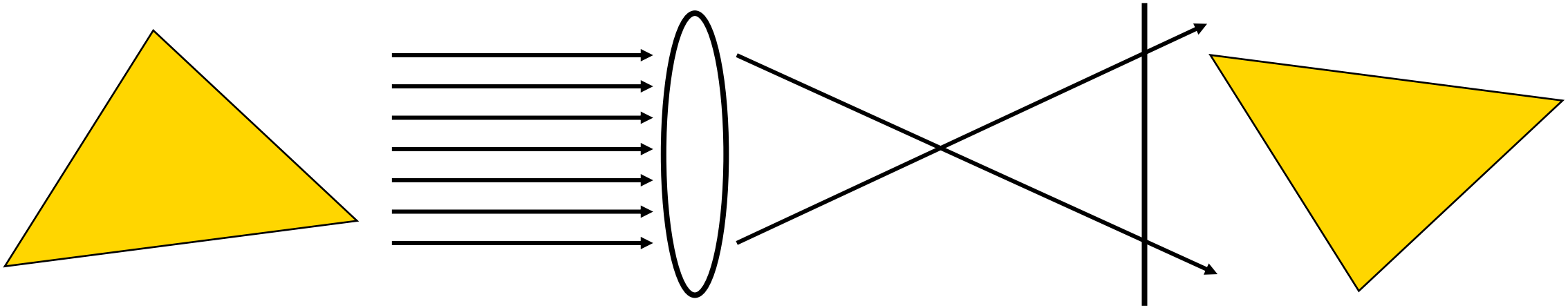
CSU44054/CS7GV4: ~~Augmented~~ Reality

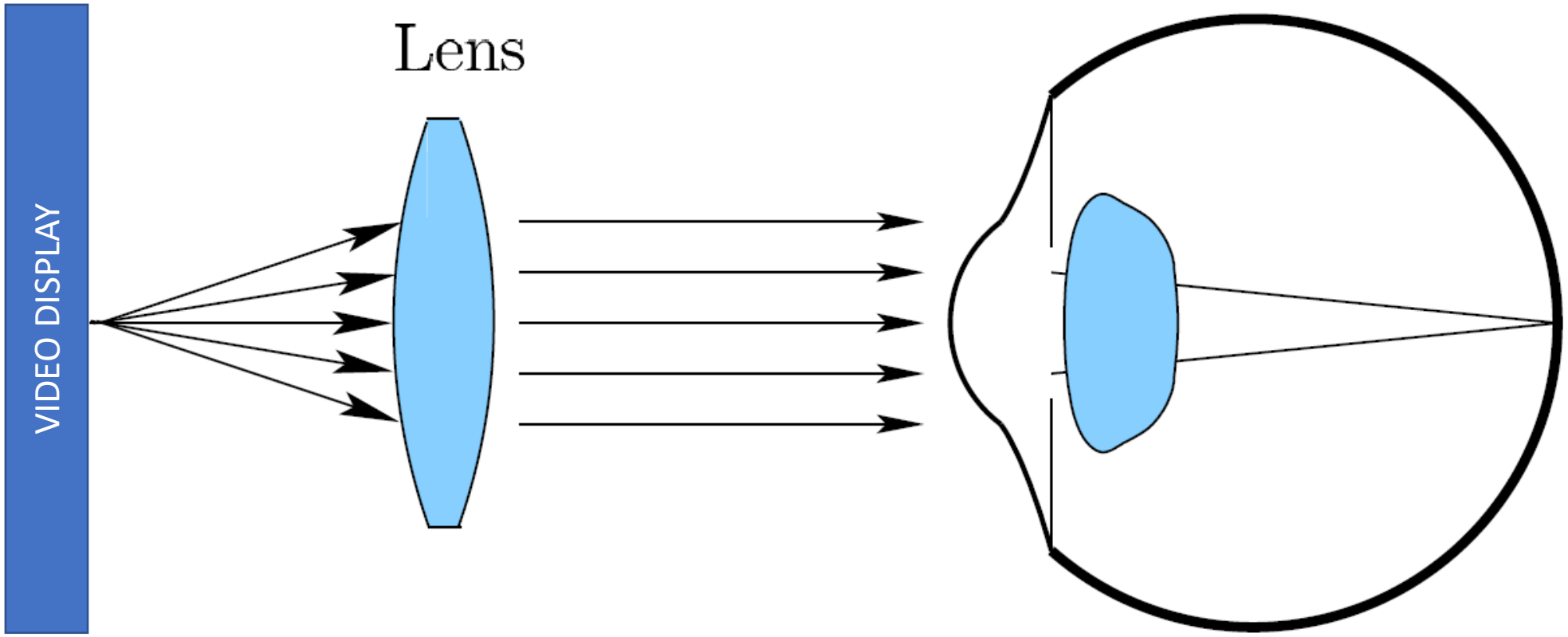
Gareth W. Young

eXtended

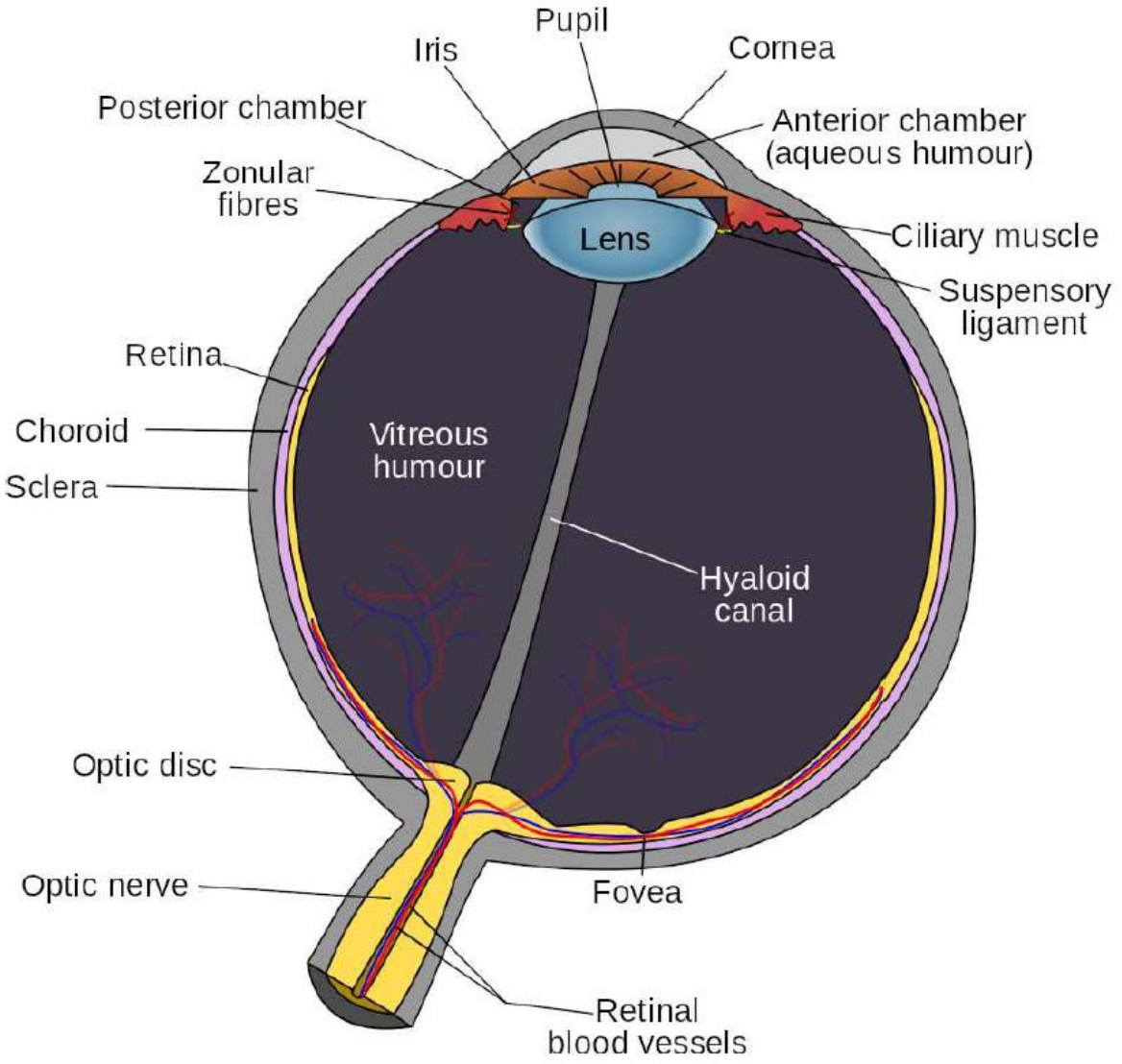
Light and Optics



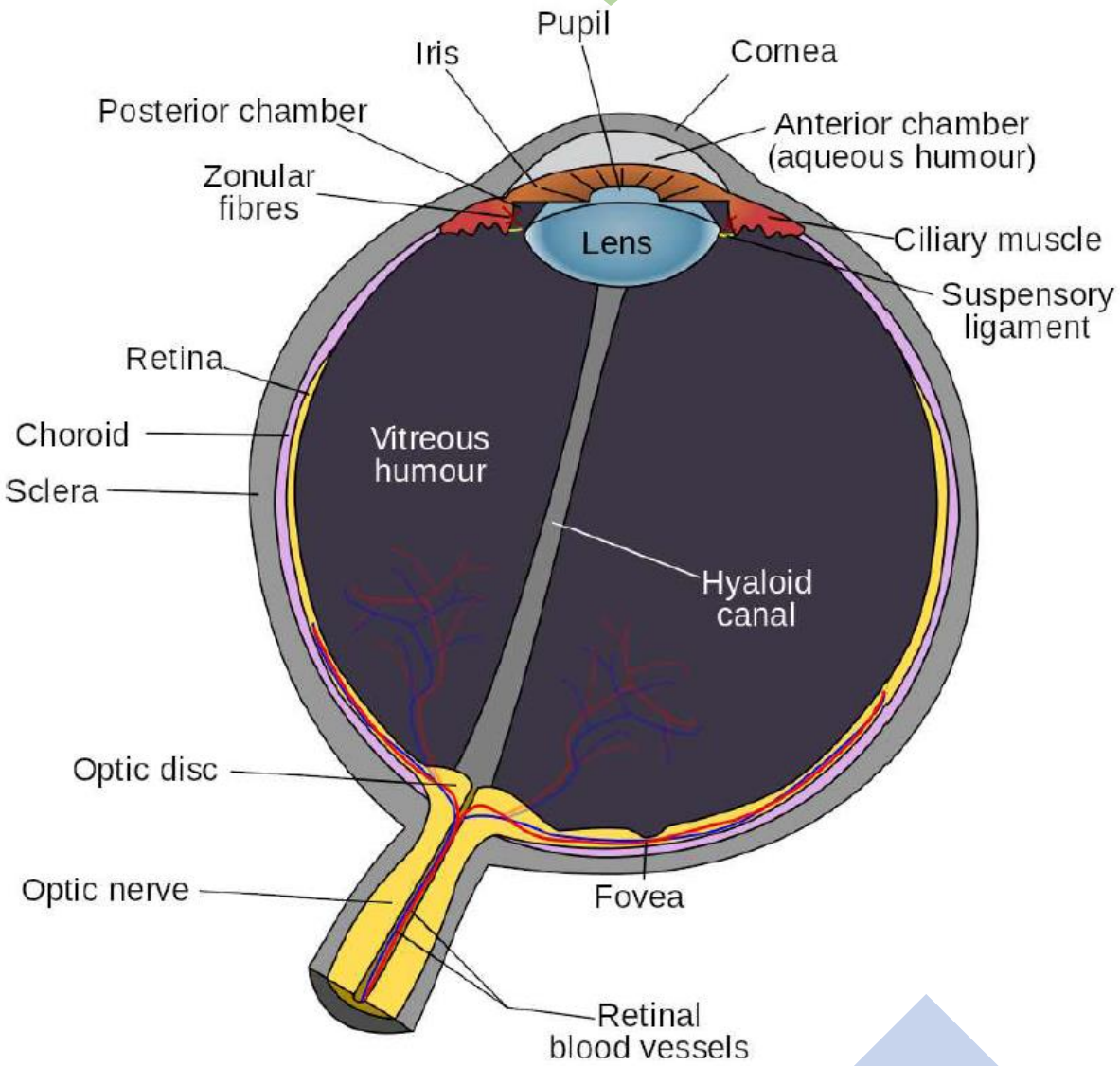
Combining Light and Optics for HMDs



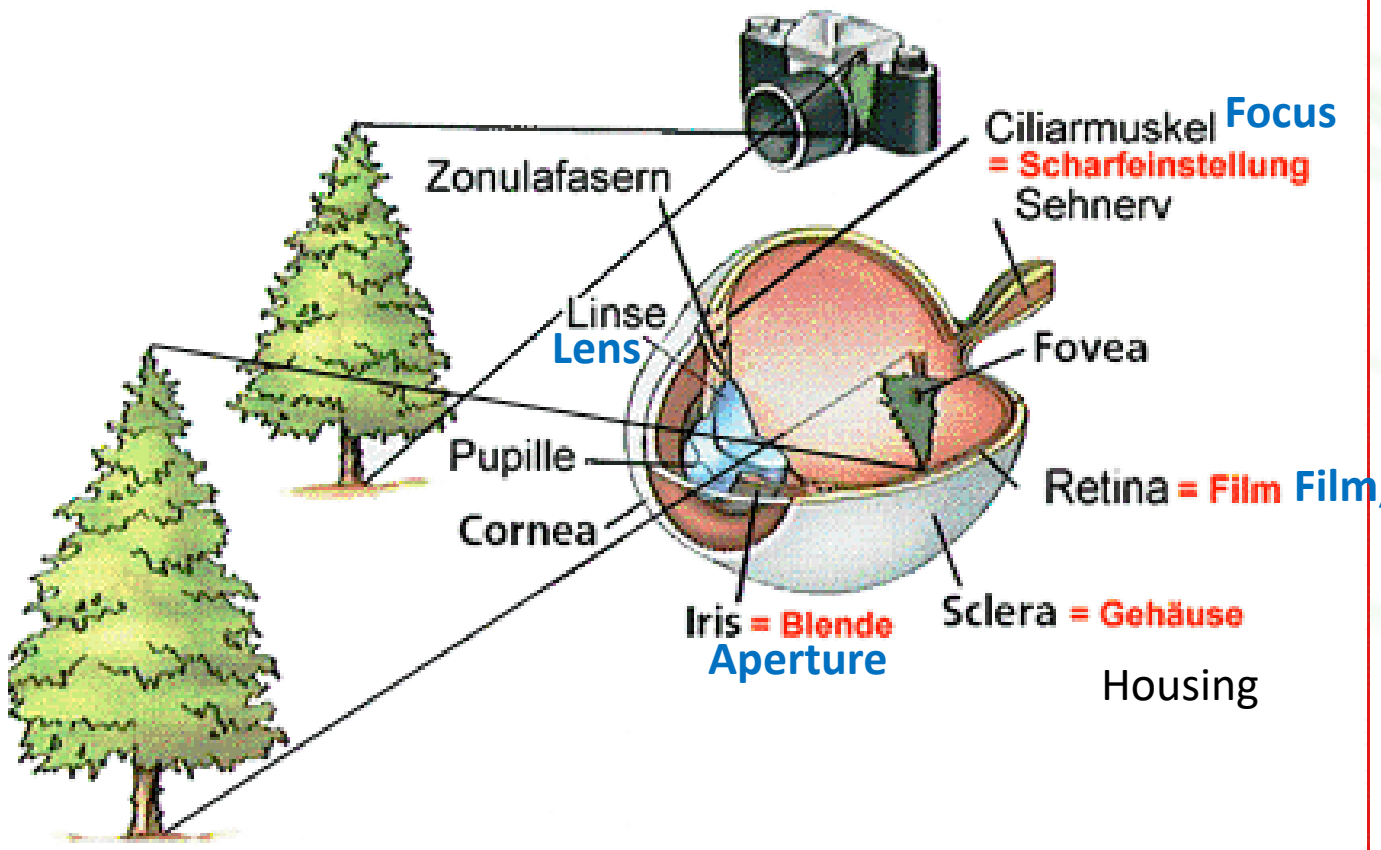
The Physiology of Human Vision



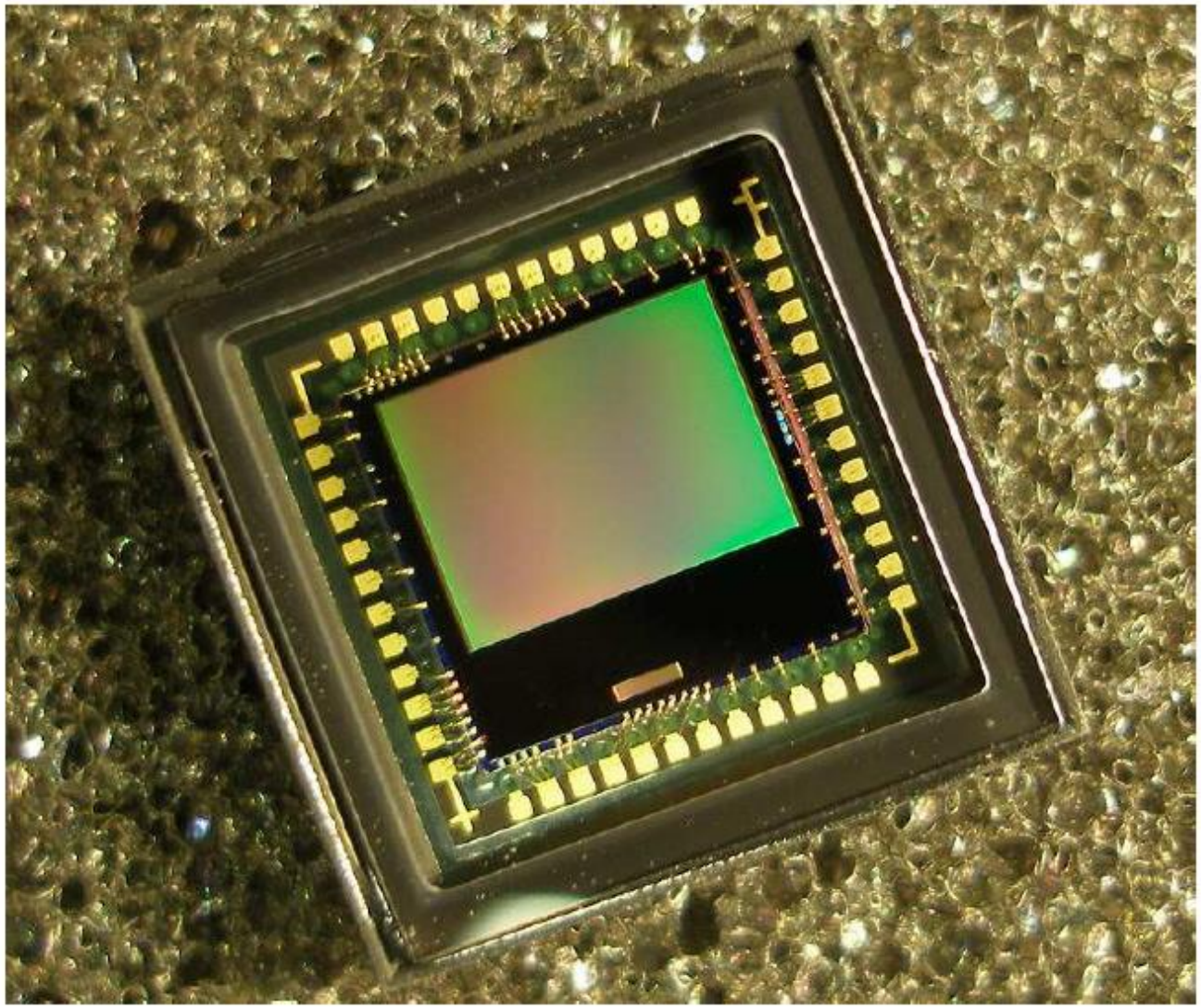
LIGHT

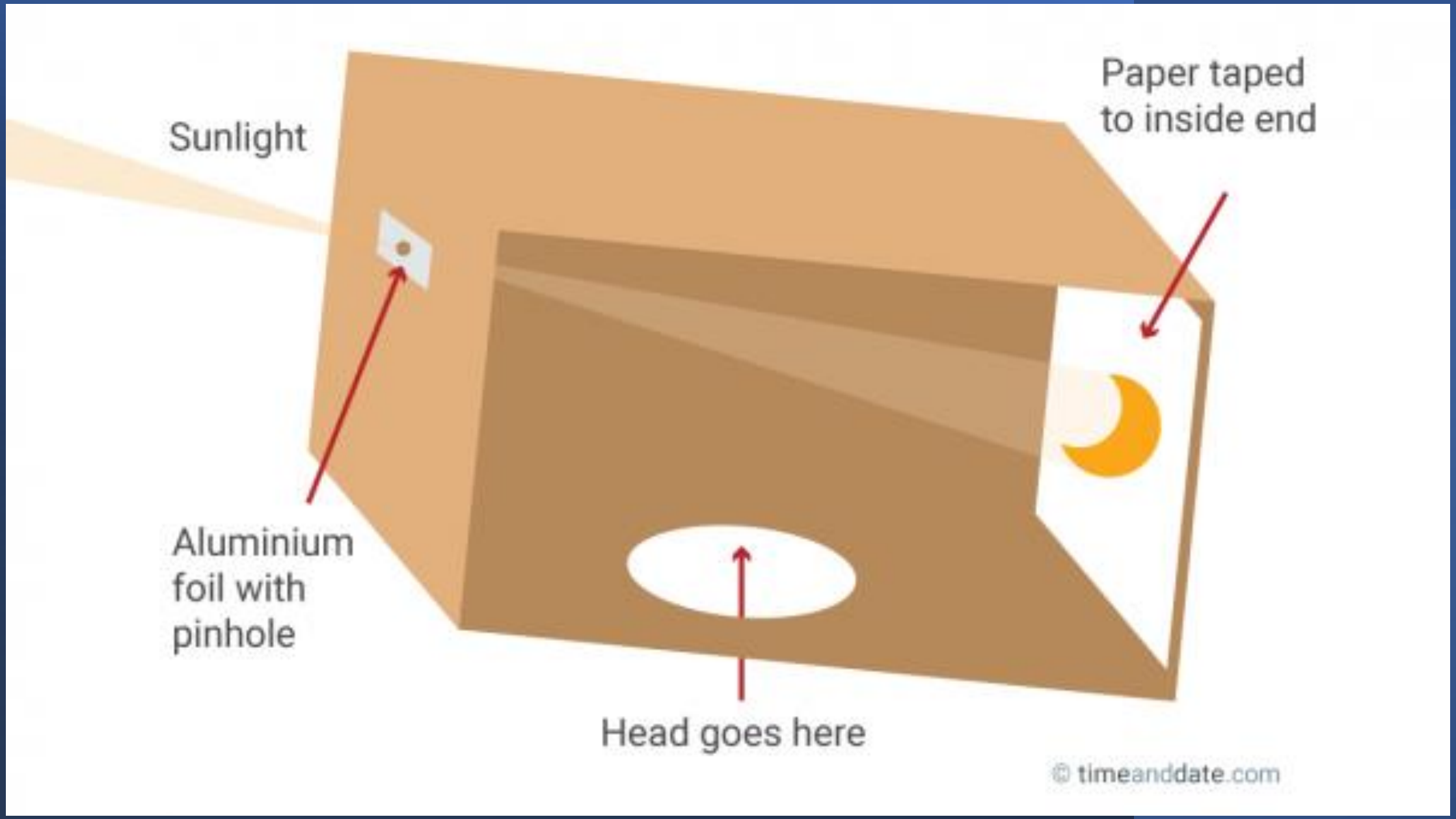

Pupil
Iris
