2 Basic Chemistry

PowerPoint® Lecture Slide Presentation by Jerry L. Cook, Sam Houston University

ESSENTIALS OF HUMAN ANATOMY & PHYSIOLOGY

EIGHTH EDITION

ELAINE N. MARIEB

Chemistry

- Chemistry – study of structure of matter
  - Composition of substances
  - Properties of matter
  - Chemical reactions
- Biochemistry – study of chemistry in living things

Matter and Energy

- Matter – anything that occupies space and has mass (weight)
- Energy – the ability to do work

(potential  kinetic)

  - Chemical – stored in bonds of chemicals
  - Electrical – movement of charged particles
  - Mechanical – directly moving matter
  - Radiant – travels in waves

Composition of Matter

- Elements
  - Fundamental units of matter
  - 96% of the body is made from four elements
    - Carbon (C)
    - Hydrogen (H)
    - Oxygen (O)
    - Nitrogen (N)
- Atoms
  - Building blocks of elements

Atomic Structure

- Nucleus
  - Protons (p^+)
  - Neutrons (n^0)
- Outside of nucleus
  - Electrons (e^-)

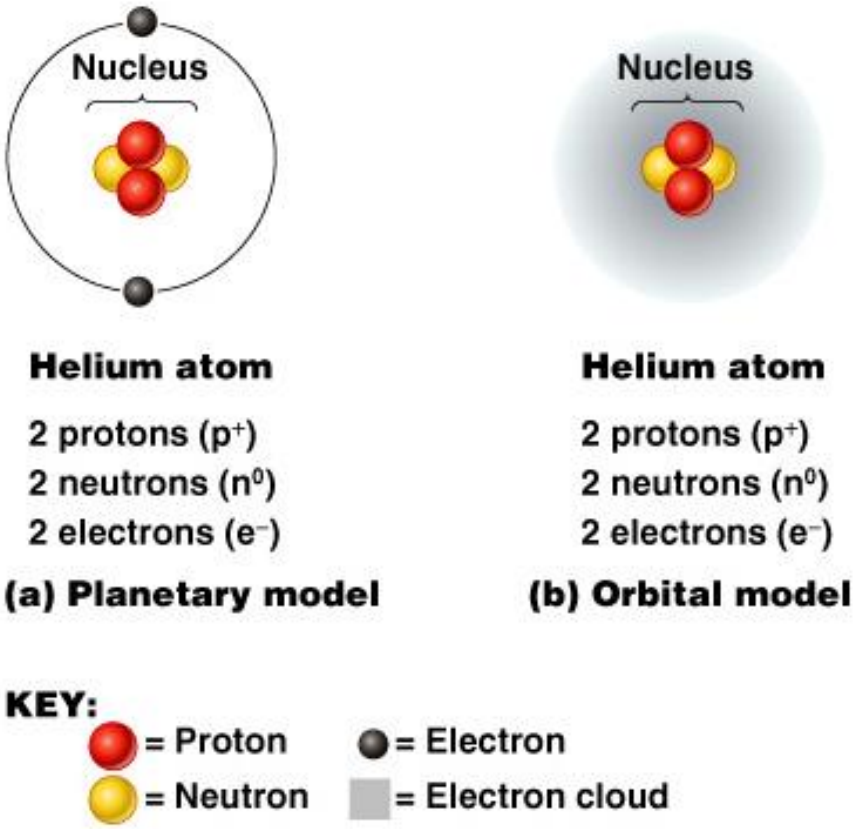


Figure 2.1

Identifying Elements

- Atomic number
  - Equal to the number of protons that the atoms contain
- Atomic mass number
  - Sum of the protons and neutrons

Isotopes and Atomic Weight

- Isotopes
  - Have the same number of protons
  - Vary in number of neutrons

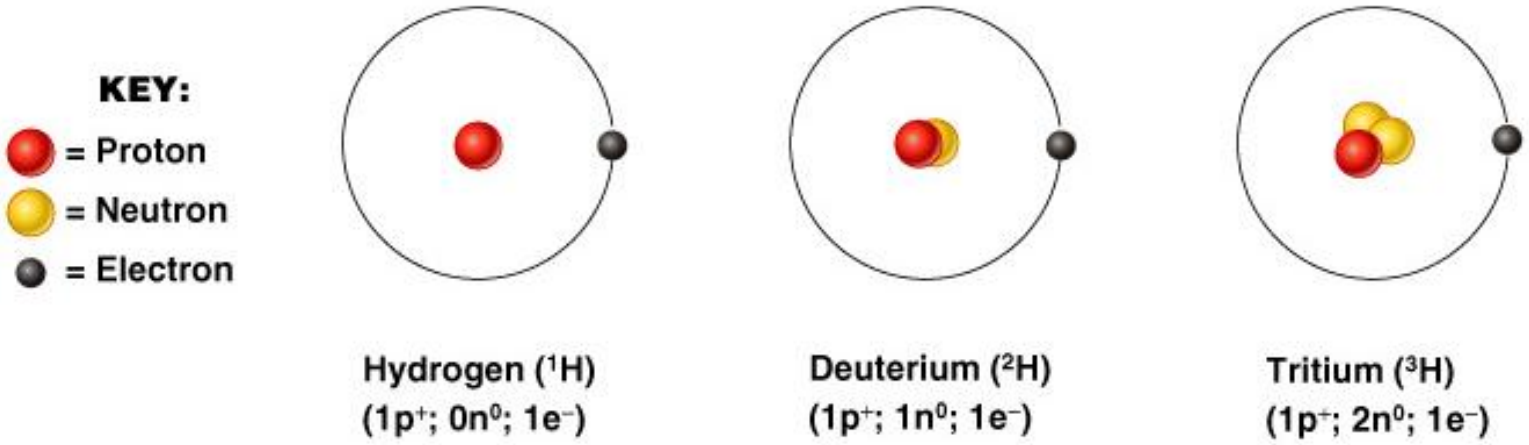


Figure 2.3

Isotopes and Atomic Weight

- Atomic weight
  - Close to mass number of most abundant isotope

    (Hydrogen 1, 2, 3 – 1 is most common)
  - Atomic weight reflects natural isotope variation

