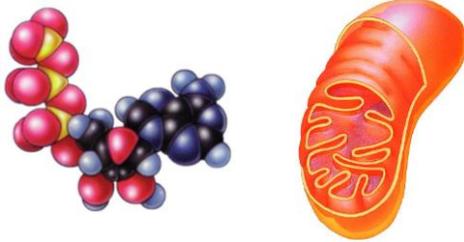


## Chapter 9.1 Cellular Respiration: Harvesting Chemical Energy



## Nutritional Requirements

- Animals are **heterotrophs**
  - ♦ need to take in food
  - ♦ Why? fulfills 3 needs...
    - **fuel** = chemical energy for production of ATP
    - **raw materials** = carbon source for synthesis
    - **essential nutrients** = animals cannot make
      - ♦ elements (N, P, K, Fe, Na, K, Ca...), NAD, FAD, etc.

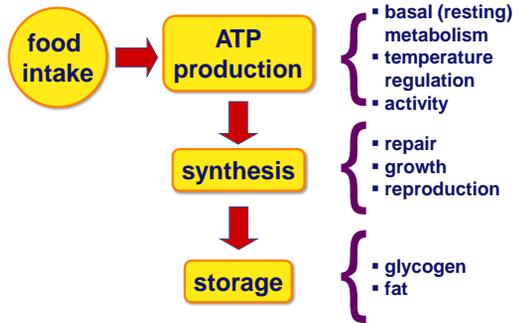


## Harvesting stored energy

- Energy is stored in organic molecules
  - ♦ heterotrophs eat food (organic molecules)
    - digest organic molecules
      - ♦ serve as **raw materials** for building & **fuels** for energy
    - controlled release of energy
      - ♦ series of step-by-step enzyme-controlled reactions
  - ♦ **“burning”** fuels
    - carbohydrates, lipids, proteins, nucleic acids

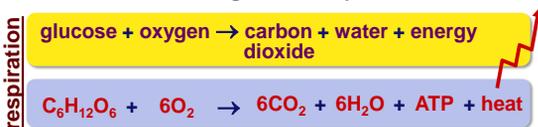


## Energy Budget



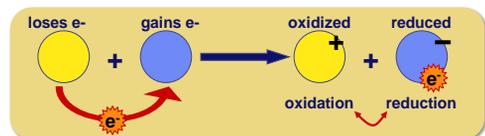
## Harvesting energy stored in glucose

- **Glucose** is the model
  - ♦ catabolism of glucose to produce ATP



## How do we harvest energy from fuels?

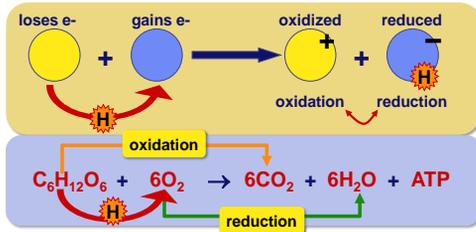
- Digest large molecules into smaller ones
  - ♦ break bonds & move electrons from one molecule to another
    - as electrons **move** they carry energy with them
    - that energy is **stored in another bond, released as heat, or harvested to make ATP**



### How do we move electrons in biology?

▪ Moving electrons

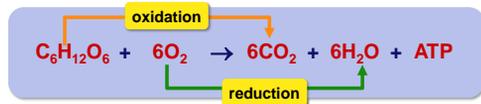
- ♦ in living systems, electrons do not move alone
- electrons move as part of **H atom**



### Coupling oxidation & reduction

▪ Redox reactions in respiration

- ♦ release energy as breakdown molecules
  - break C-C bonds
  - strip off electrons from C-H bonds by removing H atoms
    - ♦  $C_6H_{12}O_6 \rightarrow CO_2$  = fuel has been oxidized
- ♦ releases energy to synthesize ATP
- ♦ electrons attracted to more electronegative atoms
  - ♦ in **biology**, the most electronegative atom?  $\rightarrow O_2$
  - ♦  $O_2 \rightarrow H_2O$  = oxygen has been reduced



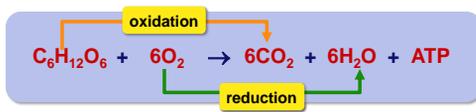
### Oxidation & reduction

▪ Oxidation

- ♦ loss of electrons
- ♦ removing H
- ♦ "adding O"
- ♦ releases energy
- ♦ **exergonic**

▪ Reduction

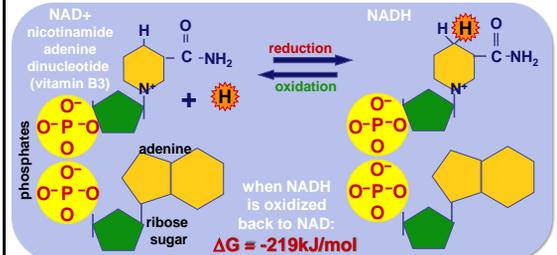
- ♦ gain of electrons
- ♦ adding H
- ♦ "removing O"
- ♦ stores energy
- ♦ **endergonic**



### Moving electrons in respiration

▪ Electron carriers move electrons (and energy) by shuttling H atoms around

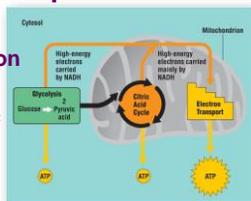
- ♦  $NAD^+ \rightarrow NADH$  (reduced)
- ♦  $FAD^{+2} \rightarrow FADH_2$  (reduced)



### Overview of cellular respiration

▪ 4 metabolic stages

- ♦ Anaerobic respiration
  - 1. Glycolysis
    - ♦ respiration **without**  $O_2$
    - ♦ in cytosol
- ♦ Aerobic respiration
  - ♦ respiration **using**  $O_2$
  - ♦ in mitochondria
  - 2. Pyruvate oxidation
  - 3. Kreb's cycle
  - 4. Electron transport chain



### What's the point of respiration?

**ATP**

The Point is to Make ATP!  
Any Questions??