which the disease is of long standing should not be subjected to this operation, nor should cases complicated by abscess. On the other hand, paralysis is rather an indication for the operation than against it. In suitable cases the procedure is practically without danger.

Duration of the Treatment of Pott's Disease.—The duration of treatment must depend upon the extent and the severity of the disease. It may be divided into two stages, one in which the disease is active, when absolute fixation is indicated, and a stage of recovery in which supervision is required. Tuberculosis of the spine is slow in progress and recovery is insecure. The course of the disease is shortest in the cervical region, but even here brace treatment will be required for at least two years. In the lumbar region twice this time may be assigned to this period, and in the upper and middle dorsal regions, where the deformity may increase long after the cure of the disease, support may be required indefinitely.

Indications of Recovery.—As pain is almost always relieved by efficient treatment, its absence is no indication of cure. Muscular spasm usually persists as long as the disease is active; it is therefore a valuable indication in prognosis. The appearance of the kyphosis has some significance. In the early stage of disease the area of the destructive process is not defined; but when consolidation has taken place, its extent is shown by the rigid vertebræ that stand out from the remainder of the spine separated from it by a well-marked depression, deeper below than above. In all cases removal of support must be gradual and its effect must be watched. When the disease is cured massage of the muscles, breathing exercises, and mild gymnastics may be employed with advantage. It may be noted that abscess or even paralysis may appear many years after the apparent cure of disease.

If recovery from Pott's disease has been complete, and if the deformity is slight, the individual may be to all intents normal; but if the deformity is great, his condition is abnormal, and he is unfitted for ordinary occupations. Such individuals usually suffer from neuralgic pain about the weakened spine, and in most instances some form of light support must be worn.

Royal Whitman.

SPIROMETER. See *Respiration.*

SPLEEN.—In the following description of the spleen the physiological is blended with the anatomical, for in the present state of our knowledge of the subject it is practically impossible to separate them. Throughout the article the description begins with the coarser structures and gradually passes to the finer ones, in order to point out more definitely that this organ is composed of a multitude of histological units. It will be apparent to the reader that our knowledge of the structure of the spleen is much more satisfactory than that of the function, but it is usually in this order that anatomy and physiology progress.

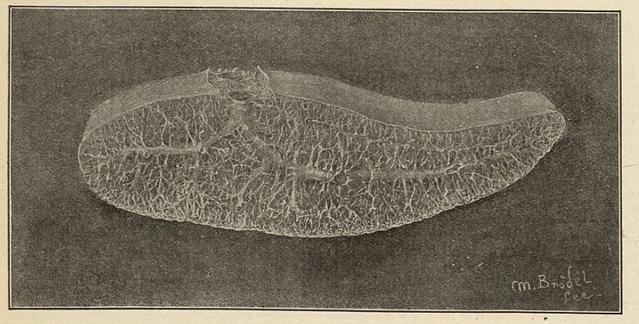

FIG. 4458.—Transverse Section of the Framework of the Spleen. Natural size. It shows the relation of the vein and the artery.

FRAMEWORK OF THE SPLEEN.—If pieces of a fresh spleen are gently crushed between the palms of the hands in a stream of water, the pulp is soon washed out, leaving only the coarser network of fibres, or trabeculæ, the capsule, and the blood-vessels. When these are examined with the low power of the microscope, it is found that the trabeculæ are of uniform size and encircle spaces, each of which is about 1 mm. in diameter. This rough method of demonstration may be aided by macerating pieces of the spleen in water or in a solution of potassium hydrate, or by digesting them in a solution of pancreatin; but the specimens thus obtained are not much more instructive than those made by the simple water method. After repeated tests I finally invented a method by which the trabecular system of the spleen is demonstrated clearly and definitely.

The spleen is removed from the body with a portion of its mesentery, care being taken not to tear the capsule. It is kept completely covered with water at ordinary room temperature for a week or more, until the pulp is soft, the water being changed from time to time in order to prevent excessive putrefaction. When the pulp is soft the tip of the spleen is cut off and the pulp stripped out. The spleen is then filled with water and washed until the trabecular system and capsule is perfectly clear and clean. By repeated washings the framework of the spleen is finally clean, and it can now be strained, blown up, and dried. After the trabecular framework is purified in this way, it can be digested, stained, or treated with various reagents in order to determine the nature of the fibres of which it is formed.

