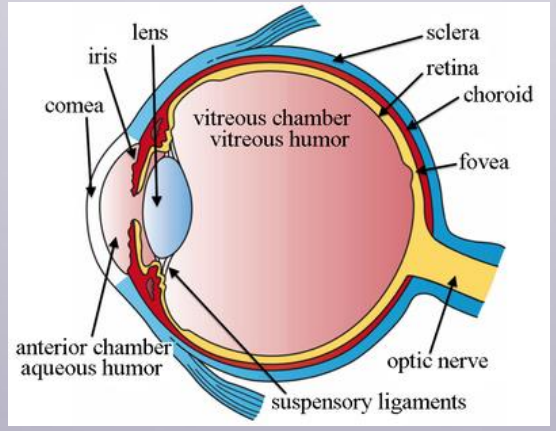
1- VISION

PNS MODULE



Prof. Sherif W. Mansour

Mutah school of medicine

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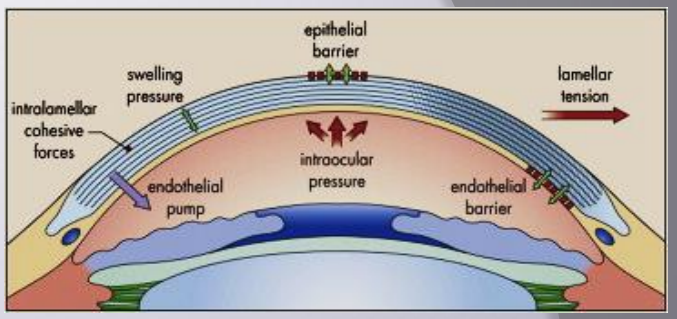
THE CORNEA

The cornea is the transparent **anterior 1/6** of the outer coat of the eye. It resemble a disc of about 11 mm in diameter and a thickness of about 1mm at the periphery and only 0.5 mm at the center. The cornea has alone a refractive power of about **44 diopters** (**75 %** the total refractive power of the whole eye).



Causes of corneal transparency:

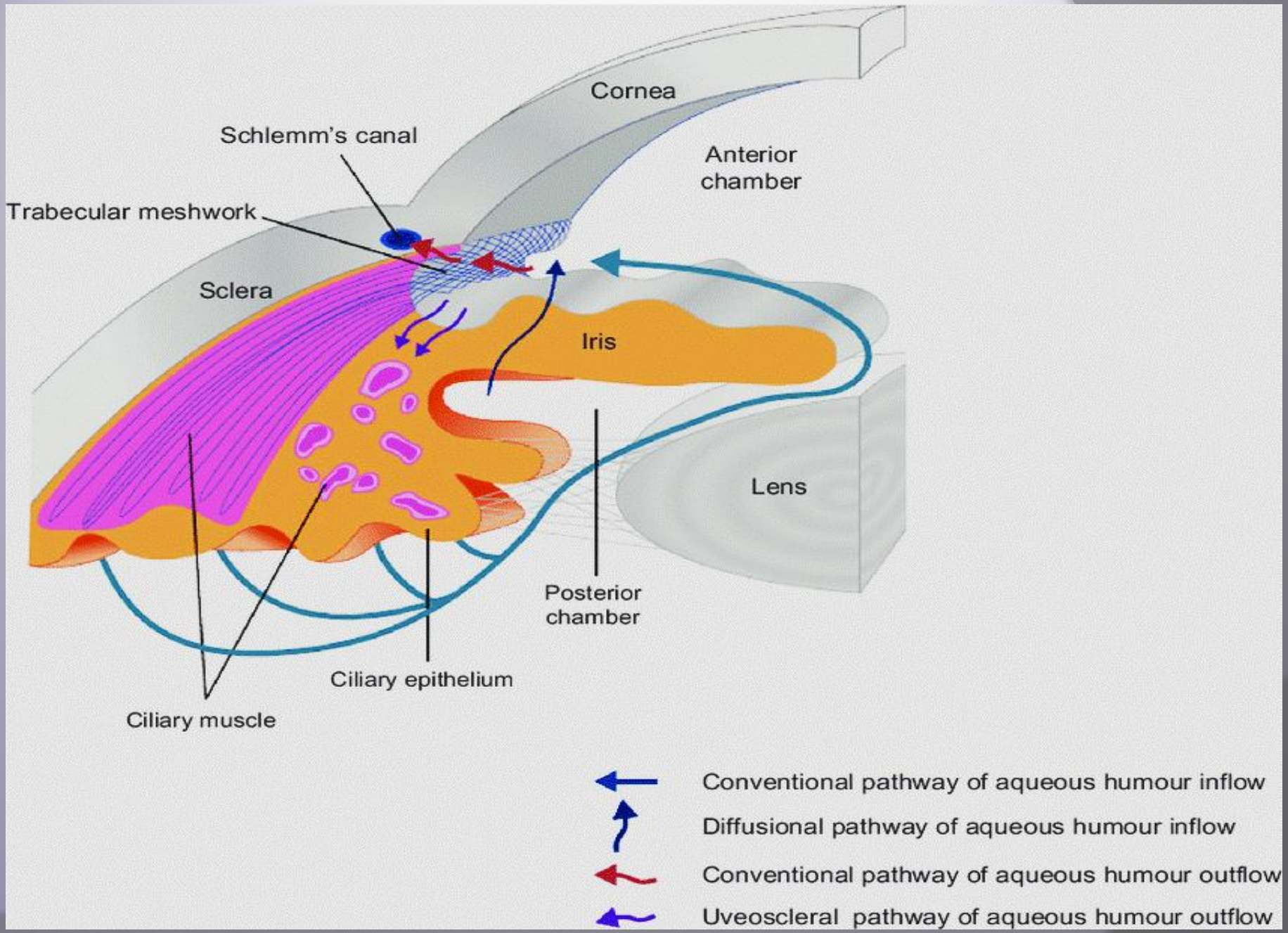
1. The avascularity of the cornea (it is devoid of blood vessels).
2. The corneal collagen bundles are regularly arranged.
3. Absence of myelin sheath in the corneal nerve fibers.
4. Relative corneal dehydration: The transparency of the cornea also depends on its water content. In order to maintain the transparency of the cornea by **(a) Metabolic pump:** This is an active process that occurs in the corneal endothelial layer and results in expulsion of fluid into the aqueous humor.

