of Kölliker.[39] In his earlier work he rejects the very misleading term "infundibulum," introduced by Rossignol,[60] but in his later publication he returns to its use.[39, a]

He figures (Fig. 3238) the final division of the bronchus as ending in a single elongated cavity into which a variable number of alveoli open; these alveoli appear as elevations on the central cavity (infundibulum). The "alveolar passage" of his later publication has also numerous alveoli opening into it (Fig. 3239).

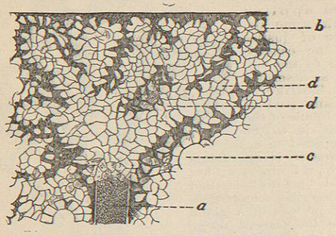

FIG. 3242.—Section of a Cat's Lung Filled and Hardened with Alcohol. *a*, Bronchiolus; *b*, infundibulum; *c*, transverse section of an alveolar passage; *d*, *d*, longitudinal section of an alveolar passage. (After Schulze.[62])

It is important to note one significant point in Kölliker's description of this alveolar passage, and that is the presence of smooth muscle. He says that it is easy to recognize smooth muscle in the walls of the alveolar passages; that it generally has a circular arrangement around the alveolar passage, and that it forms a ring-like sphincter about the opening into each infundibulum. Kölliker found no smooth muscle in the walls of the alveoli or in those of the infundibulum.

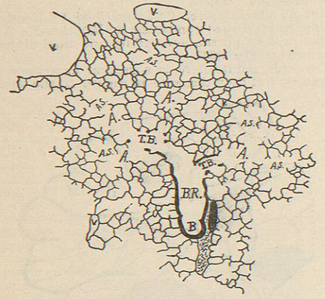

FIG. 3243.—Camera Lucida Tracing of a Section of a Cat's Lung. *B*, Bronchiolus; *B.R.*, bronchiolus respiratorius; *T.B.*, *T.B.*, ductuli alveolares (terminal bronchi); *A*, *A*, atria; *A.S.*, *A.S.*, sacculi alveolares (air-sacs); the remaining spaces are sections of sacculi and alveoli; *V*, *V*, pulmonary veins. Observe the relation which they bear to the lobule. The large vein at the left upper corner of the illustration is not completely outlined. The pulmonary artery is shown in solid black, cut obliquely, in the connective tissue beside the bronchiolus respiratorius. One of the atria is not directly connected with its ductulus alveolaris in this section, but in another section of the series the connection is shown. The heavy lines indicate the position of smooth muscle. (After Miller.[49, d])

The work of Waters[63] is not so well known to American readers as it deserves to be. He introduced the term "air-sac" in the place of the misnomer "infundibulum," and showed that a group of air-sacs communicate with each "ultimate bronchial tube" (Figs. 3240, 3241). Each air-sac communicates with the ultimate bronchial tube by means of a circular orifice. More than one air-sac may terminate at one of these openings. The group of air-sacs which communicate with a given ultimate bronchial tube form a "lobulette." Some of the air-sacs bifurcate as they pass toward the periphery of the lobulette. Alveoli were present on air-sacs and ultimate bronchial tubes. Smooth muscle was present in the bronchial tubes but wholly absent in air-sacs and alveoli.

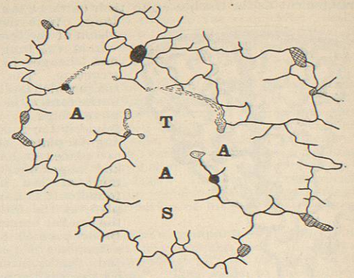

FIG. 3244.—Camera Lucida Tracing of a Section of a Dog's Lung. The plane of the section lies through the distal part of a ductulus alveolaris (*T*). Three atria (*A*) are shown and a number of sacculi alveolares (*S*). The pulmonary artery and two of its branches are shown in solid black; the pulmonary veins are shown checked. Note the small venous twig close to *T*; it is one of the small veins which corresponds to *s* in Fig. 3251. The broken lines indicate smooth muscle in longitudinal section; it is also seen in transverse section about the openings from the ductulus alveolaris into the atria. Two other atria not shown in this section belong to the lobule. (After Miller.[49])

The diagram of Schulze resembles that of Waters, but his subdivision of the air-passages is different. Schulze[62] introduced the term "Alveolargang" for those air passages which are covered with alveoli and lead to the air-sacs (infundibula). The alveolar passage of Schulze is not the last division of the bronchus, but is the name given by him to all those air-passages which have alveoli (Fig. 3242). The alveolar passage of Schulze is, therefore, not identical with that of Kölliker, for it includes more than one division of the bronchial tree.

