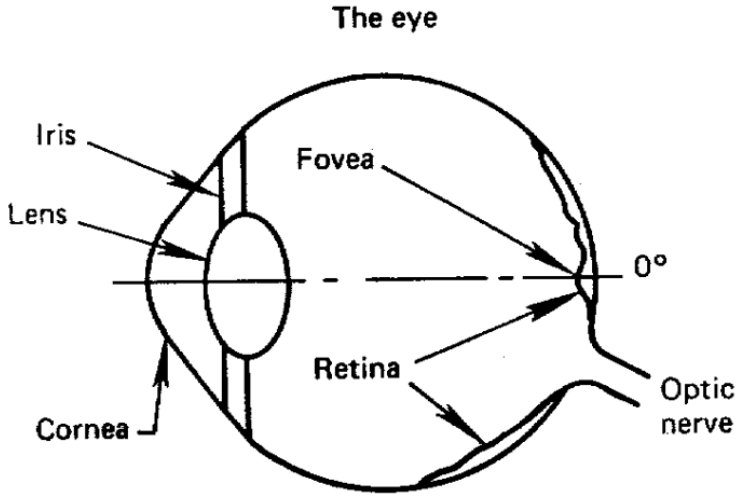


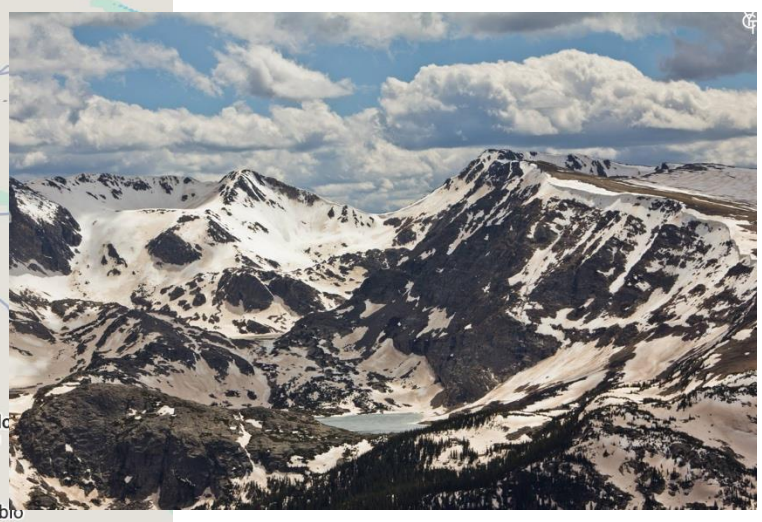
Human Vision System

Fall 2024

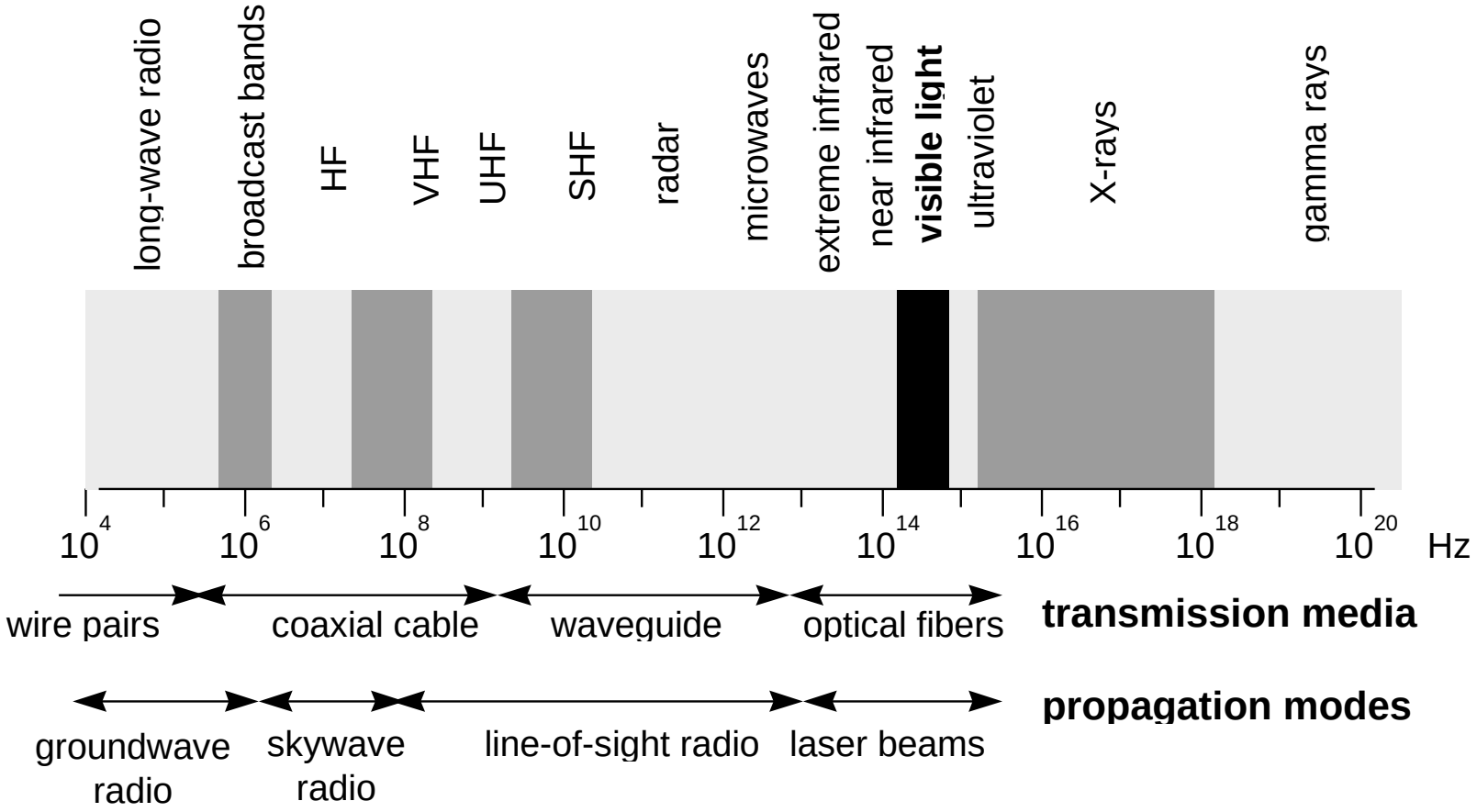
Yi-Ting Chen

https://app.sli.do/event/dmBgES25j61cW75f9K1X9X

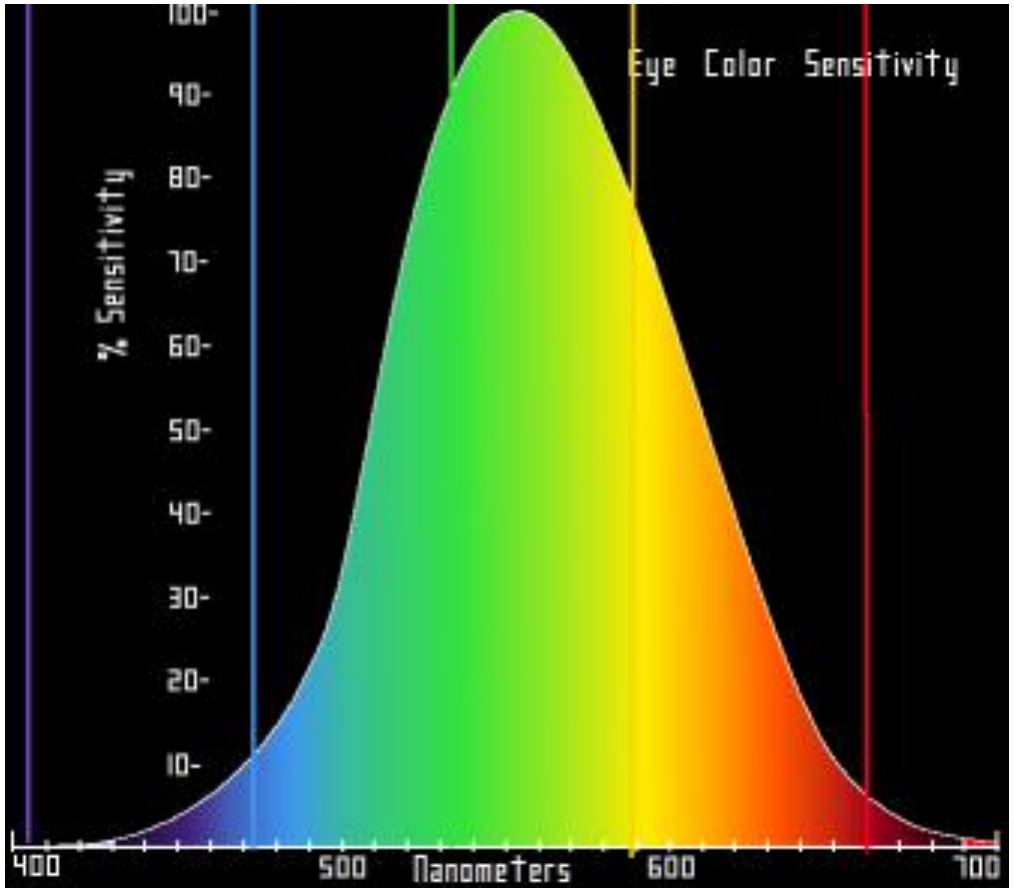
Road Trip 2013



Electromagnetic Radiation

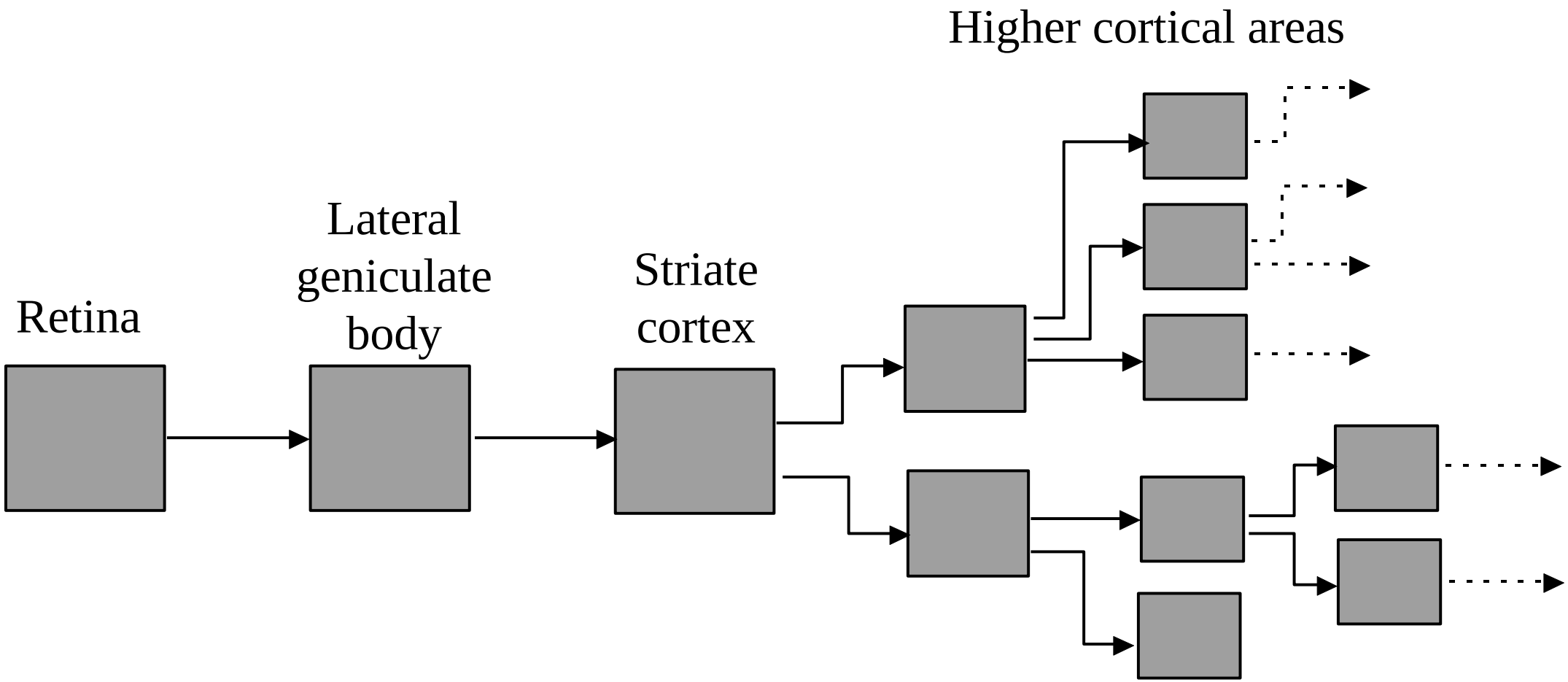


