OBSERVATIONS

ON THE

CILIARY MUSCLE IN FISH, BIRDS, AND QUADRUPEDS.

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IN the year 1813 Sir Philip Crampton described in Thompson's *Annals of Philosophy* a structure in the eye of the ostrich which had previously escaped the notice of anatomists.

The observation attracted at the time considerable attention from the promise it offered of explaining the means by which the eye is enabled to adjust itself for various distances. The reason why the line of research thus indicated has been neglected by many who have attempted the solution of that difficult and undecided question I hope to be able to explain satisfactorily in the following remarks on the structure and functions of the Ciliary Muscle.

On comparing the eye of the fish, the mammal, and the bird, the ciliary muscle is found to vary in so many respects that it is not surprising that Crampton failed to recognise it as the ciliary ligament or muscle of anatomists: and to the same cause is to be attributed in some degree the reason of its being considered by some a ligament, by others a muscle. Without entering into a minute account of its intimate structure, it is here proposed to adopt the general term of ciliary muscle under whatever conditions that structure is met with in the eyes of different animals.

Its absence in the eye of the fish, whose range of vision is more limited than that of any of the higher vertebrate animals; its perfect development in the bird, which possesses the most accurate and extensive range of sight; and its intermediate degree of development in the mammalia, led me to examine the eyes of various animals with a view to finding the true explanation of those remarkable differences and to determine if possible the functions performed by the ciliary muscle in affording the varied power of vision with which the eye is endowed. A most accurate description has been given of the muscle in the eye of the bird by Mr Rainey in the *Lancet*, 1851. It is only the want of illustration to render the description more easy to understand that has prevented his account from receiving the attention it deserves. The illustrations which accompany this communication were made from dissections at various times repeated as opportunity offered for obtaining different specimens. Those who are interested in such investigations may be willing to adopt the same mode of dissection that I have found most suitable for demonstrating the structures we are considering. The eye should be placed in water as soon after the animal is killed as possible, and exposed to the influence of a gentle flow from a tap in order to wash away all trace of blood from the tissues. After being treated for three days in this way, it should be immersed in pure alcohol, or methylic alcohol, in which it may remain for any length of time until the dissection is commenced. Even after many months have elapsed no material change will be found to have taken place in the structures.

The instruments required are a small pair of straight scissors, which are superior in most respects to a knife or razor: two pairs of finely pointed curved forceps, two needles properly mounted in handles, and a magnifying glass of one or two inch focus arranged on a moveable arm, and lastly a thin piece of cork affixed to a solid basis of lead, on which a section may be fixed and examined under alcohol or water. It is difficult to describe the great advantages of this mode over every other. Decomposition is prevented and any degree of labour may be bestowed upon one dissection; while the aid of a powerful magnifying glass and the great facility of separating the tissues when floating in fluid considerably assist the dissector.

Some have certainly found that the evaporation of alcohol is attended with unpleasant effects, and others object to the long continued use of so powerful a lens, yet a very little practice will accustom to the vapour of the spirit, while the sight will really be found to be improved instead of injured by the assistance of the lens: indeed such dissection ought not to be attempted without it.

Three views may be obtained of the ciliary muscle according to the mode of dissection. The surface which lies in contact with the sclerotic may be shewn by removing that membrane close to the cornea. Similarly the choroidal or internal surface is exposed by detaching the iris and choroid from the internal surface of the eyeball when divided into equal parts.

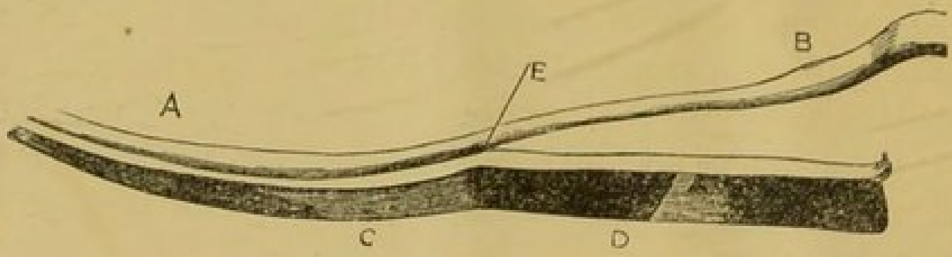
The third method allows the structures to be seen in their relative position, and is the only one by which the origin and insertion of the ciliary muscle are both preserved. The eye is divided into lateral halves by a section through the centre of the cornea, and from either of the parts, sections may be made of not less than a line in thickness with the scissors, and which may be fixed on the cork by means of needles, so that the cut surfaces of the cornea and sclerotic, the choroid and iris with the ciliary muscle interposed, are presented to the view. The dissection must be continued under alcohol or water with the assistance of the lens, one needle and a pair of forceps. The iris is to be drawn away from the cornea as far as possible without destroying its attachment, and fixed by means of the needle. In the same way the choroid is drawn from the sclerotic and similarly fixed to the cork. The ciliary muscle is thus exposed in its whole extent and may be examined under the inch object glass of the microscope with great advantage.

