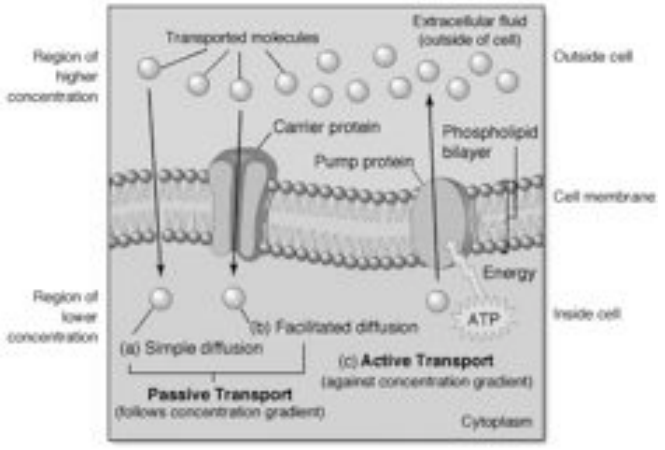
Topics

- Transport
  - Active
    - Bulk Transport
- Cellular Respiration
  - Redox reactions
  - Glycolysis

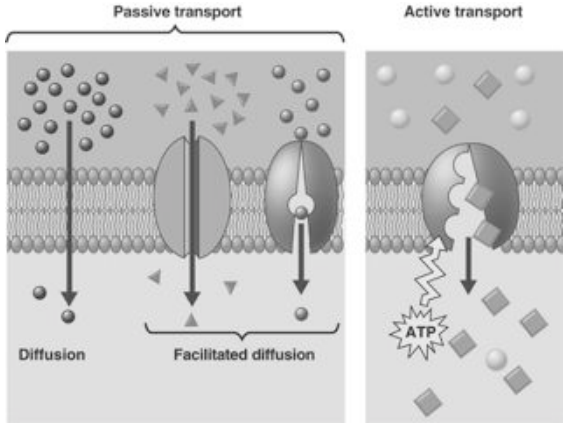
Membrane transport



Facilitated Diffusion Review

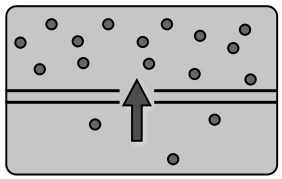
- **Passive** form of carrier-mediated transport
  - Moves molecules down their concentration gradient only
  - Aids the transport of small, polar or charged substances
  - Does not use energy
- Can become **saturated**
- Carrier proteins are **regulated** by cellular and body processes
- Carriers are often **highly specific** in what molecules they transport

Membrane transport



Active Transport

(Uses energy, can move molecules **against** a concentration gradient)



Is **directional**: Moves a substance in or out of the cell against its concentration gradient

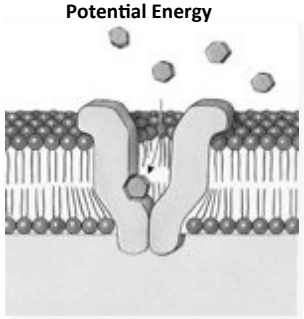
2 basic types, both requiring energy and a carrier:

Primary active transport: involves the direct hydrolysis of ATP

Secondary active transport: indirectly uses ATP to create an ionic or electrical concentration gradient to aid transport

Gradients

Potential Energy

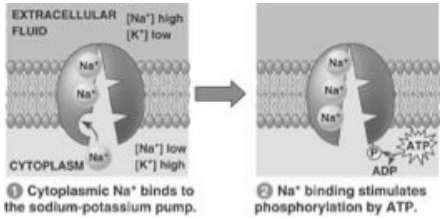


Molecules want to move from an area of high concentration to one of lower concentration

The concentration gradient for glucose creates potential energy in the cell and is a **chemical gradient**

