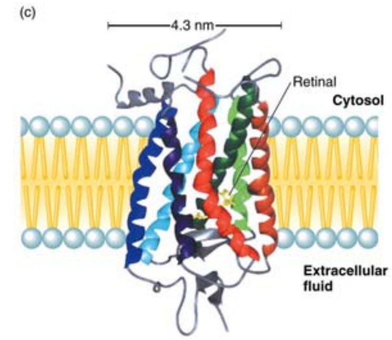
Lecture 11, 11 Feb 2008

Vertebrate Physiology
ECOL 437 (MCB/VetSci 437)
Univ. of Arizona, spring 2008

Kevin Bonine & Kevin Oh



1. Sensory Systems (Ch13)
   - Finish hearing, vision

http://eebweb.arizona.edu/eeb_course_websites.htm [1]

Housekeeping, 11 February 2008

<u>Upcoming Readings</u>
Today: Ch13
Wed 13 Feb: Ch13, maybe Ch 14
LAB Wed 13 Feb: none
Fri 15 Feb: Exam 1, through Ch13
Mon 18 Feb: Ch14
Wed 20 Feb: Ch15
LAB Wed 20 Feb: 4 readings on website
Fri 22 Feb: no lecture, work on proposal

Lab discussion leaders: 20 Feb
1pm – Virsheena, Mathew S. Arturo
3pm – Kat, Clif, Amber

Lab discussion leaders: 27 Feb
1pm – Steve & Steve
3pm – Kevin & Jennifer

2

The Edges of Life – 7pm at Centennial Hall

The Edges of Life Lecture Series

Wednesday, February 13
Life's Cognitive Edge: The Role of the Mind and What it Means to be Human
Anna Dornhaus, Assistant Professor, Ecology and Evolutionary Biology
Our human mind distinguishes us from other animal life-or does it? Recent research has revealed culture and social learning, tool use, complex communication, self-recognition, and planning for the future are not unique to the human experience. With these new findings, science is finally getting closer to understanding exactly what makes us human.

Wednesday, February 20
Life's Human Edge: Changing Perspectives on the End of Life
Michael Gill, Associate Professor, Philosophy
Nothing looms with more certainty than the final edge of one's own life. But in fact, the edge between life and death is anything but clear. This lecture will address the attempts that have been made to define the line between life and death and will explore the biological, legal, ethical, and spiritual debates that have raged around that line.

Wednesday, March 5
Life's Technological Edge: The Singularity is Near: When Humans Transcend Biology
Ray Kurzweil, *via Teleportec Teleporter*
Founder, Chairman and Chief Executive Officer, Kurzweil Technologies
Humanity is on the edge of a vast transformation, when what it means to be human will be both enriched and challenged. Inventor and futurist Ray Kurzweil will introduce this radically optimistic singularity, an era when we break our genetic shackles to create a nonbiological intelligence trillions of times more powerful than today. In this new world, humans will transcend biological limitations to achieve entirely new levels of progress and longevity.
This lecture co-sponsored by: UA College of Engineering and UA College of Science

These do not count as physiology lectures.

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Self Quiz:

1. What causes NT to be released?

2. What area of the vertebrate has an unusually high [K+] outside the cell?

3. What role do glomeruli play in chemoreception?

4. How can a hair cell transmit two kinds of information?

5. Why is the oval window smaller than the tympanum?

4

Barn Owl

Konishi and Knudsen (1977) identified an area in the midbrain containing cells called space-specific neurons that fired only when sounds were presented in a particular location. Astonishingly, the cells were organized in a precise topographic array, similar to maps of cells in the visual cortex of the brain. Aggregates of space-specific neurons, corresponding to the precise vertical and horizontal coordinates of the speaker, fired when a tone was played at that location.

5

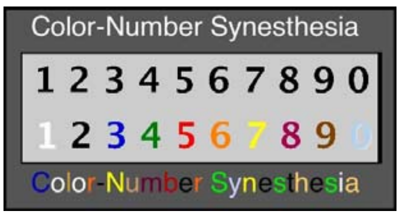
Northern Saw-whet Owl

http://people.eku.edu/ritchisong/birdbrain2.html

6

Type of sensation received depends on where in CNS (~brain) AP arrives (LABELED LINES).

Rub eyes and see light!



