

COMMUNICATIONS

NORMAL DEVELOPMENT OF THE HYALOID AND RETINAL VESSELS IN THE RAT*

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THE rat has been used extensively as an experimental animal in studies of the retinal vessels. Since a knowledge of normal development is obviously essential to the proper interpretation of developmental abnormalities, it is surprising that an adequate description is not available in the literature. Michaelson (1954), amplifying the work of Hesse (1880) and Bruns (1882), described fully the development of the main retinal vessels and the superficial capillary net, but did not discuss the hyaloid vessels or the deep capillary net in the same detail. His work has not yet been confirmed. Janes and Bounds (1955), in their study of the adult rat eye, failed to demonstrate to their satisfaction the periarterial capillary-free zone described by Michaelson. The following study has therefore been carried out to provide firm data on which future work can be based.

Material and Methods

Adult rats were anaesthetized by intra-peritoneal injection of Nembutal, and Indian ink was injected into the ventricle by means of a syringe. The injection was made slowly and at low pressure, and was terminated when the mucous membrane, splanchnic area, and conjunctivae were seen to be injected. Young rats varying in age from 1 to 22 days were also injected by a similar technique. In these young animals, no direct observation of the vessels of the eye could be made because of the persisting closure of the lids, and the injection was continued until the whole skin was black. The eyes were then removed and placed in 10 per cent. formol saline for 24 hours.

The eyes of the adult rats were opened near the ora serrata, and the retinae removed with a blunt probe and mounted in glycerine. The eyes of the younger animals were opened in the same way and any remaining adhesions between lens and ciliary body carefully broken down with fine scissors. The retina, with lens

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attached to the optic disc by the hyaloid vasculature, was then removed. The vascular connexions between the disc and the lens were then dissected up from the surface of the retinae, so that the retinal vessels proper and the hyaloid vessels could be observed in the same specimen. When the retinal vessels only were to be studied, the retinae were removed as in the adult rat and mounted in glycerine.

Findings

Hyaloid Vessels.—At one day old the hyaloid system consists of numerous vessels passing forwards from the disc to the lens (Fig. 1).



FIG. 1.—Thick section of eye of one-day-old rat injected with Indian ink (cleared by the Spalteholz method), showing the eye *in situ* with the hyaloid artery, hyaloid capillaries, and tunica vasculosa lentis. $\times 24$.

These vessels run in two groups (Fig. 2, opposite):

- (a) A central leash passing directly through the vitreous to the posterior pole of the lens;
- (b) A group which is closely applied to the surface of the retina, and runs from the disc to reach the lens at about its equator.

Both of these groups were seen to terminate at the lens, where they broke up into a dense meshwork of capillaries on its surface, forming the tunica vasculosa lentis. These vessels were extremely numerous, and the group lying on the surface of the retina completely obscured the pattern of the retinal vessels proper.

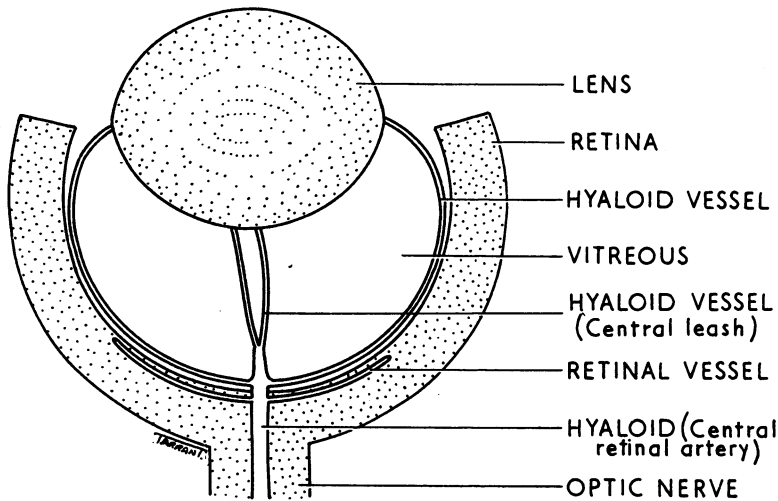


FIG. 2.—Sagittal section of lens and retina, showing two groups of hyaloid vessels. The retinal vessels are beginning to grow into the retina from the main artery.

