YAKEEN 2.0

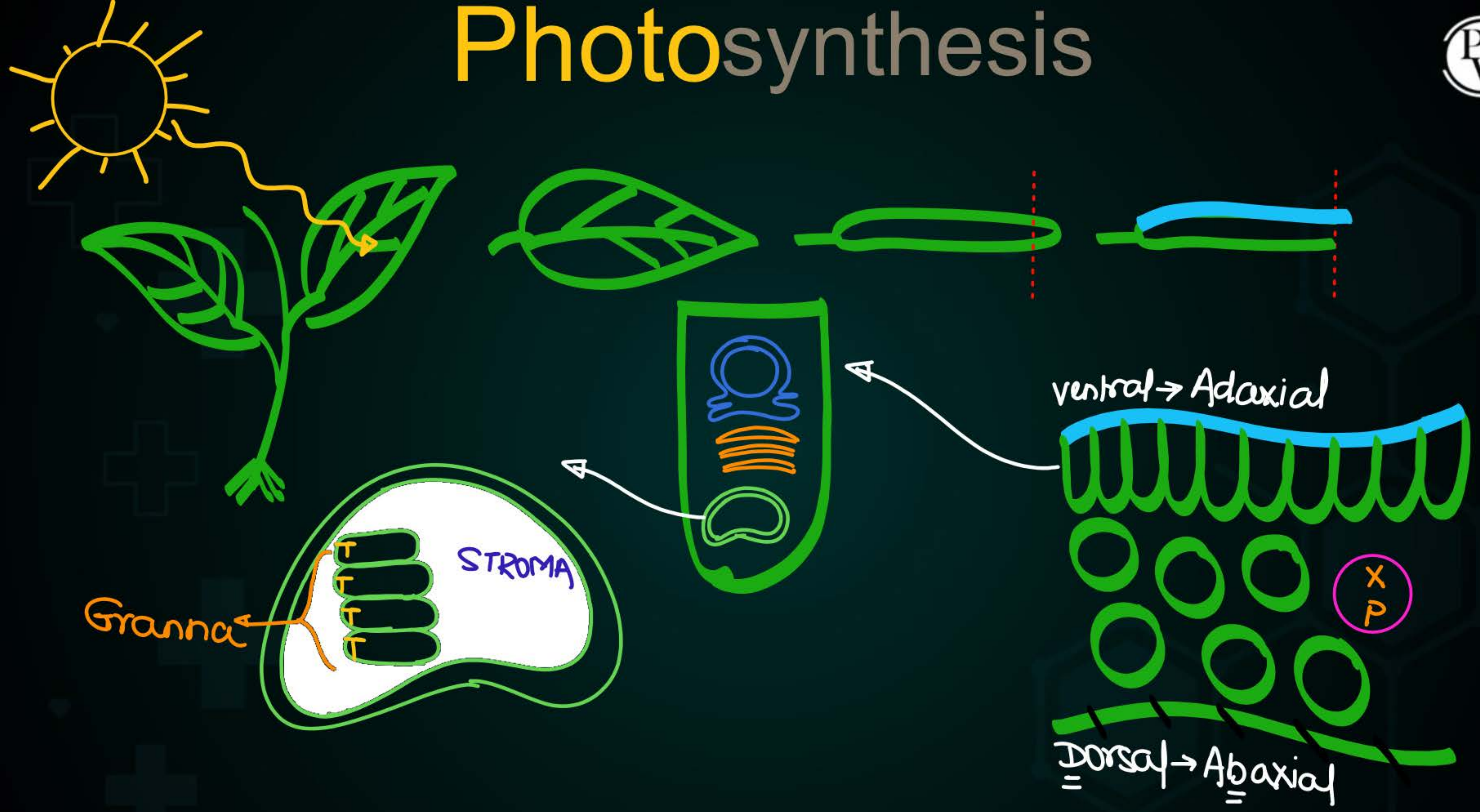
NEET 2024

- Subject - Botany
- Chapter – Photosynthesis in Higher plants

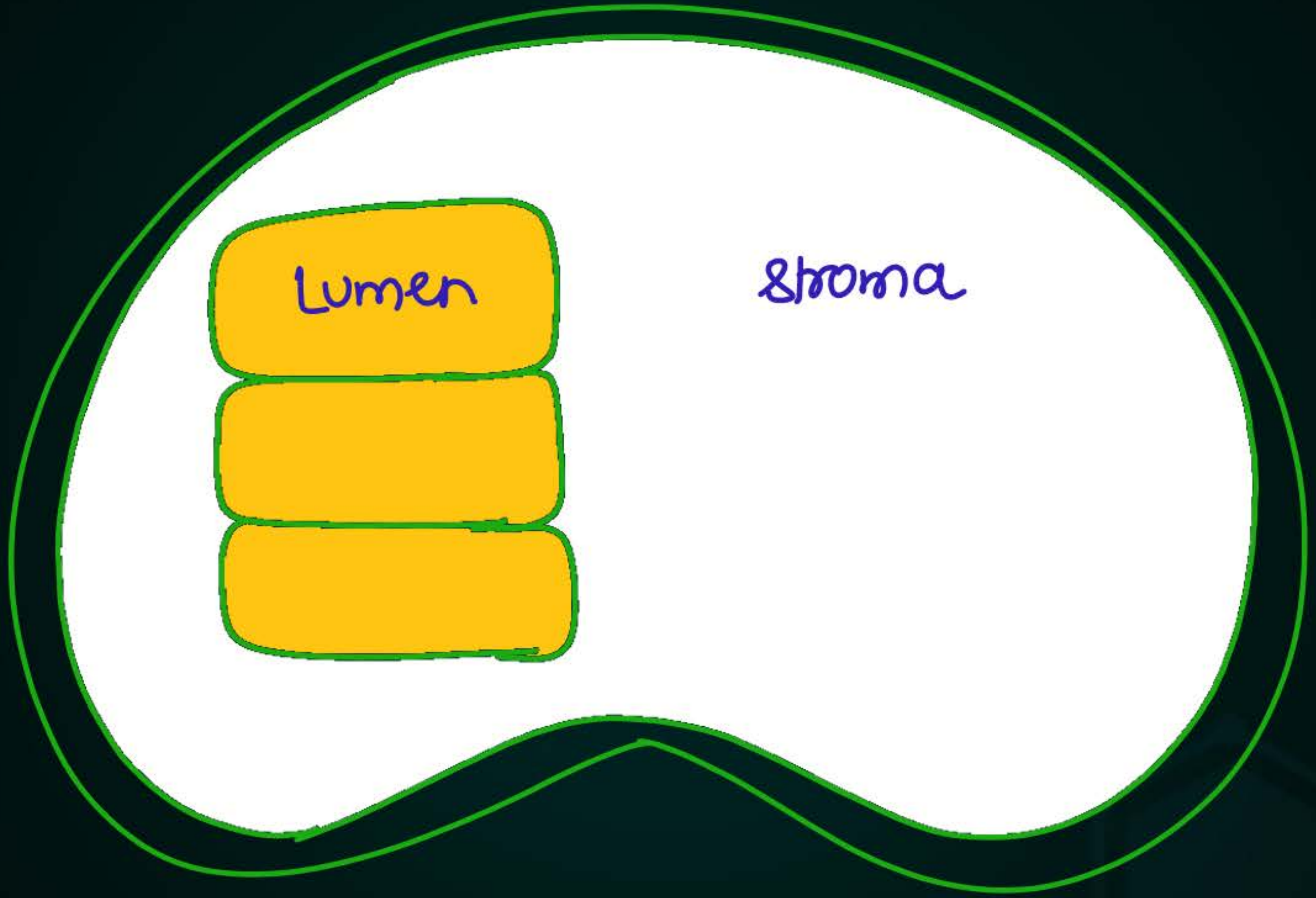
Lecture No.-01

By- Dr. Rishabh Sir

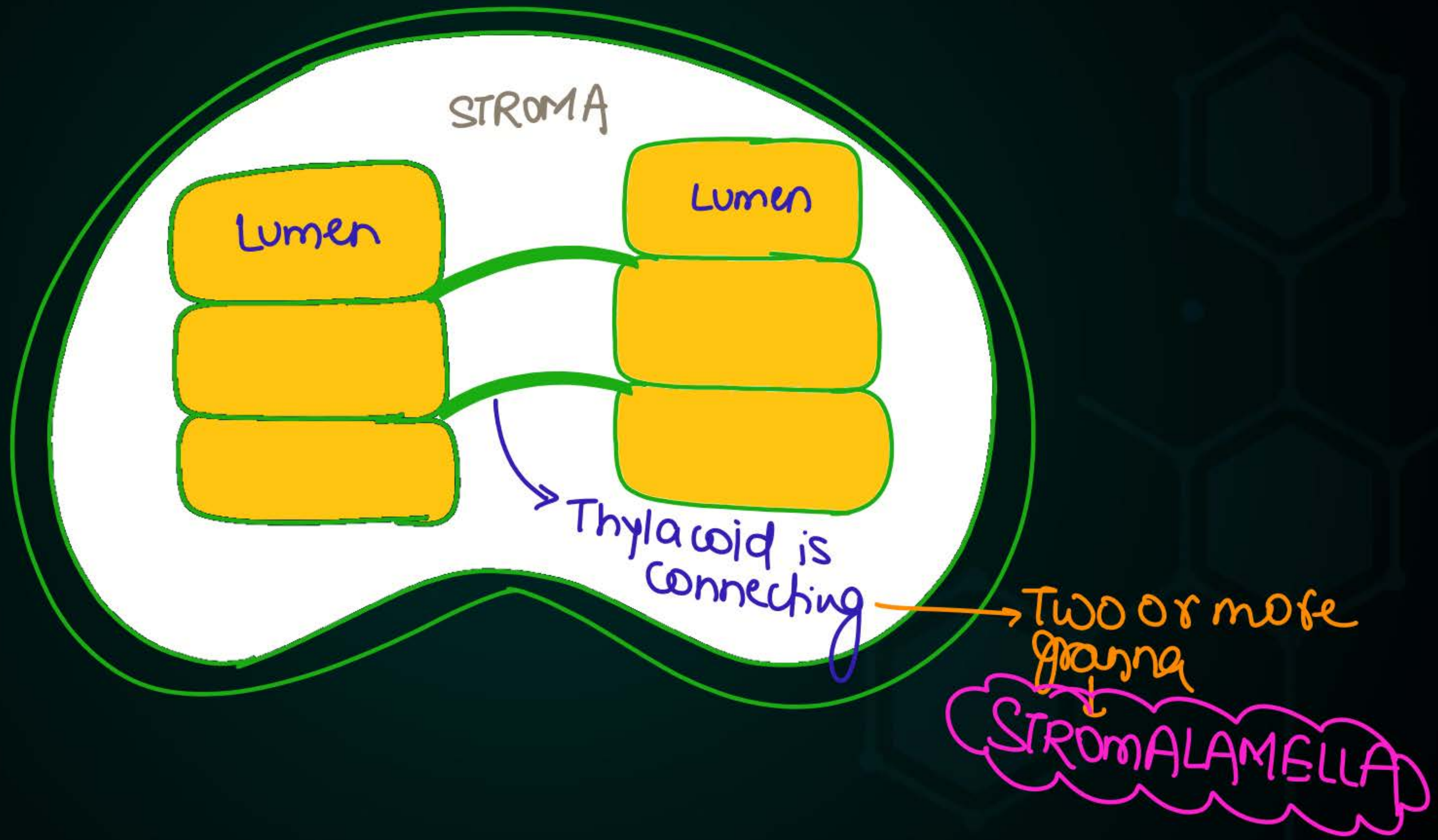
Photosynthesis



Photosynthesis



Photosynthesis



Photosynthesis

light

↓

light-dependent reaction.

Energy

synthesis of sugar.

↓

synthesis of sugar does not depend directly on sunlight

↓

But it depends on product of light reaction.

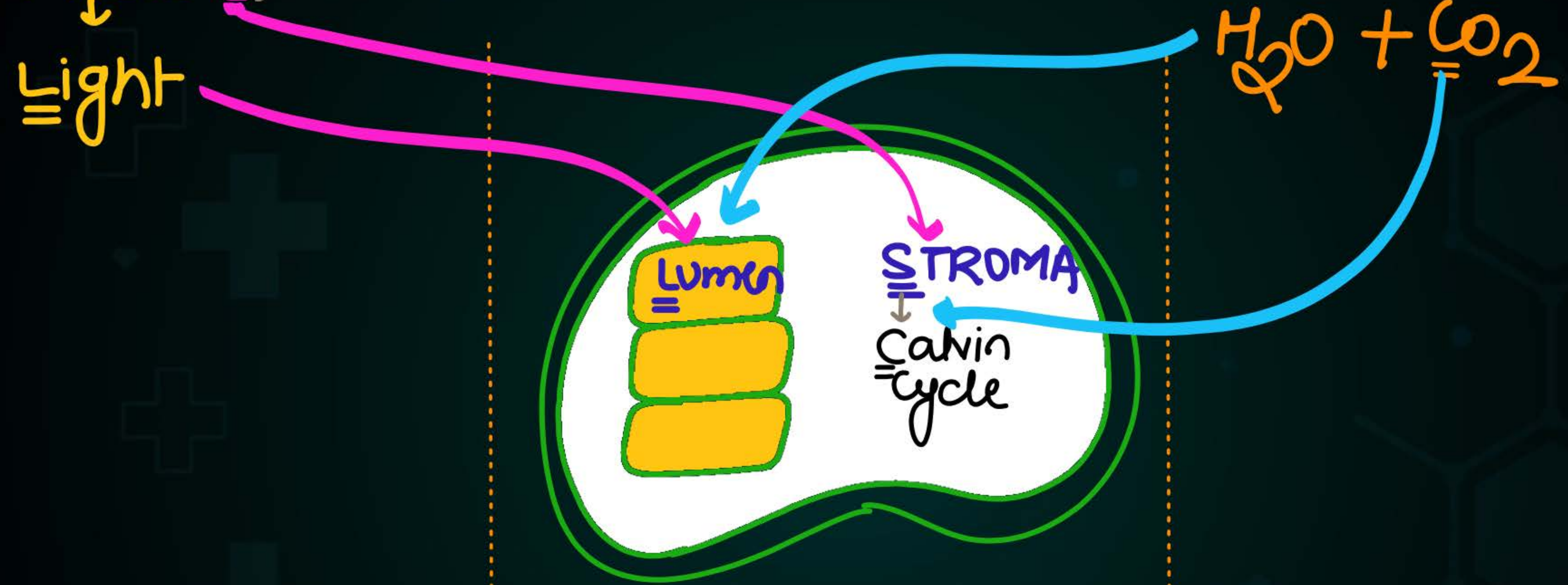
↓

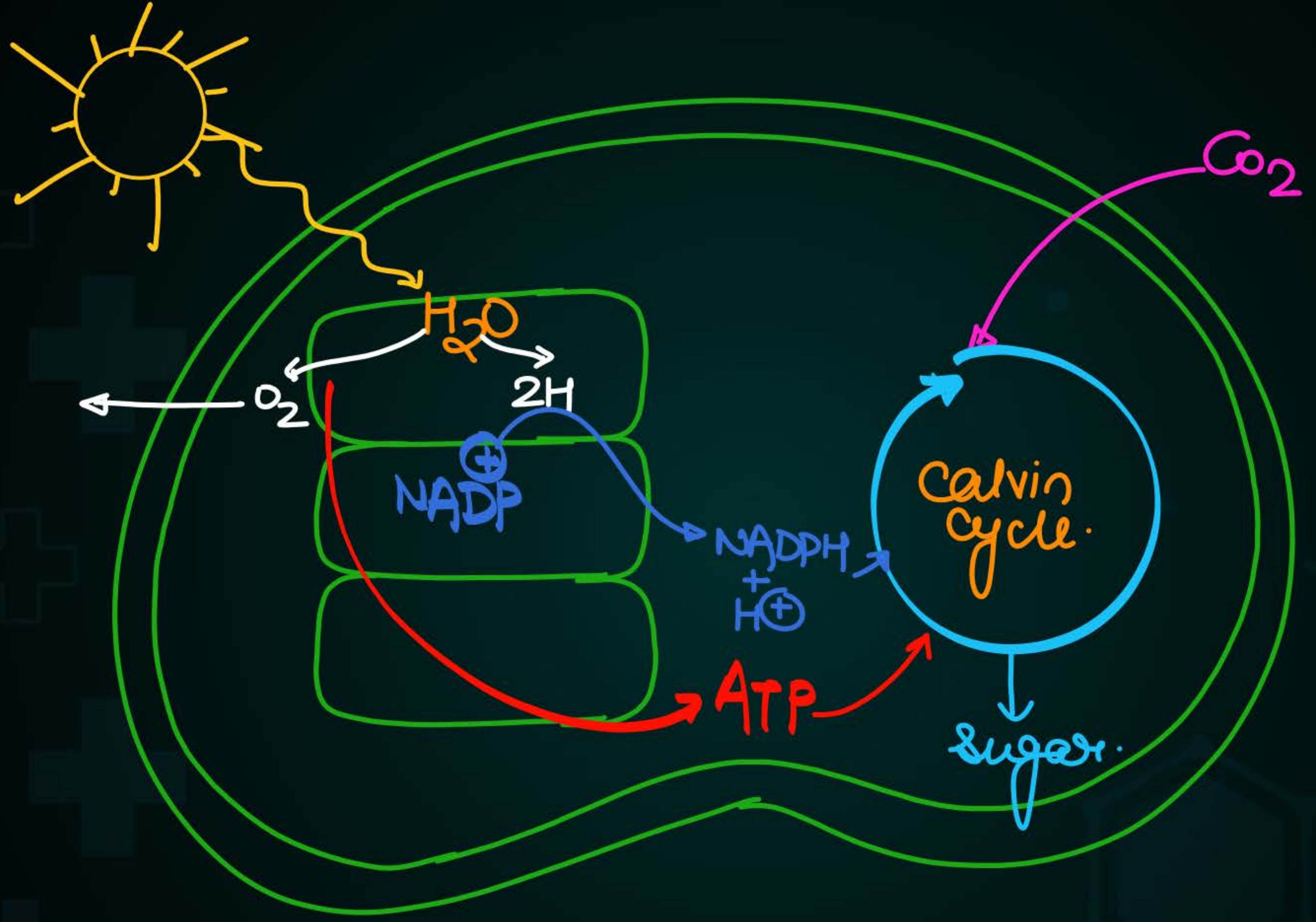
Light-independent or Dark reaction.

Assertion → synthetic phase (or) Calvin cycle is clas dark reacn or light-independent reacn but it never occurs during night

Reason → Because calvin cycle depends on product of light-reacn.

Photo synthesis





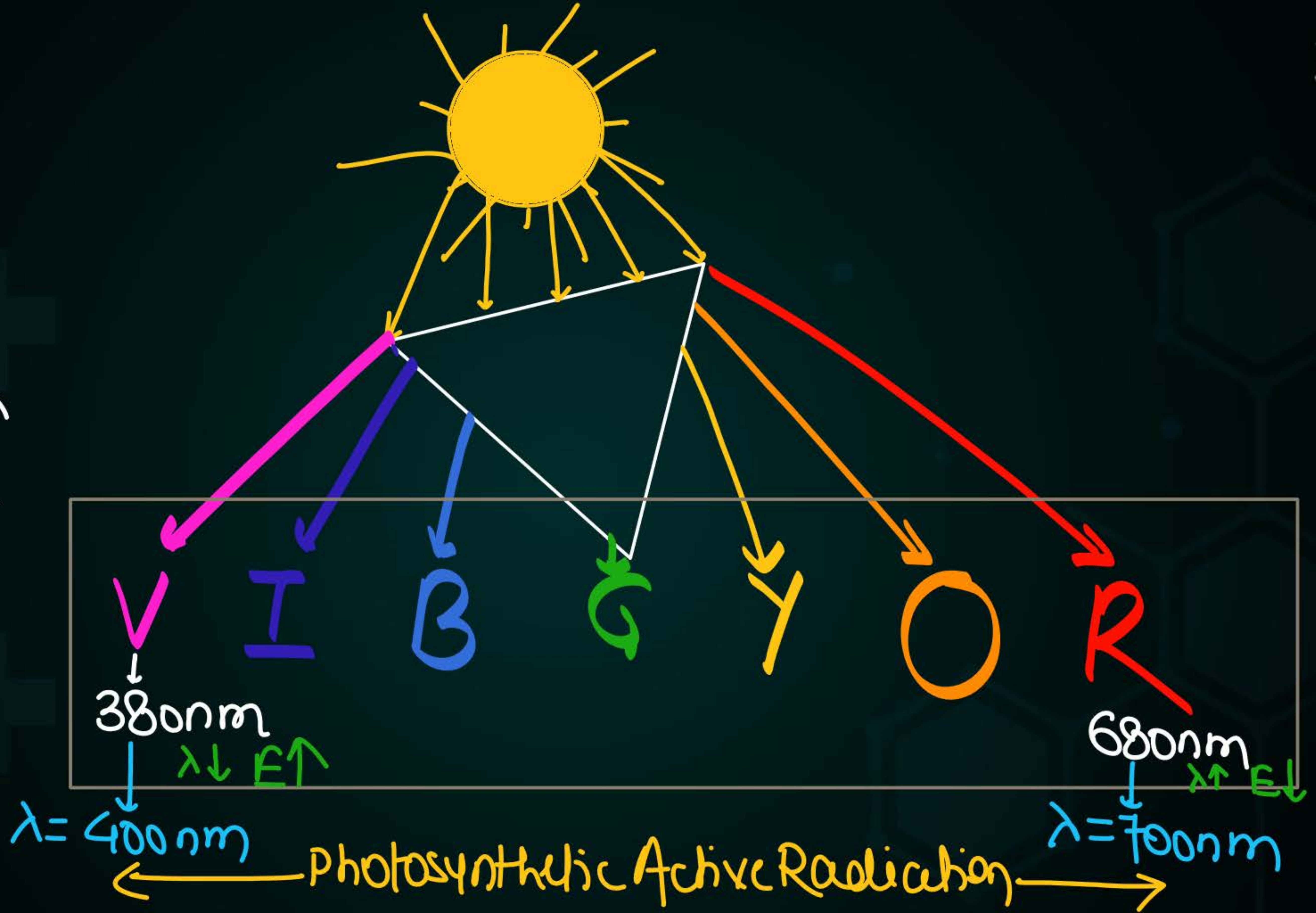
H_2O
O_2
2H
NADP
NADPH
+
H+
ATP
calvin cycle.
CO_2
sugar.

$$E = \frac{hc}{\lambda}$$

$$E \propto \frac{1}{\lambda}$$

$\lambda \downarrow \quad E \uparrow$

$\lambda \uparrow \quad E \downarrow$



photosynthesis occurs in

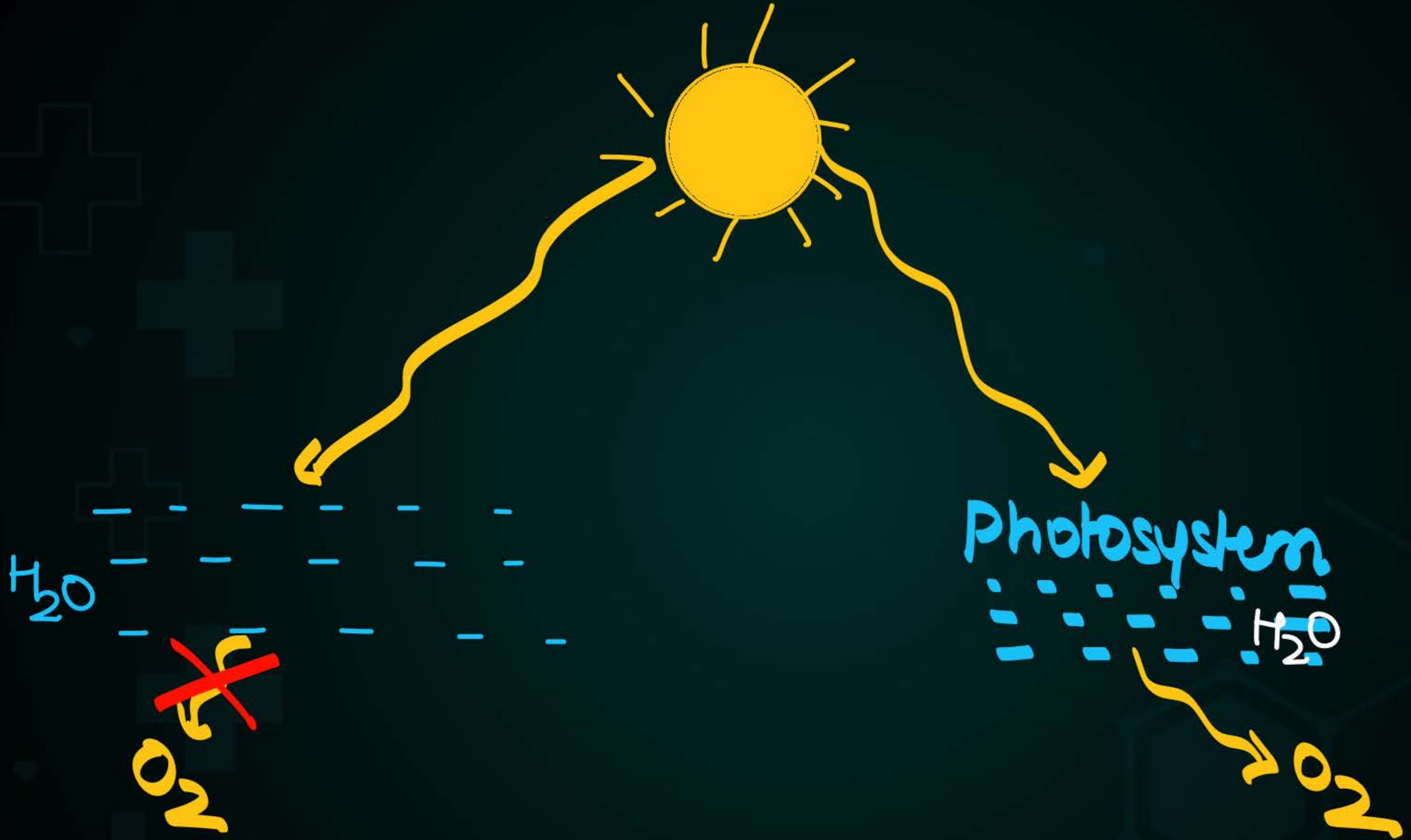
↓

visible spectrum of sunlight (400-700nm)

↓

Thats why it is also yas

photosynthetic active Radiation (PAR)



H_2O
O_2
Photosystem
H_2O
O_2

photosystem

Antenae complex
or
Light Harvesting complex (LHC)
↓
LHC is composed of → Accessary pigment + protein

Accessary pigment →
- Chl-b
- Xantho phyll
- Carotene

photosystem

is composed of

Antenae complex
or
Light Harvesting complex

Composed of

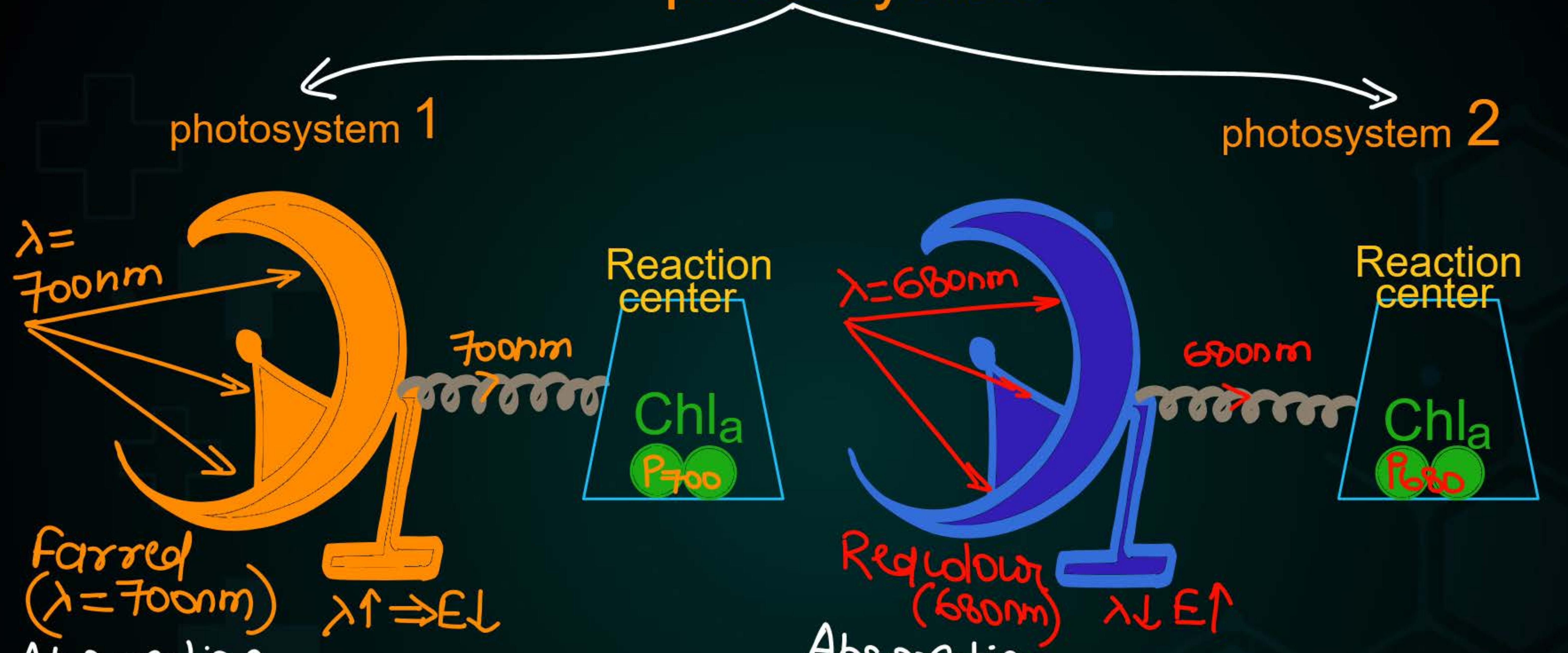
Accessary pigment
- Chlorophyll-b
- Xanthophyll
- Carotene

Protein

Reaction center.

Chlorophyll-a is present

photosystem



Absorption maxima = 700nm

Absorption maxima = 680nm.

