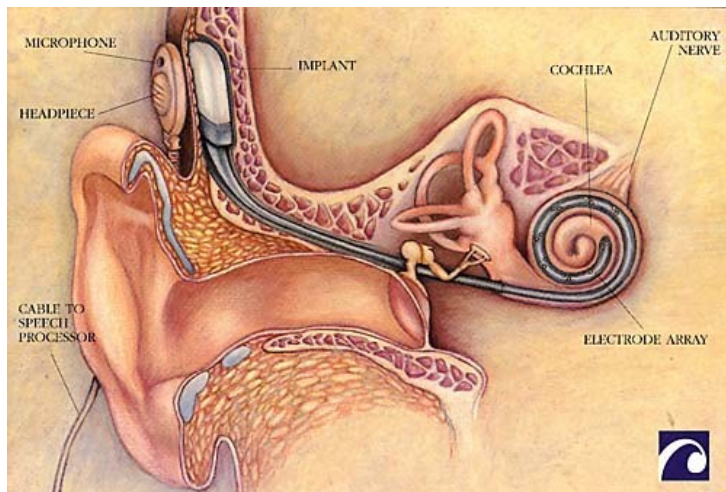


Lectures on Medical Biophysics

Department of Biophysics, Medical Faculty,
Masaryk University in Brno



Sensory perception examination and aids



Lecture outline

- Visual acuity
- Ametropia - errors of the optical system of the eye
 - Spherical ametropia: Nearsightedness and farsightedness
 - Aspherical ametropia (astigmatism)
- Examination of vision
- Electroretinography (ERG)
- Retinal implant
- Audiometry – assessment of hearing impairment
- Hearing aids for correction of hearing impairment
- Cochlear implants

Visual acuity

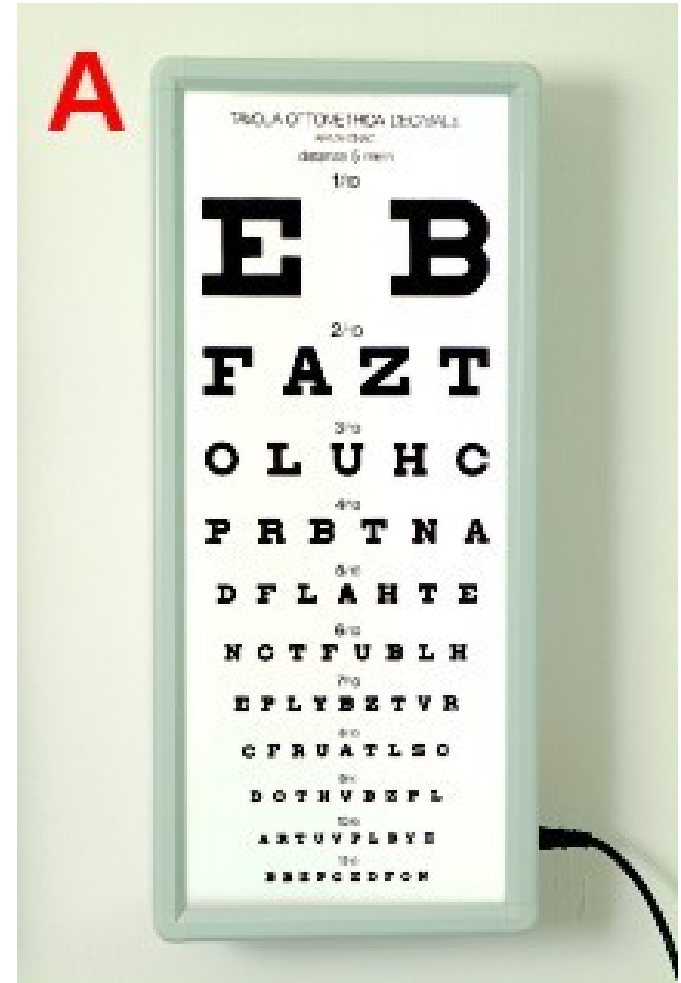
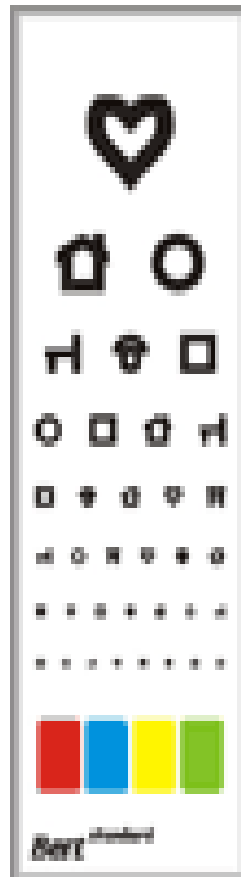
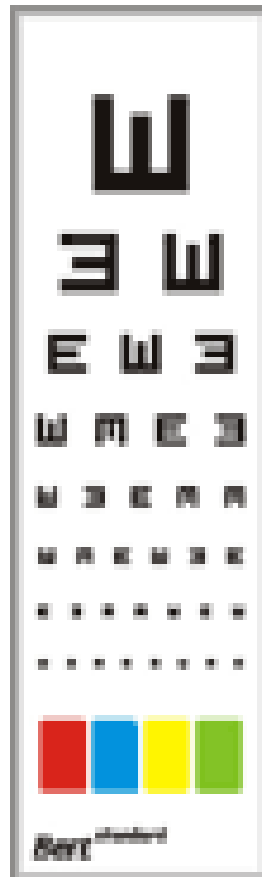
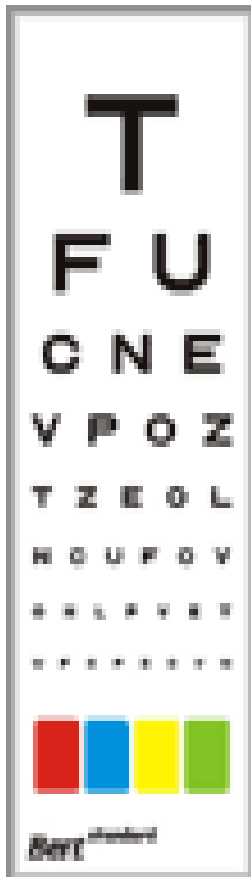
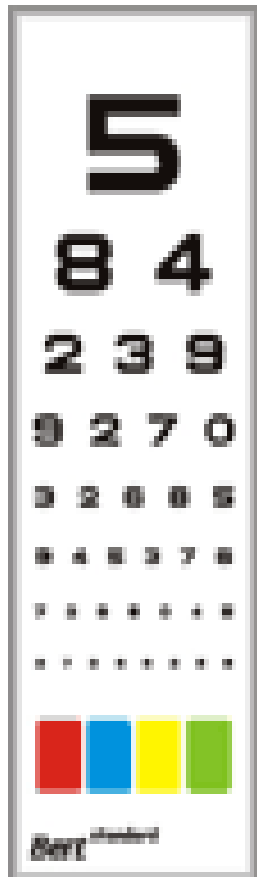
Definition: clarity and sharpness of vision (Latin “acuitas” = sharpness)

