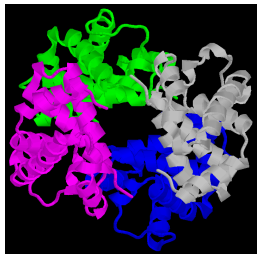
Slide 1

Chemistry for Microbiology

Lecture 3

Slide 2

Learning Outcomes



- Review
  - chemical reactions
  - Bonding
  - Oxidation and Reduction reactions
  - pH
- Biological Molecules

Slide 3

Ions and Ionic bonds

- Atoms want a complete outer electron shell
- Losing an electron → positive cation
- Gaining an electron → negative anion
  - Opposites attract
  - BUT bonds disrupted by water

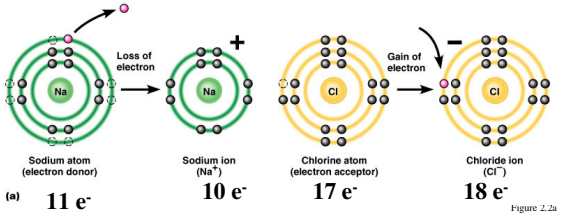


Figure 2.2a

Slide 4

Other Bonds

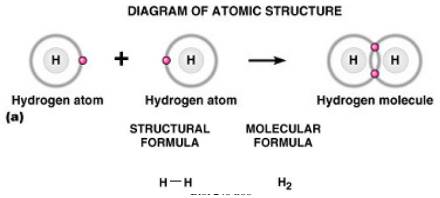
- Iconic Bonds

- Ironic Bonds

Slide 5

Covalent Bonds

- Two atoms share one or more pairs of electrons forming strong bonds
  - Molecules
  - Bonds NOT disrupted by water



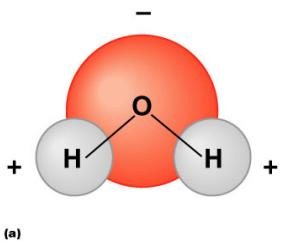
5

Figure 2.3a

Slide 6

Water is a Polar Molecule

- Different ends 'poles' have different charges
- ~ O slightly –ve; H slightly +ve



Biol 240 S06

6

Figure 2.4a

Water as a Solvent

- Ionic compounds dissociate, forming solutes
  - They dissolve

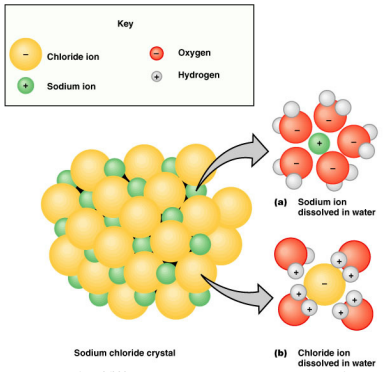
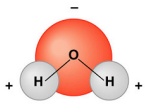


Figure 2.5

Hydrogen Bonds



- Hydrogen bonds with attractions between slightly positive and slightly negative 'poles' of polar molecules
- E.g. Between water molecules
- Between hydrogens and Oxygens or Nitrogens
  - DNA
  - Proteins secondary structure

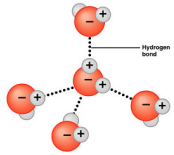
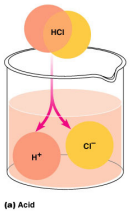


Figure 2.4

Acids

- An acid is a compound that dissociates in water (dissolves) adding H^+ To the solution
  HCl compound$\rightarrow H^+ + Cl^-$
- Organic acids acetic acid (vinegar)
- Carboxyl group $COOH \rightarrow COO^- + H^+$



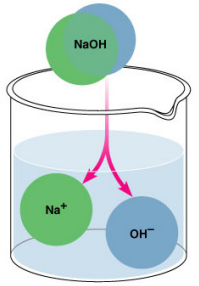
(a) Acid

Figure 2.6a

Bases

- A base is a compound that dissociates in water forming OH^- ions
- $NaOH \rightarrow Na^+ + OH^-$
- bases remove H^+ from solution

  $OH^- + H^+ \rightarrow H_2O$
- Act as buffers

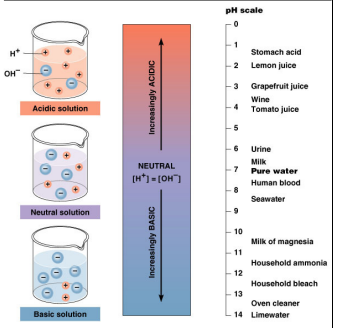


(b) Base

Figure 2.6b

Acid-Base Balance

- The amount of H^+ in a solution is expressed as pH.
- $pH = -\log[H^+]$
  - Increasing $[H^+]$, increases acidity.
  - Increasing $[OH^-]$ increases alkalinity.
- Most organisms grow best between pH 6.5 and 8.5.



