S. No.	Date	Title	No.	Sign / Remarks

Respiration in Plants

- It is the process of oxidation or breakdown of food material with in the cell to release energy and converting this energy in form of ATP.
- Energy released during respiration cannot be used for energy requiring process directly.
- Respiration occurs in all living organism.
- food is, complex organic compound.

Respiration
↓
oxidation / breakdown
↓
food ⟶ energy
↓
Life activities
- Absorption
- transport
- movement
- reproduction
- Breathing

food ← Plants, Animals, Microbes

~~Breaking~~ Breathing connected to the process of release of energy from food. → energy

- Who can prepare their own food?

→ green plants, cyanobacteria } photosynthesis

Light energy $\xrightarrow{\text{Transducers}}$ chemical energy (food)
energy stored in bonds of carbohydrates like glucose, sucrose & starch.

- Do all plants cells perform photosynthesis?

→ No, only cells containing chloroplasts perform photosynthesis.

→ such cells are often located in superficial layer.

→ Non-green cells of plant need food - so leaves transfer them in the form of sucrose.

Respiration	Breathing
- oxidation of food	- Simple inhale & exhale.
- Biochemical process	- Its physical.
- carried out by mitochondria of cells	- carried out by lungs.

Respiration	Photosynthesis
- Energy releasing process.	- Energy trapping process
- Breakdown of food into CO_2 & H_2O	- Food synthesized from CO_2 & H_2O
- Destructive or catabolic	- Anabolic or constructive.
- Takes place in living organism.	- Take place in all green plant.

-

- light independent
- Occurs in cytoplasm & mitochondria
- O_2 absorbed, CO_2 given

- light dependent
- Occurs in chloroplast
- CO_2 absorbed, O_2 given

→ Respin^n :- cellular resp^n

- it is the process of oxdn of food material (complex organic compound (C-C bond) with in the cell to release energy

complex organic compound $\xrightarrow{\text{oxid}^n}$ Simple compound + Energy ↑↑
(Respiratory substract)

- catabolic process — Amphibolic
(traditional) (more appropidte)

- multistep process
- Exorgonic process.

Respiratory substract

The compound that are oxidised during resp^n are known as respiratory sustract

examply
1) Carbs
2) fats
3) protein
4) Organic acids

→ The complete combustion of glucose which produces CO_2 & H_2O as end products yields energy most of which is given out as heat.

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2 \longrightarrow 6CO_2 + 6H_2O + E$$

Heat energy released → not useful to synthesize any molecules that plant cell requires.

→ Plant cell have strategy to catabolise / oxidize the glucose molecule not in one step but in several steps which enable the energy released can be stored in form of ATP.

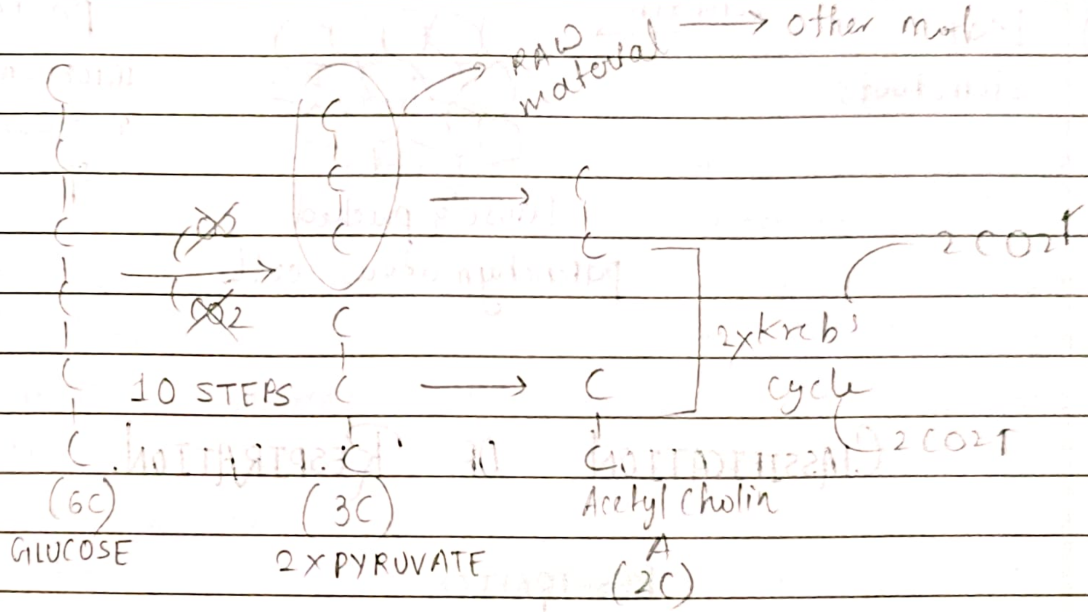
Respⁿ	Combⁿ
- inside living cell	- non-cellular process
- number of enzymes are required	- non enzymatic process
- step by step energy released	- Single step Energy release
- Number of intermediates formed.	- No intermediate formed.

