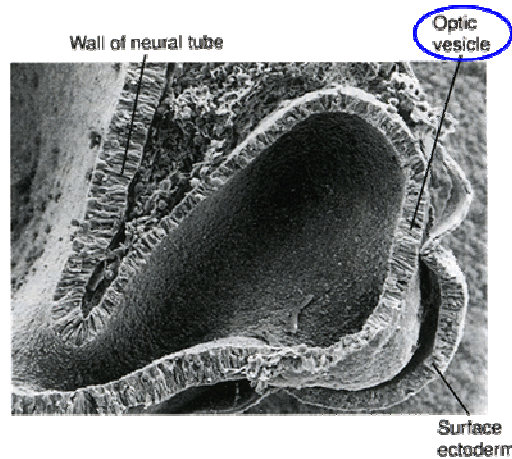


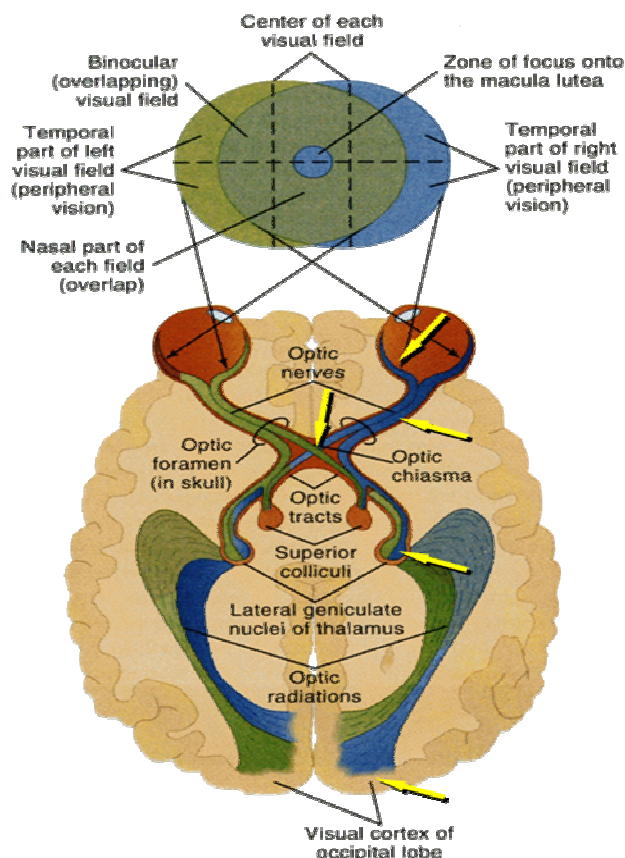
VISUAL PATHWAY

VISUAL SYSTEM :

- Vision is the most highly developed and versatile of all the sensory modalities and, arguably, the one on which humans are most dependent.
- *The “Total Illustration” teaching method is favoring vision over hearing.*
- The optic nerve and retina develop from the prosencephalic primary brain vesicle and, therefore, are regarded as an **outgrowth of the brain** itself.

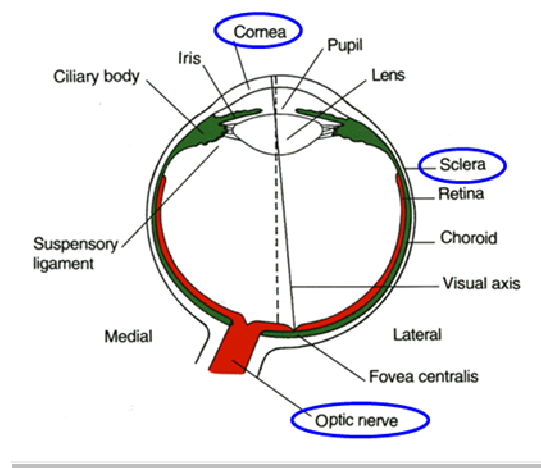


- Vision commences with the formation of an image of the external world on the photoreceptive **retina**.
- The retina encodes visual information in the discharge of neurones that project to the brain in the **optic nerve**.
- Fibres of the optic nerve undergo hemidecussation in the **optic chiasma** and project to the lateral geniculate nucleus of the **thalamus**.
- Thalamo-cortical neurones in turn project to the **primary visual cortex** of the occipital lobe where visual perception occurs.

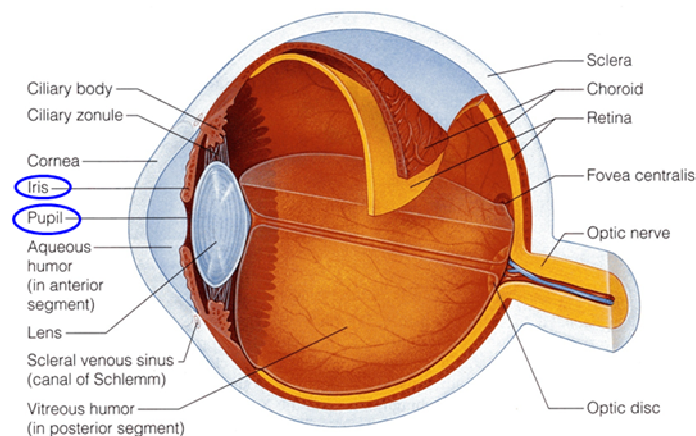


THE EYE :

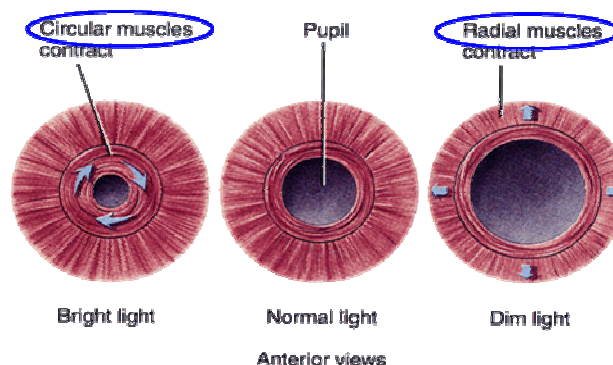
- The **eyeball**, or globe, is approximately spherical in shape.
- Near its posterior pole emerges the **optic nerve**.
- The eyeball may be considered to consist of **three concentric layers of tissue**, the outermost of which is tough, fibrous and protective.
- Over most of the globe it forms an opaque white coat, the **sclera**, to which are attached the extraocular muscles.
- Over the anterior pole of the globe it forms the transparent **cornea** through which light enters the eye.



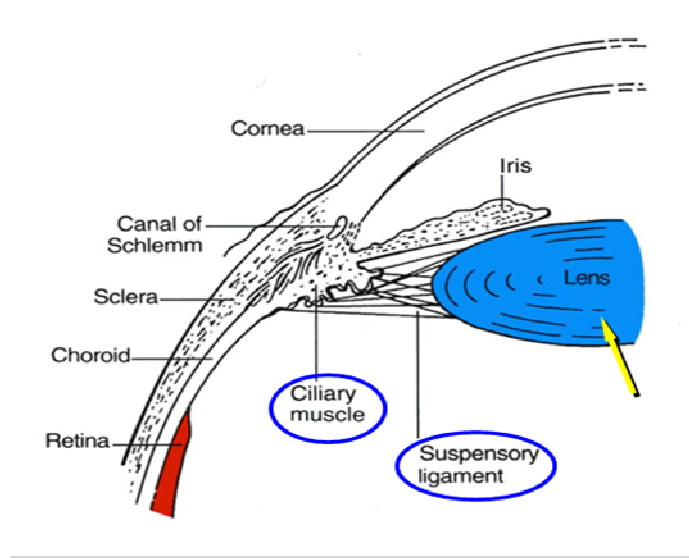
- Near to the anterior margin of the sclera, *two rings of smooth muscle* extend into the lumen of the eyeball.
- The most anterior of these is the **iris**, which has a central aperture, the **pupil**, through which light is admitted to the posterior part of the eye.



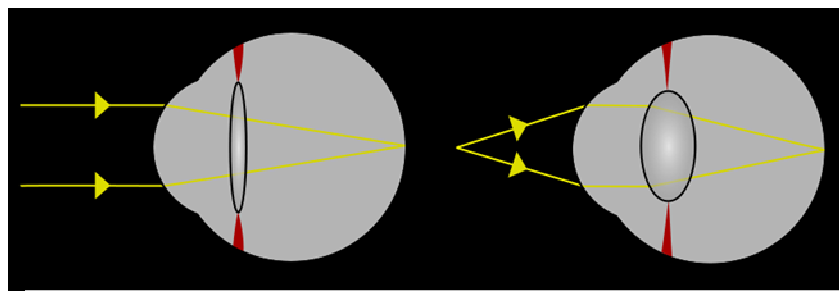
- Some of the muscle fibres of the iris are arranged in a **circular** fashion while others are oriented **radially**.
- They are under the control of the **autonomic nervous system**.
- **Circular fibres** are innervated by **parasympathetic neurones**, which *act to constrict the pupil and reduce the amount of light falling upon the retina*.
- **Radial fibres** are innervated by **sympathetic neurones** to *dilate the pupil*.