Often referred to as “Snellen” acuity. The **Snellen charts** used in its assessment are named after a 19th-century Dutch ophthalmologist Hermann Snellen (1834–1908) who created them as a test of visual acuity.

The optotypes are made for a viewing distance of 4, 5 and 6 m. Visual acuity is expressed by means of a fraction where the numerator is the viewing distance in m and the denominator the number of the row of correctly distinguishable symbols (e.g. acuity of 6/18 indicates visual acuity reduced to a third).

Someone with **6/6 vision** is just able to distinguish a symbol that subtends a visual angle of *5 minutes of arc* (written 5′) at the eye.

Snellen charts



Ametropia - errors of eye optical system

Emmetropia: the normal (“emmetropic”) eye images in points and images are focused (projected) on the retina.

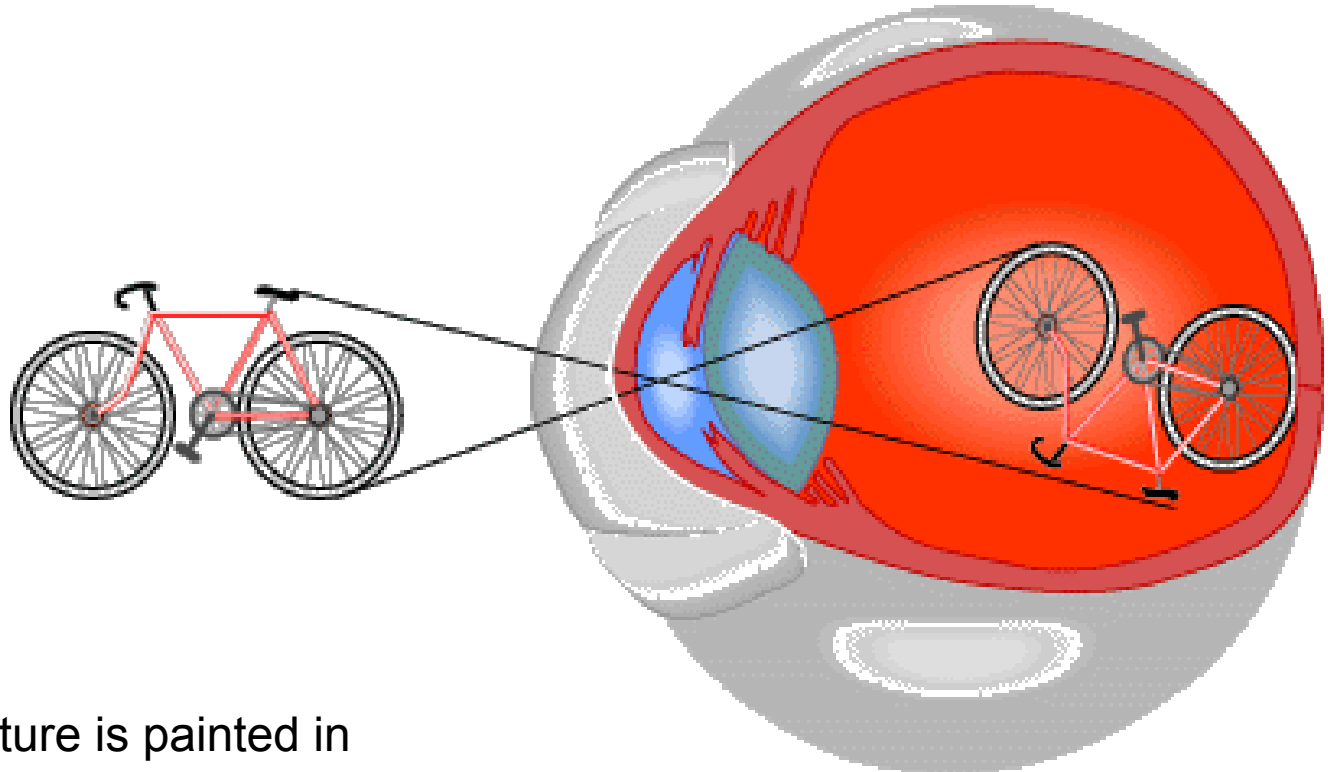
Ametropia: If the image focus is not situated on the retina or the eye does not image in points (the eye is “ametropic”).

