9.01 Introduction to Neuroscience
Fall 2007

The optic nerve carries the output of the eye

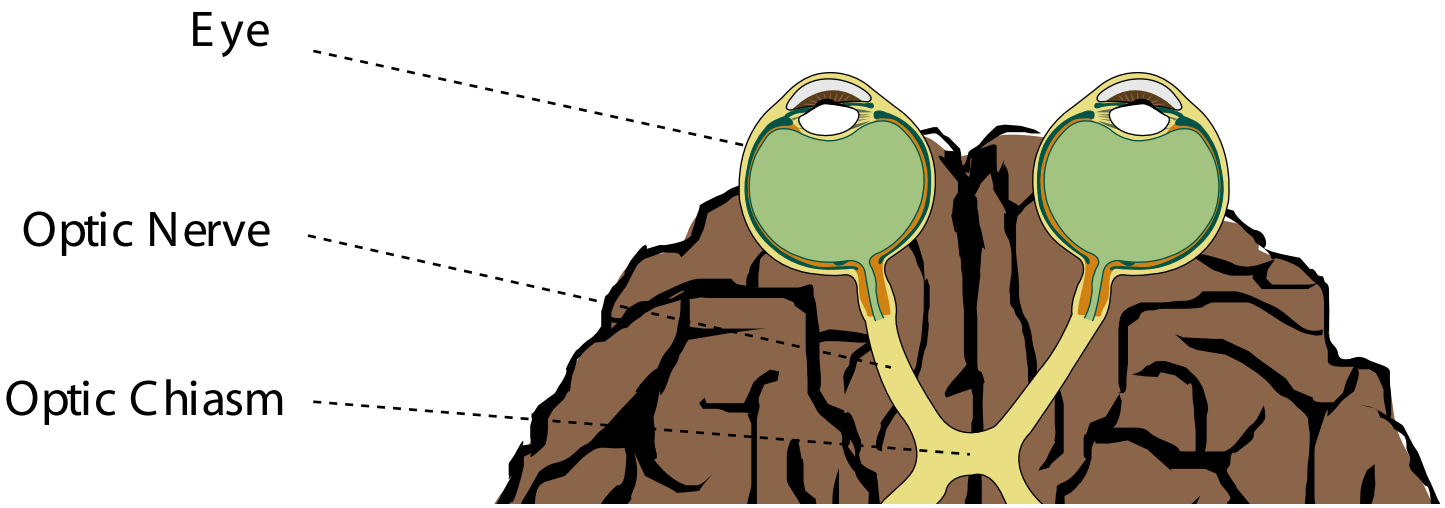

Figure by MIT OpenCourseWare. After figure 10.2 in: Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain.* 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2001. ISBN: 9780683305968.

Finding the “receptive field”

- Record the action potentials of an axon in the optic nerve
- Present visual stimuli at various locations
- Find the location at which a stimulus can cause changes in the firing rate.

ON-center cell

- There is a background firing rate.
- The rate increases when the stimulus is in the receptive field (drawn circle).

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The cornea is more refractive than the lens of the eye

