11/12/19 L-1

PHOTOSYNTHESIS

* $6CO_2 + 12H_2O \xrightarrow[\text{Pigments + enzyme}]{\text{solar energy}} C_6H_{12}O_6 + \underbrace{6O_2}_{\text{from water}} + 6H_2O$

$H_2O \xrightarrow[\text{light Rxn}]{\text{oxidatn}} 2e^{\ominus} + 2H^+ + \frac{1}{2}O_2 (\uparrow)$

Light is necessary for reductn of $CO_2 \rightarrow$ Glucose.

$CO_2 \xrightarrow[\text{Dark Rxn}]{\text{Reductn}} C_nH_{2n}O_n$

* Radioactive $\rightarrow O^{18}$
* During photosynthesis water is oxidised but CO_2 is reduced.
* Main functn of water to provide $e^{\ominus}$ & $p^{\oplus}$ + O_2 is by product.
* 1st observable product of photosynthesis is "starch".

Ques. A plant is provided with $^{14}CO_2$, How many 3-PGA molecules will have radioactive carbon

Ans. 50%

$RUBP \xrightarrow{^{14}CO_2} 12 \times 3\text{-}PGA$

C–C–C ⁞ C–C–C

C–C–C   C–C–C

Ques. A plant is provided with $^{14}CO_2$, it leaves are chlorotic, Green parts show more ~~productivity~~ radio activity & Yellow parts also show some radioactivity

Ans. Photosynthetic product are diffused into yellow parts.
chlorotic leaves are not dead part they are just mineral deficient. so photosynthesis product will also go into them.

MECHANISMS OF PHOTOSYNTHESIS

① LIGHT RXN

* Aka Hill Rxn.
* photochemical or non-enzymatic phase of photosynthesis.
* It is of 2 types.

① Non cyclic P.P

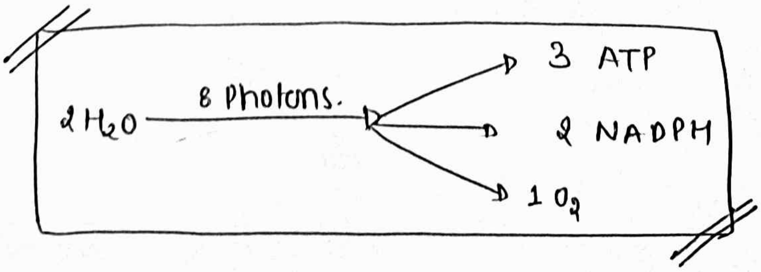
② cyclic P.P

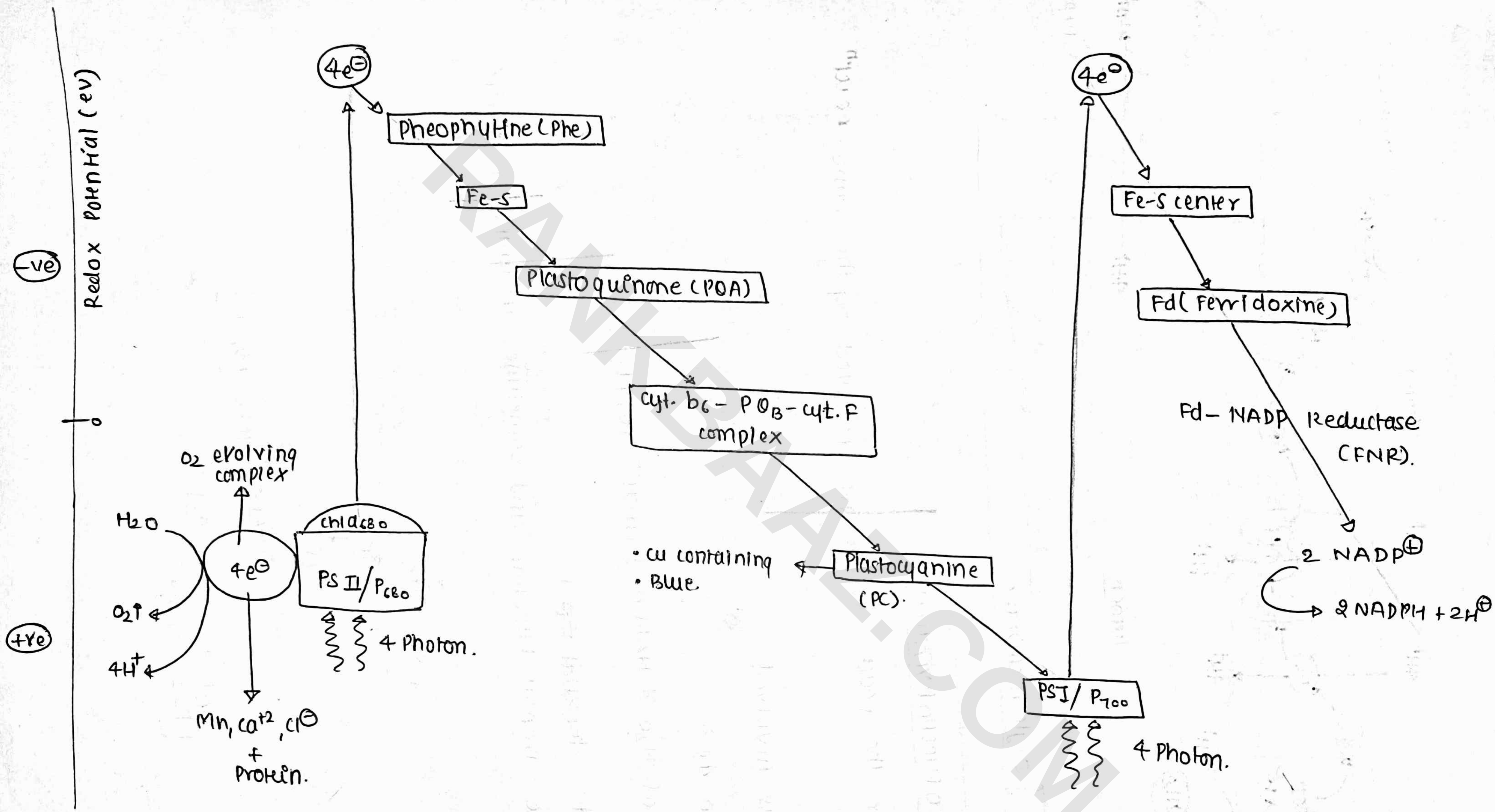
★ Non cyclic photophosphorylation.

