

On the lymphatics of cartilage or of the perichondrium / by George Hoggan and Frances Elizabeth Hoggan.

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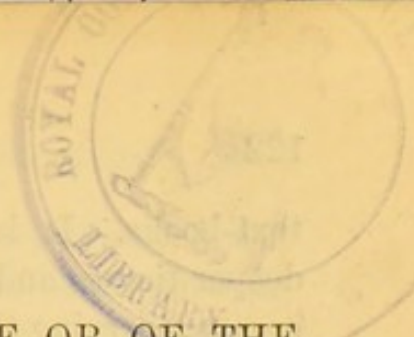
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ON THE LYMPHATICS OF CARTILAGE OR OF THE PERICHONDRIUM. By GEORGE HOGGAN, M.B. (Edin.), and FRANCES ELIZABETH HOGGAN, M.D. (Zurich), M.K.Q.C.P. (Ireland). (PLATE XIII.) (*Journal of Anatomy* Vol. XV)

THE structures described in the following pages have already formed the subject of a preliminary note announcing their discovery, which, by the great kindness of Professor Charles Robin, was presented in our name to the Académie des Sciences of Paris on the 4th July 1879, and afterwards published in full in the *Comptes Rendus* of the same date.

In several researches already published by us, which describe in detail the arrangements of the lymphatic system as it exists in relation to certain special tissues, we have adduced many facts and reasons which appeared fully to justify us in rejecting the theory of lymphatic radicles, Saftbahnen, or vasa serosa, formed by the branched cells of the connective tissue or the anastomosing cavities in which these cells are supposed to lie. We have further stated that our researches had forced upon us the conclusion that only an erroneous conception of the plan of the lymphatic system as a whole had led so many talented observers to presuppose the existence of definite channels within special tissues and organs, such, for example, as the glands of the skin and of the intestine, or inside the fibres of striated muscle, &c.

In those researches we have demonstrated that the commencements of the lymphatics were in general large collecting vessels, that in many cases they might, comparatively speaking, be called immense reservoirs into which there was simple transudation of the excess of lymph effused amongst surrounding tissue, and that as a rule, these collecting vessels or reservoirs were only found on the peripheral areas or surfaces either of the body itself or of its individual tissues and organs, acting there as the drainage adjuncts of those peripheral areas. From these superficial or peripheral collecting lymphatics the accumulated lymph is drawn off by the efferent lymphatics, those long moniliform or regularly valved lymphatics with which we have been so long familiar in preparations injected with mercury or in our general anatomical

text-books. It is these efferent lymphatics which lie in the deeper tissues and pass through the interiors or centres of special organs, carrying the lymph from the peripheral surfaces to pour it into the blood circulation near its centre.

These few preliminary remarks are necessary to explain the somewhat ambiguous title of this paper, for the lymphatics we are about to describe are functionally and physiologically the lymphatics of cartilage; that is to say, although they do not enter into its substance, but only lie upon its surface or pass through any perforations in the cartilage, forming, so to speak, anastomoses between the plexus of either surface when the cartilage is in the form of a sheet, they nevertheless drain off the lymph from the surface of the cartilage which has been exuded from the nutritive blood-vessels which nourish it, and so far are the draining adjuncts of the cartilage. On the other hand, these lymphatics lie embedded in the so-called fibrous tissue of the perichondrium, and therefore structurally and morphologically they are the lymphatics of that tissue; and as that tissue itself is only a nutritive adjunct of cartilage, we have chosen to describe these lymphatics as common to both. We may also make a preliminary remark with reference to our previous distinctions between collecting and efferent lymphatics. Following a rule pretty constant in the lymphatic system in different sized mammals, we find that while in the young or the very smallest mammals the peripheral plexus of lymphatics forms only one layer lying in one plane, and serving both as collecting and efferent lymphatics, yet as the size or age of the animal increases, so does the perichondrium increase in thickness, and the lymphatics being scattered throughout it, necessarily form a thick and intricate network; while, in addition, there is a special layer or arrangement of efferent lymphatics lying independent of the perichondrium which contains the collecting lymphatics, and these efferent lymphatics carry away the lymph which has been collected there.

