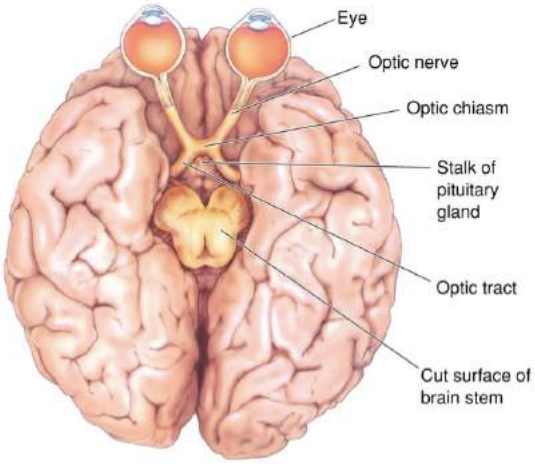
Week 4: The Central Vision System

Learning Objectives:

- Describe the relationship between vision and perception
- Describe and explain the visual pathways, including
  - Retinal input
  - The role of the lateral geniculate nucleus
  - The layers of the lateral geniculate nucleus
  - Organisation and role of the Striate Cortex
  - Visual selectivity
  - The Parallel Pathways
  - The Ventral and Dorsal Streams

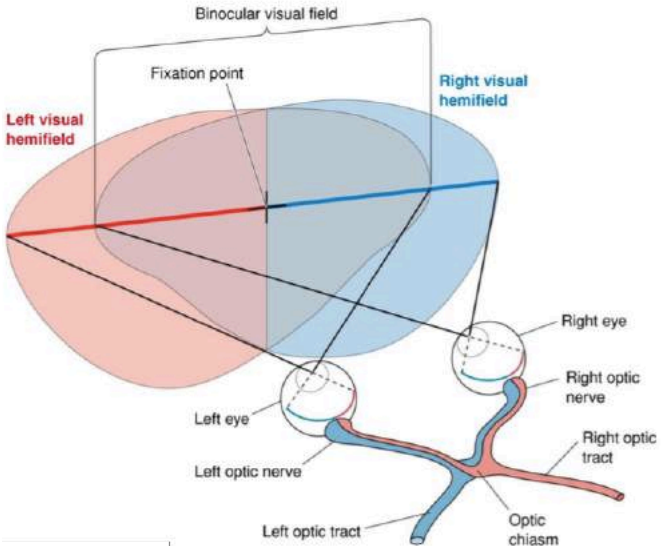
The Retinofugal Perception

- Neural processing results in perception
- Pathway of optic nerve to brain = retinofugal
- Pathway serving conscious visual perception originates in the retina
- Progresses to lateral geniculate nucleus (thalamus), primary visual cortex, and higher order visual areas in O, T + P lobes