(b) Osmotic pump: the osmolality of the fluids that surround the cornea (the aqueous humor posteriorly and the tears anteriorly) are relatively **greater** than that of the cornea.

5. The refractive index is **the same in** all the corneal layers =**1.37.**
6. Vitamins as vitamin "A" which prevents keritinization also vitamin B_2 (riboflavin) prevents corneal vascularization.

Functions of the Cornea

1. It admits light to enter the eye because of its transparency.
2. It acts as strong refractive media (**44** diopters).
3. The great sensitivity of cornea acts as protective mechanism for the inner delicate structure through the corneal reflex (touching cornea, eye lashes or eye lids leads to strong closure of lids).
4. Corneal reflex indicate degree of anesthesia.


Cornea
Schlemm's canal
Anterior chamber
Trabecular meshwork
Sclera
Iris
Lens
Posterior chamber
Ciliary epithelium
Ciliary muscle
Conventional pathway of aqueous humour inflow
Diffusional pathway of aqueous humour inflow
Conventional pathway of aqueous humour outflow
Uveoscleral pathway of aqueous humour outflow

THE AQUEOUS HUMOR

The space between the cornea and anterior lens surface is called the **anterior chamber**. The narrow circular space between the iris, lens and the ciliary body is termed the **posterior chamber**. Both anterior and posterior chambers contain aqueous humor which is a clear transparent fluid.

Formation of the aqueous humor

The volume of the aqueous humor = 200 mm3 it is formed at the rate of 2 mm / min by the ciliary processes that is projecting from the ciliary body in the posterior chamber.

Outflow of aqueous humor from the eye:

The aqueous humor is formed by the ciliary processes and enters the posterior chamber, it flows through the suspensory ligament of the lens, then through the pupil into the anterior chamber of the eye. Here, the fluid flows into the angle between the cornea and iris called irido-corneal or filtration angle and then to spaces between a network of trabeculae called **spaces of fontana** to reach the **canal of Schlemm**. The canal opens into the **aqueous veins** which lead to the **ocular veins**.

Function of the aqueous humor: -

1) It supplies the avascular cornea and lens with nutrients and removes waste products.

2) It maintains the intraocular pressure.

3) It plays a role as a refractive medium in the eye.

Intraocular pressure (IOP)

The intraocular pressure in man is **15-20** mmHg. The intraocular pressure remains constant inspite of wide changes in the arterial blood pressure. In man the intra-ocular pressure is measured indirectly by an apparatus called "Tonometers".

THE VITREOUS HUMOR

It is avascular transparent **jelly like** substance which fills the space between lens and the retina. It also called the vitreous body.

The vitreous is separated from the lens by a very narrow space that admits slight bulging of posterior surface of the lens during accommodation called the retro-lental space.

Moreover, the whole vitreous is enclosed in a thin membrane which is adherent firmly to the retina around the optic disc.

The vitreous is traversed from the posterior space of the lens to the optic disc by a canal (hyaloid canal) which acts as a lymph channel. The vitreous also takes it's nutrition by diffusion from choroid vessels.

