The Eye: III. Central Neurophysiology of Vision

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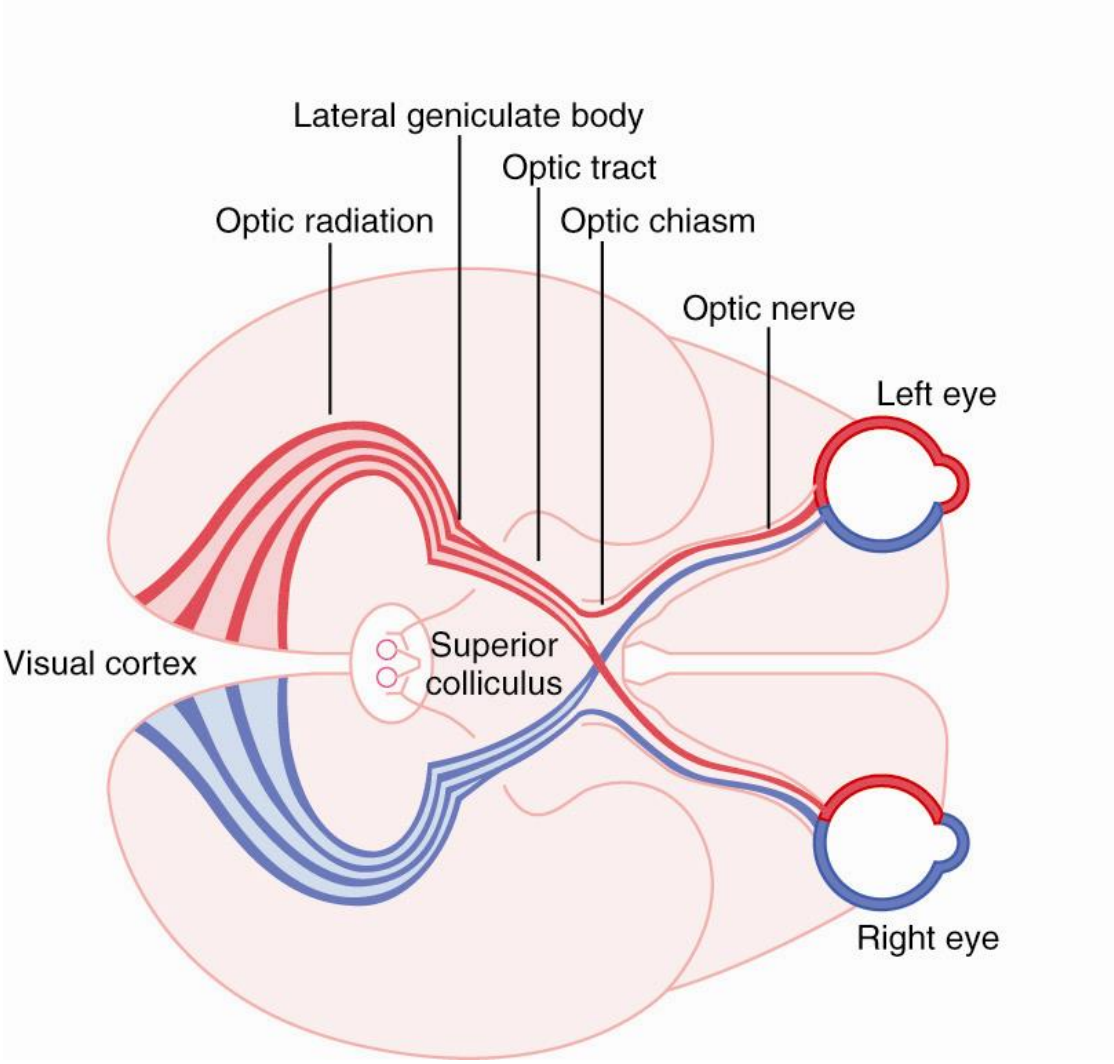
Objectives

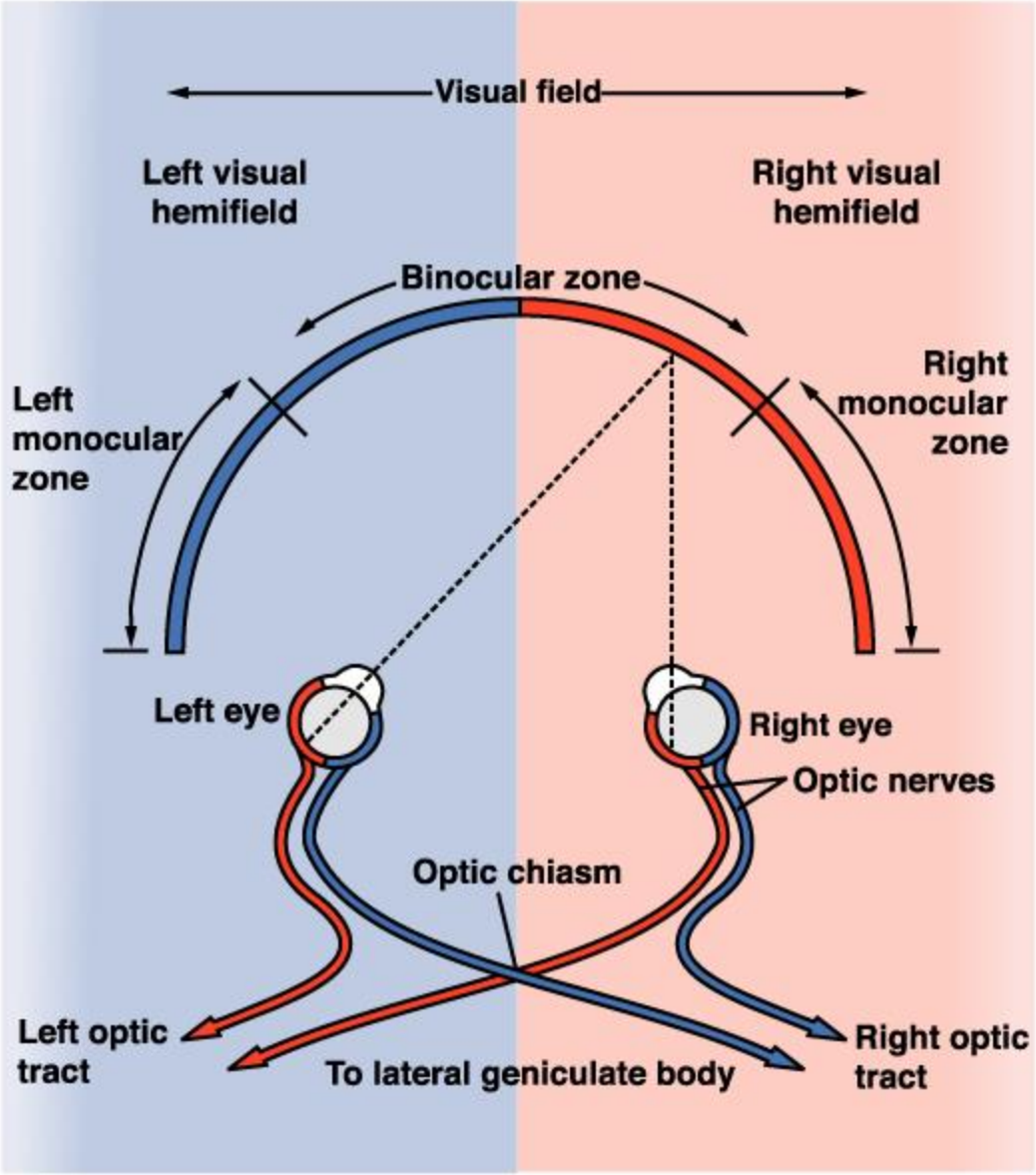
- List the stations for the visual pathway
- Determine the functions of the visual cortices
- Describe visual neural processing
- Explain the abnormalities of visual pathway lesions
- Outline the importance of the light reflexes direct and consensual

