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COMPARISON OF THE LAMINA CRIBROSA IN MAMMALIAN SPECIES WITH GOOD AND WITH INDIFFERENT VISION*

BY

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IN the course of an investigation into the inheritance of coloboma of the optic nerve sheath in mice, I noticed that the lamina cribrosa is very poorly developed even in normal animals of this species. The lamina cribrosa, as is well known, is a net-work of collagen, elastic, and neuroglial fibres, partly continuous with the sclera through which the optic nerve fibres run on their way through the back of the eyeball (Salzmann, 1912). This net-work strengthens the eyeball at what would otherwise be a very weak spot. In the mouse a suggestion of a network is sometimes present (Fig. 1), but the fibres are extremely fine and often hard to see in sections; they do not take up collagen stains. An attempt was made to discover the nature of these fibres by the use of specific tissue stains. Staining with the azan and periodic Schiff methods, which give excellent results in other animals, failed to show any but the most rudimentary collagen development in any mouse nerve; usually the result was entirely negative. Various methods of staining for elastic tissue (Verhoeff's haematoxylin, Weigert's resorcin fuchsin, and orcein) and for reticulin (Wilder's) were also tried and these too gave negative results. The very fine fibres seen in discs, such as that illustrated in Fig. 1, did show up with Mallory's phosphotungstic acid haematoxylin which is a good stain for neuroglia. According to Salzmann glial fibres make up part of the human lamina cribrosa.

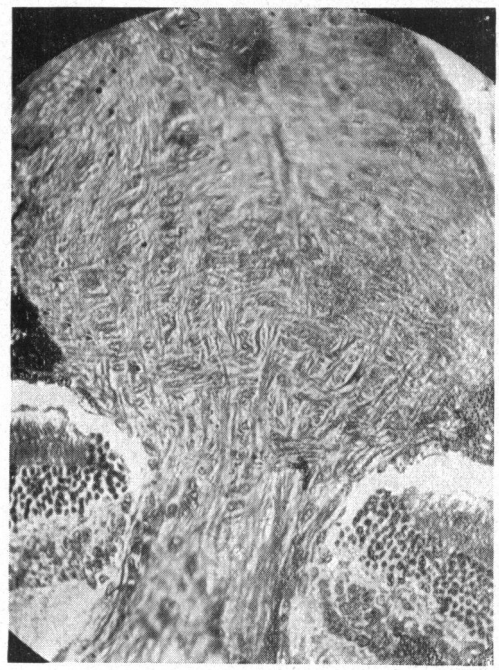

FIG. 1.—Optic nervehead of the mouse. A fine fibre network is present but there is no specific connective tissue staining (cf. Fig. 7). Kolmer's fixative; Mallory's phosphotungstic acid haematoxylin. ×330.

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In most mice no transverse fibres could be seen crossing the optic nerve (Fig. 2) and this situation was often associated with an ectasia of the retina which had broken through between the nerve and its sheath and formed a sleeve round the body of the nerve (Fig. 3). Similar colobomata, also associated with no sign of a lamina cribrosa, have already been reported in the rat (Nicholls and Tansley, 1938).

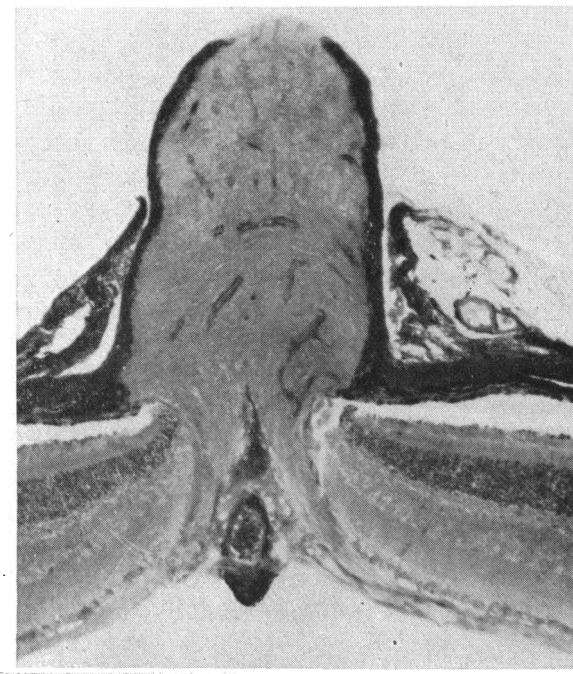

FIG. 2.—Optic nervehead of the mouse. No connective tissue fibres at site of lamina cribrosa (cf. Figs 5 and 6). Kolmer's fixative; Azan. ×66.

