

DATE: 05/01/2024.

CHAPTER - 1

FRIDAY -

PHOTOSYNTHESIS IN HIGHER PLANTS.

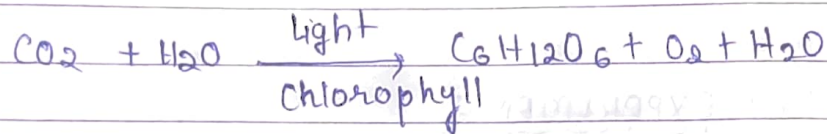
→ PHOTOSYNTHESIS:-

Physicochemical process :- gaseous Exchange.

↓
Oxidation - Reduction.

Why?

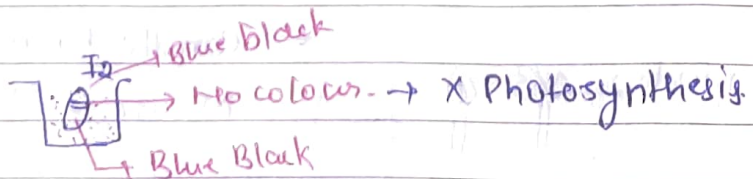
- (1) 1° Source of food on Earth.
- (2) release O_2 .



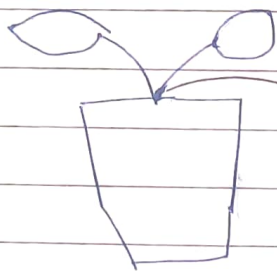
- * Goals:-
- (1) Experiments ☒ [OFFER]
 - (2) chloroplast ☒
 - (3) Photosystem ☒
 - (4) ETS ☒
 - Non cyclic
 - cyclic.

(1) Experiments:-

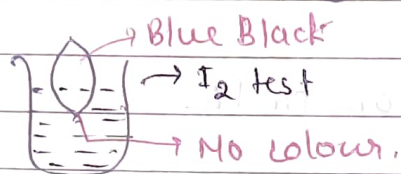
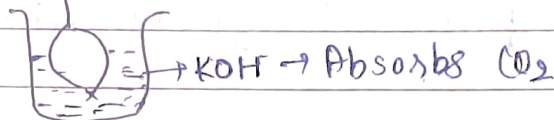
1. Essentiality of Light for photosynthesis:-



* (2) Essentially of CO_2 in photosynthesis:-



"MOLL'S Half Leaf Experiment."



* EARLY EXPERIMENTS:-

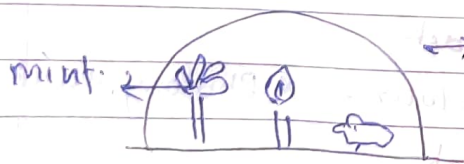
(1) "Joseph Priestley" (1770)



→ After sometimes →

Candle extinguished
Mouse - dead.

* Due to Burning of candle & Breathing of Mouse
Air → Bad.



→ Candle Burning
Mouse - Alive.

* Components which were used by mouse and candle
are Restored by Mint.

⇒ Foul Air (phlogiston) produced by Burning of candle and Mice → could be converted into dephlogiston.

→ O₂ discovered in 1774

* (2) "Jan - Ingenhous" (1779)

(a)



Light

Candle - Lit

Mouse - Alive



Dark

extinguished

Died.

Conclusion:- purification of air or formation of dephlogiston → by green plants
"only in the presence of sun light."

(b) Inverted funnel experiment:-



Bubbles

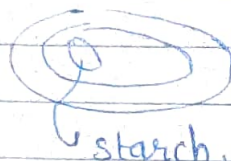
↓
O₂.

* Julius von Sachs - (1854)

photosynthesis $\rightarrow$ Glucose

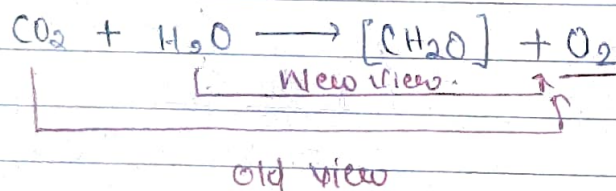


Stored as "Starch"



1st visible product of photosynthesis = "STARCH"

*



*

Experiments to prove that O_2 come from H_2O

CB van Neil

Robin Hill

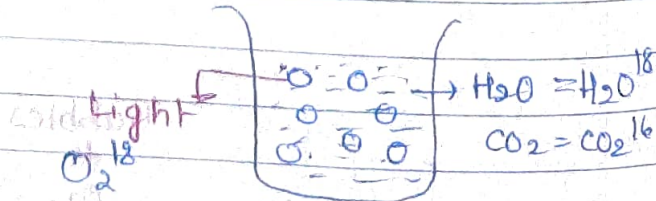
Ruben & Kamen

- Purple and green sulphur Bacteria.
photosynthetic Bacteria.

- Angiosperm
"Stellaria Media"

- chlorocella (unicellular alga).

Fix CO_2
 $\text{CO}_2 + \text{H}_2\text{S} \rightarrow \text{C}_5\text{H}_{12}\text{O}_6 + \text{S}$
Anoxygenic P.S.
No O_2



" O_2 contributed by H_2O not CO_2 "