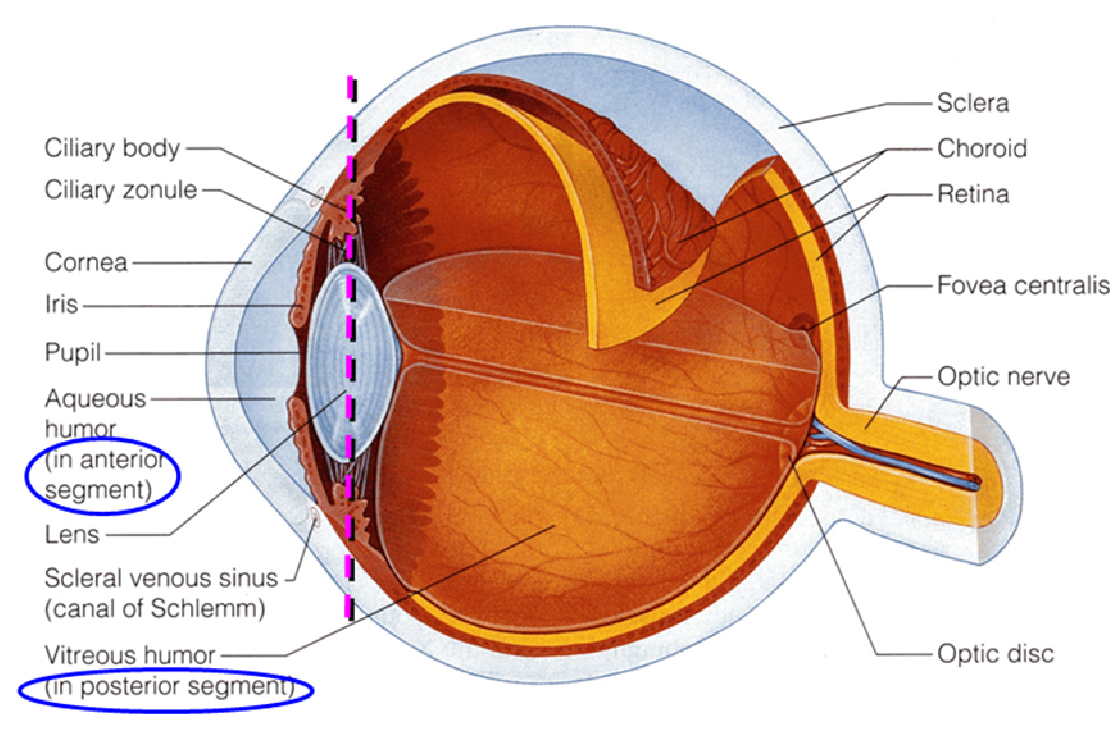
- Behind the iris lies the **ciliary body** containing **ciliary muscle**, which *receives innervation from the parasympathetic nervous system*.
- The central aperture within the annulus of the ciliary body is occupied by the transparent, biconvex **lens**, which focuses light upon the retina.
- The lens is held in place by a **suspensory ligament** that is attached to the peripheral margin of the lens and to the ciliary body.



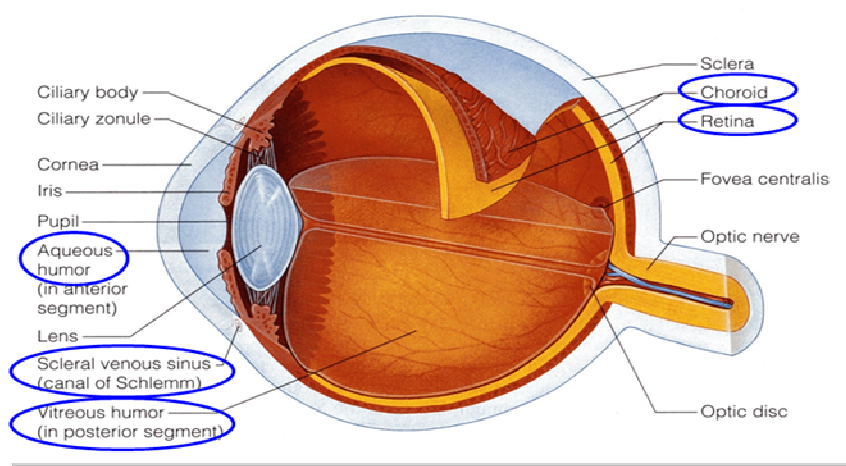
- *Contraction of the ciliary muscle* alters the shape and, therefore, the focusing power (focal length) of the lens, a process known as **accommodation**.



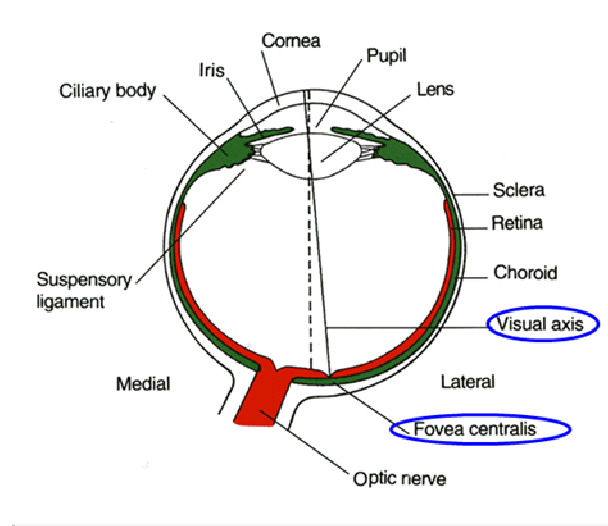
- The lens and suspensory ligament divide the lumen of the eyeball into an **anterior** and a **posterior part**.



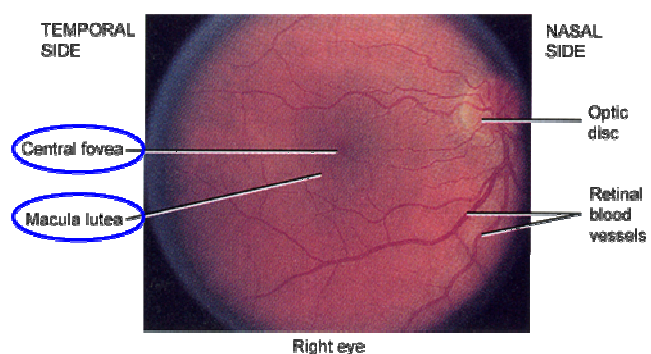
- The *anterior part*, in front of the lens, contains a thin, watery fluid, known as **aqueous humor**, which is continuously secreted from the ciliary body.
- It is also reabsorbed into the ciliary body where it accumulates in a small duct, the **canal of Schlemm**, through which it is returned to the venous system.
- The *posterior part* of the globe contains a gelatinous material known as **vitreous humor**.
- Behind the ciliary body, the inner surface of the sclera is lined by the **choroid**, the cells of which contain dark pigment that absorbs light and thus reduces reflection within the eye.
- Lining the inner surface of the choroid is the photoreceptive **retina**.



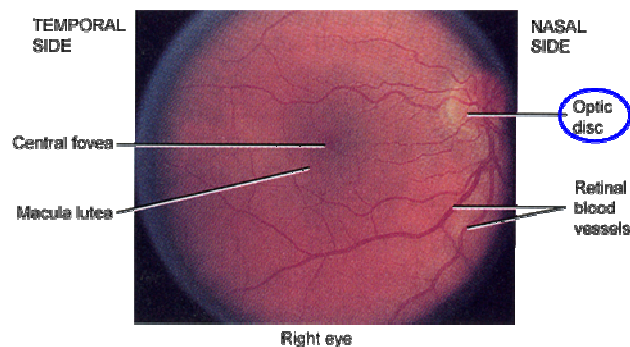
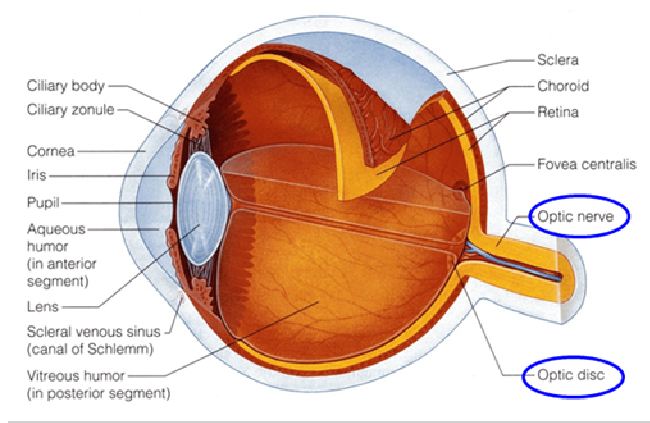
- Light passes from objects in the field of vision (**visual field**), through the narrow aperture of the pupil to subtend an image upon the retina.
- An object in the visual field, upon which attention is focused, subtends an image that is centred near the posterior pole of the eye along the line of the **visual axis**.
- The end point of the visual axis of the eye is known as the **fovea centralis**, and the surrounding 1cm is known as the **macula lutea**, the retina is specially modified for maximal visual acuity (resolving power).



- What is the meaning of *fovea centralis* ?
- What is the meaning of *macula lutea* ?
- Yellow spot.
- What gives its color ?
- What is its function ?

