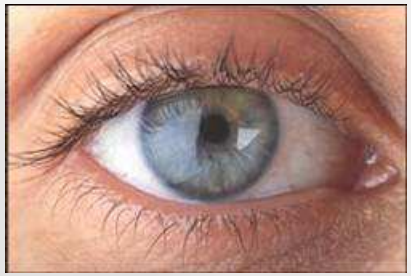
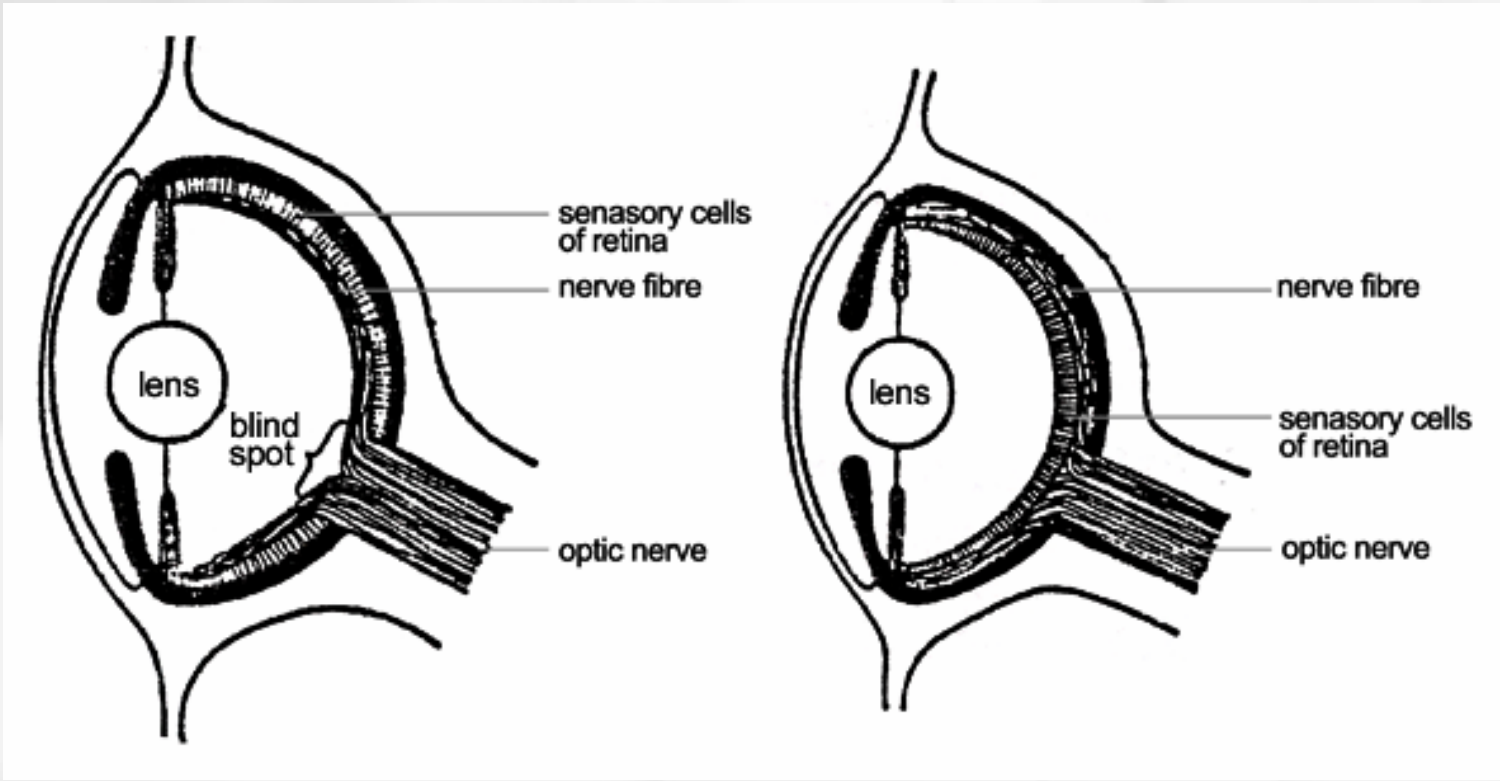
Octopus, squid and terrestrial gastropods (slugs and snails) have photoreceptors in the ‘correct’ side of the retina. They have no blind spot!