Oxygenic

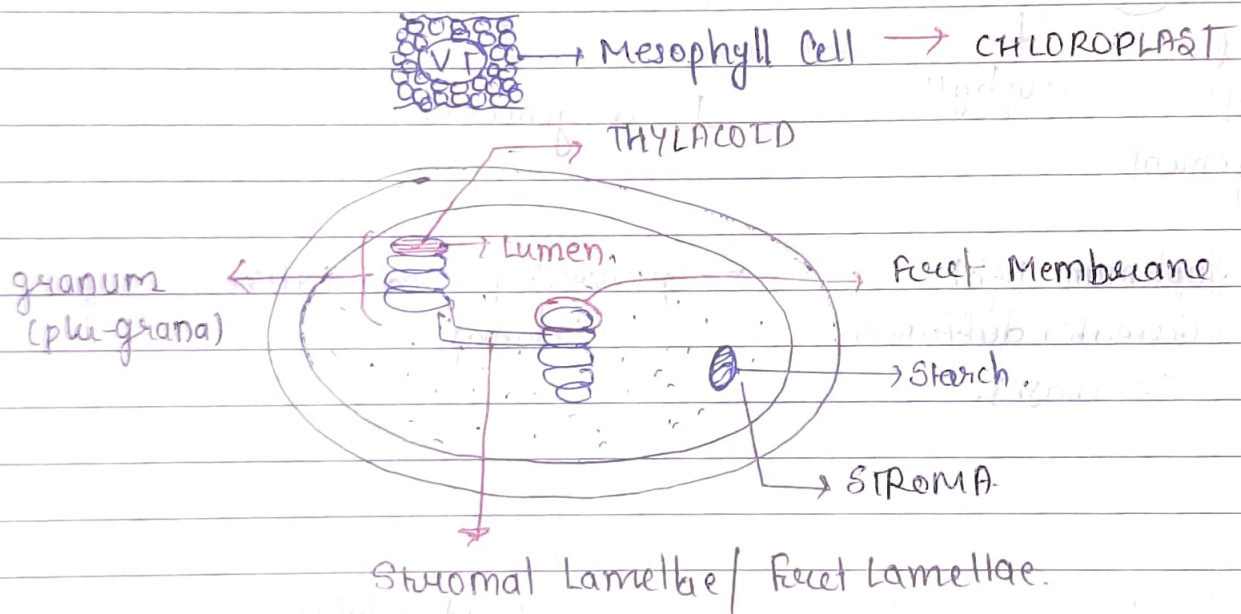
- Green plants
- Cyanobacteria / BGA

Anoxygenic

- Green and purple Sulphur Bacteria.

* Site of Photosynthesis:-

green part → Leaf



PHOTOSYNTHESIS

Dependent on products of Light Rxn.

→ Photochemical Rxn.

→ Biosynthetic phase.

Light Rxn

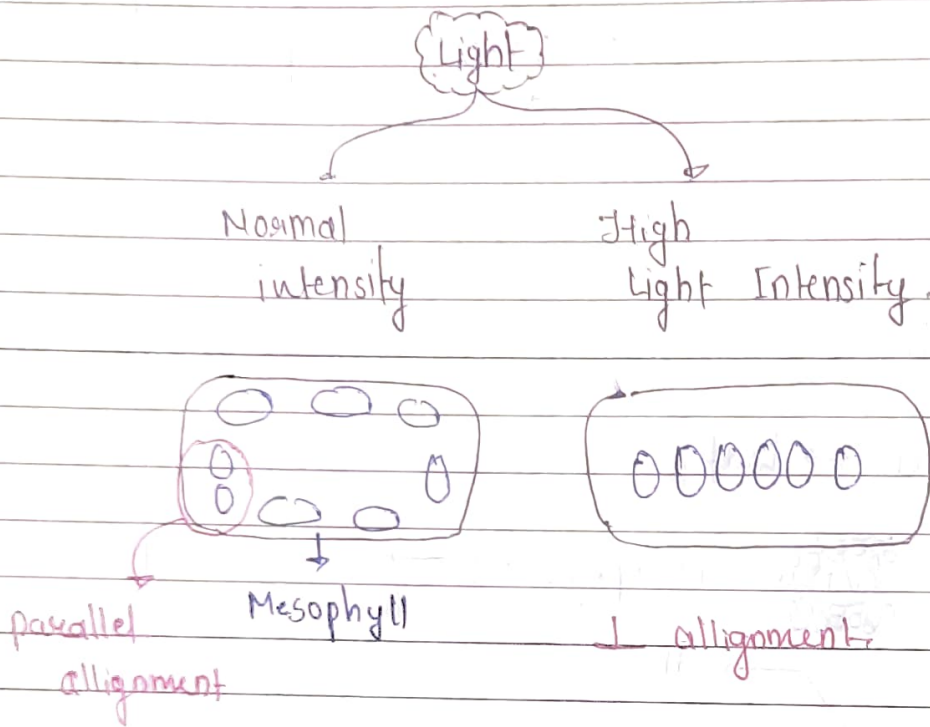
- directly dependent on light.
- membrane system
- grana, stromal lamellae.
- trap light energy
- Synthesis → ATP and NADPH

① Action
↓
Assimilatory
power

Dark Rxn

- Do not require light directly.
- Stroma
- Enzymatic to fix CO_2
- RuBisCo
- Synthesis of Sugar.

CHLOROPHYLL → "Membrane of Thylacoid."



- optimum light
- Greater diffusion of Gases.

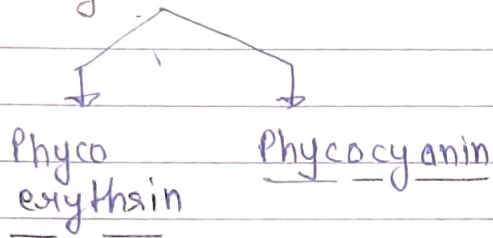
- prevent photooxidative damage.

* PHOTOSYNTHETIC PIGMENT :- Lipid soluble pigment

→ chl a chl b chl c chl d Carotenoids

- Universal
- 1^o
- present in character
- all organism.
- BGA
- Rhodospirillum rubrum → Algae → Higher Angiosperm.
- Higher plant like - Dinoflagellates
- Brown Algae
- Euglena
- Diatoms
- Red algae
- Excessory pigments
- xanthophyll
- Caroten.

