Νευροφυσιολογία και Αισθήσεις

Διάλεξη 9

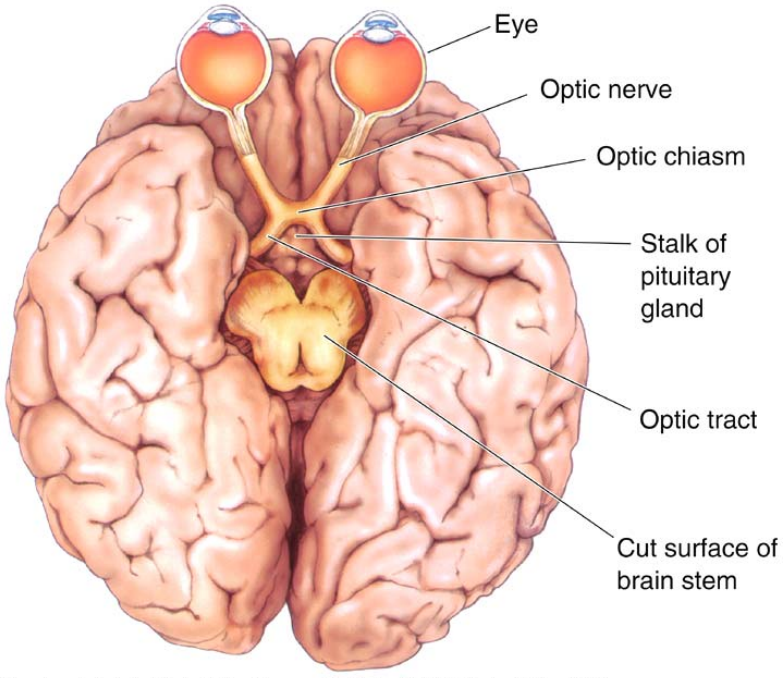
The Central Visual System

(Το Κεντρικό Οπτικό Σύστημα)

Biomedical Imaging & Applied Optics
University of Cyprus

Retinofugal Projection

- The Optic Nerve, Optic Chiasm, and Optic Tract



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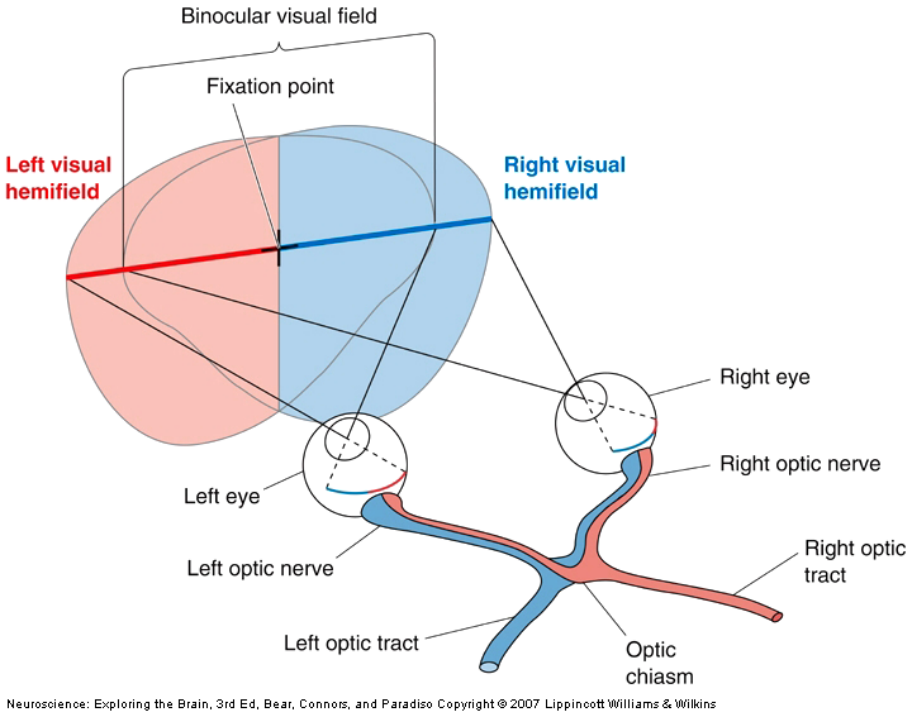
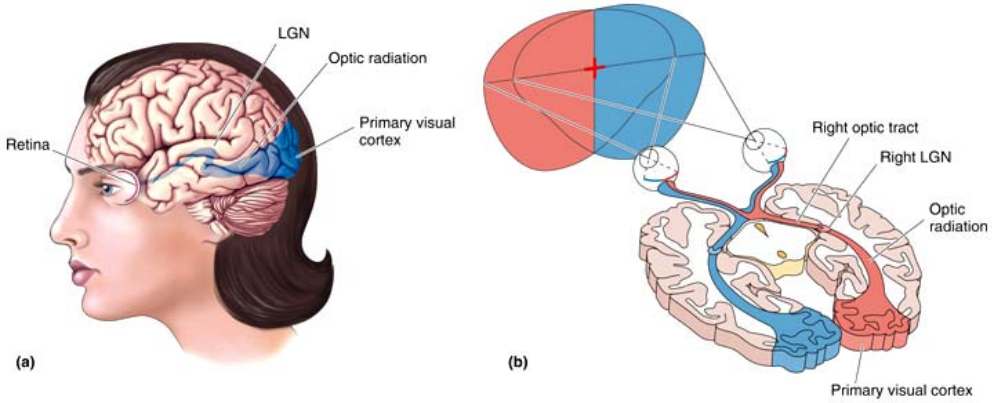
Retinofugal Projection

