

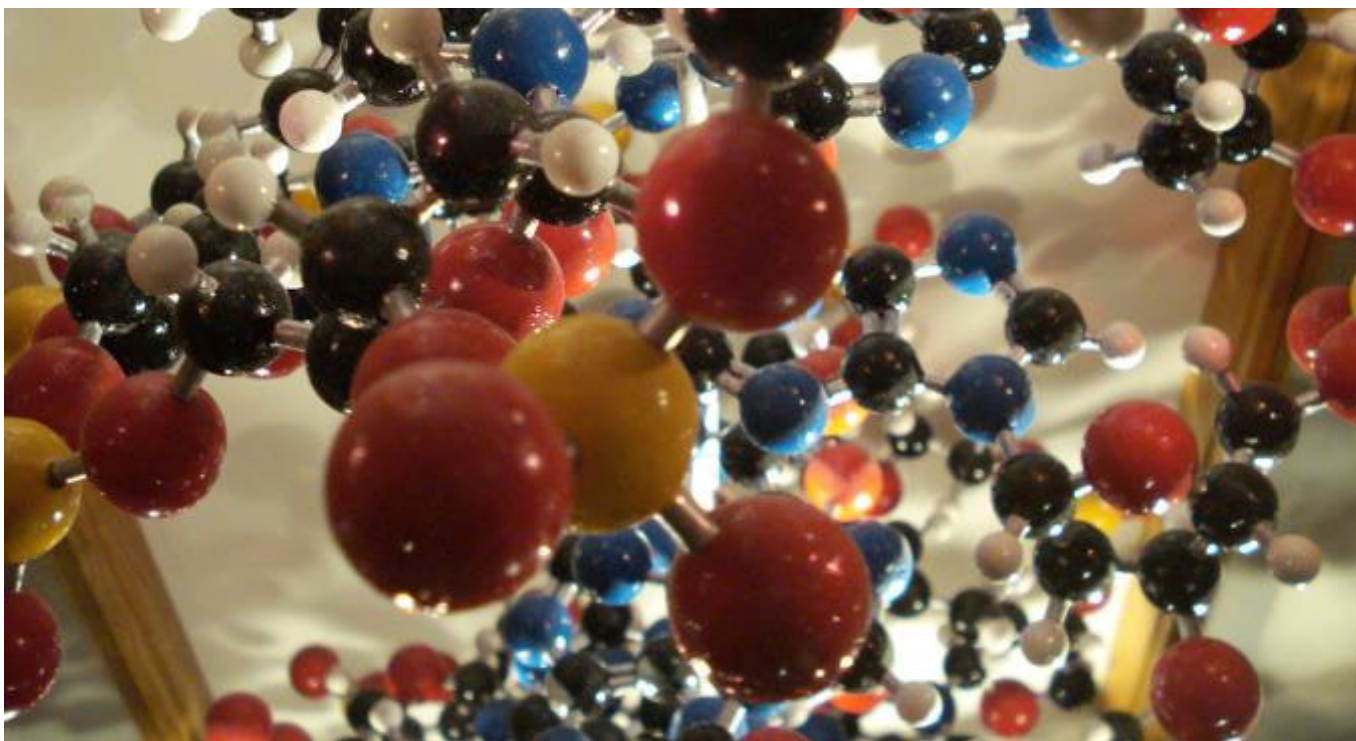
BIOLOGY 2e

Chapter 2 THE CHEMICAL FOUNDATION OF LIFE

PowerPoint Image Slide Show



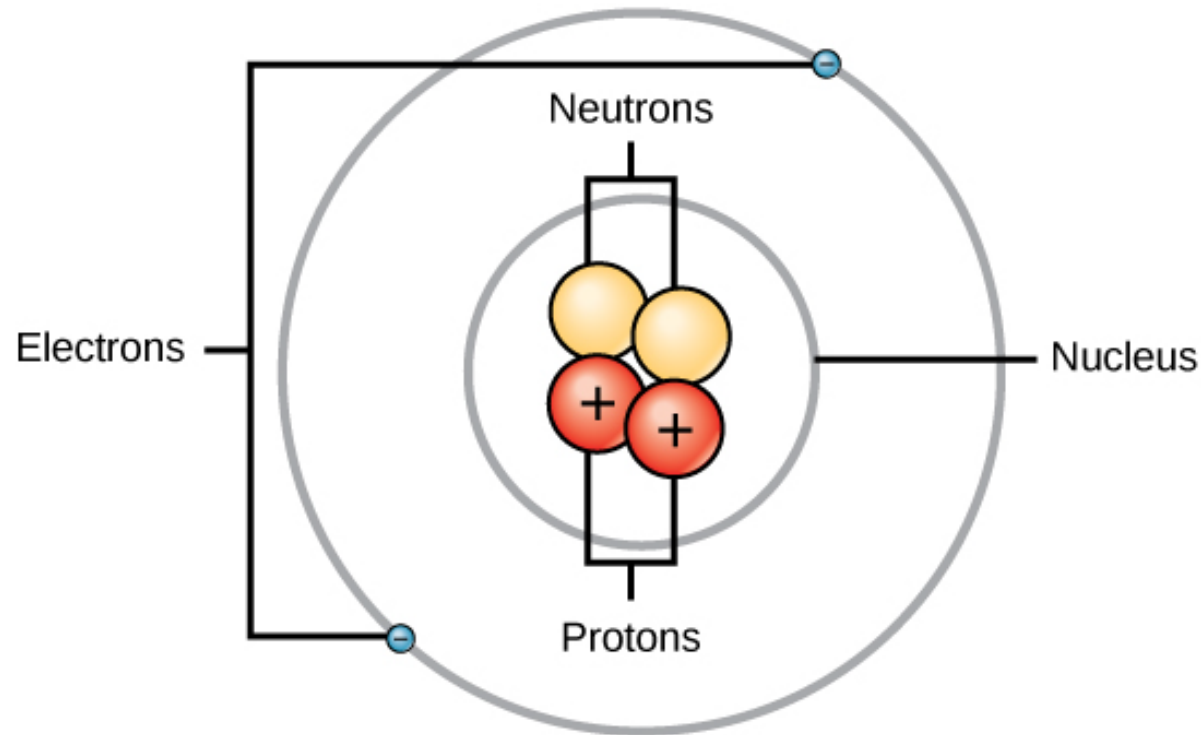
FIGURE 2.1



Atoms are the building blocks of molecules found in the universe—air, soil, water, rocks . . . and also the cells of all living organisms. In this model of an organic molecule, the atoms of carbon (black), hydrogen (white), nitrogen (blue), oxygen (red), and phosphorus (yellow) are shown in proportional atomic size. The silver rods indicate chemical bonds.

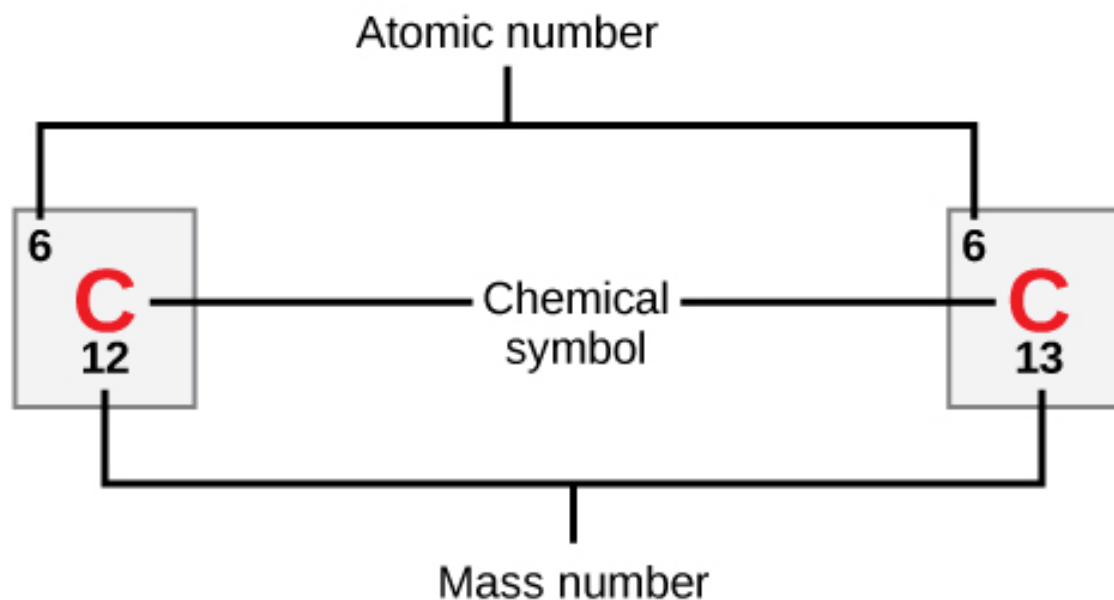
(credit: modification of work by Christian Guthier)

