LISC-322 Neuroscience

THE VISUAL SYSTEM
Central Visual Pathways

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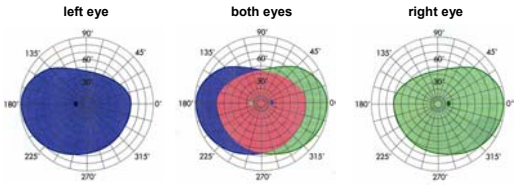
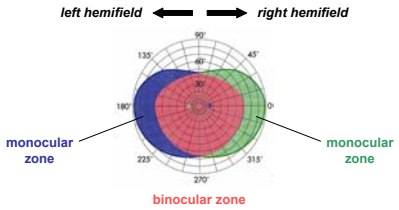
Visual Field Representation

Each eye sees a part of the visual space that defines its visual field. The visual fields of both eyes overlap extensively to create a binocular visual field.



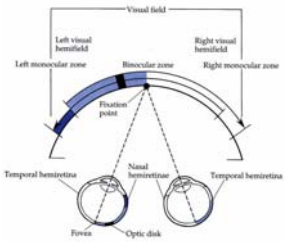
Visual Field Representation

The total visual field is the sum of the right and left *hemifields* and consists of a binocular zone and two monocular zones.



Visual Field Representation

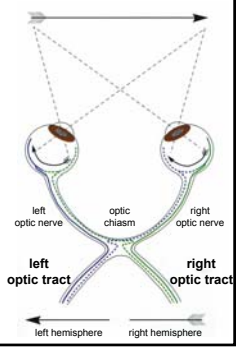
Just like the visual field is divided into two hemifields, the retina is divided in half, relative to the fovea, into a *nasal* and a *temporal hemiretina*.



Visual Field Representation

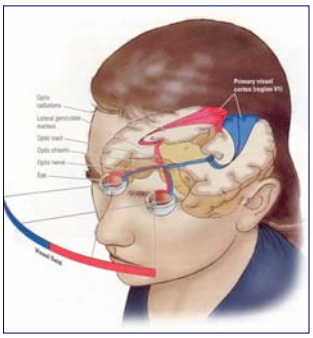
The axons of ganglion cells exit the eyes via the *optic nerve*, partially cross at the *optic chiasm*, and form two *optic tracts*, so that the right and left hemifields reach the left and right hemispheres.

Each optic tract looks at the opposite hemifield, combining inputs from the ipsilateral[1] temporal hemiretina and the contralateral[2] nasal hemiretina.



[1] "*same side*"
[2] "*opposite side*"

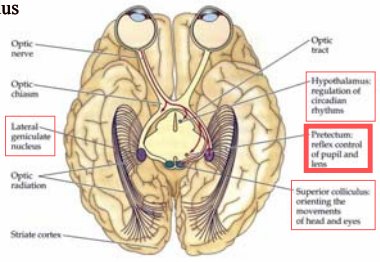
Visual Field Representation



Central Projections of the Retina

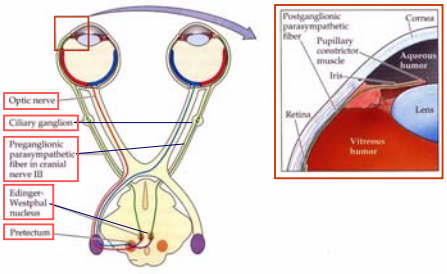
The retina projects to *four subcortical regions* in the brain:

1) Lateral Geniculate nucleus
2) Superior Colliculus
3) Hypothahalamus
4) Pretectum



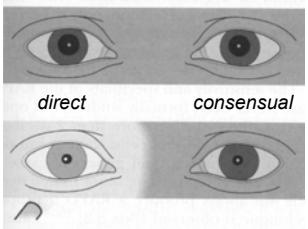
Pretectum & Pupillary Light Reflex

The pretectum controls the action of the pupillary constrictor muscle via its projection to both Edinger-Westphal nuclei.



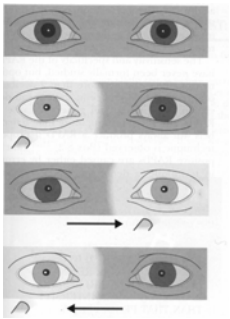
Pretectum & Pupillary Light Reflex

The pretectum bilateral projections to the Edinger-Westphal nuclei ensure that both eyes react to light: shining a light into each eye can elicit a *direct* and a *consensual* pupillary reflex. This light reflex tells us about one's visual pathways status.