As we claim to have discovered these lymphatics, it is hardly necessary for us to say that we have been unable to find out that any observers have ever described, or even looked for them. Albrecht Budge,¹ indeed, has described what he considers to be

¹ *Archiv für Microscopische Anatomie*, bd. xiv heft 1.

Saftbahnen passing between the cells of hyaline cartilage which he had been enabled to show by the injection of coloured material. It must be remarked, however, that not only have his conclusions and the appearances he described not been verified by subsequent investigators, but some of these of great eminence have stated that, although they had carefully repeated his experiments according to the instructions he gives, they had completely failed to obtain similar results, and they therefore reject his conclusions. We, on our part, have also endeavoured to verify his conclusions upon hyaline cartilage by our own special methods of using silver and gold solutions. Our preparations thus obtained have been perfectly clear and demonstrative, and had there been any channels, however small, in the cartilage, they would certainly have been shown by the silver. We have, however, found that in the outer portion of the cartilage, in that portion which it is difficult to distinguish from the perichondrium, in, therefore, the younger cell-capsules where the contained cells to the number of from four to eight were still multiplying, were, so to speak, in the embryonic condition, in a few cases the separate cells were sometimes connected to each other by delicate protoplasmic processes after the manner of the so-called branched cells of the connective-tissue. As soon, however, as the capsules had passed inside the periphery of the cartilage those processes no longer existed, and the individual cells within the capsules remained distinctly separate from each other, and unconnected either by actual processes of protoplasm or by any channel whatever to which the rôle of lymphatic radicle could be even hypothetically ascribed. We, therefore, in common with some of our more eminent fellow-workers, reject the conclusions of Budge, and consider the appearances he describes as the result of some accident, if not of some misinterpretation.

Apart from the foregoing, it is well known that there is a general concensus of opinion that cartilage possesses no lymphatics; and as for the perichondrium, we can only find one investigator who may be held to refer to it in an indirect manner, but to the effect that it possesses no lymphatics. In his *Vaissaux Lymphatiques*, published in 1874, and therefore the latest work on the lymphatic system, Professor Sappey, after enumerating different fibrous tissues, such as the dura mater, the periosteum, &c.,

which (he states) possess no lymphatics, he concludes the sentence by saying (page 11), "toutes les parties fibreuses en un mot, sont privées de ce genre de vaisseaux." Without assuming that either periosteum or perichondrium are fibrous tissues, the above extract may be held sufficient to show that at so late a date, in the opinion of so eminent an observer as Professor Sappey, such structures as the perichondrium possessed no lymphatics. For the purposes of this research we have used only the methods of treating the tissues to be examined with solutions of silver and gold, our aim being not merely to demonstrate the existence of lymphatics, but to discover the relations they bear to the other tissues or cells of the parts; and for this purpose the method of injection would be entirely unsuitable. For the same reason, we have only used the tissues of the smaller mammals, as these tissues are generally thin and transparent enough to be examined under the microscope without undergoing the manipulations necessary to cut them into slices, and without the sources of error which those manipulations too often cause. One other great advantage is obtained by using the smaller mammals, inasmuch as the lymphatics being few and generally upon or within a thin plane, we are thus enabled to arrive at a true conception of the plan of the lymphatics, which is generally obscured in the large mammals by the great number and complexity of the lymphatics in certain localities which we may wish to investigate.

We have specially directed our attention to the lymphatics of the costal and ensiform cartilages as representing the hyaline variety, and to those of the auricle as representing yellow elastic cartilage. With regard to these different cartilages, when in the embryonic condition, it need only be mentioned that, as the lymphatics lie in all cases in the perichondrium, the difference between them in the embryonic and adult conditions is merely one of increased number, size, and development, there being no difference in the plan in any case. It is also true that the cartilage of the ear of the mouse is called embryonic cartilage, although in larger mammals it is called yellow-elastic cartilage. There is, however, except in number and size, no difference whatever in the plan or arrangement of the lymphatics in the ear cartilages of different mammals. As a matter of fact, it is entirely

incorrect to speak of the one cartilage as being of a different kind compared with the others. It is merely a question of the amount of intercellular substance in each, which varies according to age or size, but has no other distinction, and least of all in the arrangement of the lymphatic, which is at present our main affair.