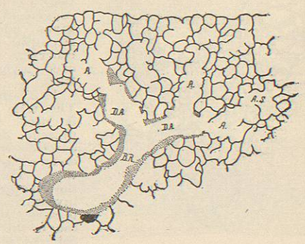

FIG. 3245.—Camera Lucida Tracing of a Section of the Lung of a Calf. The stippling indicates the nuclei of the epithelium and the position of smooth muscle. The section was a thick one and the plane was such that two ductuli alveolares (*D.A*), connected on the one hand with the bronchiolus respiratorius (*BR*), on the other with the atria (*A*), were cut longitudinally; *A.S.*, sacculus alveolaris. The pulmonary artery is shown in solid black. (Miller.)

As the result of his investigations Miller[49] found that the last branch of the bronchus, which he calls the "terminal bronchus," before breaking up into the parenchyma of the lung becomes somewhat dilated at its distal extremity. Connected with this expansion of the terminal bronchus (Fig. 3251) there are from three to six nearly spherical cavities, the atria. Each atrium communicates, on the one hand, by means of a nearly circular opening, with the terminal bronchus; on the other hand, by similar-shaped openings, with a variable number of larger and more irregular-shaped cavities (air-sacs), which have small projections from their surface (alveoli, air-cells).

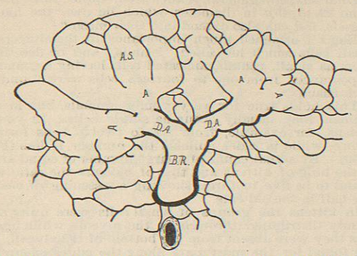

FIG. 3246.—Camera Lucida Tracing of a Section of the Lung of a Child Two and a Half Months Old. Lettering as in Fig. 3245. The heavy black lines indicate the presence of smooth muscle. Pulmonary artery in solid black. (Miller.)

From this description it will be seen that the air-sacs do not communicate directly with the terminal bronchus, as is usually described, but between each air-sac and terminal bronchus there is interposed a cavity, which is constant in all parts of the lung, viz., the atrium (Figs. 3243–3247)

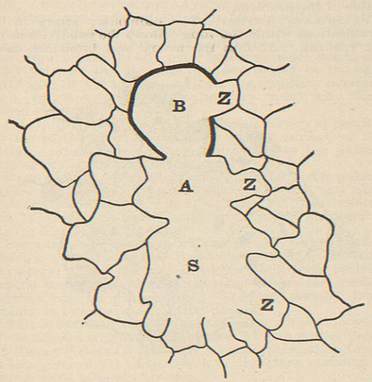

FIG. 3247.—Camera Lucida Tracing of a Section of the Lung of a Man Forty-three Years Old. *B*, Ductulus alveolaris; *A*, atrium; *S*, sacculus alveolaris; *Z*, *Z*, *Z*, alveoli. The plane of this section cuts the ductulus alveolaris transversely near its centre; smooth muscle is not present except in its walls. (Miller.)

The presence of the atrium has been confirmed by Justesen[35] in the lung of the ox; by Councilman,[16] who found it to be "the starting-point of most of the focal pneumonias of children;" and later, by Miller, whose investigations have shown its presence in the lung of the cat, dog, calf, child, and man (Figs. 3243–3247).

The atrium must not be confused with the alveolar passage of Kölliker or of Schulze. In each instance the alveolar passage contains smooth muscle, while it is absent from the walls of the atrium. The atrium is smaller than the air-sacs and, like the terminal bronchus and the air-sacs, has numerous air cells projecting from its surface. In structure the walls of the atrium resemble that of the air-sacs.

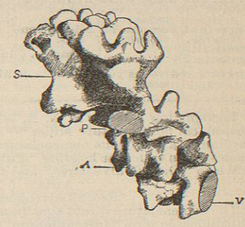

FIG. 3248.—Reconstruction in Wax of an Atrium (*A*) with a Single Sacculus Alveolaris (*S*) Attached. The surface *p* shows where the atrium was cut off from its ductulus alveolaris, and *p* shows where a second sacculus was cut off. The small projections from the atrium and sacculus are the alveoli. Five sacculi were connected with this atrium. (Miller.)