FIGURE 2.2



Elements, such as helium, depicted here, are made up of atoms. Atoms are made up of protons and neutrons located within the nucleus, with electrons in orbitals surrounding the nucleus.

FIGURE 2.3



Carbon has an atomic number of six, and two stable isotopes with mass numbers of twelve and thirteen, respectively. Its atomic mass is 12.11.

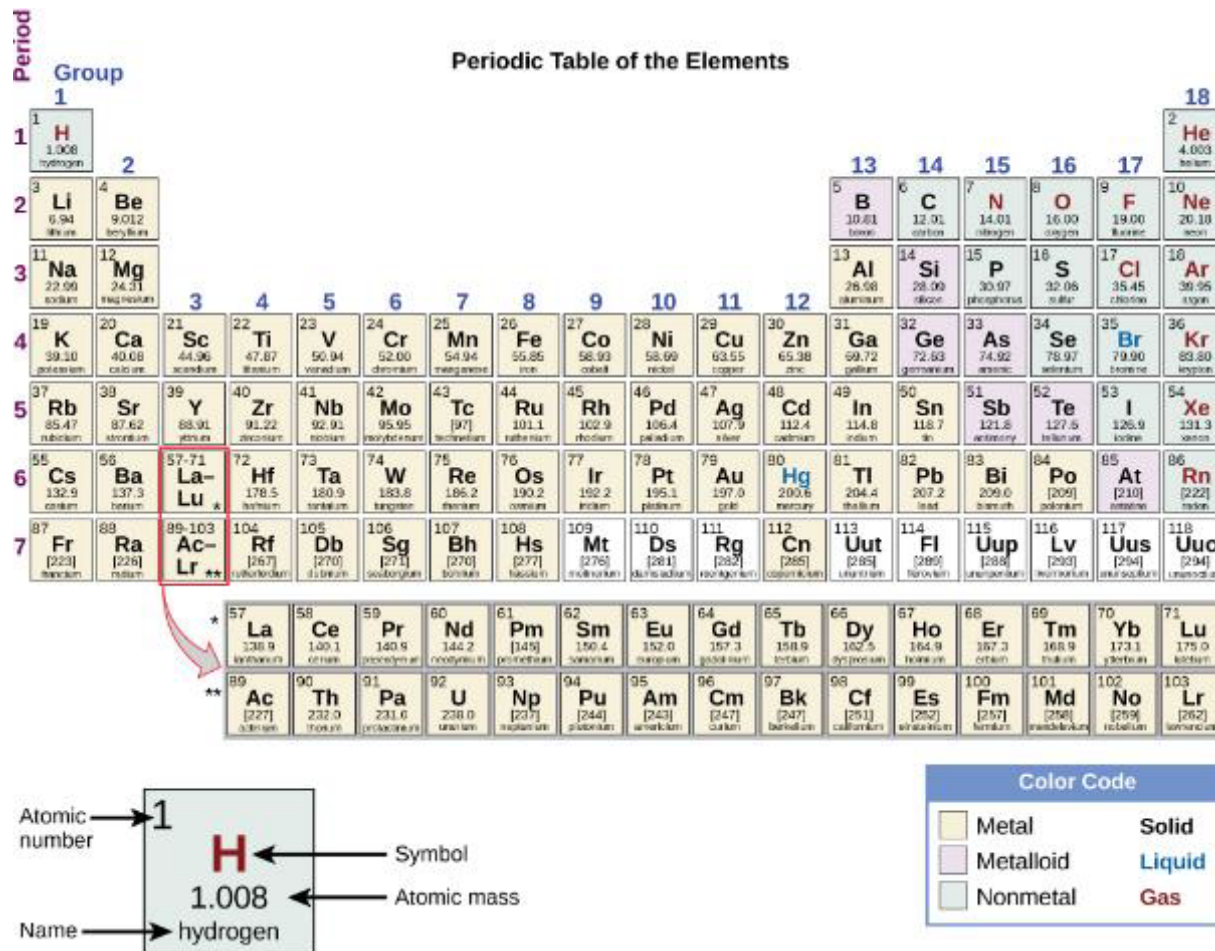
FIGURE 2.4



Scientists can determine the age of carbon-containing remains less than about 50,000 years old, such as this pygmy mammoth, using carbon dating.

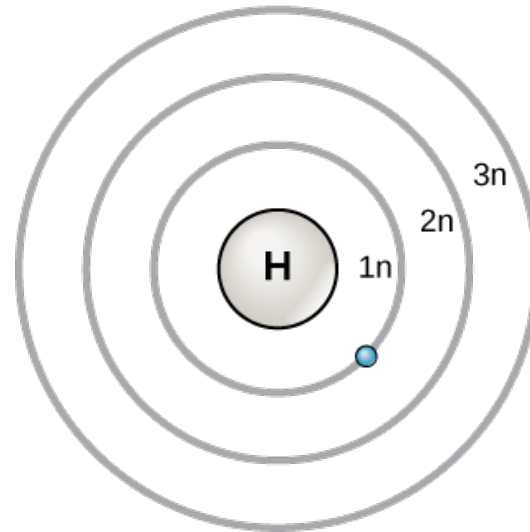
(credit: Bill Faulkner, NPS)

FIGURE 2.5



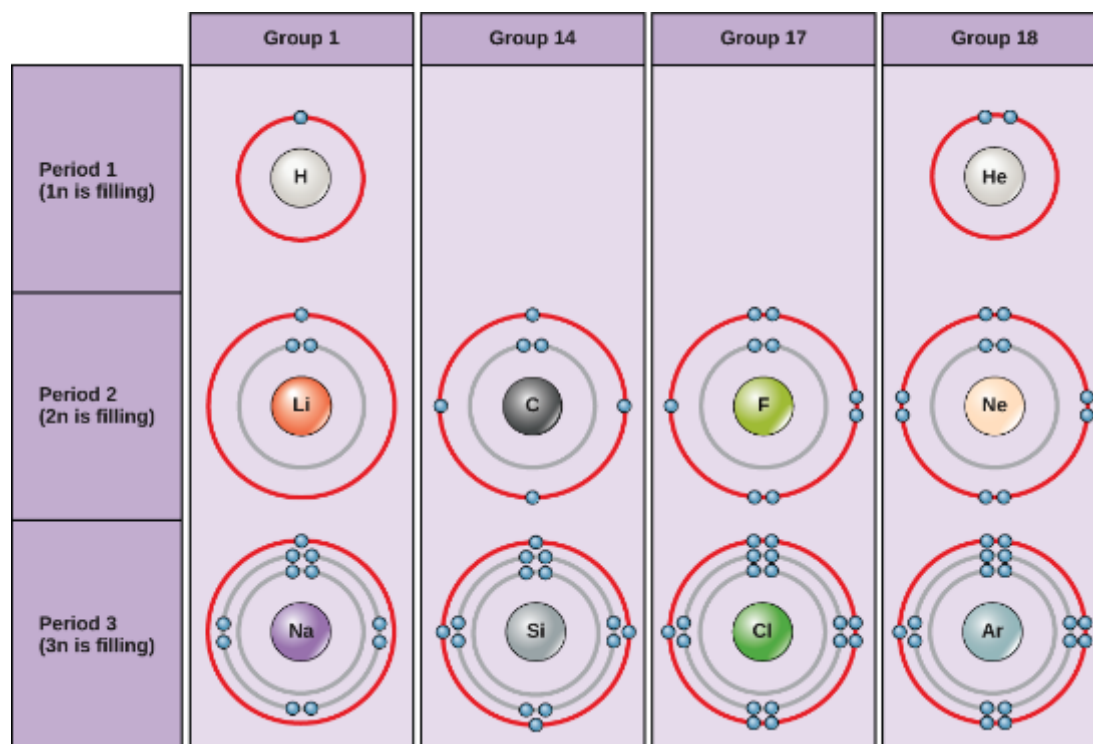
The periodic table shows each element's atomic mass and atomic number. The atomic number appears above the symbol for the element and the approximate atomic mass appears below it.

