ANATOMY OF THE HUMAN CRYSTALLINE LENS

BY

Adel Mahmoud Abdel Aziz

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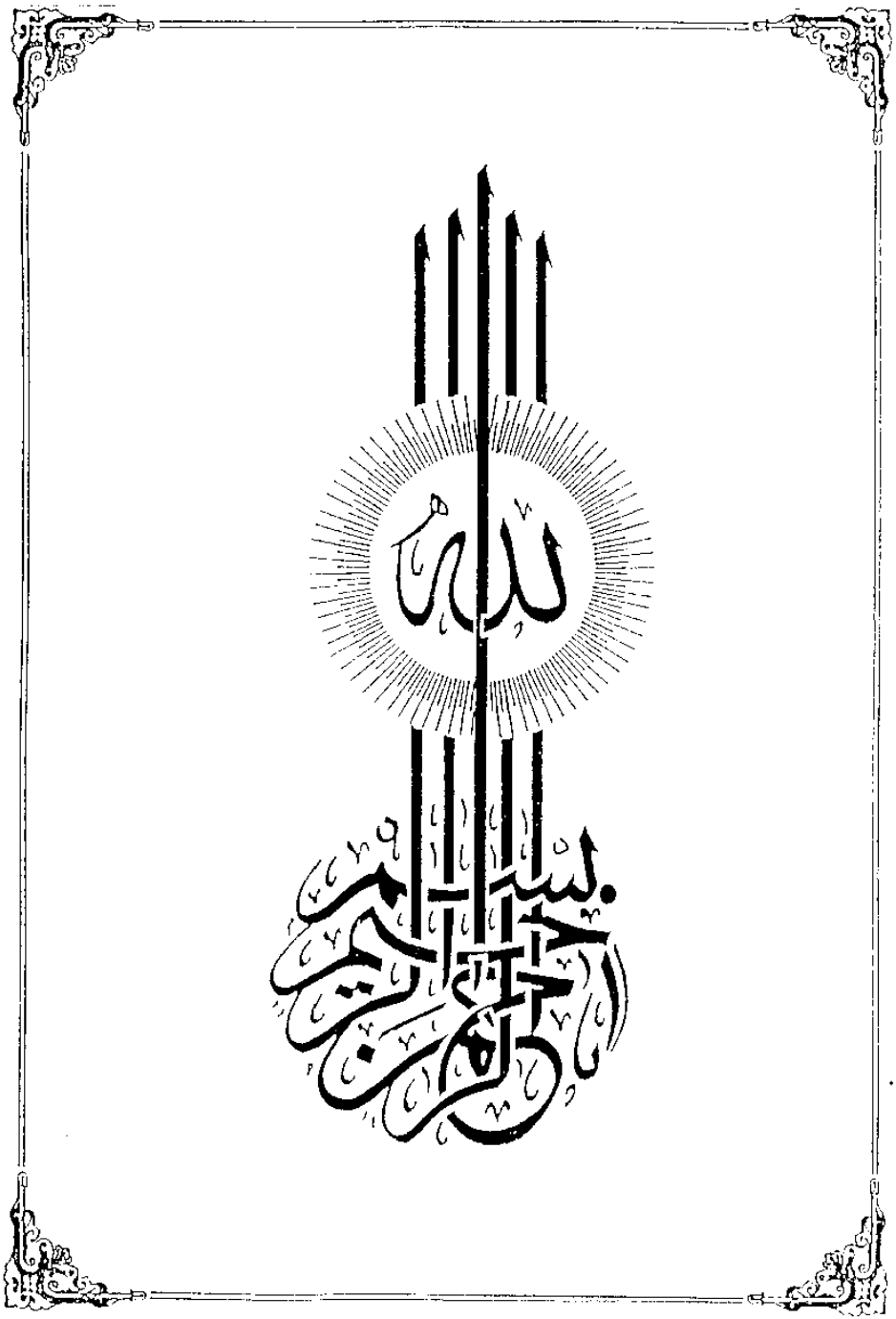

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Historical Introduction

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From very early times many misconceptions have arisen as to the existence, position, nature and function of the crystalline lens.

To the ancient Greeks the cavity of the eye was occupied by an undifferentiated humour, & Aristotle considered the lens a post-mortum appearance - a morbid accumulation of phlegm.

The Alexandrian School, however, recognized the existence of the 'crystalloides' placing it in the centre of the eye & endowing it with the importance of being the essential seat of vision. These assumptions were generally accepted for centuries. Thus writers on optics in the 13th century, such as Roger Bacon, and anatomists up to the 16th century, such as Leonard da vinci & Andrea Vesalius, maintained the Arab view of its central position. It is true that in the 12th century Ibn Rushd suggested that vision was the function of the retina, but it was not until the 16th century that Felix Platter showed that the lens was merely a dioptric medium. Moreover, it was not until

the appearance of the classical book of Fabricius ab Aquapendente, a work based on the careful dissection of human & animal eyes, that the lens was figured as lying in its correct position immediately behind the iris.

The lens was considered a homogeneous humour, but the poineer Dutch microscopist, Antony Van Leeuwenhoek (1684) described its structure as being made up of "orbicular scaly parts lying upon one another". This knowledge remained for almost a century until John Hunter (1728-93), the great English comparative anatomist & surgeon, gave the first reasonably accurate account of its "fibrous" appearance in the eye of a cuttlefish.

In the following century when the microscope came into general use, knowledge of its minute anatomy progressed.