⇒ Phycobilin ⇒ H_2O soluble



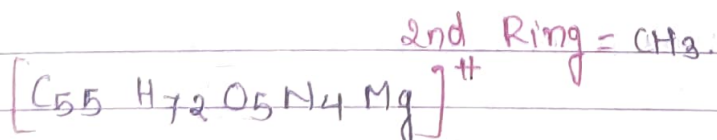
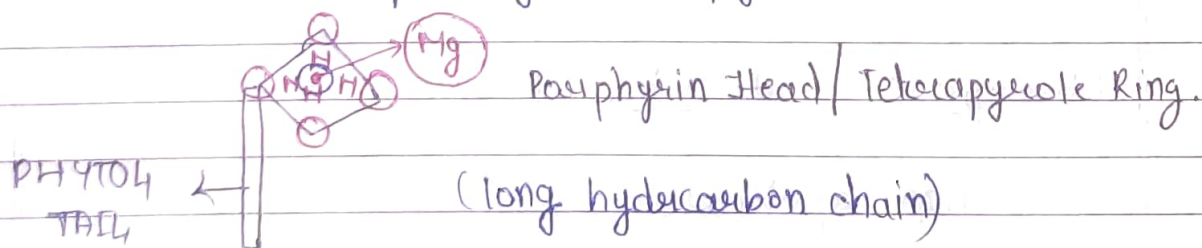
Red Blue

Algae

⇒ Higher plants :-

○ CHLOROPHYLL :-

(1) Chl (a) → - Most Abundant
- 1^o photosynthetic pigment.



(2) Chl (b) :- $[C_{55}H_{70}O_6N_4Mg]^{++}$

2nd Ring = -CHO group.

Carotenoids

Xanthophyll

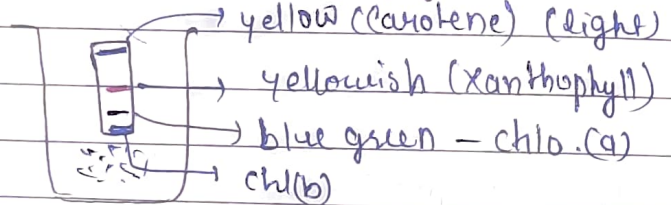
Carotene

(C₄₀H₅₆O₂)

(C₄₀H₅₆)



paper chromatography.



Carotene → yellow to yellow orange.

Xanthophyll → yellow (Bright)

chl (a) → Bright - Blue - green.

chl (b) → yellow - green.

* Absorption and Action Spectra?

Absorption Spectra:-

chl (b) - Maximum absorption - Blue

chl a - Max absorption - Red

Carotenoids - Max → green

400 500 600 700
V I B G Y O R

DATE: 05/01/2024...

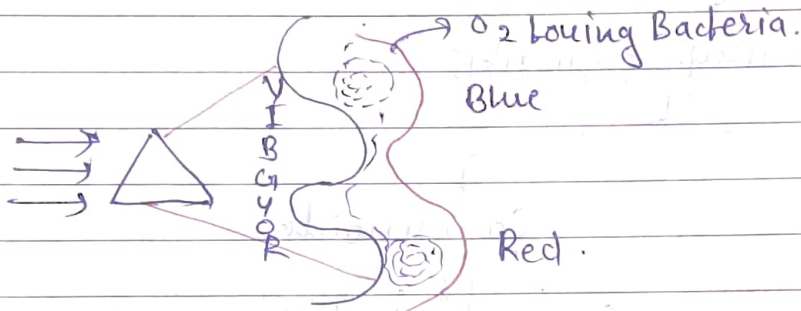
SATURDAY

- PHOTOSYNTHESIS: SPECTRA

→ Chief Photosynthetic pigment → chl(a).

* Engelmann's Experiment :-

- Cladophora (Spirogyra)



** PHOTOSYSTEM / Quantasomes

- collection of many chl pigment,
- Carotenoids, proteins

Membrane of Thylakoid:-

Stroma
thylakoid

Granum
thylakoid

PS - Light Reaction

PS I = Exposed / Non appressed part

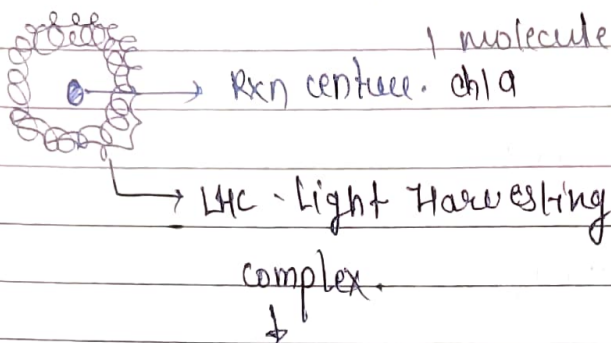


PS II - Appressed / Non exposed / sandwiched.

*

PS² - Structure

LHC - Absorbs light of different λ and hands over to Rxn centre.



Accessory pigments.

chl(b)

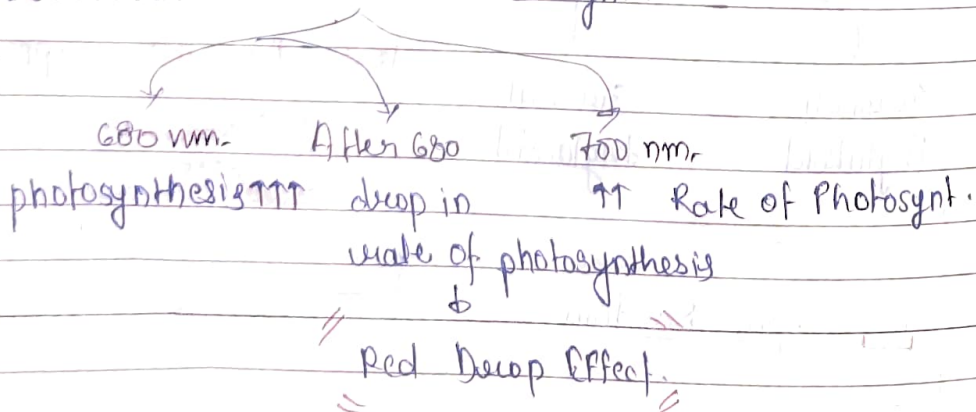
Carotenoids.

- shield pigments - prevent.
- plant from photooxidative damage.

*

Emerson enhancement effect.