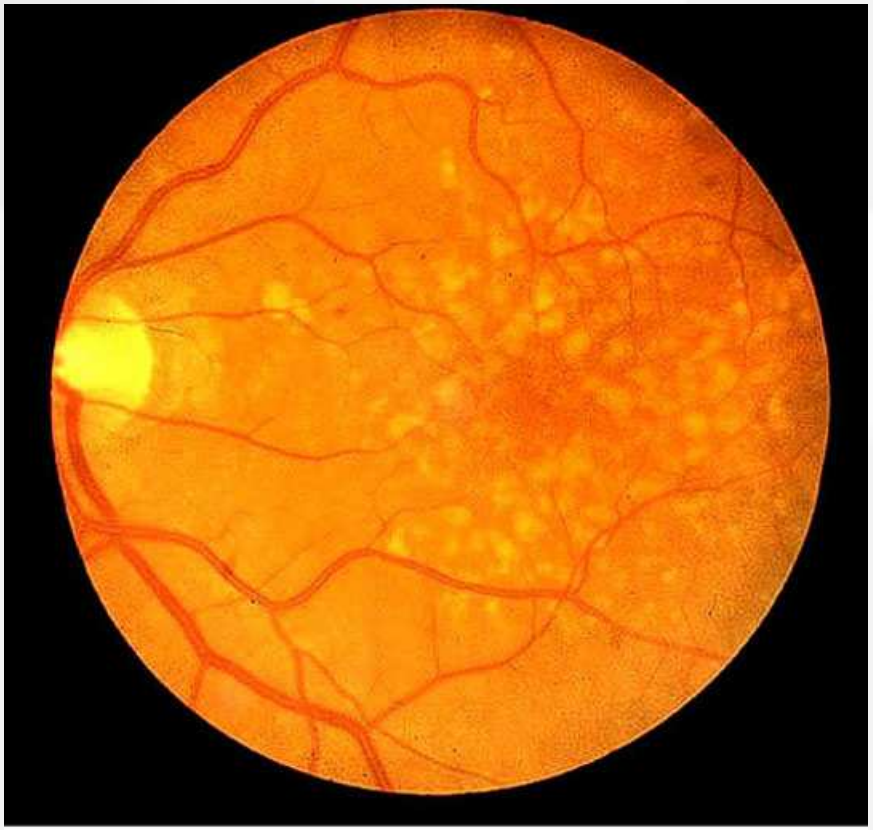


Human eye

Octopus eye

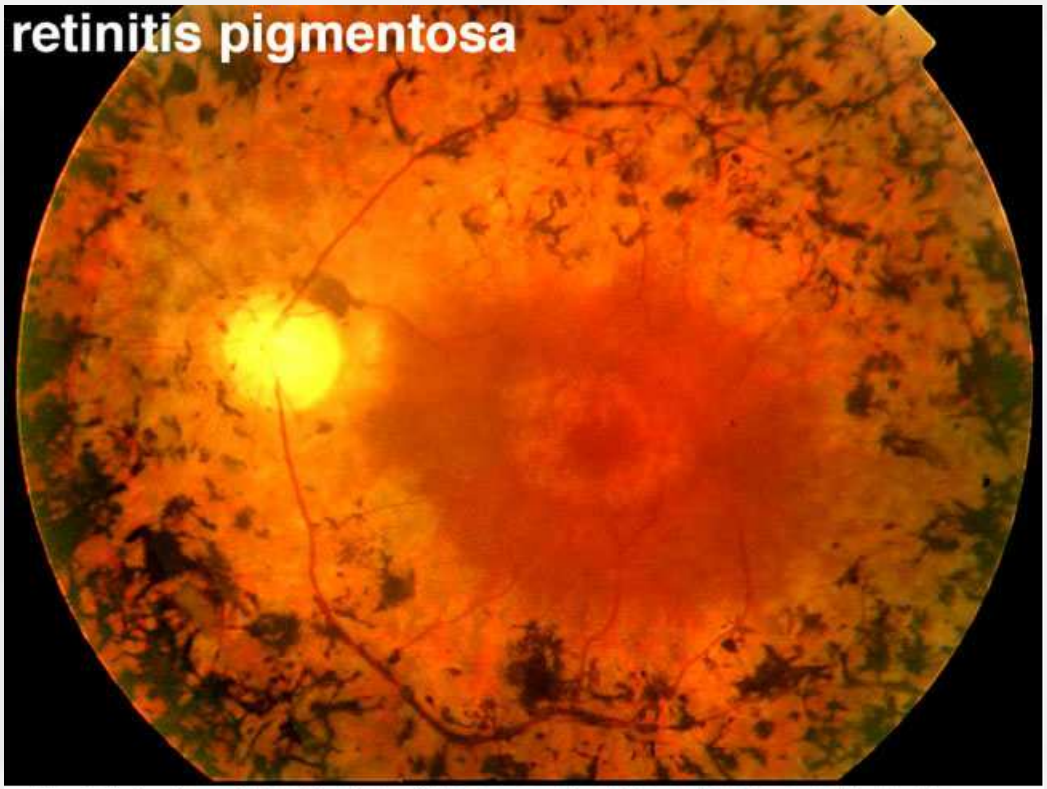
Diseases that Affect the Retina

- **Macular degeneration**
  - Fovea and small surrounding area are destroyed
  - Creates a “blind spot” on retina
  - Most common in older individuals



Fundas photograph of a patient with age related macular degeneration.

Diseases that Affect the Retina



A view of the fundus of the eye and of the retina in a patient who has retinitis pigmentosa.

- Genetic disease
- Rods are destroyed first
- Foveal cones can also be attacked
- Severe cases result in complete blindness

Diseases that Affect the Retina

- **Glaucoma**
  - Caused by elevated pressure in the eye
  - The pressure rises because the anterior chamber of the eye cannot exchange fluid properly
  - Cuts off blood vessels at the optic nerve head, starving the ganglion cells.

A view of the fundus of the eye and of the retina in a patient who has advanced glaucoma.

(a)

(b)

