THE LYMPHATIC SYSTEM OF THE DOMESTIC FOWL.

By

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C O N T E N T S.

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INTRODUCTION.

The lymphatic system only exists as a separate vascular apparatus in vertebrates. In its simplest form it consists of a number of thin-walled vessels which ultimately unite with the venous system through the medium of a few main trunks, formed by the anastomosis of numbers of the original vessels. The lymphatic vessels themselves are similar to small veins in appearance, but their walls are thinner, and their valves are more numerous in most animals. Their course is much more irregular than that of the veins, and the progressive increase in calibre as one passes along a lymphatic vessel towards a main lymphatic trunk is very slight. In addition frequent anastomoses connect lymphatic vessels in their course.

In more advanced stages of development other structures may be added to the system, such as lymph hearts and lymphatic glands. Definite thoracic ducts may occur. Lymph hearts are saccular dilatations of lymphatic vessels, which possess a covering of transversely striated muscle, and are capable of contraction. They are present in the pelvic region of animals in which they occur, but have also been observed in the cervical region. Lymphatic glands are masses of lymphoid tissue which are placed on the course of lymphatic vessels. Thoracic ducts are large lymphatic vessels which accompany the thoracic part of the aorta, and terminate by joining veins in the anterior part of the thorax. They may commence from a dilation, the cisterna chyli. Where definite thoracic ducts are present, they are responsible for the drainage of most of the lymph from the hindlimbs, abdomen and thorax.

Two thoracic ducts usually occur, but in the more highly developed animals a single duct is the usual arrangement.

The lymphatic system is present in its most primitive form in fishes, since in these animals lymph hearts and lymphatic glands do not occur, and there are no vessels which can be termed thoracic ducts. Valves are only present in the lymphatics at the points at which the vessels join the venous system. (The term "lymphatics" will be used throughout this work with reference to the lymphatic vessels.) Amphibians and reptiles exhibit a more advanced state of development in their lymphatic systems, since lymph hearts and definite thoracic ducts are present in most genera. The lymphatics themselves possess valves along their course. Most authors consider that the numerous plexuses which occur on the course of the lymphatics in fishes, amphibians and reptiles represent the lymphatic glands of the higher vertebrates.

When the mammal is considered, it is evident that the most advanced degree of development is present in its lymphatic system. Large numbers of lymphatics and of lymphatic glands, and the occurrence of definite thoracic ducts (in most genera a single thoracic duct is visible) evidence this advanced degree of development.

Birds appear to present an intermediate stage of development on their lymphatic systems as between amphibians and reptiles on the one hand, and mammals on the other. The lymphatics themselves and their valves are relatively fewer in number than in mammals. Lymph hearts have been observed in certain types of bird, and lymphatic glands occur, but only in certain aquatic birds. Thoracic ducts are always present.

As far as can be ascertained, the first author to describe lymphatic vessels was Gaspard Aselli (2), who discovered the lacteals in the mesentery of the dog in 1622. In the 17th. and 18th. centuries a few works were published in English which referred to the lymphatic system. The first appears to be by Birch (9), who described in 1676, some injected specimens of the pelvic cavity of birds made for the Royal Society. Hunter (31), in 1762, described lymphatic vessels in reptiles and birds. In 1768 and 1769, Hewson (27) (28) published papers giving detailed descriptions of the lymphatic systems in amphibia, reptiles and birds, in which he incorporated much of Hunter's work. Later, in 1774, Hewson (29) published his "Experimental Inquiries", in which the lymphatic systems in man and other animals were described. The only representative of the class Aves which appeared in the description was the goose. In his "Comparative Anatomy", published in 1783, Monro (52) gave a general account of the lymphatic system. (According to Smith (66), this book was a collection of the lectures of A.Monro Primus, which was published by A. Monro secundus.)

At about the same period, various continental authors, such as Peyer (58) and Lister (47), were investigating the lymphatic system.

Since these early beginnings, the study of the lymphatic system in different animals has been continued, but the work has been mainly performed on the mammal. The comparatively detailed knowledge of the system in the domestic mammals at the present time is mainly a result of the painstaking work of Baum. The amount of study pursued on the system in birds has, however, been very small. This is mainly due to the difficulty encountered in injecting the vessels, because of their small size in birds, and because of the absence of lymphatic glands

in all but aquatic birds, the glands being of great assistance in locating the most favourable sites of injection.

The early work on the lymphatic system was performed by the injection of mercury, a method which was not very reliable, and not until 1896, when Gerota (25) had evolved his injection mass, was more detailed study possible. Even so, very few authors have taken advantage of the opportunity.

In the 19th. century, work on the lymphatic system of the bird was mainly performed by continental authors, and evidence of this can be seen in the textbooks published in English at that time. In his monumental "Anatomy of the Vertebrates", Owen (55) quotes almost entirely Lauth (46) and Panizza (56) in his chapter dealing with the "absorbent system of birds". Chauveau (15) pays little attention to the lymphatic system of birds.

When one examines the standard textbooks on veterinary science of the present day which deal with the lymphatic system of the domestic fowl, it is evident that the works of Owen (55) and Chauveau (15) have inspired most of the descriptions, and hardly any new work has been incorporated. Many of the old misconceptions have been perpetuated and mistakes have been made in quoting from the original works. Such a mistake, which has been frequently made, is to apply a general description of the lymphatic system as it occurs in all birds to a special description of the system in the fowl, which accounts for the contradictory statements which have been made with regard to the presence or absence of lymphatic glands in the domestic fowl.

The only works of real value dealing with the lymphatic system of the domestic fowl are two comparatively recent ones. One is by

the Russian, Josifoff (42), which was published in 1930, and deals with the system in the pigeon and hen. The investigation was carried out mainly on the pigeon, and the results were incomplete in many respects. As in the case of mammals, it has been Baum (8) who has been the first to give a detailed description of the lymphatic system as it occurs in the domestic fowl. This description was published under the title of "Das Lymphgefässsystem des Huhnes" in May, 1930, 2 months after the appearance of Josifoff's paper.

It will be seen that, for all practical purposes, there has been only one detailed description of the system in the fowl, namely that by Baum (8). Because of the interest of the subject in the fields of comparative anatomy and avian pathology, it was felt that an investigation into the anatomy of the lymphatic system of the domestic fowl would be of great interest, particularly as an account of such an investigation was not available in English. Thus, this work consists of a detailed account of research carried out on the anatomy of the lymphatic system of the domestic fowl.

SUMMARY OF LITERATURE.

A general summary of the available literature as it applies to the lyphatic systems of all types of bird will now be given, since, with the exception of Baum (8), there are no authors who have dealt exclusively with the domestic fowl. In papers other than that by Baum (8) any reference to the domestic fowl is closely associated with references to other birds. Much space need not be occupied with the statements of the earliest authors, since their work is mainly of historical interest, but it seems necessary to give the more recent literature in some detail, especially the publications by Josifoff (42) and Baum (8).

At this point it should be stated that the author is indebted to the papers by Josifoff (42) and Baum (8) for many of the references from the more inaccessible continental publications.

The lymphatic system may conveniently be divided into 3 main sections for the purpose of this summary: (1) Lymph hearts, (2). Lymphatic glands, and (3). Lymphatic vessels. The statements of the various authors on these 3 different subjects will be given separately, including the references to these subjects in the standard textbooks. As far as possible the statements will be summarised in chronological order.

(1). Lymph hearts. As previously explained, these are dilations of the lymphatics, which possess a covering of striated muscle in their highest state of development.

Stannius (67) (68) appears to be one of the first authors to have described lymph hearts in birds. He discovered these bodies in the ostrich, cassowary, goose, swan and stork, and he states that they lie close to the kidneys in the pelvic cavity, and that

the lymphatics which arise from the lymph hearts run to join the renal vein. According to Stannius, there are 2 lymph hearts in each species mentioned.

Owen (55) quotes from Panizza (56) in describing "2 sacral or pelvic plexiform vesicles of the lymph" situated at the angle between the tail and the thigh. He states that each is half an inch long and quarter of an inch broad in the goose. According to Owen, the lymph hearts are attached to the adjacent bone in the ostrich, but in the cassowary, goose and stork they lie free, and in all cases their pulsations correspond with the movements of respiration. As will be seen at a later stage, this latter statement is contradicted by the discoveries of Müller (53). Owen only mentions the above birds in connection with the lymph hearts, and it is not clear whether he considered that lymph hearts occurred in all birds.

Huxley (33) states that lymph hearts or "non-pulsating sinuses corresponding with them occur in Reptilia and Aves".

Chauveau (15) makes no mention of lymph hearts in his description of the lymphatic system of birds.

Nuhn (54) discovered lymph hearts in the ostrich and in various aquatic birds, and he quotes the findings of Stannius (67) (68).

Budge (12) and, later, Sala (60) were the first authors to describe lymph hearts in connection with the domestic fowl. They both state that they occur as transitory organs in the embryo chick, appearing before the 10th. day of incubation, and disappearing on the first day after hatching. Sala, however, observed lymph hearts in the chicken 30-35 days after hatching in a few cases.

Following Budge (12) and Sala (60), Apostoleano (1) describes

lymph hearts in the chick embryo on the 17th. day of incubation.

Bronn (11), in his historic work "Klassen und Ordnungen des Tierreiches" states that lymph hearts persist in adult life in certain primitive birds, but are only present in embryonic life in more highly developed birds. He considers that they are organs which have been inherited from the reptiles.

Gegenbaur (24) describes lymph hearts in the Ratitae (Cursores of Owen), and in some of the Palmipedes (Natatores of Owen) and Grallatores. He claims that simple vesicular enlargements, which have lost their covering of muscle, do occur in other birds, and states that valves can be demonstrated in such enlargements if they still possess the power of contraction.

In his work on the Anatidae, Müller (53) asserts that regular, uniform pulsation of the lymph hearts does not occur, and claims that the contraction of the lymph hearts is a result of their distension with lymph, and, thus, is due to their irritability to mechanical stimuli.

Wiedersheim (71), quoting mainly from Sala (60), gives a full account of the embryonic development of the lymph hearts, and claims that complete development of these structures only occurs in the embryo bird. He states that traces of the lymph hearts may be visible in some chickens 30-35 days after hatching (a statement made originally by Sala), although the question whether they persist throughout life in any species of bird demands further investigation. This last assertion is made by Wiedersheim despite the fact that so many earlier authors describe persistent lymph hearts in certain species of birds.

Gourin (26) gives all the findings of the previous authorities on the occurrence of pelvic lymph hearts, which, he states, have connections with the renal veins in the goose, moa, swan and cassowary.

The next author to mention lymph hearts is Fürther (22). In his investigation into the lymphatic system of the goose he discovered 2 vesicular lymph hearts, lying under the hypogastric veins, at the point where the veins are joined by a transverse branch at the outlet of the pelvis. He states that each is drained by a fine vessel which runs forward to end in the lumbar lymph nodes, receiving numerous lymphatics from the pelvis and the pelvic limb in its course.

In his text-book, Kaupp (43) quotes almost entirely from Owen (55) for his description of the lumphatic system of the domestic fowl, but he makes the mistake of applying the whole of Owen's description to the domestic fowl, even in the numerous cases where Owen makes specific references to other types of bird. Thus Kaupp describes definite lymph hearts with striated muscular coverings in the fowl, and gives Owen's dimensions of ¼ lymph hearts in the goose, but with reference to the fowl. These statements by Kaupp are shown to be incorrect when one consults the findings of Owen and all the other authorities.

Ward and Gallagher (70), in their section on the anatomy of birds, make no reference to the occurrence of lymph hearts.

Ellenburger and Baum (18) state that, in the ostrich and some aquatic birds, the main lymph vessel of the caudal and pelvic regions possesses vesicular dilations on its course in the caudal

end of the body cavity. In the Ratitae, according to these authors, these dilations have a muscular covering and are provided with a valvular apparatus.

Josifoff (42) claims that he has often observed a lymph heart on the dorsal wall of the abdomen in pigeons, anaesthetised with ether. He states that its position corresponded with the position of the lymph hearts in aquatic birds, and that it was identified by its pulsation, when viewed under the microscope. He does not mention a muscular covering, and does not make it clear whether he has observed such a structure in the domestic fowl, although he says at a later stage that "the lymphatic sustems of the pigeon and hen are completely identical". Discussing this statement by Josifoff, Baum (8) considers that the "lymph hearts", which are described are actually simple dilations of the lymphatics at various situations, such as were described by Gegenbaur (24). Baum does not comment on Josifoff's observation of pulsation in these dilations, but according to Schafer (61), pulsation definitely occurs in the lacteals of various animals. Schafer states that the contraction is rhythmical in the rat and guinea-pig, but in other animals the lacteals only contract as a result of direct or indirect stimuli. Such contraction occurs even where no muscle is present in the walls of the lymphatics. Taking these statements into consideration, it appears that the "lymph hearts" described by Josifoff were probably simple dilations of the lymphatics, and the contractions which he observed may have been especially evident because the vessels were exposed to the atmosphere.

Baum (8) only discusses lymph hearts in his summary of the available literature, but it is evident that he considered that

they do not occur in the domestic fowl after hatching.

Bradley (10) and Sisson (65) do not refer at all to lymph hearts.

To summarise, it seems to be generally agreed that pelvic lymph hearts, lying in the angle between the pelvis and the caudal region, are present in the Cursores and in certain aquatic birds in adult life. They occur in all birds in embryonic life, but disappear at the time of hatching in the more highly developed birds. In the domestic fowl, they are definitely visible in the embryo chick, but disappear at the time of hatching, although they have been observed 30-35 days after hatching in some subjects. (2). Lymphatic Glands. When one considers the literature dealing with these structures in birds, it is surprising to find that few of the observations which have been made by workers in this field have been incorporated into the modern text-books on veterinary sciance. Most of these text-books still maintain that lymphatic glands are definitely present in the domestic fowl, though few in number, despite the conclusive findings by many authors that they are totally absent in the fowl.

Of the earliest workers, Hewson (29) denies the existence of lymphatic glands in any bird. This claim is probably a result of Hewson's enquiries not covering a wide enough range of avian species, although it is strange that he did not observe lymphatic glands in the goose.

Later, Tiedemann (69) commits the error of describing a chain of lymphatic glands lying on the course of the jugular vein in the neck of the bird. It has been demonstrated by many authors that the glandular structures are actually lobes of the thymus gland, which usually persist throughout life, but Tiedemann's error is

perpetuated in many textbooks and other publications.

Lauth (46) describes lymphatic glands in the goose, but occupies himself mainly with their microscopic structure.

Owen (55) states that lymphatic glands are few in number in birds, the most constant being at the anterior part of the chest, or at the root of the neck. It is not clear whether this is intended to apply to all birds, and also whether the glands to which he refers are the structures which have been shown to be thymus lobes. According to Owen, small lymphatic glands have been observed in the axilla and groin of sea-birds. He states that, in all birds, the lymphatic glands are replaced by plexuses of lymphatic vessels in regions where glands are not present, and that these plexuses surround the adjacent blood vessels. This suggestion has been made by other authors, along with similar statements concerning fishes, amphibians and reptiles, and seems to be probably correct.

Huxley (33) considers that there are a few lymphatic glands in the cervical region of birds, but once again it would appear that he is actually referring to lobes of the thymus gland.

Chauveau (15), having said that lymphatic glands are few in number in birds, follows the other authors in stating that they are "scarcely met with elsewhere than in the cervical region".

According to Bronn (11), the lymphatic follicles and Peyer's patches in the caeca of the goose, and the lymphoid tissue in the Bursa Fabricii take the place of lymphatic glands.

Fleury (19) and Pensa (57) both confine themselves to descriptions of the microscopic anatomy of the lymphatic glands as they occur in birds.

Barthels (4), referring to the lymphatic system of birds, states that the lymphatic glands, which are few in number, lie in the lower part of the neck, close to the entrance to the thoracic cavity, and are less complete in form than in mammals. Presumably Barthels is quoting from the previous authors.

The publications by Jolly (37) (38) (39)(40) are the first authoritative statements on the occurrence of lymphatic glands in birds, and are the first accounts which can be said to be based on extensive and detailed investigations. Jolly states that, out of 30 different species of birds examined, lymphatic glands could only be traced in the flat-billed and web-footed types, i.e. they appear to occur exclusively in most of the Natatores (or Anatidae). He affirms that lymphatic glands are readily found in the duck, but not so readily in the goose. According to Jolly, the main groups of glands, where present, are in the cervical and lumbar regions. The cervical lymphatic glands lie in the angle between the jugular and subclavian veins, the main gland being spindle-shaped, and attaining a length of 15 m.m. and a breadth of 5m.m. in the duck. Small subsidiary nodes lie close to the main gland. Jolly describes various differences in size and arrangement which occur in other birds. The main lymphatic trunks of the neck lie lateral and medial to the jugular vein, the lateral one being the vas afferens to the main gland, and the medial one being the vas afferens to the subsidiary nodes. The efferent vessels from the glands join the veins of the neck, a fact which Jolly demonstrated by injection into the glands, or into their afferent vessels. The lumbar glands, which are described, lie between the aorta and the kidney, extending from the origin of the femoral (crural) artery anteriorly,

to the origin of the ischiadic artery posteriorly. These lumbar glands were injected by a puncture into the foot, but no description of the course of the lymphatics in the leg is given. In the swam, small lymphatic glands are described which lie ventral to the root of the middle sacral artery, and also on the course of the lymphatics following the ischiadic artery. After extensive microscopic examination, Jolly asserts that lymphatic glands are modifications of the walls of the lymphatics. He is quite definite in stating that lymphatic glands only occur in some members of the order Natatores and that they are not present in the domestic fowl.

Retterer (59), in his publication, deals with the histology of the lymphatic glands in the duck and goose.

Fürther (22), after extensive research, considers that lymphatic glands are only present in aquatic birds (Natatores), but not in all birds of this type. He describes 2 pairs of lymph nodes which lie on the course of the larger lymph channels. They are spindle-shaped bodies of considerable size, the first pair lying close to the entrance to the chest, and these are termed "cervico-thoracic nodes" by Fürther. The second pair lie in the abdominal cavity, close to the genital glands, and are placed on the course of the lymphatics following the aorta. These are referred to as "lumbar nodes"[1]. This description largely confirms the statements made by Jolly (37) (38) (39) (40).

As in the case of lymph hearts, Kaupp (43) mainly follows the description by Owen (55) when he deals with lymphatic glands. He states that the glands are for the most part replaced by plexuses of lymphatics surrounding the blood vessels, and then describes a

lymphatic gland, which rests on the jugular vein in the domestic fowl. This latter statement is, of course, a result of applying a description of the glands of all birds to a special account of the glands in the fowl. In dealing with the histological structure of the various regions of the alimentary canal, Kaupp states that masses of lymphoid tissue are present in some sites, although he fails to mention the large amount of lymphoid tissue which is demonstrable in the mucous lining of the Bursa Fabricii. According to Kaupp, Eberth has discovered an elevated body in each caecum, 4m.m. from its opening, which is composed entirely of lymphoid tissue. These bodies are referred to as "Caecal tonsils" in more recent publications (see Hinshaw and McNeil (30)).

Krause (44), in his textbook, asserts that lymphatic glands do not occur in any bird.

Martin (50) quotes from the publications of Jolly (37) (38) (39) (40) and Fürther (22).

Ward and Gallagher (70), who appear to quote from Chauveau (15), state that the lymphatic glands are few in number in birds, the most conspicuous being at the base of the neck and in the anterior thoracic region.

Ellenburger and Baum (18) confine themselves to the statement that glands are usaally present in the lymphatic system of the bird, but state that they are small in size and few in number.

Seifried (62) (63) follows Jolly (37) (38) (39) (40) and Fürther (22) in making a really authoritative statement on the absence of lymphatic glands in the domestic fowl. He emphasises that lymphatic glands are not present in the fowl, and he states that the glandular structures, erroneously considered to be cervical

lymphatic glands, are actually either the thymus (in the neck) or the thyroid (at the entrance to the body cavity).

Iwanoff (34) cites the above statement made by Seifried (62) (63), but also makes the contradictory assertion that the "abdominal lymph nodes" and the "glands found in the neck" are greatly enlarged in tuberculosis of the fowl.

Gamauf (23) repeats the error of describing lymphatic glands in the neck of the fowl.

The only mention of lymphatic glands in the bird which Schafer (61) makes is that haemal lymph glands have been found in birds, although he does not indicate the species of birds to which he is referring.

Josifoff (42) confirms the statements of Jolly (37) (38) (39) (40), Fürther (22) and Seifried (62)(63) that lymphatic glands do not occur in the hen and pigeon. He came to this conclusion after frequent microscopical examination of the areas where glands are found in aquatic birds, particularly of the angle formed between the jugular and subclavian veins. He states that "star-like" enlargements of the lymphatics are present in regions where lymphatic glands are found in mammals. Presumably Josifoff implies a plexiform arrangement when he refers to these "star-like" enlargements.

Baum (8) also affirms that lymphatic glands are totally in the domestic fowl. He does mention the suggestion, which is made by many of the previous investigators, that plexuses of the lymphatics replace lymphatic glands in regions where glands would be expected to be present.

Hutyra and Marek (32) assert, in their 3rd. English edition,

that the abdominal and cervical lymphatic glands are enlarged and caseated in tuberculosis in fowls, but this has been corrected in the 4th. English edition, in which is found the statement that "sometimes the glands of the neck (thymus lobules) are affected and become enlarged and caseous in their centre".

Despite all the previous affirmations by authors who have made a special study of the lymphatic glands, Bradley (10) still maintains, in the most recent edition of his textbook on the domestic fowl, that the"lymph glands are few and small". He describes lymphoid tissue in the wall of the alimentary canal and in the mucous lining of the Bursa Fabricii, and he mentions the discovery by Eberth of the mass of lymphoid tissue in the wall of the caecum which, as has been stated, is now referred to as the "caecal tonsil".

Similarly, Sisson (65) states, in his section on the anatomy of the chicken, that "lymph glands are very small and are in the form of lymph nodules, which are very numerous in the alimentary tract, and a few are found in the cervical region".

In an important recent publication, Jordan and Robeson (41) consider that the marrow of the bones of birds contains a relatively large amount of lymphoid tissue, which compensates for the total absence of lymphatic glands in most species of birds. These workers have demonstrated the formation of actual lymph nodules in the femoral and tibial marrow of pigeons after partial or total splenectomy, and they state that these nodules take the place of the spleen as the main source of lymphocytes..

Disregarding the statements of the various textbooks, which appear to be quotations from previous textbooks, without the addition of more recent work, in the majority of cases, it seems that the

absence of lymphatic glands in the domestic fowl has been definitely proved. Lymphoid tissue is only present in the spleen, in the thymus, in the wall of the alimentary canal, in the Bursa Fabricii and in the bone marrow. It is interesting to note that Clara (16) records the frequent presence of accessory spleens in birds, these organs being placed on the course of the splenic vessels, on the course of the pancreatic duct or being embedded in the pancreas. It is strange that the fowl with such a small amount of lymphoid tissue in its body, should possess relatively more lymphocytes, whose origin is from the lymphoid tissue, than mammals. Dukes (17) gives the percentage distribution of lymphocytes as 64 in the fowl, as 38 in the horse, and as 23 in man. Acording to the statement of Jordan and Robeson (41), cited previously, it would appear that the spleen is the main source of this large number of lymphocytes.

(3). Lymphatic vessels. Under this heading, the literature which deals with the course of the lymphatic vessels in the bird will be considered. Until the description of superficial lymphatics in the skin of the domestic fowl by Baum (8), the various authors are unanimously agreed that a superficial stratum of lymphatics does not occur in the bird. It is extremely difficult to inject these vessels in the skin, and this would appear to be the reason for the fact that they were not observed by the earlier investigators. As previously stated the publications of the earliest authors are solely of historical interest, since they deal mainly with the discovery of lymphatic vessels in the bird, and they will not be summarised in any detail.

The first description of lymphatic vessels in the bird is in the publication by Birch (9), in which he gives an account of

some injected specimens of pelvic cavities of birds prepared for the Royal Society. At about the same period, Peyer (58), Jacoboeus (35), Lang (45) and Lister (47) published papers in which they describe lymphatics in various types of bird. Lacteals were discovered in the mesentery of the stork by Jacoboeus (35), and in the mesentery of the duck by Lang (45). Hunter (31) describes lymphatics in some species of bird. Hewson (29) gives an account of the lymphatic system in the goose, and includes diagrams to illustrate this account. By the injection of mercury he had demonstrated lymphatics in most of the abdominal viscera, and a single lymphatic in the hindlimb. His results, however, are lacking in detail. Monro (52) also describes lymphatics in the bird. In his textbook Tiedemann (69) gives an incomplete account of the course of some of the lymphatics in birds. Fohmann (20) succeeded in injecting a few lymphatics in the hindlimb and intestine of the bird. Magendie (48) discusses the statements of his predecessors, but claims that "absorbent vessels" are only present in the cervical region, and are only visible in that situation in the swan and the goose. He asserts that the veins assume the functions of the lymphatics in other situations in birds. These statements are made by Magendie in spite of the fact that lymphatic vessels were demonstrated in other regions, and in other birds, by earlier authors.

All the statements by these authors are incomplete, and the publication by Lauth (46) is the first to describe the course of the lymphatics of birds in any detail, probably because the technique of injection had been considerably improved. His description covers the lymphatics of the hen, turkey, heron,

stork, arctic gull, goose and duck, and he gives an illustration of the course of lymphatics in a goose, which, considering the period at which it was produced, is very illuminating. He describes the course of the thoracic ducts and of the lymphatics of the abdominal viscera, hindlimb, forelimb and head and neck. Nevertheless, his account is still incomplete, and one difficulty encountered in following his statements is that they apply to all the species examined and no comparative differences are given. It should be noted that Lauth considers that the thoracic ducts terminate in the jugular veins, and are joined by the lymphatics of the forelimb and head and neck before joining the venous system. He also states the lymphatics frequently anastomose, in the area of the coeliac artery, with the veins lying in that region.

Panizza (56) describes the lymphatics of the Proventriculus, gizzard, duodenum, rectum, spleen and kidneys in the goose, and illustrates his description with a diagram.

Meckel (51) states that the lymphatics, which have few valves, do not run so superficially as in mammals, and follow the blood vessels, around which they form plexuses. He claims that the lymphatics open into the blood vessels within these plexuses.

Owen (55) quotes mainly from Lauth (46) and Panizza (56) in his description of the course of the lymphatics. He states that the valves in these vessels are fewer in number and less complete in formation than in mammals. Owen makes the assertion that "they (the lymphatics) do not form two strata, as in Mammals, at least those only have been observed which correspond to the deep-seated absorbents which accompany the larger vessels". The statement made by Lauth (46) that the thoracic ducts end in the jugular veins is cited by Owen.

Huxley (33) makes no reference to the disposition of the lymphatics in birds.

Chauveau (15) states that the lymphatics, which are abundant in the viscera of birds, unite to form 2 thoracic ducts. "These ducts commence at the coeliac trunk, and pass along the lower face of the lung, receiving the lymphatics of that organ and those of the wings, and finally open into the jugular veins, a little in front of their union with the axillary veins. A transverse branch forms a communication between the two thoracic ducts towards their termination".