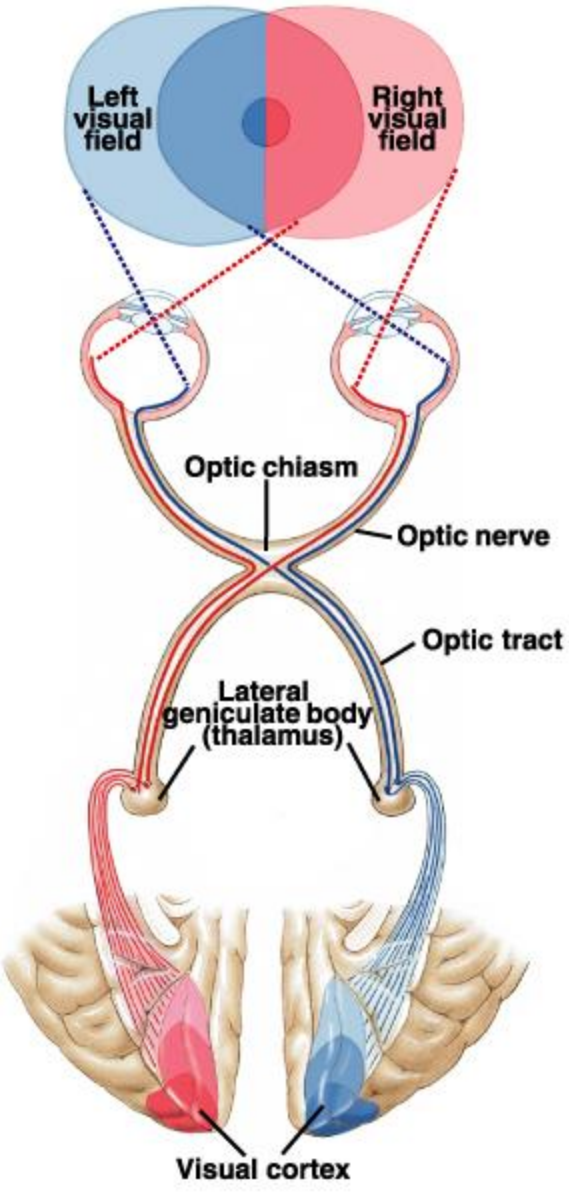
Visual Pathways to the Brain

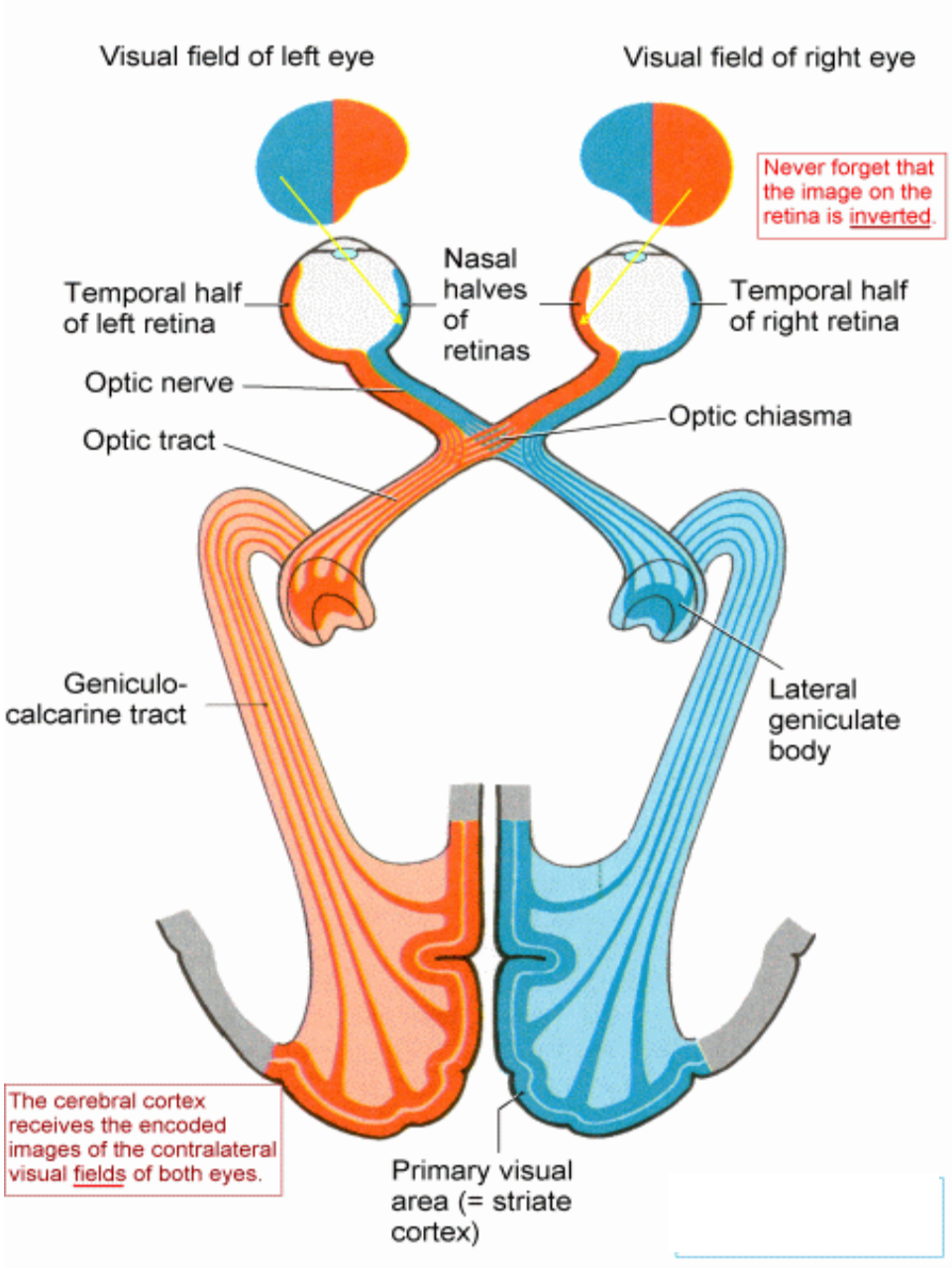
- optic nerve
  - axons of ganglion cells of the retina
- optic chiasm
  - all fibers from the nasal halves of the retina cross to the opposite side and join fibers from the opposite temporal retina to form the optic tracks
  - Fibers project to the pretectal area and superior collicolli
