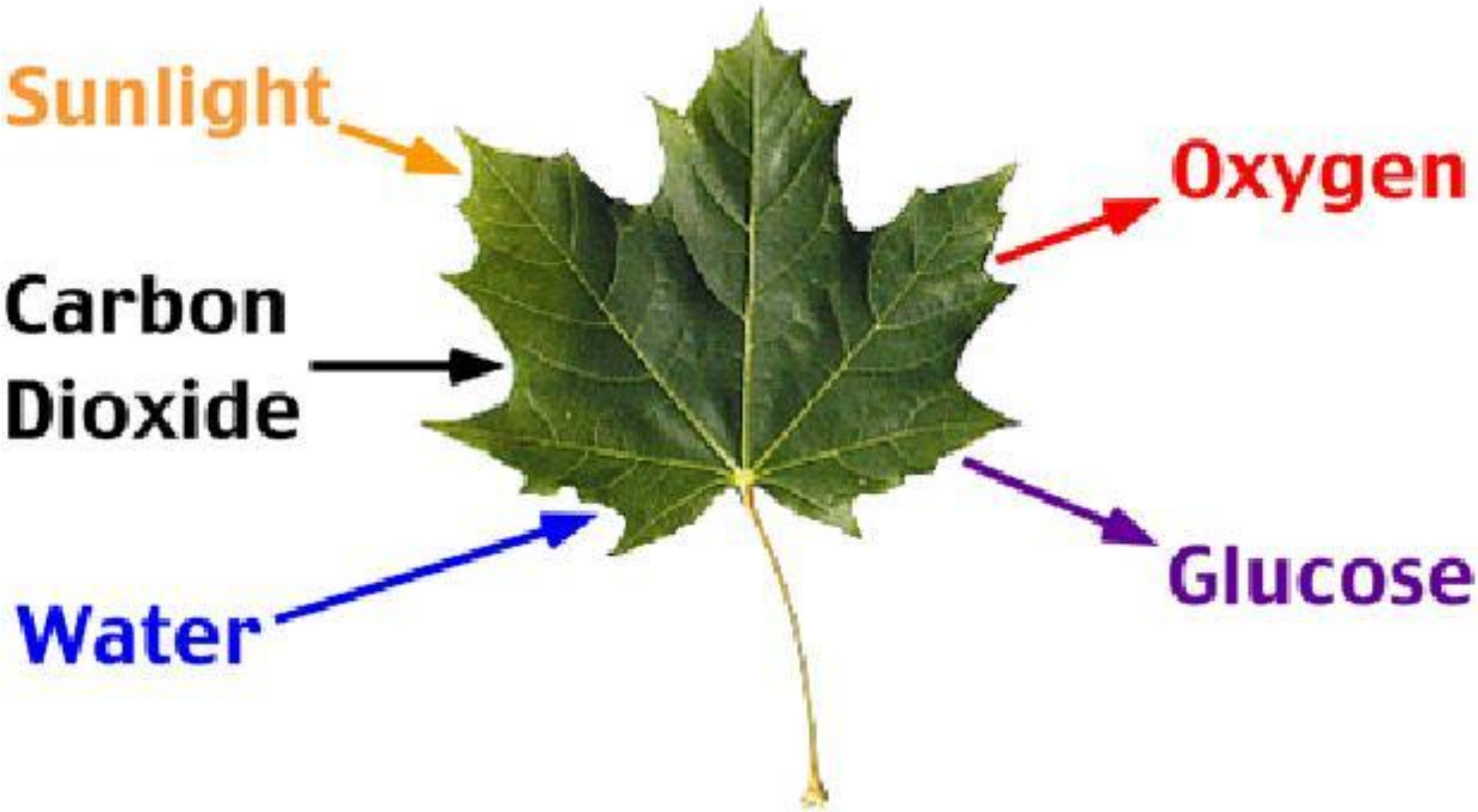
Photosynthesis

Ch. 8.2


Sunlight
Oxygen
Carbon Dioxide
Glucose
Water

A. Harnessing the sun's E

1. 1%

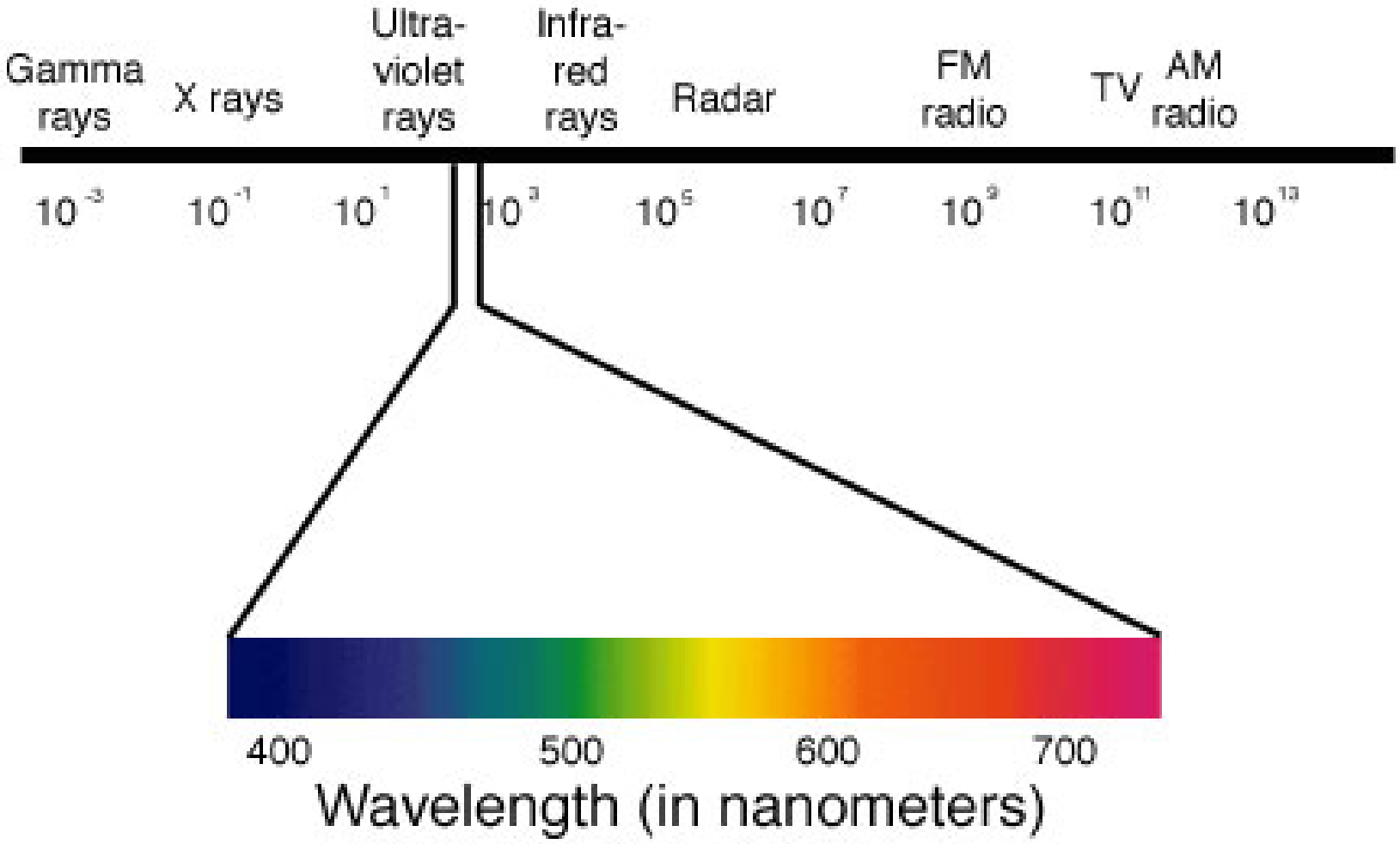
2. 2 stages

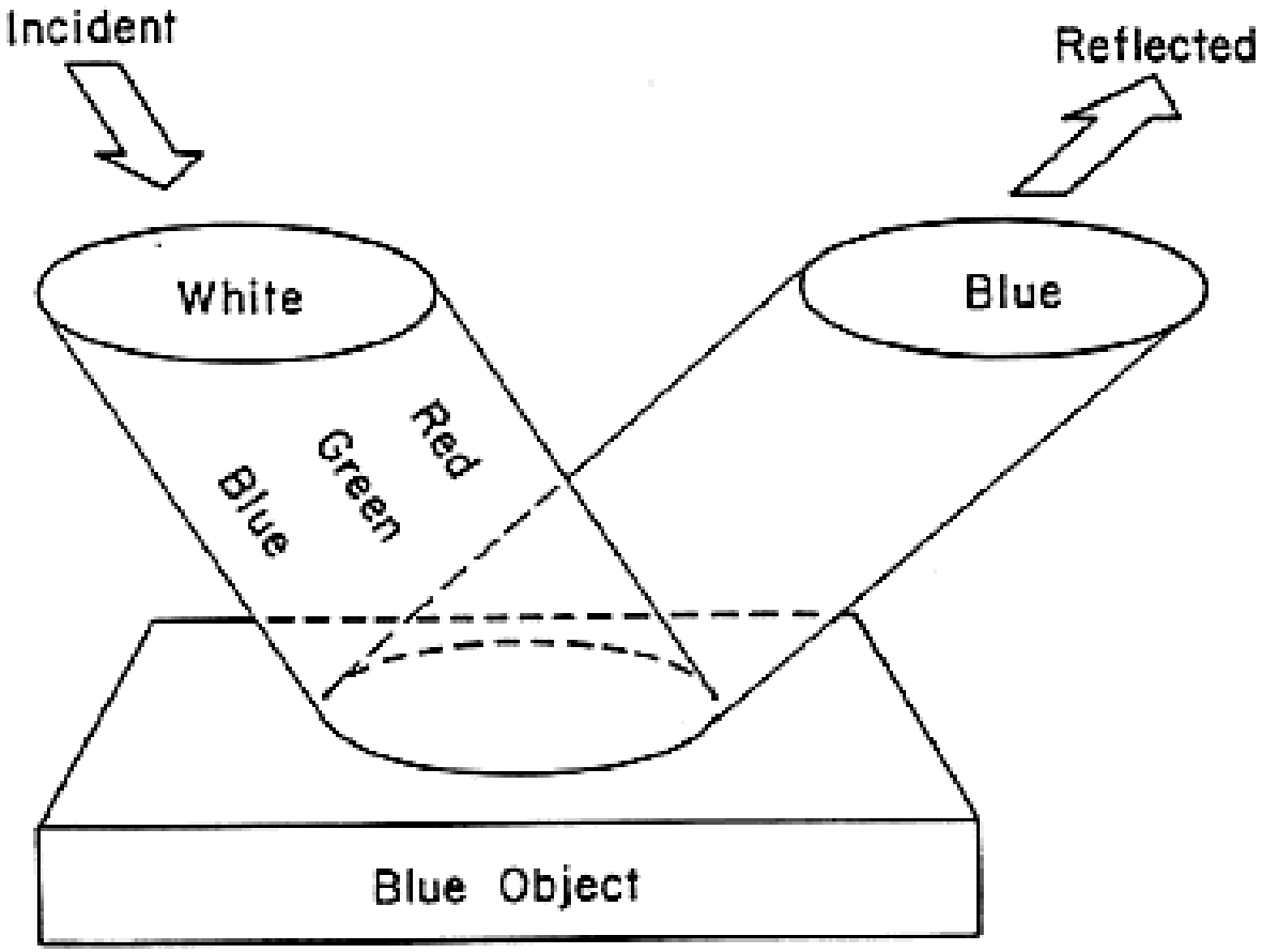
B. Stage 1

1. Electromagnetic E

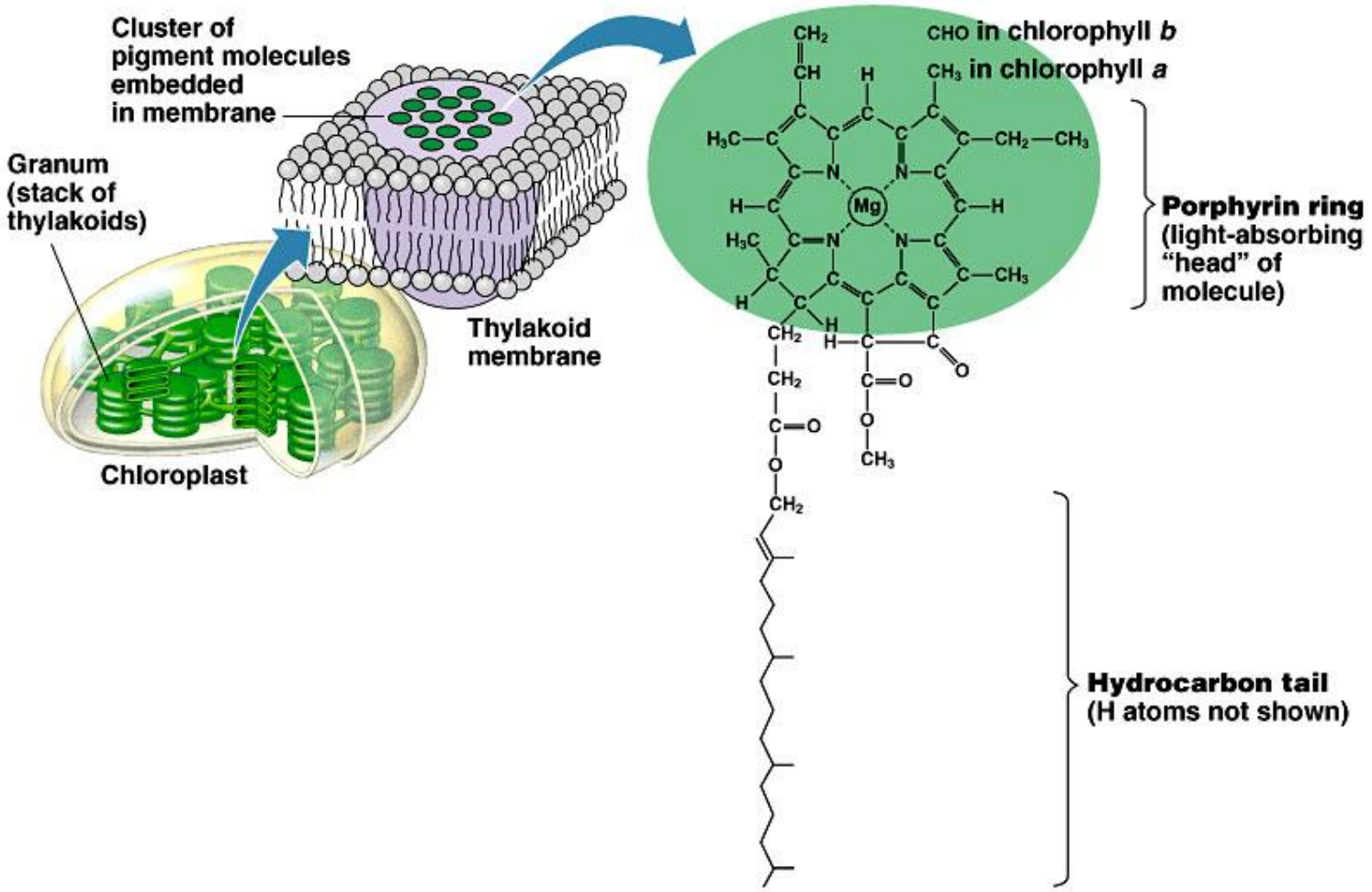
   a. Gamma→radio

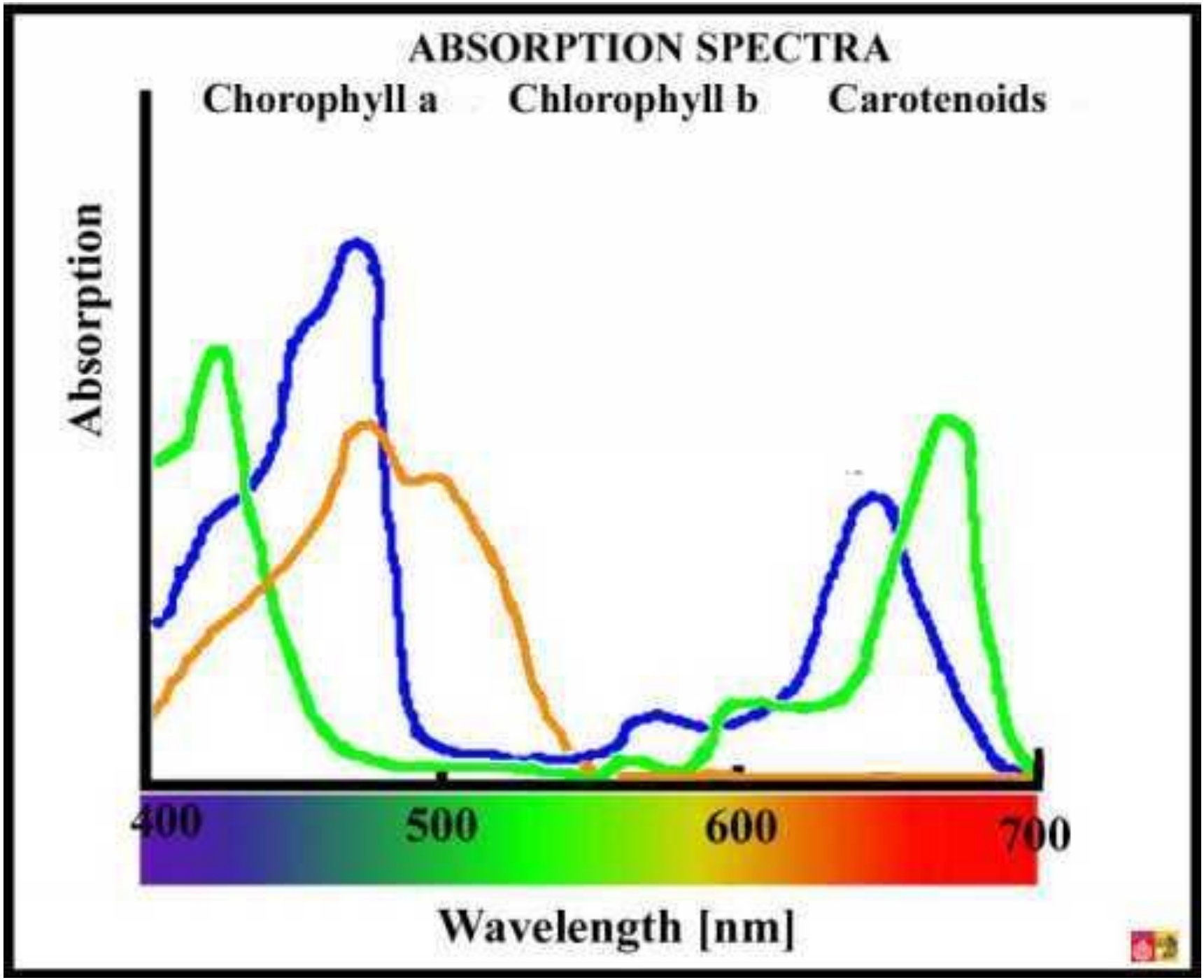
