AP Biology

Unit 1: The chemistry of Life

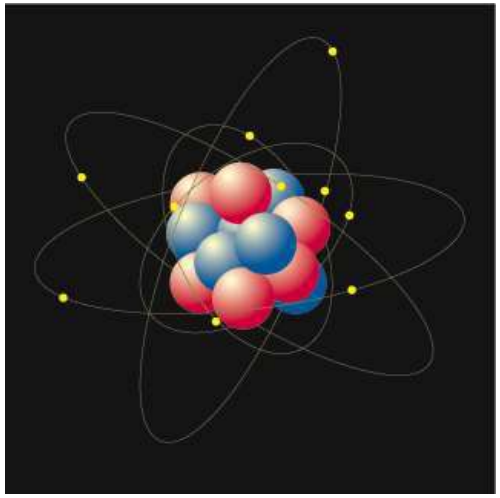
Chapter2 Chemistry Basics

Essential Knowledge. I can…

- Describe characteristics of a biological concept, process, or model represented visually.(SP2.A)
- Describe the composition of macromolecules required by living organisms.(ENE 1.A).
- Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.(SYI 1.B)
- Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule.(SYI 1.C)

Note: the following information is foundational to several upcoming associated learning targets

The Basics



- Everything is made of matter
- Matter is made of atoms
  - Matter is anything that takes up space and has mass.

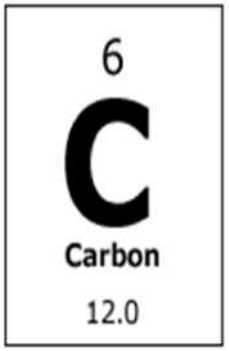
Atoms are made of:

– protons	+	mass of 1	nucleus
– neutrons	0	mass of 1	nucleus
– electrons	-	mass <<1	orbits

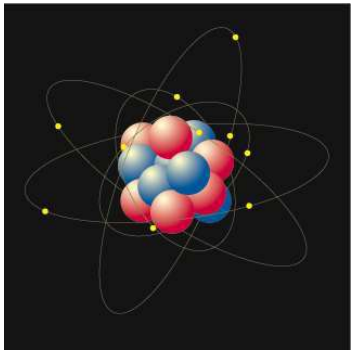
- Different kinds of atoms = elements

Atomic structure determines behavior

- # protons determines the element
  - # of protons = atomic number
  - this also tells you # of electrons, if neutral
  - # of neutrons = atomic mass- atomic #



- All atoms of an element have same chemical properties
  - all behave the same
  - properties don't change



Most *Common* Elements in all life forms

Table 2.1 Naturally Occurring Elements in the Human Body

Symbol	Element	Atomic Number (See p. 29)	Percentage of Human Body Weight
O	Oxygen	8	65.0
C	Carbon	6	18.5
H	Hydrogen	1	9.5
N	Nitrogen	7	3.3
Ca	Calcium	20	1.5
P	Phosphorus	15	1.0
K	Potassium	19	0.4
S	Sulfur	16	0.3
Na	Sodium	11	0.2
Cl	Chlorine	17	0.2
Mg	Magnesium	12	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).

Humans: 25 essential elements

CHNOPS

Element: Cannot be broken down into other substances by a chemical reaction

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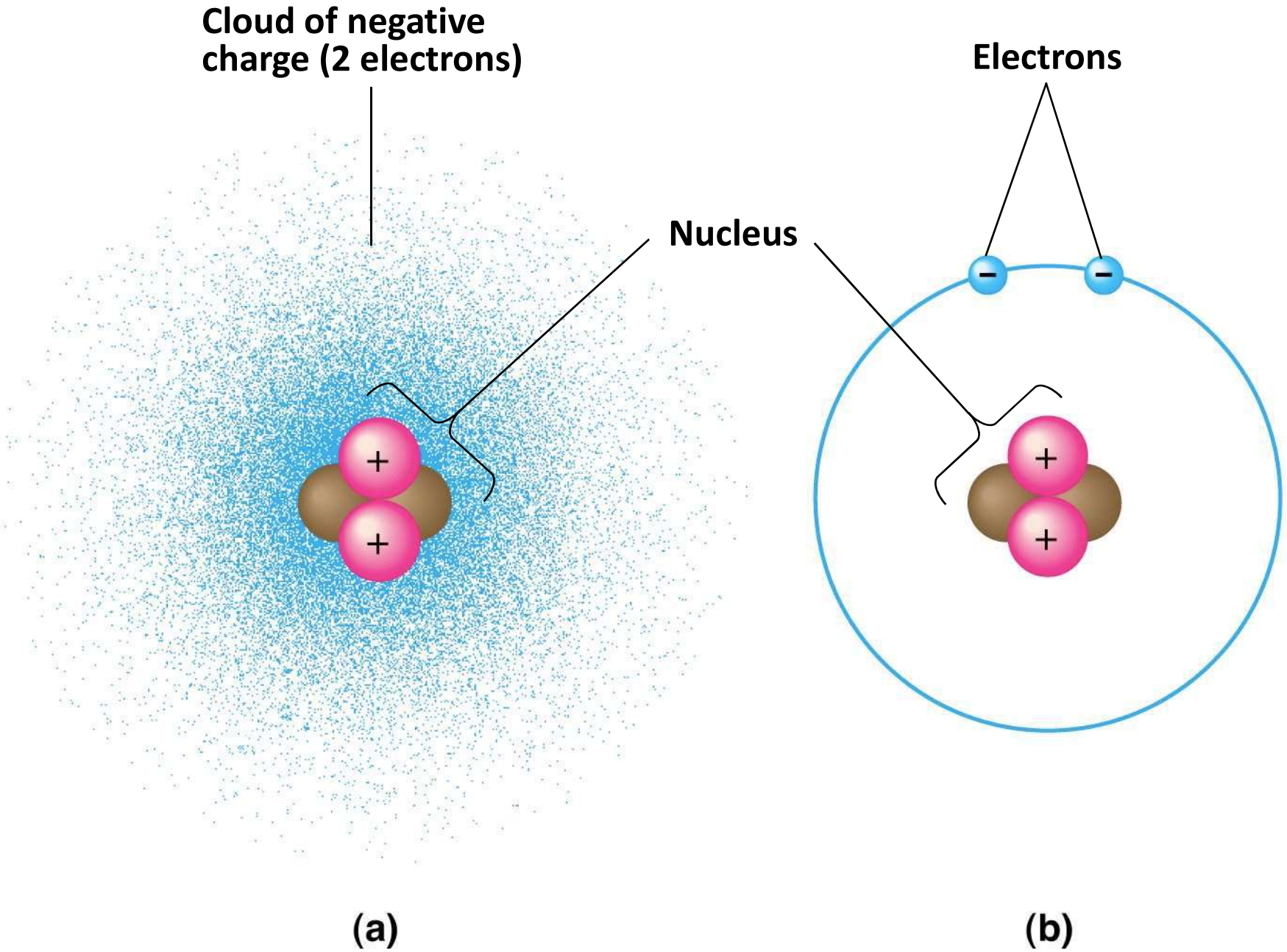
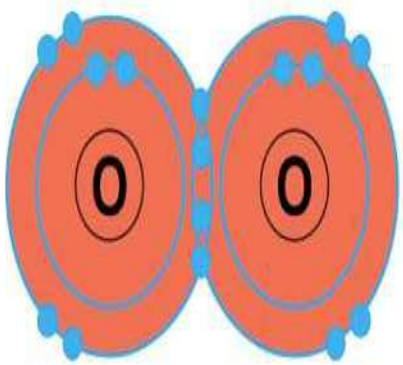
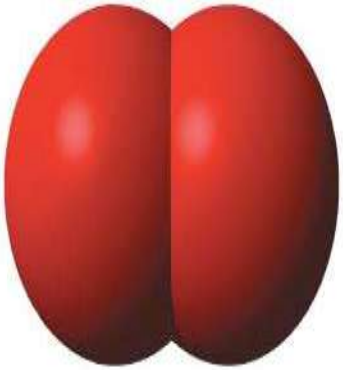


