THE

BRONCHI AND PULMONARY BLOOD-VESSELS

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BRONCHI AND PULMONARY BLOOD-VESSELS

THEIR ANATOMY AND NOMENCLATURE;
WITH A CRITICISM OF PROFESSOR AEBY'S VIEWS ON THE BRONCHIAL TREE OF MAMMALIA AND OF MAN

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PREFACE.

These pages have a general purpose which extends beyond the limits announced in their title. They represent an attempt to remove the too prevalent impression that the field of pulmonary investigation, having yielded all its fruit, is henceforth likely to remain barren. Although advised, not long ago, by an eminent physician, to turn my attention to some other organ less "worked out" than the lung, I have found no reason to complain of my subject, and I may even succeed in showing that, so far from this being an exhausted territory, there remain within it some districts almost unexplored.

The investigations set forth in this volume were long retarded in their progress by accidental circumstances and by inherent difficulties. The fact that they were opportune and in some respects indispensable, first impressed itself upon me in the course of a pathological research preparatory to the "Gulstonian Lectures on Pulmonary Cavities," delivered before the Royal College of Physicians, in 1882. At an early stage of that preparation I had become conscious that an anatomical inquiry should have preceded rather than followed the study of Pulmonary Cavities. I had also realized that the task should be approached in a spirit of completeness. This conviction is answerable for much delay, and may be thought a reasonable excuse for the perhaps excessive attention awarded to many details apparently devoid of practical interest.

Moreover, a suspicion had arisen in my mind that the present deficiencies in our anatomical knowledge (some part of which it will be my endeavour to fill) might perhaps be held responsible for the halting and spasmodic feature in the development of Pulmonary Surgery, contrasting with the steady progress made in the surgery of other organs. The detriment suffered by Medicine from the imperfection of the anatomical data, with which physicians and surgeons alike have been content to work, may have been less obvious, thanks to a certain vagueness inseparable from all branches of purely medical knowledge; but it will probably be shown to have been neither less serious nor less extensive.

The valuable and suggestive book of Professor Aeby, a solitary worker in this field, came into my hands at a comparatively late stage of the investigation. Any fertilizing influence which it may have exerted upon my own thoughts I gratefully acknowledge; but, above all, I am indebted to Professor Aeby for having rendered inevitable a completeness even greater than was at first intended.

Against an authority so eminent, and teachings which had already met with such wide acceptance, any incomplete array of facts would have been marshalled in vain. Although on questions relating to comparative anatomy I am ill prepared to speak, those of Professor Aeby's views which fall within the range of human anatomy may be criticized from a position which, I believe, is now adequately guarded.

Theoretical matter has largely encroached upon the following pages in connection with that criticism; and in itself the work, although exclusively devoted to anatomical facts, cannot claim to be practical in the strict sense of the word. It may nevertheless indicate the path which will lead to practical results. Clinical utility was its original motive, and if it should at least succeed in stimulating a search for the practical application of an improved knowledge of the bronchi and of the pulmonary blood-vessels, neither the motive nor the performance will need further justification.

I am grateful to Dr. Sheridan Delépine for having given me the benefit of some of his own experience and results in similar studies. Dr. Delépine's researches on dichotomy, on the alternation in the mode of origin of air-tubes, and on recurrent bronchi not only possess the merit of absolute priority: they have directed and greatly helped my observations on these points; and, in the main, his results have been fully confirmed by my investigations.

To my brother, Dr. Charles Ewart, I am indebted for much assistance in the revision of the proofs, and for other valuable help.

I also welcome this long-desired opportunity for gratefully acknowledging the cheerful and inspiring friendship of my former colleagues at the Brompton Hospital, and for expressing my special obligation to Dr. Pollock (then Senior Physician, now Consulting Physician), and to Dr. Reginald Thompson, my predecessor in the office of Pathologist, for much encouragement in pathological study, and for personal kindnesses, without which this contribution to the Anatomy of the Chest might not have become possible.

33 Curzon Street, Mayfair,
November 1, 1888.

POSTSCRIPT.

On reaching Switzerland, after sending this book to press, I learned, with deep regret, from Dr. Ruedi that Professor Aeby died on July 7, 1885, mourned by numerous friends and colleagues in scientific research.

The hope that the following pages would have called forth correcting remarks from that great authority whose views they have ventured to criticize, is now at an end. Had I received the sad intelligence before leaving England, I should have made some verbal alterations in the text, which are now impossible, and it only remains for me to sorrowfully inscribe to the memory of Professor Aeby a work which has been written with the highest regard for his talent and scientific achievements.

Hôtel Buol, Davos-Platz,

January 28, 1889.

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THE SCOPE AND THE DIVISION OF THE WORK.

IN the department of pulmonary anatomy, whether normal or morbid, a very large share of study has been devoted, in modern times, to microscopical appearances. The extreme periphery of the lung, comprising the bronchioles and the air-cells, has been exhaustively investigated. To such an extent has research been concentrated upon them, that attention appears to have been diverted, in the interval, from the imperfection of our knowledge of the anatomy of coarser and less superficial structures. In comparison with the searching description of purely histological details, text-books of anatomy contain but scanty information concerning the general arrangement of parts within the lung.

Modern research chiefly histological.

Comparative neglect of coarse anatomy.

And yet, from a practical standpoint, our most obvious and fundamental requirement would seem to be an accurate knowledge of the course followed by the air-tubes and by the pulmonary blood-vessels, and of their mutual and general relations. Without this knowledge neither our ætiology of the pathological processes, nor our clinical diagnosis and treatment of pulmonary diseases can enter upon a phase of systematic development.

Importance of the latter.

In the pathology of the nervous system the greatest advances have been made since the investigation of morbid changes within the nerve-cells has been supplemented by the study of the continuity of the nerve-fibres which establish distant communications between them. Although this analogy can only be argued in a very broad sense, it serves to illustrate by contrast the present stage of our knowledge of the pulmonary structure. Our information concerning the terminal structures—viz., the trachea and the air-cells, the heart and the pulmonary capillaries—is fairly complete, and, in some respects, minute; but their connecting links have received only a collective notice.

Analogy drawn from anatomy of nervous system.

The special object of the present work is to supply some part of this defect by furthering our knowledge of the individual components of the lung, and especially of the divisions of the bronchi and of the pulmonary blood-vessels.

The object and scope of the work.

As an introduction to the results obtained in this investigation, a **preliminary survey** of the facts which have hitherto been taught in relation

Advantages of a preliminary

survey of existing knowledge concerning the lungs and the bronchi.

to the lung and to the bronchi, would, I think, present definite advantages, inasmuch as it might enable the reader to connect any accruing information with that previously available. With this view, I have included in the introductory section a brief summary of the most important facts at present known in connection with pulmonary and bronchial anatomy. The information contained in the summary has been derived from the anatomical text-books, and especially from Quain's "Elements of Anatomy," from which *verbatim* quotations have sometimes been taken with a definite object.

Quotations necessary.

For the purposes of the investigation a summary of this kind was specially needed as a means of calling attention to occasional differences existing between the prevalent anatomical descriptions of parts, and the description herein given; and some literal quotations were, from this point of view, indispensable.

Theoretical and controversial matter.

In contrast with the dry facts of the anatomical summary, theoretical considerations had also to be introduced in connection with previous literature.

Professor Aeby's work.

Putting aside the text-books on general anatomy, the literature of the subject may be said to consist of a single book, "The Bronchial Tree of Mammalia and of Man," by Prof. Aeby.* For obvious reasons it was necessary to award to that work a full consideration, and to discuss, sometimes adversely, the important statements of fact and of opinion which it contains. This controversial matter, especially when relating to theory, was made to precede, as far as possible, the anatomical section. But some questions, referring to anatomical descriptions, had to be postponed till the latter section.

Materials used.

The research was conducted with the help of numerous dissections and of several injections, which were all performed by myself. The descriptions based upon them are illustrated by diagrams or by fac-similes of the preparations.

Dissections and intra-pulmonary injections.

Some of the dissections were partial; others comprised, besides the bronchial system, both sets of pulmonary blood-vessels. The intra-pulmonary injections were likewise of two kinds, single and compound. Although the results obtained by injections have been very satisfactory, especially considering the difficulties which attended their performance, yet greater success will probably be achieved by other experimenters, possessed of the advantage of technical training and of adequate mechanical assistance.

Need for a nomenclature of bronchi and of pulmonary blood-vessels.

The want of a nomenclature of the air-tubes had been seriously felt by me ever since my attention had been specially directed to pulmonary anatomy. When studying the pathological relations of pulmonary cavities I had been led by the necessities of the subject to suggest a name for one

* "Der Bronchialbaum der Säugethiere und des Menschen, nebst Bemerkungen über den Bronchialbaum der Vögel und Reptilien." Von Prof. Dr. Ch. Aeby, in Bern. Leipzig, Verlag von Wilhelm Engelmann. 1880.

of the more important bronchi. But in the attempt to deal with the much larger subject of the anatomy of the bronchial system the same need was experienced, with yet greater urgency. A successful study of the bronchial tree was found to be impossible without the assistance of names identifying the many structures under consideration. Indeed, it may be said that the need for a nomenclature was never more acutely felt than during the progress of its elaboration.

As regards the **Pulmonary Blood-vessels**, the practical importance of distinguishing by separate names their several trunks was recognised as being hardly second to the importance of the nomenclature of the bronchi themselves.

A separate nomenclature of the **Bronchial Blood-vessels** is not required, although their anatomy may, in the future, require a little more detail than is generally allotted to them in the text-books. Several dissections of these vessels were made by me, but I refrained from attempting their injection, and I have nothing to add to the description usually given of them. In spite of the great theoretical interest which attaches to the study of this special circulation, inasmuch as it offers little promise of any practical usefulness, its comparative neglect in these pages may perhaps not be considered a serious gap. The bronchial blood-vessels.

The whole nomenclature is contained, in a condensed form, in the synoptical tables which occur in the anatomical section of the book. In the construction of the tables an endeavour has been made to convey some idea of the relations existing between the air-tubes. Synoptical tables.

Throughout these pages, in view of the amount of detail involved in the descriptions, marginal notes have been introduced. These will facilitate reference, whilst serving as a running summary. Marginal notes.

A similar purpose explains the extensive use of black type in the impression. The advantage likely to accrue to the reader from the clearness and the boldness of this type in so intricate a study as the present one, greatly outweighs the disfigurement of the book which has been entailed thereby.

The illustrations included in this volume are of three kinds:— The illustrations.

(1) Photographic reproductions of dissections and of bronchial casts;
(2) Artists' drawings from the bronchial casts, and from the combined casts of the bronchi and pulmonary blood-vessels;
(3) Diagrams constructed from the dissections and from the metallic casts.

I should have gladly relied upon the exclusive use of the photographic method for the sake of its automatic accuracy. But in the case of the bronchial casts, which possess considerable depth, this advantage is counterbalanced by the inability of the process to do even justice to the repre- Objections to the photographic method.

sentations of different planes. The results obtained were so discouraging, especially in the case of the casts obtained by injecting the two sets of pulmonary blood-vessels in addition to the bronchi, that the attempt had to be abandoned. The large drawings were made with great care under my own supervision.

Scale of measurement combined with the reproduction of objects.

The cross lines, which appear in several of the drawings and photogravures, represent even distances, and serve the purposes of a scale of measurement. They were obtained by placing in front of the objects, when drawn or photographed, a frame, upon which fine wires had been stretched at intervals of twenty millimetres.

I have not attempted to repeat the determinations of the aperture of angles of bifurcation or of the diameter of the bronchial tubes which have been carried out by Professor Aeby in the case of the trachea, of the main bronchi and of their primary divisions. An approximate idea of these values may, however, be obtained by studying the drawings, which, as it has been explained, carry their own scale.

The diagrams.

Diagrams were resorted to as the only means of adequately representing some of the anatomical relations described in the text. They proved to be too intricate to be safely entrusted to other hands, and, although roughly expressing the facts which they were intended to convey, they unfortunately bear evidence of lack of skill in drawing. One of the diagrams was chromo-lithographed in three colours, with a view to a clearer rendering of the mutual relations of the bronchi and of the two sets of pulmonary blood-vessels.

THE PLAN OF THE WORK.

The book is divided into three sections :—

Section I.

Introductory matter, containing:

- A summary of current knowledge concerning (1) the structure of the lung, (2) the structure and arrangement of bronchi;
- An account of Professor Aeby's researches on the bronchial tree of mammalia and of man;
- An account of the theories proposed by that observer, with comments thereon.

Section II.

DETAILED ANATOMY OF THE BRONCHIAL SYSTEM, STUDIED FROM THE BRONCHIAL CAST AND FROM DISSECTIONS.

In this section will be found:

- A description of the methods employed;

Remarks on the nomenclature of the bronchial tree;
Professor Aeby's nomenclature and the author's nomenclature compared;
Observations on the modes of division of bronchi;
A description of the main bronchi;
An elementary sketch of the more important divisions of the bronchial tree, studied from the metallic cast;
Introductory remarks on terminology and notation;
A systematic description and nomenclature of the entire bronchial tree; with a comparison between homologous bronchial districts in the right and in the left lung.

Section III.

ANATOMY OF THE PULMONARY BLOOD-VESSELS.

This section includes:

General remarks on the pulmonary blood-vessels: their relations to each other and to the bronchi;
The detailed anatomy of the pulmonary artery;
The detailed anatomy of the pulmonary vein.

SECTION I.

OUR PRESENT KNOWLEDGE OF THE ANATOMY OF THE LUNG AND OF THE BRONCHI.

PROFESSOR AEBY'S RESEARCHES ON THE BRONCHIAL TREE.

CRITICISM OF PROFESSOR AEBY'S THEORIES.

As an introduction to the present section, I offer some reasons for not isolating the study of the bronchial system from the study of the lungs.

The bronchi viewed anatomically as internal supports for the pulmonary substance,

The bronchial system may be considered as fulfilling an **anatomical** as well as a physiological purpose. The soft, though elastic, mass of pulmonary substance requires for its support some internal structure endowed with greater firmness. Not only does the lung need this support as a whole; it also depends upon it for the preservation of the mutual relations of its various parts. In addition, throughout the pulmonary substance, adequately fixed joints, or *fulcra,* are indispensable for the control of the individual movements of each of its segments. Moreover, a large number of blood-vessels, deficient in rigidity, yet more frail lymphatics, glands and nerves, must find definite lodgment and protection. All these objects are admirably served by the air-tubes, which therefore possess, in relation to the other pulmonary constituents, the value of an endo-skeleton.

and for its vascular system.

Rigidity a feature of the larger tubes only.

The firmness and the rigidity of the bronchial tubes are not, however, proportionate to their size. The smallest among them are totally deficient in cartilages, and receive, instead of giving support; and those of rather larger size possess only as much cartilage as will ensure their patency, and are not, in the ordinary sense, rigid tubes. It is, therefore, most probable that better support would be afforded by the powerful walls of a moderate number of large tubes than could be given by a multitude of smaller divisions such as might have resulted from a very early splitting of the air-channels into their lobular or sub-lobular branches.

Physiological advantage gained through the large

An analogous inference is also arrived at from **physiological** considerations. The main object of the bronchi being the distribution of air to the respiratory tissue, if this distribution can take place along large common tubes as far as the immediate neighbourhood of the individual respiratory size of the central tubes.

surfaces, a great saving of space, of material and of friction would be the result. Such a distribution would bear a strong resemblance to the water-distribution within a town, where single tubes do not proceed from a central reservoir to each house or block, but where a "main" provides all the houses in each street with short hydrants, intended to convey water to special tubes proceeding to as many rooms.

The bronchial system has, however, other functions unparalleled in our engineering. It is meant to discharge, as well as to admit gases:—and not gases alone, but occasionally also fluids and solids in the shape of mucus. The delivery of breathed air must, further, be capable not only of a gentle and even motion, but of swift and powerful blasts. Purposes of this kind would clearly be better served by a system of central tubes of large diameter, receiving short tributaries, than by a considerable number of long narrow tubes incapable of accumulating much pressure, and occasioning very great friction.

The bronchial arrangement inferred from the shape of the lung.

Similar *à priori* considerations would likewise lead us to foretell in any **long and narrow lung** the existence of one or more large, centrally placed tubes, extending almost to its extremity, and distributing to the respiratory zones which they traversed a series of short supplying tubes.

The short and broad, and the long and narrow shape.

In a short but broad lung, we should expect the large central tube to be of insignificant development, and the supplying or "lateral" tubes to be of considerable length and obliquity. In both cases we should regard the peculiarity of bronchial distribution as the direct outcome of definite anatomical and physiological necessities.

What has been said in reference to the lung as a whole, is also applicable to each of the pulmonary lobes. And, in general terms, in any independent part of the lung, some indication of the arrangement of its bronchi may be gathered from the configuration of the part.

The two bronchial types indicated above are relatively displayed by the majority of quadrupeds on the one hand, and by man on the other hand. Beautiful illustrations of both forms are contained in Professor Aeby's work,* to which the reader is referred.

The study of the bronchi not to be dissociated from the study of the lung.

The preceding remarks are intended to show that an advantage may be gained by studying the bronchial system in connection with the lung itself. Perhaps the chief differences between Professor Aeby's views and my own have their origin in the more isolated position allotted by him to the consideration of the bronchial system, as though the latter almost possessed an abstract type, and a certain independence from surrounding influences.

Difference between the Author's

Additional divergence has doubtless arisen from Professor Aeby's endeavour to frame, on the lines of one of the two morphological varieties to which

* "Der Bronchialbaum der Säugethiere und des Menschen." Leipzig, 1880.

point of view and that of Professor Aeby.

reference has been made, a general type for the whole mammalian series; whereas the present investigation concerns essentially the opposite variety. At the same time, although the scope of this research is limited to man, a cursory allusion to the conditions existing in Mammalia cannot be omitted entirely from a criticism of the German work, since in the latter the study of the mammalian lung is inseparably bound up with that of the same organ in man.

SUMMARY OF OUR PRESENT KNOWLEDGE CONCERNING THE ANATOMY OF THE LUNG.

A.—Rough Sketch of the External Shape and Relations of the Lungs.

General Shape.—The lungs share the intra-thoracic cavity with the heart, which is received in the space left by the concavity of their opposed mesial surfaces. Their shape cannot with accuracy be compared to that of any simple geometrical figure. Viewed laterally, they present, however, a roughly coniform appearance; and, indeed, they have been described as analogous to the two lateral halves of a cone. But their apex is blunt and irregular, and their base is not perfectly horizontal, being bevelled at the expense of the posterior surface, and being moreover concave instead of plane. Irregularly coniform shape.

Surfaces and Borders.—In addition to a *basic* surface, and to a *basic* margin, each lung presents two other surfaces and two other borders. The borders are *anterior or sternal*, and *posterior or vertebral*, the latter being very blunt and smooth, the former (as well as the basic edge) extremely sharp. The *mesial surface*, which joins the sternal to the vertebral border, is relatively short, and would be yet shorter but for the concavity necessitated by the presence of the heart. The entrance into the lung of the great vessels, and of the bronchus, breaks up the smoothness of this surface. The *parietal* surface, on the contrary, is absolutely smooth and, following the broad lateral curve of the thoracic wall, it far surpasses in extent the other surfaces. Three borders: sternal, vertebral, basic. Three surfaces: parietal, mesial, basic.

Fissures and Lobes.—The lungs are divided into *lobes* by interlobar fissures or *septa*. In both lungs a *long oblique fissure*, beginning in the upper portion of the posterior surface, and ending at the anterior part of the base, completely separates the upper lobe from the lower lobe. But the right lung presents in addition a *short horizontal fissure* situated at the junction of the upper with the middle third of the lung, and confined to its anterior aspect. It extends anteriorly as far as the sternum, and posteriorly it opens into the great oblique fissure. In this manner it isolates, at the lower and anterior part of lung, a third lobe, the *middle lobe*, which otherwise might have formed part of the upper lobe. The normal division of the left lung into two Long oblique fissure in both lungs. Short horizontal fissure in the right. Three lobes in the right lung.

Two lobes in the left.

lobes, and of the right lung into three, is subject however to frequent irregularities.

Pulmonary pleura.

The Pleura.—Destined, like the heart, for a life of constantly recurring movement, the lungs are sunk into the serous cavities of the pleura, which they completely fill, and they derive from the visceral layer of the membrane a complete and closely adherent investment, which also extends for a short distance over the surface of the main bronchus on either side.

Pulmonary and bronchial vessels.

Pulmonary and Bronchial Vessels.—The lungs bear important relations to the heart, from which they receive large arterial and venous trunks; and to some of the large systemic arteries and veins, notably to the aorta from which they derive, through the bronchial arteries, their nutrient blood.

Within them are also contained lymphatic channels, glands, and nerves, respectively continuous with the general lymphatic system, and with the cerebro-spinal and sympathetic nervous systems.

The root of the lung, and hilus.

Pulmonary Root.—The main bronchus, and the pulmonary blood-vessels, nerves and lymphatics, are gathered together in the shape of a broad pedicle, as they enter the lung along the middle-third of its mesial surface. In this manner they constitute an excellent attachment for the organ, without greatly interfering with the freedom of its movements. The pleura, which covers them as they approach the lung, is from them reflected to the pulmonary surface. This it closely invests, and penetrating between the lobes, it adapts itself to the opposed surfaces of the interlobar fissures. The pedicle, thus formed, is commonly called the "Root of the Lung." It is received into the "hilus," or longitudinal incisure of the mesial pulmonary surface.

Intra-pulmonary portion of root.

Within the hilus, owing to the large size of the early bronchial divisions, and of the pulmonary vessels, and to the presence of lymphatic glands and of a tenacious fibrous tissue which firmly cements together the several structures, the intra-pulmonary portion of the "root" forms a compact mass which excludes all respiratory tissue. Beyond this the blood-vessels and the bronchial tubes rapidly diverge, and bifurcate in the lung; and the angles of bifurcation of the latter afford lodgment for the deep pulmonary lobules.

Lobar branches of the main bronchi.

The Main Bronchi.—The left bronchus divides into two branches for the supply of the upper and of the lower lobe respectively, and the blood-vessels undergo an analogous division. But the right bronchus, after giving a large branch for the upper lobe, divides again into a middle-lobar and an inferior-lobar bronchus. The more recent account of the mode of division of the main bronchi, as given by Professor Aeby, will be found on p. 70.

The relative position of each bronchus in the *root* of the corresponding lung is described by Quain, in the following words:—

Relations of structures within root.

"The root of the right lung lies behind the superior vena cava and part of the right auricle, and below the azygos vein which arches over it to enter the superior cava. That of the left lung passes below the arch of the aorta and in front of the descending aorta. The phrenic nerve descends in front of the root of each lung, and the pneumogastric nerve behind, whilst the ligamentum latum pulmonis is continued from the lower border. The bronchus, together with the bronchial arteries and veins, the lymphatics and lymphatic glands are placed on a plane posterior to the great blood-vessels, whilst the pulmonary veins are in front of the arteries. The pulmonary plexuses of nerves lie on the anterior and posterior aspect of the root beneath the pleura, the posterior being the larger of the two.

"On the right side the undivided portion of the bronchus is altogether above the pulmonary artery; on the left side the undivided portion of the bronchus, which is considerably longer than on the right side, extends to below the level of the left pulmonary artery which crosses it. On both sides the pulmonary veins are below the corresponding arteries."

Volume and Weight of the Lungs.—The *volume* of the lungs is stated by Aeby (*loc. cit.*, p. 85) to be almost one-quarter less in women than in men. He gives the following measurements:— Difference in volume due to sex

In men: Right lung = 873·0 c.c. Left lung = 744·8 c.c.
In women: Right lung = 705·2 c.c. Left lung = 585·3 c.c.

In both sexes the right lung would exceed the left in volume by 15 per cent. (almost as 11 to 10, the proportion previously taught).

According to Aeby (*loc. cit.*, p. 91) it may be proved by calculation that the lungs of infants contain the same elements as those of adults, their size only being different. He assumes that the diameter of air-cells in the new-born is one-third less than in the adult. On this basis the subsequent growth of the lung is held by him to be entirely explained by the increase in the size of the alveoli, without any addition to their number. and due to age.

Reid (quoted by Quain) found the *average weight* in twenty-nine males to be 24 oz. for the right lung and 21 oz. for the left. In twenty-one females the weights were respectively 17 oz. for the right and 15 oz. for the left lung. Average weight in adults.

B.—General Internal Structure.

Tubular Structure.—The lung is constructed entirely upon the *tubular* plan. From apex to base it exclusively consists of subdividing air-tubes—the multiplied and amplified continuations of the calibre of the trachea; and these are accompanied by numerous blood-vessels, lymphatics, and nerves, and bound together by areolar tissue. General tubular structure,

Parenchyma.—Nevertheless, throughout the greater part of the organ, the tubular character is disguised by the ubiquitous presence of an alveolated structure, inflated, during life, with more than its own bulk of air. This is the pulmonary parenchyma. It may be termed (in contrast with the more centrally situated pulmonary root) the *pulmonary* or *bronchial periphery*. This term is applicable to the parenchyma even in the depths of the lung. disguised by alveolated parenchyma at the bronchial periphery, For, however deeply it may be situated, the parenchyma represents the terminal subdivisions of the tubular system, and is morphologically equivalent to those portions of the same tissue which are quite superficial, and immediately covered by the pleura.

and becoming obvious at the root-zone.

Root-zone.—In the central zone, on the contrary, the tubular character is unmistakable. The air-tubes are larger, subdivide sparingly; and, to the exclusion of all pulmonary substance, they admit in their interstices nothing beyond large blood-vessels, lymphatic glands, nerves, and fibrous tissue. It is unnecessary to enter here upon a description of this relatively uncomplicated district. More essential, for the present, is a brief sketch of the general anatomy of the peripheral parts, which constitute the bulk of the lung.

Bronchial Periphery.—The Lobule.—In all situations, excepting the extreme sub-pleural layer, the pulmonary periphery is made up of two sets of tubes: (1) Minute *terminal* air-tubes and blood-vessels; (2) slightly larger air-tubes and blood-vessels, which are destined for more distant districts, and pass onwards between the former.

Pulmonary lobules.

The terminal air-tubes, and their attendant blood-vessels, lymphatics, and nerves, are arranged in definite groups, of the average size of a pea or small hazel-nut. These groups are surrounded by a membrane analogous to the pleura and constitute the lobules. By the peri-lobular membrane the contained pulmonary parenchyma is entirely separated from all air-distributing tubes and blood-vessels which do not belong to the lobule.

Peri-lobular membrane.

The lung, an aggregate of lobules in a bronchial and vascular frame-work.

Inasmuch as any free, or extra-lobular pulmonary parenchyma does not exist, the lung may be regarded as an aggregate of lobules, between which ramify the distributing blood-vessels and air-tubes. If all the lobules could be removed, the distributing tubes would be laid bare, and would form an empty framework, a soft endo-skeleton, differing from the central zone, or root-zone, only by the lesser size and firmness of its tubes, and by the large vacant intervals left between them. Preparations of this kind may be obtained either by dissection alone, or by the combined methods of bronchial and vascular injections, and of subsequent dissection or maceration.

This bronchial and vascular skeleton will be the subject of careful study in later parts of the work.

C.—The Pulmonary Lobule.

General Characters.—Although liable to many variations in size and in shape, all lobules agree in the possession of certain general characters. To each lobule belong:—

(1) A peri-lobular membrane.

Lobular and sub-lobular bronchioles.

(2) A single bronchiole, which furnishes the entire air-supply. This is known as the lobular bronchiole; and the air-tube which gives rise to lobular bronchioles may be termed the sub-lobular bronchiole.

(3) A lobular branch of the pulmonary artery, which accompanies the bronchiole. Lobular vessels and nerves.
(4) Two or more lobular branches of the pulmonary vein.
(5) Lymphatic vessels.
(6) Nerve filaments attached to the bronchiole.

The average size of lobules, according to Sappey ("Anat. Descript.," vol. iv. p. 450, 1874), is one cubic centimetre; but some may exceed that volume, whilst others may attain only half these dimensions. Average size.

They steadily increase in size with the growth of the lung and decrease when the latter shrinks with age. In this respect they differ from the alveoli, the individual capacity of which grows uninterruptedly throughout life. Assuming the correctness of Sappey's estimate of the average size of lobules, and of Aeby's estimate of the volume of the lung (both measured in the state of collapse), a rough estimate of the number of lobules might be readily obtained by a simple calculation. Increase in size in youth; decrease in old age.

Each lobule probably possesses not only a definite place but definite relations and a fairly constant shape. A study and a description of individual lobules would not however be rewarded by any practical result. It will suffice to remember that lobules exist everywhere as far as the boundary of the root-zone, crowding together at the surface, and filling all available space in the depth of the lung. Their mutual contact is almost direct, with the single intervention of a thin layer of connective tissue continuous with the sub-pleural tissue. According to Sappey (*loc. cit.*, p. 449) the inter-lobular interval is more appreciable, and the inter-lobular tissue more abundant, at the surface of the lungs of infants than of those of adults. The characters of individual lobules probably constant. Inter-lobular tissue.

Varieties in Shape and Position of Lobules.—The shape of individual lobules, being influenced by their surroundings, is in a certain sense accidental, and therefore varies endlessly. Sappey (*loc. cit.*, p. 450) groups these varying shapes under three types: (1) The *superficial* lobules are pyramidal, their apex pointing centrally; (2) the *marginal* lobules are wedge-shaped, their thin edge coinciding with that of the lung; (3) the *deep* lobules are facetted more or less evenly. Pyramidal, wedge-shaped and facetted lobules;

All lobules agree in being pedunculated. Between the deep lobules and those more superficially placed, no essential difference exists, except in the direction of their attachment. The bronchial and vascular supply approaches the peripheral lobules from their proximal extremity (the extremity nearest the pulmonary root). This relation is reversed in the case of the deep lobules. These are the offshoots from bronchial divisions which are distal to the angles of bifurcation in which they nestle. They are in other words *recurrent lobules*. In an intermediary position are found the lateral lobules which form the bulk of the internal substance of the lung. The angle which their axis forms with that of their parent superficial and deep lobules; recurrent lobules; lateral lobules.

bronchus varies with their distance from the surface, and according to the situations which they are destined to fill.

The lobule as structural "pulmonary unit."

The lobule is not, in a functional sense, the ultimate respiratory element; it consists of many respiratory units. But, anatomically speaking, it is the *ultimate pulmonary unit.*

The air-cell as functional "respiratory unit."

The respiratory units are the air-cells. Possessing delicate elastic walls, densely pervaded with capillaries, and lined with the thinnest epithelium, the air-cell is especially fitted for the respiratory interchange of gases. The two functions, upon which the latter may be said to depend, are represented by the elasticity of the air-cell, which permits it to expand passively, but subsequently ensures its recoil, and by its thinness, which allows the transit of gases to and from the blood coursing within its capillaries. Thus the remotest periphery is exclusively entrusted with the performance of the respiratory function. We may, therefore, consider the *infundibulum*, or, better, the *alveolus*, as the *functional respiratory unit* within the lung.

What has been said of the air-cell illustrates by contrast the full meaning of the term pulmonary unit applicable to the lobule. Within the latter are contained, invested by a membrane resembling the pleura, all the tissues which belong to a whole lung. It closely imitates the lung in outward appearance and in functional behaviour, and it is accurately described by the metaphorical expression, "miniature lung." We may therefore speak of the lobule as the structural or pulmonary unit in contrast with the functional or respiratory unit into which passes the terminal bronchiole.

D.—The Alveoli.

Minute Anatomy.—For a full description of the arrangement within the lobule works on Histology must be consulted. The short account which is here introduced for the sake of completeness is based upon the description contained in Quain's "Anatomy" (edit. 1882).

Intra-lobular and terminal bronchioles.

After entering the lobule the bronchiole divides into *intra-lobular* branches, and finally into *terminal* bronchioles. Similar bifurcations are suffered by the blood-vessels, which ultimately break up into a capillary network.

Final bifurcation.

The final dividing of bronchioles is by bifurcation. This fact was demonstrated to me very kindly by Dr. Sheridan Delépine, and in so clear a manner that no doubt remains in my mind. The bifurcation in question differs from all those which have preceded it, in the circumstance that its products are not smaller, but individually larger than the bifurcating tube; and from this they also differ in kind. The structure of their walls is modified. They possess a non-ciliated squamous epithelium instead of the non-ciliated cuboidal epithelium found in the smallest bronchioles.

Increase in calibre.

Change in epithelium.

The products of this ultimate bifurcation, the *infundibula*, are generally described as multilocular air-sacs, growing in thickness towards the periphery, and furnished with lateral and with terminal alveoli and with an *inter-alveolar passage*. According to Quain, for some distance before this final stage the terminal bronchiole is beset with lateral air-cells, here and there at first, then more thickly, so as to lose its cylindrical shape. Where the lateral air-cells make their appearance the columnar ciliated epithelium ceases, the muscular layer almost disappears, and the longitudinal elastic bundles break up into the fashioned peripheral network. Infundibula. Inter-alveolar passage.

The Epithelium.—"The change in the character of the *epithelium* first occurs in the so-called respiratory bronchioles, where patches of small pavement-epithelium cells begin to appear amongst the ciliated cells, especially in the neighbourhood of the air-cells upon the wall of these tubes. At the end of the respiratory bronchiole, near the passage to the infundibula all the cells which line the wall of the tube are of the non-ciliated pavement variety. But the air-cells themselves, both those which are scattered over the respiratory bronchioles and those which cover the infundibula, as well as intermediate portions of the infundibula which occur here and there between the air-cells, possess an epithelium. The cells of the epithelium are of two kinds—viz.: (1) large, thin, very delicate, irregular in size and shape, lying over the blood-vessels, but also in many cases extending over the interstices between them; they appear not to possess a nucleus; and (2) small, flat, polygonal, nucleated cells, which lie singly or in small groups of two or three cells between the others, and always in the interstices of the capillary network. (In the fœtus the alveoli are entirely lined with small granular pavement-cells, but with the distension which follows upon the first respiratory efforts, the cells become transformed into the large thin epithelium cells above described.)" Pavement-cells occur first in patches. Alveolar epithelium: large, non-nucleated; small, nucleated cells (between capillaries); the latter only in fœtus.

