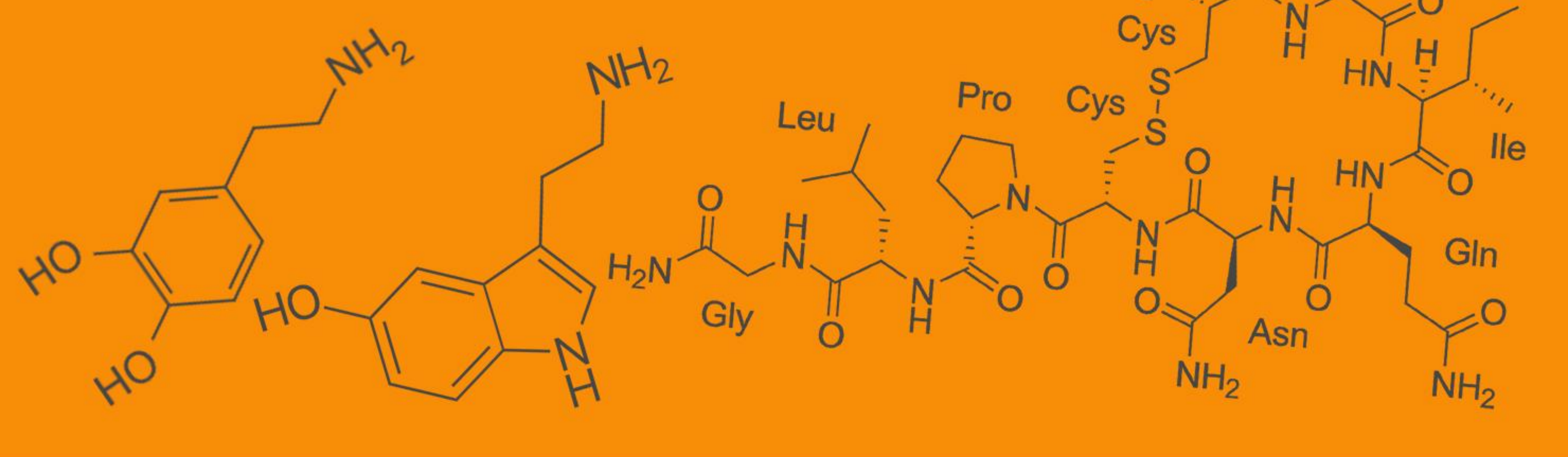


MEDICINE438's

CNS PHYSIOLOGY

LECTURE XII: Vision Accommodation

EDITING FILE   GSLIDES

IMPORTANT | MALE SLIDES | EXTRA | FEMALE SLIDES | LECTURER'S NOTES

OBJECTIVES

- At the end of this lecture ,the student should be able to Describe visual acuity & depth perception
- Contrast photopic and scotopic vision
- To know visual pathway and field of vision
- Describe the process of accommodation reflex and its pathway, contrasting the refraction of light by the lens in near vision and in far vision
- 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

The degree to which the details and contours 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

VISUAL THRESHOLD

- It Is the minimal amount of light that elicit sensation of light
- How to measure visual acuity? By Snellen chart
- Normal acuity = d/D = 6/6
  - Distance of Patient / D distance of normal person
- A person of 6/12 has less vision than normal vision

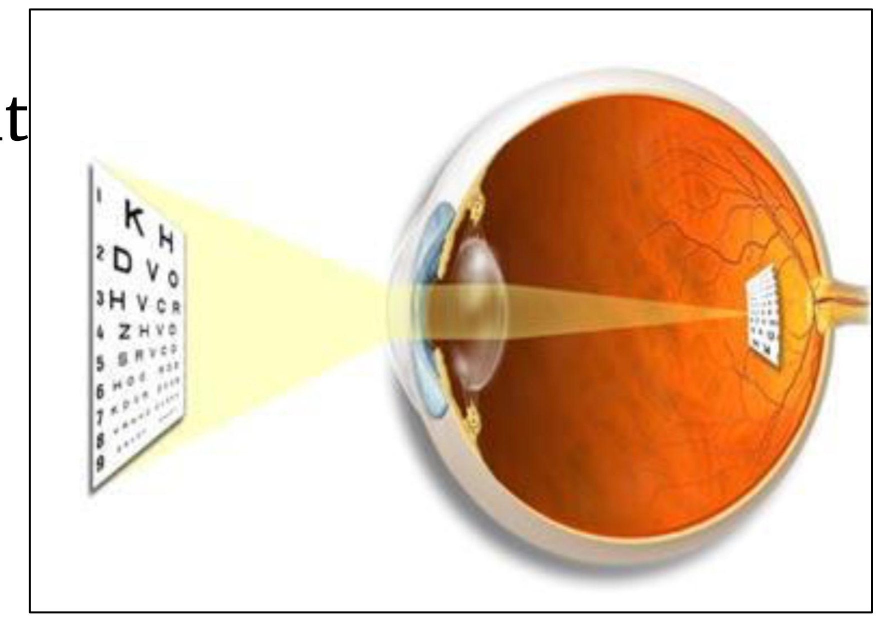


Figure 12-1

DUPLICITY THEORY OF VISION

Two kinds of vision under different conditions

1. **PHOTOPIC VISION (bright light vision)**
   a. Served by **cones**
   b. High visual acuity = colors & details (BOX 12-1)
   c. Low sensitivity to light = needs high visual threshold to be stimulated
2. **SCOTOPIC VISION (night vision, dimlight vision)**
   a. Served by **rodes**
   b. Low visual acuity = no colors or details
   c. Great sensitivity to light = low visual threshold

BOX 12-1: GUYTON AND HALL

Cones are served by Type X retinal ganglionic cells, which have limited dendritic distribution across the retina, therefore each fiber supplies a limited amount of cones. Note that cones tend to be more slender in the fovea and thicker in the peripheral parts of the retina, this helps the fovea in visual acuity, retinal X ganglionic cells allow accurate point-to-point spatial information to be carried from the cones into the primary visual cortex, allowing details of objects to be perceived more clearly.

Visual pathway

Pathway from retina to the visual centers in brain.

- **Photoreceptors:** Rods & 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 (blind spot, because it has no photoreceptors)
- Passing through the blind Spot they leave the eye, constituting the Optic Nerve.

