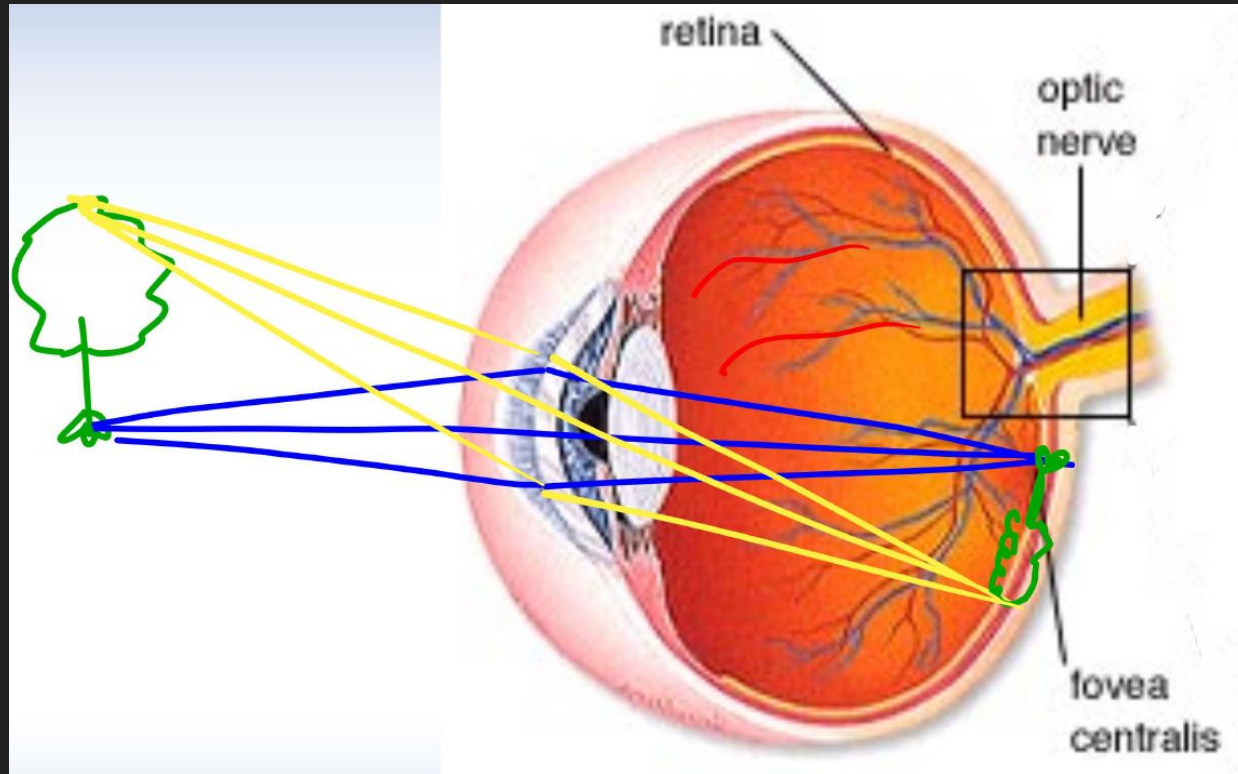# CS 498 VR

Lecture 13 - 3/7/2018

go.illinois.edu/VRlect13

Review

- How do we perceive the color of an object? And how does the color of the light source itself change how we perceive color?

