Intro to Light & Vision

Lecture 4

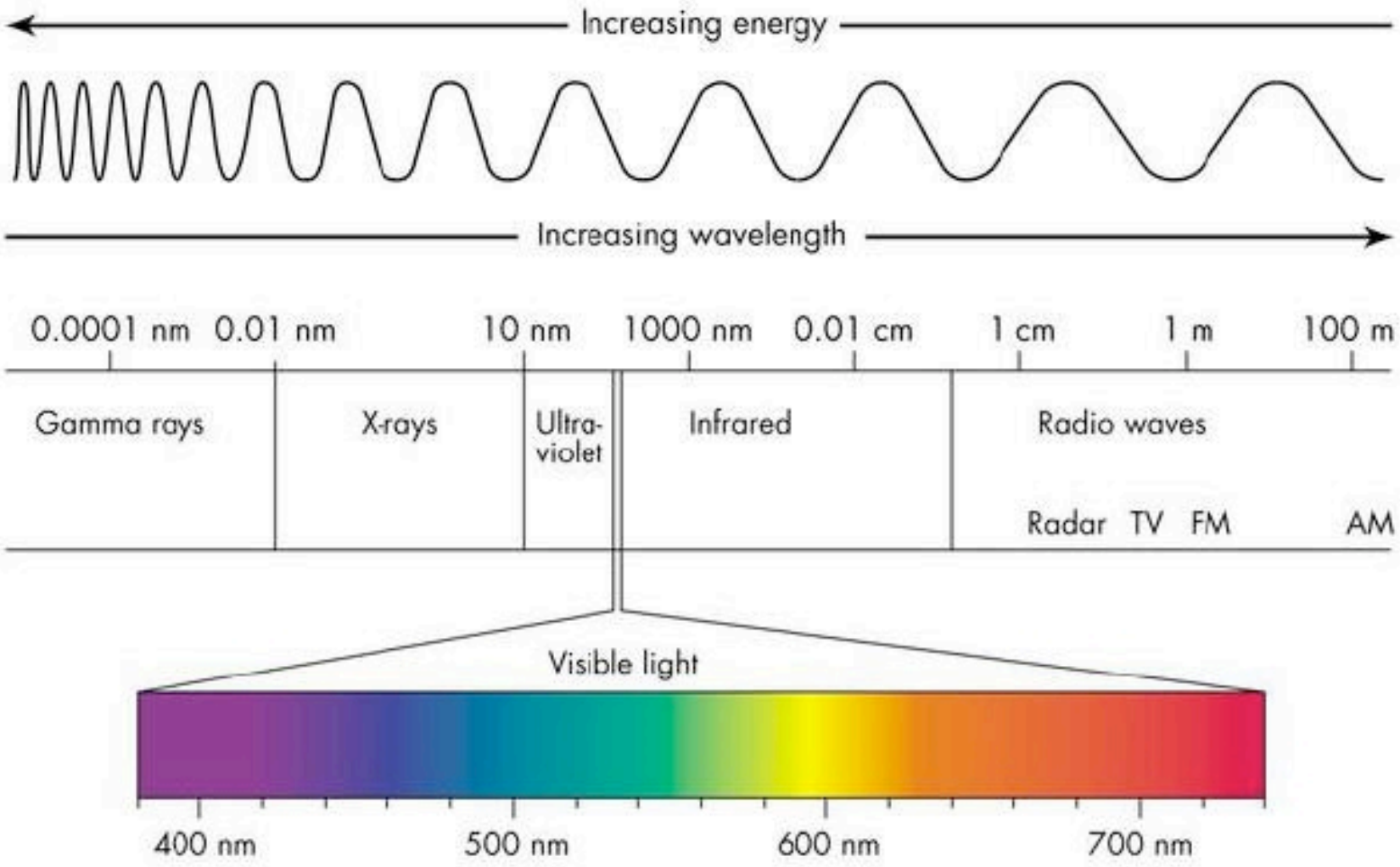
Jonathan Pillow
Sensation & Perception
(PSY 345 / NEU 325)
Princeton University, Spring 2022

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?

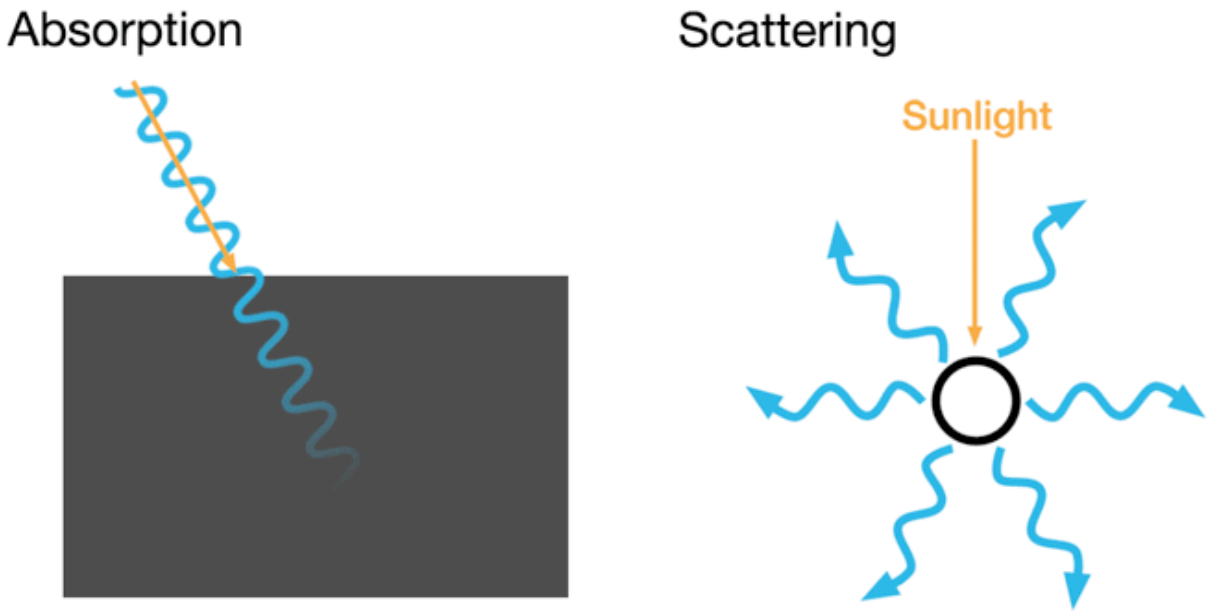
Other solutions are possible:

- 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

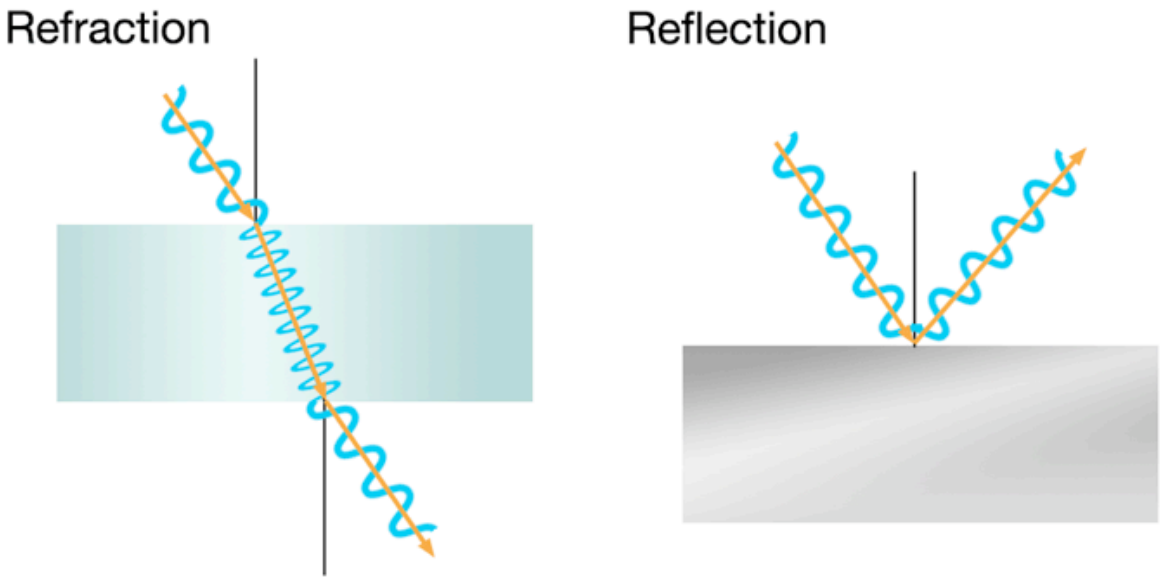
- **Scattered**: Energy that is dispersed in an irregular fashion (most light does this!)



What happens to light?