Assertion Reason

A-1 Light Harvesting complex of PS_1 and PS_{II} are different

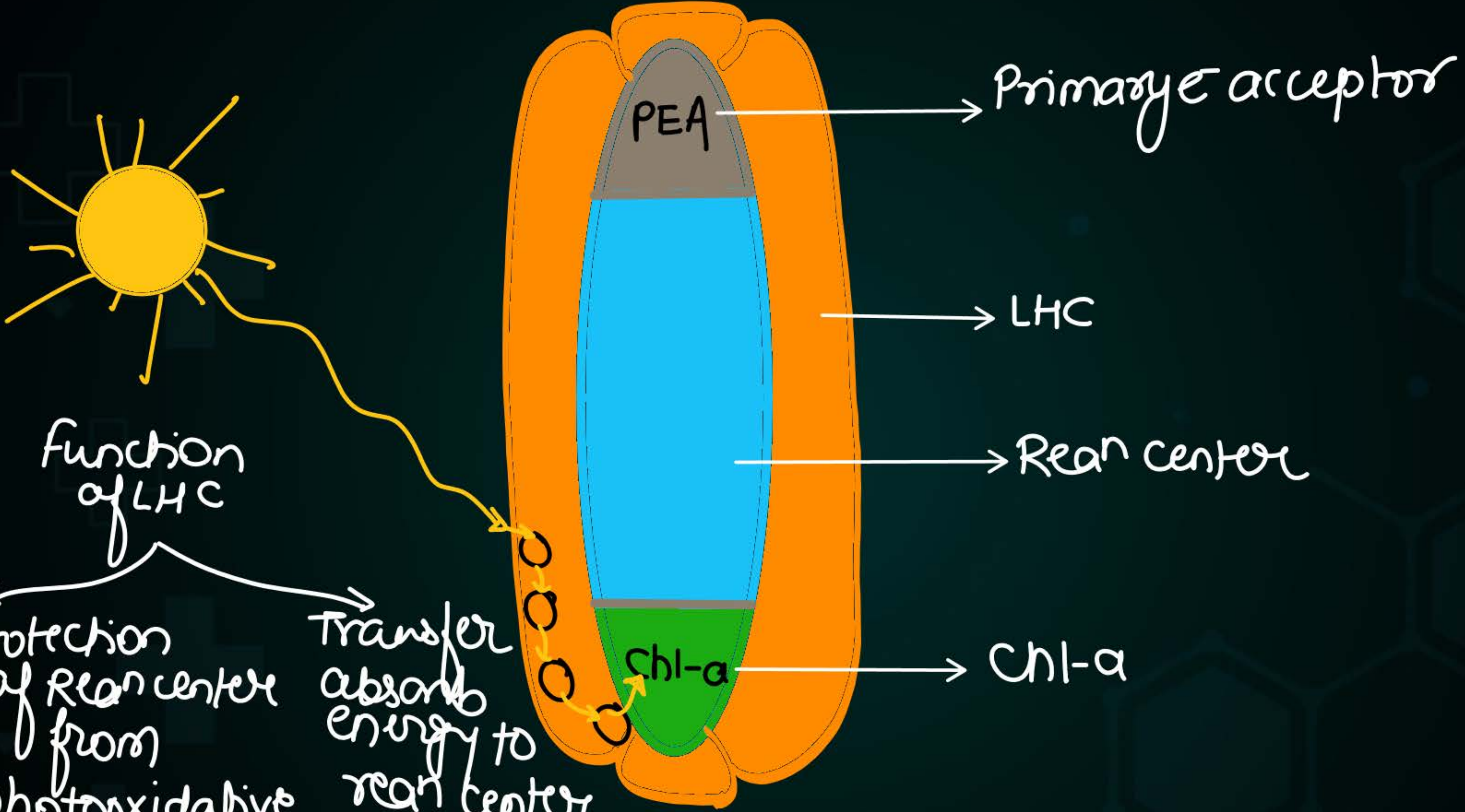
ex → Because they are absorbing different wavelength of light

↓

Reason → due to different quantities of Accessory pigment & protein.

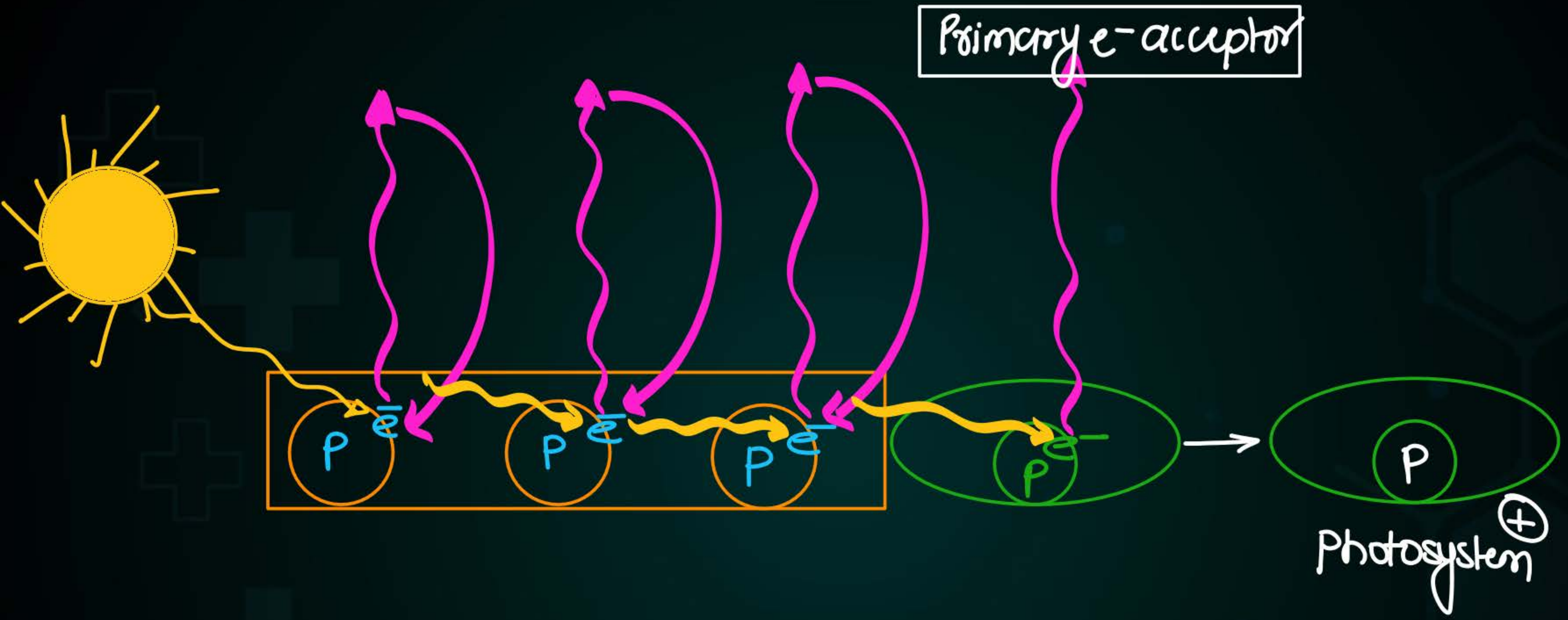
A-2 Reaction centre of PS_1 & PS_{II} are different

Reason → Because they are receiving different wavelength of light.

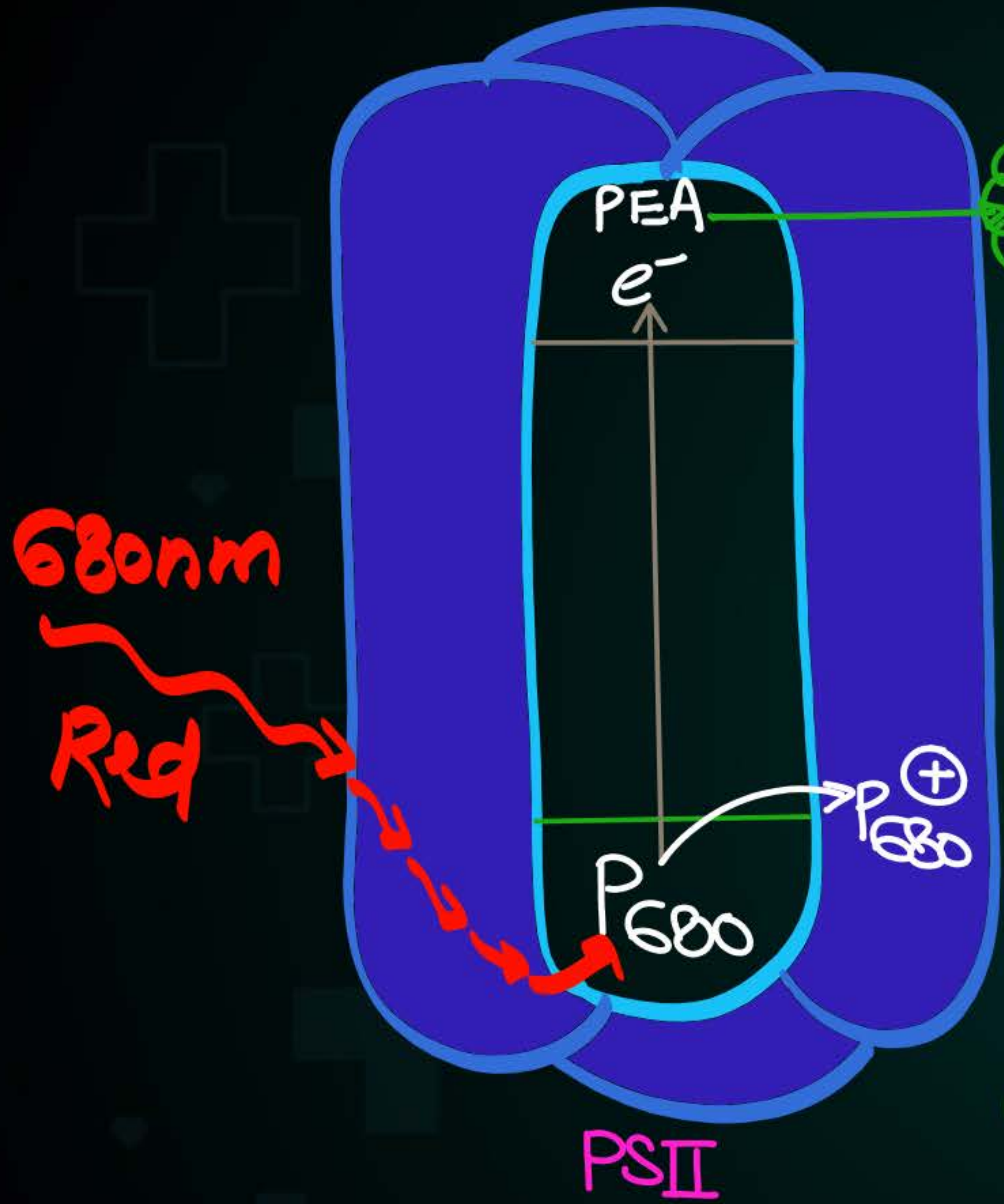


Function of LHC

- Protection of Rean center from photooxidative damage
- Transfer absorb energy to rean center



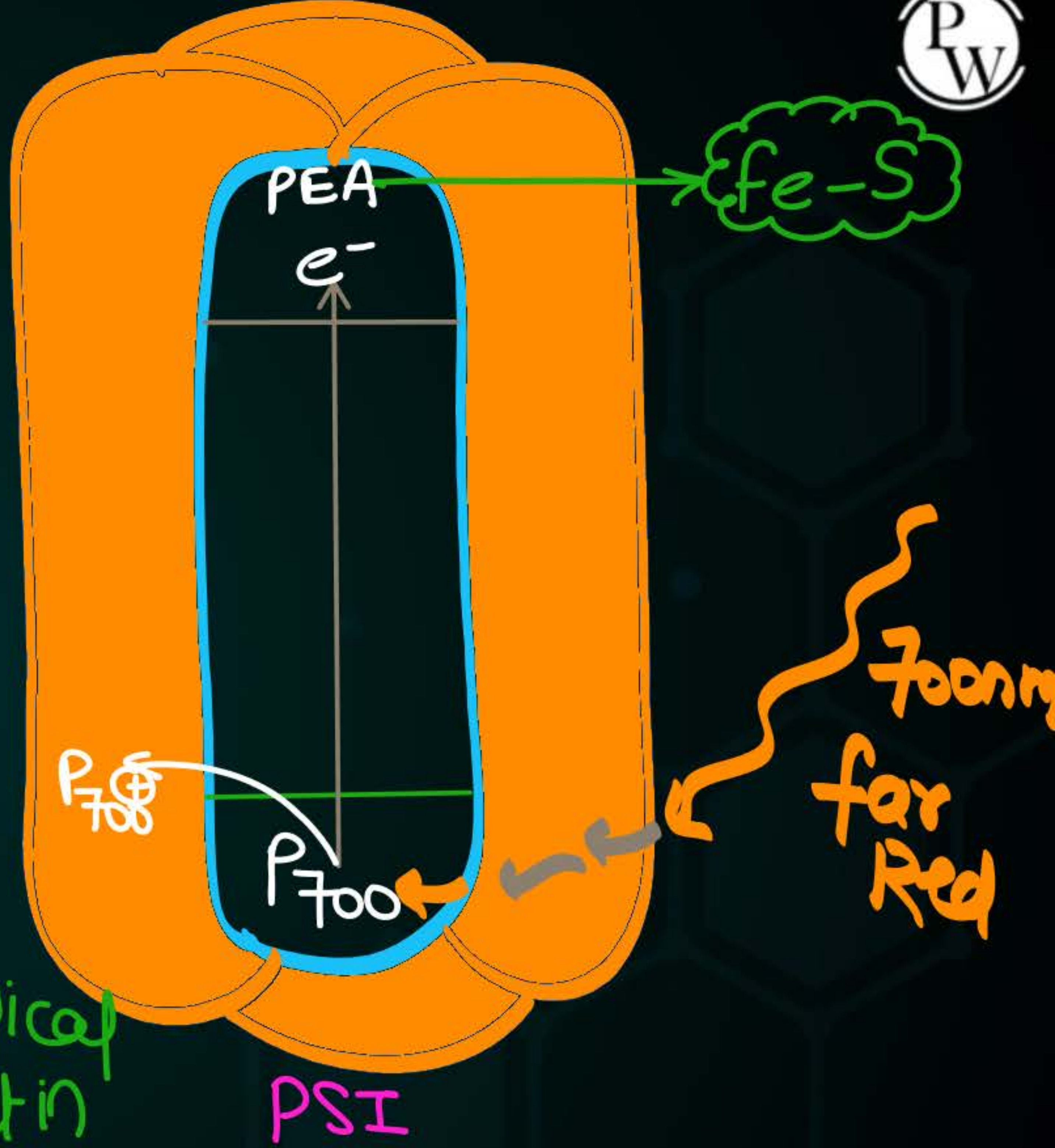
Primary e⁻ acceptor
P
e⁻
P
e⁻
P
e⁻
P
e⁻
P
+
Photosystem

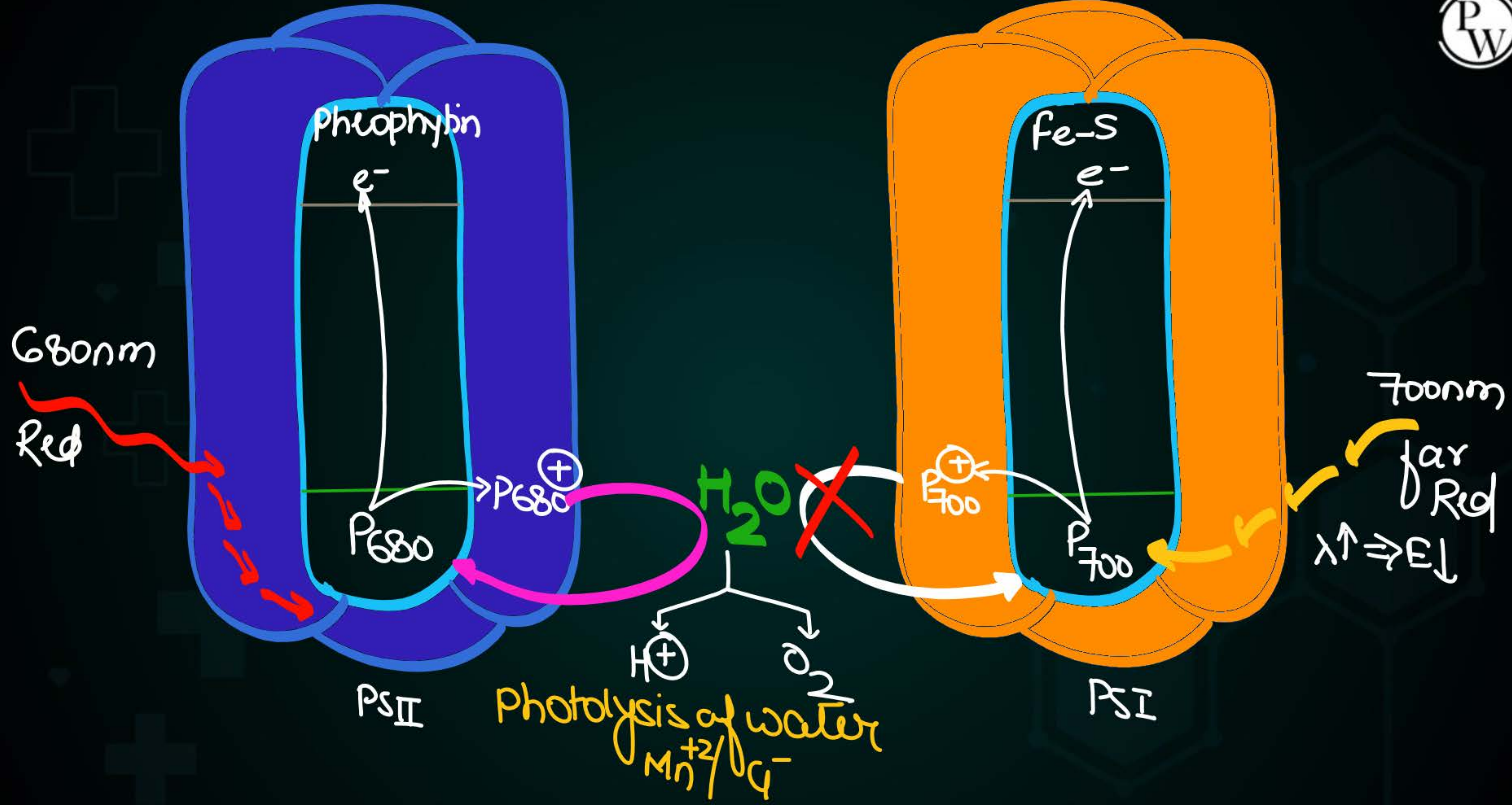


Pheophytin

Chla minus Mg

$P_{680}^{\oplus}$ is the most power Biological oxidizing agent in the plant.





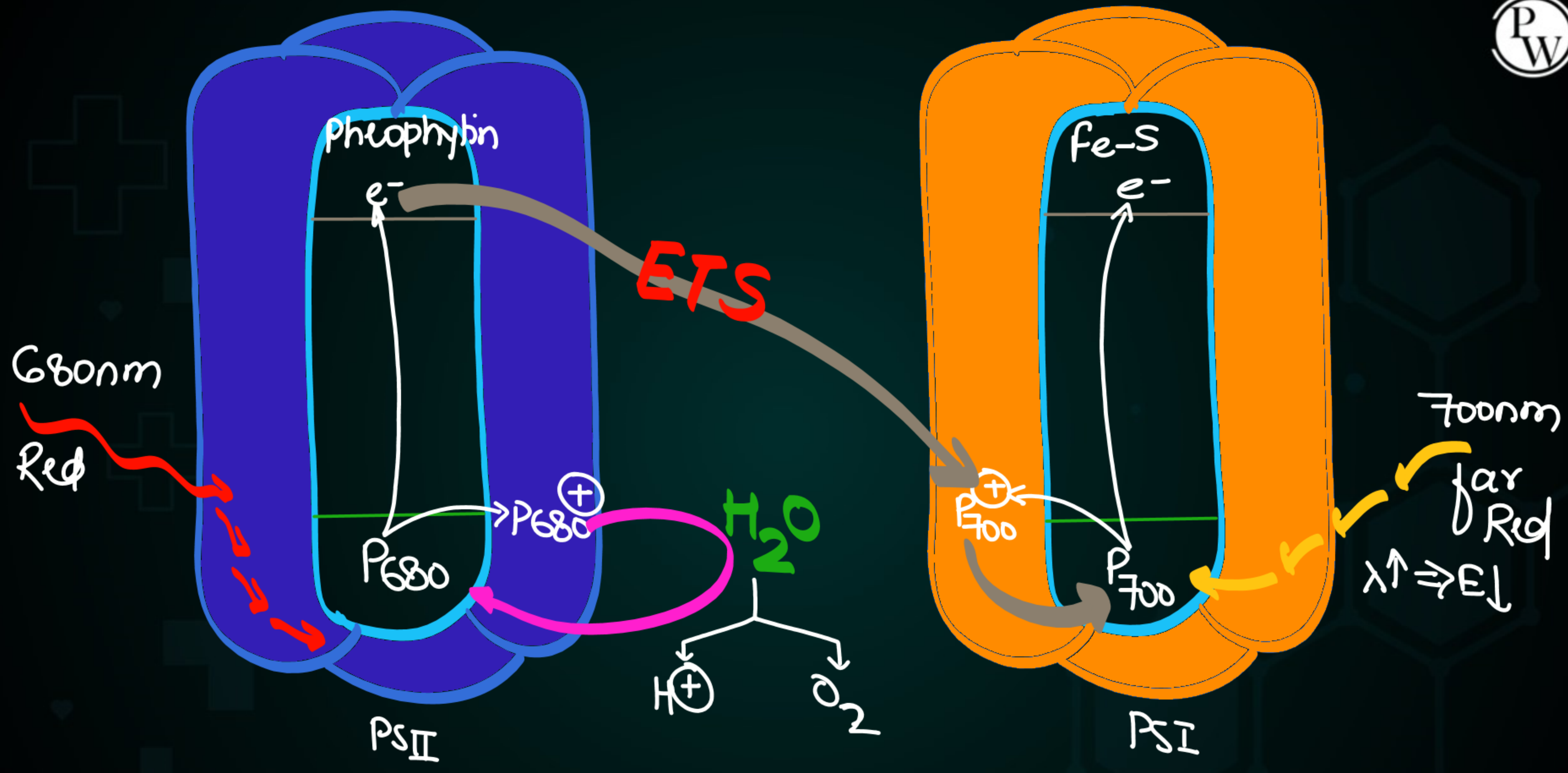
Pheophytin
e⁻
680nm
Red
P680
P680
H2O
H+
O2
PSII
Photolysis of water
Mn+2/Cl⁻
Fe-S
e⁻
P700
P700
700nm
far Red
λ↑ ⇒ E↓
PSI

$P_{680} \; P \; e^-$ $\longrightarrow$ $P_{680}^{\oplus}$ H_2O $\longrightarrow$ $P_{680} \; P \; e^-$ $\longrightarrow$ $P_{680}^{\oplus}$ H_2O

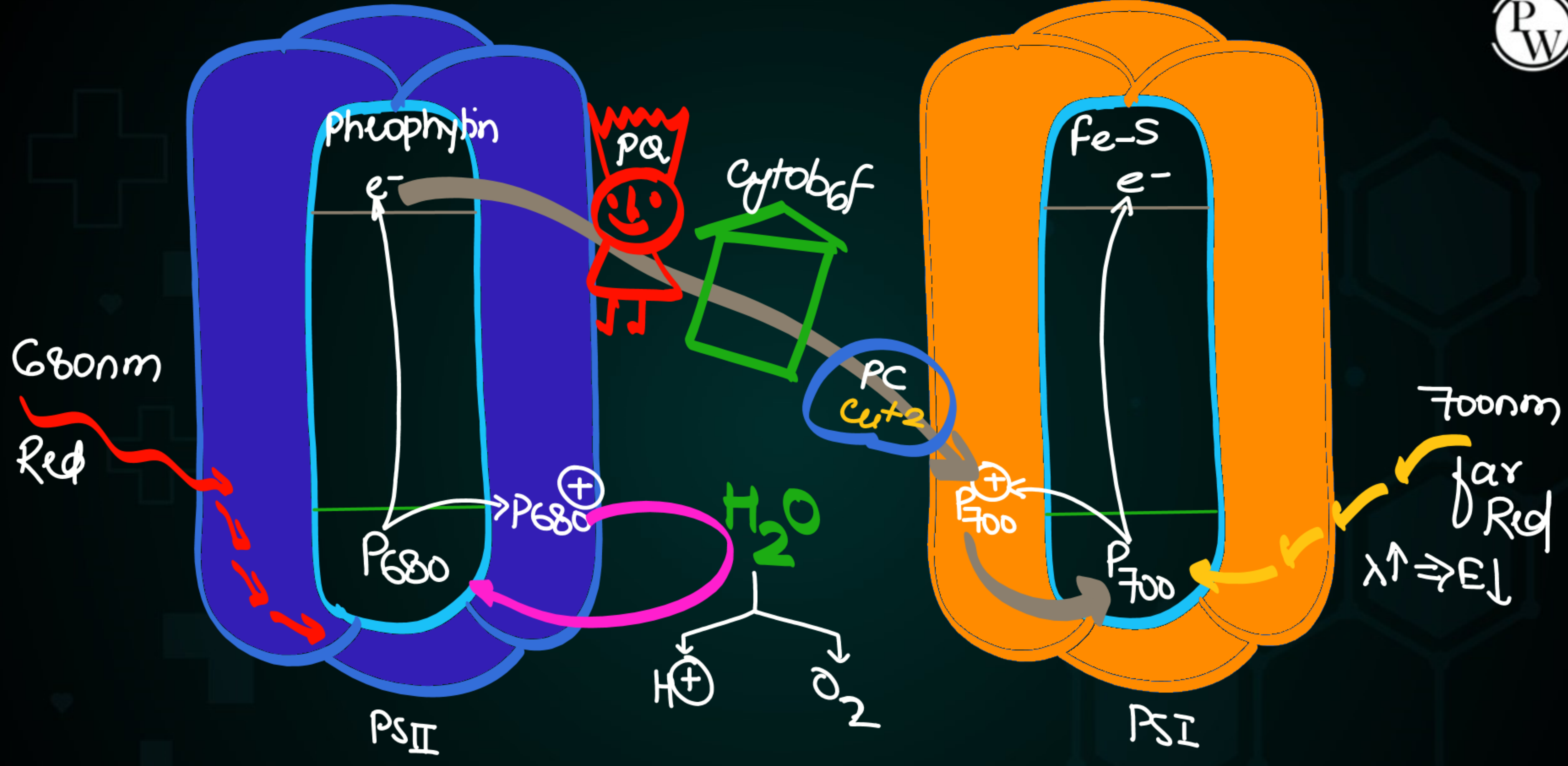
e^- (e^- comes from water)

Neet

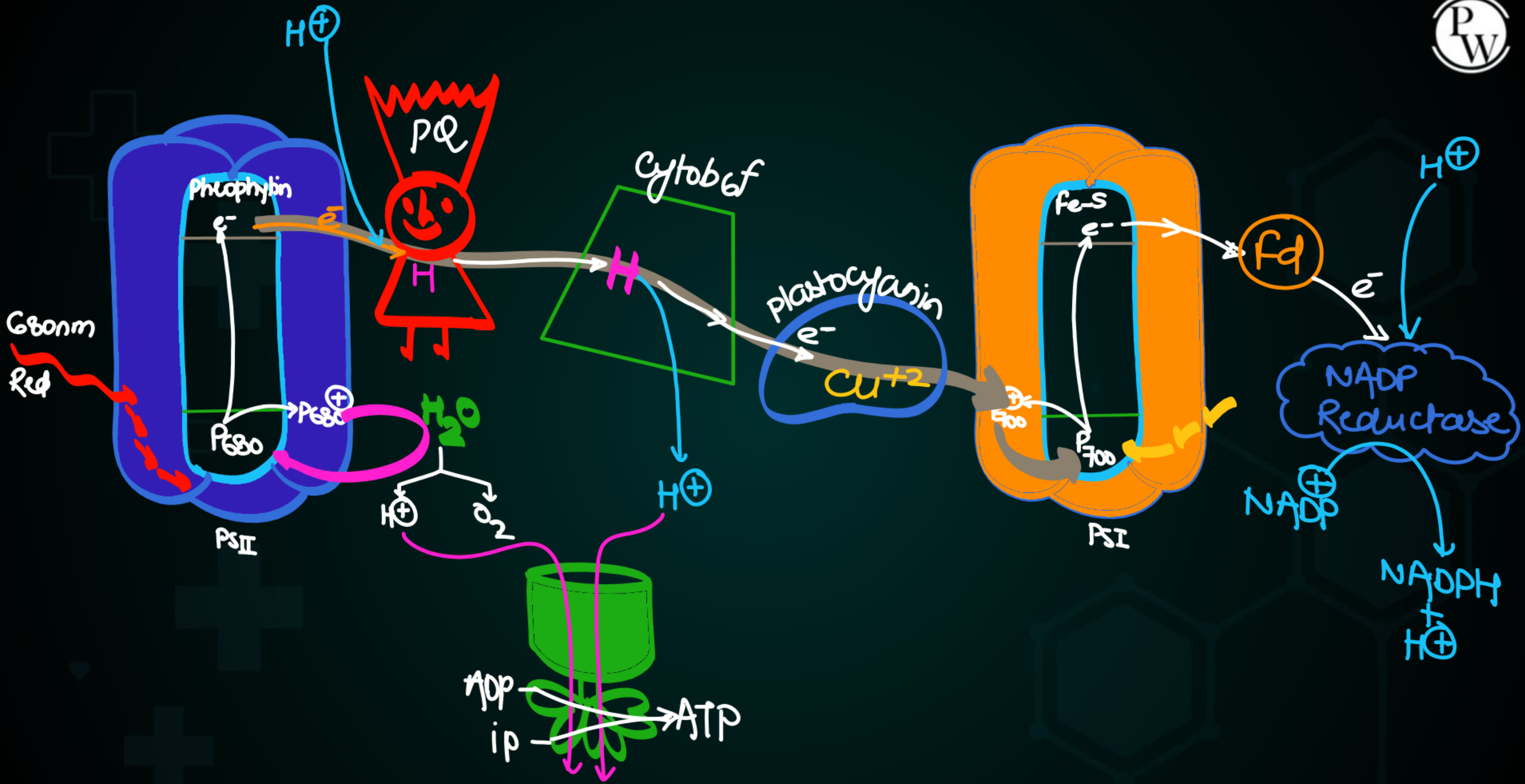
★→ water is constant source of e^- for Photosystem II



