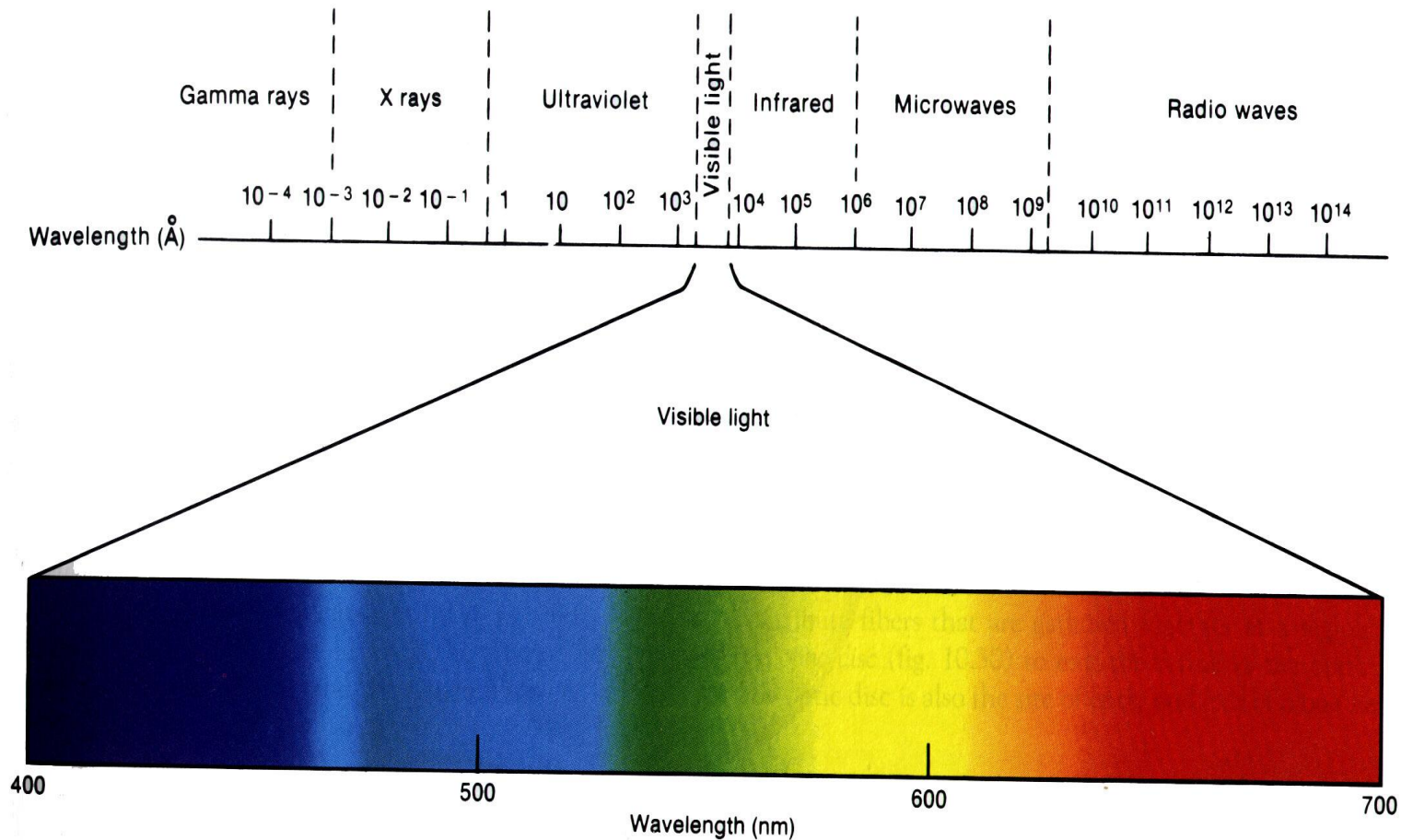


Physiology of eye. Physiology of vision



Diapasone of the visible light

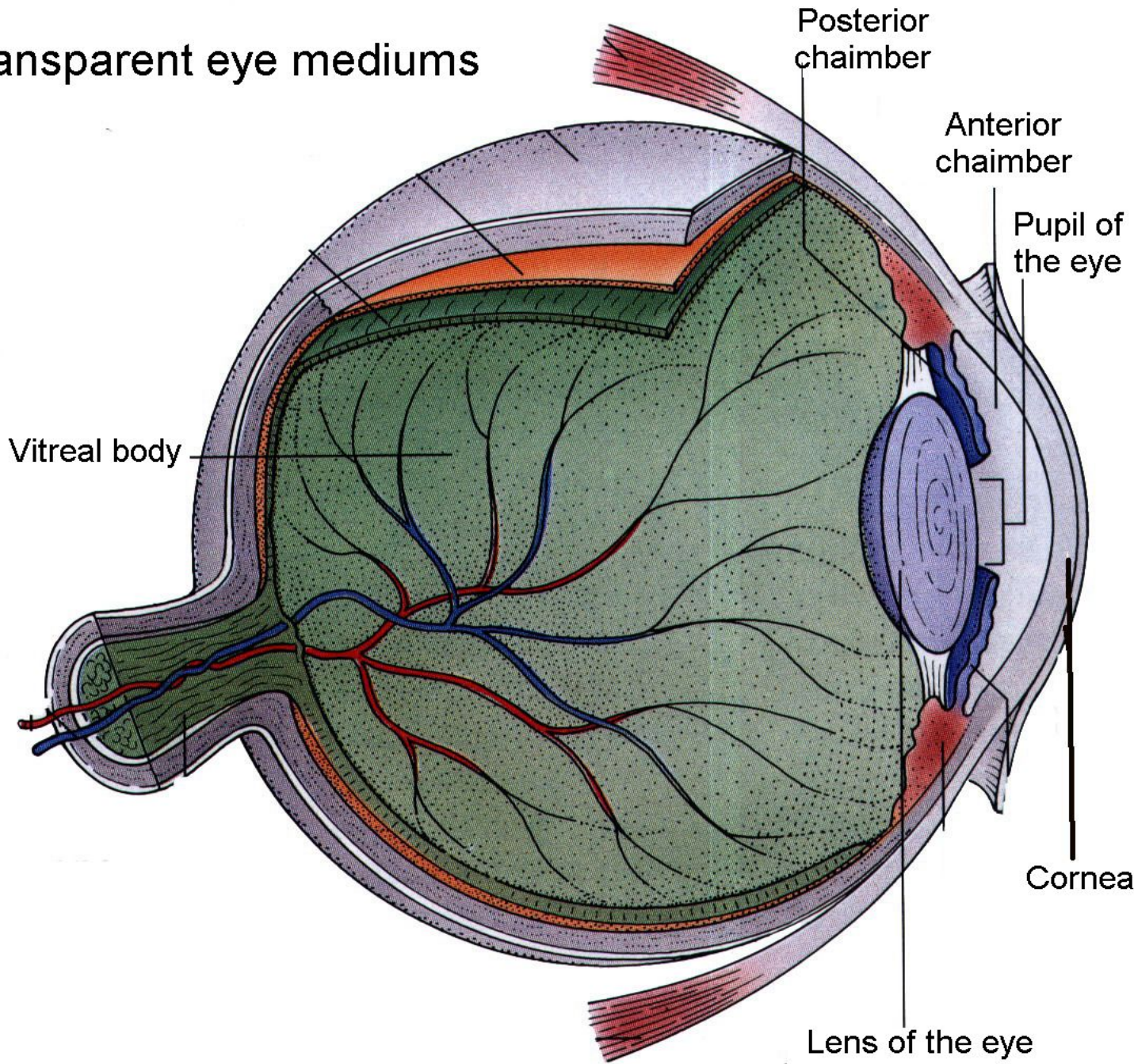


Optic system of eyeball

- Cornea allows light to enter the eyeball.
- Aqueous humor fills anterior and posterior chambers in front of lens.
- Crystalline lens is a transparent elastic and biconcave lens, which refracts light and focuses it on retina.
- Vitreous body is a transparent gel enclosed by vitreous membrane, which fills eyeball behind lens.