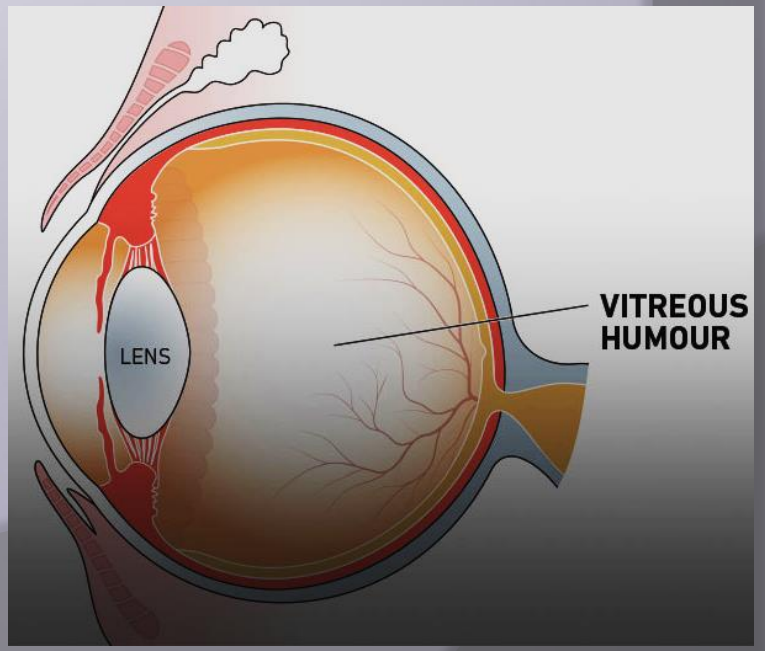
Functions of the vitreous:-

1- Shock absorber to protect delicate retina from injury.

2- Support lens in its position.

3- Maintain normal globular shape of the eye.

4- It plays a role as a refractive medium in the eye.



THE LENS

It is avascular transparent biconvex structure which is held by the suspensory ligament in position behind the iris and in front of the vitreous body. The lens is gelatinous structure enclosed in an elastic capsule.

The refractive index of the periphery of the lens is **1.38** while that of the central part is **1.4**. The refractive power of the lens during rest (none accommodated) = **15 D**. in healthy young adult and up to **32 D**. during maximum accommodation to near vision.

The causes of lens transparency:-

1- Manner of fibers arrangement.

2- The colloid solubility of its high protein content (30 - 35 %).

3-The refractive indices of its different layers are similar.

4-Effective and active metabolic processes which maintain the chemical composition of its fibers.

5- It is non vascular.

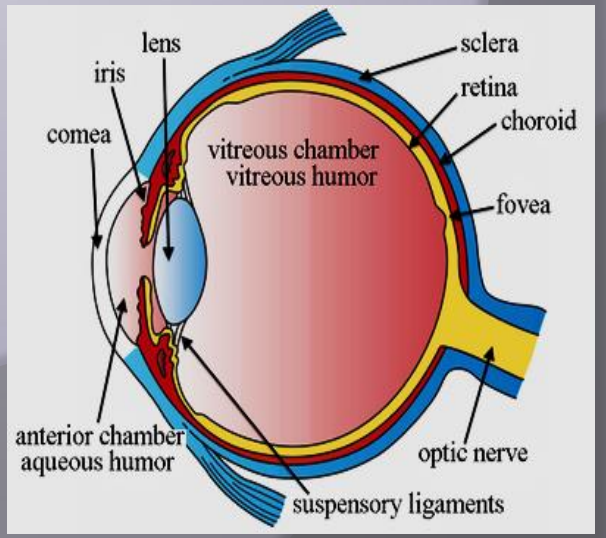
Functions of the lens:-

1 - It is a transparent media which allow light to reach the retina.

2- Acts as a refractive media having a diopteric power of **15-32** diopter.

3- Accommodation to near and far vision for accurate focusing.

4- Protect retina from harmful ultraviolet rays (by absorb them).



THE IRIS

It is a thin disc like diaphragm arises from the anterior surface of the ciliary body and lies between the cornea and lens. It is opaque and contains melanin pigment which gives the eye its characteristic color. The central aperture in the iris (pupil) is controlled by the circular and radial muscle fibers of the iris.

Functions of the iris:

1. A major function of the iris is to **control the amount of light** that enters the eye.
2. It prevents light rays from falling on the periphery of the eye lens to **decrease the spherical and chromatic aberrations.**
3. Constriction of the pupil increases the **depth of focus** of the lens system of the eye , this mechanism makes the distance of the object can be changed but it's image still focused on the retina without another new change in accommodation.
4. Recognition of iris patterns by a video camera that captures iris images and translates the landmarks into a computerized code is more foolproof than fingerprinting or even DNA testing (basis of the latest identification technology).

Some important pupillary reflexes

A- Pupillary light reflex:

When one eye is exposed to light its pupil **constricts** (direct pupillary light reflex). The pupil of the other eye also **constricts** at the same time (indirect or consensual light reflex).

Nervous pathway

When light falls on the retina → optic nerve, optic chiasma to the optic tract. Collateral fibers from the optic tract end in the pretectal nucleus in the mid brain (**center** of the reflex). Here, impulses pass to the Edinger-Westphal nuclei of oculomotor nerves of both sides and finally back through the parasympathetic nerves to constrict both eye pupils.

