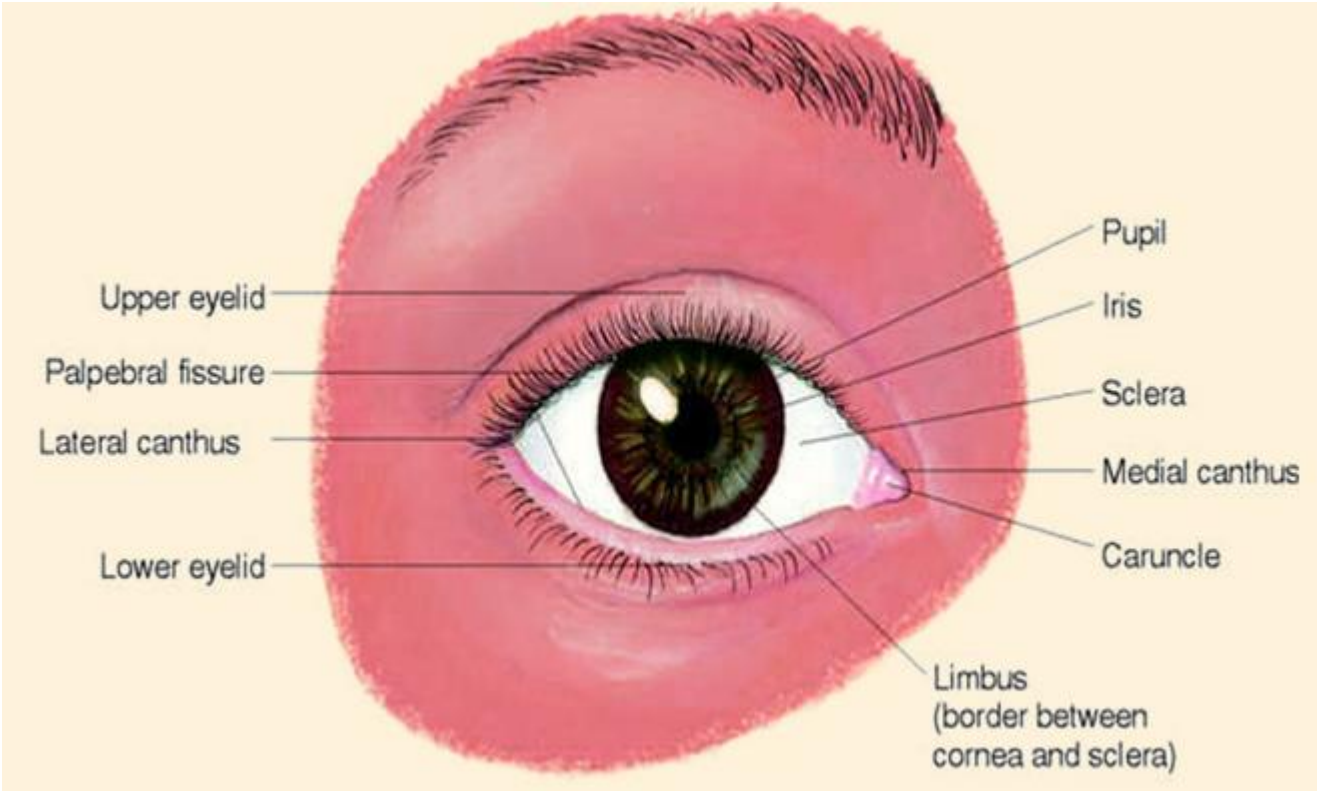
PH 301

ENGINEERING OPTICS

Lecture_Vision Optics_21

Ref.:

Geometrical and Physical Optics by R.S. Longhurst

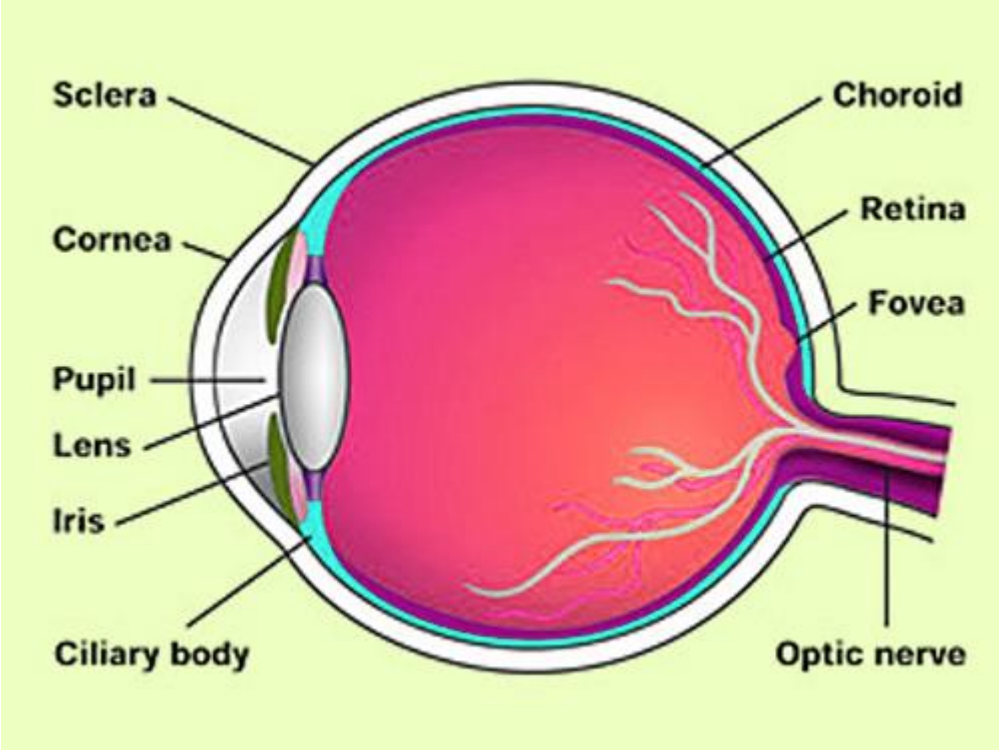


Human eye

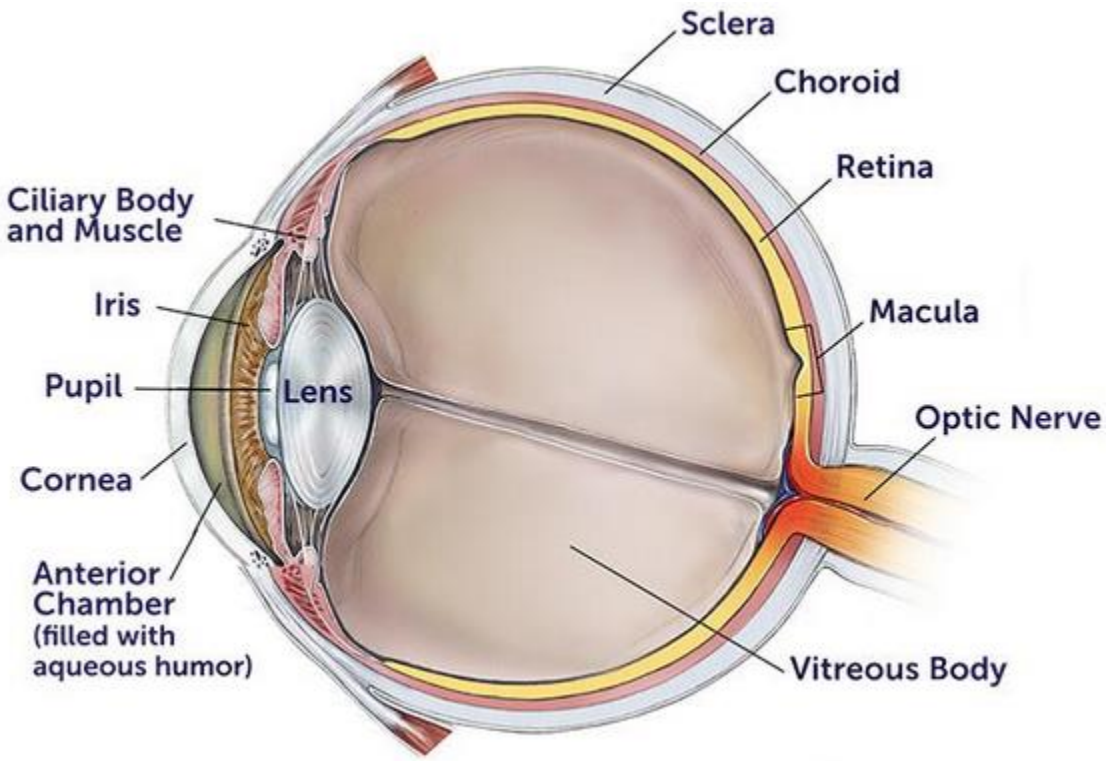
- **Greater part of eyeball is bounded by a tough, opaque, white membrane known as *sclera***

General structure of eye

- **Sclera merges into a transparent layer known as cornea (thickness of about 0.5 mm & radius of curvature of its front surface is about 7.8 mm).**
- **Spherical shape of eyeball is maintained by internal excess pressure which is some 2 – 3 cm of mercury.**
- **Behind cornea, there is *anterior chamber* which has an axial thickness of about 1.3 mm & is filled with a watery, slightly saline fluid of r.i. 1.336, known as *aqueous humor*.**
- **Crystalline lens's aperture is referred to as *pupil*, which is controlled by iris, which is strongly coloured & almost opaque.**
- **Pupil size is varied by iris from about 2 mm (diameter in bright light), to about 8 mm (diameter in darkness).**



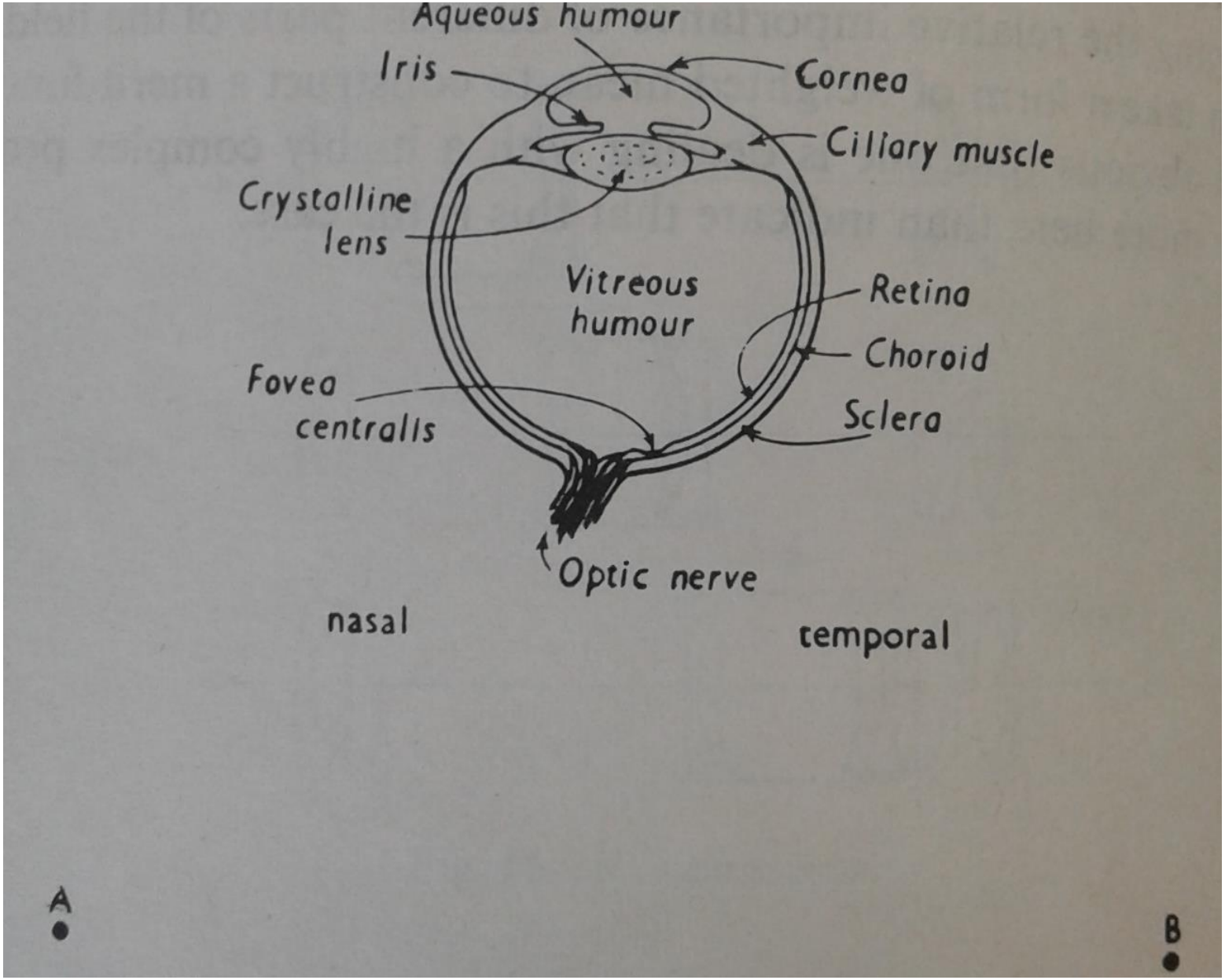
Anatomy of the eye



Anatomy of the eye

General structure of eye

- **Crystalline lens has a *bi-convex outer form*, front & back surfaces having normal radii of about 10 *mm* & 6 *mm*, respectively, & axial thickness being about 3.6 *mm*.**
- **Lens is not homogeneous but is built up of successive fibrous layers whose refractive indices vary from about 1.37 in outer parts to about 1.42 in middle.**
- ***Posterior chamber* behind crystalline lens contains a transparent jelly-like substance known as *vitreous humor* (index about 1.336).**
- **Inner surface of rear part of eyeball contains receiving screen known as *RETINA*. It consists of a mosaic of light-sensitive elements upon which image is formed when eye is in use.**
- **Retina lies on *choroid*, a layer which is dark brown in colour & richly supplied with blood vessels.**
- **Nerve impulses from retinal receptors communicate to brain through *optic nerve*.**

