ON

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PERFORMED BY THE

# CILIARY PROCESSES,

## And by the Pecten,

IN THE

## ADJUSTMENT OF THE EYE TO DISTINCT VISION AT DIFFERENT DISTANCES.

BY

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# FUNCTION PERFORMED BY THE CILIARY PROCESSES AND BY THE PECTEN, IN THE ADJUSTMENT OF THE EYE TO DISTINCT VISION AT DIFFERENT DISTANCES.

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THE ciliary processes and the pecten being only secondarily engaged in the act by which the eye adapts itself to distances, and being dependent upon the change produced in the position of the lens, and in the form of the vitreous humour, by the ciliary muscle, it will be necessary first to consider the anatomy of this muscle; and as the ciliary muscle has its highest state of development in birds, I shall describe it more particularly as it exists in that class of animals.

The ciliary muscle in birds was discovered by Sir P. Crampton as early as 1818.* It is situated behind the more flattened part of the sclerotic coat, between it and the ciliary processes. It may be said to take its origin from some fibrous plexiform tissue, (described by Mr. Bowman,) continuous with the posterior elastic lamina of the cornea, close to some passages, appearing like large areolar spaces, called the canals of Fontana, and also from the adjoining part of the sclerotic coat, and passing from thence backwards, for the distance of one-eighth of an inch, to be inserted into the choroid coat at its junction with an elastic membrane connecting the choroid with the sclerotic. The ciliary muscle has, in front of it the sclerotic coat, over which its fibres can freely glide; below and behind it, the elastic tissue connecting the iris with the

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* This description applies to the eye of the common fowl.

sclerotic; and, more posteriorly than this tissue, the ciliary processes, with which its fibres do not appear to be connected. The ciliary muscle is striped in birds, in the larger species of lizards, and in some other reptiles. The elastic membrane above mentioned corresponds to the ciliary ligament. It extends from the line of insertion of the ciliary muscle into the choroid, backwards, to be attached to the sclerotic coat. It is an exceedingly thin membrane, but its breadth is very considerable, being about one twenty-fifth of an inch. It possesses great elasticity, as can be seen by extending it under the microscope, and also from its being composed entirely of elastic tissue. I was not aware that this membrane had been before noticed, until I was informed by Mr. Bowman that he had mentioned it in a paper read at the British Association for the Advancement of Science.

Now, considering these attachments of the ciliary muscle, and the circumstance of the choroid coat being loosely connected with the sclerotic, excepting posteriorly, it seems impossible to conclude otherwise than that the effect of its contraction will be to draw the whole circumference of the choroid inwards towards the axis of vision, and thus to press the vitreous humour; and that this humour, being pressed all around, will be elongated in the direction of its antro-posterior diameter, and thereby cause the lens, with its capsule, to be carried forwards, and to be pressed more forcibly against the fluid in the posterior chamber of the eye. But as the aqueous humour is incompressible, and the posterior chamber completely closed behind and at its outer circumference by the capsule of the lens and the ciliary processes, which project a little into this chamber, the movement of the lens forwards will be impossible; and therefore this muscle would be useless, unless there be something which admits of ready displacement. Either the cornea must be forced forwards by the pressure exerted on it by the aqueous humour, or the blood must be pressed by this humour out of the ciliary processes. It is necessary to show which of these would require the greatest amount of pressure to cause it to give way. The facility with which the latter may take place will be apparent, first, from the consideration of the following anatomical facts,—namely, that the ciliary processes consist almost entirely of a net-work of capillary bloodvessels, which, posteriorly and on their deeper surface, are connected with those of the choroid by vessels which are smaller and have larger areolæ than on the other parts of the choroid; (these are by far the most difficult vessels to inject, and in plates of these parts they are frequently not represented;) whilst on their sclerotic surface the vessels are comparatively large, and communicate freely and directly with the vasa vorticosa; and, secondly, from the circumstance of the choroid, in the relaxed state of the ciliary muscle, being nearer to the sclerotic than when this muscle is in action; (this results from the curve described by the choroid being diminished when it is drawn inwards towards the axis of the eye, whilst that of the sclerotic continues the same;) so that unless there be some means of filling up the space between the sclerotic and choroid coats as it is being formed, the force exerted by the ciliary muscle would be partly lost in its effort to form a vacuum, or in its drawing the sclerotic coat in with the choroid, which, in consequence of being very strong, would doubtless not yield. Hence it is evident that the blood is both drawn and pressed out of the vessels of the ciliary processes at the same time; for, as the vasa vorticosa are being thus distended, the lens with its capsule is being pressed forwards, affording a mechanism by which any loss or misapplication of the force of the ciliary muscle is prevented, whilst the pressure required to empty the vessels of the ciliary processes into the vasa vorticosa, is diminished. The aqueous humour being now made to occupy the space before taken up by the blood in the vessels of the ciliary processes, will have the effect of enlarging the posterior chamber of the eye at its circumference, and therefore of diminishing it in a corresponding degree from behind to before, and thus be attended with an advancement of the lens. Placing, then, the facts and inferences above advanced, in contrast with the structure and great strength of the cornea, it must be obvious that the advancement of the lens, produced by the compression of the vitreous humour, is not attributable to the yielding of the cornea, but to the shrinking or collapse of the ciliary processes.