we can distinguish two main ametropias:

- spherical (nearsightedness and farsightedness)
- aspherical (astigmatism)

Normal eye

Normally, our eye can project an image exactly on the retina:



(this picture is painted in absolutely wrong way but otherwise it is nice)

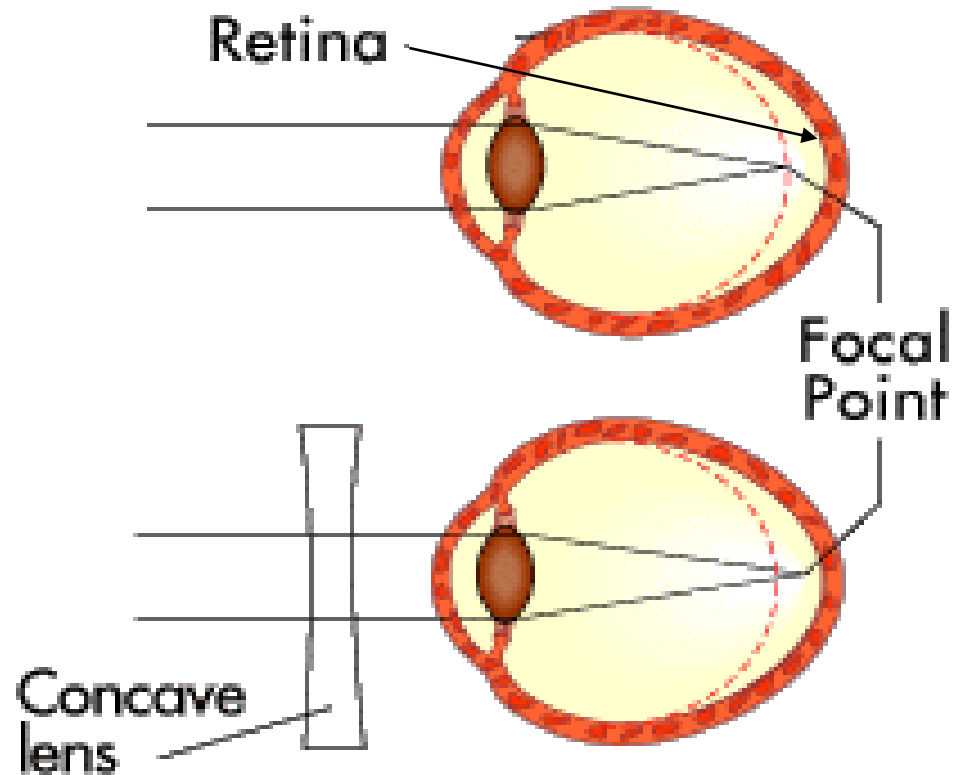
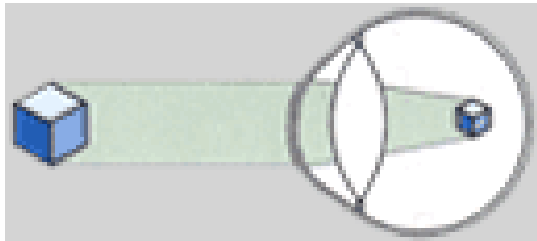
Spherical ametropia:

Nearsightedness and farsightedness

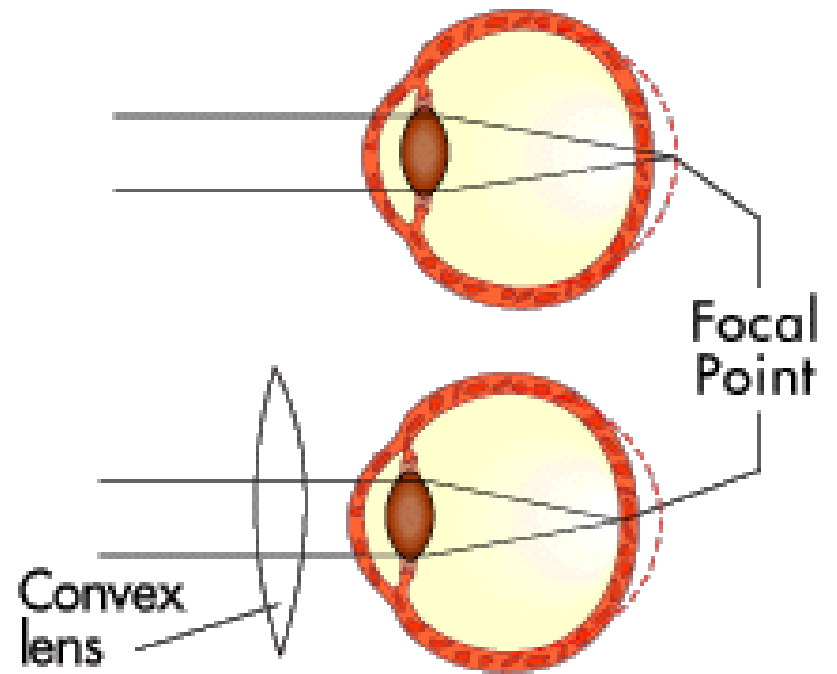
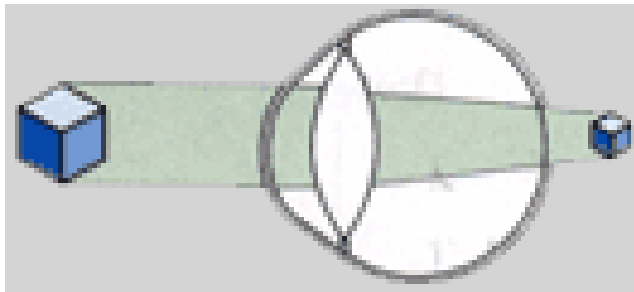
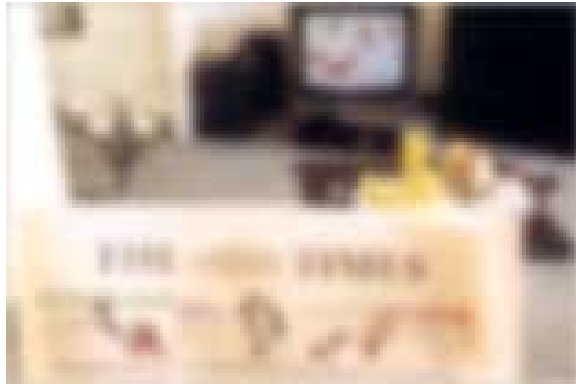
Nearsightedness (myopia): see near objects well, and difficulty seeing faraway. Light rays coming from far distance are focused in front of the retina. This is caused by an eyeball that is too long, or a lens system that has too high dioptric power. Corrected with a **concave (diverging)** lens. This lens causes the light to diverge slightly before it reaches the eye.

When **farsightedness (hyperopia):** see distant objects well but not near objects. Light rays are focused behind the retina. This is caused by an eyeball that is too short, or by a lens system that has too little dioptric power. Corrected with a **convex (converging)** lens.

Nearsightedness (myopia)

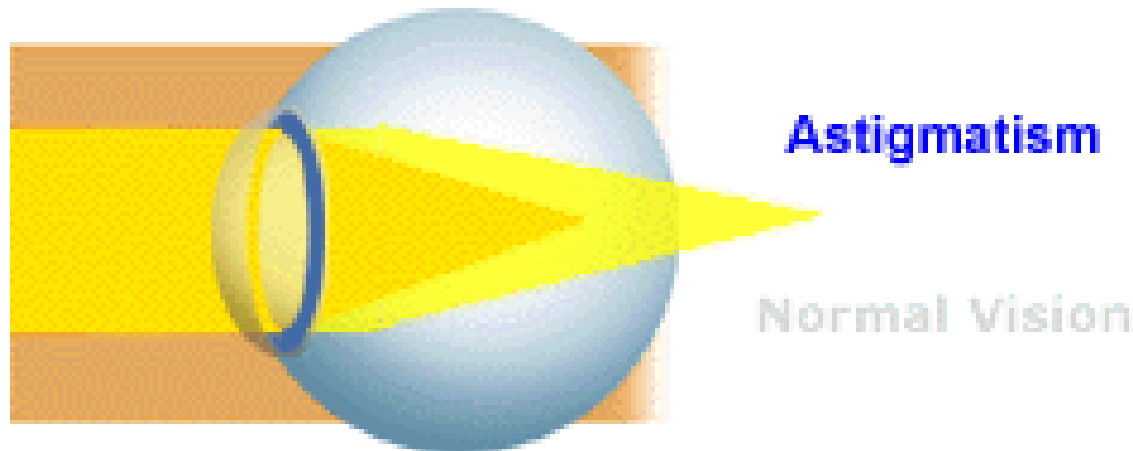


Farsightedness (hyperopia)



Aspherical ametropia (astigmatism)

Astigmatism occurs when the cornea or the lens, have a different curvature in different planes. This irregular shape prevents light from focusing properly on the retina. As a result, vision may be blurred at all distances.



Astigmatism

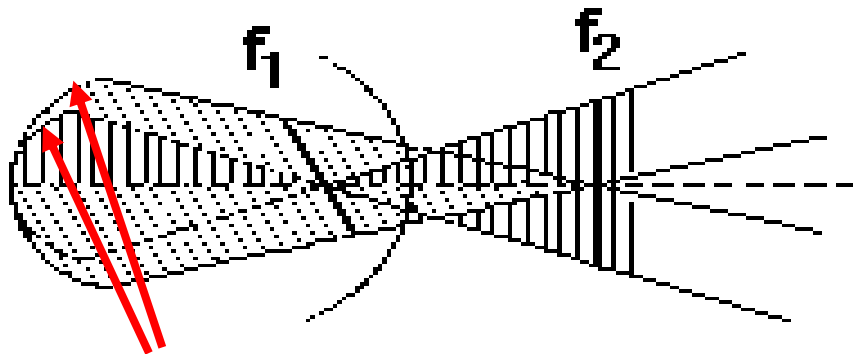


Astigmatism

Simple astigmatism: One of the focal lines does not lie on retina

Mixed astigmatism: Both focal lines are not on the retina – one in front, one behind.

