Topic 8.2 Cell Respiration

Essential idea: Energy is converted to a usable form in cell respiration.

Understandings:

- 8.2.U1 Cell respiration involves the oxidation and reduction of electron carriers.
- 8.2.U2 Phosphorylation of molecules makes them less stable.
- 8.2.U3 In glycolysis, glucose is converted to pyruvate in the cytoplasm.
- 8.2.U4 Glycolysis gives a small net gain of ATP without the use of oxygen.
- 8.2.U5 In aerobic cell respiration pyruvate is decarboxylated and oxidized, and converted into acetyl compound and attached to coenzyme A to form acetyl coenzyme A in the link reaction.

Understandings:

- 8.2.U6 In the Krebs cycle, the oxidation of acetyl groups is coupled to the reduction of hydrogen carriers, liberating carbon dioxide.
- 8.2.U7 Energy released by oxidation reactions is carried to the cristae of the mitochondria by reduced NAD and FAD.
- 8.2.U8 Transfer of electrons between carriers in the electron transport chain in the membrane of the cristae is coupled to proton pumping.
- 8.2.U9 In chemiosmosis protons diffuse through ATP synthase to generate ATP.
- 8.2.U10 Oxygen is needed to bind with the free protons to maintain the hydrogen gradient, resulting in the formation of water.
- 8.2.U11 The structure of the mitochondrion is adapted to the function it performs.

Application:

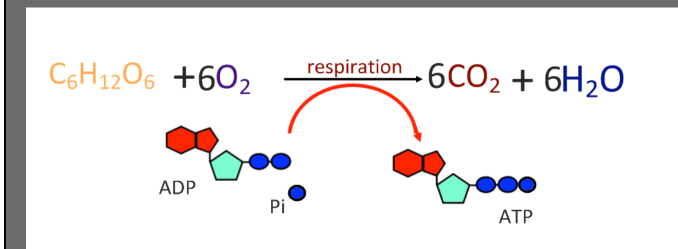
- 8.2.A1 Electron tomography used to produce images of active mitochondria.

Skills:

- 8.2.S1 Analysis of diagrams of the pathways of aerobic respiration to deduce where decarboxylation and oxidation reactions occur.
- 8.2.S2 Annotation of a diagram of a mitochondrion to indicate the adaptations to its function.

ATP is a Source of Energy

Remember this?
ADP + P_i is charged in ATP through the reactions and many enzymes used in cellular respiration.



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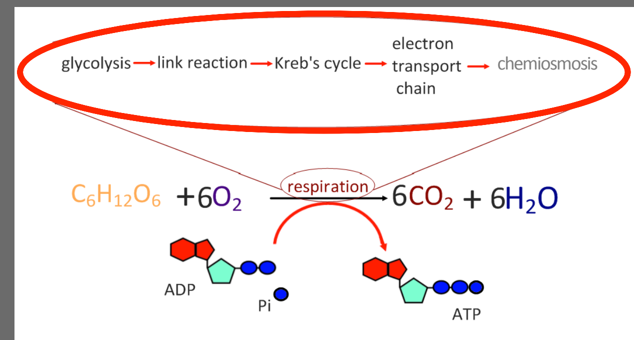
Respiration is the controlled release of the energy from organic compounds in cells to form ATP.



Respiration consists of several different interlinked metabolic pathways.

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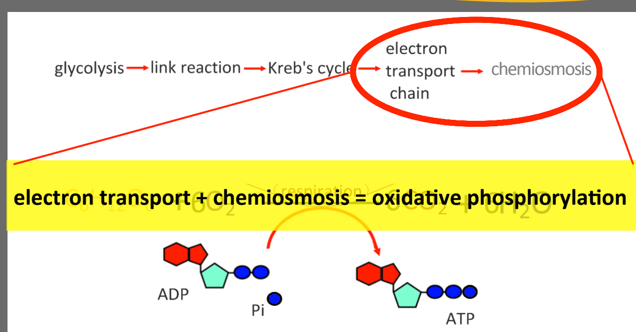

Respiration consists of several different interlinked metabolic pathways.

