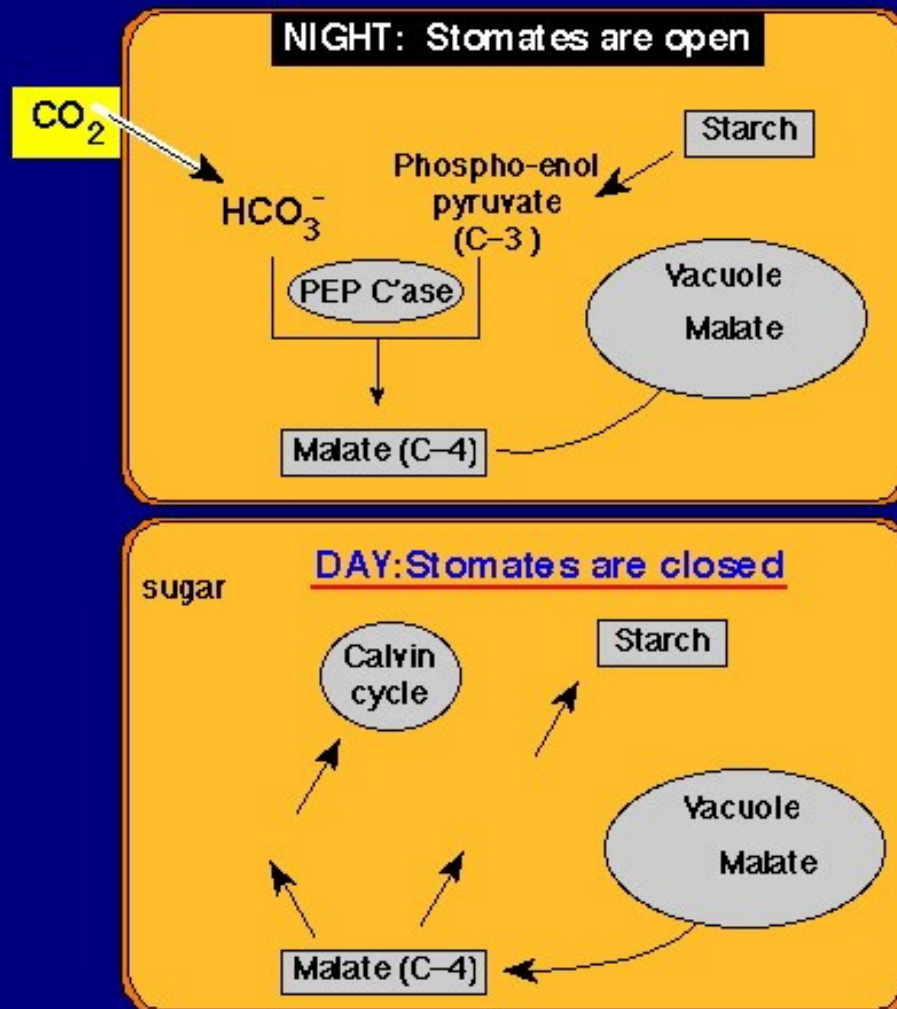


Fig. 6.6, p. 63,
handbook

As plantas C3, as plantas C4 e as plantas CAM

CO₂ fixation and transpiration rates of the CAM plant *Agave americana*.