In order to demonstrate the lymphatics of the costal and ensiform cartilages, no animal could be more suitable or convenient than an ordinary house mouse or young rat. It is, however, imperatively necessary that the animal should be absolutely lean or devoid of fat cells, as if the latter are present it is impossible, under any circumstances, to demonstrate the lymphatics by the silver method. To prevent our object from being defeated by the extravasation of blood upon the tissues we wish to examine, the animal ought not to be roughly handled, but gently destroyed with chloroform. After it is insensible, the head ought to be snipped off, so as to get rid of all the blood in its body. This having been effected, the skin is stripped off the thoracic wall, and the pectoral muscles must also be cleaned off the outer surface of the thoracic wall with a sharp scalpel or pair of fine-pointed forceps, so as to leave the costal cartilages and sternum quite bare and clean. The abdominal muscles are next separated from the thoracic wall, and the liver and diaphragm are also snipped off with fine scissors, taking care not to injure the ensiform cartilage in so doing. The lungs, which will be now observed to be lying collapsed at the back of the thoracic cavity, are to be carefully removed along with the heart, so as to leave the internal surfaces of the costal cartilage near their junction with the ribs clean and untouched. A 1 per cent. solution of nitrate of silver is now poured quickly within the thoracic cavity and upon the ensiform cartilage, and poured off again as quickly as possible, without allowing the solution to touch the outer surface of the thoracic cage, which would only serve to make the preparation less transparent by being treated on both surfaces with silver. After a few minutes exposure to a dull light, the whole may now be washed for the first time with distilled water, and a few drops of a 1 per cent. solution of chloride of gold be allowed to remain in contact with the silvered surface for a few minutes,

and afterwards washed off very thoroughly. The structures must now be clarified by glycerine before they are in any way excised, and great care is necessary at this stage to use at first glycerine largely diluted with water, but concentrating it gradually till only pure glycerine is used. In this way the distortion of the parts which would otherwise happen is entirely avoided, and when the preparation is rendered quite transparent the whole of the front wall of the thoracic cage may be clipped out external to the junction of the cartilage with the ribs, and the preparation examined under the microscope.

At this point an important caution may be given. The animal may have been perfectly suitable, the instructions carefully followed, and the lymphatics, irregular at all times both as to presence or distribution, may exist in perfection, and yet in a very large percentage of cases the operator may fail to demonstrate them. This is due to the fact that the solution has not penetrated sufficiently far, or it may be too far, to display the lymphatics. There is a point at which it saturates the tissues immediately surrounding the lymphatics without saturating the lymphatics themselves. In this case the lymphatics, with their crenated endothelium, show white in a purple matrix. Anything either short of or beyond that point will lead to failure. As a rule, the silver solution cannot remain too short a time in contact with the tissue; for the rest practice and patience will lead nearest to perfection.

If the preparation is not successful, try another; if it is a success, seal it up in glycerine in the following manner. Place the preparation on a clean glass slide. Take a cover glass of considerable thickness and strength which extends as far as possible beyond the tissue on every side, while it is narrower than the glass slide itself. Next cut a small piece of flat wood or bit of glass a little larger than the tissue, but smaller than the cover glass, and glycerine having been sufficiently interposed, clamp the slide, tissue, cover glass and guard together with an ordinary paper clip, which will flatten the preparation without injuring its surface. Wipe now the excess of glycerine carefully from the edge of the cover, and from a stick of burning sealing-wax let a few drops fall round the margin of the cover glass, and trim the whole smoothly with a hot iron wire, taking care

not to heat the slide unequally, lest it should break. In this way an excellent permanent preparation is obtained, and may be examined as necessary. We make no apology for stating the foregoing method at such length, it being entirely the fruit of our own experience, and fulfilling a desideratum much wanted and but little known, as well as being an indispensable adjunct to our special methods of preparing such tissues.