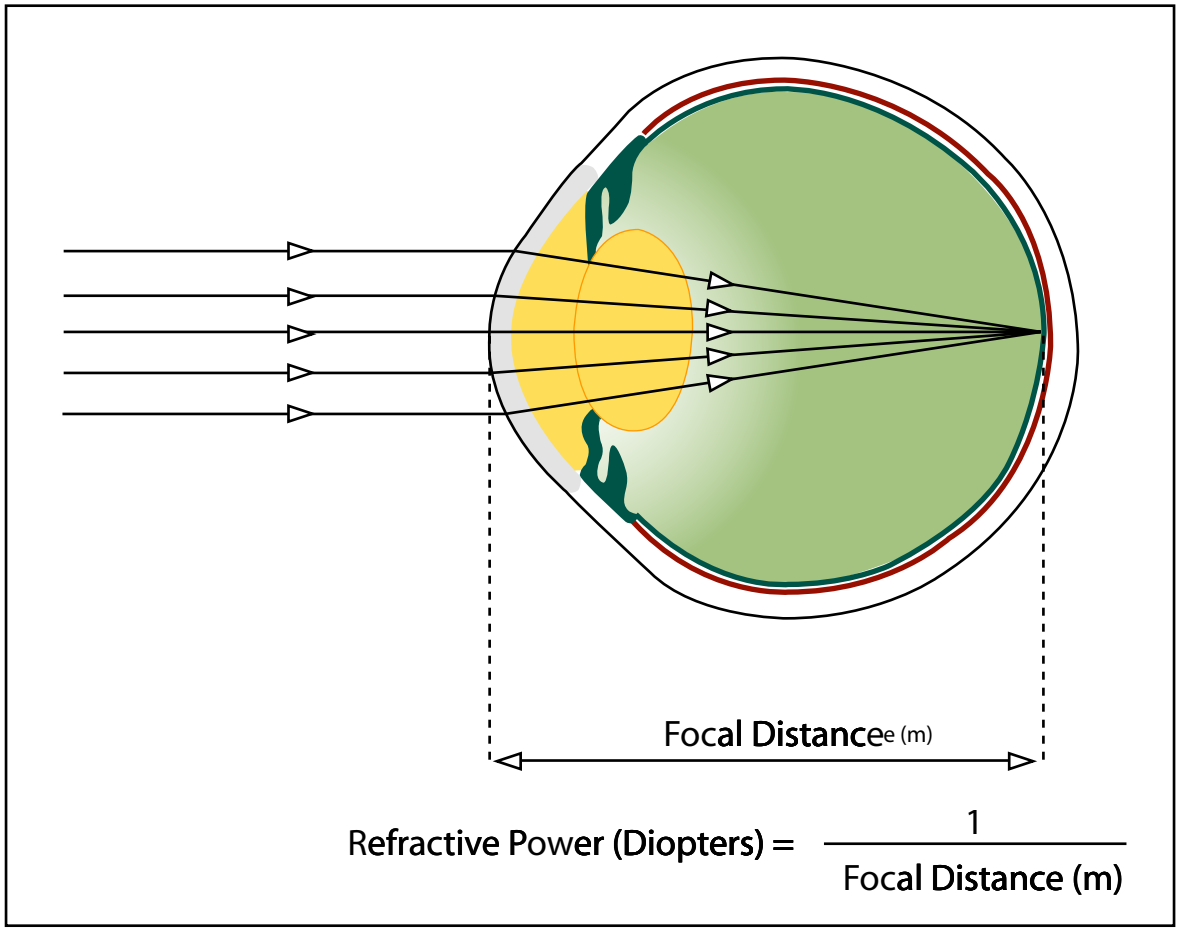

Figure by MIT OpenCourseWare. After figure 9.7 in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain.* 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2001. ISBN: 9780683305968.

Five classes of cells

- Vertical elements
  - photoreceptors
  - bipolar cells
  - ganglion cells
- Horizontal elements
  - horizontal cells
  - amacrine cells

The retina has layers

Image removed due to copyright restrictions.
Cross section electron microscope image of the human retina.
Figure 1 (Plate 32) in Boycott B. B. and J. E. Dowling. "Organization of the Primate Retina: Light Microscopy." *Phil Trans R Soc B* 255, no. 799 (March 27, 1969): 109-184. doi: 10.1098/rstb.1969.0004.

