Optic Nerve Projections

Optic nerves meet, enter the brain, and cross at the **optic chiasm.** After optic chiasm, the nerve fibers are called the **optic tract.**

Optic nerve from each eye projects partly to contralateral cortex, partly to ipsilateral cortex.

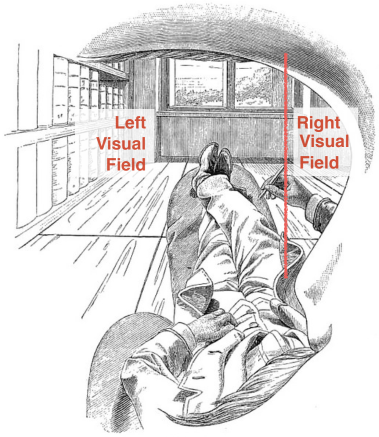
Ganglion cell axons are sorted so that:

Cells responsive to **left** visual field (from nose to the left) project to **right** cortex.

Cells responsive to **right** visual field (from nose to the right) project to **left** cortex.

So damage to **left** visual cortex causes loss of sight off all of **right** visual field (from nose to the right).

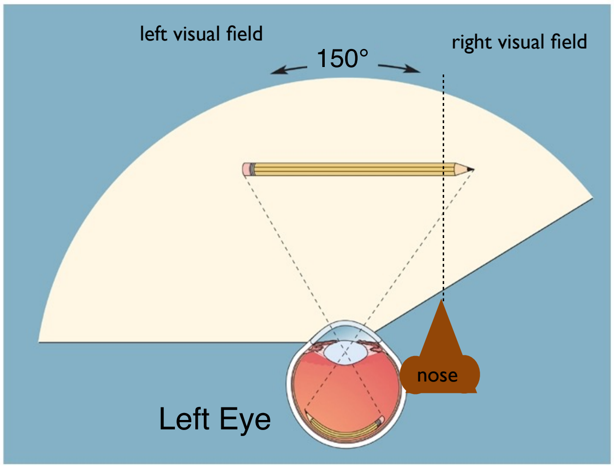
Self-Portrait by Ernst Mach (1886)

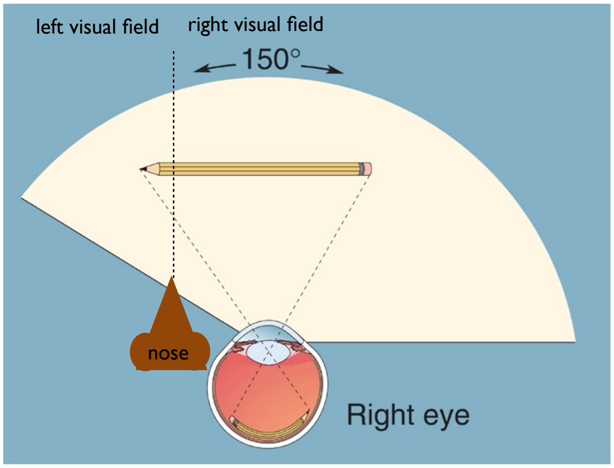


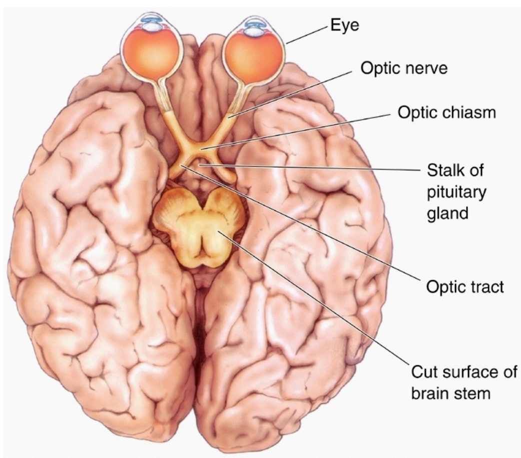
Figur 1.

"View from the left eye"

http://publicdomainreview.org/collections/self-portrait-by-ernst-mach-1886/




left visual field
right visual field
150°
nose
Right eye


Eye
Optic nerve
Optic chiasm
Stalk of pituitary gland
Optic tract
Cut surface of brain stem

