Chap # 13

Photosynthesis

Structure and function of chloroplast:

=) Watery material inside: Stroma — ground substance.

=) For light independent stage (Calvin cycle)

=) Contains enzyme — rubisco

=) also ~~sug~~ sugars, lipids, starch, small ribosomes, circular DNA (for protein synthesis needed)

=) Apart from the two membrane of envelope, there are more membrane inside.

=) called Lamellae.

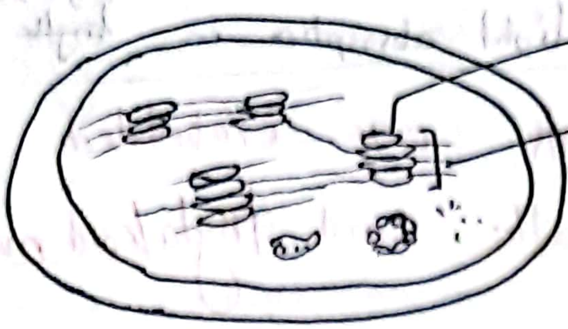
=) filled with fluid : Thylakoid
1 lamaella

=) Grana are stacks of thylakoids

=) Grana hold photosynthetic pigments
↳ have ~~...~~ large surface area
for max. light absorption

=) Pigments are arranged in photo-System.

=) Membranes of thylakoid hold
electron carriers for
photophosphorylation.



Within a chloroplast.

- ~~thyla~~ thylakoids (membrane and space)

which occur in stacks are called Grana.

- Site for Light-dependent Stage.

- Stroma is the site of light-independent Stage.

Role of Chloroplast pigment in light absorption in thylakoids.

Photosynthetic Pigments are embedded tightly in the Lamallae and thylakoid membrane

The pigments in a thylakoid membrane are arranged in ~~cluster~~ clustern called ~~Photosystem~~ Photosystem.

The pigments absorb light energy and channel it to the reaction centre

Photosystem 2 types → ① PS I : 700 nm. ② PS II : 680 nm.

The Reaction Centre for both PS is two molecules of Chlorophyll a

Chlorophyll b, carotene, and Xanthophyll — help to channel energy harvested to chlorophyll a, in reaction centre.

Chlorophyll b absorb light energy not absorbed by chlorophyll a.

Chlorophyll a → absorb red light
" b → " blue/violet "

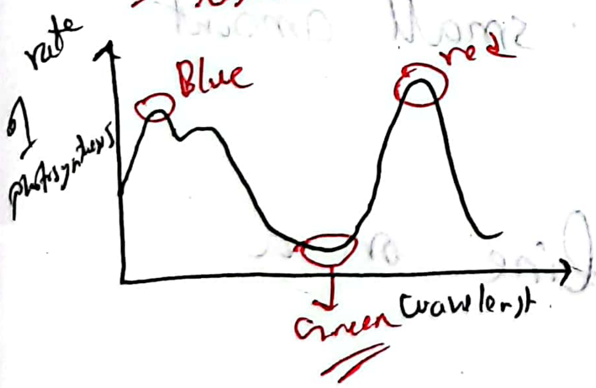
Carotenoids absorb → Blue/violet "
(carotene+ xanthophyll)

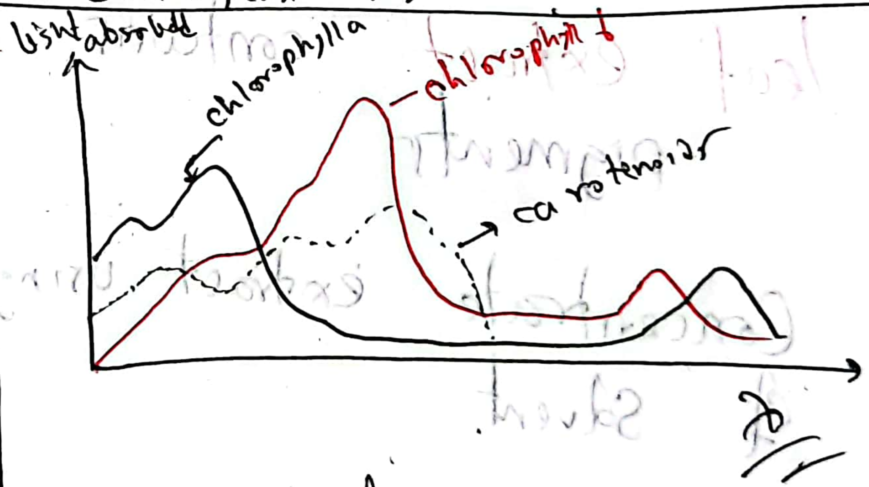
Primary pigments : Chlorophyll a

Accessory " : Chlorophyll b ~~Ch~~ ~~carton~~ carotenoids.