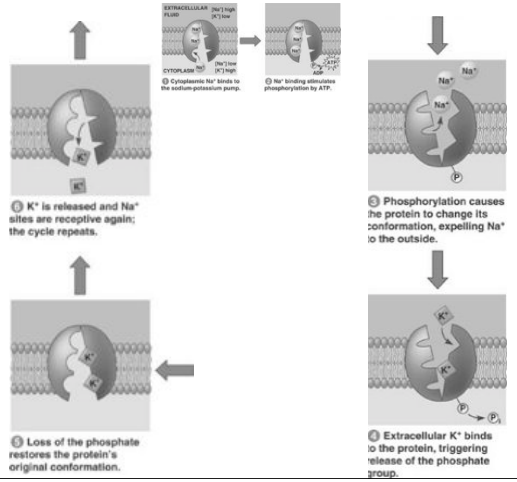
Primary active transport: Na^+ / K^+ pump

The Sodium/Potassium pump is **active carrier-mediated transport**



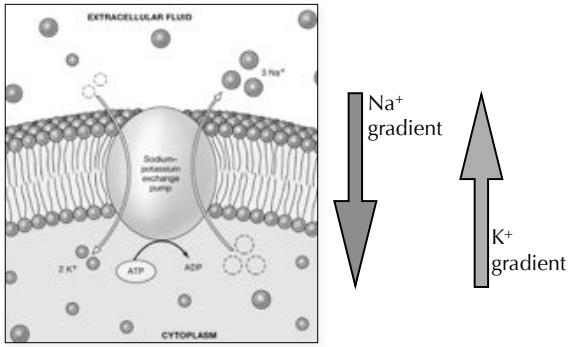
The Na^+/K^+ transporter is an ATPase

Primary active transport: Na^+ / K^+ pump



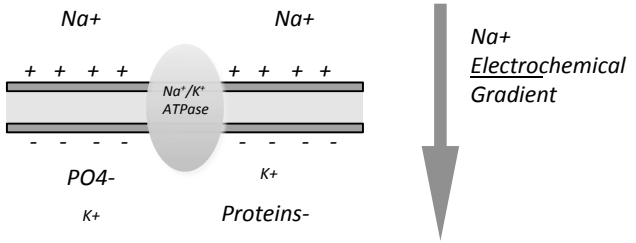
The Na^+ / K^+ pump

The Sodium/Potassium pump creates opposing **chemical gradients** of Na^+ and K^+



The Na+/K pump creates an ***electrochemical gradient*** for Na^+ ions

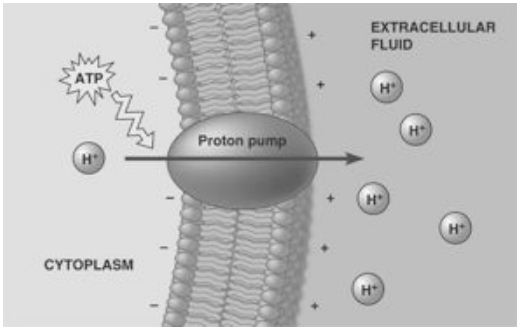
There is a separation of charge along cell membranes Creates a **membrane potential**



At physiological pH "most" proteins are negatively charged.

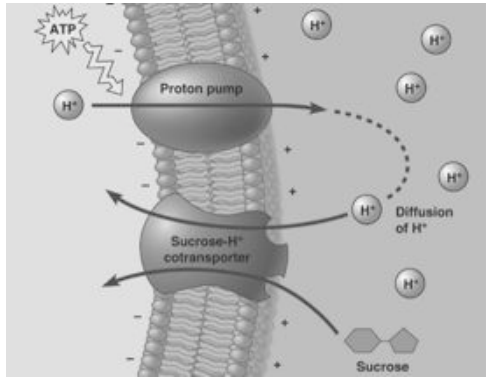
Proton Pump

- Generates voltage across cell membrane
- Usually powered by ATP (important later)



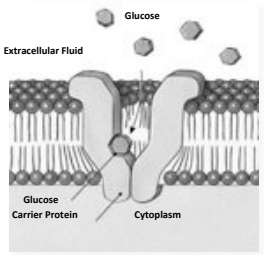
"Secondary" Active Transport

Indirectly uses energy to transport a molecule against its concentration gradient. Often referred to as **Cotransport**