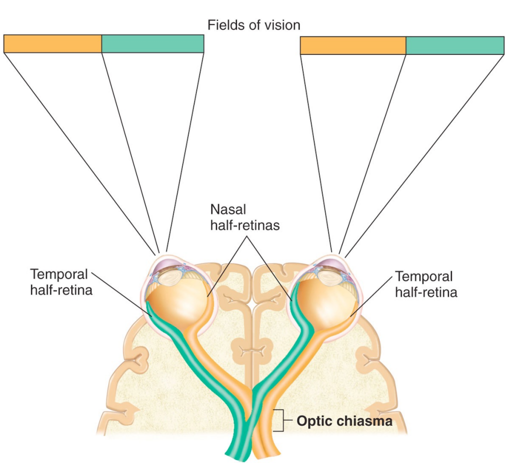
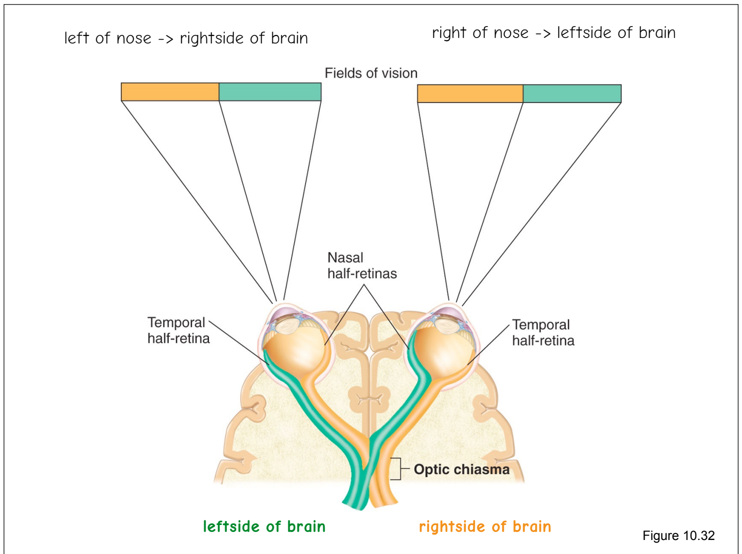
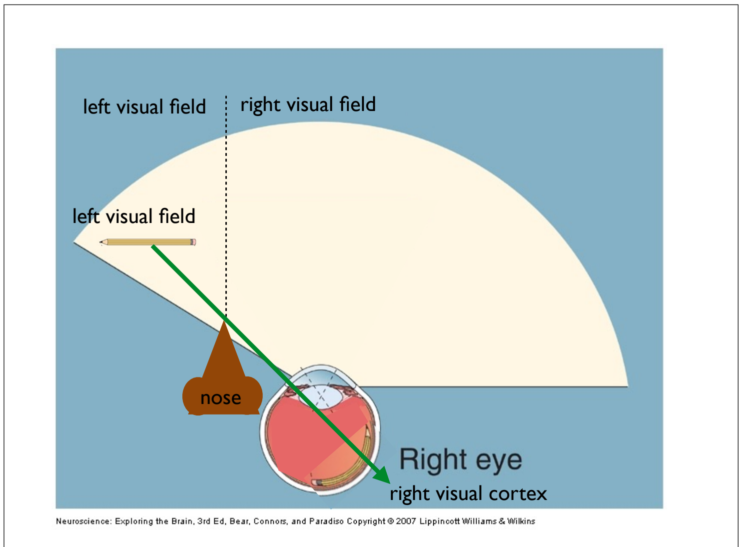
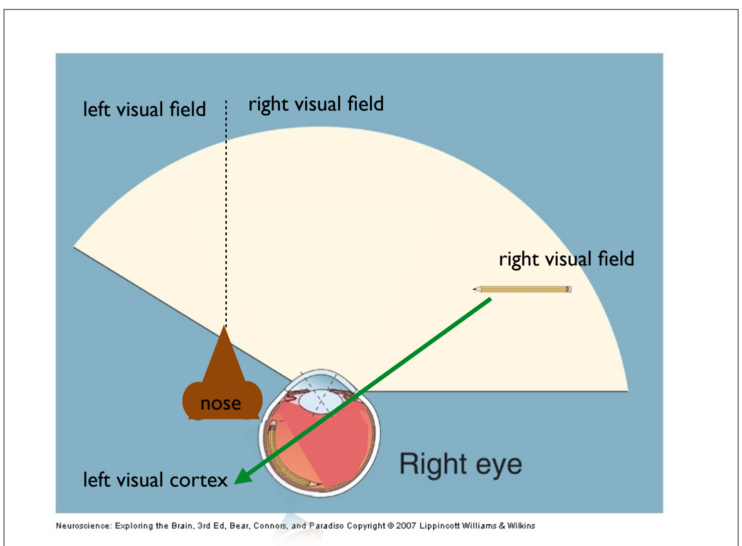

Fields of vision
Nasal half-retinas
Temporal half-retina
Temporal half-retina
Optic chiasma

Figure 10.32


left of nose -> rightside of brain
right of nose -> leftside of brain
Fields of vision
Nasal half-retinas
Temporal half-retina
Temporal half-retina
Optic chiasma
leftside of brain
rightside of brain
Figure 10.32


left visual field
right visual field
left visual field
nose
Right eye
right visual cortex
Neuroscience: Exploring the Brain, 3rd Ed, Bear, Connors, and Paradiso Copyright © 2007 Lippincott Williams & Wilkins


left visual field
right visual field
right visual field
nose
Right eye
left visual cortex
Neuroscience: Exploring the Brain, 3rd Ed, Bear, Connors, and Paradiso Copyright © 2007 Lippincott Williams & Wilkins

