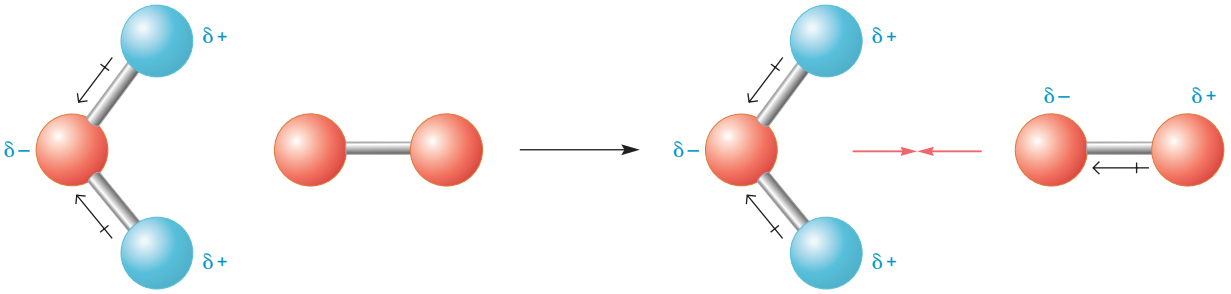


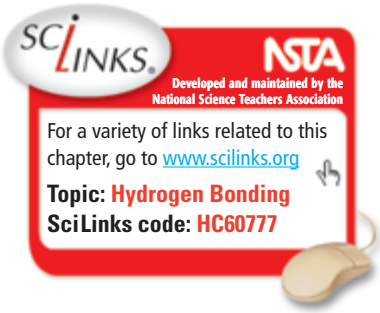
FIGURE 27 Dipole-induced dipole interaction. The positive pole of a water molecule causes a temporary change in the electron distribution of an oxygen molecule. The negative pole induced in the oxygen molecule is then attracted to the positive pole of the water molecule.

of an adjacent oxygen molecule. The oxygen molecule, then, has an induced negative pole on the side toward the water molecule and an induced positive pole on the opposite side. The result is an attraction to the water molecule, as shown in **Figure 27.**

Hydrogen Bonding

Some hydrogen-containing compounds, such as hydrogen fluoride (HF), water (H_2O), and ammonia (NH_3), have unusually high boiling points. This is explained by the presence of a particularly strong type of dipole-dipole force. In compounds containing H—F, H—O, or H—N bonds, the large electronegativity differences between hydrogen atoms and fluorine, oxygen, or nitrogen atoms make the bonds connecting them highly polar. This gives the hydrogen atom a positive charge that is almost half as large as that of a proton. Moreover, the small size of the hydrogen atom allows the atom to come very close to an unshared pair of electrons on an adjacent molecule. *The intermolecular force in which a hydrogen atom that is bonded to a highly electronegative atom is attracted to an unshared pair of electrons of an electronegative atom in a nearby molecule is known as* **hydrogen bonding.**

Hydrogen bonds are usually represented by dotted lines connecting the hydrogen-bonded hydrogen to the unshared electron pair of the electronegative atom to which it is attracted, as illustrated for water in **Figure 28.** The effect of hydrogen bonding can be seen by comparing the boiling points in **Table 7.** Look at phosphine, PH_3, compared with hydrogen-bonded ammonia, NH_3. How does hydrogen sulfide, H_2S, compare with hydrogen-bonded water, H_2O?



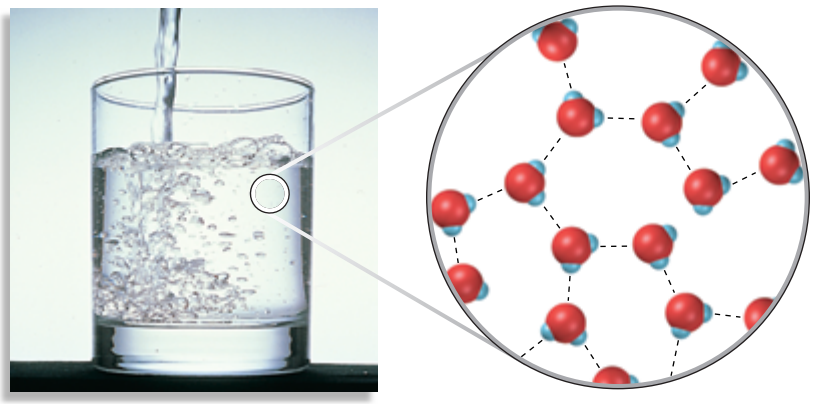


FIGURE 28 Space-filling models illustrate hydrogen bonding between water molecules. The dotted lines indicate the attraction between electronegative oxygen atoms and electropositive hydrogen atoms of neighboring molecules.