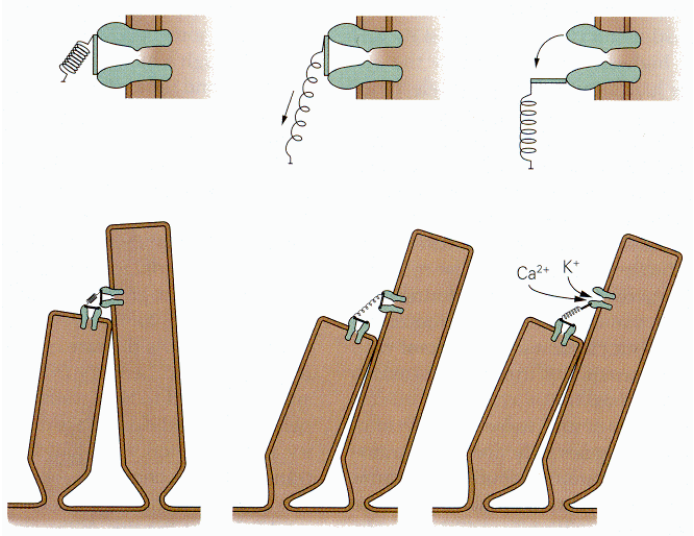
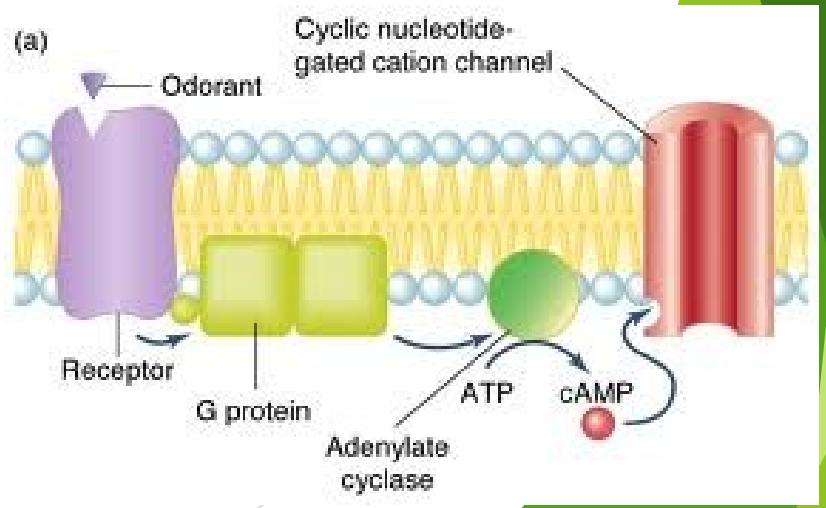
Sensory system

- Vision
- Hearing

Exteroreceptors

- Transduction of external information (light, acoustic waves, temperature, chemicals, …) to the neural system in the language of action potentials
- Mechanoreception (hearing, touch), chemoreception (olfactory system, taste), photoreception

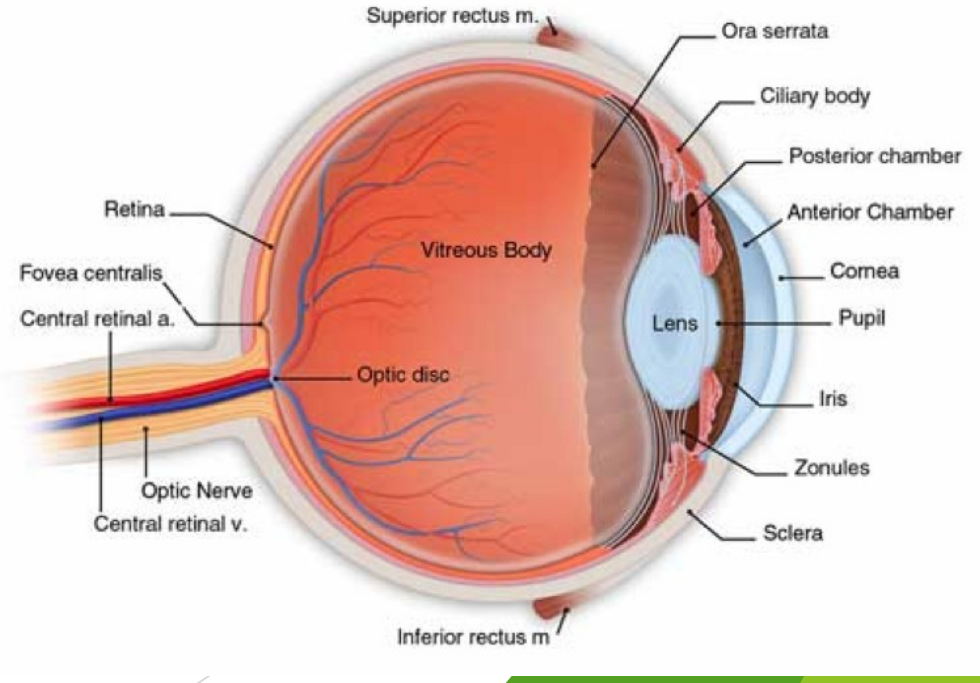




Photoreception

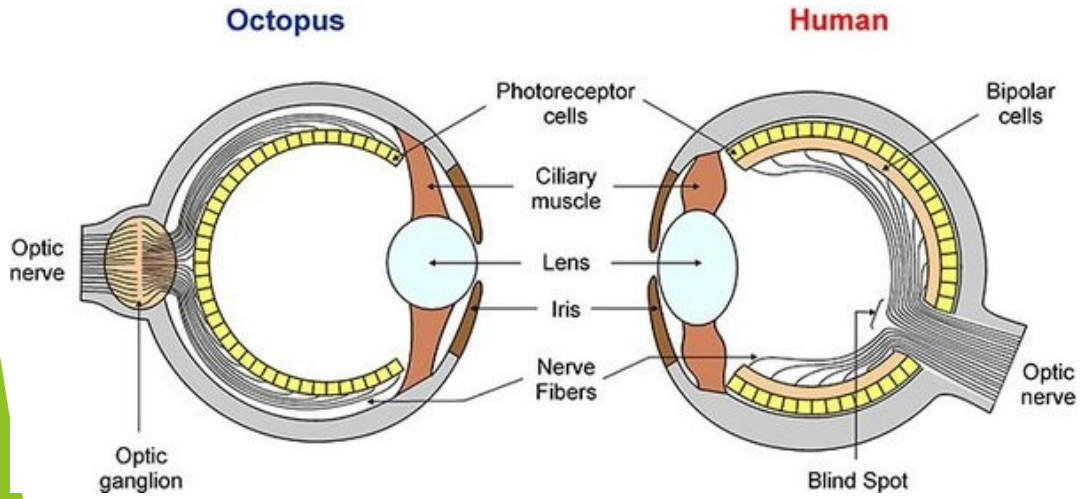
- mechanism of light detection that leads to **vision**
- main human sense, provides almost 85 % of incoming information,
- angle seen by fixed eye is about 100°, about 230° when extraocular muscles involved