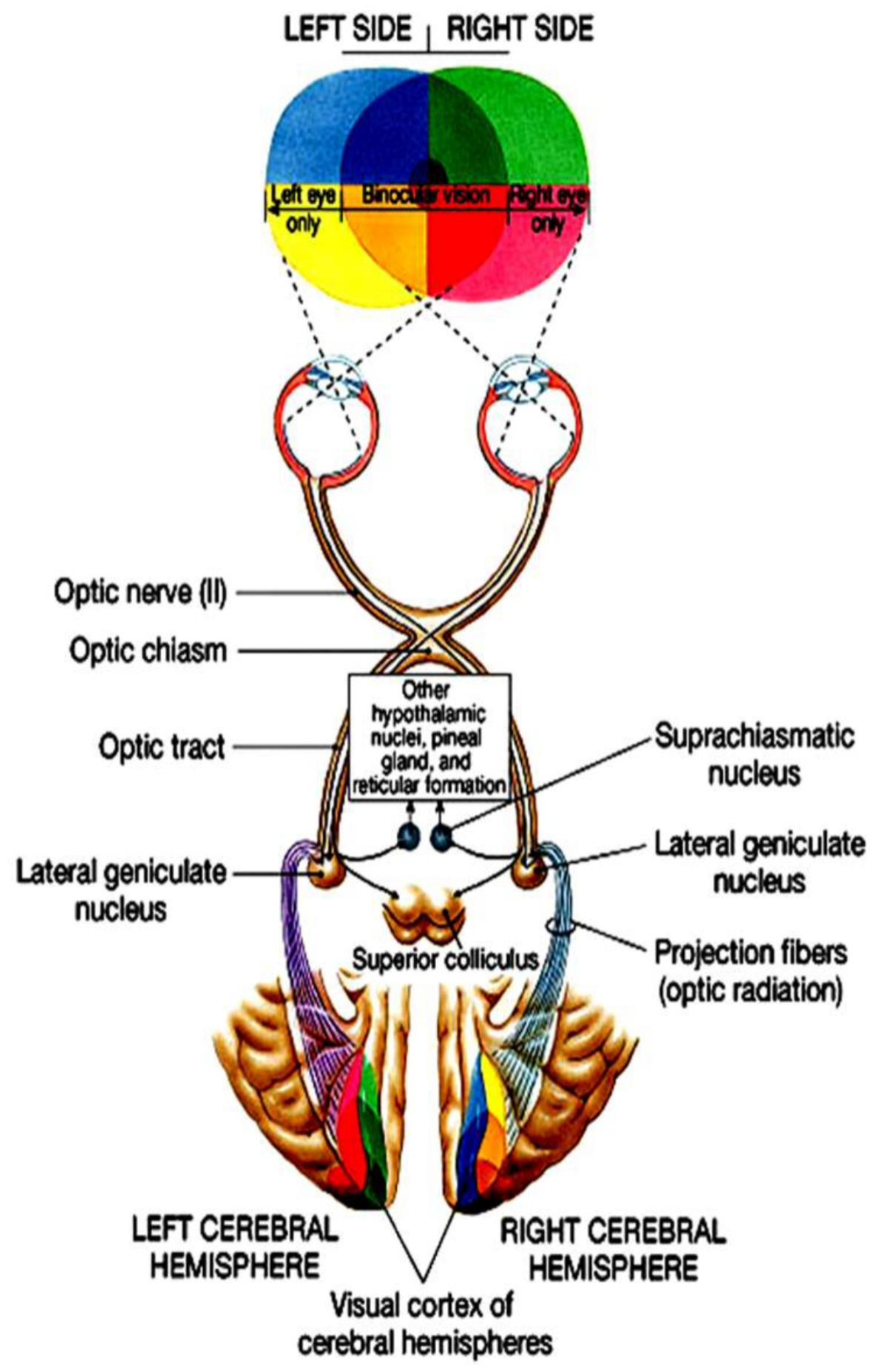


Figure 12-2

Visual pathway :

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

Optic tract send impulses → Lateral geniculate in thalamus → Its axons form geniculocalcarine tract that send to optic radiation → Visual cortex in occipital cortex (Broadmann area 17)

- Optic nerve fibers from the medial (nasal) side of retinae decussate in the Optic Chiasma
    - Therefore an **Optic Chiasm lesion** (e.g, Pituitary Tumor) will cause vision loss from the both lateral halves of the Field of Vision (bitemporal hemianopia) - because it compresses the chiasm -
- Optic nerve fibers from the **lateral (temporal) parts** of the retinae **do not decussate** . Therefore, **each optic tract carries** fibers from :
    - **<u>temporal</u> fibers** of the **<u>ipsilateral</u>** <u>retina</u> (nasal field of vision of ipsilateral retina)
        - temporal fibers (lateral) do not cross
        - conveys nasal field (inner)of vision
    - **<u>nasal</u> fibers** of the **<u>contralateral</u>** <u>retina</u> (temporal field of of vision of the contralateral retina)
        - nasal fibers (medial) cross to opposite side at optic chiasma
        - conveys temporal field (outer)of vision

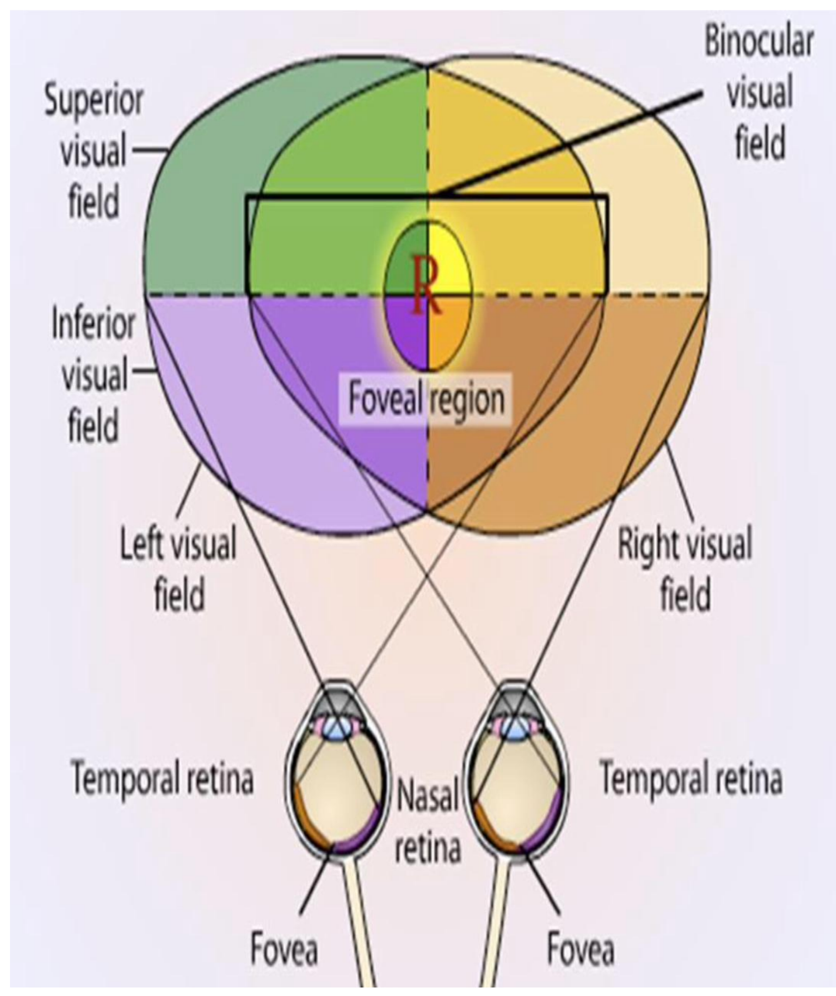


Figure 12-3

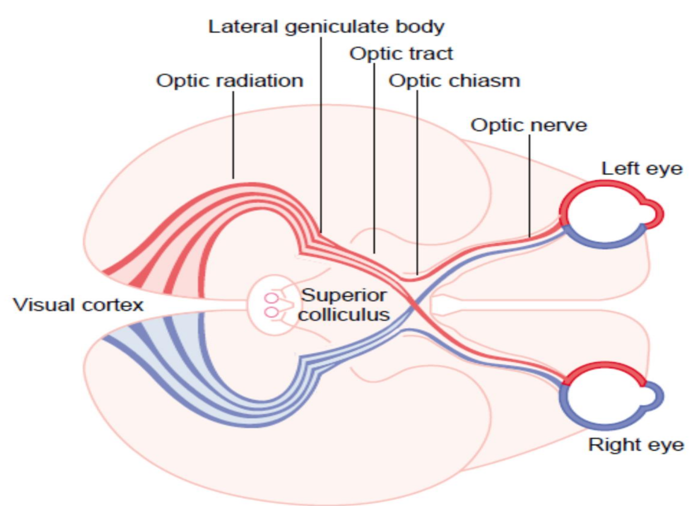
Therefore , a lesion in optic tract will cause loss of vision from the ipsilateral nasal field of vision & contralateral temporal field of vision

OPTIC TRACT :

- The **left** optic tract corresponds to the **right ½** of the visual field .
- The **right** optic tract corresponds to the **left ½** of the visual field .

VISUAL PATHWAY

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)(BOX 12-1)
3. Some axons from lateral geniculate body in thalamus **to superior colliculus in midbrain** for accomodation reflex & its miosis component.



