COGS 101A: Sensation and Perception

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UCSD

Lecture 5:

LGN and V1: Magno and Parvo streams– Chapter 3

Course Information

- Class web page: http://cogsci.ucsd.edu/ desa/101a/index.html
- Professor: Virginia de Sa
  - I'm usually in Chemistry Research Building (CRB) 214 (also office in CSB 164)
  - Office Hours: Monday 5-6pm
  - email: desa at ucsd
  - Research: Perception and Learning in Humans and Machines

For your Assistance

TAS:

- Jelena Jovanovic OH: Wed 2-3pm CSB 225
- Katherine DeLong OH: Thurs noon-1pm CSB 131

IAS:

- Jennifer Becker OH: Fri 10-11am CSB 114
- Lydia Wood OH: Mon 12-1pm CSB 114

Course Goals

- To appreciate the difficulty of sensory perception
- To learn about sensory perception at several levels of analysis
- To see similarities across the sensory modalities
- To become more attuned to multi-sensory interactions

Grading Information

- 25% each for 2 midterms
- 32% comprehensive final
- 3% each for 6 lab reports - due at the end of the lab
- Bonus for participating in a psych or cogsci experiment AND writing a paragraph description of the study

You are responsible for knowing the lecture material and the assigned readings. Read the readings before class and ask questions in class.

Academic Dishonesty

The University policy is linked off the course web page.

You will all have to sign a form in section

For this class:

- Labs are done in small groups but writeups must be in your own words
- There is no collaboration on midterms and final exam

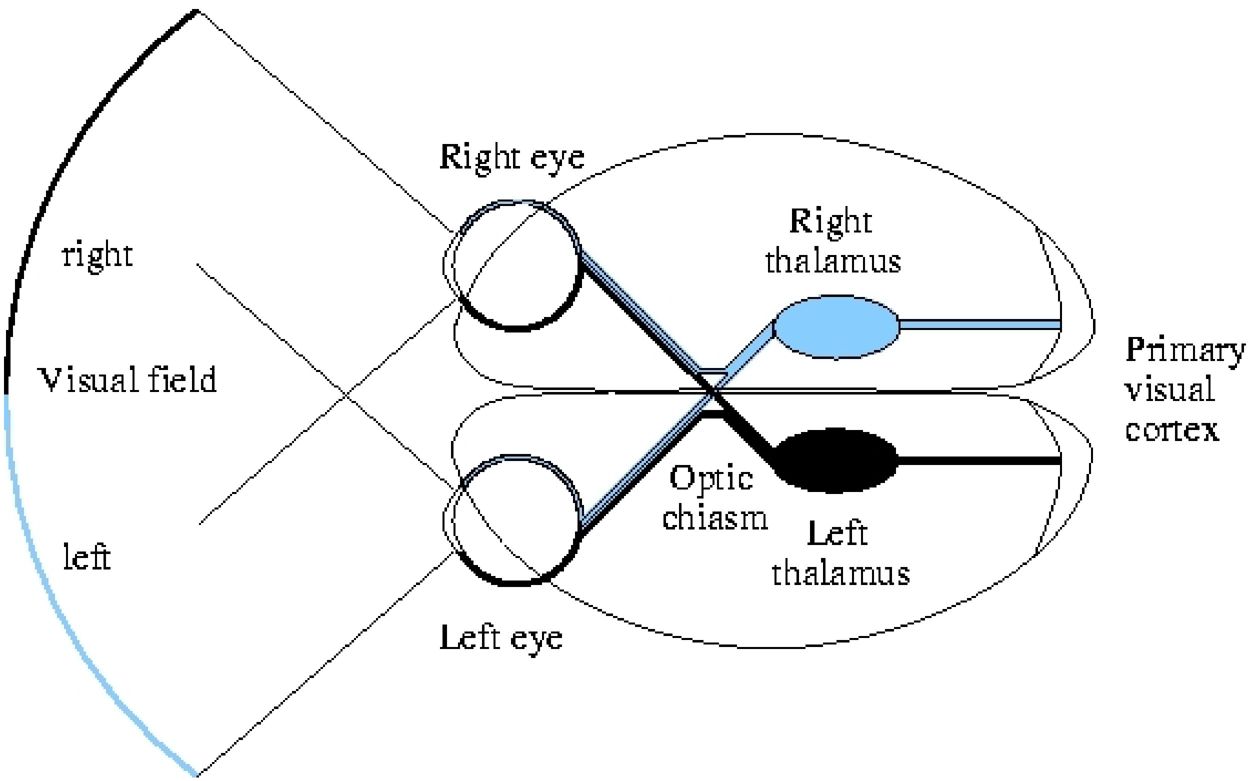
Last Class

We learned about coding in the retina

This Class

What happens after the retina: LGN and V1 processing

Pathway to Cortex



(http://www.cs.utexas.edu/users/jbednar/papers/bednar.thesis/node6.html)

Notes about pathway to cortex

90% of the optic nerve fibers go to the LGN. The other 10% to superior colliculus

LGN (lateral geniculate nucleus) is a part of the thalamus

The brain is a bilateral structure – there are 2 LGNs, 2 V1s (right and left)

The **right visual field**(RVF) projects to the left thalamus

RVF projects to left sides of retinas

ganglion axons from the left side of the left eye projects to the left LGN

ganglion axons from the left side of the right eye cross over at the **optic chiasm** and go to the the left LGN

The left LGN projects to the left V1 (striate cortex)

This crossed organization is repeated in other sensory systems

NOTE: It is not the case that the left eye goes to the right V1, it is the Left visual field (as seen by both eyes)

The LGN is divided into 6 main layers

The layers are arranged **retinotopically** - neighboring neurons in the LGN have neighboring receptive fields

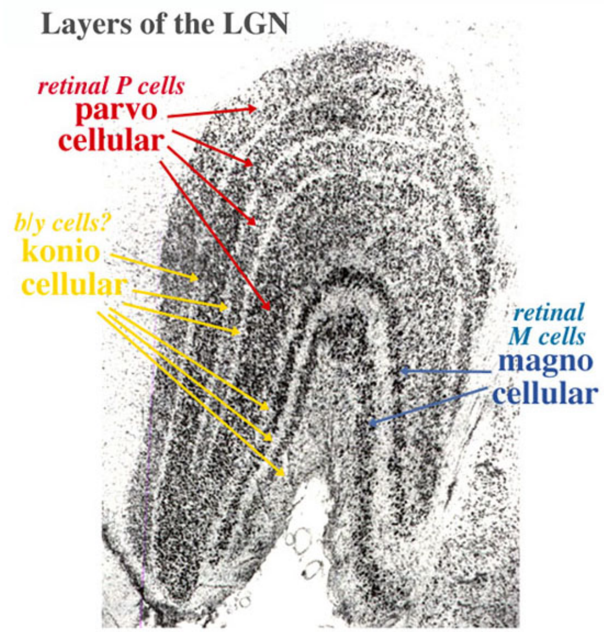


Fig. 26. Histological section through the primate lateral geniculate nucleus (LGN) to show the layering of the neurons into 4 parvocellular layers, 2 magnocellular layers and 6 koniocellular layers.

http://webvision.med.utah.edu/imageswv/LGN.jpeg

Layers are numbered from bottom out. Layers 1,4, and 6 receive from the **contralateral** (other side) eye 2,3,5 receive from the **ipsilateral** (same side) eye

Magno and parvo ganglion cells

Magno cells (m-cells) have large soma (cell bodies), receive input from rods and cones throughout the retina and give transient response to sustained stimuli

Parvo cells (p-cells) have small soma, receive input from cones in and around the fovea and give a sustained response to sustained stimuli

The magnocellular, parvocellular and koniocellular Pathways

(Note book says kinocellular- I don't know if that's a typo or the old way but we will use koniocellular)