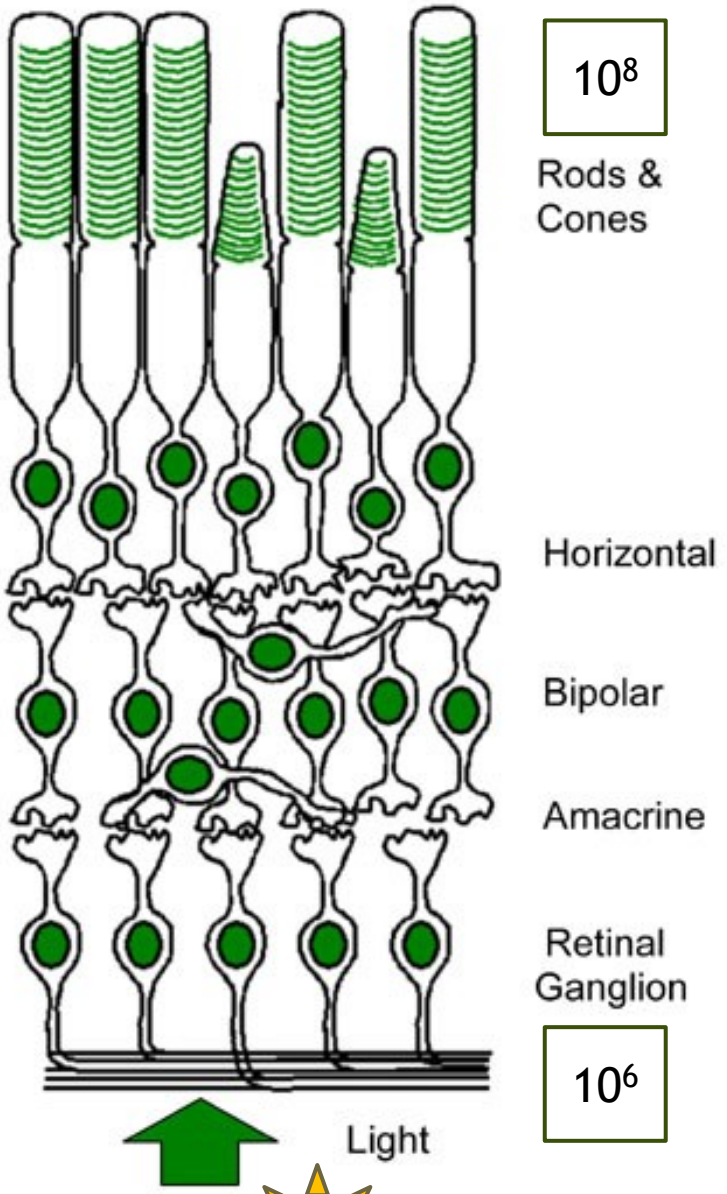
- **Blind spot** - the optic nerve passes through the optic disc, **lack** of light-detecting photoreceptors
- **Macula with fovea** - small pit that contains the largest concentration of cone cells in the eye and is responsible for central, high-resolution vision



Retina

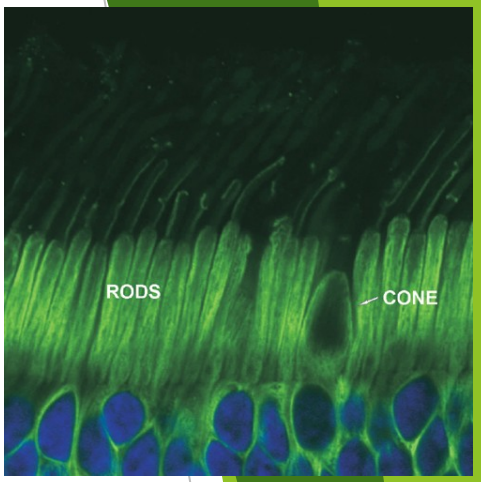
- Inverted eye – light passes through the layers of nervous tissues to the photoreceptors

