

# Chapter 2: Chemical Basis of Life

Honors Biology 2011

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## Chemistry of Life

- ♦ Living organisms are composed of about 25 chemical elements
- ♦ Matter - anything that occupies space and has mass
  - ♦ Matter is composed of elements
  - ♦ Element - substance that cannot be broken down to other substances

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## Elements

TABLE 2.1 ELEMENTS IN THE HUMAN BODY

Element	Symbol	Percentage of Human Body Weight
Oxygen	O	65.0
Carbon	C	18.5
Hydrogen	H	9.56
Nitrogen	N	3.3
Calcium	Ca	1.5
Phosphorus	P	1.0
Potassium	K	0.4
Sulfur	S	0.3
Sodium	Na	0.2
Chlorine	Cl	0.2
Magnesium	Mg	0.1

Trace elements (less than 0.01%): boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).

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# Trace Elements

- ✦ Found in concentrations less than 0.01%
- ✦ Some are required to prevent disease
  - ✦ Ex. Iron
  - ✦ Ex. Iodine
- ✦ Common additives in food and water



Fig. 2.2A

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# Compound

- ✦ Substance that consists of two or more different elements combined in a fixed ratio
  - ✦ Ex. Table salt



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Fig. 2.3

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# Organic Compounds

- ✦ Most compounds in living organisms contain four basic components:
  - ✦ Carbon, hydrogen, nitrogen, and oxygen
- ✦ The different arrangements of these elements cause different molecules to have different properties

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# Atoms

- ✦ Atom - smallest unit of matter that still retains the properties of an element
- ✦ Three subatomic particles:
  - ✦ Proton - positive electrical charge
  - ✦ Electron - negative electrical charge
  - ✦ Neutron - neutral charge

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# Atoms

- ✦ Nucleus - contains protons and neutrons
- ✦ Number of protons = atomic number
- ✦ Sum of protons and neutrons = atomic mass

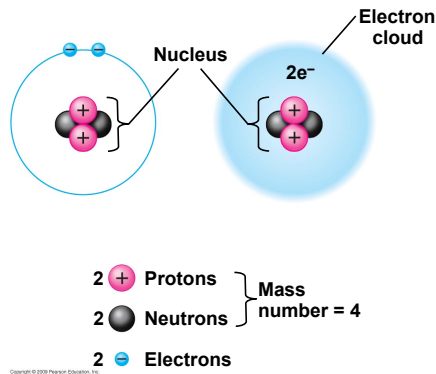


Fig. 2.4A

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# Isotopes

- ✦ Same number of protons and electrons and different numbers of neutrons
  - ✦ Ex. Carbon-14

TABLE 2.4 ISOTOPES OF CARBON			
	Carbon-12	Carbon-13	Carbon-14
Protons	6	6	6
Neutrons	6	7	8
Electrons	6	6	6

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# Isotope Uses

- ✦ Living cells cannot distinguish between isotopes of the same element; this way radioactive compounds can be used as tracers.
- ✦ Tracers can be used in research
- ✦ Tracers are often used in medical applications
- ✦ Uncontrolled exposure can cause damage to molecules like DNA

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# Electron Arrangement

- ✦ Only electrons are involved in the activity of a chemical
- ✦ Electrons occur in energy levels called electron shells
- ✦ Number of electrons in the outermost shell determines the chemical properties
- ✦ Atoms want to fill their outer electron shells
  - ✦ Do this by sharing, donating, or receiving electrons
  - ✦ This causes chemical bonding

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# Ionic Bonds

- ✦ Ion - atom or molecule with an electrical charge resulting from a gain or loss of electrons
- ✦ Ions with opposite charge attract each other
  - ✦ This forms an ionic bond

