

Human Visual System- HVS



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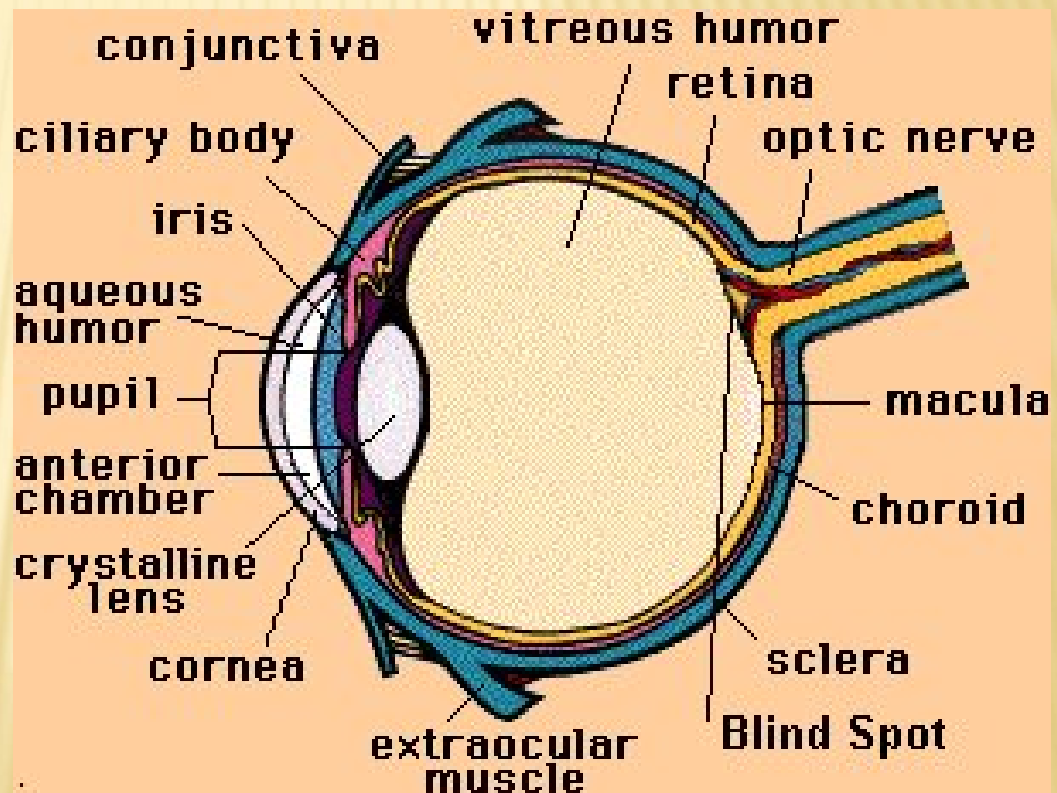
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THE HUMAN EYE