* Aka ~~is~~ "Z- scheme" due to similarity with Z-letter.
* Both PS are involved
* 1^{st} step is oxidat^n of "chl a / React^n center."
* e⊖ donor → H_2O.
* e⊖ acceptor → Pheophytin (Phe).
* e⊖ donor of PS-I ⇒ Plastocyanin.
* e⊖ acceptor of PS-I Fe-S complex.
* it show 2 uphill, 2 downhill movement of e⊖.
* Quantum requirement = 8 i.e Photon req. to produce 1 O_2.

Quantum Yield = ~~1/2~~ $\frac{1}{8}$ O_2 is produced per photon.

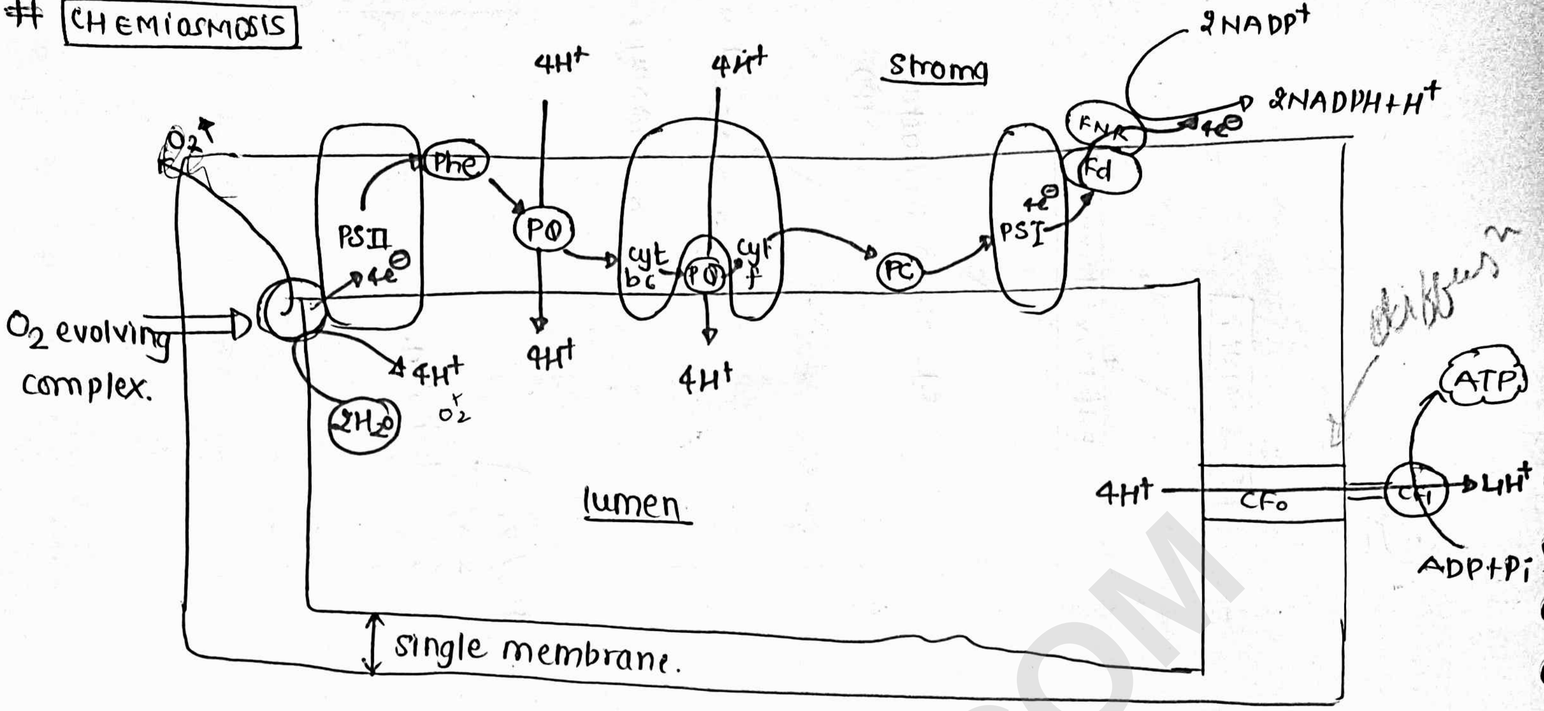
* 1 photon → 1 e⊖.