Cornea
Posterior chamber
Anterior chamber
(aqueous humour)
Zonular
fibres
Lens
Ciliary muscle
Suspensory
ligament
Retina
Choroid
Vitreous
humour
Sclera
Hyaloid
canal
Optic disc
Optic nerve
Fovea
Retinal
blood vessels

Projection



Quelle: [EGBECK]




Sunlight
Paper taped to inside end
Aluminium foil with pinhole
Head goes here
© timeanddate.com

Film

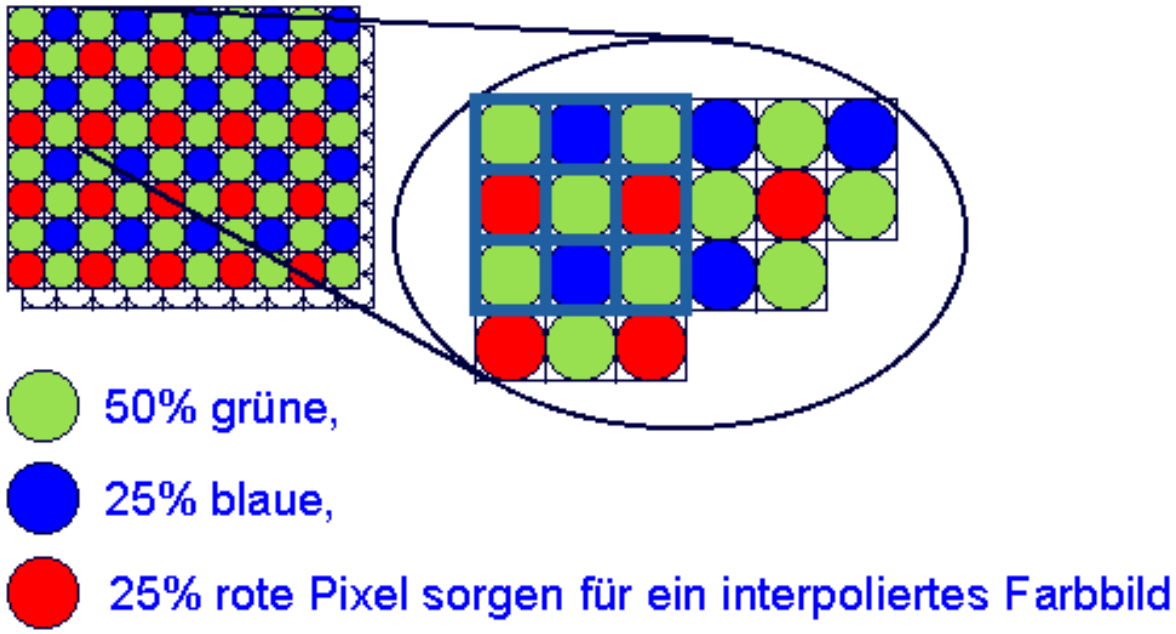
- Material is photosensitive and changes properties (structure) after exposure, which can be reproduced