This arrangement was seen to persist unchanged both in form and degree during the second, third, fourth, fifth, and sixth days of life (Figs 3 and 4, overleaf).

Closure of approximately one half of these vessels had occurred by the seventh day, and by the tenth day a leash of vessels (much less conspicuous than the original central leash) from the optic disc to the posterior pole of the lens was the only remaining element. This leash persisted in some cases up to the 22nd day, while in others at the 15th or 16th day it could not be demonstrated.

Retinal Vessels and Superficial Capillary Network.—The development of the main retinal vessels and the superficial capillary network have been described by Michaelson (1954). The central artery and vein each have characteristically six branches (Fig. 5, overleaf). These vessels are arranged symmetrically around the disc like the spokes of a wheel, artery and vein alternating. In the same plane, that is, within the nerve fibre layer, the superficial capillary net occupied the spaces between the alternating main vessels. These capillaries avoid the immediate vicinity of the artery, leaving a clear zone around the vessels. There is no such zone around the vein. This clear zone was found constantly around all arteries from the third day onwards, and sometimes was present on the first and second day in a less striking form.

At the anterior edge of the advancing capillary network (as the vessels grow out from the disc) the capillaries are of the primitive type described by Michaelson (1954). By the 11th day the superficial system of retinal vessels (main arteries, main veins and superficial net) is adult in form and extent.

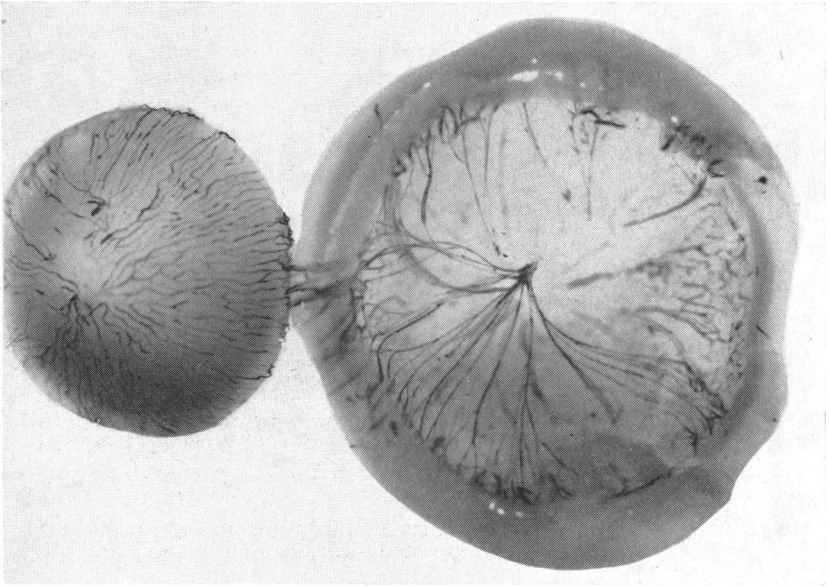


FIG. 3.—Retina and lens of 5-day-old rat, showing tunica vasculosa lentis with a leash of hyaloid vessels coming forward from the hyaloid artery, part of which has been detached and brought forward into the plane of focus. The retinal vessels are seen in the background. Injected Indian ink. $\times 14$.