Compound astigmatism: means the eye has characteristics of both astigmatism and nearsightedness / farsightedness. Both focal lines are in front or behind the retina.



Main meridians (characterised by biggest difference in curvature) of the eye can be seen – case of mixed astigmatism.

How to correct astigmatism

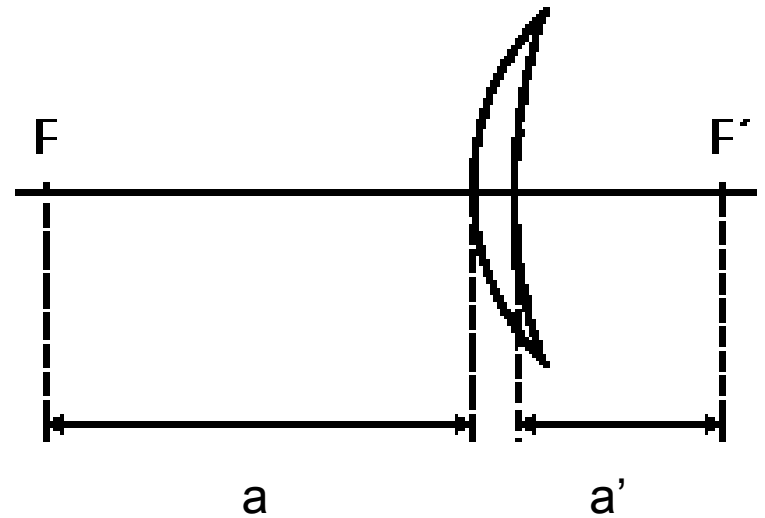
Simple astigmatism is corrected by a **cylindrical lens**, or *refractive surgery*.

Compound and mixed astigmatism are corrected by **toric lenses** (a toric refraction surface originates by a combination of cylindrical and spherical surfaces, i.e. has different radii of curvature in different planes).

Eyeglass lenses - back vertex power

- As opposed to other optical systems which are characterized by power, eyeglass lenses are characterised by their 'back vertex' power

$$A' = 1 / a'$$



Contact lens



Contact lens made of hydrophilic gel (weak)
or hard contact lenses (RGP – Rigid Gas-
Permeable)

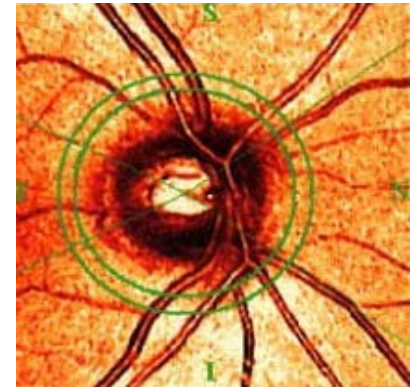
Refractometer – objective examination of vision



Further devices for examination of vision



Perimetry the investigative method to assess the extent of visual field. Its essence is the ability of the eye to distinguish two stimuli in the field of vision. One stimulus is a light mark and the second the background surrounding the light mark. It is performed at the suspected loss of visual field, called scotoma.

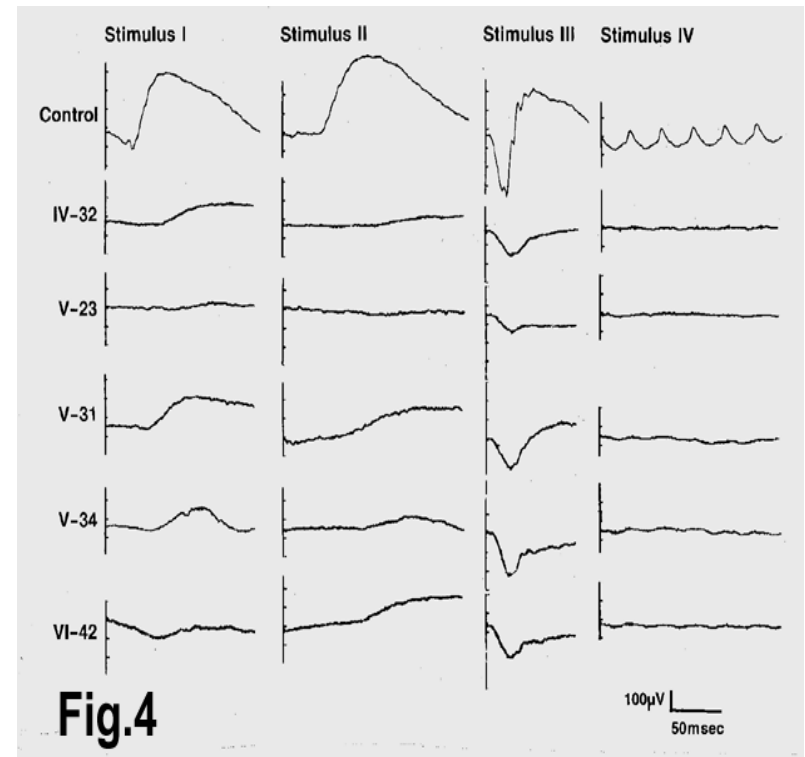


The analyzer of nerve fibres layer - GDX (Glaucoma Diagnostics). Thickness of the layer of nerve fibres of the retina is measured using a laser scanning polarimetry. This technique uses birefringence of nerve fibres. Phase shift between ordinary and extraordinary beam after passing through a layer of retinal nerve fibre will be used to measure the thickness of peripapular area. The device is equipped with a scanning unit with a light-emitting diode (wavelength 780 nm), which is associated with the computer transferring the degree of polarization in each image point to the thickness of nerve fibres using Fourier analysis.

