PHOTOSYNTHESIS

* energy transferred as ATP and reduced NADP from light dependent stage is used during light independent stage to produce complex org. molecules.

Light dependent reaction
in thylakoids / granum

Light → photosynthetic pigments → energy → ATP

energy → reduced NADP → NADPH (carries H from light dependent to independent reaction.)

NADPH → oxidised NADP (regenerated)

Light → $H_2O \longrightarrow H^+ + e^- + O_2$

Photolysis of water

O_2 waste product

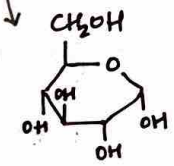
Light independent reaction
in stroma

CO_2 CO_2 CO_2 CO_2 CO_2 CO_2

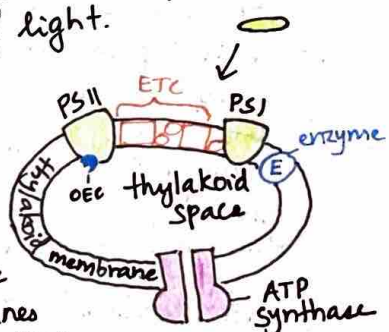
Calvin Cycle → produces complex organic molecules

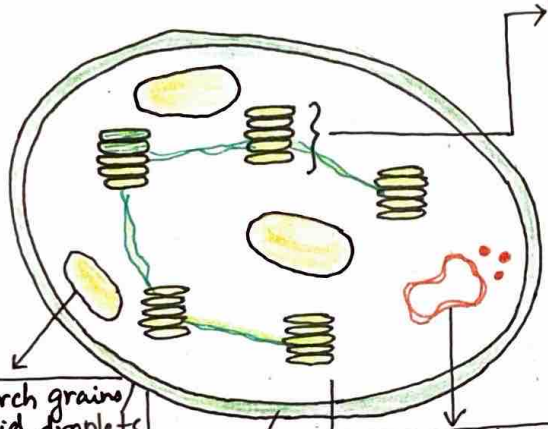
ATP + H → formation of C-C bonds

H → formation of C-H bonds



Granum (grana) – stack of thylakoids
- site of light dependent reaction / photophosphorylation
- thylakoid membranes
  - have photosystems (PSI & PSII)
    - reaction centre = light harvesting structure (LHS).
    - accessory pigments: allow absorption of diff wavelengths of light.
    - PSII contains OEC: for photolysis of H_2O.
  - have ETC: to release energy from excited e^-.
  - contain ATP synthase: to make ATP
  - many thylakoids ∴ large surface area of membranes which maximises absorption of light energy.
  - relatively impermeable: maintains proton gradient for chemiosmosis.
- thylakoid space/lumen: forms proton gradient/ has high H^+ conc.



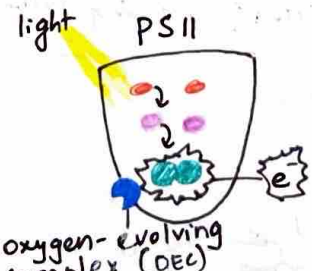


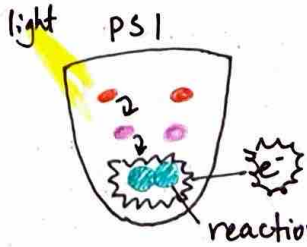
Starch grains / lipid droplets → store products of photosynth / chemical energy.

circular DNA + 70s ribosomes → make protein enzymes for photosynth.

double membrane / envelope → compartmentalisation

Stroma
- site of light independent reaction / calvin cycle.
- contains RuBP, enzymes (eg. rubisco), reduced NADP.
- colourless so light reaches thylakoids.
- contains H_2O so acts as medium for reactions / for photolysis.



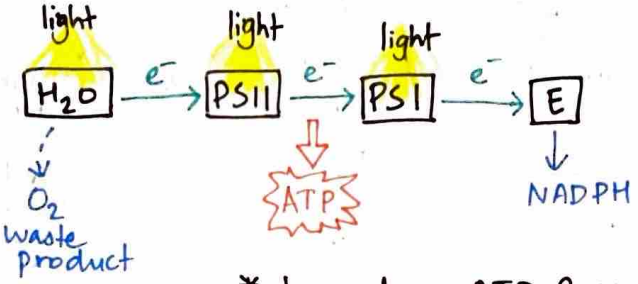


* primary pigment = chlorophyll a
  2 chlorophyll a = reaction centre
  accessory pigments = chlorophyll b, carotene, xanthophyll

i) pigments absorb light.
ii) energy is transferred to reaction centre.
iii) reaction centre becomes photo-activated.
iv) releases high energy e^-.

LIGHT-DEPENDENT REACTION

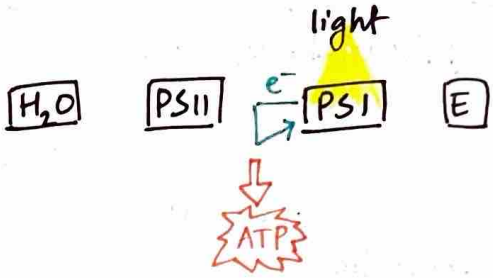
Non-cyclic Photophosphorylation



* to produce ATP & NADPH.