FIGURE 2.6



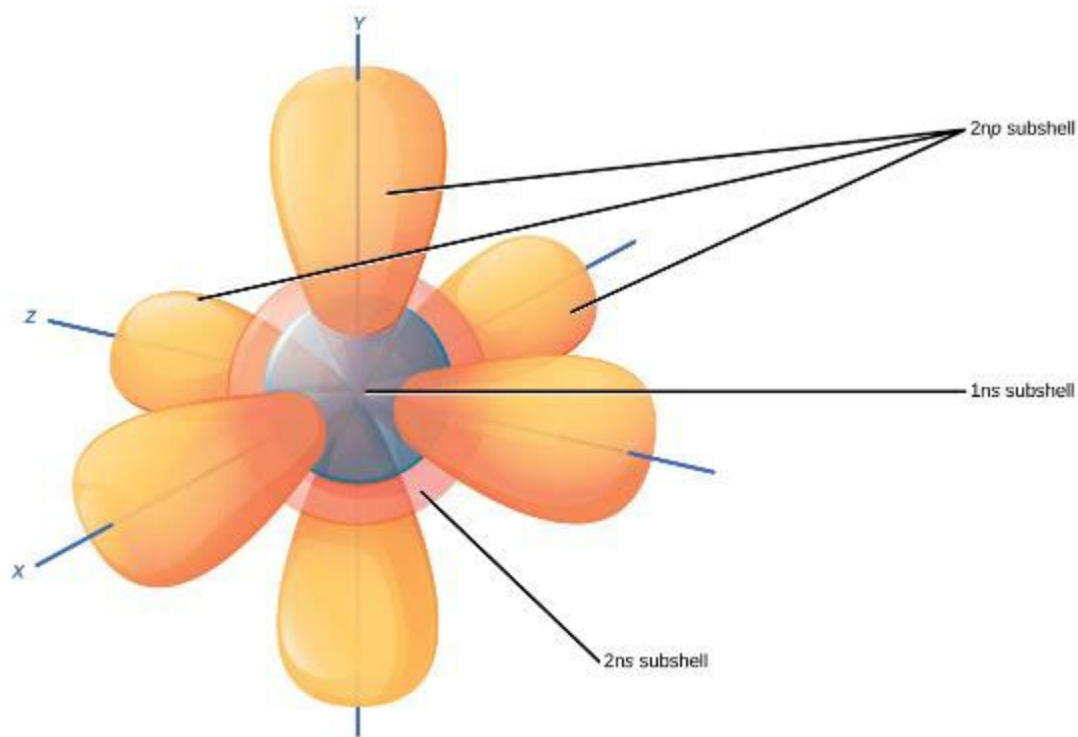
In 1913, Niels Bohrs developed the Bohr model in which electrons exist within principal shells. An electron normally exists in the lowest energy shell available, which is the one closest to the nucleus. Energy from a photon of light can bump it up to a higher energy shell, but this situation is unstable, and the electron quickly decays back to the ground state. In the process, it releases a photon of light.

FIGURE 2.7



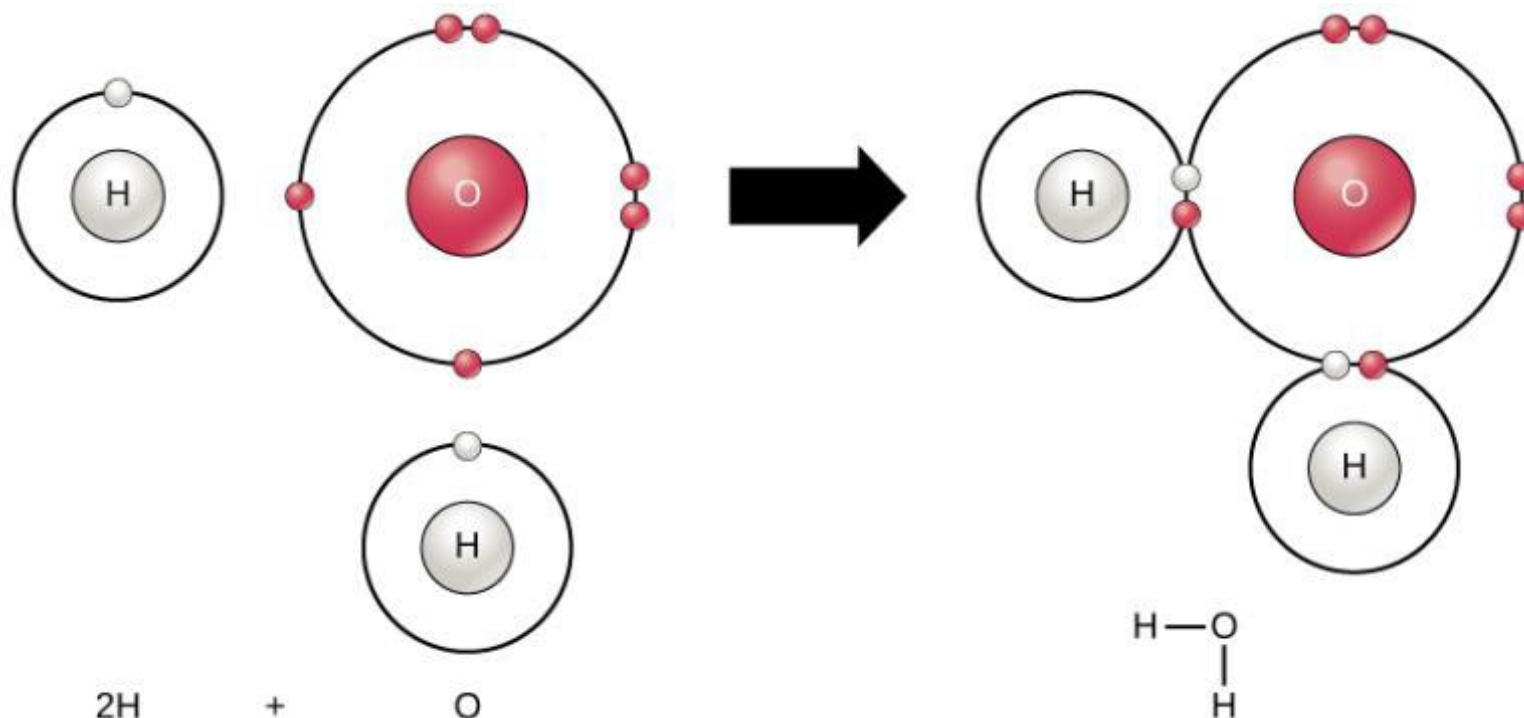
Bohr diagrams indicate how many electrons fill each principal shell. Group 18 elements (helium, neon, and argon are shown) have a full outer, or valence, shell. A full valence shell is the most stable electron configuration. Elements in other groups have partially filled valence shells and gain or lose electrons to achieve a stable electron configuration.

