Energy , Oxidation-Reduction Reactions and Electron Carriers

Energy is the capacity to do work or to cause particular changes, thus all physical and chemical processes are the result of the application or movement of energy. Living cells carry out three major types of work:

- Chemical work: involves the synthesis of complex biological molecules required by cells from much simpler precursors; energy is needed to increase the molecular complexity of a cell.
- Transport work: cells require energy input in order to uptake nutrients, eliminate wastes and maintain ions balance.
- Mechanical work: energy is required to change the physical location of organisms cells and structures within cells.

The ultimate source of most biological energy is the visible sunlight on the earth surface. Light energy is trapped by phototrophs during photosynthesis; in which it is absorbed by chlorophyll, other pigments and converted to chemical energy.

Chemolithoautotrophs derive energy by oxidizing inorganic compounds rather than obtaining it from light absorption. Chemical energy from photosynthesis and chemolithotrophy can then be used by photolithoautotrophs and chemolithoautotrophs to transform CO_2 into biological molecules such as glucose.

The complex molecules manufactured by autotrophic organisms (both plant and microorganisms) producers serve as a carbon source for chemoheterotrophs and other consumers that use complex organic molecules as a source of material and energy for building their own cellular structures (autotrophs also use complex organic molecules).

Chemoheterotrophs often employ O_2 as an electron acceptor when oxidizing glucose and other organic molecules to CO_2 ,this process in which O_2 acts as the final electron acceptor and is reduced to water is called aerobic respiration, much energy is released during this process.

The CO_2 produced during aerobic respiration can be incorporated again into complex organic molecules during photosynthesis and chemolithoautotrophy.

The cells must have a practical form of energy currency, in living organisms the major currency is adenosine 5-triphosphate (ATP).

ATP breaks down to adenosine diphosphate (ADP) and orthophosphate (Pi), energy is made available for useful work. Energy from photosynthesis, aerobic respiration, anaerobic respiration and fermentation is used to re-synthesize ATP from ADP and Pi an energy cycle is created in the cell.

The release of energy normally involves oxidation – reduction reactions (redox) reactions in which electrons move from an electron donor to an electron acceptor :

$$2H^+ + 2e \longrightarrow H_2$$

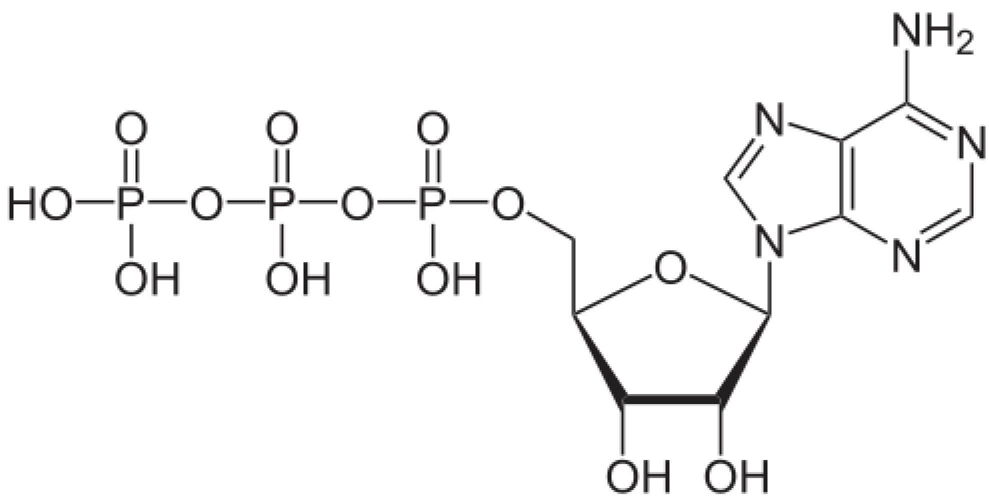
In this reaction each hydrogen atom provides one proton (H+) and one electron (e-).

Photosynthetic organisms capture light energy and use it to move electrons from water and other electron donors such as H_2S to electron acceptors such as NADP+.