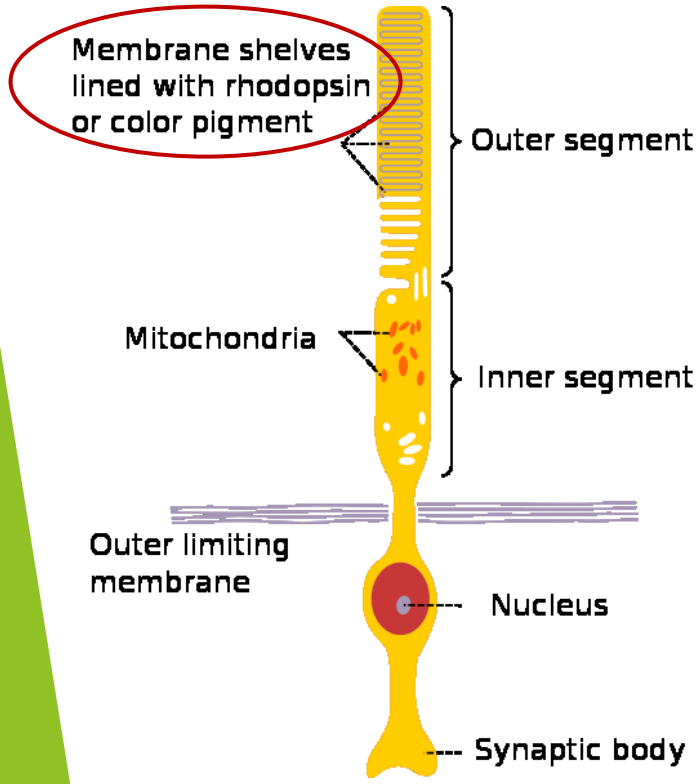


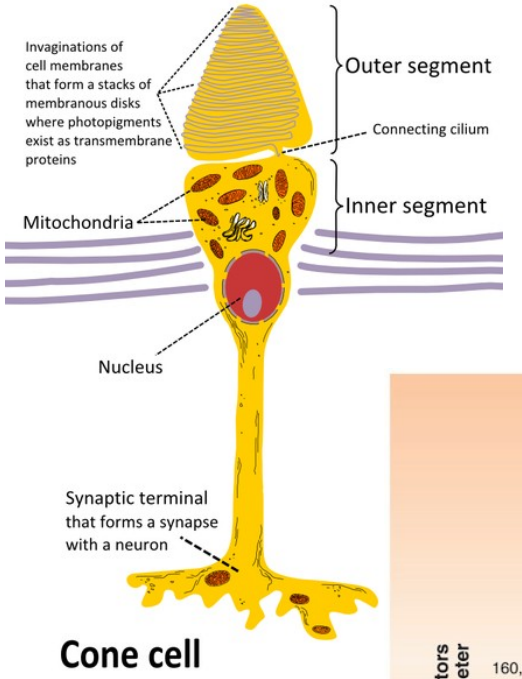


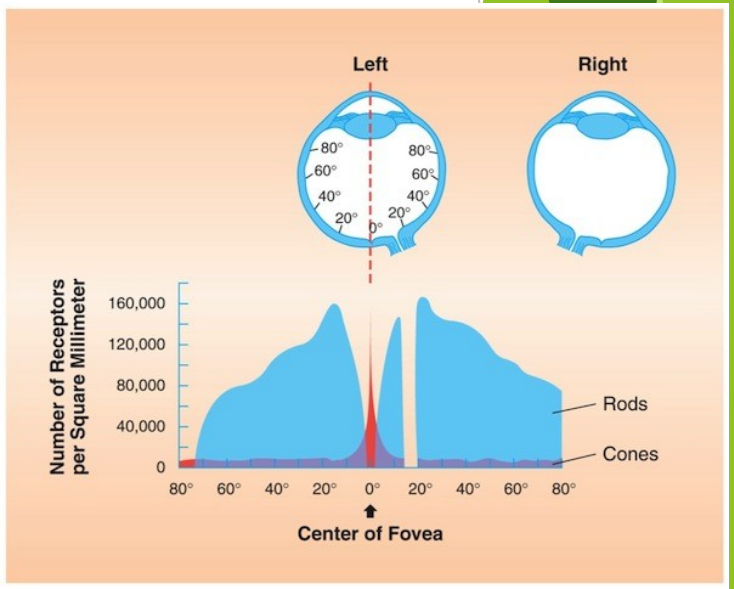
Receptor cells

- **Rods** – black-and-white vision, 120 mil.
- **Cones** – color vision, 6 mil.

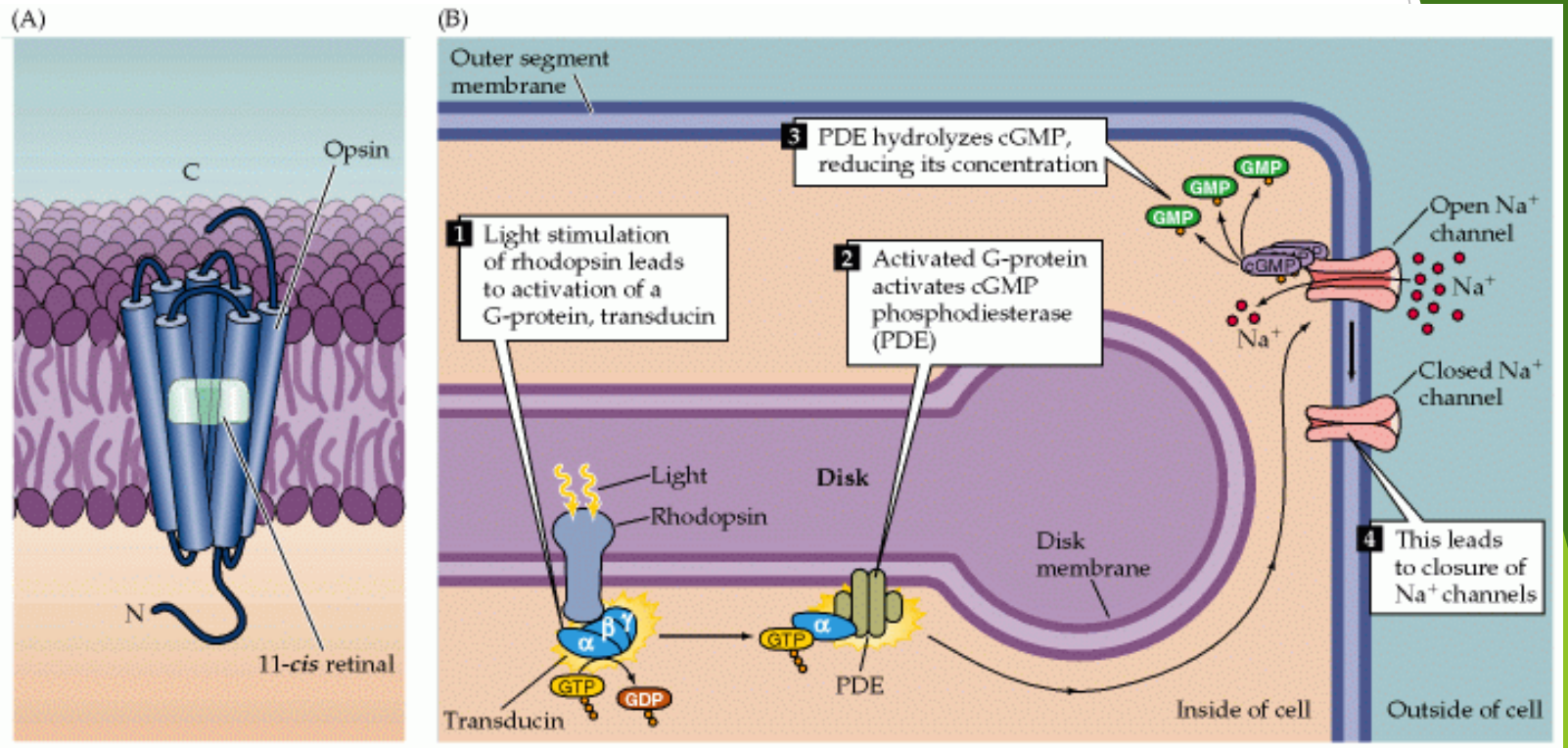








Phototransduction

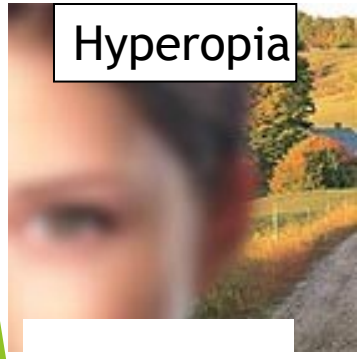


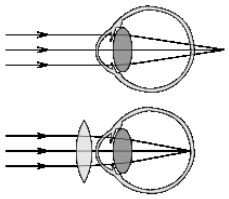
➢**Conversion of a photon into an electrical signal**

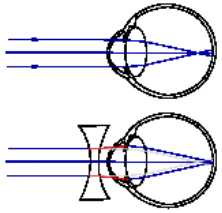
➢ Process occurs via G-protein coupled receptors called **opsins** which contain the chromophore **11-cis retinal.** 11-cis retinal is covalently linked to the opsin. When struck by a photon, 11-cis retinal undergoes **photoisomerization** to all-trans retinal which changes the conformation of the opsin GPCR leading to signal transduction cascades which causes **closure** of cyclic GMP-gated **cation channel**, and **hyperpolarization of the photoreceptor cell.**

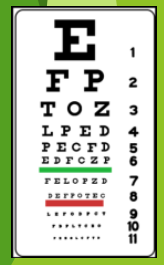
Defects of the eye

- **Glaucoma** - characteristic intraocular pressure-associated optic neuropathy, visual field loss
- **Cataract** - clouding of the lens, treatable by surgery



