lymphatica dextra).—The right common lymphatic trunk is only about 14 mm. long, but is nearly as great in diameter as the thoracic duct. It is formed by the confluence of the lymphatics from the right side of the head (*truncus lymphaticus jugularis dexter*), those from the right arm, shoulder, and breast (*truncus lymphaticus subclavius*), the efferent trunks from the right half of the sternal, and ventral mediastinal and bronchial plexuses (*truncus bronchomediastinalis dexter*). As stated above, a part of the lymphatics of the right costal region open into the left thoracic duct (Fig. 3280). As on the left side there is a tendency for the trunk to terminate by a multiple instead of a single opening. Not infrequently, there is no true common trunk formed, but the great trunks from the different regions open separately.

The great lymphatic trunks in the higher mammals conform quite closely to those of man, but the termination varies somewhat. When the internal jugular is small it is generally near the junction of the subclavian and external jugular (Figs. 3282, 3285; and 3287), in the horse

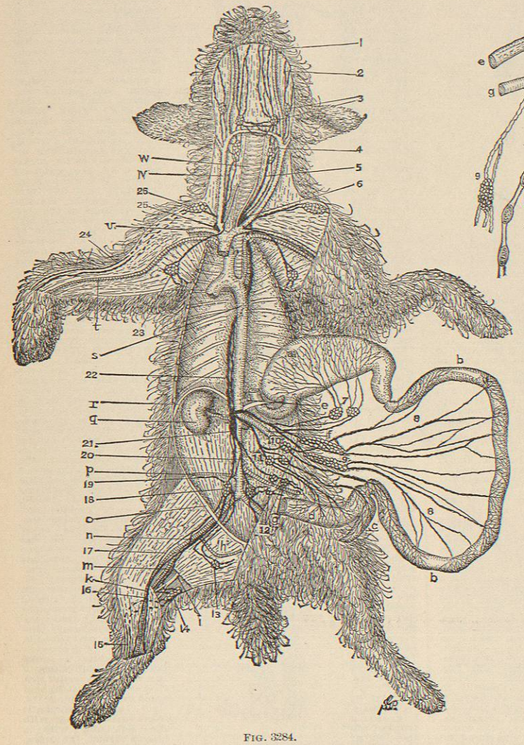


FIG. 3284.

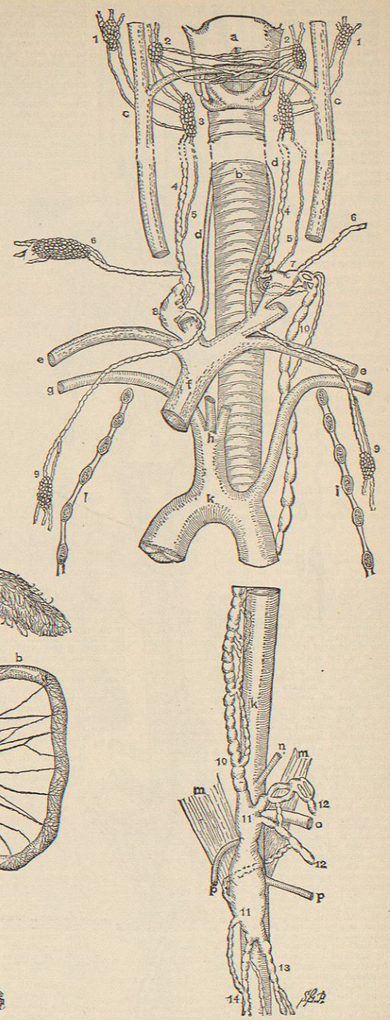


FIG. 3285.

