

Intro to Light & Vision

Lecture 4

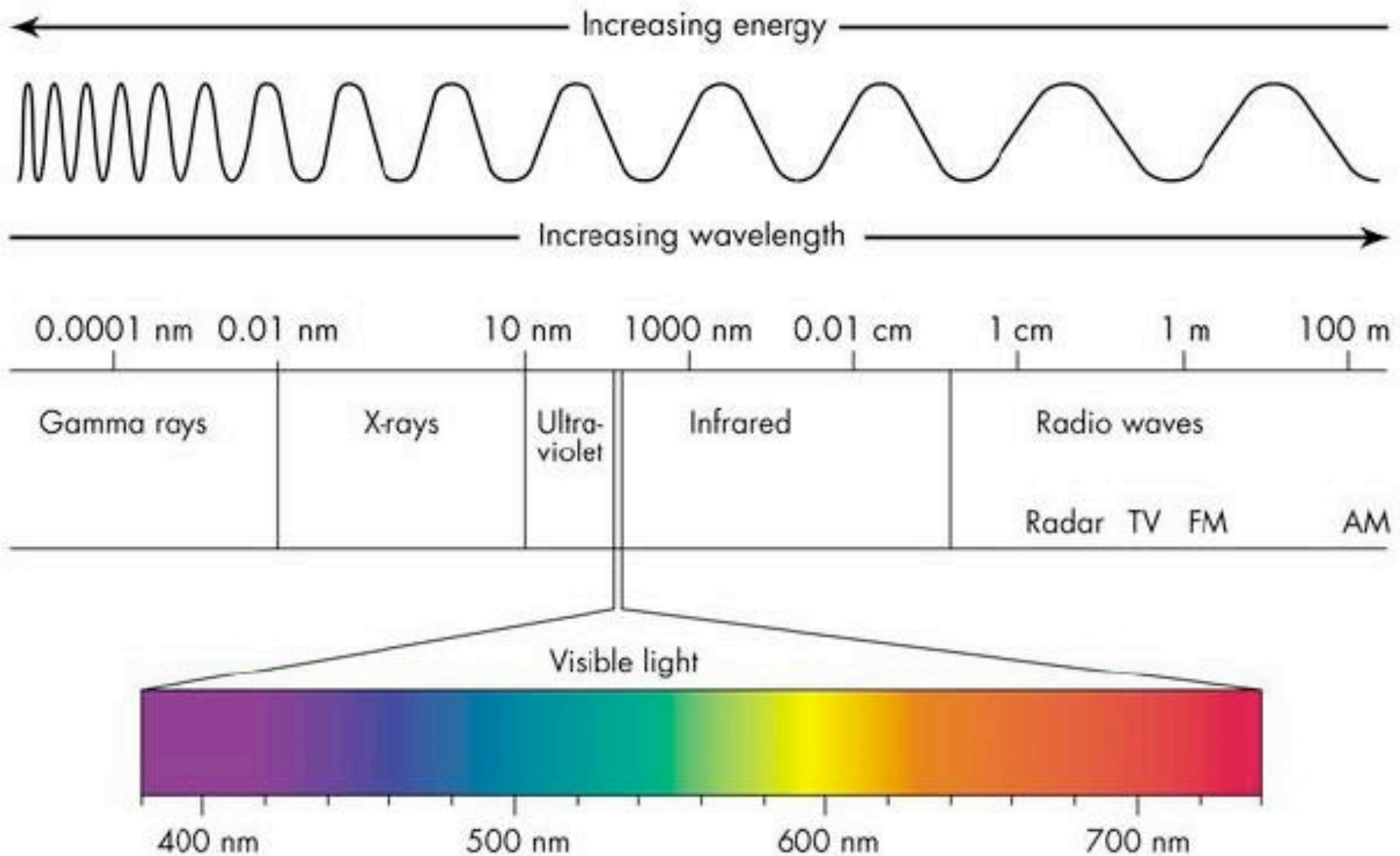
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Sensation & Perception
(PSY 345 / NEU 325)
Princeton University, Spring 2019

Chapter 2:

First steps in Vision

Light: electromagnetic radiation within a narrow energy range

- a wave: can be bent by lenses
- a particle: “photons” - can travel through a vacuum, have minimum energy that can be emitted/absorbed (quanta)



Food for thought: Why are we sensitive to such a narrow range of the electromagnetic spectrum?

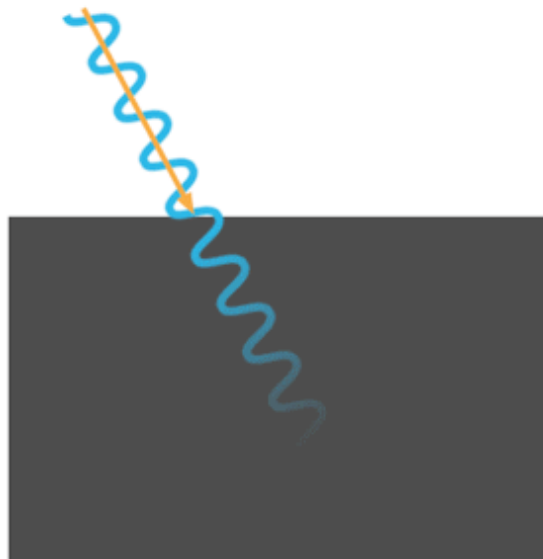
Other solutions are possible:

- bees: ultraviolet light
- pit vipers: infrared light

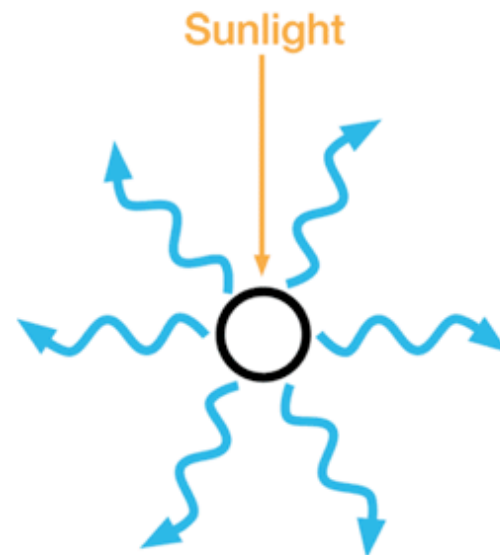
What happens to light?

- **Absorbed:** Energy (e.g., light) that is taken up, and is not transmitted at all
- **Scattered:** Energy that is dispersed in an irregular fashion (most light does this!)

Absorption



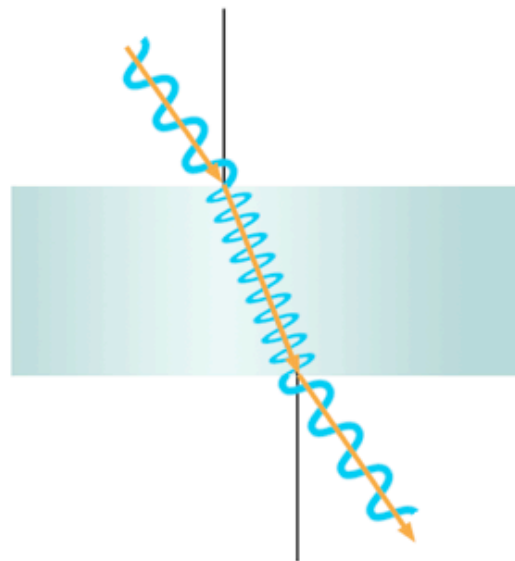
Scattering



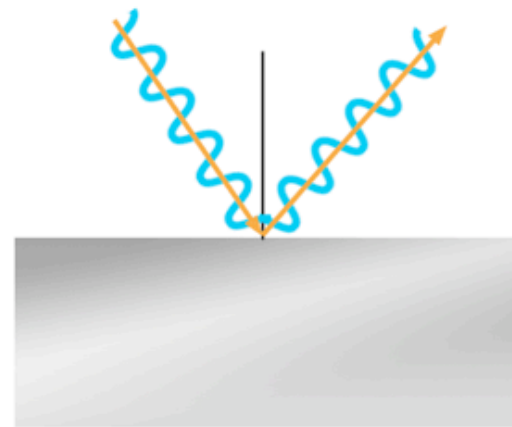
What happens to light?

