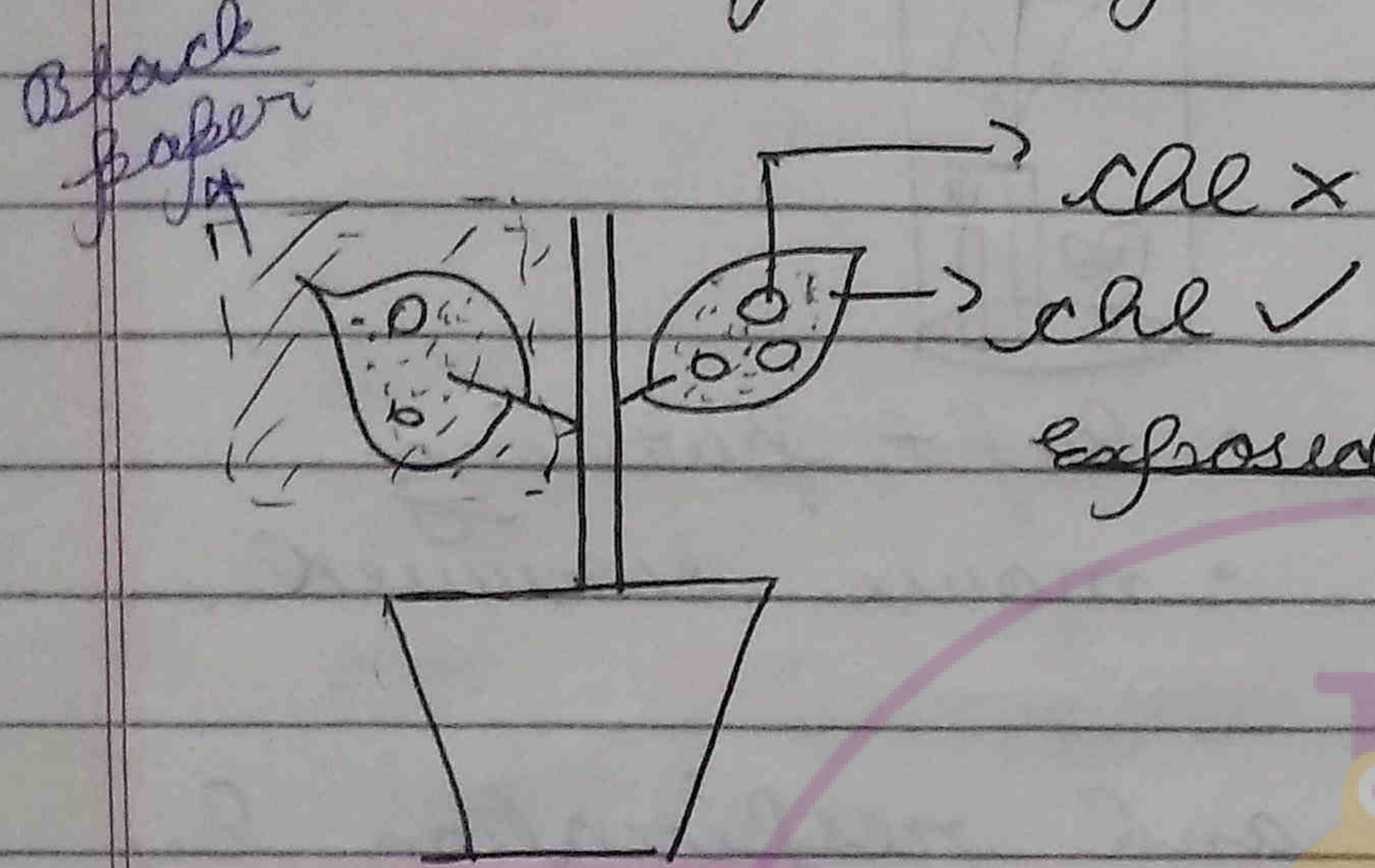
Handwritten Notes

on

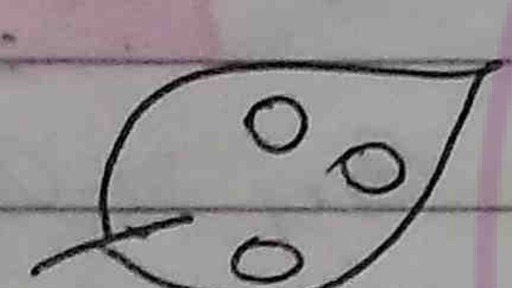
Photosynthesis

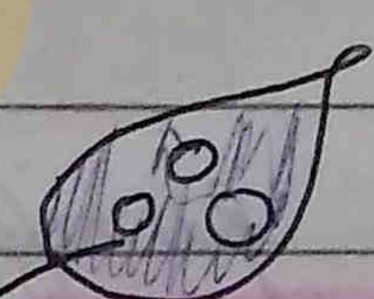
Photosynthesis

a Chlorophyll, light → photosynthesis



Exposed 1-2 hr → - plucked leaves
- starch tested
- I_2 solution
- Blue colour



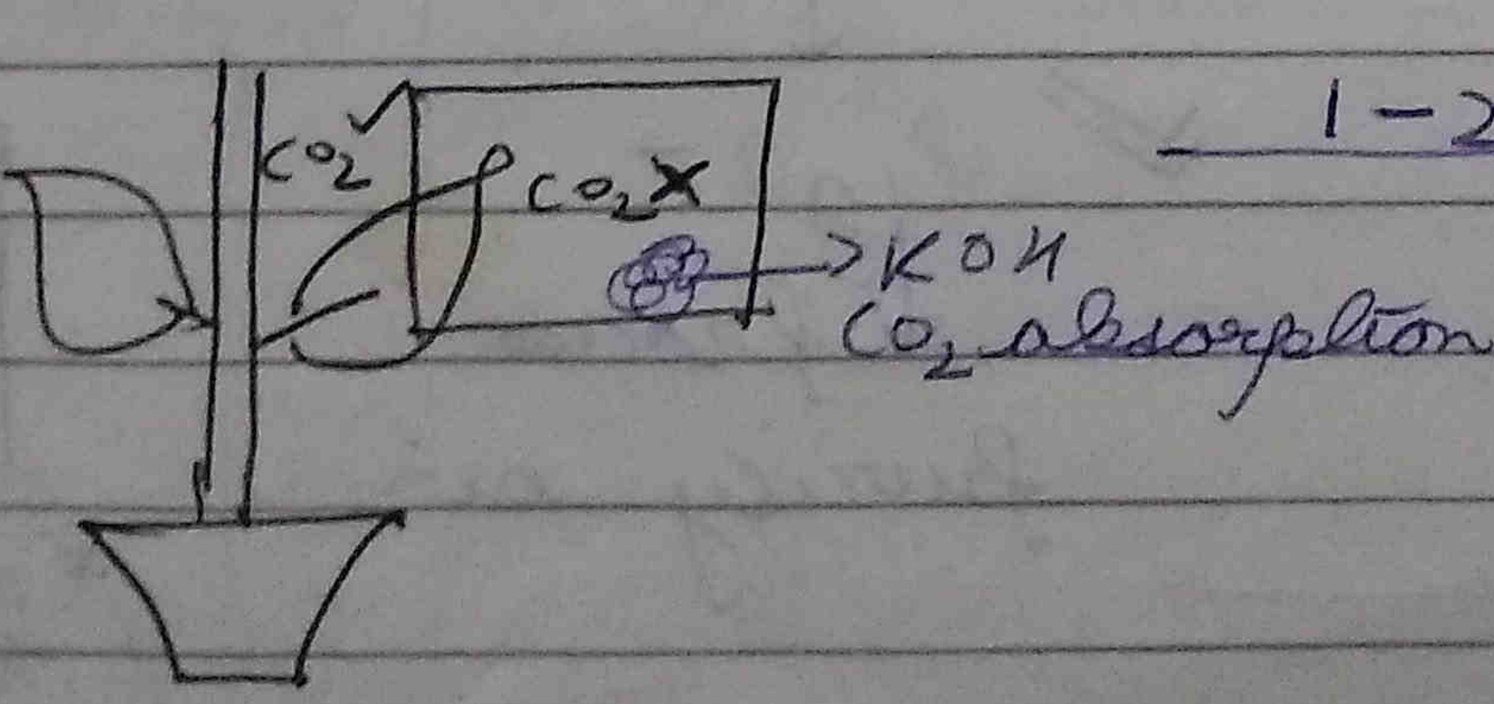


- covered leaf
- Blue colour - nt
⇒ Light is essential

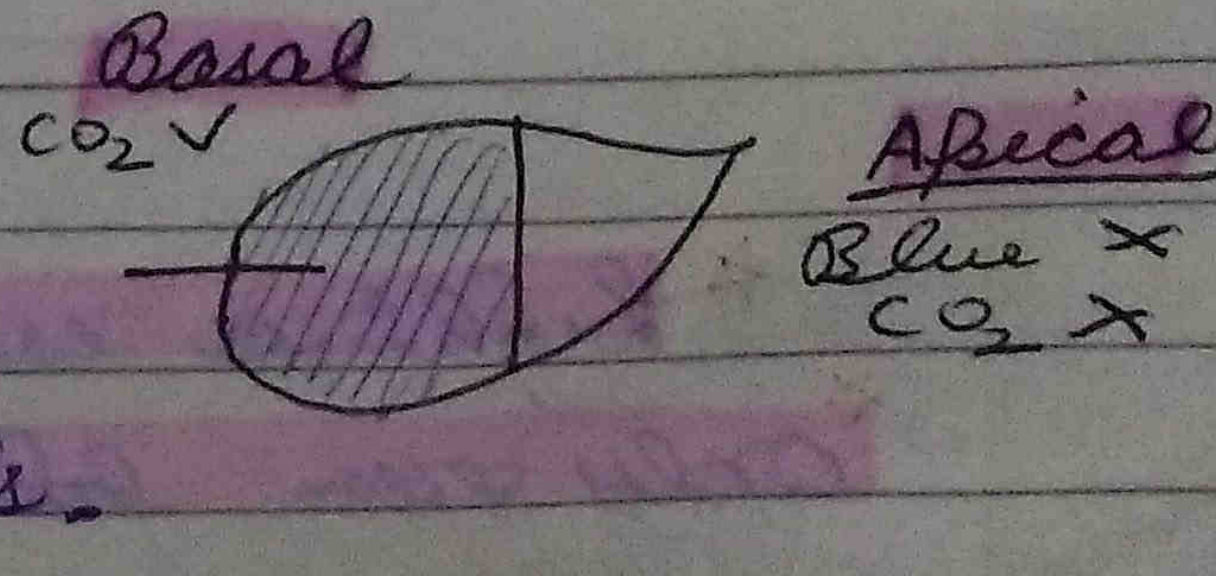
Exposed leaf
↓ ↓
Blue ×
Green area yellow area

⇒ Chlorophyll is essential

b Moll's Half leaf Experiment

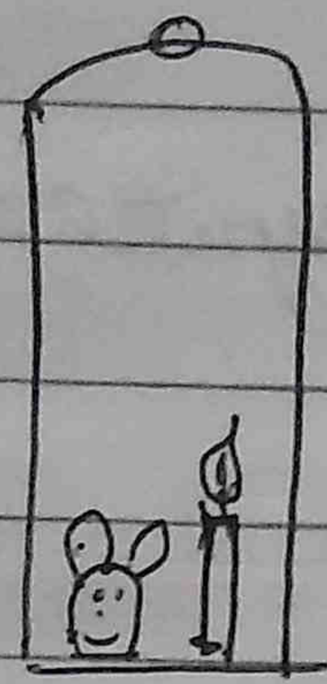


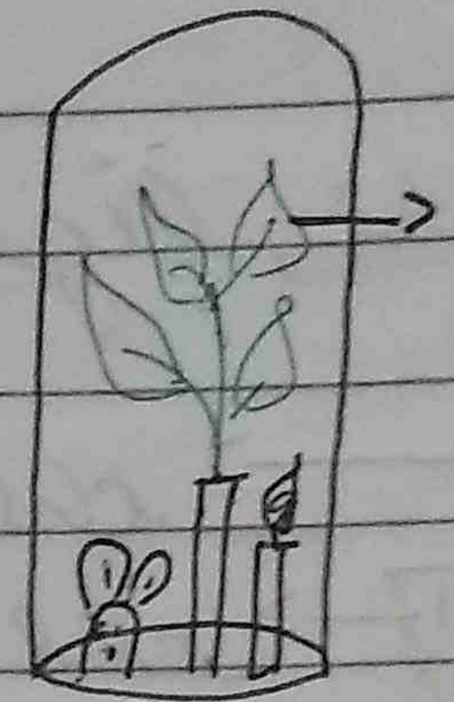
1-2 hr → • Removed
• Tested starch
• I_2 solution



proves that
⇒ CO_2 is essential for plants.

Joseph Priestly





→ mint plant

- candle extinguished
- mouse died

- kept burning
- mouse survived

- Burning of candle and respiration by mouse produce foul air (Phlogiston) ↓ CO_2
- which is purified by plants by releasing (Dephlogiston) ‖ O_2 (discovered by J. P in 1774)

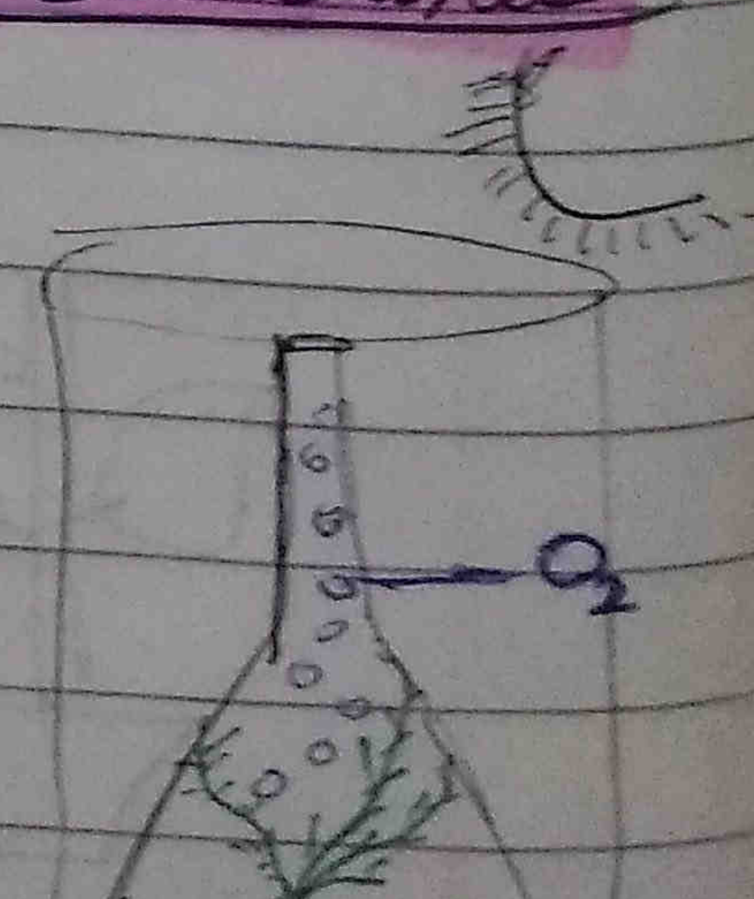
Jan Ingenhousz

↓

Similar Setup

- Dark
- ✓ Light ↓ process purify air

H_2O Plants



⇒ * Light is essential for process which purifies air.

⇒ * Only green ~~plan~~ parts of plants produce O_2

- Julis von Sach

- Plant produce glucose from green parts which is mainly stored in the form of starch.