Abnormal pupillary light reflex:

1.In neuro-syphilis, the pupillary light reflexes are lost due to lesion in the pretectal region of the brain stem. However, the pupil can still constrict due to accommodation to near objects. **"Argyll Robertson pupil".**

2.In **Horner's syndrome**, the pupil remains persistently constricted due to paralysis of the dilator pupillae muscle as a result of lesion in the sympathetic nerves to the eye.

3.Reverse Argyle Robertson pupil, in which pupil reacts with light but does not react with near accommodation. It occurs in lesions affecting the occipito-tectal tract.

Changes in the pupils during anesthesia:

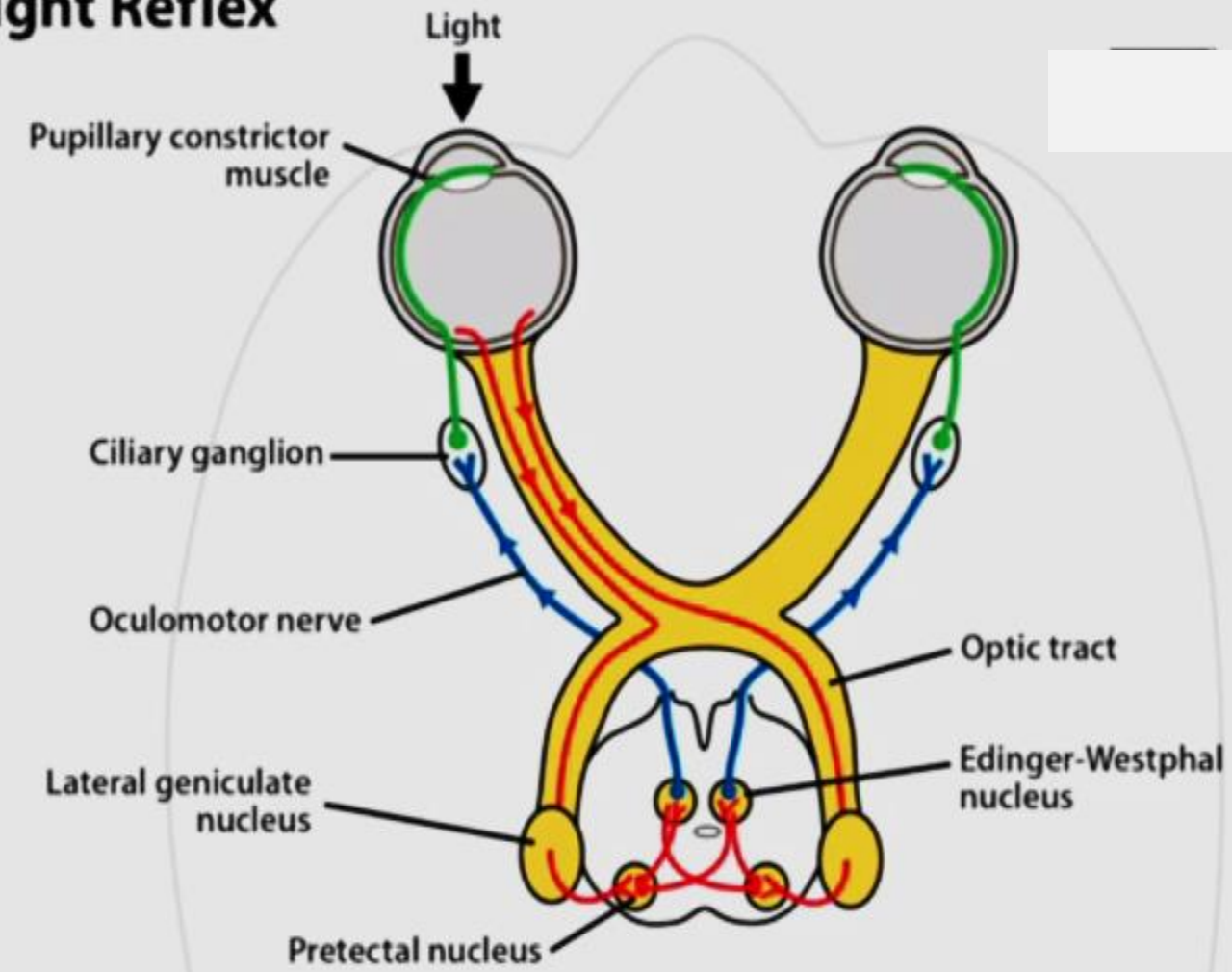
I- During the **first** stage, the pupils may be of **normal size or slightly dilated** react to light. Moreover, corneal reflex is intact.

II- During the **second** stage, the pupils are **dilated more**, with intact light and corneal reflexes. It is accompanied with sympathetic stimulation.

III- During **the third** stage, the pupils are **constricted** due to release of the Edinger-Westphal nucleus from the normal cortical inhibition, with absence of light and corneal reflexes (Stage of surgical anesthesia).