Energy trapped is in form of ATP is utilised in various energy requiring process of organism.
&
Carbon skeleton produced during respⁿ is used as precursors for biosynthesis of other molecule in cell.

→ PGAL → GLYCEROL

→ PYRUVATE → ALANINE

→ a - KETOGLUTRATE → GLUTAMATE



▲ Why plants can get along without respiratory organ.

→ 1) Each plant ~~plant~~ part take care of its own need of gas exchange.

2) Plant don't have greater demand for gaseous exchange like animals.

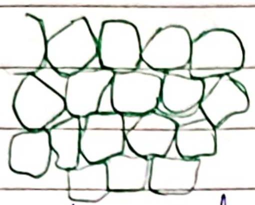
3) Very low transport of gases occurs from one part to another.

4) also when cell photosynthesis, availability of O_2 is not a problem as O_2 is released within cell itself.

5) Roots, stem & leaves respire at rate far lower than animals do.

6) Distance that gases travel in large, bulky plant is not great (living cells located close to surface of plant so remain in contact with air.

7) Leaf, stem roots $\xrightarrow{\text{contain}}$



Loosely packed parenchymatous cells

provide interconnected network of spaces.

CLASSIFICATION OF RESPIRATION.

RESPIRATION
- Respiratory Substrate
  - Floating: carbohydrates & fats
  - Protoplasmic: proteins
- Involvement of O_2
  - Aerobic
  - Anaerobic

Depending upon respiratory substrate employed

- Floating $resp^n$
  - common mode of $resp^n$
  - Continues throughout the life of cell and keep cell healthy.
  - Susbstrate utilized - carbohydrates & fats & stored protein

- protoplasmic $resp^n$
  - rare and occur during starvation,
  - cannot be continued for long liberate toxic products like ammonia that kill cell.

- deplete protoplasm of its structural & functional proteins
- Substrate is usually one protein.

AEROBIC Respⁿ	Anaerobic Respⁿ
✓ O_2 is used.	✓ O_2 is not used.
✓ complete oxidⁿ of glucose	✓ partial oxdiⁿ of glucose
✓ end product – H_2O & CO_2 (inorganic)	✓ end product – CO_2 & lactic acid & Alcohol (organic) majorly
✓ Oxidⁿ of one glucose molecule yield 38 ATP molecule.	✓ Partial oxdⁿ of one molecule glucose yields 2 ATP molecule.
✓ Process take place in mito-chondria & cytoplasm of cell.	✓ take place in cytoplasm of cell.

MECHANISM OF RESPIRATION

Mechanism of Anaerobic respiration

Respⁿ
↓
food
↓
Breakdown
↓
energy

DIRECT

A ⟶ B+C
↓
energy release
↓
ADP+ip ⟶ ATP

SUBSTRATE LEVEL PHOSPORYLATION

→ यहाँ substrate टूटा वहीं ATP formation hua.