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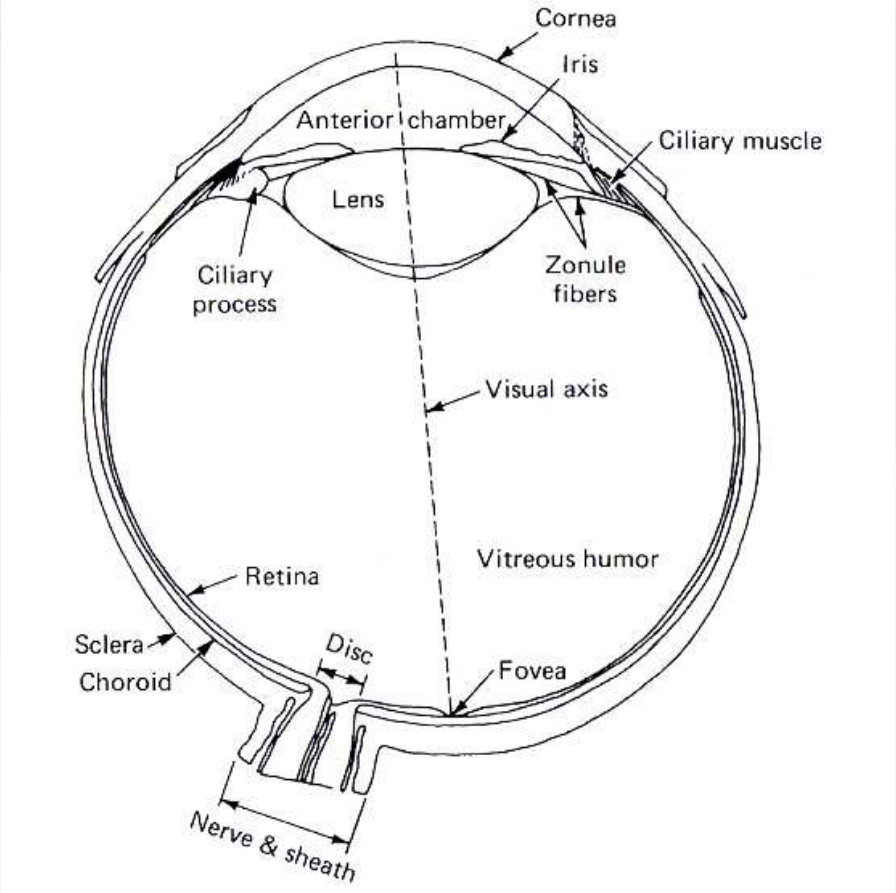
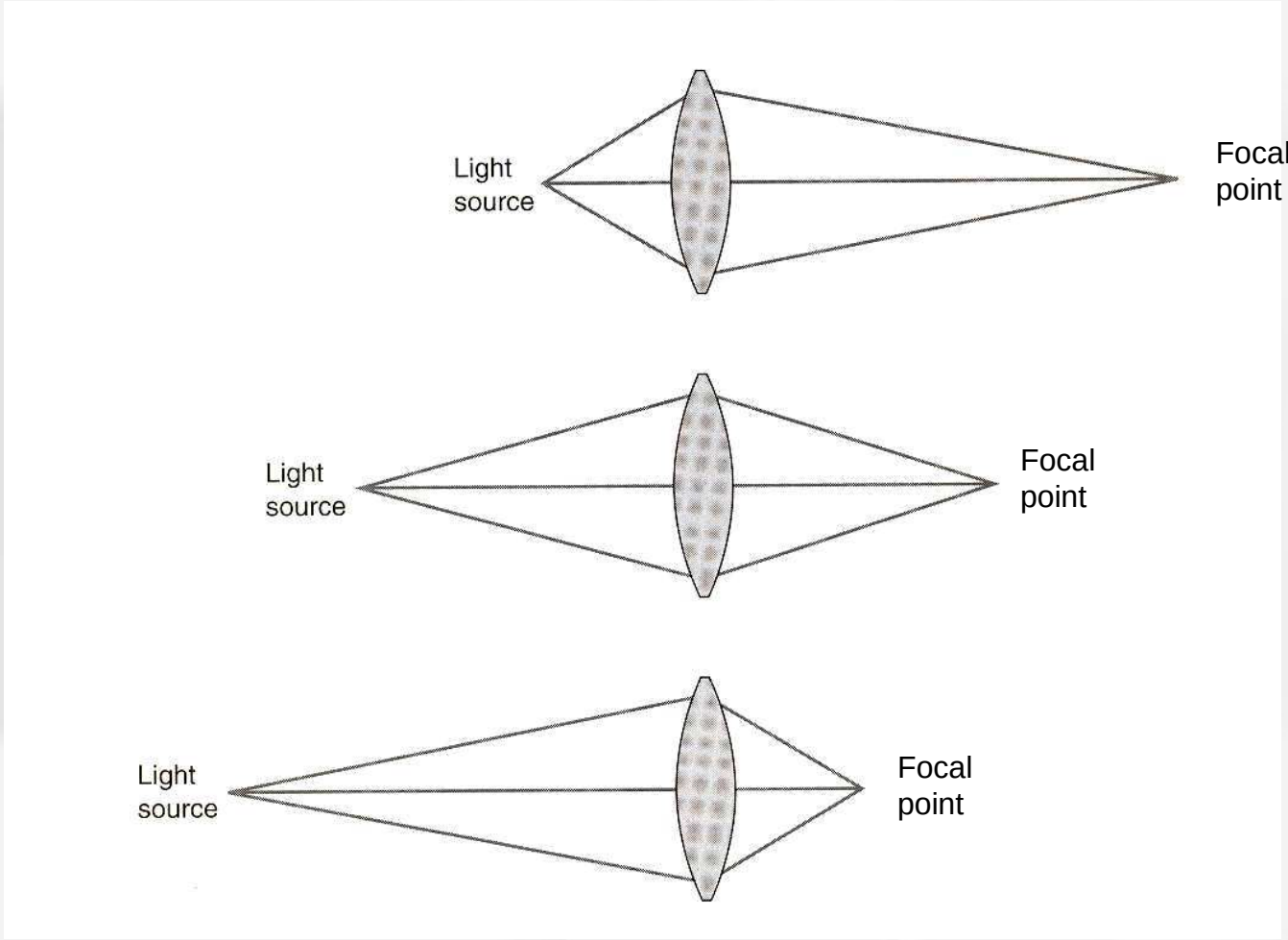
Figure 2.18 (a) With **macular degeneration**, the fovea and surrounding area degenerates so the person cannot see whatever he or she is looking at. (b) In **retinitis pigmentosa**, the peripheral retina initially degenerates and causes loss of vision in the periphery. The resulting condition is sometimes called “tunnel vision.”

Focusing Images on the Retina

- The cornea, which is fixed, accounts for about 80% of focusing
- The lens, which adjusts shape for object distance, accounts for the other 20%
  - Accommodation results when ciliary muscles are tightened which causes the lens to thicken