   b. Absorb/reflect


Gamma rays
X rays
Ultra-violet rays
Infra-red rays
Radar
FM radio
TV
AM radio
10^-3
10^-1
10^1
10^3
10^5
10^7
10^9
10^11
10^13
400
500
600
700
Wavelength (in nanometers)


Incident
Reflected
White
Blue
Red
Green
Blue
Blue Object

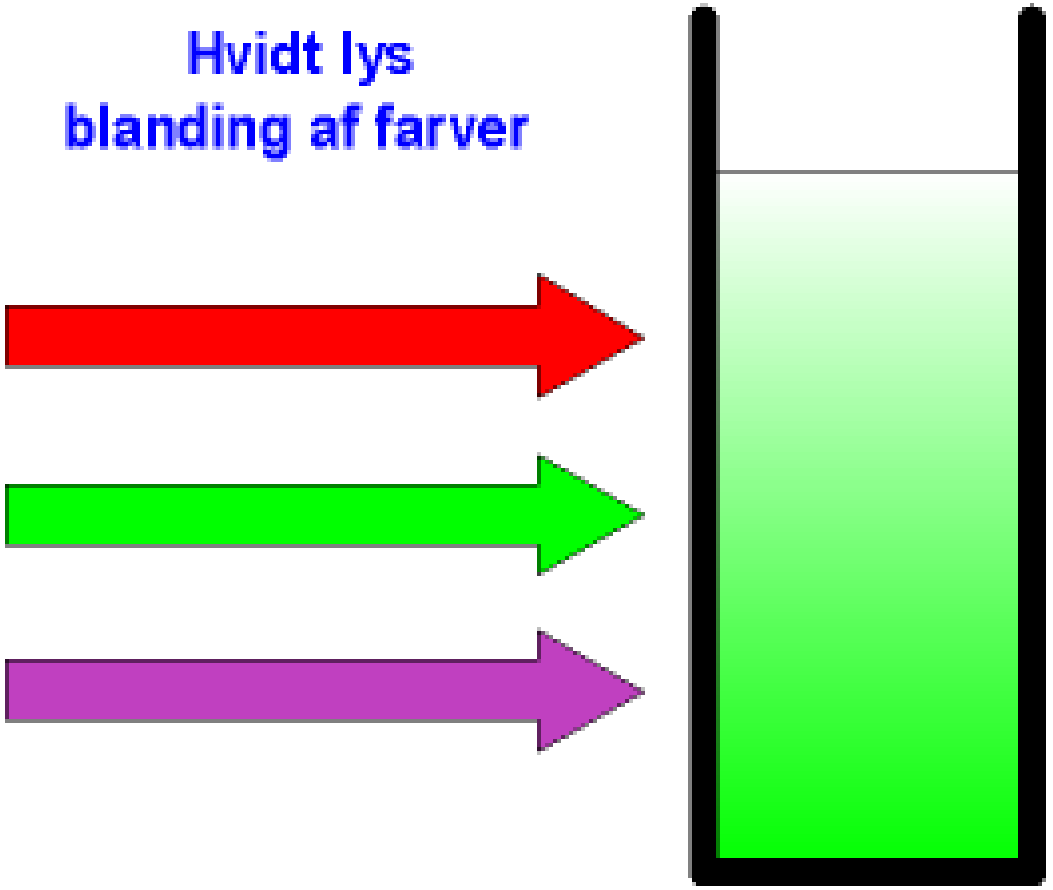
2. Chlorophyll et. al.
    a. Green
    b. Carotenoids
    c. Cold weather