Electroretinography (ERG)

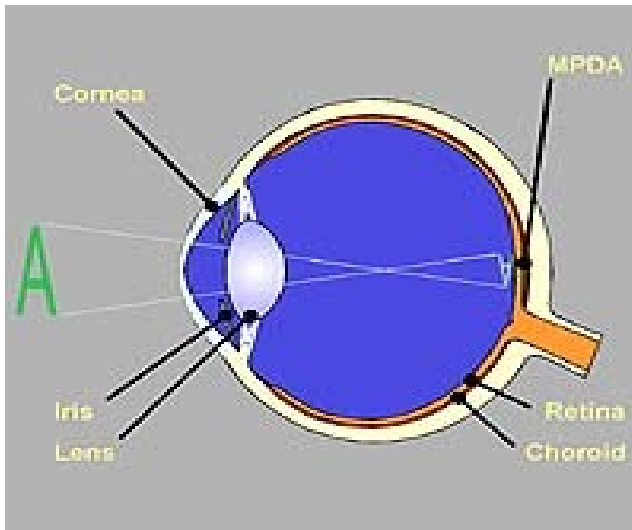
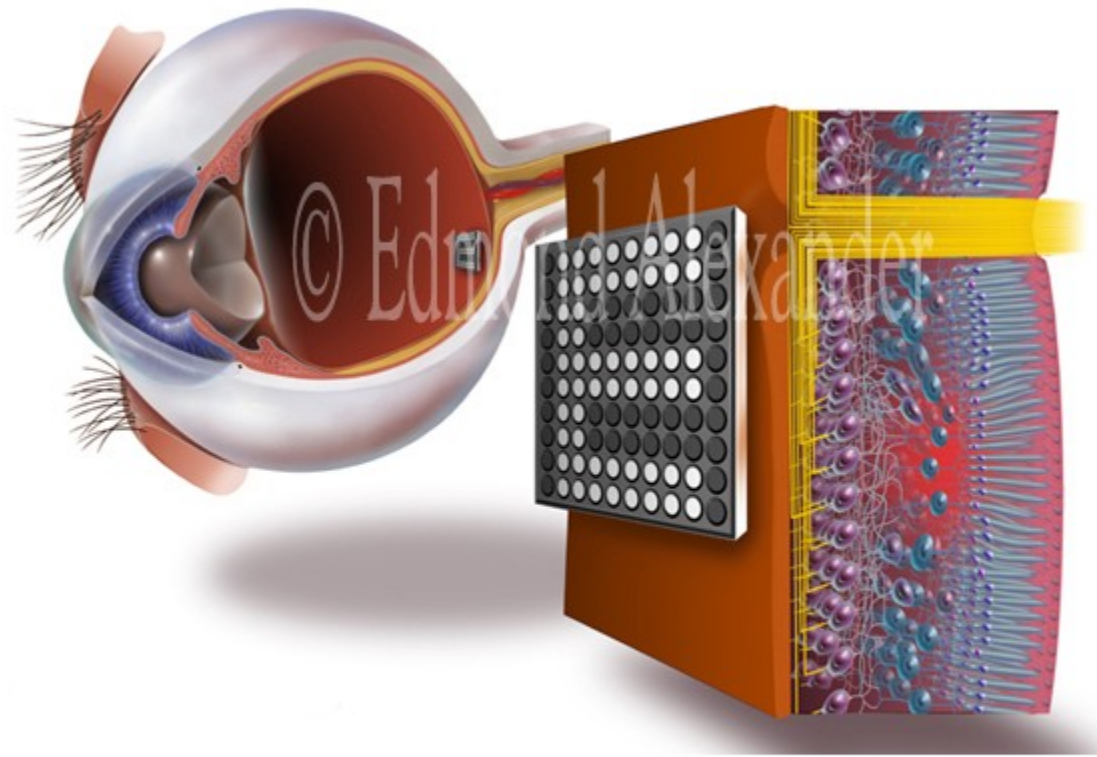
Electroretinography

is a test to measure the electrical response of the eye's light-sensitive cells (rods and cones). Electrodes are placed on the cornea and the skin near the eye (monitored by unipolar leads), 100 – 400 microvolts.