The capsule and trabecular system being perfectly clean, it is to be stained with acid fuchsin and then thoroughly washed with alcohol. A tube is now tied into the cut end of the spleen and the specimen is kept distended with compressed air. After it is dry the mesenteric border and adjacent capsule are removed with a forceps and scissors, thus giving a most magnificent preparation. Fig. 4458 is from a section of dog's spleen prepared in this way.

STRUCTURE OF THE CAPSULE.—It is easy to show that the capsule of the spleen is composed of both white fibrous and yellow elastic tissues. A strip of the capsule boiled in dilute KOH will show the one, while digesting with pancreatin and further microscopic study will show the other. After the capsule of the spleen, the trabeculæ, and a piece of tendon have been digested in pancreatin for eighteen hours to remove all the elastic tissue, boiling them in HCl 0.5 per cent. or KOH 0.5 per cent. will dissolve the tendon in five minutes, the capsule in about twenty minutes, and the trabeculæ in about one hour. In each test a control section of the lymphatic gland shows that its reticulum is less resistant than are the fibrils of the capsule of the spleen. These tests, the value of which will be discussed later on, show that the capsule of the spleen contains, besides yellow elastic tissue, also white fibrous and reticulated. The white fibres can easily be recog-

nized with the microscope by their wavy appearance and by their color, as well as by the great amount of gelatin which can be obtained from them when boiled. That it takes as much time to dissolve the capsule in boiling KOH or HCl as it does to dissolve a section of a lymphatic gland indicates that both are made up of the same tissues. That these two tissues are at least histologically unlike tendons is shown by their appearance under the microscope and by the fact that they will resist boiling acid and alkali at least four times as long as tendon does. From these observations I must conclude that the capsule of the spleen is composed of elastic, white fibrous, and reticulated tissues.

In the spleen of an ox macerated in water, digested in pancreatin, blown up and dried, the capsule is easily split into two layers—an outer which is composed in great part of white fibrous tissue, and an inner which appears to be of the same constitution as is the trabecular network. Between these two layers the lymphatics are located.

If a portion of the capsule of the spleen is first treated with hot dilute KOH, or is digested in pancreatin, and then stained and mounted in Canada balsam, it is found that the fibrils radiate toward centres from which the trabeculæ arise. Such a specimen is pictured in Fig. 4459. In case the preparation is treated with KOH the specimen thus obtained is composed of yellow elastic tissue, while if it is obtained through pancreatic digestion it is composed of white fibrous tissue and reticulum fibrils.

The three groups of fibrils forming the capsule of the spleen are all arranged after the same plan. When the white fibres and reticulum fibres are first removed by boiling the capsule in dilute KOH, leaving only the elastic tissue, a specimen is obtained which could easily be mistaken for the tissues destroyed, were it not for the chemical and color reactions, as well as the high refractive index of the elastic fibres.

Frozen sections of the spleen, which have first been macerated in water or in ten-per-cent. NaCl solution and then stained in hæmatoxylin, show the capsule and trabeculæ intensely stained, as all the non-striated muscle cells and elastic tissue are still present in them. This method is not suited to determine the character of the tissues constituting the capsule and trabeculæ, as the presence of all obscures the individual. When, however, the sections are first digested with pancreatin, it is found that the capsule is composed of delicate and wavy fibres, which in turn are arranged in heavier bundles; from these arise fine fibrils and anastomosing fibrils. That a number of white fibres are in the capsule is shown by the large quantity of gelatin easily obtained from it and by the bundles of wavy fibrils seen with the microscope. These bundles lie in great part immediately below the peritoneum, radiate toward the trabeculæ, and are continued into them. That the capsule also contains reticulated tissue is shown by the number of anastomosing fibrils present in teased specimens, as well as by the great resistance of the capsule shown when it is boiled in dilute KOH or HCl after all the cells and elastic tissue fibres have been removed by digestion with pancreatin. When boiled with dilute acid or alkali, as shown in Table I., the capsule proves to be much more resistant than is either a section of the lymphatic gland or a bundle of fibres from the tendo Achillis.

The conclusion to be drawn from these tests is that the boiling first removes the white fibres and leaves only the reticulated tissue, which finally falls into pieces. Although these tests are not absolutely definite, they at least make it highly probable that reticulated tissue exists in the capsule of the spleen. The fact that the fine anastomosing fibrils can be seen with the microscope in digested specimens is an additional argument in favor of this view. This question will not be completely solved until an extensive chemical study is made on these fibres obtained from different organs in addition to the invention of a satisfactory differential stain.