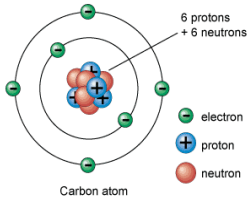
Oxidation and Reduction

- Oxidation
  - Loss of electrons
- Reduction
  - Gain of electrons
- Relative to atom or molecule
- In biology
- Oxidation ~ loss of H
  - H = 1 electron + 1 proton
- Reduction ~ gain of H

OIL RIG

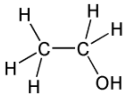
Carbon Atoms

- 6 protons
- 6 electrons 2,4
- Must make 4 covalent bonds to fill outer shell
- Huge variety of molecules
- Organic chemistry
- Life is carbon based

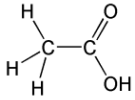


Organic Compounds

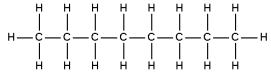
- Carbon skeleton.
- Functional groups
  - form bonds during reactions
- The more C-H the higher the potential energy
  - Oxidation replaces C-H with C-O or C=O



ethanol

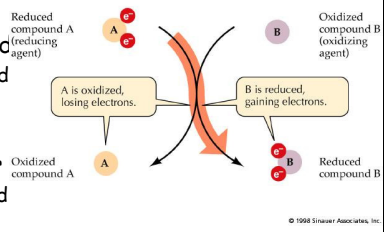


acetic acid



Respiration as a Redox Reaction

- Food energy = molecules with
  - Many C-H bonds
  - Many electrons
  - = reduced carbon atoms
- In cells food molecules oxidized
  - Electrons removed
  - Energy harvested
- Oxygen terminal electron acceptor
  - Oxygen is reduced



Macromolecules

- Smaller organic molecules monomers
- Monomers join by dehydration synthesis
- Macromolecules are polymers

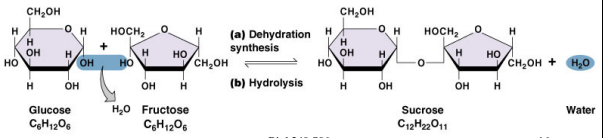


Figure 2.8

Carbohydrates

- Important for structure and energy.
- Consist of C, H, and O with the formula $(CH_2O)_n$
- Monosaccharides
  - Glucose, fructose, galactose
- Disaccharides formed via dehydration synthesis

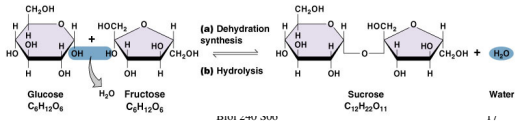
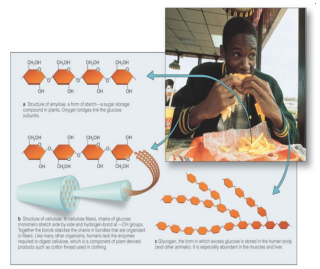


Figure 2.8

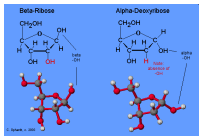
Polysaccharides

- Chains of monosaccharides
- Starch
- Amylose
  - Straight chain
- Amylopectin
- Glycogen
  - Branched chains
- Cellulose
- complex



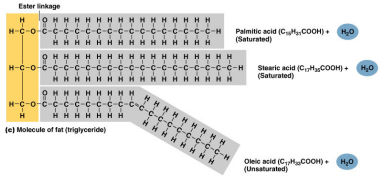
Pentoses

- Sugars with 5 carbons
- Ribose
- Deoxyribose



Lipids

- Are non-polar and insoluble in water
- Consist of C, H, and O.
- Triglycerides
- 3 C glycerol and 3 fatty acid chains
  - formed by dehydration synthesis.