Bronn (11) gives a comparatively detailed account of the course of the lymphatics in the bird, but, as with the previous authors, certain errors and omissions are present. He states that the lymphatics form frequent plexuses around the larger blood vessels, which they follow. With the exception of the coccygeal region, the lymphatics of the whole trunk unite with one another to form a large vessel, which runs forward with the aorta to the origin of the coeliac artery, where it has a plexiform arrangement, and this plexus is drained by 2 thoracic ducts. Each thoracic duct, according to Bronn, joins the anterior vena cava of its own side, just proximal to the junction of the jugular and subclavian veins. He claims that the lymphatics of the head and neck, the forelimb and the lungs join the thoracic ducts.

Müller (53) reports on his researches on the penis of the drake, and includes some statements on the course of the lymphatics in the pelvic cavities of birds. It is to Müller that is owed the first authoritative statement on the junction of abdominal and pelvic lymphatics with the veins of these regions. He states

that it is only through the medium of sacral and pelvic lymph hearts that lymphatics unite with the abdominal or pelvic veins, and in types of bird in which such lymph hearts do not persist after hatching, the union of lymphatics with the abdominal or pelvic veins does not occur. Thus the claims made by Lauth (46) and Meckel (51) on this subject are incorrect.

Barthels (4) quotes from the previous authors, and states that the lymphatic system of the bird is joined to the brachiocephalic veins (anterior venae cavae) by 2 thoracic ducts.

Wiedersheim (71) makes the ambiguous statement that the thoracic ducts in the bird are found in the region between the thyroid gland and the coelic artery. He agrees with the earlier authors that the valves in the lymphatics are rather loose and are poorly developed.

Fürther (22) was one of the first investigators to use Gerota's injection mass when studying the lymphatic system of the bird, and, as a result, his description presents much more detail. He was, however, primarily studying the lymphatic glands of the bird, working mainly on the Anatidae (Natatores), so his statements are still relatively incomplete. He is the first author who points out that the lymphatics of the forelimb usually unite with the veins in the anterior part of the thorax independently of the thoracic duct. This contradicts the statements made by Lauth (46), Chaveau (15) and Bronn (11) that the lymphatics of the wings join the thoracic ducts. He states that the lymphatics following the jugular vein join the venous system with the thoracic duct. Fürther does not mention any lymphatic vessels in the abdomen and thorax.

Kaupp (43) adds little to the descriptions of Owen (55) and

Bronn (11), from which it appears that he is quoting. He states that each thoracic duct terminates by joining the jugular vein of its own side.

Krause (44) gives a general account of the lymphatics of the bird, but does not mention the termination of the thoracic ducts and of the other main lymphatic trunks.

Ward and Gallagher (70) make the assertion, frequently found in other publications, that superficial and deep strata of the lymphatics do not occur in birds, the deep stratum alone being present. They also claim that each thoracic duct joins the jugular vein of its own side.

Ellenburger and Baum (18) state that lymphatics are present in large numbers in the bird. The unite to form right and left thoracic ducts, which run in a cranial direction, being frequently joined to one another by anastomatic branches, and each terminates by joining the jugular vein of its own side. It is also stated that the lymphatics flow into the veins in the pelvic region in many species, without citing the statement of Müller (53) that this only occurs when lymph hearts are present.

In his textbook, Awtokratoff (3) gives an account of the lymphatics, in which he states that the main vessels accompany the coccygeal arteries and the descending aorta. These trunks are continued by right and left thoracic ducts, which unite with the anterior venae cavae.

Josifoff (42) carried out his work on the hen and the pigeon, but primarily on the pigeon. He employed a new technique of injection, in which he injected Indian ink into the digital pads, the muscles and the subcutaneous tissues of the live bird,

anaesthetized with ether, and combined this method with injections of Gerota's mass in the dead bird. The method of injection in the live bird will be dealt with more fully in the section dealing with the technique of injection. When Josifoff's account is studied, it is evident that he has added little to the knowledge of the lymphatic system of the bird. He failed to demonstrate lymphatics in the skin, heart, lungs, liver, pancreas and genital organs, and his description is very similar to all the preceding statements. (It should be noted that lymphatics draining the liver of the bird were observed by many of the earlier investigators, and lymphatics of the testes are clearly shown in the drawing by Lauth (46).) Josifoff also states that superficial lymphatics are not present in the bird. The lymphatics follow the blood vessels, mainly following the veins outside the abdominal cavity. He describes the thoracic duct of each side joining the "Angulus venosus" formed by the junction of the jugular and subclavian veins. The lymphatics of the head and neck, and of the forelimb have independent openings into this same "Angulus Venosus".

Baum (8), as previously stated, gives the first detailed description of the lymphatic system of the domestic fowl, and his account is the first to describe lymphatics in the skin of any bird. As the present work covers similar ground, Baum's publication will not be summarised in any detail at this stage, but frequent reference will be made to Baum's description in the report on the present investigation. It may be mentioned here that Baum describes 2 pairs of thoracic ducts, i.e. a pair of "lumbar thoracic ducts", running from the origin of the ischiadic artery to the root of the coeliac artery, considered by Bronn (11)

to be a single trunk, and a pair of "thoracic thoracic ducts", running from the coeliac artery to end in the anterior venae cavae. According to Baum, irregularities often occur in the formation and arrangement of the thoracic ducts in the fowl, including the total absence of the right or left duct in some cases. In addition to the termination of the "thoracic thoracic ducts" in the anterior venae cavae, medial to the junction of the jugular and subclavian veins, Baum describes the lymphatics of the wing joining the subclavian vein, close to the union of that vein and the jugular vein, the lymphatics of the head and neck joining the jugular vein, and he states that the lymphatics of the lungs, heart and proventriculus all open independently into the anterior vena cava. Baum agrees with many of the other authors in stating that the lymphatics follow the main blood vessels, but he asserts that plexus formation is only rarely encountered in the body of the fowl, with the exception of the abdominal region. This contradicts the statements of some of the previous authors. He states that the lymphatics are very few in number when compared with these vessels in mammals.

Bradley (10) only mentions that the lymphatics are numerous in the fowl, and that the largest vessels, the thoracic ducts, open into the jugular veins.

Sisson (65) gives an account similar to that by Bradley (10), but adds that, before entering the jugular veins, the thoracic ducts "receive the ducts from the head, neck, thoracic limbs and anterior part of the body".

It will now be seen that many contradictory statements have been made concerning the lymphatics of the bird, particularly with regard to their termination in the venous system. It is generally

agreed that the lymphatics follow the main blood vessels, but until the discovery by Baum (8) of lymphatics in the skin of the domestic fowl, it was considered that superficial lymphatics did not occur in the bird. There is little agreement on the question whether plexuses are or are not frequently formed.

Lauth (46) and Meckel (51) claim that some of the lymphatics join the abdominal and pelvic veins in all birds, but this assertion is corrected by Müller (53), who states that this can only occur in birds which possess lymph hearts.

The authors Lauth (46), Owen (55), Chauveau (15), Kaupp (43), Ward and Gallagher (70), Ellenburger and Baum (18), Bradley (10) and Sisson(65) all agree that the thoracic ducts join the jugular veins in birds, and most of these authors claim that the lymphatics of the head and neck and of the forelimb unite with the thoracic ducts. Bronn (11), Barthels (4) and Awtokratoff (3) assert that the thoracic ducts join the anterior venae cavae, and they seem to imply that the thoracic ducts are joined by the lymphatics of the head and neck and of the forelimb. Josifoff (42) describes the thoracic duct of one side, the lymphatics of the head and neck and the vessels from the forelimb opening independently of one another into the "Angulus venosus" between the jugular and subclavian veins of the same side in the hen and pigeon. These statements refer, in most cases, to all birds, and this may account for their contradictory nature, if variations in the termination of the lymphatics occur as between different species. Baum (8) referring to the domestic fowl, states that the thoracic ducts join the anterior venae cavae, thus agreeing with Bronn (11), Barthels (4) and Awtokratoff (3), but he points out that the

lymphatics from other regions of the body have independent openings into the venous system. Baum (8) is the only author who describes the frequent absence of either the right or the left thoracic duct.

METHOD OF STUDY.

It is agreed by all who have studied the lymphatic system of the bird that great difficulty is encountered in injecting the lymphatic vessels. This is due to the fact that there are relatively few lymphatics in the bird, and that those which are present have a very small calibre. The thoracic ducts, in the subjects which have been examined during the present work, have never exceeded 1m.m. in diameter in the largest fowls, and the other lymphatics have, of course, a smaller diameter than the thoracic ducts. Microscopic examination is always necessary to trace the smaller lymphatics, e.g. in the skin, even when they are filled with injection fluid. The absence of lymphatic glands in most types of bird is a contributory cause of this difficulty of injection, since, where lymphatic glands are present, one is certain to inject many of the main lymphatics by injection directly into the glands. Because of the difficulty of injecting the lymphatics, it appears to be inevitable that isolated branches of the vessels may not be observed, but it has been the intention throughout this investigation to give as complete a picture as possible of the lymphatic system of the fowl.

The earliest investigations were carried out by the injection of air, tallow or wax into the lymphatics (see Chauveau (15) and Gerota (25), but these methods were soon discarded and, until 1869 the injection of mercury was the common method of study. Various types of injection syringe were used, but the cannulae were always of glass, drawn out in a flame to as fine a bore as possible. Because of the fragility of these cannulae, injection was only carried out in soft tissues and, even so, breakages were frequent.

The introduction of metal hypodermic needles of very small calibre, such as are suitable for lymphatic injection, is a comparatively recent event. As well as the defects in the instruments which were available, the earliest workers had to contend with the disadvantages possessed by the mercury itself for the purpose of injection. Great pressure was necessary to produce an injection of the lymphatics, and these vessels were, as a result, frequently ruptured. As soon as the slightest breach occurred in the wall of a lymphatic all the mercury ran out, rendering further study impossible. In addition, the mercury could not be fixed in the vessels by any method, so permanent specimens could not be prepared.

For the purpose of injecting the lymphatics, the fluid to be injected must be of such a consistency as to travel easily and rapidly along the vessels, and it should be possible to fix the fluid in the vessels, so that detailed macroscopic and microscopic study is possible. The mass may be constituted in such a way that it fixes itself in the vessels by the evaporation of one of the compounds which it contains, but this must only take place gradually, since injection is a long and time-consuming process and once fixation has occurred, no further injection of the vessels is possible. The material should also be of a colour which contrasts well with any colour which may be encountered in the tissues of the body, and the colour should be in the form of a suspension, since a solution of a dye will tend to pass out of the walls of the vessels and so will stain the tissues.

In 1896, Gerota (25) evolved an injection mass which satisfied all these conditions. His mass consists of the artists' oil colour Berlin Blue (Prussian Blue and Paris Blue are equally effective),

mixed to a thick cream in a mortar with oil of turpentine, and the resulting material is suspended in ether. According to Gerota's instructions, 2 parts of the colour, 3 parts of turpentine and 15 parts of ether are the correct proportions. This suspension is then strained through linen to remove large particles which would not pass through the vessels, and is preserved in a scrupulously clean bottle, which is tightly stoppered. Gerota describes other injection masses all depending on the same principles of suspension, the differences being in the colours which are employed, but Gerota and most of his successors agree that the blue injection mass is the most readily visible in the lymphatics. The mass gradually becomes fixed in the vessels as a result of the evaporation of the ether, but this fixation may be accomplished almost immediately by immersion in a solution of formalin. Gerota's mass has been modified by other workers and the common variant now employed is that described by Baum (5). In this 3 parts of the oil paint, 2 parts of oil of turpentine and 15-25 parts of ether are the proportions used, and wash-leather is recommended for the purpose of filtration. Baum used this mass for all his work on the lymphatic systems of the various animals which he studied. The mass which Josifoff (42) employed was identical with Gerota's, but more ether was added, thus giving a more lightly coloured appearance. Whatever the amounts which are used, Gerota's mass is extremely efficient. A great advantage of this type of mass is that it can readily be removed from the instruments and from the surface of the tissues surrounding the site of injection by wiping with swabs soaked in turpentine or ether.

Other injection masses have been used by some investigators,

such as dilute Indian ink and other watery suspensions. These watery suspensions, however, do not travel so rapidly along the vessels and do not penetrate so far. Also, in the author's experience, it is much more difficult to remove stains left on the tissues by watery suspensions than to remove those left by Gerota's mass. Indian ink may be used without danger in the living animal, as shown by Josifoff (42), but Gerota's mass rapidly causes death because of the ether which it contains. Another material used in the injection of the live animal is Patent Blue V., described by Burch (14), but this is mainly employed for microscopic investigations.

The instruments which have been used in the more recent researches have been the "Record" type of hypodermic syringe, fitted with a needle of as fine a bore as possible. Baum (7) had his best results with a needle .29m.m. in diameter. Jamieson and Dobson (36) devised a special pump which ensured an even pressure throughout the period of injection, but other authors consider that this is no advantage, since differing degrees of pressure are needed in different sites of injection, and a gradual increase of pressure, which is so frequently necessary, can best be attained by the control of the hand on an ordinary hypodermic syringe. Constant practice is the means of attaining success in the injection of lymphatic vessels, since too rapid an increase of pressure in injecting a vessel will result in the rupture of that vessel, and to ensure a gradual increase in pressure it is an advantage if the barrel of the syringe is fairly narrow.

The method of injecting fluid into lymphatic vessels consists of stabbing the needle into the tissues which are being studied,

and gradually exerting pressure on the plunger of the syringe. If the needle has penetrated the wall of a fine lymphatic, or has entered a tissue space drained by a lymphatic, the injection fluid will pass into the vessel, and will be visible moving along the interior of the vessel. Often, before a vessel can be injected, repeated stabs have to be made into the tissue. After stabbing into the tissue and injecting some fluid, it is an advantage to massage the area concerned. It will now be seen that a very fine needle is absolutely necessary. Baum's (8) statement that the lymphatics are few in number in the fowl has been found to be correct, and this obviously increases the difficulty of injection in the fowl, since there are wide tracts of the body where no vessels can be demonstrated. It sometimes happens that only a small amount of fluid has entered a lymphatic, but the course of the vessel may be followed, if the fluid has not become fixed in the vessel, by forcing the fluid along its course with a probe applied to the exterior. A direct injection into a large lymphatic is possible with the aid of a dissecting microscope. During the present investigation an attempt was made to inject backwards along the thoracic ducts to produce a retrograde injection of some of the lymphatics, but this was unsuccessful in all cases. Thus is would appear that the valves are efficient in preventing retrograde flow even though, as many authors state, they are loose and poorly developed in the bird.

Magnus (49) recommends the injection of Hydrogen peroxide into the region where a stab injection has been made. He claims that the oxygen bubbles which are liberated carry the coloured fluid along the lymphatic vessels. Baum (8) used this method

successfully in some regions of the fowl's body where no results had been achieved with a simple injection. In the present work this instillation of hydrogen peroxide was frequently performed in many different sites, but the results were poor, and the method was discarded in favour of the stab injection alone.

When injecting the lymphatics, it frequently happens that tributaries of veins are injected at the same time, or a vein alone may be filled with the fluid, and it may then be difficult to decide whether one is concerned with a vein or a lymphatic. It is only by continued practice and observation that this can be decided with certainty. The differences between small veins and lymphatics have been admirably summarised by Shore (64). A lymphatic vessel is smaller than the vein with which it corresponds, has a more tortuous course, does not show a marked increase in diameter as it passes towards a main trunk, and usually the walls of a lymphatic retain particles of the injection mass even if most of it has run out of the vessel. In some tissues the veins and lymphatics are, almost without exception, both filled from the same injection, and Baum (8), who also observed this, queries whether this may not be due to lymphatico-venous connections. A discussion of this controversial subject is given in an early article by Baum (6).

With the avowed object of avoiding this difficulty of the veins and lymphatics being filled with injection fluid at the same time, Josifoff (42) utilised his method of injection in the living bird. He anaesthetised the bird with ether, and injected Indian ink into various regions of the body. He states that the fluid remains in the lymphatics, and that these are readily observed when the

subject is destroyed ½-2 hours later, but any fluid which enters the veins is removed by the blood and is filtered out in the lungs and the liver. It is clear that such an injection must be carried out rapidly, and so anything like complete results cannot be achieved, and this is borne out by Josifoff's description. It appears that this method only results in the demonstration of a few of the main lymphatic trunks.

Most authors agree that injection of the lymphatics is most easily performed on the young subject, but differing opinions are expressed on the stage after death when the most successful results are obtained. Barthels (4) maintains that injection should be carried out as soon as death as possible, but Baum (7) disagrees and asserts that the onset of putrefaction is the only limiting factor. Forbes (21) working on foetal skin, allowed his material to degenerate in a warm room for 14 days. He states that injection was rendered more easy because the vessels were dilated with the gases of putrefaction. In the present work it has been found that the lacteals and most of the remaining lymphatics usually become filled with gas on the 4th. day after the death of the subject, but in this case the gases prevented rather than aided the injection of the vessels. However, if the injection is made before the onset of putrefaction, the gases of putrefaction, when they are produced, will often carry the mass along the vessels.

In the investigation which has been carried out the variant of Gerota's mass which has been described by Baum (5) was employed, with the oil colour "Prussian Blue" as the suspension. It was found that the mass could be further diluted with ether without limiting its efficiency, and if any evaporation had occurred from the mass,

more ether could be added to bring it up to its original volume. At first, the mass was filtered through wash-leather, as recommended by Baum (5), but it was found that a large amount of the ether evaporated during this process, so linen was substituted and this allowed for more rapid filtration. The mass will keep almost indefinitely, and if there is a tendency to settle on the part of the suspended colour, vigorous agitation of the container soon restores the suspension.

The syringe used was of the "Record" type, with a capacity of 2c.c., which had a slender barrel and plunger. For most tissues the finest needle obtainable, of .3m.m. diameter, was used at first, but later, due to the enterprise of the manufacturers, a needle of .25m.m. diameter was specially made for this work, and this gave excellent results. The disadvantage of such slender needles is that breakages are frequent. For injecting the lymphatics of bones these fine needles were too delicate, and a needle of .45m.m. diameter was used. The subjects for injection were fowls of all ages, different ages proving most suitable for the successful injection of the lymphatics of different tissues. The fowls were all destroyed by the administration of illuminating gas by inhalation to the subject, after it had been anaesthetised with chloroform. The Carboxyhaemoglobin in the blood vessels rendered them plainly visible even through the skin. The subjects were plucked immediately after death, and injection was commenced as soon as this process had been completed. Throughout the whole of the work the simple stab injection with the coloured mass was used in preference to all other methods. When injection had been completed or when putrefaction prevented further injection (usually after 4-6 days)

the body was immersed in 10% formalin for 24 hours in order to fix the injection mass, and then the course of the lymphatics could be traced in detail. At one stage of the investigation, an attempt was made to inject the lymphatics of a subject which had been placed in formalin immediately after death; but the results were negligible, although such a process had been found to be moderately successful in the mammal.

Injection of the lymphatics of the skin is very difficult, due mainly to the extreme thinness of the skin in the fowl and to the relatively small numbers of lymphatics which occur in the skin. Even with the finest of needles it is difficult to avoid passing the needle right through the skin into the subcutaneous tissues. Baum (8) recommends that the needle should be passed through the skin into the subcutaneous tissues, and then passed back into the skin from its deep face, if an injection into the skin is to be easily effected. Certainly this method is often successful, but, after considerable practice, it was found possible to attain an intradermal injection directly from the exterior. As in some other tissues, massage of the small amount of injection fluid which has been instilled is usually necessary. Following on the discovery that the lymphatics of the skin primarily follow the veins, injections were mainly carried out in the areas where the various cutaneous veins commence, these veins being visible through the skin, and excellent results were obtained. To trace these lymphatics, the skin has to be reflected in order that the vessels may be clearly seen, and microscopic examination is necessary in the case of all but the largest vessels. These lymphatics are closely attached to the deep face of the skin, and only when they pass deeply between

the superficial muscles do they lose their attachment to the skin. The lymphatics of the skin seem to be most readily demonstrated in birds which have not reached adult life, but the length of time after death when injection takes place has little effect on the results obtained.

The lymphatics of the muscles were injected by repeated puncture into these structures, followed by massage of the areas which had been injected. The best results were obtained in young birds. The period of rigor mortis was always avoided, although if injection had taken place before the onset of rigor mortis, the contraction of the muscles appeared to force the mass along the vessels to a certain extent.

The lymphatics of joints may be demonstrated in birds of all ages by the method evolved by Baum (7) (8). A direct injection is made into the joint cavity until the surrounding ligaments are tense, and then the joint is manipulated through its normal range of movements. This manipulation is continued for some time, and the vessels draining the joint will gradually fill with injection fluid. It has been found that where the muscles have been injected on the same specimen, the movements of the joints also helps to fill the lymphatics of the muscles.

Baum (8) states that a chick a few days old is necessary for the injection of the bones, but the author has injected these successfully in fowls up to the age of 4 months. The injection was usually made into the extremities of the long bones, where there is only a thin layer of compact bone. With a long needle it was found possible to inject the medullary space of the longest bones from their extremities. It is difficult to puncture the actual shaft

of these long bones in any but the youngest chicks. Injection of the remaining bones was relatively simple. During the puncture of bones the needle often became blocked by a plug of bone, so the needle was introduced with a stilette in its cavity to avoid this blockage, and, when the puncture had been made, the stilette was removed, the injection then being easily performed. As with all other tissues, frequent microscopic examination is necessary to follow the lymphatics of bones. The lymphatics leave the bones by nutrient and medullary foramina, and in all cases are joined by periosteal lymphatics at their point of exit from the bone. In nearly all cases the veins, as well as the lymphatics, which ran out of the bones became filled with injection fluid.

The lymphatics of most regions of the alimentary canal may be injected with relative ease. The puncture is made into the wall of the canal, and, for success, it should be made as superficially as possible, and preferably on the lateral surface. Baum (7) (8) describes a method in which 2 ligatures are placed on a portion of the gut, and the intervening part is filled with injection mass. He states that by manipulation the fluid is forced into the lymphatics draining the region. However, a simple puncture into the wall of the canal has been found to be quite as effective, and more rapidly performed. The absence of a serous covering to the oesophagus and crop renders injection more difficult in these areas, particularly as they possess relatively few lymphatics, but a superficial puncture into the muscular coat of these organs is usually effective. The lymphatics of the liver, which are few in number, may be filled with fluid by a direct puncture into the substance of the liver. Most authors state that this, to be

effective must be performed while the carcase is still warm, but these vessels were injected successfully, during the present investigation, in subjects 4 days after death had occurred.

The lymphatics of the trachea are very difficult to inject, injection being most easily performed when the mucous membrane or the tissue between the tracheal rings is punctured. Whether such vessels arise from the cartilage could not be ascertained, but Baum (7) has demonstrated lymphatics arising from the cartilage of the trachea in the calf.

The lymphatics of the lungs are injected by superficial and deep punctures into these organs, but a complete injection is a rare occurrence. Baum (8) employed Magnus' method, but this method was not successful at all in the author's hands.

The lymphatics of the ovary are most readily demonstrated in an immature bird, because there are so many large ova in the laying fowl and injection into the connective tissue is practically impossible.

Lymphatics only occur in the capsule of the spleen (Schafer (61)), so injection into this organ must be as superficial as possible.

There are no special points which need be mentioned in connection with the injection of the lymphatics of other organs of the body, but it must again be emphasised that injection is only successful after continued practice, and that microscopic examination is essential if the course of many of the smaller vessels is to be observed.

THE LYMPHATIC SYSTEM OF THE DOMESTIC FOWL : REPORT ON THE PRESENT INVESTIGATION.

Lymph hearts have not been observed in any fowl which has been examined, even in day-old chicks, but, in some subjects, slight dilations have been seen on the course of the lymphatics following the middle sacral artery, close to the junction of the sacral and coccygeal regions. In addition, lymphatic glands are totally absent in the fowl, and the author agrees with other investigators that plexuses of the lymphatics appear to take the place of such glands. Areas in which lymphatic glands occur in other birds and in mammals have been examined in detail, and in many of these areas plexuses have been demonstrated. These plexuses will be dealt with in connection with the lymphatics on the course of which they are placed, but it may be mentioned here that such plexiform arrangements are particularly noticeable because the occurrence of plexuses in the domestic fowl is comparatively rare. In regions such as the skin, plexuses are scarcely ever present, and it is only on the course of the lymphatics of the abdominal viscera that they are at all plentiful. Where 2 or more lymphatics are running a common course, they are often united to one another by successive transverse or oblique anastomosing branches, but these can hardly be called plexuses.

Thus, in the domestic fowl, the lymphatic system consists solely of an arrangement of lymphatic vessels which have several communications with the venous system. The lymphatics are relatively few in number, and, with very few exceptions, they follow the course of the blood vessels. They are closely applied to the blood vessels, and appear to be attached to the wall of the artery or vein in question by connective tissue. It has been found

that where an artery and a vein have a common course outside the body cavity, the lymphatics mainly follow the vein, but if the courses of a corresponding artery and vein are widely separated from one another, lymphatics follow both blood vessels. Within the body cavity, the lymphatics usually follow the arteries. It is most common, in all parts of the body to find 2, or even 3, lymphatics following an artery or a vein, but sometimes a single lymphatic is present. Also any lymphatic vessel may be double in some parts of its course and single in other parts. As stated, where a lymphatic is double, or where 2 lymphatics are following the course of the same blood vessel, the 2 are joined to one another throughout their course by numerous transverse or oblique anastomosing branches, which curve around the wall of the blood vessel, being closely attached to it. In most of the appended illustrations the lymphatics are shown as single trunks for the sake of clarity, and it should be borne in mind that the occurrance of 2 or even 3 vessels running together is very frequent. Although the main trunks of the lymphatics have a regular course, it must be emphasised that the tributary branches are subject to some variation, as in all animals.

Valves are present in the lymphatics of the fowl, but, as claimed by many authors, they are few in number when compared with the valves of mammalian lymphatics. They appear to be rather loosely arranged but are efficient in preventing retrograde flow. As stated, this was demonstrated by the complete lack of success when an attempt was made to inject backwards along the thoracic ducts and other lymphatics. As far as can be ascertained, no previous statement has been made on the presence of valves at the junction

of the lymphatic trunks with the venous system. When examined with the aid of a microscope, such valves are definitely visible at the actual termination of the lymphatic vessels, and they are usually in the form of 2 small cusps.

When writing an account of the course of the lymphatic vessels, one is faced with the alternatives of giving either a systematic or a topographic description of these vessels. In a systematic description the courses of the lymphatics draining different groups of organs or tissues are given separately, and this is the general plan of the publication by Baum (8). The disadvantage of this method of description appears to be that it entails much repatition, and, taking Baum's statement as an example, the course of the main lymphatic trunks is frequently not at all clear. A topographic account describes the courses of the lymphatics of a whole region of the body, including the relations of the lymphatics to one another, and this method of description will be followed in the present report, since it seems to give a more detailed and orderly outline of the lymphatic system. For the purpose of description, the body may be divided into the following regions : (1) Head and neck, (2) Forelimb, (3) Hindlimb and (4) Trunk. At the end of each section the lymphatic drainage of the various organs and tissues of the region will be summarised.