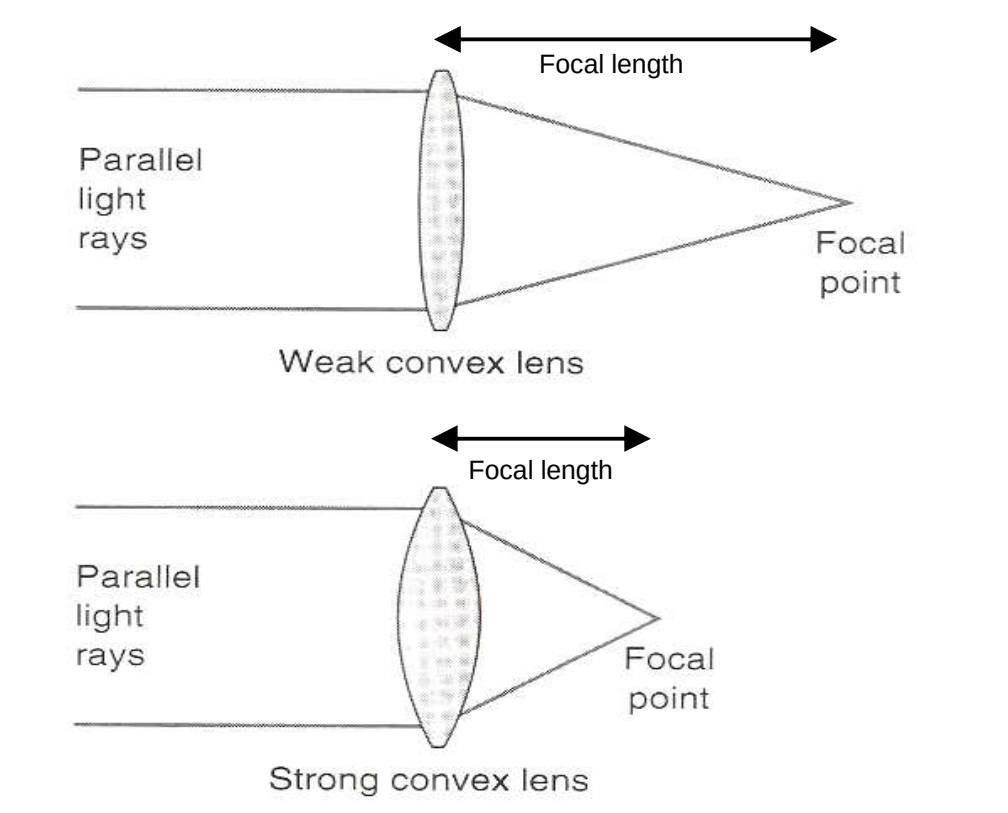


Basic Optics



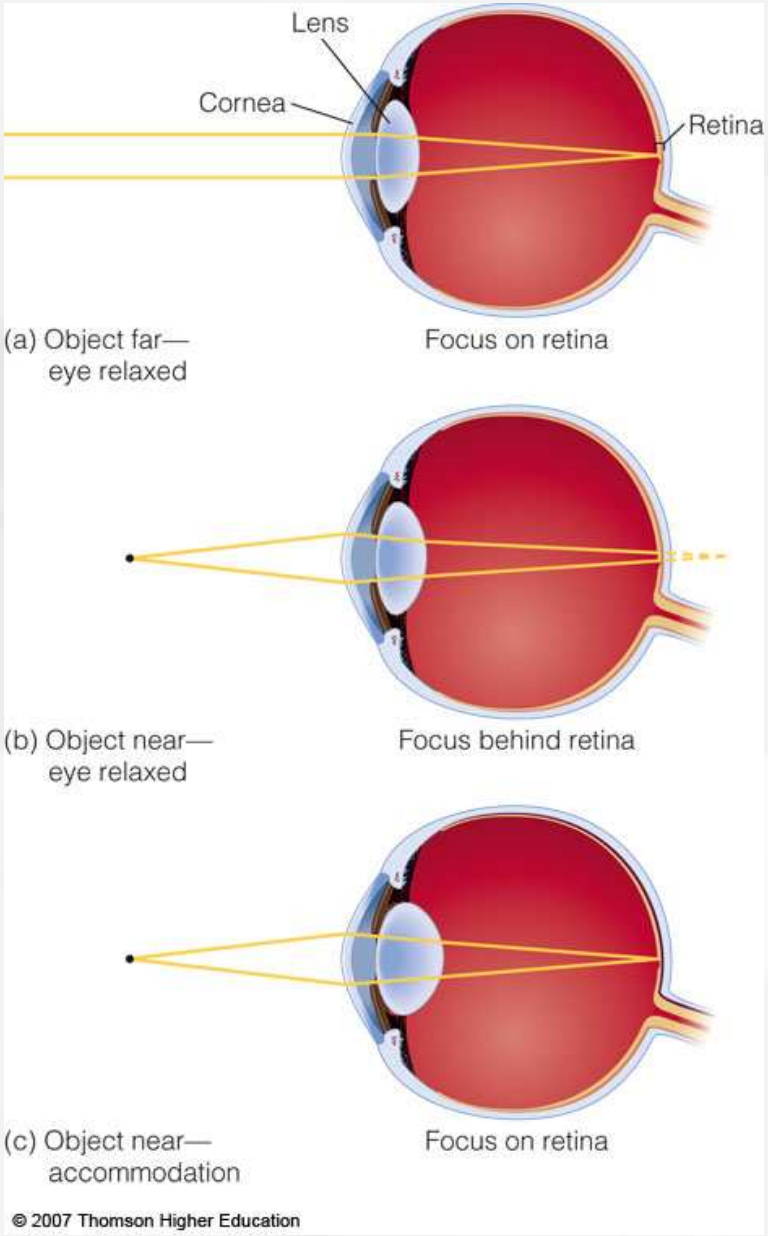
Focal point of a lens depends on the distance of the light source (or object)

Basic Optics



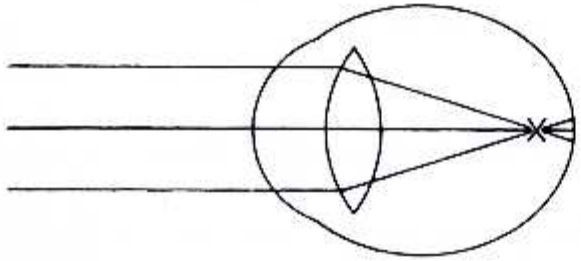
The shape of the lens affects the distance between the lens and the focal point.

A fatter, more curved lens brings the focal point closer to the lens.



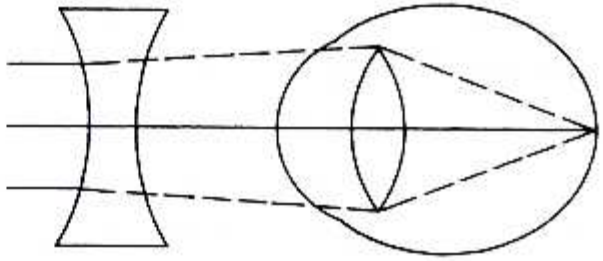
The lens of the eye changes shape to *accommodate* to different distances

Correction via convex and concave lenses



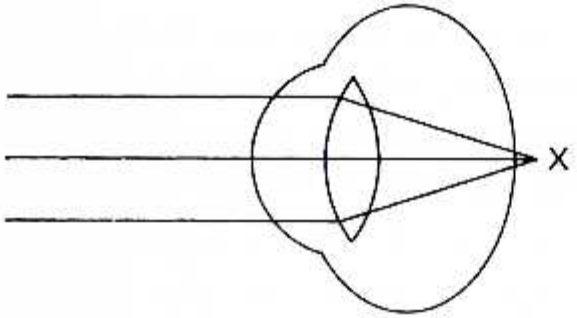
Rays focus (X) in front of retina

Nearsightedness
(a)



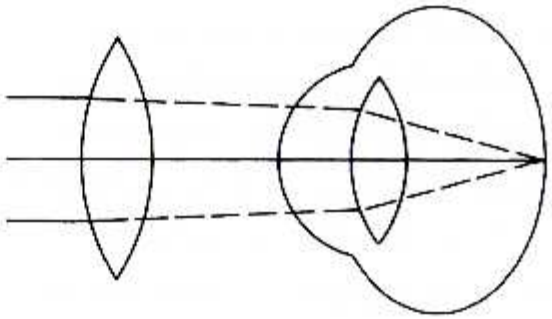
Concave lens corrects myopic error

Nearsightedness
(b)



Rays focus (X) behind retina

Farsightedness
(c)

