

260-2017-11-27-vision-II

2017-11-27 08:05:17

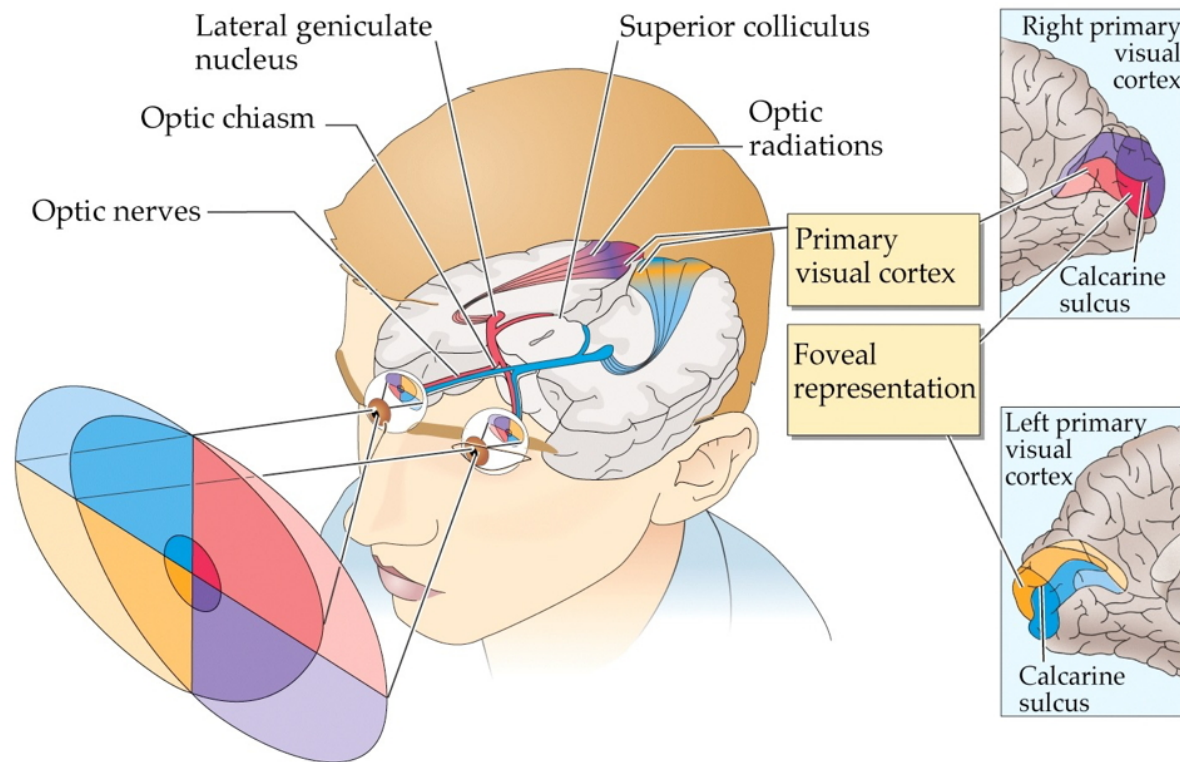
Traveling at Warp 1

<https://vimeo.com/117815404>

Today's topics

- Wrap-up on vision
- Biological basis of learning & memory
- Blog post 3/papers due **today**
- In-class lab next Mon
- Review for Exam 4 next Wed

From eye to brain



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From eye to brain

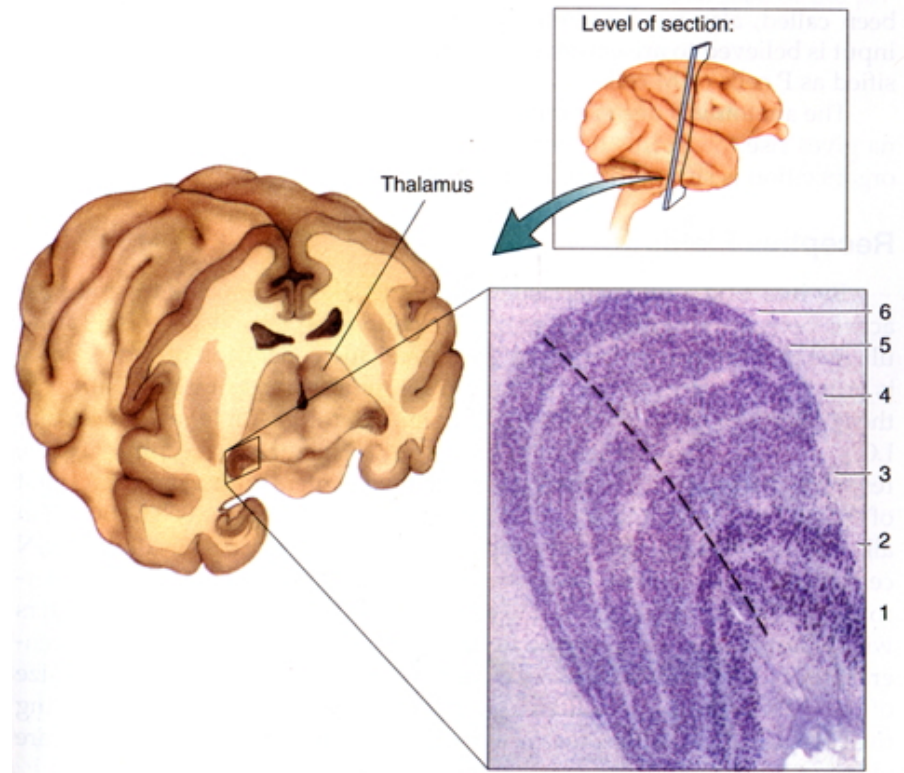
- Retinal ganglion cells
- 2nd/II cranial (optic) nerve
 - Optic chiasm
- projections)