Synesthesia:
e.g., smell colors

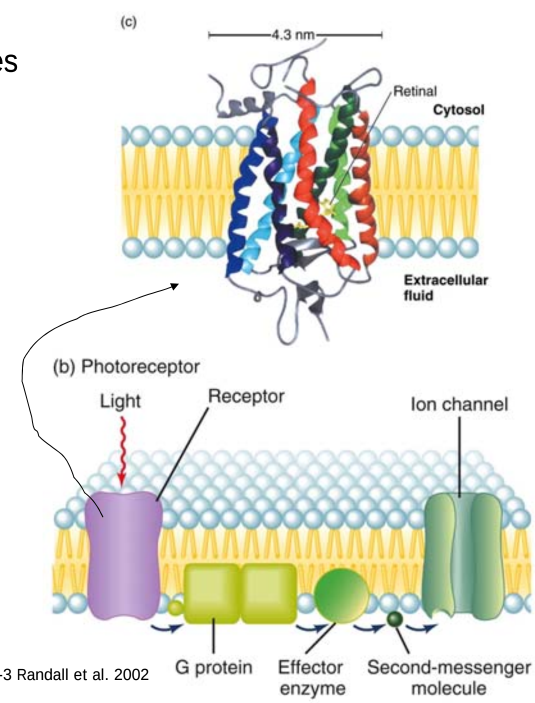
Mechanisms and Molecules

Lots of Evolutionarily Conserved Elements

e.g., 7 transmembrane helices and G-protein intermediate

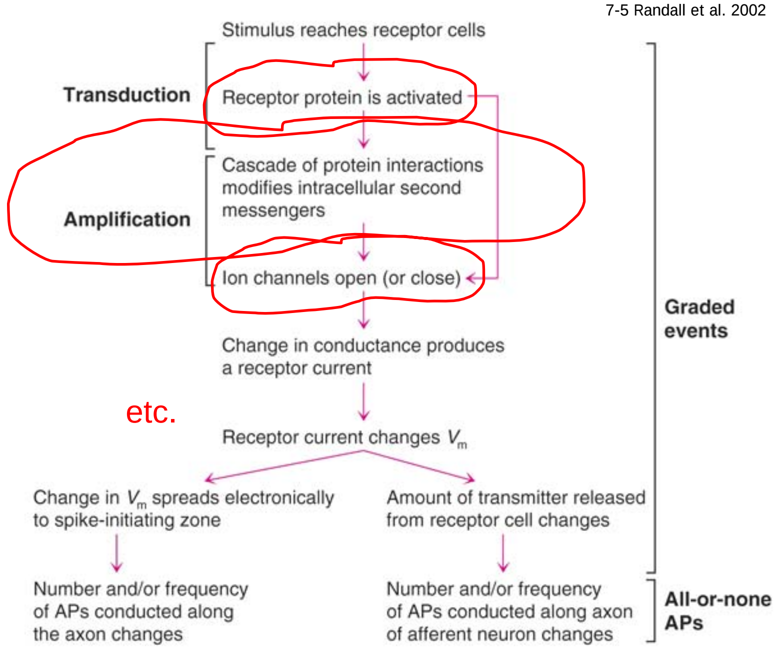
↓

e.g., Vision, olfaction, sweet and bitter taste (also muscarinic ACh receptors and many hormone receptors)



7-3 Randall et al. 2002

7-5 Randall et al. 2002



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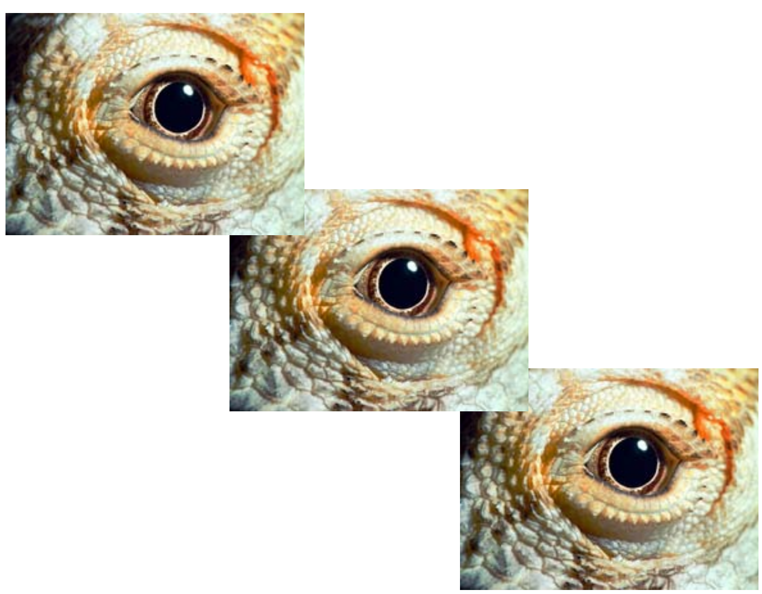
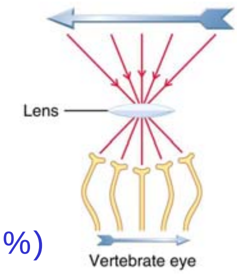


