Physiology of Vision
Lecture-2-
Accommodation & Pupillary Light Reflex

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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.
- it is usually defined in terms of the shortest distance by which two lines can be separated and still be seen as 2 lines
- -(person can normally distinguish two separate points if their centers lie up to 2 micrometers apart on the retina, which is slightly greater than the width of a foveal cone)

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

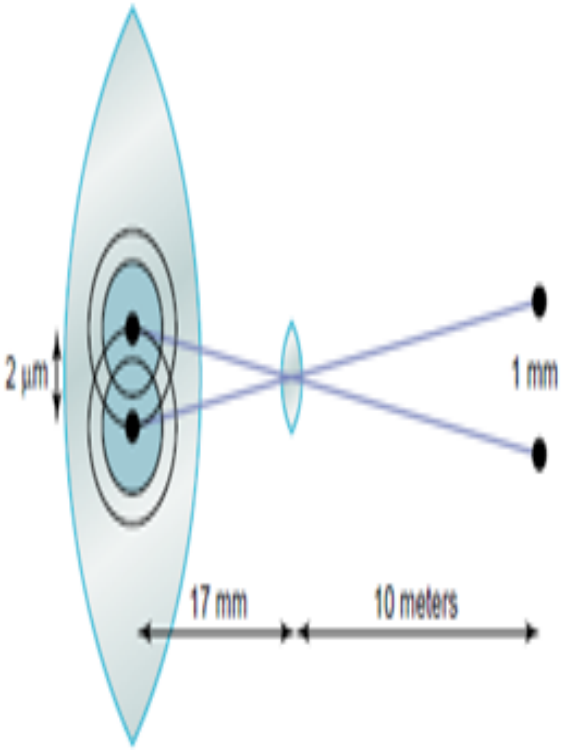
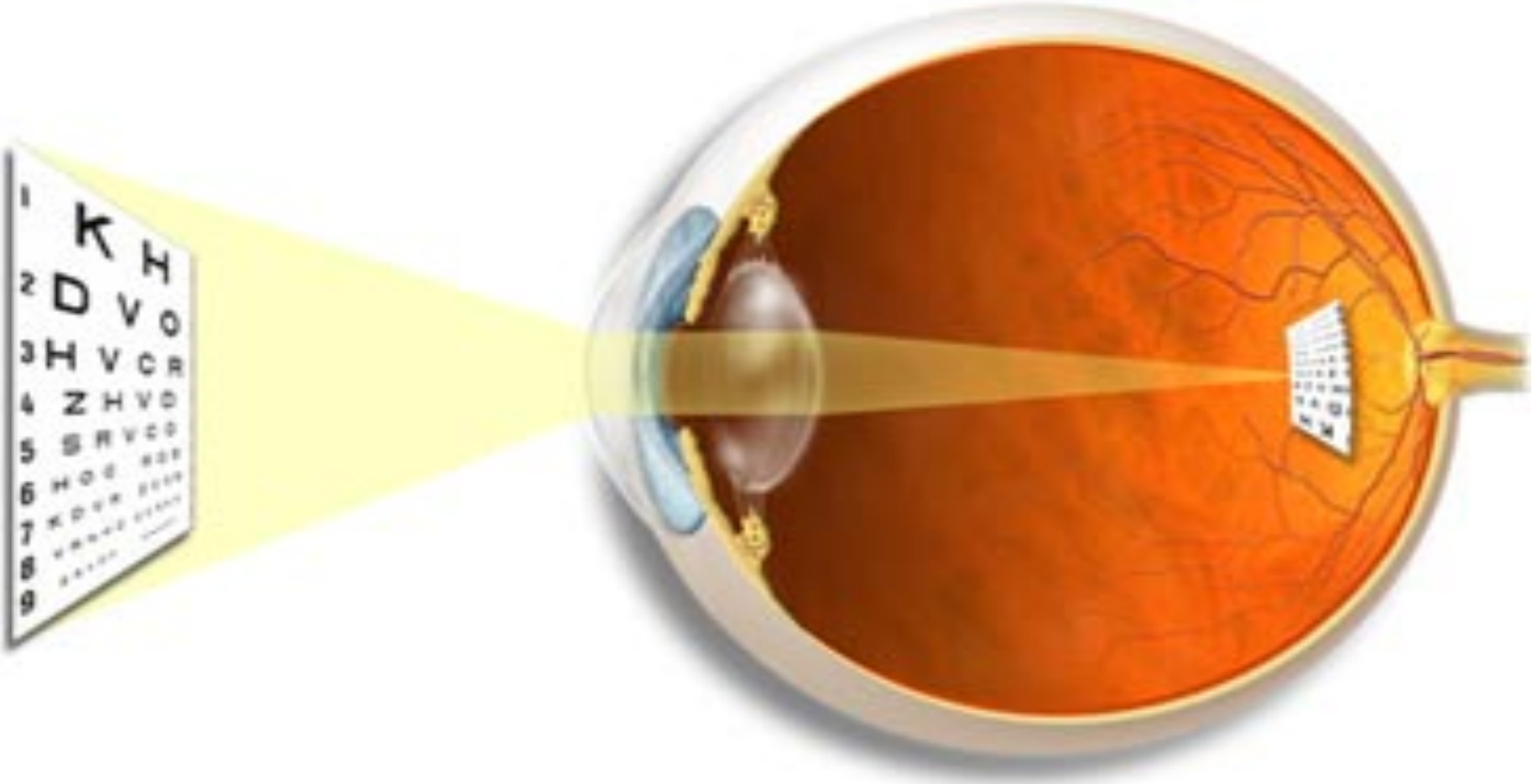


Figure 49–16



Duplicity Theory of Vision

- 2 kinds of vision under diff conditions)
- Differentiate between cones & rods vision.

1-PHOTOPIC VISION (bright light vision)

- served by cones
- high visual acuity = colours & details
- low sensitivity to light = needs high visual threshold to be stimulated

2-SCOTOPIC VISION (night vision, dimlight vision)

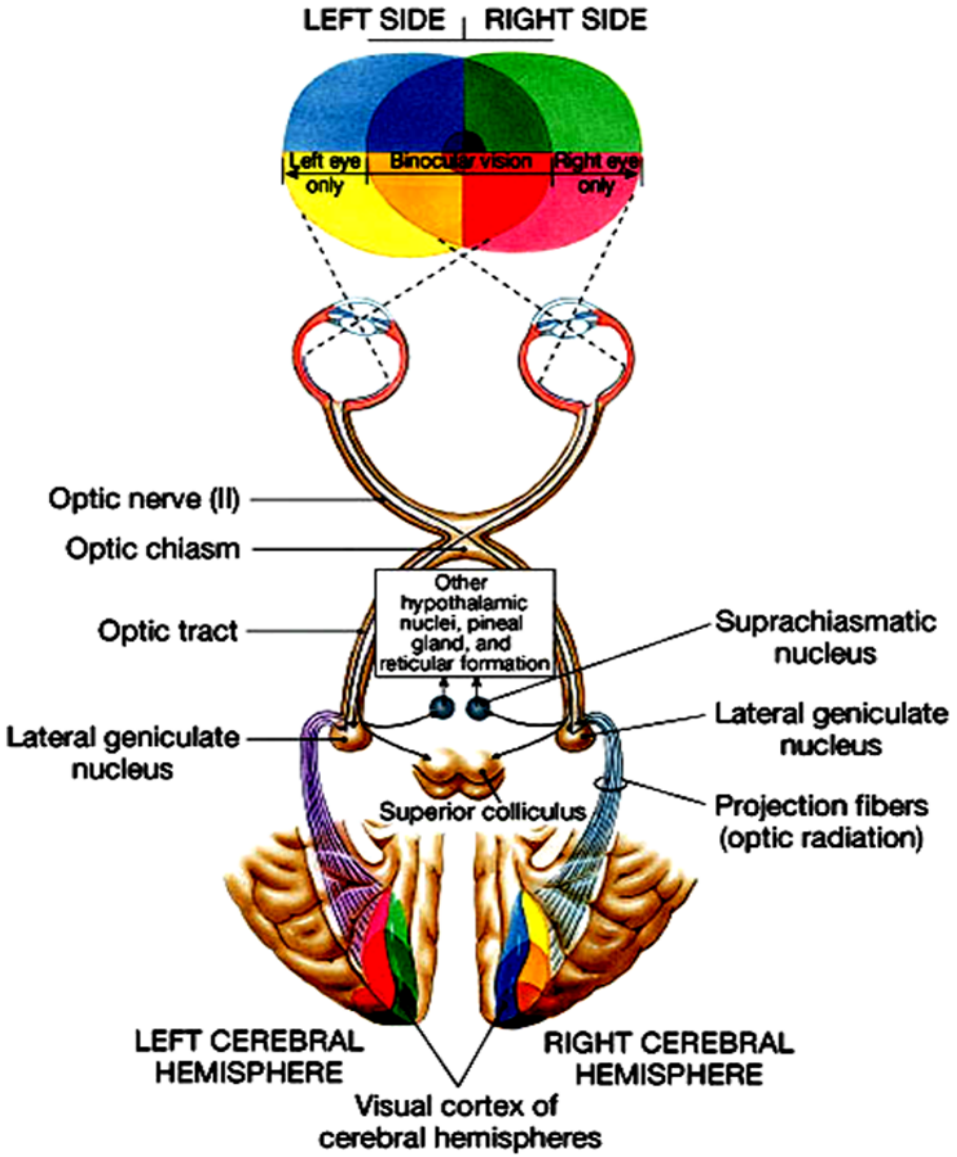
- served by rods
- low visual acuity = no colours or details
- great sensitivity to light =low visual threshold

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 .

