MCB 150

The Molecular and Cellular Basis of Life

Lecture 11: Continue with Cellular Respiration

Today's Learning Catalytics Session ID is:
39219229

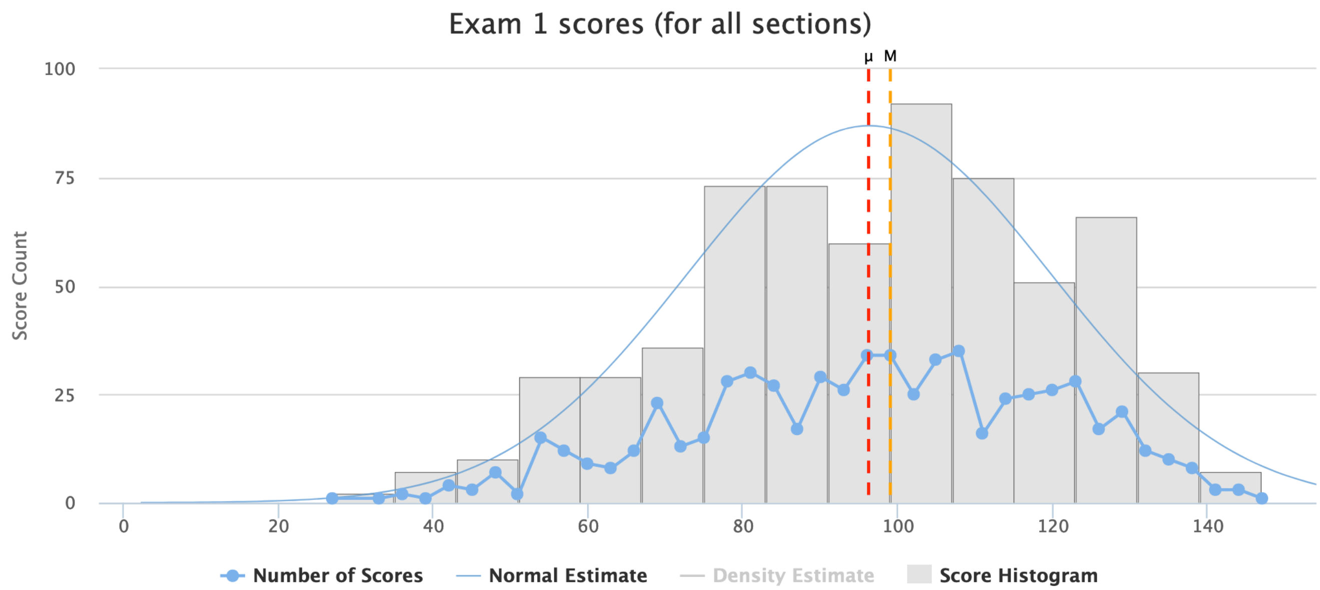
Announcements:

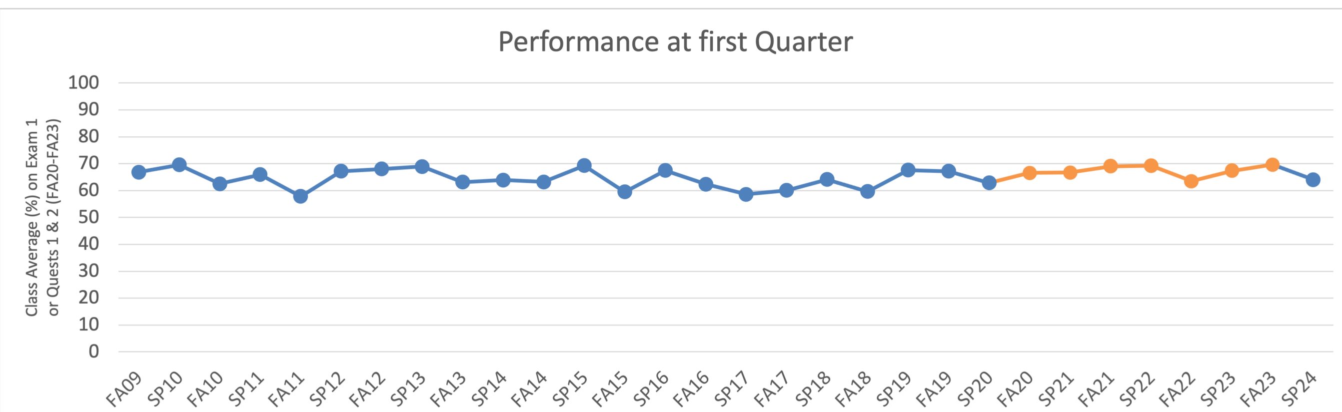
- Reminder that all exam content conversation is in person

