Physiology of Vision

Lecture-2-

Accommodation & Pupillary Light Reflex

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The Physiology of Vision

Objectives:

At the end of this lecture the student should be able to:

- Describe visual acuity & depth perception
- To know visual pathway and field of vision
- Describe the process of accommodation reflex and its pathway,
- Identify and describe pupillary light reflex , its pathway and relate these to clinical situations as Argyl Robertson pupil
- Identify the lateral geniculate body and visual cortex functions .

VISUAL ACUITY

Definition :-

- Degree to which details of objects are perceived.

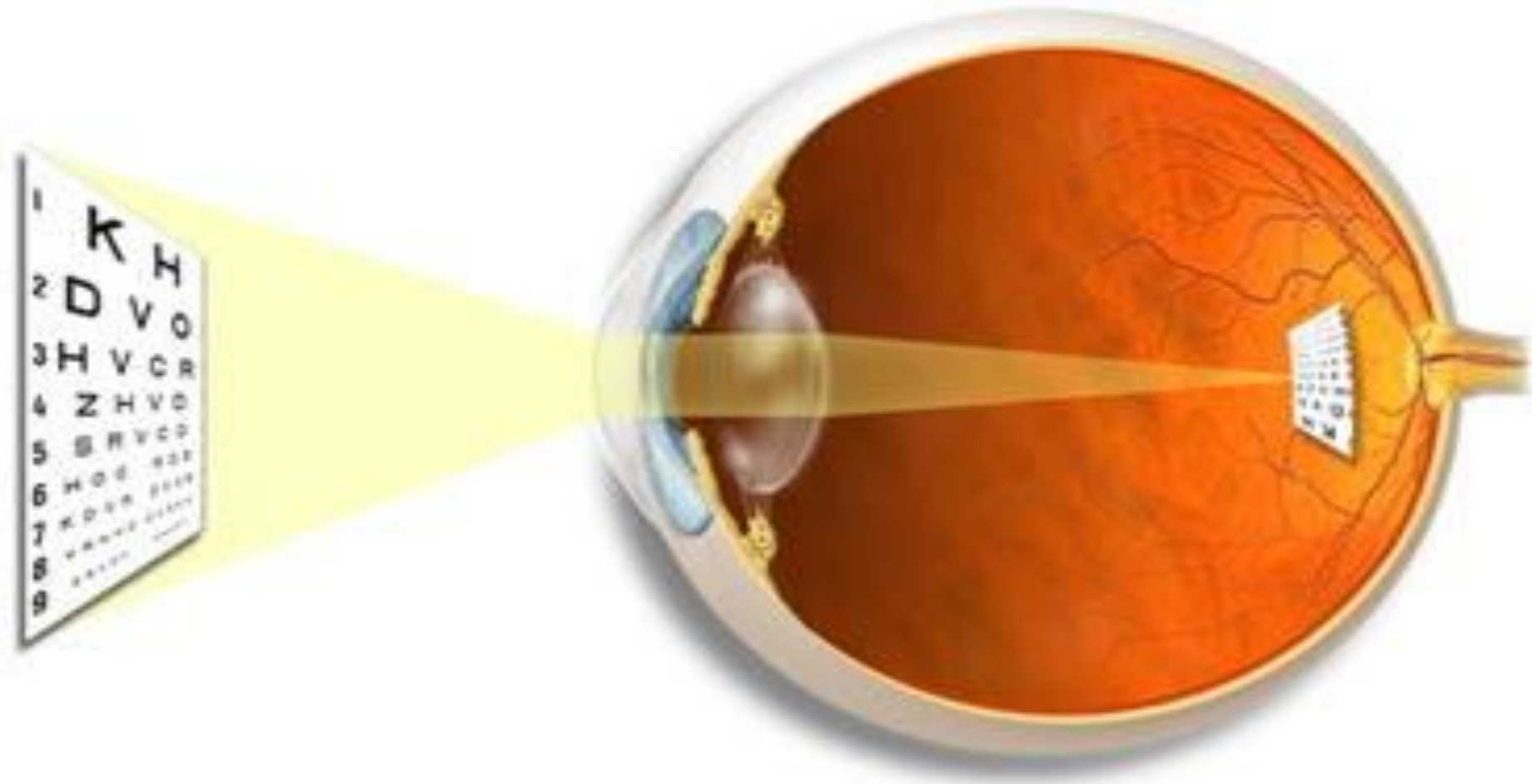
Visual threshold:

- is minimal amount of light that elicit sensation of light

- Snellen s chart

✓ Normal acuity =6/6

✓ A person of 6/12 has less vision than normal vision.



Visual Pathway

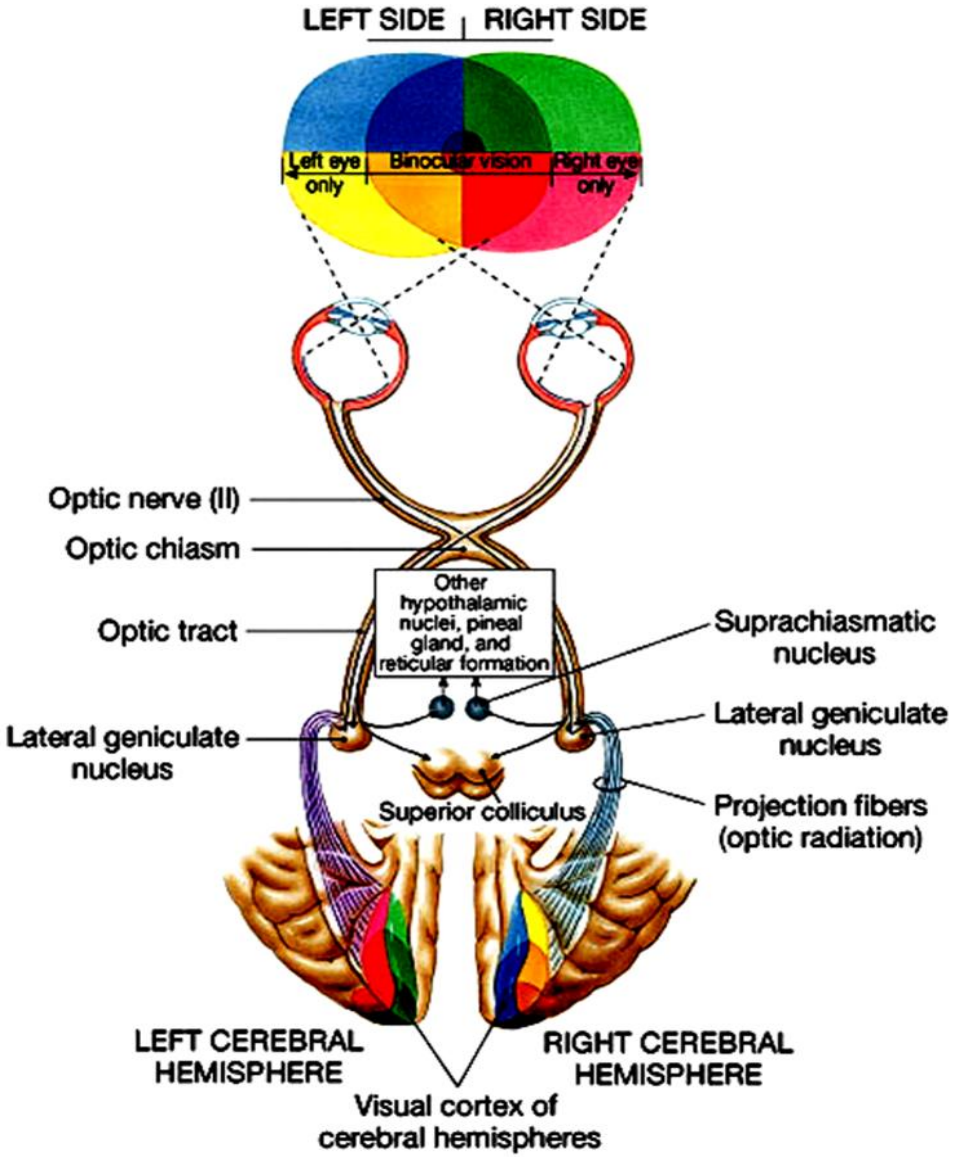
(Pathway from Retina to the Visual Centers in the Brain)

- Photoreceptors :Rods and Cones synapse on Bipolar Cells , which in turn , synapse on Ganglion Cells .
- Axons of Ganglion Cells constitute the Optic Nerve . These axons converge at the Optic disc ,which is also called Blind Spot