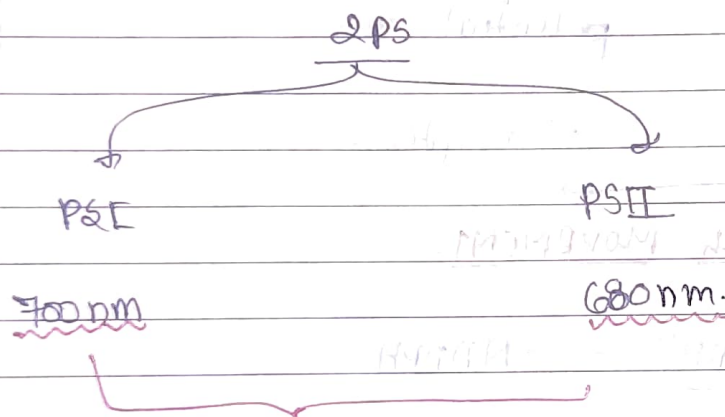
Chlorella $\rightarrow$ Monochromatic light.



(2) Chlaueella: ← 680 + 700.

Sharp ↑↑ (by 25%)

↳ Emerson Enhancement Effect.



Naming in the sequence discovery.

Photosystem I P₇₀₀

Photosystem II P₆₈₀.

- Absorption Max - 700nm.

Absorption maxima - 680nm.

- Non appressed part.
- grana thylakoid
- stroma

- Appressed - grana thylakoid.

PSI → NADP reductase.

PSII → H₂O splitting complex.

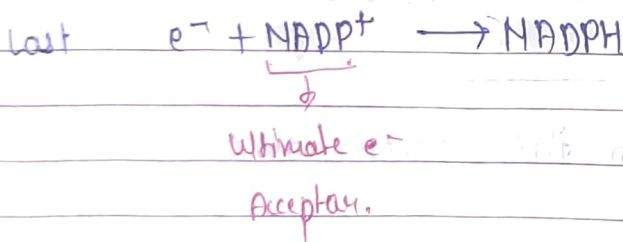
(towards lumen).

* * Electron Transport System

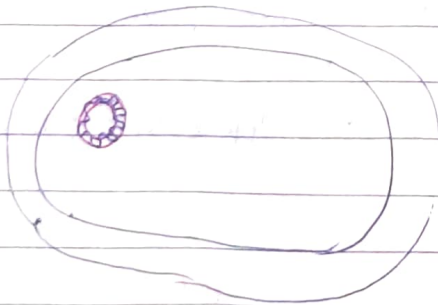
- Membrane of thylakoid.
- Redox potential

Low Redox potential $\rightarrow$ High Redox potential
 $\downarrow$
 e^- donas $\quad \quad \quad e^-$ acceptor.

DOWN Hill MOVEMENT.



Purpose $\rightarrow$ Create H^+ gradient.



H^+ less.

H^+ more
(thinner)

Energy = ETS

V.V.O IMP :- Q.

(2) PHOTOPHOSPHORYLATION :- Z

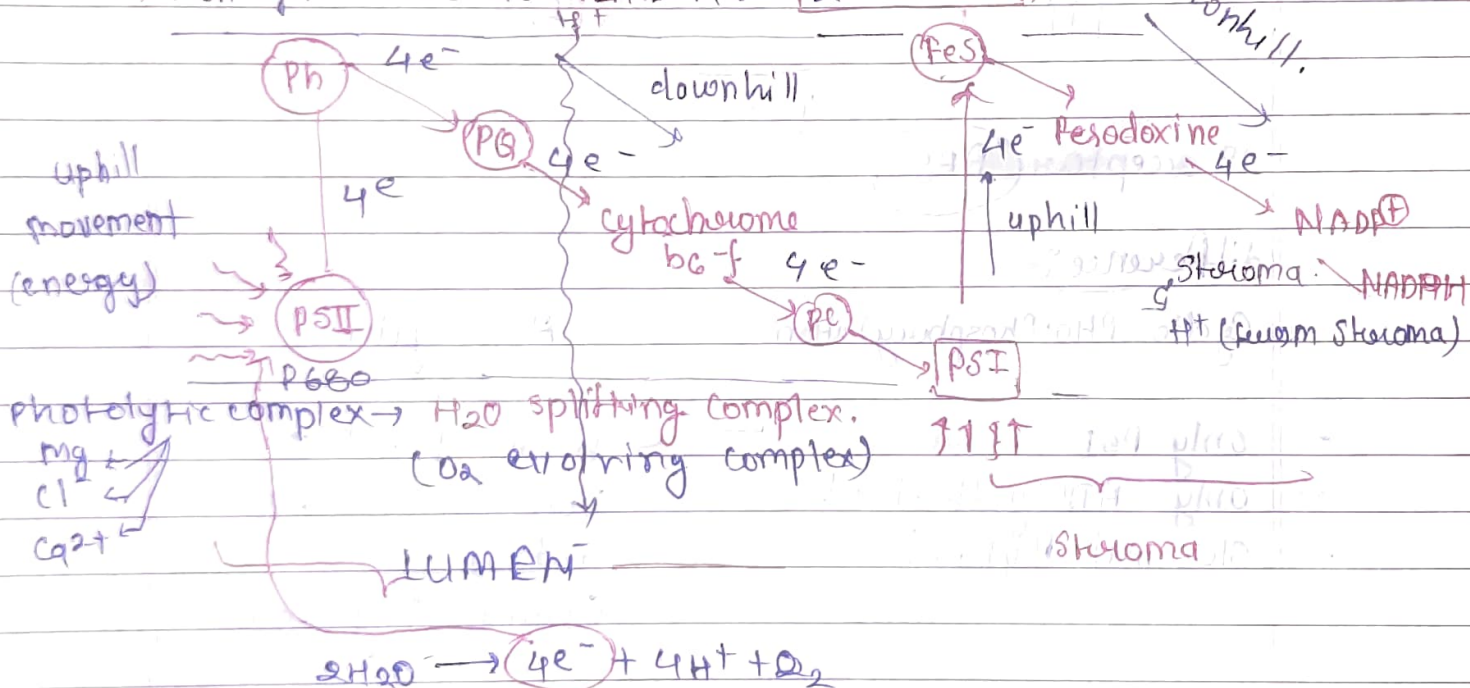
Non cyclic
cyclic.