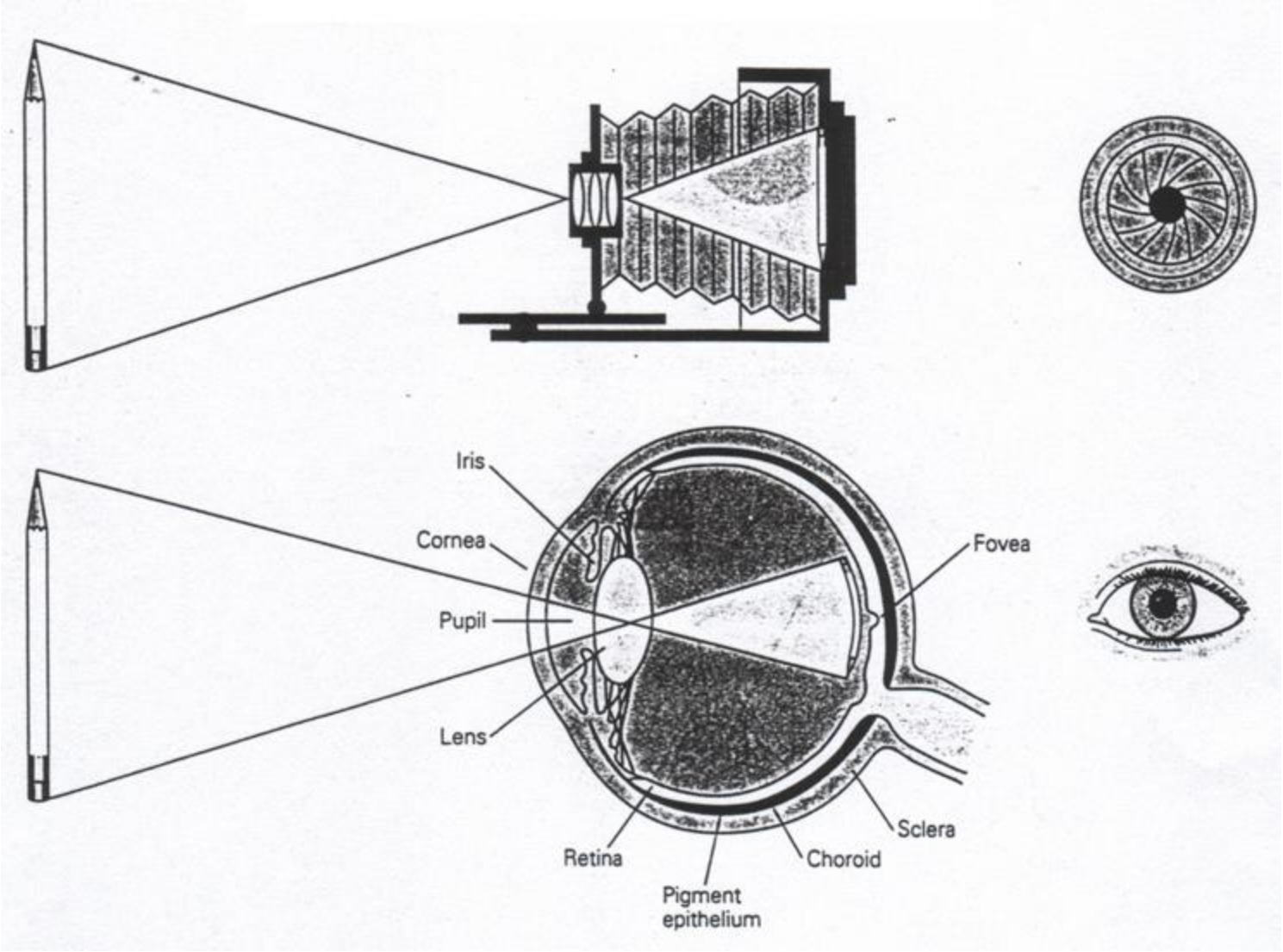


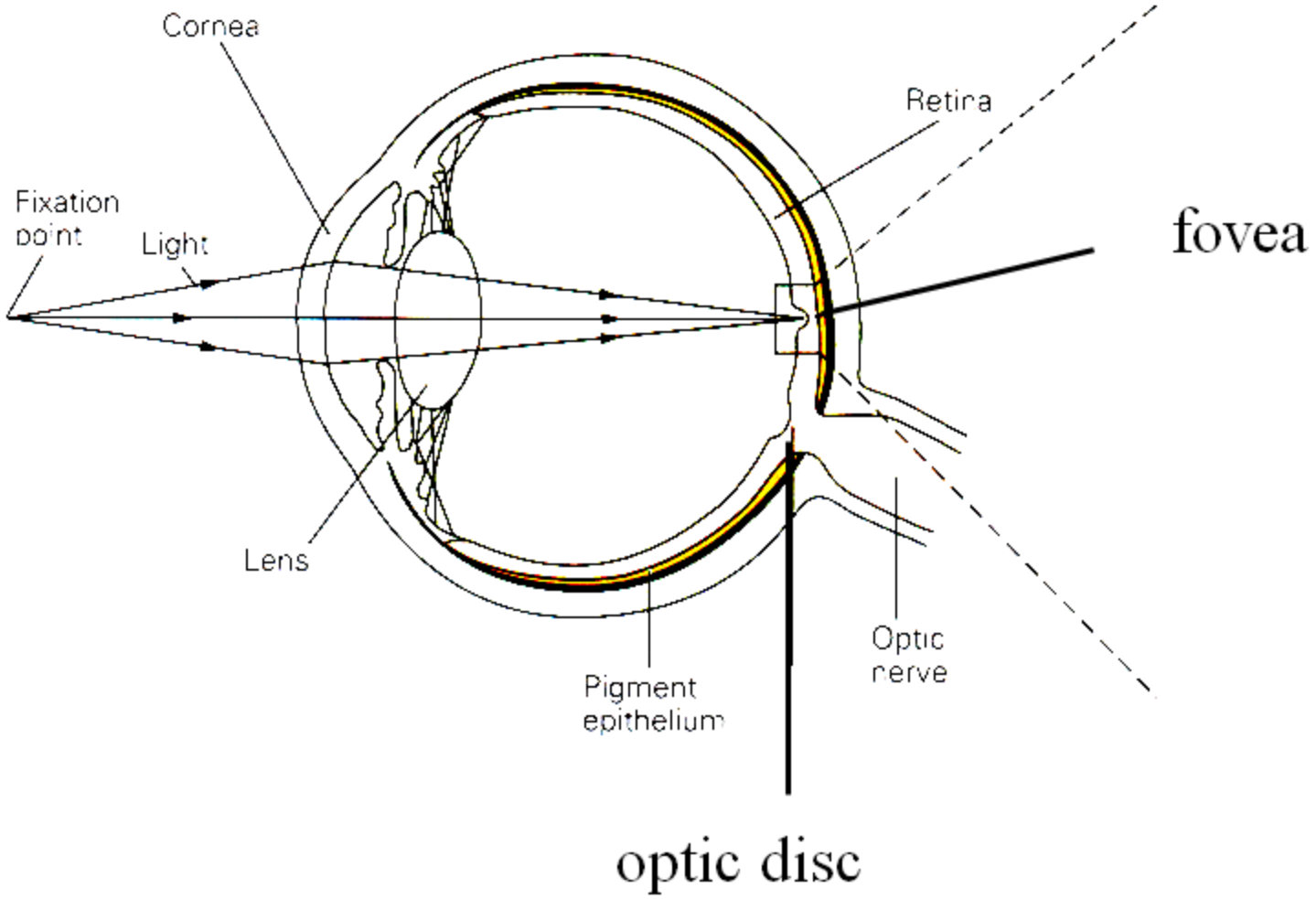
Horizontal section of a right eye

General structure of eye

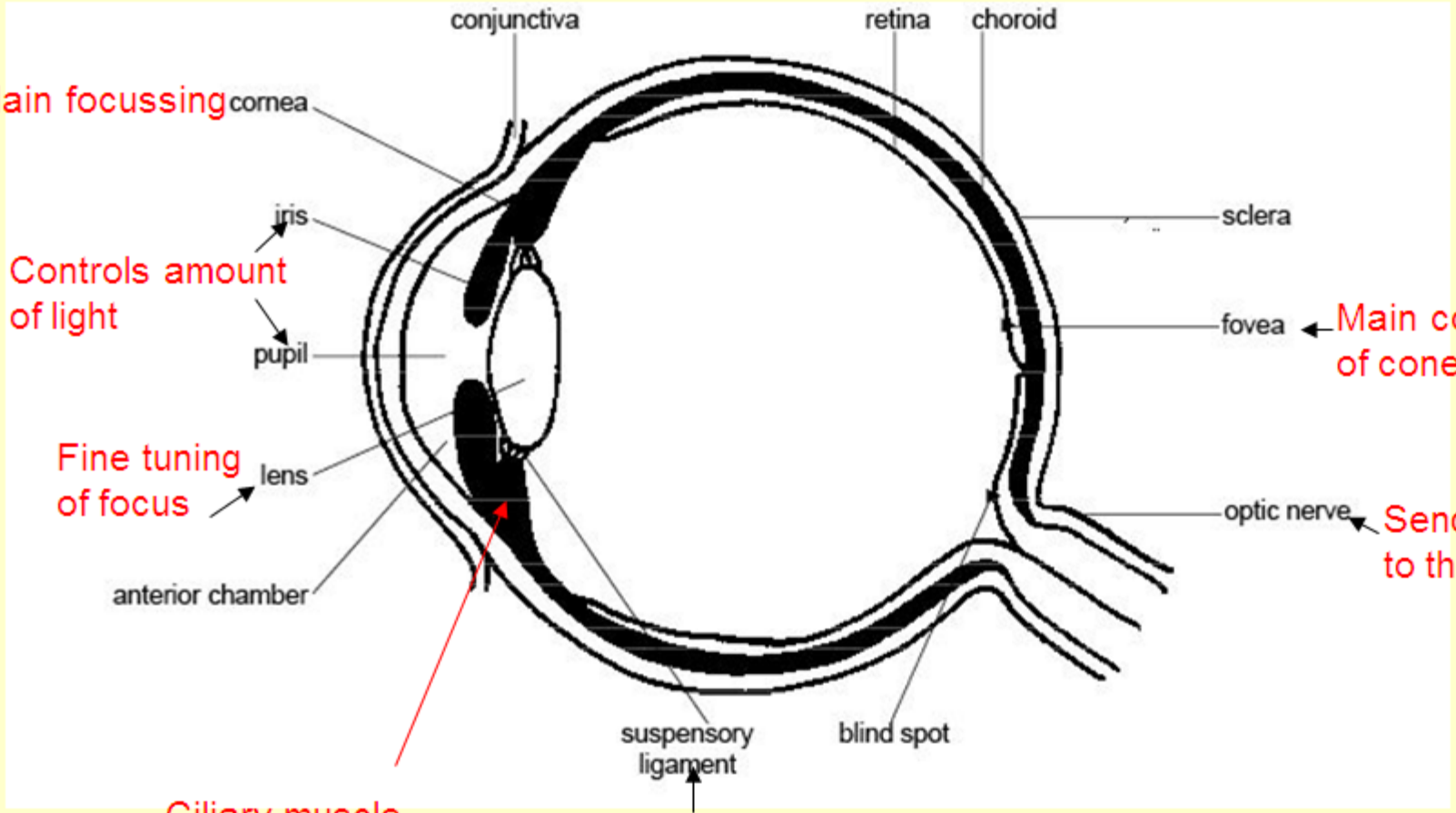
- There are no receptors where optic nerve leaves the eyeball & that region is the so-called **BLIND SPOT**. This renders invisible a field measuring about 6º horizontally & 8º vertically.
- This fact often passes unnoticed - partly because dark spot of one eye lies in the field of view of other, & partly because eyes are constantly rotating to explore the field of view.

Eye as a camera




Cornea
Retina
Fixation point
Light
fovea
Lens
Pigment epithelium
Optic nerve
optic disc