The epithelium lining the anterior capsule was described by Wilhelm Werneck of Salzburg (1835), that lining the post. Capsule by Jakob Henle of Zurich (1841-52) while the capsule itself was adequately described by G.Valetin (1842).

The lens fibres were described by Johann Christian Reil of Halle (1784) & in the following century their arrangement in the architecture of the lens was clarified by a large number of workes.

A comprehensive & accurate description of a section in the lens was available by Julius Arnold of Heidelberg in the 1st edition of his book "Graefe-Saemisch Handbuch".

Carl Rabl of Leipzig (1898-1900) studied the embryology & made an elaborate contribution to comparative anatomy of the lens.

A correct estimate of the form & appearance of the lens is difficult to obtain by histological methods (deformity & shrinkage) or by a detachment from its normal connections (altration in its shape).

The introduction of the slit-lamp added a new tool to the study of the lens whereby the configuration of its various layers was demonstrated in the living eye, a study in which the greatest single contributor was Alfred Vogt of Zurich (1921). His

assiduous & accurate observations have contributed so greatly to our knowledge of the form, the development & the pathology of this tissue.

More recently, our knowledge of the fine anatomy has been supplemented by observations with the phase contrast & electron microscope.

The structure which suspends the lens from the ciliary body is difficult to see adequately and more difficult to analyse; for this reason, innumerable descriptions differing in many essentials have been published from time to time not only as to its nature but also concerning its three-dimensional arrangement. The older anatomists in their examination of gross specimens considered that it was a membranous structure closely related to the vitreous body. The first adequate description was due to the great French surgeon, Antoine Maitre-Jan (1707), who wrote that the lens was firmly kept in place by "the membrane of the vitreous body "which divides into two parts, one of which continues over the anterior part of the vitreous while the other passes over the

lens which "l'embrasse de telle forte qu'il ne peut changer de situation. This view was maintained by Petit (1723), Petit, injected air into the potential space between the two, blowing up artificially the space subsequently called the canal of Petit. Hannover (1845-52) showed that a similar injection could be made around the periphery of the lens between the anterior and posterior leaves of the suspensory ligament, thus artificially producing a second canal, the canal of Hannover. A suspensory mechanism consisting of delicate membranes running from the ciliary body to the capsule of the lens, received its first full description from J.G. Zinn (1753), who appreciated its strand-like character and maintained that it was differentiated from the vitreous as a separate structure passing from the region of the ora serrata to the periphery of the lens.

The next stage in our knowledge of the zonule followed the introduction of the microscope. The process of histological fixation, of course, coagulated

the gel so that the membranes of the older anatomists appeared as systems of isolated fibres without any interconnecting matrix. An immense amount of time and labour were expended in the description of elaborate schemes of their architecture, how they ran, how they crossed each other, and how they aggregated into systems. An open fibrillar structure traversing spaces which formed a direct continuation backwards of the posterior chamber thus became the conception generally accepted by anatomists with only a few isolated protests.

The next advance to knowledge depended on the appearance of the zonule as seen with the better illumination and magnification afforded by the slit-lamp. As in the case of the vitreous body, the optical appearance of individual and separate fibres seemed to be confirmed. More recently, examination of the fresh structure by improved optical methods, as well as investigations by the phase-contrast and electron microscopes, have consolidated our knowledge and have demonstrated that the original view was more correct. Embryologically, we would expect the zonule to be of

the same essential structure as the vitreous, and examination of the fresh eye shows a strong structural resemblance. The material of which the zonule is composed is consolidated into strands or fibres, but these are probably of the same nature as the fibrillae of the vitreous body although more compactly aggregated together, and between them in the fresh state there lies a clear, transparent, nonstaining, gel-like substance, showing physico-chemical properties somewhat similar to the vitreous gel.

Embryology

Embryology

Development of the Lens:

At a very early stage in embryonic life there is nothing to differentiate the surface ectoderm in the region of the future eye, the whole of the ectodermal covering is uniformly composed of a single layer of cubical cells. As soon as the optic vesicle approximates the surface, however, changes begin to occur in the ectoderm. These changes involve a thickening of the epithelium to form the lens plate and its invagination into the lens vesicle from which the lens is ultimately evolved, while the surface epithelium, closing up once more over the invaginated vesicle, remains to form the epithelum of the cornea.

The development of the lens may be divided into two stages: the formation of the lens vesicle, and the development of the lens fibres with the evolution of the nuclei.

Up to the 4 mm. stage the surface ectoderm is composed of a single layer of cubical cells and is

entirely undifferentiated, but as soon as the optic vesicle approaches it (about the 4.5 mm. stage), the surface cells immediatly overlying the vesicle, while still remaining arranged in a single row, assume a columnar form and undergo mitotic division, so that their nuclei become arranged unevenly and appear on section to lie in several rows. In this way a thickening of the epithelium is formed; the lens plate (This thickening is believed to occur as a result of the action of inducer substances produced by the adjacent neuro ectoderm. Hogan; 1971).

Shortly after its appearance (about the 5 mm. stage) the lens plate begins to invaginate; making a depression on the surface towards the lower part of the plate, the lens pit. The walls of the pit are still composed of cells arranged in a single row, although the nuclei still lie at different levels. This pit rapidly deepens by cellular multiplication, and as invagination progresses it remains conneced to the surface ectoderm by an ever-narrowing stalk until at the 7 mm. stage the lumen of the stalk