FIGURE 2.8



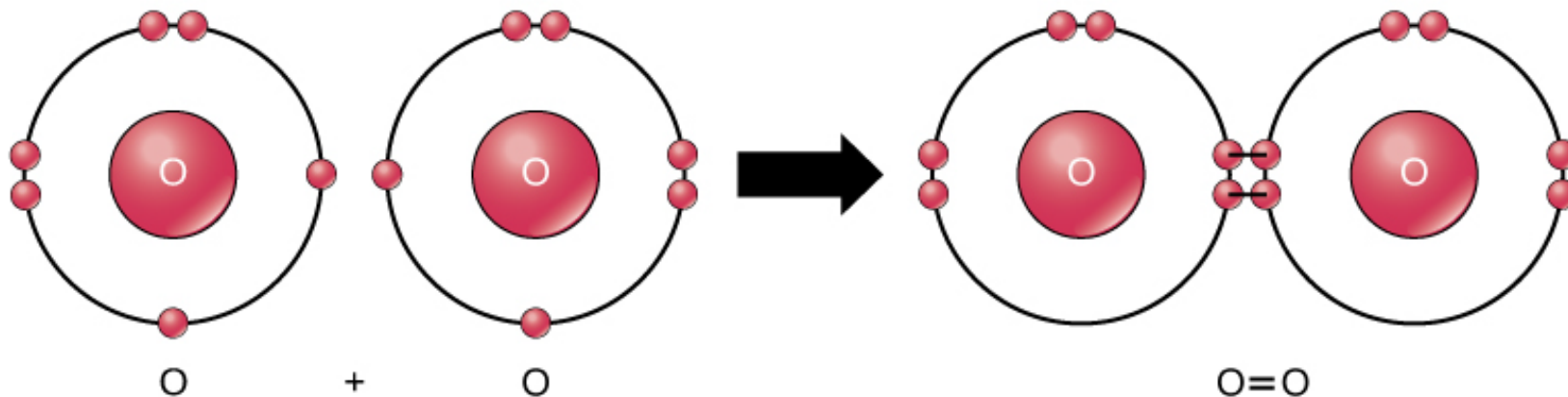
The *s* subshells are shaped like spheres. Both the $1n$ and $2n$ principal shells have an *s* orbital, but the size of the sphere is larger in the $2n$ orbital. Each sphere is a single orbital. *p* subshells are made up of three dumbbell-shaped orbitals. Principal shell $2n$ has a *p* subshell, but shell 1 does not.

FIGURE 2.9



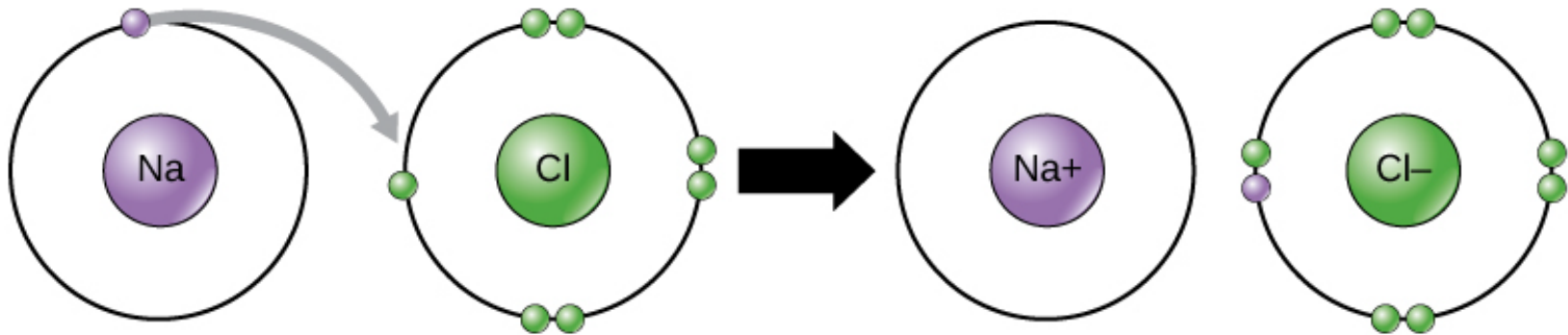
Two or more atoms may bond with each other to form a molecule. When two hydrogens and an oxygen share electrons via covalent bonds, a water molecule is formed.

FIGURE 2.10



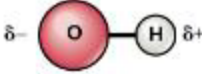
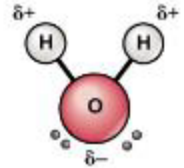

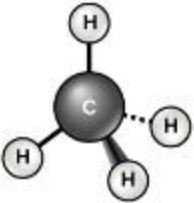
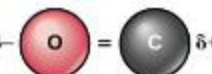

A double bond joins the oxygen atoms in an O₂ molecule.

FIGURE 2.11



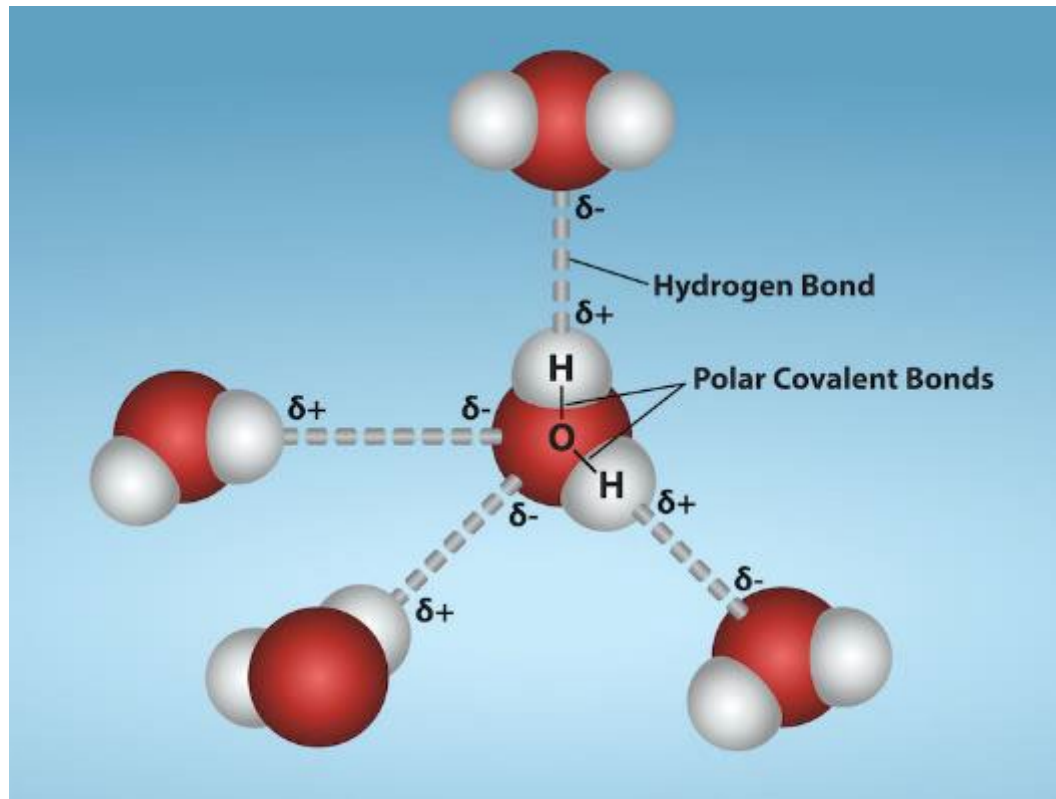
In the formation of an ionic compound, metals lose electrons and nonmetals gain electrons to achieve an octet.

