ANSI/IES LS-7-20

Illuminating ENGINEERING SOCIETY

LIGHTING SCIENCE:
VISION – EYE AND BRAIN

AN AMERICAN NATIONAL STANDARD

Approved American National Standard

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Prepared by the
IES Vision Science Committee

Approved by the IES Standards Committee October 11, 2019 as a Transaction of the Illuminating Engineering Society.

Approved February 7, 2020 as an American National Standard.

Published by the Illuminating Engineering Society, 120 Wall Street, New York, New York 10005

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Printed in the United States of America.

ISBN# 978-0-87995-348-5

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The eye is the window to the world.
– Lael Wertenbaker, 20th century author

1.0 Introduction and Scope

1.1 Introduction

The most complex of the senses, vision is perhaps the most important mechanism we have for perceiving the world. Vision results from the interaction of eye and brain. From vision come perceptions, and from perceptions we build our individual worlds, always largely affected by the luminous environment. An understanding of this process will guide the design of that environment, and to consider the eye and brain as a single unit is the best way to understand the biological machinery that provides vision.[1]

The eye contains components that work together to produce an image of the external world on a layer of photoreceptive cells in the retina at the back of the eye. This layer encodes information about this image as neutral signals that are conducted to the center of the brain, combined with similar signals from the other eye, and processed further, with the result conducted to the area at the back of the brain that is primarily responsible for visual processing. Along the way, signals are generated to move the eyes in order to track visual targets, and to change the shape of the eye's lens to bring the visual target into sharp focus. A combination of mechanical, chemical, and neural mechanisms change the system sensitivity so that is can operate in light levels ranging from starlight only to noon sunlight. Complex neural circuitry is responsible, in part, for motion detection, color vision, and pattern recognition.

1.2 Scope

The purpose of this document is to describe and explain the human visual system, including its components in the eye and the brain. The structure and function of these various components are explained, as well as the ways in which individual people differ in their visual abilities. It is important to note that this document is not intended to provide comprehensive coverage on the subjects contained herein.

2.0 Ocular Anatomy and Function

This section describes the components of the eye, giving their structure and their various mechanical, optical, and neural operation functions. **Figure 2-1** shows the anatomical structure of the eye-brain system. The general structure of the visual system is a series of layers that receive, process, and transmit visual information. These layers are connected by neural pathways that convey visual information from one layer to the next. The principal layers are the retina, located in the eye; the lateral geniculate body, located in the brain center; and the primary visual occipital cortex, located at the back of the brain. Though visual information is transmitted by the visual cortex to "higher" parts of the brain, the cortex is usually considered the last stage of the visual system proper.

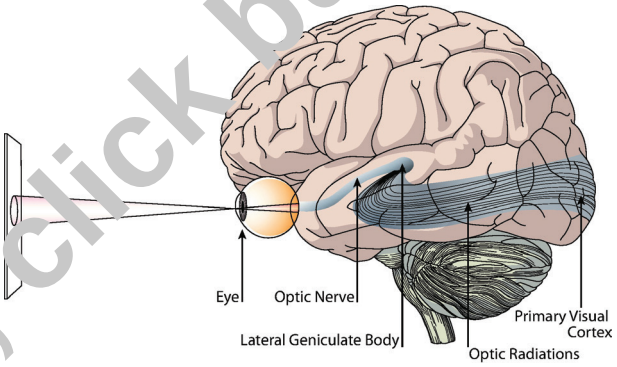

Figure 2-1. The eye and the principal components of the brain that comprise the human visual system. (Image redrawn from original, © David H. Hubel)

2.1 Structure

The anatomy of the eye consists of components that do the following: provide and hold its shape; comprise the optical elements that form an image; control the amount of optical radiation that enters the eye; encode the image; and provide for movements required to track the image. **Figure 2-2** shows the general structure of the eye. As described below, much of the eye functions purely with the purpose of maintaining a focused image of the world on the retina at the back of the eye.

2.1.1 Tunics. The *sclera* is the relatively thick, tough, opaque, white, outer layer of the eye. Filled with blood vessels, the sclera is visible from the front and is what is often called the "white of the eye." The choroid is a dark, thin layer just inside the sclera. It covers most of the back portion of the eye and brings blood vessels to the