Phospholipids

- Cell membranes are made of phospholipids
- Polar Phosphate group
- Nonpolar fatty acid chains

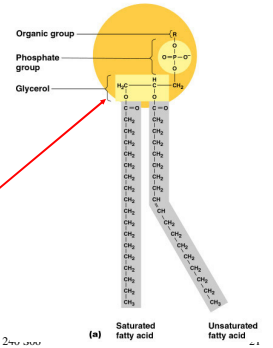
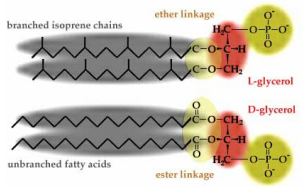


Figure 2.10a

Archaea Phospholipids

- Bacteria
  - Ester linkage
- Archaea
- Ether linkage



Steroids

- Consist of four carbon rings, with an –OH group attached to one ring.
- Are part of membranes.
  - Cholesterol
  - ergosterol

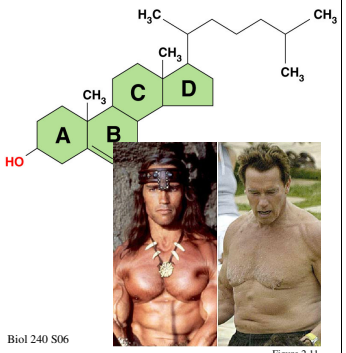


Figure 2.11

Proteins

- Are essential in cell structure and function.
- Enzymes are proteins that speed chemical reactions.
- Transporter proteins move chemicals across membranes
- Flagella are made of proteins.
- Some bacterial toxins are proteins.
- Antibodies are proteins

Peptide Bonds

- Peptide bonds between amino acids are formed by dehydration synthesis.

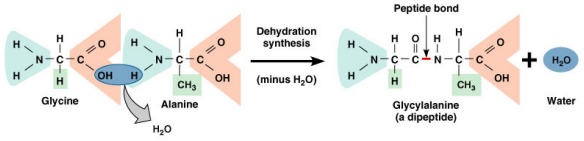
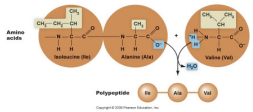


Figure 2.14

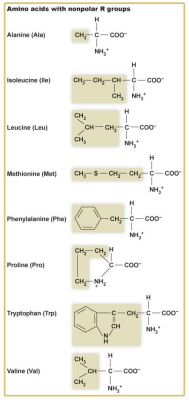
Peptide Bond

- Covalent bond
  - between amino group of one amino acid and the carboxyl group
- Protein Synthesis
- Ribosomes
  - Free or
  - Rough Endoplasmic Reticulum
- Dehydration synthesis



Amino Acids -Non Polar R Groups

- Hydrophobic
- Fold **away** from water
  - Interior of proteins
  - Hydrophobic interactions
    - Van der Waals Forces
- Leucine is the most common amino acid
- Phenylalanine
- Tryptophan



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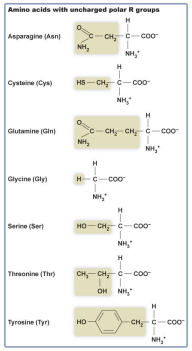
Uncharged Polar R Groups

- Interact with water and other polar molecules
- Generally found on outside of protein



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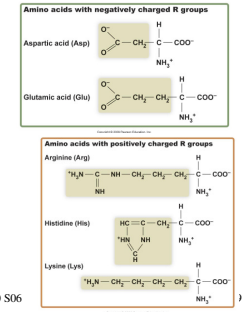
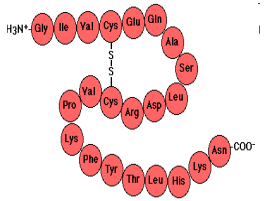
Charged R Groups

- Able to form ionic bonds
- Important in tertiary structure of proteins



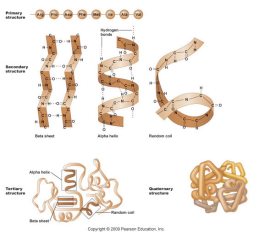
Primary Structure of Proteins

- Sequence of amino acids
- Order specified by base sequence of genes
- Position of hydrophobic amino acids and hydrophilic amino acids determines folding



Secondary Structure

- Hydrogen bonds form between amino groups of one amino acids and carboxyl groups of another in same molecule
- Secondary Structure
- http://www.wiley.com/legacy/college/boyer/0470003790/animations/protein_folding/protein_folding.htm

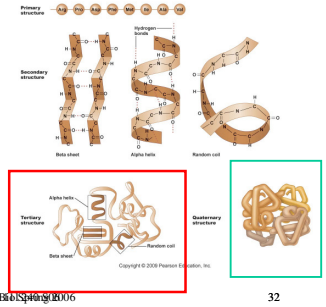


Tertiary Protein Structure

- Tertiary
- Interactions between side chains
- Disulfide bridges
- Hydrogen bonds
- Ionic bonds
- Hydrophobic interactions

