

# Biochemistry of the Eye

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### **Biochemistry of the Eye**

Elaine R. Berman

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# Biochemistry of the Eye

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Dedicated to the memory of  
Professor Isaac C. Michaelson

# Preface

My first introduction to the eye came more than three decades ago when my close friend and mentor, the late Professor Isaac C. Michaelson, convinced me that studying the biochemistry of ocular tissues would be a rewarding pursuit. I hastened to explain that I knew nothing about the subject, since relatively few basic biochemical studies on ocular tissues had appeared in the world literature. Professor Michaelson assured me, however, that two books on eye biochemistry had already been written. One of them, a beautiful monograph by Arlington Krause (1934) of Johns Hopkins Hospital, is well worth reading even today for its historical perspective. The other, published 22 years later, was written by Antoinette Pirie and Ruth van Heyningen (1956), whose pioneering achievements in eye biochemistry at the Nuffield Laboratory of Ophthalmology in Oxford, England are known throughout the eye research community and beyond. To their credit are classical investigations on retinal, corneal, and lens biochemistry, beginning in the 1940s and continuing for many decades thereafter. Their important book written in 1956 on the *Biochemistry of the Eye* is a volume that stood out as a landmark in this field for many years.

In recent years, however, a spectacular amount of new information has been generated in ocular biochemistry. Moreover, there is increasing specialization among investigators in either a specific field of biochemistry or a particular ocular tissue. Therefore, subsequent books on the biochemistry of the eye have, of necessity, been multi-authored (Graymore, 1970; Anderson, 1983).

We have now in some ways come full circle. Notwithstanding the unique structures, functions, biochemical properties, and metabolic characteristics of individual ocular tissues, it is becoming increasingly evident that they also have many features in common. These include well-known pathways of glucose oxidation, energy production, and ion transport; in addition, newer areas of research have revealed a wide variety of other metabolic activities shared by many ocular tissues such as receptor-mediated membrane signal transduction systems, G proteins, defense mechanisms against light and oxygen toxicity, drug-metabolizing and -detoxifying systems, eicosanoid production, and many more. The scope of biochemistry has expanded considerably in recent years and now includes two major disciplines: cell biology and molecular biology. Recombinant DNA technology has been successfully applied to the lens for nearly a decade and is now having its impact on other ocular tissues such as the retina. The amino acid sequences of proteins can be deduced, gene structures studied, and gene localization determined by *in situ* hybridization. Increasing numbers of ocular proteins are being cloned and sequenced, and an understanding of disease processes at the molecular level in inherited disorders such as gyrate atrophy and blue cone monochromacy has already been achieved.

The emphasis in this volume is on work published during the 1980s, and it includes literature appearing until summer of 1989. Review articles summarizing earlier investiga-

tions are cited in appropriate sections. A major attempt has been made to cover material in depth and yet with maximum brevity, which is no simple task. Early responses to preliminary drafts of several chapters prompted the inclusion of an introductory chapter on selected topics in biochemistry relevant to the eye. The six chapters that follow are descriptions of individual ocular tissues beginning with the tear film and continuing posteriorly to the retina.

Many friends and colleagues have given of their time and patience at various stages during completion of the manuscript. Their comments, suggestions, permissions to use published illustrations, as well as access to manuscripts in press are gratefully acknowledged. I especially wish to thank Gene Anderson, Yogesh Awasthi, Wolfgang Baehr, Endre Balazs, Mike Berman, Tony Bron, Jerry Chader, Hugh Davson, Darlene Dartt, Ed Dratz, Lynette Feeney-Burns, Steve Fliesler, Ilene Gipson, Greg Hageman, John Harding, Paul Hargrave, Diane Hatchell, Carole Jelsema, Gordon Klintworth, Baruch Minke, Oded Meyuhas, Tom Mittag, Robert Molday, Beryl Ortwerth, David Papermaster, Alan Proia, John Scott, John Tiffany, Brenda and Ramesh Tripathi, Nicolaas van Haeringen, and Richard Young. In addition, a special note of thanks goes to Mrs. Bela Eidelman for expert secretarial assistance.

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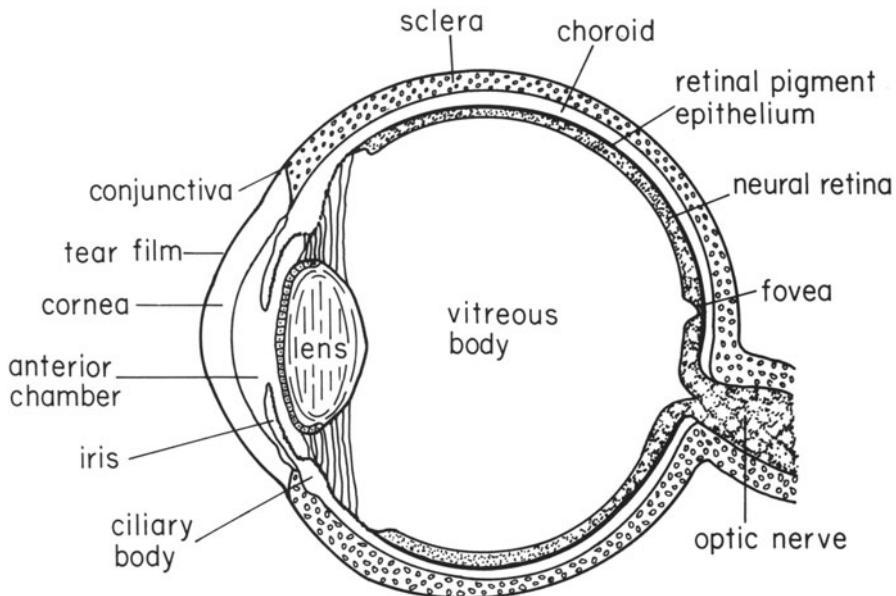
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Elaine R. Berman

# Introduction

## GROSS ANATOMY AND STRUCTURE OF THE EYE

Diagrammatic horizontal cross-section of a vertebrate eye. The primate eye is approximately spherical in shape, measuring 24 mm in diameter in human adults. The posterior 85% of the globe is covered by the *sclera*, a dense, white, opaque protective coat that is not directly involved in the visual process. The *cornea*, which is lined by a thin (7- to 8- $\mu\text{m}$ ) *tear film*, covers the remaining anterior portion of the globe. It is a uniquely transparent tissue with high refractive power and unusual metabolic characteristics. Its posterior surface is bathed by the *aqueous humor* secreted by the *ciliary epithelium* into the anterior chamber. Light passes through both of these transparent media and reaches another transparent tissue, the *lens*, whose function is to focus incoming images onto the retina. Light then passes through the last of the transparent media, the *vitreous*. This viscous gel occupies about 90% of the total volume of the eye; it provides structural support for surrounding ocular tissues and also serves as a shock absorber against mechanical impact. All of these transparent media are secondary to the neural *retina*, the center of





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the visual process. It is here that light is absorbed by the photoreceptors (specialized organelles of the outermost layer of the neural retina) and converted into an electrical signal in a process called phototransduction. Light initiates a series of events that triggers hyperpolarization of photoreceptor plasma membranes. This signal reaches the photoreceptor synaptic region; further processing and integration take place in the secondary neurons, and the final signal is transmitted through the ganglion cell layer to the brain.

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