Radioactivity

- Radioisotope
  - Heavy isotope
  - Tends to be unstable
  - Decomposes to more stable isotope
- Radioactivity
  - Process of spontaneous atomic decay

Molecules and Compounds

- Molecule – two or more *like* atoms combined chemically
  - Has capability to lead its own stable, independent existence
- Compound – two or more *different* atoms combined chemically
  - Has different properties from the elements that makes it up

Chemical Reactions

- Atoms are united by chemical bonds
- Atoms dissociate from other atoms when chemical bonds are broken

Electrons and Bonding

- Electrons occupy energy levels called electron shells
- Electrons closest to the nucleus are most strongly attracted
- Each shell has distinct properties
  - Number of electrons has an upper limit
  - Shells closest to nucleus fill first

Electrons and Bonding

- Bonding involves interactions between electrons in the outer shell (valence shell)
- Full valence shells do not form bonds

Inert Elements

- Have complete valence shells and are stable
- Rule of 8s
  - Shell 1 has 2 electrons
  - Shell 2 has 10 electrons
    - 10 = 2 + 8
  - Shell 3 has 18 electrons
    - 18 = 2 + 8 + 8

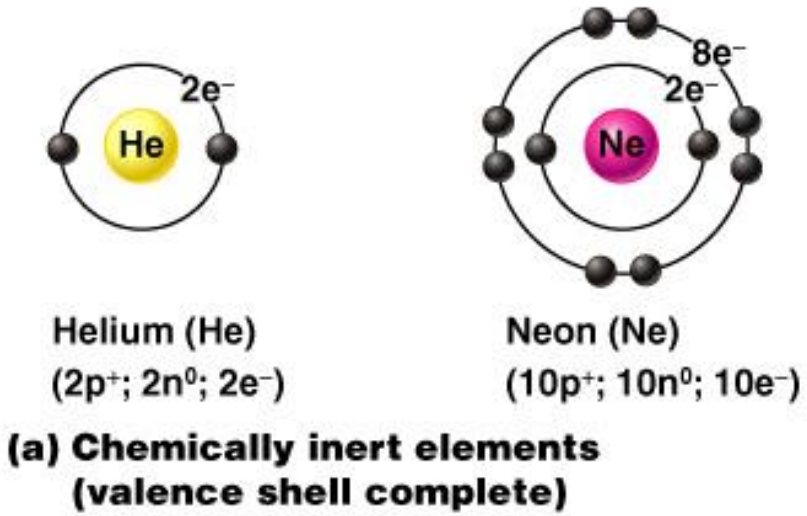


Figure 2.4a

Reactive Elements

- Valence shells are not full and are unstable
- Tend to gain, lose, or share electrons
  - Allows for bond formation, which produces stable valence

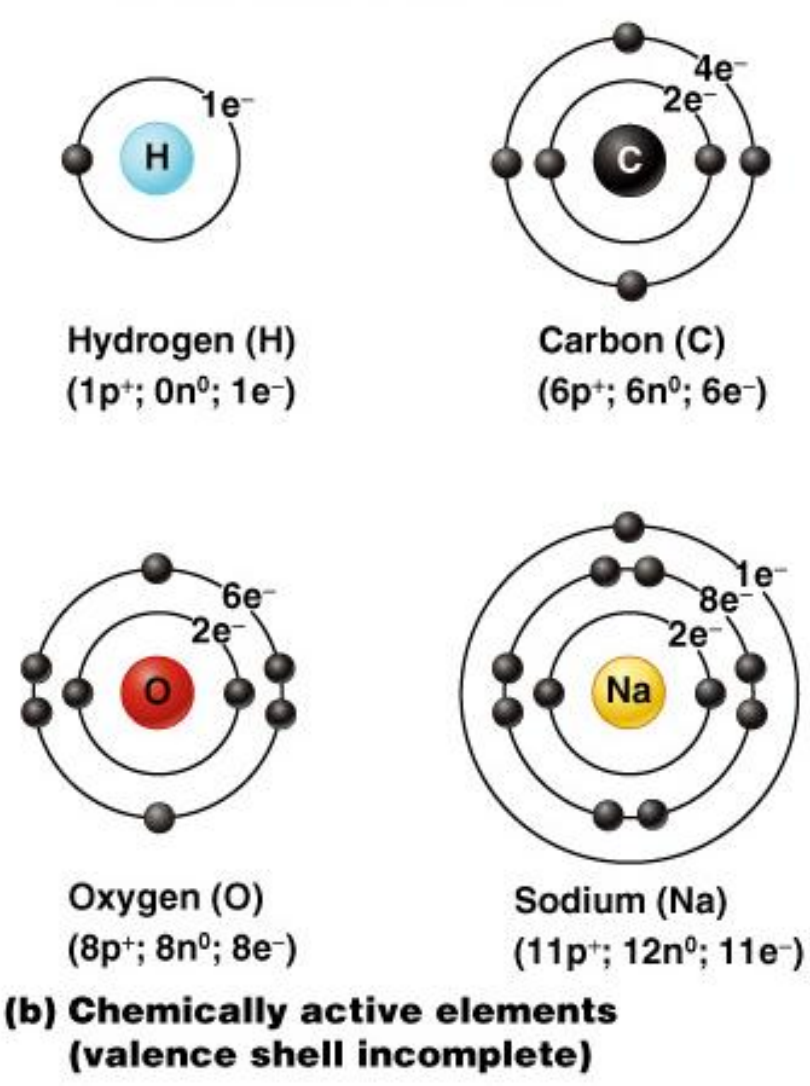


Figure 2.4b

Chemical Bonds

- Ionic Bonds
  - Form when electrons are completely transferred from one atom to another
- Ions
  - Charged particles
    - Anions are negative
    - Cations are positive
    - Either donate or accept electrons

Chemical Bonds

- Covalent Bonds
  - Atoms become stable through shared electrons
  - Single covalent bonds share one electron
  - Double covalent bonds share two electrons