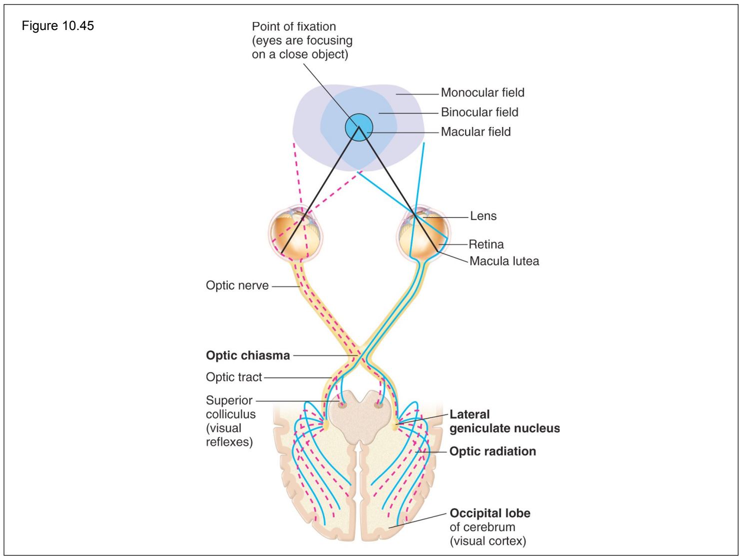
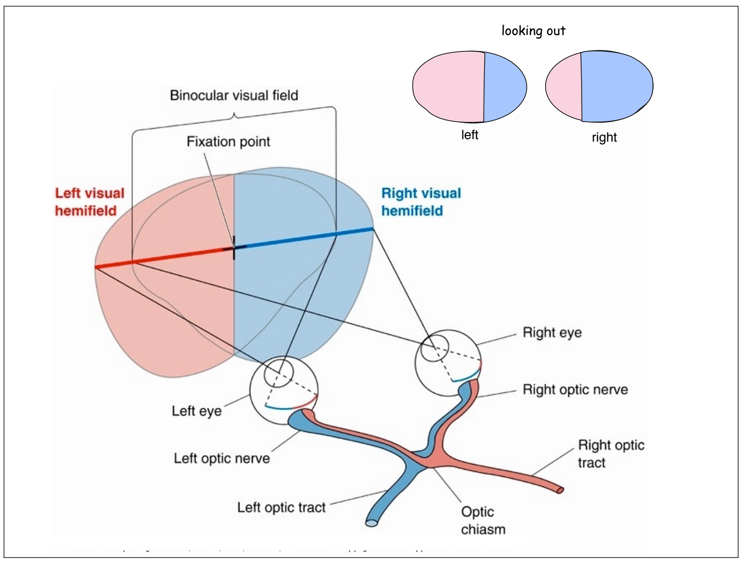
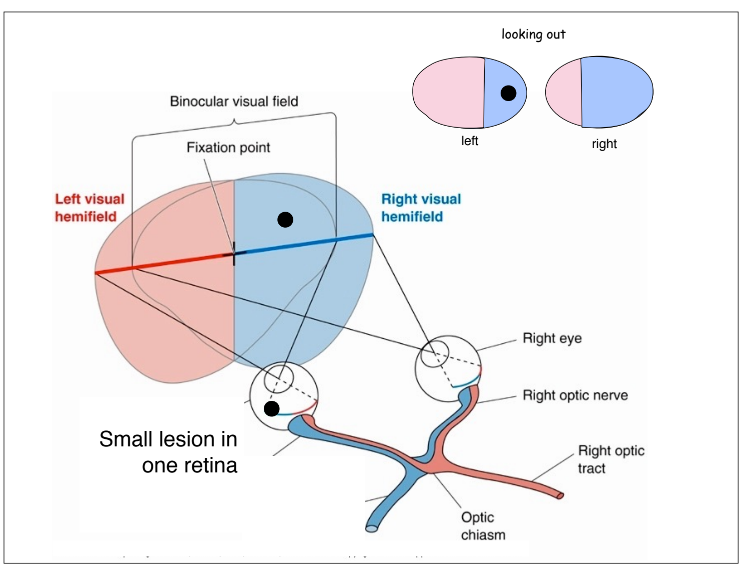
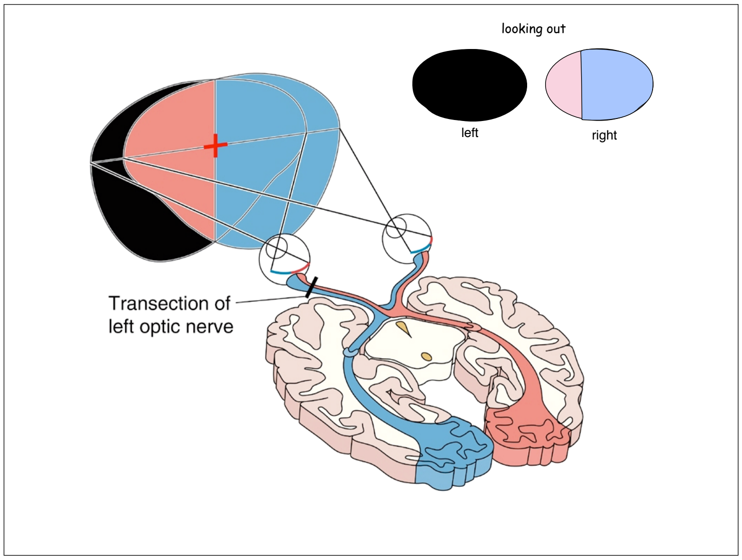
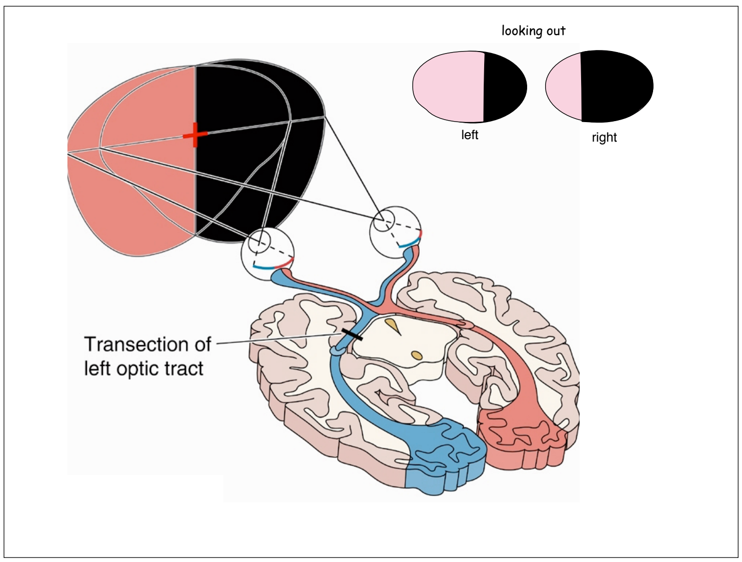