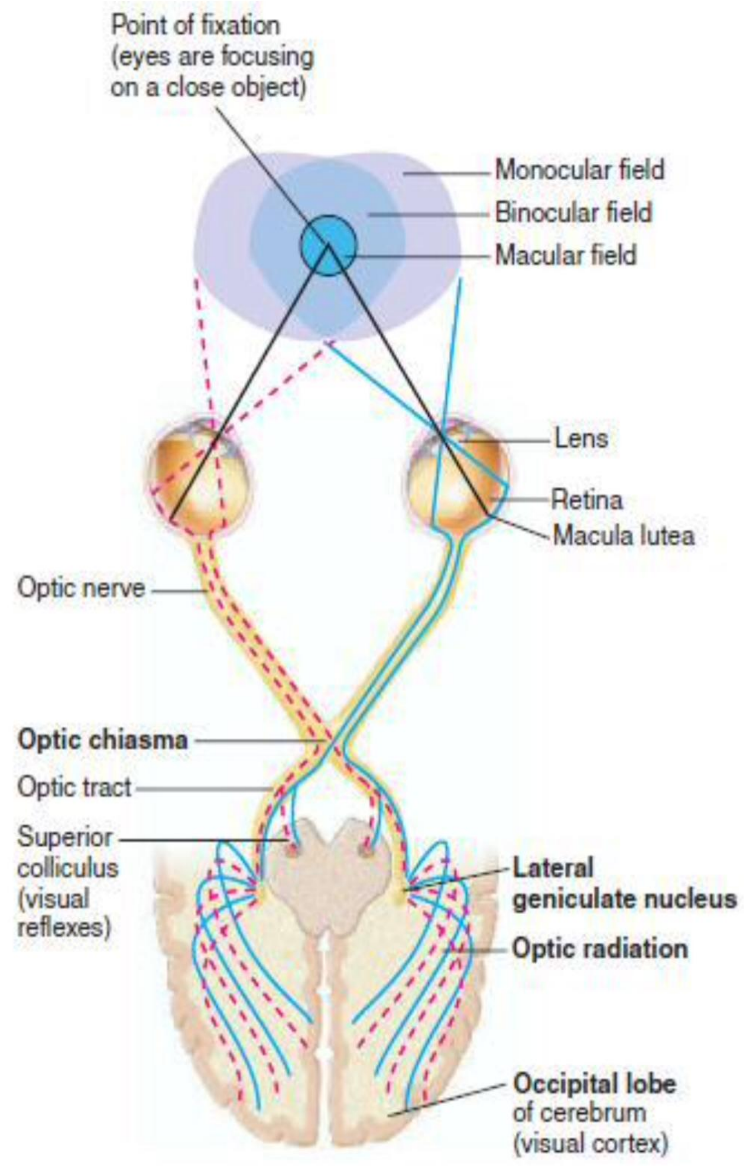


Figure 12-4

BOX 12-2: GANONG'S REVIEW OF MEDICAL PHYSIOLOGY

It communicates with suprachiasmatic nucleus of hypothalamus, from its name, this nucleus communicates with the pineal gland in a pathway that regulates melatonin (sleep hormone) secretion. Thus helpling in light-dark cycles, since melatonin is secreted in low levels of light.

Near response happens as a result of :

1. Lens change
2. Change in the pupil
3. Convergence of the eyes

Accomodation (focusing)

It Is an active process for modification of the refractive power of the eye to view a nearby object **by increasing the curvature of lens**

Accomodation (focusing)

- Ciliary muscle has two separate sets of smooth muscle fibers
  - longitudinal fibers
  - circular fibers.
- Contraction of either set in the ciliary muscle relaxes the ligaments to the lens capsule & the **lens assumes a more spherical shape**, because of the natural elasticity of the lens capsule & **increase its refractive power.**
- The ciliary muscle of accommodation is **Controlled by Parasympathetic Nerves** transmitted to the eye through **Oculomotor** nerve.

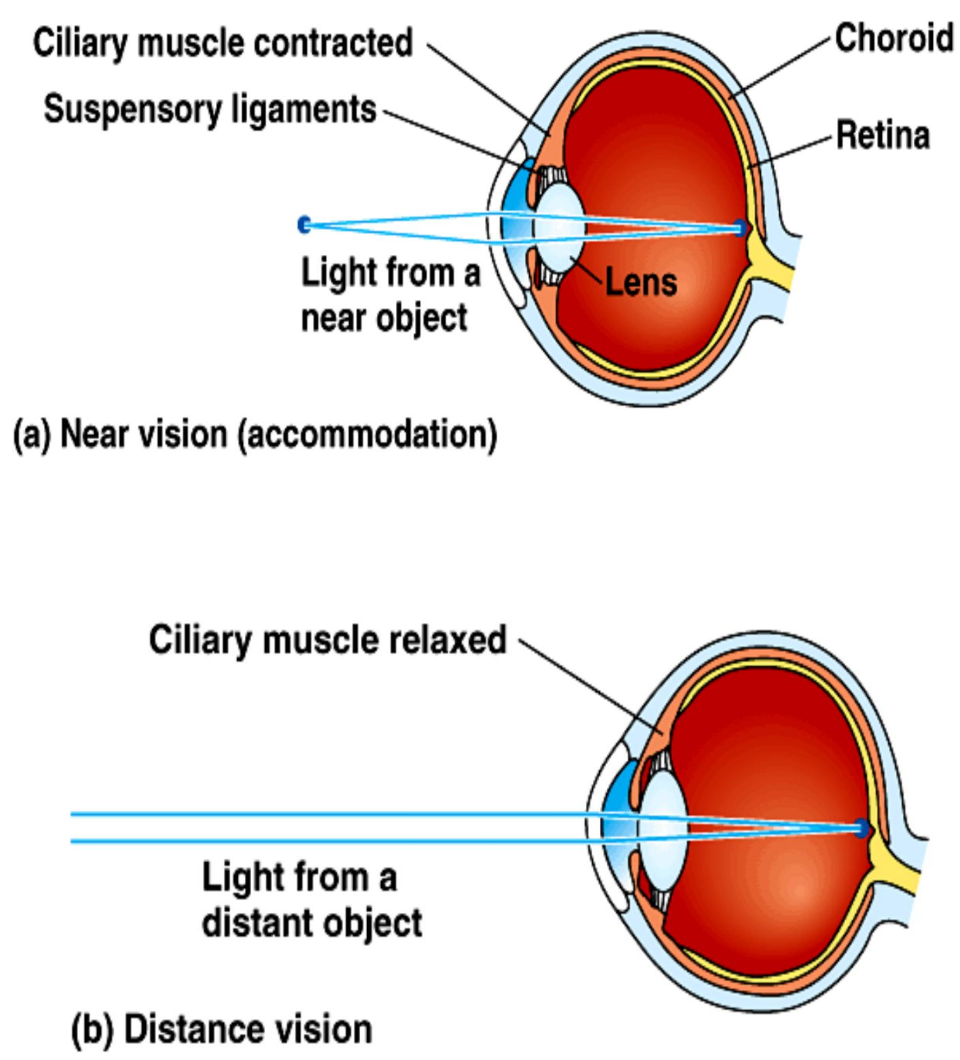


Figure 12-5

Accomodation mechanism

Ciliary muscle contraction → Relaxation of the suspensory ligament → Lens more convex → Increase diopteric power of the lens → Near object focused on the retina