IV- Stage of deep anesthesia or stage of medullary inhibition, during which the pupils are fully dilated with absence of light and corneal reflexes

Pupillary Light Reflex



Miosis	Mydriasis
I - Pupillary light reflex (light adaptation). 2-Accommodation reflex (near vision). 3- Sleep due to increase of the parasympathetic tone. 4- Surgical anesthesia (stage III). 5- Horner's syndrome (paralysis of cervical sympathetic division). 6- Stimulation of semicircular canals (during rotation). 7-Pontine hemorrhage affects pupillodilator centre. 8-Drugs: a-Parasympathomimetics e.g. • **Acetylcholine & pilocarpine**: acting directly on cholinergic receptors. • **Eserine & prostigmine:** (Anticholine esterase →↑ A.Ch. concentration). b-**Morphine** increases excitability of third cranial nerve nucleus by releasing it from inhibitory cortical effect (in morphine poisoning pupil reaches 1mm i.e pin point pupil very diagnostic sign).	1-Dark adaptation 2-Distant vision 3-Hypersecretion of adrenaline & noradretialine as in pheochromocytoma. 4- Injury of oculomotor nerve. 5-After stoppage of rotation 6- Stage I, II & VI of anesthesia. 7- Pain, emotions fear and asphyxia 8- Drugs: a.Sympathomimetics: as **adrenaline** injection stimulating the peripheral-adrenergic receptors. B.**Cocaine** increases the sensitivity of the dilator pupillae muscle to action of adrenaline or sympathetic stimulation. c.**Atropine** causes marked dilation and cycloplegia (paralysis of constrictor pupillae muscle) for long time.

B- Accommodation reflex:-

Accommodation in the eye means "changes which occurs in the eye and leads to changes in its diopteric power in order to focus objects.

These are changes which occur in the eye in order to focus near objects i.e. objects situated nearer than 6 meters. These changes are:-

1-Constriction of both pupils (miosis) due to contraction of constrictor pupillae.

2-Increase in the convexity of mainly the **anterior surface** of the lens in order to increase its diopteric power.

3-Medial convergence of both eyes.

The stimulus for the near accommodation reflex is the formation of a blurred (not clear) image on the retina.

Nervous pathway of near accommodation reflex:-

From retina (bipolar and ganglion cells) → optic nerve → optic chiasma where crossing occurs i.e. temporal fibers to same side and nasal fibers cross to opposite side → optic tract → lateral geniculate body of the thalamus →optic radiation to visuo-sensory area (area 17) in the occipital lobe → visuo-psychic area (area 18) → occipital eye field area (area 19) from these area **efferent** fibers pass as occipito-tectal tract to the midbrain where the centers of convergence are present (Edingher-Westphal nucleus). From this nucleus fibers pass to ciliary ganglia to relay in it then postganglionic fibers pass with short ciliary nerve to ciliary muscles causing its contraction, and contraction of the constrictor pupillae muscles → miosis.

Value of miosis in near accommodation:-

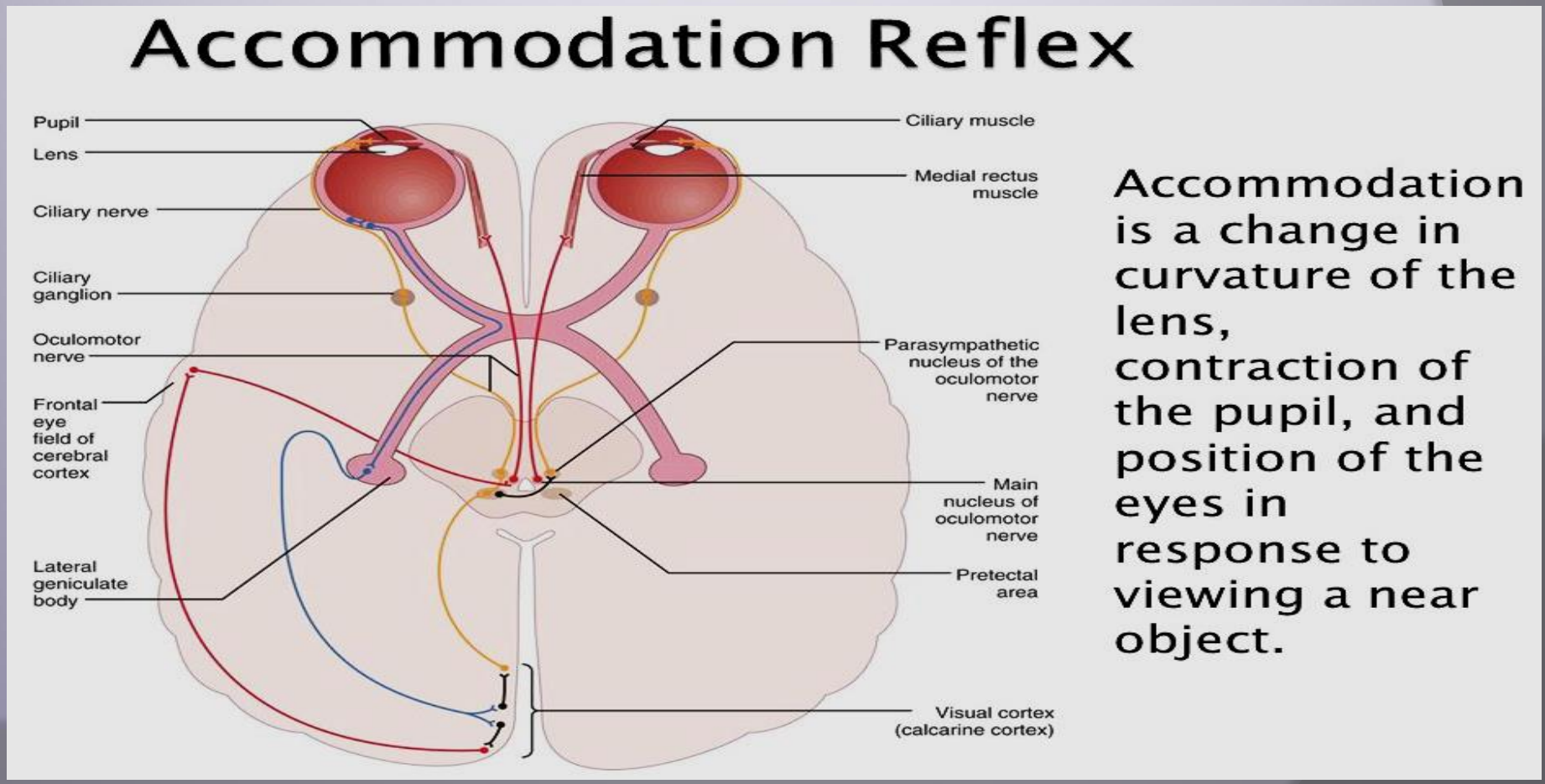
a- Covering the periphery of the lens preventing chromatic and spherical aberration,