- Empirical equation of Photosynthesis

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

- Three experiments showed → O_2 is contributed by splitting of H_2O
  - → Van Niel → Sulphur Bacteria
  - → Robert Hill → Stellaria (Angio-plant)
  - → Ruben → Chlorella

- Van Niel
- S- Bacteria

$CO_2 + 2H_2S \longrightarrow (CH_2O) + 2S + H_2O$ O_2 ×

Anoxygenic photosynthesis

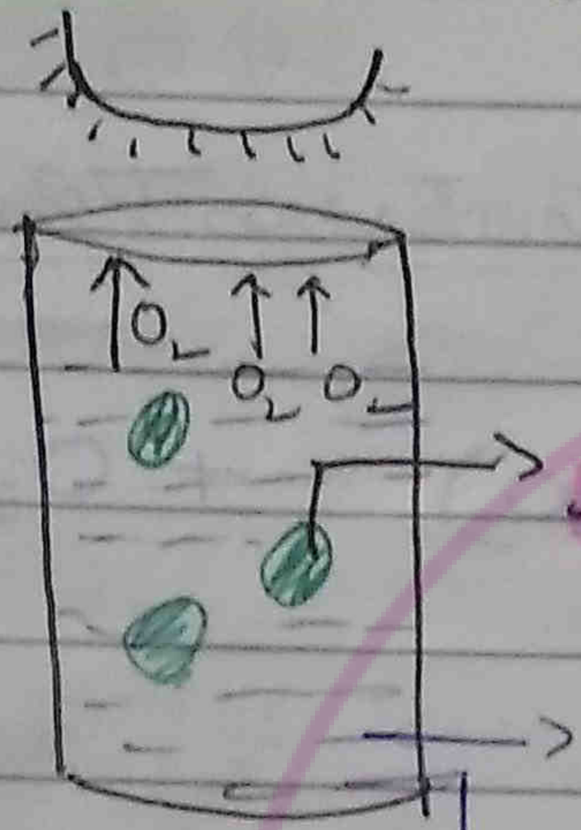
- Plant

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

DCPIP : Dichlorophenolindophenol.

☆ Blue Green Alga (BGA) / Cyanobacteria perform Oxygenic Photosynthesis
e.g Spirullina

• **Robert Hill**



→ chloroplast of Stellaria

→ H_2O ✓

CO_2 ✗

CO_2 absent in medium but still O_2 is released

→ Hydrogen acceptors

$2H_2O$
↓
$4e^-$ + $4H^+$ + O_2

- Benzoquinones
- Chromates
- Ferricynades
- DCPIP

} Hill Oxidants (Artificial)

DCPIP → Oxidised, Blue (placed in beaker) —($+e^-$)→ Reduced, colourless

☆ Natural oxidant. $NaDP^+$

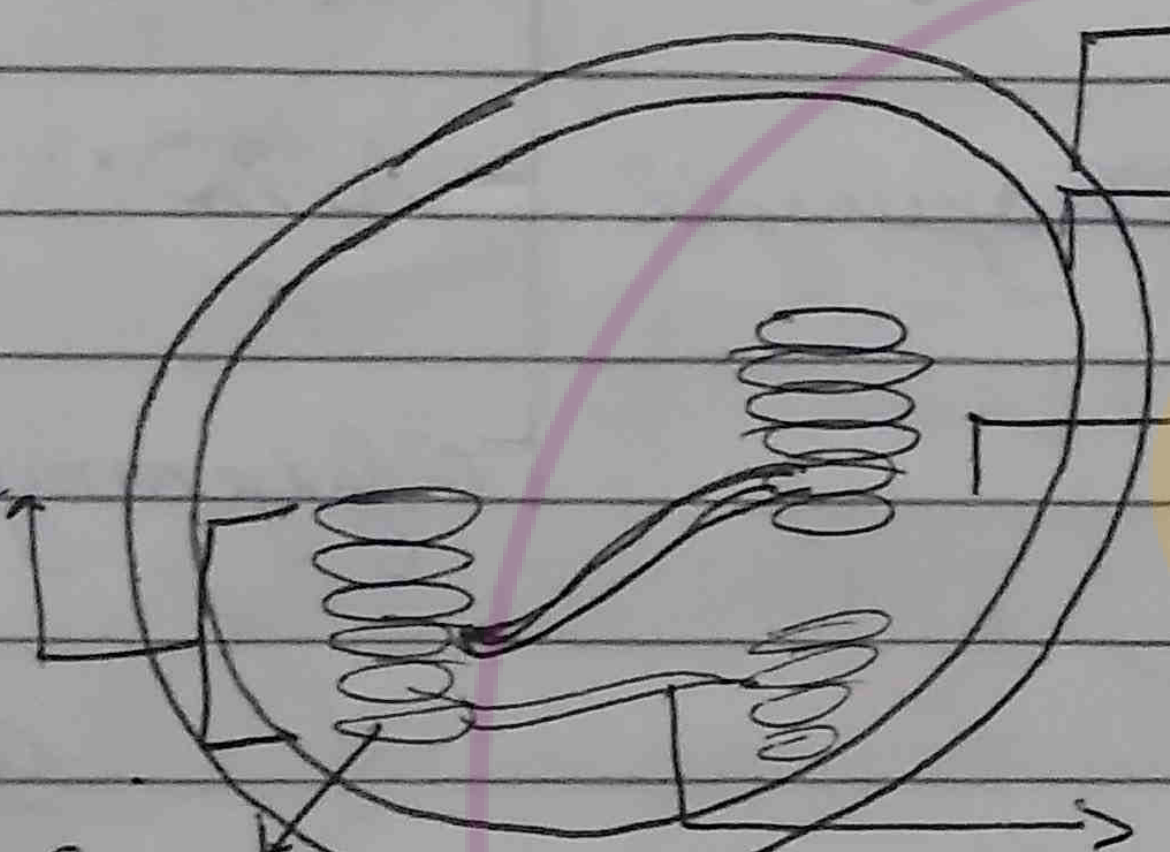
→ discovered by Virchow and Ochoa.

$NADP^+$ ⟶ $NADPH_2$

- for biosynthesis of chlorophyll succinyl Co-A and glycine is required.

- **Ruben and Kamen**
  ↓ Chlorella + H_2O^{18} + CO_2^{16} —(Light)→ O_2^{18}
  H_2O ✓ , CO_2 ✗

- **Site of photosynthesis : chloroplast**



Thylakoids	Stroma
utilise light energy ↓ convert into chemi. E	- Enzymes + nt which are responsible for - CO_2 fixation
i.e. ATP / NADPH →	utilised
Light Reactions	Dark reactions

- Phytol tail helps in attachment of chlorophyll with thylakoid membrane.
- Basic structure of all chlorophyll comprises of porphyrin system.

Photosynthetic Pigments

Chlorophyll
- green colour
- 5 types
- a, b, c, d, e

Carotenoids
- yellow-orange
  - Carotenoids
  - Xanthophyll

Phycobiline
- Red, Blue
  - Phycocyanin, Allo " → Blue
  - Phycoerythrin → Red

Chlorophyll-a

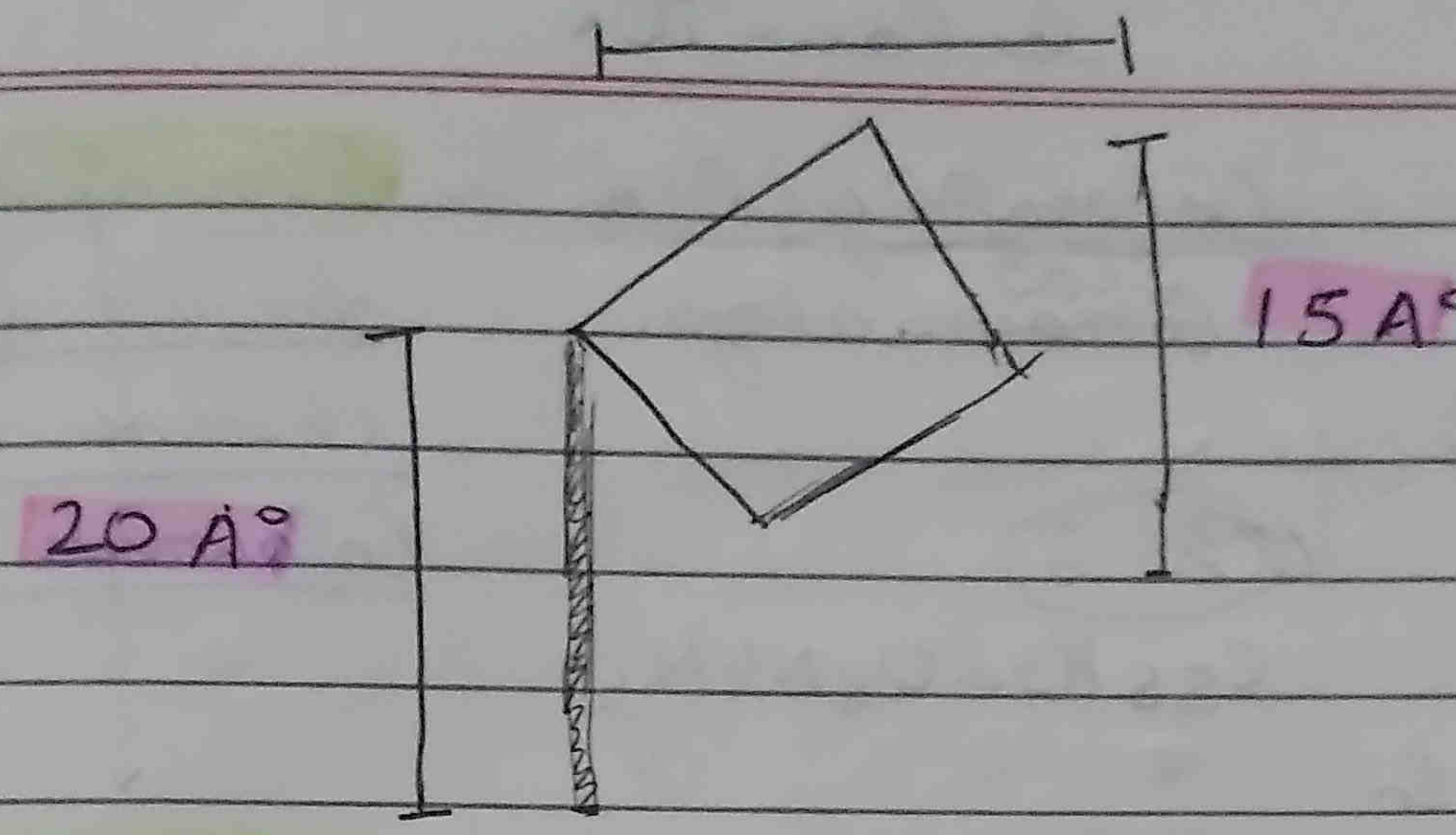
- universal photosynthetic pigment
- primary photosynthetic pigment
- $C_{55}H_{72}O_5N_4Mg$
- Molecular wt - 893
- Tadpole like structure.

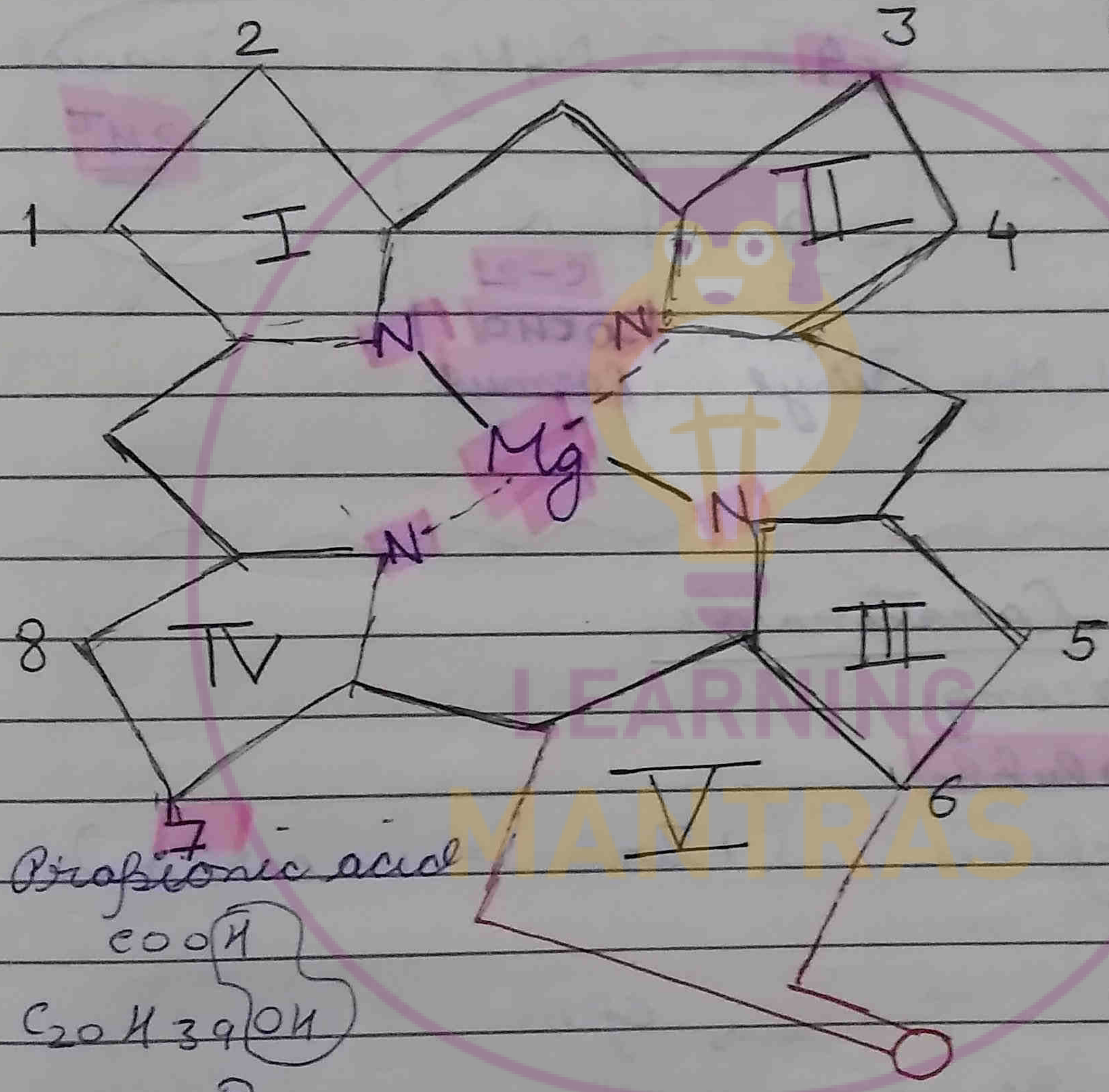
structure

Head (Hydrophillic)	Tail (Hydrophobic)
*Porphyrin head	Phytol tail
4 pyrrole ring	$C_{20}H_{39}OH$
closed tetra pyrrole str.	

* Mg is connected by two covalent, two coordinate bonds.

* Chlorophyll head has 5 rings i.e 4 pyrrole, 1 pentanone





1, 3, 5, 8 – CH_3 methyl

2 – $CH=CH_2$ vinyl

4 – CH_2-CH_3 ethyl

6 – cyclopentanone

—C(=O)—O Ester linkage

	Chlorophyll a	Chlorophyll b
	Bluish green	yellowish green
Mol wt	893	903
soluble in	Petroleum ether	Methyl alcohol
	C-3 $-CH_3$	C-3 CHO
	$C_{55}H_{72}O_5N_4Mg$	$C_{55}H_{70}O_6N_4Mg$

Chlorophyll / xanthophyll = 2/1

∴ Xanthophyll absorb 400–500nm wavelength as well as above and below it.

Chlorophyll c	Chlorophyll d	Phaeophytin
✓ Diatoms ✓ Dinoflagellates ✓ Brown alga • Head similar to chl a • Tail - nt • C_{55} → $C_{35}H_{32}O_5N_4Mg$	Red ~~Brown~~ alga Chl b $C_{55}H_{70}O_6N_4Mg$ Chl d $C_{54}H_{70}O_6N_4Mg$	derived from chlorophyll Colourless chl a ↓ Mg^{2+} - nt replaced by $2H^+$

a	d
C-2	C-2
$-CH=CH_2$ vinyl	-CHO formyl

Carotenoids

- yellow orange
- lipid soluble
- Tetra terpenes (1 terpen = 10 carbon) ⇒ C_{40}
- Ends can be → open / → closed

Carotene	Xanthophyll
→ orange	→ yellow
→ completely soluble in CS_2	Partially soluble in CS_2
→ $C_{40}H_{56}$	$C_{40}H_{56}O_x$ (1–8)

• Ab. wavelength 400–500 nm — Below ✓ Above this wavelength

ex (i) β-carotene — Lutein ← (Hydroxylation) α-carotene

(ii) Lycopene (tomato) — Zeaxanthin ← " β-carotene

★★ Carotenoids is the photopigment which convert nascent oxygen to molecular oxygen.