The structure of the terminal bronchus agrees with that of the alveolar passage of Kölliker and the distal portion of that of Schulze. It is tube-like and has a large number of air-cells opening into it. It possesses a very distinct layer of smooth muscle which forms a ring about the openings which lead into the atria, in the same manner as Kölliker described it to be present about the openings of his infundibula.

The epithelium of the terminal bronchus shows a transition from a low cubical type, in its proximal portion, to simple squamous epithelium (respiratory epithelium) in its distal portion. As Kölliker[39, a] pointed out, this transition is often quite irregular. Ciliated epithelium, goblet cells, and glands are absent in the terminal bronchi.

The form of the air-sacs is difficult to comprehend from the study of single sections because of their great irregularity both in size and in form. In the figures of Kölliker, Waters, and Schulze the air sacs (infundibula) are shown as having an elongated form. Luschka[43] states that the air-sacs just beneath the pleura are more rounded than those situated deeper in the lung. Miller[49, a] did not find this to be true.

Fig. 3248 shows a reconstruction of the air-sac and atrium shown in section in Fig. 3244; the other air-sacs have been cut off from the atrium. Fig. 3249 shows a reconstruction of an air-sac which presents a deep incision, a feature that is quite frequent, as Waters[63] pointed out.

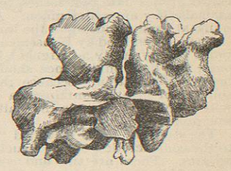

FIG. 3249.—A Reconstruction in Wax Showing a Single Sacculus Cut Off from its Atrium. The cut surface is easily made out in the figure. This sacculus has a deep septum extending a considerable distance into it, nearly dividing it into two separate parts. This sacculus presents a strong contrast to that shown in Fig. 3248. (Miller.)

It is very difficult to harmonize the descriptions of the various parts of the lung because no sharp boundary lines have been established. The different schemes of the lung and the nomenclature are also confusing.

Miller[49, d] has for the first time given a definite basis for comparison by bringing together in the following table the nomenclature used by the principal authors and

that of the "Nomenclatur-Commission an die Anatomische Gesellschaft" (B. N. A.).[13]

Miller.	B.N.A.	Schäfer.	Schulze.	Kölliker.
Bronchus III.	Bronchiolus respiratorius.	Bronchial tube.	Alveolar-gang.	Alveolar-gang.
Terminal bronchus.	Ductulus alveolaris.	Lobular bronchus.		
Atrium	.....	Air-sac	Infundibulum	Infundibulum.
Air-sac.				
Air-cell	Alveolus pulmonis.	Air-cell	Alveole.....	Alveole.

Recognizing that the B. N. A. is a decided advance in anatomical nomenclature Miller[49, d] recommends the discarding of all previous nomenclature, the retention of all names given under the heading "Pulmo" (B. N. A., p. 59) down to "Ductuli alveolares," and the insertion, then, of

"Atria"

"Sacculi alveolares."

The nomenclature would thus be made uniform and the objectionable term "infundibulum" would be discarded. The finer division of the lung would then be:

B. N. A.	English.
Bronchioli.	
Bronchioli respiratorii.	
Ductuli alveolares.	Terminal bronchi.
Atria.	Atria.
Sacculi alveolares.	Air-sacs.
Alveoli pulmonis.	Air-cells.

The work of Hansemann[23] has added fresh interest to the question of open communications between the air-sacs. Kohn[38] called attention to the fact that in pneumonia fibres of fibrin could be traced from one alveolus into another through small openings in the walls of the alveoli. He did not consider these openings to be normal, but the result of the pathological process. The investigations of Ribbert,[58] Herbig,[30] Bezzola,[10] Aigner,[4] von Ebner,[19] and Miller[49] support him in this position. On the other hand, Hauser[26] and Hansemann[23, a] maintain that these openings are normal structures.

That these openings exist was known long before the announcement of Kohn. In the first edition of the Handbook (Vol. IX., p. 572) Miller called attention to the statement of Henle in the same words used in the present edition. "He (Henle) describes communications between air-cells, but considers them anomalies. He found them in the lungs of old people and attributed them to the results of atrophy and absorption of the lung tissue." The observation of Henle is correct. It is in the lungs of old individuals and animals that these so-called "pores" are best seen. In young individuals and animals they are not common. At birth, and until some unusual strain is put upon the lung, no pores are present.

The method used by Hansemann[23] to demonstrate these pores is very faulty, as Aigner[4] has pointed out. Moreover, but little importance should be placed on Hansemann's illustrations, because they merely show that a solution of gelatin containing a large quantity of water will easily filter through the walls of the alveoli under a low pressure.