- synapse in the dorsal lateral geniculate nucleus (LGN) of the thalamus
- from LGN to primary visual cortex by way of the optic radiation

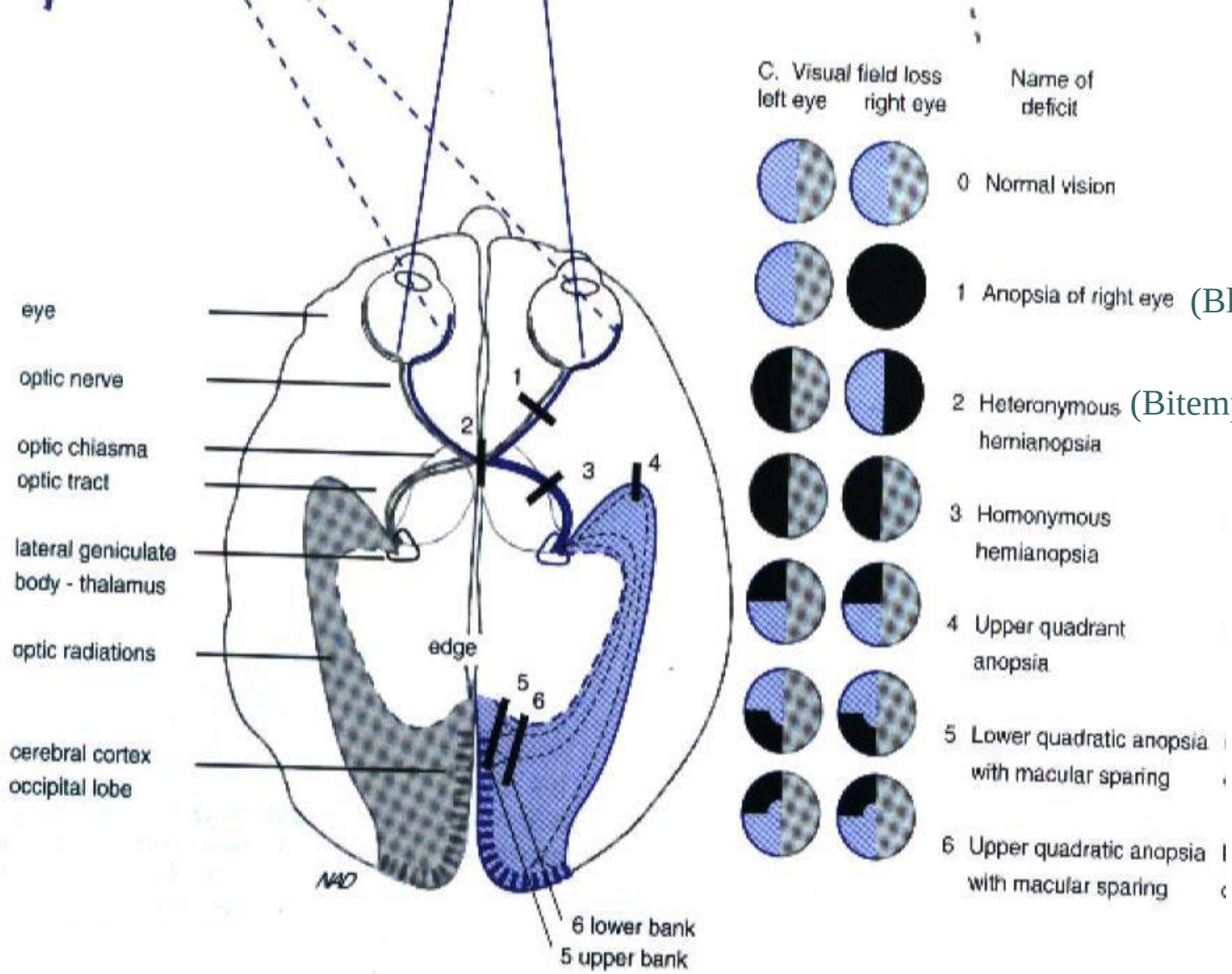
Visual pathways to the brain




Visual field
Left visual hemifield
Right visual hemifield
Binocular zone
Left monocular zone
Right monocular zone
Left eye
Right eye
Optic nerves
Optic chiasm
Left optic tract
To lateral geniculate body
Right optic tract