CO₂ flux (mg CO₂/dm²/hr) influx

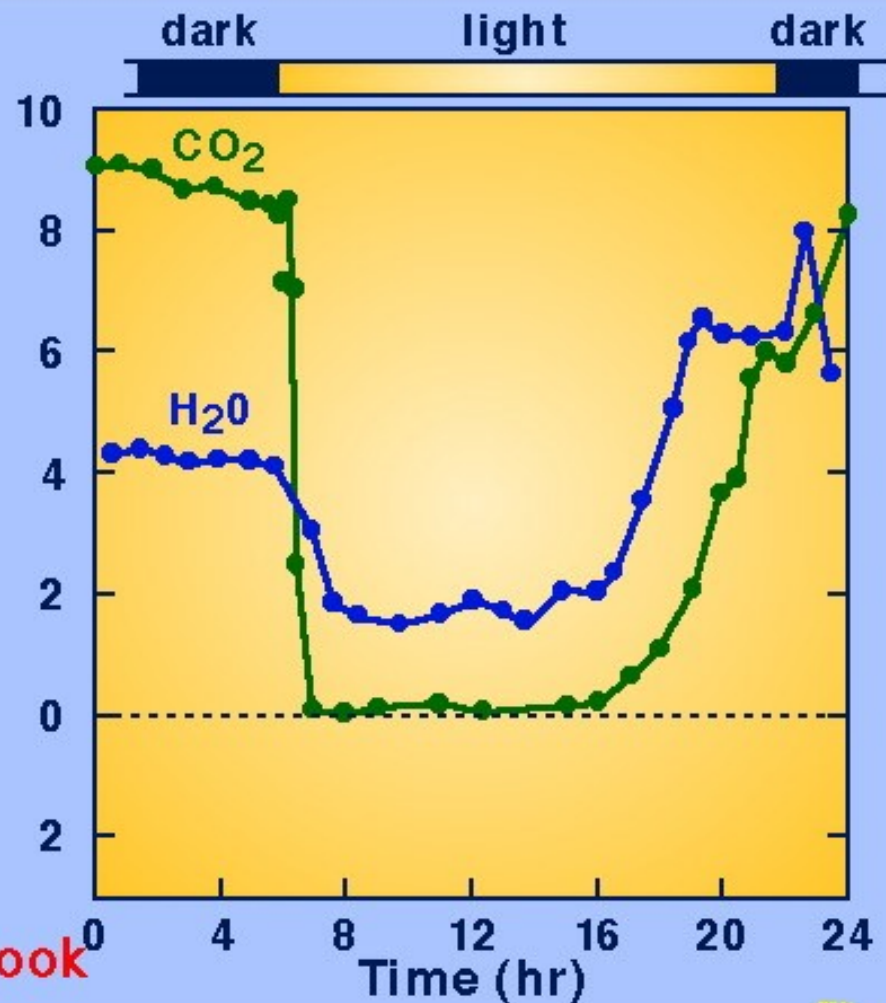


Fig. 6.7, p. 63a, handbook

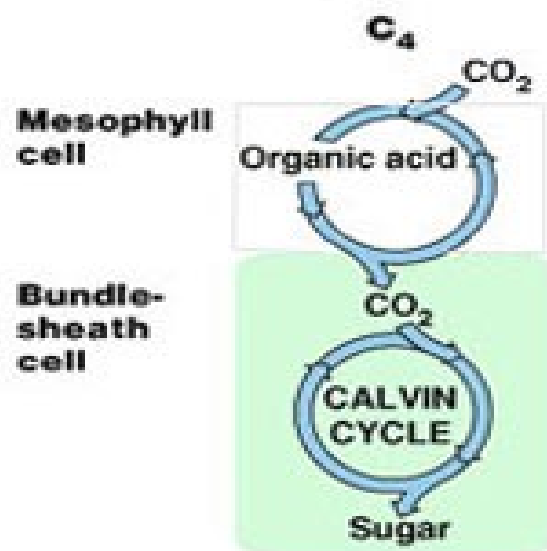
As plantas C3, as plantas C4 e as plantas CAM