Magno pathway transmits information about motion and low spatial frequency

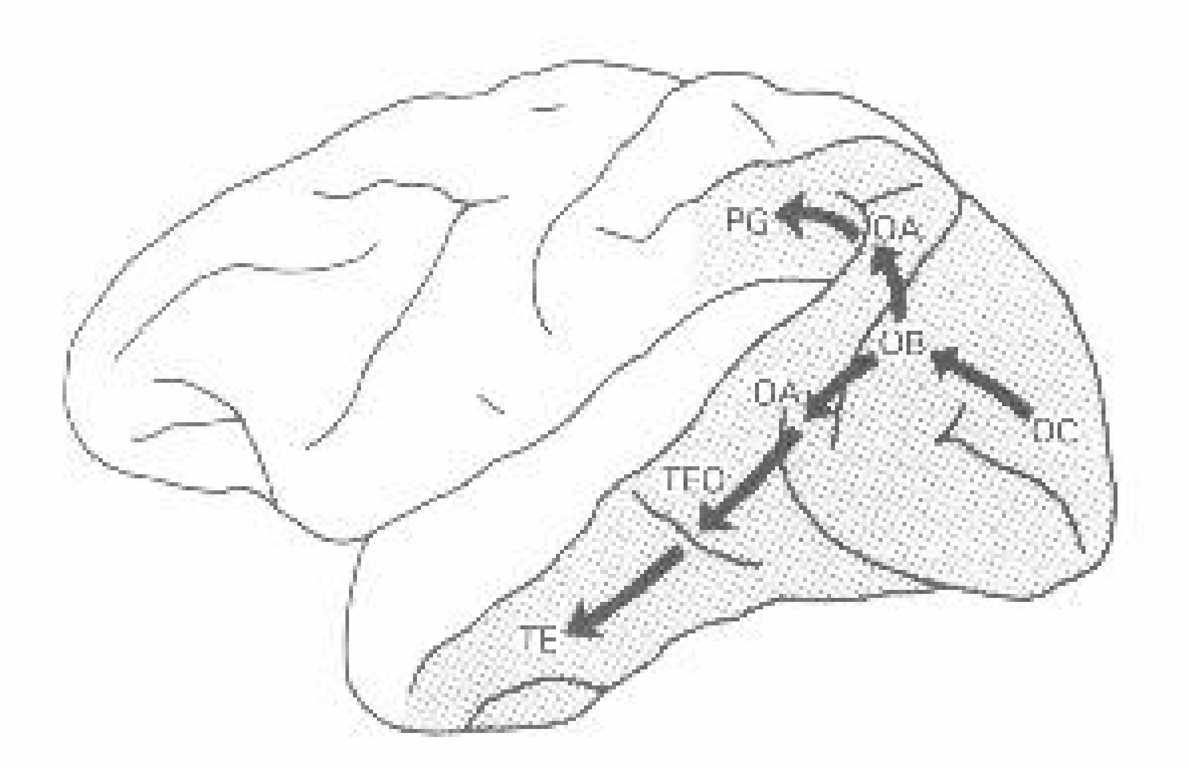
Parvo pathway transmits information about Red-green distinctions in high spatial frequency

Koniocelullar pathway more recently discovered transmits information about blue-yellow

The magno cells form the major input to the dorsal stream (parietal pathway)(where or how pathway). The parvo cells form the major input to the ventral stream (temporal pathway)(what pathway)

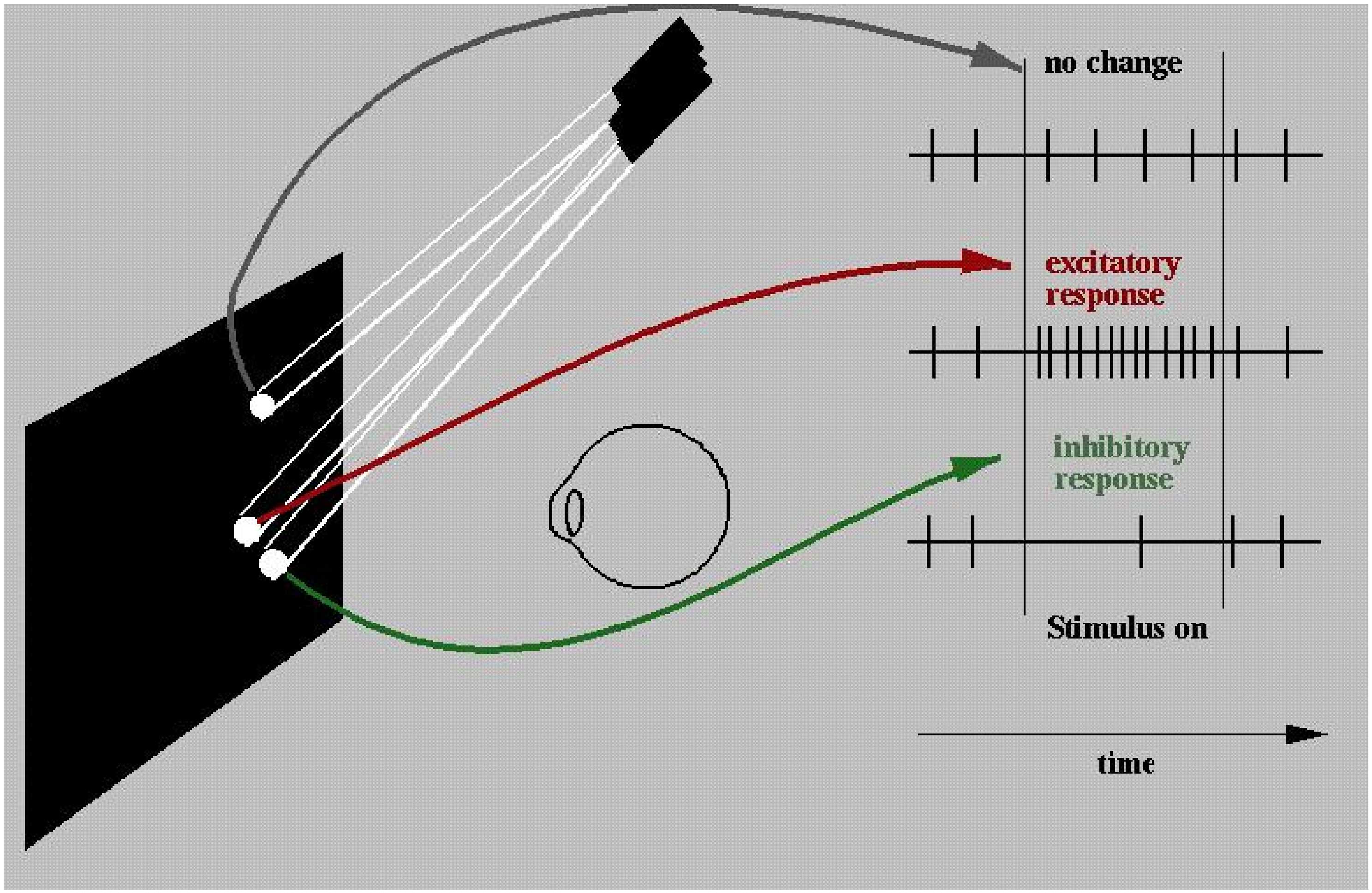
But there is significant crosstalk (especially to ventral stream)