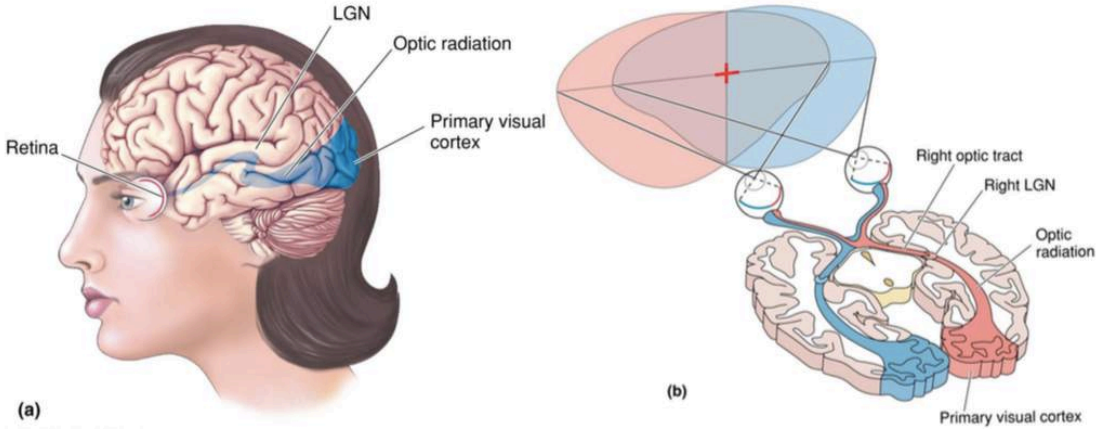
Visual Hemifields

- Overlapping receptive fields → retinal cell will take certain information and overlap it into neighbouring cells
  - Sensitive to different facets of visual input
- Binocular visual fields = where info from both hemifield if integrated together to form one image → see the same things = where the fields directly overlap
- Integration process is modifiable e.g. nose is in view of eyes but not perceived
- Left hemifield projects to right optic tract/right side of brain and vice versa
- Ganglion cell axons from medial/nasal retina decussate in optic chiasm → SWITCH



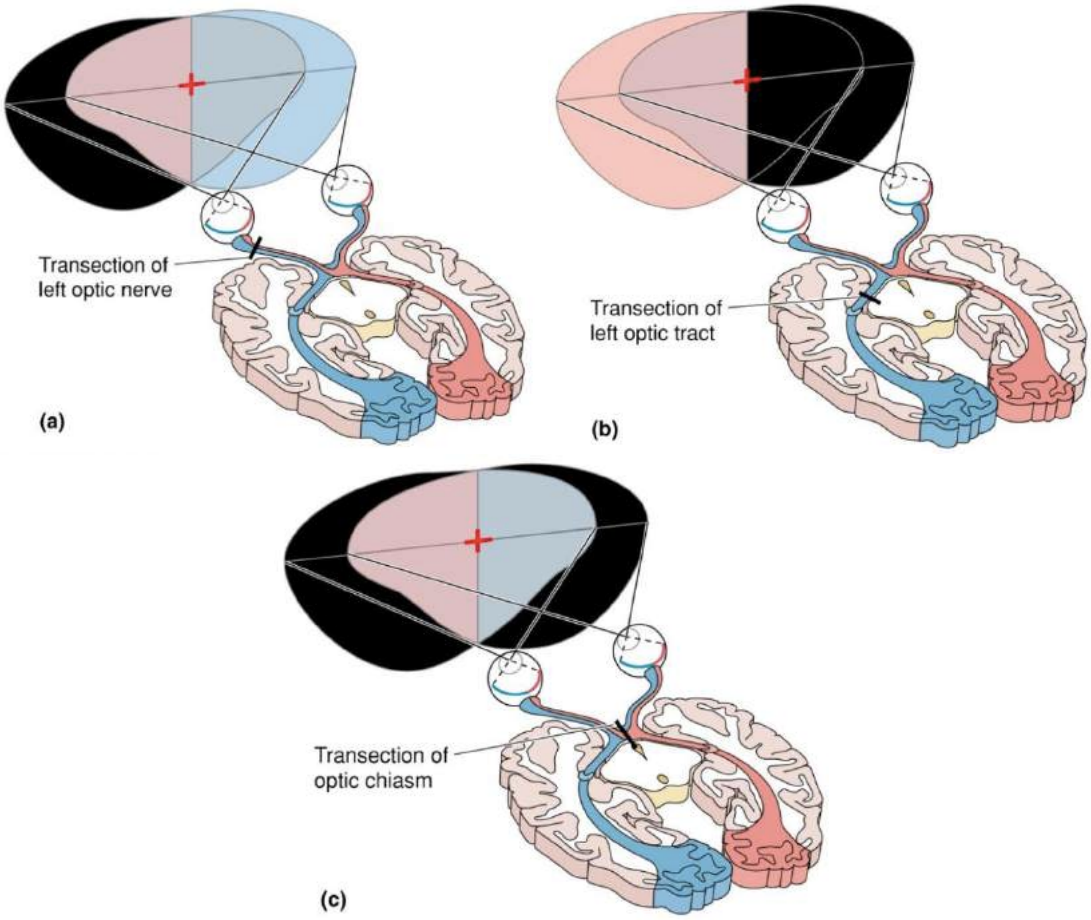
The Visual Pathway

- Mediate conscious visual perception
- Information from left and right eye is monocular
    - Divided until deep into brain at last step, where information is integrated