- **Refracted:** Energy that is altered as it passes into another medium, (e.g., light entering water from the air)
- **Reflected:** Energy that is redirected when it strikes a surface

Refraction

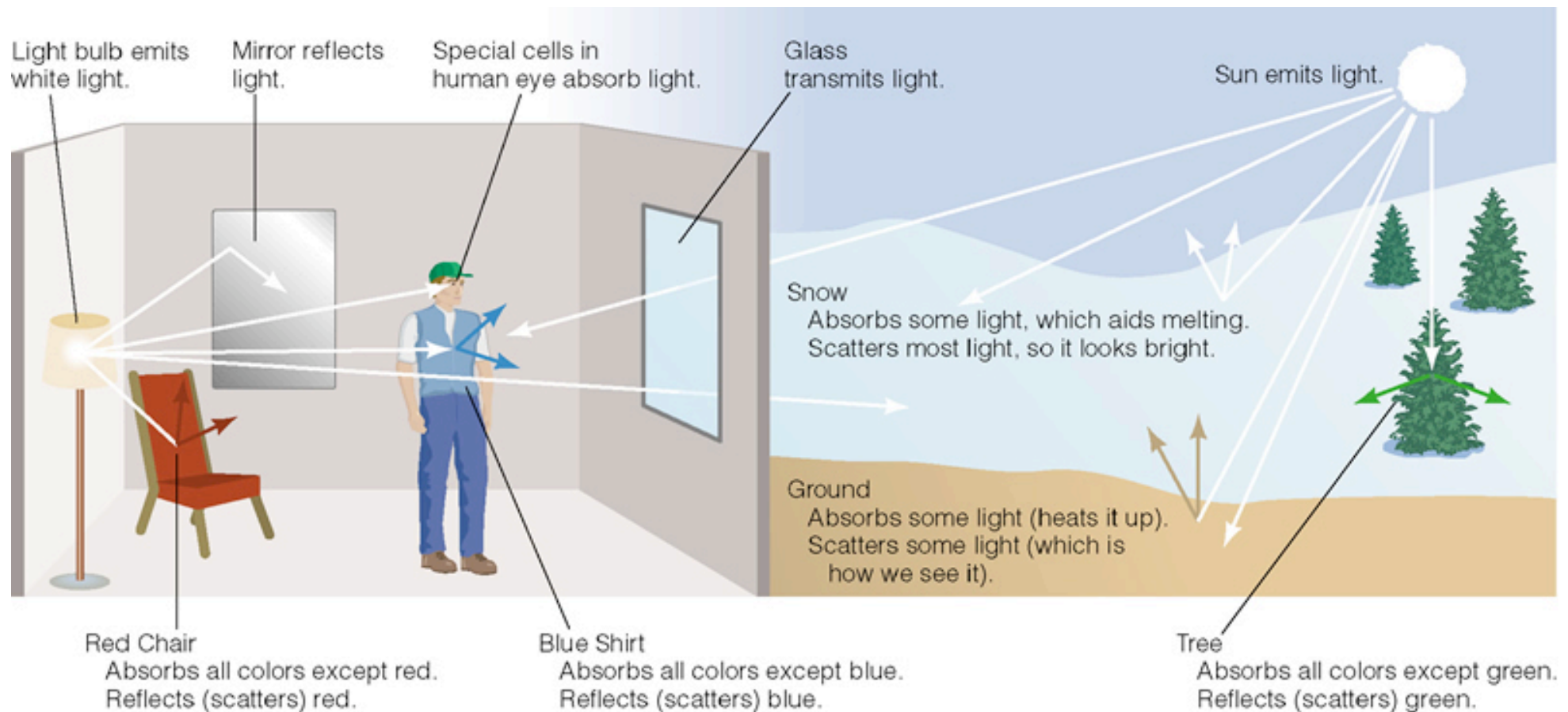


Reflection



Light Physics

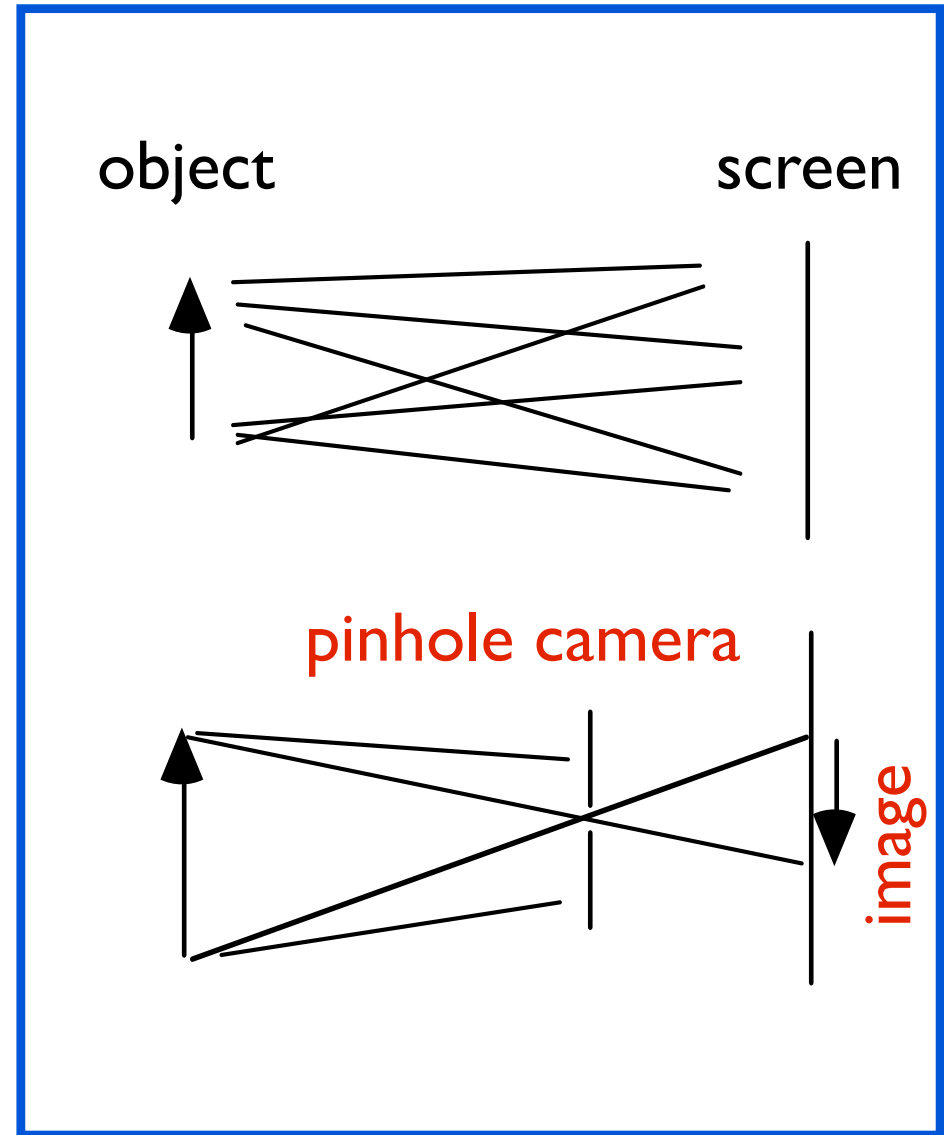
What it all looks like. (Messy!)



- each point in space has light from all angles passing through it

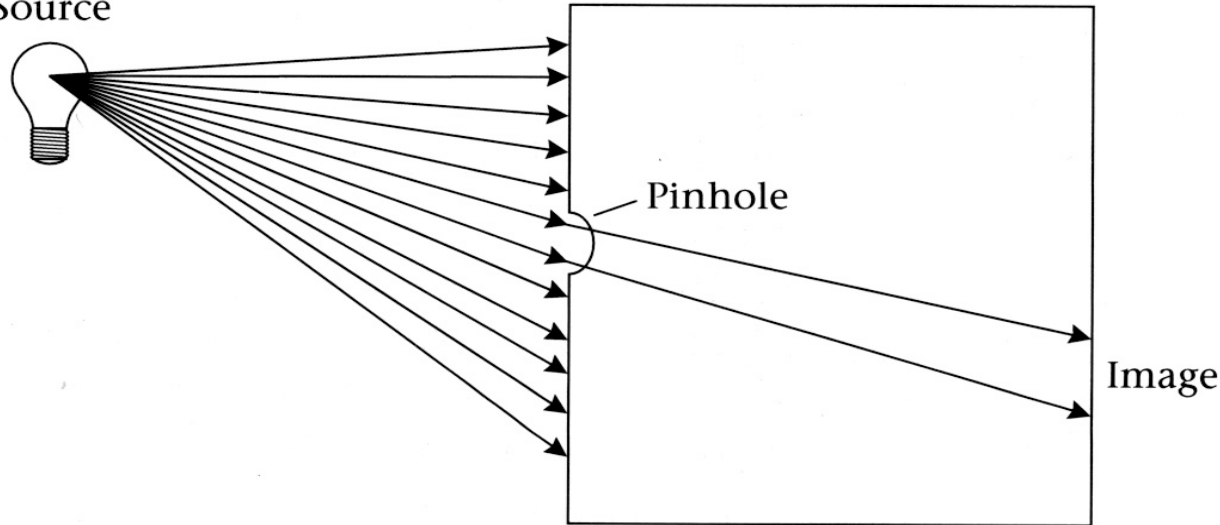
Why do we need optics?