→ बिना ETS के ATP formation

INDIRECT

A ⟶ B+C
↓
H_2 $[2H^+ + 2e^-]$
↙ ↘
NAD⁻ FAD⁺ [e⁻ carrier]
↓ ↓
$NADH_2$ $FADH_2$ [ATM card]
↘ ↙
ETS
↓
oxdation
↙ ↘
3 ATP 2 ATP

OXIDATIVE PHOSPORYLATION

Date
Page

Mechanism of aerobic respⁿ [38 ATP]

Glyölysis (partial oxdⁿ of glucose – Pyruvate in 10 steps]

2 ATP ↓ 2 $NADH_2$ 6 ATP + 2 ATP = 8 ATP

Linked / gateway reaⁿ (2 pyruvate – 2 actelyl choline)

↓ 2 $NADH_2$ 6 ATP

KREB'S CYCLE (complete oxdⁿ of 2-acetyl choline)

2 GTP ↓ 6 $NADH_2$ & 2 $FADH_2$
18 ATP 4 ATP

E⁻ transport system (ETS) – Oxdⁿ of $NADH_2$ & $FADH_2$

1 $NADH_2$ = 3 ATP ; 1 $FADH_2$ = 2 ATP

Mechanism of anaerobic respⁿ [FERMENTATIⁿ]

1] Lactic acid fermentation

GLUCOSE (6C)
2 ATP ⇃↾ 2 $NADH_2$
2 PYRUVATE (3C)
Reduction ⇃↾ 2 $NADH_2$ → 2 H_2 + 2 NAD^+ LACTATE DEHYDROGENASE
Glycolysis
2 LACTIC ACID (3C)

i) GLYCOLYSIS ⟶ Greek word
sugar breakdown

ii) Reduction
NO CO_2 release.

2] Alcohol fermentation.

GLUCOSE

2ATP ⇓ $2NADH_2$

2 PYRUVATE (3C)

$2CO_2$ ⇓ PYRUVATE DECARBOXYLASE

2 ACETALDEHYDE (2C)

reduction ⇓ $2NADH_2$ ← oxid^n

ALCOHOL DEHYDROGENASE

$2H_2$ + $2NAD^+$

2 ETHANOL (2C)

1] GLYCOLYSIS

2] DECARBOXYLATION

3] REDUCTION

PYRUVATE DECARBOXYLASE
+
ALCOHOL DEHYDROGENASE
⇓
ZYMASE COMPLEX.

FOR BOTH.

1] Net ATP → 2
2] Reduction PROCESS mein $NADH_2$, GLYCOLYSIS mein aaya.
3] Reducimg agent → $NADH_2$

- Primary Process of Resp^n

- Breakdown of complex carbohydrates into simple form such as glucose

e.g In plants, glucose derieved from sucrose (end product of photosynthesis)

(simple sugars)
Glucose
Sucrose —Invertase→ } Glycolytic pathway (glycolysis)
Fructose
(simple sugars)

- Glycolysis (G.k glycos - sugar : lysis - splitting)

- First step of resp^n & present in all organism. (universal pathway)

- Takes place in cytoplasm so called cytoplasmic resp^n.

- In this process, glucose (6C) undergoes partial oxd^n to form 2-molecules of pyruvic acid (3C)

- Glycolysis is chain of 10 rea^n & its under control of diff^n enzymes.

P49 ✓ Glycolysis also known as EMP pathway (Prof. Embdn, Meyerhof, Parnas.)

— Glycolysis / EMP pathway

There are two imp phases of glycolysis as follows :-

1. Preparatory / Investment Phase & cleavage (2 ATP's)
2. Payoff phase (return on investment)

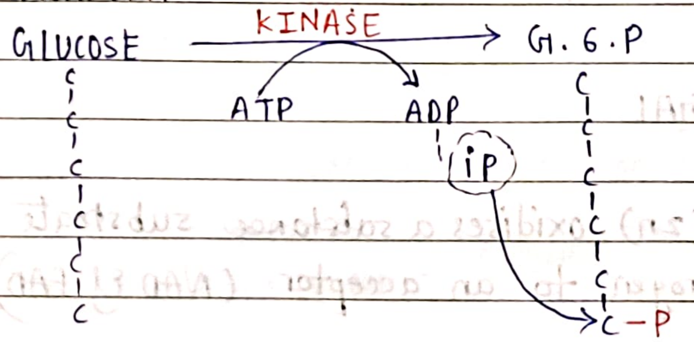
Glucose is stable & has resist to breakdown

