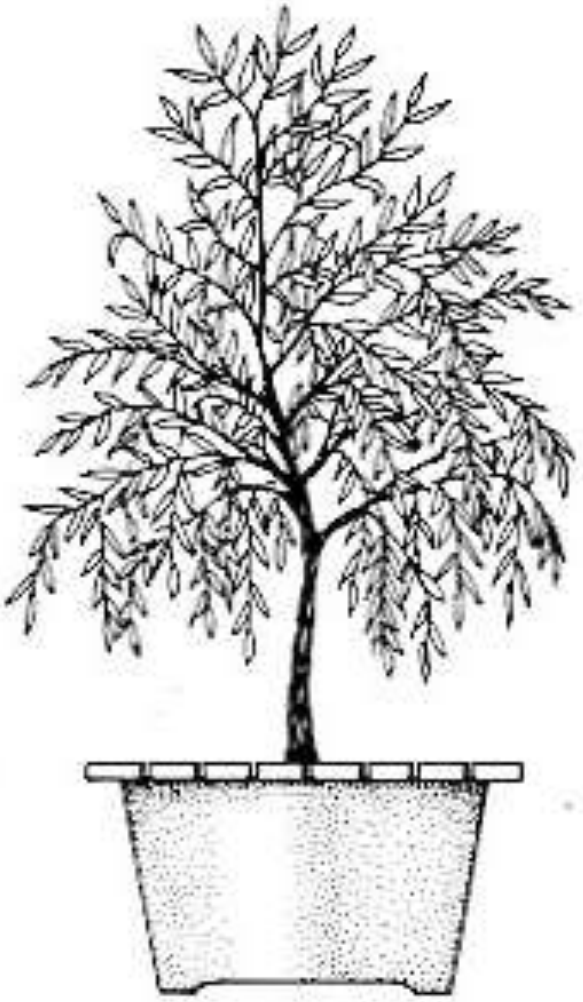
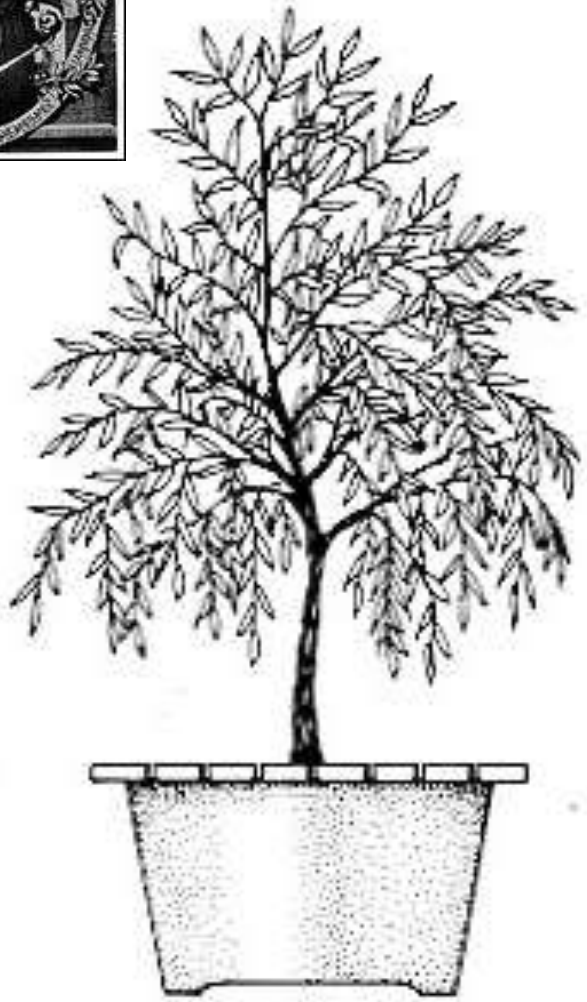
Mecanismos de síntese de ATP 2: Fotossíntese

Jean Batiste van Helmont
1648

200 lbs

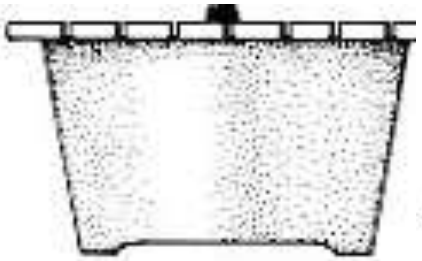
5 anos





169 lbs

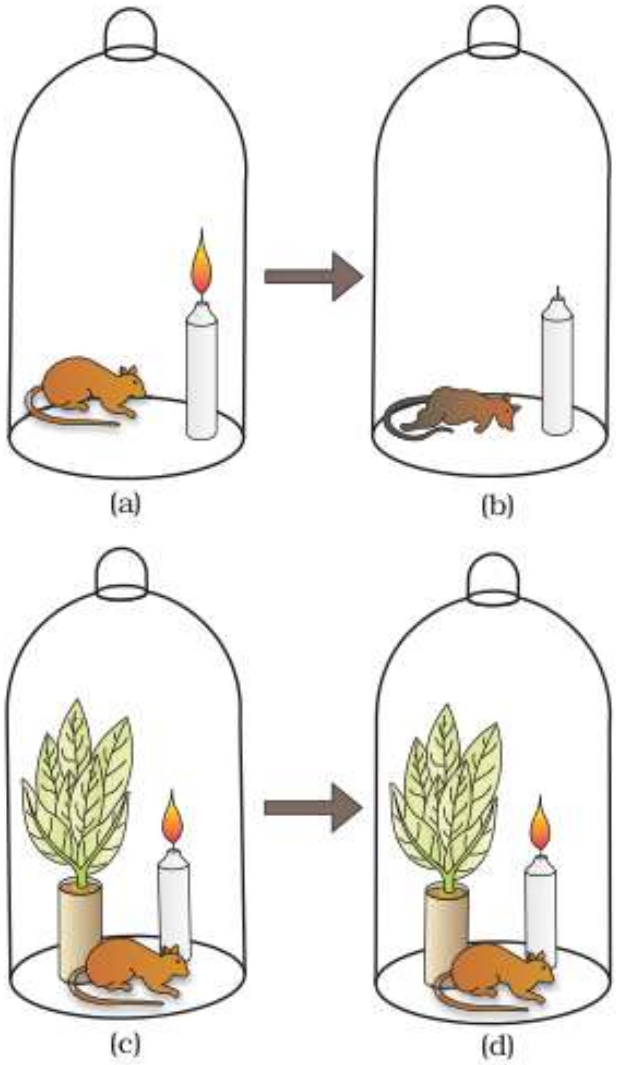
~ 200 lbs



A planta cresceu mas a terra não diminui:
então os nutrientes vieram da água

Joseph Priestley

1772 - Experiments and observations on different kinds of air



A vela ou o camundongo produzem um “ar viciado”

As plantas reconstituem o ar “bom”

Jan Ingenhousz
1730-1799
Médico

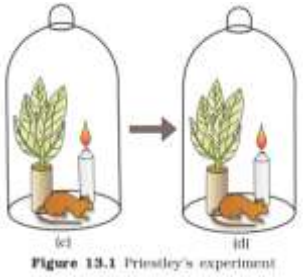


Figure 13.1 Priestley's experiment

Estudava as plantas tentando encontrar uma cura pra as doenças!

Mais de 500 experimentos em três meses!

1779 - Experiments upon vegetables, discovering their great power of purifying the common air in the sunshine and of injuring it in the shade and at night

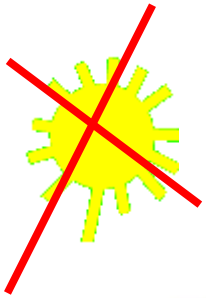
O ar fixado é "quebrado" pelas plantas na presença de luz e parte dele é liberado (O_2)

Jean Senebier
(1742-1809)
Botânico amador

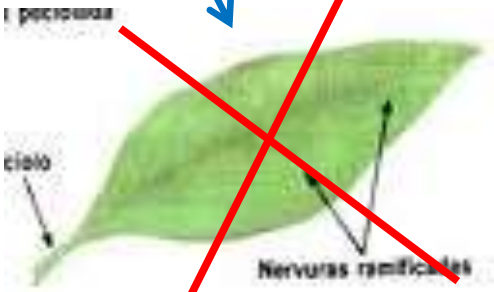
A liberação de oxigênio pelas plantas iluminadas está relacionada a disponibilidade de CO_2

1854 - A planta produz seus nutrientes?

Julius von Sachs
Botânico



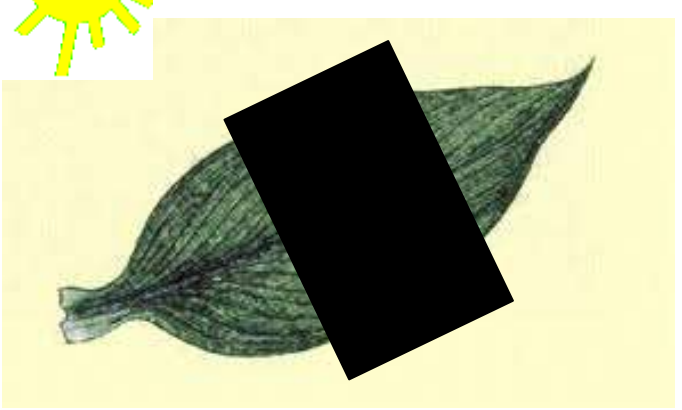
lugol

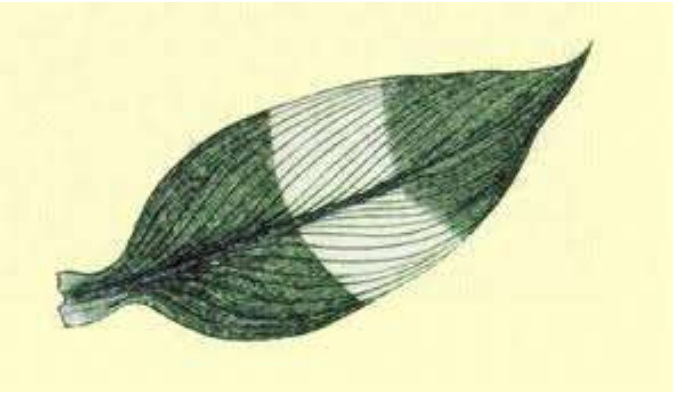


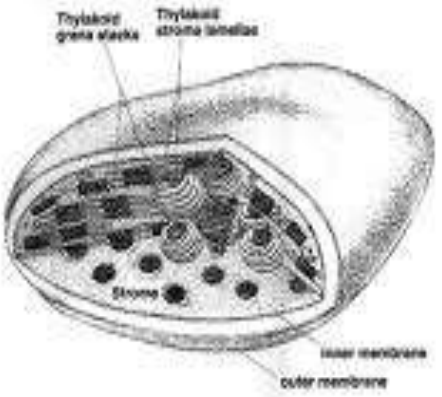
grânulos violetas

As plantas produzem amido quando expostas à luz!

Julius von Sachs
Botânico







Partes verdes das plantas ficam dentro de corpúsculos aonde é produzido o amido!

Hugo von Mohl
Botânico alemão
1844

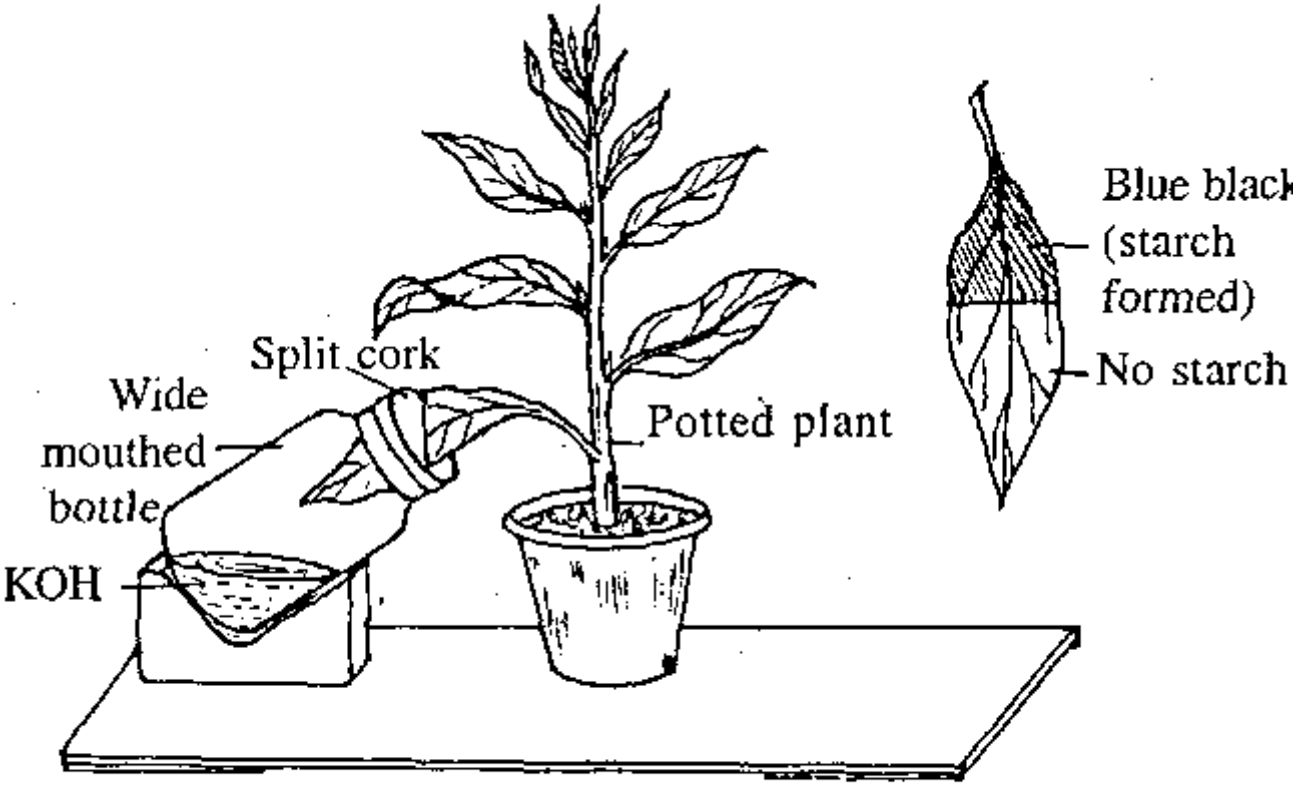


Fig. 5.2.6.5 : Mohl's half-leaf experiment to demonstrate that CO_2 is necessary for photosynthesis