Parallel Pathways in Visual Cortex

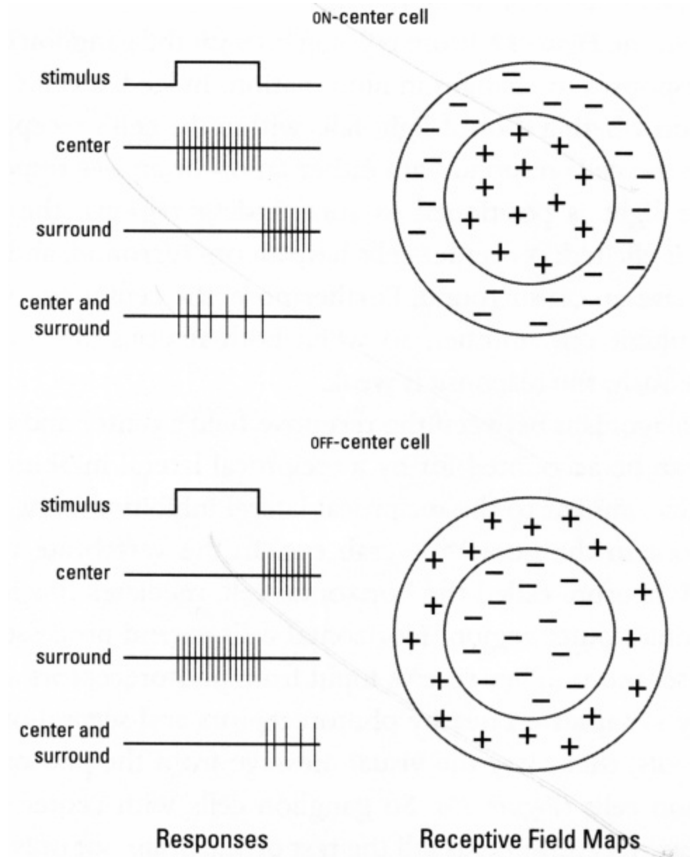


[Mishkin & Ungerleider 1982]

Remember the center-surround ganglion cell responses



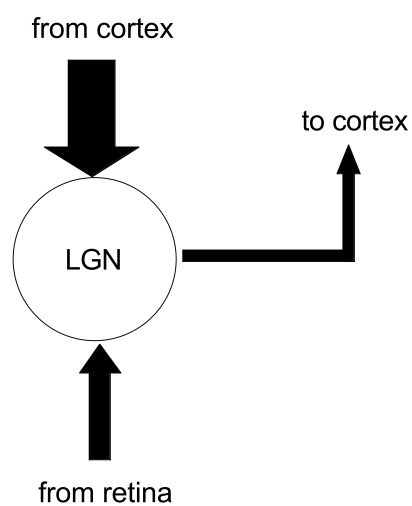
Ganglion cell responses



http://zeus.rutgers.edu/~ikovacs/SandP/prepI_3_1.html

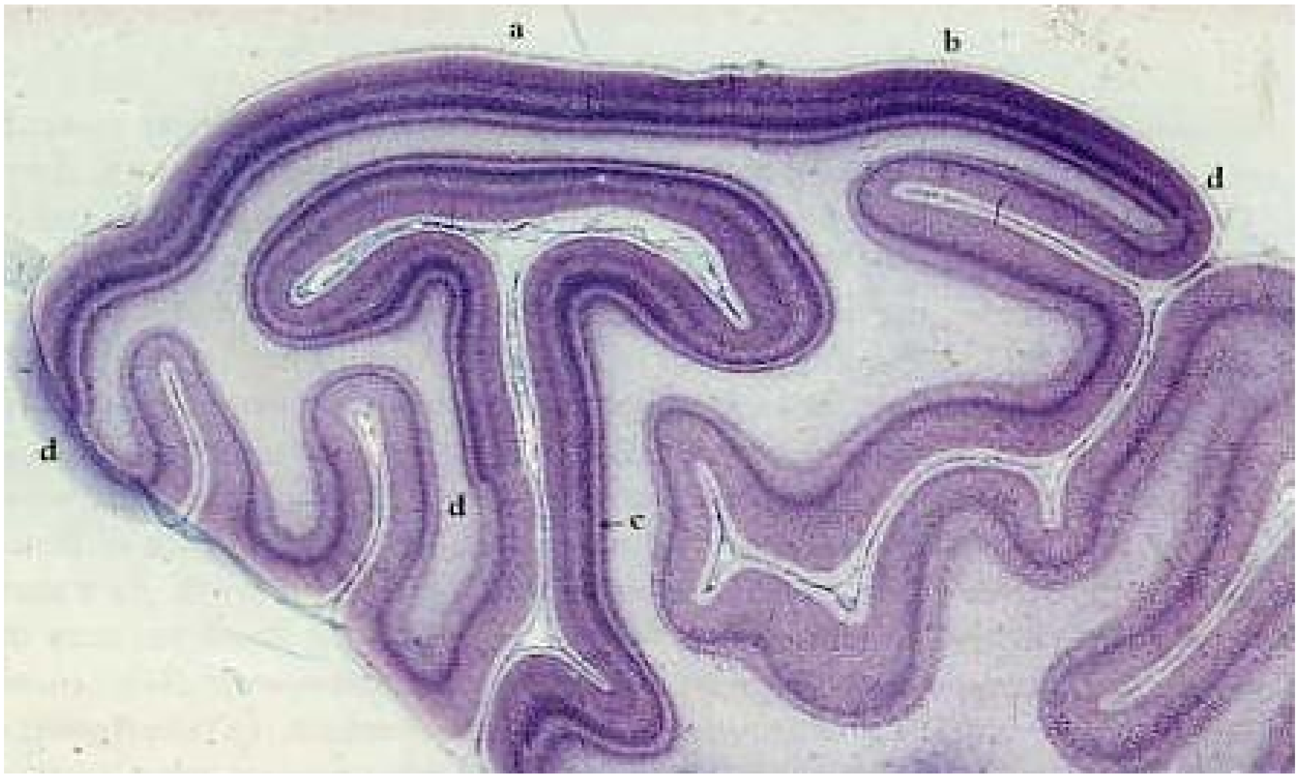
What does LGN do?

This is a big question LGN cells have a similar center surround organization but get a huge amount of input from the cortex



Thought to have a role in gating input to cortex LGN projects to V1 (first visual cortical area)

V1 is also called Striate (striped) cortex



http://neuro.med.harvard.edu/site/dh/b24.htm (from lots of sub layers in layer IV)

Responses of V1 neurons

V1 cells prefer oriented stimuli (in general)

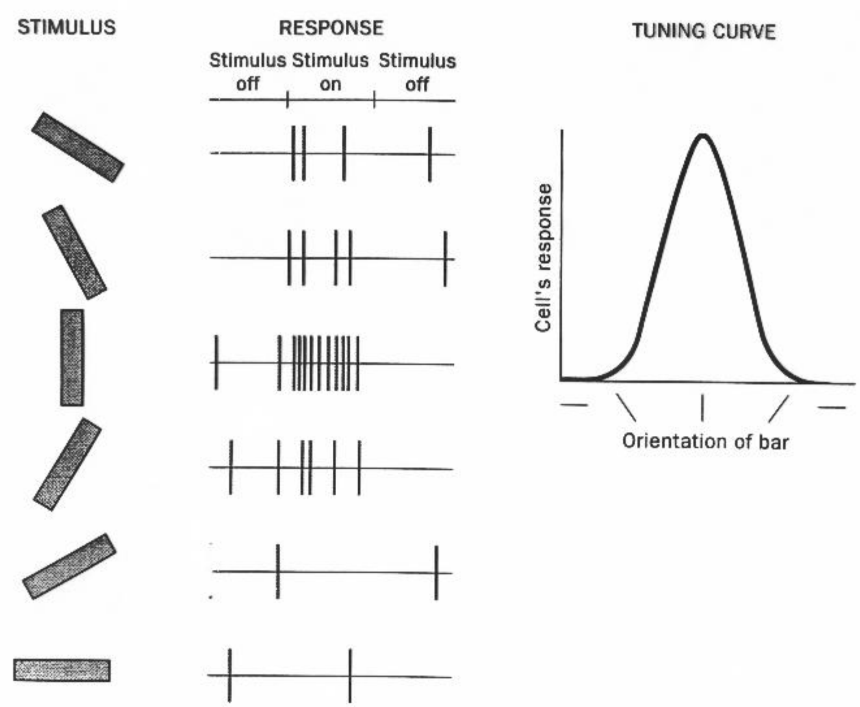
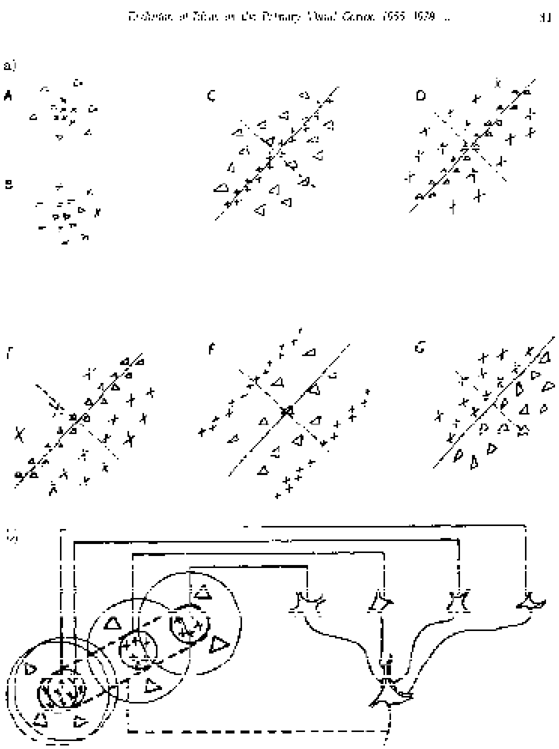