Transparent eye mediums



Aqueous humor circulation

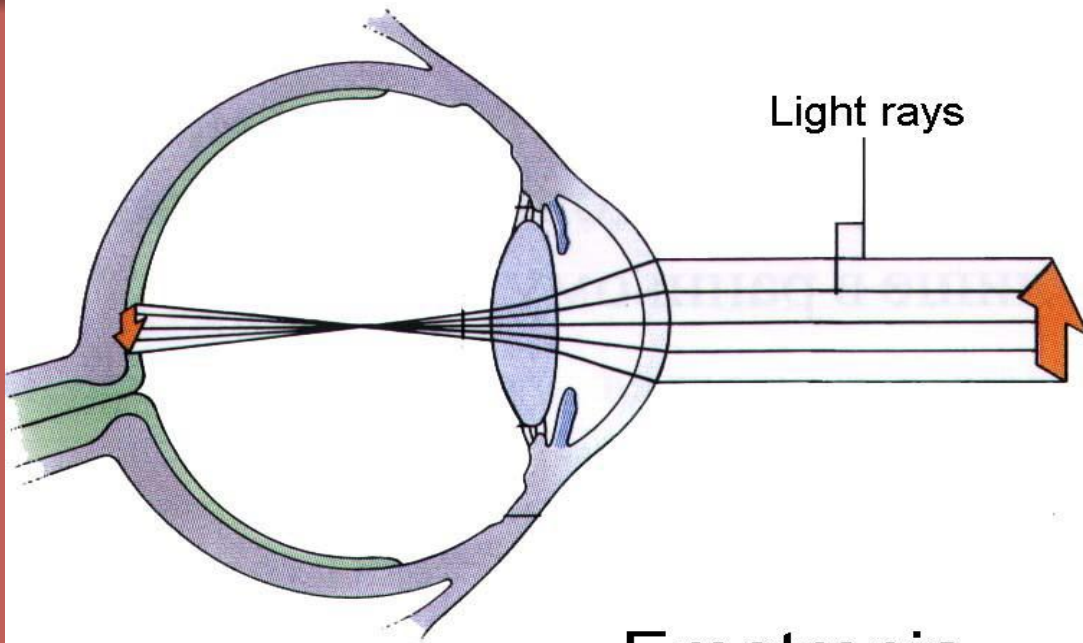
- Ciliary processes in posterior chamber secrete aqueous fluid. It flows between the ligament of the lens and then through the pupil into the anterior chamber of the eye. Then fluid passes into the angle between the cornea and the iris. Through the meshwork of trabeculli aqueous humor enters the channel of Slemm, which empties into extraocular veins.
- Functions of aqueous humor: 1) maintains intraocular pressure; 2) maintains shape of eyeball; 3) acts as refractory medium; 4) supplies nutrition; 5) drains metabolic end products.