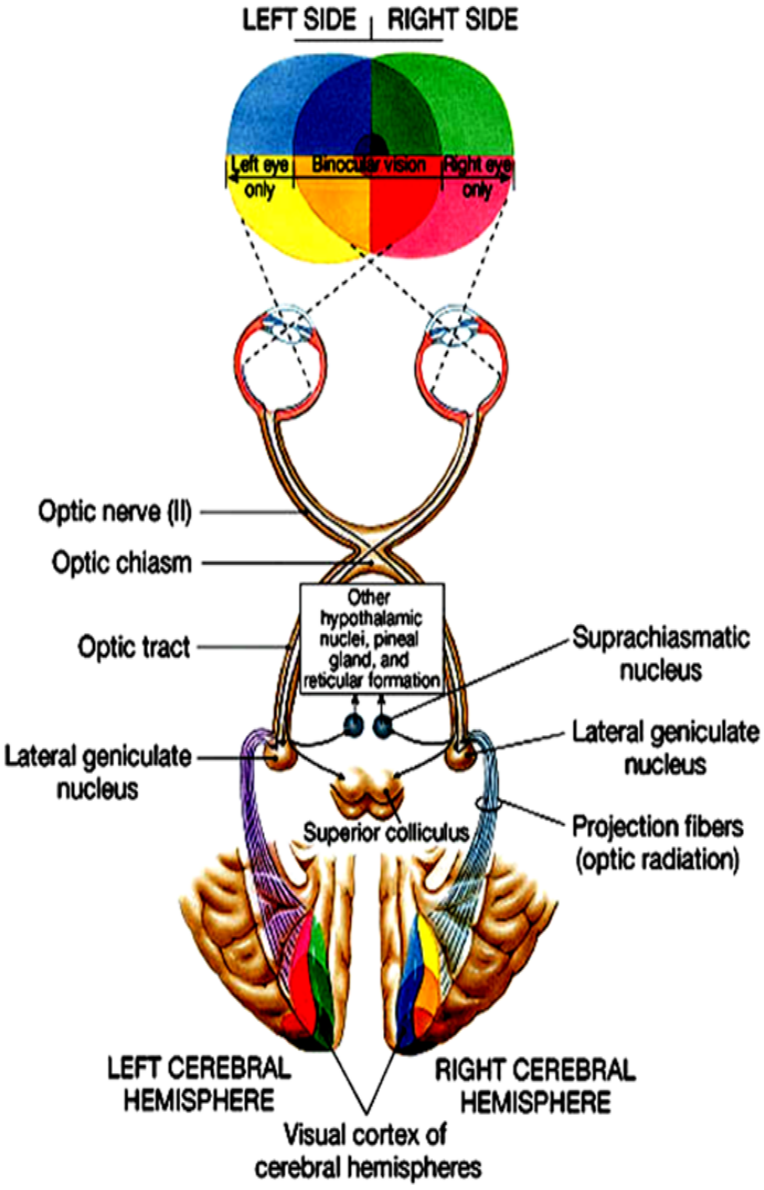
Visual Pathway -2

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



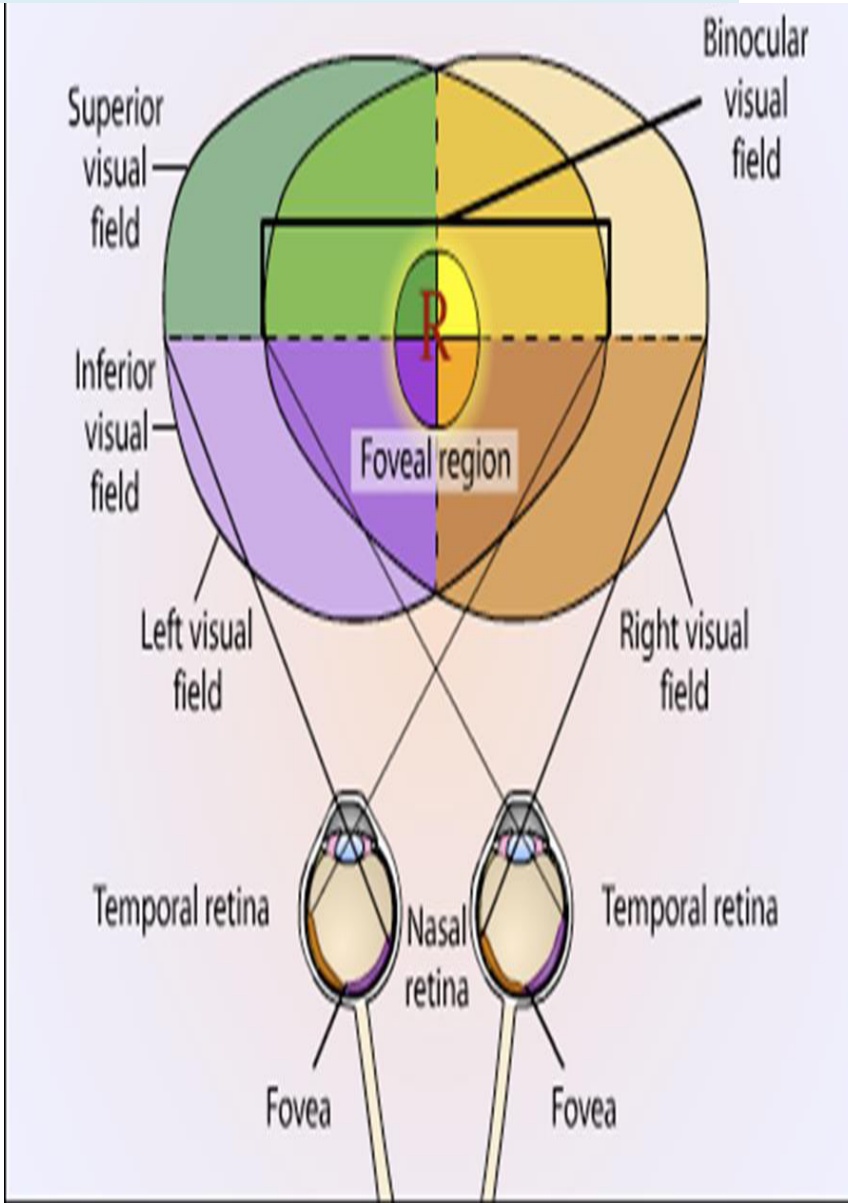
Visual Pathway -3

- 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(temporal) halves of the Field of Vision (bitemporal hemianopia)
- 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 .

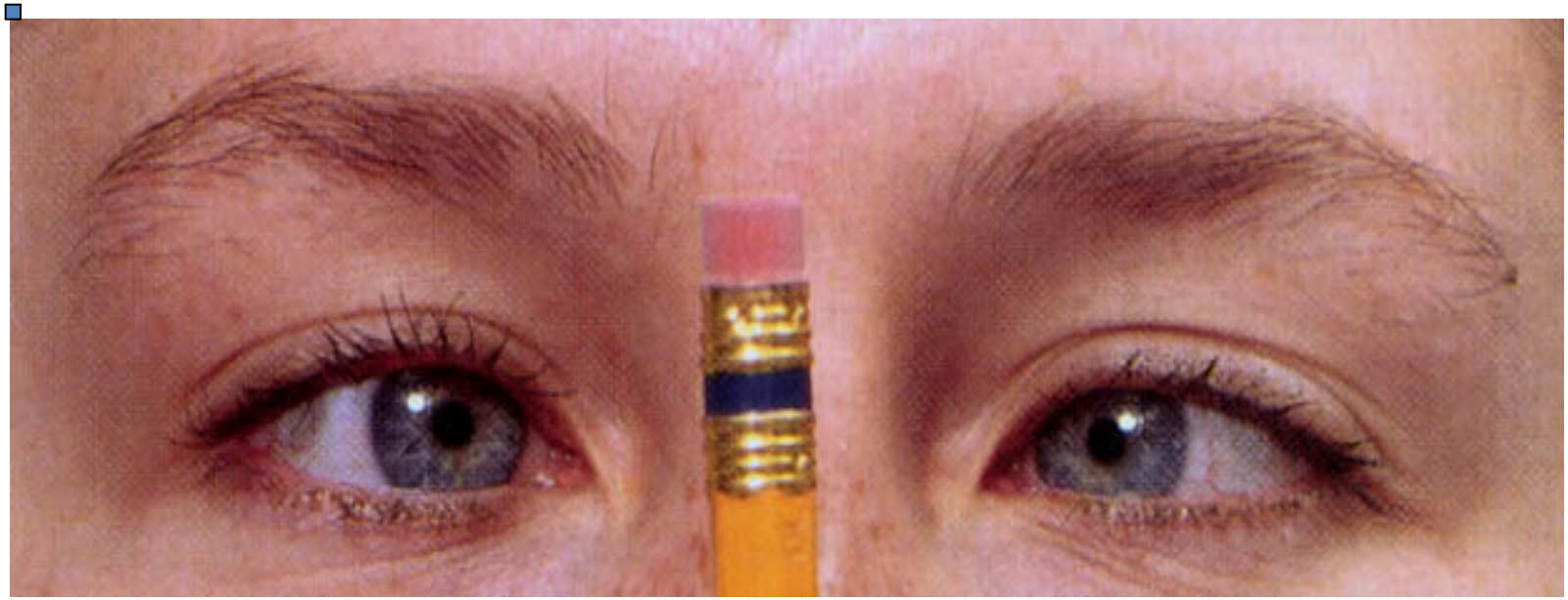


Visual Pathway -4

- 1- some ganglion cells axons pass from optic tract to pretectal region of midbrain for pupillary reflexes & eye movement
- 2- Some axons of ganglion cells from optic chiasma pass directly to hypothalamus for circadian rhythm (light-dark cycle)
- 3-Some axons from lateral geniculate body in thalamus to superior colliculus in midbrain to control rapid directional movements of the two eyes