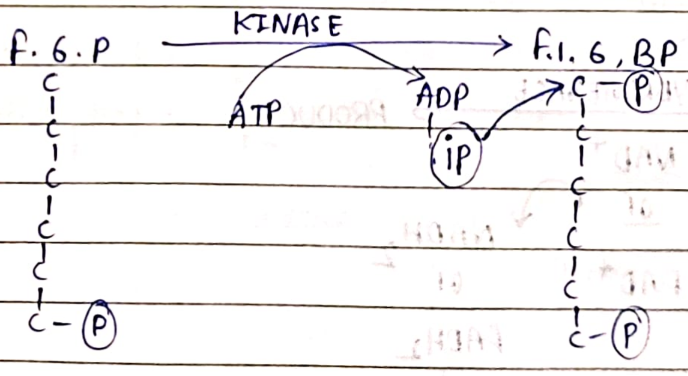
Enzymes Involved in Glycolysis

☐ kinase (II) transfer of phosphate groups.

ATP - - -> SP   SP - - -> P

I. From ATP

1) 

2) 

These two steps are ATP utilising step.

II. From SUBSTRATE

i) $\text{1,3-BPGA} \xrightarrow{\text{KINASE}} \text{3-PGA}$

$\text{P} + \text{ADP} \rightarrow \text{ATP}$

ii) $\text{2-P.E.P} \xrightarrow{\text{KINASE}} \text{PYRUVATE}$

$+ \text{P} + \text{ADP} \rightarrow \text{ATP}$

- Isomerase (V) carry out structural arrangment of a molecule.

i) $\text{G-6-P} \rightleftharpoons \text{F-6-P}$

ii) $\text{DHAP} \rightleftharpoons \text{PGAL}$

- Dehydrogenase (I) (zn) oxidises a ~~substance~~ substrate by transferring hydrogen to an acceptor (NAD & FAD)

oxidn

$\text{SUBSTRATE} \xrightarrow{\text{DEHYDROGENASE}} \text{PRODUCT}$

$\rightarrow H_2$

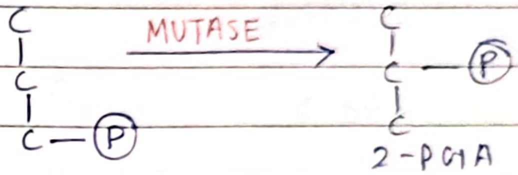
NAD^+ or FAD^+ $\rightarrow$ $NADH_2$ or $FADH_2$

oxid^n

PGAL $\xrightarrow{\text{DEHYDROGENASE}}$ 1, 3, BPGA

$\rightarrow H_2 + NAD^+ \rightarrow NADH_2$

☐ Mutase (V) :- is an isomaraze class that catalyse the shifting of f.g.p from one position to another within the same molecule.



3.PGA

2-PGA

☐ Aldolase (IV) converts fructose 1, 6 bisphosphate (6C) to DHAP (3C) & PGAL (3C)

CLEAVAGE or LYSIS or [तोड़ने वाला]

F-1, 6 BP $\xrightarrow{\text{ALDOLASE}}$ DHAP + PGAL

☐ Enolase :- also known as phosphopyruvate hydratase responsible for conversion of 2-phosphoglycerate (2-PG) to phosphophenolpyruvate (PEP)

2-PGA $\xrightarrow{\text{ENOLASE}}$ 2.P.E.P

$\rightarrow H_2O$ (released)

☐ Pyruvate kinase (II) converts phosphophenolpyruvate (PEP) to pyruvate (K^+, Mg^+)

$$2\,P.EP \xrightarrow[\text{KINASE}]{\text{PYRUVATE}} \text{Pyruvate}$$

ADP ATP

□ PFK (III) packmaker of EMP - rate limiting step.