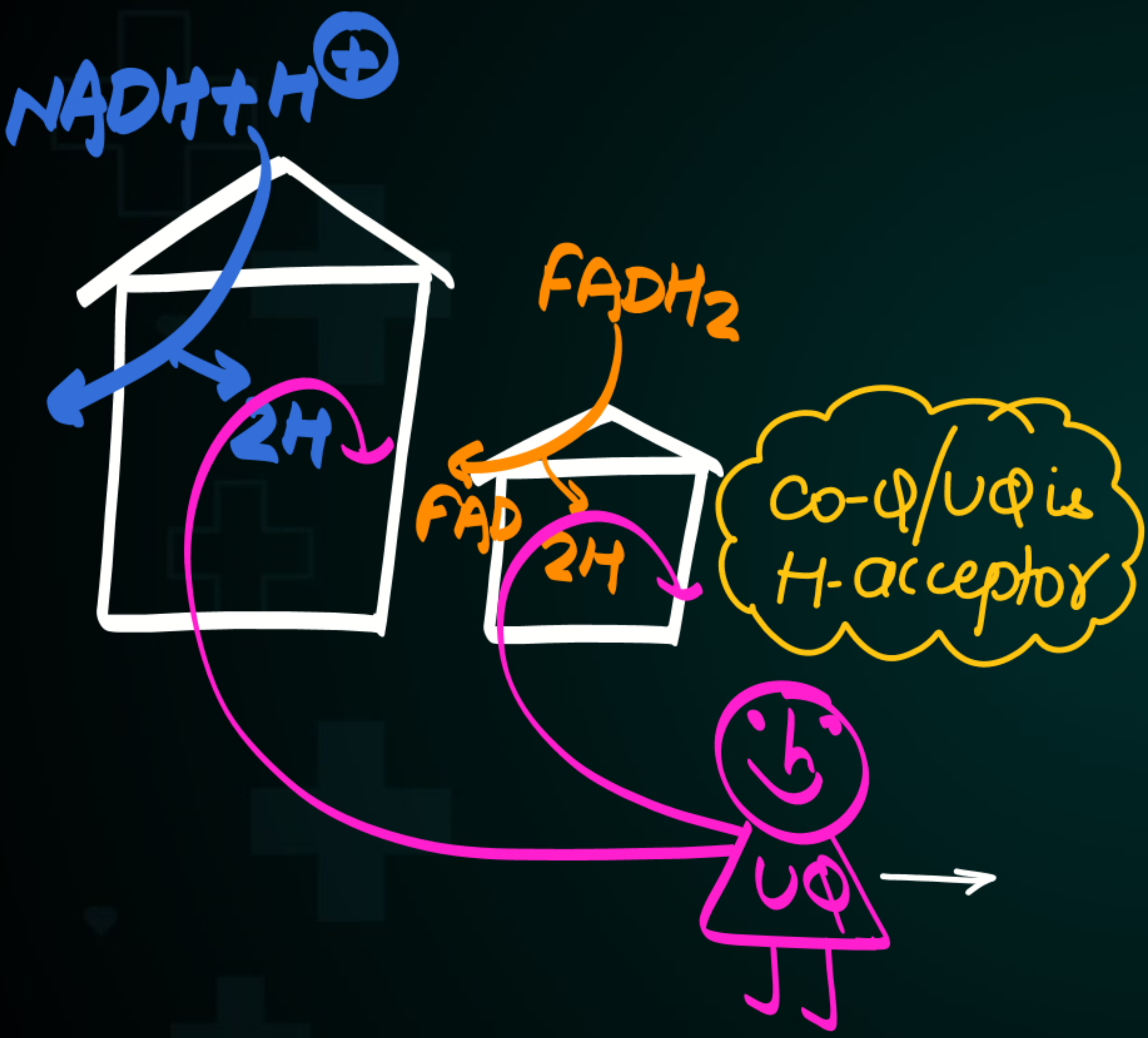
Pheophytin
e⁻
680nm
Red
P680
P680 +
H2O
H+
O2
PSII
ETS
Fe-S
e⁻
P700 +
P700
700nm
far Red
λ↑ ⇒ E↓
PSI



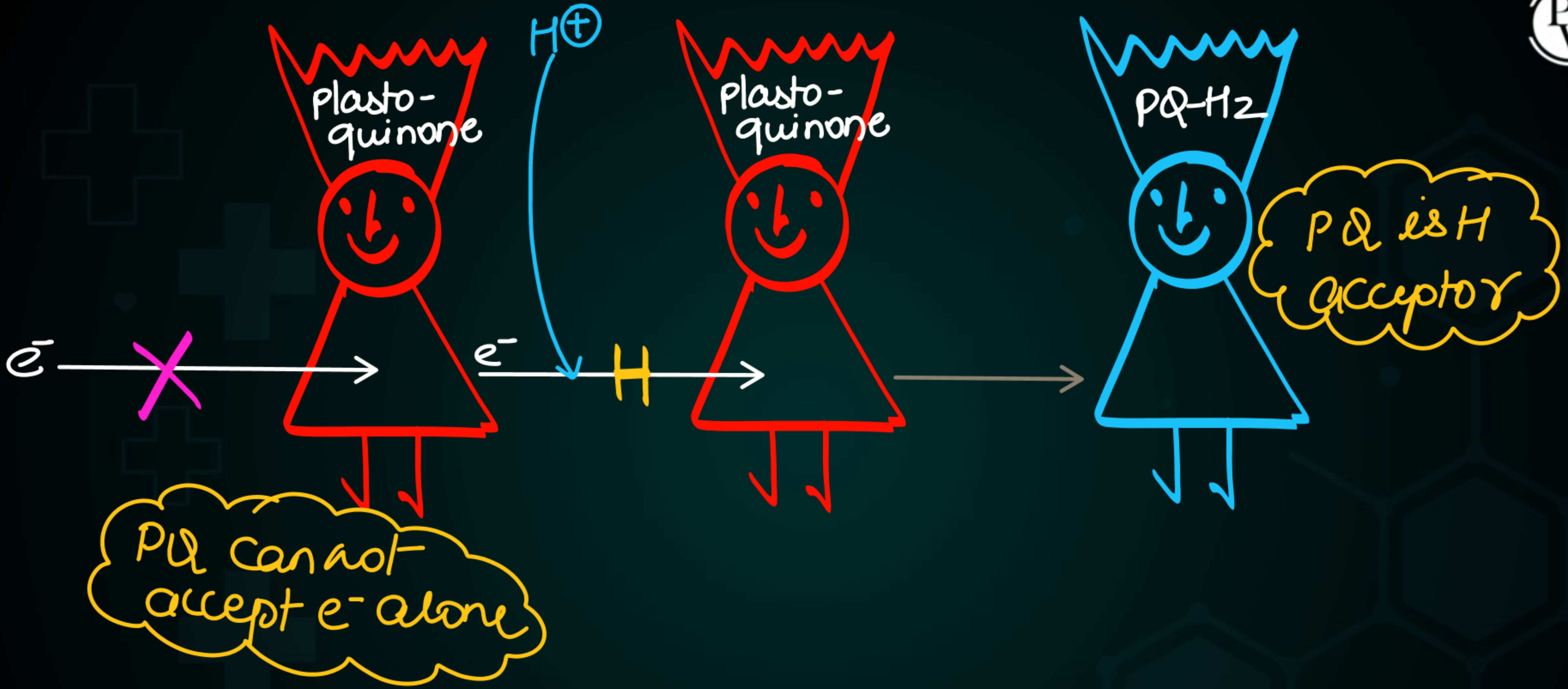
Pheophytin
e⁻
PQ
Cytob6f
PC
Cu+2
Fe-S
e⁻
680nm
Red
P680
P680
H2O
H+
O2
P700
P700
700nm
far
Red
λ↑ ⇒ E↓
PSII
PSI

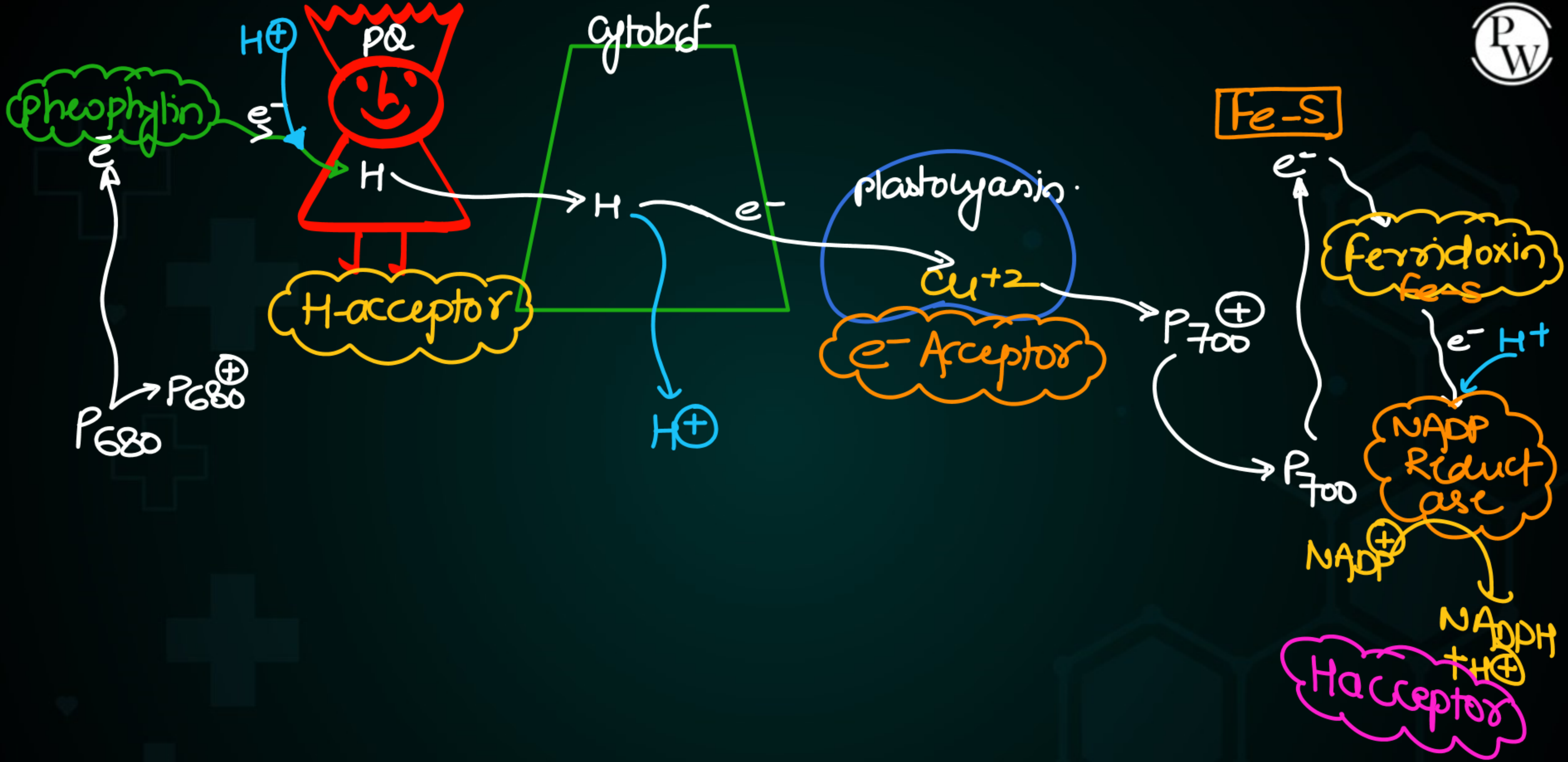


PQ
H
Cytob6f
plastocyanin
e^-
Cu^{+2}
Phcophytin
e^-
P_{680}
P_{680}^{+}
680nm
Red
H_2O
H^+
O_2
PSII
H^+
ADP
ip
ATP
Fe-S
e^-
Fd
e^-
P_{700}
PSI
NADP Reductase
$NADP^+$
NADPH
+
H^+



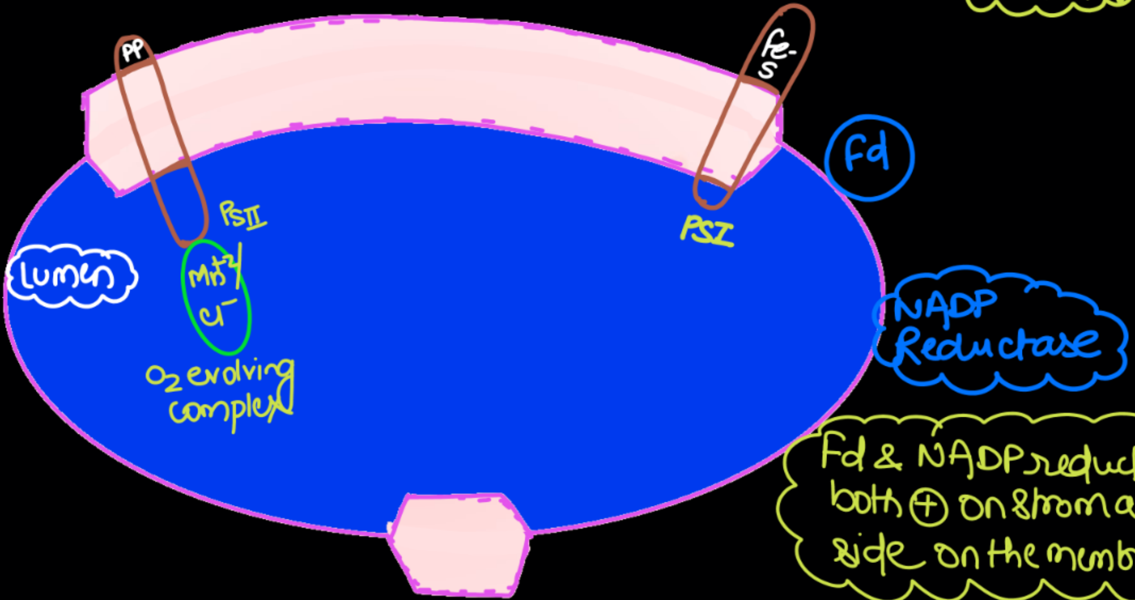
PQ is H acceptor
↓
so it can remove H^+ ion from stroma.


Plasto-
quinone
H^+
Plasto-
quinone
PQ-H_2
PQ is H
acceptor
e^-
e^-
H
PQ cannot
accept e^- alone



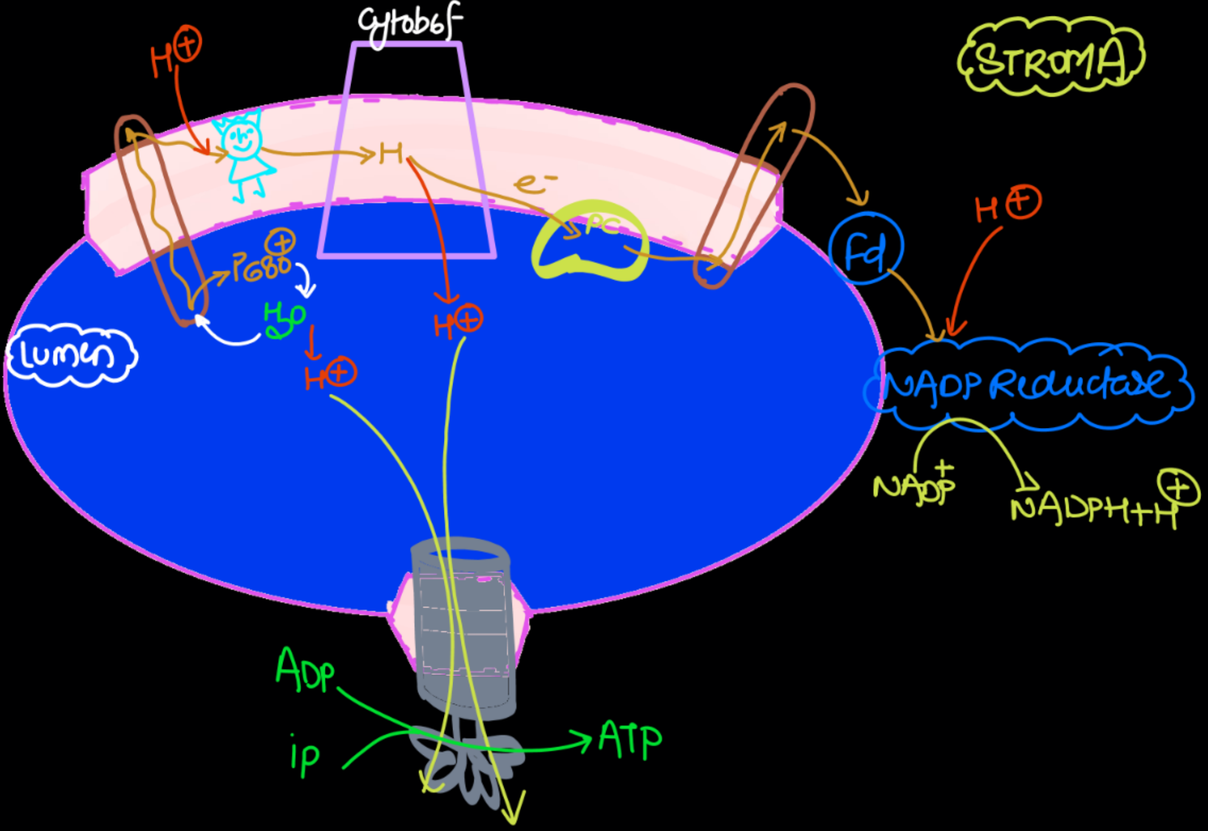
Pheophylin
e⁻
e⁻
H+
PQ
H
H-acceptor
Cytob6f
H
e⁻
H+
plastoyanin
Cu+2
e⁻ Acceptor
P700+
P700
P680
P680+
Fe-S
e⁻
Ferridoxin
Fe-S
e⁻ H+
NADP Reductase
NADP+
NADPH + H+
H acceptor

STROMA



Oxygen evolving complex is present in lumen

Fd & NADP reductase both ⊕ on stroma side on the membrane


Cytob6f
STROMA
H+
H
e-
PC
Fd
H+
NADP Reductase
NADP+
NADPH+H+
P680+
H2O
H+
H+
Lumen
ADP
ip
ATP

Ferridoxin

e^-

Oxidation

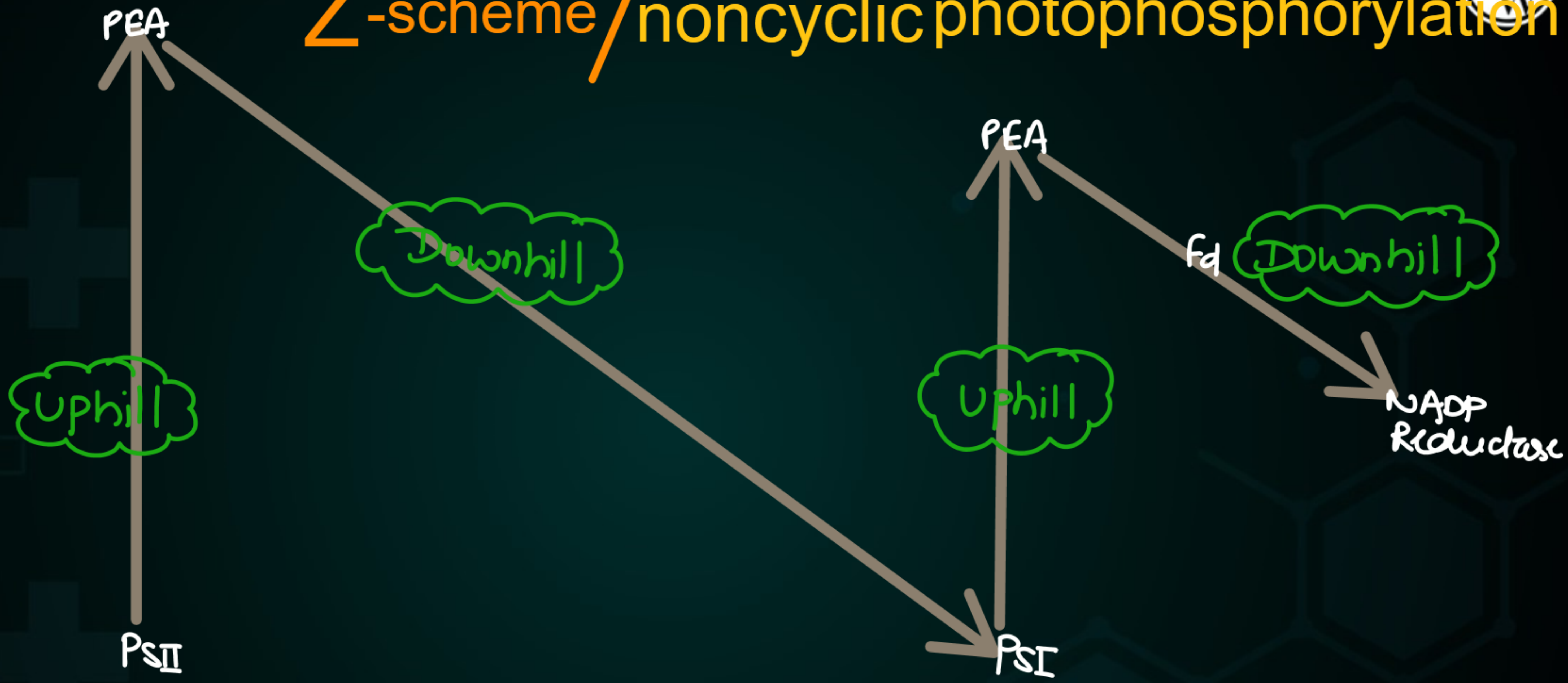
FNR → Ferridoxin NADP oxidoreductase

Reduction

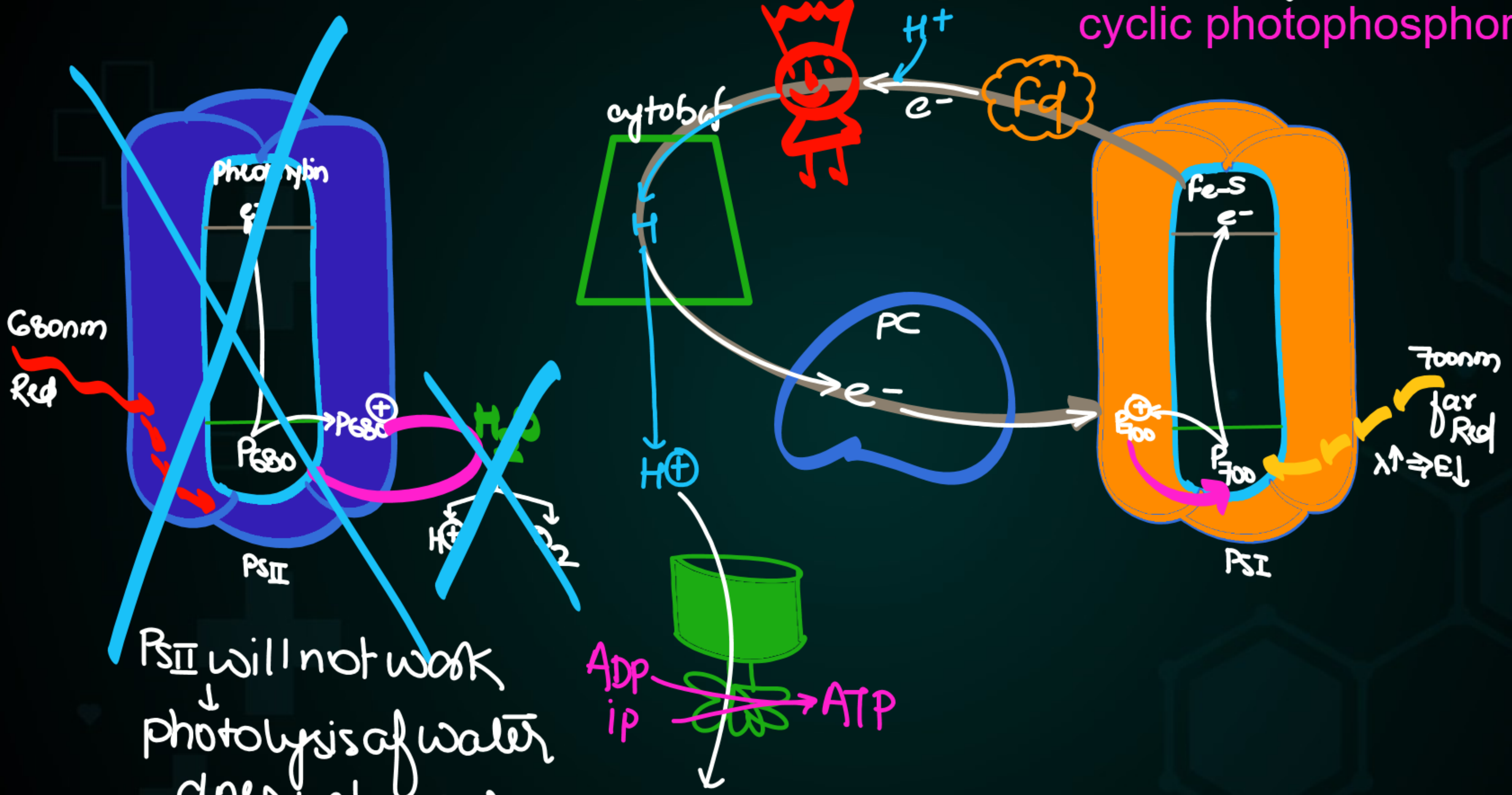
e^-

NADP Reductase

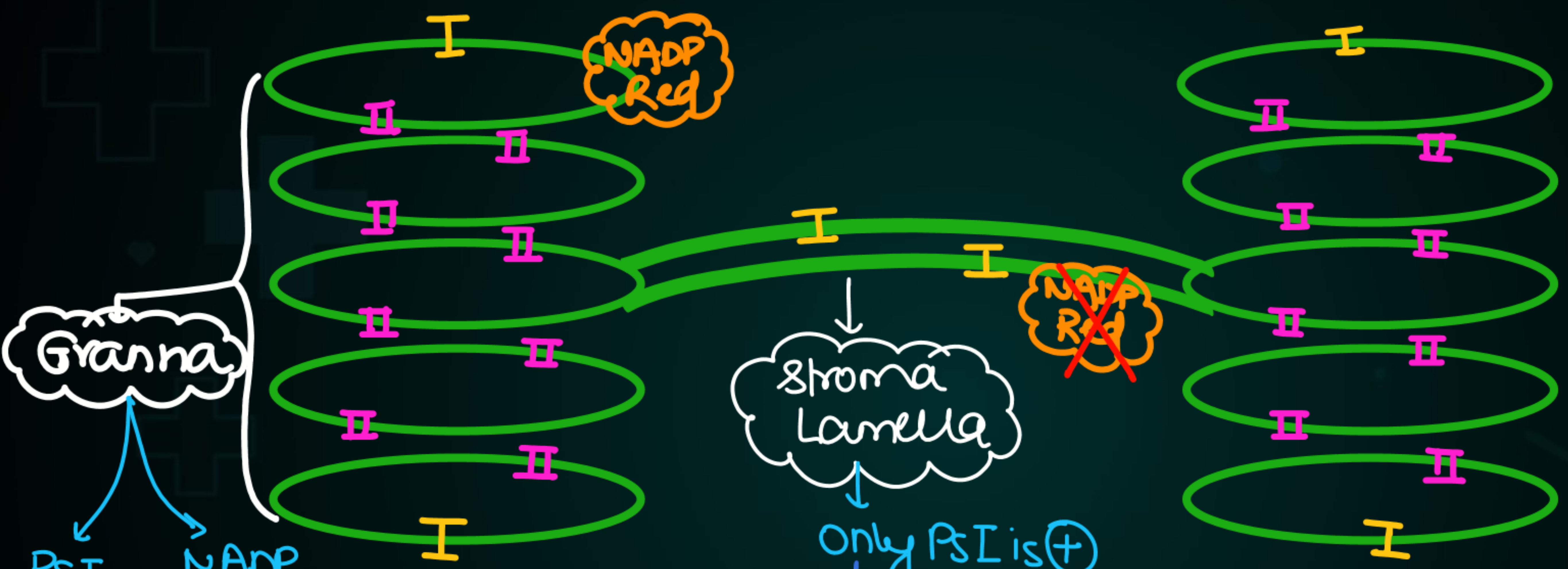
Z-scheme / noncyclic photophosphorylation



when only far Red light-is available ↴ cyclic photophosphorylation



PSII will not work
↓
photolysis of water does not occur



Granna

PS I & PS II both (+)

NADP Reductase (+)

Noncyclic

Stroma Lamella

Only PS I is (+)

Cyclic photophosphorylation

Noncyclic photophosphorylation

Noncyclic → NADPH $+H^+$

photophosphorylation → ATP

Noncyclic has 2 words

→ 2 products (NADPH + ATP)

→ 2 Photosystem (PSI & PSII)

→ 2 light (Far red & Red)

→ O_2 produced

→ photolysis of water

→ occurs in granna

cyclic photophosphorylation

photophosphorylation → ATP

cyclic → has 1 word

→ 1 product (ATP)

→ 1 photosystem (PS1)

→ 1 light (far Red)

→ NO O_2 production

→ NO photolysis of water

→ Occurs in stroma lamellae.