Accommodation



Accommodation

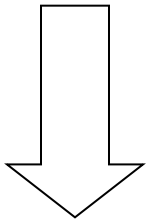
Modification of the
refractive power of the eye
(curvature of the lens)
to view a nearby object

Goal:

Clear vision of a nearby object

Near Response

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



The near response

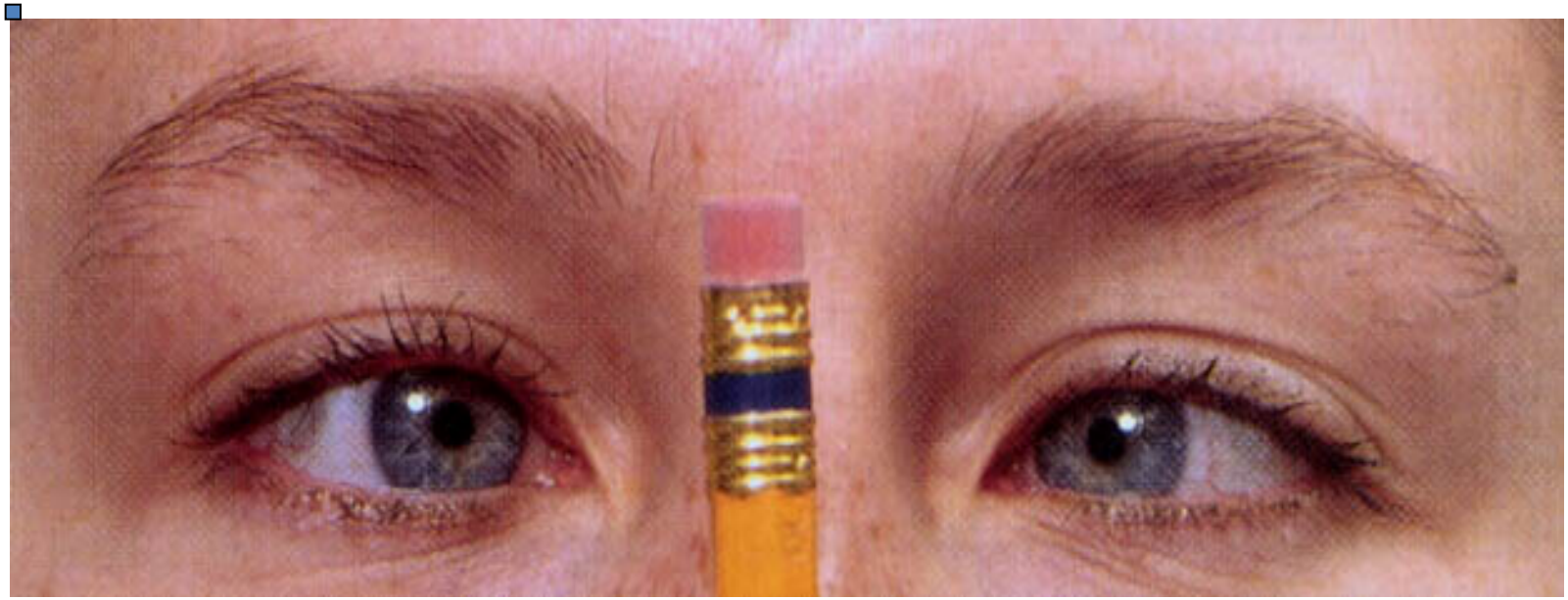
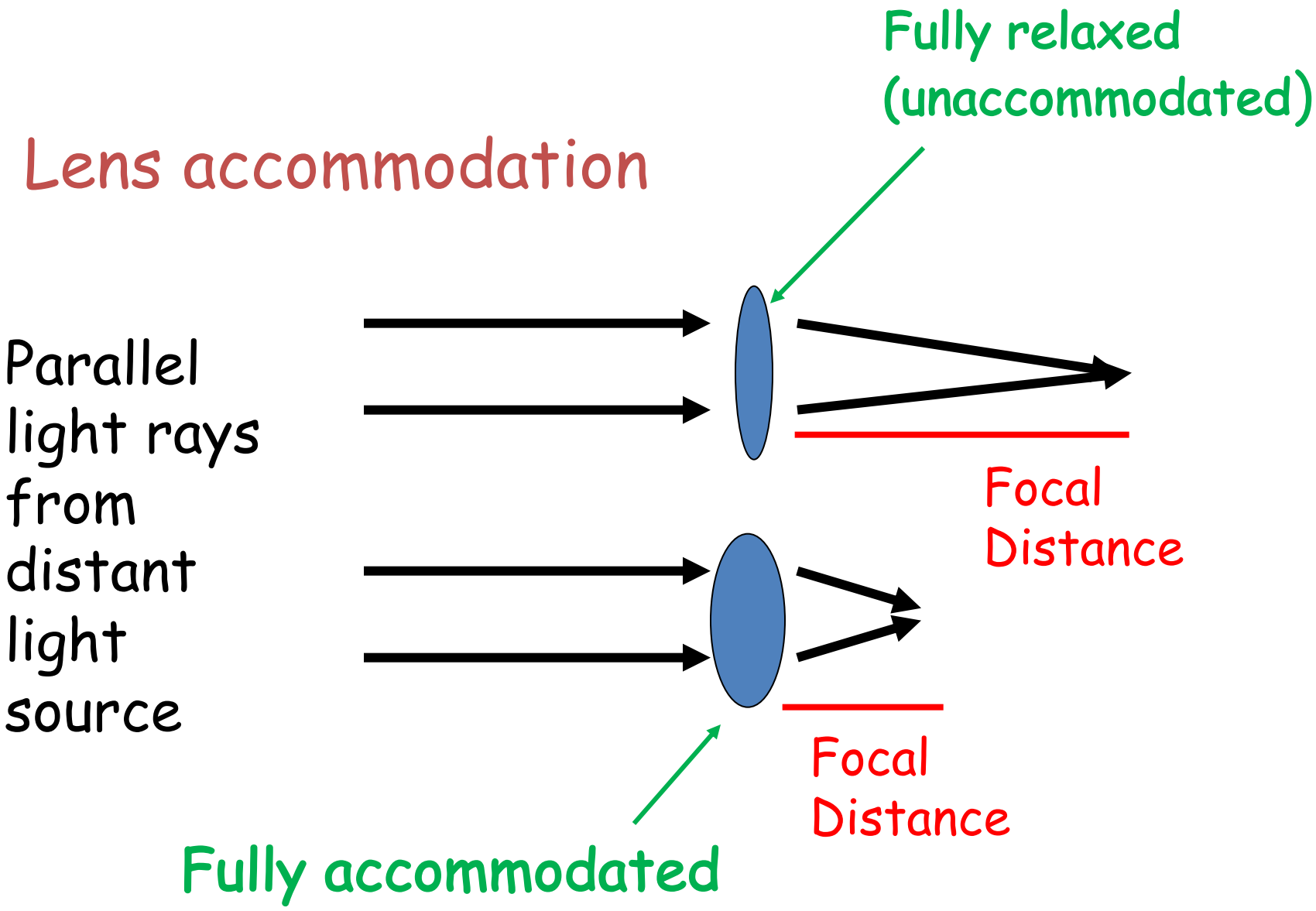


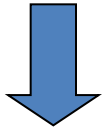
Image Focusing

- Lens accommodation



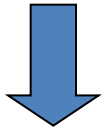
Mechanism of accomodation

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 accommodation- cont

Contraction of the suspensory ligament

↓

Lens less convex (Flat)

