THE BRITISH JOURNAL

OF

OPHTHALMOLOGY

JUNE, 1938

COMMUNICATIONS

THE VISUAL CELLS OF THE PLATYPUS (*Ornithorhynchus*)

BY

KEVIN O'DAY

MELBOURNE

IN all vertebrate animals below the mammals it is the rule to find the cones present in both single and double forms. There are two varieties of the latter—"twin" and "double" cones. The members of the former are alike in every detail, whilst in the latter they differ in structure. The chief cone resembles its solitary neighbours and contains an oil-droplet, if they possess one; the accessory stains more delicately and contains no oil-droplet. In both types of double cones, although the elements appear to be fused in the greater part of their length, the end-plates and distal segments are free, and both units probably function independently. Because of the delicate structure of the accessory cone and of its intimate association with its partner, its observation is not always easy.

The accompanying drawings (with the exception of Fig. 5), were made with the *camera lucida* and a Zeiss 90X oil-immersion objective with 10X ocular from specimens prepared by the writer. To illustrate the gross retinal structure of a series of vertebrates, the drawings were made with the high power (Fig. 5). In this last diagram no attempt was made to represent the more delicate

details of structure, but merely to demonstrate similarities and differences between homologous layers in the retina of various members of the vertebrate family.

The twin-cones of the trout are very massive and the details of structure easily seen (Fig. 1). Both members are alike, and neither contains an oil-droplet. The finely granular nuclei are

Figure I. Twin-cones of the trout.

bulging through the limitans. They do not seem to differ greatly from the rod-nuclei, except that the latter are confined within the external limiting membrane. The distal structure of the element is hidden within the densely-pigmented processes of the pigment epithelium. So dense is this that attempts at bleaching were only partially successful.

The double-cones of the pigeon are much smaller in structure (Fig. 2). The chief-member attains a deep purple with Mallory's connective-tissue stain, the ellipsoid staining more deeply than the

Figure 2. Double-cone of the pigeon.

myoid and swelling at its extremity to contain the oil-droplet. The distal portion is a long, thin cylinder, the details of which are hidden amongst the pigment epithelium. The granular nucleus is just within the limitans next to the nucleus of the accessory cone. Both resemble the rod-nuclei present in a single row above them. The accessory is in very close apposition to the chief-cone, so close that only after careful observation is it to be distinguished as a separate entity. Its outer segment is attached to the limitans by a broad base containing the paraboloid. Distally it rapidly narrows into a long, thin, cylindrical outer member. So close is its association with the chief-cone that, at first glance, the paraboloid often appears to be part of the structure of the latter. Its nucleus is just within the limitans next to that of the chief-cone.

Although Hoffman described the presence of oil-droplets in the cones of the marsupial¹, and Gunn in those of the monotreme², neither stated whether double cones were present. In view of the fact that both Greeff³ and Rochon-Duvigneaud⁴ state that the mammalian retina does not contain double-cones, the findings of the writer are of interest. Since reporting the presence of twin-cones with oil-droplets in the retina of the Australian native-cat (*Dasvurus viverrinus*)⁵, examination of the ring-tail opossum

(*Pseudochirus laniginosus*) and the bushy-tail opossum (*Trichosurus vulpecula*), has revealed similar structures. Examination of the fresh retina of the bushy-tail opossum and of the kangaroo (*Macropus giganteus*) with apochromatic lenses, shows that the oil-droplets are colourless. Owing to the difficulty in obtaining material for investigation and in ensuring prompt and efficient fixation, satisfactory observations on the retina of the marsupial have been limited to the three animals mentioned above. The drawing (Fig. 4) represents the essential features of the twin-cone of the marsupial. The two, large, finely granular nuclei are

Figure 3. Visual cells of the platypus

seated side by side on the limitans, and present a marked contrast with the rod-nuclei which are present in overwhelming numbers and contain, in the case of the ring-tail opossum, one densely staining mass, and in the native-cat and bushy-tail, two or three. The purple (Mallory) slender myoid broadens out into the much more bulbous ellipsoid with the oil-droplet. The stumpy conical distal extremity can be seen to be in close contact with the pigment-epithelium in the pigment-free tapetal area. It stains a delicate shade of blue with a suggestion of transverse (or spiral) striation. Enclosing the ellipsoid is a delicate structure which the writer has referred to as the mantle.

Examination of the retina of the monotreme platypus (*Ornithorhynchus*) reveals a striking difference in the structure of its visual cells from those of the marsupial and higher mammal, and indeed, a close resemblance to that of the sauropsidae (Fig. 3). This is

not surprising as the monotreme (*Echidna* and *Ornithorhyncus* both) retains in its sclera the cartilage of the latter. In addition to single cones with oil-droplets, double cones are present, the chief member only containing the oil-droplet (Figs. 3 and 4). The visual cells are small and whilst the droplet-bearing cones and the rods stain vividly, the delicate accessory cones are made out with difficulty. In many instances the accessory nucleus is ectopic, that is it lies outside the limitans and renders the identification of the cell somewhat more easy. The nuclei are finely granular in

Figure 4. Twin-cones of the Australian native cat.

structure and those of the rods and cones are similar. In the chief-cone there is no marked differentiation in the staining of the myoid and ellipsoid, nor is the contrast in shape between the two very great. The distal extremity is a small, stumpy, blue-staining cone. The accessory stains much more delicately and uniformly from base to tip—a fine purple with a tinge of blue. With the nucleus in its usual position within the limitans, the outer segment often presents itself as little more than a delicate line. The rods are surprisingly massive and do not seem to outnumber the cones.