Retinal circuitry

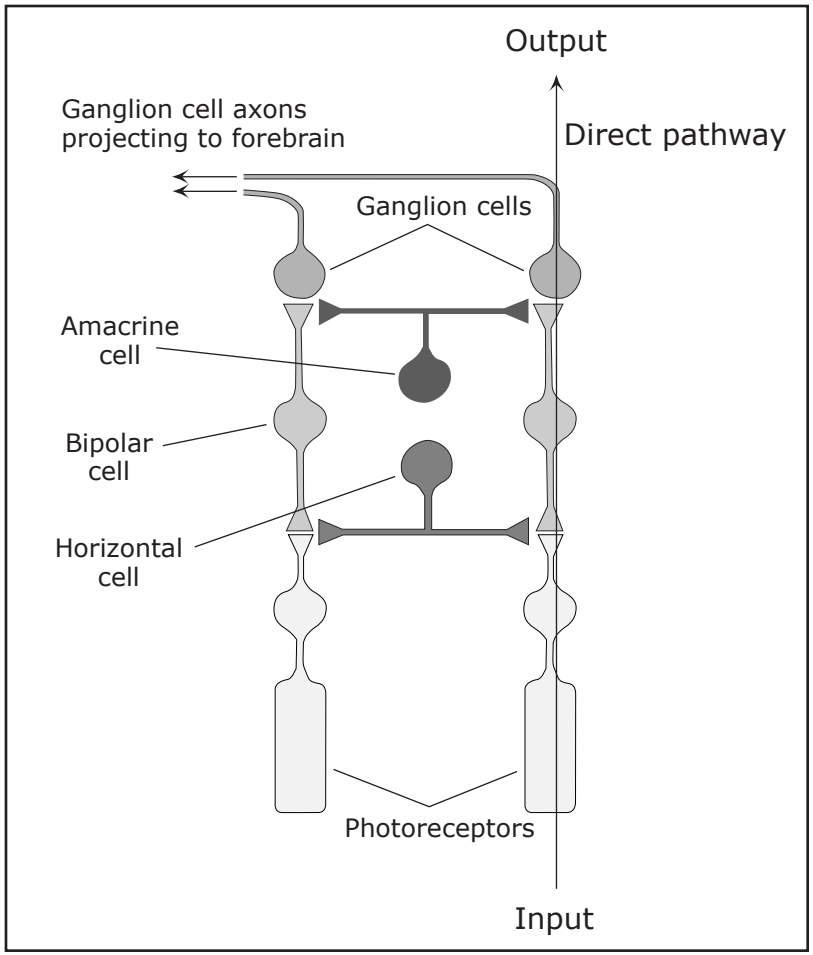

Figure by MIT OpenCourseWare. After figure 9.11 in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain.* 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2001. ISBN: 9780683305968.