The group of the three kinds of connective-tissue fibrils then radiates toward centres, as shown in Fig. 4459. From these centres the trabeculæ arise and penetrate the spleen at right angles to the capsule. In general from four to six trabeculæ surround small masses of spleen

FIG. 4459.—Capsule of the Dog's Spleen Stripped Off Fresh and Digested in Pancreatin. Thoroughly washed in water and spread on a glass slide and allowed to dry. Stained with acid fuchsin and partly decolorized with picric acid. Enlarged 30 diameters. The trabeculæ are torn off at their capsular origin.

tissue, about 1 mm. in diameter. These masses I have termed the typical lobules or anatomical unit of the spleen.[1] They are well seen on the surface of fresh contracted spleens as slight elevations about as large as pins' heads. The great number of muscle cells within the trabeculæ makes the lobules immediately below the capsule protrude when they contract.

TABLE I.—FRESH TENDO ACHILLIS, SECTIONS FROM LYMPHATIC GLAND, CAPSULE OF SPLEEN AND TRABECULÆ FROM THE DOG DIGESTED IN STRONG PANCREATIN FOR EIGHTEEN HOURS. THEN THOROUGHLY WASHED AND BOILED IN KOH ONE-HALF PER CENT. AND IN HCL ONE-HALF PER CENT.

Treated with One-Half Per Cent. KOH Solution.

Time boiled. Minutes.	Tendon.	Lymphatic gland.	Spleen capsule.	Trabeculæ.
1	×	×	×	×
4	+	×	×	×
30	+	+	×	×
75	+	+	+	×
99	+	+	+	+

Treated with One-Half Per Cent. HCl Solution.

Time boiled. Minutes.	Tendon.	Lymphatic gland.	Spleen capsule.	Trabeculæ.
1	×	×	×	×
7	+	×	×	×
15	+	+	×	×
30	+	+	+	×
90	+	+	+	+

× = swollen; + = dissolved.

STRUCTURE AND ARRANGEMENT OF THE TRABECULÆ.—The trabeculæ in the capsule are composed of elastic, white fibrous and reticulated tissues, as well as great quantities of non-striated muscle cells.

The elastic fibres may be demonstrated by boiling the isolated trabeculæ with dilute KOH, but this is not a

satisfactory method, for the elastic fibres separate and are easily lost. Henle's method[2] of treatment with cold dilute KOH and afterward washing with water is only fairly satisfactory, for it does not destroy completely the reticulum and fibrous tissue. To be sure, the elastic tissue prepared by Henle's method is easily recognized under the microscope by its high refractive index. Furthermore, the great destruction of the elements in isolating the elastic fibres by Henle's method makes it difficult to locate the part of the spleen from which the fibres have been obtained.

As regards the distribution of elastic tissue in the spleen, a decided step in advance has been made recently by Hoehl[3] in using Spalteholz's method of staining elastic tissue. By this method it is shown that there are numerous elastic fibres not only in the trabeculæ, but that they extend somewhat into the spleen tissue between the pulp cells. Sections in which the elastic fibres have been stained black by Spalteholz's method and the reticulum red with picrocarmine show that the finest elastic fibres never communicate with the reticulum.

After the cells and elastic fibres are removed from the trabeculæ, the reticulum and white fibrous tissues alone remain. To separate these two definitely again becomes the stumbling-block in connective-tissue study. That reticulum is present is shown by the fact that the fibres anastomose and by the great resistance of this tissue toward boiling KOH and HCl, as shown in the above tables. It takes more than twenty-two times as long to dissolve the trabeculæ than the tendo Achillis in one-half-per-cent. KOH, and six times as long in one-half-per-cent. HCl. To prove the presence of fibrous tissue is by no means as easy, for whatever reagent is used to dissolve the reticulum dissolves also the white fibrous tissue. Teased trabeculæ occasionally show bundles of wavy fibres which have all of the appearance of white fibrous