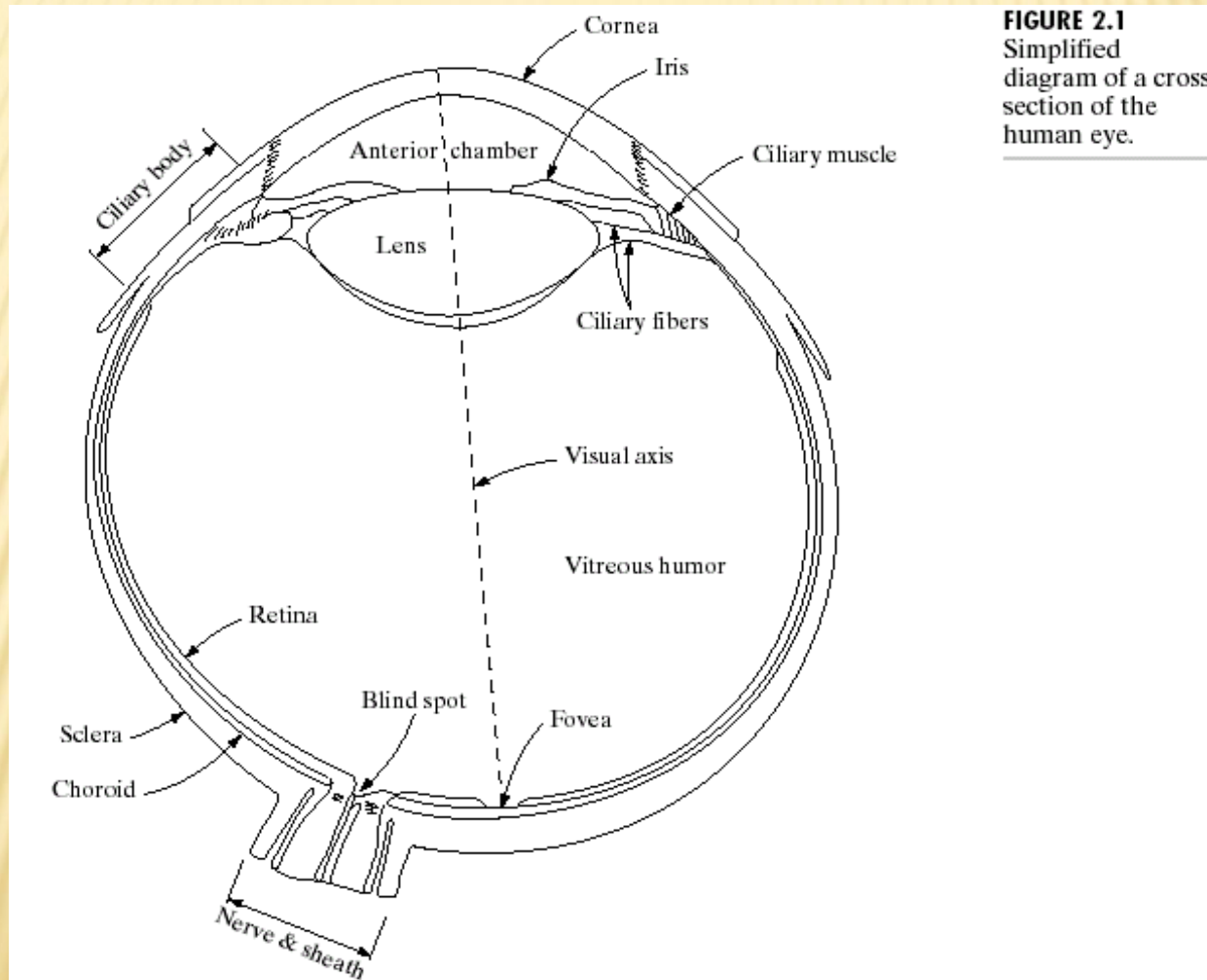
- Diameter: 11-20 mm

3 membranes enclose the eye

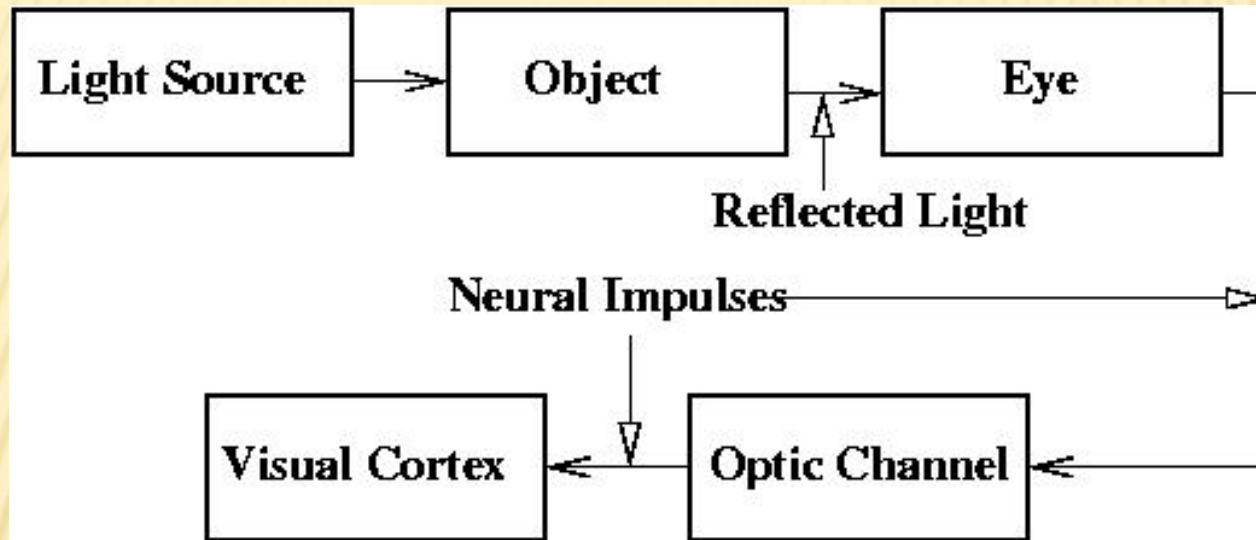
- Cornea & sclera
- Choroid
- Retina



Human Visual System

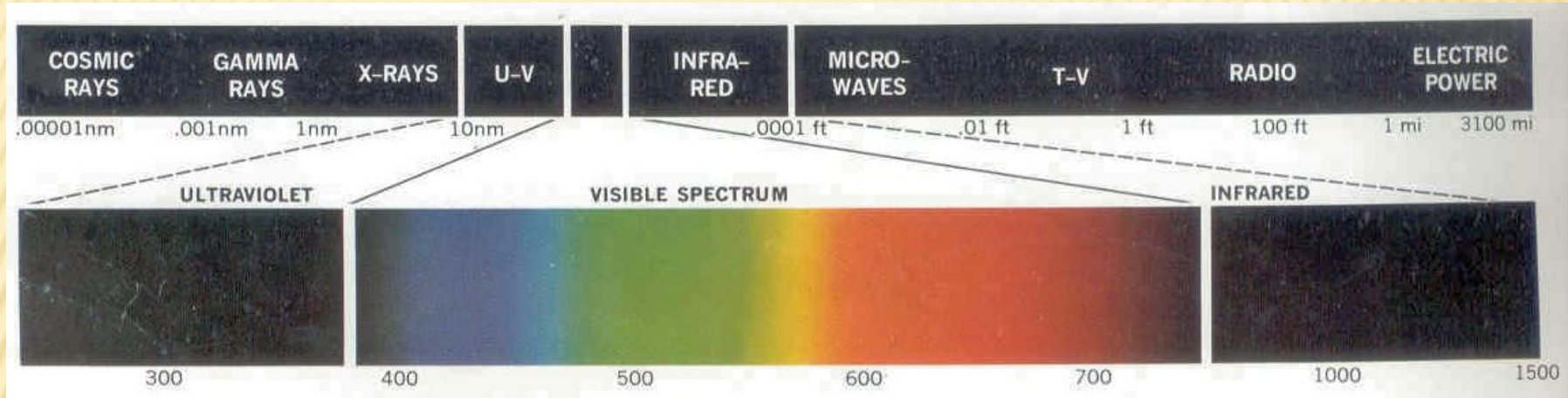


BLOCK DIAGRAM



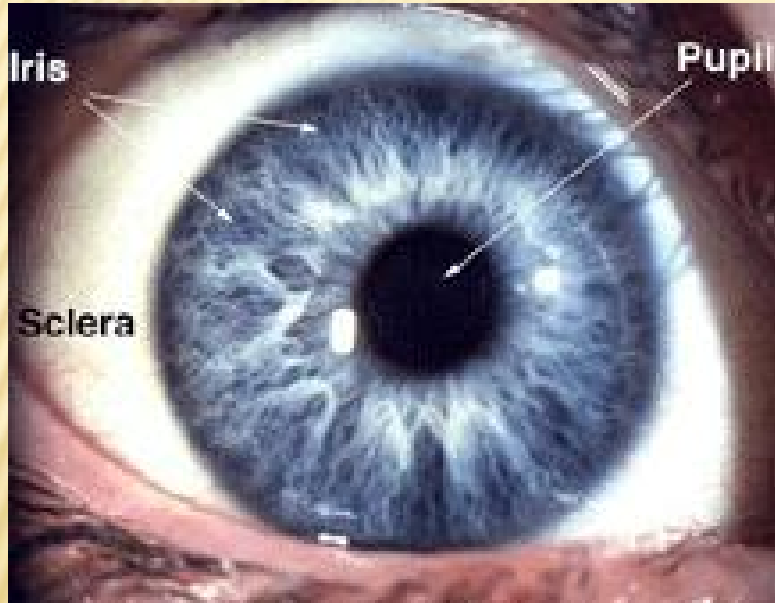
- Light reflected from object focused on the retina by the lens of eye
- Optic nerves carry the neural message to visual cortex
- Different stages of visual cortex interprets the information

VISIBLE LIGHT SPECTRUM



- Only a small portion of the EM spectrum is visible light region
- **Red** has long wavelength in visible range
- **Violet** has the shortest wavelength in visible range
- Wavelengths shorter than violet are filtered by the fluid of the eye ball - do not reach the retina

HUMAN EYE

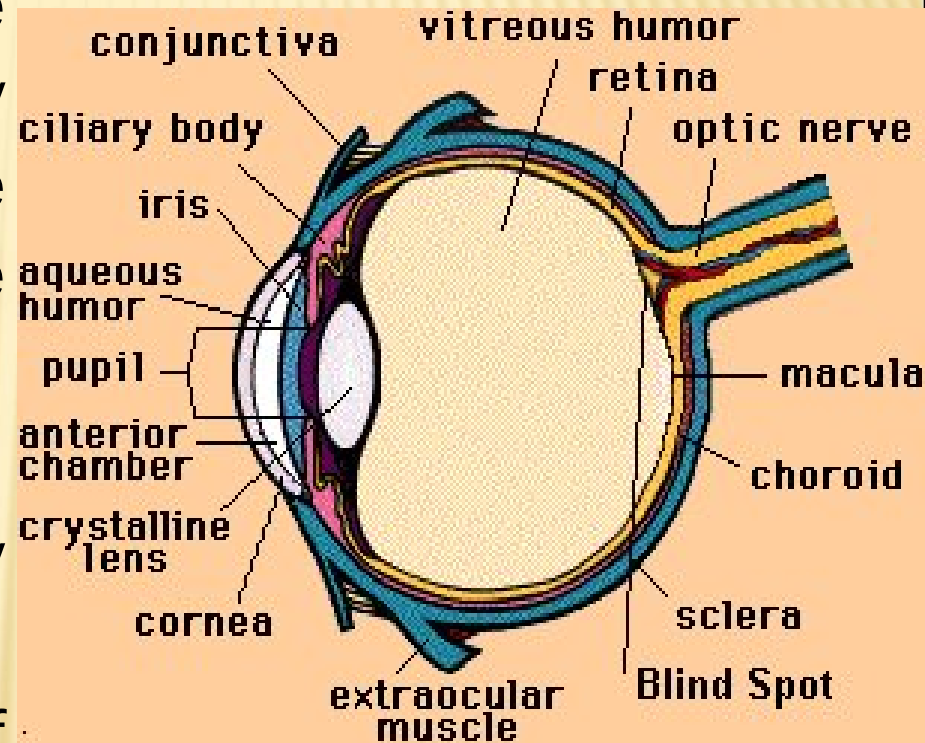


- Iris – Greek word for rainbow
- Iris has 2 layers
- Outer layer – pigments
- Inner layer blood vessels
- Pupil is the adjustable opening
- Sclera – hard, dense fibrous coat, i.e. white part of the eye