Action Spectrum for photosynthesis	Absorption spectrum of Chloroplast pigment.

Shows rate of photosynthesis at different wavelengths of light.





→ Blue light has more energy
∴ so more light absorbed by chlorophyll and higher rate of photosynthesis.

Shows different wavelengths of light absorbed by the different pigments during photosynthesis

Green light is reflected and other light absorb by chlorophyll.

Chromatography:

=> Grind and crush leaf in a solvent: propanone and petroleum ether

=> leaf extract contains mixture of pigments

=> Concentrate extract using small amount of solvent

=> Using pencil, draw a line on a chromatography paper.

=> Place extract on base line (using pipette)

=> Dry and repeat.

=) Paper placed vertically in jar of different solvent.

=) Solvent rise up the paper.

=) Each ~~Pigment~~ travels at different speed.

=) Pigments ~~are~~ ~~sp~~ seperated as they ascend.

=) measure distance travelled by pigment & solvent

R_f

Outline of photosynthesis

Photosynthesis

Grana — Light-dependent stage

Chlorophyll absorb light energy used to split H_2O into $H_2 + O_2$

$$H_2O \longrightarrow H_2 + O_2 \text{ (photolysis)}$$

The energy in H_2 is used to make ATP and reduced NADP

~~Products:~~

Reactants	Products
1) Light energy	ATP
2) water	O_2
3) oxidised NADP	reduced NADP

Stroma — Light-independent stage

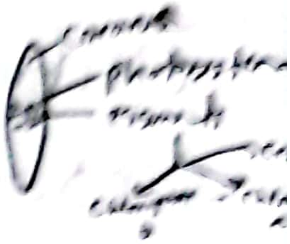
The energy in ATP and H in reduced NADP is used to reduce CO_2 to form carbohydrate in Calvin cycle

Reactants	Products
CO_2	Carbohydrate
ATP	
reduced NADP	

Light dependent Stage :

⇒ cyclic and non-cyclic ~~phosp.~~ photophosphorylation occur during Light - dependent Stage

Details :



Cyclic Photophosphorylation :

⇒ Cyclic Photophosphorylation involves only photosyst

⇒ PSI absorbs light energy at 700nm wavelength

⇒ which is chlorophyll b.

⇒ surround the reaction centre and chloroph a.

⇒ So now absorb light energy and pass the energy to chlorophyll a or reaction centre.

⇒ Light energy absorbed result in electron excitation in reaction centre [Photoactivation] (photophosphorylation).

=) electrons emitted reaction centre.

=) passes to electron acceptor

=) electron passes along chain of electron carriers.

=) ~~elet~~ electron gradually loses energy

=) The energy is used to move ~~pto~~ protons across the ~~thl~~ thylakoid membrane into thylakoid space from stroma

=) Then ~~electrons~~ H^+ ions ~~do~~ moved back into stroma through ATP synthase by facilitated diffusion down the concen. gradient, Providing energy for of ATP synthesis.

so ATP synthesised.

Non-cyclic photophosphorylation

=) Involves both PS I & PS II

=) Energy from light absorbed by both ~~the~~ photosystems.

=) and excited electrons are emitted from their ~~e~~ reaction centre.

=) ~~Pto~~ Photoactivation of A chlorophyll a described ....

=) The energetic electron emitted from PS II is used to synthesis ATP (Photophosphorylation)

=) The energetic electron emitted from PS I is passed to coenzyme ~~NA~~ NADP and produce reduced NADP.

=) Photolysis of water

=) Releases H^+

=) by PSII by enzyme called Oxygen-evolving complex.

PSII :