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I. Structure and function in the mitochondrion

A. The structure of the mitochondrion is adapted to the function it performs-
   1. Outer membrane separates the mitochondria from the cell to carry out aerobic respiration.
   2. Inner membrane (highly folded into cristae to maximize surface area) is where oxidative phosphorylation occurs.
   3. Intermembrane space allows a high concentration of hydrogen ions (protons) to accumulate as a result of electron transport.
   4. Matrix contains the enzymes needed for the link reaction and Kreb's cycle to occur.
   5. mDNA and 70S ribosomes are needed for the production of mitochondrial prtoteins.

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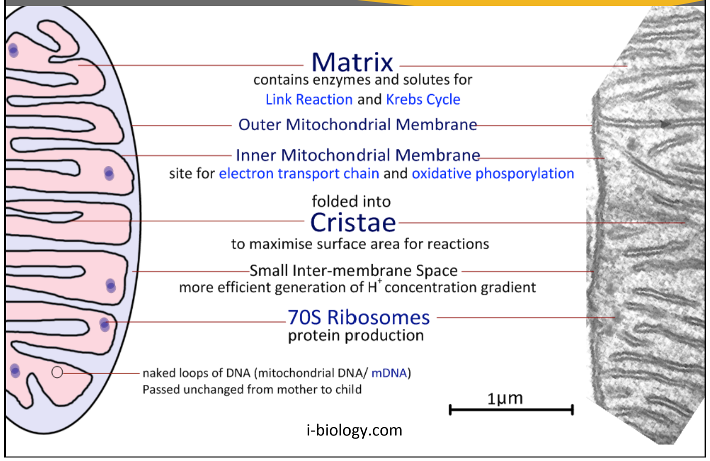
I. Structure and function in the mitochondrion



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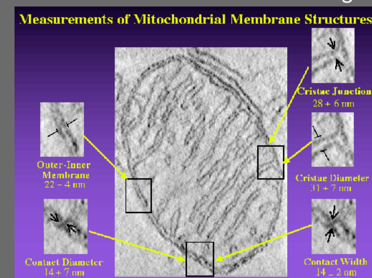
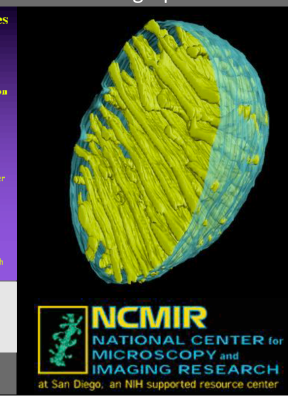
I. Structure and function in the mitochondrion

B. Electron tomography is a technique for obtaining 3D structures of sub-cellular structures using electron micrographs.



Electron tomography is improving the understanding of mitochondrial structure and function.



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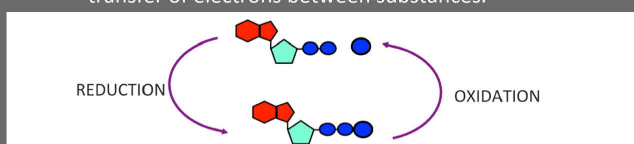
II. Oxidation and Reduction (Redox)

A. Cell respiration involves the oxidation and reduction of compounds-
   1. Oxidation and reduction (redox) reactions involve the transfer of electrons between substances.



Oxidation	Reduction
Electrons are lost *or* *Oxygen is gained* *or* *Hydrogen is removed*	*Electrons are gained* *or* *Oxygen is removed* *or* *Hydrogen is gained*

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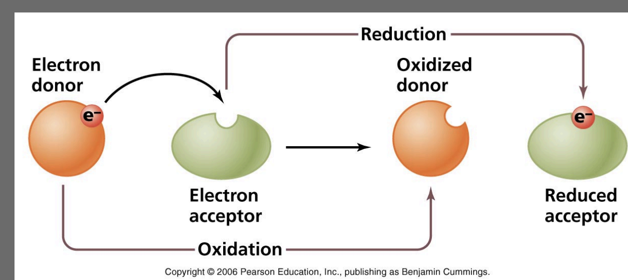
II. Oxidation and Reduction (Redox)

2. Most redox reactions are paired, with one substance donating an electron (reducing agent) and the other accepting an electron (oxidizing agent).



