Slide 1

Metabolism

Lecture 11

Bio 10 Fall 2008

Slide 2

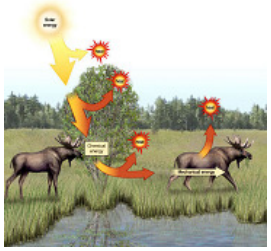
Learning Outcomes

- What is energy?
- Laws of energy
- ATP
- Enzyme action

Bio 10 Fall 2008

Slide 3

What is Energy?



- Definition:
- Capacity to do work and bring about change, occurs in various forms
- Kinetic or Mechanical energy
  - Energy of movement
- Potential energy
  - Chemical energy

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Conservation of Energy

- First Law of Thermodynamics
- Energy cannot be created nor destroyed, BUT it can be changed from one form to another

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Why We Eat

- Food provides energy for the body
- Plus
- Vitamins and minerals
- Essential building blocks
  - Amino acids

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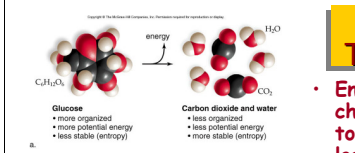
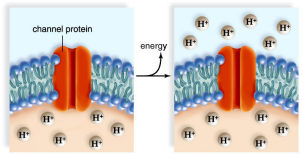


Second Law of Thermodynamics

- Energy cannot be changed from one form to another without a loss of usable energy
- Tendency in systems to become less orderly over time
- = loss of potential energy



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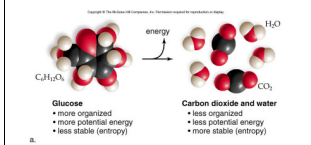

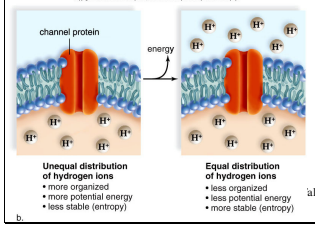

Entropy

- Tendency in systems to become less orderly over time
- = loss of potential energy
- Increase in entropy = increase in disorder

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Metabolism

- Definition:
- All of the chemical reactions that occur in a cell during growth and repair
- Anabolic reactions
  - Build macromolecules
  - Requires energy
- Catabolic reactions
  - Break down macromolecules
  - Releases energy

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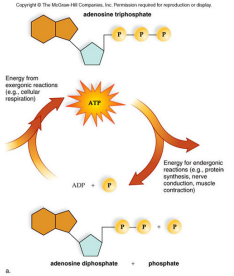
Structure of ATP



- Nucleotide consisting of adenine + ribose sugar (adenosine) plus 3 phosphate groups
- Potential energy released when bond is broken
- Energy used to do cellular work

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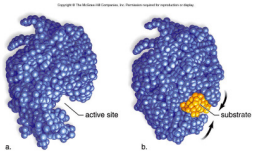
Functions of ATP

- Chemical work
  - Synthesis of molecules
- Transport work
  - Active transport of molecules and/or ions
  - Nerve impulses
- Mechanical work
  - Muscle contractions
  - Movement of organelles

Collision Theory of Chemistry

- All atoms:
  - continuously moving
  - Continuously colliding
- Reactions occur when:
  - Sufficient energy – Activation energy
  - Atoms orientated correctly
- Reaction rate
  - Frequency of collisions
    - → increased temperature
    - → increased [conc]

What is an enzyme?



- A protein synthesized in a particular cell
- Most of our genes code for enzymes
- Active site holds substrate
- Mostly have only one function
- Act as catalysts in biochemical reactions

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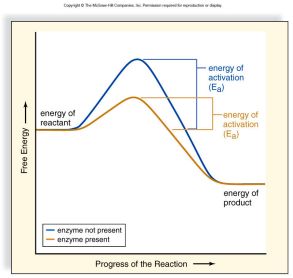
Activation Energy



- Enzymes decrease activation energy required for reaction to occur
- For synthesis
  - Hold reactants in proper orientation
- For Hydrolysis
  - Exert stress on bond to be broken

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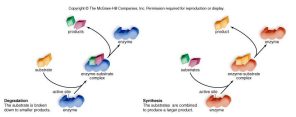
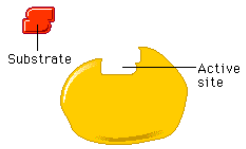
How Enzymes Work





- Three dimensional shape
- Induced fit model
- Active site
- Work on bonds or sites of bonding
- Lower activation energy