While studying the lymphatics on the pleural surface of the thoracic muscles, we had often observed that, lying upon the portion of the internal or pleural surface of the costal cartilage intervening between the attachments of the triangularis sterni, on the one hand, and the junction of the cartilage with the ribs, on the other hand, the lymphatics were generally plentiful, even when they could not be demonstrated on the neighbouring tissues. In fig. 3 *a*, we show such a plexus lying upon the inner surface of a costal cartilage in the mouse; and it will be observed that, while it stops externally (in relation to the mesial plane) at the junction *e* of the cartilage *c* with the rib *d*, it is prolonged superiorly, inferiorly, and internally at *b*, upon the pleural surface of the triangularis sterni muscle *f*, in the form of the rectangular meshed or gridiron plexus characteristic of the lymphatics of striated muscle which we were the first to describe. For a long time we hesitated to describe these as the lymphatics of the perichondrium, for it might fairly be argued that they were quite as much the lymphatics of the pleura as of the perichondrium. At that time we did not know, as we afterwards discovered to be the case, that while in man the comparatively thick pleural membrane possesses special lymphatics as well as blood-vessels of extremely irregular character, and which ramify through it entirely independent of and uninfluenced in arrangement by the intercostal spaces, in the smaller mammals, on the contrary, the serous membranes possess no special lymphatics, but are dependent for these, as for nutritive blood-vessels, upon the tissues upon which they lie. In such cases the lymphatics retain the form or arrangement given to them by their special tissues; and thus we find that, while the plexus under consideration is extremely irregular where it lies upon or in the perichondrium, it at once assumes the rectangular meshes when it passes upon the fibres of striated muscle, showing that

its shape is modified not by the pleura which lies superficial to it, but by the deeper tissues which upon it lies, and to which therefore it properly pertains. It might be imagined that, by similarly preparing the outer surface of the cartilages, the matter would be set at rest; but, unfortunately, the tissues lying upon that surface are too thick to allow the lymphatics to be shown, and any attempt to remove these tissues would completely destroy any lymphatics that might exist there.

The walls of the irregularly arranged lymphatics lying in the perichondrium are formed solely of the one layer of the crenated edged endothelium characteristic of the lymphatic system, while the meshes between these lymphatics are filled up principally by branched cells, probably wandering cells, lying in a scanty gelatinous matrix. These branched cells have no special connection with the lymphatics, although many people would be inclined hypothetically to consider them to be the radicles of the lymphatics in question.

When such a preparation is viewed under the microscope, the following structures come in focal order: first the straight-edged endothelium of the pleura; next the thin gelatinous layer of that membrane; then the crenated endothelium of the lymphatics, and the branched cells lying in the meshes between them; finally the outer cells of the cartilage, often branched at first, but becoming globular as we pass toward the centre of the cartilage,—both lymphatics and cells appearing white in the purple matrix, formed partly of cartilage, partly of gelatinous tissue. The lymphatics of the plexus seen in fig. 3 are only the collecting vessels; they become connected with the efferent lymphatics through the substance of the *triangularis sterni* muscle, and these efferent vessels lie between that muscle and the intercostal muscles until they reach the edge of the former, after which they lie in the intercostal spaces parallel to the ribs, and immediately underneath the pleura, these efferent lymphatics being common to all the lymphatics of the locality.

Perhaps one of the greatest obstacles to our considering the foregoing lymphatics as those of the cartilages lay in the fact, that for a very long time we completely failed to show by our usual methods the existence of lymphatics upon the ensiform

cartilage. In the smaller mammals, this structure is remarkably broad and thin, and being in a manner isolated from all other tissues except the peritoneum, it ought to have formed an excellent material for preparations. Latterly, however, by a happy chance, while applying our methods upon a very lean animal, we succeeded in demonstrating clearly a wonderfully plentiful supply of lymphatics lying on both surfaces of the cartilage, and it became evident to us that the cause of our failure hitherto lay in the presence of a thick layer of fat cells between the peritoneal surface and the perichondrium in which the vessels lay, a fact, however, which was of great importance in proving that the lymphatics belonged solely to the cartilage, and had no connection with the peritoneum. Once that we had discovered the cause of our previous failures, we had no difficulty afterwards in demonstrating the lymphatics of this part; for even when the animal was well nourished and the lobules of fat cells abundant upon the cartilage, yet the connection of these lobules with the other structures was so very loose that the fat layer could be removed with fine-pointed forceps from the surface of the sheet of lymphatics without in any way damaging those vessels, which could be demonstrated afterwards in whole or in part by the process we have described.