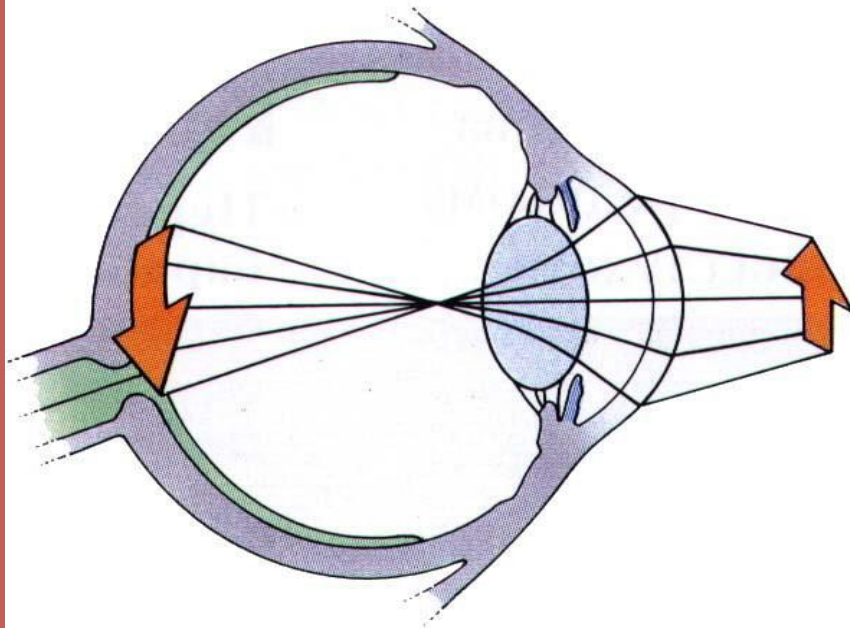
Physical refraction and reduced eye

- Refraction is bending of light rays at surface between two media. Ratio of velocity of light in air to that in a medium is called refractive index of that medium. If all refractive surfaces of the eye are added together and considered to be one single lens and shape of eyeball is perfectly spherical, eye may be simplified. This is model, which shows refraction in eyeball – “reduced eye”.
- In this model total refractive power is 59 diopters, when lens is accommodated for distant vision. It is considered that single lens exists at 17 mm in front of retina.
- As a result in the retina is formed image, which is inverted, true and reversed with respect to the object.