- How do Fresnel lenses cut costs in comparison to spherical lenses?
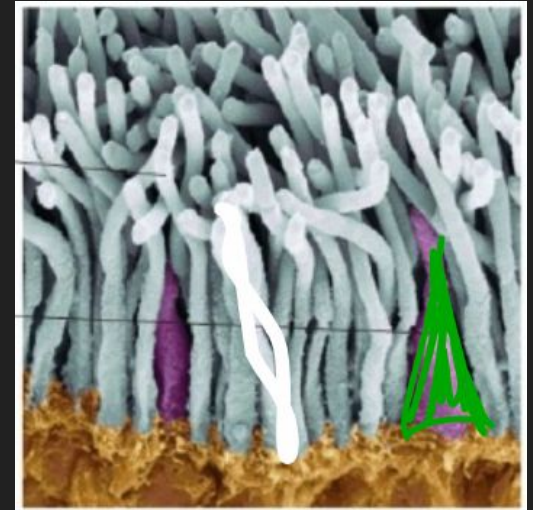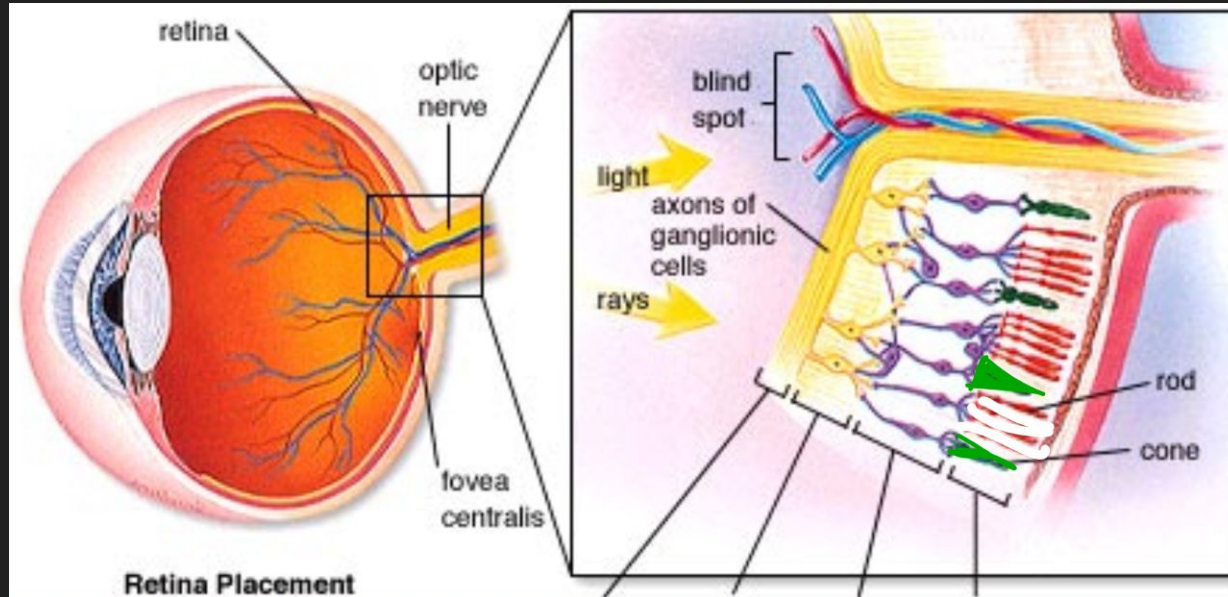
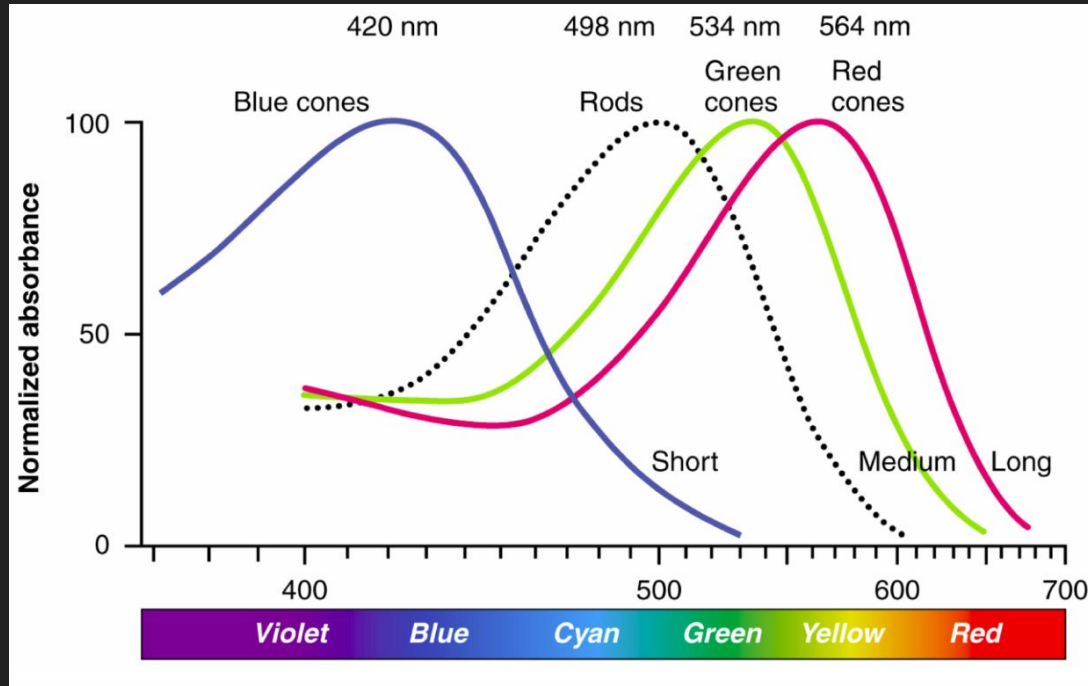# Peripheral Vision

Photoreceptors

There are two types:

Rods
120,000,000
Low light
Black/white
Peripheral vision

Cones
6,000,000
Bright light
Color, RGB
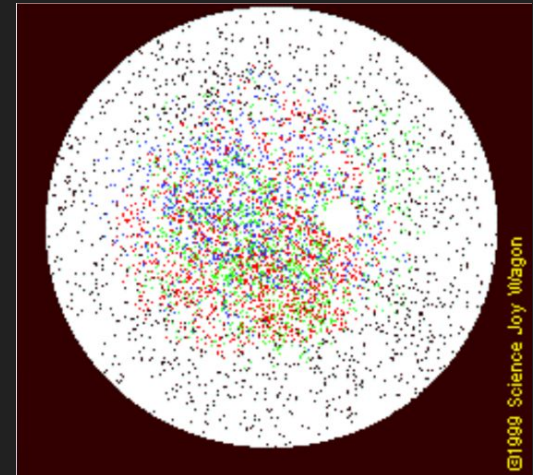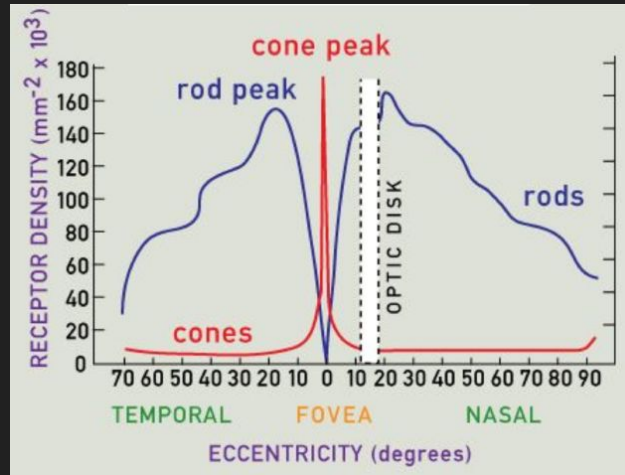Straight, high-res