of thalamus (90% of

From eye to brain

- Hypothalamus
 - Suprachiasmatic n.
- Superior colliculus & brainstem

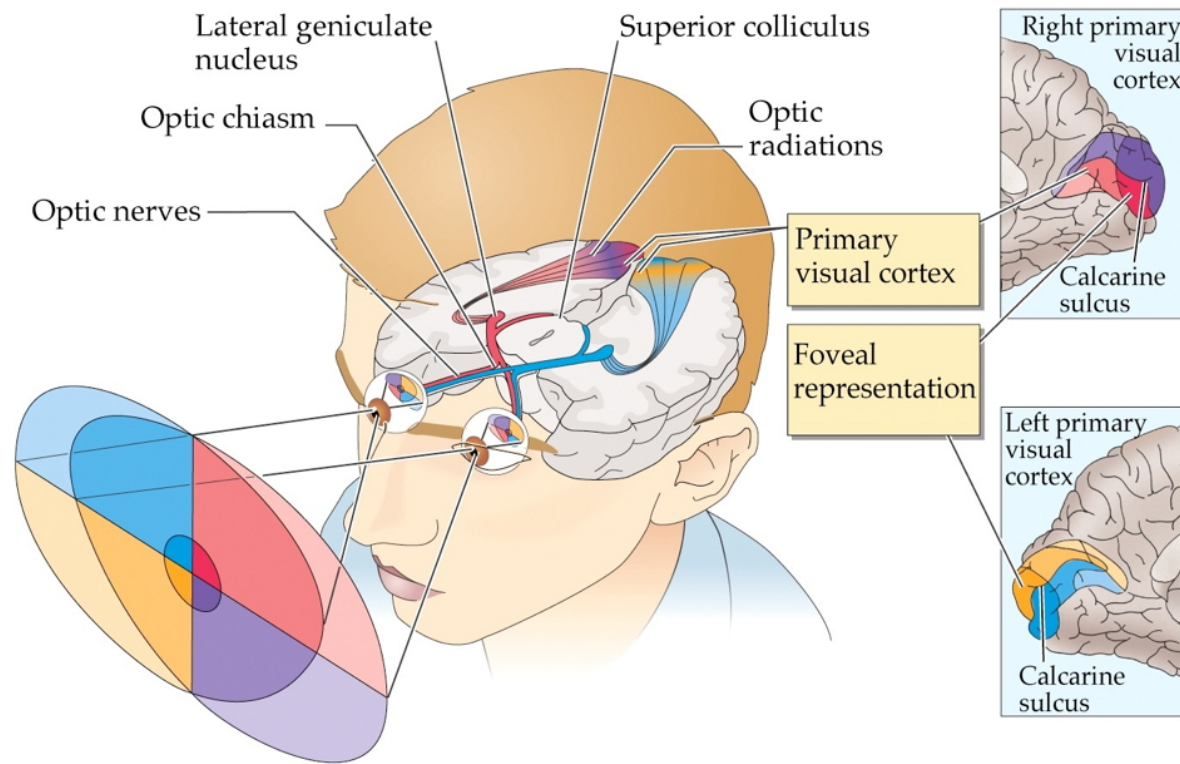
LGN



LGN

- 6 layers + intralaminar zone
 - Parvocellular (small cells): chromatic
 - Magnocellular (big cells): achromatic
 - Koniocellular (chromatic - short wavelength?)
- Retinotopic map of opposite visual field