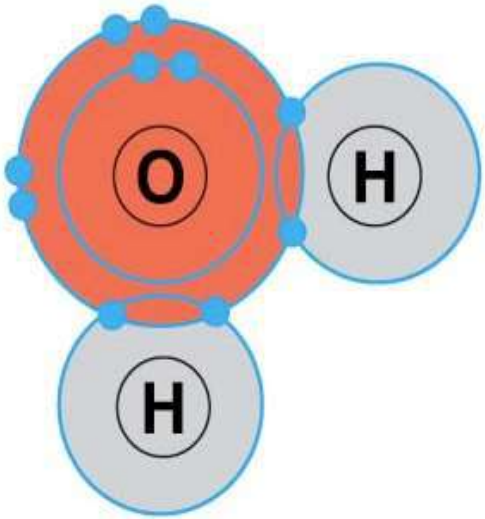
Molecule: Same element

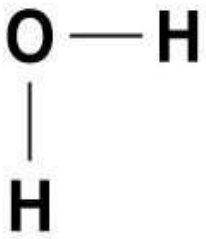


O=O



Molecule: Different elements





Isotopes

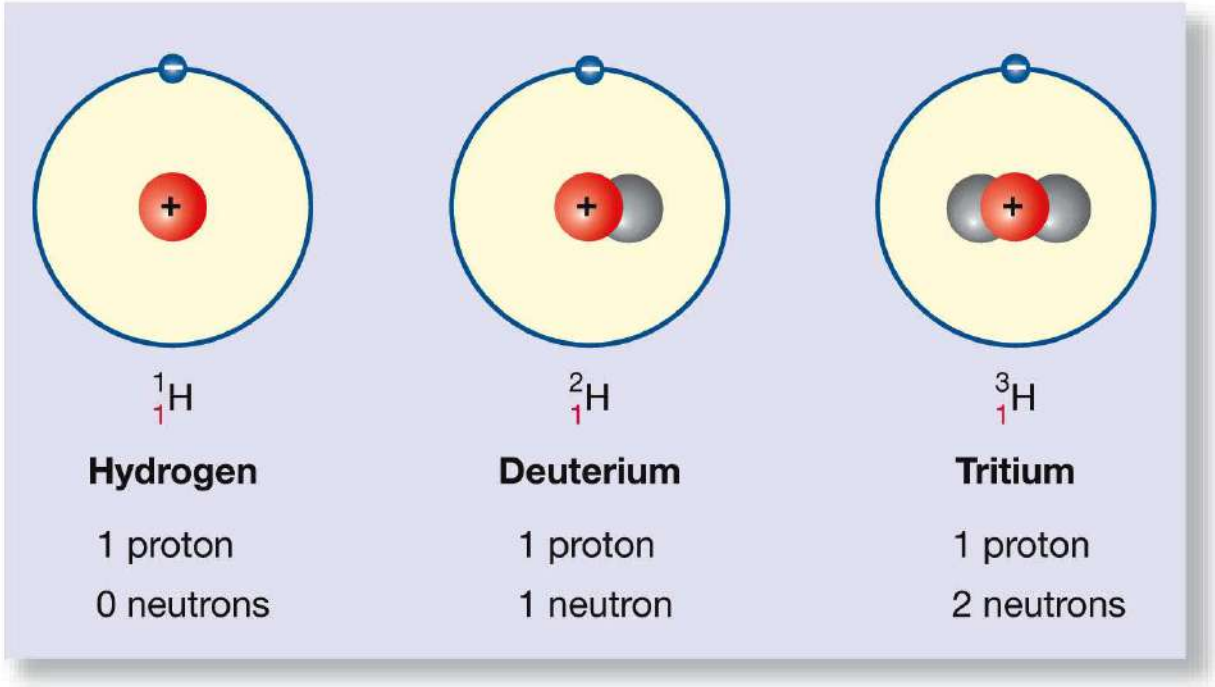
Isotopes: forms of an element with different # of neutrons