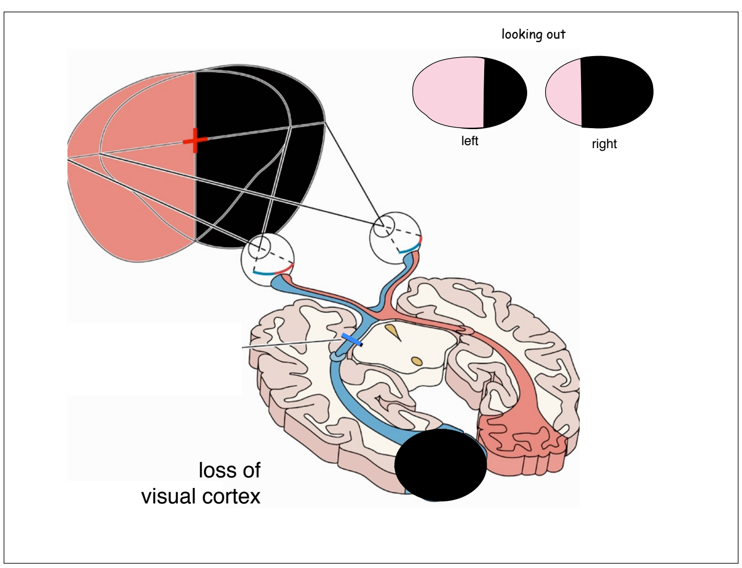
Figure 10.45
Point of fixation
(eyes are focusing
on a close object)
Monocular field
Binocular field
Macular field
Lens
Retina
Macula lutea
Optic nerve
Optic chiasma
Optic tract
Superior
colliculus
(visual
reflexes)
Lateral
geniculate nucleus
Optic radiation
Occipital lobe
of cerebrum
(visual cortex)

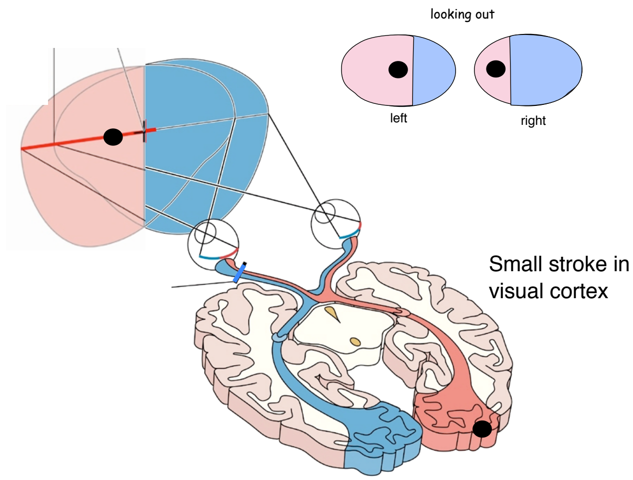

looking out
left
right
Binocular visual field
Fixation point
Left visual
hemifield
Right visual
hemifield
Right eye
Right optic nerve
Left eye
Left optic nerve
Right optic
tract
Left optic tract
Optic
chiasm