- **Right and Left Visual Hemifields**



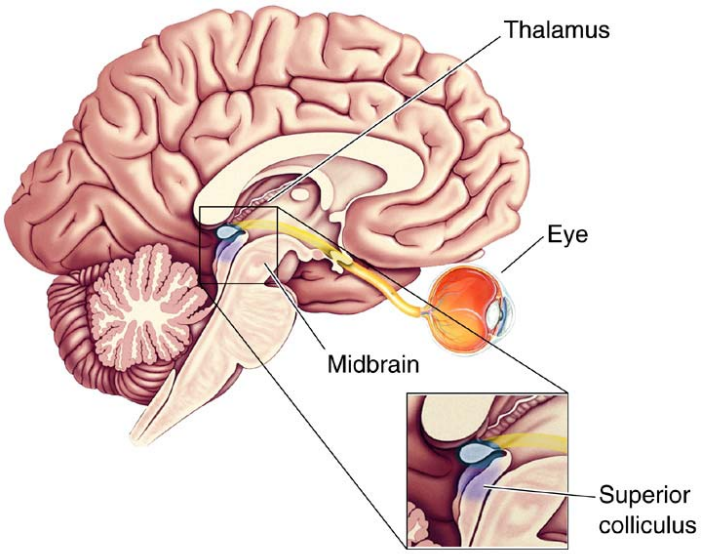
Retinofugal Projection

- **Targets of the Optic Tract**
  - Optic Tract
  - Thalamus
    - Lateral Geniculate Nucleus
  - Optic Radiation
  - Primary Visual Cortes
  - Extrastriate Areas



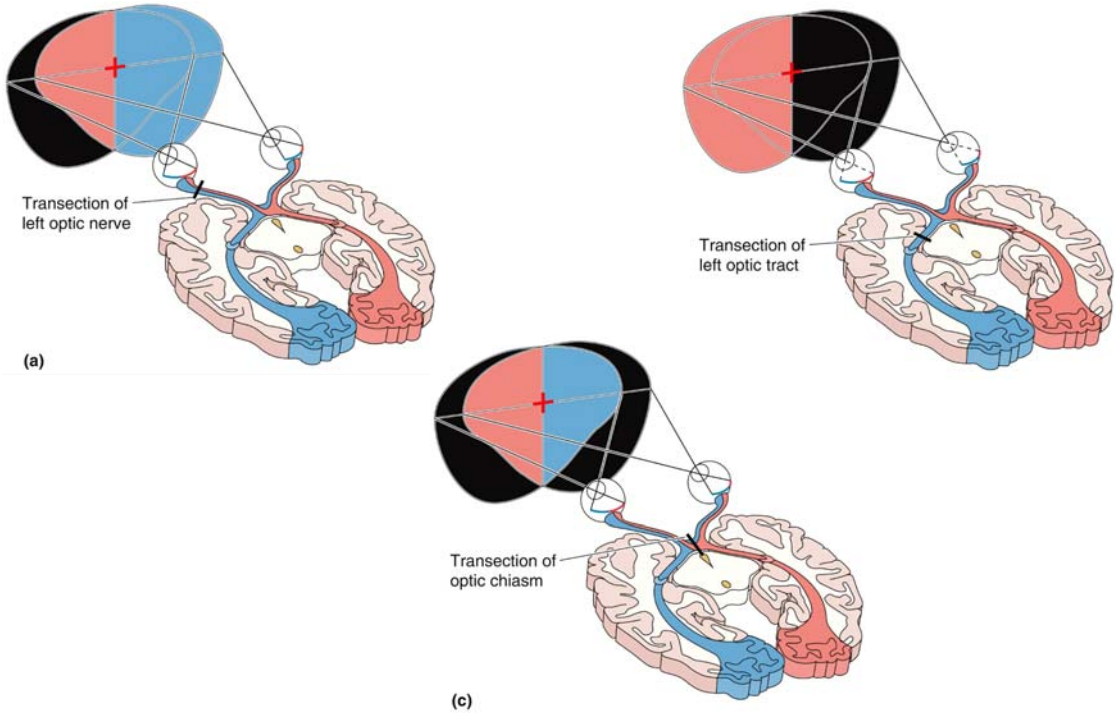
Retinofugal Projection

- **Nonthalamic Targets of the Optic Tract:**
  - Hypothalamus: Biological rhythms, including sleep and wakefulness
  - Pretectum (brain stem): Size of the pupil; certain types of eye movement
  - Superior colliculus (brain stem): Orients the eyes in response to new stimuli