The study of these so-called "pores" leads naturally to the consideration of the structure of the walls of the air-sacs. These are thin and contain the capillary network of blood-vessels, elastic fibres, and reticulum,[45] covered over by a layer of epithelium.

That the air-spaces are lined with a layer of epithelium every histologist now acknowledges, although the time is not so very distant when the presence of an epithelium was strenuously denied. At present the question is not in regard to the presence or absence of a pulmonary epithelium, but as to what are the shape, size, and arrangement of the epithelium; what is its relation to the structures it covers; is it, after all, a continuous epithelium? It will be impossible to answer these questions in the present article.

Elenz[20] says that in all mammals investigated by him the epithelium of the lung consisted of small cells in the form of "cell islands and large, membrane-like irregular plates." Kölliker[39, a] also describes the epithelium as consisting "of two types—a small, nucleated, flat, polygonal, protoplasmic cell from 7 to 15 μ in diameter, which is situated in the mesh of the capillaries, and large, irregular-shaped, generally nucleated, quite thin plates from 22 to 45 μ in diameter, which lie over the blood-vessels, but can also extend into their mesh."

Elenz[20] attached much importance to the clusters of small cells which he called "islands," and he described them as small, round, nucleated cells having a granular appearance; from one to fourteen cells were found in each island.

This holds true for very young animals, but in old animals they usually occur as single cells. In young kittens, for example, from six to twelve cells form a group, while in older animals the number is less (Fig. 3250). By actual count of a large number of equal areas in the lung of kittens and that of old cats the ratio was found to be five to three, showing a lessening of nearly one-half in the old cats.

In kittens the groups of small cells were quite uniformly distributed throughout the alveoli, while in old cats they were absent from the bottom of the alveoli, being found for the most part along the edges where the alveoli open into the air-sacs.

In studying the epithelium of the air-sacs in connection with the question whether "pores" are normal structures, it was found by Miller that in young kittens, for some length of time after birth, no openings (pores) could be found; when they were found in young cats they gave every appearance of having been caused by violence to the animal or by over-distention of the lung. In old cats they were more numerous, and were probably due to the concomitant changes of old age. The opinion already expressed is reiterated here, namely: "pores" are not to be considered normal structures.

The description of the epithelium given above is very superficial, and is by no means to be taken as the final solution of the problem.

Pulmonary Artery.—The pulmonary artery in its ramifications within the lung follows the subdivisions of the bronchi. At first the artery and bronchus have

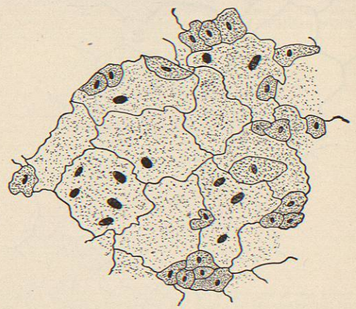

Fig. 3250.—Epithelium from an Alveolus of a Young Cat. The small granular cells and the large plates are shown. The significance of the scattered nuclei in the large plates has not been determined as yet. (Miller.)

nearly the same diameter, but the artery diminishes much more rapidly in size than the bronchus, so that by the time it reaches the lobule it is about one-fourth or one-fifth the size of the terminal bronchus. It is usually stated that the artery, as it approaches its ultimate ending, divides much more frequently than the bronchus. This would hold true for the old conception of the lung.

It has already been pointed out how the terminal bronchus gives rise to the atria, the atria to the air-sacs, and that these collectively form the lobule. When the

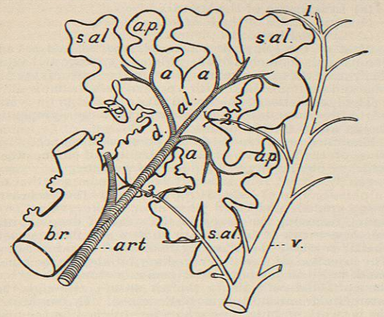

Fig. 3251.—Schematic Section of a Lobule of the Lung showing the Relation of the Blood-vessels to the Air Spaces. *b. r.*, Bronchiolus respiratorius; *d.al.*, ductulus alveolaris (the letters *al.* are in the widened distal end); a second ductulus alveolaris is shown cut off; *a*, *a*, *a*, atria; *s.al.*, *s.al.*, sacculi alveolares; *a.p.*, *a.p.*, alveoli pulmonis; *art.*, pulmonary artery with its branches to the atria and sacculi; *v*, pulmonary vein with its branches from the pleura (*1*), the ductulus alveolaris (*2*), and the place where the bronchiolus respiratorius divides into the two ductuli alveolares (*3*). (After Miller.[49, d])

artery reaches a point distal to the terminal bronchus it breaks up into as many branches as there are atria (Fig. 3251). Sometimes we find a special branch given off from the artery just before it enters the lobule which supplies the more dependent of the air-sacs (Fig. 3252). Each of the atrial arteries, after giving off twigs to the walls of its atrium, breaks up into small branches which run in the sulci between the air cells, are distributed to the central* side of the air sac, and end in a capillary network from which most of the pulmonary veins take their origin (Fig. 3251).