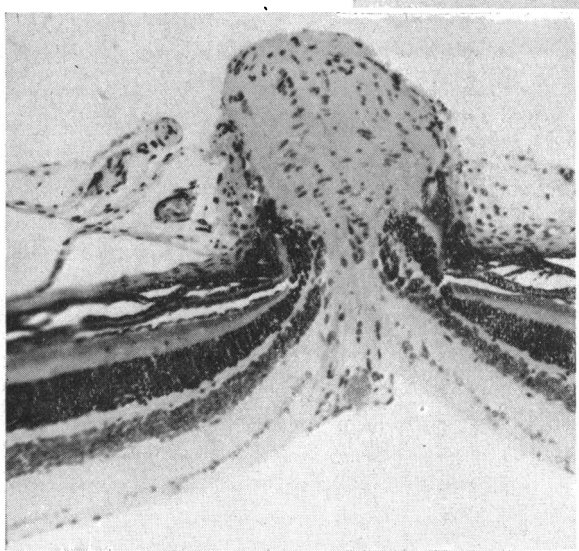

FIG. 3.—Optic nervehead of the mouse. Coloboma of optic nerve sheath. Kolmer's fixative; Feulgen. ×66.

Investigation of other laboratory mammals revealed that the rabbit also has no collagen at the site of entry of the optic nerve into the eye. Associated with this condition there was an almost universal cupping of the optic disc, more or less severe (Fig. 4). Coloboma of the optic nerve sheath has also been reported in rabbits (Koyanagi, 1921).

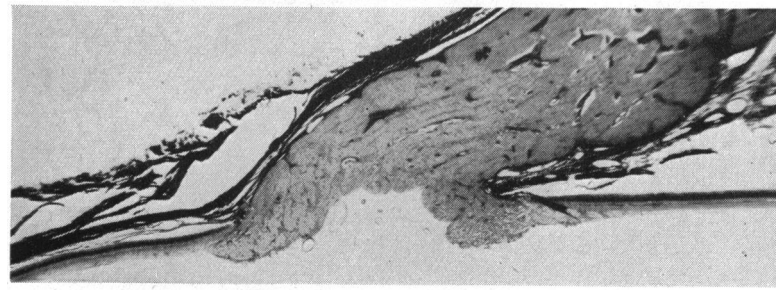

FIG. 4.—Optic nervehead of the rabbit. Note absence of collagen fibres at site of lamina cribrosa (cf. Figs 5 and 6). Kolmer's fixative; Azan. ×24.

The picture in the other species examined was very different. The cat (Fig. 5), monkey (Fig. 6), grey squirrel (Fig. 7, opposite), and souslik or European ground squirrel (*Citellus citellus*) all showed well-developed collagen fibres, making up a marked lamina cribrosa, and a flat disc. No colobomata were ever seen in these species.

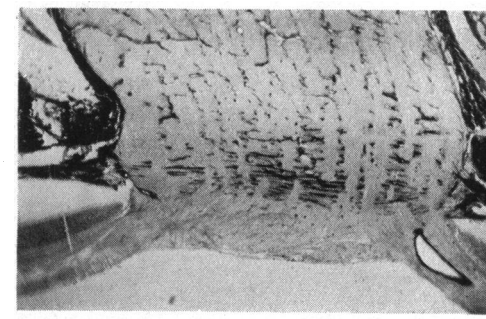

FIG. 5.—Optic nervehead of the cat. Note well-developed collagen fibres at lamina cribrosa (cf. Figs 2 and 4). Kolmer's fixative; Azan. ×44

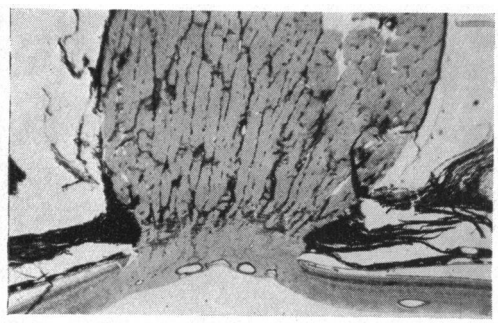

FIG. 6.—Optic nervehead of the monkey. Note fine collagen fibres at lamina cribrosa (cf. Figs 2 and 4). Kolmer's fixative; Azan. ×24.

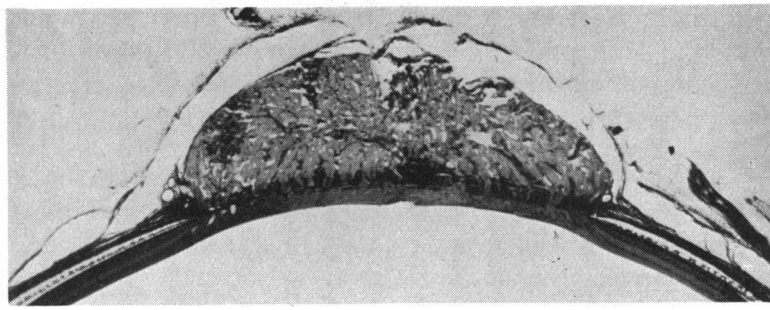

FIG. 7.—Optic nervehead of the grey squirrel. Note extremely well-developed collagen fibres at lamina cribrosa (cf. Fig. 1). Kolmer's fixative; Mallory's phosphotungstic acid haematoxylin. ×16.