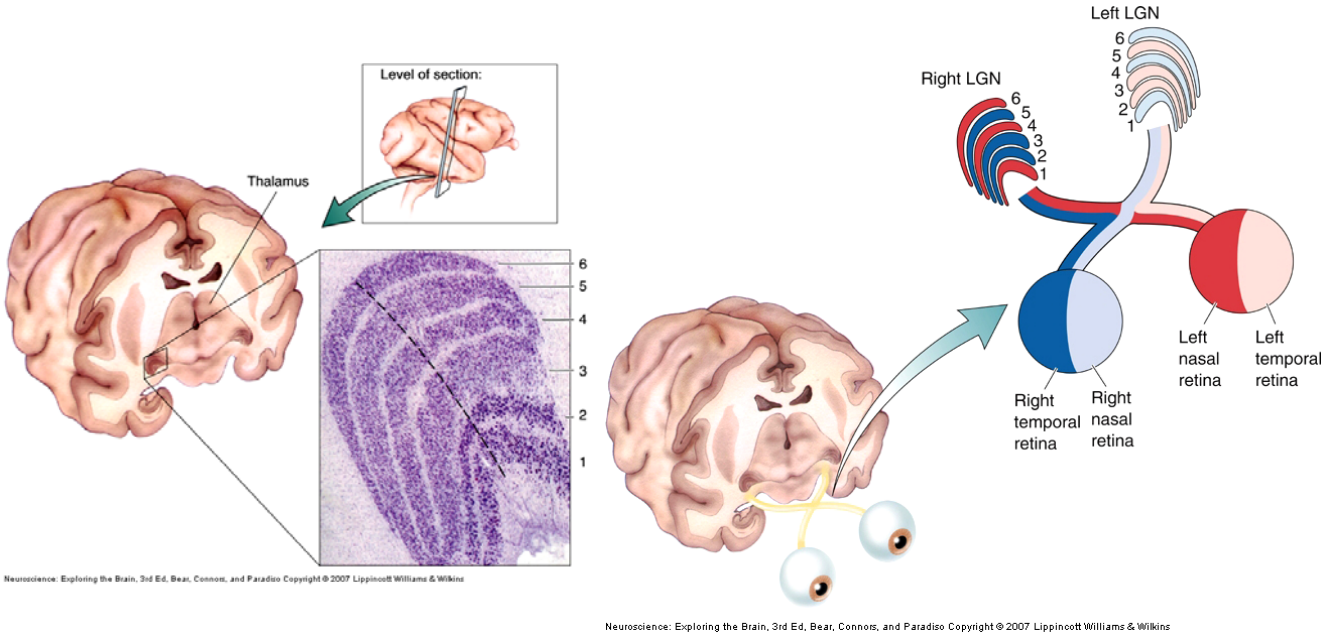
Retinofugal Projection

- **Pathway deficits**



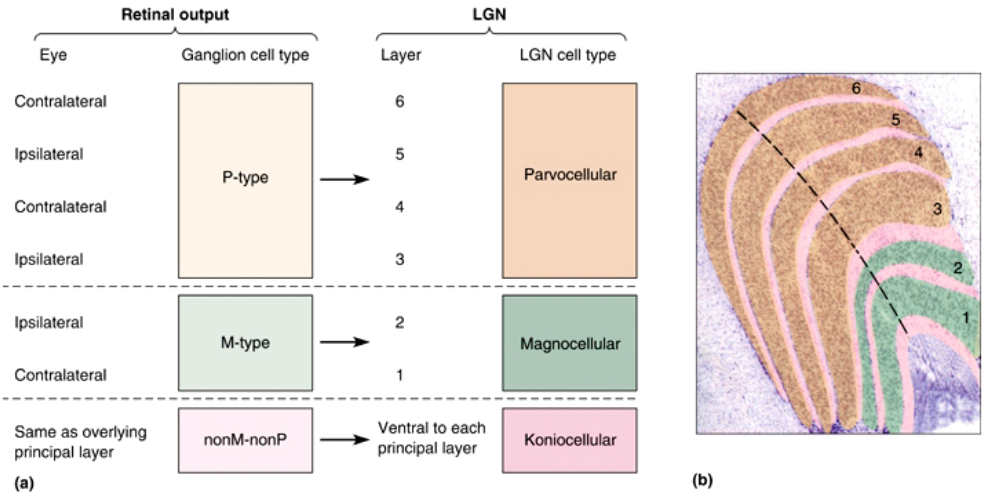
The Lateral Geniculate Nucleus (LGN)

- **Geniculate = like a knee**



The Lateral Geniculate Nucleus (LGN)

- **Receptive Fields**
  - Receptive fields of LGN neurons: Identical to the ganglion cells that feed them
  - Magnocellular LGN neurons: Large, monocular receptive fields with transient response
  - Parvocellular LGN cells: Small,monocular receptive fields with sustained response
- **The Segregation of Input by Eye and by Ganglion Cell Type**

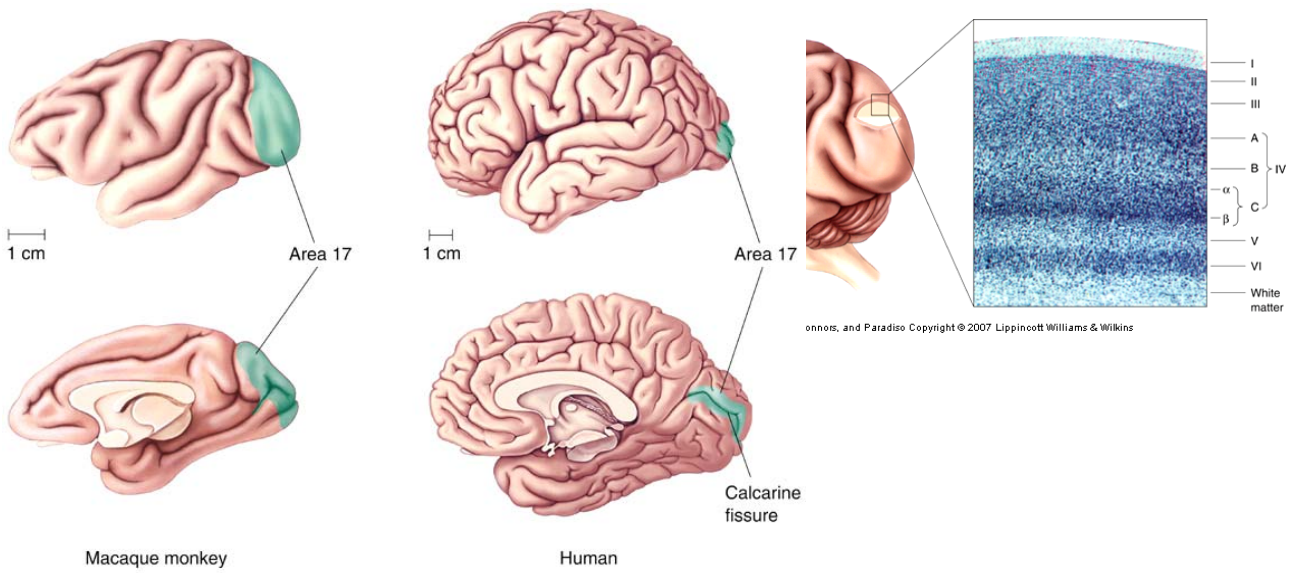


The Lateral Geniculate Nucleus (LGN)

- **Nonretinal Inputs to the LGN**
  - Retinal ganglion cells axons: Not the main source of synaptic input to the LGN
  - Primary visual cortex: 80% of the synaptic inputs
  - Neurons in the brain stem: Modulatory influence on neuronal activity