The comparative sparsity of the rods is remarkable in view of the commonly-held opinion that the animal is markedly nocturnal in its habits. When not disturbed, however, the fascinating little

creature hunts and feeds freely in brilliant sunlight. The relatively small eyes of both of the monotremes is further evidence that they are not strictly nocturnal, and present a marked contrast with the large globes of the nocturnal marsupials. The few massive rods of the former bear little resemblance to the multitudinous slender ones of the latter. There is a further difference in

FIGURE 5.—Comparative diagram of the gross retinal structure of the fish, reptile, bird, monotreme, marsupial, and higher mammal. (Camera lucida, Zeiss ocular 10X, objective 40X.) (A Size)

the structure of the nuclei of the visual cells. In the platypus the nuclei of both rod and cone are finely granular and indistinguishable as in the sauropsidae, whilst in the marsupial the very much more coarse distribution of the chromatin distinguishes the rod nucleus from that of the cone. In this the marsupial resembles the higher mammal.

The ratio between the number of nuclei in the outer and inner nuclear layers is unusual. Whilst the habits of the animal

apparently govern this ratio in each particular instance, in sauropsidae the inner nuclear layer usually outnumbers the two members of the outer nuclear layer, whilst in the higher mammal the reverse is the case (Fig. 5). The investigations of the writer tend to show that, in this respect, the marsupial resembles the higher mammal. Whilst the outer nuclear layer of the platypus is thicker than that of the bird and is nowhere less than three nuclei in thickness, nor more than four, the inner nuclear layer averages only four nuclei. This arrangement seems to bear a closer resemblance to that of the reptile and bird than to that of the higher mammal

FIG. 6.

and marsupial. The similarity in number of nuclei in the two layers as well as the thin layer of optic nerve fibres even in close proximity to the optic-disc, indicates a considerable degree of summation of visual impulses, a thesis which is not completely borne out by observation of the animal, which is very timid and darts away on the least movement of the observer.

Owing to the kindness of Mr. David Fleay of the Melbourne Zoological Gardens, a specimen of the spiny ant-eater (*Echidna*) was placed at the disposal of the writer. Unfortunately the animal had been dead for some hours before being placed in the fixative, and, on examining the sections, it was found that the outer layers of the rods and cones had disintegrated. The nuclei of the outer layer show a uniformly granular structure and are arranged in four layers at the most, whilst those of the inner layer are arranged in two or three.

The finding of double-cones in the retina of the monotreme and of twin-cones in that of the marsupial presents another interesting phenomenon to the student of comparative anatomy. A study of

the visual cells indicates that the marsupial and higher mammal are more nearly related to each other than to the monotreme. The latter resembles in many ways the sauropsidae. The absence of the pecten indicates a closer alliance with the reptile than the bird. As a probable reminder that the monotreme is, after all, a mammal, the intra-ocular musculature is unstriated.

The presence of ectopic nuclei calls for final comment. Heidenhain's iron haematoxylin proves that these structures are indeed nuclei and not paraboloids. Ectopic nuclei are found in the retina of man, the ape (*Cercopithecus*⁶), the domestic cow⁷, and the lamprey⁸. Whilst Walls⁹ is of the opinion that the position of the cone-nucleus is either permanently within or without the limitans in the higher vertebrates, the writer's sections of the platypus show occasional cones in which the nucleus appears to be streaming through the membrane as in the trout.

These investigations are being carried out in the Anatomy Department of the University of Melbourne under the direction of Professor Wood Jones, to whom the writer is indebted for his ever-ready help and valuable suggestions. He is also indebted to Sir James Barrett and Dr. Edward Ryan for supplying him with valuable material and for allowing him access to their libraries. The sections and photomicrograph were prepared with the assistance of Mr. H. Marriott.

REFERENCES

1. HOFFMAN, C. K. (1876-77).—"Zur Anatomie der Retina. II. Ueber den Bau der Retina bei den Beutelhieren." *Niederl. Arch. Zool.*, Bd. III, S. 195-8. Quoted by G. L. Walls.
2. GUNN, MARCUS (1884).—"On the eye of *ornithorhynchus paradoxus*." *Jl. Anat. and Physiol.*, Vol. XVII, pp. 400-5.
3. GREEFF, RICHARD (1900).—"Die mikroskopische Anatomie des Sehnerven und Netzhaut." *Graefe-Saemisch Handb. d. Augenheilk.*, 2 Aufl., Bd. V, Kap., S. 116.
4. ROCHON-DUVIGNEAUD, M. (1903).—"Anatomie de l'appareil nerveux sensoriel de la vision." *Encyclop. Franç. d'Ophtal.*, Vol. I, p. 618.
5. O'DAY, KEVIN (1936).—"A preliminary note on the presence of double cones and oil-droplets in the retina of marsupials." *Jl. of Anat.*, Vol. LXX, Part IV, p. 455.
6. GARTEN. 7. ZURN. 8. WALLS.—Quoted by Walls in
9. CULLER, A. M., and WALLS, G. L.—"Ectopic Cone Nuclei." *Arch. of Ophthalm.*, Vol. III, p. 106, 1930.