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ACOUSTICS – WHAT CAN THIS SCIENCE TEACH US? PART 1

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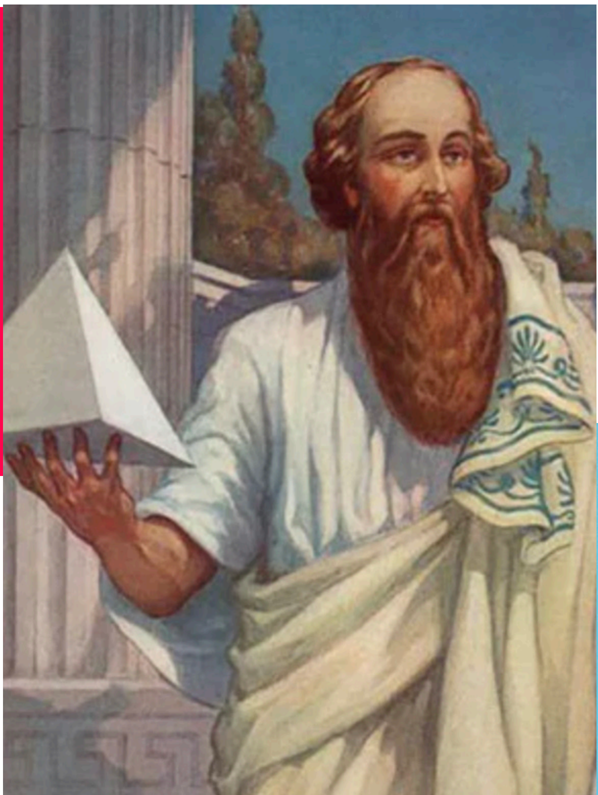
Knowledge about acoustics is often started in Physics classes. However, in the area of Health, more specifically in Audiology and Otorhinolaryngology courses, there is a need to review and improve this knowledge, since acoustics will become part of our professional experience.

Certainly, it takes more than one bulletin to address fundamental aspects of acoustics, so we additional information will be presented in later issues of this bulletin.


Philosopher Pitágoras

Acoustics studies wave phenomena, including the study of sound and focuses on its production, control, transmission, reception, and effects. The origin of acoustics is attributed to the philosopher Pythagoras (6th century before Christ).

At that time, acoustics concerned the art of musical instruments, with Pythagoras analyzing the properties of vibrating strings instruments. In the 4th century BC, Aristotle suggested that a sound wave propagates through the movement of air. Later, many other scholars endeavored to unlock the secrets of acoustics.

Galileo Galilei was responsible for an unprecedented advance in acoustics when he suggested that the pitch of a musical note (low, medium, or high) related to the frequency of a sound wave.

THE FUNDAMENTAL BASIS OF ACOUSTICS IS THE SOUND WAVE. WHAT IS IT?

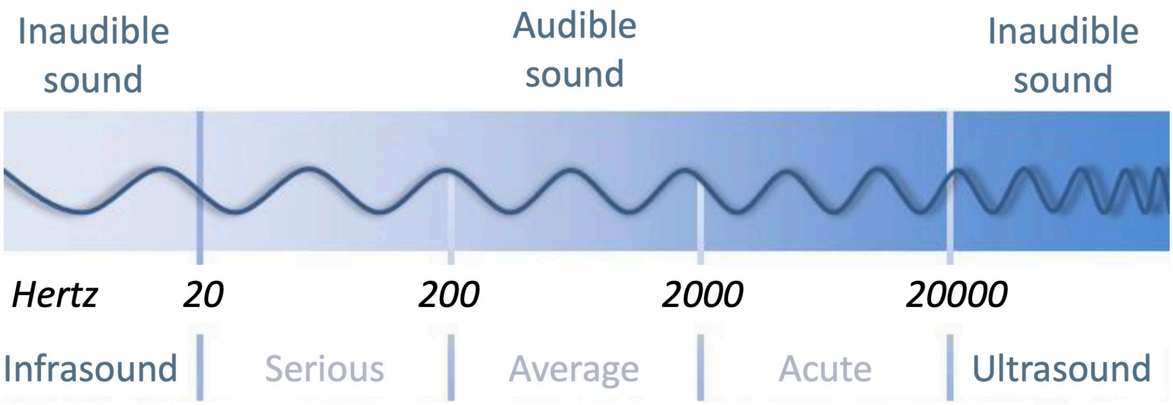


Figure 1: Representation of the frequency range of a sound.
Figure by Grandjean and Nexer (2015).

Sound is the hearing sensation caused by vibrations reaching our ears. It is a wave that needs a physical medium - such as air or bone - in which to propagate. There are audible sounds and inaudible sounds. An audible sound is one that is within the range of frequencies that human beings are able to hear - that is, it falls within the frequency range of 20 Hz to 20 kHz. Sounds with a frequency below 20 Hz are called infrasound, while sounds with a frequency above 20 kHz are called ultrasound (see Figure 1). Note, however, that the audibility range changes considerably with age or if there is any damage to the auditory system.