Visual Field Deficits

- Associated with lesions in retinofugal projection
- Pressure, bending or damage can affect vision
    - Difficulties in neural pathway transmission
- Benefit of redundancy of overlapping hemifields = allows people to retain vision
- a → only vision loss in leftmost side
- b → lose entire opposite hemisphere
- c → lose both peripheries, only have binocular vision

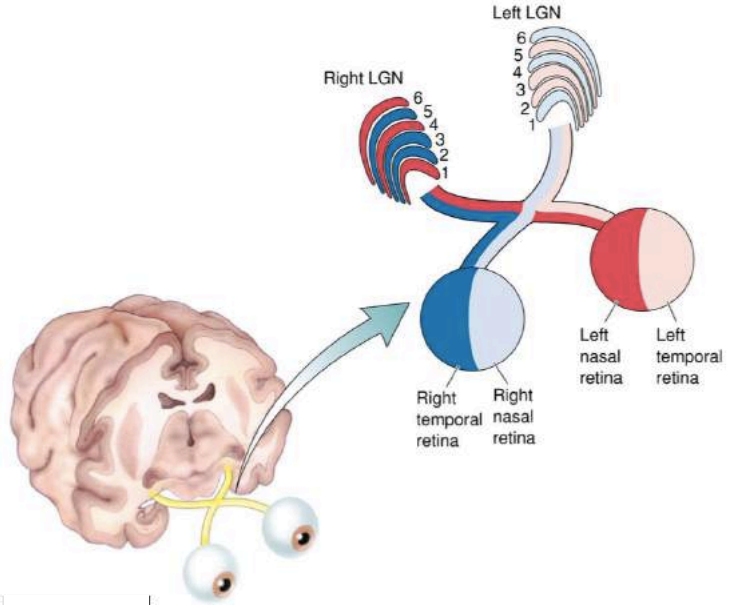


Non-thalamic Optic Tract Targets

- Hypothalamus → visual input has a large role in biological rhythms incl. sleep + wakefulness (circadian rhythm) bc detection of light
- Pretectum → motor role: control size of the pupil, eye movement = controls light
- Superior colliculus → orienting response
    - Orients eyes in response to new stimuli → move fovea to objects of interest
    - Where new info is added, we pay attention to it + perceive it

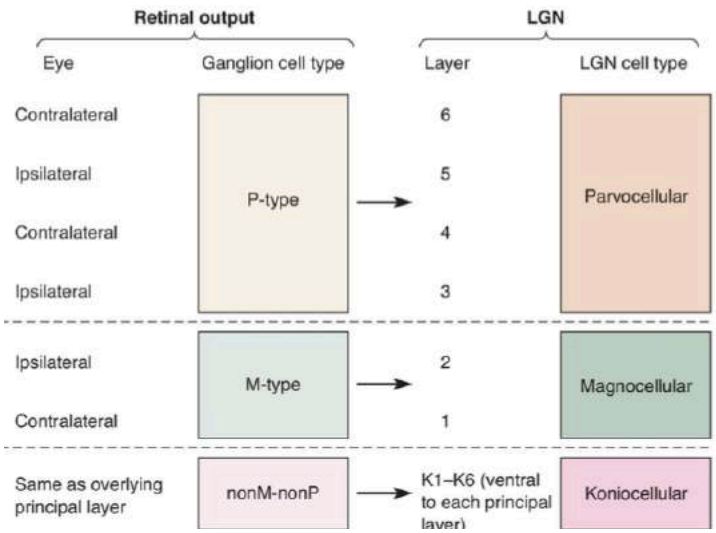
Retinal Inputs to the Lateral Geniculate Nucleus (LGN) Layers

