Sensory Systems

Visioin

Training for students of MediTec project
1. – 15.9.2019, Kosice, Slovakia

Co-funded by the
Erasmus+ Programme
of the European Union

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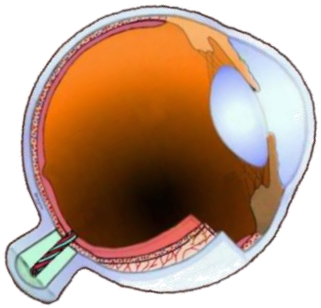
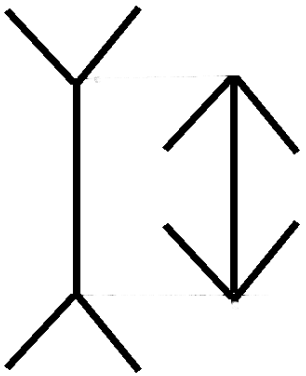
Physiology of Vision





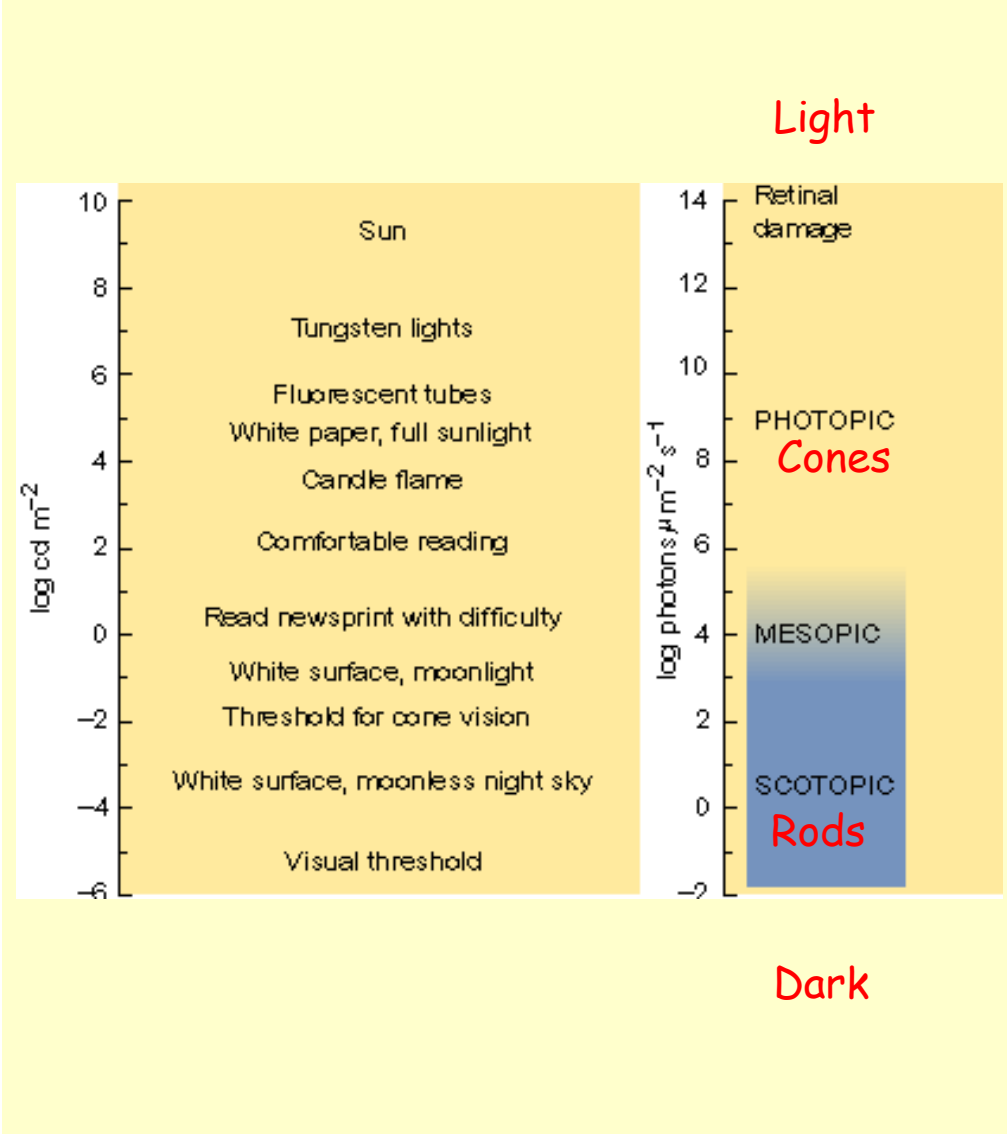
Department of Human physiology, Medical faculty UPJS in Kosice

Vision

Introduction

- The visual process is the detection and translation of light into static or dynamic mental images.
- Specialised photoreceptor cells, rods & cones, found within the retina transduce visible light energy into electrical signals that ultimately pass to the visual cortex.
- Rods are responsible for monochromatic night vision and cones for high-acuity daylight colour vision.
- The structure of the eye modifies light before it is detected by the rods & cones.

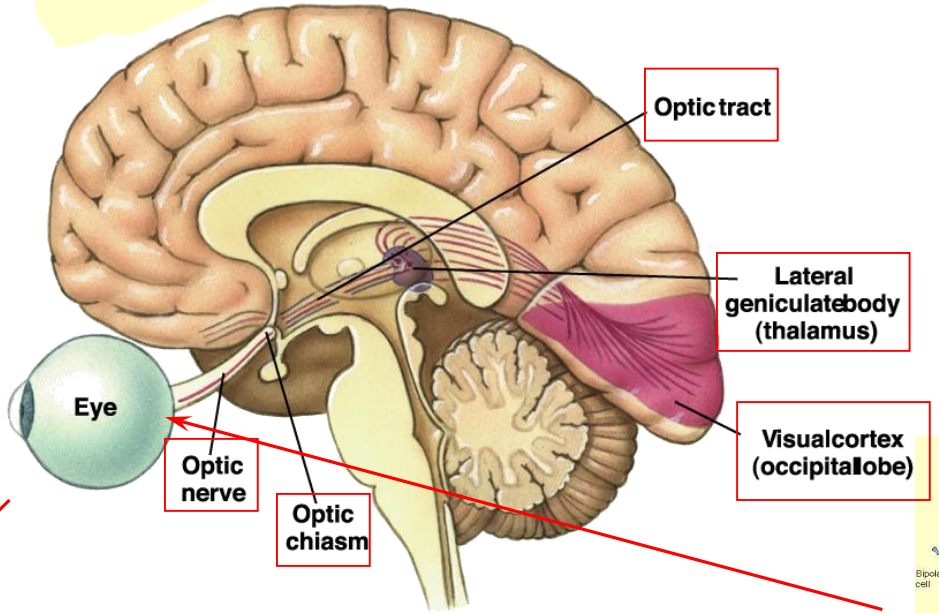
What we see

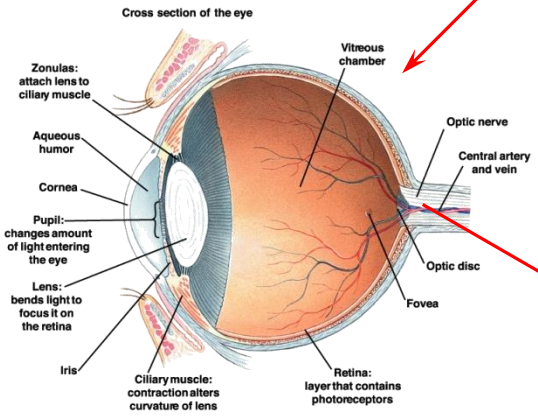


- The electromagnetic spectrum extends from high energy short wavelength gamma rays to low energy long wavelength radio waves.
- Objects emit light (candelas m^{-2}) or reflect light (lux).
- Human visible light lies only within the range ~380-750 nm.
- The eyes detect this light over an intensity range of 0.6 - 10 log cd m^{-2} (15 orders of

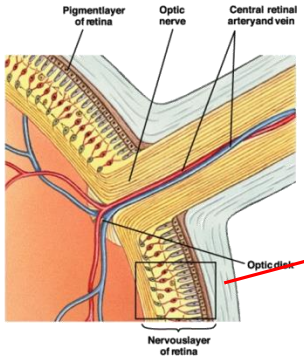
Anatomy of vision

Neural pathway for vision

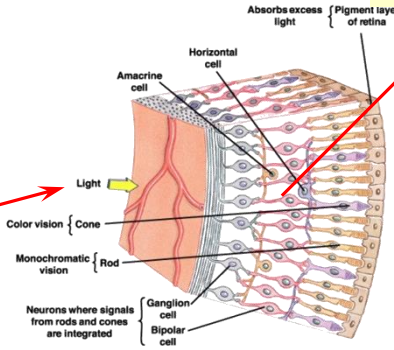




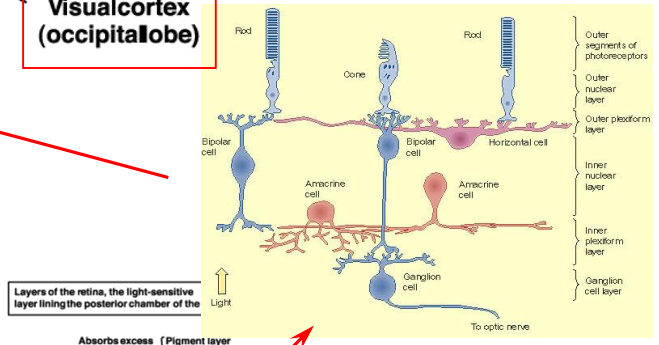
2x binocular vision plus accessory structures



