blood-vascular system through the intercellular cement and spaces, and with the lymphatic vessels in the same way, and further, these spaces frequently, if not constantly, contain branched cells, the cell body filling the larger spaces and the processes the connecting channels. These cell processes are often projected between the endothelial lining of the capillaries, thus forming the so-called pseudostomata, and therefore bring the lymphatics and blood-vessels really into continuity by the intervening cells and the spaces surrounding them. This is well shown at *e*, in Fig. 3288.

3. The third view is that of Sappey, who has represented with marvellous clearness the entire lymphatic system from origin to termination. He believes, and thinks he has proved by new and special means of research, that the lymphatic system at its origin is invariably composed of minute vessels (capillicules) from 1 μ to 4 μ in diameter, with structureless walls, which extend around and between all the structural elements. These capillicules are closed at the free end, but join, in nearly the same way as do the canaliculi of bone, to form somewhat larger spaces, the lacunes, which vary from 2 μ to 8 μ in diameter, and like the capillicules have structureless walls. By the union of many lacunes the true lymphatic capillaries are formed, and in them first appears the endothelial lining. Further, although the capillicules around and between the structural elements have blind terminations, those connected with the blood-vessels extend into the lumen between the endothelial cells, and have open mouths into which the plasma of the blood can freely enter, and in some pathological conditions they may become so large that the blood corpuscles may pass through the capillicules to the lymphatic vessels. This view is in part a return to the original doctrine, and it also differs from the doctrine of the lymph-canalicular origin in excluding the cells from the spaces or lacunes, and in giving distinct but structureless walls to the capillicules and lacunes.

The second view seems to the writer to be more in accordance with the teachings of modern biology and histology, by which the body is shown to be composed of a continuous network of interconnected structural elements independent only in the form of blood corpuscles, lymph, and wandering cells, but all the other elements being united either by cell cement or by delicate protoplasmic processes, and any spaces left between the structural elements being filled by the product of cell activity, which is known as ground or intercellular substance. This is very abundant in some tissues, as cartilage, very slight in amount in others, as epithelia. All of these structural elements are constantly bathed with lymph, and it is more in accord with what is at present known of absorption and excretion (see articles *Absorption*, *Digestion*, and *Metabolism*) to suppose that the lymph depends for its movement in certain definite directions upon the action of the living cells rather than on merely physical conditions. From the latest and most satisfactory work on the development of the lymphatics (see below) it would appear that the lymphatic system is a closed one, and all passage of lymph to it from the tissues or vice versa, must take place by diffusion as with the blood-vascular system.

The readily demonstrated or apparent origin of the

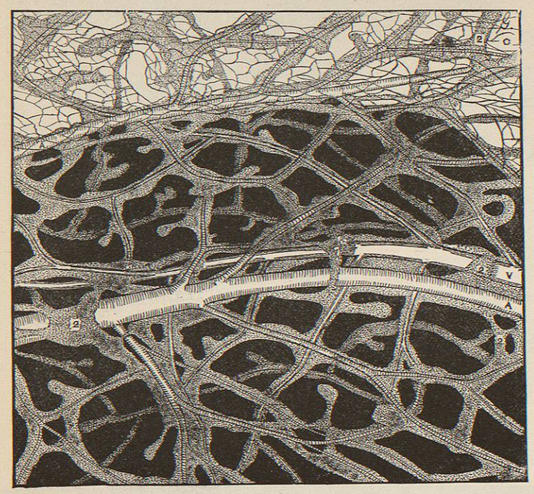

FIG. 3299. Surface View of the Lymphatic Network in the Submucosa of the Rabbit's Cæcum, showing the Form of the Network and the Relation of the Lymphatics and Blood-vessels. Magnified 55 diameters. (Drawn by Mrs. Gage.) *A*, *A*, Small arteries; *V*, small vein; *C*, the blood capillaries in the upper part of the figure; 2, 2, 2, 2, lymphatic vessels. (cf. Fig. 3300.) Throughout the entire figure is shown the tendency of the lymphatics to follow the blood-vessels and partly to surround them. The preparation was made by injecting Hoyer's chrome yellow mass into the appendix vermiformis, when it extended into the submucosa of the adjoining part of the cæcum (see Fig. 3286). The blood-vessels were then injected with fine red gelatin mass from the superior mesenteric artery. After the gelatin had cooled the cæcum was distended with alcohol, and the preparation finally mounted in Canada balsam.