- Very high resolution (quasi continuous), only depends on chemical structure of material
- Drawback: high costs and effort for reproduction, no immediate use

Charge Coupled Devices (CCD)

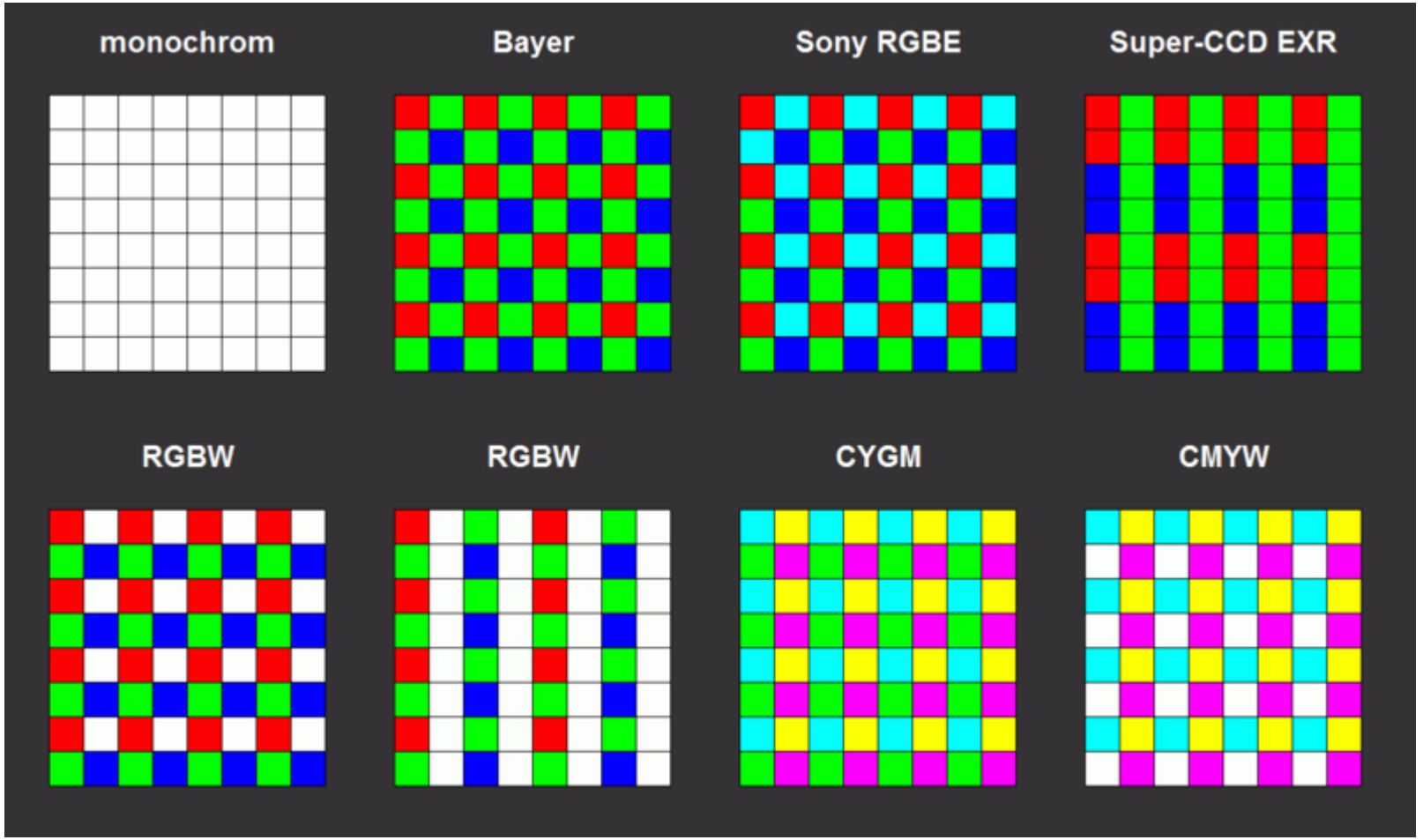
- Matrix of photo sensors (small capacitors) on a chip
- Direct usage of images
- Finite resolution (number of sensors)
- Sensors have a certain physical size
- Maybe even a certain physical aspect ratio