FIG. 3284.—General View of the Lymphatic System of the Dog (Scotch Terrier). (Drawn by Mrs. Gage.) *a*, Stomach; *b*, *b*, small intestine; *c*, cæcum; *d*, large intestine; *e*, cœliac axis; *f*, superior mesenteric artery; *g*, inferior mesenteric artery; *h*, epigastric artery displaced from the abdominal wall to the muscles of the thigh; *i*, sciatic nerve and other popliteal structures brought into view by removing a segment of the thigh muscles; *k*, saphenous or internal cutaneous artery; *m*, *n*, the femoral artery; *o*, cut edge of the abdominal wall; *p*, ilio-lumbar artery; *q*, right kidney; *r*, cut edge of the diaphragm; *s*, aorta; *t*, brachial artery and its continuation as the radial artery in the anti-brachium; *u*, subclavian vein; *v*, external jugular vein; *w*, trachea. 1, Lymphatic trunks from the ventral lip to the mesal of the two submaxillary lymphatic glands; 2, lymphatic trunks from the face and nose, and dorsal lip, injected from the snout; 3, the two submaxillary lymphatic glands with the facial vein between them—the mesal glands of the two sides are connected by several transverse vessels; 4, ental cervical gland; 5, jugular lymphatic trunk finally joining the thoracic duct on the left, the right lymphatic trunk on the right; 6, termination of the thoracic duct at the junction of the subclavian and external jugular veins; 7, cœliac glands receiving the lymphatics of the stomach, and sending efferent trunks to the intestinal trunk; 8, lymphatic or lacteal trunks from the small intestine; 9, two large mesenteric glands (so-called glands of Asellius or pancreas Asellii; from these originates the intestinal lymphatic trunk, which is quite short in the dog and much more difficult to inject than in the cat; 10, gland receiving trunks from the duodenum, ileum, and large intestine near the cæcum; 11, glands receiving the lymphatics from the cæcum, and part of the large intestine; 12, glands in the mesocolon along the inferior mesenteric artery; they receive vessels from the large intestine, and the efferent vessels go to the chylocyst and to the lumbar glands; 13, gland on the abdomen beside the external epigastric artery; 14, popliteal gland; 15, lymphatics from the foot, following the external or short saphenous vein around the calf of the leg into the popliteal gland; the parts of the vessels that would be hidden in this view are indicated by broken lines; 16, lymphatic trunk following the saphenous artery. The saphenous trunk freely anastomoses with the trunk following the femoral artery, and with it passes to the lumbar glands; 18, lumbar lymphatic glands; 19, lymphatic trunk, accompanying the ilio-lumbar artery, and terminating in the lumbar glands; 20, lumbar lymphatic trunks; 21, chylocyst; 22, thoracic duct, double for a considerable distance; 23, pectoral lymphatic gland and vessels; 24, lymphatic trunks following the cephalic vein, and terminating in the prescapular gland. The course along the brachium is indicated by broken lines, as the vessels would not appear in this view; 25, termination of the right lymphatic trunk; 26, prescapular lymphatic gland of the right side.

FIG. 3285.—Ventral View of the Chylocyst and the Great Lymphatic Trunks in their Relation to the Principal Blood-vessels of the Dog (Scotch Terrier). The blanks with dotted lines in the cervical region, and the blank in the thorax, indicate that part of the length has been omitted. About natural size. (Drawn by Mrs. Gage.) *a*, Larynx; *b*, trachea; *c*, *c*, the right and left external jugular veins, with segments removed; *d*, *d*, the two internal jugular veins; *e*, *e*, subclavian veins; *f*, precava; *g*, *g*, right and left subclavian arteries; *h*, brachio-cephalic artery, near its division into the subclavian and the two carotids; *i*, *i*, aorta; *m*, *m*, pillars of the diaphragm; *n*, *p*, cœliac axis; *o*, superior mesenteric artery; *p*, *p*, renal arteries. 1, 1, Right and left lateral submaxillary lymphatic glands, receiving trunks from the face, nose, and dorsal lip; 2, 2, mesal submaxillary lymphatic glands, receiving trunks from the ventral lip; these two glands are connected by numerous anastomosing and crossing trunks; 3, 3, ental cervical glands, receiving the efferents from 1 and 2; 4, 5, 4, 5, jugular trunks from the ental cervical glands to the thoracic duct and right common lymphatic trunk; 6, 6, trunks from the prescapular glands, only the right gland being shown; 7, termination of the thoracic duct on the mesal surface of the external jugular, near its junction with the internal jugular vein. The arch in the duct is on the dorsal side of the great subclavian vessels, and it arches toward the mesom instead of laterad as with the cat, and before terminating enlarges considerably. Into the enlargement terminate the jugular trunks and the one from the prescapular gland; the enlargement narrows markedly before entering the vein; 8, enlargement and termination of the right lymphatic trunk; 9, 9, pectoral glands and trunks; the one on the left terminates independently in the lateral aspect of the external jugular, near its junction with the subclavian; 10, 10, thoracic duct; it is considerably divided just within the thorax, and then again just before enlarging near its termination; 11, 11, chylocyst on the ventral and right side of the aorta, and extending for a short distance into the thorax; 12, 12, intestinal lymphatic trunks; one branch winds round the left side of the aorta, and terminates finally on the right side of the chylocyst; 13, left lumbar lymphatic trunk; 14, right lumbar lymphatic trunk.