Optic disk - blood supply optic nerve

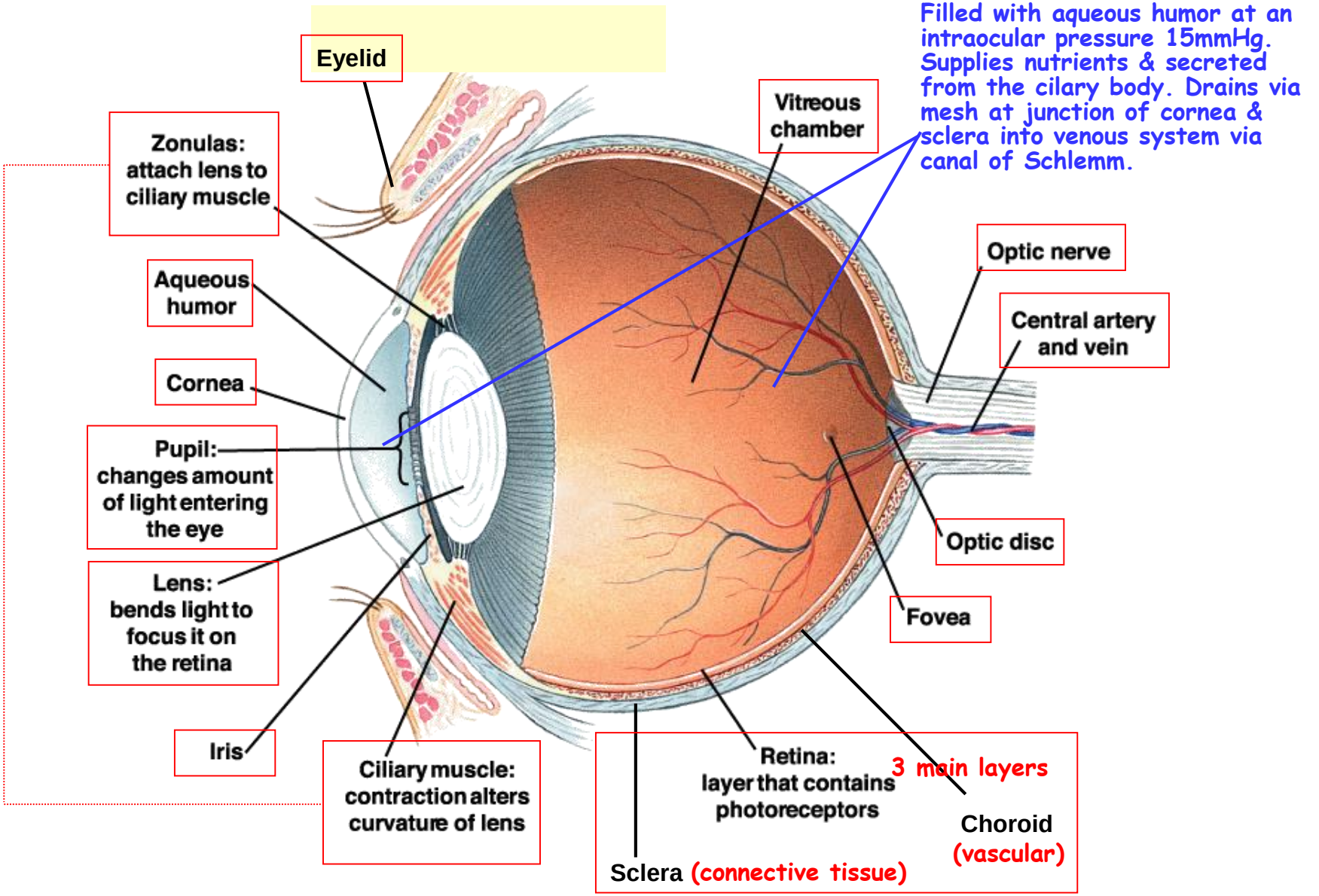


Retina

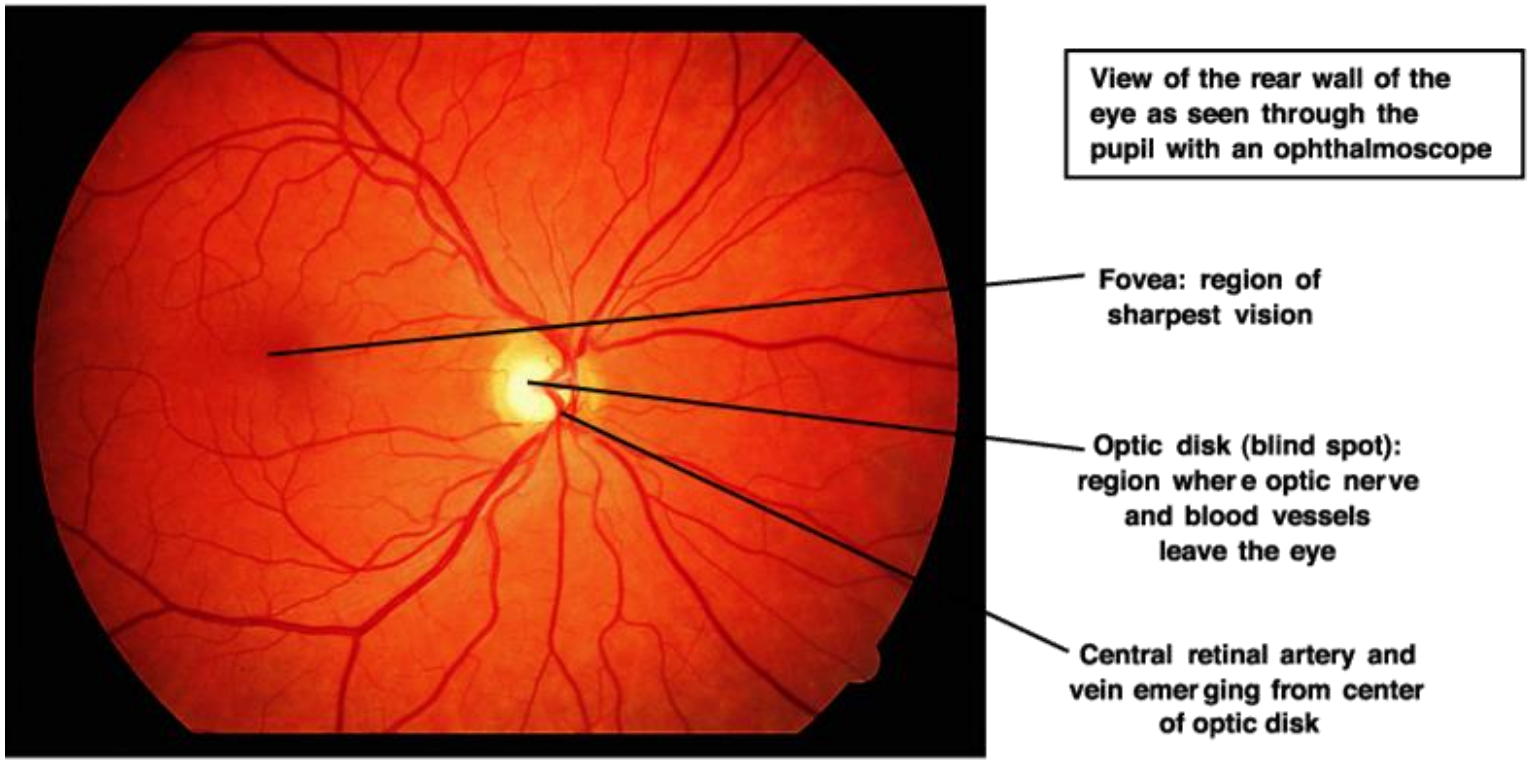


Retinal cells

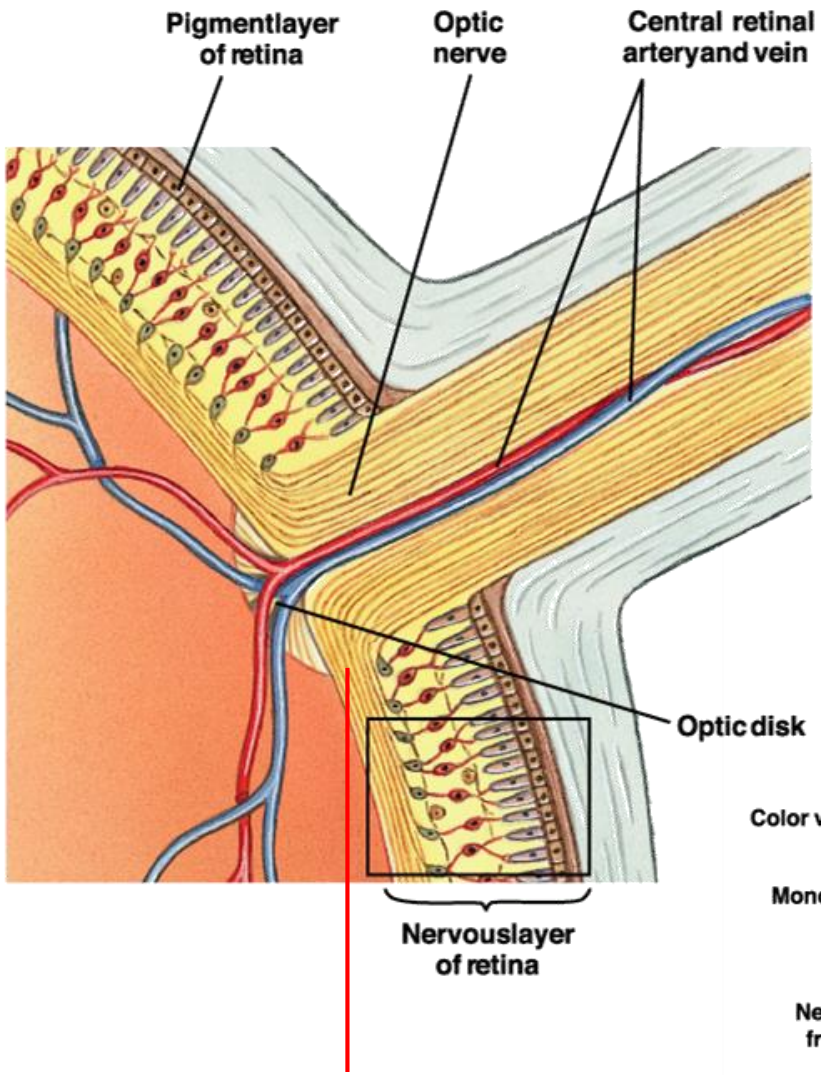
Cross-section of the eye

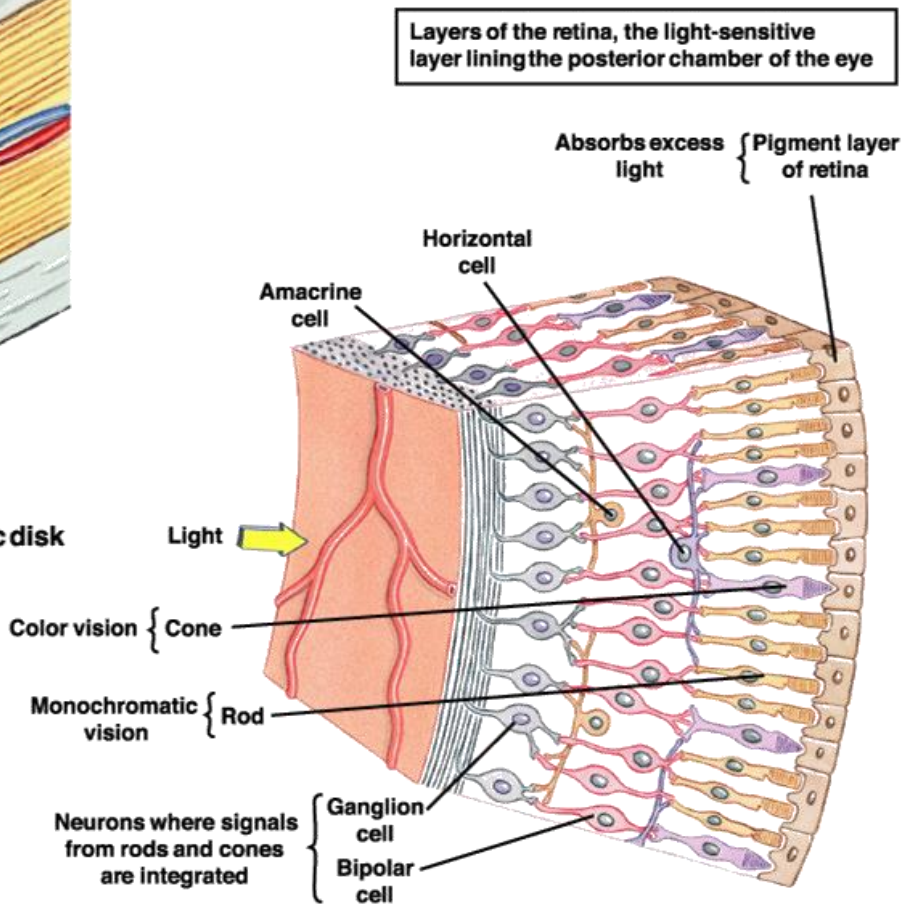


A peek with an ophthalmoscope



Retinal layers

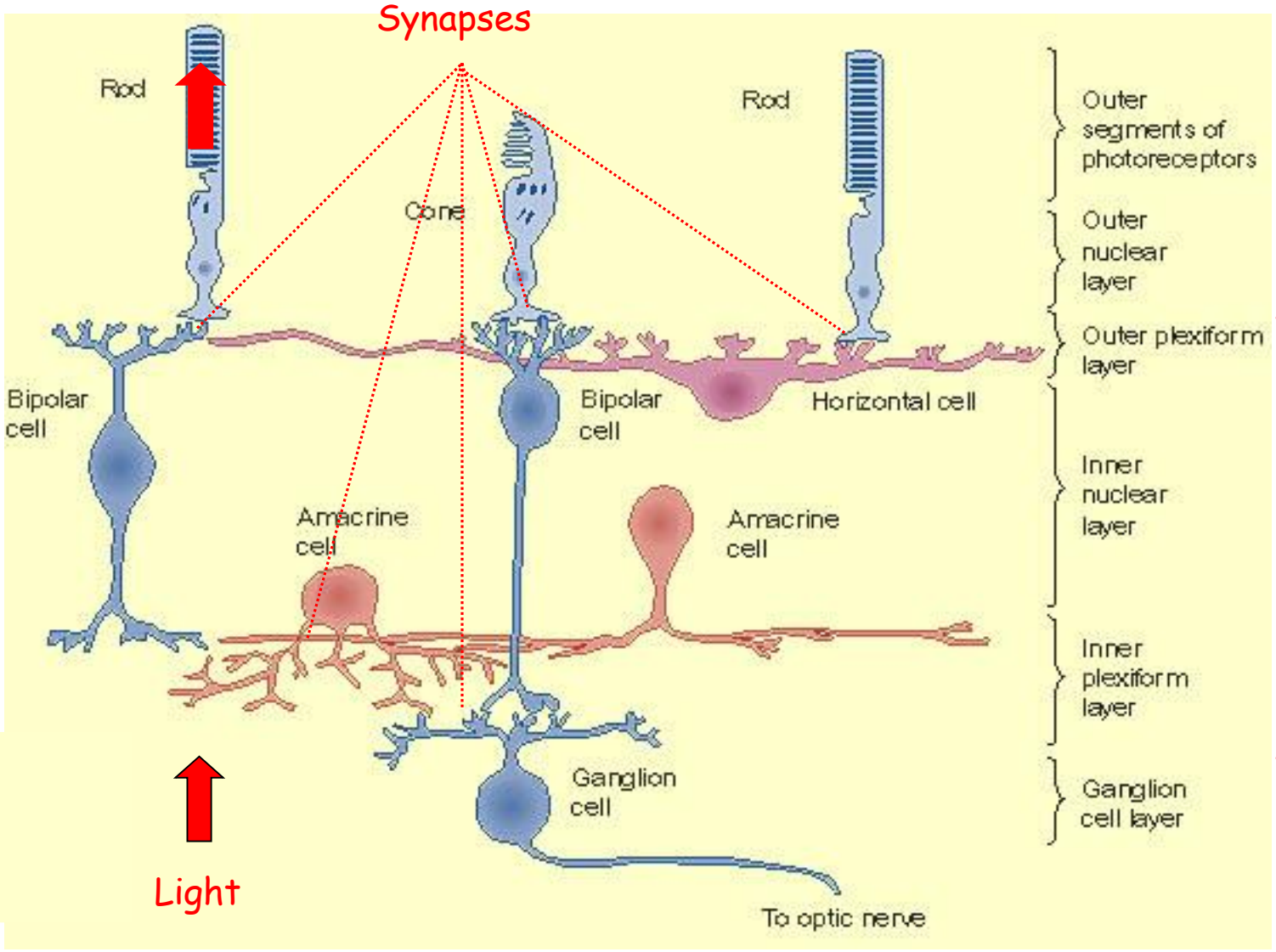




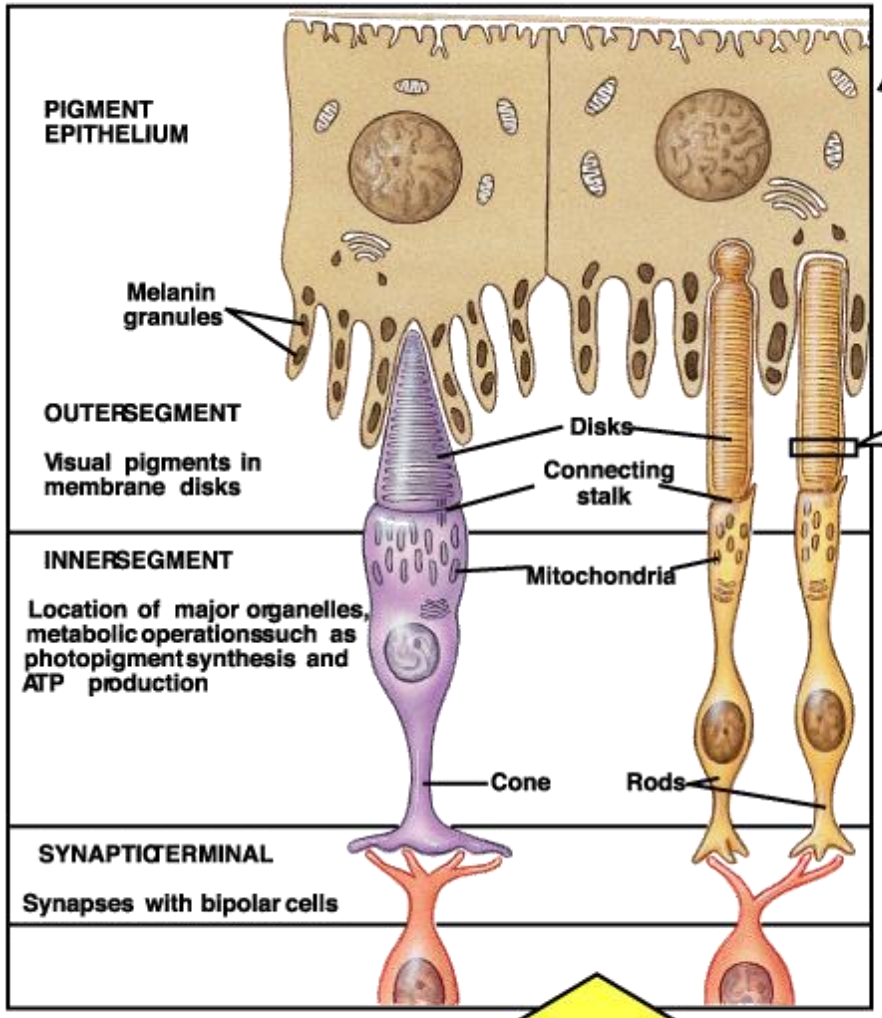
Ganglion cell axons form the optic nerve

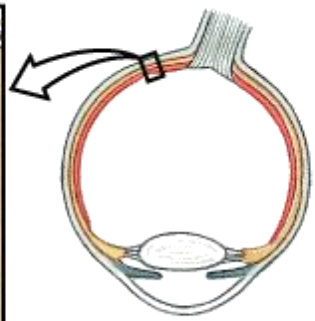
Cellular organisation of the retina

Light must pass through all layers before reaching rods & cones

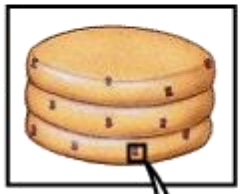


Rods and cones..

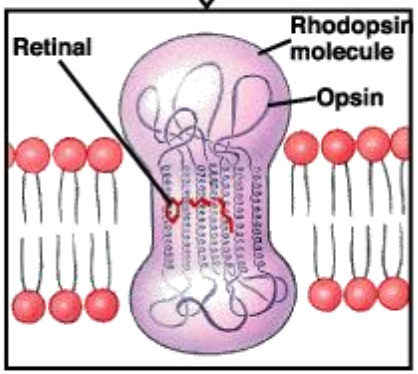




Dark pigment layer absorbs stray light & reduces reflection



Disks in rods & cones are the site of transduction



Transduction process mediated by pigments in the disks ..example is rod

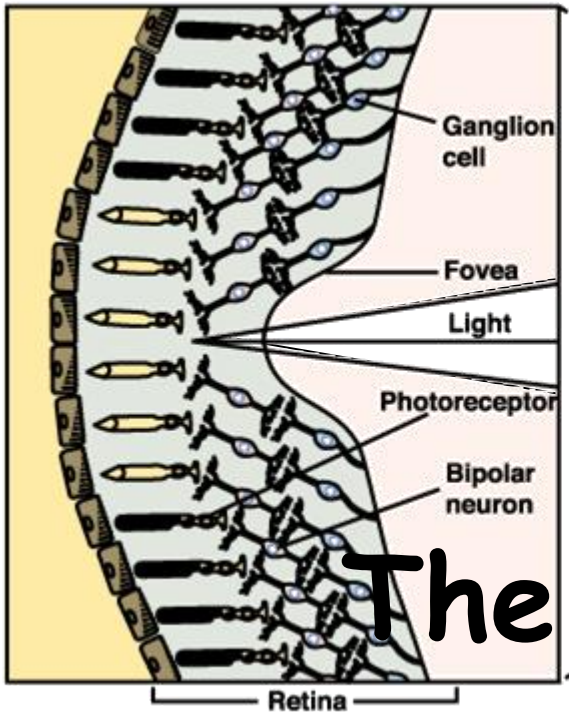
...are light transducers

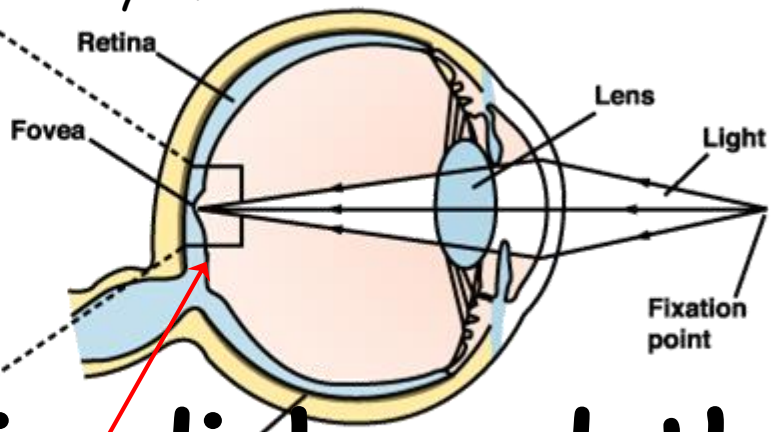
Optics & image formation

- The fovea & the focal point
- The optic disk and the blind spot
- The retina & visual acuity
- Image projection
- Pupils & depth of field
- Optics & the focal point
- Accommodation
- Refractive errors
- Binocular vision

The fovea & the focal point

Light is focussed on the fovea, an area of highest cone density with least overlap between receptive fields. Note thin overlying cell layer.