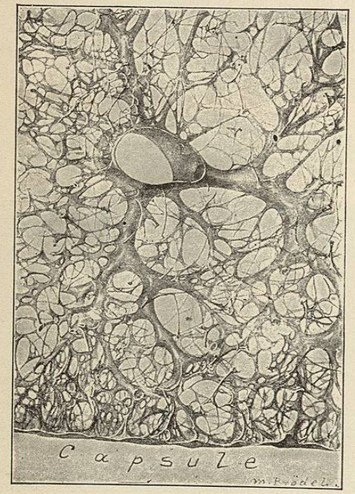

FIG. 4460.—Section of the Spleen Treated as that from which Fig. 4458 was Drawn. The vein had been injected with Prussian blue. Enlarged 8 diameters.

tissue. In case it is finally proved that reticulated tissue does not yield gelatin when boiled, the presence of gelatin will indicate the presence of white fibrous tissue.

Hoehl[4] has shown that the non-striated muscle fibres are embedded in a mass of most delicate connective-tissue fibrils, which, if I may judge from specimens he has sent me, appear to be reticulum fibrils. I have investigated non-striated muscle from the stomach, intestine, and uterus, and can fully confirm Hoehl's observation. It appears to me that the reticulum of the trabeculæ of the spleen may be considered as a sheath to the muscle, as is the case of non-striated muscles in other parts of the body. It is a very resistant reticulum, more so than that of the lymph follicle, and much more so than that of the pulp of the spleen.

All of the connective tissues and muscles which constitute the trabeculæ form the main skeleton of the spleen. From a number of estimations I find that there are from fifteen thousand to twenty-five thousand trabeculæ, each from 0.05 to 0.1 mm. in diameter, arising from the capsule of the dog's spleen to pass at right angles into the pulp. These many beautiful muscle strands outlining about twenty-five thousand subcapsular lobules pass into the depth of the spleen, anastomose and subdivide, and finally attach themselves to the walls of the veins as well as to the trabeculæ arising from the opposite side of the spleen.

The trabecular system of the spleen appears to be irregular in arrangement, but when examined closely it is shown that it surrounds distinct areas, about 1 mm. in diameter. Not only are these areas shown in the picture when the capsule has been removed, but they also appear as rounded elevations immediately below the capsule. This mottled appearance on the surface of the spleen is seen still better in the fresh spleen, as the contraction of the muscles causes the pulp between the trabeculæ to protrude under the capsule. When the artery of the fresh spleen is injected with an aqueous solution of Prussian blue, it will be noticed that the centres of these elevations are first injected, making the spleen mottled. The blue centres of these elevations gradually extend as the injection is continued, and finally flow together, when it is found that the fluid has entered the veins.

By comparing the specimens thus obtained, it is seen that we are dealing with an orderly arrangement of the spleen tissue which can easily be recognized with the naked eye. It is practically identical with the arrangement of that of the liver, and I shall speak of these anatomical units as the lobules of the spleen. *The anatomical unit of the spleen is a mass of pulp about one millimetre in diameter, with the main veins and muscle on its periphery and the artery in its centre.*

In turn the lobule is broken up into histological units, which I shall consider when discussing the termination of the arteries. If the pulp of the spleen is removed by washing it out and the trabecular system distended and dried, the lobules are seen outlined beautifully when the specimen is viewed as a transparent object. They appear five- or six-cornered, with darker points at about three of the corners, as is the case in the liver. These darker corners represent the position of the more important veins which encircle the lobule. But in addition to the trabeculæ which encircle the lobule, as shown in Fig. 4460, there are many other trabeculæ around the lobule, and a number of them penetrate it, although the greater number of the trabeculæ are on the periphery. The illustrations of the corroded spleen, as shown in Fig. 4458, do not show the lobules as well as Fig. 4460 does, for the former was drawn from a specimen in which the veins were not injected, while the latter is from a specimen in which they were injected. In case the veins are not injected but are only distended by the general distention of the whole organ, the tips of the veins blend with the trabeculæ and thus partly obliterate the sharpness of the lobule. In case the veins are partly injected, as in Fig. 4460, the lobule is outlined by the veins, while the trabeculæ which penetrate the lobule are also shown. Stained sections of injected spleens also bring out this point. Fig. 4460 shows beautifully the deep lobules as well as the ones immediately below the capsules. While there are from fifteen thousand to

twenty-five thousand subcapsular lobules in the dog's spleen, there are from fifty thousand to one hundred thousand deep lobules, making the sum total of lobules between sixty-five thousand and one hundred and twenty-five thousand, or an average of eighty thousand. Lobules in any portion of the spleen can be seen very well in corroded specimens, either injected or uninjected, but they are somewhat obscure in an ordinary section, because the lobules are perforated by a number of trabeculæ. Yet if only the coarser arteries and veins are injected, the peripheries of lobules are outlined by the veins, while the main arterioles mark the centres of them.