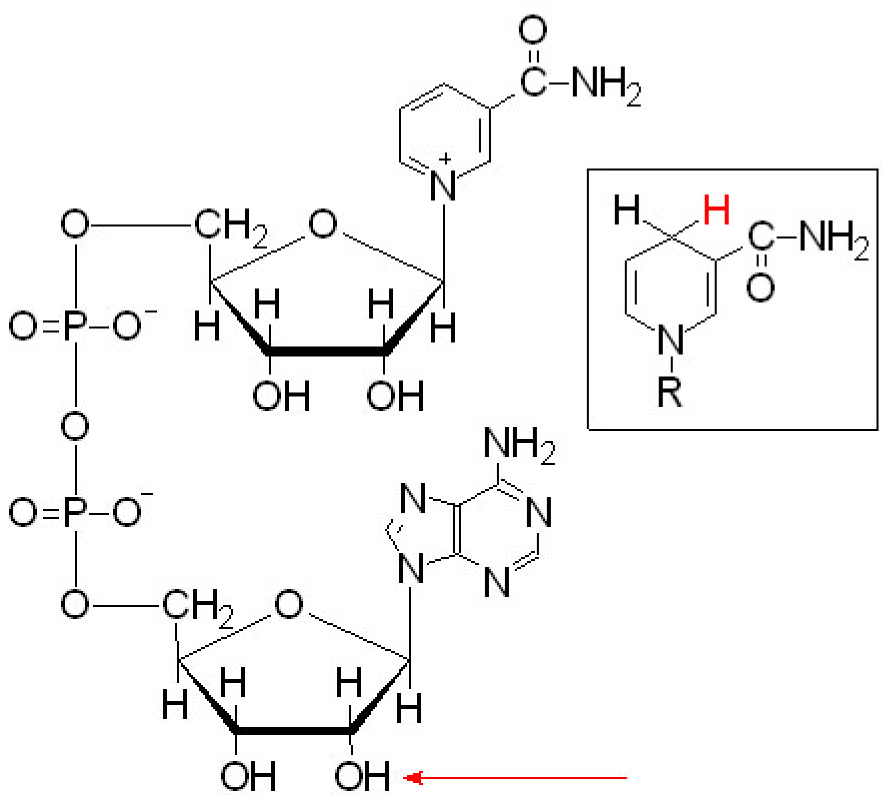
Photoautotrophs use ATP and NADPH to synthesize complex molecules from CO_2. Chemoheterotrophs also make use of energy released during the movement of electrons by oxidizing complex nutrients during respiration to produce NADH which donates it's electrons to O_2 and the energy released during electron transfer is trapped in the form of ATP.

The energy from sunlight is made available to all living organisms because of this relationship between electron flow and energy. Electron transport is important in aerobic, anaerobic respiration, chemolithotrophy and photosynthesis. Electron movement in cells requires the participation of carriers such as NAD^+ and $NADP^+$.

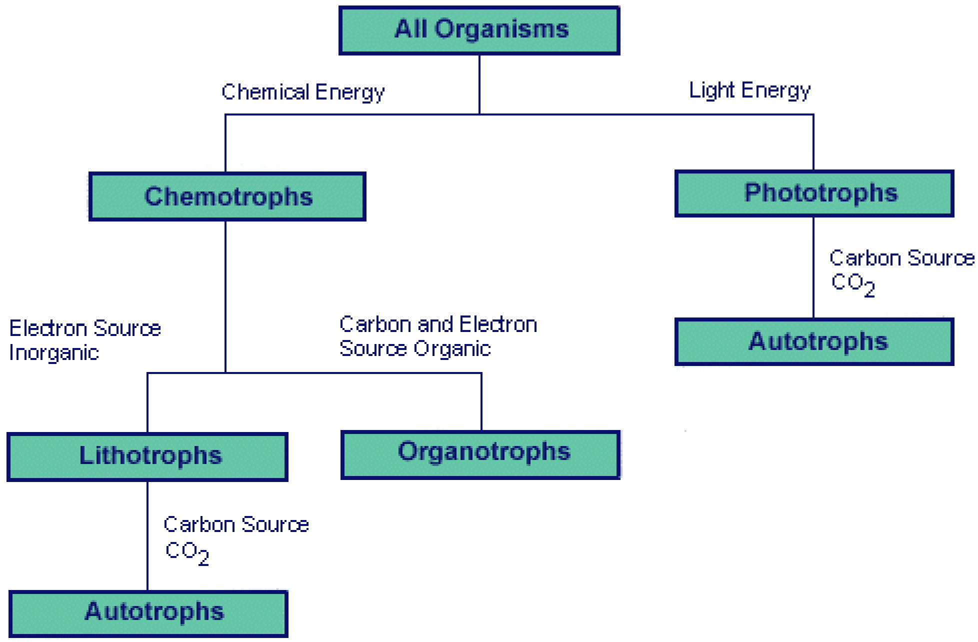
There are several other electron carriers of importance in microbial metabolism: FAD = Flavin adenine dinucleotide and FMN =Flavin mononucleotide bear two electrons and two protons , Coenzyme Q (CoQ) or ubiquinon ,Cytochromes and several other carriers use iron atoms to transport electrons .



Adenosine Triphosphate (ATP) chemical structure



Structure of NAD,NADP and NADH



Source of energy for microorganisms