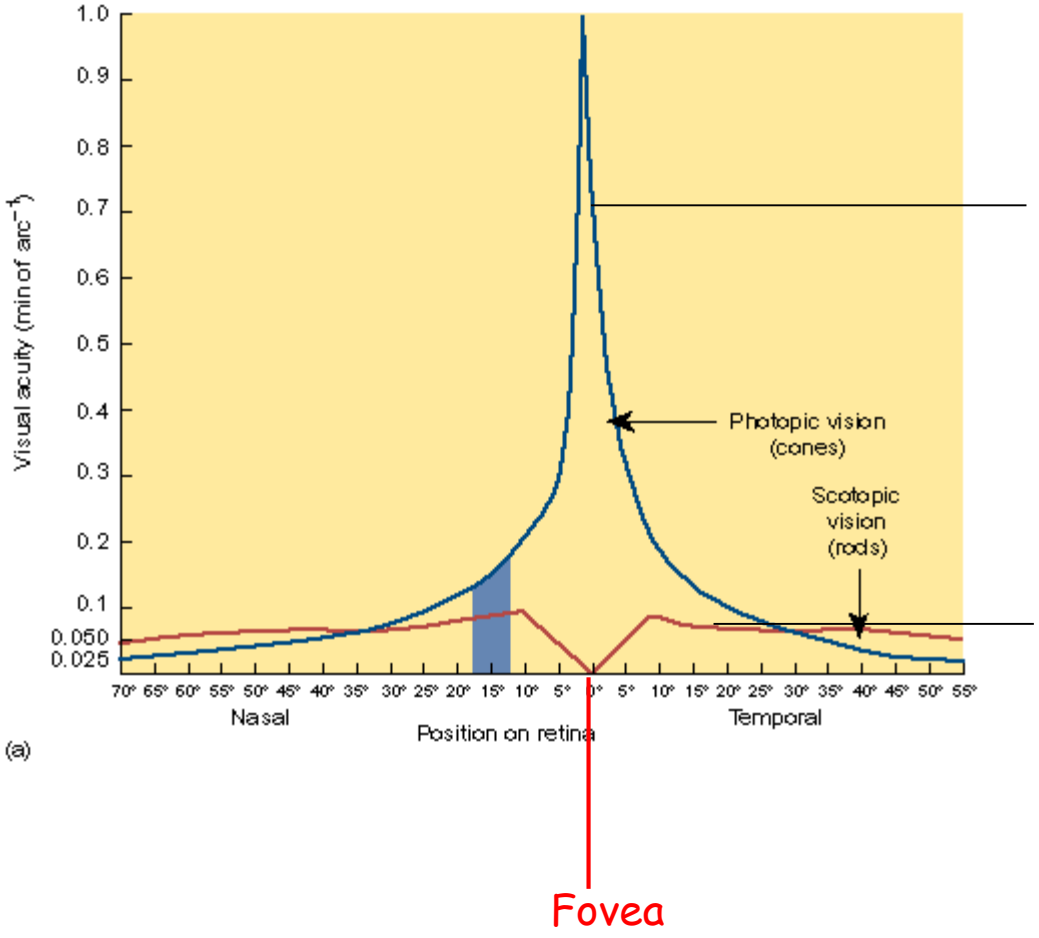


The optic disk and the blind spot

The optic disk is the region where the optic nerve & blood vessels leave or enter the eye. Light falling on the optic disk is not detected due to the absence of rods & cones.

The retina & visual acuity

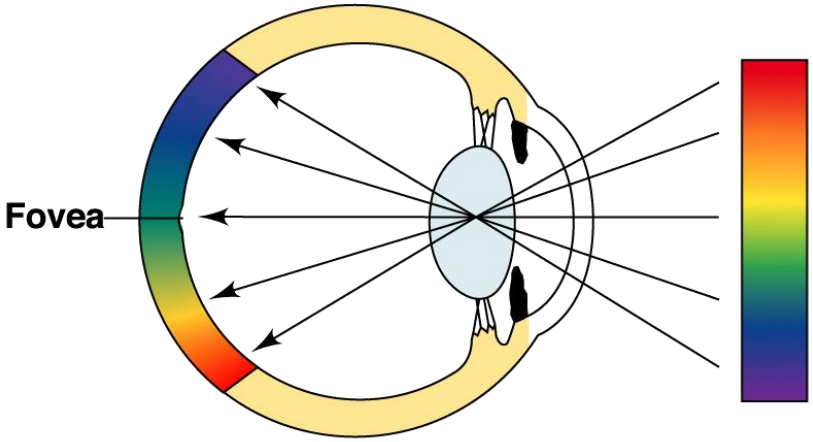
- the ability of the eye to resolve detail



Light adapted eye has greatest visual acuity at the fovea - Photopic vision (cones)

Dark adapted eye has least visual acuity at the fovea but has greater acuity in the parafoveal region Scotopic vision (rods)

Image projection



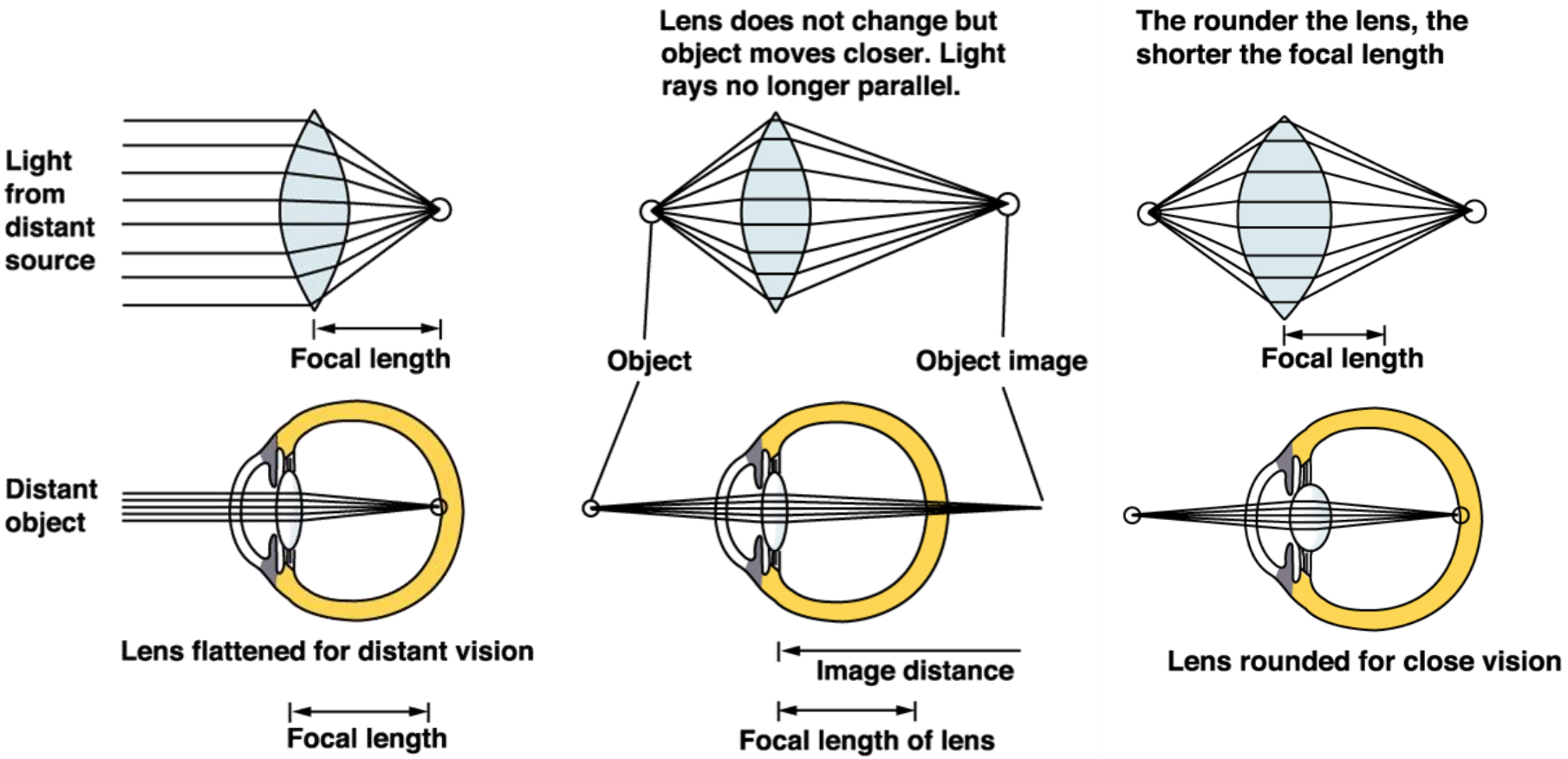
The image projected onto the retina is inverted or upside down. Visual processing in the brain reverses the image

Pupils & depth of field

The diameter of the pupils is controlled by the autonomic nervous system

The pupils regulate the amount of light entering the eye. In bright light they constrict to ca 1.5 mm. In the dark they dilate to ca 8 mm. The increase in the depth of field seen under bright light results from a narrower beam of light focussing on the retina.

Optics & the focal point

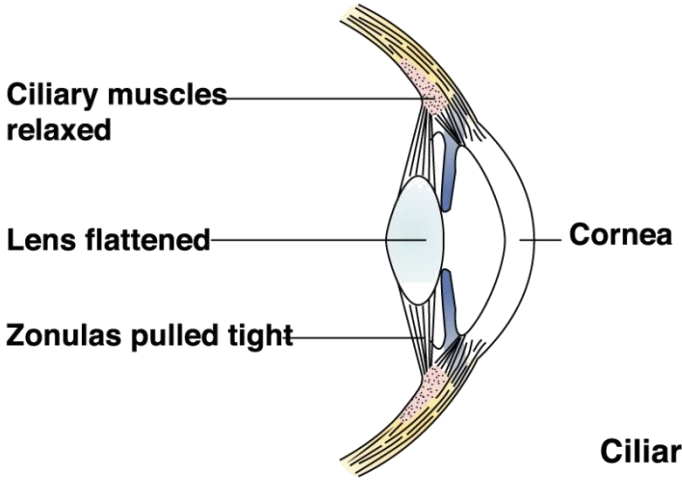


Focal point falls on retina, image in focus

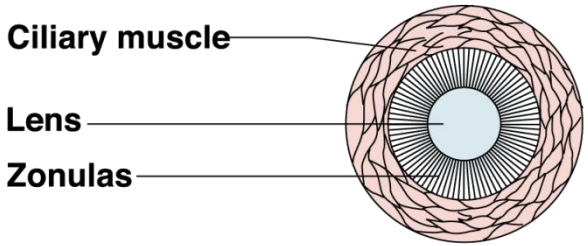
Focal point falls on beyond retina, image not in focus

Lens accommodates to correct focal point, image becomes in focus

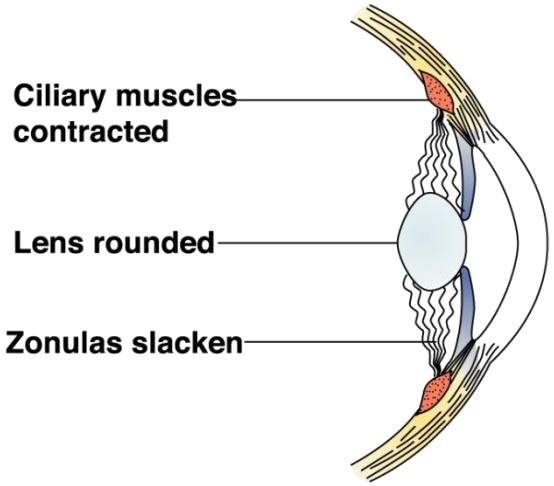
Accommodation



When the cilary muscles are relaxed, the zonalus pulls tight and keeps the lens flattened for distant vision

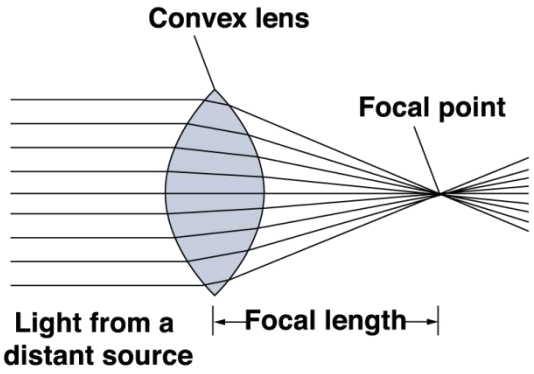


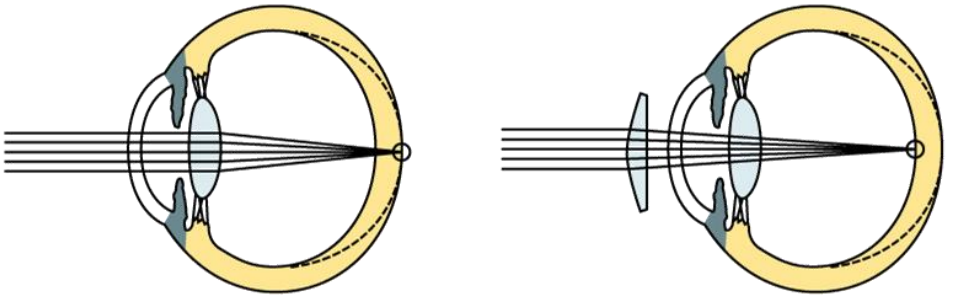
The elastic lens is attached to the circular cilary muscles by the zonalus which is made of inelastic fibres



When the cilary muscles contract, it releases the tension on the zonalus and the elastic lens returns to a more rounded shape suitable for near vision

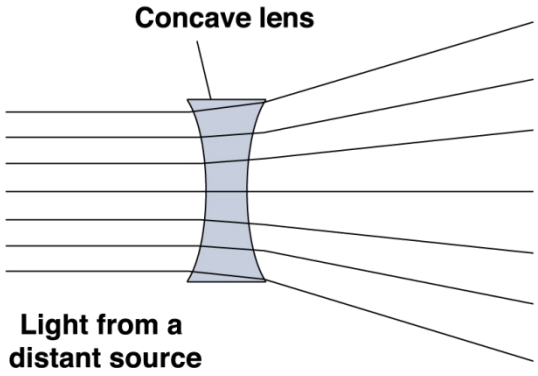
Refractive errors

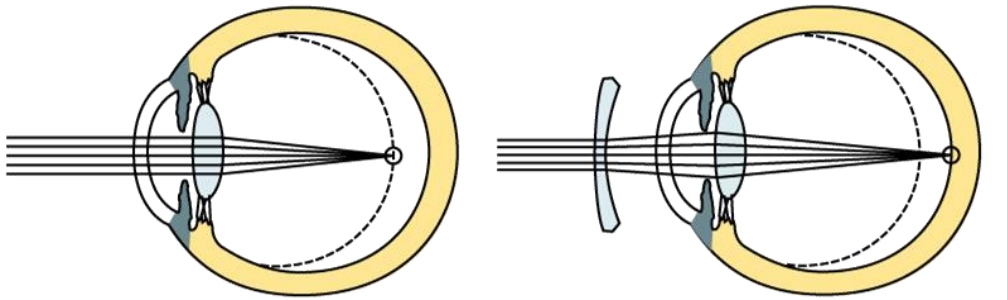




Hyperopia Hyperopia (corrected with a convex lens)