FIGURE 2.12

	Bond type	Molecular shape	Molecular type
Water	 Polar covalent	 Bent	Polar
Methane	 Nonpolar covalent	 Tetrahedral	Nonpolar
Carbon dioxide	 Polar covalent	 Linear	Nonpolar

Whether a molecule is polar or nonpolar depends both on bond type and molecular shape. Both water and carbon dioxide have polar covalent bonds, but carbon dioxide is linear, so the partial charges on the molecule cancel each other out.

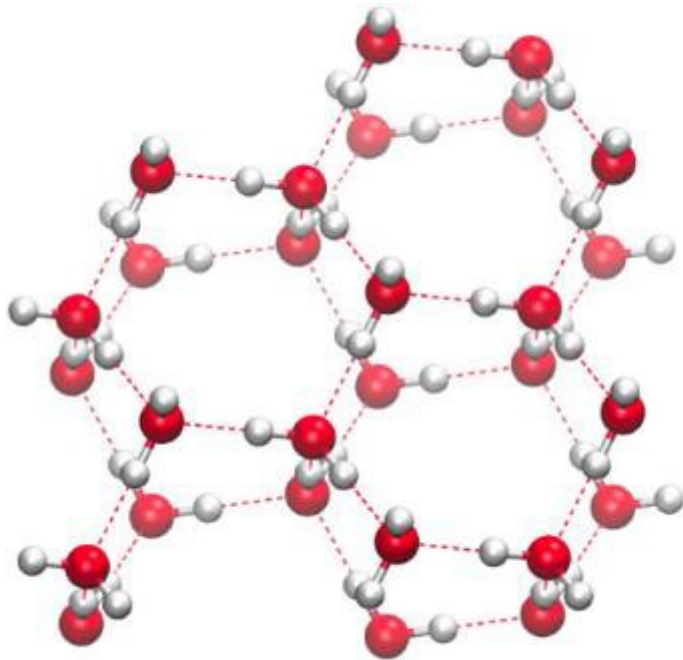
FIGURE 2.13



The polarity of water. The polarity of water is due to the differing electronegativities of hydrogen and oxygen. As a consequence, hydrogen bonds are formed when the slightly negative oxygen on one water molecule is attracted to the slightly positive hydrogen of another water molecule.

(credit: Rao, A., Fletcher, S., Ryan, K., Tag, A. and Hawkins, A. Department of Biology, Texas A&M University)

FIGURE 2.14



(a)

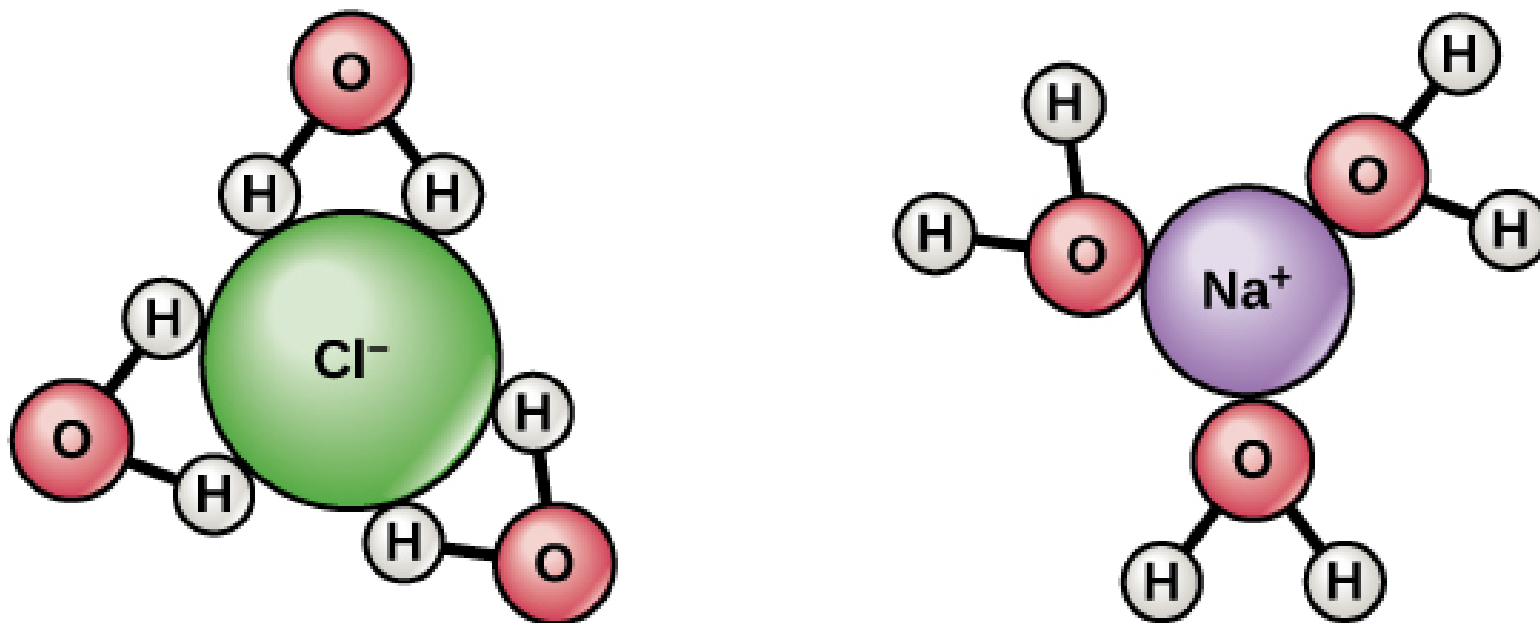


(b)

Hydrogen bonding makes ice less dense than liquid water. The (a) lattice structure of ice makes it less dense than the freely flowing molecules of liquid water, enabling it to (b) float on water.

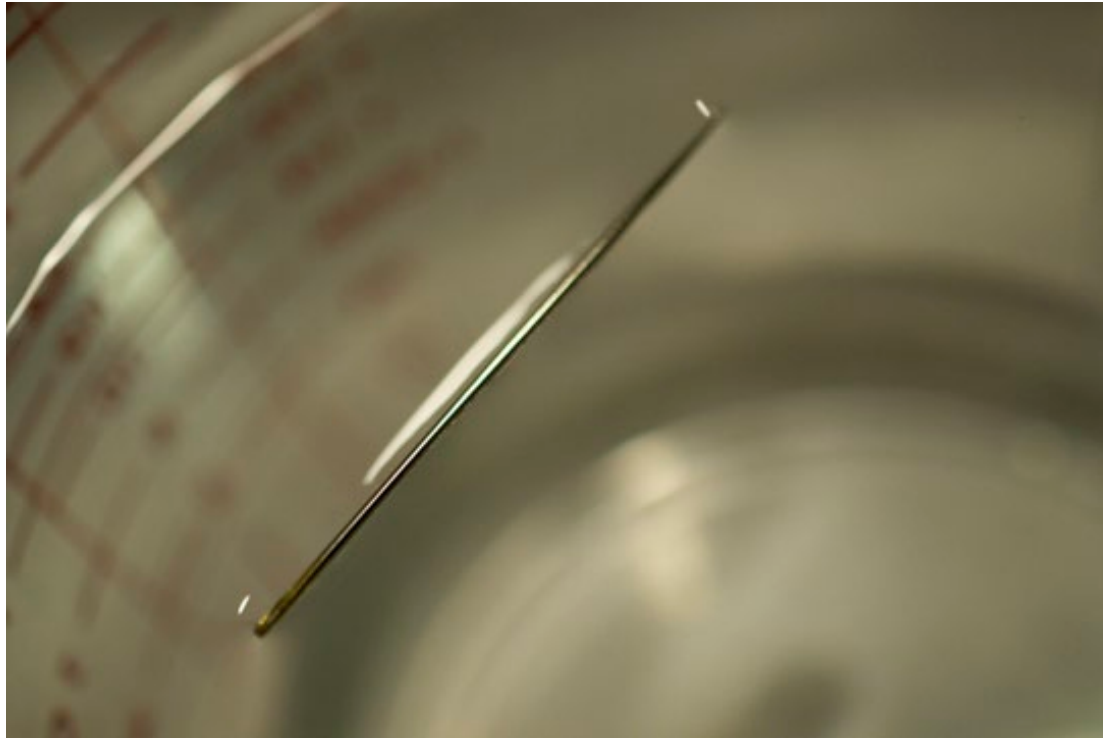
(credit a: modification of work by Jane Whitney, image created using Visual Molecular Dynamics (VMD) software [1]; credit b: modification of work by Carlos Ponte)

FIGURE 2.15



When we mix table salt (NaCl) in water, it forms spheres of hydration around the ions.