- Functions of Carotenoids-

Accessory Pigments

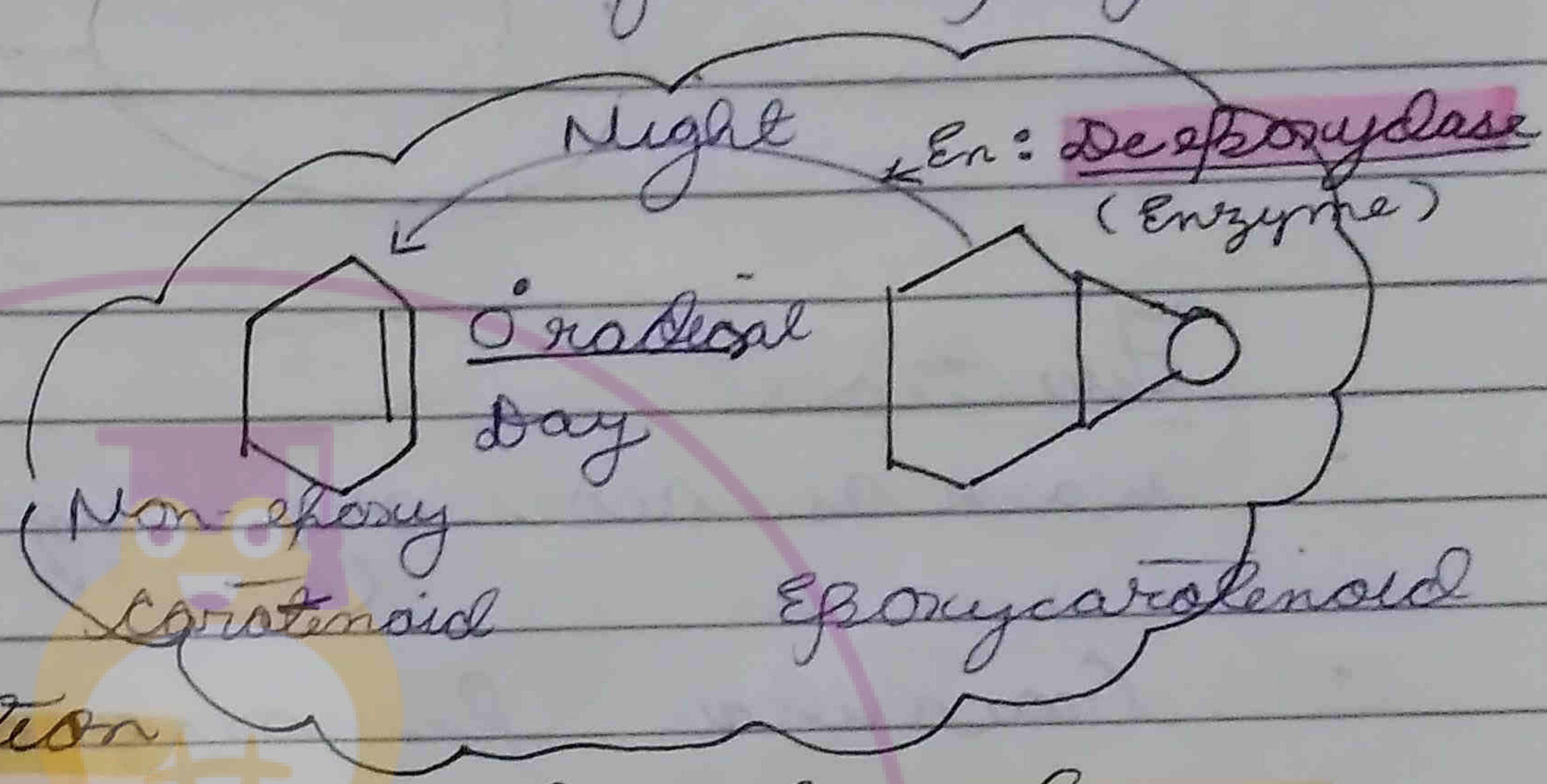
chl a → Blue + Red light

- carotinoid absorb light energy from other wavelengths and transfer it to chl a.

⇒ with the help of carotenoids absorption spectrum of chl A broadens.

Shield Pigments

Prevent photooxidation of chlorophyll a



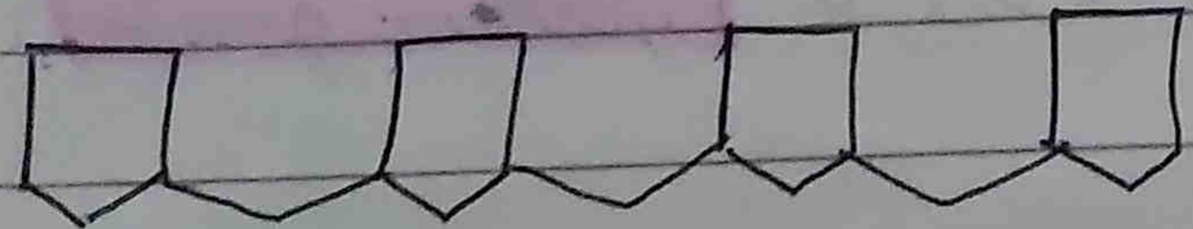
- Phycobiline

present in Red alga, BGA

Blue { Allophycocyanin
{ Phycocyanin

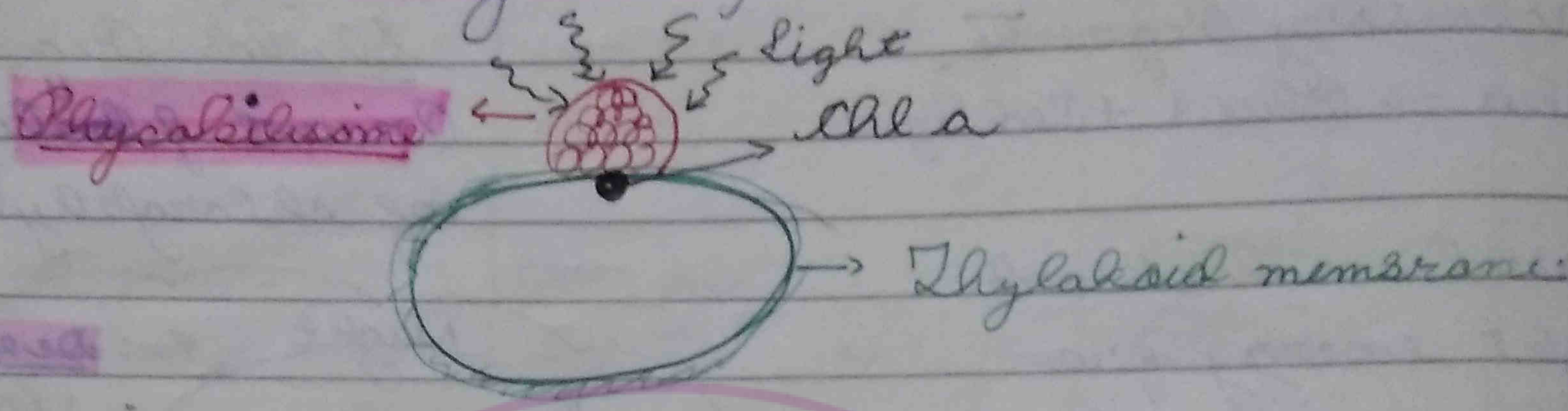
Red { Phycoerythrin

- 4 pyrolle rings having open chain structure i.e Open tetrapyrolle ring



Mg^{+2} - nt	H_2O soluble
Tail - nt	Heat labile

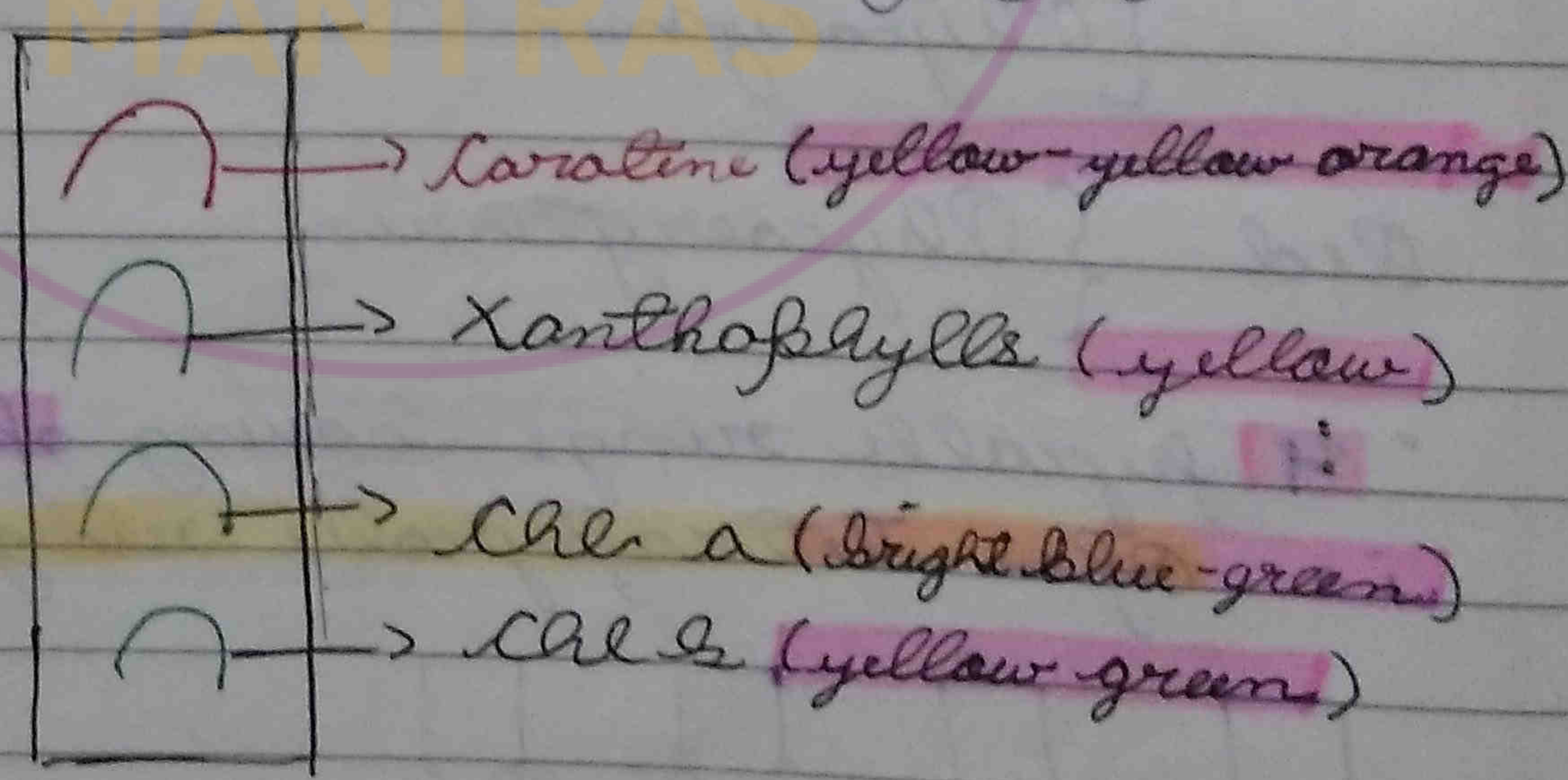
Pigments Phycobilins
+ Protein
Phycobiliprotein



Functions

- work as accessory pigments.
- Graidukov phenomena

lower
=> ~~Higher~~ the molecular wt higher its position on chromatography paper.

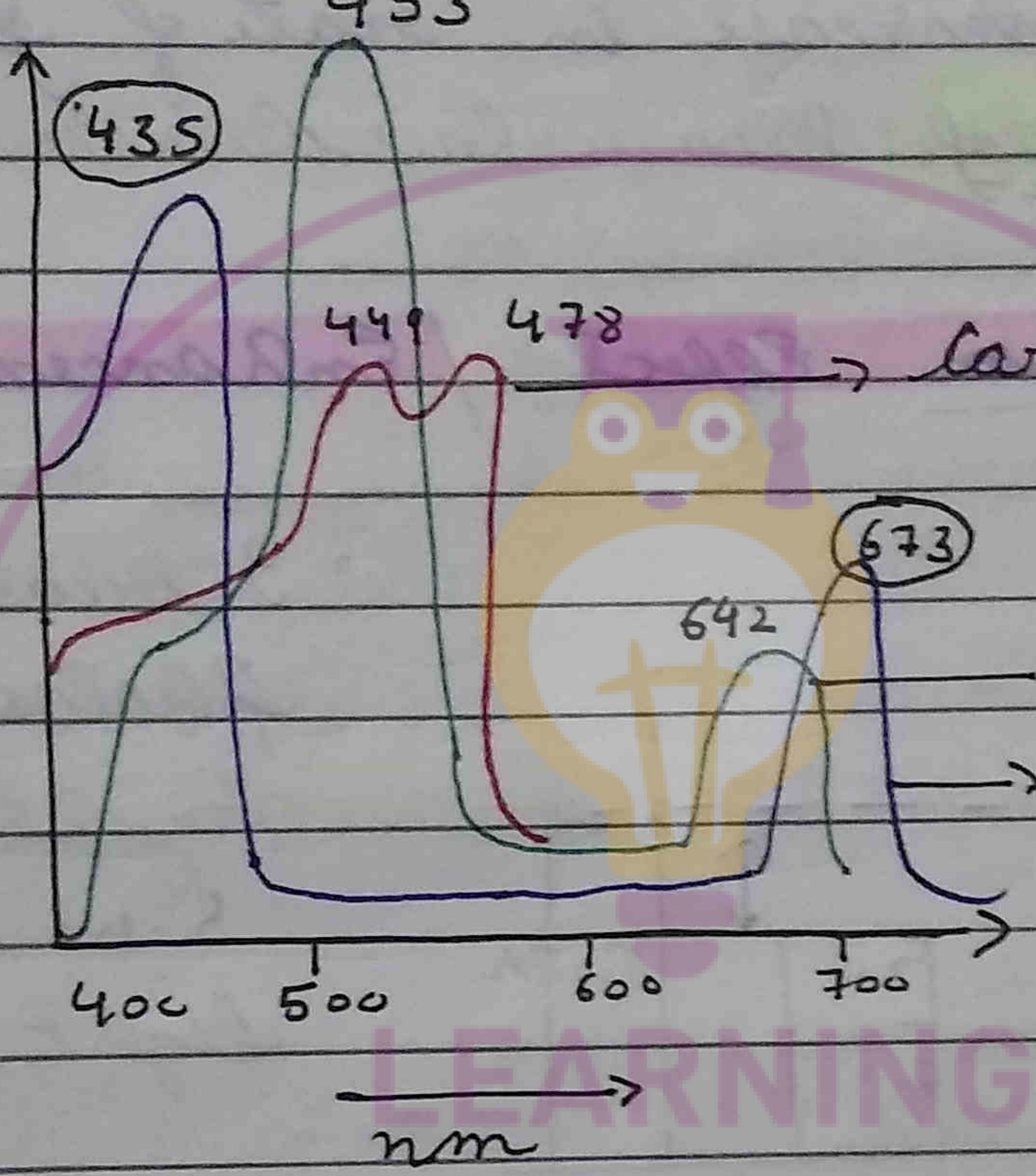
☆


A.R = ∵ Carotene have the highest position on chromatographic paper they have low molecular mass
=> True