If photosystem is illuminated by

Red light
↓
PS_I & PS_{II} both work
↓
Noncyclic operate
↓
ATP & NADPH produced
↓
More energy → more productivity
↓
Emerson enhancement

Far red light
↓
only PS_1 work
↓
cyclic operate
↓
only ATP produce
↓
less energy → less productivity
↓
Reddrop

photosystems 1

1. First discovered
2. present on Non appressed surface
3. present in both Granna & stroma lamella
4. Absorption maxima — 700nm (far Red)
5. Involved in both cyclic & Non cyclic
6. Not involve in photolysis
7. donot produces O_2

photosystems 2

1. Later discovered
2. present on appressed surface
3. Only present in granna
4. Absorption maxima → 680nm (Red)
5. Only involved in Non cyclic
6. Involve in photolysis
7. Produces O_2

Imp point

O_2

↓

PS_{II}

PS_{II} & NADP reductase

↓

are absent in stroma lamella

Check ur knowledge

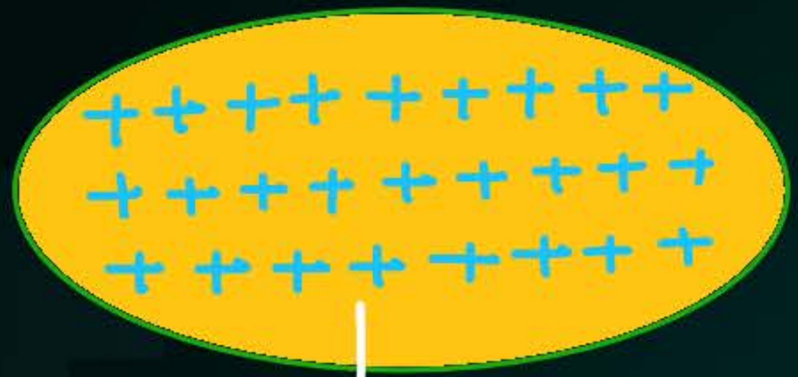
Qus In cyclic process who will provide e^- to Ps 1

Ans →

Qus In non cyclic process who will provide e^- to Ps II

non

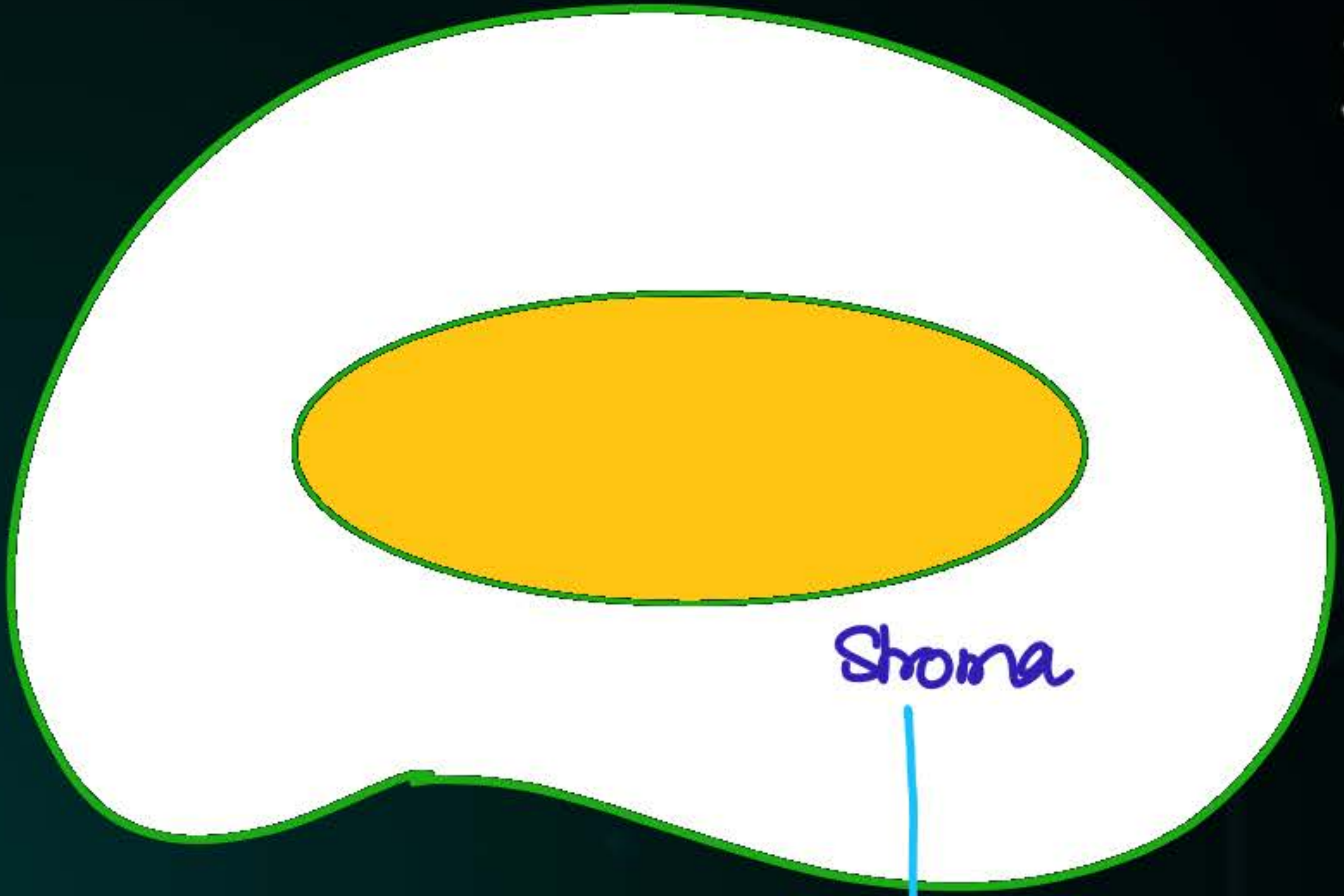
Qus In cyclic process who will provide e^- to Ps 1



High H^{+} or Low pH
in Lumen

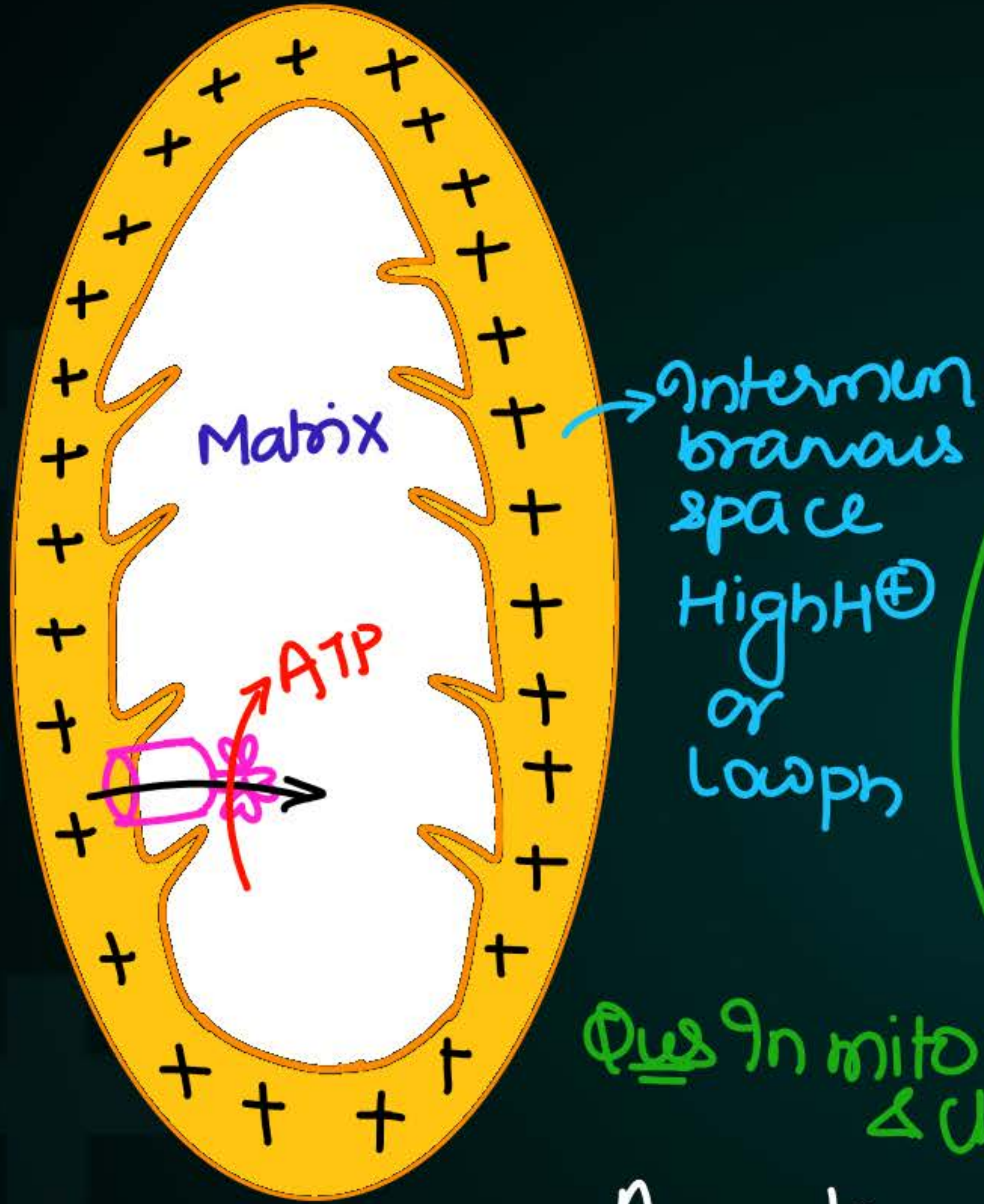
Photolysis
of water

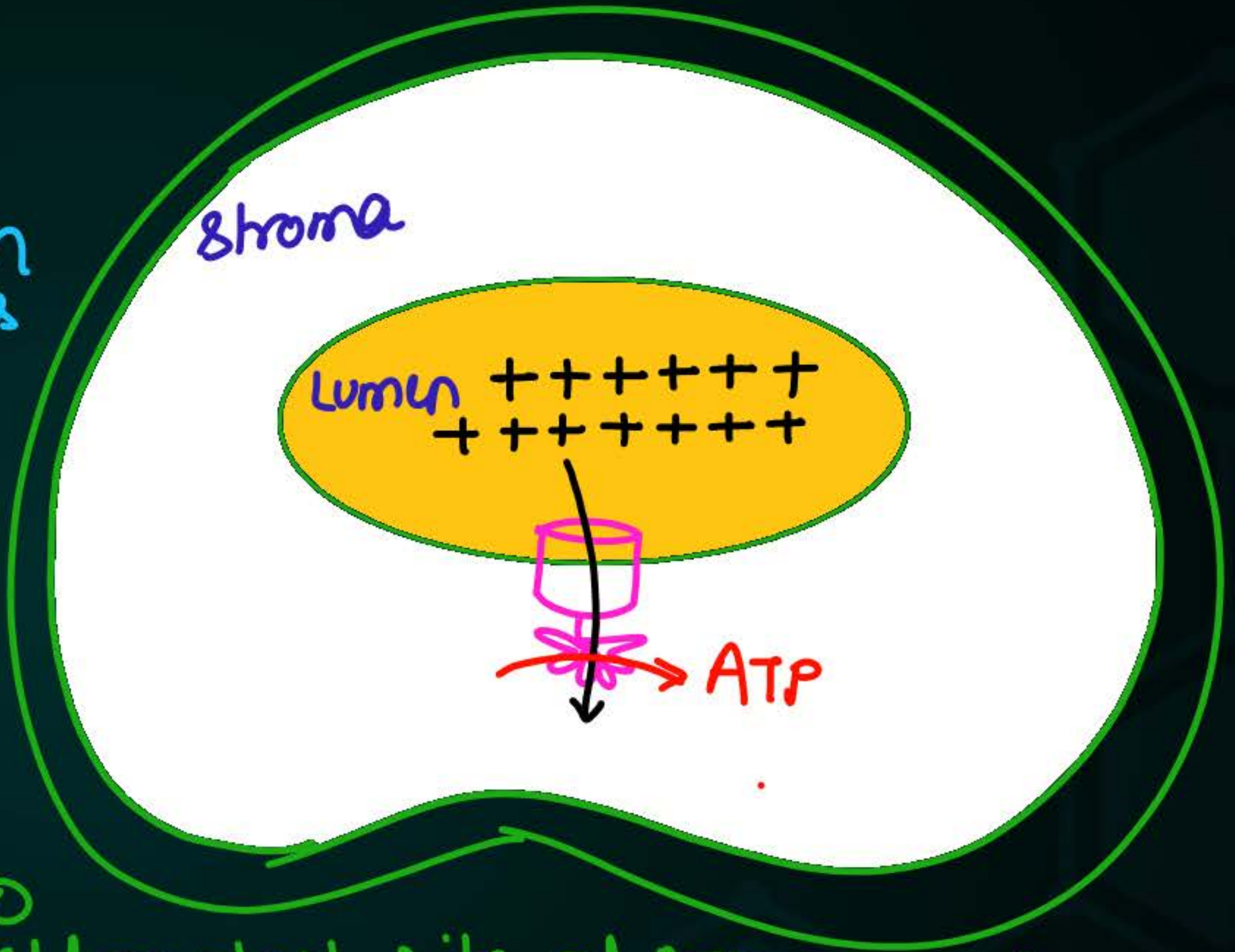
Active pumping
of H^{+} ion from
stroma to lumen.



Low H^{+} or High pH

Because NADP-red is
removing H^{+} ion
from stroma.





Ques In mito & chloroplast site of ATP production

Ans place where Low $H^{\oplus}$ ion are available

Synthetic phase (or) Dark reaction (or) Light-independent

calvincycle.

CO_2

① Carbon-fixation

most crucial step

RuBP

Ribulose bisphosphate

ketose sugar.

Glucose
↓
G-6-P
↓
F-6-P
↓
F1,6BP → DHAP
F1,6BP → G-3P

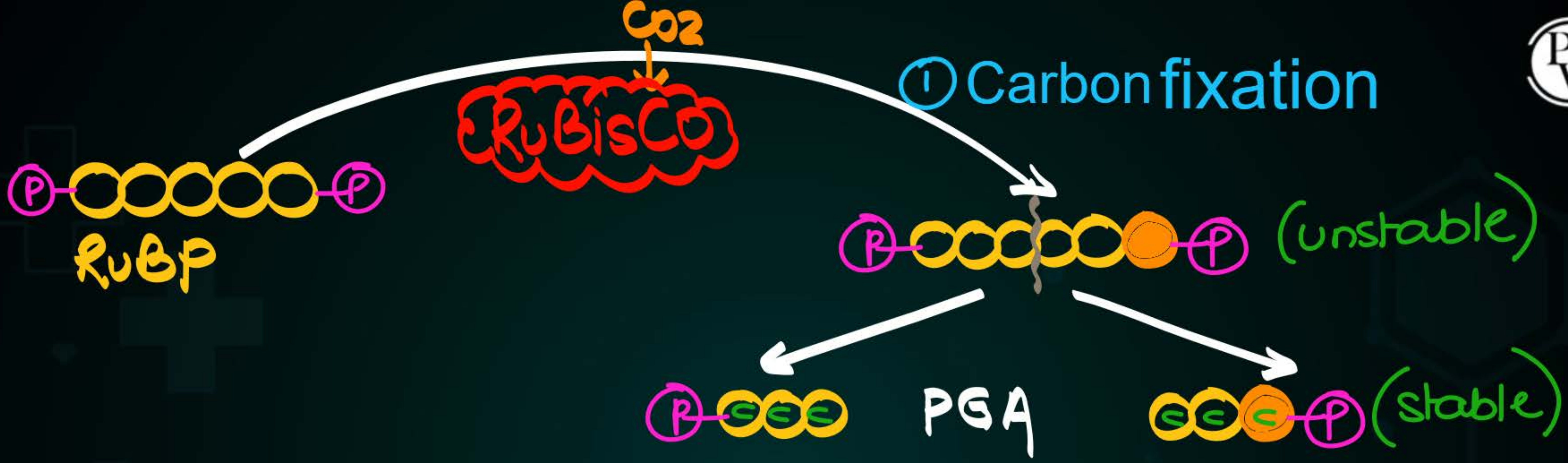
Glycolysis (Partial oxidation)

G-3P (PGAL)
↓ → NADH + H^+
1,3 BPG
↓ → ATP
3PG (PGA)

Calvin cycle (Reduction)

3PG (PGA)
ATP → ↓
1,3BPG
NADPH + H^+ → ↓
G3P (PGAL)

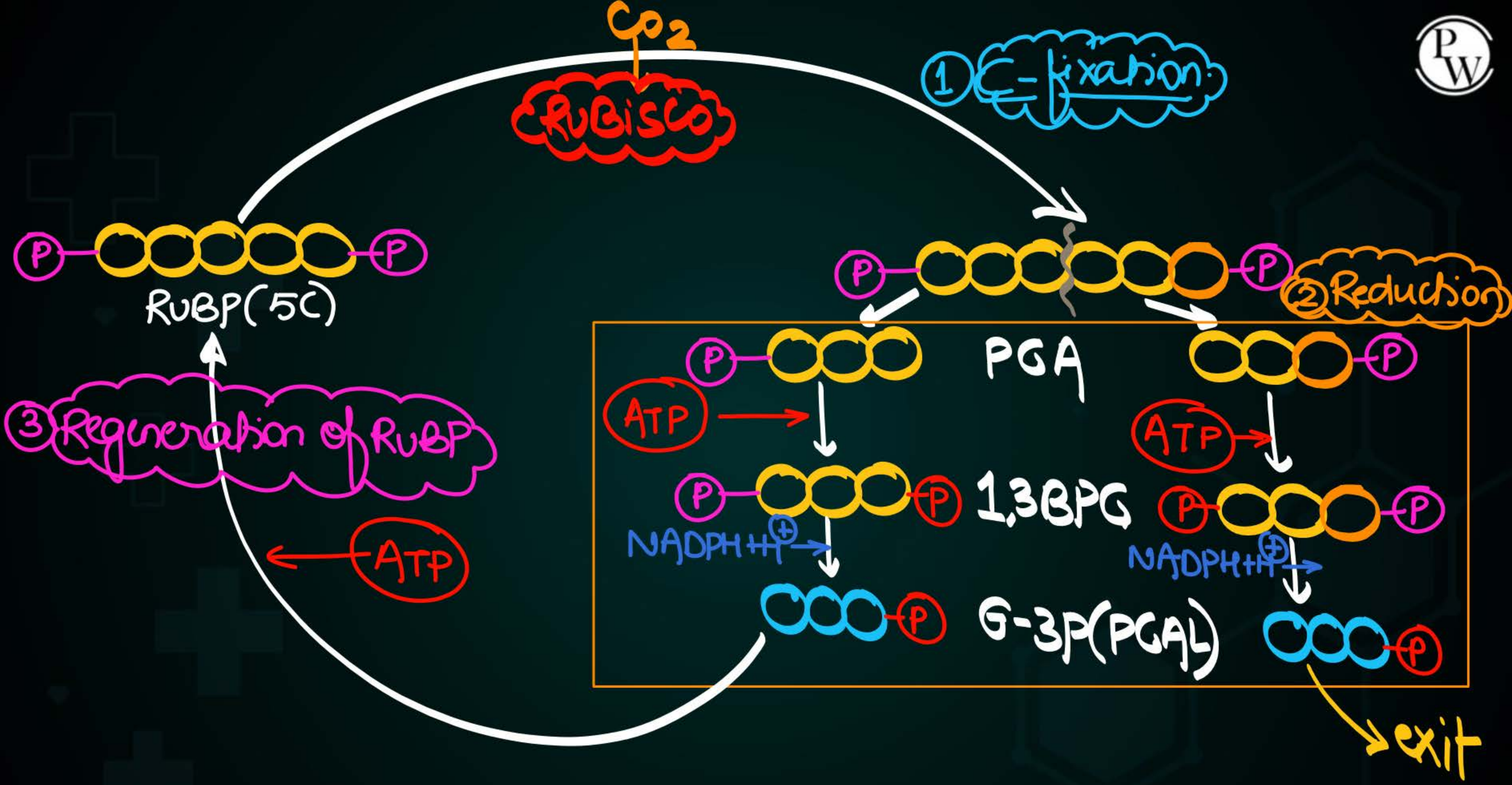
① Carbon fixation



* first stable product of calvin cycle is 3 Carbon compound → PGA (phosphoglyceric acid)

↓

so calvin cycle is also C_3 cycle.



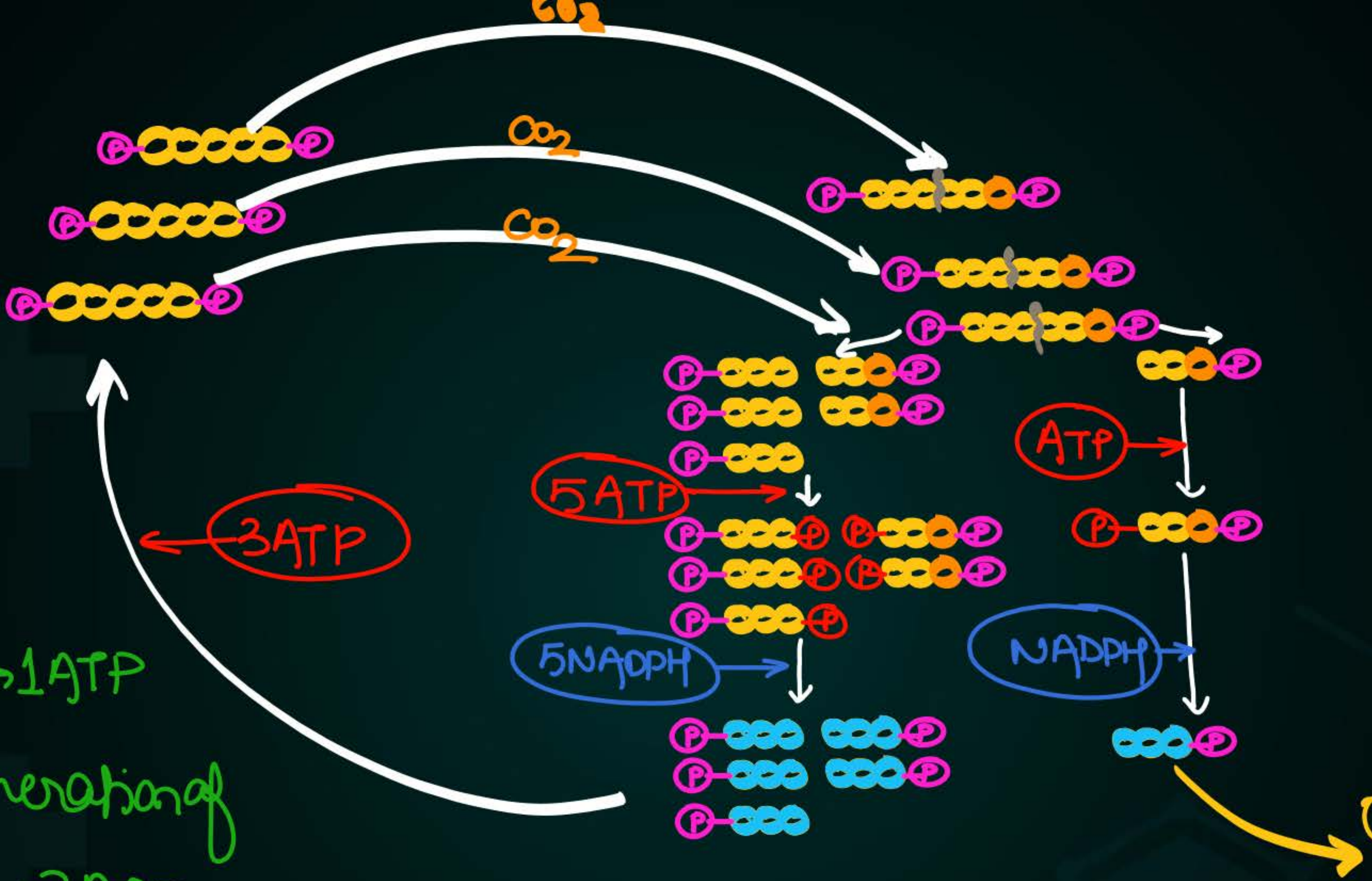
CO_2
RuBisCO
① C-fixation
RuBP(5C)
② Reduction
PGA
ATP
1,3BPG
NADPH+H^+
G-3P(PGAL)
③ Regeneration of RuBP
ATP
exit

for fixation of $1 CO_2 \Rightarrow$ 1 Turn of calvin cycle

$\Rightarrow$ 1 RuBP required

$\Rightarrow$ 3ATP + 2NADPH + H^{+}

No of CO_2	No of RuBP required	Turn of calvin cycle	No of ATP	No of NADPH
1	1	1	3	2
3	3	3	3x3	3x2
6	6	6	6x3	6x2
12	12	12	12x3	12x2
18	18	18	18x3	18x2



One molecule of G-3P will exit

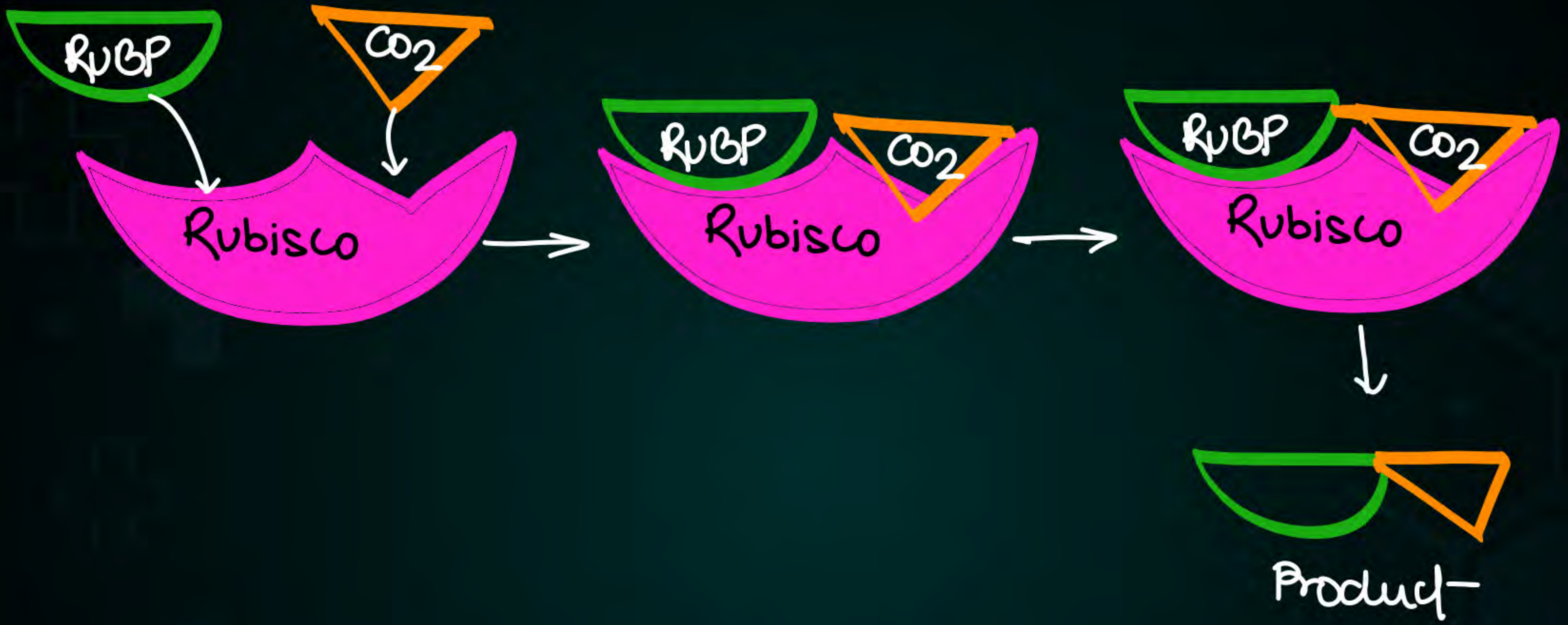
∴ for rg of
1 RuBP → 1 ATP

∴ for regeneration of
3 RuBP = 3ATP

Product	No of 'C' in product	= No of CO_2 req	= No of RuBP req	= Turn of Calvin cycle	ATP required	NADPH+H required
G-3P (PGAL)	3	3	3	3	3x3	3x2
Glucose	6	6	6	6	6x3	6x2
Sucrose	12	12	12	12	12x3	12x2
$C_{18}H_{36}O_{18}$	18	18	18	18	18x3	18x2
$C_{100}H_{200}O_{100}$	100	100	100	100	100x3	100x2

Calvin Cycle

1. First discovered by Melvin Calvin in Algae by using radioactive Carbon (C^{14})
2. 3 steps → 1. Carbon fixation
   2. Reduction
   3. Regeneration
3. Calvin cycle occurs in all the plants
4. First stable product is 3 carbon compound → C_3 cycle
5. 1 Turn of calvin cycle Required 3ATP + 2NADPH



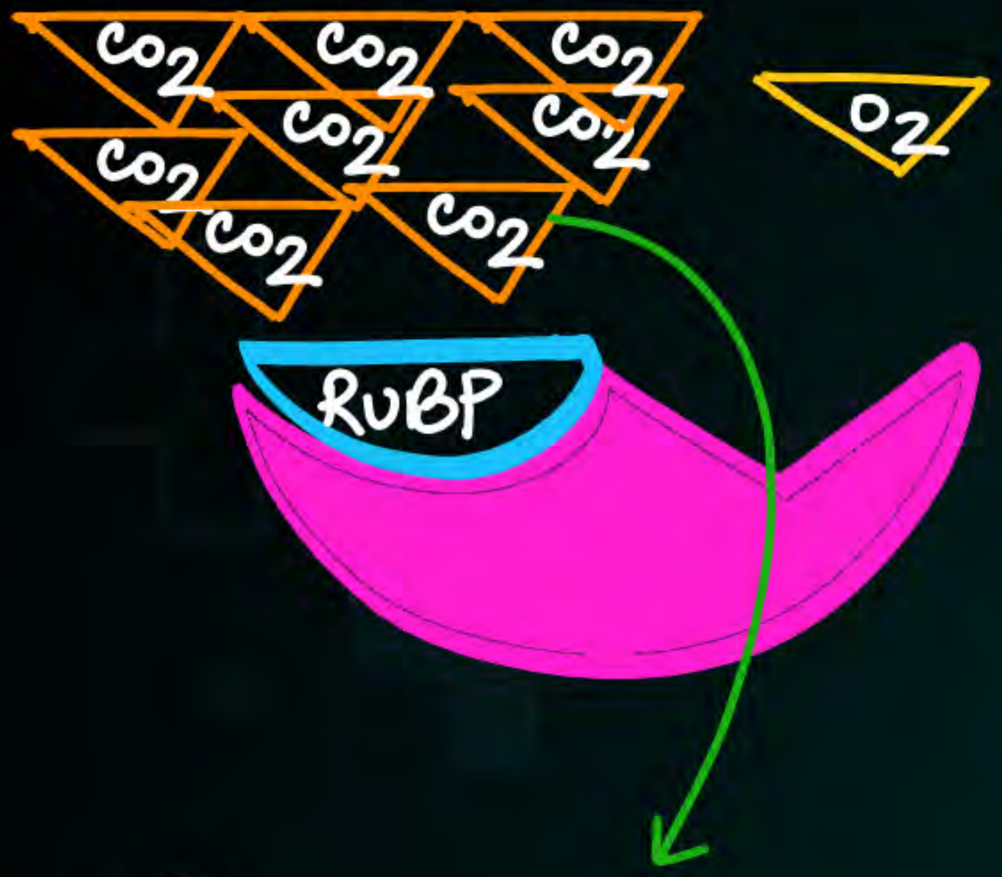
RuBP
CO_2
Rubisco
RuBP
CO_2
Rubisco
RuBP
CO_2
Rubisco
Product

