Since sound is a wave-based condition, let's briefly run through "how sound is made and sound waves work," which will be our focus for the rest of this chapter:

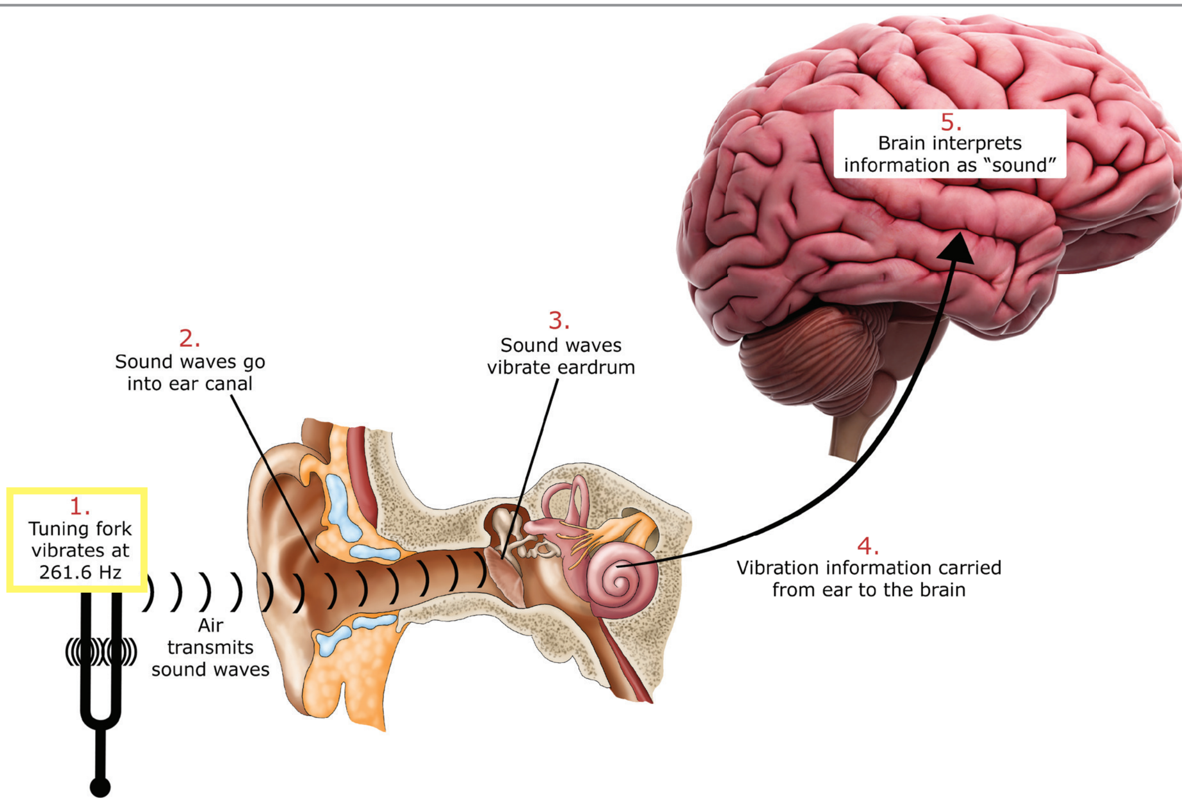
- Like all waves, sound waves need a wave-maker.
- The sound wave-maker is something that vibrates a medium.
- When the medium vibrates, it transmits (propagates) sound waves.
  - Gases, liquids and solids are all capable of transmitting sound waves.
- When the sound waves arrive at a functional hearing organ, they cause the hearing apparatus to vibrate.
- When the hearing apparatus vibrates, it causes electrical signals to be sent to the brain.
- When the brain interprets the electrical signals, it identifies the sound source, sound loudness, sound pitch, and performs other activities (like associating the sound with something, as in when your ear receives soundwaves from your mom's voice box, your brain associates those sound waves so that you know it is your mom's voice). Note that for the rest of the chapter, I will be referring to human beings, their sound reception organs (ears) and their brains, unless otherwise specified.

