Chapter 02
Lecture and Animation Outline

To run the animations you must be in Slideshow View. Use the buttons on the animation to play, pause, and turn audio/text on or off.

Please Note: Once you have used any of the animation functions (such as Play or Pause), you must first click on the slide’s background before you can advance to the next slide.

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes and animations.
Composition of Matter

- **Matter:**
  anything that occupies space and has mass (solid, liquid, or gas)

- **Mass:**
  amount of matter in an object

- **Weight:**
  gravitational force acting on object
Elements and Atoms

• **Element:**
  - simplest form of matter
  - Ex. C, H, O, N, Ca, K, Na, Cl

• **Atom:**
  - smallest particle of an element
  - contains protons, electrons, and neutrons
Figure 2.2 Hydrogen, Carbon, and Oxygen Atoms

Within the nucleus of an atom are specific numbers of positively charged protons ($p^+$) and uncharged neutrons ($n^0$). The negatively charged electrons ($e^-$) are around the nucleus. The atoms depicted here are electrically neutral because the number of protons and number of electrons within each atom are equal.
• Proton:
  + charge, inside nucleus

• Electron:
  - charge, outside nucleus

• Neutron:
  neutral, inside nucleus
Figure 2.1 Model of an Atom

The tiny, dense nucleus consists of positively charged protons and uncharged neutrons. Most of the volume of an atom is occupied by rapidly moving, negatively charged electrons, which can be represented as an electron cloud.
• **Atomic Number:**
  number of protons in each atom

• **Mass Number:**
  number of proton and neutrons in each atom
Chemical Bonds

• What is it?
  occurs when outermost electrons are transferred or shared between atoms

• Ionic bonding:
  - attraction between two oppositely charged ions
  - Ex. NaCl

• Ion:
  - charged particle
  - Ex. Na⁺
Sodium atom (Na)

- 11e−

Sodium ion (Na⁺)

- 10e−

Loses electron

Sodium chloride

Gains electron

Chlorine atom (Cl)

- 17e−

Chloride ion (Cl⁻)

(a)
• **Covalent bonding:**
  - atoms share one or more pairs of electrons
  - Ex. Hydrogen molecule

• **Polar covalent bonds:**
  - unequal sharing of electrons
  - Ex. Water (H₂O)

• **Polar molecules:**
  asymmetrical electrical charge

• **Nonpolar molecules:**
  symmetrical electrical charge
The two hydrogen atoms do not interact because they are too far apart.

The positively charged nucleus of each hydrogen atom begins to attract the electron of the other.

A covalent bond forms when the electrons are shared between the nuclei because the electrons are equally attracted to each nucleus.

**Figure 2.4 Covalent Bonding**
Figure 2.5 Polar Covalent Bonds

(a) A water molecule forms when two hydrogen atoms form covalent bonds with an oxygen atom. (b) Electron pairs (indicated by the black dots) are shared between the hydrogen atoms and oxygen. The dashed outline shows the expected location of the electron cloud if the electrons are shared equally. The electrons are shared unequally, as shown by the electron cloud (yellow) not coinciding with the dashed outline. Consequently, the oxygen side of the molecule has a slight negative charge (indicated by δ⁻), and the hydrogen side of the molecule has a slight positive charge (indicated by δ⁺).
Hydrogen Bonds

- Polar molecules have a positive end and a negative end

- Hydrogen bond forms when positive end of one polar molecule is weakly attracted to negative end of another polar molecule

- Weaker bond than ionic or covalent
Figure 2.6 Hydrogen Bonds

The positive hydrogen part of one water molecule ($\delta^+$) forms a hydrogen bond (red dotted line) with the negative oxygen part of another water molecule ($\delta^-$). As a result, hydrogen bonds hold the water molecules together.
Molecules and Compounds

- **Molecule**: 2 or more atoms chemically combine
  - Ex. Water (H\textsubscript{2}O)

- **Compound**: chemical combination of 2 or more different types of atoms
  - Ex. NaCl
Chemical Reactions

• What are they?
  formation or breaking of chemical bonds

• Reactants:
  what is put into reaction

• Products:
  end result of reaction

\[ A + B \rightarrow C + D \]

Reactants \hspace{1cm} Product
Types of Chemical Reactions

• Synthesis reaction:
  - build a new molecule
  - energy-requiring
  - Ex. ADP + P → ATP

• Decomposition reaction:
  - break down molecule
  - energy-releasing
  - Ex. ATP → ADP + P
(a) ATP → ADP + P_i + Energy

Less potential energy

(b) ADP + P_i + Energy → ATP

More potential energy
• Exchange reaction:
  - combination of synthesis and decomposition reactions
  - Ex. $\text{AB} + \text{CD} \rightarrow \text{AC} + \text{BD}$
  - Ex. $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

• Enzymes:
  proteins that speed up reactions
Molecule A

Enzyme

Molecule B

New molecule AB
Energy

• **What is it?**
  ability to do work

• **Kinetic energy:**
  energy in motion

• **Potential energy:**
  stored energy
• Chemical energy:
  energy stored in chemical bonds (food)

• Glucose:
  - sugar found in food
  - glucose is used to make ATP (energy)

• Glycogen:
  - stored glucose
  - stored in liver, skeletal muscle, and fat
ATP

• What does it stand for?
  adenosine triphosphate

• What is it?
  stored energy

• When ATP is broken down (ATP $\rightarrow$ ADP + P)
  energy is released.
Figure 2.20 Structure of ATP
Acids and Bases

• **Acids:**
  - donate H\(^+\) (proton)
  - pH below 7
  - Ex. HCl (hydrochloric acid)

• **Bases:**
  - accept H\(^+\) (proton)
  - pH above 7
  - Ex. NaOH (sodium hydroxide)