THE CHOROID

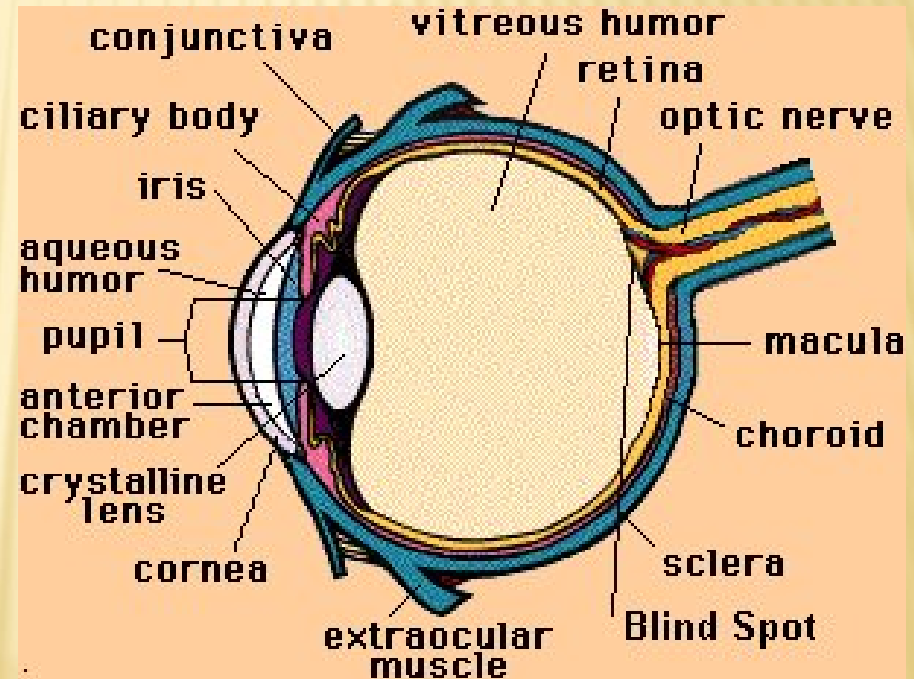
The choroid contains blood vessels for eye nutrition and is heavily pigmented to reduce extraneous light entrance and backscatter.

It is divided into the ciliary body and the iris diaphragm, which controls the amount of light that enters the pupil (2 mm ~ 8 mm).



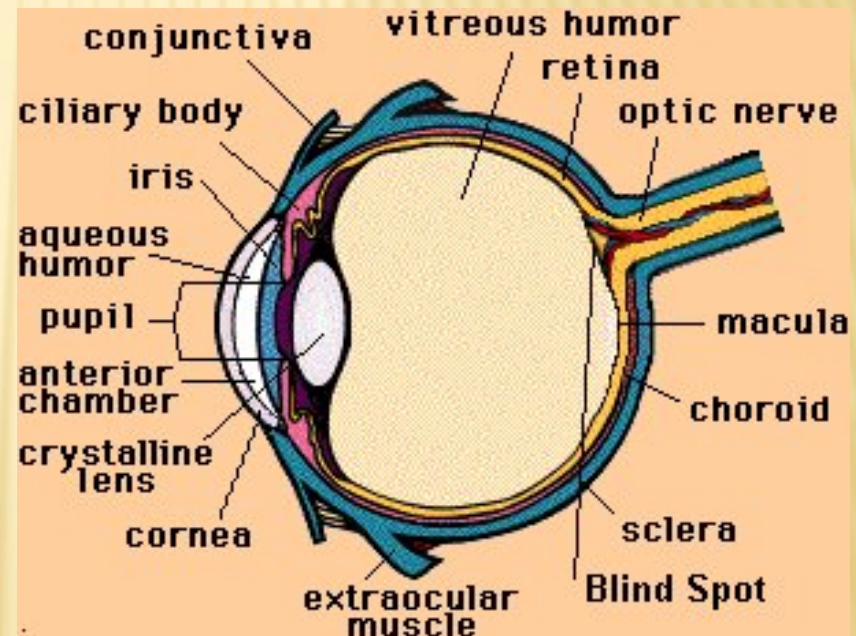
THE LENS

- The lens is made up of fibrous cells and is suspended by fibers that attach it to the ciliary body.
- It is slightly yellow and absorbs approx. 8% of the visible light spectrum.



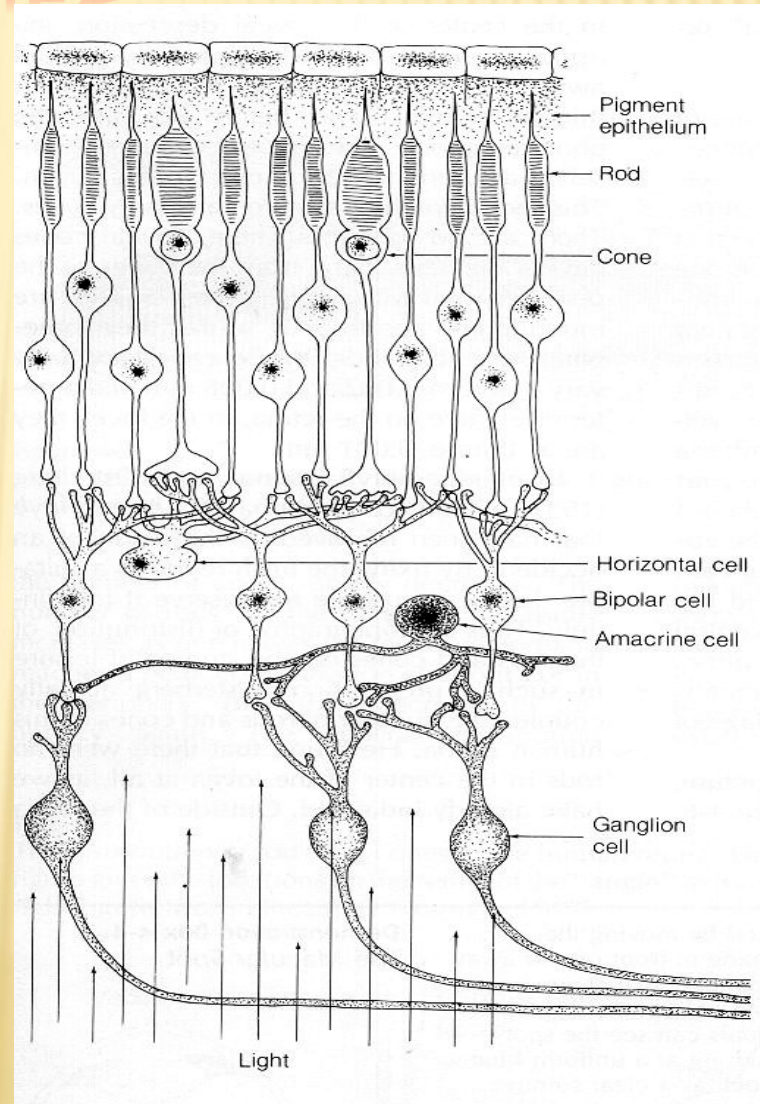
THE RETINA

- The retina lies the entire posterior portion.
- Discrete light receptors are distributed over the surface of the retina:
 - Cones
(6-7 million per eye) and
 - rods
(75-150 million per eye)