Continued

1. The lens is flattened for distant objects.
2. The lens is rounded for near objects.

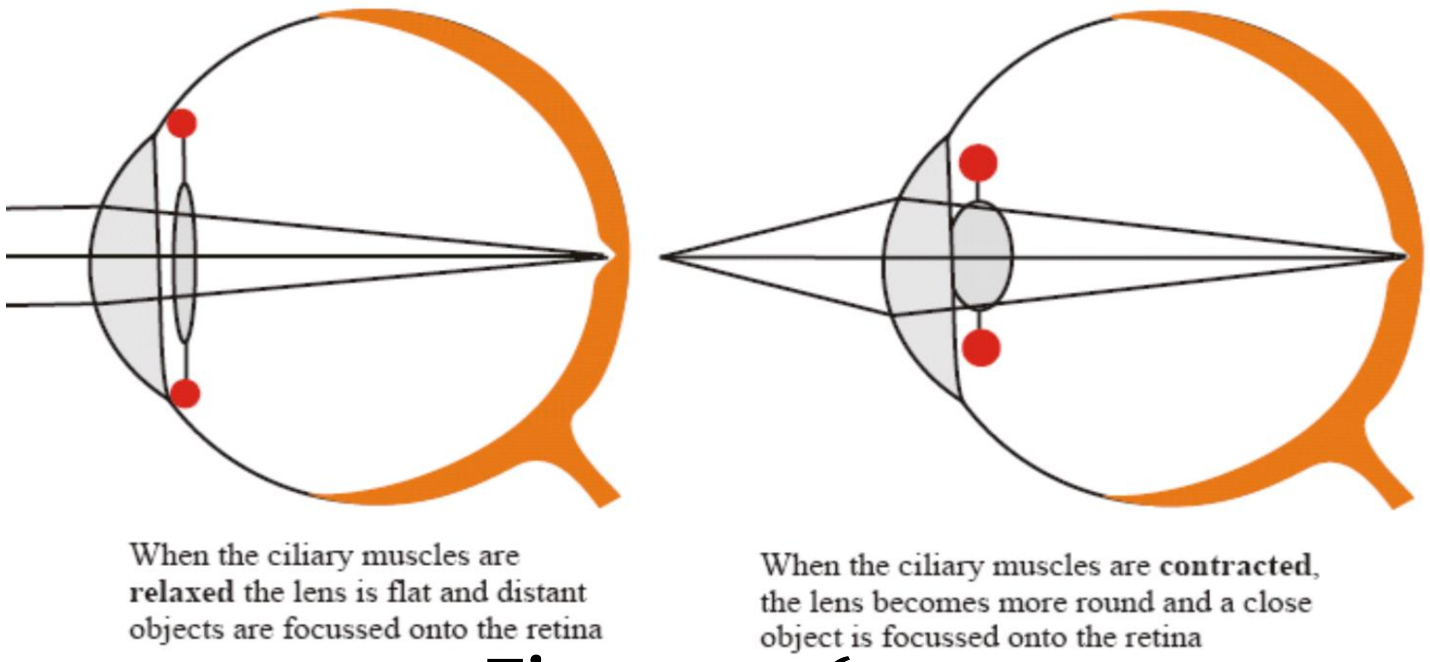
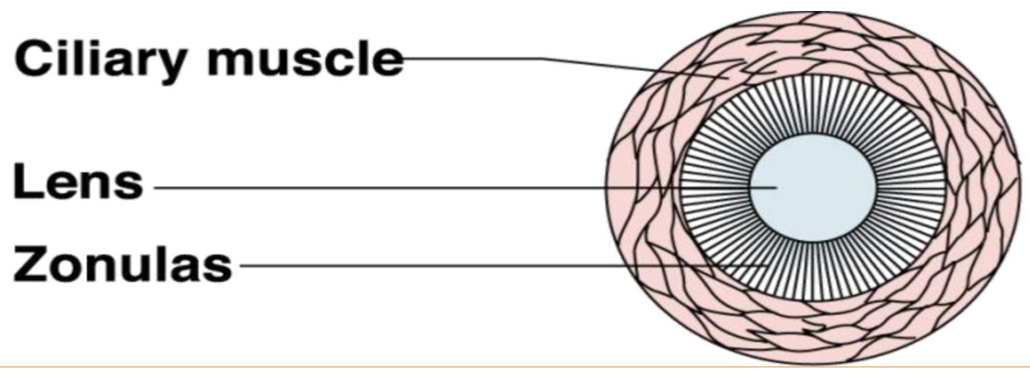


Figure 12-6

At rest (looking at far objects):-
- Ciliary muscles are relaxed
- taut (tense) ligaments
- flat lens

looking at near objects:
from near (close) objects, parallel rays focus behind retina (if ciliary muscles remain relaxed) —> **blurred vision**
- Solution: **increase curvature & refractive power of lens** by **<u>accomodation</u>** to bring focus on retina.

Diopteric power if the eye :
- Cornea = 40-45 D
- Lens = 15-20
- With Accomodation = +12 D



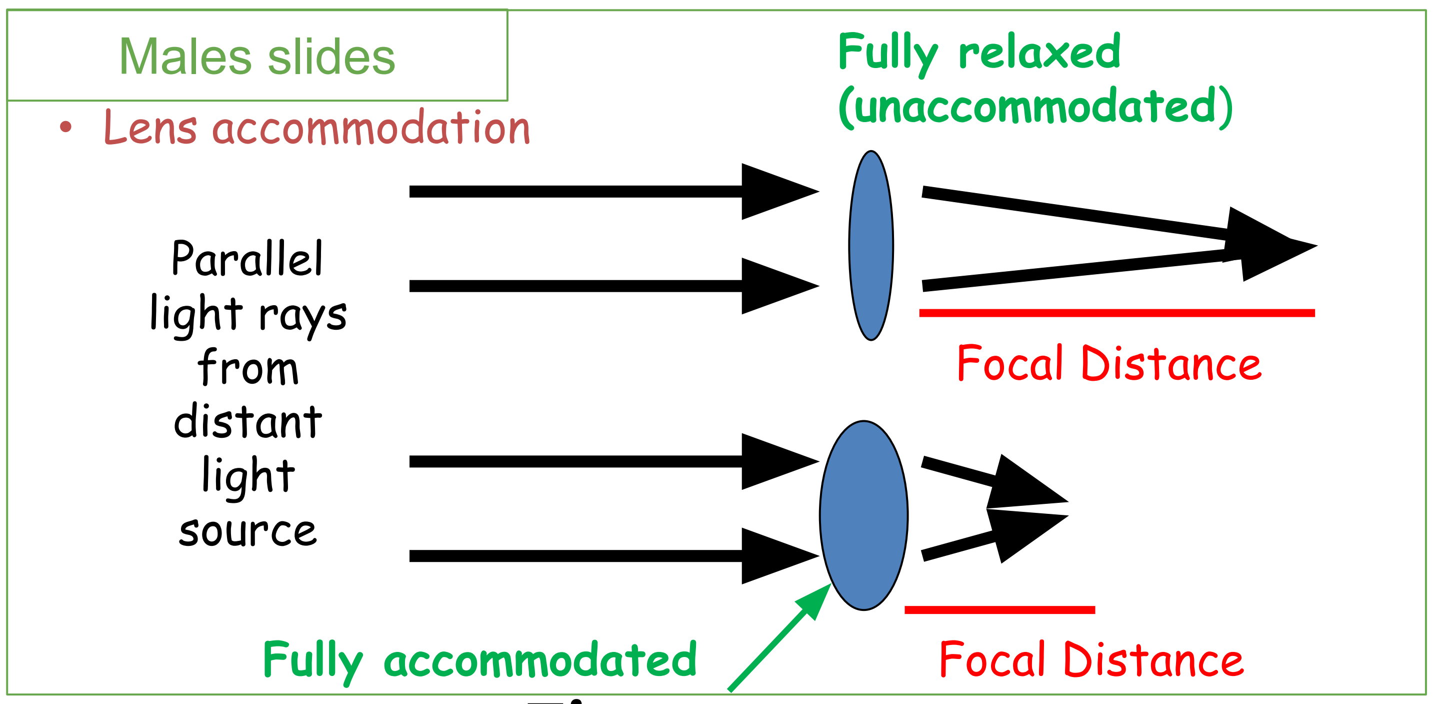


Figure 12-7

Accommodation Reflex

- Focusing at near object (increased anterior surface curvature of lens by ciliary muscles contraction —> slack = relaxed ligaments & increased anterior surface curvature of lens)
- **Add 12D to refractive power of lens.**
- Both circular & longitudinal ciliary muscles contract to pull ciliary muscle forwards & inwards —> ciliary muscles edges come close to each other to increase anterior surface curvature of lens.
- **Tested by :** sanson purkinje image