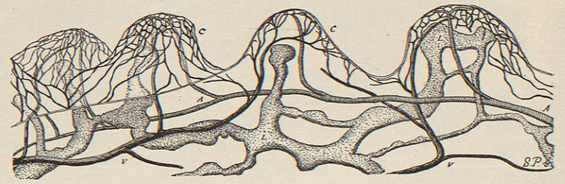

FIG. 3300.—Side View of the Lymphatics and Blood-vessels in the Cæcum of the Rabbit. (Drawn by Mrs. Gage.) *A*, *A*, artery; *V*, *V*, veins; *L*, *L*, lymphatics; *C*, villi. This figure shows the villus-like elevations persisting in the cæcum of the rabbit (Hilton [13]) with the vascular and lymph vessels. It will be noted that the artery for each villus extends to the summit and breaks up a network of capillaries which form a kind of mantle or tent. The lymphatics show the usual appearance, but with a kind of network in the villus at the right. On the left the whole villus is present at the top; on the right the part toward the observer has been removed from the two villi.

lymphatic vessels is in a plexiform network of valveless capillaries of varying sizes (Plates XLII., XLIII., and XLIV., and Figs. 3298 and 3299). From this capillary network extend collecting trunks with abundant valves (Fig. 3267). The serous cavities are likewise directly connected with the lymphatic vessels through the stomata or pseudostomata (Figs. 3295–3297). But the pleuro-peritoneal cavities are not primarily connected with the lymphatic system, but come to be so connected later.

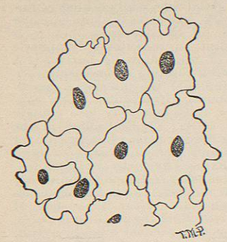

FIG. 3301.—Endothelial Cells from a Small Lymphatic Capillary of the Central Tendon of the Rabbit. This figure shows well the characteristic sinuous outlines and the nuclei of the endothelial cells. (Prudden.)

A distinct plexus of origin has been satisfactorily demonstrated in all the tissues and organs except the following, and in some of these, as the cornea, the lymph is known to circulate, although not in an independent network of vessels.

1. The central and peripheral nervous system and retina. The lymph in these situations is either in perivascular spaces or in perineural spaces. In the optic nerve, however, Key and Retzius figure a well-defined lymphatic network.

2. A lymphatic network has not been satisfactorily made out for bone or cartilage, and Sappey denies the presence of lymphatic vessels in these structures.

3. All forms of epithelia, including hair, nails, and teeth. But Klein figures and describes processes of branched cells projecting between epithelial cells and serving as lymph channels; but no distinct capillaries with endothelial walls are present. (See also Mall,[14] and Fig. 3293.)

4. Cornea and, according to Sappey, all forms of fibrous tissue, tendons, aponeurosis, fascia, and all serous membranes. Where a plexus of origin appears to be in these it belongs to the underlying tissue. According to many authors the connective tissue is a favorite place for the origin of the capillary lymphatic networks. There is no doubt of the presence of the network, the only question is whether it belongs to the connective tissue or to the surrounding tissues.

The ducts of some glands (as the pancreas) have never yet been shown to contain lymphatics, although in the ducts of other glands, as the liver, lymphatics have been shown in great numbers.

These networks or plexuses of origin show considerable variety in different parts of the body. As a rule, the lymph capillaries are considerably larger than the blood capillaries (Figs. 3299, 3300), and there is a great tendency to form blind, often ampulliform enlargements (Fig. 3300). In the villi of elongated narrow form, the origin by a blind central vessel is normal, or there may be a simple loop instead (Fig. 3294). In man, where the villi are mostly short and broad, there is a complicated network something like the blood capillaries, except that the lacteal capillaries are much larger. The simple blind end and loop are also seen in some of the more elongated villi. The presence of ampulliform enlargements, or even blind endings, in a vessel is not enough to determine whether it is a blood-vessel or a lymphatic, for some blood-vessels in muscle (Ranvier) and in the dura of the brain (Key and Retzius) have the form which is usually considered so characteristic of lymphatic vessels. The final test must be the connections of the vessel with a lymphatic gland or with an undoubted blood-vessel.