The "viewing screen" of the eye



Main focussing

Controls amount of light

Main concentration of cones

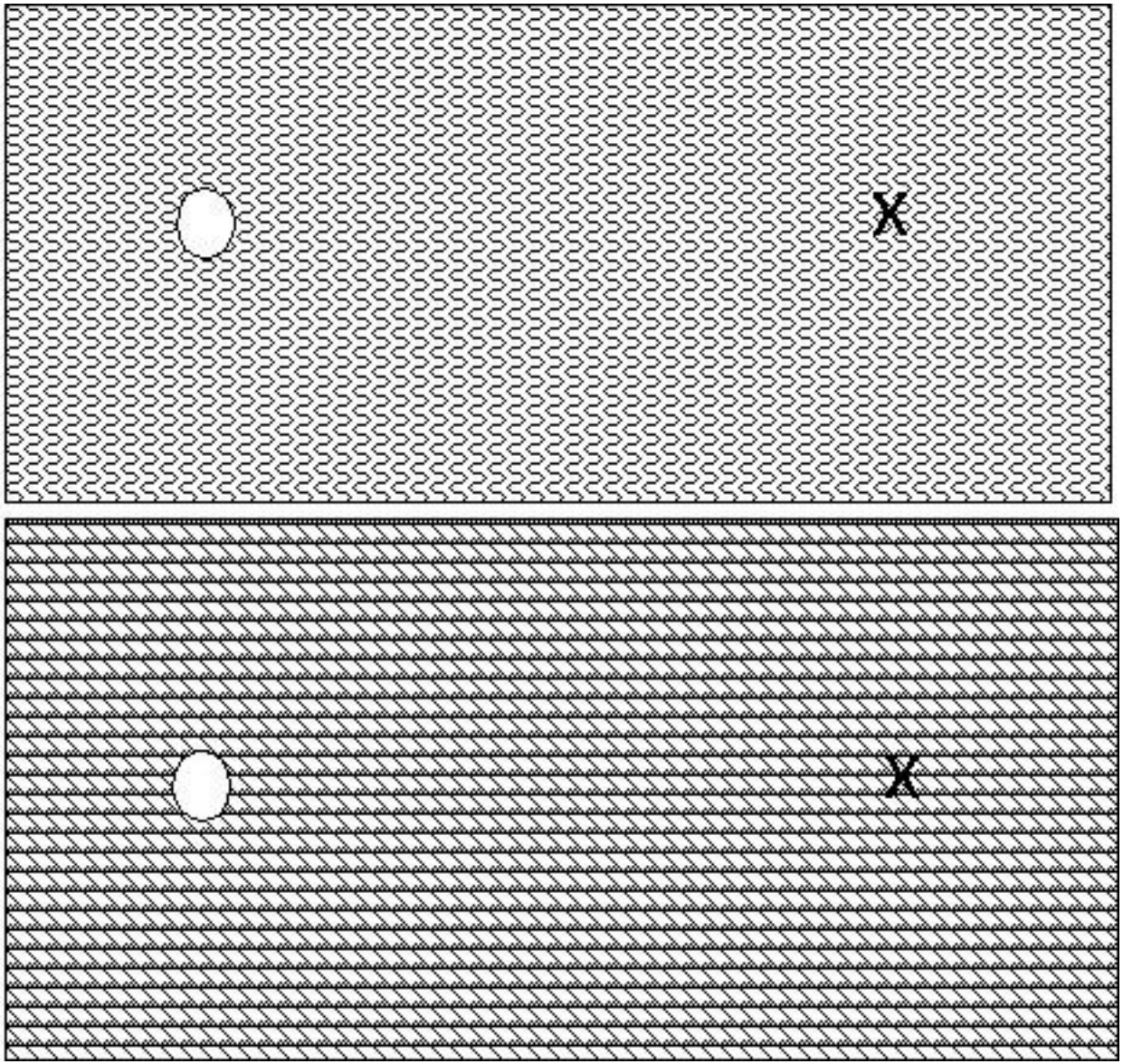
Fine tuning of focus

Sends the signal to the brain

Ciliary muscle changes the lens

aka - ciliary fibers...Changes the shape of the lens

Demonstration of blind spot



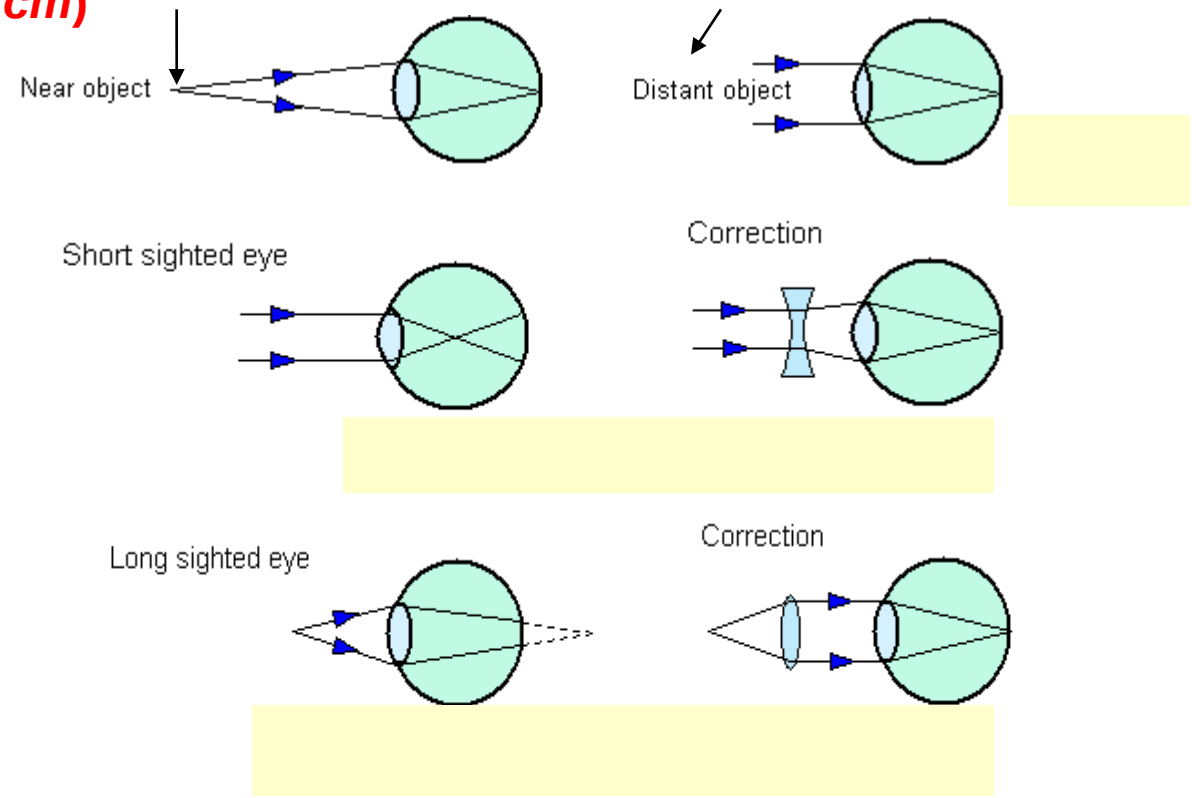
Accomodation

- **Ciliary muscles control focusing (thickness & curvature)**
- **Power of eye increased for near objects**
- **Accommodation & convergence**
- **Power of cornea ~ 43 *D*; lens ~ 17D (Total`60 *D*)**
  Far point > 6 *m*, Near point ~ 25 *cm*

Depth of vision & accommodation

(Closest distance without straining) near point (25 *cm*)