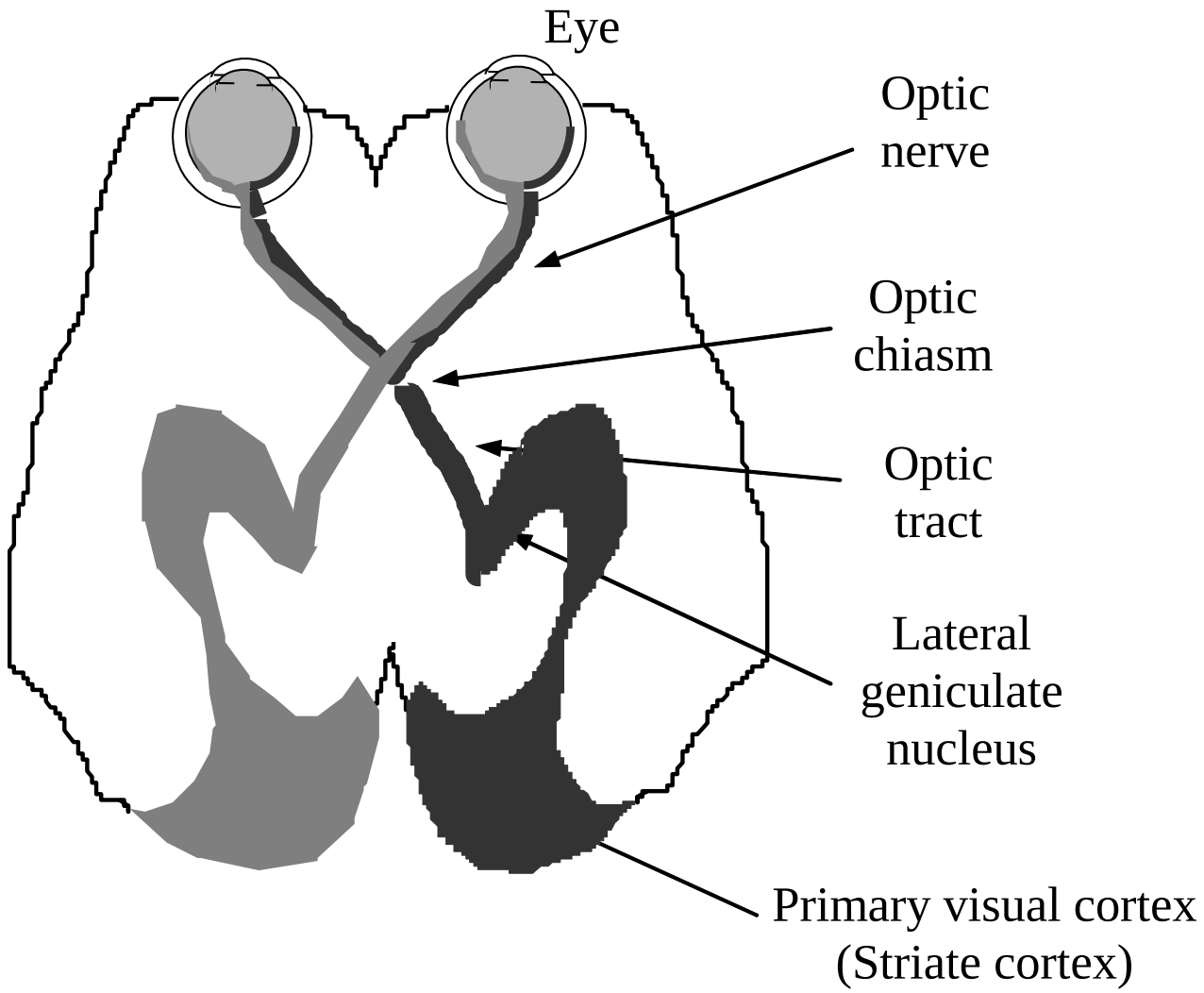
Human Visual Sensitivity



http://scienceblogs.com/builtonfacts/2013/01/29/the-human-eye-optimized-for-sunlight-maybe/

Human Visual Pathway




Eye
Optic nerve
Optic chiasm
Optic tract
Lateral geniculate nucleus
Primary visual cortex (Striate cortex)

How do we perceive depth?

Interactive Demo (Binocular Parallax)