Hill Rxdg.

STROMA.

NADP Reductase.

Non Cyclic PHOSPHORYLATION :- Z - Scheme



- Ph - Pheophytin - 1st acceptor of PSII (colourless chl)

Plastoquinone

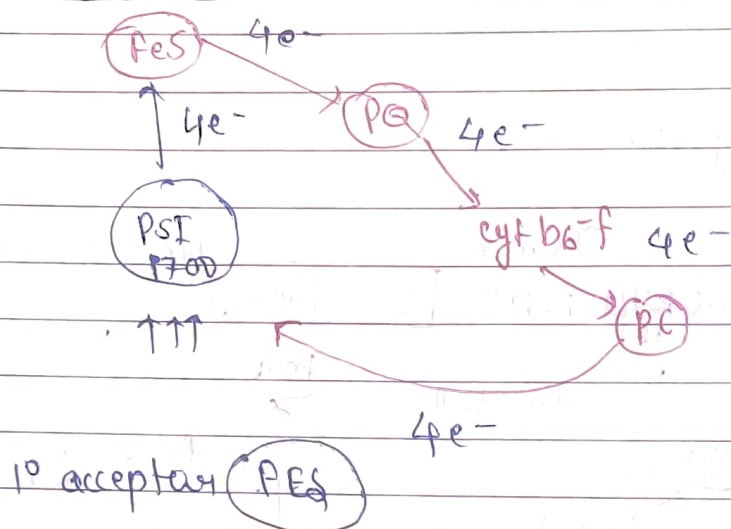
- PQ - mobile e⁻ carrier → H⁺ pump

1 PC - Blue e⁻ carrier

IMP:- Non-cyclic

- 2NADPH
- 2H₂O split
- 1 O₂ Released
- 4H⁺ Release (Lumen)
- 4e⁻ released
- 3 ATP formation.

CYCLIC PHOTOPHOSPHORYLATION



difference:-

Cyclic Pho. Phosphorylation

Non cyclic.

- | | |
|---|---|
| <ul style="list-style-type: none"> - only PSI - only ATP Synthesised - Stroma thylakoid | <ul style="list-style-type: none"> - both PSI, PSII - both ATP and NADPH - and O_2 - Grana thylakoid |
| <ul style="list-style-type: none"> - No, required of e^- from outside | <ul style="list-style-type: none"> - e^- Required. |
| <ul style="list-style-type: none"> - Anaerobic Conditions. - poor CO_2 availability - Low light | <ul style="list-style-type: none"> - Aerobic condn - High concentration CO_2 - optimum light Required. |

* CHEMOSMOTIC HYPOTHESIS:- Explains ATP formation.

"by Peter Mitchell"

Requirement:- H^+ gradient (made during ETS)

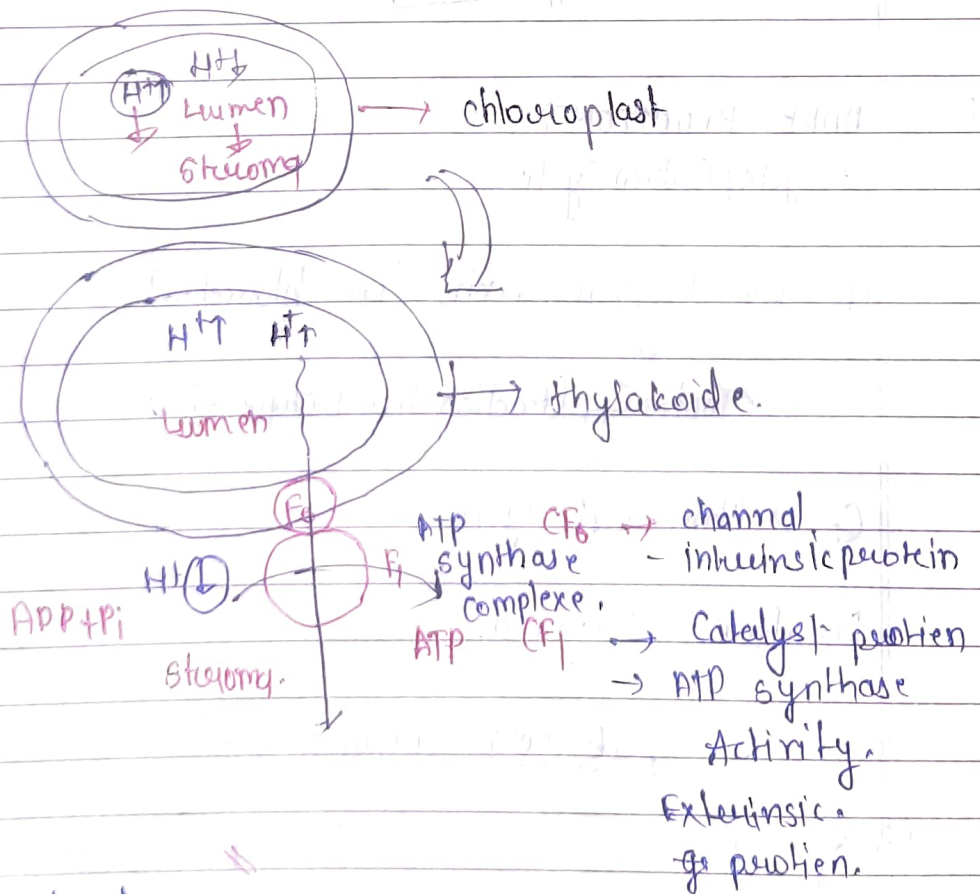
- Now we will break it:-



PMP (H^+ motive force)



Use to Synthesis ATP.