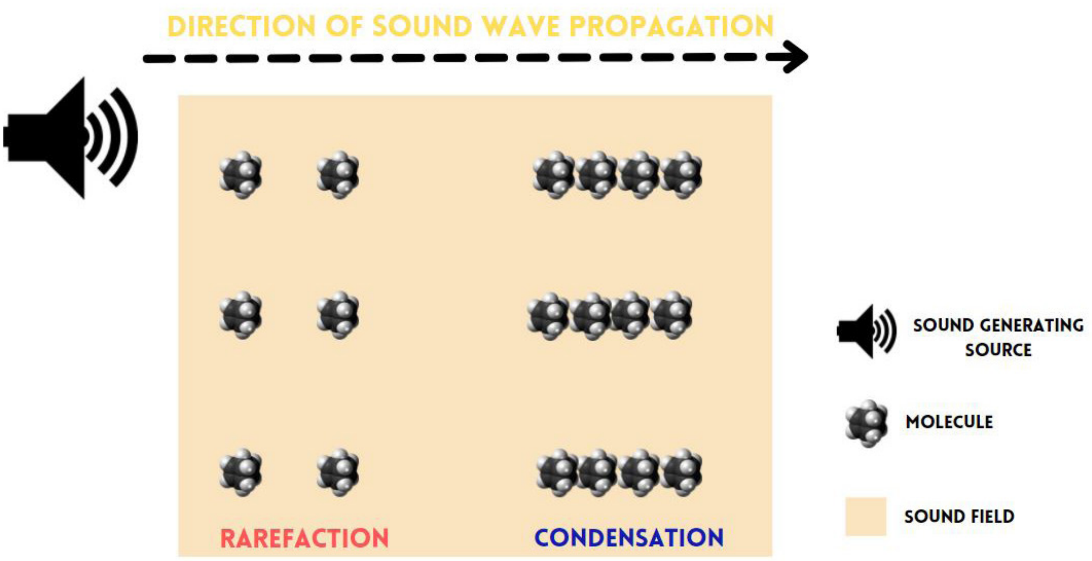


Figure 2: Sound field and molecules.
Figure developed by the authors.

Sound is caused by a change in pressure that propagates through the medium. To better understand, let's think about when we clap our hands. When we move our hands, there is also movement of air close to it and when the palms touch, there is no more air in that space, creating a region of low pressure, or rarefaction. To restore balance, the air molecules near this low pressure region will move towards the hands. This movement of molecules is passed to neighboring regions and there is a pressure variation, or sound wave, which propagates through the air. This type of wave, whose vibration movement of the medium is parallel to the wave propagation direction, is known as longitudinal wave (Figure 2). We can plot the sound wave at a point in space as a graph that shows the change in pressure (compression and rarefaction) over time (Figure 3).