- without optics, light from everything hits the whole retina/screen/film
- with optics, we form an *image*
- i.e. light from a single point in space hits a single spot on the retina

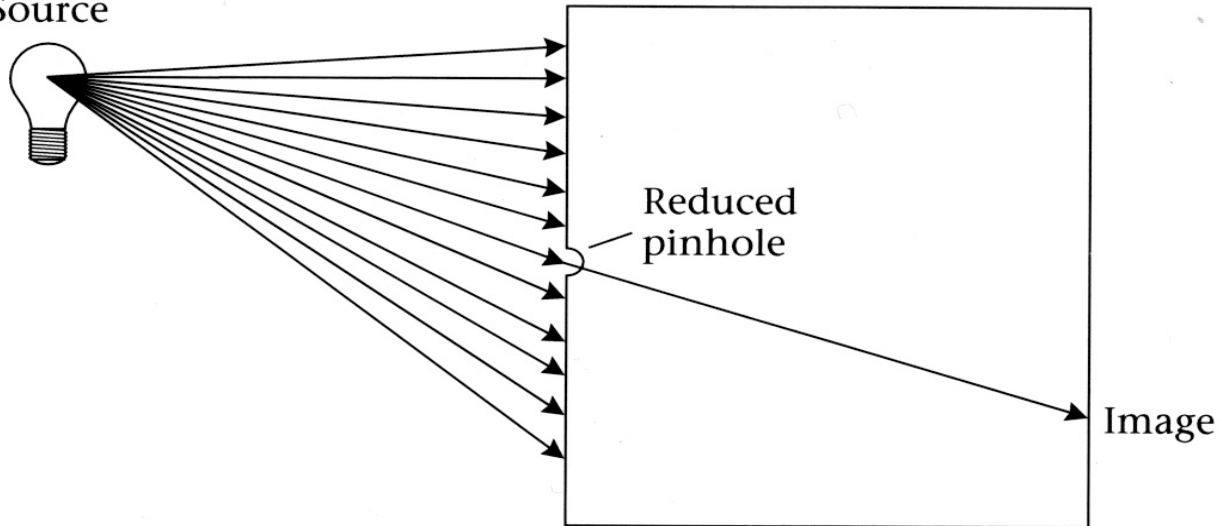


Pinhole camera: problem of pinhole size

(A) Source



(B) Source



smaller aperture

= fewer rays

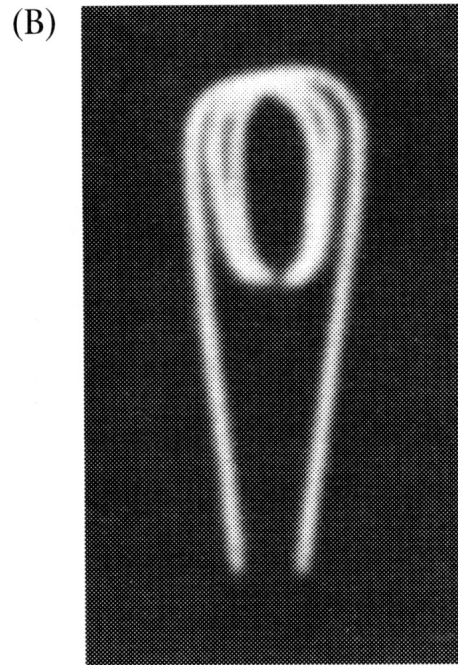
= sharper image

= *dimmer* image

Some pinhole images



big pinhole



small pinhole

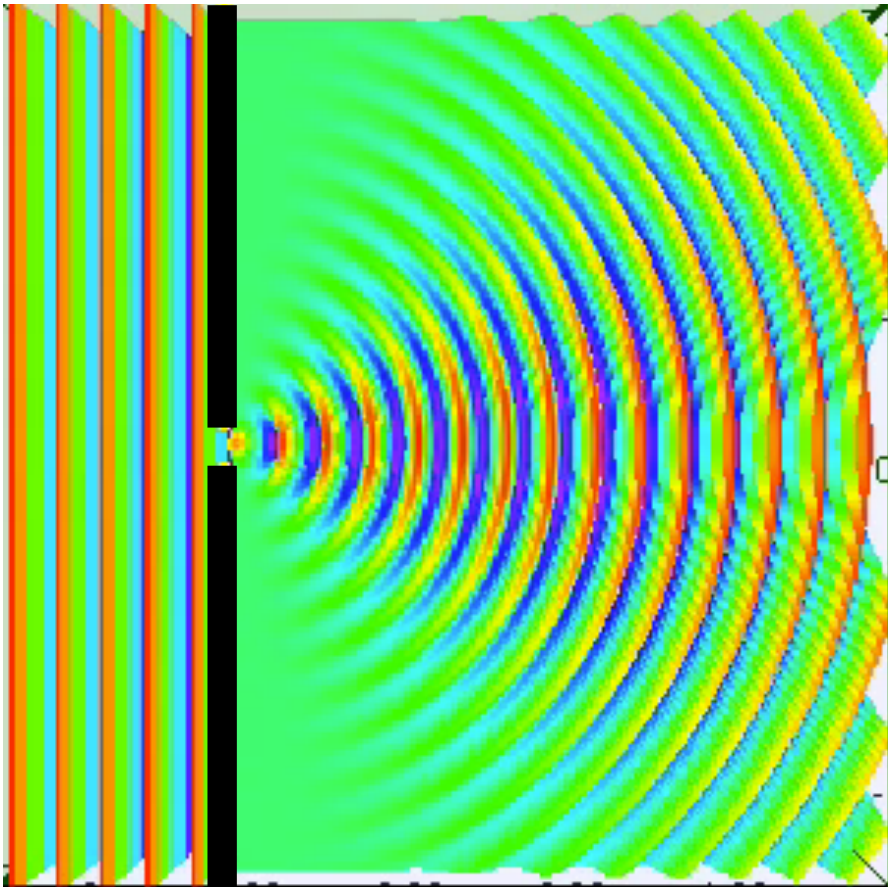


tiny pinhole

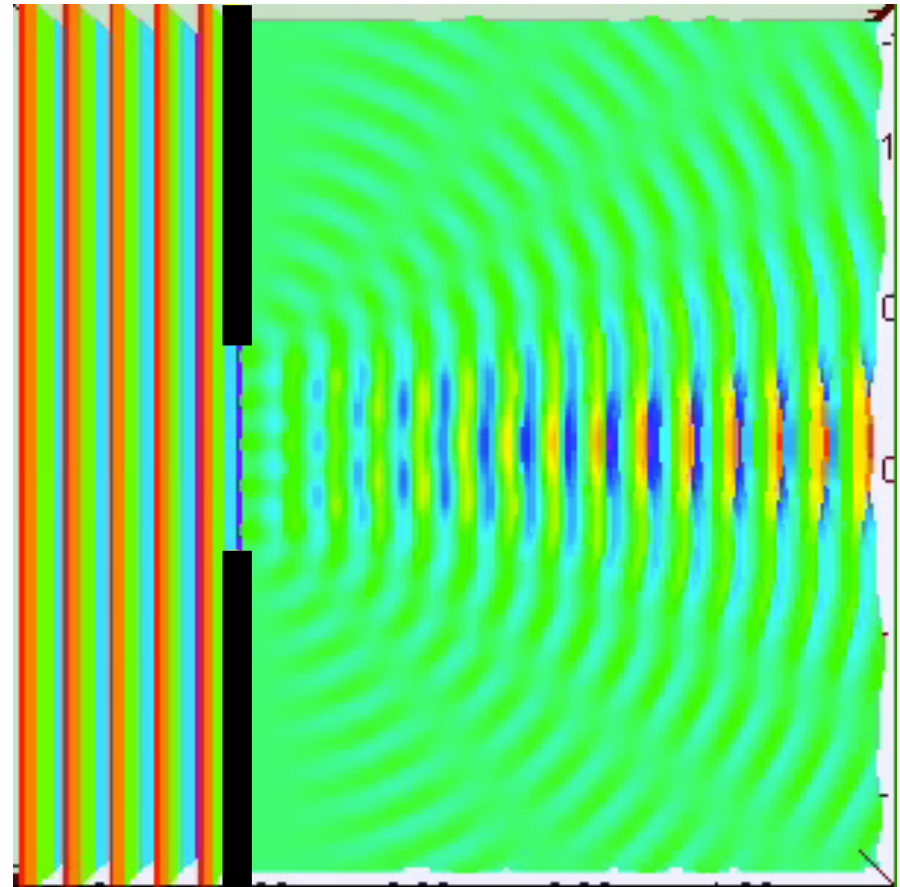
diffraction

- bending of waves around small obstacles or through small apertures

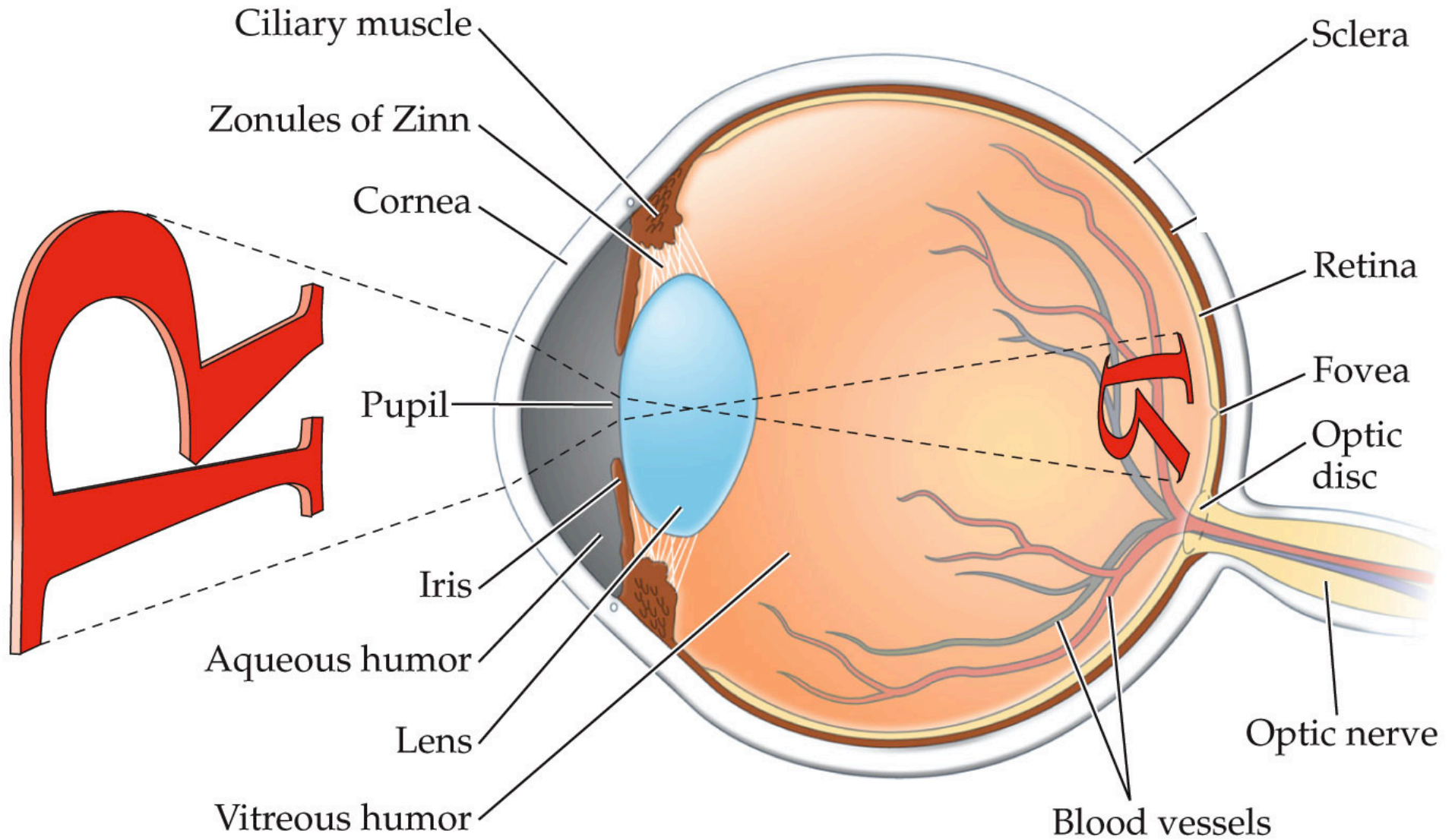
slit = 1 x wavelength



slit = 5 x wavelength



the eye (viewed from above)