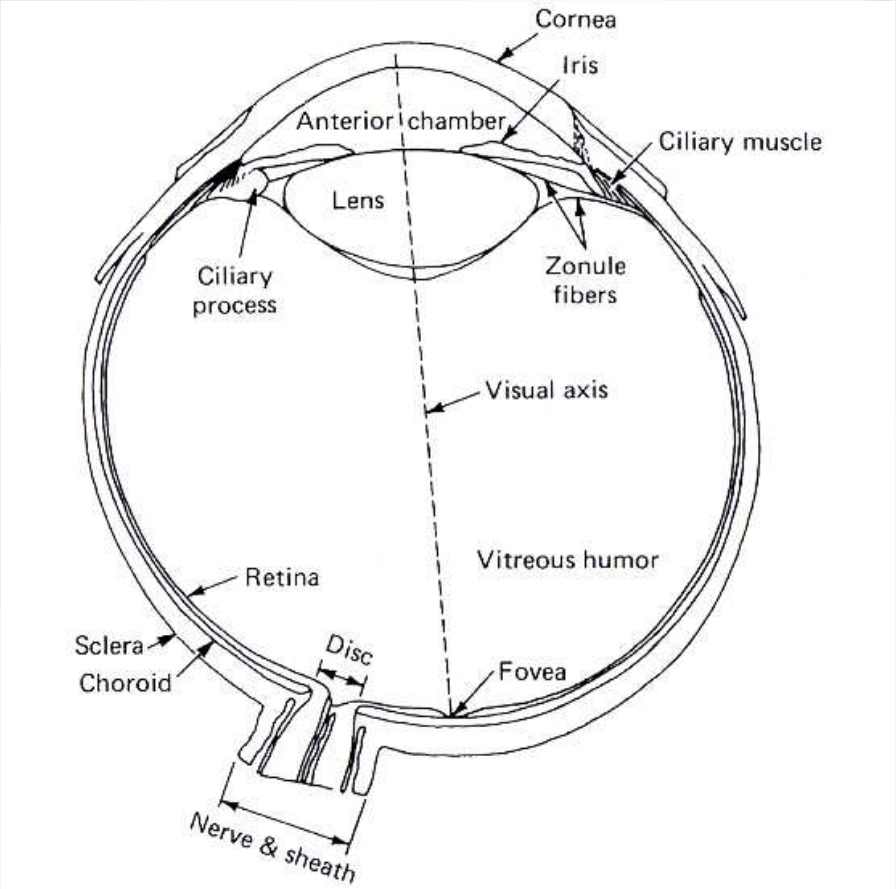


Convex lens corrects hypermetropic error

Farsightedness
(d)

Presbyopia - “old eye”

- Distance of near point increases
- Due to hardening of lens and weakening of ciliary muscles
- Corrective lenses are needed for close activities, such as reading



Presbyopia - “old eye”

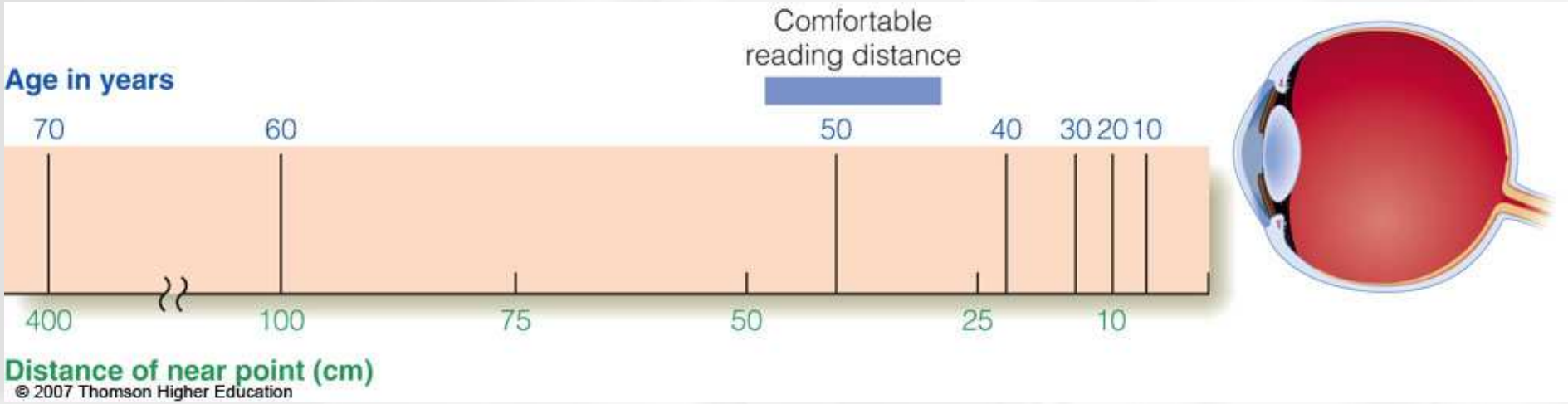
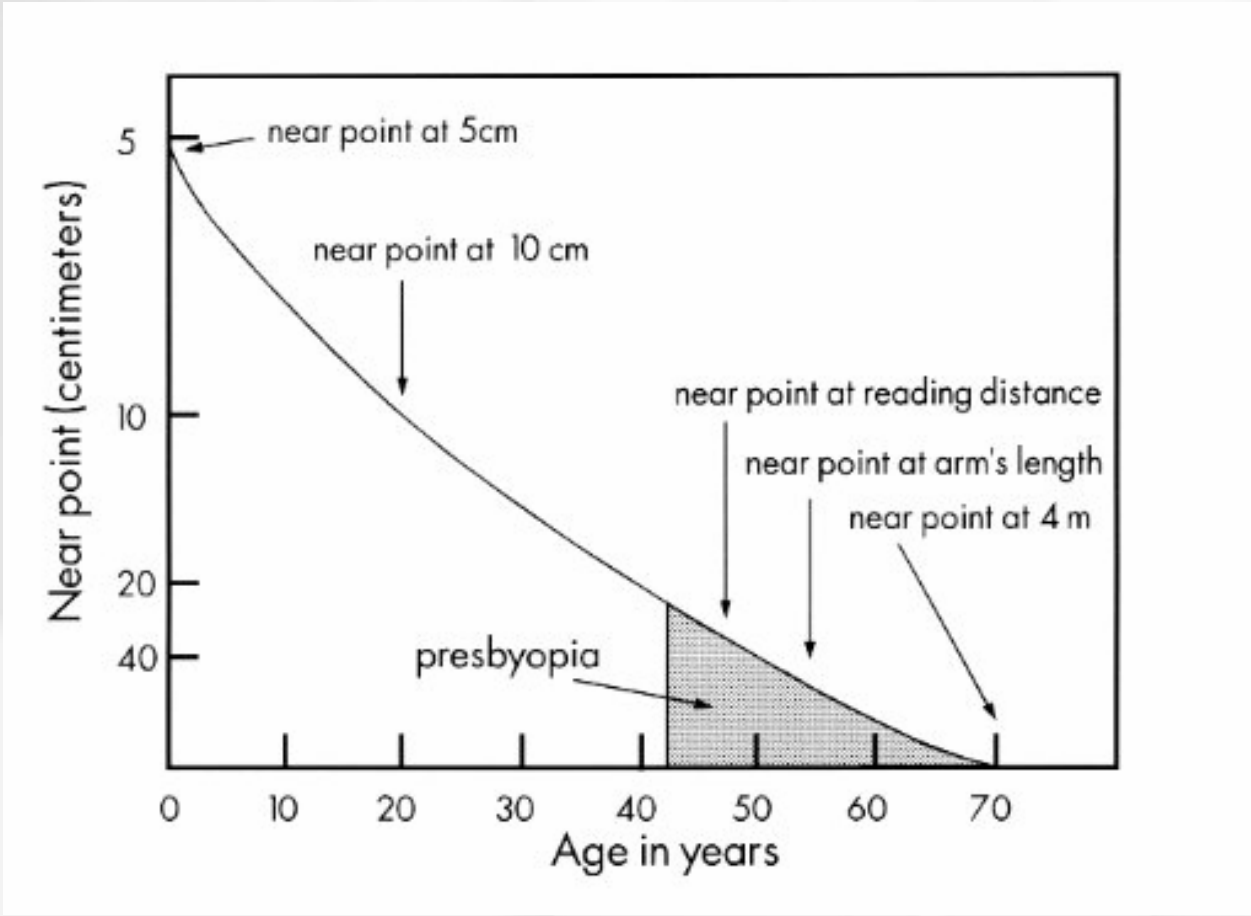