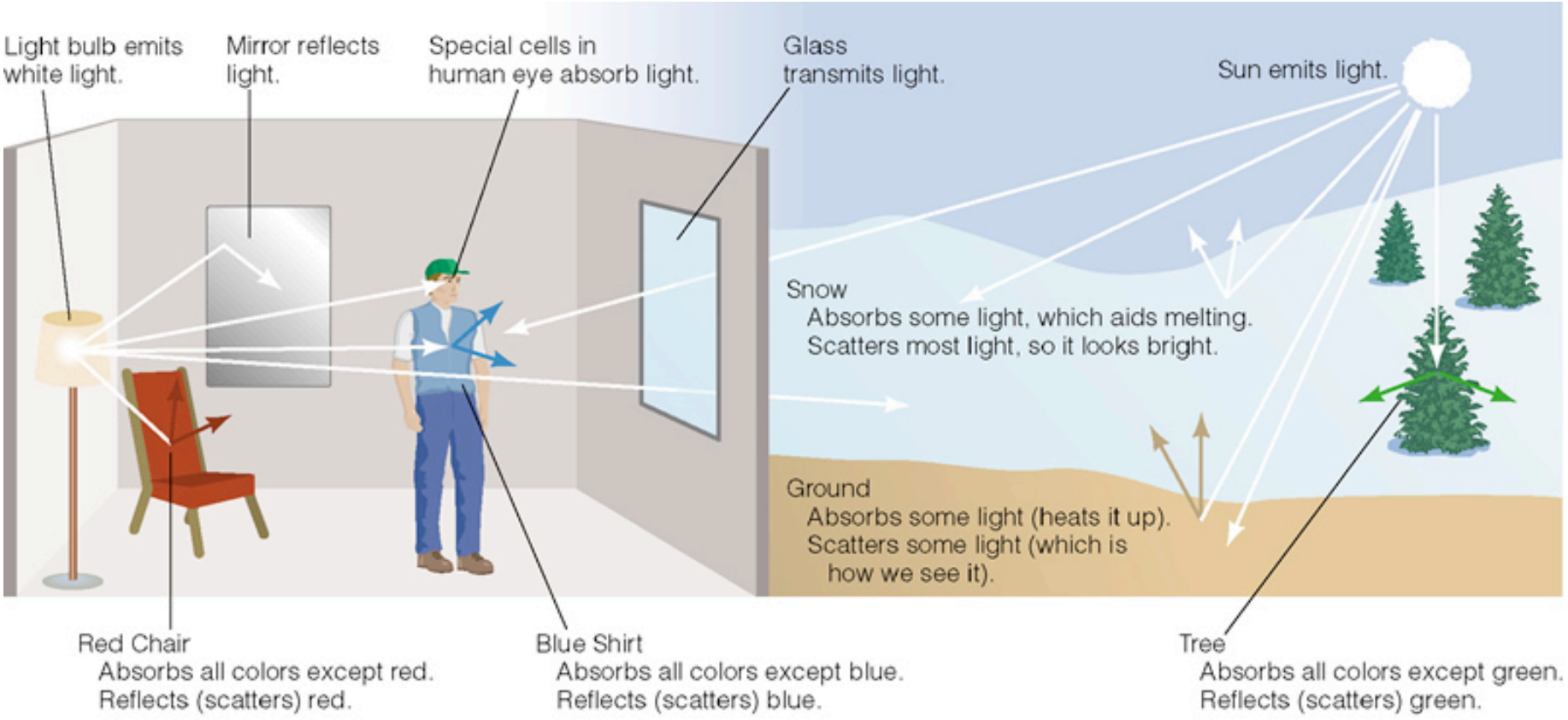
- **Refracted**: Energy that is altered as it passes into another medium, (e.g., light entering water from the air)

- **Reflected**: Energy that is redirected when it strikes a surface



Light Physics

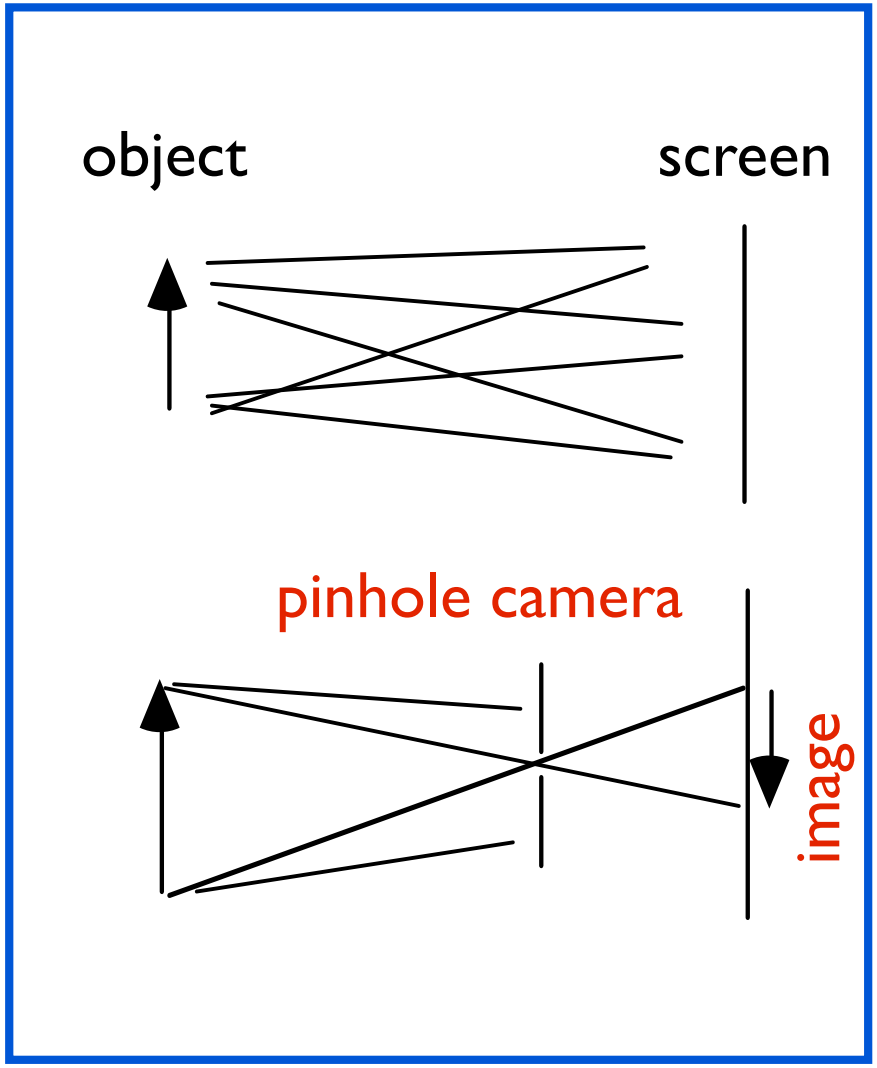
What it all looks like. (Messy!)



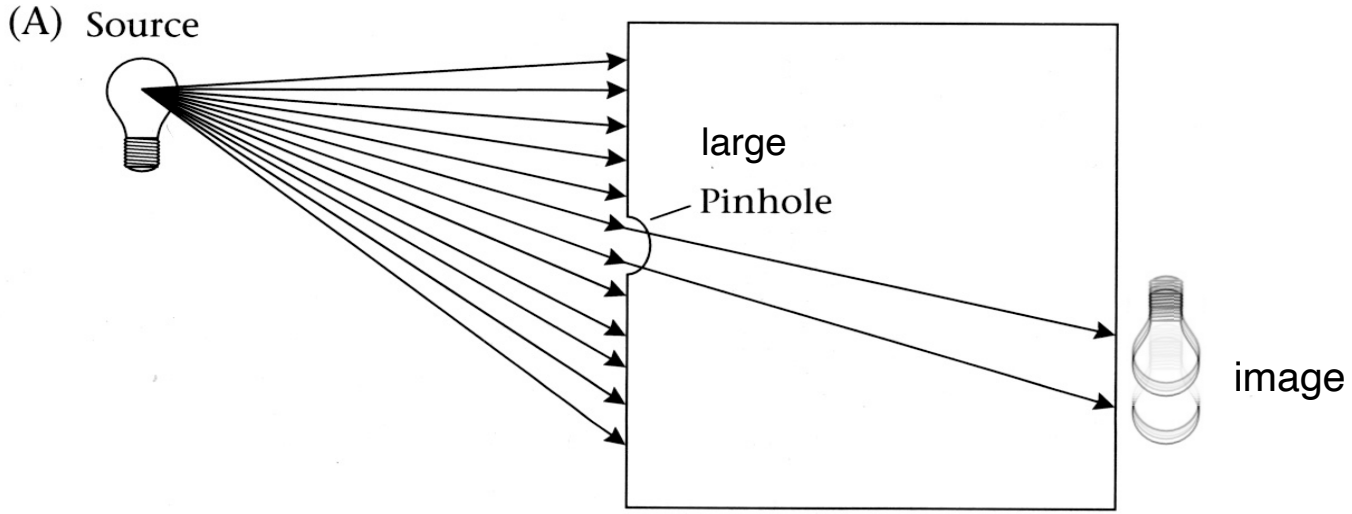
- each point in space has light from all angles passing through it