Numeration and Measurement of Air-cells.—Although much divergence exists in the various accounts given of the structure of bronchioles, of infundibula, and of air-cells (and especially of their mutual relations), with the air-cell or alveolus a definite quantity is reached, as regards both size and structure. Their number is also capable of being roughly calculated.

The aggregate *number* of air-cells in both lungs was estimated by Huschke at 1700—1800 millions. In quoting these figures Professor Aeby states that they are much too high. His own calculations are based upon an estimate of 250 air-cells in each cubic millimetre (each cell having a diameter of 0·2 mm., and a surface of 0·125 sq. mm.). Assuming that the total volume of the male lung is equivalent to 1617 cubic cm., and that of the female lung to 1290 cubic cm., he arrives at the figures 400 and 300 millions as representing the probable number of air-cells. Estimated number of air-cells.

The entire extent of the respiratory surface is given as varying between 40 and 50 square metres. But Aeby points out that in the stage of deep Extent of respiratory area.

inspiration the male lung would expand to a surface of 129·84 metres, and the female lung to a surface of 103·52 metres.

Diameter of air-cells, larger in males; greatest at apex and margins;

The *diameter* of air-cells in the human lung is, according to Quain (*loc. cit.*), most commonly, about $\frac{1}{100}$th of an inch (0·25 mm.), but it varies from $\frac{1}{150}$th to $\frac{1}{70}$th of an inch. "The air-cells are larger on the surface than in the interior, and largest towards the thin edges of the organ; they are also very large at the apex of the lung. Their dimensions go on increasing from birth to old age, and they are larger in men than in women. In the infant the diameter is usually under $\frac{1}{200}$th of an inch." The alveoli, according to Rossignol (Sappey, *loc. cit.*, p. 464), continually enlarge from birth, when their capacity measures 0·05 mm., to middle age (40), when it measures 0·23 mm., and to advanced age (70–80), when it attains 0·34 mm.

increases with age.

E.—The Pulmonary Blood-vessels.

The following description is extracted from Quain's "Elements of Anatomy." Several of the statements which it contains will be again referred to in the third section.

I.—The Pulmonary Artery.

Situation of pulmonary arteries.

Distribution and Relations.—"The branches of the pulmonary artery accompany the bronchial tubes, but in their remote ramifications they subdivide more frequently. The main arterial trunk runs down *immediately behind** the main bronchial trunk, giving off corresponding branches as it proceeds. They ramify without anastomoses, and at last terminate in small arteries about $\frac{1}{1000}$ inch in diameter, which lie between the alveoli partially encircling their mouths. From these vessels the capillary network arises, and covers each alveolus, passing in the inter-alveolar septa between the adjacent air-cells. As was pointed out by Rainey, the capillary network, in these partitions, is single in the lungs of man and mammalia, although it forms a double layer in the lungs of amphibia and of reptiles."

No anastomosis.

Single layer of capillaries.

Close network;

"The capillaries are very fine, and the network they form is so close that the meshes are scarcely wider than the vessels themselves. They are very superficial, being covered only by the thin layer of tessellated epithelium above mentioned; and in the partitions between contiguous alveoli the vessels of the network project on either side in an arched or loop-like manner into the cavities of the alveoli. The mucous membrane of the bronchial tubes, especially near the air-cells, is partly supplied with blood from branches of the pulmonary artery."

occasionally projecting into air-cell.

Branches to terminal bronchioles.

* The italics are mine. For my account see pp. 181 to 197.

II.—The Pulmonary Veins.

Distribution and Relations.*—" The radicles of the pulmonary veins arise from the capillary network of the alveoli, and from that of the smaller bronchial tubes. The branches of these veins which arise from the infundibula near the surface of the lung, *frequently do not* accompany the bronchia and arterial branches, but are found to run alone *for a short distance* through the substance of the organ. They finally either join some deeper vein which *passes by the side* of a bronchial tube, or they remain superficial, forming a wide-meshed plexus near the surface of the lung, finally tending towards the hilus to join the larger veins near the root of the lung, also forming, according to Rossignol, frequent lateral communications." Origin from alveoli and from bronchioles. Deep and superficial veins. Frequent anastomosis.

" The veins from the more deeply situated infundibula form frequent communications, and finally coalesce into large branches which *accompany the bronchial tubes* and the arteries, and thus proceed to the root of the lung."

" In their course through the lung, the artery is *usually* found above and behind a bronchial tube, and the veins below and in front." Relations.

The Muscular Layer.—*Striped muscular fibres* are found on the four pulmonary veins where they join the left auricle (Landois, Text-book of Human Physiology, translated by Stirling, vol. i. p. 68, 1885). " These fibres (which are arranged as an inner circular, and an outer longitudinal layer) can be traced to the hilus of the lung in man and some mammals; in the ape and rat they extend on the pulmonary veins right into the lung. In the mouse and bat, again, the striped muscular fibres pass so far into the lungs that the walls of the smaller veins are largely composed of striped muscle (Stieda)." In connection with the last statement it is interesting to note that " independent rhythmical contractions are often noticed in the pulmonary veins as well as in the venæ cavæ after the heart has ceased to beat. (Haller, Nysten.) [This beating can also be observed in those veins in a rabbit after the heart is cut out of the body.] " Striped fibres, longitudinal and circular, near auricle; in mouse and in bat, even in smaller veins. Rhythmic contraction.

Differences between Pulmonary and Systemic Vessels.—" The pulmonary vessels differ from the systemic in regard to their contents, inasmuch as the arteries convey dark blood, whilst the veins carry red blood. The pulmonary veins, unlike the other veins of the body, are not more capacious than their corresponding arteries; indeed, according to Winslow, Santorini, Haller, and others, they are somewhat less so. These veins have no valves. Lastly, it may be remarked that, whilst the arteries of different lobules are usually independent, their veins freely anastomose" (Quain). Pulmonary veins less capacious than pulmonary arteries. No valves.

In connection with the pulmonary blood circuit, the description of the bronchial blood-vessels should also be consulted in anatomical text-books.

* All italics are mine. Compare the description given at p. 198.

F.—The Lymphatics of the Lung.

Radicles from

Mode of Origin and of Termination.—According to Quain, the pulmonary lymphatics have two modes of origin:—

(1) alveoli.

(1) From the inter-alveolar lymphatic capillaries lymphatic vessels arise, which lie, in twos or threes, in contact with the pulmonary arteries and veins, frequently anastomosing. They may sometimes completely invest the blood-vessels.

(2) bronchioles.

(2) The lymphatics originating in the bronchial mucous membrane, traversing the muscular coat, give rise to a plexus in the fibrous layer, which is specially developed on the side adjacent to the pulmonary artery.

Lymphoid tissue.

"Lymphoid tissue, according to Arnold, is found in various parts—viz., under the pulmonary pleura; in the peri-bronchial and peri-vascular tissue; in the bronchial wall and around the alveolar passages."

Inter-epithelial radicles.

"The branched connective-tissue corpuscles, and cell-spaces, with which the inter-alveolar lymphatics are in connection at their origin, send processes upwards to the inner surface of the alveoli, between the epithelial cells."

Sub-pleural plexus.

The sub-pleural lymphatic plexus is in connection with the inter-alveolar lymphatics of the pulmonary surface.

Deep plexus.

"At the root of the lung the superficial and deep lymphatics unite into a few anastomosing trunks before entering the bronchial lymphatic glands From the latter two or three trunks issue, which ascend along the trachea to the root of the neck, and terminate, on the left side in the thoracic duct, and on the right in one of the right lymphatic trunks."

Termination of efferent ducts.

Bronchial glands.

"The bronchial glands are ten or twelve in number. The largest of these occupy the interval between the right and left bronchi at their divergence, whilst others of smaller size rest upon the first divisions of these tubes for a short distance within the lungs."

Stomata in pulmonary pleura.

Stomata and Pseudo-stomata.—Klein (The Anatomy of the Lymphatic System, 1875, and Proceedings of the Royal Society, Jan. 1874) has described at the surface of the pulmonary pleura stomata, placing in communication the cavity of the pleura with the pleural and with the inter-alveolar sub-pleural lymphatics. After pointing out the effect upon the intra-pulmonary lymph-stream of the alternating expansion and contraction of the lung, he adds: "Likewise it is clear that during inspiration those lymphatic branches also will become distended that originate in the septa of the superficial alveoli of the lung, and discharge themselves, as has been mentioned, into the network of the sub-pleural lymphatics. During respiration, again, they will become compressed." The branches connecting the intra-pulmonary and the pleural lymphatics "represent, so to speak, the safety-valves for the sub-pleural lymphatics during expiration."

Influence of respiratory movements on lymph-stream.

Dybkowski (Arbeiten aus der Physiolog., Anstalt in Leipzig, 1866) had previously described the existence of stomata in the parietal pleura: these stomata are stated to be absent from the pleura which covers the ribs, although present in their interspaces. Stomata in parietal pleura.

[The following observations, quoted by Landois (Text-book of Physiology, Stirling's translation, vol. i. p. 224, 1883) refer to the fine anatomy of the intra-pulmonary system:—

According to Pierret and Renaut every air-cell of the lung of the ox is surrounded by a large lymph space, such as occurs in the salivary glands. Nothnagel found that, if blood was sucked into the lung of a rabbit, the blood corpuscles were discovered within the interstitial connective-tissue of the lung after $3\frac{1}{2}$–5 minutes, and he concludes that the communications between the cavity of the air-cells and the lymphatics must be very numerous. Rapid absorption of extravasated blood.

According to Klein, *pseudo-stomata*, opening into the canaliculi, exist in the cement-substance uniting the epithelial cells of the alveolus: they are most easily seen in the distended air-cell. They would afford passage for lymph corpuscles and particles of pigment; but according to v. Wittich the latter are independent of any pre-existing apertures and make their way through the soft semi-fluid cement-substance.] Pseudo-stomata between alveolar cells denied by some.

Intra-alveolar Channels.—Wiwodzoff (Wiener Med. Jahrb., Bd. xi. 1866), quoted by Klein (*loc. cit.*, p. 29), describes, in the connective-tissue of the alveoli of dogs and horses, small lymph canals, the larger of which run parallel to the elastic fibres, and then follow the course of the capillary blood-vessels, but in many cases cross the latter, and in their meshes become confluent, so as to form *lacunæ*. Canaliculi and lacunæ.

Sikorsky (Centralblatt für Med. Wiss., No. 52, 1870), quoted by Klein (*loc. cit.*), likewise described canaliculi and lacunæ, the latter being situated at the nodes where the canaliculi anastomose, and exclusively in the meshes between capillary blood-vessels.

G.—The Nerve-supply to the Lungs.

An *anterior* and a *posterior* pulmonary *plexus* are stated to be formed by branches of the *vagus* in association with *sympathetic* fibres; and their branches enter the root of the lung and accompany the bronchial divisions. Remak, and subsequently Stirling, have described in connection with these nerves, solitary and grouped ganglia of minute size. Anterior and posterior pulmonary plexus.

The pulmonary branches of the vagus are divided by Quain into two sets, distributed to the anterior and to the posterior aspect of the root of the lung. "The anterior pulmonary nerves, two or three in number, are of small size. They join with filaments of the sympathetic ramifying on the pulmonary artery, and with these nerves constitute the anterior pulmonary plexus. Pulmonary branches from vagus: anterior, smaller;

posterior, larger.

Behind the root of the lung the pneumogastric nerve becomes flattened, and gives several branches of much larger size than the anterior branches, which, with filaments derived from the second, third, and fourth ganglia of the sympathetic, form the posterior pulmonary plexus. Offsets from this plexus extend along the ramifications of the air-tube, through the substance of the lung."

Sympathetic supply.

See also *infra*, the nerve supply to the bronchi.

SUMMARY OF PRESENT KNOWLEDGE CONCERNING THE BRONCHI AND THEIR VASCULAR AND NERVE SUPPLY.

A.—Arrangement and Structure of Bronchi.

THE following account is based upon the description contained in Quain's "Elements of Anatomy" (eighth edition, 1882), from which quotations are given.

General Structure.—Before entering the lungs, the bronchi present the same structure and appearance as the trachea. Their posterior wall is membranous, and their roughly cylindrical anterior and lateral surfaces are supported and stiffened by semicircular cartilaginous bands. Bronchi resemble trachea in structure.

The right bronchus, short and wide (about 1″ or 2·5 cm. in length), as it descends into the lung, is crossed from above and from behind by the *vena azygos;* and it lies at first above, and subsequently behind the right pulmonary artery. Vena azygos. Right pulmonary artery.

The left bronchus, nearly twice as long as its fellow, terminates about an inch lower than the latter. "The left bronchus crosses over the front of the gullet and descending aorta; the arch of the aorta turns backwards and to the left over it, and the left pulmonary artery lies first above it, and then on its anterior surface." Aortic arch; left pulmonary artery.

"Before entering the substance of the lung the right bronchus gives off the branch to the upper lobe, and is then continued on into the lower lobe, the branch for the middle lobe being given off from the continuation. The corresponding branch of the left bronchus is considerably larger and enters the upper part of its lung."* Lobar bronchi.

"The principal divisions of the bronchi, as they pass into the lungs, divide into tubes of less calibre, and these again subdivide in succession into smaller and smaller tubes, often distinguished as bronchia, bronchioles, or bronchial tubes, which, diverging in all directions, never anastomose, but terminate separately. The larger branches diverge at rather acute angles, but the more remote and smaller ramifications spring less and less acutely. After Subdivision and divergence of air tubes. No anastomoses. Angles of divergence.

* Since the difference in size between the right and the left upper lobar bronchi is not considerable, we must infer that the expression "corresponding branch" applies, in the text, to a branch corresponding to the bronchus which is supplied to the right middle lobe. But, in itself, the sentence in question is evenly ambiguous.

a certain stage of subdivision each bronchial tube, reduced to a small size (about 1 mm.), is termed a *lobular*, or '*respiratory bronchial tube*' (Kölliker), and its walls become beset with small hemispherical saccules termed air-cells or alveoli."

Lobular bronchioles.

Fibrous coat.

The Bronchial Wall.—The *structure* of the bronchial wall is essentially *fibrous*, but it contains abundant elastic and muscular fibres (the former being chiefly longitudinal, the latter chiefly transverse in their direction), in addition to the cartilages which keep the tubes patent, and to the mucous membrane which lines them internally.

Cartilages.

The *cartilaginous* hoops (from 6 to 8 in the right bronchus, from 9 to 12 in the left) resemble on a smaller scale the tracheal cartilages. A three-limbed cartilage, common to both bronchi and to the trachea, adds strength to the junction between the three tubes. It is not perfectly symmetrical, and the right bronchus, when viewed from within the trachea, therefore appears to occupy more than half the sectional area of the latter.

Transverse muscular fibres; a few longitudinal.

The *muscular* layer, consisting of unstriped fibres which are transversely placed, and are inserted not only into the extremity and along the neighbouring internal surface of the hoops, but also into the inter-cartilaginous structure, is contained within the fibrous membrane. A few longitudinal muscular bundles lie outside the continuous transverse layer.

Longitudinal elastic bundles.

The white longitudinal striæ (or "flutings"), visible inside the tubes along their posterior wall, are due to powerful *elastic* bundles placed beneath the mucous membrane, and connected with the elastic fibres which pervade the bronchial walls.

Mucous membrane.

Epithelium, and Debove's membrane. Lymphoid tissue.

The *submucous* tissue contains numerous *glands* and some *adipose* tissue. The *mucous membrane*, rich in lymphoid tissue, is lined by a layer of columnar, ciliated epithelium, and subjacent smaller cells (Debove's membrane), with scattered lymphoid cells, all supported by a basement membrane. The columnar cells are rendered irregular at their lower extremity by lateral pressure. Goblet-cells are of frequent occurrence among them. Elongated cells are also seen, possessing a free prolongation upwards, and a simple or forked attachment to the basement membrane.

Mucous glands, lying external to fibrous coat.

The *mucous glands* (compound, racemose, with columnar or cubical epithelium) lie within the fibrous layer of the inter-cartilaginous membrane. But the larger glands are situated more posteriorly, outside the fibrous membrane, or partly within its thickness. The orifices of the ducts, which traverse the muscular and mucous layer, may be seen at the internal surface.

Cartilaginous scales instead of hoops.

Structure of Smaller Bronchi.—The mucous membrane, the columnar epithelium, the elastic and the muscular fibres are all continued for a considerable distance into the lung, almost as far as the smallest tubes. The cartilages soon lose their horse-shoe shape, and their parallel arrangement, and take the form of irregular scales, loosely scattered over the whole circumference of the small tubes, which are cylindrical. Where the latter divide, they possess incomplete cartilaginous rings, and these rings present "a sharp concave ridge projecting inwards into the tube." Progressively smaller and further apart, the cartilaginous scales are no longer found in bronchioles less than 1 mm. in diameter. Inside the cartilaginous layer, the *muscular* fibres, completely encircling the tubes, form at first a continuous coat; but they are less abundant beyond bronchioles 1 mm. in diameter; they occur as separate rings even in the smallest tubes (and also, according to Moleschott, in company with elastic fibres, at the orifice of alveoli).

Bronchioles 1 mm. in diameter lose cartilage.

Scattered muscle fibres.

The *fibrous* coat is represented in the smallest tubes by areolar tissue, and in the walls of alveoli by an exceedingly delicate connective tissue, kept in shape by curved elastic fibrils.

Areolar tissue and elastic fibrils.

B.—The Bronchial Blood-vessels.

Their Origin.—The bronchial arteries are said to vary in number (from one to three on each side). Their origin is also variable: they may arise from the aorta or from an intercostal artery. The bronchial veins, which will be seen to collect only part of the blood supplied by the bronchial arteries, open, on the right side into the vena azygos, and on the left into the left upper azygos vein.

Bronchial arteries vary in number and origin.

Their Distribution.—Although the larger branches of the bronchial vessels lie upon the air-tubes, their area of distribution is not solely bronchial. They supply, in addition:—

(*a*) The lymphatic glands and areolar tissue at the root of the lung.
(*b*) The pleura pulmonalis and the sub-pleural and inter-lobular tissue.*
(*c*) They are also believed to distribute nutrient blood to the pulmonary parenchyma, and *vasa vasorum* to the pulmonary vessels, &c.

Blood supplied to the pleura pulmonalis, pulmonary substance, glands, &c.

The special supply to the bronchial wall ends in two capillary plexuses. The outer plexus, destined for the muscular layer, has transverse meshes; the rich, inner plexus, distributed to the mucous surface, presents a longitudinal arrangement.

Separate capillary layers for mucous and for muscular layer.

Relation to Pulmonary Blood-circulation.—An important anastomosis occurs, at the extremity of the smaller bronchioles, between the capillary plexuses of the bronchial and of the pulmonary circulation. Moreover it is stated by Zuckerkandl (quoted by Quain) that even some of the veins which originate in the walls of the larger bronchial tubes, or in the bronchial glands, or at the posterior surface of the pericardium, terminate in the large pulmonary veins, setting up in this manner a contamination, which must be considered normal, of the arterialized blood within the latter.

Anastomosis of bronchial and pulmonary capillaries.

Some larger bronchial veins opening into pulmonary veins.

Zuckerkandl (quoted by Landois, *loc. cit.*, p. 223) states that the

* The pulmonary pleura and the surface of the lung also receive (according to Turner, quoted by Quain) small branches from the intercostal arteries, which are conducted to the lung along the *ligamentum latum pulmonis*.

veins of the smaller bronchi (fourth order onwards) open into the pulmonary veins, and that the anterior bronchial (? veins) also communicate with the pulmonary veins.

C.—Nerve-supply to the Bronchi.

The source of the pulmonary nerve-supply has already been described (see p. 19).

Landois' "Text-book of Physiology," translated by Stirling (1885, vol. i. p. 225), contains the following description:—

Relation of nerve-fibres to arteries of bronchi. Numerous small ganglia.

"Several sections of nerve-trunks are usually found in a section of a large bronchial tube. These nerves lie inside the cartilages and are in close relation with the branches of the bronchial arteries. Medullated and non-medullated nerve-fibres occur in the nerves, which also contain numerous small *ganglia* (Remak, Klein, Stirling). In the lung of the calf these ganglia are so large as to be macroscopic."

Mode of termination not ascertained in mammals.

"The exact mode of termination of the nerve-fibres within the lung has yet to be ascertained in mammals, but some fibres pass to the bronchial muscles, others to the large blood-vessels of the lung, and it is highly probable that the mucous glands are also supplied with nerve filaments. In the comparatively simple lungs of the frog, nerves with numerous nerve-cells in their course are found (Arnold, Stirling), and in the very simple lung of the newt there are also numerous nerve-cells disposed along the course of the intra-pulmonary nerves. Some of these fibres terminate in the uniform layer of non-striped muscle which forms part of the pulmonary wall in the frog and newt, and others end in the muscular coat of the pulmonary blood-vessels (Stirling). The functions of these ganglia are unknown, but they may be compared to the nerve-plexuses existing in the walls of the digestive tract."

In frog fibres end in pulmonary muscle, and muscular fibre of vessels.

ANALYSIS OF

PROFESSOR AEBY'S WORK "ON THE BRONCHIAL TREE."

At the time when Professor Aeby's work * was published, no modern treatise of importance was in existence on the subject of the anatomy of the bronchial system, and since its publication, as far as I am aware, no other work dealing with the same matter has appeared. Professor Aeby's views have been transcribed into various anatomical text-books, and anatomists have either actually expressed their acceptance of them or, by withholding any adverse criticism, have given them their tacit assent. These views therefore rank among the recognized additions to anatomical knowledge, and, as such, they possess a claim to our most careful consideration.

No modern literature on this subject.

Aeby's views accepted or not opposed.

The Bronchial Tree of Aeby.—The term "bronchial tree" is obviously metaphorical, and should be understood as such whenever used in these pages. A literal meaning is however capable of being attached to this expression. According to Aeby the bronchial distribution resembles a *tree*, not only in possessing branches, but because the branches are all derived from a trunk or *stem* which preserves its individuality, and its axial character, from its origin to its termination. For each lung this "bronchial stem" is represented by the main bronchus.

The "bronchial stem."

The alleged breaking up of the bronchus into two equivalent lobar bronchi on the left side and into three on the right, as hitherto described in anatomical text-books, has for him no existence in reality. Far from disappearing at so early a stage, the main bronchus in both lungs gives a *succession* of branches, and itself proceeds as an independent structure as far as the lower extremity of the lung. Moreover, each of the branches which it delivers in this course arises singly, according to a plan of "monopodic evolution."

Older view as to division of main bronchus rejected.

Monopodic evolution of its branches.

Hitherto *symmetry* was held to be the guiding principle in the pulmonary structure, and *dichotomy* was supposed to be the means to that end. But Professor Aeby finds that symmetry holds very limited sway in the lung, and dichotomy he absolutely rejects as contrary to his own anatomical observations.

Symmetry not a strong feature.

Dichotomy untenable.

* "Der Bronchialbaum der Säugethiere und des Menschen, nebst Bemerkungen über den Bronchialbaum der Vögel und Reptilien." Leipzig, 1880.

From what has been said, a sufficiently clear idea may be gained of the originality of views, and of the boldness in their expression, which characterize the work. To use his own words, in "breaking with tradition," Professor Aeby has done signal service to anatomy. He has cast upon us the duty of testing, in the light of his new facts, the truth of older teachings. So long as theories only are proposed as substitutes for the latter, we shall do well to hesitate before we agree to the exchange. And it cannot be denied that Professor Aeby's book, so remarkable in respect of anatomical study, is no less remarkable for the amount of theory which it contains. But his theories are so closely dovetailed with facts, that to single them out is a work of nicety. This will be best accomplished by means of a careful analysis of the book, and by a separate consideration of its various contents under separate headings. With this object, all controversy must, for the present, be postponed.

Theoretical aspects of Professor Aeby's work.

Facts mingled with theories.

I.—Professor Aeby's Facts.

The facts brought forward by Professor Aeby may be arranged in two classes:

Old errors corrected.

A. Facts in refutation of previous anatomical errors. Several of these corrections relate to the behaviour of the main bronchi and of the pulmonary artery, and possess great importance. They will be fully given elsewhere.

New anatomical facts.

B. Facts of another class are entirely novel. Thus some of the statements refer to individual branches arising from the bronchial stem, in other words, to primary bronchi, which had not hitherto been the subject of anatomical description. This study was unfortunately not pushed far by Aeby; and the purely anatomical descriptions are few and short. They will be noticed in connection with the systematic description of the bronchial tree.

Extensive investigation of dimensions of air-tubes, angles of divergence, &c.

On the other hand, within this relatively limited range of anatomy, Professor Aeby has crowded an astounding number of exact observations relating to measurement, which render the work a monument of patient research. It would be impossible to do justice to so great a mass of facts even in mere summary. But the following headings will give some idea of the direction which his labours have taken:

Mensuration of the bronchi and of the "Eparterial," and "Hyparterial" branches, and of their internodia.

1. Measurements of the angle of inclination of the main bronchus, and of its branches;
2. Direction of the bronchial branches;
3. Measurement of the "eparterial" and of the "hyparterial" sections of the bronchial stem, expressed in percentages of the length of that stem;
4. Length of internodia separating the first four ventral hyparterial branches, expressed in percentages of the length of the bronchial stem;

5. Length of interval separating the "eparterial" bronchus from the trachea above, and from the first "hyparterial" branch below, compared with the average length of internodia in the "hyparterial" system;
6. Distances of the various bronchial tubes from the bifurcation of the trachea, expressed in percentages of the length of the bronchial stem;
7. Diameter of the bronchial stem at various heights, expressed in percentages of the diameter of the trachea;
8. Diameter of the several primary divisions, expressed in the same terms; Measurement (absolute and comparative), of the diameter of the various tubes.
9. Ratio between the diameters of the latter, and that of the bronchial stem;
10. Absolute initial and terminal diameters of the "eparterial" and of the "hyparterial" systems, expressed in square millimetres;
11. Relative terminal diameter of the same systems, expressed in percentages of their initial diameters;
12. Absolute calibre of the bronchial tree at various heights, expressed in square millimetres;
13. The same, expressed in percentages of the initial calibre;
14. Aggregate absolute calibre of the right and left halves of the bronchial tree, expressed in square millimetres;
15. The same expressed in percentages of the tracheal calibre;
16. Table illustrating the relations of the primary bronchi to the number of pulmonary lobes.

Many of the measurements, which have been enumerated above, were carried out in specimens, or in metallic casts obtained from some 48 individual species, belonging to fourteen mammalian families, and most of the tables, of which there is a great number, include separate columns for the right and for the left lung respectively. Tabulation of results in mammalia,

In the section devoted to the human bronchial tree the same analysis is repeated with all its detail, in connection with specimens derived from a series of individuals. But, in addition, elaborate tables are here constructed, which show the absolute, the relative, and the average volume of the pulmonary lobes in the right and in the left lung in different sexes, and at various ages, including the later fœtal months. and in man. Comparative volume of the several lobes at different ages, &c.

A short chapter is devoted to the approximate measurement of the pulmonary respiratory surface; and a concluding chapter deals briefly with the subject of the bronchial tree in birds and in reptiles. Estimate of the total respiratory area.

The human section is a mine of information concerning the measurements of the trachea, bronchi, and primary bronchial branches. It is unfortunate that these determinations should have been made exclusively on metallic casts, a kind of preparation capable of great perfection of detail, but liable also to serious errors. Measurements (in man) made from the metallic casts.

Such, in distant outline, is the range of the facts ascertained by Professor Aeby.

II.—Professor Aeby's Theories.

The theories, for which Professor Aeby endeavours to find a basis in his anatomical facts are limited to three, but their importance is far-reaching. They respectively relate to:—

(*a*) The existence of a bronchial stem;
(*b*) The monopodic branching of the bronchial tree;
(*c*) The distinction between an eparterial and an hyparterial segment in the lung of mammalia, and the essential asymmetry, in man, of the right and of the left lung.

Each of these theories must be considered separately in the following pages.

CRITICISM OF PROFESSOR AEBY'S VIEWS.

Professor Aeby's First Theory:

The Bronchial Stem viewed as an Axial Structure.

In connection with the remarks to be ventured in this criticism, it must be pointed out that the theoretical nature of the propositions to be considered limits the range of their discussion. Just as Professor Aeby has sometimes failed adequately to support his theories with facts, facts may not be forthcoming to overthrow them, and the conflict may of necessity remain one of opinions. A discussion of this kind is not, however, without some utility, since it may draw attention to the debatable nature of propositions which have hitherto passed unchallenged, and to the need for decisive facts. The discussion partly theoretical. Its uses.

The "Bronchial Stem" of Aeby.—Anatomists in the past had been content to look upon the remainder left after the delivery of the upper lobar bronchus, as the *lower lobar bronchus*, on the left side, and, on the right side, as the bronchus destined for the *middle* and *lower lobes*. With that view Professor Aeby is unable to sympathize. The main bronchi according to the older view.

According to him, each lung possesses a fundamental ("*grundlegendes*") axial structure, which he terms the "bronchial stem"; but the axis in question is not supposed by Aeby to be symmetrically placed in the lung. Upon this stem, as an independent basis, he appears to rest the whole system of pulmonary architecture. Aeby's "bronchial stem."

In most quadrupeds the disproportion existing between the "remainder," or continuation, of the main bronchus is much more obvious than in man; and it is from a consideration of their bronchial tree that Aeby derives his strongest arguments in favour of the theory of an axial bronchus. Among mammalia, man appears to present the only instance in which the existence of a "bronchial stem" is difficult to recognize at a glance; in Aeby's estimation this is a difference rather in degree than in kind. The excellent illustrations in Professor Aeby's work sufficiently demonstrate how well the axial theory fits the anatomical appearances in many mammals. Even in man a continuation of the main bronchus may be traced for some distance in both lungs, as a tube somewhat wider and more direct than those which branch from it. Contrast in size between stem and branches, obvious in some animals, less so in man.

The bronchial stem cannot be identified in lower part of human lung.

Facts and Reasons opposed to the Theory.—But the description of the human bronchial tree, which will be given in Section II., affords proof that in man any distinct trace of the "bronchial stem" of Aeby is lost below the level of the upper third of the lower lobe. The same conclusion may be also derived from an inspection of the photographic reproductions of human bronchial casts contained in Professor Aeby's book.

Professor Aeby's measurements point to same conclusion.

His own measurements are singularly instructive on this point. The third ventral hyparterial bronchus and the bronchial stem are found relatively to possess a diameter of 5·1 mm. and 5·8 mm. in the right lung, and of 5·7 mm. and 6·4 mm. in the left lung (*loc. cit.*, p. 74), a disproportion which is admitted to be trifling.

Opposite ends of the Mammalian series selected as starting-point by Aeby and by the author.

It might be suggested that it is unfair to discuss, in relation to one particular case, a theory which was devised for general application, especially since this particular case is pointed out by Aeby as affording imperfect support to the theory. On the other hand, if the whole mammalian class is to be taken into consideration in connection with the question at issue, it must remain matter of free choice which end of the series shall be selected as the point of departure in the inquiry. Professor Aeby has preferred to start from the inferior representatives of the group, which, it is only right to own, are the more numerous; and the conclusions which he bases upon them are made to apply, not without considerable strain, to the higher representatives also. I propose, with a view to testing the theory, to reverse this march. But I cannot lay claim to that even familiarity with human and with comparative anatomy which adds so much weight to any views expressed by Professor Aeby. In the field of comparative anatomy I am dealing with data, not my own, but for which I am entirely indebted to that observer. Although this circumstance detracts much from their value, the following considerations may serve a useful purpose as suggestions arising from an opposite standpoint, and, at any rate, they may throw some side light upon a train of thought developed by the excluside study of the bronchial system in man.

Advantages in studying the differences, rather than the similarities in the two groups.

Professor Aeby insists mainly upon the points of agreement which he discovers in the two groups. But, by directing attention to the points of difference and investigating their causes, we may step nearer to a correct appreciation of the stem-like appearance described by him; and we may perhaps succeed in tracing the diversities in its growth to some definite anatomical and physiological influences, instead of calling to aid abstract morphological tendencies.

Difference in the Thorax of Man and of Quadrupeds.—The contrast between the bronchial tree of man and that of most other mammals, to which attention has been called, is associated with a no less striking contrast in the shape of the thoracic cavity and in the anatomical relations of the heart and of the lungs in the same animal groups. In man the sternum is relatively long, almost reaching to the lower level of the

In man a long sternum, a

dorsal spine, and the diaphragm, between its anterior and posterior points of attachment, assumes a practically horizontal position. In a large number of quadrupeds, on the other hand, the sternum is short, the dorsal spine extends far below* the level of the xiphoid notch, and the diaphragm acquires an obliquity which may be occasionally of considerable degree. Moreover, the heart, resting in quadrupeds along the dorsal surface of the short sternum, is situated at a relatively higher level in the thorax than in man, in whom it is supported by the central portions of the diaphragm, and occupies the entire distance between the xiphoid notch and the lower dorsal spine.

horizontal diaphragm.

In quadrupeds, sternum short, diaphragm oblique.

Differences in position and relations of heart, and in shape of thorax.

Resulting Difference in Bronchial Tree.—The long, narrow thorax of quadrupeds, instead of being, as that of man, shallow and broad, is flattened from side to side, like the keel of a ship, and would present on transverse section a heart-shaped outline. The vertebral groove of the thorax acquires in them considerable depth and width, and being relatively long, it affords lodgment for a large mass of pulmonary substance. Indeed, it may be said that in these animals the bulk of the respiratory space is to be found in the dorsal and postero-lateral thoracic regions.

Vertebral groove deep and long in quadrupeds.