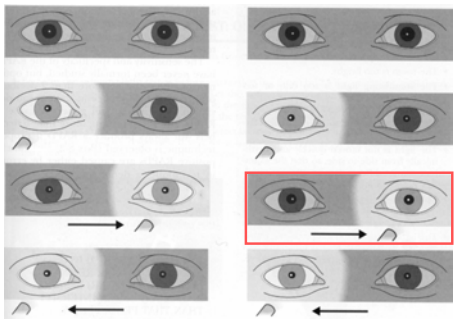
The Swinging Light Test

Normal



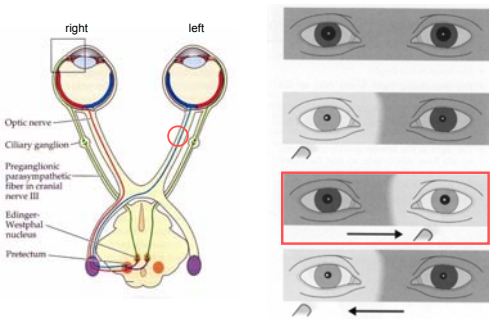
The Swinging Light Test

Normal Defective

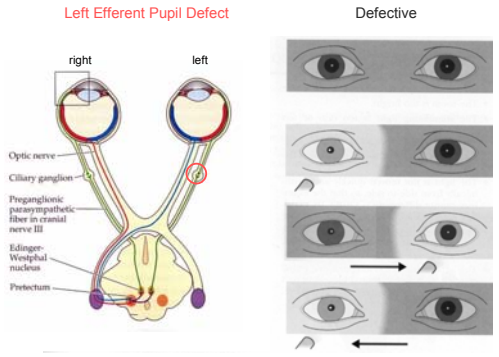


Pretectum & Pupillary Light Reflex

Left Afferent Pupil Defect Defective



Pretectum & Pupillary Light Reflex



Pretectum & Pupillary Light Reflex

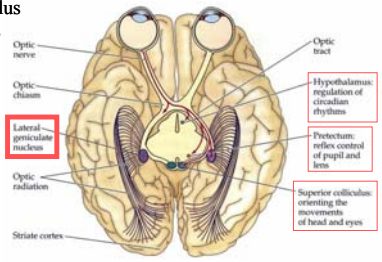
In summary, pupillary reflexes are clinically important because they indicate the functional state of the afferent and efferent pathways mediating them.

The absence of pupillary reflexes in an unconscious patient is a symptom of damage to the pretectum.

Central Projections of the Retina

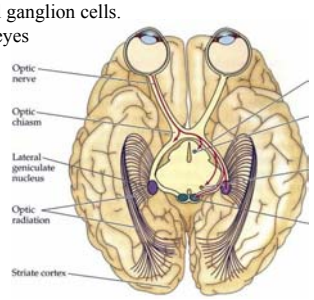
The retina projects to *four subcortical regions* in the brain:

1) Lateral Geniculate nucleus
2) Superior Colliculus
3) Hypothahalamus
4) Pretectum

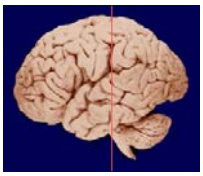


Lateral Geniculate Nucleus

The Lateral Geniculate nucleus (LGN) in the thalamus is the major target of the retinal ganglion cells. It receives inputs from both eyes and relays these messages to the primary visual cortex via the optic radiation.



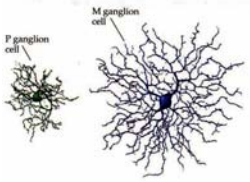
Lateral Geniculate Nucleus



Lateral Geniculate Nucleus

The retinal Magno and Parvo ganglion cells respectively project to 2 ventral *magnocellular* layers and 4 dorsal *parvocellular* layers of the Lateral Geniculate Nucleus.

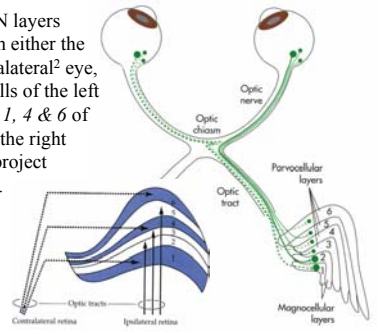
Retinal Inputs



LGN Organization

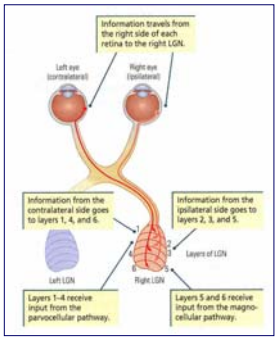
Lateral Geniculate Nucleus

Each of the six LGN layers receives inputs from either the ipsilateral[1] or contralateral[2] eye, i.e., the ganglion cells of the left eye project to *layer 1, 4 & 6* of the right LGN, and the right eye ganglion cells project to its *layer 2, 3 & 5*.



