Dicker & Tio 17-1959.

Photorespiration / PCO / C2 Cycle

⇒ Introduction :-

* ~~Defn~~ * The word 'Photorespiration' is made up of two words, ⇒ • Photo → meaning light.
  • Respiration → meaning taking in O_2 & giving out CO_2

⇒ * **Definition** :- Photorespiration is a process of light dependent uptake of molecular Oxygen (O_2) accompanied with the release of carbon di oxide (CO_2) from organic compounds.

PCO * It is also called as Photosynthetic Carbon Oxidation / C_2 cycle.

* It is the characteristic feature of C_3 plants.

⇒ * **Discovery** :- • The photorespiratory pathway was discovered by Dicker & Tio 1959.

* in 1959 when they observed that the rate of respiration of green leaves is much higher in light than in the dark.

• W.L. Ogren et al. discovered the dual role of Rubisco.

~~Photorespiration :~~

⇒ RubisCo enzyme :-

* RuBisCo is a 'Thermolabile enzyme.
* RuBisCo has an active site on which CO_2 & O_2 binds competitively.
* Rubisco has more affinity towards CO_2.
* But when Concentration of O_2 > CO_2, it will bind with O_2.
* It is the most abundant enzyme on earth.

Teacher's Signature

RuBP RuBisCO — O_2 → Photorespiration.
RuBP RuBisCO — CO_2 → Calvin cycle.

⇒ Environmental Conditions favouring photorespiration

* High light intensity & high temperature.
eg: Sunny noon.
↓
Stomata gets closed to avoid transpiration.
↓
CO_2 cannot enter mesophyll cells from atmosphere.
↓
O_2 is produced in light reaction.
↓
$O_2 > CO_2$ in mesophyll cells.
↓ result in
Photorespiration instead of Calvin cycle.

⇒ Photorespiratory pathway :

* Sites of photorespiration :— Photorespiration takes place in three organelles. CPM
1) Chloroplast
2) Peroxisome
3) Mitochondria.

* The gas exchange resembles respiration and is the reverse of photosynthesis where CO_2 is fixed and O_2 is released.

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RuBisCO → Ribulose Bisphosphate Carboxylase/Oxygenase

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* When the CO_2 levels inside the leaf drop to around 50ppm, Rubisco starts to combine O_2 with RUBP instead of CO_2.

* Rubisco fixes oxygen, by acting as Oxygen
  - → One molecule of PGA &
  - → One molecule of 2-phosphoglycolate

  are formed.

* The plant must get rid of the phospho-glycolate since it is highly toxic.

* It converts the molecule to glycolate.

