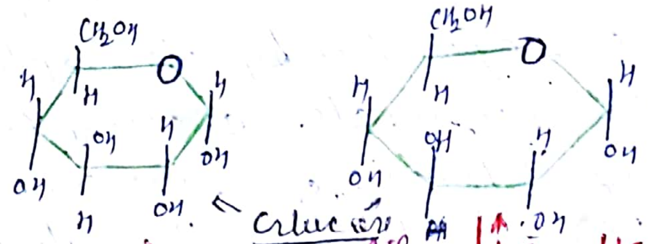
EMP — Embden Meyerhof Parnas

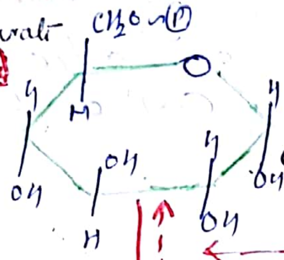
Prokaryotes | Eukaryotes



Glucose

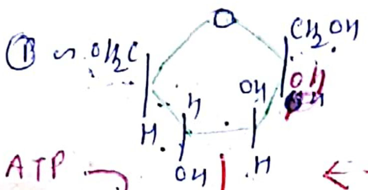
Glucose ← Group transport enzyme (PEP → Pyruvate)

ATP → ADP ← Hexokinase



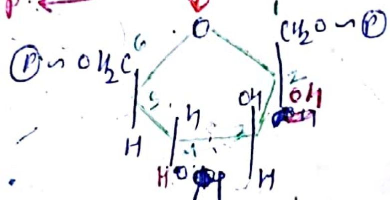
Glucose-6-phosphate

← Phosphohexoisomerase



Fructose 6-phosphate

ATP → ADP ← Phosphofructokinase



Fructose 1-6, biphosphate

← Fructo biphosphate al[dolase]

Used → 2 ATP
Formed → 4 ATP
Net gain → 2 ATP

$NADH+H^+ \rightarrow 2$

1 pair of $H^+ \rightarrow 3$ ATP
↓
In ETC

Total → 3×2=6

Total (Aerobic) – 8

3 phosphoglyceraldehyde		Dihydroxyacetone phosphate
CHO H – C – OH CH₂O~Ⓟ	⇌ Isomerase	CH₂O~Ⓟ C = O CH₂OH

Pi, NAD^+ → $NADH+H^+$ — Phosphoglyceraldehyde dehydrogenase

COO~Ⓟ H – C – OH CH₂O~Ⓟ

1,3, biphosphoglyceric acid (glyceraldehyde)