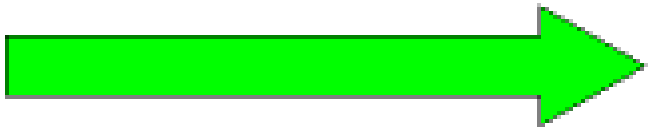

ABSORPTION SPECTRA
Chorophyll a
Chlorophyll b
Carotenoids
Absorption
400
500
600
700
Wavelength [nm]

Kuvette med chlorophyllopløsning

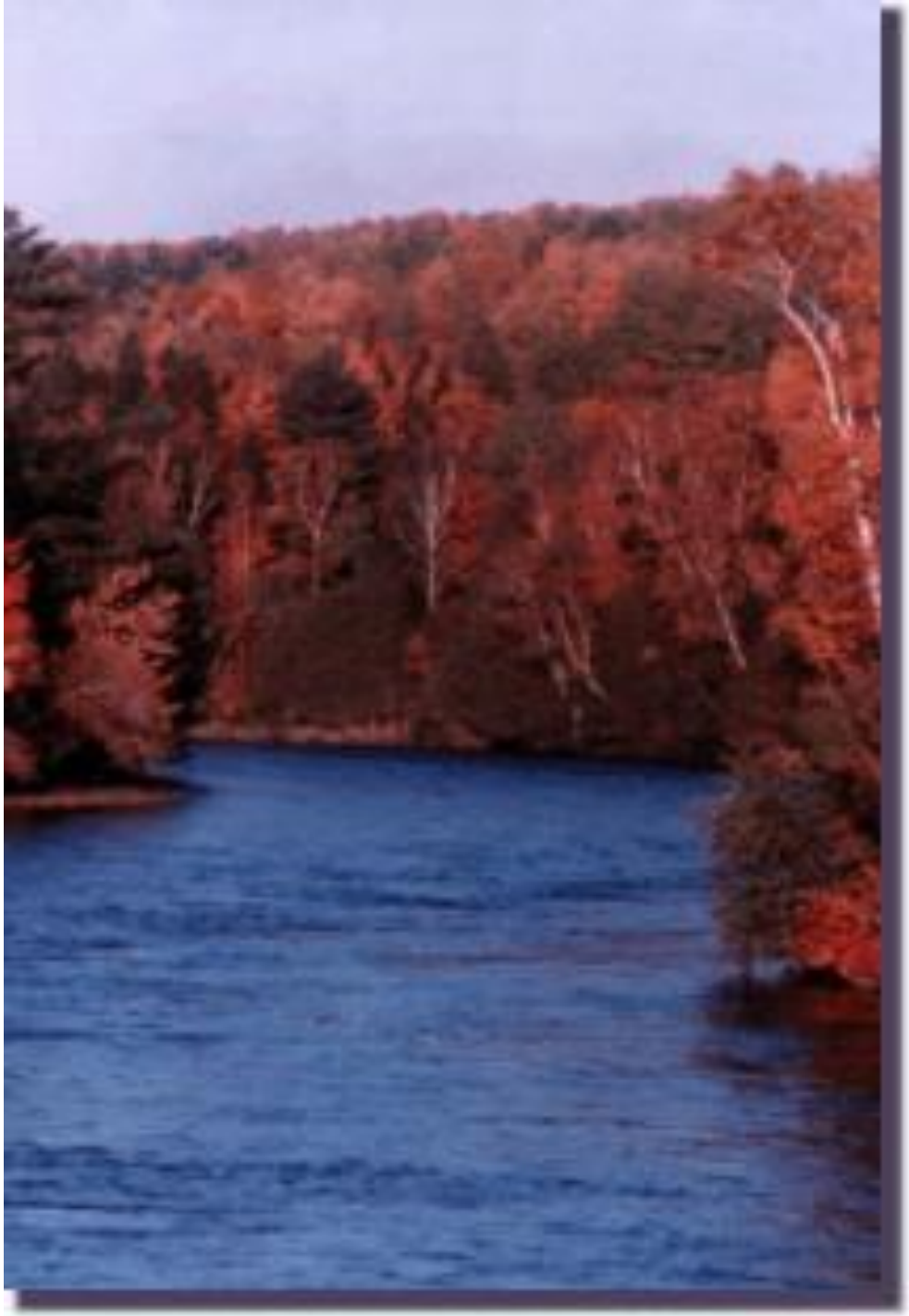
Hvidt lys
blanding af farver



Grønt lys absorberes ikke
opløsningen ser derfor
grøn ud



BioSite 7/12,03



d. Pigment

e. Retinal

f. Insects

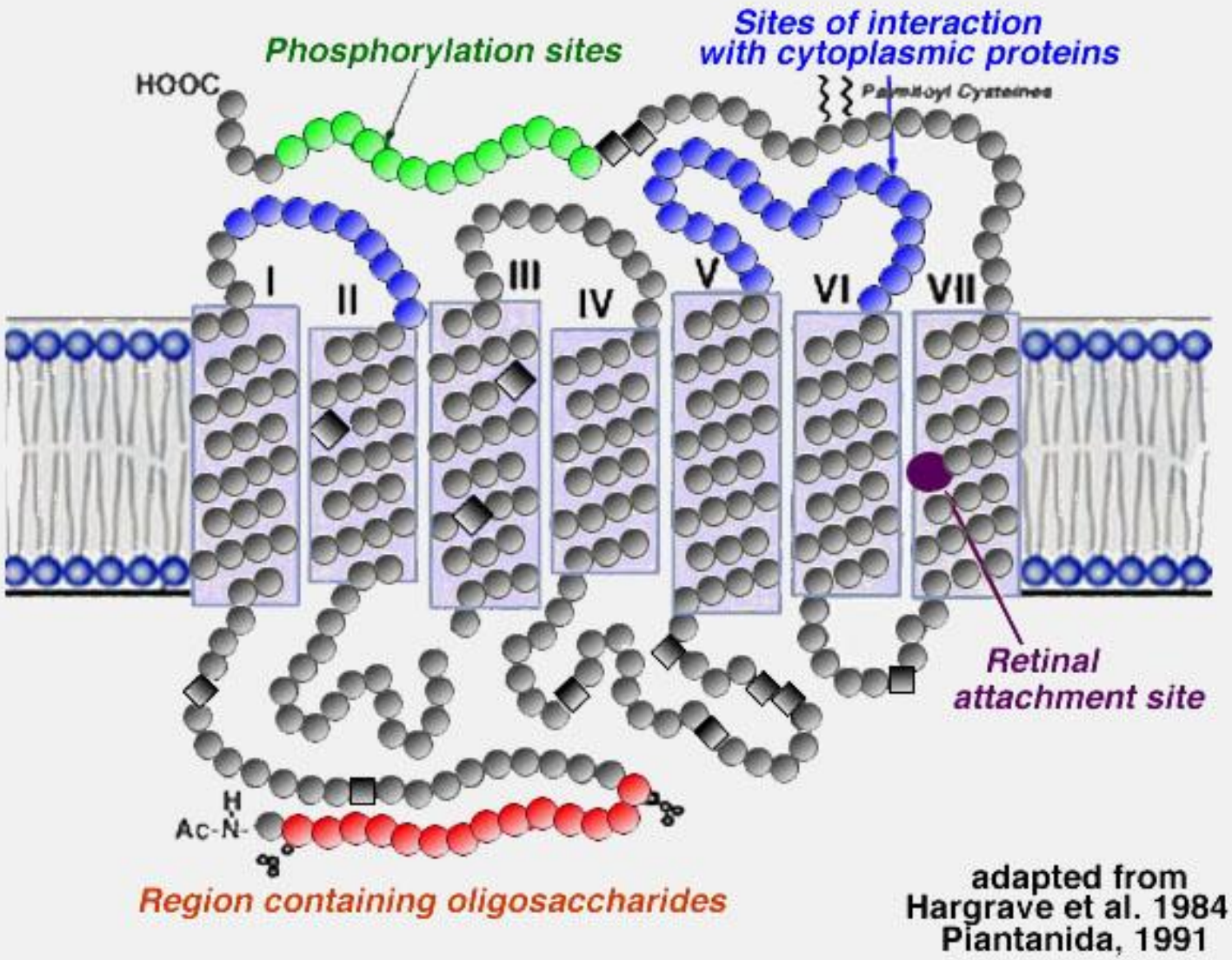


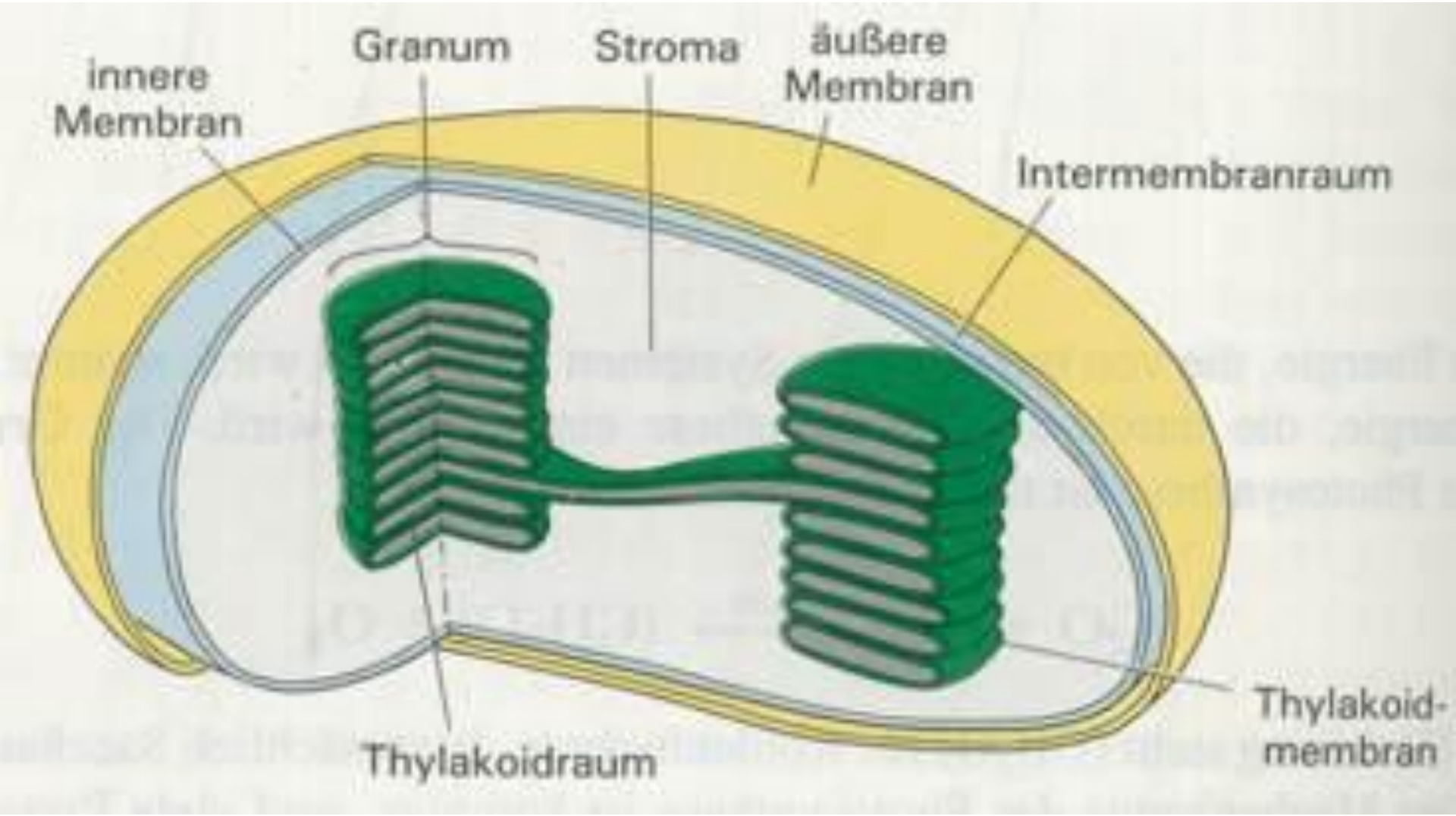
Fig. 9. Structural model of rhodopsin showing seven transmembrane components and the attachment site for retinal.