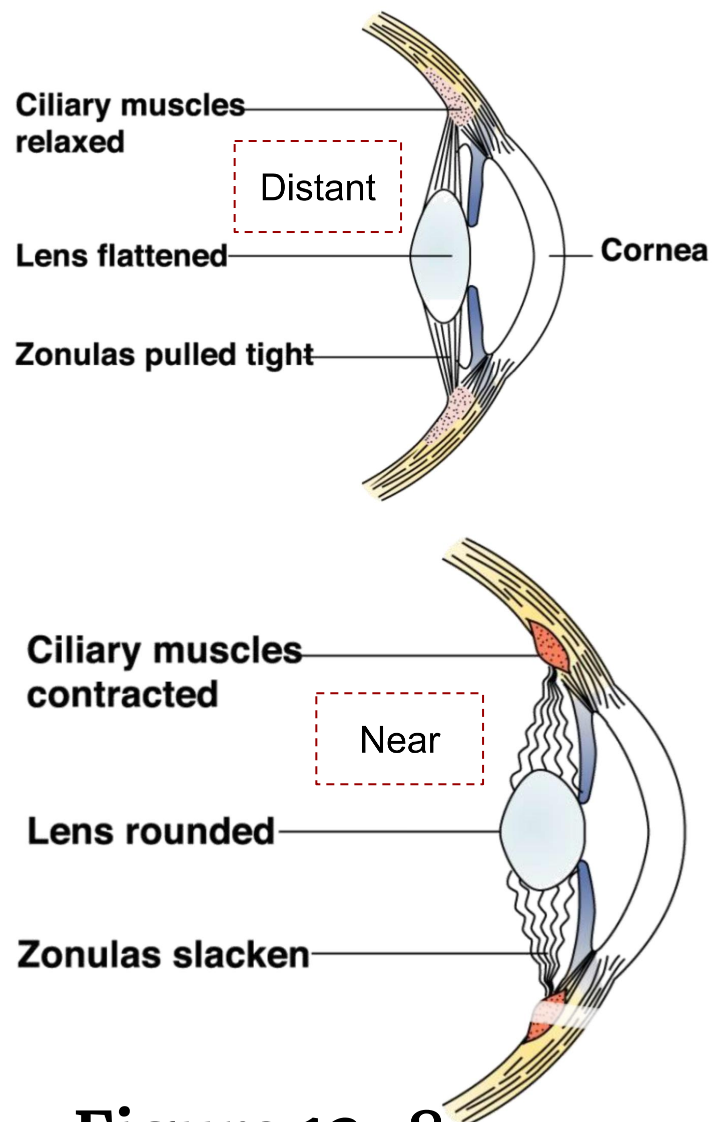


Figure 12-8

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**

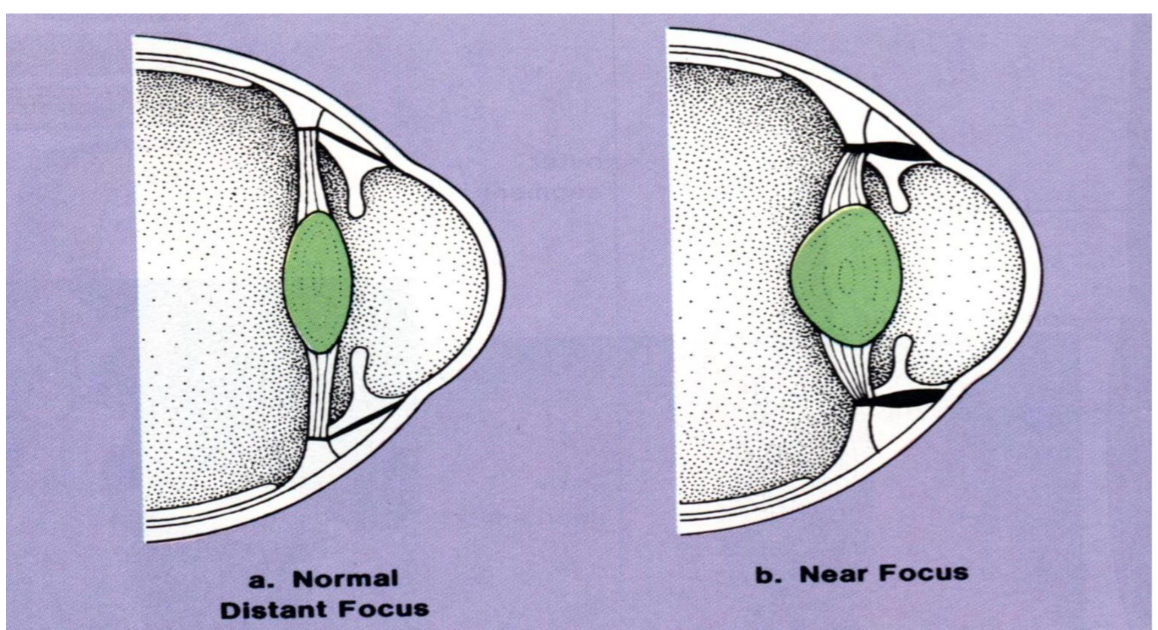


Figure 12-9

LOOKING AT A CLOSE OBJECT (NEAR RESPONSE)

A. Convergence of both visual axis.
B. Pupil constriction.
C. Accommodation.

NEAR POINT

Nearest point to eye at which object can brought into focus on retina by accommodation.

- 10 years = 9 cm
- At 60 years = 80-100 cm, due to hardness of lens & loss of accommodation.

Presbyopia (Triade):-

1. Loss of accommodation & focus behind retina.
2. Loss of lens elasticity.
3. Near point recede.

- Correction by biconvex lens

- 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

Amplitude of Accommodation

The additional diopters added by increasing the convexity of the lens

Age (yrs)	Near point (cm) Increases w/ age	Amplitude of accommodation Decreases w/ age
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

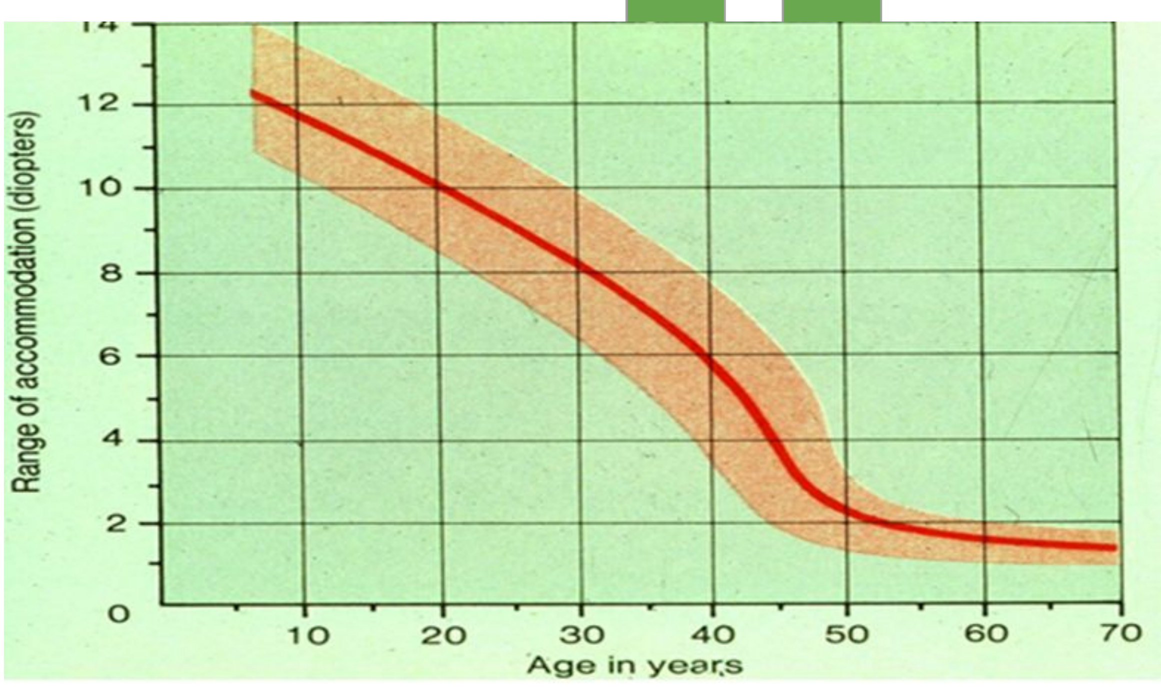


Figure 12-10

Pathway of Accommodation

Afferent

Light on eye → Retina → Optic nerve → Optic chiasma → Optic tract

Efferent

Optic tract → Lateral geniculate body in thalamus to **superior colliculus in midbrain** → Oculomotor nucleus (parasympathetic) → Ciliary ganglion to oculomotor nerve → Bilateral ciliary muscle contraction (accommodation. R) and contraction of iris muscles for miosis of near response

Pupillary light reflex

Light fall on one eye pupil → constriction of this pupil **(direct pupillary reflex)** and the other pupil (**indirect or consensual**).