1-Chip-CCD

- Color: different types of sensors: red, green, blue
- Drawback: reduction of resolution, interpolation (artifacts at sharp edges)

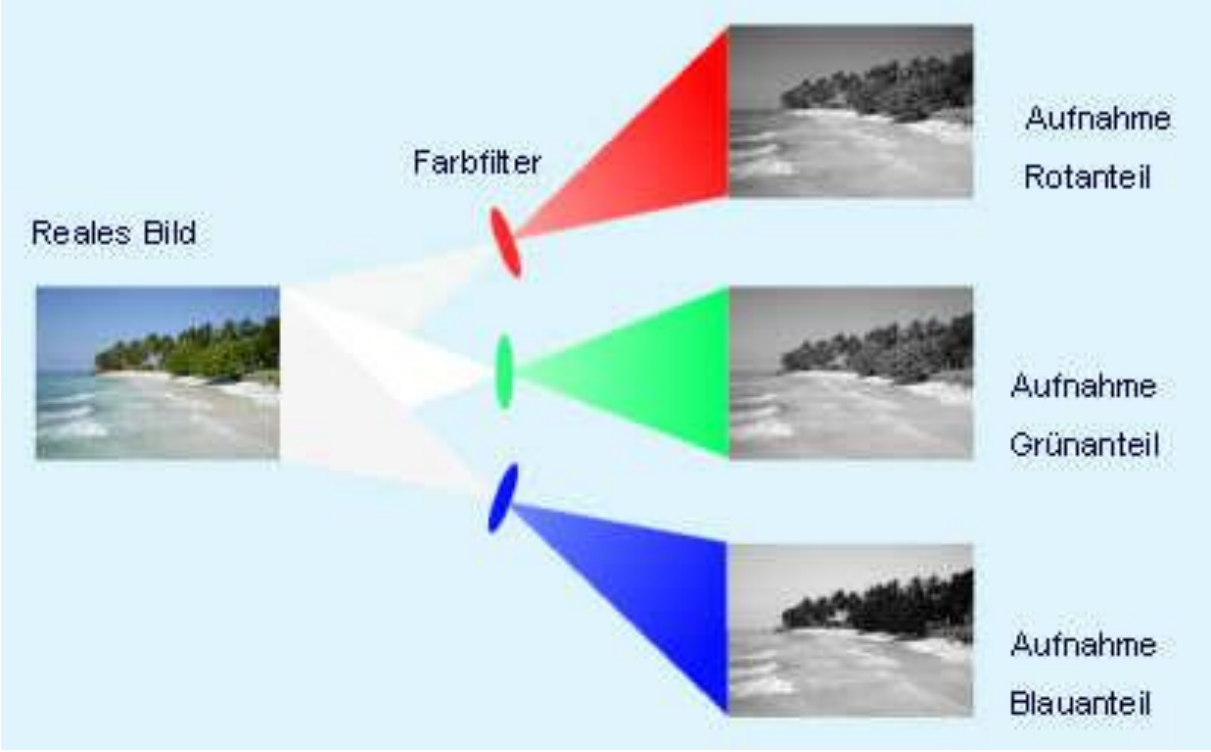


1-Chip-CCD

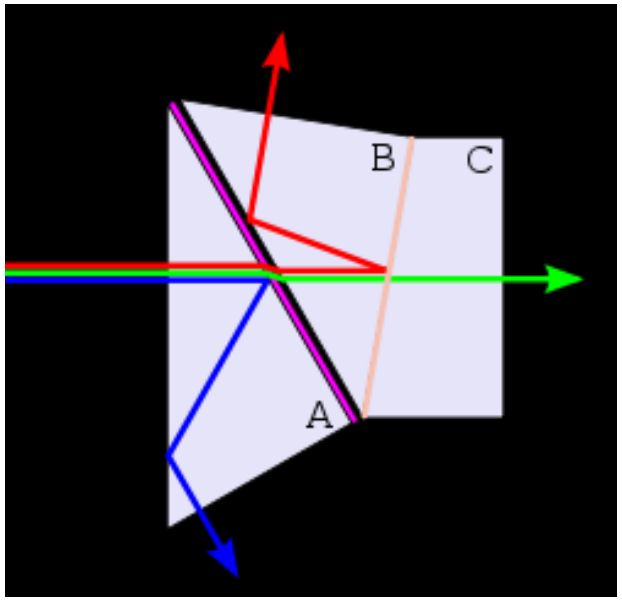


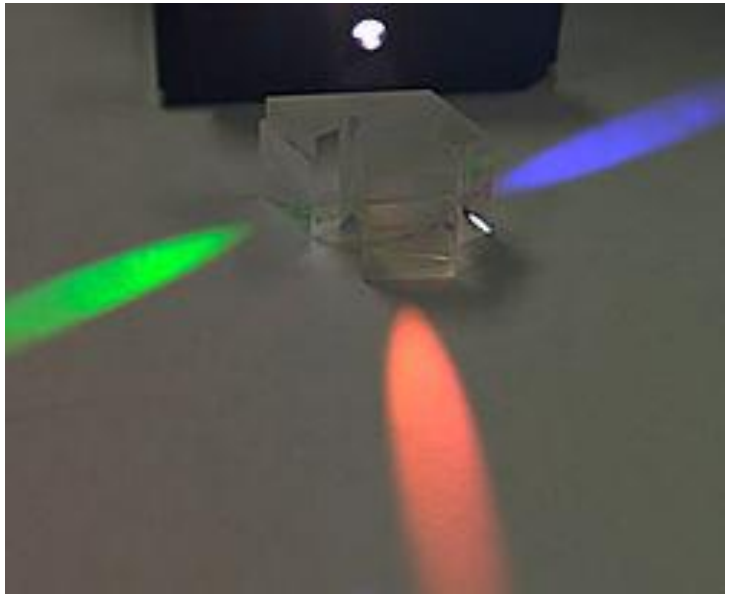
3CCD

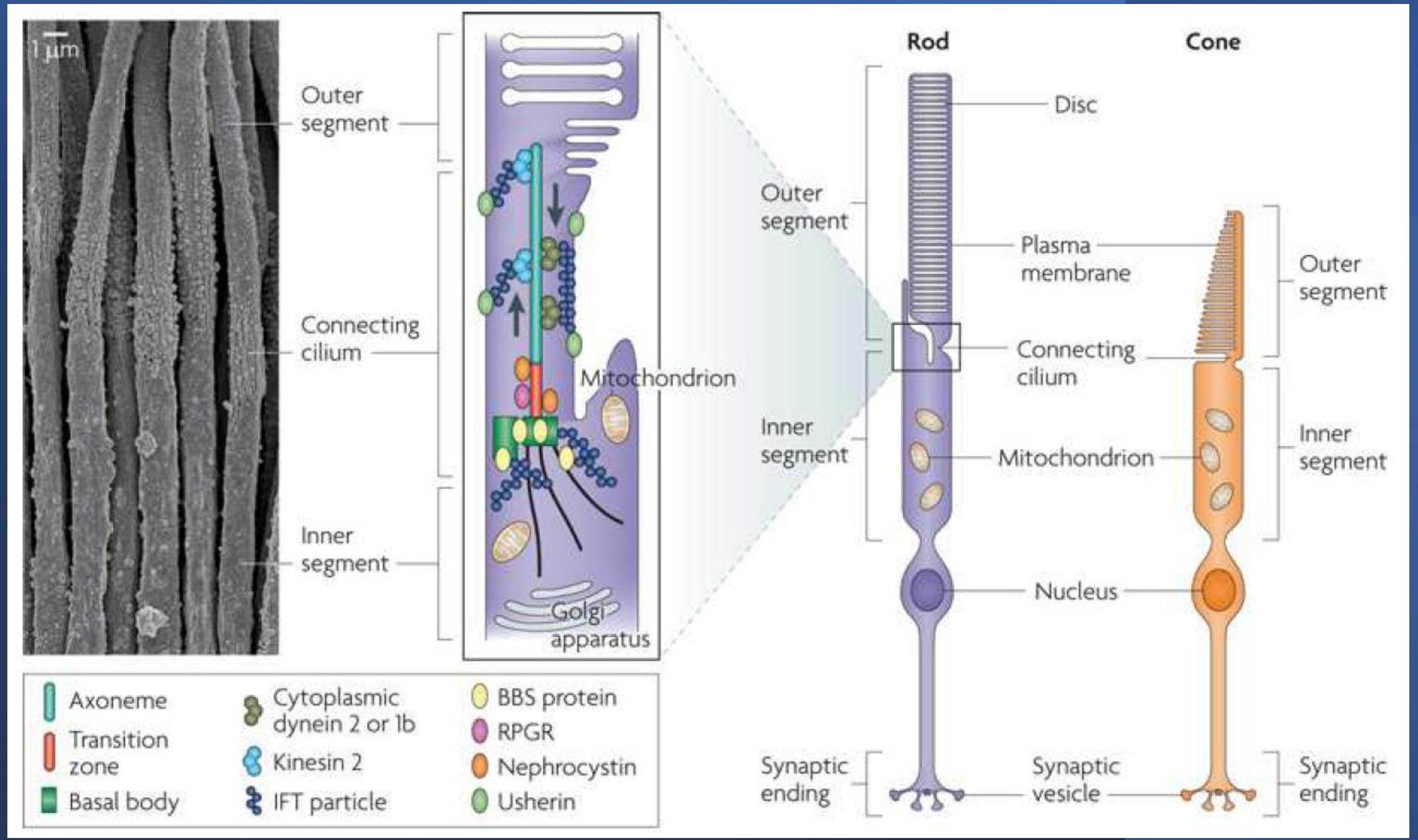
- Different color filters
- Complex optics (expensive)