Exam Data:

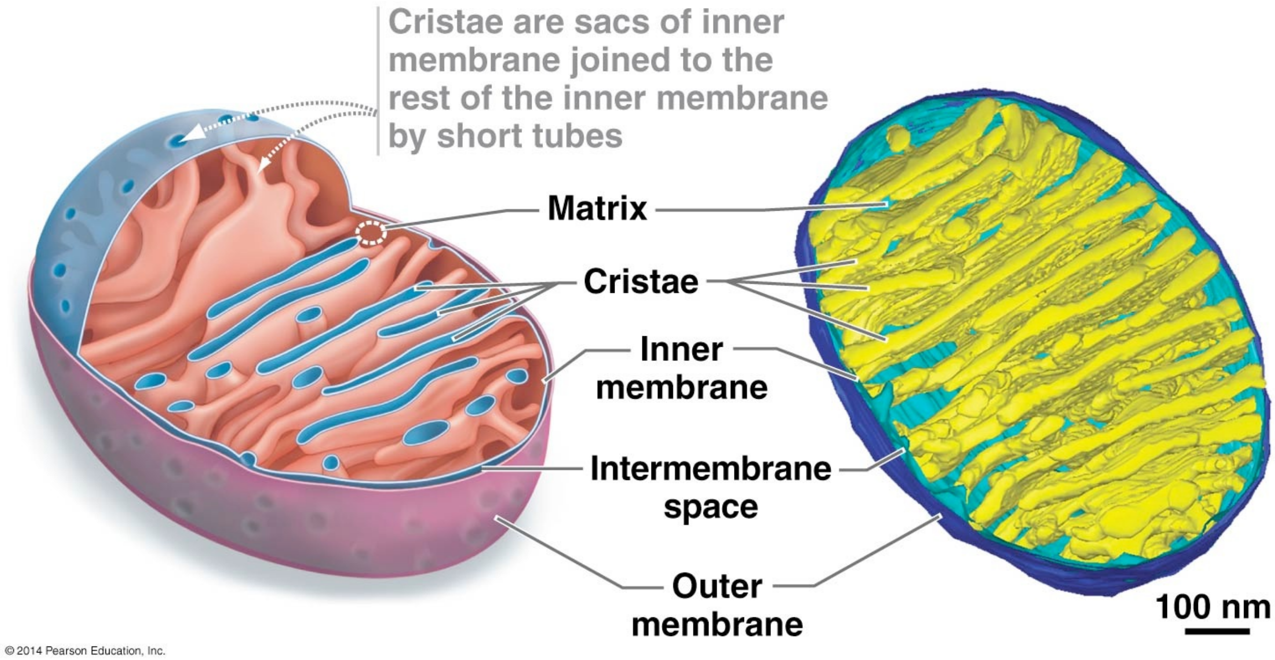
- Mean: 64.2% (64% is a C in MCB 150); Median: 66.0%
- High Score = 147 (98%)

