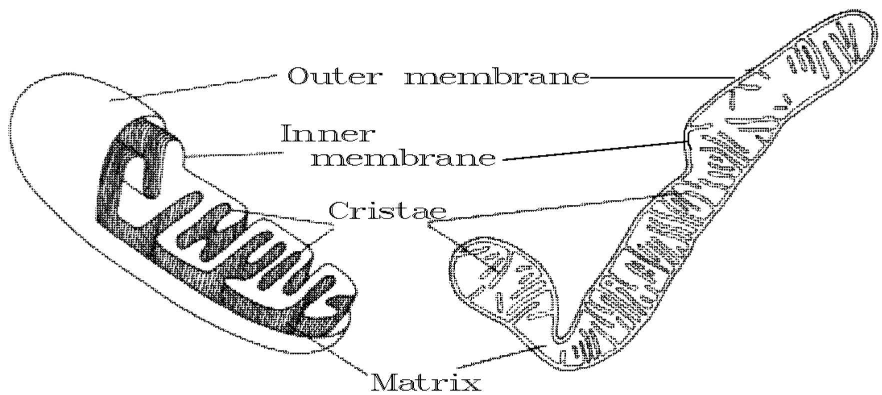
Unit II
Respiration and Photosynthesis

I. Bonds and chemical Energy

A. Respiration defined: the conversion of chemical energy within organic molecules into metabolically usable energy inside living cells.

B. Organelle involved: **Mitochondria**



Mitochondria

II. Oxidation and Reduction

Fuel→Fuel Fragments

$2e^-$ ↘

2H+ ↘

Oxygen →→→ Water

A. Oxidation defined: removal of hydrogen and electrons, and always followed by reduction; usually oxygen is the terminal acceptor.

B. Reduction defined: The acceptance of hydrogen and electrons.

A. What kind of molecule serve as fuel?

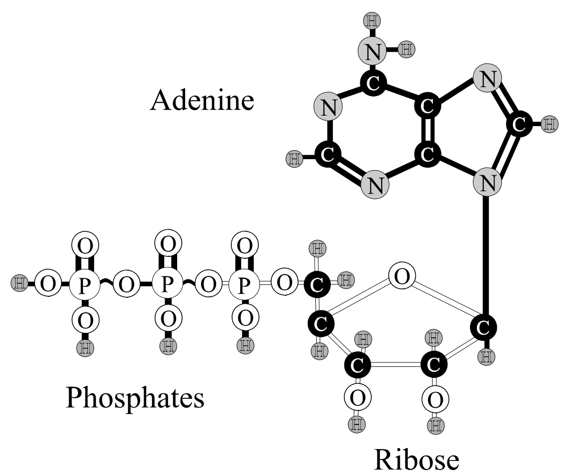
1) any organic constituent of a cell:
carbohydrate - used first
fats - used second
proteins - used last

2) Respiration does not differentiate between expendable and non-expendable fuels. Although cell structure is usually used last, respiration will even break down mitochondria.

B. In what form is the energy initially stored?

1) Adenosine triphosphate or ATP

2) ATP → ADP + P (energy) → ATP



IV. Energy Transfer

A. The shifting of bond energy within the fuel molecule.

1) Rearrangement reactions will often shift the bond energy around to special bonds within the molecule; these become the high energy bonds.

2) This is accomplished through oxidation such as:

dehydrogenation	$\rightarrow H^+$
dehydration	$\rightarrow H_2O$
decarboxylation	$\rightarrow CO_2$
ionization	$\rightarrow e^-$

3) Fuels with low energy bonds go through oxidation and become fuels with high energy bonds.

B. The Process of Energy capture

1)Principle type of high energy bond is the **Phosphate** bond.

2) Phosphate bonds have the capability of storing more energy than is necessary to maintain the bond.

3) A low energy phosphate bond can be converted to a high energy phosphate bond through oxidation.

Fuel-P <u>Oxidation</u> ➜ Fuel~P

2 H^+ ↘
2e

4) But before the above can occur, a phosphate must first be added to the fuel; this is called **Phosphorylation.**

Fuel <u>Phosphorylation</u> ➜ Fuel-P →<u>Oxidation</u>➜ Fuel~P
↗ ↘
-P 2 H^+ + 2e-

5) Generally the molecule supplying the phosphate is **ATP.**

ATP ------➜ ADP +P

Fuel <u>Phosphorylation</u> → Fuel-P➜ <u>Oxidation</u>➜ Fuel~P
-P↗ ↘
ATP➜ ADP 2H+,2e-

6) The high energy phosphate bond is harvested from the fuel by a molecule of ADP.

ADP + fuel~P ---➜ ATP + fuel

6) What happens to the $\mathbf{H^+}$ and $\mathbf{e^-}$ during oxidation?

C. Hydrogen Transport or the Electron Transport System

Fuel-P <u>Oxidation</u> →Fuel~P
↘
H^+, e^- both are release and transferred to electron carriers.

1) These carriers are special molecules which can be ionized to accept electrons (e^-) and then subsequently the protons (H^+).

2) When the carriers receive the electrons and protons they become **reduced** and when they pass them on they become **oxidized**.

e^-, H^+ --→ Reduced*H_2 Oxidized--→ Reduced*H_2
↘ ↘ ↘
Carrier A Carrier B Carrier C
↗ ↗ ↘
Oxidized ---→ Reduced*H_2 Oxidized --→ e^-,H^+

3) The electrons which have been lost during oxidation are high energy electrons and the carriers take a little bit of energy away from the electrons and with each transfer they use the energy to do work.

4) The work that is accomplished is the coupling of free phosphate with ADP to make ATP.

5) The final electron and hydrogen acceptor is **oxygen.**

$2H^+ + 2e^- + O_2$ ------→ H_2O

6) Therefore, there are two sources of high energy phosphate bonds to make ATP; one from the substrate (or fuel) the other from Oxidation.

Substrate Phosphorylation

and

Oxidative Phosphorylation

7) Of the two, the second, oxidative Phosphorylation is most important. For every two electrons and two protons sent through the oxidative Phosphorylation system, three molecules of ATP are produced (reduced).

D. Aerobic Transport (Oxidative Phosphorylation) Major Carriers

1) Nicotinamide adenine dinucleotide (**NAD**)

Part derived from the nucleotides
Part derived from nicotinic acid (Vit. B)

2) Flavin adenine dinucleotide (**FAD**)

Part derived from riboflavin (Vit. B)
Part derived from nucleotides

3) **Cytochrome System**

A complex series of carriers which are protein in nature and have reactive iron atoms that help them transfer electrons.

4) These carriers are located within the inner membranes of the mitochondria.

5) Theory of Chemosmosis (Peter Mitchell,1978)

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