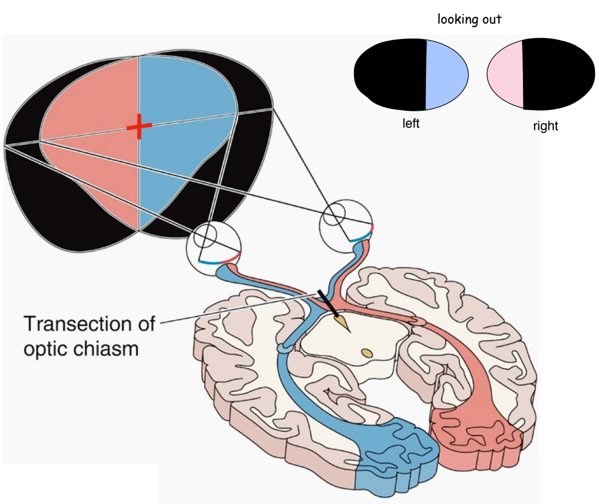

looking out
left
right
Binocular visual field
Fixation point
Left visual
hemifield
Right visual
hemifield
Right eye
Right optic nerve
Small lesion in
one retina
Right optic
tract
Optic
chiasm


looking out
left
right
Transection of
left optic nerve


looking out
left
right
Transection of
left optic tract


looking out
left
right
loss of
visual cortex





Feature Extraction by Visual Cortex

Primary Visual Cortex (V1) contains simple and complex cells

Simple cells
respond to orientation of stimulus at a specific spot in visual field; built up from input of ganglion cells

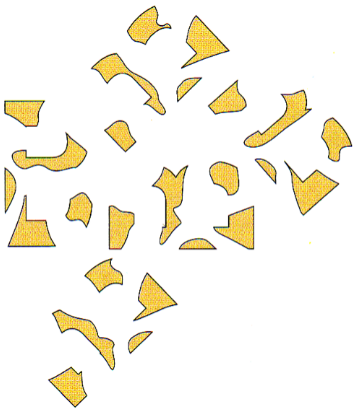
Complex cells
respond to orientation & direction of movement anywhere in the field; built up from input of simple cells

Extrastriate Cortices receives input from visual cortex V1

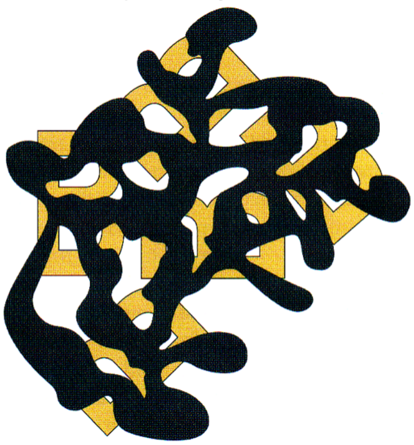
Dorsal Pathway (Visual Cortex -> Parietal Cortex)
- Action or spatial tasks - “where” info
- Lesions -> can’t pick up or orient objects

Ventral Pathway (Visual Cortex -> Temporal Lobe, speech centers)
- Form recognition - “what info”
- Lesions -> can’t recognize or describe objects & orientations, but visually guided motor responses okay

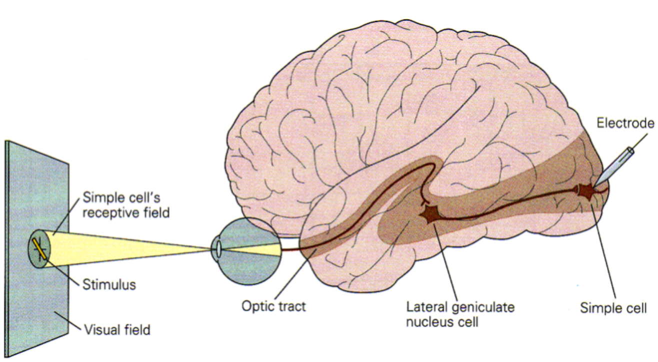
More to vision than just edges



More to vision than just edges



Testing the Cortical Response



Receptive Field of a Neuron

- Area on the surface of the sense organ which, when stimulated, causes a response in the neuron (activates or inhibits firing).
- Usually overlaps with receptive field of other neurons
- Variable size at different sites; smaller receptive field gives better acuity (smaller in fovea, bigger at periphery)
- Can be mapped at different levels of the nervous system (retinal ganglion cells, LGN, visual cortex)
- Often forms a topographically similar map of sense organ surface across surface of neurons.
- Determined empirically by probing surface and recording response of a neuron.

