ON THE TAPETUM LUCIDUM.

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No satisfactory account has yet been given of the use of the tapetum lucidum, nor has its disposition in different animals been accurately described.

The tapetum has generally been examined after the eye has been removed from its socket. It is then difficult to replace it in its exact natural position, and it has consequently been generally loosely described as irregularly placed at the back, or outer part of the back of the eye.

In order to ascertain the exact position of the tapetum, in its relation to surrounding parts, it should be examined *in situ*, before the eyeball is removed. For this purpose the upper part of the orbit may be taken away, leaving the eye in its natural position. The anterior part of the eye, including the iris, must also be removed, any colouring matter that may have escaped from the choroid must be washed out with a thin stream of water, and the retina, which becomes opaque a few hours after death, must be removed in the same way. The tapetum will then be fully exposed, and the light reflected from its surface

will be seen to have a very definite direction, adapted to the habits and instincts of the different classes of animals which possess it.

In the ox and in the sheep the tapetum is seen principally on the upper and outer part, in relation to the socket of the eyeball ; whereas in the dog and the cat it is seen rather on the inner side.

The eyes in the ox and the sheep are placed on the sides of the head. In the lion, the dog, and the cat the eyes are placed more forward, and they can therefore use both eyes at once. In relation to the eyeball itself, the tapetum is found to occupy a different position in these different classes of animals. Taking the entrance of the optic nerve as a given point, the tapetum in the ox and in the sheep is seen principally on the upper and outer part. In the dog and the cat it is situated above the optic nerve and extends to about the same distance inwards and outwards.

The direction of the rays of light reflected from the tapetum is very remarkable. In the ox and in the sheep they are brought to an ill-defined focus ; in the cat and the dog they are nearly parallel. This may even be observed without dissection. The reflection from the tapetum in a recently killed cat may be seen from the end of a room if the pupil be dilated. In the ox and in the sheep it can be best seen when the eye of the observer is near the animal's nose. When the anterior part of the eye, including the iris, is removed, the direction of the reflected rays becomes much more apparent, especially when the experiment is made some hours after the animal's death.

Experiment I.—In a calf's head, the roof of the orbit was taken away and the anterior part of the eyeball removed behind the ciliary ligament. The vitreous humour, some pigment which had escaped, and the retina were washed away. The tapetum was now seen, accurately and sharply defined, to occupy exclusively the upper and outer quadrant of the posterior half of the eye, with the

exception of a spur with a bulbous extremity which projected inward.¹ The tapetum had a bright metallic lustre, resembling mother-of-pearl. A light was now thrown on it in a room otherwise darkened, and the rays were reflected so as to be brought to an ill-defined focus about three inches to the outer side of the animal's nose. This focal concentration of light was very apparent on a black surface.

Experiment II.—A sheep's head was prepared in the same way as in the first experiment, and a light was thrown into the eye. The reflected rays from the tapetum were now found to come to the same kind of ill-defined focus, not on the side of the nose, but three or four inches in front of it.

In connection with these two experiments it is remarkable that the ox grazes from side to side; the sheep, forward.

Experiment III.—A cat was placed in a box with some chloroform. When it was dead, the pupils were found to be greatly dilated. The reflection from the tapetum could be seen in ordinary light from any part of a large room. It was visible, however, in one direction only, and that was in a line slightly diverging from the median plane laterally, and nearly parallel to the nose downward. The roof of the orbit was now removed and the anterior part of the eye taken away, as in the two former experiments. The reflection of light from the tapetum, which before was of a light yellow colour, now appeared of a very light green, of the brightest metallic lustre. The reflected rays of light did not here come to a focus as in the ox and the sheep, but were projected forwards and downwards, very much in the same direction as they were before the anterior part of the eye was removed. The tapetum was found to be situated altogether above the entrance of the optic nerve, extending nearly equally to its inner and outer side. It had a very sharp

¹ This spur varies in shape in different specimens, and is better developed in the sheep than in the ox.

well-defined outline, about the size and shape of a longitudinal section of a kidney bean, with its slightly convex edge upward. In relation to the orbit the tapetum appeared in great part on its inner side, and could only be partially seen from the median plane.

Experiment IV.—A young cat was chloroformed; the nictitating membrane and the eyelids being removed, the bright yellow glare from the tapetum was seen with nearly the same brilliancy from any part of the room. The cornea, iris, and lens were now removed, and the tapetum was seen in this instance to be of a bright yellow lustre. It was on the inner side of the orbit, so that, viewed from the median line, the whole of it could not be seen.

These experiments have been repeated in various ways, always with the same general results.