FIG. 3286.—General View of the Lymphatic System of a White Rabbit. (Drawn by Mrs. Gage.) *a*, Stomach; *b*, *b*, small intestine; *c*, *c*, cæcum; *d*, the so-called vermiform appendix; *e*, large intestine; *f*, cœliac axis; *g*, superior mesenteric, and *h*, inferior mesenteric artery; *i*, external epigastric artery displaced from the abdominal wall to the muscles of the thigh; *k*, sciatic nerve and other popliteal structures exposed by removal of a segment of the thigh muscles; *m*, saphenous or internal cutaneous artery; *n*, *o*, femoral artery; *p*, cut edge of the abdominal wall; *q*, ilio-lumbar artery; *r*, right kidney; the left has been omitted, although the beginning of the renal artery is shown; *s*, cut edge of the diaphragm; *t*, aorta; *u*, brachial and ulnar artery; *v*, subclavian vein; *w*, external jugular vein; *x*, trachea. 1, Trunks from the ventral lip and sides of the mouth; 2, trunks from the snout; 3, the two submaxillary lymphatic glands on either side of the facial vessels; 4, lymphatic glands near the base of the ear; 5, ental cervical lymphatic gland; 6, left jugular lymphatic trunk on its way to join the thoracic duct; 7, thoracic duct near its termination in the vein; 8, cœliac glands, receiving the lymphatics of the stomach; 9, 9, lacteals from the small intestine to 10, the great mesenteric gland (gland or pancreas of Asellius); it gives rise to two intestinal trunks, which are short, small, and difficult to inject with a coarse mass; 11, large mesenteric gland receiving the vessels from the mass of lymphoid follicles at the termination of the ileum; 12, lymphoid tissue, *sacculus rotundus*, at the termination of the ileum; 13, gland receiving the lymphatic trunks from the vermiform appendix; 14, glands in the mesocolon along the inferior mesenteric vessels; the efferent vessels pass to the lumbar trunks; 15, hypogastric or sacral lymphatic gland; 16, gland on the abdomen by the external epigastric vessels —it has been displaced with the artery to the thigh muscles; 17, popliteal glands receiving vessels from both sides of the crus, sending efferent branches between the peroneal and tibial nerves to follow the femoral artery, and another to accompany the ischiadic artery; 18, lymphatic trunks from the dorsum of the foot, winding round the tibial or outer side of the calf to join the popliteal gland; 19, lymphatic following the saphenous artery; it usually divides near the knee, sending one branch to the popliteal gland; 20, lymphatic trunk extending along with the femoral artery; it is formed by the intimate anastomosis of those accompanying the saphenous and deep femoral arteries; 21, lumbar lymphatic glands; 22, subcutaneous lymphatic gland near the ilio-lumbar blood-vessels, just at the lateral margin of the sartorius muscle; the efferent lymphatics follow the ilio-lumbar vessels and enter the lumbar glands; 23, lumbar lymphatic trunks; the right one is much more divided than the left; 24, chylocyst; 25, thoracic duct; this is almost invariably more or less divided and sends out a considerable branch to the right lymphatic trunk; 26, pectoral lymphatic glands; 27, anasto-