Example:

^{12}C has 6 neutrons

^{13}C has 7 neutrons

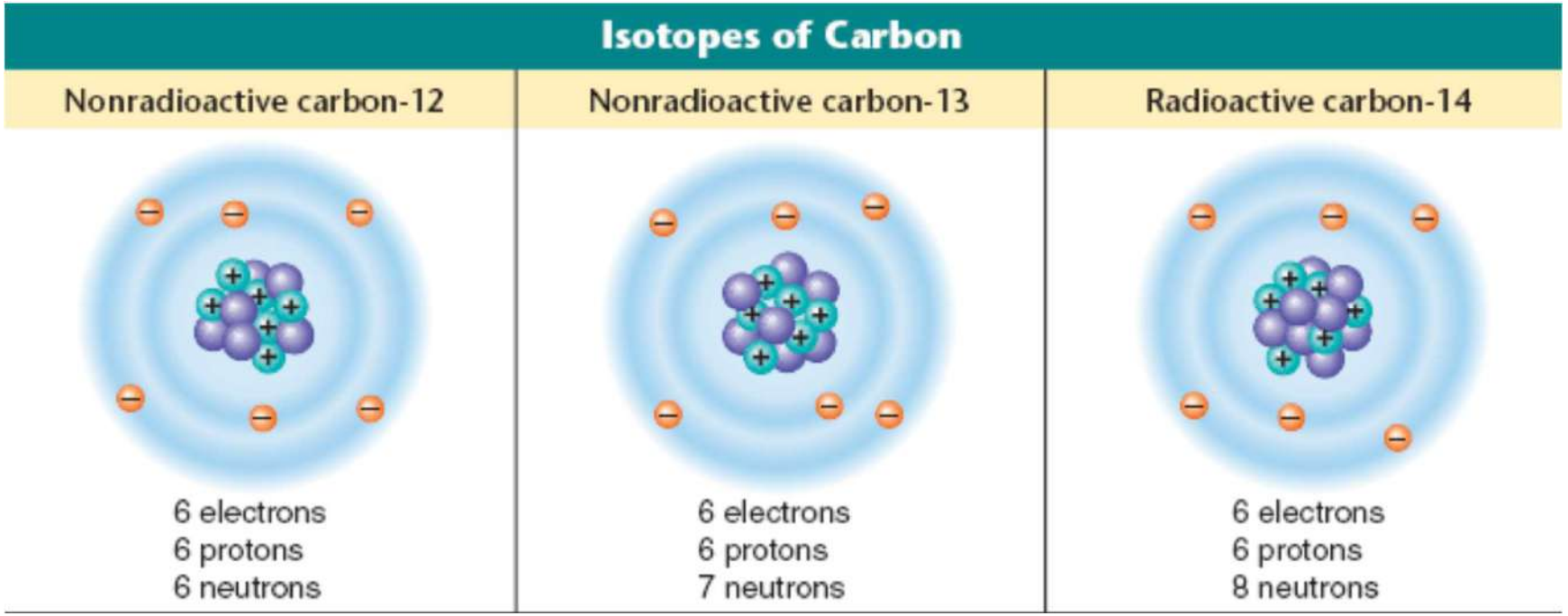
^{14}C has 8 neutrons



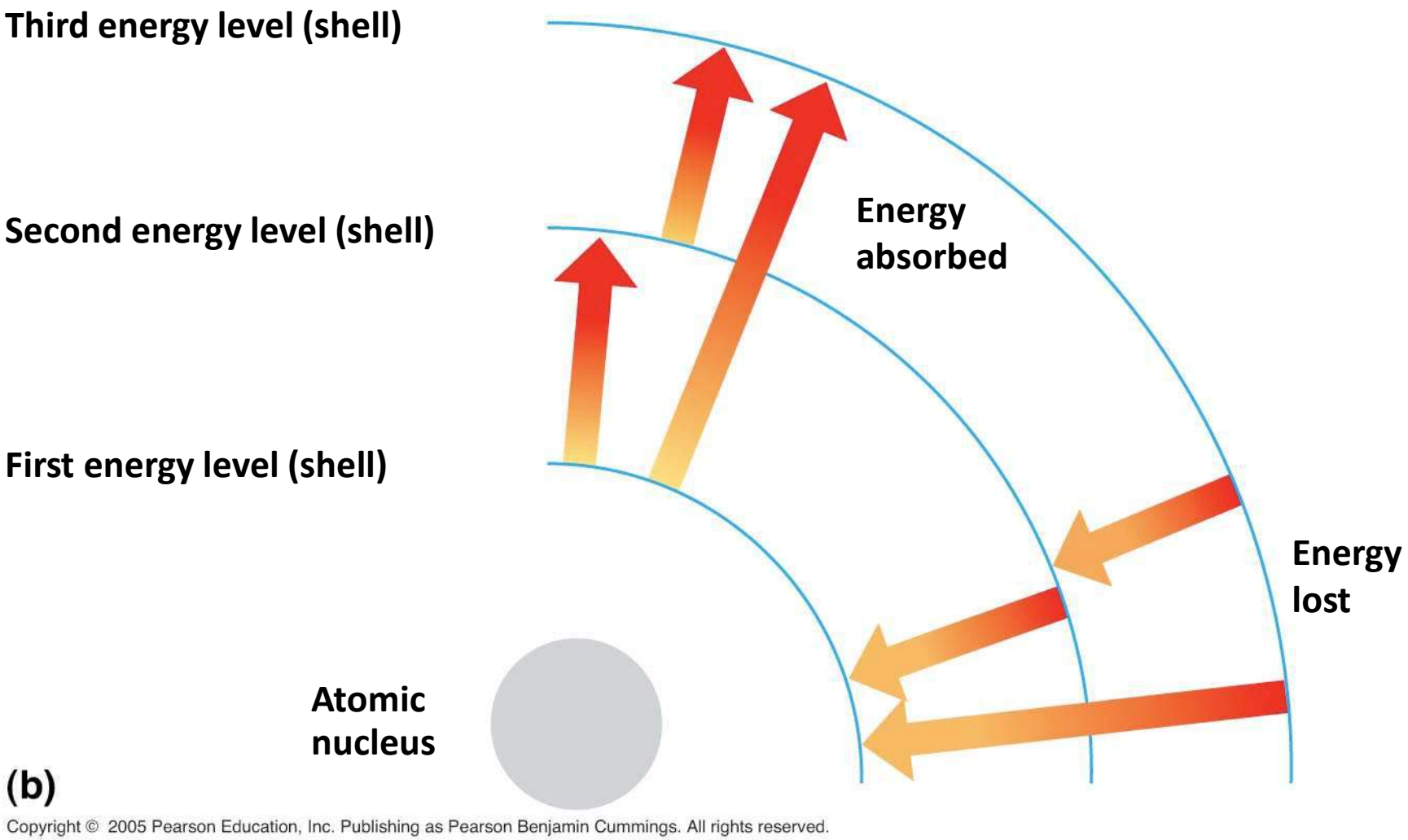
LIFE 8e, Figure 2.3

Radioactive Isotopes

- Spontaneously give off particles and energy
  - Alpha, beta, gamma radiation
  - P^{32}, H^{3}, etc used in research
  - Decay changes number of protons, changing atom identity