FIG. 3302.—Nucleated Endothelial Cells from One of the Larger Lymph Channels of the Central Tendon of the Rabbit's Diaphragm, to show the Elongated Form of the Cells in the Larger Vessels. Cf. Fig. 3301. (Prudden.)

Structure of Lymphatic Vessels.—Beginning with the lymph capillaries the wall is composed only of endothelial cells arranged mostly in the form of a tube. They may, however, be more like flattened clefts, the walls of which are in apposition except when containing lymph. The lining cells have sinuous edges (Fig. 3301). On the larger vessels the lining endothelium has more elongated cell outlines (Fig. 3302), and there progressively appear coats like those of the blood-vessels, except that they are thinner. The adventitia is easily separated from the vessel, is composed of a network of fine elastic fibres and a few longitudinally arranged muscular fibre cells. The middle coat has, besides the fine elastic tissue, many circularly arranged muscular fibre cells. This circular arrangement is not strictly adhered to, especially in the thoracic duct. Finally, the inner layer has its elastic fibres mostly in a longitudinal direction, and the endothelium covers the ental surface. In the thoracic duct there is usually a considerable addition of white fibrous tissue to the middle layer, and, as stated above, many of the muscular fibres of this layer may be oblique or even longitudinal. In general, then, the lymphatic vessels agree with the veins quite closely in structure. The amount and the fineness of the elastic tissue present is supposed to exert a marked influence in causing the speedy return of the vessel to its normal calibre after its distention by the lymph.

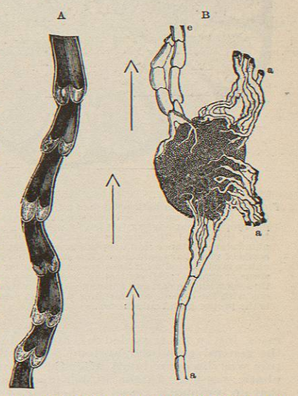

FIG. 3303.—Valves of a Lymphatic Trunk, and a Lymphatic Gland with its Afferent and Efferent Vessels. (Sappey.) *A*. Lymphatic trunk slit lengthwise and opened to show that the valves are in pairs—they are close together and they are at the level of the enlargements; further, that the intervalvular segments are in general of a conical shape, the apex of the cone pointing in the direction of the current, up in this figure. *B*. Lymphatic gland; *a*, *a*, *a*, the numerous afferent lymphatic vessels; *e*, the two voluminous efferent lymphatics.

Like the veins, the lymphatics are distinguished by the presence of valves; but they are much more abundant, there being, for example, sixty to eighty double valves from the hand to the axilla (Fig. 3303). In examining a well-injected preparation, it is very easy to determine the direction of the lymph stream as the segments of the vessel are approximately conical, the apex of the cone pointing in the direction of the stream (Fig. 3303). This is more marked in the smaller than in the larger vessels.

Valves are not found in the lymphatics of fishes, and are much less numerous in the other groups than in mammals.

LYMPHATIC GLANDS OR NODES AND LYMPHOID TISSUE.—The lymphatic glands or ganglia or conglobate glands are rounded or flattened bodies placed in the course of the lymphatic vessels. These glands were known to Hippocrates, but were regarded by him as forming a part of the general glandular system. Naturally their true nature was discovered only after the discovery of the lymphatic vessels. In the higher mammals it is believed that no lymphatic vessel reaches one of the common terminal trunks without first traversing one or more of these glands. They first appear in the birds, or perhaps some of the highest reptiles, but lymphoid tissue is present in all the forms; and as the glands are practically concentrations of this lymphoid tissue their absence is not so important as might at first appear. The glands are sometimes solitary but usually are in groups or chains; they are mostly near blood-vessels, and so placed and loosely attached that they readily move aside to avoid pressure. In the limbs pressure is further avoided by position in the flexures of the joints. The glands vary greatly in number and size in the different mammals. In man they reach the highest number (five hundred to six hundred) and vary from a few millimetres to two or more centimetres in diameter.