Ribulose bisphosphate Carboxylase oxygenase

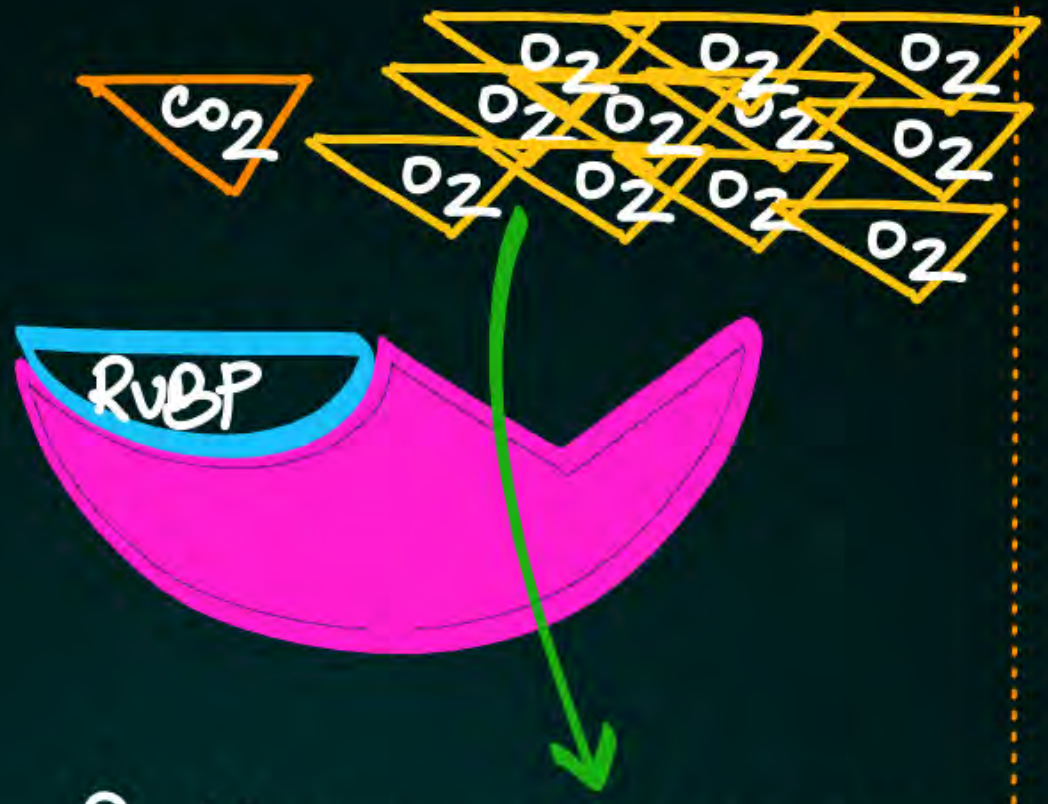
Carboxylase → Combines $\bar{c}$ CO_2

oxygenase → Combines $\bar{c}$ O_2

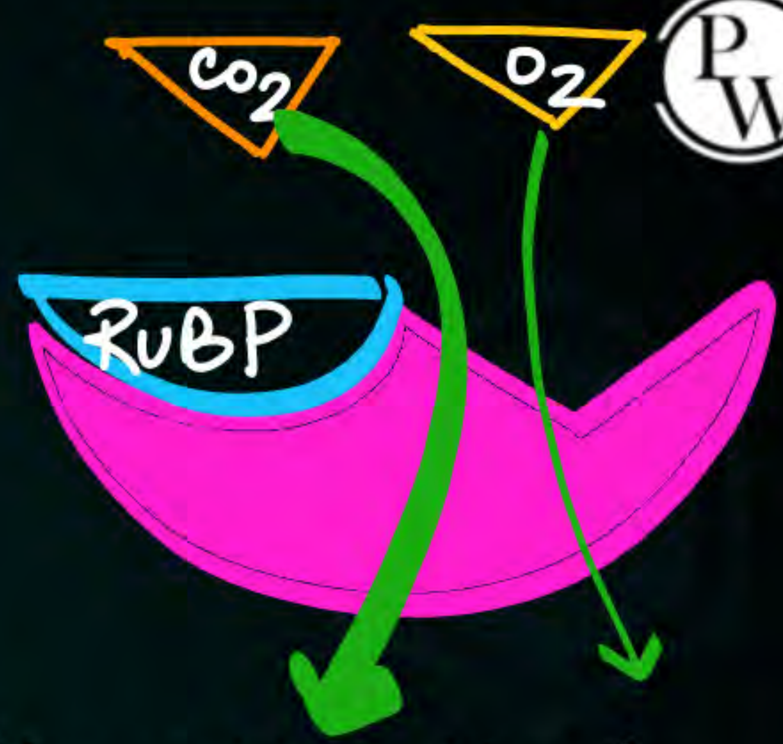
1. Most abundant enzyme in the planet
2. Rubisco can combines $\bar{c}$ CO_2 & O_2
3. Combining capacities depends on concentration of gases.
4. But its affinity is more towards CO_2



Rubisco works as Carboxylase minimising oxygenase activity

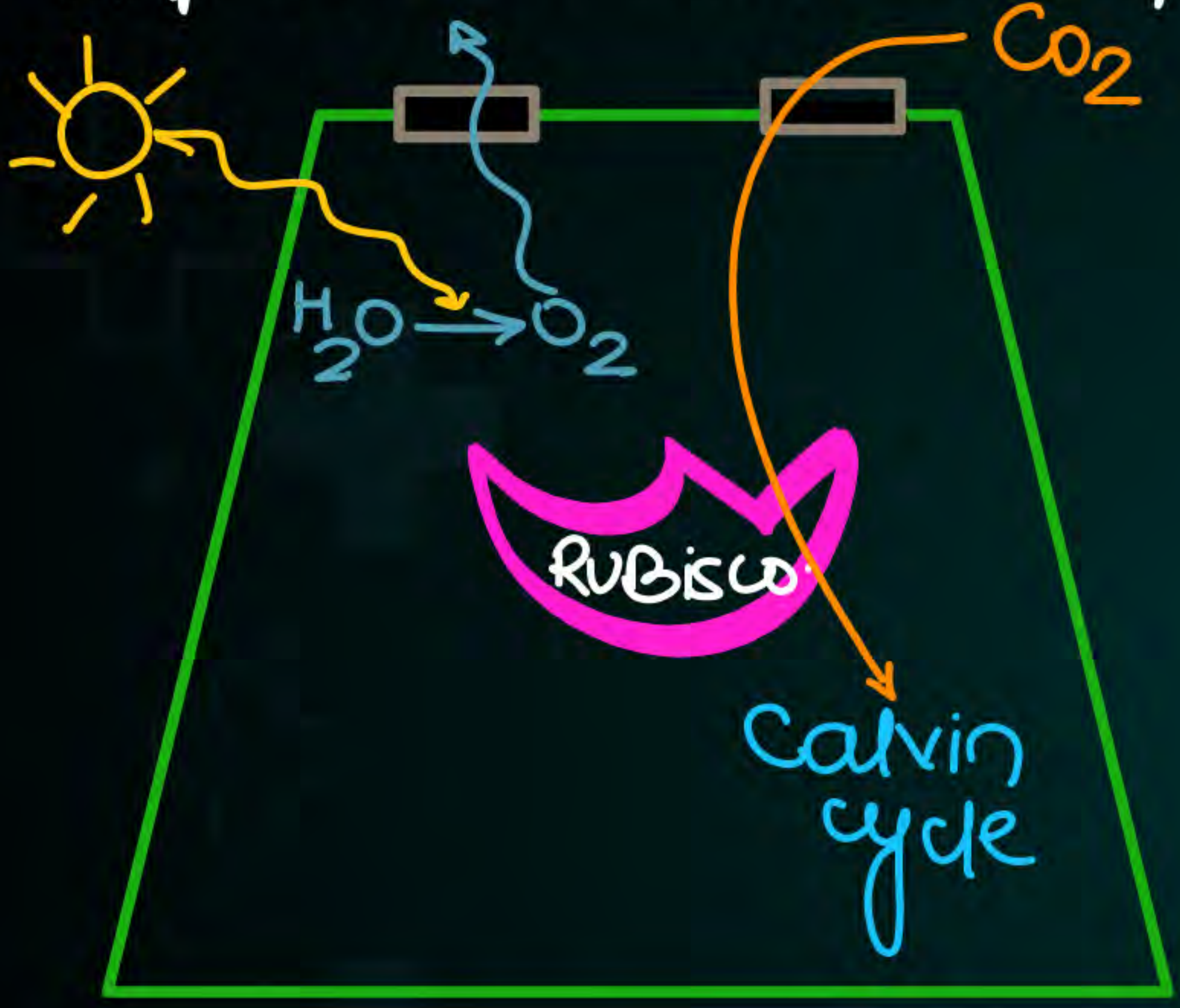


Rubisco works as oxygenase



Its affinity is more towards $\underline{\underline{CO_2}}$

Temp → 20-25°C → stomata → open.



Temp↑ ⇒ 40-45°C → stomata → close

↓

Waste process

↓

- Loss of ATP & CO_2
- Toxin produced.

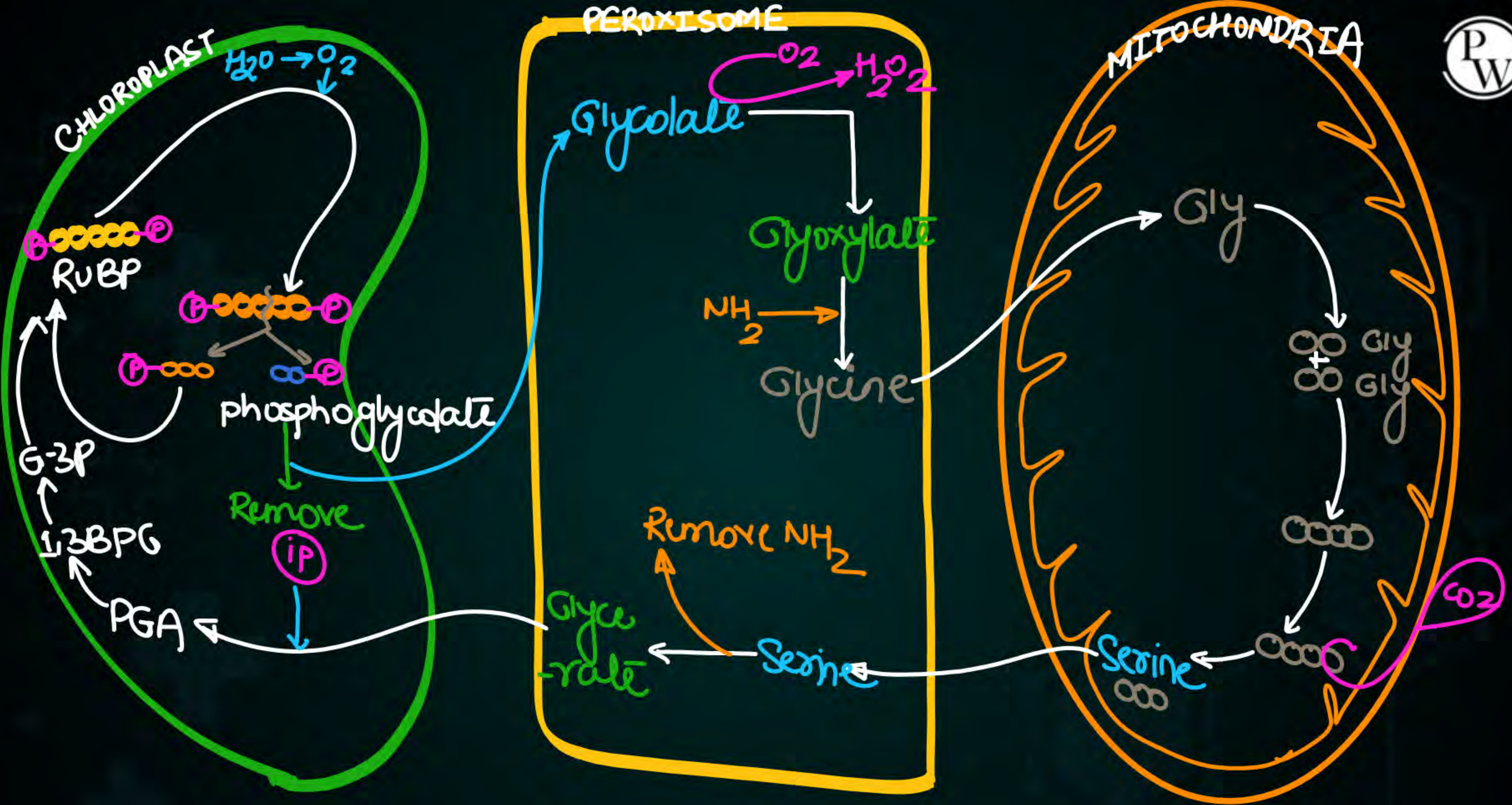
Long time ago
↓
when C_3 plants
↓
faced high temp & drought
↓
As a result plant closed their stomata to minimize water loss
↓
O_2 cannot exit & CO_2 cannot enters the leaf
↓
There is continuous accumulation of O_2 inside the leaf.
↓
which can induce photooxidation in leaf.
↓
To protect leaf from photooxidative damage Rubisco combines with O_2
↓
with loss of ATP & CO_2 & produces metabolic waste

Temp → 20-25°C

Temp → High

Toxin
↓
Send for detoxification
↓
Peroxisome

1st stable product
↓
2-carbon compound
↓
C_2 cycle


CHLOROPLAST
PEROXISOME
MITOCHONDRIA
H2O → O2
RUBP
phosphoglycolate
Remove
iP
G-3P
1,3BPG
PGA
Glycolate
O2
H2O2
Glyoxylate
NH2
Glycine
Remove NH2
Glyce-rate
Serine
Gly
Gly
Gly
Serine
CO2

Vimp

RuBP (5C) $\xrightarrow{O_2}$ 3C + 2C

3C ↓ PGA

2C ↓ Phosphoglycolate

organelles used

C P M

oxygen using organelle

In chloroplast

In peroxisome

RuBP + O_2 →

glycolate

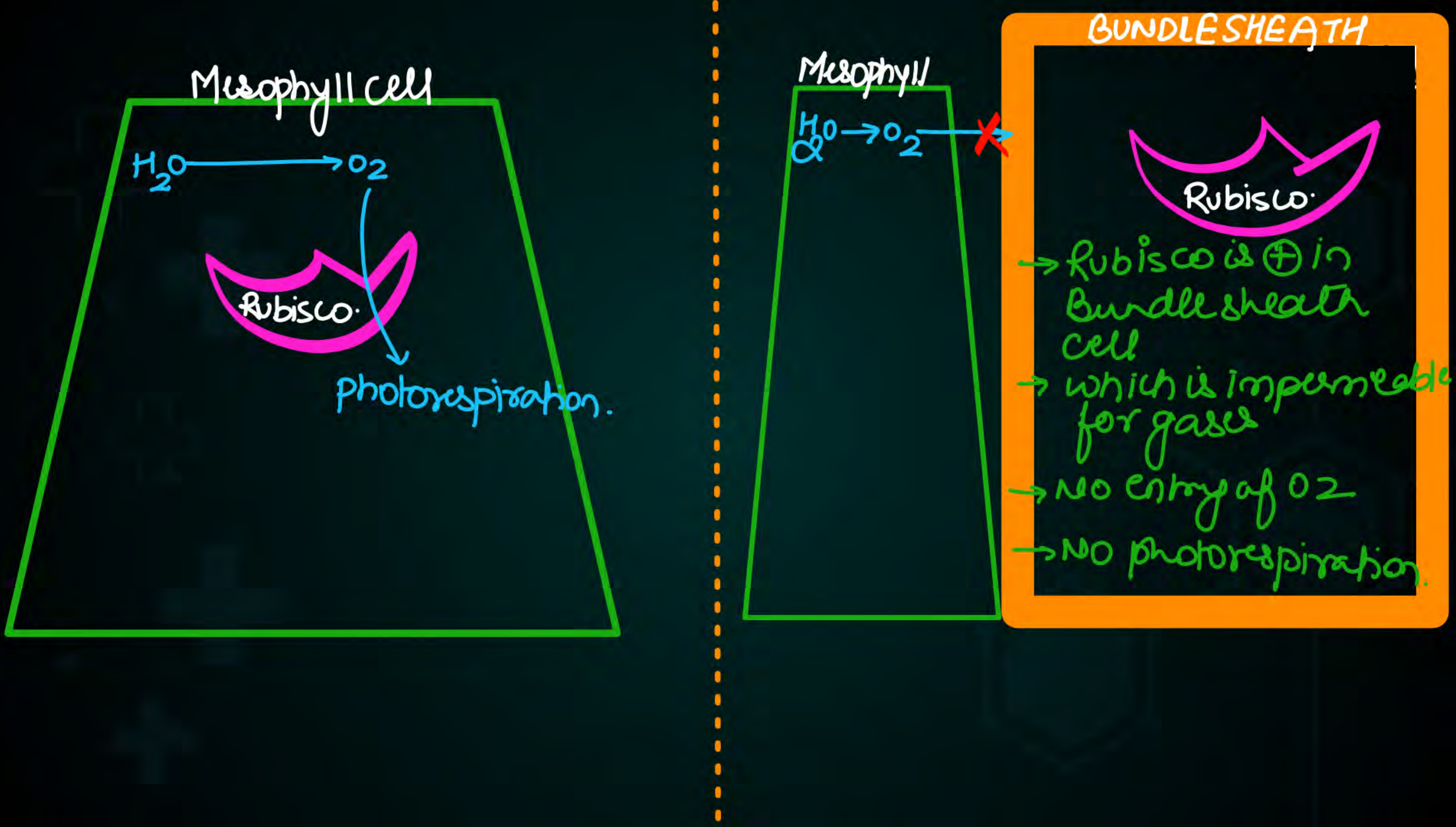
O_2 is Removing H from glycolate

O_2

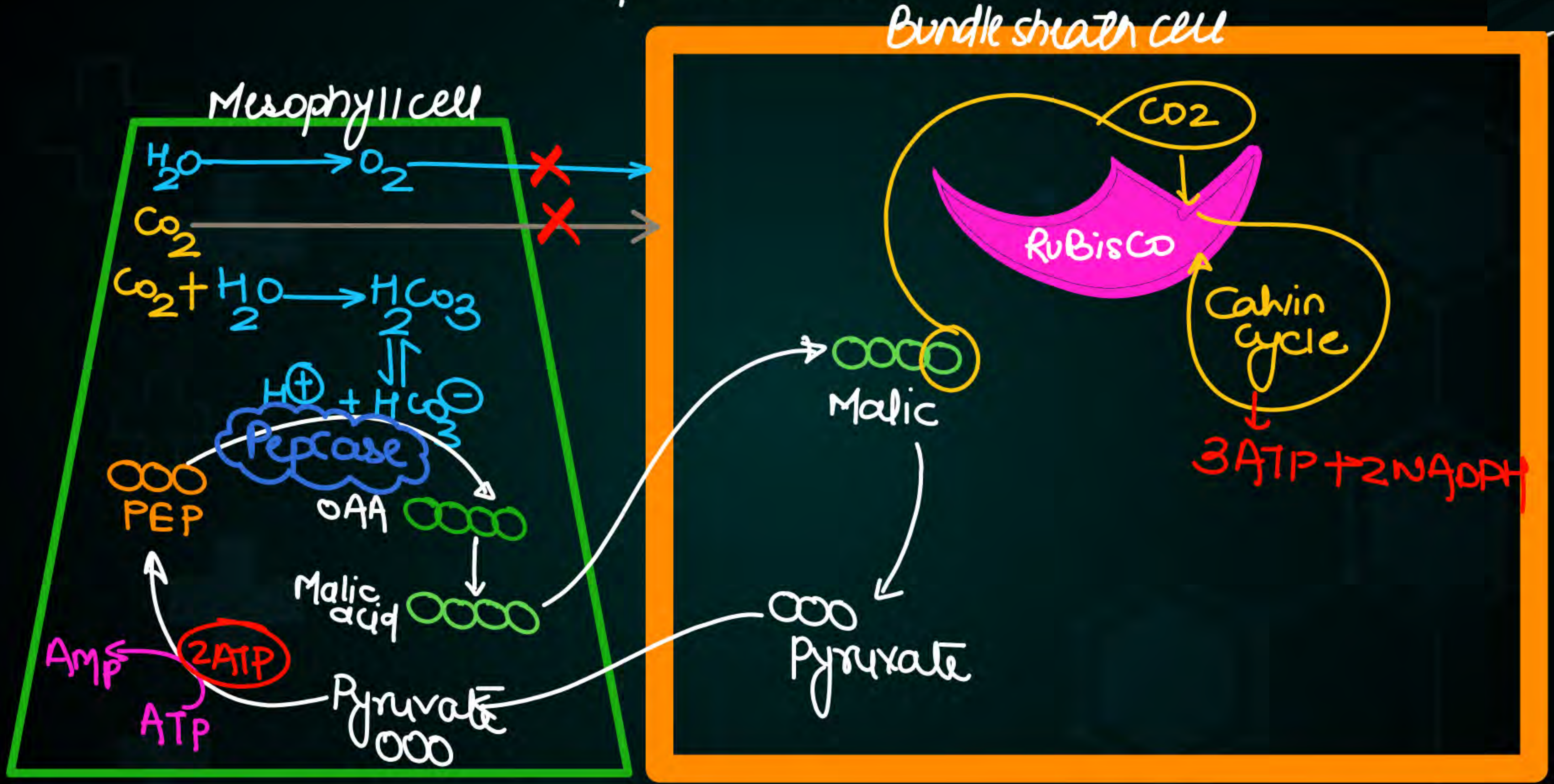
→ NO ATP produced & wastage of ATP without sugar produced.

→ used O_2 & produced CO_2 → photorespiration.

→ Toxin produced → phosphoglycolate.


Mesophyll cell
$H_2O \rightarrow O_2$
Rubisco.
Photorespiration.
Mesophyll
$H_2O \rightarrow O_2$
BUNDLESHEATH
Rubisco.
→ Rubisco is ⊕ in Bundle sheath cell
→ which is impermeable for gases
→ No entry of O2
→ No photorespiration.

C_4-Mechanism



Last step of glycolysis.

PEP ~ P

$$PEP \xrightarrow{ADP \rightarrow ATP} Pyruvate$$

In Last step of C_4 Mechanism

$$Pyruvate \longrightarrow PEP$$

ATP A-P-P-P

ADP A-P-P

AMP A-P

$$ATP \longrightarrow AMP$$

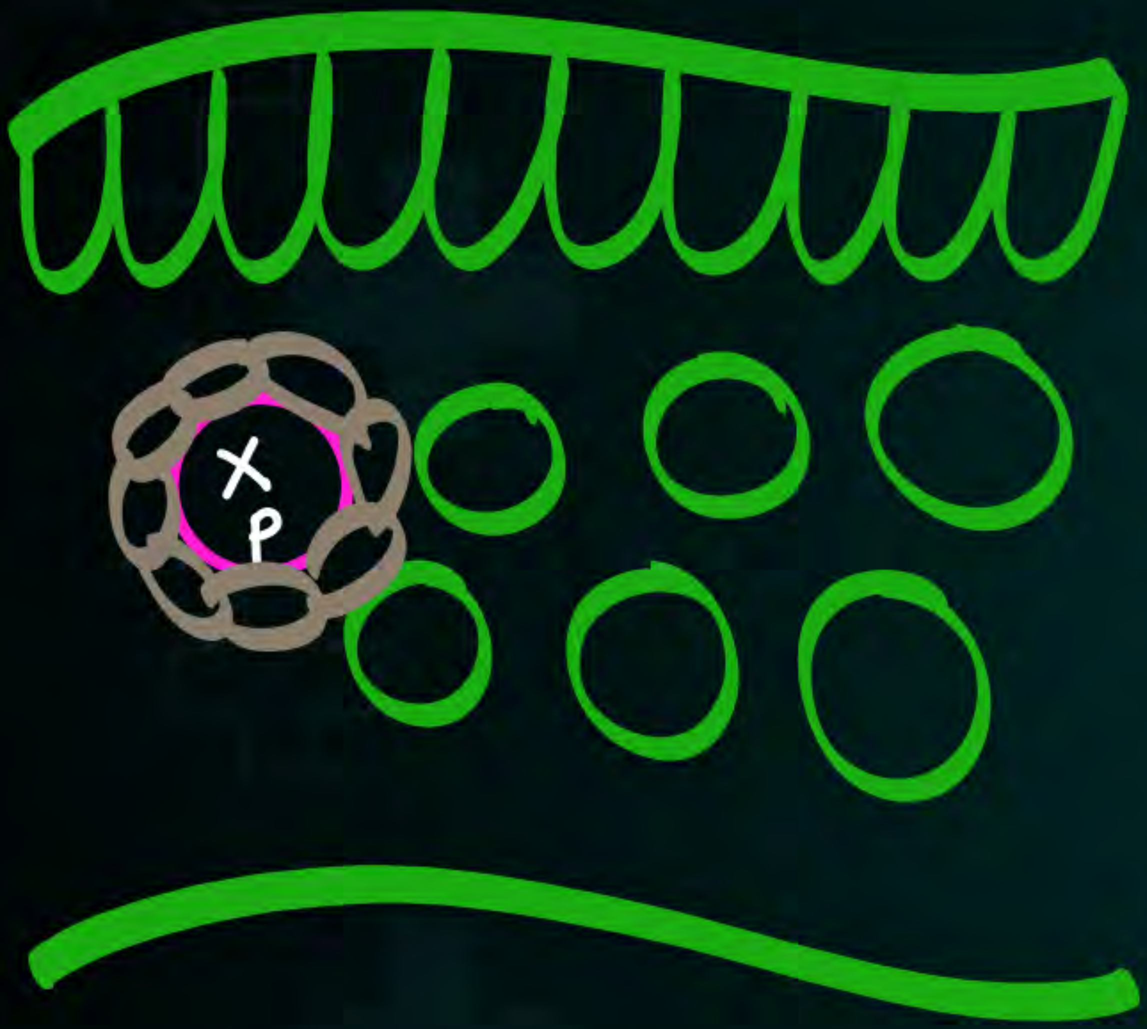
Consider 2ATP are used

In C_4 Mechanism → for fixation of 1 CO_2

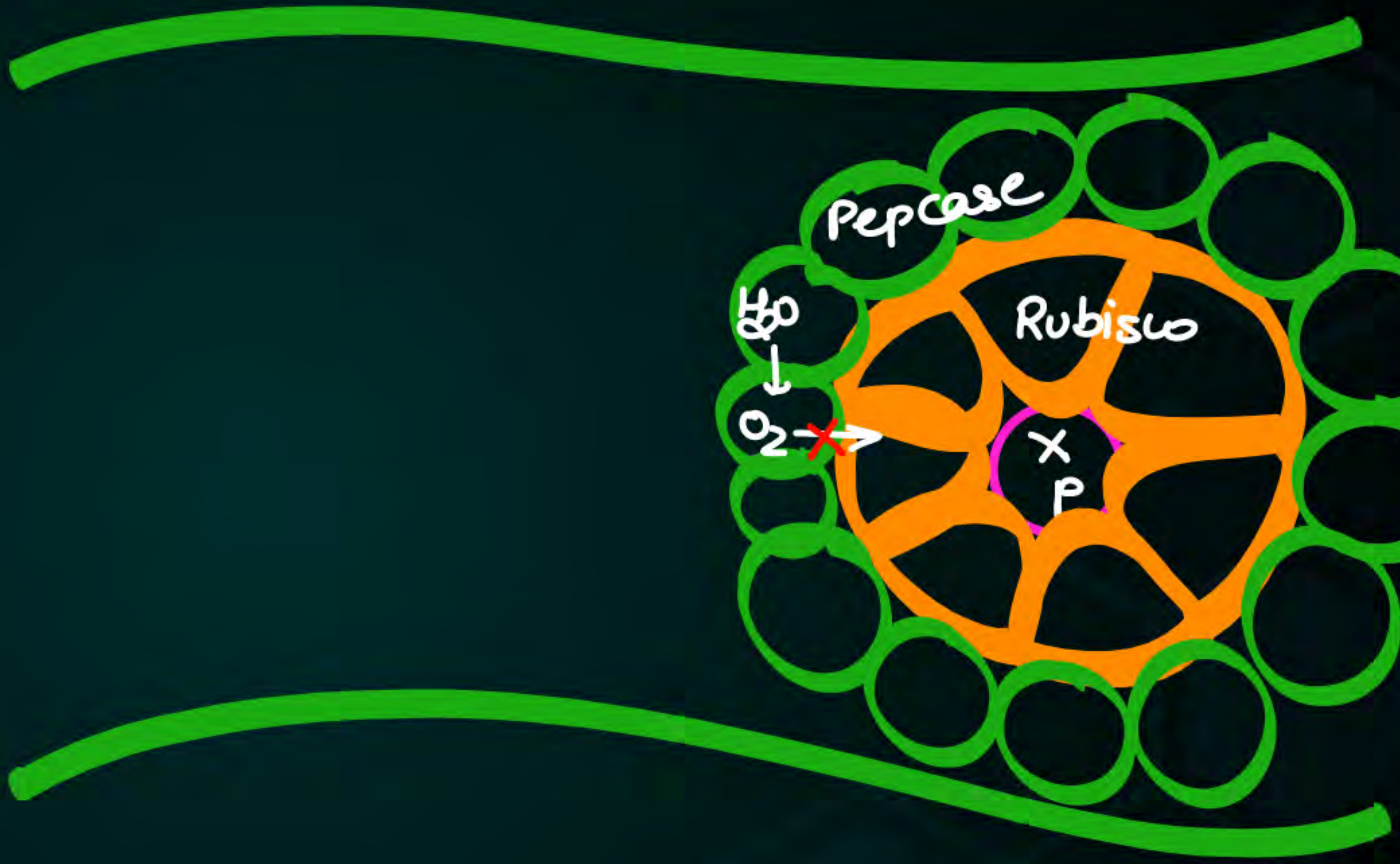
↓

$\underbrace{3ATP}_{\text{for calvin cycle}} + \underbrace{2ATP}_{\text{for regeneration of PEP}} + \underbrace{2NADPH}_{\text{for calvin cycle}}$