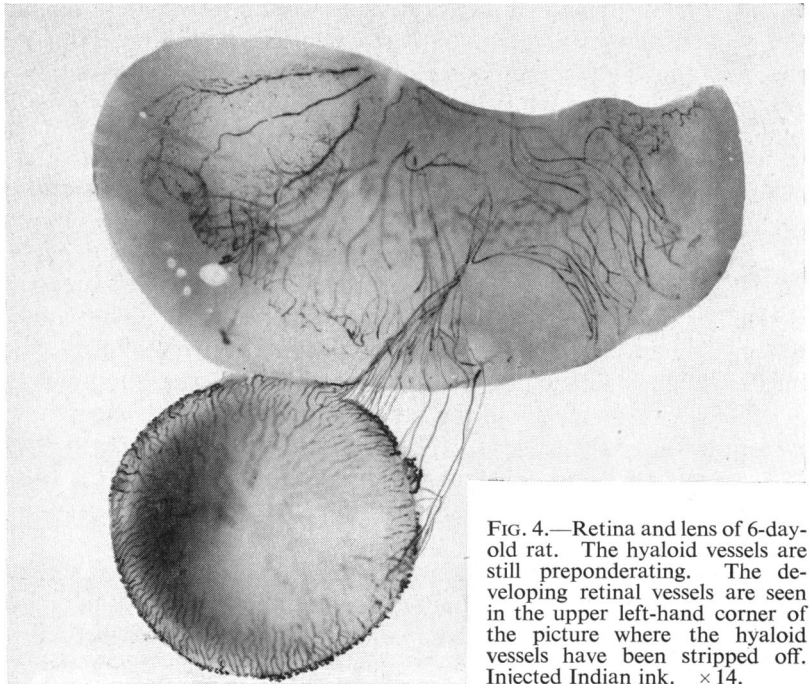


FIG. 4.—Retina and lens of 6-day-old rat. The hyaloid vessels are still preponderating. The developing retinal vessels are seen in the upper left-hand corner of the picture where the hyaloid vessels have been stripped off. Injected Indian ink. $\times 14$.

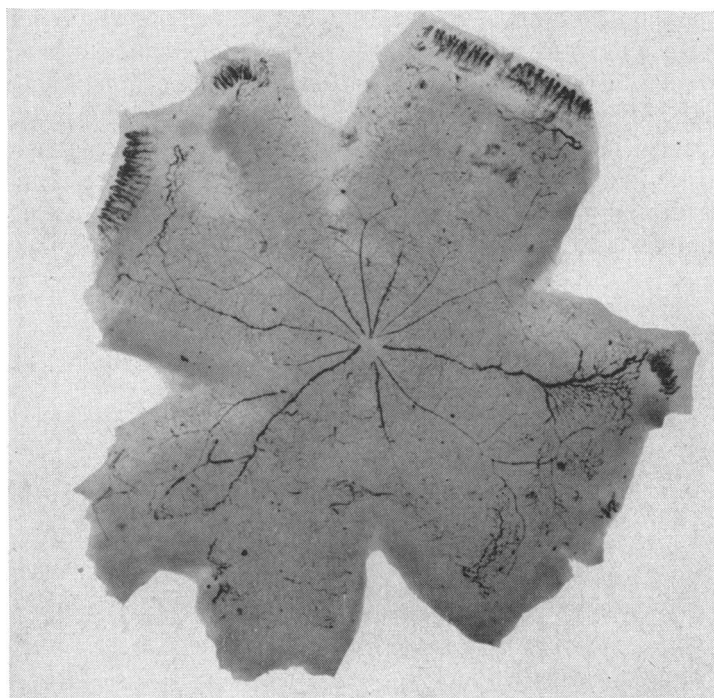


FIG. 5.—Retina of 10-day-old rat, showing vessels reaching to periphery of retina. In the lower right-hand corner of the picture there are some primitive capillaries. Parts of the ciliary body have been left attached at the top of the picture. Injected Indian ink. $\times 8$.

Figures for the development of these vessels taken from the present series are included in Table I. They are approximately the same as those given by Michaelson (1954).

TABLE I
DEVELOPMENT OF RETINAL VESSELS AND CAPILLARIES

Age of Rat (days)	Periarterial Capillary-Free Zone Distinguishable	Distance from Disc of Growing Edge (mm.)	Presence of Primitive Capillaries
1	Around some arteries	0.20	+
2		0.50	+
3	Around all arteries	1.00	+
4		1.50	+
5		1.60	+
6		2.00	+
7		2.50	+
10		2.90	+
11		3.00	+
15		3.00	-

Deep Capillary Network.—In the adult rat retina, the deep capillary network forms a reticular capillary bed deep to the inner nuclear layer. Large collecting veins arise from the net and perforate the inner nuclear layer, usually perpendicularly, or nearly so, to the surface of the retina. These vessels increase in size as the periphery is approached, so that while the connecting channels in the posterior area are of little more than capillary size, those draining the peripheral area often appear to be as large as the main retinal veins to which they are tributaries (Figs 6 and 7).