Left visual field
Right visual field
Optic chiasm
Optic nerve
Optic tract
Lateral geniculate body (thalamus)
Visual cortex

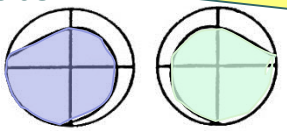

Visual field of left eye
Visual field of right eye
Never forget that the image on the retina is inverted.
Temporal half of left retina
Nasal halves of retinas
Temporal half of right retina
Optic nerve
Optic chiasma
Optic tract
Geniculo-calcarine tract
Lateral geniculate body
The cerebral cortex receives the encoded images of the contralateral visual fields of both eyes.
Primary visual area (= striate cortex)


eye
optic nerve
optic chiasma
optic tract
lateral geniculate body - thalamus
optic radiations
cerebral cortex occipital lobe
1
2
3
4
5
6
edge
6 lower bank
5 upper bank
NAD
C. Visual field loss
left eye
right eye
Name of deficit
0 Normal vision
1 Anopsia of right eye (Blindness)
2 Heteronymous hemianopsia (Bitemporal)
3 Homonymous hemianopsia
4 Upper quadrant anopsia
5 Lower quadratic anopsia with macular sparing
6 Upper quadratic anopsia with macular sparing

Lesions of the Visual Pathway

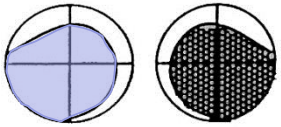
Left Right

1. Normal visual fields

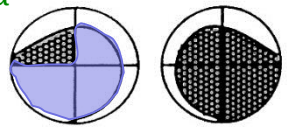


Fields, not retinal quadrants

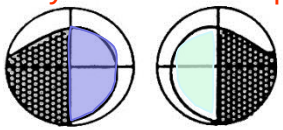
2. Blindness of the right eye



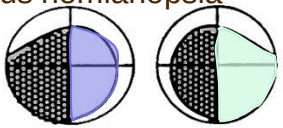
3. Blindness of right eye + contralateral left upper quadrantanopia