b- Miosis increases **the depth of the focus** i.e. enable object to move and still its image is focused in retina without new accommodation.

c- Miosis makes image to be focused in **fovea centralis** which is the most visual acuity area in the retina.

d- Preventing **excess light** entry to fell on retina (protective function).

e- Bilateral miosis in near vision allows light rays to fell on the corresponding retinal points.



THE RETINA

The retina contains the photoreceptors (rods and cones) which transform light into action potential, beside it contains the neural elements of the first and second order neurons in the visual pathway.

Structure of the retina

The retina is formed of ten layers: the most important;

1- **Layers of rods and cones** (receptor layer). There are about 120 millions rods and only 6 millions cones. **Rods** are concentrated in the periphery of the retina and to less extent in the middle part. Rods are more sensitive to light than cones but less accurate in determining the visual acuity and are more functioning in dim (night or scotopic vision), beside rods can't determine color vision.

On the other hand, **cones** are more concentrated in the middle of the retina (fovea centralis contains cones only), they are less sensitive to light than rods more accurate in determining visual acuity. Also they are specialized in color vision and day or "photobic vision".

2- **Ganglion cell layer** (second order neuron in visual pathway).

Importance of some areas in the retina:-

1- **The optic disc**: it the site of the optic nerve exit from the retina, it is about 1.5 mm diameter and located about 3 mm to the nasal side. The optic disc is also the site of entry of the central retinal artery and exit of the retinal vein.

It does not contain photoreceptors, hence it is the cause of **the physiological blind spot** in the visual field which is not noticed due to great overlap between visual field of the both eyes.

2- **The macula lutea**: it is a yellowish spot about 1 mm2 located about 3 mm to the temporal side of the optic disc opposite to the posterior pole of the eye. The central part of the macula contains the **fovea centralis** which is a pit like depression about 0.4 mm2 in the center of the macula. The fovea is the most visual acuity area in the retina because it is composed of densely packed thin **cones** only. In the fovea each **one cone** is connected to **one bipolar cell** and this bipolar cell is connected to **one ganglion** cell which it's axon form separate fiber in the optic nerve.

Photoreceptor potential

• When the eye is not exposed to light (in the dark) Na+ is continuously pumped from the inner segment of the rods and cones to flow inside again at the outer segment in which it's Na+ channels are remain opened by cGMP.

• The continuous inflow of positively charged Na+ ions inside outer segment of rods decreases negativity inside them and thus the resting membrane potential (r.m.p) of them becomes low (only - 40 mv). The movements of Na+ from inner segment to enter into outer segment is called "dark Na+ current".

• The low R.M.P causes continuous release of an inhibitory chemical transmitter that inhibits synaptic transmission.