[1] "*same side*"
[2] "*opposite side*"

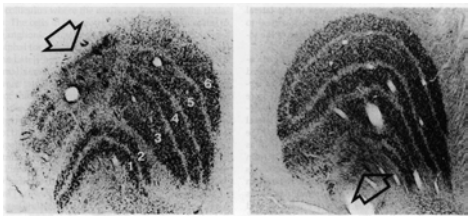
Lateral Geniculate Nucleus



Lateral Geniculate Nucleus

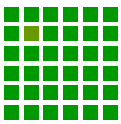
Selective lesions of the parvocellular and magnocellular LGN layers alter specific visual functions.

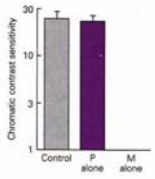
Parvocellular lesion *Magnocellular lesion*



Lateral Geniculate Nucleus

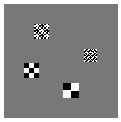
Lesions restricted to the *parvocellular* layers severely disrupt the processing of color, while lesions of the *magnocellular* layers leave color vision unaffected.

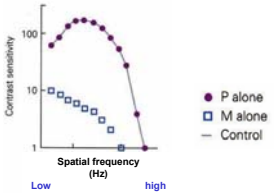


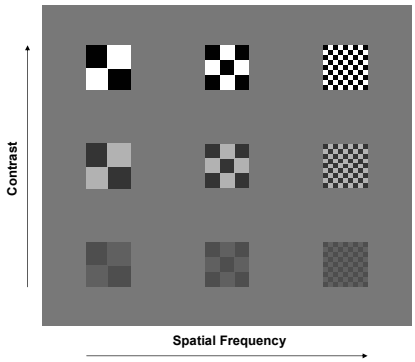


Lateral Geniculate Nucleus

Lesions restricted to the *parvocellular* layers severely disrupts the processing of fine detail, while lesions of the *magnocellular* layers leave fine detail vision unaffected.

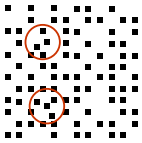


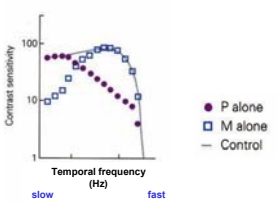




Lateral Geniculate Nucleus

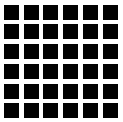
Lesions restricted to the *magnocellular* layers severely disrupt the detection of fast moving stimuli, while lesions of the *parvocellular* layers affect only slow motion vision.

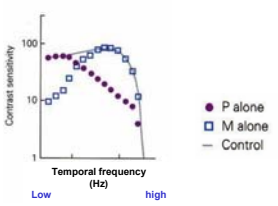




Lateral Geniculate Nucleus

Lesions restricted to the *magnocellular* layers severely disrupt the detection of fast flickering stimuli, while lesions of the *parvocellular* layers affect only slow flickering vision.



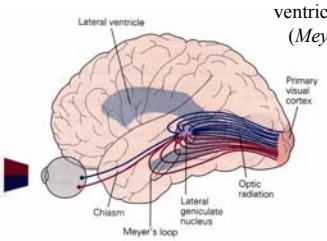


Lateral Geniculate Nucleus

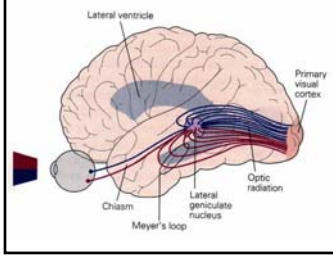
Parvocellular layers	**Magnocellular layers**
Chromatic vision	Achromatic vision
High fine detail vision	Low fine detail vision
Slow motion vision	Fast motion vision

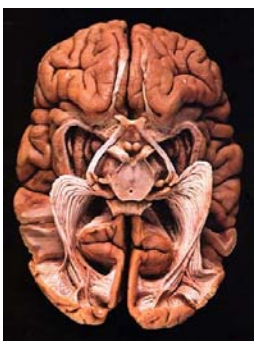
Optic Radiation

The LGN projections reach the primary visual cortex through the *optic radiation*. Axons carrying information about the superior visual field sweep around the lateral horn of the ventricle under the temporal lobe (*Meyer's loop*). Those carrying information about the inferior visual field travel under the cortex of the parietal lobe.