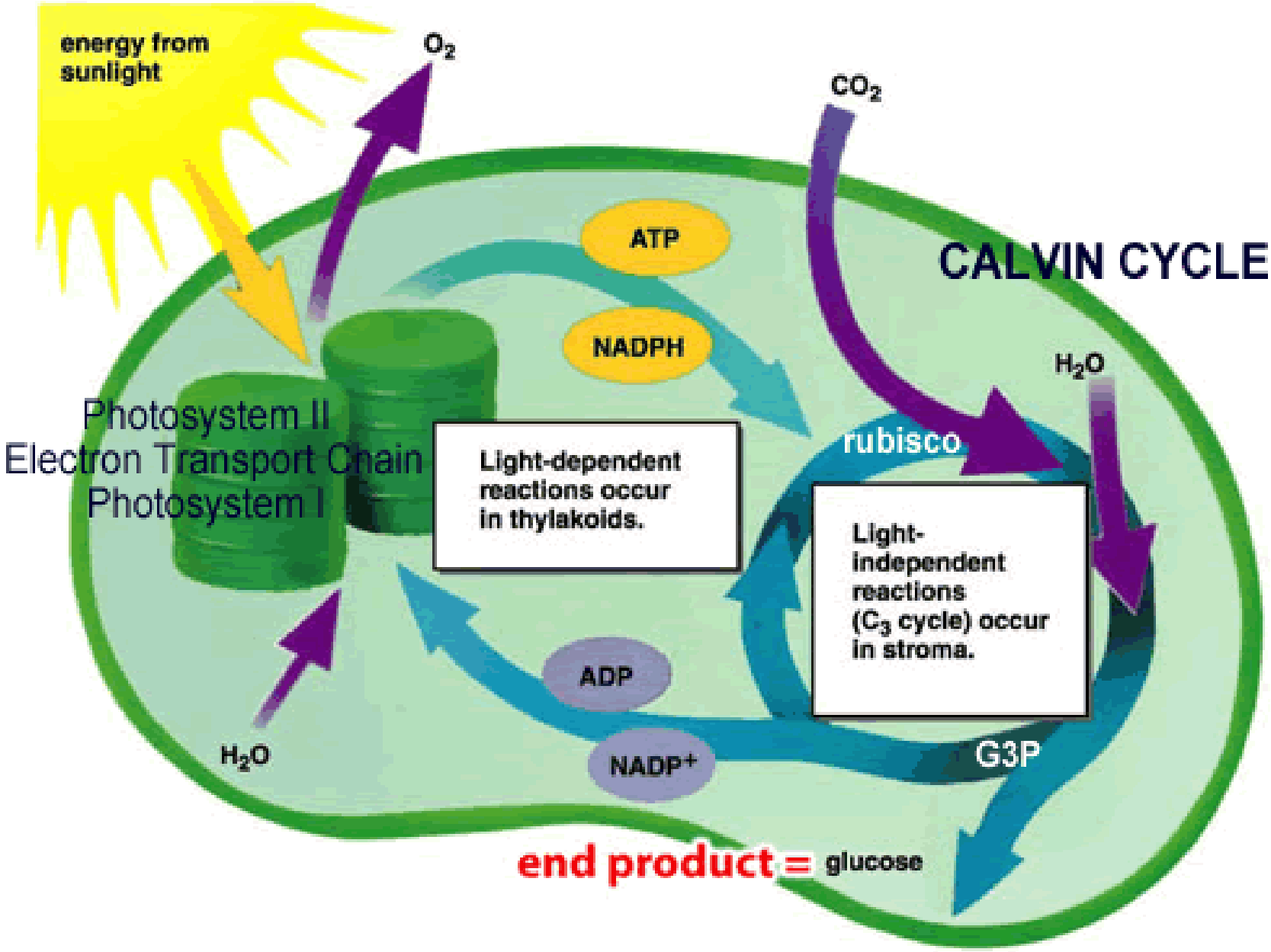
Visible Appearance

Spurious/false color

Recorded by digital camera through 18A UV filter

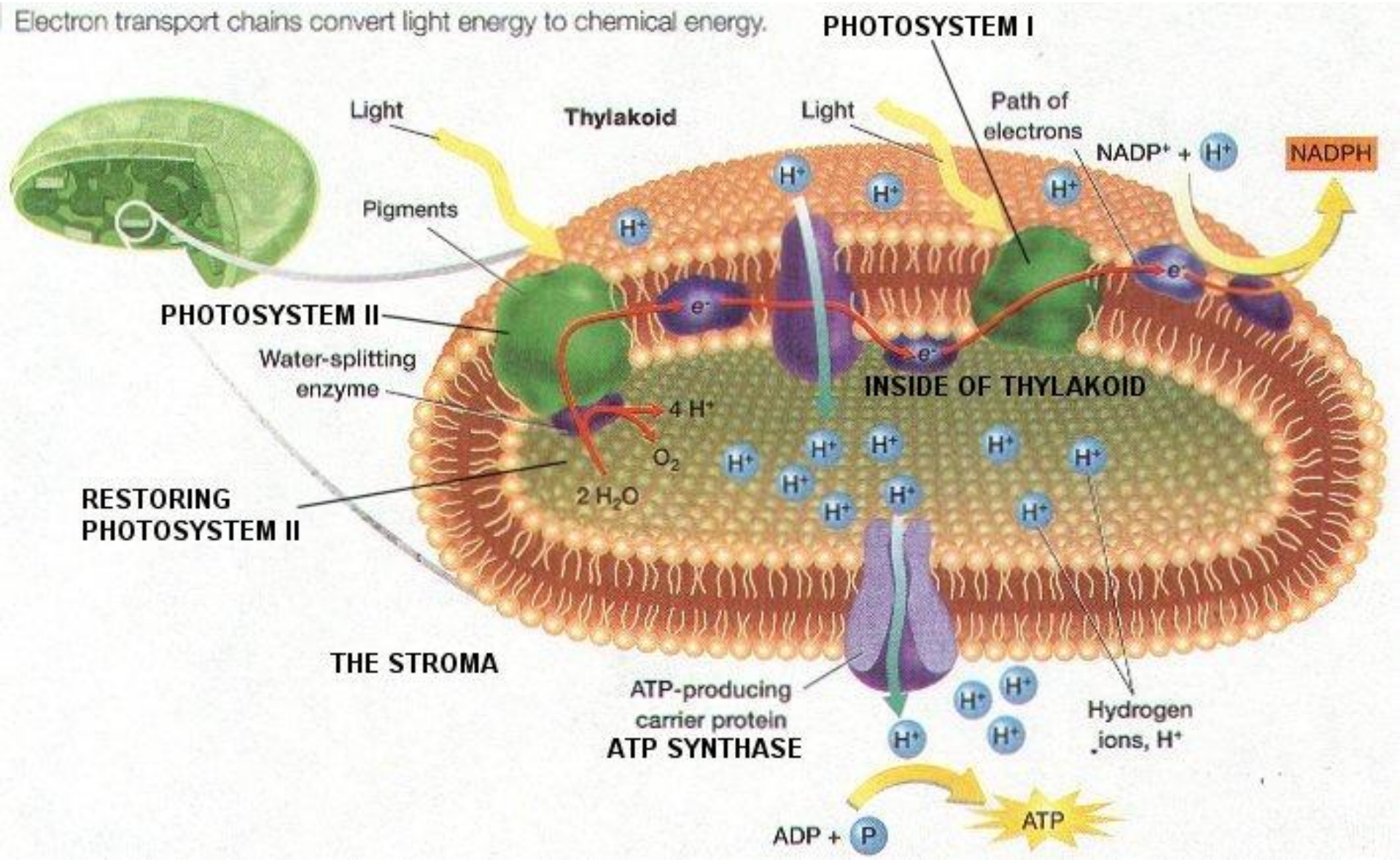
Greyscale, UV, record

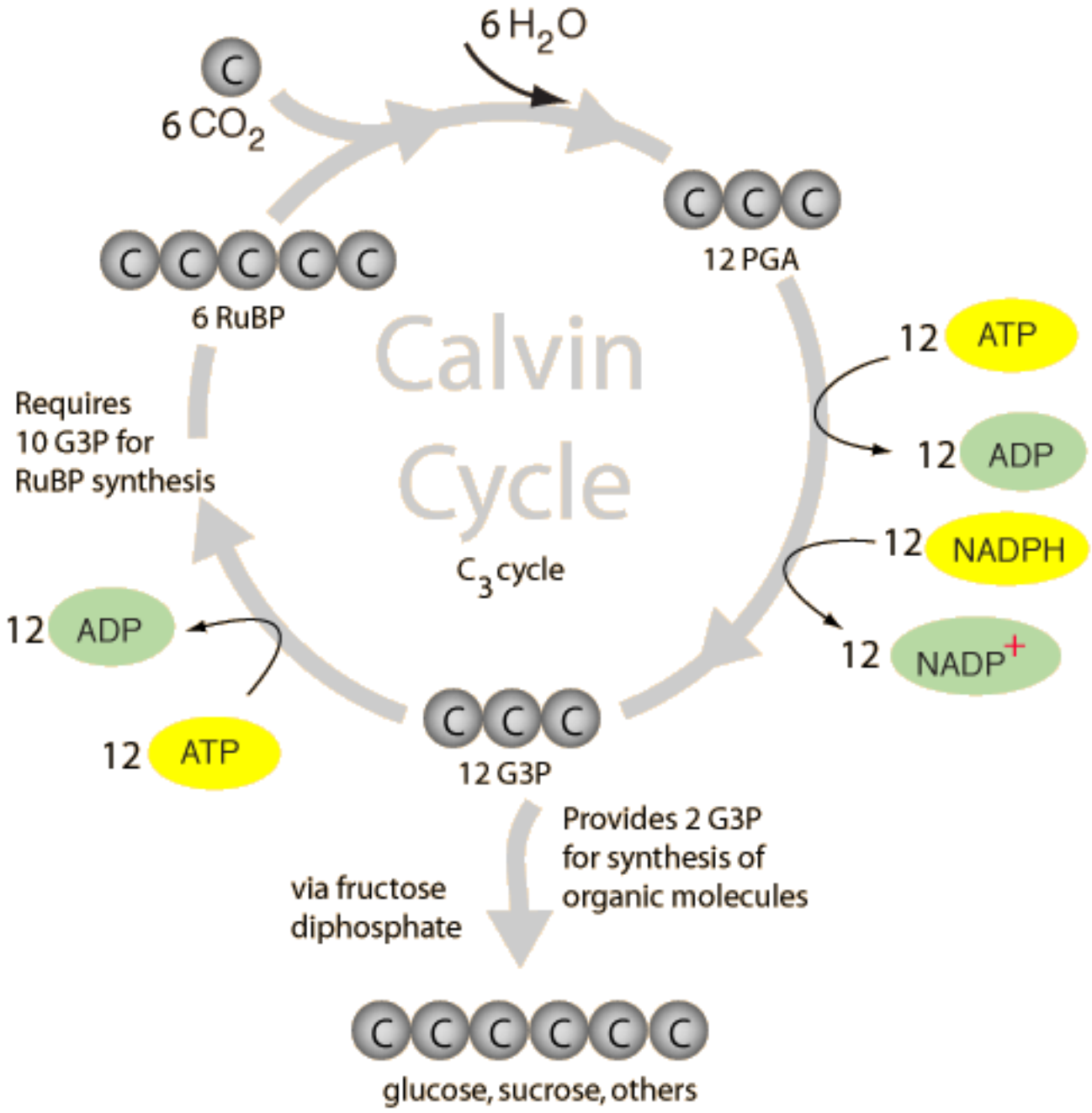

innere Membran
Granum
Stroma
äußere Membran
Intermembranraum
Thylakoidraum
Thylakoid-membran


energy from sunlight
O_2
CO_2
ATP
NADPH
CALVIN CYCLE
H_2O
Photosystem II
Electron Transport Chain
Photosystem I
Light-dependent reactions occur in thylakoids.
rubisco
Light-independent reactions (C_3 cycle) occur in stroma.