Exam 1 scores (for all sections) Plot





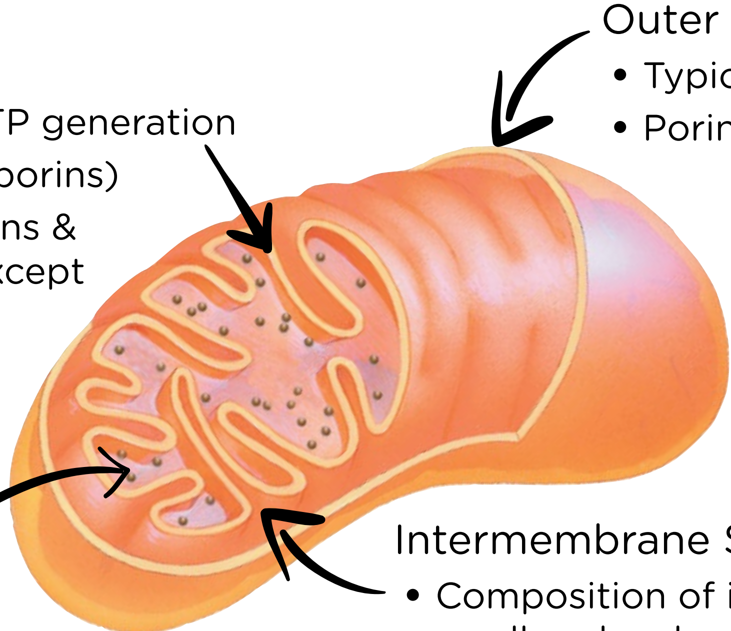
A Mitochondrion:



Organization of mitochondria:

Inner Membrane
- Principal site of ATP generation
- >70% protein (no porins)
- Impenetrable to ions & small molecules except by transporters

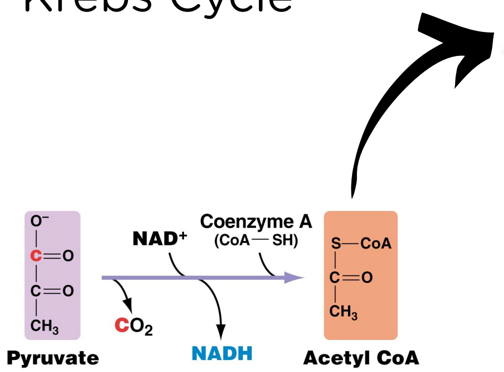
Outer Membrane
- Typical protein %
- Porins