From LGN to V1

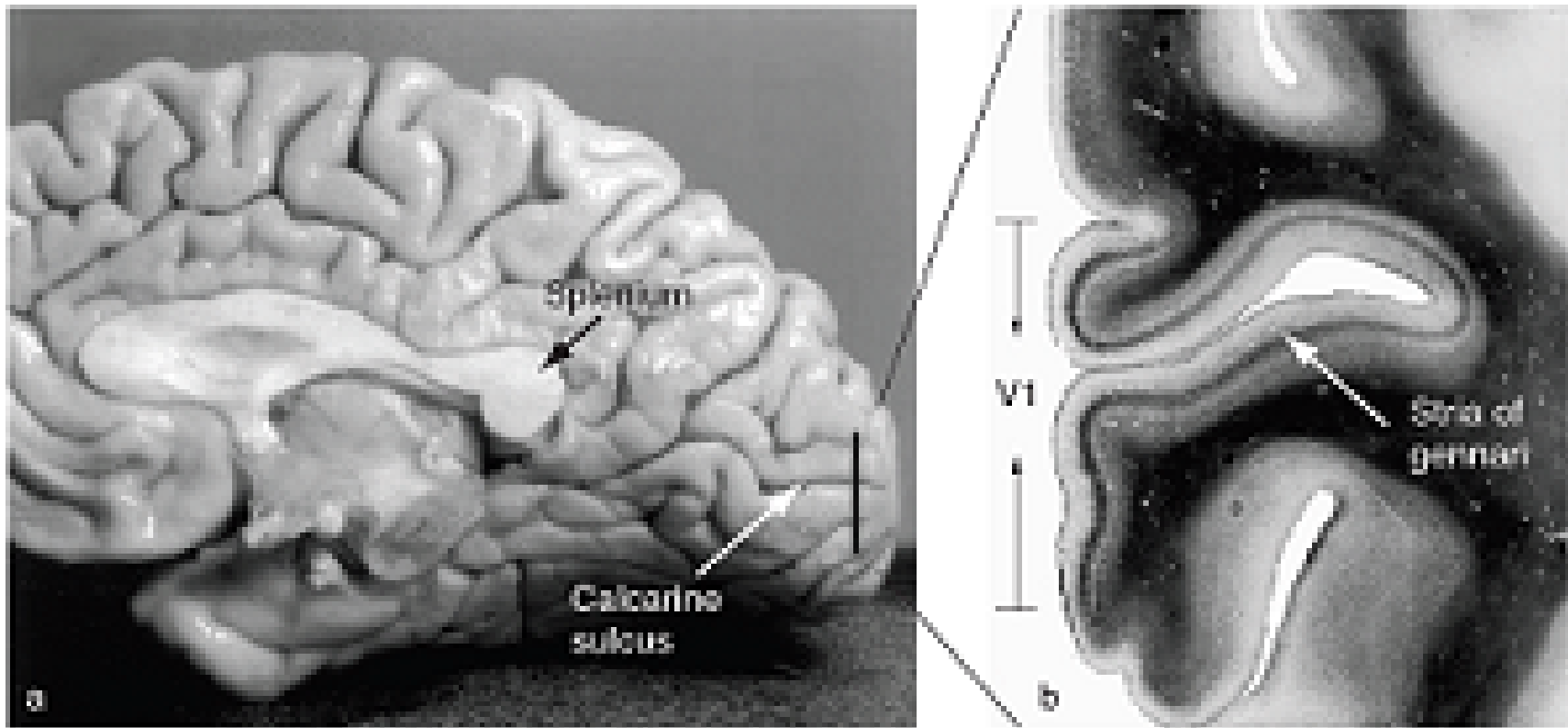


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From LGN to V1

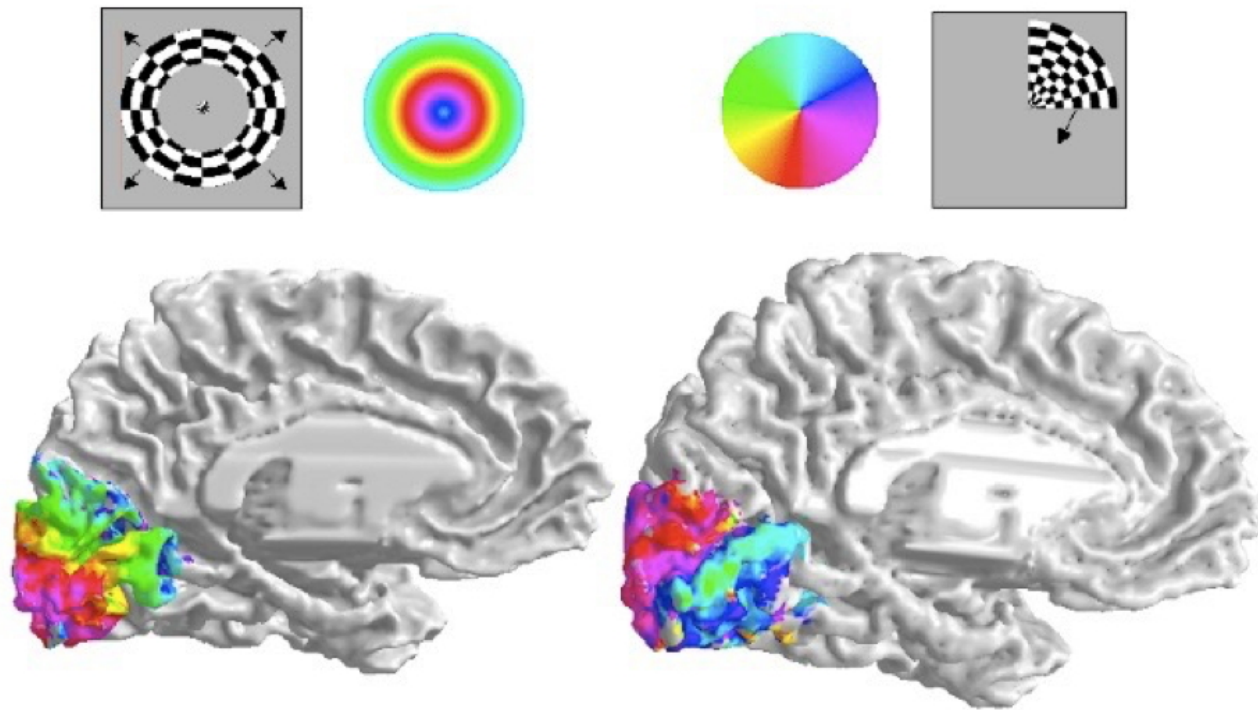
- Via optic radiations