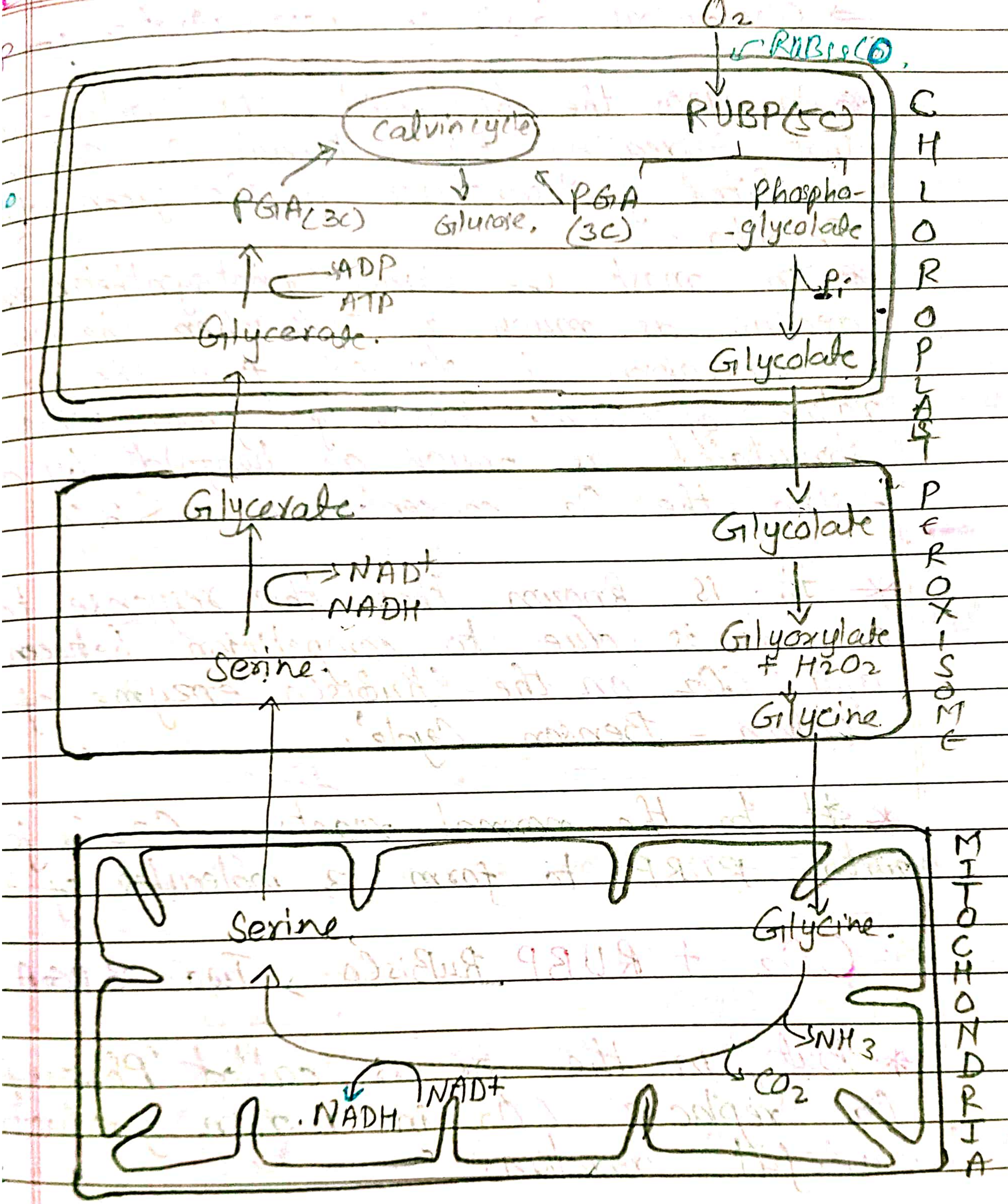
* ~~Glycolate is converted into Glyox~~

* Glycolate is ~~then~~ transported to the peroxisome and there converted into Glyoxylate and then to Glycine.

* Glycine is transported to Mitochondria where it gets converted into Serine.

* Serine enters into Peroxisome then ~~Hydropyruvate & then~~ to Glycerate.

* Glycerate is again transported to Chloroplast where it is converted into a three Carbon molecules PGA.
* It will enter into the Calvin Cycle.



Photorespiratory pathway in plants

Oxygen used = 2

CO_2 lost = 1 (25%)

CO_2 conserved = 3 (75%)

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⇒ Biochemical basis of Photorespiration :-

* In 1920s, the biochemist Otto Warburg discovered that increasing the external O_2 concentration inhibited photosynthesis in the green alga Chlorella.

* In most C_3 plants, photosynthetic rates decline as much as 50% when the O_2 concentration is doubled from the ambient value of 21%. Conversely, photosynthesis is stimulated as much as twofold by decreasing the O_2 concentration to < 2%.

* It is known that this response to oxygen is due to competition between O_2 and CO_2 on the 'RuBisCo' enzyme of the 'Calvin - Benson Cycle'.

* In the normal reaction, CO_2 is joined with RUBP to form 2 molecules of 3 PGA.

$$CO_2 + RUBP \xrightarrow{RuBisCo} \text{Two 3 PGA}$$

* But, in the process called 'Photorespiration', O_2 replaces CO_2 in a non productive wasteful reaction.

$$O_2 + RUBP \xrightarrow{RuBisCo} \text{One 3PGA} + \text{Phosphoglycolate}$$

Phosphoglycolate → CO_2

Teacher's Signature

* High rates of photorespiration are restricted to C_3 plants.

* C_4 and CAM plants have evolved relatively sophisticated biochemical mechanisms that limit photorespiration by concentrating CO_2 at the site of carbon fixation.

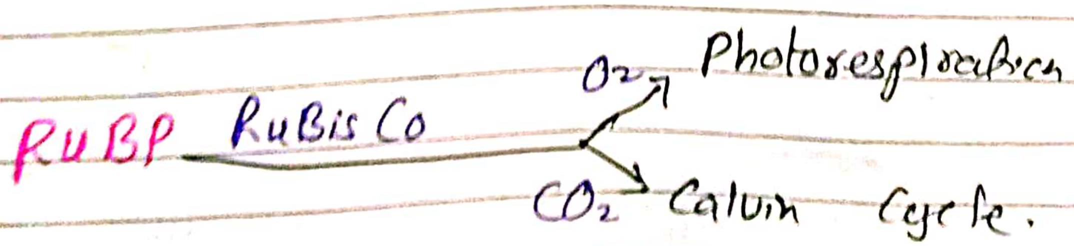
* Many oxygenic photosynthetic organisms living in aquatic environments, including algae, cyanobacteria, and some plants have also developed mechanisms for minimising the rate of photorespiration.

* The origin of photorespiration is found in the kinetic properties of Rubisco.

→ Rubisco enzyme :-

* RuBisCo is a 'thermolabile enzyme.

* It has an active site on which CO_2 or O_2 binds competitively.
* It has more affinity towards CO_2.
* When $CO_2 \geq O_2$, RuBisCo binds with CO_2.
* But when $O_2 > CO_2$, RuBisCo binds with O_2.



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⇒ Conclusion :-

* The end result is that,
  → Photorespiration decreases the net amount of Carbon dioxide which is converted into sugars by a photosynthesizing plant.
  → By interfering with photosynthesis in this way, photorespiration may significantly limit the growth rate of some plants.