SECTION 1

Sound Waves

SECTION OBJECTIVES

- **Explain how sound waves are produced.**
- **Relate frequency to pitch.**
- **Compare the speed of sound in various media.**
- **Relate plane waves to spherical waves.**
- **Recognize the Doppler effect, and determine the direction of a frequency shift when there is relative motion between a source and an observer.**

THE PRODUCTION OF SOUND WAVES

Whether a sound wave conveys the shrill whine of a jet engine or the melodic whistling of a bird, it begins with a vibrating object. We will explore how sound waves are produced by considering a vibrating tuning fork, as shown in **Figure 1(a).**

The vibrating prong of a tuning fork, shown in **Figure 1(b),** sets the air molecules near it in motion. As the prong swings to the right, as in **Figure 1(c),** the air molecules in front of the movement are forced closer together. (This situation is exaggerated in the figure for clarity.) Such a region of high molecular density and high air pressure is called a **compression.** As the prong moves to the left, as in **Figure 1(d),** the molecules to the right spread apart, and the density and air pressure in this region become lower than normal. This region of lower density and pressure is called a **rarefaction.**

As the tuning fork continues to vibrate, a series of compressions and rarefactions forms and spreads away from each prong. These compressions and rarefactions spread out in all directions, like ripple waves on a pond. When the tuning fork vibrates with simple harmonic motion, the air molecules also vibrate back and forth with simple harmonic motion.

compression

the region of a longitudinal wave in which the density and pressure are at a maximum

rarefaction

the region of a longitudinal wave in which the density and pressure are at a minimum

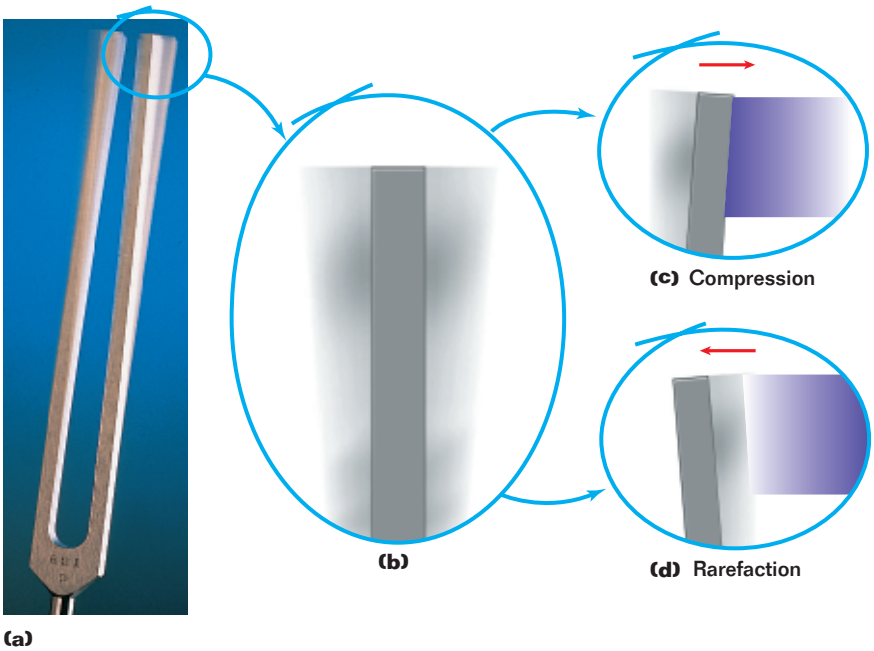

Figure 1
(a) The sound from a tuning fork is produced by **(b)** the vibrations of each of its prongs. **(c)** When a prong swings to the right, there is a region of high density and pressure. **(d)** When the prong swings back to the left, a region of lower density and pressure exists.