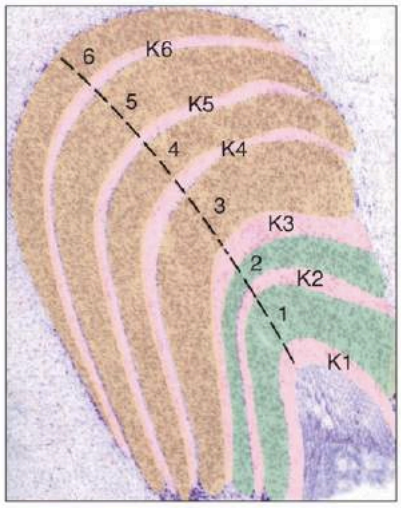
- Each layer of the LGN has a distinct left or right category
    - Portions of retina are divided in LGN
- Layer 1 = deepest in the brain, closest to white matter



Organisation of the LGN

- Inputs segregated by eye and ganglion cell type
- Each retinal cell activates slightly different parts of the ganglion based on cell type
- P + M have different responses → speed, information they carry differ
- nonM–nonP = 'everything else', function is not entirely known, theory they are involved in the spatial and temporal characteristics of vision





Receptive Fields

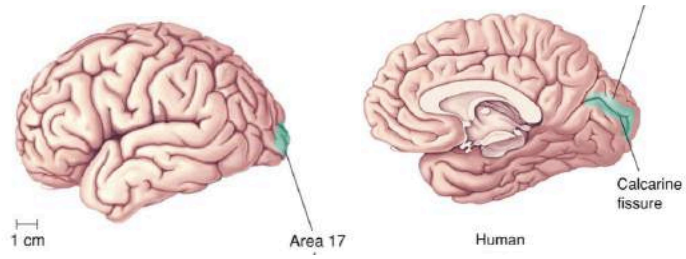
- Receptive fields of LGN neurons
    - Almost identical to the ganglion cells that feed them
    - Almost identical patterns as transmission progresses from step to step
- Magnocellular LGN neurons
    - Large center-surround receptive fields
    - Transient response, v fast but not activated for long time
    - Monochrome information, shape and orientation
    - Spatial position → vague
- Parvocellular LGN cells
    - Small center-surround receptive fields
    - Sustained response, slower but last longer
    - Colour vision
    - High spatial resolution → detail
- These cells carry information through the LGN independently

Non-retinal Inputs to the LGN

- Information from retina and optic nerve only constitutes 20% of info input into LGN
- Primary visual cortex provides 80% of the synaptic input to the LGN
    - Role not clearly identified
- "Top-down" modulation may gate "bottom-up" input from LGN back to cortex
    - "Top-down" = higher order brain structures modulate other pathways
    - Information coming into brain is controlled by what brain wants to see
- Could be related to alertness and attentiveness → orienting response
- Brain stem neurons provide modulatory influence on neuronal activity
    - First place you have discrepancy between what we see and what we perceive, affected by emotional state

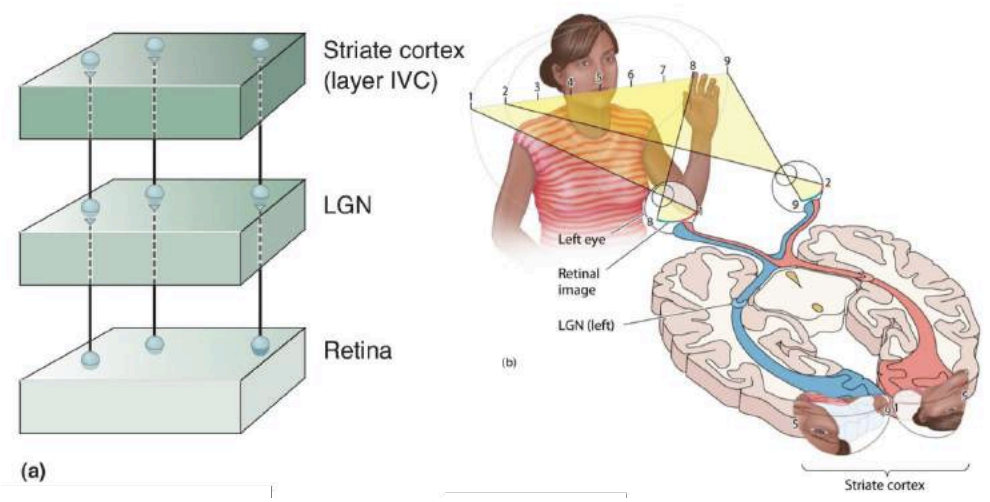
Striate Complex

- Primary visual cortex/striate cortex (Area 17)
- Where all information travels after LGN