Baum (8) gives definite name to some of the main lymphatic trunks; for example, Vasa lymphacea jugularia, Vasa lymphacea axillaria, Vasa lymphacea intestinalia, etc. The exact course and extent of some of these vessels is not defined with any certainty in Baum's description, and it is not intended to use these terms in the present account. It is felt that the lymphatics can best be

indicated by the names of the veins or arteries which they follow, without introducing any additional nomenclature. Thus, where it is necessary to refer to any lymphatic vessels by name the terms "the lymphatics following the ----- vein", or "the lymphatics of the ---- vein" will be used. As previously stated, Baum (8) considers that each thoracic duct consists of 2 parts - a "Ductus thoracicus thoracalis" corresponding with the thoracic duct of other authors, and a "Ductus thoracicus lumbalis" lying in the abdominal cavity by the side of the aorta, and he states that the latter corresponds with the cisterna chyli of the mammal. This description seems to be rather artificial and the term thoracic duct will be applied only to the large vessels lying within the thoracic cavity.

Throughout the description the terminology of Kaupp (43) will be used, since his is the only really detailed statement in English on the anatomy of the fowl.

THE LYMPHATICS OF THE HEAD AND NECK. The main lymphatic trunks which drain the head and neck follow the jugular veins, and are formed by the confluence of lymphatics following the anterior and posterior cephalic veins at the junction of the head and neck. The courses of the numerous lymphatic vessels which unite to form these main trunks will now be described.

Lymphatics following the cutaneous facial vein. (Figs.1. and 1A.)

On each side of the middle line of the head 3 fine lymphatics arise from the anterior two-thirds of the comb, and these unite to form a single vessel which is frequently double in its course. It follows the cutaneous facial vein, and passes downwards, anterior

to the orbital region. Below the orbit it curves backwards, still in company with the vein, and comes to lie just above the malar bone, running parallel with the upper border of that bone. The vessel passes over the outer surface of the masseter muscle, and under the lateral temporomaxillary ligament, to reach the posterior edge of the masseter muscle. It then runs deeply behind this border of the muscle to pass between it and the anterior edge of the quadrate bone. Having curved obliquely downwards and backwards between the quadrate bone and the pterygoid muscles, it reaches the space between the posterior extremity of the inferior maxilla and the pointed process of that bone which projects inwards, and here the lymphatic unites with the common trunk of the vessels following the palpebral and temporal veins. The combined vessel follows the external facial vein.

Tributary branches.

(1). In the early part of its course, anterior to the orbit, the vessel following the cutaneous facial vein receives several lymphatics from the skin which lies anterior to the orbit.

(2). 2 lymphatics, draining the anterior parts of the upper and lower eyelids, also join the main vessel independently of one another, anterior to the orbit.

(3). At the point where the lymphatic from the lower eyelid flows into the main vessel, several fine lymphatics arising from the anterior part of the nasal chamber and the region of the anterior nares also join it, and,

(4), it is joined, in approximately the same area, by some delicate vessels from the facial bones.

(5). A lymphatic, which drains the skin of the upper beak and the

upper beak itself, runs horizontally backwards to unite with the vessel following the cutaneous facial vein as it curves backwards to lie parallel with the malar bone.

(6). Just before the main vessel passes under the lateral temporo-maxillary ligament, it receives a branch which drains the skin over the lower jaw and the wattle. This tributary also drains the part of the masseter muscle which lies below the malar, and it runs deep to the malar to reach the main vessel. This is the last tributary branch before the lymphatic of the cutaneous facial vein unites with the common trunk of the vessels of the palpebral and temporal veins.

Lymphatics following the palpebral vein. (Figs. 1. and 1A.)

The main lymphatic, which again is usually double, is formed by the junction of 2 small vessels, which drain the skin over the temporalis muscle. The main vessel curves around the anterior wall of the external auditory meatus, following the contour of the wall, and it passes downwards in this way to join the lymphatic of the temporal vein on the inferior aspect of the wall of the external auditory meatus.

Tributary branches.

(1). On the anterior part of the wall of the external auditory meatus the main vessel is joined by a lymphatic draining of the temporalis muscle.

(2). A little later, a tributary is visible which is formed by 3 separate branches. A lymphatic draining the posterior part of the lower eyelid and the adjacent area of the skin of the face runs directly backwards across the upper part of the masseter muscle,

and across the superficial face of the upper part of the lateral temporo-maxillary ligament. After crossing the ligament, it is joined by a vessel arising from the part of the masseter muscle lying above the malar, which runs deep to the lateral temporo-maxillary ligament. In the same region the vessel so formed unites with a lymphatic from the posterior part of the upper eyelid, and then this tributary joins the main vessel.

Lymphatics following the temporal vein. (Figs. 1 and 1A).

The double main vessel which follows the temporal vein commences as a lymphatic draining the skin over the posterior part of the temporalis muscle. As in the case of the lymphatic of the palpebral vein, it follows the contour of the wall of the external auditory meatus, but runs around the posterior aspect of the wall to reach its inferior face, where it unites with the vessel following the palpebral vein.

Tributary branches.

(1). A vessel which drains the skin over the roof of the cranium and the posterior third of the comb, and which receives lymphatics from the bones forming the lateral wall of the cranium, joins the main lymphatic at the point where it lies on the posterior part of the wall of the external auditory meatus.

(2). In the same region, the main vessel receives a small branch which arises from the deep face of the biventer maxillae muscle, turning around the anterior edge of that muscle to reach the main vessel.

(3). Just before the termination of the main trunk, it is joined by a cutaneous lymphatic from the skin lying over the biventer

maxillae muscle.

Lymphatics following the common trunk of the palpebral and temporal veins. (Figs.1. and 1A).

The vessels following the palpebral and temporal veins, unite on the lower aspect of the wall of the external auditory meatus, and the resulting lymphatic passes deep to the anterior edge of the biventer maxillae muscle, immediately above the posterior extremity of the malar bone. It crosses the posterior edge of the quadrate bone just above its lower extremity, and runs downwards and backwards to unite with the vessel following the cutaneous facial vein, at the point where this latter is lying between the main part of the posterior end of the inferior maxilla and its inwardly projecting process.

Thus, the lymphatics following the cutaneous facial,palpebral and temporal veins ultimately unite to form a common trunk which then follows the external facial vein.

Lymphatics following the external facial vein.(Fig. 1A).

The lymphatic of this vein is frequently double, and continues the course of the vessel following the cutaneous facial vein. Having passed between the posterior extremity of the inferior maxilla and its inwardly projecting process, it runs obliquely downwards and backwards and, after a very short course, it unites with the lymphatic following the internal facial vein.

Tributary branch.

(1). Arising from the postero-medial aspect of the temporo - maxillary joint is a single fine lymphatic, which unites almost

immediately with the main vessel. Baum (8) states that this vessel joins the lymphatics of the jugular vein through the medium of the lymphatic plexus formed on the vena transversa. However, according to the subjects examined, this vessel joins the lymphatic of the external facial vein and, as will be seen later, it does eventually join the lymphatics of the jugular vein, but not through the plexus formed on the lymphatics of the transverse vein.

Lymphatics following the internal facial vein. Numerous small lymphatics which follow branches of the internal facial vein, drain the extrinsic muscles of the tongue and the muscles of the inner side of the inferior maxilla. They join one another to form a common lymphatic trunk which follows the internal facial vein, and runs between the posterior part of the internal pterygoid muscle and the pharyngeal muscles to join the vessel which accompanies the external facial vein.

Tributary branch.

(1). Lymphatics draining the orbital muscles unite to form a trunk following the opthalmic vein, and this joins the vessel which accompanies the internal facial vein.

The lymphatic vessels of the internal and external facial veins unite and form a common lymphatic, which is frequently double, and follows the anterior cephalic or common facial vein.

Lymphatics following the anterior cephalic vein. (Fig.1.)

The main trunk following this vein continues the course of the lymphatic of the external facial vein, and runs downwards and backwards, at first being deeply placed to the genio-hyoideus muscle

and the hyoid apparatus. Continuing this course it leaves the cover of the genio-hyoideus muscle and, running over the rectus capitis anticus minor muscle for a short distance, it finally unites with the lymphatic of the posterior cephalic vein about the middle of that muscle.

Tributary branches.

(1). Close to its formation, the main vessel receives a lymphatic which drains the tongue and follows the course of the lingual vein. (According to Kaupp (43), the right lingual vein may join the vena cephalica posterior, but such an arrangement has not been observed in any of the subjects examined.) Several lymphatics arise from the mucous membrane and intrinsic musculature of the tongue which unite to form a single trunk. In its course this trunk is joined by vessels from the extrinsic muscles of the tongue, which are additional to those following the internal facial vein, and, later, by branches which drain the wall of the pharynx. The vessel following the lingual vein then runs outwards and backwards to unite with the lymphatic of the anterior cephalic vein.

(2). A lymphatic which drains one half of the inferior maxilla joins the main vessel at the point at which the lymphatic of the lingual vein flows into it, the 2 vessels often having a short common trunk before uniting with the main vessel. The lymphatic from the inferior maxilla is formed by the union of 2 branches. One arises from a foramen on the inner side of the ramus, close to its junction with the body (Baum (8) considers that this arises from the body itself), and this runs backwards on the medial surface of the ramus. About the middle of the ramus, it receives the second vessel which passes out of a large foramen on the medial

surface of the ramus. The lymphatic then runs backwards over the lateral wall of the pharynx, being joined by several fine branches from the skin of the intermaxillary space, and terminates in the manner already described. This vessel exhibits a regular, well defined plexus close to its termination which may possibly represent the submaxillary lymphatic glands of the mammal. Baum (8) states that this plexus lies just behind the inferior maxilla, but its position seems to be considerably further forward.

(3). A lymphatic vessel, which is frequently double, arises on each side of the middle line from the hard palate, and runs backwards under the mucous membrane of the pharynx where it is joined by branches arising from the posterior part of the nasal chamber and from the pharynx itself. The main vessel then curves outwards over the lateral wall of the pharynx to join the lymphatic of the anterior cephalic vein, immediately before it leaves the cover of the genio-hyoideus muscle. Baum's (8) statement that the lymphatics from the nasal chamber join the vessels following the jugular vein is not strictly correct, since vessels from the anterior part of the nasal chamber follow the cutaneous facial vein, and vessels from the posterior part of the chamber join the lymphatics of the anterior cephalic vein. Eventually, of course, they do join the vessels following the jugular vein.

(4). Close to the point where the preceding lymphatic enters the main trunk the latter receives a short vessel draining the lower third of the genio-hyoideus muscle.

(5). When the main vessel has left the cover of the genio-hyoideus muscle and lies on the commencement of the neck, it is joined by a lymphatic arising from the middle of that muscle, which drains the

middle and upper thirds of the muscle, and which runs downwards and backwards to reach the main vessel.

(6). A little later, the main trunk receives a lymphatic which drains the larynx and the commencement of the trachea and oesophagus. This arises as several small plexiform branches in the wall of the early part of the oesophagus which unite with one another. The resulting trunk runs downwards and forwards to reach the lateral face of the commencement of the trachea, where it receives branches from this part of the trachea and from the larynx. It then curves upwards and forwards to unite with the main vessel of the anterior cephalic vein. (Fig.3). It should be noted that the lymphatics draining the 2 sides of the larynx appear to anastomose with one another on the lower face of the larynx.

(7). Joining the main trunk at the same point as the preceding vessel is a trunk which follows the transverse vein and connects the vessel of the anterior cephalic vein with the same lymphatic of the opposite side of the body. It runs between the oesophagus below and the rectus capitis anticus minor and flexor capitis inferior muscles above. This lymphatic is nearly always doubled and possesses on its course a wide plexiform network which surrounds the vein. The vessel and the vein which it follows are not strictly transverse, but run obliquely downwards from the left side to the right. (It is after this transverse anastomosis has occurred that the discrepancy in size between the right and left anterior cephalic and jugular veins is visible). The plexus on the lymphatic following the transverse vein receives branches, on either side of the middle line, from the bones which form the floor of the cranium. It is possible that the plexus represents the pharyngeal

(retropharyngeal) lymphatic glands of the mammal, lying as it does above the dorsal wall of the pharynx. The transverse lymphatic vessel is responsible for the phenomenon, which has been frequently observed when injecting the lymphatics of the head, and which is noted by Baum (8), of a puncture into one side of the head producing an injection of the vessel following the jugular vein on both sides or on the opposite side of the neck.
(8). The last tributary of the main vessel joins it close to its union with the lymphatic following the posterior cephalic vein. This is a cutaneous branch which drains the skin of the inter-maxillary space and the skin on the outer surface of the inferior maxilla posterior to the attachment of the wattle. It passes backwards on the deep face of the skin and, reaching the larynx, it curves upwards over its lateral face to reach the main lymphatic.

Lymphatics of the posterior cephalic vein.(Fig.1.) Several small vessels arise from the bones forming the roof of the cranium and these unite to form one lymphatic, which is sometimes double and follows the vena cephalica posterior. This lymphatic runs backwards, through the rectus capitis posticus major and complexus muscles, to appear superficially behind the genio-hyoideus muscle about the middle of the muscle. It then runs downwards and backwards to unite with the vessel following the anterior cephalic vein, the resulting trunk following the course of the jugular vein.

It can now be seen that all the lymphatic vessels which drain the tissues of the head eventually unite with one another to form a vessel or vessels which follow the jugular vein on each side

of the neck.

The foregoing description augments to a considerable degree the account given by Baum (8), who, in most cases, confines himself to the statement that the lymphatics of the different tissues of the head run to join the lymphatics of the jugular vein, without describing the course of these vessels or the way in which they unite with one another.

Lymphatics following the jugular vein. (Figs. 1, 2, 3, and 7).

A fairly large vessel follows the jugular vein and it is frequently double inits course. However, there may only be a single vessel throughout the neck with occasional sections which are double. In any case, the vessel nearly always becomes single just before its termination. Where 2 trunks are present, they are joined to one another by frequent transverse and oblique anastomosing branches, and lie dorsal and ventral or ventro-medial to the vein. This agrees with the statements of Owen (55) and Baum (8). It may be noted here that Jolly (39) considers that the lymphatics lie lateral and medial to the vein. Where a single lymphatic is present, it seems to lie most commonly on the dorsal wall of the jugular vein, but this is not constant. The right jugular vein of the fowl has a considerably greater calibre than the left, and Baum (8) states that the lymphatics on the right side appear to be wider than those on the left side. The author cannot agree with this since, in all subjects examined, no difference in size between the lymphatics of the right and the left sides could be distinguished.

The lymphatic (or lymphatics) following the jugular vein continues the course of the vessel of the anterior cephalic vein,

and the course of the vessel has slightly different relations on the right and left sides. On the right side, the lymphatic runs with the vein along the dorsal surface of the oesophagus, lying between that organ and the musculature of the neck. In the upper part of the neck it lies on the rectus capitis anticus minor and rectus capitis lateralis muscles, but at the junction of the upper and middle thirds of the neck it comes to lie on the intertransversales colli muscles. It passes down the neck on these muscles, between them and the dorsal wall of the oesophagus. Anterior to the shoulder region the vessel lies in relation to the dorsal wall of the crop. The lymphatic runs on to the medial face of the shoulder joint, diverging downwards slightly to lie on the lateral surface of the upper part of the crop. It is covered laterally by the clavicle at first, later by the interclavicular aponeurosis, and it then passes between the cervical air sac and the crop to enter the thorax. Inside the thorax, it lies on the lateral aspect of the thoracic part of the oesophagus and terminates by uniting with the right jugular vein immediately before the vein joins the subclavian vein to form the anterior vena cava. In the lower third of the neck the lymphatic is mainly concealed by the lobules of the thymus gland.

On the left side, the lymphatic vessel following the jugular vein lies on the dorso-lateral aspect of the trachea, between it and the cervical muscles. Having passed over the rectus capitis anticus minor muscle, it immediately comes to lie on the inter-transversales colli muscles, and lies on these muscles as far as the region of the shoulder joint. It will be seen from this statement that the lymphatics of the left side are placed rather

nearer to the inferior border of the neck than those of the right side. Just before it reaches the shoulder region, the vessel diverges upwards slightly from the trachea to lie on the inter-transversales colli muscles. The remainder of its course is similar to that of the vessel on the right side. The lymphatic following the left jugular vein is usually covered by thymus lobes, which, of course, persist throughout life, in the lower half of the neck. It appears to be the usual arrangement for the right trunk to be covered by thymus lobes in the lower third of the neck, while the left trunk is covered in the lower half of the neck.

The usual point of termination of the lymphatic of the jugular vein is the one which has been described, namely, in the jugular vein close to its junction with the subclavian vein, but occasionally the opening may be more anteriorly placed. In any case it is always considerably behind the point where the vertebral vein joins the jugular vein. Baum's (8) statement that it may join the jugular or vertebral veins cranial to their union with one another has not been substantiated in any of the subjects examined.

As stated, if 2 vessels are present following the vein, they usually unite before their termination, but if they remain separate from one another, their junctions with the vein are close together.

Tributary branches.

Numerous branches join the lymphatic following the jugular vein, some of which occur on both sides of the neck, and some of which are only present on one side. The former will be described first.

(1). Vessels draining the skin of the neck join the main lymphatic trunk at regular intervals in its course down the neck. Baum (8)

states that 2 or 3 vessels are present draining the skin of the dorsal part of the neck and 2 or 3 draining the skin in the ventral part, but, during the present study, 4 or 5 lymphatics have been found to occur most frequently in each case. Each vessel arises as several distinct branches which then unite with one another, and duplication of these trunks is relatively infrequent. The lymphatics from the dorsal part of the neck drain the skin over the cervical muscles, i.e. the skin dorsal and posterior to the jugular vein, while those from the ventral part of the neck drain the skin over the trachea and, on the right side, the oesophagus,i.e. the skin ventral and anterior to the jugular vein. As in the case of all cutaneous lymphatics these vessels remain on the deep face of the skin throughout most of their course, and the ventral lymphatics usually join the corresponding dorsal lymphatics close to their termination. If they do not form a short common trunk, they join the main vessel at approximately the same point. The most posterior dorsal branch drains the skin directly above the dorsal wall of the crop, and the corresponding ventral branch drains the skin just anterior to the region of the crop. Where these cutaneous lymphatics lie in relation to the lobes of the thymus gland, they pass over the outer surface of the lobes and dip between adjacent lobes to reach the main vessel.

In addition to these lymphatics, there is a vessel which drains the skin over the shoulder joint, particularly the pad of fibro-fatty tissue which lies dorsal to the joint. The vessel runs downwards and forwards in front of the shoulder region, receiving a branch from the skin lying over the longus colli posticus muscle in this area, and joins the main trunk anterior to the shoulder.

(2). Also joining the main vessel at regular intervals in its course ~~down the neck~~ are 7 or 8 lymphatics on each side of the neck, which drain the muscles on the lateral and inferior aspects of the neck. 7 appears to be the usual number. Each vessel arises from the muscles in the area of an intervertebral articulation, and passes between the longus colli anticus and intertransversales colli muscles to reach the main vessel. The first arises between the 4th and 5th cervical vertebrae and pierces the rectus capitis anticus minor muscle to gain the main trunk, and the last usually arises between the 10th and 11th cervical vertebrae. (Fig.2.) Baum (8) only mentions 2 of these vessels.

(3). Small lymphatics, which can only be injected with difficulty, arise from the lobes of the thymus gland, 1 or 2 vessels arising from each lobe. They emerge from the deep faces of the lobes, which are closely applied to the underlying jugular vein and its lymphatic trunk, and the vessels join the main lymphatic trunk after a very short course.

(4). Before the main vessel passes deep to the clavicle and the interclavicular aponeurosis, it is joined by 2 vessels (or a common trunk of the 2 vessels) which arise as numerous branches from the skin lying over the wall of the crop, and unite with the main trunk at the same point as the branch from the skin over the shoulder joint.

(5). Immediately after the main trunk has passed deep to the clavicle and the interclavicular aponeurosis it is joined by a vessel which drains the muscles at the proximal extremity of the humerus and the shoulder joint. This lymphatic arises as numerous small branches from the deltoid, scapulo-humeralis, tensor

patagii brevis and the upper end of the triceps muscles. These unite to form a common trunk which lies at first on the outer aspect of the upper extremity of the humerus, following the course of a small vein. It passes under the anterior edge of the deltoid muscle, lying at first between this muscle and the humerus, and it is joined here by a lymphatic which emerges from a nutrient foramen on the upper crest (external tuberosity) of the humerus. Later, it runs vertically upwards to cross the outer surface and upper edge of the scapula close behind the glenoid cavity, and then curves downwards to reach the medial aspect of the shoulder joint, where it is joined by a branch from the upper end of the clavicle and by a vessel arising from the shoulder joint. It lies posterior to the latter vessel before receiving it, and the combined lymphatic runs downwards to unite with the main trunk following the jugular vein (Figs.6 and 7.) Baum (8) makes no mention of these vessels.

(6). In the same area the main lymphatic receives a branch, which is rarely double, and which follows the subscapular vein. (Kaupp (43) states in one section of his book that the subscapular vein joins the jugular vein and in another that it joins the vertebral vein. In all the subjects encountered it joined the jugular vein.) This vessel drains all the muscles of the scapular region, with the exception of the latissimus dorsi, teres et infraspinatus and supraspinatus muscles. It runs downwards and forwards on the deep face of the subscapularis muscle, being joined by a branch from the anterior half of the scapula, to reach the medial face of the shoulder joint where it unites with the main vessel.(Fig 7).

(7). At the same point, the main trunk receives a short vessel arising from the thyroid gland.

(8). Later, opposite the 11th. cervical vertebra, the main vessel is joined by a lymphatic which follows the vertebral vein. (Fig.2). This received branches from all the cervical vertebrae and from the muscles lying dorsal and lateral to the vertebrae. (Baum (8) states that branches which join the vessels of the vertebral vein only arise from the muscles in the lower third of the neck and from the vertebrae in the lower three-fourths of the neck). The vessel formed by these branches runs down the neck through the chain of vertebral foramina and, having passed through the foramen in the 10th. vertebra, it diverges outwards between the scalenus medius and longus colli anticus muscles to join the main trunk posterior to the thyroid gland. Before it joins the main vessel, it receives a branch from the muscles which lie above the more anterior dorsal vertebrae (longus colli posticus, biventer cervicis and longissimus dorsi). This branch also drains the last few cervical vertebrae.

(9). Close behind the junction of the lymphatics of the jugular and vertebral veins, the vessel following the jugular vein receives a small lymphatic which follows the common carotid artery. (Fig.2). Although Baum (8) states that this drains the muscles of the middle third of the neck and the vertebrae in the whole of the neck, it appears, according to the present study, only to drain the muscles of the lateral and inferior surfaces of the neck, and the vertebrae, in the lower three-fourths of the neck. The vessel runs down the neck in company with the common carotid artery of its own side, lying on the lower face of the chain of vertebrae, deep to the longus colli anticus muscle. At the 9th. cervical vertebra it

becomes superficially placed, diverging outwards from its fellow, and runs downwards and backwards to join the main vessel.

The remaining tributaries drain the oesophagus, the crop and the trachea and their arrangement is different on the right and the left sides of the neck.

(10). In its course down the neck the main trunk following the right jugular vein is joined by about 10 fine lymphatics which arise at regular intervals from the cervical part of the oesophagus, excluding the commencement of that organ, which, as stated, is drained on each side by a lymphatic which flows into the vessel of the anterior cephalic vein. The branches may arise from small plexuses in the wall of the oesophagus, and they primarily drain the upper and right surfaces. They have a short course and join the main vessel independently of one another.(Fig.3)

(11). Anterior to the region of the shoulder joint and deep to the clavicle, the main trunk of the right jugular vein receives 5 or 6 lymphatics from the right surface of the wall of the crop. Again, although they are small, plexuses do occur in the wall of this organ. The lymphatics run upwards on the right surface of the crop to join the main vessel of the right side independently of one another. In no subject did these vessels form a common trunk before uniting with the main lymphatic, an arrangement described as typical by Baum (8). The most posterior of these 5 or 6 branches is joined close to its termination, by a vessel which is a result of the union of several branches from the anterior and middle thirds of the thoracic part of the oesophagus, but this latter may flow independently into the vessel of the jugular vein. (Fig.3.)

(12). On the left side the main vessel is joined, anterior to the thyroid gland, by a large lymphatic which is responsible for the drainage of part of the cervical section of the oesophagus, the left surface of the crop and the whole of the trachea, with the exception of its commencement. (Figs.3. and 13.). This vessel arises as several small branches draining the ventral part of the anterior extremity of the oesophagus, just behind its commencement. These branches unite to form a trunk, which is rarely double, and which runs along the inferior wall of the oesophagus in company with a vein. In its course down the neck it receives numerous branches from the ventral and left surfaces of the oesophagus, which join it independently and at regular intervals. Reaching the crop, the lymphatic trunk runs across the upper part of its left surface and receives 5 or 6 branches from this surface of the wall of the crop, which are similar to those on the right surface. At the posterior extremity of the crop the vessel diverges towards the left side, crossing the middle line by passing between the trachea below and the longus colli anticus muscle above, and reaches the main vessel of the left jugular vein, as stated, just in front of the thyroid gland. Immediately it has passed above the trachea, this branch is joined by a lymphatic which drains the trachea. Branches arising from the early part of the trachea, just behind its commencement, unite to form 2 distinct vessels, one running along the dorsal aspect of the trachea and the other running along its ventral aspect. The dorsal vessel receives branches from the dorsal and right surfaces on the trachea, and the ventral vessel is joined by branches from the ventral and left surfaces. These branches emerge from the tissue between the

tracheal rings. At the posterior extremity of the crop, the vessel lying on the dorsal surface curves downwards over the right surface of the trachea to join the vessel lying on the ventral surface. The combined vessel then curves towards the left side, across the ventral surface of the trachea, receiving, soon after it has been formed, a branch which drains the terminal part of the trachea and the early parts of the bronchi, and it then unites with the trunk which drains the oesophagus and the left surface of the crop.

This description differs considerably from that given by Baum (8), the most obvious difference being that Baum states that the vessels of the left side of the crop form a common trunk which joins the lymphatic of the right jugular vein, and that the branches draining the trachea form a vessel which leaves the middle of the trachea to join the right jugular vein. Baum may have injected a very small vein which does arise from the middle of the trachea, but this always joins a vein following the inferior surface of the oesphagus and not the right jugular vein.

It will now be seen that all the lymphatics which drain the tissues of the head and neck and parts of the shoulder region eventually join the vessels following the jugular veins, which end by uniting with the jugular veins close to the point at which the vein joins the subclavian vein.

