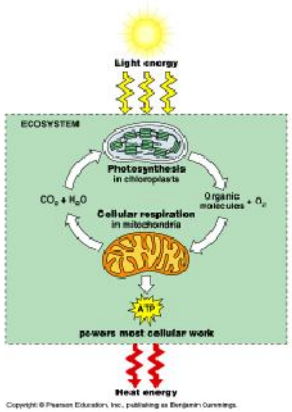
Chapter 9: Cellular Respiration Notes

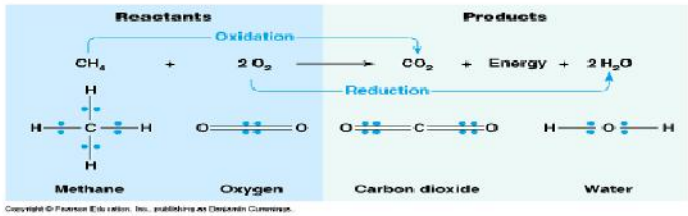


THE PRINCIPLES OF ENERGY HARVEST

- Chemical elements important to life are recycled by respiration and photosynthesis, but energy is not (p. 156)
  - Web/CD Activity9A: Build a Chemical Cycling System
- Cellular respiration and fermentation are catabolic, energy-yielding pathways (pp. 155-156) The breakdown of glucose and other organic fuels to simpler products is exergonic, yielding energy for ATP synthesis.
- Cells recycle the ATP they use for work (p. 156)
  - ATP transfers phosphate groups to various substrates, priming them to do work.
  - To keep working, a cell must regenerate ATP.
  - Starting with glucose or another organic fuel, and using O_2, cellular respiration yields H_2O, CO_2, and energy in the form of ATP and heat.

- Redox reactions release energy when electrons move closer to electronegative atoms (pp. 156-158)
  - The cell taps the energy stored in food molecules through redox reactions, in which one substance partially or totally shifts electrons to another.
  - The substance receiving electrons is reduced; the substance losing electrons is oxidized.

LEO
GER

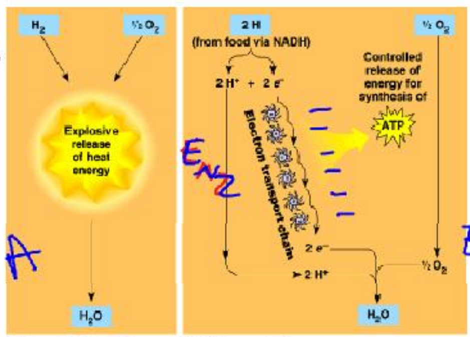


- Electrons "fall" from organic molecules to oxygen during cellular respiration (p. 158)
  - Glucose ($C_6H_{12}O_6$) is oxidized to CO_2, and O_2 is reduced to H_2O.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 +$$

GLUCOSE OXYGEN CARBON DIOXIDE

  - Electrons lose potential energy during their transfer from organic compounds to oxygen, and this energy drives ATP synthesis.
  - The "fall" of electrons during respiration is stepwise, via NAD^+ and an electron transport chain (pp. 158-159)
  - Electrons from food passed to to an electron transport chain, which conducts them to O_2 in energy-releasing steps.
  - The energy released is used to make ATP by oxidative phosphorylation.



(a) Uncontrolled reaction (b) Cellular respiration

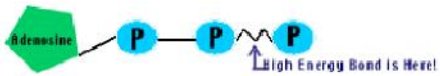
High Energy → Low Energy

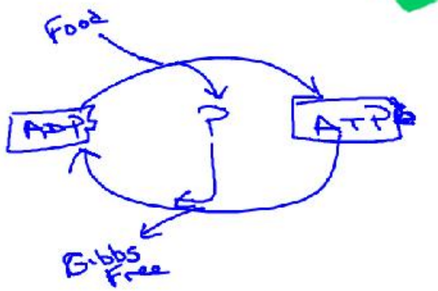
e^- electron

H^+ Hydrogen Ion

Free Energy

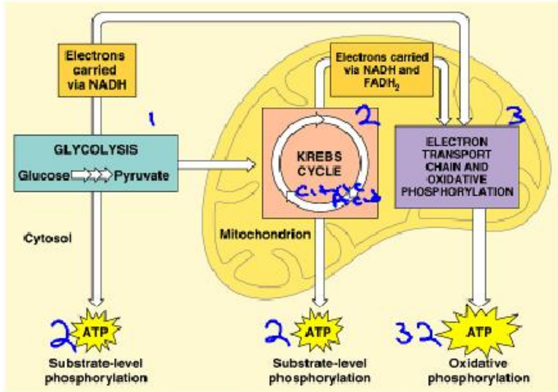
- ADP - ATP Cycle(the battery charger analogy)



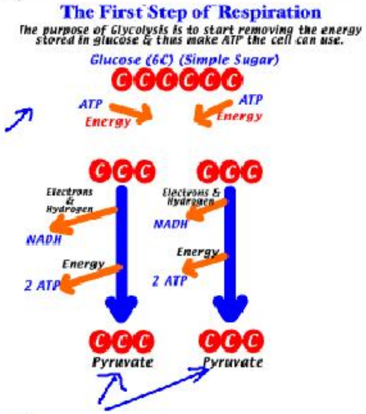


THE PROCESS OF CELLULAR RESPIRATION

- Respiration: glycolysis, the Krebs cycle, and electron transport chain: (pp. 160-161)
  - Glycolysis and the Krebs cycle supply electrons (via NADH) to the transport chain, which drives oxidative phosphorylation.
  - Glycolysis occurs in the cytosol, the Krebs cycle in the mitochondrial matrix. The electron transport chain is built into the inner mitochondrial membrane.