Anatomy of the Striate Cortex

- **Primary Visual Cortex**
  - or Broadman's area 17 or V1 or Striate Cortex



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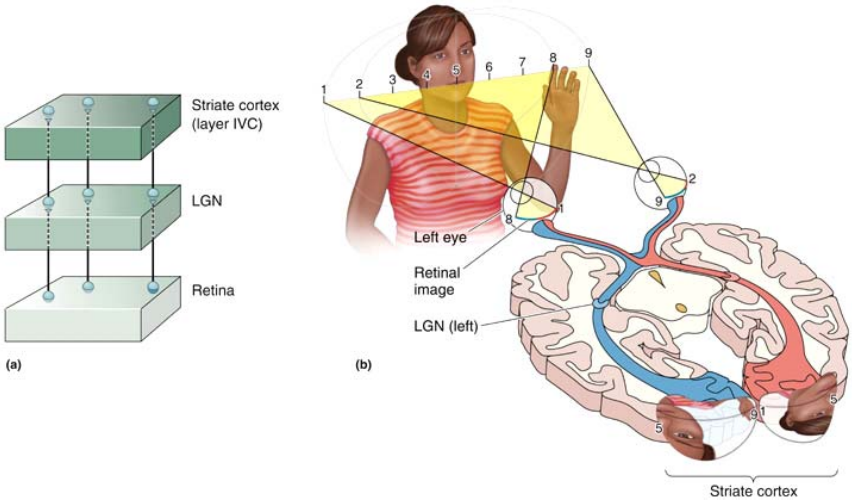
Anatomy of the Striate Cortex

- **Retinotopy**
  - Map of the visual field onto a target structure (retina, LGN, superior colliculus, striate cortex) - overrepresentation of central visual field
  - Discrete point of light: Activates many cells in the target structure
  - Perception: Based on the brain's interpretation of distributed patterns of activity

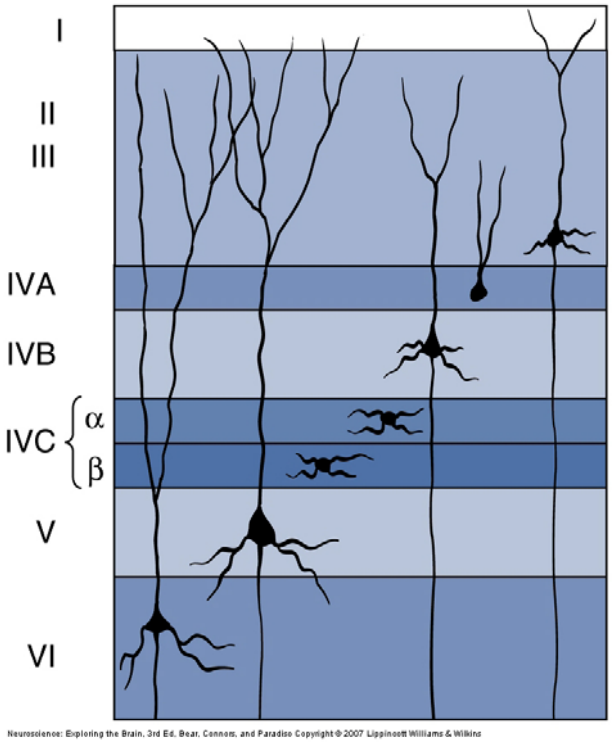


The picture is not entirely accurate!

We have many parallel pathways of information and interleaving

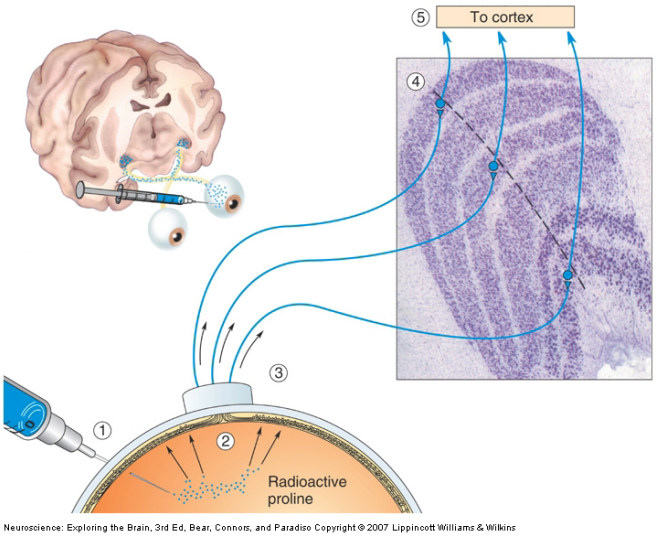
Anatomy of the Striate Cortex

- **Lamination of the Striate Cortex**
  - Layers I - VI
  - Spiny stellate cells
    - Spine-covered dendrites
    - Layer IVC
  - Pyramidal cells
    - Spines
    - Thick apical dendrite
    - Layers III, IVβ, V, VI
  - Inhibitory neurons
    - Lack spines
    - All cortical layers
    - Form local connections
- **Inputs to the Striate Cortex**
  - Magnocellular LGN neurons
    - Project to layer IVCα
  - Parvocellular LGN neurons
    - Project to layer IVCβ
  - Koniocellular LGN axons
    - Bypasses layer IV to make synapses in layers II and III



Anatomy of the Striate Cortex

- **Ocular Dominance Columns**
  - Input from LGN segmentd into equally spaced patches
  - Alternating (left or right eye)