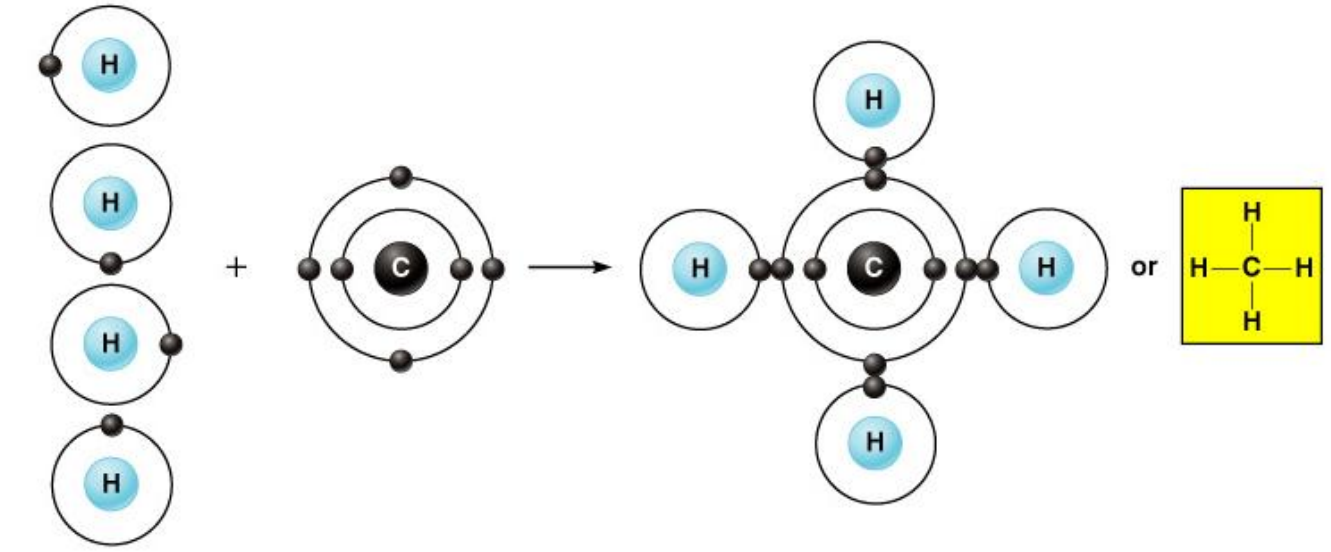


Figure 2.6c

Examples of Covalent Bonds

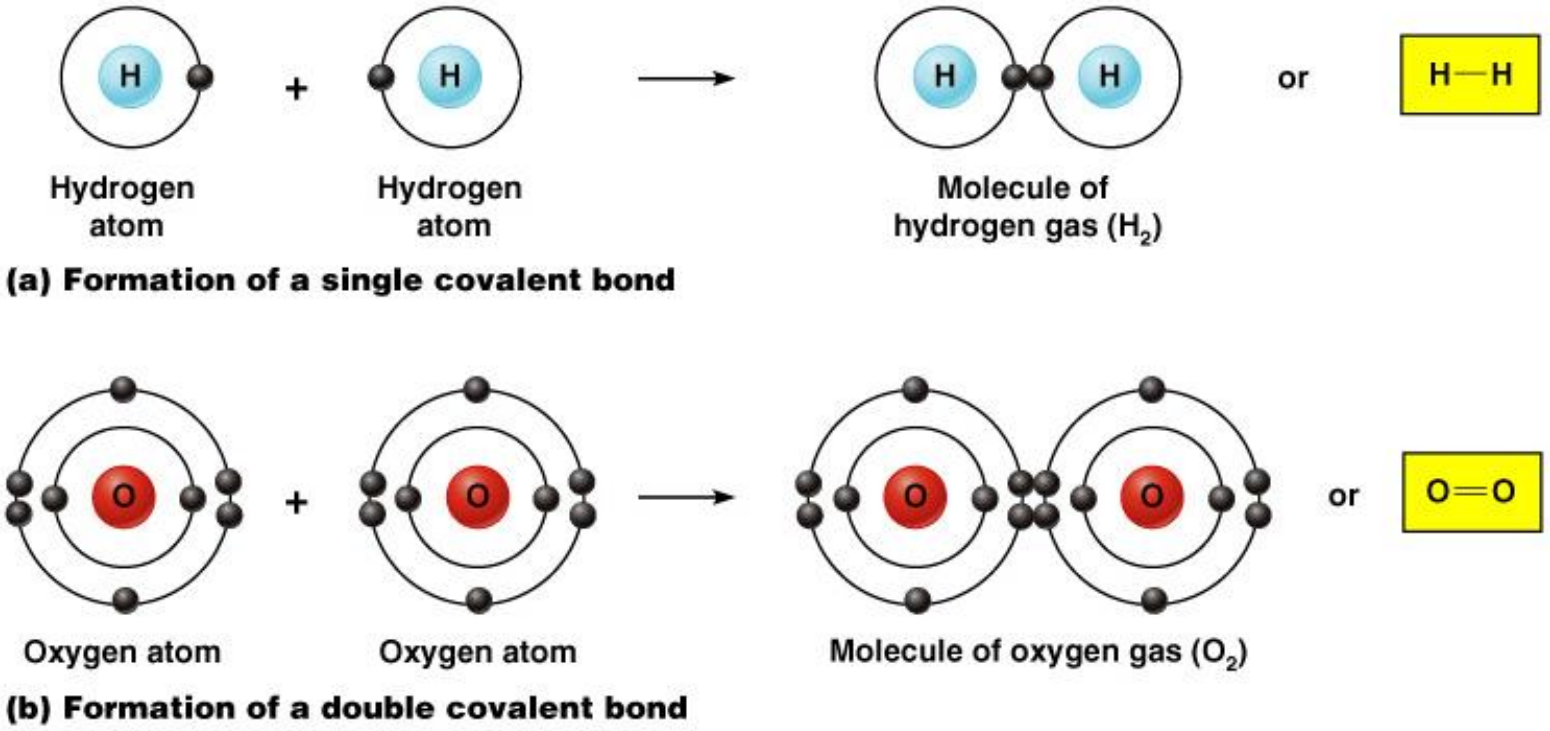


Figure 2.6a–b

Polarity

- Covalent bonded molecules
  - Some are non-polar
    - Electrically neutral as a molecule
  - Some are polar
    - Have a positive and negative side