- _____ in occipital lobe

Human V1



<http://www.scholarpedia.org/w/images/3/3a/03-Human-V1.png>

Measuring retinotopy in V1

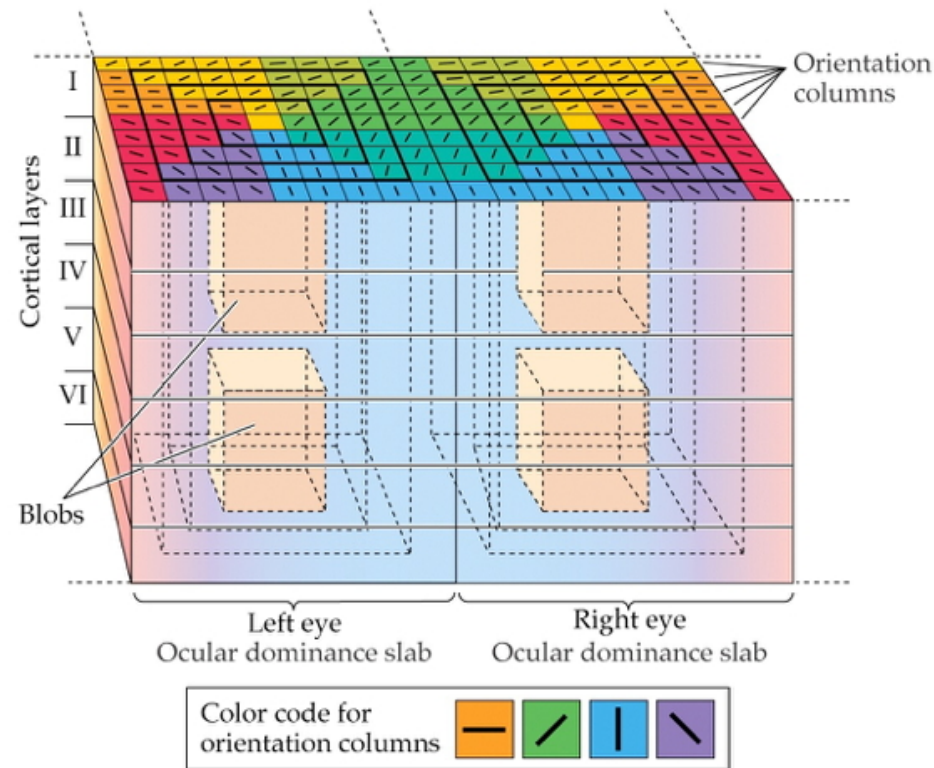


(Dougherty et al. 2003)