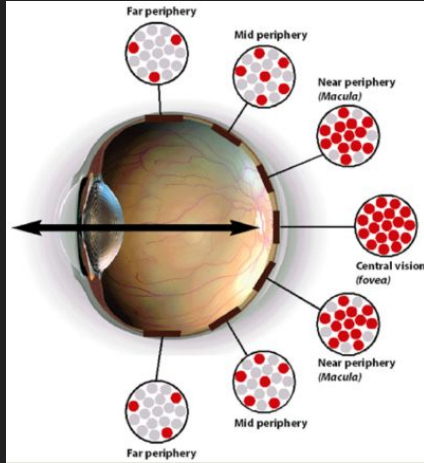# Rods and Cones Sensitivity

Examples: 1. We do not see colors at night, or on periphery
2. Red rose at dusk
3. Green leaf at dusk

Rods and Cones Placement

Which eye is this?
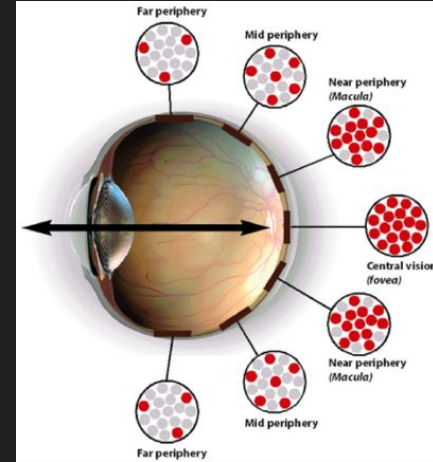
Why is there asymmetry?

Density at fovea: ~200,000 rec/1 mm^2

Examples
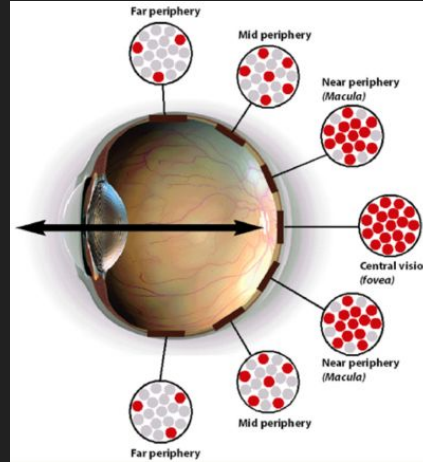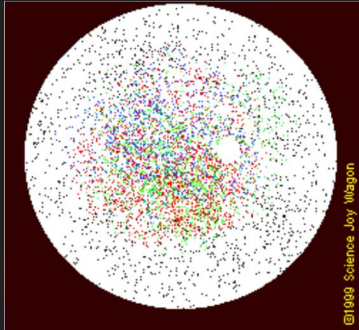
Examples	Day, light	Dusk, night
Straight		
Periphery		
Damaged rods		
Bright red charts		
Faint red charts		

How to see "stuff" blocking photoreceptors
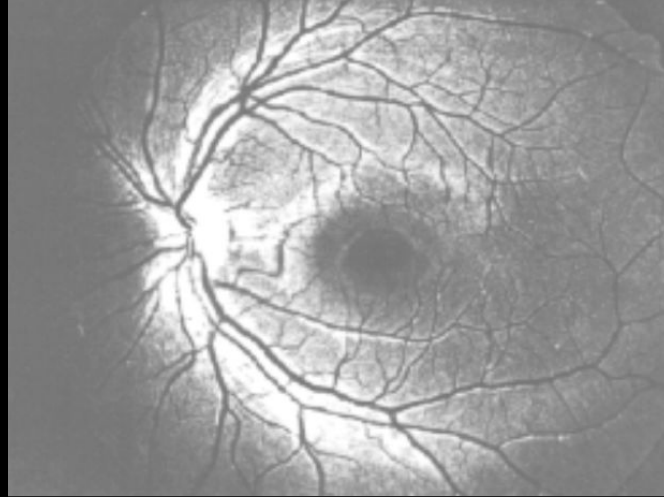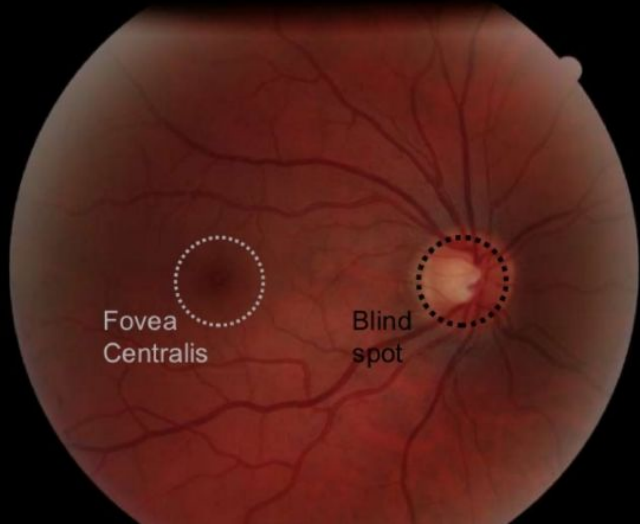
Hypothesis: We only see moving stuff!