Retinal implant

www.nmi.de/deutsch/showprj.php3?id=3&typ=1



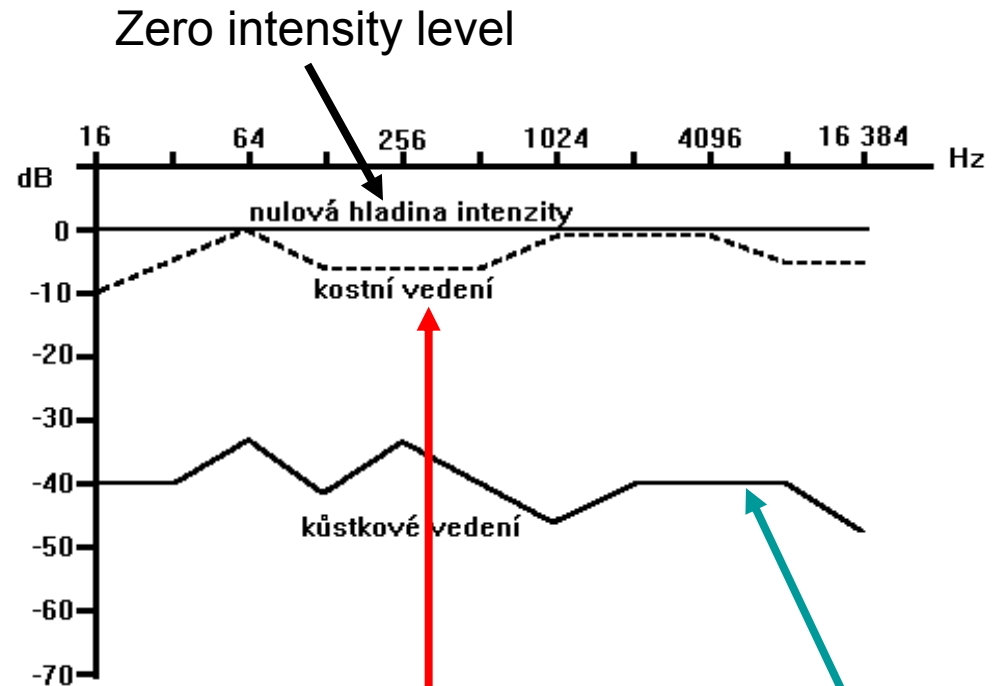
RETINAL IMPLANT
Bionic implant in retina simulates vision.
For Popular Mechanics Journal, © Edmond Alexander

MPDA – micro-photo-diode-array

This device is in clinical testing. It should enable basic spatial orientation of blind people.

Audiometry - hearing disorder examination

- **Audiometry** - see practical exercises. In practice, we obtain a **graph of loudness differences versus frequency** in comparison with normal hearing.
- **Bone conduction** is examined by tuning forks or **special oscillators** laid on *proc. mastoideus*.



