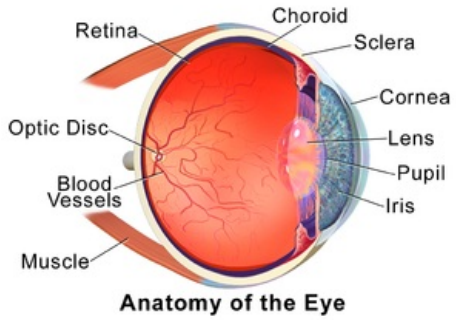
Eyesight

Sight is the most important sense for humans. A person obtains **up to 90%** of information from the external environment using vision. Vision is a *complex process*, the essence of which is the reception and processing of signals in the form of photons, therefore we refer to **visible light** as that which has a wavelength in the range of **400-760 nm**. The main organ of vision is the **eye**. The human eye is a *spherical organ* with a diameter of about 24 mm.

Basic parts of the eye

The basic parts of the eye include:

- **retina**
- **choroid**
- **sclera**
- **vitreous body** (vitreous humor)
- suspension lens apparatus
- **lens**
- **posterior chamber** of the eye
- **anterior chamber** of the eye
- **pupil**
- **iris**
- **cornea**
- **ciliary body** (*corpus ciliare*)
- limbus



Anatomy of the eye

The **choroid** expands into the **ciliary body**, which includes the smooth muscle *musculus ciliaris* . The choroid also creates a *continuous septum* called the **iris**, which contains 2 main muscles: the *sphincter pupillae* innervated by the **parasympathetic** and *the dilator pupillae* innervated by the **sympathetic**. In the center of the iris is a circular opening called the **pupil**.

The **lens** is located behind the iris, on the edge of which fine fibers (*fibrae zonulares*) are attached, which originates from the ciliary body. The inner layer of the wall of the bulb is formed by the **retina**. In the region of the posterior pole of the eye, the retina is suddenly narrowed, this entire area is about 3mm in diameter and is called the *macula lutea* (yellow spot) and **the place of sharpest vision**. The entire space of the bulb behind the lens is filled by the **vitreous humor**. Both *eye chambers* are filled with aqueous humor.

Functions of aqueous humor

The **aqueous humor** serves to ensure optimal optical properties of the eye. It creates a certain pressure on the vitreous body and the wall of the bulb, thereby creating the *correct tone* of the eyeball. The pressure of the aqueous humor is referred to as **the intraocular pressure** and its value is around **15 mmHg.** This proper size is maintained by the balance between the formation and outflow of aqueous humor. If there is an increase in the pressure of the aqueous humor, this disease is called *glaucoma*. Aqueous fluid has a similar composition to blood plasma and circulates constantly, it is formed by the ciliary body and first drains into the posterior chamber of the eye, from where it then passes into the anterior chamber of the eye, drains into **Schlemm's canal** and then into the venous system of the eye.

Optical system

The light beam must pass through **4 different environments** (cornea, aqueous humor, lens and the vitreous body). A real, inverted and reduced image is created on the retina. The CNS itself transforms it into its true form. The total **optical power** of the eye when looking into the distance is **+59D**. Light rays emanating from an object located further than 6 m already arrive **parallel** and intersect in the focal plane. When the eye lens is flattened, it has the smallest *optical mass of 19 D*. However, if the object were to approach less than 6 m, then the rays would appear as **diverging**. Based on this, there must be a change in the eye, otherwise the rays would cross *behind the retina*. Therefore, when looking at close objects, the *optical power of the eye increases*, and this process is called **accommodation**.

Close point is the place *closest to the eye* where we can still see the object **clearly**. The **far point** is the *farthest point from the eye* where we can still see the object **clearly**, for a legally functioning eye the far point lies at infinity. The *accommodation mechanism* is relatively simple. The lens is suspended by fibers on the suspension apparatus on the ciliary body, and when looking into the distance, the fibers are *tense* - the lens is *flattened* and its power is the *smallest*. During accommodation, the ciliary muscle contracts - the ciliary body moves forward and inward, which causes the tension of the fibers to relax, the lens to *arch* and *increase its power*.

