動物生理学 III　Handout No. 7

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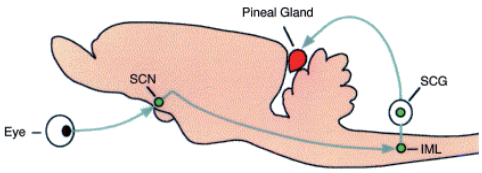

Fig. Neuronal pathway regulating pineal melatonin synthesis in the rodent.
Photic information is transmitted to the pineal through the suprachiasmatic nucleus (SCN) and the superior cervical ganglion (SCG). Abbreviation: IML, intermediolateral cell column.

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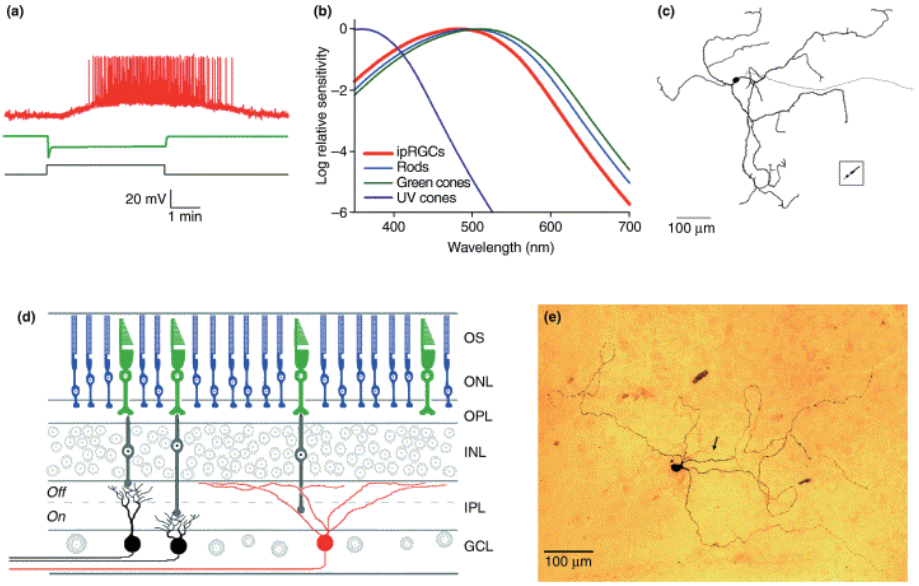

Fig. 1. Functional and structural properties of intrinsically photosensitive retinal ganglion cells (ipRGCs) in relation to those of conventional rod and cone photoreceptors. (a) Schematic representation of contrasting voltage responses of an ipRGC (red) and a cone (green) to a step increase in illumination (black). In the ipRGC, the light response is delayed, depo- larizing and includes fast action potentials. In the cone, the response is rapid, hyperpolarizing and lacks spikes. (b) Comparison of action spectra for photoreceptors of the rat retina. The similarity in the forms of the curves indicates that each is based on a photopigment using a vitamin A derivative as the chromophore. Relative displacements of the curves on the wavelength axis reflect differences in the protein (opsin) component of the photopigment. Optimal wavelengths: ipRGC (red), 484 nm; green cone (green), 510 nm; ultraviolet cone (purple), 359 nm; rod (blue), 500 nm. (c) Tracing of a rat ipRGC as viewed in the flat-mounted retina; the axon is shown in gray. The inset shows a rod photoreceptor drawn to scale. (d) Schematic vertical section of retina showing inter-relationships between ipRGCs and other photo- receptors (shown in color), other retinal cells (shown in gray or black) and retinal layers. The ipRGC (red) has a cell body in the ganglion cell layer (GCL), whereas rods (blue) and cones (green) have cell bodies in the outer nuclear layer (ONL). The ipRGC has an axon that leaves the eye to communicate with the brain, whereas rods and cones communicate only with other retinal cells through synapses in the outer plexiform layer (OPL). Rods and cones drive conventional ganglion cells (black) by way of bipolar cells (gray), which have their cell bodies in the inner nuclear layer (INL). For clarity, only the cone pathway is shown. This vertical pathway might also influence ipRGCs. Dendrites of ipRGCs stratify in the upper part ('off sublayer') of the inner plexiform layer (IPL). This is surprising because it is typical of retinal ganglion cells that are hyperpolarized by light but not of those, such as the ipRGCs, that are depolarized by light. The dendrites of ipRGCs are photosensitive and spread far more widely in the plane of the retina than do the outer segments (OS) of the classical photoreceptors, permitting greater spatial integration. (e) Photo-micrograph of a rat ipRGC, filled by intracellular dye during recording and viewed in the flat-mounted retina after histochemical processing. The axon is indicated by the arrow.