- **Cornea:** The transparent “window” into the eyeball (carries 2/3 of eye’s total refractive power)
- **Aqueous humor:** watery fluid in behind cornea
- **Lens:** allows changing of focus
- **Pupil:** The dark circular opening at the center of the iris in the eye, where light enters the eye
- **Vitreous humor:** transparent fluid that fills main cavity of the eye (gel-like; may contain “floaters”)
- **Retina:** light-sensitive membrane in the back of the eye that contains rods and cones.

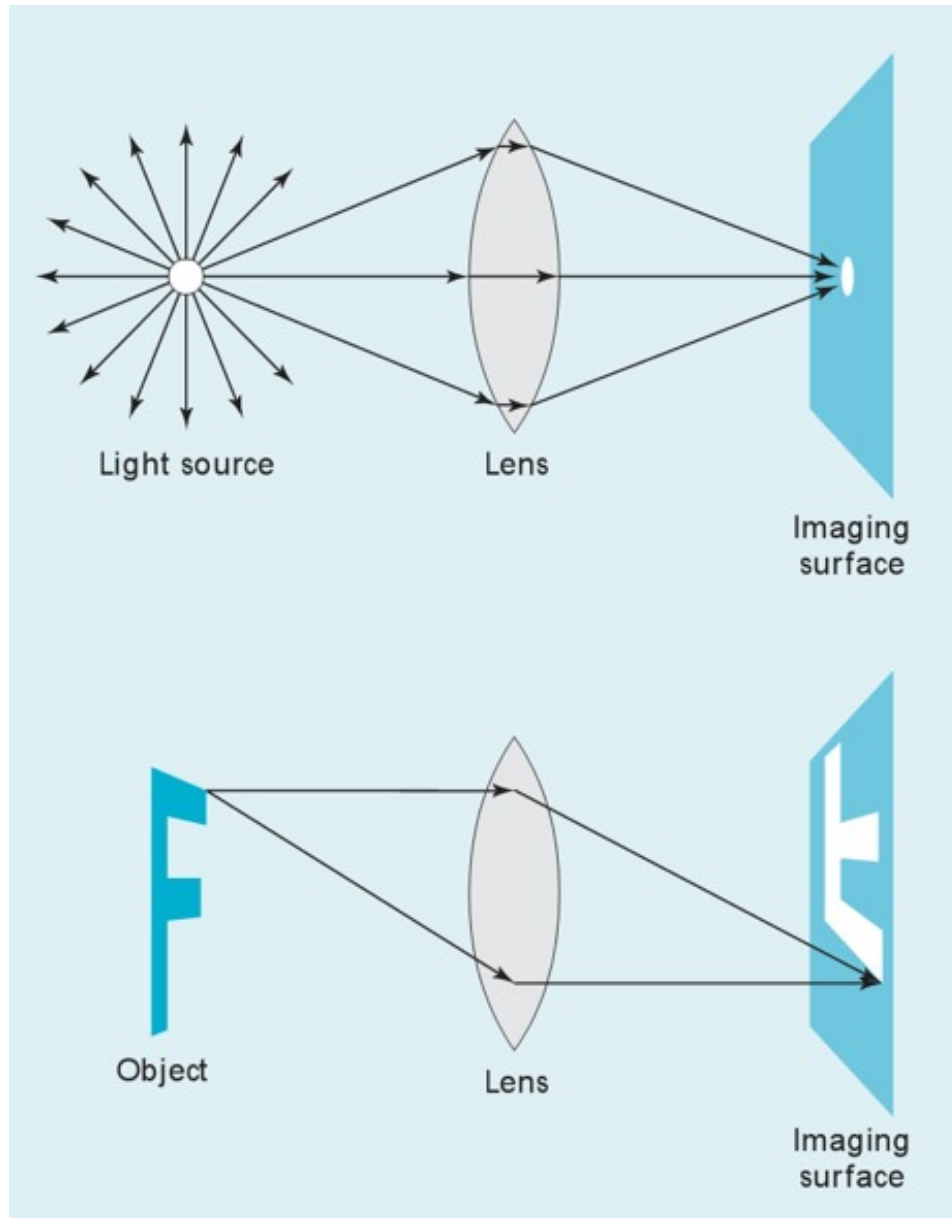
- **photic sneeze reflex**

tendency to sneeze when walking from a dark room into bright light

topic of debate:

- Aristotle - “sun heats the nose.”
- Bacon - closed eyes and didn’t sneeze!
- current thinking: “crossed wiring”