To these regions air must be conveyed with directness and in quantity. Hence the continuation of the main bronchus is decidedly dorsal in position, and its channel is both long and wide. Its plane is almost posterior to that of the heart, which occupies a mesial position immediately behind the sternum. From a stem thus placed, long anterior branches would arise at a considerable angle, for the supply of the anterior parts; and the short posterior branches, recurring at regular intervals, would further accentuate the axial appearance of the continuation of the main bronchus.

Hence a greater width and length, and a dorsal position of continuation of bronchus, and an axial appearance.

In man the anatomical conditions are widely different. The heart occupies more thoracic space at the base of the thorax than at any other level, and fills the mediastinum from front to back. Thus the main bronchi and their continuation cannot become posterior to it, but they diverge so as almost to embrace it laterally. In other words, the main bronchus assumes a less dorsal, or, in relation to each lung, a more central position in man than in quadrupeds. This central position of the bronchus, taken in conjunction with the relative shortness of the human lung, and with the almost circular outline of the inferior aperture of the human thorax, necessarily leads to a breaking up of the air-supplying stem into diverging tubes of almost equal size. Among the latter it becomes next to impossible to demonstrate the existence of any axial tube differing in value from other bronchi. It is also of importance to note that the same circumstances give rise to a, roughly speaking, radiating arrangement of the bronchial divisions.

In man the tube is less dorsal.

Hence, owing to short and wide thorax, branches diverge and radiate more evenly.

Had not the size and position of the heart prevented the bronchus from assuming, in each half of the chest, a strictly central position, the radiating arrangement would probably have presented absolute regularity, and the

* The terms anterior and posterior have here the same value as in human anatomy. The trunk is to be imagined in the upright position.

"bronchial stem" of Aeby which ceases to be recognizable in the lower third of the human lung, would have become incapable of demonstration at a yet higher level.

The appearance of a "bronchial stem" a result of anatomical and physiological conditions, not of any abstract law.

Conclusion.—It would thus appear that where it does exist, the bronchial stem is the result of anatomical and physiological necessities, and that where it is missed, the disappearance is associated with analogous changes in the anatomical and physiological requirements. It may, therefore, be held that, far from being the expression of an abstract law of development the axial feature which Professor Aeby finds to be so characteristic of the bronchial tree of most mammals, is in them associated, as a result, with certain anatomical and physiological peculiarities. The almost entire disappearance of the axial type in man strongly suggests that the question is mainly one of adaptation.

Professor Aeby's Second Theory:

Monopodic Branching in the Bronchial Tree, instead of Dichotomy.

Dichotomy a wider question than the preceding one.

Importance of the Question.—The theory of an "axial bronchial stem" applies only to the main bronchus and to its primary branches. It may be held or rejected without any prejudice as to the characters of the bronchial tree in general. But a rejection of the principle of dichotomy would possess much wider significance and should not be entertained without deliberate consideration. There are reasons for believing that dichotomy prevails on a large scale in the depth of the lung. If this were clearly shown to obtain, the primary divisions themselves might, on renewed consideration, be found not to depart so widely from the type in question as was at first suggested by their general features.

Limited scope of Aeby's investigation of the bronchial tree.

Statement of Professor Aeby's Views.—The description of the bronchial tree by the German anatomist does not extend beyond the primary branches derived from the main bronchus. As far as they relate to this important, but comparatively limited, portion of the bronchial system, his remarks are obviously justified by the appearances. To quote his own words (*loc. cit.*, p. 4): "The bronchial tree is not polypodic, as was admitted on the strength of the erroneous assumption of a dichotomous mode of division, but strictly monopodic. This is also true of the further branching of the lateral bronchi. Departures from this strict law do not, in general, occur except in outlying districts; the contrast between stem and branch gradually vanishing as they acquire equality in size, and outwardly assume thereby the aspect of equivalent parts of a common whole. In the terminal divisions this is probably the rule, but on this point I possess no personal information."

Existence of dichotomy at the periphery suspected by him.

Wider Scope of the Author's Investigation.—The present investigation is not confined to any one portion of the bronchial system, and in using the term "bronchial tree," I refer to the entire set of air-tubes, all of which, from the trachea onwards, have been subjected by me to examination. But, whereas Professor Aeby starts from the anatomy of the primary bronchi, and from them draws inferences as to the probable behaviour of the smaller divisions, I am inclined to seek the genuine type of bronchial architecture in those portions of the bronchial tree which are in intimate relation with the respiratory district. This difference in points of view sufficiently explains a slight divergence in the interpretations awarded to anatomical facts concerning which there can be no disagreement.

Genuine bronchial type to be sought within respiratory district.

Tracheal Bifurcation—Why Unequal?—The first division occurring in the respiratory tract, that of the trachea, is an uneven one, and this is made to serve Professor Aeby's contention. But the obvious inequality in the size of the two main bronchi should not make us regardless of the yet more important fact that they are the products of a bifurcation. Their want of equality, as well as that of the lungs themselves, will be later on shown not to rest upon any principle of asymmetrical construction, but to be ultimately due to the unavoidable encroachment of the heart towards the left side. Similar reasoning is also applicable, on either side, to the primary divisions of the main bronchus, the differences between which are most obvious,—although Professor Aeby was the first to draw sufficient attention to their inequality.

The main bronchi unequal; yet the products of a bifurcation.

Their inequality due to position of heart.

Dichotomy at the Periphery.—But the trachea and main bronchi are after all extra-pulmonary;—and their primary divisions are not contained entirely within the pulmonary boundaries. The behaviour of the bronchial tree within the depths of the lung is a more trustworthy indication of the architectural principle upon which both are built. The further dissection is carried within the lung, the less rarely does *even dichotomy* occur. At the periphery of the bronchial system perfect bifurcation preponderates, and a multitude of simultaneous and equal bifurcations take place immediately above, or at the level of, the furthest bronchial zone. These may readily be seen in dissections as lobular and sub-lobular bronchioles. Moreover, under the microscope bifurcation is found to be, to a great extent, the mode of origin of terminal bronchioles.

The smaller the tubes, the more even the dichotomy.

Dichotomy of terminal bronchioles.

Even Dichotomy Unsuitable for the Lung.—Although, even in the peripheral districts, instances of want of symmetry occur, their paucity adds force to the rule; and it may be advanced that dichotomy is unmistakably displayed both at the tracheal and at the pulmonary extremity of the bronchial tree; and that it constitutes, so to say, the alpha and the omega of bronchial division. But absolute evenness of dichotomy is not to be looked for. Due regard being paid to the shape of the thorax, unevenness is more likely than regularity. The products of a dichotomy which had been carried through with mathematical precision would

Exceptions few.

Dichotomy, the alpha and omega of the bronchial system.

Even dichotomy impossible in the lung.

have fitted ill within the pleural boundaries. Nay, even the more elastic principle of "monopodic branching" requires, in its working, to be allowed some latitude. All so-called principles, or laws, are overruled by a higher law, the *law of adaptation*. But that principle will best lend itself to a wide application which is least restrictive in its terms. In bifurcation pure and simple, in other words in dichotomy not necessarily even, we possess a principle sufficiently broad to cover every individual irregularity of form, and sufficiently comprehensive to contain even that principle of monopodic branching which Professor Aeby advocates in connection with the primary divisions of the bronchi.

The law of adaptation overrules others.

Dichotomy, in broader sense, implied in "monopodic branchings."

Uneven Dichotomy implied in Professor Aeby's Theory.— It is obvious from Professor Aeby's pleading that his objections are addressed to *even dichotomy*, which means the divisions of a tube into two equal derivatives equally diverging from it. But the words employed by him in describing the mode of division which he recognizes, contains the admission of dichotomy in a broader sense. Does not monopodic branching imply that two tubes are invariably the outcome of division—viz., the parent tube, which he considers to be axial, and the lesser tube, or branch from the stem? In the course of this investigation it will be shown that dichotomy, in this sense, is a rule without exception in the lung. Professor Aeby admits in one or two instances a tripodic division; but these exceptions exist only in appearance.

Tripodic divisions, &c., exist in appearance only.

It is not contested that, for the larger tubes at any rate, uneven dichotomy is the rule, and even dichotomy the exception. But, were it only as a means of asserting that never more than two tubes originate from the division of any bronchus, and that tripodic and tetrapodic branchings do not exist, the use of the term dichotomy is both justified and serviceable.

One structural principle should suffice in the lung.

If admissible, the principle of dichotomy would save us from the necessity implied in the adoption of Professor Aeby's theory, of assuming monopodic branching at one level of the bronchial tree and dipodic branching at another. It remains for us, however, to consider whether, dichotomy can be reconciled with the instances which are argued against it.

Mode of adaptation.

By what modifications is the principle of dichotomy rendered capable of adaptation to the varying requirements of shape and of space? The answer is simple, but the facts are infinitely complicated.

Disparity of bifurcated tubes equivalent to disparity of pulmonary districts.

Dichotomy Modified by Anatomical Circumstances.—Two bronchial tubes arise from a common parent tube. Their disparity in diameter is their most obvious feature of contrast. Whether this be called overgrowth in the case of the one, or arrested development in the case of the other, the difference is exactly correlated with equivalent differences in the size of the relative pulmonary districts. Moreover just in the measure as these districts differ in their situation, a difference will also arise between the direction taken by the parent bronchus and that taken by each of its

Disparity of angles.

derivatives. And lastly, in order to suit the variety in shape of the individual pulmonary districts, the length of internodium of each of the products of any bifurcation will often display considerable disparity. Disparity of internodia.

Varying Internodia.—It may be incidentally mentioned that, in general, the variability in the length of internodia plays a very important part in the architecture of the bronchial tree; and, if duly regarded, may serve as an explanation for apparent irregularities. A comparison of the right and of the left bronchial system is, in this respect, most instructive; and it will be pointed out later on that some internodia may become rudimentary in one lung whilst retaining a fair size in the other, and *vice versâ*. Importance of length of internodium. Vanishing internodia.

Varying Angles of Divergence.—It is an almost invariable rule that of two diverging bronchi the smaller one diverges most from the direction of the parent tube. This observation, which lies at the root of Professor Aeby's theory of monopodic branching and of an axial stem, is not in my estimation incompatible with the assumption of a pervading system of modified dichotomy,* even when the divergence of one of the two branches is infinitely diminished (as in the case of the bronchial stem of Aeby) and when this branch appears both in size and in direction to be the continuation of the parent trunk. The rule holds good even in the case of the tracheal bifurcation, the left product of which is more oblique as well as smaller than the right. But it suffers an interesting exception in the case of the *left pectori-apical* bronchus, to be elsewhere described. The smaller tube diverges most. Vanishing angle of divergence.

Cause of the Disparity of Tubes and Angles.—Unevenness in the size and in the divergence of bronchial tubes may be largely ascribed, as already hinted in the remarks made concerning the influence of physiological factors, to the relative delay which occurs in the earlier branchings of the bronchial tree, as compared with its more rapid subdivision at the periphery. It results from this circumstance that tubes of large diameter supply to pulmonary districts which they traverse or approach, lateral tubes of relatively small size, and that the latter arise at a comparatively large angle. Delay of the early branchings causes unevenness.

In contrast with this delayed branching, and comparative infrequency of divisions at the root, the internodia become much shorter, the angles of divergence less uneven, and the bifurcated bronchi less unequal in size, as soon as the respiratory zone is reached. Yet, even in the depth of the lung, many of the distributing bronchi which supply sub-lobular and lobular branches, present, as a result of peculiarities of environment and of the necessity for adaptation, an irregular course. Attention will presently be called to some of these aberrant types. Evenness returns towards periphery. Here also some aberrant type.

Conclusion.—The foregoing considerations tend, in spite of *primâ facie* All bronchi dichotomous.

* I warmly acknowledge at this stage the courtesy of Dr. Sheridan Delépine in communicating to me some of his unpublished observations on the construction of the bronchial tree, and my indebtedness to him for the suggestion of a view which anatomical observation has enabled me to confirm.

appearances, to support the view (1) that all bronchi are dichotomous; and (2) that in any bronchial pair, the greater size of one bronchus is correlated with the greater mass of lung-tissue which it must supply with air. Thus unevenness of size is not necessarily a negative evidence against dichotomy; and dichotomy does exist, at any rate in the limited sense that never more than two branches arise from any one division.

Size of district and of bronchia correlated.

With these reservations in favour of a pervading dichotomy, the use of the term "bronchial stem" is conceded in respect of its convenience; just as the expression "bronchial tree," conveying a purely metaphorical meaning, was adopted for the sake of brevity.

The use of the term "bronchial stem."

Professor Aeby's Third Theory:

The Eparterial and Hyparterial System.

Statement of Theory.—The subsequent remarks will be more readily understood if the fundamental ideas upon which the theory rests are laid before the reader with some detail. For the sake of greater clearness these views have been arranged in the shape of definite propositions, which, I believe, faithfully represent Professor Aeby's own statements.

This theory analysed into definite propositions.

1. **Surfaces and Borders.**—The human lung, in harmony with the arrangement of the "lateral bronchi," presents two borders only, which are relatively anterior and posterior; and only two surfaces, an external or parietal surface, opposed to the thoracic walls, and an internal or visceral surface, which faces on the one hand the mediastinum, and on the other hand the diaphragm (*loc. cit.*, p. 53).

Two borders, anterior and posterior. Two surfaces, parietal and visceral.

2. **Bronchial Stem.**—A continuous bronchial stem, or axis, pervades each of the lungs, and from this stem successive bronchial divisions are derived, just as so many branches might arise from the trunk of a tree.

A tree-like stem.

3. **"Lateral Bronchi."**—In their origin from the stem the bronchi are either *dorsal* or *ventral*, with one exception, that of the right upper bronchus, which is neither ventral nor dorsal, but which supplies ventral and dorsal branches as products of its own division.

Right upper bronchus not ventral nor dorsal.

4. **Bronchial Asymmetry.**—The right and the left lung are not, in most mammalia, symmetrical in their lobes, neither are they symmetrical in their bronchial supply.

Lobes and bronchi asymmetrical.

5. **The Pulmonary Artery** as it enters each lung, bears a definite anatomical relation to the main bronchus, and to its first branch; but this relation is widely different in the two lungs.

Difference between the lungs as to site of trans-bronchial passage of pulmonary artery.

6. **The Bronchus Crossed by the Artery.**—On both sides the artery crosses the bronchus from before backwards, at a given point, which is constant. But in most mammalia and in man the passage of the artery occurs on the left side *before* any branches have arisen from the bronchus.

All the branches of the left bronchus are therefore situated below the artery; they are therefore termed *hyparterial*. The right bronchus on the contrary is crossed by the artery *after* delivering its first branch. The pulmonary artery thus separates the branches arising from the right bronchus into two sets, one of which is *hyparterial*, the other *eparterial*.

Left lateral bronchi "hyparterial." Right bronchi "eparterial" and "hyparterial."

7. **Instances of Complete Symmetry, in Animals.**—In a few mammalia the arrangement is symmetrical on both sides, owing to a symmetrical passage of the pulmonary artery; and in them both lungs possess an *eparterial* and an *hyparterial* set of bronchial branches. This arrangement is never seen in man.

Bilateral presence of "eparterial system" in some mammals.

8. **Pure Hyparterial Type.**—In one genus only (Hystrix cristata, the hedge-hog), symmetry of an opposite kind obtains. In this animal neither the right nor the left bronchus bears any branches superior to the pulmonary artery. Both its lungs are entirely *hyparterial*.

Its bilateral absence in Hystrix only.

9. **Eparterial and Hyparterial Distribution.**—In respect of their ventral and dorsal branches the eparterial and the hyparterial districts show a marked contrast. Whereas in the hyparterial the ventral and the dorsal branches arise separately from the bronchial stem, in the eparterial system they coalesce into a single eparterial trunk (the right upper lobar bronchus).

10. **Upper Right and Upper Left Lobe not Analogous.**—Inasmuch as in man and in most mammalia the left lung does not possess an eparterial district corresponding to the right upper lobe, the *superior of the two left* pulmonary lobes, being hyparterial, is the *equivalent* not of the right upper lobe, or eparterial lobe, but of the *right middle lobe* which is hyparterial. But the left inferior lobe exactly corresponds with the right lower lobe.

Upper left lobe equivalent to middle right lobe. Lower lobes equivalent.

11. **Mixed Type.**—The human lungs are an instance of a *mixed type* in which only one lung contains an eparterial district.

Mixed type in man.

12. **Eparterial Type.**—The presence in some animals of a left eparterial bronchus in addition to a right eparterial bronchus gives rise, in them, to the *true eparterial type*.

Eparterial and hyparterial types.

13. **Hyparterial Type.**—The absence of both eparterial branches, where it occurs (in Hystrix cristata) constitutes the *true hyparterial type*, which may be looked upon as the lowest morphological expression in mammalian pulmonary architecture.

14. **Lateral and Accessory Bronchi.**—In man the right and the left hyparterial districts are almost identical, each possessing about four ventral and four dorsal branches, in addition to some accessory bronchi.

Four ventral bronchi; four dorsal; and some accessory.

15. **The Left, a Diminished Lung.**—The right human lung possesses, in its eparterial lobe, an additional district, non-existent in the left lung; in other words, the left lung is deficient in a true upper lobe, such as would belong to the complete eparterial type of lungs.

Left lung possesses no eparterial upper lobe.

Criticism.—Such, in bare outline is Aeby's ingenious theory, which

Aeby's strong

belief in the eparterial theory.

may be known in these pages as the "eparterial theory." Founded upon anatomical research it is considered by its author to be unassailable; and hitherto the event has fully justified that belief. The diffidence with which I approach its discussion is not due to my entertaining a belief of the same nature, or even any doubts; but rather to respect for the authority which belongs to any views coming from so distinguished a source; and especially for the great value of the work in which they are conveyed.

Any criticisms now ventured against the eparterial theory are primarily directed against its applicability to the genus Homo. In connection with comparative anatomy my opinions can claim only a secondary value.

If inapplicable to man, the theory is self-condemned in mammalia in general.

Nevertheless should evidence arise showing the absolute inapplicability of the eparterial theory in man, its applicability to the mammalian series must become exposed to serious doubt. Professor Aeby's whole endeavour has been to unify the bronchial peculiarities of the mammalian genera under one comprehensive scheme. If in the more limited district of human anatomy the theory should prove to be untenable, it is but logical that the arguments by which he has sought to establish the general fitness of his doctrine should complete its refutation in the field of comparative anatomy.

Generalization was probably applied prematurely to insufficient facts.

Professor Aeby's Facts Correct, but Incomplete.—The facts advanced by Professor Aeby in connection with the eparterial theory are obviously correct: we can only object to his having given us so few. Nay, it was a misfortune that the analytical study of the bronchial system, which he has initiated, should not have been pushed further by him before the generalizing methods of comparative anatomy were brought into play. Facts though correct may be incomplete; and doctrines built upon them in their immature stage may lapse into the rank of theories when further facts give room for larger constructions. The anatomical facts hereafter to be described possess this completing value. Their conflict is with the theory not with Professor Aeby's laborious conquests in the field of anatomy.

Complete criticism later.

The Principle of the Theory questioned.—Although the adequate criticism of the eparterial theory must of necessity be postponed to the section of this work dealing with anatomical detail, it is possible even at this stage briefly to examine the principle which underlies it. A question at once

Doubt as to the competence of the pulmonary artery as a test for the bronchi.

arises as to the competence of the standard used as a test for the morphological value of the bronchial tubes. Are we sufficiently justified in using the position of the pulmonary artery as a qualitative test? Is it seniority in development, or is it greater physiological importance, which is considered to raise the pulmonary artery so far above pulmonary structures, and to render it

If precedence determined by bulk, bronchi and air cells would rank first.

standard-giving? Were precedence regulated according to bulk, the bronchial tree, taken together with its parenchymatous extension, would be found in mammalia greatly to exceed in cubic space the vascular, and therefore to be more entitled to the first place among all pulmonary structures.

Assuming equality between

Alternative Terminology proposed.—That the lung is pre-eminently an air-organ we may perhaps not venture to assert, for throughout the animal series the vascular component is a constant one, whereas the bronchial component is only found in air-breathers. In the mammalian lung we cannot do less than allot to the aërating mechanism at least an even share of importance. But if equal dignity should belong to vessels and to bronchi it would be as plausible to speak of the left pulmonary artery as "*epibronchial*" and of the right pulmonary artery as "*hypobronchial*" as to couple the Greek prefixes with the name of the blood-vessel.

vascular and aërating systems the terms, "epibronchial" and "hypobronchial" equally justified,

Practical Considerations.—It may be argued however that theoretical considerations such as these are not the best guides, and that in questions of nomenclature it is wiser to study convenience. This view also may be pleaded in favour of the terms just proposed. For it will be shown in the course of the description of the bronchial tree that the employment of such terms as "*epibronchial*" and "*hypobronchial*," although not indispensable, would serve a practical purpose in surgical anatomy.

and practically more useful.

SECTION II.

THE DETAILED ANATOMY OF THE BRONCHIAL SYSTEM STUDIED FROM THE BRONCHIAL CASTS AND FROM DISSECTIONS.

THE METHODS EMPLOYED.

A BRIEF reference to the methods used in the present investigations will serve as a natural introduction to the anatomical description of the bronchial system. The results were obtained by means of a combination of the methods of *dissection* and of *intra-bronchial injection*. The two methods may be conveniently considered under separate headings.

A.—Dissection.

i. *Dissection of Non-injected Lungs.*

The specimens used. Difficulty increases with complexity of dissection. A sodden state of the lung favourable. Pathological lungs. Necessary implements.

Mode of Performance.—For this purpose lungs were used either fresh, or after short maceration in water, or after preservation in spirit. A successful dissection of the bronchial tree is essentially a work of patience. The difficulty varies with the completeness which it is desired to attain in the preparation, and culminates in the dissection of specimens intended to show all three tubular systems in their *mutual* relations and in their relation to the *pleura*. Professor Aeby rightly points out that a lung, when slightly sodden, becomes easier to dissect. Lungs derived from the *post-mortem* room differ much, according to the variety of their pathological conditions, in their fitness for the object in view. For the rest the usual methods and instruments of dissection, a dissecting board and a large assortment of pins of various sizes will answer all requirements.

ij. *Dissection of Injected Lungs.*

Curved forceps and scissors, &c.

Dissection Compared with Maceration.—The process of cleaning by dissection the casts of the injected air-tubes and blood-vessels is one of excessive labour and difficulty. It is well to be provided with an assortment of forceps and scissors with varying lengths of blade and different curves. But, even armed with the best weapons, the dissector will scarcely escape the disappointment of being compelled to sacrifice, for the completion of his task, many of the finest and most ornamental ramifications of the injection. I had, for the same reason, and on a very large scale, to submit to this almost unavoidable disfigurement of my specimens. The latter were, however, dissected with ordinary forceps and angular scissors. The alternative method, that of putrefactive maceration, is greatly to be preferred, whenever applicable.

Dissection difficult, and destructive to finer injections.

Maceration.

B.—Intra-bronchial Injections.

The Injection-mass.—The only material which can be recommended is fusible metal. I owe to Dr. Sheridan Delépine the suggestion of this excellent method. Numerous mixtures of wax, paraffin, resins, &c., were tried in vain. Attempts to inflate the lungs permanently by passing through them a continuous current of dried air ended likewise in complete failure.

Fusible metal.

The fusible metal used had the following composition :—

Its composition.

Tin	2 parts
Lead	4 ,,
Bismuth	7 ,,
Cadmium	1 ,,

The melting-point of this alloy is 158° F.

i. *Injection of the Lungs, in situ, before opening the Chest.*

Drawbacks to this Method.—Of this proceeding I have no personal experience. It is described by Professor Aeby as being extremely simple. Were it as successful as it is stated to be easy of performance, its results would surpass in respect of anatomical truthfulness those attainable by any other method. But, judged by the photographs of specimens prepared by Professor Aeby with its help, it appears to be uncertain in its operation, and it must probably be held responsible for some of those conclusions of that eminent observer with which I am unable to agree. It is only right to suggest that the principle of intra-cadaveric injection may have been less at fault than the manner in which it was carried out. But, under the most favourable circumstances, there are still inherent objections to its use, some of which may be enumerated :

Method recommended by Professor Aeby.

Its uncertainty and frequent failures.

(1) Inability to judge of the fitness, or otherwise, of the organs to be injected.
(2) Inability to drain the air-passages from any accumulated secretion.
(3) Inability to empty the contents of the pulmonary blood-vessels, and to control absolutely the factor of *post-mortem hypostasis*.

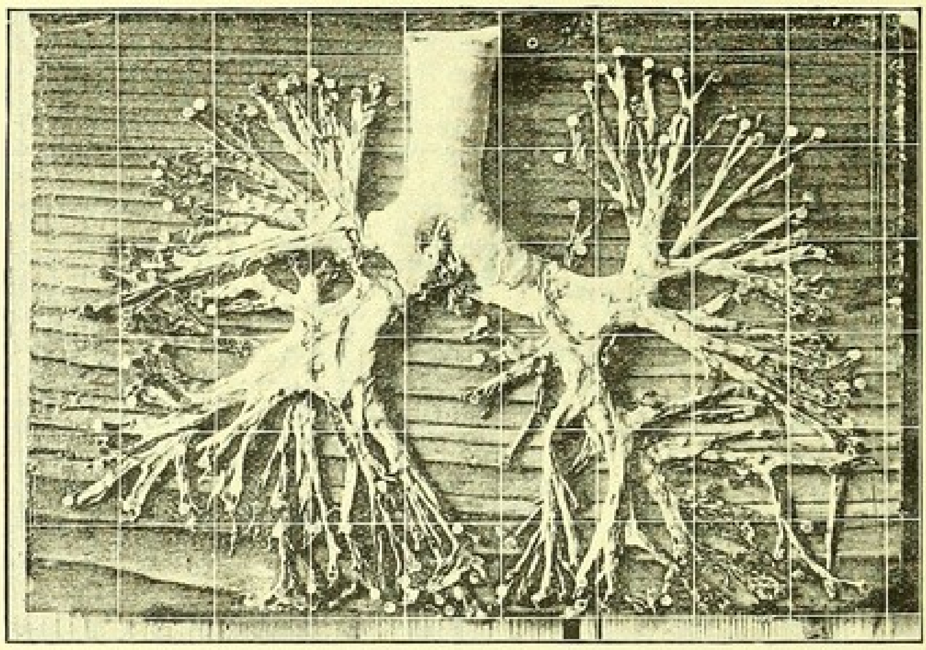
Inherent objections to its use.

(4) Difficulty arising from cadaveric coldness in northern climates.

(5) Absence of any outlet for the pressure of air produced by the injection (if forcible).

(6) Inapplicability of this method to the injection of the pulmonary blood-vessels.

FIG. I.



FRONT VIEW OF BRONCHIAL TREE, DISSECTED AND PRESERVED IN THE WET STATE. (*From a Photograph.*)

The side of each square in the framework measures 2 cm.

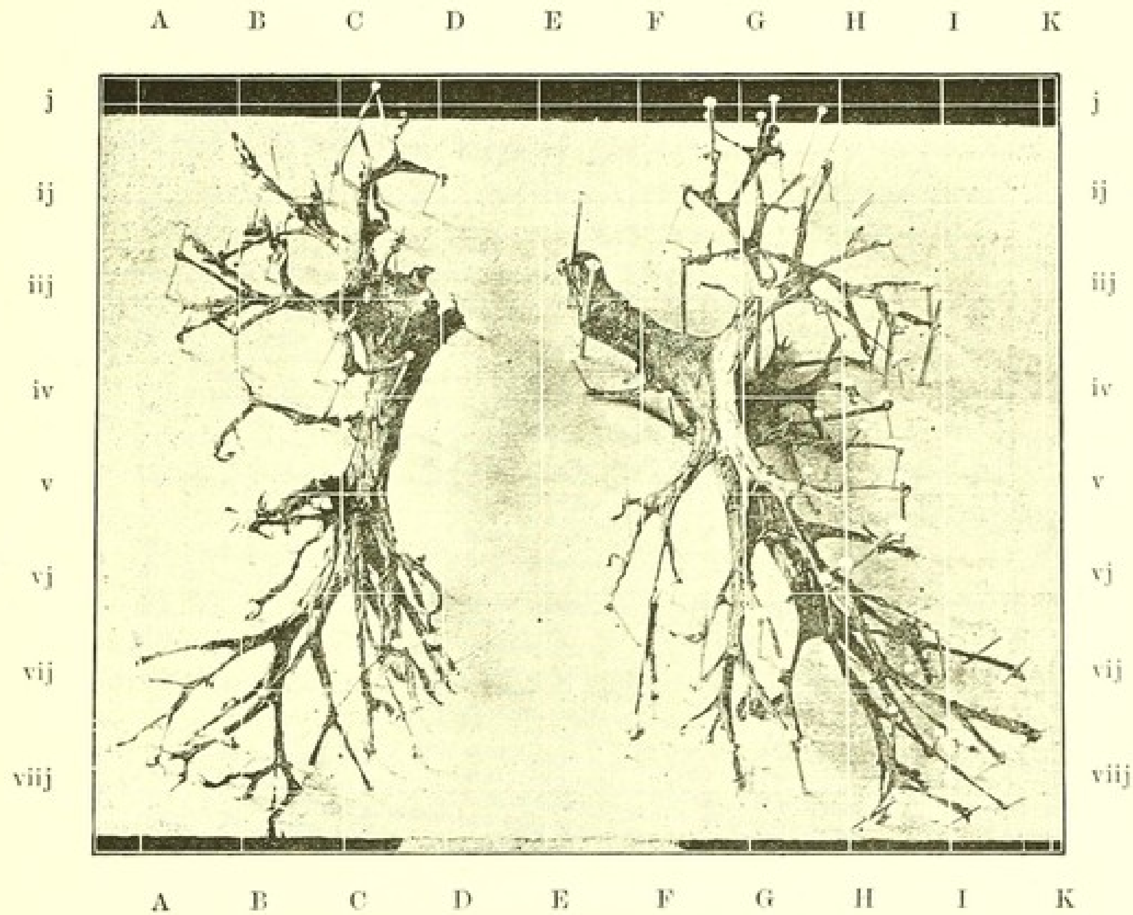
The specimen was obtained from the body of a child affected with old scrofulous disease. Irregular masses of calcareous matter are seen below the trachea, and in the right pulmonary root. An increase of the peri-bronchial fibrous tissue, and a slightly webbed condition of the bronchi of the right lower lobe are additional abnormalities.

The relations of the bronchi are somewhat disturbed, owing to the tubes being all pinned to a plane surface; and to some of them having been forced into unnatural positions. In this manner the right posterior-horizontal bronchus and its branches are shown in square C iv; part of the left posterior-horizontal's distribution occupies square F v, &c.

It may be serviceable in some cases.

In spite of these drawbacks (which, in pioneer-experiments for the determination of the normal features of the bronchial tree, were but too likely to give rise to erroneous results), its employment for the elucidation of special points may present great advantages, and it is well suited, as a preliminary step, whenever a subsequent injection of the blood-vessels, after removal of the lungs from the thorax, is intended.

FIG. 2.



DRY SPECIMEN OF THE BRONCHIAL SYSTEM: FRONT VIEW. (*From a Photograph.*)

Dissected and pinned in the moist state, subsequently stiffened by drying. The wires of the framework cross each other at intervals of 2 cm.

The bronchi had been severed from the trachea at the autopsy by jagged cuts. Many of the small ramifications have disappeared, especially on the right side. Moreover the right cardiac, anterior-basic, and posterior-horizontal districts are not displayed to advantage; and the left pectoral distribution has been raised above its normal level, disclosing the posterior-horizontal distribution.

ij. *Injection of the Lungs after Removal from the Body.*

Advantages and Objections.—This method has yielded good results in my hands, and with sufficient care is capable of complete success. It presents some facilities for manipulation in which the other method is deficient; but the loss of the natural support afforded by the thoracic

Method adopted by the author.

Its defects. parietes adds greatly to the difficulty of its performance and to the danger of a shifting of the specimen, or of a disturbance of its normal relations, during the injection. This danger may be avoided with the help of appropriate mechanical means.

Modus Operandi.

Preparations for a simple and for a compound injection.

Preliminary Measures.—The lungs are secured in a manner which allows room for expansion, without any disarrangement of their normal relations, and the necessary cannulæ and fittings must be fixed into the orifices of the tubes to be injected with metal — namely, in the case of an intra-bronchial injection, into the inferior orifice of the larynx, or lower down into some part of the trachea; in the case of an intra-arterial injection, into the common trunk of the pulmonary artery; in the case of an intra-venous injection, into the inferior part of the left auricle; and lastly, in the case of a threefold injection, into each of the orifices mentioned. The metallic tube conveying the heated metal is made continuous with the cannula, and the metal is injected under moderate pressure until a steady resistance is felt. When more than one set of tubes were dealt with, the several systems were injected in succession. Simultaneous injections were not attempted; but they would probably yield very good results. A previous warming of the lungs, and the application of tolerably strong heat to the metallic tube near its pulmonary end, immediately before the passage of the fusible metal, are precautions which I have found essential to the success of the injection.

Simultaneous injections not tried.

The apparatus.

The Injecting Apparatus used by me consisted (1) of an ordinary tall, broad-necked bottle, provided with two tubes (the longer one being metallic and reaching to the bottom); (2) of a pressure-bottle, provided with proximal and distal taps; and (3) of a stomach-pump for the supply of compressed air.

Mode of performance.

The bottle containing the fused metal was immersed completely in water kept boiling, and it was connected, on the one hand, with the pressure-bottle, on the other hand with the cannula. As soon as, by a turn of the tap, the compressed air had been admitted, active pumping was used for the purpose of keeping up and increasing the pressure. The amount of pressure applied at the onset and subsequently, and the amount of resistance which was taken as an indication to cease pumping, were not registered in any way, as they might have been with advantage, but were entirely left to appreciation by muscular sense and by personal experience, which proved to be satisfactory guides.