- Photosynthetically active radiation (PAR) — (400 — 700) nm

Absorption Spectrum

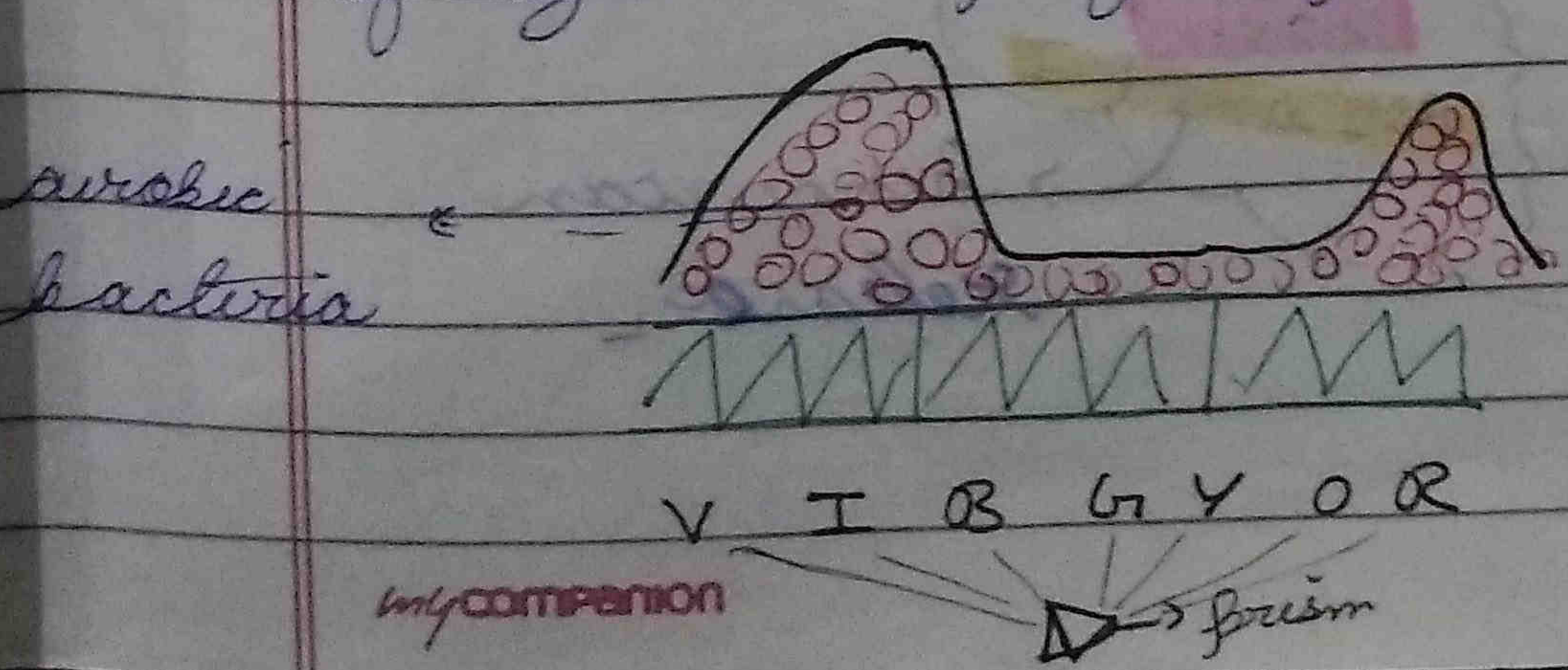
- Graph representing degree and portion of wavelength of light absorbed by the pigment
- It behaves as finger print of substance.



- ☆ chl a shows more absorption in red region
- chl b shows more absorption in blue region
- Overall absorption is more in blue region

Action Spectrum

- Graph depicting effectiveness of diff wavelength of light to perform photosynthesis.



☆ Englemann — Spirogyra, Cladophora → led to the development of action spectrum

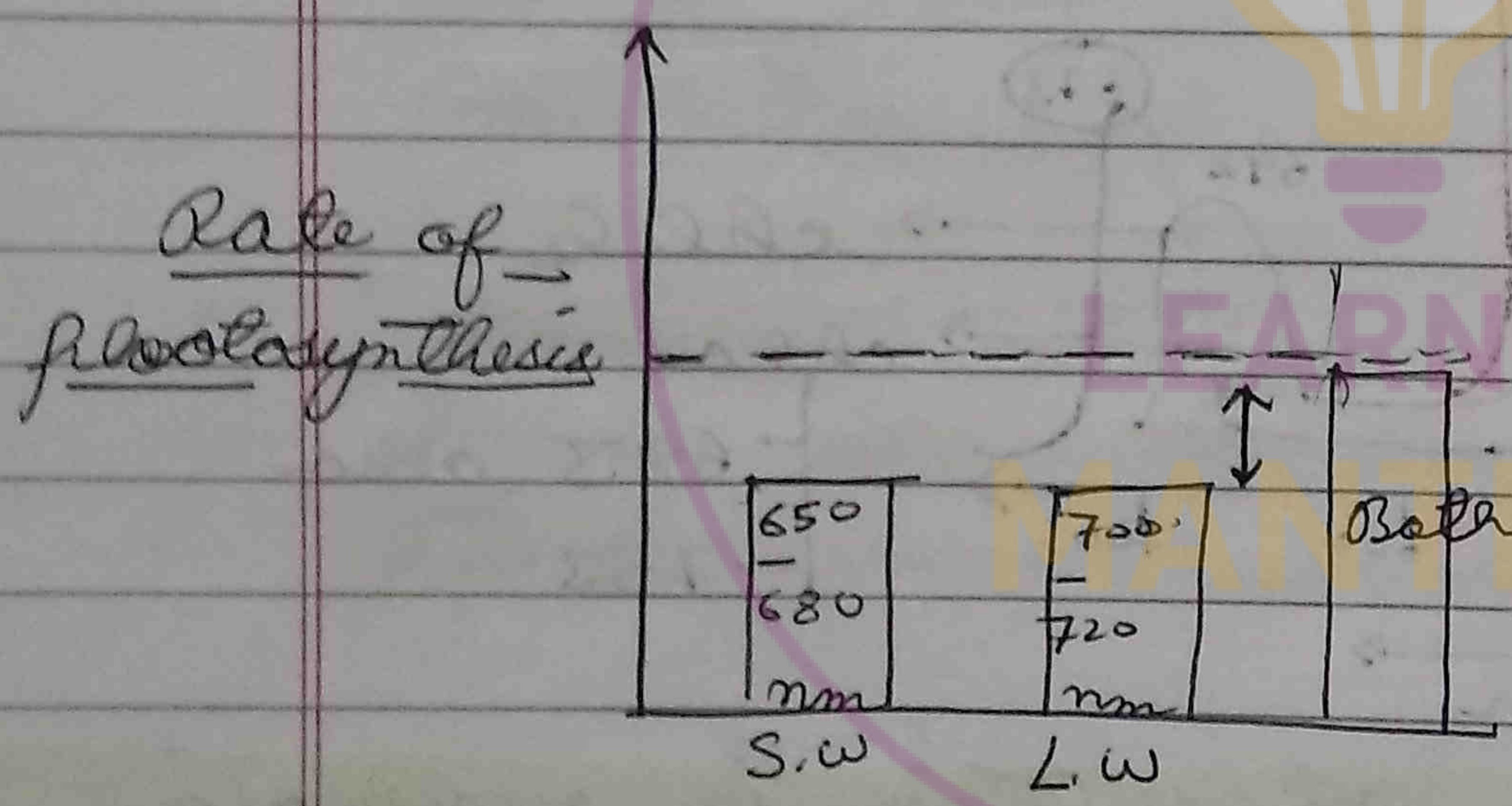
Emerson

- Observed effect of monochromatic light of different wavelength on Photosynthetic activity in *Chlorella.

- He observed that after 680 nm ↓ there is sharp decrease in rate of photosynthesis.

⇒ **Red Drop** because this decrease is in far red region.

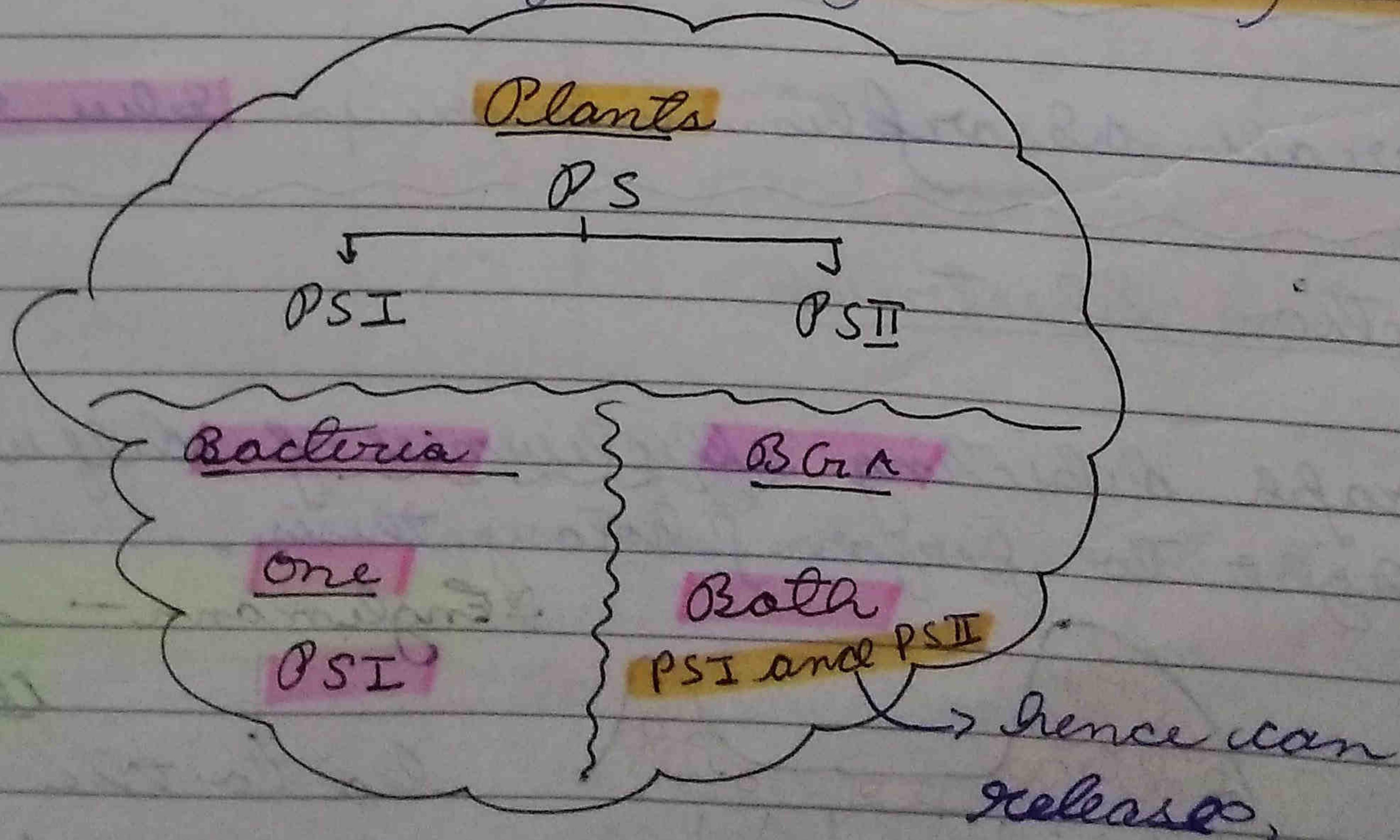
Emerson Effect / Enhancement effect -



- Increase in rate of photosynthesis ~~when~~ by PS I when both S.W and L.W of light was supplied

He concluded:

⇒ Two photosystems present in plants.



LHC ≃ Quantosome = 250 - 400 pigment molecules

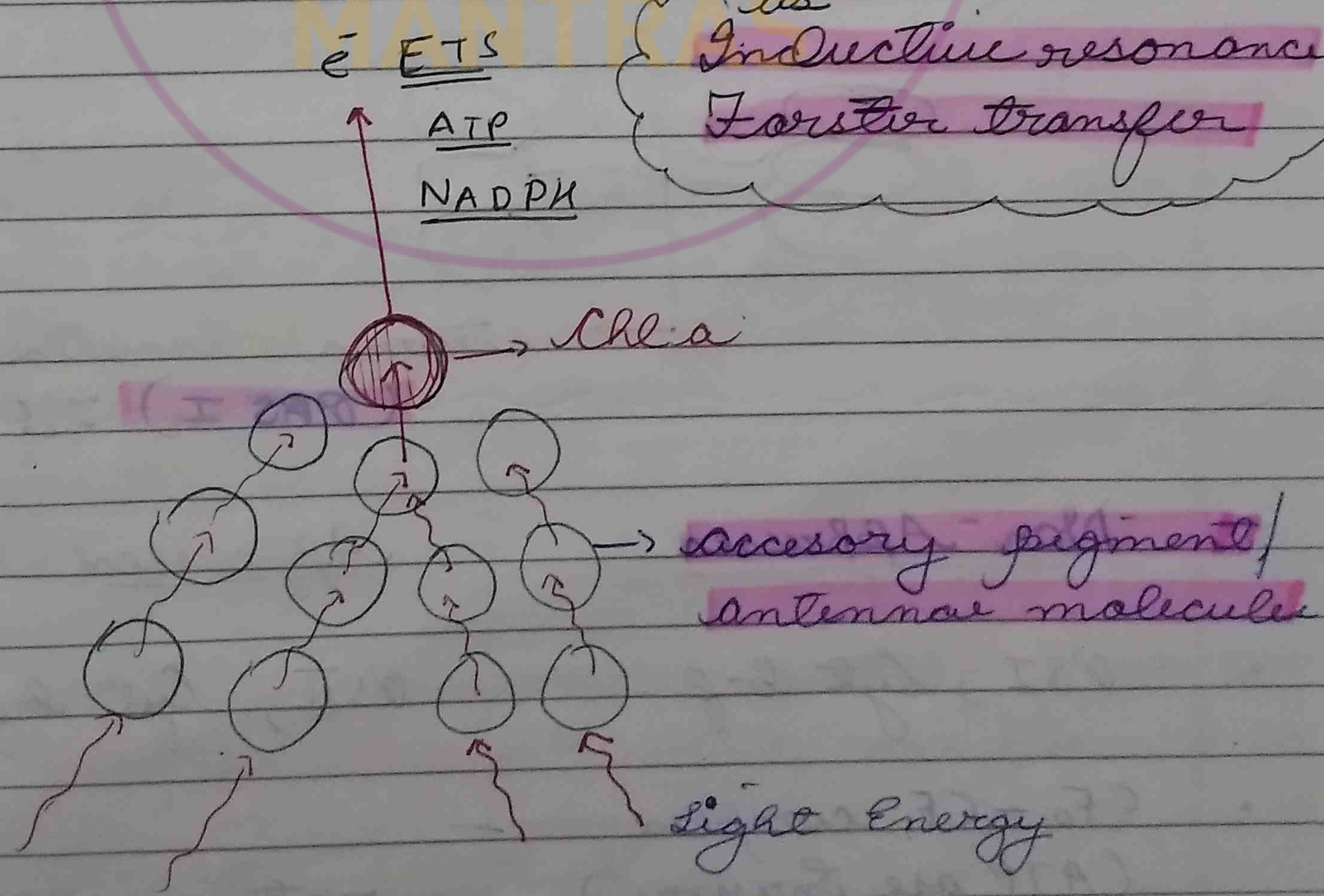
Photosystem

Reaction centre → chl a → One molecule → absorbs light energy and converts into chemical energy i.e Quantum Conversion

LHC Light Harvesting Complex → Light Harvesting pigments (LHP) i.e carotenoids + Proteins