Energy and Atoms



Potential energy low when close to nucleus

Chemical reactivity

- Atoms tend to
  - Complete a partially filled outer (valence) electron shell

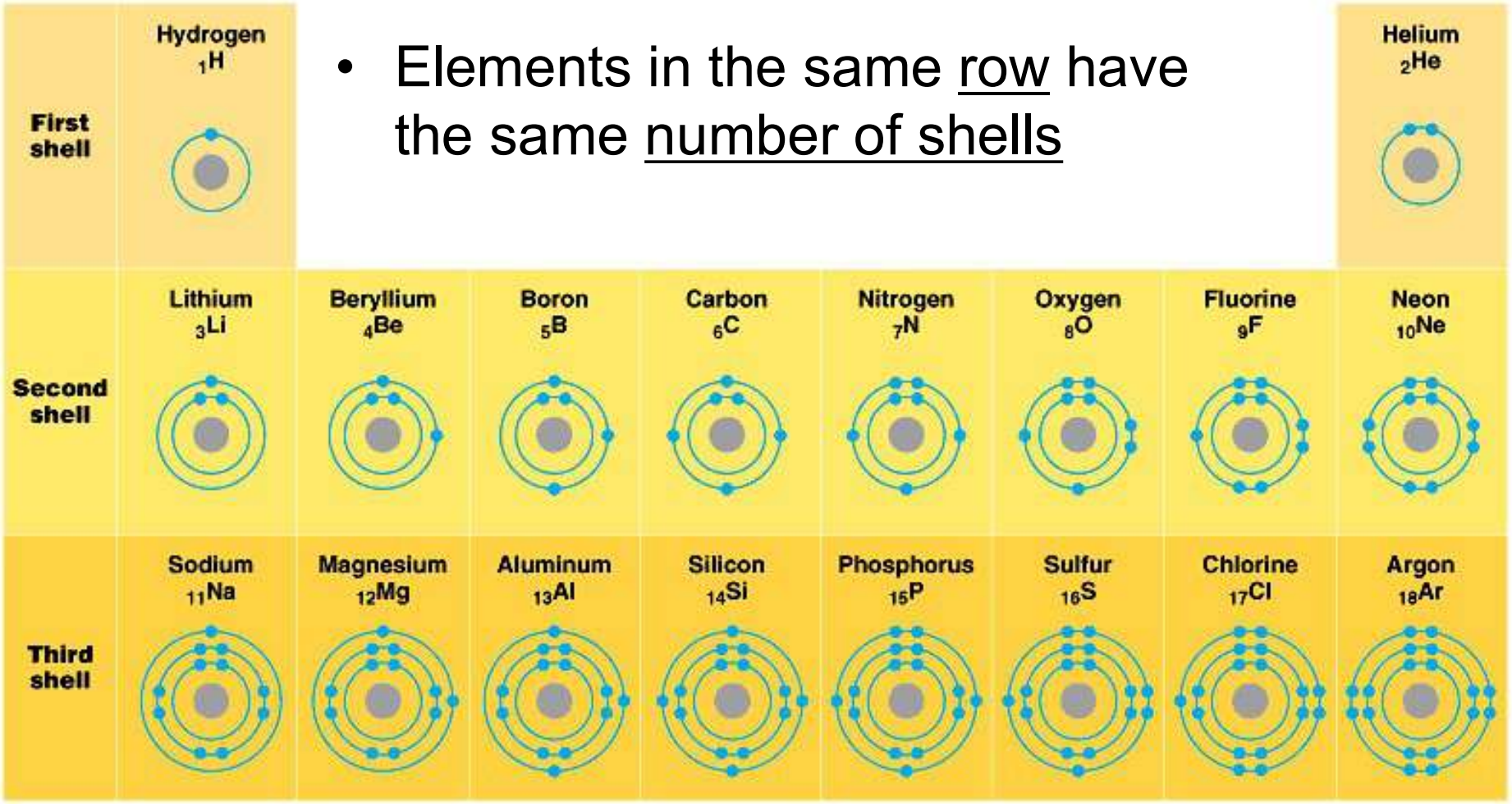
  or

  - Empty a partially filled outer (valence) electron shell

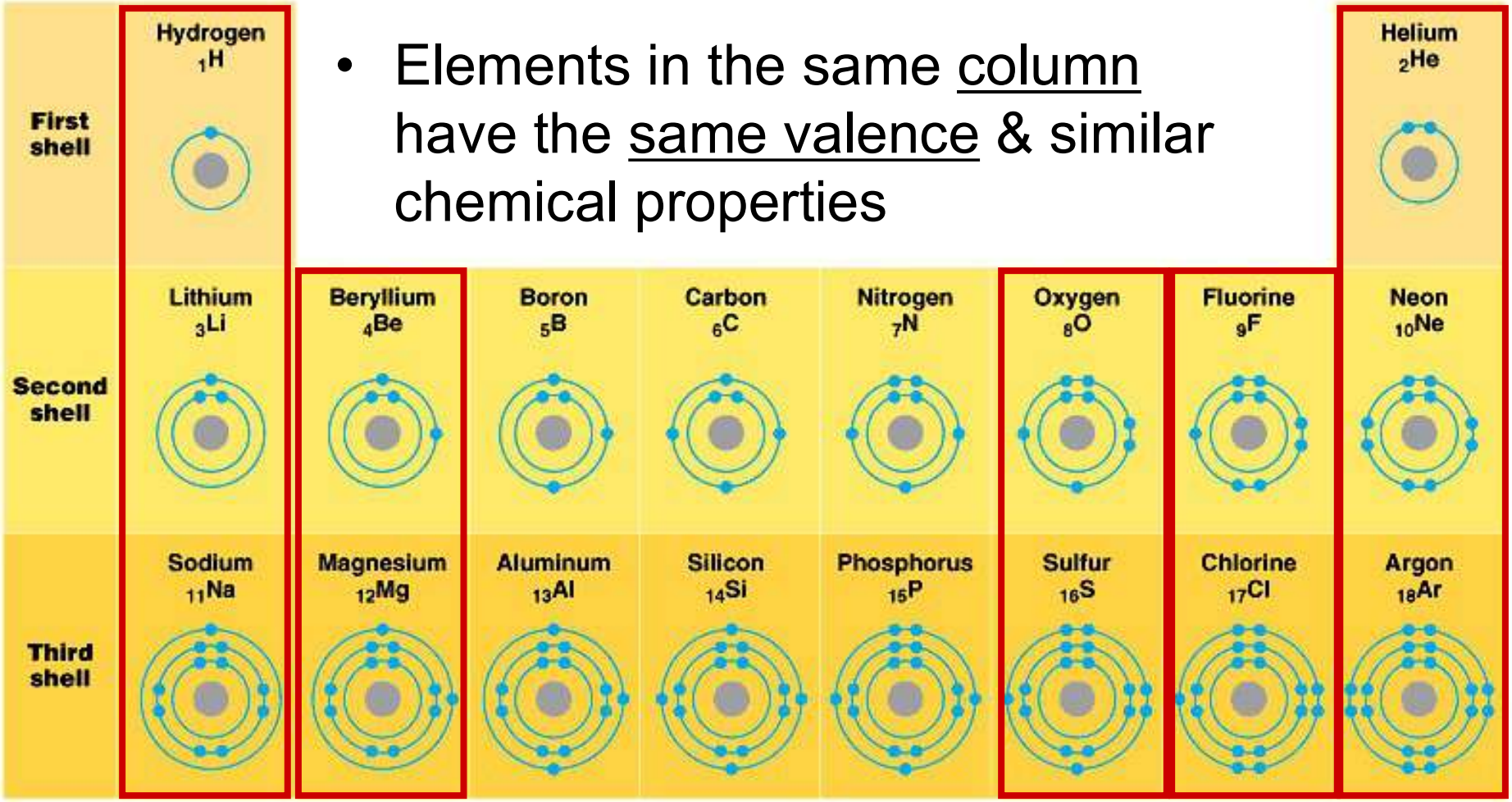
