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Perspective

A Perspective Study over Structure and Functions of Intrinsically Photosensitive Ganglion Cells of the Human Retina

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ABOUT THE STUDY

Intrinsically photosensitive Retinal Ganglion Cells (ipRGCs) are a type of neuron found in the retina of the mammalian eye. They are also known as photosensitive Retinal Ganglion Cells (ipRGCs) or melanopsin-containing Retinal Ganglion Cells (mRGCs). The presence of (something like) ipRGCs was first suspected in 1927, when rod less, cone less mice nonetheless constrict their pupils in response to a light stimulus, implying that rods and cones aren't the only light-sensitive neurons in the retina. Advances in research on these cells did not begin until the 1980s. Due to the presence of melanopsin, a light-sensitive protein, these retinal ganglion cells, unlike other retinal ganglion cells, are fundamentally photosensitive, according to recent study. As a result, in addition to rod and cone cells, they form a third class of photoreceptors.

Structure of the intrinsically photosensitive Retinal Ganglion Cells (ipRGC)

ipRGC receptor: These photoreceptor cells project into the brain as well as throughout the retina. They have different amounts of the photo pigment melanopsin along the cell membrane, including on the axons up to the optic disc, the soma, and the cell's dendrites. Membrane receptors for the neurotransmitters glutamate, glycine, and GABA are found in ipRGCs. In contrast to other photoreceptor cells, which hyperpolarize in reaction to light, photosensitive ganglion cells depolarize in response to light, increasing the pace at which they fire nerve impulses.

Melanopsin: Melanopsin, unlike other photoreceptor pigments, can function as both an excitable photo pigment and a photoisomerase. Unlike photoreceptor cones, which rely on Müller cells and retinal pigment epithelium cells to convert all trans retinal back into 11-cis-retinal before they can undergo another photo transduction, melanopsin is able to isomerize all-trans-retinal into 11-cis-retinal when stimulated with light without the help of additional cells. The spectral sensitivity of the two isoforms of melanopsin differs, with the 11-cis-retinal isoform being more receptive to shorter wavelengths of light and the all-trans isoform being more susceptible to longer wavelengths of light.

Synaptic inputs and outputs

Inputs: Dopaminergic Amacrine cells (DA cells) are pre and postsynaptic to ipRGCs *via* reciprocal synapses, with ipRGCs sending excitatory signals to the DA cells and the DA cells sending inhibitory signals to the ipRGCs. GABA, which is released with dopamine from DA cells, is responsible for these inhibitory signals. Dopamine helps with light adaptation by enhancing the sensitivity of photoreceptors by up regulating melanopsin transcription in ipRGCs. Somatostatin-releasing amacrine cells, which are themselves inhibited by DA amacrine cells, inhibit ipRGCs in tandem with DA amacrine cells. Cone bipolar cells and rod bipolar cells are two other synaptic inputs to ipRGC dendrites.

Outputs: The Suprachiasmatic Nucleus (SCN) of the hypothalamus, which functions as an organism's circadian clock, is one of ipRGCs postsynaptic targets. Through a monosynaptic connection known as the retino hypothalamic tract, ipRGCs release both Pituitary Adenylyl Cyclase-Activating Protein (PACAP) and glutamate onto the SCN (RHT). PACAP appears to augment the effects of glutamate in the hypothalamus, as glutamate has an excitatory effect on SCN neurons. The Intergenticulate Leaflet (IGL), a cluster of neurons in the thalamus that controls the pupillary light reflex; the Olivary Pretectal Nucleus (OPN), a cluster of neurons in the midbrain that controls the pupillary light reflex; and the Ventro Lateral Pre Optic Nucleus (VLPO), a control center for sleep, are all post synaptic targets of ipRGCs.

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Functions of the intrinsically photosensitive Retinal Ganglion Cells (ipRGC)

Pupillary light reflex: The role of ipRGCs in both transient and sustained signaling of the pupillary light reflex using diverse Photoreceptor Knockout Animals (PLR). Photo transduction occurs in rod cells, which provide synaptic input to ipRGCs, which then transmit the information to the olivary pretectal nucleus in the midbrain, resulting in transient PLR at dim to moderate light intensities. In the transient PLR, glutamate is the neurotransmitter involved in relaying information from the ipRGCs to the midbrain. Sustained PLR occurs at brighter light intensities, involving photo transduction of the rod supplying input to the ipRGCs as well as photo transduction of the ipRGCs themselves *via* melanopsin.

Possible role in conscious sight: Experiments with rod less and cone less individuals revealed yet another potential role for the receptor. The photoreceptive ganglion cell was discovered to have a new function in 2007. In humans, the retinal ganglion cell photoreceptor contributes to conscious vision as well as non-image-forming processes like circadian cycles, behavior, and pupillary reflexes. Because these cells respond mostly to blue light, it has been proposed that they have a role in mesopic vision, implying that the classic hypothesis of a purely duplex retina with rod (dark) and cone (light) light perception was oversimplified. The study of rod less, cone less human patients has thus opened the door to the ganglion cell photoreceptor's image-forming (visual) roles.

The authors of the rod less, cone less human model think that the receptor could be useful in understanding a variety of disorders, including important causes of blindness around the world such as glaucoma, which affects ganglion cells. Photosensitive ganglia have been shown to play a genuine part in conscious vision in various mammals that the rats lacking rods and cones could learn to swim toward vertical bar sequences rather than a similarly luminous grey screen.

Violet to blue light: The receptor's peak spectral sensitivity, according to most studies, lies between 460 nm and 484 nm that the 460 nm (blue) wavelengths decrease melatonin twice as much as 555 nm (green) light, the photopic visual system's highest sensitivity. Using a rod less, cone less person, extremely bright 481 nm stimulation resulted in some conscious light perception, implying that some rudimentary vision was accomplished.