We can therefore classify the trabeculæ as well as the veins as interlobular and intralobular; the interlobular veins and trabeculæ are closely related, while the intralobular veins and trabeculæ are not related.

With the naked eye the different kinds of trabeculæ cannot be observed (Fig. 4458) unless the veins are exceedingly well shown, but with a slight magnification the various kinds of trabeculæ are easily seen. Fig. 4460 shows this beautifully. The interlobular trabeculæ are here seen to surround in part the terminal or interlobular veins, a portion of them lie between the veins, while another portion of them perforate the lobule. Those which lie between the lobules together with the veins make the greater part of the network of the spleen, as shown in Fig. 4458. In Fig. 4460 the lobule is outlined by interlobular trabeculæ and veins, while the interior of the lobule is cut up into compartments by the intralobular trabeculæ. These intralobular trabeculæ communicate with one another to form a group of meshes within the lobule, each 0.2 to 0.3 mm. in diameter. So the lobule, which is about 1 c.mm. in volume, is subdivided into about ten parts by the intralobular trabeculæ. Within each of these subdivisions there is a fine venous plexus which extends in all planes throughout the lobule. Each of the meshes formed by the venous plexus is 0.05 mm. in diameter, and there are about six thousand of them within each lobule, or about five hundred million for the whole spleen. In a number of specimens the estimation of the histological units obtained by dividing the volume of the spleen by the cube of the diameter of the histological unit gave in each instance about five hundred million. The meshes formed by the venous plexus of the lobule are occupied by the spleen pulp, within the centre of which the terminal arteries end. This small mass of spleen tissue encircled by a vein with the terminal arteriole in its centre forms the histological unit of the spleen.

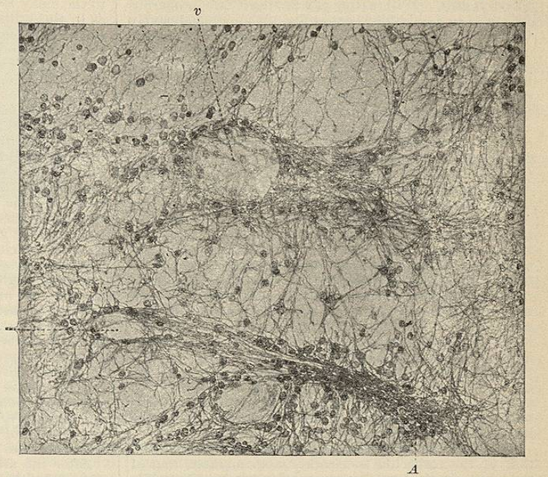

FIG. 4461.—Frozen Section of a Spleen made Œdematous by Injecting it with Colorless Gelatin. The section was then washed in warm water, which removed the gelatin and most of the cells, leaving the reticulum. Stained with gentian violet and mounted in glycerin. Enlarged 250 diameters.

RETICULUM OF THE SPLEEN.—I have shown above that the trabeculæ are composed in great part of a very resistant reticulum placed between the muscle cells. That this should be the case is not very remarkable, since Hoehl has shown that the non-striated muscle fibres in other parts of the body are enveloped in a most delicate and extensive network of reticulum fibrils. I have tested Hoehl's work and can confirm it in every respect as regards the sheath of non-striated muscle fibres. This envelopment certainly has the greatest meaning in aiding those cells to perform their function. Were they simply stuck together by a cement substance, it is very difficult to conceive how they could act so very delicately and also with so much power without pulling apart. But as it is, each cell lies within a basket of delicate reticulum fibrils, which acts as ligaments passing in all directions.

The reticulum fibrils in the trabeculæ must be viewed as the sheath of their muscle cells. It aids to tie them together. Since the trabeculæ are in strands the fibrils are also in strands, in order to give them their best support. The reticulum fibrils of the trabeculæ are more resistant when boiled in dilute HCl or dilute KOH than are those of the capsule of the spleen or those of the lymph gland, as Tables I. and II. show. It is therefore a very tough reticulum.

