Mitochondria & Generating Energy

**How cells generate energy**
ATP is used to drive energetically unfavorable reactions (such as molecular synthesis, active transport, motility) in coupled reactions.

- **Single reaction**
  - Reactants: Glucose, Fructose
  - Products: Sucrose
  - $\Delta G^\circ = +5.5 \text{ kcal/mole}$
  - NET RESULT: will not occur

- **Coupled reaction**
  - Reactants: Glucose, ATP
  - Products: Glucose-6-P, ADP, $\text{PO}_4$
  - $\Delta G^\circ = -1.8 \text{ kcal/mole}$
  - NET RESULT: sucrose is made in a reaction driven by the hydrolysis of ATP

*Background material in Essential Cell Biology Chap 3*

Review 4 major metabolic pathways involved in producing ATP in eukaryotic cells: Glycolysis, Krebs cycle, Electron transport, Oxidative phosphorylation

### AEROBIC RESPIRATION

<table>
<thead>
<tr>
<th>REACTANTS</th>
<th>PROCESS</th>
<th>PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose, ADP, $H^+$, NAD$^+$</td>
<td>GLYCOLYSIS</td>
<td>Pyruvate, ATP, NADH</td>
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<tr>
<td>Pyruvate, NAD$^+$, FAD, GDP</td>
<td>KREBS CYCLE</td>
<td>CO2, GTP, FADH, NADH</td>
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<tr>
<td>NADH, FADH$^2$, O$2$</td>
<td>ELECTRON TRANSPORT</td>
<td>H2O</td>
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<tr>
<td>$H^+$, ADP</td>
<td>OXIDATIVE PHOSPHORYLATION</td>
<td>ATP</td>
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</table>
Q: How can we determine where in the cell each of these pathways occur?
A: Fractionate cell into cytosol and organelles, add individual reactants for one pathway at a time, and then assay for the production of ATP.

**The mitochondrion**: contains two membrane-bounded compartments:

![Diagram of mitochondrion](image)

(0.5 - 1.0 µm diameter)

Q: How can we determine where in the mitochondrion the Krebs cycle occurs? where electron transport and oxidative phosphorylation occur?

The electron transport chain generates a proton (H⁺) gradient across the inner membrane. This proton gradient drives ATP synthesis. The protein that makes this possible is ATP synthase:

![Diagram of ATP synthase](image)

Protons flow down their gradient across the inner membrane by passing through a channel in ATP synthase, and this flow causes rotation of part of the ATP synthase. Conformational changes occurring in the rotation are used to phosphorylate ADP, producing ATP.