Close one eye

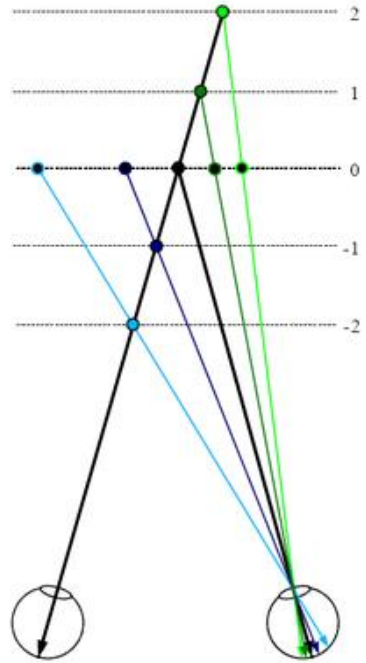
Cover the robot with your thumb

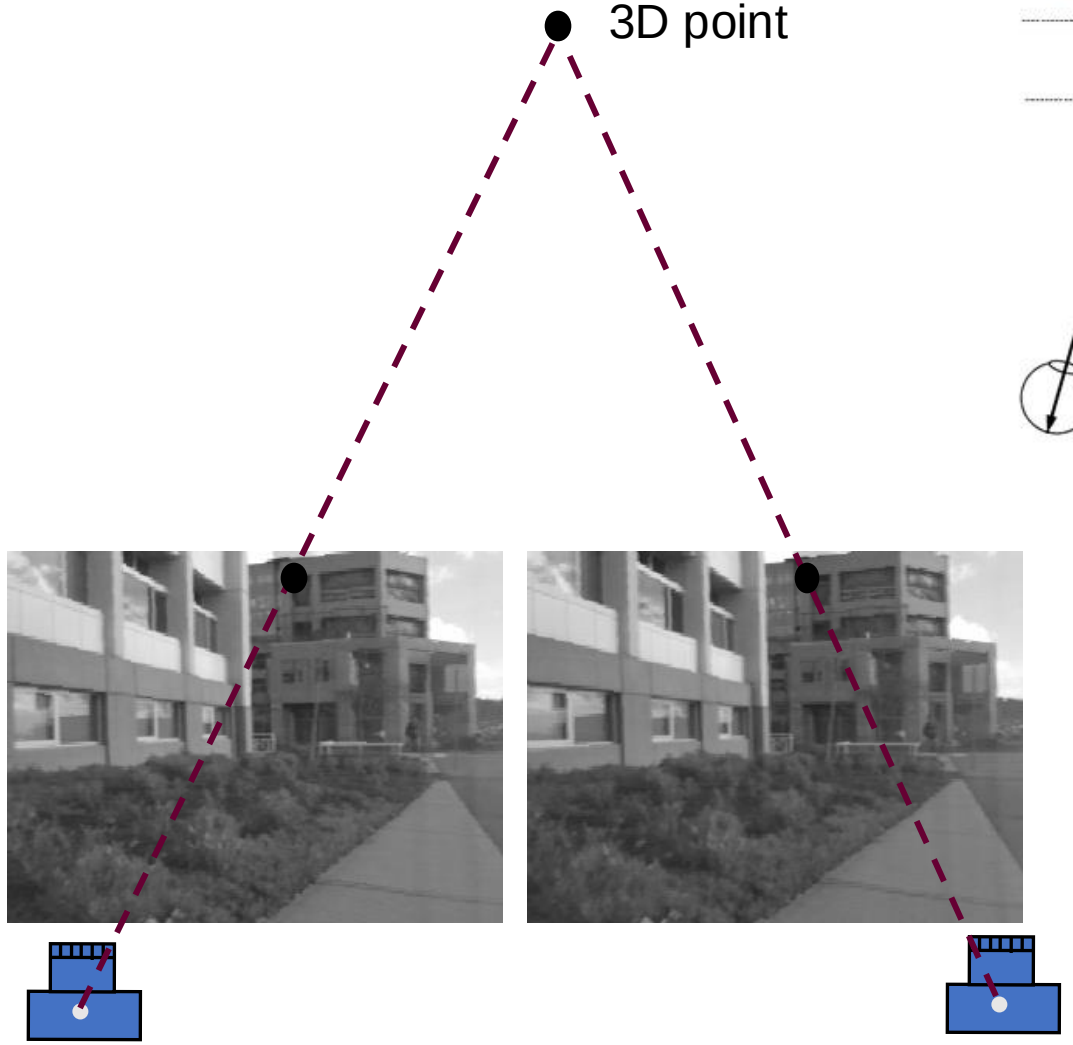
Open your other eye and close the first

The hand moved!

Stereo Camera

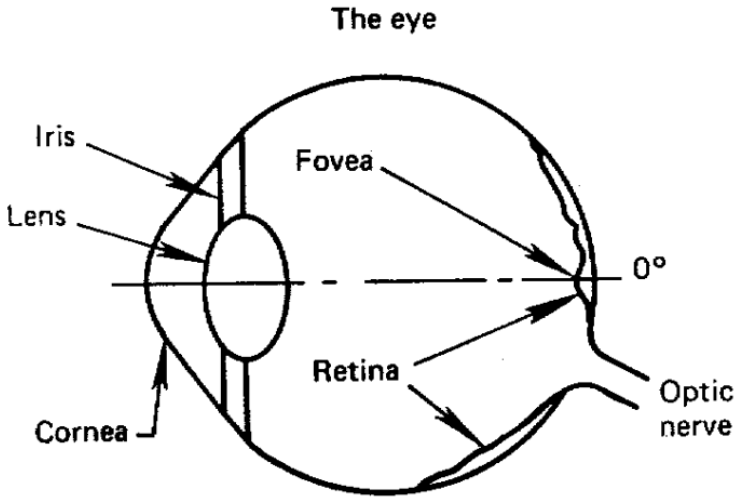
- As camera is shifted (viewpoint changed):
  - 3D points are projected to different 2D locations
- 2D shifts
  - stereo disparity



