Another example of a nonpolar covalent bond is methane (CH_4) (Figure 2.17). Carbon has four electrons in its outermost shell and needs four more to fill it. With methane, (CH_4), it obtains these four electrons from four hydrogen atoms. Each hydrogen atom shares one electron, making a stable outer shell. Hydrogen also now has a full outer shell because it only needs to acquire one additional electron to fill its valence shell. Carbon and hydrogen do not have the same electronegativity but are similar enough that the bonds that form are nonpolar. **Electronegativity** can be thought of as an atom's ability to attract a shared pair of electrons more closely to its own nucleus. If two atoms have the same or similar electronegativities then they will share the pair of electrons equally and partial charges on the atoms participating in the bond will not occur or will be minimal. In the case of methane (CH_4), because the electronegativity of hydrogen and carbon are similar, they share the electrons in a way that creates a nonpolar covalent bond.

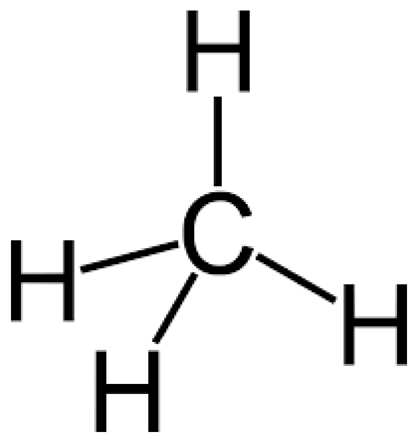

Figure 2.17 A molecule of methane is held together with nonpolar covalent bonds. (credit: Benjah-bmm27/Public Domain)

In a **polar covalent bond**, the shared pair of electrons spend more time closer to one atom's nucleus than to the other atom's nucleus. Because of the unequal distribution of electrons between the different nuclei, a slightly positive (δ+) or slightly negative (δ–) charge develops. The bonds between hydrogen and oxygen atoms in water are polar covalent bonds (Figure 2.18). The shared electrons spend more time near the oxygen nucleus than they spend near the hydrogen nuclei. This results in the oxygen atom having a small negative charge, and the hydrogen atoms having a small positive charge.

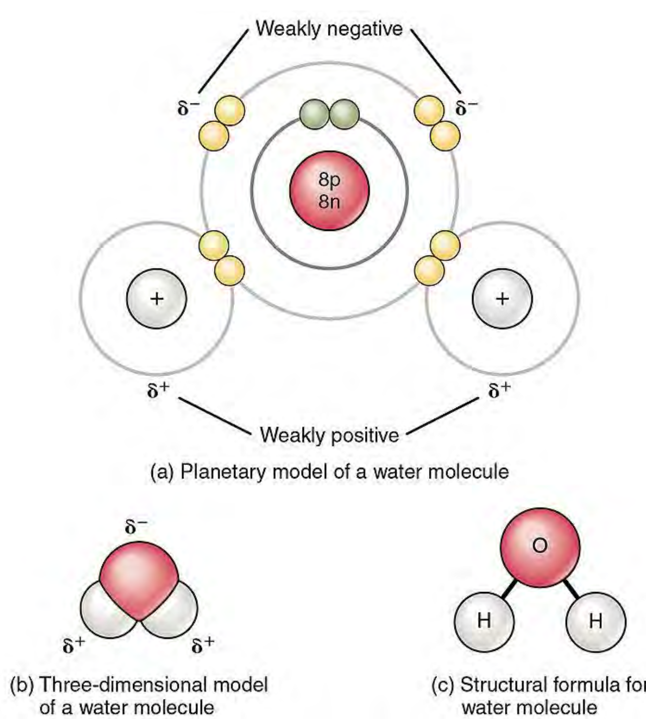

Figure 2.18 Polar Covalent Bonds in a Water Molecule (credit: Betts et al./Anatomy and Physiology OpenStax)

The hydrogen atoms' partial positive charge and the oxygen atom's partial negative charge can be explained by looking at the different electronegativities of these two atoms. The nucleus of an oxygen atom is more attractive to the shared pair of electrons than the hydrogen's nucleus. Thus, oxygen has a higher **electronegativity** than hydrogen and the shared electrons spend more time near the oxygen nucleus than the hydrogen atoms' nucleus (Figure 2.18).

The atom's relative electronegativity contributes to developing partial charges whenever one atom is significantly more electronegative than the other (Figure 2.19). The charges that these polar bonds generate may then be used to form hydrogen bonds. Hydrogen bonds are weak bonds between slightly positively charged hydrogen atoms to slightly negatively charged atoms in other molecules.

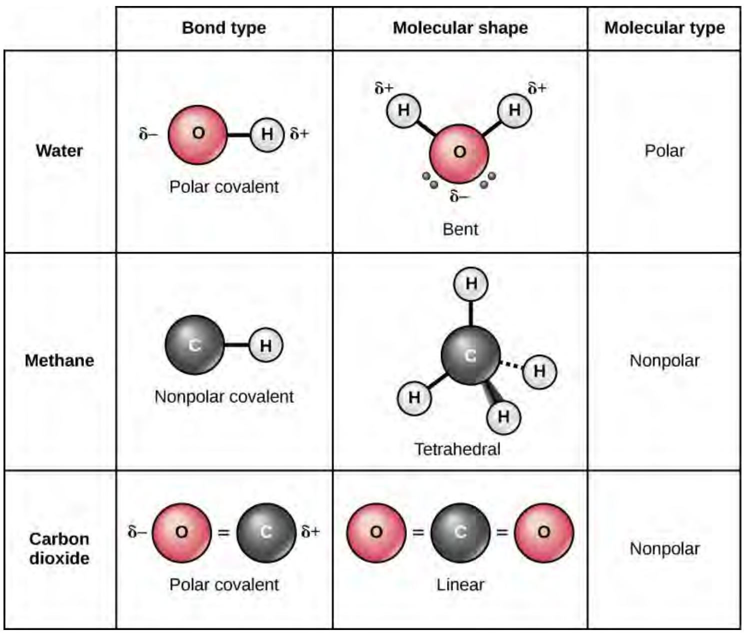

Figure 2.19 Whether a molecule is polar or nonpolar depends both on bond type and molecular shape. (credit: Clark et al./Biology 2E OpenStax)