Opthalmoscopic view

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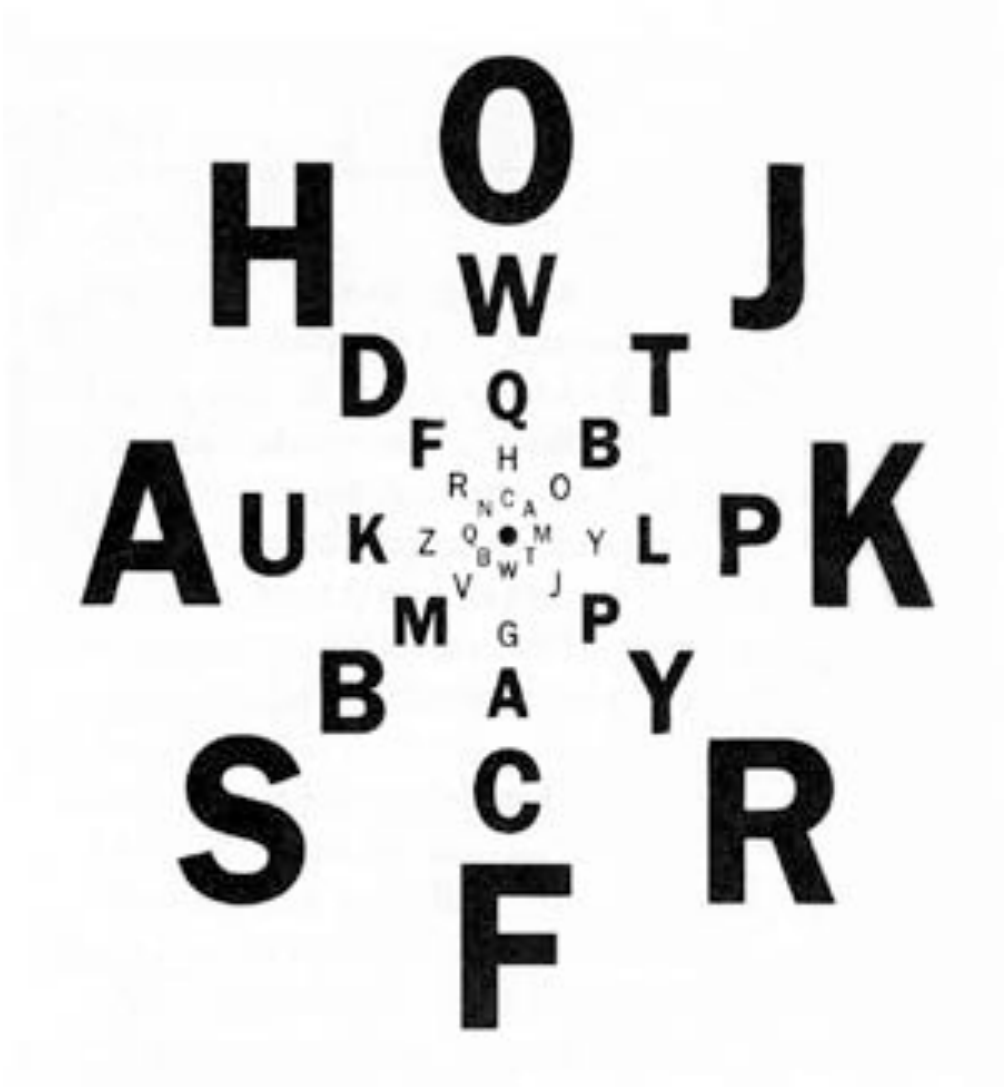
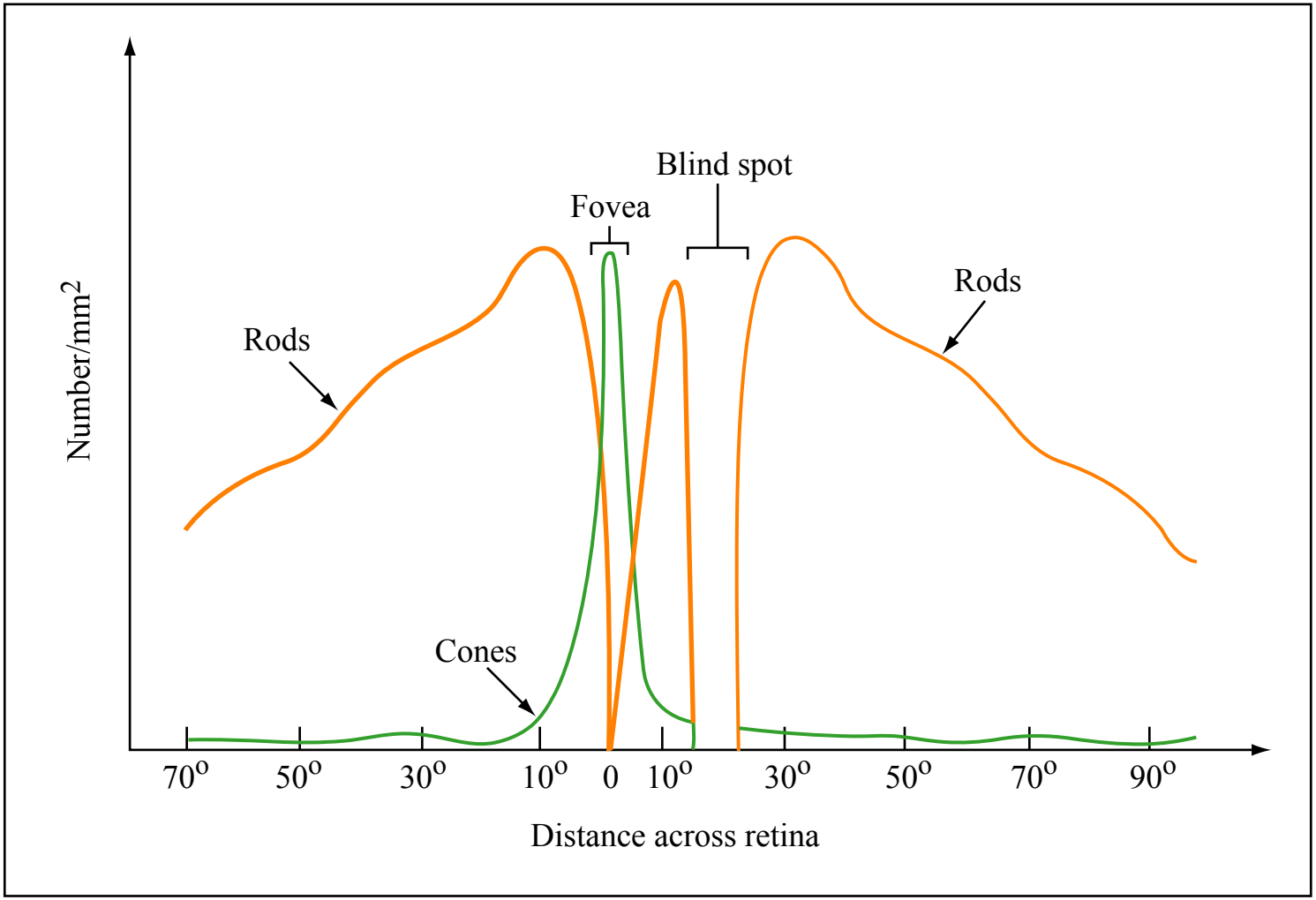
The retina, as viewed through an opthalmoscope.
Figure 9.5 in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2007. ISBN: 9780781760034.