1914

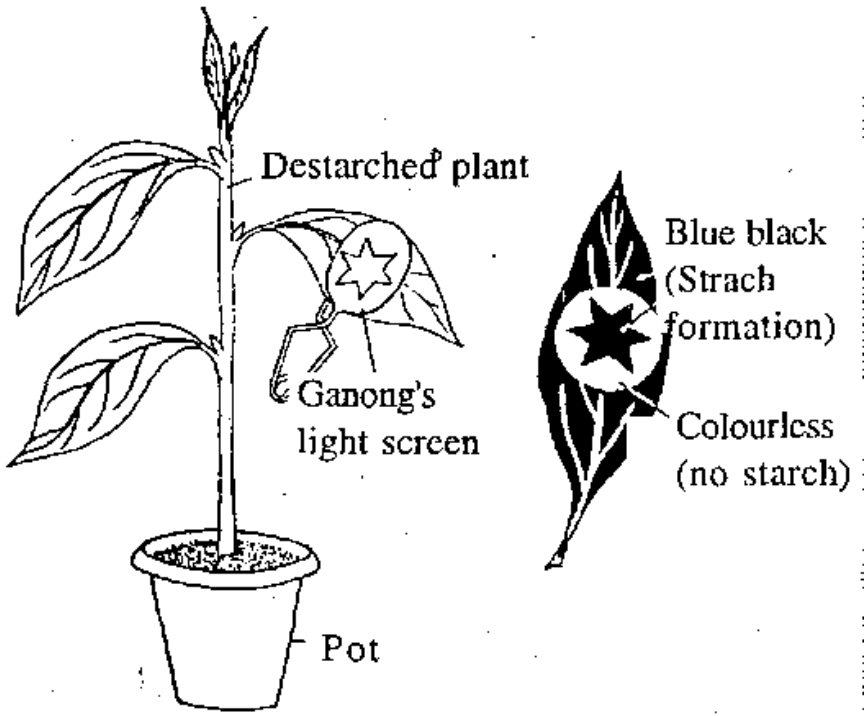
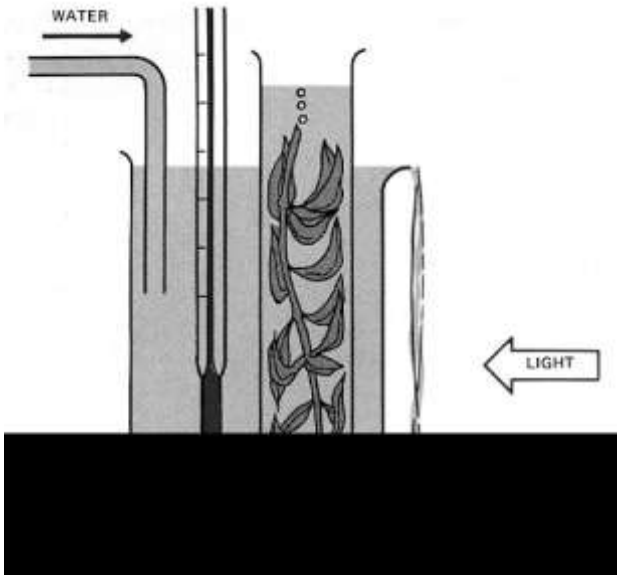
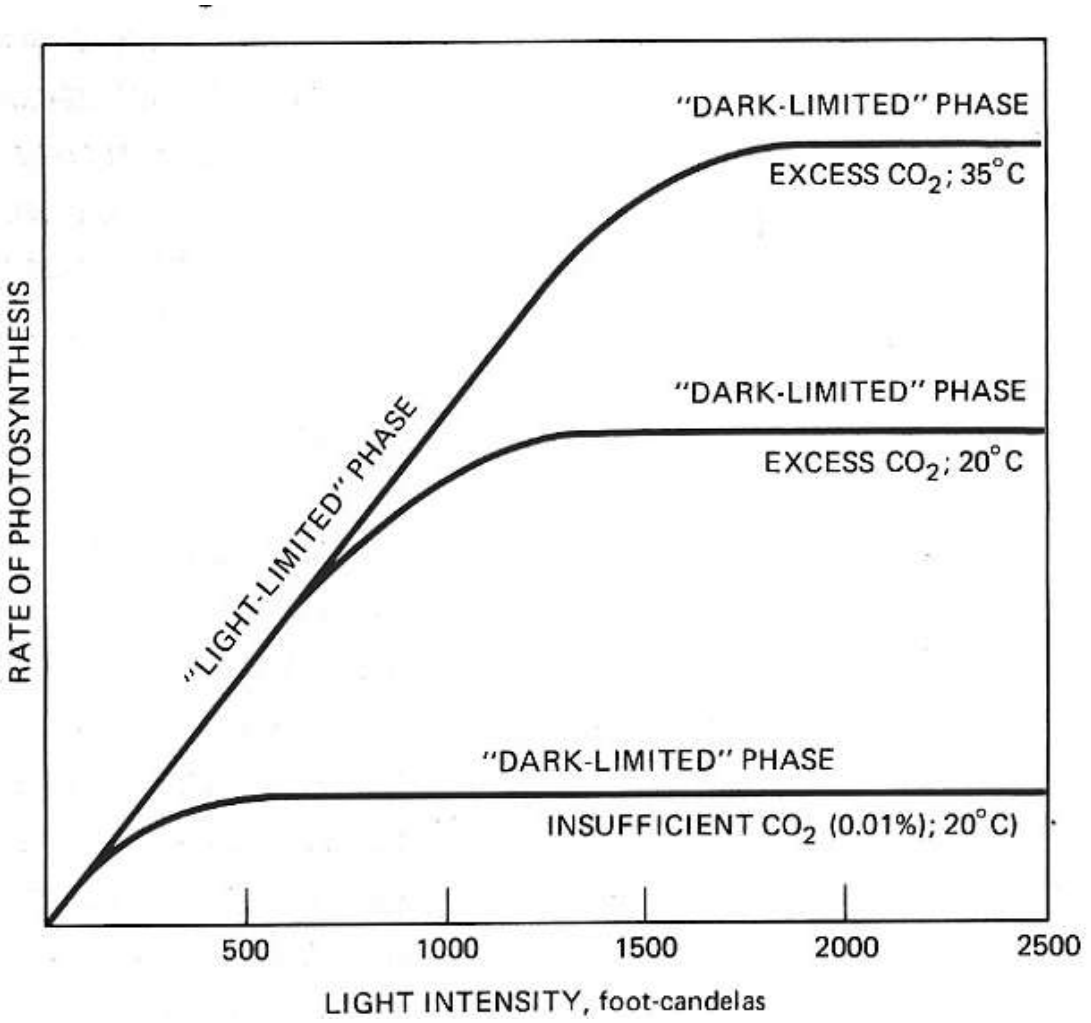


Fig. 5.2.6.4 : Experiment to demonstrate that the light is necessary for photosynthesis

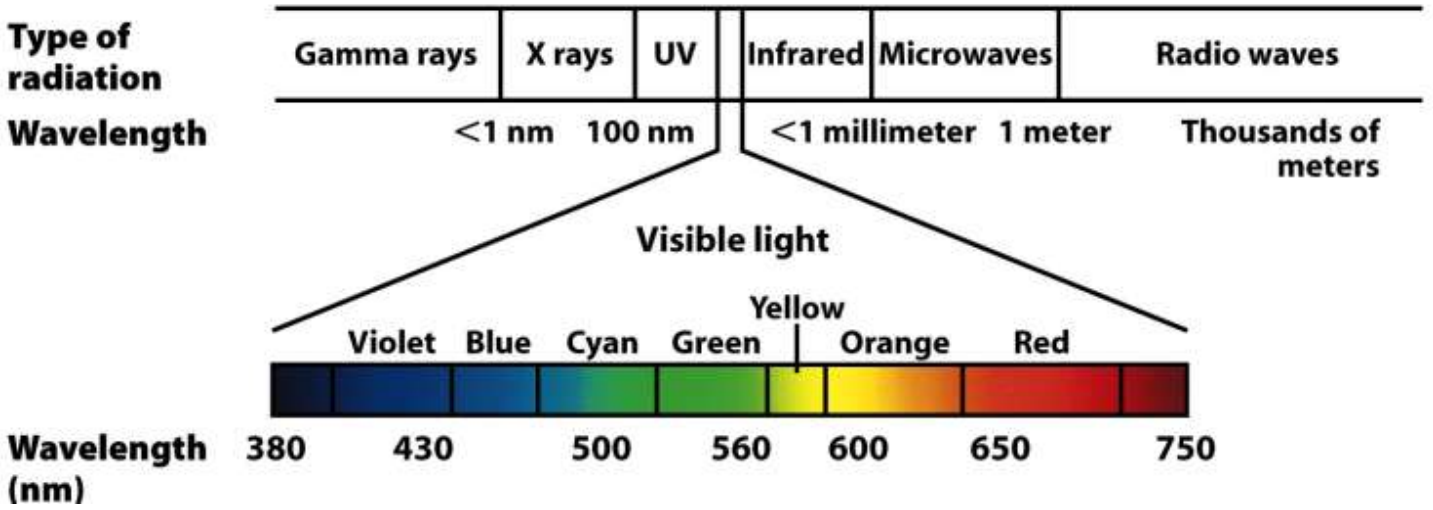
Frederick Blackman
1905

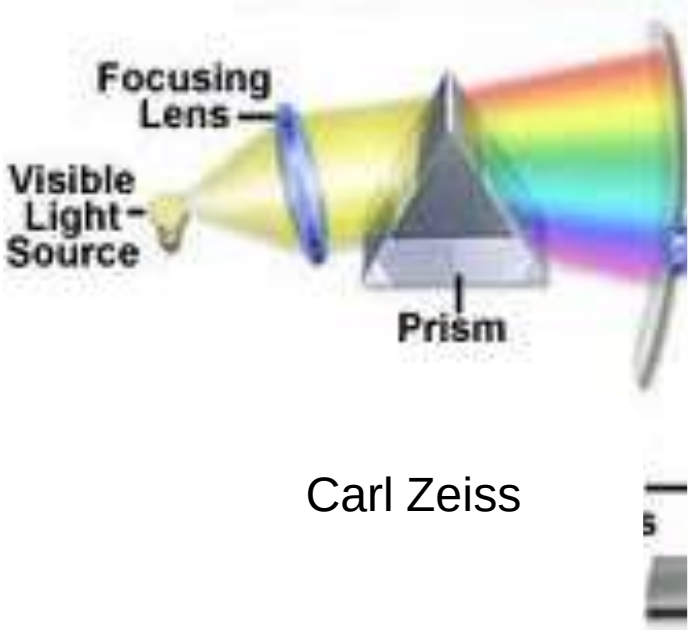




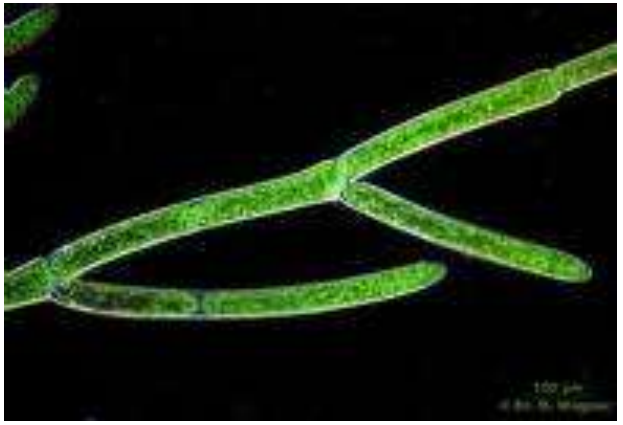
"...photosynthesis consists of two types of reactions: a rapid light-dependent photochemical process and a slower temperature-dependent biochemical process. These are later termed "light reactions" and "dark reactions," respectively".