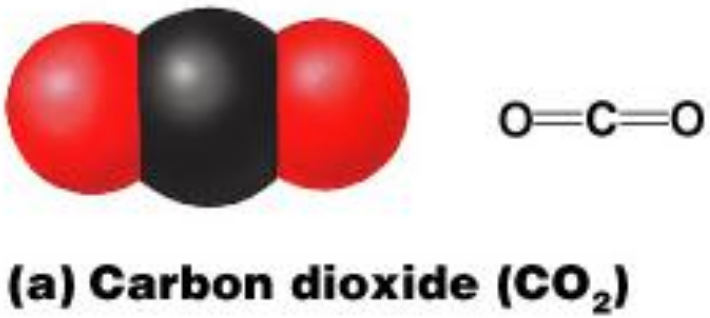


Figure 2.7

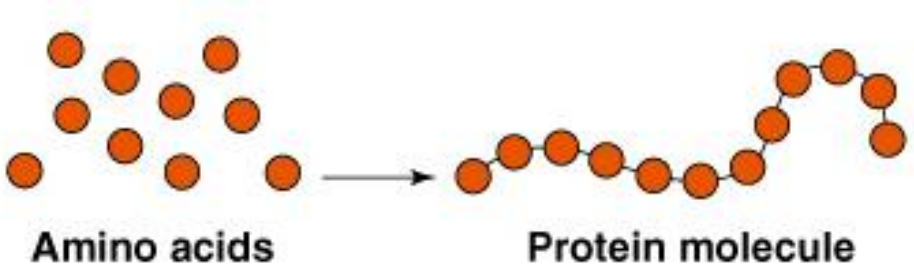
Chemical Bonds

- Hydrogen bonds
  - Weak chemical bonds
  - Hydrogen is attracted to negative portion of polar molecule
  - Provides attraction between molecules

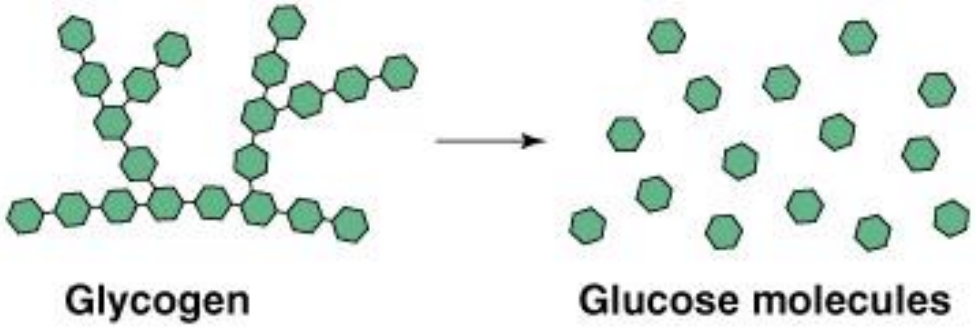
Patterns of Chemical Reactions

- Synthesis reaction (A+B→AB)
  - Atoms or molecules combine
  - Energy is absorbed for bond formation
- Decomposition reaction (AB→A+B)
  - Molecule is broken down
  - Chemical energy is released

Synthesis and Decomposition Reactions



(a) Example of a synthesis reaction: amino acids are joined to form a protein molecule

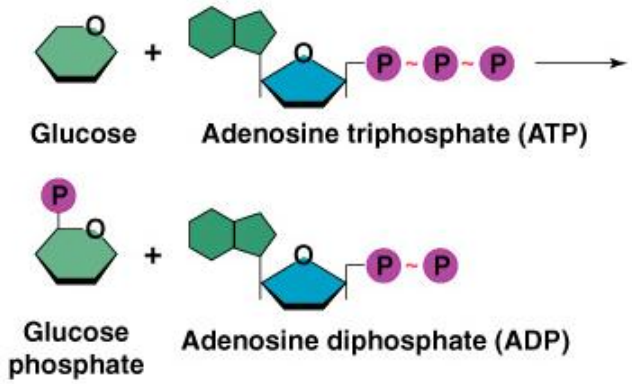


(b) Example of a decomposition reaction: breakdown of glycogen to release glucose units

Figure 2.9a–b

Patterns of Chemical Reactions

- Exchange reaction (AB→AC+B)
  - Involves both synthesis and decomposition reactions
  - Switch is made between molecule parts and different molecules are made



(c) Example of an exchange reaction: ATP transfers its terminal phosphate group to glucose to form glucose phosphate

Figure 2.9c

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ESSENTIALS OF HUMAN ANATOMY & PHYSIOLOGY

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Biochemistry: Essentials for Life

- Organic compounds
  - Contain carbon
  - Most are covalently bonded
  - Example: $C_6H_{12}O_6$ (glucose)
- Inorganic compounds
  - Lack carbon
  - Tend to be simpler compounds
  - Example: H_2O (water)

Important Inorganic Compounds

- Water
  - Most abundant inorganic compounds
  - Vital properties
    - High heat capacity – absorbs & releases large amounts of heat w/o major T change
    - Polarity/solvent properties – “universal solvent”
    - Chemical reactivity – hydrolysis reactions
    - Cushioning – protect (CSF)

Important Inorganic Compounds

- Salts
  - Easily dissociate into ions in the presence of water
  - Vital to many body functions
  - Include electrolytes which conduct electrical currents

Important Inorganic Compounds

- Acids
  - Can release detectable hydrogen ions
- Bases
  - Proton acceptors (OH- seeks H+)
- Neutralization reaction
  - Acids and bases react to form water and a salt

pH

- Measures relative concentration of hydrogen ions
  - pH 7 = neutral
  - pH below 7 = acidic
  - pH above 7 = basic
  - Buffers: chemicals that can regulate pH change