- Quaternary
- Only in some proteins
- Polypeptide chains linked together

- Hemoglobin



Slide 33

Protein Structure Activity

- Groups of 3 students
- Fold sheet of paper into shape corresponding to number
  - 1 = ball
  - 2 = cylinder
  - 3 = triangle
  - 4 = cone
  - 5 = box
  - 6 = boat
  - 7 = spiral

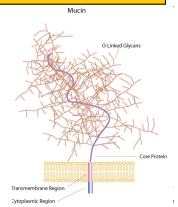
Slide 34

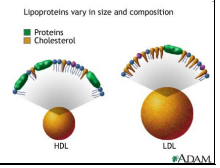
Ceviche

- Shrimp meat (protein) initially translucent
- Acid of Lime marinade [H^+] breaks H bonds
- Protein structure unravels
  - White (scatters light)
  - Chewy
- Why cook fish?

Conjugated Proteins

- Conjugated proteins consist of amino acids and other organic molecules:
  - Glycoproteins
    - mucin
  - Lipoproteins
  - Nucleoproteins





Nucleic Acids

- Consist of nucleotides.
- Nucleotides consist of a:
  - Pentose
  - Phosphate group
  - Nitrogen-containing (purine or pyrimidine) base

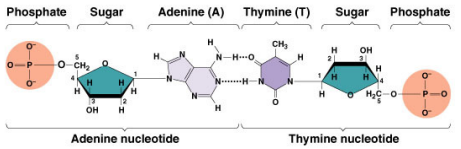


Figure 2.16

DNA

- Has deoxyribose
- Forms a double helix through Hydrogen bonding
- **Adenine** hydrogen bonds with **Thymine**
- **Cytosine** hydrogen bonds with **Guanine**

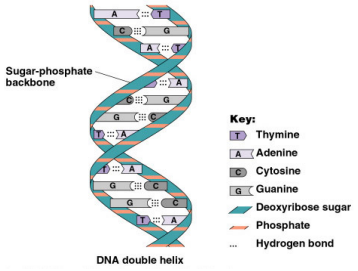


Figure 2.16

Function of DNA

- Genes are composed of DNA
- Hereditary information of organisms
- Genes inherited
- Genes provide code for proteins
- One gene one protein

RNA

- Has ribose
- Is single-stranded
- *A* hydrogen bonds with **Uracil**
- *C* hydrogen bonds with *G*

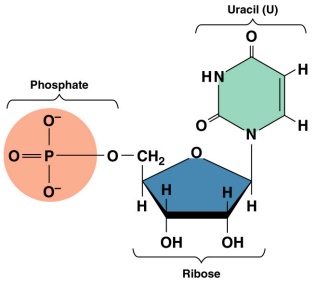
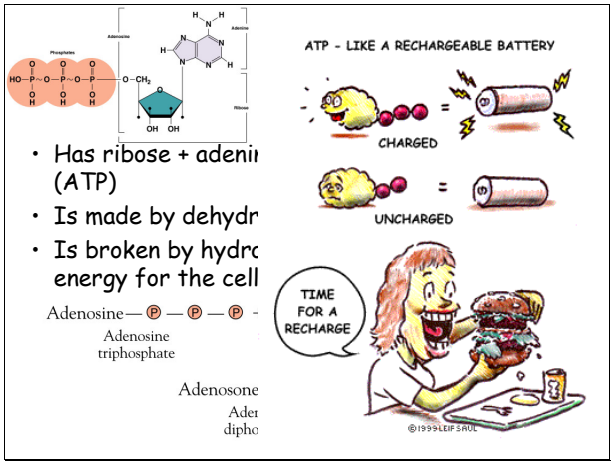


Figure 2.17

Functions of RNA

- Participate in protein construction
- All organisms possess both DNA and RNA
- Some Viruses (RNA Viruses) only possess RNA
- Viruses never possess BOTH DNA and RNA

Slide 41


• Has ribose + adeni
(ATP)
• Is made by dehydr
• Is broken by hydro
energy for the cell
Adenosine — Ⓟ — Ⓟ — Ⓟ -
Adenosine
triphosphate
Adenosone
Ader
dipho
ATP - LIKE A RECHARGEABLE BATTERY
CHARGED
UNCHARGED
TIME FOR A RECHARGE
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