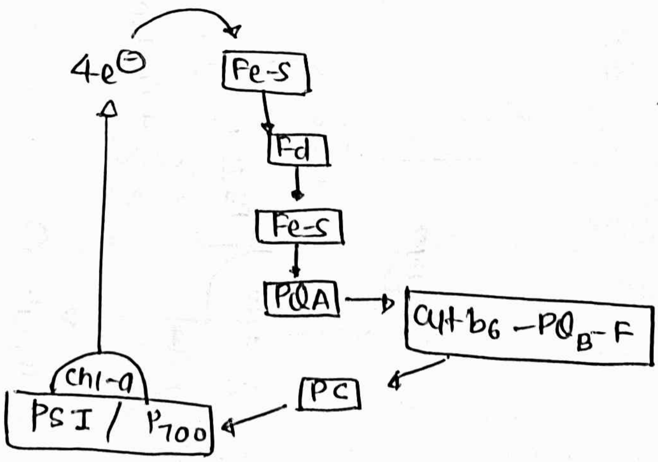
Redox Potential (ev)
-ve
0
+ve
4e
Pheophytine (Phe)
Fe-S
Plastoquinone (PQA)
cyt. b6 – PQB – cyt. F complex
Plastocyanine (PC).
• cu containing
• Blue.
O2 evolving complex
H2O
4e
O2
4H+
Mn, Ca+2, Cl
+
Protein.
chla680
PS II / P680
4 Photon.
PSI / P700
4 Photon.
4e
Fe-S center
Fd (Ferridoxine)
Fd – NADP Reductase (FNR).
2 NADP+
2 NADPH + 2H+

CHEMIOSMOSIS



CYCLIC PHOTO PHOSPORYLATION

* e⊖ emit from the reactn center are recieved by the same reactn center (PSI)
* only PSI is involved
* 2 ATP from 4e⊖
* photolysis of H_2O + NADPH formatn absent.
* ~~occurs in the stomatal exp~~ ।
* occurs in the stromal lamellae and sometime in grana in specific conditions.



✱ Photo / Pigment system

- **Reaction center** ($React^n$ center)
  - ✱ only 1 molecule of Chl-a
    - ↓ Diff. in both Pigment system
    - PSI – $Chl\text{-}a_{700\,nm}$
    - PSII – $Chl\text{-}a_{680\,nm}$ → Appressed part of Grana (Q.)
    - Pn
      - → Stromal lamellae
      - → Non appressed part of Grana.
- **Light Harvesting system** (LHC)
  - → Pst in all photosynthetic plants except bacteria i.e. जो O_2 release करते [illegible]
  - ✱ Antenna Pigments (Chl-a, Chl b & carotenoids) + Proteins.

✱ **PAR** = 400 nm – 700 nm

- → Photosynthetically active Radiations (Most of visible light)
- → Green light is also a part of PAR.

DARK RXN

✱ Also k/a "Blackmann's $React^n$" OR "C – $Reduct^n$" OR "C – $Fixat^n$" OR "enzymatic phase of photosynthesis"

✱ Term Dark rxn is a misnomer b'coz –

① It depends on the product of light rxn

② Enzymes of Dark rxn are light independent.