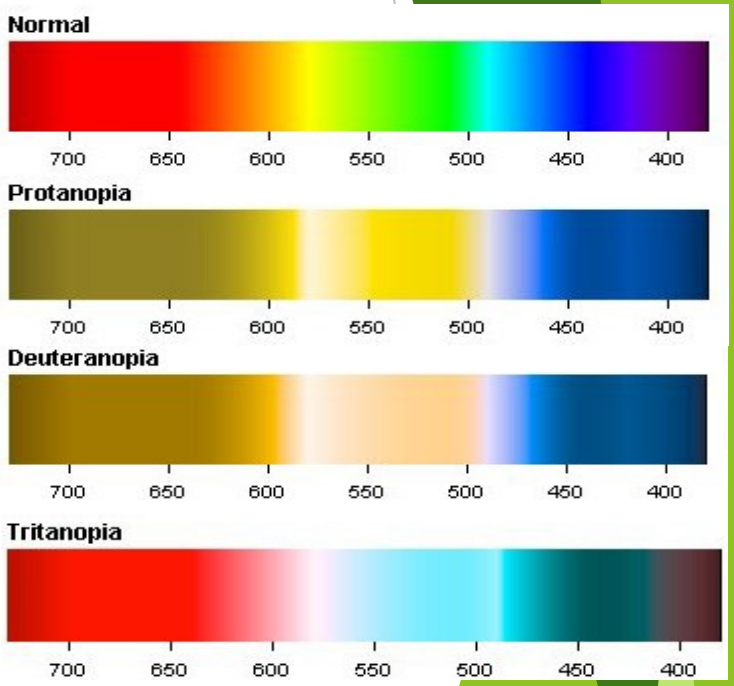


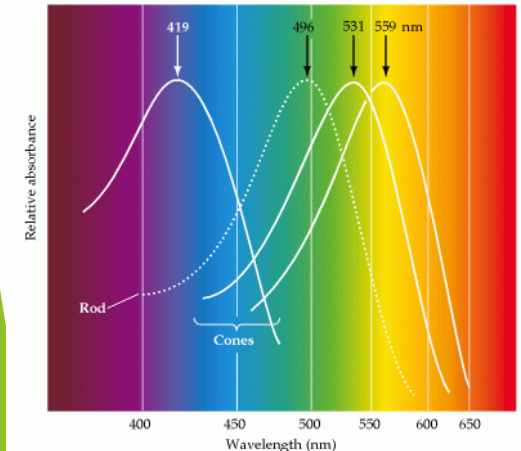


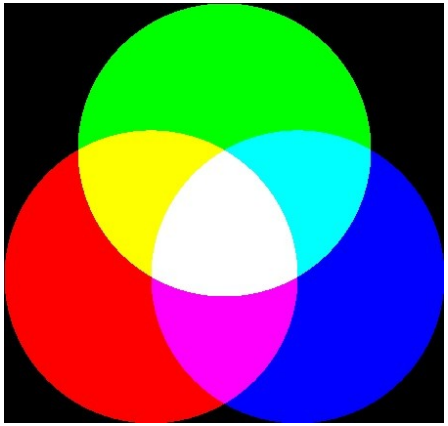


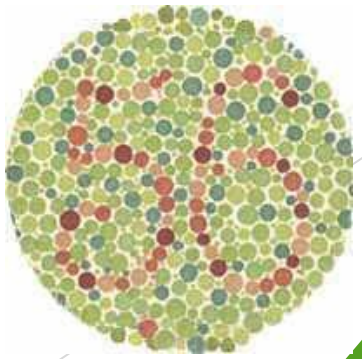
Color vision

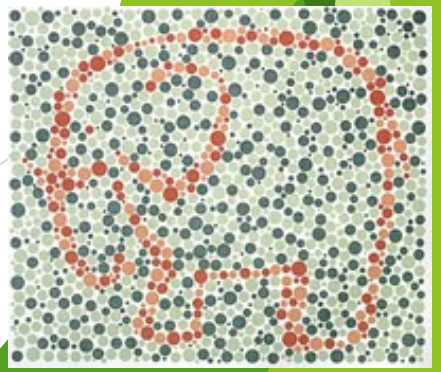
- In human retina 3 types of cones
- Pigments detects light of wavelenghts corresponding to red, blue and green color
- Unequal stimulation of different types of cones → different colors
- Most common deficiency – daltonism (red/green)
- Color blindness - **Ishihara test**









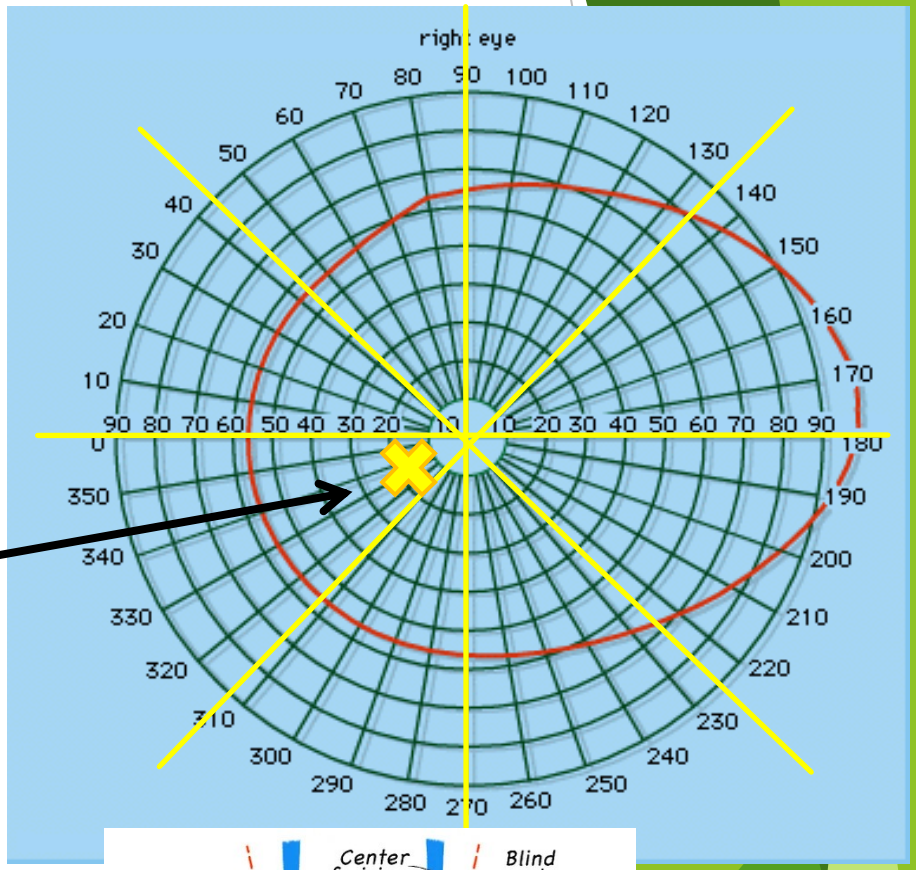


Experiment n.1 - VISION

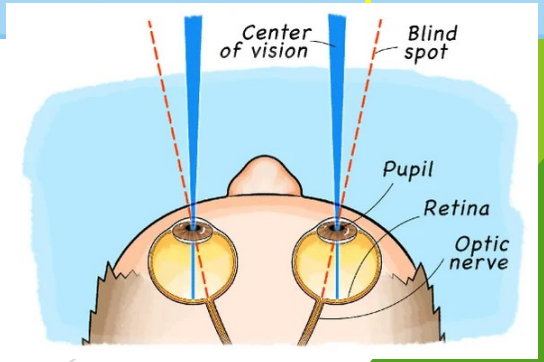
- **Visual field detecting (perimetry test)**