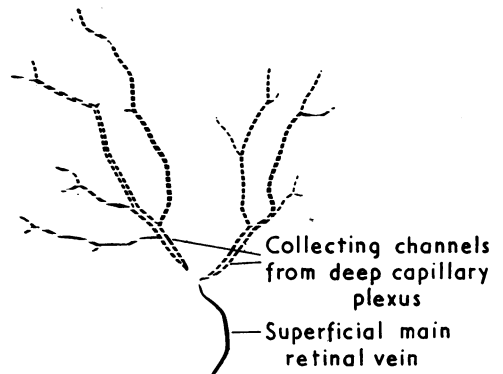
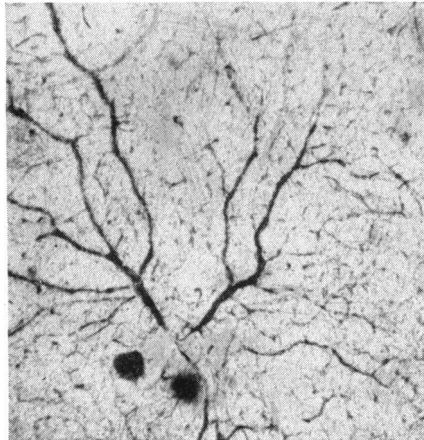


FIG. 6.—Retinal vein of 22-day-old rat (with explanatory drawing), showing formation of a main vein nearer the periphery of the retina by the junction of two collecting veins from the deep capillary net. Injected Indian ink. $\times 76$.

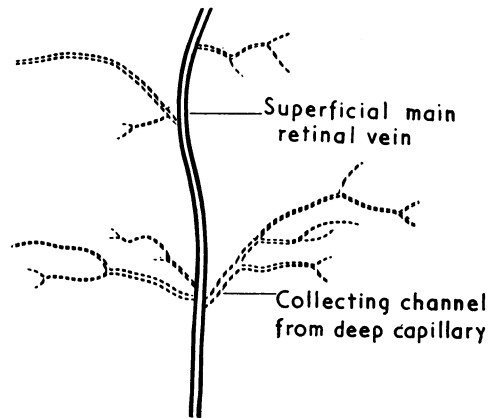
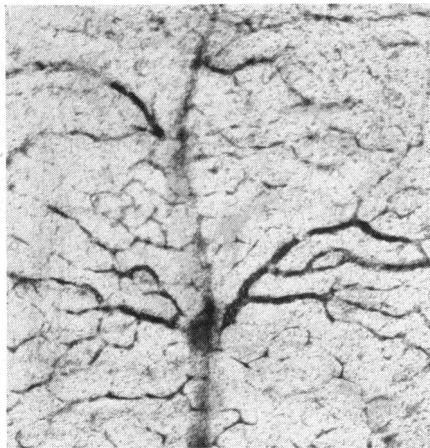


FIG. 7.—Retinal vein of 16-day-old rat (with explanatory drawing), showing main vein running at a superficial level. The deep branches and the deep capillary net are in focus. The photograph is taken from a peripheral area of the retina, and shows the large size of some of the collecting veins from the deep plexus. Injected Indian ink. $\times 120$.

The deep plexus was not present in any form in the 8-day-old rat. At 9 days, a few capillaries could be seen passing deeply from the main vessels and from the superficial capillary net into the substance of the retina. By the 11th day, these penetrating vessels were much more numerous, but no larger vessels had developed in the deeper layer. By the 15th day, the deep network had become fully adult in form, draining area by area through larger collecting veins into the main retinal veins. No vessel of larger than capillary size could be found connecting the deep plexus with the main retinal arteries (Fig. 8, overleaf). In the posterior retina there is a third capillary network situated intermediately between the superficial and deep networks.

Summary

In the eye of the newborn rat, the hyaloid vessels occupy most of the vitreous space, and cover the surface of the retina. The retinal vessels have just begun to grow out from the disc. The hyaloid vessels persist until the 7th day, by which time the retinal vessels have reached nearly to the periphery. The hyaloid vessels then undergo a rapid involution and the retinal vessels continue growing to reach the periphery by the 11th day, by which time the hyaloid vessels are vestigial or absent (Table II).

TABLE II
DEVELOPMENT OF HYALOID AND RETINAL VESSELS

Age of Rat (days)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Hyaloid Vessels				← Persisting →					← In-voluting →						← Vestigial →						
Retinal Vessels and Superficial Capillary Network					← Developing →										← Adult in Form →						
Deep Capillary Network				← Not Formed →								← Developing →				← Adult in Form →					

The deep capillary network, entirely venous in character, develops from the superficial retinal vessels between the 9th and 15th days. The retina is thus fully adult in form, having six main arteries, six main veins, and superficial, intermediate, and deep capillary networks, by the 15th day (Fig. 8).

