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The Nature of Sound

The ear is a sensory organ designed to capture, transmit and translate sound waves into action potentials. Before we can understand how this is done we need to have a working knowledge of what sound waves are. Sound waves are pressure waves with alternating regions of compressed air and non-compressed (rarefied) atoms. Typically these waves occur in air, but they can also occur in other media such as fluids, and even solids. We will focus on the sound waves in the air since this is the usual means by which they enter our ears. We often depict sound waves visually as an undulating line with the peak of the wave representing the compressed air and the valley the rarefied air. What we perceive as sound is a translation of the **frequency** and **amplitude** of the sound waves entering the ear. The frequency of sound is expressed as the number of peaks of the sound wave that pass a stationary point each second. Audible frequencies range from 20 **Hertz** (Hz) to 20,000 Hz (Hertz = cycles or peaks per second). Humans are most sensitive to sounds in the 1000-3000 Hz range. Our sense of hearing perceives different frequencies as different pitches. For example, low-frequency sound waves are perceived as low-pitched sounds and high-frequency sound waves are perceived as high-pitched sounds. The amplitude of the sound wave is the degree of compression and rarefaction. Visually we would depict sounds of higher amplitude as greater undulations in our line. Perceptually, amplitude determines the loudness of the sound. The loudness of a sound is measured in **decibels** (dB). A whisper measures about 30 dB while normal conversation measures about 60 dB. The decibel scale is a log scale which means that for every 10 dB increase there is a 10-fold increase in intensity, hence normal conversation is about 1000 times louder than a whisper. Sounds that are too loud can damage the hearing apparatus and cause severe hearing loss. The pain threshold for sound is about 120 dB. The table below illustrates types of sounds associated with the decibel level and how long the unprotected ear can withstand the sound without being damaged.

Decibel Level	Type	Maximum time until damage without protection
0	Quietest sound you can hear	n/a
30	Whisper	n/a
60	Normal conversations	n/a
90	Lawnmower, shop tools	8 hours per day
100	Chainsaw, snowmobile	2 hours per day
115	Sandblasting, rock concert	15 minutes per day
140	Gun blast, jet engine	0 minutes per day



Ear and hearing anatomy

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