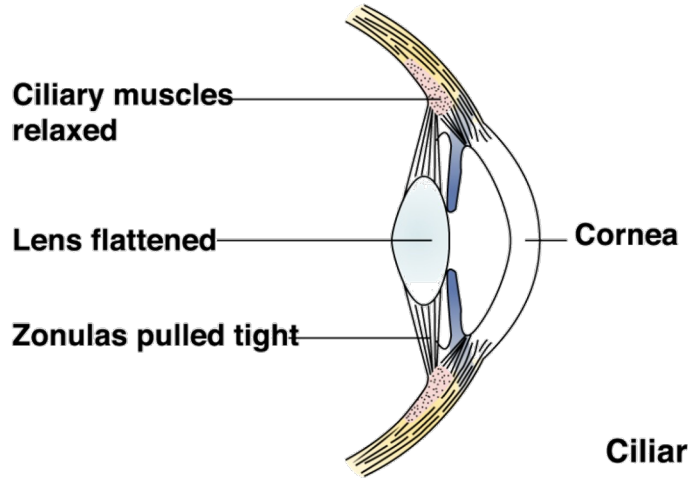
↓

Decrease diopteric power of the eye

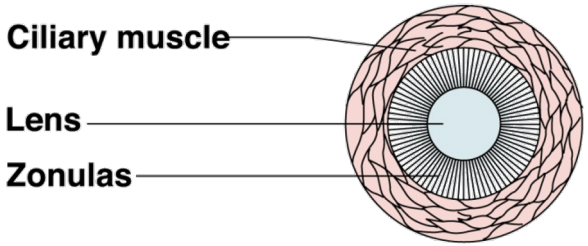
↓

Far object focussed on the retina

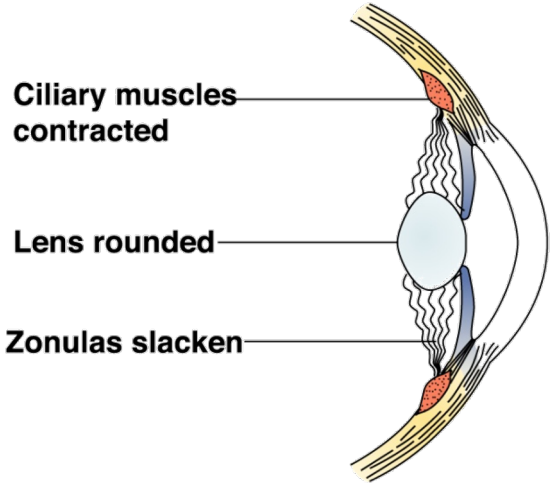
Accommodation



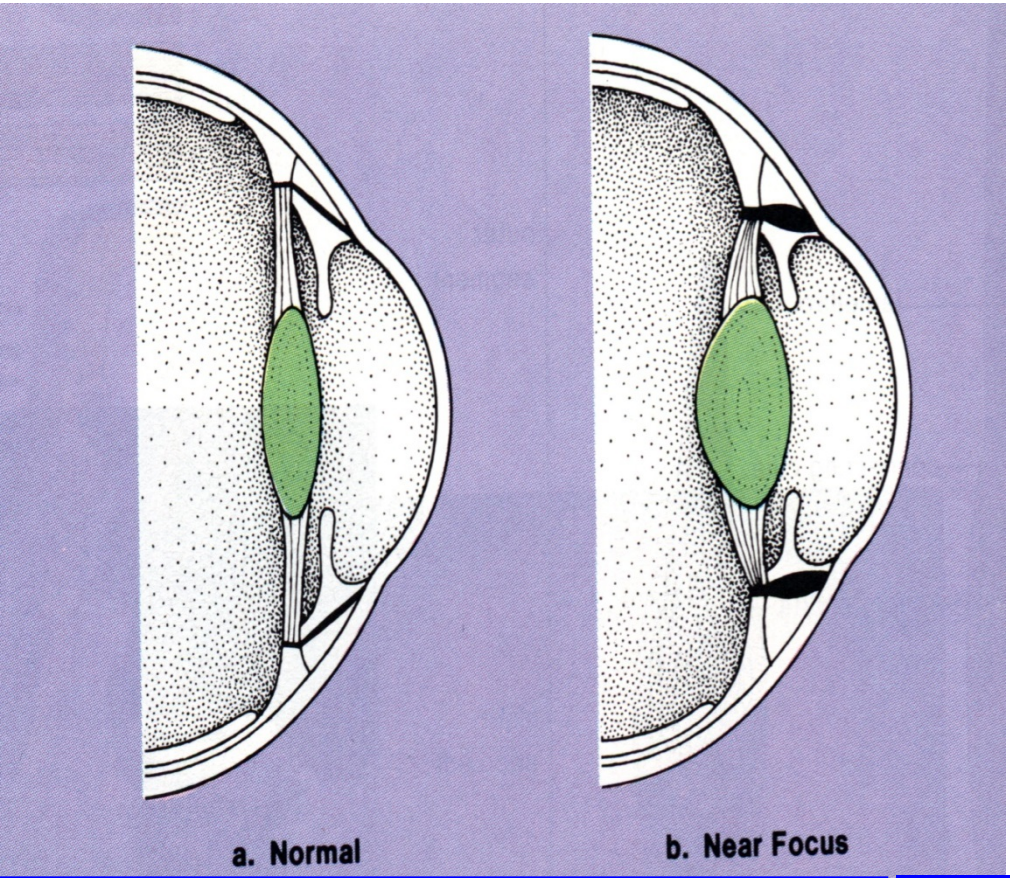
When the cilary muscles are relaxed, the zonalus pulls tight and keeps the lens flattened for distant vision

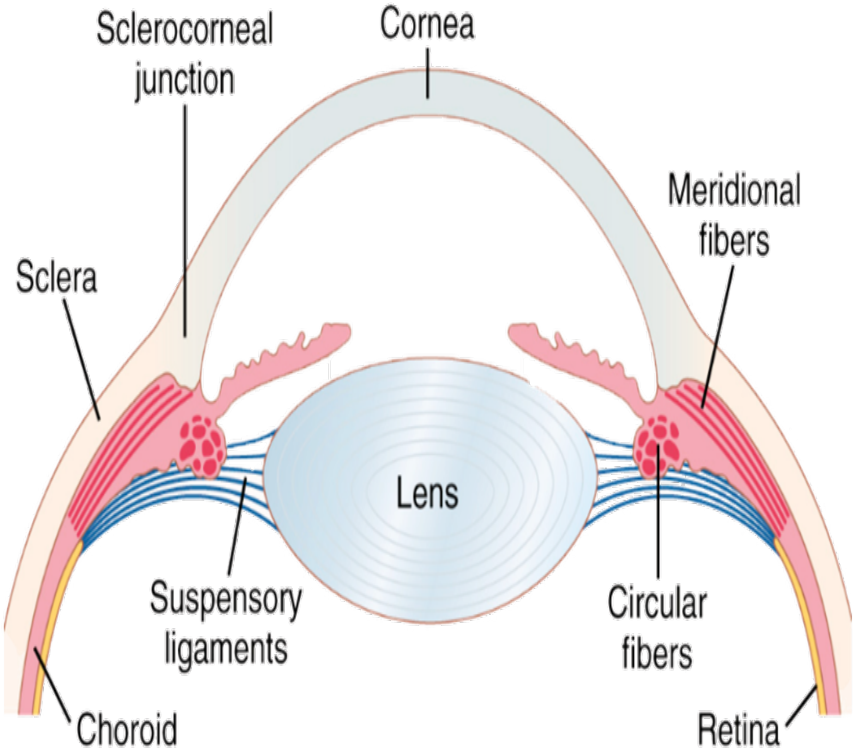


The elastic lens is attached to the circular cilliary muscles by the zonalus



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





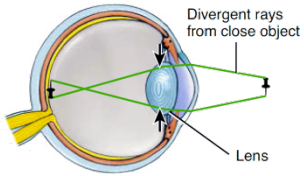
Distant Vision:

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
both circular & longitudinal cilliary muscles contract to pull cilliary

Accommodation to near objects

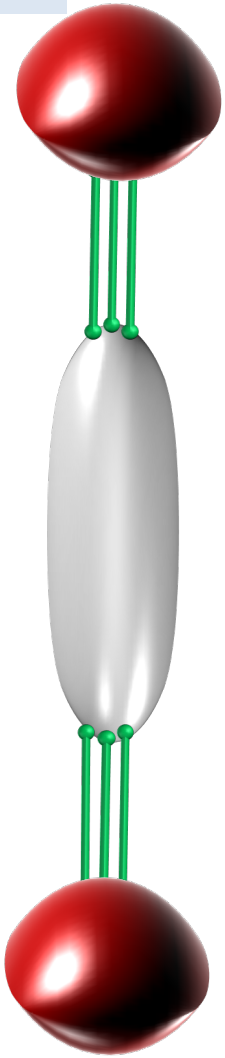


The Ciliary Muscle Contracts

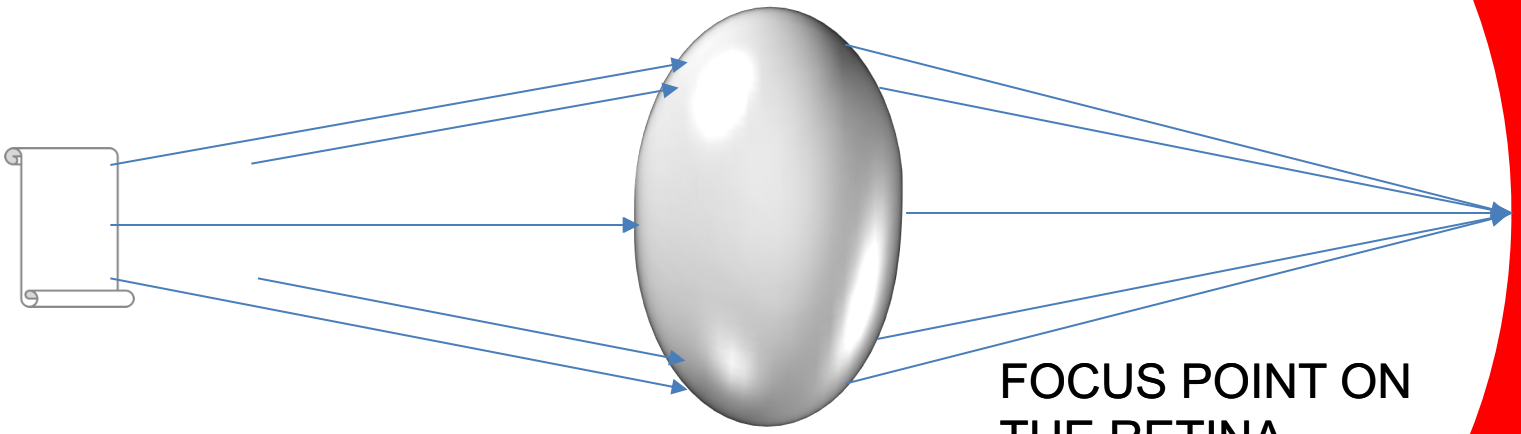
The Tension on the suspensory ligaments decreases