Now, so long as the ciliary muscle is in action, it is evident that the elastic membrane (ciliary ligament) is elongated, and upon the stretch; and that, as soon as the former becomes relaxed, the latter will, by drawing the choroid coat backwards and outwards from the direction of the axis of vision, bring it close to the sclerotic, and thus, removing the pressure from the vitreous humour, allow the lens to pass back into its former place, whilst the blood is re-distending the vessels of the ciliary processes: the elastic membrane serving in this case as an antagonist to the ciliary muscle, and thus fulfilling the office of a higher form of tissue. These changes having taken place in the position of the lens, the eye will have resumed its passive state,—namely, that in which it is adapted for viewing distant objects.

At one time I was inclined to regard the compression of the vitreous humour in mammals as due to the muscularity of the choroid coat. I was led to this opinion from the great resemblance which I observed to exist between the fibres of the tapetum, when treated with a solution of chlorine or any vegetable acid, and striped muscular fibre. I am now, however, disposed to relinquish this view, as other properties belonging to this species of muscle are altogether absent from the fibres of the tapetum, and to regard the structure which has been described by several anatomists as the ciliary muscle in mammals to be in reality such, and to believe that it performs the same function as the ciliary muscle in birds does, although in the latter it is striped, but in the former unstriped. This seems especially to be the case, from the fact of the same difference existing in the fibres of the iris also in these two classes of animals, whilst their function is the same, both equally indicating muscularity, when physiologically considered. I will now make some observations upon the function of the "pecten," which I believe will not only show what that function really is, but which will also corroborate the correctness of the explanation above given of the use of the ciliary processes.

It may at first sight appear rather at variance with the explanation above proposed, respecting the mechanism of the ciliary processes, that these parts should be comparatively so little developed in the class of animals in which the ciliary muscle is most perfect, and in which also the adapting power of the eye is considered to be very great. It also seems somewhat at variance with my explanation, that there should not be some correspondence between the development of the ciliary muscle and the optical perfection of the lens, which, comparing these parts in the eyes of birds and mammals, does not appear to be the case. (The lens of the bird is much less dense, especially at its centre, than that of the mammal. This can be seen by drying the bird's lens, when it will be found to shrink more than that of the mammal, and, in the place of preserving its convexity, to become very much indented at its centre.) For if the adjusting power of the eye depended wholly upon the motion of the lens, one would expect to find co-existing with a lens of inferior density, (and consequently of longer focus,) and with a larger ciliary muscle, also larger ciliary processes, the distance between the geometrical focus of parallel and divergent rays being required to vary more under the same circumstances than if the focal distance of the lens were less, (see Wood's or any other work on Optics.) But if such had been the case in the eye of the bird, then birds must necessarily have had a more globular form of eye than mammals, admitting that the form of the eye of the latter is just what it ought to be; whilst, on the contrary, the eye of the bird is required to be much more flat, in consequence of the form and size of the head; therefore some other means must be looked for in the bird, to aid those already described, for adapting the eye to distances. Now, it must be recollected that in the eyes of birds, lizards, and some other species of reptiles, there is, besides ciliary processes, a distinct organ called "pecten," that it has the same structure as the ciliary processes, and that where one is large the other is small, and the reverse; and therefore it seems not impossible that the pecten performs a function similar to that performed by the ciliary processes.

