Vertebrate Photoreceptors

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Editors

Vertebrate Photoreceptors

Functional Molecular Bases

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Preface

Our vision entirely relies on photoreceptors in our retina. The main role of these cells is to transduce the capture of a photon into an electrical signal that is processed in the retina and sent to the brain to induce the sensation of vision. In the retina, cells are layered to process the visual information step by step. This layered structure of the cells is advantageous for the study of photoreceptors: they all are in the outermost layer of the retina. Thanks to this layered structure, we can identify a photoreceptor easily and reliably and measure its light response, and we can collect photoreceptors in a quantity large enough and pure enough for biochemical studies. Furthermore, photoreceptors are polarized and each part is compartmented: the outer segment, the inner segment, the cilia connecting the outer segment and the inner segment, the ellipsoid, the myoid, the nucleus, and the synaptic terminal. Each part can be recognized easily under a light microscope, which makes it straightforward to study the specialized role of each compartment. Thanks to all of these advantages, photoreceptors have been studied from various perspectives including protein chemistry, biochemistry, electrophysiology, cell biology, and developmental biology utilizing a variety of simple and sophisticated experimental methods. Mutant animals with defects in genes that are expressed only in photoreceptors allow investigators to circumvent lethality issues. Molecular genetics tools such as photoreceptor-specific promoter sequences are available to express mutant proteins specifically in photoreceptor neurons. Therefore, investigators have been able to exploit powerful molecular genetics tools to manipulate the expression or deletion of a normal or mutant protein to be able to perform in vivo biochemical and physiological studies on the molecular mechanisms underlying the function and the structure of vertebrate photoreceptors. Because photoreceptors are critical for our vision, gene mutations that cause photoreceptor dysfunction and/or degeneration lead to visual impairment or blindness in humans. Subjugation of photoreceptor diseases such as retinitis pigmentosa and macular dystrophy cannot be achieved without a correct understanding of photoreceptor development, photoreceptor metabolism, survival and death of photoreceptor neurons, and function. In addition, stem cell and iPSC technology have provided a foundation for realizing therapies

based on regeneration and tissue design for currently incurable photoreceptor and retinal degeneration diseases.

This book is meant to provide a series of comprehensive views on various important aspects of vertebrate photoreceptors. The chapters are selected from fields of studies that have contributed a broad understanding of the birth, development, structure, function, and death of photoreceptor neurons. The underlying common word in all of the chapters that is used to describe these mechanisms is "molecule". Only with this word can we understand how these highly specific neurons function and survive. We hope that this theme will be evident throughout each of the chapters in the book. It is challenging for even the foremost researchers to cover all aspects of the subject. We hope that understanding photoreceptors from several different points of view that share a molecular perspective will provide readers with a useful interdisciplinary perspective.

Photoreceptors are the most deeply studied sensory receptor cells, but readers will find that many important questions remain. We still do not know how photoreceptors, visual pigments, and their signaling pathways evolved, how they were generated and how they are maintained. This book will make clear what is known and what is not known. As has always been the case, pioneering studies in photoreceptors will surely guide the studies of sensory cells in general. In addition, because the retina is a part of the central nervous system, developmental aspects of photoreceptors will provide insights into developmental mechanisms of the brain. Photoreceptors, how they work, how they develop, and how they stay alive are topics of intrinsic general interest.

We hope that this book will help readers to develop an integrated understanding of vertebrate photoreceptors as a whole. In this sense, the book will be a guide for graduate students in studies of photoreceptors and other sensory cells. For the same reason, we hope that this book will help to stimulate multidisciplinary collaboration among researchers with different types of expertise and that such studies may open up new and important avenues of research in this field.

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