finding: **bone conduction** normal, **air conduction** impaired

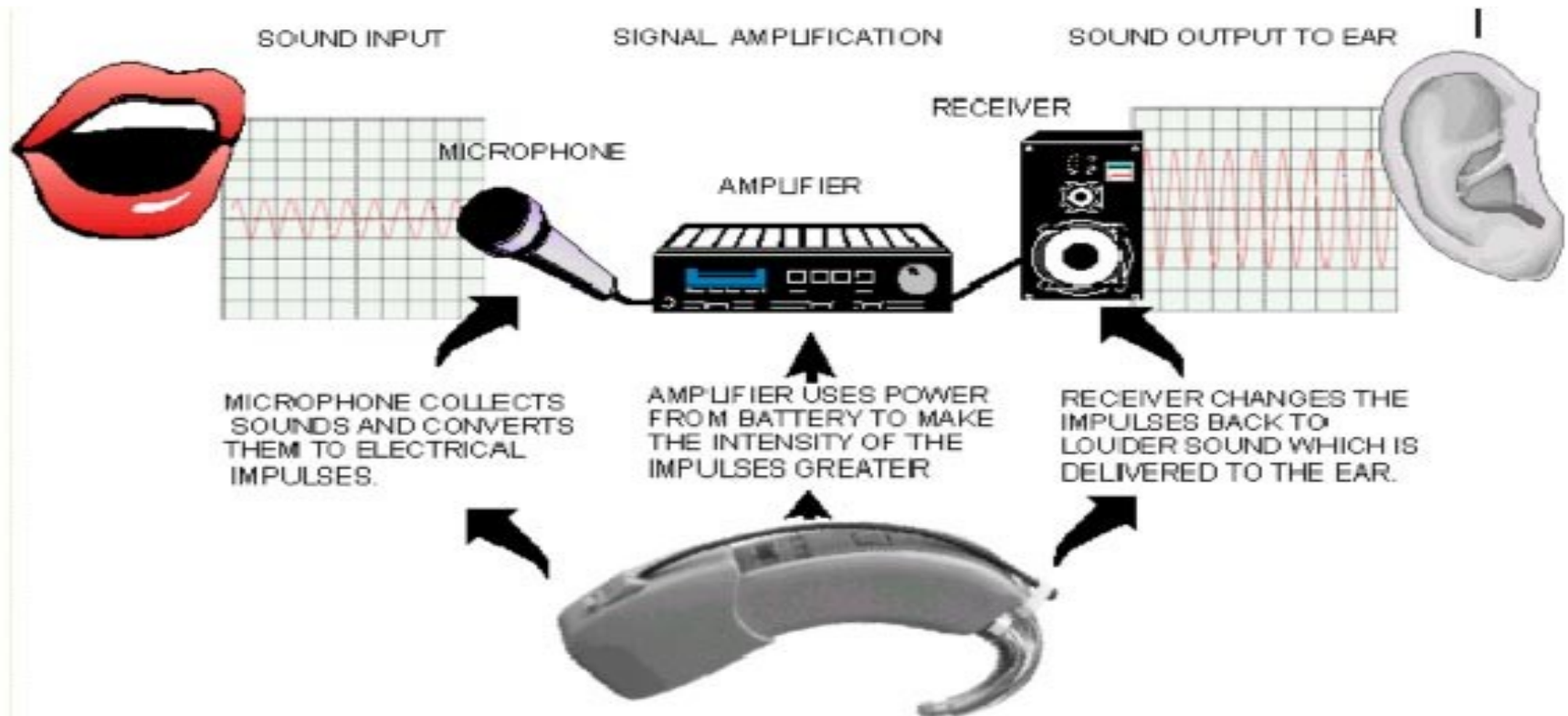
Two types of hearing disorders

- **1) Sound conduction disorder** - caused by cerumen (ear wax), Exudate or mucus in meatus, rigid drum, lowering of ossicular motility after inflammation. No full hearing loss is caused in this case - sound partly penetrates through bones into inner ear. The audiogram for air conduction is lowered in the whole range of audible frequencies, however the bone conduction is not damaged.
- **2) Perception or nerve conduction disorder.** Initially often limited to frequencies around 4000 Hz. It can be caused by long action of strong noise. Patient sound perception is distorted. Audiogram shows lowering of perception at these frequencies, bone conduction lowers as well. It increases with age.

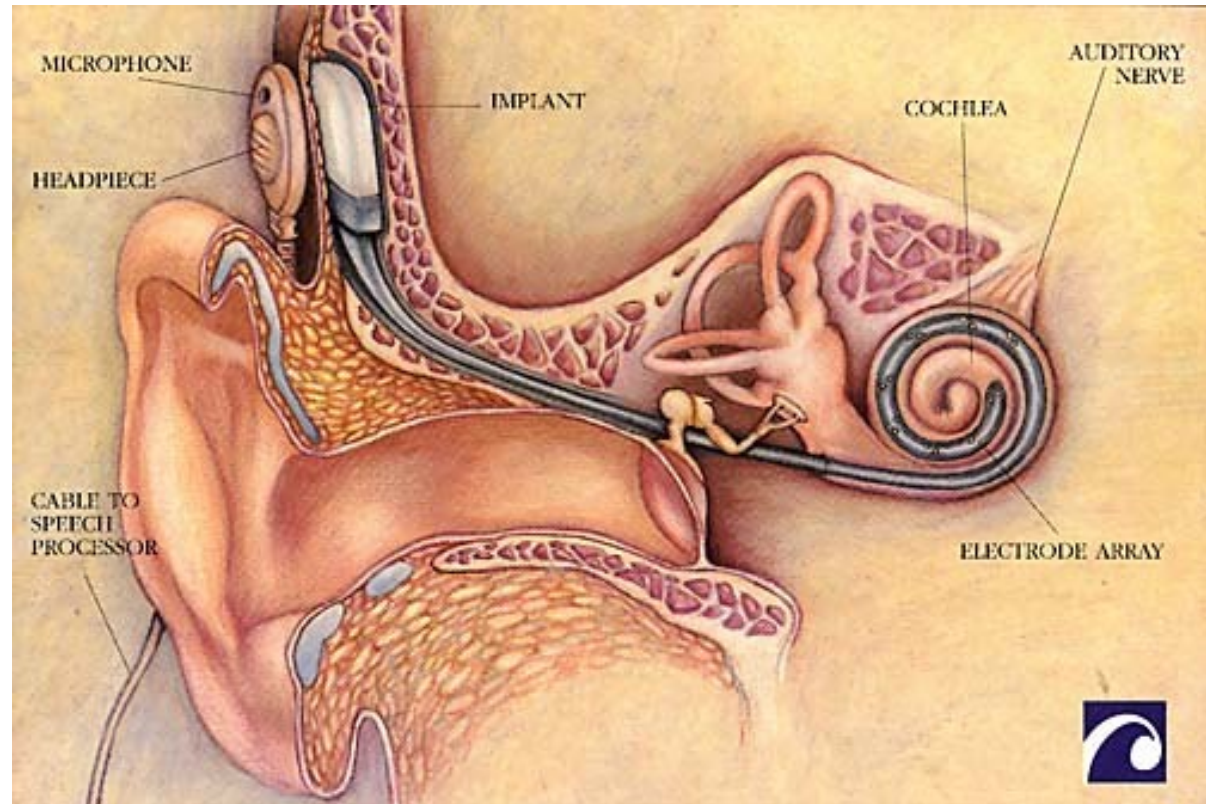
Hearing aid - correction of hearing disorders

Hearing aid: Consists of a microphone, amplifier, energy supply and a reproduction system (loudspeaker). It is an earphone with the end-piece inserted into meatus. For bone conduction, it is better to use a **vibrator** fixed to *proc. mastoideus*.

Purpose of hearing aids: amplification of frequencies at which hearing is lowered. Filtration. Hearing aids can be mounted into side-pieces of glasses.



Cochlear implant



• <http://www.accessexcellence.org/AB/BA/biochip3.html>

- This up to date method utilises the electronic cochlear implants, which can partly replace the Corti's organ, mainly in children which have functioning auditory nerve. It is an electrode system implanted into cochlea, which can stimulate the nerve, by impulses generated by a so-called speech-processor.

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