In order to understand the remark which has been made respecting the degree of development of the ciliary muscle in various animals, attention is directed to the woodcuts, 1, 2, 3.

The eye of the cod fish (Fig. 1) may be taken as an example of the general condition of the structures in the class of fishes.

The line from E to where the sclerotic passes into the cornea, and the choroid into the iris, points out the situation where the ciliary muscle would be found if it existed, but in all the species of fish which are common in this country there is no vestige of any structure corresponding to it. 'The iris in fish,' says Haller, 'does not move,' and where this is the case it

Fig. 1.

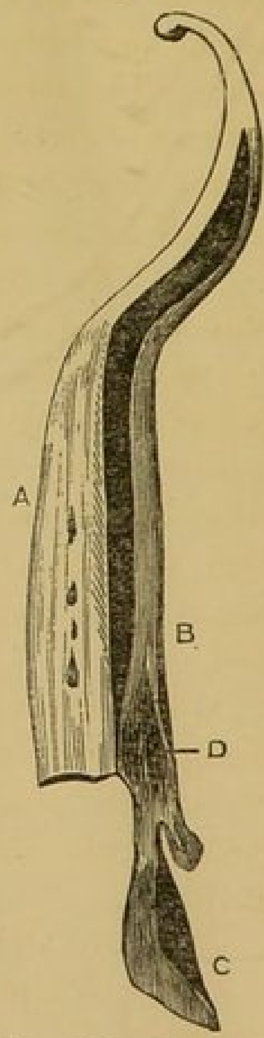


From a dissection of the membranes of the Eye of the Cod Fish.

A. Sclerotic. B. Cornea. C. Choroid. D. Iris.
E. Position of Ciliary Muscle in mammalia and birds.

will be found that the ciliary muscle does not exist; a conclusion which is one part of a general law I have observed, that the activity of the iris is directly proportional to the degree of development of the ciliary muscle.

Fig. 2.



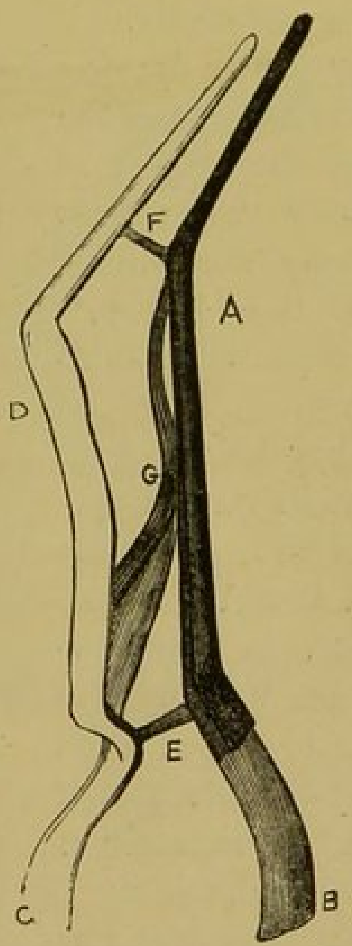
Section of the membranes of the Eye of the Cat.
A. Sclerotic. B. Choroid.
C. Iris. D. Ciliary Muscle.

The next illustration (Fig. 2) is taken from a section of the eye of the cat. There is a peculiarity in the structure of the ciliary muscle in this animal which, at first, induced me to choose that of one of the larger quadrupeds; but as the reader will find such illustrations in most works on physiology, and as the muscle in the feline species is chiefly remarkable for its size, no objection can be made to it for the purpose of comparison.

The muscle is seen to arise from the anterior border of the sclerotic close to the margin of the cornea which has been removed in the dissection, and to pass backwards to the choroid, forming so intimate a connexion with it as to appear really a part of that membrane. I have reasons for believing that its chief function in this class of animals is to increase or diminish in a remarkable manner the flow of blood to the erectile tissue of the iris on which the size of the pupil depends.