THE LYMPHATICS OF THE FORELIMB. Under this heading are included the lymphatics draining the pectoral region and part of the shoulder region. In the manus and forearm the main lymphatic trunks follow the profunda ulnaris, profunda radialis and basilic

veins, while in the arm they follow the basilic, brachial and profunda humeri veins. Ultimately all the vessels unite to form a trunk which follows the subclavian vein. Although Kaupp (43) considers that the formation of the subclavian vein is a result of the confluence of the brachial, basilic, external thoracic, coracoid and sternal veins, it appears to be more convenient, and more accurate, to describe the brachial and basilic veins joining to form the subclavian vein, which then receives the remaining veins as tributary branches. In addition, the profunda ulnaris and the profunda radialis veins usually appear to join the basilic vein rather than the brachial vein, but the brachial and basilic veins are often united by anastomosing branches in the same area.

Lymphatics following the profunda ulnaris vein. (Figs.5. and 6.)

The main lymphatic trunk following this vein is usually double and commences on the outer surface of the manus as several small branches which drain the skin of the 3rd. digit. These join one another to form a vessel which runs upwards on the outer face of this digit and crosses the metacarpo-phalangeal articulation of the digit. It then passes across the anterior edge of the distal extremity of the 3rd. metacarpal bone and dips between the interosseous dorsalis and interosseous palmaris muscles, thus lying in the space between the 2nd. and 3rd. metacarpal bones. Running vertically upwards, it pierces the upper end of the interosseous palmaris muscle and becomes superficially placed on the inner aspect of the manus. Almost immediately it passes deep to the ligamentous band which connects the anterior border of the carpal region with the back of the 3rd. metacarpal bone, and in this area passes over the tendon of the flexor carpi ulnaris muscle.

On emerging from the cover of the ligamentous band, it crosses the carpal joint and runs straight up the forearm, following the anterior border of the flexor carpi ulnaris muscle. In its course it lies at first on the flexor digitorum profundus muscle, and later on the pronator longus muscle. It ends just above the elbow joint, anterior to the origin of the flexor carpi ulnaris muscle, by uniting with the lymphatic which follows the basilic vein.

Tributary branches.

(1). Close to its commencement, the main vessel is joined by a branch which emerges from the outer surface of the phalanx of the 3rd. digit.

(2). A little later, after the vessel has passed over the metacarpo-phalangeal articulation, it receives a lymphatic which arises from this joint, and

(3). at the same point a cutaneous branch from the skin of the posterior part of the 2nd digit also unites with the main trunk.

(4). In the region where the main lymphatic is dipping beneath the posterior edge of the interosseous dorsalis muscle, it receives 2 small tributaries which drain the distal ends of the 2nd. and 3rd. metacarpal bones, the branch from the 2nd. metacarpal running upwards and backwards, and that from the 3rd. metacarpal running upwards and forwards, to reach the main trunk.

(5). A fine vessel arises from the interosseous dorsalis muscle which unites with the main vessel as it lies between this muscle and the interosseous palmaris muscle, and a branch which drains part of the lattermuscle joins the vessel at the point at which it pierces the muscle.

(6). 2 cutaneous lymphatics from the skin on the inner aspect of

the 2nd. digit join the main trunk when it has perforated the interosseous palmaris muscle.

(7). When the main vessel is lying deep to the ligamentous band connecting the carpus with the 3rd. metacarpal bone, it receives a vessel which emerges from the region of fusion of the proximal extremities of the original 1st. and 2nd. metacarpal bones, and a second vessel from the proximal extremity of the original 3rd. metacarpal bone.

(8). A lymphatic arises from each carpal bone and the 2 branches unite to form a trunk which runs distally to join the main vessel before it leaves the cover of the ligamentous band.

(9). When it has left the cover of this ligamentous band, the main trunk is joined by a lymphatic which drains the skin on the inner side of the 1st. digit, the phalanx of the 1st. digit and the metacarpo-phalangeal joint of this digit. This branch runs deep to the ligamentous band to reach the main vessel.

(10). The main trunk is now lying, with the profunda ulnaris vein, on the medial surface of the carpal joint, and is connected to the lymphatic of the basilic vein in this region by an anastomatic branch.

(11). A little later, a vessel which arises from the carpal joint flows into the main lymphatic.

(12). At about the same point, the vessel receives a branch from the skin lying over the anterior part of the distal third of the forearm on its medial surface, and

(13). a lymphatic which arises from the medial aspect of the lower end of the ulna.

(14). In its course up the forearm, the vessel is joined by 2 lymphatics draining the skin which lies anterior to it on the

medial surface of the upper and lower thirds of the forearm. (The middle third is drained by the lymphatic of the flight membrane). (15). Also in its course up the forearm, the main trunk receives tributaries from the flexor carpi ulnaris and the underlying muscles which lie behind the vessel, and from the flexor digitorum profundus and the 2 pronator muscles which lie in front of it.

Lymphatics following the profunda radialis vein.(Figs.5, 5A, 6, and 6A.)

The lymphatic which follows this vein may be considered to arise as a small vessel which emerges from a nutrient foramen on the medial surface of the lower end of the radius. This vessel runs up the forearm, lying between the radius and the flexor digitorum profundus muscle on the medial aspect of the limb in the early part of its course. Later it passes deep to the pronator longus muscle and runs up the remainder of the forearm in this position. At the upper edge of the pronator longus muscle., i.e. distal to the elbow joint, it comes to lie superficially on the inner side of the limb by curving between the pronator brevis and extensor metacarpi radialis longior muscles. It then runs vertically upwards, anterior to the elbow joint, and, crossing the medial surface of the tendon of insertion of the biceps muscle, it ends by joining the vessel which follows the basilic vein, some distance proximal to the elbow joint.

Tributary branches.

(1). About the middle of the shaft of the radius, a branch emerges from the large medullary foramen of the bone and this joins the lymphatic of the profunda radialis vein after a very short course.

(2). In the same region, a similar branch arising from the medullary foramen of the ulna also joins the main trunk.

(3). In the upper third of the forearm the lymphatic receives branches from the pronator brevis, pronator longus, supinator brevis and extensor metacarpi radialis longior muscles. These branches may form a common trunk. (Fig. 5A).

(4). The next vessel joins the main trunk at the upper edge of the pronator longus muscle and drains the skin and some of the muscles on the outer side of the forearm. (Fig.6. and 6A.) It commences as numerous branches which arise from the skin lying on the outer aspect of the forearm. These unite to form a single vessel which passes upwards on the extensor digitorum communis muscle, and which becomes deeply placed just below the elbow by curving around the anterior edge of this muscle, between it and the supinator brevis muscle. At this point it receives branches from the extensor digitorum communis and flexor metacarpi radialis muscles, which may form a common trunk. A little later the vessel passes between the shaft of the radius and the anterior edge of the anconeus muscle, where it is joined by a branch from this muscle and the supinator brevis muscle. In the same region a lymphatic is visible, which emerges from the outer aspect of the upper extremity of the radius, and runs distally to join the main tributary vessel. The latter then passes through the upper end of the radio-ulnar interosseous space to join the main vessel of the profunda radialis vein.

(5). A second lymphatic draining the proximal extremity of the radius passes out of its medial surface, and, running betweeen the pronator brevis and the extensor metacarpi radialis longior

muscles, it joins the main trunk following the radialis profunda vein immediately after the latter has left the cover of these 2 muscles.

(6). As soon as the main vessel has crossed the tendon of insertion of the biceps muscle it receives its last branch, which drains the skin and other tissues of the flight membrane. (Figs.5 and 6.) This is formed about the centre of the membrane, towards its free edge, by the union of 2 long vessels which drain the skin of its free edge. The more distal branch receives a lymphatic from the skin over the pronator brevis and extensor metacarpi radialis longior muscles in the middle of the forearm. The main lymphatic draining the flight membrane then runs directly backwards towards the elbow region, being joined by 1 or 2 further branches from the membrane, and passes between the tendon of insertion of the biceps muscle and the shaft of the humerous to join the vessel of the radialis profunda vein. Just before its termination, the lymphatic of the flight membrane is joined by a common trunk of 2 vessels arising from the distal extremity of the humerus. They both arise from the anterior surface of the bone, one passing around the inner surface of the origin of the brachialis anticus muscle, and the other passing around the upper edge of the origin of that muscle.

Lymphatics following the basilic vein.(Figs.5 and 6.)

The main lymphatic is frequently double and commences as several small branches which drain the skin on the anterior border of the outer aspect of the 2nd. digit. The vessel runs up the anterior border of this digit and, at the junction of the upper and middle thirds of the metacarpal region, it diverges backwards,

running across the outer surface of the interosseous dorsalis muscle, to reach the back of the carpal joint. The lymphatic turns around the back of the joint to gain the medial surface of the limb, on which it lies for the remainder of its course. In the forearm, it lies on the shaft of the ulna, along the posterior edge of the flexor carpi ulnaris muscle, being closely related to the follicles of the secondary feathers. Just distal to the elbow joint the vessel, still in company with the basilic vein, turns sharply forwards across the origins of the flexor carpi ulnaris and pronator brevis muscles, following the anterior edge of the inner surface of the triceps muscle. It runs along this edge of the triceps muscle as far as the middle of the arm, where it comes to lie on the medial surface of the muscle, behind the posterior edge of the biceps muscle. At the junction of the upper and middle thirds of the arm it curves backwards and, having reached the posterior border of the arm close to the upper edge of the pectoralis major muscle, it unites with the lymphatic of the brachial vein, the resulting vessel following the subclavian vein.

Tributary branches.

(1). Where the main trunk lies on the outer surface of the 2nd. digit, it receives several cutaneous branches, and also vessels which arise from the phalanges and the interphalangeal and metacarpo-phalangeal joints of this digit.

(2). About the middle of its course across the interosseous dorsalis muscle, the main vessel is joined by a lymphatic from the skin on the outer side of the 1st. digit, which receives a branch from the phalanx of this digit.

(3). A vessel, which is the result of the fusion of several

branches from the skin on the lateral surface of the metacarpal region, joins the main trunk at the posterior edge of the interosseous dorsalis muscle.

(4). At the point where the vessel following the basilic vein is curving around the posterior border of the carpal joint, it receives a branch which emerges from the outer surface of the lower end of the ulna.

(5). As soon as the main trunk has reached the inner surface of the limb in the region of the carpus, it is joined by a cutaneous vessel from the skin of the inner side of the 3rd. digit, which receives a lymphatic arising from the posterior part of the interosseous palmaris muscle. This common trunk runs deep to the ligamentous band which connects the carpus with the back of the 3rd. metacarpal bone.

(6). The vessel receives 2 or 3 lymphatics from the skin lying over the flexor carpi ulnaris muscle in its course up the forearm, and (7). it is joined by a small vessel from the follicle of each secondary feather.

(8). In its course up the forearm, a few branches from the flexor carpi ulnaris and the underlying muscles, which lie anterior to the vessel, unite with it.

(9). At the anterior edge of the origin of the flexor carpi ulnaris muscle, the vessel following the basilic vein is joined by the lymphatic of the profunda ulnaris vein.

(10). In the same area, a vessel arises from the inner surface of the upper end of the ulna and curves around the anterior edge of the origin of the flexor carpi ulnaris muscle to unite with the main trunk.

(11). A branch emerges from the inner surface of the elbow joint (Baum (8) considers that it arises from the flexor surface) and passes upwards and forwards, along the anterior border of the triceps muscle, to join the main vessel proximal to the lower extremity of the humerus.

(12). At the same point, the vessel receives a branch which drains the origin of the extensor metacarpi radialis longior muscle.

(13). A little later, the junction of the lymphatic following the profunda radialis vein is visible.

(14). The cutaneous lymphatics of the inner surface of the arm all unite with this main vessel, there being 3 or 4 vessels draining the skin over triceps muscle, which have independent terminations, and 3 or 4 draining the skin over the biceps muscle, which unite to form a common trunk.

(15). Close to its junction with the vessel following the brachial vein, the main trunk is joined by a lymphatic which is usually double and follows the profunda humeri vein. (Figs.6. and 6B.) This vessel commences as a small lymphatic emerging from the external surface (extensor surface, according to Baum (8)) of the elbow joint. It runs up the arm, lying at first along the anterior edge of the outer part of the triceps muscle, but later it runs deep to the triceps muscle, lying between it and the humerus, and here it is closely related to the brachialis longus superior nerve. About the middle of the arm, a lymphatic, which emerges from the medullary foramen of the humerus, runs upwards and outwards to join this vessel, and it is also joined in this region by branches from the triceps muscle. It then passes over the medial face of the tendon of insertion of the latissimus dorsi muscle and, just

above this tendon, it is joined by a common trunk of several vessels which drain the skin over the outer surface of the arm and the skin over the posterior part of the shoulder region. This common trunk dips between the triceps and deltoid muscles in the upper part of the arm to gain the vessel following the profunda humeri vein. The latter then passes medially between the long scapular head and the remainder of the triceps muscle, and after a short upward course, it joins the vessel following the basilic vein. Just before this junction, the vessel of the profunda humeri vein is joined by a lymphatic draining the latissimus dorsi, which runs along the posterior edge of that muscle after emerging from it.

Lymphatics following the brachial vein. (Fig.5). The main vessel which follows this vein is rarely double in its course, and is formed by the union of a few branches which emerge from the deep face of the lower end of the biceps muscle. The vessel lies between the deep face of the muscle and the anterior surface of the humerus, and it runs up the arm in this position. Distal to the proximal extremity of the humerus it curves upwards and backwards and, passing between the biceps and triceps muscles to become superficially placed on the inner surface of the arm, it joins the vessel following the basilic vein close to the upper edge of the pectoralis major muscle.

Tributary branches.

(1). Before it passes between the biceps and triceps muscles, this trunk receives a branch from the tensor patagii longus muscle

and the upper end of the biceps muscle.

(2). Close to its termination, it is joined by a vessel which is compounded of 2 branches, one arising from the posterior surface of the shoulder joint (the only lymphatic of the shoulder joint which is mentioned by Baum (8)), and the other emerging from the lower crest (internal tuberosity) of the humerus, anterior to its pneumatic fossa.

Lymphatics following the subclavian vein. (Figs. 4, 5, 7, and 7A.)

The lymphatic which results from the union of the trunks following the brachial and basilic veins follows the subclavian vein. It is formed close to the edge of the pectoralis major muscle and is frequently double in its course. Soon after its formation the vessel curves over this edge of the muscle, passing deep to it, and follows the anterior edge of the thoraco-scapularis muscle to enter the thoracic cavity. It runs downwards and backwards inside the thorax to end by uniting with the subclavian vein, close to the confluence of this vein and the jugular vein to form the anterior vena cava.

Tributary branches.

(1). Immediately after the main vessel has passed deep to the upper edge of the pectoralis major muscle, it receives a lymphatic following the vena cutanea abdomino-pectoralis and its branches. (Figs. 4, 7, and 7A.) This vessel drains the skin lying over the thorax, and commences as a result of the union of several small branches arising from the skin over the posterior part of the sternal crest. It runs upwards and forwards in the skin lying over the pectoralis major muscle, being joined, anterior to the knee joint, by 2 branches

which drain the skin over the anterior part of this joint. Continuing this course it receives several branches from the skin over the pectoralis major and derma-ulnaris muscles, and eventually gains the upper edge of the pectoralis major muscle. Here a common trunk of the numerous vessels from the skin lying over the latissimus dorsi and teres et infraspinatus muscles joins this lymphatic, and, at the same point, it receives a branch from the teres et infraspinatus muscle and the posterior half of the scapula, which runs along the posterior edge of the muscle after emerging from it. The vessel then curves over the upper edge of the pectoralis major muscle, dipping beneath it, posterior to the point at which the trunk following the subclavian vein passes beneath it, and it unites with the latter main trunk almost at once. At its termination, the vessel of the vena cutanea abdomino- pectoralis possesses a wide regular plexus on its course. This plexus envelopes the vein and it also envelopes part of the subclavian vein. It may possibly represent some of the axillary lymphatic glands of the mammal.

(2). Later, the trunk following the subclavian vein is joined by a lymphatic following the external thoracic vein. (Figs.7 and 7A.) (Kaupp (43) considers that the vena cutanea abdomino-pectoralis and the external thoracic vein form a common trunk, the external pectoral vein, but in all the subjects examined their junctions with the subclavian vein were distinct from one another.) The vessel of the external thoracic vein is formed by the junction of 2 branches which drain the larger part of the pectoral muscles. The posterior lymphatic originates from the posterior parts of the pectoralis major and secundus muscles, and runs through the substance

of these muscles. In its course it receives three branches which originate from the sternum. One branch emerges from the outer surface of the body of the sternum and runs upwards and forwards between the sternum on the one hand and the pectoralis secundus and tertius muscles on the other. It drains the body, the costal process and the adjacent part of the sternal crest. A second vessel emerges from the middle of the sternal crest and this drains the metasternum and most of the sternal crest. The third vessel drains the postero-lateral process of the sternum, and emerges from it at the point where it is dividing into its 2 branches. The anterior lymphatic branch of the vessel following the external thoracic vein drains the anterior parts of the pectoralis major and secundus muscles and the whole of the pectoralis tertius muscle. At the point where the 2 lymphatic vessels unite, an extensive plexus is formed, which is situated mainly on the anterior branch, and this may represent some of the axillary lymphatic glands of the mammal. From this plexus a short lymphatic trunk arises, which is usually double and which joins the trunk following the subclavian vein.

(3). The next branch to unite with the main trunk is a lymphatic following the coracoid vein. (Fig.7A.) A branch arising from the inner side of the shoulder joint unites with a branch which emerges from the outer surface of the upper end of the coracoid bone, and the resulting vessel runs backwards for a short distance on the upper edge of this bone. It is joined by branches from the coraco-brachialis muscle, and then turns upwards and backwards to flow into the main trunk following the subclavian vein.

(4). The last tributary is a lymphatic following the sternal vein. (Fig.7A). Several vessels which drain the antero-inferior parts of

the pectoralis major and secundus muscles unite to form one trunk in the substance of the latter muscle. This trunk passes upwards through the muscle, receiving branches from the anterior part of the sternal crest and the hypocledium of the 2 clavicles. It then runs deep to the inferior border of the coracoid at its lower end to gain its medial surface, and here it is joined by a vessel from the sterno-coracoid articulation and the lower end of the inner surface of the coracoid. A little later, a lymphatic which emerges from a nutrient foramen on the dorsal surface of the body of the sternum, just behind the pneumatic foramen, unites with the trunk following the sternal vein. The latter then runs vertically upwards to unite with the lymphatic of the subclavian vein close to the termination of the latter.

Thus, all the lymphatics of the forelimb and the region of the thoracic wall unite directly or indirectly with a vessel (or vessels) following the subclavian vein, and this vessel joins the venous system by uniting with the subclavian vein close to its termination.

This description of the vessels of the forelimb includes numerous lymphatics from the various tissues which are not given in Baum's (8) statement. Baum's description of the lymphatics in this region is rather incomplete since, in most cases, he merely states that the vessels join the "Vasa Lymphacea axillaria". This term is used with reference to the lymphatics following the brachial and basilic veins and the vena cutanea abdomino-pectoralis, a fact which renders parts of Baum's statement very difficult to follow.

THE LYMPHATICS OF THE HINDLIMB. A large vessel which is often double and follows the popliteal vein and, later, the external iliac vein, is the trunk which receives most of the lymph from the hindlimb, but some of the lymphatics follow the ischiadic vein. The skin over the upper part of the thigh is drained by vessels which will be described in connection with the lymphatics of the trunk. Some of the lymphatics of the hindlimb also drain the skin of the abdominal wall.

In the region of the pes, the main lymphatics follow the external metatarsal, internal metatarsal and deep dorsal metatarsal veins. These receive the lymphatic vessels which run along the lateral and medial surfaces of the digits, draining the tissues of the digits. The courses of these latter vessels are similar in all digits, so a description common to all these vessels will be given first, and then the drainage of the lymphatics by the trunks following the 3 metatarsal veins will be indicated.

Lymphatics of the digits. (Figs.8 and 9.) The terminal phalanx of each digit is drained by 2 small lymphatics, one on its lateral surface and the other on its medial surface. Each vessel passes along its own surface of the digit, being joined at each inter-phalangeal joint by a trunk which drains the joint and the proximal end of the more distal of the 2 phalanges. The vessels from these structures may have independent openings into the main trunks, and they may be absent on the lateral surface of the digit in the case of a few of the joints and phalanges. The trunk also receives small branches from the skin. With the exception of the vessels of the 1st. digit, each is joined, close to the metatarso-phalangeal joint, by a large branch from the skin and fibrous tissue of the

main central digital pad, and, a little later, in all the digits by a tributary from the metatarso-phalangeal joint and the proximal end of the 1st. phalanx. The vessels of the 1st. digit also receive lymphatics from the intermetatarsal joint and the proximal end of the 1st. metatarsal bone.

From this point the courses of the digital lymphatics differ from one another, and will be described separately. (It is assumed in this description that the 1st. digit is directed backwards in its normal position.) The lymphatic of the deep dorsal metatarsal vein drains the vessels of the lateral face of the 2nd. digit and the medial face of the 3rd., the lymphatic of the external metatarsal vein drains the vessel of the lateral face of the 4th. digit, and the lymphatic of the internal metatarsal vein drains the vessels of the medial face of the 1st. digit and the medial face of the 2nd. The vessel of the lateral face of the 1st. digit joins an anastomatic branch between the lymphatics of the external and internal metatarsal veins, and the vessels of the medial face of the 4th. digit and the lateral face of the 3rd. are drained by a branch of the vessel following the deep dorsal metatarsal vein.

Lymphatics following the deep dorsal metatarsal vein.(Figs.9 and 10). The main vessel following this vein is formed by the union of the lymphatics of the lateral face of the 2nd. digit and the medial face of the 3rd. digit at the point at which these digits are continuous with one another. It runs upwards and inwards, beneath the division of the tendon of the extensor digitorum longus muscle which passes to the 2nd. digit, to reach the medial edge of this tendon, along which it runs. At the junction of the middle and lower thirds

of the metatarsus it diverges outwards to run deep to the extensor digitorum longus tendon, lying on the anterior surface of the bone, and maintains this position for the rest of its course up the metatarsal region. At the front of the intertarsal joint (tibio-metatarsal joint) it becomes more superficially placed by coming to lie between the extensor digitorum longus and tibialis anticus tendons, close to the insertion of the latter. At this point the vessel divides into 2 branches, one following the anterior tibial vein, with which it will be described, and the other running upwards and outwards over the tendon of the extensor digitorum communis muscle to unite with the vessel which follows the internal metatarsal vein.

Tributary branches.

(1). In its course it usually receives 2 fine branches from the skin lying on the anterior aspect of the metatarsus.

(2). As soon as the vessel has passed under the tendon of the extensor digitorum longus muscle at the lower end of the metatarsus, it is joined to the lymphatic following the internal metatarsal vein by an anastomatic branch, which runs upwards and backwards to join the latter vessel close to its formation.

(3). At about the same point it receives a branch which drains the lower end of the metatarsal bone, and emerges from a nutrient foramen above the space between the trochleae for the 2nd. and 3rd. digits.

(4). At the middle of the metatarsus, the main lymphatic is joined by another anastomatic branch to the vessel following the internal metatarsal vein. This branch follows the vena metatarsalis dorsalis interna and has a curved course, with the convexity of the curve directed downwards.

(5). Some fine branches arise from the muscles on the anterior aspect of the upper third of the metatarsal bone, and these join the main trunk almost at once.

(6). In the same area, the lymphatic is joined by a vessel which receives the lymphatics of the lateral aspect of the 3rd. digit and the medial aspect of the 4th. digit. It runs up the metatarsus deep to the tendon of the extensor digitorum longus muscle.(Fig.8).

(7). At the upper extremity of the metatarsal bone, it is joined by a tributary which emerges from a nutrient foramen in the bone, which lies just above the anterior opening of the canal which runs through its upper extremity.

(8). A lymphatic vessel which runs through the canal in the upper extremity of the metatarsal bone, and which is considered by Baum (8) to be present in all cases, is, according to the subjects examined, only rarely encountered. When it is present, the lymphatic connects the vessel following the deep dorsal metatarsal vein with that following the external metatarsal vein by passing in an antero-posterior direction through the canal, and curving upwards through the canal in the hypotarsus. It is always a very small vessel.

Lymphatics following the external metatarsal vein.(Figs.8 and 11.)

The main vessel commences on the outer aspect of the metatarsus as a direct continuation of the lymphatic which drains the lateral surface of the 4th digit. It is often double, and runs straight up the metatarsal region in the groove between the podothecal sheath surrounding the flexor tendons and the outer surface of the metatarsal bone. It crosses the intertarsal joint

by following the outer edge of the gastrocnemius tendon, and just above the joint, it passes between the gastrocnemius tendon and the underlying flexor muscles of the digit, running towards the inner side of the limb. It terminates by uniting with the vessel which follows the internal metatarsal vein, above the intertarsal joint, and the resulting vessel follows the posterior tibial vein.

Tributary branches.

(1). In its course it receives 2 or 3 fine branches which drain the skin lying over the outer surface of the metatarsus.

(2). A short distance above the trochlea for the 4th.digit, a branch, which drains the lower extremity of the metatarsal bone, and emerges from a nutrient foramen in the bone in this region, runs upwards to join the main vessel.

(3). In the same area, the trunk is joined by an anastomatic branch to the lymphatic of the internal metatarsal vein. This branch runs across the back of the podothecal sheath of the flexor tendons, being curved in its course, with the convexity of the curve directed downwards. It receives a branch from the central digital pad, and it also receives the lymphatic of the lateral surface of the 1st. digit.

(4). A small vessel emerges from a nutrient foramen on the external surface of the upper end of the metatarsal bone and unites with the main trunk.

(5). Above the intertarsal joint, before the main vessel passes beneath the gastrocnemius tendon, it receives a branch from the lateral surface of this joint.

(6). At the point at which the vessel is lying between the gastrocnemius tendon and the flexor muscles, it may be joined by

the connecting branch from the trunk following the deep dorsal metatarsal vein. As already stated this branch is rarely present, but when it occurs it runs through the canal in the upper end of the metatarsal bone, and through the canal in the hypotarsus, to reach the vessel following the external metatarsal vein.

Lymphatics following the internal metatarsal vein.(Figs.8, 9, 10 and 11).

The main vessel in this case is formed by the union of the lymphatics draining the medial surfaces of the 1st. and 2nd. digits. The vessel runs vertically upwards over the tendon of the extensor hallucis brevis to gain the groove between the podothecal sheath of the flexor tendons and the internal surface of the metatarsal bone. It preserves these relations in its course up the inner surface of the metatarsus as far as the upper extremity of the bone. It then passes upwards and forwards to cross the intertarsal joint on its anterior surface, where it lies close to the inner edge of the extensor digitorum longus tendon. Having crossed the joint, it inclines upwards and backwards across the lower end of the inner surface of the tibia, and dips beneath the inner edge of the gastrocnemius tendon. Between this tendon and the flexor muscles it unites with the main trunk following the external metatarsal vein. The lymphatic which results from this union follows the posterior tibial vein.