ATP kuchnhi ATP kunchnhi kuchnhi NADH ATP kuch nhi Pani ATP

1 Acetyl CoA ⟶ 3NADH

GLYCOLYSIS

ENZYMES

Glucose (6C)

1) Hexokinase [Mg^{++}] — Glucose (6C) $\xrightarrow{ATP \to ADP}$ Glucose 6-phosphate (6C) — Phosphorisation

2) Phosphoglucose Isomarase — Glucose 6-phosphate (6C) ⟶ Fructose 6-phosphate (6C) — Isomarization

3) Phosphofructo-kinase — Fructose 6-phosphate (6C) $\xrightarrow{ATP \to ADP}$ Fructose-1-6, bisphosphate (6C) — Phosphorylation

4) Aldolase — Fructose-1-6, bisphosphate (6C) ⟶ Dihydroxyacetone phosphate (3C) + Phosphate 3-Glyceraldehyde — Cleavage or lysis

5) Triosphosphate isomarase — Dihydroxyacetone phosphate (3C) ⟶ Phosphate 3-Glyceraldehyde (3C) — Isomarisation

6) Triose Dehydrogenase — Phosphate 3-Glyceraldehyde (3C) $\xrightarrow{2NAD^+ \to 2NADH + 2H^+}$ 1,3-Bisphosphoglyceric acid (3C) — oxid^n & phosphorilation

7) Phosphoglycero kinase — 1,3-Bisphosphoglyceric acid (3C) $\xrightarrow{2ADP \to 2ATP}$ 3-phospoglyceric acid (3C) — ATP Generation (I) / Substrate level phospho

8) Phosphoglycero kinase — 3-phospoglyceric acid (3C) ⟶ 2-phosphoglyceric acid — Isomerisation

9) Enolase — 2-phosphoglyceric acid (3C) $\xrightarrow{-H_2O}$ Phosphophenol pyruvate — Dehydration

10) Pyruvate kinase. — Phosphophenol pyruvate (3C) $\xrightarrow{2ADP \to 2ATP}$ PYRUVATE (3C) — ATP Generation (II) Substrate level phosphorylation

OUTPUT.

2 ATP's, 2NADH, 2 PYRUVATE.

- steps 1, 3, 10 are irreversible reaⁿ in EMP pathway

- Glycolysis is also known as Oxidative anabolism or Catabolic resynthesis because it links with anabolism of fats & Amino acids.

PGAL → Glycerol
PGA → Serine, Glycine
Pyruvate → Alanine.

Q. How many isomerisation reaⁿ are there in glycolysis
→ 3 glucose - 6 - p to fructose - 6p
(2) DHAP to PGAL (3) - 3 phosphoglycero.

Q. At which step ATP is consumed?

LINK Rea^n

1) Connect / Link glycolysis with kreb's cycle → Link rea^n

2) Gateway Rea^n

3) Acetylation of Pyruvate
   ↳ Pyruvic acid → acetyl co-A

4) Matrix of Mitochondria

5) O_2 is not used directly but presence required [ETS]

6) CO_2 is released first time.

7) Enzyme → pyruvate dehydrogenase complex
   ↳ Also found in prokaryotes

   - mg^{++}
   - Lipoic Acid
   - Thiamin Pyrophosphate
   - NAD^+
   - CO-A

8) Thiamin / Vitamin-B1 — Deficiency causes

   Pyruvic Acidosis & Lactic Acidosis.

$2H_2 + 2NAD^+ \rightarrow 2NADH_2$

$$\underset{(3C)}{2\ \text{PYRUVATE}} + \underset{(2C)}{2\ \text{CO-A}} \xrightarrow[\text{COMPLEX}]{\text{PYRUVATE DEHYDROGENASE}} 2\ \text{ACETYL CO-A} + 2CO_2$$

Decarboxylation

(9) 1st Oxidative decarboxylation / Oxidative Dehydrogenation

(10) Acetyl CO-A (2C)

↓

Substrate entrance of krebs cycle

Respiratory Quotient (RQ) or Respiratory ratio.