Long- or far-sighted



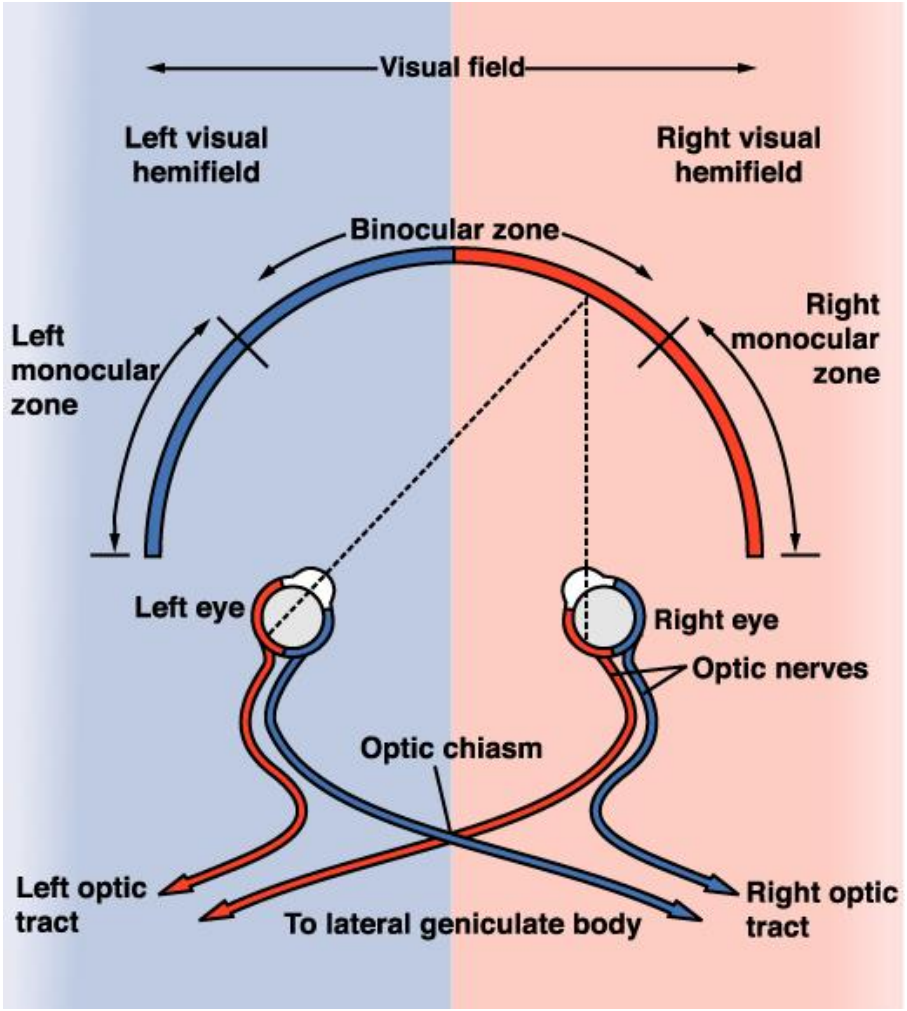


Myopia Myopia (corrected with a concave lens)

Short- or near-sighted

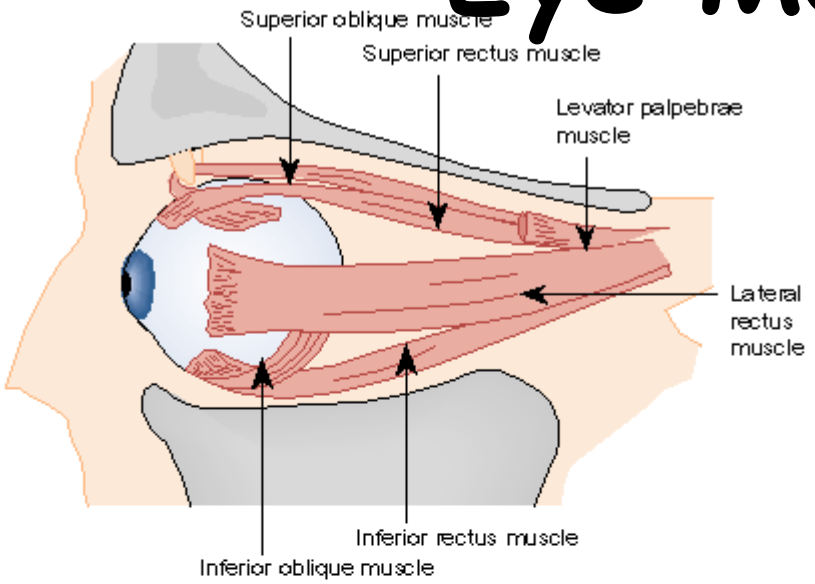
Corrective lenses

Binocular vision

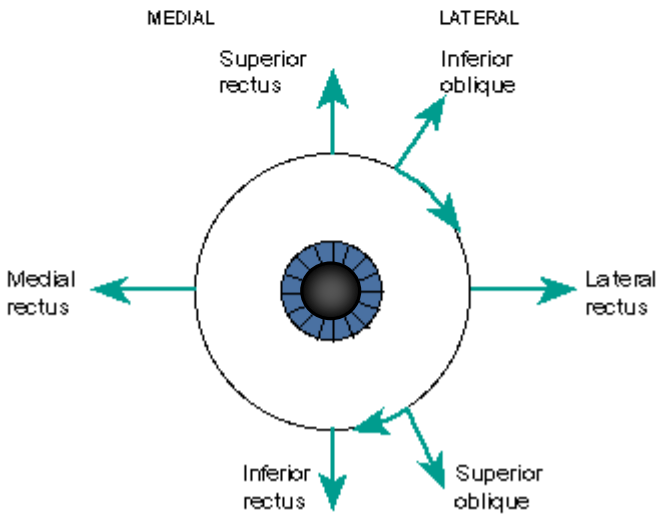


- Visual field is the area of space that can be seen at one time - restricted by facial features.
- Binocular zone is the degree of overlap between the visual fields of the left and right eyes. Objects in this zone are perceived in 3D in two dimensions.
- Objects seen in the left and right monocular zone are perceived in 2D
- Objects seen in the right visual filed are projected to the left visual cortex and vice-versa.
- The cortical cells reflect the spatial organisation of the visual fields

Eye Movements



Eye muscles



Movement controlled by muscles

Movement is controlled by six muscle groups, innervated by the 3rd, 4th & 6th cranial nerves.

Movement is driven by visual input and input from the vestibular system. Reflex & voluntary.

Objects are tracked using both head & eye movements and keeps the image focussed on the fovea.

Movement are classed as saccades, smooth pursuit and vergence.

Saccadic (high angular velocity) and smooth pursuit movement the eyes move together (conjugate). Vergent movement allows the eyes to converge for close focus.

Nystagmus occurs when saccadic movement is followed by repeated smooth pursuit movement.

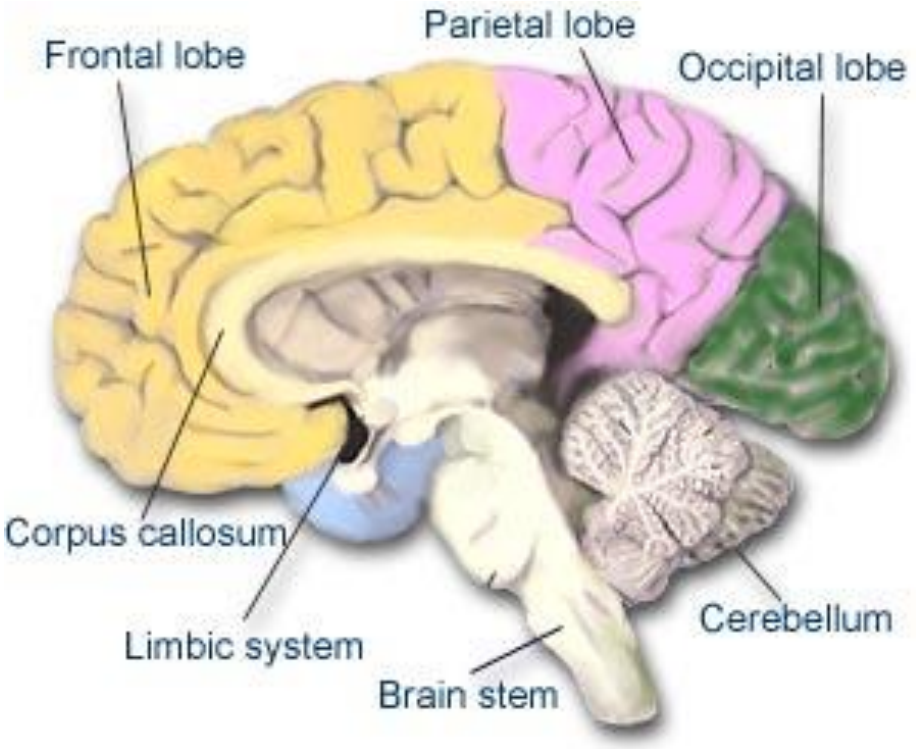
Summary

- The eye consists of 3 layers, the sclera, the choroid), and a photoreceptive layer - the retina. Light enters the eye via a clear zone (the cornea) and is focused on the retina by the lens. Light is transduced by rods & cones.
- The lens can alter its shape to bring near objects into focus. This is controlled by the ciliary muscle, and the zonal fibers.
- The pupil controls the amount of light falling on the retina.
- The capacity of the eye to resolve the detail of an object is its visual acuity. Under photopic conditions, visual acuity is best in the central region of the visual field but, under scotopic conditions, visual acuity in the area surrounding the central region.
- The major problems in image formation are due to

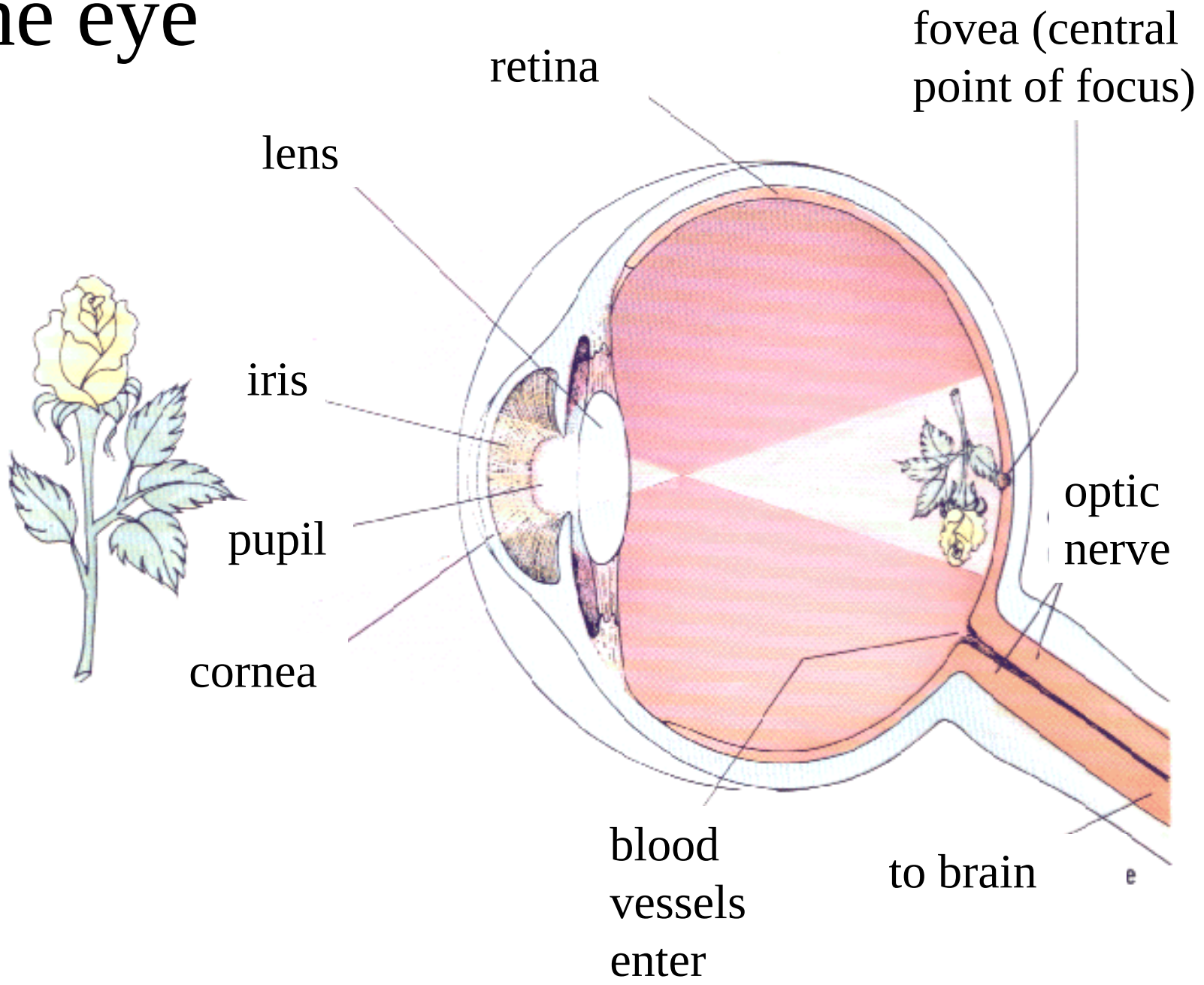
Major parts

- **Occipital lobe**: visual perception system

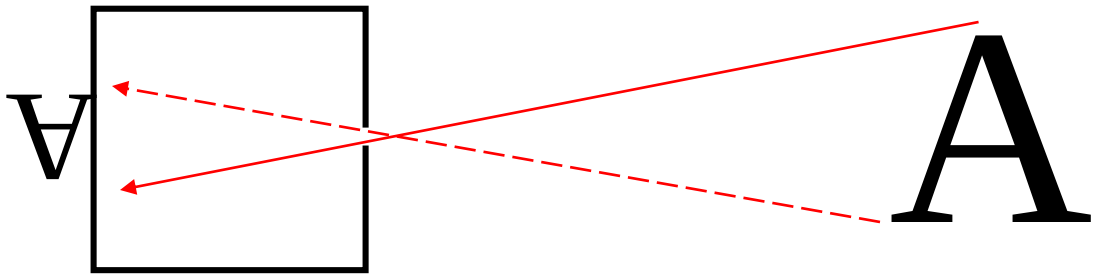
- E.g., visuospatial processing, discrimination of movement and colour discrimination



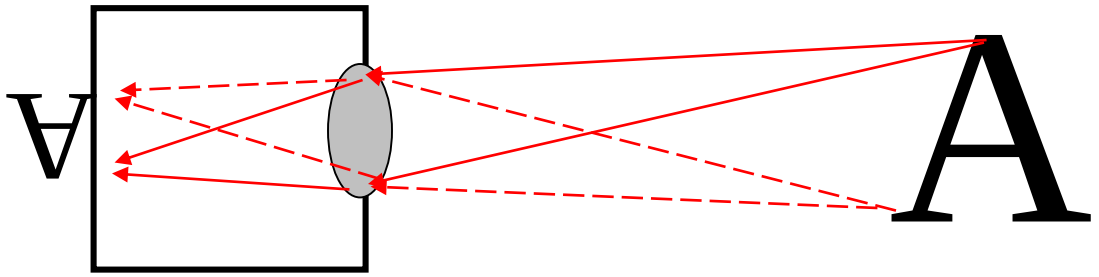
The eye


retina
fovea (central point of focus)
lens
iris
pupil
cornea
optic nerve
blood vessels enter
to brain