ADP
H_2O
$NADP^+$
G3P
end product = glucose

C. Photosynthesis:

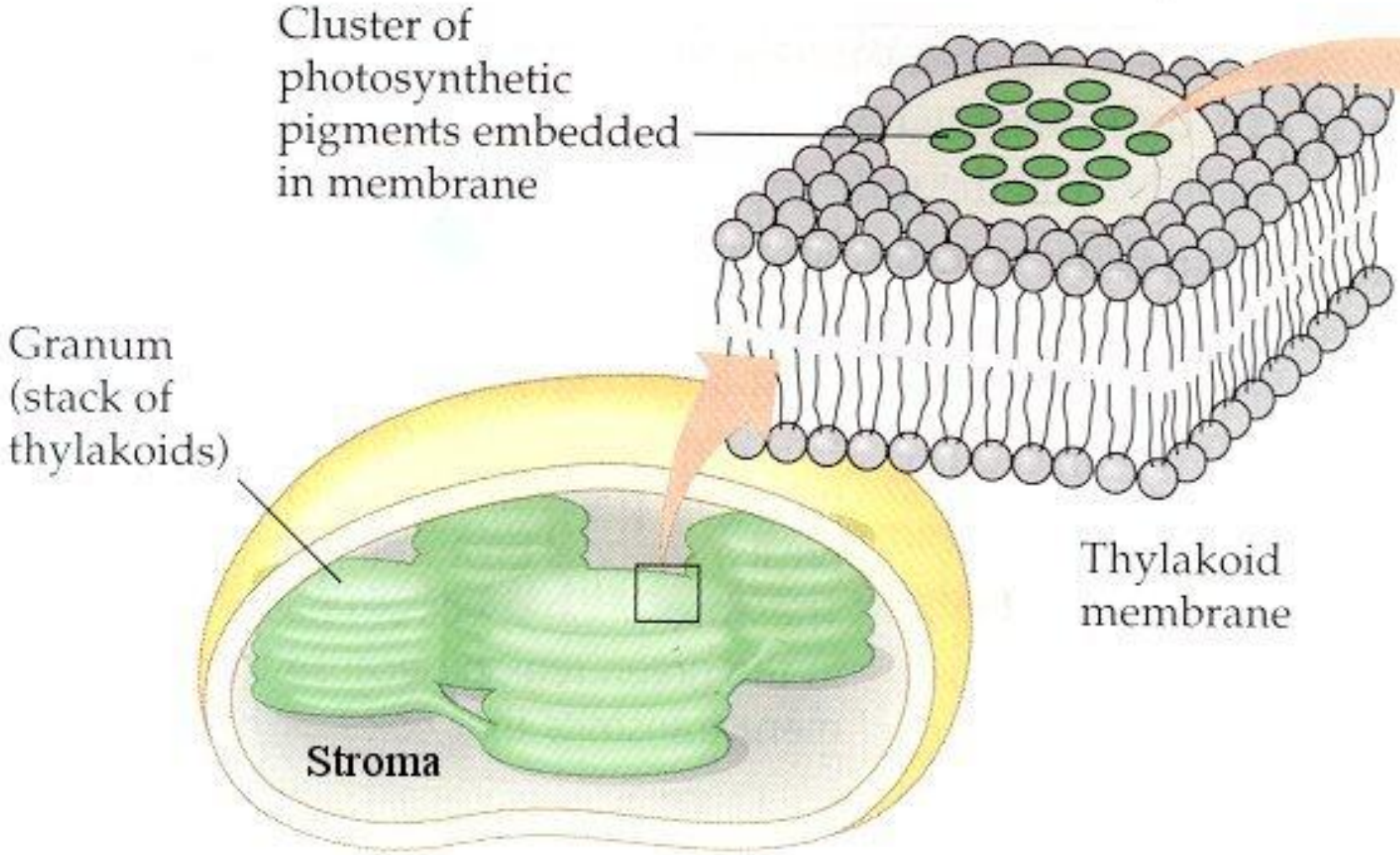
1. Light dependent reaction
2. Calvin cycle
3. All same

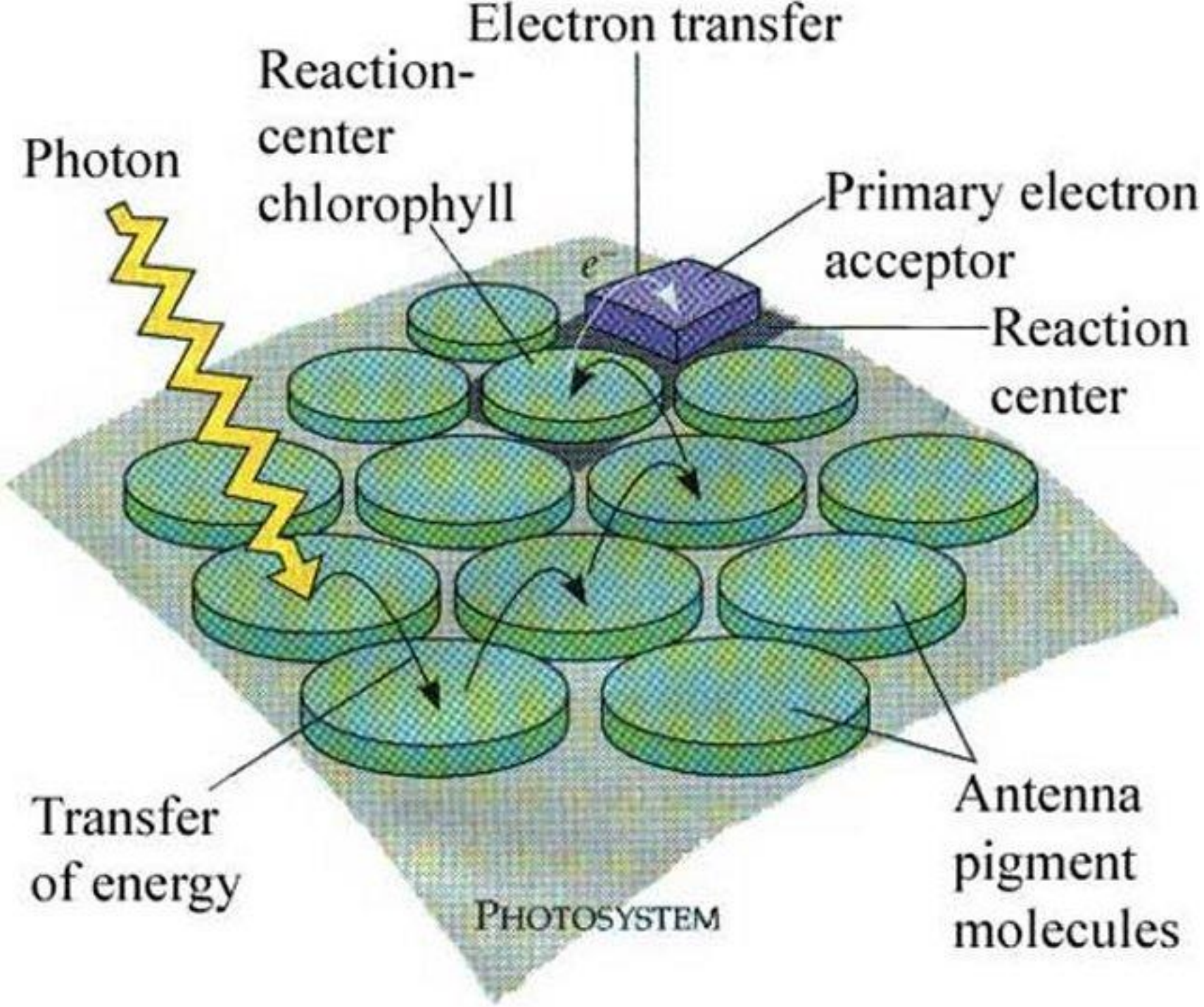

Electron transport chains convert light energy to chemical energy.
PHOTOSYSTEM I
Light
Thylakoid
Light
Path of electrons
NADP+ + H+
NADPH
Pigments
PHOTOSYSTEM II
Water-splitting enzyme
4 H+
O2
2 H2O
INSIDE OF THYLAKOID
RESTORING PHOTOSYSTEM II
THE STROMA
ATP-producing carrier protein
ATP SYNTHASE
Hydrogen ions, H+
ADP + P
ATP