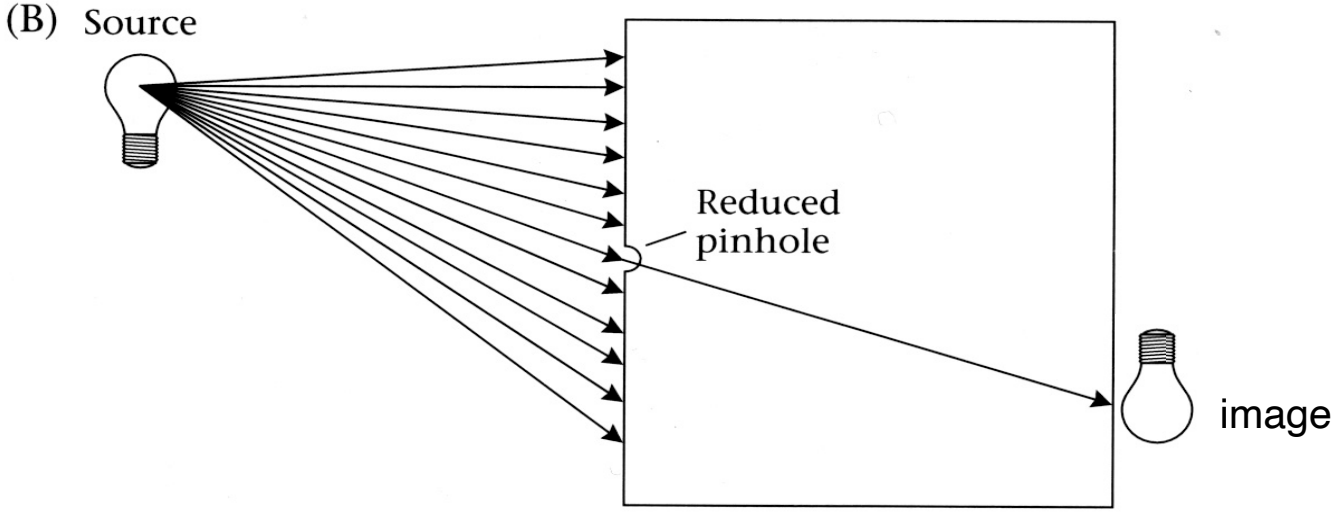
Why do we need optics?