Would astigmatism affect seeing eye blood vessels?
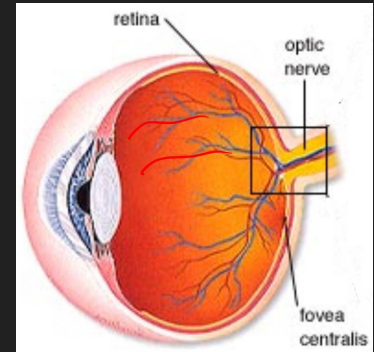
How to see "stuff" blocking photoreceptors

A lot is not known about the human eye

Concentrate on the 4 dots for 30 secs.
Then, shift your eyes to the wall and blink.
Who do you see???

How much display resolution is enough in VR?

Output pixels: RGB

Interface

Input pixels: Photoreceptors
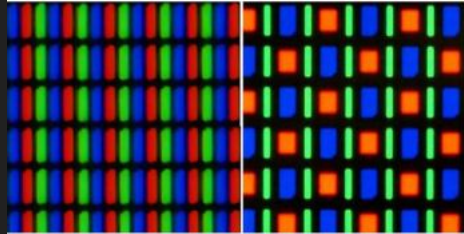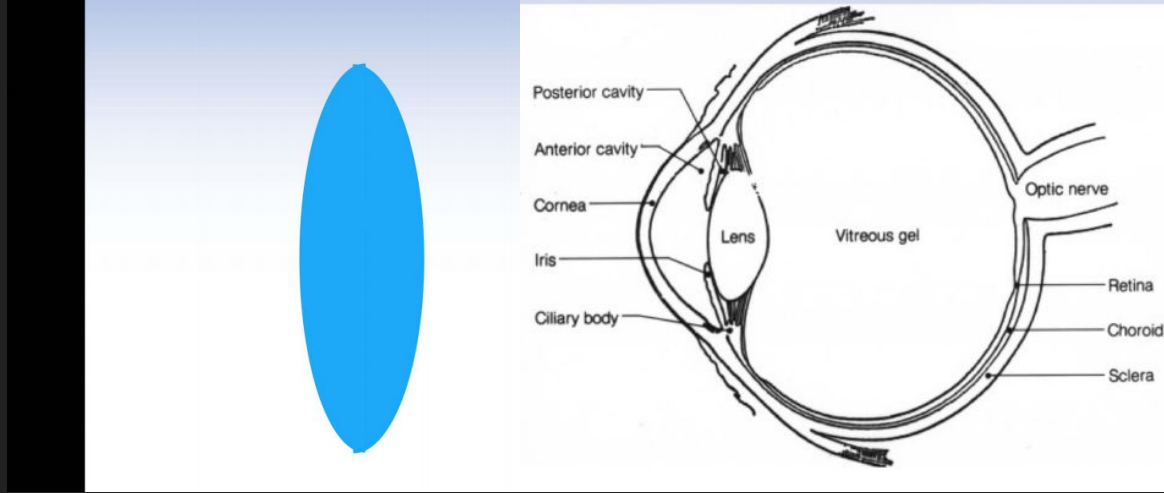
Is 1080p per eye enough?
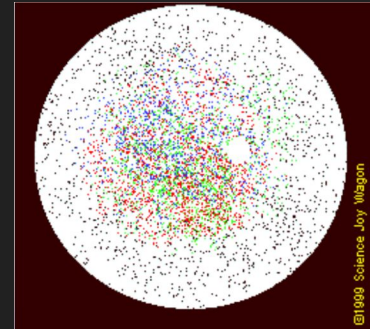
How much display resolution is enough in VR?

Conservative estimate:

\# photoreceptors = \# pixels

Resolution = $\sqrt{\# \text{ pixels}}$ =

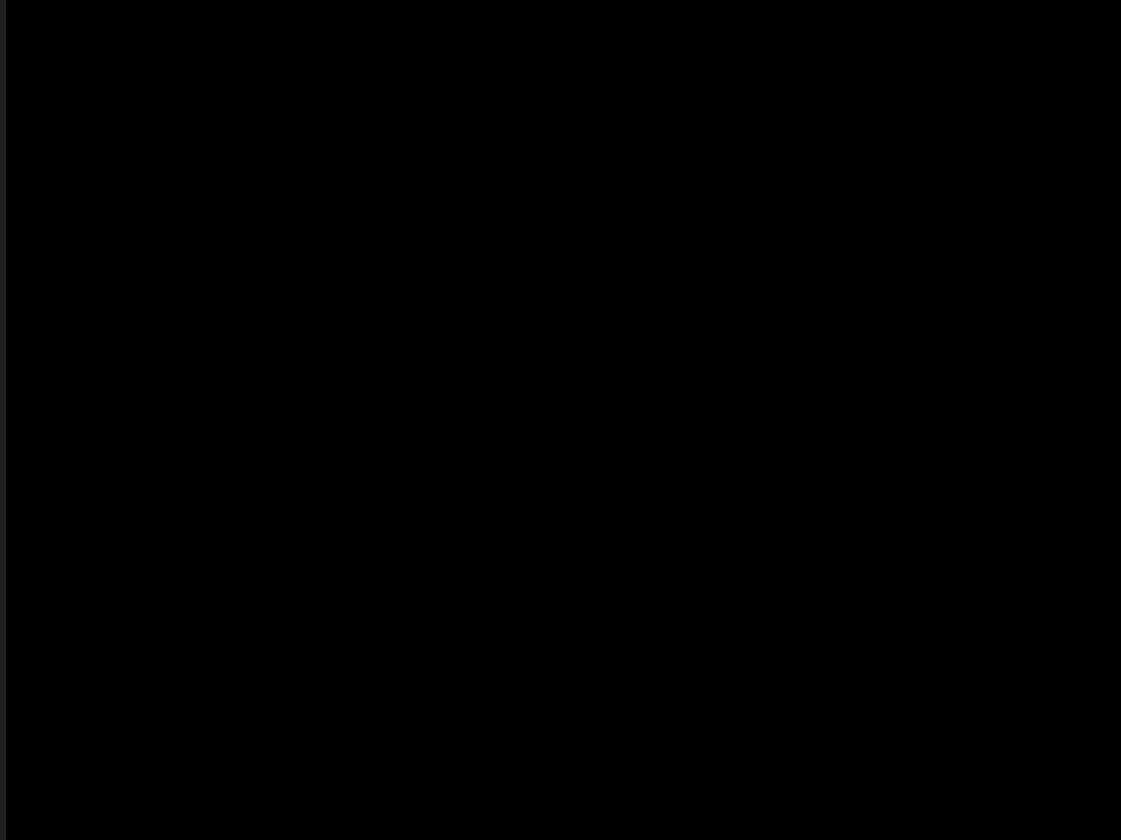Current resolution?

CV1 res is 1080x1200 per eye, 2160x1200 total

Overkill?

\# pixels = highest density/mm^2 x Retinal area (mm^2)

Resolution = $\sqrt{\# \text{ pixels}}$ =
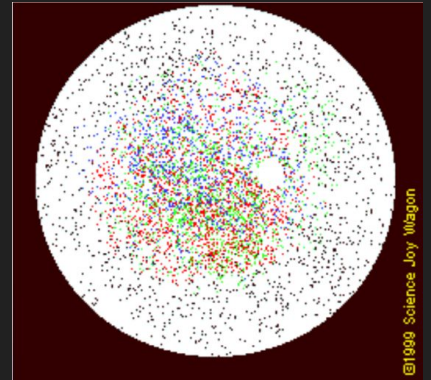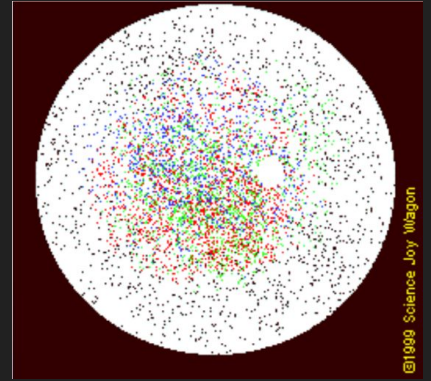
Light Intensity

Luminance and retinal illumination

Left scale (log cd/m²): 10, 8, 6, 4, 2, 0, -2, -4, -6

- Sun
- Fluorescent light/bulbs
- White paper, full sunlight
- Candle flame
- Comfortable reading
- Print read with difficulty
- White surface, moonlight
- Threshold for cone vision
- White surface, moonless night
- Visual threshold

Right scale (log photons/μm²/sec): 14, 12, 10, 8, 6, 4, 2, 0, -2

- PHOTOPIC
- MESOPIC — 10^5, 10^2
- SCOTOPIC — 10^{-2}
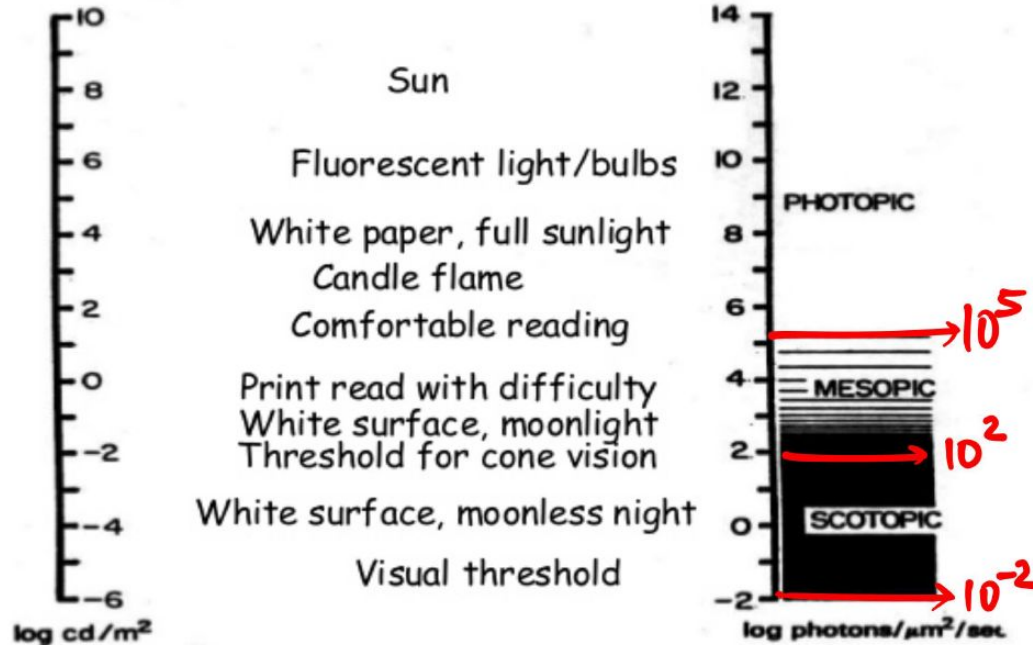
The range of luminances (left) and retinal illumination (right) found in the natural world