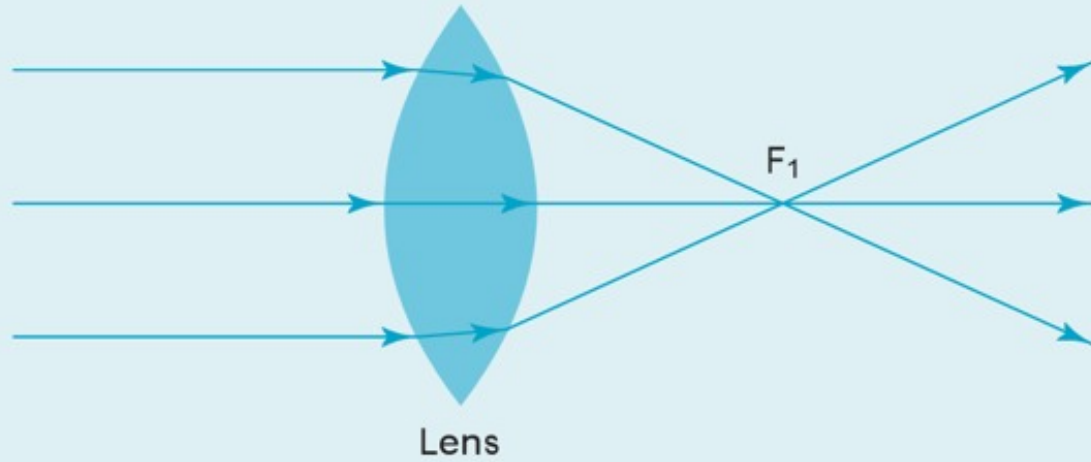
Image formation with a lens



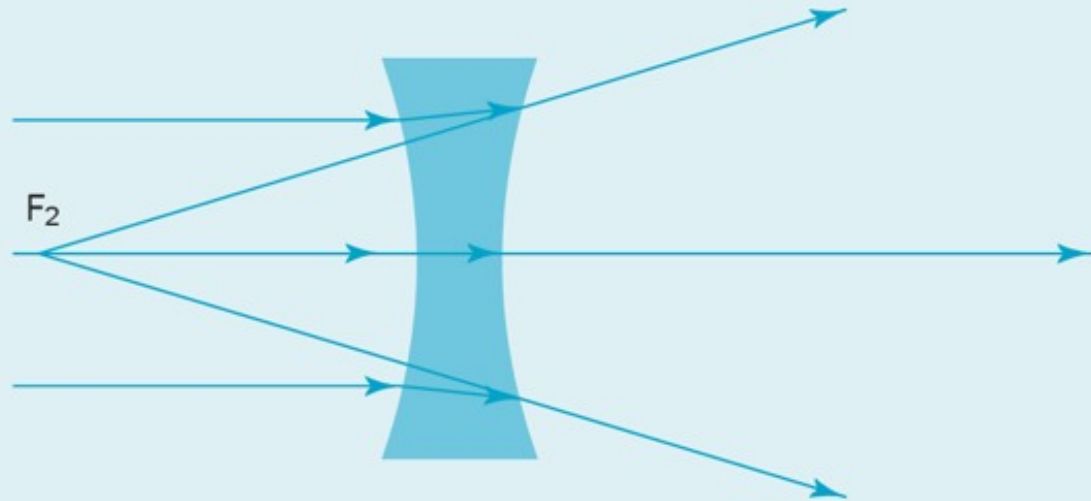
Goal is to focus the light rays emanating from a single point to a single point on the imaging surface

lenses

converging



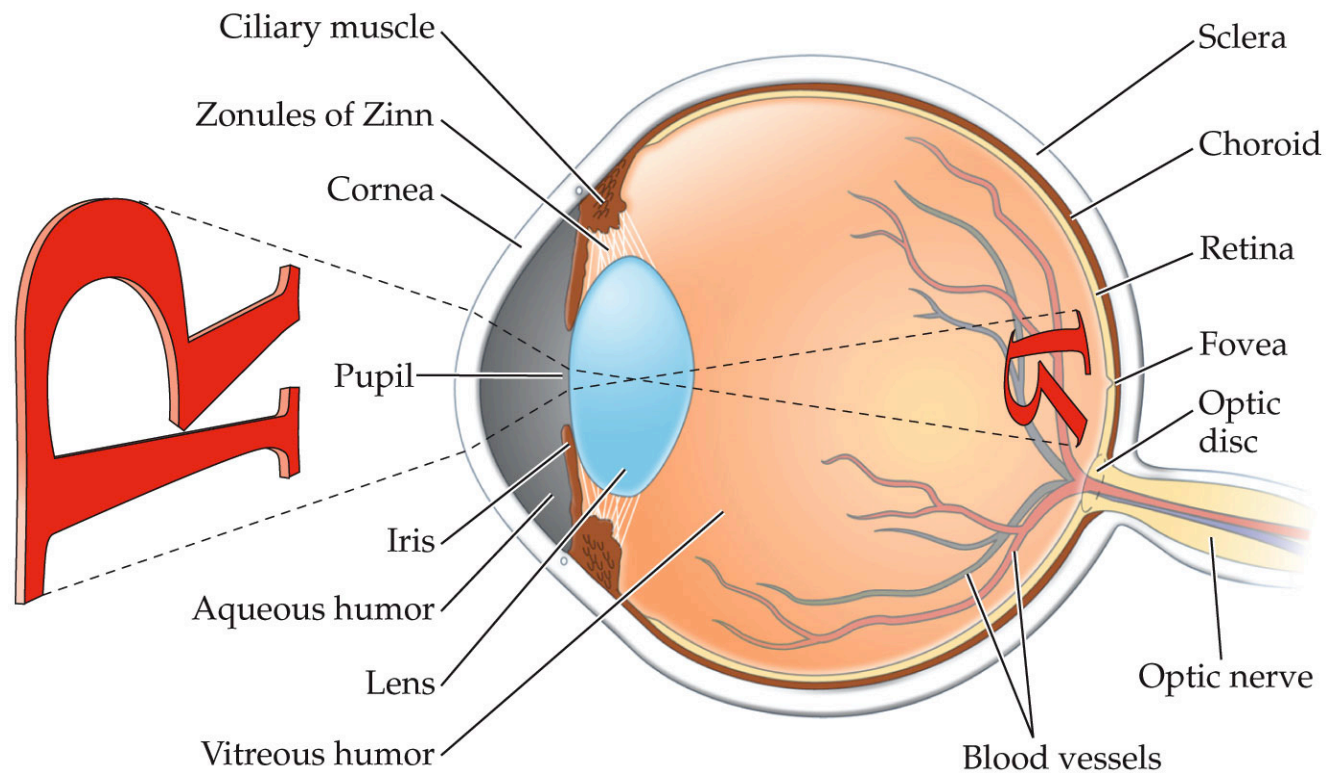
diverging



Refraction:

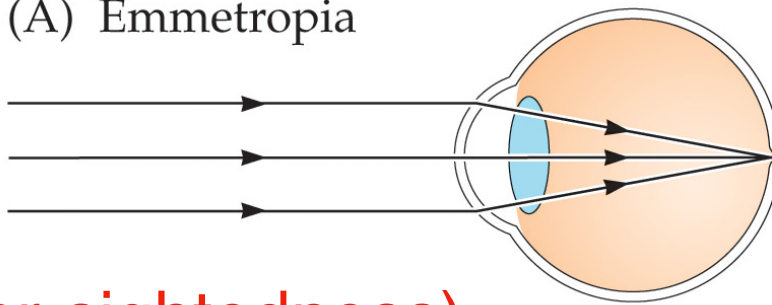
necessary to focus light rays, carried out by lens

- **Accommodation:** process in which the lens changes its shape, altering its refractive power
- **Emmetropia:** no refractive error



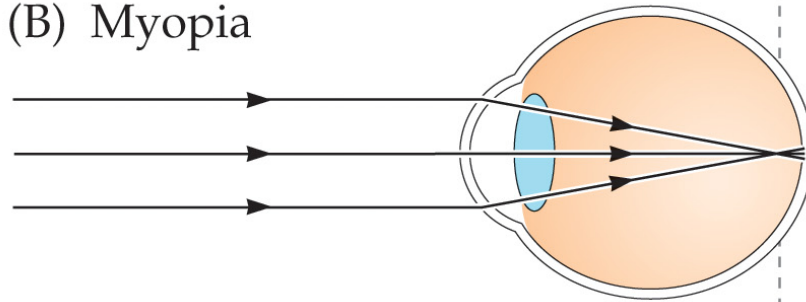
Refractive errors in vision

(A) Emmetropia

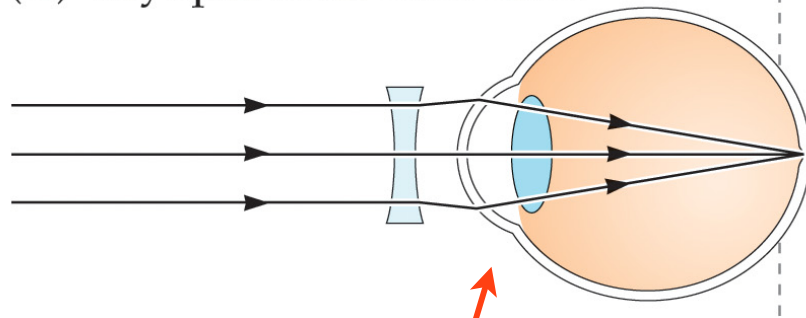


(near-sightedness)