Optic Radiation



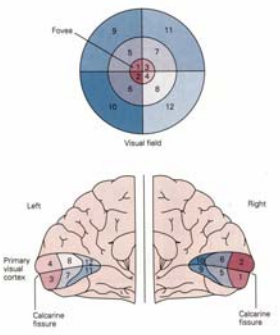


Primary Visual Cortex

The primary visual cortex (V1) has a representation of the contralateral visual hemifield.

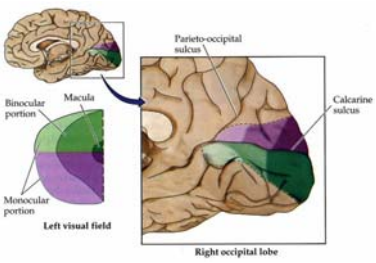
The foveal region is mapped in its most posterior part, whereas the more peripheral regions are mapped in progressively more anterior parts.

The upper visual field is mapped below the calcarine fissure, the lower visual field above.



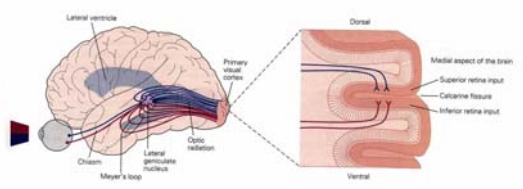
Primary Visual Cortex

Because of the high density of ganglion cells in the fovea, the visual cortex has an expanded representation of the fovea.



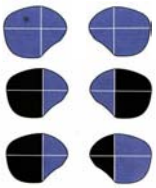
Visual Field Deficits

The highway of visual information (retina-LGN-V1) can be vulnerable to strokes and tumors. Because of the orderly organization of this central visual pathway, such lesions produce characteristic gaps in the visual field.



Visual Field Deficits

Relatively small visual field deficits are called *scotomas*, while large ones are called *anopsias*.
Deficits in vision resulting from a single lesion can either be *homonymous* or *nonhomonymous*, i.e., affecting the same or different parts of the two eyes' visual field.



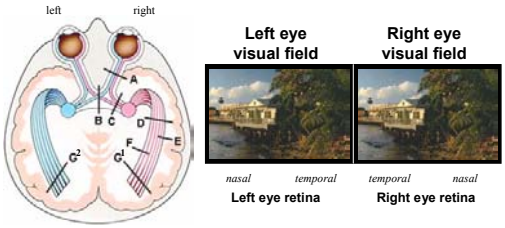
Scotoma

Nonhomonymous anopsia

Homonymous anopsia

Visual Field Deficits

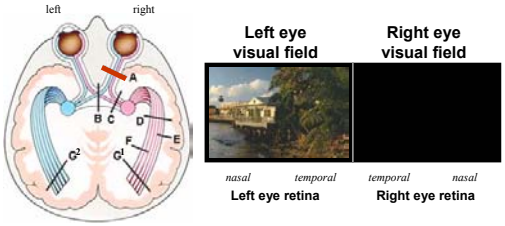
INTACT VISION



Both left- and right-eye visual fields are normal.

Visual Field Deficits

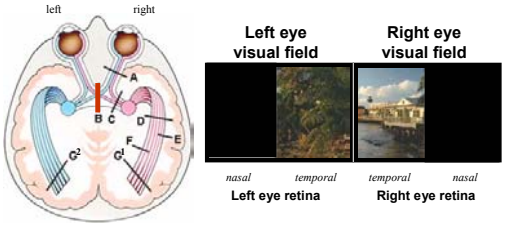
Cut at level A



A lesion of the *right optic nerve* causes a total loss of vision in the right eye; it also produces a right afferent pupil deficit.

Visual Field Deficits

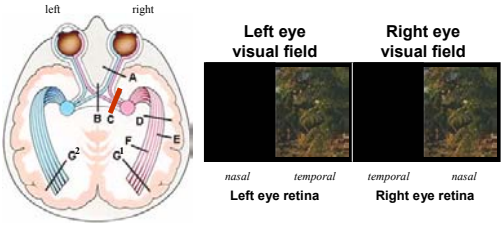
Cut at level B



A lesion of the *optic chiasm* causes a loss of vision in the temporal half of both visual fields: *bitemporal hemianopsia*.

Visual Field Deficits

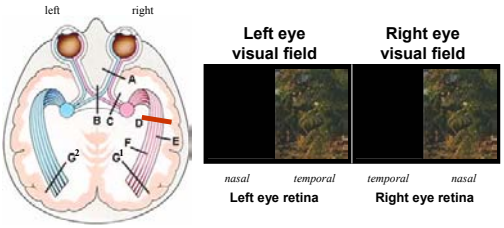
Cut at level C



A lesion of the *right optic tract* causes a complete loss of vision in the left hemifield: *contralateral hemianopsia*.