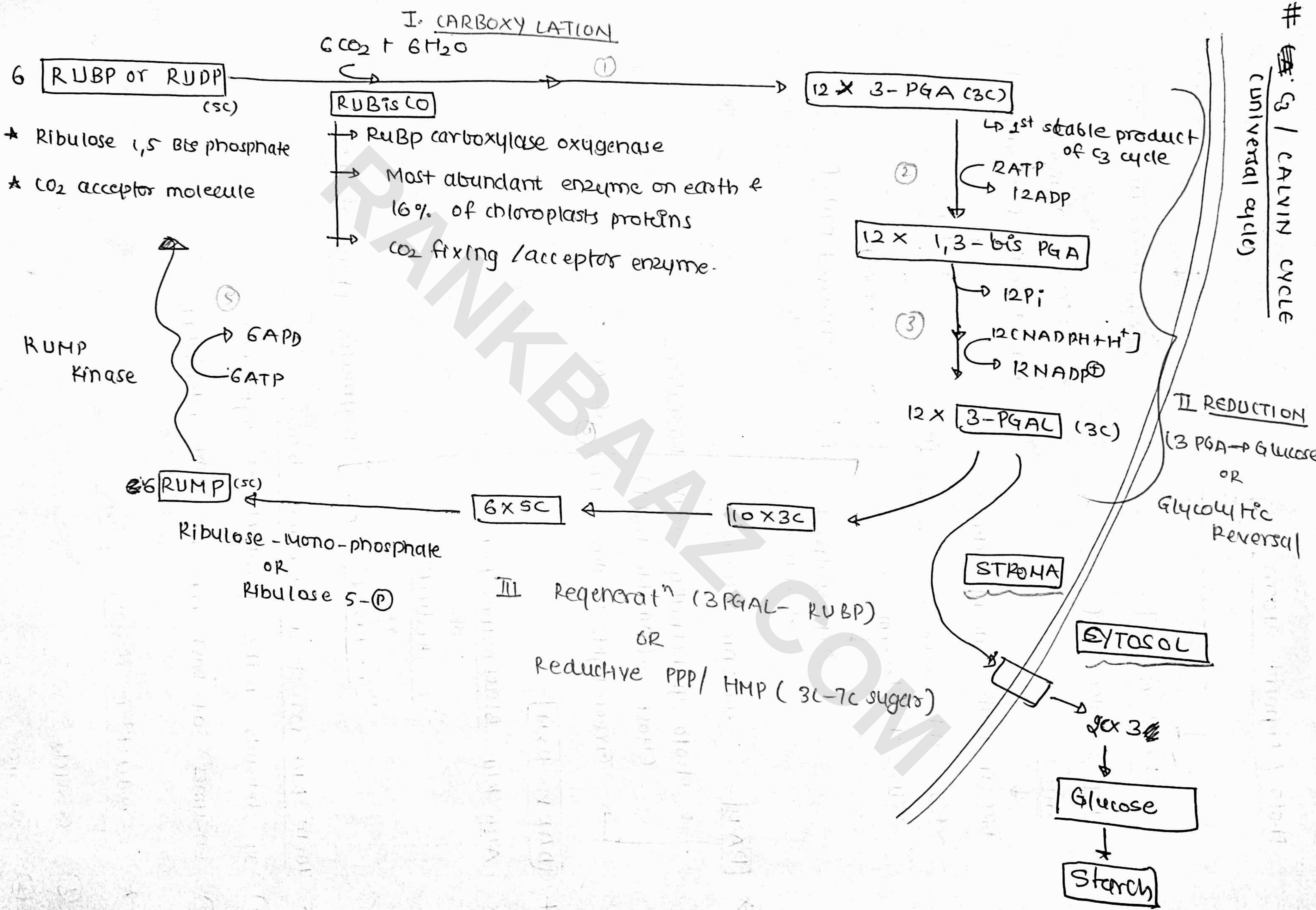
✱ C-$reduct^n$ is of following types:-

① C_3 cycle

② C_4 cycle

③ CAM

C3 / CALVIN CYCLE
(universal cycle)



Ques. on calvin cycle

* discovered by M. clavine + Benson with help of Radioactive isotope C^{14} in chlorella + Senedesmus

* They used $^{14}CO_2$, Paper chromatography + Autoradiography.

* FOR 1 Glucose formatn → 6 calvin cycle
  → Reductn of $6CO_2$
  → 18 ATP + 12 NADPH (54 ATP equivalents)
  → 48 photons in light Rxn

* FOR 1 CO_2 fixatn → 3 ATP + 2NADPH (reducing power) } Assimilatory Power.

* In Reductn step of clavin cycle only 2 ATP + 2 NADPH are used.

* C_3 cycle is universal in all photosynthetic organisms whether they are bacteria, C_3 plants, C_4 Plants, CAM plants etc.

16/12/19 L-3 TL-66.

SOLARISATION OR ~~ROLA~~ PHOTOXIDATION

→ during High light condition much more O_2 is produced + Temp. is ↑, which can cause oxidatn or destructn of photosynthetic pigments, enzymes etc. which is kla "Photoxidatn".

* RUBISCO has oxygenase activity which is used to protect the plant from solarisatn by photo respiration.