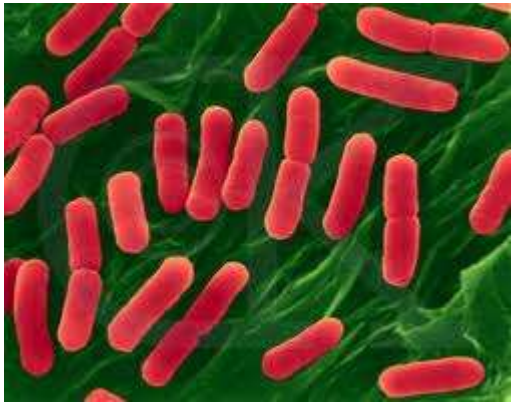
Theodor Engelmann
Botânico alemão
1881

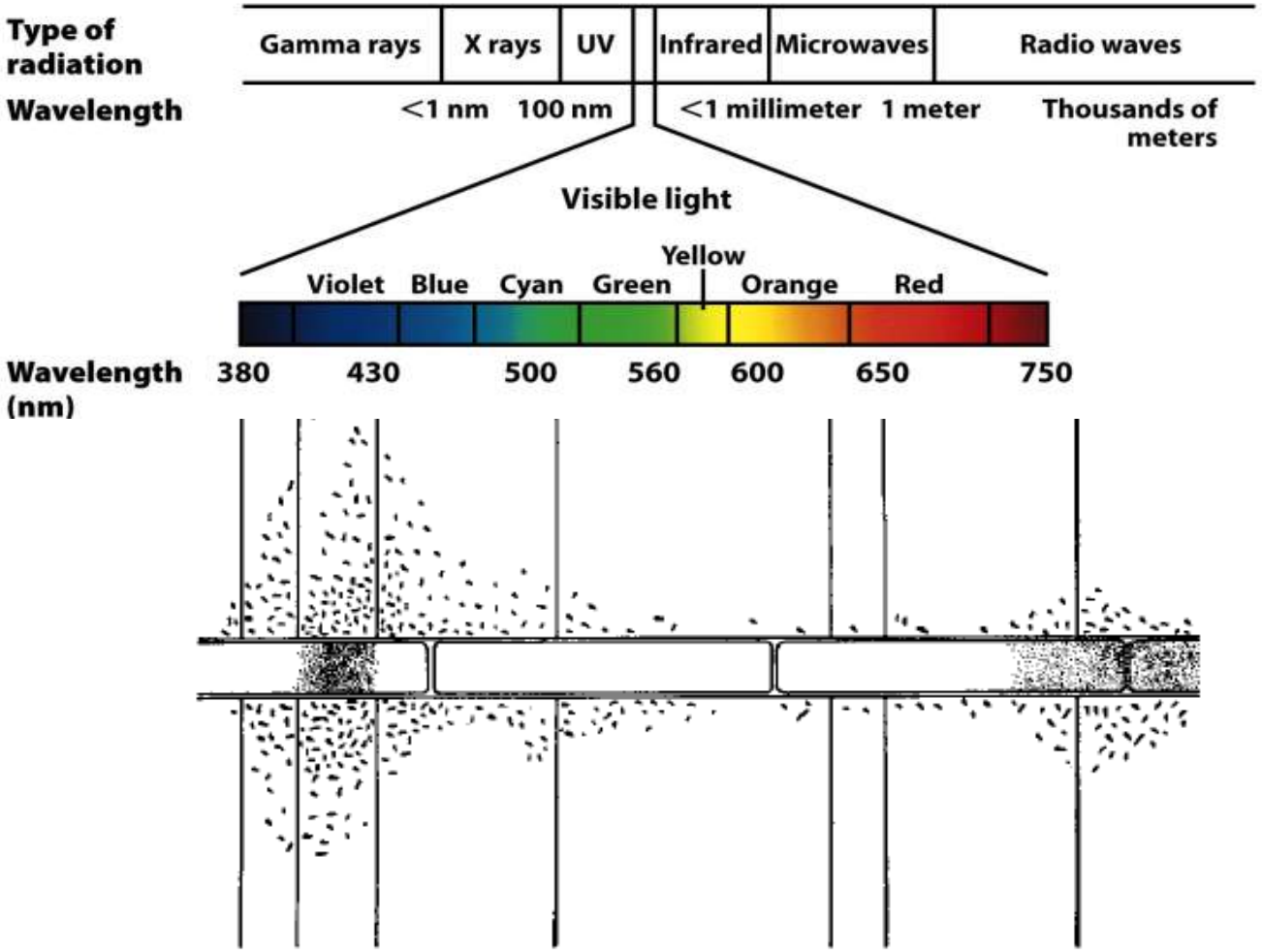


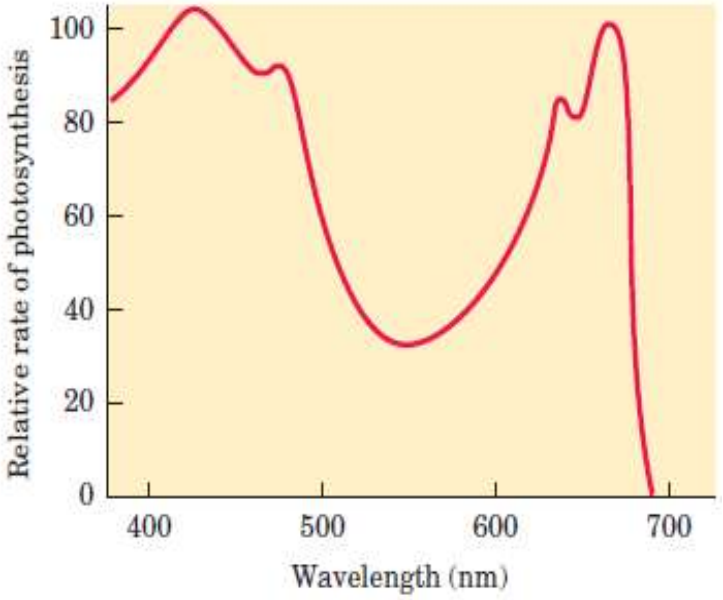


Carl Zeiss



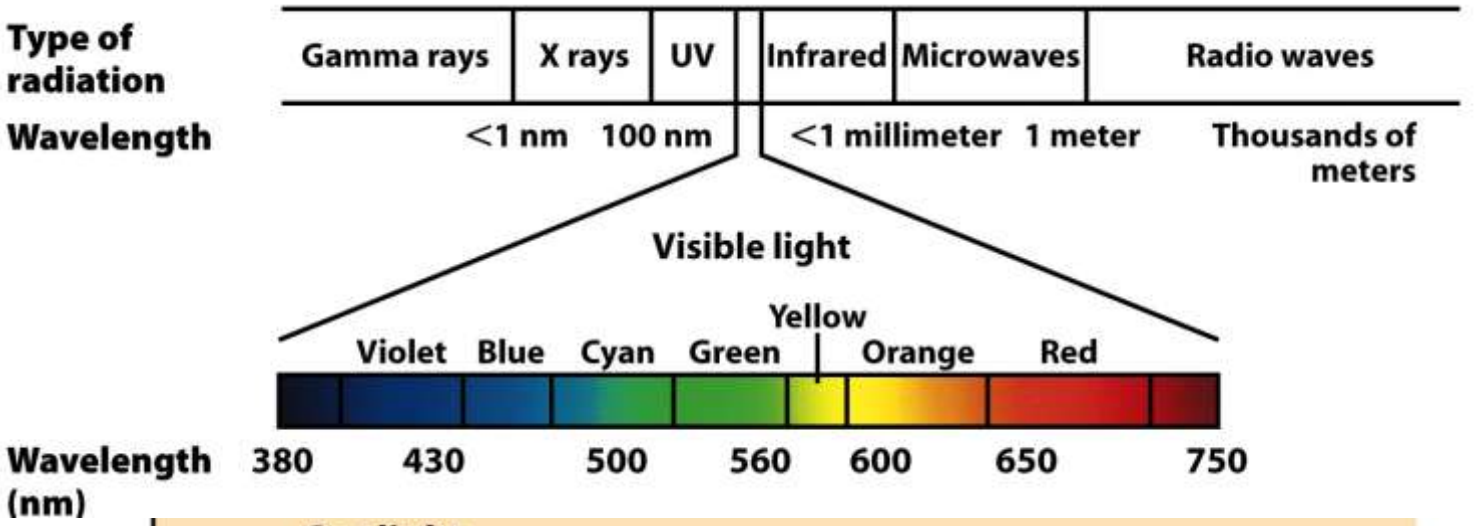


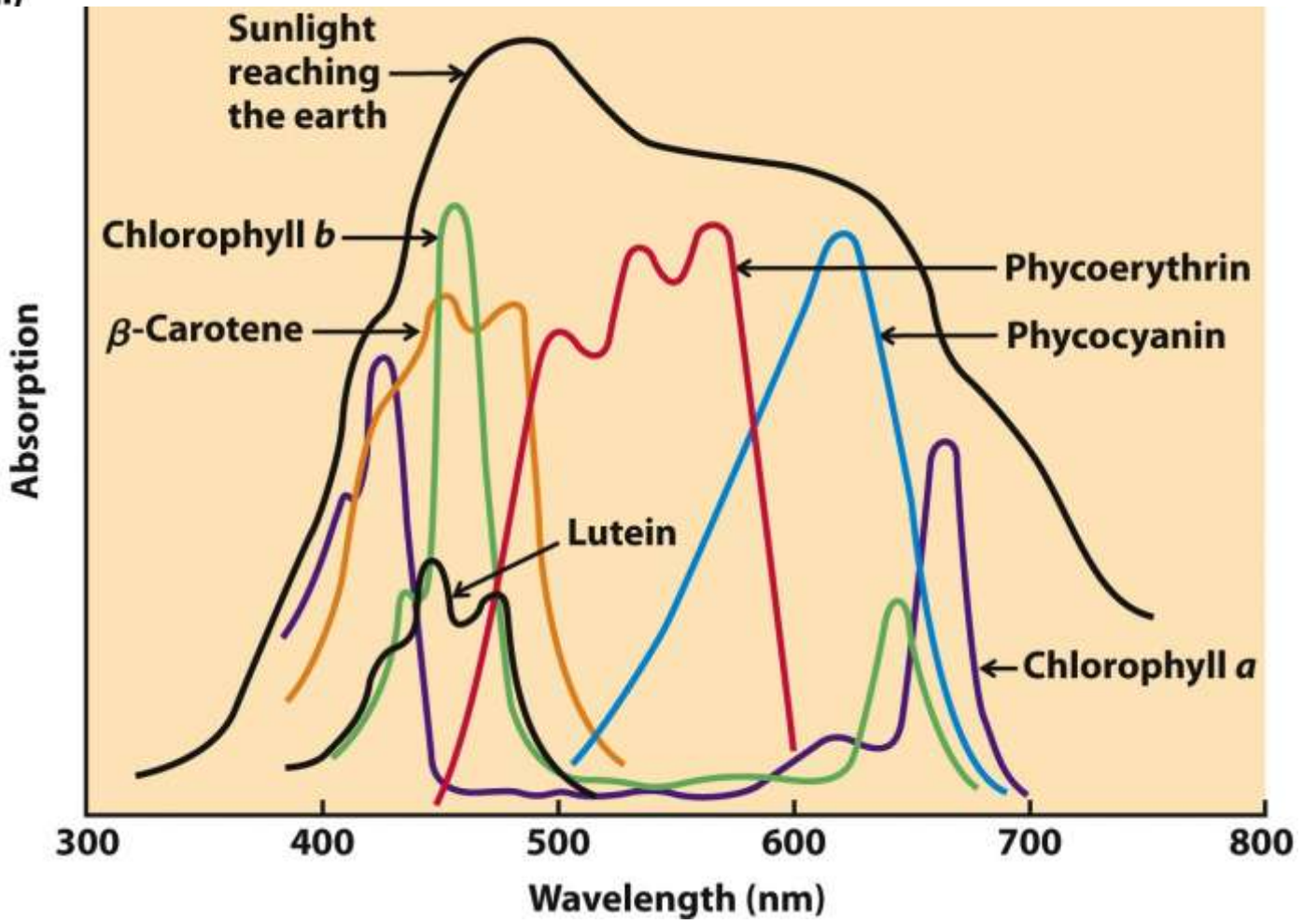

Type of radiation
Gamma rays
X rays
UV
Infrared
Microwaves
Radio waves
Wavelength
<1 nm
100 nm
<1 millimeter
1 meter
Thousands of meters
Visible light
Violet
Blue
Cyan
Green
Yellow
Orange
Red
Wavelength (nm)
380
430
500
560
600
650
750


Relative rate of photosynthesis
100
80
60
40
20
0
400
500
600
700
Wavelength (nm)

(b)

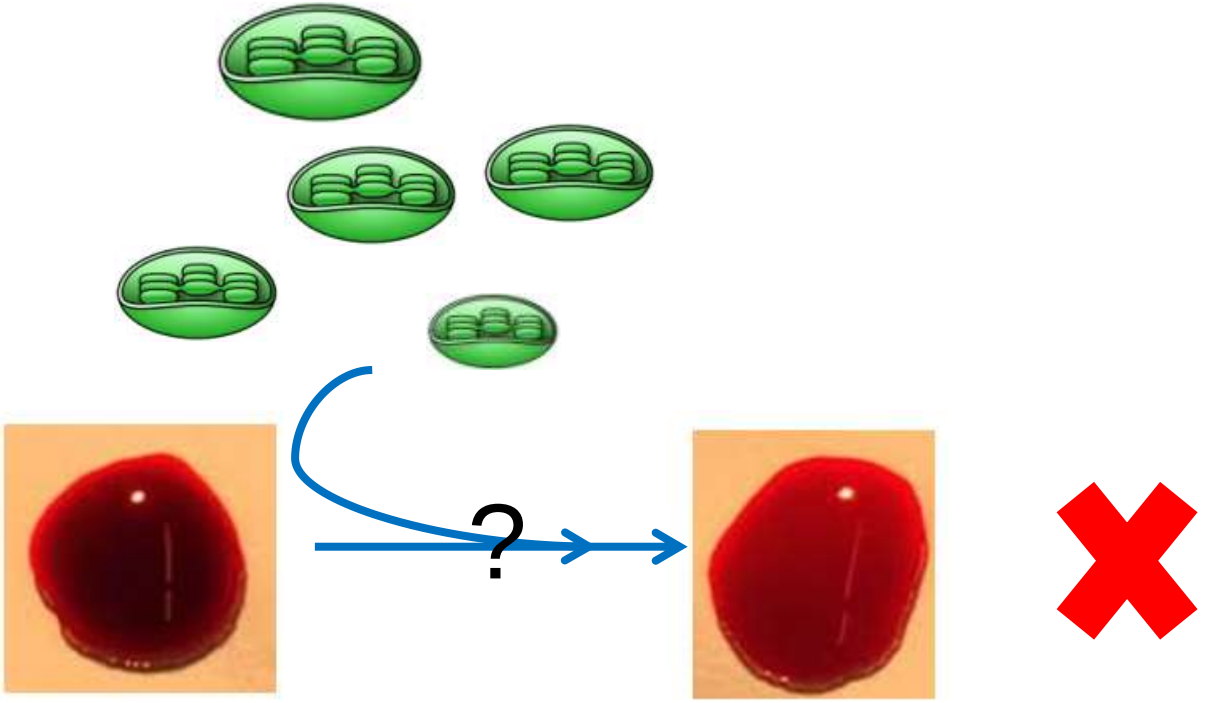
Espectro de absorção dos pigmentos





Robert Hill

1930s - Um cloroplasto isolado é capaz de realizar fotossíntese?



Tentando encontrar uma maneira de aumentar a capacidade de fotossíntese de sua preparacao de cloroplastos, Hill descobriu que a presenca de diferentes aceptores de elétrons era suficiente para causar oxigenacao do sangue

$$2H_2O + 4Fe^{3+} \rightarrow O_2 + 4Fe^{2+} + 4H^+$$

Assim, postulou que o oxigênio liberado na fase clara da fotossíntese era proveniente de moléculas de agua, e não do gás carbônico como se acreditava a época

Da mesma forma, o CO_2 resultante da fosforilação oxidativa não é formado pelo oxigênio que respiramos!!

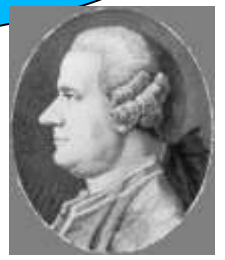
Recapitulando…

As plantas não obtêm seus nutrientes da agua!

As plantas quebram o ar fixado (CO_2) e liberam o ar bom!

A fotossíntese possui duas etapas: uma limitada por luz outra por CO_2

As plantas precisam de luz para reconstituir o ar bom!



E de CO_2 também!

As plantas precisam de luz para sintetizar amido

As plantas precisam de CO_2 para liberar oxigenio!

Recapitulando…

O oxigênio vem da água!!!