Figure 2.12 Vertical lines show how the distance of the near point increases with increasing age (green numbers). When the near point becomes further than a comfortable reading distance, corrective lenses (reading glasses) become necessary.

Presbyopia - “old eye”



Bifocals

Quiz Time!

Accommodation increases the focusing power of the lens to bring close objects into focus by making the lens

a. fatter.

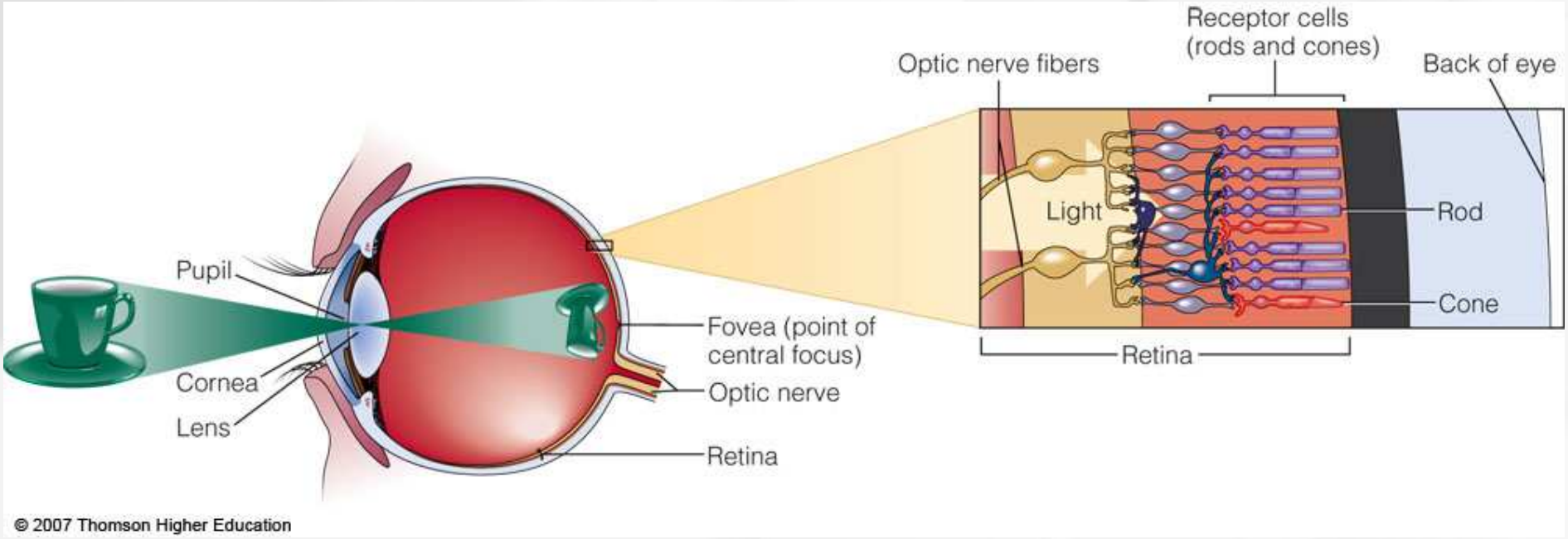
b. longer.

c. more transparent.

d. thinner.

Retinal Processing - Rods and Cones

- Differences between rods and cones
  - **Shape**
    - Rods - large and cylindrical
    - Cones - small and tapered