In addition to this resistant reticulum of the trabeculæ, the lobule itself is filled with a very delicate reticulum, which is very easily destroyed and therefore hard to demonstrate by ordinary methods. I have noted in my earlier communication on reticulum that by the ordinary methods it was impossible to demonstrate the presence of reticulum between the trabeculæ within the spleen. At the same time Oppel[5] showed by using Golgi's method that the Malpighian corpuscle of the spleen and the tissue surrounding it was literally filled with a network of fibrils, which he termed *Gitterfasern*. Their appearance and arrangement at once showed that they must be reticular fibrils, but I was never able to isolate them by means of pancreatic digestion. In addition to Oppel's observation, we are all familiar with the reticulum of the spleen as seen in fresh as well as in hardened specimens. Hoehl has also shown us that when small pieces of spleen are washed for days in flowing water the cells are all washed out, leaving a beautiful network of fibrils, which he describes as reticulum. A frozen section of the spleen can also be washed out in flowing water, but the method is not satisfactory, as the section becomes matted together or is very liable to fall into pieces. When, however, a spleen is made œdematous by injecting it with gelatin, it can easily be cut by the freezing method, and the sections thus obtained are well suited for further study. The gelatin separates the tissue and holds everything in place. Such sections can be fixed with formalin and stained, or can be shaken out by simply placing them in warm water to dissolve the gelatin. They can be used for further tests with acid and alkali, or they can be digested with pancreatin.

When a frozen section of spleen made œdematous with gelatin is passed through formalin, it becomes well fixed and the gelatin can no longer be dissolved by heating or

by digesting. Such a section stained with hæmatoxylin carmine, or a dilute aniline, gives most instructive pictures. The fibrils of reticulum are widely separated, upon them lie the fixed cells, and between them pass the blood-vessels. Within the gelatin itself are numerous free cells, and red blood corpuscles, proving conclusively that they are not within the blood-vessels. If, instead of hardening the section in formalin, it is placed in warm water to dissolve the gelatin, it is seen that the section becomes smaller in area, showing that the reticulum is elastic, but in so doing the gelatin carries out all of the free cells, leaving almost a pure reticulum. Such a section can be coaxed upon a glass slide, stained under the cover glass with acid fuchsin or with gentian violet, differentiated with picric acid, and preserved in glycerin (Fig. 4461). Such specimens are easily made, and they show perfectly the reticulum as demonstrated by Oppel and by Hoehl.

Further tests with pancreatin show that the reticulum of the spleen lobule is easily digested in it. The same is true if sections or blocks either of fresh or of hardened spleen are digested in pancreatin. In all cases the reticulum of the lobule is dissolved, but that of the trabeculæ remains. In pancreatin, then, this reticulum, as elastic tissue, dissolves. When, however, sections of reticulum are treated with dilute KOH, dilute HCl, or acetic acid, it at once swells, becomes transparent, while the elastic fibres show their usual reactions. With these reagents the reticulum shows its usual reactions. The reticulum of the spleen lobule is about as delicate as fibrin and at times I have thought that it is fibrin, but its distinct anatomical relation to other structures within the lobule proves that it must be constantly present.

The difference between the reticulum of the lobule and that of the trabeculæ is certainly most marked; that of the lobule is the least resistant reticulum known, while that of the trabeculæ is the most resistant. It only shows that there are a variety of reticula, and here we encounter side by side the two extremes. An analogous condition is found in fibrin. Newly formed fibrin is very easily digested, while fibrin from old fibrinous deposits is most resistant, not being digested in pepsin or pancreatin nor dissolved in strong acids. It is also not possible that the two reticula found in the spleen could be two varieties of the same thing, as it is impossible to conceive of the reticulum of the lobule shifting to become the reticulum of the trabeculæ.[6]

The main reactions of the connective-tissue fibrils are expressed in the following table:

Table II.

	Yellow elastic.	White fibrous.	Reticulum ordinary.	Reticulum from lobule of the spleen.
Boiling dilute HCl or KOH	0	+	+	+
Pepsin digestion	+	+	+	+
Pancreatic digestion	+	0	0	+
Maceration	+(?)	0	0	+
Gelatin	0	+	+(?)	(?)
Reticulin	0	0	+	(?)

0 = not changed or no.
+ = dissolved or yes.