Temperature and pressure employed.

Pressure-gauge not used, but desirable.

Aeby uses no pressure; imperfect injections in consequence.

Active Pressure Indispensable.—The employment of pressure is of primary importance. Professor Aeby thought that in the supine subject, the proper weight of the metal, when it was poured into the trachea, was sufficient to inject the bronchial tree. This, doubtless, would be the case with any permanent fluid of high density; but, with fusible metal, his results plainly demonstrate that it is otherwise. Some additional pressure is required in order to obtain the necessary velocity and to convey the fused metal into the smaller tubes within the brief delay which precedes the solidification of its surface.

Too much pressure was obviated through elasticity of tubing, &c.

The Avoidance of Undue Pressure was partly secured, in my own injections, by the imperfection of the joints in my apparatus, and by the elasticity of the india-rubber which formed most of the connections. But every operator must be prepared to learn experience at the cost of a few failures, in the direction of either too little or too much pressure.

Failures and Faulty Results.—Rupture of the lung, should it occur, resulting in general escape of the injected mass, irretrievably puts an end to the experiment. But more serious than this form of disaster would be the error of mistaking, after maceration, the cast from an imperfect injection for a faithful representation of the bronchial tree. Errors of this kind I have sought to avoid by comparing the casts with the results of numerous collateral dissections of non-injected specimens; and by giving the preference to the method by dissection as a means of isolating the cast. Maceration removes all collateral indications which might throw light upon deficiencies in the injection. But, where the bronchial membrane is allowed to remain in contact with the metal, tubes which the latter did not reach are still there to tell the tale.

Errors to be avoided in the study of isolated casts.

How best avoided.

Concluding Remarks.—The process of injection by this rough and ready method demands of the operator quickness and judgment at the time of injecting, in addition to a laborious preliminary preparation. That the difficulties are not excessive even in the case of a triple injection is shown by the fact that the writer's successful injections, reproductions of which are contained in this book, were conducted from beginning to end without human aid or witness, although in other less fortunate injections the intelligent help* which he received was truly welcome.

Difficulties, may be met even by single-handed operator, if skilful and duly prepared.

* Mr. Artlett, anatomical-attendant, and Mr. Philpot, museum-attendant, at St. George's Hospital, have both deserved my thanks for their faithful and willing services on various occasions.

THE METALLIC BRONCHIAL CAST.

General Remarks on Metallic Bronchial Casts.

Good metallic casts superior to all other preparations.

Shortcomings and Fallacies in Metallic Casts. — Whether for study, or for demonstration, a good metallic cast of the bronchial tree presents advantages which cannot be surpassed by those of any other method at present in use. Certain drawbacks are however inseparable from these advantages. In the first place casts of the bronchi in general, but more especially metallic casts, fail even to suggest the qualities of lightness, of pliability and of mobility, which characterize the air-tubes and the blood-vessels of the lung: they are rigid to a fault. Moreover, whereas in a non-injected lung the mutual relations of the bronchi vary within definite limits corresponding to the state of extreme distension and to that of extreme collapse of the lung, the injection of a heavy mass within them is capable of materially altering these relations, if sufficient care be not exercised; and any artificial position of the tubes, brought about in this manner in a cast, is thenceforth permanent.

Their rigidity is a fault. The weight of the metal may deflect the tubes;

Again, owing to the rapid cooling of the fused metal it is difficult, within the brief delay, to inject enough metal to fill the peripheral tubes without employing an amount of pressure which may lead to over-distension and unevenness of those tubes which are situated nearer the trachea. Thus on the one hand metallic tube-casts are seldom evenly regular; and on the other the tubes may receive too much, or too little, or none of the metal injected. The last-named is by far the most common defect.

the pressure required may unevenly distend some; others may remain uninjected.

Intra-lobular injection not wanted.

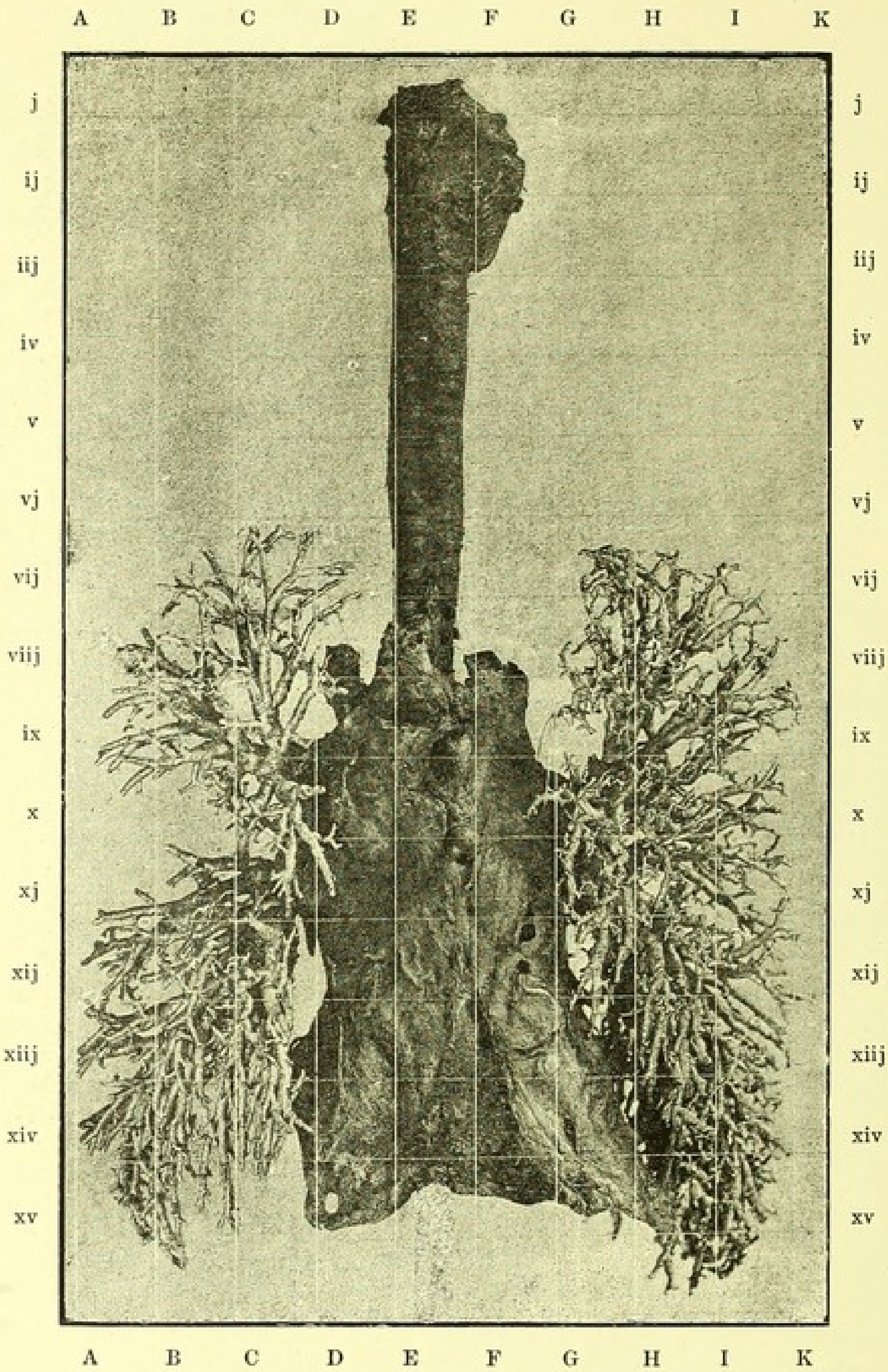
Degrees in Completeness of Injection: its Tests.—An absolutely perfect pulmonary injection would fill the intra-lobular structure as well as the bronchial branchings. A cast of this nature would be too complete to be of use for the study of the bronchi, inasmuch as the latter would be deeply buried in the midst of their injected lobules, and altogether hidden from sight.

A less perfect, but more serviceable degree of injection is that which reaches, but does not go beyond, the lobular bronchioles.

Bronchiolar casts as tests.

The uniform presence of the casts of the latter in all the parts of a bronchial injection may be taken as an adequate test of its completeness.

FIG. 3.



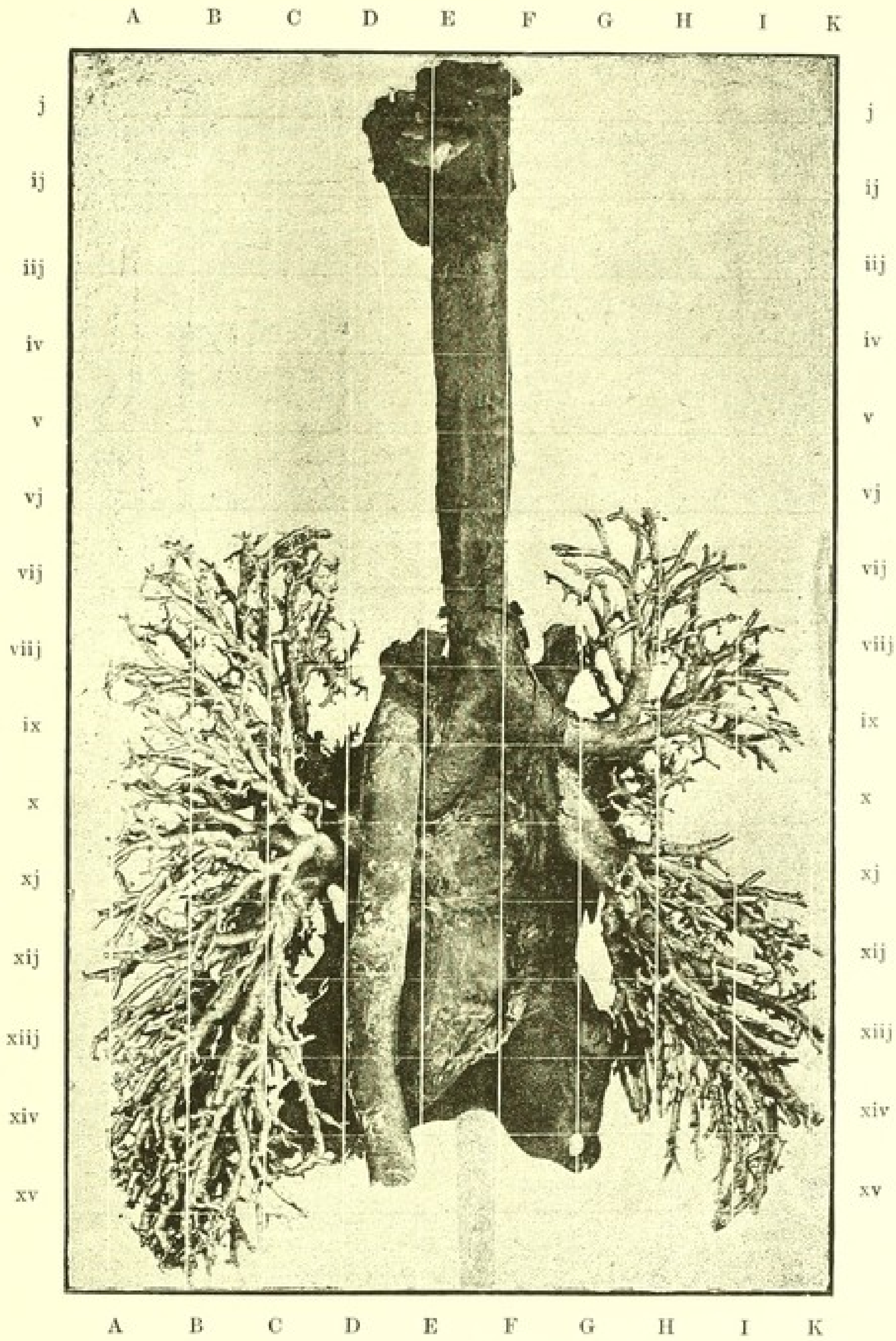
FRONT VIEW OF THE METALLIC CAST OF THE BRONCHIAL TREE, AND OF THE PERICARDIAL MEMBRANE; REDUCED RATHER MORE THAN ½ DIAMETER.

(*From a Photograph.*)

The side of each square measures 20 mm. (here 10 mm., nearly).

At line viij the three large arteries rise from the pericardium, and the divided azygos vein is raised. At line ix the orifice of the divided left innominate vein may be recognized, and above it, to its right, that of the right innominate vein. At the junction of lines x and F is seen the head of a nail for the fixation of the specimen. The lines of the sternal reflection of the pleural membrane are dimly seen, resembling the outline of a letter *x*. The other markings are accidental holes or wrinkles. The arrangement of the bronchi will be explained in connection with other illustrations.

FIG. 4.



BACK VIEW OF THE METALLIC CAST OF THE BRONCHIAL TREE, AND OF THE PERICARDIAL MEMBRANE; REDUCED RATHER MORE THAN ½ DIAMETER.

(*From a Photograph.*)

The side of each square measures 20 mm. (here 10 mm., nearly).

On the left side of the lower end of the trachea is seen the aorta and its large left-hand branches. In square C x the dark mass is the collapsed arch of the left pulmonary artery. Its apical branch may be noticed rising for a short distance behind and to the right of the apical bronchi. In squares C xij, C xiij the outlines of the superior and of the inferior pulmonary vein come into view. The aorta conceals the line of pleural reflection.

On the right side the vena azygos has been raised. The dark mass in square G x is the silhouette of the trunk of the right pulmonary artery, and of the right superior pulmonary vein. The origin of the inferior pulmonary vein projects downwards below the bronchus, beyond line xj. The bronchial membrane has been removed from the peripheral parts of the cast as far as the line of reflection of the pleura. The lower end of the same line of reflection crosses obliquely square F xiij.

On the contrary, wherever the bronchioles are missed, the value of those tubes which carry injection can be judged only approximately from their individual appearance. If the surface of a tube-cast be plainly indented with transverse striæ, corresponding to the circular muscular fibres, and if its diameter should present no sudden diminution, excepting at the seat of a bifurcation, a strong inference exists in favour of the injection of the said tube and of its immediate derivatives having been complete. Nevertheless, even then, we should bear in mind the possible contingency that one or more of its branches may have failed to admit the fused metal, owing to a temporary obstruction at the orifice.

Other rough tests for tube-casts,

sometimes fallacious.

Incomplete Casts.—All metallic casts which show only the larger tubes, must be regarded with considerable suspicion. The failure of injection of the medium-sized tubes in such cases can only be explained (1) by an imperfect supply of metal, or (2) by an imperfect amount of pressure, or (3) by too rapid a cooling of the injection-mass. Any one of these causes, operating singly, would vitiate the experiment, and might lead to the non-injection of one or more of the big tubes, and concurrently to the absence of any trace of the small-tube injection.

Causes of incompleteness.

Unequal Results in Right and Left Lung.—It is important incidentally to point out that the right and the left lungs differ in the readiness with which they receive a metallic injection, and the two casts are apt to present a marked difference in the fulness of their detail. In my own experience the difference has invariably been in favour of the left lung, the bronchi of which have been completely injected even in cases where somewhat important bronchi in the right lung had failed to be filled. This difference in behaviour of the two sides of the bronchial tree is probably correlated with the greater length of the left bronchus, and with the smaller distance which separates its apical and basic branches.

Left bronchi fill more readily.

Suggested cause.

I have dwelt, at some length, upon this part of my subject, in view of its practical importance. It is clear that metallic casts should not be implicitly trusted, unless obviously complete in all their branchings. I have not succeeded in obtaining perfect injections of this kind; but those which I have obtained have been carefully checked by comparison with numerous dissections of the non-injected bronchial tree, some of which were studied in the moist state, and others, after drying. A similar precaution is to be recommended in all cases.

Incomplete casts untrustworthy unless compared with dissection.

General Configuration of the Metallic Cast of the Bronchial Tree.

The Great Anatomical Gap in the Cast.—When viewed as a whole, and from a moderate distance, the metallic bronchial cast yields a rough reproduction of the outward shape of the lung. First to attract

Transverse gap in right cast.

notice, as an apparent defect, is a considerable interruption of outline, corresponding to the interval between the right upper lobe, and the middle and lower lobes. A broad transverse gap extends from the outer border of the lung to the root, and from the upper lobe to the middle lobe. Comparison with the dissected specimens clearly shows that this is not a failure of injection, but an anatomical gap. In the fresh lung, this gap is not foretold by any break in the outline of the visceral pleura. The left bronchial cast presents no gap in the situation described; but its equivalent is found in another position. In it the trachea and the pulmonary apex are separated by a much broader interval than is the case on the right side. An inspection of the specimens with triple injection shows that both these gaps are occupied by blood-vessels. The transverse gap in the right bronchial tree accommodates the right lower pulmonary artery, the upper division of the pulmonary vein, and some of their branches. The vertical gap, in the apex of the left lung, is filled below and inwards by the arch of the aorta, and externally to this by the left pulmonary artery, and by one of the branches of the left pulmonary vein.

No indication of gap in fresh lung.

Situation in right and in left lung different.

Left gap vertical. Blood-vessels contained in gaps.

Relations of gaps differ.

The Encroachment of the Pulmonary Artery occurs, therefore, not only at different levels in the two lungs, but on opposite sides of the bronchial tree, viz., on the inner side of the left and partly on the outer side of the right. Moreover, on the left side the gap is not bounded above as in the right cast, by a bronchus following a transverse direction.

Separate description of right and left tree necessary.

No other difference of equal importance is noticed at first sight between the two casts. But want of perfect agreement in details becomes evident on closer inspection. For this reason it is impossible to give a single description which shall suit both lungs; each lung must be dealt with separately.

In connection with the preceding remarks, and with those to follow, the reader should consult the illustrations, more especially those of the metallic cast (figs. 10 and 11) and the diagrams (figs. 6 and 9).

REMARKS ON THE NOMENCLATURE OF BRONCHI AND BLOOD-VESSELS.

Significance of the Absence of a Bronchial Nomenclature.—No serious attempt appears to have hitherto been made to construct a systematic nomenclature of the air-tubes. Beyond the point of bifurcation of the main bronchus into lobar bronchi, they cease to be known by individual names. This absence of a nomenclature may be taken to indicate that the need for a nomenclature had not been experienced. In this absence lies also a further admission, viz., that the bronchial distribution had not been made the subject of a systematic study. Bronchial tubes are still spoken of as being of the first, second, third, or other order. This kind of classification may be theoretically satisfying to the mind: it is nevertheless singularly inadequate for the purpose of expressing anatomical conditions. Accuracy and clearness of description are not to be attained without the assistance of some more definite terms.

No nomenclature—argues no need felt for the same, and no systematic study.

Old notation inadequate.

Professor Aeby's Classification.—The old classification was not found sufficient by Professor Aeby in his inquiry into the bronchial system, and there is special significance in the fact that, just in proportion to the scope of that inquiry the old nomenclature, or, more aptly, the old system of notation was modified by him. His investigation being limited to the primary branches of the main bronchus, he did not suggest any departure from the current terminology for bronchi of smaller size. But the early branches studied by him were designated under new and more descriptive names. Had his anatomical description extended further, he would have felt the necessity for a more complicated and a more definite nomenclature. Indeed it may be said that in so intricate a study as that of the bronchial system the naming of individual constituents is not only an object in itself, but also an indispensable condition for the accomplishment of the anatomical task.

Aeby's changes in nomenclature proportionate to scope of his inquiry.

Definite terminology an indispensable condition for successful study.

We may so far anticipate the description of Professor Aeby's nomenclature as to mention that whilst referring to the several primary branches of the main bronchus to the extent of stating their exact number, he was content to classify them according to certain characteristics into three series. In each of these series individual bronchi were distinguished only by a numeral. In this respect the new nomenclature was not much more than a further elaboration of the old one. And in connection with this fact it will hereafter be seen that although he had gone so far as to isolate and

Professor Aeby's notation a mere modification of old one:

his description likewise not

anatomically complete. enumerate the various primary branches, their complete anatomical description was not attempted.

The Present Investigation has for its object to attempt a definite description of the anatomical features of individual bronchi, not only of the primary order but of more advanced series. With this purpose in view, a first objection to the old numerical method of notation is discovered in the multiplicity of the tubes to be designated. But yet greater difficulties stand in the way of the adoption of the old plan, difficulties connected with the peculiarities of the bronchial distribution. Had the attempt been made to treat each individual bronchus as the local representative of a certain degree of relationship to, or better, of descendance from the main bronchus, values of the greatest diversity, in respect of size, would have been represented by identical numbers; for a considerable difference in the size of tubes of equal degree of descendance is but the natural outcome of the great differences in the length of the internodia between successive bronchi, and of the prevailing unevenness of dichotomy. Moreover little help would have been offered by this notation towards the localization of the various tubes.

Objections to old numerical method: number, and uneven value of tubes.

The Employment of Definite Names in addition to numerals was unavoidable, for the reasons which I have stated. But the selection of suitable terms was felt to be a responsible duty. Bearing in mind the practical object to be attained, as well as the difficulty which the reader would inevitably experience in mentally identifying the position of any tube of which he was perusing the description, I thought it expedient to notify as much as possible, in the names given to the bronchial divisions, the thoracic region, or the pulmonary district, or the neighbouring organs, which would most clearly define the exact situation of the tubes. With what measure of success this intention was fulfilled the subsequent matter will afford an opportunity to judge. Whether or not the majority of the names may be found to deserve permanent adoption, they will, at any rate, serve the temporary purposes of description in this book.

Specific names required. Localization, the principle in their selection.

Nomenclature of Blood-vessels.—In the nomenclature of the pulmonary blood-vessels the same principle was made to serve. Indeed, with few exceptions the names applied to the bronchi were also applicable to the blood-vessels, or at any rate to the arteries, and their adoption presented among other advantages that of uniformity.

The same applicable to blood-vessels.

Synoptical Tables of the bronchial ramifications have been constructed. They will probably be useful in conjunction with the diagrams, and with the reproductions of actual specimens.

A Lettered Notation associated with a number indicating the degree of relationship to the main bronchus has been appended, in the systematic description, to each of the bronchial tubes described. The object of the notation is to facilitate the endeavour to follow, mentally, or on the plates the successive changes in direction suffered by the air channels from the trachea down to any individual tube. Its principle will be explained at the beginning of the detailed anatomical description.

Lettered notation; its object.

PROFESSOR AEBY'S NOMENCLATURE AND THE AUTHOR'S ELEMENTARY NOMENCLATURE.

Preliminary Observations.

The Three Classifications. — Reference has been made, in the preceding pages, to three nomenclatures or classifications: (1) the old classification, (2) Aeby's modification of the old classification, (3) the new classification devised by me. Of these, the last two only require special notice; and I now propose to take them jointly into consideration. The old classification; Aeby's and the Author's.

Risk of a Confusion in Names.—The object of a nomenclature being to provide the means of better distinguishing from each other the bronchial tubes, and of thereby facilitating the study and description of the bronchial system, our first duty is to avoid any measure capable of adding fresh complications to that study. The danger of aggravating existing confusion is incidental to all new nomenclatures, but more especially to a nomenclature of the bronchial tree. The danger in this case is of two kinds. There is a risk of a confusion in the names, and there is also a risk of a confusion between the tubes to which the names refer. Danger of confusion in the names, and of mistakes in the tubes.

Thus the names themselves might be multiplied unnecessarily; or such of the older names as could have done good service might be rejected, whilst less suitable terms might be put in their place; or again a given name possessing, in an earlier nomenclature, a certain meaning, might be introduced into a later one with a different significance, and thus objects essentially different might run a risk of being thought identical or alike. These are but a few of the faults of which a new nomenclature is capable. Various faults to be avoided in any new nomenclature

Risk of Mistaking Identity of Tubes.—Quite as serious is the confusion which, apart from any doubt connected with the terminology, may affect the names in their application to the tubes. It must be remembered that, between the various bronchial tubes, there is much resemblance. To determine, in the actual specimen, which tube is meant in the nomenclature under a given name may be a task of some difficulty. The risk of confusion grows and becomes complex, when a second nomenclature is added. Confusion between tubes due to their general resemblance

Necessity of Reviewing Aeby's Nomenclature.—Some of the dangers to which I have hinted may be obviated by obtaining a full preliminary acquaintance with the nomenclature which it is desired to supersede A previous account of Aeby's nomenclature needed.

before venturing to suggest any other in its place. It is therefore necessary that I should give a complete account of Professor Aeby's nomenclature, before I proceed to propose my own. In connection with the latter it will be my endeavour to avoid any chance of a misapprehension as to which tubes in the specimen correspond to the names. But, with regard to Professor Aeby's classification, I cannot entertain the same confidence, feeling some hesitation as to the identity of some of the tubes to which he makes allusion. I shall call attention to this uncertainty wherever it exists: in all other cases it will be understood that any doubt as to identity is excluded.

Some obscurities in the latter.

Comparative Study of both Nomenclatures.—The preliminary considerations into which I have entered will probably suffice to explain the advantage likely to accrue from the comparative study of the two nomenclatures. The simplest and the most effectual way of comparing them is to view them simultaneously; and, with this object, I have arranged them side by side, in the shape of synoptical tables. (See pp. 54, 55.) Moreover, in order to guard against the danger of any mistake in identifying the tubes in question, and to further facilitate reference, I have likewise brought into juxtaposition diagrams representing the two schemes of the bronchial tree (see next page), my own and that of Professor Aeby.

Synoptical arrangement of tables, and of diagrams.

Professor Aeby's Nomenclature of the Bronchial Tree, studied from the Diagram.

Professor Aeby's diagram.

For greater clearness in the exposition of Professor Aeby's views I have ventured to reproduce, from his work, the diagram representing the front aspect of the bronchial tree in man.

The "bronchial stem," shaded for ease of recognition.

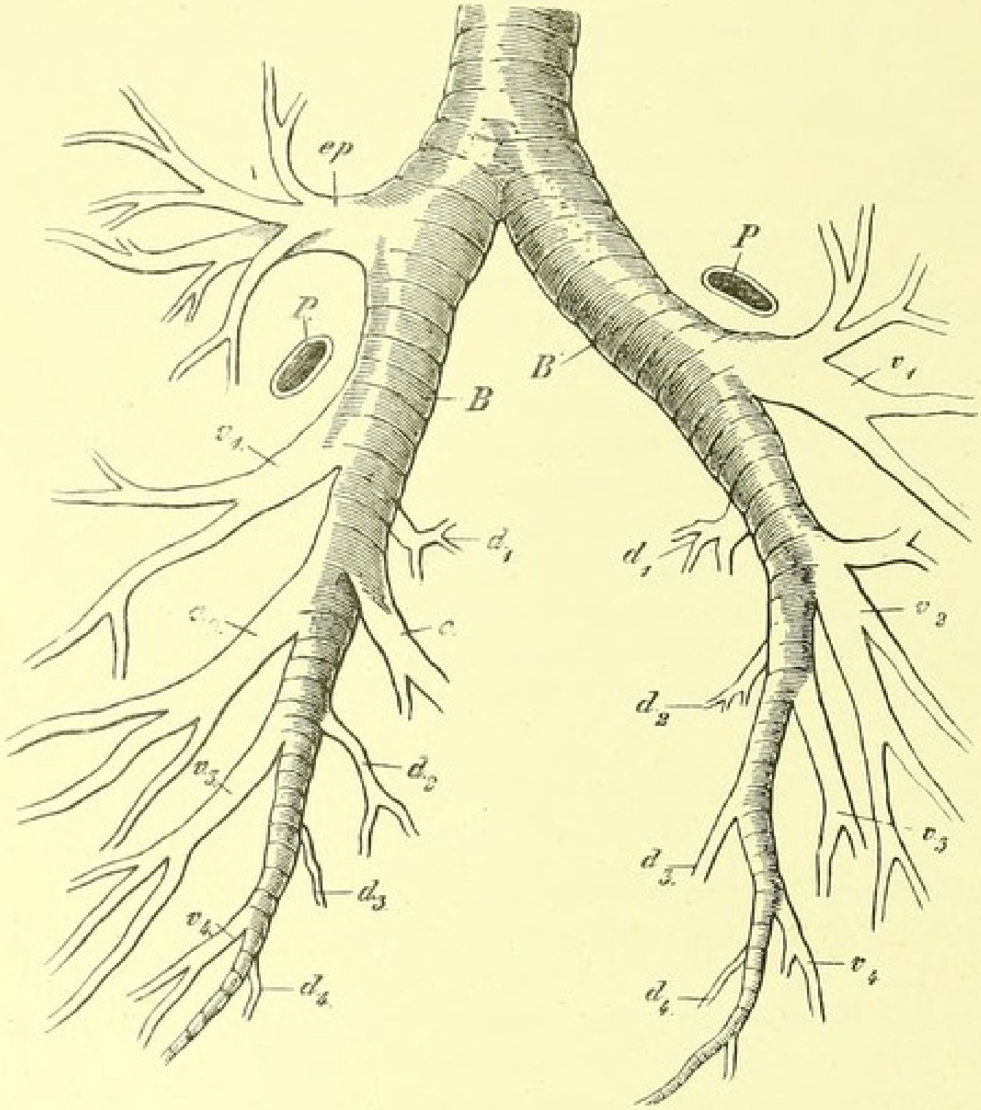
The Diagram (fig. 5) gives special prominence to the "bronchial stem" (of Aeby). The trachea, the main bronchus of each lung, and the bronchial stem, which is but the bronchus continued, are all readily identified in the drawing. The annular shading which represents the cartilages of the trachea is continued downwards along the main bronchus to its extremity; and this tube is represented as axial. The shading, which is confined to this one tube, has presumably no significance beyond facilitating the recognition of the bronchial stem; and does not convey the meaning that any difference in the structure of the bronchial walls exists between this tube and its branches. No statement suggesting such an interpretation is made by Aeby.

The Pulmonary Artery.—The important difference in the situation of the right and of the left pulmonary arteries is also made conspicuous: it will be noticed that the vessels are here represented in section at P. and P.

Lateral Bronchi.—Two sets of branches are seen to arise from the stem. They are lettered in two series as v. 1; v. 2; v. 3; and v. 4; these are, in both lungs, the *hyparterial ventral branches:* and as d. 1; d. 2; d. 3;

Hyparterial ven-

Fig. 5.



Professor Aeby's Diagram of the Bronchial Tree; front view.

B. B'. : Main bronchi, arising from the trachea, and, in either lung, continued into the bronchial stem.

c. : Cardiac bronchus (not represented in the left lung).

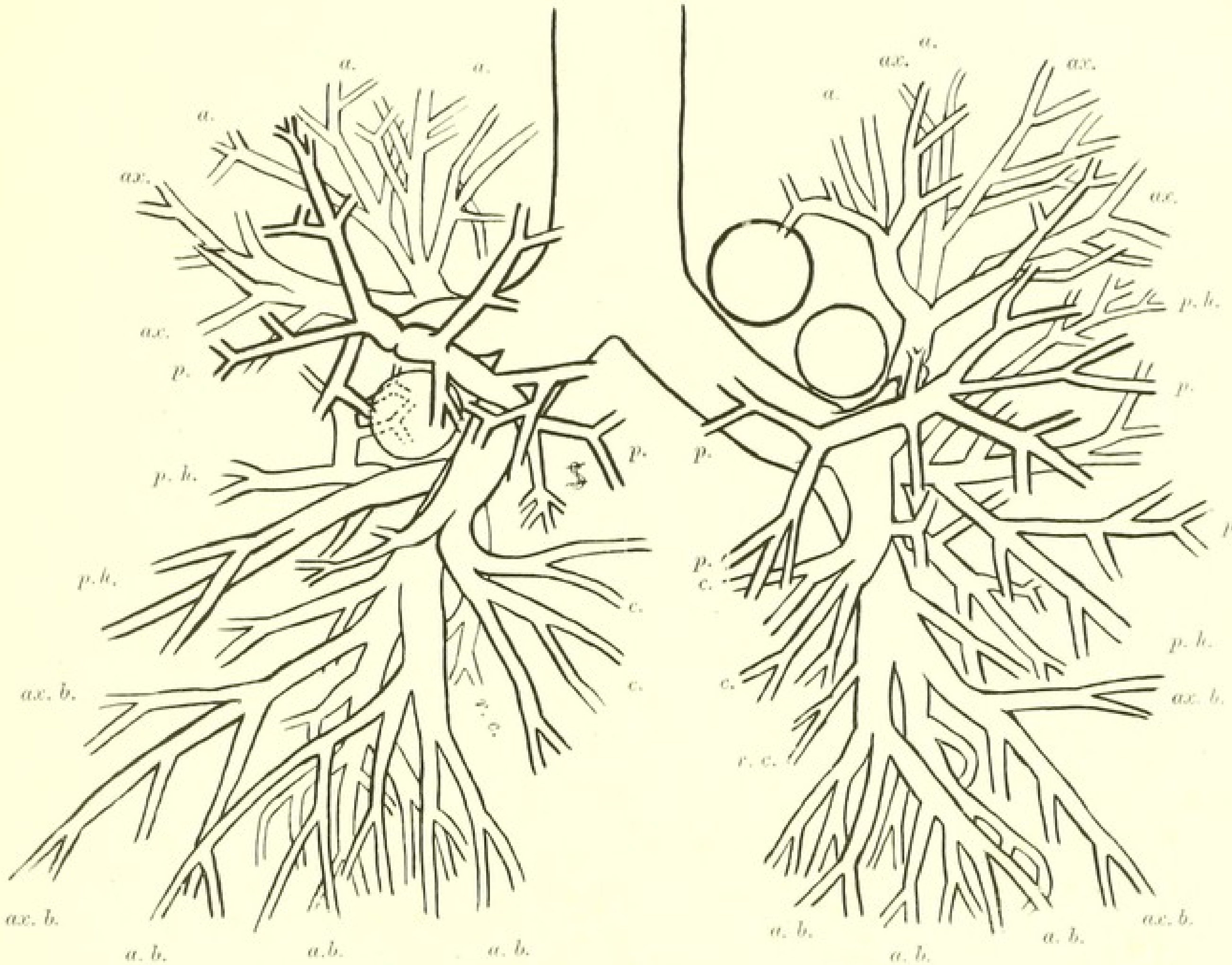
d_1, d_2, d_3, d_4: Hyparterial dorsal branches, evenly present on both sides.

ep. : Eparterial bronchus, found only in the right lung. Its ventral and its dorsal divisions are shown.

v_1, v_2, v_3, v_4: Hyparterial ventral branches, evenly present on both sides.