FIGURE 4.8 Response of a single cortical cell to bars presented at various orientations.

`http://zeus.rutgers.edu/~ikovacs/SandP/prepI_3_1.html`

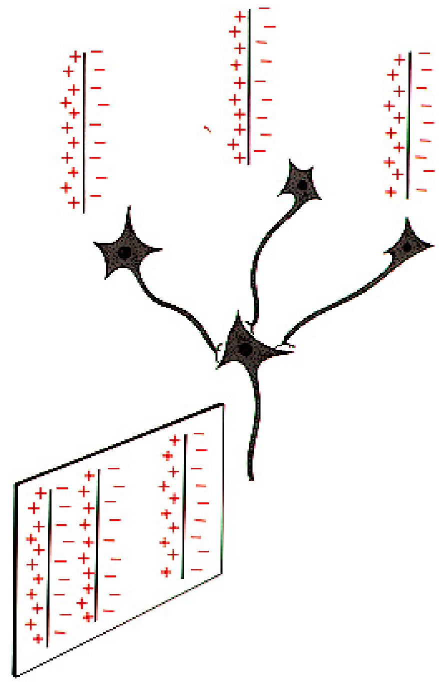
We can talk about the tuning **bandwidth** - measure of the width of the tuning curve

Simple cells in V1



How might one get a simple cell?

Complex cells in V1



from Mark McCourt's Psy 486 web page

How might one get a complex cell?

Subtelties

There are also end-stopped cells that decrease firing if the stimulus gets too long.

There is evidence now that simple and complex cells might just be two ends of a continuum

Columnar organization

Like all known areas of cortex, neurons in a vertical column have similar (almost identical) prefered stimuli

Neighboring columns have somewhat similar prefered stimuli (e.g. orientation preference changes slowly over cortex)

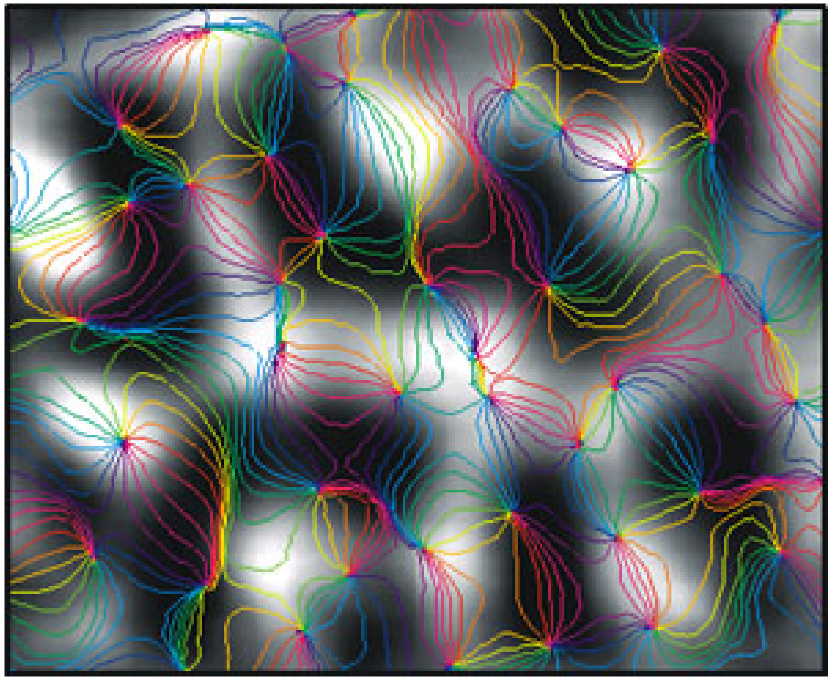
Orientation, receptive field center, ocular dominance are all changed slowly (these are competing constraints)

ocular dominance - cells in input layers of V1 have a stronger input from one eye or the other. The ocular dominance pattern across V1 looks like zebra stipes

Ocular dominance columns across V1

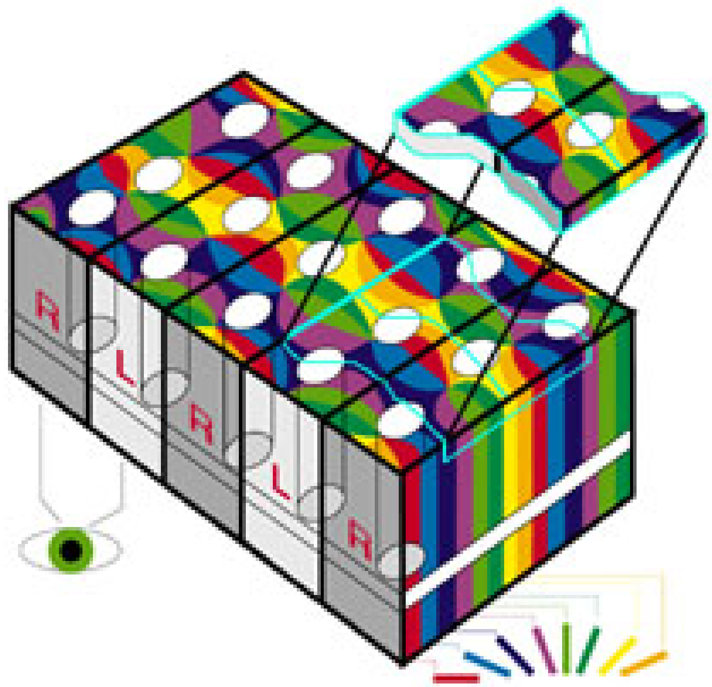
http://www.utoronto.ca/psy280sh/PSY_4_slide32.jpg