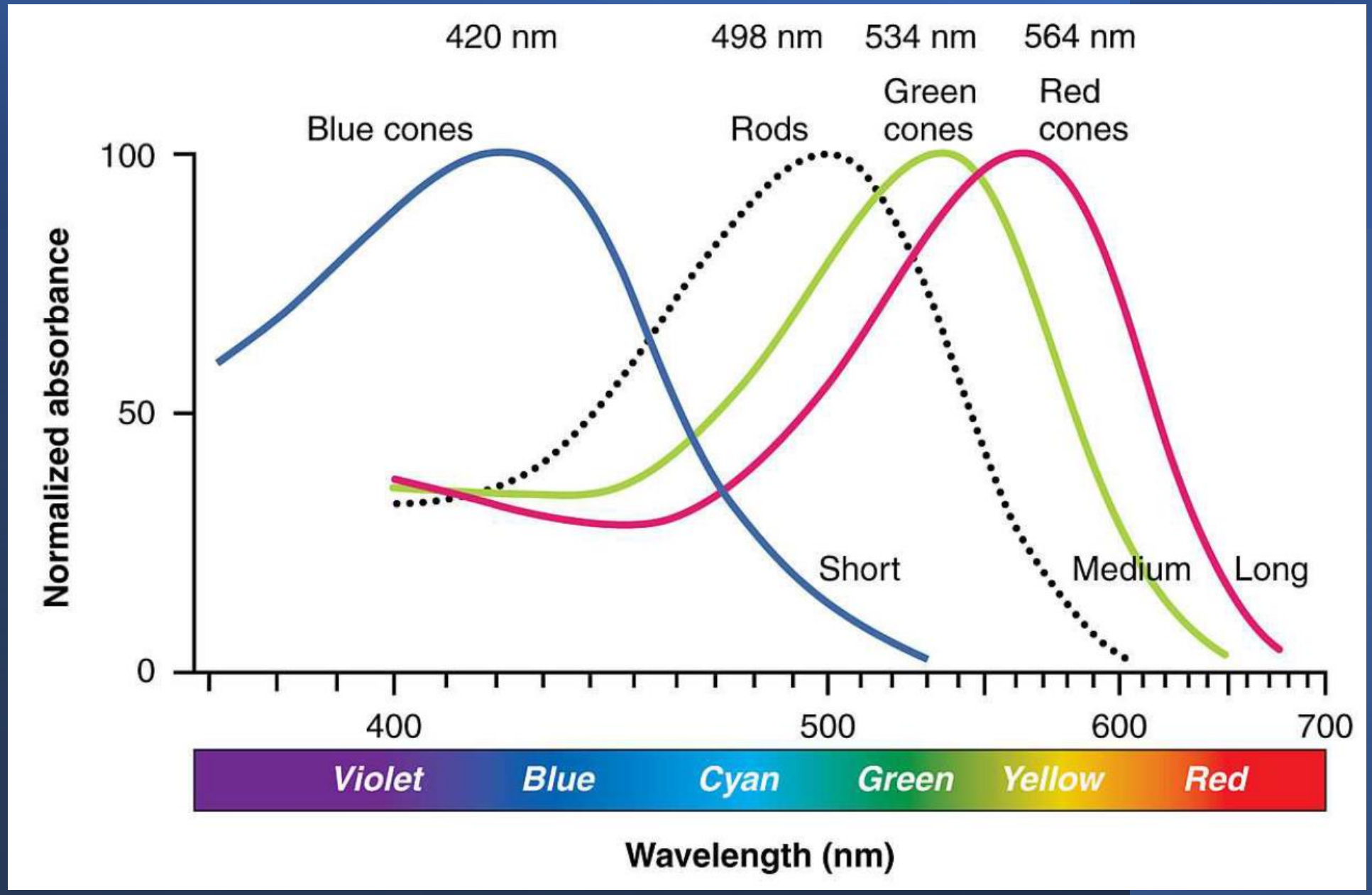


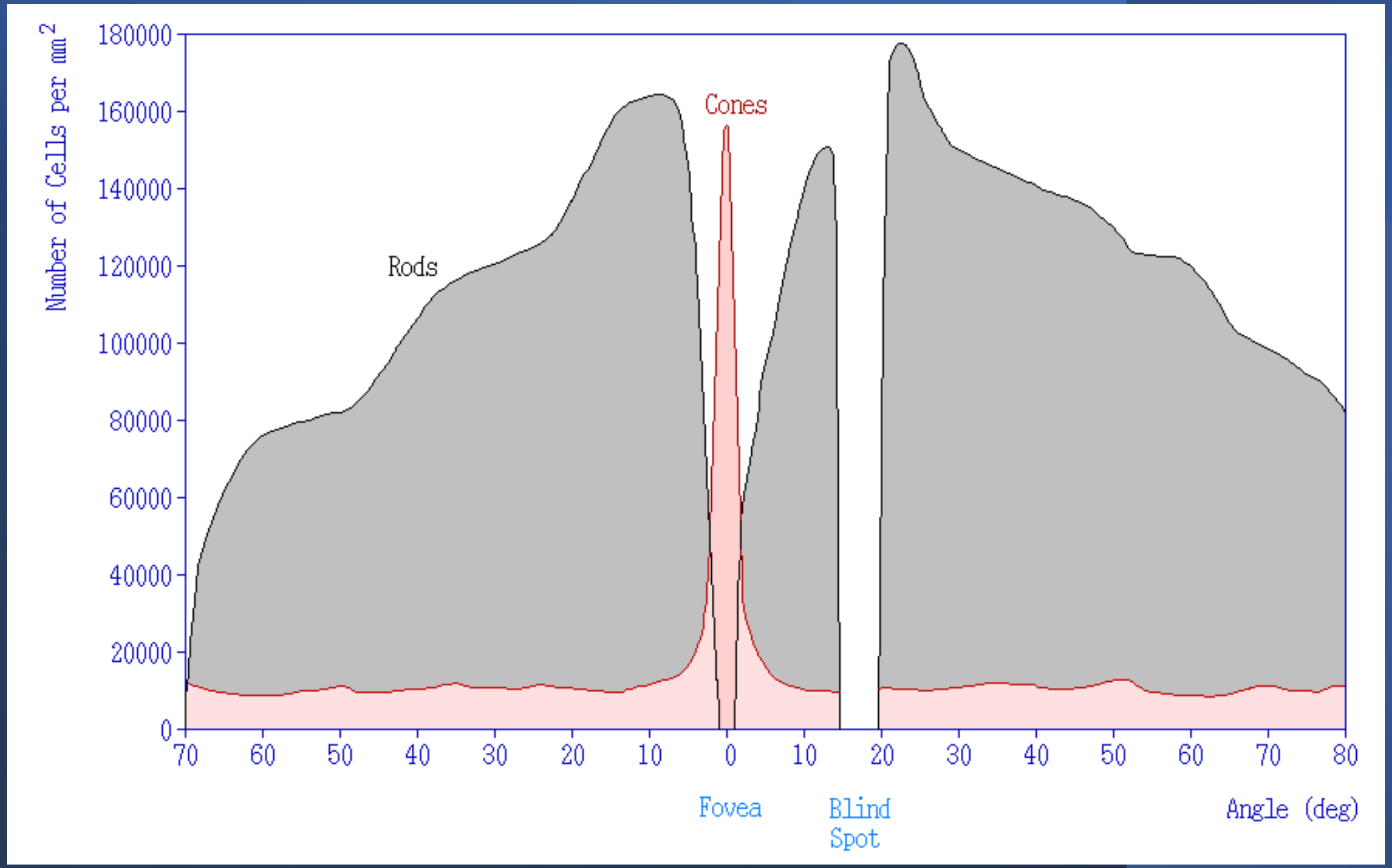
3CCD



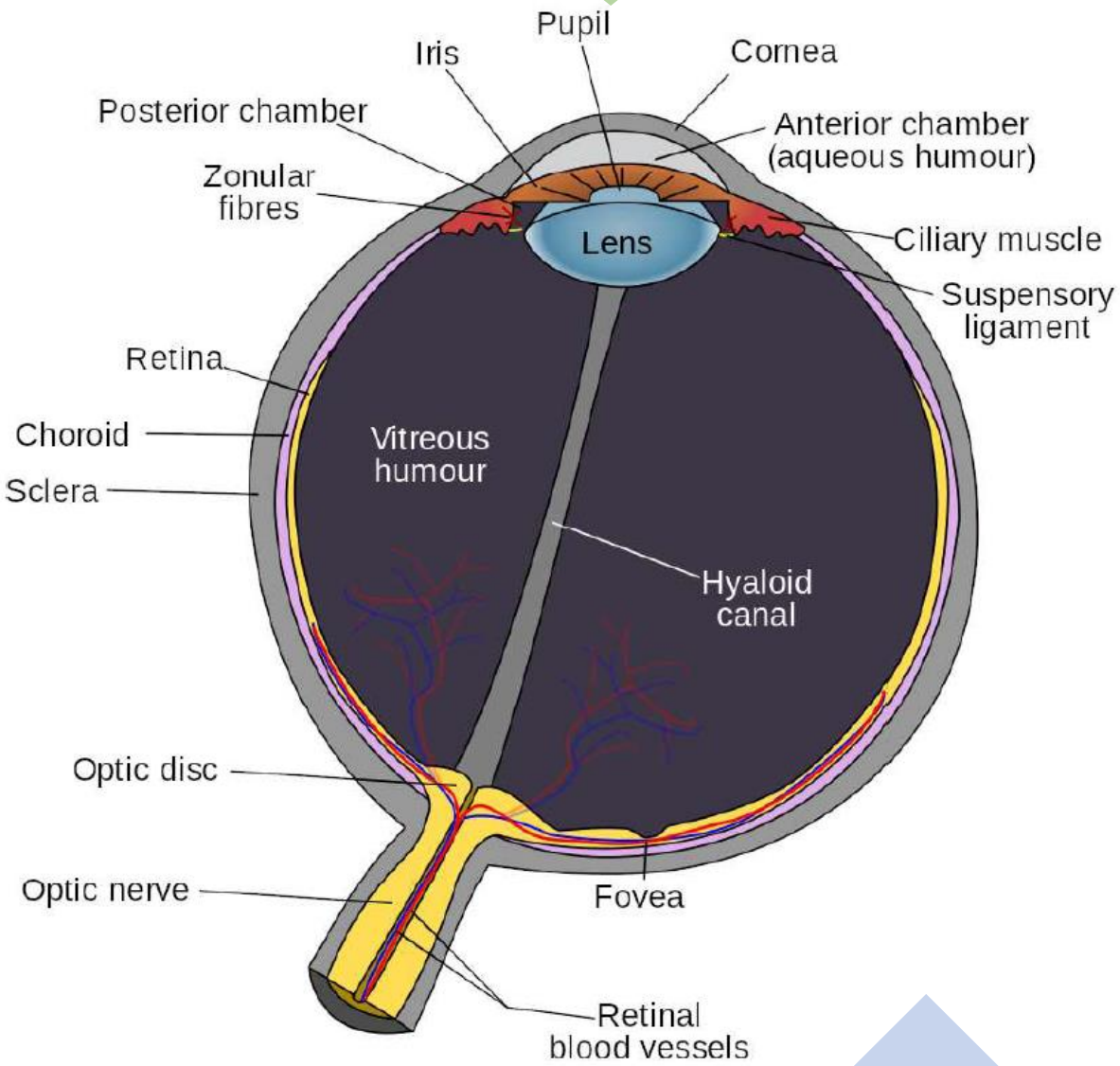



1 µm
Outer segment
Connecting cilium
Inner segment
Mitochondrion
Golgi apparatus
Axoneme
Transition zone
Basal body
Cytoplasmic dynein 2 or 1b
Kinesin 2
IFT particle
BBS protein
RPGR
Nephrocystin
Usherin
Rod
Cone
Disc
Outer segment
Plasma membrane
Connecting cilium
Inner segment
Mitochondrion
Nucleus
Synaptic ending
Synaptic vesicle
Outer segment
Inner segment
Synaptic ending

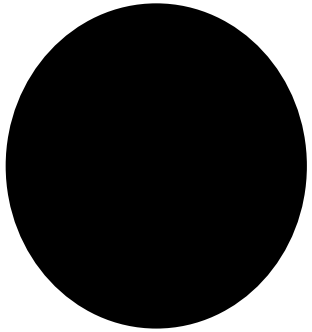

420 nm
498 nm
534 nm
564 nm
Blue cones
Rods
Green cones
Red cones
100
50
0