Facilitated Diffusion

* Reason for H^+ gradient:-

Lumen $H^+ \uparrow \uparrow$

Stroma $H^+ \downarrow \downarrow$

- ① H_2O splitting in lumen
- ② Pq. pump (H^+ from stroma to lumen)

- ③ NADP Reductase picked H^+ from stroma.

—————||—————

* DARK REACTION:-
 C_3 cycle / Calvin Cycle

④ by Melvin Calvin (in chlorella)

↓

Took C_{14} (radioactive isotope of C)

$C_3 \rightarrow$ Universal cycle

Location - Stroma.

↓

RUBISCO (Bifunctional)

③ ↙

Carboxylase

$RuBP + CO_2$

↘

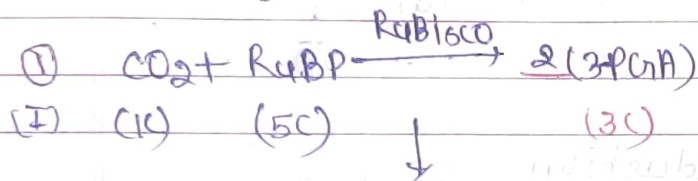
Oxygenase.

$RuBP + O_2$

C_2 (photorespiration)



① Carboxylation Reduction Regeneration.

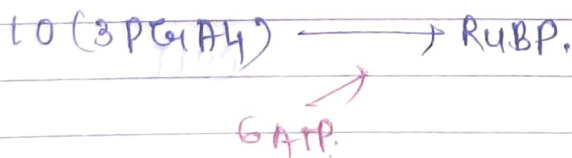
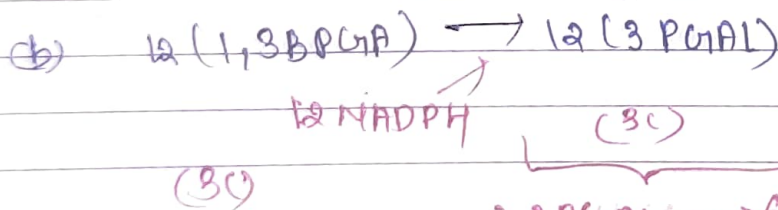
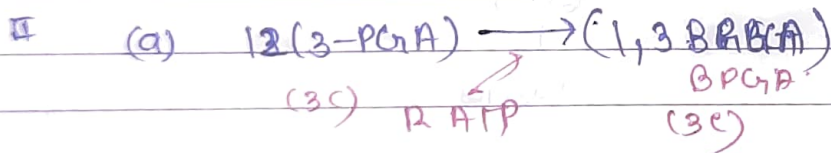


② Reduction :-

PGA - Phosphoglyceric Acid

BPGA - Bisphospho-

PGA - Phosphoglycerol aldehyde

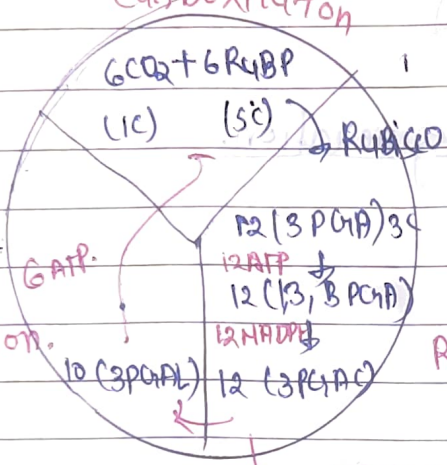


(III)

→ Most imp.

carboxylation

- 1^o Acceptor = RuBP (5C)



- 1st stable product.

- 3PGA

C₃ cycle.

Regeneration.

Reduction

→ 3PGA

1 glucose ⇒ Turns of C₃ → 6C

↓
cycle = 6

CO₂ = 6

ATP = 18 ATP

↓
6 CO₂
↓
6 turns.

For 1 CO₂ - 3 ATP

3-Reduction + Regeneration.

IN

OUT

6 CO₂
18 ATP
12 NADPH

1 Glucose
18 ADP
12 NADP⁺

DATE: 8/11/2024.

MONDAY.

Q. 1 CO_2 C_3 cycle

ATP $\rightarrow 3$

NADPH $- 2$

Q. Regeneration 1 RuBP

ATP = 1 ATP

Q. Reduce ① PGA $\rightarrow$ ① PGAL

ATP = 1

NADPH = 1

Q. 1 CO_2 during reduction

ATP = 2

NADPH = 2

$6 \text{ CO}_2 - 12 \text{ ATP}$
 12 NADPH

Q. for 4 CO_2 molecule in Reduction

ATP = 8

NADPH = 8

C4 PLANTS

- Dry tropical region.
- only 1% of total plants = C4
- Most Reproductive.

Ex: Maize

Sugarcane

Sorghum

} Monocots and also Dicots are present in this category: Amaranthus

- Kranz Anatomy - crown

- Chenopodium

like wreath like arrangement.

- Concentric Rings:-



Bundle sheath cells

- large sized
- No ECS
- Thick wall
- several layered,

Mesophyll Cell

- smaller
- wall - thin (permeable to gases)

chloroplast - Granal
thylakoid



- PSI, PSII both

- Cyclic & Non cyclic

- O₂ produced

Nov - RuBisCO → X
Imp. have

- PEPCASE in
Cytoplasm.



Bundle sheath

- larger
- Thick (impermeable)

chloroplast - Agranal chloroplast



} Dimorphic
chloroplast.

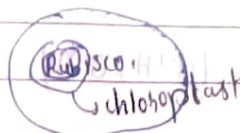
- Only PSI present

- only Cyclic

- O₂ not produced.