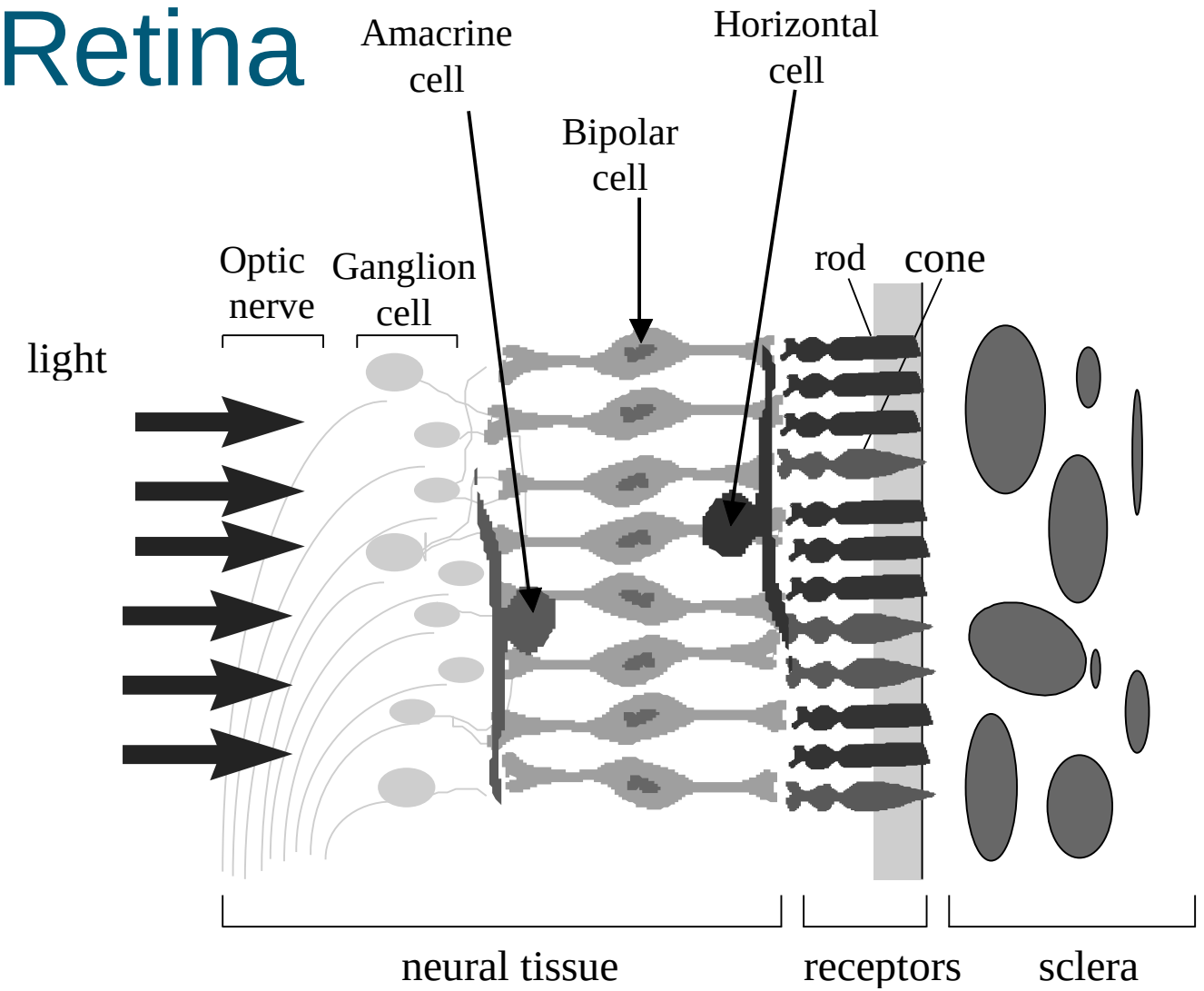


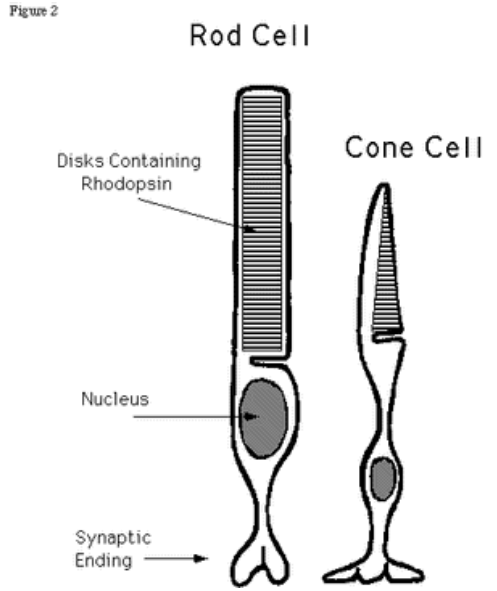
KITTI Dataset

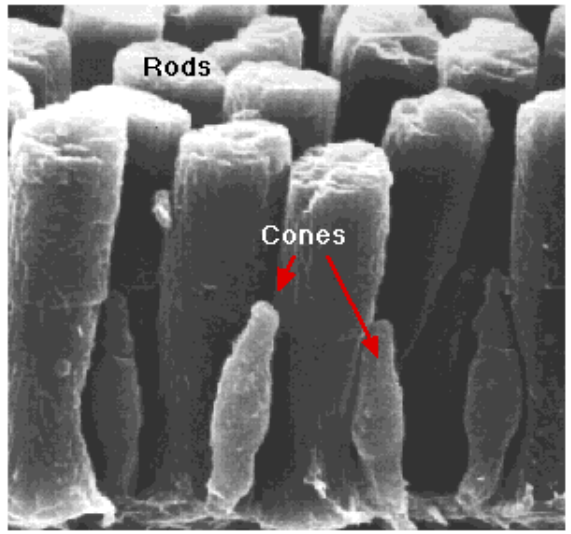
https://www.cvlibs.net/datasets/kitti/


The eye
Iris
Lens
Fovea
0°
Retina
Cornea
Optic
nerve

Retina



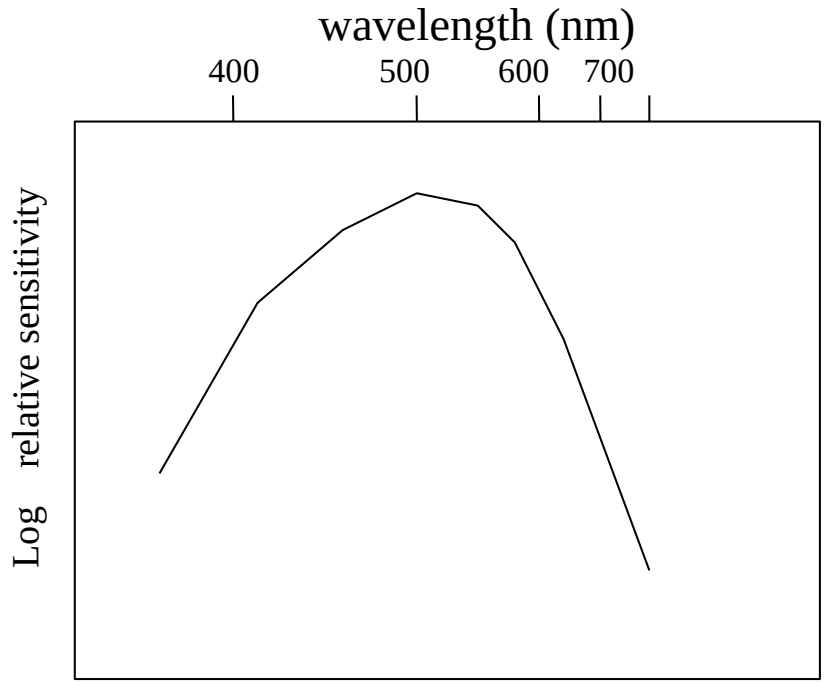




http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/V/Vision.html

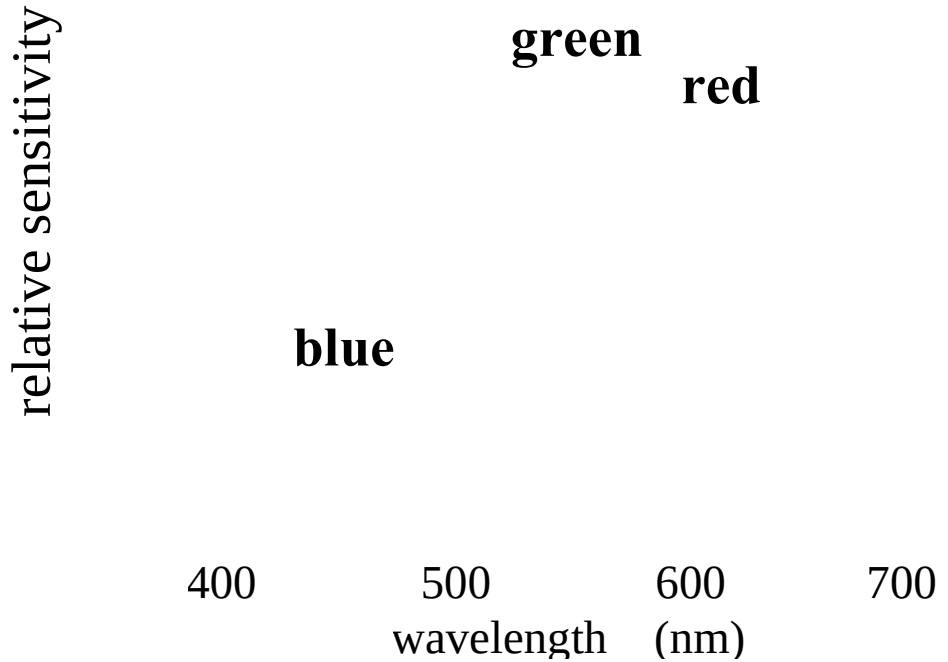
Rod

- sensitive to low levels of illumination (scotopic vision)
- not involved in color vision
- 75~150 million
- general, overall picture
- slower response
- about 25 times more sensitive than cones



Cones

- for high levels of illumination (photopic vision)
- color vision (trichromacy)
- ~ 6.5 million
- high density in fovea
- faster response



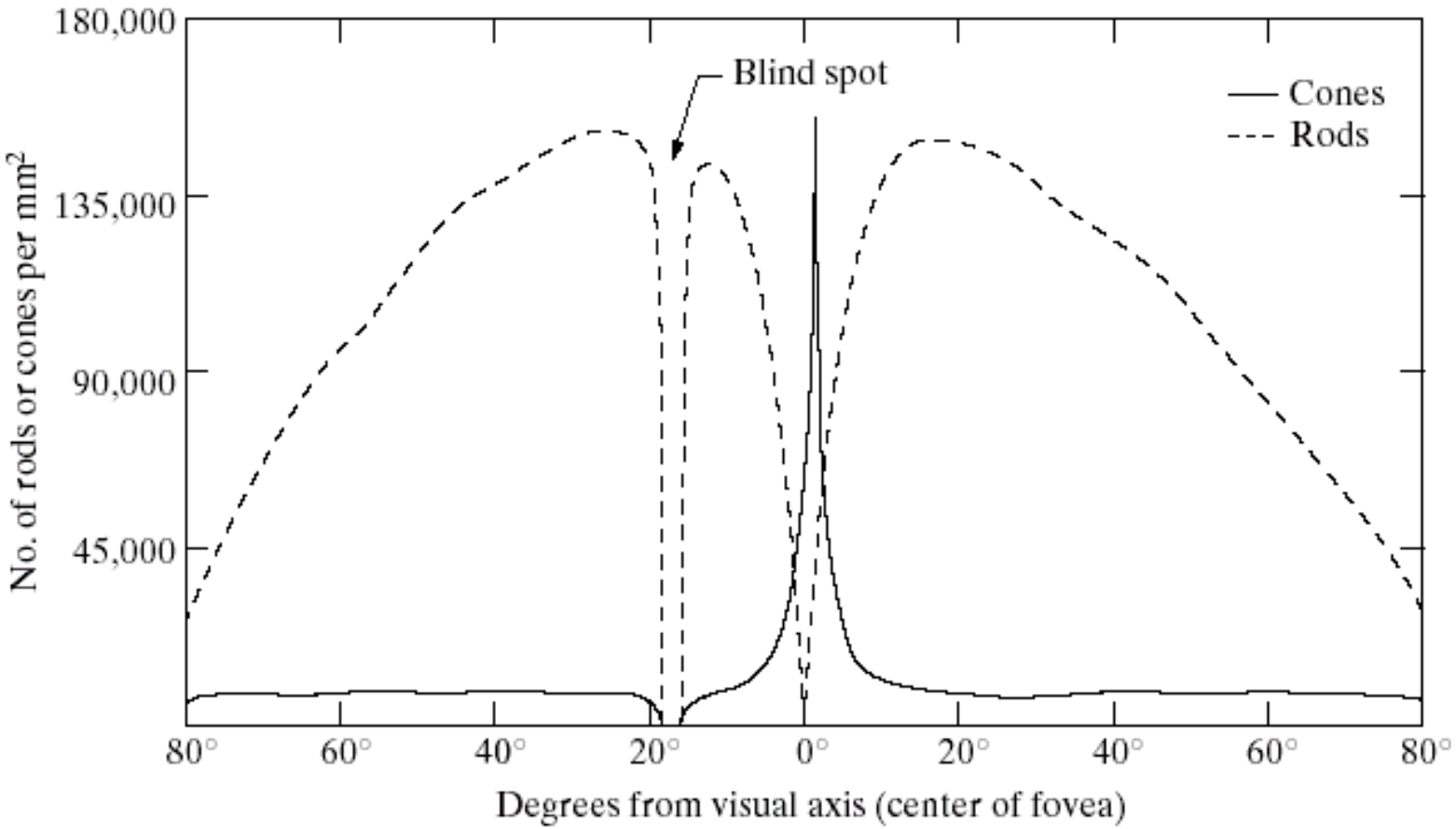


FIGURE 2.2
Distribution of rods and cones in the retina.