Retinotopy in V1

- Fovea overrepresented
 - Analogous to somatosensation
 - High acuity in fovea vs. lower outside it
- Upper visual field/lower (ventral) V1 and

V1 has laminar, columnar organization



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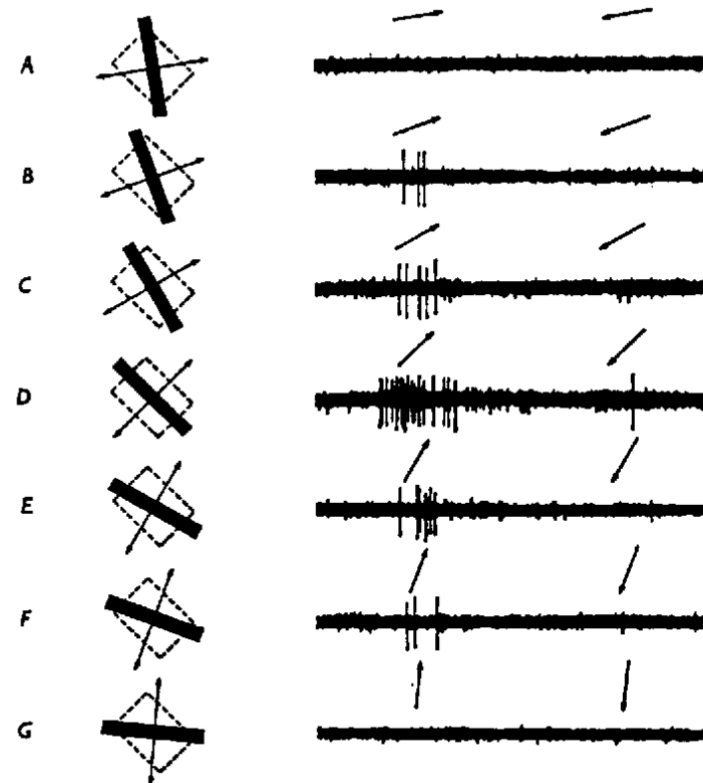
V1 has laminar, columnar organization

- 6 laminae (layers)
 - Input: Layer 4
 - ~80% is from other cortical areas!
 - Output:
 - Layers 2-3 (to cortex)
 - Layer 5 (to brainstem)
 - Layer 6 (to LGN)

V1 has laminar, columnar organization

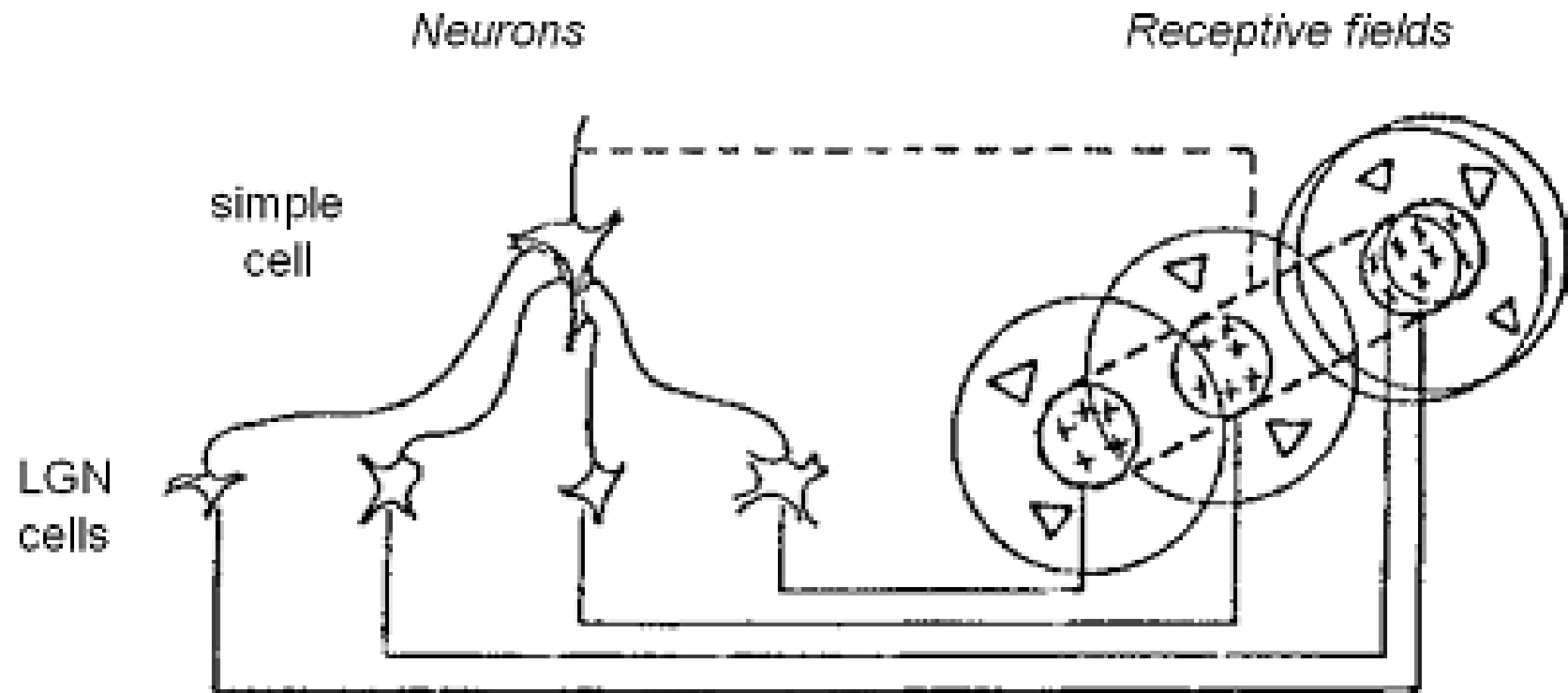
- Columns
 - Orientation/angle
 - Spatial frequency