The Arteries of the Spleen.—The arterial system of the spleen is arranged, as in all other organs, in such a manner that equal parts of it will receive equal quantities of blood during a given period of time. So definite is this adjustment that in studying organs we must always look for terminal branches which supply the final units of tissue, as is the case in the villus of the intestine. These tissue units are piled upon one another in the solid organs much like the grapes in a bunch, but in turn they may be clustered around centres as are the bunches of grapes upon a vine, which again may be repeated many times like the vines in a vineyard. This is the arrangement in the spleen, and when it is studied embryologically as well as physiologically it is found that it could not well be otherwise.

Without discussing the question extensively I allude to the many researches of Ludwig and his pupils as well as to the brilliant studies of Thoma bearing upon this question. Ludwig has shown us that in the circulation through an organ no part of the organ is favored more than another, while Thoma has demonstrated the conditions which regulate the size of the arteries not only in the embryo but also in the adult. Ignoring the causes which produce the first growth of the capillaries, Thoma's work establishes the fact that in a given vessel there is a relation between its lumen and the circulation through it. Any factor which makes the blood flow more rapidly will cause the vessel to enlarge, while anything which diminishes the circulation will make the vessel become smaller. This law is constantly at work not only in increasing the number and size of the blood-vessels in the growth of an organ, but also in diminishing and reducing them. It follows that in a finished organ the arteries are beautifully distributed according to system throughout it and that the forces which produced this relation are ever ready to correct little difficulties which are constantly arising.

The main trunk of the splenic artery gives off a number of branches, which, according to their size, are distributed to proportionately large parts of the spleen. In general, throughout the spleen the arteries are separated as far as possible from their corresponding veins, but at their points of entrance a number of the arteries are located close to the veins. This must be due to a secondary shifting of the large vessels in their development, as is also the case in the lung and the liver.

After the arteries enter the spleen their main trunks remain on the proximal side of the veins, as Fig. 4458 shows. In general, they lie midway between the larger veins and the capsule. These primary branches in turn give rise to branches of the second order, which pass directly toward the capsule, there passing to the proximal side of the spleen, crossing the large veins, but keeping away from them as far as possible, and give rise to all of the lobular arteries of the spleen.

The spleen of an animal killed by bleeding is found to be contracted and relatively pale after having been exposed to the air for a very short time. Its surface is rough, due to a protrusion of the lobules immediately below the capsule. If the artery of a spleen which shows these characteristics is injected with aqueous Prussian blue, it will be found that the centres of the lobules below the capsule first turn blue, thus showing conclusively the relation of the artery in the lobule. From these many blue points in the centres of the lobule the blue spreads as the injection is continued until their peripheries are reached. At this time the blue lobules coalesce and the Prussian blue appears in the veins. As soon as the blue has once entered the veins, secondary injections take place through the veins in distant portions of the spleen, giving pictures the reverse of the ones just described.

The lymphatic tissue encircles the arteries, increases at points into marked follicles, and accompanies them until they reach the histological units, where they form the splenic ellipsoids. The thickness of this lymphatic sheath varies very much in different spleens, and often in different portions of the same spleen. Whether these variations are transient or permanent in a given spleen is difficult to determine, but it is certain that in all cases the lymphatic follicles, cords, and ellipsoids lie around the artery and in the centres of the lobules and pulp cords. The relation of the artery and the vein to the lymphatic tissue in the spleen is identical with that of the lymphatic gland, as recently shown by Calvert.[7] The spleen structure differs, however, from the lymphatic gland in that its lobule contains no lymphatic channels like the follicle, but in their stead there is a marked and peculiar plexus of veins, which surround the lymphatic tissue of the arteries to complete the spleen

lobule. In other words, the spleen can be viewed as a modified lymphatic gland without lymphatic channels.