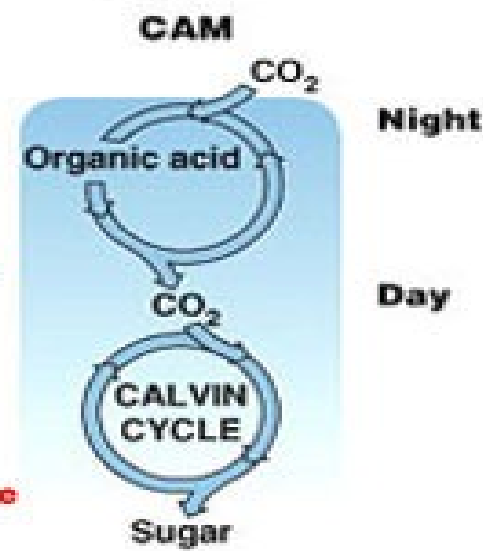
Sugarcane



Pineapple



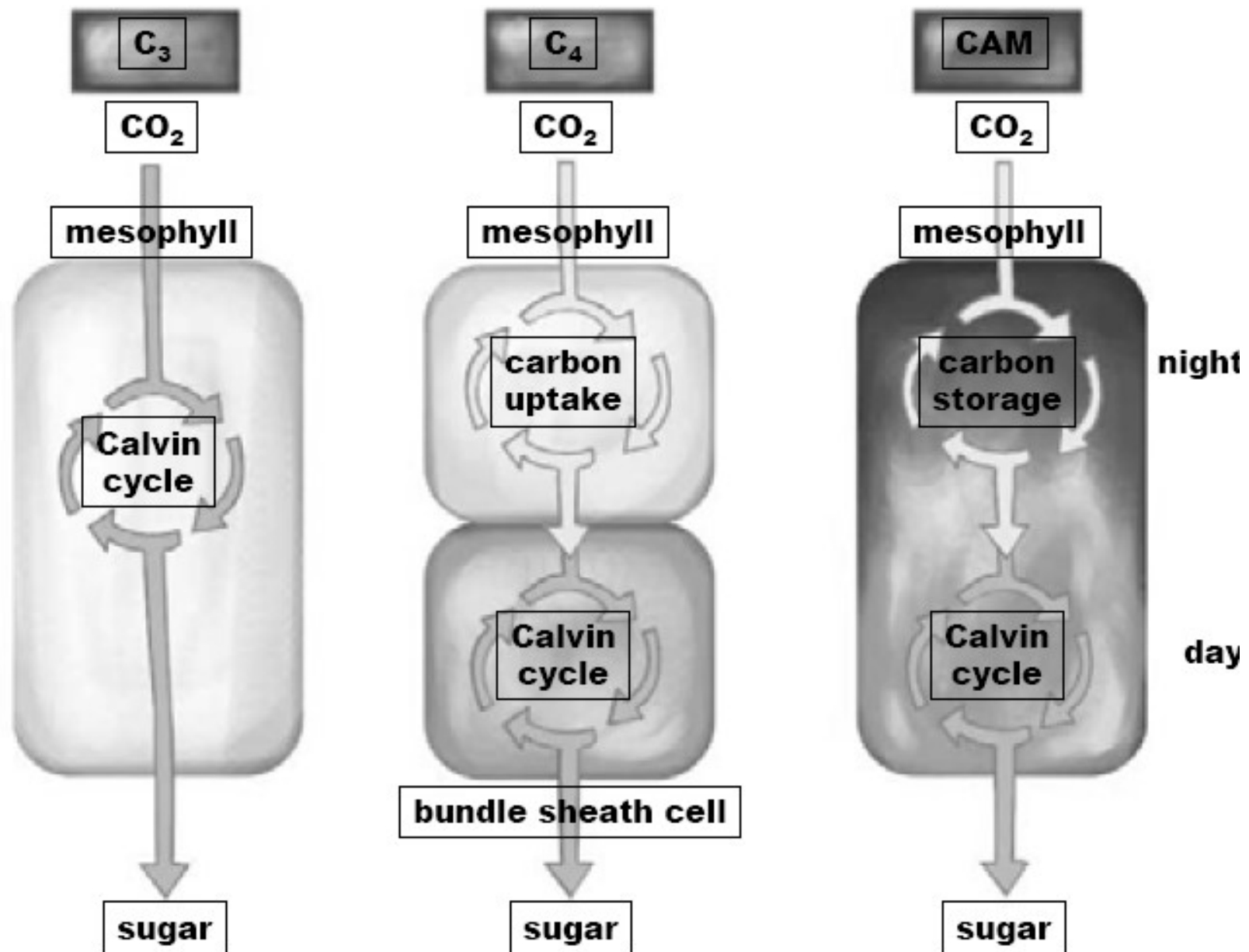
- 1 CO₂ incorporated into four-carbon organic acids (carbon fixation)
PEP carboxylase
- 2 Organic acids release CO₂ to Calvin cycle
RuBP carboxylase