• **Neutral:**
  pH of 7
The pH Scale

<table>
<thead>
<tr>
<th>Concentration in moles/liter</th>
<th>pH Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing acidity</td>
<td></td>
</tr>
<tr>
<td>$10^{-14}$</td>
<td>0 Hydrochloric acid</td>
</tr>
<tr>
<td>$10^{-13}$</td>
<td>1 Stomach acid</td>
</tr>
<tr>
<td>$10^{-12}$</td>
<td>2 Lemon juice</td>
</tr>
<tr>
<td>$10^{-11}$</td>
<td>3 Vinegar, cola, beer</td>
</tr>
<tr>
<td>$10^{-10}$</td>
<td>4 Tomatoes</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>5 Black coffee</td>
</tr>
<tr>
<td>$10^{-8}$</td>
<td>6 Urine (6.5)</td>
</tr>
<tr>
<td>$10^{-7}$</td>
<td>7 Distilled water (7.4)</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>8 Seawater</td>
</tr>
<tr>
<td>$10^{-5}$</td>
<td>9 Baking soda</td>
</tr>
<tr>
<td>$10^{-4}$</td>
<td>10 Great Salt Lake</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>11 Household ammonia</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>12 Soda ash</td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>13 Oven cleaner</td>
</tr>
<tr>
<td>$10^{0}$</td>
<td>14 Sodium hydroxide (NaOH)</td>
</tr>
</tbody>
</table>

Neutral

Increasing alkalinity (basicity)

$10^{-14}$
Inorganic Chemistry

• What is it?
  - substances that do not contain carbon or hydrogen
  - Ex. $O_2$ and $CO_2$
Organic Molecules

Characteristics of Carbohydrates

• Contain C, H, O
• H:O is a 2:1 ratio
  - Ex. C$_6$H$_{12}$O$_6$
• Monosaccharides are the building blocks.
• Monosaccharide:
  - simple sugar (1 sugar)
  - Ex. Glucose and fructose
• **Disaccharide:**
  - 2 sugars
  - Ex. Glucose + fructose = sucrose
  - Ex. Glucose + galactose = lactose

• **Polysaccharide:**
  - many sugars
  - Ex. Starch, grain, vegetables, glycogen, etc.
Figure 2.11a

Glucose + Fructose → Sucrose
Functions of Carbohydrates

• Short-term energy storage

• Converted to glucose quickly

• Glucose is used to make ATP (energy)

• Brain cells require glucose
Characteristics of Proteins

- Contains C, H, O, N

- Amino acids are the building blocks.

- 20 different amino acids

- Amino acids contain an amine (NH$_2$) group and carboxyl group

- Amino acids aren’t stored so a daily supply is required
(c) A protein consists of a chain of different amino acids (represented by different colored spheres).
(a) Two examples of amino acids. Each amino acid has an amine group (—NH₂) and a carboxyl group (—COOH).

(b) The individual amino acids are joined.
Functions of Proteins

• Used to make skin, hair, nails, muscles

• Hemoglobin

• Act as enzymes

• Immune system functions

• Muscle contractions (actin and myosin)

• Part of cell membrane
Protein Denaturation

1. Increase Temperature

2. Decrease pH
Please note that due to differing operating systems, some animations will not appear until the presentation is viewed in Presentation Mode (Slide Show view). You may see blank slides in the “Normal” or “Slide Sorter” views. All animations will appear after viewing in Presentation Mode and playing each animation. Most animations will require the latest version of the Flash Player, which is available at http://get.adobe.com/flashplayer.

This familiar gelatin dessert actually is a good example of the process of coagulation of proteins into a three dimensional latticework that entraps water molecules to produce a semisolid gel.
Enzymes

1. Catalyst

2. Activation Energy
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An example of how enzymes function in the body is from the enzyme sucrase. Sucrase resides on the surface of the microvilli on the intestinal epithelial (mucosal) cell surfaces.
Characteristics of Lipids

• Contain C, H, O

• No 2:1 ratio of H:O

• Insoluble in water

• Ex. Fats, oils, cholesterol, triglycerides, phospholipids

• Glycerol and fatty acids are the building blocks.
Functions of Lipids

• Long term energy storage

• Insulates against heat loss

• Protective cushion for organs

• Cholesterol is part of the cell membrane structure
Types of Lipids

• **Saturated:**
  - single covalent bonds between carbon atoms
  - Ex. Beef, port, whole milk, cheese, eggs

• **Unsaturated:**
  - one or more double covalent bonds between carbons
  - Ex. Olive oil, fish oil, sunflower oil
Figure 2.12 Triglyceride

One glycerol molecule and three fatty acids are combined to produce a triglyceride.
(a) Palmitic acid (saturated)

(b) Linolenic acid (unsaturated)
Figure 2.14 Phospholipids

(a) Molecular model of a phospholipid. (b) Simplified depiction of a phospholipid.
Nucleic Acids

• Composed of C, H, O, N, P

• Ex. DNA (deoxyribonucleic acid) and RNA (ribonucleic acid)

• Nucleotides are the building blocks

• Nucleotides composed of nitrogen base, phosphate, and 5 carbon sugar
1. The building blocks of nucleic acids are nucleotides, which consist of a phosphate group, a sugar, and a nitrogen base.

2. The phosphate groups connect the sugars to form two strands of nucleotides (purple columns).

3. Hydrogen bonds (dotted red lines) between the nucleotides join the two nucleotide strands together. Adenine binds to thymine, and cytosine binds to guanine.

4. The two nucleotide strands coil to form a double-stranded helix.

Figure 2.19 Structure of DNA
thexgene.weebly.com