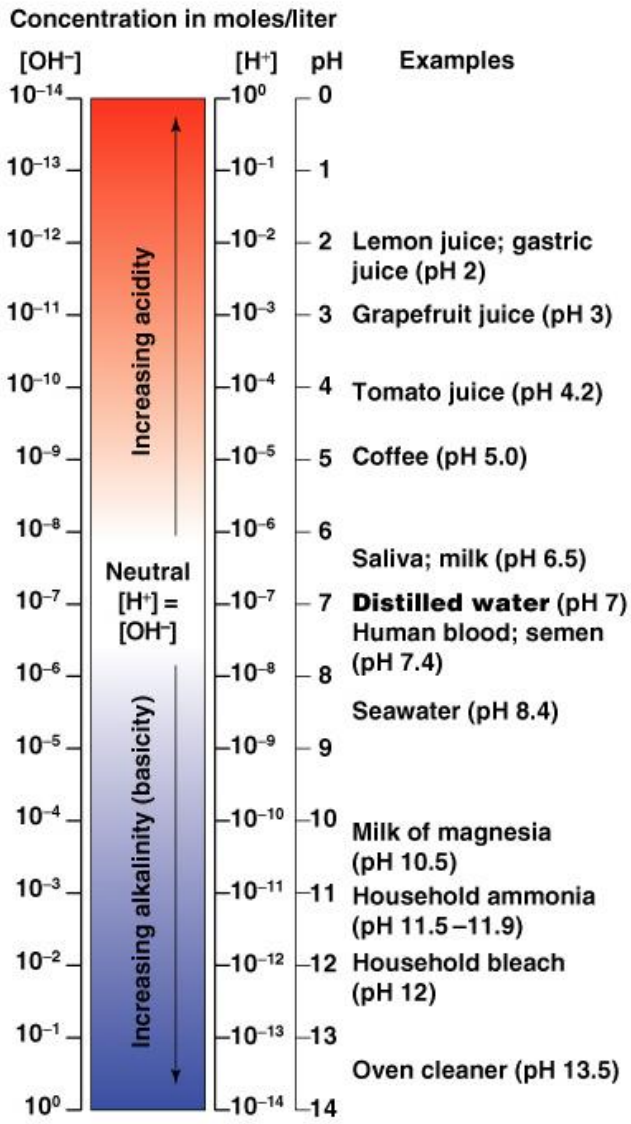
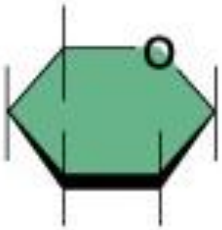


Figure 2.11

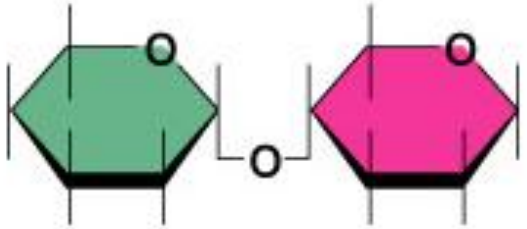
Important Organic Compounds

- Carbohydrates
  - Contain carbon, hydrogen, and oxygen
  - Include sugars and starches
  - Classified according to size
    - Monosaccharides – simple sugars
    - Disaccharides – two simple sugars joined by dehydration synthesis
    - Polysaccharides – long branching chains of linked simple sugars

Carbohydrates



(a) Simple sugar (monosaccharide)



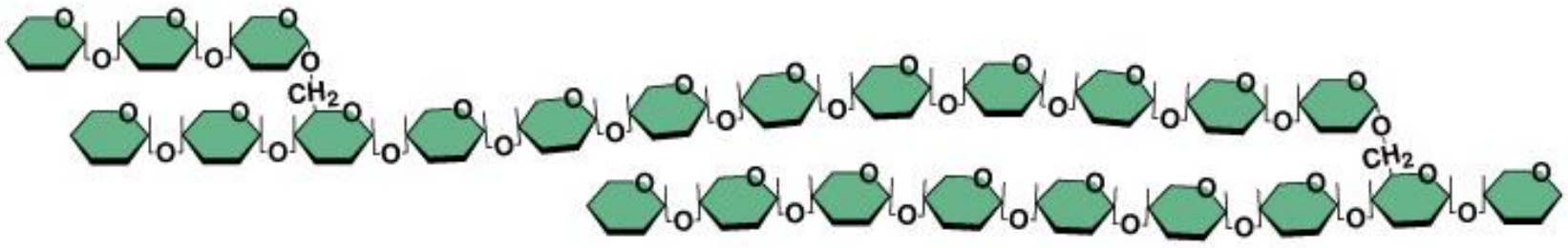
(b) Double sugar (disaccharide)

PRESS TO PLAY

DISACCHARIDES ANIMATION

Figure 2.12a–b

Carbohydrates



(c) Starch (polysaccharide)

PRESS TO PLAY

POLYSACCHARIDES ANIMATION

Figure 2.12c

Important Organic Compounds

- Lipids
  - Contain carbon, hydrogen, and oxygen
    - Carbon and hydrogen outnumber oxygen
  - Insoluble in water

PRESS TO PLAY LIPIDS ANIMATION

Lipids

- Common lipids in the human body
  - Neutral fats (triglycerides)
    - Found in fat deposits
    - Composed of fatty acids and glycerol
    - Source of stored energy

Lipids

- Common lipids in the human body (continued)
  - Phospholipids – contain Phosphorus
    - Form cell membranes
  - Steroids
    - Include cholesterol, bile salts, vitamin D, and some hormones