- RuBisCO - present in
stroma

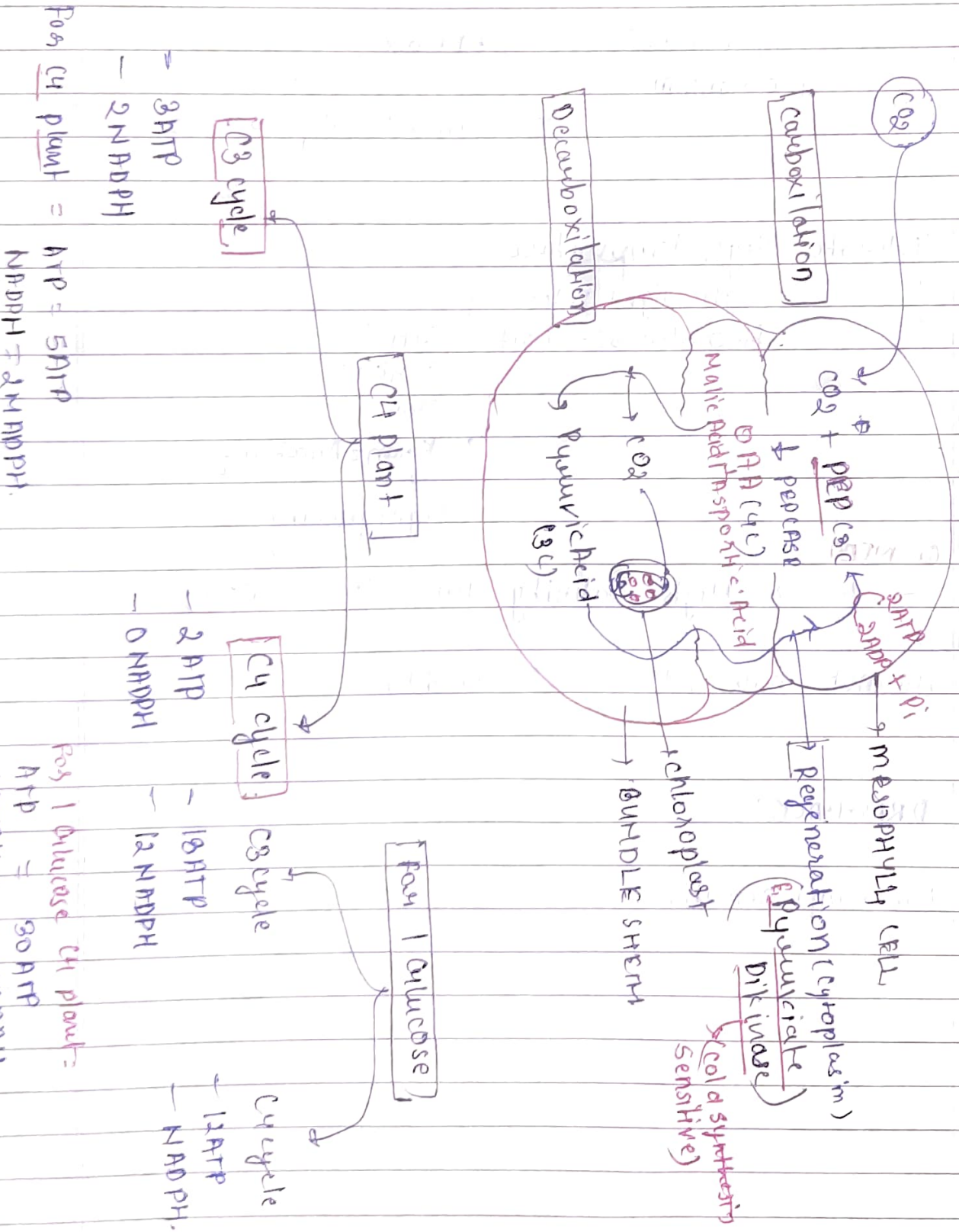
- not present.



Bu cell

C4 CYCLE

C4 CYCLE 8. Hatch and Slack pathway.



①
C₄ plant:- Tolerate CO₂ stress:-

CO₂ concentration
Mechanism

PEPcase
- very efficient
- High affinity for CO₂

② Tolerate High temperature

③ " " High light Intensity

④ " " H₂O stress - Leaf - Cuticle

- Sunken
- Stomata

Kranz Anatomy

→
tight packing

IMP. Q. NEET

⑤ -- 1 --> High Salinity stress (High salt)

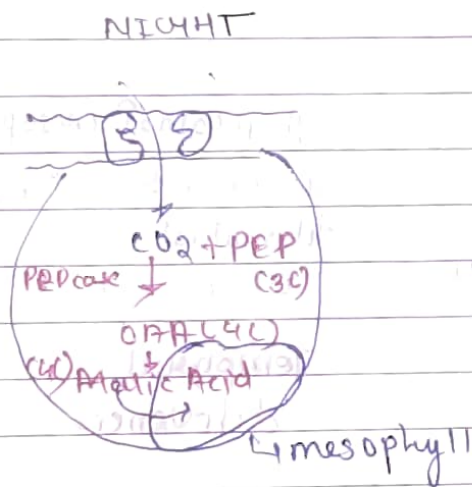
⑥ do not show PHOTORESPIRATION:-

* DRAWBACK:-

- Low temp. sensitive.

* CAM PLANT : Crassulacean Acid metabolism.

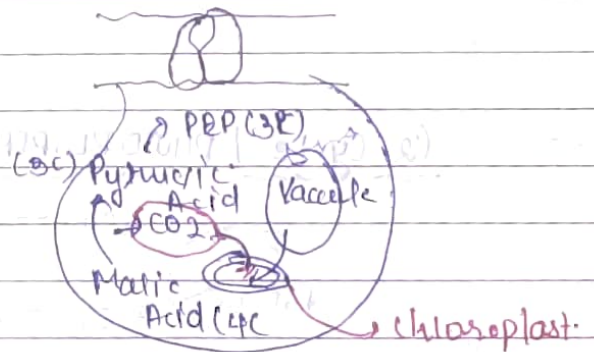
- Succulent ex: Cactaceae, Opuntia
 - Pineapple
 - Sedum
- Thick cuticle
- Sunken Stomata
- Scotoactive Stomata - opening at Night



DARK ACIDIFICATION

DAY

OAA - Oxaloacetic Acid
1st stable product
to acceptor PEP.