Interaction of ocular dominance and orientation columns



http://www.neuro.mpg.de/research/csn/visual_cort_map/

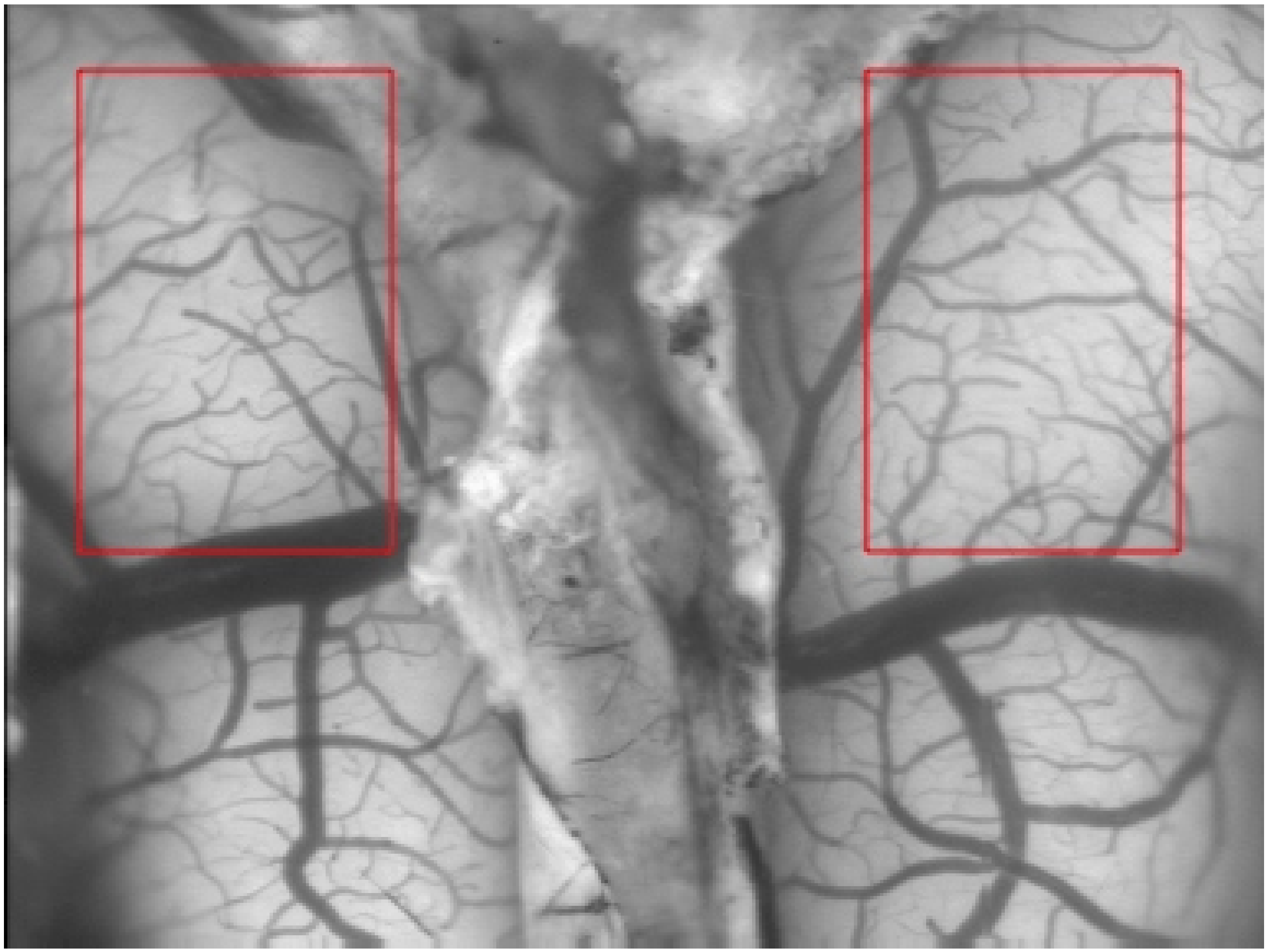
The cortical hypercolumn



cut out part is one hypercolumn

http://www.weizmann.ac.il/brain/images/icecubens.jpg

Optical Imaging reveals Orientation/Ocular dominance map



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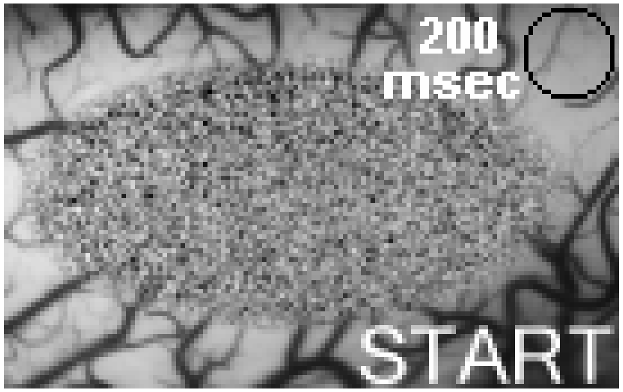
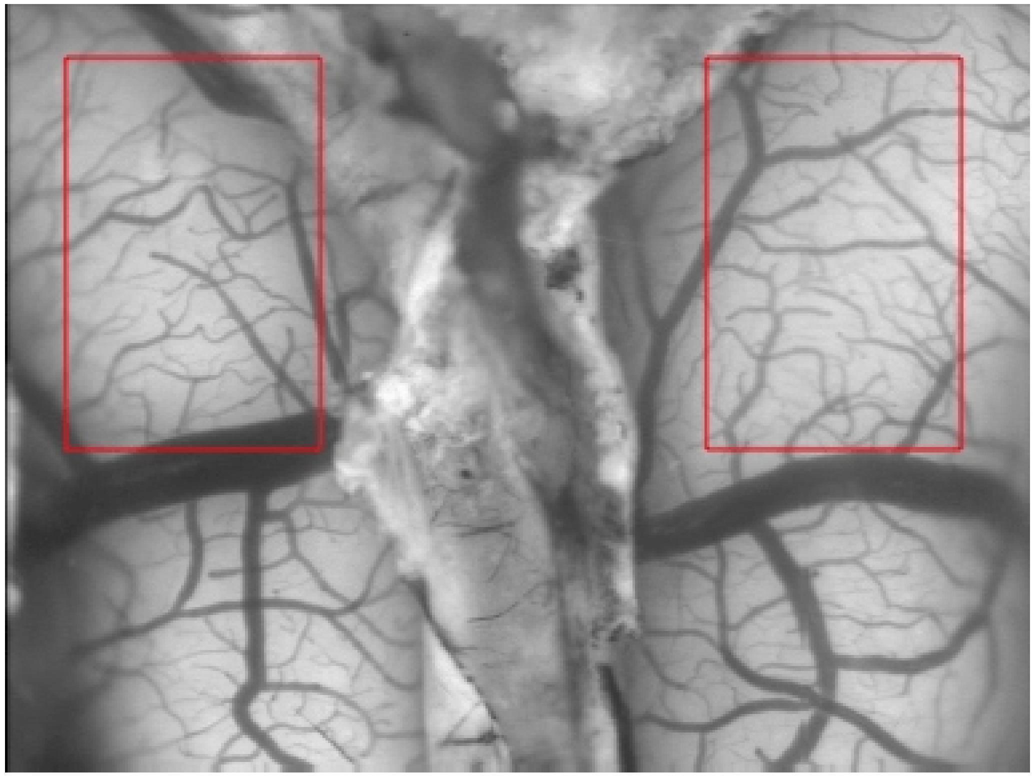