10

Vision

7-34 Randall et al. 2002



FOCUS

- light is focused by lens (and cornea) to create an image on the retina

- refraction by cornea (85%) and by lens (15%)

- alter focal length by altering shape and curvature of lens
  (zonular fibers and ciliary muscle 'sphincter')

- binocular convergence (both eyes on same part of retina)

LIGHT INTENSITY

- pupil for variable aperture via iris and radial muscle

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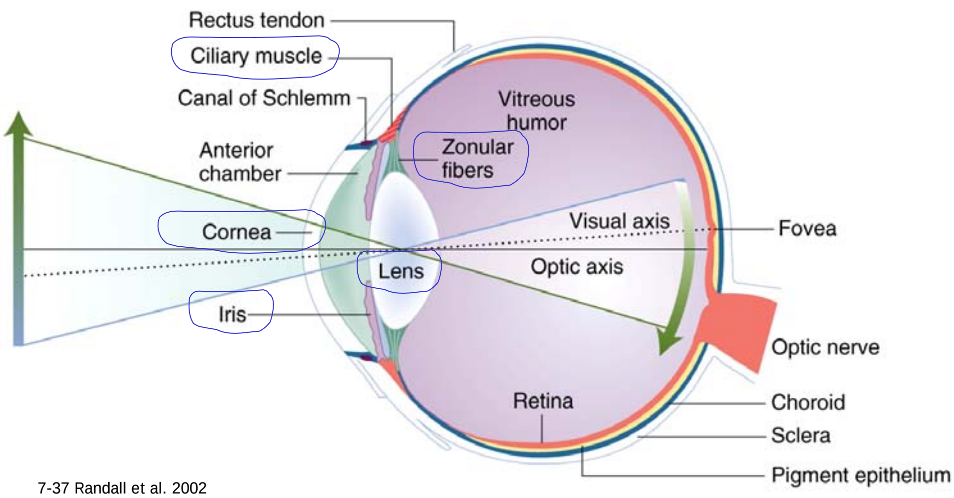

7-37 Randall et al. 2002

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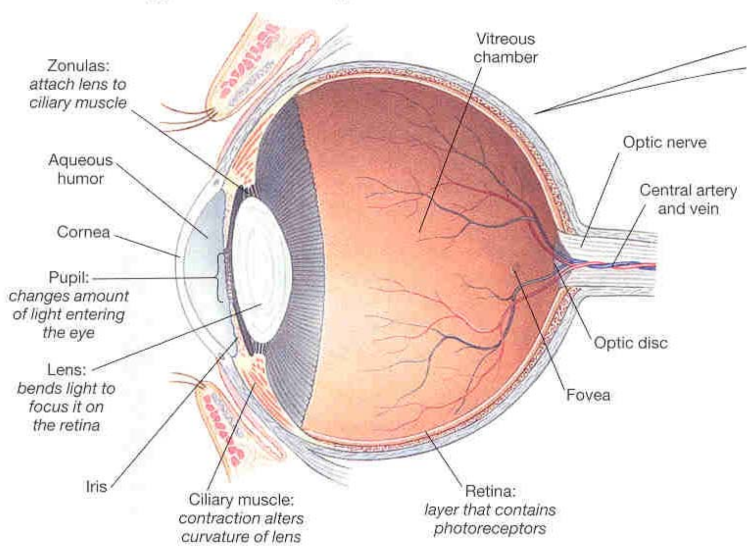
10-27 Silverthorn 2001



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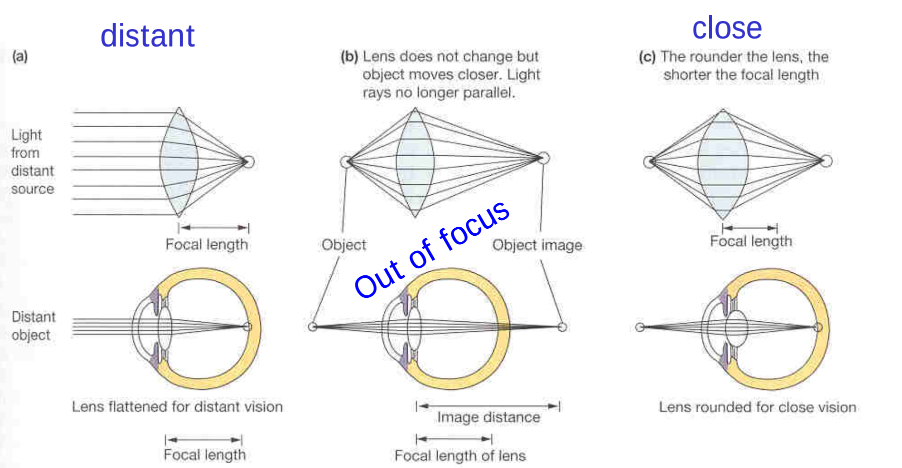