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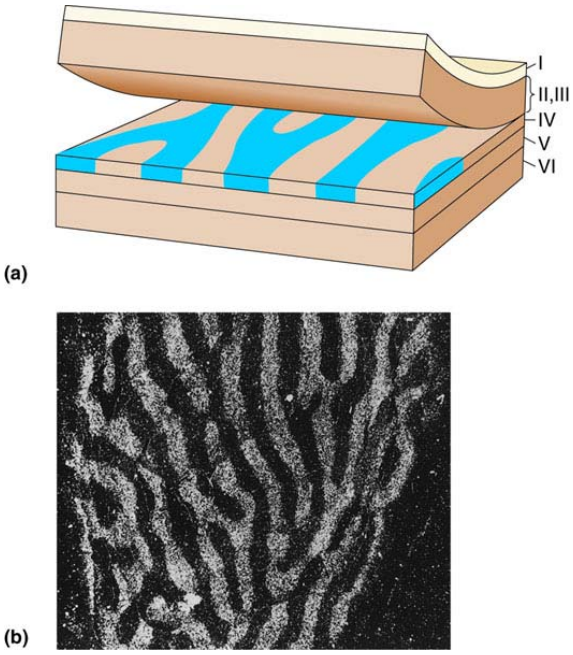
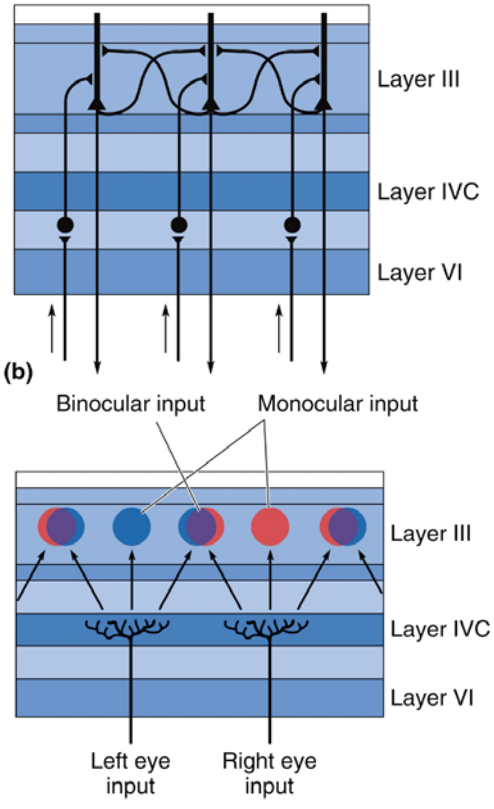


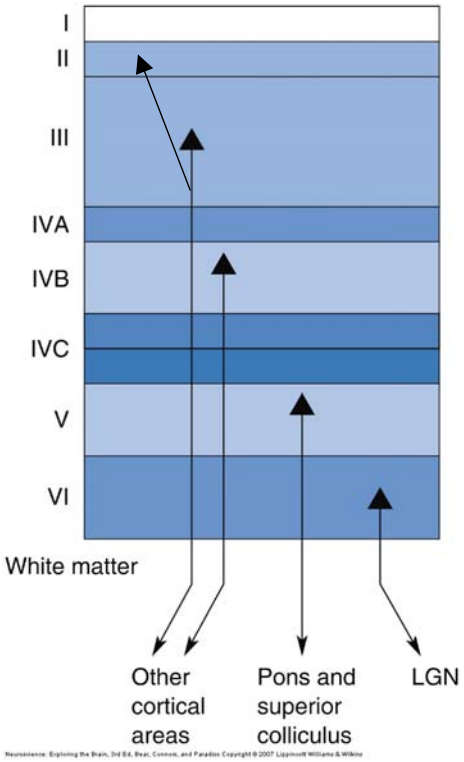
Anatomy of the Striate Cortex

- **Connections**
  - Different roles in the analysis of the visual world
  - Radial connections
    - Maintain retinotopy
  - Horizontal connections
    - Within layer III
- **Inputs to the Striate Cortex**
  - Layer IVC innervates superficial layers
    - Magno → IVCα → IVB
    - Parvo → IVCβ → III
  - Layers II and III have some binocular fields



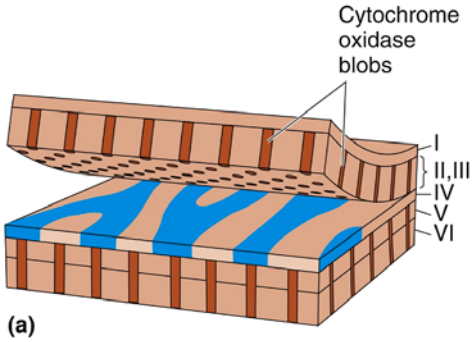
Anatomy of the Striate Cortex

- **Outputs of the Striate Cortex:**
  - Layers II, III, and IVB: Projects to other cortical areas
  - Layer V: Projects to the superior colliculus and pons
  - Layer VI: Projects back to the LGN

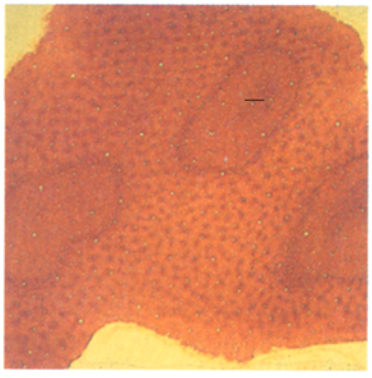


Anatomy of the Striate Cortex

- **Cytochrome Oxidase Blobs**
  - Layers II and III play a critical role in processing and output from V1
  - Cytochrome oxidase is a mitochondrial enzyme used for cell metabolism
  - Blobs: Cytochrome oxidase staining in cross sections of the striate cortex
    - Layers II & III as well as V and VI
  - Receive direct input from koniocellular cells as well as parvo- and magno-cellular input from IVC



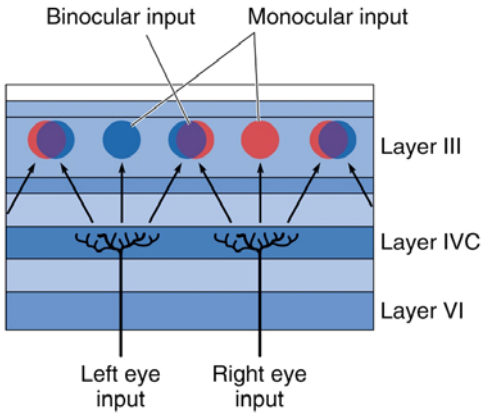
(a)



