

A hidden photoreceptor that is not for vision in our eye: From neuronal circuits to their physiological functions.

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Retinal ganglion cells (RGCs) in the retina receive input from classical photoreceptor rod and cone through bipolar cells and lateral processing from horizontal cells and amacrine cells. Using parallel pathways, different types of RGCs transmit distinct features such as color, contrast information, the direction of moving light to the brain for pattern vision. Therefore, classic photoreceptor rods and cones are essential photon detectors located at the outer retina for image forming function. However, recent studies showed that a small population of intrinsically photosensitive retinal ganglion cells (ipRGCs) located at the inner retina using photopigment melanopsin to detect light directly. There are many subtypes of ipRGCs that innervate many brain regions and provide environmental luminance signals for circadian photoentrainment, pupillary light reflex. However, whether ipRGCs involved in other non-clock functions remain unclear. Using the genetic labeling method, we showed that single ipRGC could send collateral axons to multiple brain regions for various physiological functions. For example, light stimulation of animals' eyes results in rapid activation of hair follicle stem cells with prominent hair regeneration through the ipRGC-SCN-sympathetic nerve circuit. Furthermore, ipRGC could also modulate the daily oscillation of gut microbiota or regulate social interaction in mice. Together, our studies showed that the atypical photoreceptor in the retina could modulate many of our peripheral physiological functions with their diverse targets in the brain.