— Ratio of the Volume of CO_2 evolved to the volume of O_2 consumed in respⁿ is called respiratory quotient or respiratory ratio.

$$RQ = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$$

RQ demand upon type of respiratory substrate used during respⁿ.

Respir. substrate	R.Q
1) Glucose / Carbohydrates	→ 1
2) fats / fatty Acid / Tripalmitin / $C_{51}H_{98}O_6$	→ 0.7 / <1
3) Protein	→ 0.9
4) Organic Acid	→ >1

5) Anaerobic resp^n $\longrightarrow \infty$

6) Oxd^n of carbs to produce organic acid $\longrightarrow 0$

7) Opuntia / succulents / Xerophytes $\longrightarrow 0$

$$2(C_{51}H_{98}O_6) + 145\, CO_2 \longrightarrow 102\, CO_2 + 98 H_2O + E$$
(Tripalmitin)

$$RQ = \frac{102\, CO_2 \text{ evolved}}{145\, O_2 \text{ consumed}} = 0.7$$

But protein and fats are used as respiratory substrate.

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Page ______

KREB'S CYCLE

1) Acetyl CO-A (2C) + Oxalo acetic acid (4C) [First memb of T.C.A] $\xrightarrow[\text{Citrate synthase}]{H_2O \downarrow \quad \uparrow \text{CO-A}}$ citric acid (6C) [1st stable product]

\# CONDENSATION

2) Citric acid (6C) $\xrightarrow[\text{cis aconitase}]{\nearrow H_2O}$ Aconitic ac (6C) $\xrightarrow[\text{cis aconitase}]{H_2O \downarrow}$ Isocitric acid (6C)

\# Dehydration \# Rehydration

Isomarisation

3) Isocitric acid (6C) $\xrightarrow[\text{Isocitrate Dehydrogenase}]{\;}$ Oxalo Succinic acid (6C)

$H_2 + NAD^+ \rightarrow$ $\boxed{NADH_2}$

oxid

\# Oxidation

4) Oxalosuccinic acid (6C) $\xrightarrow[\text{Decarboxylase}]{\nearrow CO_2}$ α-ketoglutratic acid (5C)

\# Decarboxylation

5) α-ketoglutaric acid (5C) $\xrightarrow[\text{α-ketoglutarate Dehydogenase}]{\;}$ Succynyl CO-A (4C)

$H_2 + NAD^+ \rightarrow$ $\boxed{NADH_2}$ $\uparrow CO_2$

\# Oxidative decarboxylation

6) Succynyl CO-A (4C) $\xrightarrow[\text{Succynyl CO-A SYNTHTHASE/ Thiokinase.}]{iP + GDP \rightarrow GTP;\ GTP \rightarrow GDP;\ ATP \rightarrow ADP + iP}$ Succinic Acid (4C)

Substrate level phosphorylation

7) Succinic acid (4C) $\xrightarrow[\text{Succinate Dehydrogenase}]{H_2 + FAD^+ \rightarrow \boxed{FADH_2}}$ fumaric acid (4C)

Oxidation

8) fumaric acid (4C) $\xrightarrow[\text{fumarase}]{H_2O}$ Malic Acid (4C).

Hydration

9) Malic acid $\xrightarrow[\text{Malate Dehydrogenase}]{H_2 + NAD^+ \rightarrow \boxed{NADH_2}}$ Oxalo acetic acid

Oxidation

* TCA also called amphibolic or anaplerotic pathway as intermediate compounds which are formed in TCA cycle are used in synthetic (anabolic) pathway.

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Page

1) Succynyl CO-A :- porphyrin ring compounds like Chlorophyll, phytochromes, Haemoglobin etc...

2) Ketoglutaric acid (5C) :- Amino Acid formation.