Fotossíntese

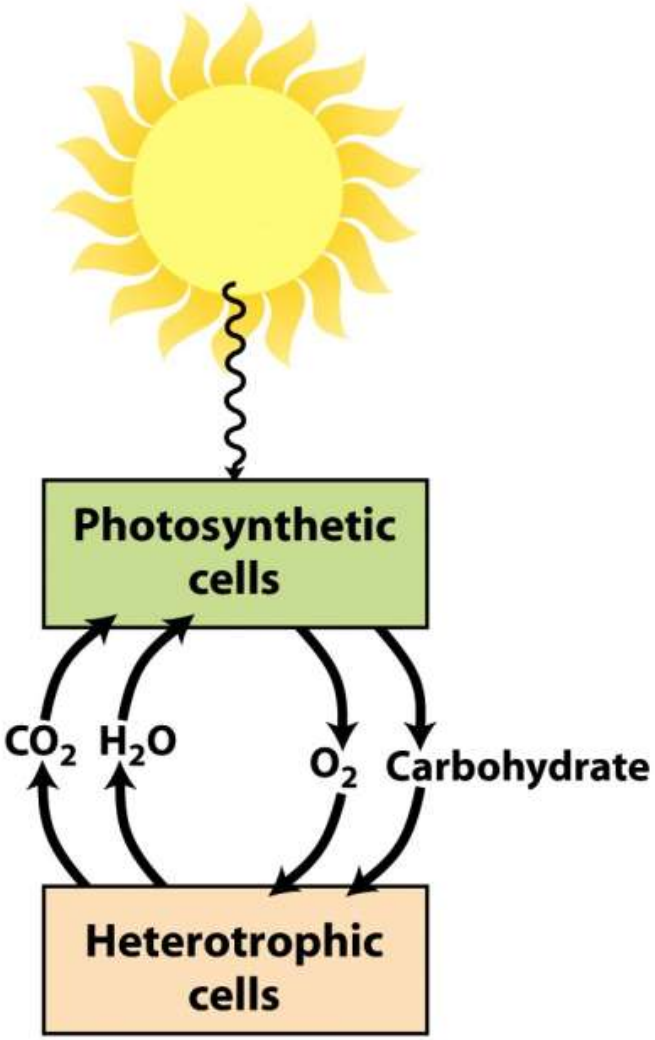


Figure 19-43
Lehninger Principles of Biochemistry, Fifth Edition

Bactérias, eucariotos unicelulares (algas) e plantas superiores.

$$CO_2 + H_2O \xrightarrow{\text{light}} O_2 + (CH_2O)$$

A água doa elétrons para reduzir CO_2 a carboidrato

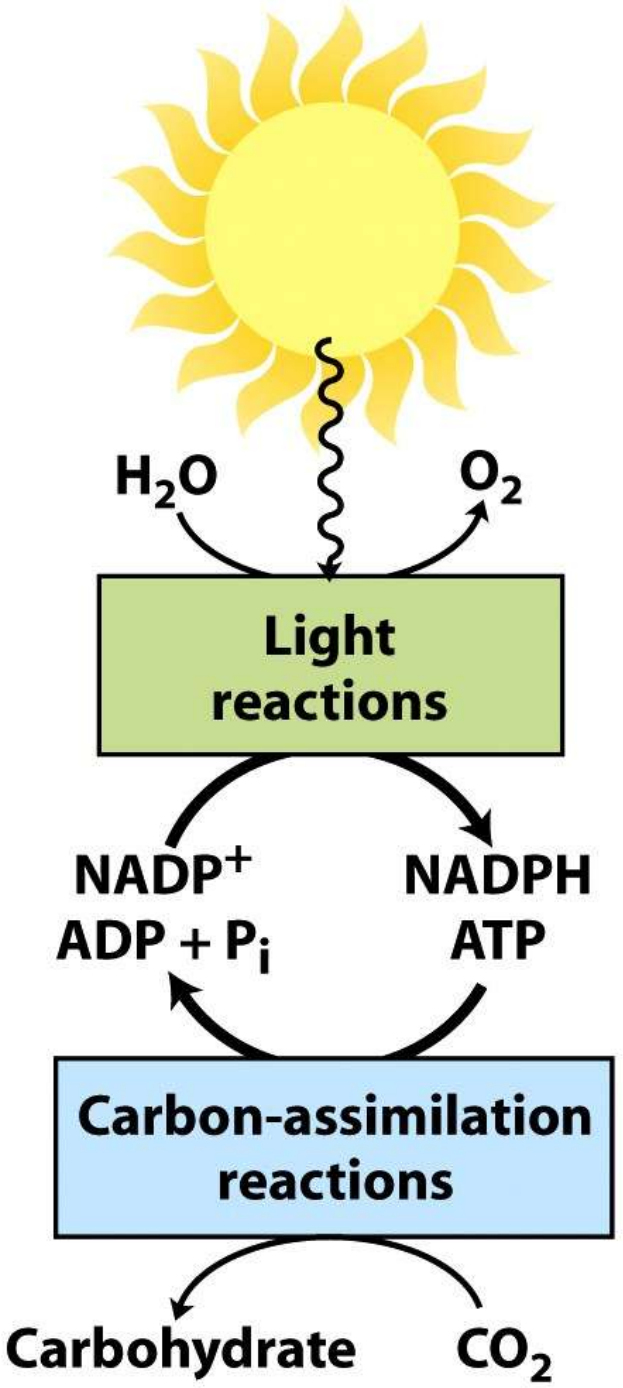


Figure 19-44
Lehninger Principles of Biochemistry, Fifth Edition

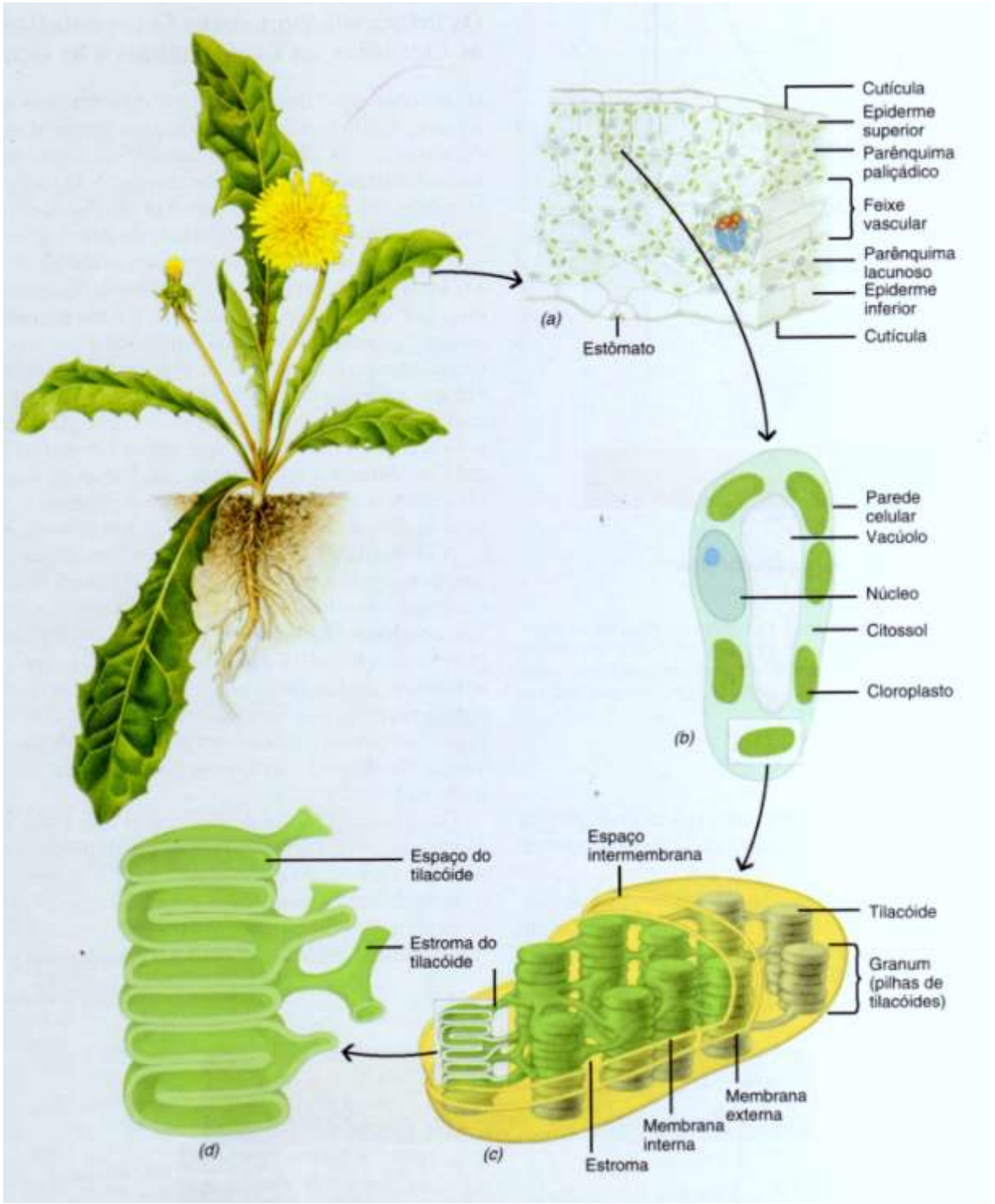
Fases da Fotossíntese

Reações de Claro:

- Absorção da luz e fotólise da agua
- Transporte primário de elétrons, síntese de ATP
- Estabilização energética, reducao de NADP+

Reações de Escuro:

- Síntese e exportacao de produtos estaveis (Ciclo de Calvin)



As reações dependentes de luz e as reações de assimilação de carbono ocorrem nos cloroplastos.

Células fotossintéticas eucarióticas.