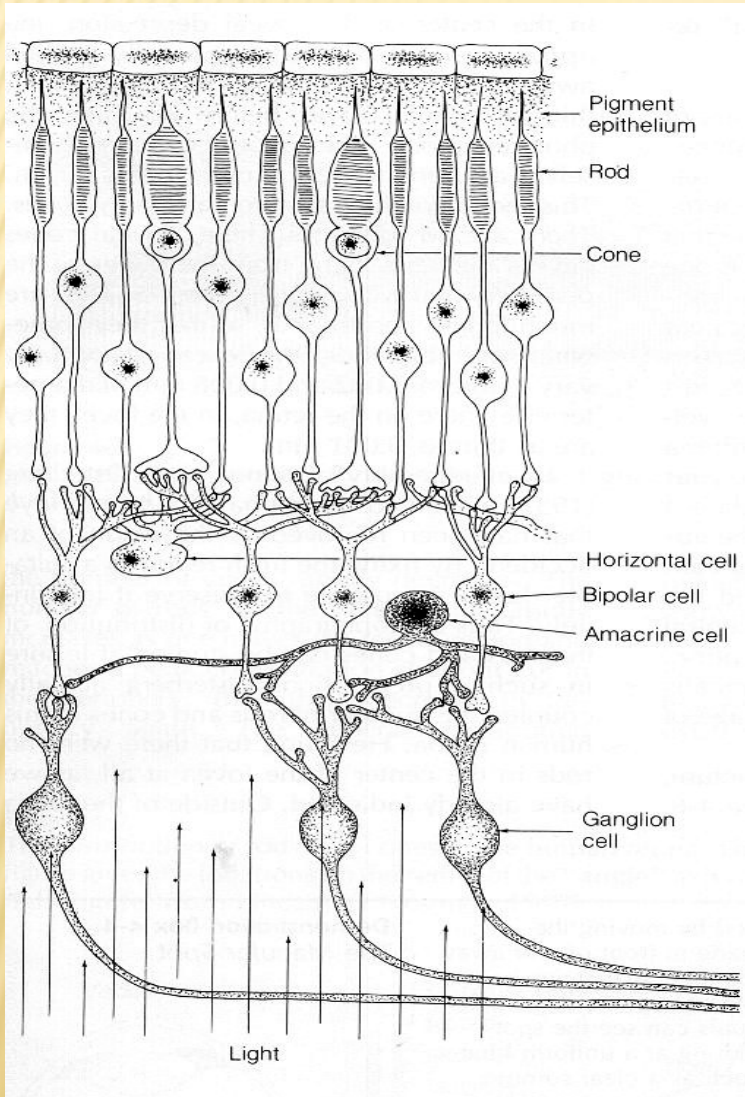
CONES

- Cones are located in the fovea and are sensitive to color.
- Each one is connected to its own nerve end.
- Cone vision is called *photopic* (or bright-light) vision.



RODS

- Rods are giving a general, overall picture of the field of view and **are not involved in color vision.**
- Several rods are connected to a single nerve and are sensitive to low levels of illumination (scotopic or dim-light vision).



RECEPTOR DISTRIBUTION

- The distribution of receptors is radially symmetric about the fovea.
- Cones are most dense in the center of the fovea while rods increase in density from the center out to approximately 20% off axis and then decrease.

Cones & Rods

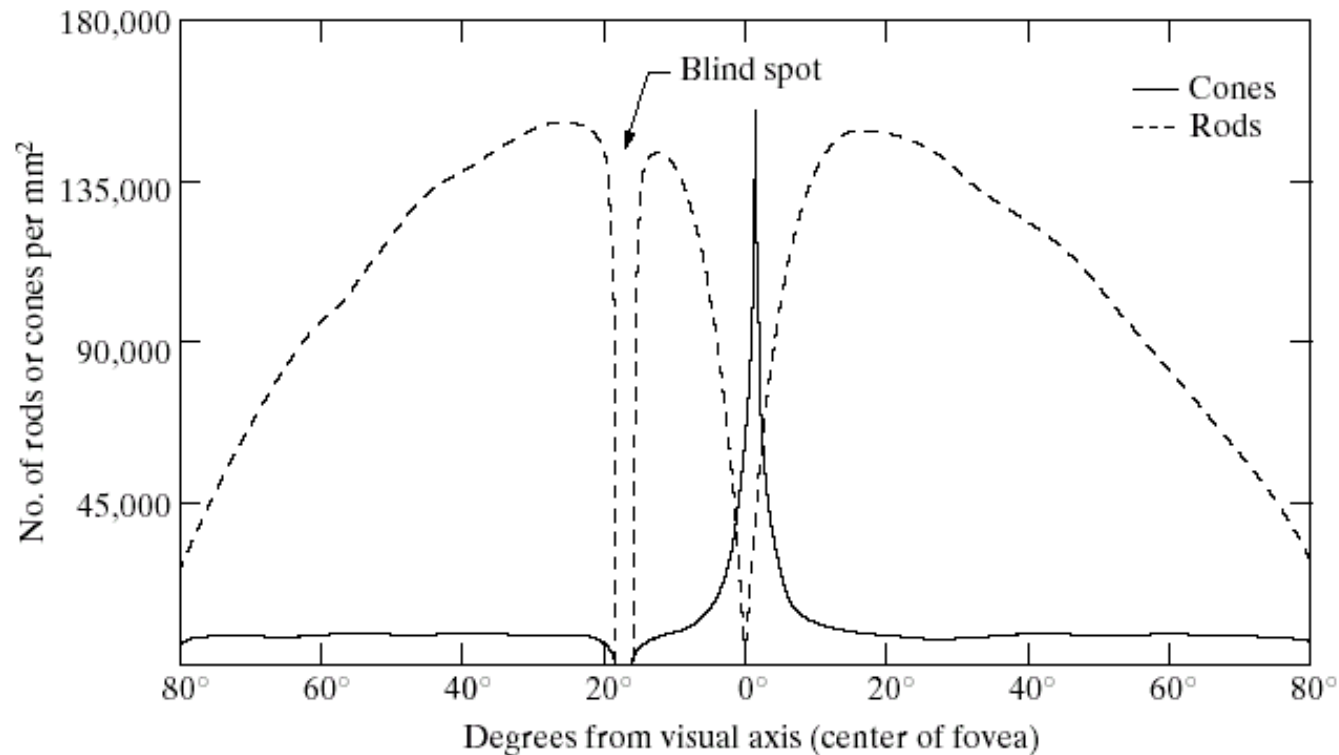


FIGURE 2.2
Distribution of rods and cones in the retina.