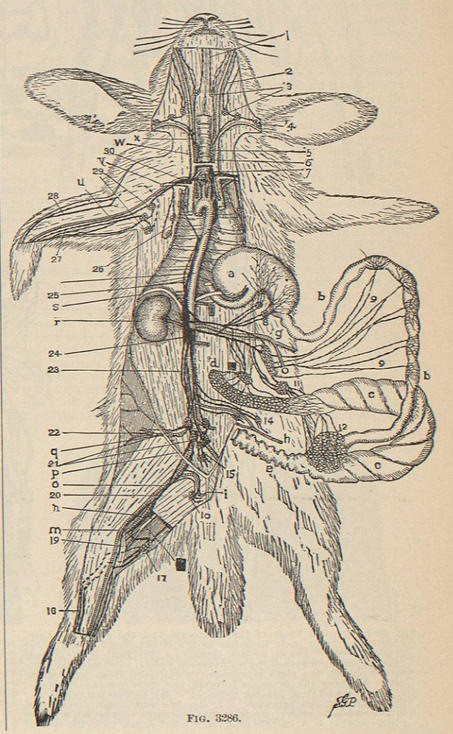


FIG. 3286.

mosing trunks following the radial and brachial artery to the axillary glands; 28, trunk following the radial nerve, winding round the brachium to terminate in the axillary glands also; the broken line indicates that the trunk would be out of sight in this view; 29, axillary lymphatic glands; these are not very closely connected with the axillary vessels; 30, termination of the right lymphatic trunk.

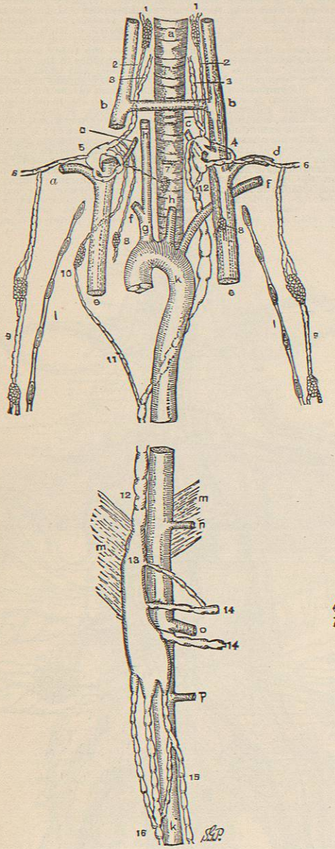


FIG. 3287.—Ventral View of the Chylocyst and the Principal Lymphatic Trunks in their Relation to the Great Blood-vessels in the White Rabbit. (Drawn by Mrs. Gage.) *a*, Trachea; *b*, *b*, external jugular veins connected by a transverse vessel; *c*, *c*, internal jugular veins; on the right a segment is removed from the jugular better to show the branches forming the right lymphatic trunk; *e*, *e*, the two internal jugular veins; *d*, *d*, the subclavian veins; *e*, *e*, the right and left precavæ; *f*, *f*, the two subclavian arteries; *g*, brachiocephalic artery dividing into the right subclavian and the right carotid; *h*, *h*, carotid arteries, the left arises from the arch of the aorta; *i*, *i*, cut thoracic wall and ends of five of the ribs; *k*, *k*, aorta; *m*, *m*, pillars of the diaphragm; *n*, cœliac axis; *o*, superior mesenteric artery; *p*, left renal artery, the right not being shown. 1, 1, Two ental cervical glands; 2, 2, efferent trunks of the ental cervical glands; 3, 3, ectal lymphatic trunks from the glands near the ear; they follow the external jugular vein for a considerable distance, then penetrate the tissues to join the jugular trunk; 4, the termination of the thoracic duct; this is very complex, forming a ring around the jugular, and becoming ampulliform, it terminates by a narrowed neck at the junction of the external and internal jugular veins; the numerous trunks opening into the expanded end of the thoracic duct, have their mouths guarded by a paired valve; 5, termination of the right lymphatic trunk; it is expanded like the thoracic duct and receives many trunks. The external jugular vein is encircled as on the left. A segment of the vein has been removed, better to show the parts. The right trunk opens into the vein at the junction of the right subclavian and external jugular, as is the usual method on both sides in the dog and cat; 6, 6, right and left trunks from the axillary glands; 7, tracheal gland with trunk going to the right; there is probably one going to the left also, as with the cat; 8, 8, glands in the thorax sending their efferent trunks to the corresponding common trunks; 9, 9, pectoral glands, and trunks on the two sides; their efferent trunks unite with those from the axillary glands to form the subclavian lymphatic trunk; 10, lymphatic gland on the right, near the second rib, through which passes the branch from the thoracic duct to the right lymphatic trunk; 11, branch of the thoracic duct going to the right side; this right branch is a very frequent, if not a constant, feature in the rabbit; 12, 12, thoracic duct; it is frequently much more divided than is shown in this figure. The blank space near the middle indicates that a part of the length was omitted; 13, chylocyst; this is as in the dog and cat, inclined to the right side of the aorta, but it does not extend so far into the thorax; 14, intestinal lymphatic trunk; this is small, usually multiple, short, and difficult to inject with a coarse mass; 15, 16, the right and left lumbar trunks; they form a long-meshed network, and in this specimen terminate in the chylocyst by three trunks.