(a) Spatial separation of steps

(b) Temporal separation of steps

As plantas C3, as plantas C4 e as plantas CAM



As plantas C3, as plantas C4 e as plantas CAM

	C₃ (soja)	C₄ (milho, cana)	CAM (abacaxi)
Anatomia	Células esponjosas e paliçádicas	Mesófilo e células da bainha do feixe vascular	Células com grande vacúolos
Taxa de crescimento (g.dm ⁻² .dia ⁻¹)	1	4	0,02
Estômatos	Abertos durante o dia e fechados à noite	Abertos durante o dia e fechados à noite	Fechados durante o dia e abertos à noite
Eficiência do uso da água (g CO ₂ .kg ⁻¹ H ₂ O)	1-3	2-5	10-40
Taxa fotossintética ótima (mg CO ₂ .dm ⁻² h ⁻¹)	30	60	3
Temperatura ótima	20-30°C	30-45°C	30-45°C
Ponto de compensação de CO ₂ *	50 ppm	5 ppm	2 ppm (no escuro)
Fotorrespiração	Alta	Baixa	Baixa
Enzima-chave da carboxilação	Rubisco (apenas)	PEPcase, Rubisco	PEPcase, Rubisco

* Concentração de CO₂ onde não há fotossíntese líquida.

As plantas C3, as plantas C4 e as plantas CAM

CARACTERÍSTICA	PLANTAS C3	PLANTAS C4	PLANTAS CAM
Anatomia foliar	Células do parênquima paliçádico e lacunoso com cloroplastos com grana	Anatomia de "Kranz", com células mesofílicas com cloroplastos com grana e células da bainha do feixe vascular, com cloroplastos sem grana	Usualmente sem células paliçádicas, vacuolos grandes nas células do mesófilo
Enzimas carboxilativas	RUBISCO em todas as células fotossintéticas	<i>Separação espacial:</i> PEP-carboxilase nas células mesofílicas; RUBISCO nas células da bainha vascular	<i>Separação temporal:</i> PEP-carboxilase à noite (escuro); RUBISCO durante o dia (luz)
Requerimento energético CO ₂ : ATP : NADPH	1 : 3 : 2	1 : 5 : 2	1 : 6,5 : 2
Razão de transpiração (g H ₂ O/g MS.)	450 - 950	250 - 350	50 - 55
Razão clorofila a/b	2,8 ± 0,4	3,9 ± 0,6	2,5 a 3,0
Requerimento de Na	Não	Sim -é necessário para a entrada de piruvato na célula do mesófilo onde ele regenera o fosfoenolpiruvato (PEP), que é substrato da enzima <i>PEPCase</i> .	Desconhecido
Ponto de compensação de CO ₂ (µ L /L)	30 - 70	0 -10	0 -5 (no escuro)
Inibição da fotossíntese na presença de O ₂ (21%)	Sim	Não	Sim
Fotorrespiração	Sim	Não detectável	Muito baixa
Temperatura ótima para fotossíntese	15 - 25 °C	30 - 40 °C	35 °C
Produção de matéria seca (toneladas/ha/ano)	22 ± 0,3	39 ± 1,7	Difícil detectar
Redistribuição de fotoassimilados	lenta	rápida	variável

Table 6.5, p. 63b, handbook
Table : Comparison of C-3, C-4 and CAM Plants

	C-3 Soybean	C-4 Maize	CAM Pineapple
Anatomy	spongy and palisade cells	mesophyll and bundle sheath cells	cells with large vacuoles
Growth rates (gdm⁻² day⁻¹)	1	4	0.02
Stomates	open in day closed at night	open in day closed at night	closed in day open at night

Table 6.5, p. 63b, handbook
Table: Comparison of C-3, C-4 and CAM Plants
(continued)

	C-3 Soybean	C-4 Maize	CAM Pineapple
Water use efficiency $\text{gCO}_2 \text{ kg}^{-1} \text{ H}_2\text{O}$	1 - 3	2 - 5	10 - 40
Max photosynthetic rate (± 5 range)	30 $\text{mgCO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$	60 $\text{mgCO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$	3 $\text{mgCO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$
Optimum temperature	20- 30°C	30 - 45°C	30-45°C

Table 6.5,p. 63b, handbook
Table: Comparison of C-3, C-4 and CAM Plants
(continued)

	C-3 Soybean	C-4 Maize	CAM Pineapple
Compensation point: CO ₂ conc. when there is no net photosynthesis	50 ppm	5 ppm	2 ppm (in dark)
Photorespiration	High	Low	Low
Key carboxylating enzyme	RUBISCO only	PEP'Case RUBISCO	PEP'Case RUBISCO