Bioenergetics

→ Energy → Relationship/ Transformation
→ Follows law of thermodynamics.
→ Occurs in living system.

Photosynthesis:

$$6CO_2 + 6H_2O \rightleftharpoons C_6H_{12}O_6 + 6O_2$$

"Energy poor inorganic compound into energy rich organic compound."

→ (ΔE) Energy → use
→ Endogenic
→ Light dependent/anabreaction

Respiration:

$$C_6H_{12}O_6 + 6O_2 \rightleftharpoons 6CO_2 + 6H_2O + ATP$$

"Energy rich organic compound into energy poor inorganic compound."

→ Energy → release
→ Exogenic
→ Light Independent/reaction.

Compensation Point.

Photosynthesis = Respiration.

↳ This happened at dawn and dusk when light intensity is low.

Pigments: Light-Sensitive substance
→ Absorb light.

① Chlorophyll:
Light: V-B & O-R

② Carotenoids.

Structure:

Head:
→ Porphyrin ring
→ 4- pyrole ring
→ Mg^{++} central atom
→ Flat and square
→ Hydrophylic
→ Light absorb

Tail:
→ Phytole Tail ($C_{20}H_{39}$)
→ Isoprenoid units
→ Linear
→ Hydrophobic
→ Anchor → Chlorophyll membrane
→ 4th pyrole ring
↳ Ester bond

Types:
→ Prokaryotes → Bacterial
→ Eukaryotes → In Photosynthetic Orgs (a, b, c, d, e)

Chlorophyll a:
→ $C_{55}H_{72}N_4O_5Mg_1$
→ CH_3 (II pyrole)
→ present in all
→ Main pigment
→ Bluish green
4-types
Chl a
→ 670nm
→ 680nm
→ 690nm
→ 700nm

Chlorophyll b:
$C_{55}H_{70}O_6N_4Mg$
-CHO
→ Higher plants & algae
→ Accessory pigment
→ Yellowish green

No type.

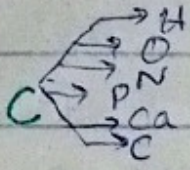
Photosynthesis:

$$6CO_2 + 6H_2O \xrightarrow[\text{Pigments}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

Raw Materials:

CO_2: 0.03 – 0.04% in Air Stomata → 1-2% area.

Stroma → Reduced → Sugar



∴ C can form bonds with almost all elements.

H_2O: Soil → Roots

Oxidize → O_2

→ Reducing agent

Van Niel Hypothesis:

Group 1:

$$CO_2^{18} + H_2O \longrightarrow C_6H_{12}O_6^{18} + 6O_2$$

Group 2:

$$CO_2 + H_2O^{18} \longrightarrow C_6H_{12}O_6 + 6O_2^{18}$$

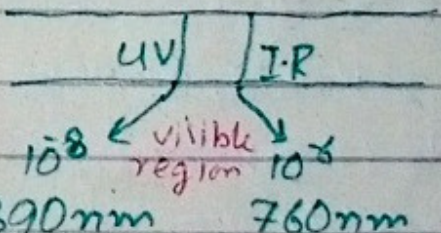
Sunlight:

40% reaches earth

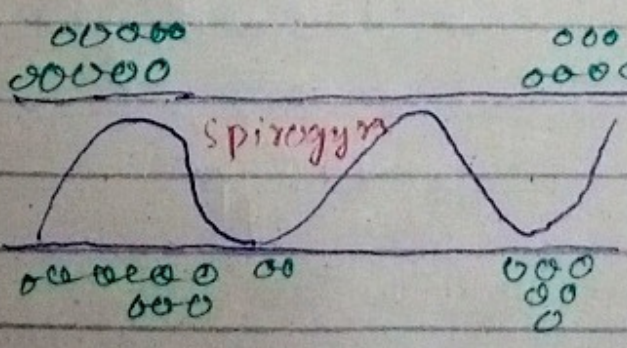
1% utilizes

→ Electromagnetic radiation

→ Radiant Energy



V I B G Y O R



∴ Where more Light will absorb there more O_2 will produce and more bacteria will accumulate

Arrangement Of Pigments:

↳ Is called photosystem.

Photosystem:

Structure:

1: Antenna Complex:

→ Present in peripheral region

→ Light Absorb and transfer to reaction center, this is known as Inductive resonance.