Tributary branches.

(1). In its course up the metatarsal region it is joined by 2 or 3 vessels from the skin lying over the inner and posterior surfaces of the metatarsus.

(2). Close to its formation, the main vessel is joined by a

lymphatic which connects it with the vessel following the deep dorsal metatarsal vein. This branch runs upwards and backwards on the inner surface of the limb.

(3). A little later, it is joined to the lymphatic of the external metatarsal vein by another anastomatic branch. As stated, this branch is curved, with the convexity of the curve directed downwards, and crosses the back of the podothecal sheath of the flexor muscles, receiving a branch from the central digital pad and the lymphatic of the lateral surface of the 1st. digit.

(4). About the middle of the metatarsal region, an anastomatic branch, which unites this trunk with the lymphatic following the deep dorsal vein and which lies with the internal dorsal metatarsal vein, flows into the main trunk.

(5). Above the intertarsal joint, it receives one of the 2 terminal branches of the vessel which follows the deep dorsal metatarsal vein, after this branch has crossed the tendon of the extensor digitorum longus muscle.

(6). A little later, it is joined by a small lymphatic which arises from the front of the intertarsal joint, medial to the tendon of the extensor digitorum longus muscle.

(7). At about the same point, a vessel, which arises from the tibia just above the inner attachment of the ligamentous band (ossified in the adult) retaining the tibialis anticus and extensor digitorum longus tendons at the lower end of the bone, joins the main vessel. This branch runs downwards and outwards in its course.

(8). When the lymphatic following the internal metatarsal vein is passing beneath the inner edge of the gastrocnemius tendon, it is joined by a branch from the upper extremity of the metatarsal bone.

This arises from the inner aspect of the bone and runs upwards along the inner edge of the podothecal sheath of the flexor tendons and along the inner edge of the gastrocnemius tendon.

As stated, the lymphatics which follow the external and internal metatarsal veins join one another to form a trunk which follows the posterior tibial vein, and one of the terminal branches of the vessel following the deep dorsal metatarsal vein accompanies the anterior tibial vein. In the leg, these lymphatics of the anterior and posterior tibial veins are the main trunks and eventually unite at the back of the knee joint to form a vessel which follows the popliteal vein.

Lymphatics following the anterior tibial vein.(Figs.10 and 11.)

The main vessel is nearly always double, the 2 trunks being joined to one another by numerous anastomatic branches. At its commencement it lies between the tendons of the extensor digitorum longus and tibialis anticus muscles, but it soon passes deep to the tendon of the latter muscle and runs with it through the ligamentous band on the anterior aspect of the lower extremity of the tibia. In its course up the leg it lies between the muscular belly of the tibialis anticus muscle and the shaft of the tibia. Below the proximal extremity of the tibia the trunk diverges outwards to reach the lower of the 2 tibio-fibular arches, through which it runs to gain the posterior aspect of the tibia. It unites with the vessel following the posterior tibial vein soon after passing through this lower tibio-fibular arch.

Tributary branches.

(1). Close to its commencement, it is joined by a vessel which

emerges from the anterior surface of the intertarsal joint between the tibialis anticus and extensor digitorum longus tendons.

(2). Later, it receives a branch which drains the lower extremity of the tibia. It emerges from a foramen which lies deep to the ligamentous band which retains the tibialis anticus and extensor digitorum longus tendons and runs upwards and outwards to reach the main vessel.

(3). Below the middle of the tibia, a cutaneous vessel flows into the main lymphatic. This drains the skin over the outer aspect of the intertarsal joint. It curves around the posterior edge of the peroneus longus muscle and passes upwards and forwards, between the tibialis anticus muscle and the tibia, to reach the main lymphatic. (Fig.8.)

(4). At the middle of the leg, a large branch draining the extensor digitorum longus muscle runs upwards and outwards to unite with the main lymphatic, and,

(5). a little later, a vessel, which drains the tibialis anticus and peroneus longus muscles, runs through the substance of these muscles to join the main trunk.

(6). As soon as the lymphatic following the anterior tibial vein has passed through the lower tibio-fibular arch, it receives a vessel which drains the distal extremity of the tibia. This arises from the inner surface of this extremity of the bone and runs upwards and outwards on the posterior surface of the tibia, between the flexor muscles and the bone. About the middle of the tibia, it reaches the posterior aspect of the interosseous ligament between the tibia and fibula. It is joined at this point by vessels draining the flexor muscles, and for the rest of its course it runs

up the posterior surface of the tibio-fibular interosseous ligement. It terminates by joining the main vessel soon after it has received a large branch which emerges from the medullary foramen of the tibia, just below the lower tibio-fibular arch.

(7). The last branch to join the main vessel is formed by the union of numerous lymphatics which arise from the upper ends of the peroneus longus, tibialis anticus, gastrocnemius (inner head) and extensor digitorum longus muscles. These branches unite to form a vessel which follows the peroneal vein and which is joined, close to the upper tibio-fibular arch, by a lymphatic draining the upper end of the tibia. The main tributary then runs through the upper tibio-fibular arch, receiving a branch from the fibula, and unites with the lymphatic following the anterior tibial vein, close to the junction of the latter with the lymphatic of the posterior tibial vein. In some cases it may join the vessel following the popliteal vein.

Lymphatics following the posterior tibial vein. (Fig.11). As stated, the main vessel following this vein commences between the gastrocnemius tendon and the flexor muscles, just above the intertarsal joint. It is usually double in its course and lies towards the medial side of the limb, between the soleus tendon behind and the flexor perforans digitorum profundus muscle in front. It maintains this relationship, under the cover of the inner head of the gastrocnemius muscle, throughout most of its course up the leg. Just below the upper end of the tibia, the lymphatic becomes more deeply placed and lies between the soleus muscle and the back of the tibia. At this point it unites with the trunk following the

anterior tibial vein.

Tributary branches.

(1). In its course this vessel receives branches at regular intervals from the muscles at the back of the tibia.

Lymphatics following the popliteal vein. (Figs. 9. 11 and 12.)

The main vessel, which is usually double, is formed just below the knee joint by the union of the lymphatics following the anterior and posterior tibial veins. At its commencement it lies on the lateral face of the soleus muscle. Running vertically upwards across this face of the muscle, it passes between the outer head of the gastrocnemius muscle on the one hand, and the inner and tibial heads of that muscle on the other. As it lies between these parts of the gastrocnemius muscle, at the back of the knee joint, it usually exhibits a large plexus on its course which may represent the popliteal lymphatic glands of the mammal. The vessel passes upwards between the semimembranosus muscle and the outer head of the gastrocnemius muscle, and thus comes to lie in the thigh. It runs up the thigh under the cover of the gluteus primus muscle, lying on the lateral surface of the semimembranosus muscle, and it is related anteriorly to the back of the femur and posteriorly to the biceps flexor cruris muscle. (It should be noted that Baum's (8) references to the muscles of this region, in his drawings and in his text, are not strictly accurate.) The lymphatic maintains this relationship until it reaches the lower edge of the insertion of the adductor magnus muscle. At this point it curves forwards with the popliteal vein, away from the ischiadic artery and nerve, and passes across the medial aspect of the femur, just below its articular head.

It lies for a short distance between the femur and the ambiens muscle, above the origin of the vastus internus muscle. Anterior to the femur, the lymphatic following the popliteal vein lies between the gluteus primus and the abdominal muscles, in front of the extensor femoris muscle. It runs upwards and forwards to pass between the lower edge of the gluteus minimus muscle and the abdominal wall, and at this point it unites with the lymphatic following the anterior femoral vein, forming a trunk which accompanies the external iliac vein. (Kaupp (43) states that the vena cutanea abdominalis femoralis, the anterior femoral vein and other veins have a common trunk, the vena cruralis, which joins the popliteal vein to form the external iliac vein. In all the subjects examined the veins had separate terminations, and it seems more accurate to describe the anterior femoral and popliteal veins uniting to form the external iliac vein.)

Tributary branches.

(1). Its first tributary may be the lymphatic which follows the peroneal vein, which drains the muscles at the supero-external part of the leg, the tibia and the fibula, but, as stated, this vessel usually joins the trunk following the anterior tibial vein.

(2). In the same area, the main vessel receives 2 branches which may possess a short common trunk and which drain the upper ends of the soleus and outer head of the gastrocnemius muscles.

(3). The next tributary originates as several branches which arise from the deep surface of the inner head of the gastrocnemius muscle. They form a common trunk which runs upwards and backwards along the posterior edge of the semimembranosus muscle. In its course this vessel receives branches from the semimembranosus and vastus internus

muscles, and a lymphatic which emerges from a nutrient foramen on the medial surface of the upper end of the tibia, deep to the gastrocnemius muscle. The tributary runs backwards to join the main vessel following the popliteal vein, at the point where it exhibits the large plexus on its course. Before it joins this plexus it occasionally receives a branch from the posterior surface of the knee joint.

(4). When the main vessel has passed between the semimembranosus and the outer head of the gastrocnemius muscles to lie in the thigh, it is joined by a tributary which drains the lower ends of the biceps flexor cruris and semitendinosus muscles.

(5). In the same region, the main trunk receives a large lymphatic which drains the lower ends of the gluteus primus and biceps flexor cruris muscles. In its course this branch is joined by a common trunk of lymphatics arising from the posterior surface of the knee joint and from the outer surface of the lower and of the femur. Baum (8) describes a lymphatic arising from the lateral surface of the joint, but this appears to occur only in isolated cases. When present it joins the vessel arising from the femur in this area.

(6). At the junction of the middle and lower thirds of the thigh, a cutaneous vessel unites with the main trunk. This commences as numerous branches draining the skin on the outer surface of the leg. These all run upwards towards the back of the knee joint where they unite to form a common trunk. This trunk receives branches from the skin on the inner side of the leg, the skin over the lower part of the abdominal wall and the skin over the postero-inferior part of the outer side of the thigh. The trunk then passes deeply between the gluteus primus and biceps flexor cruris muscles,

running upwards and forwards to join the main vessel following the popliteal vein. (Figs. 8 and 9.)

(7). In its course up the thigh, the main trunk receives branches at fairly regular intervals from the muscles which lie around it, i.e. the biceps flexor cruris, extensor femoris, semimembranosus and gluteus primus muscles.

(8). At the middle of the shaft of the femur a vessel arises from the medullary foramen on the posterior surface of the bone, and runs upwards and backwards to unite with the main lymphatic.

(9). Immediately below the lower edge of the adductor magnus muscle, a cutaneous vessel, which follows the vena cutanea abdominalis femoralis, unites with the main vessel. (Fig. 8. and 12). This commences as several branches which drain the skin of the lateral surface of the abdomen and the skin of the posterior part of the outer aspect of the thigh. These form a common trunk which is joined by some vessels from the abdominal muscles and passes between the semitendinosus and biceps flexor cruris muscles, running across the medial face of the latter muscle, just above the middle of the thigh. In its course it receives large branches from the semitendinosus and biceps flexor cruris muscles, and, at the anterior edge of the biceps, it curves upwards to gain the main trunk. The cutaneous parts of this tributary may be absent on one or both sides of the body, in which case the other cutaneous vessels of the abdomen and thigh have correspondingly longer and more extensive courses.

(10). At the same point, the main vessel receives a common trunk of branches draining the adductor and gluteus primus muscles.

(11). As it lies on the medial surface of the femur, the lymphatic following the popliteal vein is joined by a trunk which accompanies

the vena femoralis interna profunda. (Fig.9.) This branch is formed by the union of a vessel arising from the inner aspect of the knee joint and a vessel emerging from the inner surface of the lower end of the femur. It runs vertically upwards on the medial surface of the thigh, lying between the vastus internus and semimembranosus muscles, and it receives many branches from these muscles in its course. It joins the main vessel at the upper extremity of the vastus internus muscle.

(12). Close to the junction of the preceding vessel with the main lymphatic, the latter receives a tributary which drains the obturator externus, gemellus and adductor muscles, and which is joined by a branch emerging from the inner aspect of the upper end of the femur.

(13). At the lower edge of the gluteus minimus muscle, the last tributary joins the main trunk. This formed by the union of several branches from the gluteus primus, extensor femoris, sartorius and ambiens muscles, and it also receives some branches from the abdominal muscles.

Lymphatics following the anterior femoral vein.(Fig.12) The main lymphatic is formed by the confluence of numerous branches arising from the skin over the central and anterior parts of the outer side of the thigh. The trunk passes between the sartorius and gluteus primus muscles at the junction of the upper and middle thirds of the thigh, and runs upwards and backwards, deep to the gluteus primus muscle. It terminates by joining the lymphatic of the popliteal vein beneath the gluteus minimum muscle.

Tributary branches.

(1). In its course, deep to the gluteus primus muscle, it receives

1 or 2 branches from the sartorius muscle.

Lymphatics following the external iliac vein. (Fig.12). The main vessel formed by the union of the lymphatics following the popliteal and anterior femoral veins, continues the course of the former and runs upwards and forwards, deep to the gluteus minimus muscle. It is usually plexiform in its course. After a very short course it gains the lateral edge of the ilium, about its middle, and perforates the abdominal muscles to enter the abdominal cavity. Its course within the abdomen will be described in connection with the lymphatics of the trunk.

Tributary branches.

(1). At its formation, the lymphatic is joined by a branch compounded of vessels arising from the gluteus medius and minimus muscles and a lymphatic which arises from the anterior surface of the hip joint.

(2). Close to the point at which the vessel perforates the abdominal wall, it is joined by a lymphatic emerging from a nutrient foramen on the outer surface of the ilium, anterior to the cotyloid cavity.

Some of the tissues of the hindlimb are drained by a lymphatic trunk which follows the ischiadic vein.

Lymphatics following the ischiadic vein. The main vessel is formed by the junction of several branches from the obturator externus, gemellus and adductor muscles. It runs vertically upwards on the outer surfaces of the pubis and ischium to again the ischiadic foramen, through which it passes. Its course within the pelvis will be dealt with at a later stage. It is often double and may exhibit a large plexus on its course.

Tributary branches.

(1). When it is passing through the ischiadic foramen, it receives a branch which drains the pubis and ischium. This emerges from a small foramen posterior to the ischiadic foramen and runs forwards along the origin of the obturator externus muscle, deep to the biceps flexor cruris and semitendinosus muscles.

(2). In the same area, a common trunk of vessels arising from the back of the upper end of the femur and the posterior surface of the hip joint flows into the main vessel.

(3). As it lies in the ischiadic foramen, the trunk is joined by branches from the obturator internus muscle.

It will be seen from the foregoing statement that all the lymphatics of the hindlimb and some of the vessels from the abdominal wall are joined directly or indirectly to the vessels following the external iliac and ischiadic veins. As will be seen at a later stage, these latter trunks are eventually drained by the thoracic ducts.

The description of the lymphatics of the hindlimb, as with that of the vessels of the forelimb, includes many branches which are not found in Baum's (8) statement. Also, Baum states that the various branches join the "Vasa lymphacea ischiadica" without giving details of their courses, although it appears that the term "Vasa lymphacea ischiadica" is applied to the lymphatics of the popliteal and external iliac veins.

THE LYMPHATICS OF THE TRUNK. It has already been stated that in this work the term thoracic duct will only be applied to the vessels accompanying the aorta within the thorax, i.e. to the lymphatics

lying by the aorta after they have been joined by the vessels which follow the coeliac axis and the anterior mesenteric artery. This is an arbitary distinction since the vessels are not dilated to any extent within the thorax, but it seems preferable to Baum's (8) description of "lumbar" and"thoracic" thoracic ducts.

Plexuses are frequent and extensive on the course of the lymphatics draining most of the tissues of the abdominal and thoracic cavities and it seems likely that these plexuses represent some of the lymphatic glands of the abdominal and thoracic cavities of the mammal. The plexuses are rather irregular and are so extensive that they tend to merge with one another. As a result it is not considered possible to make any detailed suggestions as to the lymphatic glands which are represented by such plexuses. Plexuses occur in the wall of the different parts of the alimentary canal, and these appear to be quite as extensive and intricate in formation as in the mammal.

Within the abdominal cavity, the main lymphatic trunks (or trunk) follow the aorta and are formed by the union of vessels following the middle sacral and common pudendal arteries. As already stated, the lymphatics of the trunk primarily follow the arteries. Lymphatics following the middle sacral artery. (Fig.13). There are usually 2 vessels following this artery, one lymphatic being placed on each side of the artery, and these vessels are joined to one another by frequent anastomatic branches. They commence as several small branches arising from the muscles and bones of the coccygeal region. These unite to form a common trunk on each side of the middle line, each trunk following the coccygeal vein of its own side. The 2 vessels lie on the inferior surface of the vertebrae, deep to and between the 2 bundles of the infracoccygis muscle. Running

forwards the 2 vessels receive numerous branches from the skin on the under aspect of the uropygium, the follicles of the rectrices and the dorsal lip of the cloaca, and pass through the connective tissue between the dorsal wall of the cloaca and the coccygeal region to enter the cavity of the pelvis. (Fig.8). At this point they lose their relationship to the coccygeal veins and come to lie on either side of the middle sacral artery. The lymphatics run forwards with the artery on the under surface of the sacral vertebrae and, after a very short course, unite with the lymphatics of the common pudendal arteries. The trunks so formed pass forwards on each side of the terminal part of the aorta.

Tributary branches.

In addition to the branches from the coccygeal region, other tributaries flow into the trunks following the middle sacral artery. (1). The main vessel of each side is joined by a lymphatic which follows the common trunk of the cutaneous caudal and cutaneous pubic veins outside the pelvic cavity. This lymphatic is formed by the junction of branches following the 2 veins and these branches are rarely double in their courses. The lymphatic following the cutaneous caudal vein (Fig. 8 and 12.) is formed by the union of small branches draining the skin of the dorsal surface of the uropygium. It runs downwards and forwards across the levator caudae, transversus perinei and femoro-caudal muscles to reach the posterior border of the semitendinosus muscle. In its course this trunk receives branches from the coccygeal muscles and vertebrae, and a lymphatic which drains the skin over the uropygial gland and the gland itself. The trunk passes deep to the angle between the upper part of the posterior border of the ischium and the coccygeal

vertebrae, where it joins the vessel following the cutaneous pubic vein. The lymphatic following the cutaneous pubic vein, (Figs.8 and 12) is formed by the union of branches from the skin over the upper and posterior parts of the abdominal wall. It receives a branch from the posterior extremity of the pubis (which is not mentioned in the description by Baum (8)), and runs upwards and forwards to pass underneath the femoro-caudal muscle. It follows the posterior border of the ischium, deep to the semitendinosus muscle and, close to its junction with the lymphatic of the cutaneous caudal vein, it is joined by a branch which drains the ventral lip of the cloaca and the skin of the supero-posterior part of the thigh. This latter runs deep to the transversus perinei and femoro-caudal muscles and receives lymphatics from these muscles.

The common trunk of these lymphatics following the cutaneous caudal and cutaneous pubic veins pierces the abdominal wall in the space between the supero-posterior angle of the ischium and the coccygeal vertebrae, and thus enters the pelvic cavity, where it loses its relationship to the vein. It joins the vessel of its own side which accompanies the middle sacral artery.

(2). Just before the junction with the vessels following the common pudendal arteries, one of the anastomatic branches between the trunks following the middle sacral artery is joined by a single median lymphatic which drains the rounded anterior end of the Bursa Fabricii. This, of course, disappears at the time of the regression of the Bursa. (Baum (8) does not describe any of the lymphatics of the Bursa Fabricii.)

Lymphatics following the common pudendal artery. (Fig. 13).

The main trunk is sometimes double and is formed by the union of branches draining the terminal part of the large intestine or rectum, i.e. the terminal part of the region of the gut which extends from the junction of the caeca and the ileum to the cloaca. This trunk runs forwards on the side of the large intestine, and the Bursa Fabricii if the bird is young, and, diverging upwards and inwards, it joins the vessel following the middle sacral artery, in common with its fellow of the opposite side. A slight plexus is usually formed at this junction.

Tributary branches.

(1). At its commencement it is joined by lymphatics from the cloacal wall and from the posterior part of the Bursa Fabricii, if this is present.

(2). Later, the main trunk receives a branch from the terminal part of the ureter of its own side.

(3). In the male, the vessel is joined by a branch from the final part of the vas deferens of its own side, which forms a common trunk with the lymphatic arising from the ureter.

In the female, the vessel on the left side is joined by a lymphatic draining the posterior third of the oviduct.

Lymphatics following the abdominal aorta. (Fig. 13). As already explained, the main lymphatics result from the union of vessels following the middle sacral and common pudendal arteries. Usually a lymphatic trunk is present on each side of the aorta, the 2 trunks being joined by frequent anastomatic branches, but occasionally a single trunk may occur in part or the whole of this part of the

course of the aorta. If a single lymphatic is present its relationship to the aorta is very variable. The vessels (or vessel) run forwards on each side of the aorta, immediately beneath the vertebral column. Each is closely related to the kidney of its own side in the greater part of its course. At the root of the anterior mesenteric artery, i.e. just before the diaphragm, an extensive plexus is formed around the aorta, and this plexus extends forwards into the thoracic cavity in company with the aorta. The plexus is reinforced by the plexiform terminations of the lymphatics of the anterior mesenteric artery and the coeliac axis, which join it respectively behind and in front of the diaphragm. Only a small part of the plexus lies within the thoracic cavity, and it is drained by the 2 thoracic ducts (or occasionally by the single thoracic duct) which run forwards from it. Thus, the thoracic ducts may be considered to arise from a plexus, surrounding the aorta in the region of the diaphragm, which is formed by the confluence of the lymphatic vessels following the abdominal aorta, the anterior mesenteric artery and the coeliac axis.

Tributary branches.

(1). In its course on the lower surface of the lumbo-sacral part of the vertebral column, the lymphatic on each side of the aorta is joined by 4 or 5 cutaneous vessels from its own side of the body.(Fig.8). These join the main trunk independently of one another and drain the skin lying over the upper part of the thigh. In each case numerous branches from this region unite to form a vessel, which is also joined by branches from the skin lying over the levator coccygis muscle. This vessel passes between the lateral edge of the levator coccygis muscle and the innominate bone,

receiving branches from this muscle, and runs towards a foramen between the original transverse processes of 2 lumbo-sacral vertebrae, through which it passes. There does not appear to be any regularity in the position of the foramen through which any one of these vessels passes. Each vessel runs downwards and inwards to unite with the main trunk, being joined, close to its termination, by branches from the lumbo-sacral vertebrae. One of these vessels receives a lymphatic draining part of the ilium and ischium close to the point at which it is passing through the foramen in the lumbo-sacral region. This branch arises from the parts of the bones which lie medial to the cotyloid cavity. It runs vertically upwards, deep to the origins of the biceps flexor cruris and gluteus primus muscles and it passes through the upper parts of these origins. (2). Soon after their formation, the trunks receive lymphatics which follow the posterior mesenteric artery. (Fig. 14). These vessels arise as numerous plexiform branches in the wall of the large intestine with the exception of its termination, which is drained by branches following the common pudendal artery. The branches from the posterior half of the large intestine form a trunk which follows the course of the artery in the mesentery, while the vessels from its anterior half form a trunk which runs upwards in the mesentery, a short distance in front of the artery. This latter is one of the exceptions to the rule that the lymphatics follow the course of the blood vessels, although its branches do follow branches of the artery on the wall of the gut. Both trunks join the lymphatics following the abdominal aorta close to the root of the posterior mesenteric artery, a plexus being formed in this region.

(3). In the same area, the trunk on each side is joined by a lymphatic which drains part of the ureter of its own side. In the male, this lymphatic receives branches from the vas deferens. It runs inwards across the lower face of the internal iliac vein to reach the main vessel.

(4). Midway between the junctions of the lymphatics following the posterior mesenteric and ischiadic arteries with the main vessels, each is joined by another tributary from the ureter and, in the male, the vas deferens.

(5). As the trunk on each side is lying between the kidney and the aorta, it receives 5 or 6 fine lymphatics which arise from the medial border of the kidney at regular intervals. Their courses, which do not follow the blood vessels, are very short. (Baum (8) considers that these vessels emerge from the lower surface of the kidney, and they are the only lymphatics of the kidney which he describes.) Plexuses are not formed by these lymphatics in the substance of the kidney.

(6). At the level of the 9th. or 10th. lumbo-sacral vertebra, approximately at the junction between the middle and posterior lobes of the kidney, the vessel on each side of the aorta is joined by the lymphatics which follow the ischiadic artery.(Fig.13). The lymphatic vessel which follows the ischiadic vein in the hindlimb has already been dealt with in the description of the vessels of the hindlimb. As stated, it passes through the ischiadic foramen to enter the pelvic cavity, where it loses its relationship to the vein, and it accompanies the ischiadic artery for the rest of its course. It runs forwards and inwards across the lower surface of the kidney at the junction of its middle and posterior lobes, and

it receives branches from these parts of the kidney. In the male, the lymphatic passes above the vas deferens and the ureter, being joined by vessels which arise from these structures. In the female, it passes above the ureter and receives branches from it. The vessel of the left side of the female fowl runs over the upper surface of the oviduct and at this point a lymphatic draining the middle third of this organ joins the trunk. It runs over the oviduct before it reaches the ureter. The vessel following the ischiadic artery is usually double, and a plexus, which surrounds the aorta is usually visible at its termination.

(7). In the male, midway between the junctions of the lymphatics of the ischiadic and crural arteries with the main vessel of each side, the latter is joined by a tributary which drains the posterior fourth of the testicle of the same side.(Fig.17). The lymphatics from the upper and lower surfaces of the testicle unite between the medial border of this organ and the epididymis, the resulting trunk running inwards across the lower surface of the epididymis. It is joined by a branch from the latter structure and from the commencement of the vas deferens, and it joins the main vessel after a very short course. It may be mentioned here that the lymphatics of the testicle form an extensive, intricate plexus in the fibrous capsule, and this plexus is drained by 4 or 5 (usually 5) lymphatics which run medially. Thus all the lymphatics which are responsible for the actual drainage of the testicle are connected with one another by means of this plexus. The 4 vessels draining the anterior three-fourths of the organ join either the lymphatics of the anterior mesenteric artery, or the plexus at the root of the anterior mesenteric artery.

(8). At the 2nd. or 3rd. lumbo-sacral vertebra, the trunk of each side is joined by a vessel following the crural artery of its own side.(Fig.13). This vessel, which is usually double, is the direct continuation of the lymphatic following the external iliac vein in the hindlimb. As already explained, the latter enters the abdominal cavity by perforating the abdominal wall close to the middle of the lateral edge of the ilium. It immediately becomes related to the crural artery, and, at its entrance to the body cavity, it is joined by a vessel, following the epigastric artery and vein, which drains parts of the obturator internus and the abdominal muscles. This runs upwards and forwards on the deep face of the abdominal muscles to reach the lymphatic following the crural artery. At the same point, the latter receives a tributary from the kidney which emerges from the middle of its lateral edge in company with the internal iliac vein. The lymphatic of the crural artery then runs forwards and inwards, between the dorsal surface of the kidney and the roof of the abdomen, to gain the vessel following the abdominal aorta. It is joined by some branches from the anterior part of the kidney.