Facilitated Diffusion vs. "Secondary" Active Transport

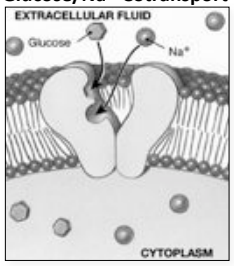
Facilitated Diffusion



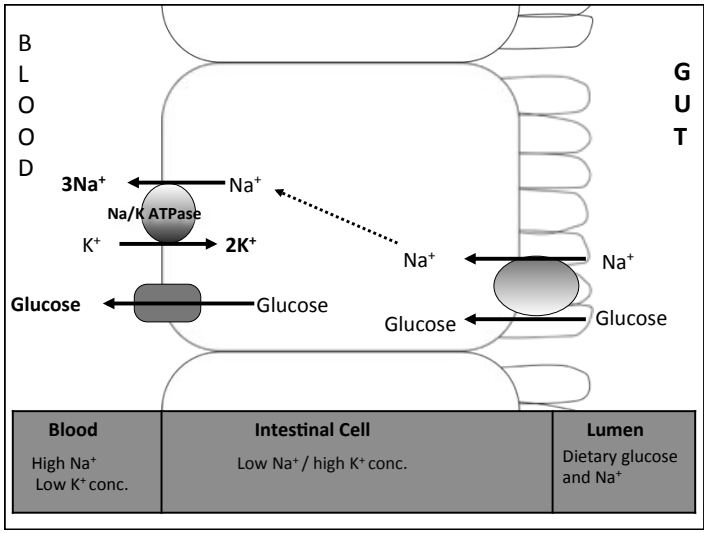
Glucose moving **down** its concentration gradient (passive)

VS.

Glucose/Na+ Cotransport



Glucose moving **up** its concentration gradient, driven by the powerful, **electrochemical gradient** of Na^+



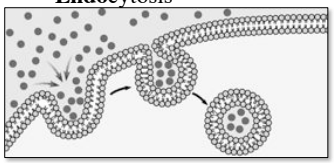
Transport Mechanisms

Property	Passive Diffusion	Facilitated Diffusion	Active Transport	Cotransport*
Requires specific protein	–	+	+	+
Solute transported against its gradient	–	–	+	+
Coupled to ATP hydrolysis	–	–	+	–
Driven by movement of a cotransported ion down its gradient	–	–	–	+
Examples of molecules transported	O_2, CO_2, steroid hormones, many drugs	Glucose and amino acids (uniporters); ions and water (channels)	Ions, small hydrophilic molecules, lipids (ATP-powered pumps)	Glucose and amino acids (symporters); various ions and sucrose (antiporters)

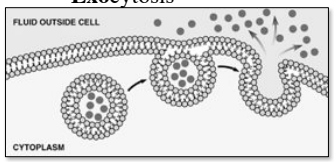
*Also called secondary active transport.

Bulk Transport

Endocytosis



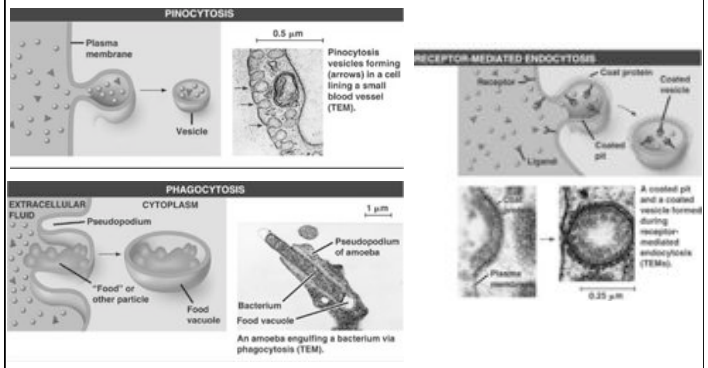
Exocytosis



• Used for transfer of molecules too large for carriers or channels (proteins, large lipids, whole cells, etc.)