O cloroplasto

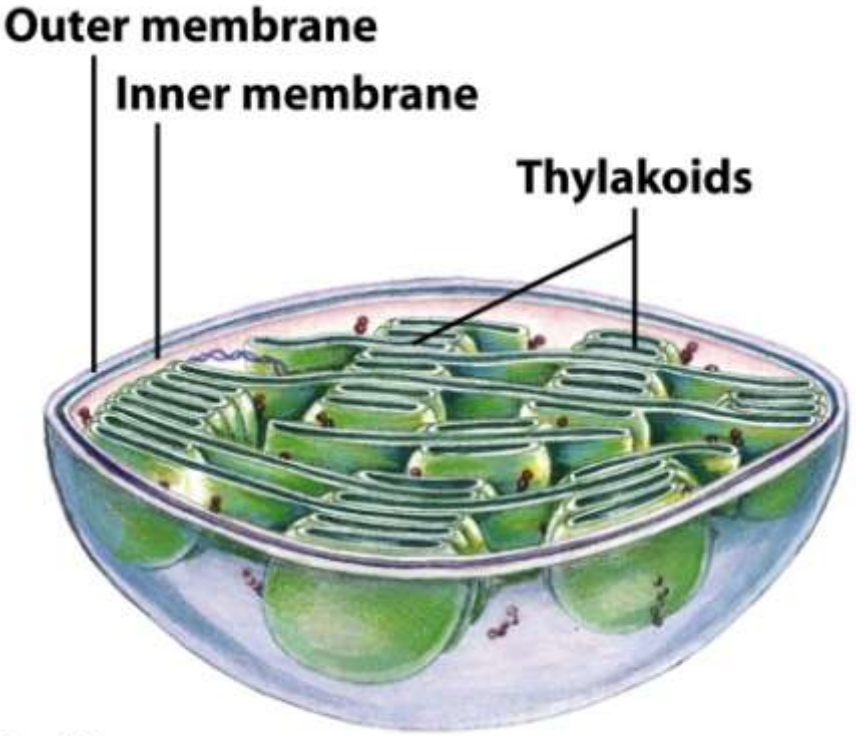


Figure 19-45a
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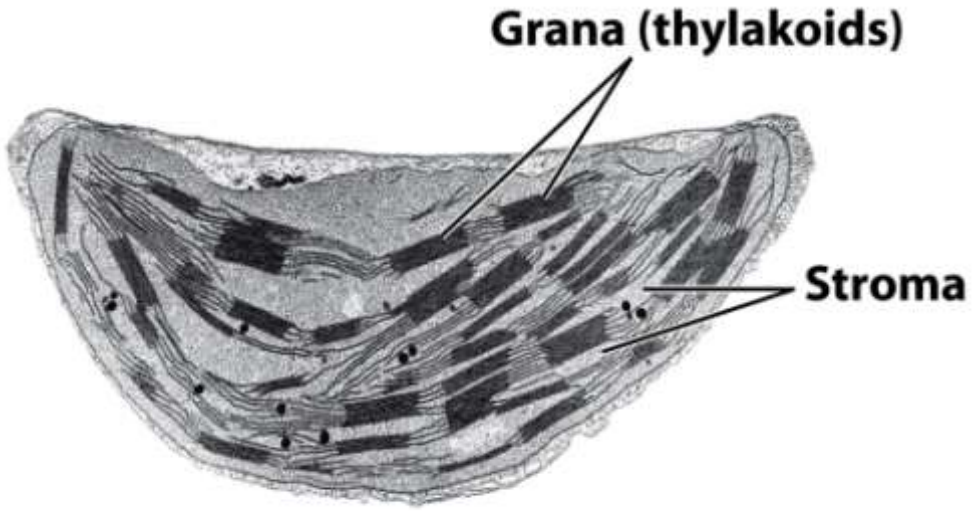
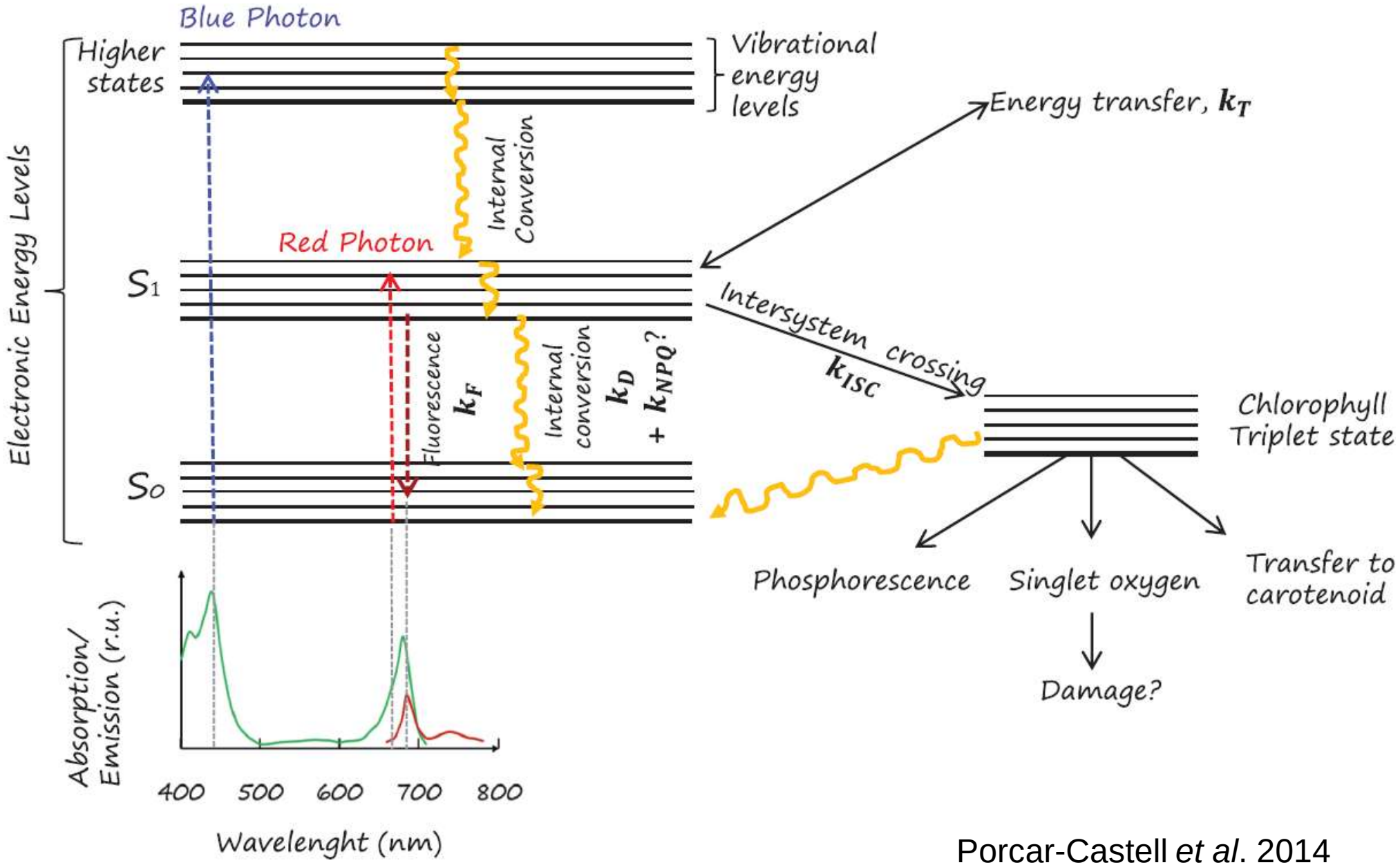
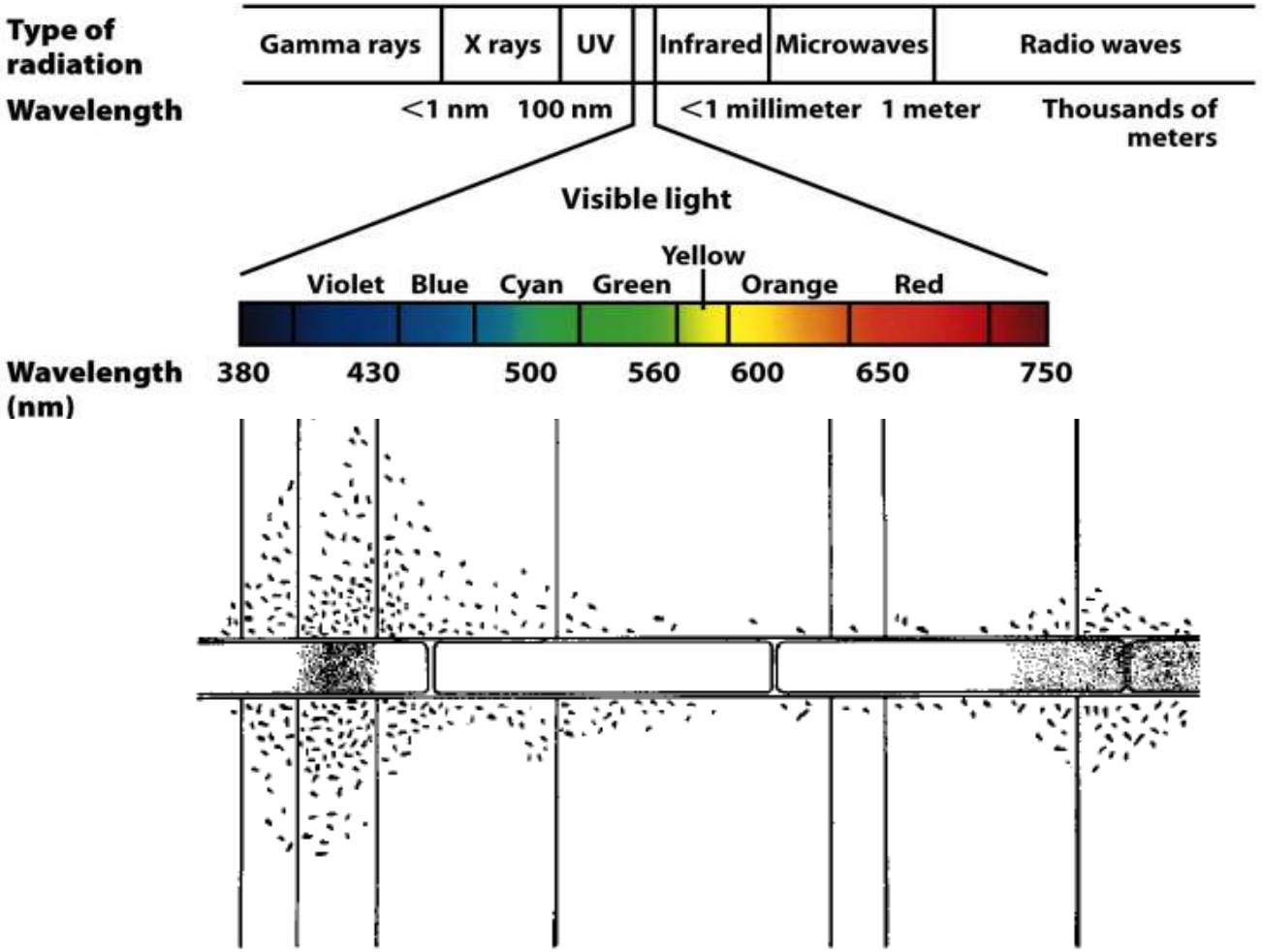


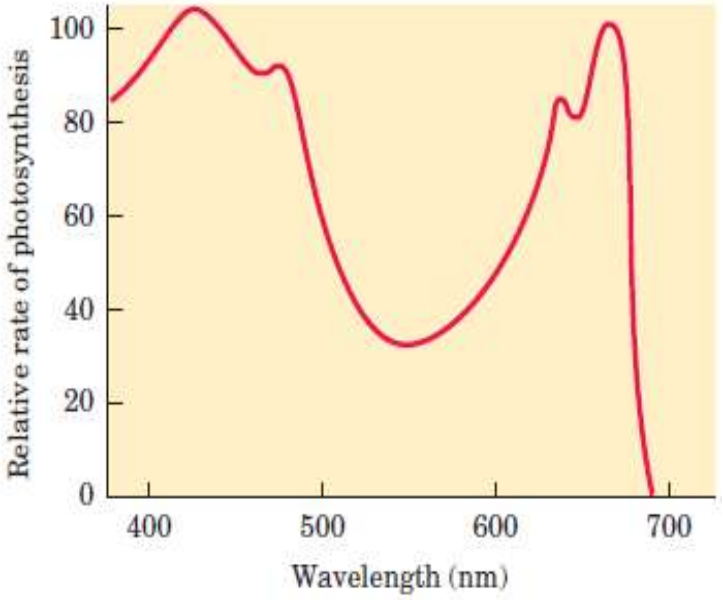
Figure 19-45b
Lehninger Principles of Biochemistry, Fifth Edition

O que é absorver um fóton?



Porcar-Castell *et al*. 2014


Type of radiation
Gamma rays
X rays
UV
Infrared
Microwaves
Radio waves
Wavelength
<1 nm
100 nm
<1 millimeter
1 meter
Thousands of meters
Visible light
Violet
Blue
Cyan
Green
Yellow
Orange
Red
Wavelength (nm)
380
430
500
560
600
650
750


Relative rate of photosynthesis
100
80
60
40
20
0
400
500
600
700
Wavelength (nm)

(b)

Espectro de absorção dos pigmentos

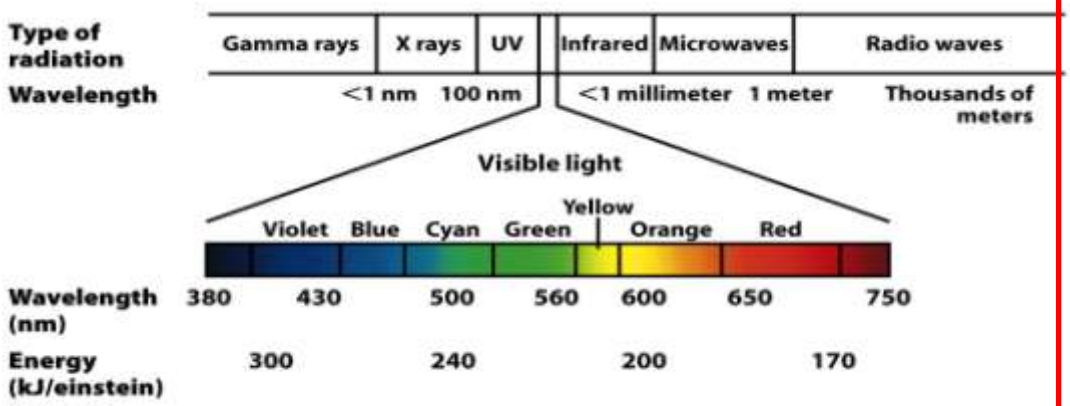


Figure 19-46
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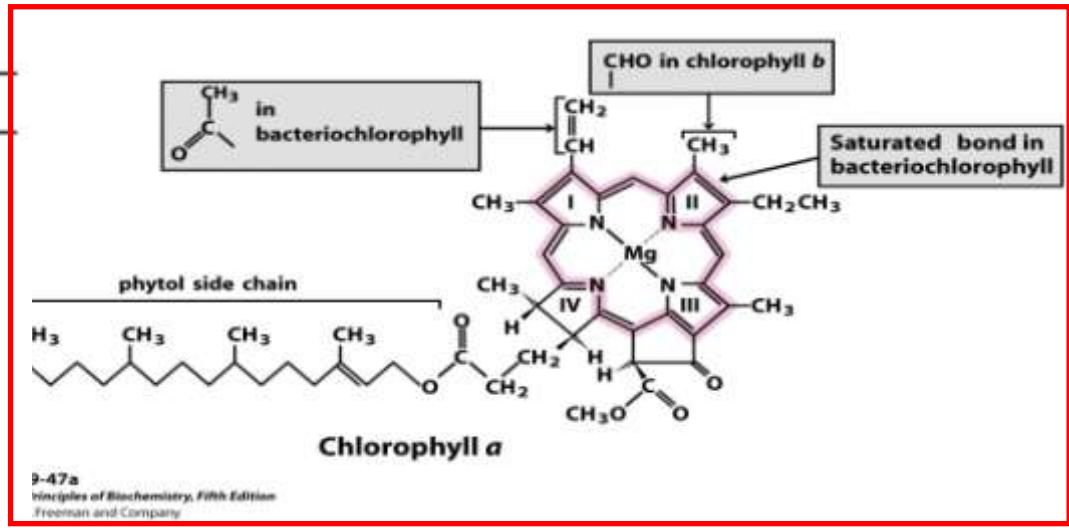

9-47a
rinciples of Biochemistry, Fifth Edition
Freeman and Company

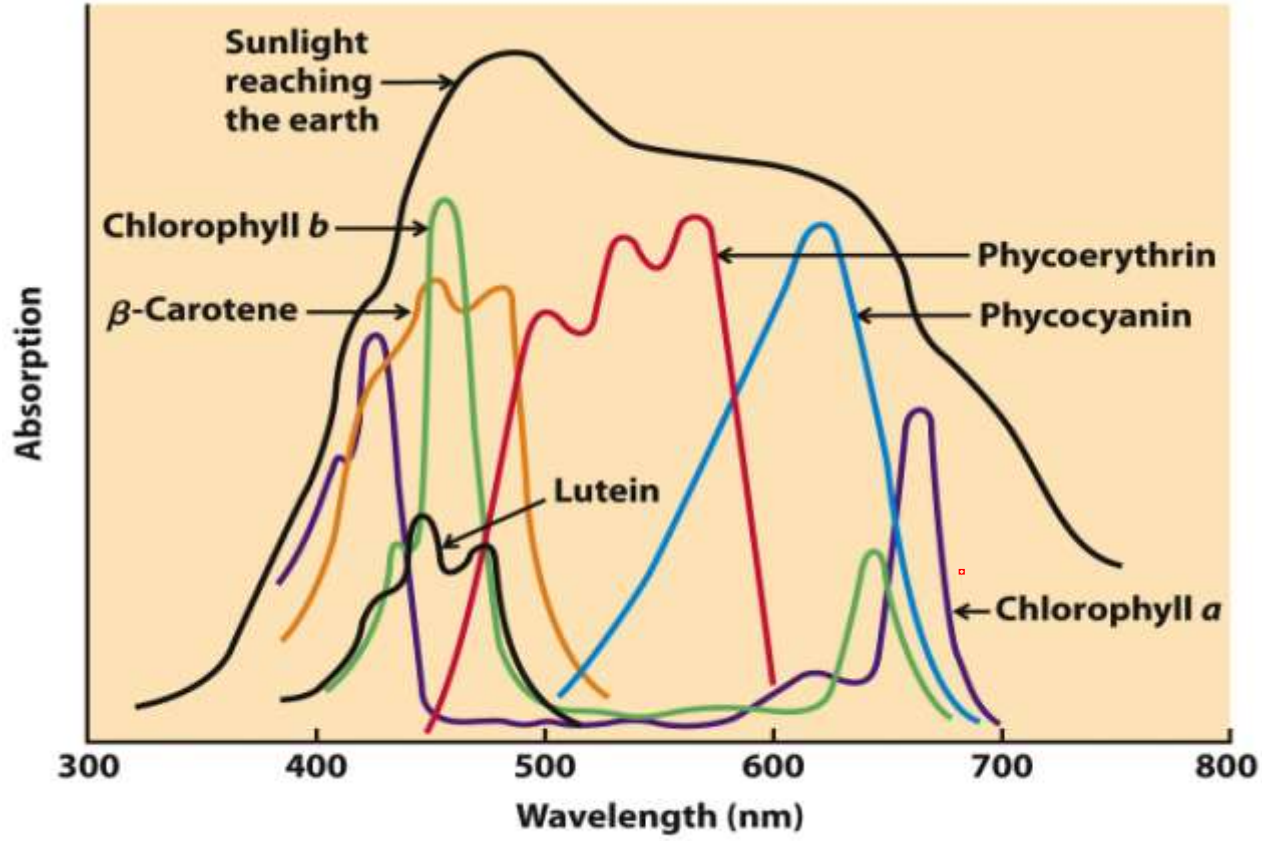

Figure 19-48
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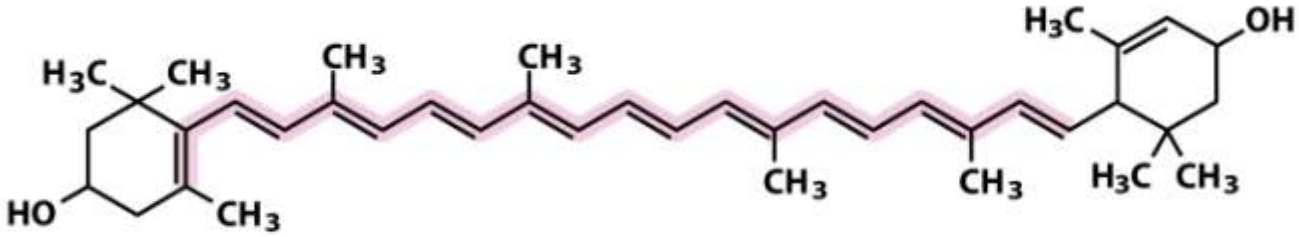
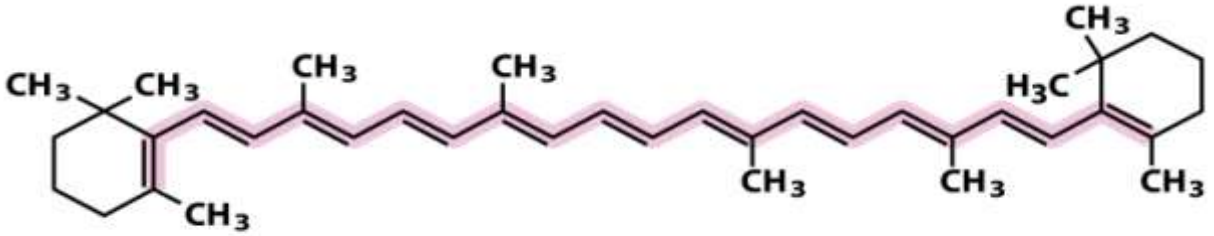
Fotossíntese – Pigmentos acessórios



