# The Human Ear — Hearing, Sound Intensity and Loudness Levels

We've been discussing the ***generation*** of sounds, so now we'll discuss the ***perception*** of sounds.

## Human Senses:

The astounding ~ 4 billion year evolution of living organisms on this planet, from the earliest single-cell life form(s) to the present day, with our current abilities to hear / see / smell / taste / feel / *etc*. – all are the result of the evolutionary forces of nature associated with "survival of the fittest" – *i.e*. it is evolutionarily{very} _beneficial_ for us to be able to hear/perceive the natural sounds that do exist in the environment – it helps us to locate/find food/keep from becoming food, etc., just as vision/sight enables us to perceive objects in our 3-D environment, the ability to move /locomote through the environment enhances our ability to find food/keep from becoming food; Our sense of balance, via a stereo-pair (!) of semi-circular canals (= inertial guidance system!) helps us respond to 3-D inertial forces (*e.g*. gravity) and maintain our balance/avoid injury, *etc*. Our sense of taste & smell warn us of things that are bad to eat and/or breathe…

## Human Perception of Sound:

* The human ear responds to disturbances/temporal variations in <u>pressure</u>. Amazingly sensitive! It has more than 6 orders of magnitude in dynamic range of pressure sensitivity (12 orders of magnitude in sound intensity, $I \propto p^2$) and 3 orders of magnitude in frequency (20 *Hz* – 20 *KHz*)!
* Existence of 2 ears (stereo!) greatly enhances 3-D localization of sounds, and also the determination of pitch (*i.e*. frequency resolution)!
* <u>Pinpoint</u> accuracy for 3-D localization of sounds in the $f \sim 100\ Hz \rightarrow \sim 1.5\ KHz$ range; good sound localization accuracy up to ~ few *KHz*, and ~ reasonable, below ~ 100 *Hz*!
* Mechanical & auditory sensory structure of ear preserves/***is*** sensitive to/utilizes ***phase*** information over the $f \sim 100\ Hz \rightarrow \sim 1.5\ KHz$ frequency range.
* Our brains process/use frequency/timing, amplitude/loudness ***and*** phase information in different frequency ranges for enhanced/improved localization of sound sources…

## The Human Ear has Three Basic Parts:

* **Outer  Ear** – pinna - concentrates sound waves into the ear canal (*aka* meatus)

* **Middle Ear** – eardrum (tympanium) transforms pressure variations into mechanical displacements ($p = F/A$);  the ossicles (hammer, anvil, stirrup = malleus, incus, stapes) also mechanically <u>amplify</u> the sounds!

* **Inner  Ear** – cochlea (& semi-circular canals – for balance/orientation) hair cells convert pressure signals into neural signals, send them to _various_ centers in brain for processing via auditory nerve(s)