THE FOVEA

- The fovea is circular (1.5 mm in diameter) but can be assumed to be a square sensor array (1.5 mm x 1.5 mm).
- The density of cones: 150,000 elements/mm²
337,000 for the fovea.
- A CCD imaging chip of medium resolution needs 5 mm x 5 mm for this number of elements.

IMAGE FORMATION IN THE EYE

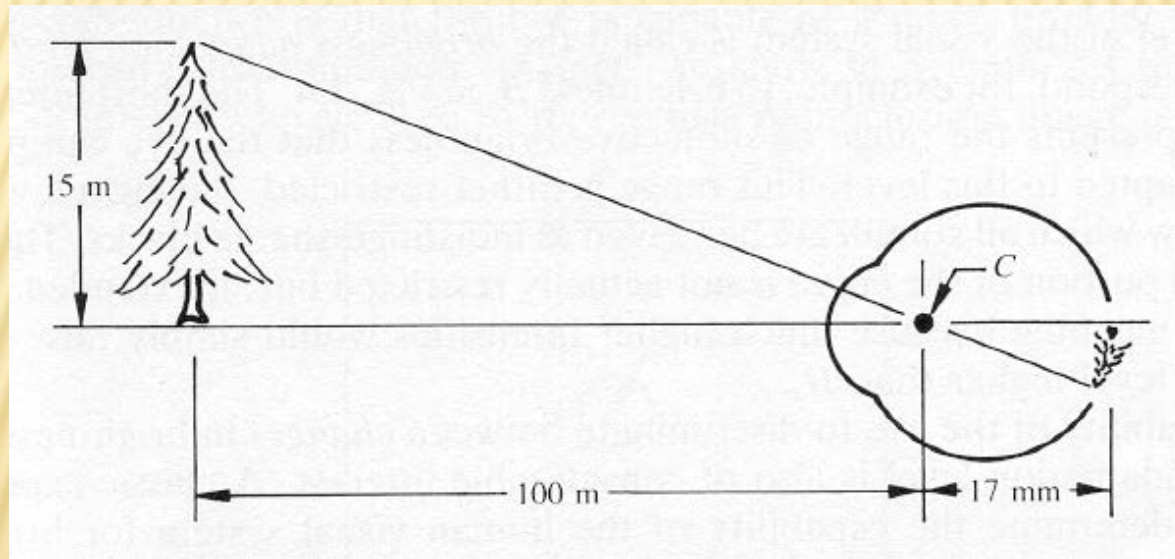
- The eye lens (if compared to an optical lens) is flexible.
- It gets controlled by the fibers of the ciliary body and to focus on distant objects it gets flatter (and vice versa).

IMAGE FORMATION IN THE EYE

- Distance between the center of the lens and the retina (*focal length*):
 - varies from 17 mm to 14 mm (refractive power of lens goes from minimum to maximum).
- Objects farther than 3 meter use minimum refractive lens powers (and vice versa).

IMAGE FORMATION IN THE EYE

- Example:
 - Calculation of retinal image of an object



$$\frac{15}{100} = \frac{x}{17}$$

$$x = 2.55 \text{ mm}$$

IMAGE FORMATION IN THE EYE

- Perception takes place by the relative excitation of light receptors.
- These receptors transform radiant energy into electrical impulses that are ultimately decoded by the brain.

BRIGHTNESS ADAPTATION & DISCRIMINATION

- Range of light intensity levels to which HVS (human visual system) can adapt:
 - on the order of **10^{10}** .
- Subjective brightness (i.e. intensity as perceived by the HVS) is a logarithmic function of the light intensity incident on the eye.

Brightness adaptation and discrimination

- The HVS cannot operate over such a range simultaneously.
- For any given set of conditions, the current sensitivity level of HVS is called the brightness adaptation level.

Brightness adaptation and discrimination

The eye also discriminates between changes in brightness at any specific adaptation level.

$$\frac{\Delta I_c}{I} \rightarrow \text{Weber ratio}$$

Where: ΔI_c : the increment of illumination discriminable
/differentiable 50% of the time and
 I : background illumination

Brightness adaptation and discrimination

- Small values of Weber ratio mean good brightness discrimination (and vice versa).
- At low levels of illumination brightness discrimination is poor (rods) and it improves significantly as background illumination increases (cones).

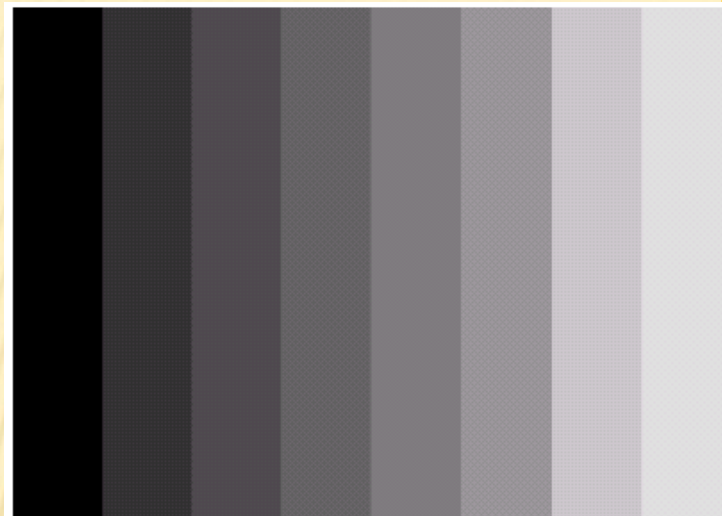
Brightness Adaptation and Discrimination

- The typical observer can discern/differentiate one to two dozen different (Gray-level) intensity changes...
- i.e. the number of different intensities a person can see at any one point in a monochrome image

Brightness adaptation and discrimination

- Overall intensity discrimination is broad due to different set of incremental changes to be detected at each new adaptation level.
- Perceived brightness is not a simple function of intensity
 - 'Mach' band effect
 - Simultaneous contrast

Perceived Brightness

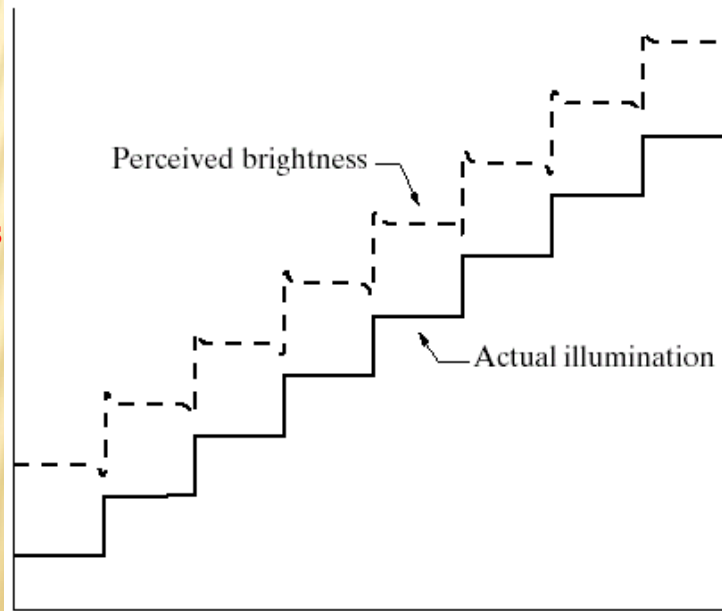


a
b

FIGURE 2.7

(a) An example showing that perceived brightness is not a simple function of intensity. The relative vertical positions between the two profiles in (b) have no special significance; they were chosen for clarity.