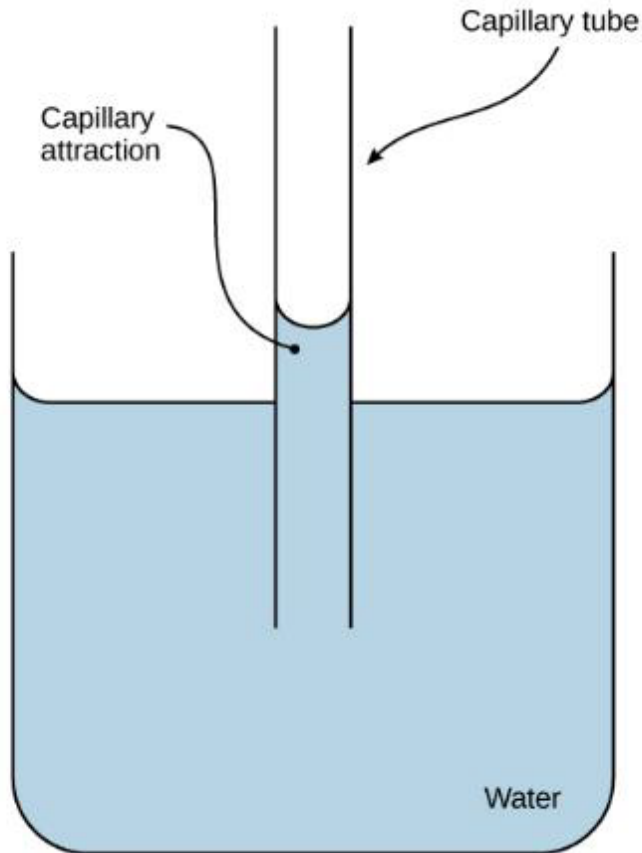
FIGURE 2.16



A needle's weight pulls the surface downward. At the same time, the surface tension pulls it up, suspending it on the water's surface preventing it from sinking. Notice the indentation in the water around the needle.

(credit: Cory Zanker)

FIGURE 2.17



The adhesive forces exerted by the glass' internal surface exceeding the cohesive forces between the water molecules themselves causes capillary action in a glass tube.

(credit: modification of work by Pearson-Scott Foresman, donated to the Wikimedia Foundation)

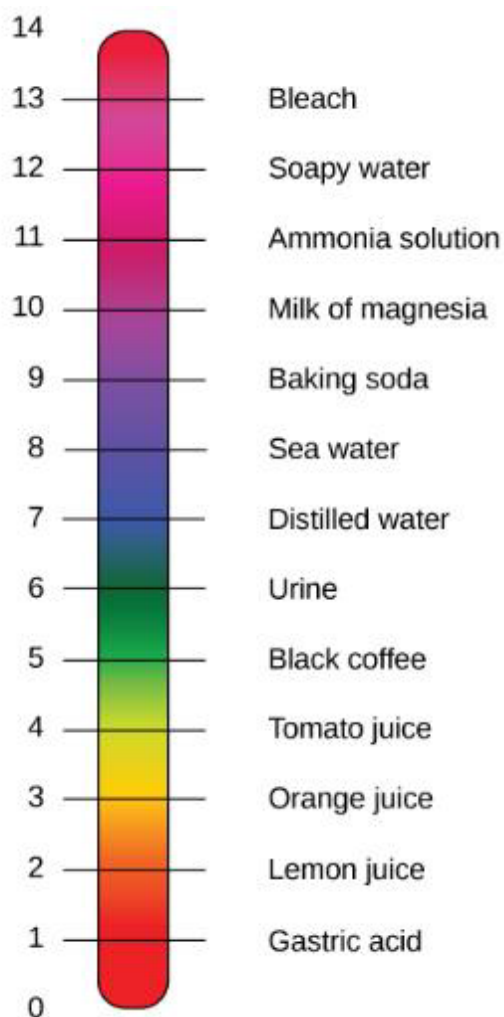
FIGURE 2.18



Water's cohesive and adhesive properties allow this water strider (*Gerris* sp.) to stay afloat.

(credit: Tim Vickers)

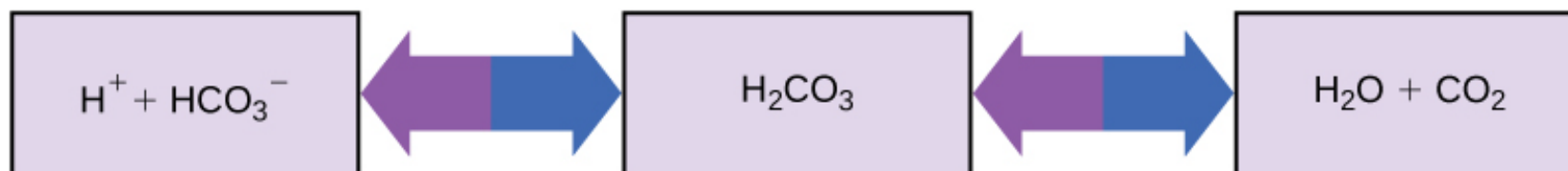
FIGURE 2.19



The pH scale measures the concentration of hydrogen ions (H^+) in a solution.

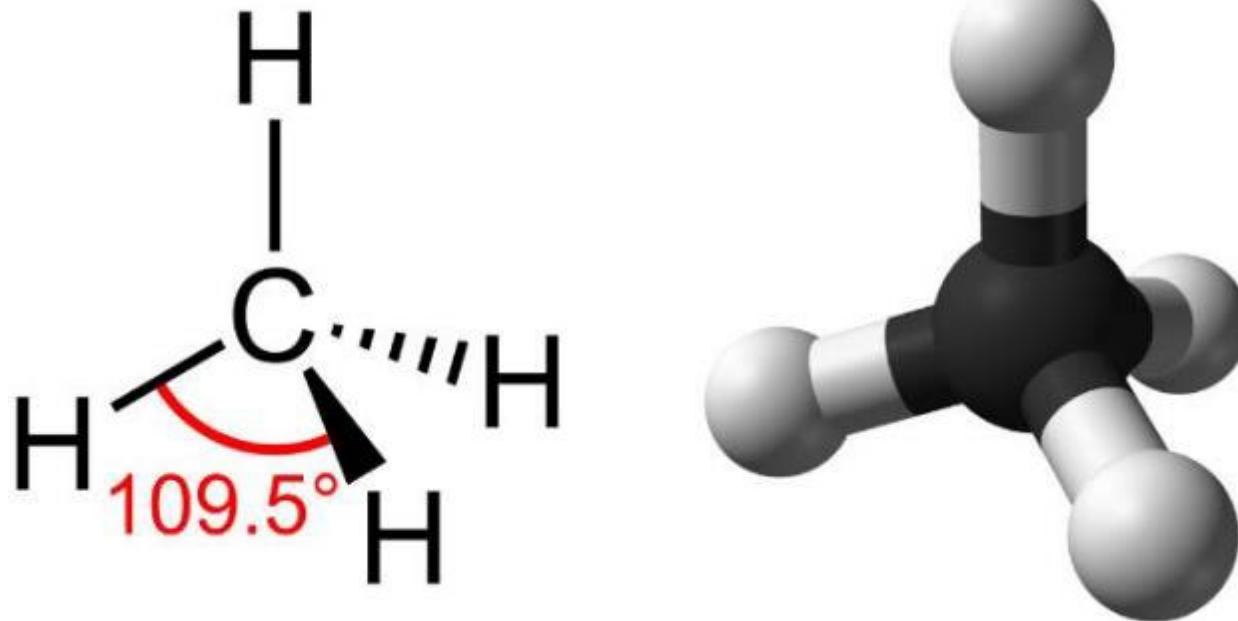
(credit: modification of work by Edward Stevens)