- 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





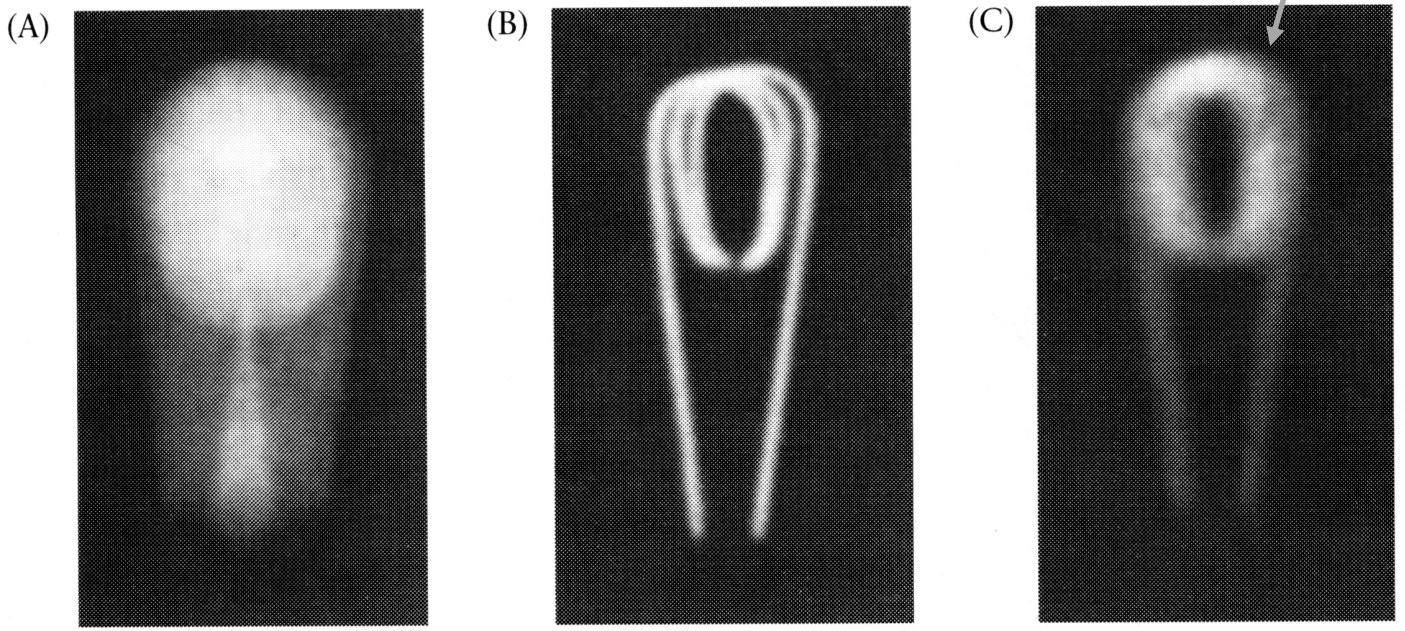
smaller aperture

= fewer rays

= sharper image

= *dimmer* image

Some pinhole images

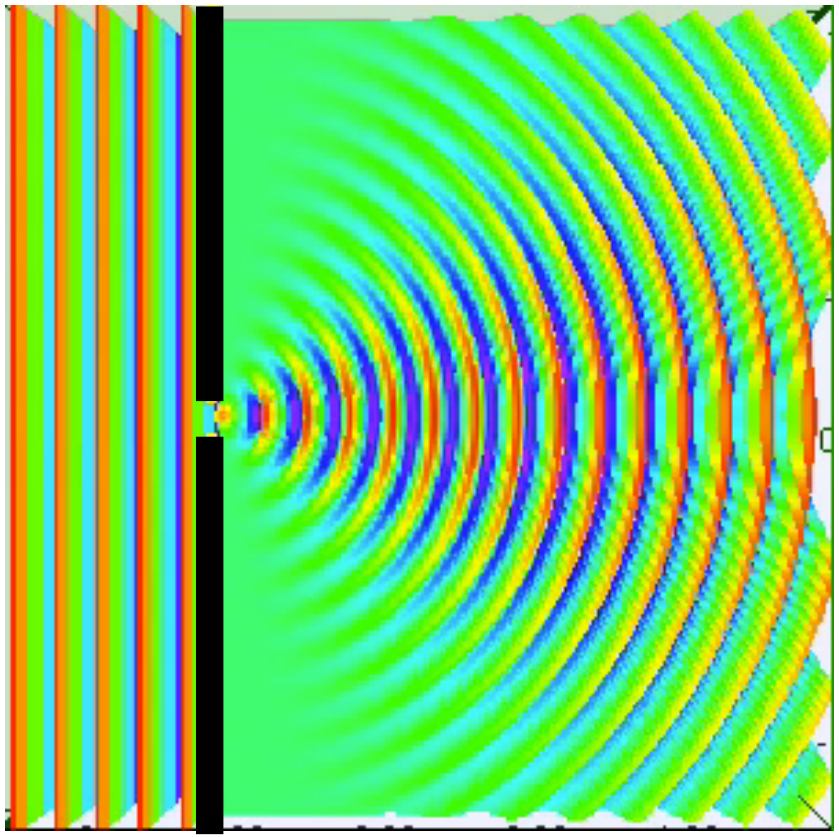


big pinhole small pinhole tiny pinhole

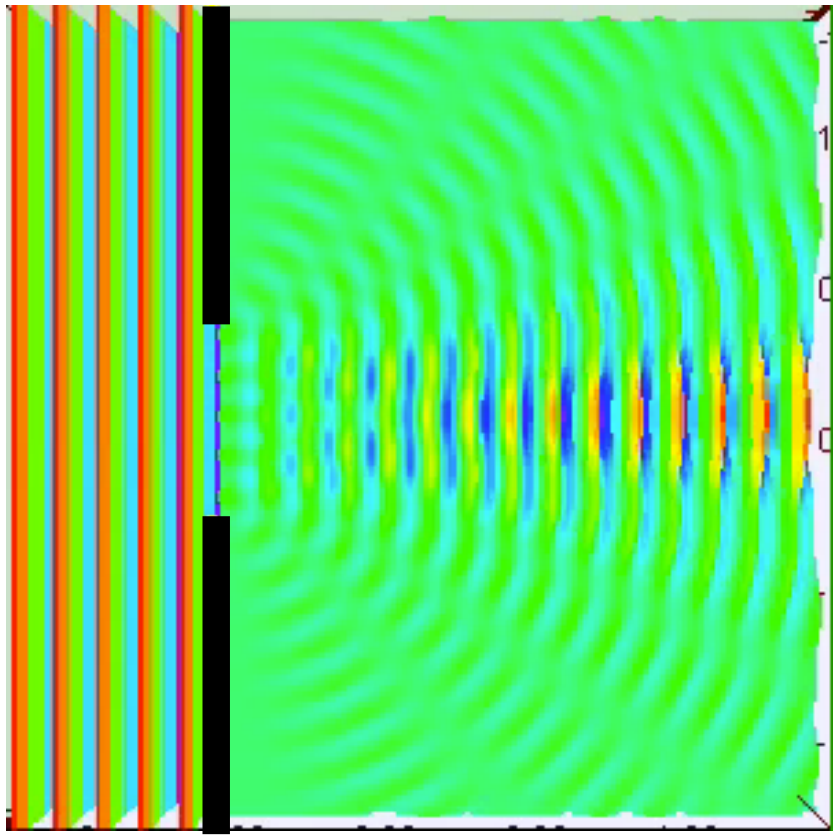
diffraction

- bending of waves around small obstacles or through small apertures

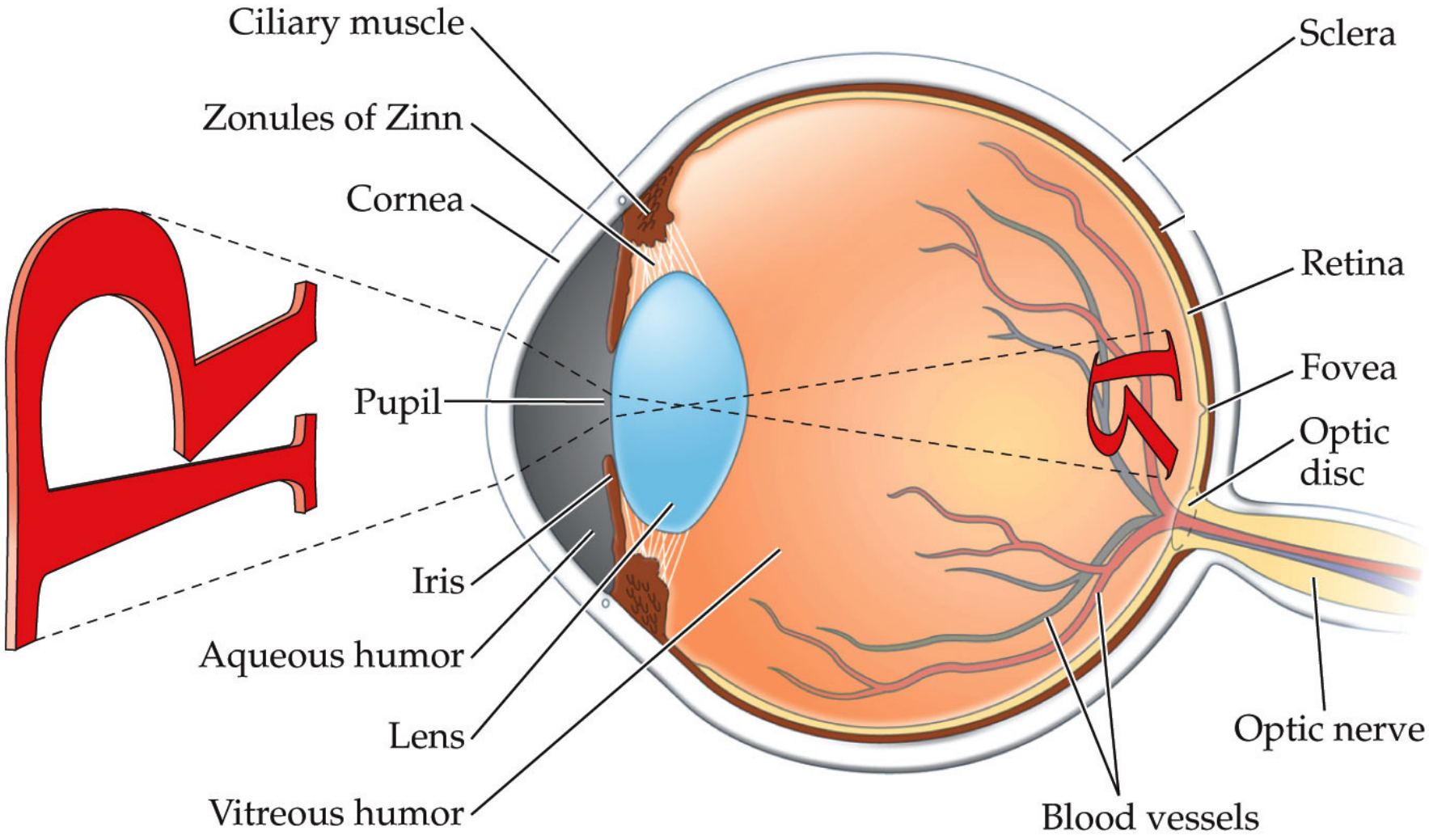
slit = 1 x wavelength



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.

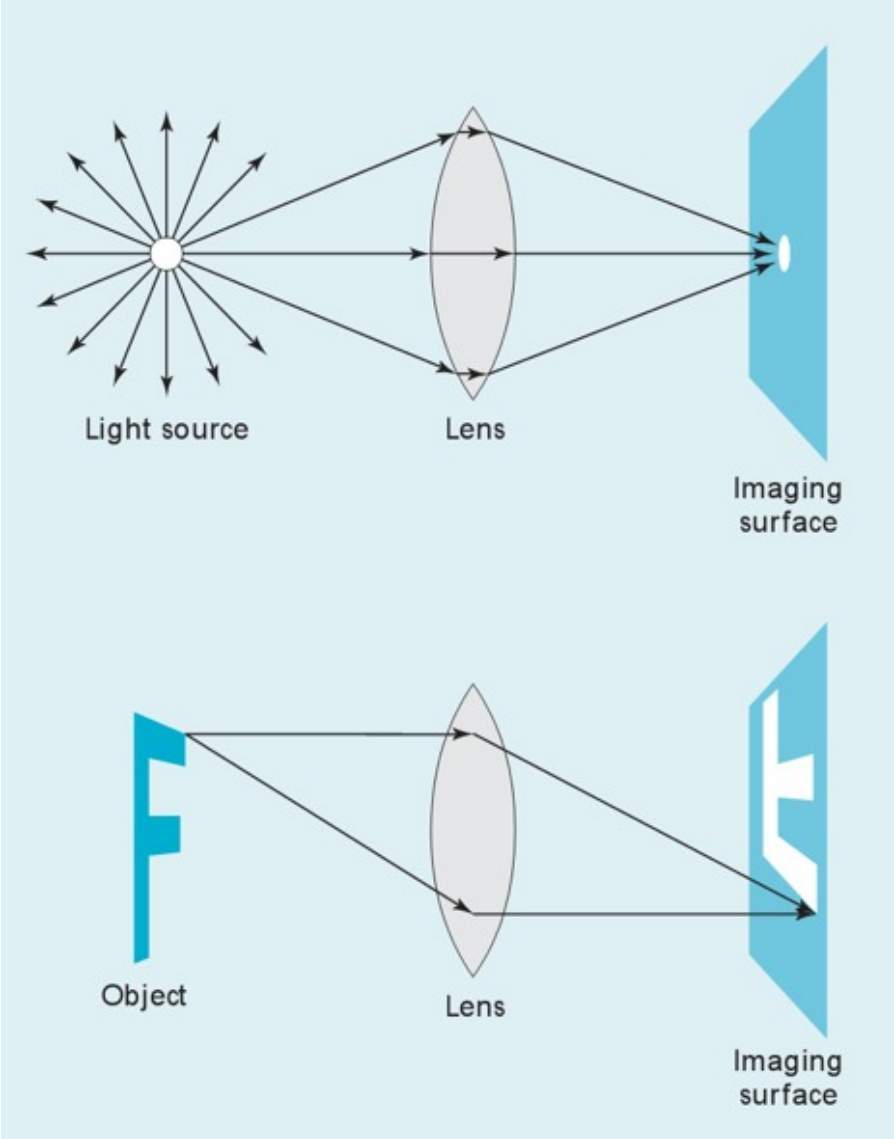
- **photic sneeze reflex**
  tendency to sneeze when walking from a dark room into bright light

    - affects 18-35% of the population
    - usually: 1-10 sneezes followed by refractory period
    - aka "pepper on the sun"

Explanations:

- Aristotle: "sun heats the nose."
- Bacon: closed eyes and didn't sneeze!
- current theory: "crossed wiring" in trigeminal nerve