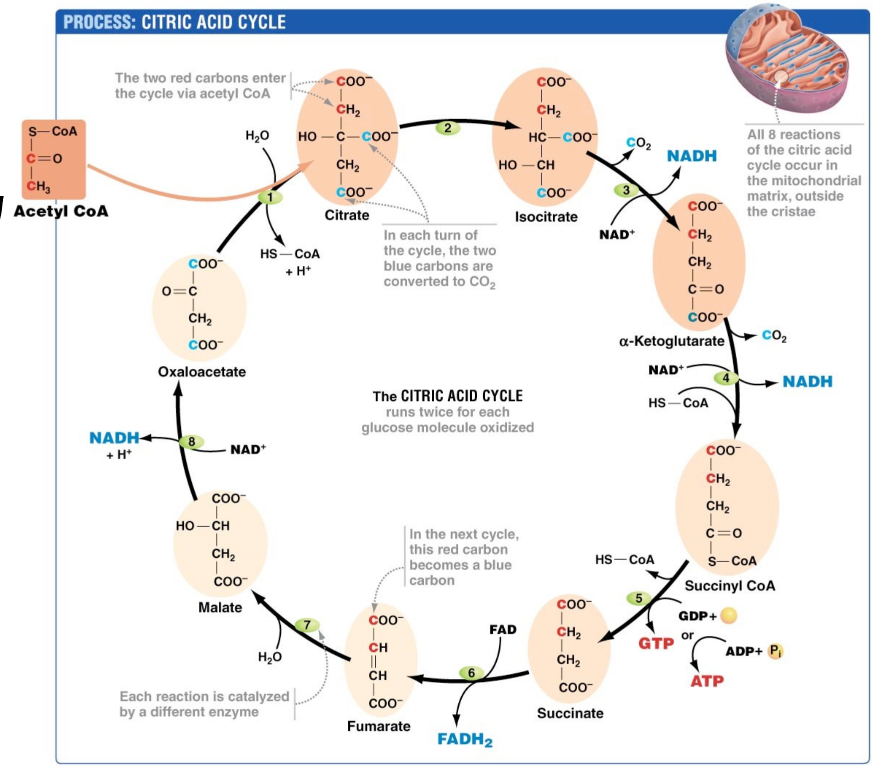


Matrix
- Krebs enzymes
- DNA & ribosomes

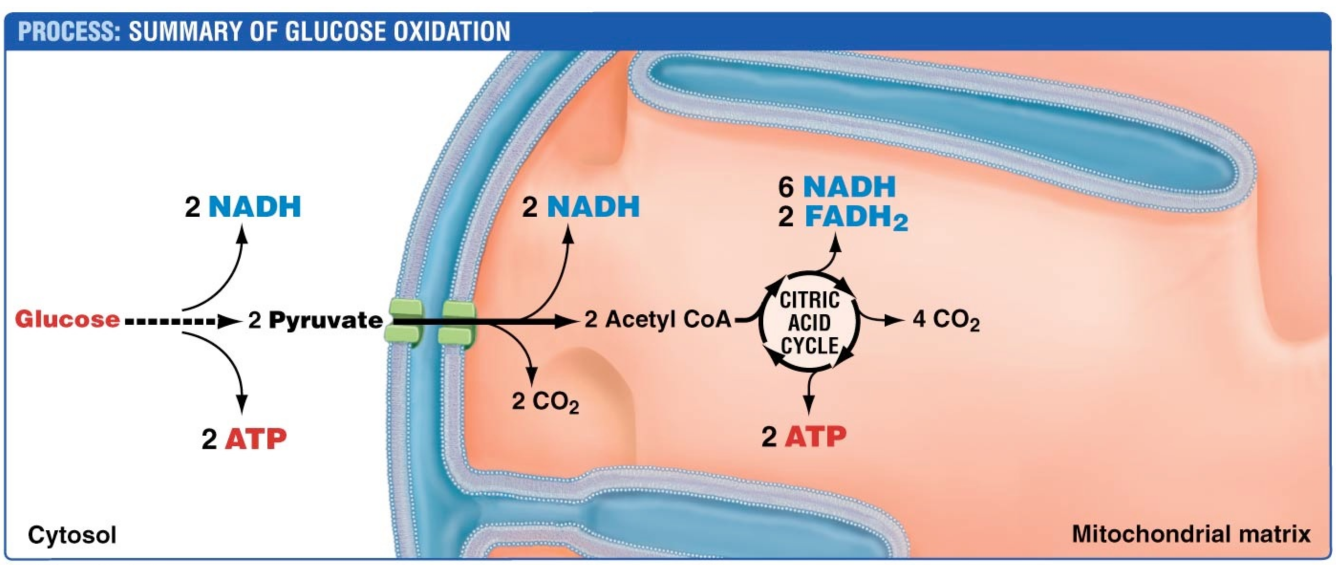
Intermembrane Space (IMS)
- Composition of ions and small molecules is the same as the cytoplasm

Phase 2: Pyruvate Oxidation and Krebs Cycle





Net results of Phase 1 (**Glycolysis**) and Phase 2 (**Pyruvate Oxidation** and **Krebs Cycle**) for every glucose:



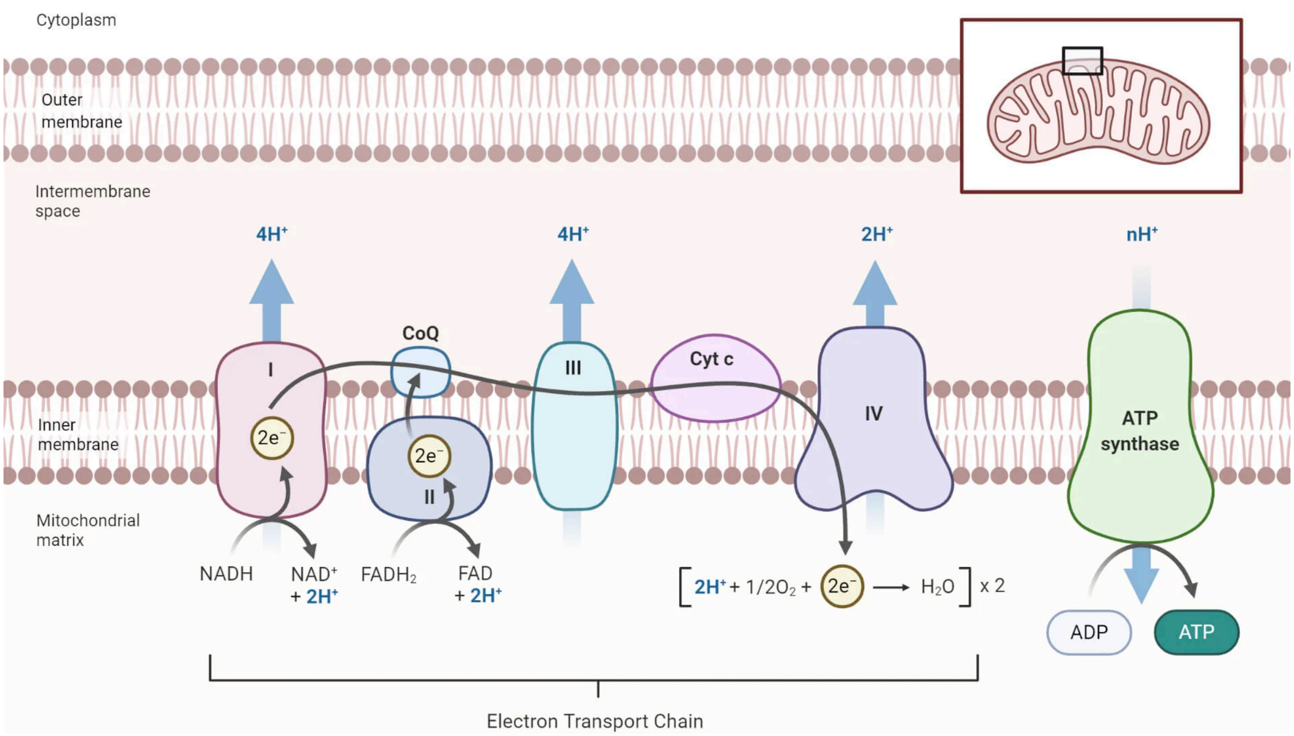
Problems at the end of Krebs Cycle:

1. Still haven't replaced NAD^+; in fact, more NADH is made
2. Now you have $FADH_2$ that needs to be re-oxidized
3. Still haven't transferred energy carried by cofactors to ATP

Also, why is this dependent on oxygen?

- Aerobic respiration requires oxygen, but Krebs Cycle itself does not
- Because Krebs Cycle is coupled to the next pathway which *does* require oxygen –– the Electron Transport Chain

Oxidative Phosphorylation:



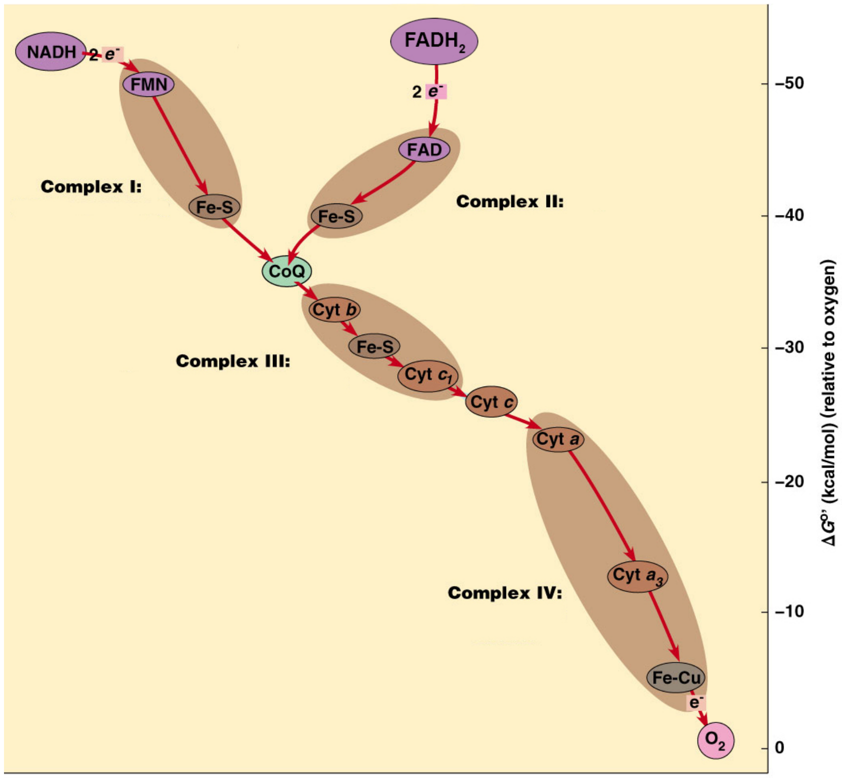
The Electron Transport Chain:

- NADH passes its electrons (and is re-oxidized to NAD^+) to the first carrier in the membrane
  - This ends NAD^+ / NADH's involvement, and NAD^+ is now free to participate in another redox reaction
- First electron carrier passes to second, second carrier passes to third, and so on
  - Because carriers are at successively lower energy levels, energy is released when the electrons are passed
  - This energy is used to pump protons across the membrane
    - ❖ a proton gradient (aka electrochemical gradient) is produced

The Electron Transport Chain:

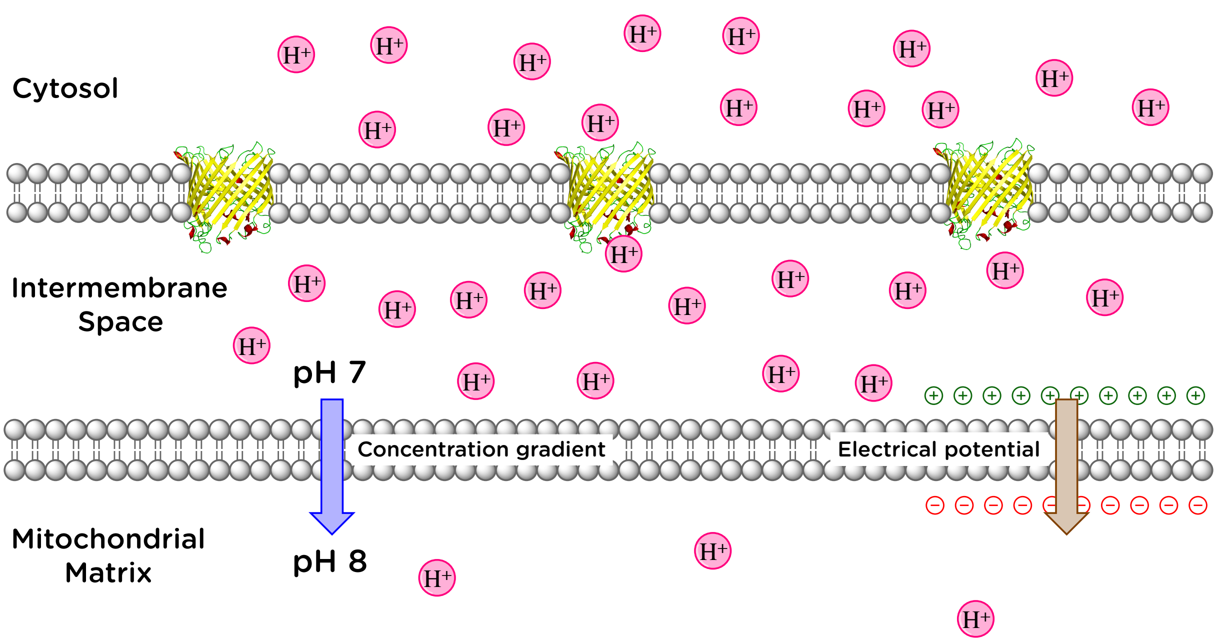
- Last electron carrier passes electrons to **oxygen**, which combines with protons to form **water**
  - Now we've accounted for the CO_2 (Krebs) and H_2O (ETC)
- $FADH_2$ also joins the party, but passes its electrons to a carrier down the line
  - Bypasses Complex I
  - Not as many protons pumped across the membrane
    - ❖ Less of a contribution to the overall electrochemical gradient