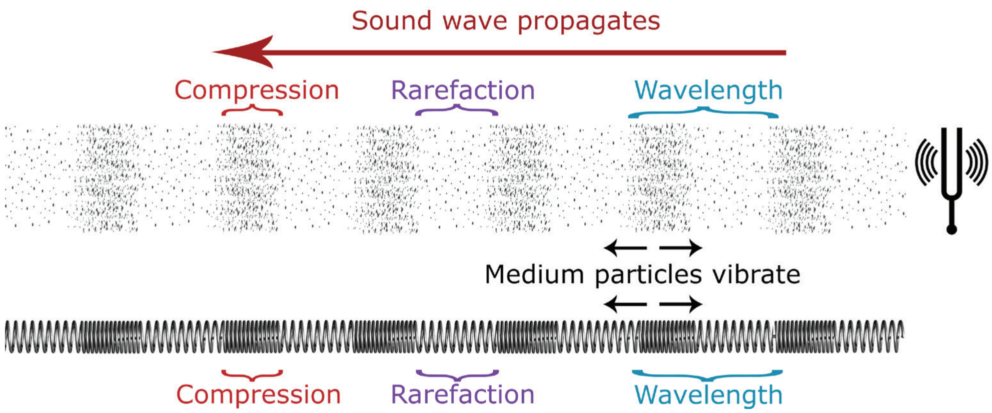
Figure 10.1.2

Brief Overview of Sound

This is just to set the stage for how we hear. The key to hearing is the same as the key to generating the initial sound wave—vibration.

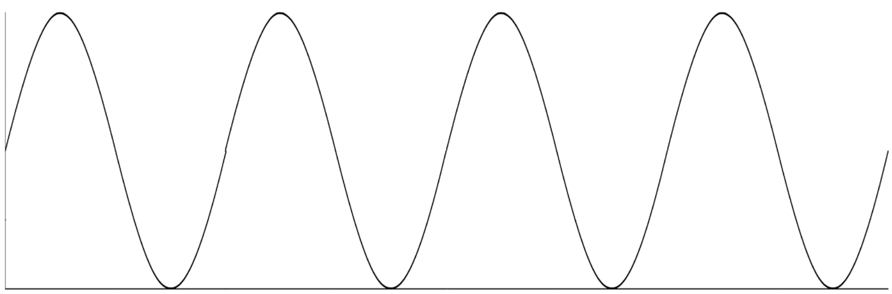
1. The tuning fork vibrates at a frequency of 261.6 Hz, which vibrates the air around it at the same frequency. This is a critically important fact to remember about sound production! The thing making the sound vibrates at a certain frequency, which vibrates the medium at the same frequency.
2. Being a decent medium, air vibrates at the same frequency as the tuning fork, 261.6 Hz, which creates mechanical waves that propagate out from the sound source. The vibrating air transmits the 261.6 Hz sound waves to the ear.
3. The sound waves hit the eardrum, which vibrates at the same frequency as the soundwaves that hit it.
4. When the eardrum vibrates, that generates electrical signals deep in the hearing apparatus, and those electrical signals are transmitted from the ear to the part of the brain that receives sound.
5. When the electrical signal reaches the brain, it interprets the signal. If the person receiving this signal is a musical person, his/her brain would interpret the 261.6 Hz sound waves as the musical note of "middle C."



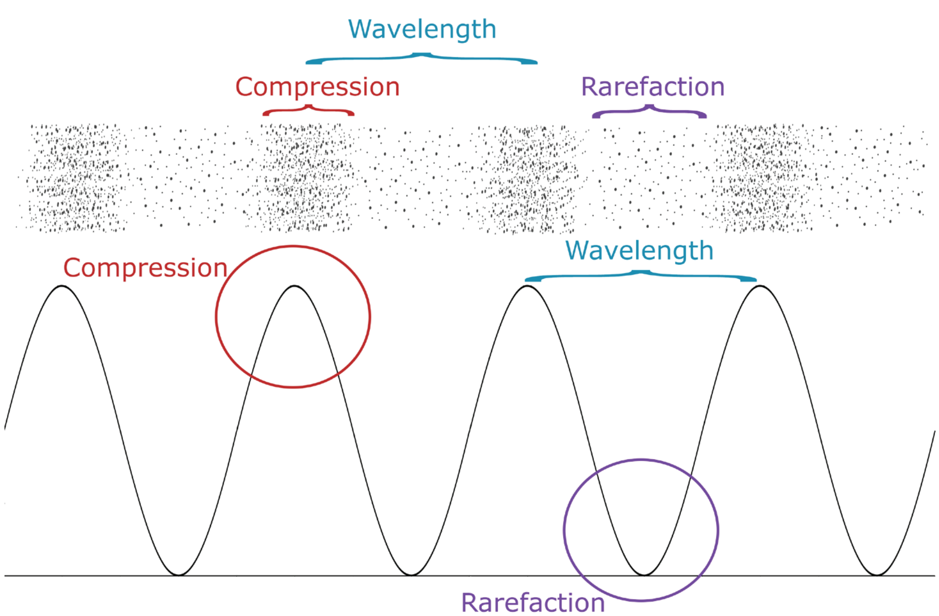


If the medium depicted above is air, then those little dots are the actual molecules of oxygen, nitrogen, argon, carbon dioxide, water, etc., that make up the atmospheric gases. They are vibrating because the wavemaker is vibrating, introducing a disturbance into the air, which makes a sound wave. As that tuning fork vibrates at 261.6 Hz, the air particles—the molecules—vibrate at the same frequency. They conduct each one of those 261.6 waves per second through the air as the vibration from the fork makes the air molecules form alternating compressions and rarefactions, with the waves constantly propagating out from the tuning fork through the medium.