Endocytosis	Exocytosis
Import of lipids	Salt in tears
White blood cell attacks on bacteria	Hormone secretion

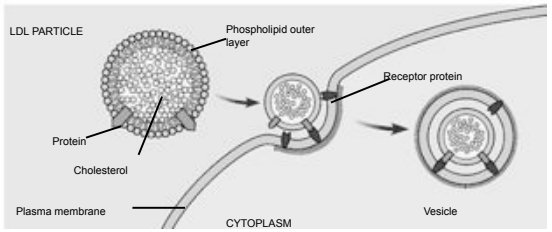
Bulk Transport- Endocytosis



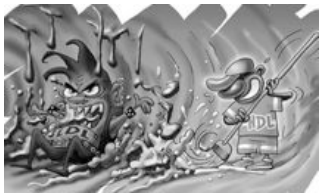
- Vesicle budding and fusion can occur on any membrane
- **Receptor** proteins guide the process in most cases

Receptor-mediated endocytosis: responsible for cholesterol uptake

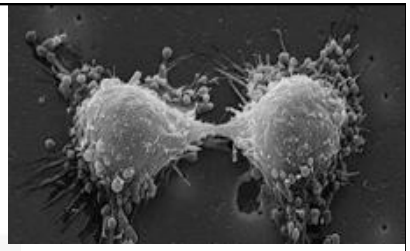
LDL/HDL is "low/high density lipoprotein", particles that carries cholesterol and fat

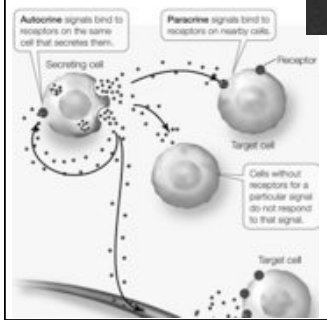


Harmful levels of cholesterol can accumulate in the blood if membranes lack HDL receptors