When light stimulates the photoreceptor and activated rhodopsin is formed it leads to activation of cGMP phosphodiesterase enzyme which transform cGMP into 5'GMP and **lowering** concentration of cGMP in the cytoplasm of photoreceptors with subsequent **closure of Na+ channels** in the outer segment

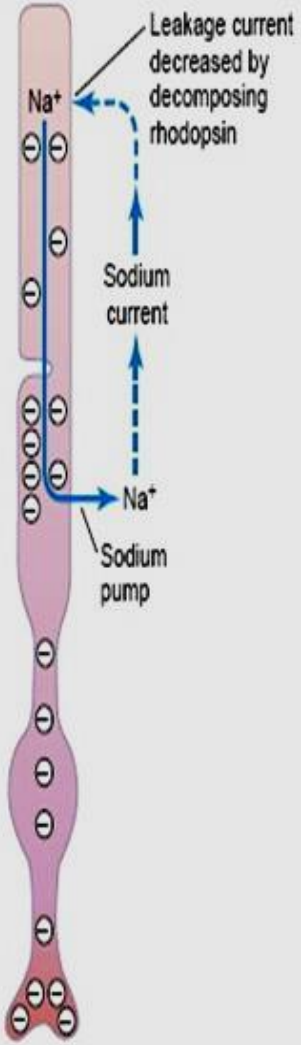
• Thus, Na+ is continuously pumped from inner segment but now is accumulated outside at the outer segment leading to **hyperpolarization** reaching up **to -70 mv instead of -40 mv**.

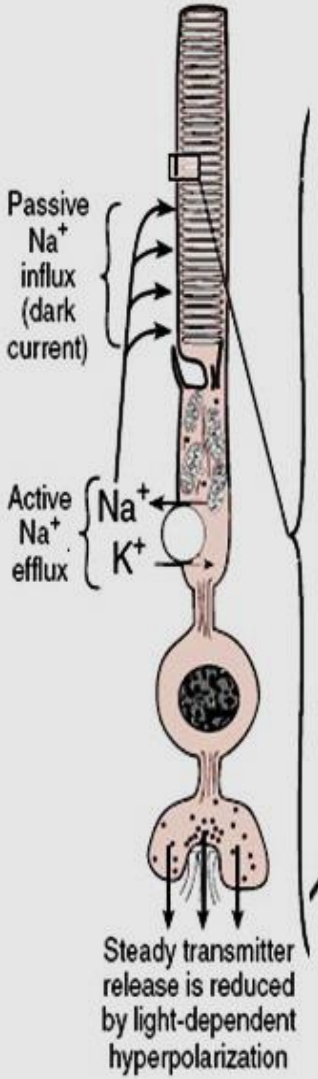
This hyperpolarization leads to **reduction** of the release of the **inhibitory** chemical transmitter which markedly facilitates synaptic neural transmission of the visual pathway. Thus the only receptor in the body which its receptor potential is generated by state of hyperpolarization instead of normal depolarization is the photoreceptors in the retina.

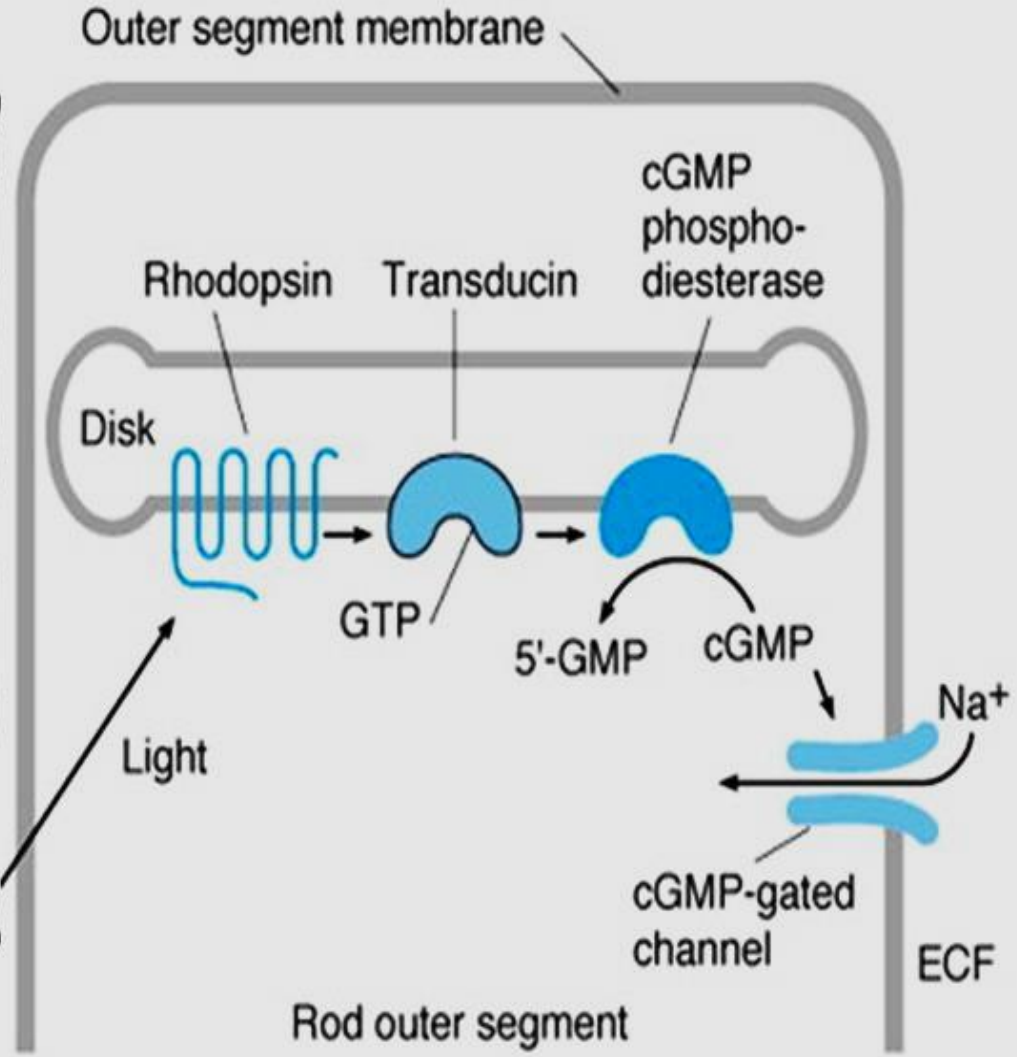
• **On removal of light (Dark)**, inactivation of All trans-retinal takes place by the retinal isomerase enzyme and re-synthesis of cGMP occurs with subsequent **opening of Na+ channels** and the membrane potential returns back **to -40 mv** which facilitates release of **inhibitory chemical transmitter** again (**glutamate** which is released by the cones and inhibit bipolar cells, also **GABA**).

