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XLIX. *On that Power of the Eye, by which it is adjusted to see Objects distinctly at different Distances. By*
Ez. WALKER, Esq.

To Mr. Tilloch.

SIR,

PHILOSOPHERS have varied much in their opinions, for near two hundred years, respecting that power of the eye by which it is adjusted to see objects distinctly at different distances.

Kepler, M. le Cat, and some other philosophers supposed, that when we view distant objects the eye contracts itself and becomes flatted, by which means the distance between the crystalline lens and the retina is decreased; but when near objects are seen, the axis of the eye is lengthened, and this distance is therefore greater. Des Cartes, Dr. Pemberton, and Dr. Young, have adopted the opinion that the form of the crystalline lens alters with the distance of the object from the eye. Dr. Porterfield thinks, that the adjustment of the eye is produced by an alteration in the curvature of the cornea and a motion of the crystalline lens. De la Hire imagined, that the eye undergoes no change, except the contraction and dilatation of the pupil. Mr. Ramsden and Mr. Home conclude from their experiments, that the adjustment is produced by three changes in the eye; a motion in the crystalline lens, an elongation of the axis of vision, and an increase of curvature in the cornea. Haller, Smith, Jurin, Monro, and many others, have also written upon this subject. But as none of the hypotheses hitherto advanced have been demonstrated, either by decisive experiments or from the known laws of dioptrics, this property of vision seems still to remain in much obscurity.

On entering upon an inquiry of this nature, it will be necessary to reject all suppositions that are not conformable to those beautiful mechanical laws which are seen in every other part of the animal œconomy. I cannot therefore suppose that the whole globe of the eye alters its form
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every time we view objects at different distances. Nor does it appear probable that the power of adjustment lies either in the vitreous humour or in the crystalline lens, for they are too dense to admit of that infinite variety of changes which the eye undergoes every day.

As the crystalline lens alone is sufficient to form a distinct image of an object upon the retina, it is therefore very reasonable to suppose that the aqueous and the vitreous humours are designed for other purposes than merely to act as refracting mediums.

The vitreous humour is a dense transparent substance, which seems designed by nature to preserve the lenticular form of the crystalline, and to keep it at the same distance from the retina; for the crystalline lens is so deeply imbedded in the vitreous humour, and adheres so closely to it, that the crystalline cannot suffer any change in its form, without giving motion to some part of the vitreous.

Now, as nature performs all her mechanical operations by the most perfect mechanical laws, it must appear improbable, from the density of these substances, that any change should take place, either in the figure of the crystalline lens or in its distance from the retina.

Just before the crystalline lens the iris is placed. The use of this organ is to contract and enlarge the pupil; and as it is put in motion by almost every ray of light that falls upon the cornea, it seems necessary for its preservation that it should meet with the least resistance possible; therefore it swims in a limpid fluid called the aqueous humour.

The contraction of the pupil answers two important purposes; one to exclude too great a quantity of light, which would be injurious to the eye, and the other to give us a distinct view of near objects. But how a contracted pupil should produce this effect may be explained from the following property of vision, viz.—

That we have no vision perfectly distinct, but by rays which enter the eye in a direction parallel to the axis of the crystalline lens.

This will be easily understood from the following observations:

First Observation.

If we look attentively at a remote object, which subtends a very small angle at the eye, that object will be seen more distinctly than any other object that may be near it; because those rays that enter the eye near the axis of vision are so nearly parallel, on account of the great distance of the object, that the eye can distinguish no difference between these and parallel rays; and those rays passing through the crystalline lens, near its axis, and falling perpendicularly upon the retina, produce vision as perfect as the distance and magnitude of the object will admit. But those rays which form an angle with the visual axis fall obliquely upon the retina, and produce indistinct vision.

Second Observation.

If we look at a near and small object with attention, the pupil will contract so as to admit only those rays that are nearly parallel to the axis of vision. Suppose, for example, that we look at the point on the letter *i* in a printed book, the remaining part of the letter, and all the surrounding letters, will be seen imperfectly, for the same reason that was given above.

Third Observation.

Let the same object (·) be brought within two inches of the eye, and it will appear indistinct, because the rays issuing from it will enter the eye in a diverging state, in consequence of the pupil's being too large for the object. But if the pupil be contracted by means of a perforation about $\frac{1}{30}$ of an inch in diameter, placed before the eye, made either in a thin piece of metal or a slip of paper, the object will be seen distinctly, because no rays will then enter the eye, except those that are nearly parallel to the axis of vision.

Hence it is evident, that we have no perfect vision, but by rays which enter the eye in a direction parallel to the axis of the crystalline lens, and fall perpendicularly upon the retina; and as all rays that fall upon a convex lens parallel to its axis are converged to the same point, the following conclusion must be strictly true, viz.

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It is a property of the convex lens, that when its aperture is contracted, the image of a near object is painted at the same distance from the glass, as a remote one when its aperture is enlarged.

The instrument with which I made the following experiments consists of two large tubes, one within the other, like the tubes of a telescope. At the end of the large tube a double convex lens of 24 inches focus is fixed to represent the crystalline lens; and the other end of the instrument contains a piece of ground glass, $4\frac{1}{2}$ inches in diameter, polished on one side, to represent the retina. This instrument, being fixed upon a proper stand, was carried into a room and placed at about five feet from a window from which I had an extensive view.

After I had contracted the object glass to two inches, I drew out the inner tube until the picture of remote objects was distinctly painted upon the rough glass, but near objects were represented imperfectly.

When I had contracted the aperture of the lens to half an inch, near objects were represented very distinctly, but the picture of remote objects was less conspicuous.

The aperture of the lens being further contracted to $\frac{1}{4}$ of an inch in diameter, all outward objects appeared indistinct; but a plumb-line, which hung down the middle of the window, was clearly represented upon the artificial retina. This line was not seen upon the retina in the first experiment, and only like an enlarged shadow in the second. The distance between the glasses was the same in all the experi-

ments, and no alteration whatever was made in the instrument, except in the aperture of the lens.

Whence it is evident, that a large pupil gives us a distinct view of remote objects; that a contracted pupil gives us a clear view of near objects; and that no part of the eye, except the iris, suffers any change in making these adjustments.

The same Property of Vision demonstrated by a more simple Experiment.

Let a remote object be observed through an aperture of about $\frac{1}{50}$ of an inch in diameter, made in the manner already mentioned, and if the object be seen in a proper light it will appear as distinct as to the naked eye. Then introduce a pin, or any other small object, in a line between the remote object and the eye, at the distance of five or six inches from it, and these two objects will appear as distinct when seen together as when they are viewed separately; but the moment the aperture is taken away from before the eye, the near object will be seen very indistinctly; and as the aperture may be removed so instantaneously as to render it impossible for any change to take place in the internal parts of the eye, it is therefore evident, that the iris is the only organ by which the eye is adjusted to distinct vision.

Hence it is as clearly proved as any proposition in optics, that the rays issuing from a near object, after having passed through a small aperture, are conveyed to the same point upon the retina as those from a remote one; the rays from both objects being nearly parallel.

These experiments also prove, that an eye which has lost the crystalline lens, if the iris has not received any injury, may still retain its power of adjustment.

I am, sir,

Your humble servant,

ED. WALKER.

Lynn,
6th Jan. 1808.

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