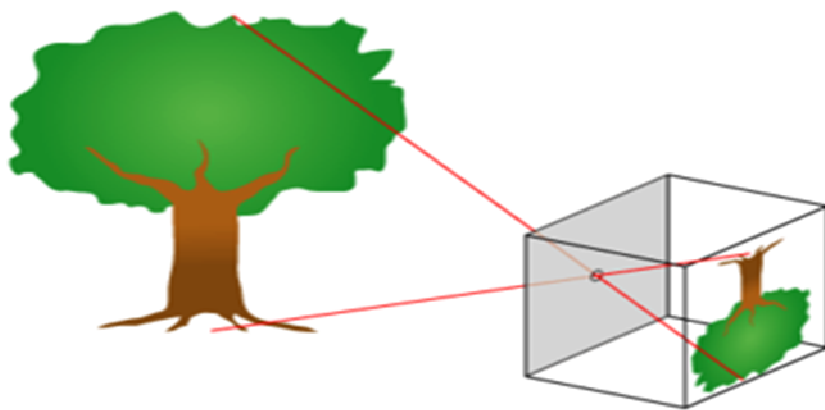


- Medial to the macula is a region where retinal axons accumulate to leave the eye in the **optic nerve**.
- This is known as the **optic disc**.
- *Photoreceptors are absent from this region, which is also referred to as the **blind spot**.*



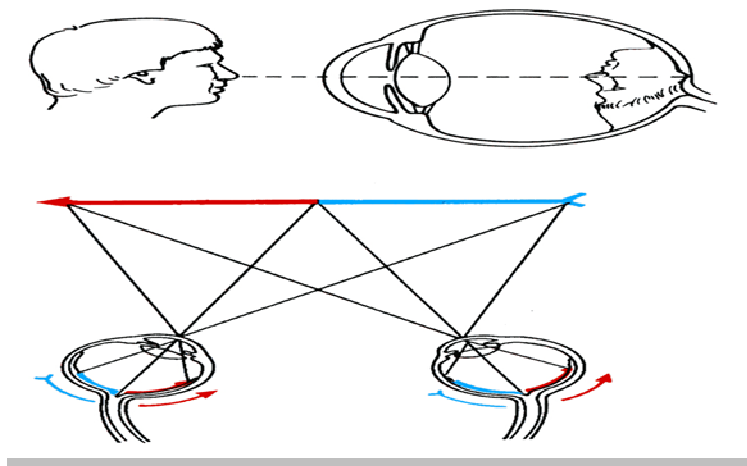
THE EYE AS PIN-HOLE CAMERA :

- The basic optical properties of the eye may be likened to those of a **pin-hole camera** (<http://www.kodak.com/global/en/consumer/education/lessonPlans/pinholeCamera/>).
- Who has discovered this optical instrument?



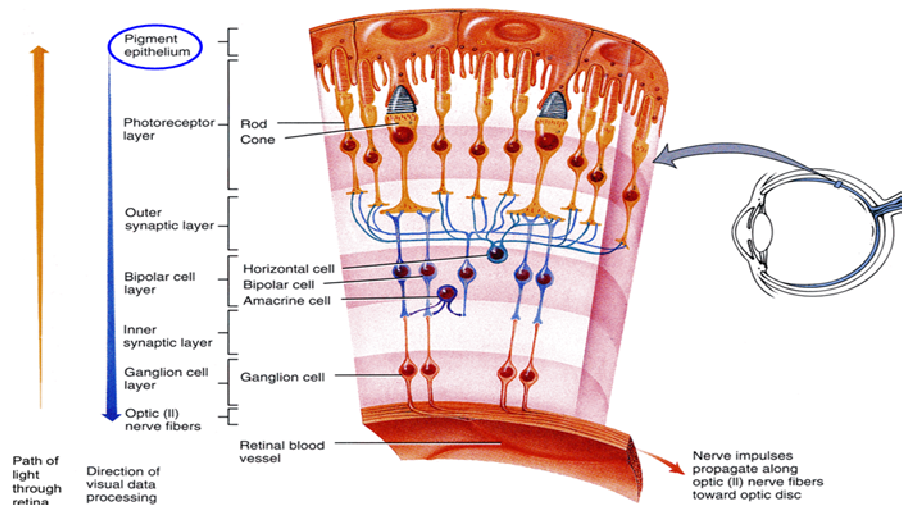
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- The basic optic properties of the eye dictate that the image so formed *is inverted in both lateral and vertical dimensions*.
- *Furthermore, objects that lie in the left half of the visual field form an image upon the nasal (right) half of the left retina and the temporal (right) half of the right retina, and vice versa.*



RETINA :

- The retina consists of a **non-neural** and a **neural portion**.
- The *non-neural part* is represented by the **pigment epithelium**, a single layer of light-absorbing, pigmented cells lying adjacent to the choroid.



- The *neural part* of the retina contains **photoreceptors and neurones** as well as neuroglia and a rich capillary network.
- The **photoreceptive cells** lie deepest within the retina and interdigitate with the pigment epithelium.
- Light entering the eye, therefore, passes through, and is refracted and partially absorbed by, these additional elements before reaching the photo-receptors.

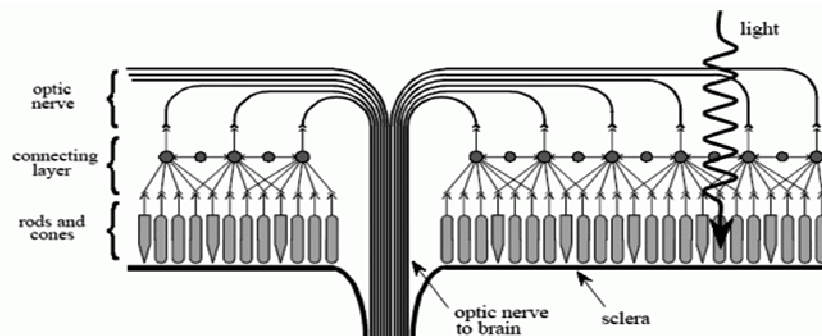
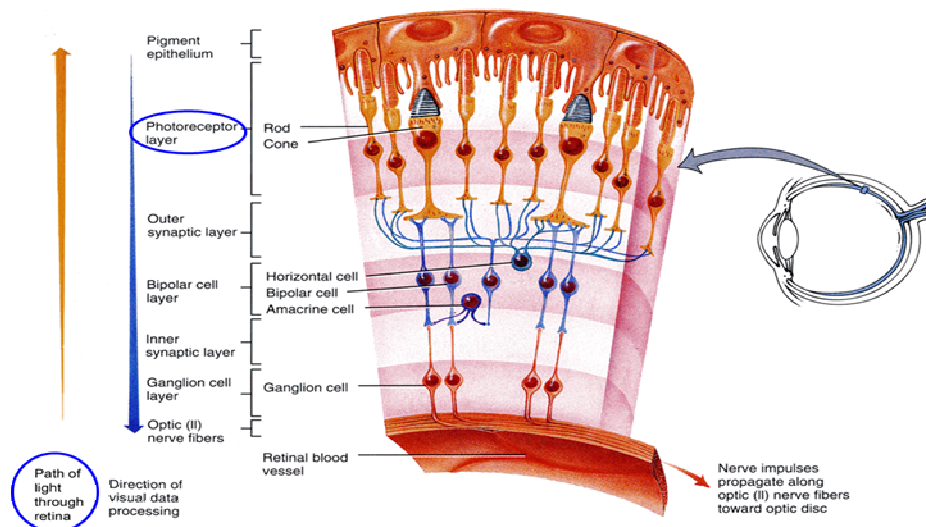
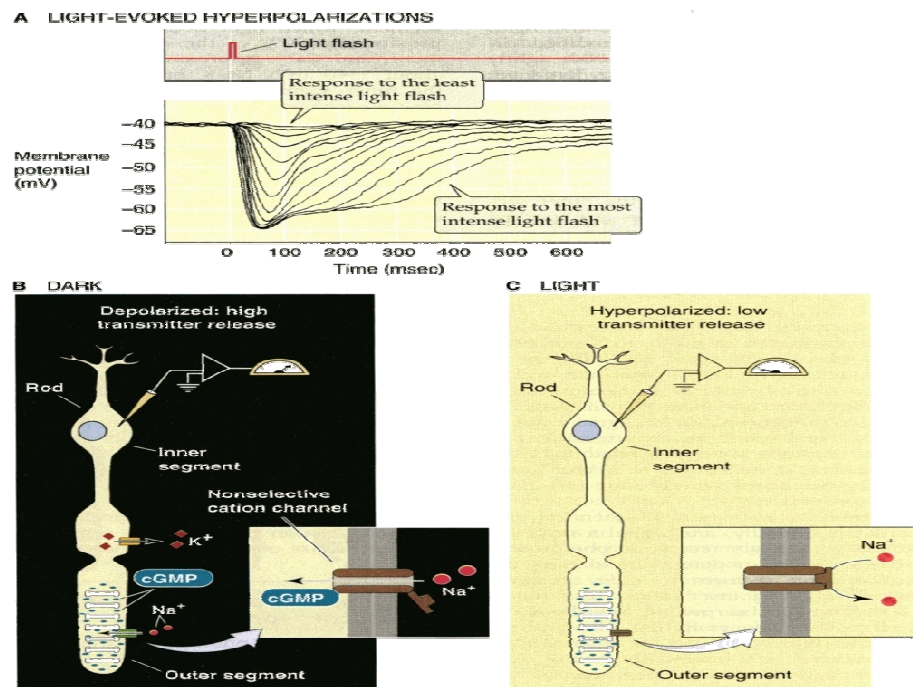


FIGURE 23-5
The human retina. The retina contains three principle layers: (1) the rod and cone light receptors, (2) an intermediate layer for data reduction and image processing, and (3) the optic nerve fibers that lead to the brain. The structure of these layers is seemingly *backward*, requiring light to pass through the other layers before reaching the light receptors.