P. P. : Situation of the right and of the left pulmonary artery after crossing the bronchial stem.

Fig. 6.



Author's Rough Diagram.*

(*For more accurate detail consult diagram fig.* 9.)

The aorta and, below this, the left pulmonary artery are seen above the left bronchus.—Below and to the left of the left pulmonary artery are seen (1) the left upper lobar bronchus, (2) its ascending branch, the pectori-apical, and (3) its descending branch, the cardiac.—Immediately above the right pulmonary artery, is the right upper lobar bronchus, or pectori-apical. To the inner side of the artery arises the cardiac.—The letters *a.*, *ax.*, *p.*, indicate in both lungs respectively the apical, the axillary, and the pectoral distributions.—*p. h.* points to the extensive posterior-horizontal district; some distance lower is seen the small lesser posterior-horizontal bronchus.—*a. b.*, *ax. b.* represent the anterior- and the axillary-basic districts; *c.*; *r. c.*, the cardiac and the retro-cardiac branches. The posterior-basic distribution is shown behind the anterior-basic bronchi.

* Details are not sufficiently faithful in this diagram, which was not drawn by myself: but it will give a rough idea of the position and distribution of the larger tubes.

and d. 4; these are the *hyparterial dorsal branches.* All these hyparterial branches receive from Aeby the name of "*lateral bronchi.*"

tral and dorsal branches.

The Eparterial Bronchus.—The left bronchial stem carries no other branch. But the right bronchial stem gives rise to a large bronchus (Ep.) immediately above P.; and lower down, and towards the middle line, to a smaller one C.

Eparterial bronchus;

The important branch (Ep.) is, in Aeby's terminology *eparterial.* It divides into *anterior* or *eparterial ventral branches,* and into *posterior,* or *eparterial dorsal branches.*

its ventral and dorsal branches.

Disparity of Left Lung.—If, in the diagram, the outline of the bronchus (Ep.) be temporarily covered, so that its origin and its branches be hidden from view, the right bronchial tree will have the appearance of being almost identical with the left. The members of the ventral and of the dorsal series in both would then correspond with each other almost exactly, with the sole exception of the branch C, which does not appear in the left bronchial tree.

Absence of bronchi (Ep.) and (C) in left lung.

"Cardiac Bronchus" of Aeby.—The origin of the branch (C) is seen to be neither ventral nor dorsal, and therefore excludes it from the two series previously mentioned. It is described as the "*cardiac bronchus,*" being the only air-tube upon which Aeby bestows an individual name.

Origin of cardiac bronchus (C) not ventral or dorsal;

Occasional "Cardiac Lobule."—It is not suggested by Aeby that bronchus (C) is otherwise than constant—on the contrary special prominence is awarded to it, owing to its constancy, to its size, and to the circumstance that in some animals it forms the basis of a separate lobule in the right lung. It must be noted however that no cardiac branch is described by him as forming part of the left bronchial tree.

its constancy; a lobule sometimes attached to it; its absence from left lung.

Accessory Bronchi.—In spite of its constancy, the cardiac bronchus is made in Aeby's nomenclature, to serve as the type of an inferior class of air-tubes. These are the *accessory bronchi* ("neben-bronchen"), so termed on account of their apparently less regular and less constant situation. In contrast with this exceptional instance, the *accessory bronchi* are stated to be subject to variations, in their number and position, in the several mammalian classes. But, in most of the latter, they are specially abundant in the lower part of the bronchial tree; and they occur always on the inner side of the bronchial stem (*loc. cit.*, pp. 6 and 7) and most frequently possess a downward direction.

It serves as special type. "Accessory bronchi;" their variability; their chief site, the lower lobe, to inner side of stem: their course downwards.

The Rank of Accessory Bronchi.—As far as I have been able to gather the meaning of the remarks of the German author, these tubes do not possess the value of typical primary bronchi; they are rather to be regarded as the dorsal and the ventral branches of the latter,—in other words, as "*secondary bronchi.*" Whenever, as in the lower portions of the bronchial tree, they arise directly from the bronchial stem, this is the result of a transfer (Uebertragung). Neither their origin from the stem, their number, nor even their size, should be allowed to establish a confusion

They are essentially secondary; but, by transfer, may arise from stem; but do not even then rank as typical bronchi.

NOMENCLATURE AND ORDER

OF THE PRIMARY BRANCHES OF THE MAIN BRONCHUS, OR ITS CONTINUATION, COMPARED WITH PROF. AEBY'S NOMENCLATURE.

RIGHT LUNG.

AUTHOR'S NOMENCLATURE.	AEBY'S NOMENCLATURE.
1. Upper-lobar Bronchus . . . . (or *Rt. Pectori-apical B.*)	1. Eparterial Bronchus.
2. Middle-lobar or Cardiac Bronchus .	2. First Hyparterial Ventral Bronchus.
3. Posterior-horizontal Bronchus . .	3. First Hyparterial Dorsal Bronchus.
4. Retro-cardiac Bronchus	4. ———————— Cardiac (Accesso Bronchus.
5. Anterior-basic Bronchus	5. (?) Second Hyparterial Ventral Bronc
6. Lesser Posterior-horizontal Bronchus	6. (?) Second Hyparterial Dorsal Bronch
7. Axillary-basic Bronchus	7. (?) Third Hyparterial Ventral Bronch
8. ————————————	8. (?) Third Hyparterial Dorsal Bronchu
9. Posterior-basic Bronchus . . .	9. (?) Fourth Hyparterial Ventral Bronc
10. „ „ „ . . .	10. (?) Fourth Hyparterial Dorsal Bronch

N.B.—A query placed before some of the names given by Prof. Aeby sig

NOMENCLATURE AND ORDER

OF THE PRIMARY BRANCHES OF THE MAIN BRONCHUS, OR ITS CONTINUATION, COMPARED WITH PROF. AEBY'S NOMENCLATURE.

LEFT LUNG.

AEBY'S NOMENCLATURE.	AUTHOR'S NOMENCLATURE.	
———	1. Upper-lobar Bronchus (or *Bronchus Impar*)	*Left Pectori-apical B.*
First Hyparterial Ventral Bronchus	2. ———	Cardiac Bronchus.
First Hyparterial Dorsal Bronchus	3. Posterior-horizontal Bronchus.	
———	4. ———	Retro-cardiac Bronchus.
(?) Second Hyparterial Ventral Bronchus	5. Anterior-basic Bronchus.	
(?) Third Hyparterial Ventral Bronchus	6. Axillary-basic Bronchus.	
(?) Second Hyparterial Dorsal Bronchus	7. ———	Lesser Posterior-horizontal Bronchus.
(?) Third Hyparterial Dorsal Bronchus	8. Posterior-basic Bronchus.	
(?) Fourth Hyparterial Ventral Bronchus	9. " " "	
(?) Fourth Hyparterial Dorsal Bronchus.	10. " " "	

...bt as to the figure which should be prefixed to them in the synopsis.

between them and the genuine "typical bronchi," enumerated in the nomenclature.

Mostly anterior, may be absent behind, in animals.

Accessory bronchi are most usually given off from the anterior aspect of the bronchial stem. In some animals they are altogether absent behind, although still occurring anteriorly.

Subordinate position in man.

Accessory Bronchi in Man.—In man (*loc. cit.*, p. 53) accessory bronchi play a very subordinate part. Their only important and constant representative is the cardiac bronchus found in the right lung.

In diagram ventral bronchi are external; dorsal bronchi are internal.

Position of Lateral Bronchi at their Point of Origin.—It will be noted that the origin of the ventral bronchi is depicted as lateral; and that d_2 on the right, and d_3 on the left side, are rather internal than dorsal in their origin. In this connection the following passage from the German book, although occurring in the section devoted to Mammalia, deserves to be quoted (*loc. cit.*, p. 6):—"The two rows of lateral bronchi are never exactly opposite each other. The origins of the ventral bronchi always drift outwards and backwards, and they approach so closely those of the dorsal branches, that only a narrow strip of the bronchial stem intervenes. This is for the reception of the chief artery after it has arched backwards with rapid curve, over the first ventral bronchus."

Aeby's description of their origin.

Short Analysis of Aeby's Bronchial Tree.—In conclusion the bronchial tree of man, according to Aeby, consists of the following parts:

1. **Bronchial Stem**;
2. **Eparterial Bronchus** and its ventral and dorsal branches—occurring in the right lung only;
3. **Hyparterial Bronchi** occurring evenly in both lungs and classified into:
    a. **Four Ventral Hyparterial Bronchi,**
    b. **Four Dorsal Hyparterial Bronchi**;
4. **Accessory Bronchi,** of which one only, the **Cardiac Bronchus,** (which is not found in the left lung) possesses any considerable size.

The Author's Nomenclature, studied from the Diagram.

Author's diagram more complete.

Chief Points of Difference.—The diagram (fig. 6) is more complicated than Aeby's diagram, owing to the introduction into it of branches other than the primary. Thereby it is made to appear more different from the latter than it is in reality.

Essential differences.

Even, however, if we disregard the smaller branches (not all of which are as faithfully depicted as I could wish), and if we confine our attention to the primary divisions,—a few essential differences between the two diagrams still remain:

No artificial distinctive marks.

1. No shading or other distinctive mark has been used in the author's diagram for the purpose of distinguishing one bronchus from

another, all bronchi of same size presenting, in the human lung, identical structure.

2. The aorta, which possesses important relations to the left bronchus and to the pulmonary artery, has been shown, in section, in connection with the latter. The aorta displayed.

3. The origins of the various bronchi, in relation to the surfaces of the main bronchus (or of its continuation), do not occupy the positions which are allotted to them in fig. 5. The bronchial origins different.

4. The names appended to the tubes in the diagram are altogether distinct from those employed by Aeby. The names differ.

Chief Points of Agreement.—If we put aside these differences some general agreement may be traced between the series of branches respectively depicted in each diagram. Identical tubes in both diagrams.

Thus in the right lung:—

1. **The Upper-lobar Bronchus** corresponds with Professor Aeby's "eparterial bronchus," and carries anterior, as well as posterior, branches. Their new names, in right lung;
2. **The Middle-lobar (Cardiac) Bronchus** arises at the same level as, although more anteriorly than the bronchus described in Aeby's diagram as first hyparterial ventral.
3. **The Posterior-horizontal Bronchus** occupies the position of Aeby's second hyparterial dorsal branch.
4. **The Retro-cardiac Bronchus** likewise tallies with Aeby's cardiac branch,—excepting in its mode of origin, and in the name which it receives.
5. The second hyparterial ventral branch of Aeby is represented here by **the Anterior-basic Bronchus**, allowance being made for the peculiar position given, in the German diagram, to all the ventral branches.
6. **In the Lesser Posterior-horizontal Bronchus** may be recognized the second dorsal branch of Aeby.
7. **The Axillary-basic Bronchus** corresponds to the third hyparterial ventral branch.
8. The third hyparterial dorsal branch has a representative in **the Inferior Dorsal Bronchus**, a secondary branch not specially lettered in the diagram.

9 and 10. The anterior and the posterior divisions of **the Posterior-basic Bronchus** respectively correspond to the fourth ventral and to the fourth dorsal branch of Aeby.

In the left lung:—

1 and 2. **The Upper-lobar Bronchus**, which Aeby designates under the name of first ventral hyparterial bronchus, differs widely in left lung.

from the right upper lobar in serving as *joint origin* for **the Pectori-apical Trunk** and for **the Cardiac Trunk**. I have termed it **Bronchus Impar**.

3. **The Posterior-horizontal Bronchus** is the equivalent of the first dorsal in the other nomenclature.

4 and 5. **The Anterior-basic Bronchus** may be taken to be the bronchus which Aeby describes as the second ventral; although in his diagram the latter takes its origin from the outer side of the "bronchial stem." **The Retro-cardiac Bronchus** arising from it, and corresponding to Aeby's "cardiac bronchus" in the right lung, is not mentioned by him in connection with the left.

6. Arising next in the descending series, **the Axillary-basic Bronchus** claims the position of the third ventral in Aeby's diagram.

7. **The Lesser Posterior-horizontal** is the second dorsal branch according to Aeby. It is a branch from the posterior-basic bronchus.

8. The third dorsal branch is represented by **the Posterior-basic Bronchus**.

9 and 10. The anterior and the posterior divisions of **the Posterior-basic Bronchus**, as in the right lung, represent the fourth ventral and the fourth dorsal branch of Aeby's bronchial stem.

The correspondence thus shown to exist between the two nomenclatures is, for easier reference, set forth in a tabular form on pp. 54, 55.

CLOSER INSPECTION OF THE BRONCHIAL CAST. MODES OF DIVISION OF BRONCHI.

General Radiating Arrangement.—The general plan of the bronchial distribution is, in a broad sense radiating (see figs. 4 and 7), since the extensive sub-pleural surface of the lung, for the greater part convex, derives its supply from a comparatively limited region, the pulmonary root. This may be seen most plainly from the posterior view of the cast where the early branches are within sight. Radiation from a small root to a large surface.

No True Centre of Radiation.—There is, however within the lung, no precise centre of radiation. The divergence of the larger bronchi occurs in various directions: upwards, outwards, backwards, forwards, and downwards. If we trace them from their periphery to their origin, they are seen to converge towards a *short vertical line*, namely, towards that segment of the main bronchus (or, strictly, of its continuation) which is included between the origin of the upper-lobar bronchus and the origin of the three basic bronchi. All bronchi converge towards a short vertical line (the bronchus continued).

Secondary Systems of Radiation.—Inasmuch as in each lobe the supplying bronchus gives rise to a roughly radiating system, the regularity of the general radiation first mentioned is broken up to a certain extent. Radiation within lobes.

Again, a *fan-shaped* arrangement is commonly seen in the branchings of individual primary bronchi. The most striking instance of this kind is seen in the left posterior-horizontal distribution. Fan-shaped distributions—*e.g.*, that of left posterior-horizontal.

Peripheral Sub-lobular and Intra-lobular Radiation.—Lastly, a radiating arrangement is faintly indicated, at the great convex surface of the lungs, by the direction of the sub-lobular tubes perpendicular to the free surface. And within the lobules in every situation, the tendency to radiation is dimly represented by the intra-lobular bifurcations. Sub-lobular bronchioles perpendicular to surface. Intra-lobular bifurcation.

Individuality of Primary Bronchi.—The closer they are placed to the root the more individuality do bronchi display in their shape and in their direction. Whereas from the general appearance of the cast of any peripheral bronchus, isolated from the other tubes, it would be impossible to tell the exact position which was occupied by it in the bronchial tree, in An isolated cast of a large tube is capable of being recognized.

the case of a large bronchus, thus isolated, identification would be comparatively easy to the expert.

Constancy in large tubes; probably also in small ones.

Constancy in Primary Bronchi.—It may also be stated of the larger tubes that their position and arrangement are constant in man. The same constancy, which is capable of demonstration in them, most probably also prevails, as a rule, in the smaller tubes as far as the periphery. Individual peculiarities would however occur more frequently within this district than at the pulmonary root.

The smaller tubes more exposed to modifying influences. Abnormalities in larger tubes alone influence the outline of bronchial tree.

Abnormalities are not absolutely restricted to the smaller bronchi. The latter, in addition to the chances which arise from mere numbers, are more exposed to external pressure and possess less resistance. But irregularities are occasionally also found in the larger tubes from causes which have not hitherto been traced. None but these coarser abnormalities would produce any obvious modification in the outline of the bronchial tree. I have observed abnormalities in the middle-sized branches, but their importance has not been such as to mar the general features of the specimen, taken as a whole; and as to the smallest tubes, peculiarities in their arrangement would be hardly perceived at first sight.

Bronchi arise as near as possible to their district; the air-supply is therefore more direct.

Advantages Special to the Mode of Origin of the Primary Bronchi.—The origin of the larger tubes at the pulmonary root, from a vertical line instead of from a point, constitutes a decided gain with regard to the distribution of air. In this manner bronchi originate nearer to their respective peripheral districts than they could have done if the division of the main bronchus had taken place at a central point within the long pulmonary boundary. Although the actual distribution of air to the pulmonary parenchyma is not a part of the functions of the large tubes, it is essential that the air should be transmitted through them to the smaller tubes with the least possible friction and with directness.

Secondary bronchi far between and have long internodia.

Secondary Bronchi.—In like manner the earlier divisions from the primary bronchi, constructed for the same purposes as the latter, and obeying the same rules, are relatively few, and their internodia are relatively long. Thanks to this arrangement the periphery is approached by few and rapid strides.

No lobules usually arise from primary, secondary, (sometimes tertiary) tubes.

Peripheral directions foreshadowed in the framework.

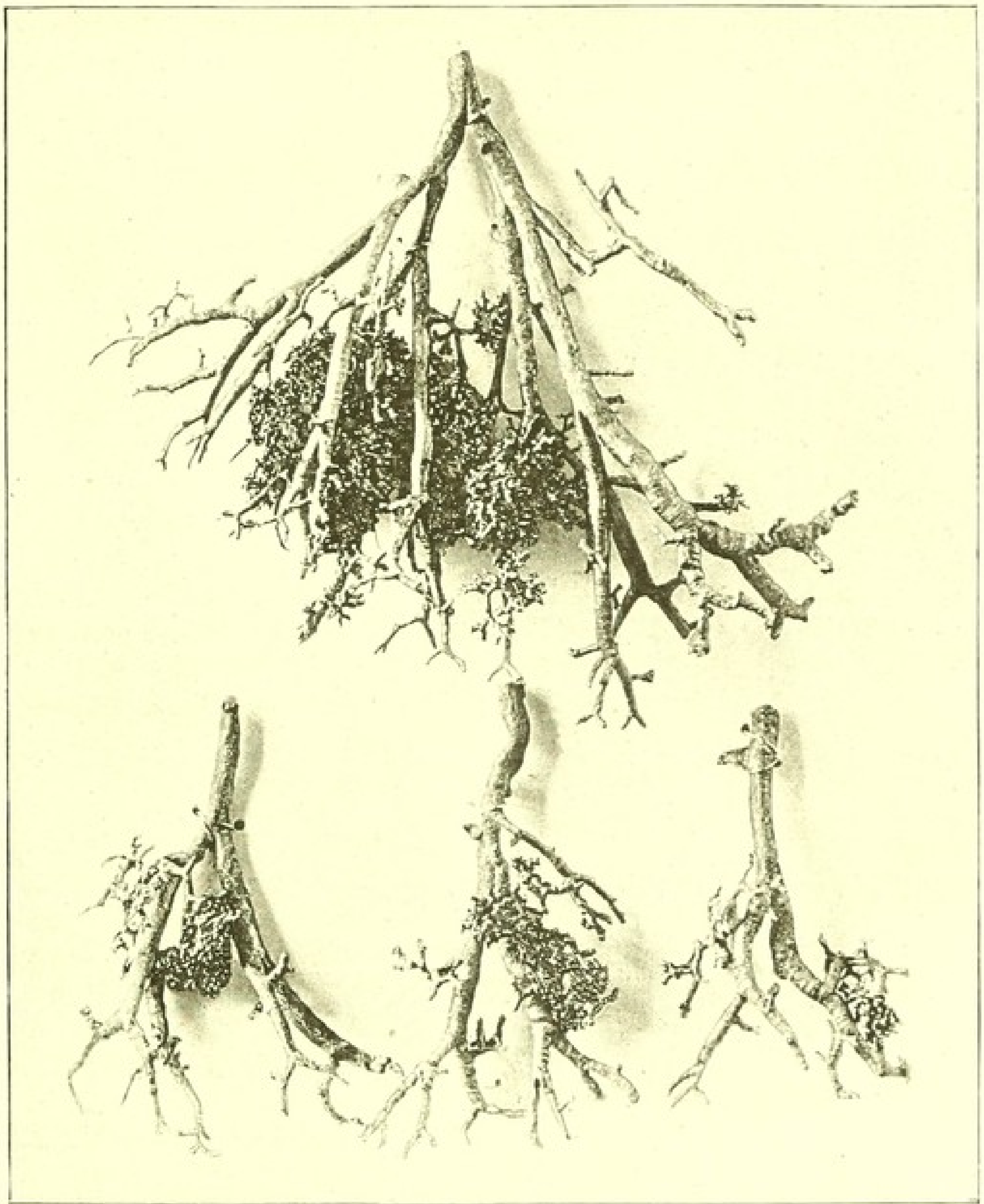
The Central Framework gives the Bronchial Directions.—Thus, although passing between lobules, the primary, the secondary, and sometimes the tertiary division from the main bronchus bear no lobules of their own. Lobular bronchioles do not arise until by a more rapid progress of bifurcation the larger tubes have broken up into a central framework, shaped into almost as many directions as are, with growing complexity, represented at the periphery.

Also those of parietally placed bronchioles.

Parietal Sub-pleural Bronchioles.—The sub-lobular bronchioles which are situated at the parietal surface of the lung preserve, almost unmodified, the leading directions supplied in this manner by the central framework; and the same may be said of some of the less superficial bronchioles.

Fig. 7.

A



B C D

Four fragments of the Bronchial Cast of a child, in which several deep-seated lobules have taken the metallic injection; cleaned by maceration. *(From an enlarged Photograph.)*

The specimens illustrate the varieties in the mode of division of bronchi, the alternation of their planes of bifurcation, the varying apertures of their angles, and their very open, arch-like, bifurcations at the periphery. Recurrent bronchi and lobules are also seen. The empty angular spaces were probably supplied by recurrent tubes, analogous to the upward-pointing bronchiole seen 1" vertically below the main angle of A. A good instance of a T-shaped bronchus is to be noticed on the observer's right-hand side of the same specimen, in its upper part.

Central Bronchioles.—But the case is very different with those lobules which make up the inner bulk of the lung. The deeper lobules are arranged with endless variety of axis, and their supplying bronchioles assume in consequence the most varied directions. The mode in which this variety is attained may be briefly explained. Central bronchioles vary greatly in direction.

Conversion of Directions; its Mechanism.—While long internodia and few bifurcations are the special means adopted for transmitting the tracheal air, through the airless root-zone, to the distant periphery, repeated bifurcation and short internodia are the rule whenever, within a short distance, considerable change of direction is needed. Internodia may even become so short as to be difficult of recognition, and at first sight may altogether escape observation. Repeated bifurcations, short internodia, (some may be "vanishing") and varying angles, are the means of converting bronchial directions rapidly.

The Angles of Divergence.—In addition to these variations in the length of the internodium, and of the frequency of bifurcation, the *aperture* of the *angles* of divergence varies in accordance with the situation of parts, without however going beyond a definite size. An aperture of 180° is often approached but never exceeded. In this manner air-tubes are enabled, by the help of two or three bifurcations with large angle of divergence, to furnish lobular bronchioles possessing the same direction as their own original direction, and also bronchioles of exactly opposite direction.

Among the many varieties of direction assumed by the deeper bronchial off-shoots there are two specially deserving to be noted: Special forms of conversion.

1. **Recurrent Bronchi and Bronchioles.**—Of this large class no better examples exist than the tubes supplying the lobules which fill up the inter-bronchial angles. Most of the lobules in question receive their bronchiole not *a tergo*, but *a fronte*. In other words bronchioles supplied to lobules of this kind arise from their parent-tube at a point further removed from the pulmonary root than the lobule for which they are intended. Their course is therefore exactly opposed in direction to that of their parent. Recurrent tubes approaching deep lobules *a fronte* with a direction contrary to the original one.

2. **T-shaped Bronchi** represent another important type of somewhat irregular distribution. This is well illustrated by the behaviour of bronchi supplying the often narrow intertubal intervals. These intervals and the inter-bronchial angles both afford excellent instances of the many inequalities of position and of space, which exclude from the bronchial system the universal application of any rigid geometrical law. T-shaped bronchi in the narrow intertubal spaces;

A bronchus entering laterally a long narrow interspace will bifurcate under difficulties. Instead of forming an acute angle, its two branches will probably take diverging rectilinear directions—their aperture will be 180°. The centripetal branch, meeting with a cul-de-sac, will be curtailed in development and fail to attain more than a sub-lobular size and will end in two lobular bronchioles; the centrifugal branch, free to extend outwards, may acquire a size and an importance such as to obscure the dichotomous character of its origin. In culs-de-sac, different behaviour of their central and peripheral branches.

The conditions to which the preceding paragraph refers may be difficult to realize from a written description, but a glance at the figures 1, 10 and 11 will clear up any obscurity.

Recurrent and T-shaped bronchioles also at the surface (*see* mesial surface of Apex),

The Same Varieties seen at the Pulmonary Surface, and at Septal Surfaces.—Reversal of direction is not exclusively confined to bronchi supplying interspaces where respiratory tissue is thickly massed, and where space is not available for the regular, wedge-shaped, development of the lobular groups. Recurrent tubes and lobular masses may also be seen in injected specimens of the bronchial tree in various superficial situations. A striking instance of the recurrent type, in a superficial position, may be readily recognized in the apex-region of the metallic cast, where the surface of the lung faces the trachea.

and likewise at opposed septal surfaces.

The T-shaped bifurcation is invariably found along the opposed surfaces of interlobar septa; and by noticing the position of these T-shaped ends in a metallic cast, the position of the interlobar septum may readily be traced, without further help. But the same peculiarity is also noticed at the parietal surfaces of the lung. Indeed the appearances presented by the fine superficial terminations of a metallic cast are almost characteristic. The tubules, as they approach the surface with perpendicular direction, divide into two delicate branchlets. The angle formed by the latter varies between 90° and 180°, being larger than is witnessed at other bifurcations. In this manner the branchlets become almost or absolutely parallel with the pulmonary surface. These appearances are best seen in specimens in which the injected metal has not reached the infundibula.

Mode of termination of superficial T-shaped branchlets.

T-shaped bronchioles in contact with large vessels and bronchi.

T-shaped Tubes found in Deep Situations.—The same mode of termination is observed likewise in many situations within the depth of the lung, not only along the interlobar fissures, but wherever the lobules abut against a resisting surface—*e.g.*, in contact with the larger vessels and bronchi.

The "bronchial stem" bipinnate, according to Aeby, but not strictly so.

The Bipinnate Arrangement, alleged by Professor Aeby.—Reverting to the primary bronchi we are enabled by an inspection of the metallic cast to test the accuracy of Professor Aeby's description of their mode of origin and main direction. The "bronchial stem" is alleged to be bipinnate, its branches arising in two directions, ventrally and dorsally. This statement is however slightly qualified by Professor Aeby, who points out that these two directions are not followed with absolute accuracy by the branches at their origin from the stem (*cf.* p. 56). A careful observation will show that the departures from the arrangement described are relatively numerous and considerable. We have on this point Professor Aeby's own admission. He is compelled to form a special class of "accessory bronchi," in order to accommodate bronchi, whose origin is obviously neither ventral nor dorsal. Neither is it *a priori* probable that branches should be given up only in two directions. It will be readily seen in the cast that

This is disproved by his segregating the "accessory bronchi."

A priori improbability.

branches also arise, as necessity requires, on the outer and on the inner side of the bronchial stem which he describes, as well as dorsally and ventrally.

Analogy in Mode of Branching of Bronchial Stem, and of its Derivatives.—A special case will perhaps be pleaded for the "bronchial stem" itself, as a tube distinct from all other bronchial tubes—and not necessarily constructed on the same plan. But, on comparing its behaviour with that of later divisions in the bronchial tree, it is possible to trace between it and the latter considerable analogy. Analogy between "stem" and primary bronchi.

General Uniformity in Sequence of Bronchial Branches.—All the component parts of the bronchial tree show a marked tendency towards uniformity in the order of origin of their branches. An invariable rule cannot be framed; but, in spite of the great variations occurring in the length of the internodia, it is possible to recognize a regular system, determining the relative direction of successive bifurcations. Habitual regularity in directions of successive bifurcations.

Alternation of Bifurcations at Right Angles.—According to the prevailing arrangement each bifurcation occurs in a plane perpendicular to that of the preceding bifurcation, alternate bifurcations thus taking place in the same plane. This order would obviously facilitate the even distribution of lobules on all sides of the bronchial tubes. But this arrangement is occasionally modified to suit the irregularities in the configuration of the lungs; and I shall have occasion in describing the bronchial tree to point out the more striking exceptions to the rule. The planes of successive bifurcations at right angles to each other. Occasional exceptions.

In the mode of subdivision of the right main bronchus tolerably plain vestiges of the alternation in question will be recognized in the metallic cast. The first bifurcation, which gives rise to the upper-lobar bronchus, lies in the transverse plane of the body. The plane of the second bifurcation (from which the cardiac bronchus takes its origin), is sagittal. But the third bifurcation, giving off the posterior-horizontal bronchus, is irregular in also occupying a sagittal plane. The retro-cardiac bronchus is produced by a transverse bifurcation, and the anterior-basic by a sagittal bifurcation. The sagittal plane is, however, repeated by the lesser posterior-horizontal at its origin, and by the larger bifurcation of the lower end of the bronchus into axillary-basic and into posterior-basic branches. Analogous conditions will be found in the left half of the bronchial tree. Branches of the right main bronchus. The posterior-horizontal, the lesser posterior-horizontal are exceptions.

The Uniform Alternation unnoticed by Prof. Aeby.—Prof. Aeby's classification of the primary bronchi as ventral and dorsal branches, is not capable of being reconciled with the facts just described. According to that theory the primary branches of the bronchial stem would all be given off in the sagittal plane of the body. But the exceptions which he admits in favour of the "Eparterial" bronchus (described as arising from the external surface of the bronchial stem), and of the "cardiac" (retro-cardiac) bronchus (which is given off internally), go far to invalidate the theory which he proposes; and they afford a strong argument in support of the view that the primary bronchi follow, in their mode of origin, the same rules which In Aeby's theory all primary branches are sagittal, except "eparterial" and "cardiac" bronchi.

Alternations more regular with diminishing size of bronchi.

determine the relations of successive bifurcations throughout the bronchial tree. Moreover, if we remember that the alternation of planes acquires increasing regularity as the tubes decrease in size and increase in number, and that it becomes almost invariable in the case of the bronchioles, we are the more justified in venturing to draw the early bifurcations into the general scheme, and to regard their few irregularities as, numerically speaking, insignificant.

CONCLUDING REMARKS ON SOME IMPORTANT FEATURES COMMON TO ALL BRONCHI.

In concluding the general remarks devoted to the bronchial tree, the following statements may be put forward.

Dichotomy of bronchi.

(1) **More or Less Even Dichotomy** is the mode of division of bronchi in general. In this respect they are imitated by the blood-vessels of the lung; or at any rate by the pulmonary artery.

The pulmonary artery accompanies bronchi.

(2) **The Pulmonary Arteries are Faithful Attendants** upon the bronchi, resting upon them, as it were, for support and for protection from pressure, and conveying venous blood into the immediate vicinity of the air-supply, by which it is to be refreshed. Leaving aside details which will be fully given in subsequent pages, it will suffice to point to the constancy of this association, and to the assistance which it affords us in identifying any vascular branches as belonging to the pulmonary artery.

Absence of bronchial anastomosis.

Possible eddies or overflow of air into neighbouring branches, especially at periphery.

(3) **The Bronchial Tubes do not anastomose.** Each lobe therefore receives from the main bronchus a distinct air-supply. The same principle of separate supply extends, within the lobe, as far as the infundibula. This absence of anastomosis is physiologically of great moment. It does not, however, exclude a possibility that air-currents may pass from one bronchus to another, at least at the periphery. The bronchial distance separating two neighbouring lobules (and *a fortiori* two neighbouring *infundibula*) from their common trunk of origin, is small, and occasional interchange of air between them is easily conceived, nay, may be looked upon as probable, whether as a result of diffusion, or by mere overflow due to uneven tensions.

Lobes contain isolated respiratory districts.

Possible air-interchange within the latter, but not between them, except in extreme pathological conditions.

Respiratory Districts.—At the *root* of the lung the conditions are very different, since the primary, secondary, and tertiary branches from the main bronchus radiate towards the periphery for considerable distances, without bearing any lobules. Within each lobe, large groups of lobules being served by separate bronchi are thus kept in practical isolation from each other as regards their air-supply. Each of these sublobar groups may be considered as forming a *separate respiratory district*, within which the tidal air, or the bronchial contents in general, may, perhaps, be capable of interchange from lobule to lobule. Definite support is given to this assumption by the anatomy and the pathology of various morbid processes. Only in extreme pathological conditions does a similar overflow occur between tubes of sublobar, or even of lobar magnitude.

Their enumeration would be premature.

A knowledge of the situation, within each lobe, of the respiratory districts of which it is composed, is likely to be valuable to the clinical physician. But an attempt to define their anatomical boundaries would with advantage be postponed until a full description of the bronchial tree had supplied a sound basis for the subdivision of each lobe into its lobular groups.

THE MAIN BRONCHI.

What is, strictly, to be understood under the Term "Main Bronchus"?

Doubt as to the Limits of the Main Bronchi.—The origin of the bronchi occurs opposite the inter-vertebral disc separating the fourth and the fifth dorsal vertebræ (Quain). Almost identical statements are given on this point by all anatomists. But there is a lack of agreement, nay some degree of confusion, as to where the main bronchi terminate. To this question we shall presently revert. Their origin obvious, their termination doubtful.