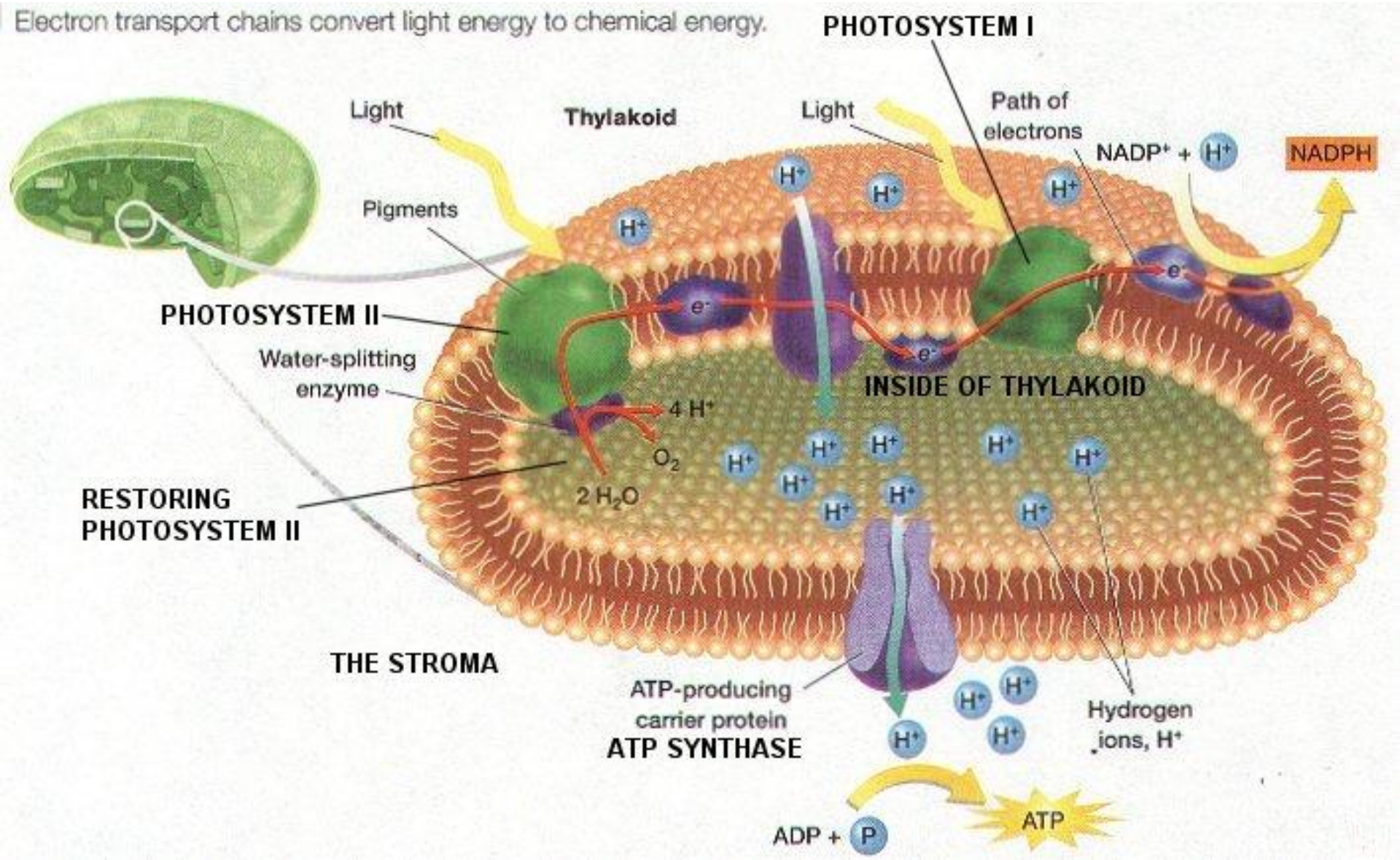

6 H_2O
C
6 CO_2
C C C
12 PGA
C C C C C
6 RuBP
Calvin Cycle
C_3 cycle
12 ATP
12 ADP
12 NADPH
12 $NADP^+$
Requires 10 G3P for RuBP synthesis
12 ADP
12 ATP
C C C
12 G3P
Provides 2 G3P for synthesis of organic molecules
via fructose diphosphate
C C C C C C
glucose, sucrose, others

D. Light Dependent

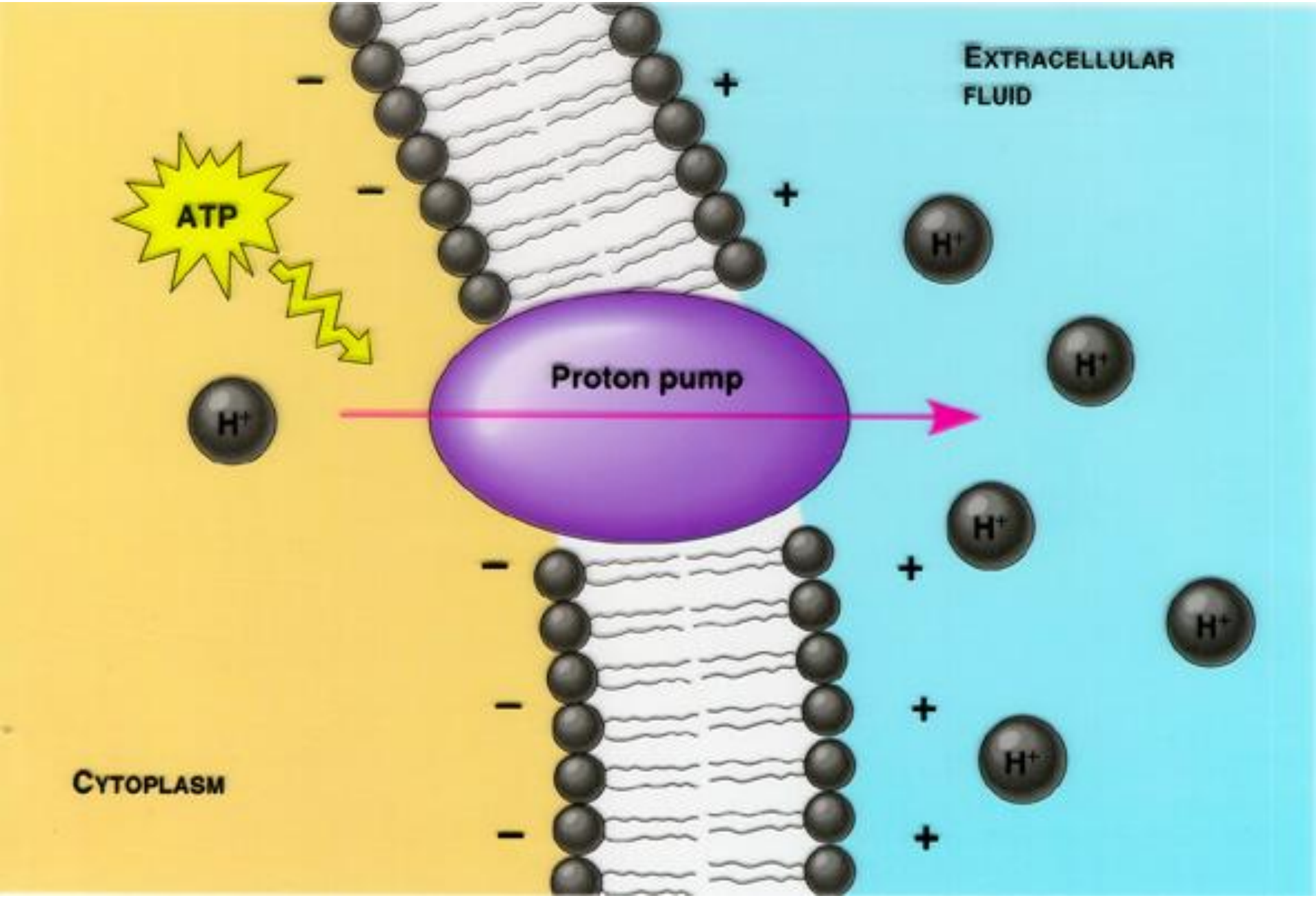
1. Thylakoids
2. Light boosts
3. Break up water


Cluster of photosynthetic pigments embedded in membrane
Granum (stack of thylakoids)
Thylakoid membrane
Stroma


Electron transfer
Reaction-center chlorophyll
Photon
Primary electron acceptor
e^-
Reaction center
Transfer of energy
PHOTOSYSTEM
Antenna pigment molecules


Electron transport chains convert light energy to chemical energy.
PHOTOSYSTEM I
Light
Thylakoid
Light
Path of electrons
NADP+ + H+
NADPH
Pigments
PHOTOSYSTEM II
Water-splitting enzyme
4 H+
O2
2 H2O
INSIDE OF THYLAKOID
RESTORING PHOTOSYSTEM II
THE STROMA
ATP-producing carrier protein
ATP SYNTHASE
Hydrogen ions, H+
ADP + P
ATP

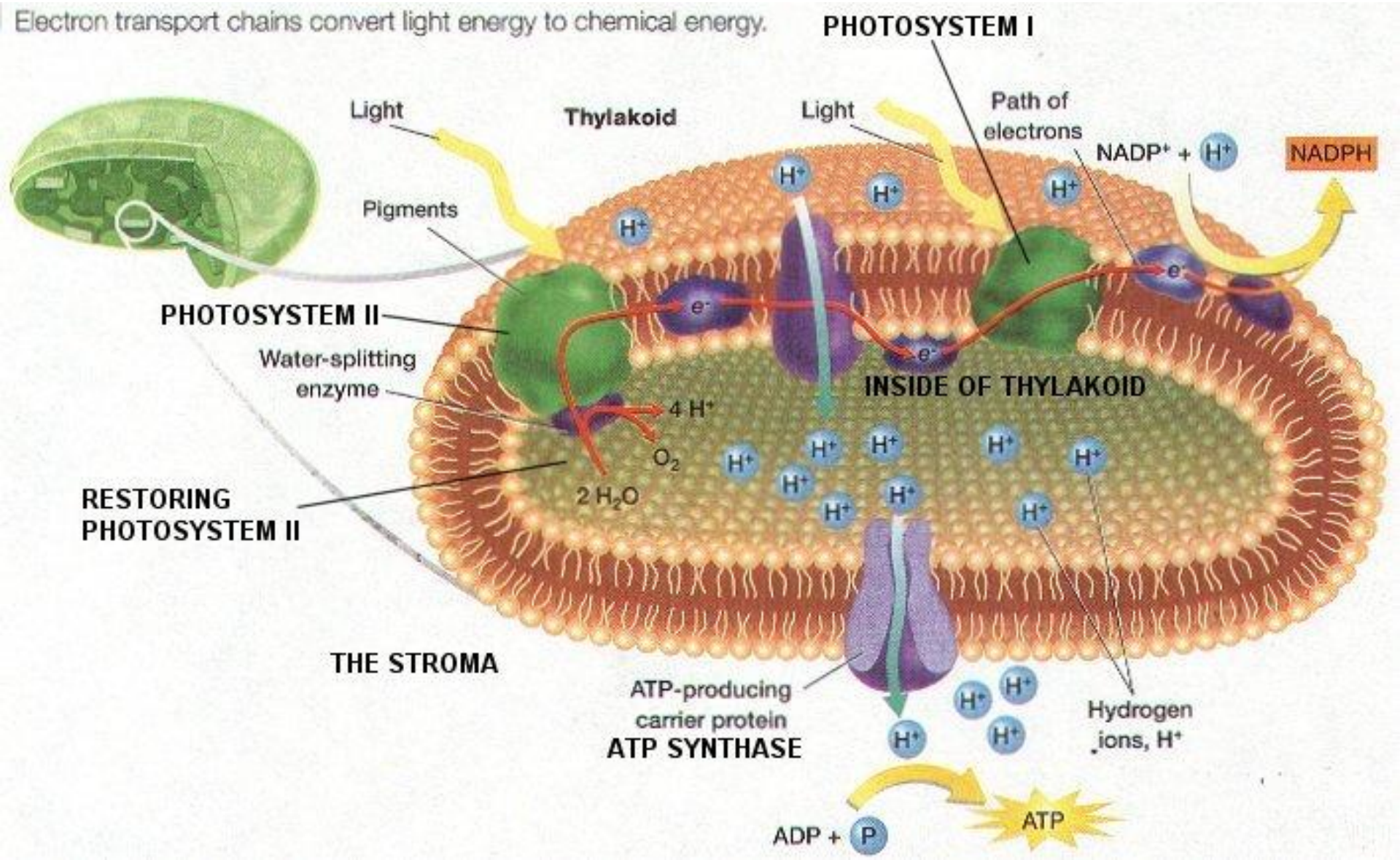
4. Electron lost by chlorophyll goes on through the ETC
5. Electron give energy to the proton pump
6. High concentration of H+ inside thylakoid


