Cellular Respiration
Stage 4: Electron Transport Chain

What's the point?
The point is to make ATP!

ATP accounting so far...
- Glycolysis $\rightarrow$ 2 ATP
- Kreb's cycle $\rightarrow$ 2 ATP
- Life takes a lot of energy to run, need to extract more energy than 4 ATP!

There's got to be a better way!

A working muscle recycles over 10 million ATPs per second
There is a better way!

- Electron Transport Chain
  - series of proteins built into inner mitochondrial membrane
  - along cristae
  - transport proteins & enzymes
  - transport of electrons down ETC linked to pumping of H⁺ to create H⁺ gradient
  - yields ~36 ATP from 1 glucose!
  - only in presence of O₂ (aerobic respiration)

- Mitochondria
  - Double membrane
    - outer membrane
    - inner membrane
    - highly folded cristae
    - enzymes & transport proteins
    - intermembrane space
    - fluid-filled space between membranes

Ooooh! Form fits function!

Electron Transport Chain

Glycolysis
- glucose
- G3P
- 2 NADH
- Time to break open the piggybank

Krebs cycle
- 8 NADH
- 2 FADH₂
- Remember the Electron Carriers?
**Electron Transport Chain**

- NADH → NAD⁺ + H⁺
- H⁺ → e⁻ + H⁺

**Building proton gradient!**

- Intermembrane space
- Inner mitochondrial membrane

**What powers the proton (H⁺) pumps?...**

**Stripping H from Electron Carriers**

- Electron carriers pass electrons & H⁺ to ETC
- H cleaved off NADH & FADH₂
- Electrons stripped from H atoms → H⁺ (protons)

**Electrons flow downhill**

- Electrons move in steps from carrier to carrier downhill to oxygen
  - Each carrier more electronegative
  - Controlled oxidation
  - Controlled release of energy

- Make ATP instead of fire!
We did it!

- Set up a H⁺ gradient
- Allow the protons to flow through ATP synthase
- Synthesizes ATP

We did it!

Chemiosmosis

- The diffusion of ions across a membrane
- Build up of proton gradient just so H⁺ could flow through ATP synthase enzyme to build ATP

Chemiosmosis links the Electron Transport Chain to ATP synthesis

Proton motive force

Are we there yet?

So that's the point!

Peter Mitchell

- Proposed chemiosmotic hypothesis
- Revolutionary idea at the time

1961 | 1978

Proton motive force

1920-1992
AP Biology

Cellular respiration

Summary of cellular respiration

\[ C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \sim 38 \text{ ATP} \]

- Where did the glucose come from?
- Where did the O\(_2\) come from?
- Where did the CO\(_2\) come from?
- Where did the CO\(_2\) go?
- Where did the H\(_2\)O come from?
- Where did the ATP come from?
- What else is produced that is not listed in this equation?
- Why do we breathe?

Taking it beyond...

- What is the final electron acceptor in Electron Transport Chain?
  - \(O_2\)
  - So what happens if \(O_2\) unavailable?
    - ETC backs up
    - nothing to pull electrons down chain
    - NADH & FADH\(_2\) can't unload H
    - ATP production ceases
    - cells run out of energy
    - and you die!