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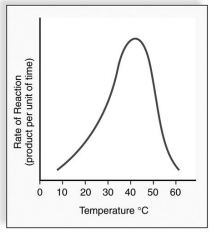

a. Rate of reaction as a function of

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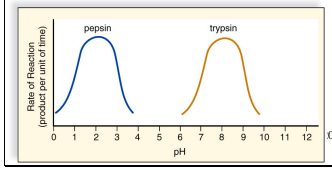

Reaction Rate

- Depends upon
- Temperature
- Concentration of substrate
- pH

Naming Enzymes

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TABLE 6.1

Enzymes Named for Their Substrate

Substrate	*Enzyme*
Lipid	Lipase
Urea	Urease
Maltose	Maltase
Ribonucleic acid	Ribonuclease
Lactose	Lactase
Sucrose	Sucrase

- Substrate is the molecule that binds to the enzyme
- -ase ending denotes the enzyme of…

Lactose Intolerance

- All human babies drink milk – contains lactose sugar
- BUT lactase NOT synthesized after weaning
- Lactose passes to large intestine
  - Digested by bacteria → CO_2
  - Gas and bloating
- Options?
  - Avoid all dairy
  - Take lactase enzyme
- 75% of humans lactose intolerant
- Except in mutants that continue synthesizing lactase

Cofactors and Coenzymes

- Cofactors
  - Inorganic ions
  - minerals
- Coenzymes
  - Small organic molecules
  - Vitamins
    - Beta carotene
    - Precursor of Vitamin A
- Certain important enzymes require cofactors OR coenzymes to function

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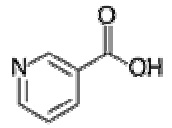
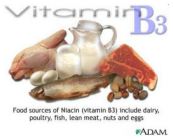
Niacin





- Vitamin B_3
- All B vitamins help body extract energy from foods
- Niacin converted to nicotinamide in the body
- Coenzyme NAD+

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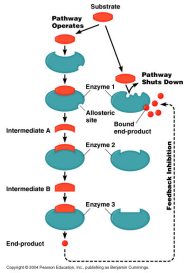
Feedback Inhibition



- Mechanism to shut off enzyme pathway when no longer needed
- End product molecule binds to allosteric site on $Enzyme_1$
- $Enzyme_1$ shape changed
- Can no longer accept $reactant_1$
- Pathway shutdown
- Reversible

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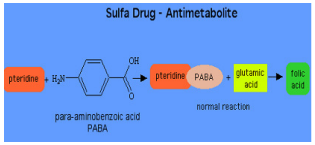
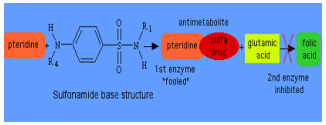
How Drugs Work

- Sulfonamide drugs
- Antimetabolites
- Compete for active site of PABA a precursor for Folic Acid synthesis in bacteria
- Mammals do NOT synthesize Folic Acid
- Drug has not effect on us
- Selective Toxicity





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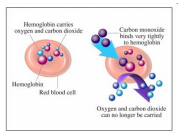
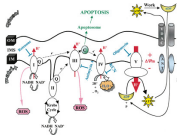
Poisons

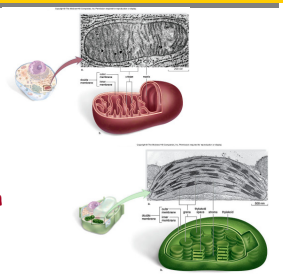


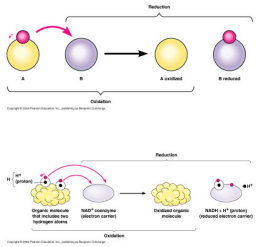


- Carbon Monoxide
- Binds to hemoglobin
- Inhibits binding of oxygen
- Cyanide inhibits Cytochrome c Oxidase enzyme
- Enzyme is part of Electron Transport Chain
- Cells cannot geerate ATP
- Present in every cell
- Irreversible
- Fatal
- Fast

Phosphorylation

- Adding P to ADP → ATP
- Substrate level
  - Glycolysis
- Electron Transport Chain
  - Mitochondria
- Photophosphorylation
  - Chloroplasts
    - Why light is necessary for PHOTOsynthesis



Oxidation and Reduction Reactions

- Oxidation is a loss of electrons from outer shell of an atom
- Reduction is gain of electrons to outer shell of an atom
- In cells accompanied by H+ ions
- In cellular respiration coenzyme NAD+ + 2e- + H+ → NADH