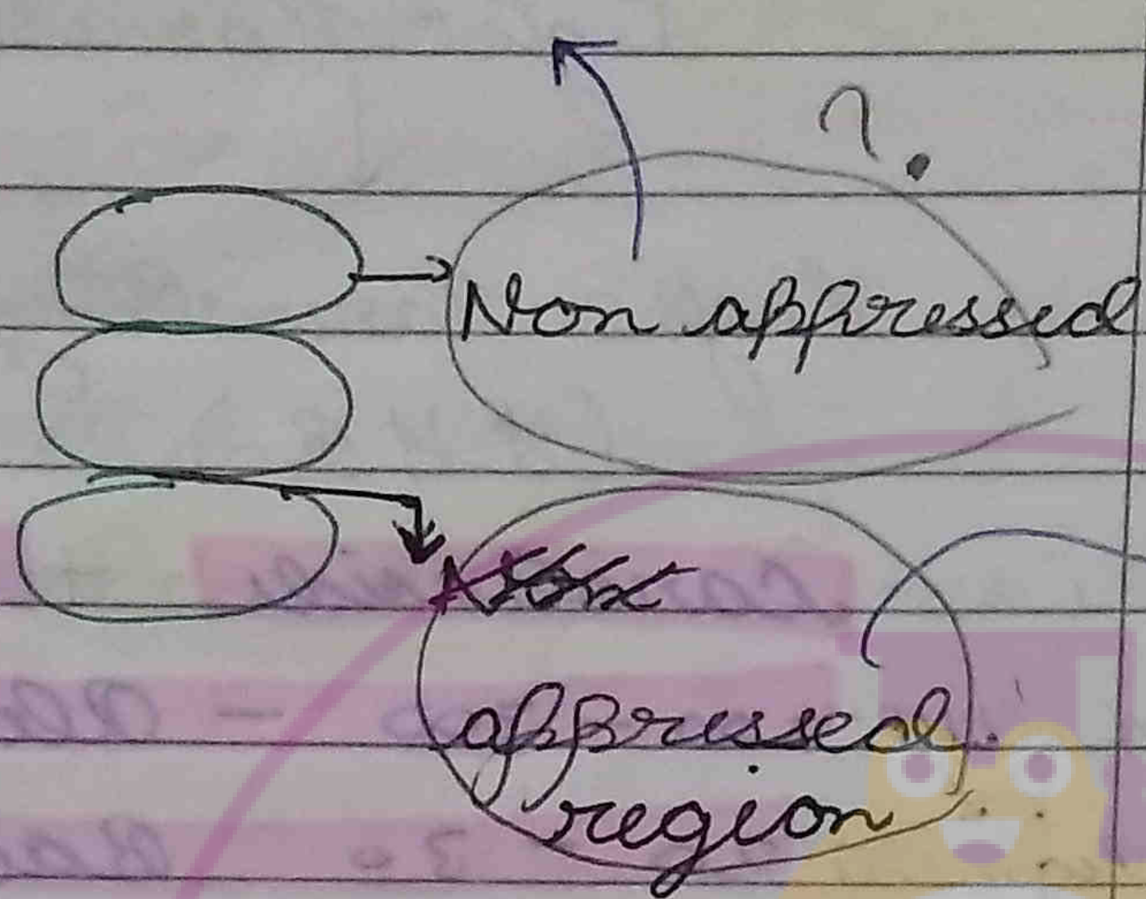
no. of LHP: 200 - 300 - Plants
Pigments 20 - 30 Bacteria

→ absorb light energy and transfer to reaction centre through a process known as Inductive resonance / Forster transfer

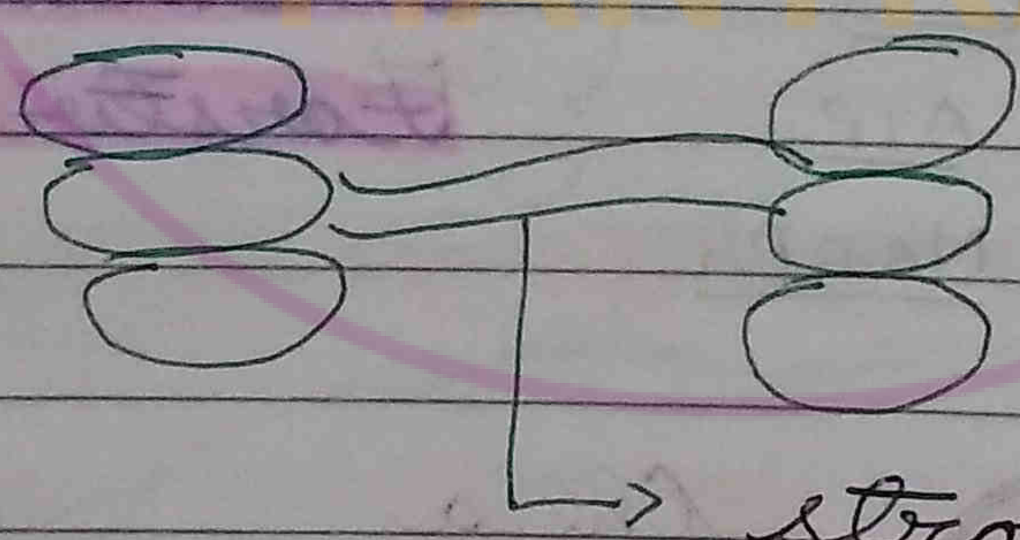


	PS I	PS II
Reaction centre	P_{700}	P_{680}

Chl a shown absorption maxima —— nm



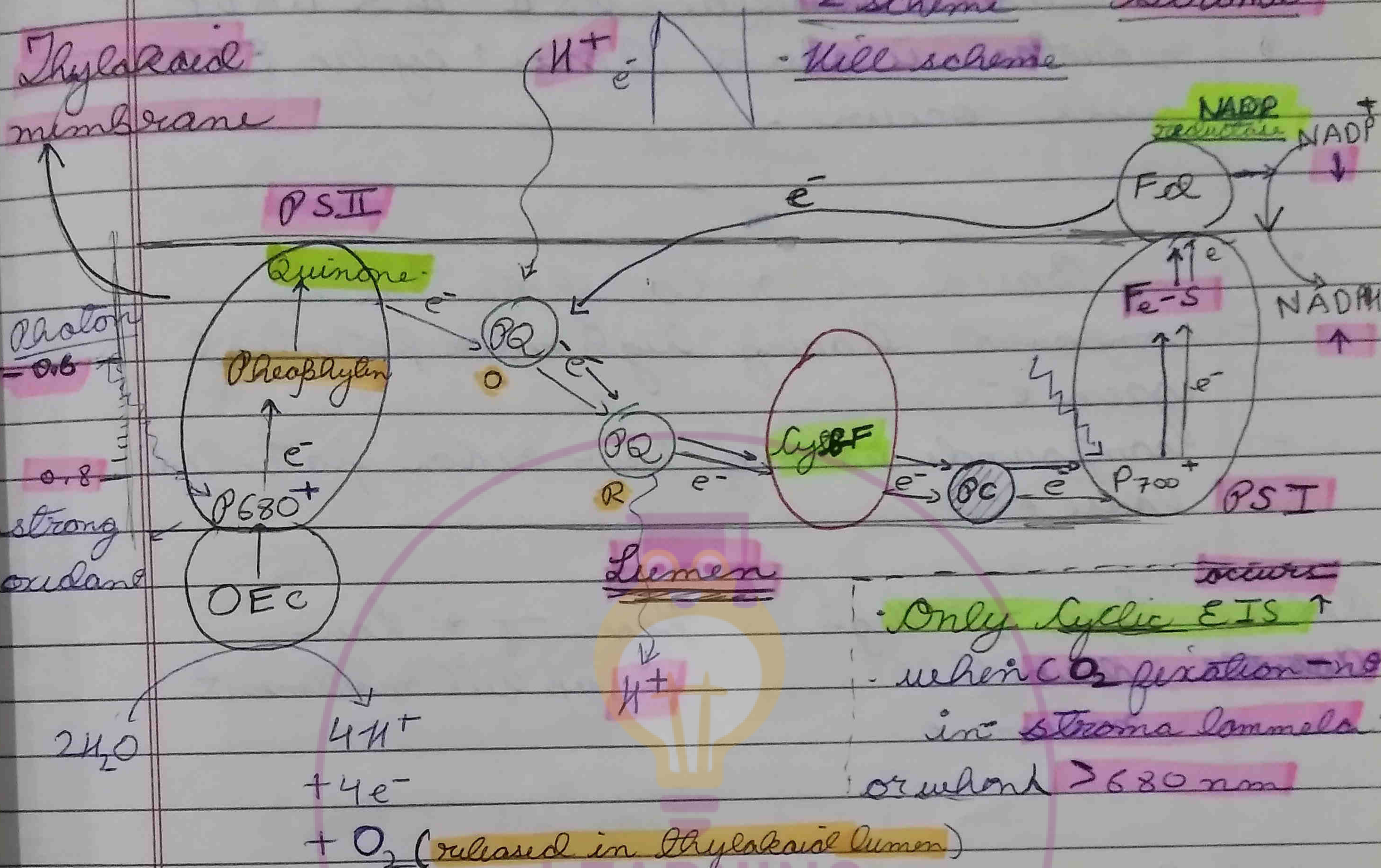
	PS I	PS II
• $\frac{chl\ a}{chl\ b}$	= 2–4	$\frac{chl\ a}{chl\ b}$ = 1.4
• $\frac{chl}{caratenoids}$	= 25 : 1	5 : 1



Non-Appressed	Appressed
• PS I, Cyt b-f.	PS II, Cyt b-f complex
• $CF_0 - CF_1$ complex (ATPase Enzyme) A	–nt in appressed region

- Phaeophytin → Primary $\bar{e}$ acceptor of PS II
- Fd → Ferredoxin
- OEC present inside thylakoid membrane whereas Fd (ferredoxin) is attached outside the thylakoid membrane.

- Z scheme
- Hill scheme



- Only Cyclic ETS ↑ occurs
- when CO_2 fixation -ve
  in stroma lammela
  or when > 680 nm

OEC :

Oxygen Evolving complex contains Mg complex, Cl^-, Ca^{+2} utilised for splitting of water.

Non-Cyclic ETS	Cyclic ETS
PS I, PS II	PS I
NADPH	-ve
External $\bar{e}$ donor H_2O	-ve
ATP ✓	ATP ✓

- Phaeophytin is primary $\bar{e}$ acceptor in PS II.
- PQ → Plastoquinone → mobile carrier which carries $\bar{e}$ as well as H
- Cyt-b-f contain iron → Red → Red carriers
- PC → Plastocyanin → contain copper → blue coloured
- Fe-S : primary $\bar{e}$ acceptor in PS I.

* In stroma lamellae PS II and NADP reductase is absent hence only cyclic ETS will occur.

- Based on redox potential.
  - compounds having high redox potential gain e^-
  - compounds having low redox potential loose e^-

Redox Potential: Low → High — down hill movement; High → Low — up hill movement

* Cyt b-f complex accept the electron from plastoquinone but cant accept H^+ because of which H^+ ion enter lumen.

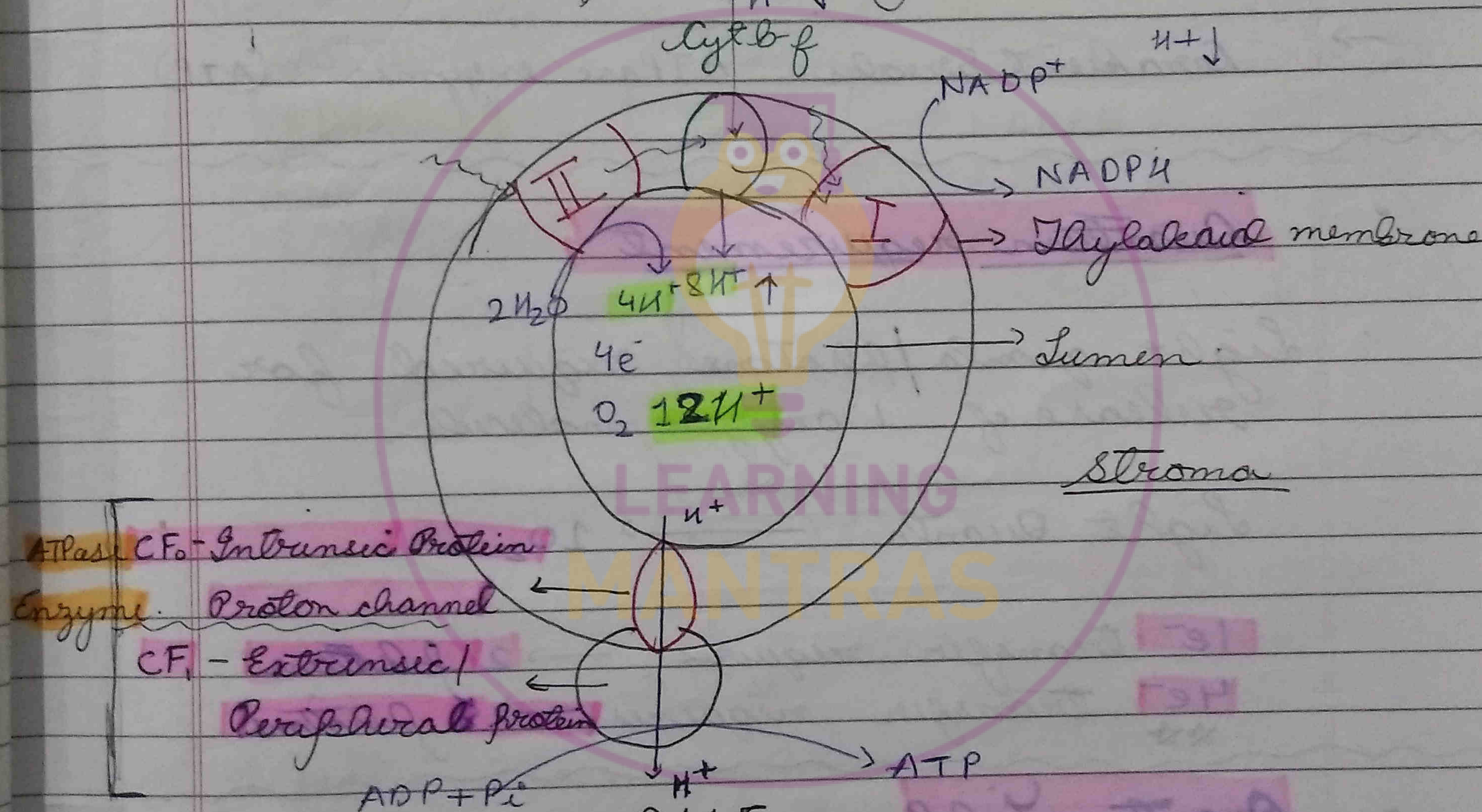
- Plastoquinone is e^- as well as H carrier.

* Plastocyanine and plastoquinone are mobile e^- carrier.

Chemiosmatic Hypothesis

— Mitchell.

- Electron transport performs osmotic work of pumping of protons ~~electron~~ from stroma to thylakoid lumen.
- Proton gradient / PMF: Proton Motive force is responsible for forming ATP.



PMF

- Splitting of H_2O results in H^+ increase in lumen
- H carrier pump H^+ ion from stroma to lumen
- NADP reductase utilise H^+ ion from stroma to form NADPH.

- Hence H^+ ion concentration decreases in stroma and increases in lumen.

☆☆ ⇒ 8 photons required for formation of one O_2 molecule

Chemiosmosis

→ Membrane is required

→ IMP Energy used for pumping of proton Proton Pump (i.e from stroma to lumen)

→ PMF formed

→ Gradient breaks ATPase enzyme ⋯ (ATP)

- **Quantum requirement**

- Light quanta/photons required for release of 1 oxygen molecule.

Light Quanta ⟶ $1 O_2$

1e⁻ transfer requires ⟶ 2 photons

4e⁻ transfer requires ⟶ 8 photons

☆☆

- **Quantum Yield**

Amount of O_2 released per quanta of light absorbed.

8 photons ⟶ $1 O_2$

1 photon ⟶ $\frac{1}{8}$ O_2

★ for $1e^-$ transfer there is pumping of $2H^+$ ions in the lumen.