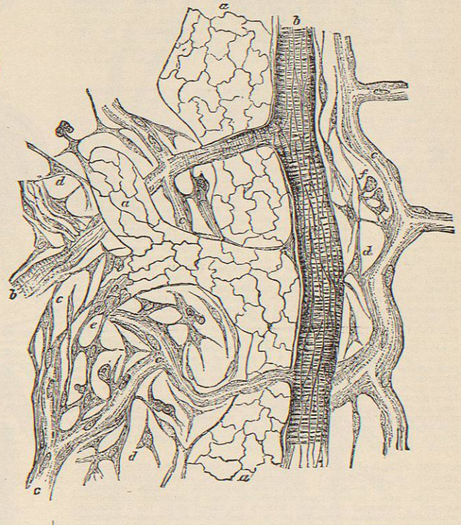


FIG. 3288.—A Pencilled and Silver-stained Preparation of the Normal Omentum of a Rabbit, to Show the Relation of the Blood- and Lymph-vessels to the Tissue Cells. (Klein.[7]) *a*, Lymphatic capillary with the outlines of its endothelial cells stained with silver; *b*, small artery showing spindle-shaped endothelial lining, and two small branches to the left; *c*, capillary blood-vessels; *d*, branched cells in the surrounding tissue; *e*, direct continuation of the endothelium of a lymph capillary with branched cells of the surrounding tissue; these cells are also attached directly to the blood capillary; *f*, wandering cells.

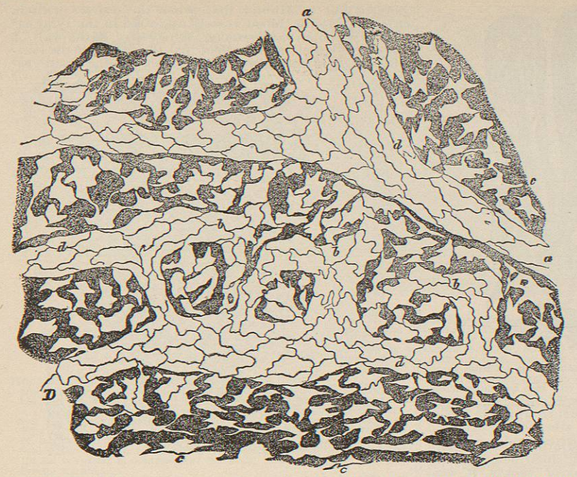


FIG. 3289.—Pencilled and Silver-stained Preparation of the Pleural Aspect of the Central Tendon of a Rabbit's Diaphragm, to show Lymphatic Capillaries and their Relation with the Cell Spaces. (Recklinghausen.[8]) Magnified 300 diameters. *b*, Beginning of the lymph capillaries by a continuity with the cell spaces; *c*, *c*, *c*, cell spaces surrounded by the dark ground substance. These spaces contain cells, lymph-canalicular cells, and the cell processes partly fill the white lines connecting the cell spaces (*cf.* Fig. 3288). *d*, *d*, *d*, *d*, Lymphatic capillaries with the serrated endothelial cells.