Forming an image

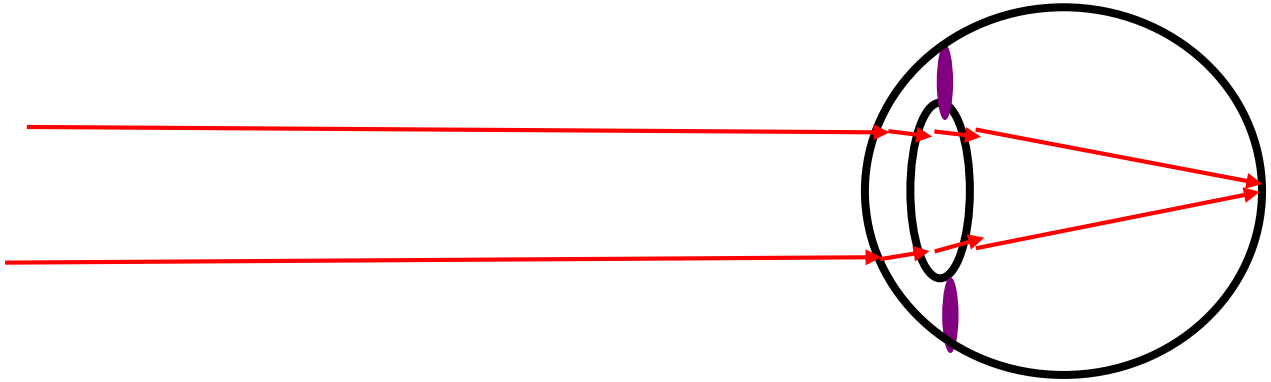


Pinhole camera



camera with lens

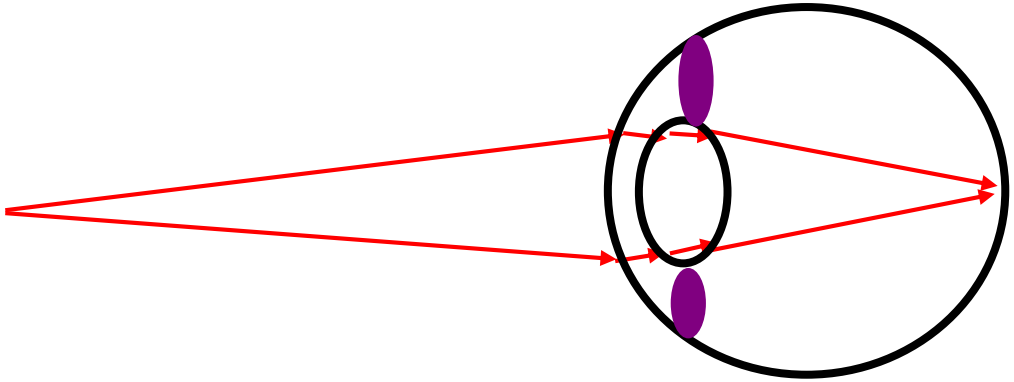
Focusing



Muscles relaxed

Lens less spherical

Focus far



Muscles working

Lens more spherical

Focus near

Components of the eye

- **Cornea**
  Forms image

- **Lens**
  Adjusts focus for near or far objects
  Near focus = more spherical lens
  (ciliary muscles contracted; more eye strain)

- **Near-Point**
  The lens gets stiff with age
  Therefore nearest point of focus recedes

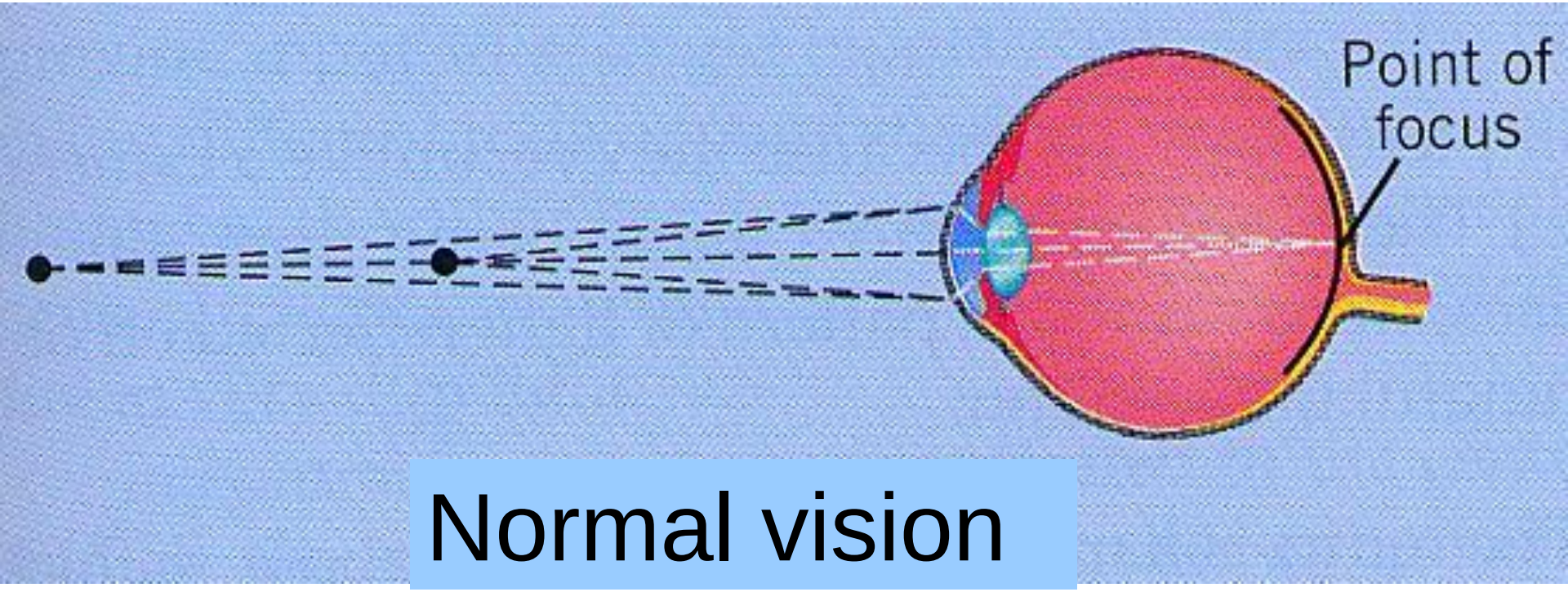
Iris

- Controls amount of light entering eye

  Both pupils controlled together by reflex

  No pupil reflex indicates brain damage/pressure

Normal Sight



Problems forming an image

Short and Long Sight

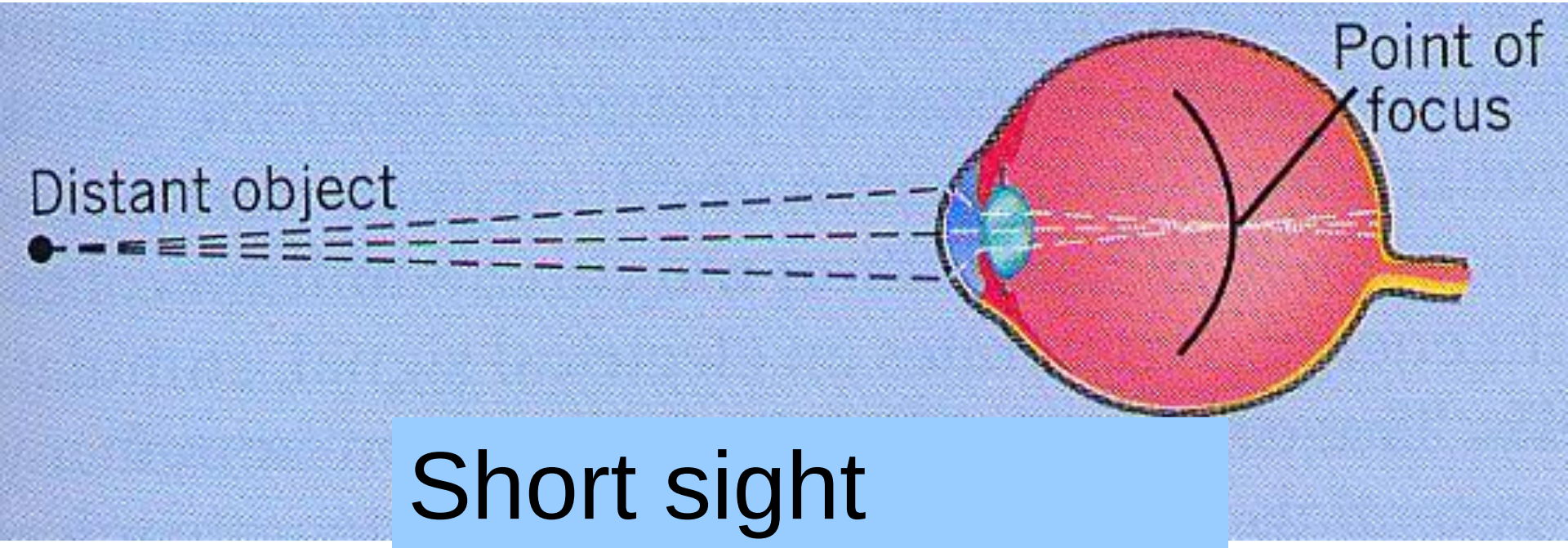
Eye shape and focussing power not matched