C_3 plants

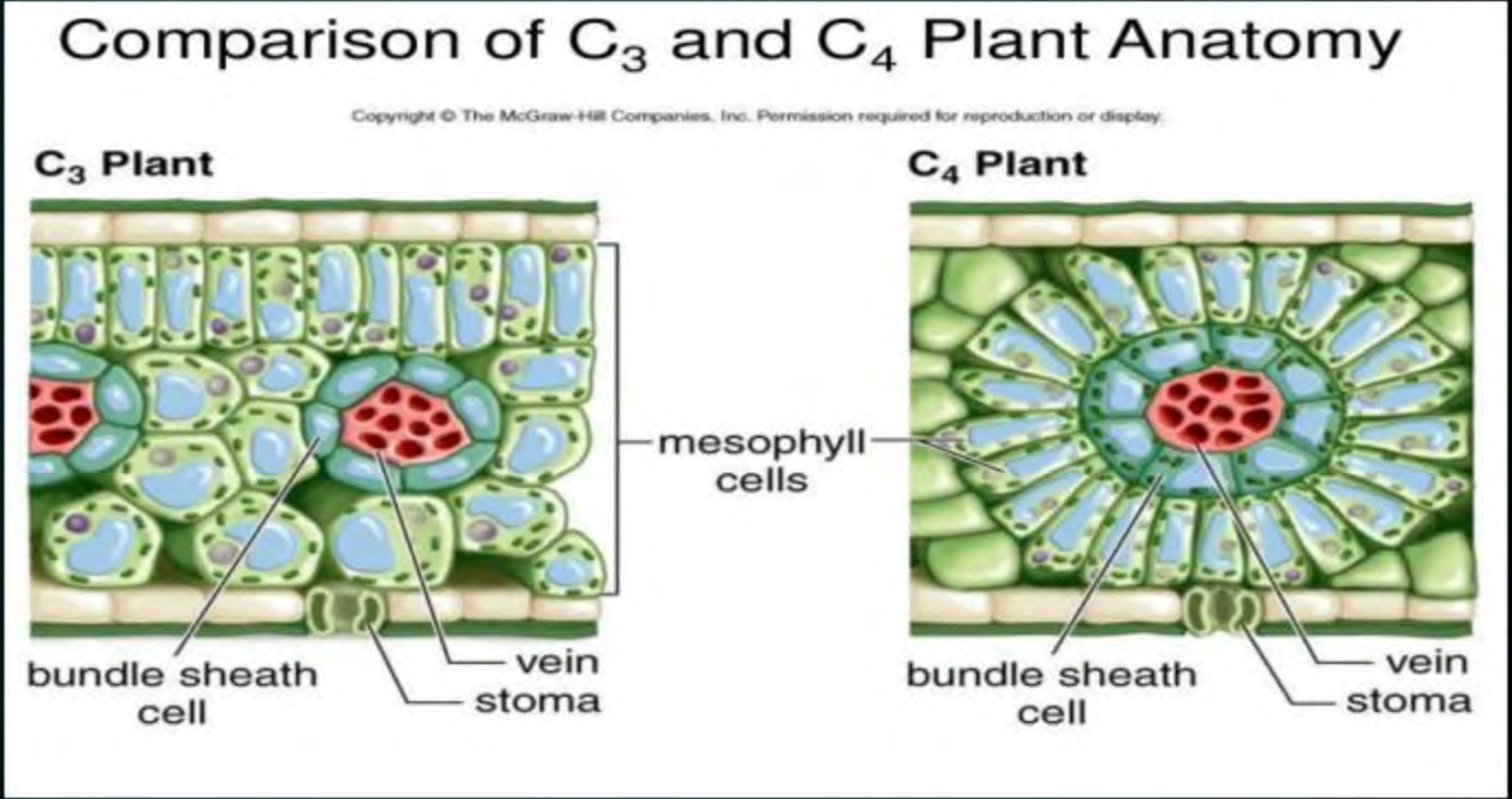


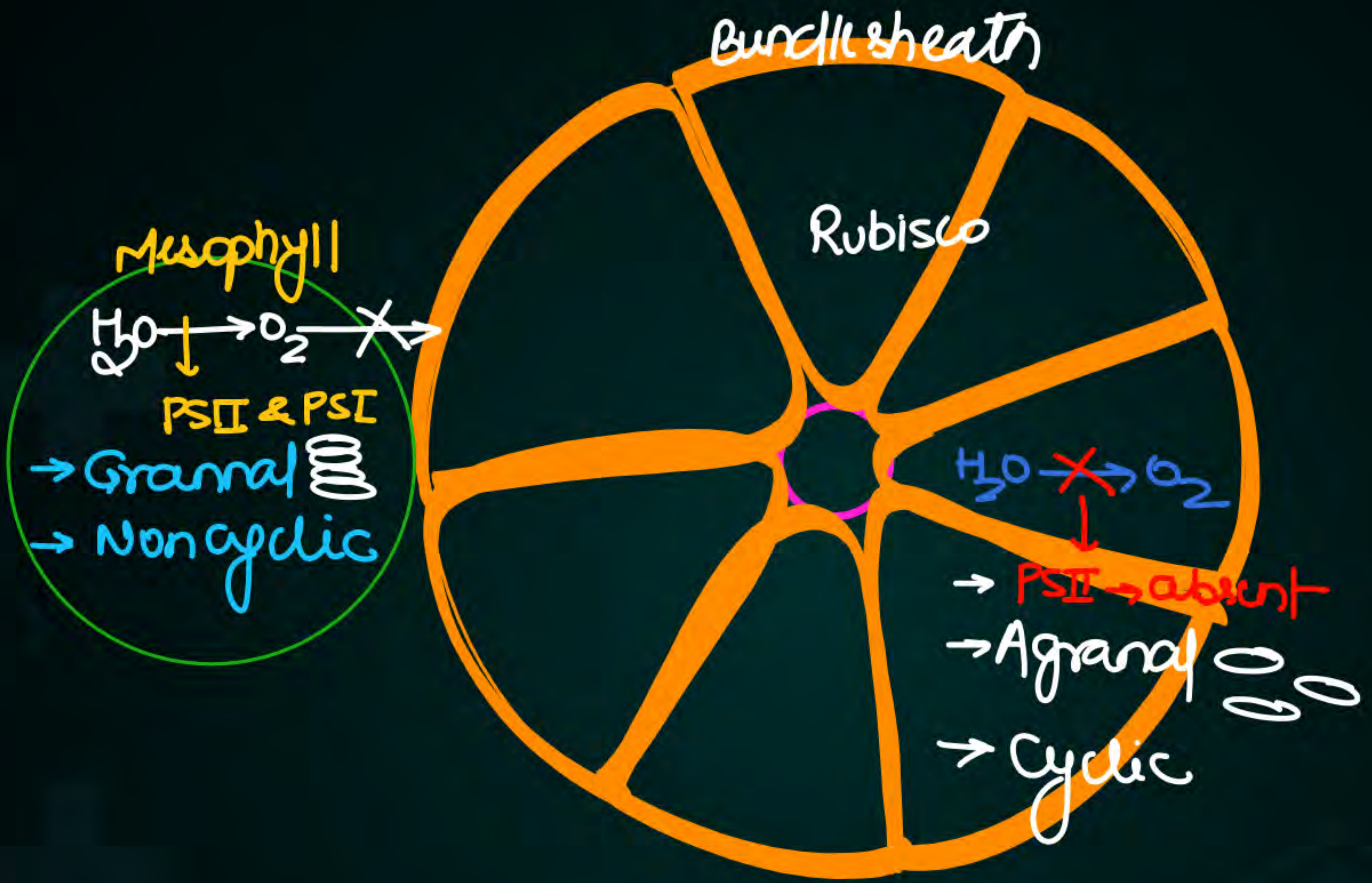
C_4 Plants



C_4 Leaf anatomy

- Kranz anatomy ("wreath": German):





Bundle sheath
Rubisco
Mesophyll
$H_2O \rightarrow O_2$
PSII & PSI
→ Granal
→ Noncyclic
$H_2O \not\rightarrow O_2$
→ PSII → absent
→ Agranal
→ Cyclic

Mesophyll

Pepcase
or
PepCarboxylase

→ PS II & PS I ⊕
→ Grannal
→ Noncyclic photo.

Diamorphic

Bundle sheath.

Rubisco

- Big cell
- Thick cell
- Impermeable for gaseous exchange
- No intercellular space

→ PS II & grannal chloroplast absent
→ Agranal chloroplast ⊕
→ cyclic photo.

NEET

Que why photorespiration is absent in C_4 plants

Ans Because they have special mechanism

↓

In Malic acid (C_4 acid) of Mesophyll cell

↓

Breakdown in Bundle sheath cell

↓

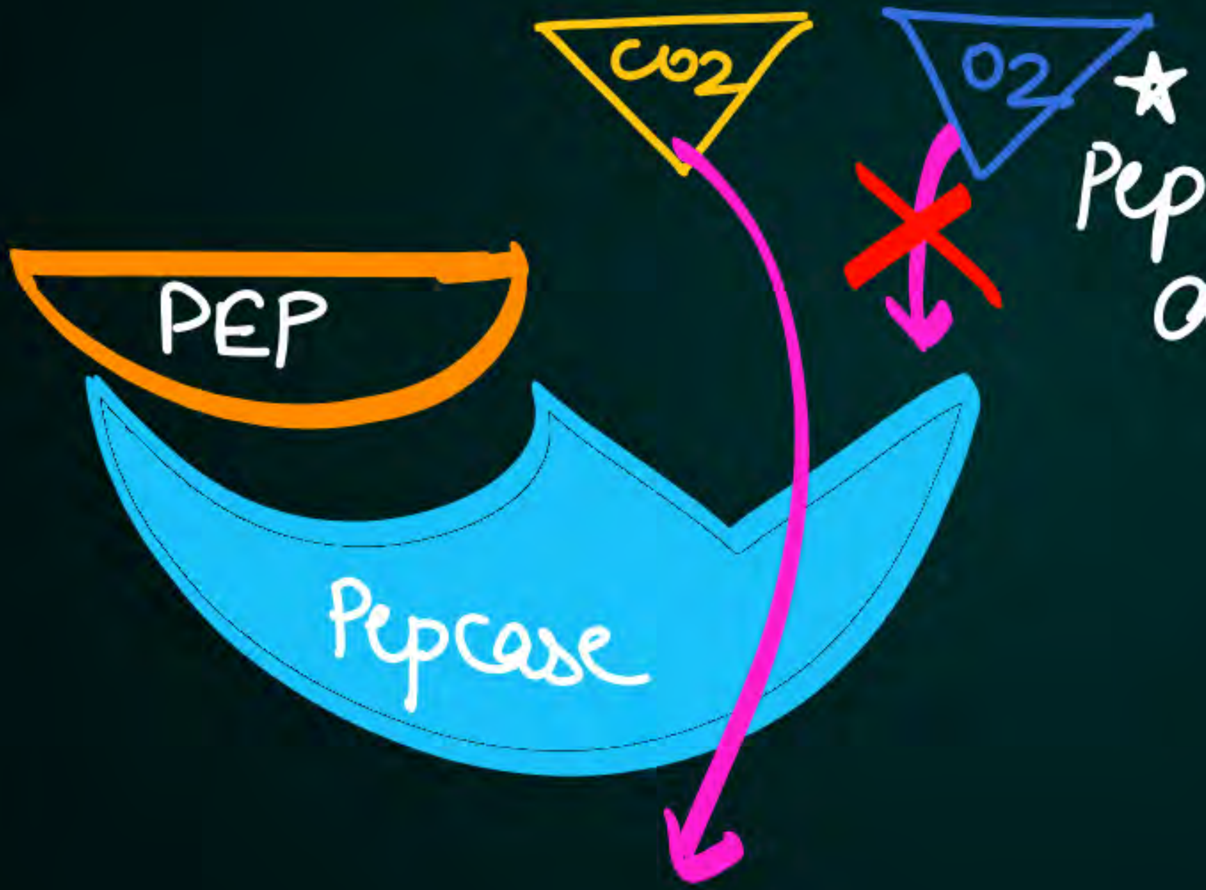
which will increase intracellular Concentration of CO_2 at enzyme site

↓

as a result Rubisco works as a Carboxylase, minimizing Oxygenase activity.

Pepcase or Pep Carboxylase.

Phosphoenol pyruvate Carboxylase



★ Pepcase donot have oxygenase activity

Qus C_4 plants are present in tropical area, but they are absent in temperate area absent

Ans

Tropical area	Temperate area
Day Time → 40°C	Day time → 30–35°C
Night Time → 20°C	Night Time → 0–5°C

Reason → Because pepease is cold sensitive

C_4 Mechanism

(1) 1st stable product is 4 carbon compound → OAA that's why it is 4 as C_4 cycle.

(2) First discovered by Hatch & Slack

(3) Diamorphic chloroplast → Agranal, → Granal

(4) Kranz anatomy

(5) CO_2 fixating enzyme → Pepcase, → Rubisco.

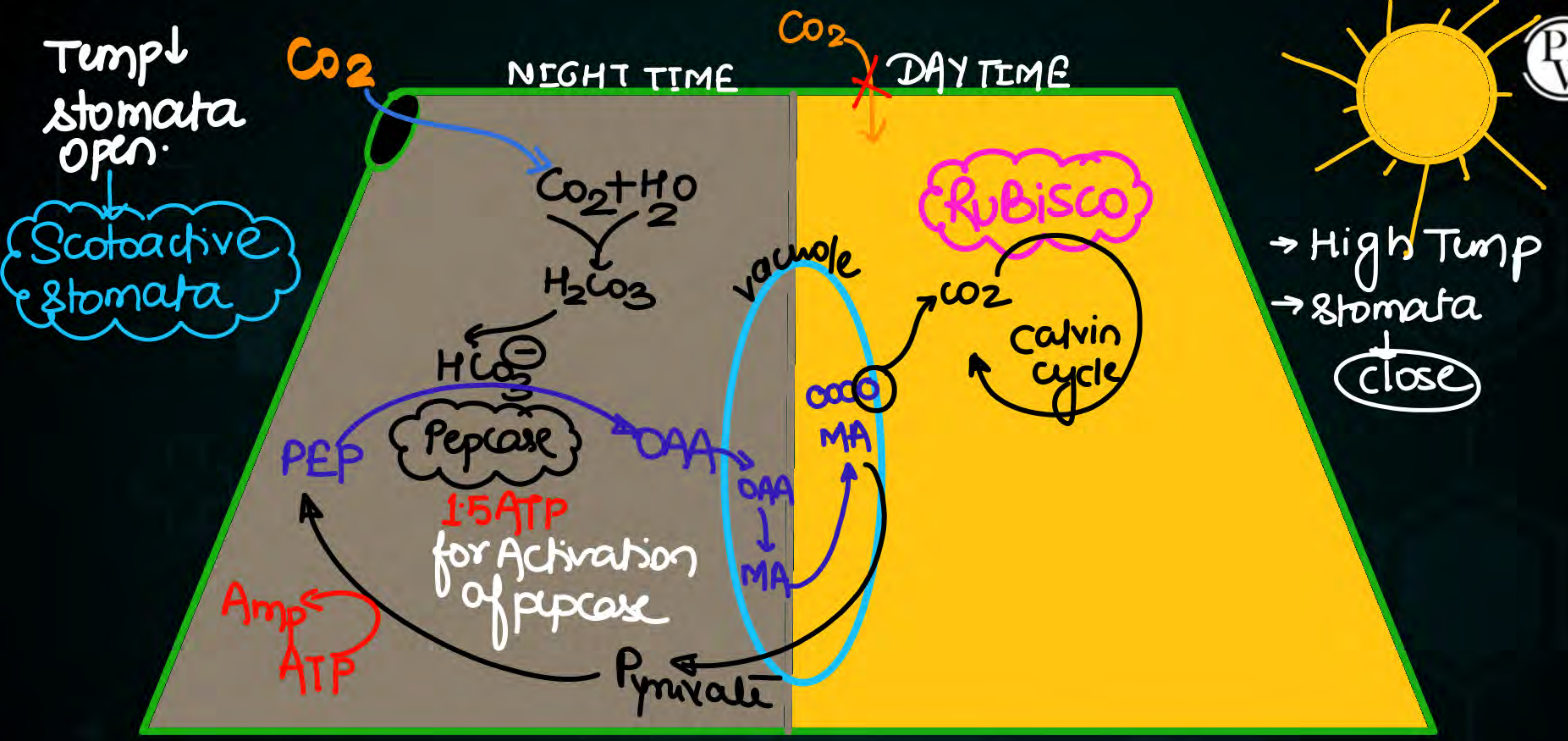
CAM

↓

Crassulacean Acid Metabolism

↓

Because this mechanism was first discovered in crassulaceae family.



Temp↓
stomata open.
Scotoactive stomata
CO_2
NIGHT TIME
CO_2
DAY TIME
$CO_2 + H_2O$
H_2CO_3
HCO_3^{-}
Pepcase
PEP
OAA
1.5 ATP
for Activation of pepcase
Amp
ATP
Pyruvate
vacuole
OAA
MA
MA
COO
CO_2
RuBisco
calvin cycle
→ High Temp
→ stomata
close

(A) → Rubisco or Calvin cycle never operate during night time

(1) Because Calvin cycle depends on product of Light reaction

(2) Rubisco is indirectly activated by sunlight

(Rubisco रात में काम नहीं करता)

C_3 plants

Mesophyll

Rubisco

↓

Calvin cycle

3ATP + 2 NADPH

for fixation of 1 CO_2 =

3ATP + 2NADPH

C_4 plants

M

Pepcase

2ATP

↓

for Reg of PEP

Bundlesheath.

Rubisco

↓

Calvin cycle

3ATP + 2NADPH

for fixation of 1 CO_2 =

5ATP + 2NADPH

CAM plants

Mesophyll

Pepcase

2ATP + 1.5ATP

Reg of PEP

Activation of Pepcase

Rubisco

↓

Calvin cycle

3ATP + 2NADPH

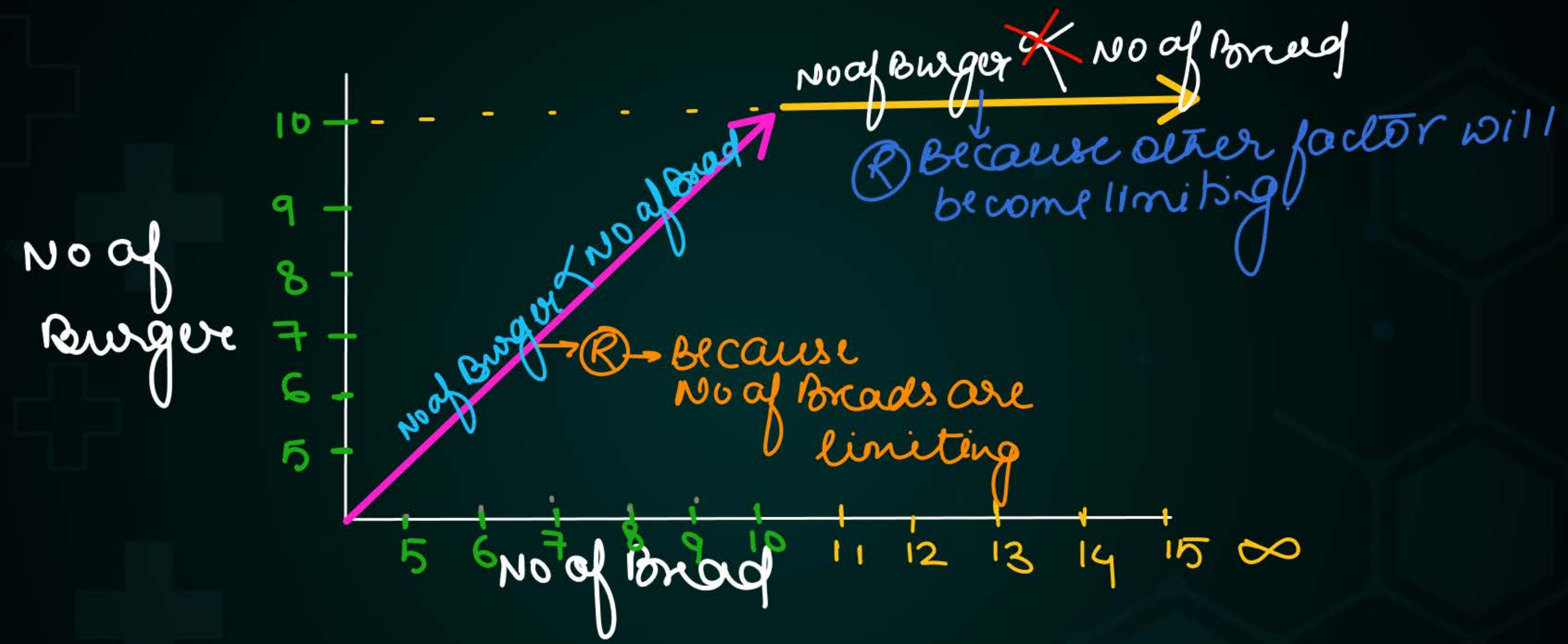
for fixation of 1 CO_2 = 6.5ATP + 2NADPH

	C_3 plants	C_4 plants	CAM plants
Rubisco present in	M	B	M
Calvin Cycle	M	B	M
Calvin Cycle Time	DAY	DAY	DAY
Type of Chloroplast	Monomorphic	Diamorphic	Monomorphic
Initial Co_2 Fixation cell	Mesophyll	Mesophyll	Mesophyll
Initial Co_2 Fixation Time	DAY	DAY	NIGHT

	C_3 plants	C_4 plants	CAM plants
CO_2 fixating enzyme	Rubisco.	I Pepcase F Rubisco	I pepcase F Rubisco
CO_2 fixating substrate	RuBP	I → PEP F → RuBP	I → PEP F → RuBP
H.W. CO_2 fixating product		I F	I F
Photorespiration	+++	Nil	+

$\longrightarrow$

Bread	Aloo	Cheese	Burger
1	1	1	1
5	5	5	5
5	10	15	5
5 → 6 → 8 → 10			5 → 6 → 8 → 10
10 ↓ 11 - 12 - 14			10 - 10 - 10 - 10


No of Burger ~~<~~ No of Bread
R Because other factor will become limiting
No of Burger
10
9
8
7
6
5
No of Burger < No of Bread
R Because No of Breads are limiting
5 6 7 8 9 10 11 12 13 14 15 ∞
No of Bread

Law of Limiting Factor

Blackman

If any chemical reaction is controlled by more than one factor ,Then rate of reaction is determined by the factor

↓

Which is nearest to its minimal value

↓

And that factor is called is limiting factor

* By changing concentration of limiting factor Rate of reaction will change

Photosynthesis is Controlled by

External factor

- Light
- Co_2
- H_2o
- Temp
- O_2

Internal factor

- Leaf
- Amount of Chlorophyll
- Internal Co_2 concentration
- Amount of mesophyll

NCERT

Internal factors

↓

depends on

Genetics | growth

इमली   आम

छोटा आम का पेड़   बड़ा आम का पेड़

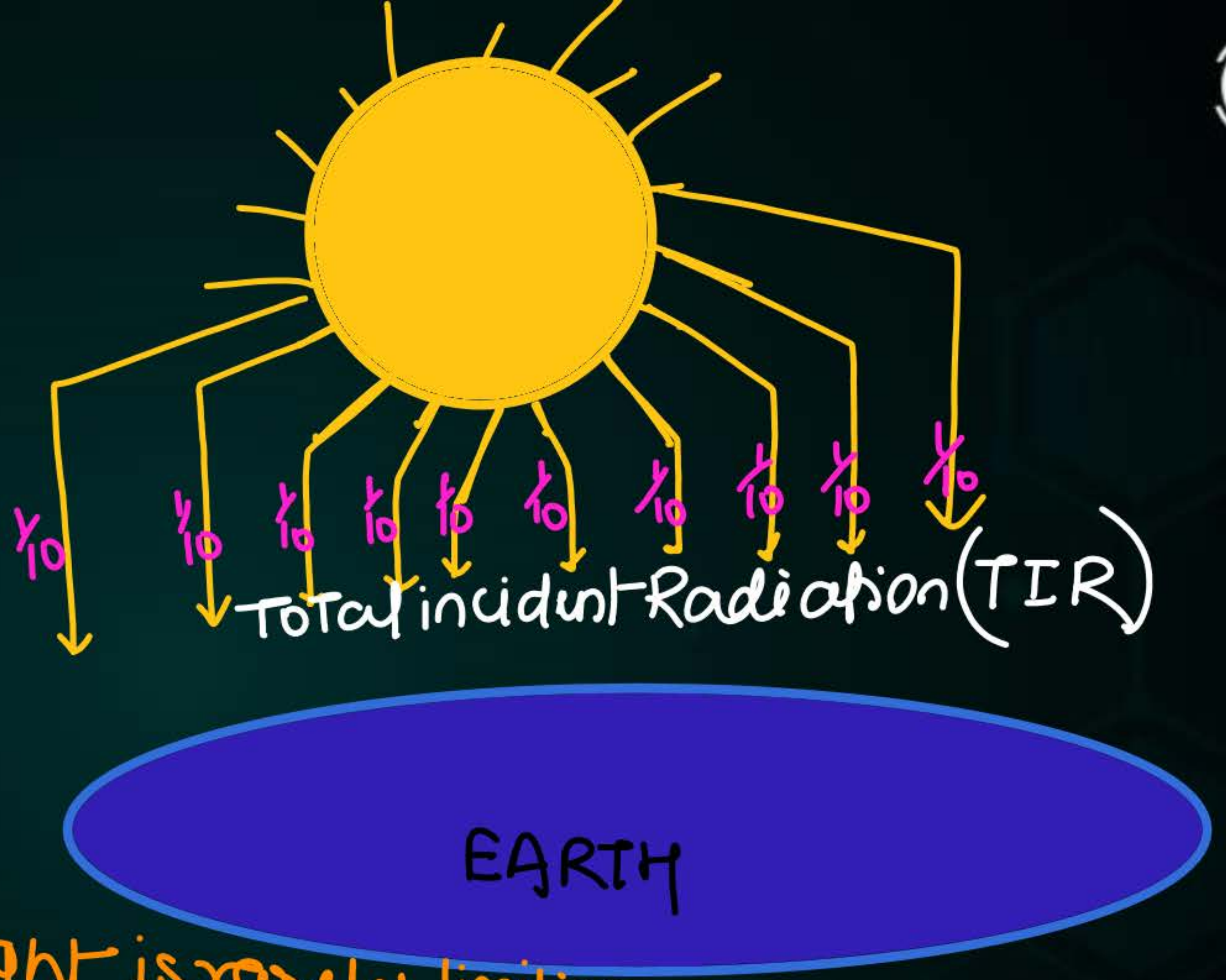
Light

Rarely limiting

except

In dense forest

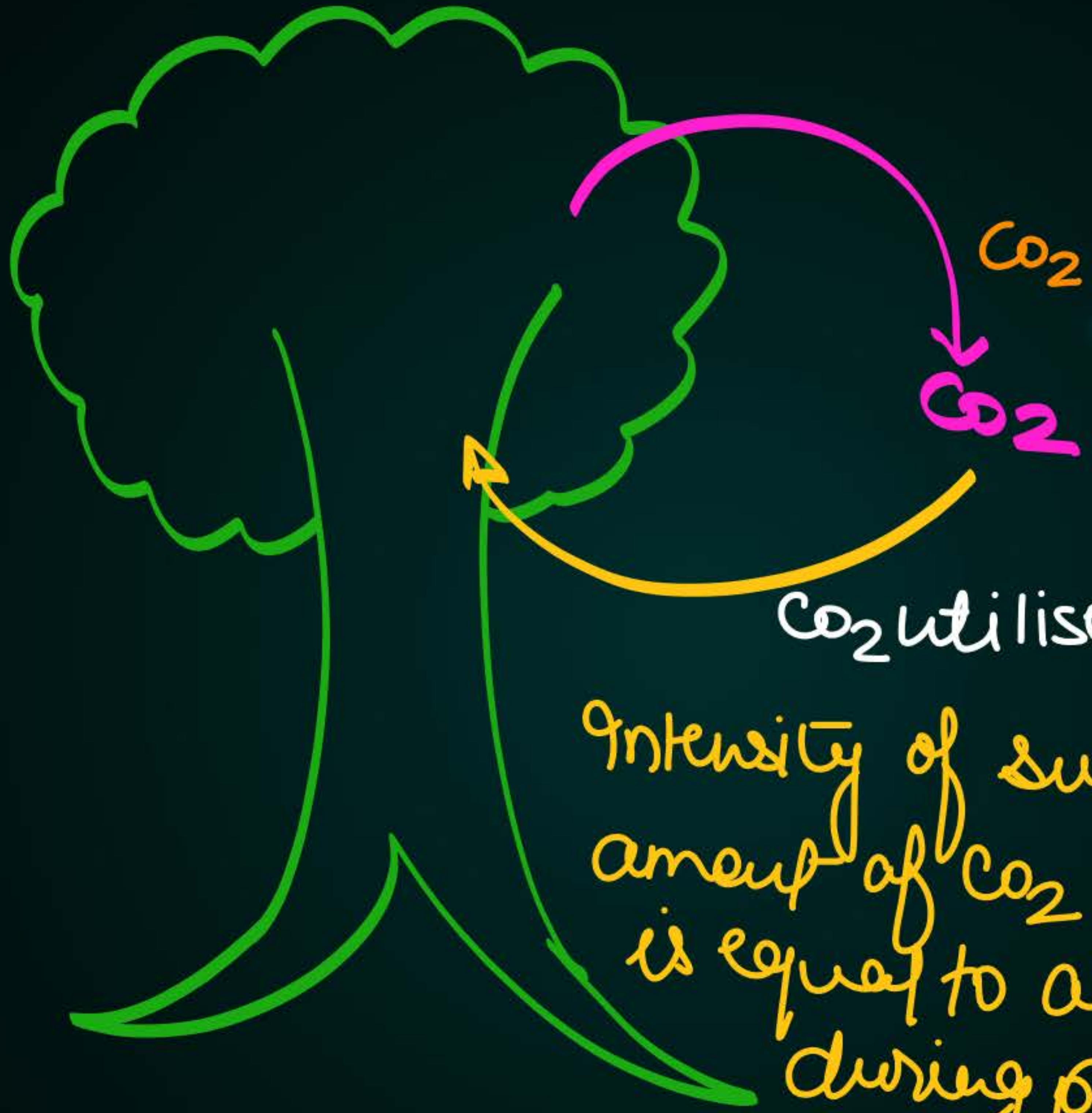
In deep ocean



(A) Sunlight is rarely limiting

(R) → Because all the plants will saturate on 1/10th of TIR

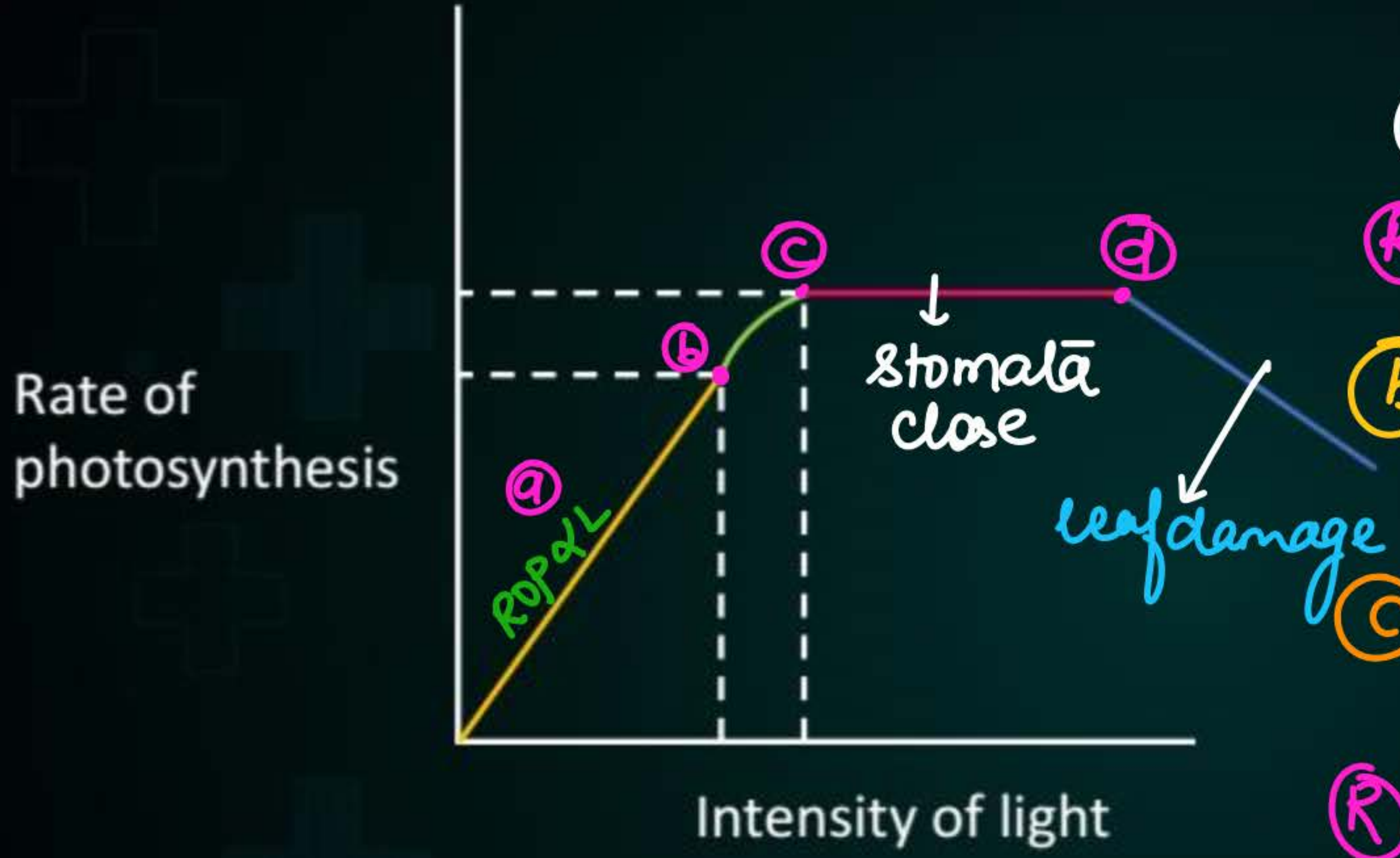
Time (Light intensity)	CO_2 Produced by Respiration (All day)	CO_2 Utilised by Photosynthesis
3 Am	100 unit	→ No sunlight → No photo
4 Am	100 unit	→ No CO_2 used
5 Am	100 unit	→ No CO_2 used
6 Am	100 unit	→ sunrise → CO_2 utilisation start 10 unit
8 Am	100 unit	→ 50 unit
10 Am	100 unit	→ 100 unit
12 Am	100 unit	→



CO_2 produced during Respiration

CO_2 utilised during photosynthesis

Intensity of sunlight at which amount of CO_2 produced by respiration is equal to amount of CO_2 utilised during photosynthesis.



a → ROP ∝ Intensity of sunlight

R → Because light is limiting factor

b Compensation point

$\boxed{R = P}$

c ROP $\cancel{\propto}$ Intensity of sunlight

light saturation point

R Because other factor will become limiting

d ROP $\propto \frac{1}{\text{Intensity of light}}$

R leaf & chlorophyll damage.