Image formation with a lens

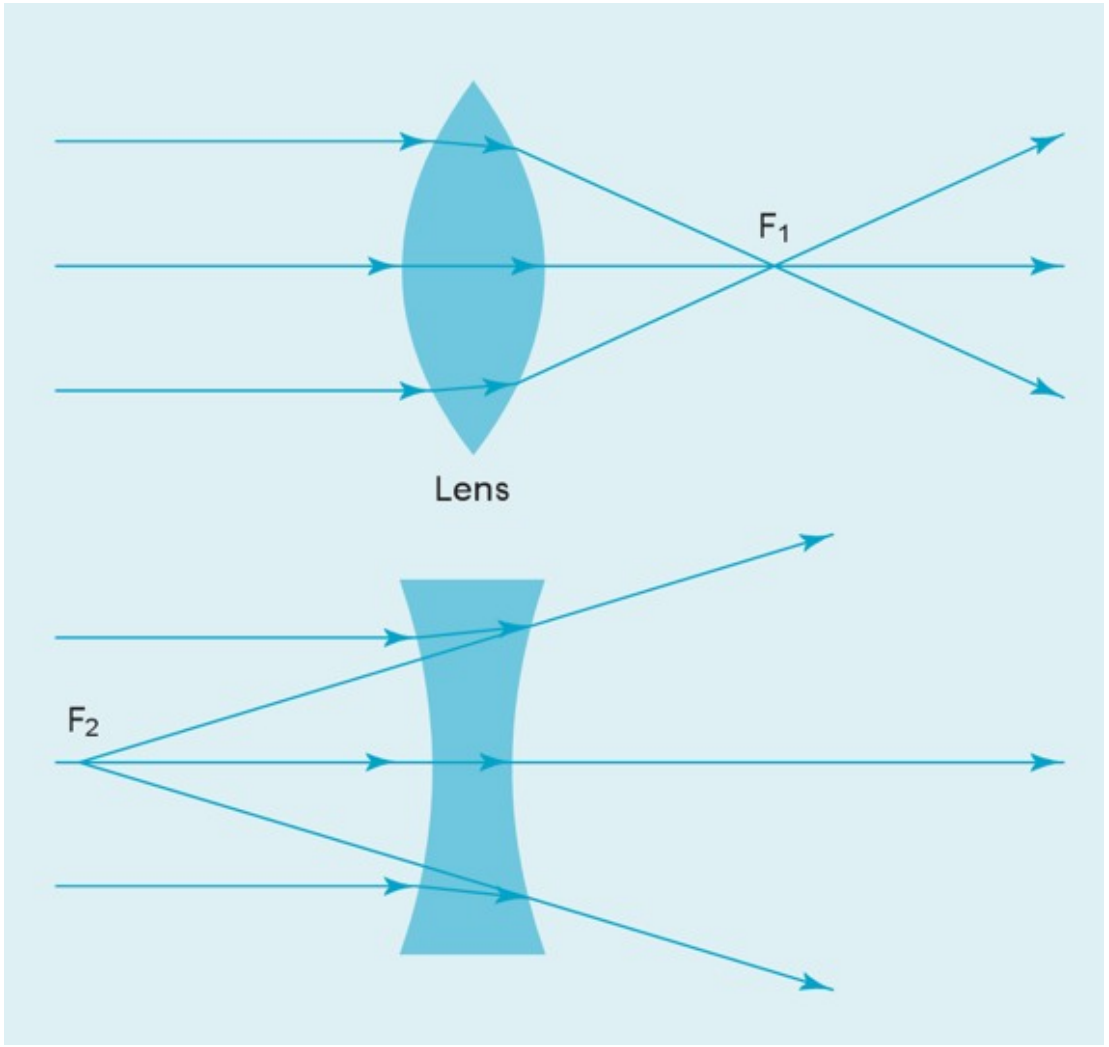


Goal is to focus the light rays emanating from a single point to a single point on the imaging surface

lenses

converging

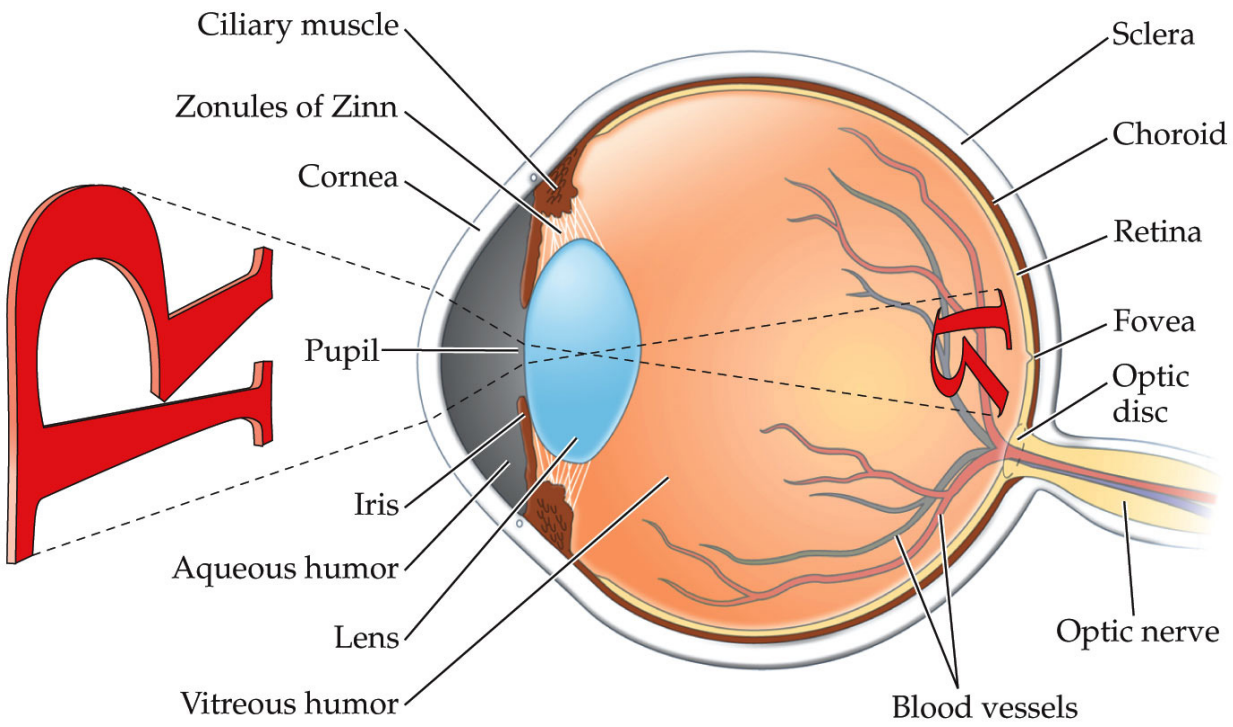
diverging



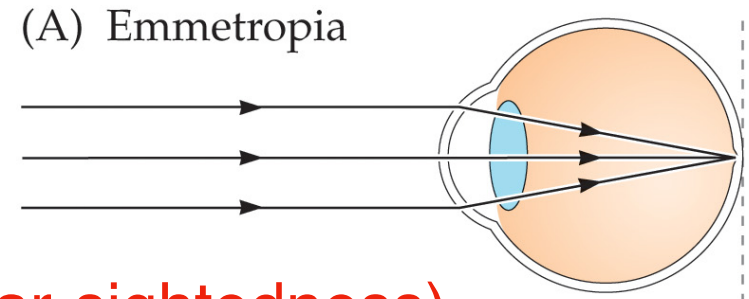
Refraction:

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

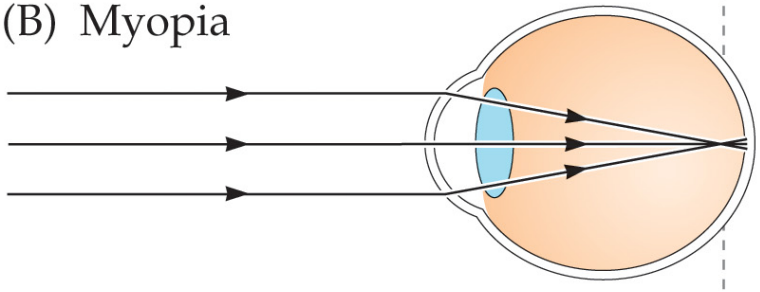


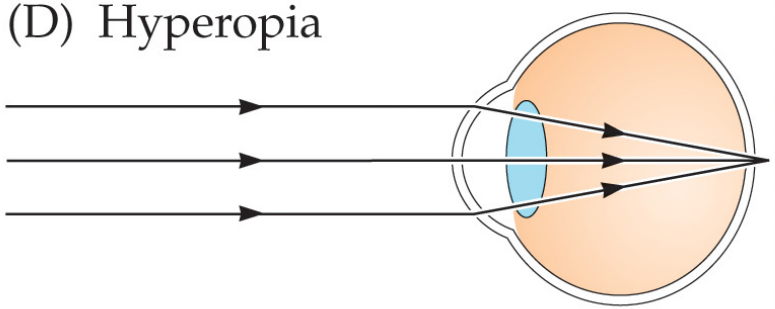
Refractive errors in vision

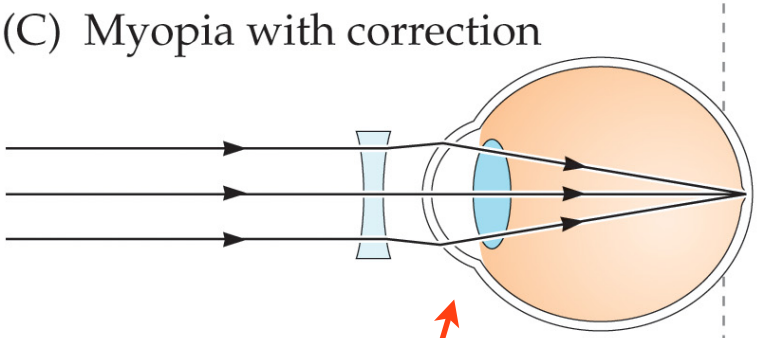


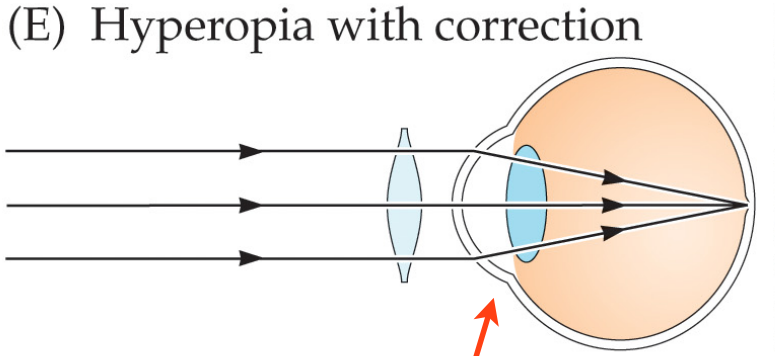
(near-sightedness)

