Phototransduction

What a cell can do

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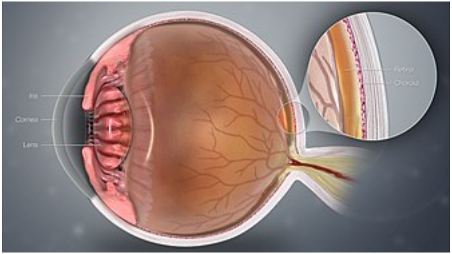
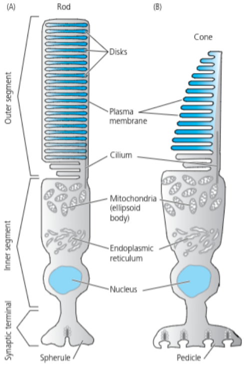
Physics/Neuro 141

Week 1



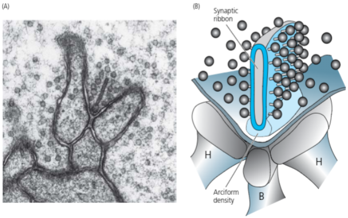
Vertebrate photoreceptors

Rods and cones

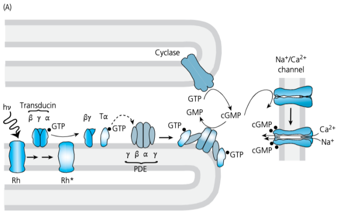


- Two kinds of vertebrate photoreceptors
- Both have outer segments containing visual pigment. Area of sensory membrane is increased by lamellar structure (1100 rod disks and 750 cone lamellae.
- In a mammalian rod cell 25 μm long, roughly 2/3 of light is absorbed
- The inner segment keeps the cell alive
- The synaptic terminal communicates with bipolar cells and horizontal cells.
- Photoreceptors lack axons or voltage-gated Na^+ channels.

Rod photoreceptors



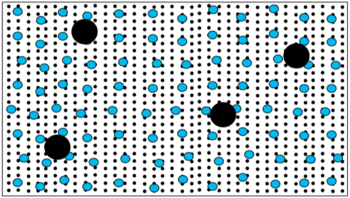
- The change in membrane potential produced by light is communicated at specialized synapses onto second-order horizontal and bipolar cells.
- The presynaptic terminals contain dense bodies that in rods and cones are called synaptic ribbons.
- Vesicle release is Ca^{2+} dependent
- The synaptic transmitter is glutamate
- Both rods and cones are depolarized in darkness and hyperpolarize to light
- Synaptic transmission is continuous in darkness, and decreased by illumination



- The formation of Rh* produces a change in the conformation of the parts of the rhodopsin molecule exposed to the cytoplasm
- movements open up a binding site for a heterotrimeric G protein called transducin
- Transducin binding triggers a change in the conformation of the guanosine nucleotide binding site on the transducin α subunit ($T\alpha$)
- GDP then falls off this binding site, and GTP binds in its place
- $T\alpha - GTP$ then binds to an effector enzyme, a cyclic nucleotide phosphodiesterase (PDE6)

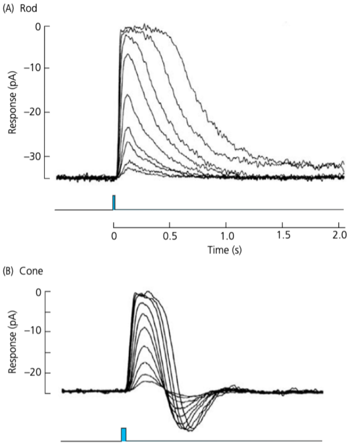
SIGNAL AMPLIFICATION

(B)



- For every thousand rhodopsin molecules in the disk membrane of a rod, there are about a hundred transducins and about ten PDE6 molecules
- A single Rh* during its lifetime can collide randomly with many transducin molecules and produce many molecules of $T\alpha - GTP$, perhaps 10-15 in a mouse rod but 100s in amphibians
- The cGMP-gated channels in rods and cones are non-specifically permeable to monovalent cations

Current responses



- Rods in mammals are about one-hundred times more sensitive to light than cones.
- Responses of cones reach peak amplitude and decay much more rapidly than do those of rods
- Rods evolved from cones by a series of small changes in many of the transduction proteins until rod sensitivity reached single-photon responses above noise.