PHOTORECEPTORS RESPONSE TO LIGHT

PHOTORECEPTOR POTENTIAL







COLOR VISION

Color vision is the sense of discrimination of the various wave lengths that constitute the visible spectrum. Color vision is mainly the function of **cones**, hence it is highly developed in **fovea**.

Theories of color vision:-

A-Trichromatic theory or young - Helmholtz theory which suggests the presence of **3 types of cones** each one is maximally stimulated or maximally sensitive to one of the primary color.

-First cone contains pigment that is maximally sensitive to **blue violet** part of the spectrum

-Second cone contains pigment that is maximally sensitive **to green** portion of spectrum,

-Third cone contains pigment that is maximally sensitive to **the red** portion of the spectrum.

Any different colored object stimulates the three cones but in an un-equal manner and thus number of impulses that are emitted from these cone to the visual cortex differ in frequency and number and this difference gives the specific sensation by that color.

On the other hand equal stimulation of all the three cones gives the sensation of **white color**.

B-Neural theory of color vision:

The **ganglion** continuously discharge even when un-simulated .

There are 3 types of the ganglion cells:

(1) **W** cells (40%). (2) **X** cells (55%). (3)**Y** cells (5%),

Therefore, neural theory states that perception of colors is mainly a function of group of neural cells starts at **X ganglion** cells in the retina. Then from theses X ganglion cells to another group of cells in the **lateral geniculate body in the thalamus** called "parvocellular neurons". Finally impulses reach color sensitive neurons in **visual cortex** called neurons of "**blobs**" to relay in lingual and fusiform gyri of the occipital cortex which were proved to be concerned with color vision.

THE VISUAL PATHWAYS

It has been previously stated that the photoreceptors of the retina stimulate the bipolar cells (**1st. order neuron**) which in turn stimulate the ganglion cells (**2nd order neuron**), the axons of which constitute the optic nerve fibers.

The optic serve fibers transmitting visual impulses from the **nasal half** of each retina **cross** to the opposite side. In this manner each optic tract conducts impulses from the temporal half of the retina of its own side and from the nasal half of the retina of the opposite side. The optic tract fibers terminate in: - (1) pretectal nucleus "pupillary reflex" (2) superior colliculus " visuo-spinal reflexes that control posture and equilibrium". (3) Lateral genicullate body "visual fibers". (4) reticular formation "arousal state". (5) supra-chiasmatic nuclei "circadian rhythm".

Cells of the lateral geniculate body are the **third order neurons** that pass their axons " the optic radiation" through the posterior part of the internal capsule to the **area 17** "visuo-sensory area" on the medial aspect of the occipital lobe.

The functions of **area 17** (the primary visual cortex):

1-Perception of visual sensations. 2- Fusion of the 2 images formed on both retinas.

3- Localization of objects in space in relation to each other. 4- Perception of color vision.

The functions of area (18):

1. Understand the meanings of the seen objects, 2. Understand the significance of the written words.

3. Determination of relative positions of objects to each other.

The functions of area (19): 1.It shares area 18 its functions.

2.It sends information to other parts of the cerebral cortex e.g. frontal eye field area (area 8) during accommodation.

3.It exerts motor functions, including (a) conjugate deviation of both eyes to the opposite side. (b) fixation movements by which the eyes are fixed on an object. (c) physiologic nystagmus.

4. Integration of visual sensations with other forms of sensations

Thank You