this duct terminates in the precava, and in the ox usually at the junction of the left jugular and the precava. In the ox also it usually traverses a special opening in the diaphragm. In the horse the duct is dilated at its termination, as it is also in the dog and rabbit (Figs. 3285 and 3287); in all the animals both trunks tend to open by two or more mouths (Fig. 3283), and in all the thoracic duct shows a strong tendency to conform to the lymphatics in general and break up into a kind of network instead of remaining of considerable size. Sometimes this network encloses the aorta, but more frequently it assumes the condition shown in Fig. 3283. In the rabbit almost constantly, and very frequently in the cat, there is a branch of the thoracic duct extending to the right (Figs. 3282 and 3287).

The chylocyst is large in the dog, cat, and rabbit, and in many other animals, and there is a strong tendency for its component trunks (intestinal and lumbar) to divide before entering it, so that it is formed by the union of a coarse network rather than by a few simple vessels (Figs. 3282, 3283, 3285, and 3287).

In the non-mammalia, birds, reptiles, amphibia, and fishes, the great trunks are symmetrical, that is, nearly equal on the two sides. They open into the great veins near the heart. There is also a pair of vessels opening into the ischiadic or other pelvic veins, and in the frog and toad there is a lymph heart on each great trunk, near the opening. In the non-amphibian forms, where lymph hearts are present, they are confined to the pelvic region. (See under Development, below.)

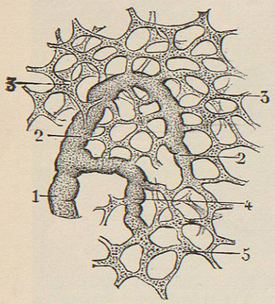


FIG. 3290.—Formation of a Lymphatic Capillary in the Skin of the External Ear. (Sappey, Atlas.) 1, Lymphatic capillary; 2 and 4, two minute branches uniting to form the larger capillary; 3, 3, 3, lacunes or dilatations formed by the union of the minutest lymphatic vessels, the capillicules. The union of a multitude of these lacunes forms a lymphatic capillary. This is shown best at the lower part of the figure.

ORIGIN AND STRUCTURE OF THE LYMPHATIC VESSELS.—There are three distinct views as to the ultimate origin of the lymphatic vessels: 1. That they are in direct communication with the blood-vessels at the periphery by means of connecting radicles so small that in normal conditions only the blood plasma can traverse them, and that under pathological conditions these connecting radicles may increase sufficiently in size to admit the passage of blood-corpuscles. This was one of the earliest views, and it is supported by the fact of the ready appearance of water or even colored gelatin in the lymphatics soon after the blood-vessels were injected. This was, and

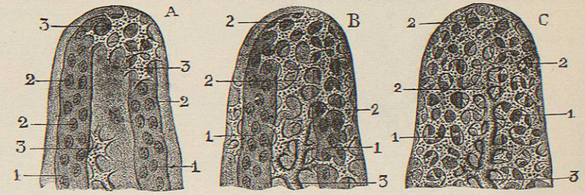


FIG. 3291.—A Simple Papilla from the Corium of the Hairy Skin of the Head, showing the Blood-vessels and Three Stages of Lymphatic Injection. (Sappey, Atlas.) *A*, A papilla, the simple blood-capillary loop (1 and 2) with very few lymphatic lacunes (3) and no sign of a lymphatic capillary. *B*, The lymphatic capillary (3) has appeared, and the lymphatic lacunes and capillicules (2) are very prominent, but the blood-capillary loop (1) is still evident. *C*, The blood-capillary loop (1) is almost invisible from the dense network of lymphatic lacunes and capillicules (2); the lymphatic capillary (3) is prominent. This series is an excellent illustration of the structures that remain invisible in ordinary preparations. Probably in very few histological preparations are more than half or one-third of the structures seen.