Therefore image not focused on the retina

Short Sight

Cause Cornea/lens too powerful
Image is focused in front of the retina

Symptom Close objects clear, far objects always blurred

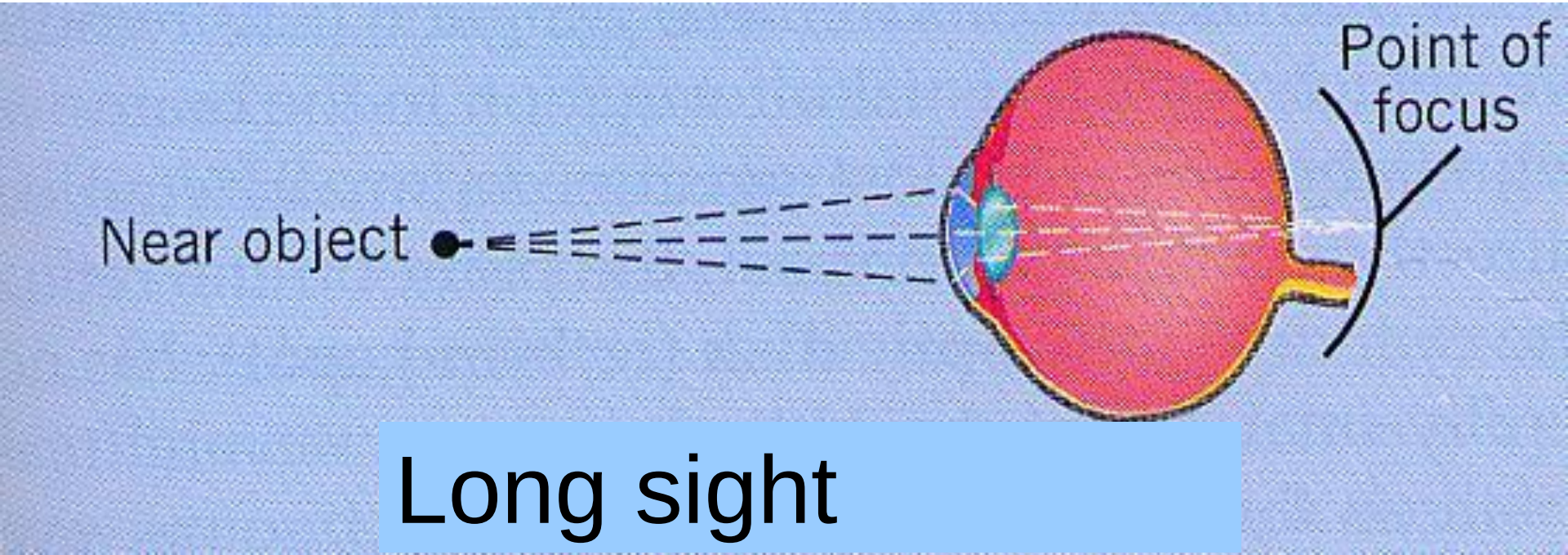


Long Sight

Cause Cornea/lens too weak

Image is focused behind the retina

Symptom Far objects clear, close objects always blurred



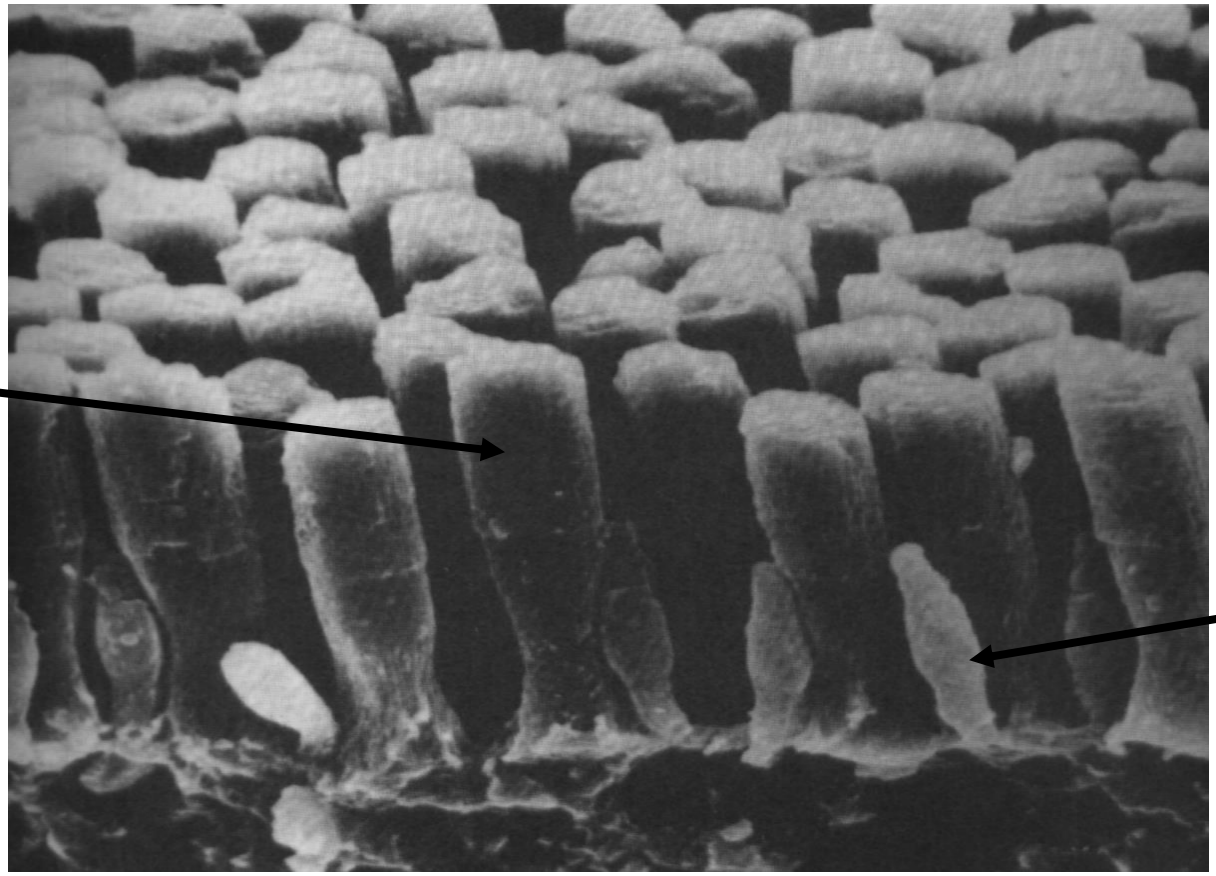
How the image is analysed

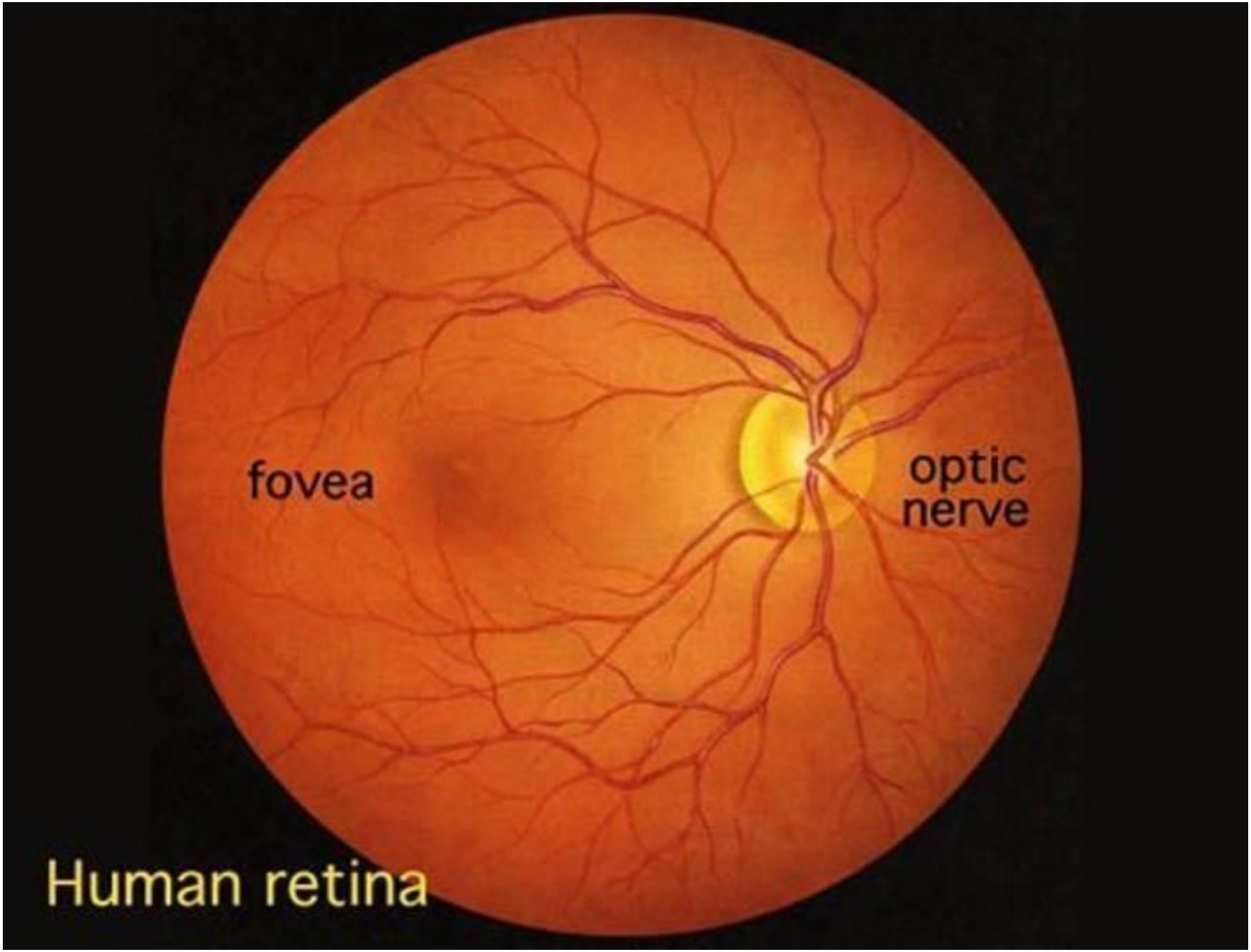
- **Retina**

  Visual image is formed on the retina and analysed by photoreceptors

- **2 types of photoreceptors**
  - Rods
  - and cones

Photoreceptors




fovea
optic nerve
Human retina

Receptor distribution

- **The optic nerve**

  Axons + blood vessels leave eye at one point

  There are no receptors at this point

  We should be blind at this point – humans have a "blind spot"

Receptor Distribution

Draw a + 5 inches to left of a dot,

close left eye,

hold stimulus at arm's length,

fixate + ,

bring slowly forward.

Does the dot remain visible?

Receptor Distribution

- **The optic disk (blind spot)**

  Axons + blood vessels leave eye at one point

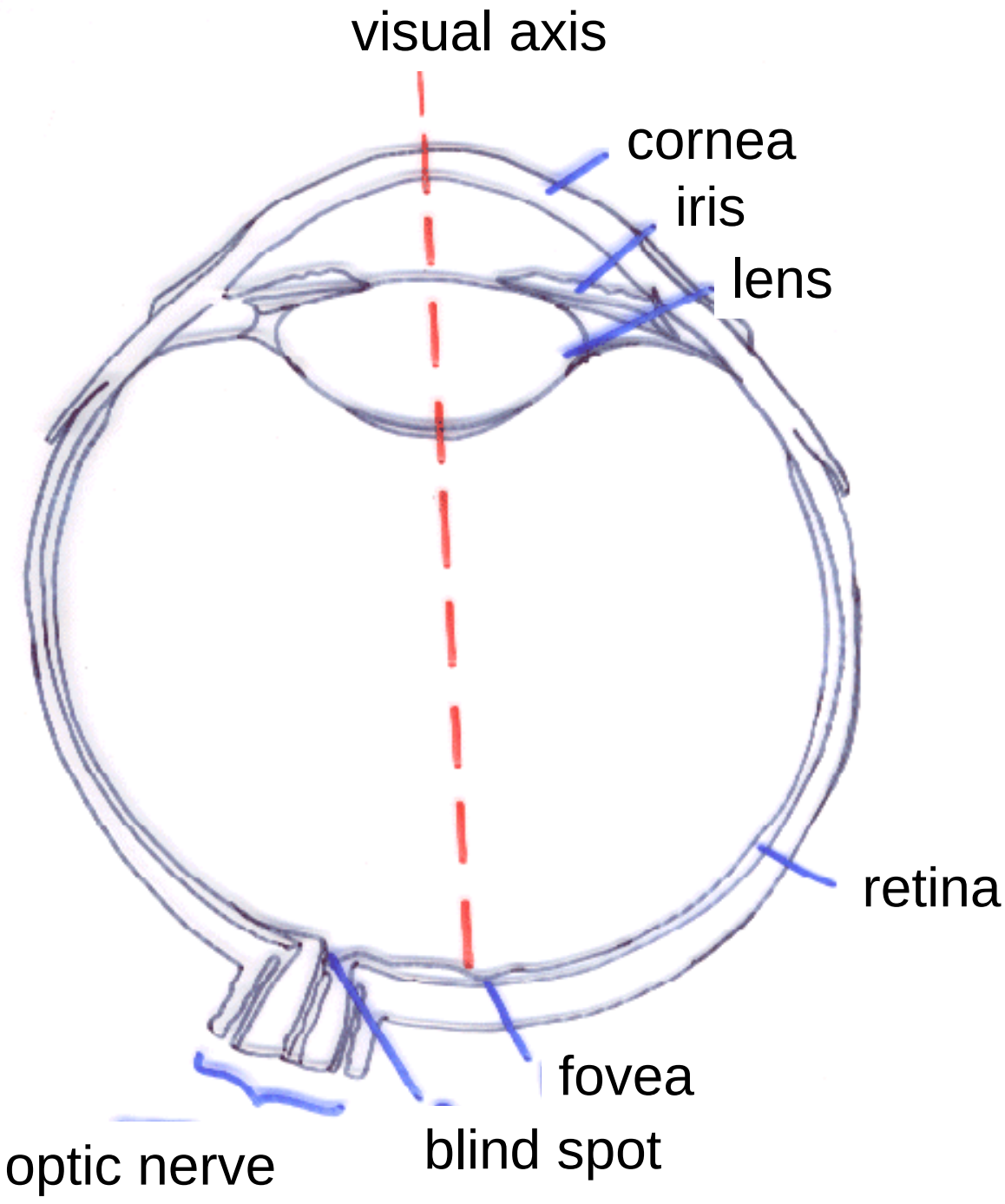
  There are no receptors at this point

  we should be blind at this point

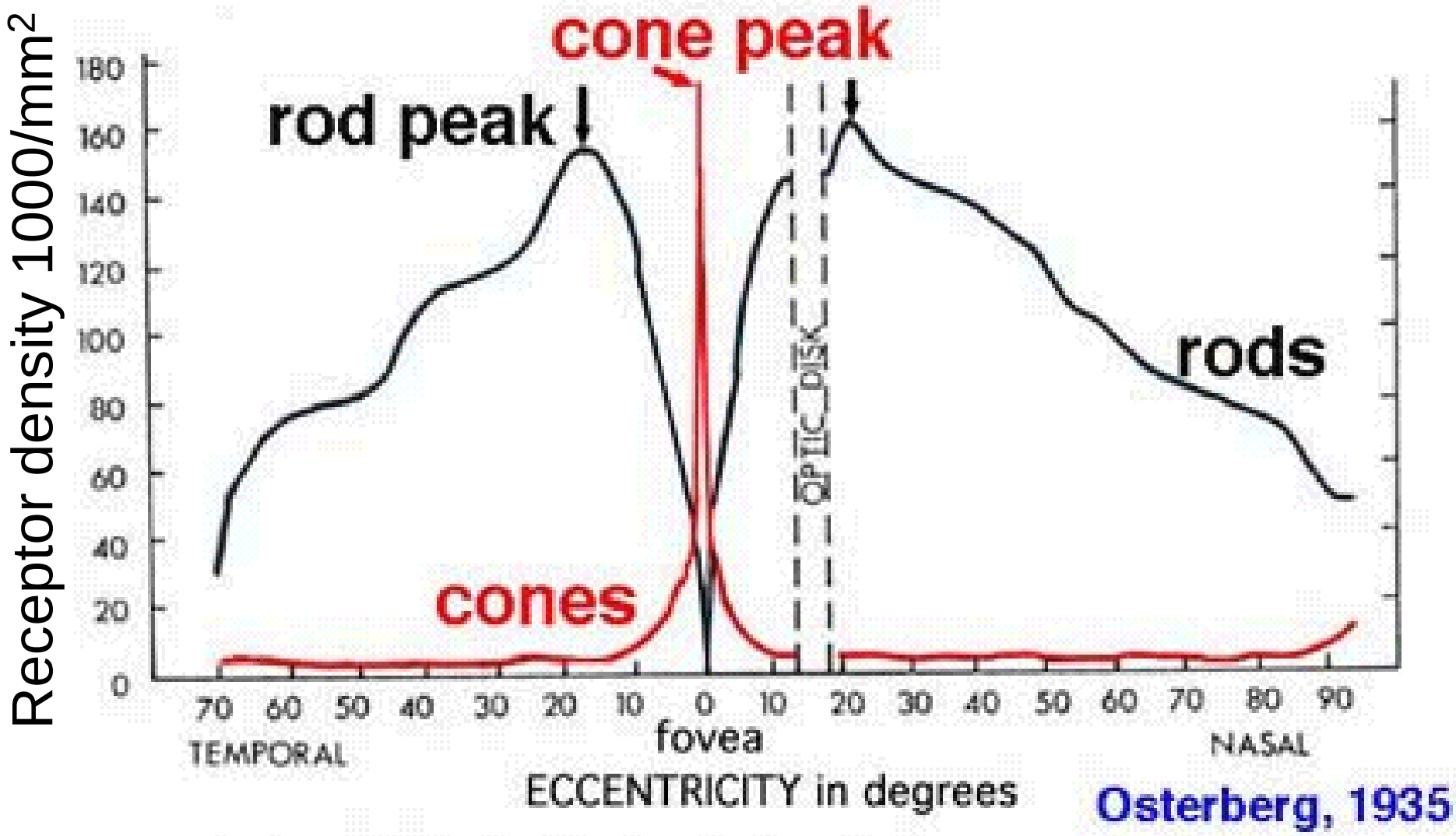
- **Why don't we see our blind spots?**

  The brain 'fills in' the gap

  Can happen even with large areas of blindness


visual axis
cornea
iris
lens
retina
fovea
blind spot
optic nerve

Distribution of rods and cones



Receptor Distribution

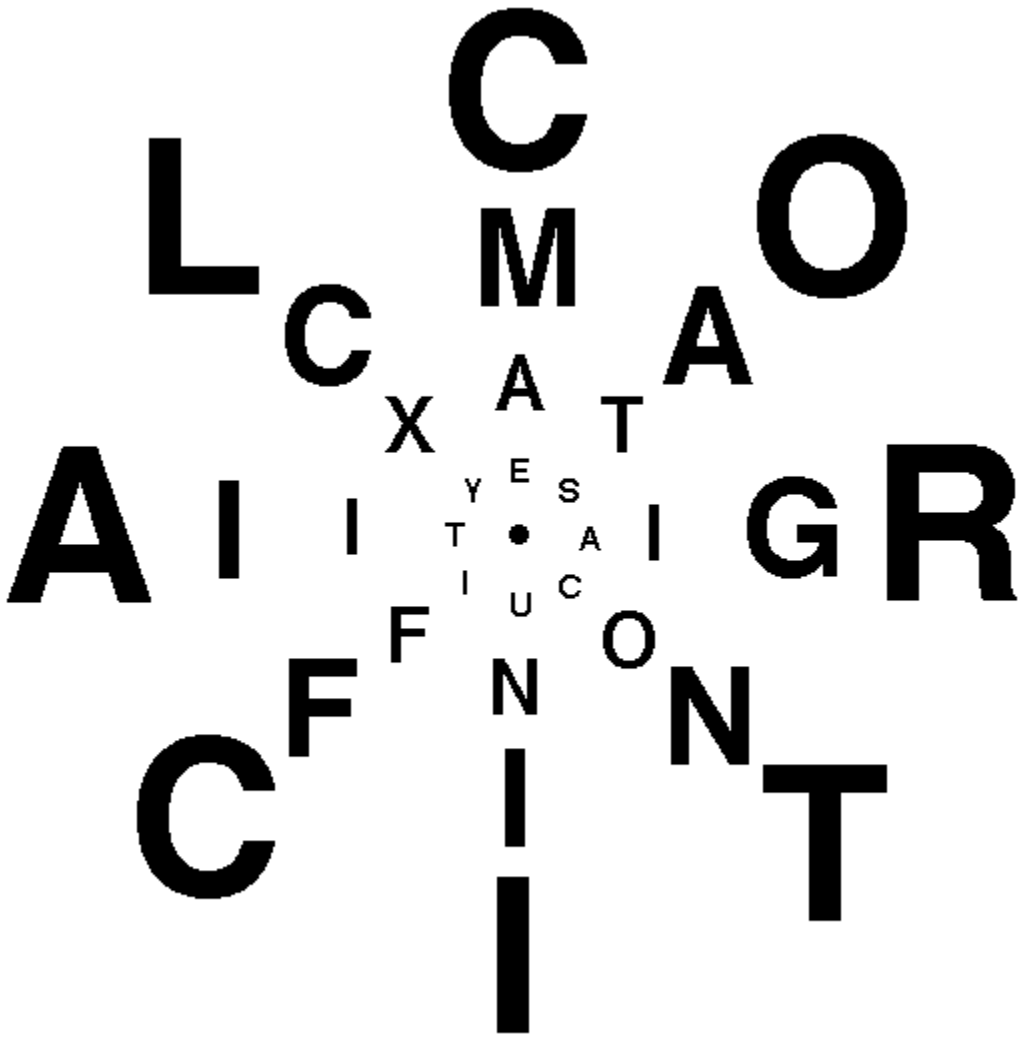
- Receptor density decreases towards periphery

- Acuity = ability to resolve separate points
- Acuity declines rapidly in periphery