Emetropia



Clinical refraction

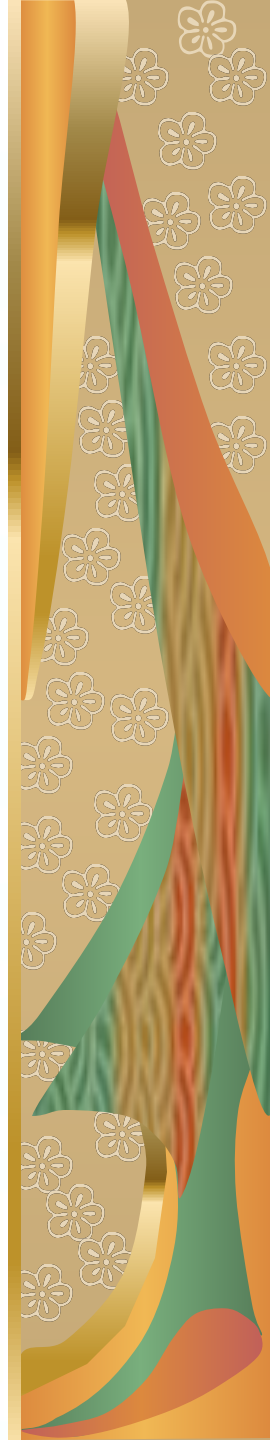
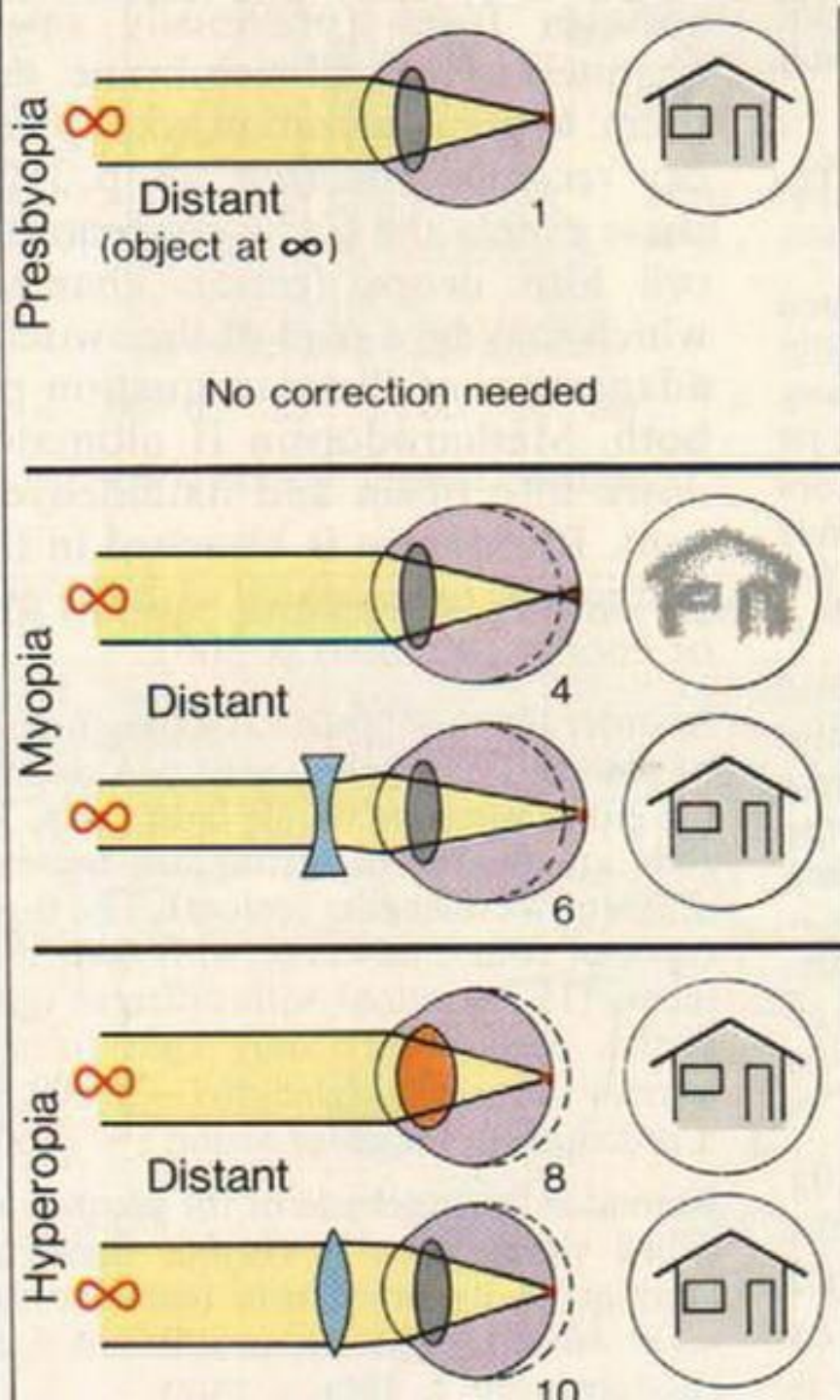
- All variants of refraction, which are observed in patients we call clinical refraction. These are emmetropia, hypermetropia and myopia.
- Emmetropia is normal and ideal condition of eye, when parallel light rays from distant object are focused on the retina with ciliary muscle completely relaxed. Such a condition is observed in perfectly spherical eyeball.
- In hypermetropia parallel light rays are focused behind retina because of shortening anatomical axis of eyeball. Concave lenses should correct it.
- In myopia parallel light rays are focused before retina because of long anatomical axis of eyeball. Convex lenses should correct it.



- Presbyopia occurs due to a lessening of flexibility of the crystalline lens, as well as to a weakening of the ciliary muscles which control lens focusing, both attributable to the aging process.

- If the incoming light from a far away object focuses before it gets to the back of the eye, that eye's refractive error is called "myopia" (nearsightedness).

- If incoming light from something far away has not focused by the time it reaches the back of the eye, that eye's refractive error is "hyperopia"



