

# *Texts and Documents*

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## G. B. AIRY'S MODEL EYE

by

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FOLLOWING Kepler's theoretical account of the formation of the retinal images, the first practical investigations appear to be those of the Jesuit mathematician, Christopher Scheiner (1575—1650).<sup>1</sup> Scheiner was probably the first to construct a model eye, complete with cornea, crystalline lens, spherical glass retina, and two chambers filled with water.<sup>2</sup> Shortly after Scheiner's experiments, many model eyes subsequently made their appearance and were constructed by anatomists, philosophers, and opticians, each model serving to demonstrate a particular optical principle or philosophical concept.<sup>3</sup> By the end of the eighteenth century, the model eye was mainly employed to demonstrate the principles of vision generally, and the optical conditions and corrections of myopia, presbyopia, and aphakia.

In 1828, George (later Sir George) Biddell Airy (1801—1892), having been Lucasian Professor of Mathematics and Plumian Professor of Astronomy at Cambridge, was appointed, at the age of 27, Director of the new Cambridge University Observatory. The letter which follows, describing the construction of a model eye, was written during his first year at the Observatory, in answer to an enquiry from Dr. Dionysius Lardner (1793—1859) concerning the model. From the general tone of Airy's letter to Lardner, it would appear that Airy had constructed the eye a considerable time before 1828. Lardner, who in 1827 had been elected to the chair of natural philosophy and astronomy, at the newly founded London University (now University College), may have requested information about the model eye for demonstration purposes. The letter (fig. 1), which is now in the Wellcome Historical Medical Library, has not previously been published, and reads as follows:—

Observatory Cambridge, April 25, 1828

My dear Sir,

To illustrate the functions of the eye I merely constructed something as much resembling the eye in form and operation as I could devise. My eye was a foot in diameter, and held about threequarters of a common pailful of water, but I should think that for your purposes a larger eye would be necessary. It was constructed of copper excepting a hole (I forget the size) in front, which was filled up with a glass like a watch-glass *ground* to its proper convexity; and a hole behind which was filled up with a glass—as its accuracy of form was not so important it was merely *blown*. Upon this was pasted lawn paper for the retina. In place of the iris was a copper partition with a circular hole for the pupil and a cell to receive a convex lens representing the crystalline. The whole cavity was filled with water, for pouring in which a hole was left at the top. The figure is a section. I had three lenses for crystallines, one to represent the eye in a state of good vision, one to make it longsighted,<sup>4</sup> and one to make it shortsighted: and had a huge pair of spectacles with lenses which corrected these defects. Also one lens to produce distinct vision when the crystalline was removed, to imitate the couched eye. Also a large telescope for my eye to look through at a distant object. The whole of these imitations succeeded

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perfectly. I should have some difficulty in ascertaining the focal length, curvatures, etc., of the glasses: I only recalled that the lenses for the crystalline were of focal lengths  $2\frac{1}{2}$ , 3,  $3\frac{1}{2}$ , inches respectively *in air*. However the whole thing was made upon conclusions (which you can repeat quite as correctly as I can) and so constructed it answered well.

'I shall not fail to ask you for a rep[ort of you]r apparatus when I come to town.

I am Sir,

Yours very truly,

G. B. Airy

Airy's model eye may be compared with the somewhat elaborate model constructed and described<sup>5</sup> towards the end of the eighteenth century by George Adams the Younger (1750—1795), optician and Mathematical Instrument Maker to King George III.

Whereas Adams had been content to make the front of his artificial eye in a 'piece of glass placed on which the form of the eye is painted, a part being left transparent, to represent the pupil,'<sup>6</sup> Airy was anxious to make an accurate representation, i.e. having a cornea ' . . . *ground* to its proper convexity', rather than merely 'blown'. The idea of using three lenses to represent the crystalline lens had been previously described in Adams' account. In Airy's model, the lenses could be inserted into a cell through the hole in the top of the eye, whereas in the model constructed by Adams, the three lenses were inserted within the globe, and brought in front of the hole (representing the pupil), as each one was required.

Airy may have constructed his model eye for teaching purposes, or perhaps during his student days. Evidently he did not demonstrate the optical defect and correction of a stigmatism.

Airy, although primarily an astronomer (Astronomer Royal, 1835—1881), had a particular interest throughout life in physiological optics, having made the important discovery of astigmatism in his own eye, and corrected this defect with the first cylindrical lens.<sup>7</sup> Other items, specifically related to vision, are mentioned throughout his autobiography,<sup>8</sup> in addition to his later, almost classic, illustrated description of the visual phenomena associated with migraine.<sup>9</sup>

At all events, the model eye provides an additional demonstration of Airy's interest in the eye and vision generally.