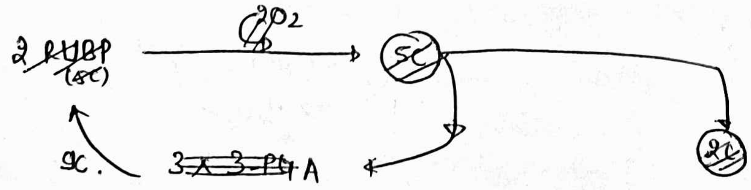


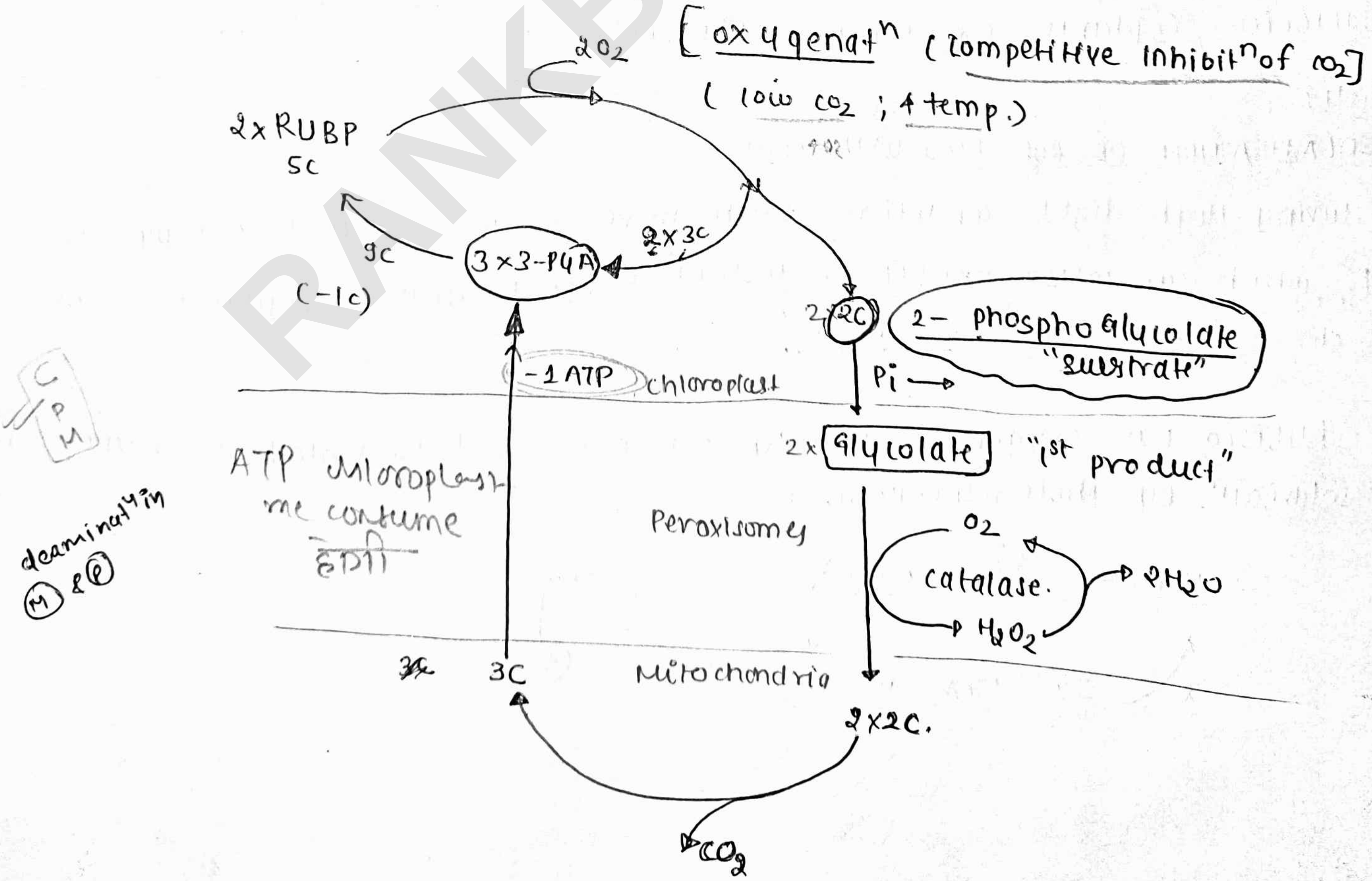
PHOTO RESPIRATION

* AKA Glycolate cycle.
* C_2 cycle or PCO [Photosynthetic carbon oxidatn]
* Discovered by Decker + Tio.
* It is a protective pathway which protect plant from solarisatn but economically it is wasteful pathway. b/c CO_2 as per NCERT
  i) it does not produce ATP + NADPH.
  ii) There is loss of carbon → 10%.
  iii) Loss of ATP.
  iv)
* Photo respiratn commonly observed in C_3 plants
  Negligible in C_4 + CAM plants.
* Photosynthetic productn is reduced by 25%.

$2CO_2 \longrightarrow 4 \times$ 3-PGA

$2O_2 \longrightarrow 3 \times$ 3-PGA

loss 25%.