Variation in acuity with retinal position



Anstis, 1974

The density of photoreceptors decreases in the periphery



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Rods and cones

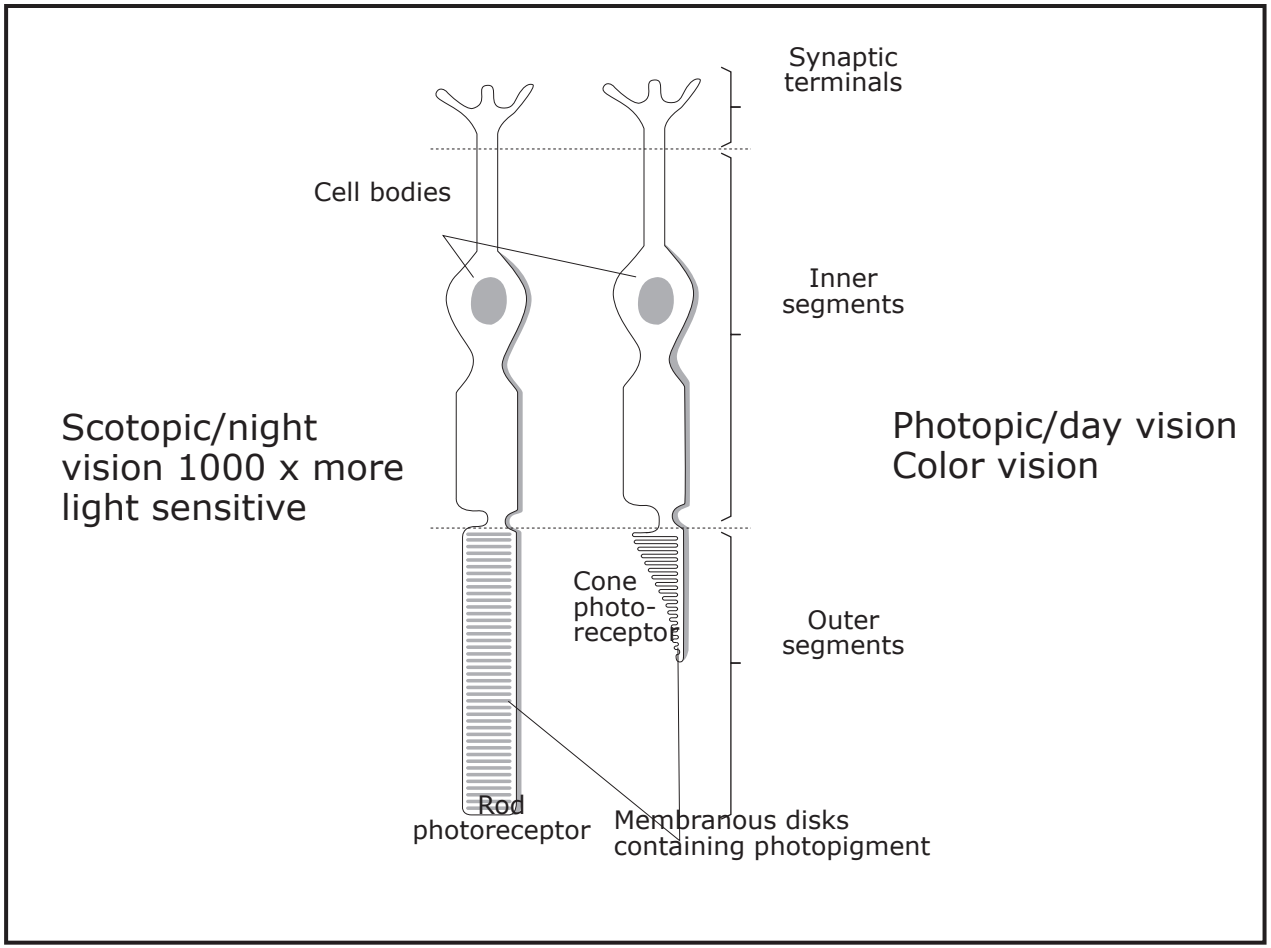


Figure by MIT OpenCourseWare. After figure 9.13 in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain.* 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2001. ISBN: 9780683305968.