http://www.opt-imaging.com/



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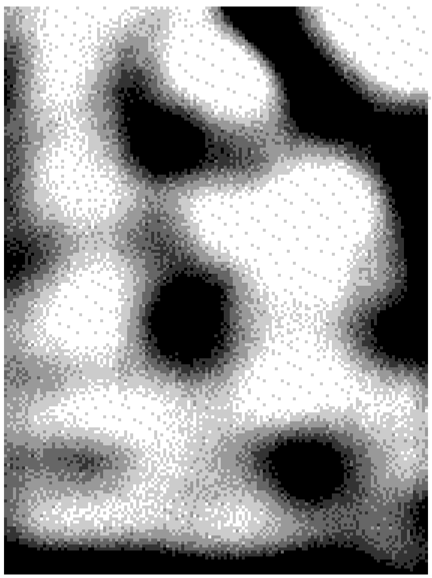
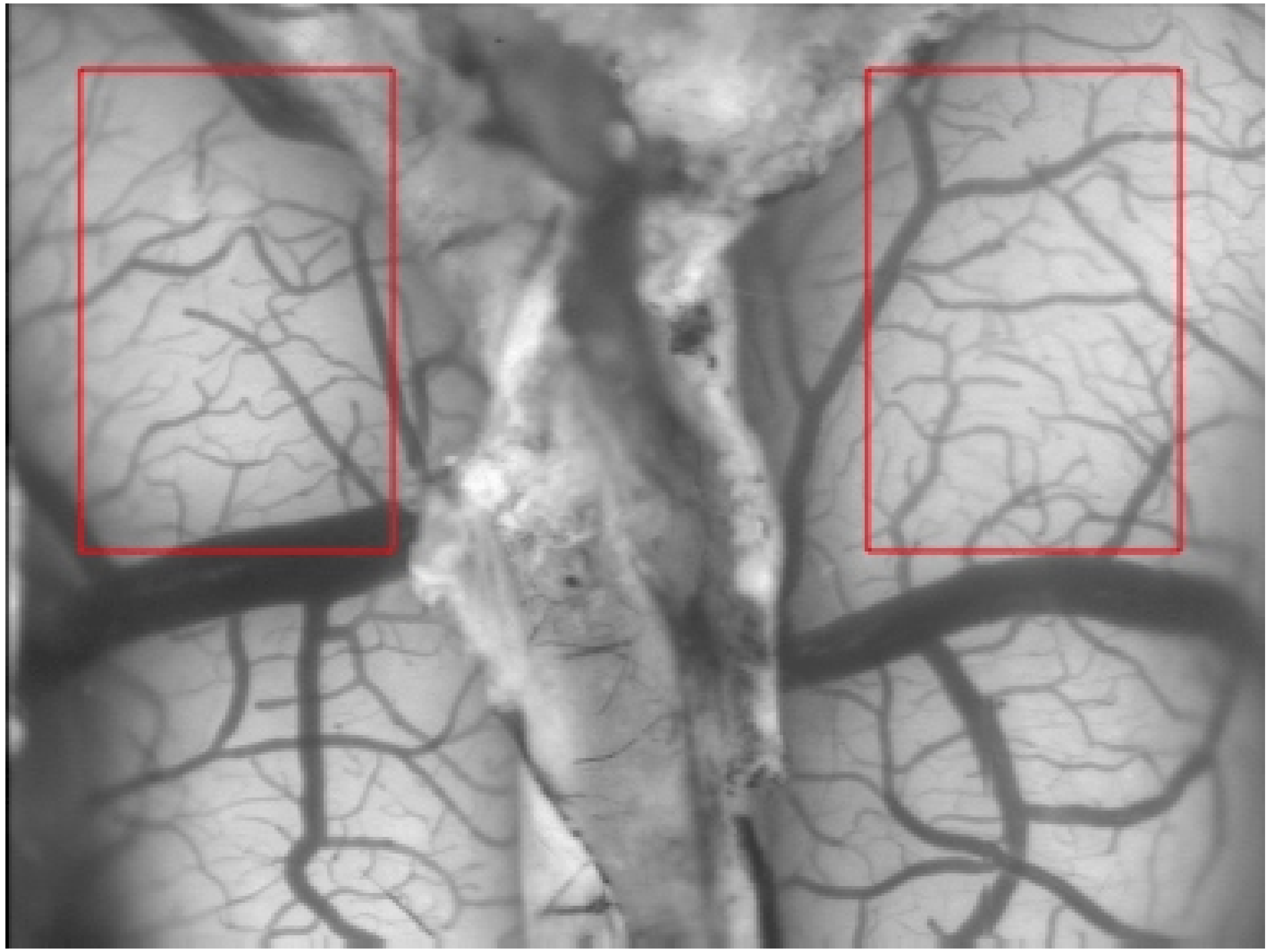
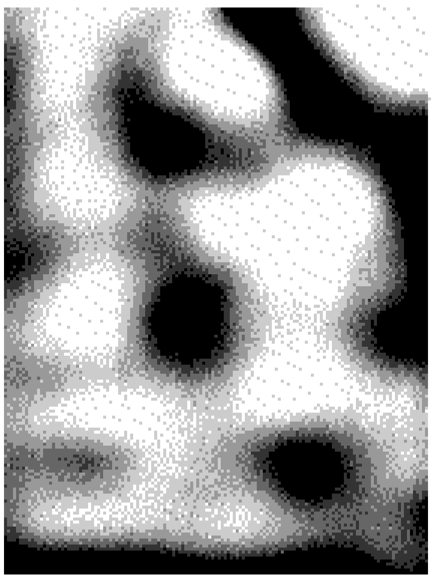
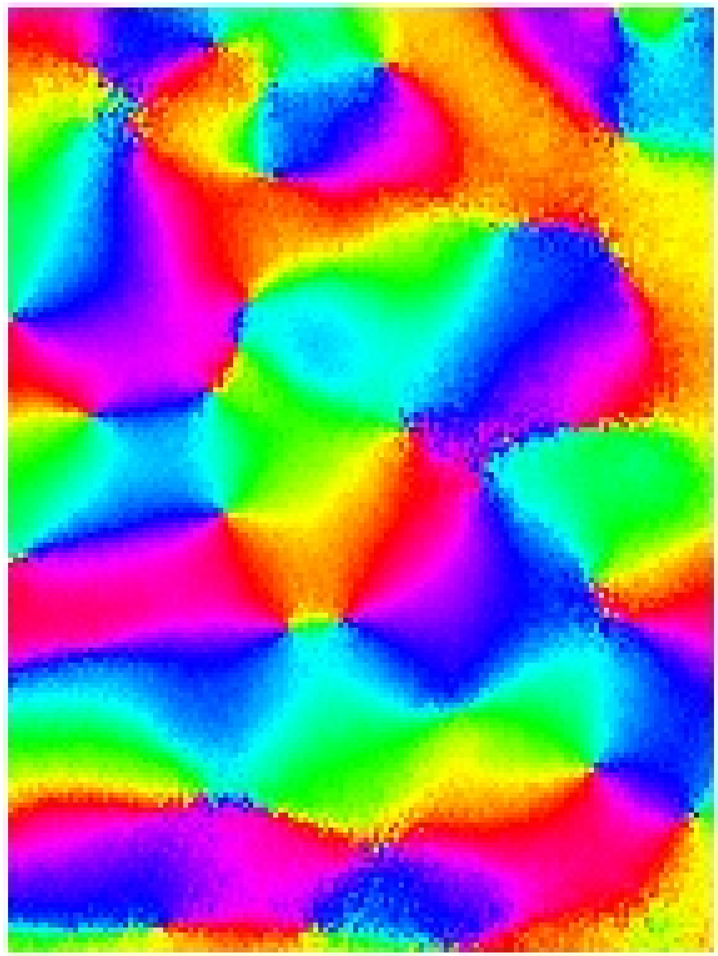




Optical Imaging reveals Orientation/Ocular dominance map





from Josh Trachtenberg

(http://phy.ucsf.edu/~joshua/postdoctoral.html)

Cortical hypercolumn

There are also (cytochrome oxidase) blobs that are specialised for color processing

Cortical magnification factor - There is much more cortical area given to central vision than peripheral vision

The fovea takes up .01% of the retina but 8% of visual cortex

Contrast and spatial frequency

Neurons are also tuned to specific spatial frequency ranges

become familiar with the terms

Spatial frequency - how rapidly a stimulus changes across space (actually across the retina) . It is measured in cycles per degree.

There are 360 degrees of visual space. Thumb at arms length takes up about 2 degrees.