  8 measurements in 4 axis (0°, 45°, 90°, 135°, 180°, …)

  for 1 eye and 1 color



- **Blind spot detection**
  - about 15°, bellow horizontal axis



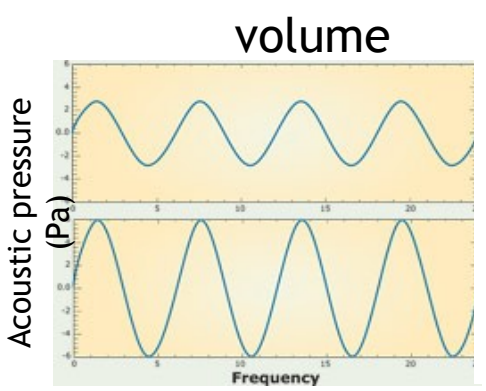
- **Color vision deficiency**

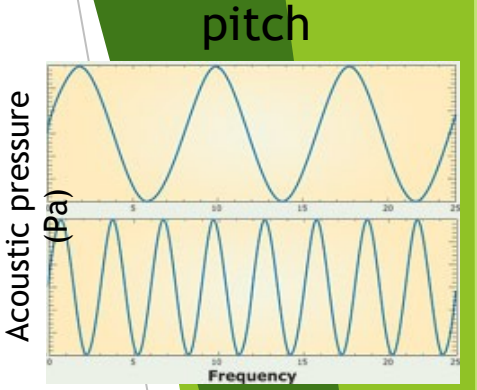
  Ishihara color test, on-line test

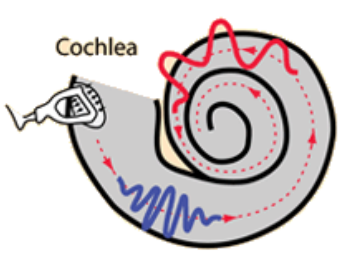
Ishihara tests/color deficiency

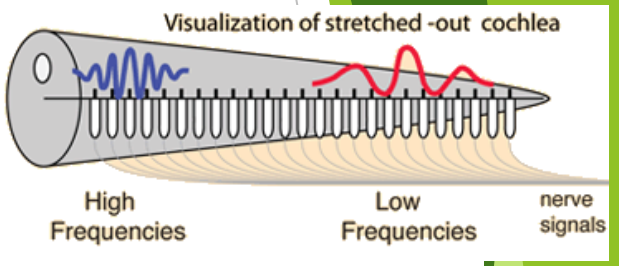
HEARING

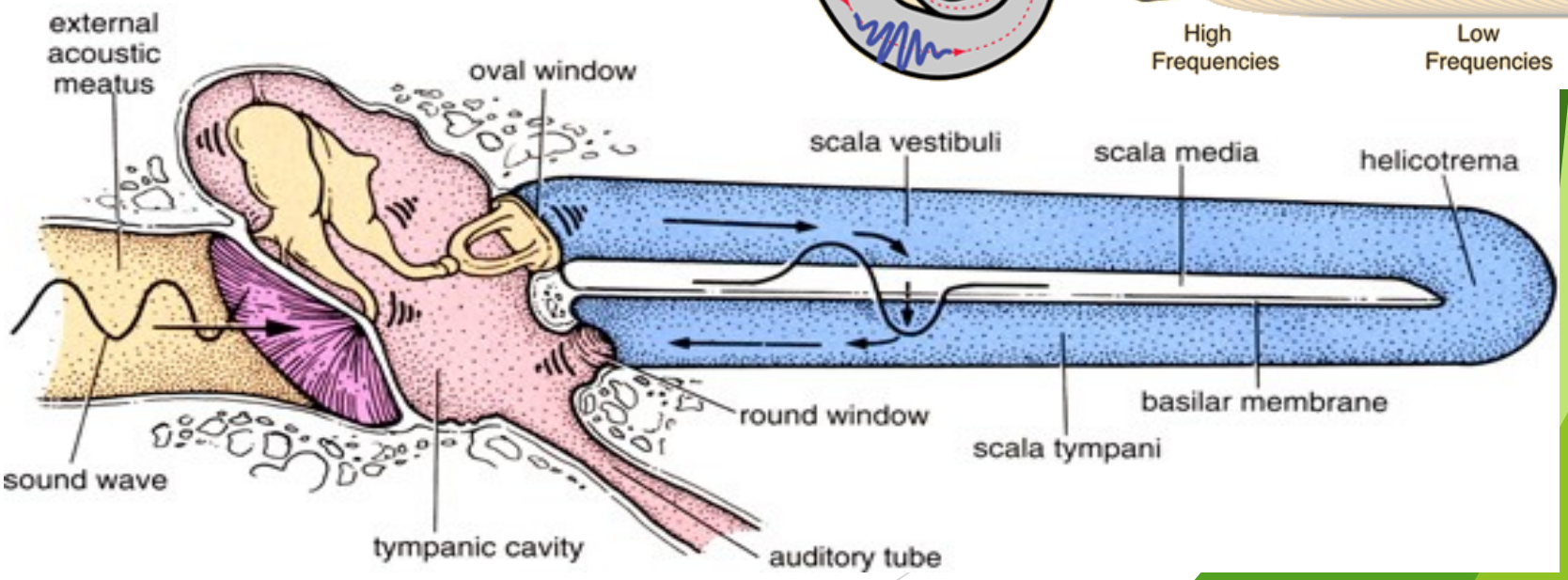
- Sound = periodical waves of pressure
- Transforming sound pressure waves from the outside into a signal of nerve impulses sent to the brain
- Amplitude + frequency