$$H_2O \rightleftharpoons 2H^+ + 2e^- + \frac{1}{2}O_2$$

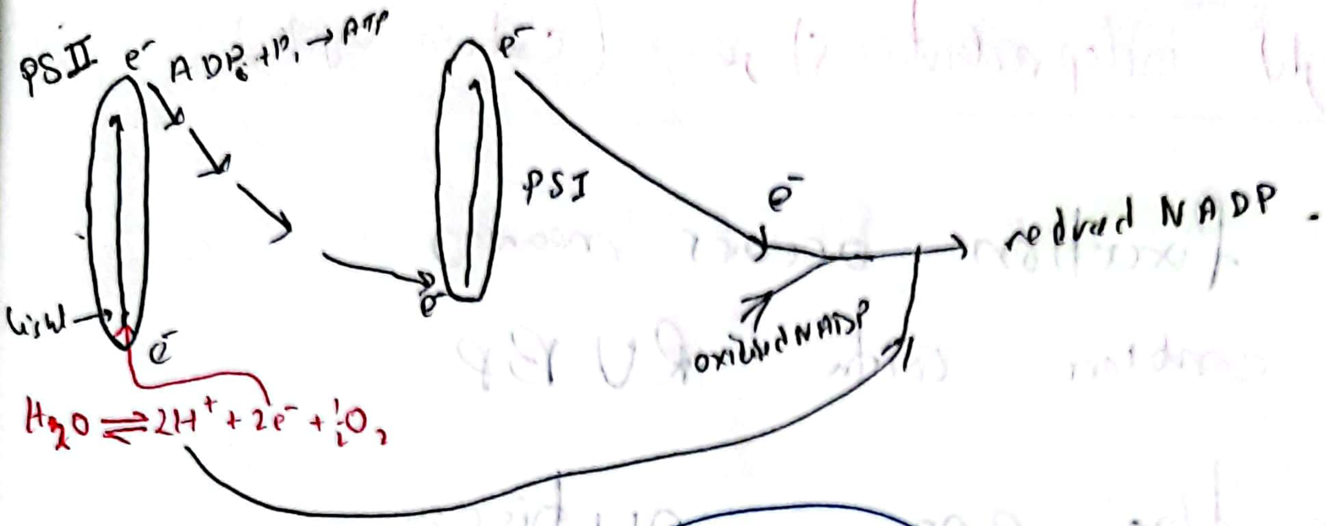
Catalyses by

=) Electron released from PSI and H^+ from PSII combine with NADP ~~to~~ to form NADPH.

$$2H^+ + 2e^- + NADP \longrightarrow \text{reduced NADP.}$$

=) Electron ~~lost~~ lost by PSI is replaced by electron lost by PSII

=) Electron lost by PSII is replaced by electron from H_2O photolysis.



PS I	PS II
1) Photoactivation → electron produced used in reduction of NADP	1) Photoactivation → electron used to produce ATP.
	2) Photolysis : $H_2O \rightleftharpoons 2H^+ + 2e^- + \frac{1}{2}O_2$

2)

e⁻

H⁺

NADP

reduced NADP.

The light independent stage (calvin cycle)

2) CO_2 fixation occurs meaning CO_2 combines with RUBP

=) Using the enzyme rubisco.

) 6C compound formed is unstable

hence 2 molecules 4 GP formed.
(3C)