→ Caroteroid

→ Chl b.

→ Many molecules of Chl a.

2: Reaction Center:

→ Channalise Energy

→ Few chl a.

→ Electron carriers.

Types:

1: Photosystem I:

→ Chlorophyll a

→ 700nm

2: Photosystem II:

→ Chlorophyll a

→ 680nm

Carotenoids: V-B
→ Lipids soluble
→ Isoprenoid units

Carotenes:
Orange - Red
↓
B-carotenes
↓
Carrot

Xanthophyll.
Yellow - Oranges
↓
Lutein
↓
Yellow leafs

Spectrum:

Absorption:
→ Quality of light absorb?
→ Which pigment absorbs which light?

Action:
→ Effectiveness of absorbed light
↓
drive photosynthesis

Peaks:
Sharp
Deep

Valleys
Broad
Narrow

→ Maximum Absorb → Orange-Red / Voilet-blue
→ Not Absorb → Green & Yellow
→ Transmit light → Indigo

Carotenoids
↓
Chlorophyll b
↓
Chlorophyll a

} Accessory Pigments

Mechanism Of Photosynthesis:

2nd step (Reduction) → Dark Rxn

$6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$

(CO_2 ← $NADH_2$)

1st step (oxidation) → Light Rxn

Light Reaction: (1st step)

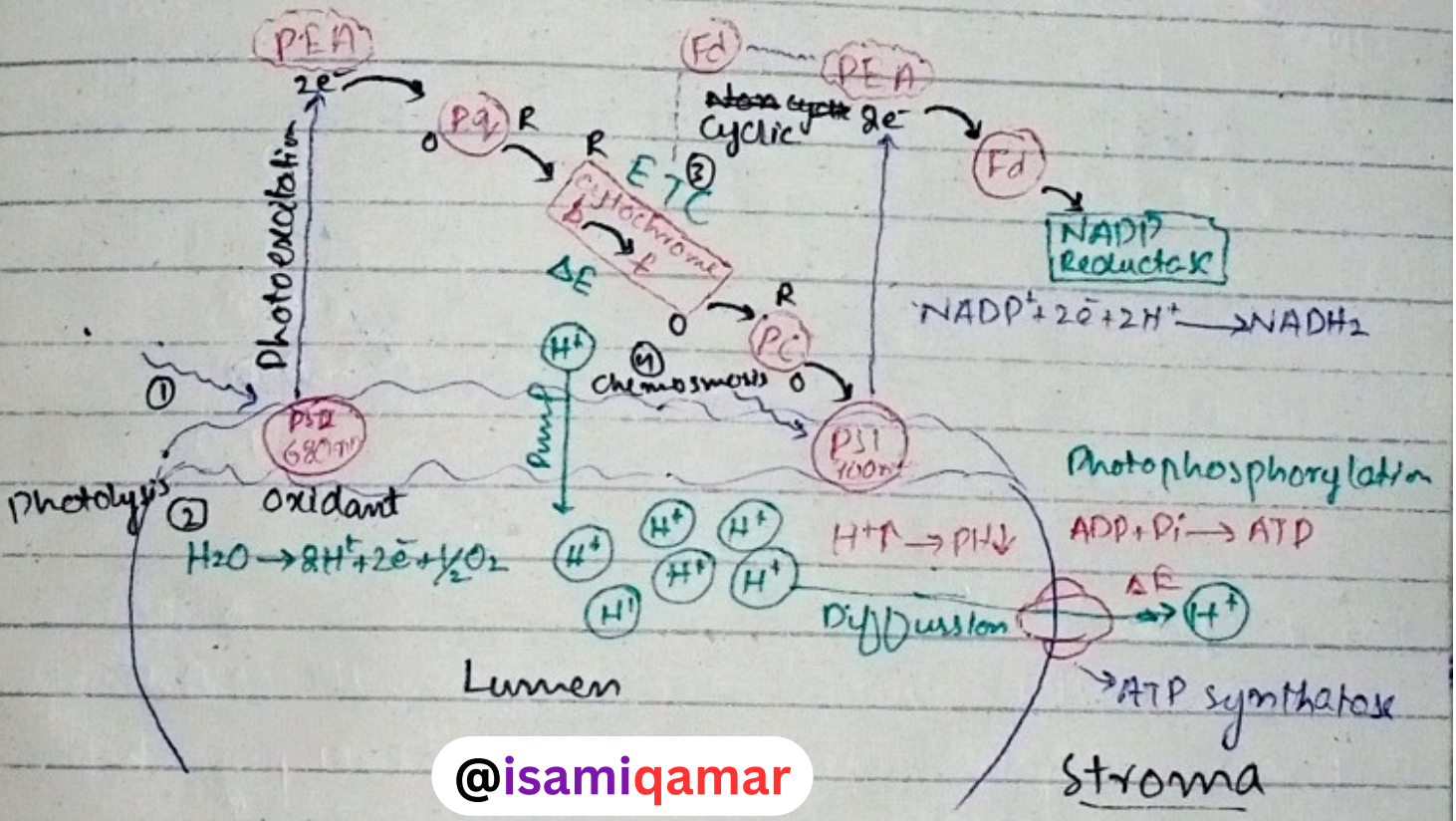
→ Takes place in thylakoid.