⇒ $4e^-$ ⟶ $8H^+$ ions pumped in lumen

• 3ATP and 2NADPH requried to fix one CO_2 molecule

$2H_2O$ split to form

$1 O_2$ molecule

$4e^-$ formed

8 photons required e^- transfer

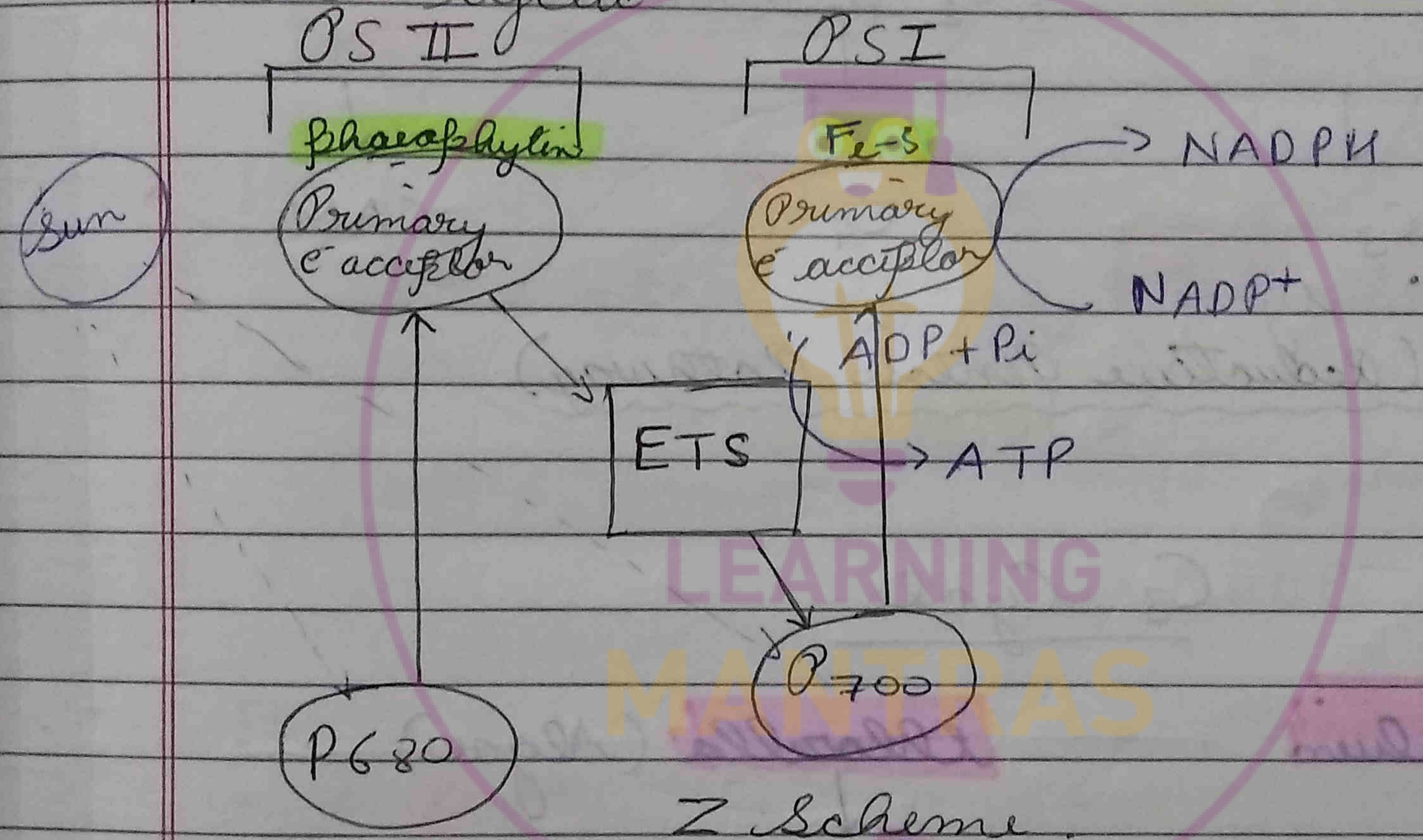
2 NADPH — ($2e^-$ form 1 NADPH)

3 ATP — ($4H^+$ ⟶ 1ATP ⇒ $12H^+$ ⟶ 3ATP)

↓

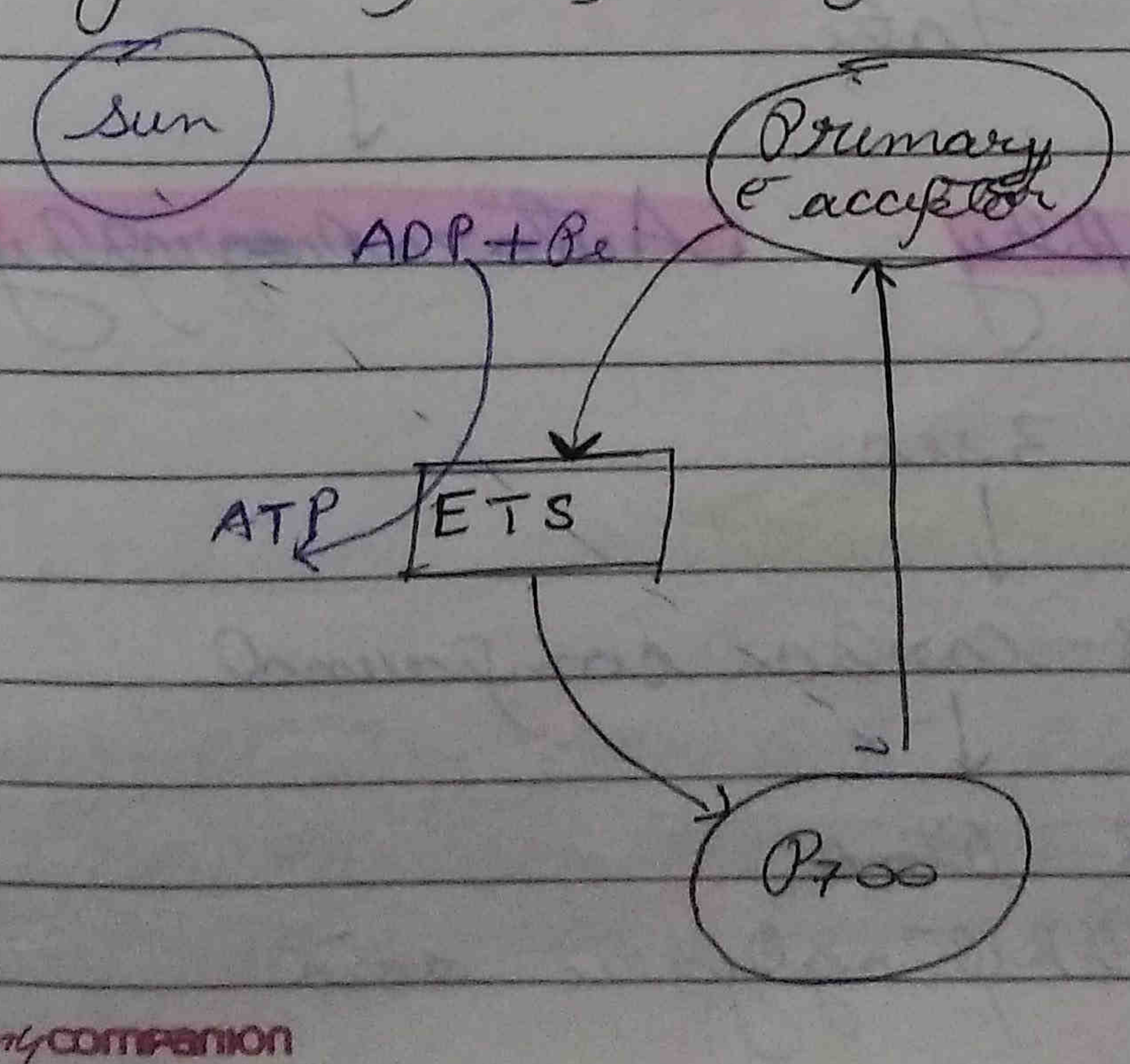
1 CO_2 fixation (calvin cycle : C_3 plants)

→ Non - Cyclic



Z Scheme.

→ Cyclic phosphorylation



☆ Chlorella was used by
→ Calvin
→ Emerson
→ Ruben and Kamen.

Date / / Page

Dark Phase

☆ · Biosynthetic reactions
☆ · Stroma reactions
☆ · Blackman reactions
☆ · PCR (Photosynthetic Carbon reduction cycle)

CO_2 assimilation
↓ C_3 ↓ C_4 ↓ CAM

C_3
- Calvin cycle
- RPP (Reductive Pentose Pathway)

C_3 Cycle

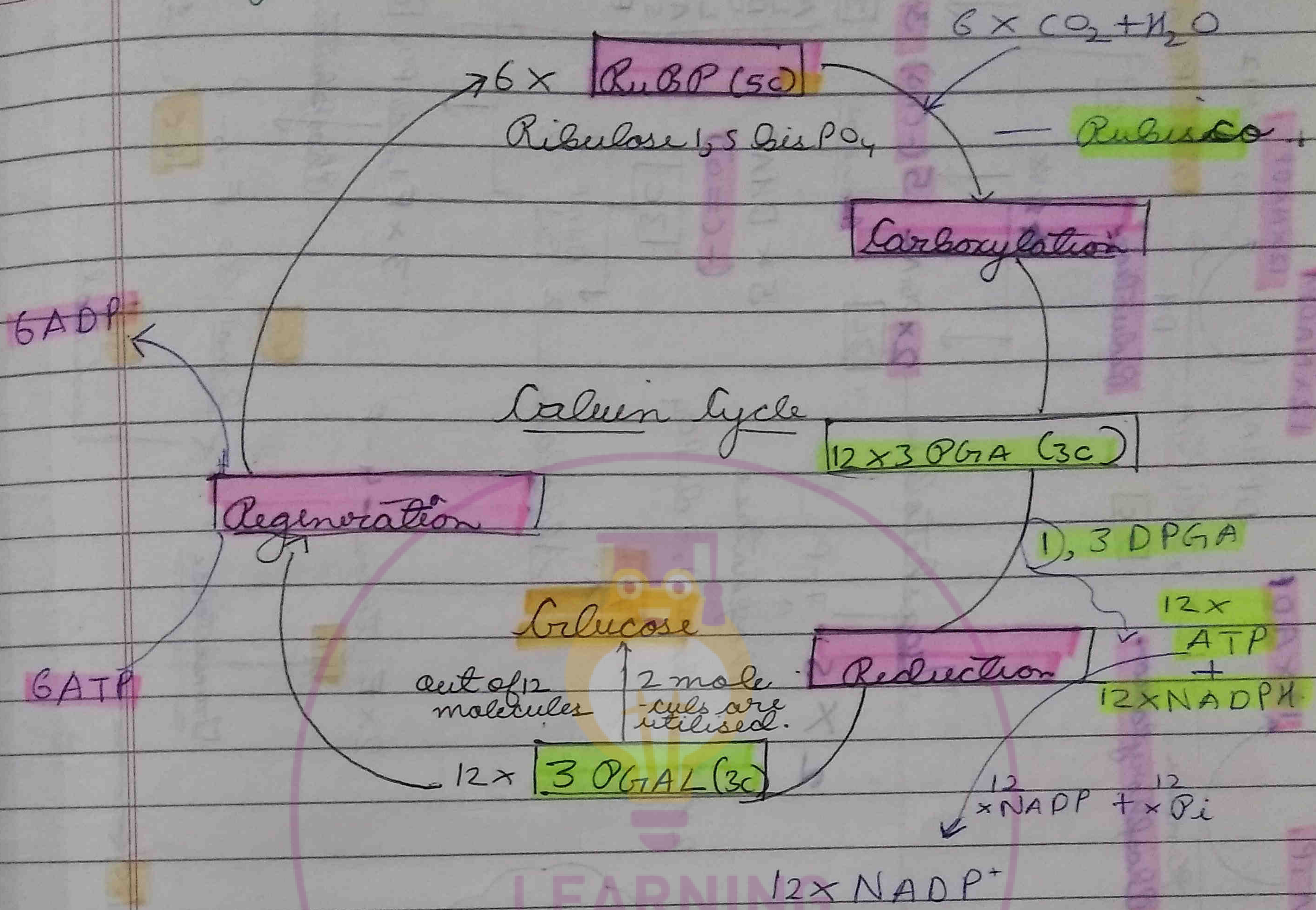
- Calvin — Chlorella (Algae)
↓
$^{14}CO_2$
Fate
↓ 2-D Chromatography (D → dimensional)
↓ Autoradiography

3 sec
↓
3-carbon compound
↓
3-PGA
3-Phosphoglyceric acid.

☆ RuBP is a 5-C ketose sugar.

• 1,3 DPGA (acid) —reduction→ 3, β GAL (aldehyde)

☆ Carboxylation is the most crucial step of photosynthesis.



• To activate Rubisco enzyme → CO_2, light and Mg^{2+} is required.

• To form 1 G → 18 ATP + 12 NADPH required
⇒ 6 CO_2 fixed.

• 1 CO_2 fixation → 3 ATP + 2 NADPH

• C_3 - Plants → Rice, Wheat, Tomato.
Graminaceae which show C_3 pathway

☆ At reduction for 6 CO_2 fixation 12 ATP and 12 NADPH are required hence for reduction of 1 CO_2 2 ATP and 2 NADPH are required


6 × RuBP
5C
$6CO_2$
RuBisCO
Carboxylation
12 × 3 PGA
3C
12 × ATP
12 × ADP
Kinase
Phosphorylation
12 × 1,3 Di PGA
DPGA/
3C
12 × NADPH
12 × NADP+
Pi × 12
DH
Reduction
12 × 3 PGAL / GAP
3C
2 × PGAL
3C
5 (-CHO)
3 × PGAL
3C
2
Isomerase
5 × DHAP
(-C=O)
3C
DHAP
3C
2
3
ALDOLASE
3 × F 1,6 di PO4
6C
Phosphatase
3 × F-6-P
6C
1
GLUCOSE
2 mol
6C
2 mol
3C
Transketolase
2 × Erythrose-4-P
4C
Aldolase
7C
2 × S-heptulose 1,7 di PO4
Phosphatase
2 × S-7-P
2C
Transketolase
2 × Ribose-5-P
2 mol
5C
Isomerase
4-C-OH
Glucose
18 ATP
12 NADPH
2 mol
2 × Xylulose-5-P
5C
Epimerase
RUMP
KINASE
6ADP + Pi
6ATP

Q Find the quantum requirement for fix of $2CO_2$ through C_3 pathway?

ans
$2H_2O$
↓
$4e^-$, $4H^+$, O_2
↓
8 photons
↓
3 ATP
2 NADPH → $1CO_2$ fix

$1CO_2$ → 8 photons
$2CO_2$ → 16 photons

☆ These reaction help in synthesis of glucose. hence these reactions are called **glycolysis reversal**.

☆ $4H^+$, $4e^-$ and 8 photons are involved in the photolysis of water to make one molecule of oxygen.

• Pepcase is so strong that it can even use CO_2 formed during respiration

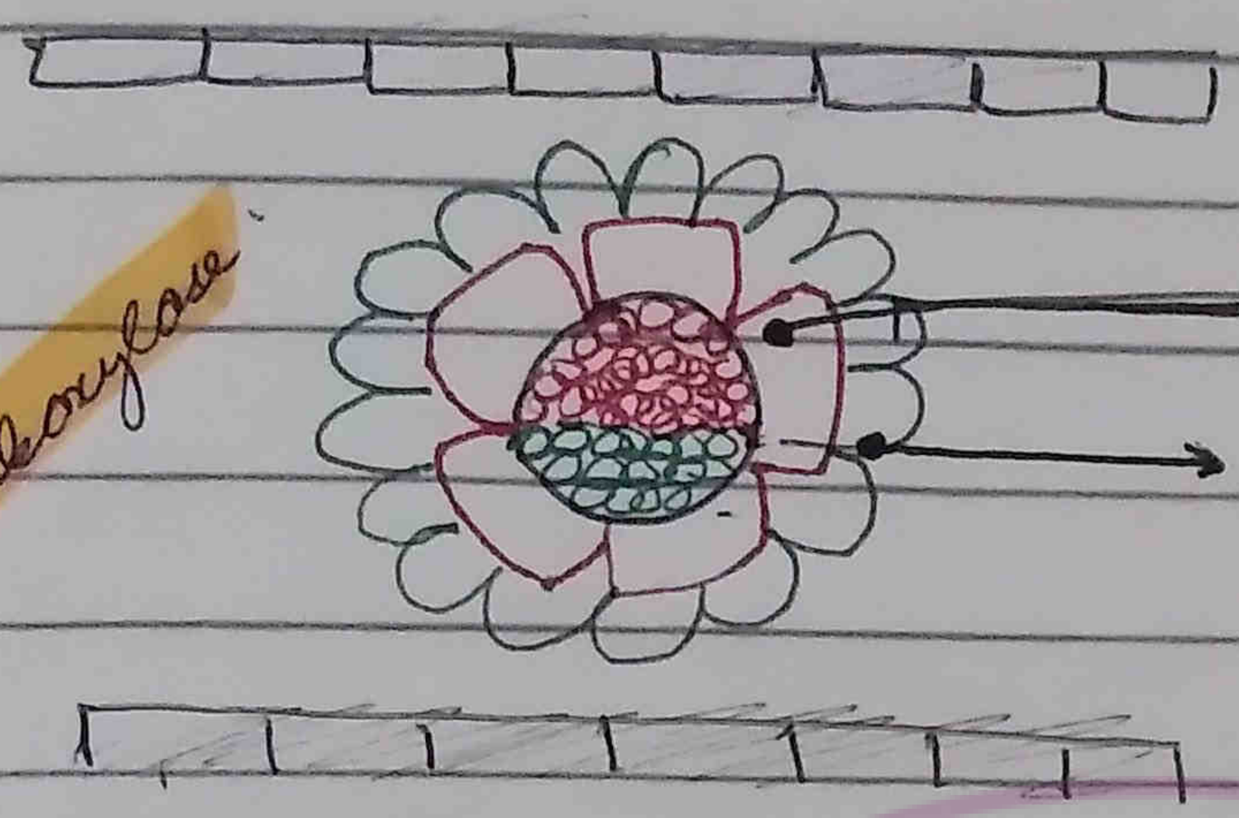
☆ Chlorophyll synthesis.