C₄ plant = 2 cells - sometime
CAM plant = 1 cell → different time.

C₄ > C₃ > CAM.

C₃ plant

C₄ plant

CAM

Kranz

X

✓

X

Anatomy

Photo Respiration

✓

X

X

Parasymphic
chloroplast

X

✓

X

Carboxylation. - 1 time

- 2 times

- Stroma
of chloroplast +
of mesophyll

① cytoplasm of m.
② stroma of
chloroplast of
Bundle sheath

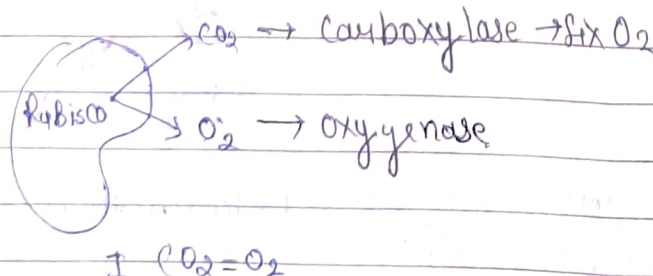
① cytoplasm of mesophyll (PEP case)
② stroma of (Rubisco)
chloroplast of
mesophyll

SPATIAL
difference

Temporal
difference.

*

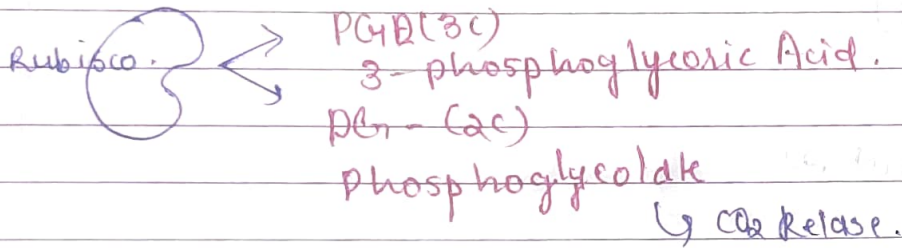
C₂ cycle / PHOTORESPIRATION:-



RuBisCO = more affinity for CO_2

work like Carboxylase.

→ In C3 plant:- Some O₂ binds with RuBisCo:



uptake of O₂ → Release CO₂. } Light
↳ Photorespiration

- No organic compound is formed.
- Instead RuBP - Breaking

Wasteful process:-

- No CO₂ fixation
- Instead CO₂ Release
- Utilisation of ATP
- No organic Acid Formed.

* When Temp ↑ :- → low CO₂ conc.

↓
Promote oxygenation.

↓
Low productivity.

3 Organelles:-

Chloroplast
glycolate synthesis
- ATP utilisation

Peroxisome
- glycine
synthesis

Mitochondria.
- CO₂ Released

Light dependent.

RUBP + O_2

RuBisco - oxygease

only 2c

only 3c

Ans ✓ only 3c and 2c

* Factors affecting Photosynthesis:-

FACTORS

Internal /
factor /
plant factor

External /
Factor /
extrinsic factor

- Leaf - Age, Size
- orientation
- No. of chloroplast
- " mesophyll
- chlorophyll content
- Internal CO_2 conc.
- CO_2 (Ext)
- Light
- Temperature
- H_2O .

* Law of Limiting factors:-

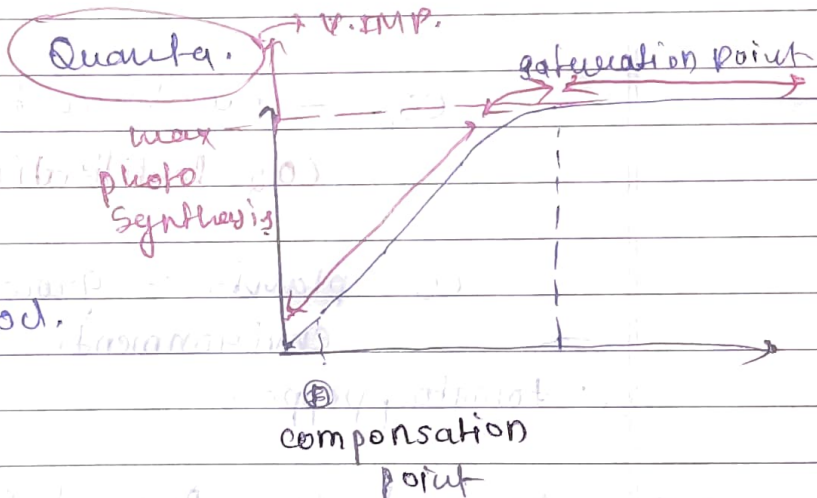
"by Blackmann"

At any point, the factor which is present at least directly control rate of photosynthesis -

Light

Quality Duration Intensity

- PAR - photoperiod
400 - 700nm - do not control (rate/speed)
- max - Red & Blue. Rather
- min = green
It controls overall period.



"Light is rarely a limiting factor. Except for plant growing in shady area / under canopy.

Rate of Respiration = Rate of photosynthesis

Light will act as limiting factor only at low light intensity.

CO_2 → most imp limiting factor.

Atmosphere - CO_2 - 380ppm / 380 μL
Plant can tolerate - 500ppm.
max.

C₃

C₄

450 Hl
ppm

360 Hl/
36 ppm

CO₂ Saturation
point.

CO₂ - we have to give externally
CO₂ fertilisation effect

C₃ plants - grow in CO₂ rich
environment.

Ex: tomato, pepper

C₃ and C₄ → Respond to High CO₂ conc
during ~~Low/High~~ Light Intensity.



Light - less → Limiting factor

Light - High → ~~x~~ limiting

CO₂ - will act as limiting factor

Temperature →

C₃ = 20-25°C

C₄ = 30-40°C

CAM = 50-56°C

DATE: 11/01/2024

THURSDAY

Water

Affect but indirectly.

H₂O stress

Stomata
close



CO₂ Intake stopped

Curved
leaf



Surface

Avea.

||

NCERT Reptile

ventilation
muscle