In order, however, to show the complete plexus, it is always necessary to choose a very lean animal, and some of our best preparations were made upon the ensiform cartilages of young rats only one or two days old, for however well nourished the mothers may have been, we generally find that fat does not begin to develop in this locality in the young until after the period we have mentioned; and, moreover, at this time the lymphatics are undergoing rapid development, which enables us more easily to seize the plan of their formation. In such specimens we find the lymphatics develop from above downwards as an irregular arch lying parallel to the edge of the cartilage, but some little distance back from that edge. The pillars of the arch are formed by one or more lymphatics on either side of the mesial line, which are afterwards the special efferent lymphatics of the part, as shown in *a*, fig. 2, from the anterior surface of the cartilage of an adult rat. From the zigzag arched vessel thus formed branches are developed at the angular bends, which pass towards

the centre, bifurcate, and join again with neighbouring branches so as to form the very irregular plexus shown in fig. 2.

Nor is their course more irregular than their shape and size. Small narrow lymphatics suddenly become dilated into great pouches, which deserve the name of lymphatic sacs, and again contract as suddenly into narrow channels. Here also, as elsewhere, the lymphatics bear no regular relationship to the blood-vessels, which ramify quite independently amongst the tissues of the part, as shown in fig. 5 *b*—a much more highly magnified view of the same lymphatics from the posterior surface of the cartilage in a young rat. The description given of the structure of the lymphatics of the costal cartilages applies equally well to those now under consideration, the meshes between them being also largely occupied by branched cells *cc*, which readily develop fat within them, and become the fat cells *dd*, that finally succeed so thoroughly in hiding the lymphatics *aa*, in fairly nourished animals.

In fig. 2 only a portion of the lymphatics on the anterior surface is shown under a low power, as the lymphatics of the whole surface could not well be brought within one field of the microscope. The plexus is not, however, equally dense over all the surface, there being a narrow peripheral zone near the edge unprovided with lymphatics, or upon which only a short branch passes here and there from the main plexus towards the edge on either surface; but it seldom reaches the very edge, and in no case have we ever found any anastomosis taking place at the edge between the lymphatics on the anterior and posterior surfaces; and there are no perforations in the cartilaginous sheet (as in the case of the auricle) through which anastomosis between them could be effected. These lymphatics are, as a rule, provided with valves where they bifurcate or join each other, but the size of these valves, and the distances between them, are quite as irregular as the size and form of the lymphatics in which they are found.

The value of the fat cells interposed between the peritoneum and the cartilage, as a diagnostic element for proving that the lymphatics only belong to the latter structure, is very evident. Although in lean animals the peritoneum may lie close upon the lymphatic plexus, the development of a layer of fat, equal in thickness to

the cartilage itself between the perichondrium and its lymphatics on the one hand, and the peritoneum on the other, tends to lift the latter up or away from the lymphatics. The further fact, that when silver is applied to the peritoneal surface it makes the markings of the serous endothelium and of the subjacent fat cells distinct, without showing any trace of lymphatics or connection between them and the peritoneum, goes to prove that the lymphatics in question belong only to the perichondrium; for, owing to the transitory character of the fat cells and the isolated condition of the cartilage, the lymphatics cannot be ascribed to any other tissue whatsoever.

