XII. *Observations on the Structure of the Eyes of Birds. By Mr.* Pierce Smith, *Student of Physic. Communicated by* George Pearson, *M. D. F. R. S.*

Read March 26, 1795.

WHILE examining the eyes of birds, I observed in them a singular structure, which I believe has not been hitherto noticed; and though not the object I had in view in the examination, it will perhaps elucidate several remarkable circumstances in the natural history of these animals, and may ultimately be applied to the eyes of other animals, and add one additional discovery to those already made on this beautifully constructed organ.

In March, 1792, I observed, while dissecting the eyes of birds, an irregular appearance of the sclerotica, in that part of it which immediately surrounds the cornea, and which in them is generally flat. On a more minute examination, it appeared to be scales lying over each other, and which appeared capable of motion on each other. These appearances I shewed to Dr. FOWLER, of London, and likewise to Mr. THOMSON, surgeon, Edinburgh. In June, this paper was copied out at my request, by Mr. IRVING, who resided in the same house with me. On investigating this singular structure, the scales were found to be of bony hardness, at least much more so than any other part of the sclerotica. On the inside of the sclerotic coat of the eye there was no appearance of these

scales, that part of it being similar to the rest of the sclerotica. Tendinous fibres were detected spreading over the scales, and terminating at last in forming the four recti muscles belonging to the eye, so that, upon the contraction of these muscles, motion of the scales would be produced. This imbricated appearance of part of the sclerotica, and the detection of the tendinous fibres spreading over scales terminating at last in the four recti muscles, led me to consider the use of this structure, what would be the effect of motion of the scales upon the vision of birds, and how far this can be applied to other animals.

It is a fact so well known to persons acquainted with optics that it is almost unnecessary to mention it, that the rays of light, passing through a lens, will be refracted to a point or focus beyond the lens, and this focus will be less distant in proportion as the lens approaches to a sphere in shape. Now this principle is very naturally applied to the explanation of the use of this apparatus. These scales lying each partly over the next, so as to allow of motion, will, on the contraction of the recti muscles inserted into, and covering them, move over each other, and thus the circle of the sclerotica will be diminished, and of course the cornea, which is immediately within the circle made by these scales, will be pressed forwards, or in other words rendered more convex, and thus the focus of the eye becomes altered, its axis being elongated. This construction, and consequent convexity of the cornea, must render small objects near the animal very distinct.

On these muscles relaxing, the elasticity of the sclerotic coat will restore the cornea to its original flatness; it thus becomes fitted for viewing objects placed at a greater distance

from the eye, and this will be in proportion to the degree of relaxation.

There seems to exist in nature an œconomy of motion, to prevent fatigue, and exhaustion of the animal powers, by continued voluntary muscular action. If two opposite actions of the same frequency occur in two muscles, the one being antagonist to the other, the action of one ceasing, the action of the other must take place previously to farther motion of the part; for instance, on the biceps flexor of the arm acting, the arm will be bent, but on discontinuing its action the arm will remain in the same state, unless it was straightened by the action of the biceps extensor, its antagonist: but where one action in a part is required to take place almost constantly, and the opposite action but seldom, to save the animal from fatigue, necessarily induced by muscular contraction, she gives an elastic ligament, which from its elasticity may be said to be in continual action, without exhausting the animal. Thus when the opposite action which is of less frequent occurrence is required, it is performed by overcoming the resistance, or elasticity of this elastic ligament, which on the muscle giving over its action again, resumes its former state. The elastic cartilages of the ribs, performing in some degree the functions of a muscle, are of use in respiration; likewise the elastic ligaments which support the claws of all the feline genus, keeping them from friction against the ground. These claws, at the volition of the animal, by muscles appropriated for that purpose, are brought into action, or extended. From the abovementioned structure, the same thing appears to take place in the eyes of animals. When an animal is desirous of seeing minute objects, the recti muscles act, and thus, by

rendering the eye more convex, enlarge the angle under which the object is seen. How necessary is this structure to these animals in particular; for without it a bird would be continually exposed to have its head dashed against a tree when flying in a thick forest, its motions being too rapid for the common structure of the eye. The eagle, when soaring high in the air, observes small objects on the earth below him, inconceivable to us, and darts upon them instantaneously. Here we must allow that there must be an extraordinary alteration in the focus in this eye, in almost an instant of time. How could this be performed unless the animal had this apparatus? The eyes of quadrupeds, as I shall afterwards shew, can perform this alteration, though not in the same degree, as it is not necessary, their modes of life being different. A swallow sailing through the air pursues a gnat or small fly to almost certain destruction. This apparatus is very distinct in all these birds. Wherever we find the subsistence or safety of an animal intrusted to, or depending more particularly upon one sense than the rest, we are sure to find that sense proportionably perfect; as in quadrupeds the organ of smelling is remarkably perfect, and leads them to their prey, so the eyes of birds are proportionably perfect, being the means not only of their support, but from them they receive the first intimation of approaching danger.