Before considering further the office of the pecten, it will be necessary to give a brief description of its structure and situation. The pecten is a plicated vascular membrane, present only in the eyes of birds, the larger kinds of lizards, and some other reptiles. In the common fowl it is situated at the inferior and outer part of the eye, extending from the entrance of the optic nerve, with which it is very much connected, almost as far forwards as the inferior and outer part of the lens, to which, however, it has no special attachment. Its form is quadrilateral. By its outer border it is attached to the sclerotic coat and optic nerve, following the oblique course of the latter through the tunics of the eye; this is between one-fifth and one-fourth of an inch in length. (It may be observed that in birds the optic nerve perforates the sclerotic coat on its posterior and *outer* side.) Its inner border is free in the substance of the vitreous humour, and not quite so long as the former. In the eyes of some animals this border is very short, and the pecten is then of a triangular figure; the distance between these two borders—that is, its breadth, is greatest at its middle, being about one-tenth of an inch; the surfaces of the pecten are so placed that one looks outwards and a little upwards; the other, of course, in the opposite directions. After it has been cut from a band of fibrous tissue, which connects it to the sclerotic coat, and drawn out under the microscope, it will be seen in the fowl and the pigeon to consist of about twenty oval folds, plaited like the folds of a fan, each plait, at its middle, which is its broadest part, being about one-fiftieth of an inch in depth, so that as two layers of membrane form each plait, the entire organ consists of nearly one-inch in length of vascular membrane. The whole extent of this membrane supports a rich plexus of capillaries, resembling in their disposition and size those of the ciliary processes; it is covered also more or less by pigment epithelium. The vessels enter and leave it at its attached border. Now, considering the facts just stated, especially the manner in which the pecten is situated in the very substance of the vitreous humour, it will be evident that when this humour is compressed in consequence of the action of the ciliary muscle upon the choroid coat, the vessels of the pecten will be compressed also; and that, unless there be some express contrivance to prevent the escape of the blood from them, which there is no reason whatever to suppose, they will be more or less emptied of their blood, according to the degree of pressure to which they are subjected. It is further evident, considering the manner in which the pressure is exerted upon the vitreous humour, and the position of the pecten, that after the vitreous humour has been made to take up the space before occupied by the fluid contents of the vessels of the pecten, its form will be altered, being more flattened laterally, but rendered more convex posteriorly—that is, the quantity of fluid before contained in the vessels of the pecten, being subtracted from the entire mass of vitreous humour, the latter will have become pressed into a smaller spheroid, with its transverse axis shortened, whilst its antro-posterior one remains the same.

Now, it is admitted by all physiologists that the image of visible objects is in some part of the retina; therefore, the rays of light, to have arrived at this part, must have first emerged at the posterior surface of the vitreous body, and then crossed the serous space between the tunica vitria and the retina. It is certain that these rays, after their emergence, do not enter a denser refracting medium, or they would have been dispersed, and no image could have been formed; hence they may be considered to have taken their last direction at the instant of their emergence at the posterior surface of the vitreous body; and therefore, as the refracting power of lenses composed of the same material is in proportion to their degree of convexity, (Wood's Optics, 71,) so the rays emerging at the posterior surface of the vitreous body must be refracted most when its convexity is greatest, and *vice versâ;* and thus the rays of light are brought to a focus soonest when the ciliary muscle is in action: and in this way the pecten is made to contribute to the same end, though in a different way, as the ciliary processes, and to assist these in a form of eye where perfect adjustment is inadmissible solely by the motion of the lens. From the mobility of the retina, and the manner in which it is adapted to the posterior surface of the vitreous body, it is almost certain that these will always remain parallel and equidistant, whatever may be the change in the convexity of the latter, and therefore that the law of refraction, as influenced by convexity, will not be in the least affected in its application by the change of curvature which the vitreous humour will undergo from the effect of pressure upon the pecten. It has been noticed that the lens is less perfect in the bird than in the mammal; so the vitreous humour, having more to do in the former than in the latter, is more so. The vitreous humours of the fowl and sheep, dried under precisely the same circumstances, lost different quantities of fluid; the sheep lost 98 per cent., and the fowl only 93. We may now also see a reason why there should be a stronger ciliary muscle in the bird, and other animals having eyes of a similar construction, than in the mammal; and lastly, according to this explanation of the function performed by the ciliary processes, and by the pecten, in the adjustment of the eye to distinct vision, whenever we meet with animals having a very small head, but comparatively large eyes, we may expect that they will have these organs of a flattened form, with the sclerotic coat strong anteriorly; a large ciliary muscle, probably a lens of inferior density; a very dense vitreous humour; small ciliary processes, and a pecten.

Physiologists, in treating of the adaption of the eye to distances, have attributed much to change of the convexity of the cornea, and but little or nothing to that of the posterior surface of the vitreous humour, although the effect in altering the focal distance of the eye is the same. It is true that the vitreous humour is very near to the retina, but still there is a serous space between them, as can be demonstrated by the facility with which air or fluid can be injected into it, especially at the posterior part of the eye; besides, there is, between the tunica vitria and the retina, a layer of very transparent cells. The minuteness of this space does not, however, affect the principle upon which the posterior part of the vitreous humour acts as a lens, since it is at the instant of emergence that the last direction is given to the emergent rays, and therefore the degree of refraction which these rays suffer will be in proportion to its convexity; and the position of the image with respect to the retina must vary accordingly.