  - This tendency drives chemical reactions

Elements & their valence shells

- Elements in the same row have the same number of shells



Elements & their valence shells

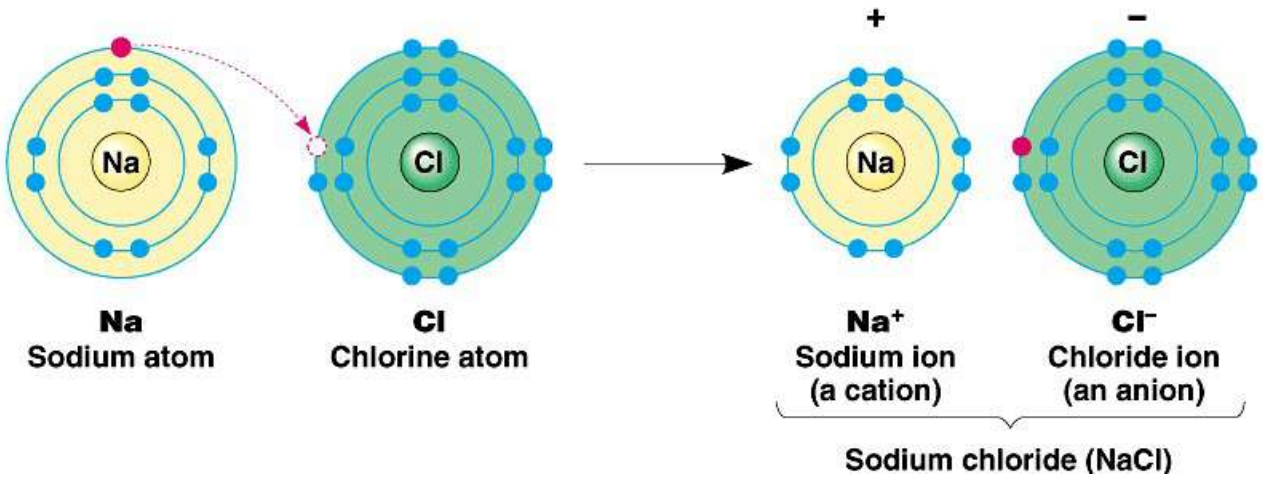


- Elements in the same column have the same valence & similar chemical properties