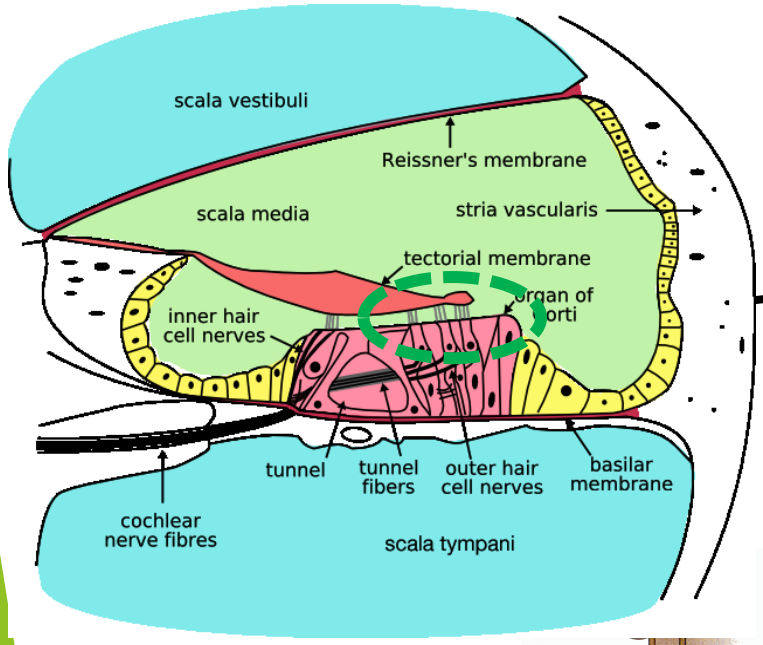


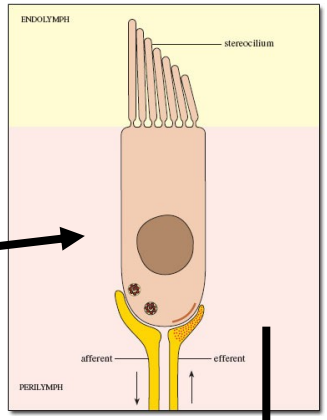


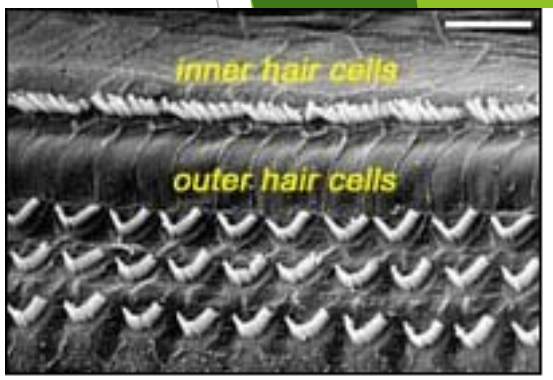




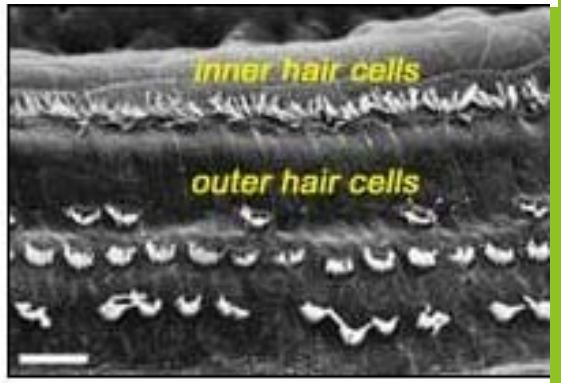
- hair cells – mechanoreceptors, auditory receptors in inner ear (organ of Corti)



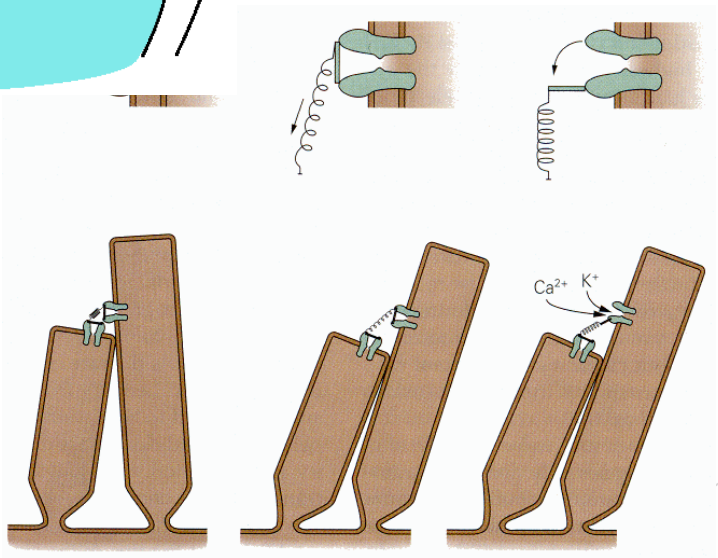




Normal



Damaged

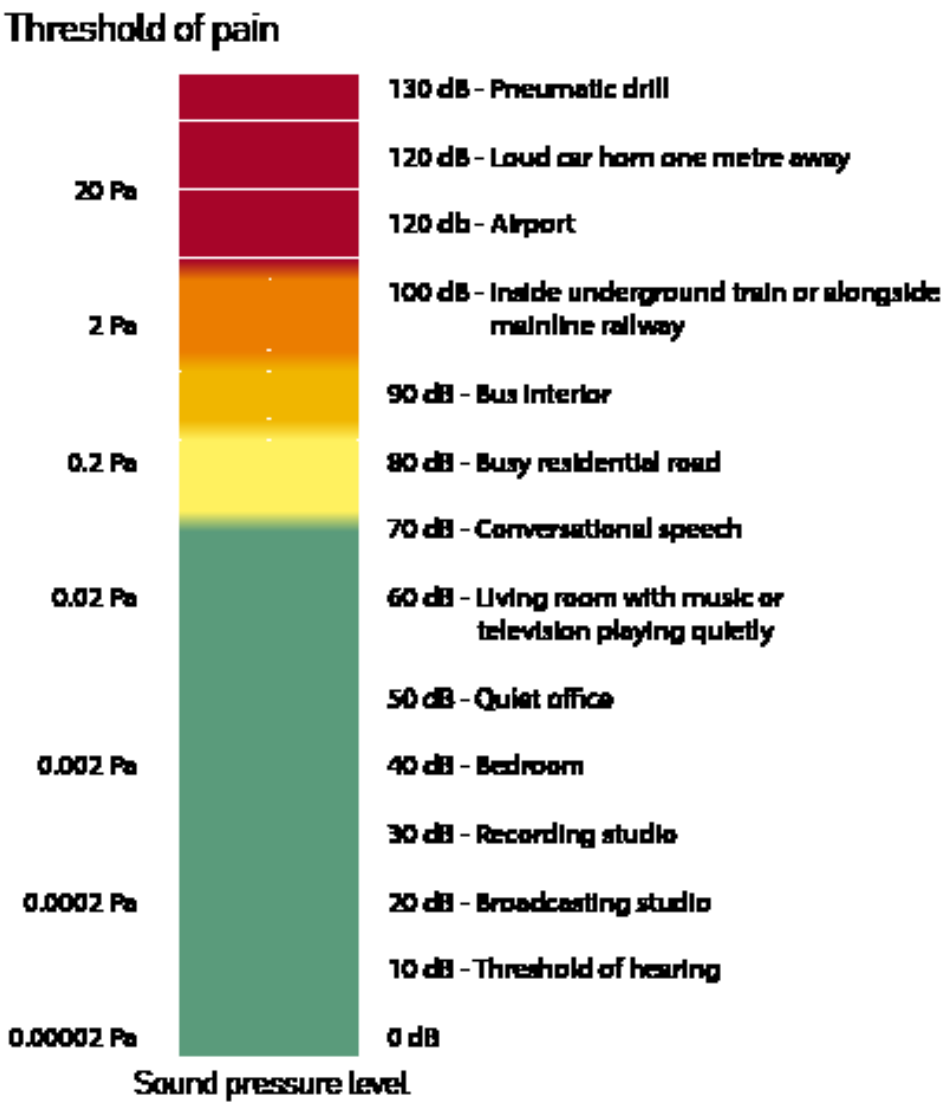


VIDEO!

