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A spatially dependent model for photoreceptors in a healthy eye

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Abstract

Retinal degenerations include disorders that lead to photoreceptor loss. These light-sensing cells in the retina convert light into signals that are sent to the brain. There are two types of photoreceptors – rods and cones. Rods contribute to night vision while cones contribute to color vision and visual acuity. Rods and cones both have an outer segment (OS) which is the part of the photoreceptors that absorbs light. Photoreceptors undergo shedding and renewal of their OS to prevent the toxic effects of accumulated photooxidative products. An interruption in these processes leads to photoreceptor degeneration and loss. Photoreceptor loss is common to degenerative eye disorders such as retinitis pigmentosa, age-related macular degeneration, and cone-rod dystrophy. Research in this field is focused on developing strategies to delay or prevent the onset of photoreceptor degeneration but, there is currently no cure for diseases linked to photoreceptor degeneration. There exist mathematical models of regions of the retina in retinal development, health, and disease. Most of these models are not spatially dependent. To our knowledge, there is no mathematical model of the physiology of photoreceptors in a healthy eye that incorporates the interplay between the spatial density distribution, OS length, and nutrient source. We have developed a novel mathematical model of these processes. Our results illustrate the beneficial role of mathematical modeling in this research effort.