EXTRACELLULAR FLUID
ATP
Proton pump
H+
CYTOPLASM

7. Energyless electron goes to next photosystem and gets reenergized

8. Making NADPH

    a. $NADP^+ + H^+ + 2e^-$--->


Electron transport chains convert light energy to chemical energy.
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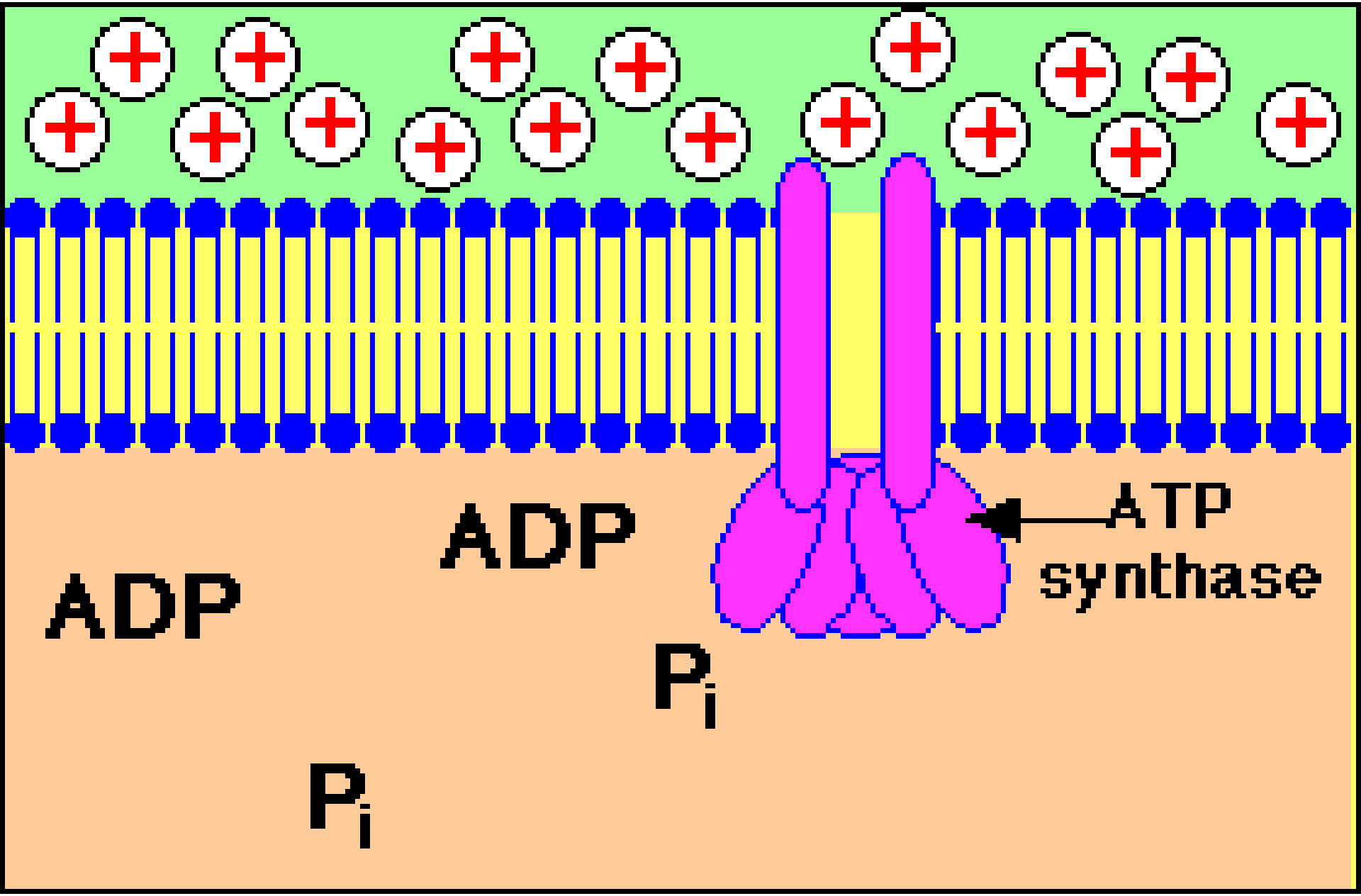
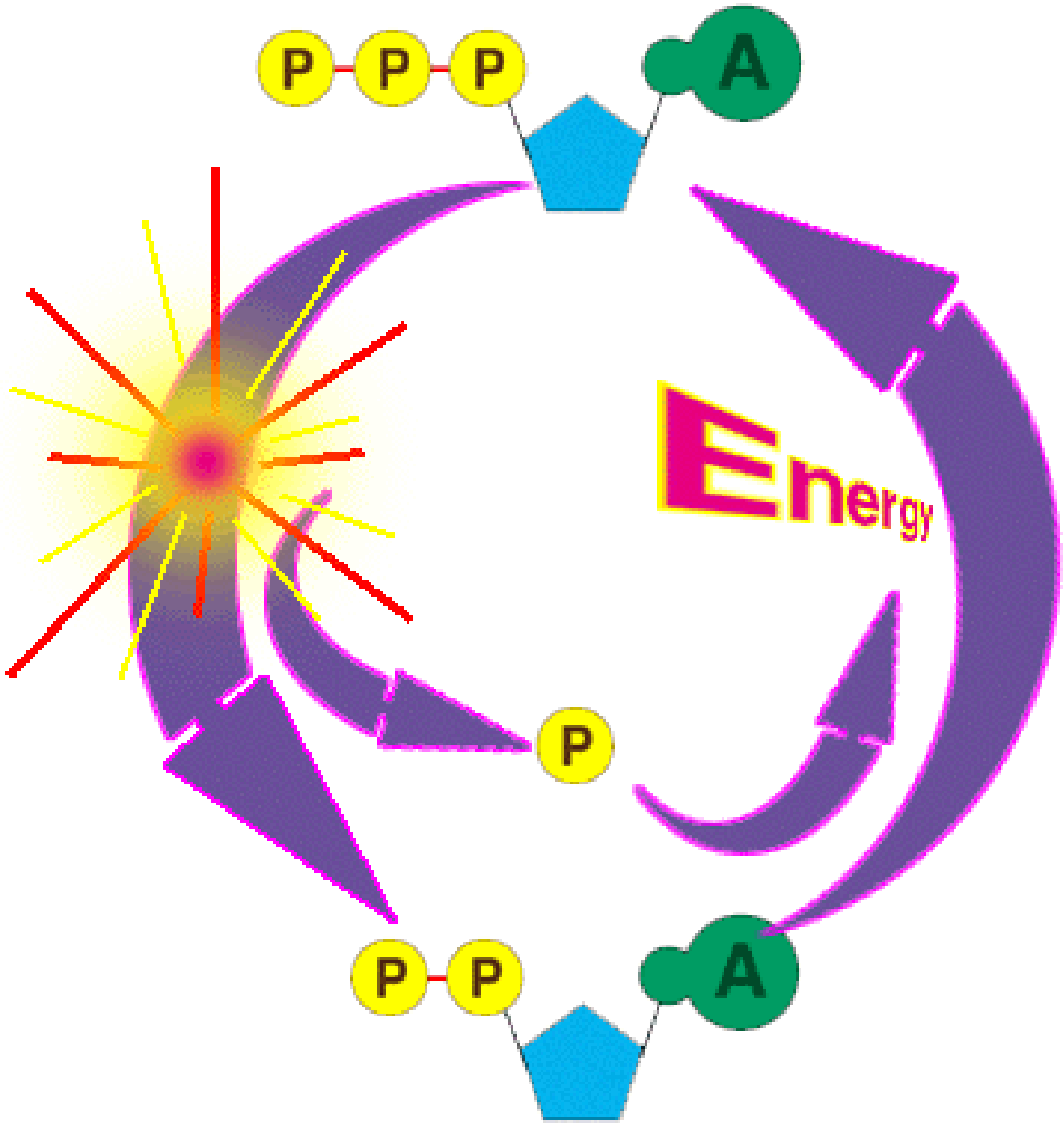
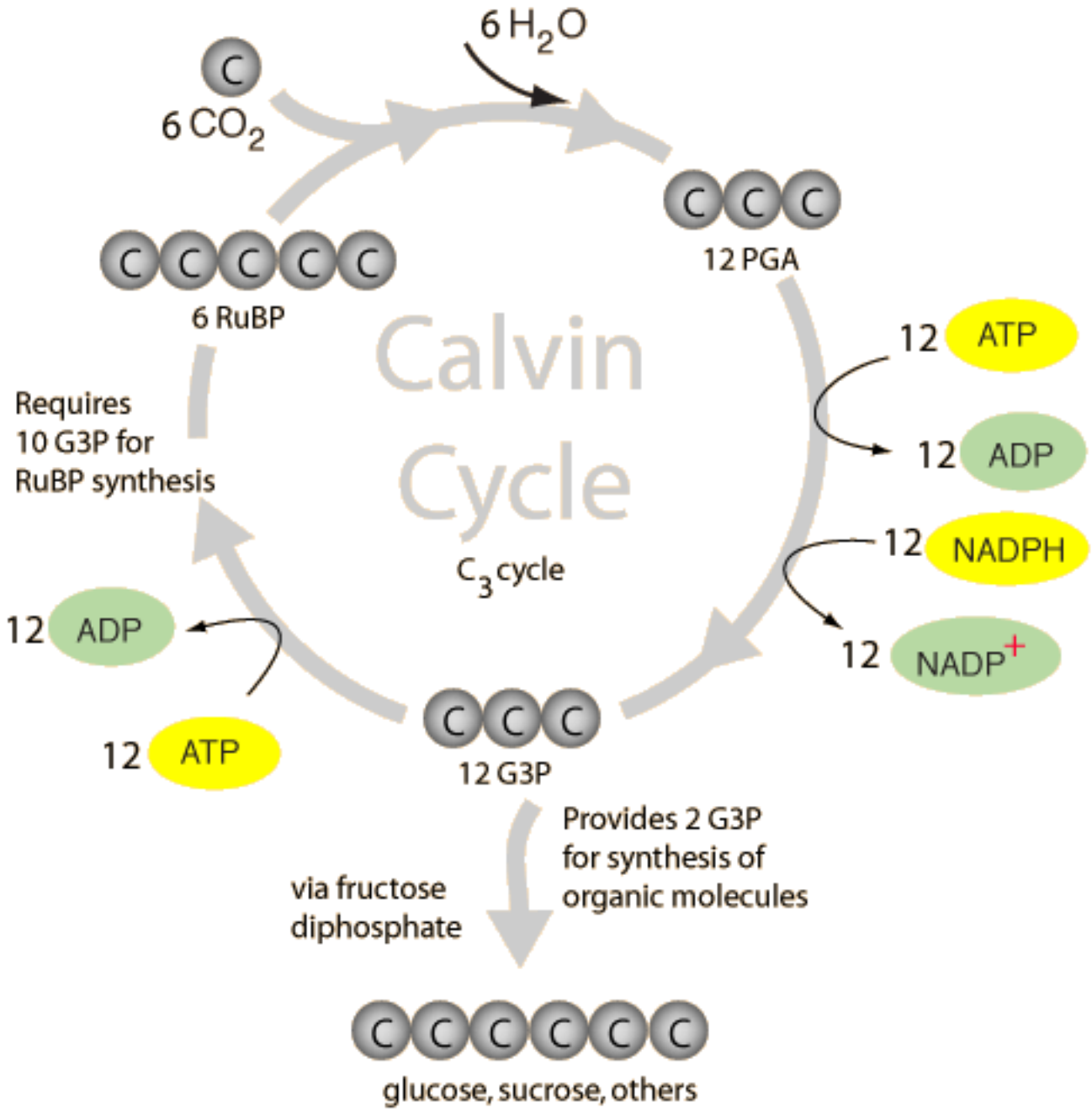
Thylakoid
Light
Path of electrons
NADP+ + H+
NADPH
Pigments
PHOTOSYSTEM II
Water-splitting enzyme
4 H+
O2
2 H2O
INSIDE OF THYLAKOID
RESTORING PHOTOSYSTEM II
THE STROMA
ATP-producing carrier protein
ATP SYNTHASE
Hydrogen ions, H+
ADP + P
ATP