Aberrations and astigmatism

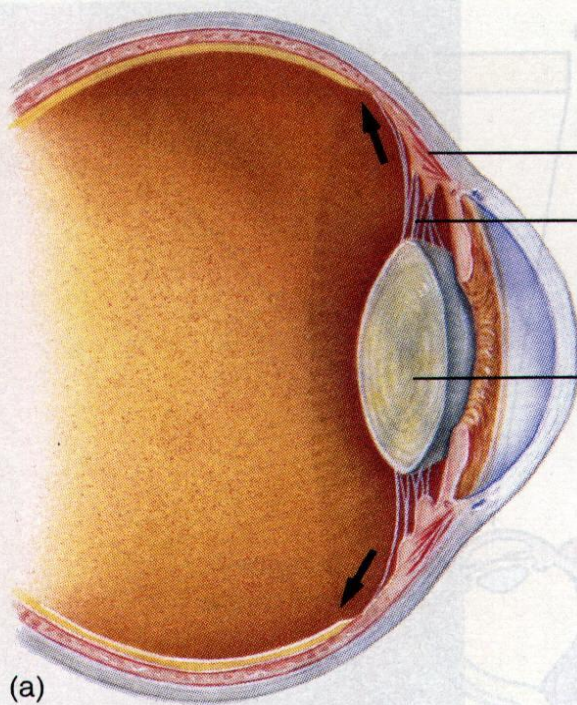
- In spherical aberration light rays pass through peripheral parts of the eye lens and are not focused sharply. This is because of more refractive power in central part of lens. Due to this effect object lose clear contour.
- Unequal deviation of light rays of different wavelengths causes in this condition chromatic aberration. This is focusing of different colors at different distances behind lens. Due to this object get rainbow contour.
- Diffractive aberration occur in case of small dust interfere to light rays in clear mediums of eyeball (for instance foreign body). So point object looks like rounded by gray and white circles.
- Astigmatism is an error of refraction in which light rays do not all come to a common focal point. Oblong shape of cornea or lens causes it. So, cylindrical lenses may correct this defect of refraction.



Accommodation and its regulation

- Accommodation is adjustment of eye lens for various distances. Relaxation of ciliary muscle cause decrease of refractive power of eye lens and provides clear vision for long distance.
- Decrease of parasympathetic influence to ciliary muscle controls it. In case of parasympathetic stimulation of ciliary muscle, it contracts, lens ligament relax, lens get more spherical, refractive power increases and eye can see clear near objects.



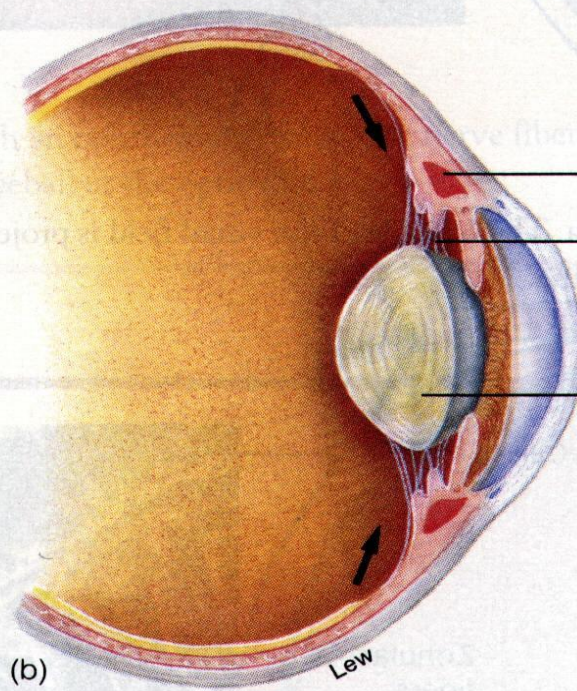
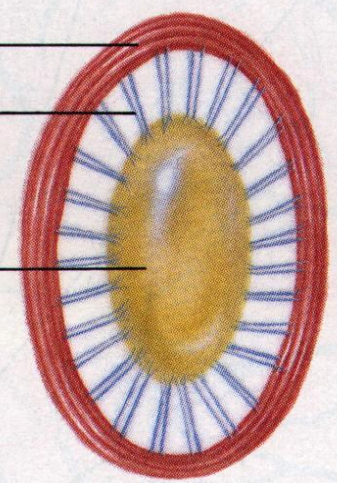


Ciliary muscle relaxed

Suspensory ligament taut

Lens thin and focused for distant vision

(a)