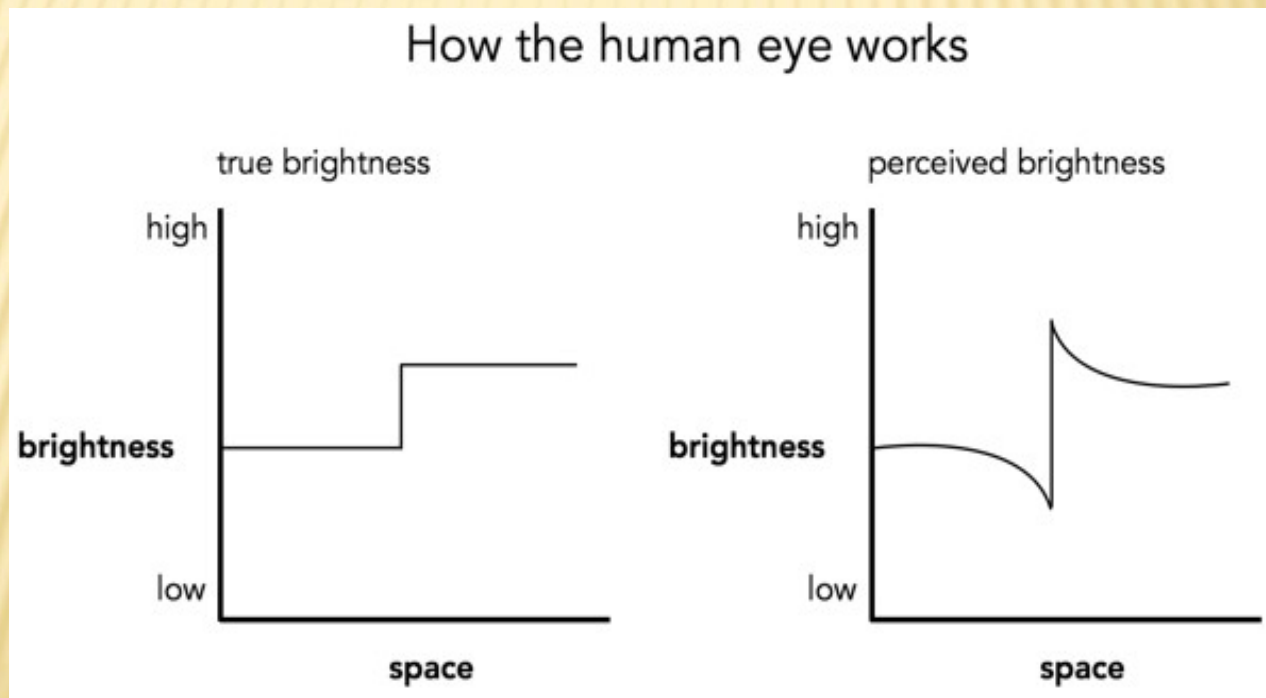
Brightness



Space

'MACH' band effect

'Mach' bands are an **optical illusion** where a band of gradients will appear in places to be lighter or darker than they actually are.



Simultaneous Contrast



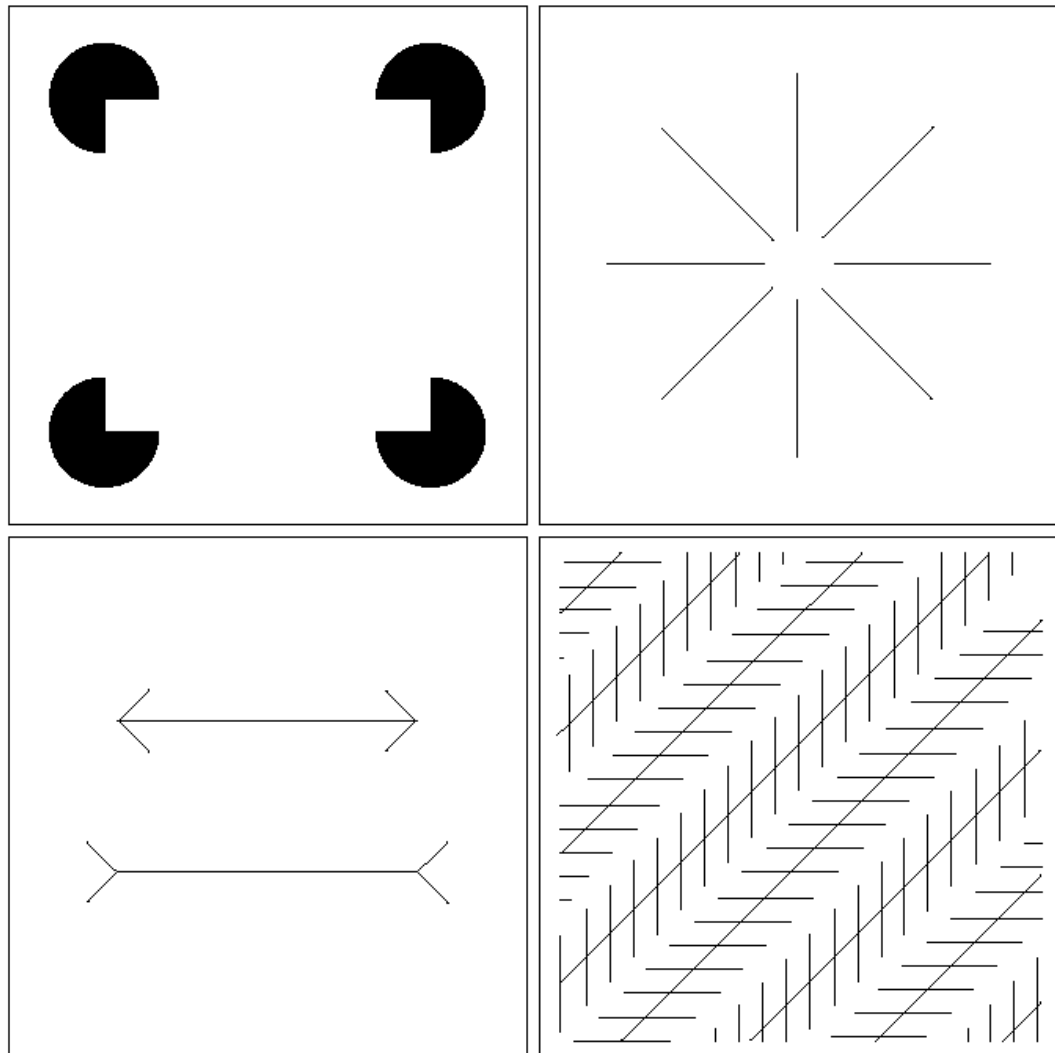
a b c

FIGURE 2.8 Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.