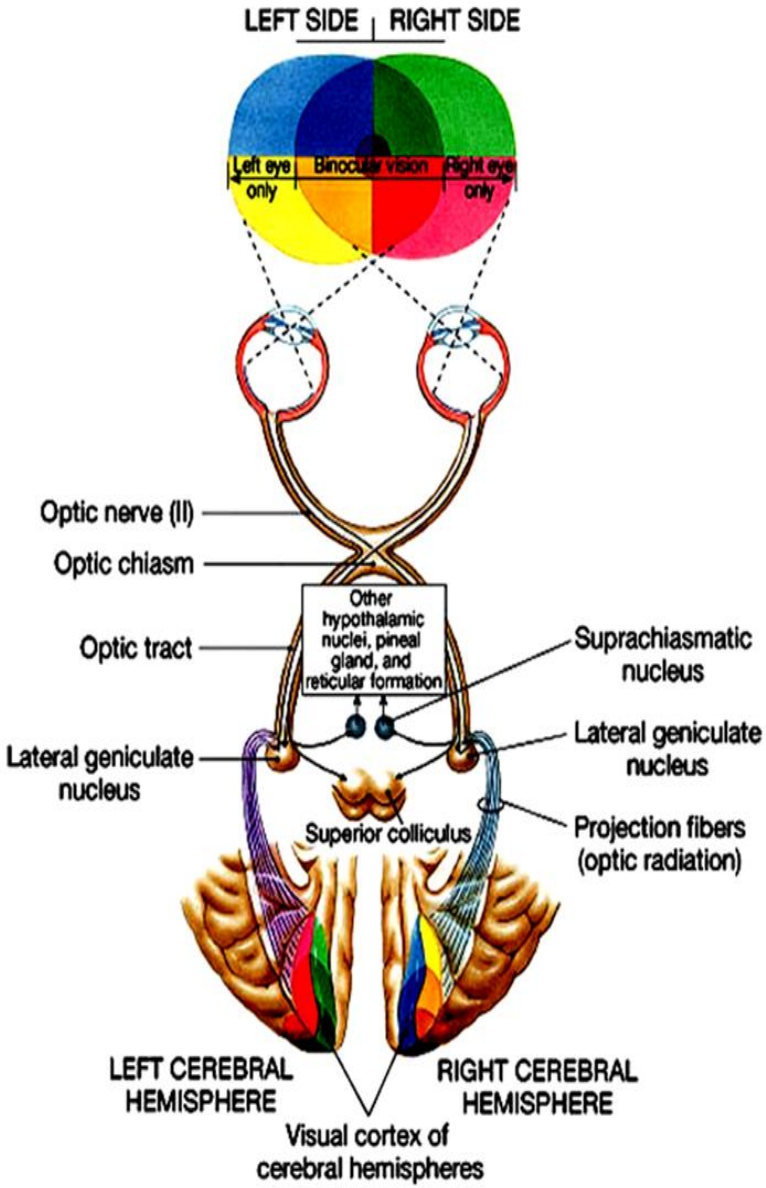
  (Why ?) .
- Passing through the Blind Spot → they leave the eye , constituting the Optic Nerve .

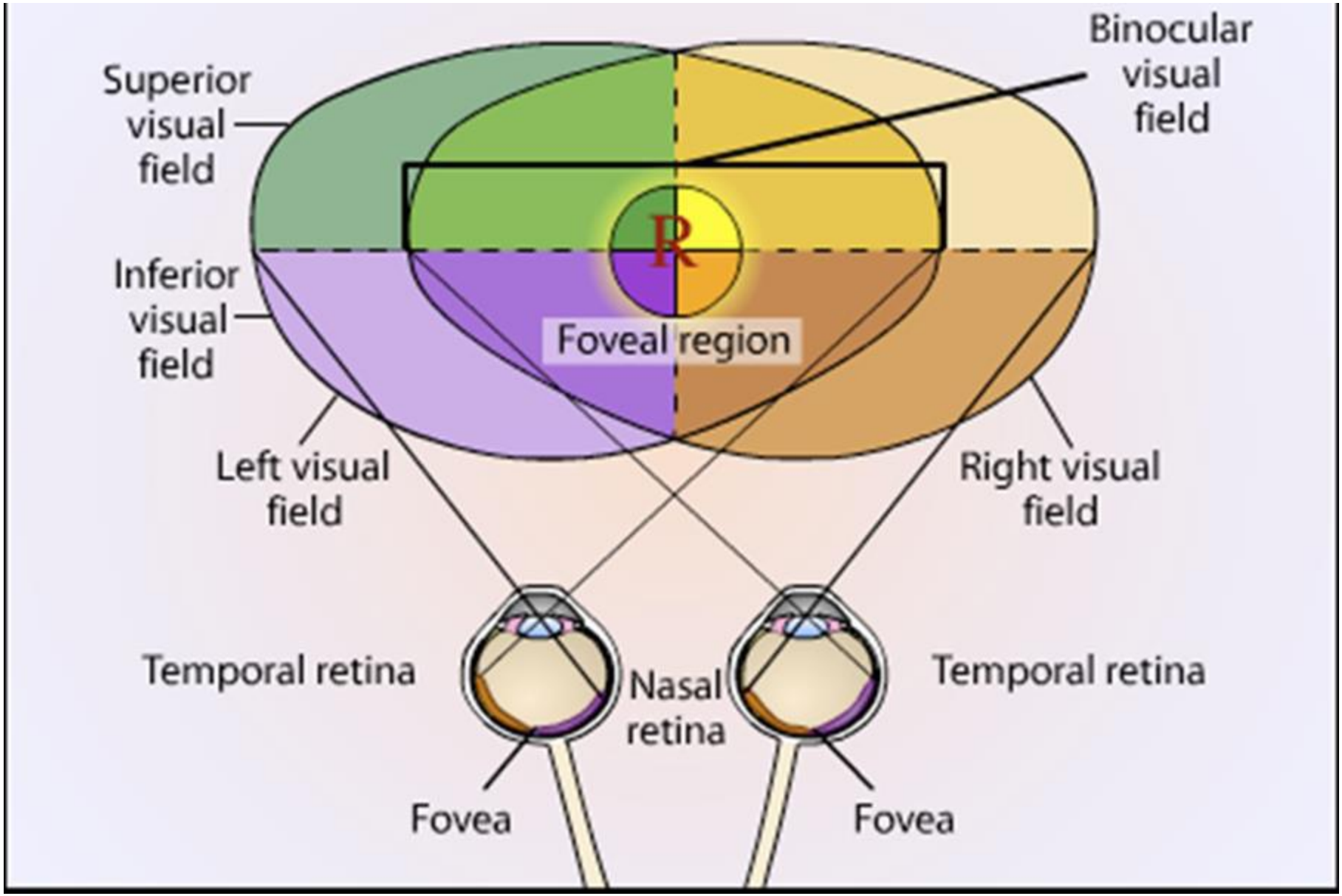
Visual Pathway

1. Optic nerve
2. Optic chiasm
3. Optic tract
4. Lateral geniculate body (nucleus)
5. Optic radiation
6. Visual cortex



- Optic nerve fibers from the medial (nasal) side of retinae decussate in the Optic Chiasma .
- Therefore an Optic Chiasma lesion (e,g, Pituitary Tumor) will cause vision loss from the both lateral halves of the Field of Vision
- Optic nerve fibers from the lateral (temporal) parts of the retinae do not decussate .
- Therefore , each optic tract carries fibers from the both the temporal side of the ipsilateral retina + nasal side of the contralateral retina.
- Therefore , a lesion in optic tract will cause loss of vision from the ipsilateral nasal field of vision + contralateral temporal field of vision .




Binocular visual field
Superior visual field
R
Inferior visual field
Foveal region
Left visual field
Right visual field
Temporal retina
Nasal retina
Temporal retina
Fovea
Fovea

Accomodation

Accomodation

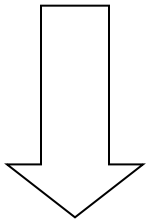
Modification of the
refractive power of the eye
(curvature of the lens)
to view a nearby object

Goal:

Clear vision of a nearby object

Accomodation- cont.