Signal Transduction Pathways





Step 1: the signal

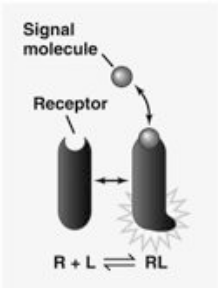
Signal Transduction Pathways

Step 1: the signal

Ligand: signal that binds receptor

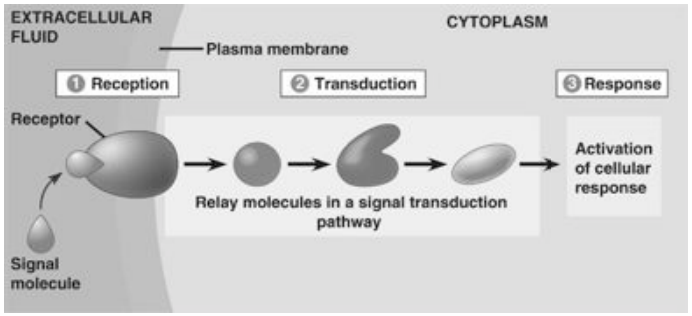
Induces conformational change

Exposes active site on intracellular end



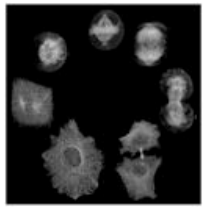
Signal Transduction Pathways

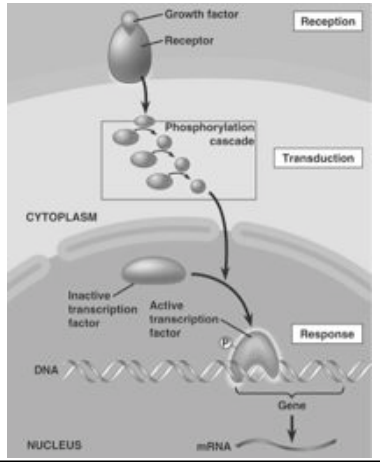
Step 2: transduction Step 3: response

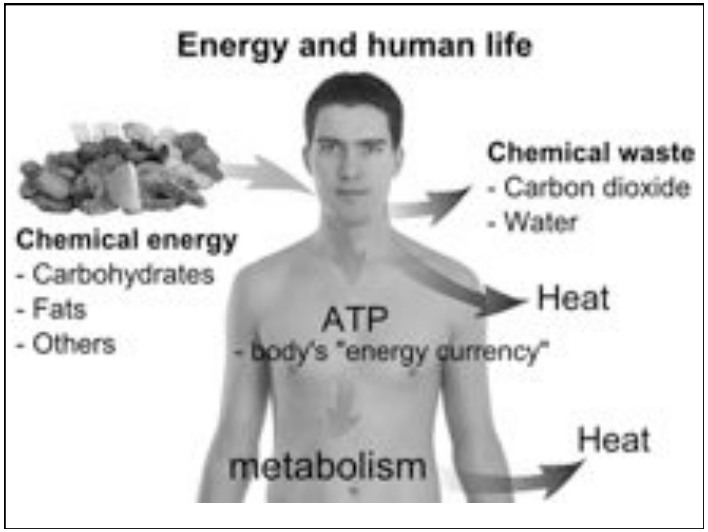


Signal Transduction Pathways

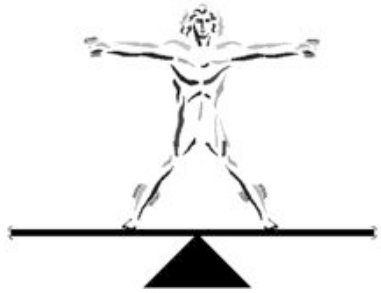
Growth Factors stimulate cell growth and division







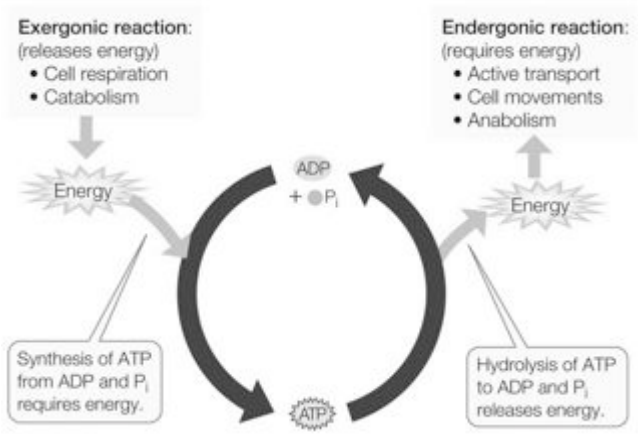
Enzymes catalyze metabolic reactions and maintain **homeostasis**



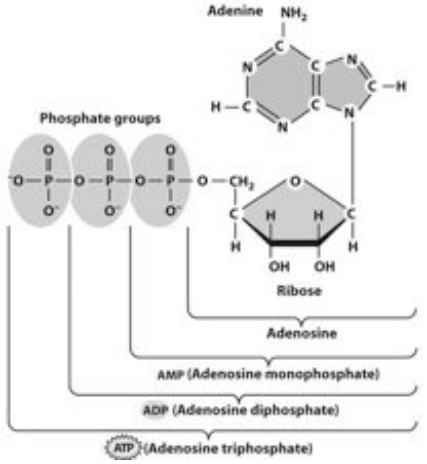
How do cells create this balance?

- regulation of enzyme expression levels
- regulation of enzyme activity

Review- Exergonic vs Endergonic

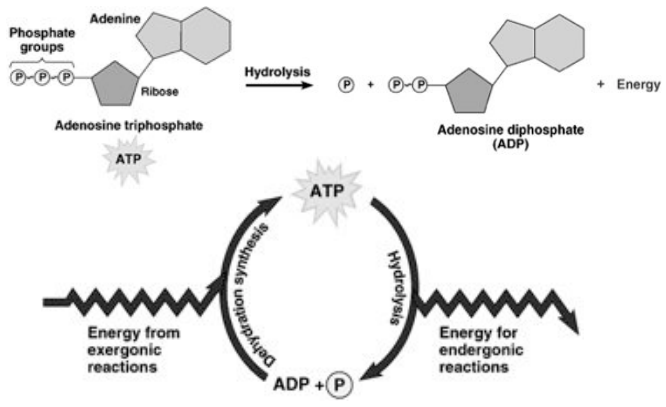


What do cells use for energy?