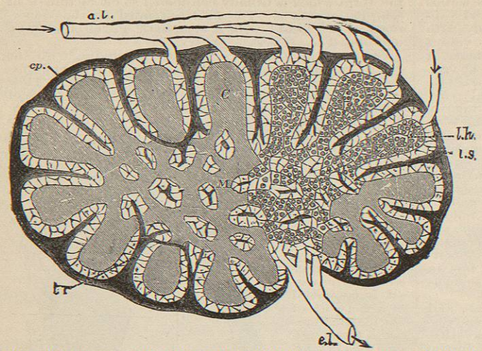

FIG. 3304.—Diagrammatic Section of a Lymphatic Gland. (Sharpey.) *a, l*, Afferent trunk breaking up into several smaller trunks before entering the gland; *e, l*, efferent lymphatic trunk formed by the union of several smaller trunks emerging from the gland (the arrows indicate the direction of the current); *C*, cortical glandular substance; *cp.*, capsule sending septa into the gland; *l.h.*, reticulated cords of medullary substance (it is shown in only a small part of the figure; the entire area shaded with lines possesses similar glandular substance); *t.s.*, lymph sinus or channel; *M*, central or medullary part of the gland (it is directly continuous with the cortical substance); *tr.*, trabeculæ or fibrous substance continuous with the capsule and forming a coarse meshwork in the gland (in this mesh is the proper gland substance).

Afferent and Efferent Vessels.—The vessel approaching a gland is said to be afferent or inferrent; the one leaving the gland is called efferent. On approaching a gland the afferent usually breaks up into several smaller vessels which enter the gland (Figs. 3303 and 3304). After traversing the gland the vessels leaving the surface unite usually in larger trunks than the afferent vessels, and continue to the next gland, where the process is repeated, or the vessel may terminate in one of the common trunks.

The structure of the lymphatic glands was long enigmatical. It was held by many, and is still so held, that the gland was really a kind of fine capillary network, like a renal glomerulus, or a rete mirabile, of blood-vessels; but it is now quite generally agreed that a lymphatic gland consists of the following parts: (1) A fibrous framework forming an enclosing capsule and sending into the interior a multitude of anastomosing trabeculæ. The capsule and larger trabeculæ may also contain muscular-fibre cells. (2) Embedded in the meshes of this fibrous network is the proper glandular substance, which consists of lymphoid tissue; that is, a fine network of branching and anastomosing cells and fibres containing in their meshes lymphoid corpuscles or young lymph cells. Near the surface of the gland the lymphoid tissue is arranged in quite regular masses (cortical lobes or aveoli) by the projecting trabeculæ (Fig. 3304). This is the so-called cortical portion, while in the central part (medullary portion) the lymphoid tissue is in more cylindrical masses (the medullary cylinders or lymphoid cords), but the tissue in the two parts is directly continuous. (3) The lymph sinus or channel. This is the path taken by the lymph in passing through the gland from the afferent to the efferent vessels. It is a narrow space filled with rather coarse retiform tissue, between the proper glandular substance and the fibrous framework (Fig. 3304, *l.s.*). The relations of this space may be clearly understood by comparing the fibrous framework to a mould and the proper glandular substance to the material poured into the mould and which, upon cooling, had shrunken evenly from the mould throughout the entire gland, thus leaving a narrow space which would represent the lymph channel. The afferent lymph vessel penetrates the sheath or capsule of the gland and pours its contents into the lymph sinus. The lymph then slowly

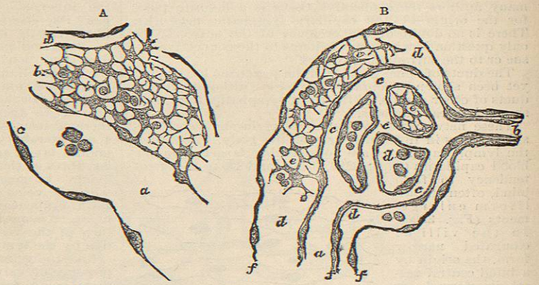

FIG. 3305.—Figures of Fresh Preparations of an Œdematous Omentum of a Guinea-pig suffering from Chronic Peritonitis, to Show Developing Lymphatic Nodules seen in Optical Section. (Klein.[7]) *A*, Perilymphatic or lymphangial nodule; *a*, lymphatic vessel; *b*, a portion of the lymphangeal nodule on the side of the vessel; *c*, endothelial wall of the lymphatic seen in profile; *d*, blood capillary of the nodule; *e*, lymph corpuscles in the lymphatic vessel (this nodule is like the reticular substance forming the proper glandular substance of the lymphatic glands, and as seen both in *A* and *B* the cells of the reticulum are in direct connection with the endothelium of the lymphatic vessel). *B*, An endolymphatic or lymphangial nodule in which the reticular tissue is within instead of being on the side of the vessel; *a*, vein; *b*, artery; *c*, blood capillaries; *d*, a lymphatic vessel enclosing the whole system of blood-vessels; *e*, reticulum of nucleated branched cells or lymphoid tissue connected with the wall of the lymphatic and filling the entire lumen.