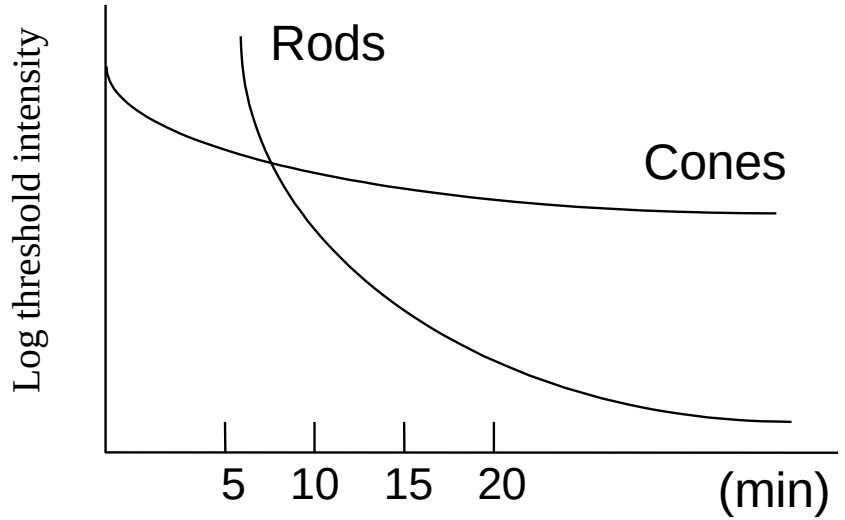
Dynamic Range between Scenes

outdoors: sunlight (10^{5} lux) ------ starlight (10^{-4} lux)

(9 orders of magnitude) (1 lux = 0.0929 foot-candle = 1 meter-candle)

human: reasonable vision over about 6 orders of magnitude; can detect 1~2 photons.

dark adaptation



How to test your blind spot?

1. Preparation:

• Draw a **small dot** on the left side of a piece of paper and a **small plus sign (+)** on the right side, about 6 to 8 inches (15-20 cm) apart.

• Hold the paper at eye level.

2. Testing the Right Eye:

• **Cover your left eye** with your hand.

• Focus **only on the plus sign (+)** with your right eye.

• Slowly bring the paper closer or farther away while keeping your right eye focused on the plus sign.

• At some point, the **dot** on the left should disappear from your peripheral vision. This is where the image is falling on your **blind spot**.

3. Testing the Left Eye:

• **Cover your right eye** with your hand.

• Focus **only on the dot** with your left eye.

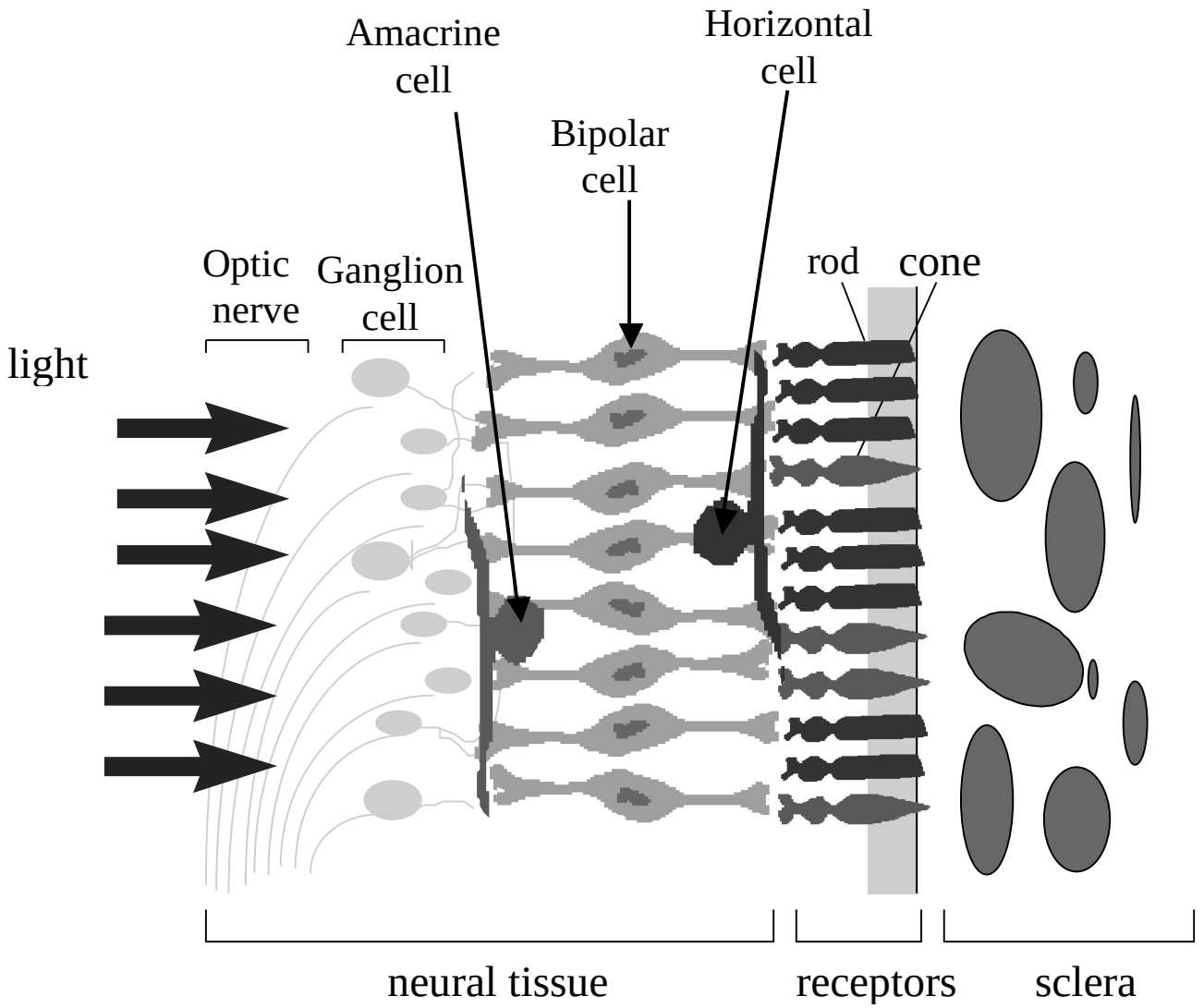
• Again, slowly move the paper toward or away from your face.

• The **plus sign** will disappear from your vision at some point, revealing the blind spot in your left eye.

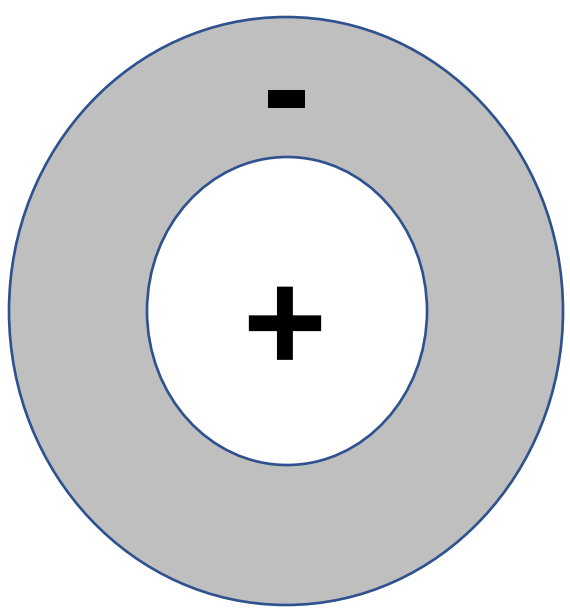
Testing your Blind Spot

https://youtube.com/shorts/ADBXtnsdkHY?si=xP-XVLqczX4aNtlM

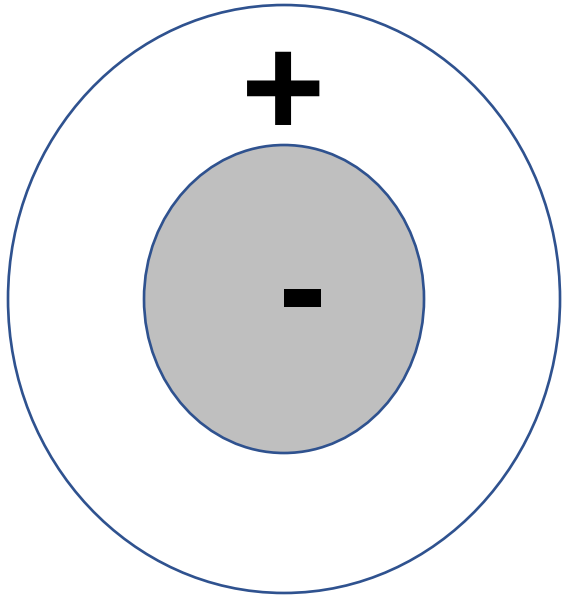
Receptive Fields of Retinal Ganglion Cells