We pass next to the lymphatics of yellow elastic cartilage, to show which we choose the cartilage of the auricle, on account of its isolated and accessible condition. In order to prepare this structure, it is necessary to strip the skin off carefully, so that we may be able to apply the reacting solutions directly upon the perichondrium. To do this it is preferable to begin with the posterior surface, for there the skin is loose and easily removed, and the lymphatics most abundant. An incision is first made in the antero-posterior direction through the skin at the root of the auricle with a pair of fine-pointed scissors, and two incisions are then made at right angles to the first one by pushing the point of the scissors between skin and cartilage in the direction of the borders of the auricle. It is now easy to drag the skin off the auricle (which is still attached to the head), helping it by snipping through any small nerve or bit of tissue that may appear to bind skin and cartilage together. When the skin has been stripped off to the very tip it should still be left attached to the tip; and the auricle being then cut off near its attachment, the two tissues are pinned down with small pins inserted near its edges upon a piece of cork, leaving the bared surface of both auricle and skin uppermost and untouched, while it lies stretched upon the slab of cork. Upon this surface the re-agents and clarifying fluids are to be applied according to the instructions already given, and if successful—and it generally is successful—the tissue may be put up as a permanent preparation. Indeed, we may here remark, that we know no tissue or locality in the whole body where the lymphatics can be shown so beautifully or with such certainty; for out of above a hundred specimens

we have never missed one preparation, and that ratio is sometimes reversed in seeking for the lymphatics of some other localities or tissues, this success being probably due to the general absence of fat cells from the subcutaneous tissue of the skin covering the auricle. The utility of leaving the skin attached is to make it clearly evident that the lymphatics seen lying upon the cartilage are certainly not the lymphatics of the skin, for the two structures, being prepared at the same time, show their respective lymphatics equally well, and their exact relations to each other can also be verified at any time; and, indeed, we may even remark here that it is impossible to get a better demonstration of the collecting lymphatics of the skin, and their relations to its appendages, than that which is given in such a preparation.

The arrangement and amount of the lymphatics in this locality are greatly influenced by the size of the animal. In the mouse they are comparatively few, and the collecting lymphatics of skin and cartilage serve, to a certain extent, as efferent vessels for the respective sides. In the rat, however, we find the efferent lymphatics coming in as a third layer between the collecting sheets of lymphatics for the skin and cartilage respectively, and being common to both in their efferent functions. These accompany the posterior auricular vessels and nerves, and unless special care be exercised these vessels may be left either upon the cartilage or skin-flap. In fig. 1 we have a view, under a very low power, of the arrangement of the lymphatics *aa*, on the posterior surface of the cartilage of the ear of a rat, and their relationship, or rather want of relationship, to the posterior auricular vessels and nerves. As these latter structures lie close together and parallel to each other, only the arteries *bb*, are shown in the drawing in order to avoid confusion. Fig 4, again, shows, under a much higher power, a portion of the lymphatic plexus lying near the root of the auricle of a rat, in which locality it is much denser than elsewhere, and the vessels themselves much larger and dilated. In the same preparation the relation of the blood-vessels and capillaries of the part to the lymphatics, and their small size, as compared to these immensely dilated lymphatics, are well seen. In the auricle of the mouse, as shown in fig. 6, the lymphatics *aa*, are much more scanty,

but for that same reason it is easier to determine the plan of their formation. In this case, also, the tissue of the perichondrium is so extremely thin, that the cells of the cartilage itself take on the markings resulting from the application of the silver solution, so as to show the exact relations of the cartilage and its cells *d*, to the lymphatics *aa*.

There is a feature of special interest in the structure of the cartilage of the auricle, which has an important bearing upon the character and distribution of the lymphatics of the part, and in proving beyond dispute that these are the lymphatics of the cartilage proper. This feature consists of the presence of a large number of circular holes perforating the cartilage, and giving to it a cribriform character, as seen in *bb*, fig. 6. Through these holes the lymphatics of the one surface form so complete an anastomosis with those of the other surface as to make us look upon the lymphatics of the two surfaces as forming only one plexus, the communication between them being as frequent as if the lymphatics lay actually within the cartilage, that tissue lying, as it were, within the lymphatic meshes. These holes also give passage to nervous and arterial twigs occasionally, but the lymphatics are evidently the structures they are specially adapted for; and as they are much larger than those vessels (at all events in the collapsed condition), the remainder of the lumen is filled up with fat cells and branched cells. On the anterior surface of the cartilage the lymphatics present pretty much the same appearance as those shown in fig. 6, this enlacement being apparently adapted to the requirements of the part, as there is little provision for efferent lymphatics on the anterior surface of the cartilage. When the skin is carefully removed from the anterior surface, these lymphatics are easily made apparent; but, at the same time, it is a matter of considerable difficulty to remove it, on account of its intimate adhesions to the perichondrium of that surface, so that as often as not the perichondrium becomes stripped off the cartilage along with the skin. We have already mentioned that in the case of rats and larger mammals we have the main chain of efferent lymphatics lying between the posterior surface of the cartilage and the skin, along with the posterior auricular vessels and nerves; and these efferent lymphatics seem to serve as drainage adjuncts for the