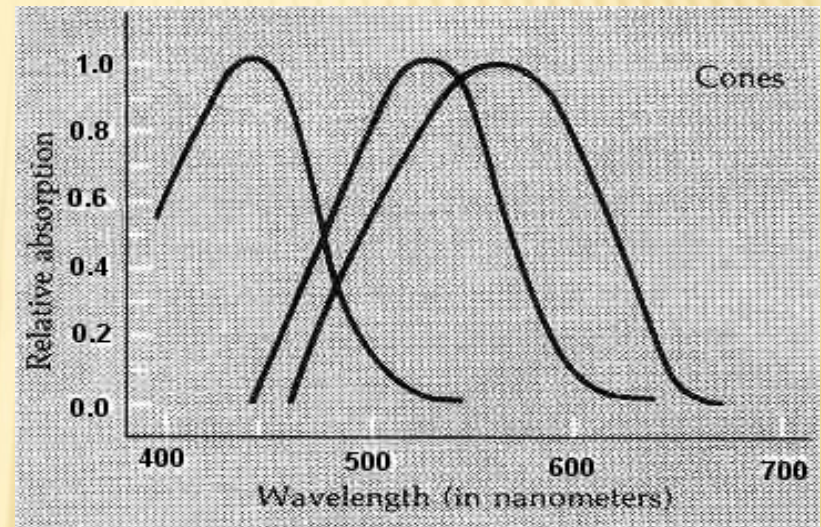
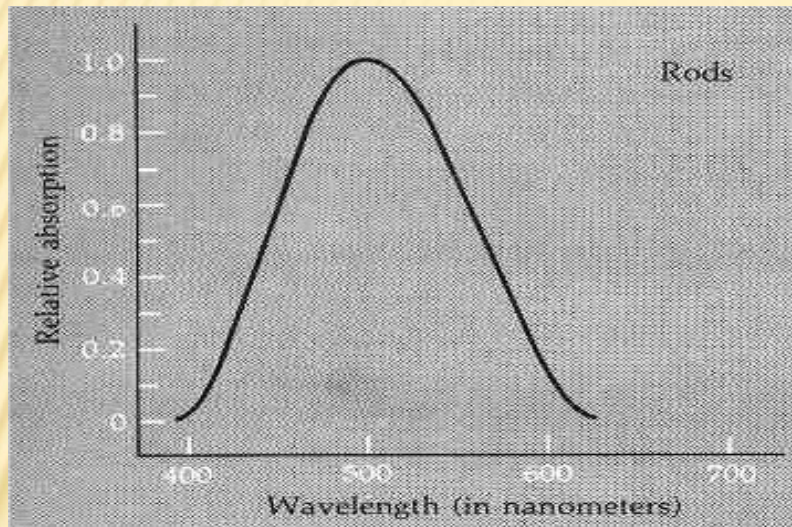
Illusions

a b
c d

FIGURE 2.9 Some well-known optical illusions.

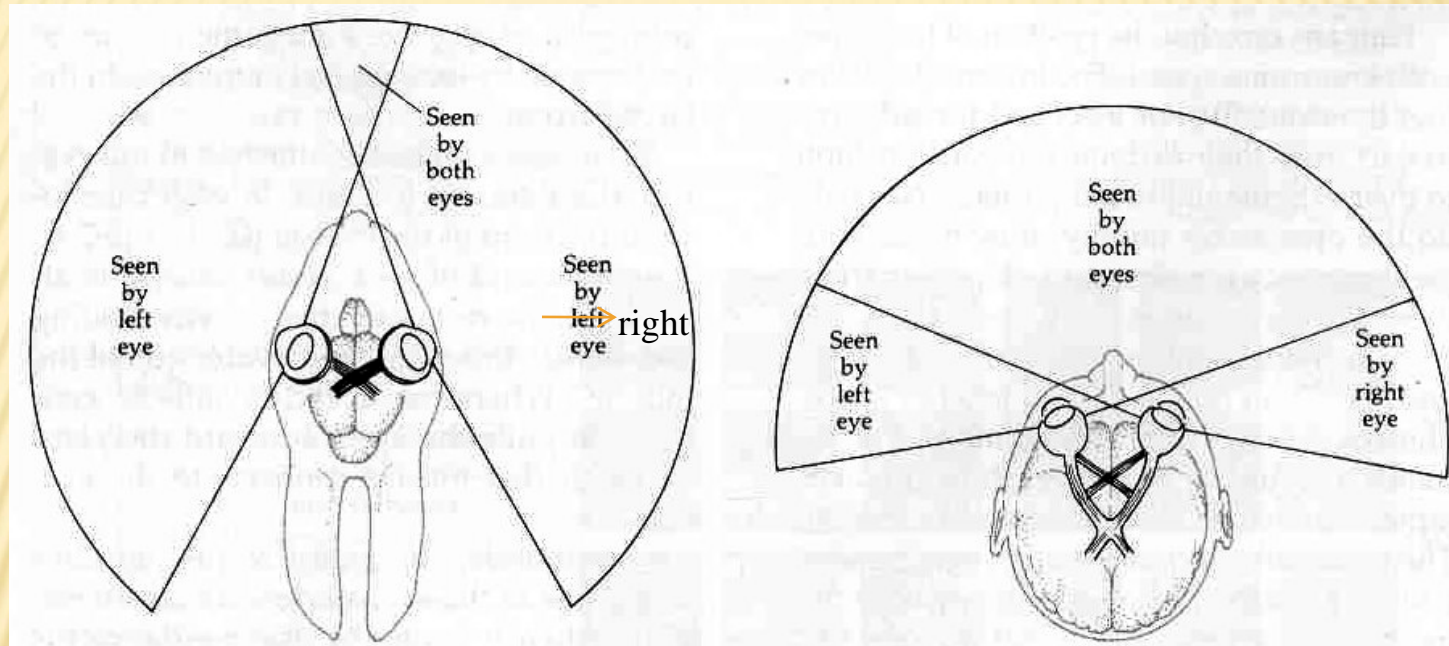


FREQUENCY RESPONSE OF PHOTORECEPTORS



- Three types of cones
 - ✓ Centered at 440 nm – violet
 - ✓ Centered at 550 nm – yellowish-green
 - ✓ Centered at 570 nm – yellow
- Rods centered at 500 nm