Scotopic vs. Photopic Vision

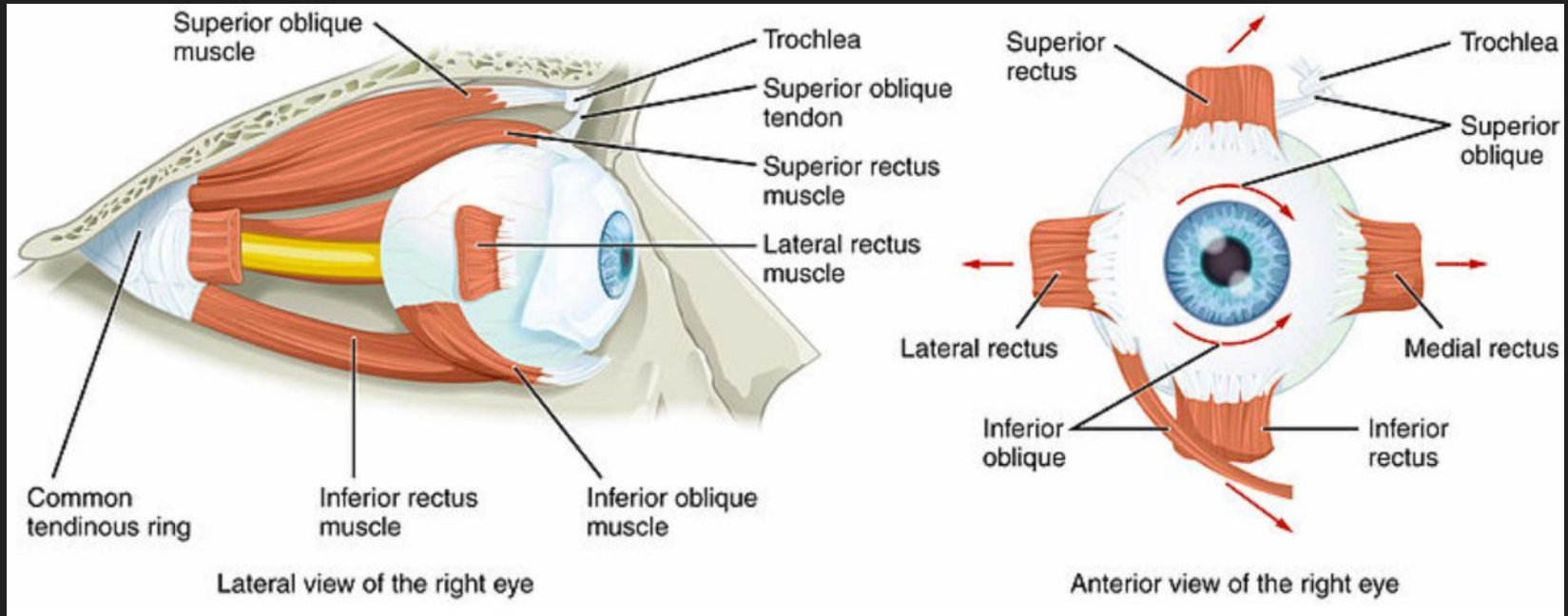|	Scotopic Vision	Photopic Vision
Photoreceptors	Rods	Cones
Light levels	$< 10^2$ ph/μm^2/sec	$> 10^5$ ph/μm^2/sec
Color	Monochromatic	Trichromatic
Adaptation	35 mins	10 min

Eye Muscles

Lateral view of the right eye

Anterior view of the right eye

Implications for VR: 1) Uncanny Valley
                       2) Foveated rendering