Ionic bonds

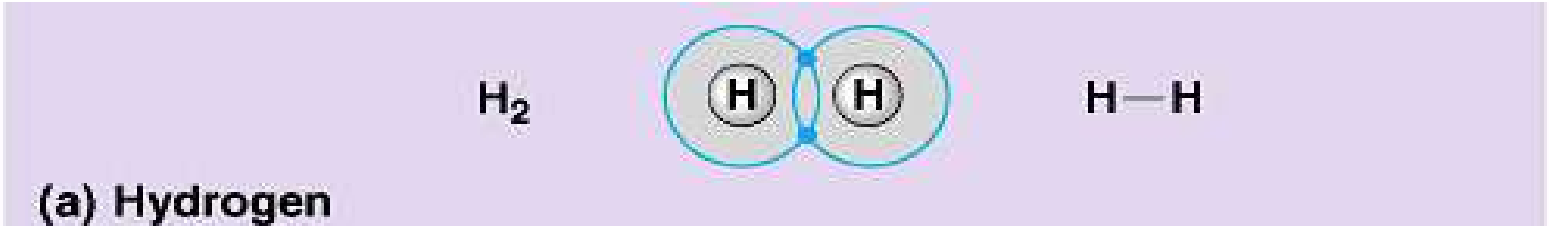
- Transfer of an electron
- Forms + & - ions
  - + = cation
  - – = anion
- <u>Weak</u> bond

- **example:**
  - **salt = dissolves easily in water**



Covalent bonds

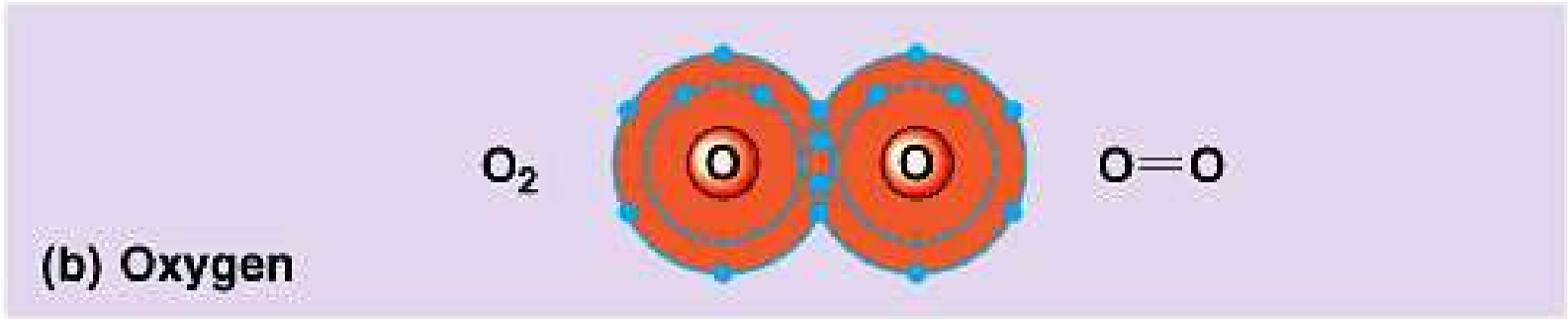
- Two atoms need an electron
- Share a pair of electrons
- Strong bond
  - both atoms holding onto the electrons
- Forms molecules



- 1 atom can form covalent bonds with two or more other atoms
- example:
  - water = takes energy to separate

Double covalent bonds

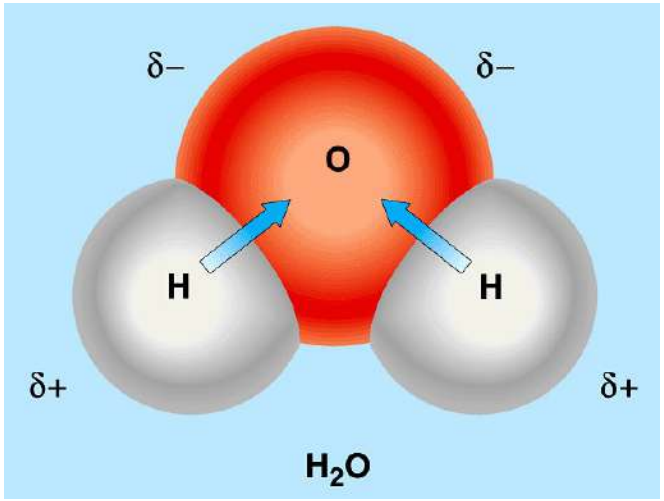
- Two atoms can share more than one pair of electrons
  - double bonds (2 pairs of electrons)
  - triple bonds (3 pairs of electrons)
- Very strong bonds



Polar covalent bonds

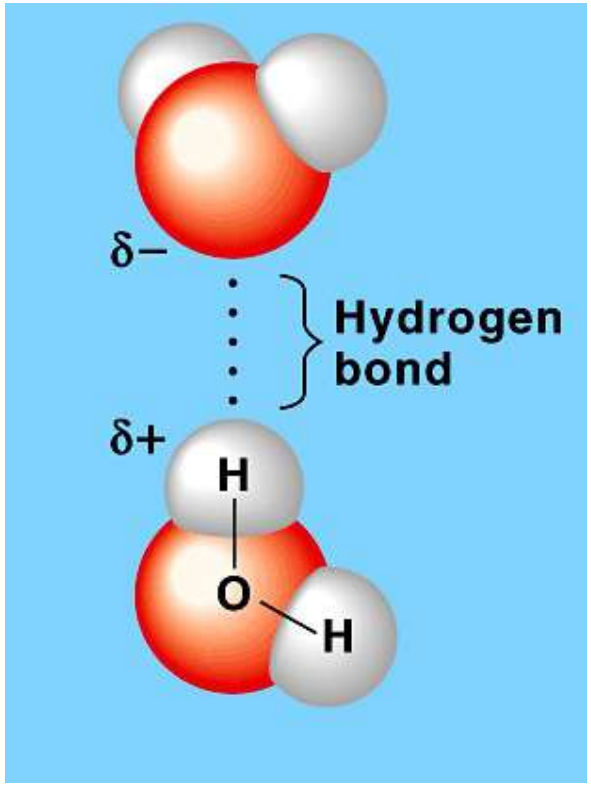
- Pair of electrons not shared equally
- 2 hydrogens in the water molecule form an angle
- Water molecule is polar
  - oxygen end is –
  - hydrogen end is +