It is appropriate at this place to speak of the lymphatic channels of the spleen, because in their true sense—*i.e.*,

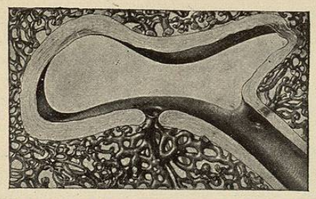

Fig. 4462.—Section of a Spleen in which the Veins had been Injected with Aqueous Prussian Blue. Canada balsam preparation. Enlarged 30 diameters.

in their relation to the Malpighian follicles—they do not exist. Although nearly every text-book on histology states that the lymphatic channels exist in the spleen, I must assert that the books are wrong. Nor can I find any proof of their existence in reliable literature, nor by hundreds of injections of many kinds made by me. To be sure, the capsule of the spleen of the ox, pig, and horse contain large lymphatic channels which enter the spleen along the trabeculæ, but I could not trace them back to the lobule. In the dog a few lymphatic channels are occasionally seen at the hilum of the organ, but these do not penetrate the spleen, much less do they meet the Malpighian follicle. Moreover, most careful analysis of the lobule of the dog's spleen never shows their presence, unless we consider the intestinal spaces lymphatic radicals which never collect into efferent vessels but enter the veins at once.[8]

The Veins.—The spleens of most dogs have eight large veins emerging at the hilum, although frequently there is a tendency for two or three of them to unite within the substance of the large end of the spleen before they pass out of the organ. These eight main trunks pass deep into the splenic tissue and ramify on the distal side of the artery in all directions, as the section pictured in Fig. 4458 shows.

The first group of branches, those of the first order, are all distributed in the flat plane of the spleen. The veins of the second order arise at right angles from this first group and pass directly toward the capsule. The terminal branches of the second group become the interlobular veins (Fig. 4460).

As the large veins enter the spleen its capsule accompanies them and in a measure helps to form their walls. The walls gradually thicken and from them arise numerous trabeculæ which are directly continuous with the general trabecular network of the spleen. As the vein divides and subdivides, the trabeculæ attaching themselves to them increase in number, so that by the time the interlobular veins are reached the small size of the veins makes it appear as if they ran within the trabeculæ.

Thus the veins show a definite relation to the trabeculæ throughout the spleen until the lobule is reached. The intralobular veins not having a muscular wall must communicate with the interlobular veins through numerous openings in their thick sheaths, as is shown by the opening pictured in Fig. 4462. The larger veins, *i.e.*, veins of the second order, also receive collecting veins directly from the intralobular plexus. All the systems of the veins are shown in Fig. 4463. In this figure the veins of the first order are cut transversely; those of the second order give rise to the interlobular veins; the intralobular venous plexus is shown opposite, at *L*, while the intralobular collecting veins are shown at *L'*. The relation of the trabeculæ to the veins is such that when the veins and trabeculæ are stretched the larger veins are distended, as a number of the figures show.

This arrangement must be of the utmost physiological importance, for increasing the tension of the pulp of the

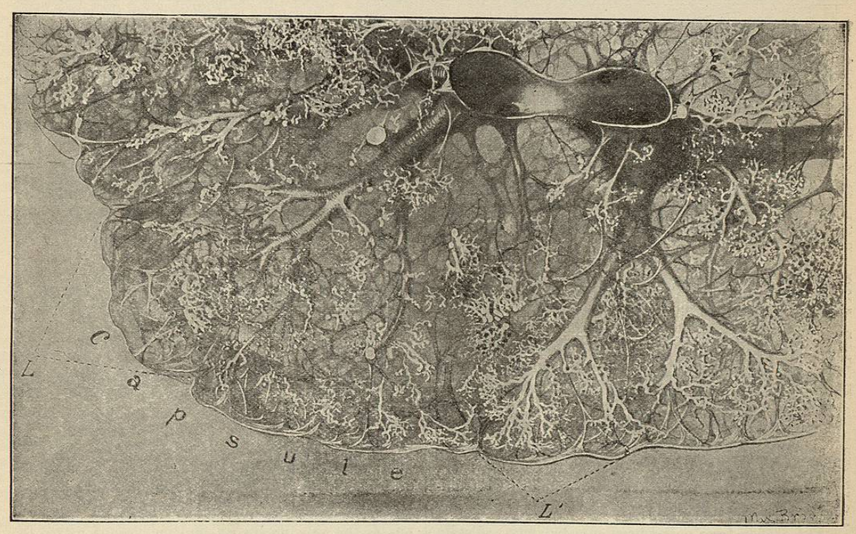

Fig. 4463.—Section of a Spleen in which the Vein had been Injected with Celloidin Colored with Prussian Blue. The whole spleen was macerated for weeks in water, then digested in pancreatin, washed, stained, distended, and dried. The dried spleen was next sectioned and mounted in Canada balsam. Enlarged 16 diameters.