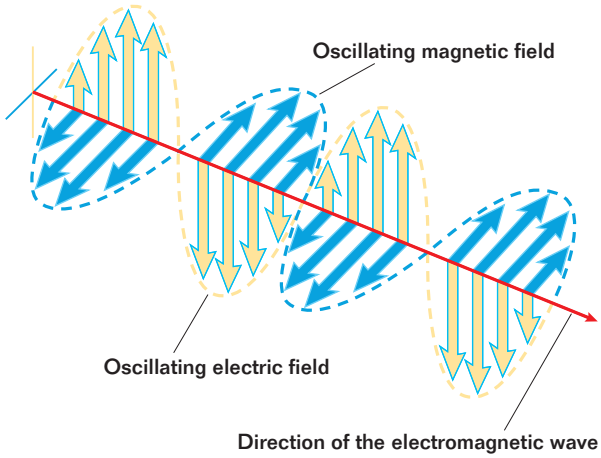

Figure 20
An electromagnetic wave consists of electric and magnetic field waves at right angles to each other. The wave moves in the direction perpendicular to both oscillating waves.

Maxwell predicted that light was electromagnetic in nature. The scientific community did not immediately accept Maxwell's equations. However, in 1887, a German physicist named Heinrich Hertz generated and detected electromagnetic waves in his laboratory. Hertz's experimental confirmation of Maxwell's work convinced the scientific community to accept the work.

Electromagnetic waves are simply oscillating electric and magnetic fields. The electric and magnetic fields are at right angles to each other and also at right angles to the direction that the wave is moving. **Figure 20** is a simple illustration of an electromagnetic wave at a single point in time. The electric field oscillates back and forth in one plane while the magnetic field oscillates back and forth in a perpendicular plane. The wave travels in the direction that is perpendicular to both of the oscillating fields. In the chapter on vibrations and waves you learned that this kind of wave is called a *transverse wave.*

Electric and magnetic forces are aspects of a single force

Although magnetism and electricity seem like very different things, we know that both electric and magnetic fields can produce forces on charged particles. These forces are aspects of one and the same force, called the *electromagnetic force.* Physicists have identified four *fundamental forces* in the universe: the strong force, which holds together the nucleus of an atom; the electromagnetic force, which is discussed here; the weak force, which is involved in nuclear decay; and the gravitational force, discussed in the chapter "Circular Motion and Gravitation". In the 1970s, physicists came to regard the electromagnetic and the weak force as two aspects of a single *electroweak interaction.*

The electromagnetic force obeys the *inverse-square law.* The force's magnitude decreases as one over the distance from the source squared. The inverse-square law applies to phenomena—such as gravity, light, and sound—that spread their influence equally in all directions and with an infinite range.

All electromagnetic waves are produced by accelerating charges

The simplest radiation source is an oscillating charged particle. Consider a negatively charged particle (electron) moving back and forth beside a fixed positive charge (proton). Recall that the changing electric field induces a magnetic field perpendicular to the electric field. In this way, the wave *propagates* itself as each changing field induces the other.

The frequency of oscillation determines the frequency of the wave that is produced. In an antenna, two metal rods are connected to an alternating voltage source that is changed from positive to negative voltage at the desired frequency. The wavelength λ of the wave is related to the frequency f by the equation $\lambda = c/f$, in which c is the speed of light.