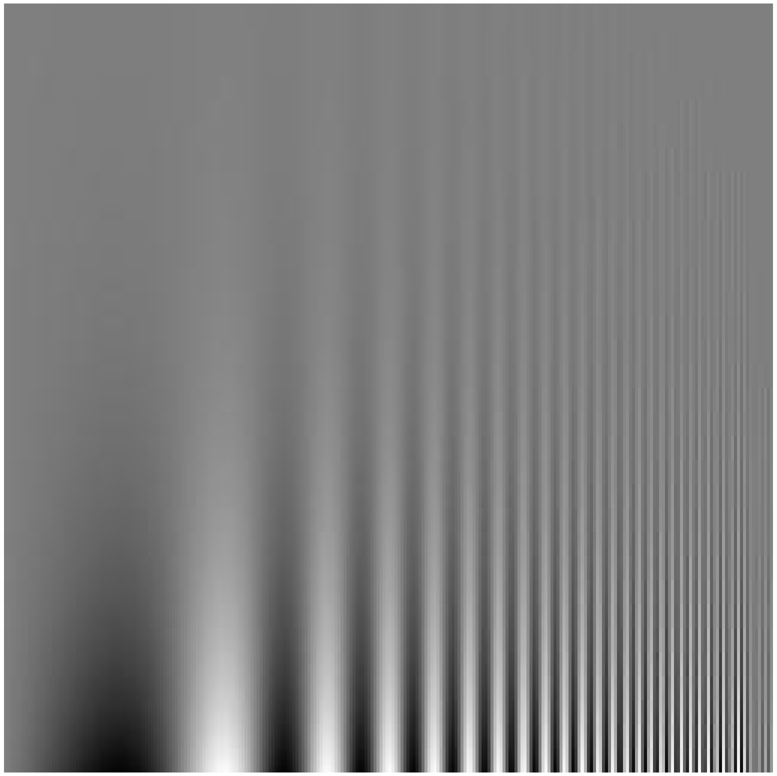
Contrast of a grating is the amplitude (max deviation from mean) divided by the mean intensity

(There are actually different definitions for different measurements)

Test your own Contrast Sensitivity Function

Contrast Sensitivity is the inverse of **contrast threshold**

contrast threshold - the contrast at which you can just detect a grating



http://www.bradford.ac.uk/acad/lifesci/optometry/resources/modules/stage1/pvp1/C

Adaptation

adaptation can demonstrate tuning bandwidth What would happen during adaptation if neurons were only sensitive to tiny variations of orientation? tilt aftereffect

A great set of flash lecture notes

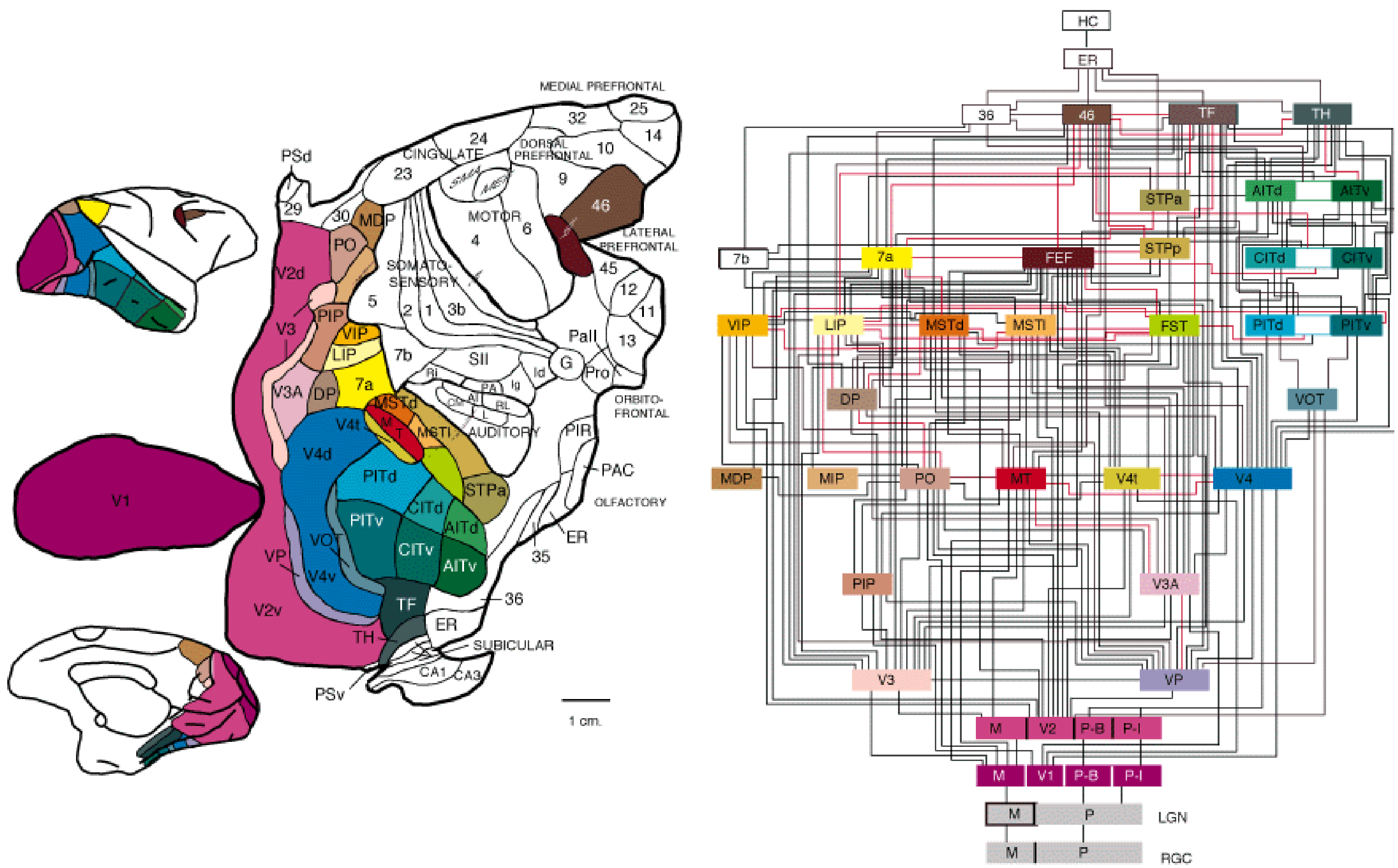
link to notes

http://www.med.uwo.ca/physiology/courses/sensesweb by Tutis Vilis, University of Western Ontario, Canada

After V1

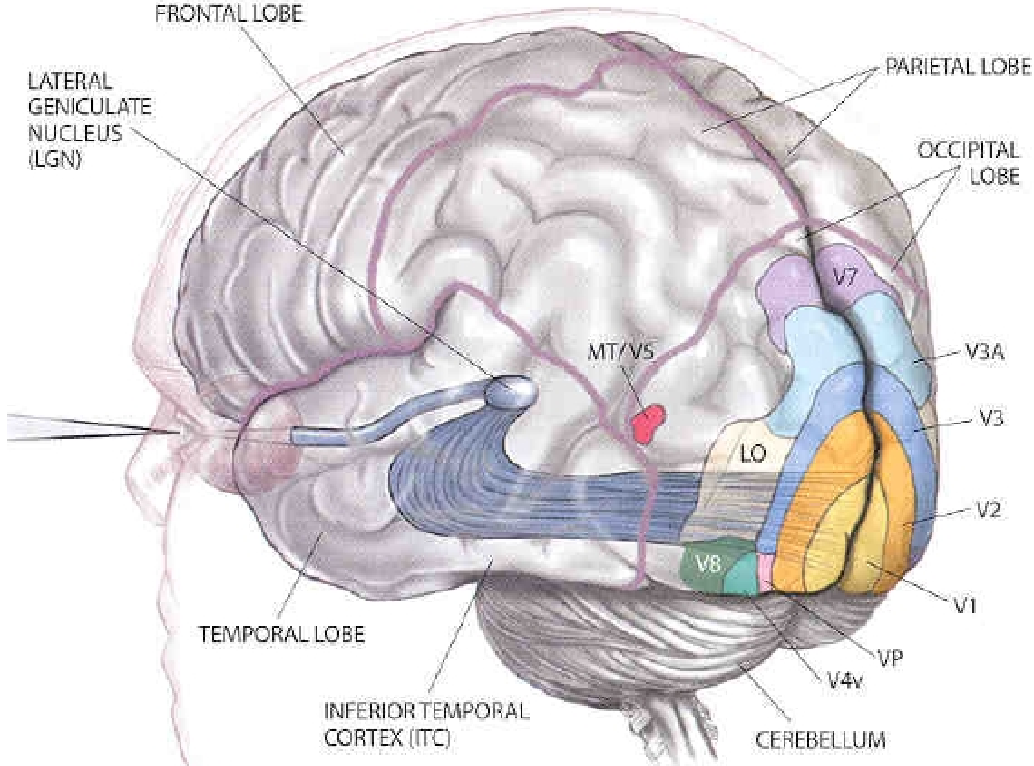
neurons prefered stimuli gets more complex but they have less sensitivity to location

Visual Cortical Areas



from Felleman, D.J. and Van Essen, D.C. (1991) *Cerebral Cortex* 1:1-47.