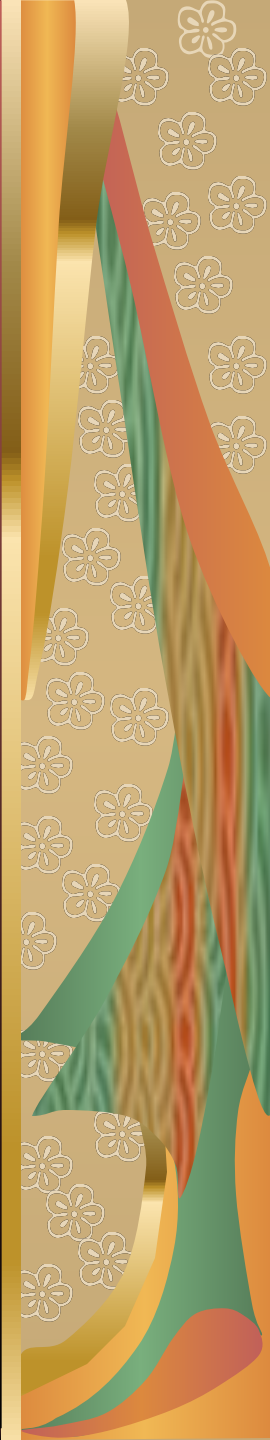
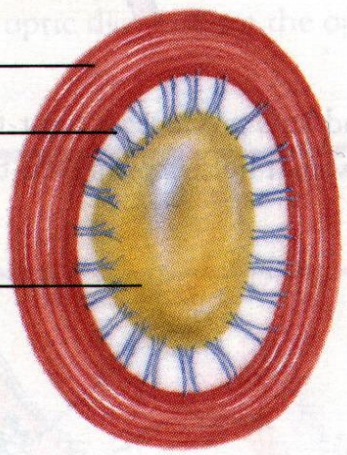
Ciliary muscle fibers contracted

Suspensory ligament relaxed

Lens thick and focused for close vision

(b)

Lew



Defensive mechanisms in eye

- Fibrous tunic of eyeball is composed by avascular connective tissue, which gives shape to eyeball and protect structures inside eyeball.
- Functional defensive mechanisms are presented by cornea reflexes. Irritation of cornea receptors gives impulses to parasympathetic center in medulla oblongata (Edinger-Westfal nucleus) and than in hypothalamus, which permits tears secretion.
- Limbic system also controls tear secretion. Blinking reflex is controlled by n. trigeminus and n. facialis, which innervate m. orbicularis oculi.



Pupillary reflexes

- When light pass into eye, pupil contracts. In darkness pupil dilates. This is pupillary light reflex, which helps to adaptation to light conditions. Reflex arc: light receptors - optic nerve- optic tract - pretectal area - Edinger-Westfal nucleus - parasympathetic fibers of n. oculomotorius (from n. trigeminus) - n. ciliaris - m. sphincter pupillae - decrease of pupillary diameter.
- Consensual pupillary light reflex: reaction of eye pupil to light irritation of opposite eye. It is possible due to diverging of nerve fibers from one pretectal nucleus to both Edinger-Westfal nuclei.



Age peculiarities in eye structure

- In old age lens of eye loose elasticity. So this condition, when lens become non-accommodating, called pressbiopia. It should be corrected by bifocal glasses with upper segment focused for far-seeing and lower segment focusing for near-seeing.
- In newborn anatomical axis of eyeball is shorter, comparing to adults.



Development of refraction

- In newborn eye is hypermetropic. Eyeball grows with age, and normally gets spherical at maturation period. This process is called emetropisation.
- Grate visual load in childhood and maturation period lead to increase of intraocular pressure. It may result in increase of anatomical axis of eyeball and myopia.



Composition of retina

Layers of retina from outside to inside:

- pigmented layer;
- layer of rods and cones;
- outer limiting membrane;
- outer nuclear layer;
- outer plexiform layer;
- inner nuclear layer;
- inner plexiform layer;
- ganglionic layer;
- layer of optic nerve fibers;
- inner limiting membrane.