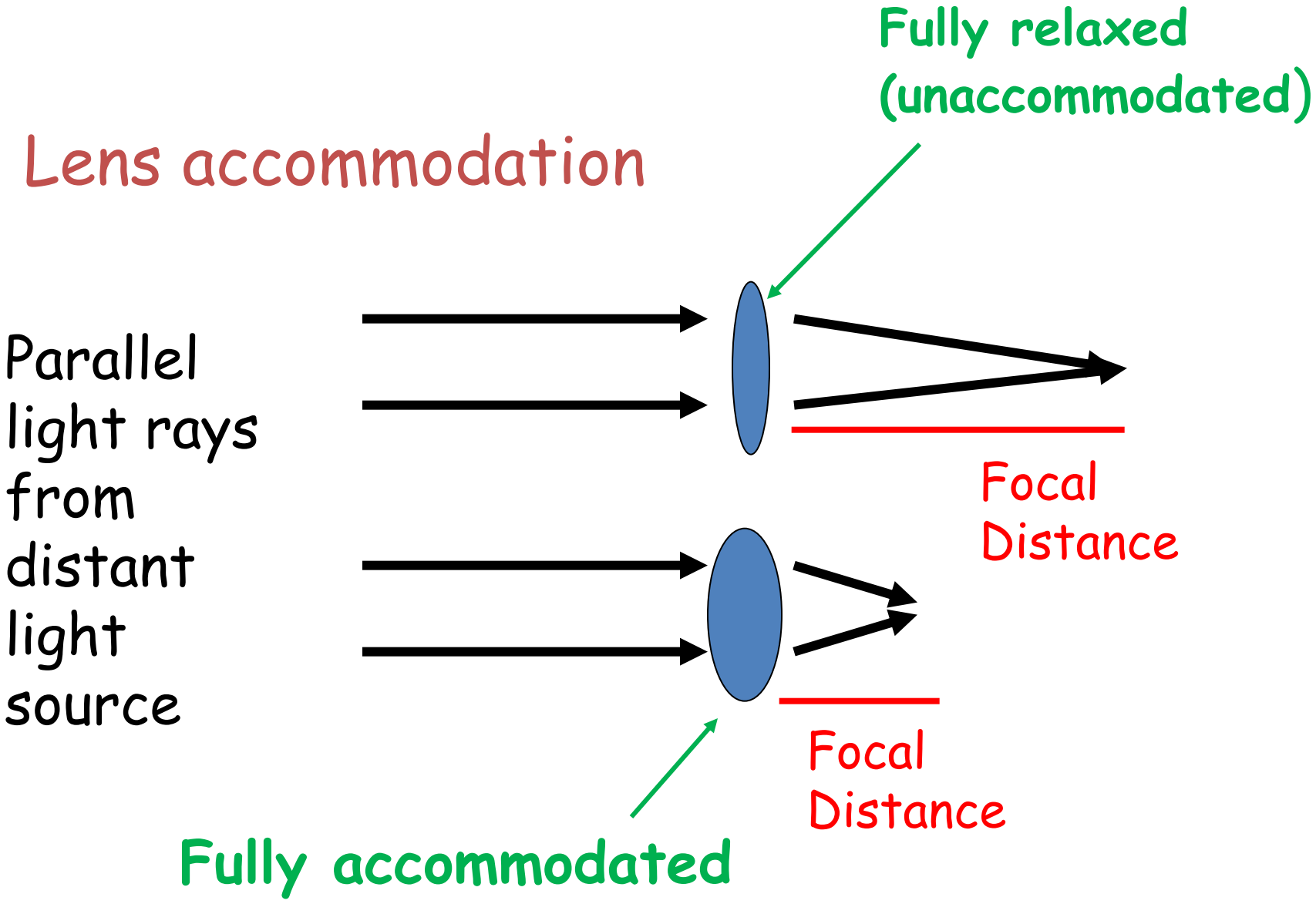
- Lens changes (accomodation)
- Changes in the pupil
- Convergence of the eyes



The near response

Image Focusing

- Lens accommodation



Mechanism of accomodation

Ciliary muscle..Contraction:

↓

Relaxation of the suspensory ligament

↓

Lens more convex

↓

Increase diopteric power of the eye

↓

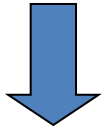
Near object focused on the retina

Mechanism of accomodation- cont

Contraction of the suspensory ligament

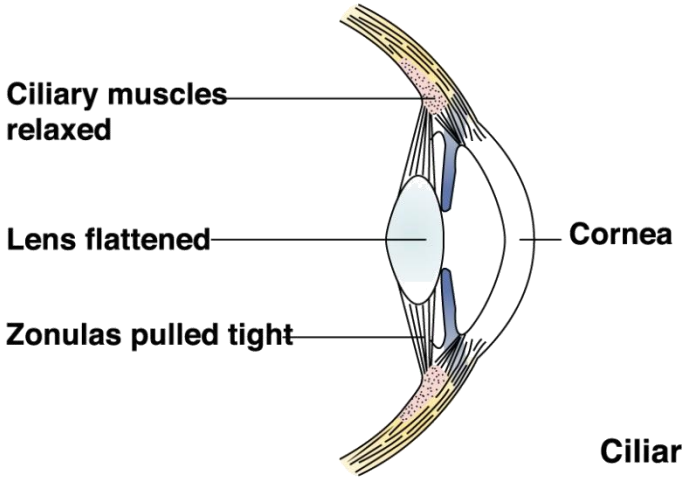
Lens less convex (Flat)

Decrease diopteric power of the eye

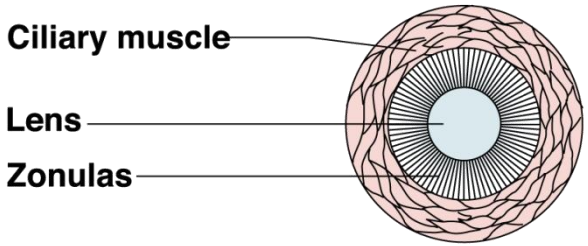


Far object focussed on the retina

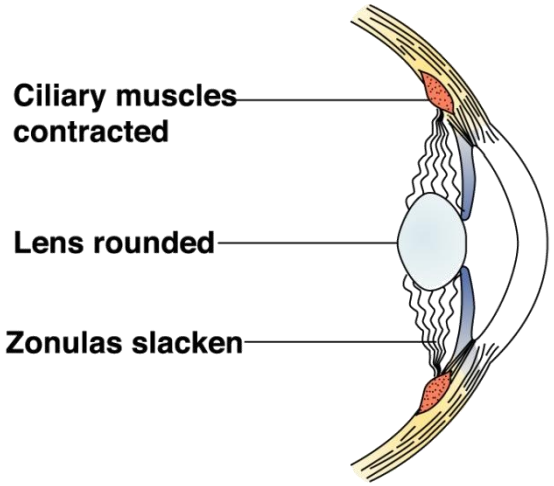
Accommodation



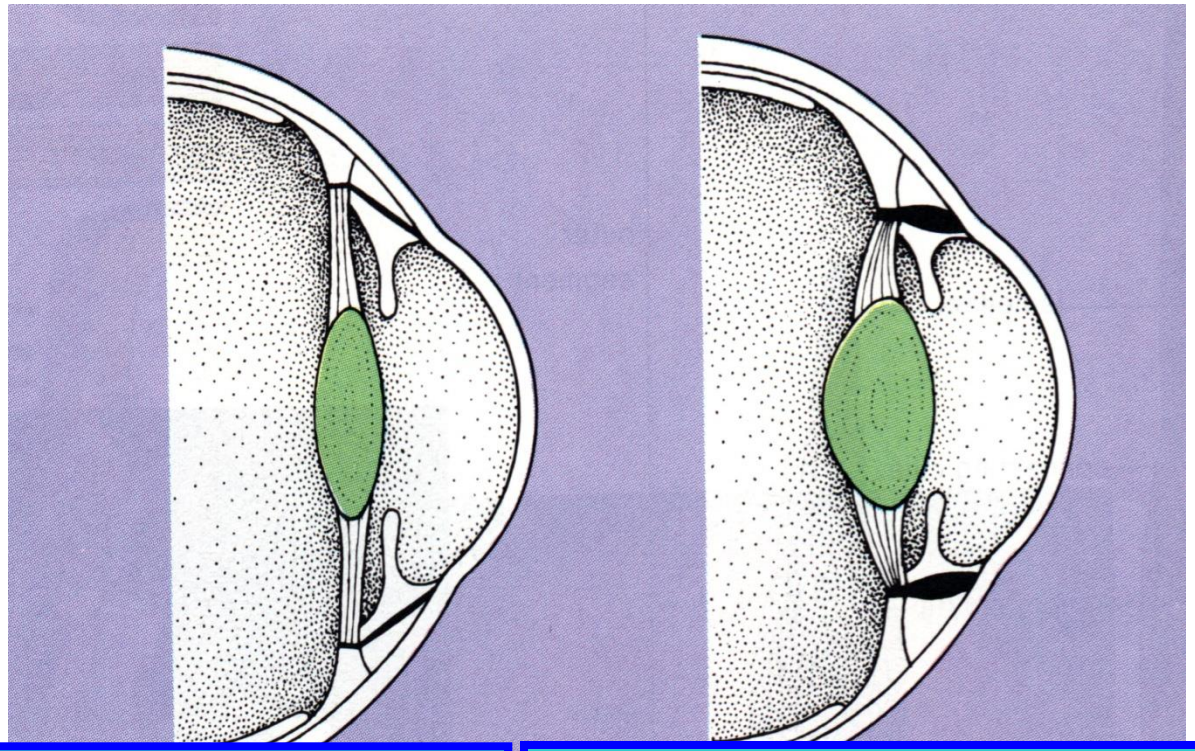
When the cilary muscles are relaxed, the zonalus pulls tight and keeps the lens flattened for distant vision