(9). In the region where the plexus is being formed at the root of the anterior mesenteric artery, the trunks may be joined by tributaries from the testicles or the ovary, but in the majority of cases these branches join the plexiform termination of the anterior mesenteric artery.

It must be mentioned at this stage that an error appears in Baum's (8) statement and drawings in that he transposes the descriptions of the vessels following the anterior mesenteric artery

and the coeliac axis. Where Baum refers to the lymphatics following the coeliac axis, he is actually describing those which follow the anterior mesenteric artery, and vice versa. This accounts for the differences between the following statements on the lymphatics accompanying these vessels and the description given by Baum.

Lymphatics following the anterior mesenteric artery.(Fig.14).

In this description the terminal part of the small intestine which lies between the 2 caeca will be referred to as the ileum, the 2 parts of the small intestine between which the pancreas is found will be referred to as the duodenum, and the intervening, freely suspended part will be named the jejeunum.

The lymphatics which follow branches of the anterior mesenteric artery are frequently double and exhibit plexuses on their courses. They are always plexiform where they lie on the wall of the gut, beneath the serosa, and they lie with the corresponding arterial branches. In the mesentery, the majority of the lymphatics accompany the arteries, but occasional branches from parts of the intestine, at the middle of arterial arches on the dorsal wall, may run independently in the mesentery for a considerable distance before gaining a branch of the artery.

The main lymphatic vessel following the anterior mesenteric artery may be considered to commence as a number of fine branches draining the anterior, blind extremities of the caeca, and the commencement of the ileum which lies between them. These form a single vessel which runs forwards and upwards in the great mesentery, across the right surfaces of the gizzard and proventriculus, and eventually reaches the roof of the abdomen. Gaining the root of

the anterior mesenteric artery, it divides into numerous plexiform branches which form part of the plexus at the roots of the anterior mesenteric artery and the coeliac axis.

Tributary branches.

(1). The vessel is joined by lymphatics which drain successively more anterior sections of the jejeunum. These join it at fairly regular intervals in its course in the mesentery. The last branch from the jejeunum, draining the commencement of this part of the alimentary canal, joins the main trunk at about the middle of its course.

(2). A short distance from its termination, the main vessel is joined by a tributary which receives branches from the posterior halves of the 2 caeca and the section of the ileum lying between them. This tributary runs forwards in the mesentery to gain the main trunk and follows the recurrens ileo-coeliacus branch of the anterior mesenteric artery.

(3). In the male the plexiform termination of the main lymphatic is joined, on each side, by a common trunk of 2 or 3 lymphatics which drain most of the anterior three-fourths of the testicle. (Fig.17) As stated, these common trunks occasionally join the terminal parts of the lymphatics following the abdominal aorta. Each of the 2 or 3 branches results from the union of lymphatics which drain the plexuses on the dorsal and ventral surfaces of the testicle, the most posterior lymphatics uniting between the testicle and epididymis and receiving branches from the latter organ. The common trunk is formed on the lower surface of the termination of the external iliac vein on each side. On the left side, the trunk runs directly forwards to join the main vessel following the anterior mesenteric artery, but on the

right side, it usually curves around the left surface of the posterior vena cava before it joins the main vessel. In a few cases it crosses the right surface of the posterior vena cava. In the female, a vessel which drains the ovary and the anterior third of the oviduct is visible on the inner face of the ovary, and this runs forwards and inwards to join the plexiform termination of the main lymphatic.(Fig.13)

The plexus which surrounds the aorta receives some branches as it lies between the anterior mesenteric artery and the coeliac axis, posterior to the diaphragm.(Fig.13)

(1). On each side a delicate vessel arises from the adrenal gland and joins the plexus after a short course.

(2). In the male, a vessel runs forwards from the extreme anterior end of eachtesticle to unite with the plexus.

Lymphatics following the coeliac axis.(Figs 15. and 16) The main trunk may be considered to be formed by the union of plexiform branches from the middle of the duodenum,i.e. the junction of the 2 arms of the loop of the duodenum, close to the posterior extremity of the pancreas. It runs forwards and upwards between the 2 halves of the pancreas, and between the 2 arms of the duodenal loop, being mainly concealed by the pancreas. At the anterior extremity of the pancreas it leaves the cover of the gland and, continuing its course forwards and upwards, it runs along the anterior border of the spleen and across the right surface of the proventriculus. It then passes forwards and upwards on the posterior surface of the liver to reach the roof of the abdomen. Passing through the upper

border of the diaphragm, it divides into numerous plexiform branches surrounding the root of the coeliac axis and the aorta, and thus forms the anterior part of the plexus which has already been described.

Tributary branches.

(1). As it lies between the 2 halves of the pancreas, it is joined by branches from the 2 arms of the duodenal loop which run through the substance of the pancreas and receive lymphatics from the gland. These join the main vessel at regular intervals.

(2). As soon as it has left the cover of the pancreas, the main vessel receives a lymphatic which follows the recurrens ileo-colicus branch of the coeliac axis. (Fig.15) This drains the anterior halves of the 2 caeca, with the exception of the anterior, blind extremities, and the corresponding part of the ileum.

(3). A vessel which is formed by the union of plexiform branches from the right surface and upper border of the gizzard, unites with the main trunk in the same region as the preceding tributary, and the 2 vessels may have a short common trunk. (Fig.15)

(4). At the point at which the main vessel lies on the anterior border of the spleen, it is joined by 1 or 2 vessels which drain the lymphatic plexus in the splenic capsule.

(5). At the same point it receives a lymphatic which drains the right lobe of the liver and emerges through the portal fissure. This branch is joined by vessels from the wall of the gall bladder. Occasionally it joins the main trunk further along its course.

(6). At the lower edge of the proventriculus, a vessel unites with the main trunk which follows the recurrens sinister branch of the coeliac axis.(Fig.16) This commences as several branches which

drain the left surface and lower border of the gizzard. These form a trunk at the anterior border of the gizzard which immediately receives a vessel emerging from a fissure in the left lobe of the liver, and a vessel which drains the left surface and lower border of the posterior half of the proventriculus. The branches from the latter organ usually commence as plexuses in its wall. The trunk following the recurrens sinister artery then runs forwards along the lower border of the proventriculus to reach the lymphatic following the coeliac axis. Rarely, the most anterior branch from the posterior half of the inferior border of the proventriculus may be connected with the commencement of the vessel following the vena proventricularis communis which drains the anterior half of the left side of the proventriculus. This arrangement is slightly similar to the arrangement which Baum (8) describes as the typical one. He states that the vessels from the dorsal half of the left side of the gizzard run with the common proventricular vein and not with the coeliac axis, but such an arrangement has not been observed in the present investigation.

(7). As it lies on the right surface of the proventriculus, the main vessel is joined by its last branch, which drains the upper border and right surface of the posterior half of this organ.(Fig.15)

As stated, the plexus formed by the junction of the lymphatics following the abdominal aorta, the anterior mesenteric artery and the coeliac axis is drained by the 2 thoracic ducts.

The 2 thoracic ducts.(Fig.13) These arise at the anterior end of the plexus, at the root of the coeliac axis, and just within the thoracic cavity. They run forwards, one on each lateral surface

of the thoracic part of the aorta, and are joined to one another by frequent transverse and oblique anastomatic branches. They are the largest lymphatic vessels of the body but, even so, their maximum diameter is about 1m.m. At the level of the 2nd. or 3rd. thoracic vertebra, they diverge outwards, away from one another and from the aorta, and each passes dorsal to the pulmonary artery and vein, between these vessels and the lung, to unite with the anterior vena cava of its own side, midway between its formation and termination. Baum (8) shows the left thoracic duct running below the pulmonary vessels in one of his diagrams, but this appears to be an error in the drawing itself. A single thoracic duct may occur in part or the whole of its course, and occasionally a single duct may bifurcate close to its termination, thus having 2 communications with the venous system. Where a single termination is present, it may be on either the right or the left side. These variations occur quite frequently.

Tributary branches.

(1). A lymphatic which drains the skin over the longissimus dorsi muscle, anterior to the sartorius muscle, runs downwards and backwards, deep to the latter muscle, and receives branches from the muscles of the thoracic wall. It passes between the 6th. and 7th. ribs, at the posterior edge of the serratus magnus anticus muscle, to enter the thoracic cavity, and then runs upwards between the lung and the thoracic wall to join the thoracic duct of its own side. It is joined by branches from the thoracic vertebrae and it may receive vessels draining the costo-vertebral articulations. (Fig.4)

(2). A cutaneous vessel draining the skin over the upper end of-

the sartorius muscle passes through the longissimus dorsi muscle at the anterior edge of the sartorius muscle, and this vessel is joined by branches from these muscles. It runs between the heads of the 5th. and 6th. ribs to enter the thoracic cavity, and it gains the thoracic duct of its own side, with which it unites, by passing medial to the lung of its own side. It receives branches from the thoracic vertebrae and the costo-vertebral articulations. (Fig.4)

(3). Similar branches to the preceding lymphatic drain the skin over the back and pass between the heads of the 4th and 5th. ribs and the 3rd. and 4th. ribs to join the thoracic ducts. They also receive branches from the vertebra and the cost-vertebral articulations. (Fig.4)

(4). The left thoracic duct is joined, in the region of the 3rd. thoracic vertebra by a vessel which is formed on the dorsal border of the proventriculus by the union of branches from the right surface and dorsal border of the anterior half of the proventriculus and branches from the posterior third of the thoracic part of the oesophagus. This vessel runs inwards across the lower face of the left lung.

(5). At its termination, the thoracic duct of the left side may be joined by the common trunk formed by the union of the deep lymphatics of the lungs and the lymphatic following the common proventricular vein, but these vessels usually join the venous system independently of the thoracic duct and of one another, and they will be described separately.

The lymphatics which remain to be described are those which drain the lungs and the heart and those which follow the common proventricular vein and the internal thoracic artery.

Lymphatics of the lungs.(Fig.13) Superficial and deep groups of lymphatics are demonstrable in each lung. The superficial vessels form an interconnecting network, with wide spaces between the vessels, on the lower surface of each lung. This network is drained by vessels which run from it on the external border of the lung to join the vessel following the internal thoracic artery, and they will be described at a later stage. The deep lymphatics of each lung communicate freely with the superficial vessels, and they appear to follow the branches of the pulmonary artery and vein in the substance of the lung. They unite to form a trunk which is usually double and emerges from the lower surface of the anterior extremity of the lung, in company with the pulmonary vein. A plexus is formed around the vein. The trunk following the right vein crosses the middle line, lying on the junction of the 2 pulmonary veins, and unites with the trunk from the left lung. The vessel so formed runs upwards and outwards to terminate by joining the left anterior vena cava, medial to the junction of the left thoracic duct. As stated, it may join the thoracic duct of the left side close to its termination.

Lymphatics following the internal thoracic artery.(Fig.13) The main vessel, which is rarely double, commences as several branches which drain part of the abdominal muscles behind the last rib. These unite to form the main vessel which passes between the diaphragm and the last rib and enters the thoracic cavity. It runs forwards on the

thoracic wall just above the articulations between the dorsal and ventral segments of the true (sternal) ribs. It usually lies along the outer edge of the lung, but it may be placed between the outer part of the upper surface of the lung and the thoracic wall. At the 1st. rib it curves inwards to join the anterior vena cava, close to the junction of the internal thoracic vein, i.e. soon after the formation of the anterior vena cava.

Tributary branches.

(1). As it passes into the thoracic cavity, it is joined by a branch which drains the diaphragm.

(2). In its course within the thorax, it receives branches at regular intervals which arise from the junctions between the dorsal and ventral segments of the true (sternal) ribs and from the lower ends of the false (asternal) ribs. These branches drain the ribs and are joined by vessels arising from the intercostal muscles.

(3). 6 or 7 lymphatics, which emerge from the network of the superficial lymphatics of the lung at the outer edge of the lung, also join the main vessel within the thorax. Baum (8) states that these branches form a marginal vessel (Randgefässe), but it is not clear whether he considers that this follows the internal thoracic vein. He states that it occasionally unites with the pulmonary vein, but no such termination has been observed in the present investigation.

Lymphatics following the vena proventricularis communis. (Fig.16)

The main vessel, which is an exception to the statement that the lymphatics of the abdomen usually follow the arteries, results from the union of numerous branches draining the left surface and inferior

border of the anterior half of the proventriculus. These branches commence as plexuses and the main trunk is often plexiform in its course. It runs forwards on the inferior border of the proventriculus, and ends by joining the left anterior vena cava, close to or in common with the left thoracic duct. As previously stated, the posterior part of this vessel may be connected with the vessel draining the left surface and inferior border of the posterior half of the organ, in which case it has a connection with the lymphatics following the coeliac axis. Such an arrangement is rarely present.

Lymphatics of the heart. (Fig.18) The lymphatic vessels which drain the wall of the heart do not follow the courses of the coronary arteries and veins. 2 main lymphatic vessels are present, one draining the left auricle and ventricle and parts of the right auricle and ventricle, which will be referred to as the left lymphatic trunk, and the other draining most of the right auricle and ventricle, which will be referred to as the right lymphatic trunk.

(1). The left lymphatic trunk of the heart. This is formed on the ventral (sternal) surface of the heart by the union of branches draining the apex of the heart, i.e. the apex of the left ventricle, at the lower end of the ventral interventricular groove. It immediately turns around the right border of the heart, lying in or near the lower end of the dorsal interventricular groove, to reach the dorsal (hepatic) surface. It runs up this surface to the right of the dorsal interventricular groove, and receives branches from the wall of the right ventricle. Just below the coronary groove, it crosses the coronary artery and vein as they lie in the

interventricular groove, and at this point it receives a long vessel which drains the apex of the heart on this surface, and runs upwards on the left of the interventricular groove. The main vessel then runs up to the coronary groove and for the rest of its course it is concealed by the large amount of fat which is usually present in this region. Having reached the coronary groove, it is joined by a branch from the right ventricle and the adjacent part of the right auricle. It runs in the coronary groove, distinctly separate from the coronary artery and vein, towards the left border of the heart, and receives several branches from the dorsal surface of the left auricle and ventricle. These branches are all obscured by a covering of fat in the later parts of their courses. Curving around the left border of the heart, the left lymphatic trunk reaches the ventral surface. As it continues its course in the coronary groove, several branches from the ventral surfaces of the left auricle and ventricle unite with it. The vessel then crosses the root of the pulmonary artery and receives 3 or 4 tributaries from the part of the right ventricle which lies close to the ventral interventricular groove. It may be joined at this point by the right lymphatic trunk of the heart. It passes deeply between the pulmonary artery and the right auricle, and at this point a lymphatic from the left auricle runs between the pulmonary artery and the aorta to unite with it. (Baum (8) states that this latter tributary joins the right lymphatic trunk). The left lymphatic trunk passes over the medial face of the right auricle, receiving branches from it, to reach the roof of this auricle and it terminates by opening into the medial side of the right anterior vena cava, close to its junction with the auricle. It usually opens into the vena cava in

common with the right lymphatic trunk.

(2). The right lymphatic trunk of the heart. This vessel is formed on the dorsal surface of the right ventricle, some distance to the right of the dorsal interventricular groove. It runs upwards to reach the coronary groove, in which it lies with relationships similar to those of the left lymphatic trunk. It courses towards the right border of the heart, receiving branches from the right auricle and ventricle, and turns around this border to gain the ventral surface. Continuing its course in the coronary groove, it reaches the root of the pulmonary artery, where it may terminate by joining the left lymphatic trunk. Usually it runs deep to the latter trunk to curve around the root of the pulmonary artery. The vessel then runs towards the right, across the dorsal aspect of the aorta, to reach the roof of the right auricle. Branches from this auricle join the trunk, which ends by joining the right anterior vena cava at the point at which the left lymphatic trunk joins the vein. As stated, these 2 trunks usually open in common into the right anterior vena cava. Baum (8) states that the right lymphatic trunk may join the left anterior vena cava, but such an arrangement has not been observed.

These lymphatic trunks of the heart lie within the fibrous pericardium throughout the whole of their courses.

To summarise the above description, the lymphatics of most of the trunk (and of the hindlimb) are ultimately drained by the thoracic ducts, which join the anterior venae cavae midway between the commencements and terminations of these veins. Lymphatics from the deep parts of the lungs and from the proventriculus may join

either the left thoracic duct at its termination or the left anterior vena cava independently. Vessels from the chest wall and from the superficial parts of the lung form a trunk which always has an independent opening into the anterior vena cava of its own side.

SUMMARY.

(1). The literature appertaining to the lymphatic system as it occurs in the class Aves is reviewed.

(2). The technique of injection of the lymphatic vessels is discussed. For the present study the method of Gerota was employed.

(3). A topographic description of the lymphatic system of the domestic fowl (Gallus domesticus) is given.

(4). The lymphatic vessels are relatively few in number in the fowl and, with a few exceptions, they follow the course of the blood vessels. They primarily follow the arteries within the abdominal and thoracic cavities. Elsewhere, they mainly follow the veins.

(5). The lymphatic system has several distinct communications with the veins in the anterior thoracic region in the fowl.

(6). 2 Thoracic ducts are usually present in the fowl, but a single duct is sometimes observed. These ducts unite with the anterior venae cavae and not with the jugular veins, as is so frequently asserted in the standard textbooks.

(7). Lymph hearts have not been found in any fowl which has been examined.

(8). Contrary to the many statements in the textbooks, lymphatic glands do not occur in the fowl and it appears that they are replaced by plexuses of the lymphatic vessels. Several of these plexuses are described. Such plexuses are particularly noticeable because the occurrence of plexuses is relatively infrequent in the fowl.

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ILLUSTRATIONS.

For the sake of clarity, the lymphatics are shown as single vessels in most of the illustrations and, with some exceptions, the blood vessels are omitted.

Abbreviations used in the legends are as follows: A.Artery. V.Vein. N.Nerve. L.Lymphatic.

In accordance with what appears to be the usual convention, the cut end of a lymphatic is shown by a small circle at the end of the vessel.

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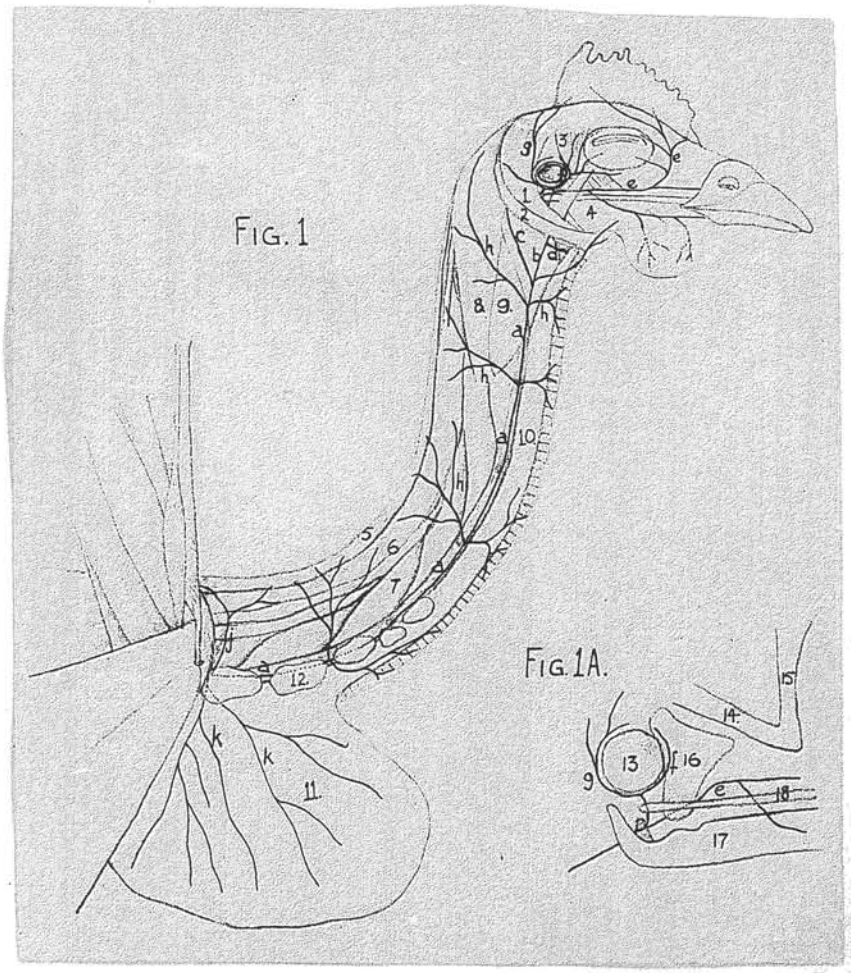

Fig. 1. Superficial lymphatics of right side of head and neck.
Fig. 1A. Diagram to show relations of lymphatics in region of temporo-maxillary joint.
a. L. following V. jugularis. b. L. following V. cephalica anterior. c. L. following V. cephalica posterior. d. L. following V. transversa. e. L. following V. facialis cutanea. f. L. following V. palpebralis. g. L. following V. temporalis. h. L. draining skin of neck. j. L. draining skin over shoulder joint. k. L. draining skin over crop. 1. M. biventer maxillae. 2. M. genio-hyoideus. 3. M. temporalis. 4. M. masseter. 5. M. biventer cervicis. 6. M. longus colli posticus. 7. M. obliquus colli. 8. M. complexus. 9. M. rectus capitis lateralis. 10. Oesophagus. 11. Crop. 12. Lobe of thymus gland. 13. External auditory meatus. 14. Zygomatic process of squamous temporal. 15. Supraorbital process. 16. Quadrate. 17. Inferior maxilla. 18. Malar.

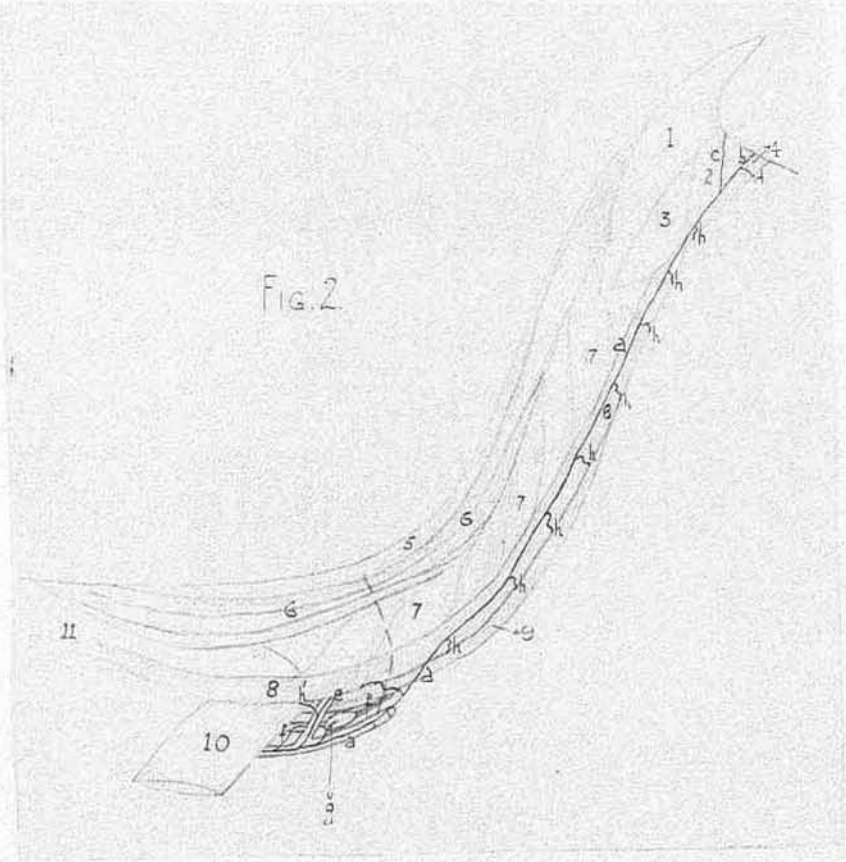

Fig. 2. Lymphatics of muscles and vertebrae of right side of neck. (Oesophagus, crop, trachea, and forelimb removed.)
a. L. following V. jugularis. b. L. following V. cephalica anterior. c. L. following V. cephalica posterior. d. L. following V. transversa e. L. following V. vertebralis. f. L. following A. carotis communis. g. L. draining thyroid gland. h. L. draining muscles on lateral and inferior aspects of neck. h'. L. draining muscles and vertebrae of posterior cervical and anterior thoracic regions. 1. M. complexus. 2. M. rectus capitis anticus minor. 3. M. rectus capitis lateralis. 4. M. flexor capitis inferior. 5. M. biventer cervicis. 6. M. longus colli posticus. 7. M. obliquus colli. 8. M. intertransversales colli. 9. M. longus colli anticus. 10. M. scalenus medius. 11. M. longissimus dorsi.

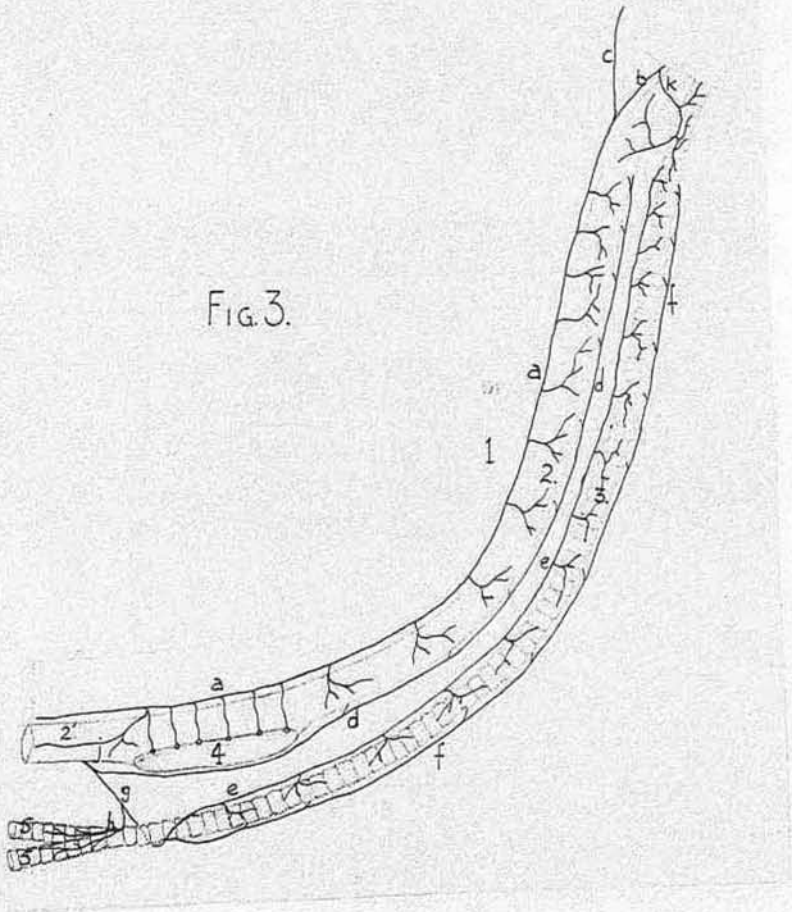

Fig. 3. Diagram of lymphatic drainage of oesophagus, crop and trachea. (Crop removed.)
a. L. following V. jugularis, receiving L. from dorsal and right surfaces of cervical part of oesophagus and from right surface of crop. b. L. following V. cephalica anterior. c. L. following V. cephalica posterior. d. L. following ventral surface of cervical part of oesophagus, receiving L. from its ventral and left surfaces. e. L. following dorsal surface of trachea, receiving L. from its dorsal and right surfaces. f. L. following ventral surface of trachea, receiving L. from its ventral and left surfaces. g. Common trunk of L. of trachea. h. L. draining bronchi. j. L. draining anterior two-thirds of thoracic part of oesophagus. k. L. draining larynx and commencement of trachea and oesophagus. 1. Neck (right side). 2. Cervical part of oesophagus. 2'. Thoracic part of oesophagus. 3. Trachea. 4. Cavity of crop. 5. Bronchi.