Orientation/angle tuning



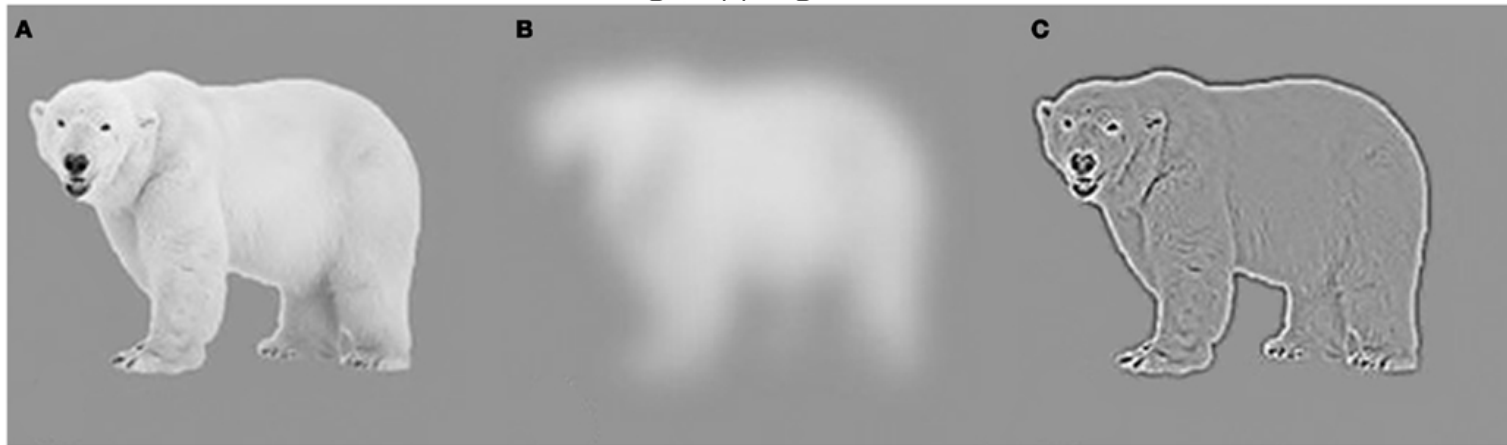
<https://foundationsofvision.stanford.edu/wp-content/uploads/2012/02/dir.selective.png>