Eye Muscles
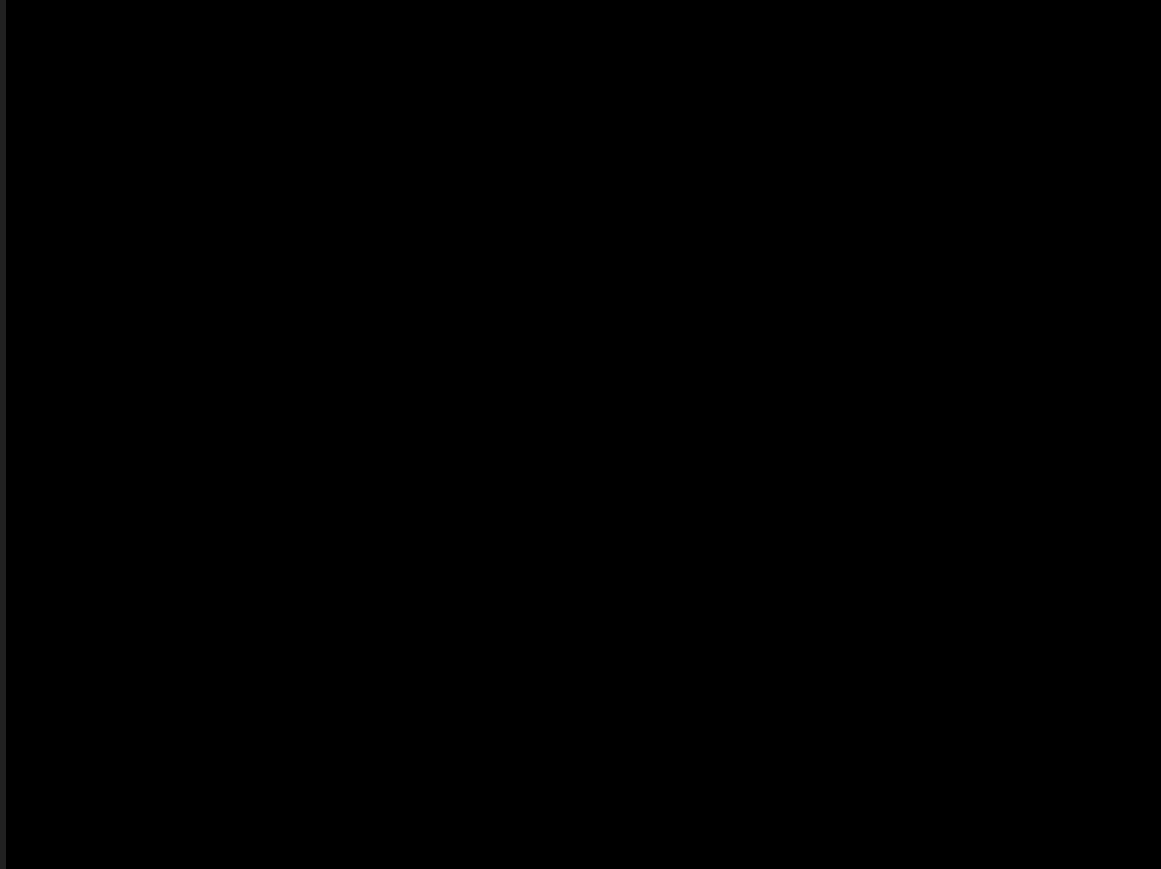
VR is an interdisciplinary topic

- VR is **NOT** a purely CS topic.

- If you work in a VR company, expect to work side by side with computer scientists, engineers, psychologists, optical engineers, optometrists, neuroscientists and artists.

- Most of the design questions in VR are open problems, almost everything is **unchartered territory.**

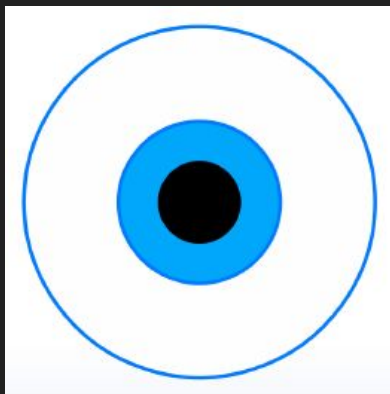- Pick any field, you probably can make a difference there with VR.

- A great place to make impact and change the world.