#### ACKNOWLEDGEMENTS

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#### REFERENCES

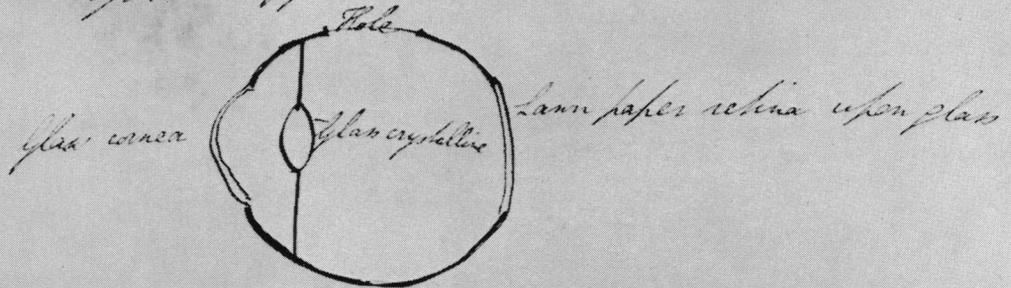
1. For a survey of the early history of the model eye, see S. L. Polyak, *The Retina*, Chicago, 1941, pp. 136–139.
2. *Ibid.*, p. 138.
3. The model eye could be used for demonstrating the formation of the retinal image, while a second use was in attempting to settle a philosophical dispute, concerning the concept of 'species'. Rees (Dr. Abraham Rees's *Cyclopaedia of Arts*, art. "Species", 1819) in summarizing the main arguments states that whether the species of objects which were said to give the soul an occasion of seeing, was 'an effusion of the substance

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of the body, a mere impression which they make on all bodies under certain circumstances; or whether they are not some more subtile body such as light,' concludes that 'the moderns have decided the point by the invention of artificial eyes, in which the species of objects are received on paper, in the same manner as in the actual eye.' A similar account is also to be found in the *Encyclopedia Britannica* (7th edition).

4. Airy's illustration of longsight would refer to presbyopia rather than hyperopia. Admittedly hyperopia had by that time been described in England by the physician W. C. Wells (1757–1817) (*Phil. Trans.*, 1811, 101, 379) and surgeon, James Ware (1756–1815) (*Phil. Trans.*, 1813, 103, 31) but these (possibly the first two accounts in the literature) are two isolated cases.
5. George Adams, *An Essay on Vision* . . . London, 1789, p. 50, Fig. 7; 2nd edition 1792 p. 52, Fig. 7. An example of this type of model is to be seen in the Science Museum, South Kensington, London (exhibit Inv. 1925–137) constructed by W. & S. Jones, opticians and instrument makers, who succeeded George Adams in business.
6. *Ibid.*, 1st ed., p. 50.
7. G. B. Airy, *Trans. Camb. phil. Soc.*, 1827, 2, 267–271. Further accounts of his astigmatism appeared in *Trans. Camb. phil. Soc.*, 1849, 8, 361–362, and 1879, 12, 392–293, and in *Proc. Camb. phil. Soc.*, 1876, 2, 47–49, and 1886, 5, 132–133.
8. *Autobiography*, edited with a personal sketch and bibliographical appendix, by Airy's eldest son, Wilfrid Airy, Cambridge, 1896, pp. 35, 63, 65, 220, 237, 244.
9. G. B. Airy, *Phil. Mag.*, 1865(4), 30, 19. Airy's description of the visual phenomena associated with migraine includes the scintillating scotoma and fortification spectrum ' . . . zigzags that nearly resemble those in the ornaments of a Norman arch. . . they tremble strongly . . . appearance of scarlet colour on one edge . . . ' The migraine attacks lasting from twenty to thirty minutes were not accompanied or followed by headache. On one occasion he experienced an attack while conversing with an acquaintance in a railway-carriage. Airy reports that 'I soon became painfully sensible that I had not the usual command of speech, that my memory failed so much that I did not know what I had said or had attempted to say, and that I might be talking incoherently.' As a result of this, Airy was probably led to his conclusion that 'the seat of the disease is in the brain . . . and that the ocular affection is only a secondary symptom.' His son, Hubert Airy, M.D., provided one of the first detailed analyses of the signs and symptoms of migraine, including a historical account of the condition. (See *Proc. roy. Soc.*, 1870, 18, 212–216, and *Phil. Trans.*, 1870, 160, 247–264.)

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Figure 1

Sir George Biddell Airy's letter to Dr. Dionysius Lardner from the Observatory, Cambridge,  
 25 April 1828. Includes a sketch of Airy's model of the eye.  
 (By courtesy of the Wellcome Trustees)

(see p. 198)