Light causes photoreceptors to hyperpolarize

- Dark current due to open sodium channels
- Light depletes cGMP, closing sodium channels

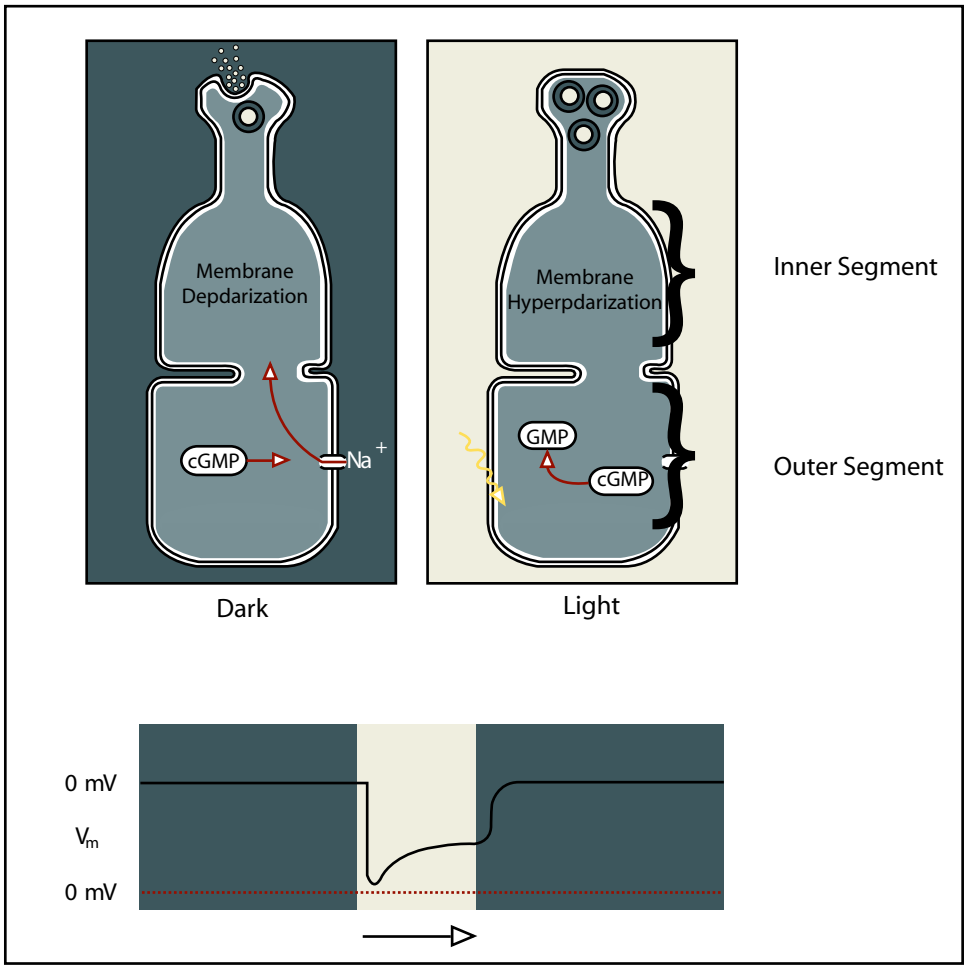


Figure by MIT OpenCourseWare. After figure 9.17 a and b in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain.* 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2001. ISBN: 9780683305968.

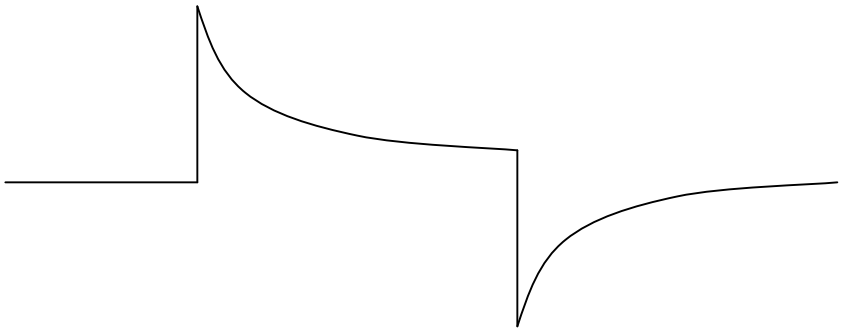
ON and OFF bipolar cells

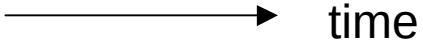
- Light has different effects on bipolar cells
- ON cells depolarize
- OFF cells hyperpolarize

Transient vs. sustained responses

- Stimulus

- Response





Temporal antagonism

- Stimulating the center causes a transient increase.
- Removal of the stimulus causes a transient decrease (relative to background).