(far-sightedness)





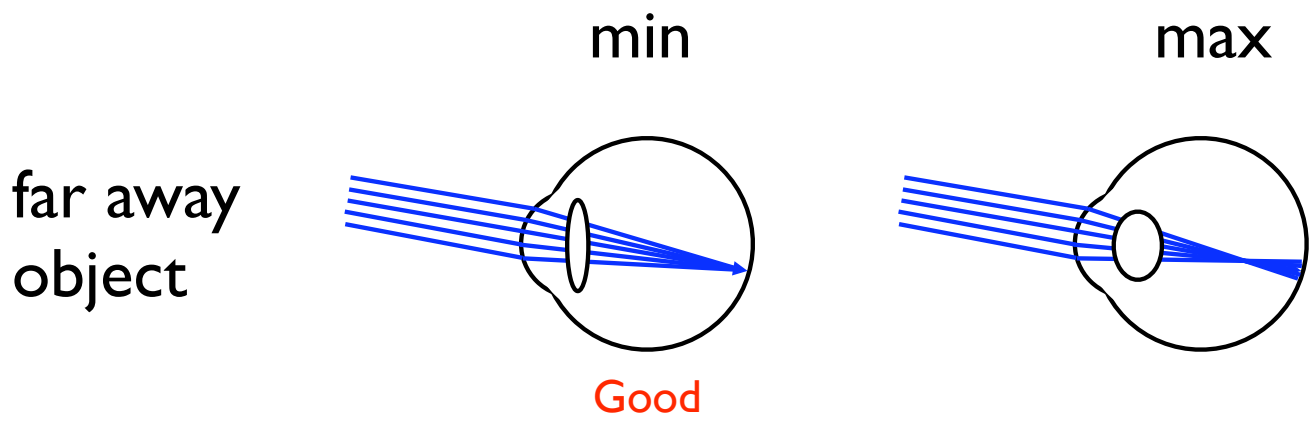




- too fat / powerful
- eye is too long

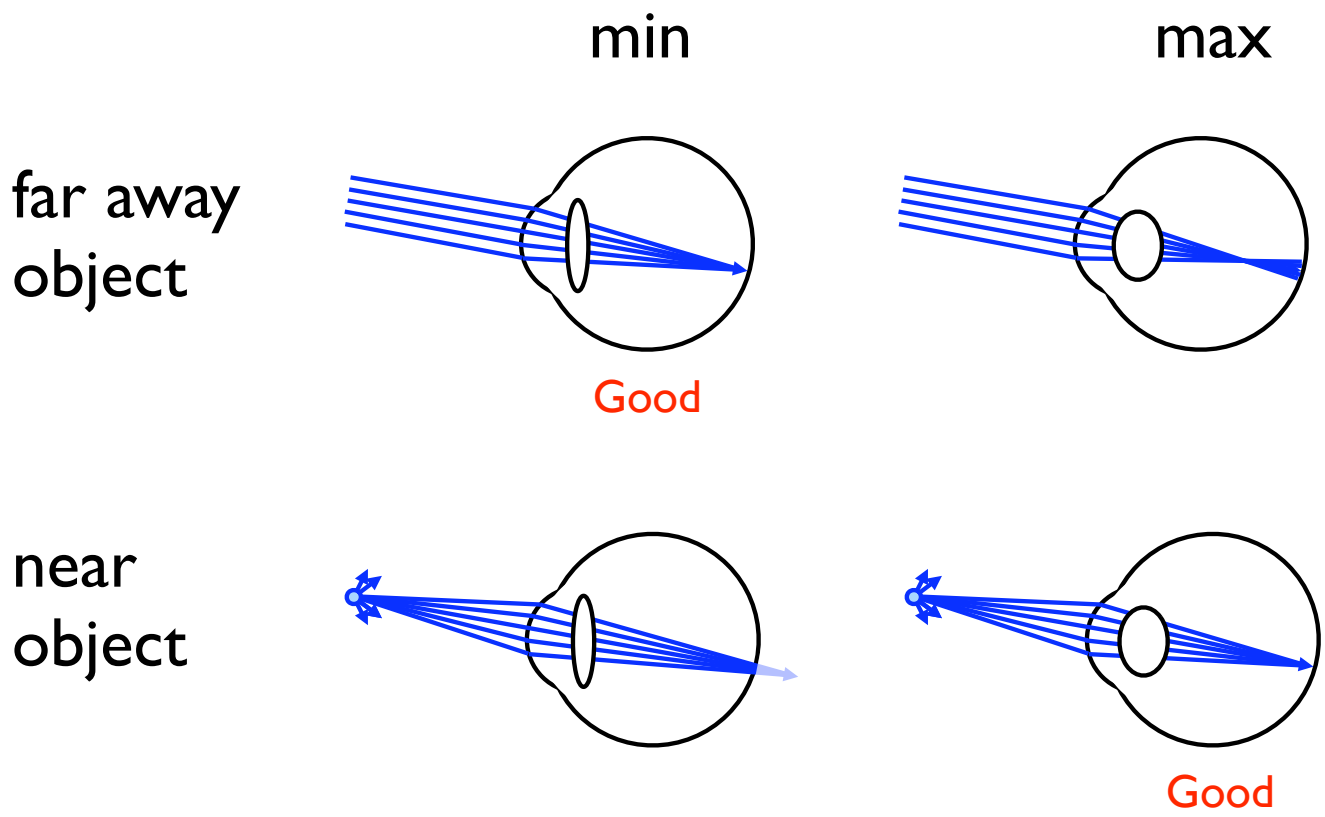
- too thin / not enough accommodation
- eye is too short

normal eye - accomodation



(courtesy ben backus)

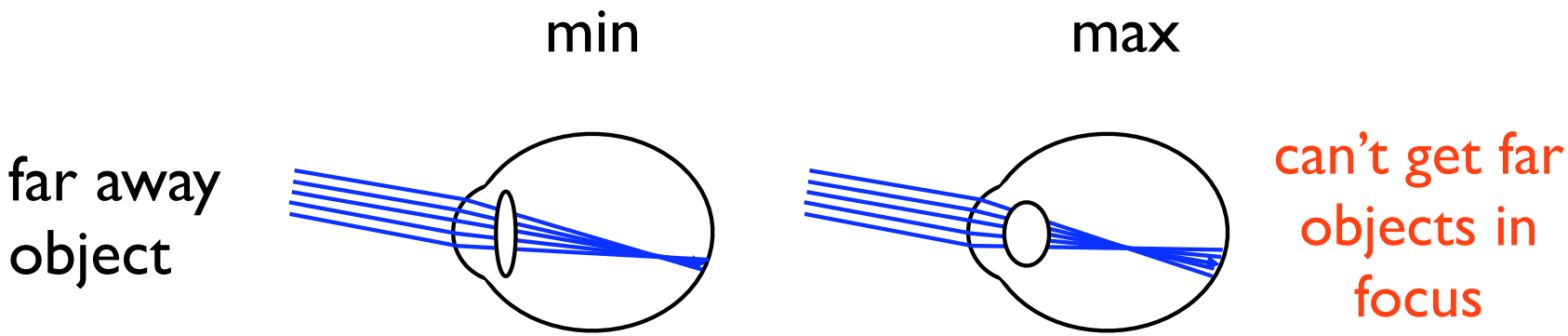
normal eye - accomodation



(courtesy ben backus)