ATP hydrolysis
ATP + H2O ➔
ADP + Pi + free energy

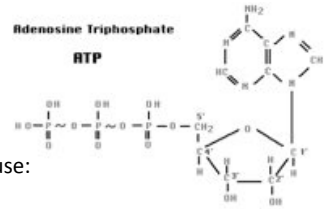
Chemical Energy in Biology



Chemical Energy in Biology

ATP hydrolysis
ATP + H2O ➔ ADP + Pi + free energy

ΔG = the **change** in free energy of products – reactants
= -7.3 kcal/mol



Free energy is released because:

1) Free energy of P-O bond is much higher than O-H bond
2) Phosphate groups are negatively charged and repel each other
   Takes a lot of energy to get these groups in close proximity

Chemical Energy in Biology

Endergonic reaction: ΔG is positive, reaction is not spontaneous

Glu + NH_3 → NH_2 Glu

Glutamic acid + Ammonia → Glutamine

ΔG = +3.4 kcal/mol

Exergonic reaction: ΔG is negative, reaction is spontaneous

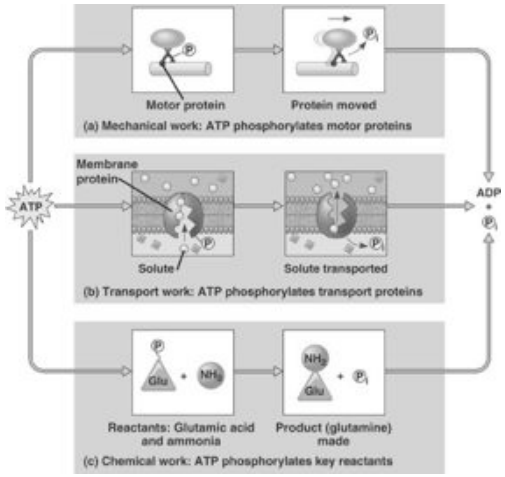
ATP + H_2O → ADP + P_i

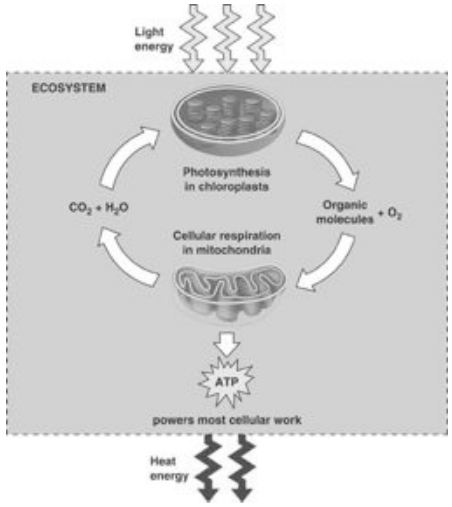
ΔG = –7.3 kcal/mol

Coupled reactions: Overall ΔG is negative; together, reactions are spontaneous

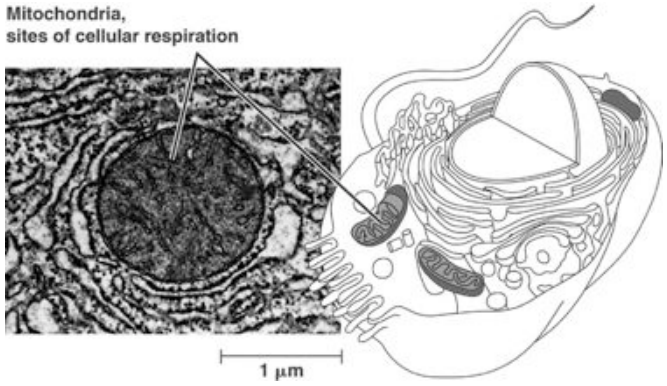
ΔG = –3.9 kcal/mol

Cellular uses of ATP





Chemical Energy in Biology



Another mechanism for energy transfer: transfer of electrons

Oxidation and Reduction

Oxidation is the process of ***losing*** an electron (often a whole H atom)