(b)

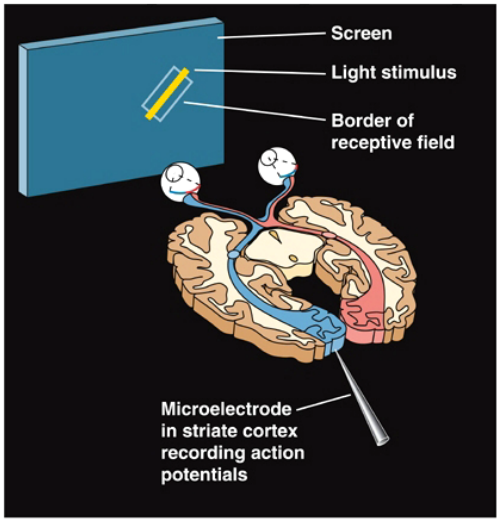
Physiology of the Striate Cortex

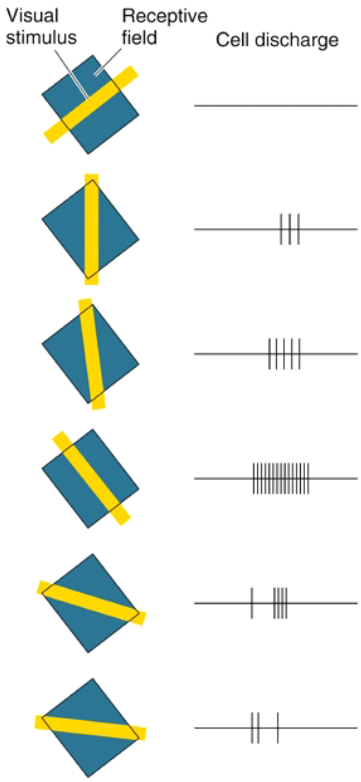
- **Input**
  - Magno → IVCα → IVB
  - Parvo → IVCβ → III
  - Konio → Blobs (II & III)
- **Receptive Fields**
  - Layer IVC: Monocular; center-surround
    - Layer IVCα: Insensitive to the wavelength
    - Layer IVCβ: Center-surround color opponency
- **Binocularity**
  - Layers superficial to IVC
  - First binocular receptive fields in the visual pathway



Physiology of the Striate Cortex

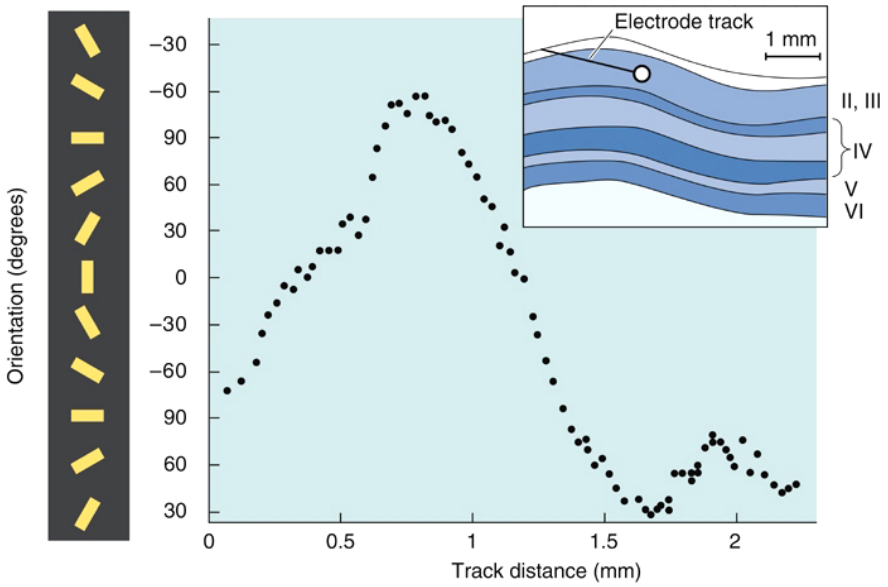
- **Receptive Fields Outside IVC**
  - Orientation Selectivity





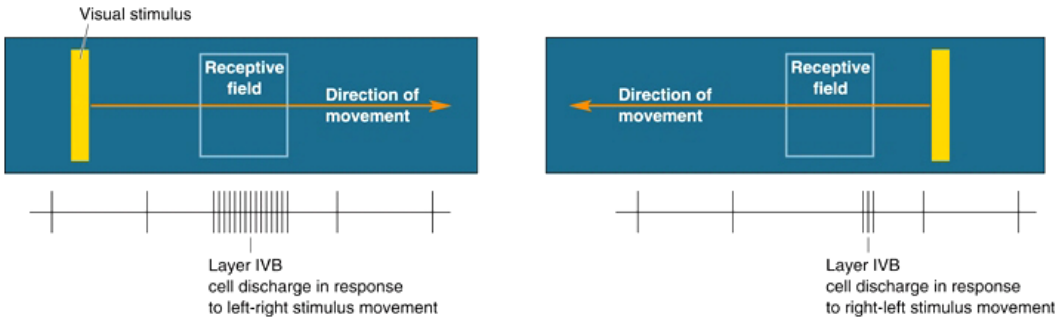
Physiology of the Striate Cortex

- **Receptive Fields Outside IVC**
  - Orientation Selectivity
    - Orientation radial columns