collecting lymphatics of skin and cartilage of both surfaces. While, however, the collecting lymphatics of the skin on both surfaces are continuous round the edges or tip of the auricle, we do not find the lymphatics of both surfaces of the cartilage anastomosing over the edges of the cartilage in a similar manner. They never pass beyond the holes formed near the extreme border of the cartilage through which they pass and form the terminal enlacements of the plexus. The only exceptions to this rule are merely apparent, and are due to the fact that the ordinary hole, in consequence of the absence of material at its external side, forms a notch through or round which a lymphatic may be seen to pass.

Another peculiar feature in the auricle is the presence of innumerable small bundles of striated muscle, microscopical in size, which pass in every conceivable direction from one part of the auricle to another, and are attached at both extremities to the perichondrium. These are seen at *cc*, figs. 4 and 6. In the latter preparation they were especially small, consisting at times of two or three fibres only, which were so short that they appeared like elongated cells. Amongst these bundles the lymphatics of the part ramify in every possible direction, sometimes superficial to them, sometimes between them and the cartilage, and at other times ramifying in their substance, in which position they might almost be held to belong more to the muscle than to the cartilage. They never showed, however, the peculiar rectangular meshes, or gridiron plexus, that seems to be the special form of the lymphatics of striated muscle. In rats and the larger mammals, the lymphatics which lie in the spaces between the attachments of the extrinsic muscles of the auricle are very much larger, and form a denser plexus than elsewhere, as shown in fig. 4. This dilated condition of the lymphatics at those localities probably subserves some function which we have not as yet been able to find out.

Here, as elsewhere throughout the body, the lymphatics bear no relation whatever to the blood-vessels or nerves of the part, either as regards position or relative amount. As in the specially isolated cartilages which we have described, the lymphatics in the perichondrium seem to be equally plentiful and equally irregular in distribution, it may be taken for granted

that similar conditions exist in the less isolated cartilages throughout the body, upon which the silver method of preparation could not conveniently be applied. For the same reason, although the silver method cannot well be applied to the same tissues in the case of man and the larger mammals, on account of their great thickness and the destruction that would ensue to the lymphatics in any attempt to make sections, yet the general relationship of the lymphatic system, as found relatively in small and large mammals, which our previous researches have enabled us to understand, warrant us in saying that if the injection method be applied, the lymphatics will be found to exist in the perichondrium of larger mammals as a dense complicated plexus, too intricate to enable us to recognise the plan of distribution as we can recognise it in the smaller mammals, but to which the researches we now put on record form the certain key.

Previous researches on the lymphatics referred to in the preceding pages:—

1st. Étude sur les lymphatiques de la peau. *Journal d'Anatomie*, Paris, January 1879.

2d. Étude sur les lymphatiques des muscles striés. *Ibid*, November 1879.

3d. On the condition of the lymphatics in Eastern leprosy. *Transactions of the Pathological Society of London*, 1879.

4th. Étude sur le rôle des lymphatiques de la peau dans l'infection cancéreuse. *Archives de Physiologie*, Paris 188, p. 284.

DESCRIPTION OF PLATE XIII.

(Drawings made by the aid of the Camera Lucida.)

