Section C: Photoreceptors And Vision

1. A diversity of photoreceptors has evolved among invertebrates
2. Vertebrates have single-lens eyes
3. The light-absorbing pigment rhodopsin triggers a signal-transduction pathway
4. The retina assists the cerebral cortex in processing visual information
• Most, if not all, animal photoreceptors may be homologous.
1. A diversity of photoreceptors has evolved among invertebrates

- **Eye cups** are among the simplest photoreceptors
  - Detect light intensity and direction — no image formation.
  - The movement of a planarian is integrated with photoreception.
• Image-forming eyes.

• **Compound eyes** of insects and crustaceans.
  
  • Each eye consists of **ommatidia**, each with its own light-focusing lens.
  
  • This type of eye is very good at detecting movement.
• **Single-lens eyes** of invertebrates such as jellies, polychaetes, spiders, and mollusks.
  
  • The eye of an octopus works much like a camera and is similar to the vertebrate eye.
2. Vertebrates have single-lens eyes

- Is structurally analogous to the invertebrate single-lens eye.
• **Sclera**: a tough white layer of connective tissue that covers all of the eyeball except the cornea.

• **Conjunctiva**: external cover of the sclera — keeps the eye moist.
• **Cornea**: transparent covering of the front of the eye.
  
  • Allows for the passage of light into the eye and functions as a fixed lens.
- **Choroid**: thin, pigmented layer lining the interior surface of the sclera.
  - Prevents light rays from scattering and distorting the image.
  - Anteriorly it forms the **iris**.
    - The iris regulates the size of the **pupil**.
• **Retina**: lines the interior surface of the choroid.
  • Contains photoreceptors.
    • Except at the **optic disk** (where the optic nerve attaches).
• The lens and ciliary body divide the eye into two cavities.

• The anterior cavity is filled with aqueous humor produced by the ciliary body.
  • Glaucoma results when the duct that drain aqueous humor are blocked.

• The posterior cavity is filled with vitreous humor.

• The lens, the aqueous humor, and the vitreous humor all play a role in focusing light onto the retina.
• **Accommodation** is the focusing of light in the retina.

• In squid, octopuses, and many fish this is accomplished by moving the lens forward and backward.
• In mammals accommodation is accomplished by changing the shape of the lens.

• The lens is flattened for focusing on distant objects.

• The lens is rounded for focusing on near objects.

Fig. 49.10
• Photoreceptors of the retina.
  • About 125 million **rod cells**.
    • Rod cells are light sensitive but do not distinguish colors.
  • About 6 million **cone cells**.
    • Not as light sensitive as rods but provide color vision.
    • Most highly concentrated on the **fovea** – an area of the retina that lacks rods.
3. The light-absorbing pigment rhodopsin triggers a signal-transduction pathway

- **Rhodopsin (retinal + opsin)** is the visual pigment of rods.
- The absorption of light by rhodopsin initiates a signal-transduction pathway.

![Diagram](Fig. 49.13)
• Color reception is more complex than the rhodopsin mechanism.

• There are three subclasses of cone cells each with its own type of photopsin.

• Color perception is based on the brain’s analysis of the relative responses of each type of cone.

• In humans, colorblindness is due to a deficiency, or absence, of one or more photopsins.

• Inherited as an X-linked trait.
4. The retina assists the cerebral cortex in processing visual information

- Visual processing begins with rods and cones synapsing with **bipolar cells**.
  - Bipolar cells synapse with **ganglion cells**.
- Visual processing in the retina also involves **horizontal cells** and **amacrine cells**.
• Vertical pathway: photoreceptors $\rightarrow$ bipolar cells $\rightarrow$ ganglion cells axons.
• Lateral pathways:
  • Photoreceptors → horizontal cells → other photoreceptors.
    • Results in lateral inhibition.
      • More distance photoreceptors and bipolar cells are inhibited → sharpens edges and enhances contrast in the image.
  • Photoreceptors → bipolar cells → amacrine cells → ganglion cells.
    • Also results in lateral inhibition, this time of the ganglion cells.
• The optic nerves of the two eyes meet at the **optic chiasm**.
  • Where the nasal half of each tract crosses to the opposite side.

• Ganglion cell axons make up the optic tract.
  • Most synapse in the **lateral geniculate nuclei** of the thalamus.
  • Neurons then convey information to the primary visual cortex of the optic lobe.