→ Light is captured → electrons excitation.

→ ATP (Assimilatory) } produce

→ $NADH_2$ (Reducing) }

∴ Assimilatory → which use in dark rxn.



Z scheme: → Non cyclic Photophospho rylation

→ PS II & PS I

→ Both ATP & $NADH_2$

→ Photolysis

→ $NADP^+ \rightsquigarrow \bar{e}$

Sunlight
↓
$\bar{e}$ energy
↓
H^+ energy
↓
ATP

Cyclic Photophospho rylation

→ PS I only.

→ ATP only

→ No Photolysis

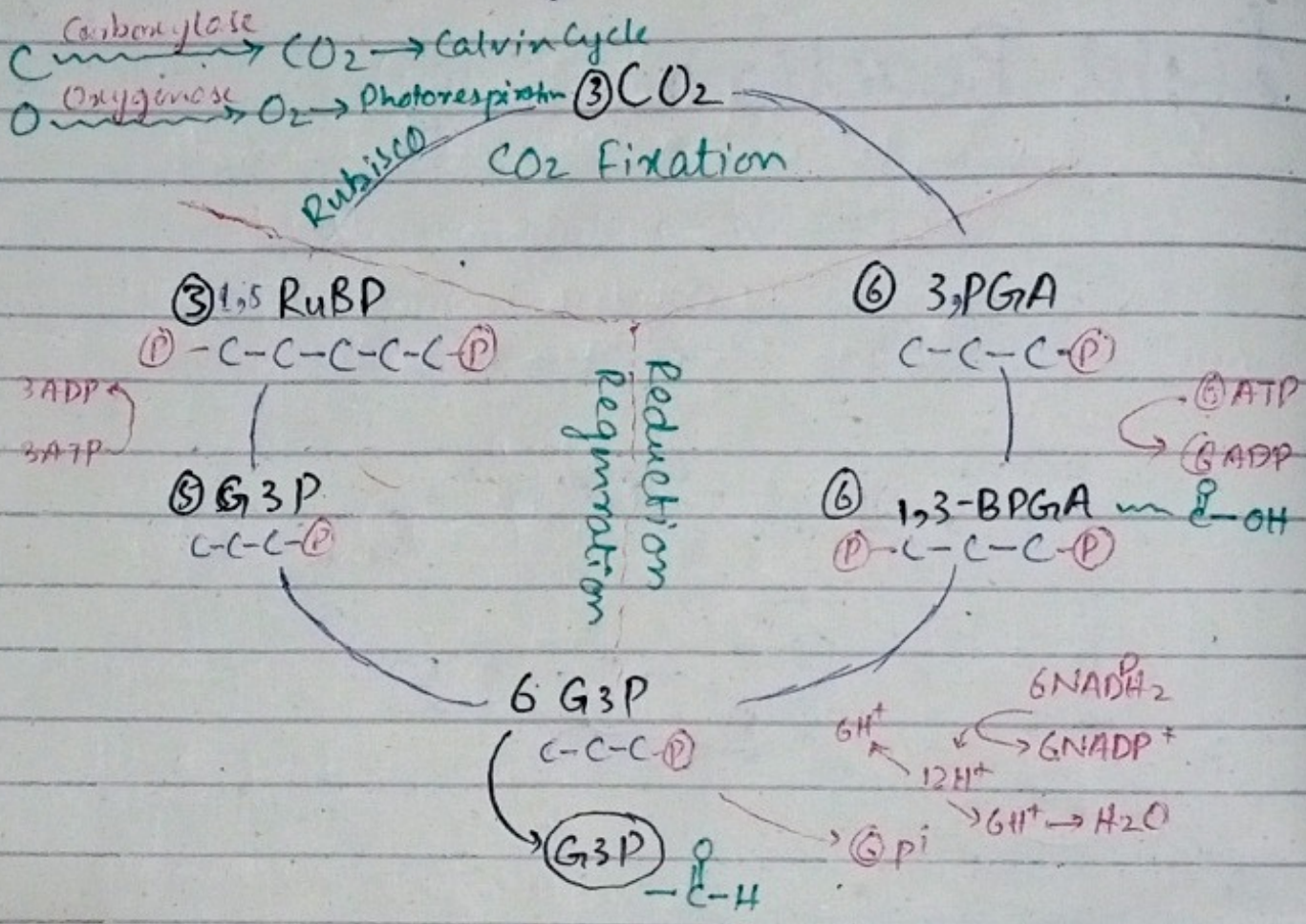
→ $\bar{e}$s recycle.