Light-Compensation point

Intensity of sunlight at which

$$\boxed{R = P}$$

Light-Saturation

ROP $\cancel{\propto}$ Intensity of sunlight

Because stomata will close

↓

CO_2 can not enters inside leaf

↓

so CO_2 will become limiting.

CO_2

Major limiting factor

Neet

Because present availability of CO_2 is very less in environment

CO_2 saturation point

$C_3 \longrightarrow$ 450ppm

$C_4 \longrightarrow$ 360ppm

0.03% —— 0.04% —— 0.05

0.03% ↓ 300ppm

0.04% ↓ 400ppm.

C_4 = 360ppm

C_3 = 450ppm

* present availability of CO_2 is sufficient for C_4 plants

* present availability is limiting for C_3 plants.

By increasing concentration of CO_2

↓

Both C_3 & C_4 plants shows ↑ in their productivity

upto 360ppm

↓

C_4 plants shows ↑ productivity

upto 450ppm

↓

C_3 plants will show ↑ in their productivity

★ Beyond these concentration CO_2 shows damaging effect on leaf → due to formation of excess acid.

NEET

→ CO_2 is a green house gas

↓

By ↑ concentration of green house gase

↓

significant productivity rise in C_3 plants

↓

That's why they are also green house crops.

eg Tomato & Bell pepar.

CO_2 Compensation Point

concentration of CO_2 at which

$\boxed{R = P}$

CO_2 produced during Respiration

CO_2 utilised during photosynthesis

CO_2 Compensation point

C_4 → 0-10ppm

C_3 → 25-100ppm

Temperature

Temperature directly affects enzyme kinetics.

low Temp → Enzyme inactive

very high temp → Enzyme denatured

Optimum temp → maximum enzyme activity

for C_3 plants

20-25°C

C_4 plants

30-45°C (High temp optimum)

At high temperature

low productivity in C_3 plants

Reason → Due to photorespiratory loss

High productivity in C_4 plants

Reason → No photorespi-ration & High temp optimum.

H_2O

↓

water is one of the substrate of photosynthesis

↓

Rarely limiting

↓

Because plant can only utilise 1% of total absorb water for photosynthesis.

If water stress develop

wilting of leaf → surface area ↓ → Transpiration ↓

stomata close → Transpiration ↓

Oxygen

$\downarrow$

$O_2 \uparrow$

$\downarrow$

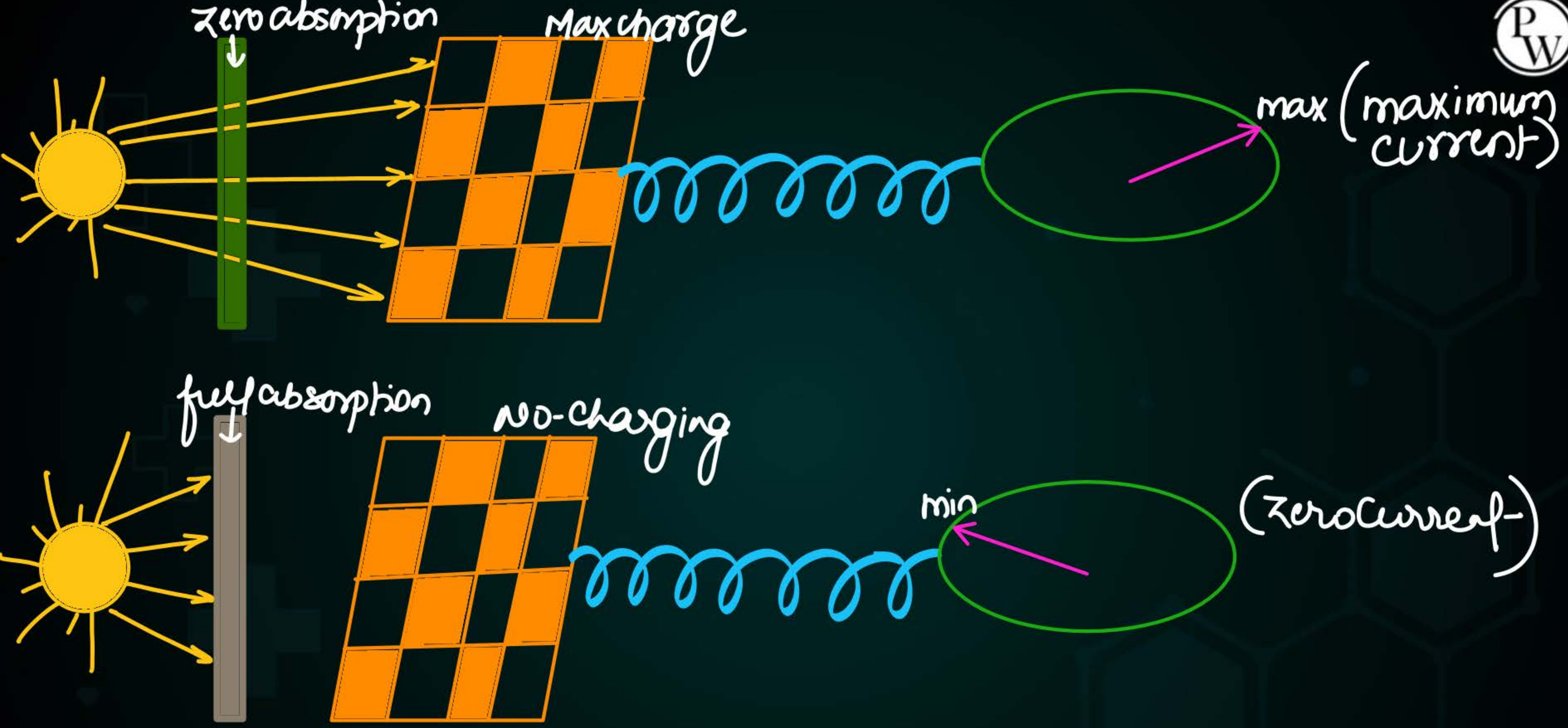
O_2 will Combine to Rubisco

$\downarrow$

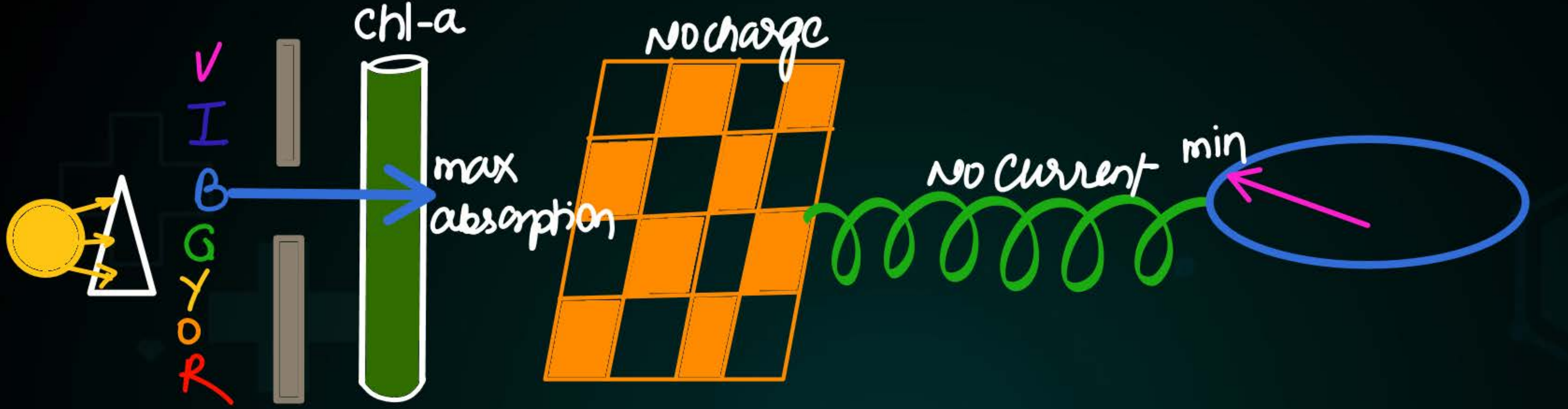
photorespiration

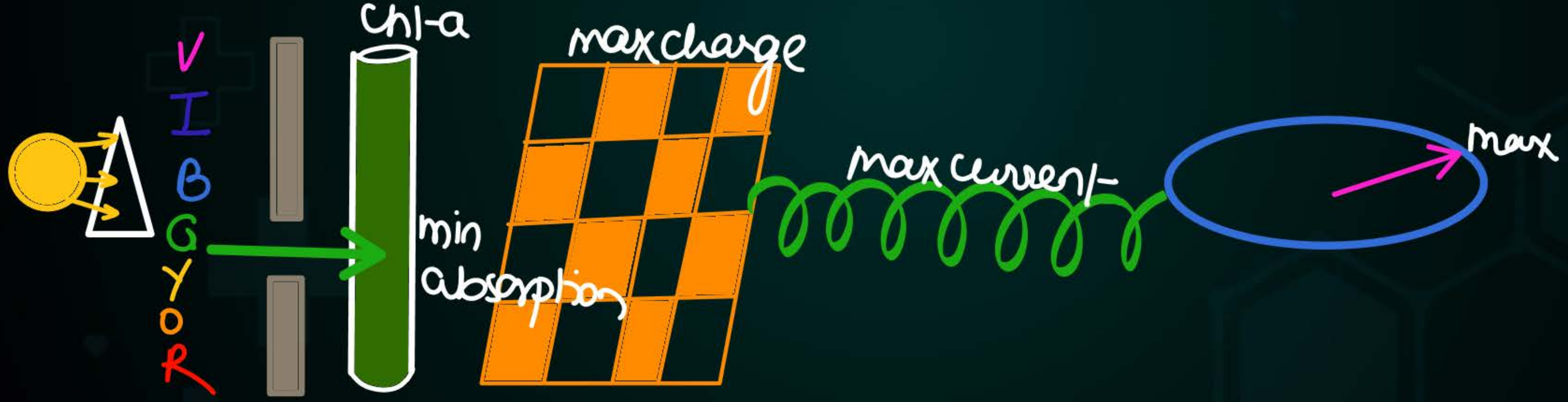
$\downarrow$

productivity $\downarrow$

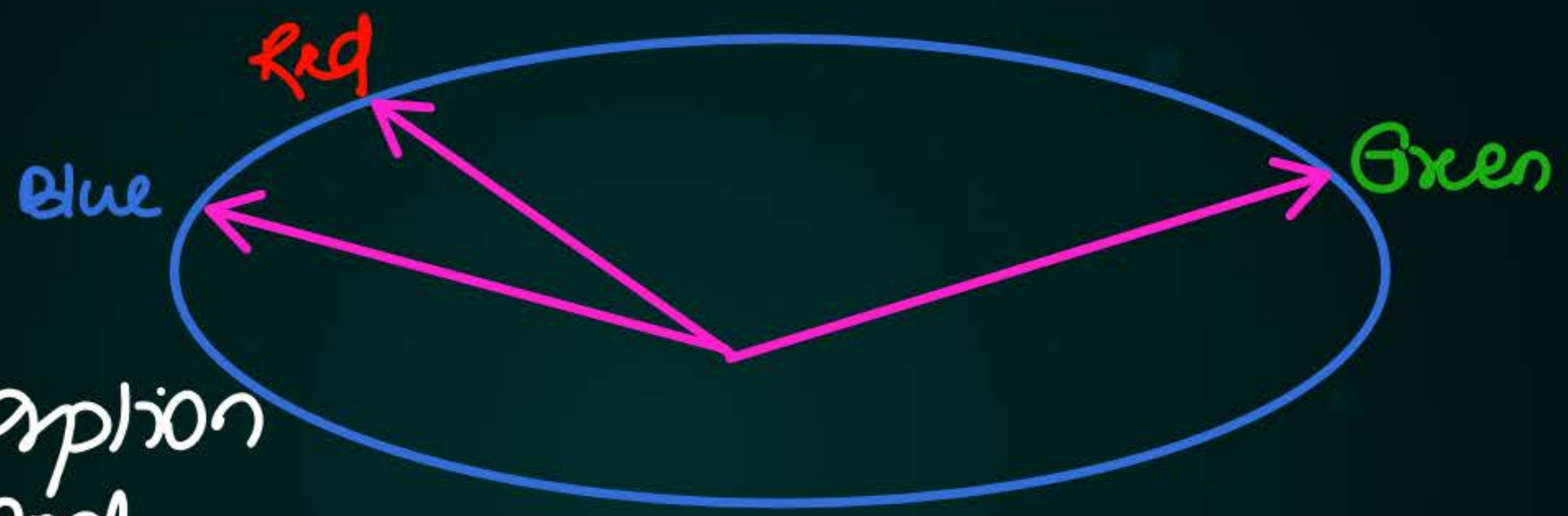


zero absorption
Max charge
max (maximum current)
full absorption
No-charging
min
(zero current)


V
I
B
G
Y
O
R
Chl-a
max absorption
No charge
No current
min


V
I
B
G
Y
O
R
Chl-a
min absorption
max charge
max current
max

chlorophyll a
↓
shows max absorption of blue than Red
&
min absorption of green light.



Spectro Photometer

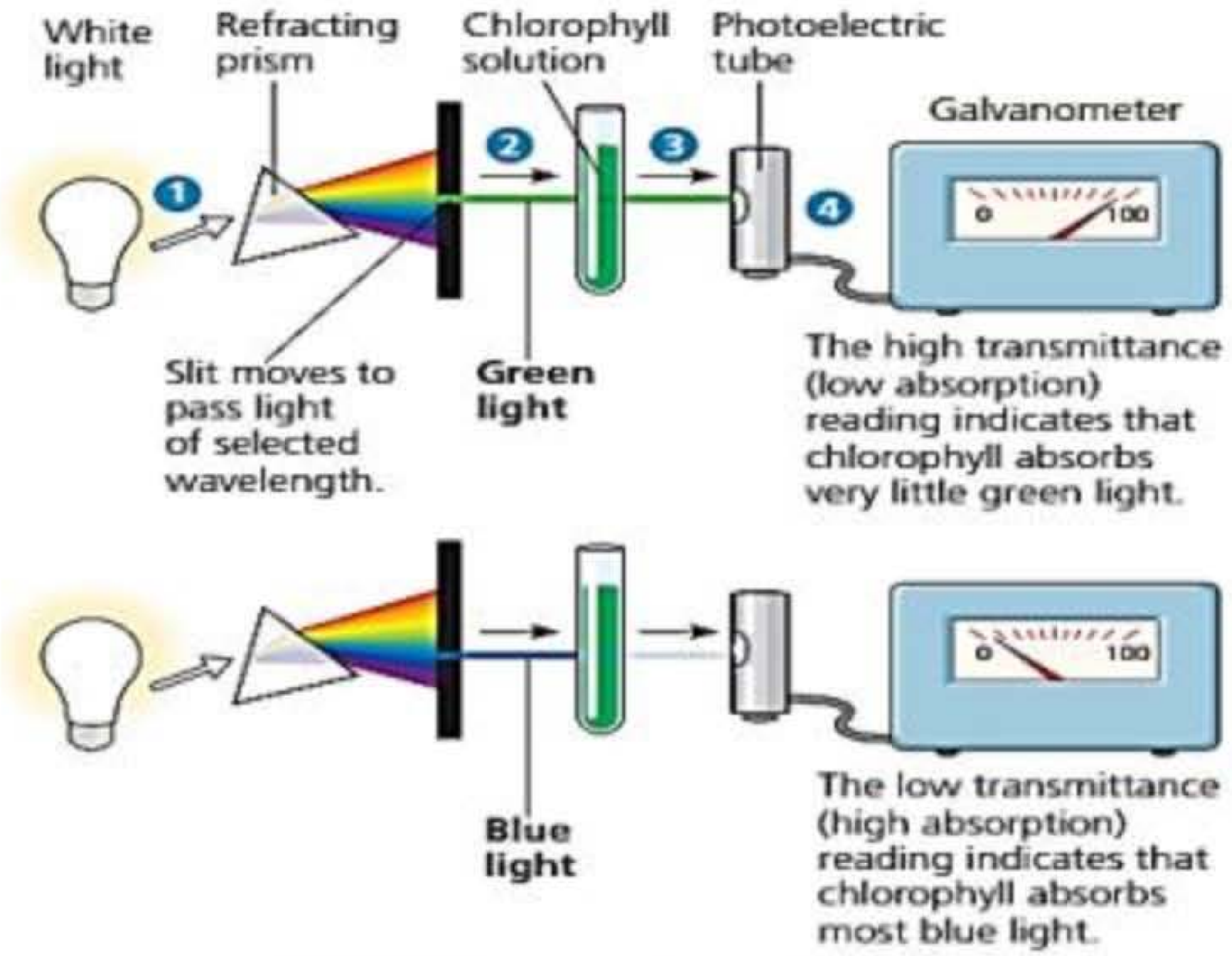
Chl-a absorption

Blue > Red >>> Green

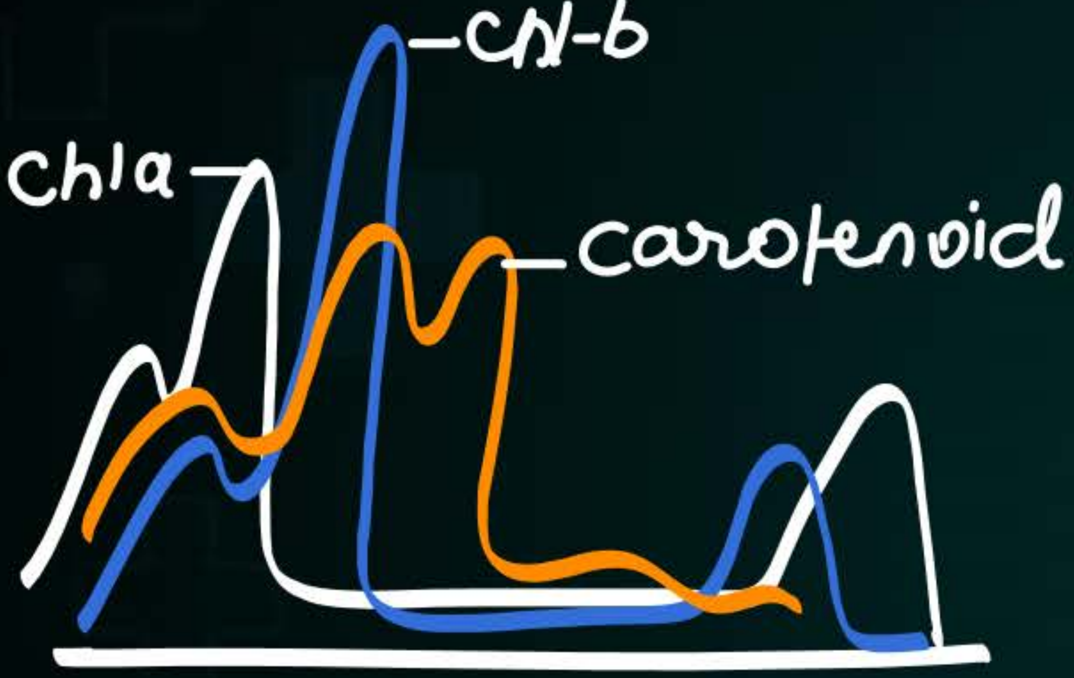
Application An absorption spectrum is a visual representation of how well a particular pigment absorbs different wavelengths of visible light. Absorption spectra of various chloroplast pigments help scientists decipher the role of each pigment in a plant.

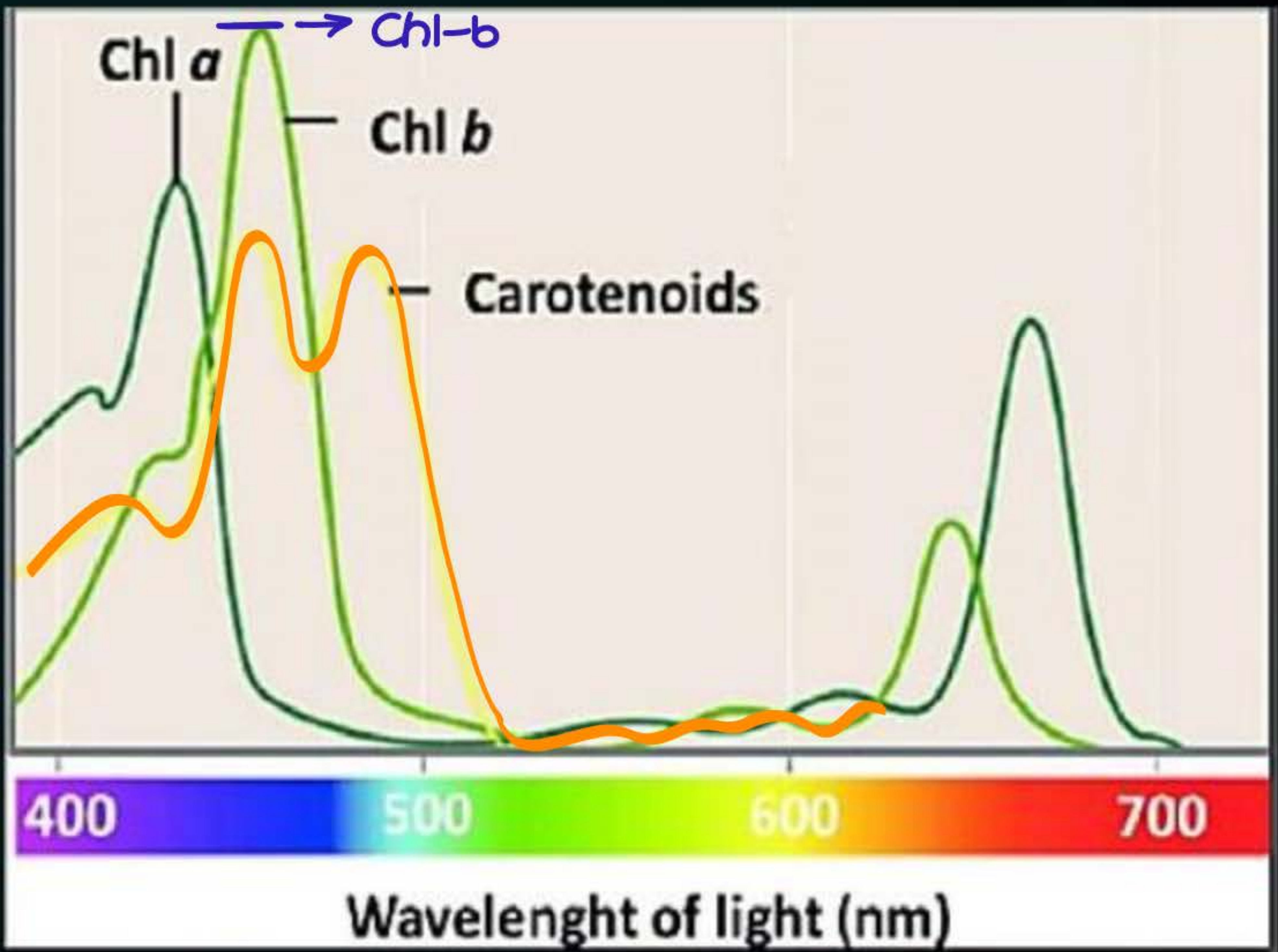
Technique A spectrophotometer measures the relative amounts of light of different wavelengths absorbed and transmitted by a pigment solution.

1. White light is separated into colors (wavelengths) by a prism.
2. One by one, the different colors of light are passed through the sample (chlorophyll in this example). Green light and blue light are shown here.
3. The transmitted light strikes a photoelectric tube, which converts the light energy to electricity.
4. The electric current is measured by a galvanometer. The meter indicates the fraction of light transmitted through the sample, from which we can determine the amount of light absorbed.

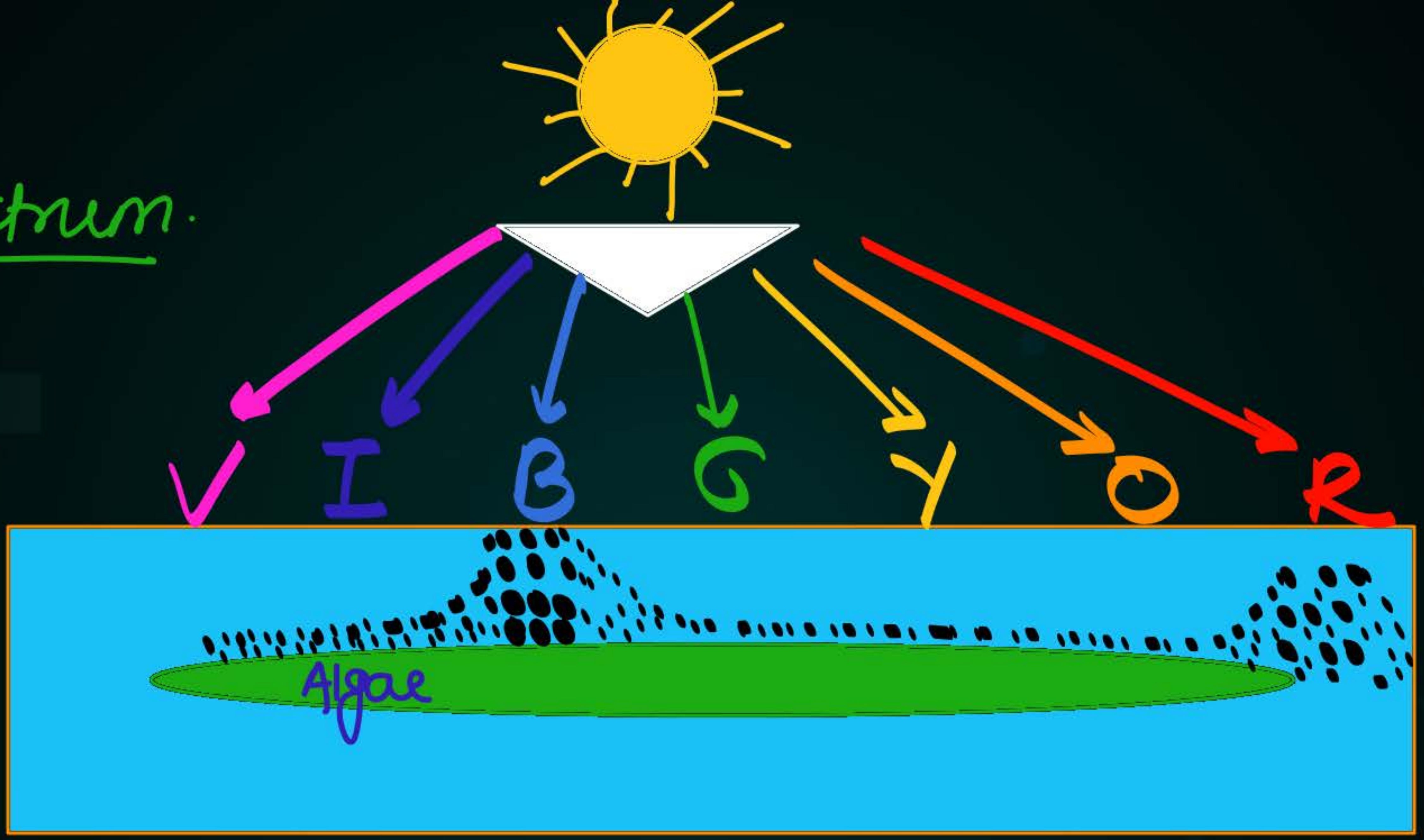


Absorption Spectrum



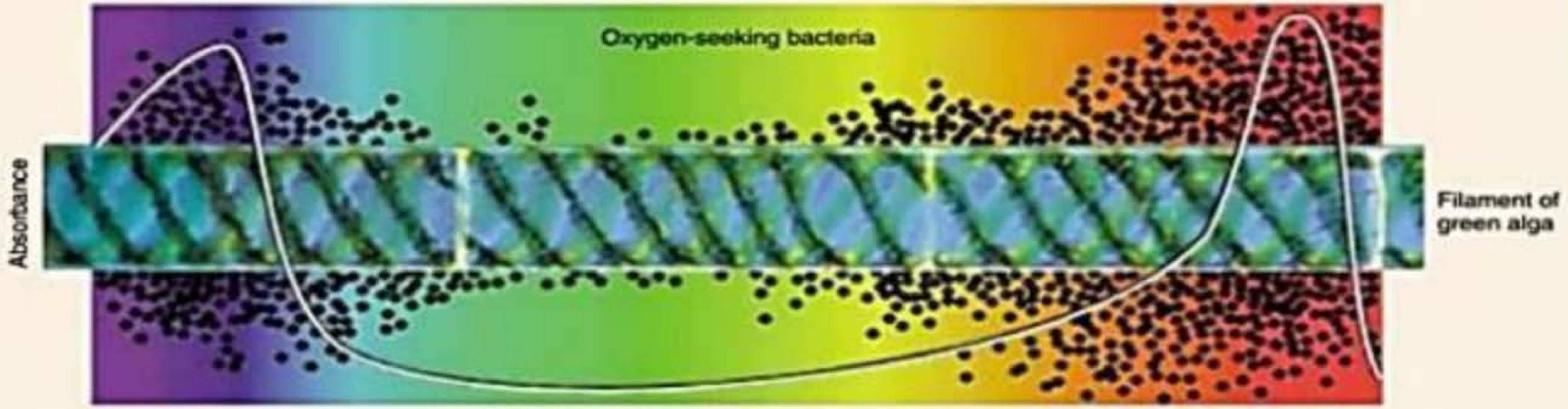


Action spectrum.