FIG. 4.

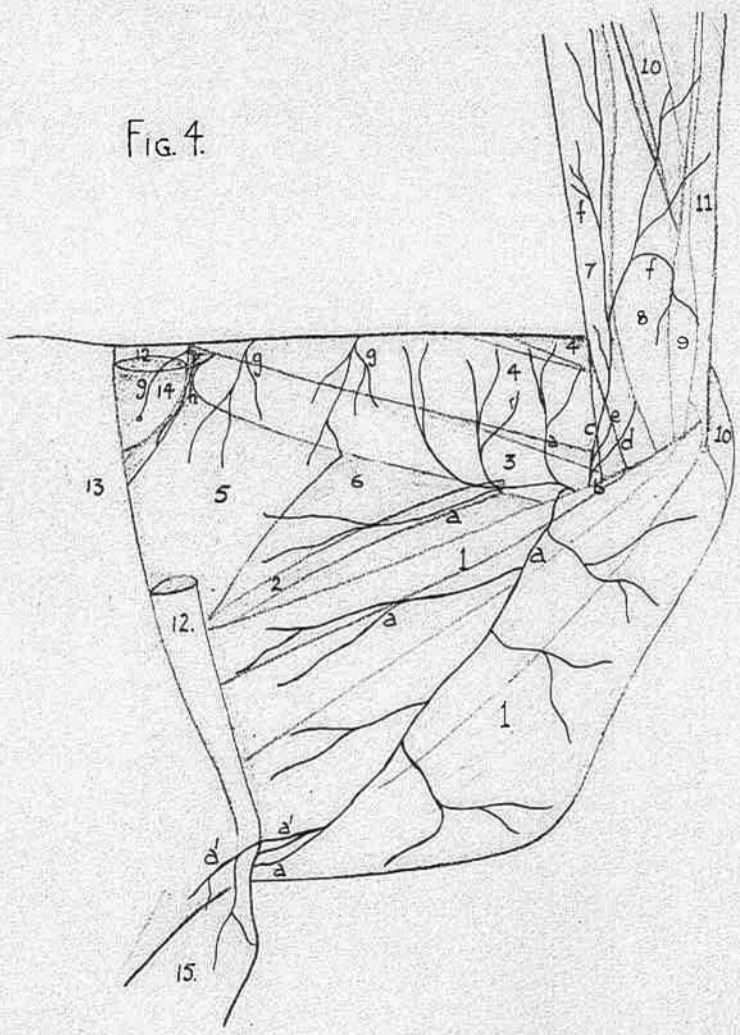

Fig. 4. Superficial lymphatics of right side of thoracic region. (M. sartorius partly removed.)
a. L. following V. cutanea abdomino-pectoralis. a'. L. draining skin over anterior part of knee joint. b. L. following V. subclavia. c. L. following V. basilica. d. L. following V. brachialis. e. L. following V. profunda humeri. f. Cutaneous tributaries of c. g. Cutaneous tributaries of thoracic ducts and L. following abdominal aorta. h. L. draining skin over M. longissimus dorsi. 1. M. pectoralis major. 2. M. dermo-ulnaris. 3. M. teres et infraspinatus. 4. M. latissimus dorsi. 5. M. serratus magnus anticus. 6. Thoracic wall. 7. M. triceps. 8. M. biceps. 9. M. tensor patagii longus. 10. M. tensor patagii brevis. 11. Elastic ligament at free edge of flight membrane. 12. M. sartorius. 13. M. gluteus primus. 14. M. gluteus medius. 15. M. peroneus longus.

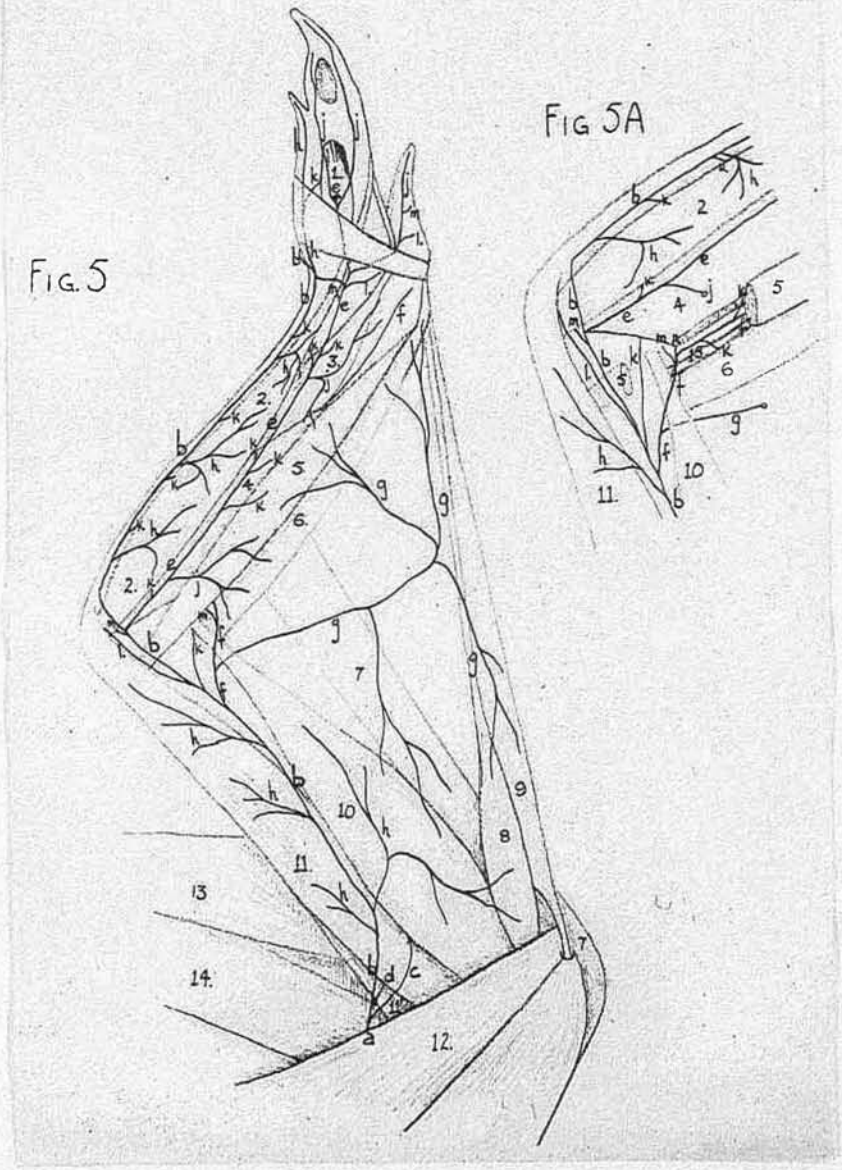

Fig. 5. Superficial lymphatics of inner surface of right forelimb.
Fig. 5A. Part of course of lymphatics following profunda radialis vein. (M.m. pronator brevis and pronator longus partly removed.)
a. L. following V. subclavia. b. L. following V. basilica. c. L. following V. brachialis. d. L. following V. profunda humeri. e. L. following V. profunda ulnaris. f. L. following V. profunda radialis. g. L. of flight membrane. h. Cutaneous tributaries of b. j. Cutaneous tributaries of e. k. L. draining muscles. l. L. draining articulations. m. L. draining bones. n. Tributary of f. from skin on outer surface of forearm. 1. M. interosseous palmaris. 2. M. flexor carpi ulnaris. 3. M. flexor digitorum profundus. 4. M. pronator longus. 5. M. pronator brevis. 6. M. extensor metacarpi radialis longior. 7. M. tensor patagii brevis. 8. M. tensor patagii longus. 9. Elastic ligament at free edge of flight membrane. 10. M. biceps. 11. M. triceps. 11'. Long head of 11. 12. M. pectoralis major. 13. M. latissimus dorsi. 14. M. teres et infraspinatus. 15. M. supinator brevis.

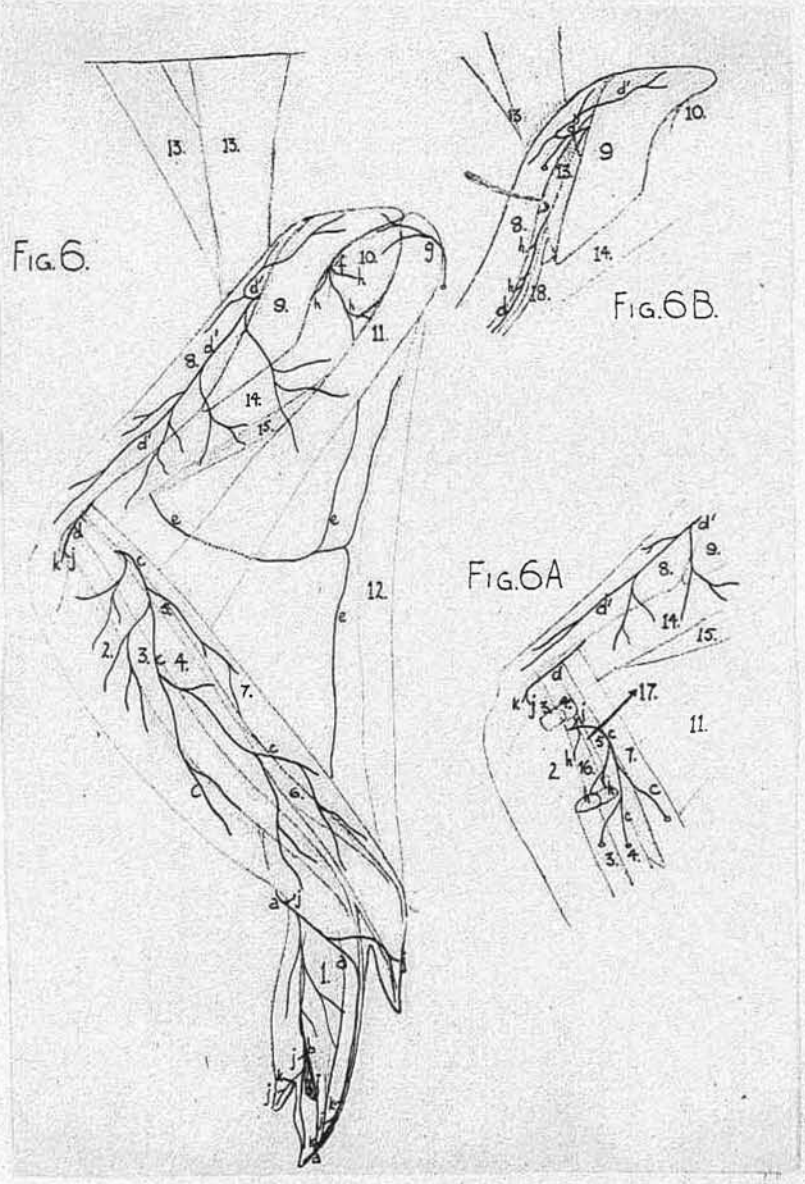

Fig. 6. Superficial lymphatics of outer surface of right forelimb.
Fig. 6A. Part of course of lymphatics following profunda radialis vein. (M.m. flexor metacarpi radialis and extensor digitorum communis partly removed.)
Fig. 6B. Part of course of lymphatics following profunda humeri vein. (M. triceps retracted.)
a. L. following V. basilica. b. L. following V. profunda ulnaris. c. L. following cutaneous tributaries of V. profunda radialis. d. L. following V. profunda humeri. d'. Cutaneous tributaries of d. e. L. of flight membrane. f. L. draining M.m. at proximo-lateral part of arm, which join L. following V. jugularis. g. Cutaneous tributary of L. following V. jugularis. h. L. draining muscles. j. L. draining bones. k. L. draining articulations. 1. M. interosseous dorsalis. 2. M. anconeus. 3. M. flexor metacarpi radialis. 4. M. extensor digitorum communis. 5. M. supinator brevis. 6. M. extensor ossis metacarpi pollicis. 7. M. extensor metacarpi radialis longior. 8. M. triceps. 9. M. deltoideus. 10. M. scapulo-humeralis. 11. M. tensor patagii brevis. 12. Elastic ligament at free edge of flight membrane. 13. M.

Figs. 6., 6A., and 6B. continued.
latissimus dorsi. 14. Humerus. 15. M. biceps. 16. Radio-ulnar interosseous space. 17. Radius. 18. N. brachialis longus superior.

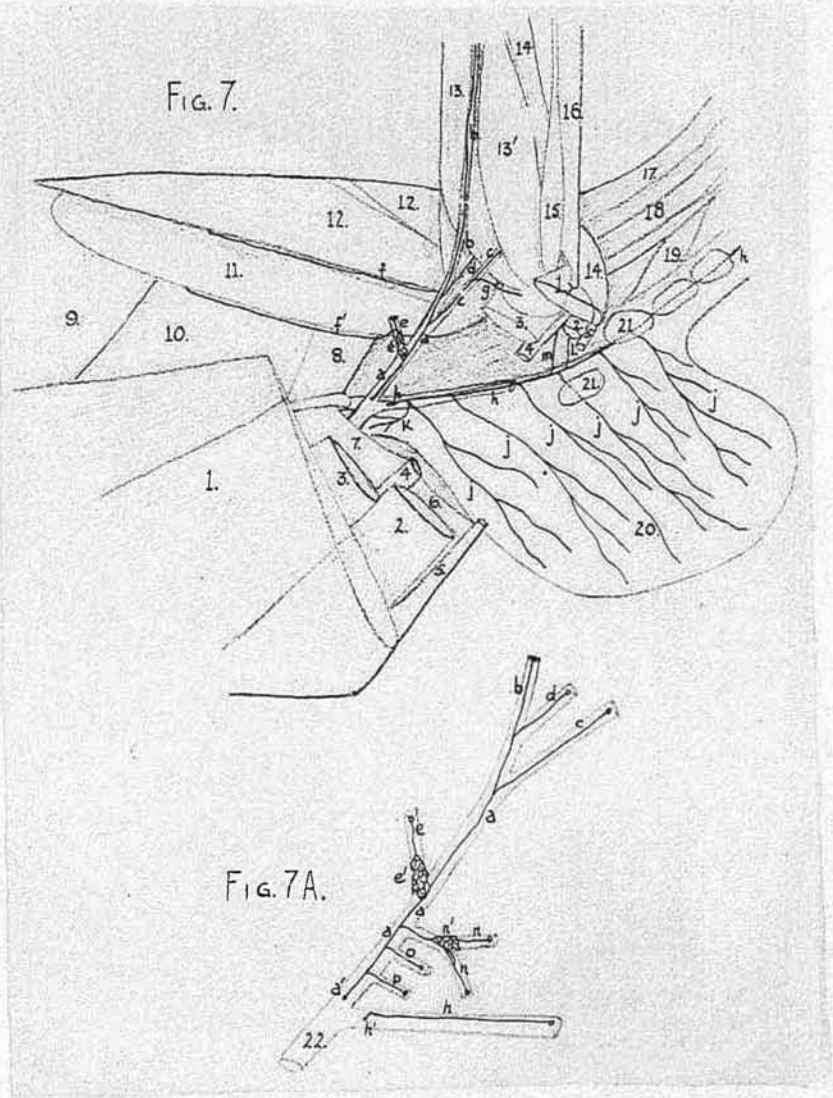

Fig. 7. Lymphatics of right side of anterior thoracic region. (M.m. pectoralis major, pectoralis secundus, pectoralis tertius and tensor patagii brevis partly removed. Coracoid, clavicle and inter-clavicular aponeurosis partly removed. Some tributaries of L. following V. subclavia omitted.)

Fig. 7A. Diagram to show terminations of lymphatics of forelimb, thoracic wall and head and neck.

a. L. following V. subclavia. a'. Termination of a. b. L. following V. basilica. c. L. following V. brachialis. d. L. following V. profunda humeri. e. L. following V. cutanea abdomino-pectoralis. e'. Plexus on course of e. f. L. draining M. latissimus dorsi which joins d. f'. L. draining M. teres et infraspinatus. g. L. draining shoulder joint. h. L. following V. jugularis. h'. Termination of h. j. L. draining wall of crop. k. L. draining anterior two-thirds of thoracic part of oesophagus. l. L. from M.m. at proximo-lateral part of arm. m. L. following V. subscapularis. n. L. following V. thoracica externa. n'. Plexus on course of n. o. L. following V. coracoidea.

Figs. 7. and 7A. continued.
p. L. following V. sternalis. 1. M. pectoralis major. 2. M. pectoralis secundus. 3. M. pectoralis tertius. 4. Coracoid. 5. Clavicle. 6. Interclavicular aponeurosis. 7. M. subclavius. 8. M. thoraco-scapularis. 9. M. serratus magnus anticus. 10. Thoracic wall. 11. M. teres et infraspinatus. 12 M. latissimus dorsi. 13. M. triceps. 14. M. tensor patagii brevis. 15. M. tensor patagii longus. 16. Elastic ligament at free edge of flight membrane. 17. M. biventer cervicis. 18. M. longus colli posticus. 19. M. obliquus colli. 20. Crop. 21. Lobes of thymus gland. 22. Anterior vena cava. 13'. M. biceps.

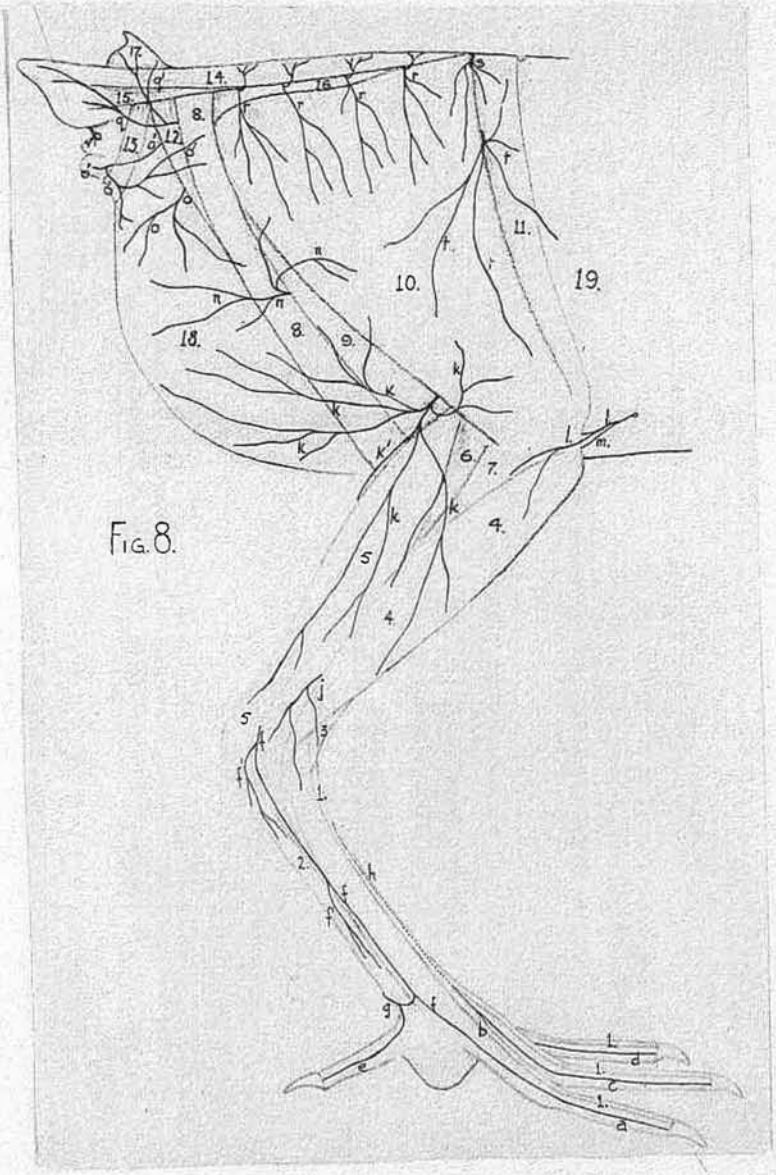

Fig. 8. Superficial lymphatics of abdominal wall, pelvic region, coccygeal region and outer surface of right hindlimb. a. L. of lateral surface of 4th. digit. b. L. of medial surface of 4th digit. c. L. of lateral surface of 3rd. digit. d. L. of lateral surface of 2nd. digit. e. L. of lateral surface of 1st. digit. f. L. following V. metatarsalis externa. f'. Cutaneous tributaries of f. g. L. connecting L. following V.v. metatarsalis externa and metatarsalis interna. h. L. following tributary of V. metatarsalis dorsalis profunda. j. Cutaneous tributaries of L. following V. tibialis anterior. k. Cutaneous tributaries of L. following V. popliteal is. k'. Branch of k. draining skin on medial surface of leg. l. Cutaneous tributaries of m. m. L. following V. cutanea abdomino-pectoralis. n. L. following V. cutanea abdominalis femoralis. o. L. following V. cutanea pubica. o'. Tributaries of o. o". L. draining ventral lip of cloaca. p. L. draining dorsal lip of cloaca which joins L. following V. coccygea. q. L. following V. cutanea caudalis. q'. Tributary of q. r.s. Cutaneous tributaries of L. following

Fig. 8. continued.
abdominal aorta. t. Cutaneous tributaries of L. following V. femoralis anterior. 1. Tendons of M. extensor digitorum longus. 2. Podothecal sheath of flexor tendons. 3. M. tibialis anticus. 4. M. peroneus longus. 5. M. gastrocnemius. 6. M. flexor perforatus indicus secundus pedis. 7. M. flexor perforatus medius secundus pedis. 8. M. semitendinosus. 9. M. biceps flexor cruris. 10. M. gluteus primus. 11. M. sartorius. 12. M. femoro-caudalis. 13. M. transversus perinei. 14. M. levator coccygis. 15. M. levator caudae. 16. Innominate bone. 17. Uropygial gland. 18. Abdominal wall. 19. Thoracic wall.

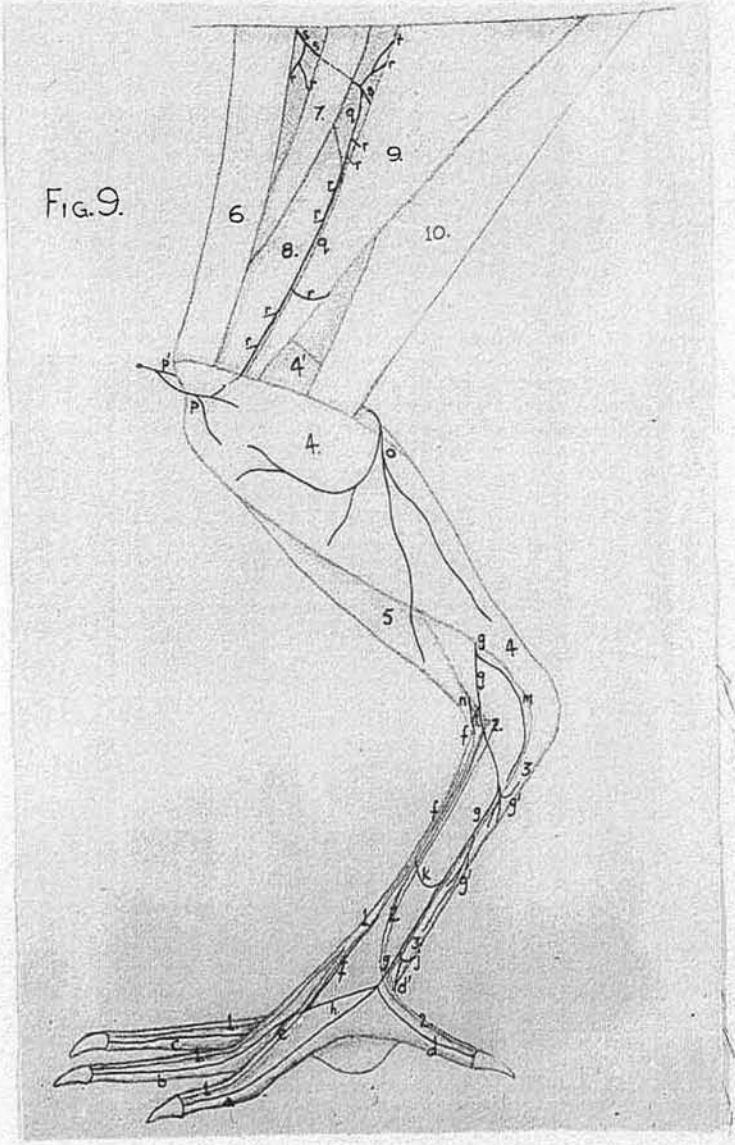

Fig. 9. Superficial lymphatics of inner surface of right hindlimb. a. L. of medial surface of 2nd. digit. b. L. of medial surface of 3rd. digit. c. L. of medial surface of 4th. digit. d. L. of medial surface of 1st. digit. d'. L. of lateral surface of 1st. digit. e. L. of lateral surface of 2nd. digit. f. L. following V. metatarsalis dorsalis profunda. g. L. following V. metatarsalis interna. g'. Cutaneous tributaries of g. h. L. connecting L. following V.v. metatarsalis dorsalis profunda and metatarsalis interna. j. L. connecting L. following V.v. metatarsalis interna and metatarsalis externa. k. L. following V. metatarsalis dorsalis interna. l. Terminal branch of f. m. L. draining upper end of metatarsal bone. n. L. following V. tibialis anterior. o. Cutaneous tributaries of L. following V. poplitealis. p.p'. Cutaneous tributaries of L. following V. cutanea abdomino-pectoralis. q. L. following V. femoralis interna profunda. r. L. draining muscles. s. L. following V. poplitealis on medial side of femur. t. L. draining upper end of femur. 1. Tendons of M. extensor digitorum longus. 2. M. extensor hallucis brevis.

Fig. 9. continued.
3. Podothecal sheath of flexor tendons. 4. M. gastrocnemius (inner head). 4'. M. gastrocnemius (outer head). 5. M. tibialis anticus. 6. M. sartorius. 7. M. ambiens. 8. M. vastus internus. 9. M. semimembranosus. 10. M. semitendinosus.

