Light-sensitive elements

Article to be checked

Check of this article is requested.

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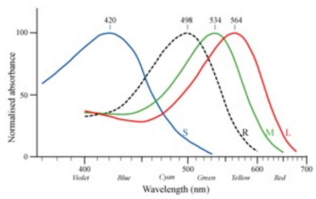
Retina (Intro)

The main structure of the eye that is ultimately responsible for the light reception in humans is the retina (from Latin *rete*, meaning «*net*»). It is a light-sensitive layer of tissue located as a thin line at the inner surface of the eye. As light reaches the retina, electrical and chemical events trigger nerve impulses that are sent to numerous visual centers of the brain trough the optic nerve. More specifically, the retina comprises complex neural circuitry that converts the graded electrical activity of photoreceptors into action potentials that travel to the brain via axons in the optic nerve. This means that retina is brain tissue, and thus, is directly a part of the CNS (central nervous system).

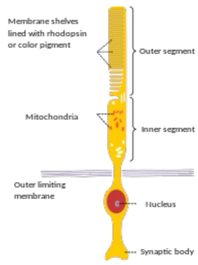


Normalized responsivity spectra of human rod cells & cone cells, **S**, **M**, and **L** types.

The cell of the retina that is specialized in light reception, more specifically phototransduction, is called «photoreceptor cell». Its significance is that it converts visible light into electrical signals that can be analyzed biologically, absorbing photons and causing a change in the photoreceptor cell's membrane potential. The two types of photoreceptors are «cones» and «rods». Each of these cells contribute in visual sight. Although each of these cells have their differences in structure and specific functionality, their chemical process of phototransduction is in common.

Rod cell

«Rods» are responsible for the reception of small intensity light and for peripheral view. These cells are counted approximately at 125•10^6 in humans and are located on the outer edges of the retina.



Structure of a Rod Cell.

Structure

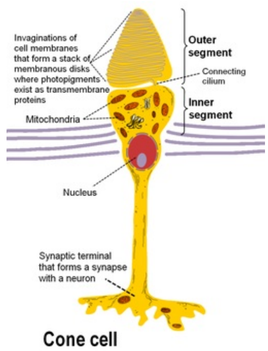
Rod cells have an elongated structure and consist of three distinct regions: outer segment, inner segment and the synaptic region. The outer segment contains the phototransduction apparatus. It is composed of a series of closely packed membrane disks that contain the photoreceptor molecule Rhodopsin (derivate of vitamin A). The inner segment contains organelles and the cell's nucleus. The synaptic region is the site where the rod cell relays its information to intermediate neurons in the retina. These neurons connect with bipolar cells and ganglion neurons whose axons form the approximately one million fibres of the optic nerve.

Function

When stimulated, for example, in the dark, rod cells depolarize and release a neurotransmitter spontaneously. This one hyperpolarizes the bipolar cell that exist between photoreceptors and ganglion cells and act to transmit signals from the photoreceptors to the ganglion cells. As a result of the bipolar cell being hyperpolarized, it does not release its transmitter at the bipolar-ganglion synapse and the synapse is not excited. When light hits photoreceptive pigments within the photoreceptor cell, the pigment called rhodopsin activates due to a series of chemical reactions. This leads to a massive reaction in the cell because the signal is amplified. Once activated, rhodopsin can activate hundreds of transducin molecules, each of which in turn activates a phosphodiesterase molecule, which can break down over a thousand cGMP molecules per second. Thus, rods have a big response to a small amount of light.

Cone cell

Types



Structure of a Cone Cell.

Cones are further classified into 3 kinds of cone cells, each type responding to visible light of different wavelengths on the electromagnetic spectrum. The first type of cones, the **L** (Long) cones, respond to light of long wavelengths, peaking at the color red. More specifically, about 570 nm. Second, the **M** (Medium) cones peak between 534-545 nm, the color green. The third type, responsible for responding most to light of short wavelengths, are the **S** (Short) cones; they are most sensitive to light at wavelengths around 440 nm, which is the wavelength of the color blue. Because of the color distinctions, many a time, these different kinds of cones are named according to their respective colors that are responded to (i.e. "blue" cones). As of current understanding, between 6 and 7 million cone cells exist in an individual. This number is roughly divided as **L**-cones being 64%, **M**-cones 32%, and **S**-cones 2%.

Structure

In relativity, cone cells are somewhat shorter than rod cells, but are structurally wider. Quantitatively, there are also significantly fewer than rod cells in number, in most parts of the retina. However, in the area of the fovea, the cones outnumber the rods by a massive amount. With reference to the structure, and the cell's given name, cone cells are cone-shaped at one end of the cell, where a pigment filters all incoming light, offering them their various response curves. In length, a cone is usually 40-50 µm long, with their diameter measuring from 0.5-4.0 µm. As mentioned earlier, the percentage of each type of cone (**S**, **M**, and **L** types) varies greatly from individual to individual, assuming subjects have regular vision. Each cone has a synaptic terminal, an inner segment, and an outer segment, as well as an interior nucleus and various mitochondria contained in the cell; these properties are shared between rods and cones. The inner segment of the cell contains all of the cell's organelles, as well as the cell nucleus. On the other hand, the outer segment points towards the posterior of the eye, and contains the light-absorbing materials. The outer and inner segments are connected by a cilium. Neither rods nor cones tend to divide normally, but their membranous disks in the outer segments (visible in diagram) do wear out, and are thus consumed and recycled regularly by phagocytes.

Function

Principally, a photoreceptor is a form of neuron found in the retina of the eye that is capable of phototransduction. Cones are photoreceptors mainly specialized for the process of high visual acuity and the perception of color. Unlike rods, cones require significantly bright light (i.e. great amounts of photons) in order to manipulate it into a biologically accessible signal. The cones are less sensitive to light than the rods. As mentioned earlier, three types of cone cells exist: the **S**-cones, **M**-cones, and **L**-cones. Each of them are distinguished by their pattern of response to different wavelengths of light. These differences in signals received by the three different types of cones are what allow the human brain to perceive a continuous spectrum of colors. Similar to all typical neurons, cones fire to produce an electrical impulse on the nerve fiber. Following this occurrence, they must then reset themselves to fire once again. The light adaption is thought to occur by adjusting this reset time of the cell.

Connected diseases & Clinical Signifance

There are some diseases that affect the retina itself and the particular structures that were described before.

- Retinal detachment: emergency situation, when the retina is pulled away from the back of the eye.
- Retinoblastoma: Cancer of the retina. It is most common in young children. Caused by the mutation of both copies of retinoblastoma genes. In retinoblastoma, the retina seem to be white, or have white spots on it.
- Rod and cone dystrophy: It`s an inherited problem that consists in degeneration of these photoreceptor cells.

References

http://www.ncbi.nlm.nih.gov/books/NBK10885/http://en.wikipedia.org/wiki/Rod_cell http://www.cis.rit.edu/people/faculty/montag/vandplite/pages/chap_9/ch9p1.htmlhttp://www.britannica.com/EBchecked/topic/506498/rodhttp://en.wikipedia.org/wiki/Cone_cell#Types http://hyperphysics.phy-astr.gsu.edu/hbase/vision/rodcone.htmlhttp://www.ncbi.nlm.nih.gov/books/NBK10850/ http://www.nlm.nih.gov/medlineplus/retinaldisorders.html http://www.naturaleyecare.com/eye-conditions/rod-cone-dystrophy/

books*: "retina" by Stephen J. RyanMosby, 1994*

Picures:

1. Normalized responsivity spectra of human rod cells & cone cells, S, M, and L types.
2. Structure of a Cone Cell.

3. Structure of a Rod Cell.