C4 CYCLE / C4 PLANTS

* These are tropical desertic grasses for eg:-
  - sugarcane
  - Maize
  - shorghum (ज्वार)
  - ~~dicots~~
  - dicots → Amaranthus.

* These plants are ↑ly efficient for photosynthesis due to
  - ↑ no. of chloroplast
  - chloroplast dimorphism → in Mesophyll cells; → in Bundle Sheath cells.
  - Krenz anatomy in leaves
  - ↑ly reduced Photorespiratⁿ

* KRENZ ANATOMY (only in leaves)
  ↓
  wreathⁿ ⇒ concentric.

* found in leaves of C4 plants

* word Krenz (German word) ⟶ wreath (concentricness)
  so it represent concentric arrangement of Bundle sheath cell.

* chloroplast dimorphism

ⓐ Granal chloroplast

* in mesophyll cells grana + light Rxn +nt.

* C_3 cycle, starch granules, RUBISCO -nt.

ⓑ Agranal chloroplast

* Grana -nt or poorly developed, so light Rxn -nt.

* However cyclic photophosphorylatⁿ occur to provide extra ATP's.

* RUBISCO, C_3 cycle, starch granules +nt.

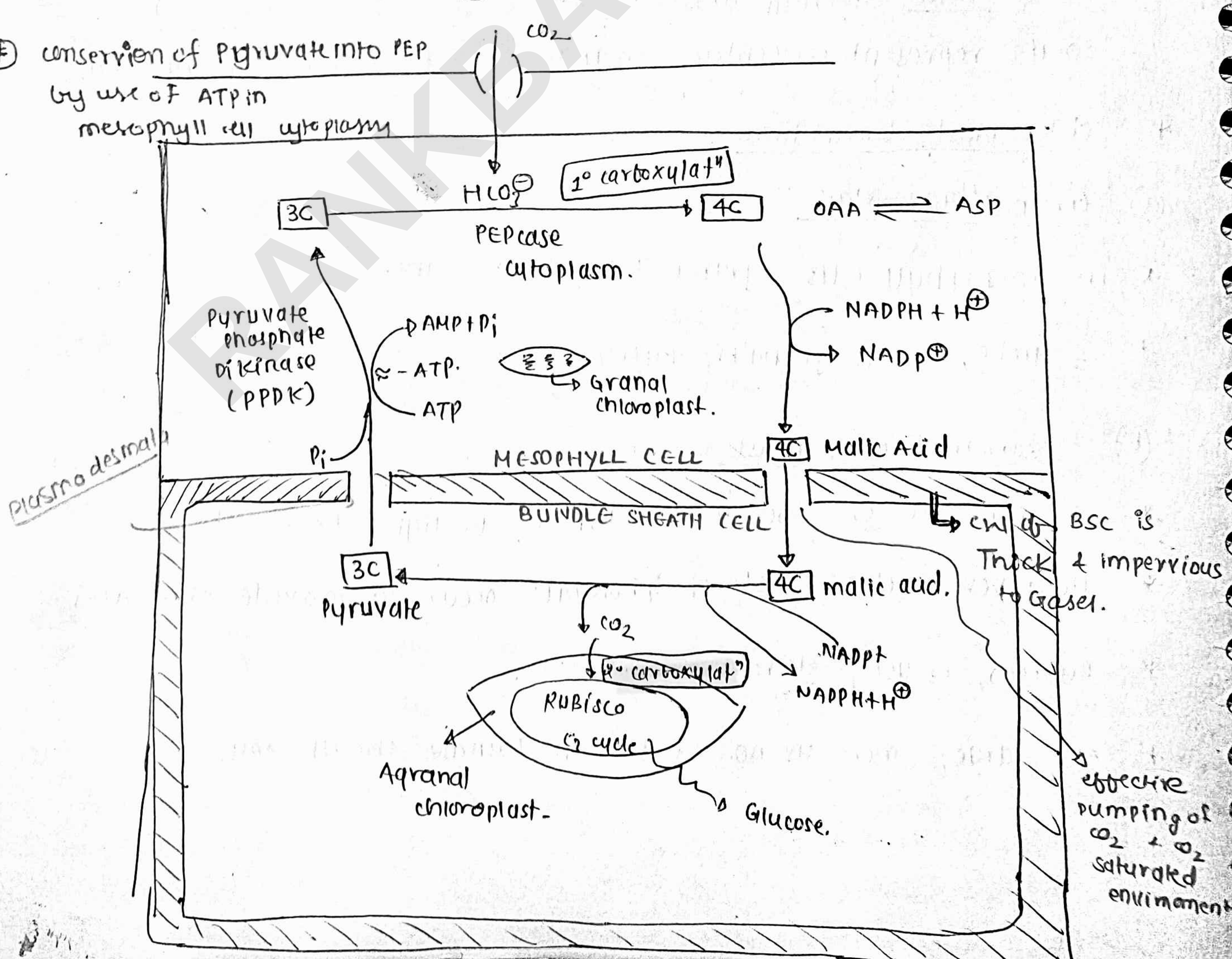
* Are large, more in no. + +nt in Bundle sheath cell.