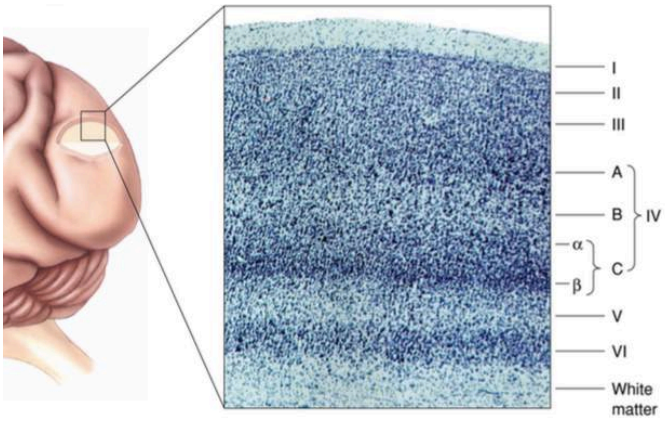
Retinotopy + Retinotopic Map of the Striate Complex

- Retinotopy = map of the visual field onto a target structure, carried between target structures
    - Retina, LGN, superior colliculus, striate cortex
    - Innervates same adjacent neurons
    - Neighbouring locations on retina project to neighbouring locations on LGN, which is then preserved again, and projected on the visual cortex
- Central visual field (fovea) overrepresented in map
    - Pay less attention to peripheral vision, need to correct the proportions
- Upper portion of cortex represents lower portion of visual space, and vice versa
    - Upside down map ∴ need to flip right way up
- Discrete point of light can activate many cells in the target structure due to overlapping receptive fields
- Perception is based on the brain's interpretation of distributed patterns of activity
    - NOT a literal map → 'activation pattern'



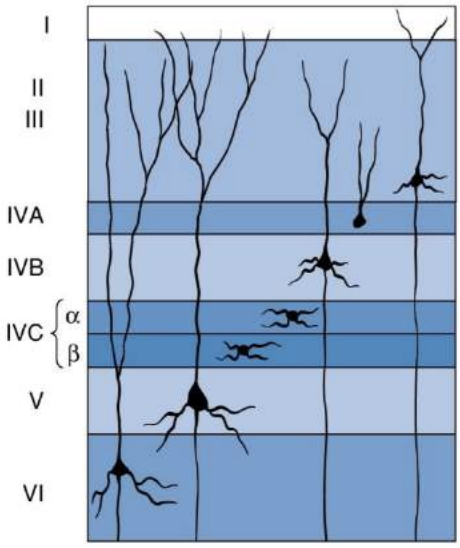
Cytoarchitecture of the Striate

- Layered structure (6)
- Directly under pia mater
  - I is outermost
  - VI is innermost, above white matter
- Each layer has different characteristics: cell body, density, neural structure, and inputs/outputs
- Scale: image ~2mm thick



Lamination of the Striate: Layers I to VI

- Spiny stellate cells:
  - Layer IVC
  - Spine-covered dendrites (send info across cells)
- Pyramidal cells:
  - Layers III, IVB, V, VI
  - Spines and thick apical dendrite
  - Projections across all layers
  - Only cell that sends information out of striate to other areas
    - ∴ further communication
    - E.g. approaching ball = send info to motor cortex
- Inhibitory neurons:
  - All cortical layers
  - Lack spines
  - Form local connections
  - Function as off switches



Inputs to the Striate Cortex: PROJECTION MAP IS STILL PRESERVED

- Magnocellular LGN neurons project primarily to layer IVCa
- Parvocellular LGN neurons project to layer IVCB
- Koniocellular LGN axons make synapses primarily in layers I and III