MINIREVIEW PROLOGUE

Thematic Minireview Series on Focus on Vision
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Human visual perception is initiated through absorption of light by photoreceptors in the retina. To maintain vision, 11-cis-retinal, which is photoisomerized to all-trans-retinal, is continuously regenerated through the retinoid (visual) cycle. In the first minireview of this thematic series, entitled “Chemistry and Biology of Vision,” I describe the visual system from both chemical and structural perspectives. First, I note that a complete set of transcripts is now available for all gene products in the retina. Translated products give rise to a unique retinal architecture that includes rod and cone photoreceptor cells and the adjacent retinal pigmented epithelium. Further molecular understanding of phototransduction will require even higher resolution structures of phototransduction and retinoid cycle components obtained by x-ray and NMR techniques. This minireview also describes the chemistry of spent chromophore regeneration via the retinoid cycle. As post-mitotic neurons, photoreceptor cells regenerate chromophore and shed their outer segments throughout their life. Nothing is stated about phagocytosis of the outer segments. Finally, I summarize recent discoveries about other light-sensitive reactions governing circadian rhythm that occur in the eye as well as substantial progress in identifying novel therapies for blinding retinal diseases.

Photon absorption and visual signaling occur in the outer segments, ciliary organelles of rods and cones tightly packed with stacks of membranous discs containing extremely high densities of visual pigments and other signaling proteins such as those in the associated G-protein cascade. In the second minireview, entitled “Photoreceptor Signaling: Supporting Vision across a Wide Range of Light Intensities,” Vadim Y. Arshavsky and Marie E. Burns describe molecular and cellular mechanisms that allow photoreceptors to both detect low light levels, including single photons, and continue to rapidly and reliably signal changes in light intensity as illuminance increases over 10 orders of magnitude during the course of a typical day. Two topics are emphasized: the role of light-induced calcium changes in photoreceptor light adaptation and both mechanistic and functional aspects of the massive light-driven translocation of several major signaling proteins between photoreceptor outer segments and other compartments of these cells.

The vitamin A derivative retinal possesses a unique chemistry that makes it an ideal visual chromophore. Retinal can reversibly bind to visual pigments via its aldehyde group, and its double bonds can undergo light-dependent cis-to-trans-isomerization. Animals have evolved pathways by which dietary chromophore precursors are absorbed in the intestine, transported in the body, taken up by the eyes, and metabolized to this chromophore. Ocular 11-cis-retinal must be continu-

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Other than classical rod and cone photoreceptors, the eye also contains a recently discovered class of photoreceptors that transmit brightness information to deep centers of the brain, including the hypothalamus and tectum. The physiology and biochemistry of this “vision” are summarized in the last mini-review, entitled “Melanopsin and Mechanisms of Non-visual Ocular Photoreception,” by Timothy Sexton, Ethan Buhr, and Russell N. Van Gelder. Intrinsically photosensitive retinal ganglion cells synchronize the circadian clock to external light/dark cycles and control the pupillary light response by using a different opsin pigment, melanopsin, as their photopigment. Melanopsin photoreceptive mechanisms resemble those employed by invertebrate rhabdomeric opsins more than those used by vertebrate rhodopsin or cone opsins. The melanopsin photocycle can function independently of the classical pigment epithelium-based photocycle and may rely on a bistable sequential photoisomerization mechanism for photopigment regeneration.

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