Normalized absorbance
Short
Medium
Long
400
500
600
700
Violet
Blue
Cyan
Green
Yellow
Red
Wavelength (nm)

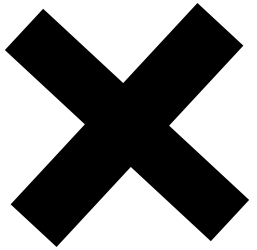

Number of Cells per mm^2
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Rods
Cones
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
Fovea
Blind Spot
Angle (deg)

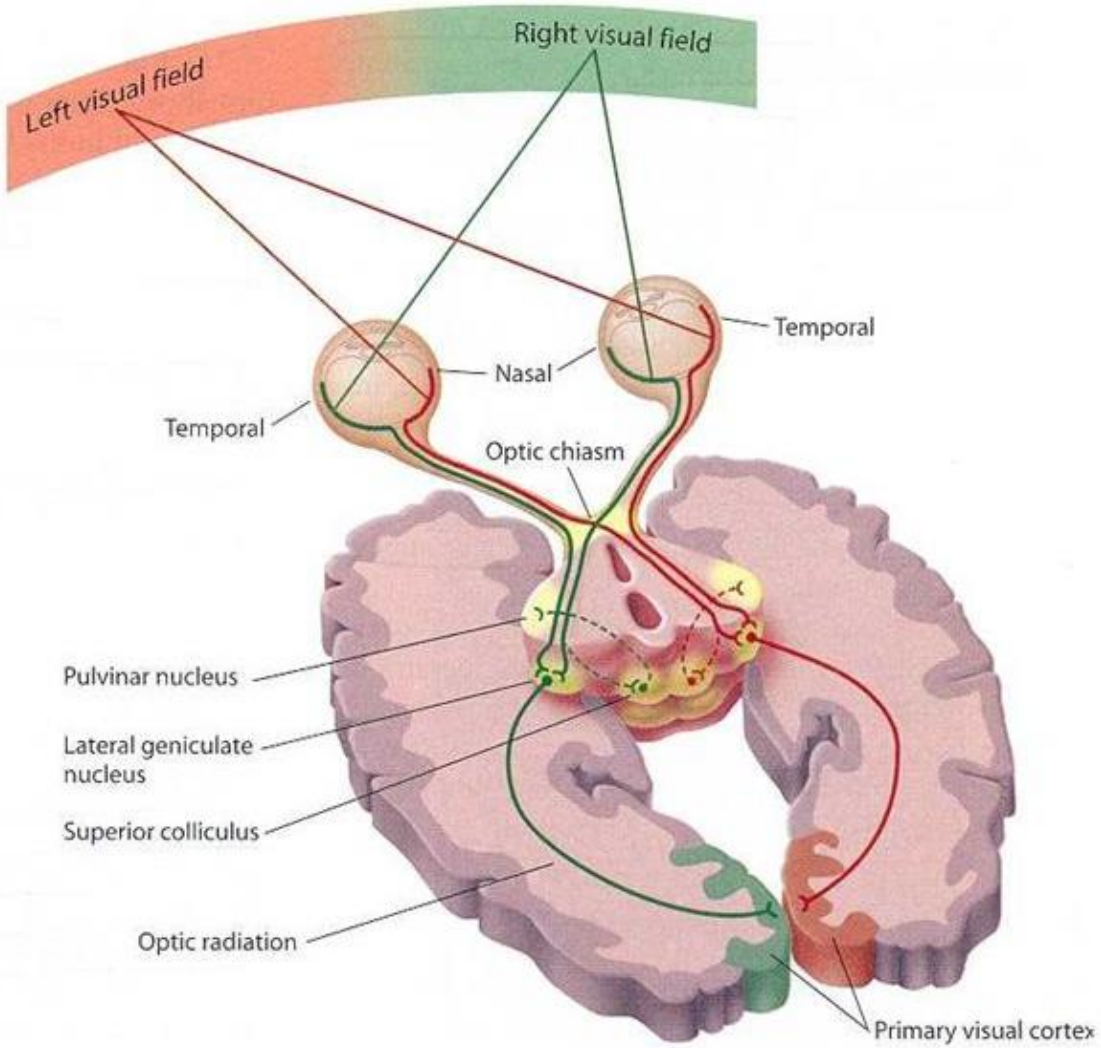
LIGHT

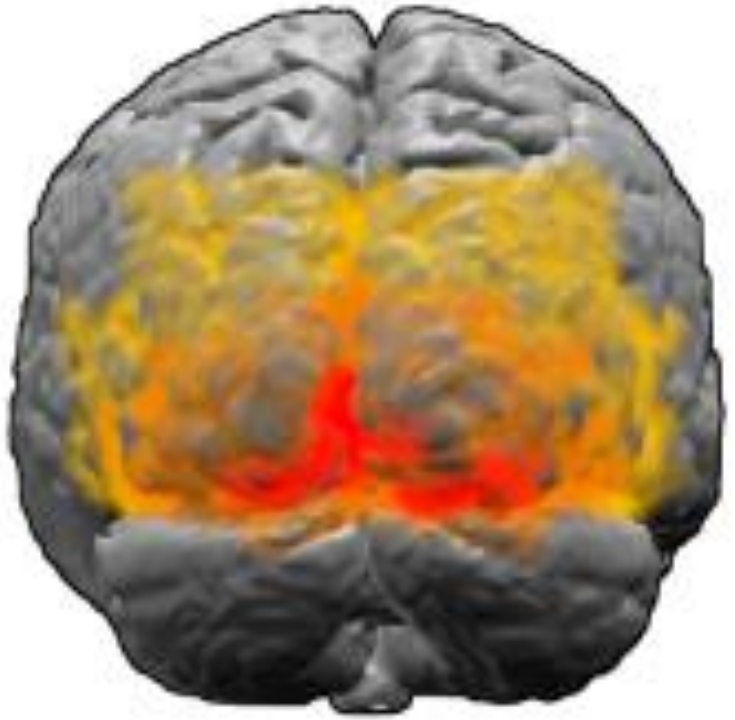

Pupil
Iris
Cornea
Posterior chamber
Anterior chamber
(aqueous humour)
Zonular
fibres
Lens
Ciliary muscle
Suspensory
ligament
Retina
Choroid
Vitreous
humour
Sclera
Hyaloid
canal
Optic disc
Optic nerve
Fovea
Retinal
blood vessels