Tuning or Selectivity of a Neuron

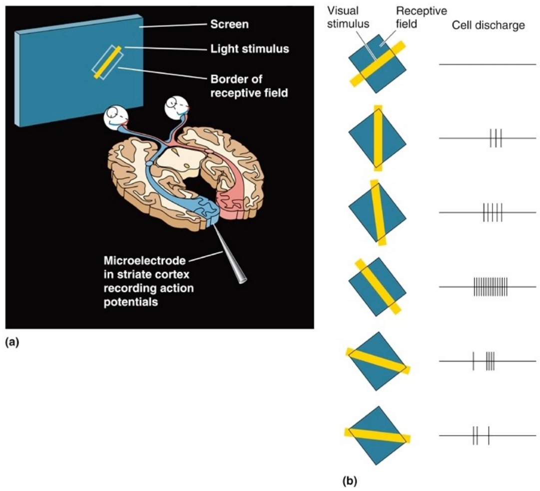
- Analogous to Receptive Field, but instead of spatial dimension, refers to another feature
- For example:
  - color of light, orientation of a bar
  - texture of an object, temperature of an object
  - taste quality
  - molecular feature of an odorant
- May be organized into topographic maps of tuning surface across surface of neurons (audition), but not always (taste)
- Again, determined empirically

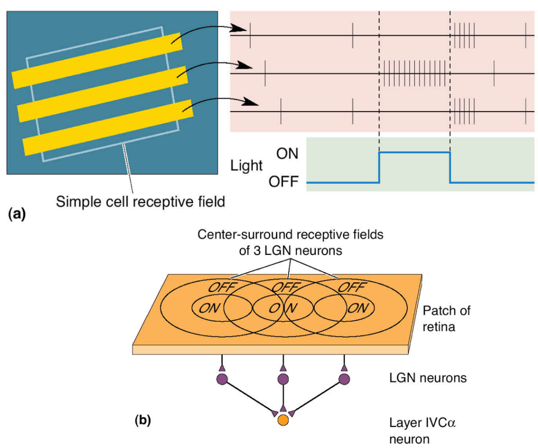
Hubel & Weisel Video
Recording from visual cortex of cat while it looks at visual stimulus on projection screen

https://www.youtube.com/watch?v=IOHayh06LJ4

https://www.youtube.com/watch?v=UU2esxycMAw

Simple Cell Response to Bar of Light





Simple Cell Response to Bar of Light

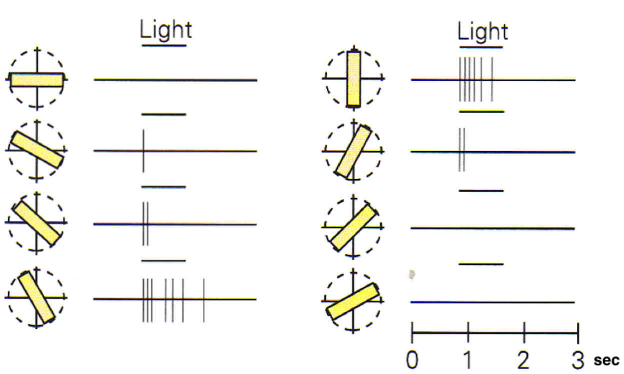
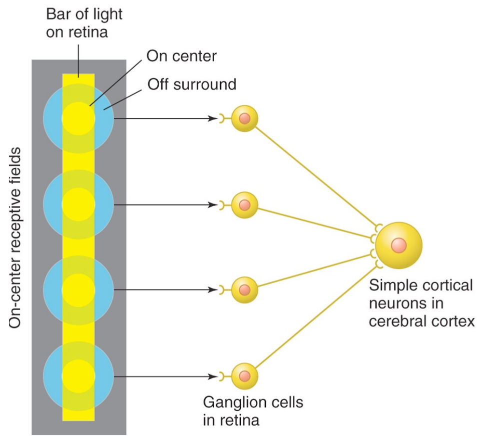
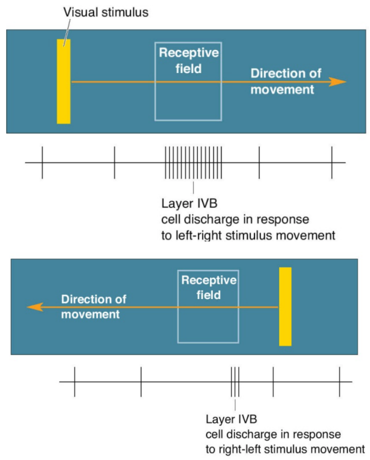


Figure 10.48 **Several ganglion cells -> 1 Simple cell**



Complex Cell responds to bar of light moving in specific direction



Cortical Architecture

3 overlapping cell types (categorized by their response patterns)

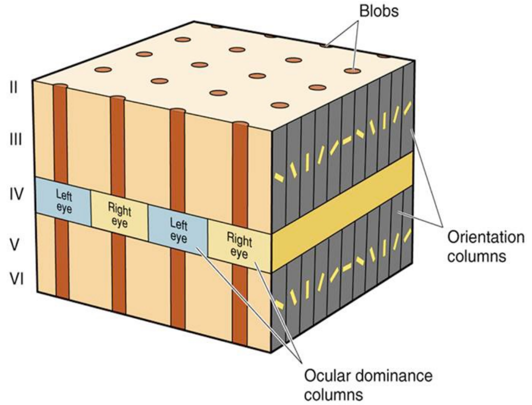
Orientation columns
columns of cortex that are arranged cells that respond to orientations