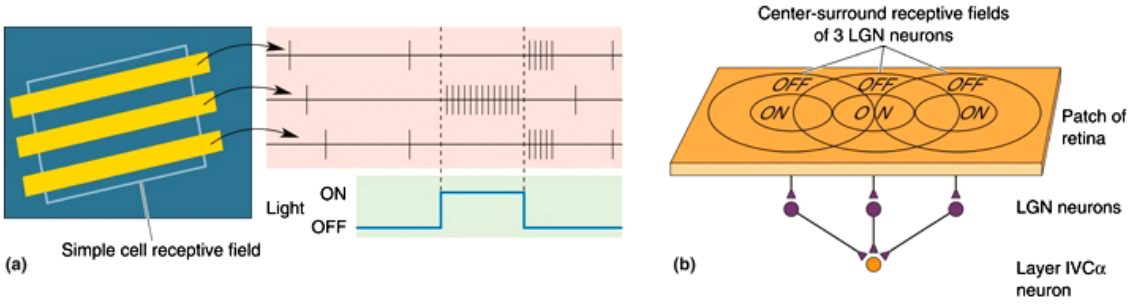
Physiology of the Striate Cortex

- **Receptive Fields in IVB**
  - Direction Selectivity
    - Neuron fires action potentials in response to moving bar of light
    - IVB (input from magnocellular)



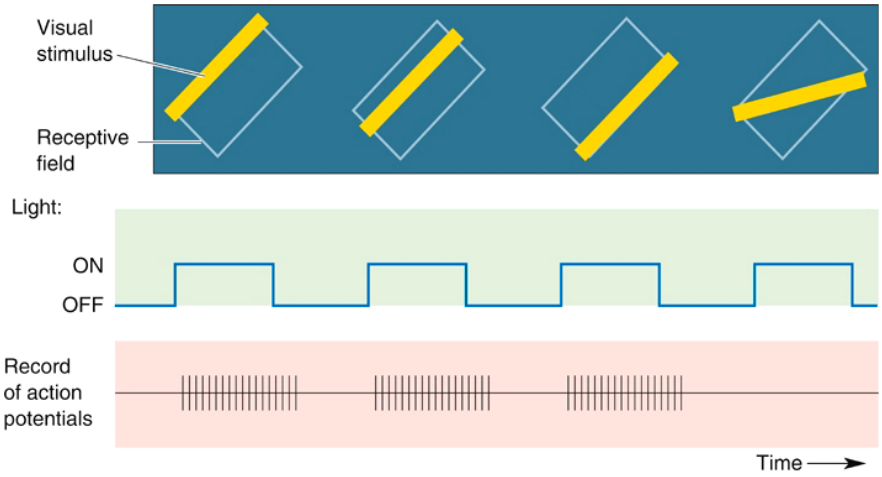
Physiology of the Striate Cortex

- **Receptive Fields**
  - Simple cells
    - Binocular; Orientation-selective
    - Elongated on-off region with antagonistic flanks
    - Responds to optimally oriented bar of light
    - Possibly composed of three LGN cell axons with center-surround receptive fields



Physiology of the Striate Cortex

- **Receptive Fields**
  - Complex cells
    - Binocular
    - Orientation-selective
    - ON and OFF responses to the bar of light but unlike simple cells, no distinct on-off regions



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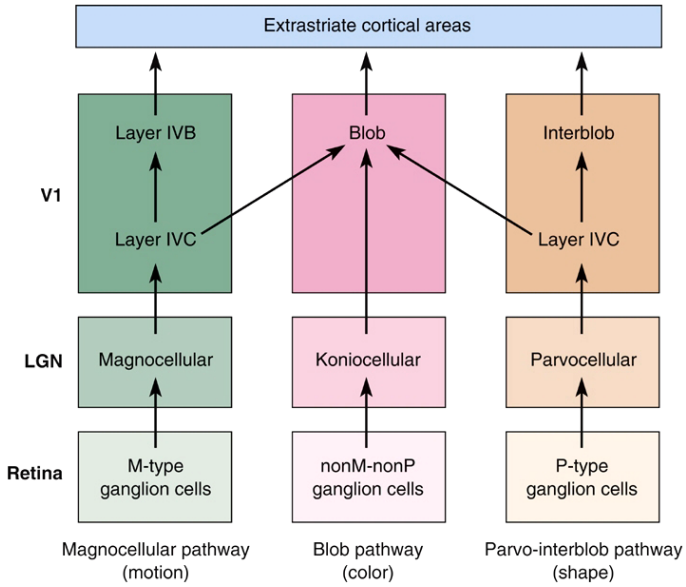
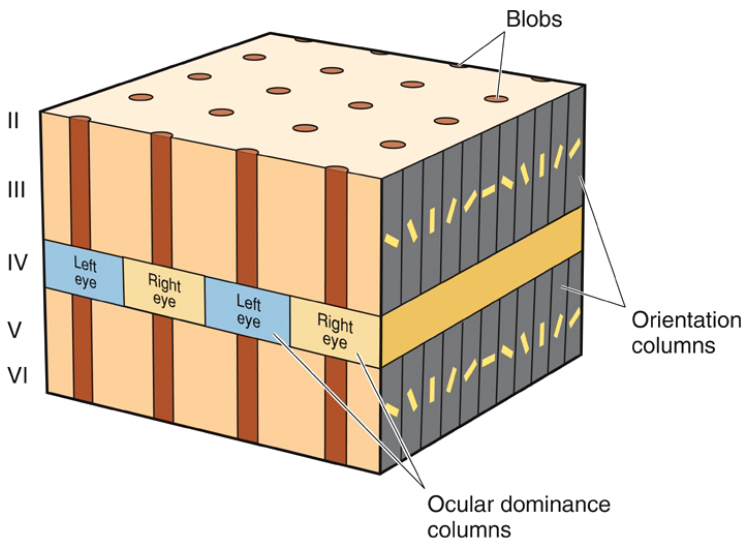
Physiology of the Striate Cortex

- **Parallel Pathways**
  - Magnocellular
    - Analysis of motion and guidance of motor actions
    - Large receptive fields, transient response, binocular, simplex & complex, orientation & dierection selective, not wavelength sensitive
  - Parvo Interblob
    - Analysis of fine objects
    - Small receptive fields, sustained response, binocular, simplex & complex, orientation & dierection selective, not wavelength sensitive
  - Blob (Koniocellular)
    - Analysis of object color
    - Canter-surround, color opponent, monocular, not orientation & dierection selective
  - Mixing
    - Useless contamination or integration?