moves along the labyrinthine channels until it reaches the efferent vessels, when it enters them and continues toward the common lymph trunk. In passing through the sinus the lymph bathes the glandular substance and probably soaks into it. Along the edge of the channel the newly developed lymph cells enter the lymph stream and are carried along to the efferent vessel.

Blood-vessels are very abundant in the lymphatic glands and are found almost exclusively in the proper glandular substance. These blood-vessels are also accompanied by nerves. In some glands the efferent vessels and the blood-vessels are found mostly in a small depression which, in analogy with the kidney, has been called the hilus. This is not a marked feature and is absent in many cases.

In infancy and youth the glands near the surface are grayish in color while those in the interior of the body are pinkish. In adult and advanced life the glands are usually somewhat atrophied and darker in color, and those of the bronchial plexus are often dark brown or even black.

Lymphoid or adenoid tissue is like that described for the proper glandular substance of the lymphatic glands; that is, a fine network of branching and anastomosing cells or fibres with the meshes crowded with lymphoid cells. Sometimes this tissue is quite sharply defined, when it is called a follicle or simple lymphatic gland; in other situations it is diffuse. The tissue is abundantly supplied with blood-vessels, and the lymphatic vessels on its surface and emerging from the interior are in great abundance (Fig. 3306). The diffuse and follicular form of the tissue is found in great abundance in the alimentary canal of man and the lower animals. In the tonsils and the pharyngeal tonsil it is aggregated in considerable masses; so also in the Peyerian patches, which are simply an aggregation of lymph nodules, follicles, or solitary glands. The mucosa of the vermiform appendix of the rabbit (Fig. 3286) is almost entirely occupied by a great Peyer's patch; and the so-called solitary glands (Fig. 3306) are lymphoid nodules or follicles with a dense meshwork pervaded by blood capillaries and filled with lymph corpuscles. They are surrounded by a capillary network which helps to separate them somewhat from the surrounding less condensed lymphoid tissue (Fig. 3306).

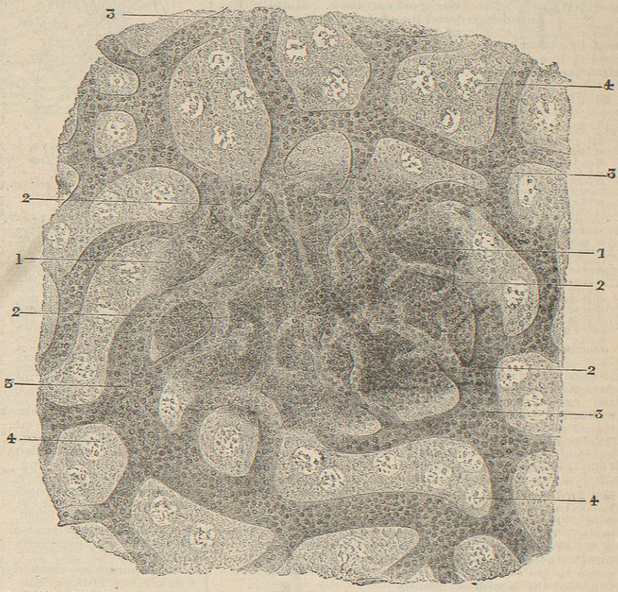

FIG. 3306.—Lymphatic Vessels arising from a Lymph Follicle or Solitary Gland of the Large Intestine of Man. (Sappey, Atlas.) Magnified 100 diameters and reduced about one-fourth. 1, Lymph follicle seen from the submucosa; 2, 2, 2, 2, lymphatic radicles arising in the depth of the follicle and appearing on the surface; 3, 3, 3, trunklets formed by the union of the smallest radicles; 4, 4, base of the crypts of Lieberkühn.

Hæmolymph Glands.—Deep red or chocolate-colored bodies from 1 to 20 mm. in diameter with the general structure of lymph glands but with the sinuses filled with blood instead of lymph.