Sanity Check: DOFs
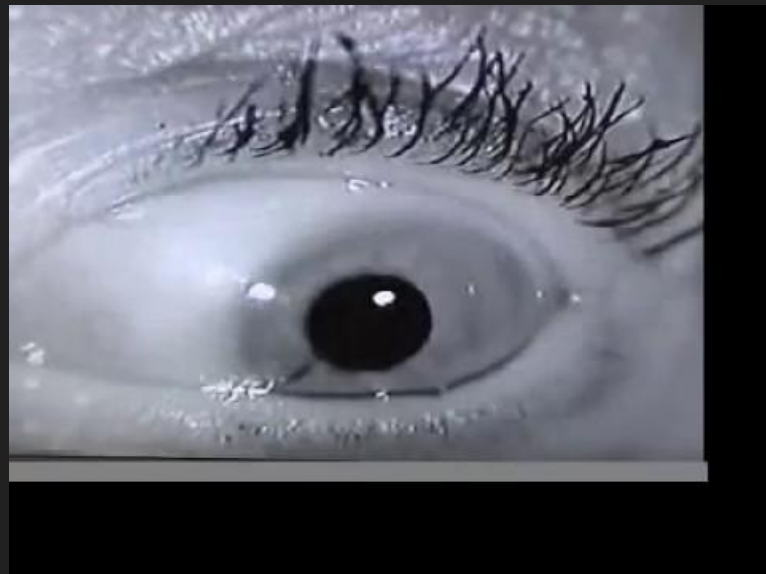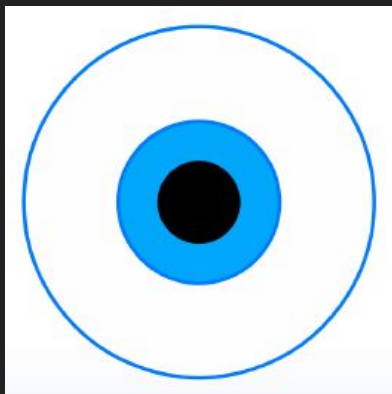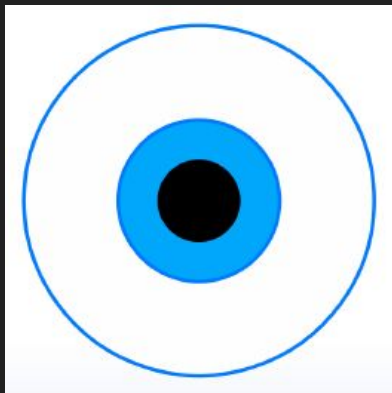
Eye Motion Modes
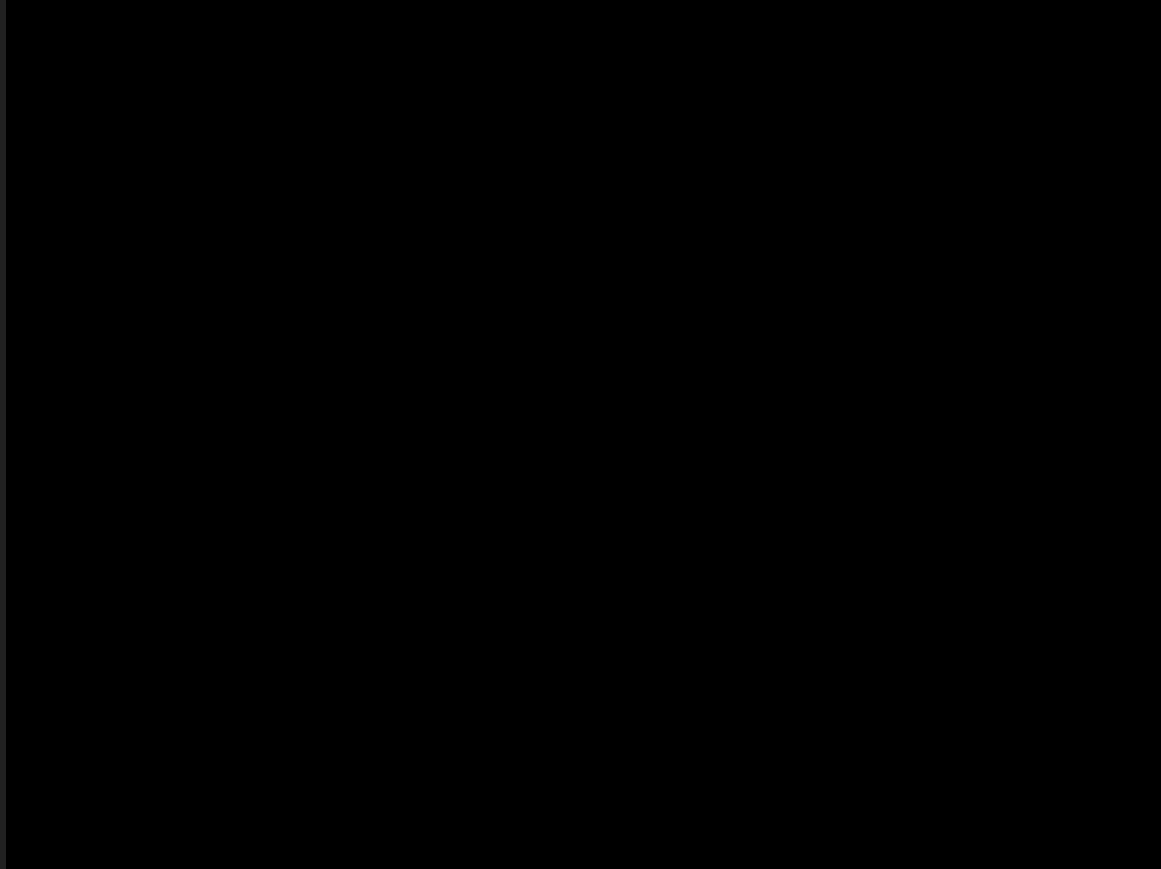
Eye Motion Modes

	Conjugate	Disjunctive
Voluntary	Saccades Pursuit	Vergence (Convergence + divergence)
Involuntary	Vestibulo-ocular reflex (VOR) Optokinetic Microsaccades	N/A

Review

- Explain the four main differences between rods and cones

- Why are many navigation lights colored bright red?

- How long will it take for us to start seeing things really well when going from a room with really bright light to very dark light? Which mode of vision is this?

Announcements

- MP 4 due March 26th - but start early!
  - Takes a long time to do & lab will be full closer to due date so start now!

- From now on, you will have mandatory weekly final project meetings - TA for your project will contact you

- Your <u>attendance will be logged</u> and <u>work you completed will be kept track of</u>. You could get a lower grade than the rest of your team if you don't contribute equally to the final project

Read LaValle, Chapter 4, 5

VIRTUAL REALITY

Steven M. LaValle