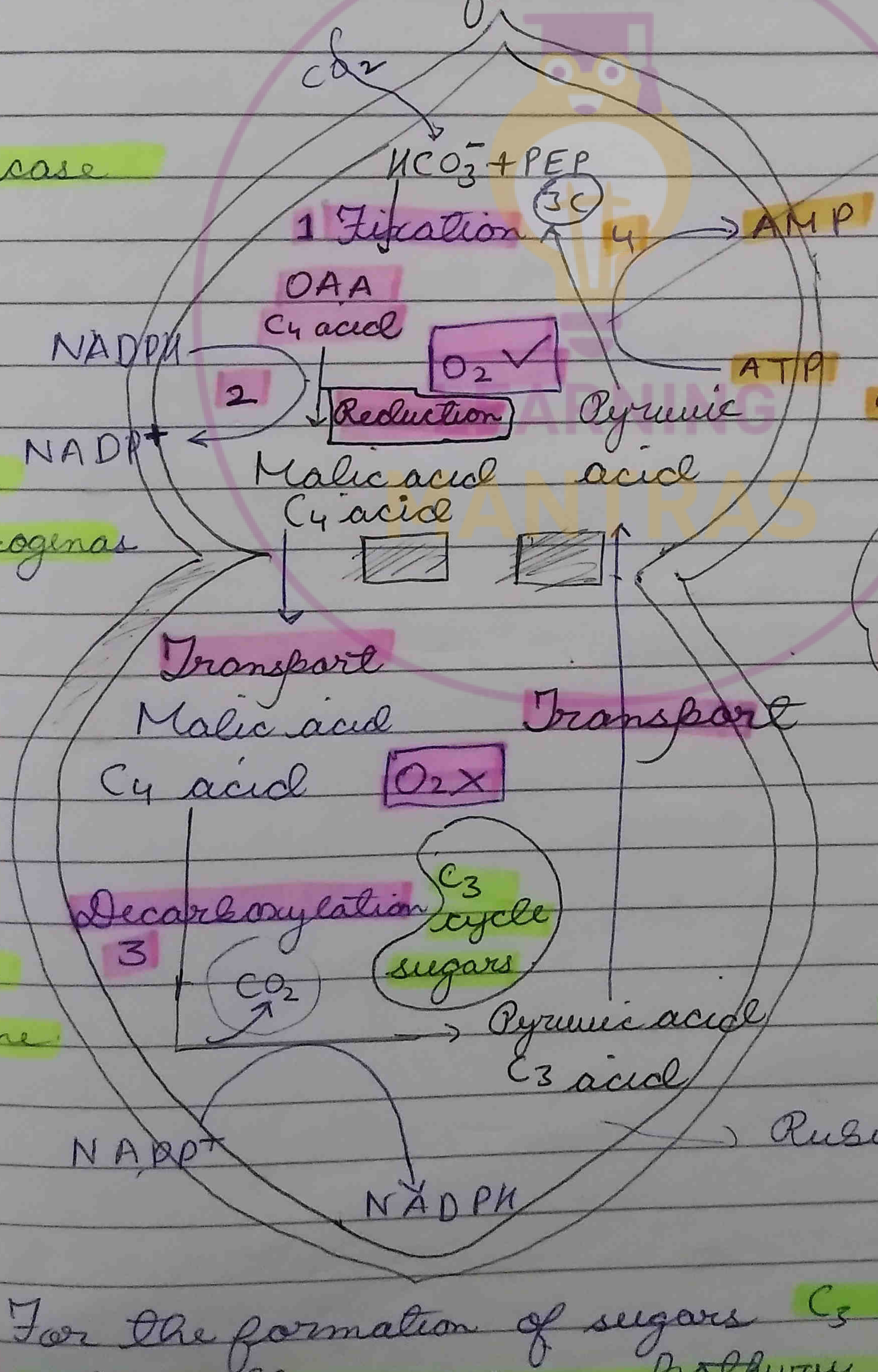
Succinyl CoA + Glycine ⟶ Protochlorophyll (Protochlorophyllide)

Chlorophyll ← (Light, 2H)

- Both Bundle Sheath and Mesophyll cells are chlorenchymatous.
  ⇒ Cooperative Photosynthesis

- ## Kranz Anatomy





- For the formation of sugars C_3 Pathway is a universally occuring pathway.

- Photooxidation of chlorophyll is also called solarisation
- Photorespiration occurs in stroma of chloroplast

Page

- Photorespiration

PCO cycle : Photosynthetic carbon Oxidation cycle

C_2 : cycle, Glycolate cycle

P
C
M

Dicker & Tio : Tobacco plant
(Discovery)

Rubisco (Dual Enzyme)
↓
Active site
CO_2, O_2

$CO_2 > O_2$	O_2↑	· High temp. · High light intensity O_2↑

works like : carboxylase — C_3

Oxygenase
- Oxidation of organic compounds by O_2, in presence of light
- CO_2 release.

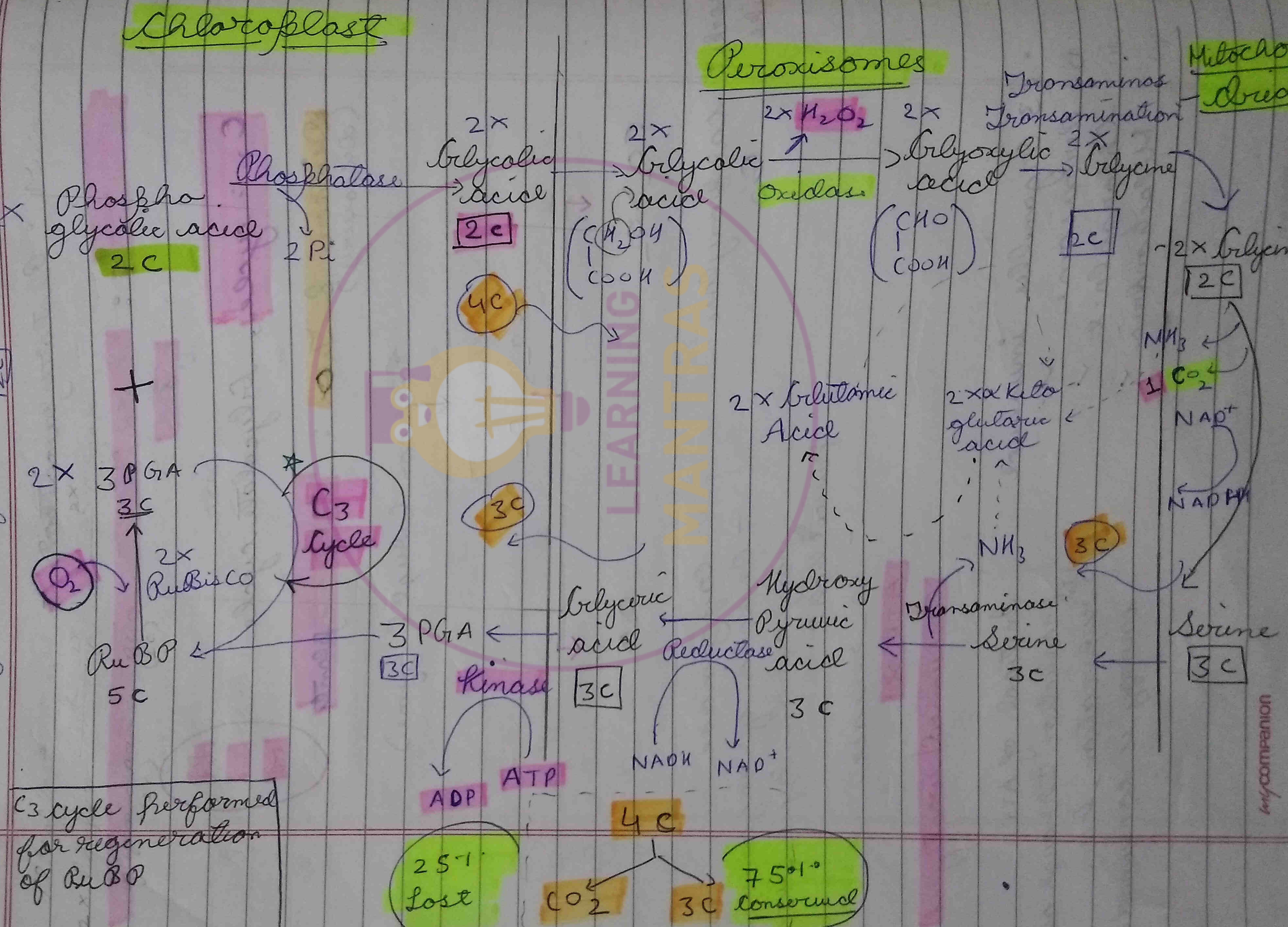
ATP ✗
↓
consumed / wasteful

Instead of ATP production through as in respiration, here energy is consumed.

- 3 Organelles involved
(i) Peroxisome ✓
(ii) Chloroplast ✓
(iii) Mitochondria ✓

myCOMPANION

- Oxygenation in Chloroplast, Mitochondria, Peroxisome.
- Decarboxylation → Mitochondria
- CO_2 is being respired from Glycolic acid ⇒ C_2 cycle



- C_2 cycle protect plant from photoxidation of pigments

C_2 cycle:

1 ATP production absent
ATP utilisation ✓

2 CO_2 release (Breakdown organic compounds)
Plant yield ↓

3 Photo oxidation protect chloroplast

- High light intensity

↙ ↘

- Transpiration ↑
- Closure stomata
- Dark reaction inhibited.

Light reaction
↓
ATP, NADH
↓
Accumulation
↓ react with.
O_2
↓
Reactive state
↓
causes oxidation of Pigments
(Photooxidation)

C_2 cycle

- 2 carboxylations occur in C_4 plants for fixation of one CO_2

☆ C_4 plants are adapted to hot and dry climate.

C_4 Pathway:

- Hatch and Slack pathway
- Cooperative photosynthesis
- ★ IMP — Dicarboxylic acid cycle
- Kortshack observed in
- Sugarcane

Sugarcane ↓ CO_2 fix

3C ✗ 4C ✓

COOH
|
CH_2
|
C=O
|
COOH

Dicarboxylic acid : OAA

Tropical plant

- 18 families of angiosperms.
- 1500 species
- Monocots + Dicots

M → Maize
A → Amaranthus
P → Pennisetum
S → Sorghum
Sugarcane (Most productive C_4 plant)

- C_4 plants → dimorphism w.r.t chloroplast
- CO_2 fixing enzymes Pepco, Rubisco

∴ in BSC PS II is -nt, non-cyclic ETS -nt ⇒ O_2 release -nt.

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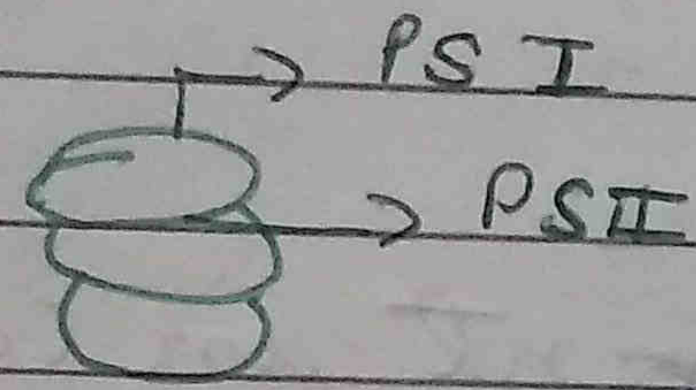
MSC	BSC
Mesophyll cell	Bundle sheath cell
• Granal	Agranal
PS I, PS II	Only PS I (∵ agranal)
Non cyclic ETS, Cyclic ETS	Cyclic ETS
PEPco	PEPco ×
$2H_2O \rightarrow 4e^- + 4H^+ + O_2$ (oxygen release)	oxygen release -nt
• Rubisco ×	✓
• Starch ×	✓

Phosphoenol pyruvate carboxylase

BSC:
- Large size
- Thick wall
- ICS × (Inter cellular space)
- Gaseous exchange ×
- Several layers of cell.
- Size of chloroplast is large
- ☆ p.y.q higher no. of chloroplast.



• Carboxylation

	Ist	IInd
	PEP case	RuBisco
	MSC	BSC
CO_2 acceptor	PEP	RuBP
	3C	5C
Product:	C_4 acid	C_3 acid
	OAA	PGA

• Pepcase is +nt in cytoplasm and Rubisco in stroma. ¦ 12 more ATP are required by C4 plants for glucose formation.

		ATP	NADPH
C4	1 CO_2 fix	5 ATP	2 NADPH
	Glucose	30 ATP	12 NADP
C3	"	18 ATP	12 NADP

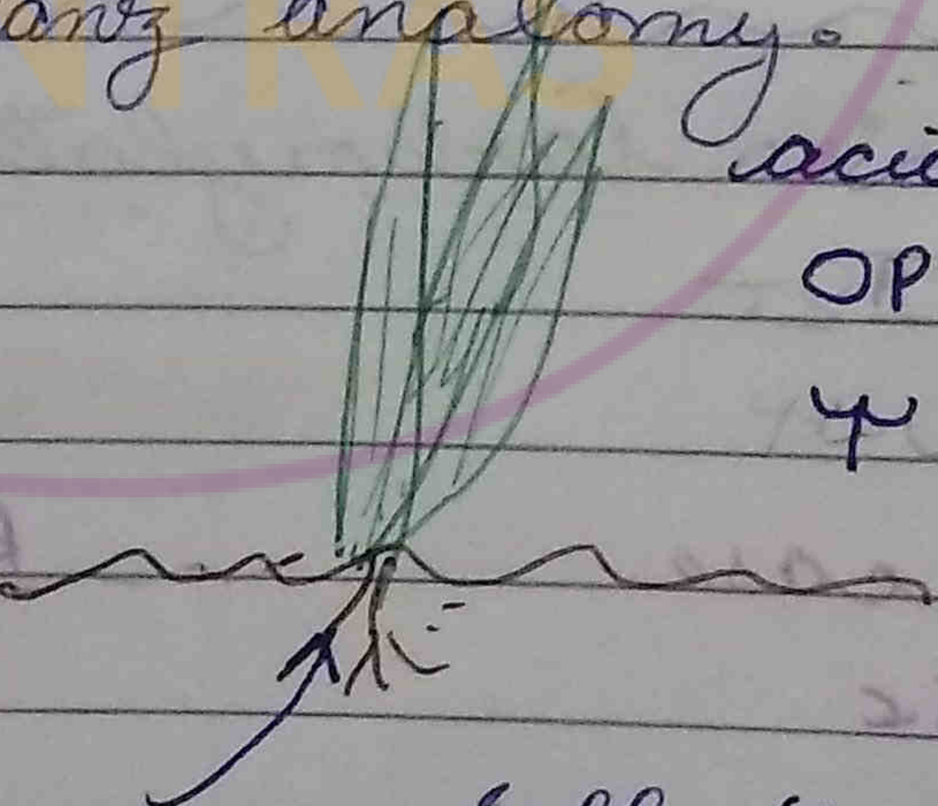
At 4 step of Hatch and slack pathway said 2 ATPs are consumed since ATP ⟶ AMP + 2

can tolerate
↑
1 High Temperature stress
Photorespiration ▬ nt in C_4 plants.
where Rubisco is +nt

a High CO_2 concentration is maintained in BSC
Due to continous breakdown of malic acid.