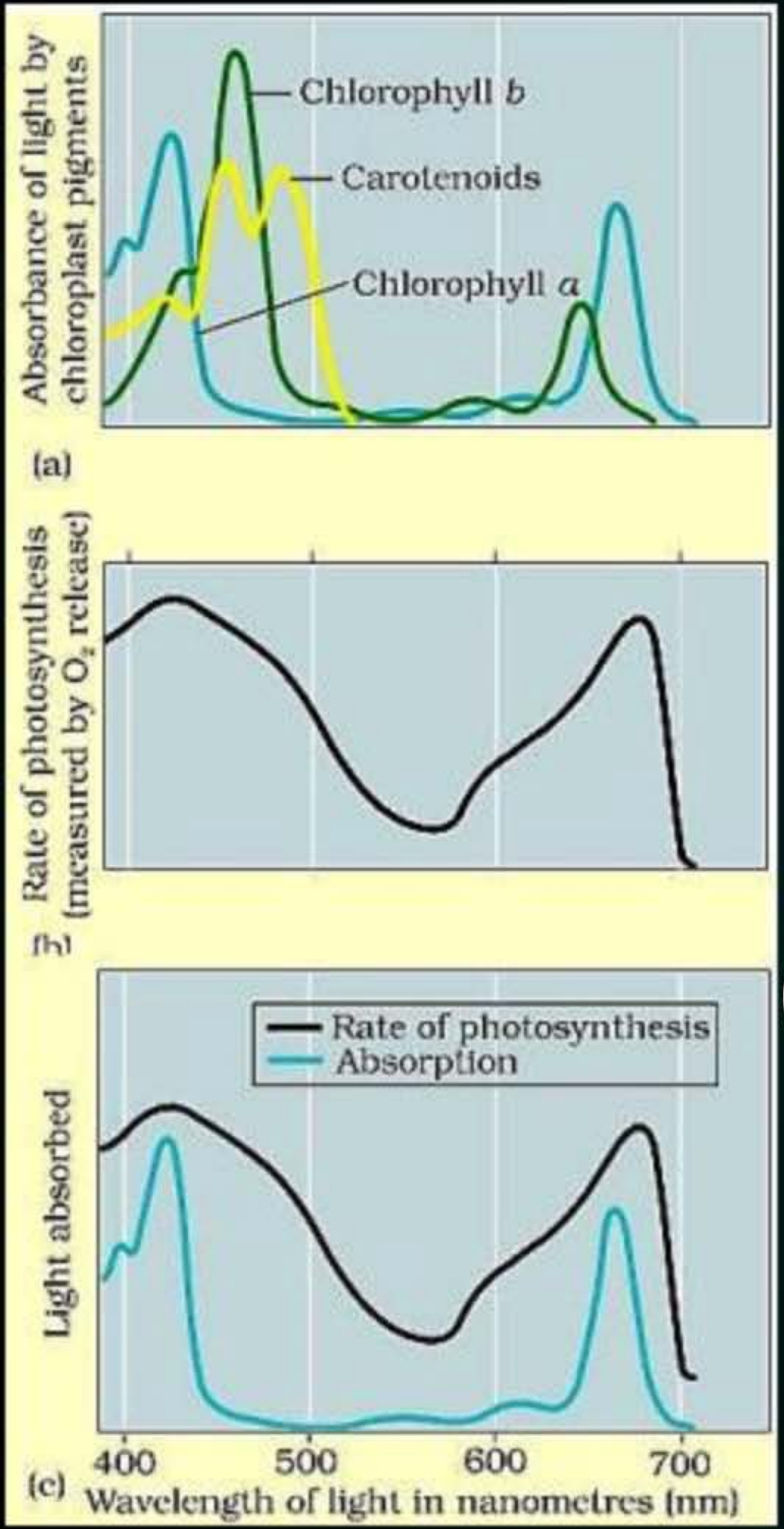


Action Spectrum

T.W. Engelman.



T.W. Englemann revealed the action spectrum of photosynthesis in the filamentous alga *Spirogyra* in 1882. Englemann used the rate of oxygen production to measure the rate of photosynthesis. As his oxygen indicator, he chose bacteria that are attracted by oxygen. In place of the mirror and diaphragm usually used to illuminate objects under view in his microscope, he substituted a "microspectral apparatus," which, as its name implies, produced a tiny spectrum of colors that it projected upon the slide under the microscope. Then he arranged a filament of algal cells parallel to the spread of the spectrum. The oxygen-seeking bacteria congregated mostly in the areas where the violet and red wavelengths fell upon the algal filament.



(A) → Action spectrum of photosynthesis is similar to absorption spectrum of Chl-a

(R) → Chl-a is the main photosynthetic pigment

(A) → But action spectrum of photosynthesis is not 100% identical to absorption spectrum of Chla

(R) → Due to presence of accessary pigment Chl-b, carotenoid.

Role of Accessory pigment

Neet

① Protection of chl-a from photooxidative damage

② Transfer absorb energy to reaction center

③ Enhance Action spectrum of photosynthesis

Pigments

- Main photosynthetic pigment
  - Chlorophyll a
    - नीला-हरा
    - blue-green
- Accessory pigment
  - Chlorophyll-b
    - पीला हरा
    - yellow-green
  - Carotenoid
    - Xanthophyll
      - Yellow
    - Carotene
      - Yellow-orange

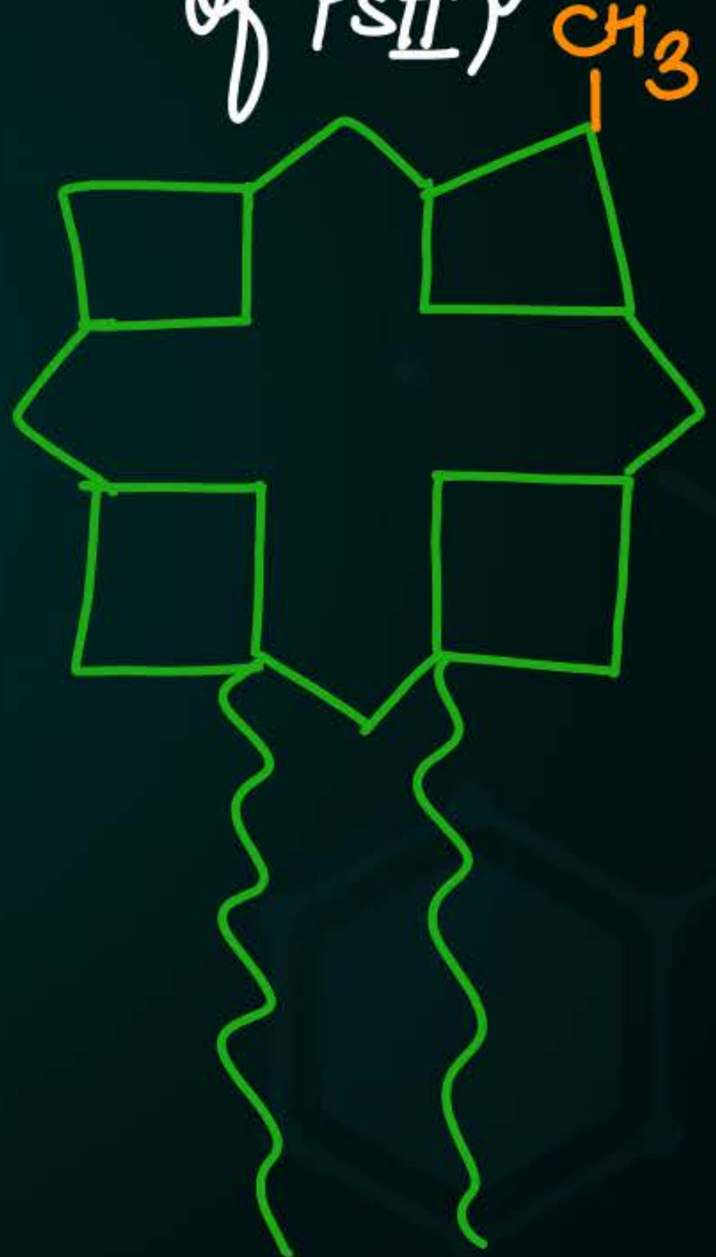
Chl-a

Chl-b

Molecular wt of

Chl-a $<$ Chl-b

Chl-a $\xrightarrow{-Mg^{+2}}$ pheophytin (primary e^- acceptor of PS_{II})



Early experiments

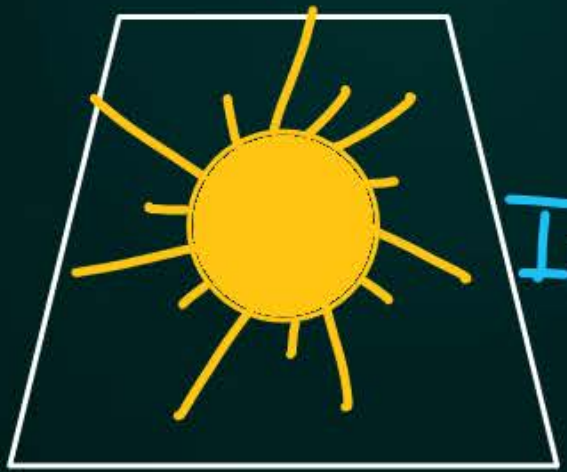
$$CO_2 + H_2O \longrightarrow C_6H_{12}O_6 + O_2$$

CO_2 → Moll's half leaf exp.

H_2O → Von Neil's experiment

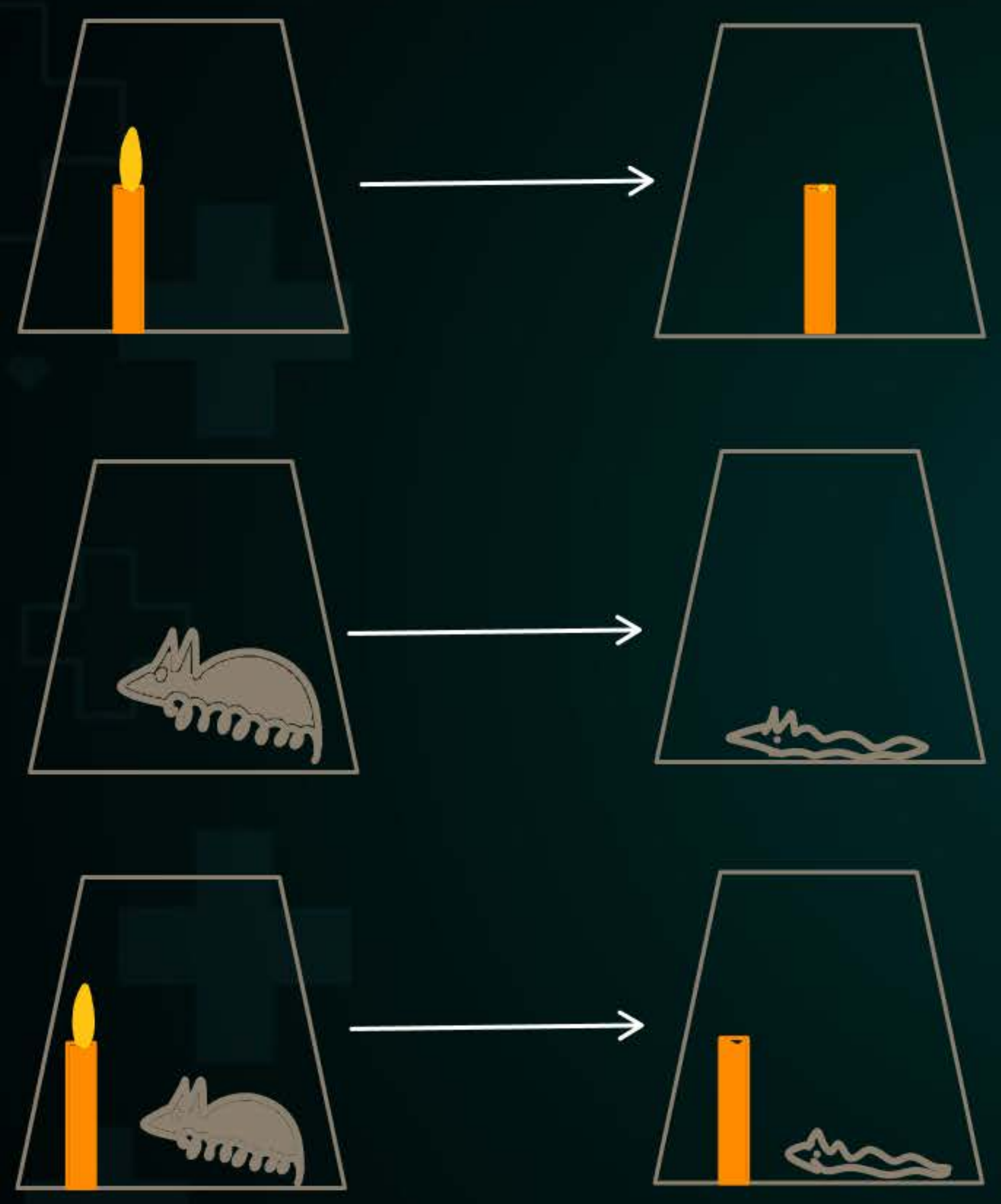
$C_6H_{12}O_6$ → sugar → Von-Sac

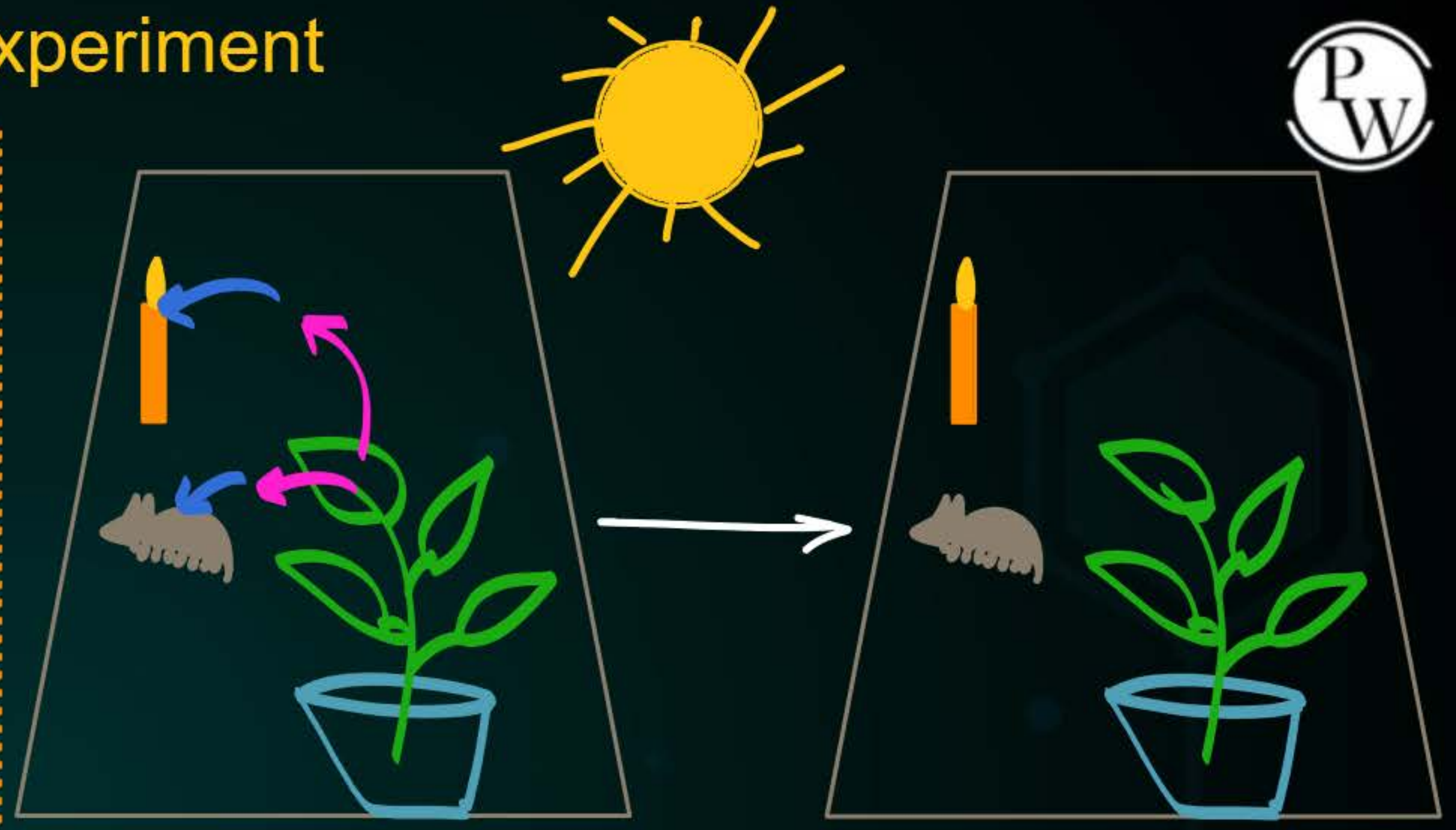
O_2 → Pristley



Ingenhouse

Priestley experiment

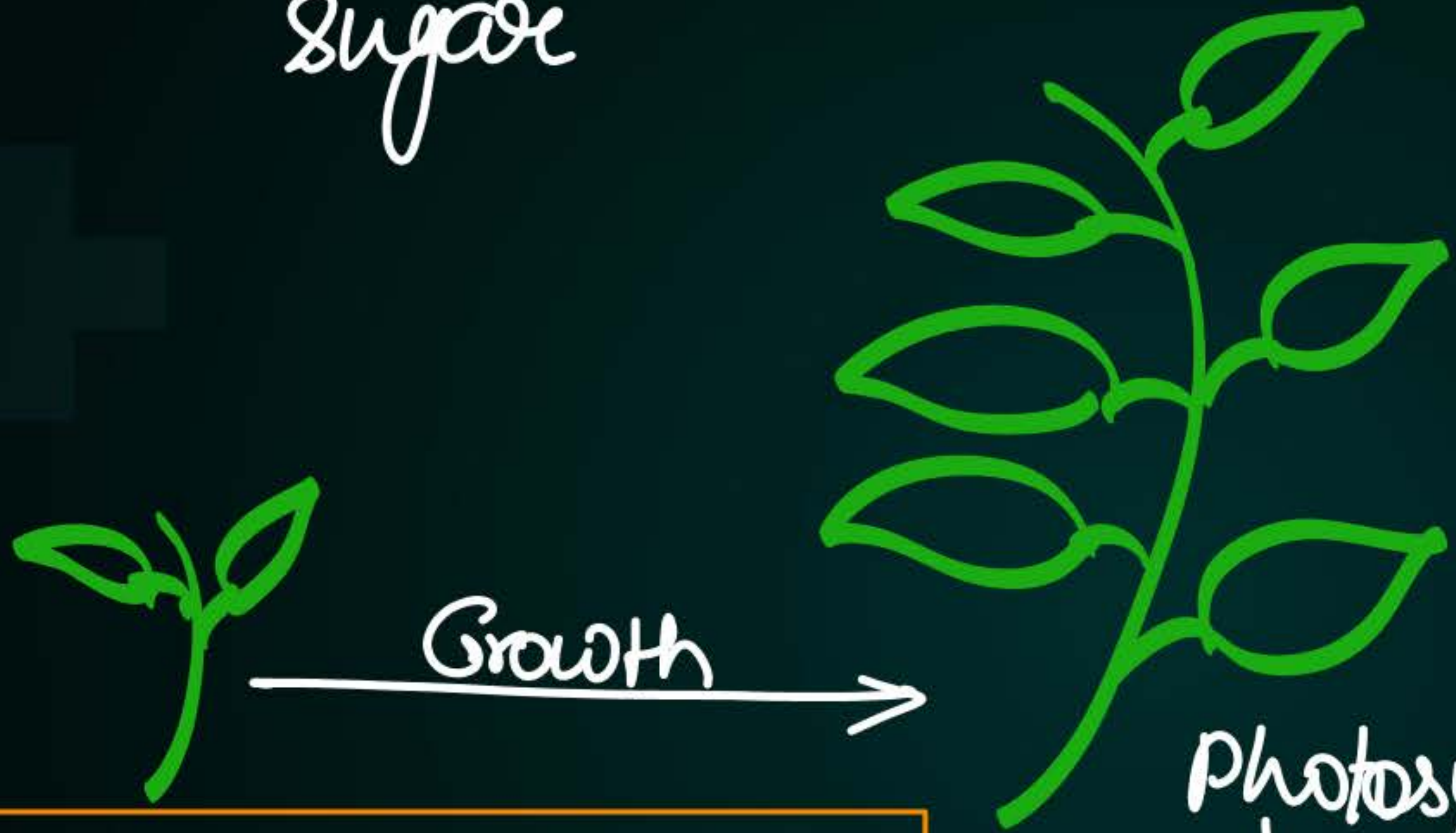




*→ Component of air which was removed by burning & Respirati[on] is restored by plants.

Von sac experiment

sugar



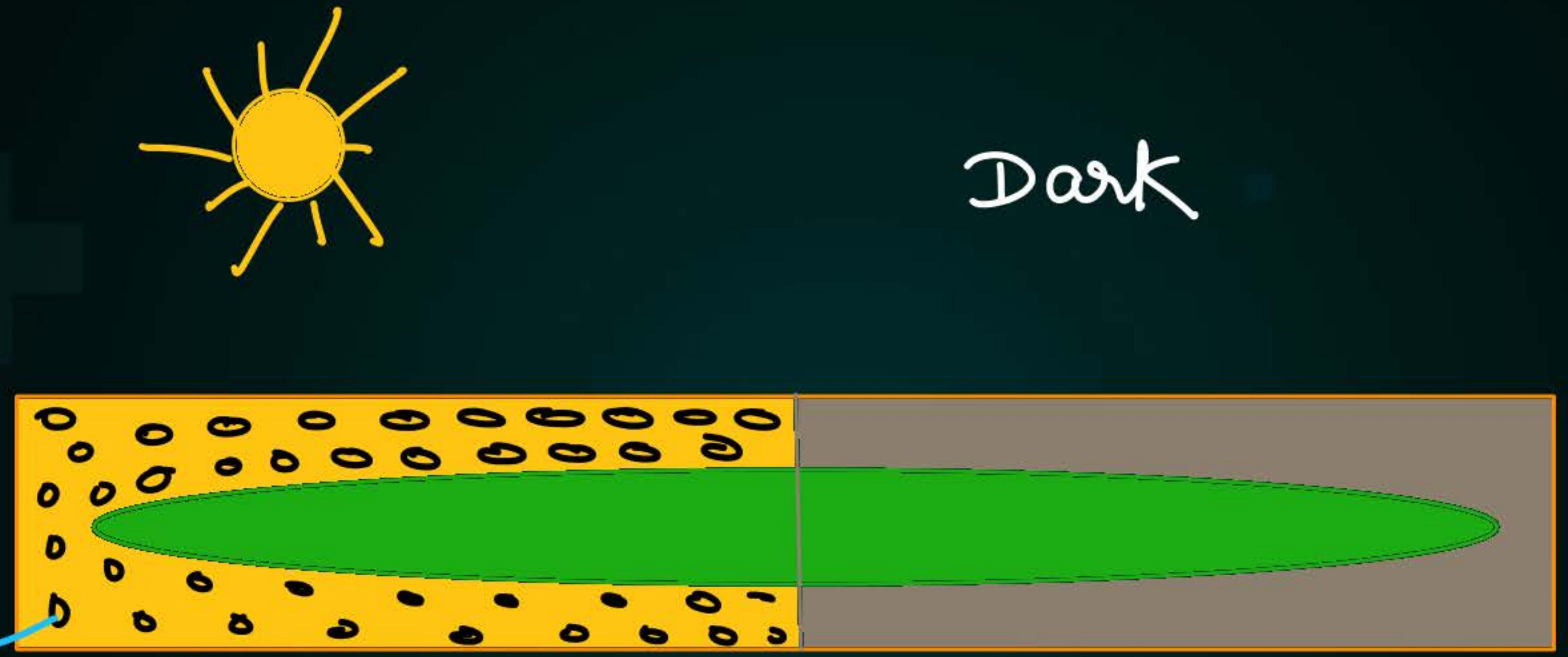
$\boxed{\text{Amount of sugar} \propto \text{Growth}}$

Photosynthesis will ↑

↓

sugar Amount will also ↑

Ingenhouse Experiment



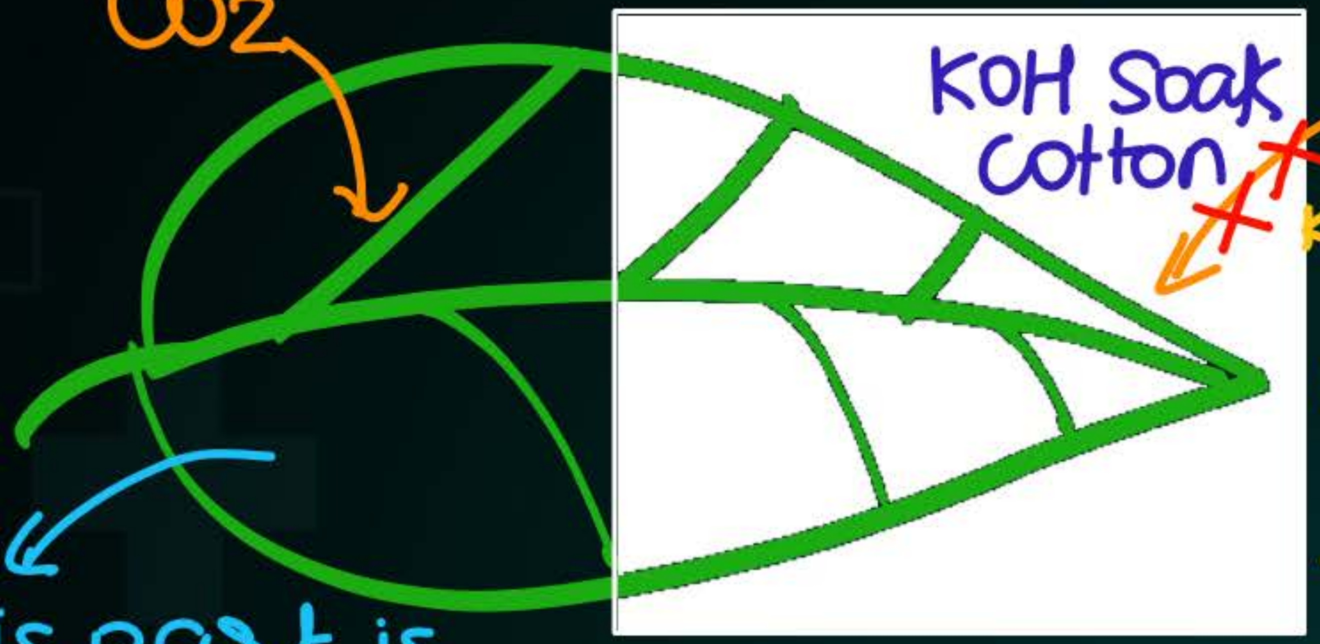
* Bubbles of O_2 were + on illuminated area

↓

Light is necessary for photosynthesis.

Moll's half leaf experiment (A/R Qus)

CO_2



CO_2

KOH absorb CO_2

↓

CO_2 can not reach to leaf.

↓

This half part of leaf will be Treated with Iodine

↓

No colour

↓

starch absent so no colour with I_2

↓

photosynthesis (ab)

This part is also treated $\bar{c}$ Iodine

↓

blue colour

↓

Starch $+ I_2 \rightarrow$ Blue colour.

↓

photosynthesis (P)

★ → CO_2 is necessary for photosynthesis

Von Neil's experiment

Before Von Neil

Rean of photosynthesis

$$6CO_{2(g)} + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_{2(g)}$$

Von Neil was working sulphur bacteria

Perform Non oxygenic photosynth

$$\cancel{6CO_2} + 6H_2S \longrightarrow \cancel{C_6H_{12}O_6} + 6S_2$$

$$\cancel{6CO_{2(g)}} + 6H_2O \longrightarrow \cancel{C_6H_{12}O_6} + 6O_{2(g)}$$

Von neil concluded → oxygen comes from water

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

No of O_2 atoms $= 6$

No of Oxygen atoms $= 12$

$+ 6H_2O$ (von Neil's modification)

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

Photosynthesis is Redox Reaction

H_2O

oxidation number of oxygen in water $= -2$

O_2

oxidation number of oxygen in oxygen molecule $= 0$

↑ON = oxidation

CO_2

Calvin cycle

1. Carboxylation
2. Reduction
3. Regeneration.

oxygenic photosynthesis	nonoxygenic photosynthesis
↓	↓
O_2 production ⊕	O_2 production ab
↓	↓
photolysis of water ⊕	photolysis of water ab
↓	↓
PSII ⊕	PSII ab
↓	↓
Chl a present	Chl a ab
	Bacteriochlorophyll ⊕
H_2 donar → H_2O	H_2 donar → H_2S
eg → BGA, Algae, plants	eg Sulphur Bacteria.