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



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



Distant Vision:

Ciliary Muscle Relaxed

Suspensory Ligaments Under Tension

Lens is Flattened

Focus on Distant Objects

Accommodation:

Ciliary Muscle Contracts

Reduced Tension on Suspensory Ligaments

Lens becomes Round

Focus on Near Objects

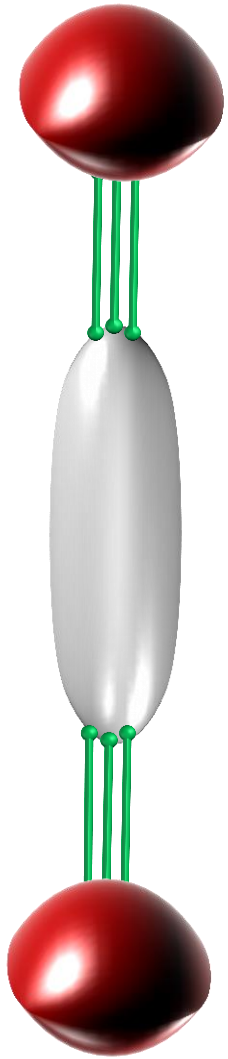
ACCOMMODATION TO NEAR OBJECTS

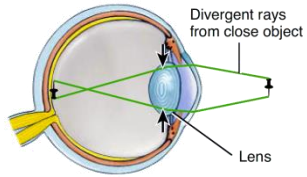
The Ciliary Muscle Contracts

The Tension on the suspensory ligaments decreases

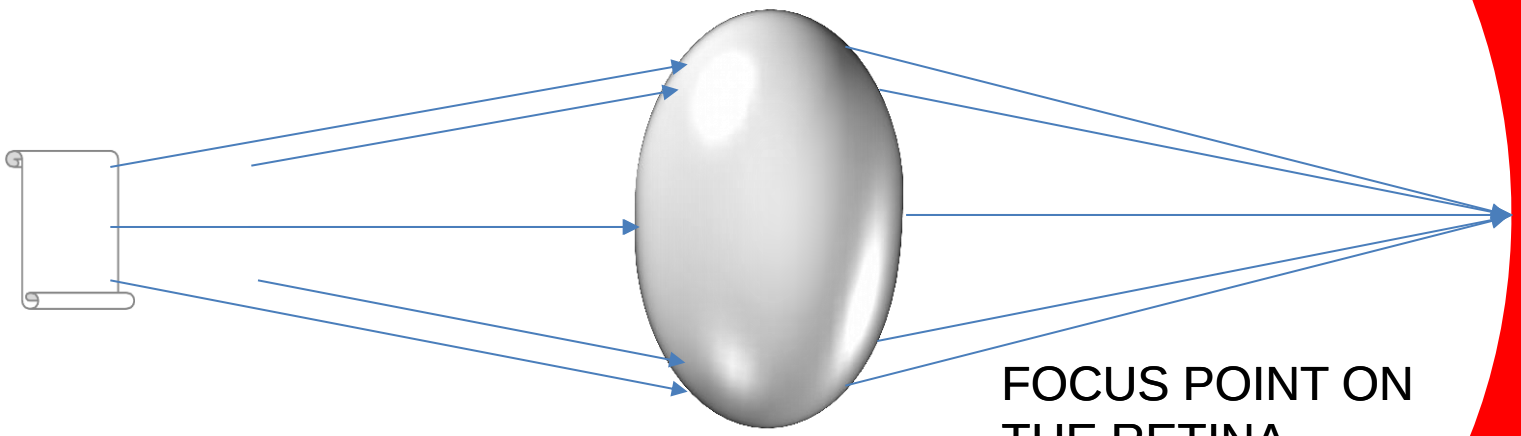
The lens become more globular in shape

Accommodation to view closer objects





NEAR OBJECT



- The problem bringing diverging from close objects to a focus on retina can be solved by increasing curvature of anterior surface of the lens
- ***THIS IS ACCOMMODATION***

Diopter (D)

$$\text{Dioptre (s)} = \frac{1}{\text{Focal length}}$$

Diopteric power if the eye:

Cornea ……40-45 D

Lens …… 15-20 D

Accomodation …. +12 D

Amplitude of Accomodation

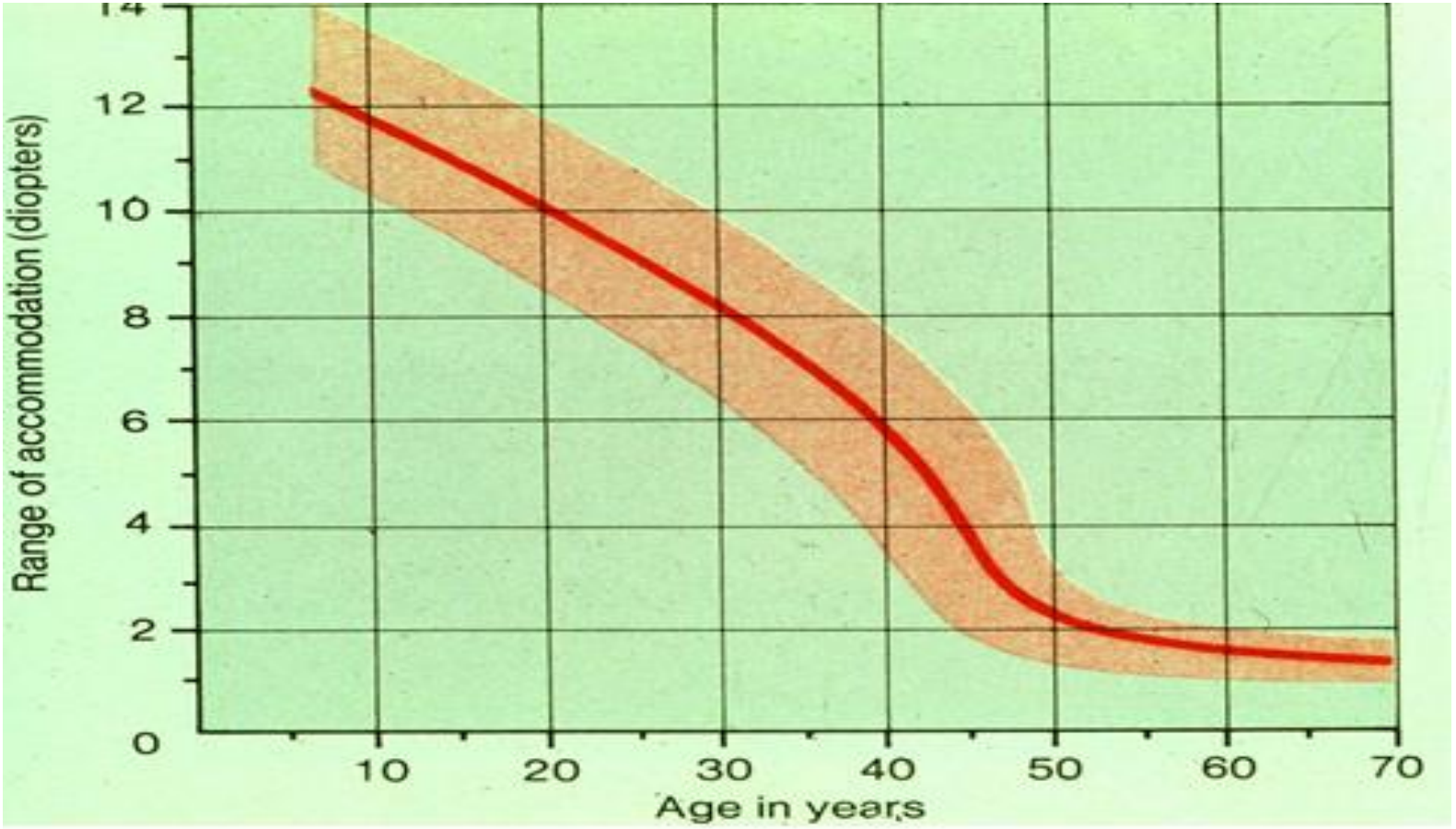
The additional diopters added by increasing the convexity of the lens