Because it takes a really long time to draw a sound wave with tons of little dots in it, we often "convert" them to look like transverse waves. When you see a sound wave represented like this...



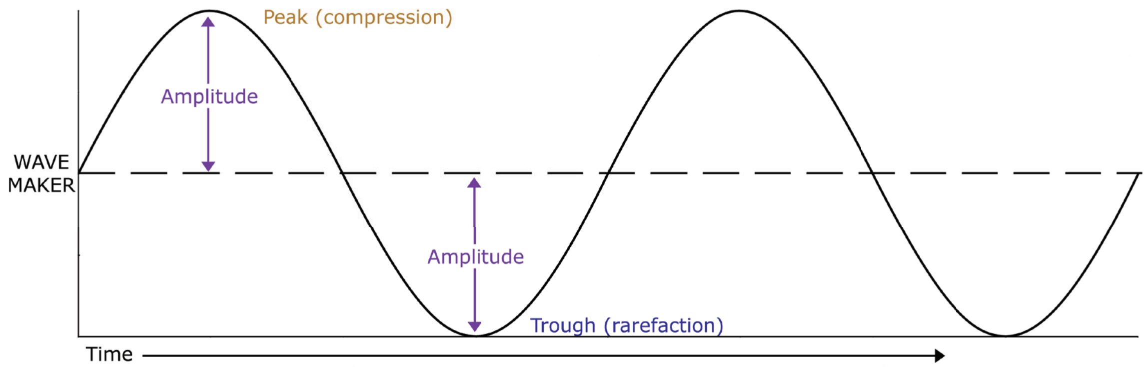
...the peaks correspond to the compressions and the troughs to rarefactions:



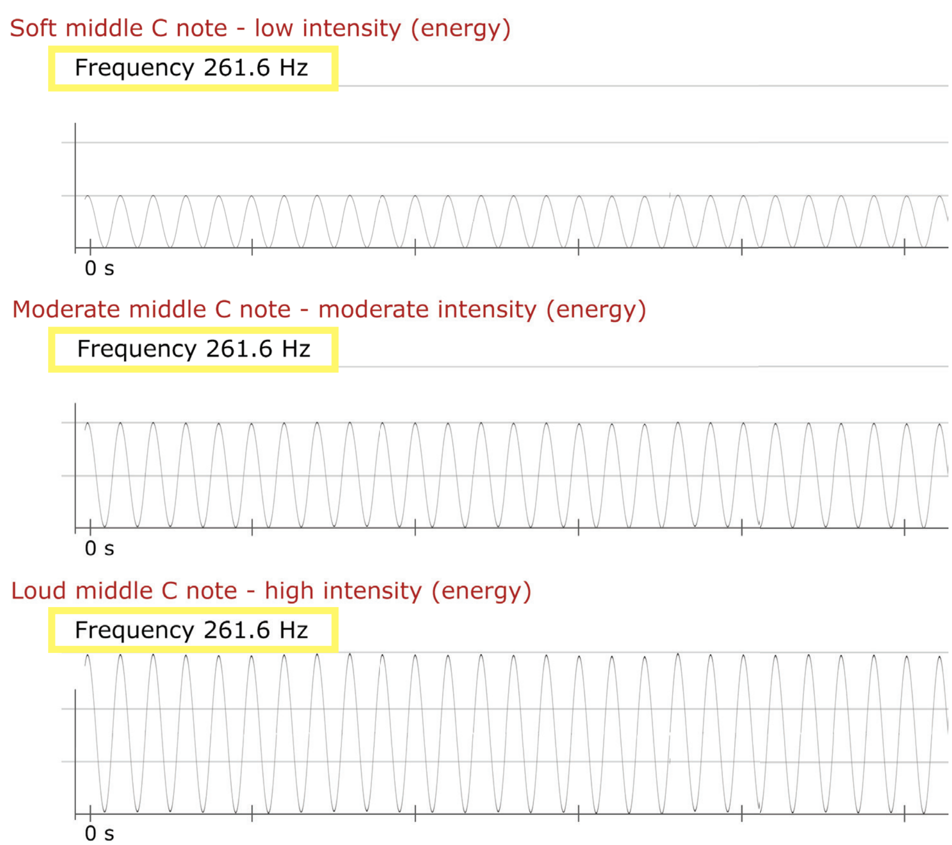
10.4 SOUND LOUDNESS VS INTENSITY

Intensity and loudness are another property of sound and are similar but not exactly the same thing. From a technical standpoint, combined with the preciseness of physicists, the relationship of sound loudness and intensity can be kind of confusing, so I am going to simplify it a little bit for our course. **Sound intensity** is a reflection of the amount of energy a sound wave carries, whereas **sound loudness** is the perception by the sound-hearer of how "soft" or "loud" the sound is. Usually, the more intensity a sound has, the louder the hearer perceives it.