From center-surround receptive fields to line detection



Spatial frequency tuning

Low == gist || high == details

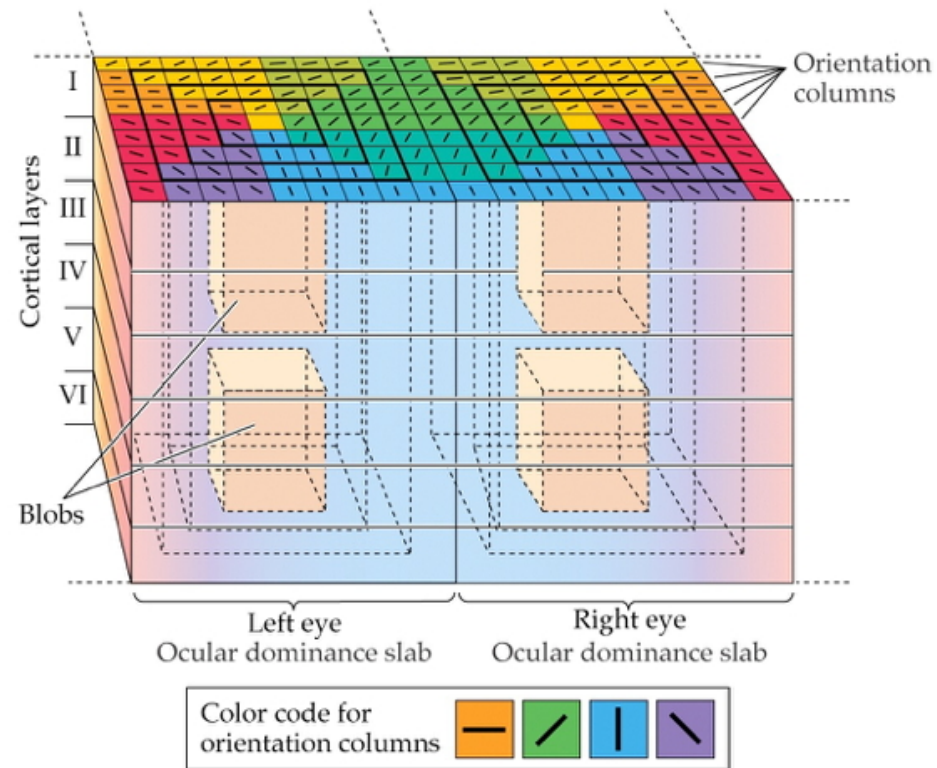


(Panichello, Cheung, and Bar 2013)

V1 has laminar, columnar organization

- Columns
 - Color/wavelength
 - Eye of origin,

Ocular dominance columns



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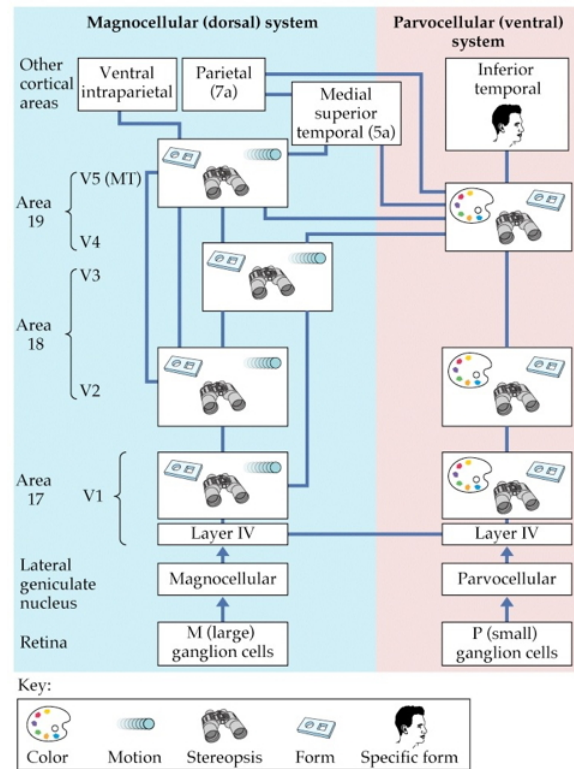
Ocular dominance signals retinal disparity

Cloudy with a Chance of Meatballs 3D Snippet (yt3d:enable=true)



<http://www.scholarpedia.org/w/images/9/99/11-Hubel-Wiesel-model.png>

Beyond V1



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Beyond V1

- Larger, more complex receptive fields
- (where/how)
 - Toward parietal lobe
- (what)
 - Toward temporal lobe

What is vision for?

- What is it? (form perception)
- Where is it? (space perception)
- How do I get from here to there (action control)
- What time (or time of year) is it?

Comparing sensory systems

- Functional segregation/specificity
- Topographic maps
- Variable resolution

Learning and memory

Memory capacity of the human brain?

- $1e11$ neurons
- $1e3$ synapses/neuron
- $1e14$ synapses or $1.25e13$ bytes
- $1e9$ gigabyte, $1e12$ terabyte, $1e15$ petabyte

<http://www.scientificamerican.com/article.cfm?id=what-is-the-memory-capacity>

What is learning and memory anyway?

- Learning
 - ?
- Memory
 - ?

How do you know when you've

- Learned?
- Remembered?

What is learning and memory anyway?

- Learning
 - Change in perception, thought, behavior, emotion over time
- Memory
 - Information derived from past experience that influences current behavior

How computer memory \neq biological memory

- Stored in sequences of binary digits (bits): $\{0,1\}$
- Stored by address: "011000" stored in "1110000"
- Single characters, images, sounds, data stored as sequences of bits.
- Volatile vs. non-volatile
- Computers have separate memory stores; brains store info everywhere

Biological basis of L&M?