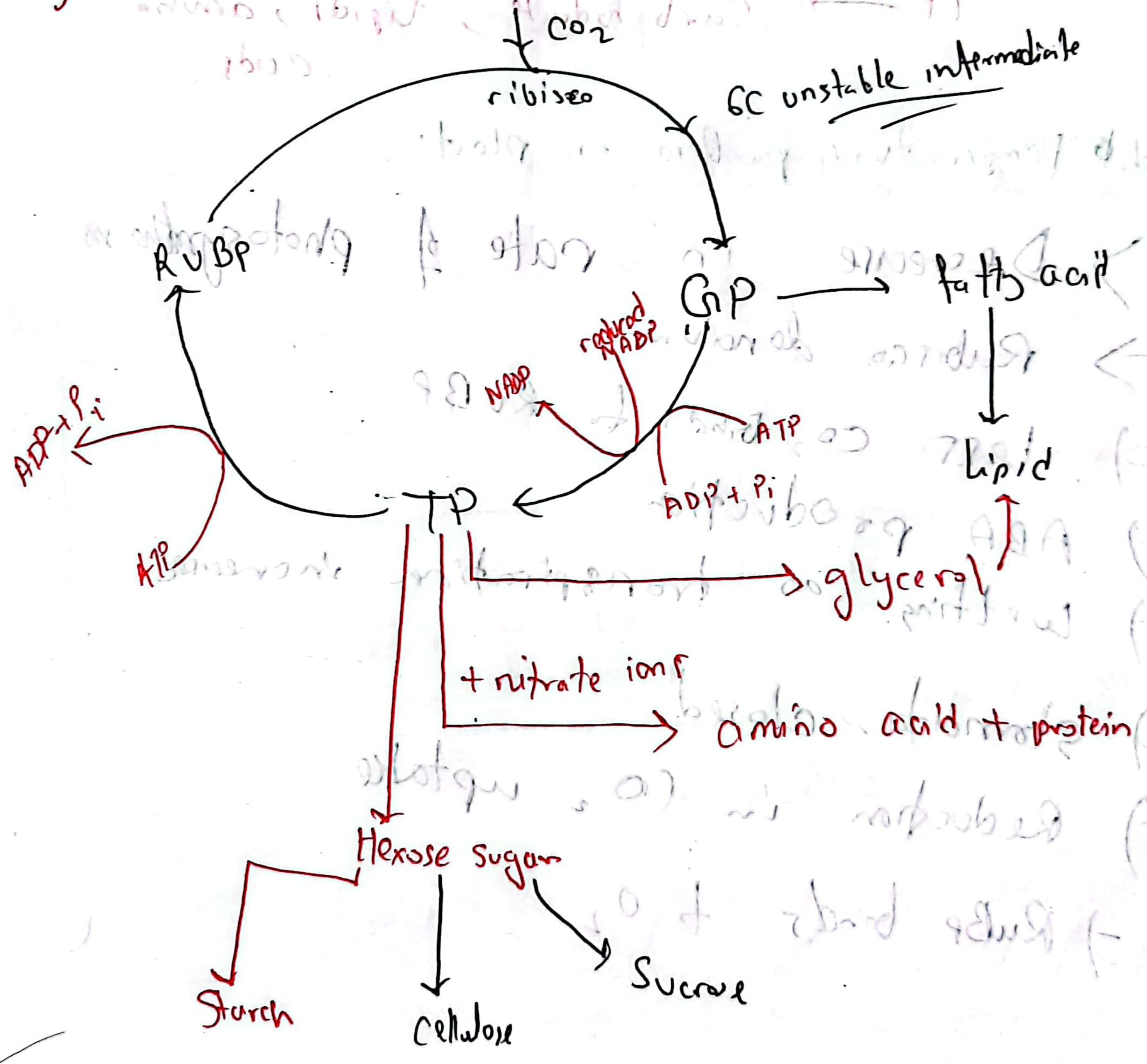
$GP \xrightarrow{\text{reduced}} TP$

Using ~~enzyme~~ ATP and reduced NADP from light dependent stage.

GP/TC combines with nitrates ions to form amino acids.

=) Ions enter via roots need ATP.

=) Some of the TP ~~many~~ may be used to rejenerate RuBP to continue Calvin cycle.



(*)(*) Calvin cycle intermediates are used to produce other molecules.

GP ⟶ Some amino acids.

TP ⟶ Carbohydrate, lipids, amino acids.

High temperature problem on plant:

⇒ Decrease in rate of photosynthesis.

⇒ Rubisco denatured

⇒ less CO_2 binds to RuBP

⇒ ABA production

⇒ wilting as transpiration increased

⇒ stomata closed

⇒ Reduction in CO_2 uptake

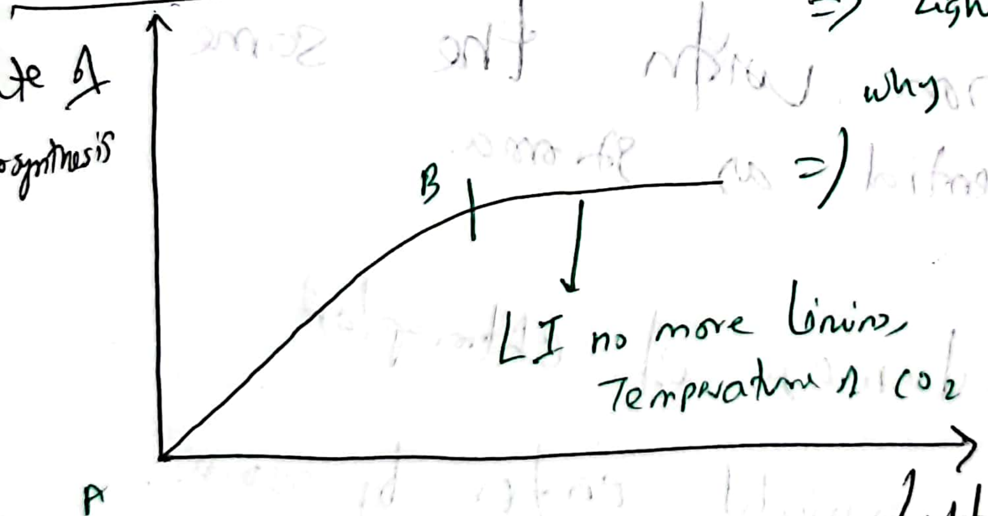
⇒ RuBP binds to O_2.

Investigating limiting factors:

=) At lowest value or in short ~~sq~~ supply
=) the one factor of several that affects rate.

=) a process is affected by more than one factor

Effect of light intensity



A => B
=> Light increases, rate increases
why
=) more light energy absorbed
=) more faster photolysis.

=) more electrons released
=) more faster proton released

Investigations with redox indicator:

DCPIP: — (replaced by NADP)

oxidised DCPIP ⟶ reduced DCPIP

blue ⟶ colourless

Rate of ~~reaction at~~ photosynthesis at different light intensities:

⇒ Buffer solution with the same water potential as stroma.

⇒ why prevent damage of chloroplast

⇒ as water might enter by osmosis.

⇒ Buffer solution is used to maintain constant pH

⇒ High/Low pH can denature enzyme like rubisco.

Low temperature used:

⇒ to reduced activity of chloroplast and prevent denaturation.

⇒ ~~high~~ prevent damage of chloroplast.

D) Afferent light ~~O~~ wavelength (λ)