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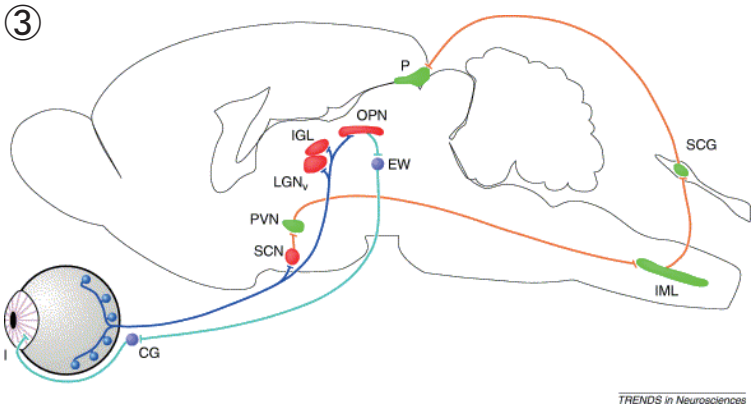

Fig. 2. Schematic summary of brain regions and circuits influenced by intrinsically photosensitive retinal ganglion cells (ipRGCs). The ipRGCs and their axons are shown in dark blue, their principal targets in red. Projections of ipRGCs to the suprachiasmatic nucleus (SCN) form the bulk of the retino-hypothalamic tract and contribute to photic entrainment of the circadian clock. The orange pathway with green nuclei shows a polysynaptic circuit that originates in the SCN and photically regulates melatonin release by the pineal gland (P) through its sympathetic innervation. Synaptic links in this pathway include the paraventricular nucleus (PVN) of the hypothalamus, the intermediolateral nucleus (IML) of the spinal cord and the superior cervical ganglion (SCG). Another direct target of ipRGCs is the olivary pretectal nucleus (OPN), a crucial link in the circuit underlying the pupillary light reflex, shown in light blue (fibers) and purple (nuclei). Synapses in this parasympathetic circuit are found at the Edinger–Westphal nucleus (EW), the ciliary ganglion (CG) and the iris muscles (I). Other targets of ipRGCs include two components of the lateral geniculate nucleus of the thalamus, the ventral division (LGNv) and the intergeniculate leaflet (IGL).

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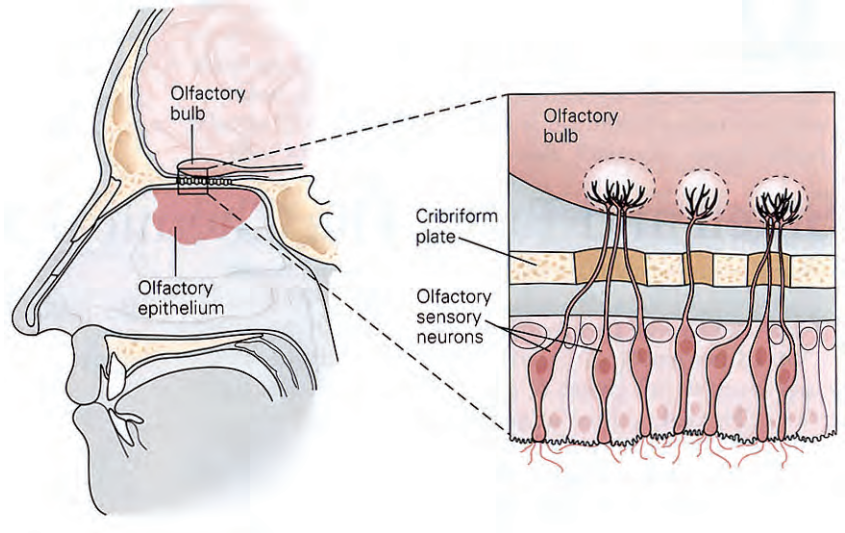

Figure 32-1 Olfactory sensory neurons are embedded in a small area of specialized epithelium in the dorsal posterior recess of the nasal cavity. These neurons project axons to the olfactory bulb of the brain, a small ovoid structure that rests on the cribriform plate of the ethmoid bone.

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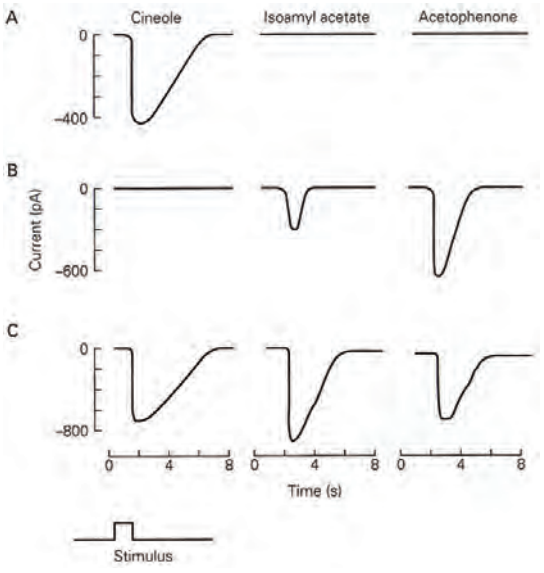

Figure 32-3 Individual olfactory sensory neurons respond to different odorants. The records are from patch clamp recordings of the responses of three neurons (A, B, C) to three odorants, each at a concentration of 5 x 10^{-4} M. One cell responded only to one of the odorants while another responded to two odorants; the third cell was stimulated by all three odorants, (Adapted from Firestein et al. 1993.)