Figure 10-29 Optics (a) Light reflecting off a distant object reaches the eye as nearly parallel rays. The lens is flattened so that the focal point falls on the retina. (b) If an object moves within 20 feet, the light rays from it are no longer parallel. The object is seen out of focus because the light beam is not focused on the retina. (c) To keep an object in focus as it moves closer, the lens becomes more rounded. This adjustment is known as accommodation.

10-29 Silverthorn 2001

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Vision

~ANATOMY

- sclera white tough outer layer
- choroid lots of blood vessels
- pigment layer with photoreceptors
- fovea where highest acuity and highest # cones
    -(visual streak?)

TRANSDUCTION

- photoreceptors (rods and cones)
    -Transduce photons (light) into electrical signal

- rhodopsins (visual pigments)
    opsin (7-transmembrane lipoprotein)
    plus
    retinal (absorbs photon)

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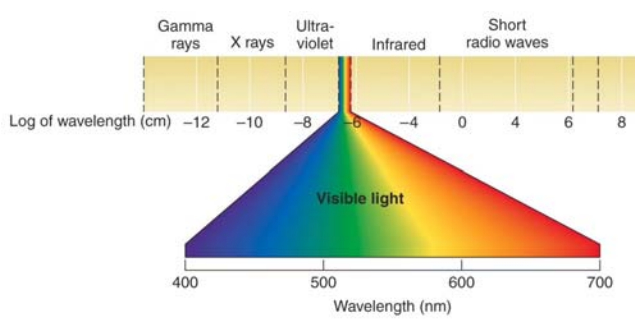
Vision Receptor Cells

Rods -Dim light, low resolution
and
Cones -Bright light, high resolution



7-38 Randall et al. 2002

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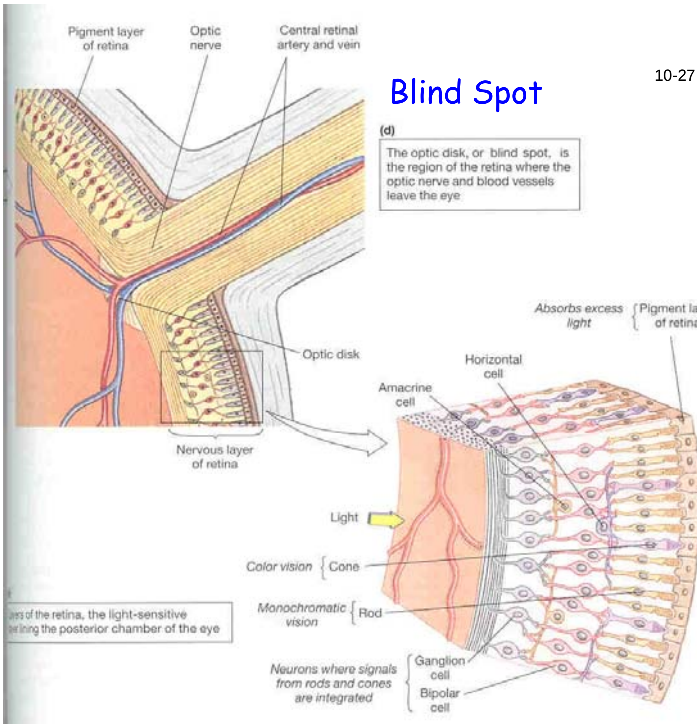
10-27 Silverthorn 2001

Blind Spot



Rods and **Cones**

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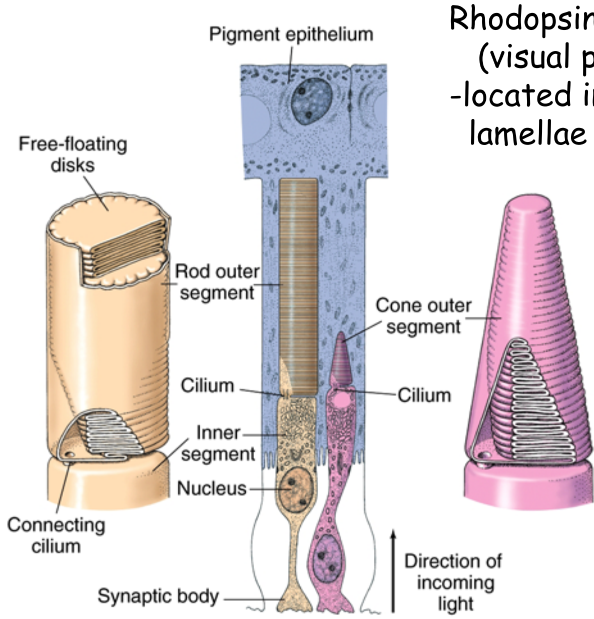
Rhodopsins
(visual pigments)
-located in stacked lamellae