Blind spot experiment



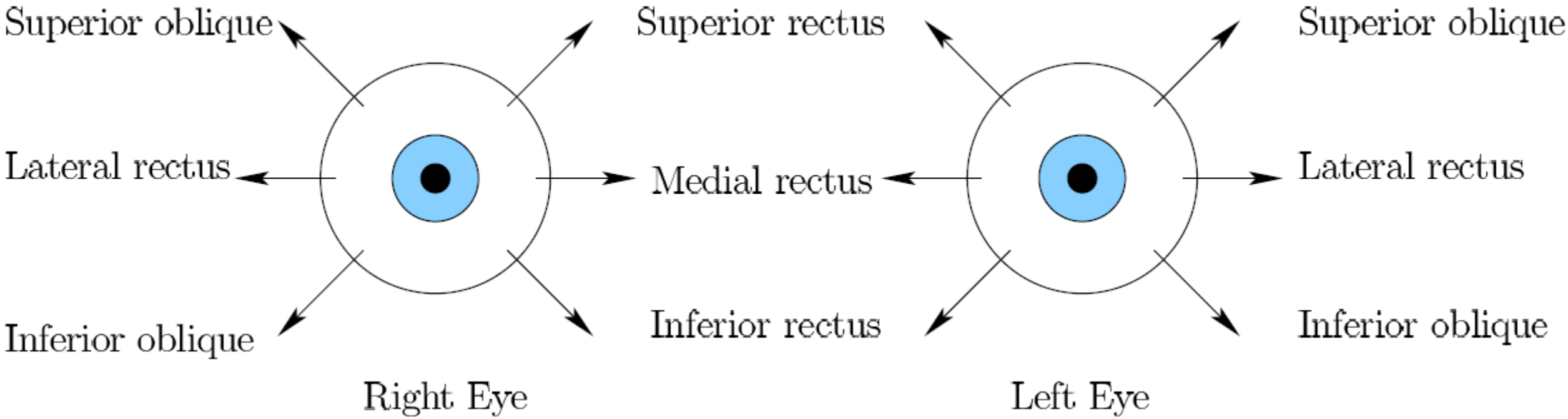






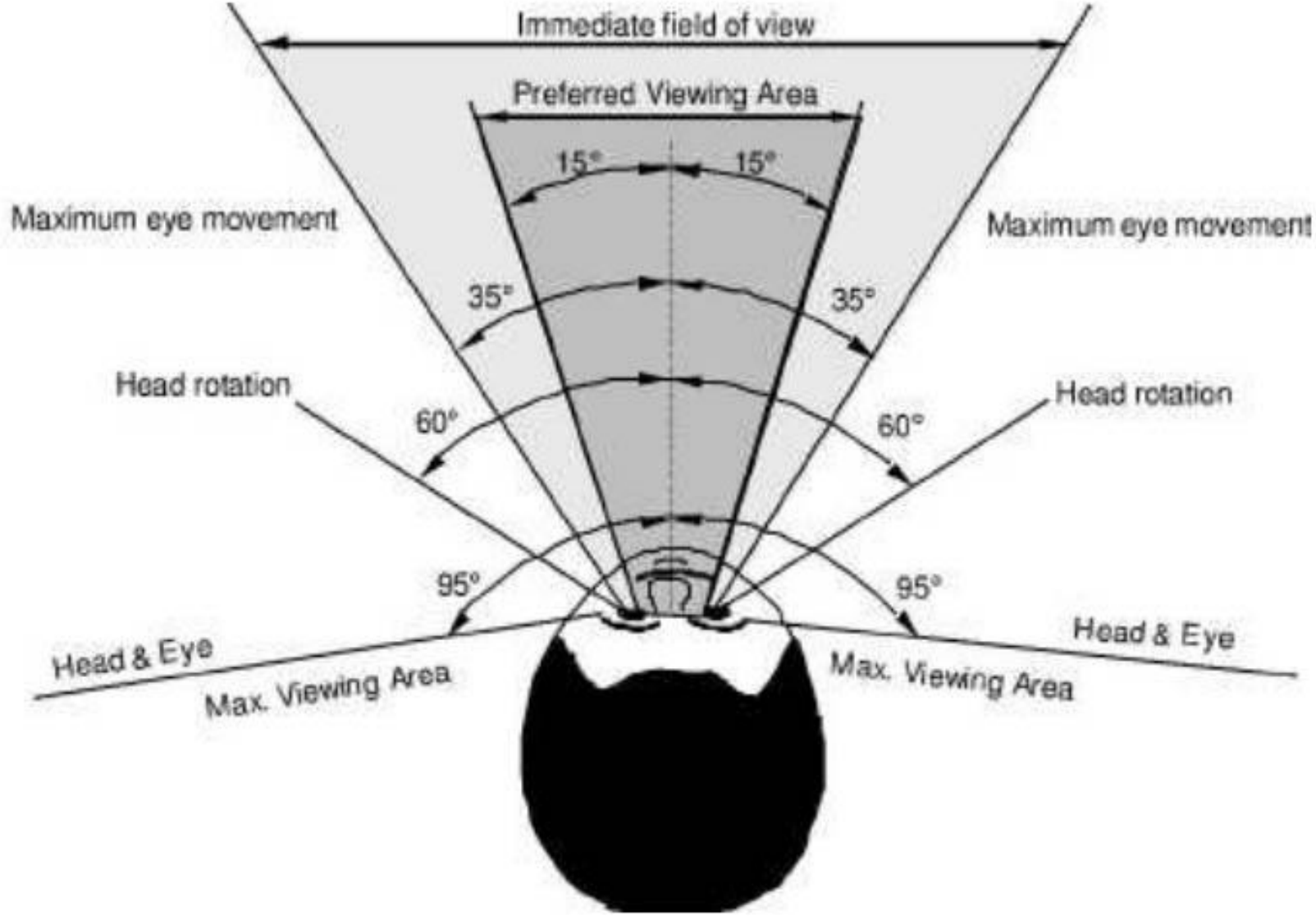
From Photoreceptors to the Visual Cortex

Eye Movements

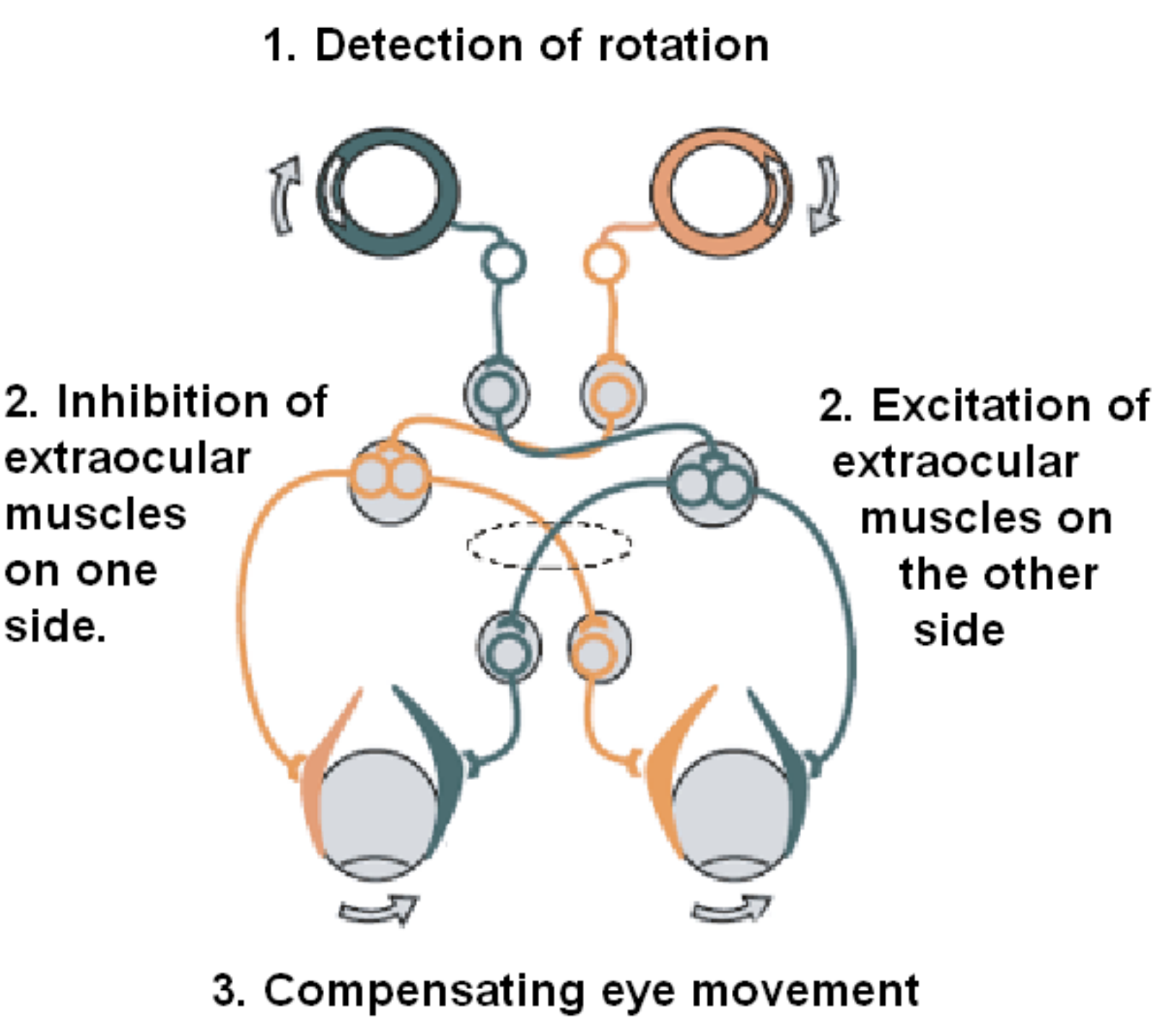


Warning Optical Illusion!