Visual Field Deficits

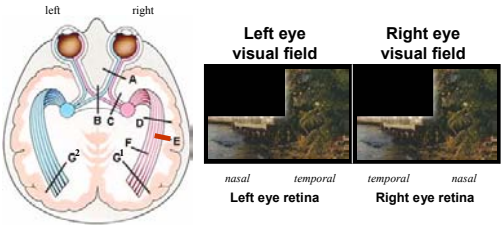
Cut at level D



A lesion of the *right optic radiation* just after the LGN also causes a loss of vision in the left hemifield: *contralateral hemianopsia*.

Visual Field Deficits

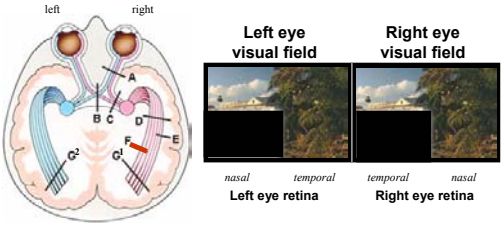
Cut at level E



A lesion of the *right optic radiation* specific to *Meyer's loop* causes a loss of vision in the upper quadrant of the left hemifield. The same is true for lesions to the *lower bank of the calcarine sulcus*.

Visual Field Deficits

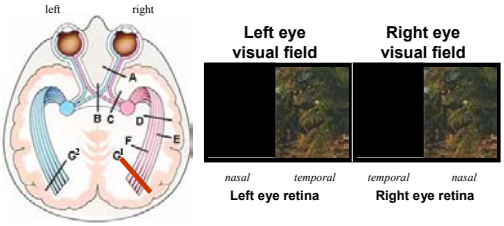
Cut at level F



A lesion of the *parietal* portion of the *right optic radiation* causes a loss of vision in the lower quadrant of the left hemifield. The same is true for lesions to the *upper bank of the calcarine sulcus*.

Visual Field Deficits

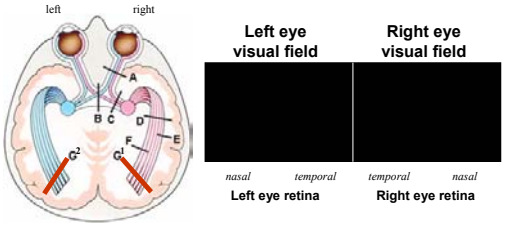
Cut at level G^1



A lesion of the right visual cortex causes a complete loss of vision in the left hemifield: *contralateral hemianopsia*.

Visual Field Deficits

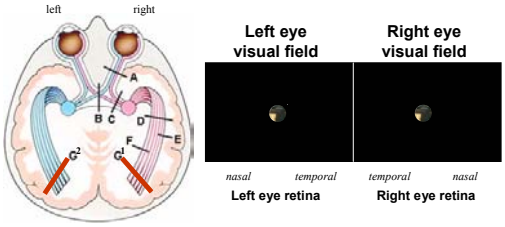
Cut at levels G^1 & G^2



A lesion of both visual cortices causes a complete blindness.

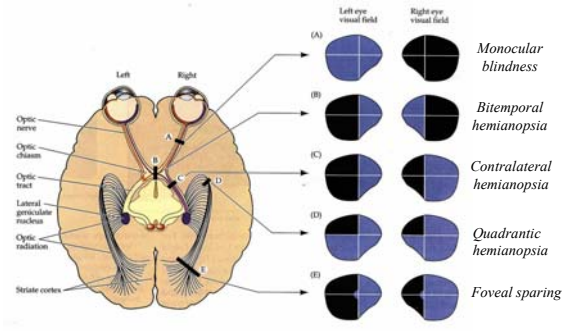
Visual Field Deficits

Cut at levels G^1 & G^2



Lesions to visual cortex are usually only partial and *spare foveal vision*, probably because the foveal representation is so extensive that a single lesion is unlikely to destroy it all.

Visual Field Deficits



Visual System: Central Visual Pathways

Reference for this Lecture:

- Neuroscience, 2nd edition (2001) by Purves et al., Chapter 12.

Reference for next Lecture:

- Neuroscience, 2nd edition (2001) by Purves et al., Chapter 12 & 26.

Lectures are posted:

- http://brain.phgy.queensu.ca/pare

Office Time:

- Tuesday & Thursday (15:00-17:00)
  Botterell Hall, Room 438