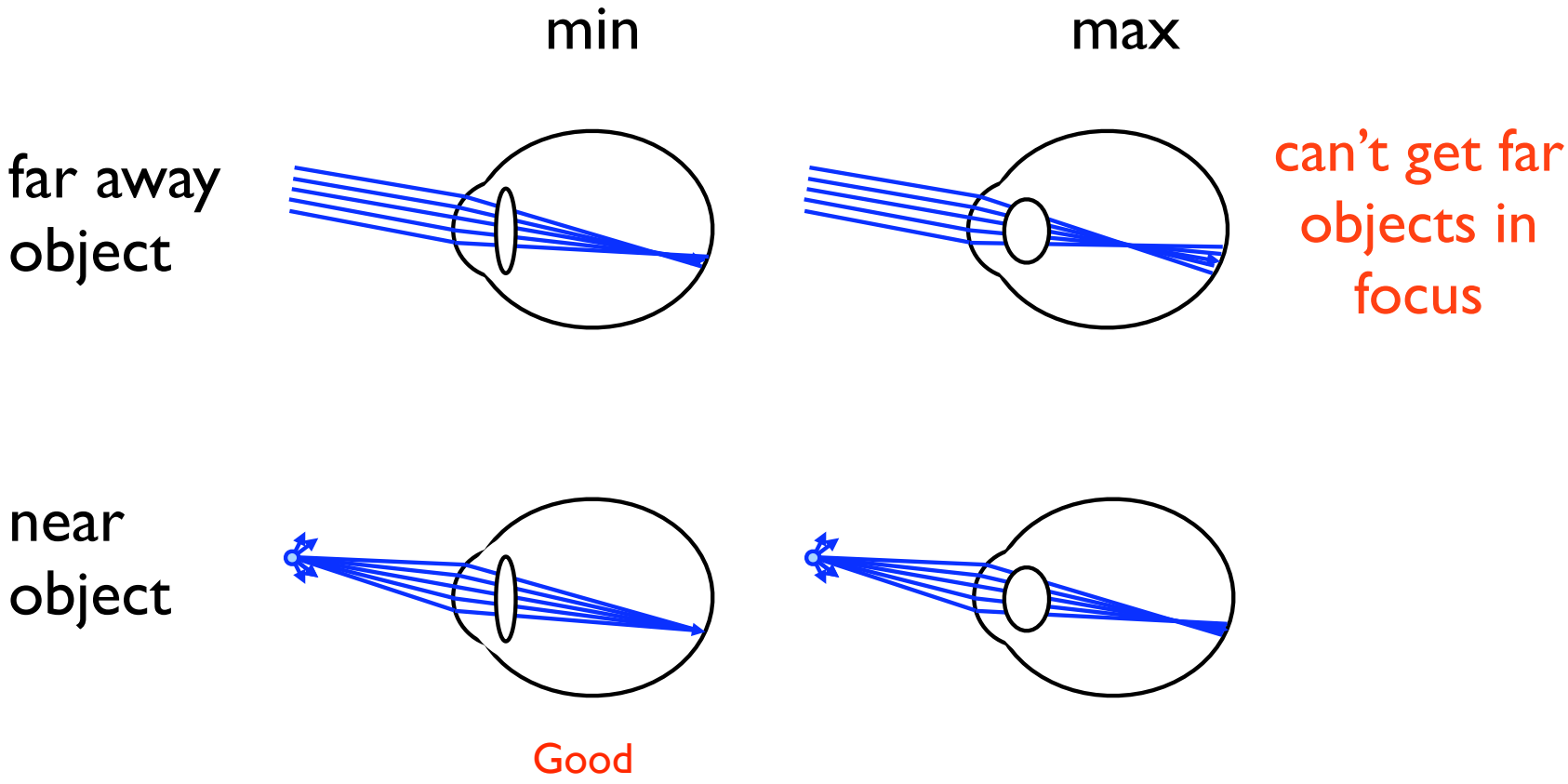
myopic (near-sighted) eye

- lens too powerful



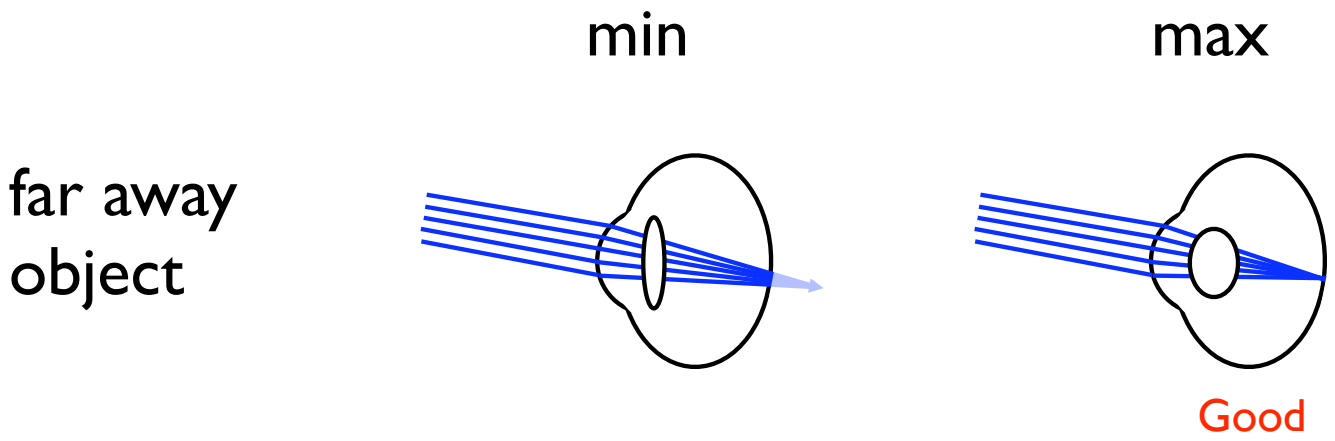
myopic (near-sighted) eye

- lens too powerful



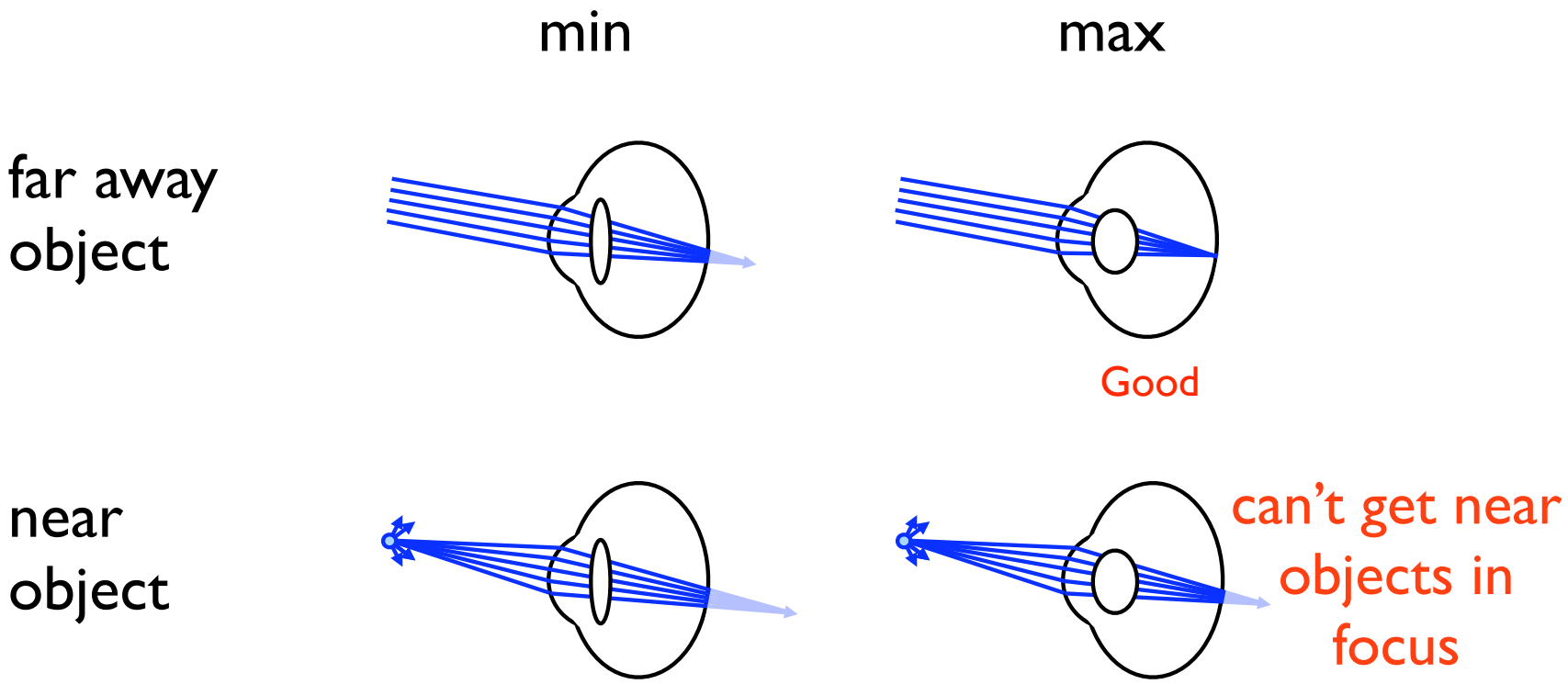
hyperopic (farsighted) eye

- lens not powerful enough

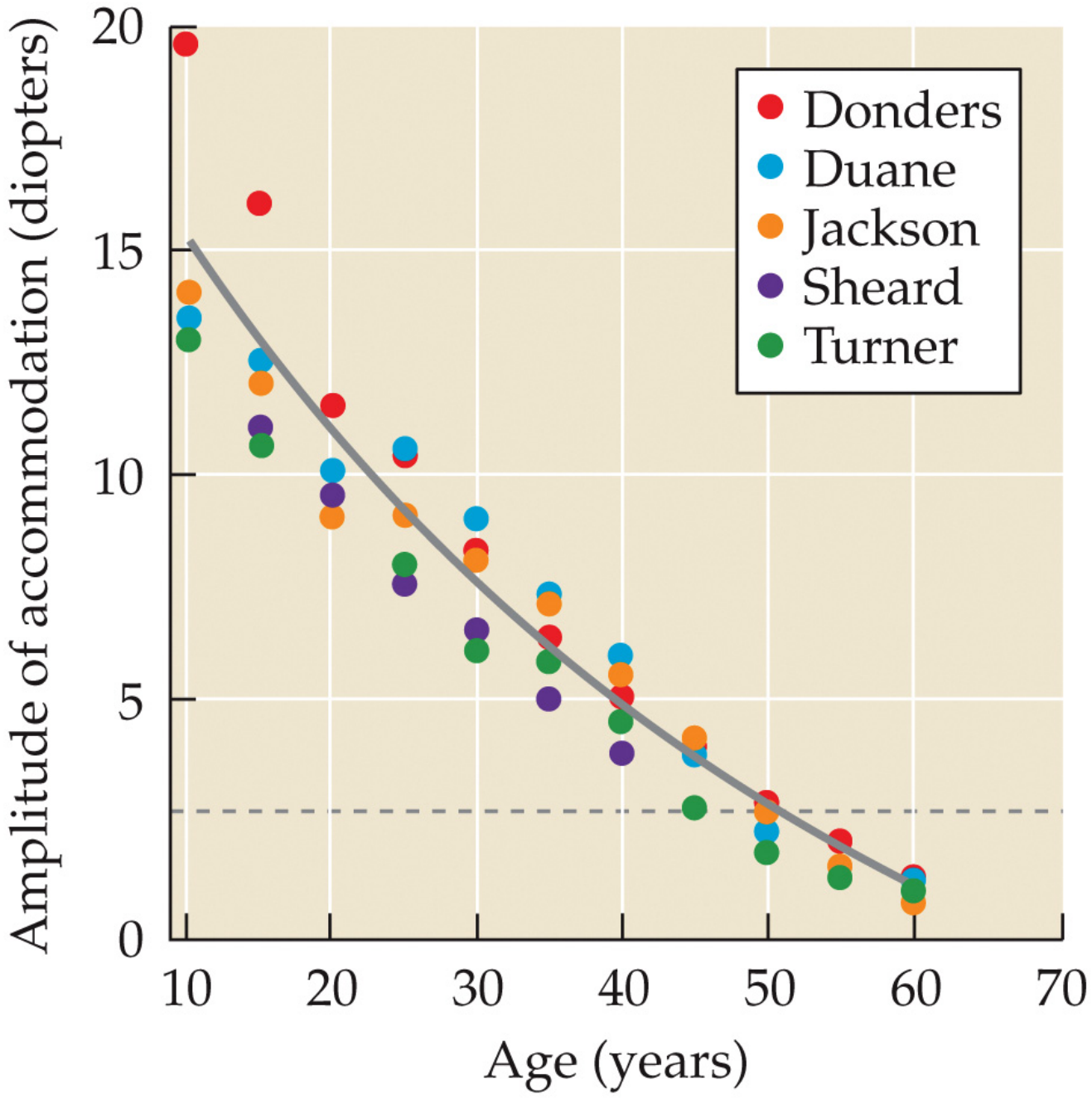


hyperopic (farsighted) eye

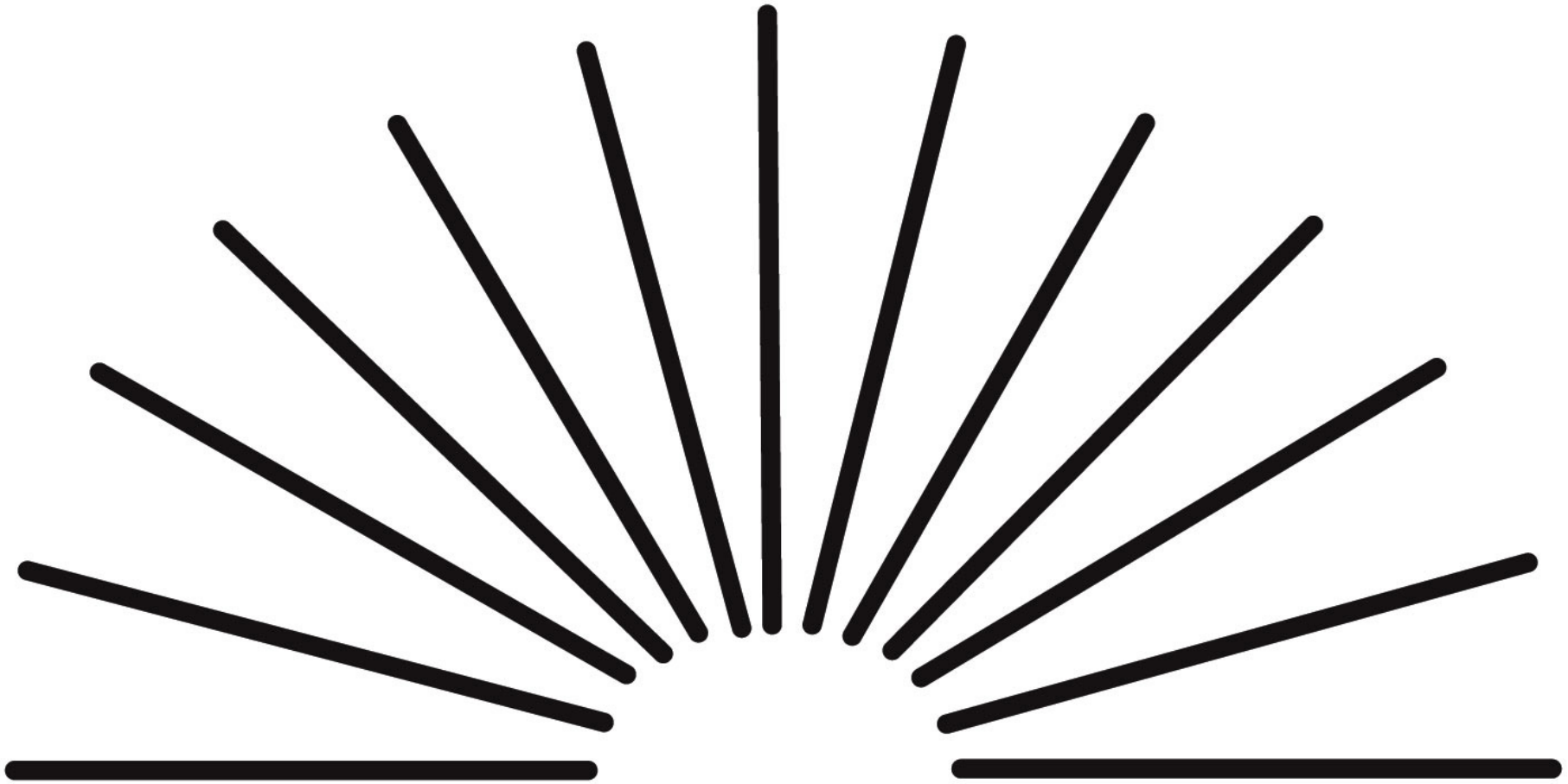
- lens not powerful enough



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 be blurrier

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

(A)

