Why it Matters

Reverberation

Auditoriums, churches, concert halls, libraries, and music rooms are designed with specific functions in mind. One auditorium may be made for rock concerts, while another is constructed for use as a lecture hall. Your school's auditorium, for instance, may allow you to hear a speaker well but make a band sound damped and muffled.

Rooms are often constructed so that sounds made by a speaker or a musical instrument bounce back and forth against the ceiling, walls, floor, and other surfaces. This repetitive echo is called *reverberation.* The reverberation time is the amount of time it takes for a sound's intensity to decrease by 60 dB.

For speech, the auditorium should be designed so that the reverberation time is relatively short. A repeated echo of each word could become confusing to listeners.

Music halls may differ in construction depending on the type of music usually played there. For example, rock music is generally less pleasing with a large amount of reverberation, but more reverberation is sometimes desired for orchestral and choral music.

For these reasons, you may notice a difference in the way ceilings, walls, and furnishings are designed in different rooms. Ceilings designed for a lot of reverberation are flat and hard. Ceilings in

libraries and other quiet places are often made of soft or textured material to muffle sounds. Padded furnishings and plants can also be strategically arranged to absorb sound. All of these different factors are considered and combined to accommodate the auditory function of a room.

The intensity of each harmonic varies within a particular instrument, depending on frequency, amplitude of vibration, and a variety of other factors. With a violin, for example, the intensity of each harmonic depends on where the string is bowed, the speed of the bow on the string, and the force the bow exerts on the string. Because there are so many factors involved, most instruments can produce a wide variety of tones.

Even though the waveforms of a clarinet and a viola are more complex than those of a tuning fork, note that each consists of repeating patterns. Such waveforms are said to be *periodic.* These repeating patterns occur because each frequency is an integral multiple of the fundamental frequency.

Fundamental frequency determines pitch

As you saw in Section 1, the frequency of a sound determines its pitch. In musical instruments, the fundamental frequency of a vibration typically determines pitch. Other harmonics are sometimes referred to as *overtones.* In the chromatic (half-step) musical scale, there are 12 notes, each of which has a characteristic frequency. The frequency of the thirteenth note is exactly twice that of the first note, and together the 13 notes constitute an *octave.* For stringed instruments and open-ended wind instruments, the frequency of the second harmonic of a note corresponds to the frequency of the octave above that note.