- PSI involved
- occurs in thylakoid/granum
- produces ATP
- PSII involved
- produces reduced NADP
- photolysis of H_2O

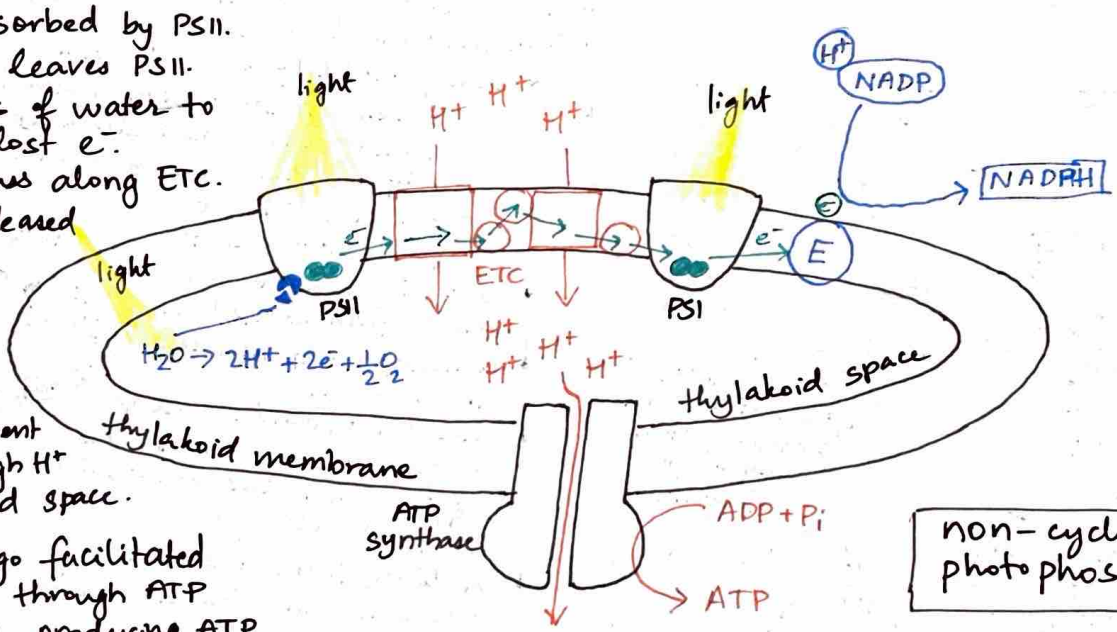
Cyclic Photophosphorylation



* to produce extra ATP.

- PSI involved.
- occurs in thylakoid/granum
- produces ATP
- ×
- ×
- ×

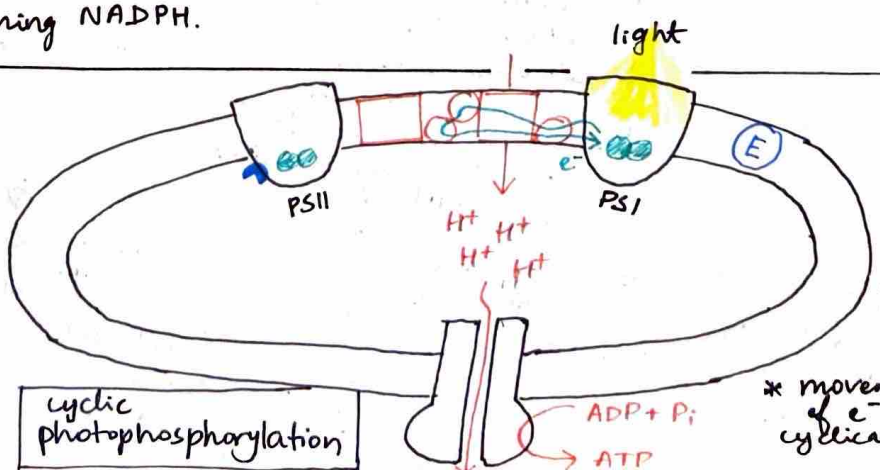
i) light is absorbed by PSII.
ii) excited e^- leaves PSII.
iii) photolysis of water to replace lost e^-.
iv) excite$^-$ pass along ETC.
v) energy released is used to pump H^+ into thylakoid space.
vi) proton gradient created: high H^+ in thylakoid space.
vii) H^+ undergo facilitated diffusion through ATP synthase, producing ATP.
viii) e^- reach PSI and are re-excited by light.
ix) e^- transferred to $NADP^+$, forming NADPH.



non-cyclic photophosphorylation

* movement of e^- is linear.