oxygen has higher electronegativity

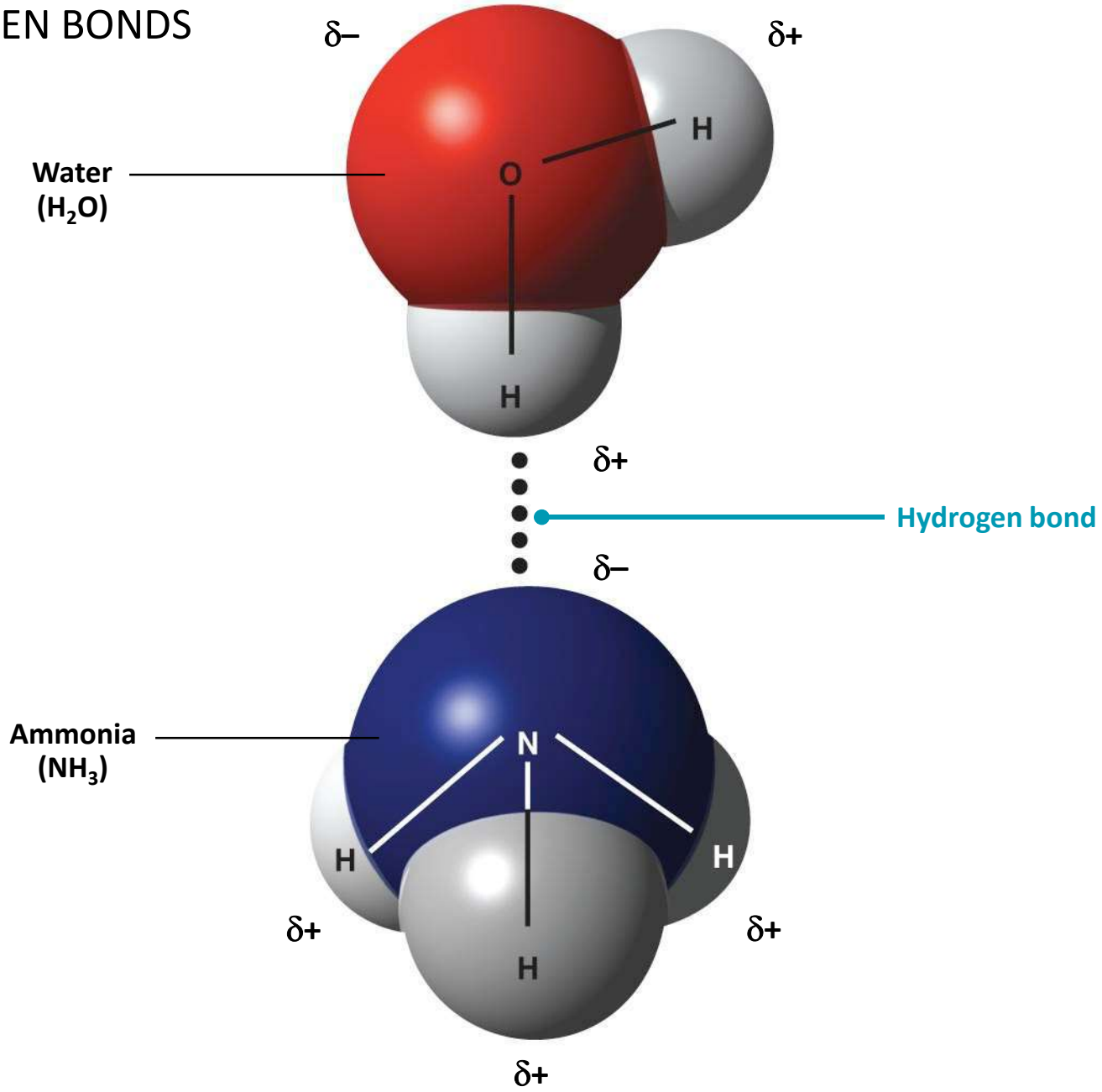


Hydrogen bonds (H-bonds)

- Positive H atom in 1 water molecule is attracted to negative O in another
- Can occur wherever an -OH exists in a larger molecule
- <u>Weak</u> bonds



HYDROGEN BONDS



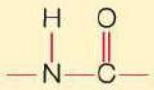
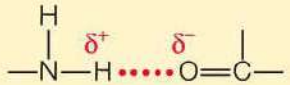
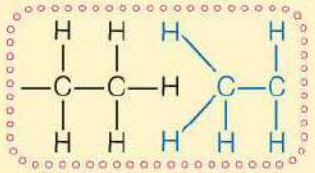
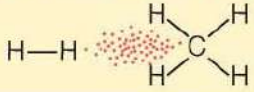
Van der Waals Interactions

- Van der Waals interactions
  - Occur when transiently positive and negative regions of molecules attract each other