Near point:

The nearest point to the eye where an object can be seen clearly

Presbyobia:

Loss of lens elasticity in old age >>loss of accomodation


Range of accommodation (diopters)
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
Age in years

Near point and amplitude of accomodation

Age (yrs)	Near point (cm)	Amplitude of Accomodation
10	9.0	11.0
20	10.0	10.0
30	12.5	8.0
40	18	5.5
60	83	1.2
70	100	1.0

The accomodation Reflex

Afferent:

Retina ➡ optic nerve ➡ optic chiasma ➡
optic tract ➡ lateral geniculate body ➡
visual cortex

Efferent:

Occuluomotor nucleus ➡ (parasympathetic) ➡
ciliary ganglion ➡
➡ ciliary muscle
➡ circular pupillary muscle

PRESBYOPIA

FOCUS POINT BEYOND THE RETINA

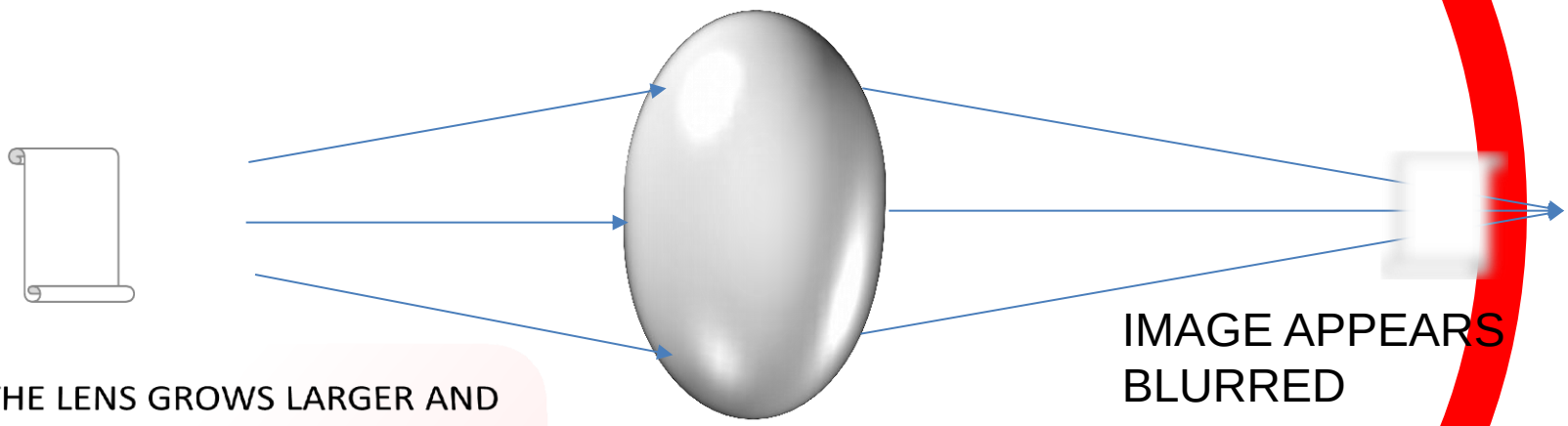


IMAGE APPEARS BLURRED

WITH AGE, THE LENS GROWS LARGER AND THICKER AND BECOMES FAR LESS ELASTIC

THE LENS CAN NO LONGER BECOME AS SPHERICAL AS AT A YOUNGER AGE

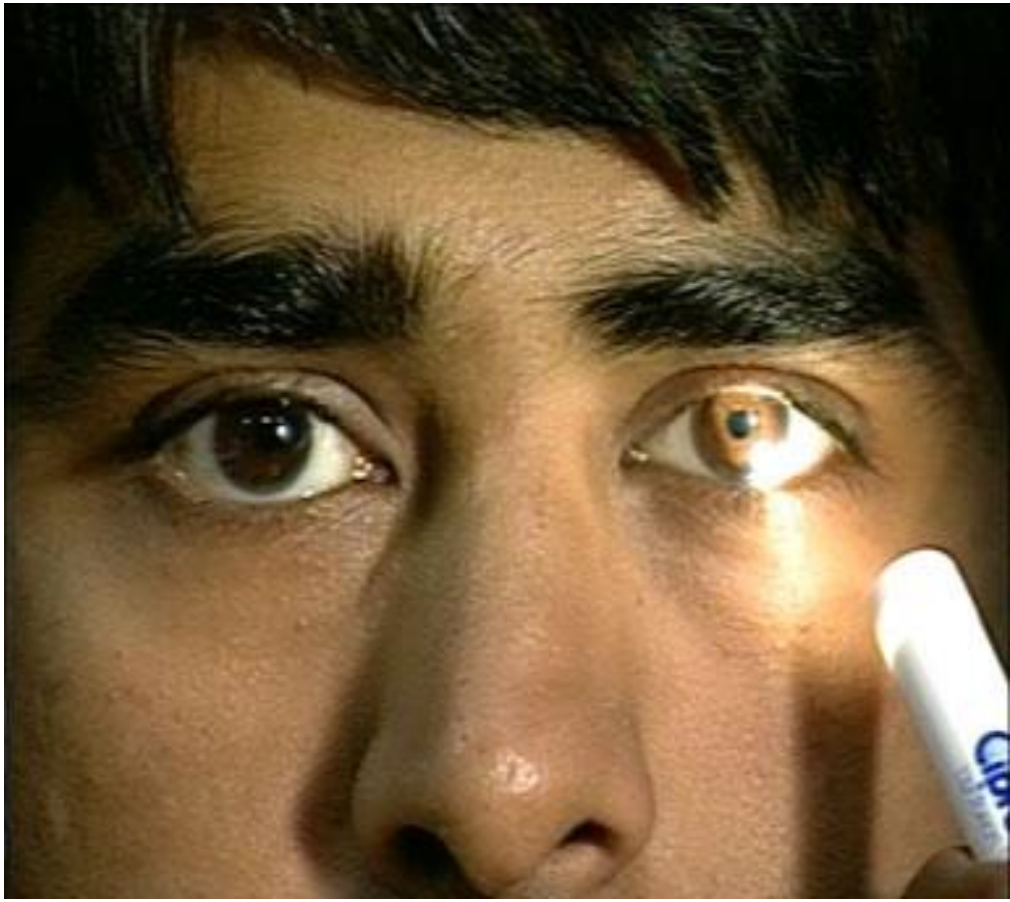
THIS RESULTS IN LOSS OF ACCOMMODATION DUE TO THE DECREASE IN THE DEGREE TO WHICH THE CURVATURE OF THE LENS CAN BE INCREASED.