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Center-surround antagonism

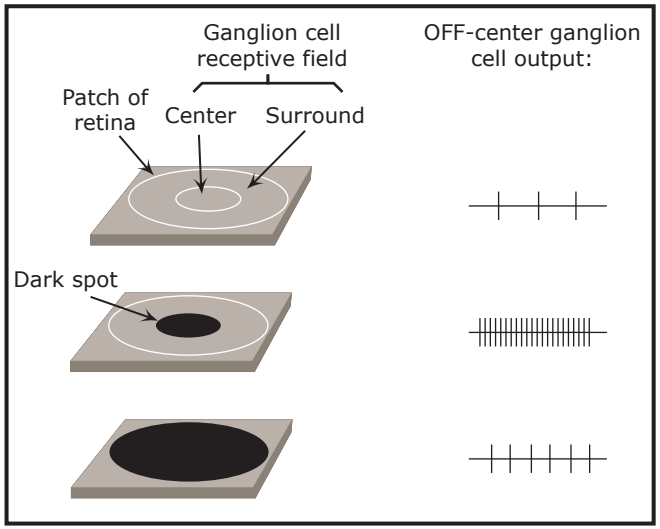

Figure by MIT OCW. After figures 9.23 a, b, and c in: Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain*. 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2001. ISBN: 9780683305968.

- OFF-center prefers:
  - dark spot in center
  - light annulus
- ON-center prefers:
  - light spot in center
  - dark annulus

Horizontal cells are coupled by gap junctions

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Xin and Bloomfield

Resistive network model

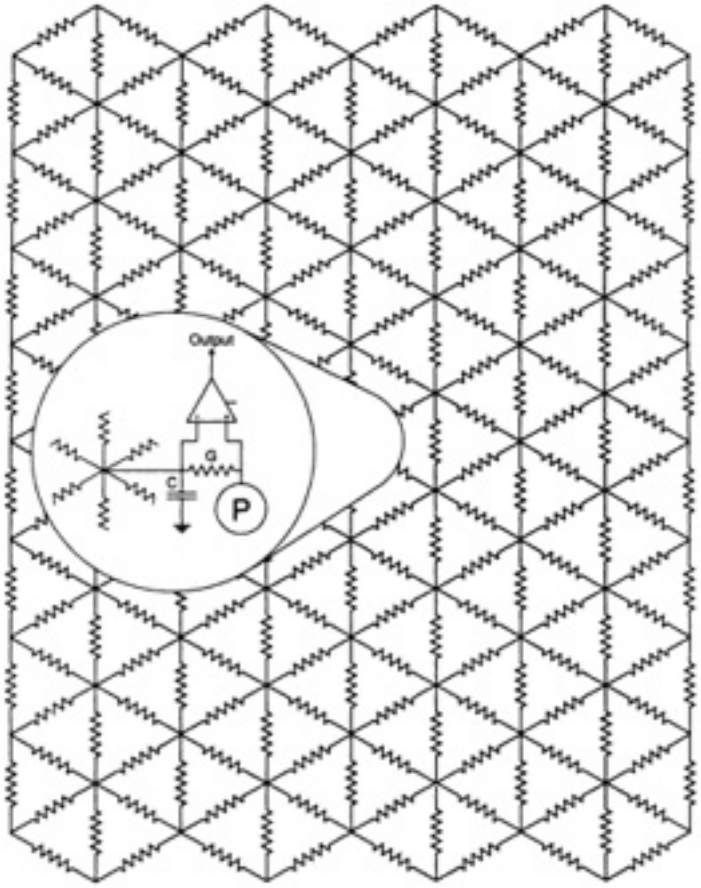
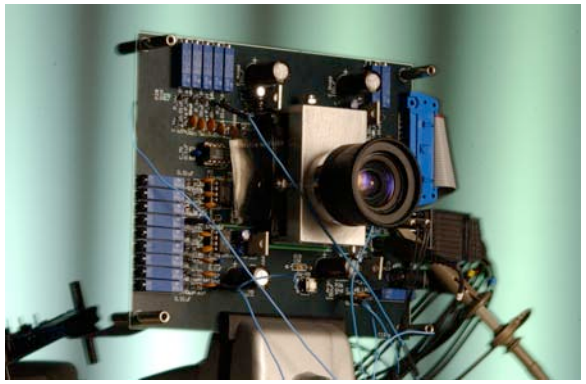


Figure 3.
The silicon retina. Diagram of the resistive network and a single pixel element, shown in the circular window. The silicon model of the triad synapse consists of the conductance (G) by which the photoreceptor drives the resistive network, and the amplifier that takes the difference between the photoreceptor (P) output and the voltage on the resistive network. In addition to a triad synapse, each pixel contains six resistors and a capacitor C that represents the parasitic capacitance of the resistive network. These pixels are tiled in a hexagonal array. The resistive network results from a hexagonal tilling of pixels.