Light Independant Reaction.

→ 2nd step

→ Occurrence → Stroma

→ CO_2 → Fix → Sugars



For 1 cycle:

$3CO_2 + 9ATP + 6NADH_2 \longrightarrow G3P + 9ADP + 9Pi + 6NADP^+ + 3H_2O$

But Calvin cycle runs 2 times so multiply whole equation with 2.

18ATP & $12NADH_2$ ⟶ 1 Glucose

3ATP & $2NADH_2$ ⟶ 1-C

12 Z-schemes. + 6 Cyclic photophosphorylation

↓ ↓

12ATP + $12NADH_2$ — 6 ATP

↓

18ATP + $12NADH_2$

Respiration:

Glycolysis:

Glucose

phosphorylation → (ATP → ADP)

Glucose-6-phosphate
C-C-C-C-C-C

Isomerism (Isomerase)

Fructose-6-phosphate

phosphorylation → (ATP → ADP)

Fructose-1,6 Bisphosphate
(P)-C-C-C-C-C-C-(P)

Aldolase

G3P ⇌ (Isomerism) DHAP

Dehydrogenation → $2NADH_2$

1,3 BPGA

ATP synthesis

3-PGA

Rearrangement

2-PGA

Dehydration

PEP

ATP synthesis

Pyruvate.

$C_6H_{12}O_6$

② $C_3H_4O_3$ ← $2H_2O$, $2NADH_2$, 4ATP

$C_3H_4O_3 + O_2$ → Pyruvate Oxidation.

O_2 ✗ incomplete oxidation.

Alcoholic Fermentation

$C_3H_4O_3 \xrightarrow{NADH_2} C_2H_5OH + CO_2$

Yeast

Lactic Acid Fermentation

$C_3H_4O_3 \longrightarrow C_3H_6O_3$

Lactobacillus

Muscle → fatigue

Pyruvate Oxidation: (Link Reaction)

Pyruvates (Cytoplasm) → Pyruvate Translocase → Mitochondria
Pyruvate Translocase → Protein

→ 3 steps Process:

1: $CH_3-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-O-H \xrightarrow{\text{Decarboxylation}} CH_3-\overset{O}{\overset{\|}{C}}-H + CO_2$
Acetate

2: $CH_3-\overset{O}{\overset{\|}{C}}-H + CoA \xrightarrow{\text{Acetyl CoA synthesis}} CH_3-\overset{O}{\overset{\|}{C}}-CoA + H^+$
Acetyl CoA

3: $NAD^+ + H^+ \xrightarrow{\text{Dehydrogeration/Oxidation}} NADH$
A complex of 3 enzymes + 5 cofactors

Output:
CO_2:
$NADH_2$

Krebs Cycle:

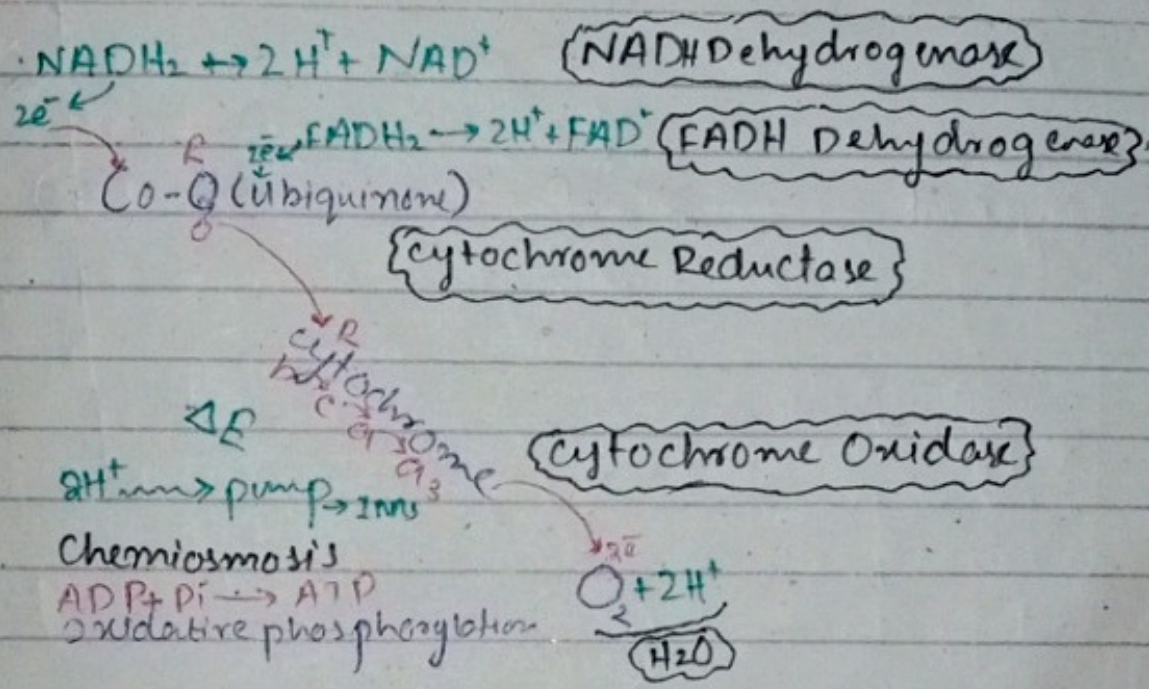
Output:
2 CO_2
3 $NADH_2$
1 $FADH_2$
1 GTP

Acetyl CoA (2C) + H_2O → CoA
Oxaloacetate (4C) → $NADH_2$ IV → Citrate 6C → H_2O
Malate (4C) ← H_2O ③ ← Cis Aconitase 6C ← H_2O ①
Fumarate (4C) → $FADH_2$ III ← Iso citrate 6C
Succinate (4C) ← H_2O ② ← $NADH_2$ I → CO_2 ①
Succinyl CoA 4C ← $NADH_2$ II ← α-Ketoglutrate 5C
Succinyl CoA 4C → GTP + CoA → CO_2 ②
CoA

Respiratory Chain:

→ Energy Extraction → $NADH_2$ & $FADH_2$

→ Cristae



$1\ NADH_2 \longrightarrow 3\ ATP$

$1\ FADH_2 \longrightarrow 2\ ATP$

Energy Budget:

	ATP	$NADH_2$	$FADH_2$
Glycolysis	4	2	0
P.A.O	0	2	0
Kreb cycle	2	6	2
	6	10	2

• substrate level ~~Oxidative~~ phosphorylation → 4 ATPs
↳ 2 → glycolysis
↳ 2 - Krebs cycle