LENS IS HARDENED AND CANNOT BECOME MORE SPHERICAL TO REFRACT LIGHT FROM THE CLOSER OBJECT

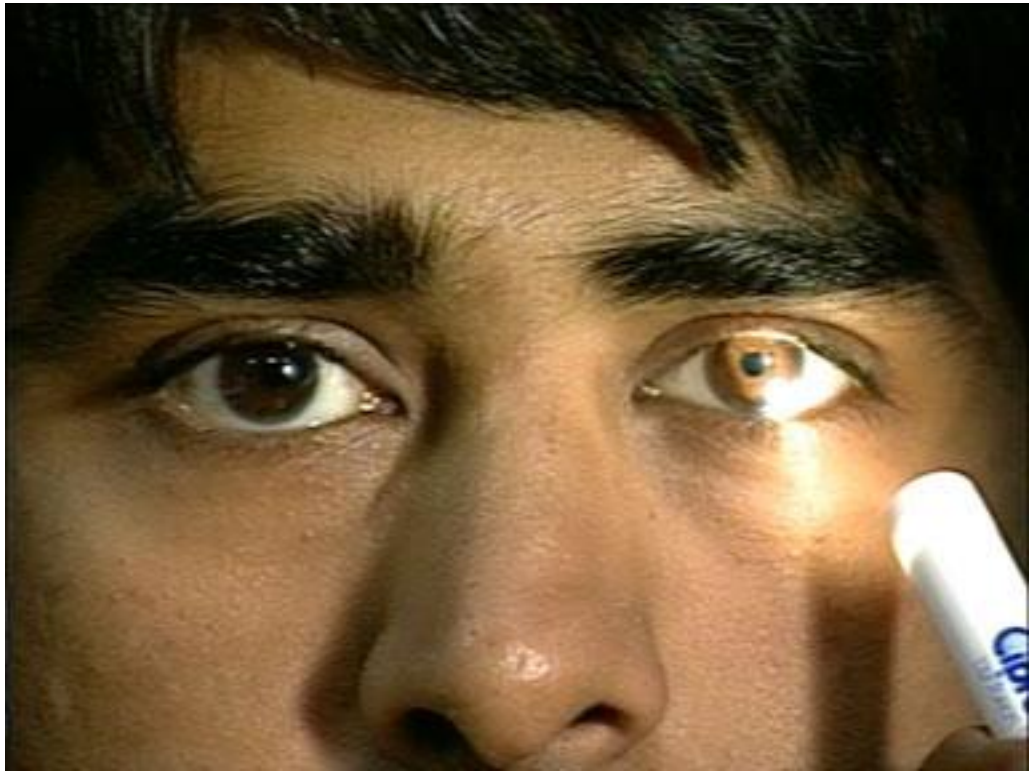
The light reflex

Light Reflex

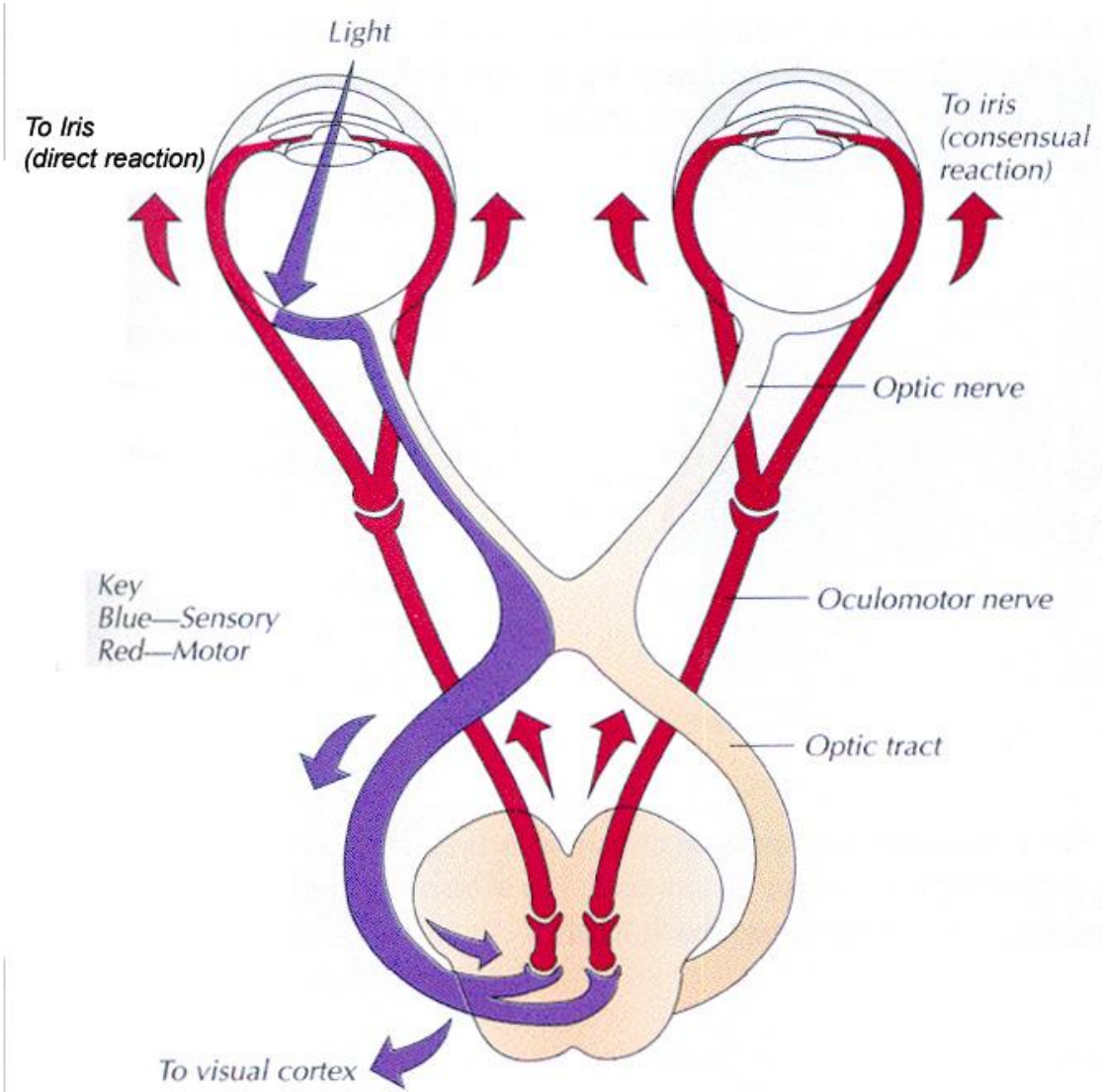
When an eye (Left) is subject to bright light, a direct light reflex occurs(constriction of the pupil) as well as a consensual (indirect) reflex of the other (Right) pupil



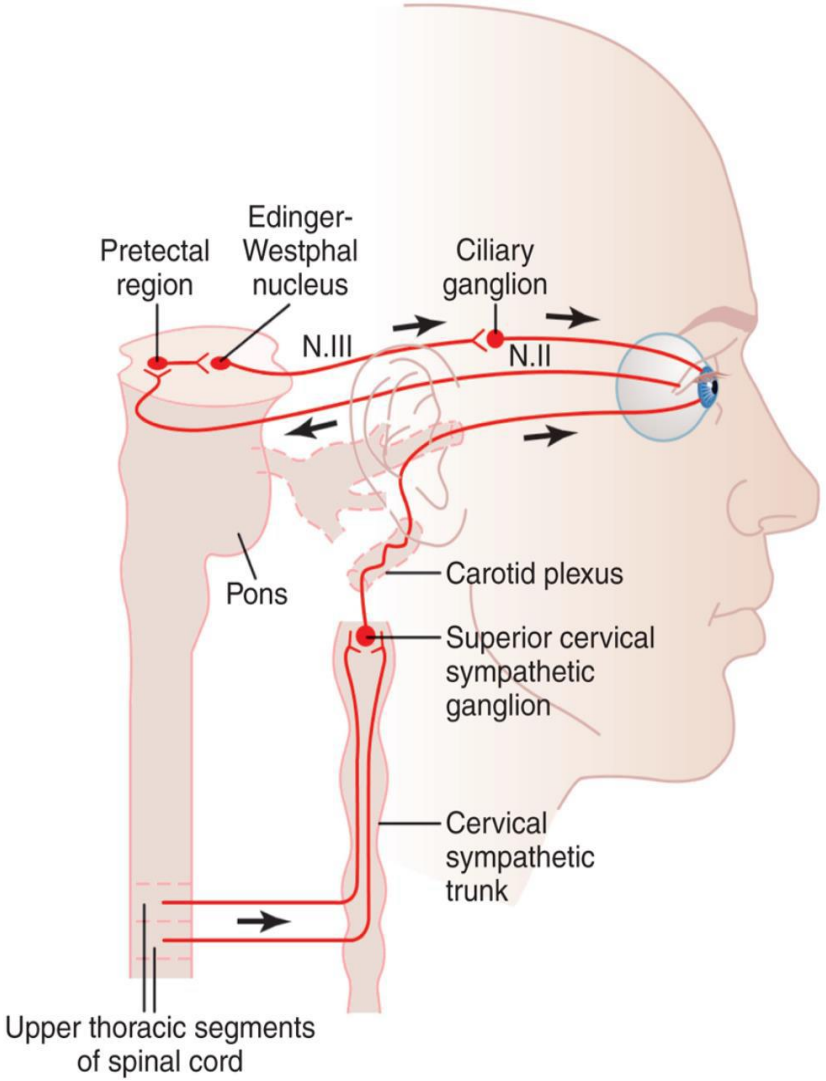
(Quantity of light changes X30 fold)



Direct reflex on right Consensual reflex on left



PATHWAYS OF THE LIGHT REACTION


Pretectal region
Edinger-Westphal nucleus
Ciliary ganglion
N.III
N.II
Pons
Carotid plexus
Superior cervical sympathetic ganglion
Cervical sympathetic trunk
Upper thoracic segments of spinal cord

Constriction of the pupil

The pupil constricts in response to:

- The accomodation Reflex
- The light reflex

Argyll Robertson pupils (Neurosyphilis)

constrict in response:

to accomodation reflex

but not

to the light reflex

Lateral Geniculate Body; LGB

FUNCTION OF LGB:-

1- Acts as a relay station for visual information from optic tract to cortex.