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 Accommodation

- The additional diopters added by increasing the convexity of the lens

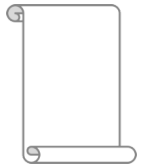
Near point:

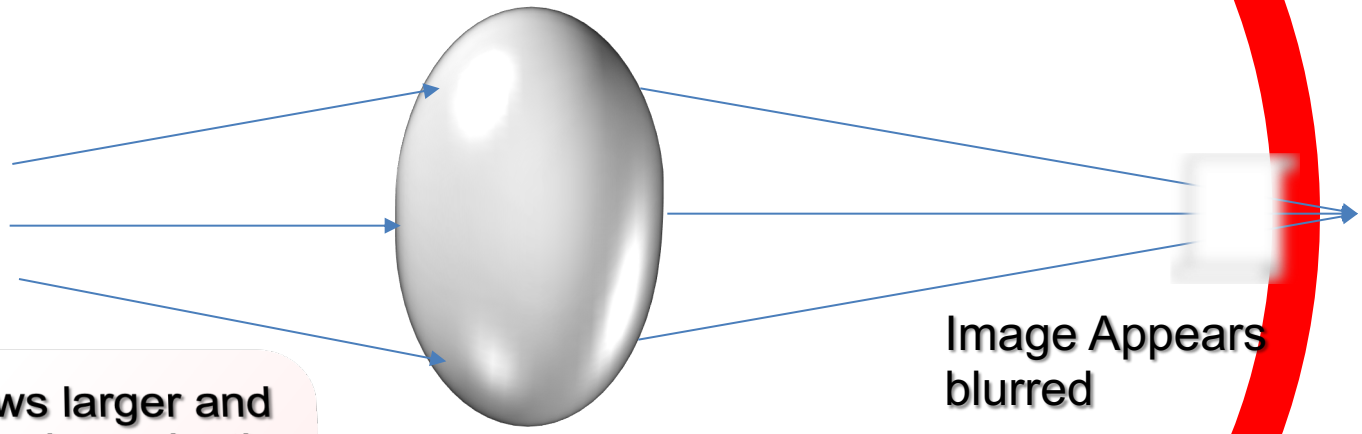
- The nearest point to the eye where an object can be seen clearly

Presbyopia triade:

- Loss of lens elasticity in old age
- loss of accommodation'
- near point recede
- correction by biconvex lens

Presbyopia





Focus Point beyond retina

Image Appears blurred

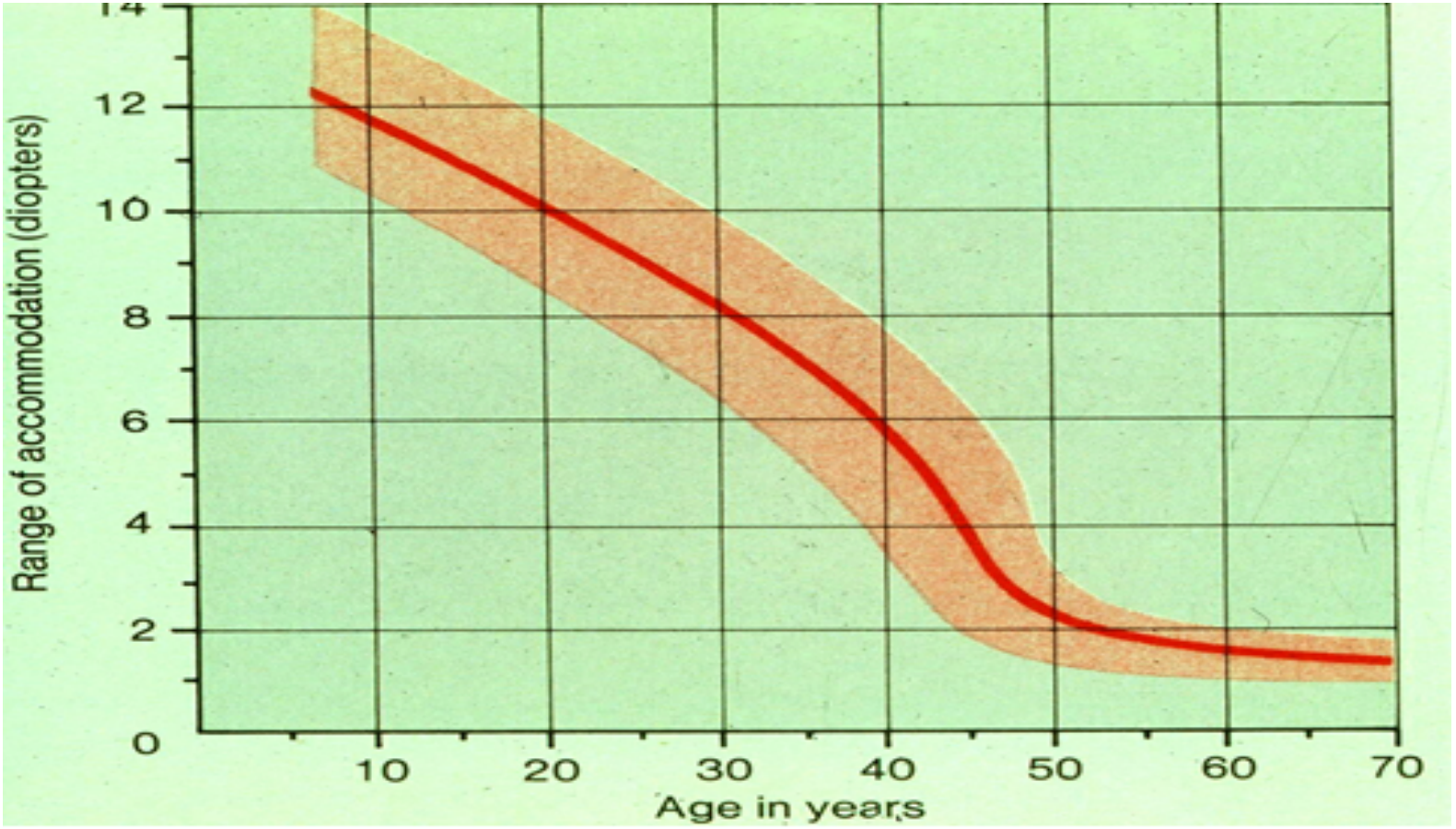
with age, the lens grows larger and thicker and becomes far less elastic

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

Amplitude of Accommodation-2



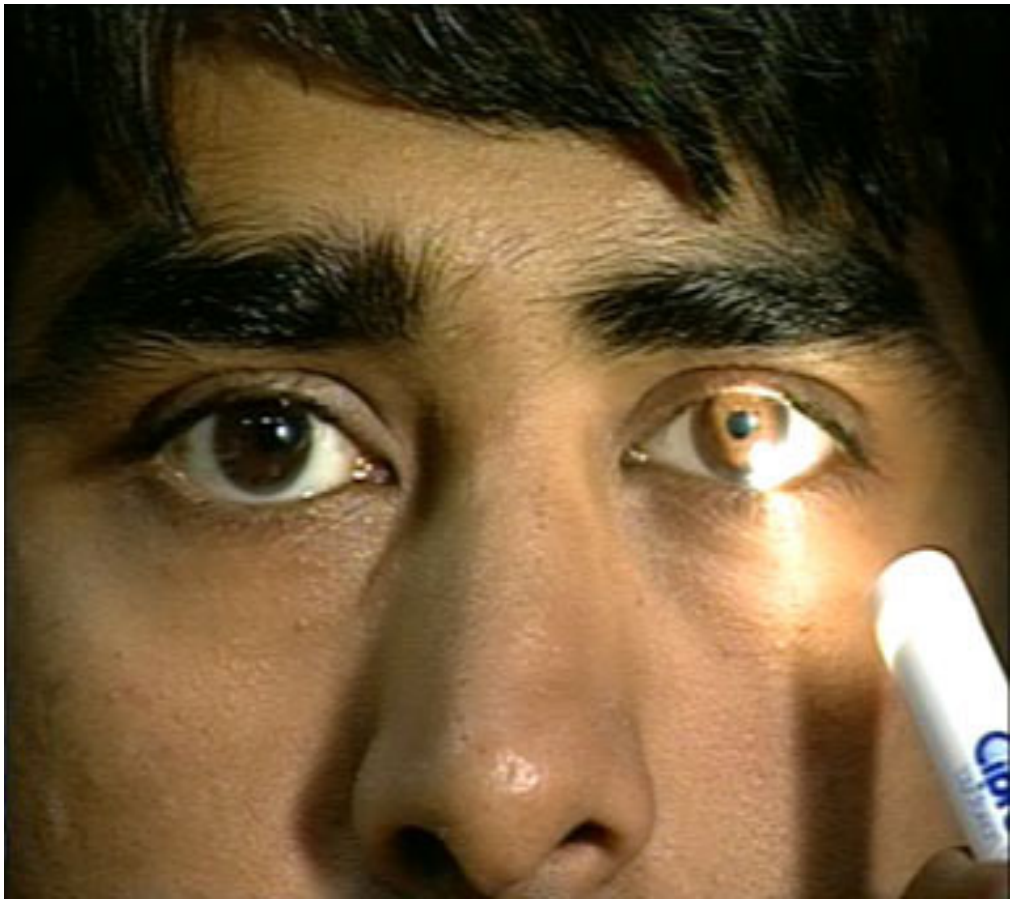
Near point and amplitude of accommodation