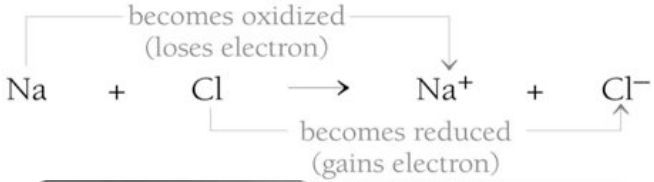
Reduction is the process of ***gaining*** an electron (often a whole H atom)

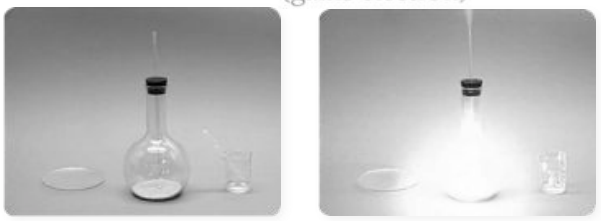
LEO the lion says GERRRR!

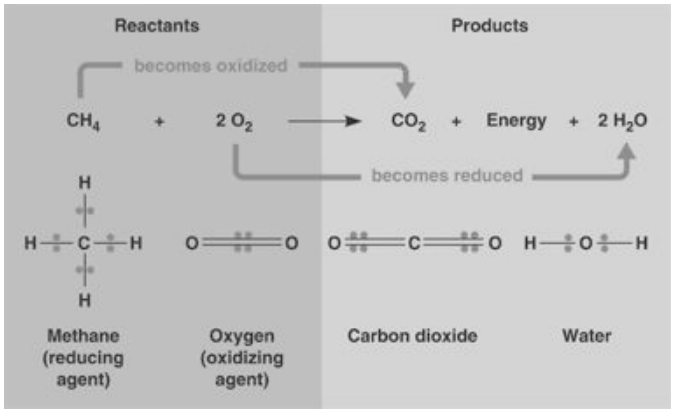
Lose electrons = oxidation
Gain electrons = reduction

Oxidation / Reduction

Always "coupled"



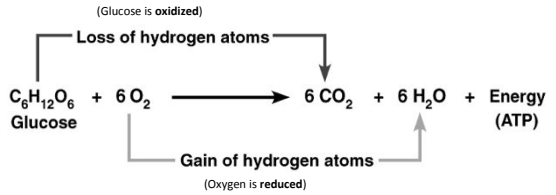




Redox Reactions

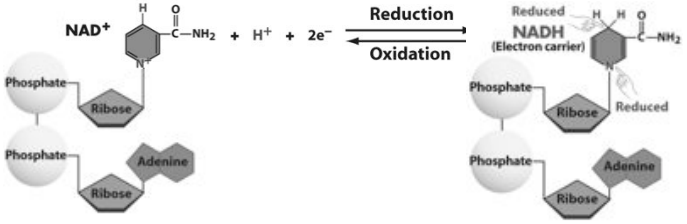
- **Redox** is short for Reduction/Oxidation
- Oxidizing/Reducing agents
- Can also think in terms of gain or loss of H+

  (H = H+ + e-)



Electron carriers

NAD is a coenzyme that holds electrons



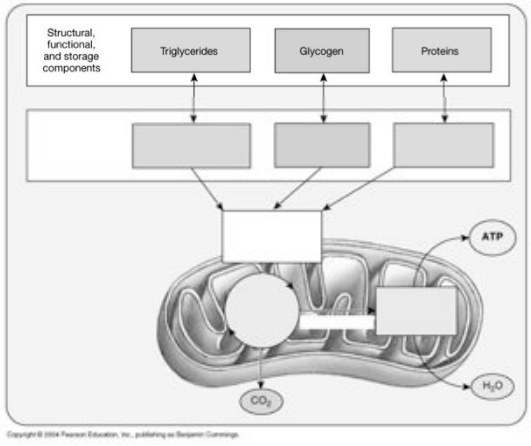
NAD can easily pick up *and release* electrons (a carrier).
Is reduced to form **NADH**, a molecule containing much chemical energy