Receptive Field

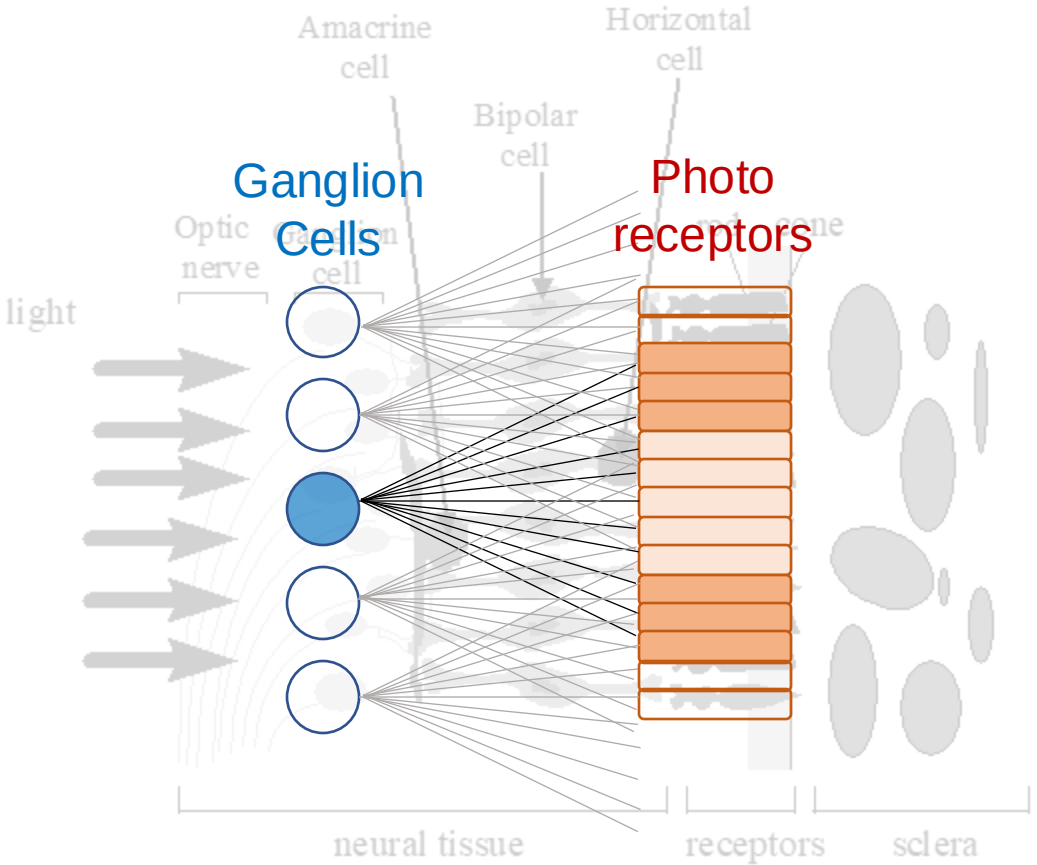


On-center



Off-center

On-center


Amacrine cell
Horizontal cell
Bipolar cell
Ganglion Cells
Photo receptors
Optic nerve
light
neural tissue
receptors
sclera

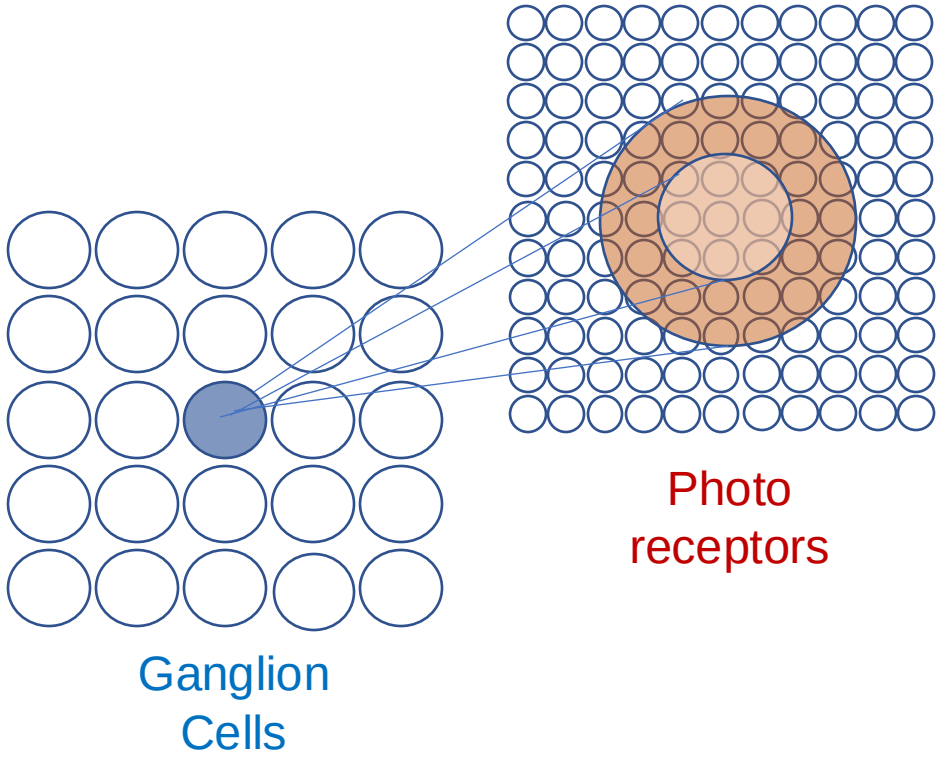
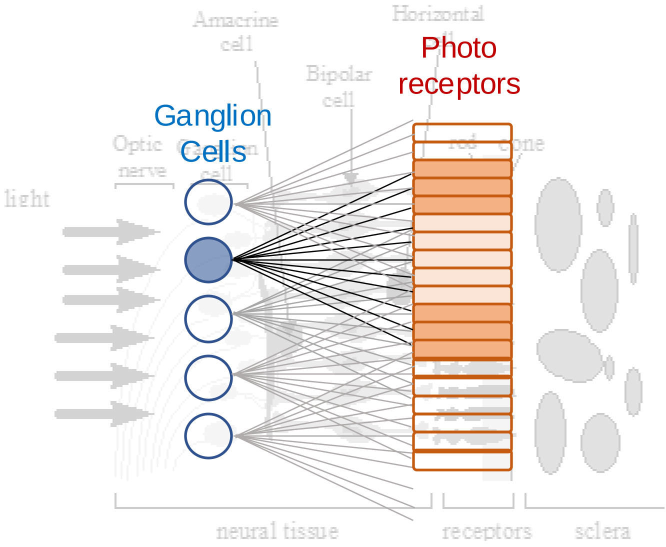
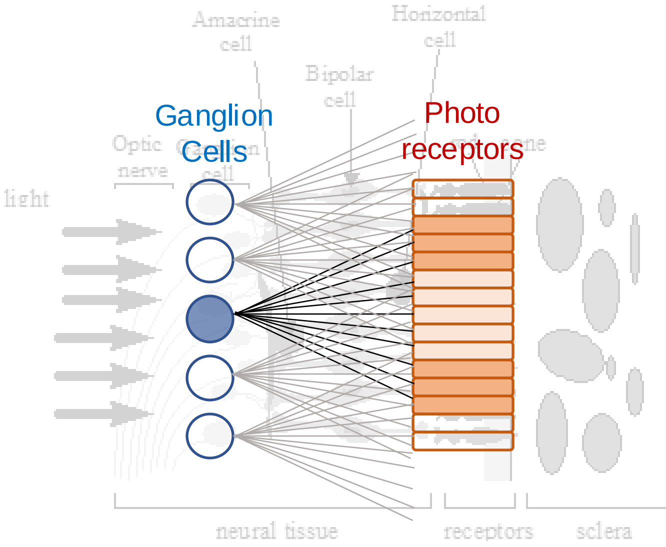
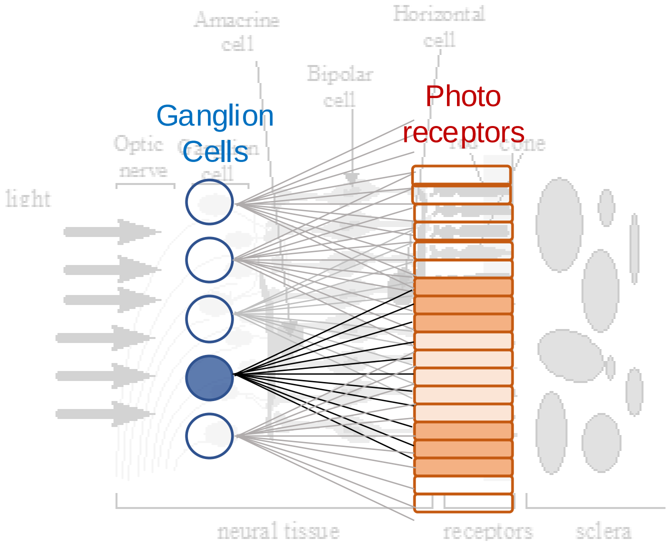


Photo receptors
Ganglion Cells


Amacrine cell
Horizontal cell
Photo receptors
Bipolar cell
Ganglion Cells
Optic nerve
light
neural tissue
receptors
sclera


Amacrine cell
Horizontal cell
Bipolar cell
Ganglion Cells
Photo receptors
Optic nerve
light
neural tissue
receptors
sclera


Amacrine cell
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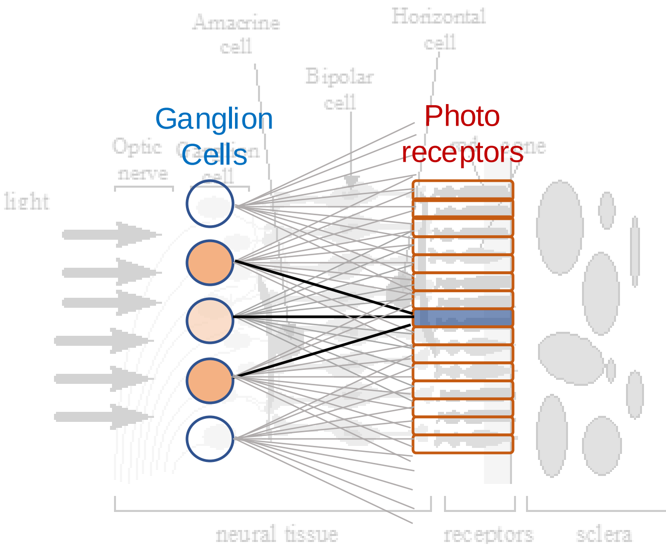
Amacrine cell
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Bipolar cell
Ganglion Cells
Photo receptors
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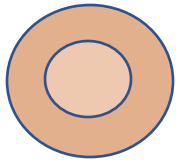