Retina

Axons of glial cells converge to the papilla of the **optic nerve** (*discus nervi optici*) and leave the eyeball as the *optic nerve* . There are around **120 million rods** and **6 million cones** on the retina of one eye. The optic nerve contains *1 million axons*. Rod photopigment absorbs light of wavelength *505 nm (blue-green)*, and cone photopigment absorbs light of wavelength *420 nm (blue), 531 nm (green), and 558 nm (red)*.

In the area of **the central pit**, there is the greatest concentration of cones and rods are completely absent. Color vision is best perceived in this place, but at the same time there is lower sensitivity to light. At an angle of 20° from the central pit, there is the greatest concentration of rods and cones are almost completely absent. There is a high sensitivity to light in this place, but only monochrome vision is perceived here. **The blind spot** is located in the area of the optic nerve papilla and the rods and cones are absent.

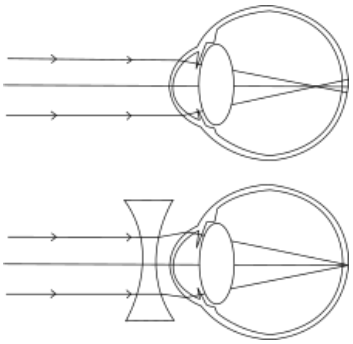
Signal transformation

The impact of appropriate light on the disk membrane causes **the breakdown of photopigment** (rhodopsin, which is composed of **11-cis retinal and opsin**) - GP, which has the character of *hyperpolarization.* In the dark, sodium channels are open and the photoreceptor membrane is *depolarized* (−30mV). The light then decomposes pigment to **11-cis retinal**, one of its intermediates activates transducin (g-protein), which activates **photodiesterase**. Photodiesterase then breaks down cGMP to GMP, then sodium channels close and hyperpolarize. In the dark, trans-retinal is then regenerated into 11-cis retinal. The alcohol trans-retinol - 11-cis retinol circulates in the blood and it is oxidized to 11-cis retinal.

Defects

- **Myopia (nearsightedness)**

The bulb is too long for the optical power of the eye. *Rays* from a distant object *converge **in front of** the retina.* Therefore, the distant point is not at infinity, but at a distance of less than 6 m. Correction using **scatterers (concave lens)**.



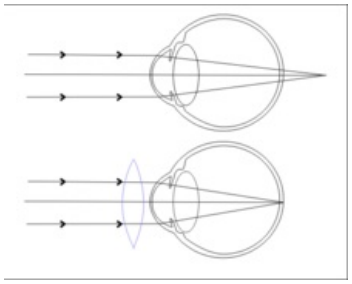
Myopia

- **Hyperopia (farsightedness)**

The bulb is too short for its optical power. *Rays* from a distant object *converge **behind** the retina*. So the distant point does not lie at infinity, but behind the retina. Correction using **conjunctions.**

- **Astigmatism**

Under normal circumstances, *the cornea is curved equally* in all planes. If the cornea is curved more in one of the planes than in the others, it shows greater optical power in this plane. A person with this disease sees an object that is composed of vertical and horizontal lines clearly only horizontally. Even the cornea of a healthy eye is not curved the same everywhere - *physiological astigmatism* . Correction using a **cylindrical lens** (with an overlap of 1 D).



Hyperopia

- **Presbyopia**

This is the loss of the accommodation ability of the lens. It can be corrected with couplings.

- **Black blindness**

11-cis retinol is formed from **vitamin A** metabolites . Its deficiency leads to reduced production and this causes reduced sensitivity to light, especially at low light intensities.

- **Diabetic retinopathy**

One of the most common diseases of the retina. Cells around small blood vessels (*pericytes*) form sorbitol when there is an increased need for glucose, which causes swelling and narrowing of vessels and subsequent tissue ischemia. The formation of angiotensin II, which stimulates the formation of VEGF - increased permeability of blood vessels and new formation of blood vessels and bleeding, cloudiness occurs.

Fundus photo showing scatter laser surgery for diabetic retinopathy

- **Central artery occlusion**

It leads to the destruction of amacrine, bipolar and ganglion cells and thus to blindness.

Links

Related articles

- Cataract
- Glaucoma

References

- KRÁLÍČEK, Petr. *Úvod do speciální neurofyziologie.* 3. edition. Galén, c2011. ISBN 97-880-7262-618-2.
- SILBERNAGL, Stefan – LANG, Florian. *Atlas patofyziologie.* 2. edition. Grada, 2012. ISBN 978-80-247-3555-9.