Strong and weak chemical bonds

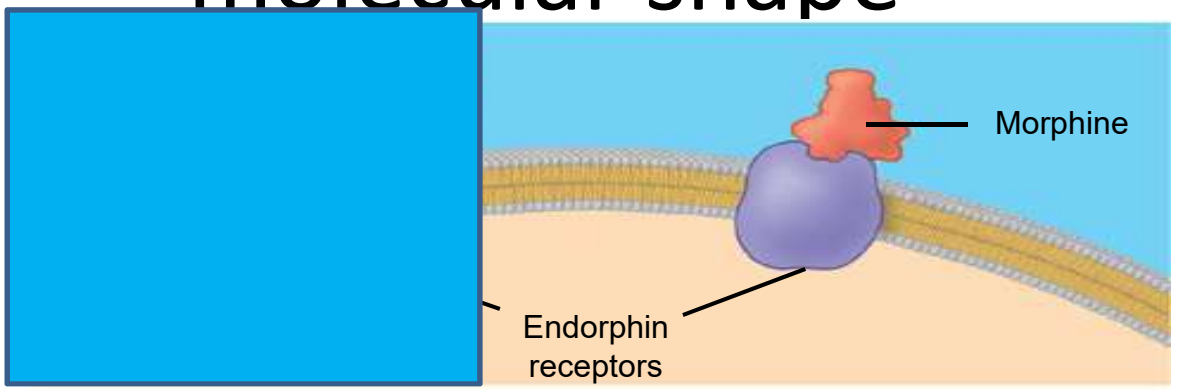
TABLE 2.1

Chemical Bonds and Interactions

NAME	BASIS OF INTERACTION	STRUCTURE	BOND ENERGY[a] (KCAL/MOL)
Covalent bond	Sharing of electron pairs		50–110
Ionic bond	Attraction of opposite changes		3–7
Hydrogen bond	Sharing of H atom		3–7
Hydrophobic interaction	Interaction of nonpolar substances in the presence of polar substances (especially water)		1–2
van der Waals interaction	Interaction of electrons of nonpolar substances		1

[a]*Bond energy* is the amount of energy needed to separate two bonded or interacting atoms under physiological conditions.

Biological function is related to molecular shape



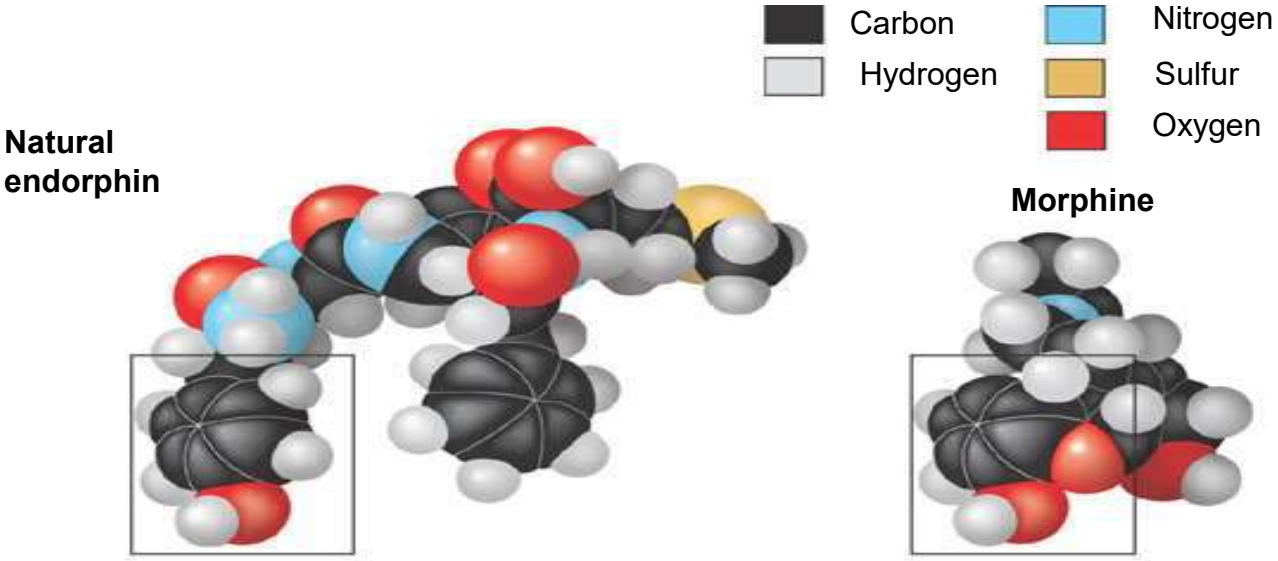
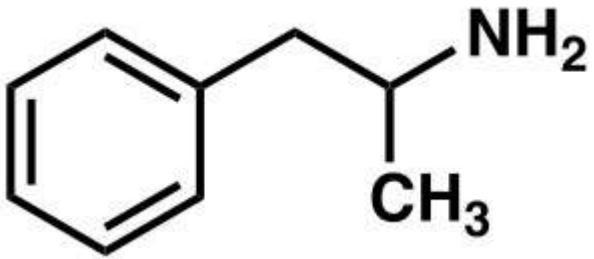
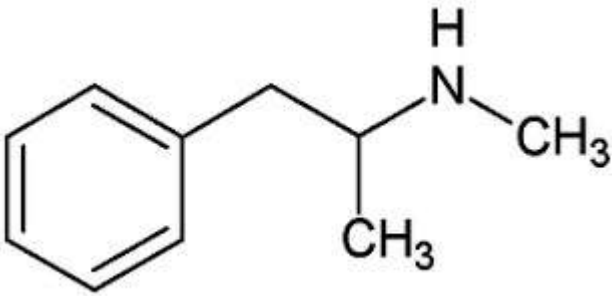


Figure 2.17

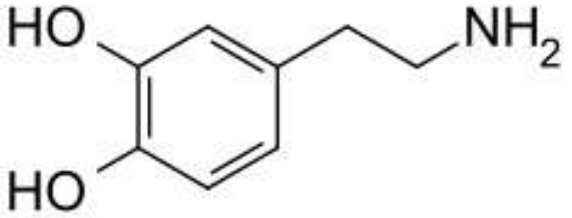


amphetamine

Serotonin (5-HT)



methamphetamine



dopamine