Retinal Processing - Rods and Cones

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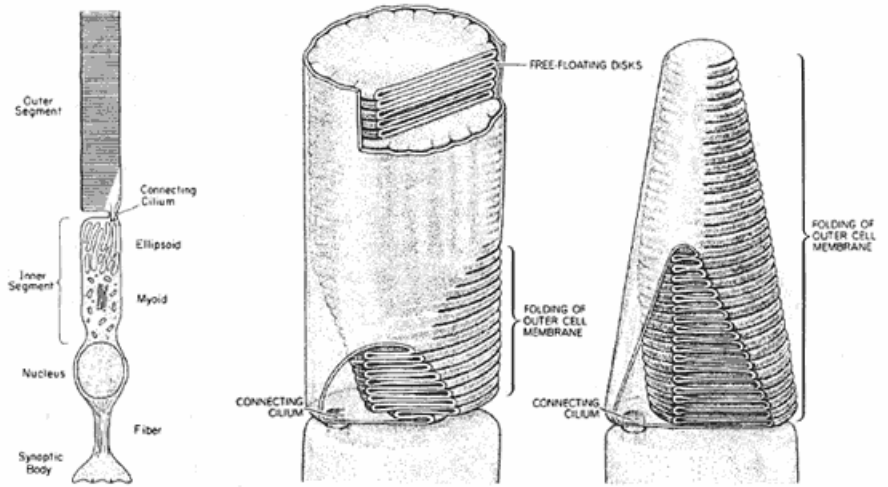
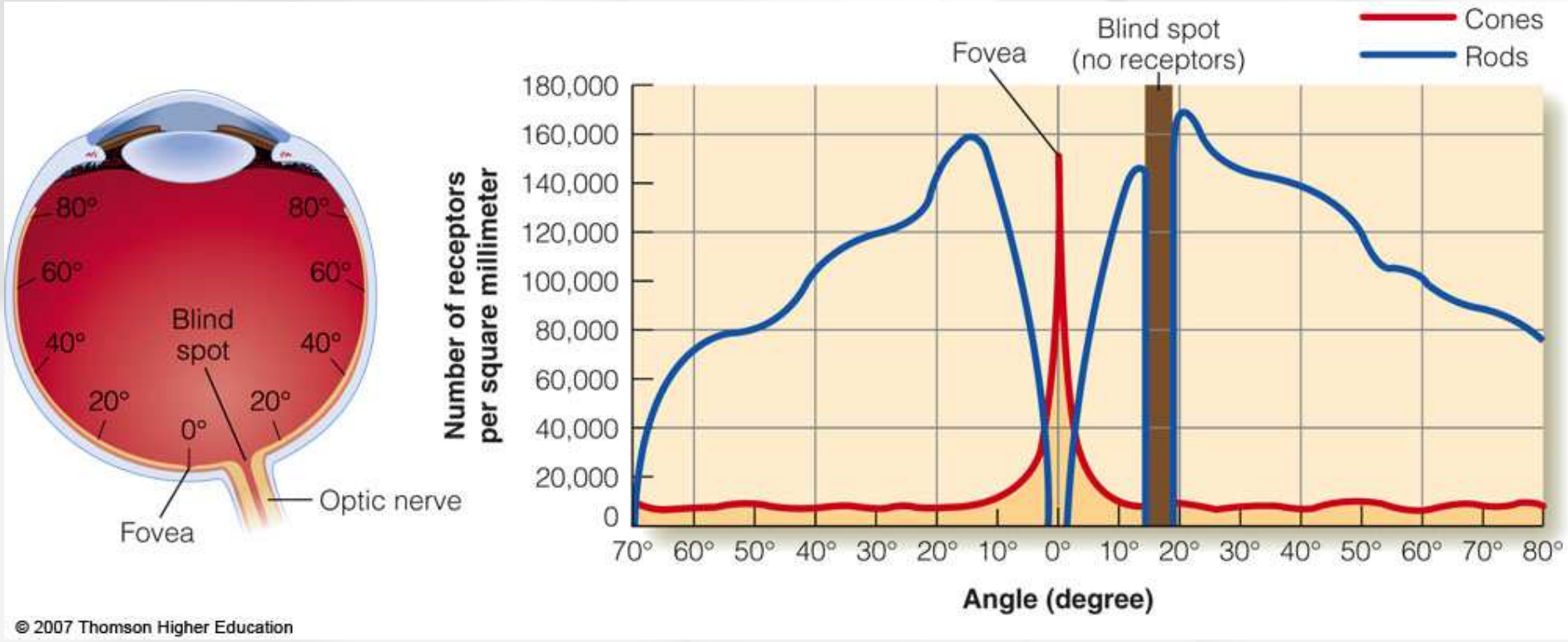


At the left is a generalized conception of the important structural features of a vertebrate photoreceptor cell. At the right are shown the differences between the structure of rod (left) and cone (right) outer segments. These diagrams are from Young (1970) and Young (1971).

Retinal Processing - Rods and Cones

- Differences between rods and cones
  - **Distribution on retina**
    - Fovea consists solely of cones
    - Peripheral retina has both rods and cones
    - More rods than cones in periphery



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Retinal Processing - Rods and Cones

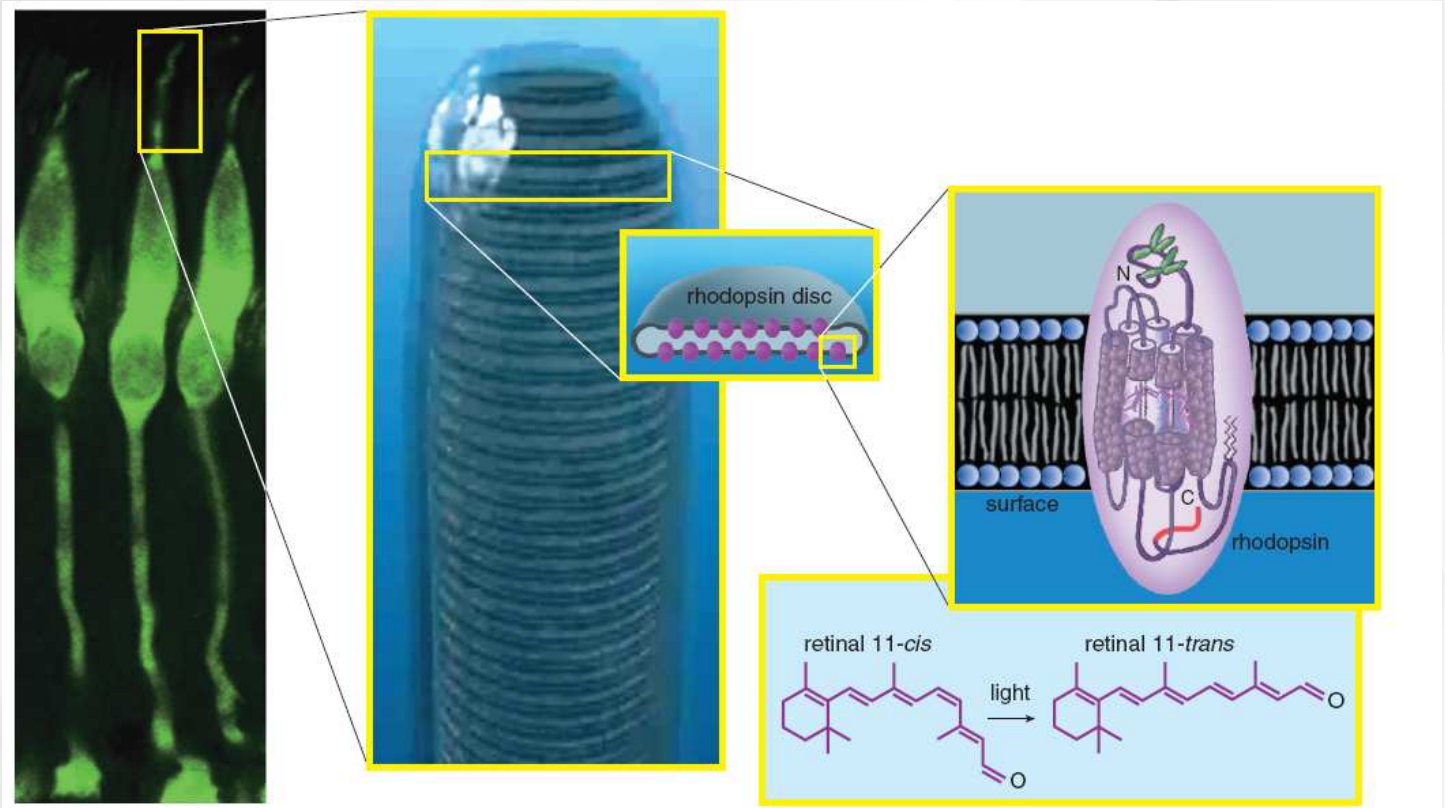
- Differences between rods and cones
  - **Function**
    - Cones: daylight vision and color (photopic light levels)
    - Rods: night vision (scototopic light levels)