3) Acetyl CO-A :- raw material carotenoids, terpenes, gibberllins.

4) OAA :- raw material for alkaloids, pyrimidines.

SUMMARY

- Krebs cycle produces 3 molecules of $NADH_2$, 1 molecule of $FADH_2$ & 1 molecule of GTP but for each glucose molecule krebs cycle is repeated twice.

- Two turn of krebs cycle produces

a) 3 molecule of $NADH_2 \times 2 = 6\,NADH_2 = 18\,ATP$

b) 1 molecule of $FADH_2 \times 2 = 2\,FADH_2 = 4\,ATP$

c) 1 molecule of GTP $= 1 \times 2 = 2\,GTP = 2\,ATP$

Glucose → 2 pyruvate → 2 Acetyl CO·A → 2 Krebs cycle

$1\,NADH_2 = 3\,ATP$
$1\,FADH_2 = 2\,ATP$
$1\,GTP = 1\,ATP$

□ Krebs cycle / TCA (Tricarboxylic acid) / citric acid cycle :-

- Discovered by H.A Kreb (1937) (Nobel prize)
- Citric acid is tri-carboxylic acid so called TCA cycle.
- Occurs in mitochondrial matrix
- All enzymes of TCA cycle except 1 enzyme succinate dehydrogenase present in matrix.
  → pr. in inner memb. of mitochondria
- Krebs cycle is cyclic process through which acetyl co-A is completely oxidised & CO_2 released in stepwise manner.

Electron Transport Chain / ETS (Redox reaⁿ)

- metabolic pathway through which E- are passes from one carrier to another.

Why e⁻ passes?
To release the utilise energy which is stored in $NADH_2$ & $FADH_2$.

- In ETS $NADH_2$ & $FADH_2$ are oxidised to NAD^+ & FAD^+

$$H_2 \longrightarrow 2H^+ + 2e^-$$

Released into mitochondrial matrix. (← $2H^+$)

move along electron carrier. (← $2e^-$)

Complex 1 :- FMN - NADH dehydrogenase (oxidises $NADH_2$)

Complex II :- Succinate dehydrogenase / FADH dehydrogenase (oxidises $FADH_2$)

Complex III :- Cytochrome bc-1

Complex IV :- Cytochrome c oxidase

Complex V :- ATP synthase / ATPase
- → Fo → integral memb. protein
  - → H^+ channel
- → F1
  - → peripheral m. pro^n
  - → ATP synthesis.

H^+ pump → C-I, C III, C IV

H^+ channel :- High to low (without energy)

H^+ pump :- low to high (with energy)

UQ — Ubiquinone
- Present in inner membrane.
- mobile carrier for e^- & H^+

UQH_2 → Ubiquinol ~~or~~ reduced Ubiquinone

Cyt c → mobile carrier only for e^-
- Present at outer surface of inner memb.