Eye and head movements together



The vestibulo-ocular reflex (VOR).



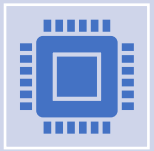
Implications for XR

Screen-door Effect

How good do XR visual displays need to be?

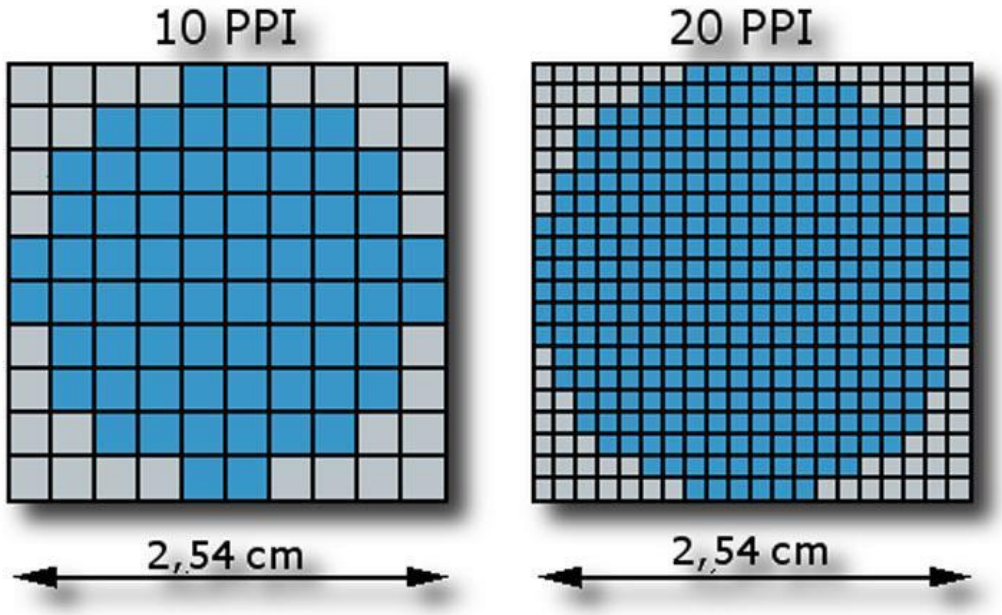
Spatial resolution: How many pixels per square area are needed?

Intensity resolution and range: How many intensity values can be produced, and what are the minimum and maximum intensity values?

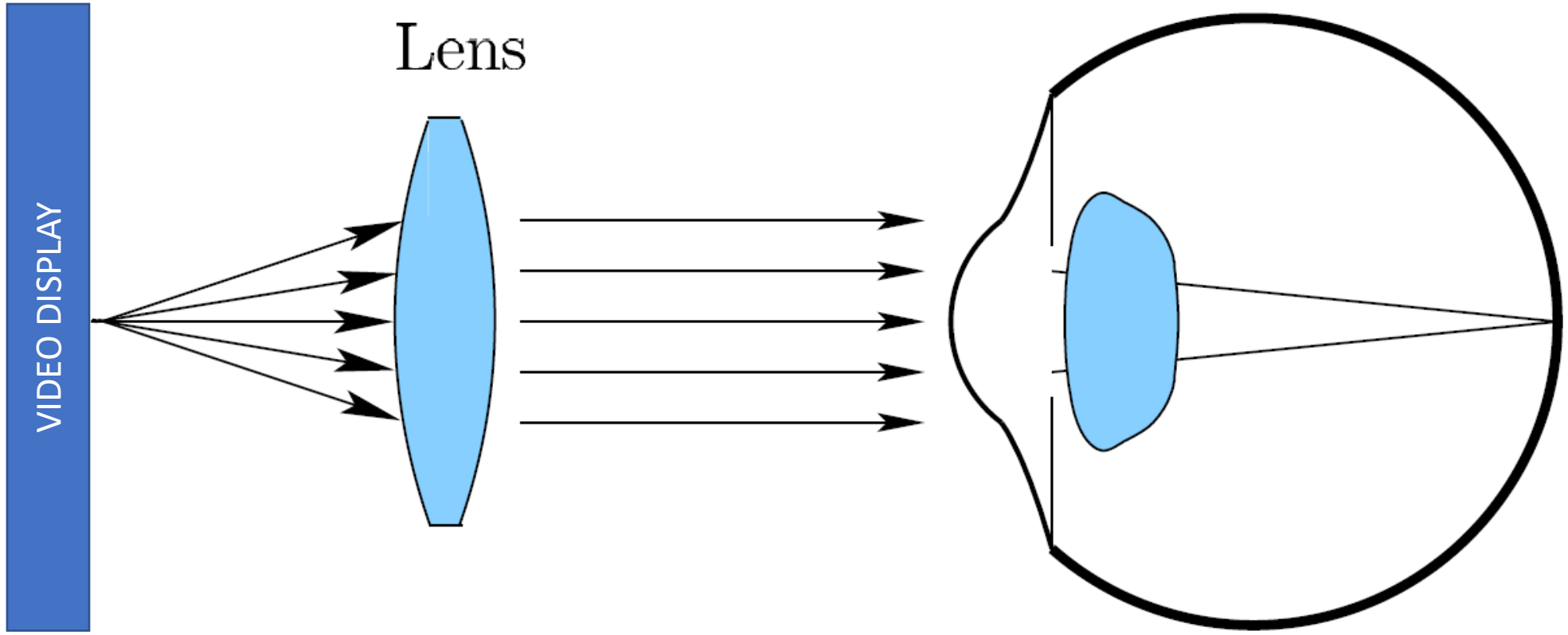


Temporal resolution: How fast do displays need to change their pixels?

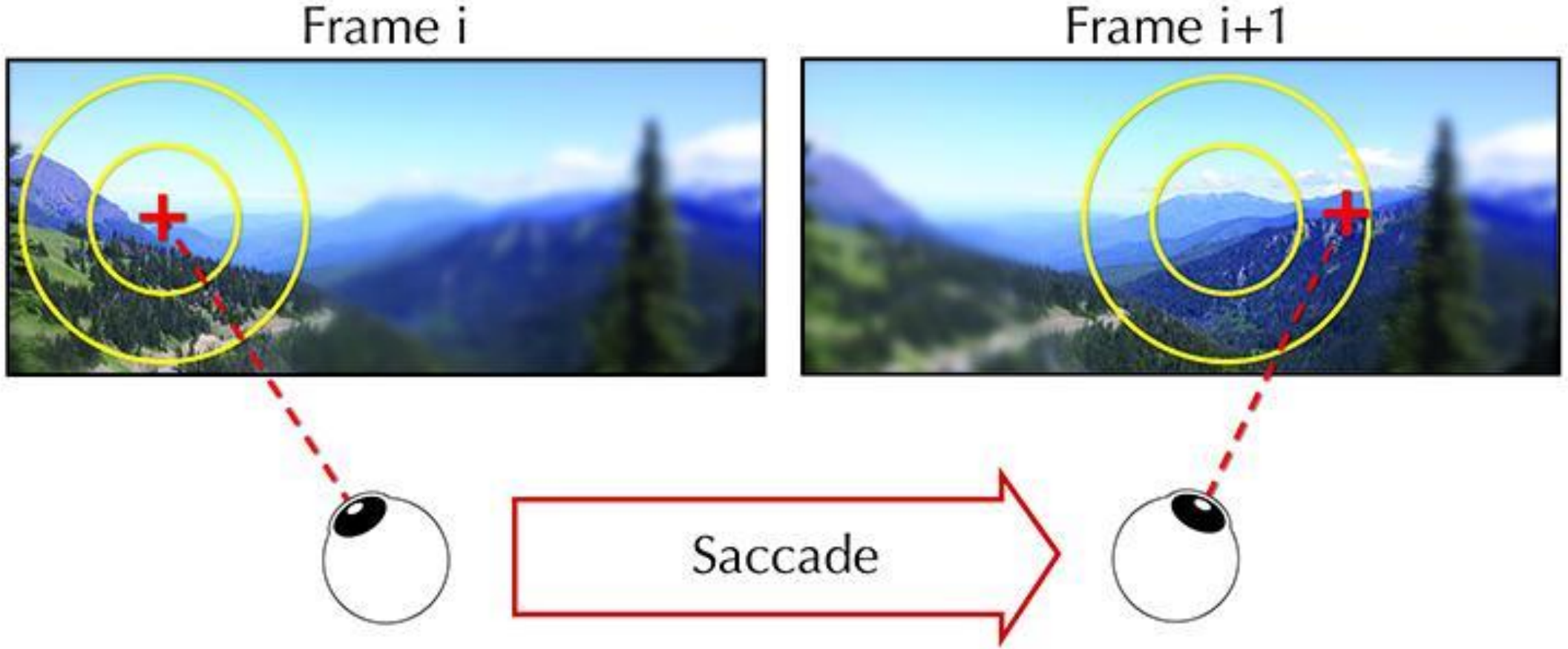
How much pixel density is enough?



How much field of view is enough?



Foveated rendering



Further Reading

- E. B. Goldstein. Sensation and Perception, 9th Ed. Wadsworth, Belmont, CA, 2014.
- G. Mather. Foundations of Sensation and Perception. Psychology Press, Hove, UK, 2008.
- J. M. Wolfe, K. R. Kluender, and D. M. Levi. Sensation and Perception, 4th Ed. Sinauer, Sunderland, MA, 2015.
- B. Guentner, M. Finch, S. Drucker, D. Tan, and J. Snyder. Foveated 3D graphics. Technical report, Microsoft Research, 2012. Available at http://research.microsoft.com/.
- G. Smith and D. A. Atchison. The Eye and Visual Optical Instruments. Cambridge University Press, Cambridge, U.K., 1997.