The third illustration (Fig. 3) is made from a dissection of the eye of the common fowl, in which the mode of arrangement of the membranes above described has been adopted. A needle was passed through the cornea at C by which it was held firmly fixed to the cork. Another needle was inserted between the choroid and sclerotic near F so that the iris could be drawn away from the cornea, and fixed by a third needle. The choroid A was then drawn away from the sclerotic D, so that the fibres at F were stretched in the same manner as those at E. By means of a mounted needle the ciliary muscle was carefully cleaned and exposed in its whole extent.

Fig. 3.



From a dissection of the Ciliary Muscle of the Fowl.

A. Choroid. B. Iris. C. Cornea. D. Sclerotic. E. Elastic Fibres passing between C and A. F. Elastic Fibres between D and A.

Illustration 4 is made from a similar dissection to the last, in which the section obtained was thinner and more highly magnified.

In the dissection illustrated in Fig. 5 the elastic fibres which pass between the cornea and choroid have been cut away. Those which attach the sclerotic and choroid remain (F). The ciliary muscle has been divided and a part of the sclerotic removed.

There are thus seen to be three structures in the eye of the bird which demand attention before considering the functions which they are intended to perform.

The first set of fibres which attach the choroid to the sclerotic or to the outer margin of the cornea are composed of soft filamentous structure of great delicacy and of less elasticity than those which attach the two membranes posteriorly.

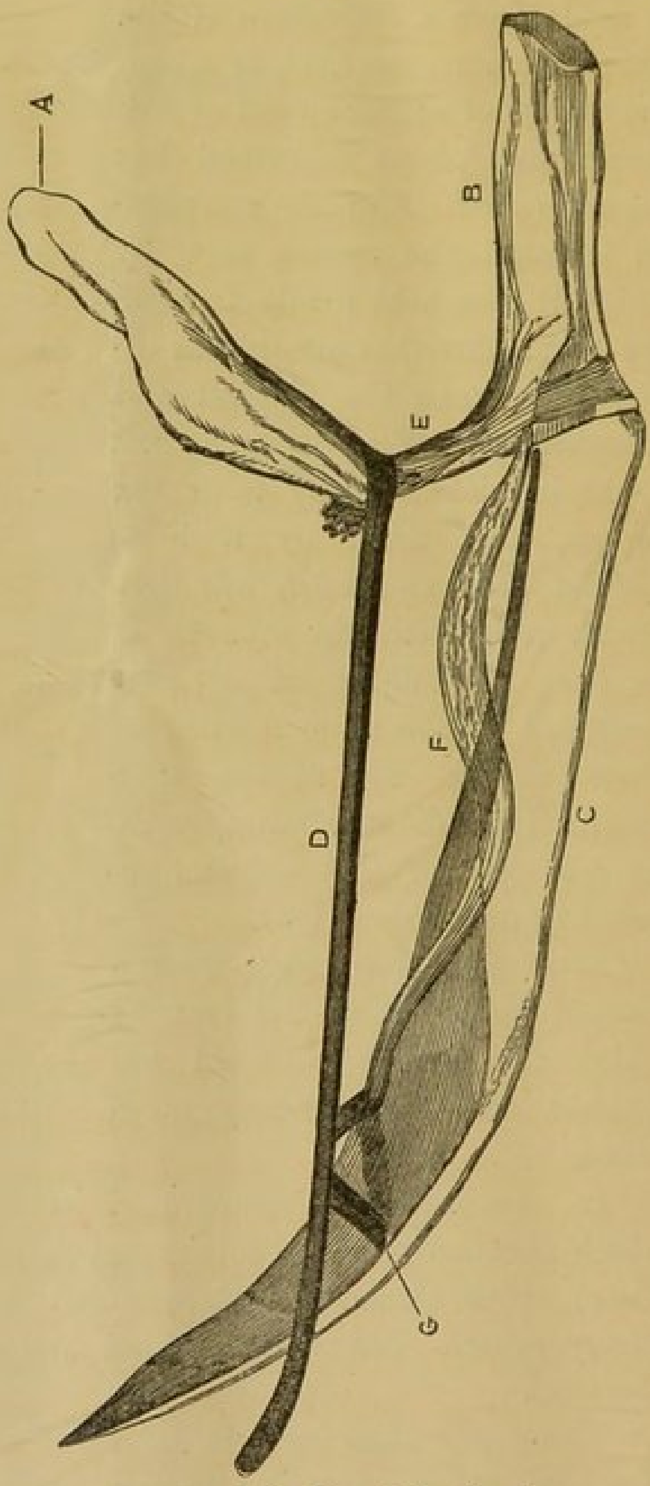
By gently drawing the iris away from the cornea the degree of elasticity they possess is easily ascertained, while the filaments are separately exhibited.