Lipids

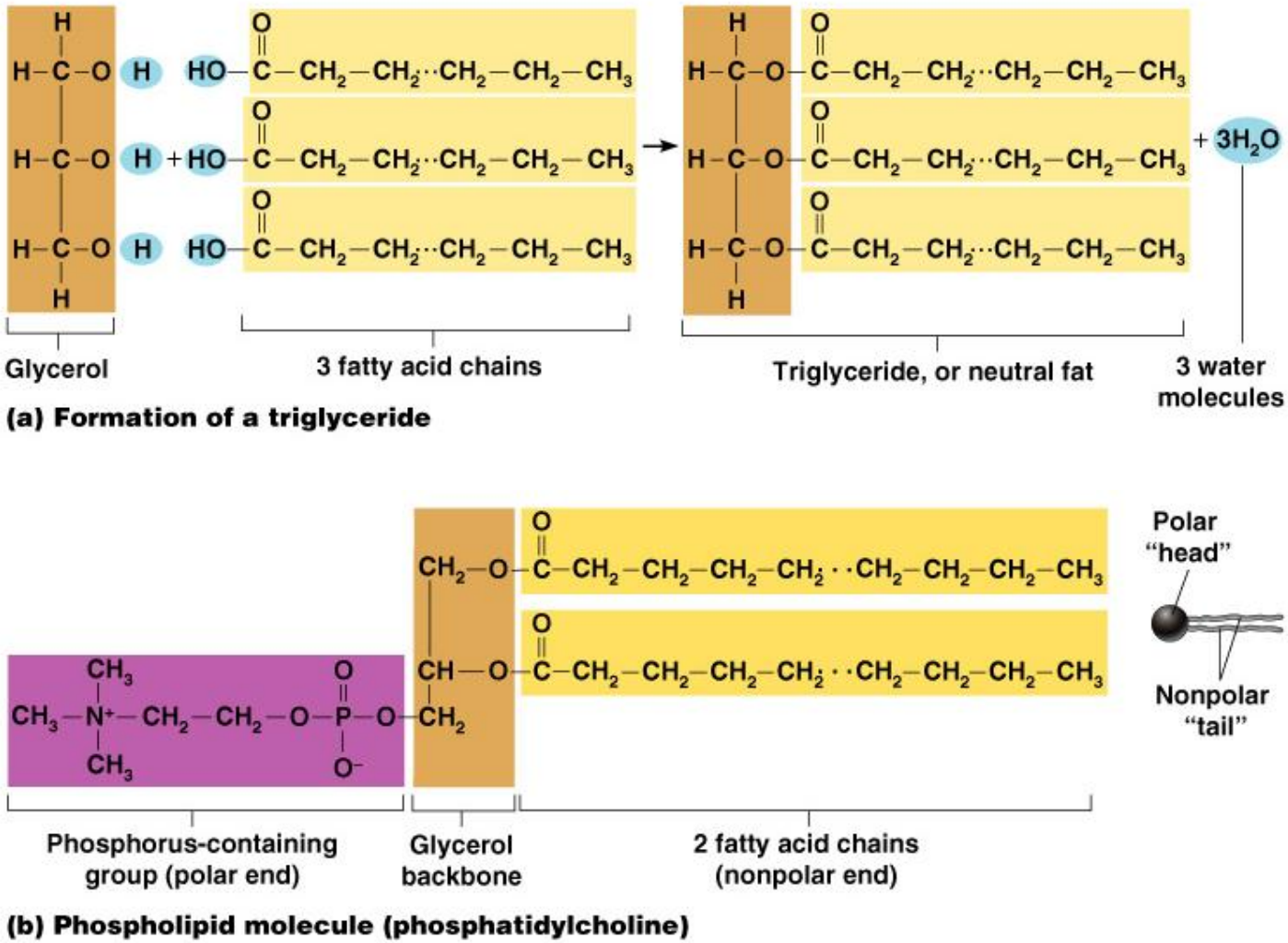
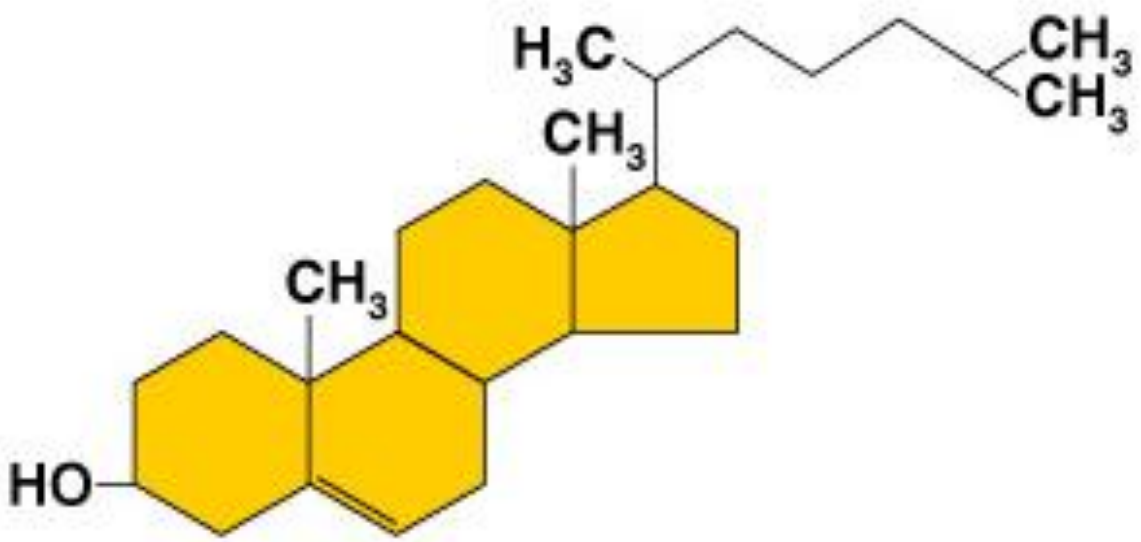


Figure 2.14a–b

Cholesterol

- The basis for all steroids made in the body



(c) Cholesterol

Figure 2.14c

Important Organic Compounds

- Proteins
  - Made of amino acids
    - Contain carbon, oxygen, hydrogen, nitrogen, and sometimes sulfur

Proteins

- Account for over half of the body's organic matter
  - Provides for construction materials for body tissues
  - Plays a vital role in cell function
- Act as enzymes, hormones, and antibodies