In structure the parenchyma of these glands resembles spleen or red marrow (splenolymph or marrow-lymph glands). The glands resembling spleen are most common. Intermediate or transition forms between hæmolymph glands and the ordinary lymph glands occur.

Hæmolymph glands have been reported in the following animals: Hen, turkey, rat, dog, sheep, goat, ox, pig, horse, and in man. They occur most frequently along the great blood-vessels, especially those of the abdomen. They are most easily found in the root of the mesentery, and in the neighborhood of the renal and adrenal vessels. In the cervical region they are commonly near the parathyroids (Warthin[9] and Vol. IV. of this Handbook).

DEVELOPMENT OF THE LYMPHATIC SYSTEM.—While in the past much serious study has been given to the development of the lymphatic system in the embryo, the matter has remained in a very unsatisfactory condition until recently. From the time when this system was discovered and worked out, in the adult it has been known that it is an appendage of the venous system. It has also been known for many years that the lymphatic system develops considerably later than the blood-vascular system. However, it is only within the present year (1902) that it has been shown conclusively that this system does not grow in from the exterior part of the body and finally form a union with the veins, *but on the other hand that it is a direct outgrowth of the venous system* (Sabin[10]).

As worked out for the pig it was found that the lymphatic system is at first symmetrical and grows out from the veins at four points, that is at the junction of the veins of the limbs with the cardinal veins, viz., at the junction of the subclavian and precardinal veins in the base of the neck, and in the lumbar region at the junction of the sciatic and femoral veins with the post-cardinals. Slightly beyond its origin from the vein each of the four original lymph trunks or ducts dilates to form a lymph sac or lymph heart. In lower forms, as the frog, lymph hearts contain striated muscle and are rhythmically contractile; it has not yet been shown, however, whether these sacs in the developing mammal are contractile or not.

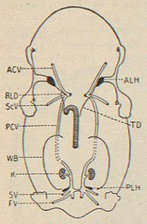

FIG. 3307.—Diagram of the Lymphatic System of an Embryo Pig 20 Mm. Long. × 2. (Sabin.) *ACV*, Precardinal vein; *RLD*, right lymphatic duct; *ScV*, subclavian vein; *PCV*, post-cardinal vein; *WB*, Wolffian body; *K*, kidney; *SV*, sciatic vein; *FV*, femoral vein; *ALH*, anterior lymph sac or lymph heart; *TD*, thoracic duct; *PLH*, posterior lymph sac or lymph heart. It is to be noted that the lymphatic system is symmetrical, but that in the cephalic part of the body it is considerably more advanced than in the caudal half.

As demonstrated in the following figures the lymphatics develop first in the cephalic half of the body; the system is symmetrical, but soon the left side preponderates; the connection of the lymphatics with the veins in the caudal half of the body is soon lost; there are very early two chylocysts, and two thoracic ducts, but as both thoracic ducts grow down to join the lumbar ducts from the left side, the asymmetry of the lymph trunks in the cephalic half of mammals is original and not secondary. It is also seen that the lymphatics as they grow out to the periphery are in a close-meshed network, the ends of the tubes forming the network ending blindly, and extending farther and farther over the body by a continual sprouting of the tubes.

The lymphatic glands are developed from a network of lymph vessels by an ingrowth of lymphoid tissue and by the formation of a connective-tissue capsule around the outside. Finally it should be stated that beginning with Kölliker in 1879 an increasing number of embryologists have come to believe that the real origin of the lymph corpuscles of the body is from the epithelial cells of the thymus (Beard[11]).

Methods. — The lymphatic vessels are so thin that unless they contain some liquid or solid they are not visible. One of the first ways of making the general lymphatics visible was to inject water or colored gelatin into the arteries of an organ. The mass exudes and fills the lymph vessels; this is especially successful if the vein is tied. The lacteals are made evident by feeding the animal some fatty food, like milk, an hour or two before death.

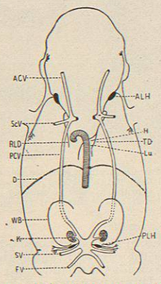

FIG. 3308.—Diagram of the Lymphatic System in an Embryo Pig 27 Mm. Long. × 2. (Sabin.) *D*, Diaphragm; *H*, duct to the heart; *Lu*, duct to the lungs. The other letters as in the previous figure. In this figure it is seen that the lymphatics in the cephalic half are more advanced on the left than on the right.