far point

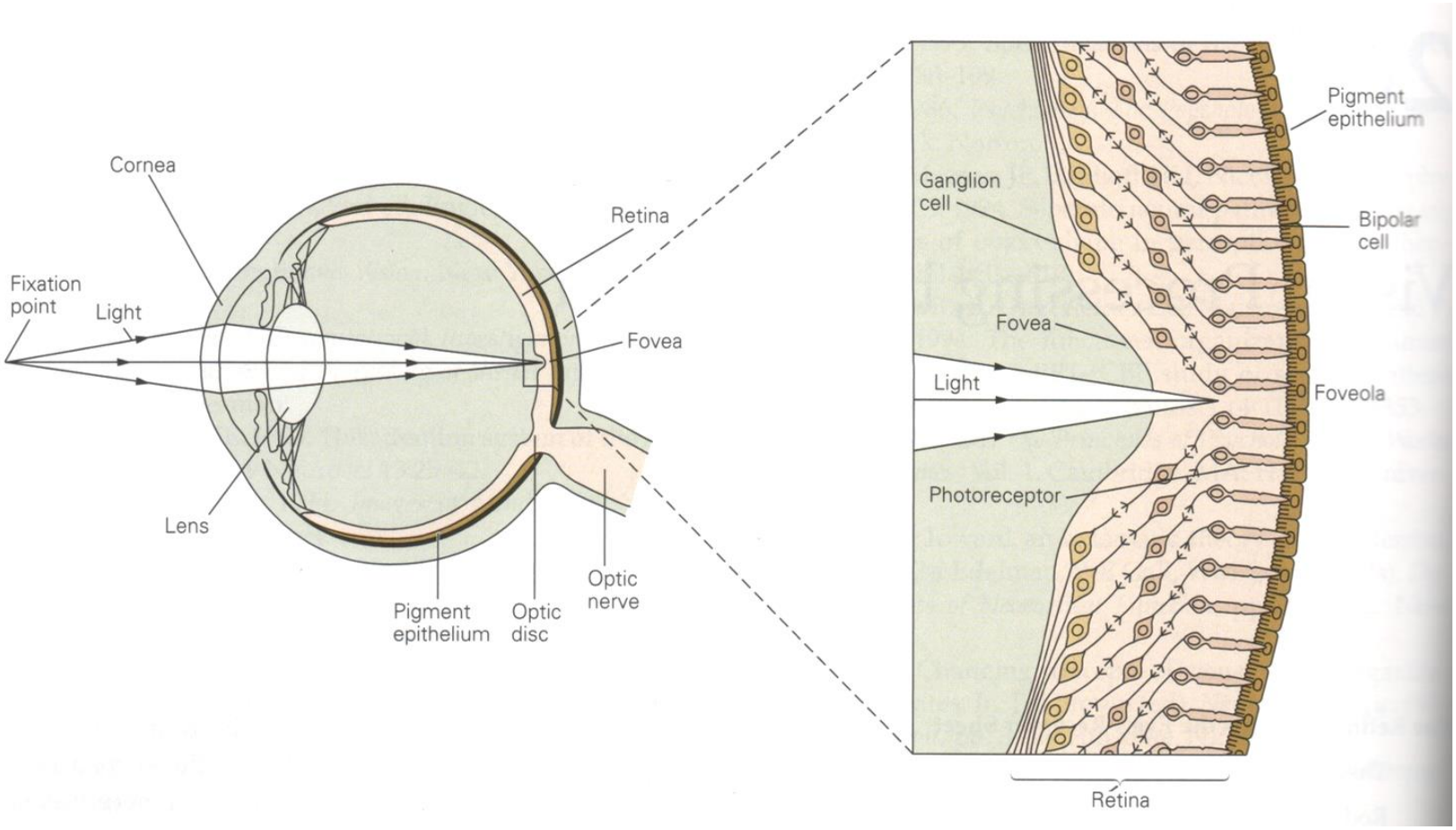


Iris

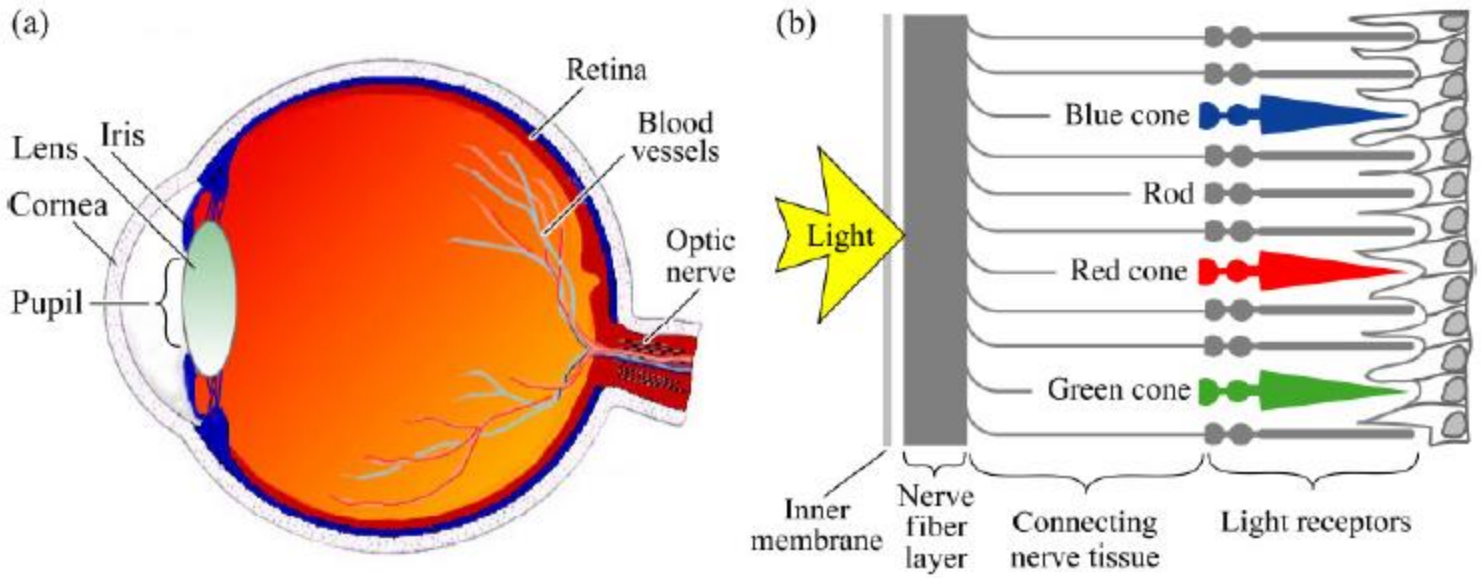
- Optical aperture of eye
- Diameter varies in accordance with available light
- Closes down rapidly in bright light (Red eye reduction)

- Quality of image is best with small aperture
- Depth of field: Range of object distance over which a good image is obtained
- Depth of field is inversely proportional to Iris diameter
- Geometric Depth of field:

Photoreceptors in the retina



Human Vision



- **Retina has rods & cones as light receptors**

Rods & Cones

- **Rods & cones cover retina**
  - 120 million rods (night vision – Scotopic Vision)
  - 7 million cones (day vision – Photopic Vision)

- **1 kind of rod**
  - “Monochromatic” vision in dim light, but much more sensitive
  - Contain photopigment rhodopsin

- **3 kinds of cones, each sensitive at different wavelength**
  - “Trichromatic” vision

Photopic vs Scotopic vision

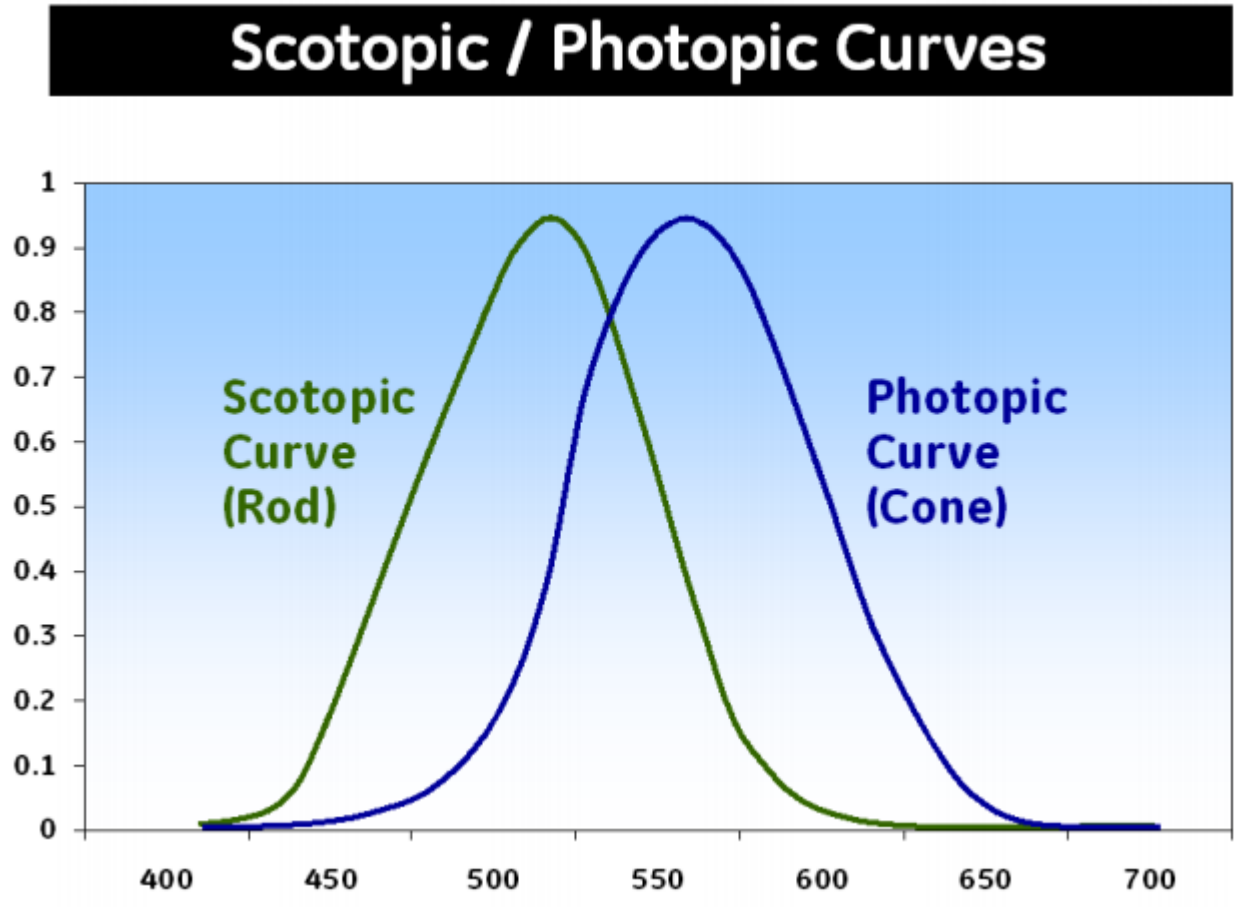
Photopic vision

- at high light intensities
- colour vision
- high resolution
- low sensitivity
- best in fovea
- Stiles-Crawford effect
- mediated by cones