E. Making ATP

1. ATP synthase (ETC)
2. [H+]
3. ADP + P--->ATP


ADP
ADP
ADP
P_i
P_i
ATP
synthase


P
P
P
A
Energy
P
P
P
A


6 H_2O
C
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6 RuBP
Calvin Cycle
C_3 cycle
12 ATP
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12 NADPH
12 $NADP^+$
Requires 10 G3P for RuBP synthesis
12 ADP
12 ATP
C C C
12 G3P
Provides 2 G3P for synthesis of organic molecules
via fructose diphosphate
C C C C C C
glucose, sucrose, others

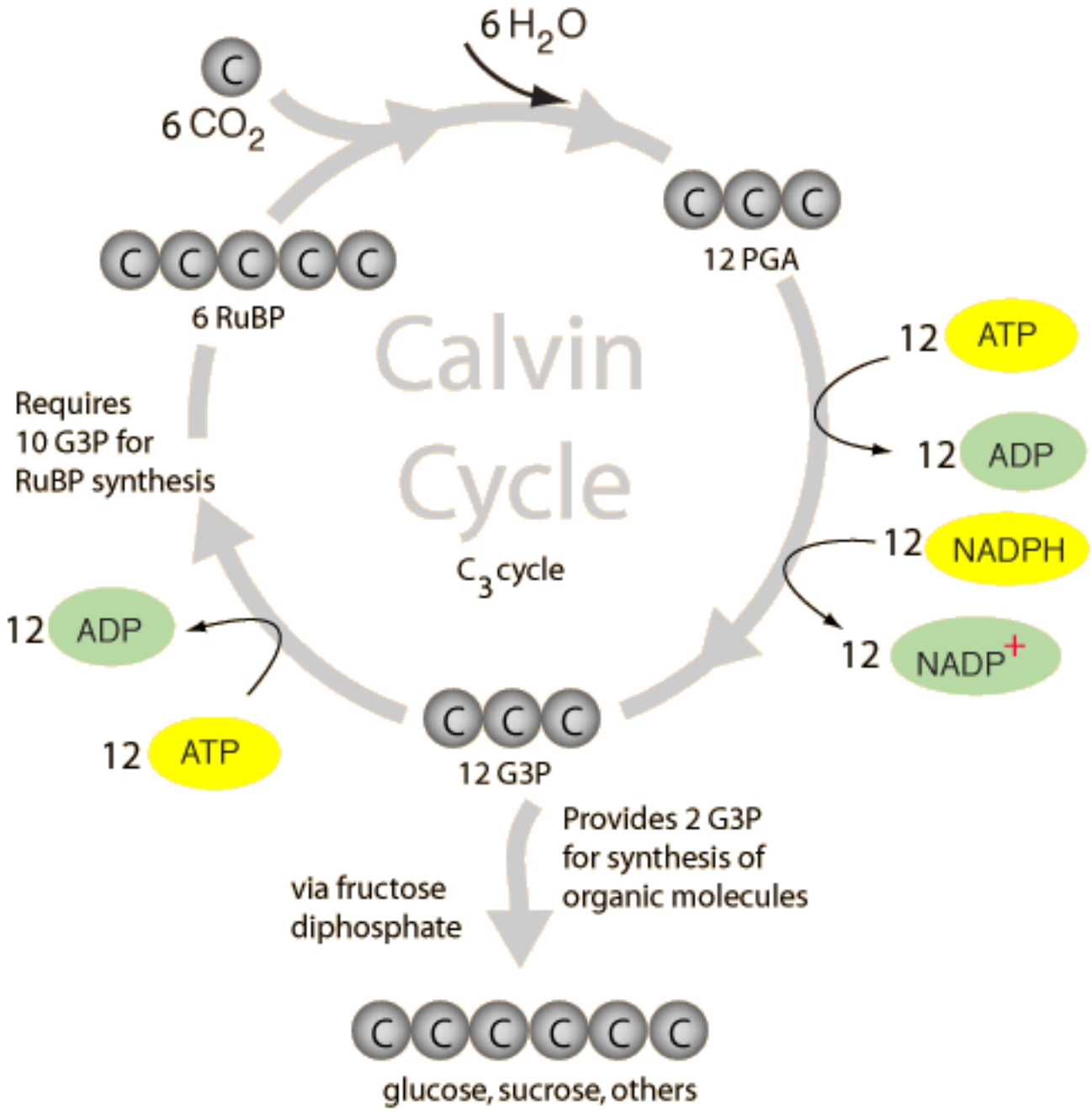
F. Calvin Cycle (stroma)

1. consumes CO_2 (w/ help from enzyme Rubisco)

2. ATP--->ADP

   NADPH--->$NADP^+$

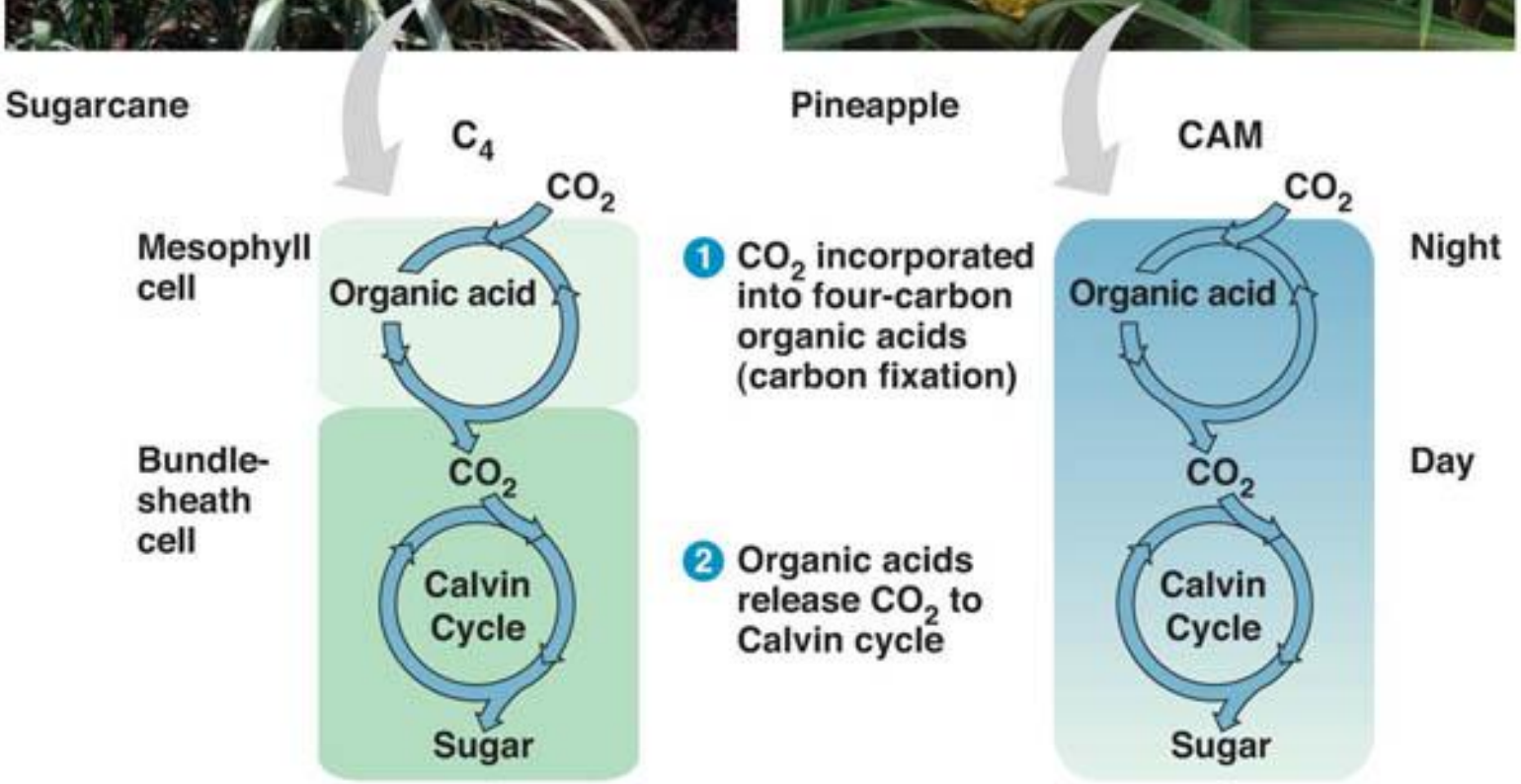
3. creates carbohydrates (glucose)
4. 5-C “waste” molecule is then recycled (RuBP)


6 H_2O
C
6 CO_2
C C C
12 PGA
C C C C C
6 RuBP
Calvin Cycle
C_3 cycle
12 ATP
12 ADP
12 NADPH
12 $NADP^+$
Requires 10 G3P for RuBP synthesis
12 ADP
12 ATP
C C C
12 G3P
Provides 2 G3P for synthesis of organic molecules
via fructose diphosphate
C C C C C C
glucose, sucrose, others

G. CAM plants

Sugarcane

Pineapple



(a) Spatial separation of steps

(b) Temporal separation of steps