FIGURE 2.20



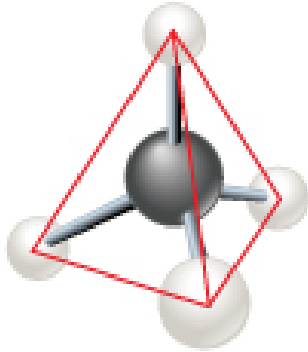
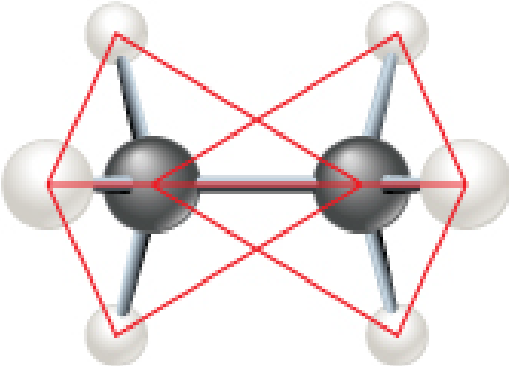
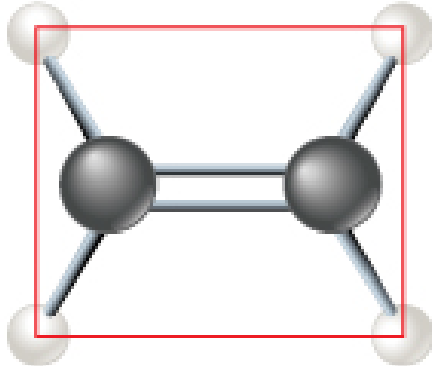
This diagram shows the body's buffering of blood pH levels. The blue arrows show the process of raising pH as more CO_2 is made. The purple arrows indicate the reverse process: the lowering of pH as more bicarbonate is created.

FIGURE 2.21



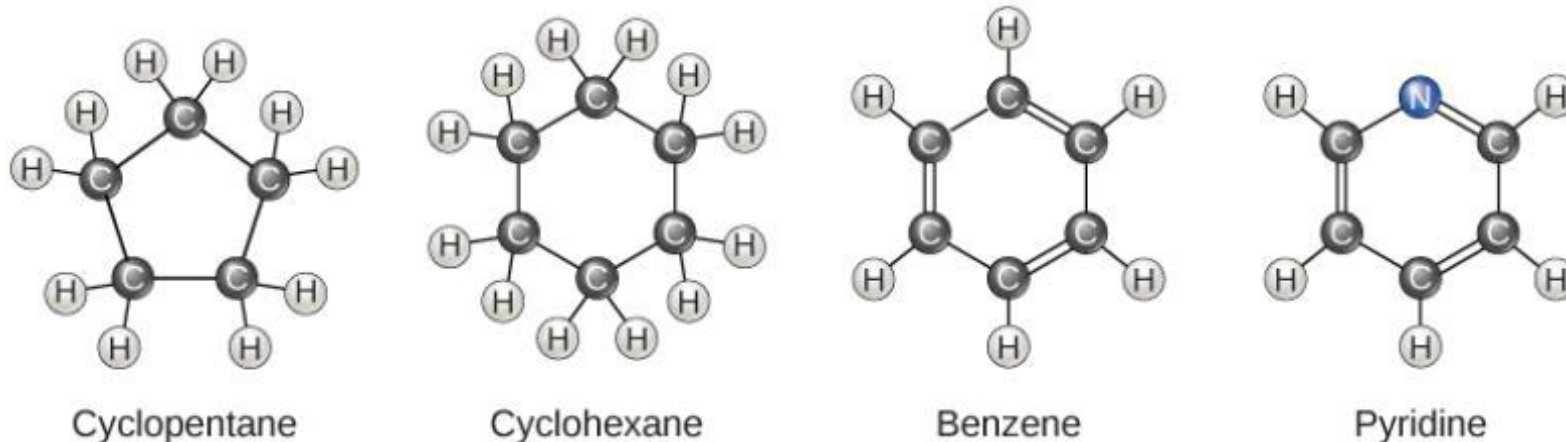
Methane has a tetrahedral geometry, with each of the four hydrogen atoms spaced 109.5° apart.

FIGURE 2.22

Methane (CH ₄)	Ethane (C ₂ H ₆)	Ethene (C ₂ H ₄)
 <p data-bbox="239 782 575 905">Tetrahedral (single bond)</p>	 <p data-bbox="795 782 1132 905">Tetrahedral (single bond)</p>	 <p data-bbox="1340 782 1696 905">Planar (double bond)</p>

When carbon forms single bonds with other atoms, the shape is tetrahedral. When two carbon atoms form a double bond, the shape is planar, or flat. Single bonds, like those found in ethane, are able to rotate. Double bonds, like those found in ethene cannot rotate, so the atoms on either side are locked in place.

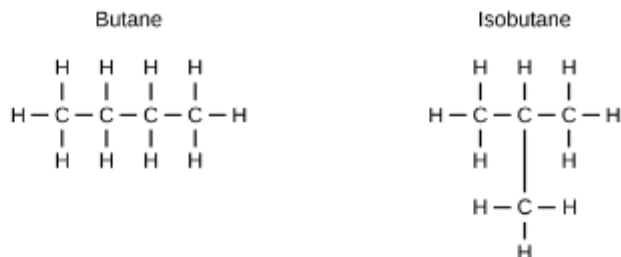
FIGURE 2.23



Carbon can form five- and six-membered rings. Single or double bonds may connect the carbons in the ring, and nitrogen may be substituted for carbon.

FIGURE 2.24

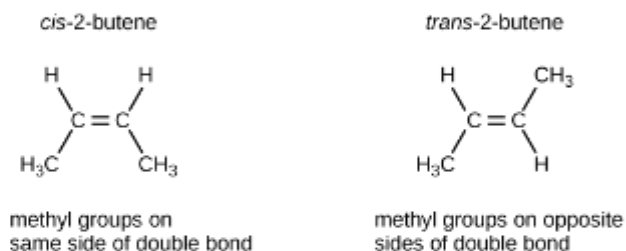
(a) Structural isomers



We call molecules that have the same number and type of atoms arranged differently isomers.

(a) Structural isomers have a different covalent arrangement of atoms.

(b) Geometric isomers



(b) Geometric isomers have a different arrangement of atoms around a double bond.

(c) Enantiomers are mirror images of each other.