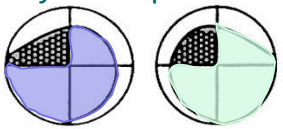
4. Bitemporal heteronymous hemianopsia



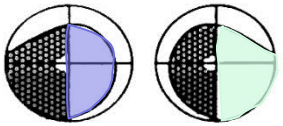
5. Left homonymous hemianopsia

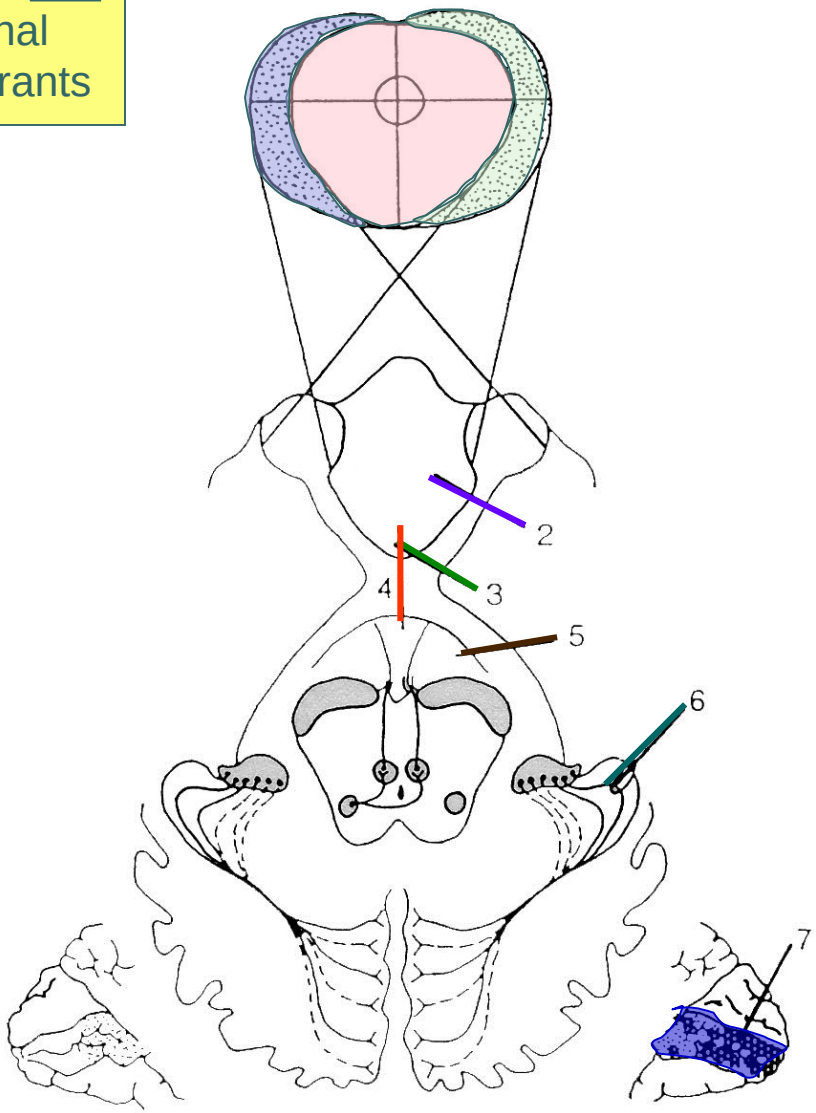


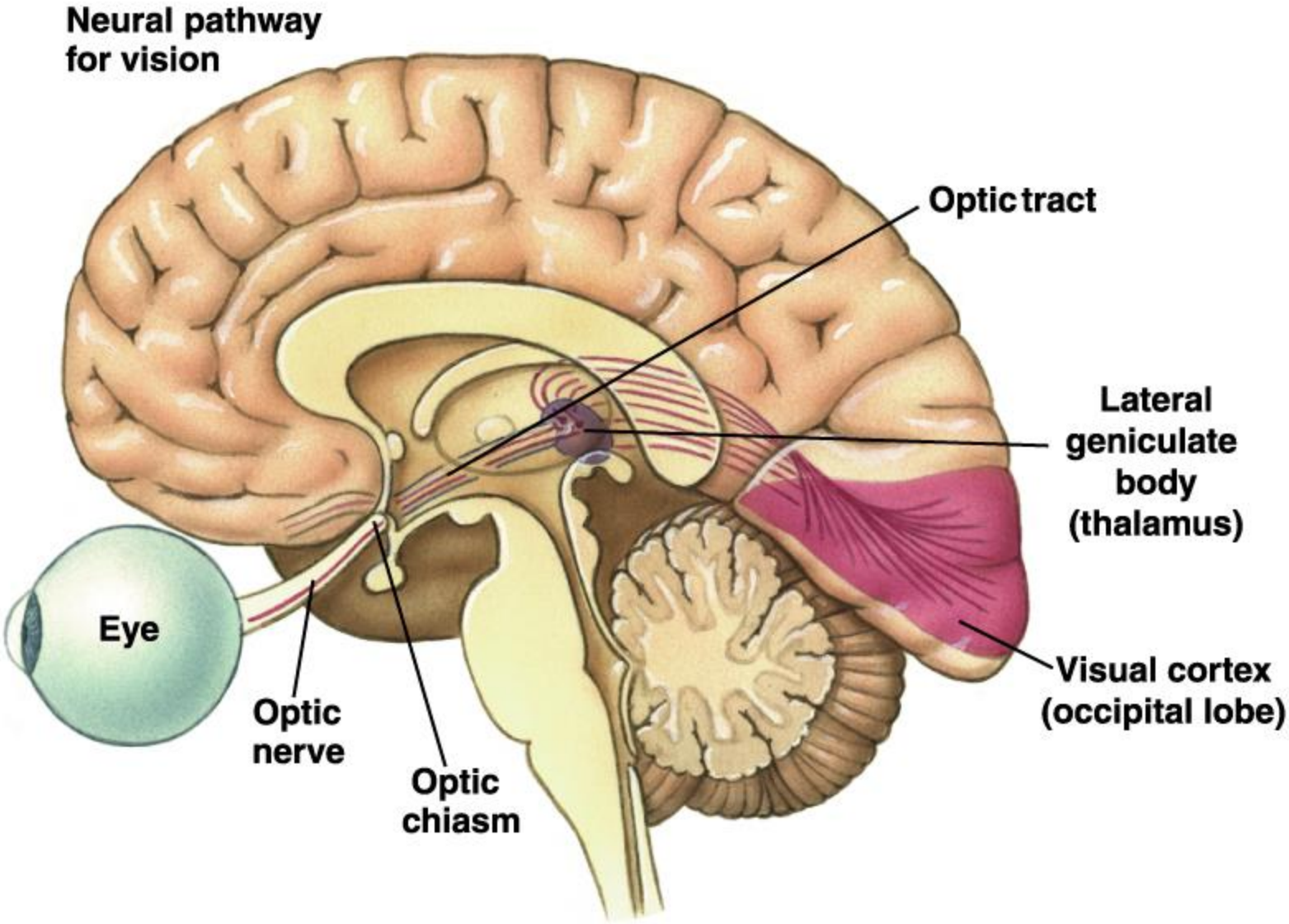
6. Left upper homonymous quadrantanopsia



7. Left homonymous hemianopsia with macular sparing



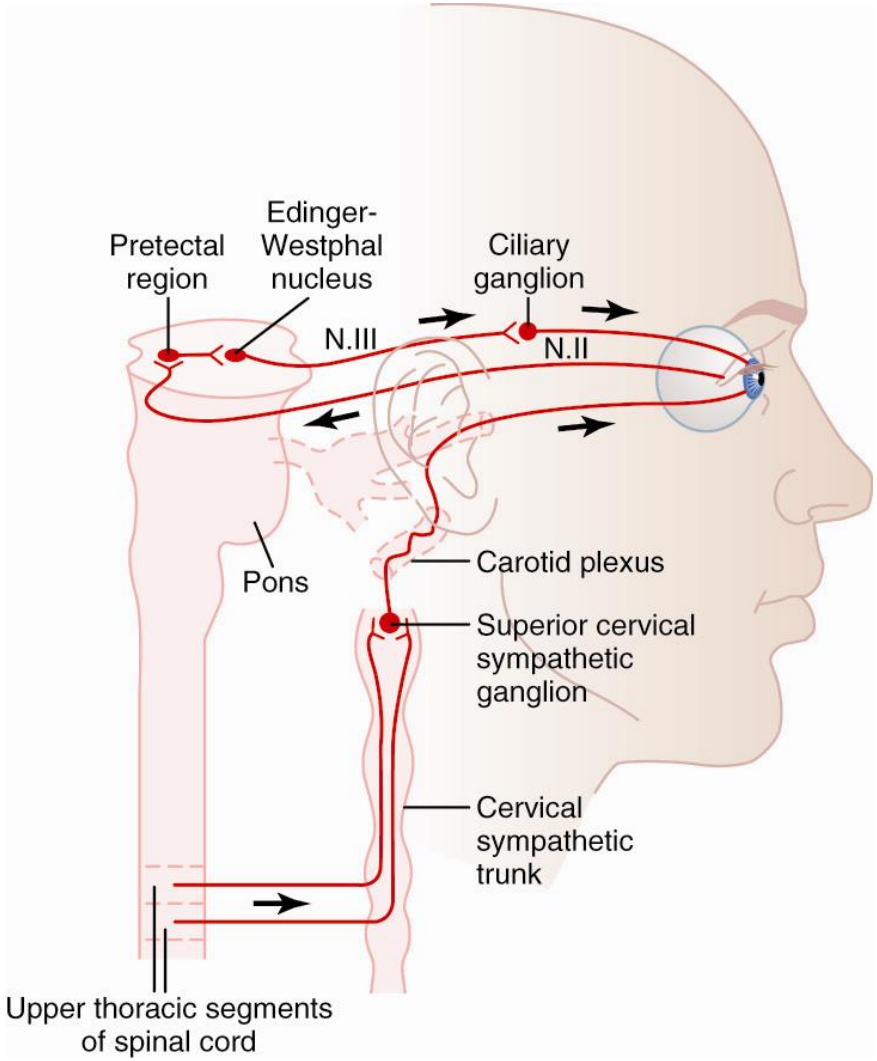



Neural pathway
for vision
Optic tract
Lateral
geniculate
body
(thalamus)
Eye
Visual cortex
(occipital lobe)
Optic
nerve
Optic
chiasm