Pathway of consensual Pupillary light reflex

Afferent

Light on eye → Retina → Optic nerve → Optic chiasma → Optic tract

Efferent

Optic tract → **Pass through superior colliculus to end in pretectal nucleus** → Both oculomotor nerve nuclei (EWN) → Both ciliary ganglia → Supply both eyes by oculomotor nerves → (Short ciliary nerve to constrictor pupillae) → Miosis in both eyes

- Conversely, in darkness, the reflex becomes inhibited, which results in dilation of the pupil.

The pupil constricts in response to:

- The accommodation Reflex
- The light reflex

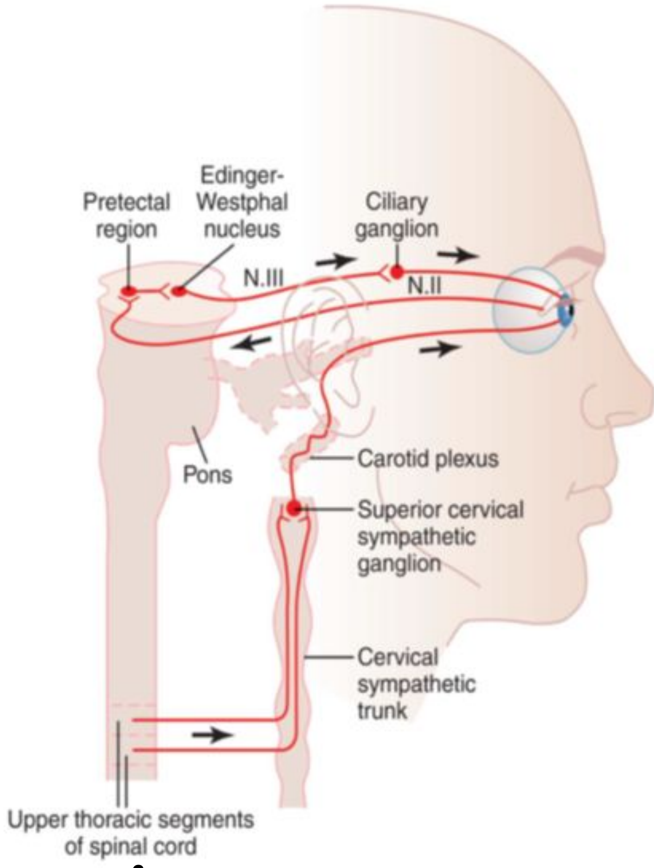


Figure 12-11

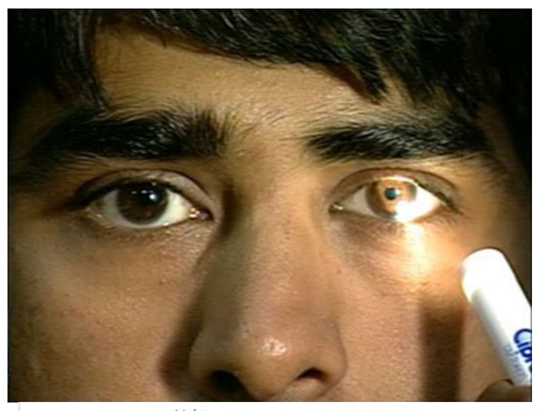
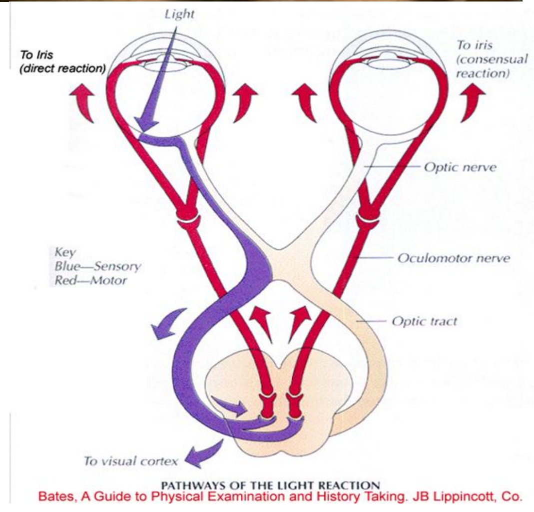



Figure 12-12

Argyll Robertson Pupil (Neurosyphilis)

- **Pupils constrict in response: to accomodation reflex, but not to the light reflex**
- In syphilis tabes dorsalis which destroy pretectal nucleus only, away from superior colliculus & fibers of accomodation.
- light reflex is lost but accomodation reflex remains.

THREE TYPES OF RETINAL GANGLION CELLS AND THEIR RESPECTIVE FIELDS (BOX 12-3)

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.

Lateral geniculate body LGB

- left LGB (similar to left optic tract) has all layers receive from RIGHT ½ of visual field.
- Right LGB (similar to right optic tract) has all layers receive from LEFT ½ of visual field.
- **LGB has 6 layers.**

Function of LGB:-

1. acts as a **relay station** for visual information from optic tract to cortex.
2. It has point to point transmission with high degree of fidelity spatial
3. Acts as a gate which controls signal transmission to visual cortex i.e control how much signals reach visual cortex
4. color vision & detect shapes & texture
5. 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
   - 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

BOX 12-3: GUYTON AND HAL

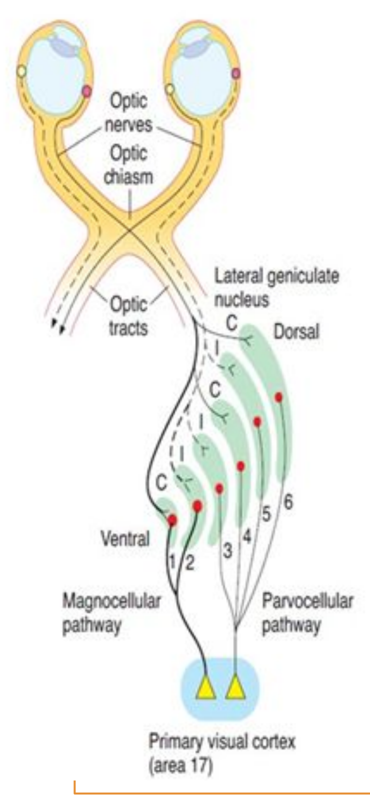
Retinal Ganglion Cells

- W Cells: These cells have wide dendritic distribution along the retina, thus they are efficient in detecting the shift of focus in the visual field.
- X Cells: Their dendritic fields do not distribute widely within the retina, therefore they transmit signals from discrete, small areas of the retina. Consequently, it is mainly through X Cells that details regarding visual acuity and color are transmitted. Each X Cell receive input from at least one cone, therefore it is most probably responsible for transmitting all color vision.
- Y Cells: Much like W cells these cells have wide dendritic distribution along the retina, Y and W cells make synaptic connections with the superior colliculus and mediate their functions through transmitting information about rapid changes in the visual field.
-

LGB pathways to visual cortex

1-The magnocellular pathway

- From layers **1 and 2** which have large cells and are called **magnocellular**, carries signals for detection of: **movement, depth, and flicker.**
- These receive their input almost entirely from the large type Y retinal ganglion cells.
- A rapidly conducting pathway to the visual cortex.
- This system is color blind, transmitting only black- and-white information.