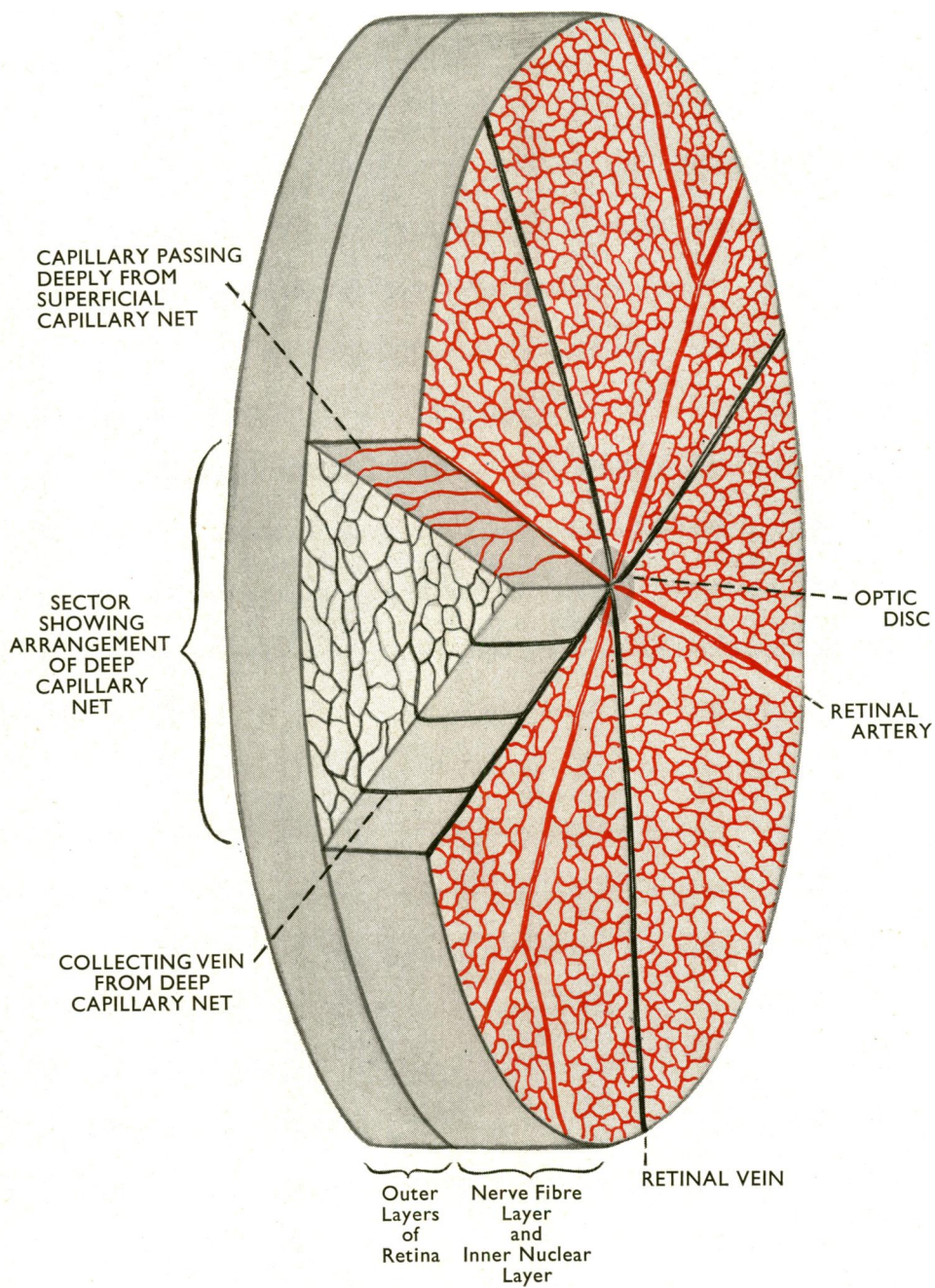


FIG. 8.—Diagram of central area of retina of adult rat, showing retinal vessels and capillary networks.

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