Retinal Projections to Subcortical Regions

- suprachiasmatic nucleus of the hypothalamus
  - control of circadian rhythms??
- pretectal nuclei
  - pupillary light reflex
  - accommodation of the lens
- superior colliculus
  - rapid directional movement of both eyes
- ventral lateral geniculate
  - control of bodies behavioral functions??

Autonomic Pathways to the Eye



Function of the Dorsal Lateral Geniculate

- Two principle functions:
  - relay of information to primary visual cortex
  - “gate control” of information to primary visual cortex

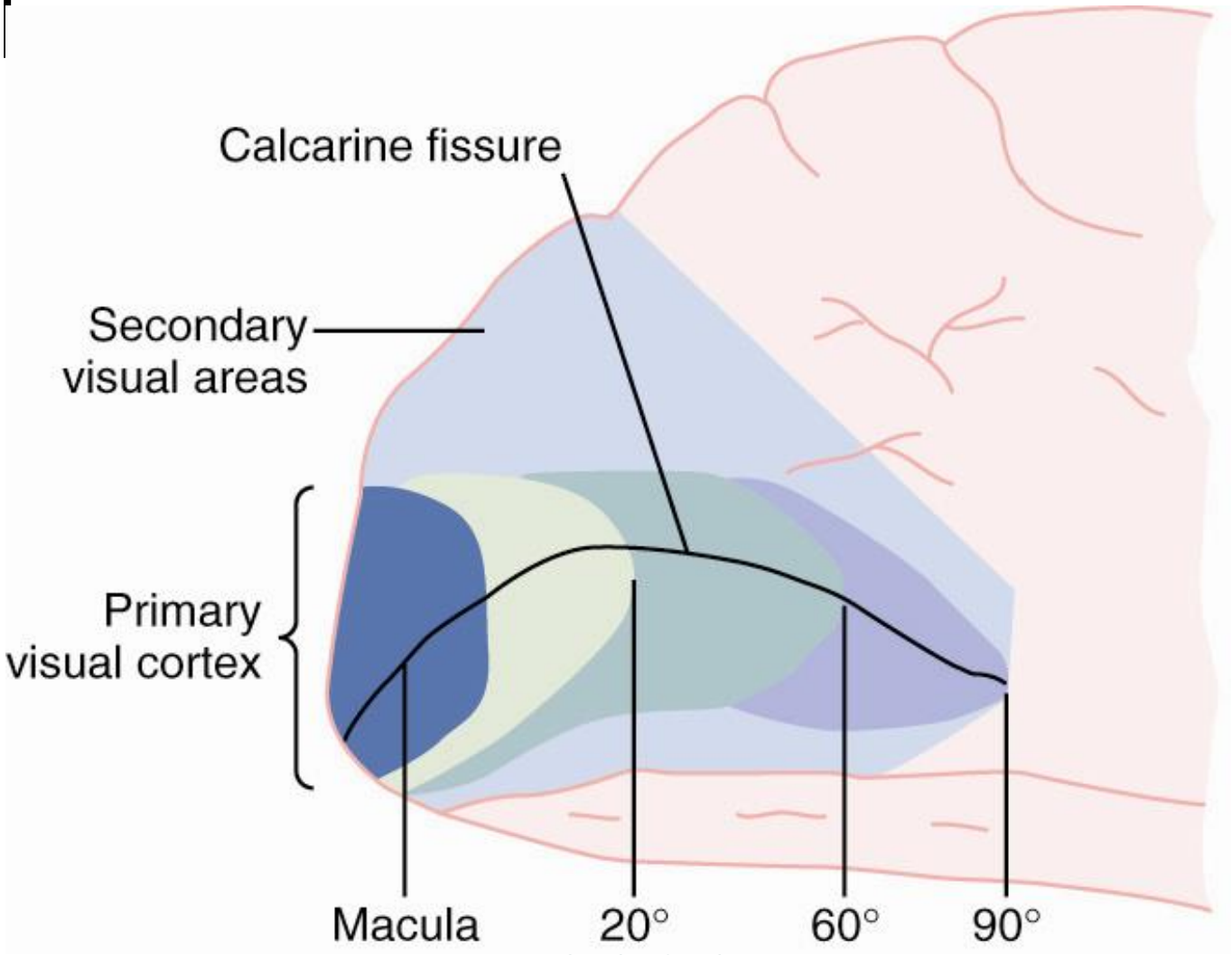
“Gate” Function of the LGN

- LGN receives input from corticofugal fibers originating in the primary visual cortex.
- Input from reticular areas of the midbrain
- Both inputs are inhibitory and can turn off transmission of the signal in select areas of the LGN.
- Both inhibitory inputs presumably control the visual input that is allowed to pass to the cortex.