Fig. 1. Lymphatics of the posterior surface of the cartilage of the auricle, under a very low power, in an adult rat.—*aa*, lymphatics; *bb*, arteries to which correspond also the nerves and veins; *c*, one of the perforations in the cartilage through which pass the peripheral enlacements of the lymphatic plexus ($\frac{1}{18}$).

Fig. 2. Lymphatics of the anterior surface of the ensiform cartilage, under a low power, in an adult rat.—*aa*, efferent lymphatics; *cc*,

collecting lymphatics; *b*, interval in mesial line between attachment of rectus thoracis muscles ($\frac{1}{18}$).

Fig. 3. Lymphatics on posterior surface of costal cartilage in an adult mouse.—*a*, lymphatics of cartilage; *bb*, lymphatics of striated muscle forming part of the same plexus; *c*, costal cartilage; *d*, end of rib; *e*, joint between cartilage and rib; *f*, fibres of triangularis sterni muscle ($\frac{1}{30}$).

Fig. 4. Dense plexus of large lymphatics on posterior surface of the cartilage of the auricle in an adult rat.—*aa*, lymphatics; *bb*, blood-vessels; *cc*, fibres of striated muscle; *dd*, branched cells of the perichondrium ($\frac{1}{100}$).

Fig. 5. Lymphatics on the posterior surface of ensiform cartilage, under a high power, in the rat.—*aa*, lymphatics; *bb*, blood-vessels; *cc*, branched cells of perichondrium; *dd*, fat cells developing from the afore-mentioned branched cells ($\frac{1}{150}$).

Fig. 6. Lymphatics on the posterior surface of the cartilage of the auricle in the mouse.—*aa*, lymphatics; *bb*, holes perforating the cartilaginous sheet through which pass the lymphatics to anastomose with those of the anterior surface, and containing fat cells; *cc*, striated muscle fibres; *dd*, cells of cartilage ($\frac{1}{100}$).



Fig. 2.



Fig. 5.

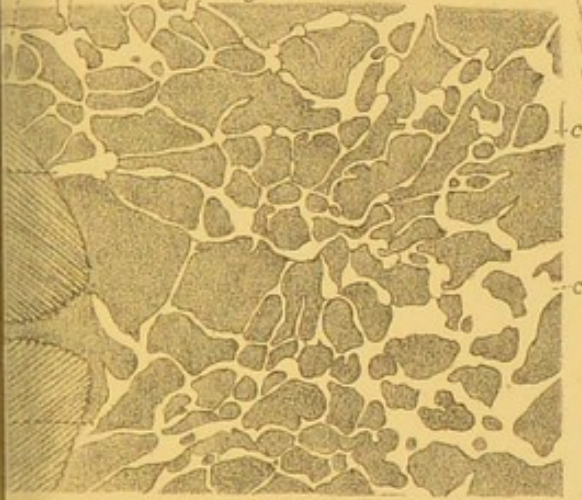


Fig. 3.

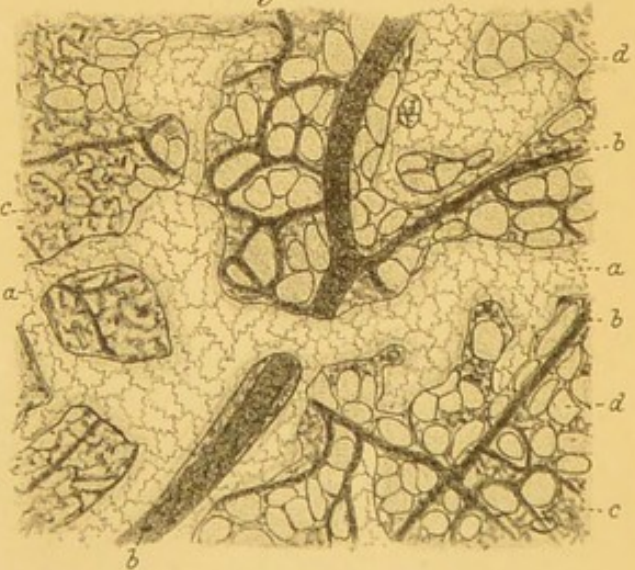


Fig. 6.