- Therefore scan eyes to see clearly over scene

Limited Resolution

Resolution decreases in periphery



Rods & cones

Photopic vision

Depends on cones

Day-time light levels

Full range of colours

Cones dense in the fovea

Cone density falls off sharply in periphery

Low sensitivity to light

Quick recovery in dark

Scotopic vision

Depends on rods

Low (moon) light levels

No colours

No rods at the fovea

Rod density rises in near periphery

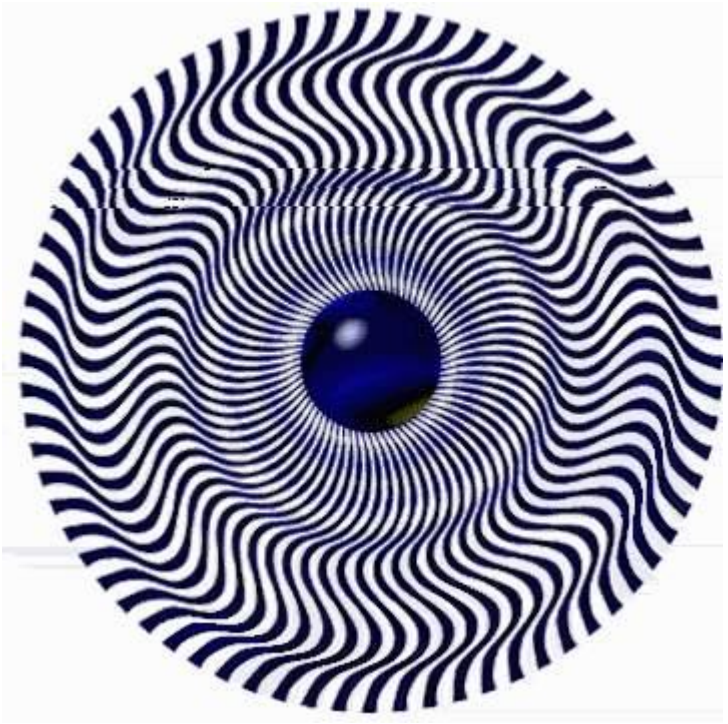
High sensitivity to light

Slow recovery in dark

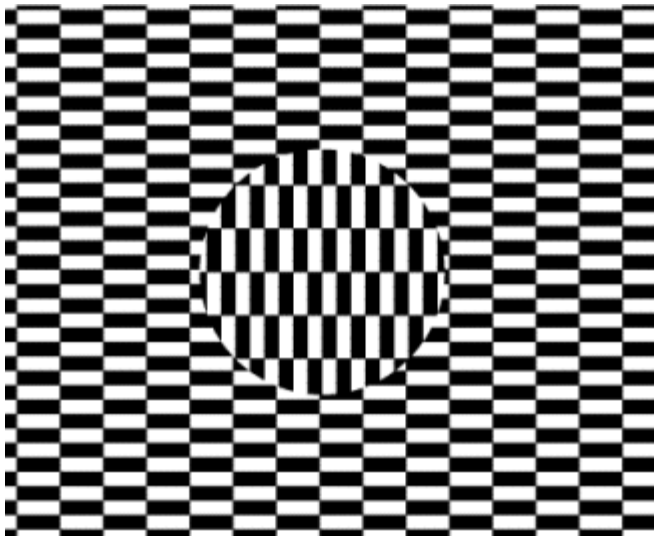
Rod distribution

- Rods peak in density 18^{o} from the fovea
- No rods in central fovea
- Rods most sensitive to low light levels so…

- To see dim stars best to look directly slightly to one side



When you keep looking at the image, it seems to be moving before your eyes. That's because the lens of you eye is not perfectly round. You can't see all of the image sharp, and your eye is constantly making small movements. When you follow the outer rim, you will see that it is impossible.



This one is really great, try it : look just above or below the circle, keep looking forward and move your head to the left and the right. It's like the background in the circle is moving !

7 srdc

7 koní

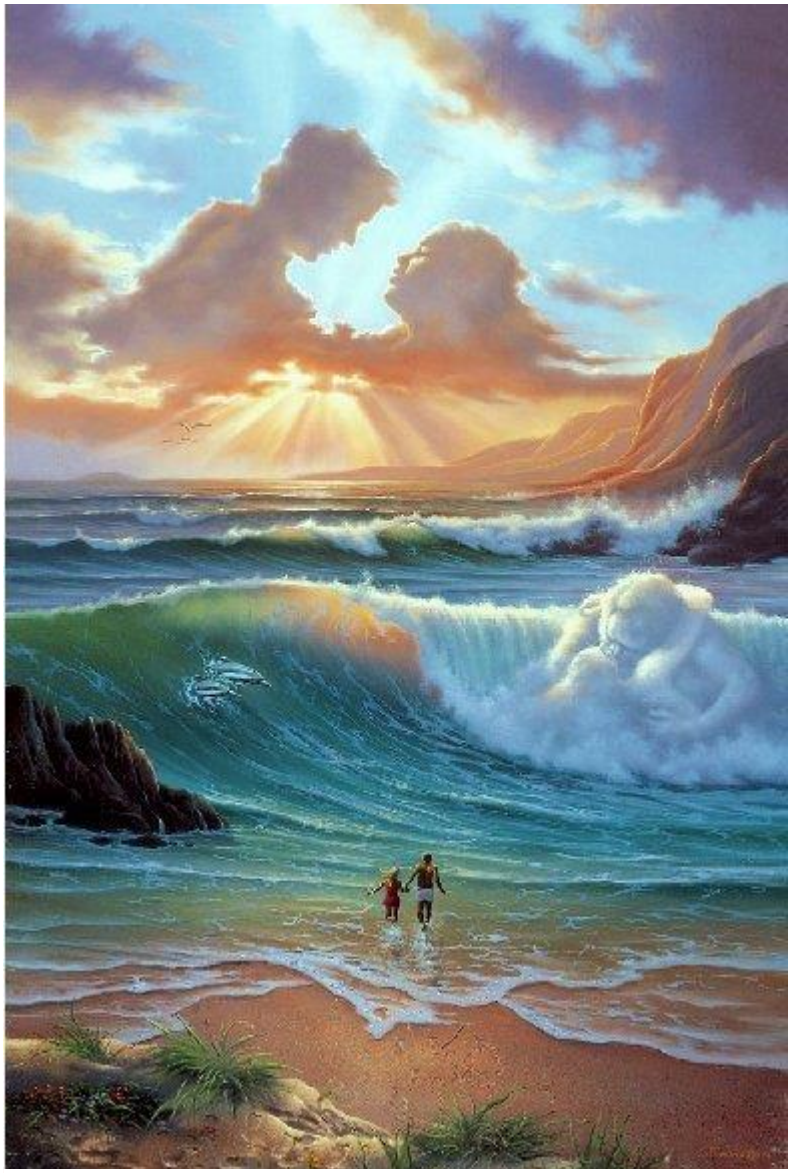
The birds spell the word LOVE

house in the waterfall.

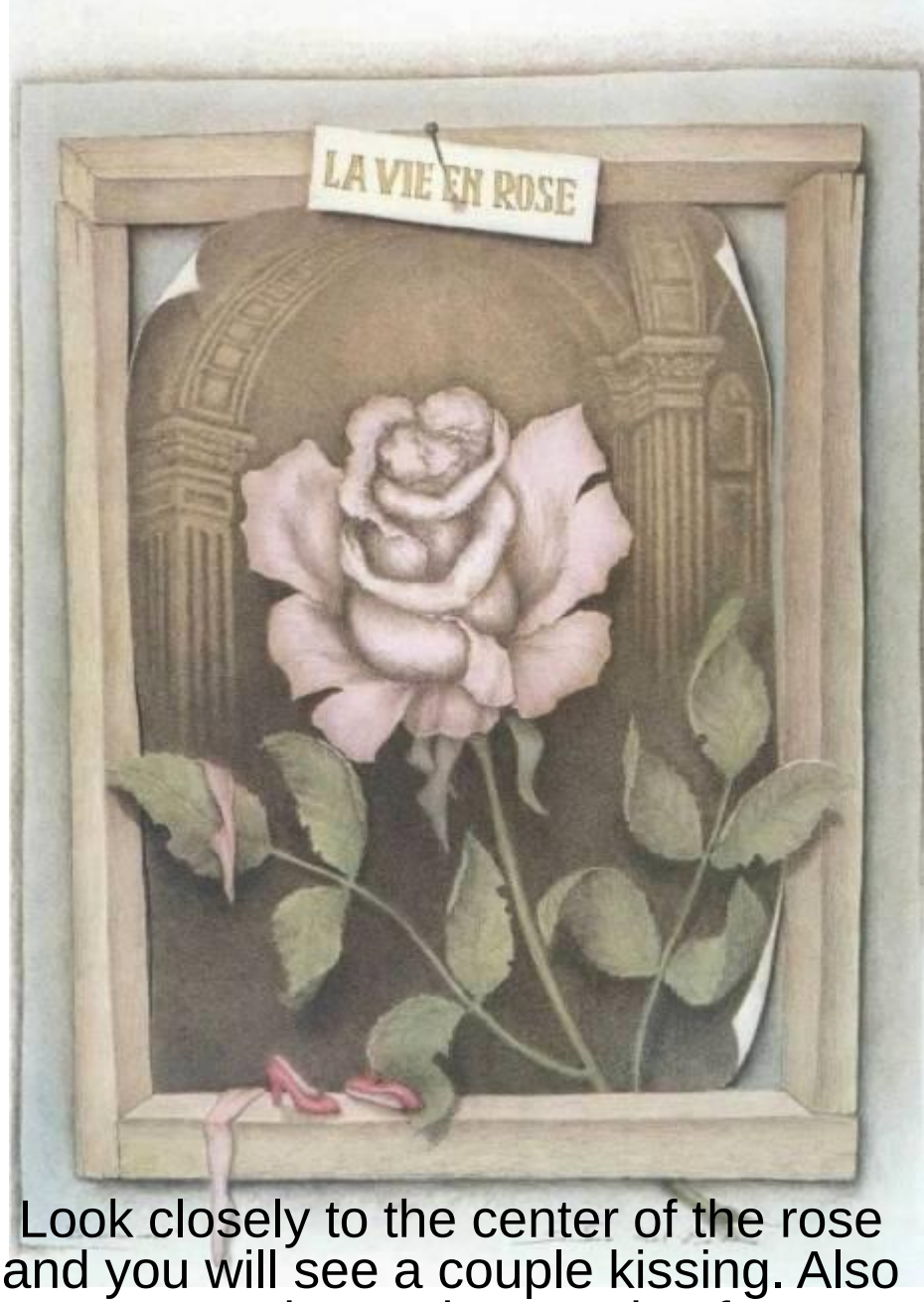
This is a nice one ! The eagle is catching a fish. If look closely, you can see its entire path before the catch.

Except for Queen Elisabeth II, there is something more on this (real !) banknote. Hint : it's a word, and it's pretty large. It's hidden but pretty obious once you know it.

Turn your head to the right, you can read the word SEX in the palm trees.



You can discover a few couples kissing in the air and in the sea.



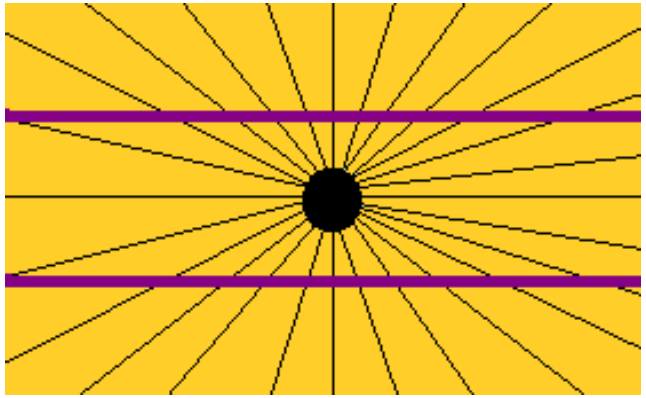
Look closely to the center of the rose and you will see a couple kissing. Also pay attention to the wooden frame around the picture. It's impossible to construct !

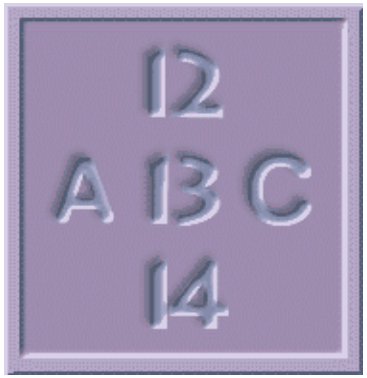
What is hidden in this picture ?

The rocks look like a naked woman.

BEFORE 6 BEERS

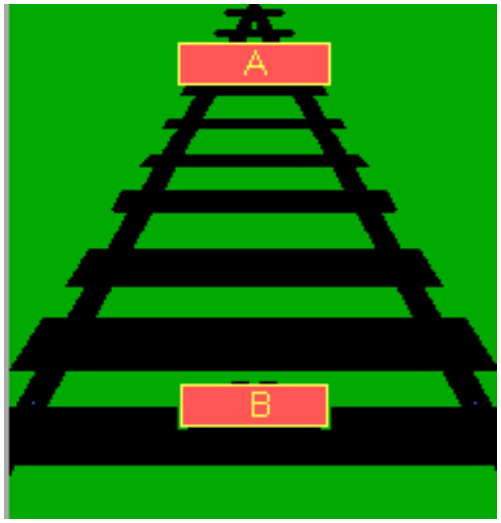
AFTER 6 BEERS

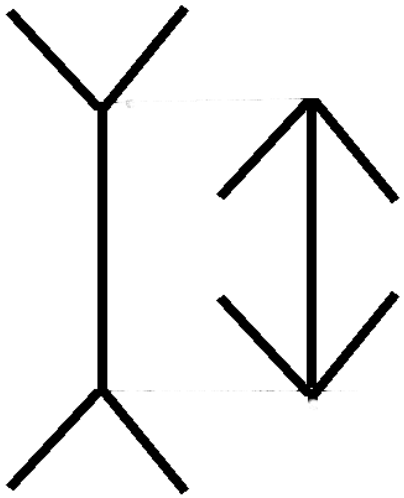


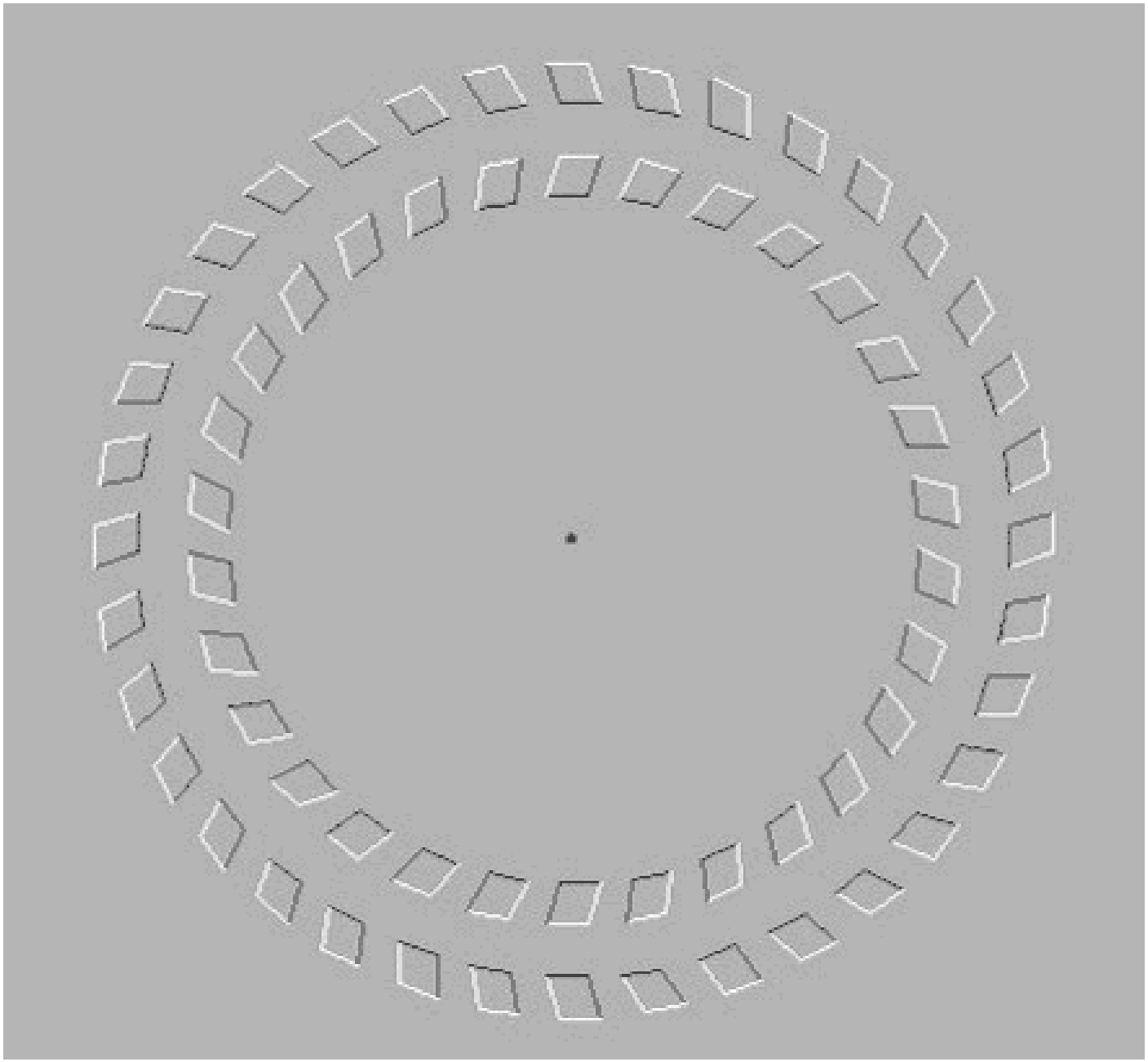


najprv prečítajte (→),
potom (↓)