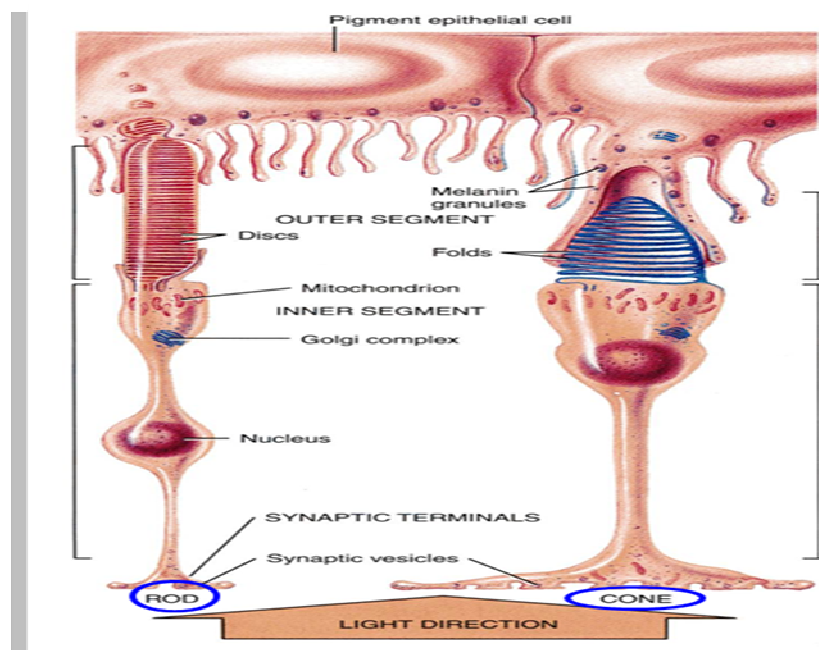
PHOTOTRANSDUCTION :

- By means of a series of photochemical reactions and physicochemical changes, retinal photoreceptors transduce light energy into electrical energy (changes in membrane potential).
- Name the key protein in this process.**
 - Rhodopsin.

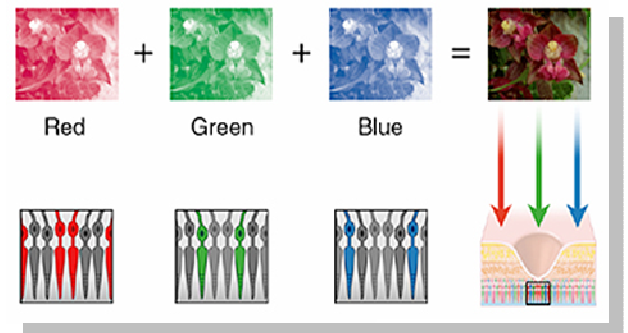
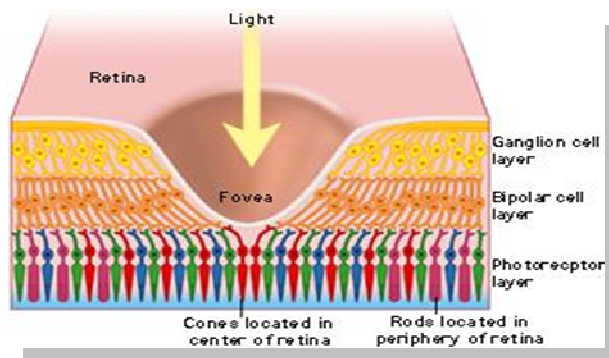


RETINAL PHOTORECEPTORS :

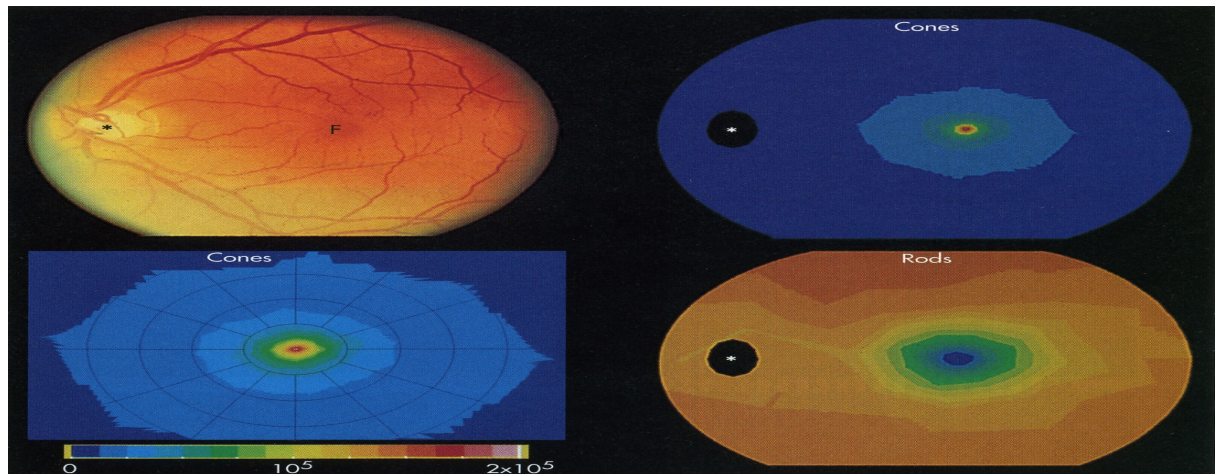
- Retinal photoreceptors are of two types, **rods and cones**, of which the rods are about 20 times more numerous.
- These cells share many structural similarities but have important functional distinctions.
- Rods** are exquisitely sensitive to light.
- They are particularly important for vision in dim lighting conditions.
- Cones** are responsible for colour vision and, because of their arrangement and neuronal connections, they confer high visual acuity.



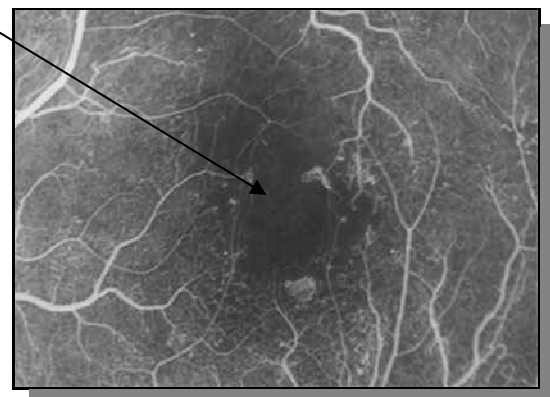
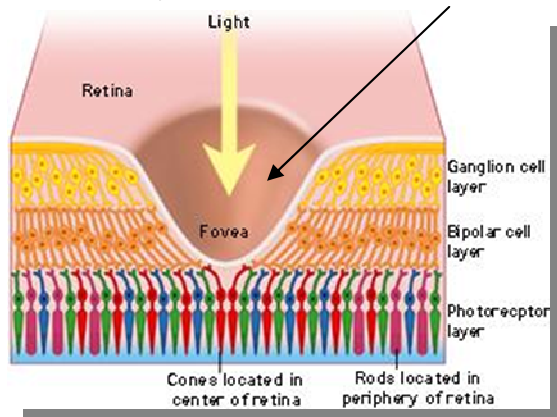
- Color detection by the cones.
- What is the principle of color detection by the retina ?
- What happens if one type of cones is missing ?
- How do we call this state ?



- Rods and cones are *heterogeneously distributed* across the retina.
- Rods greatly *predominate in the peripheral parts of the retina* but their relative numbers decrease towards the *macula*, where cones are more abundant.
- **At the fovea only cones are present.**

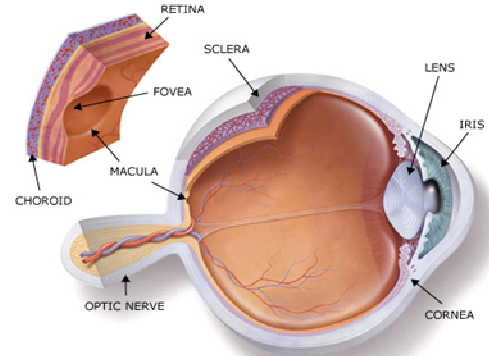


- Furthermore, at the fovea the *neurones* and *capillaries*,

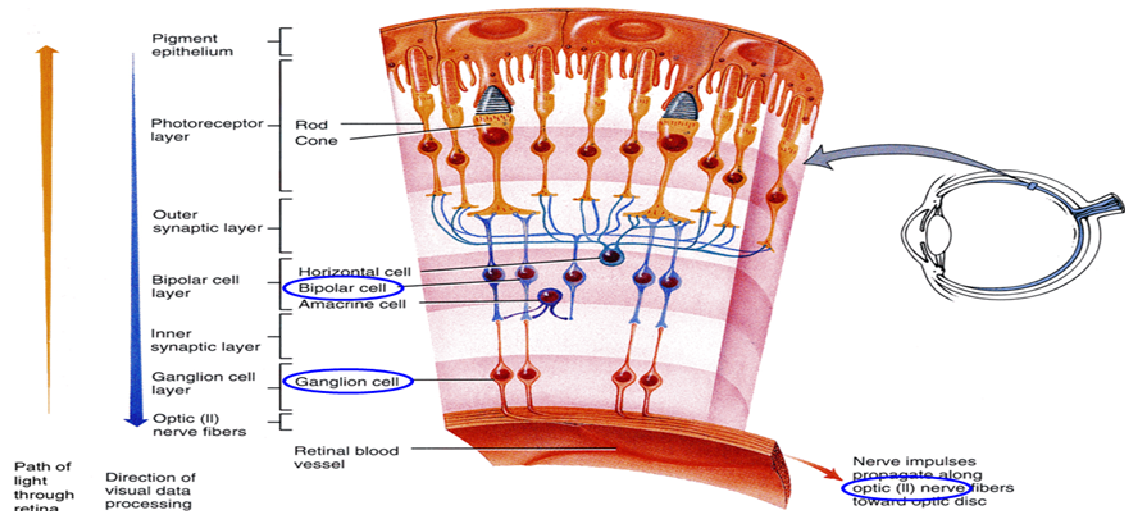


through which light has to pass to reach the photoreceptors, **are displaced** so that the cones are directly exposed to light.