C4 CYCLE

HATCH + SLACK PATHWAY

* discovered + detailed study by Hatch + Slack ∴ Termed as
* AKA "DCA cycle" b/102 its 1st stable product is O.A.A. which is a 4C dicarboxylic acid.
* 1° CO_2 acceptor :→ PEP.
* CO_2 acceptor :→ both PEP + RUBP.
* 1° CO_2 fixing enzyme → : PEPcase
* CO_2 fixing enzyme → both PEPcase & RUBisco
* Requirements for
  - 1 CO_2 fixat^n :- 5 ATP + 2 NADPH
  - 1 Glucose format^n :- 30 ATP + 12 NADPH (≈ 66 ATP)
* C4 plants are more efficient for C-reduct^n but more expensive [12 ATP's extra per Glucose].

(*) conversion of Pyruvate into PEP by use of ATP in mesophyll cell cytoplasm



CRASSULACEAN ACID METABOLISM

(CO_2 acceptor → Ribulose 1-5 bis phosphate)

* it was discovered in family crassulace. but found in many families of desertic succulents. (drought resistance Plants)
* eg:- Bryophyllum, Aloe, Agave, Pineapple, cactus, Euphorbia etc.
* These plants store Mucilage due to water Holding capacity & have a scotho active stomata i.e open at night due to dark activated PEPcase.

* Most of CO_2 is available at night which is reduced in form Malic acid by pep case, (dark acidificatⁿ) & store in vacoule.

* During day time, maleic acid provide CO_2 to RuBisCo [light deacidificatⁿ] (CO_2 acceptor)

* Metabolic pathway similar to C_4 cycle but all rxn occur in mesophyll cells. in diff. time periods.

* CAM plants do not show solarisatⁿ, photo respiratⁿ (Negligible), Krenz Anatomy, chloroplasts dimorphism.

CO_2 acceptor — Day → PEP; Night → RUBP

FACTORS AFFECTING PHOTOSYNTHESIS

① CO_2

* it is substrate for photosynthesis.

* CO_2 in atmosphere approx 350 ppm [300pm - 400pm]

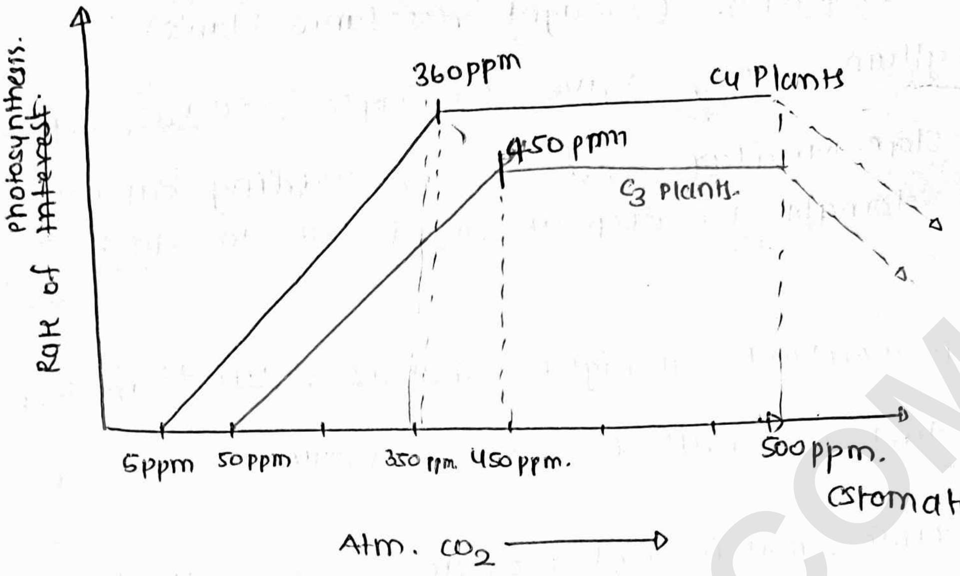
* saturatⁿ for C_3 plants → 450 ppm. & so CO_2 is the Natural limiting factors

* saturatⁿ for C_4 Plants → 360 ppm so these plant perform nearly best in best conditⁿ.

* compensatⁿ point:- Rate of Photosynthesis is decreased or fixed & become equals to rate of repisratⁿ due to CO_2 conc.