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.
- Moderate velocity of conduction.
- These neurons receive their input almost entirely from the type X retinal ganglion cells

Figure 12-13

Cortical Visual Areas

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

Visual Cortex

- On medial aspect of each occipital lobe
- The **Primary Visual Cortex** Has **Six** Major Layers of cells arranged vertically each act as a separate unit for processing of informations.
- The fovea is responsible for the highest degree of visual acuity, so it has larger representation in the primary visual cortex than the most peripheral portions of the retina.
- Signals from the **retinal fovea** transmits its signals **terminate near the occipital pole**, whereas signals from the more peripheral retina terminate in concentric half circles anterior to the pole on the medial occipital lobe.
- The upper portion of the retina is represented superiorly and the lower portion inferiorly

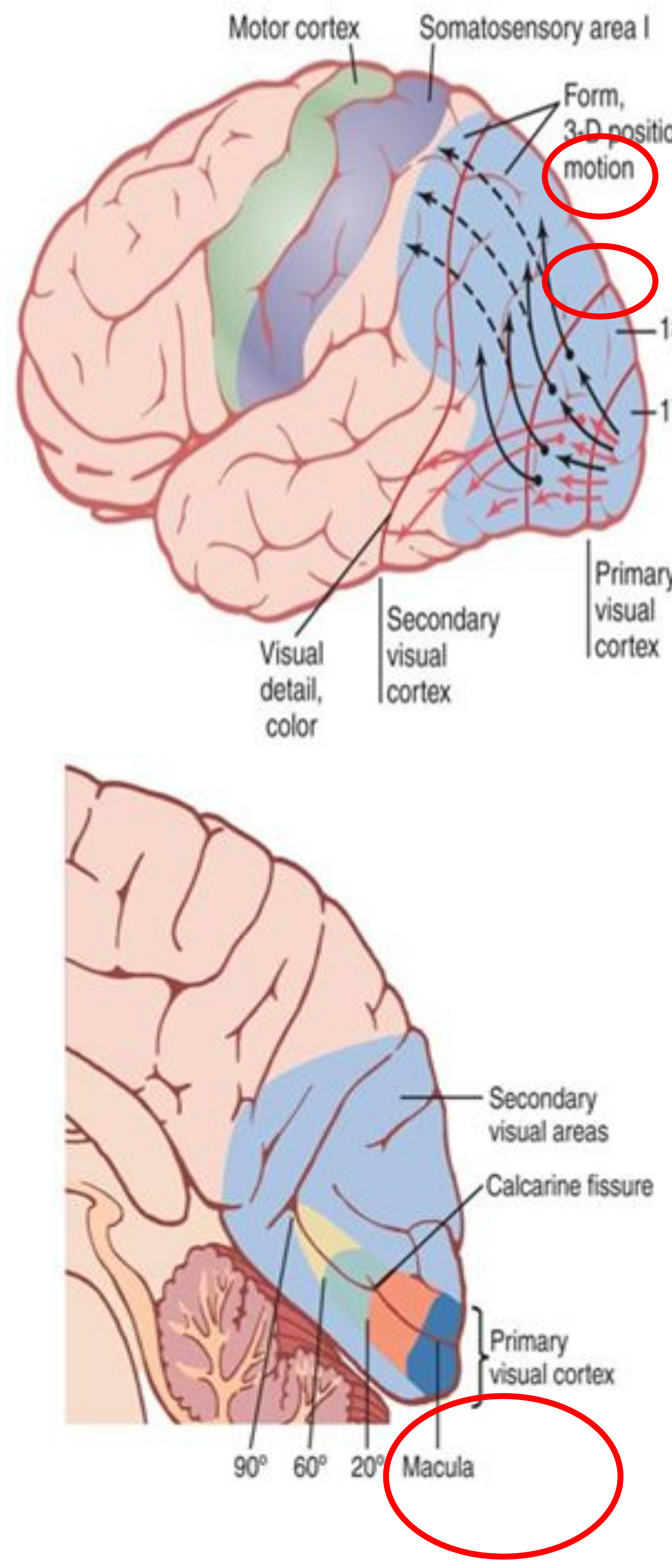


Figure 12-14

1. Primary visual cortex (braodmann area 17):-

- Perceive sensation of vision (movement + shapes + stereoscopic vision + brightness) and has blobs for color detection
- Perception of visible objects without knowing the meaning of these objects.
- 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 subserved by neuronal pathways that pass from the optic tracts mainly into the superior colliculi.

2. Association visual cortex (area 18&19) (secondary visual areas):-

located mainly anterior to the primary visual cortex extend to parietal & temporal lobes function:-

1. **interpretation of visual stimuli**
2. dealing with complex perception of patterns & forms & responsible for object recognition
3. the fixation mechanism that causes the eyes to "lock" on the object of attention is controlled by secondary visual center.
4. When this fixation area is destroyed bilaterally , causes difficulty keeping its eyes directed toward a given fixation point.

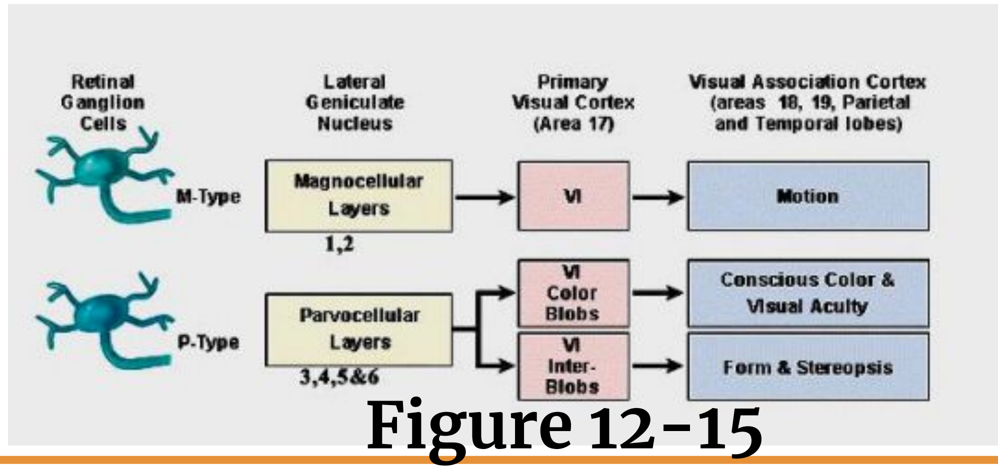


Figure 12-15

Visual Projections to Area 17

1. **Color Blobs** are in the Visual Cortex. Interspersed among the primary visual columns & among the columns of the secondary visual areas. Clusters of cells responsible for **color detection.**
2. **Simple cells** detect color contrast details, bars of **light, lines , borders and edges**
3. **Complex cells** detect Line Orientation When a Line Is Displaced Laterally or Vertically in the Visual Field (**linear movements of a stimulus**)

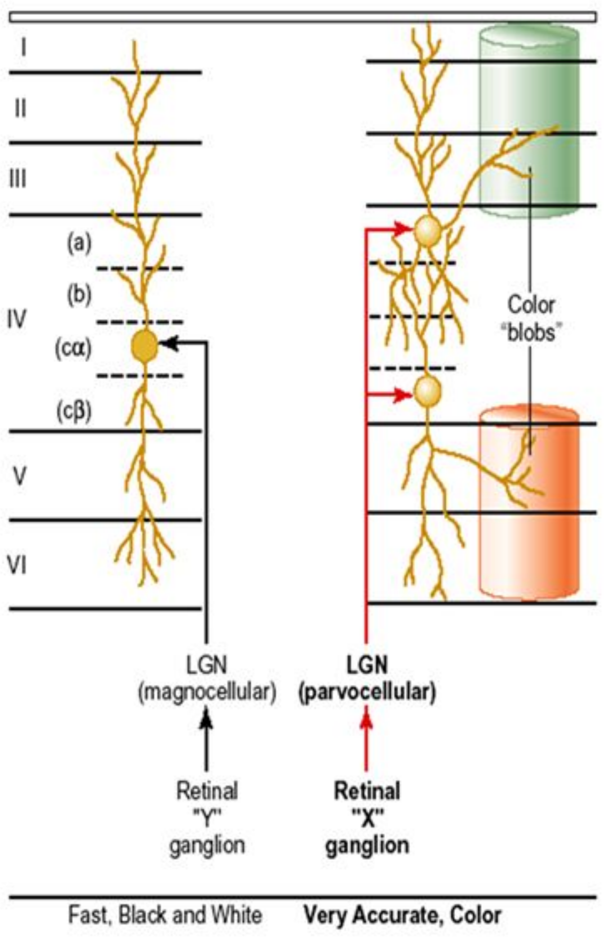


Figure 12-16

Macular sparing = loss of peripheral vision with intact macular vision because the macular representation is separate from that of the peripheral fields and is very large relative to that of the peripheral fields.

