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The Visual System
Anatomy of the eye
Intraocular Fluid

Glaucoma
Figure 10.11  Diagrammatic cross section through the human fovea. The overlying cellular layers and blood vessels are displaced so that light is subjected to a minimum of scattering before photons strike the outer segments of the cones in the center of the fovea, called the foveola.
- Macular Degeneration
- age-related macular degeneration
- juvenile macular degeneration
  “Stargardt disease”
Retina

- Pigmented layer
- Photoreceptors
- Bipolar cells
- Ganglion cells
- Horizontal cell
- Amacrine cell
Photoreceptors

- Cones
- Rods
Photoreceptors

- Cones
- Rods
Photoreceptors

- Cones
- Rods

Light absorption (per cent of maximum)

Wavelength (nanometers)

0 25 50 75 100

400 500 600 700

Blue cone, Green cone, Red cone

Violet, Blue, Green, Yellow, Orange, Red

Pigment epithelial cell

Melanin granules

Discs

Folds

Mitochondrion

Golgi complex

Nucleus

Synaptic terminal

Synaptic vesicles

LIGHT DIRECTION
Light Detection

- cGMP-gated Na⁺ channels open
- Inflow of Na⁺ (dark current)
- Membrane potential of -30 mV
- Glutamate released at synaptic terminals inhibits bipolar cell

(a) In darkness
Light Detection

Diagram: The light detection process involves the conversion of retinal to opsin and vice versa. The cyclic process is as follows:

1. Isomerization of retinal to trans-retinal.
2. Trans-retinal separates from opsin (bleaching).
3. Retinal isomerase converts trans-retinal to cis-retinal.
4. Cis-retinal binds to opsin (regeneration).

The diagram illustrates the interactions between retinal, opsin, and Rhodopsin molecules in the outer segment of the rod.
Light Detection

Light energy

Rhodopsin

Bathorhodopsin (nsec)

Lumirhodopsin (μsec)

Metarhodopsin I (msec)

Metarhodopsin II (sec)

Scotopsin

11-cis retinal

11-cis retinol

Isomerase

Isomerase

all-trans retinal

all-trans retinol (Vitamin A)

Rod disc in outer segment

Rhodopsin molecule

cis-retinal

opsin

Cis-retinal binds to ops in (regeneration)

Disc membrane

Colored photopigment (rhodopsin)

trans-retinal

opsin

Trans-retinal separates from ops in (bleaching)

Retinal isomerase converts trans- to cis-retinal

Colorless products

Isomerization of retinal
Light Detection

(a) In darkness

1. Isomerization of retinal

2. Light

3. Retinal isomerase converts trans-retinal to cis-retinal

4. Cis-retinal binds to opsin (regeneration)

5. Rod disc in outer segment

6. Rhodopsin molecule

7. Trans-retinal separates from opsin (bleaching)

Colorless products

Inflow of Na⁺ (dark current)

Membrane potential of −30 mV

Glutamate released at synaptic terminals inhibits bipolar cell
Light Detection

(a) In darkness

- cGMP-gated Na⁺ channels open
- Inflow of Na⁺ (dark current)
- Membrane potential of −30 mV
- Glutamate released at synaptic terminals inhibits bipolar cell

(b) In light

- Isomerization of retinal activates enzyme that breaks down cGMP
- cGMP-gated Na⁺ channels close
- Inflow of Na⁺ slows
- Hyperpolarizing receptor potential
- Glutamate release turned off, which excites bipolar cell

Rod disc in outer segment

- Rhodopsin molecule

- Cis-retinal
- Disc membrane
- Cis-retinal
- Opsin
- Colorless products

1. Isomerization of retinal

2. Opsin

3. Cis-retinal

4. Opsin

5. Retinal isomerase converts trans-to cis-retinal

6. Cis-retinal

7. Trans-retinal separates from opsins (bleaching)
Photoreceptors

- Cones
- Rods

Photopsin: blue, green and red sensitive pigments
Light Adaptation

- Pupillary size
Pupillary Light Reflex
Olivary pretectal nucleus

Edinger-Westphal nucleus
Edinger-Westphal nucleus
Light Adaptation

- Pupillary size
- Neural adaptation
- Photoreceptor adaptation
Light Adaptation

- Pupillary size
- Neural adaptation
- Photoreceptor adaptation
Night blindness
Retinitis pigmentosa
Comparing tunnel vision with normal vision

The patient with tunnel vision experiences drastic constriction of his peripheral visual field. The illustrations here convey the extent of this constriction, comparing test findings for normal and tunnel vision.

Normal field of vision in the right eye, as shown on a perimetry chart

Tunnel vision in the right eye, as shown on a perimetry chart

Normal field of vision in the right eye, as seen in advanced glaucoma during perimeter examination

Tunnel vision in the right eye, as seen in advanced glaucoma during perimeter examination
VISUAL PATHWAY
Visual pathway:

- Optic (II) nerve
- Optic chiasm
- Optic tract
- Lateral geniculate nucleus of thalamus
- Optic radiations
- Primary visual area of cerebral cortex (area 17) in occipital lobe
Visual field of left eye
Temporal half
Nasal half

Visual field of right eye
Temporal half
Nasal half

Optic (II) nerves

Midbrain
Optic tract
Optic radiations

(d) Right eye and its pathways
Hemi-anopia
Quadrant - anopia
Field of Vision

Visual Field Defects

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Brain viewed from above
Clinical correlation of Meyer’s loop in the coronal plane.
Clinical correlation of Meyer’s loop in the axial plane.