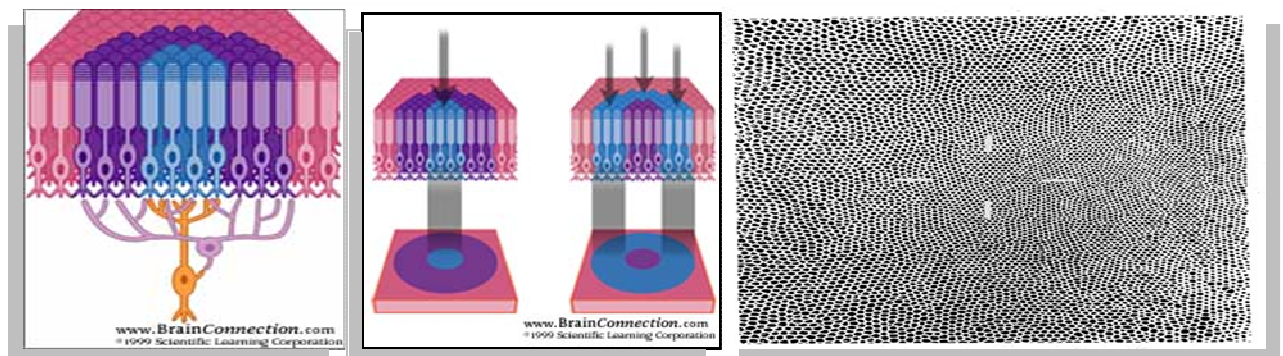
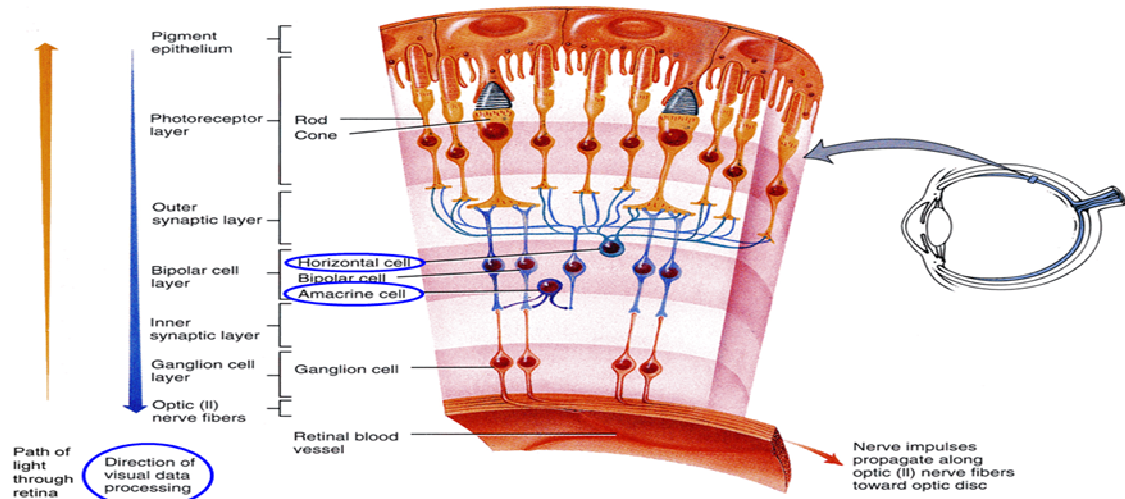
- This combination provides for **maximal visual acuity**.

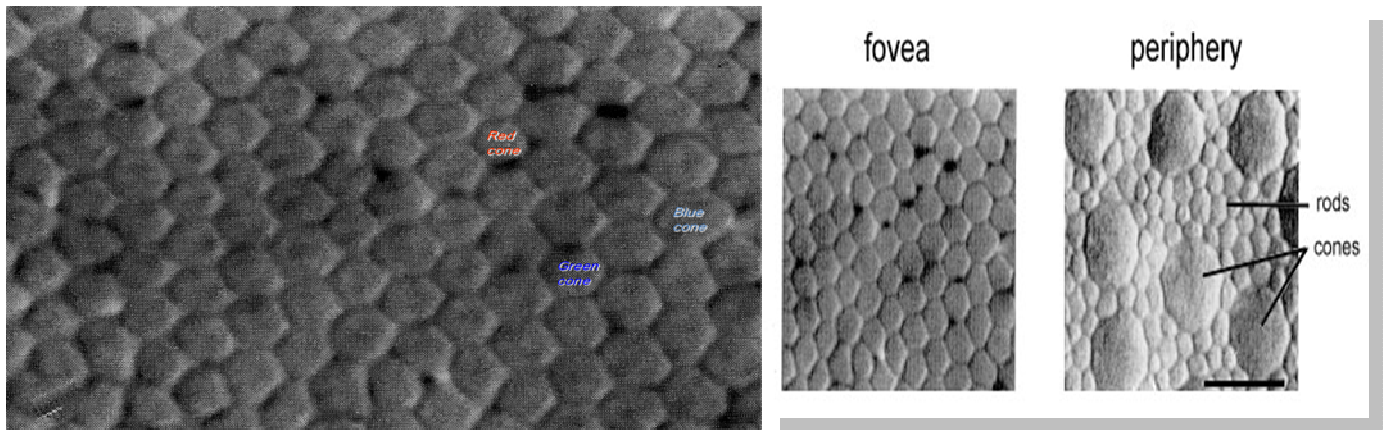


- If the retinal rods are progressively destroyed, what will be the symptoms ?
 - Nyctalopia.
 - Gradual peripheral vision loss.
 - Complete blindness.
- In addition to photoreceptive cells, the retina contains both the first- and second-order **neurones** of the central visual pathway.
- The first-order neurone, or **bipolar cell**, lies entirely within the retina while the axon of the second-order neurone, or **ganglion cell**, forms the optic nerve.



- Information is transferred from photoreceptors to bipolar cells and then to ganglion cells, *with greater convergence for rods than for cones*.
- The retina also contains *interneurons* known as **horizontal cells** and **amacrine cells**.
- These **modulate transmission** between photoreceptors and bipolar cells and between bipolar cells and ganglion cells, respectively.

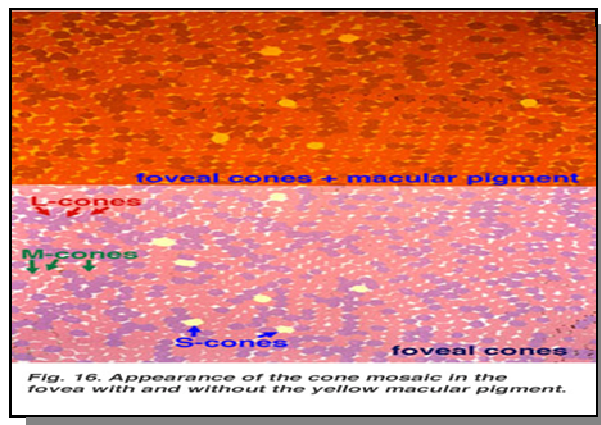




Cones in human fovea

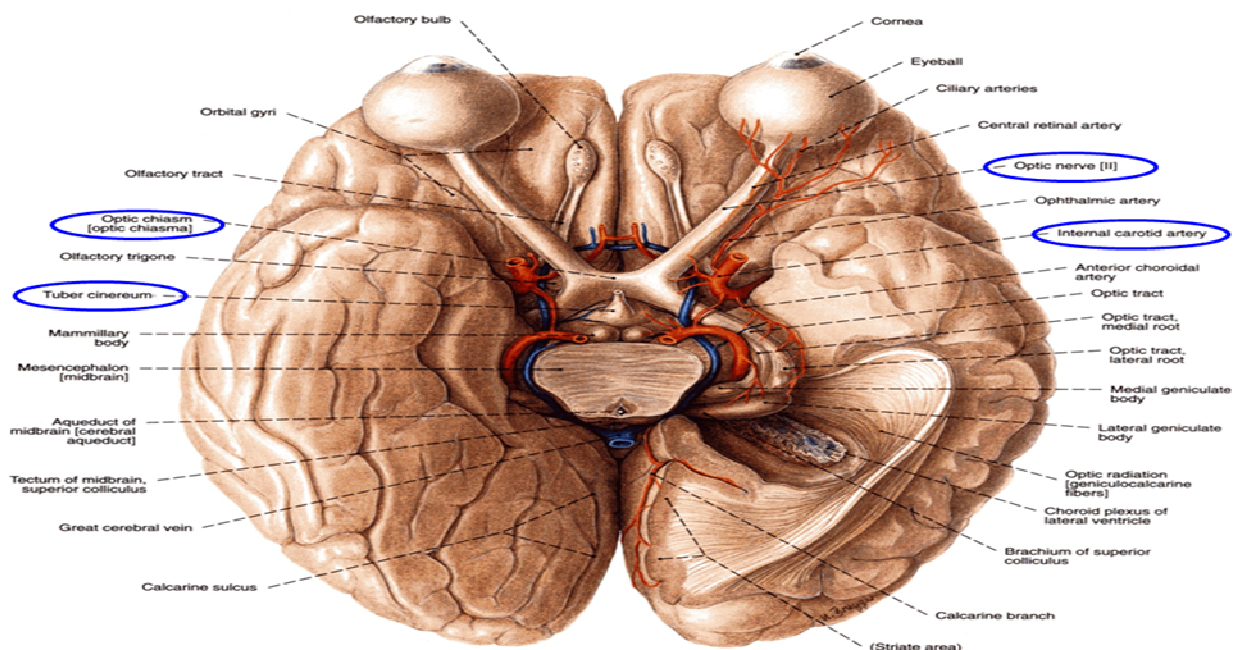
Tangential section

(<http://webvision.med.utah.edu/sretina.html>)