It is quite rare to find the pulmonary artery appearing on the periphery of a lobule or on the surface of the pleura. Anastomoses between branches of the pulmonary artery occur very exceptionally.

Capillaries.—The capillaries into which the pulmonary artery breaks up form within the lung a very close network, the mesh of which, as Schulze[63] has pointed out, is exceedingly small, often less than the diameter of the capillaries that bound it.

From this capillary network venous radicles are formed which are situated on the opposite side of the air-sac from the artery. From the last point where the arterial radicles can be recognized to the first point where the venous radicles can be distinguished there are usually from twenty to twenty-five capillary loops.

This network of capillaries is situated within the walls of the air-sacs and, as already stated, forms a part of them. As Rainey[55] pointed out, only a single network is found in any given wall; the network is, therefore, common to two or more adjacent air-sacs.

Just beneath the pleura the mesh of the capillary network is much wider than that within the lung, the proportion being nearly four to one.

Veins.—The veins are, with an exception to be noted later, always situated on the periphery of the lobule, while the arteries are within the lobule (Figs. 3251 and 3244).

The pulmonary veins can be traced to three separate sources.

(*a*) The capillary network into which the pulmonary artery breaks up.

(*b*) The capillary network of the pleura.

(*c*) The capillary network in the walls of the bronchi.

(*b*) is in fact a subdivision of (*a*), but it is convenient to consider it separately, owing to its peculiar situation.

Veins Arising from the Capillary Network of the Pulmonary Artery.—The radicles of these veins arise from the capillary network just described and are situated on the peripheral side of the air-sacs. They do not run between the air-cells, as the arterial radicles do, but over the air-cells.* The greater part of the pulmonary veins have their origin from this network, and the trunks thus formed are found on the periphery of the lobule (Figs. 3244 and 3251).

Veins Arising from the Capillary Network of the Pleura.—Exceptionally, the pulmonary artery reaches the pleura; when this occurs it at once breaks up into capillaries which take part in the formation of the network to be described; usually, the pulmonary artery breaks up into capillaries before it reaches the pleura. These capillaries unite to form a wide-meshed network on the pleural side of the air-sacs and give rise to venous radicles. As a rule two, three, sometimes four, of these radicles unite to form a small vein just beneath the pleura, which at once passes along the periphery of a lobule to the deeper part of the lung, receiving on its way small veins which come from the air-sacs (Fig. 3251, 1). Anastomoses between the capillaries of the pleura are very numerous; consequently blood brought to the pleura by any given artery may be returned by several different veins.

This pleural network of capillaries has been described as being derived from the bronchial artery by Küttner,[40] Zuckerkandl,[74] and others. A careful study of the question, and of the illustrations of actual sections given by the author of this article in a previous publication (Miller[49, d]) will convince the reader, I feel certain, of the error of their statement.

Along the margins of the lung the radicles of the pulmonary veins are very distinct and superficial, and are often mistaken for other vessels.

Veins Arising from the Capillary Network in the Walls of the Bronchi. — The bronchial artery forms within the walls of the bronchi a network of blood-vessels, the mesh of which is elongated in the long axis of the bronchi. Wherever a branch is given off, be it from the main bronchus or from any of its branches, some of these capillaries unite on opposite sides of the bronchus to form small radicles, and these in turn unite to form a small vein, which immediately receives other radicles coming from the adjoining air-sacs. Two veins are thus

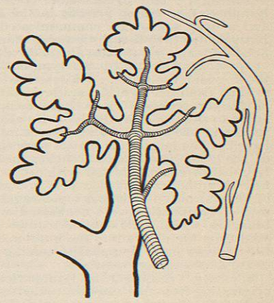

Fig. 3252.—Scheme of the Lobule of the Lung Cut at Right Angles to Fig. 3251. The artery is shaded; the vein on the periphery is in outline. The first scheme of the lung constructed by Miller. It shows the same arrangement of air spaces as in Fig. 3251, and also a small branch of the pulmonary artery that is frequently given off just as the artery enters the lobule. (After Miller.[49])

* I use "central" to designate that part of the air-sac which is nearest to the centre of the lobule, "peripheral" for that which is most distal.