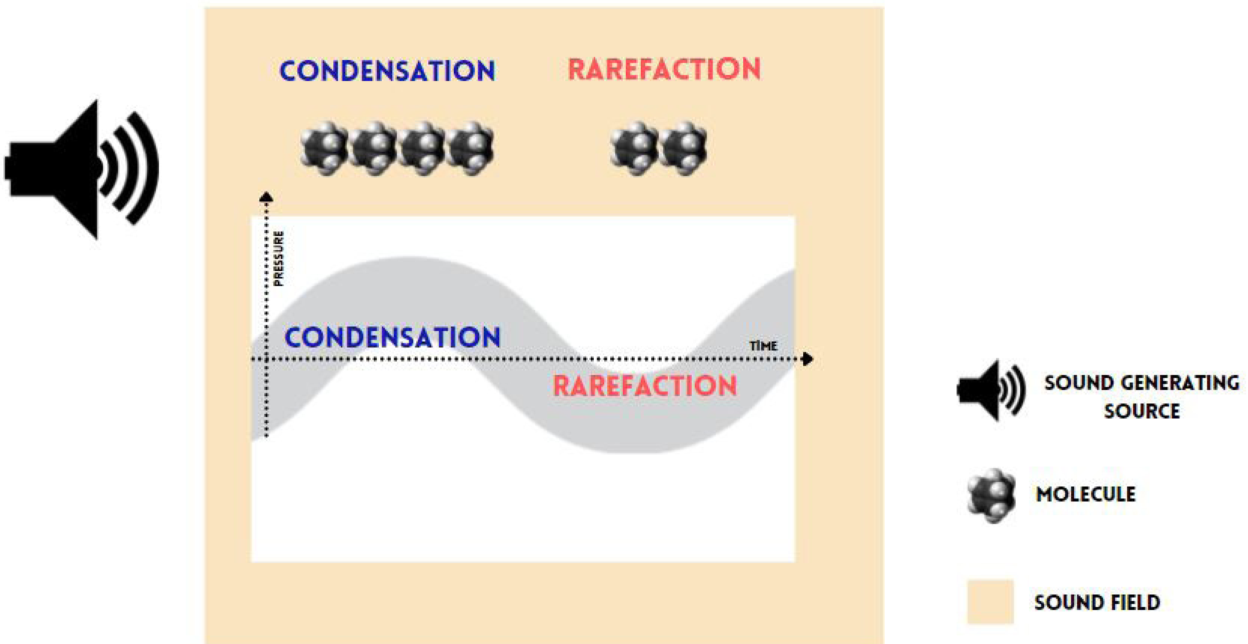


Figure 3: Representation of condensed and rarefied polarity.
Figure developed by the authors.

The main properties of a sound wave that we use to describe a sound wave are:

- **SOUND SPEED:** directly related to the physical medium in which the sound travels. When there is a greater number of molecules in the environment, sound tends to propagate faster (see Figure 2). In air, sound propagates at 340 m/s; in water it propagates almost five times faster at 1,480 m/s.

- **FREQUENCY:** is related to the perception of the pitch of a sound. The frequency of a sound wave is measured in hertz (Hz) and tells us how many times a wave oscillates in one second. The lower the frequency of the sound, the lower the pitch, while higher frequencies will be perceived as having a higher pitch.

- **AMPLITUDE:** is related to the perception of sound volume. Amplitude is measured in pascal (Pa) and represents how much the pressure varies. Compression represents an increase in pressure and rarefaction a decrease in pressure (negative pressure in the graph in Figure 4).

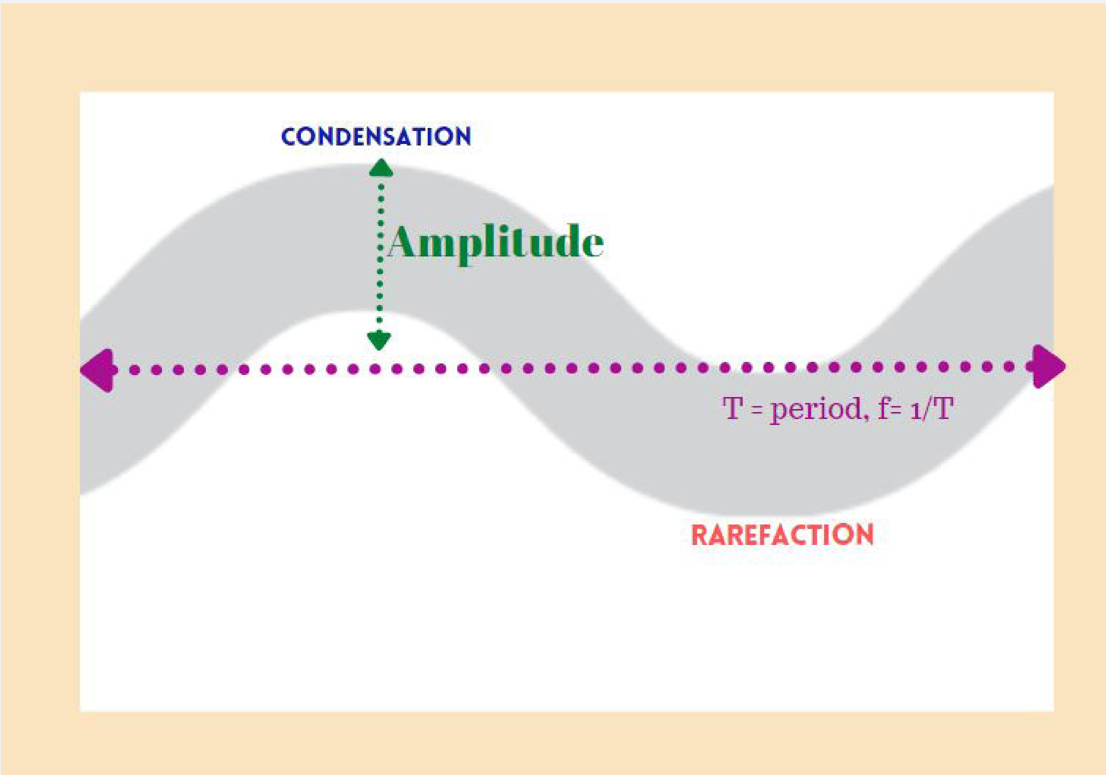


Figure 4: Representation of the properties of a sound wave.
Figure developed by the authors.

- **WAVELENGTH:** is directly related to how the sound wave propagates through the medium. Wavelength can be understood as the distance between two points of maximum compression (see Figure 4). A 100 Hz tone in air has a wavelength of 3.4 m.

We'll be back with more information about acoustics shortly!

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