Age (yrs)	Near point (cm)	Amplitude of Accommodation
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 light reflex

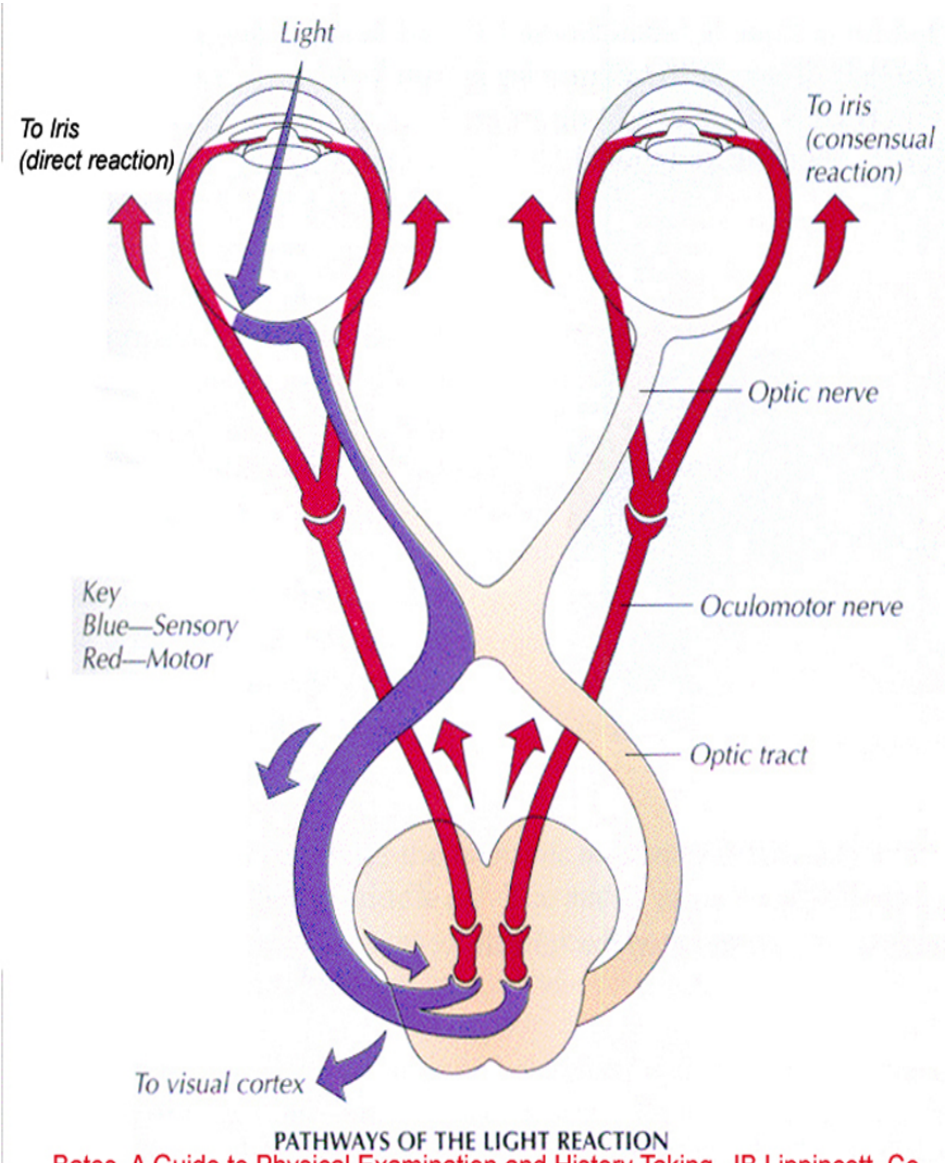
Light Reflex

- 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



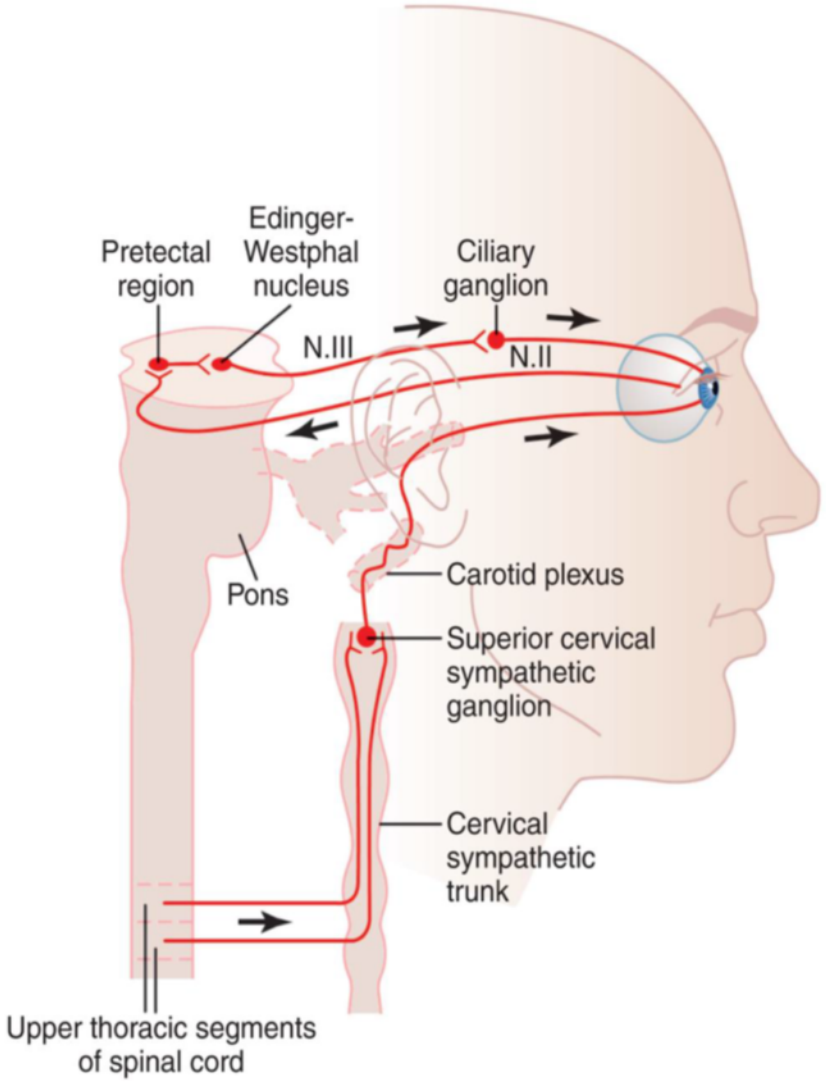
(Quantity of light changes X30 fold)

Direct Reflex on Right Consensual Reflex on Left



PATHWAYS OF THE LIGHT REACTION

Bates, A Guide to Physical Examination and History Taking. JB Lippincott, Co.



Constriction of the pupil

The pupil constricts in response to:

- The accommodation Reflex
- The light reflex

Argyll Robertson pupils (Neurosyphilis)

constrict in response:

to accommodation reflex

but not

to the light reflex

Three Types of Retinal Ganglion Cells and Their Respective Fields

1-W cells:

- 40%with small diameter
- 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 :

- 55% has a medium size diameter
- Transmission of the Visual Image and Color Vision

3-Y Cells :

- 5% only with large diameter
- To Transmit Instantaneous & rapid Changes in the Visual Image , either rapid movement or rapid change in light intensity