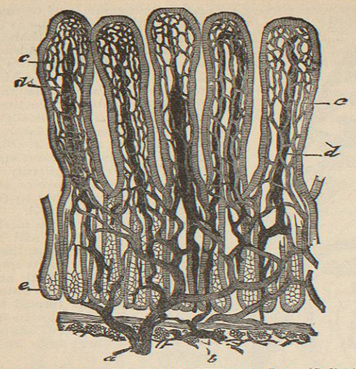


FIG. 3292.—Lacteals of the Intestinal Villi of the Dog. (Cadiat.) *a*, Artery extending into the villi to form a capillary network (light shading); *b*, lacteal extending from the villi into the submucosa (dark shading); *c*, *c*, blood capillaries in the villi; *d*, *d*, central lacteal of the villi. In one it forms a loop, in the others it ends blindly; *e*, crypts of Lieberkühn.

still is, a favorite method of demonstrating the lymphatics of an organ. In objection to the doctrine of the direct connection of the two systems of vessels, it was

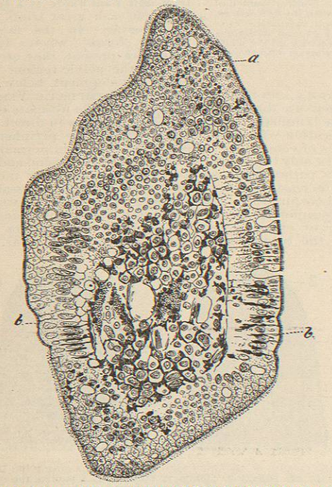


FIG. 3293.—Transection of a Villus (Mall [14]) in which the Lymphatics have been Injected with Berlin blue. The blue is represented by black in the figure. From the centre fine streams of the injecting mass have penetrated to the epithelium and even between the epithelial cells. *a*, sectional view of the epithelial cells with the lymph channels in section; *b*, *b*, longisections of the epithelial cells showing the lymph channels between them.

pointed out by Hunter that, when the coarser matters injected into the blood-vessels appeared in the lymphatics, it was due to a breakage somewhere in the wall of the blood-vessel; and further, that the filling of the lymphatics by injecting water or gelatin into the blood-ves-

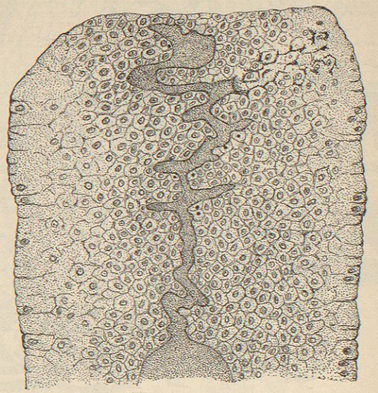


FIG. 3294.—Longisection of the Terminal Part of a Villus (Mall [14]) to show the narrow, spiral extension of the central lacteal, with fine branches reaching out from it toward the surface. The epithelium has been removed and the lymphatics have been injected with Berlin blue (cf. Plate XLIV. and Fig. 3293).

sels was but natural, as it is one of the properties of the blood-vessels to allow the contents to diffuse through their walls, and the lymphatics, from their office as a drainage system, take up the exuded liquid. This does

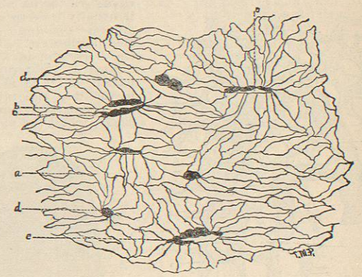
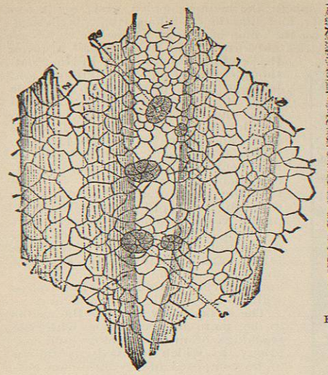


FIG. 3295.—Portion of the Cisterna Lymphatica Magna of the Frog, to show Endothelium and Stomata. (Prudden.) *a*, Ordinary endothelial cells, the nuclei not being shown; *b*, *b*, stomata leading from the peritoneal cavity into the dorsal lymph sac; *c*, *c*, germinating endothelium surrounding the stomata; *d*, germinating endothelia among the ordinary cells; these are frequently called pseudostomata.