Hydrogen Bonds

Ionic and covalent bonds are strong bonds. As a result, they require large amounts of energy to break. However, not all bonds between elements are ionic or covalent. Weaker bonds can also form. These bonds occur between positive and negative charges that do not require much energy to break. **Hydrogen bonds** are weak bonds but are important because they allow three-dimensional molecules to fold into their appropriate shapes and contribute to the unique properties of water (Figure 2.20).

When polar covalent bonds containing a hydrogen atom form, the hydrogen atom in the bond has a slightly positive charge. Because the hydrogen atom is slightly positive (δ+), it will be attracted to neighboring negative partial charges (δ–). When this happens, a weak interaction occurs between the δ+ charge of the hydrogen atom of one molecule and the δ– charge of the other molecule. This interaction is called a hydrogen bond (Figure 2.20). For example, the liquid nature of water is caused by the hydrogen bonds between water molecules. Hydrogen bonds give water the unique properties that sustain life. If it were not for hydrogen bonding, water would be a gas rather than a liquid at room temperature.

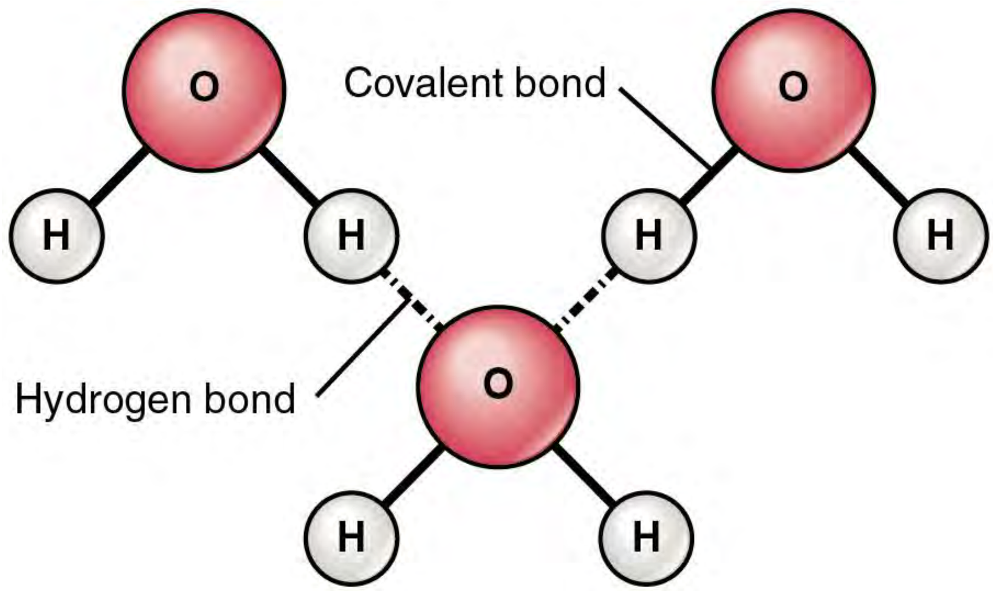

Figure 2.20 Hydrogen bonds form between slightly positive (δ+) and slightly negative (δ–) charges of polar covalent molecules, such as water. (credit: Betts et al. / Anatomy and Physiology)

Hydrogen bonds form between many different molecules not just water. For example, hydrogen bonds hold together two long strands of DNA to give the DNA molecule its characteristic double-stranded structure (Figure 2.21). Hydrogen bonds also cause some proteins to fold into their three-dimensional shapes.

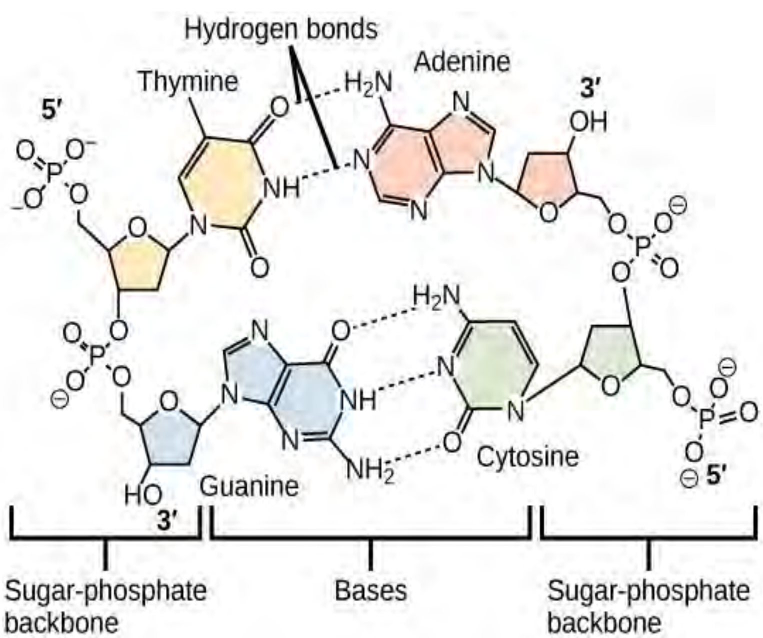

Figure 2.21 Hydrogen bonds connect two strands of DNA to create the double-helix structure. (credit: Clark et al./ Biology 2E OpenStax)