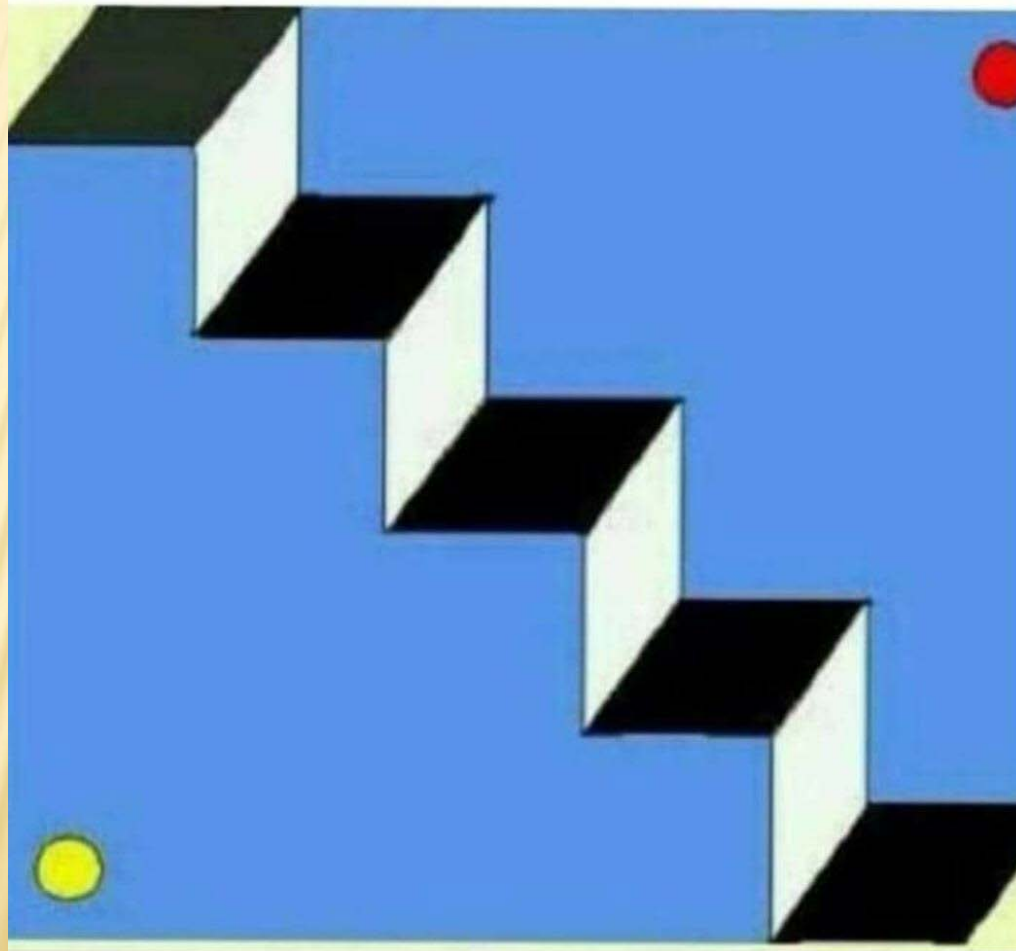
VISUAL FIELD



- Visual field of a rabbit (left) almost completely panoramic – lateral eye placement
- Frontal eye placement – Humans field of view only about 160-180 degrees

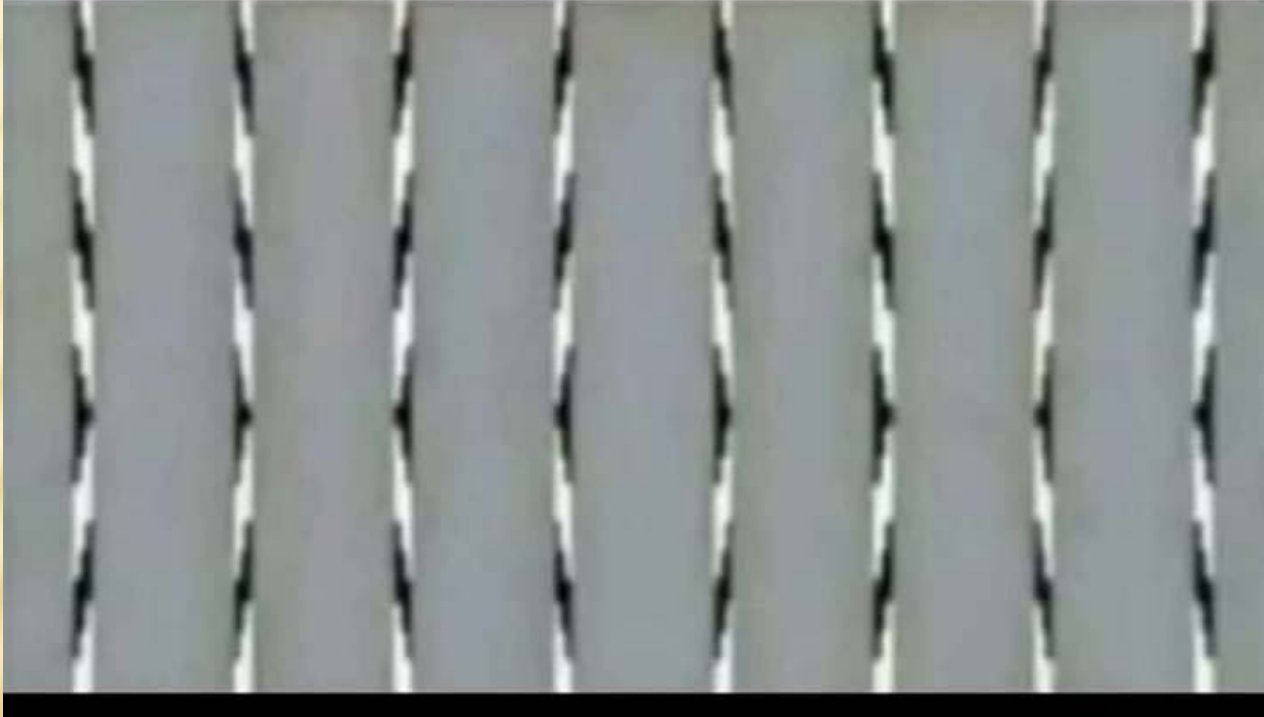
ILLUSION

15 सैकिंड लगातार इसे देखें,,,इसके स्टेप बदल जाएंगे ऐसा ही जीवन में भी होता है , उतार चढ़ाव आते रहते हैं ! 🌸

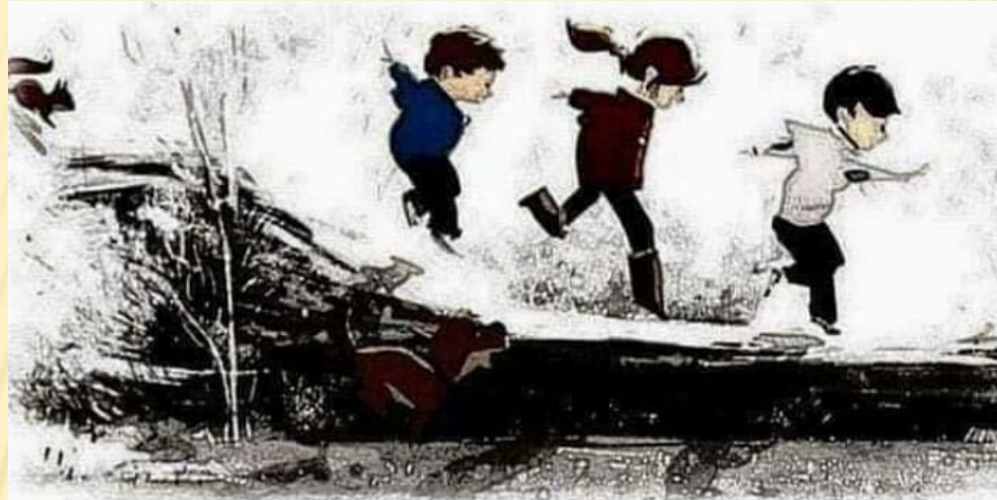
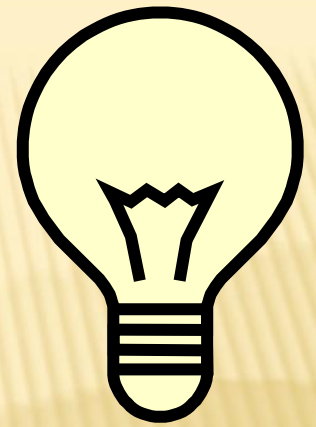


चित्रातील प्रत्येक रेघ ही सरळच आहे, वाकडी दिसणं हा फक्त नजरेचा खेळ आहे.

एखाद्याविषयी आपलं मत ताबडतोब व्यक्त करण्याआधी 10 वेळा विचार करा 😊



Any Questions Please ?



Life gives beautiful friends
Friends give beautiful life

Good Morning

Thanks!