* See Journal of Morphology, vol. viii., pl. vii., Fig. 16.

formed, one on either side of the bronchus, which, running between the lobules, soon join one of the venous trunks (Fig. 3251, 3).

By the giving off of these venous radicles at each place where the bronchus divides, the bronchial network of capillaries becomes so diminished that when the ductuli alveolares (terminal bronchi) are reached it is reduced to a few capillaries, which at the distal end of each ductulus take part in the formation of two small veins in the same manner as those just described at the branching of the bronchi. The two small veins thus formed are the only ones found within the lobule; all others are on the periphery of the lobule. These also receive, on their way out, small branches from the adjoining air-sacs and eventually join one of the veins on the periphery of the lobule (Fig. 3251, 2). The bronchial vessels do not extend beyond the ductuli alveolares.

Zuckerkandl[74] has described blood-vessels arising from the bronchi, but their course is quite different from the above-described veins; and it is quite apparent he has mistaken the identity of some of the vessels which he describes.

In an article on "Lobar Pneumonia" Smith[65] advances some peculiar views in regard to the pulmonary circulation. He describes two sets of capillaries as being present in the septa between the air-sacs: one, the "functional capillaries," derived from the pulmonary artery; the other, the "nutritive vessels," derived from the bronchial artery.

That a very grave error is contained in the above statement every one who has made a study of the lung will recognize. It is difficult to understand how the error was made. A careful consideration of the preceding description of the blood-vessels will make the relation which they bear to the air-sacs and to each other clear, and show the fallacy of his statement.

Lymphatics.—Olof Rudbeck first described the lymphatics of the lung in 1651–54. He saw them on the lung of a dog and thought that they opened into the cavity of the heart. Willis[71] saw the superficial lymphatics of the lung of a calf and gave a very good illustration of them.

Mascagni[48] and Cruikshank[17] described two sets of lymphatics as being present in the lung—a superficial and a deep set, which communicated with each other. Both confine their description almost wholly to the superficial set, saying but little about the deep set.

Wywodzoff[73] studied the lymphatics of the lung of the dog and the horse. He described the lymphatics as arising from fine lymph capillaries situated in the walls of the air spaces. These lymph capillaries ran at an angle to the blood capillaries. He also described lymph spaces in the walls of the air-sacs in which lymph collected. The larger lymphatics were situated in the walls of the blood-vessels and bronchi; these two sets of deep lymphatics communicated with each other. The superficial lymphatics formed a network which was destitute of valves; only the deep set possessed valves. The two sets of lymphatics were connected with each other by branches which followed the course of the pulmonary vein from the pleura into the interior of the lung, where they joined other lymphatics coming from the bronchi or from other blood-vessels.

Sikorsky[64] described the lymphatics of the bronchi as originating from fine vessels situated between the ciliated epithelial cells lining the bronchi. These vessels united to form a network, which in turn gave rise to the main trunks which passed out of the lung at the hilus. In the walls of the air spaces a network of fine canals and lacunæ was found, which gave rise to a system of lymphatics which ran in the walls of the blood-vessels. In his second paper[64,a] he made no reference to his previous statements and evidently abandoned them. The pleural lymphatics he described as arising from the subpleural air spaces, and eventually formed trunks which passed to the hilus of the lung.

Sappey[61] does not favor the division of lymphatics into superficial and deep sets; for, he says, the two sets are in close communication everywhere. Each lobule of the lung is surrounded by lymph vessels, which are arranged in such a manner that they form a network between adjacent lobules in much the same manner as the blood capillaries do between adjacent air sacs.

Klein[36] divides the lymphatics into three sets:

(*a*) Lymphatics of the alveoli.
(*b*) Lymphatics of the bronchi.
(*c*) Lymphatics of the pleura.

Most of the lymphatics belonging to the first set accompany the branches of the pulmonary artery and vein. They arise from irregular spaces in the walls of the air sacs and are "provided with a special endothelial wall."

The lymphatics of the second set are found in the walls of the bronchi and communicate with the larger lymphatic trunks about the blood-vessels.