2- Acts as gate controls signal transmission to visual cortex i.e control how much signals reach visual cortex

N.B/- It receives gating control signals from two major sources:

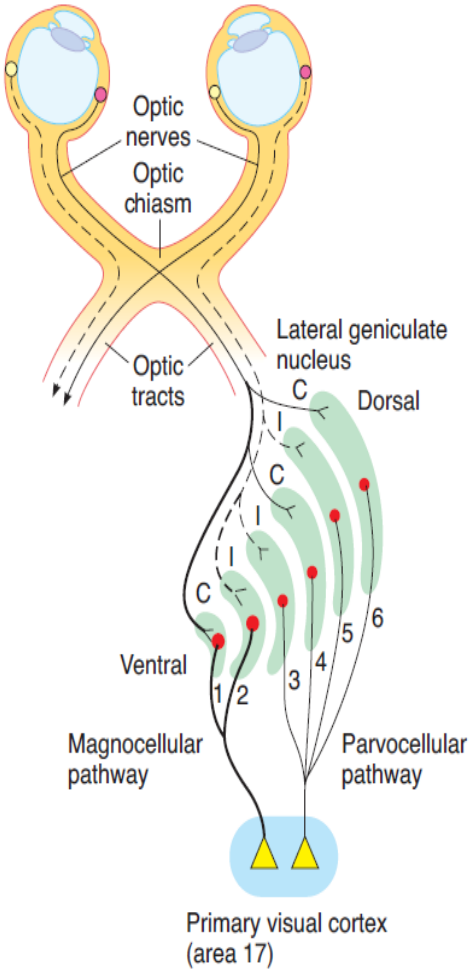
(1) *Corticofugal fibers returning in a backward direction from the primary visual cortex to the lateral geniculate nucleus*

(2) *Reticular areas of the mesencephalon. Both of these are inhibitory and, when stimulated, can turn off transmission through selected portions of the dorsal lateral geniculate nucleus*

Lateral Geniculate Body; LGB

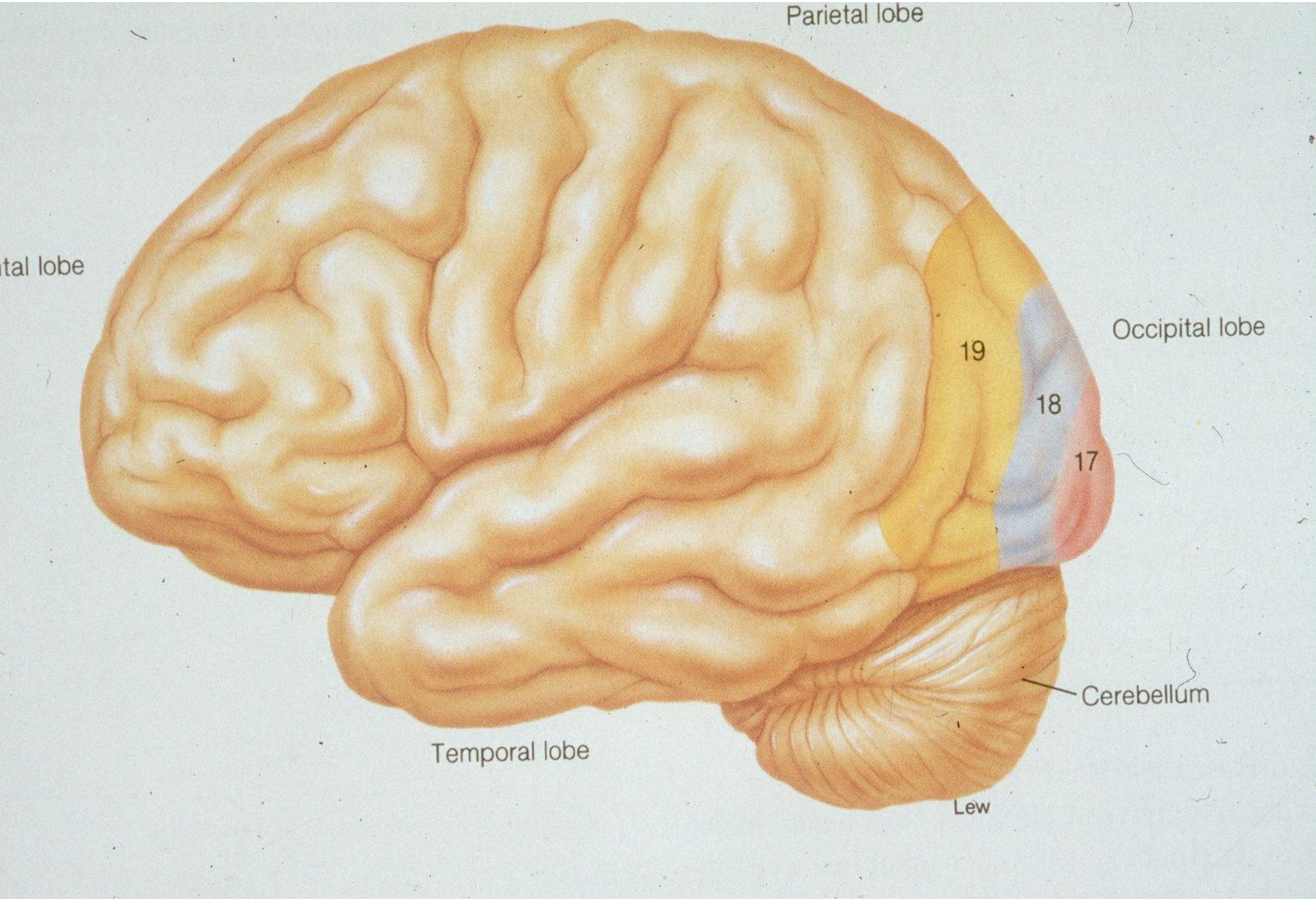
1-Th magnocellular pathway, from layers 1 and 2 which have large cells and are called magnocellular., carries signals for detection of movement,depth, and flicker.

2. The parvocellular pathway, from layers 3,4,5,6 which have small cells and are called parvocellular, carries signals for color vision, texture, shape, and fine detail



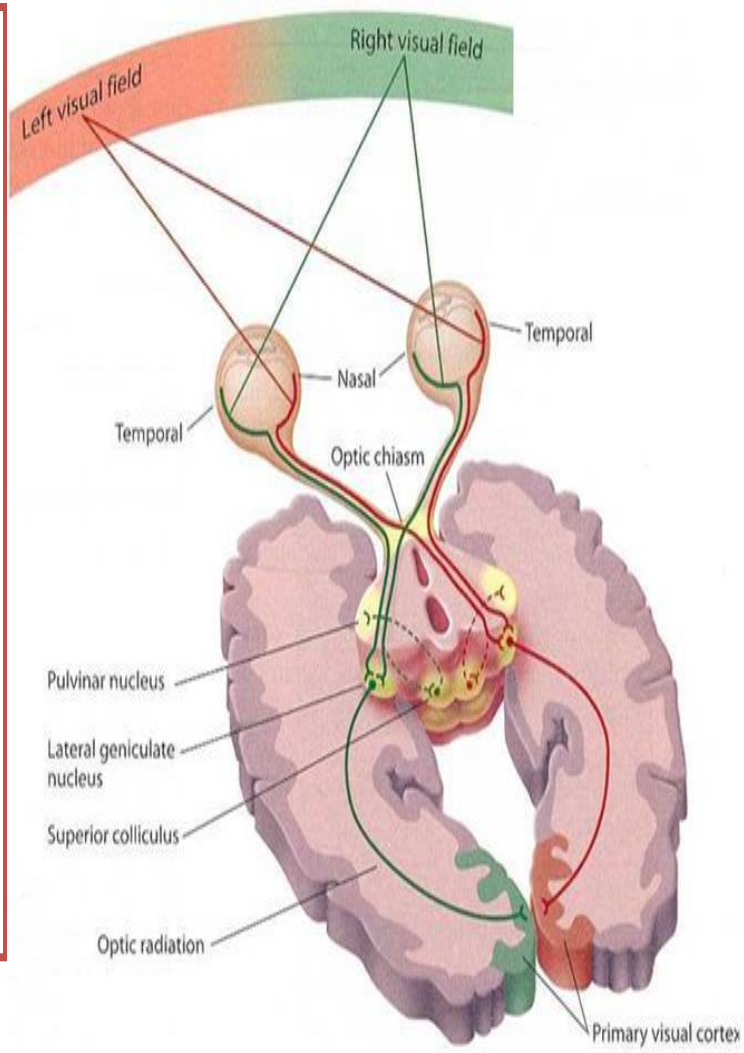
Cortical Visual areas

- Primary (area 17)
- Secondary association area, (areas 18, 19)