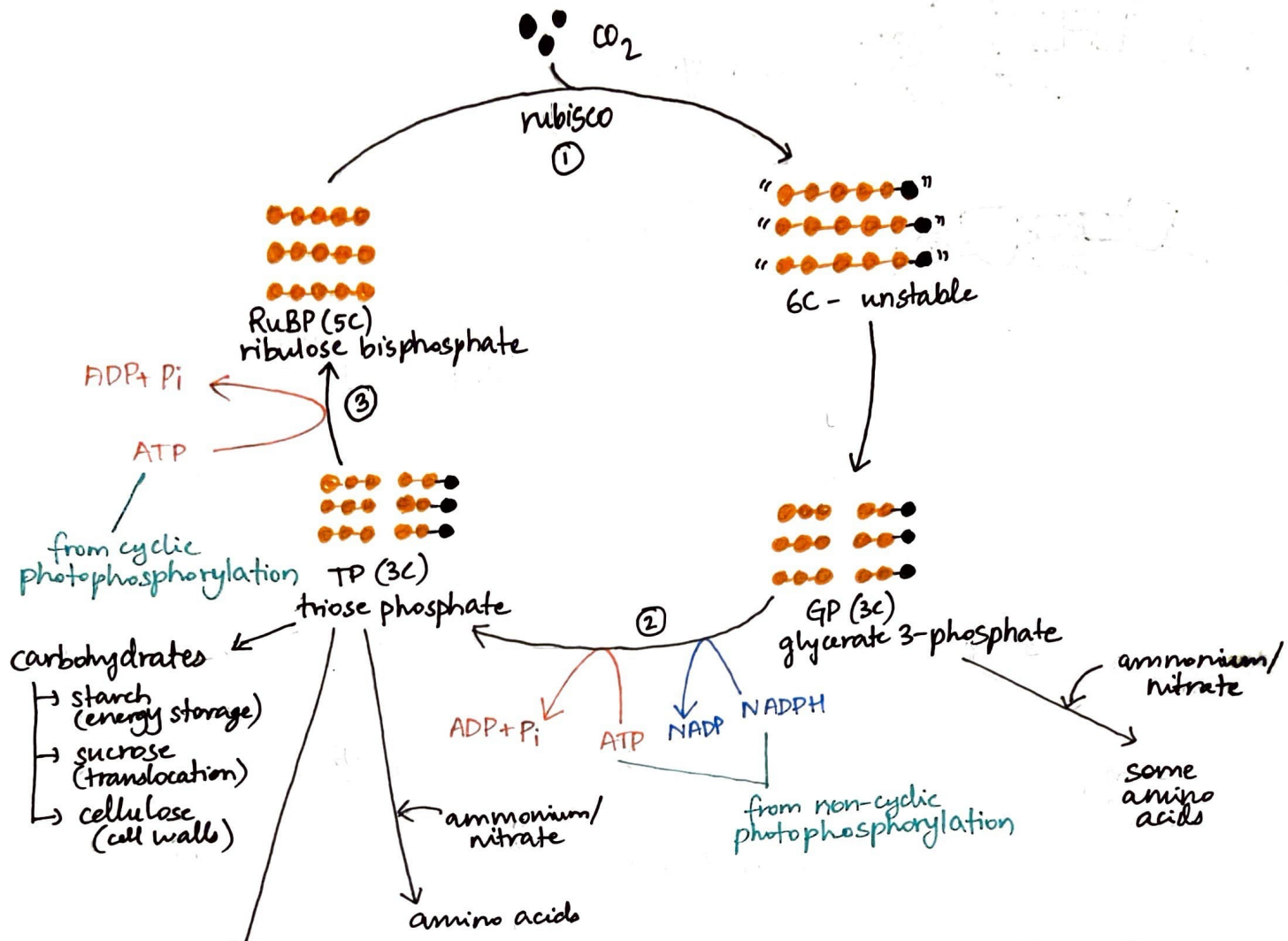
i) light is absorbed by PSI.
ii) excited e^- leave PSI.
iii) e^- pass along ETC.
iv) energy released is used to pump H^+ into thylakoid space.
v) proton gradient created.
vi) H^+ diffuse through ATP synthase, producing ATP.
vii) e^- return to PSI to replace lost e^-.



cyclic photophosphorylation

* movement of e^- is cyclical.

LIGHT-INDEPENDENT REACTION — CALVIN CYCLE



① rubisco catalyses fixation of carbon dioxide

② reduction of GP

③ regeneration of RuBP

Factors affecting rate of photosynthesis

1) Light intensity

more light ⇒ more absorption by pigment ⇒ high rate of light dependent reaction ⇒ more ATP & NADPH produced

2) CO_2 concentration

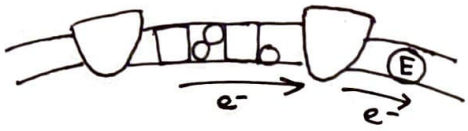
more CO_2 ⇒ more carboxylation with RuBP ⇒ high rate of light independent reaction ⇒ more organic compounds produced

3) Temperature

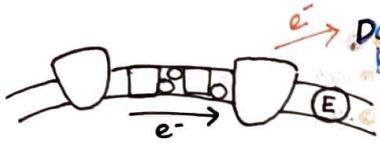
higher → optimum ⇒ more E-S complexes formed ⇒ high rate of light dependent & independent

higher → too high ⇒ enzymes denature ⇒ very low rate of photosynthesis

* enzymes = rubisco, ATP synthase, NADP reductase



normally



e⁻ → DCPIP (blue) → reduced DCPIP (colourless)