Visual Cortical Areas – Human



KEY TO FUNCTION

V1: Primary visual cortex; receives all visual input. Begins processing of color, motion and shape. Cells in this area have the smallest receptive fields.

V2, **V3** and **VP:** Continue processing; cells of each area have progressively larger receptive fields.

V3A: Biased for perceiving motion.

V4v: Function unknown.

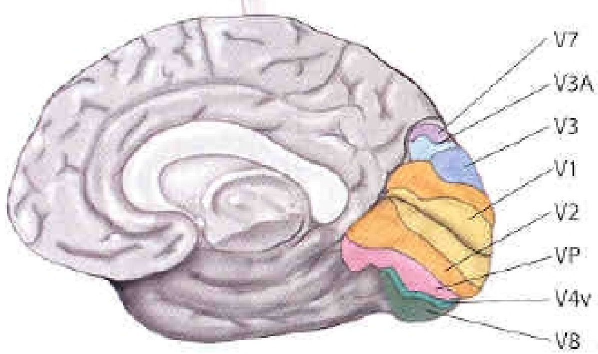
MT/V5: Detects motion.

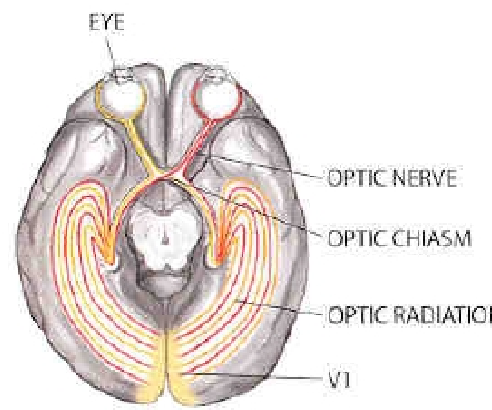
V7: Function unknown.

V8: Processes color vision.

LO: Plays a role in recognizing large-scale objects.

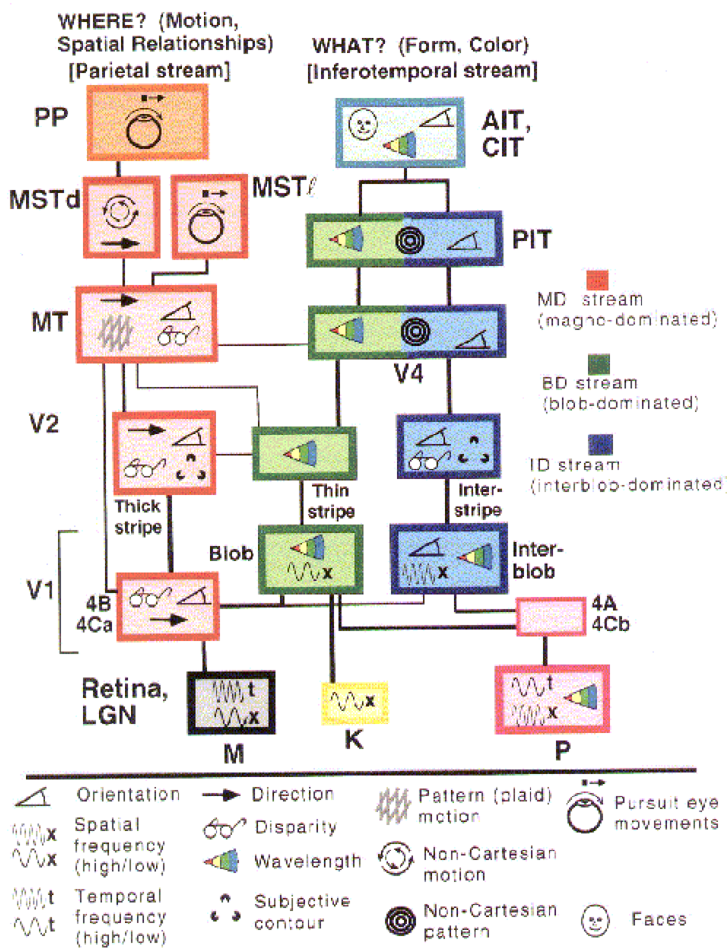
Note: A V6 region has been identified only in monkeys.





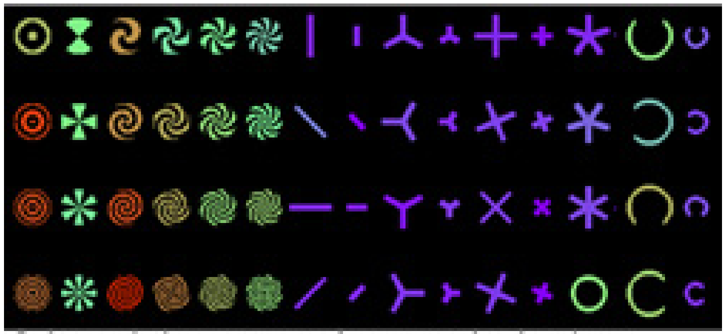
Scientific American, November 1999 (Vision: A Window on Consciousness)

Parallel Pathways in Visual Cortex



[Van Essen & Gallant 1994]

higher-level neurons require more complex stimuli



Color-coded responses of a neuron in visual area V2 to different geometric stimuli.

“optimal patterns” for IT neurons (from Keiji Tanaka) are even more complex but require much less spatial precision

Neurons near the end of the Temporal pathway respond to very complex stimuli

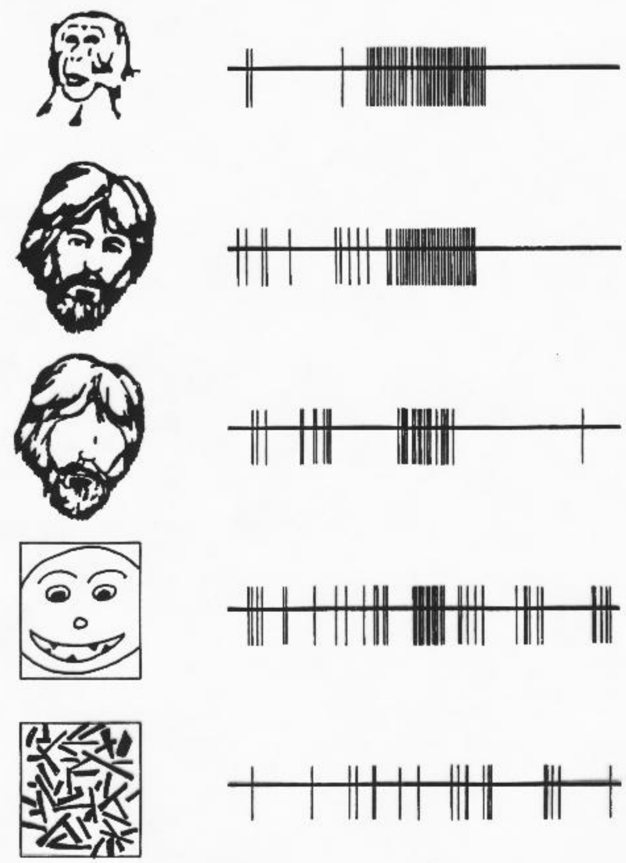


Figure 3.24
Responses of a neuron in a monkey's area IT to various

http://zeus.rutgers.edu/~ikovacs/SandP/prepI_3_1.html

Next Class

more details on beyond V1