Acoustic & audiometry

Senses are most sensitive to changes of weak stimuli, receptors do not register linear change in intensity, but logarithm of this change

- **Sound pressure level** (Pa, dBell)
- logarithmic scale to represent the sound pressure of a sound **relative to a reference pressure.**
- The sound pressure level at the threshold of human hearing is actually 0 dB, which has the same pressure as the reference pressure, 2 x 10^{-5} Pa.

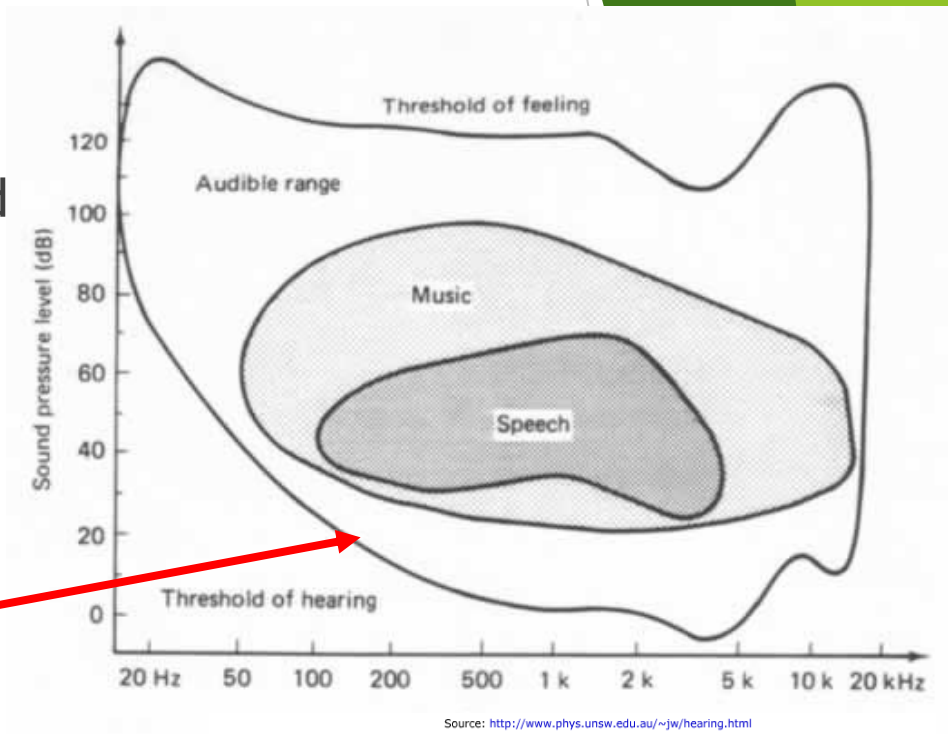


Experiment n. 2 - Audiogram

Audiogram = graph that shows the audible threshold for standardized frequencies as measured by an audiometer

Human hearing frequency range:

16-20.000 Hz, **best in 2-5kHz**

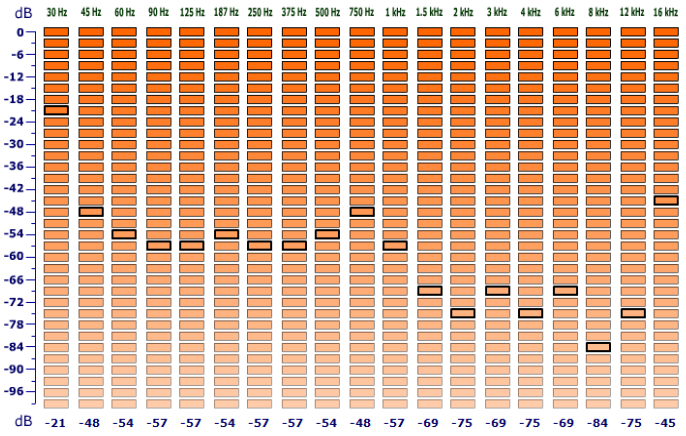


- **Absolute treshold of hearing**

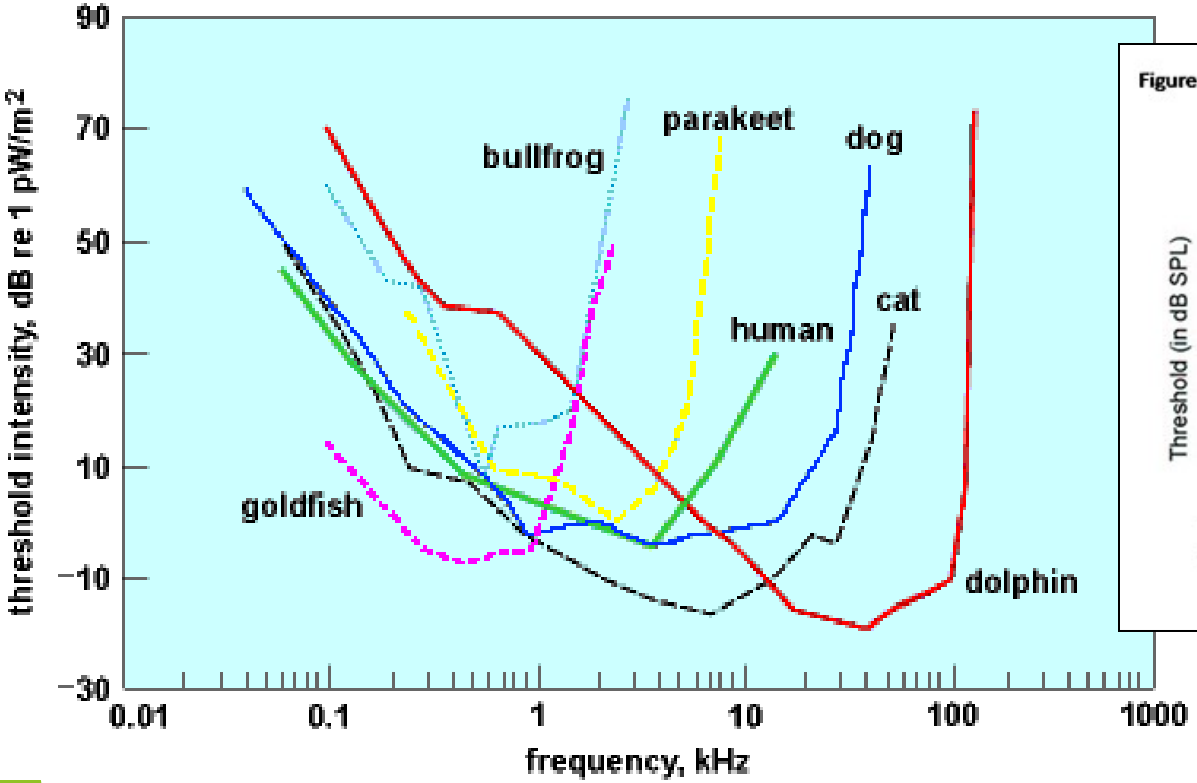
on-line test

- Set the frequency of the sound, mark the first point the sound is present, go to an another frequency etc.