Provisional Subdivision.—In order to facilitate description, we may assume, temporarily, that each bronchus presents the following parts:—

(1) **An Extra-pulmonary Portion;**
(2) **A Non-branched Intra-pulmonary Portion;**
(3) **A Branching Intra-pulmonary Portion.**

(1) **The Extra-pulmonary**, or extra-pleural, portion bears the same relation to the pleura as the trachea itself, being a mediastinal structure situated altogether outside the membranous sac. The length of this portion is very different on the two sides of the chest, as may be seen from the drawing (fig. 11) of the posterior aspect of the metallic cast. The empty pericardial sac is there shown from behind, and the line of pleural reflection occurs on the right side a little external to line G, and on the left side nearer to the line E than to the line D. Measured horizontally, according to the scale in the drawing, this portion extends outwards, on the "right side" for a distance of 19 mm., and on the left side for a distance of 30 mm., from the vertical line bisecting the tracheal bifurcation. Extra-pulmonary or mediastinal portion. Its extent on the right and on the left side.

(2) **The Intra-pleural** portion at first bears no branches. This is a very brief interval, measured, on the left side, by a horizontal distance of 5 mm., and on the right side, by a yet smaller fraction. Indeed, on the right side, this portion does not, strictly speaking, exist, since the separation of the upper lobar bronchus from the main trunk is already foreshadowed by a transverse furrow on the posterior aspect of the extra-pleural portion. Intra-pleural portion at first branchless.

Doubt begins at the origin of branches.

(3) **The Branched Portion,** or rather that portion which is situated below the first branch, is the only one which gives matter for doubt.

The bronchus ends at the first bifurcation.

Oldest View.—So long as anatomists paid no attention to the intra-pulmonary bronchial tree, and were content to describe the right main bronchus as dividing into three lobar bronchi, and the left main bronchus as dividing into two, the point did not arise for consideration. According to this *oldest view* the bronchus came to an end by the fact of its undergoing division. The application of the term "main bronchus" to either of the tubes beyond that point would have been inconsistent with the principle of dichotomy, then recognized.

Professor Aeby continues the main bronchus to the base, as "bronchial stem."

Contrary View held by Professor Aeby.—With this view Professor Aeby's theory is in complete opposition. Not only does he not admit so early a termination of the main bronchus. He considers that this tube is continued without losing its chief characters, as far as the base of the lung; and he gives further emphasis to this opinion by employing the term "bronchial stem." This expression is felicitous not alone because it avoids the obvious inconsistency in terms which would have been implied in the use of the name "main bronchus," but because it asserts his rejection of the lobar principle in bronchial nomenclature.

Lobation variable; rejected by Professor Aeby as a basis of classification.

Reasons for retaining it, especially in man.

Pulmonary Lobes as a Basis of Bronchial Classification.—According to the old style, at the point where the main bronchus came to an end, each lobe was supplied with its own bronchus. Perceiving the varieties, which exist among mammalia in respect of lobation, and the variability of the lobation in each species, Professor Aeby preferred to deal with the bronchi in their "naked condition," entirely discarding the lobes as a basis of description. I venture to uphold an opposite opinion, to which I have previously referred (*cf.* p. 7), and to suggest that it is wise not to dissociate the bronchi from the lungs in respect either of their study or of their nomenclature.

For the special purpose of human anatomy, in its connection with surgery and medicine, the retention of the lobar basis of nomenclature is not only appropriate but indispensable. This necessity must be considered entirely apart from the theoretical question and does not bear with the slightest weight upon its solution. It constitutes a strong additional reason for upholding the use of the old terminology in these pages.

The left main bronchus ends at its bifurcation.

Subdivision of Main Bronchi reconsidered.—The Left Bronchus.—Holding fast by the lobar principle of bronchial nomenclature, we find it easy to choose between the old and the new view as to the length of the main bronchus. On the left side, at least, there is no room for ambiguity. This lung has but two lobes; and the main bronchus likewise supplies but two branches, one for each lobe. It comes to an end at the level of that bifurcation, as was formerly taught. It is therefore clear that a branched portion of the left bronchus does not exist. The latter consists of two

It has only two por-

portions only, an extra-pulmonary and an intra-pulmonary portion, both branchless. tions, extra- and intra-pulmonary.

The Right Bronchus.—Some complication exists, however, on the right side. The three lobar bronchi do not, as it was long ago thought, arise simultaneously. A first bifurcation sets free the upper lobar bronchus—and the large tube, which remains, subsequently divides into the middle and the lower lobar bronchi. This tube may, or may not, be described as the "continuation of the main bronchus." Accuracy would be best served by restricting the use of the name to the undivided bronchus, and denying it to its offshoot. In respect of simplicity and of uniformity there would also be an advantage in viewing the right bronchus as coming to an end with the first bifurcation in the same manner as the left. Moreover the inferior segment in question, which soon divides into the middle and the lower lobar bronchi, may well claim a separate name by reason of its size and of its important relations. The three right lobar bronchi not simultaneous. The intervening tube; by what name to be known? Better not as main bronchus, but by a separate name,

Bronchus Intermedius.—I would suggest for it the term "intermediate stem" (*bronchus intermedius*), which is conveniently short, and conveys some reference to the somewhat central position of the tube, and to its character as an *internodium* between the upper and the middle lobar bronchus. The right main bronchus would thus bifurcate into the upper lobar bronchus, and the *bronchus intermedius*. The bronchus intermedius in its turn would break up into the middle lobar and into the inferior lobar bronchus. "Bronchus intermedius." Bifurcation of this tube.

Objection to a Misapplication of the Term "Main Bronchus."—The alternative plan of continuing to the intermediate portion the designation of main bronchus, besides involving possible ambiguity, is open to the serious objection that this would serve as a precedent leading to much confusion in the further nomenclature of the bronchial tree. Thus, within the lower lobe, it would be difficult to refuse the name lobar bronchus to that branch of bifurcation which might appear to be the strict continuation of the main tube; the same difficulty would arise at the second bifurcation; and no logical excuse could be advanced against the application of the term "lower lobar" to a very small linear descendant of the great lobar trunk. No finality to the use of the term "main bronchus" if misapplied once.

We are therefore justified in refusing to extend the term "main bronchus" to any portion of the bronchial system situated below the origin of the first branch from that trunk; and, on the right side of the chest as well as on the left, we must speak of the main bronchus as consisting of two parts only, an extra-pleural and an intra-pleural part, to the exclusion of a third, or branched, portion. Two sections only in the right bronchus, as in the left.

Description of the Main Bronchi.

Taking leave of the question of nomenclature, we now turn to a description of the main bronchi. What progress has been made, during the last few years, in our knowledge concerning them, may be gathered by comparing the account contained in the last edition of Quain's "Anatomy" with Modern progress in our knowledge of the main bronchi.

the following extract from an edition, not twenty years old, of another well-known text-book of anatomy: *

Previous errors.

"The right bronchus wider, shorter and *more horizontal than the left* is about an inch in length, and enters the right lung opposite the *fourth dorsal* vertebra. The vena azygos arches over it from behind; and the right pulmonary artery lies below and then in front of it. The left bronchus is smaller, *more oblique* and longer than the right, being nearly two inches in length. It enters the root of the left lung opposite the fifth dorsal vertebra about an inch lower than the right bronchus." (The italics are not contained in the original; they indicate statements which have been found inaccurate and have been corrected in later editions of this excellent manual.)

Points of Difference between the Two Bronchi.—Whilst both bronchi agree in possessing a direction downwards and outwards, considerable differences exist between them in the following respects:

Right bronchus is more inclined than the left.

1. **Inclination.**—The right bronchus departs from the horizontal to a greater extent than the left,—not less than the left, as stated by Sappey and by the great majority of anatomists previous to Aeby. The old misconception as to the relative inclination of the bronchi is traceable to two causes: (1) the neglect of intra-pulmonary dissections; (2) the practice, apparently prevalent among former anatomists, of following the upper border only as a guide to the position of the right bronchus. This upper border rapidly ceases to belong to the main bronchus and becomes the upper border of its first, or upper lobar branch; whilst the lower border is hidden from view by the pleura before it has strongly diverged from a direction parallel to the same upper border. The confusion due to this mistake is removed by the most superficial dissection, which brings into view the lower border of the lobar branch, and the angle between it and the main bronchus; in this manner I happened to recognize the true anatomical relations independently of Professor Aeby's description, which had not then come to hand.

Causes of the old mistake, readily avoidable.

A glance at fig. 11 will enable the reader to appreciate the meaning of the preceding remarks: it will also enable him to perceive the corrections required for the *italicized* statements on this page. It is clearly shown by the cast, that the main bronchus, or rather its continuation, does not enter the lung at the level of the fourth dorsal vertebra, but lower. At the same level as the termination of the trachea, which corresponds to the fourth inter-vertebral disc, a bronchus does enter the lung; this is however the upper lobar, not the main bronchus. This circumstance may likewise, at least in some cases, cause us to qualify the statement that the vena azygos arches over the main bronchus. Would it not be often more correct to speak of the vein as arching over the upper lobar bronchus?

Corrected statement.

* "Anatomy, Descriptive and Surgical," by Henry Gray. Fifth edition. 1869. Edited by T. Holmes.

2. **Curvature.**—In this respect the main bronchi, and their continuations within the lung present not only differences, but contrasts. To these Professor Aeby has drawn attention; and, in order to follow him, I must, for the present, adopt his terminology, and speak in terms of the "bronchial stem." The right bronchial stem, rectilinear near its first part, gradually assumes a faint curvature with concavity inward. The shape of an elongated letter C would express the direction of this curve; but so slight is the the latter, that, in order to detect it, a careful inspection is needed. C-shaped curve of right "bronchial stem,"

The left bronchial stem, beyond its first portion, which is straight, or nearly so, is said by Aeby to present a double curve somewhat resembling that of the letter S. With that description I cannot entirely agree. I have succeeded in recognizing a very distant resemblance to that letter in the outline of the bronchial stem, not however from the anterior aspect, but from behind. When viewed from the front, the outline would be that of a *reversed* S whose curves would face in the same directions as the retiring angles of a letter Z. But it is necessary to add that the degree of curvature is quite insignificant as compared with that which belongs to the ordinary capital letter. The old-fashioned elongated ʃ (duly reversed thus: ʅ) is much more nearly a correct representation of the bronchial curve. Even in this letter the middle third only can be fairly compared with the curve in question. and S-shaped curve of left bronchial stem, according to Aeby. Shape of reversed-S, according to Author, or rather shape of reversed *ʃ*.

Thus, whilst similar to the right bronchus in its lower part, the left bronchial stem performs an opposite excursion in its upper part. Nor is this all. In addition to the downward and inward bend of that portion of its course which is immediately above the upper lobar bronchus, the left bronchial stem, according to Aeby, is also, in a slight degree, bowed from front to back, with concavity backwards. The origin of these curves is easily explained, in connection with the relations of the left bronchus to the heart and to the large vessels. Additional bend with convexity backwards (Aeby).

3. **Length.**—Professor Aeby (*loc. cit.*, p. 65) gives for the non-branched portion of the bronchi the following average lengths:

Right bronchus, 21·1 mm.
Left bronchus, 49 mm.

The average given for the right bronchus is stated to be depressed slightly below the usual standard by the occurrence, among Professor Aeby's specimens, of a case of very high origin of the right upper lobar bronchus.

Sappey's averages (*loc. cit.*, p. 430) are: Length of the bronchi according to various observers.

For the right bronchus, 15 to 18 mm.
For the left bronchus, 30 to 35 mm.

But, in exceptional cases, 10 to 12 mm. for the right, and 40 and 45 to 50 mm. for the left, have been recorded.

Quain (*loc. cit.*, p. 265) gives for the right bronchus, a length of 1 inch (25 mm.), and for the left bronchus, a length of nearly 2 inches (50 mm.).

My own measurements agree with those of Professor Aeby.

4. **Diameter.**—Measuring the transverse diameter at the origin of the bronchi, Aeby finds :—

For the right bronchus, 16·7 mm.
For the left bronchus, 14· mm.

Diameter of the bronchi according to various observers.

These figures closely resemble those obtained by Sappey for the mean diameters, viz. :

For the right bronchus, 16 mm.
For the left bronchus, 12 to 14 mm.

Marc Sée* gives values slightly differing from these, viz. :

Diameter of right bronchus	In 18 males, on an average		14 mm.
	In 12 females,	„	12 mm.
Diameter of left bronchus	In 18 males,	„	11·6 mm.
	In 12 females	„	9 mm.

The diameter of the right bronchus, in persons older than twenty years, varied between 17·75 and 17·5 mm.

The diameter of the left bronchus, in persons older than twenty years, varied between 7 and 13·5 mm.

The disproportion between initial size of right and of left bronchus explained.

At its origin the right is much the wider of the two bronchi, the difference according to Aeby being almost in the proportion of 3 to 2. The sectional surfaces are stated by him to be equal to 222 sq. mm. and 157 sq. mm. respectively. This is a greater difference than can be accounted for by the difference in size between the two lungs. The following circumstances appear to me to assist in its production. In the first place the orifice of the right bronchus is not entirely lateral, but is also partly inferior to the trachea. And again, by reason of the early origin of its upper lobar division, the upper and the lower surfaces of the right bronchus, instead of being cylindrical, are caused to diverge almost from the beginning.

The left bronchus equal, in calibre, to half the trachea; the calibre of both bronchi much in excess of the tracheal calibre.

Relative Size of Trachea and of Bronchi.—A knowledge of the relative size of the trachea and of the bronchi is of much theoretical interest. According to Professor Aeby (*loc. cit.*, p. 71), if the diameter of the trachea be taken as 100, the diameter of the right bronchus would be represented by 70, and that of the left, by 49·3. The aggregate lumen of the two bronchi would thus considerably exceed that of the trachea; whilst the smaller bronchus would practically be equal to half the tracheal calibre.

In all cases examined by him Professor Aeby (*loc. cit.*, p. 79) found the aggregate calibre of the main bronchi to exceed that of the trachea by about $\frac{1}{5}$.

* "Du Calibre relatif de la Trachée et des Bronches," *Bull. de l'Acad. de Méd.*, 2me Série, vol. vii. p. 408.

The figures obtained by Marc Sée (*loc. cit.*) for the bronchi have been given above. For the trachea his measurements led to the following results:—

Diameter of trachea	In 21 males, on an average		18 mm.
	In 12 females	„	14·5 mm.

In 8 subjects examined by Marc Sée the calibre of the trachea was inferior to the sum of the calibre of both bronchi (of these subjects 5 had extensive pulmonary tuberculosis, the others were adults with normal lungs). In 11 other subjects the tracheal calibre was superior to the joint bronchial calibre.

Marc Sée's observations.

Aggregate Calibre of the Bronchial Tree.—From the observations which I have quoted Marc Sée concludes that, normally, the calibre of the two bronchi equals that of the trachea; that likewise the branches of any bronchus have an aggregate calibre equal to that of its parent-tube; and that the respiratory channels therefore represent a cylinder. Pathologically the equilibrium may be upset in favour of the bronchi, as in phthisis, or in favour of the trachea as in emphysema.

According to Sée, the calibre of the bronchial system is represented by a cylinder;

Professor Aeby (*loc. cit.*, p. 75) contends that this alleged equality is never found. The rule is that the products of any division of the bronchial stem exceed in capacity that of the parent stem, and that the relation would be represented graphically not by a cylinder but by an inverted cone.

according to Aeby, by an inverted cone.

Calibre of the Trachea.—The same is, according to him, also true of the tracheal calibre (*loc. cit.*, p. 68) when its diameter is compared at various levels. Thus the sectional area of the lower extremity being taken to be 100, that of the upper end is 52·2 per cent., that of the middle third 63·5 per cent., and that of the lower third, 83·5 per cent.

The tracheal calibre likewise.

Exception to Aeby's Rule.—An important exception to the rule occurs however in the bronchial tree, at the level of the eparterial bronchus. Since in man no eparterial bronchus is to be found on the left side, the variation in question is not referable to any division in this tube, but occurs in its continuity, and, according to Aeby, may be taken to mark the site of the suppressed bronchus.

Irregularity in the bronchial calibre at the "Eparterial" level.

The exception consists in the aggregate capacity of the right eparterial bronchus and lower bronchial stem being not larger, but smaller than that of the bronchial stem prior to division. In like manner, at a corresponding level, the left bronchus generally presents a narrowing; this being an exception to another rule, viz., that the calibre of an *internodium* preserves a cylindrical value. It is however to be noted that Professor Aeby, in determining the superior measurement, selects not the section of the main bronchus situated immediately above the eparterial bronchus, but the orifice of the bronchus at the tracheal bifurcation, an orifice which is apt to be considerably wider than the bronchus itself.

Instead of a gradual expansion, a shrinking at this level, even in the left bronchus, although internodia are usually cylindrical.

Relations of the Main Bronchi at the Root of the Lung.—This important subject will be much more conveniently treated in connection with a description of the blood-vessels in Section III. and to that section the reader is therefore referred.

THE BRONCHUS INTERMEDIUS OR CONTINUATION OF THE RIGHT MAIN BRONCHUS BELOW THE ORIGIN OF THE UPPER LOBAR BRANCH.

The directions followed by the continuation of the main bronchi have already been mentioned under the heading of the latter; and they will be further noticed in the course of the detailed account of the bronchial tree. This is however the place for a brief description of the differences which occur in the mode of termination of the right and of the left bronchus.

Joint origin of the left upper and lower lobar bronchi.

In the Left Lung, the origin of the upper lobar division, or *bronchus impar*, which marks the end of the main bronchus, also defines exactly the beginning of the lower lobar bronchus. Between the two last-named bronchi there is no transition, the latter being the direct continuation of the former tube.

On the right side, an internodium between the upper and the middle lobar bronchi.

The bronchus intermedius an odd structure, produced by a drawing-out of the main bronchus.

Bronchus Intermedius.—In the right lung, on the contrary, a considerable interval separates the origin of the upper lobar bronchus on the one hand, and the joint origin of the middle and lower lobar bronchi on the other. Inasmuch as this transitional section of the length of the main air-tube belongs neither to the upper lobe nor to the lower lobes, it has the value of an *internodium* inserted between the great lobar bronchi, for the purpose of increasing their distance. I have already proposed for it the term *bronchus intermedius*. Not existing in the left lung, this is an odd structure; it is not, however, odd in the sense of obviously disturbing the symmetry of line, or of constituting a numerical addition to the branches of the bronchial tree; for it is nothing more than the continuation of the main bronchus drawn out, as it were, at a given spot. Indeed it may be pointed out that, in the left lung, at a lower level, an analogous drawing-out takes place in the length of the lower lobar bronchus, causing a short internodium to precede the origin of the posterior-horizontal bronchus, whereas, on the right side, an interval can hardly be recognized between the level of origin of the cardiac bronchus and that of the posterior-horizontal.

Analogous internodium in the left lower lobar bronchus.

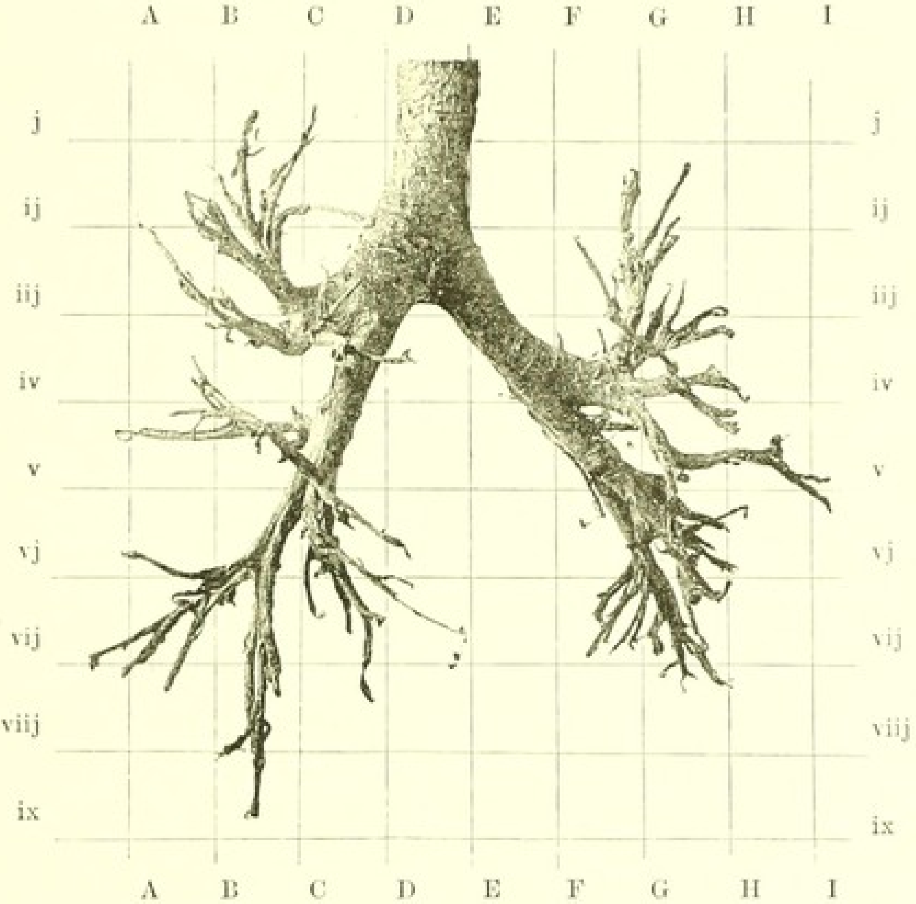
The bronchus impar more truly odd.

It will be shown hereafter that the *bronchus impar* (left upper lobar bronchus) does constitute a numerical addition to the branches of the bronchial tree, and therefore deserves, in a much more definite manner, to be qualified as odd.

Length of bronchus intermedius.

Dimensions and Direction.—Measured from the retiring angle below the origin of the upper lobar bronchus to the similar angle below that of the middle lobar bronchus, the intermediate stem, in the metallic cast under consideration, has a length of 2·5 cm. Its direction is identical with that of the main bronchus. Viewed from behind it is however readily seen that its lower extremity swerves outwards from the straight downward-and-outward course. A similar outward tendency may also be observed in the middle and inferior lobar bronchi; but in them it is much more deve-

FIG. 8.



PREPARATION OF THE CHIEF BRONCHI, DISSECTED IN THE MOIST STATE, AND ALLOWED TO DRY AFTER BEING PACKED FULL OF DRIED SPONGE, AND STIFFENED WITH WIRE. FRONT VIEW, TAKEN FROM THE RIGHT. (*From a Photograph.*)

The side of each small square measures 20 mm.

Several of the bronchi having given way, or shrunk in drying, the specimen imperfectly illustrates the branchings of the bronchial tree. But the main bronchi, their mode of origin and of termination, and their general relations are clearly seen. The bronchus intermedius traverses square C iv; and the bronchus impar lies across square F iv.

loped. The irregularity in question is a strong argument in favour of the view that the "bronchial stem" of Aeby does not preserve beyond this level the value of an axial structure. The intermediate stem is cylindrical and possesses a considerable calibre, although, as far as the unaided eye can judge, this is rather less than the aggregate calibre of the two bronchi derived from it.

Outward deflection.

Cylindrical bore.

Posteriorly an intra-pulmonary and a sub-pleural part. Its mesial surface above is extra-pleural.

Relations.—The relations of the intermediate stem are of importance. At its origin it is not entirely included within the pulmonary pleura. Its oblique posterior surface is divided into two parts, a larger, distal, intra-pulmonary, and a smaller, mesial, sub-pleural portion, by the vertical line of reflection of the pleura. In fig. 11, which represents the posterior aspect of the metallic cast, the actual conditions will be readily recognized. The pleural membrane has been divided along the line of its reflection, and may be seen (in square (G iv)) extending vertically across the oblique course of the stem. It will also be seen that the mesial surface of the stem is in its upper part, entirely extra-pleural, in other words mediastinal.

The lower lobe covers its posterior surface.

The pulmonary tissue which clothes, from behind, the intra-pulmonary portion, belongs to the inferior lobe; for it should be noted that, in spite of the origin of the middle lobar or cardiac bronchus being superior to that of the posterior-horizontal bronchus, the distribution of the latter rises higher than any branch from the former.

The lower branch of the pulmonary artery crosses it in front; lower down the cardiac bronchus covers it anteriorly.

Anteriorly the intermediate stem is not in immediate relation with pulmonary tissue, nor with pleura. The interlobar septum and its pleural lining do not penetrate as far as the bronchial surface, but the latter is in direct contact with the lower branch of the right pulmonary artery, and separated by this from the superior branch of the right pulmonary vein (see chromo-lithograph, p. 180). Further down, the mesial half of the anterior surface is also in direct relation with the posterior aspect of the cardiac bronchus, which, in its first part, descends in front of its parent trunk, and in close proximity to it.

ELEMENTARY SKETCH OF THE MORE IMPORTANT DIVISIONS OF THE BRONCHIAL TREE STUDIED FROM THE METALLIC CAST.

My present object is to convey a general idea of the situation and of the names of the chief air-tubes, without loading their description with any unnecessary detail. This first stage in the study of the bronchial tree will be much facilitated for the reader by his frequently consulting the diagram fig. 6 at p. 52, and the synopsis of the primary bronchi at pp. 54 and 55. The introduction of an elementary sketch to be followed by a more complete description brings with it the evil of repetition, but there are practical reasons which recommend such a course.

The Right Bronchial Tree.

Chief characters.

Right Bronchus.—This short and wide tube is chiefly remarkable for its directness, for the steepness of its downward-and-outward slope, and for the early bifurcation which it undergoes, soon after its origin from the trachea, and before it is fairly buried within the lung (*cf.* p. 10 and p. 70).

Upper lobar bronchus ("Eparterial" bronchus). Its horizontal direction. Formerly mistaken for main bronchus. Pleural line and vena azygos cross it. The pulmonary artery lies below it.

Upper Lobar Bronchus.—The uppermost division of the main bronchus is entirely devoted to the upper lobe, which receives no other supply. Anatomists had known it exclusively under the name given above, until Professor Aeby proposed for it the term "eparterial." The direction of this important tube is almost always horizontal, as is very clearly shown in fig. 11 (see also other drawings and diagrams). It appears to have been habitually mistaken, in the past, for the main bronchus, which for this reason was, until recent years, described as horizontal. The line of pleural reflection crosses its origin posteriorly, and the vena azygos from above (see fig. 11, column G, line iij). This bronchus may arise even higher than the usual level, but in every case it is superior to the pulmonary artery (see chromo-lithograph).

Its distribution.

The branches of the upper lobar bronchus respectively supply the centre and the three sides of the apex of the lung (*cf.* p. 89).

Bronchus intermedius.

Bronchus Intermedius.—This name is applied to the *remainder* left by the separation of the upper lobar division from the main bronchus (see figs. 9 and 11). It is the continuation of the latter.

Cardiac bronchus, crossed anteriorly by lower division of pulmonary artery,

Middle Lobar, or Cardiac Bronchus.—The branch for the middle lobe is given off at the bifurcation of the intermediate stem, immediately behind the lower division of the right pulmonary artery (the upper division having risen into the upper lobe). This lower division, roughly preserving the transverse direction of the main right artery, crosses, at this level, the descending air-tubes, and partly rests upon the bronchus which is being described. The bronchus lies at first in immediate contact with, and anterior to the lower lobar stem, separating it from the artery. Just below the point where the blood-vessel passes outwards, the air-tube bends slightly forwards in order to supply the middle lobe. Anatomists have hitherto described it solely as the *middle lobar bronchus*, a name not normally applicable to any bronchus in the left lung. There are good reasons, hereafter to be set forth, for using, at least as an alternative, the name *cardiac bronchus*, which is based upon its visceral relations. In association with the fact that it arises anteriorly, and is situated below the arterial trunk, Professor Aeby designates this branch as the *first hyparterial ventral bronchus*.

supplies the middle lobe.

The lower lobar bronchus arises below upper level of its lobe.

Lower Lobar Bronchus.—The other product of the bifurcation of the intermediate stem, the lower lobar bronchus, is, from the first, situated within the lower lobe (this lobe rising posteriorly above the level of the last-named bifurcation); its undivided portion is restricted to a very short course.

Posterior-horizontal bronchus: its dorso-lateral origin; its name;

Posterior-horizontal Bronchus.—This large branch bifurcates from the preceding trunk a few millimetres below the level of the cardiac bronchus. It arises from the posterior, or more strictly, from the dorso-lateral bronchial wall, and is termed by Aeby *first dorsal hyparterial bronchus*. The designation which I suggest instead of the latter was first applied by me to branches of this air-tube, some years ago, in the Gulstonian Lectures on Pulmonary Cavities. (See *Lancet* and *British Medical Journal*, 1882.) The direction of this interesting, but unusually short trunk, is sufficiently indicated by its name. It distributes branches upwards to the infra-spinous region, downwards to the middle dorsal third of the lung, and horizontally outwards and forwards, to its middle axillary third.

its distribution.

The "cardiac" branch of Aeby more properly called retro-cardiac; its distribution and its origin are internal.

Retro-cardiac Bronchus.—Barely 9 millimetres below the origin of the posterior-horizontal bronchus, there arises, from the inner surface of the continuation of the lower bronchus, a downward branch termed by Aeby the "*cardiac bronchus*," but described by me, with closer regard to its anatomical relations, as *retro-cardiac*. It is destined to aërate the two posterior thirds of the inner aspect of the lower lobe. The strictly internal origin of this bronchus (see fig. 11, line H, square G vj) excludes it from the scheme of dorsal and ventral bronchi set forth by Aeby in his nomenclature. He frankly recognizes the difficulty, and he gives to this air-tube a place among the accessory bronchi. Very strong reasons should be adduced before we could consign to a secondary position so constant and so large a bronchus, and one distributed to a district peculiarly isolated from other branches of the bronchial tree. The fact that, in some animals, and rarely in man, this

Reasons why it should not be regarded as accessory.

district is constituted into a separate retro-cardiac lobe (Herz-lappen, lobus infracardiacus, Aeby), (azygos lobe, lobulus impar, Owen), strongly illustrates its claim to be individually considered in any scheme of the bronchial system. Occasional retro-cardiac lobe.

The Three Basic Bronchi.—Three large trunks arise at the extremity of the lower bronchus, and divide between themselves the air-supply of the base, although not in accurately even shares. Their arrangement is in the antero-posterior order; the axillary-basic occupying the middle place between the anterior-basic in front of it and the posterior-basic behind. All three bronchi retain the downward and outward direction; and their joint distributions assume a distant resemblance to a vertical segment of an inverted funnel, with convexity outward. In consequence of this arrangement the inner basic surface of the lung would remain isolated as to its bronchial supply,—as it was stated above. The basic bronchi; their mutual relations; their direction. They do not supply the inner base.

Their Origin and Relative Size.—The mode of origin of the three basic trunks is *not* by simultaneous *trifurcation*, but by a rapid repetition of bifurcation. The posterior-basic bronchus is not only the largest of these but the last, and might therefore claim to contain the continuation and the end of the alleged "bronchial stem." It will be seen that some difficulty exists, even for Professor Aeby, in determining, in man, which of its branches is to be regarded as the ultimate tube. For supporters of the old theory of bifurcation, this question does not occur. Repeated bifurcation at their origin. Which of them is the "bronchial stem"?

Professor Aeby's attention does not appear to have specially dwelt upon the even size and importance which all three basic bronchi assume in man. But I have elsewhere suggested (see p. 31) that in quadrupeds with short sternum, the anterior-basic bronchus would probably shrink into secondary dimensions, whilst the size of the posterior-basic bronchus would so materially increase as to maintain for it, almost as far as the base, that pre-eminence in calibre, which Professor Aeby considers synonymous with an architectural axial quality. This is more doubtful in man than in quadrupeds.

The Anterior-basic Bronchus, or, more fully named, the anterior-lateral-basic, larger than the axillary-basic, but not so important as the posterior-basic bronchus, takes its origin from the anterior aspect of the continuation of the lower bronchus, about 9 millimetres below the origin of the retro-cardiac bronchus, and distributes branches to the anterior and to the antero-lateral regions of the base. In Professor Aeby's nomenclature this trunk would represent the *second hyparterial ventral bronchus*. Anterior-basic bronchus. Its origin. Its distribution.

Lesser Posterior-horizontal Bronchus.—Between the level of origin of the anterior-basic and that of the axillary-basic a smaller bronchus, for the supply of the third fourth of the dorsal surface is given off backwards. This is the lesser, or inferior horizontal bronchus (or *second hyparterial dorsal bronchus* of Aeby). Lesser posterior-horizontal; its origin and distribution.

The Axillary-basic Bronchus, the anterior product of the final bifurcation of the remainder, or continuation of the lower lobar bronchus, Axillary-basic; its origin and distribution.

is probably identical with the *third hyparterial ventral bronchus* of Aeby (as far as it is possible to guess, in the absence of any individual description of this air-tube). Since its distribution is entirely axillary, the signification of the word "ventral," when applied to it, is rather strained. The employment of that term was probably determined by the fact that the bifurcation, which gives rise to this tube, is contained, not within a transverse, but rather within an antero-posterior plane.

Posterior-basic bronchus, rather larger than the other two. Its branches thought to represent the lower primary branches of Aeby. Its distribution superficial and deep.

Posterior-basic Bronchus.—From the posterior-basic, which even in the human subject possessed of a horizontal diaphragm, is somewhat larger than the other two basic trunks, Aeby probably derives the *fourth hyparterial ventral bronchus*, and the *third and fourth hyparterial dorsal bronchi* which form part of his nomenclature. Branches from the trunk in question may be pointed out which would suit these designations; but in the human subject they could hardly be placed on a footing of morphological equality with those branches which arise directly from the bronchial stem by means of bifurcations contained within the root-zone. The areas of distribution of the posterior-basic bronchus are the posterior-axillary surface, the dorsal surface with the exception of its innermost section (which is within the province of the retro-cardiac bronchus), and the inferior surface. It likewise, and to a greater extent than the other basic bronchi, furnishes deep branches for the intra-pulmonary tissue.

The Left Bronchial Tree.