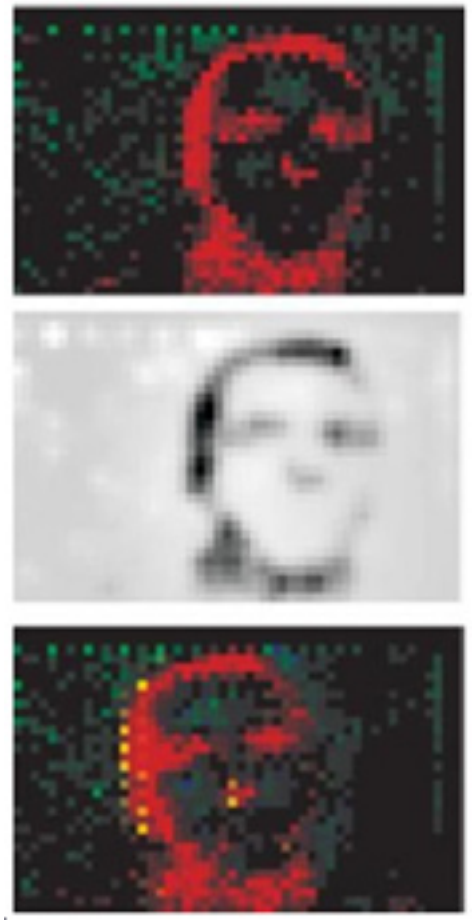
Figure 3 in Carver A. Mead and Misha Mahowald. "A Silicon Model of Early Visual Processing." In *Computational Neuroscience*. Cambridge, MA: MIT Press, 1993. Courtesy of Carver A. Mead and Misha Mahowald, authors, and Eric L. Schwartz, editor. Used with permission.

Silicon retina

- Neuromorphic VLSI
- K. Zaghloul and K. Boahen, 2004 [f]



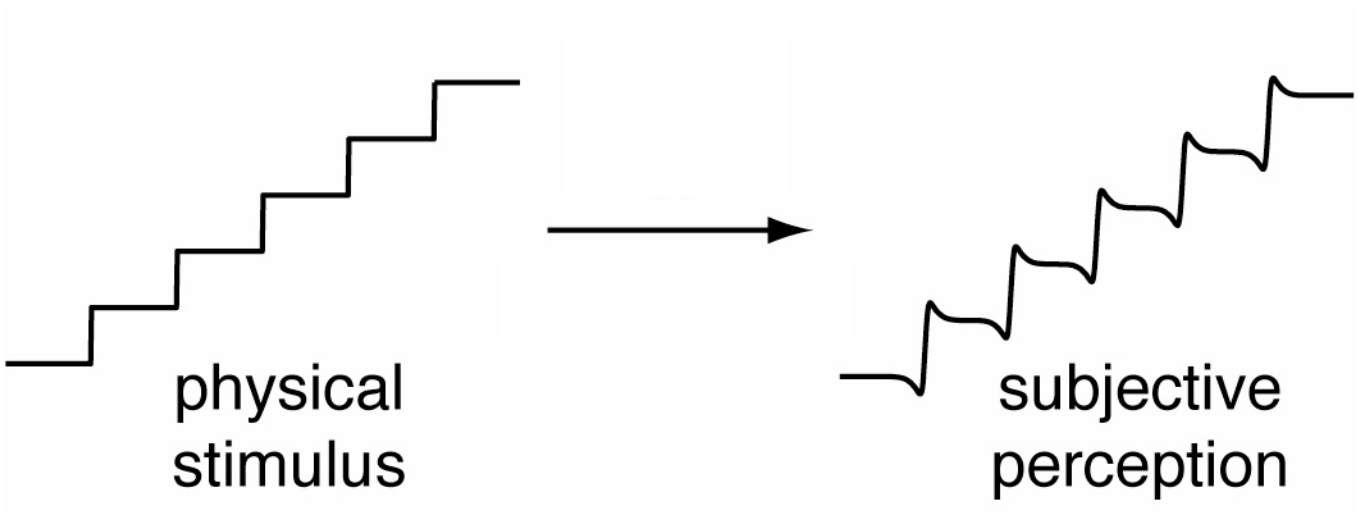
Courtesy of Kareem Zaghloul. Used with permission.



Source: Zaghloul, Kareem A., and Kwabena Boahen. "A Silicon Retina that Reproduces Signals in the Optic Nerve." *J Neural Eng* 3 (2006) 257–267. Courtesy of IOP Publishing, Inc. Used with permission.

Chevreul’s illusion

Light: reality vs. perception



Receptive field model