In the horse the tapetum is very well developed, and that part which is to the inner side of the entrance of the optic nerve is larger than in the ox. When the anterior half of the eye is removed and the vitreous humour washed out, the reflection from the two portions of the tapetum is seen of a very bright lustre. The light, however, from the two portions is not reflected in the same direction, nor can both be well seen at once. That from the outer portion is directed downwards and inwards, as in the ox—that from the inner portion, downwards and forwards.

The reflection from the outer portion is best seen at about a foot distant; that from the inner is seen clearly at the distance of six feet.

The tapetum in the horse when spread out measures fully two inches in its transverse diameter. From its extent the reflected light is thrown over a larger area than in the ox, and the rays are not parallel to each other as in the cat.

This extended reflecting surface, with a prominent and moveable eye, must give the horse the assistance of a considerable range of vision in twilight (or, as it appears to us, in the dark) from reflected light.

In dogs the disposition of the tapetum is very much the same as in cats. The lustre has appeared not so bright as in cats, but brighter than in the ox.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

Figs. 1 and 2 represent the tapetum, *in situ*, in the two eyes of the same cat. They were necessarily drawn separately, as they could not be fully seen together without removing the nasal bones. Viewed from the front, where the whole of the tapetum could be seen, it appeared almost circular. The rays of light from the natural concave surface were reflected in nearly parallel lines within an area that would allow the whole to pass through a dilated pupil.

Figs. 3 and 4 represent the tapetum in two eyes of another cat, after they had been removed from their sockets. More of the anterior parts of the eyes had been removed than in those represented in Figs. 1 and 2. The tapetum in Figs. 3 and 4 is represented as it lay expanded on a flat surface. The transverse diameter therefore appears longer than it would in its natural concave position.

The ox and the sheep, having their eyes placed on the

sides of the head, see an object accurately with one eye only. The dog, the cat, and the lion having their eyes placed more forward, can use both at once. If the tapetum in the cat had been placed on the outside of the eyeball, as in the ox, the rays of light reflected from its surface would have fallen on the nose, or crossed each other immediately above it. In any case the reflected light could have been thrown on the same object from one eye only at the same time, and that in a different direction to that which is required by the animal's instincts. On the other hand if the tapetum of the ox had the same relative position as in the cat, it would be of little use as far as grazing is concerned.

The ox and the sheep have both very large pupils in the transverse diameter. All the rays of light reflected from the ground within a given area, which impinge upon the tapetum in these animals, are collected as from a concave mirror and again reflected in a concentrated form directly on their food. This provision must enable them to feed in the dim twilight with comparative comfort and safety from the admixture of foreign matter, alive or dead. The concave mirror situated within the eye itself acts the part of the concave mirror in an ordinary ear speculum.

In the daylight the pupil of the cat is often contracted to a mere line from above downward, but when the cat is excited the pupil becomes round and fully dilated. The glare of a cat's eyes when met in a dark passage has long been noticed, and from the fact that this is seen equally on both sides, it appears that the cat has the power of directing the reflected light from both eyes to the same object at the same time. The degree of convergence of the optic axes may therefore give the cat the power of estimating accurately the distance of its prey before making its spring.

The glare of the lion's eye was not unknown to Shakespeare. In his description of the dreadful night on the eve of the ides of March, he makes Casca say :—

“Against the Capitol I met a lion,
Who glar’d upon me.”

The tapetum is situated in front of the choroid and may be dissected off it, leaving the choroid of its natural colour. This colour, according to Hunter, presents in different animals every shade from nearly white to black. A coloured choroid may therefore be mistaken for a true tapetum.

Among the eyes that I have examined I have found that the tapetum does not exist in the hare, rabbit, rat, sea-gull, heron, plover, rook, common fowl, landrail, moorhen, hawk, owl,¹ Egyptian vulture (*Neophron pereopterus*), &c. The tapetum does not exist in the eyes of any fish which I have been able to obtain.

The conclusions arrived at are :—

1. That where the tapetum exists, the eye has, by reflected light, an illuminating power.
2. That this power can be utilised only at comparatively short distances, and that the eyes of fish and of birds (which have the longest and keenest vision) have it not.
3. That in animals which possess the tapetum the light reflected from its surface is directed in different classes of animals respectively in accordance with the wants and instincts of each.

¹ The eyeball of the owl is peculiar; it somewhat resembles a very small opera-glass. In common with the eagles and the hawks, the owl takes its food in its claws. Mice and rats generally take it in their fore paws; rabbits and hares eat deliberately and slowly, and masticate their food as they take it. None of these require the assistance of a tapetum either in catching their prey or in avoiding any foreign matter that might accidentally be mixed with their food.

(For report of the discussion on this paper, see ‘Proceedings of the Royal Medical and Chirurgical Society,’ New Series, vol. ii, p. 50.)