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BOOK REVIEW

David A. Atchison, George Smith. *Optics of the Human Eye (2nd edition)*. CRC Press; 2023.

Vision is a very complex process, where the visual system transforms light stimuli into information that is processed by the brain, adjusting extraordinarily to changes in the environment, as well as within the eye, adapting continuously to maintain a match between visual coding and visual environment. Such a complex process is done in different stages, beginning with the eye working as a sophisticated imperfect optical system projecting images of the outer world onto the retina, and ending with the fast processing of huge amounts of information. Understanding the optical structure and properties of the human eye is essential to understand the visual process, its failures and possible therapeutical approaches. The first edition of *Optics of the human eye* (Atchison & Smith, 2000) was already a very useful resource to those interested in the optics of the visual process, from optometrists, ophthalmologists, vision scientists, optical physicists, and students of visual optics and optical engineering, eventually becoming one of the most widely used books in the field. The book was split in five big sections covering the basic optical structure of the human eye, image formation and refraction, light and the eye, aberrations and retinal image quality, and the aging eye. An excellent summary of the eye as an optical system.

This second edition comes as a detailed update, which covers important areas that have experienced significant developments in the last 20 years. Novel imaging and biometry techniques have allowed a deeper knowledge of the basic optical structures of the human eye, particularly the cornea and the lens, both, the unaccommodated and accommodates states, as shown in Chapter 2. Updates on the description of the different axes of the eye covered in Chapter 4, in combination with the paraxial schematic eyes section (Chapter 5), make them a very comprehensive and informative tool. Special attention is given to the image formation on the eye and refractive errors (Chapters 6 and 7), particularly Myopia, due to its increased prevalence and association with severe ocular pathologies. Refractive error measurement methods section (Chapter 8) has been nicely updated, and objective refraction techniques section includes now different monochromatic aberrometry based methods (Hartmann-Shack wavefront sensing and laser ray tracing), and their clinical applications. Accuracy and reliability of current clinical refraction methods are analyzed, identifying the factors affecting refraction, which novel objective refraction techniques aim to compensate using motorized phoropters in combination with automatic algorithms, hybridizing objective and subjective measurements within the same instruments, or using new visual tasks beyond letter identification to obtain the refractive error subjectively. The defocused paraxial image formation and its optical correction description (Chapters 9 and 10) has been greatly widened, with specific sections focused on lens design, beyond ophthalmic lenses correction. The book covers now a brief approach to monochromatic Contact and Intraocular lenses optics design, as well as Spectacle lens design, a useful tool to navigate the increasing number of optical designs in the market (ranging from mono- to multifocal, refractive to diffractive designs).

Similarly to the previous edition, a thorough review of the most important light-tissue interactions and its quantification is comprised in different chapters of section Light and the Eye, covering Photometry, including a new section on Colorimetry, the Passage of Light into the Eye, and light level calculations at the retinal level. Chapter 14, light interaction with the fundus, leaves out some of the last discoveries about photorreceptors and fundus imaging developments, but, on the other hand, the Stiles-Crawford Effect and retinal directionality are covered in detail in an updated and expanded section.

One of the most useful sections of the previous edition was the one dedicated to ocular aberrations (mono- and chromatic) and retinal image quality, and this is probable the section that has undergone the most considerable revision. When the first edition was published, aberrations and their impact was studied only in laboratory settings, and described using a Taylor polynomial base. Now, ocular aberrations are measured in the clinic, and described using the more intuitive Zernike polynomial expansion. Furthermore, ocular aberrations can be manipulated to better understand their effects on visual performance and perception, to improve different imaging techniques, and to develop novel treatments (ie. Persbyopia, Myopia). This new edition covers this ocular aberrations description in detail (Chapter 15), comparing Taylor and Zernike expansions, while keeping Seidel expansion to show surface contributions to aberrations, including asphericity, and the influence of monochromatic aberrations and its correction in visual performance.

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Described aberrations measurement techniques are Hartmann-Shack wavefront sensing and Laser Ray Tracing, although the focus is on the first one, incorporating now the magnitude of both, central and peripheral aberrations. Optical model eyes section include wavelength dependency and peripheral optics, as well as contributions of gradient index. Chapter 16 covers now customized eye models, and a very useful section describing the different characteristics of eye models and how to use them in monochromatic conditions. Chromatic aberrations are discussed detail in Chapter 17: its measurement, compensation, modeling and impact on visual quality, including a new section on Estimating Lengths is Eyes. Polychromatic optical and visual quality are not fully covered in detail, nor their impact on optical design (i.e. IOLs). Similarly, the retinal image quality section focus on monochromatic optical quality, describing in a very comprehensive way the line between the Point Spread Function and the different optical and visual quality metrics, including the Visual Strehl metric, one of the most widely used nowadays to predict visual performance from ocular aberrations. The aging eye is covered in an updated last Chapter, which follows changes associated with age in all ocular optics and components, as well as the way of modeling them using schematic eyes.

This second edition summarizes all recent details on the optical structure and properties of the human eye, and is an useful tool for those interested in the understanding of the versatile optical instrument, which is the eye.

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