Vessels of sufficient size may be injected centrad with starch or plaster-of-Paris. It is not necessary to tie the cannula in place; simply pressing upon it with the fingers is sufficient. The insertion of the cannula is greatly facilitated by first inserting a beaded bristle into the lymphatic, then by raising the bristle the cut in the vessel may be seen. Where the vessels are too small to be seen, very successful injections may be made by the puncture method. That is, a hypodermic cannula is connected with a syringe or a constant-pressure apparatus, and inserted where lymphatics are supposed to be. The cannula is forced in as in ordinary hypodermic injections, and the mass allowed to flow or it is forced in. If the attempt is successful, the fine network and collecting trunks of a limited area will be injected. The toes and the finger-tips of man are favorite places for injection. In animals the pads of the feet and the bare spot on the snout are good. A lymphatic gland is always easy to inject. For an injecting mass mercury was much used by the older anatomists. Colored gelatin was also used and is now much more employed than mercury as it flows readily through the lymph glands. An excellent gelatin mass is Hoyer's chrome yellow: dry gelatin, 15 gm.; water, 75 c.c. After the gelatin is softened it is melted over a water-bath and heated to 80° C., then 75 c.c. of a cold saturated solution of bichromate of potash, the gelatin; finally, 75 c.c. of acetate of lead is heated to 80° C. and added with constant stirring. Berlin blue in gelatin is preferable for microscopic specimens (Plate XLIV. and Figs. 3293, 3300). India ink in water is also of great service, especially in embryos.[10]

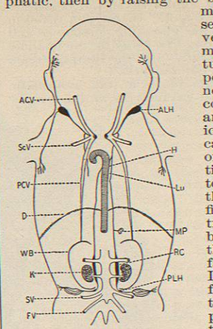

FIG. 3309.—Diagram of the Lymphatic System in the Embryo Pig 30 Mm. Long. × 2. (Sabin.) *MP*, Mesenteric plexus; *RE*, receptaculum chyli (chyloeyst). The other letters as in Fig. 3307. It will be seen that in this figure the chylocyst is double, and that the thoracic duct is also double nearly to its termination. In this stage the caudal lymph sacs have lost their connection with the vein, and from now on the only connection with the vascular system is through the thoracic duct as in the adult.

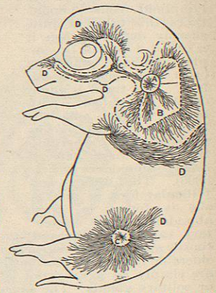

FIG. 3310. — Composite Picture of the Spreading of the Superficial Lymphatics in the Embryo Pig. (Sabin.) *A*, Area of lymphatics in a pig 18 mm. long; *B*, area in a pig 20 mm.; *C*, area in a pig 30 mm. long, *D*, area in a pig of 40 mm. long. In the stages shown there are no lymphatics beyond the outlines indicated.

The puncture method was used by Hunter, Mascagni, and Cruikshank. Cruikshank, in his "Anatomy of the Absorbing Vessels" (1790), p. 44, says: "I have sometimes injected the lacteals from punctures made by the side of the veins where I knew they must be, though they were then invisible to the naked eye." He also injected the lymphatic glands by puncture.

Young animals are best for studying the lymphatics, and the leaner the animal the better. For investigating the embryology of the lymphatics, embryos in which the heart is still beating are best. After the embryos are cold they cannot be satisfactorily injected (Sabin[10]). In man lymphatics have been demonstrated in organs in the fœtus when they could not be in the adult. Mature animals are better for the lymphatics of the reproductive organs; and, for the pancreas, an old man or animal is to be chosen.

Simon Henry Gage.

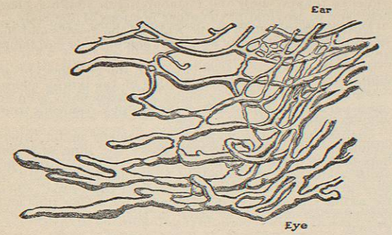

FIG. 3311.—Terminal Lymphatics of the Skin Between the Eye and Ear in a Pig 50 Mm. Long. × 11. (Sabin.)

BIBLIOGRAPHY.