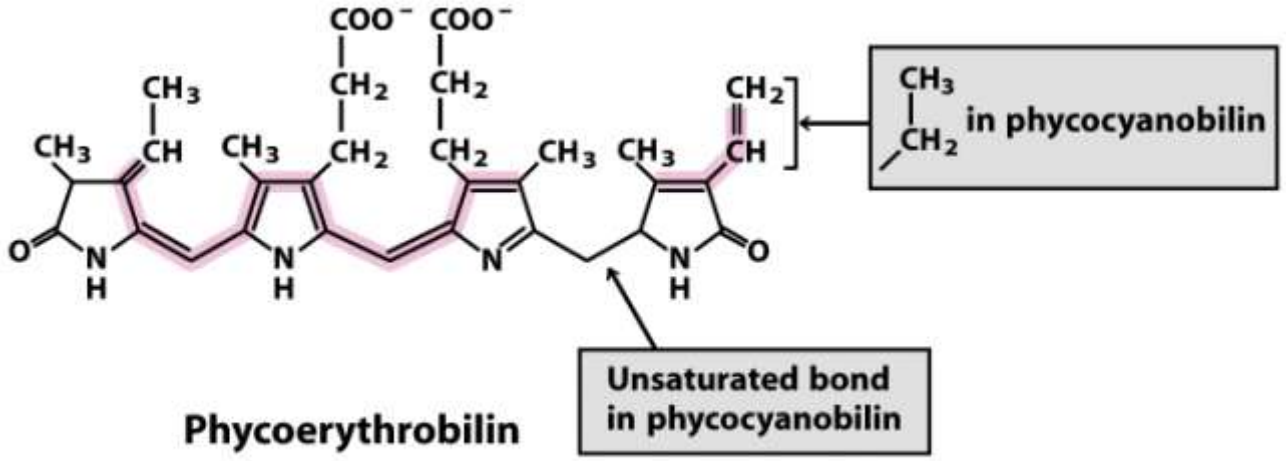
Lutein (xanthophyll)

Figure 19-47d
Lehninger Principles of Biochemistry, Fifth Edition



β-Carotene

Cianobactérias e algas vermelhas



Phycoerythrobilin

Figure 19-47b
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Funil energético derivado dos sistemas de antenas

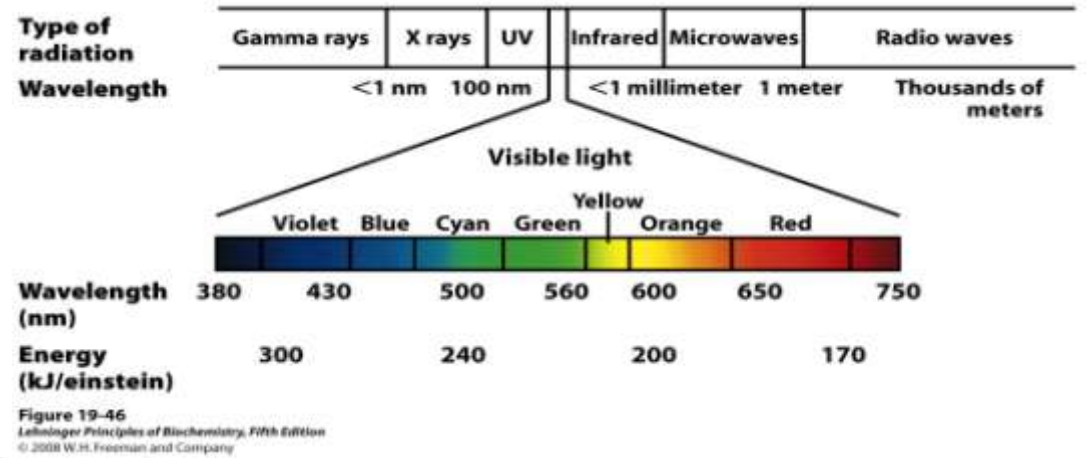

Figure 19-46
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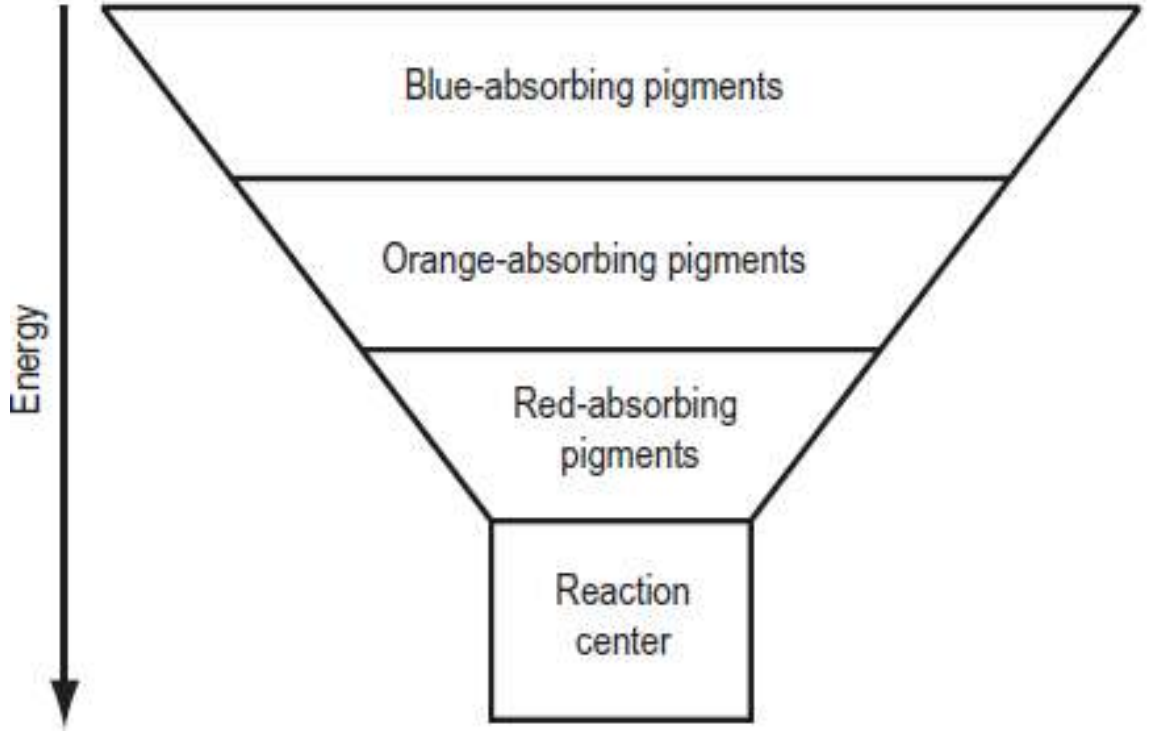
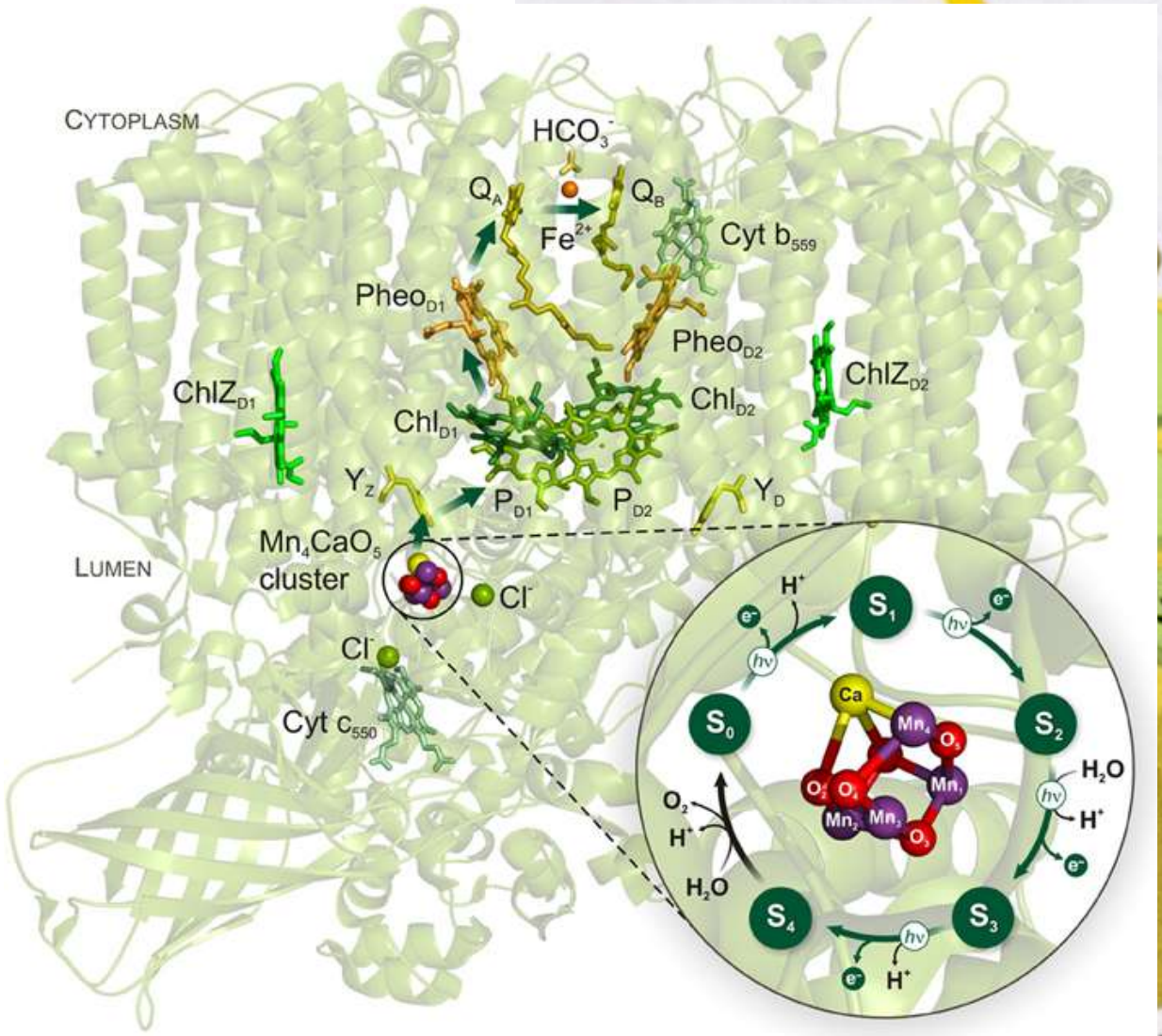
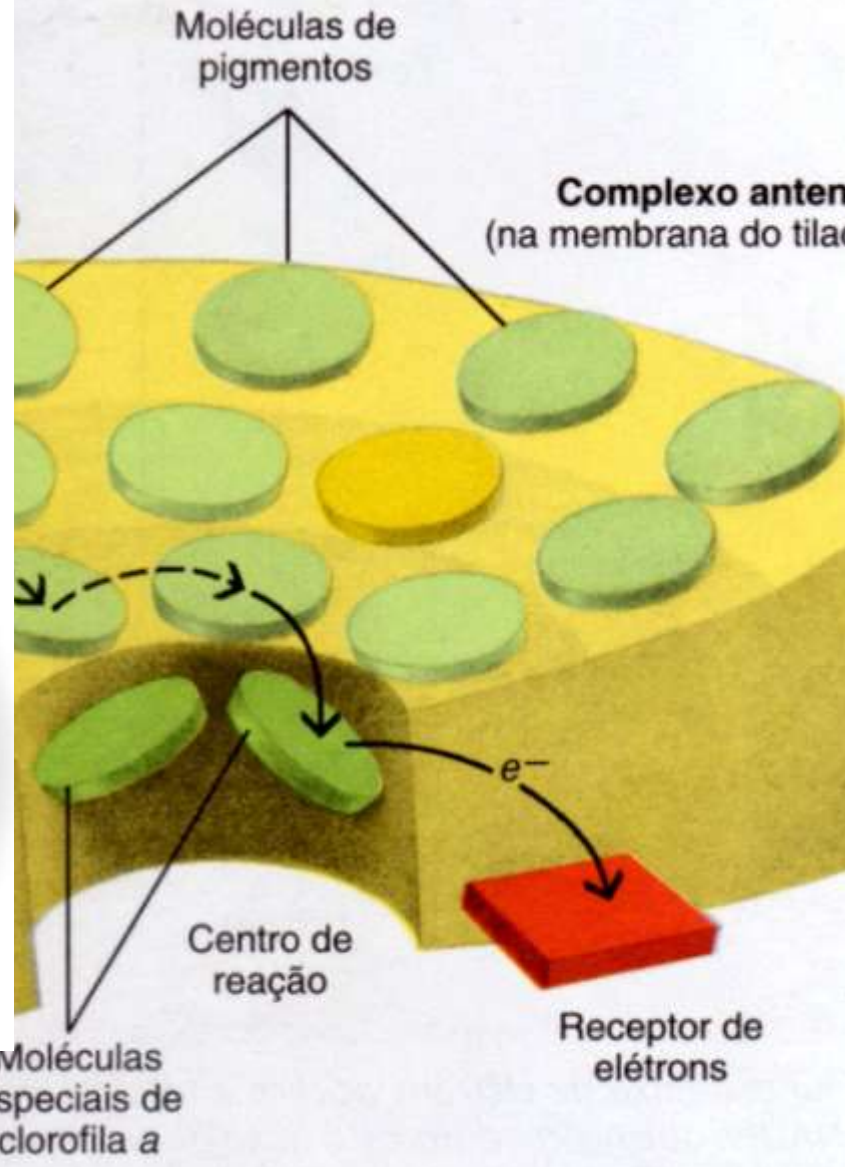
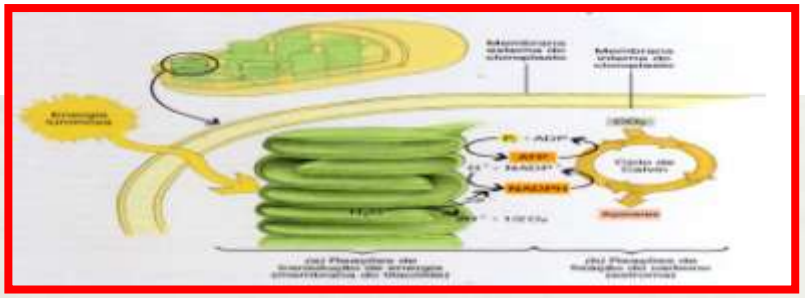