7-39 Randall et al. 2002

Membranes **hyperpolarize** in response to light

Na^+ 'dark current'

When light hits, the Na^+ current into the cell is stopped and membrane hyperpolarizes stopping release of NT

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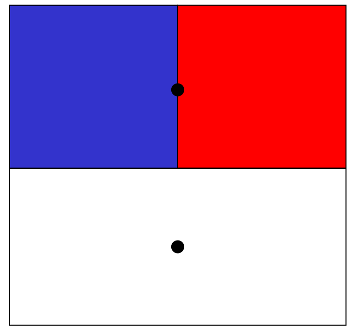
Bleaching of retinal photoreceptors

Expectation after 15 seconds?



Photoreceptors called cones respond to particular wavelengths of light. Their response involves “bleaching” of their responsive pigment, so that for some seconds they are unable to respond again. 19

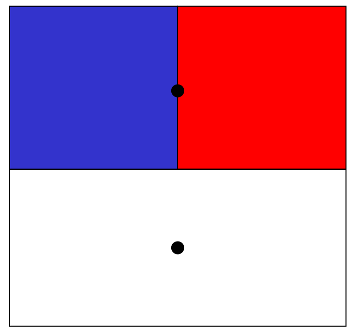
Bleaching of retinal photoreceptors

Expectation after 15 seconds?

Photoreceptors called cones respond to particular wavelengths of light. Their response involves “bleaching” of their responsive pigment, so that for some seconds they are unable to respond again. 20

Bleaching of retinal photoreceptors

Expectation after 15 seconds?

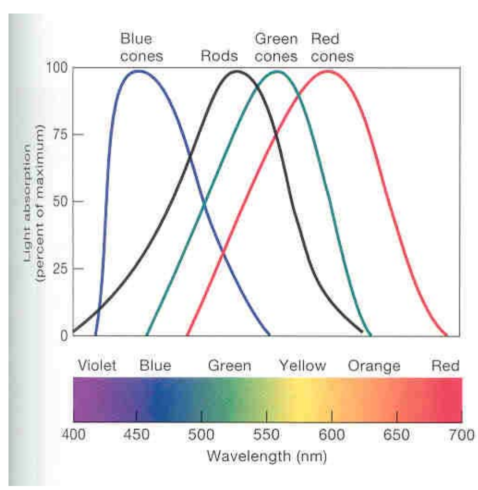


Photoreceptors called cones respond to particular wavelengths of light. Their response involves "bleaching" of their responsive pigment, so that for some seconds they are unable to respond again. 21

Rod and Cone details   Sensitivity vs. Acuity

Action spectrum (where absorb light)

10-35 Silverthorn 2001

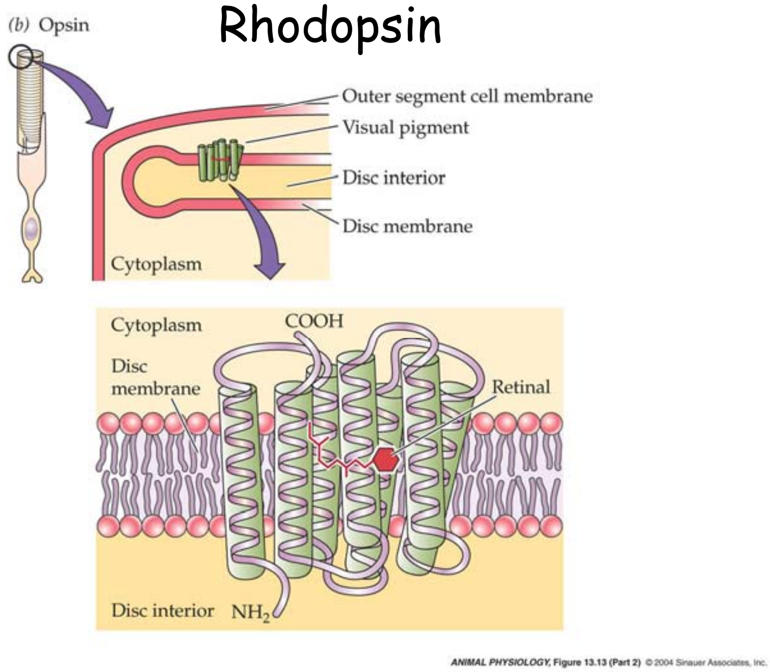


3 (e.g., humans, fish)
5 (e.g,. birds)

different photopigments
(opsin varies, retinal ~same)

