

THE CEREBRAL CAPILLARY SYSTEM OF *Myxine glutinosa*.

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Following systemic injection many compounds penetrate the central nervous system slowly and to a limited extent due to the restricted permeability created by the cerebral capillary-glia complex or blood-brain barrier. In most vertebrates, cerebral endothelial cells are joined by belts of tight junctions which prevent the passage of large molecules from plasma to brain. In sharks these endothelial tight junctions appear to be absent but the barrier functions are performed by tight junctions between perivascular glial cells. Furthermore cerebral endothelial cells of higher vertebrates are characterized by an almost complete absence of the cytoplasmic vesicles which in capillaries of other organs subserve transport functions between plasma and tissue. In the hagfish *Myxine glutinosa* physiological evidence suggests that the blood-brain barrier is less developed than in higher vertebrates. In an attempt to provide an anatomical basis for the physiological differences between hagfish and higher vertebrates we examined the cerebral capillary-glia complex at the light and electron microscopic levels in the brains of a series of adult hagfish.

Hagfish were fixed by vascular perfusion with phosphate-buffered glutaraldehyde-paraformaldehyde fixative embedded in epon and sectioned for light and electron microscopy.

At the light microscopic level the hagfish cerebral capillaries can be seen to have an unusually large diameter. The capillaries are lined by rather thick-walled endothelial cells under which lies an exceptionally thick and dense basement membrane (Figure 1). At the ultrastructural level the capillary endothelium can be seen to contain a large number of long tubular or vesicular structures (Figures 2-6, 8). These vesicles and tubules sometimes appear to communicate with the capillary lumen, with the space between adjacent endothelial plasma membranes (Figure 2), and with the basement membrane (Figure 5).

Plasma membranes of adjacent endothelial cells frequently interdigitate in a rather complex fashion (Figures 2,4); regions of apparent fusion of adjacent membranes can occasionally be seen (Figure 2) but such regions are far less common than in higher vertebrates.

The most striking morphological characteristic of these capillaries is the exceedingly thick trilaminar basement membrane (Figures 3-8). This membrane sometimes gives off spoke-like processes (Figure 6) similar to those occurring in elasmobranchs. In addition to the communication between endothelial vesicles and basement membrane the clefts between adjacent perivascular glial cells on the abluminal side also seem to be continuous with the basement membrane (Figure 7).

Hagfish capillaries thus differ in several important respects from typical vertebrate cerebral capillaries. Firstly tight junctions between endothelial cells appear to be quite rare and thus presumably do not constitute a barrier. Secondly hagfish endothelial cells contain a great many vesicles. These vesicles conceivably could transport materials between plasma and brain such as the granules shown in Figure 8, as the vesicles of muscle capillaries are thought to do in higher vertebrates. This hypothesis is being investigated in tissues from animals injected with horseradish peroxidase. The significance of the thick basement membrane remains to be determined.

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