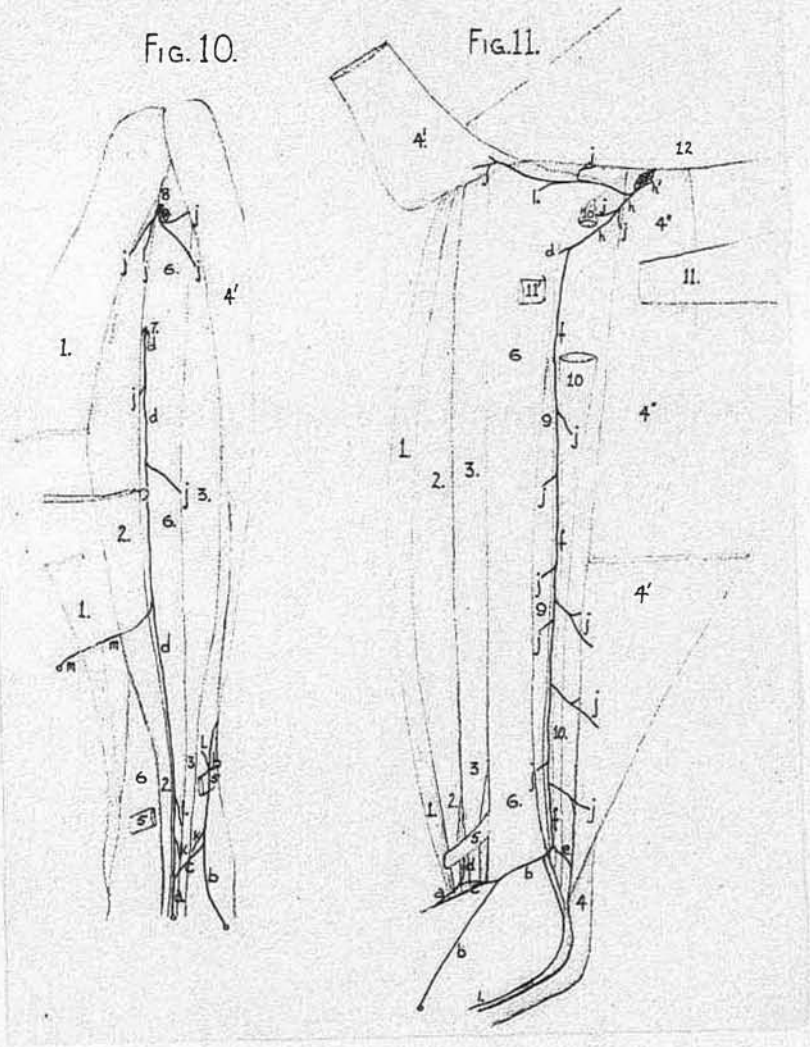

Fig. 10. Lymphatics following right anterior tibial vein. (Anterior aspect of leg, with M.peroneus longus and ligamentous band at lower end of tibia partly removed, and M. tibialis anticus retracted.)
Fig. 11. Lymphatics following right posterior tibial vein. (Internal aspect of leg, with M.m. gastrocnemius (inner head), soleus and semitendinosus partly removed.)
a. L. following V. metatarsalis dorsalis profunda. b. L. following V. metatarsalis interna. c. Terminal branch of a. d. L. following V. tibialis anterior. e. L. following V. metatarsalis externa. f. L. following V. tibialis posterior. g. L. following V. peronealis. h. L. following V. popliteal is. h'. Plexus on course of h. j. L. draining muscles. k. L. draining articulations. l. L. draining bones. m. Tributary of d. from skin over infero-lateral part of leg. 1. M. peroneus.longus. 2. M. tibialis anticus. 3. M. extensor digitorum longus. 4. M. gastrocnemius. 4'. Inner head of 4. 4". Outer head of 4. 5. Ligamentous band at lower end of tibia. 6. Tibia. 7. Lower tibio-fibular arch. 8. Upper tibio-fibular arch. 9. M. flexor perforans digitorum profundus. 10. M. soleus. 11. M. semitendinosus. 11'. Tendon of 11. retracted. 12. M. semimembranosus.

FIG. 12.

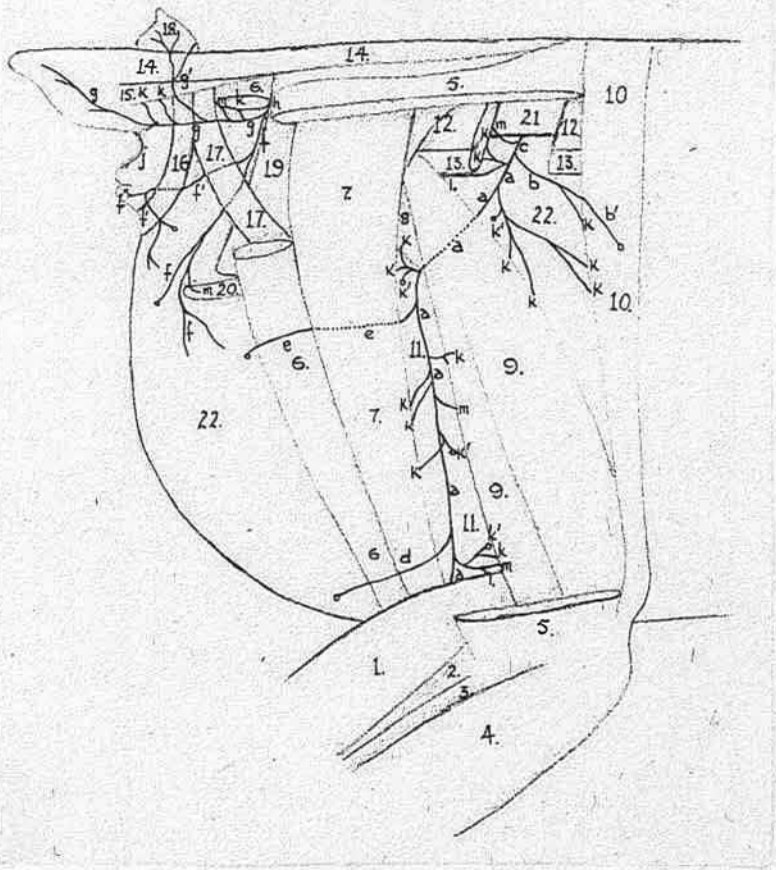

Fig. 12. Deep lymphatics of right thigh and right side of tail. (M.m. gluteus primus, gluteus medius, gluteus minimus and semitendinosus partly removed.)
a. L. following V. popliteal is. b. L. following V. femoralis anterior. b'. Cutaneous tributary of b. c. L. following V. iliaca externa. d. Tributary of a. from skin of leg and abdominal wall. e. L. following V. cutanea abdominalis femoralis. f. L. following V. cutanea pubica. f'. Tributary of f. f". L. draining ventral lip of cloaca. g. L. following V. cutanea caudalis. g'. Cutaneous tributary of g. h. Common trunk of L. following V.v. cutanea pubica and cutanea caudalis. j. L. draining dorsal lip of cloaca. k. L. draining muscles. k'. L. draining M. gluteus primus (cut). l.L. draining articulations. m. L. draining bones. 1. M. gastrocnemius. 2. M. flexor ~~medius~~ perforatus indicus secundus pedis. 3. M. flexor perforatus medius secundus pedis. 4. M. peroneus longus. 5. M. gluteus primus. 7. M. biceps flexor cruris. 6. M. semitendinosus. 8. M. adductor magnus. 9. M. extensor femoris. 10. M. sartorius. 11. M. semimembranosus. 12. M. gluteus medius. 13. M. gluteus minimus. 14. M. levator coccygis. 15. M. levator caudae. 16. M. transversus perinei. 17. M.femoro-caudalis. 18. Uropygial gland.

Fig. 12. continued.
19. Ischium. 20. Pubis. 21. Ilium. 22. Abdominal wall.

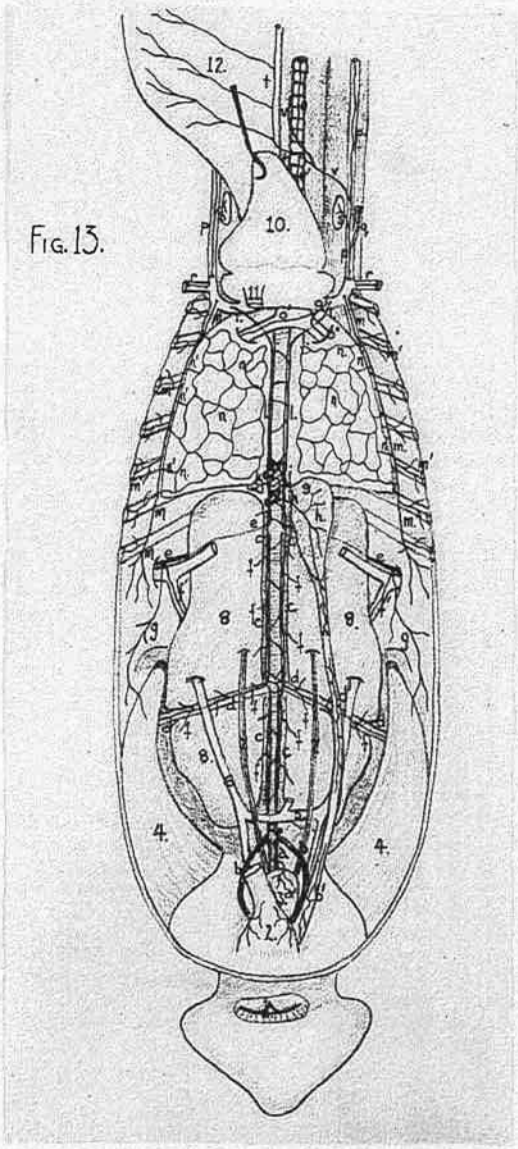

Fig. 13.

Fig. 13. Lymphatics of trunk. (Most of alimentary system removed. Parts of posterior vena cava and V.v. iliacae communes removed. Heart retracted.)
a. L. following A. sacralis media. a'. Tributary of a. b. L. following A. pudenda communis. b'. Tributary of b. from posterior third of oviduct. c. L. following abdominal aorta. d. L. following A. ischiadica. d'. Tributary of d. from middle third of oviduct. e. L. following A. cruralis. f. L. draining kidney. f'. L. draining kidney which follow V. iliaca interna. g. L. following A. epigastrica. h. L. draining ovary and anterior third of oviduct. j. Plexus formed by L. following abdominal aorta, anterior mesenteric artery and coeliac axis. k. L. draining adrenal gland. l. Thoracic ducts. m. L. following A. thoracica interna. m'. Tributaries of m. from ribs and intercostal muscles. n. Network of superficial L. of lungs. n'. L. draining n. o. Common trunk of deep L. of lungs. o'. L. following V. pulmonis dextra. o". L. following V. pulmonis sinistra. p. L. following V. jugularis. q.L. following

Fig. 13. continued.
V. vertebralis. r. L. following V. subclavia. s. L. draining thyroid gland. t. L. draining ventral and left surfaces of oesophagus and left surface of crop. u. L. draining trachea. v. Common trunk of t. and u. 1. Cloaca. 2. Rectum (Large intestine). 3. Bursa Fabricii. 4. M. obturator internus. 5. Anastomatic branch joining V.v. iliacae internae. 6. V. iliaca interna. 7. Ureter. 8. Kidney. 9. Ovary. 10. Heart. 11. Posterior vena cava. 12. Crop.

FIG. 14.

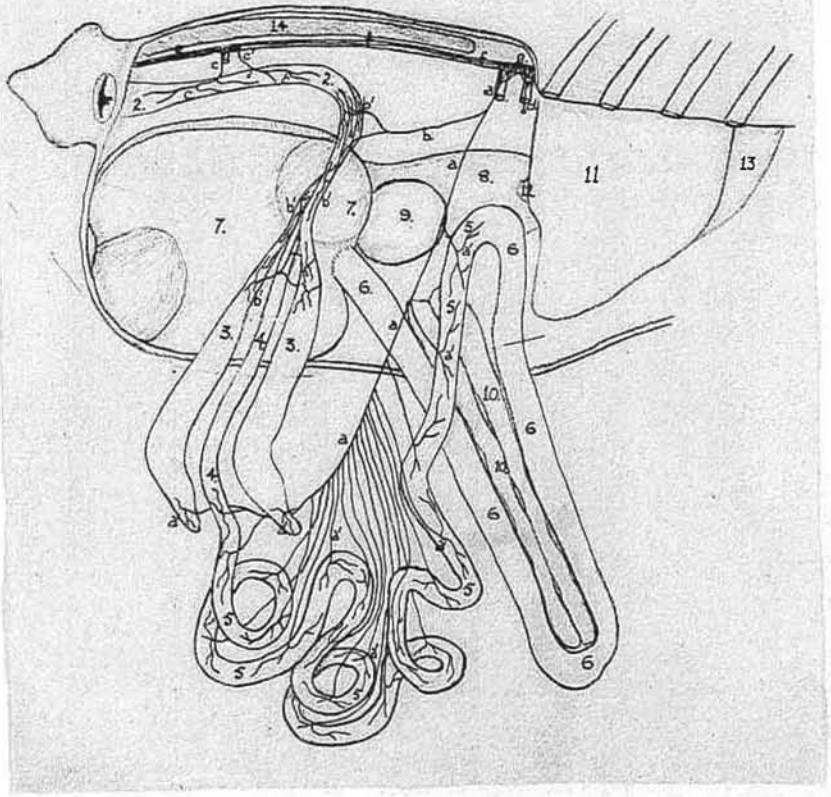

Fig. 14. Lymphatics following anterior and posterior mesenteric arteries. (Viscera viewed from right side and below.)
a. L. following A. mesenterica cranialis. a'. Tributaries of a. from jejeunum, ileum and caeca. b. L. following A. recurrens ileocoeliacus. b'. Tributaries of b. c.c'. L. following A. mesenterica caudalis, of which c'. does not follow artery in the mesentery. d. L. following coeliac axis. e. L. following A. sacralis media. f. L. following abdominal aorta. g. Plexus formed by L. following abdominal aorta, anterior mesenteric artery and coeliac axis. 1. Cloaca. 2. Rectum (Large intestine). 3. Caeca. 4. Ileum. 5. Jejeunum. 6. Duodenum. 7. Gizzard. 8. Proventriculus. 9. Spleen. 10. Pancreas. 11. Liver. 12. Gall bladder. 13. Heart. 14. KIdney.

Fig.15.

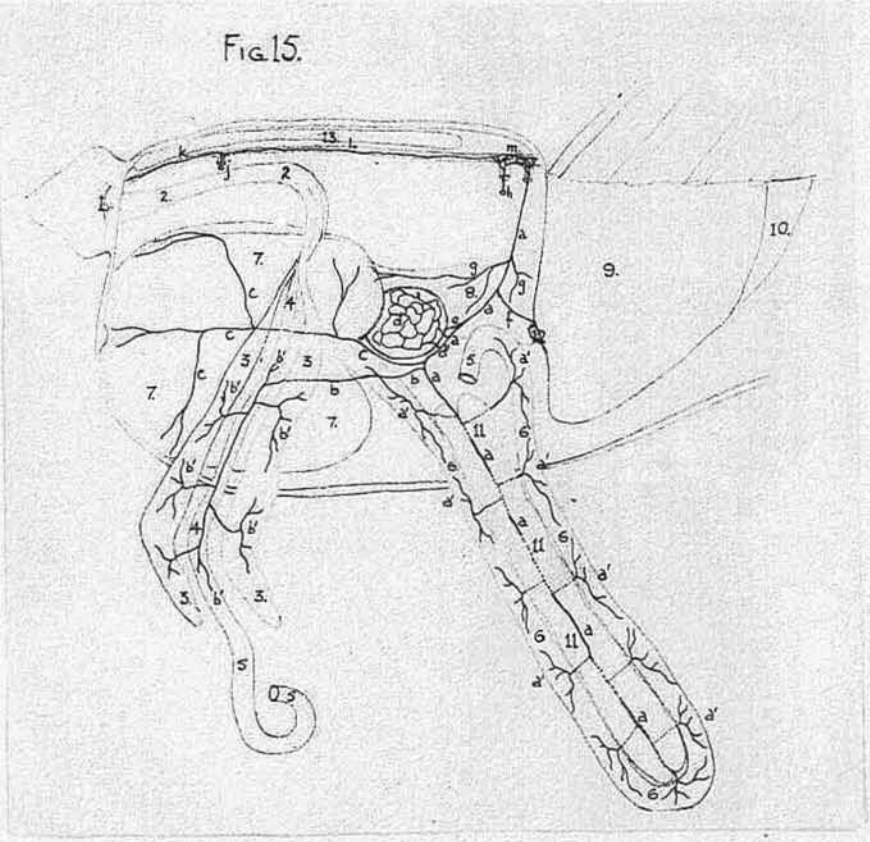

Fig.15. Lymphatics following coeliac axis. (Most of jejeunum removed. Duodenum drawn forwards. Viscera viewed from right side and from below.)
a. L. following coeliac axis. a'. Tributaries of a. from duodenum. b. L. following A. recurrens ileo-colicus. b'. Tributaries of b. c. L. draining right surface and dorsal border of gizzard. d. Plexus in splenic capsule. d'. L. draining d. e. L. draining left surface and ventral border of posterior half of proventriculus and left surface and ventral border of gizzard. f. L. draining right lobe of liver. g. L. draining right surface and dorsal border of posterior half of proventriculus. h. L. following A. mesenterica cranialis. j. L. following A. mesenterica caudalis. k. L. following A. sacralis media. l. L. following abdominal aorta. m. Plexus formed by L. following abdominal aorta, anterior mesenteric artery and coeliac axis. 1. Cloaca. 2. Rectum (Large intestine). 3. Caeca. 4. Ileum. 5. Jejeunum. 6. Duodenum. 7. Gizzard. 8. Proventriculus. 9. Liver. 10. Heart. 11. Pancreas. 12. Gall bladder. 13. Kidney.

Fig.16.

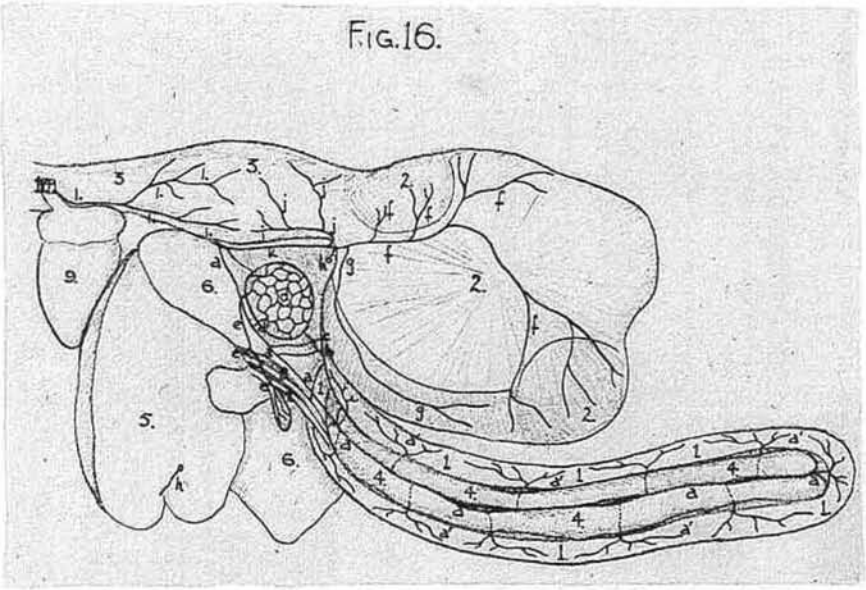

Fig. 16. Lymphatics following coeliac axis. (Left lobe of liver drawn forwards. Viscera viewed from left side and from below.)
a. L. following coeliac axis. a'. Tributaries of a. from duodenum. b. L. following A. ileo-colicus recurrens. c. L. draining right surface and dorsal border of gizzard. d. Plexus in splenic capsule. d'. L. draining d. e. L. draining right lobe of liver. e'. Tributary of e. from wall of gall bladder. f. L. draining left surface of gizzard. g. L. draining ventral border of gizzard. h. L. draining left lobe of liver (cut). j. L. draining left surface and ventral border of posterior half of proventriculus. k. Common trunk of f., g., h. and j. l. L. following V. proventricularis communis.
1. Duodenum. 2. Gizzard. 3. Proventriculus. 4. Pancreas. 5. Left lobe of liver. 6. Right lobe of liver. 7. Cystic duct. 8. Hepatic duct. 9. Heart. 10. Left anterior vena cava.

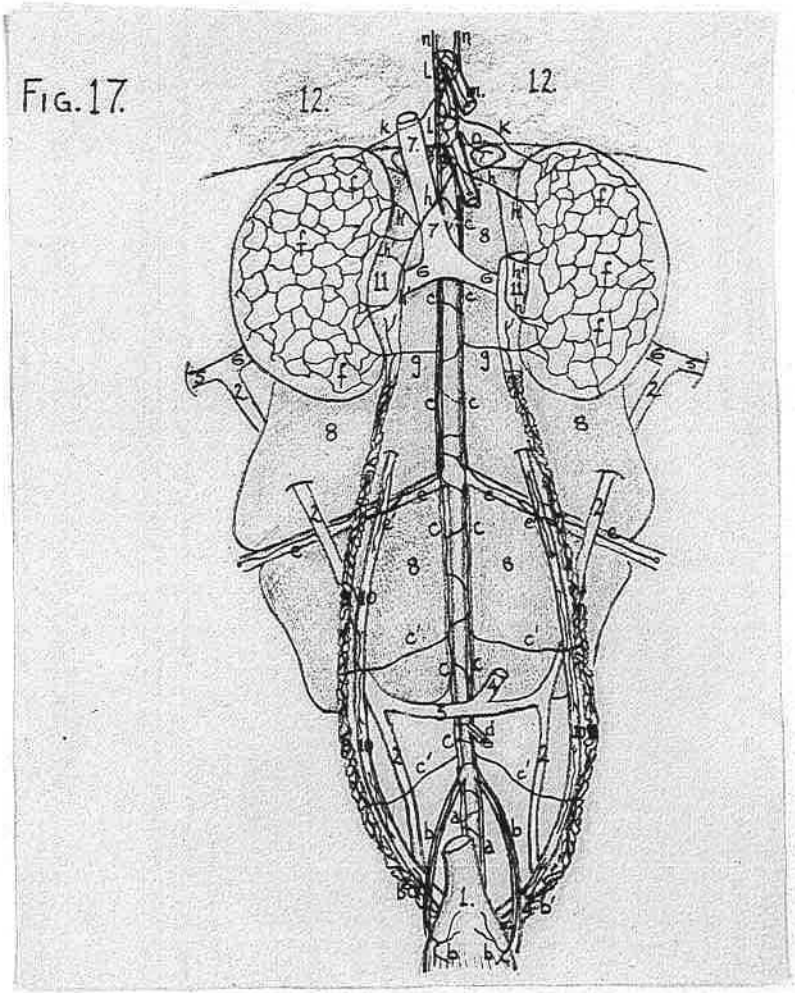

Fig. 17. Lymphatics of male genital organs.
a. L. following A. sacralis media. b. L. following A. pudenda communis. b'. Tributaries of b. from vas deferens and ureter. c. L. following abdominal aorta. c'. Tributaries of c. from vas deferens and ureter. d. L. following A. mesenterica caudalis. e. L. following A. ischiadica. e'. Tributaries of e. from vas deferens and ureter. f. Plexus in capsule of testicle. g. L. draining posterior fourth of testicle, epididymis and part of vas deferens. h. L. draining anterior three-fourths of testicle. h'. Tributaries of h. j. L. following A. mesenterica cranialis. k. L. draining anterior extremity of testicle. l. Plexus formed by L. following abdominal aorta, anterior mesenteric artery and coeliac axis. m. L. following coeliac axis. n. Thoracic ducts. o. L. draining adrenal gland. 1. Rectum (Large intestine). 2. V. iliaca interna. 3. Anastomatic branch between V.v. iliacae internae. 4. V. coccygeo-mesenterica. 5. V. iliaca externa. 6. V. ilica communis. 7. Posterior vena cava. 8. Kidney. 9. Vas deferens. 10. Ureter. 11. Epididymis. 12. Lung.

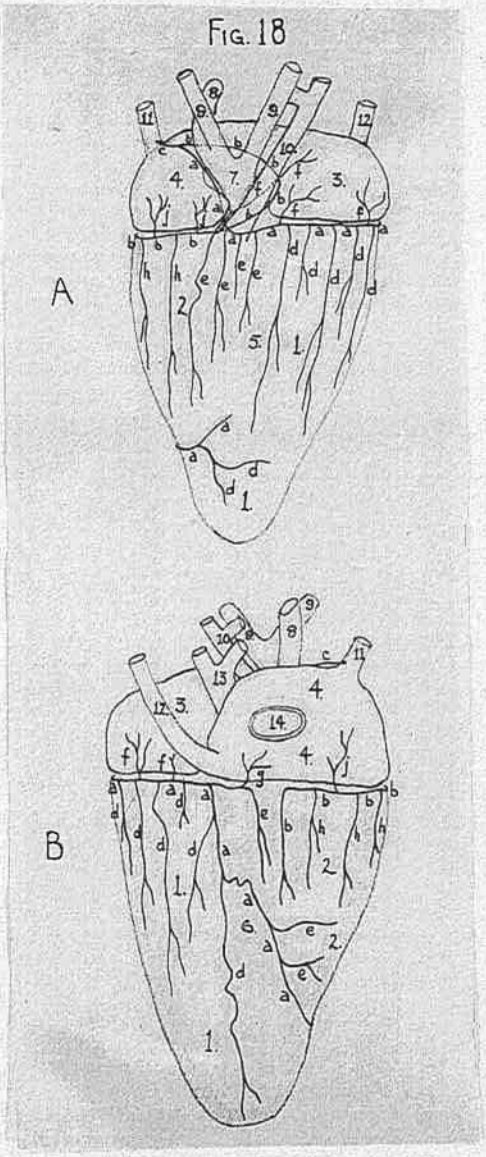

Fig. 18. Lymphatics of the heart. (A. Ventral or sternal surface. B. Dorsal or hepatic surface.)
a. Left lymphatic trunk of heart. b. Right lymphatic trunk of heart. c. Common termination of a. and b. d. Tributaries of a. from left ventricle. e. Tributaries of a. from right ventricle. f. Tributaries of a. from left auricle. g. Tributaries of a. from right auricle. h. Tributaries of b. from right ventricle. j. Tributaries of b. from right auricle. 1. Left ventricle. 2. Right ventricle. 3. Left auricle. 4. Right auricle. 5. Ventral interventricular groove. 6. Dorsal interventricular groove. 7.8. Aorta. 9. A. brachio-cephalica. 10. A. pulmonis. 11. Right anterior vena cava. 12. Left anterior vena cava. 13. V. pulmonis. 14. Posterior vena cava.