

Ch 2

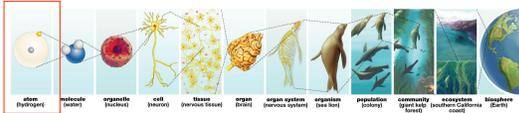
Chemistry of Life

BIOL 160

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Chemistry's Building Block: The Atom

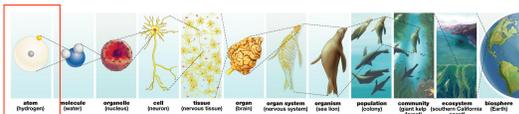
- Structural Hierarchy (reviewed)
 - Atom → Molecule → Organelle → Cell → Tissue → Organ...
- The atom is the fundamental unit of matter.
 - Elements



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Chemistry's Building Block: The Atom

- Element
 - any substance that cannot be reduced to any simpler set of constituent substances through chemical means.
 - defined by the **number of protons** in its nucleus.



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Organization of Periodic Table

PERIODIC TABLE OF THE ELEMENTS

Hydrogen (H)

Helium (He)

Labels for diagrams:
 electron shell
 nucleus
 electron (negative charge)
 proton (positive charge)
 neutron (no charge)

Atomic Characteristics

- Atomic number = # of protons (*never changes*)
- Atomic weight = # of protons + neutrons
- Radioactive isotope - neutron # different

PERIODIC TABLE

Isotopes

Hydrogen

1 proton
0 neutrons

Deuterium

1 proton
1 neutron

Tritium

1 proton
2 neutrons

Bonds

- Atoms can link to one another in the process of chemical bonding
- The ability of an atom to combine depends on the number of electrons in its outer shell

● Electron from hydrogen
● Electron from carbon

Bonds

- Chemical bonding comes about as atoms "seek" their *lowest energy state*.
- An atom achieves this state when it has a filled outer electron shell.

Elements tend to fill their outermost shells with electrons. To do this, they can either share, donate, or accept electrons with/ from other elements.

Bonds

- Hydrogen and helium require two electrons in orbit around their nuclei to have filled outer shells.
- Most other elements require eight electrons to have filled outer shells.

Unstable, very reactive atoms

hydrogen (H)
carbon (C)
sodium (Na)
Outermost electron shells unfilled

Stable, unreactive atoms

helium (He)
neon (Ne)
argon (Ar)
Outermost electron shells filled

Bonds

- Covalent bond
 - atoms share one or more electrons
- Ionic bond
 - atoms lose and accept electrons from each other

Polar covalent bond

Nonpolar covalent bond

Nonpolar covalent bond

The water molecule (left) depicts a polar bond with a slightly positive charge on the hydrogen atoms and a slightly negative charge on the oxygen. Examples of nonpolar bonds include methane (middle) and oxygen (right).

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Covalent Bonds

- electronegativity
 - Atoms of *different elements* differ in their power to attract electrons
 - Through electronegativity, a molecule can take on a **polarity**—a difference in electrical charge at one end compared to the other
 - Due to the unequal sharing of electrons

Electronegativity

Covalent Bonds

Polar or Nonpolar?

- polar covalent bond
 - shared electrons are not shared equally
 - due to electronegativity differences

(a) Polar water molecule

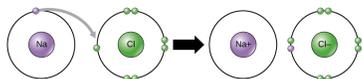
O: EN=3.5
H: EN=2.1

(b) Nonpolar methane molecule

nonpolar because charges are symmetric

Ionic Bonds

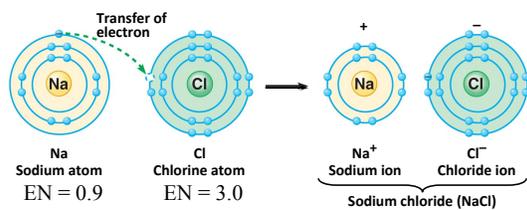
- **Ions**
 - charged because either gain or lose an electron
 - electronegativity differences between atoms are great enough that one atom loses one or more electrons to the other
- This process creates **ions**: atoms whose number of electrons differs from their number of protons



In the formation of an ionic compound, metals lose electrons and nonmetals gain electrons to achieve an octet.

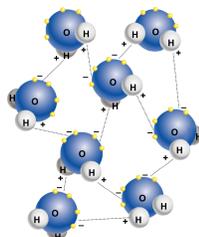
Ionic Bonds

- Charge differences that result from ionization can produce an electrostatic attraction between ions
- This attraction is an ionic bond
- When atoms of two or more elements bond together ionically, the result is an ionic compound



Hydrogen Bonds

- **Hydrogen Bonds**
 - attraction of H⁺ to an opposite charge (-)
- In water, a hydrogen atom of one water molecule will form a hydrogen bond with an unshared oxygen electron of a neighboring water molecule



Compounds

- Substance containing two or more **elements** in a fixed ratio
 - Table Salt (NaCl) and Water (H₂O)



Sodium

+



Chlorine

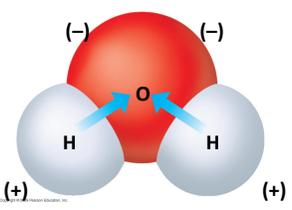
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Sodium Chloride

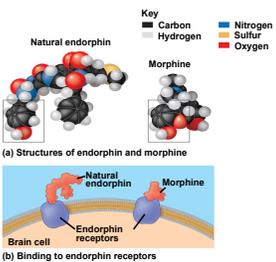
Molecules

- two or more **atoms** held together by bonds
 - Therefore, compounds are molecules, molecules are not necessarily compounds



Molecules

- Biological molecules
 - recognize and interact with each other
 - with a specificity based on molecular shape
- Molecules with similar shapes
 - can have similar biological effects
 - Shape dictates function



(a) Structures of endorphin and morphine

(b) Binding to endorphin receptors

Water and Life

- Water has several qualities that have strongly affected life on Earth
 - Structure
 - Polarity

Water and Life

- **solution**
 - homogeneous mixture of two or more kinds of molecules, atoms, or ions
- **Solute**
 - compound dissolved in solution
- **Solvent**
 - compound doing the dissolving
- Water is a powerful solvent, with the ability to dissolve more compounds in greater amounts than any other liquid.