Scotopic vision

- at low light intensities
- achromatic
- low resolution
- high sensitivity
- foveal scotoma
- no Stiles-Crawford effect
- mediated by rods

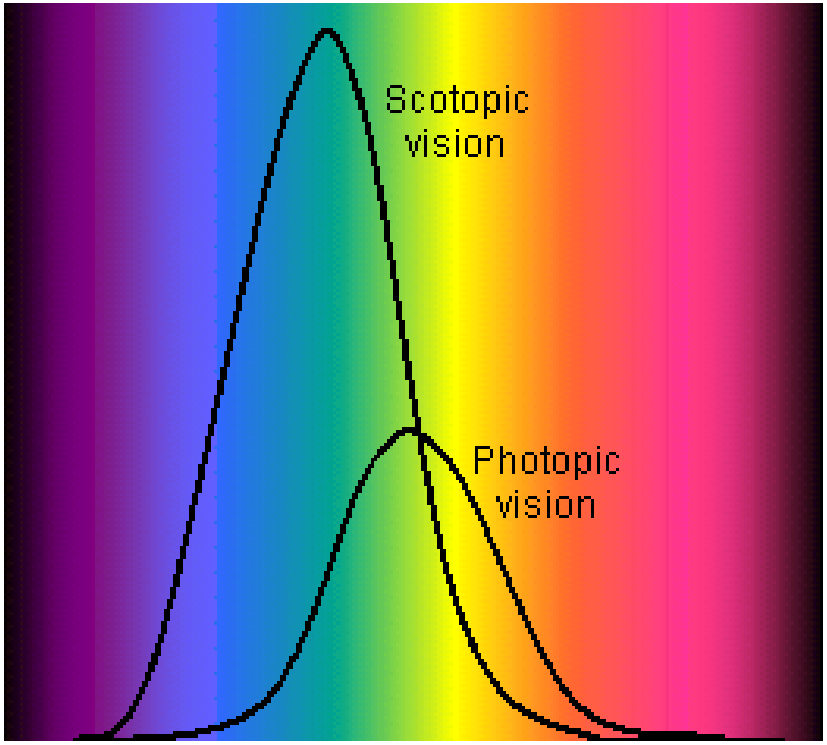
Spectral sensitivity of eye



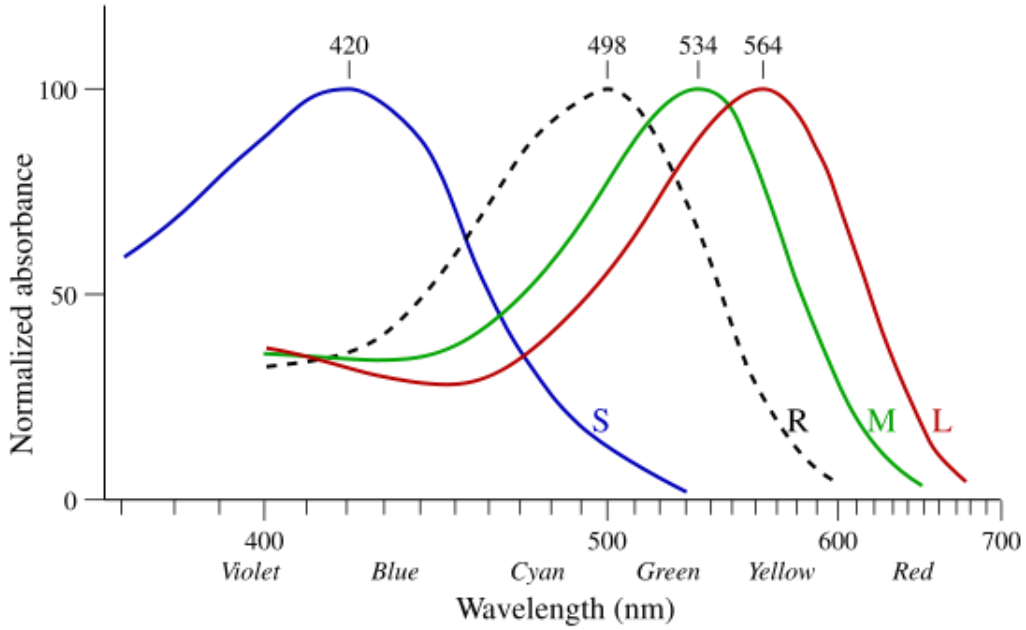
Scotopic & photopic vision

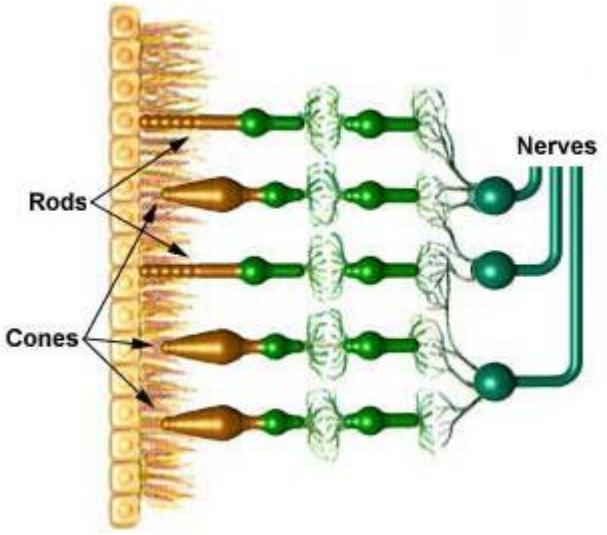
Sensitivity of cones in your eye is known as the ***photopic response*** & refers to colour vision & perception of fine detail.

Sensitivity of rods in your eye is known as ***scotopic response*** & refers to vision under conditions of low level light intensity – so called '**night vision**'.



Function of the rods & of the cones in photopic (cones) & scotopic (rods) vision.