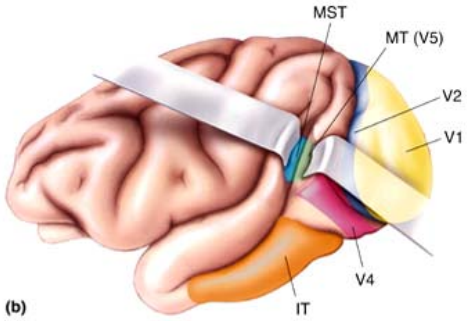
Physiology of the Striate Cortex

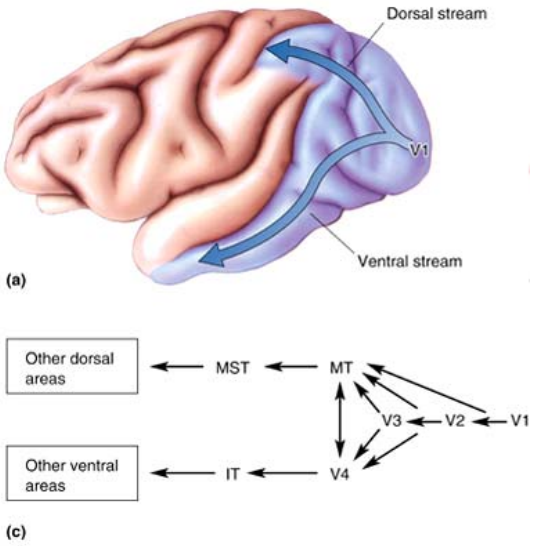
- **Cortical Module**
  - Each processing a section of the scene



Beyond Striate Cortex

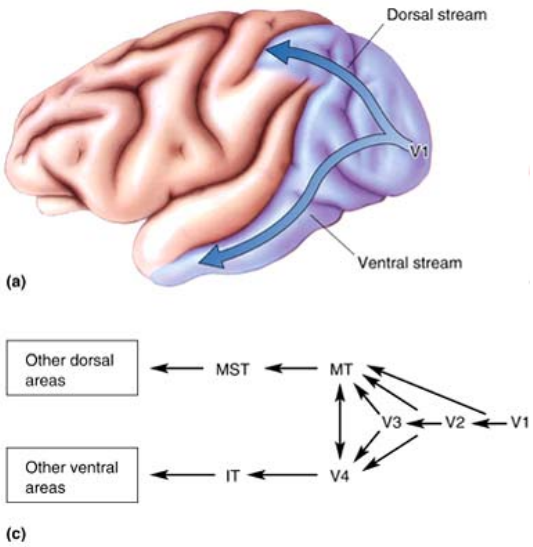
- **Dorsal stream**
  - Analysis of visual motion and the visual control of action
- **Ventral stream**
  - Perception of the visual world and the recognition of objects





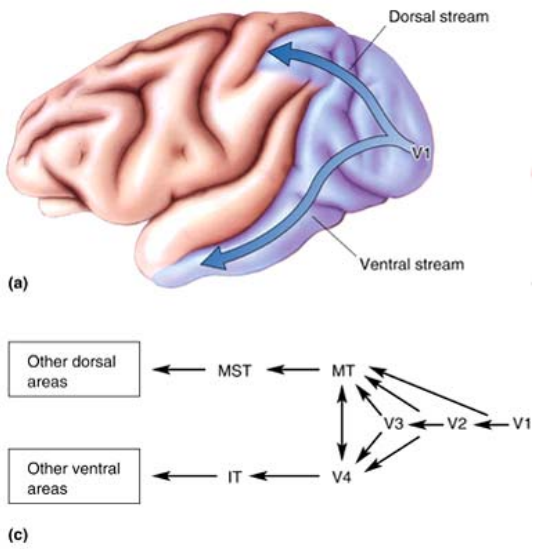
Beyond Striate Cortex

- **The Dorsal Stream (V1, V2, V3, MT, MST, Other dorsal areas)**
  - Analysis of visual motion and the visual control of action
  - Area MT (temporal lobe)
    - Most cells: Direction-selective; Respond more to the motion of objects than their shape
  - Beyond area MT - Three roles of cells in area MST (parietal lobe)
    - Navigation
    - Directing eye movements
    - Motion perception



Beyond Striate Cortex

- **The Ventral Stream (V1, V2, V3, V4, IT, Other ventral areas)**
  - Perception of the visual world and the recognition of objects Area V4
    - Achromatopsia: Clinical syndrome in humans-caused by damage to area V4; Partial or complete loss of color vision
  - Area IT
    - Major output of V4
    - Receptive fields respond to a wide variety of colors and abstract shapes
    - Prosopoagnosia: syndrome of not recognizing faces; highly face-selective neurons



From Single Neurons to Perception

- **Visual perception**
  - Identifying & assigning meaning to objects
- **Hierarchy of complex receptive fields**
  - Retinal ganglion cells: Center-surround structure, Sensitive to contrast, and wavelength of light
  - Striate cortex: Orientation selectivity, direction selectivity, and binocularity
  - Extrastriate cortical areas: Selective responsive to complex shapes; e.g., Faces
- **From Photoreceptors to Grandmother Cells**
  - Grandmother cells: Face-selective neurons in area IT?
  - Probably not: Perception is not based on the activity of individual, higher order cells
- **Parallel Processing and Perception**
  - Groups of cortical areas contribute to the perception of color,motion, and identifying object meaning
- **Parallel processing**
  - Like the sound produced by an orchestra of visual areas rather than the end product of an assembly line

Επόμενη Διάλεξη …

Διάλεξη 10

Χημικές Αισθήσεις

(Chemical Senses)