(B) Myopia



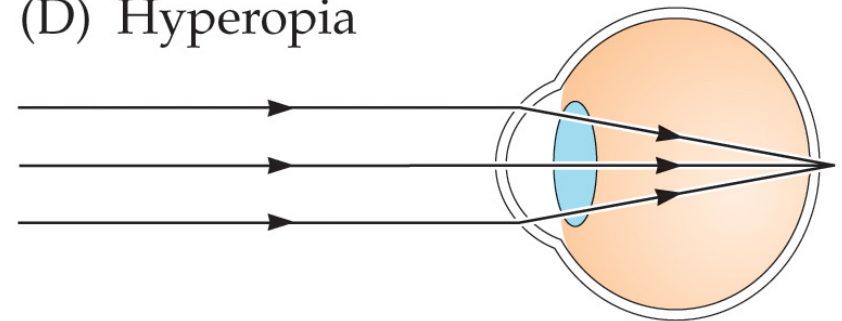
(C) Myopia with correction



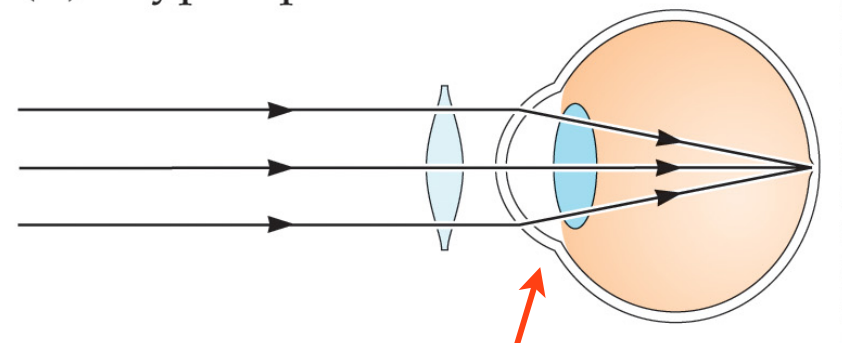
- too fat / powerful
- eye is too long

(far-sightedness)

(D) Hyperopia

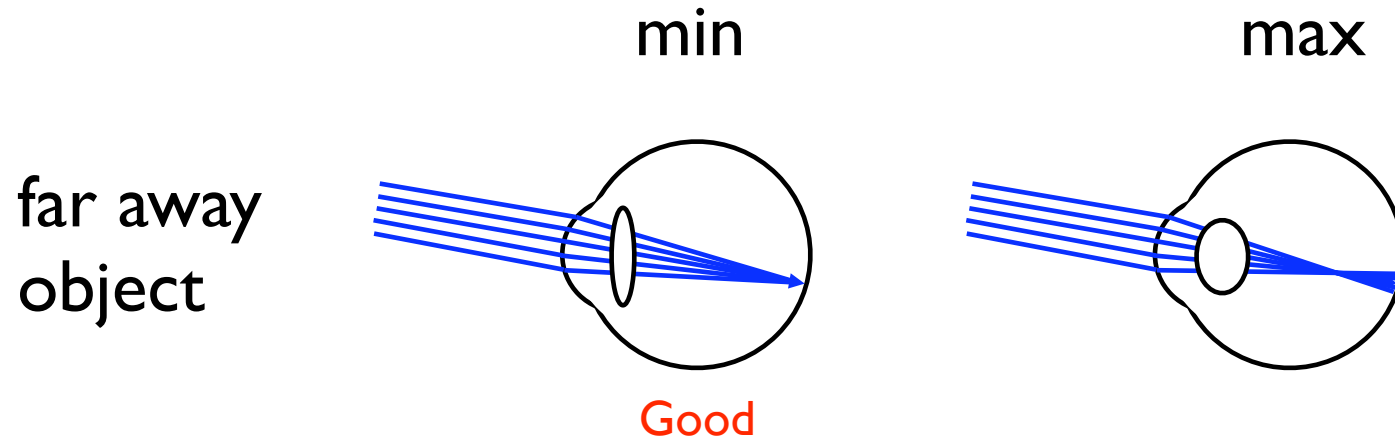


(E) Hyperopia with correction



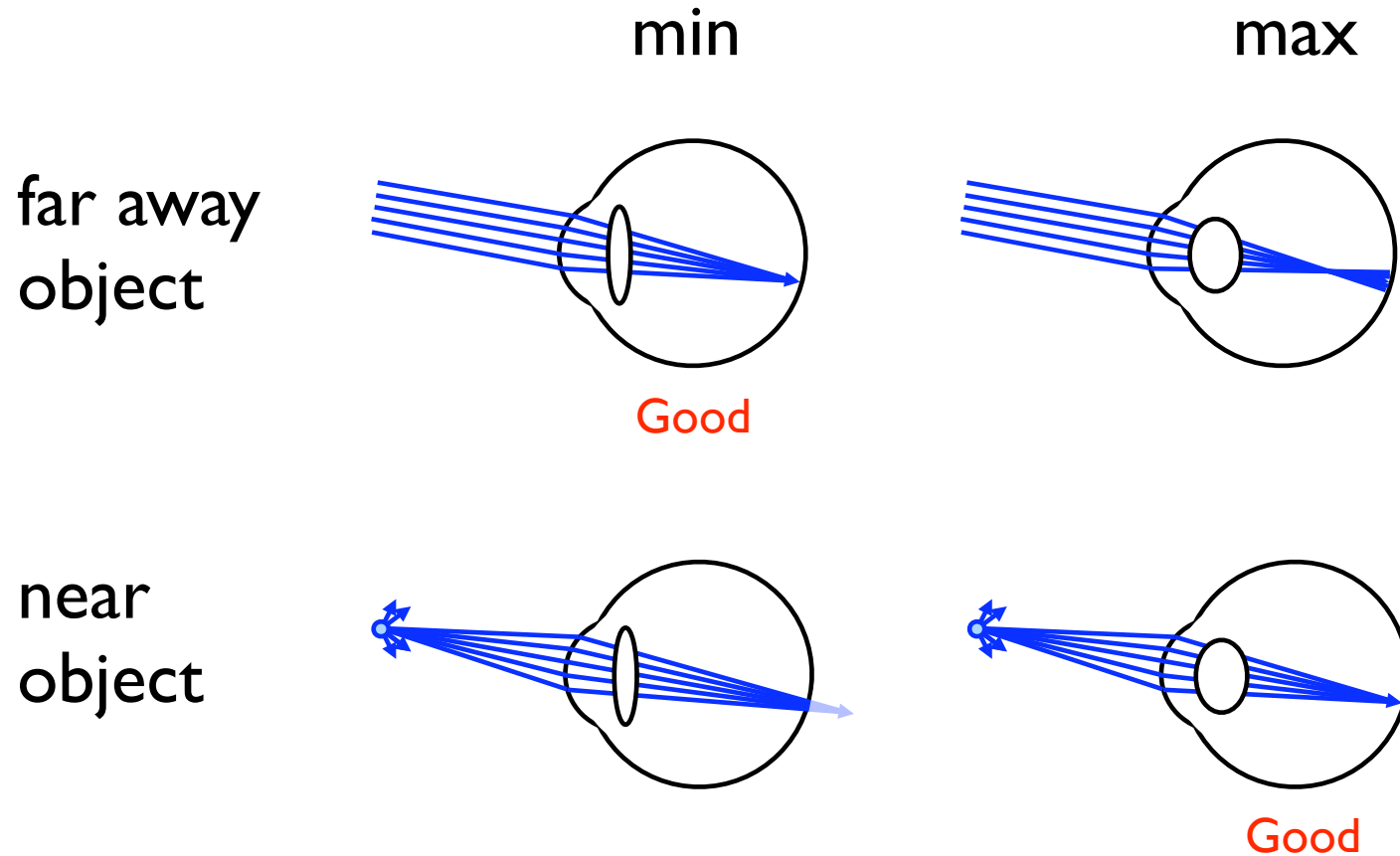
- too thin / not enough accommodation
- eye is too short

normal eye - accomodation



(courtesy ben backus)

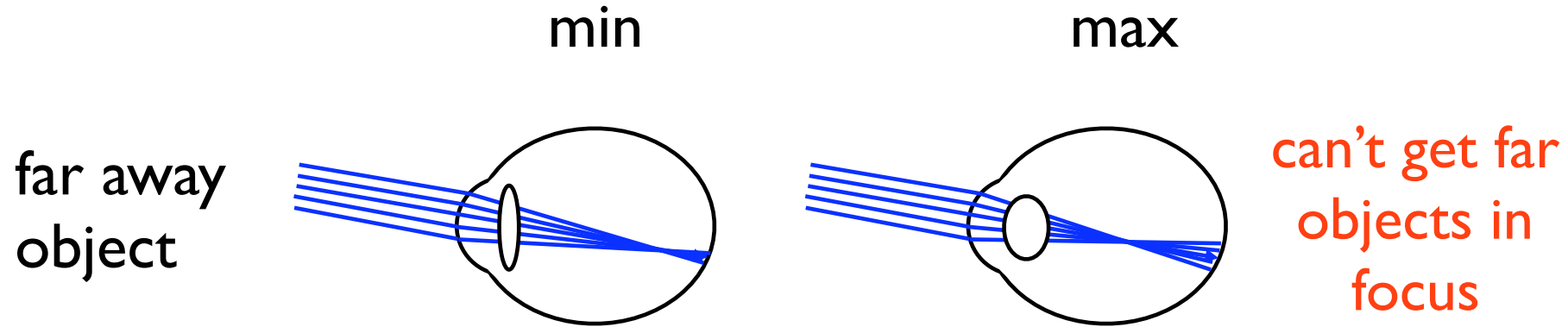
normal eye - accommodation



(courtesy ben backus)