ADP → ATP — Phosphoglycerate kinase

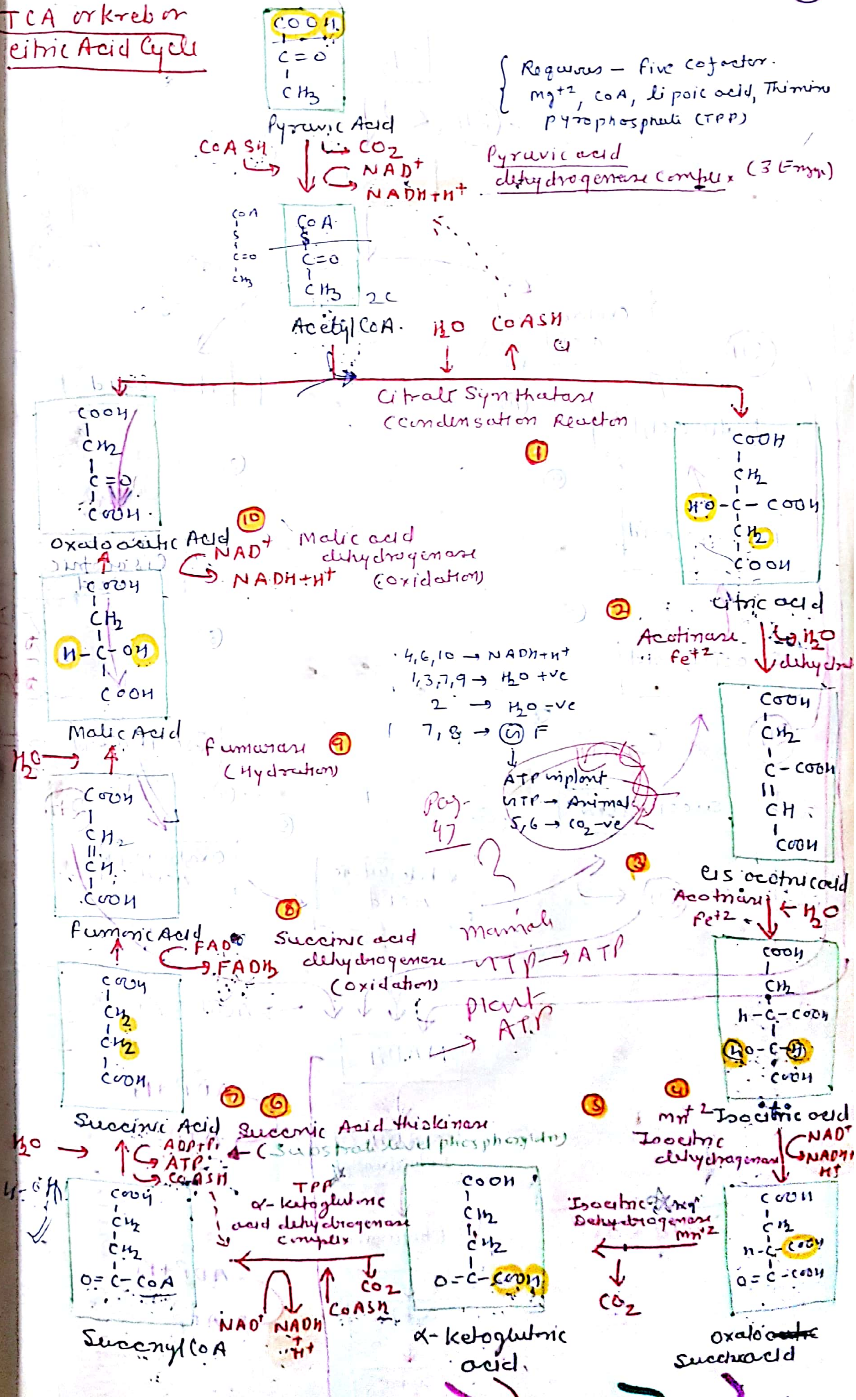
3 phosphoglycerate		2-phosphoglycerate
COOH H – C – OH CH₂O~Ⓟ	→ Phosphoglycerate Mutase, Mg^{+2}	COOH H – C – O – Ⓟ CH₂OH