Fresh collagen fibres are birefringent. Frozen sections of the nervehead of two contrasted species, the cat and the rabbit, were, therefore, examined in polarized light. In the cat the lamina cribrosa showed up clearly as a band of bright fibres continuous with the sclera, but nothing of the sort could be seen in the rabbit, where the walls of the vessels running in the optic nerve were perfectly distinct but no continuous fibrous band across the nerve was present.

In mice with an otherwise normal disc in which a distinct suggestion of a network could be seen, there were columns of long oval nuclei lying between the incoming bundles of optic nerve fibres in the position at which the collagen fibres of the lamina cribrosa are present in other species (Fig. 8). These

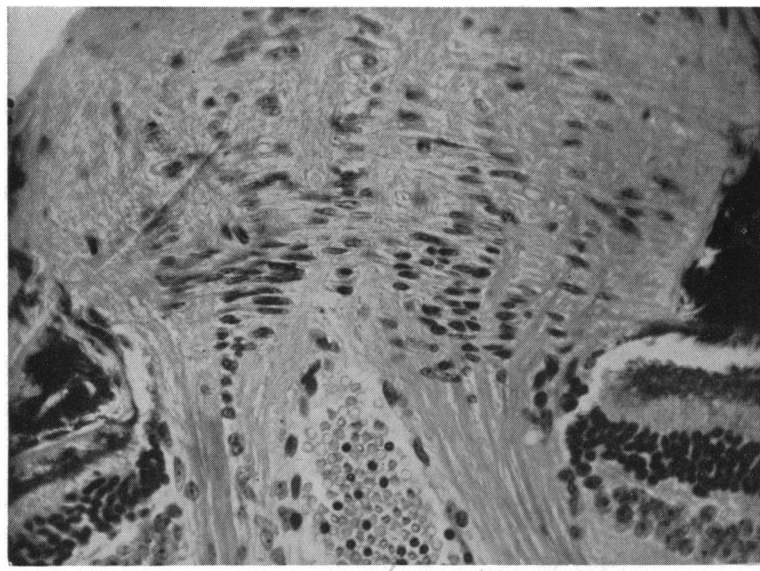

FIG. 8.—Optic nervehead of the mouse. Note band of evenly arranged oval nuclei running across nerve. Kolmer's fixative; Feulgen. ×330.

cells resemble fibroblasts and it is probable that in the mouse the embryological pattern for the development of connective tissue is laid down but that the final production of reticulin and collagen is, for some reason, prevented.

The major relevant difference between the rat, mouse, and rabbit on the one hand and the cat, squirrel, and monkey on the other appears to be their visual capacity. The rat and mouse each has a practically pure-rod retina; the rabbit possesses some rudimentary cones but the retina is not one from which one would expect good visual acuity. All these species appear to have poor general vision although their night vision is probably good. In the laboratory it is impossible to distinguish rats and mice with a completely degenerate retina from normal animals in daylight, and the same is true of rabbits with mature bilateral cataracts. Cats and monkeys are well known to be extremely dependent on the use of their eyes and the same is probably true of the squirrels and ground squirrels. These two last have a pure-cone retina (Vilter, 1954; Karli, 1951; Arden and Tansley, 1955a,b) and a very large optic nerve compared with the size of the eye. The eye of the grey squirrel is only about one-third the size of the rabbit eye, but the optic nerve is about the same size or a little larger. The nervehead of the squirrel is not round but horizontally elongated (Walls, 1942). The section illustrated in Fig. 7 was cut in a nearly horizontal plane and this is why the nerve appears so much larger than that of the rabbit shown in Fig. 4.

It is obvious that, if an eye is to preserve good form vision, it must be reasonably rigid so as to keep the retina undistorted. The poor development of the lamina cribrosa in rats, mice, and rabbits is not only associated with colobomata of the optic nerve sheath but often also with folding of the retina and sometimes even with microphthalmia. In my experience such abnormalities are not common in cats, squirrels, and monkeys. In rabbits and rats coloboma of the optic nerve sheath is often an inherited condition and it seems possible that faulty development of the lamina cribrosa is also genetically determined. If this is so then it may be that in animals with a poor visual capacity and, therefore, no need for a faithful retinal image, natural selection does not act to eliminate the individuals with badly developed eyes.

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