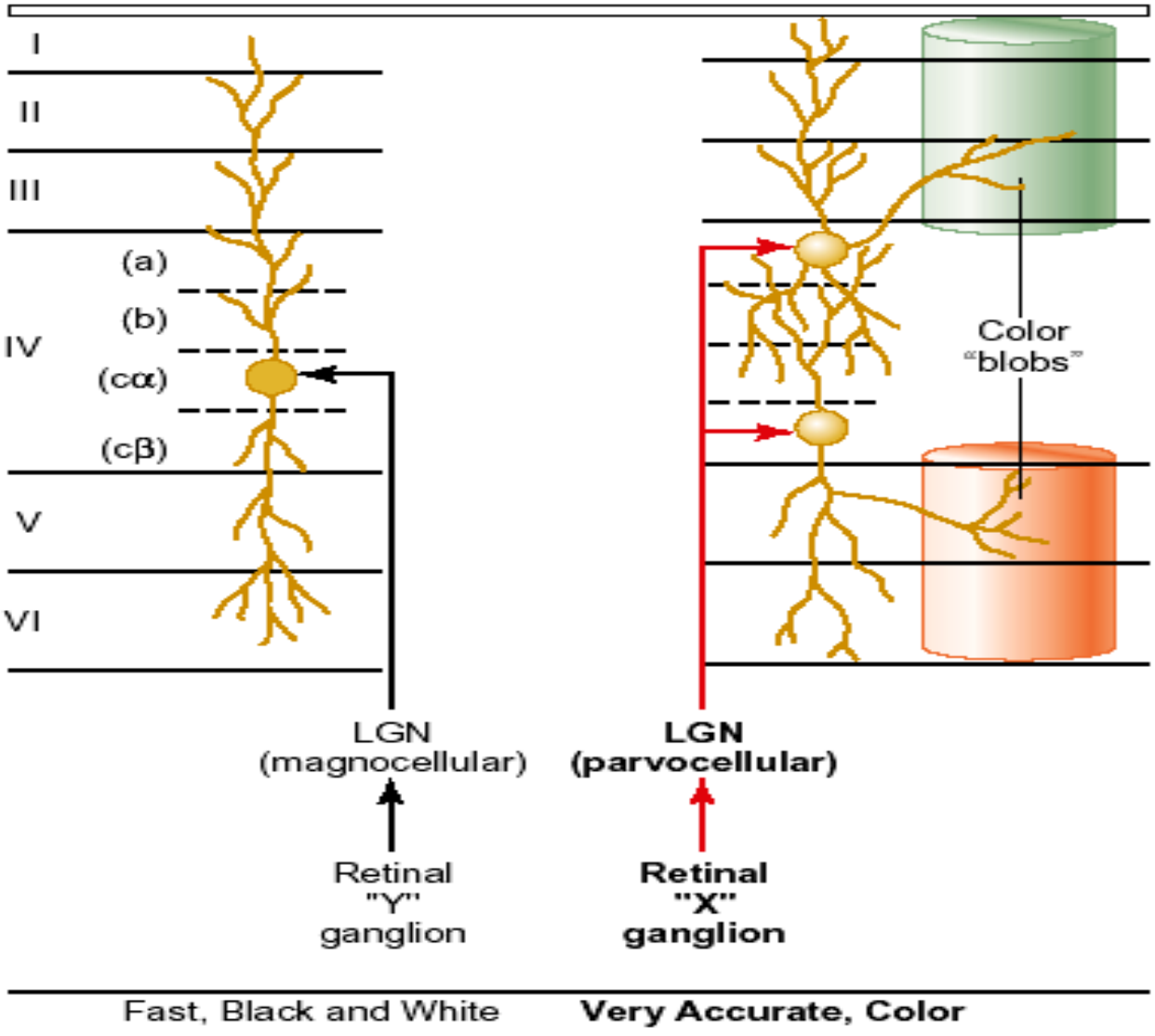

Parietal lobe
tal lobe
Occipital lobe
19
18
17
Cerebellum
Temporal lobe
Lew

Primary Visual area (Area 17)

- On medial aspect of each occipital lobe
- Its neurons arranged in the form of columns forming 6 distinct layers
- Fovea has broad presentation



Visual Projections to Area 17



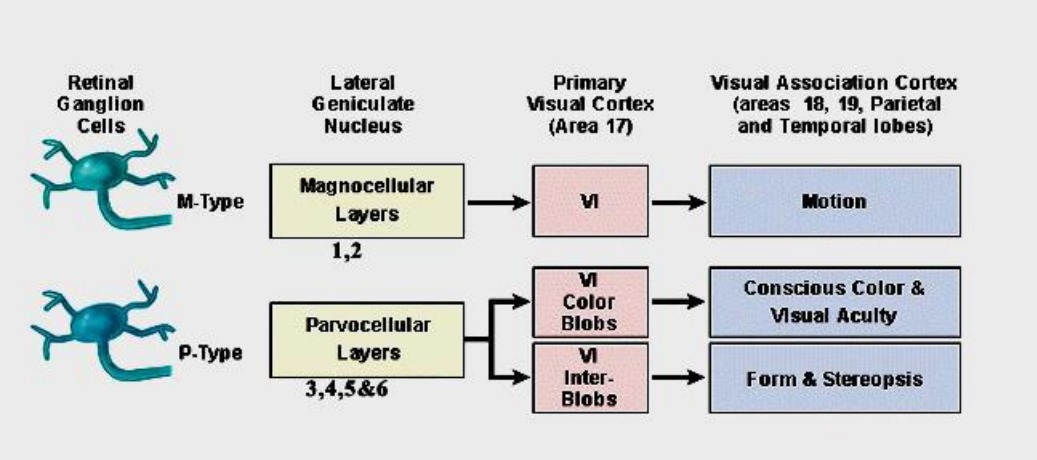
Role of Area 17

- Perception of visible objects without knowing the meaning of these objects

Secondary Visual Processing: Association Areas (18 &19)

- In parietal & temporal lobes
- Interpretation of visual stimuli
- Dealing with complex perception of patterns & forms & responsible for object recognition

Retinotopic Organization & Processing of visual information



Three Types of Retinal Ganglion Cells and Their Respective Fields

- 1-W cells/ sensitive or detecting directional movement in the field of vision, and they are probably important for much of our rod vision under dark
- 2- X Cells / Transmission of the Visual Image and Color Vision
- 3-Y Cells // to Transmit Instantaneous & rapid Changes in the Visual Image , either rapid movement or rapid change in light intensity

Retinal Ganglion Cells Cont …..

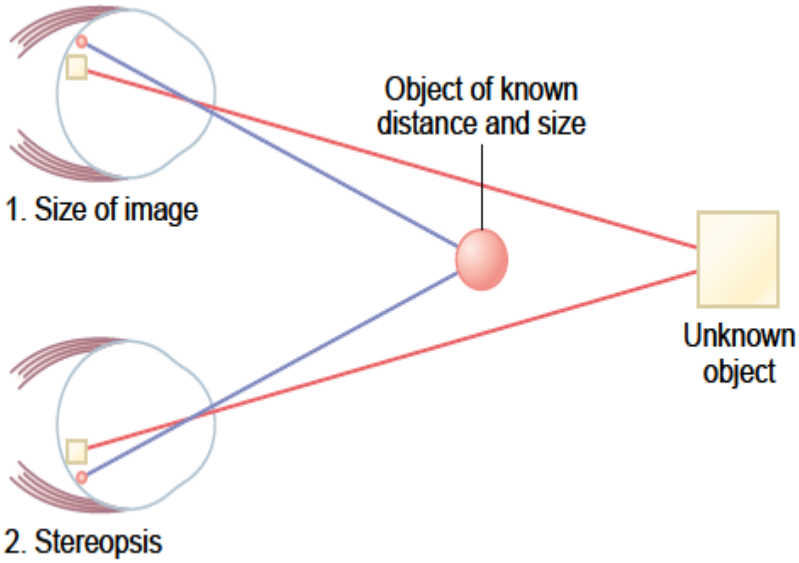
- In primates a different classification is used:

1. Parvocellular (P) cells which project to parvocellular layer of LGB, conducting signal of fine details & colors

2. Magnocellur(M) cells , which project to magnocellular layer of LGB, and they are high sensitive to low contrast stimuli and to rapid movement visual signals

Determination of Distance of an Object from the Eye—"Depth Perception"

- A person normally perceives distance by three major means:
- (1) the sizes of the images of known objects on the retina
- (2) the phenomenon of moving parallax :*when the person moves his head to one side or the other, the images of close-by objects move rapidly across the retinas, while the images of distant objects remain almost completely stationary*
- (3) the phenomenon of stereopsis or Binocular Vision



Sunset Over the Mississippi River, Arkansas