Point Spread Function
$h(x, y)$

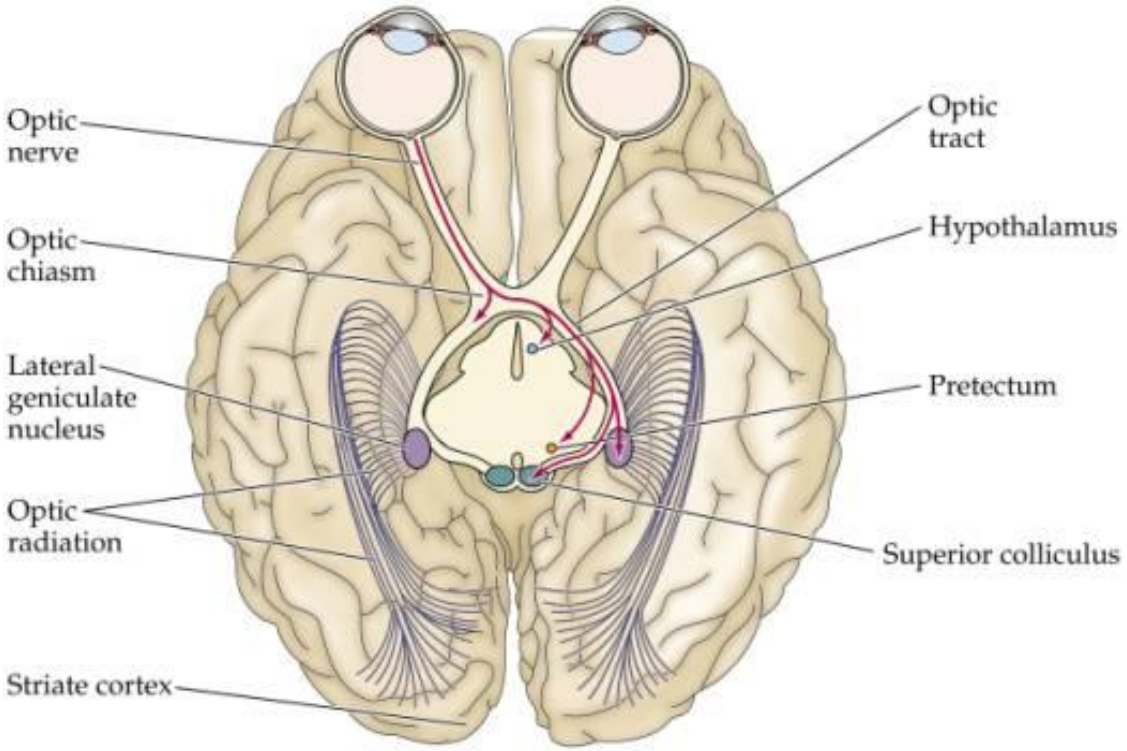
Image projected
on receptor layer
$f(x, y)$

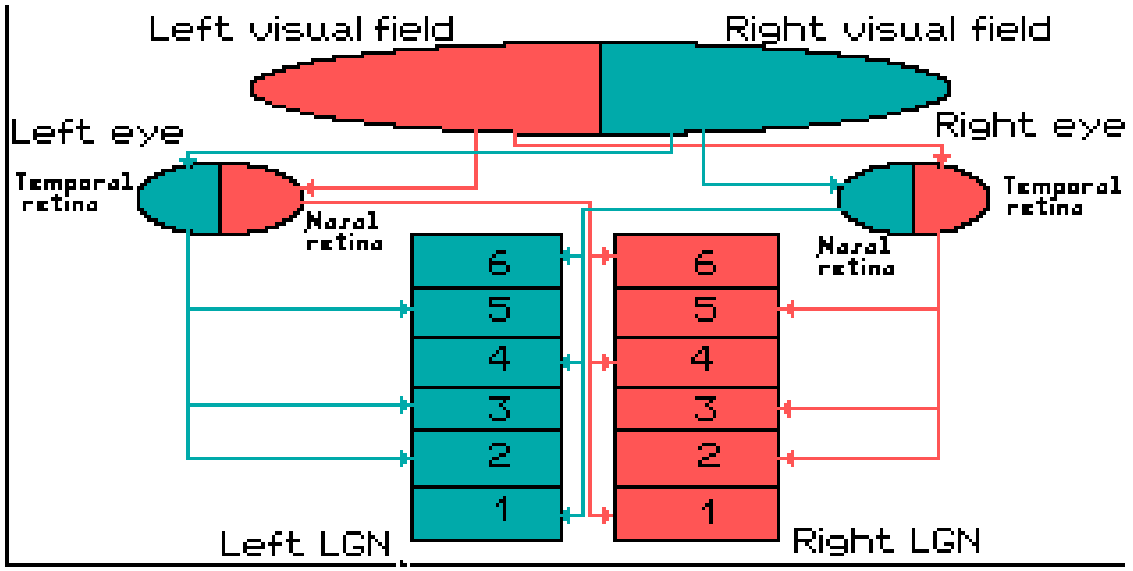
Linear Shift-Invariant
System

Image on ganglion layer
$f(x, y) * h(x, y)$

$*$: convolution operation

Lateral Geniculate Nucleus

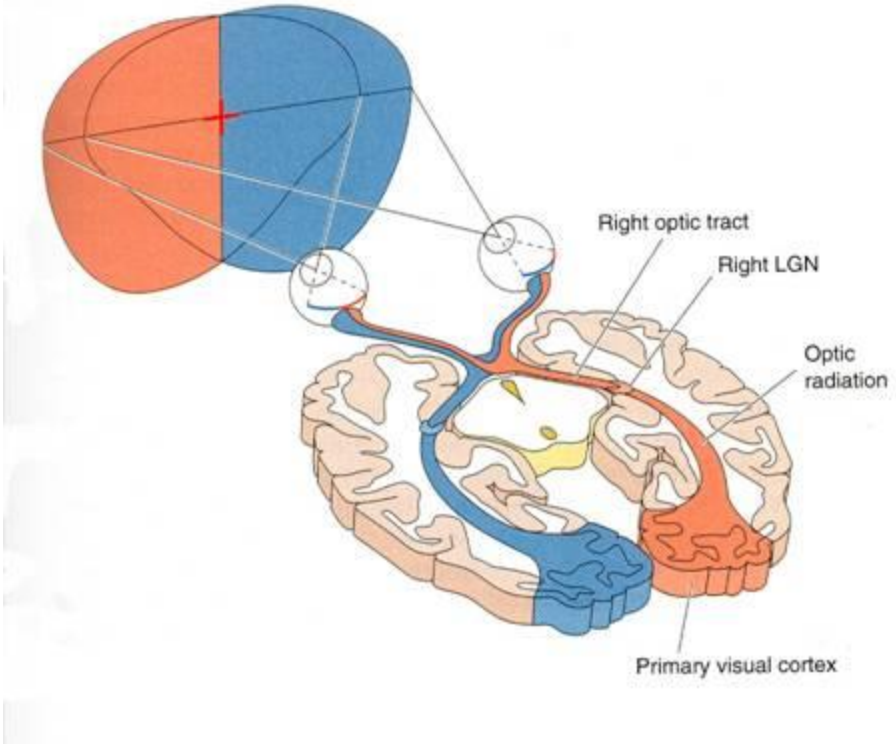




http://wiki.ahuman.org/index.php/BrainRegionNSA_FD_LGN

Primary Visual Cortex (Striate Cortex)

* A plate of cells 2 millimeter thick.
* ~ 200 million cells.