not, however, show how the exuded liquid gets into the lymphatics. The pressure which forces the plasma through the walls of the blood-vessels would seem rather to collapse the lymphatics, as the pressure is on the outside. In a word, there has been no conclusive proof



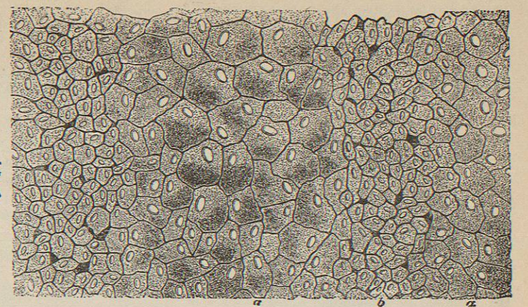


FIG. 3297.—Peritoneal Endothelium from the Central Tendon of the Rabbit's Diaphragm, to show the Difference in the Size of the Cells, and the Pseudostomata between them. (Klein.) *a*, *a*, Irregular rows of large nucleated endothelial cells, corresponding to underlying tendinous bundles; *b*, rows of smaller endothelial cells with numerous pseudostomata between them (the dark spots). The rows of small cells correspond to the lymph channels between the bundles (cf. Fig. 3296).

FIG. 3296.—Silver-stained Peritoneal Aspect of the Central Tendon of a Rabbit's Diaphragm, to show Stomata. (Klein.[7]) *l*, Lymph channel between the tendon bundles; *s*, *s*, five stomata, surrounded by germinating endothelium and leading into the lymph channel between the two tendinous bundles. Part of the stomata are open and part closed; *t*, *t*, two bundles of the central tendon, between which is the lymph channel into which the stomata open. Over the tendinous bundles the endothelial covering is composed of markedly larger cells than over the lymph channel.

given that there is or is not a direct connection between blood-vessels and lymphatics.

2. That there is a network of minute spaces in the tissues between and around the individual structural elements, through which the diffused plasma slowly moves, bathing all the cells and fibres, giving to them oxygen and the other nutritive elements, and taking in return carbon dioxide and the other products of waste. Part of this waste, especially the carbon dioxide, diffuses back into the blood capillaries. This system has been called *juice spaces and canals* by Recklinghausen [8] and the *lymphcanalicular system* by Klein.[7] These minute channels and spaces are all interconnected and continuous with the

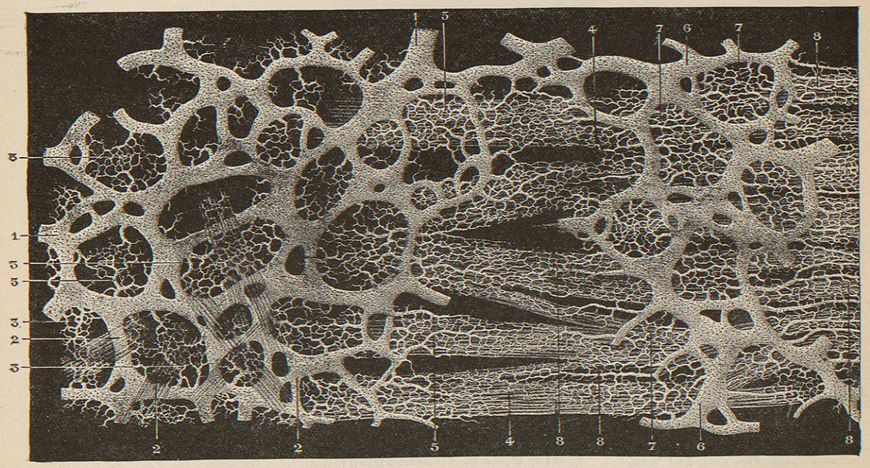


FIG. 3298.—Finer and Coarser Lymphatic Network of the Muscularis of the Small Intestine of a Child at Birth. (Sappey, Atlas.) Magnified 200 diameters and reduced about one-third. 1, 2, and 6, Coarse network of lymphatics resting upon the longitudinal muscles; 3, 4, 5, 7, and 8, finest lymphatic network around the muscular fibres, and uniting to form the larger network.