	C-I	C-II	C III	C IV	V	Total
$NADH_2$	$4H^+$	0	$4H^+$	$2H^+$	$10H^+$	3
$FADH_2$	0	0	$4H^+$	$2H^+$	$6H^+$	2

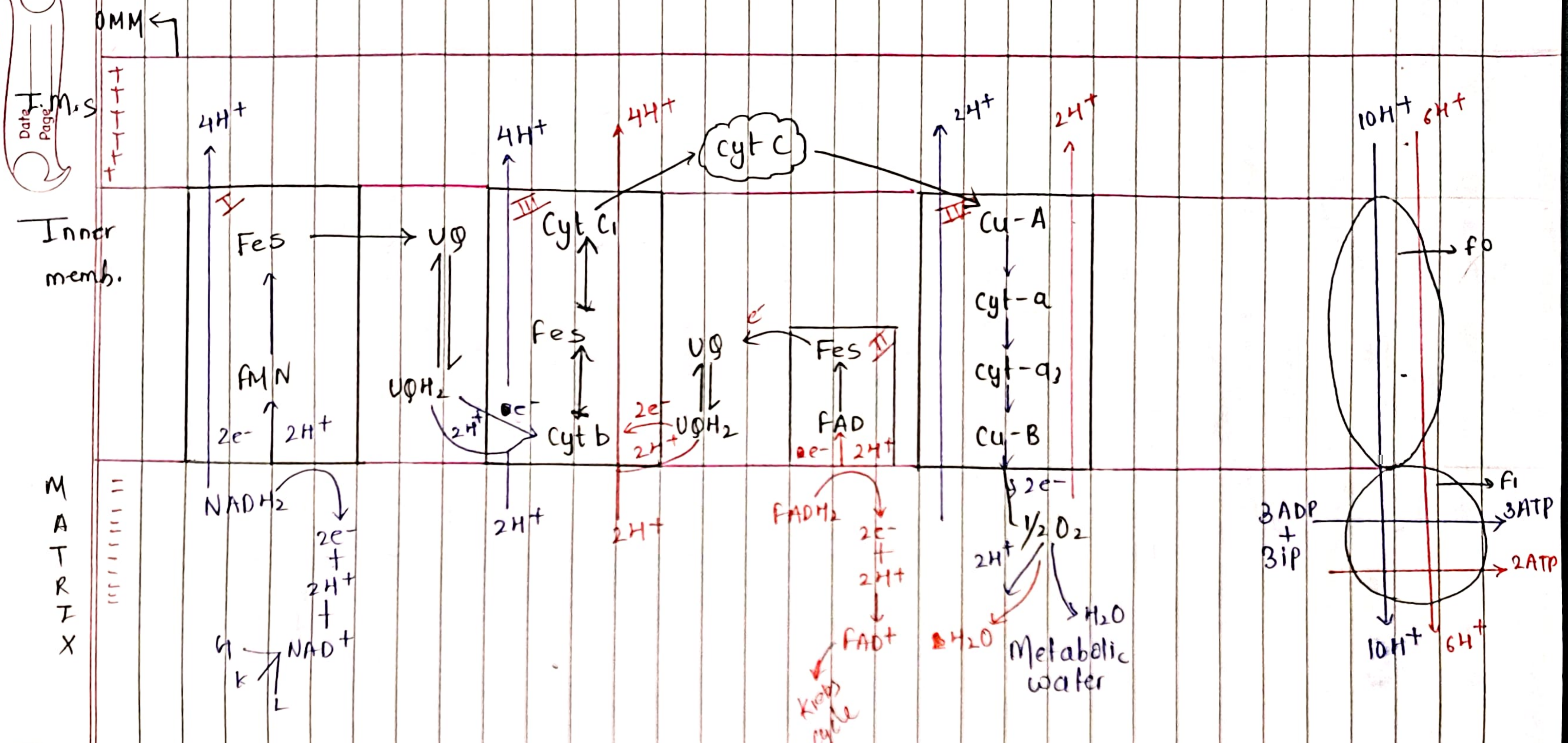
☆ Movement of e^- from cytochrome
cyt-b → c_1 → c → a → a_3

☆ FeS is present in
C I, C II, C III

☆ O_2 ~~from~~ → final H_2 / e^- / H^+ acceptor

Movement of e^- from
Lower Redox Potential → Higher Redox Potential
e^- खींचने की capacity

e^- movement during ETS is
Downhill movement


OMM
I.M.S
Inner memb.
MATRIX
4H+
I
FeS
FMN
2e-
2H+
NADH2
2e- + 2H+ + NAD+
UQ
UQH2
2H+
4H+
III
Cyt C1
FeS
Cyt b
e-
2H+
4H+
cyt C
2e-
2H+
UQ
UQH2
e-
FeS
II
FAD
e-
2H+
FADH2
2e- + 2H+
FAD+
Krebs cycle
2H+
IV
Cu-A
Cyt-a
Cyt-a3
Cu-B
2e-
1/2 O2
2H+
H2O
H2O
Metabolic water
2H+
10H+
6H+
fo
f1
3ADP + 3iP
3ATP
2ATP
10H+
6H+