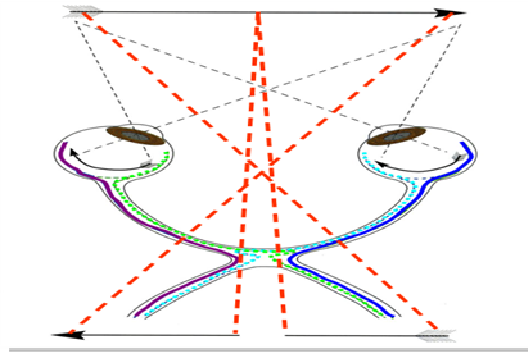


THE CENTRAL VISUAL PATHWAY :

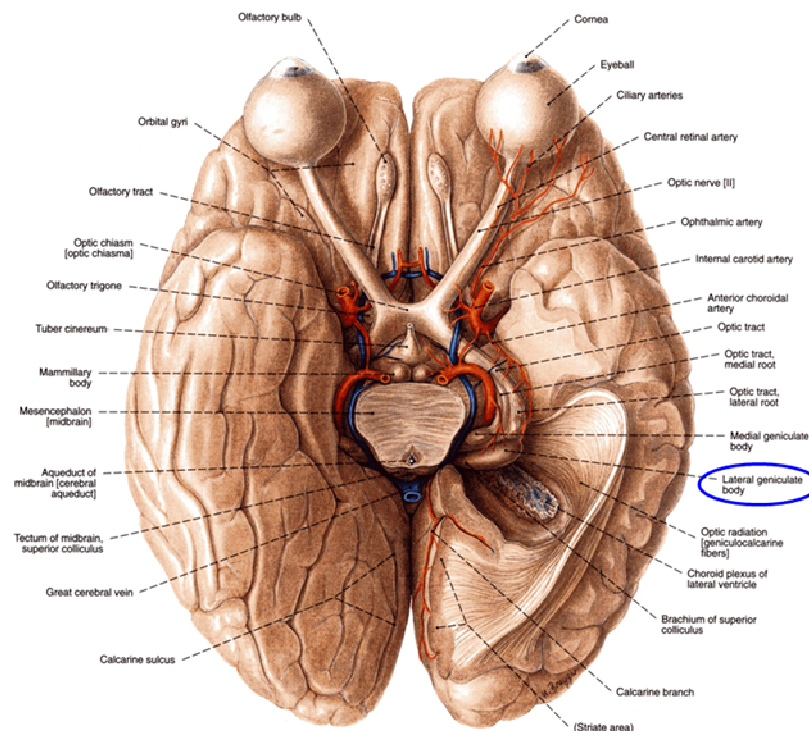
- The axons of retinal ganglion cells assemble at the optic disc and pass into the **optic nerve**, which enters the cranial cavity through the optic canal.
- The two optic nerves converge to form the **optic chiasma** on the base of the brain.
- The chiasma lies immediately **rostral** to the **tuber cinereum** of the hypothalamus and **between** the terminating **internal carotid arteries**.



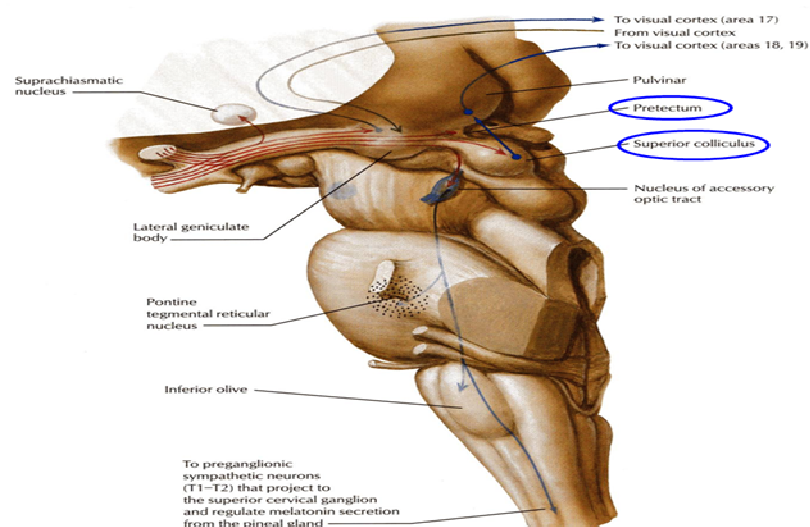
- In the chiasma :
 - axons derived from the **nasal portions** of the two retinae *decussate and pass into the contralateral optic tract*,
 - while those from the **temporal hemiretinae** *remain ipsilateral*.



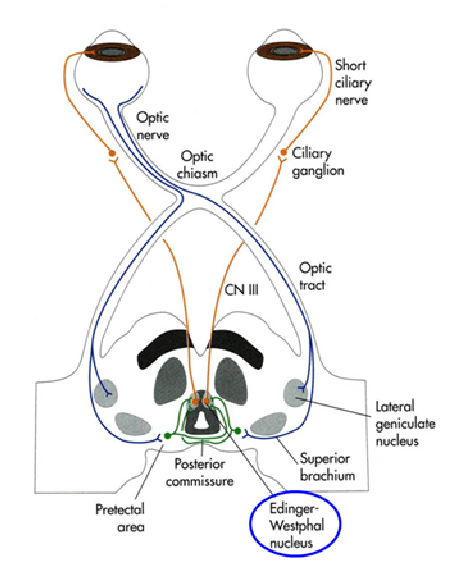
- The optic tracts diverge away from the chiasma and pass round the cerebral peduncle to terminate mainly in the **lateral geniculate nucleus** (within the lateral geniculate body) of the thalamus.



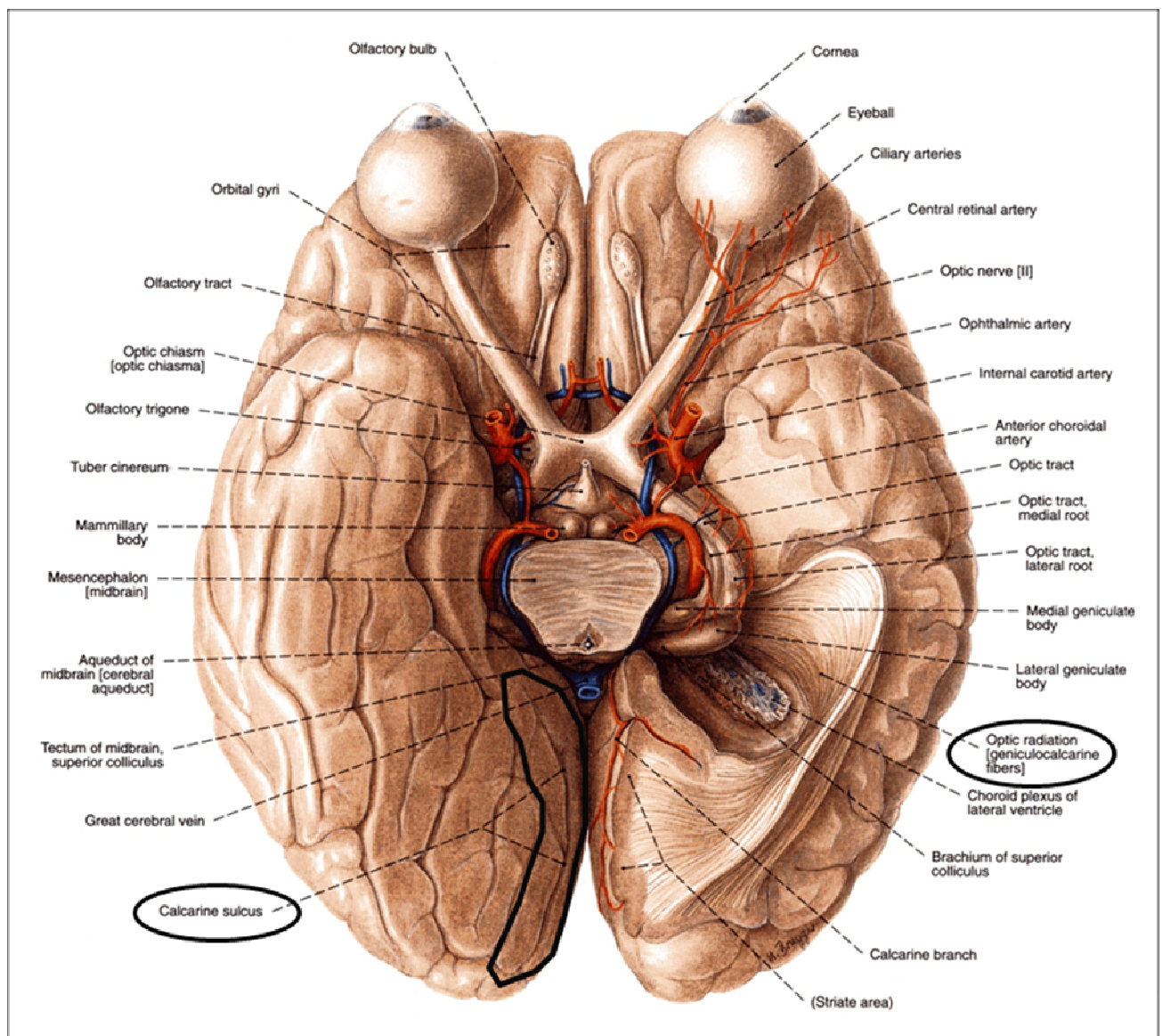
- A relatively small number of fibres leave the optic nerve, *before reaching the lateral geniculate nucleus*, to terminate in the **pretectal area** and the **superior colliculus**.