Source: http://www.phys.unsw.edu.au/~jw/hearing.html



Audiograms


threshold intensity, dB re 1 pW/m^2
90
70
50
30
10
−10
−30
0.01
0.1
1
10
100
1000
frequency, kHz
bullfrog
parakeet
dog
cat
human
goldfish
dolphin

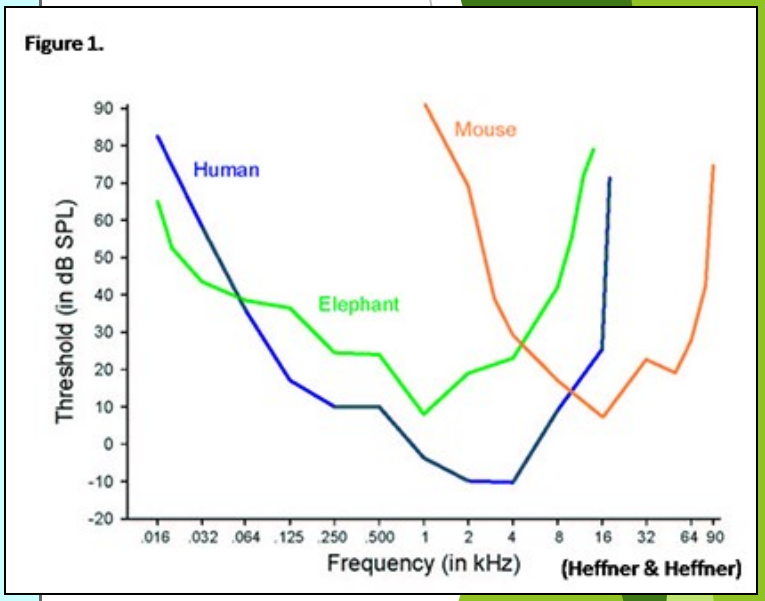


Figure 1.
Threshold (in dB SPL)
90
80
70
60
50
40
30
20
10
0
-10
-20
.016
.032
.064
.125
.250
.500
1
2
4
8
16
32
64
90
Frequency (in kHz)
Human
Mouse
Elephant
(Heffner & Heffner)

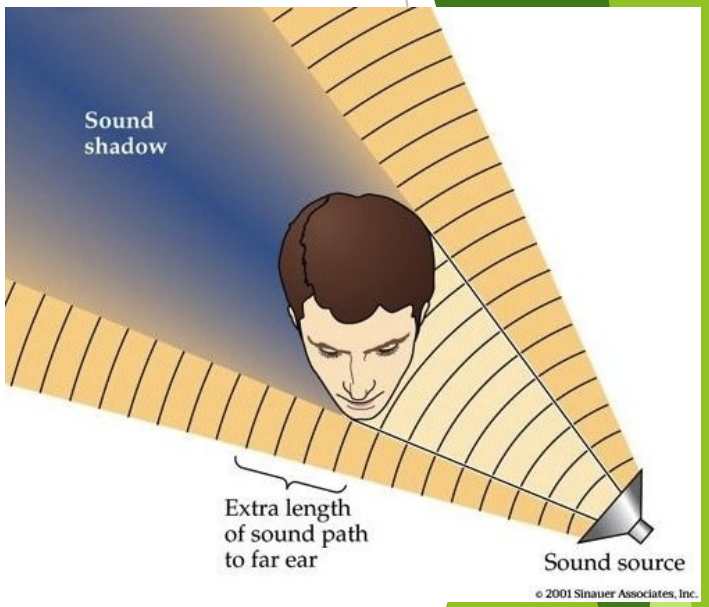
Experiment n. 3 - Sound localization

- **Where does the sound come from?**

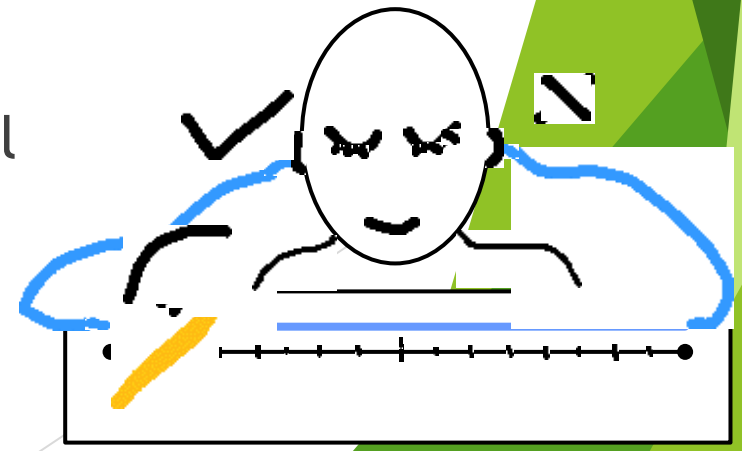
Detection based on:

- Intensity
- Time delay (ms)

Humans can detect ±4° spatial angle

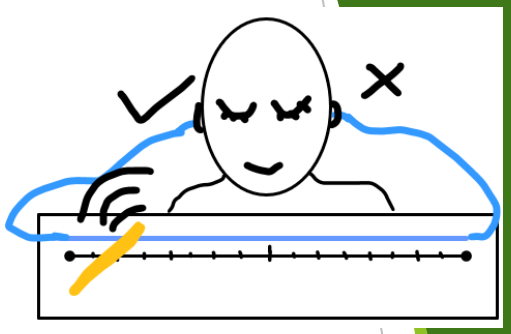


- Mechanical tapping on the special board, person under the test reports sides where the sound came from



Sound localization - results

Was the side guess right or wrong?



Distance from centre of the table

20	18	16	14	12	10	8	6	4	2	2	4	6	8	10	12	14	16	18	20
	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+	+	+	+	+
		+	+	+	+	+	-	-	-	+	+	+	+	+	+	+	+	+	
		+	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+	
		+	+	+	+	+	+	-	-	-	+	+	+	+	+	+			
			+	+	+	+	+	-	-	-	+	+	+	+	+				