Retinal Processing - Rods and Cones

- Differences between rods and cones
  - **Number**
    - 120 million rods in each eye
    - Only 5 million cones

Transduction of Light into Nerve Impulses

- Receptors have outer segments, which contain:
  - Visual pigment molecules, which have two components:
    - Opsin - a large protein
    - Retinal - a light sensitive molecule
- Visual transduction occurs when the retinal absorbs one photon
  - Retinal changes it shape, called isomerization



How sensitive is the human eye?

- Experiment by Hecht et al. (1942)
  - Determine the **absolute threshold** for detecting a light
  - Determine how many visual pigment molecules the threshold level light would affect
  - Results showed that only one photon was needed to excite one visual pigment molecule

Subjects can reliably detect a stimulus containing only 100 photons

From this, it is calculated that it takes only 1 photon to activate a rod receptor

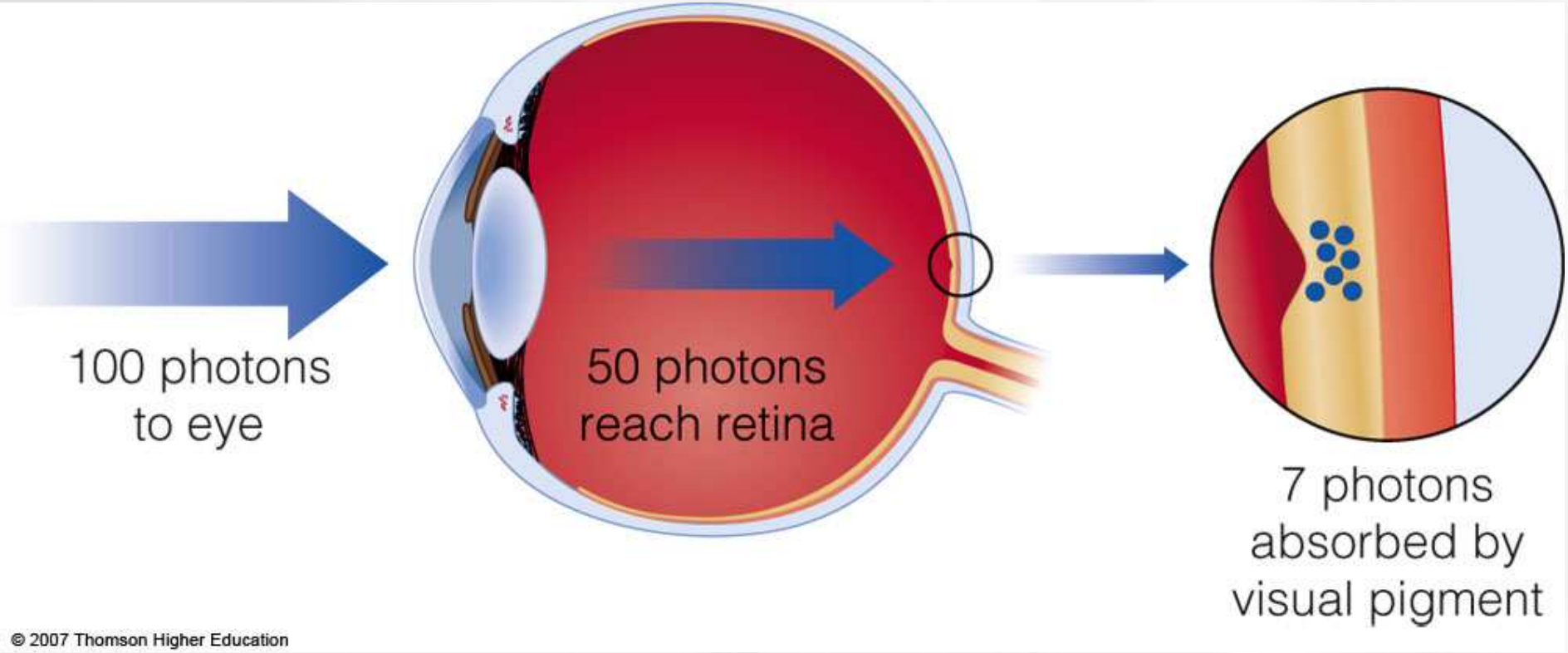


Figure 2.21 Hecht et al.’s (1942) experiment.

Light/Dark Adaptation

Adaptation allows you to adjust your sensitivity to see detail within a particular light range.

Light intensities range across 9 orders of magnitude.

A piece of white paper can be 1,000,000,000 times brighter in outdoor sunlight than in a moonless night.

But in a given lighting condition, light ranges over only about two orders of magnitude.

Dark night

Indoor lighting

Seattle day

Sunny day

If we were sensitive to this whole range all the time, there wouldn't be able to discriminate lightness levels in a typical scene.

The visual system solves this problem by restricting the ‘dynamic range’ of its response to match the current overall or ‘ambient’ light level.