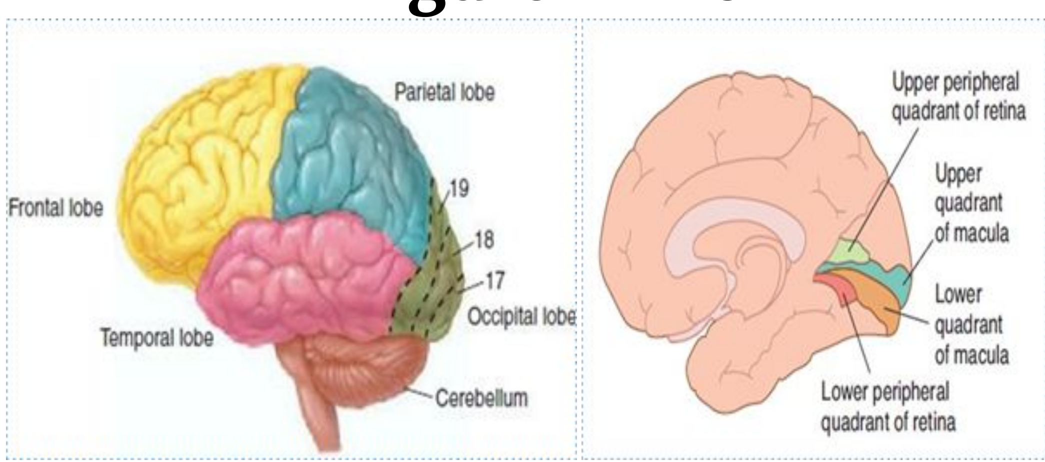


Figure 12-17

Determination of Distance of an Object from the Eye—“Depth Perception” (BOX 12-4)

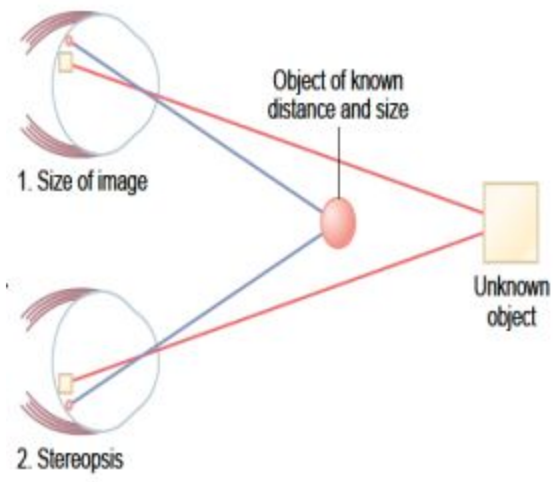


Figure 12-18

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

BOX 12-4: GUYTON AND HAL

- The retina can distinguish the distance of objects if the object’s size is known by the brain, since the size of the object is known, and the image size on the retina is known, the brain computes this set of information to calculate the relative distance of the object.
- Binocular vision can also help detect depth and relative distance of objects, that is, each eye sees objects at a slightly different angle, this causes each eye to see different aspects of a certain object. This gives the perception of three dimensions and depth. This can be demonstrated by closing one eye or the other alternatively and observing how the object will appear slightly different.

Summary

Duplicity theory of vision:

1. Photopic (by cones)
   - High acuity & see color & details
   - Low sensitivity to light
2. Scotopic(by rodes)
   - Low acuity
   - High sensitivity to light

Visual pathway :

1. Optic nerve
2. Optic chiasm
3. Optic tract
   - **left** optic tract = **right** ½ of visual field
   - **right** optic tract = **left** ½ of visual field
4. Lateral geniculate body (nucleus)
5. Optic radiation
6. Visual cortex

Accommodation mechanism:

Ciliary muscle contract & the suspensory ligaments relax making the lens more convex which increase the dioptric power +12D —> near objects focused ion retina

Tested by : sanson purkinje image , in short :

- Ciliary Muscle Contracts
- Reduced Tension on Suspensory Ligaments
- Lens becomes Round

Focus on **Near Objects**

Distant Vision:

- Ciliary Muscle Relaxed
- Suspensory Ligaments Under Tension
- Lens is Flattened

Focus on **Distant Objects**

retinal ganglion cells	W cell	sensitive or detecting directional movement in the field of vision, and they are probably important for much of our rod vision under dark
	X Cells	Transmission of the Visual Image and Color Vision •
	Y Cells	to Transmit Instantaneous & rapid Changes in the Visual Image , either rapid movement or rapid change in light intensity
Lateral geniculate body	Parvocellular (P) cells	cells which project to parvocellular layer of LGB, color vision, texture, shape, and fine detail.
	Magnocellur (M) cells	which project to magnocellular layer of LGB, movement,depth, and flicker.
Area 17	Color Blobs	are in the Visual Cortex. Interspersed among the primary visual columns & among the columns of the secondary visual areas clusters of cells responsible for color detection.
	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)

QUIZ

MEDICINE438's CNSPHYSIOLOGY

MCQ:

1.when light falls on one eye the response will be:

A. Relaxation of ciliary muscles
B. Contraction of ciliary muscles in one eye
C. Relaxation of iris muscles
D. Bilateral ciliary muscle contraction

2.In Argyll robertson pupil the pupils constrict in response to:

A. Light reflex but not accommodation
B. Accommodation but not light
C. Doesn't respond to accommodation and light
D. Both accommodation and light

3.Large cells that detects movement, depth, and flicker:

A. Parvocellular cells
B. Magnocellular cells
C. Y cells
D. X cells

4. The cones is ...

A. High visual acuity & low sensitivity to light
B. High visual acuity & great sensitivity to light
C. Low visual acuity & great sensitivity to light
D. Low visual acuity & low sensitivity to light

5. From which part of the brainstem there are fibers that inhibit lateral geniculate nucleus ?

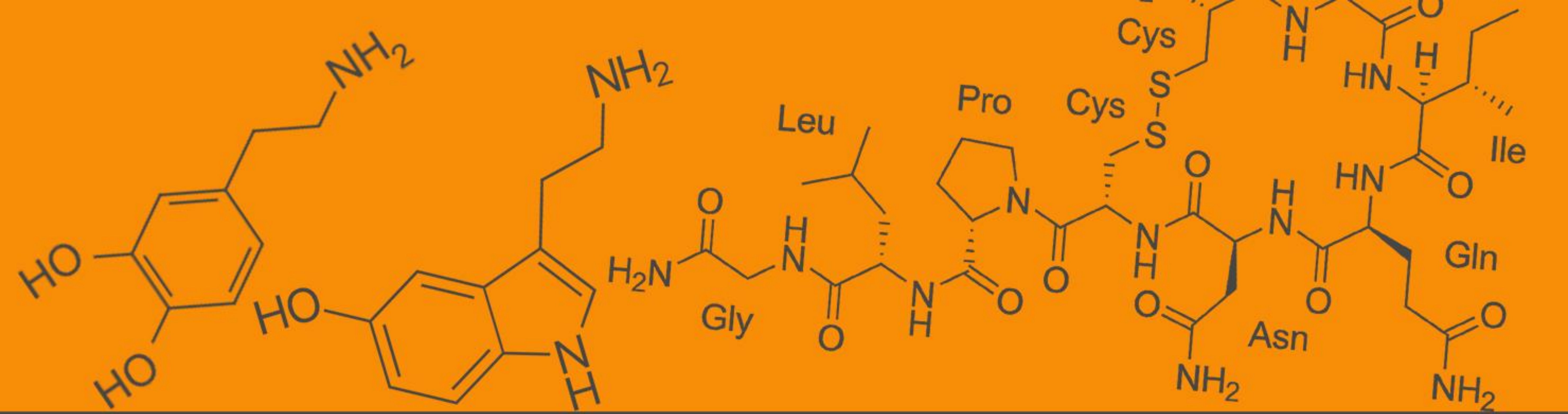
A. Midbrain
B. Medulla
C. Red nucleus
D. Pins

Sac

1.What do color blobs, simple, and complex cells detect in the visual cortex?
2. What is the mechanism of accommodation?

SAC	SAC
1. **Color blobs:** color detection **Simple cells:** detect color contrast details, bars of light, lines , borders and edges **Complex cells:**detect Line Orientation	2. Ciliary muscle contract then the suspensory ligament relax making the lens more convex which increase the dioptric of the lens causing the near objects to be focused on the retina

ANSWER KEY: D, B, B, A, A



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REFERENCES

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- Ganong's Review of Medical Physiology