Enzymes

- Act as biological catalysts
- Increase the rate of chemical reactions

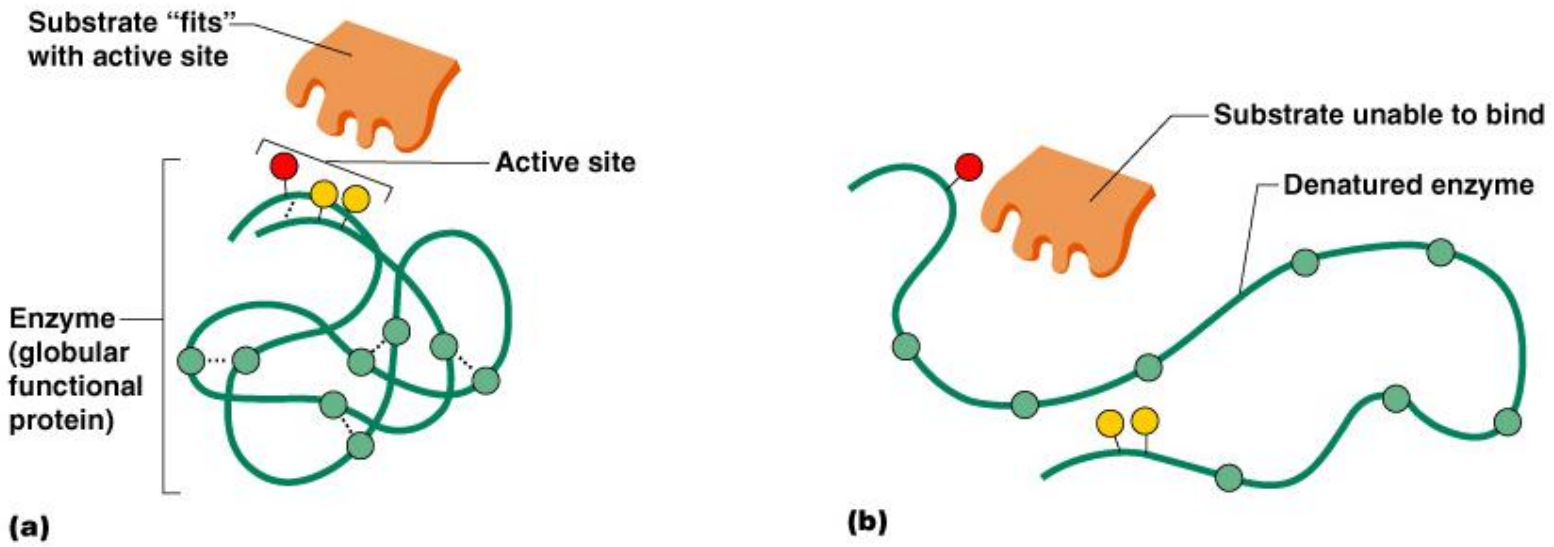


Figure 2.17

Important Organic Compounds

- Nucleic Acids
  - Provide blueprint of life
  - Nucleotide bases
    - A = Adenine
    - G = Guanine
    - C = Cytosine
    - T = Thymine
    - U = Uracil
  - Make DNA and RNA

Nucleic Acids

- Deoxyribonucleic acid (DNA)
  - Organized by complimentary bases to form double helix
  - Replicates before cell division
  - Provides instruction for every protein in the body

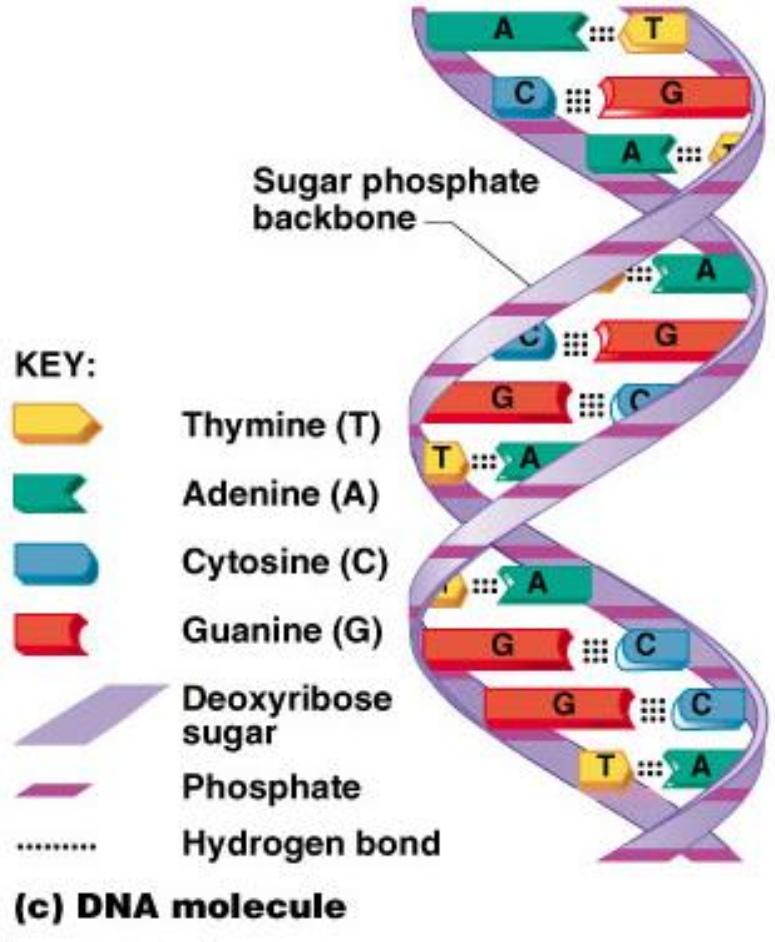
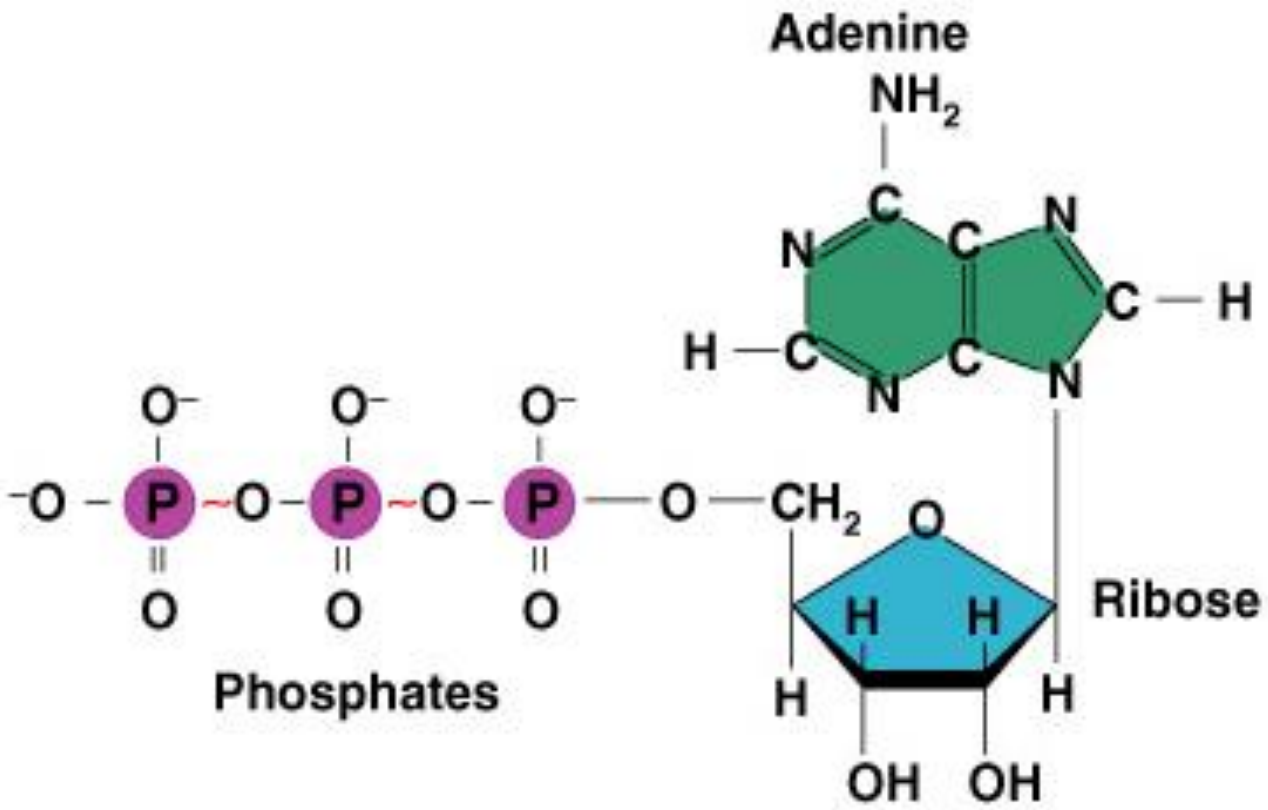