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In preparing the article free use has been made of the larger works on physiology: Flint's treatise, Landois and Stirling; Milne-Edwards, Leçons, etc. In human anatomy, Allen, Gray, and Quain in English; Sappey in French; Henle, Krause, Gegenbauer, and Hoffmann in German. The clinical remarks are especially complete and satisfactory in Allen; many very suggestive remarks are also made in Sappey's Atlas. In comparative anatomy the works of Owen, Gegenbaur, and Parker's translation of Wiedersheim, in English, and Milne-Edwards' Leçons, in French, are the most satisfactory. For the bibliography of the subject Mascagni, Milne-Edwards, Hoffmann, and Robin (see [5] below) are especially commendable, as is also the Index Catalogue of the Surgeon-General's library. Specific references have been made to the following:

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LYMPH NODES, DISEASES OF.—ANATOMICAL CONSIDERATIONS.—The proper appreciation of the pathological changes met with in the lymph nodes presumes a slight knowledge of the normal anatomy of these organs. They are small, bean-shaped or oval nodules which lie in the course of the lymphatic vessels and on the more protected portions of the body, as, for example, in the lateral regions of the neck, the axillæ, the inguinal regions, about the peritoneal and pleural cavities, and in the folds of the mesentery. A small depression, known as the hilus, is usually present at one portion of the node, marking the point of exit of the efferent lymphatics and the blood-vessels. The nodes lie in a soft connective tissue and are quite freely movable in the fat which often surrounds them. They are normally of a reddish-gray color, and a cross-section of a freshly removed node is usually somewhat translucent.

The nodes are surrounded by a thin, fibrous capsule containing some fat tissue and blood-vessels, and occasionally a few smooth muscle fibres. The capsule sends processes into the node which are known as trabeculæ. The capsule and the trabeculæ send off fine connective-tissue fibres into the substance of the node, forming a delicate network in the meshes of which lie the leucocytes forming the parenchyma of the organ. These cells are chiefly of the variety known as lymphocytes, which possess a single large spherical nucleus and a relatively small amount of cell body.

The masses of lymphocytes near the periphery of the node are collected into nodules known as the follicles or secondary lymph nodules. They are surrounded by a lymph sinus, derived from the division of the afferent lymphatics into an anastomosing network of spaces lined with flattened endothelium. In the centre of the follicles a lighter area can often be seen in stained sections, where the cells are slightly larger than in the periphery of the nodule and often show karyokinetic figures. The lymphocytes are formed in these germinal centres, as they are called, and pass from them to the periphery of the nodule, from which they are set free in the lymph stream of the sinus.

In the centre of the lymph nodes the arrangement of the lymphocytes is somewhat different. They do not lie in masses as in the cortical nodules, but are suspended in strands in the connective-tissue network lying between the trabeculæ, and are called medullary cords. Each cord is surrounded by a lymph sinus which separates it from the trabeculæ.

The lymph sinuses are formed from the afferent lymphatics, some of which enter the node at the sinus, others through the capsule. They pass to the periphery of the node and break up there into an anastomosing series of vessels which pass inward and surround the follicles and the medullary cords, and finally reunite to form the efferent lymphatics and pass out at the hilus. The lymph sinuses so formed are lined with flattened endothelium.

The blood-vessels enter chiefly at the hilus and are distributed first to the medullary cords and then to the secondary nodules.

Reticular tissue containing lymphocytes is not confined to the lymph nodes, but is found in the organs and especially in the mucous membrane of the digestive tract. The tonsils and crypts in the tongue, the solitary and agminate follicles of the intestine are examples of such collections. The structure of these deposits of lymphoid tissue varies from that of the lymph nodes. The development of lymph sinuses and germinal centres is much less complete than in the nodes. The lymphocytes are also not wholly carried off in the lymph circulation, but many of them wander out through the epithelial layer covering these collections of lymphoid tissue and enter the digestive tract.

The agents which incite pathological changes in lymph nodes are as a rule carried in the lymphatics to the node and first enter the lymph sinuses at the periphery of the node. Coarser particles of foreign matter, such as dust or soot, are often deposited in this portion of the node, and are taken up by the phagocytic endothelial cells of the sinus. The same is true of the cells of tumors which are found first in the periphery of the node where they occupy the sinuses. The effects of bacterial poisons are often most marked in the peripheral portions, though the bacteria are usually caught in the filters of the nodules or