The third set are found in the pleura and connect with those of the first set on the one hand, and on the other with the pleural cavity by means of stomata.

von Wittich[72] found that if he allowed a solution of sulphindigotate of soda to drop slowly into the trachea of living animals and killed them after an interval of two hours, removing the lungs in the stage of deep expiration, a network of blue lines with here and there lacunæ similar to those described by Sikorsky[64] could be seen. The injection of a solution of silver nitrate, on the other hand, failed to demonstrate stigmata or stomata between the epithelial cells lining the air spaces, although the intercellular substance was well stained. He considered the network of blue lines which he obtained by the first method to be a coloration of the intercellular substance and referred the results obtained by Küttner[40,a] to the same cause.

Councilman[16] found a set of lymphatics accompanying the pulmonary artery, and a second set which was situated in the connective-tissue septa and joined the lymphatics of the pleura. Valves were found which opened toward the pleura. He failed to find any lymphatics about the veins. He considered that the second set of lymphatics "play an important part in the pathology of the lung, for it is undoubtedly by this route that infections in the centre of the lung extend to the pleura."

The latest investigations of the lymphatics are those of Miller.[49,c,d]

He classifies them as follows:

(*a*) Lymphatics of the bronchi.
(*b*) Lymphatics of the arteries.
(*c*) Lymphatics of the veins.
(*d*) Lymphatics of the pleura.

Lymphatics of the Bronchi.—In preparations in which the lymphatics have been successfully injected and occasionally in uninjected specimens a number of large-sized lymphatics can be seen coming from the hilus of each lung between the bronchus and blood-vessels. These lymphatics pass along the right and left bronchus to form a network on the posterior wall of the trachea and eventually become connected with a number of lymph nodes which are situated about the bifurcation. Valves are present in these vessels in large number and open toward the lymph nodes.

Within the lung the bronchial lymphatics have a different arrangement, depending on the presence or absence of cartilaginous rings. Where the rings are present there is a double network of lymphatics present which encloses the cartilage. That part of the lymphatic network which is situated just beneath the epithelium is composed of finer vessels, as Teichmann[67] pointed out many years ago.

In the finer rami bronchiales and bronchioli only a single plexus of lymphatics is present; the vessels of this plexus vary greatly in size and shape, and the mesh of the network which they form is elongated in the long axis of the bronchioli. In the terminal bronchi the lymphatics have been reduced to three small vessels which in transverse sections of the terminal bronchi are placed nearly equidistant from one another. Of these three lymphatics two pass to the small veins which arise at this place, while the third passes to the artery. Distal to the terminal bronchus no lymphatics are present.

This statement of Miller has been confirmed by Teichmann.[67,a]

Lymphatics also pass from the bronchial network to the veins which arise from the place where the bronchi divide and to the pulmonary artery. We have then, at the place where bronchi divide, the same arrangement as at the terminal bronchus, namely, two lymphatics passing to the veins and one to the artery. This emphasizes the fact that in order to comprehend the distribution of the lymphatics the arrangement of the blood-vessels must be fully understood (see Fig. 3251).

Fine lymphatics have been described by Sikorsky[64] as being found between the epithelial cells lining the bronchi and communicating on the one hand with the deeper lymphatics of the bronchi and on the other with the lumen of the bronchus. Sikorsky[64,a] in his later paper evidently abandoned the theory of open communication between the lymphatics and the bronchial cavity. A somewhat similar condition has been described by Klein under the name of "pseudo-stomata." Neither of these statements was confirmed by Miller.[49,d]

Wherever lymphatics unite triangular enlargements (lacunæ) are found. These lacunæ are especially well developed at the forking of the bronchi and seem to be associated with the small aggregations of lymphoid tissue found at this place by Arnold,[5] Klein,[36] and others.

Pigment, when present, is found along the lymphatics of the bronchi; at the forking of the bronchi it is associated with the lacunæ and lymphoid tissue found here, often completely obscuring them from view.

Valves are present in the lymphatics of the larger bronchi, but are absent in those of the finer divisions of the bronchial tree.

Lymphatics of the Arteries.—We have seen in the preceding account that the network of lymphatics in the walls of the bronchi gradually diminishes until in each terminal bronchus there remain only three small vessels, one of which joins the lymphatics about the artery.

Not only is there a communication between the bronchial and arterial lymphatics at the terminal bronchi, but there is also one at the place where branching of a bronchus takes place.

The larger branches of the pulmonary artery have as a rule two main lymphatics accompanying them. These are situated on opposite sides of the artery, and are so placed that one of them lies between it and the bronchus. The two main lymphatics are connected together by numerous loops, and in this way a long-meshed network is formed about each artery.