Web/CD Activity9B: Overview of Cellular Respiration



Glycolysis harvests chemical energy by oxidizing glucose (6C) to 2 pyruvate (3C): (p. 161)

- Glycolysis nets 2 ATP (Used 2 ATP as activation energy, got 4 out), produced by substrate-level phosphorylation, and 2 NADH carrying 2 electrons each.

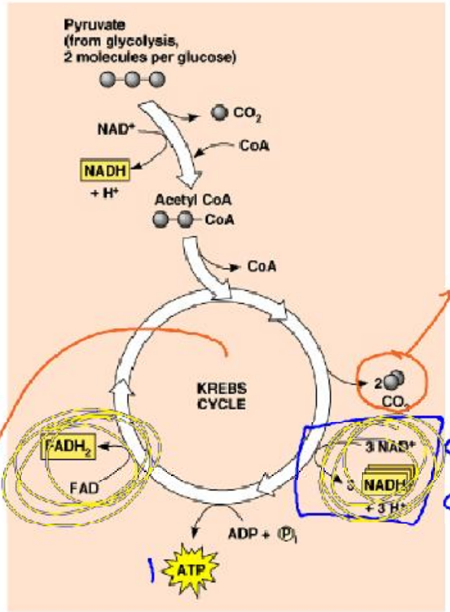
Web/CD Activity9C: Glycolysis

No O_2 - Anaerobic

This is what Citric Acid can use

Citric

- **The Krebs cycle** completes the energy-yielding oxidation of organic molecules: a closer look (pp. 161-166) ***(The disassembly line analogy)***
  - pyruvate is converted to acetyl CoA links glycolysis to the Krebs cycle. The two-carbon acetate of acetyl CoA (Analogy: wood) joins the four-carbon oxaloacetate (Analogy: worker) to form the six-carbon citrate (Worker holding wood), which is degraded back to oxaloacetate (by chopping the . The cycle releases CO_2, forms 1 ATP by substrate-level phosphorylation, and passes electrons to 3 NAD^+ and 1 FAD.

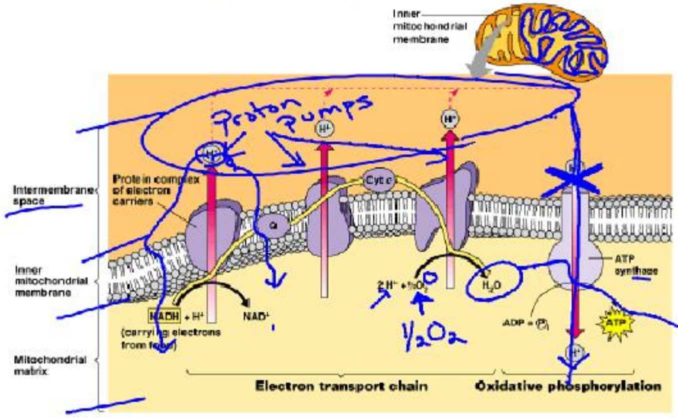


Web/CD Activity9D: The Krebs Cycle

Harvest e⁻ from Pyruvate and capture in matrix

Electron Transport Chain

- The inner mitochondrial membrane couples electron transport to ATP synthesis: (pp. 164-168)
  - Most of the ATP made in cellular respiration is produced by oxidative phosphorylation when NADH and $FADH_2$ donate electrons to the series of electron carriers in the electron transport chain.
  - At the end of the chain, electrons are passed to O_2, reducing it to H_2O.



  - Electron transport is coupled to ATP synthesis by chemiosmosis. At certain steps along the chain, electron transfer causes electron-carrying protein complexes to move H^+ from the matrix to the intermembrane space, storing energy as a proton-motive force (H^+ gradient). As H^+ diffuses back into the matrix through ATP synthase, its exergonic passage drives the endergonic phosphorylation of ADP.

Web/CD Activity9E: Electron Transport

- Cellular respiration generates many ATP molecules for each sugar molecule it oxidizes: a review (pp. 169-170, FIGURE 9.16) The oxidation of glucose to CO_2 produces a maximum of about 38 ATP.
- Biology Labs On-Line: MitochondriaLab

  Web/CD Case Study in the Process of Science: How Is the Rate of Cellular Respiration Measured?

RELATED METABOLIC PROCESSES

Fermentation

- Fermentation enables some cells to produce ATP without the help of oxygen (pp. 170-172, FIGURES 9.17, 9.18)
- Fermentation is anaerobic catabolism of organic nutrients.
- It yields ATP from glycolysis.
- The electrons from NADH made in glycolysis are passed to pyruvate, restoring the NAD^+ required to sustain glycolysis.
- Yeasts and certain bacteria are facultative anaerobes, capable of making ATP by either aerobic respiration or fermentation.
- Of the two pathways, respiration is the more efficient in terms of ATP yield per glucose.
  - Respiration - 36 ATP/Glucose,
  - Fermentation - 2 ATP/Glucose
- Glycolysis occurs in nearly all organisms and probably evolved in ancient prokaryotes before there was O_2 in the atmosphere.
- Humans do Lactic Acid Fermentation with Lactic Acid as the product.

  Web/CD Activity9F: Fermentation

- Glycolysis and the Krebs cycle connect to many other metabolic pathways (pp. 172-173, FIGURE 9.19) These catabolic pathways combine to funnel electrons from all kinds of food molecules into cellular respiration. Carbon skeletons for anabolism (biosynthesis) come directly from digestion or from intermediates of glycolysis and the Krebs cycle.
- Feedback mechanisms control cellular respiration (p. 173, FIGURE 9.20) Cellular respiration is controlled by allosteric enzymes at key points in glycolysis and the Krebs cycle. This helps the cell strike a moment-to-moment balance between catabolism and anabolism.