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

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

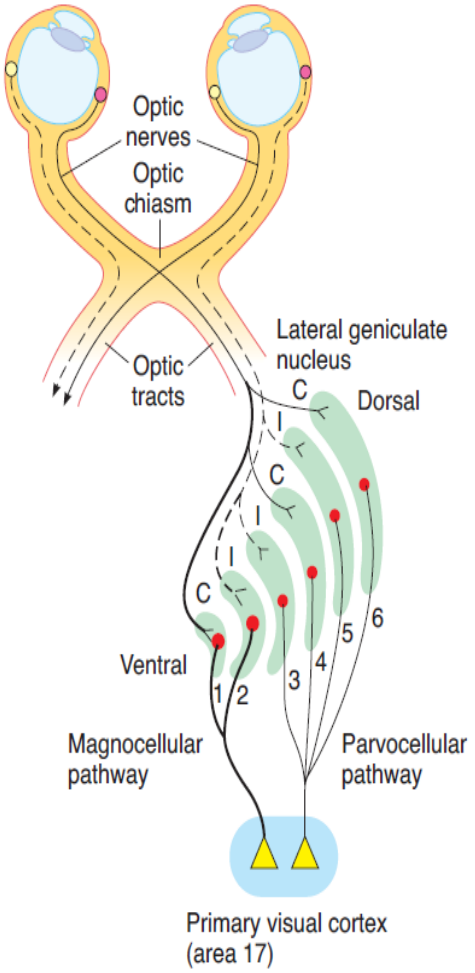
- N.B/- It receives gating control signals from two major sources:
- *Corticofugal fibers returning in a backward direction from the primary visual cortex to the lateral geniculate nucleus*
- (2) *Reticular areas of the mesencephalon. Both of these are inhibitory and, when stimulated, can turn off transmission 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 magnocell,
- It carries signals for detection of movement ,depth, and flicker.
- These receive their input almost entirely from the large type Y retinal ganglion cells.
- This magnocellular system provides a rapidly conducting pathway to

the visual cortex, but, this system is colour blind,



Lateral Geniculate Body; LGB

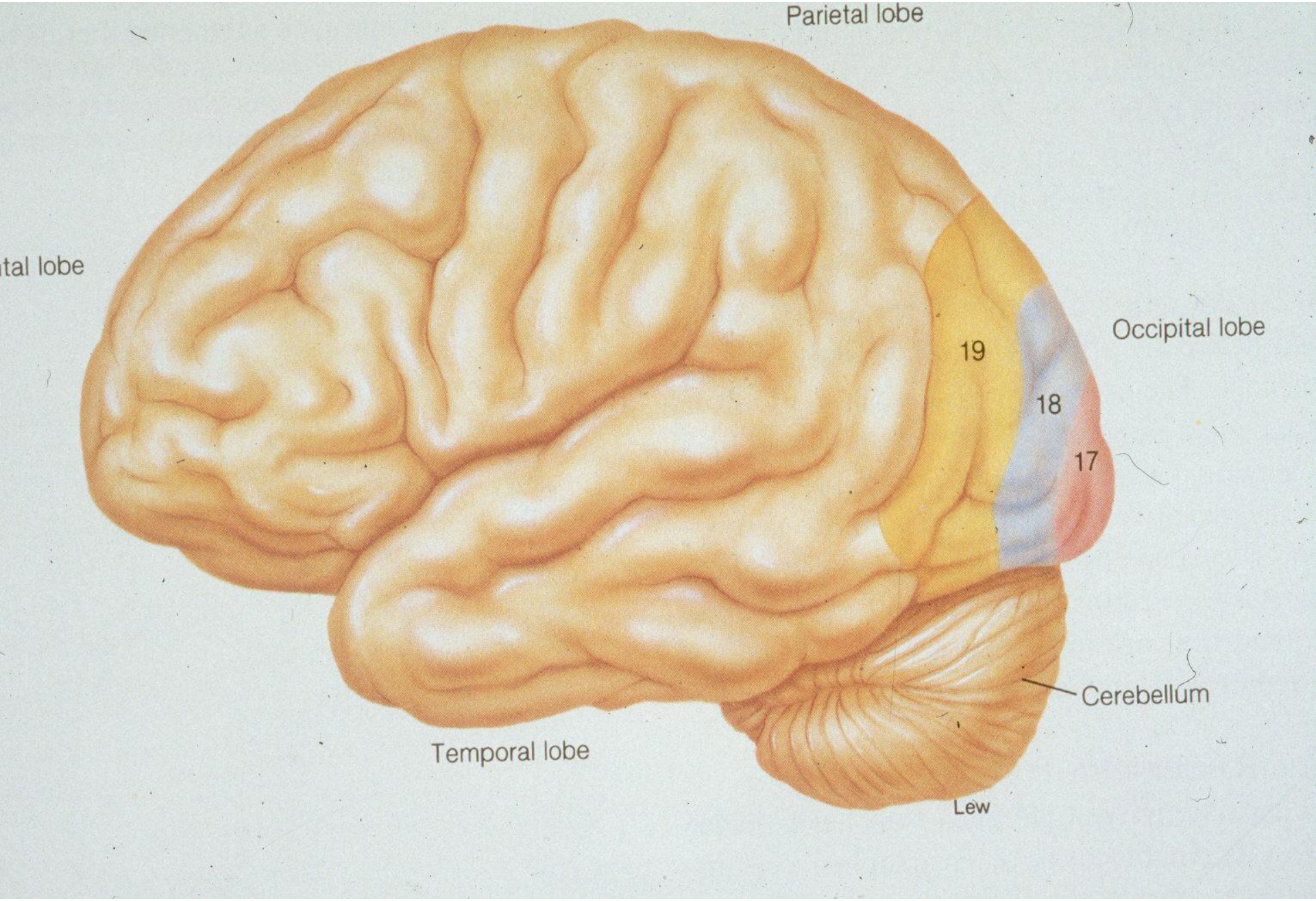
2. The parvocellular pathway:

- from layers 3,4,5,6 which have small cells and are called parvocell, carries signals for color vision, texture, shape, and fine detail

- These neurons receive their input almost entirely from the type X retinal ganglion cells that transmit colour and convey accurate point-to-point spatial information, but at only a moderate velocity of conduction rather than at high velocity.

Cortical Visual areas

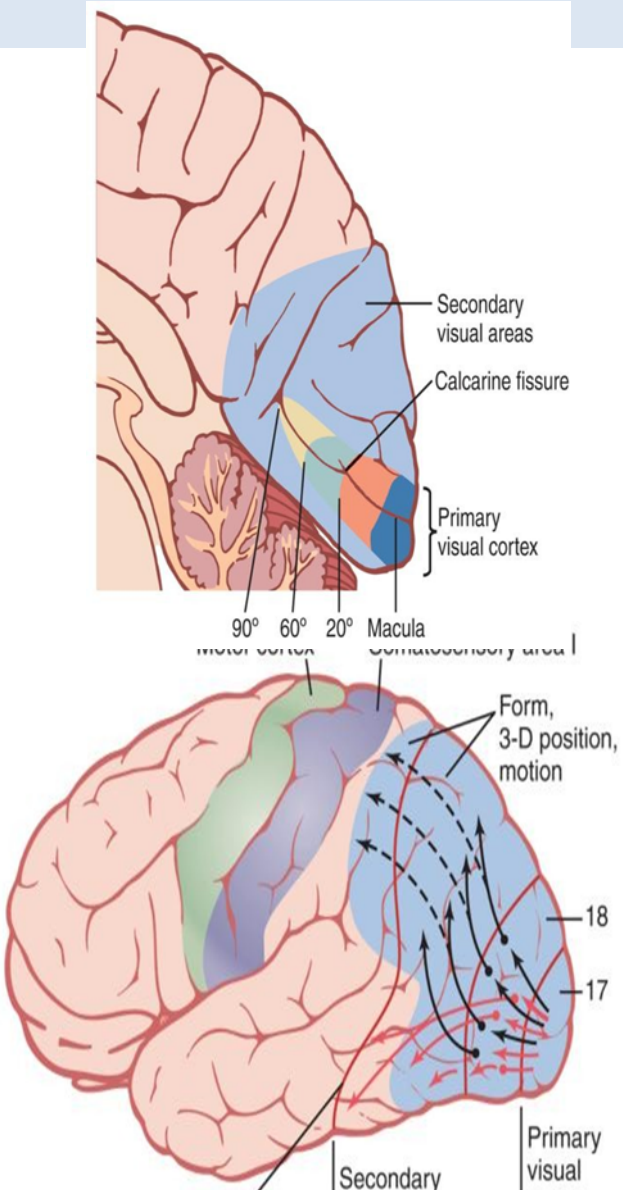
- Primary (area 17)
- Secondary association area, (areas 18, 19)


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

- Perceive sensation of vision (movement + shapes+ stereoscopic vision + brightness) &has blobs for colour detection



Primary Visual area (Area 17)-2

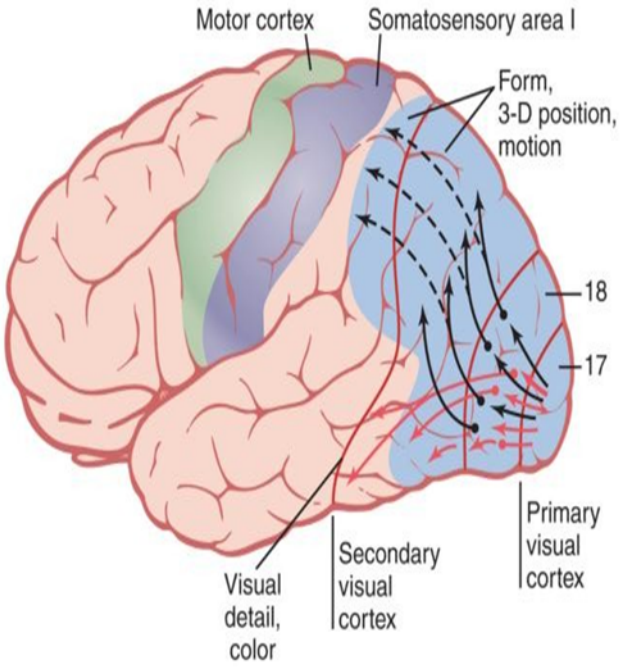
Effect of Removing the Primary Visual Cortex:

- Removal of the primary visual cortex causes loss of conscious vision, (blindness)

- *(but patient react subconsciously to changes in light intensity, to movement in the visual scene.)*
- *-These reactions include turning the eyes, turning the head, and avoidance.*
- *This vision is believed to be sub served by neuronal pathways that pass from the optic tracts mainly into the superior colliculi*

Secondary Visual Processing: Association Areas (18 &19)

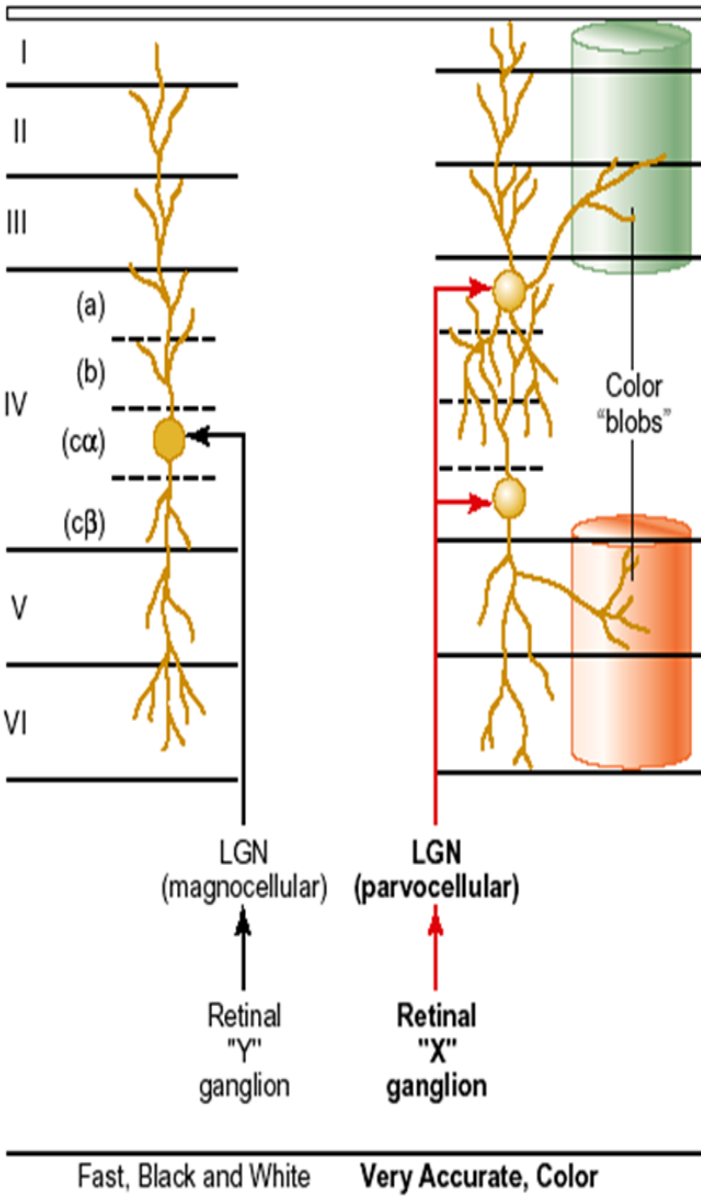
- Located anterior, lateral, inferior and superior to primary visual area
- Interpretation of visual stimuli
- Dealing with complex perception of patterns & forms & responsible for object recognition



- Colour Blobs are in the visual Cortex. Interspersed among the primary visual columns & among the columns of the secondary visual areas
- Column-like areas called colour blobs. clusters of cells responsible for colour detection

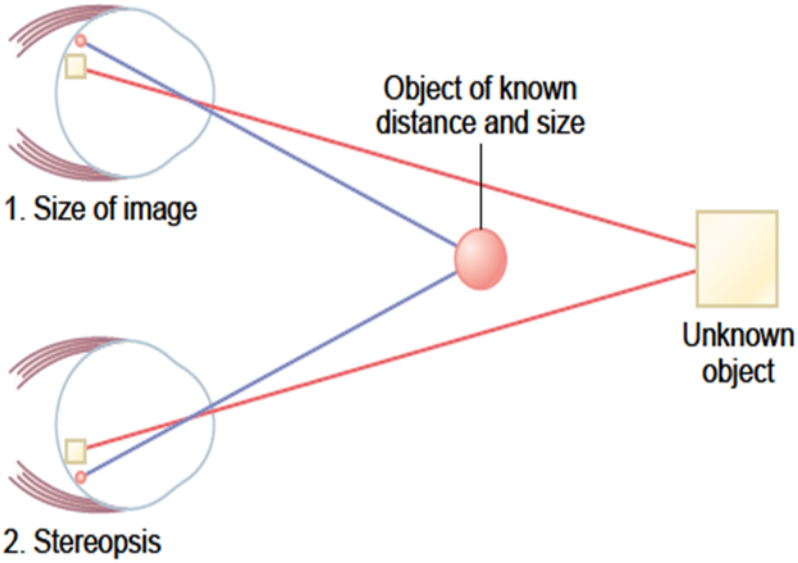
- Two types of cortical neurons:
- Simple cells detect color contrast details, bars of light, lines , borders and edges

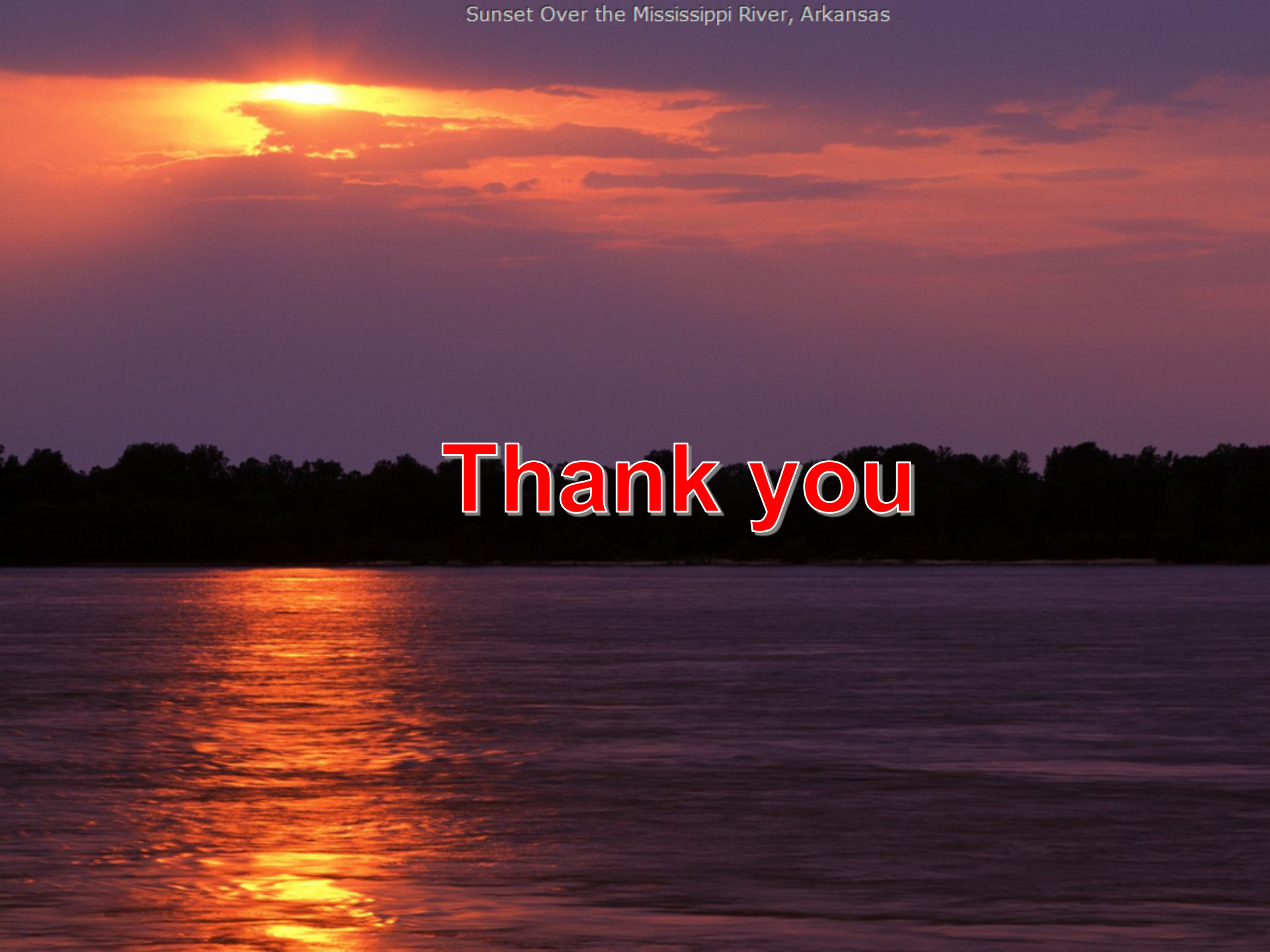
- Complex cells detect line orientation When a line is displaced laterally or vertically in the visual Field (linear movements of a stimulus)



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) Binocular Vision through the phenomenon of stereopsis
- *The perception of depth and 3-dimensional structure obtained on the basis of visual information deriving from two eyes by individuals with normally developed binocular vision*




Sunset Over the Mississippi River, Arkansas
Thank you