As the artery divides the lymphatics also divide, but the size of the lymphatics does not diminish so rapidly as that of the artery. When we come to the smaller arteries only a single lymphatic is found accompanying them. This generally runs parallel to the artery, between it and the bronchus.

Lymphatics of the Veins.—The two remaining lymphatics which arise from the terminal bronchus pass, one on either side, to the smaller veins which arise at this place, and have usually more of a spiral course than those about the artery. Lymphatics also pass from the bronchial network to the veins which arise at the place where the bronchi divide. We have, therefore, at the place where bronchi divide, the same relation of lymphatics to blood-vessels as at the terminal bronchi; that is, there are three lymphatics, one of which passes to the artery, the other two to the veins.

Finally, there are lymphatics which accompany those pulmonary veins which go to the pleura; these join the network of pleural lymphatics. There is always a well-marked lacuna at the junction of this vessel with the pleural network, and if pigment is present anywhere on the surface of the lung it is found about this lacuna.

The smaller veins, like the arteries, have but a single lymph vessel accompanying them, while the larger venous trunks have two, and often three, main lymphatics. These are connected together by numerous loops, and there is thus formed a network with a long mesh.

Pigment may be present about the lymph vessels accompanying the veins, but not so abundantly as about the arterial lymph vessels.

Wywodzoff,[73] Klein,[36] and other authors describe the lymphatics about the pulmonary artery and vein as having their origin in fine canals, which are situated in the walls of the air-sacs of the lung. In the study by Miller, already referred to, he shows that the appearances on which they based their conclusions, as shown in their illustrations, are artifacts, and says he has never found in the walls of the air-sacs anything which he could call a lymphatic or lymph capillary.

Lymphatics of the Pleura.—The lymphatics of the pleura are irregular in size and form a plexus which has no definite relation to the lobule of the lung (Fig. 3253). Many of these lymphatics are of quite large calibre, as Sappey[61] has pointed out. Sometimes these large lymphatics form an incomplete network in the mesh of which smaller lymphatics are situated, thus giving the appearance of a double network of lymphatics.

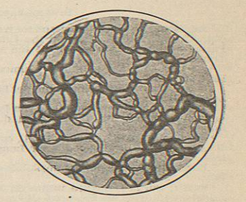

Fig. 3253.—Lymphatics of the Pleura. Note the irregularity of size and the numerous constrictions indicating the positions of valves. (After Miller.[49,d])

The lymphatics of the pleura have numerous valves (Fig. 3253), though Wywodzoff[73] says valves are present only in the deep lymphatics. The fact that there are so free anastomoses between the pleural lymphatics allows them to be easily filled with the injecting mass. While the presence of valves does not prevent the injection of the pleural lymphatics, they do prevent the injection of lymphatics within the lung from the pleura.

Pappenheim[53] has described two layers of lymphatics in the pleura of the horse. If his observation is correct, the condition is quite different from that in man. Klein,[36] as already observed, describes the pleural lymphatics as communicating with the pleural cavities by means of "true stomata."

Miller[49,c] denies the presence of stomata in the pulmonary pleura, and von Ebner[19] confirms his observation.

The ordinary method of attempting to inject the lymphatics by the very unscientific "puncture method" leads to many erroneous observations. Miller[49,d] gives a method by which they can be injected by inserting a specially devised cannula directly into one of the large lymph trunks. The reader is referred to the original paper for the details of the procedure.

Nerves.—At the present time our knowledge of the nerve distribution within the lung is very deficient. The main trunks which supply the lung come from the pneumogastric and sympathetic; these unite at the root of the lung and form the anterior and posterior pulmonary plexuses. The posterior plexus is the larger of the two. From these plexuses branches extend into the lung and are distributed along the bronchi and the pulmonary and bronchial blood-vessels. Along the course of those branches which accompany the bronchi Remak[56] found numerous small ganglia. Since the investigations of Remak the only important work on the nervous supply of the mammalian lung has been done by Retzius and Berkley. Retzius[57] found in the lung of a human embryo, 15 cm. long, which had been stained by Golgi's method, that he could follow the nerves as far as the last division of the bronchus; distal to that point he does not seem to have found any nerves.

Berkley[8] also used the silver method in his study. His results may be summed up as follows:

The main nerve supply to the lung tissue is derived from the nerves which accompany the bronchial arteries. Nerve fibres are frequently seen in the septa between the alveoli, in the central portion of the lung as well as near