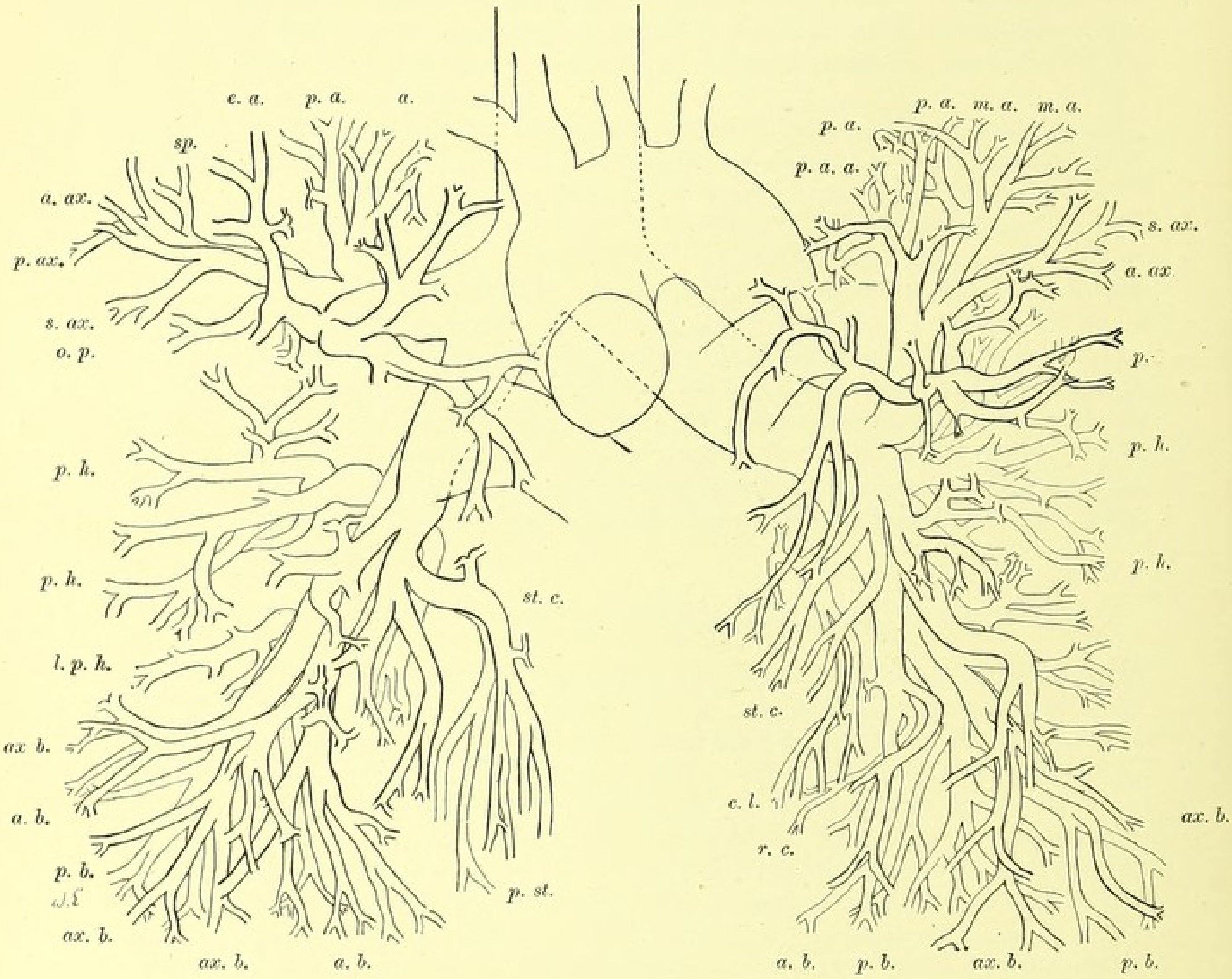
The left bronchus long, and slightly convex downwards bends suddenly downwards. The cardiac curve occurs in the lower lobar trunk, not in the bronchus.

The Left Bronchus is elsewhere stated to be much longer than the right bronchus, and to present, in its extra-pulmonary part, a very feeble curve, with convexity downwards and slightly inwards. Being less steep than its fellow, it forms a larger angle with the vertical axis of the lung. It endeavours, after penetrating into the hilus, to rectify this strong divergence by a somewhat sudden downward bend. Just below the level of this bend begins the important *cardiac curve* which is concave inwards and slightly forward, and terminates with a gradual outward deflection. This curve was first described by Aeby in connection with the "bronchial stem." I have already (*cf.* p. 71) criticized the description given by him, and I would only add in this place that, according to the terminology which I have advocated, it is the inferior lobar trunk, and not the main bronchus which undergoes the curvature mentioned, the latter tube having come to an end above that level.

Origin of this tube from the anterior and lateral aspect of bronchus.

The Upper Lobar Bronchus: Bronchus Impar.—The first bifurcation takes place immediately before the downward bend, at a relatively long distance from the trachea, and well within the root of the lung. It gives rise to the large *left upper lobar bronchus*. The insertion of this air-tube into the main bronchus is not strictly lateral, like that of its fellow, but is in a large measure, anterior also.

FIG. 9.



ROUGH DIAGRAM OF THE BRONCHIAL TREE; FRONT VIEW.

The outline of the trachea and of the main bronchi is dotted where it is crossed by the aorta, and by the pulmonary arteries respectively; a small portion of the latter is outlined on either side.

FIG. 9.

EXPLANATION OF THE DIAGRAM.

RIGHT UPPER LOBE:

a.: anterior, and *p. a. a.:* posterior ascending-apical branches.

a. ax.: anterior, and *p. ax.:* posterior axillary-apical branches—*sp.:* supra-spinate, *s. ax.:* superior axillary branches.

e. a.: External anterior apical branches, and *o. p.:* outer-pectoral branches, both from the mid-pectoral division of the pectoral stem. (The ascending, and the horizontal sterno-pectoral divisions are seen extending inwards towards the aorta.)

RIGHT MIDDLE LOBE:

p. st.: parallel-sternal branches derived from—*st. c.:* the sterno-cardiac bronchus. The latter joins the more vertical posterior mammary-cardiac bronchus, which is not lettered. The external division of the cardiac bronchus (middle lobar bronchus), or mammary-cardiac, approaches in the diagram the posterior-horizontal distribution.

RIGHT LOWER LOBE:

p. h.: posterior-horizontal distribution, originating opposite the retro-cardiac bronchus which descends behind *st. c.*

a. b.: anterior-basic branches—*ax. b.:* axillary-basic branches—*p. b.:* posterior-basic branches.

LEFT UPPER LOBE:

p. a. a.: posterior ascending-apical distribution (in front of which lies the anterior ascending-apical).

p. a.: posterior-apical branches—*m. a.:* mid-apical bronchus dividing into outer and inner distributions.

p.: pectoral branches.

a. ax.: anterior axillary branch—*s. ax.:* superior axillary branch.

o. p.: outer-pectoral branches (the whole pectoral distribution extends along the same level, except the ascending mid-pectoral and the sterno-pectoral, and sternal branches).

st. c.: sterno-cardiac branches, from the anterior cardiac trunk (the outer division of the latter, or mammary-cardiac, is not lettered).

c. l.: cardiac lobular branches, from the posterior cardiac trunk.

LEFT LOWER LOBE:

p. h.: posterior-horizontal distribution.

r. c.: retro-cardiac branches from the anterior-basic.

a. b.: anterior-basic branches—*ax. b.:* axillary-basic branches—*p. b.:* posterior-basic branches.

The following Differences between the right and the left upper lobar bronchi should be noted:—

(1) The left upper bronchus is not superior to the pulmonary artery at the root, but inferior to it. In Aeby's terminology it is not "eparterial," but "hyparterial." It is inferior to the pulmonary artery.

(2) It corresponds strictly neither to the right upper lobar, nor, as Aeby contends, to the right middle lobar bronchus, but to both combined. We must look upon it either as a trunk which does not exist on the right side (a supernumerary trunk), or more probably as a mixed product, due to the blending of the first portion of the pectori-apical bronchus and of the cardiac bronchus.

(3) It carries the air-supply destined for the apex and for the cardiac districts and feeds therefore a more comprehensive lobe than the right upper lobe can claim to be. Indeed its two branches, the ascending and the descending branch, must be regarded, in connection with the districts in question, as being each equivalent to a lobar bronchus of the right lung. Its two branches, the equivalents of lobar bronchi.

The Ascending Branch is strictly the counterpart of the right upper lobar, or apex-bronchus, although it is rather smaller than the latter. It further differs from this tube in approaching the apex from below, instead of horizontally and from the inner side. A close resemblance exists nevertheless between its branches and those of the right apex-bronchus. (See for full description p. 99.) The ascending corresponds to the right apex-bronchus;

The Descending or Cardiac Branch, putting aside its peculiar mode of origin, is almost identical with the right cardiac, or middle lobar bronchus. It is however rather smaller, owing to the slightly smaller size of the corresponding district. Its undivided length is about 1·2 cm. the descending, to the right middle lobar.

With the description just given, it is difficult to reconcile Professor Aeby's statement that there is neither a true upper lobe, nor a true upper lobar bronchus on the left side, and that the structures commonly known by those names are respectively the equivalents of the right middle lobe and of the right middle lobar bronchus. The ingenuity of that view is the most probable explanation for the remarkable success which it has enjoyed. Professor Aeby's statements in opposition with these facts.

The Inferior Lobar Bronchus is the other branch of the bifurcation of the main bronchus (of which it is the apparent continuation (see fig. 11, square D v)). The downward and backward bend to which reference has been made occurs in this tube. But before the curve in question has become fully developed, the lower lobar bronchus yields, directly backwards, its first branch, the posterior-horizontal. Inferior lobar bronchus; downward bend.

The Posterior-horizontal Bronchus occupies at its origin almost the same level as its fellow in the right lung, but it is separated by a much less interval from the level of the upper lobar bronchus. Although posterior in its origin, it rapidly assumes an outward direction. Its distribu- Posterior-horizontal. Direction at first backwards, then out-

Distribution symmetrical.

tion is more extensive and shows greater symmetry than that of the right posterior-horizontal trunk.

This bronchus is theoretically interesting as offering the earliest evidence of obvious symmetry between the two sides. Even Professor Aeby fails to detect any want of agreement between the lower lobes. In my own estimation, after careful study, the agreement existing between the two upper lobes is no less striking than that between the two lower. The lower lobes in general and the posterior-horizontal bronchi, their highest bronchi, in particular, are far from being faithful duplicates of each other. But their differences, as well as those noticed between the upper lobes, although they are by no means trifling, are powerless to break up the morphological equation.

Basic bronchi begin by apparent trifurcation.

The Basic Bronchi.—The ultimate splitting-up of the continuation of the lower lobar stem occurs on the left side at a slightly higher level than on the right. So rapid is the subdivision that the three resulting bronchi appear to belong to a *trifurcation*. (See fig. 11, square C vj.) These bronchi have the same names and the same relative positions as in the right lung but their mode of distribution is not quite identical.

The retro-cardiac a secondary branch, from anterior-basic.

The Retro-cardiac Branch, so prominent a member of the right bronchial tree, does not form part of the left primary series, but arises as a secondary division from the anterior-basic bronchus; its existence appears to have escaped Professor Aeby's attention, and probably for this reason he has been led to regard the retro-cardiac as an accessory bronchus.

Lesser posterior-horizontal a branch of the posterior-basic.

The Lesser Posterior-horizontal likewise differs, in point of its origin, from its fellow on the right, and it is notably smaller than the latter. It is a branch of the posterior-basic, instead of arising above the origin of this trunk.

The Anterior-basic Bronchus is of greater size than its fellow, and aërates a larger district.

Axillary-basic.

The Axillary-basic Bronchus requires no separate description in this place.

The Posterior-basic Bronchus is, as in the right lung, the most powerful of the three tubes and provides an equally large district, although in a somewhat different manner. The detailed account of its distribution will be found under a subsequent heading. The posterior-basic would contain according to Aeby's description, the termination of the "bronchial stem." But there exists yet more difficulty in this lung than in the right in determining which of the branches of the trunk is to be singled out as the terminal representative of the stem.

Which of the three bears the end of the "bronchial stem"?

The inward concavity of the left bronchial tree persists almost as far as the base. But in the posterior-basic district this curve is converted into an opposite one.

Mobility necessary in connec-

Special Characters of Left Bronchial Tree.—The serpentine course of the main bronchial tubes, the length of the ascending-apical branches, and the higher level of origin of the basic branches, are among the circumstances which lend to the left bronchial tree an aspect of greater elegance and of greater mobility than belongs to the right. The latter quality is of importance in connection with the normal and pathological variations to which this lung is exposed in connection with the varying size and position of the heart.

tion with the heart.

Deferred Criticism.

Professor Aeby's Illustrations.—Let us turn from this most elementary sketch of the metallic bronchial cast to Professor Aeby's illustrations. In the photographic prints taken of his own metallic injections, although some of the latter were incomplete specimens, there is little difficulty in recognizing the leading facts which I have described. Even in the diagram (reproduced in fig. 5) most of the general features of the bronchial tree may be traced. So faint however are some of the indications, that they can be appreciated only by those who are familiar with the subject. To all others an erroneous impression must be conveyed both by the diagram and by the metallic casts. The latter might be expected to supply evidence which might lead to corrections in the diagram; but they fail to serve as standards of comparison owing to their incompleteness.

Aeby's metallic casts incomplete.

His diagram misleading.

The Bipinnate Arrangement.—Greater confidence may be claimed by the bronchial cast of which drawings are contained in this book; and if the reader will compare figs. 10 and 11 with my diagrams (figs. 6 and 9) on the one hand and with Professor Aeby's diagram on the other, he will be able to trace for himself the nature of the discrepancies between the two systems. He will probably realize that the classification of the hyparterial bronchi into a *ventral* and a *dorsal* series is not strictly compatible with anatomical facts. If the designations in question have reference to the relations existing between the bronchial stem and the several bronchial divisions at their origin, Professor Aeby's diagram is the chief witness against their suitability. If on the other hand, in spite of an origin which may be neither strictly ventral nor strictly dorsal, they are meant to describe the relation of these air-tubes to the peripheral districts supplied by them, the terms may be shown to be inaccurate at least in the case of the axillary-basic bronchus, which is slightly lateral in its origin and entirely lateral in its distribution.

The ventral and dorsal classification not in harmony with fact.

But the inherent difficulty of describing the bronchial tree on an exclusive basis of ventral and dorsal branchings has been pointed out in connection with the eparterial and the cardiac bronchus of Aeby (*cf.* p. 63); and to this I need not further allude.

Much stress is laid by Professor Aeby upon the alleged fact that, among other differences, the first division from the left main bronchus contrasts with the right upper or eparterial in failing to supply any dorsal branches. This statement does not agree with my own observations. One of the three branches which are seen in fig. 11 (in square C iv), namely the middle branch

The left bronchus supplies a posterior branch, as does the right bronchus.

of the apparent trifurcation, assumes a direction backwards and upwards; and some of its subsequent branches are in their course decidedly posterior. These however arise above the upper level of the lower lobe, which in the left lung rises decidedly higher than in the right. It is clearly shown in fig. 11 that the presence of a large upward branch of the posterior horizontal trunk immediately behind the apparent trifurcation prevents the bronchus destined for the posterior supply of the apex, from projecting at once boldly backwards.

The alternation of branches not regular in man.

In connection with the alternation of branches, Professor Aeby's specimens and my own show that the regularity which he describes in the bronchial tree of mammalia is not to the same extent present in that of man. I have elsewhere stated that our observations do not agree as regards the mode of alternation (*cf.* p. 63).

THE DETAILED ANATOMY AND NOMENCLATURE OF THE BRONCHIAL TREE.

Preliminary Remarks.

The objects to be aimed at in dealing with the description of the bronchial tree are, firstly to give an accurate and, if possible, a complete account of the latter, and, secondly, by every means to endeavour to render its perusal easy as well as clear. Completeness and clearness aimed at.

No effort of mine can deprive the subject of its aridity; and it is of the essence of the bronchial system to be complicated. Indeed, when viewed as a whole, the bronchial cast presents an overwhelming amount of detail which may well cause the student to recoil from its thorough investigation. Yet, when its parts are separately taken, the study of each need not offer insuperable difficulty and, it is hoped, will not do so in these pages. Dryness and complexity of the subject.

Again, just as a stranger, introduced into a large family, may at first experience some difficulty in knowing one child from another, until he has learnt to associate with the name of each certain minor characteristics, and ultimately may wonder that he should once have thought them all so alike; in like manner, in spite of the number and of the general resemblance of bronchi, closer acquaintance with them reveals among them more and more diversity of feature, and their names, if appropriately selected, become a source of assistance, and lighten the burden of description. The nomenclature a source of help.

It is therefore essential to briefly dwell (1) upon the plan of subdivision to be followed in the anatomical description; (2) upon the terminology and the notations which it is proposed to use.

1.—The Subdivision of the Anatomical Description.

Right and Left Bronchial Tree Dissimilar.—The differences found in the lungs are such as to preclude the possibility of a simultaneous description doing equal justice to both lungs. Since we must bestow upon each a separate consideration, will it be more profitable that we should proceed with each lung, as a whole, and that we should abstain from any reference to the other lung until the first shall have been completely described? By such a course we should avoid certain complications. But, since the differences are, Separate description for right and left sides;

but the accounts of like parts should be coupled together.

after all, less prominent than the common features, we should lose obvious facilities by keeping the two descriptions apart. After mature thought I am of opinion that most advantage can be gained by bringing into close association the accounts to be given of like parts in both lungs.

The lobar subdivision insufficient.

The Subdivision of the Bronchial Tree.—The natural subdivision of each lung is into its lobes, and the help which this alone supplies towards a description of the lung is considerable. But the pulmonary lobes are too few, and too large to afford us the full assistance which we claim. We require to divide the lung into yet smaller regions in order to attain simplicity in description. In clinical anatomy some regions of this kind have long been defined; and these divisions it is expedient that we should adopt; but the remaining parts have not hitherto been the subject of delimitation. Thus, in addition to the apex and to the base, to the upper and to the lower axillary regions, we shall have to speak of the "pectoral," of the "cardiac," of the "mid-dorsal," of the "retro-cardiac" and of other regions, and to describe the mode of the bronchial supply in each. But in doing so, we discover that the districts in question are practically identical with the respective territories of the several primary bronchi.

Smaller regions or districts must be defined.

These correspond with the distributions of the primary bronchi.

We thus fall back upon the natural divisions of the bronchial tree as the best guide to a subdivision of its study; and we may adopt as a basis the rough sketch which has already been given in the preceding pages. This circumstance pleads an excuse for what may otherwise have appeared to be an unnecessary repetition. It was essential to familiarize the reader with the broad lines of the elementary bronchial tree, in order subsequently to elaborate, on that foundation, the greater detail of the present description.

I therefore propose, after taking a preliminary survey of each region, but especially of those which are clinically important, to proceed to the description of the several bronchial distributions, that is, of the bronchi undergoing systematic evolution into bifurcations and branches.

The following bronchial distributions will be described:

1. The apical distribution.
2. The axillary distribution.
3. The pectoral distribution.
4. The cardiac distribution.
5. The posterior-horizontal distribution.
6. The retro-cardiac distribution.
7. The anterior-basic distribution.
8. The axillary-basic distribution.
9. The posterior-basic distribution.

Each distribution will be studied in the right lung, and in the left, in immediate succession; an opportunity will thus be afforded for noting the discrepancies as well as the common features on each side of the chest, with reference to limited areas.

2.—Terminology and Notation.

Principle of the Nomenclature.—The names given to bronchi have been selected almost exclusively with regard to their anatomical relations. The terms "apical," "cardiac," "retro-cardiac," "pectoral," "sternal," &c., are instances of this kind. The names based upon anatomical relations,

Sometimes, as in the term "posterior-horizontal," peculiarities in the direction or in the shape of bronchi have supplied the designation, or have been included within it. or peculiarities.

In order to avoid an undue multiplication of names, and also for greater ease in following the description, the terms applied to bronchi have as much as possible been continued to their remote branchings, with such modifications as were claimed by their changing directions. Names continued to smaller bronchi from the larger,

For the same reasons, although the principle of dichotomy desires the employment, for each of the branches of a bifurcation, of a name differing from that of the bifurcating trunk, in most cases the name used above a bifurcation has been retained below the same for one of its two products. In contrast with this practice, the "intermediate bronchus" has been described by a special term, and not as the "main bronchus"; I have elsewhere explained why the new name was deemed necessary. in spite of principle of dichotomy.

The terminology, apart from the notation to be presently described, does not supply any indication of the relative size of air-tubes. The expression *bronchiole* is free from ambiguity; and bronchioles may be classified with some precision as *sub-lobular*, *lobular*, *intra-lobular* and *terminal*. But all other air-tubes possess an equal claim to the name of "bronchi." The terms *bronchi*, *bronchia* and *bronchial tubes* are really synonymous, and unfit to express definite differences in size. In these pages, whilst the word bronchus retains its widest meaning, it has been found advisable to employ concurrently the expressions *bronchial stem* and *bronchial trunk*, in connection with the larger bronchial divisions. These should be understood to be merely alternative terms, introduced for greater facility of description but not as possessing any distinguishing value. Meaning of the terms *bronchioles*, *bronchi*, *bronchia*, *bronchial trunks*, *bronchial stems*.

Aids to the Reader.—Special attention has been devoted to the object of facilitating to the utmost the ready localization of the tubes described. The following devices are the outcome of this endeavour:—

1. Tables embodying in a synoptical form the names and modes of branching of the tubes have been added, for each separate district, to the descriptions given; these may readily be consulted in connection with the latter, or in connection with the drawings of the metallic casts. Tables.

2. The marginal notes also contain, in an abbreviated form, a complete list of the bronchi; and they may enable the reader with greater rapidity to review the construction of the bronchial tree. The occurrence of bifurcations Marginal notes.

is indicated in the marginal notes by brackets coupling the names of the two resulting branches.

Special notation, figured and lettered.

3. Lastly, a special notation has been appended to the names of all the tubes, with the exception of the smallest; this consists in each case of a Roman numeral and of one or more letters. The purpose of the notation is, likewise, twofold:

Purpose of the numeral.

By the numeral is meant to be conveyed the degree of relationship existing between the main bronchus and the tube under consideration, in other words the number of bifurcations occurring between the tube and the trachea;

Significance of the letters.

The letters appended to the numerals are, on the other hand, intended to represent the changes in directions successively undergone by the air-channel from the main bronchus onwards. In the notation attached to any bronchus there occur as many letters as there are internodia between it and the main bronchus, and each letter possesses a definite significance according to the code set forth below. A succession of different letters means an equivalent number of internodia of different directions, and a repetition of the same letter implies a persistence in the original direction in spite of one or of many bifurcations. The last letter expresses in every case the direction of the bronchus under consideration.

Use of the notation.

With the help of this notation it is possible to form a rough idea of the probable position in the bronchial cast, and in the lung, of any given tube. In other words the notation is meant to serve the office of a "finder" in connection with specimens of the bronchial tree under actual observation, and in the absence of any specimen, to assist in the production of a mental image of one.

Code of the Lettered Notation.

In the notation	*a*	stands for	anteriorly.
	e	,,	externally.
	i	,,	internally.
	d	,,	downwards.
	s	,,	upwards.
	p	,,	posteriorly.

Key to the Illustrations.—In most of the illustrations letters have not been introduced within the figures for reference. But, wherever the scale of measurement has been included in the illustrations, the separate lines of the scale have been lettered or numbered. Each of the letters or numbers is so placed that it serves, at will, to designate either a line or an interspace. It is therefore possible, by combining a letter and a number, to refer either to the point of intersection of two given lines, or to the square intercepting two given columns. By this means it is easy to refer to any spot in the figure.

THE PULMONARY APEX.

THE RIGHT APEX AND ITS BRONCHIAL SUPPLY.

General Survey of the Bronchial Distribution to the Right Apex.

The right apex is mainly indebted for its aëration to a large bronchial trunk, presently to be described as the *ascending apical bronchus*. Its entire inner and posterior range is occupied by this distribution, branches from which also extend to the sterno-clavicular region in front, and to the outer supra-spinous region behind. If an imaginary vertical plane be drawn through the extreme mesial, and the extreme lateral point respectively reached by these branches, the vertical plane will define the anterior limits of the distribution in question. Everything behind the plane is part of the domain of the ascending apical bronchus; and within the same boundary is included the actual summit of the lung, the apex in the narrowest sense.

Main supply from the ascending apical bronchus.

But the anterior and the antero-lateral surfaces of the dome-shaped apical district are supplied by bronchi belonging to other systems. These *accessory apical bronchi*, enumerated in their order from the sterno-clavicular region outwards, are:

Additional supply to the apex from the ascending sterno-pectoral, the mid-pectoral, and the anterior and posterior axillary bronchi.

(1) The *sterno-clavicular bronchus;*
(2) The *ascending apical parasternal bronchus;*
(Both these are derived from the *ascending sterno-pectoral trunk*);
(3) The mid-pectoral apical bronchus;
(4) The anterior axillary-apical bronchus;
(5) The posterior axillary-apical bronchus.

The last-named bronchus belongs to a plane posterior to the boundary-line above described; but it is concerned with the supply of the inferior part only of the dome-shaped district.

The Sterno-scapular Inter-bronchial Sulcus.—In the metallic cast of the bronchial tree, it may be seen at a glance that the bronchi just enumerated form an anterior zone, which is separated from the ascending apical distribution by a broad space or avenue. To this inter-bronchial space the name *sterno-scapular sulcus* may, for purposes of description, be applied with advantage, inasmuch, as it suggests the anatomical relations of the parts, and the obliquity of the transverse axis of the space. The bronchial inter-

Sterno-scapular sulcus between the ascending apical and the accessory apical bronchi.

Its contents.

space is occupied, in the non-dissected lung, by blood-vessels, by fibrous stroma, and by lymphatics. As a space it exists only in artificial preparations, where the bronchial tree has been isolated by the removal of the spongy tissue, and of the pulmonary vessels. In the diagrams (figs. 6 and 9) the long sterno-scapular sulcus is very plainly shown; it will also be recognized in the drawing (fig. 10), just below the intersection of line C and line iij.

The Right Upper Lobar Bronchus.

Peculiarities of this bronchus.

The peculiarities of this bronchus are—

(1) The high level of its origin;
(2) Its shortness;
(3) Its horizontal direction;
(4) The unusual mode of its terminal division.

Its upper level the same as that of tracheal angle.

(1) **The Level of Origin of the Bronchus.**—In the metallic cast, depicted in fig. 11, the upper surface of the upper lobar bronchus, viewed from behind, occupies exactly the same level as the summit of the infra-tracheal angle; and its lower surface extends to 1·1 cm. below the said level (see fig. 11, line iij).

Its length greater along the upper surface.

(2) **The Length of the Bronchus.**—The distance from the infra-tracheal angle to the inter-bronchial angle between the upper lobar bronchus and the bronchus intermedius is equal to 2·1 cm. On the other hand the linear distance between the infra-tracheal angle, and the termination of the bronchus (which cannot be seen from behind), is 3·3 cm.* From a comparison of these two quantities it is seen that the length of the bronchus, measured along its inferior posterior surface, is 1·2 cm. The upper measurement exceeds this length by an amount difficult to determine with precision, owing to the very regular semicircular curve, by means of which the vertical tracheal border passes into the horizontal border of the bronchus. But the difference may be estimated at a maximum of 5 mm. According to these figures the right main bronchus would possess an undivided length of only 15 mm.

Its axis horizontal.

(3) **The Axis of the Upper Lobar Bronchus** is strictly horizontal, and belongs to the same vertical transverse plane as the tracheal axis; for it will be noted that the bronchus arises from the lateral surface of the main bronchus; namely, from the two posterior thirds only of that surface. But neither the upper nor the lower surface are absolutely parallel to the axis of the tube; they converge towards its termination, and the upper surface

Its upper and lower sides not strictly horizontal.

* These measurements, and all subsequent ones, were made on the metallic cast. They may not always coincide absolutely with the apparent proportions in the drawings.

appears to drop slightly, whilst the lower surface rises by more than an equal amount. Moreover, it is noteworthy that the tube is not circular, but slightly flattened from above downwards. The tracheal border passes into the horizontal upper surface of the upper lobar bronchus so gradually, that it is possible for the inadvertent to mistake this surface for that of the tube continuing the direction of the trachea. Although not a continuation of the trachea, the upper lobar stem is certainly one of the continuations of the main bronchus; for the upper and the lower surfaces of the latter diverge by an equal amount for some distance above the angle formed by its two divisions. This is a repetition of the lateral divergence of the two sides of the trachea above the infra-tracheal angle.

It is flattened from above downwards.

It is one of the continuations of the main bronchus.

The Mode of Division of the Upper Lobar Bronchus,—a Bifurcation.—Thus early, at its central end, does the upper lobar bronchus proclaim the principle of dichotomy. A confirmation of the same principle is afforded, although in a less obvious form, by its distal extremity. The appearances presented by the latter might be pronounced, from a merely superficial inspection, unequivocal: the main tube comes to an end, and three tubes replace it, diverging, respectively, upwards, outwards, and forwards, exactly like the feet of a tripod. This is not, however, a genuine trifurcation—however close the outward resemblance. For it can be demonstrated that the lobar bronchus does not come to an end at once, and that the three tubes do not start from a common level. A front view of the matter will show that the anterior tube, which we may call at once the *pectoral stem*, detaches itself from the lobar bronchus, and projects forward before the other two stems have attained individual existence. In other words the pectoral stem diverges from a remainder of the lobar bronchus. There are but two tubes as yet in contrast—viz., the remainder in question and the pectoral stem: therefore this is clearly a bifurcation.

It gives three branches; yet trifurcation is apparent only.

A first division into pectoral stem and remainder of upper lobar is seen anteriorly.

The posterior view gives in a different manner almost equally complete a proof of bifurcation. The posterior surface of the bronchus passes without any break into the posterior surface of the ascending apical stem, and of the outward or axillary stem (see fig. 11, line H). The continuity of these two tubes with the posterior half of the calibre of the lobar bronchus is as plainly shown here, as the continuity of the anterior half with the pectoral trunk is displayed anteriorly.

Posteriorly, ascending apical stem and axillary stem.

The Apparent Trifurcation really consists of *two bifurcations* following each other very rapidly. Had the process been carried on symmetrically a tetrapod would have resulted. The tripodic appearance is therefore due to a unilateral, or asymmetrical repetition of the bifurcation of the lobar bronchus. The tube divides dichotomously, and one only of its divisions undergoes immediately a second bifurcation. According to this view the first bronchial subdivision in the right lung, instead of disproving the principle of dichotomy, as Aeby contends, affords at once a double instance of its application.

The tripodic appearance due to one-sided repetition of bifurcation, giving double confirmation of the principle of dichotomy.

It was necessary to enter into some detail, both in order to explain a view

Several analogous instances occur.

contrary to the appearances, and because this mode of division repeatedly occurs in the bronchial tree, and invariably bears the construction which I have applied to the *spurious trifurcation* in the upper lobe.

The "remainder" is the axillary-apical stem.

The *remainder* of the lobar bronchus after separation of the pectoral stem derives from its branches the name of *axillary-apical stem*. Its length measured anteriorly does not exceed 3 mm., a quantity so small as to have been readily overlooked.

Some Difficulties Explained.—It is now easy to explain some of the difficulties which may have occurred to the reader whilst perusing the preceding pages:

Difference in curve and length of upper and of lower border.

(1) The upper and the lower border of the lobar bronchus are not parallel, because the upper curve of origin begins higher and nearer the middle line than the lower, and has a different radius.

(2) For the same reason the length of the lobar bronchus is different when measured respectively above and below.

Tapering extremity belonging to the axillary-apical stem.

(3) In the posterior view of the metallic cast, and in fig. 9, the bronchus tapers towards its termination, because more than one-third of its calibre has separated from it in the shape of the pectoral stem, with direction forwards.

(4) That which from behind appears to be the termination of the lobar bronchus (see fig. 11 to left of the intersection of the line H and of the line iij), really belongs to the remainder from the bronchus—viz., to the axillary-apical stem, which represents barely two-thirds of the original calibre.

Spurious appearance of length presented by the posterior surface.

(5) Inasmuch as the upper lobar bronchus originates from the posterior two-thirds only of the lateral surface of the main bronchus, the posterior fold of this bifurcation is free to extend further inwards than the anterior fold, which comes to an abrupt end. Thus at both its extremities the posterior aspect of the lobar bronchus acquires a spurious extension which does not exist in the bore of the tube.

The advantages of this distribution for study.

In conclusion, no better opportunity occurs in the bronchial tree for the study both of the rules and of the exceptions in the system of bifurcation than is afforded by the distribution of the upper lobar bronchus.

The Right Ascending Apical Distribution.

N.B.—This distribution is included in the Synoptical Table I. The drawings (fig. 10 and fig. 11) and the diagram (fig. 9) will assist the reader. He will also find a reference to the dissections useful (see figs. 1 and 3).

Ascending apical stem (iij. es). Axillary stem (iij. ee).

Axillary-apical Bifurcation.—In the bronchial system bifurcation usually means divergence of both products of division from the axis of their parent stem. In the case of the axillary-apical stem this divergence is entirely confined to one of the branches, the ascending apical; but it is considerable, since the upper horizontal border of the stem passes into the almost vertical apical trunk, which also presents a very slight inclination forwards. The axillary, or lower branch of bifurcation, instead of diverging downwards from the line of the original axis, approaches and ultimately crosses this horizontal line, and by a gradual upward curve, diminishes the angle which intervenes between its own direction and that of its twin bronchus. Roughly, the axillary stem may be said to continue the lower curve of the upper lobar bronchus.

The ascending apical diverges, the axillary does not.