Energy levels of electron carriers:

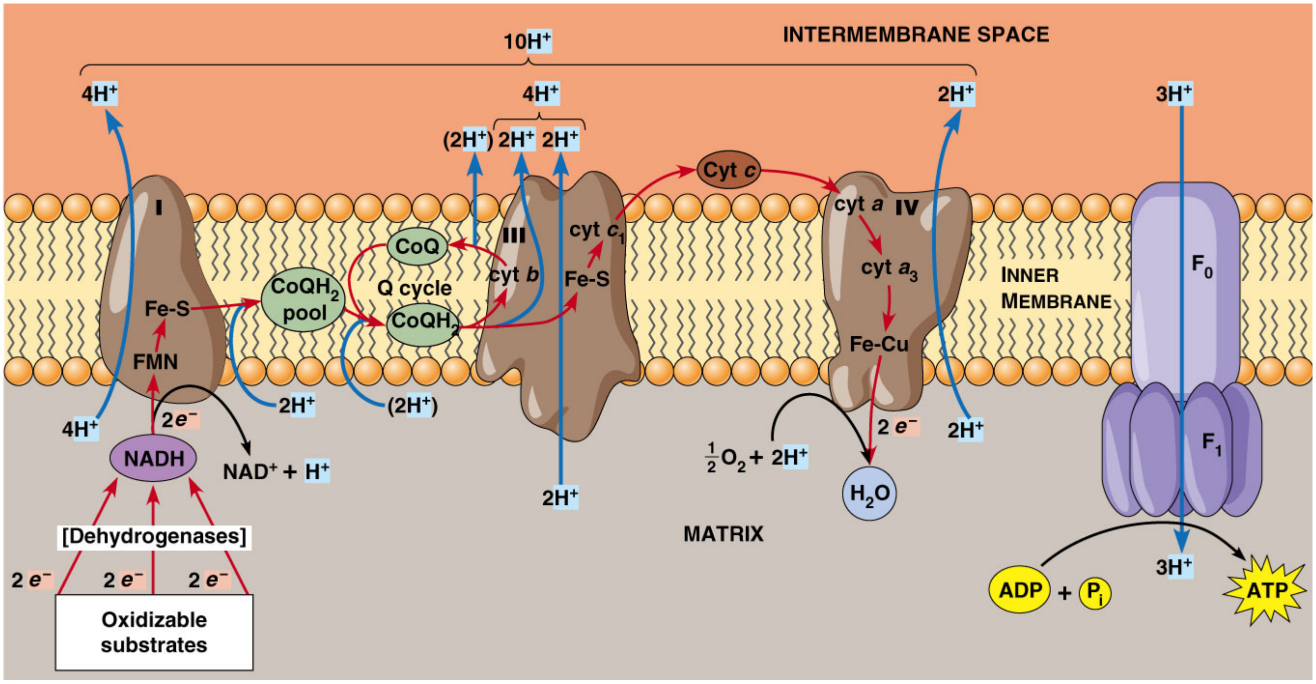


Result of Electron Transport Chain:

- Regenerated cofactors and built gradient, but no ATP!



Proton gradient is unstable → protons want back in:



All energy from breakdown of glucose (not lost as heat) is ultimately used to make ATP:

$$Glucose + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

Theoretical ATP production from full oxidation of glucose:

2 ATP from Glycolysis	=	2	ATP
2 NADH from Glycolysis (x 2 ATP each)	=	4	ATP
2 GTP (≡ ATP) from Krebs cycle	=	2	ATP
8 NADH from Krebs cycle (x 3 ATP each)	=	24	ATP
2 $FADH_2$ from Krebs cycle (x 2 ATP each)	=	4	ATP
Total (theoretical) ATP per Glucose molecule	=	36	ATP