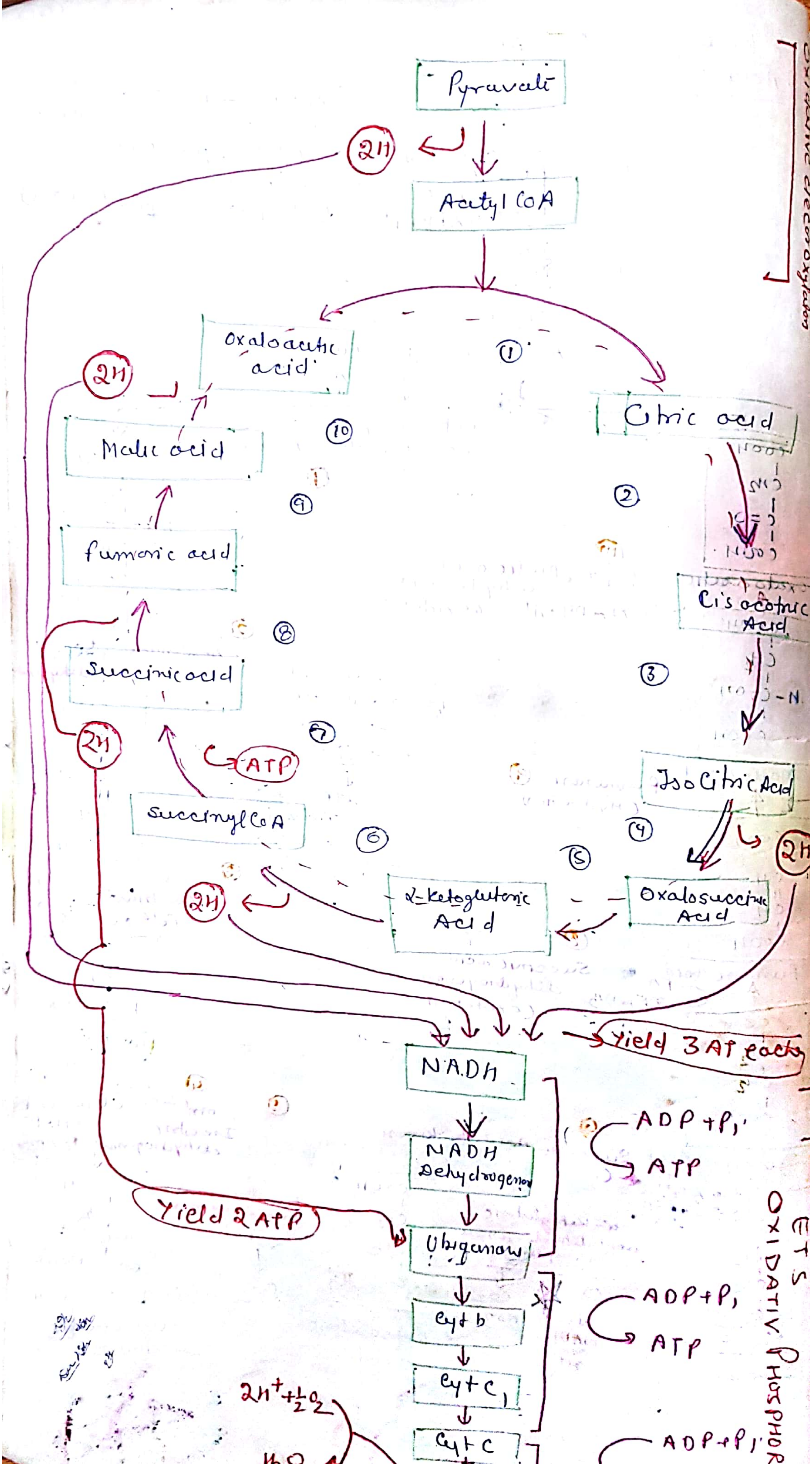
→ H_2O Enolase

Pyruvate kinase

COOH | COOH

TCA or kreb or citric Acid Cycle




Pyruvate
2H
Acetyl CoA
Oxidative decarboxylation
Oxaloacetic acid
1
Citric acid
2
Cis aconitic Acid
3
Iso Citric Acid
4
2H
Oxalosuccinic Acid
5
α-Ketoglutaric Acid
2H
6
Succinyl CoA
ATP
7
2H
Succinic acid
8
Fumaric acid
9
Malic acid
10
2H
Yield 3 ATP each
NADH
NADH Dehydrogenase
Ubiquinone
Cyt b
Cyt c1
Cyt c
ADP + Pi
ATP
ADP + Pi
ATP
ADP + Pi
Yield 2 ATP
2H+ + 1/2 O2
H2O
ETS
OXIDATIVE PHOSPHOR

Decarboxylation of pyruvic acid occurs in mitochondrial matrix and considered as critical reaction in aerobic respiration.

The kreb cycle was named in honor of H.A Krebs, who in 1937 proposed a cyclic reaction to explain how pyruvate breakdown take place in breast muscle of pigeons.

Kinnely & Lehninger discovered that pyruvate & all intermediate of citric acid were oxidised by mitochondria of rat liver.

Acetyl CoA is the connecting link between glycolysis & kreb cycle.

Step-7:→ It is the only step of TCA cycle that directly yield ATP from ADP & Pi (substrate level phosphorylation). In mammals, but apparently not in plants, formation of ATP at this step requires GTP)

* Reduction of NAD^+ and FAD to electron donors NADH & $FADH_2$ that are subsequently oxidized to yield ATP (NADP+ is not used)

* There are five (4 when ATP at 7th step) oxidation step in pyruvic acid oxidation. In each step a pair of H^+ and a pair of electrons are removed

* The total amount of O_2 consumed in five oxidation steps of pyruvic acid is $2\frac{1}{2}$ molecule.

* water produced at 6 steps of kreb cycle out of them 2 step required water hence net gain of water is 4

* Overall reaction is—

$$2\,pyruvate + 8\,NAD^+ + 2FAD + 2ADP + 2H_2PO_4^- + 4H_2O$$

$$\downarrow$$

$$6\,CO_2 + 2ATP + 8\,NADH + 8H^+ + 2FADH_2 + 3H_2O$$

Specific Points about respiration

* About 50% of total energy released during respiration may be utilised for synthesis of biomolecules & other life activities.