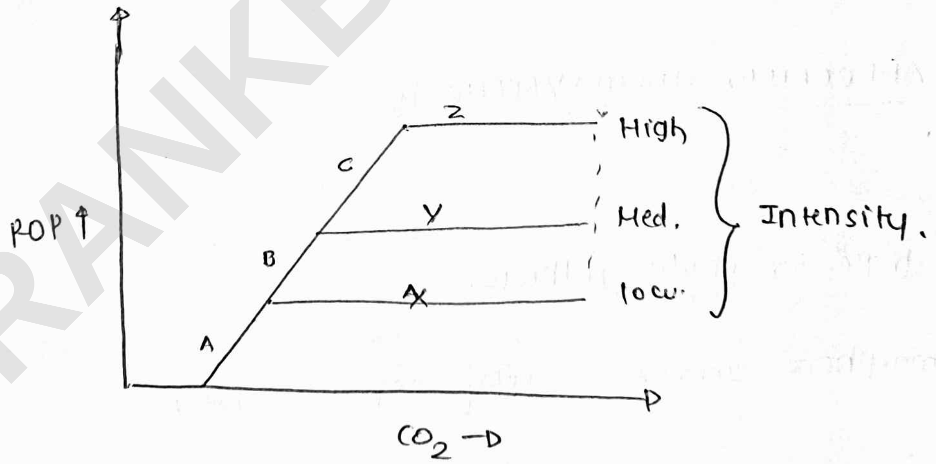
* during morning & evening time, changes are due to light intensity

* CO_2 → compensatⁿ point for C_3 = 40-100 ppm.
C_4 = 8 - 10 ppm.



* An increase in environment CO_2 will ↑ ROP mainly in C_3 Plants; that's why they may be grown in green ~~plan~~ Houses to ↑es productⁿ

eg:- • Tomato
• Bell pepper



- CO_2 is limiting at A, B, C
- L.I is limiting at X, Y, Z.

* Plant can't survive at compensatⁿ point for longer time.

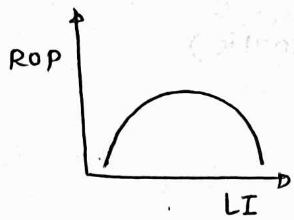
* In a day compensat^n point is twice, morning + evening due to light intensity.

② **LIGHT**

ⓐ **Quantity ξ**

→ light intensity

→ effect on the photorespirat^n



ⓑ **Quality (λ)**

PAR - 400 - 700 nm.

ROP = sun light > Mixed light > Red (680 nm) > Blue >>> Green (least).

* **Red Drop effect** → λ just above 680 nm (due to ↓es activity of PSII)

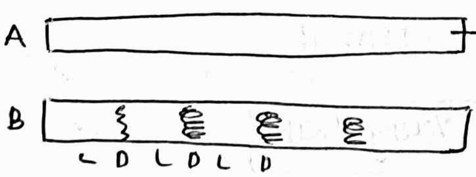
Red light effect PSII

* Emerson's enhancement effect + Red drop effect proves the existence of 2 photosystems.

ⓒ **Duration**

→ No effect in Natural conditions.

** Warburg's light intermittent experiment



→ ROP is ↓ed if continous light is provided of 3-4 days. due to accumulat^n of products (starch).

* Normally 10% sunlight is sufficient for plants so, usually light is not a limiting factor.
except plant growing in dark habitats like dense forest + deep water bodies.

③ **Temp.**

* Optimum temp. for C_3 plants → 20 - 25°c
  for C_4 plants → 30 - 40°c

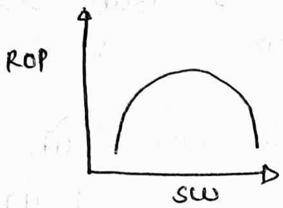
* $Q_{10}=1$ for light Rxn
  $Q_{10}=2$ for dark Rxn. (being enzymatic)

④ **OXYGEN**

ROP ∝ $\frac{1}{O_2 \text{ conc.}}$ ⇒ warburg's effect

⑤ **WATER**

soil water



⑥ **INHIBITORS**

* DCMU ⇒ (Dichloro phenyl Di methyl urea)

* DCMU & CMU Block e^- transport from PS II to PQ.

★ **Internal factors**

* storage of excessive starch will reduce ROP
* chlorophyll is usually supra optimal
* ROP in mature leaf > Young leaf

BACTERIAL PHOTOSYNTHESIS

* excluding BGA

* Most primitive + anoxygenic b'coz they do not use ~~water~~ water as $e^{\ominus}$ + $p^{\oplus}$ donor.

* only 1 pigment system ~~B810-890~~ $B_{870} - B_{890}$ nm. + cyclic photo-phosphorylat^n are tnt.

* Assimilatory power are ATP + NADH.

20/12/19

L-5

TL-68

Starch Test

↳ KI sol. → colourless → starch -nt
→ Blue → starch tnt

To destrach a plant :- Kept in complete darkness for 3-4 days.

* Demonstrations:-

(A) CO_2 is required :- Moll's Half leaf experiment (with KOH)

(B) Light is required :- Ganong's Photoscreen or Black chart

(C) chlorophyll's req. :- variegated leaves of Pathos or coleus

(d) O_2 Produced in photo. :- By Hydrilla