(c) Enantiomers

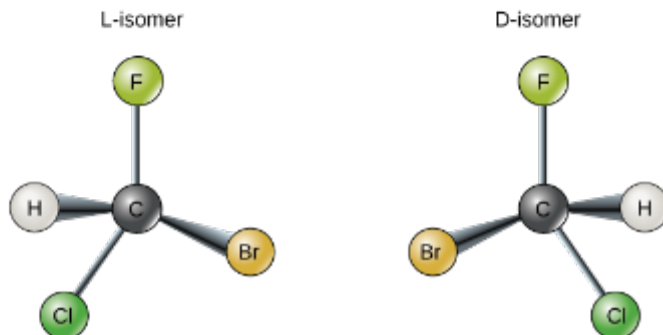
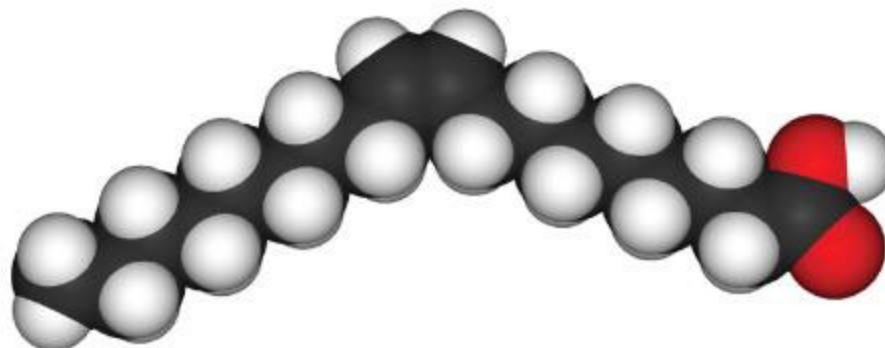


FIGURE 2.25



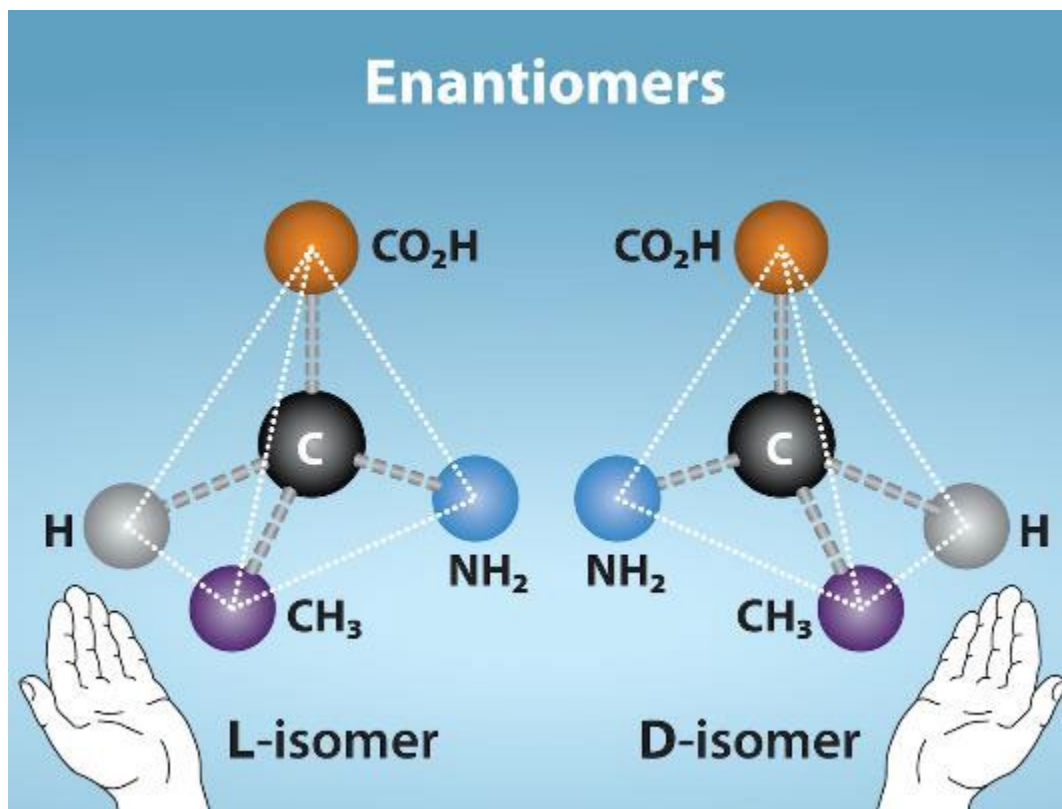
Eliadic acid



Oleic acid

These space-filling models show a *cis* (oleic acid) and a *trans* (eliadic acid) fatty acid. Notice the bend in the molecule cause by the *cis* configuration.

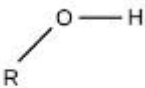
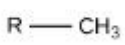
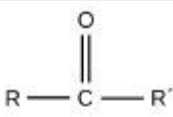
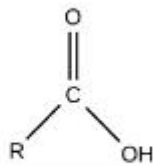
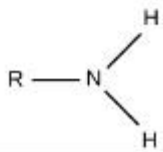
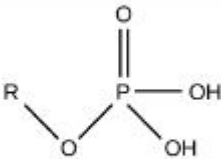
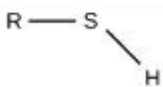
FIGURE 2.26



Enantiomers are molecules that are mirror images of each other and are non-superimposable. The L/D naming system is from the Latin words for left and right: laevus and dexter, respectively. This example shows the L and D isomers of the amino acid alanine.

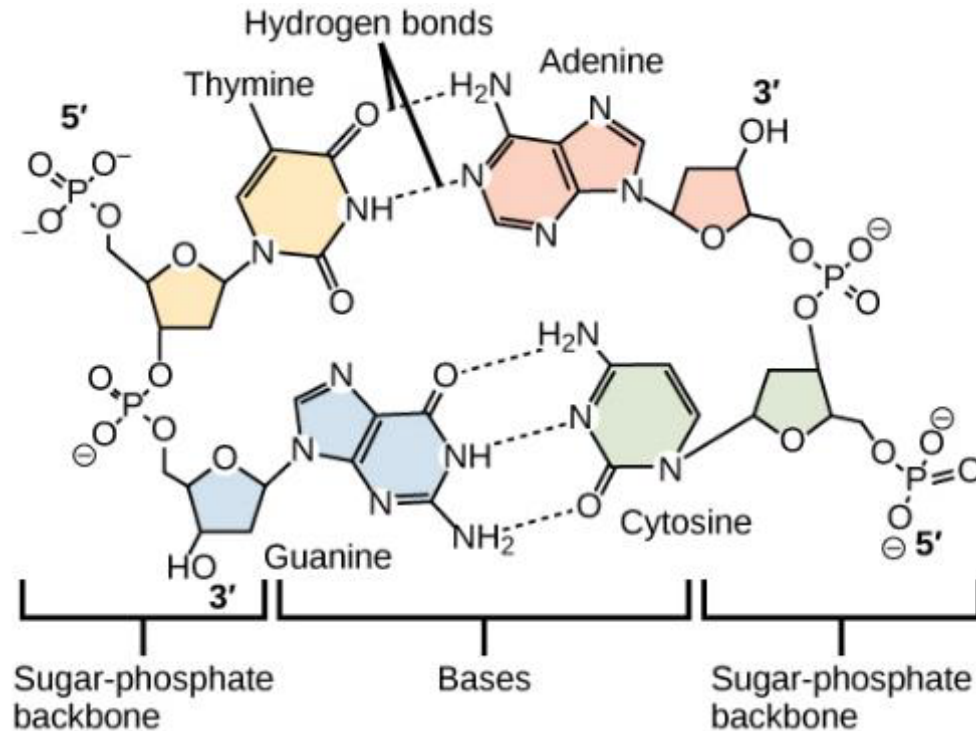
(credit: Rao, A., Hawkins, A., Fletcher, S. and Ryan K. Department of Biology, Texas A&M University)

FIGURE 2.27

Functional Group	Structure	Properties
Hydroxyl		Polar
Methyl		Nonpolar
Carbonyl		Polar
Carboxyl		Charged, ionizes to release H ⁺ . Since carboxyl groups can release H ⁺ ions into solution, they are considered acidic.
Amino		Charged, accepts H ⁺ to form NH ₃ ⁺ . Since amino groups can remove H ⁺ from solution, they are considered basic.
Phosphate		Charged, ionizes to release H ⁺ . Since phosphate groups can release H ⁺ ions into solution, they are considered acidic.
Sulfhydryl		Polar

These functional groups are in many different biological molecules. R, also known as R-group, is an abbreviation for any group in which a carbon or hydrogen atom is attached to the rest of the molecule.

FIGURE 2.28



Hydrogen bonds connect two strands of DNA together to create the double-helix structure.