* Biological oxidation may yield as much as 100 k cal/mol of O_2 reduced. This energy is then used to synthesize 6 high energy bonds of ATP ($3 \times 2 = 6$ ATP)

* O_2 ultimately reduced to form H_2O
* O_2 is ultimate acceptor of $2e^-$
* LAVOISER: Animals take O_2 from air & gave out $CO_2 + H_2O$.

Glycolysis

* The attachment of phosphate to any substrate called phosphorylation & its activation.
* F-1,6-Di-P, G-6-P, this is process of phosphorylation and activates the sugar & prevent it from getting out of cell.

• $NAD^+ \xrightarrow[2e^-]{2H^+} NADH + H^+$
Reduced — oxidised

In muscle $NADH + H^+ \rightarrow NAD^+ + 2H^+ + 2e^-$
Oxidised

* 2 ATP used in phosphorylation
* $2 \times 2 = 4$ ATP are formed
* Net gain $4 - 2 = 2$ ATP ($2 \times 2 = 4$ Two steps)
* Two NADH (2 steps)

In muscles

$NADH \rightarrow NAD^+ + 2H^+ + 2e^-$ donate

Lactic acid ← Pyruvic acid

* Red muscle fibre (Rich in myoglobin) → Use of O_2 myoglobin to continue energy production over long time. This enables them to perform sustained work over a long period.
* While myoglobin is less in White M. fibre → Produced energy for fast work but short period.

* So Athlets → high Red fibre → physiologically better equipped for sustaine events. eg- Swimming, running, over long distance.

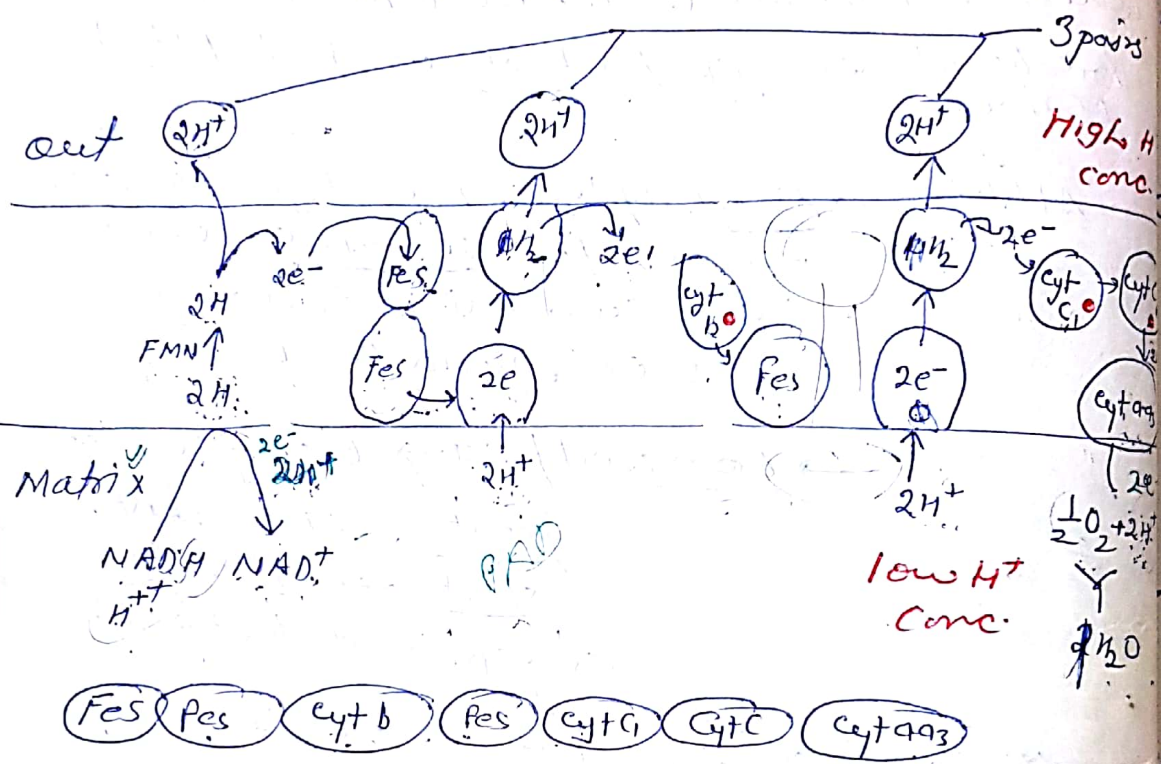
* " " → Low Red fibre → Equpeed for fast, intense, but short activites. ex – sprint & short put.

