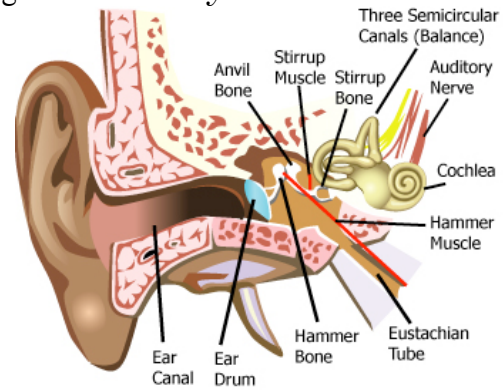
HEARING

"He who has ears to hear, let him hear!" Matthew 11:15

How we hear

- path of sound waves: outer ear —> eardrum —> middle ear (malleus/incus/stapes) —> inner ear —> cochlea —> auditory nerve —> brain
- outer ear lined with hairs and wax glands which trap dust, pollen, etc. to guard against infection
- eardrum: taut membrane; sounds bounce against eardrum and cause vibrations
- middle ear structures amplify vibrations while preserving quality of sound
- cochlea: lined with thousands of hairlike nerve cells caused to wave when vibrations hit fluid; waving of cells sends signals to auditory nerve then to brain

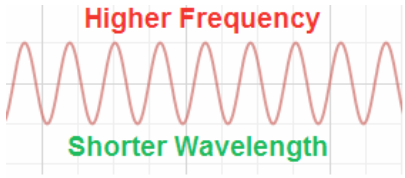


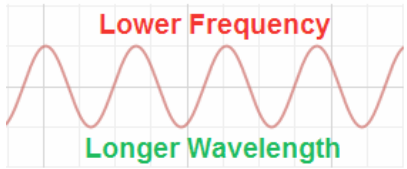
Frequency

- Regardless of what vibrating object is creating the sound wave, the particles of the medium through which the sound moves is vibrating in a back and forth motion at a given **frequency**
- frequency: how often the particles of the medium vibrate when a wave passes through a medium; measured as the number of complete back-and-forth vibrations of a particle per unit of time; frequency is measured in Hertz (Hz):

1 Hertz = 1 vibration/second

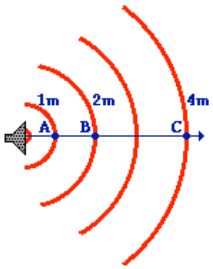
- the human ear is capable of detecting sound waves with a wide range of frequencies, ranging between approximately 20 Hz to 20 000 Hz
- any sound with a frequency below the audible range of hearing (i.e., less than 20 Hz) is known as an **infrasound** and any sound with a frequency above the audible range of hearing (i.e., more than 20 000 Hz) is known as an **ultrasound**
- dogs can detect frequencies as low as approximately 50 Hz and as high as 45 000 Hz
  cats can detect frequencies as low as approximately 45 Hz and as high as 85 000 Hz
  bats, being nocturnal creature, must rely on sound echolocation for navigation and hunting; bats can detect frequencies as high as 120 000 Hz
  dolphins can detect frequencies as high as 200 000 Hz
  elephant possesses the unusual ability to detect infrasound, having an audible range from approximately 5 Hz to approximately 10 000 Hz
- the sensation of a frequency is commonly referred to as the **pitch** of a sound; high pitch sound corresponds to a high frequency sound wave and a low pitch sound corresponds to a low frequency sound wave





Intensity

- the amount of energy that is transported past a given area of the medium per unit of time is known as the **intensity** of the sound wave; the greater the amplitude of vibrations of the particles of the medium, the greater the rate at which energy is transported through it, and the more intense that the sound wave is
- as a sound wave carries its energy through a two-dimensional or three-dimensional medium, the intensity of the sound wave decreases with increasing distance from the source
- the decrease in intensity with increasing distance is explained by the fact that the wave is spreading out over a circular (2 dimensions) or spherical (3 dimensions) surface and thus the energy of the sound wave is being distributed over a greater surface area. The diagram at the right shows that the sound wave in a 2-dimensional medium is spreading out in space over a circular pattern.



- the scale for measuring intensity is the decibel scale
- if one sound is 10x times more intense than another sound, then it has a sound level that is 10*x more decibels than the less intense sound
- the loudness of a sound is more of a subjective response; the same sound will not be perceived to have the same loudness to all individuals. Age is one factor that affects the human ear's response to a sound
- two sounds with the same intensity but different frequencies will not be perceived to have the same loudness. Because of the human ear's tendency to amplify sounds having frequencies in the range from 1000 Hz to 5000 Hz, sounds with these intensities seem louder to the human ear; more intense sounds will be perceived to be the loudest sounds