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II. Oxidation and Reduction (Redox)

COMPARE OXIDATION AND REDUCTION

OXIDATION		REDUCTION
	electrons (gained/lost?)	
	oxygen	
	hydrogen	

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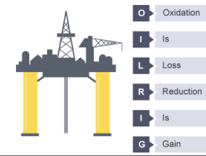
II. Oxidation and Reduction (Redox)

COMPARE OXIDATION AND REDUCTION

OXIDATION		REDUCTION
lost	electrons (gained/lost?)	gained
gained	oxygen	lost
lost	hydrogen	gained

remember : OILRIG



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II. Oxidation and Reduction (Redox)

B. Electron carriers are utilized in cell respiration to shuttle electrons from compounds to the electron transport chain by readily accepting and releasing electrons.

1. The most common hydrogen carrier is NAD (Nicotinamide Adenine Dinucleotide)

$$NAD^+ + 2H^+ + 2e^- \underset{\text{oxidation}}{\overset{\text{reduction}}{\rightleftharpoons}} NADH + H^+$$

Use the simplified form of the equation omitting the detail of the H^+ ions and electrons:

$$NAD^+ \underset{\text{oxidation}}{\overset{\text{reduction}}{\rightleftharpoons}} NADH + H^+$$

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II. Oxidation and Reduction (Redox)

2. Another less frequently used hydrogen carrier is FAD (Flavin Adenine Dinucleotide).

$$FAD + 2H^+ + 2e^- \underset{\text{oxidation}}{\overset{\text{reduction}}{\rightleftharpoons}} FADH_2$$

Use the simplified form of the equation omitting the detail of the H^+ ions and electrons:

$$FAD \underset{\text{oxidation}}{\overset{\text{reduction}}{\rightleftharpoons}} FADH_2$$

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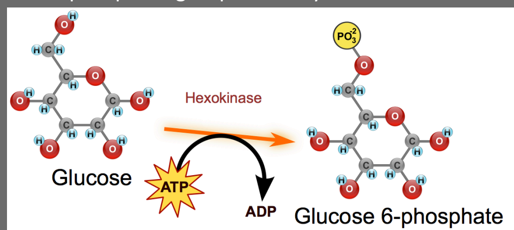
III. Phosphorylation

A. Phosphorylation of molecules makes them less stable-
   1. Phosphorylation is a reaction where a phosphate group (PO_4^{3-}) is added to an organic molecule.
   2. The phosphorylated molecule is less stable and therefore reacts more easily in the metabolic pathway.
   3. The phosphate group is usually transferred from ATP.



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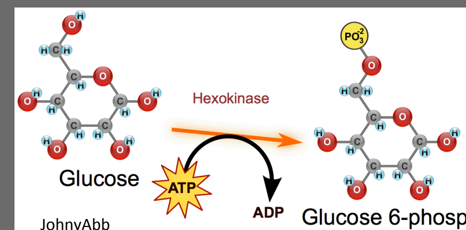
III. Phosphorylation

B. Phosphorylation is a coupled reaction.
   1. Hydrolysis of ATP is exergonic (releases energy).
   2. Converting glucose to glucose-6-phosphate is endergonic (requires energy).
   3. Coupling an exergonic reaction with an endergonic reaction makes the reaction occur spontaneously (a reaction that requires little/no activation energy).



Most metabolic reactions are coupled to the hydrolysis of ATP. How does ATP help reactions occur more easily?

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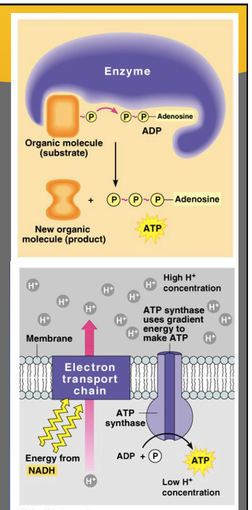
III. Phosphorylation

C. Substrate level phosphorylation versus oxidative phosphorylation.
   1. Substrate level phosphorylation occurs when one compound directly phosphorylates (adds a phosphate group) another compound as in glycolysis and the Kreb's cycle.
   2. Oxidative phosphorylation occurs when one compound is oxidized to indirectly phosphorylate another compound as in the generation of ATP from ADP through the electron transport chain and chemiosmosis.



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