(Ref: http://dgward.com/physo101/sm06_pages/labs/Peripheral%20Vision%20and%20Visual%20Pathways.htm)

A bit of history:

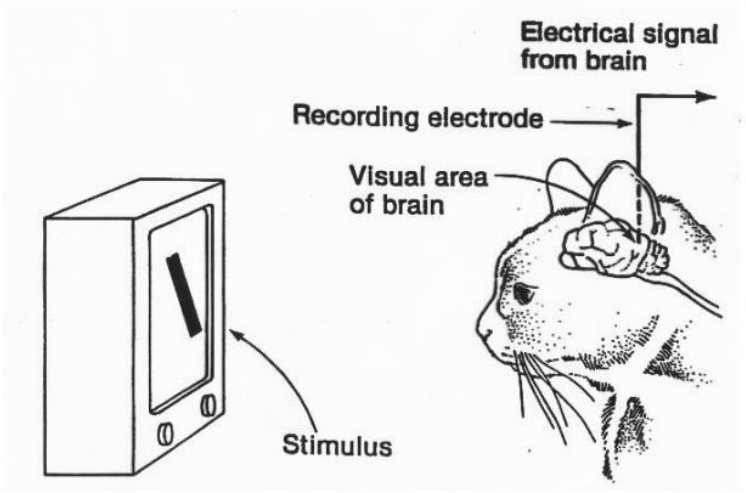
Hubel & Wiesel, 1959

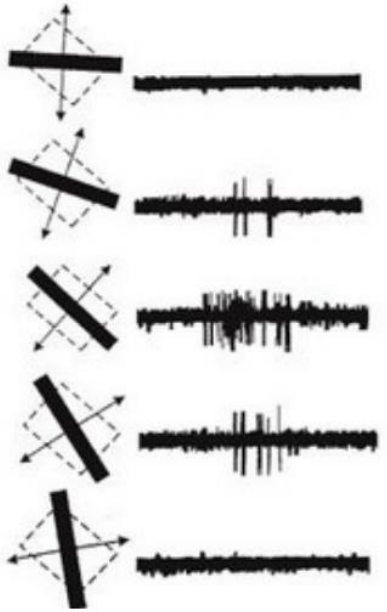
RECEPTIVE FIELDS OF SINGLE NEURONES IN
THE CAT'S STRIATE CORTEX

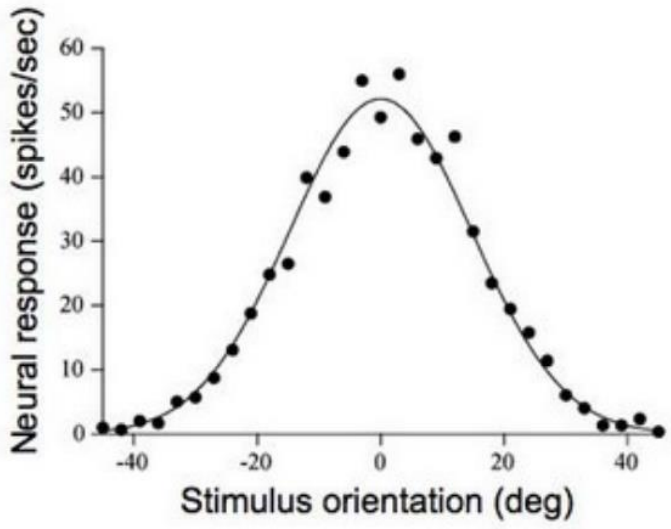
1962

RECEPTIVE FIELDS, BINOCULAR INTERACTION
AND FUNCTIONAL ARCHITECTURE IN
THE CAT'S VISUAL CORTEX

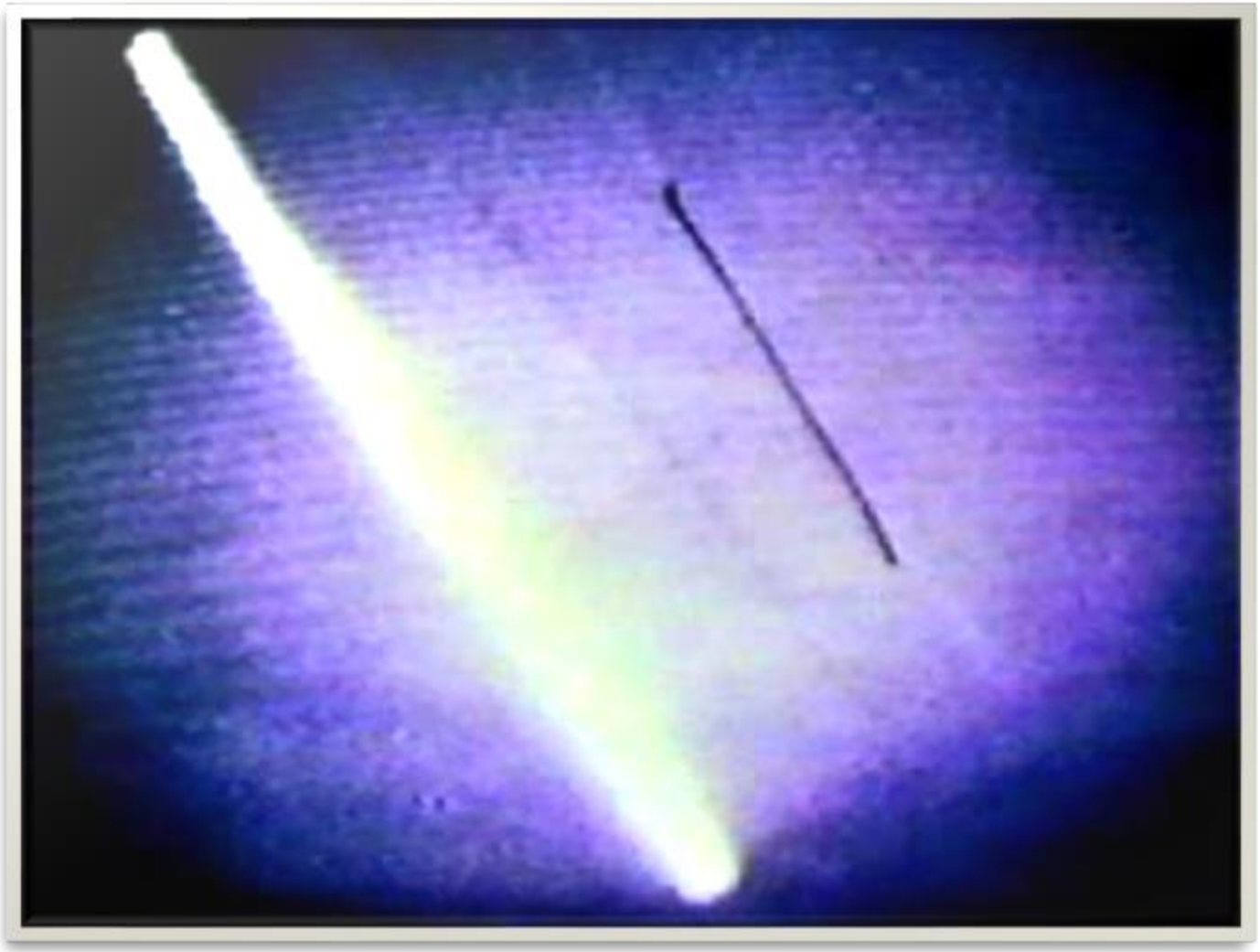
1968...







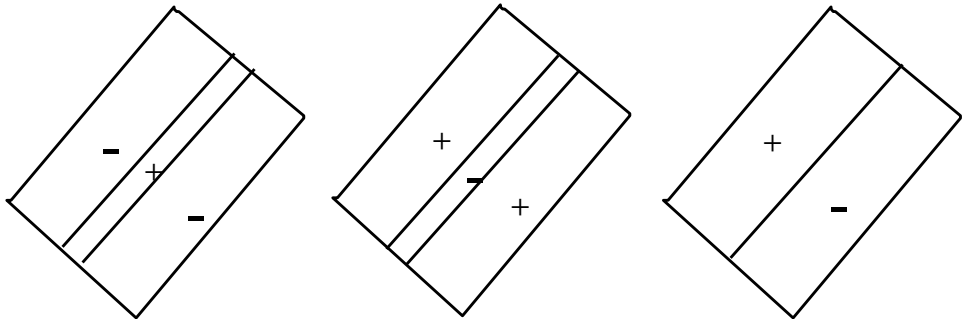
Experiments

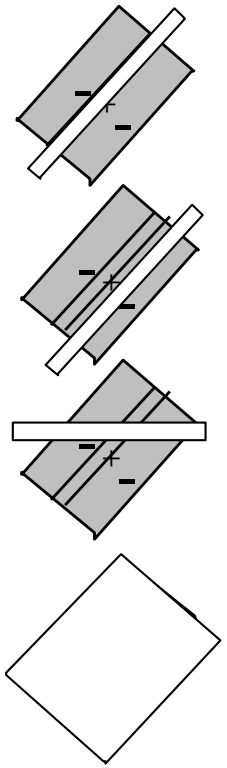


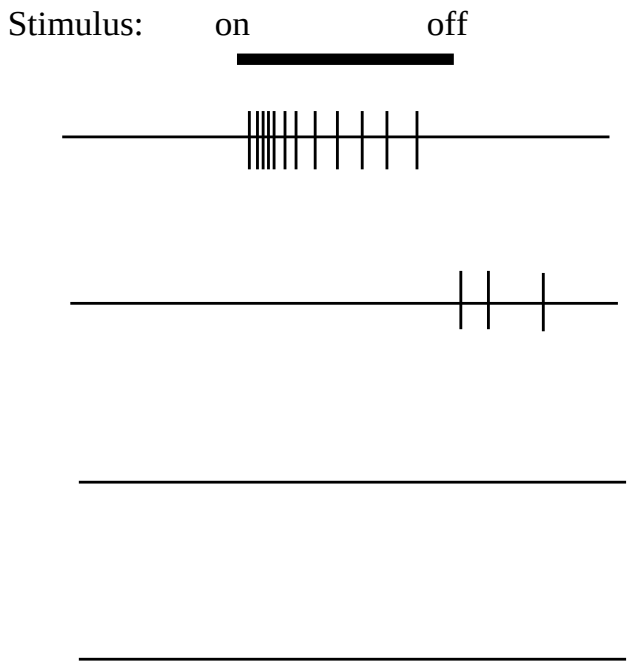
https://youtu.be/8VdFf3egwfg

Simple Cells

- Orientation Selectivity







Complex Cells

- The commonest cells in the striate cortex
- Orientation Selectivity
- Directional Selectivity