Color Blobs
groups of cells that respond to one color

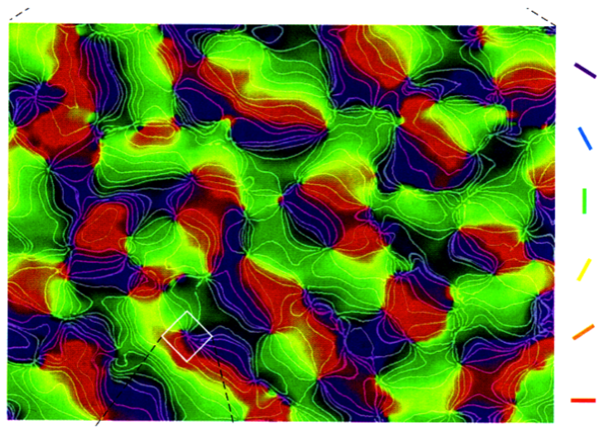
Ocular dominance columns
ribbons of columns that get input from one eye or the other.

Cortical Module

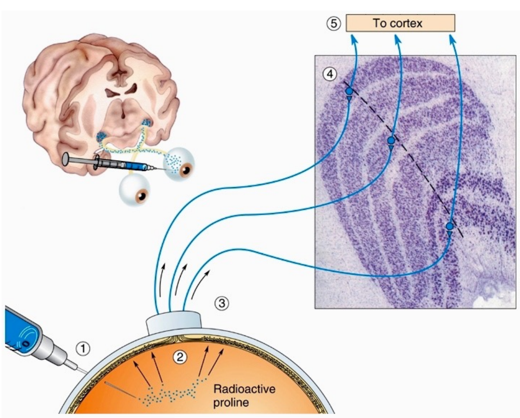
- Each module capable of analyzing every aspect of a portion of the visual field



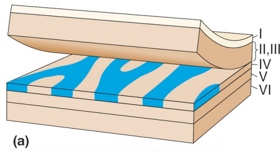
Orientation Columns from surface of cortex

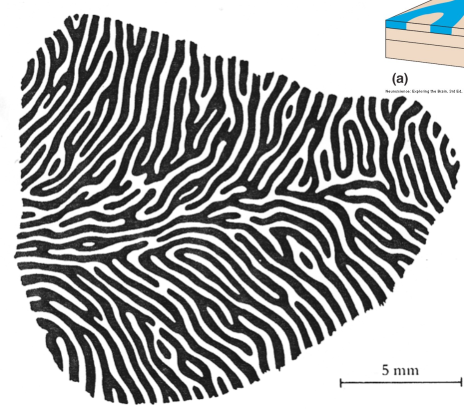


Ocular Dominance Columns



Ocular Dominance Columns





Inject one eye with radioactive proline. Transported transynaptically to cortical cells

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

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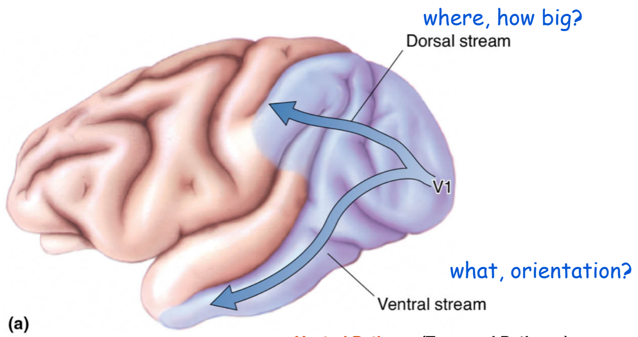
Form recognition - “what info”
Lesions -> can’t recognize or describe objects & orientations, but visually guided motor responses okay

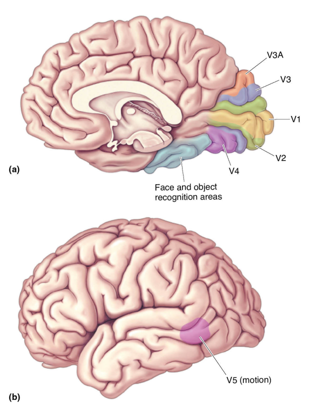
Extrastriate pathways beyond V1 for visual info:

Dorsal Pathway (Parietal Pathway)
- Action or spatial tasks - "where" info
- Lesions -> can't pick up or orient objects

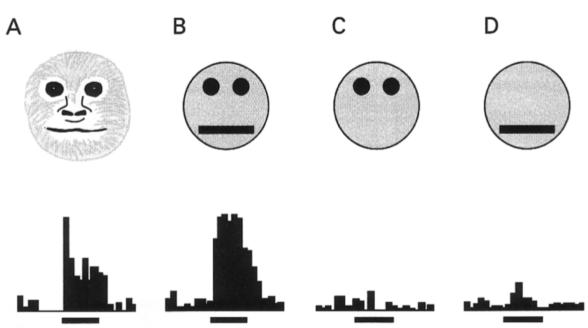


Ventral Pathway (Temporal Pathway)
- Form recognition - "what info"
- Lesions -> can't recognize or describe objects & orientations, but motor okay