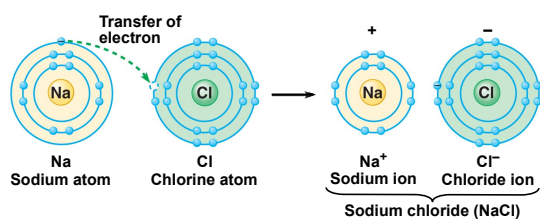
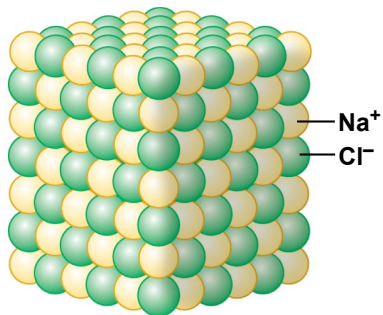


Fig.  
2.7A

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# Ionic Bonds

- Can form crystals



Fig, 2.7B

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# Covalent Bonds

- Covalent Bond - when atoms share outer-shell electrons
- Molecule - formed when atoms are held together by covalent bonds

TABLE 2.8 ALTERNATIVE WAYS TO REPRESENT FOUR COMMON MOLECULES			
Molecular Formula	Electron-Distribution Diagram	Structural Formula	Space-Filling Model
H <sub>2</sub>		H—H Single bond	
O <sub>2</sub>		O=O Double bond	
CH <sub>4</sub> Methane		$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{H} \\   \\ \text{H} \end{array}$	
H <sub>2</sub> O Water		$\begin{array}{c} \text{O}-\text{H} \\   \\ \text{H} \end{array}$	

Fig. 2.8

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# Polar Molecules

- Electronegativity - atom's attraction for shared electrons
- Non-polar covalent bonds - electrons shared equally between atoms
- Polar covalent bonds - electrons are shared unequally between atoms
- Polar molecule - molecule with an uneven distribution of charges

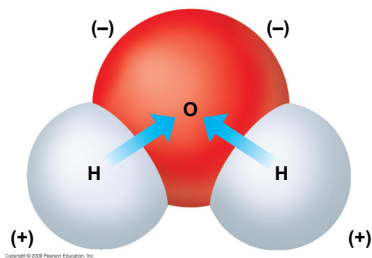


Fig. 2.9

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# Hydrogen Bonds

- ✦ Weak type of bond
- ✦ Interaction between partial positive and partial negative charges of polar molecules

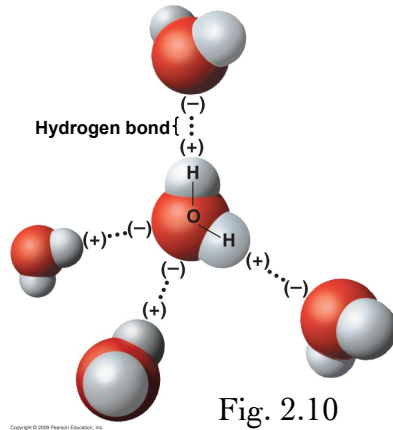


Fig. 2.10

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# Cohesion and Adhesion

- ✦ Caused by hydrogen bonding
- ✦ Hydrogen bonds only last for a few trillionths of a second
- ✦ Cohesion - tendency of molecules to stick to each other
  - ✦ Surface tension - measure of how difficult it is to stretch or break the surface of a liquid
- ✦ Adhesion - tendency of molecules to stick to other types of molecules

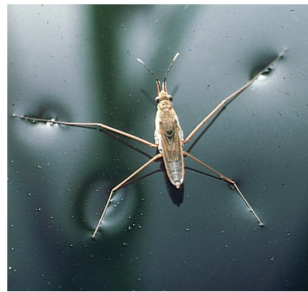
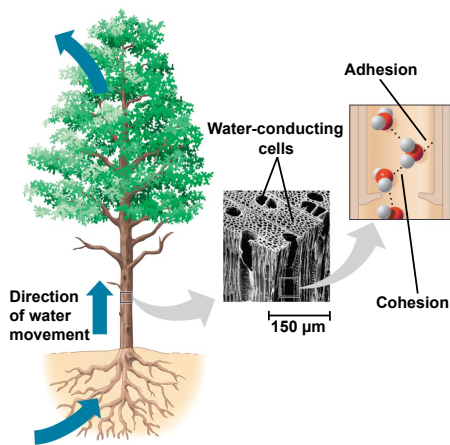