* In the presence of O_2 yest can respire aerobically
* Aerobic respiration consists of two distinct but mutully dependent process TCA & ETS
* In ETS reduced co-enzymes are ~~responsible~~ regenrated & O_2 is reduced to water
* Pyruvic acid enters in mitochondria & ~~convert~~ combine with CoA & form acetyl CoA & CO_2 release.
* There are 4- Steps of Oxidation in this cycle
* One molecule of ATP is also produced for every molecules of citric acid oxidized.

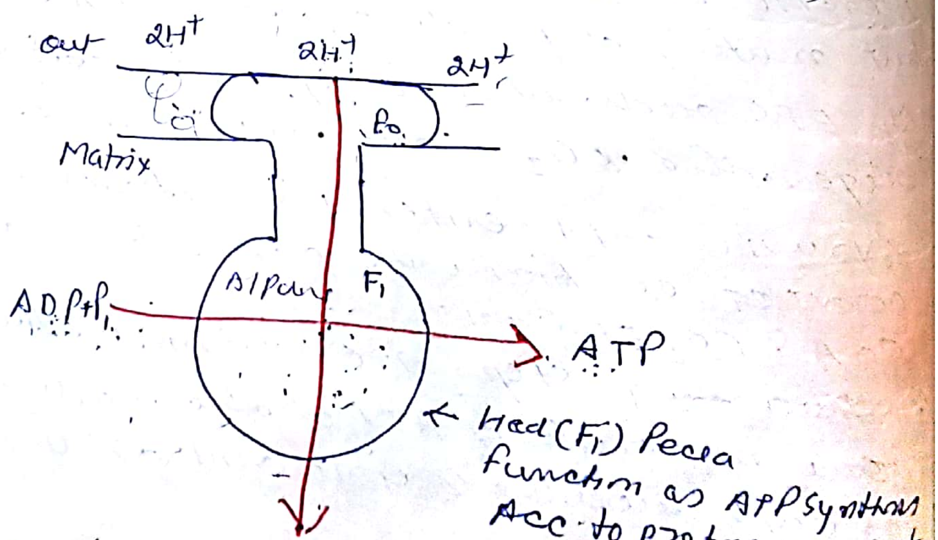
ETS

$NAD^+ \xrightarrow{2H^+, 2e^-} NADH + H^+$

$FAD \xrightarrow{\text{'' \quad ''}} FADH_2$



Oxidative phosphorylation at $F_0 - F_1$ (oxysome)



* ETS recevied e⁻ form NADH & $FADH_2$
* AT the end H^+ & e⁻ combine with O_2 to form H_2O.
* O_2 is terminal acceptor of ETS
* At each step e⁻ acceptor have high e⁻ affinity than e⁻ donar from which it receves e⁻
  Electron Affinity → cyt a-a₃ > cyt C > ...

* The energy from e- transport is utilised for transport H^+ from matrix to out side through inner membrane.

* Proton Gradient → The Δ in H^+ conc across the memb. (i.e Matrix & outside)
→ out side H^+ high conc, Inside Low H^+ conc.

○ Oxidative phosphorylation →

H^+ return to matrix down the conc. gradient (because H^+ conc. higher out side) And the energy release from H^+ flow utilized in ATP formation.

(↑)

* Transport of ~~NAD~~$^+$ 2e- from NAD^+ produce →
3 pair of H^+ → Each pair produce 1 ATP → 3 ATP

* $FADH_2$ → 2 pair H^+ → 2 ATP

* From one Glucose →

Glycolysis → 2 ATP }
TCA → 2 ATP } 4 ATP

4 NADH & 1 $FADH_2$ per TCA = 10 NAD^+ → 30 ATP
2 NAD^+ → Glycolysis = 2 $FADH_2$ → 4 ATP
34 ATP

Total = 34 + 4 ATP = 38 ATP

* In most eukaryotic cells the 2 NAD^+ of glycolysis require 2 ATP from transport NAD^+ to matrix
hence net gain 38-2 = 36 ATP

* Cyanide effect cytochrome oxidase → Cyt b.