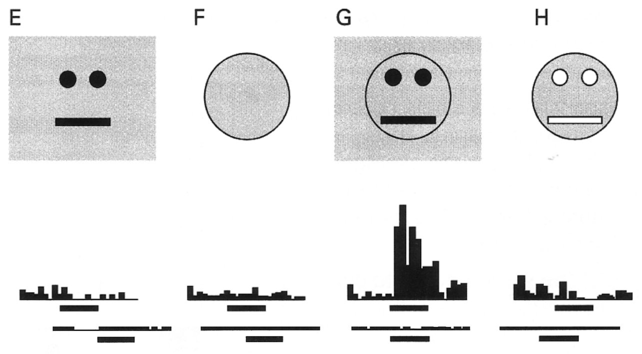
Visual Areas in Human Brain



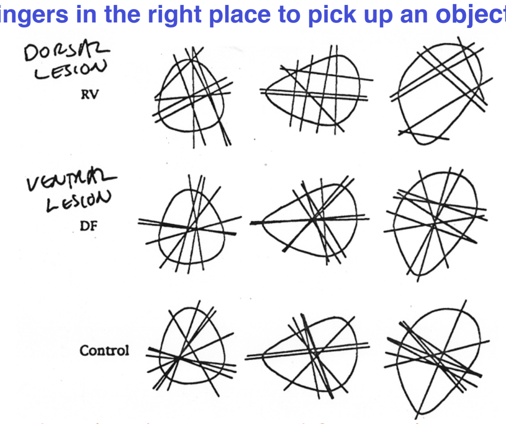
Beyond the visual cortex: shape detection in temporal cortex



Beyond the visual cortex: shape detection in temporal cortex



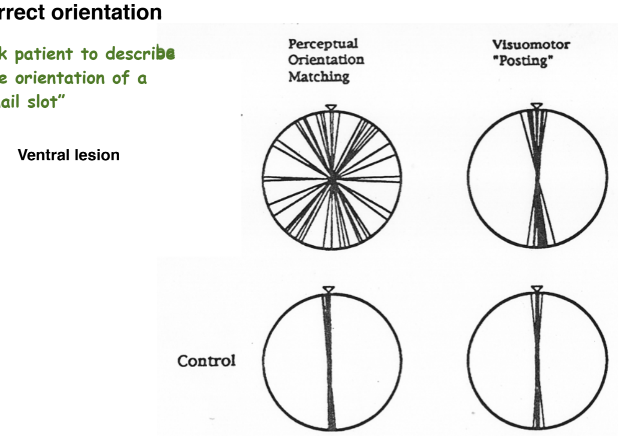
Task -- pick up an object
Patients with dorsal lesions cannot use vison to place their fingers in the right place to pick up an object



so dorsal pathway required for visual **motor** skills

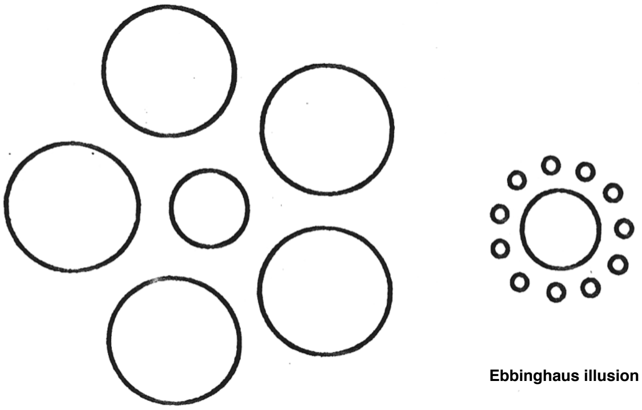
Ventral lesion:
can't recognize orientation of card, but can move card to correct orientation

ask patient to describe the orientation of a "mail slot"



so ventral pathway required for **perception** of visual scene

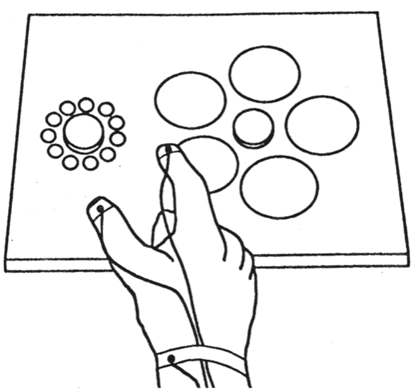
Normal people have these two pathways



Ebbinghaus illusion

ventral pathway sees two different sizes

"Physical" Ebbinghaus
Ask subject to pick up the middle disk, and measure how they seperate their thumb and finger



finger separation anticipates same disc size even though discs "look" different

dorsal pathway sees same sizes