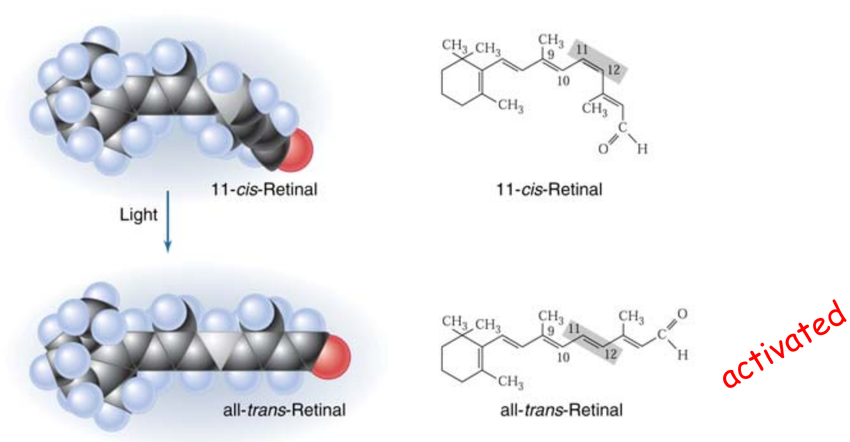
Porphyropsins (different retinal) seem better than rhodopsins in freshwater

Rhodopsin



ANIMAL PHYSIOLOGY, Figure 13.13 (Part 2) © 2004 Sinauer Associates, Inc.

Rhodopsin mechanism:
cis-trans isomerization of retinal molecule



7-43 Randall et al. 2002

Changes conformation of opsin molecule and therefore initiates transduction

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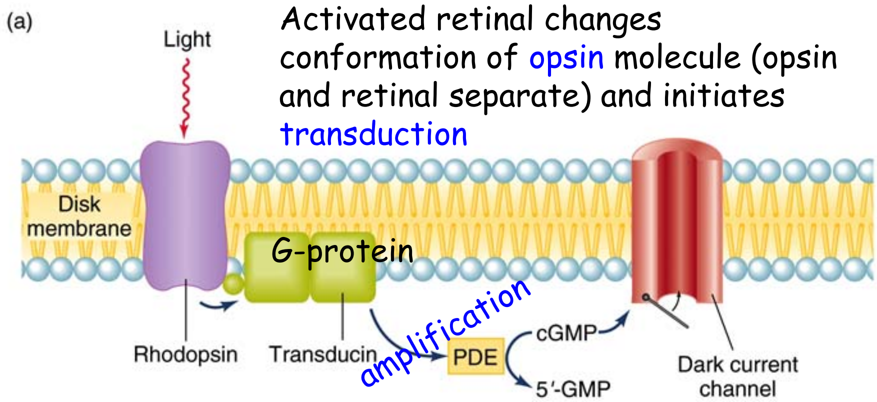
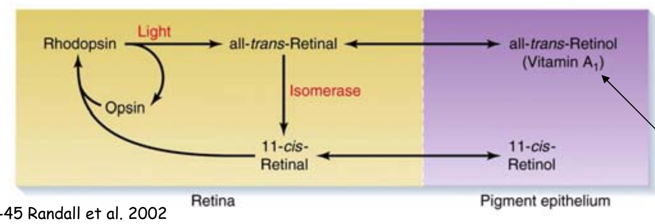
7-44 Randall et al. 2002

Activated retinal changes conformation of opsin molecule (opsin and retinal separate) and initiates transduction



PDE = Phosphodiesterase



7-45 Randall et al. 2002

Need to reconstitute the rhodopsin

(night blindness)

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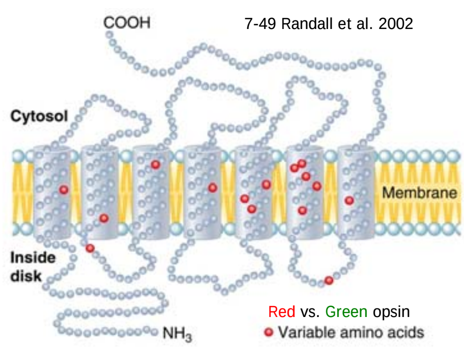
Physiology Players Theatre

-2 competing casts
-Judge(s)
  -accuracy
  -enthusiasm

7-49 Randall et al. 2002



Actors:

1. Photon	4. Transducin	7&8. Ion channel
2. Retinal	5. PDE	9. Cation (Na^+)
3. Opsin	6. cGMP	

Act I

Photon enters stage right. Other players assembled within or near membrane. …photo transduction…
Dark current reduced as curtain closes.