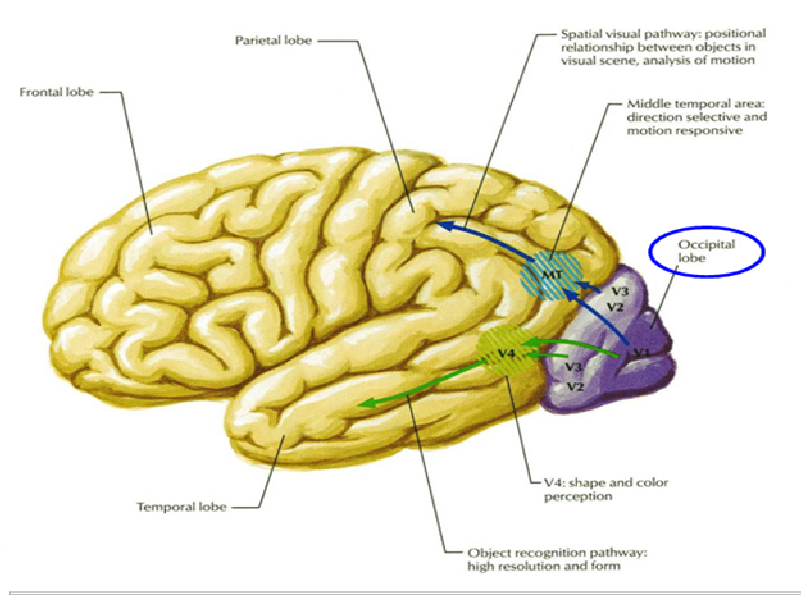
- These fibres are involved in mediation of the **pupillary light reflex**.



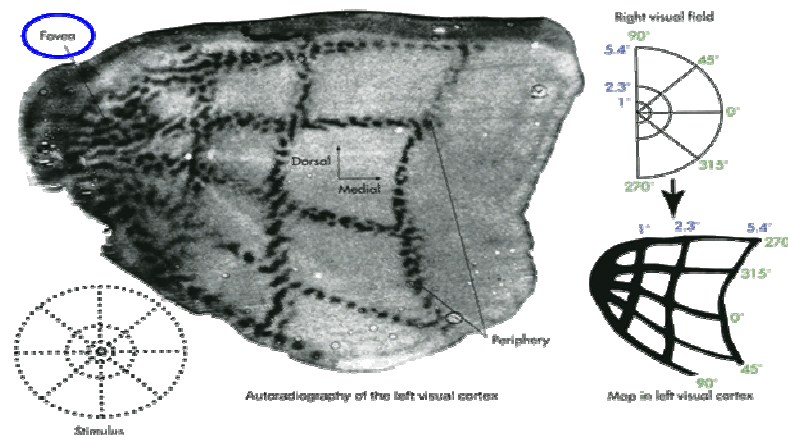
- From the lateral geniculate nucleus, third-order thalamocortical neurones project through the retrolenticular part of the internal capsule and form the **optic radiation**, which terminates in the primary visual cortex of the occipital lobe.
- The **primary visual cortex** is located predominantly on the medial surface of the hemisphere in the region *above and below the calcarine sulcus*.



- Surrounding this area, the rest of the occipital lobe constitutes the **visual association cortex**.
- It is concerned with interpretation of visual images, recognition, depth perception and colour vision.

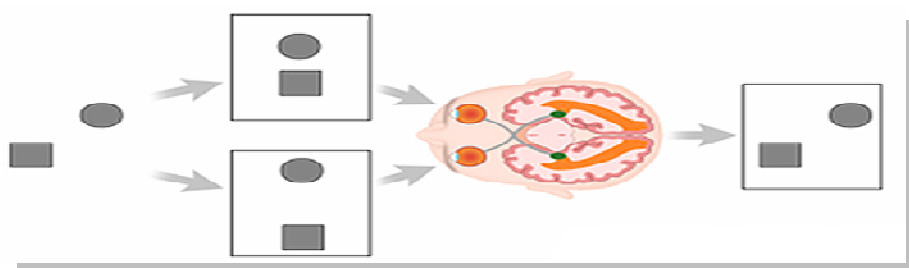


- There is a *precise point-to-point relationship* between the retina and the visual cortex.
- Because of the **importance of the macula** in vision, it is represented by disproportionately large volumes (relative to its size) of the lateral geniculate nucleus and the visual cortex.
- Within the visual cortex the macula is represented *most posteriorly*, in the region of the occipital pole.



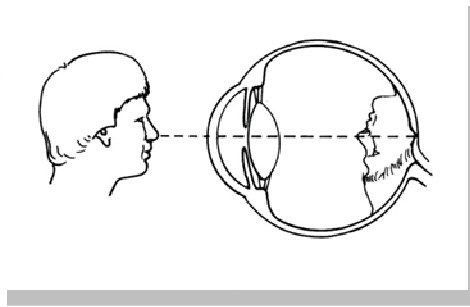
DEPTH PERCEPTION :

- Objects in either half (left or right) of the visual field produce images upon the nasal hemiretina of the ipsilateral eye and the temporal hemiretina of the contralateral eye.
- Each optic nerve, therefore, carries information concerning both halves of the visual field.*
- Because of the decussation of fibres from the nasal hemiretinae at the optic chiasma, however, *each optic tract, lateral geniculate nucleus and visual cortex receives information relating only to the contralateral half of the visual field.*
- This combination of the images from both eyes is necessary for **stereoscopic vision** (depth perception).

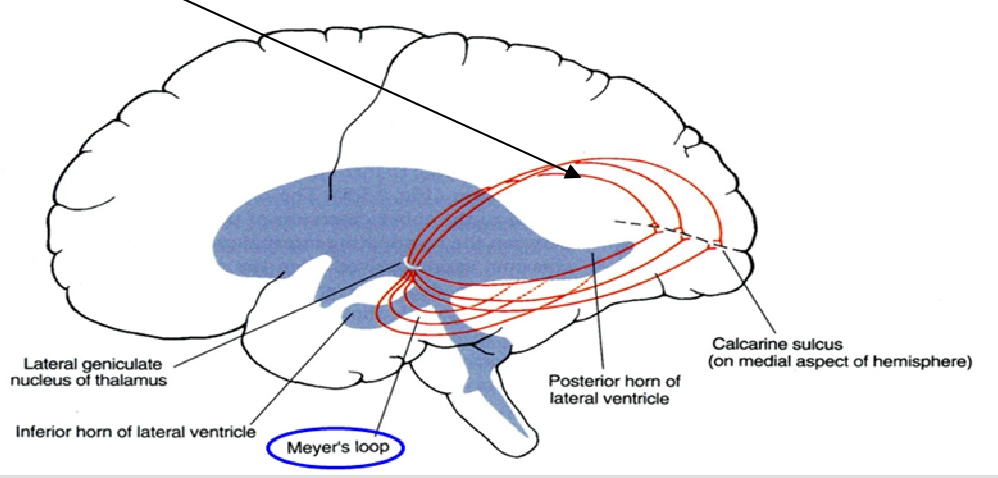


COURSE OF THE THALAMOCORTICAL FIBERS :

- The upper half of the visual field forms images upon the lower halves of the retinae, the lower visual field upon the upper hemiretinae.