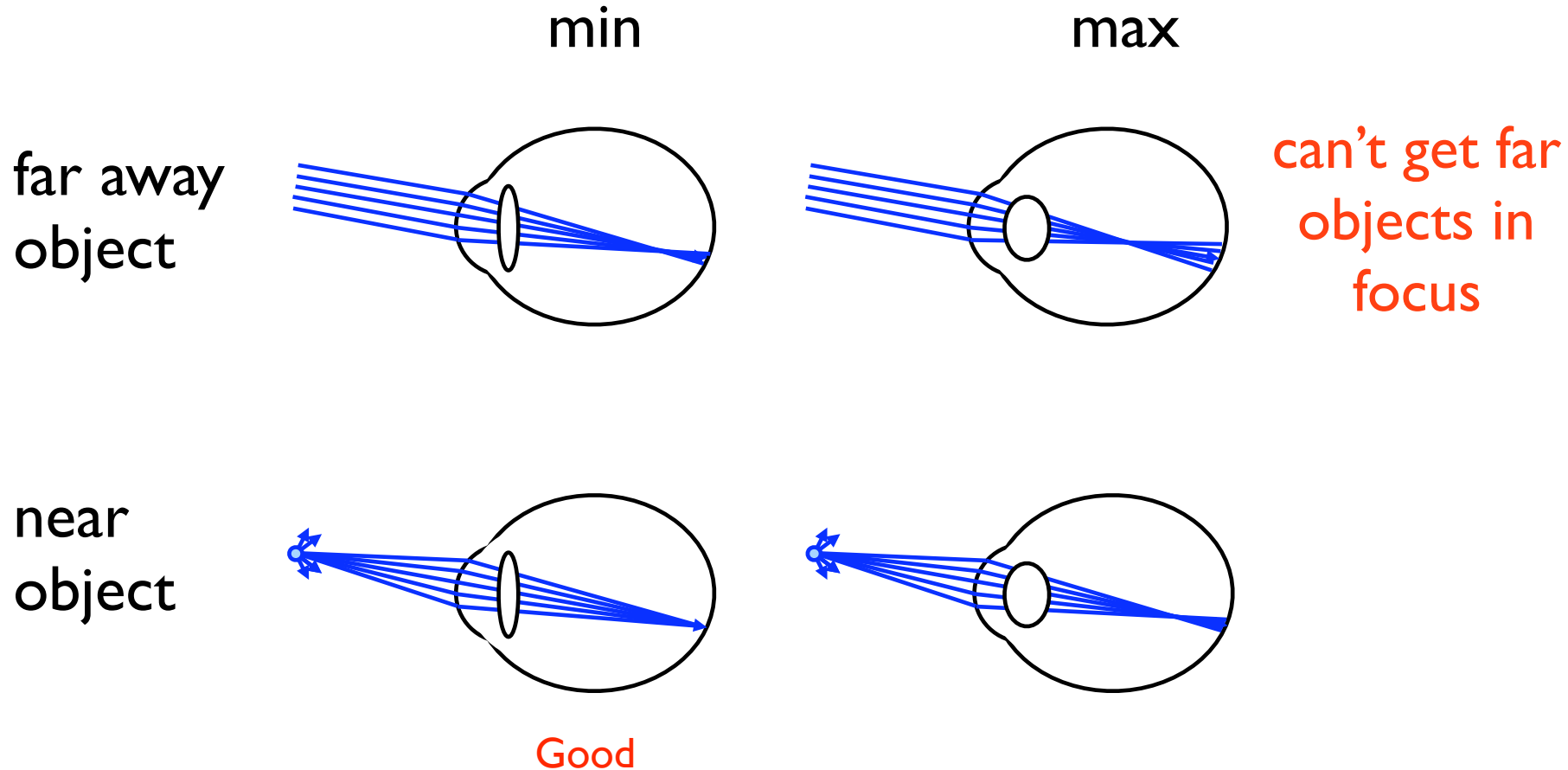
myopic (near-sighted) eye

- lens too powerful



myopic (near-sighted) eye

- lens too powerful



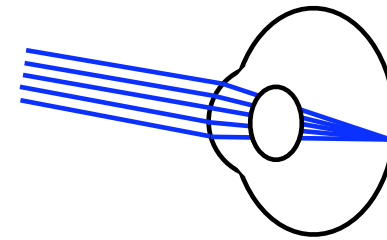
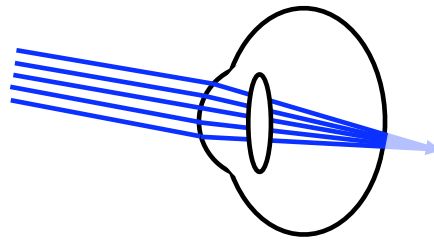
hyperopic (farsighted) eye

- lens not powerful enough

min

max

far away
object



Good

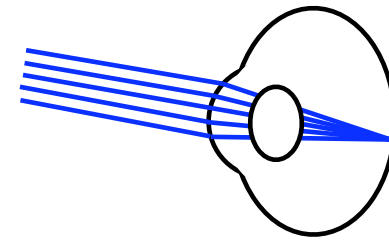
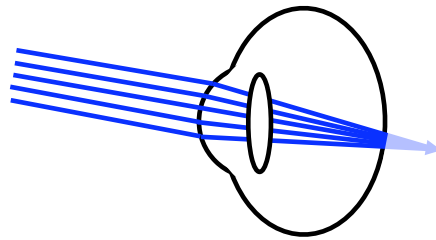
hyperopic (farsighted) eye

- lens not powerful enough

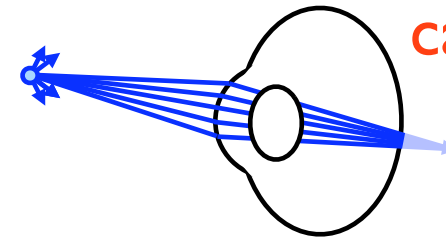
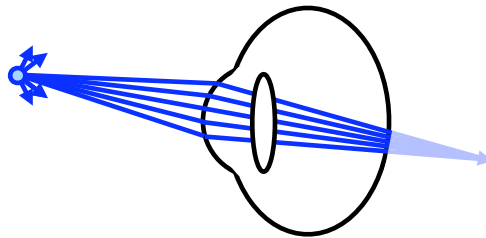
min