Primary Visual Cortex

- located in the occipital lobe in the calcarine fissure region
- large representation in visual cortex for the macula (region for highest visual acuity)
- layered structure like other cortical areas
- columnar organization as well
- receives the primary visual input

Location of Visual Areas in the Cortex



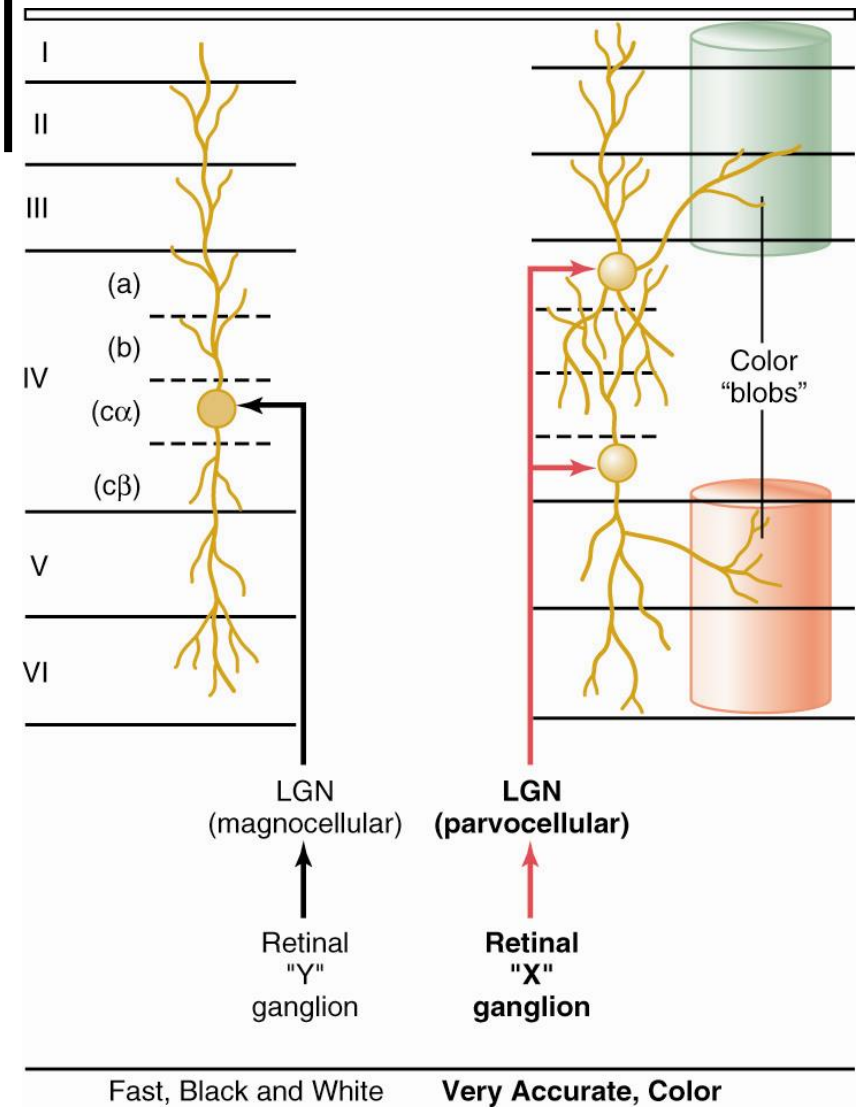
Secondary Visual Areas

- visual association cortex
- responsible for analyzing the visual information
- area for 3 dimensional position, gross form, and motion
- area for color analysis

Processing in the Visual Cortex

- separation of the signals from the two eyes is lost in the primary visual cortex
- signals from one eye enter every other column, alternating with signals from the other eye
- allows the cortex to decipher whether the two signals match

Connections in the Visual Cortex



Analysis of the Visual Image

- The visual signal in the primary visual cortex is concerned mainly with contrasts in the visual scene.
- The greater the sharpness of the contrast, the greater the degree of stimulation.
- Also detects the direction of orientation of each line and border.
  - for each orientation of a line, a specific neuronal cell is stimulated.

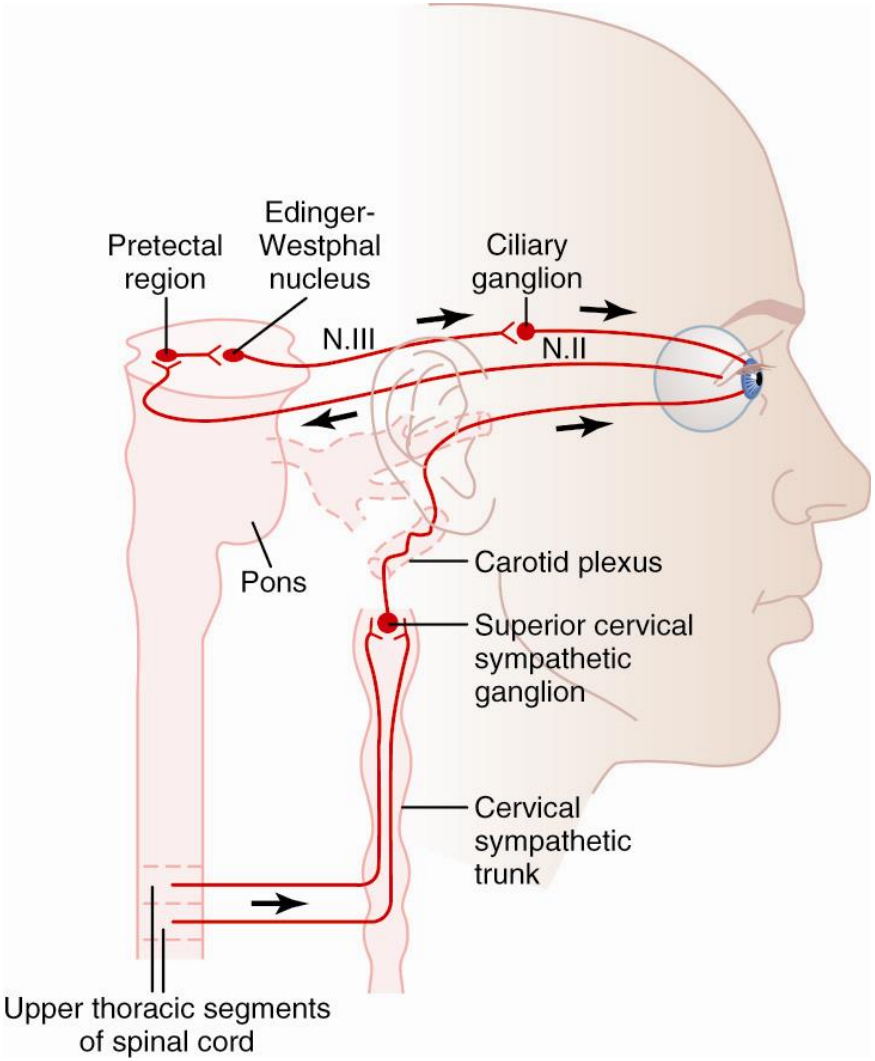
Fields of Vision

- nasal field located on the temporal side of the retina
- temporal field located on the nasal side of the retina
- interruption of the visual pathway at different points leads to very specific visual field defects
- “blind spot” located about 15 degrees lateral to the central point of vision
- no rods or cones in this area, called the optic disc, exit point for axons of the ganglion cells