Physiological peculiarities of pigmented layer and photoreceptors.

- Light falls on retina on inner side i.e. on inner limiting membrane. It is a minute area of 1 mm in center of retina. It provides acute and detail vision.
- Central portion of macula called fovea centralis. This is composed entirely of cones.
- Pigmented layer of retina contains black pigment, i.e. melanin. It prevents light reflection through the globe of eyeball and stores vitamin A.



Photochemical reactions in retina

- Outer segment of photoreceptors contain photochemicals. Inner segment contains nucleus, synaptic body and other organelles. Photochemicals are light-sensitive chemicals that decompose on exposure to light and excite nerve fibers leading from eye to central nervous system.
- Rhodopsin is present in rods. Scotopsin and 11-cis-retinal compose it. Iodopsin is photochemical pigment of cones. Photopsin and 11-cis-retinal compose it. Rhodopsin cycle: rhodopsin under the influence of light converts to prelumirhodopsin – lumirhodopsin – metaphodopsin I - metaphodopsin II – opsin – rhodopsin. Metarhodopsin II converts also to all-transretinal (vitamin A) – (isomerase's action) – 11 cis-retinal – rhodopsin.



Central division of visual analyzer

- Impulses from retina pass to optic nerve – optic chiasm (fibers from nasal halves of retina cross to opposite side) – optic tracts – synapse in lateral genicular body – geniculocalcarine fibers – pass through optic radiation or geniculocalcarine tract – primary visual cortex in calcarine fissure or medial aspect of occipital lobe.



Other connections of optic tract

In addition to lateral genicular body, fibers from optic tract also pass to:

- - suprachiasmatic nucleus of hypothalamus for controlling circadian rhythms;
- - pretectal nuclei – for control of fixation of eyes on objects of importance and for pupillary light reflex;
- - superior colliculus – for control of bilateral simultaneous movements of two eyes;
- - pulvinar – forms secondary visual pathway.
- Corpus callosum causes exchange of visual information between right and left hemispheres.



Light and dark adaptation

- . If a person remains in bright light for a long time, photochemicals in rods and cones reduce to all-transretinal and opsins. Most all-transretinal converts to all-transretinol (vitamin A). So, sensitivity of eye to light gets decreased. This is light adaptation.
- If a person remains in dark for a long time, all vitamin A convert to 11-cis retinal and than to photochemicals. Sensitivity of eye to light gets increased. This is dark adaptation.



Theories of color perception

- According to Jung-Helmholtz theory there are three types of cones for three fundamental colors: cones for red color contain erythrolab; cones for green color contain chlorolab; cones for blue color contain cyanolab.
- According to Gering theory there are couples of opponent colors: green – red; yellow – blue; white – black. Subcortical neurons percept it due to on- and off-centers mechanism.



Disorders of color perception

- There are three fundamental colors: red, which is marked “protos”; green – “dateros”; blue – “tritos”. So normal color perception is called normal trichromasia.
- If a person has abnormal perception of some fundamental color, this is prot-, daiter- or tritanomalia. If a person percept only some two fundamental colors, this is dichromasia.
- If a person differentiates only one fundamental color this is monochromasia. In case of black and white vision a person has color blindness.



Visual acuity

- Ability of human eye to discriminate between point sources of light is called visual acuity.
- Normally a person with vision acuity 1,0 can differentiate two point objects, which lay under the angle 1 minute from distance 5 m.



Field of vision

- Field of vision is area that is seeing by an eye at a given instant. It has nasal and temporal division.
- Determination of extent of peripheral visual field and thereby diagnosis of blindness in specific portions of retina, is called perimetry.
- Optic disc produces physiological scotoma in 15 degrees lateral to central point of vision in perimetry chart.



Binocular vision

- Binocular vision provides detection of distance and three-dimensional appearance of object in front of eyes.
- This is due to central analysis of fields of vision from both eyes.
- Final visual image is formed in visual cortex.