Studying the oxidation of water to molecular oxygen in photosynthetic and artificial systems by time-resolved membrane-inlet mass spectrometry







Nível mais alto de energia

P_{680}

Feofitina

Plastoquinona (Q_a)

Plastoquinona (Q_b)

H^+

Complexo citocromo *b/f*

ADP + P_i

ATP

Fotofosforilação

H^+

Plastocianina

P_{700}

Clorofila *a* modificada (A_0)

Filoquinona (A_1)

Proteínas ferro-enxofre

Ferredoxina (Fd)

Flavoproteína

NADP$^+$ + H^+

NADPH

$2e^-$

Energia luminosa

Centro de reação

Complexo de clivagem da água

H_2O

Mn

$2H^+$

$1/2\ O_2$

$2e^-$

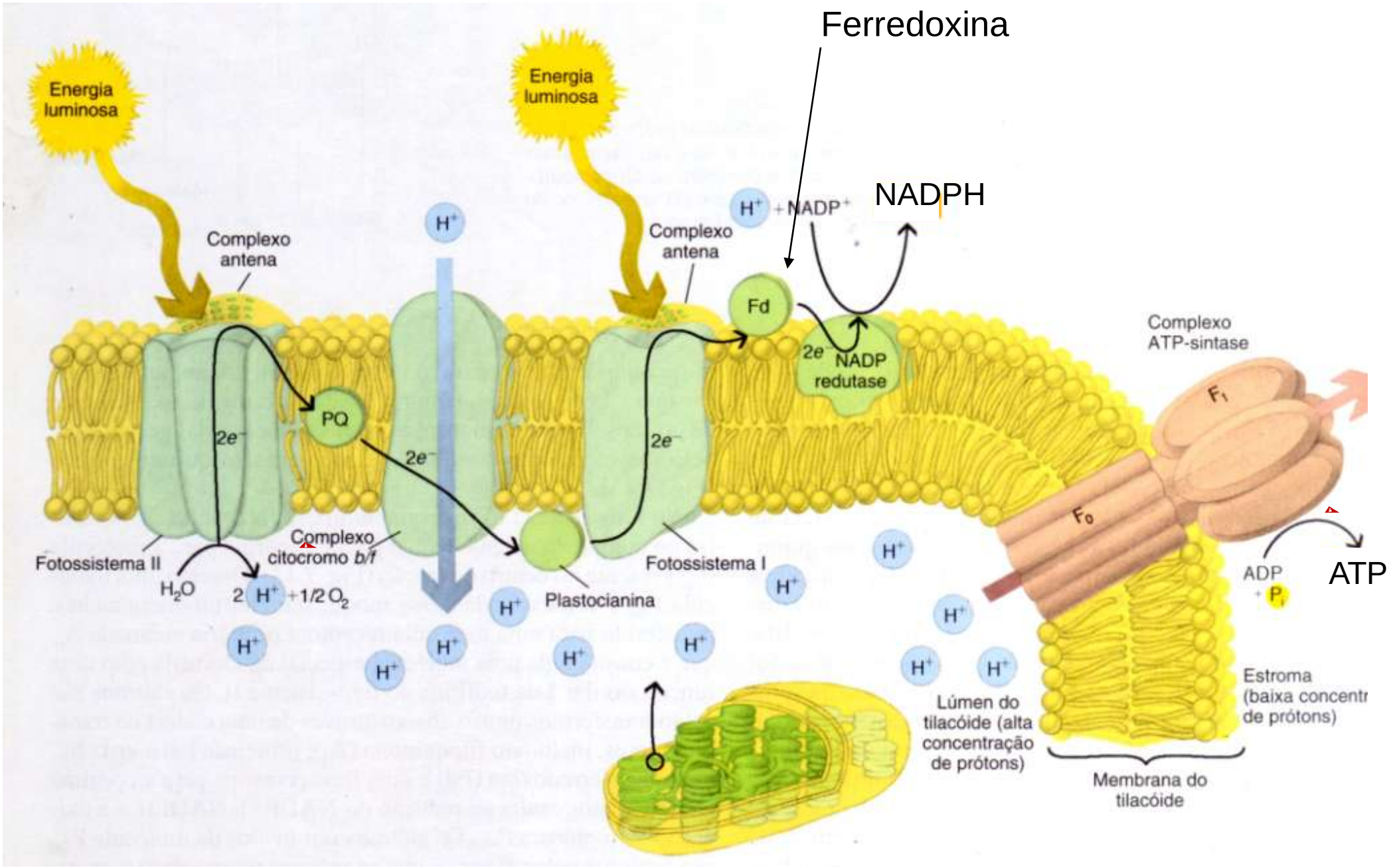
Centro de reação

Fotossistema II

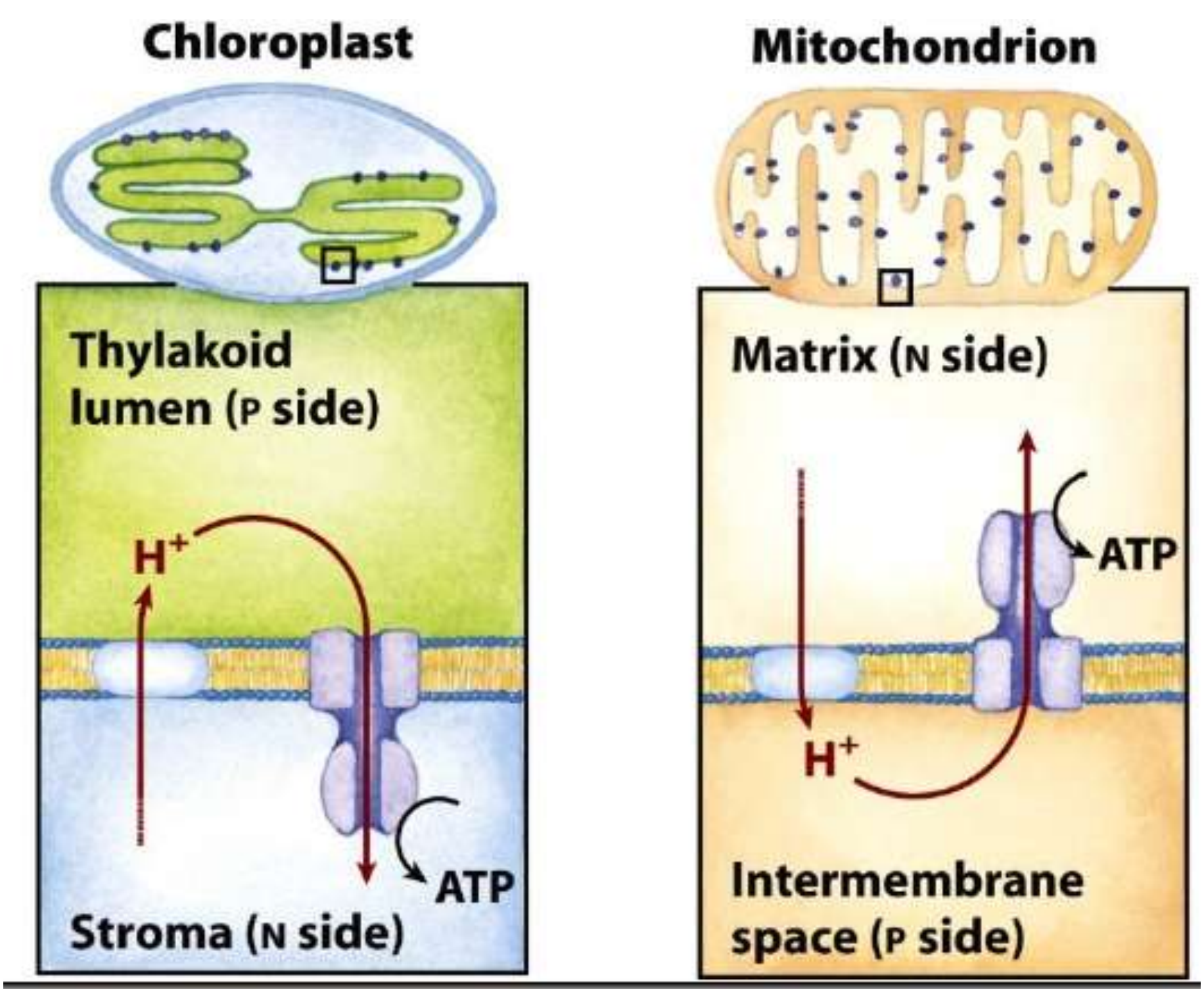
Fotossistema I

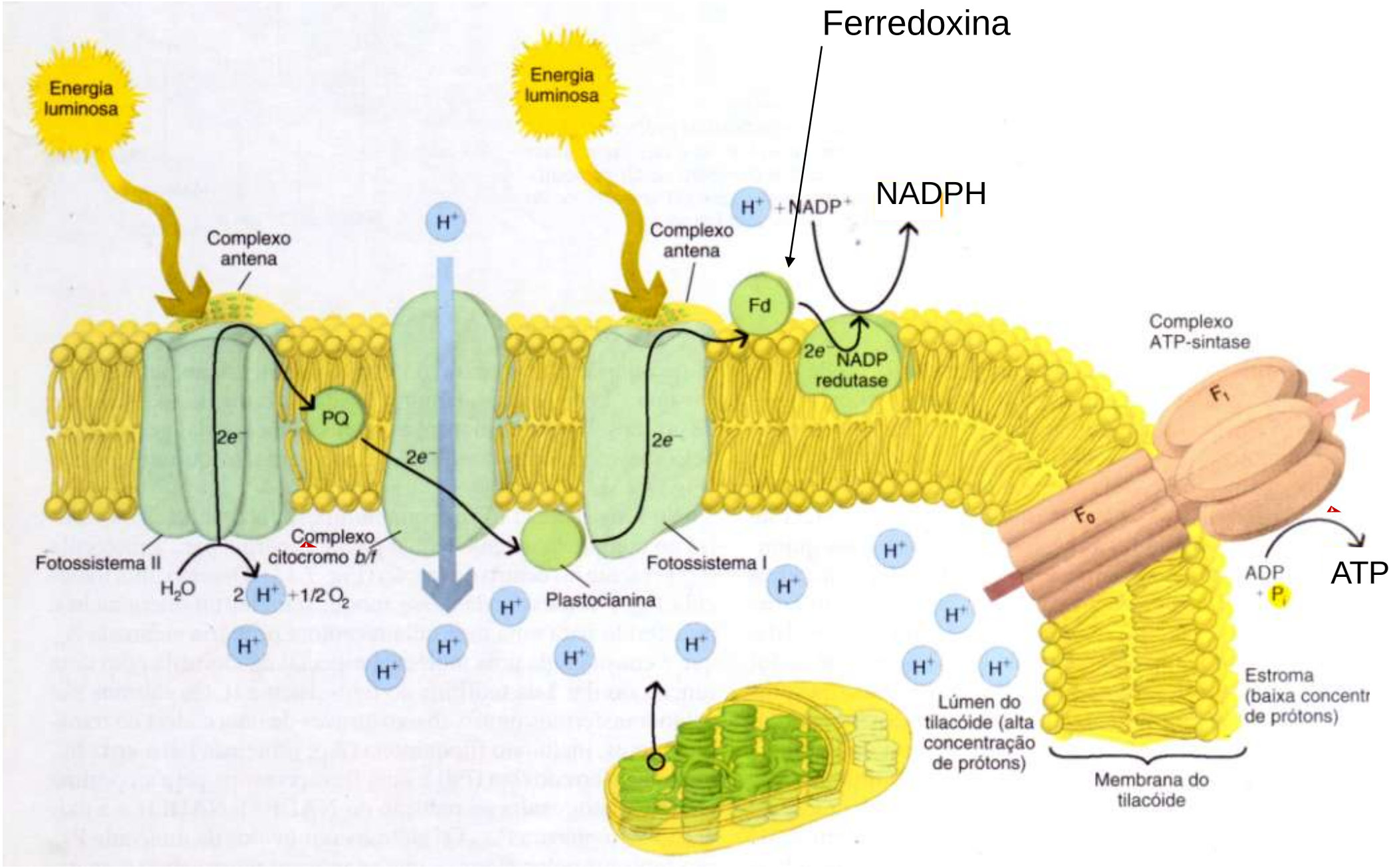
Ciclo de Calvin

Síntese do ATP



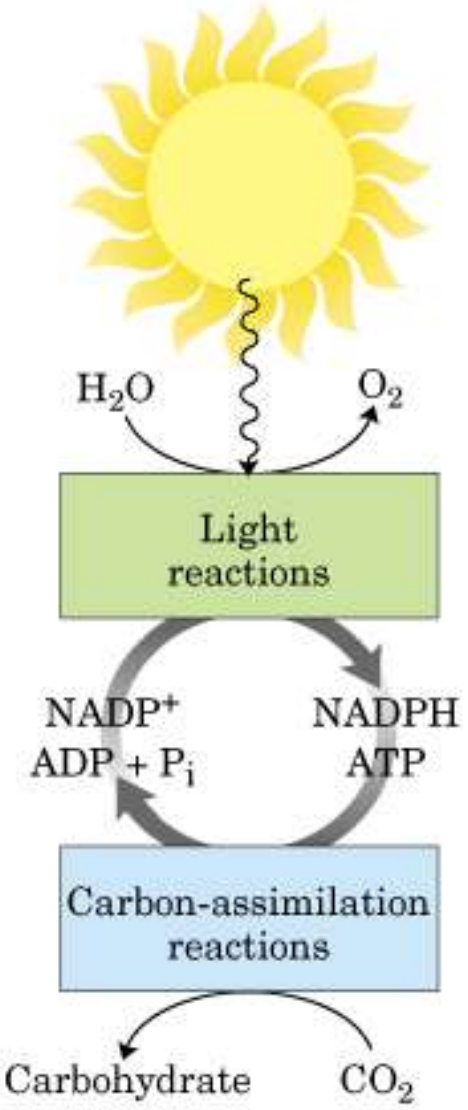
H2O + NADP+ → NADPH + H+ + ½ O2


Chloroplast
Thylakoid lumen (P side)
H+
ATP
Stroma (N side)
Mitochondrion
Matrix (N side)
ATP
H+
Intermembrane space (P side)



H2O + NADP+ → NADPH + H+ + ½ O2

Fixação de Carbono



- *Acoplamento entre as duas vias*
- *para transformar energia luminosa em um esqueleto carbonado*