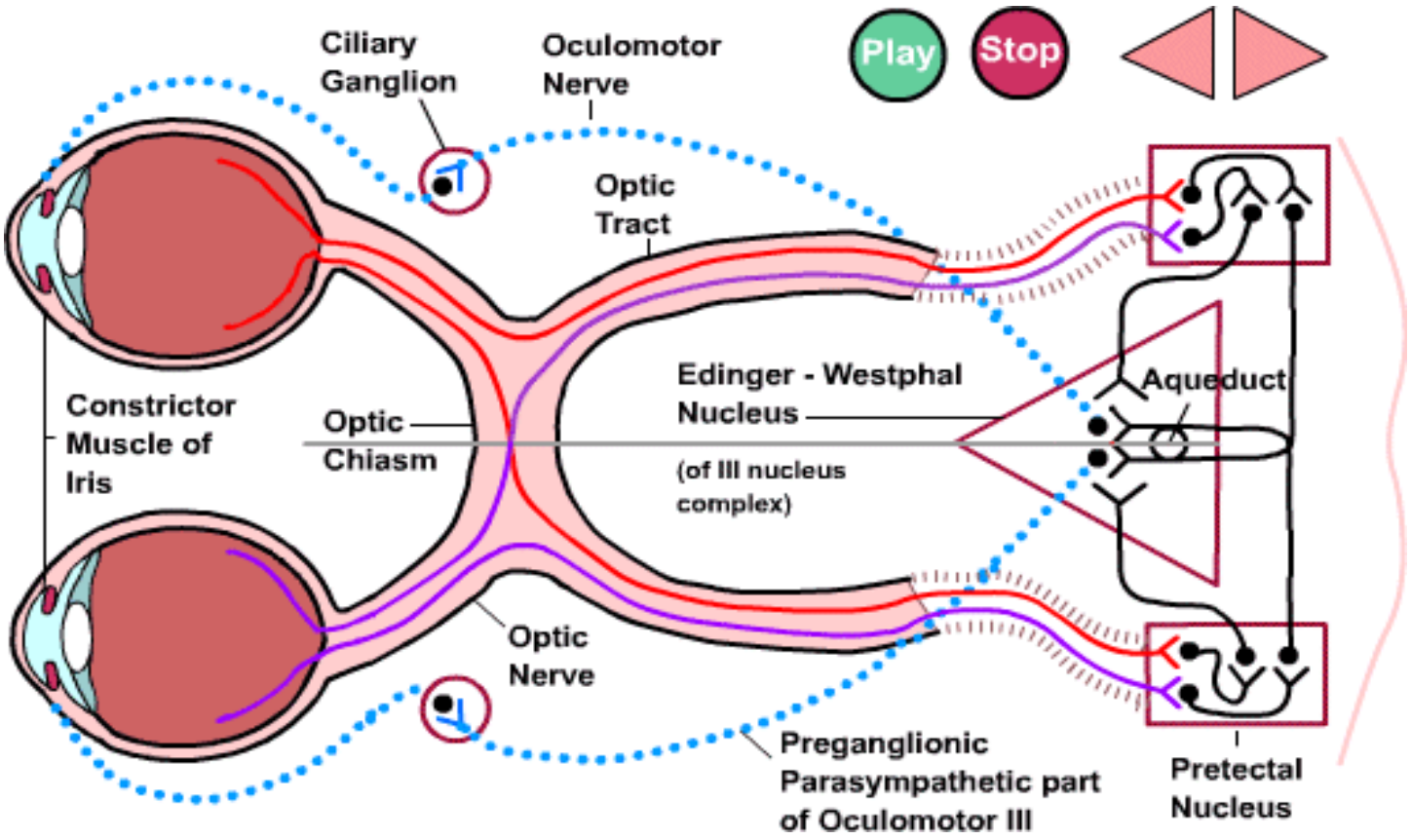
The Autonomic Nerves to the Eyes

- The eye is innervated by both parasympathetic and sympathetic neurons.
- Parasympathetic fibers arise in the Edinger-Westphal nucleus, pass in the 3rd cranial nerve to the ciliary ganglion.
  - Postganglionic fibers excite the ciliary muscle and sphincter of the iris.
- Sympathetic fibers originate in the intermediolateral horn cells of the superior cervical ganglion.
  - Postganglionic fibers spread along the corotid artery and eventually innervate the radial fibers of the iris.

Autonomic Pathways to the Eye



Pupillary reflex pathway (Direct and Consensual –Indirect)



Control of Accommodation (Focusing the Eyes)

- results from contraction or relaxation of the ciliary muscle
- regulated by negative feedback mechanism that automatically adjust the focal power of the lens for highest degree of visual acuity within about 1 sec
- exact mechanism is not known

Control of Pupillary Diameter

- *miosis*: decreasing of pupillary aperture due to stimulation of parasympathetic nerves that excite the pupillary sphincter muscle
- *mydriasis*: dilation of pupillary aperture due to stimulation of sympathetic nerves that excite the radial fibers of the iris

Pupillary Light Reflex

- When the amount of light entering the eyes increases, the pupils constrict.
- Functions to help the eye adapt extremely rapidly to changing light conditions.
- Light excites fibers going to pretectal nuclei.
- From pretectal nuclei fibers pass to Edinger-Westphal nucleus and back through parasympathetic nerves to constrict iris sphincter.

Thank You