Oxidative phosphorylation: → 32 - ATPs
↳ $NADH_2$
↳ $FADH_2$

(6) ATPs → 4 - glycolysis — 2 - Krebs cycle

$NADH_2 \rightarrow 3 \times 10 = 30\ ATP$

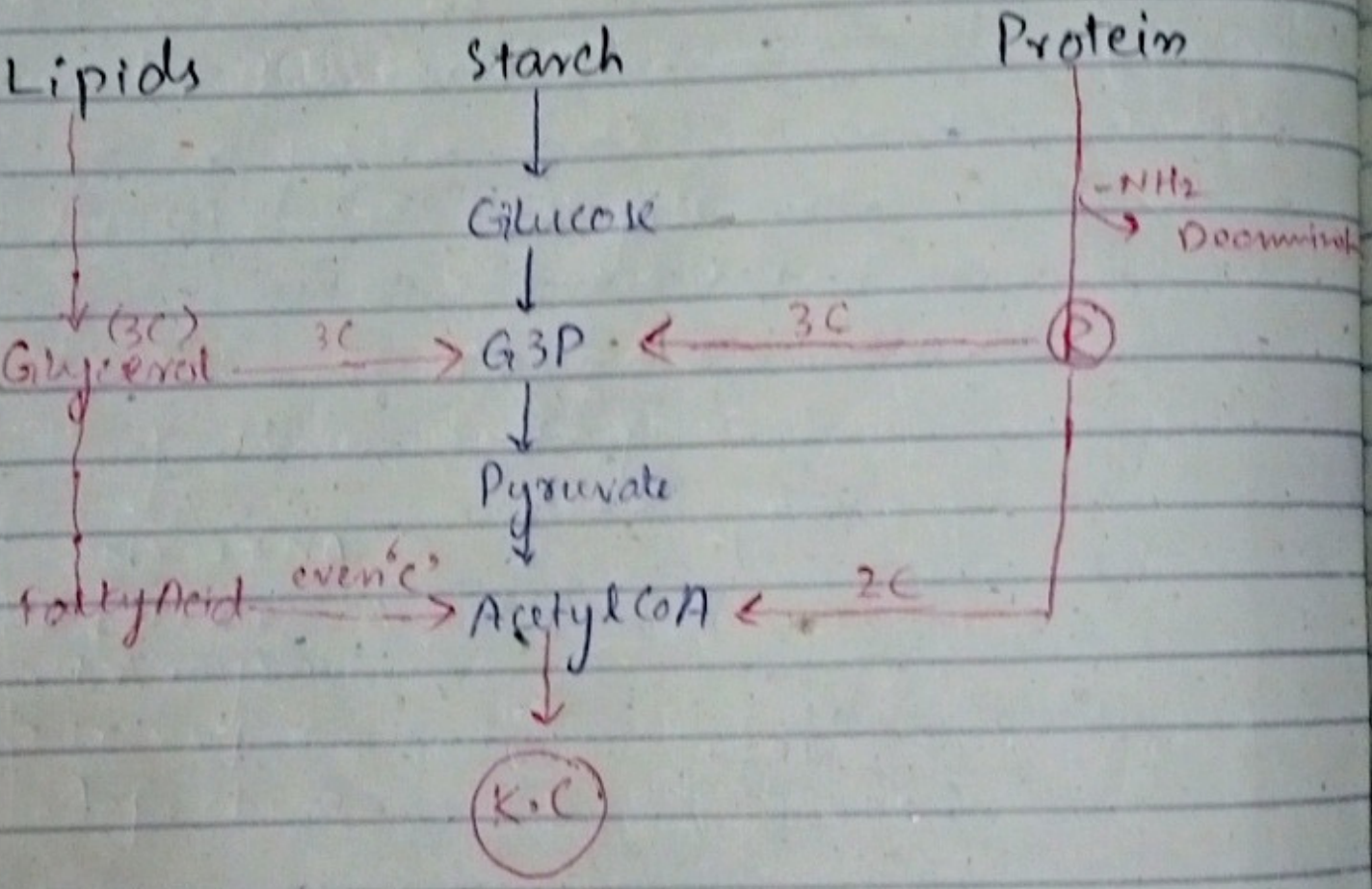
$FADH_2 \rightarrow 2 \times 2 = 4\ ATP$

Total → 40 ATP

$40 - 2 = 38$ → glycolysis

$38 - 2 = 36$ → 2 ATP use in Mitochondrial membrane to transport $NADH_2$ ~~of~~

G3P — Link :


Lipids
Starch
Protein
Glucose
-NH2
Deaminat
(3C)
Glycerol
3C
G3P
3C
P
Pyruvate
Fatty Acid
even 'C'
Acetyl CoA
2C
K.C