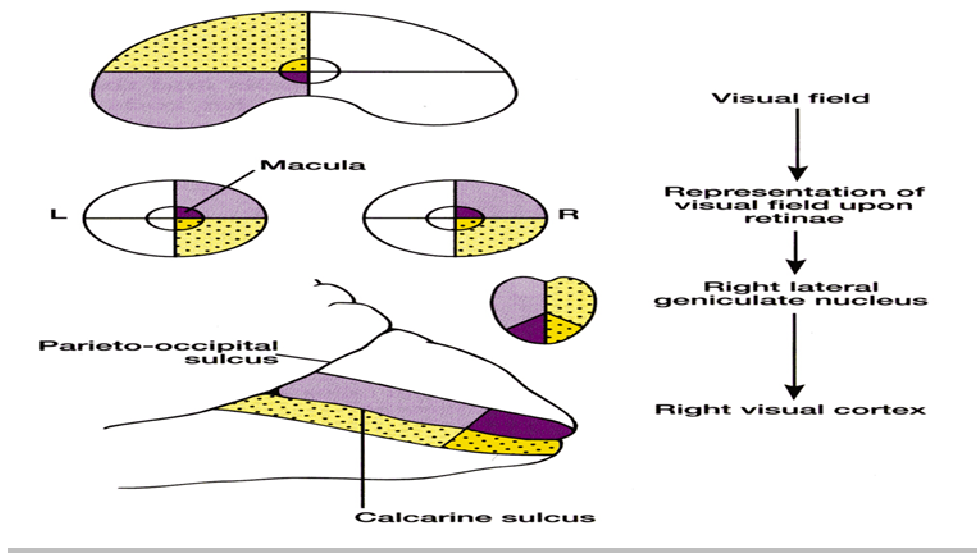
- As **thalamocortical fibres** leave the lateral geniculate nucleus they pass around the lateral ventricle, *those representing the lower part of the visual field coursing superiorly to terminate in the visual cortex above the calcarine sulcus.*



- Those which represent the upper part of the visual field sweep into the temporal lobe (**Meyer's loop**) before terminating below the calcarine sulcus.*

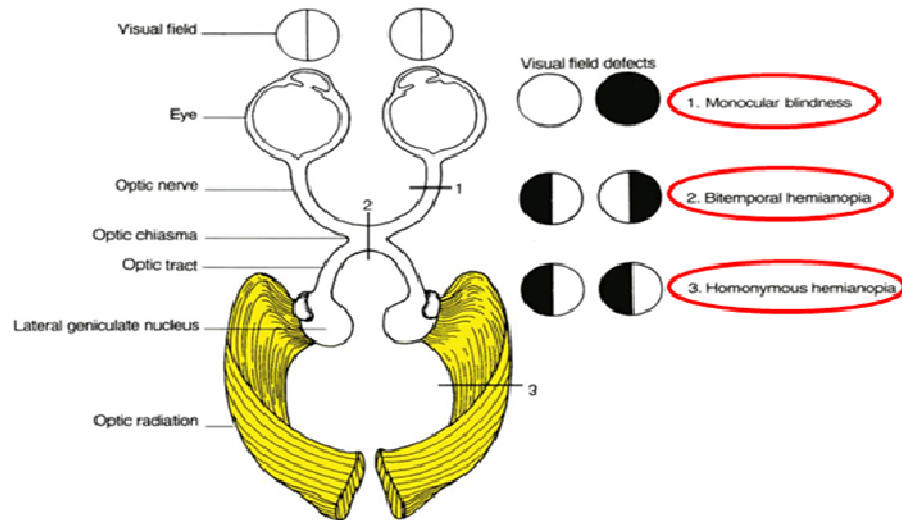
REPRESENTATION OF THE VISUAL FIELD AT THE PRIMARY VISUAL CORTEX :

- The visual field can be considered as comprising **four quadrants** (left/right, upper/lower) each projecting to its own quadrant of the primary visual cortex (left/right hemispheres, above/below the calcarine sulcus).
- There is both **lateral and vertical inversion** in the projection of the visual field upon the visual cortex such that, for example, the upper left quadrant of the visual field is represented in the lower right quadrant of the visual cortex.



VISUAL FIELD DEFICITS :

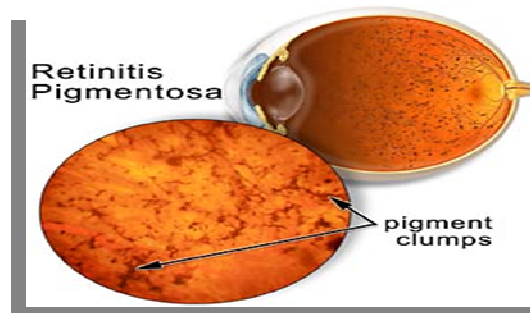
1. Disease of the eyeball (cataract, intraocular haemorrhage, retinal detachment) and disease of the optic nerve (multiple sclerosis and optic nerve tumours) lead to loss of vision in the affected eye (**monocular blindness**).
2. Compression of the optic chiasm by an adjacent pituitary tumour leads to **bitemporal hemianopia**.
3. Vascular and neoplastic lesions of the optic tract, optic radiation or occipital cortex produce a contralateral **homonymous hemianopia**.



Which disease is this ?

RETINITIS PIGMENTOSA :

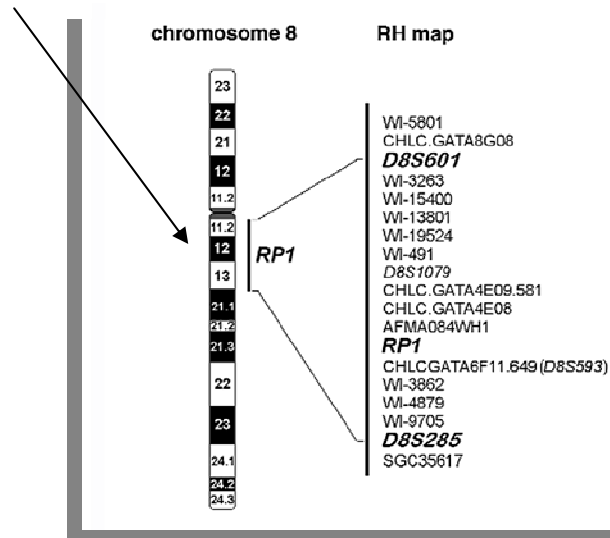
- **Retinitis pigmentosa** is an *inherited* metabolic disorder of the photoreceptor and retinal pigment epithelial cells.
- *It is due to mutation of a key protein in the retinal photoreceptors. Which protein ?*
 - **Rhodopsin.**
- There is progressive night blindness, peripheral visual field constriction and pigmentation of the retina visible on ophthalmoscopy.
- *Which type of photoreceptor is affected ?*
 - **Rods.**



For more information, see

<http://www.emedicine.com/oph/topic704.htm>

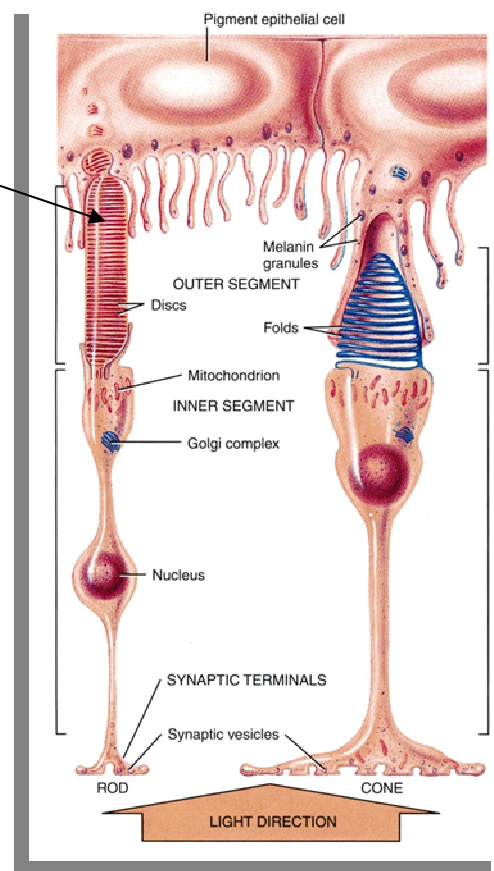
- Can you name some of the genes whose mutation leads to retinitis pigmentosa ?
 - RPGR (X-linked), RP1, chromosome 8** (http://www.nature.com/ng/journal/v22/n3/full/ng0799_248.html)



- Which part of the rods is affected first ?
 - The photoreceptor segment.**
- What happens next ?
 - The entire cells dies.**
- What you can do to help ?
 - Very little.**
- What drugs adversely affect RP ?
 - Isoretinoin (Accutane)**
 - Sildenafil (Viagra)**
 - Vitamin E (high doses, >400 U/d)**

<http://content.nejm.org/cgi/content/abstract/323/19/1302>

<http://www.emedicine.com/oph/topic704.htm>



THE END



LoveTomy Team 426

Team leader : Dr. hams

Dr. S Dr. noop Omar H

ابتنسم !! همي بروحي

M.A.M Abo Slo7 Cute Killer

SELF QUIZ

1- Regarding the vision system which one is incorrect :

- a. Optic nerve & retina developed from the prosencephalon.
- b. Vision is the most highly developed of all sensory in human.
- c. Formation of image from external world is on the photoreceptive retina.
- d. Optic nerve fibers undergo decussation in the optic chiasma.
- e. None of the above.

2- The following statements concern the visual areas of the cortex, the correct one is :

- a. The 1st visual area is located in the walls of the parieto-occipital sulcus.
- b. The visual cortex receives afferent fibers from the medial geniculate body.
- c. The right half of the visual field is represented in the visual cortex of the right cerebral hemisphere.
- d. The superior retinal quadrants pass to the inferior portion of the visual cortex.
- e. None of the above.

3- The cerebral cortex is important for which of the following :

- a. Corneal reflex.
- b. Accommodation reflex.
- c. Papillary reflex.
- d. Visual body reflex.
- e. None of the above.

4- The nasal field of the right eye is projected to the :

- a. Left lateral geniculate body.
- b. Both banks of the left calcarine fissure.
- c. Temporal retina of the right eye.
- d. Left optic radiation.
- e. None of the above.

1. d	2. d	3. b	4. c
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