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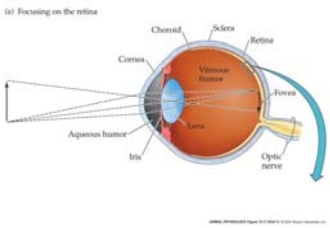
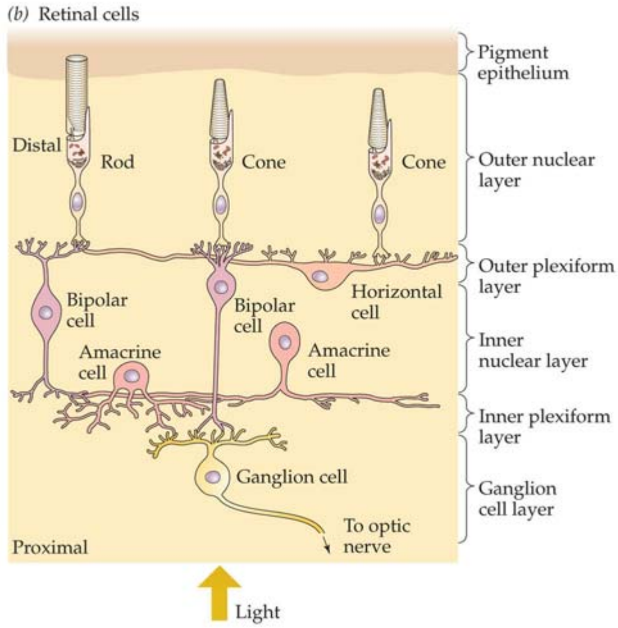
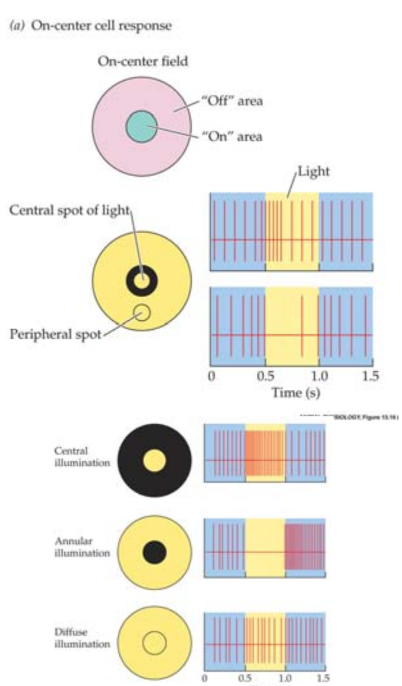
Photon Transduced…Now what?

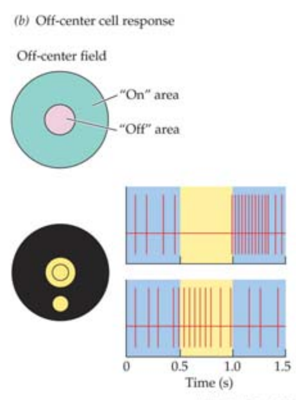




- •Horizontal
- •Bipolar
- •Amacrine
- •Ganglion

Hill et al. 2004, Fig 13.11





Hill et al. 2004, Fig 13.16

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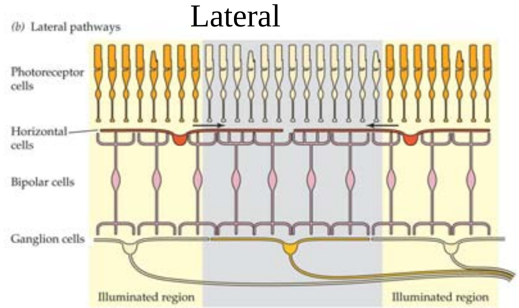
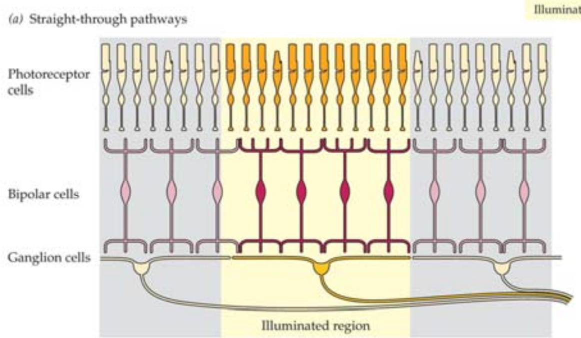
Lateral