- *Ciclo de Calvin*

Fixação de Carbono

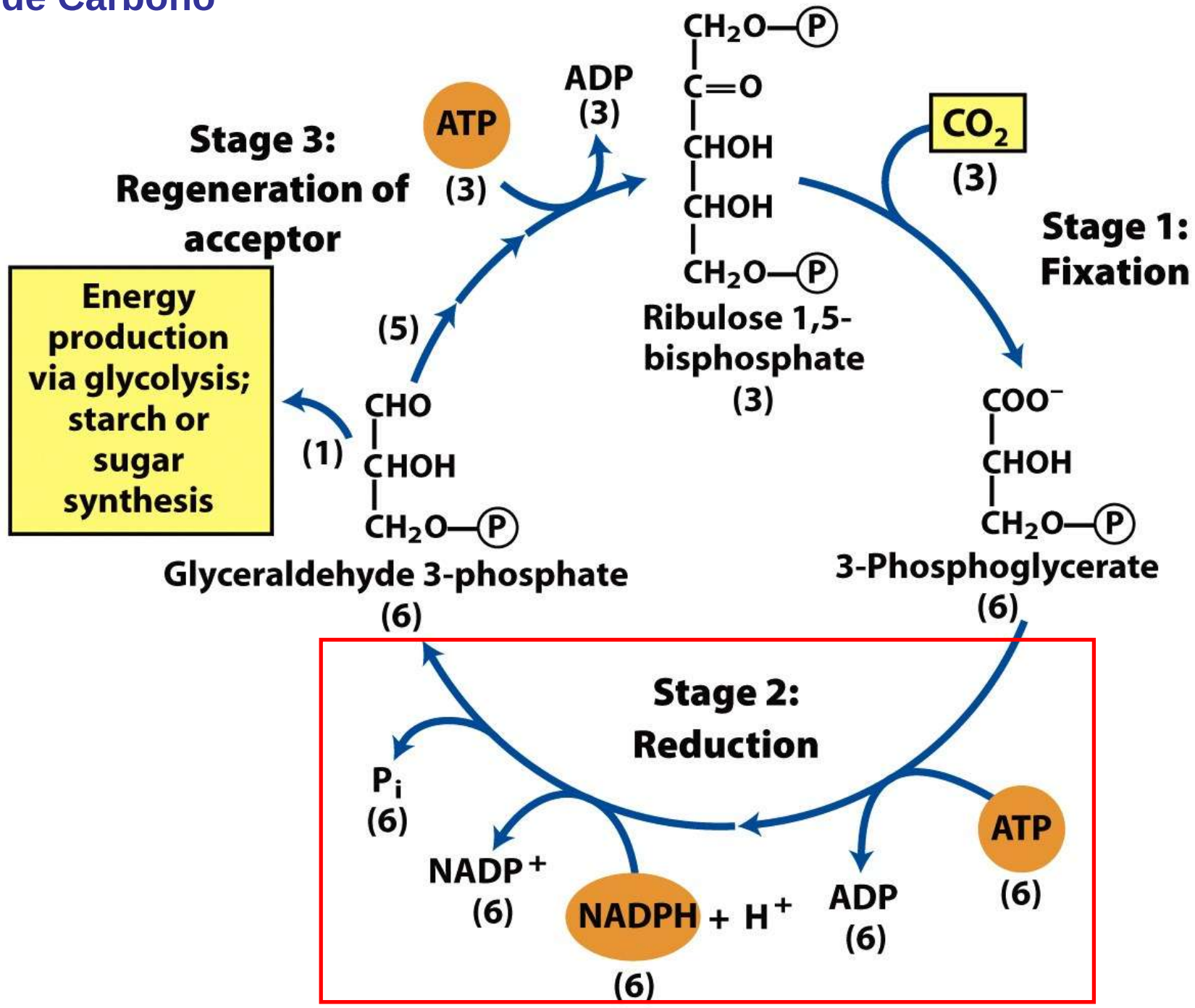


Figure 20-4
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Fixação de Carbono – 2º estágio

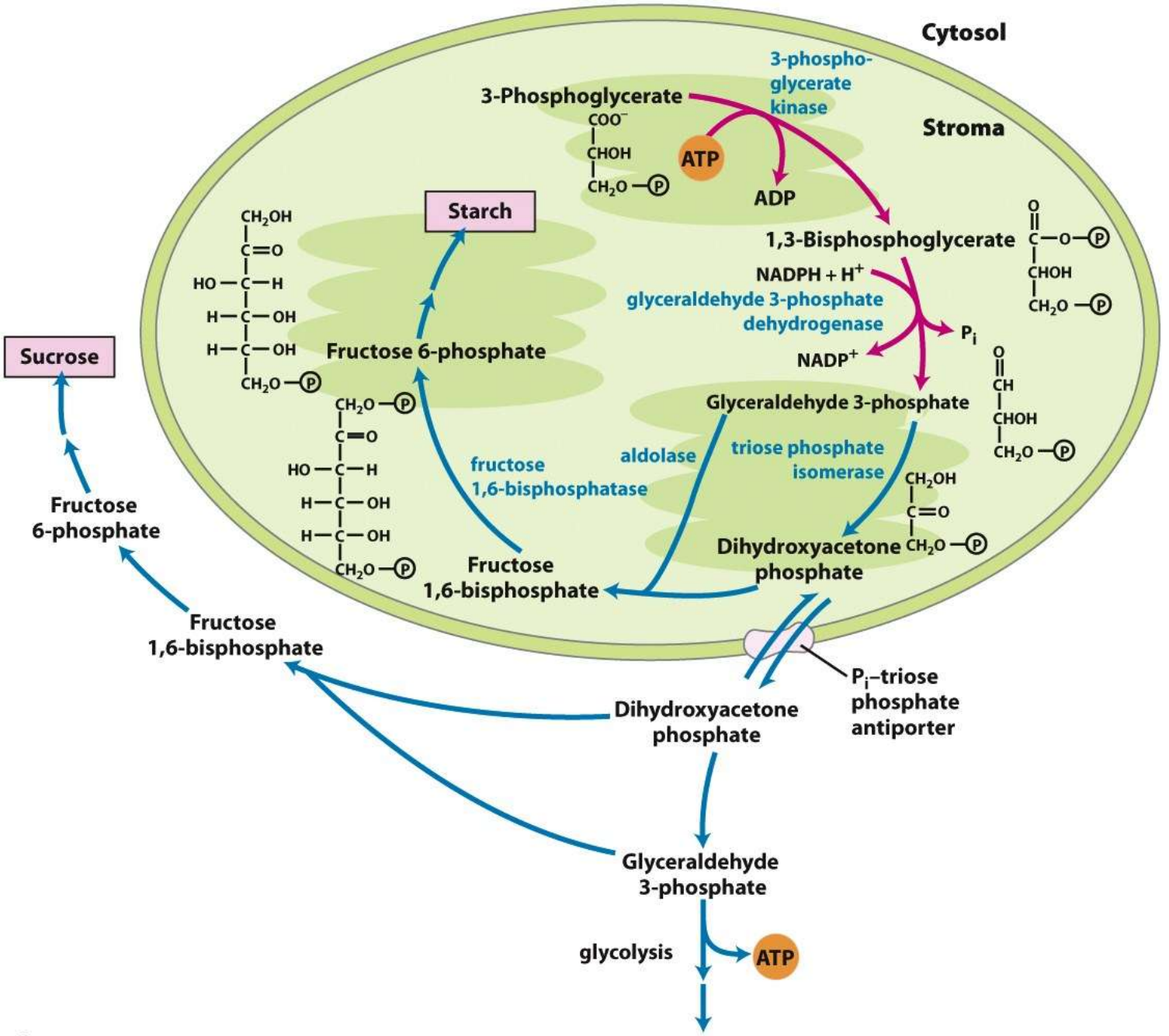

Figure 20-9
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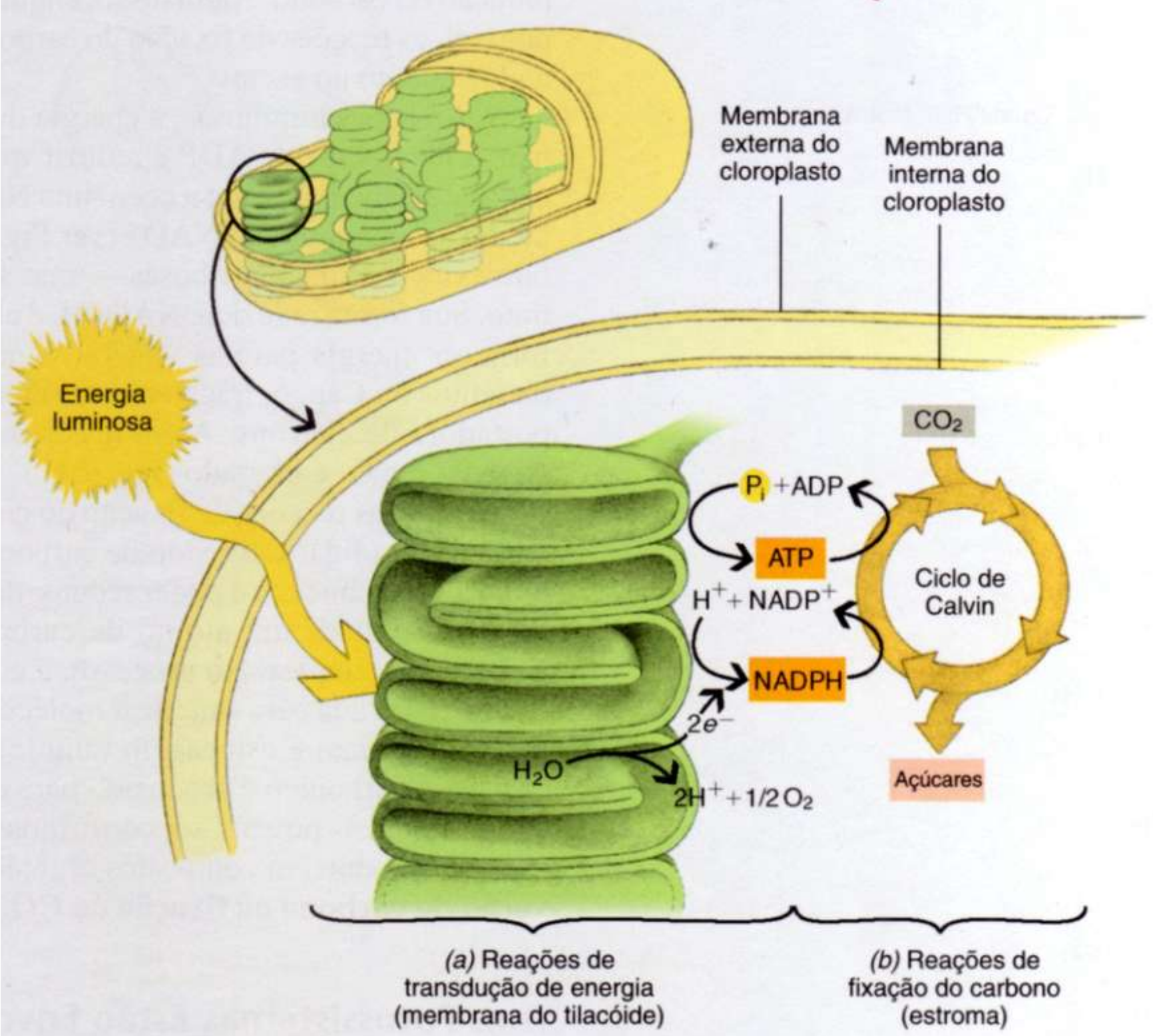
Membrana externa do cloroplasto
Membrana interna do cloroplasto
Energia luminosa
CO_2
P_i + ADP
ATP
Ciclo de Calvin
$H^+ + NADP^+$
NADPH
$2e^-$
H_2O
$2H^+ + 1/2\,O_2$
Açúcares
(a) Reações de transdução de energia (membrana do tilacóide)
(b) Reações de fixação do carbono (estroma)

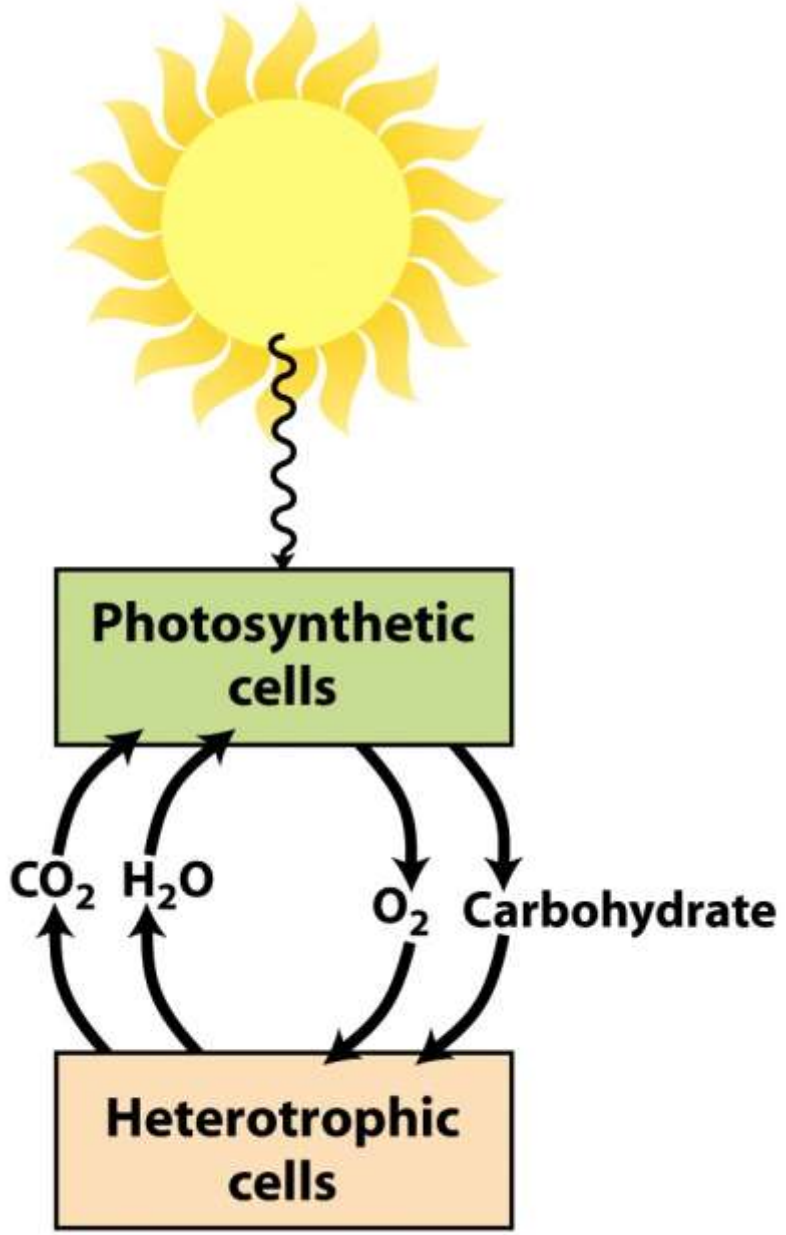

Figure 19-43
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