They differ to some extent in various species of birds, but exist in all that I have examined. In none however are the fibres so much developed as in the eye of the owl, of which an illustration is subjoined.

The dissection was made by removing the cornea to within a line of the sclerotic, thus exhibiting the iris, which is attached to the margin of the sclerotic by the elastic fibres. By drawing the iris away from the sclerotic the fibres are clearly seen.

The figure, however, does not represent with sufficient accuracy this simple and

Fig. 4.

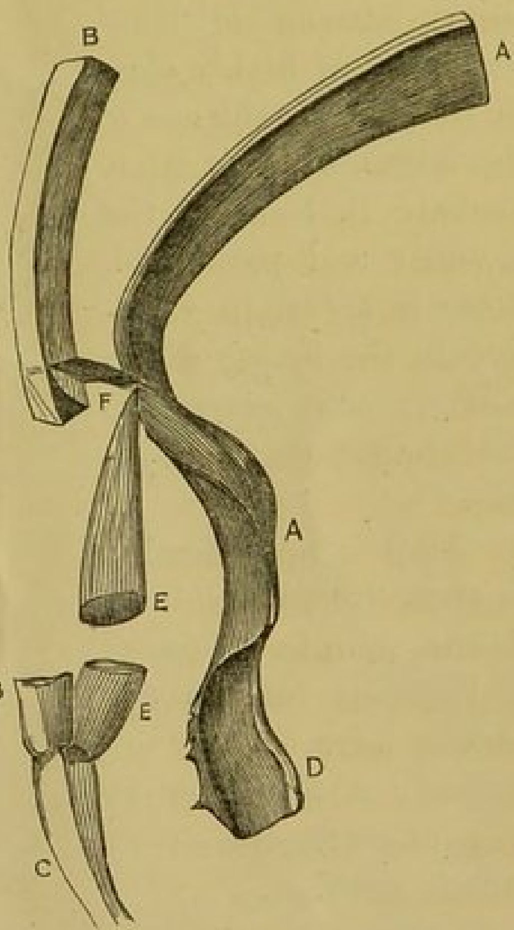


Section of the Eye of the Fowl.

A. Iris. B. Cornea. C. Sclerotic. D. Choroid. E. Elastic Fibres attaching Choroid to Cornea. F. Ciliary Muscle. G. Elastic Fibres attaching the Choroid to the Sclerotic.

beautiful mode of arrangement, nor the delicate structure of the tissues.

Fig. 5.



Dissection of the Eye of the Fowl.

A. Choroid. B. Sclerotic. C. Cornea. D. Iris. E. Ciliary Muscle. F. Elastic Fibres connecting B and A.

The posterior elastic fibres (Fig. 3, F) are composed of a different kind of tissue. Indeed they appear to form a distinct membranous band, somewhat resembling elastic ligamentous tissue in composition; and are possessed of considerable strength and great elasticity. It is important that this peculiar property should be distinctly exhibited in order to understand the function the structure performs. This may be done in the following manner. In the dissection (Fig. 3) the iris (B) is held by the forceps, and drawn in such a direction as to extend the fibres (F), and if carefully done it is not difficult to stretch them to more than double their length. On relaxing the tension they immediately resume their former condition.

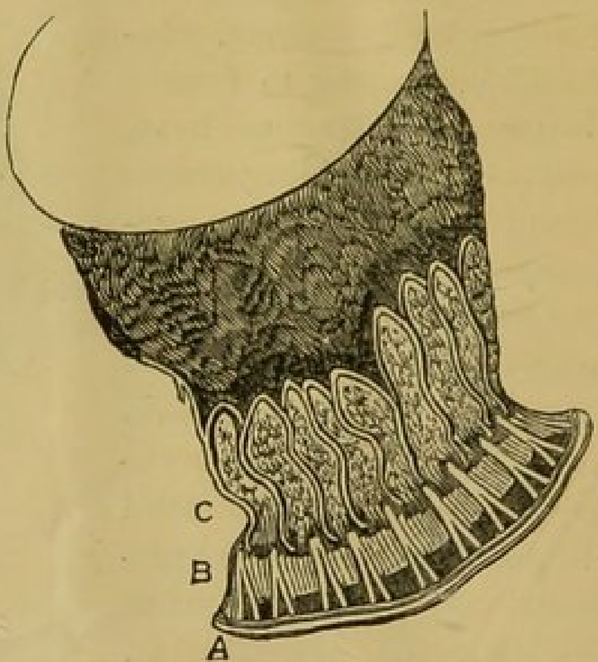
So much information is derived from this experiment that it should be frequently repeated and carefully considered. It is evident that this structure is intended to counteract the ciliary muscle, and to restore to their natural position those parts on which the muscle exerts its influence.