The eyes of birds, like those of other animals, consist of three coats, the sclerotica, choroides, and retina. The human eye, as well as those of quadrupeds, is nearly spherical; in birds the sphere is more oblate, the sclerotica as it approaches the cornea becoming suddenly flat. The cornea, though small when compared with the size of the whole eye, is more convex,

as it forms the segment of a smaller circle, added to the larger formed by the sclerotica. The reason or advantage of this flatness is not very evident. It prevents them, perhaps, from projecting so far as to expose them to danger from the trees and grass, amongst which these animals live.

As no description, however accurate, can give an exact idea of the structure of any part of the animal body, I have caused small sketches to be made, explaining all the different circumstances that I have mentioned in this paper.

After having examined the eyes of birds, and seeing this curious apparatus, I was next led to the examination of the eyes of quadrupeds, that I might see in what manner they resembled the eyes of birds, and if I could account for their being able to accommodate their eyes to objects at different distances.

This was a subject I found involved in much difficulty, as the eyes of quadrupeds appeared on examination not to have these imbricated scales, which are so obvious in birds; but all this difficulty vanished on taking hold of one of the four recti muscles of the eye of a sheep; and by tearing and dissecting, I found that it terminated in, and with the other parts composed, the cornea; so that on the first volition of the mind, the recti muscles on contracting will have the power of fixing the eye, and keeping it steady, and at the same time by contracting more or less, will adapt the focus of the eye to the distance of the object, but in a less degree than in birds. On these muscles giving over acting, the eye will be restored to its former state by the elasticity of the sclerotic coat.

From a knowledge of these circumstances, we may from

rational principles explain, why people by being long accustomed to view small objects obtain in time a sort of microscopic power, if it may be so called; that is, the muscles which contract the cornea will by custom increase their power of action, and grow stronger, like the other muscles of the body. Other phænomena of vision on these principles may be explained.

EXPLANATION OF THE PLATE (Tab. XXII.)

Fig. 1. represents the eye of a buzzard, blown up and dried, the lesser circle of the cornea suddenly rising above the sclerotic coats.

Fig. 3. is a representation of the imbricated or loricated appearance of the scales which cover part of the sclerotic coat of the eye, divested of its muscles.

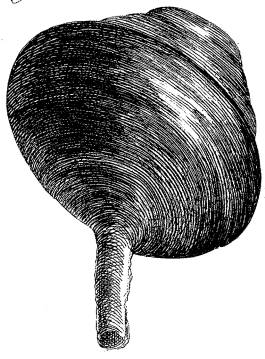
Fig. 4. shews that the scaly appearance is weaker in some birds than in others, according to their different modes of life, more so in the turkey than in the buzzard, (see fig. 3.) representing likewise one of the recti muscles attached to the scales.

Fig. 5. the inside view of these scales in the eye of a turkey, the internal coat of the cornea being torn up, or separated from the external.

Fig. 6. the four recti muscles in the eye of the sheep, dissected so as to shew their fibres inserted into, and going to form, the outer coat of the cornea.

Fig. 7. the four recti muscles of the eye of the turkey,

Fig. 1



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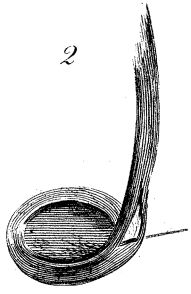

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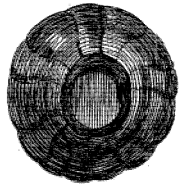

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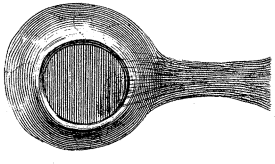

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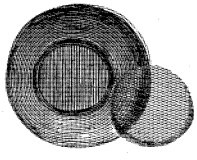

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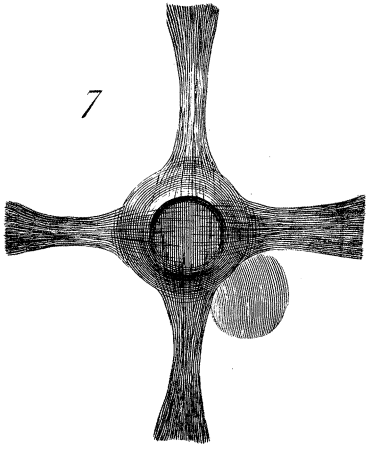

which are partly inserted into and running to form part of the outer coat of the cornea.

Fig. 2. one of the recti muscles, dissected in such a manner as to shew that a part of it is inserted into, and the rest of the muscle going to form, the outer coat of the cornea.