- Changes in patterns of neural activity
- Changes in patterns of connectivity
 - New synapses
 - Changes in synaptic strength (+/-)

How do synapses change strength?

Donald Hebb's Insight

(Hebb, 1949, p. 62)

1992, p. 211).

(Lowell & Singer,

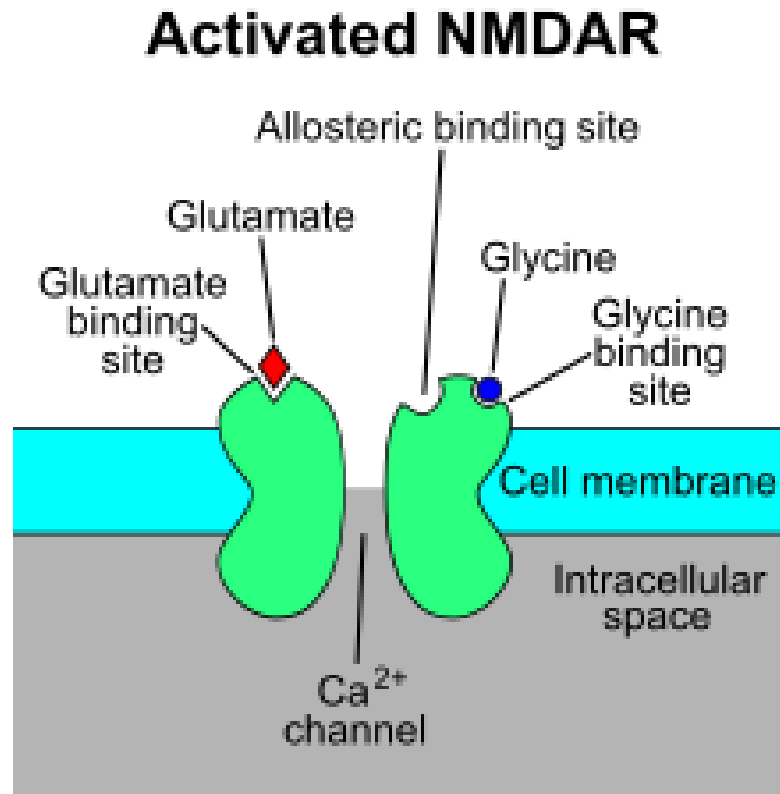
'Hebbian' learning via NMDA receptor

- NMDA receptor (NMDAR)
- 'Coincidence' detector
 - Sending cell has released NT
 - Receiving cell is/has been recently active

'Hebbian' learning

- Chemically-gated AND
 - Ligand- (glutamate/aspartate + glycine) gated
 - Sending cell active
- Voltage-gated
 - Zn^{++} or Mg^{++} ion 'plug' removed under depolarization
 - Na^+ & Ca^{++} influx; K^+ outflux
 - Receiving cell responds

NMDA receptor figure



https://upload.wikimedia.org/wikipedia/commons/thumb/0/00/Activated_NMDAR.svg/220px-Activated_NMDAR.svg.png

NMDA receptors contribute to associative learning

- Associate (link)
 - Concept A -> Concept B
 - Neuron A -> Neuron B

Donald

Donald

- Trump
- Duck
- Draper

NMDA clinical significance

- (Alzheimer's Disease treatment) blocks NMDAR
 - Controls over-activation and Ca^{++} excitotoxicity?
- Implicated in effects of (PCP)
 - Link to glu hypothesis of schizophrenia?

NMDA clinical significance

- is NMDA receptor antagonist
 - anesthesia, sedation pain relief
 - possible short-term relief for depression
- Analgesic effects of nitrous oxide (laughing gas; NO)
- Ethanol inhibits [\(Ron et al., 2011\)](#)

Next time...

- Long-term potentiation/depression
- Disorders of learning & memory

References

Dougherty, R. F., V. M. Koch, A. A. Brewer, B. Fischer, J. Modersitzki, and B. A. Wandell. 2003. "Visual Field Representations and Locations of Visual Areas V1/2/3 in Human Visual Cortex." 3 (10): 1–1. doi:[10.1167/3.10.1](https://doi.org/10.1167/3.10.1).

Panichello, Matthew F., Olivia S. Cheung, and Moshe Bar. 2013. "Predictive Feedback and Conscious Visual Experience." 3: 620. doi:[10.3389/fpsyg.2012.00620](https://doi.org/10.3389/fpsyg.2012.00620).