(b) Rubisco — BSC hence BSC does not interact with O_2 release in → MSC where Rubisco is absent.

can tolerate
2 ↑ CO_2 stress due to strong CO_2 fixing enzyme Pepcase
3 H_2O stress → water loss reduced due to kranz anatomy.
4 salt stress



acids formed durin C_4
OP ↑
Ψ ↓ −4

Salt Ψ_w ↓ e.g −3

• Pep case has higher affinity for CO_2 than Rubisco.

• C_4 plants cannot tolerate low temperature stress because of cold sensitive "Phosphopyruvic dikinase" enzyme.

• CO_2 fixation done twice due to presence of both Rubisco and Pepcase.

CAM Pathway

• C → Crassulacean Acid Metabolism Pathway

Succulents

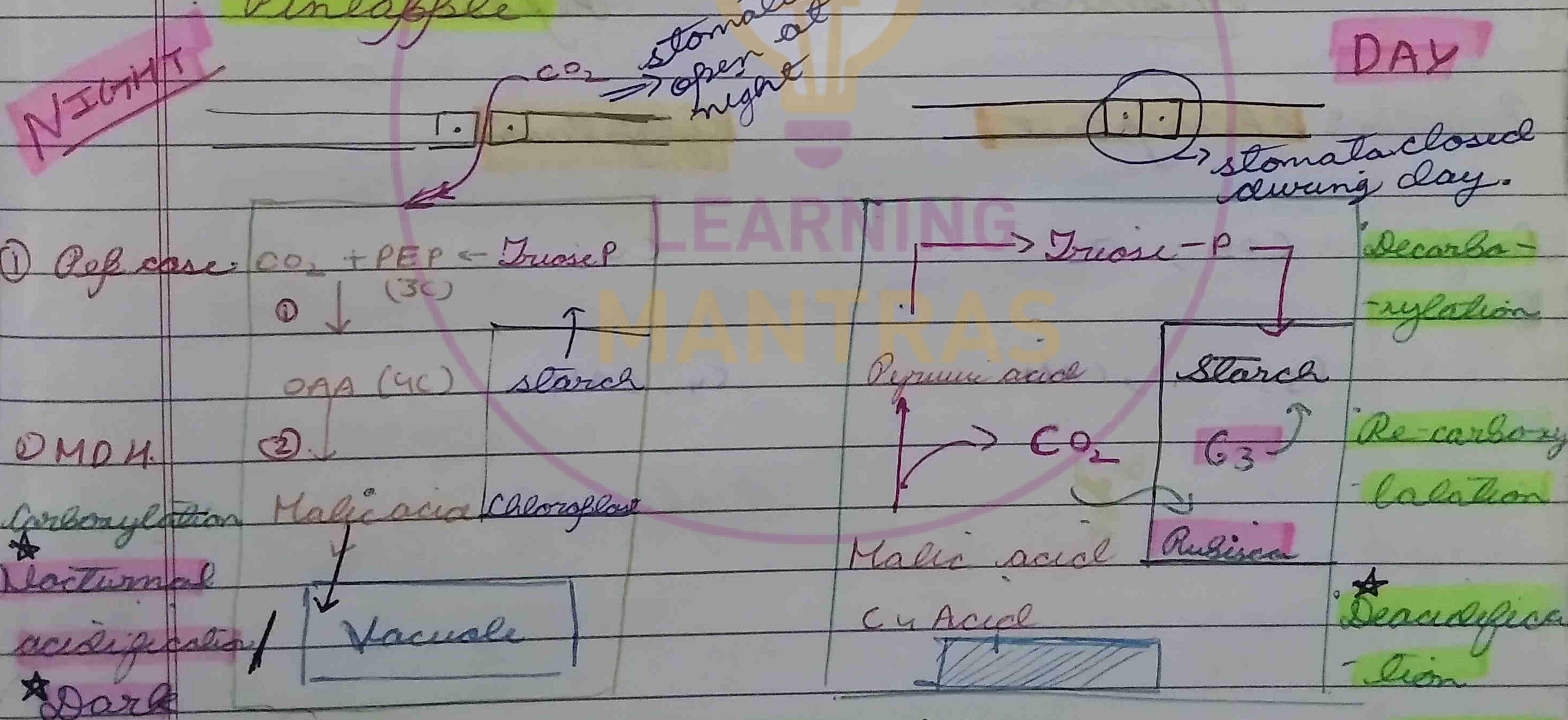
• Scotoactive stomata → open (night) / → close (day)

Kranz anatomy ✗

MSC (CO_2 fixation)

CO_2 fixation ⇒ 2 times because 2 enzymes present

• Kalanchoe
• Sedum
• Opuntia
• Pineapple



Mesophyll Cells

MDH: Malate Dehydrogenase

★ In CAM plants ~~photosynthesis~~ phosphorylation occurs in mesophyll cells during day time

	C_4		CAM	
1st Carboxylation	MSC	Day	MSC	Night
2nd Carboxylation	BSC	Day	MSC	Day

- Spatial differentiation because both I, II carboxylation occur in different compartments.
- Temporal Variation differentiation because I, II Decarbox... at different time.

Rubisco	Pepcase
Present in: chloroplast	Cytoplasm
Can fix: CO_2, O_2	CO_2
C_3, C_4, CAM	C_4, CAM
	(Higher affinity for CO_2)

☆ Transpiration ration: no of ~~CO_2~~ H_2O released per CO_2 fixation.

* CO_2 compensation →* when rate of CO_2 fixation by photosynthesis is equal to rate at which it released by respiration.

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*value of CO_2

Plant No.	C3	C4	CAM Plants
1	94%	< 1%	5-6%
2	Kranz anatomy ✗	✓	✗
3	✗	Chloroplast Dimorphism ✓	✗
4	Times - CO_2 fixation 1 - Rubisco	Ist → Pepcase IInd → Rubisco	Ist → Pepcase IInd → Rubisco
5	Photorespiration ✓	✗	✗
•	Productivity Low	Highest	
6	CO_2 compensation pt = 25-100 ppm	0 - 10 ppm	0 - 5 ppm
7	Transpiration ratio : H_2O lost per CO_2 fixed 600	300	50
8	Sodium ✗ Phospho Pyruvic ✗ dikinase	✓	✓

* CO_2 fix (Photosynthesis) = CO_2 release (R) respiration

mycompanion

	Plant	Bacteria
1	Photosystem = 2 PS I — PS II P700 — P620	One (GSP, PSB) B870 / B890 except Cyanobacteria
2	2 - H_2O ↓ O_2 release Oxygenic	H_2O ↓ O_2 X Anoxygenic except cyanobacteria
3	e- donor H_2O	H_2S, Na thiosulphate (Na ↓ sodium)
4	ATP, NADPH	ATP, NADH

this effect show the presence of two photosystem — Red drop, Enhancement

X

∴ only one photosystem is present.

Factors → Affecting Photosynthesis

Genetic makeup

Internal Factors — Plant

Growth of plant

→ No, size, age and orientation of leaves, mesophyll cells and chloroplast

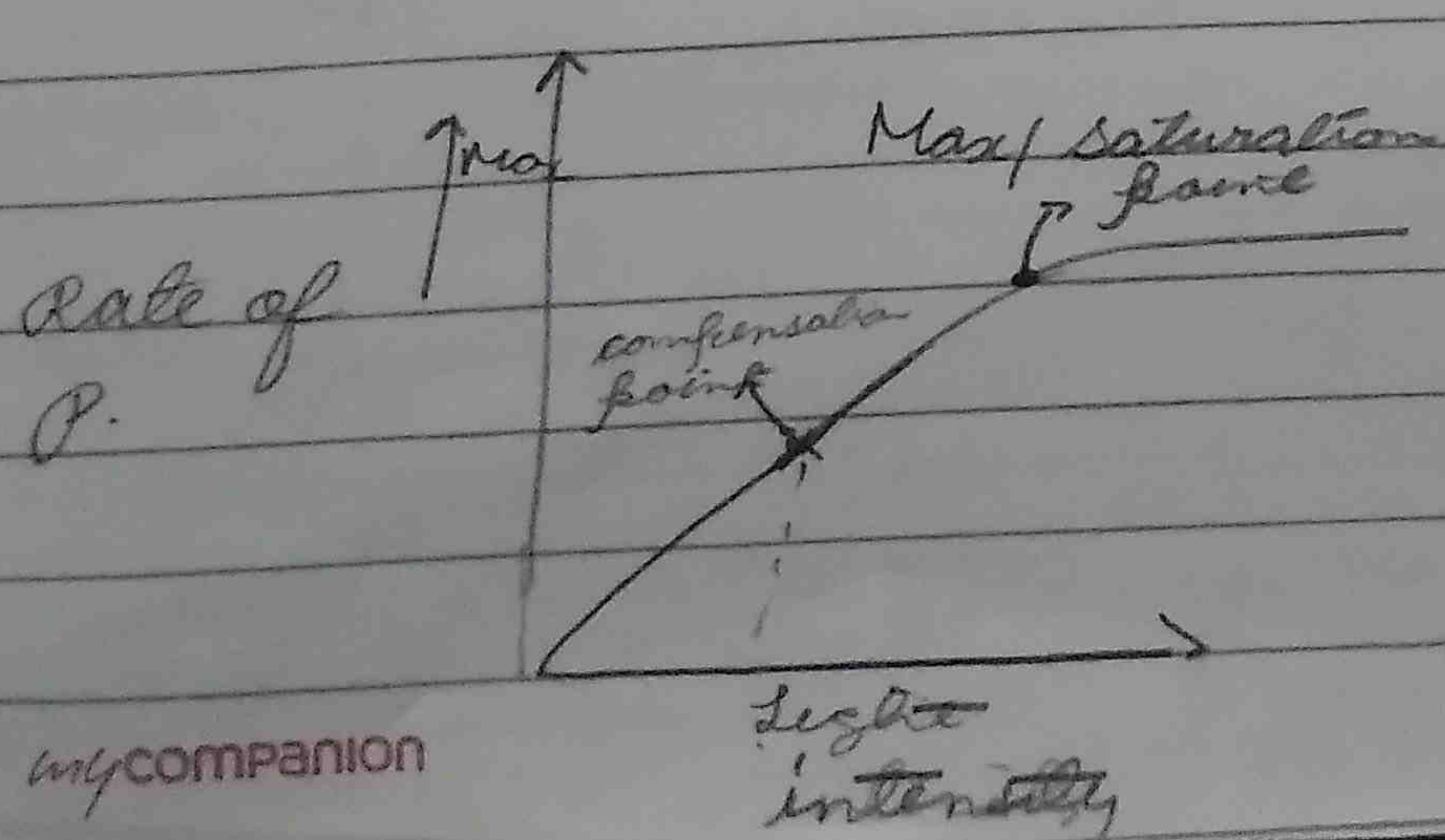
→ Chlorophyll amount

External Factors — environment

- H_2O
- Light
- CO_2
- Temperature
- O_2

Blackman's Law of Limiting factor (1905): When a chemical process is affected by more than one factor, the rate is determined by the factor present at its minimal value.

① Light → Light intensity
→ Light quality
→ duration



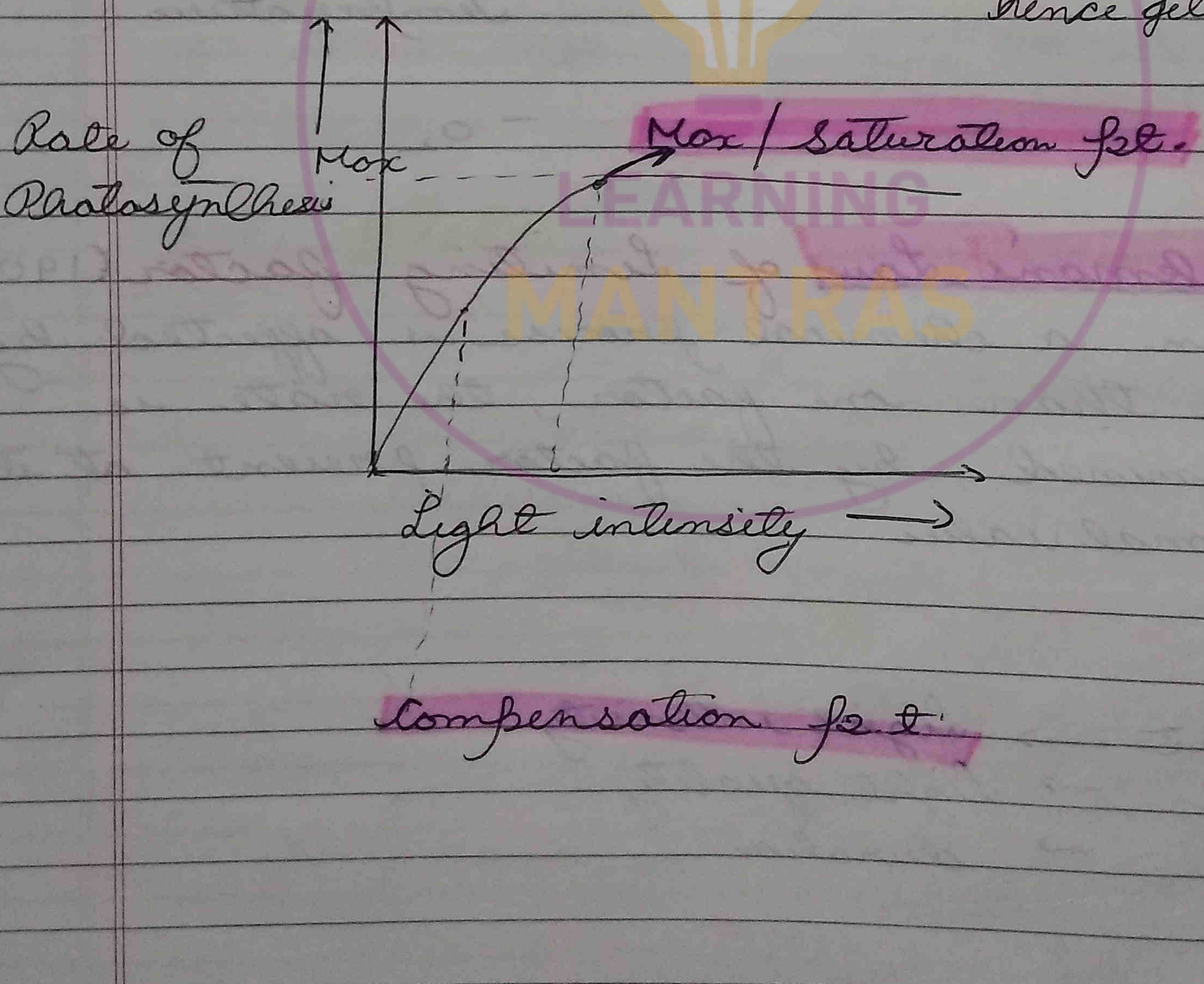
- Saturation point occurs at
- 10% of full sunlight causes saturation.
- Rarely a limiting factor for plants.
- Dense forest (limiting factors)

Rate of Photosyntheses ↓ if light intensity further increased ↑

This is known as → Photo-oxidation

Solarisation.

It is because of two reasons → Photoinhibition: PS II ↑ more sensitive hence gets inhibited



→ Increase in CO_2 will mainly benefit C_3 plants.

2 CO_2

Most limiting factor

	CO_2 compensation	Saturation pt
C_3	25 - 100 ppm	→ 450 ppm → (CO_2 ↑ · Photosynthesis ↑ · CO_2 fertilisation effect)
C_4	0 — 10 ppm	360 ppm

3 H_2O
↓
1% of Ab H_2O is utilised for photosynthesis

Direct ✗

Indirect
→ Stomata closure
→ Wilting leaves
→ Metabolic activities ↓

	Temp opt	
4 C_3	20 - 25°C	Temp ↑ Photorespiration Photosynthetic ↓
C_4	30 - 45°C	→ If Temp ↓ Phospho Pyruvic dikinase ✗

5 O_2 ↑

- Photorespiration ↑ / Photosynthesis will decrease

Warburg Effect
Chlorella

With increase in O_2 photosynthesis activity of plant decreases known as Warburg effect.

5 Herbicides which inhibit photosynthesis

☆ DCMU
Inhibits → PS II ×

☆ Paraquat
☆ Diquat
Inhibits → PS I ×

DCMU → Dichlorophenyl dimethyl urea.