S,M,L = short, medium and long wavelengths of cones

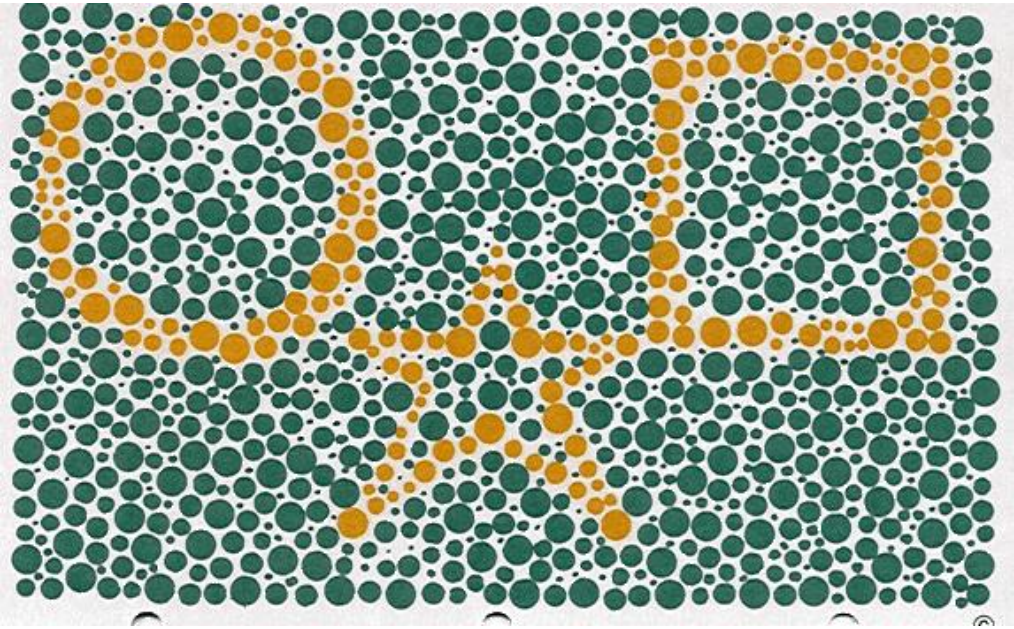
R = rods

Photopic vision is vision of eye under well-lit conditions. In humans & many animals, photopic vision allows colour perception, mediated by the cone cells.

Scotopic vision is monochromatic vision of eye in low light. Since cone cells are nonfunctional in low light, scotopic vision is produced exclusively through rod cells so therefore there is no colour perception.

Colour Blindness

Colour deficiency, Impaired colour vision

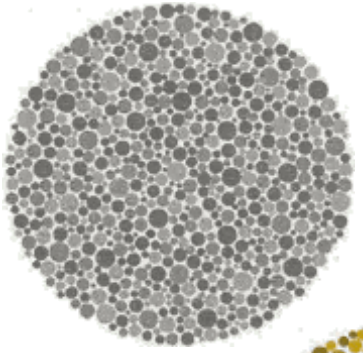


Cones & Colour

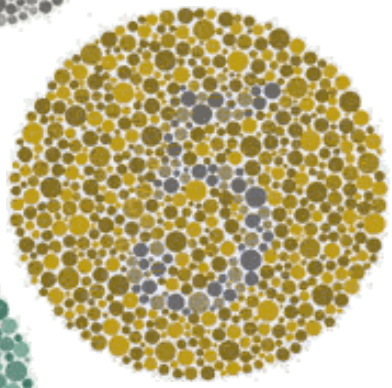
There are "**red**," "**blue**," & "**green**" cones, which are sensitive to those colors & combinations of them. You need all three types to see colours properly. When your cones don't work properly, or you don't have the right combination, your brain doesn't get the right message about which colours you're seeing.

How are Tests Made?

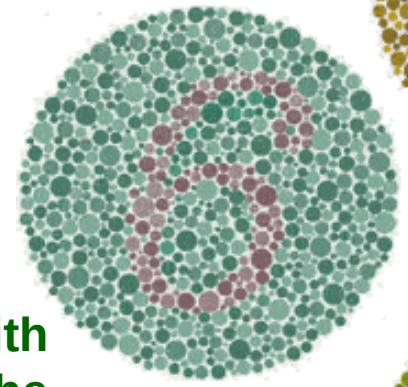
- A random pattern of gray level dots is first put together.



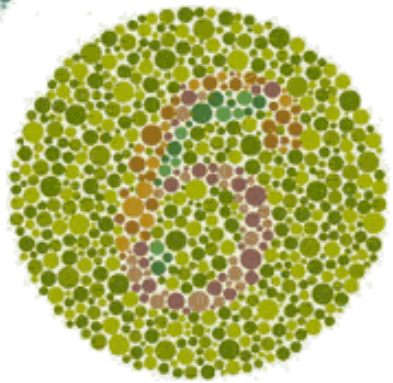
- A digit pattern is then added which is defined by yellow/blue variation only. Since most people with red/green colorblindness can see yellow/blue they will be able to see the digit 5 in this test pattern.

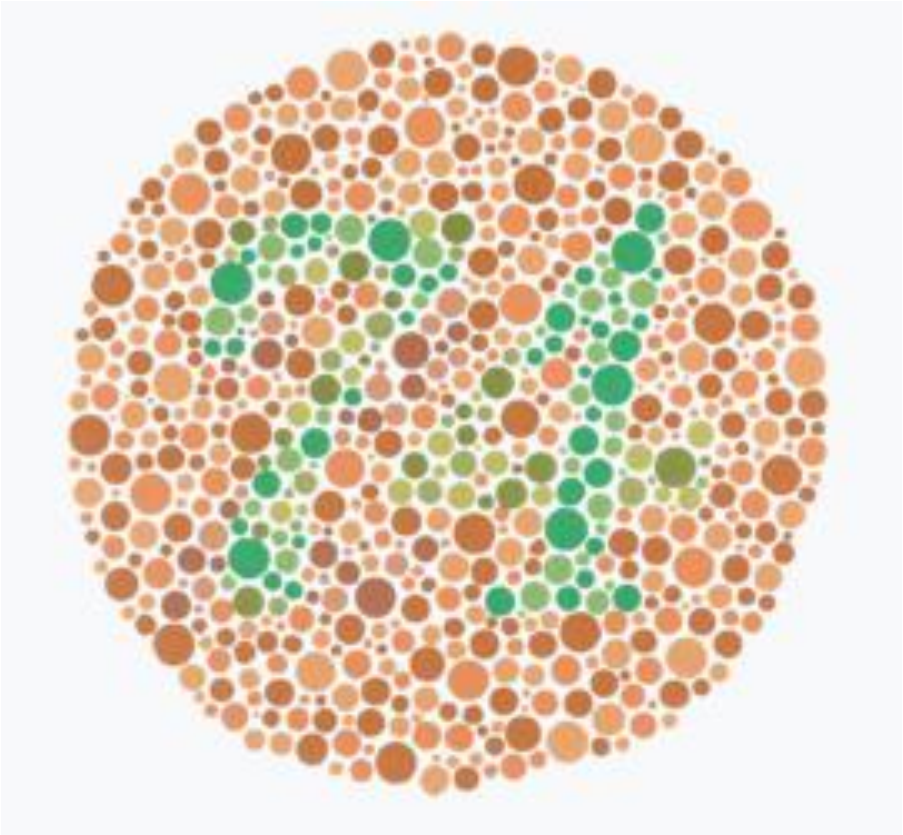


- Another digit pattern which is defined by red/green variation is added. Here is the pattern composed of the random brightness pattern & red/green pattern.



- Finally all three are added: People with red/green deficiency will not be able to see the red/green pattern and will see the 5. People with normal vision will see both the patterns, but since the red/green is stronger than the yellow/blue, the normal person will see the digit 6.





Ex. of an Ishihara colour test plate. With properly configured computer displays, people with normal vision should see the number "74". Many people who are colour blind see it as "21", & those with total colour blindness may not see any numbers

Colour Blindness

- **Colour blindness is the decreased ability to see colour or differences in colour. It can make some educational activities difficult such as buying fruit, picking clothing, reading traffic light, etc [Pilot, train driver, & armed forces].**

- **Males are more likely to be colour blind than females.**

- **There is no cure for colour blindness.**

- **Red-green colour blindness,**
  Blue-yellow colour blindness,
  Total colour blindness.