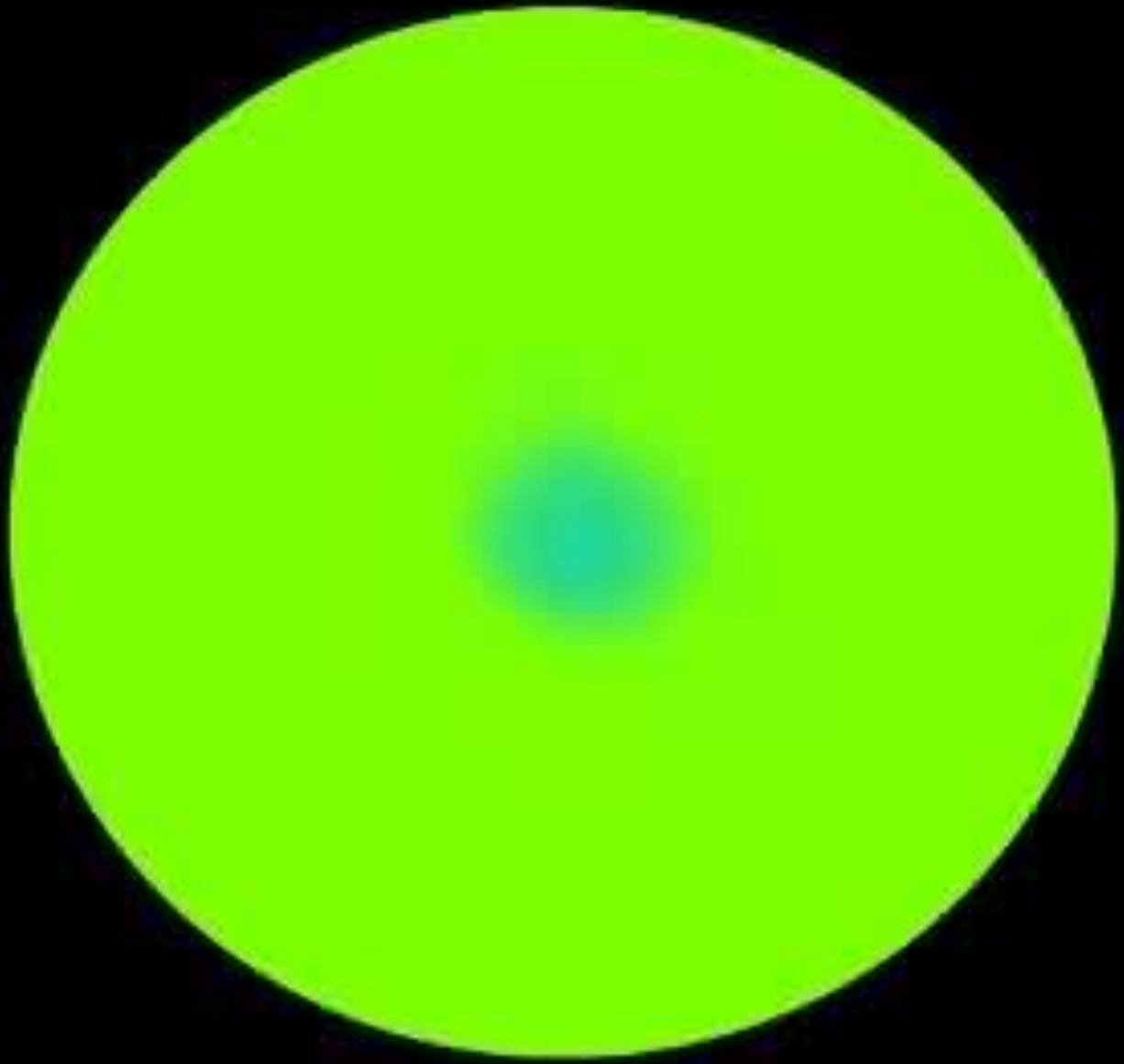
Interpretáciu ovplyvňuje kontext

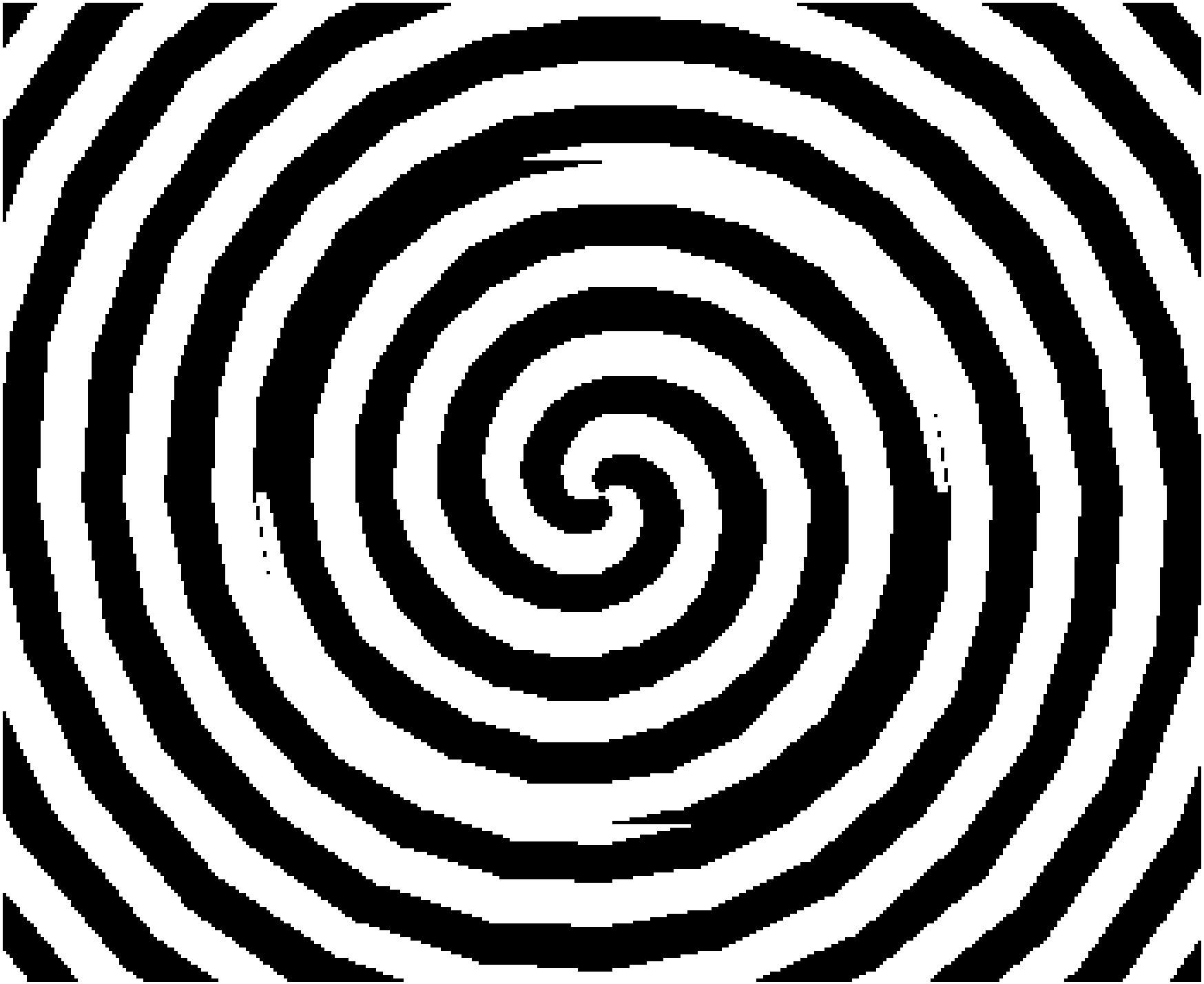


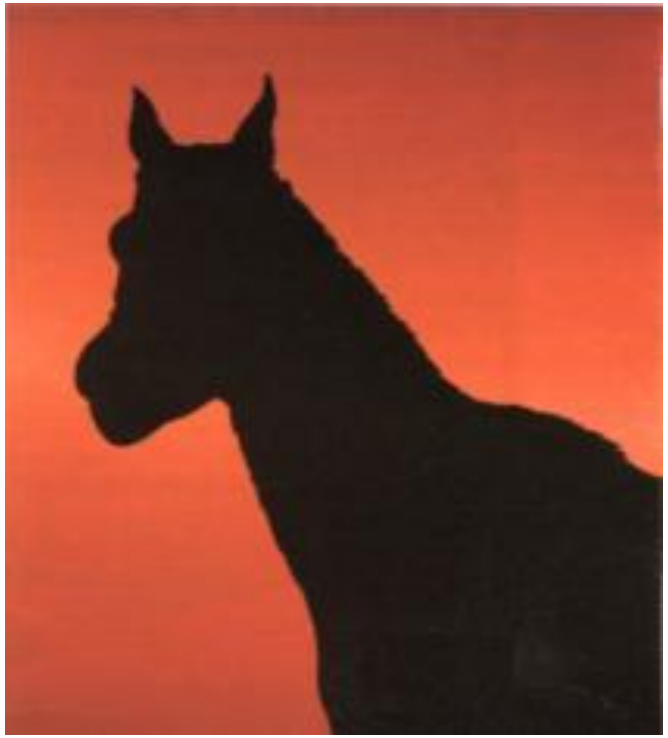


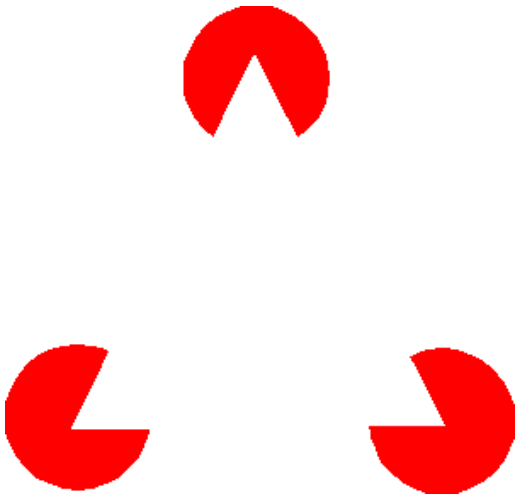


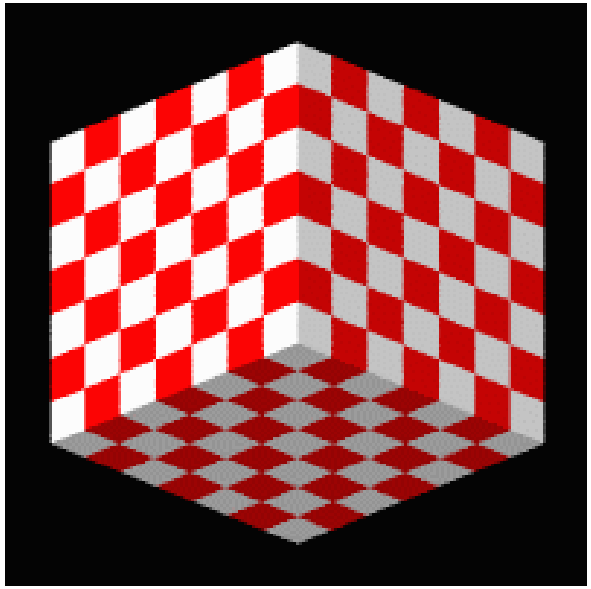
Pri pohybe hlavy dozadu sú kružnice menšie, každý symbol sa pohybuje dovnútra a ich šikmé hrany spôsobujú pocit krúživého pohybu.

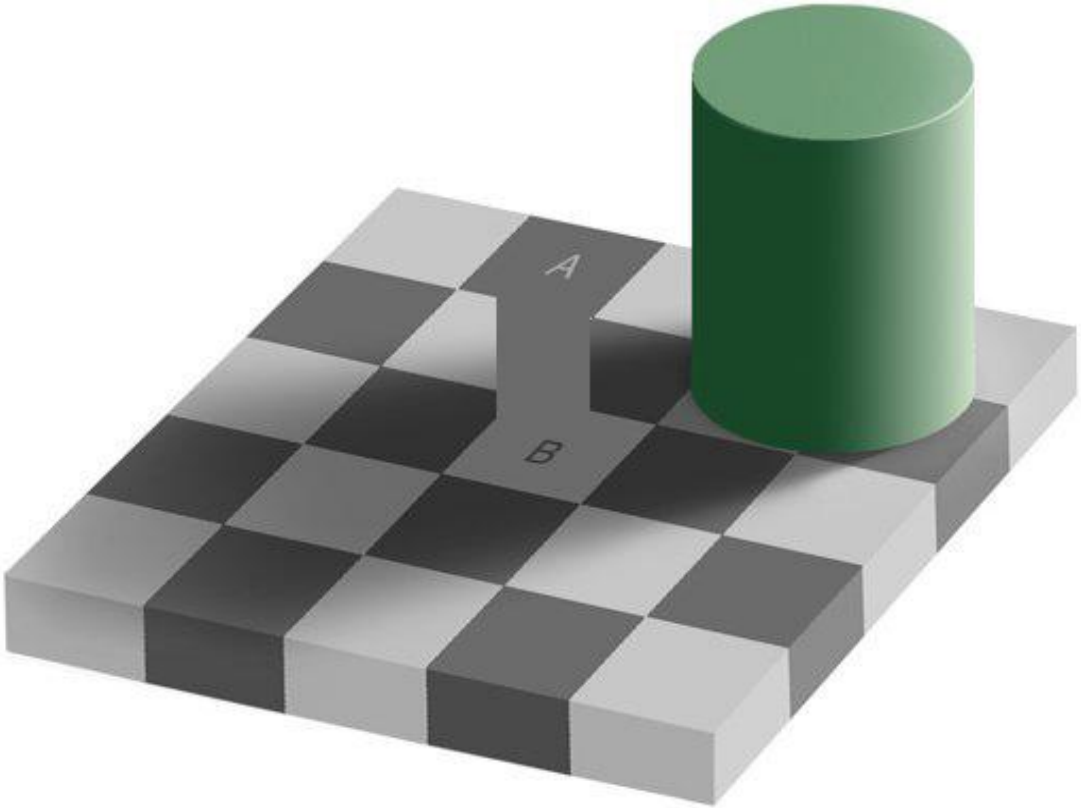











A
B