The dissections of the eyes of the owl and the falcon exhibit a different arrangement of the elastic fibres required by the shape of the eye-ball in these species of birds.

In the above illustration, the ciliary muscle (*d*) is seen to lie upon the sclerotic, which presents a convexity of surface requiring no special means of attachment for the choroid.

As a substitute for the elastic fibres, and to oppose the muscle, that part of the choroid (*R*) which lies between *k* and the insertion of the ciliary muscle is itself composed of highly elastic tissue. In the eye of the falcon, which is intermediate in form to the globular and pyramidal, there is a certain variation in the length of the ciliary muscle adapted to the shape of the eyeball.

Fig. 6.



Iris of the Owl.

A. Edge of Cornea. B. Elastic Fibres. C. Choroidal Filaments expanding to form the Iris.

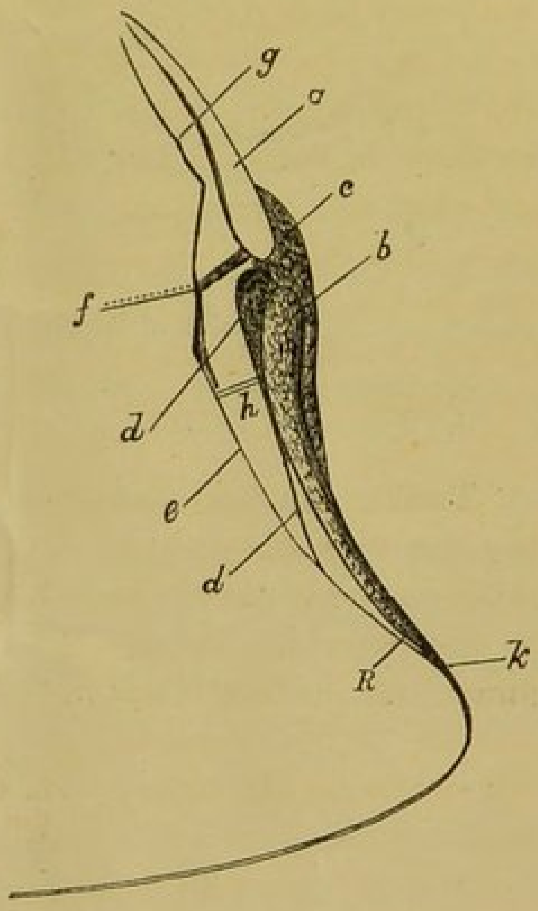
As it is not intended to enter into the subject of the minute structure of the parts of the eye which have been described, a few remarks will suffice for the ciliary muscle itself.

It arises generally from the margin of the cornea, or from the cornea and sclerotic where those membranes unite. In the eye of the owl (Fig. 6) the fibres of the muscle are attached to the strong tissue which lies between the cornea and osseous ring of the sclerotic. The insertion of the muscle however, that is to say, the full extent of its muscular and tendinous structure, was not known to Sir P. Crampton; and the same cause has led many physiologists to misunderstand its functions. It was supposed by Crampton that the origin of the muscle was the inner surface of the sclerotic quite close to the cornea, and that the muscle was inserted into the cornea so as to produce by its contraction such changes in the convexity of the cornea as would adjust the sight to objects at various distances.

In illustration 7 it is seen that the chief portion of the ciliary muscle lies between the point designated by *h* and the edge of the cornea. Similarly in Fig. 4 it can easily be conceived that the muscle might appear to extend only from the sclerotic at the point F to the edge of the cornea.

By separating the parts in the manner described the whole extent of the muscle is exhibited, which is not the case when a simple section is examined without this preparation. There are thus seen to be three structures of a peculiar and remarkable character in the eye of the bird. By means of two rows of elastic fibres with a muscle interposed, the choroid is so attached to the sclerotic that a certain degree of movement may take place between them. That part of the choroid which is thus attached to the sclerotic is the portion which is supplied with the ciliary processes on its internal surface, and to which the crystalline lens is affixed; that is to say, the whole arrangement described is intended for the alteration of the position of the crystalline lens.