Coenzymes

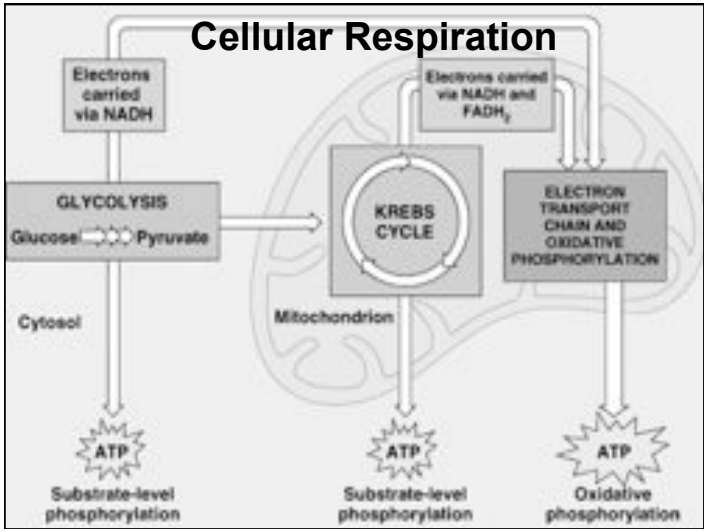
NAD **FAD** **Coenzyme B_{12}**

Many coenzymes are members of the water-soluble B vitamin family

Cellular Metabolism



Cellular Respiration



Cellular Respiration

Chemical energy is released and partially captured in the form of ATP.

Carbohydrates, fats, and proteins can all be used as fuel
glucose is most commonly used

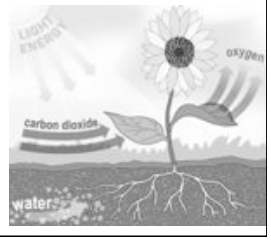
Loss of hydrogen atoms

$C_6H_{12}O_6$ + 6 O_2 → 6 CO_2 + 6 H_2O + energy (ATP)
glucose

Gain of hydrogen atoms

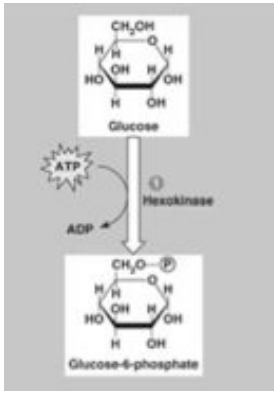
Photosynthesis

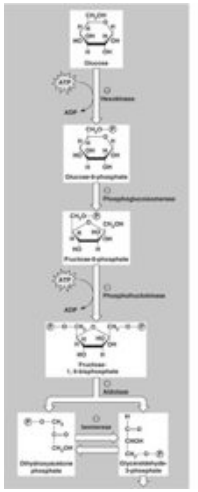
6 CO_2 + 6 H_2O (+ light energy) → $C_6H_{12}O_6$ + 6 O_2

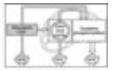


Glycolysis

Energy Investment Phase

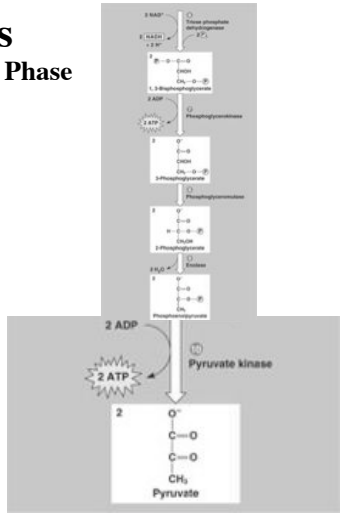






Glycolysis

Energy Payoff Phase



Glycolysis

Energy Investment Phase