max

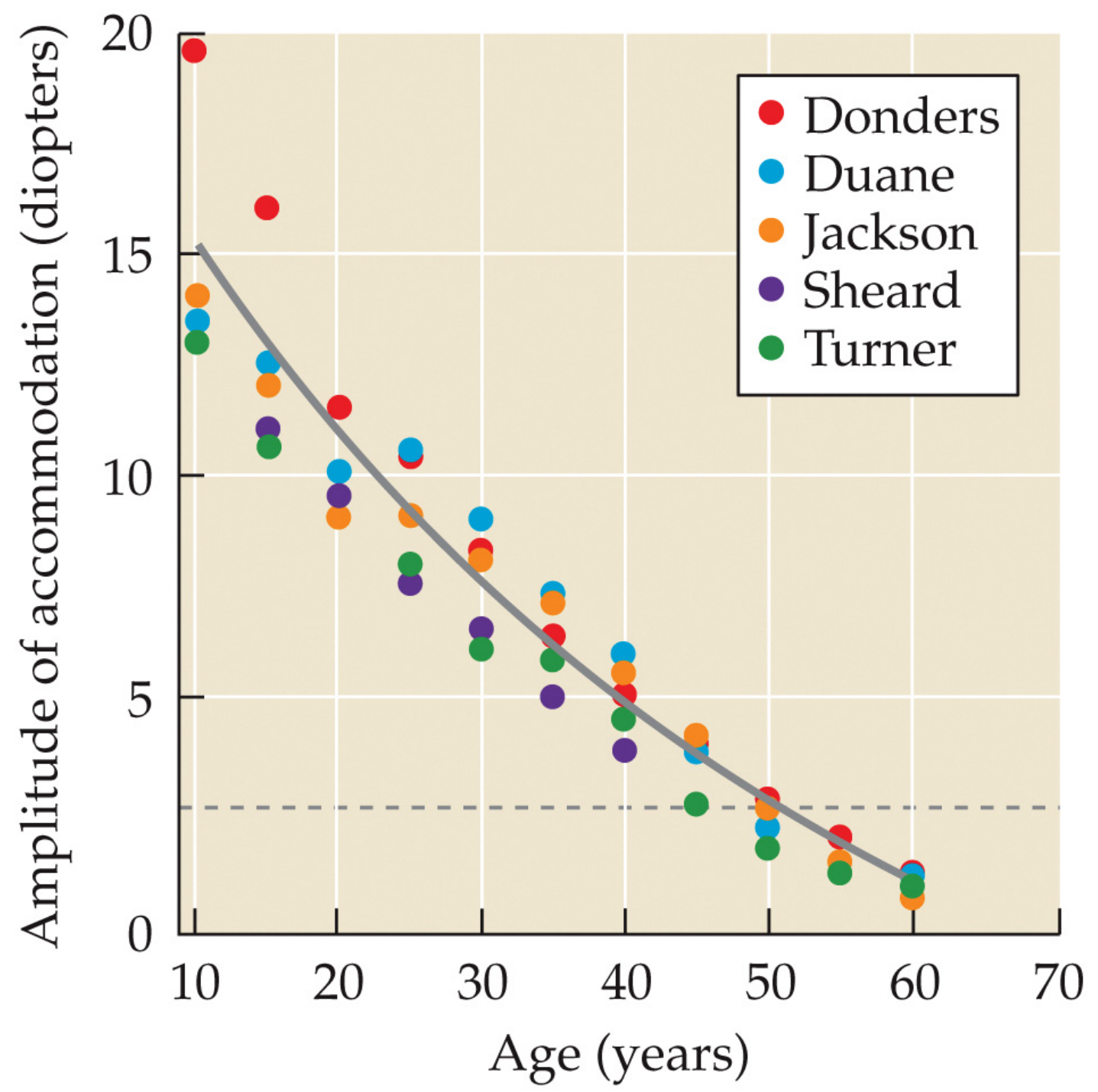
far away
object



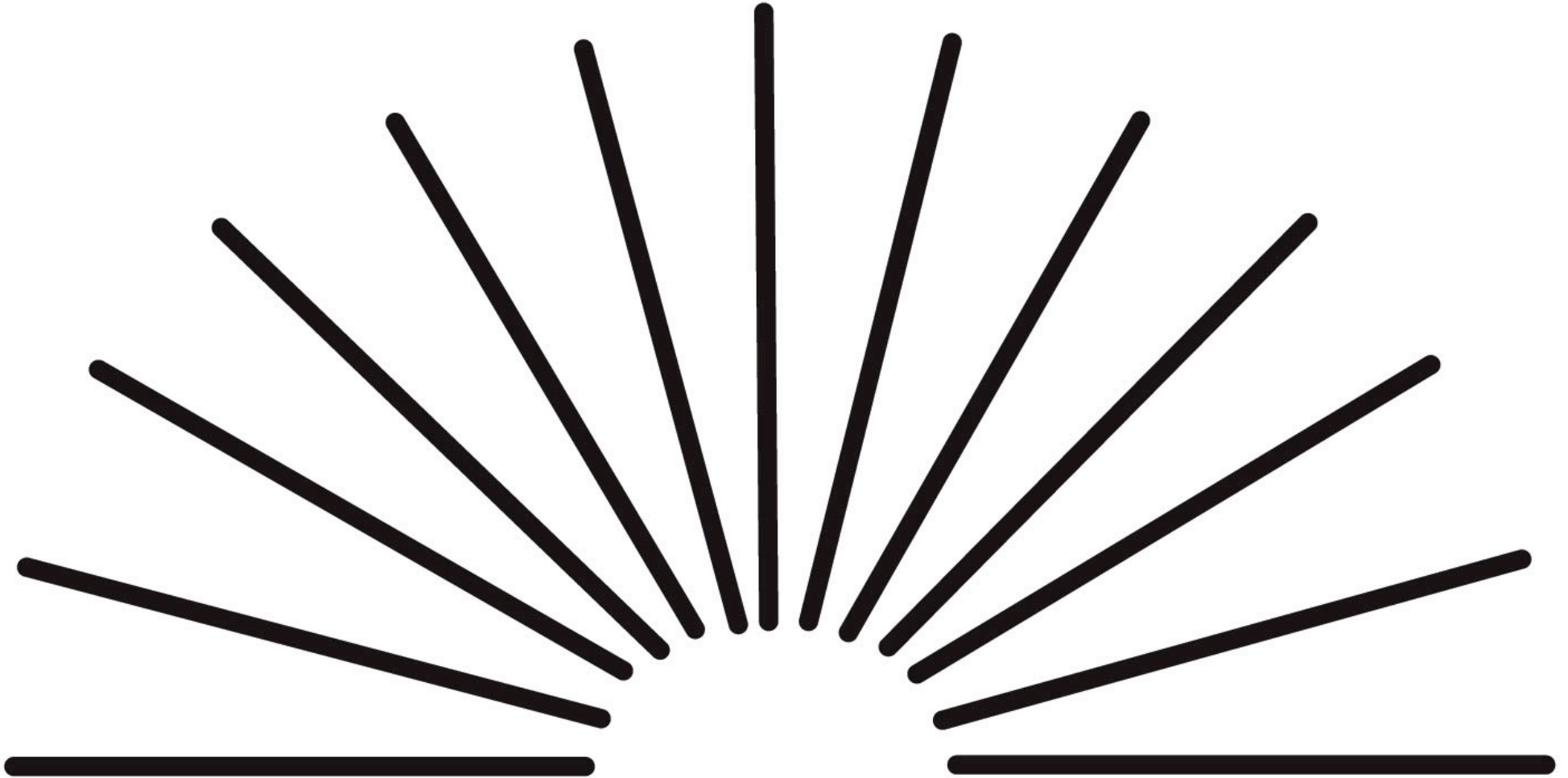
near
object



The precipitous drop in amplitude of accommodation with age



- **Astigmatism:** visual defect caused by the unequal curving of one or more of the refractive surfaces of the eye, usually the cornea



- if you have an astigmatism, some lines will have lower contrast

Camera analogy for the eye

- **Aperture** (F-stop) = **Iris/pupil**. Regulates the amount of light coming into the eye
- **Focus = Lens**.
Changes shape to change focus
- **Film = Retina**.
Records the image

Summary

- light, electromagnetic spectrum, visible spectrum
- light as a wave / particle
- pinhole cameras, lenses, image formation, blur, diffraction, optics of the eye
- anatomy of the eye (cornea, pupil, iris, aqueous, ciliary muscle, lens, vitreous, fovea, retina, and who could forget the Zonules of Zinn!)
- accommodation, emmetropia, refractive errors (hyperopia, myopia, astigmatism)

the retina

(“smart” film in your camera)

What does the retina do?

1. Transduction

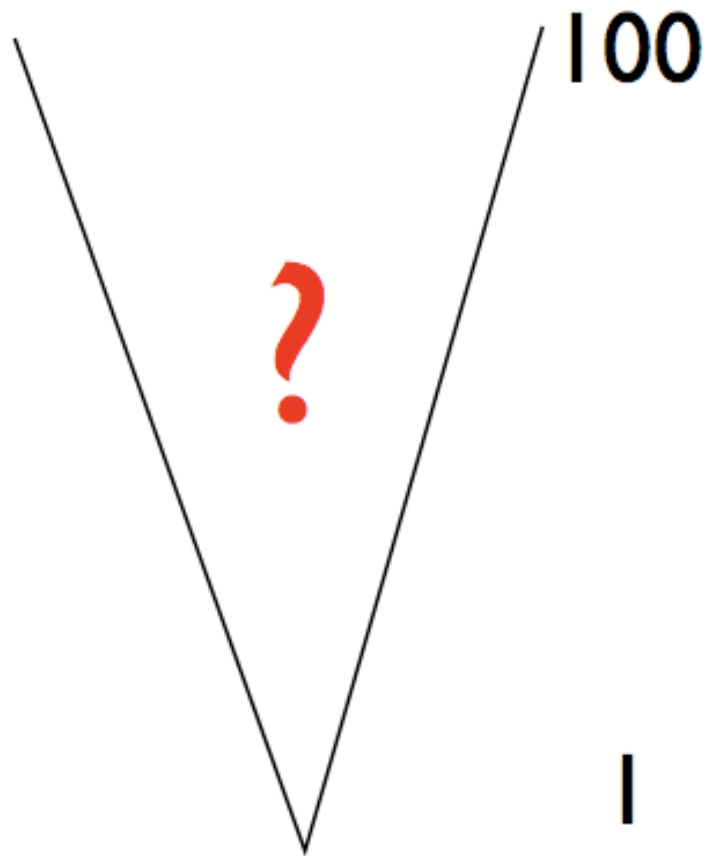
- Conversion of energy from one form to another (i.e., “light” into “electrical energy”)

this is a
major,
important
concept

2. Processing

- **Amplification** of very weak signals
(1-2 photons can be detected!)
- **Compression** of image into more compact form so that information can be efficiently sent to the brain
optic nerve = “bottleneck”
analogy: jpeg compression of images

photoreceptors



ganglion cells