Figure 2.18c

Important Organic Compounds

- Adenosine triphosphate (ATP)
  - Chemical energy used by all cells
  - Energy is released by breaking high energy phosphate bond
  - ATP is replenished by oxidation of food fuels

Adenosine Triphosphate (ATP)



(a) Adenosine triphosphate (ATP)

Figure 2.19a

How ATP Drives Cellular Work

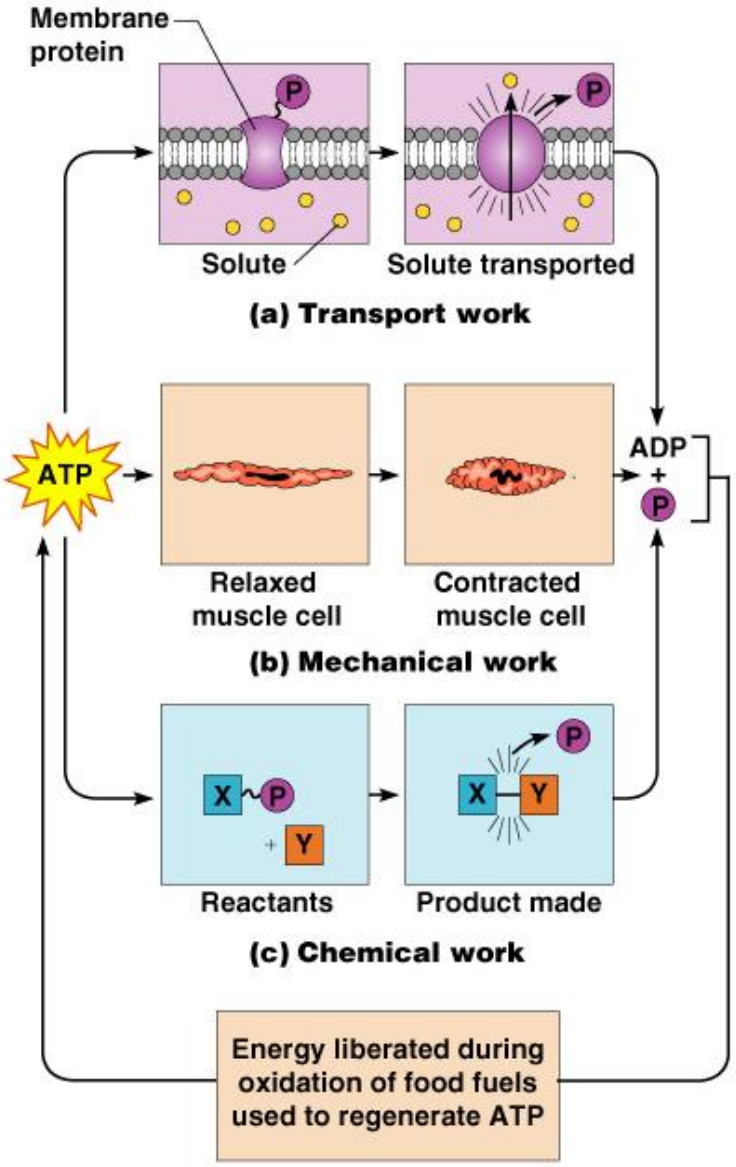


Figure 2.20