Fig. 2.11

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# Cohesion and Adhesion in Plants



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# Moderation of Temperature

- ✦ Because of hydrogen bonding, water has a better ability to resist temperature changes than most other substances
- ✦ Bodies of water impact the temperature of the land
- ✦ Evaporation

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# Density

- ✦ Ice is less dense than liquid water because of hydrogen bonding

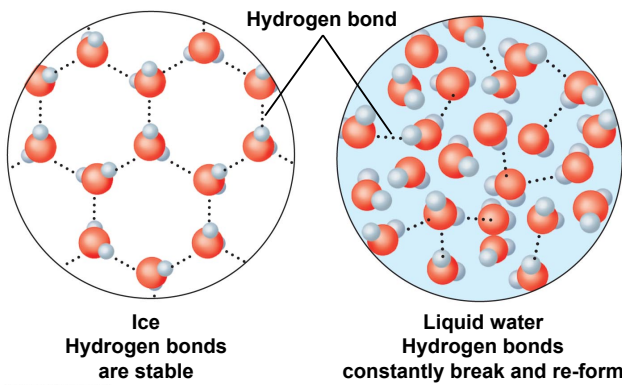


Fig. 2.13A

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# Solvent of Life

- ✦ Solution - liquid consisting of a uniform mixture of two or more substances
  - ✦ Solute - substance that is dissolved
  - ✦ Solvent - substance that is the dissolving agent
- ✦ Aqueous solution - when water is the solvent
- ✦ Water is a great solvent because of its polarity.

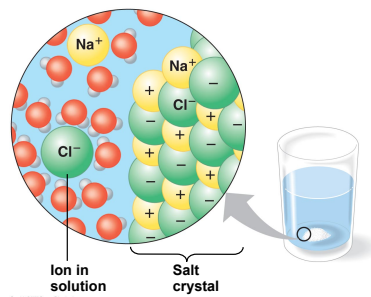
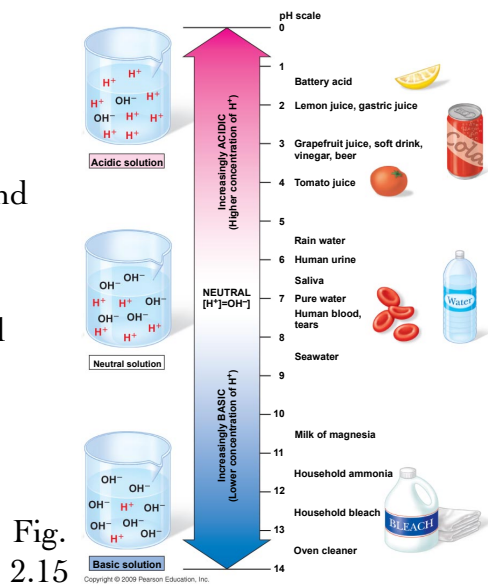


Fig. 2.14

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# Acids and Bases

- ✦ Acid - a compound that donates a hydrogen ion
- ✦ Base - compound that accepts a hydrogen ion
- ✦ pH scale - potential of hydrogen



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# Acid Precipitation

- ✦ Rain, snow, or fog with a pH lower than 5.6
- ✦ Kills fish
- ✦ Changes soil chemistry

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# Chemical Reactions

- ✦ Chemical reaction involves the making and breaking of chemical bonds that lead to a change in the composition of matter
- ✦ Reactants - starting materials
- ✦ Products - the end materials

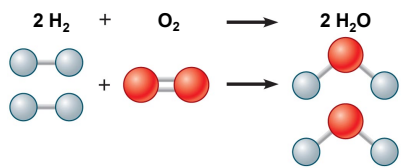


Fig. 2.18

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