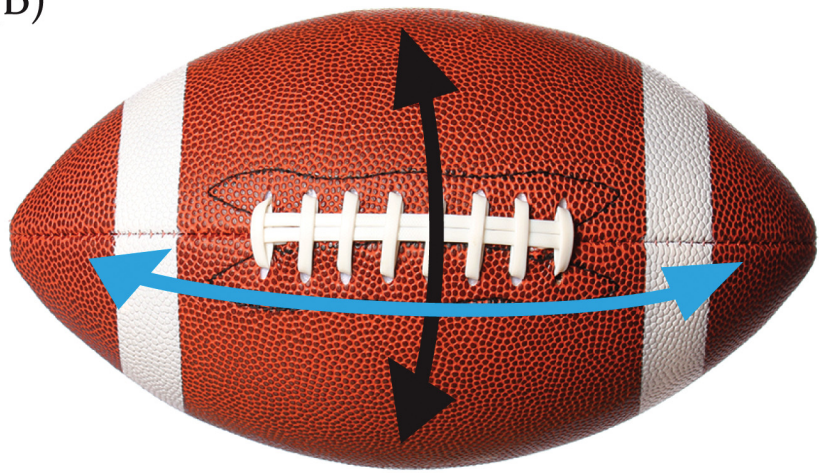
© karn684/Shutterstock.com.

SENSATION & PERCEPTION 5e, Figure 2.6 (Part 1)
© 2018 Oxford University Press

spherical
shape

("no astigmatism")

(B)



© bestv/Shutterstock.com.

SENSATION & PERCEPTION 5e, Figure 2.6 (Part 2)
© 2018 Oxford University Press

shape w/ more curvature
along vertical
than horizontal

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, cilliary muscle, lens, vitreous, fovea, retina, and who could forget the Zonules of Zinn!)
- accommodation, emmetropia, refractive errors (hyperopia, myopia, astigmatism)