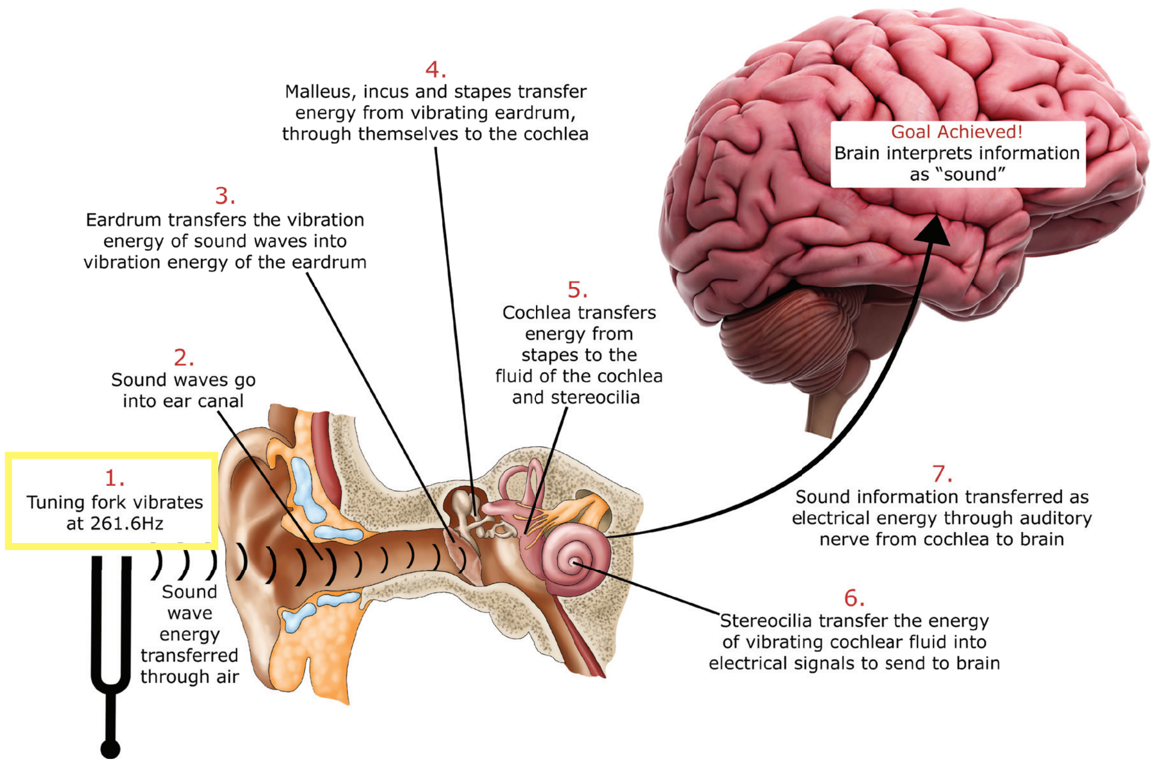
Understanding sound intensity takes us back to the anatomy of a wave because sound intensity—the amount of energy in a sound wave—is related to the amplitude of the wave. Remember the amplitude of the peak (compression) of a wave is how far above the baseline it goes, and the amplitude of the trough (rarefaction) is how far below the baseline it goes.



Sound waves with larger amplitudes have more energy; they are more intense. If I play middle C on the piano by pressing softly on the key, moderately hard on the key and really hard on the key, the three waves look like this:



The release of photon energy is also why we can see. Remember that physics is all about understanding what happens when energy is transferred. We learned last chapter that we hear because the vibrational energy in sound waves is transferred to the energy of electrical signals from the stereocilia cells and sent to the brain:



Like hearing, vision requires an energy transfer, and that energy comes from the light's energy that photons carry. When photons, riding electromagnetic waves, pass into the eyes and land on the light sensitive cells inside, they release their energy onto these special vision cells. When they absorb photon energy, the light sensitive cells convert that energy into electrical signals and send them to the brain so the brain can interpret the signals and tell us what we see. This is the basic "how we see" description, and we'll talk about it some more in the next chapter.