Fig. 7.

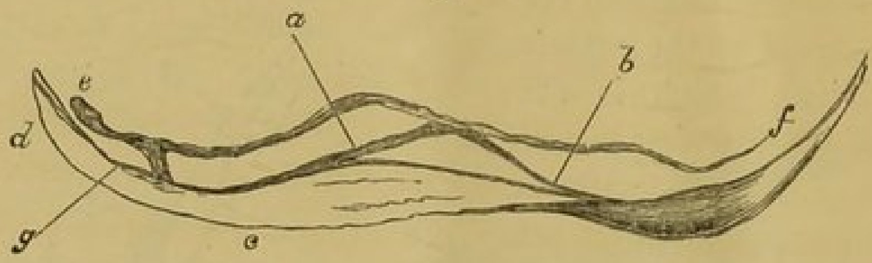


Section of the Eye of the Owl.

a. Cornea. *b.* Osseous ring in Sclerotic. *c.* Cartilaginous portion of Sclerotic. *d.* Ciliary muscle. *e.* Choroid. *f.* Elastic fibres. *g.* Iris. *R.* Elastic portion of Choroid.

The result of the numerous dissections which I have made leads me to consider that the various theories which have been advanced at different times to explain the means by which the eye is enabled to adjust itself for distance are inconsistent with the anatomy of the organ of vision, and I trust that it will not be thought presumptuous to express my belief that this phenomenon will be found to be explicable by the simple law of optical science which requires nothing more than a change in the relative position of the lens and the retina to accommodate the sight to near and distant objects.

Fig. 8.

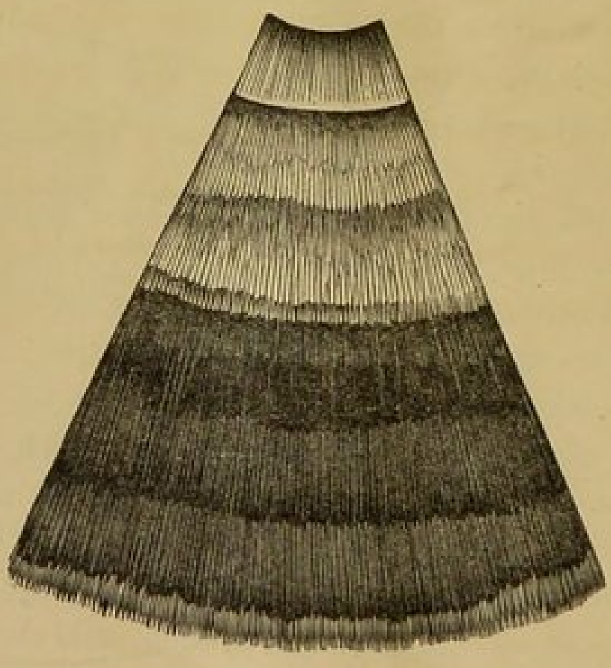


Section of the Eye of a species of Falcon.

a. Ciliary muscle. *b.* Posterior elastic fibres. *c.* Sclerotic.
d. Cornea. *e.* Iris. *f.* Choroid. *g.* Anterior elastic fibres.

The last illustration is introduced for the purpose of exhibiting the view obtained of the ciliary muscle by removing the sclerotic and cornea in such a way as to expose the muscle lying on the choroid. The iris, the ciliary muscle, and the choroid form three distinct bands in the accompanying drawing.

Fig. 9.



Ciliary Muscle of the Pheasant's Eye.

On reconsidering the above description, which was published some months ago, it appears to me that the subject might have been made more interesting if a fuller explanation had been offered of the mode of action of the ciliary muscle, and the attention of the reader had been directed to the advantages which are enjoyed by the bird from the possession of such a structure in its organ of vision.

But I was deterred from doing this by the observation that writers on subjects connected with natural philosophy often do injustice to the intelligence of their readers, and deprive them by intruding too much their own opinions, of the pleasurable exercise of reason which is enjoyed in the undisturbed contemplation of any object of interest in nature or art.

It may be allowed me to suggest the idea which firmly occupies my mind, that this peculiar muscle in the eye of the bird is connected with those extraordinary powers of perception to which the name of instinct has been given, and which enable the bird to traverse the trackless regions of the air as its habits require or changing seasons compel.

March 4, 1870.

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