Straight-through



Hill et al. 2004, Fig 13.17

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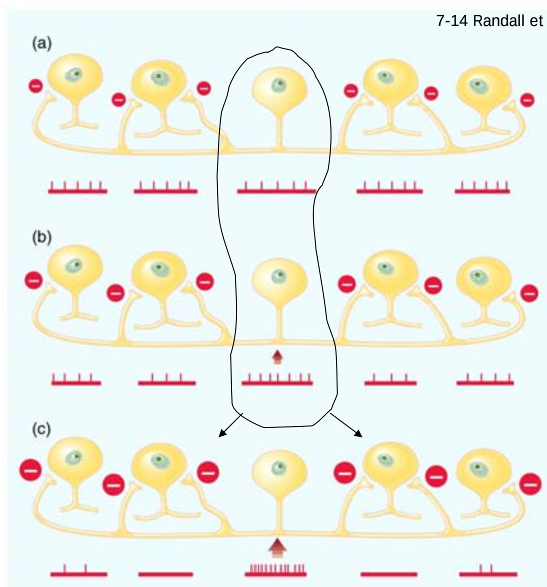
Enhancing Receptor Sensitivity

- Lateral Inhibition

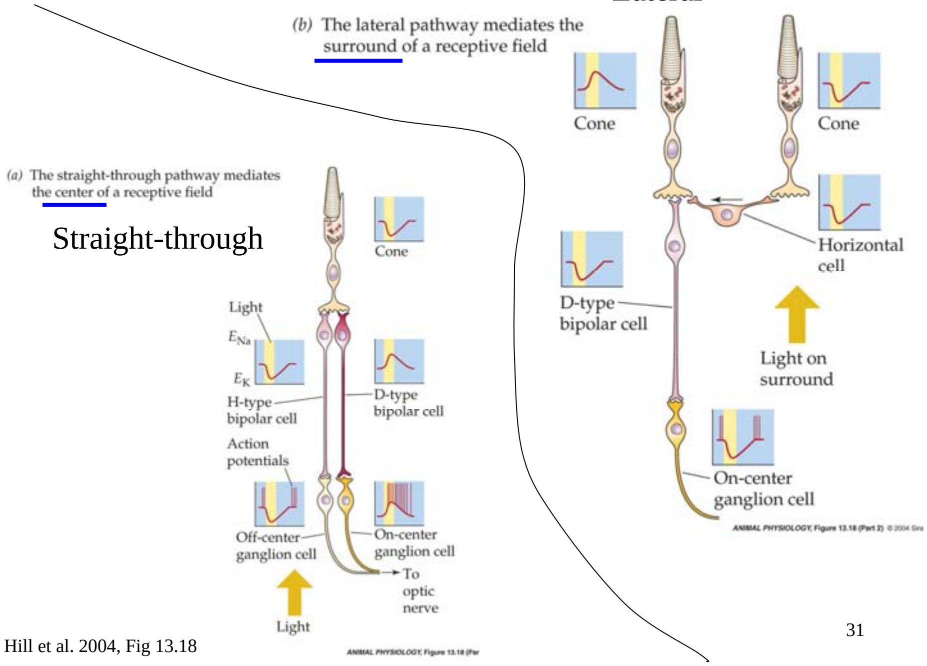
e.g., improve touch sensitivity and visual acuity (edges especially)

7-14 Randall et al. 2002



Lateral

Straight-through



Hill et al. 2004, Fig 13.18

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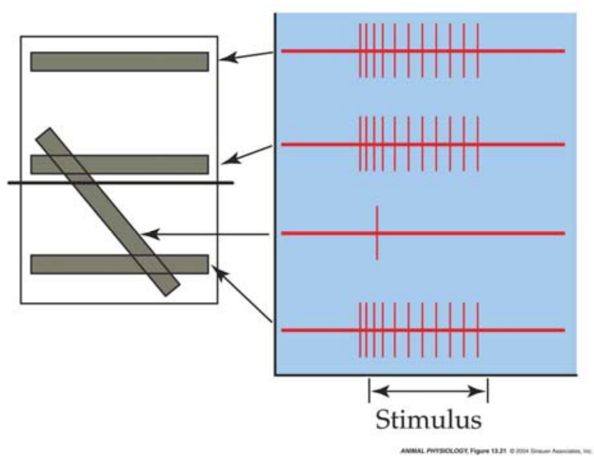
Receptive Field of Complex Cell in Visual Cortex



Hill et al. 2004, Fig 13.21

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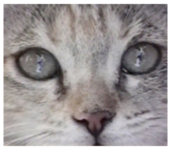

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