The height, or length, of the **Ascending Apical Trunk**, measured from the upper surface of the lobar bronchus, is 8 mm. At this distance the trunk bifurcates into an *anterior* and a *posterior ascending apical* trunk. The anterior trunk combines its rise with a decided forward, and a slight inward, movement, and its distribution takes place inwards and forwards. The posterior trunk inherits the upward and very slightly outward tendency of the common apical stem, and devotes its branches to the service of the posterior and of the central parts of the apex. Each of these distributions will be separately studied.

Anterior ascending apical (iv. esa). Posterior ascending apical (iv. ess).

Distribution of Right Anterior Ascending Apical Trunk.

The Anterior Ascending Apical Trunk rises upwards and forwards (faintly inwards also) for a distance of 7 mm. Its divisions, the *inner* or *tracheal apical trunk* and the *anterior ascending apical trunk* are situated side by side. **The Tracheal** division inclines inwards and upwards, and is distributed to the anterior part of the inner surface of the apex. Twice as long as this stem the **Anterior Ascending Apical** rises undivided for a distance of 1·8 cm. with slight forward curvature. At the upper level of the clavicle it divides into a posterior trunk, the *anterior inner apical bronchus*, which, continuing the same curvature, inclines backwards and slightly inwards in its ascent, and into the *superficial anterior apical bronchus* which rises straight forwards.

Tracheal trunk (v. esai). Anterior ascending apical (v. esas).

Anterior inner apical trunk (vj. esass). Superficial anterior apical trunk (vj. esasa).

Superficial Anterior Apical Bronchus.—Numerous branchlets are given in various directions from this bronchus, which terminates by two lateral bronchioles at the anterior surface of the apex just above the clavicle.

The Anterior Inner Apical Bronchus ascends for the distance of 1 cm. and divides into the **Anterior Central Apical**, a continuation of the previous direction with slight outward bend; and into the **Inner Superior Apical.** This bronchus takes a bold ascending curve, concave towards the left, and ends as **Superior Inner Marginal** by means of a horizontal bifurcation situated above the branches from the tracheal distribution. The bifurcation which gives rise to the superior inner marginal also yields the **Ascending Inner Apical Bronchus**, the innermost peripheral branch among those ascending to the summit. This bronchus terminates in

Anterior central apical (vij. esasss). Inner superior apical (vij. esassi).

Inner ascending apical (viij. esassis). Superior inner marginal (viij. esassii).

two final, anterior and posterior, branches, which face upwards, whereas the final bifurcation of the superior inner marginal faces inwards. In fig. 11 the termination of the superior inner marginal coincides with line j, the pitch-fork appearance presented by the anterior and middle tracheal, to be presently described, occupies the middle of the square G ij, and the ⊤-shaped tracheal recurrent is seen just external to the divided azygos vein.

Tracheal apical trunk (v. esai).

The Tracheal Apical Trunk is concerned with the supply of the anterior half of the inner surface of the upper lobe excluding the upper extremity of this surface which is served by the inner superior apical. The trunk has a length of 1 cm. and a direction upwards and slightly inwards. Its two branches, the *anterior* and the *middle tracheal*, preserve this direction at first, but ultimately bend slightly inwards and terminate on either side, but a short distance below the level, of the *superior inner marginal*. The much larger curve formed by the latter bronchus and by its parent trunk, a curve which closely resembles that of the davits of a ship, overshadows the distribution of the tracheal stem.

Anterior tracheal (vj. esaia). Middle tracheal (vj. esais).

The Anterior and the Middle Tracheal are so symmetrically arranged that to describe one is almost to describe the other. Together they exactly resemble the curved prongs of a pitch-fork held upwards, with its concavity towards the trachea. Their chief bifurcation takes place early, within 3 mm. of their origin; in the resulting inward branch some want of uniformity may be noted.

Anterior tracheal (vij. esaias). Sterno-tracheal (vij. esaiai).

The inward or **Sterno-tracheal Bronchus** derived from the anterior tracheal, has a forward as well as an inward direction and breaks up into small sub-lobular tubes, at the posterior surface of the upper sternal fringe, exactly behind the branching of the *sterno-clavicular* branch from the *sterno-pectoral*. The sterno-tracheal bronchus is in its course almost horizontal, but it presents a slight declivity.

Middle tracheal (vij. esaiss). Tracheal recurrent (vij. esaisi).

The Middle Tracheal Bronchus.—The inward branch from the *middle tracheal* is of interest as being a good instance of a ⊤-shaped recurrent bronchus. This short bronchus, **the Tracheal Recurrent**, measuring 3 mm. in length, has a direction inwards and slightly downwards. Its two branches, directed respectively upwards and downwards, form with it two right angles, like the branches of a T. They are in the same relation to it as the legs of an acrobat to his body, during the performance commonly termed "the splits." I may here call attention to an interesting fact in connection with the direction of their air-currents. During inspiration the air would follow, in the descending branch, a direction parallel to that followed by it in the neighbouring trachea. But, in the small bronchus, the air would have previously completed a circular journey through a succession of bronchial tubes.

T-shape of this bifurcation.

Direction of the air within the tracheal recurrent.

The ⊤-shaped disposition of the branches is explained in connection with the neighbourhood (*cf.* p. 62) of the free surface of the lung and beyond it of the vena azygos and of the trachea.

Both divisions of the recurrent bronchus are freely provided with *branchlets* which are supplied to the intra-pulmonary tissue in every direction, and with sub-pleural branchlets for the aëration of superficial lobules. Deep and sub-pleural branchlets.

Distribution of the Right Posterior Ascending Apical Bronchus.

Posterior Ascending Apical Bronchus.—(See fig. 10, external to line C; and fig. 11, in square H ij.) This stem rises vertically, with very slight inclination outwards, in continuation of the ascending apical stem, for a distance of 1·2 cm.; and it divides into the *axial apical trunk* and the *posterior apical*, the latter being slightly internal as well as posterior in its direction. Posterior ascending apical (iv. ess). Posterior apical (v. essp). Axial apical (v. esss).

The Axial Apical Bronchus needs no description, as regards direction, since this trunk is the unbroken prolongation upwards of the main apical stem. Its first bifurcation takes place at the level of the origin of the inward tracheal branches and of the T-shaped posterior branch from the mid-pectoral apical. From this bifurcation arises outwards the **Axial Apical Interlobar Bronchus**, a T-shaped tube with flattened distribution, which faces (across the sterno-scapular inter-bronchial sulcus) the axillary apical trunk. In fig. 11 the small T-shaped bifurcation is seen (in right lower corner of square H ij) lying almost vertically across a shaded tube. Axial apical (vj. essss). Axial apical interlobar (vj. essse).

An *anterior ascending deep-pulmonary branch* arises from the continuation of the trunk and breaks the long interval (2·1 cm.) between the last-named bifurcation and the ensuing one. Deep-pulmonary from the axial apical.

The branch given up from the continuation of the stem, the **Outer Central Apical** has a direction upwards and outwards, and after supplying an *outer deep-pulmonary branch*, ends at the apex by means of an anterior and of a posterior termination. Outer central apical (vij. essssse). Axial apical (vij. esssss). Outer deep-pulmonary.

The *continuation of the axial apical* swerves very slightly inwards, beyond this bifurcation, and presents an *inner deep-pulmonary*, symmetrical with that derived from the outer central bronchus.

The last bifurcation takes place high up into the **Axial Terminal Bronchus** and the **Posterior Central Apical**, a slightly curved branch which lies behind the anterior central apical but has an opposite direction and curvature. Both bronchi end by means of the customary sub-pleural forkings. Axial terminal (viij. essssss). Posterior central apical (viij. esssssi).

The Posterior Apical Bronchus (fig. 11, left upper corner of square H iij) rises upwards and slightly backwards for a distance of 1 cm. Its inner and its outer branch respectively supply the posterior-inner surface and the posterior surface of the apex. To the first of these the designation *posterior tracheal* rightly belongs since this bronchus is contained in the transverse body-plane which also contains the trachea, and therefore directly faces the trachea. The other, larger, branch with strong outward slope is Posterior apical (v. essp). Posterior tracheal (vj. esspi). Apical supra-spinate (vj. esspe).

TABLE I.

RIGHT U[...]

Bronchial supply to RIGHT APEX.

- Axillary-apical trunk (ij. e).
  - Right ascending apical stem (iij. es).
    - Anterior ascending apical (iv. esa).
      - Tracheal apical (v. esai).
        - Anterior tracheal (vj. esaia).
          - Anterior tracheal (vij. esaias).
          - Sterno-tracheal (vij. esaiai).
        - Middle tracheal (vj. esais).
          - Middle tracheal (vij. esaiss).
          - Tracheal recurrent (vij. esaisi).
      - Anterior ascending apical (v. esas).
        - Anterior inner apical (vj. esass).
          - Anterior central apical (vij. esasss).
          - Inner superior apical (vij. esassi).
            - Inner ascending apical (viij. esassis).
            - Inner superior marginal (viij. esassii).
        - Superficial anterior apical (vj. esasa).
    - Posterior ascending apical (iv. ess).
      - Posterior apical (v. essp).
        - Posterior tracheal (vj. esspi).
          - Posterior tracheal recurrent (vij. esspii).
          - Posterior tracheal (vij. esspis).
        - Apical supra-spinate (vj. esspe).
          - T-shaped dorsal supra-spinate (vij. esspep).
          - Apical supra-spinate (vij. esspep).
      - Axial apical (v. esss).
        - Inter-lobar (vj. essse).
        - Axial apical (vj. essss).
          - Outer central apical (vij. esssse).
            - Intra-pulmonary branch.
            - Terminal branch.
          - Axial apical (vij. esssss)
            - Posterior central apical (viij. essssi).
            - A[...] te[...] (viij. s[...]

N.B.—In addition to the above, the Right Apex receives the following bronchi from the **Pectoral Distribution :—External Anterior** [...]

Bronchial supply to LEFT APEX.

LEFT U[...]
(BRON[...]

- Left cardiac bronchus (ij. d). (See Table III.)
- Ax[...]
  - Left ascending apical stem (iv. ass).
    - Anterior ascending apical (v. assa).
      - Apical sterno-clavicular (vj. assai).
        - Anterior clavicular (vij. assaia).
        - Apical sterno-clavicular (vij. assaii).
          - Inward T-shaped bronchus (viij. assaiii).
          - Forward T-shaped bronchus (viij. assaiia).
      - Inner anterior apical (vj. assaa).
        - Anterior clavicular (vij. assaaa).
        - Inner anterior apical (vij. assaas).
          - Outer terminal (viij. assaase).
          - Inner terminal (viij. assaasi).
    - Posterior ascending apical (v. asss).
      - Aortic apical (vj. asssi).
        - Aortic apical recurrent (vij. asssii).
          - Descending branch.
          - Anterior branch.
        - Ascending aortic apical (vij. asssis).
          - Anterior ascending aortic (viij. asssisa).
          - Posterior ascending aortic (viij. asssisp).
      - Vertical apical (vj. assss).
        - Intra-apical (vij. assssp).
        - Vertical apical (vij. asssss).
          - Anterior vertical apical (viij. asssssa).
            - Anterior vertical (ix. assssssas).
            - Vertical marginal (ix. assssssai).
              - Inner vertical marginal (x. assssssaia).
              - Anterior vertical marginal (x. assssssaii).
          - Posterior vertical apical (viij. asssssp).

N.B.—The meaning of the letters used as notation is explained on page 88.

AR BRONCHUS.

Pectoral trunk (ij. a). (See Table II.)

Right axillary stem (iij. ee).

Central axillary interlobar (iv. eed).

Axillary stem (iv. eee).

Retro-axillary (v. eeep).

Axillary (v. eeee).

Retro-axillary interlobar (vj. eeepd).

Retro-axillary (vj. eeeps).

External interlobar (vj. eeeed).

Axillary (vj. eeeee).

Supra-spinate (vij. eeepsp).

Posterior axillary apical (vij. eeepse).

Superior axillary (vij. eeeees).

Anterior axillary apical (vij. eeeeep).

Ascending supra-spinate (viij. eeepsps).

Retro-axillary supra-spinate (viij. eeepspp).

Descending posterior axillary (viij. eeepsed).

Posterior axillary apical (viij. eeepses).

Superior terminal (viij. eeeeess).

Inferior terminal (viij. eeeeesd).

Superior terminal (viij. eeeeeps).

Inferior terminal (viij. eeeeepd).

d C[…]vicular Branches (from the Mid-pectoral); Sterno-clavicular and Apical Parasternal (from the Ascending Parasternal).

O[…]R BRONCHUS

[…]M[…]R).

Left pectori-apical bronchus (ij. a).

ICA[…]EM

).

Pectoral trunk (iij. aa). (See Table II.)

Left (rudimentary) axillary stem (iv. ase).

Posterior axillary stem (v. ases).

Axillary stem (v. asee).

Posterior apical (vj. asess).

Mid-apical (vj. asese).

Axillary posterior interlobar (vj. aseep).

Axillary stem (vj. aseee).

Inner posterior apical (vij. asesss).

Outer posterior apical (vij. asesse).

Inner mid-apical (vij. asesei).

Outer mid-apical (vij. asesee).

Outer ascending apical (vij. aseees).

Superior axillary (vij. aseeee).

T-shaped deep pulmonary (viij. aseseia).

Inner mid-apical (viij. asesels).

Outer mid-apical (viij. aseseea).

Outer posterior apical (viij. asesееp).

T-shaped posterior interlobar (viij. aseeeep).

Superior axillary (viij. aseeeee).

T-shaped posterior marginal (viij. asessep).

Outer posterior apical (viij. asesses).

Outer central (ix. aseseise).

Inner mid-apical (ix. aseseiss).

Inferior outer mid-apical (ix. aseseeae).

Superior outer mid-apical (ix. aseseeas).

Outer posterior apical (ix. aseseepe).

Posterior outer central (ix. aseseeps).

Descending superior axillary (ix. aseeeeed).

Ascending superior axillary (ix. aseeeees).

Horizontal outer posterior apical (ix. asessese).

Ascending outer posterior apical (ix. asessess).

Central ascending (x. aseseisss).

Inner mid-apical (x. aseseissi).

Posterior terminal.

Outer terminal.

Horizontal superior axillary (x. aseeeeese).

Axillary apical bronchus (x. aseeeeess).

Posterior inner terminal.

Anterior inner terminal.

Outer ascending apical (viij. aseeess).

Anterior axillary branch (viij. aseeese).

OST[…]R CAL[…]TIC ECU[…]NT (ij. a[…]si).

Inner posterior apical (viij. asessss).

Clavicular and other branches.

Inner [t]erminal ([…] asessssi).

Outer terminal (ix. asessse).

the *apical supra-spinate.* Both branches are readily seen in fig. 11, square H ij.

Posterior tracheal (vj. esspi). **The Posterior Tracheal Bronchus** closely resembles in shape and general direction the anterior tracheal bronchi and gives up early an inward, slightly descending, horizontal branch ending with T-shaped bifurcation, the **Posterior Tracheal Recurrent.** The branches of this bronchus (ascending and descending) run in a line with the posterior-inner border of the apex. The small trunk continued yields a *deep-pulmonary,*—and various small branches. After a full curve with concavity inwards, it terminates at the same level as the anterior tracheal bronchi, at the inner apical surface.

Posterior tracheal (vij. esspis). Posterior tracheal recurrent (vij. esspii).

Apical supra-spinate (vj. esspe). **The Apical Supra-spinate,** diverging from its twin-tube, curves in the opposite direction, with concavity outwards and downwards; the sweep of this curve is a much longer one, this bronchus sending a branch to the extreme outer-posterior surface at the level of the acromion.

Apical supra-spinate (vij. esspes). T-shaped dorsal supra-spinate (vij. esspep). The branches of this trunk imitate the two bifurcations of the preceding one. But the T-*shaped* **Dorsal Supra-spinate Bronchus** (seen in foreshortening in fig. 11 at lower part of square H ij) is directed straight backwards, and the deep-pulmonary, instead of being anterior, is lateral. The trunk itself terminates in an anterior and a posterior outer supra-spinate branch of small size; and these, by their sub-pleural divisions, supply the district above mentioned.

The accessory apex bronchi will be described under the respective headings of the pectoral, and of the axillary distributions.

THE LEFT APEX AND ITS BRONCHIAL SUPPLY.

The Left Upper Lobar Bronchus (Bronchus Impar) and the Pectori-apical Stem.

A short preliminary description of the behaviour of the *upper lobar stem* is indispensable for the due appreciation of the relations of the apical bronchi.

Left upper lobar bronchus. **The Left Upper Lobar Bronchus** arises at a level 3 cm. below the level of the right upper lobar. Its horizontal distance or "longitude" from the infra-tracheal angle is 4·3 cm. It takes its origin from the upper anterior (and, slightly perhaps, outer) aspect of the main bronchus, which, bending downwards at that spot, alters the slight upper concavity of its transverse portion into the inner or cardiac concavity of its intra-pulmonary segment.

Site and mode of origin.

Direction forwards and outwards. Length 1·3 cm. **Direction, Calibre, and Length.**—A direction forwards and outwards is assumed by the upper lobar trunk. Its length is only 1·3 cm., but it possesses a calibre of considerable size. Although not as large as that of the inferior lobar bronchus, its diameter is apparently equal to that of the right upper lobar bronchus.* But it should be borne in mind that the left upper lobar bronchus is not the perfect equivalent of the right upper lobar. Inasmuch as it supplies the cardiac besides the apical and pectoral districts, it must be supposed to contain the elements of a cardiac, as well as those of an apex-bronchus.

Calibre equal to that of right upper lobar.

Reasons for using the Name "Bronchus Impar."—By following the two branches it is easy to verify the correctness of this assumption. One of these, the descending branch, is distributed in a manner and in a situation analogous to those of the right cardiac bronchus. The other branch rises, with a direction which will be presently described; but it soon gives off, by bifurcation, a large anterior bronchus, which is devoted to the supply of the pectoral region, and which is at once recognized as the fellow to the right pectoral bronchus. The other product of this division, after a straight upward course, supplies three branches to the apex; this tube is obviously the equivalent of the right axillary-apical. It is equally manifest that the trunk from which both the pectoral and the axillary-apical arise is no other than the fellow to the right pectori-apical trunk.

A descending branch, the cardiac bronchus; an ascending branch, soon bifurcating into a pectoral and an axillary-apical,—the pectori-apical trunk.

It is now clear that, whereas the right pectori-apical trunk is the upper lobar bronchus for the right lung, the same trunk in the left lung is only a branch of the upper lobar bronchus, and a twin-tube to the cardiac bronchus.

The right pectori-apical is the lobar bronchus; not so in the left lung.

The left upper lobe therefore contains an *additional*, and, judged by the standard of the right bronchial tree, an *irregular tube*. Beyond this tube the left upper lobe presents an equality with the right as regards the number of internodia and of bifurcations. But the tube under discussion is essentially different from the right upper lobar bronchus in its behaviour and in its branches; and, since it is impossible to deprive it of the name "upper lobar," it is at least necessary to add to this name another which shall express the essential dissimilarity between it and the right upper lobar bronchus. Hence the term "bronchus impar" which I propose for it.

The left upper lobar not comparable with the right; best designated as "bronchus impar."

The Pectori-apical Stem.—On the other hand, although the left lung contains a stem exactly the counterpart of the right upper lobar bronchus, it is impossible to give to this stem the name "left upper lobar." It must be known merely as the pectori-apical stem. This difficulty has led me to use an alternative name for the right upper lobar bronchus also. I term it the right pectori-apical; and by this means I am able to secure a correspondence in the names which shall express the correspondence which exists between the tubes.

The left pectori-apical, analogous to the right upperlobar, cannot be termed left upperlobar. But the right upper lobar may be termed pectori-apical.

Differences between the Left and the Right Pectori-apical Bronchi.—There is however a great disproportion between these two bronchi in their size, in their direction, in their level of origin, and in their distance

Different size, origin, direction,

* *Cf.* p. 21.

and position of the two pectori-apical bronchi.

from the infra-tracheal angle. The left pectori-apical is a short trunk measuring only 8 mm. It does not continue the direction of the bronchus impar forwards and outwards, but abruptly rises, almost in a vertical line, and with a slight inclination forwards and outwards.

Elongation of left apical internodia rendered necessary by low origin of pectori-apical.

Thereby it serves the purpose of diminishing the vertical distance which exists between the level of origin of the left axillary-apical trunk and that of the right. Nevertheless a vertical distance of 2 cm. persists between these two points of origin; and inasmuch as the upper level reached by the right apical distribution is practically identical with that reached by the left, the difference must be made up by a lengthening of the ascending branches of the left distribution.

Pectoral trunk (iij. aa). Axillary-apical trunk iij. as).

Branches of the Left Pectori-apical.—Two large trunks arise from the bifurcation of the pectori-apical trunk: the *pectoral stem*, which proceeds straight forwards and a little upwards; and the *axillary apical stem* which is almost vertical, preserving the slight forward inclination, but losing the faint outward tendency special to the pectori-apical. The pectoral distribution will be separately considered; but the apical and the axillary distributions cannot readily be treated independently of each other, owing to their common origin from one trunk, but chiefly because they take almost even shares in the bronchial supply to the apex.

General Survey of the Bronchial Distribution to the Left Apex.

The left apical bronchus has a smaller distribution than the right.

Area of Distribution of the Apical Bronchus.—The apical division of the left axillary-apical trunk plays a much less important part in the bronchial supply of the apex than that which belongs to the right apical. The latter was shown to occupy the whole inner aspect, and also the whole upper-posterior aspect of the apex. In the left lung the apical bronchus is restricted to the inner-anterior corner of the apex. Its branches supply the inner-anterior border and a section of the adjoining inner, and of the adjoining anterior surfaces, not quite amounting to half of each of these surfaces. Of the cubic space of the apex this distribution may be said to occupy the anterior-inner third. The general shape of the distribution is that of a pyramid presenting an anterior, an inner, and a posterior-external side, a base facing downwards towards the infra-apical bronchial interspace, and a summit pointing upwards towards the inner-anterior angle of the apex.

Extent and shape of the distribution.

Distribution of the posterior axillary,

Areas of Distribution of the Anterior and Posterior Axillary Bronchi.—Both divisions of the axillary stem, but especially the posterior, possess, in the left lung, a predominating upward tendency. To the *posterior axillary division* belongs the bronchial supply of the following surfaces of the upper apex, viz., the posterior part of the inner surface, the whole posterior surface and outer surface, and the outer part of the anterior surface.

The *anterior axillary division* is distributed to the lower, or basic zone of the apex, in the outer-anterior and in the superior-axillary regions.

and of the anterior axillary.

Accessory Apical Supply.—Only one branch from the pectoral distribution the *ascending mid-pectoral* comes into relation with the apex, rising anteriorly as far as its lower or basic boundary at about the level of the inferior border of the clavicle. But it does not take any part in the air-supply about to be described.

The ascg. pectoral approaches the base of the apex.

Peculiarities of the Left Axillary-apical Trunk.—Strongly contrasting with the *rudimentary* right axillary-apical trunk, the corresponding stem on the left side has a length of 1 cm. Moreover, instead of being horizontal outwards, it is almost vertical upwards and slightly forwards. This circumstance enables not only the apical trunk, but also the axillary to arise from a level relatively less inferior than would otherwise have obtained. The manner in which these two trunks originate is in one sense analogous to the arrangement at the right apex; it is a *spurious trifurcation*. That Professor Aeby should select this as an instance of bifurcation in contrast to the trifurcation which he describes (*loc. cit.*, p. 62) at the right apex is the more astonishing as, in the specimens which have been examined by me, the left division was so evenly tripartite that it was difficult to determine which two, among the three apparently simultaneous tubes, were linked together by an abortive common trunk. Probably Professor Aeby's specimens presented a different arrangement of tubes. Nevertheless this is essentially a bifurcation repeated unilaterally, of the same type as that elsewhere described (see p. 91); and we are enabled to analyse and interpret correctly its deceptive appearances thanks to our knowledge of the faithful analogy existing between the upper right and the upper left lobes, which Professor Aeby had thought to have disproved.

Vertical direction and considerable length of the axillary-apical.

Spurious trifurcation.

Prof. Aeby describes a bifurcation here, but a trifurcation at the right apex.

The left tripod, the most difficult to analyse,

Studied in the light of that analogy the left ascending apical trunk is seen most clearly to be a complete though a diminutive reproduction of the right ascending apical; and it follows that the two other members of the apparent trifurcation are respectively reproductions of the two axillary divisions in the right lung.

consists of the left ascg.apical, and of the antr. and posterior axillary bronchi.

A confirmation of these views is readily obtained by a close inspection of the mode of division of the axillary-apical trunk. The ascending apical is not the direct continuation of this trunk. It tends to form an angle with the latter by diverging slightly forwards and inwards. Had the axillary-apical trunk been horizontal, as in the right lung, the size and the morphological value of this angle would have become more obvious; it would have directly pointed to the morphological identity between the right and the left apical bronchi.

The ascending apical tends to form an angle with the axillary-apical trunk as in the right lung.

Viewed anteriorly, the three trunks in question are placed side by side, and the two angles which separate them have their apices at the same level. Posteriorly, however, this is not the case. The two axillary divisions arise from a short common trunk of origin, directly continuous with the parent

The trifurcation most deceiving anteriorly.

Posteriorly the bifurcation is recognized. A rudimentary axillary stem is visible.

stem, and are decidedly posterior to the ascending apical, which the said trunk partly hides from view. The separate existence of this rudimentary stem is capable of demonstration in the metallic cast (see fig. 11, square C iv), owing to the fact that the furrow dividing its two branches terminates fully 2 mm. higher than the furrow dividing it from the ascending apical trunk.

The differences explained by the assumption of a horizontal pectori-apical stem having become vertical. The ascending apical would be dwarfed by this rotation; the axillary bronchi would acquire greater size.

In conclusion the differences noticed between the bronchial tree of the two apices are readily to be explained if we imagine that a lobar bronchus bearing the same branches as the right upper lobar bronchus had been lifted bodily from the horizontal into the vertical position. Certain re-arrangements of direction, of size, of length, and of branching of bronchi would be necessary in order to fit within the pleural space a bronchial district thus rotated; but no important member of the bronchial system need in the process have been altered past recognition. The greatest sufferer in a process of this kind would obviously have been the ascending apical trunk, for in the right lung, with horizontal axillary-apical stem, this was the only large ascending trunk. In a similar way the axillary divisions would have gained largely in importance as members of the apex-supply; and they would, of necessity, have usurped part of the posterior and outer territory otherwise monopolized by the ascending apical. These are precisely the conditions observed at the left apex.

Subdivision to be adopted.—In view of the importance thus attained by the two axillary divisions, the description of the apex-supply will be subdivided into three sections respectively devoted to the ascending apical, to the anterior axillary and to the posterior axillary bronchi.

Distribution of the Left Ascending Apical Bronchus.

Anterior ascending apical (v. assa). Posterior ascending apical (v. asss).

The Ascending Apical Bronchus rises forwards and inwards, for a distance of 1·2 cm., as far as its bifurcation into the *anterior* and the *posterior ascending apical*. The posterior trunk assumes an almost vertical direction. The anterior, on the contrary, improves upon the forward tendency of the common trunk; but its two branches subsequently revert to a more upward direction. The anterior trunk and its two branches are seen in fig. 10 (in square F iv close to line F).

Anterior Ascending Apical Distribution.

Apical sterno-clavicular (vj. assai). Inner anterior apical (vj. assaa).

The Anterior Ascending Apical, a short stem, 8 mm. in length, closely corresponds to the same trunk in the right apex; but instead of facing inwards, its two branches are distributed forwards, to the anterior surface of the apex. They are respectively named *apical sterno-clavicular* and *inner anterior apical*. They are both very wavy in outline, or even angular, especially the sterno-clavicular. (See fig. 10, squares F iv and E iv.)

A descending intra-pulmonary branch, of small size, is supplied by both, or by the anterior branch from each of them.

Apical sterno-clavicular (vij assaii). Ant. small clavicular (vij. assaia).

The Apical Sterno-clavicular contributes its descending deep pulmonary branch before bifurcating. Both its branches of bifurcation are mainly horizontal. The outer, a **Superficial Clavicular Branch,** is of small importance.

Inward T-shaped branch (viij. assaiii). Anterior T-shaped branch (viij. assaiia).

The Apical Sterno-clavicular Branch, bending inwards at a right angle, divides into two large T-shaped bronchi respectively directed towards the anterior surface and towards the internal surface of the apex.

The Anterior Inner Apical follows a serpentine course upwards, where its termination does not reach the highest level. (See fig. 10, squares F iv and F iij.)

Anterior inner apical (vij.assaas). Anterior clavicular branch (vij. assaaa).

Its Anterior Clavicular Branch is given at the same level as that from the sterno-clavicular (see fig. 10, square F iv), horizontally forwards. It is more important than the inner clavicular, and comes into contact below with the extremity of the ascending mid-pectoral trunk (the latter tube has been interrupted in fig. 10, near the right upper corner of square F v). The descending deep intra-pulmonary is given off from this branch.

Outer terminal (viij. assaase). Inner terminal (viij. assaasi).

The continuation of the trunk supplies deep intra-pulmonary branchlets, and one larger ascending, posterior, intra-pulmonary and finally divides into an inner larger and taller, and a smaller outer terminal branch for the supply of the anterior apical surface, just below the higher distribution of the vertical apical and of the central apical bronchi. These two terminal tubes are seen in fig. 10, square F iij, the inner branch ending on line ij, the outer branch in the middle of the square.

Posterior Ascending Apical Distribution.

Posterior ascending apical (v. asss).

The Posterior Ascending Apical supplies the anterior part of the inner surface of the lower apex, and the inner fourth or third of the true summit of the lung. Part of this distribution is shown, in fig. 10, occupying a posterior plane, at the boundary between squares E iij, E iv, and F iij, F iv. Its direction is almost vertically upwards, and its length about 8 mm. It differs from the right trunk bearing the same name, in not being in any sense dorsal, and in dividing, not into an anterior and a posterior, but into inner and outer branches, which may be described as aortic apical and as vertical apical bronchi, respectively.

Aortic apical (vj. asssi). Vertical apical (vj. assss).

Rising intra-apical branch (vij. assssp). Vertical apical (vij. asssss).

The Vertical Apical resembles closely the axial apical of the right apex, but lies nearer the internal surface. It is a long thin branch supplying upward branches at acute angles. Its first bifurcation yields posteriorly a *rising intra-apical branch*. Its second bifurcation supplies to the mesial surface of the apex two trunks known as *posterior* and as *anterior vertical apical bronchi*, which diverge but slightly at first. The vertical apical and its two branches are shown in fig. 10, chiefly in square F iij, close, and almost parallel, to line F.

Antr. (viij. asssssa), and postr. vertical apical (viij. assssssp).

The Posterior Vertical Apical, after an upright course, during which small inward branches are given to the sub-pleural surface, arches backwards and inwards towards the corresponding upper corner of the apex, which it does not quite reach.

Antr. vertical (ix. assssssas). Antr. marginal (ix. assssssai).

The Anterior Vertical Apical divides, after a course of 1·3 cm., into an *anterior vertical* and a *vertical marginal bronchus*. The vertical apical bronchus terminates upwards in a line with the ascending apical stem. The *vertical marginal* bending inwards horizontally gives rise to two **T**-shaped branches distributed to the inner and to the anterior surfaces in the same manner as, but at a much higher level than, the branches from the sterno-clavicular. (See fig. 10, squares E ij and Eiij.)

Anterior vertical marginal (x. assssssaia). Inner vertical marginal (x. assssssaii).

Aortic apical trunk (vj. asssi).

The Aortic Apical Trunk (for this distribution see fig. 10, squares E iij and E iv) in its supply to the lower part of the inner surface of the apex is overtopped by the taller arching branches from the ascending apical and from the ascending axillary. It may be regarded as the displaced and diminished equivalent of the right supra-spinate. Its length is 4 mm. It bifurcates into an *ascending portion* and into an inward **Aortic Apical Recurrent Bronchus.** The latter presents a strongly hooked descending branch and a small anterior branch, both freely provided with branchlets (seen in fig. 10, square E iv in a posterior plane).

Ascg. aortic apical (vij. asssis). Aortic apical recurrent (vij. asssii).

Antr. superficial ascg. aortic (viij. asssisa). Postr. supl. ascg. aortic (viij. asssisp).

The Ascending Aortic Apical divides into an anterior and a posterior superficial bronchus, which diverge upwards in the shape of a letter **V**, and are also well furnished with sub-lobular branches. (See fig. 10, square E iij.)

LEFT AXILLARY DISTRIBUTION.

Rudimentary axillary stem (iv. ase).

The Rudimentary Axillary Stem (see fig. 10, square F v; and fig. 11, square C iv) is the continuation of the axillary-apical stem. Viewed from the front, it presents no appreciable length, but immediately bifurcates. Of its two divisions one only, the posterior axillary, preserves the original direction upwards, outwards, and very slightly forwards. The other, or axillary division assumes greater obliquity outwards, forming with the horizontal an angle of 45°. Owing to these directions the former becomes essentially an apex-bronchus, the latter remains to a great extent axillary. The whole of this distribution may with advantage be studied from the posterior aspect of the cast, in fig. 11.

Posterior axillary stem (v. ases). Axillary stem (v. asee).

Distribution of the Posterior Axillary Trunk.

Posterior axillary trunk (v. ases).

The course followed by this bronchus takes it past the central point of the apex, a little behind that point. At the level of the centre it breaks up into four branches (an anterior and a posterior inner, and an anterior and a posterior outer) for the aëration of the central and of the posterior parts of the apex. These arch in bold curves respectively outwards and inwards, and thus assume a distant resemblance to the lateral leaves of a palm-tree. (See fig. 10, square F ij; the distribution is best shown however in the posterior view, fig. 11.)

The Posterior Axillary, in its undivided portion, has a length of 1·3 cm. In the apparent trifurcation of the axillary-apical stem (seen in square F v of fig. 10), it lies slightly behind the two other trunks which, viewed from the front, appear to arise at the same horizontal level with it. Its first bifurcation supplies the strictly vertical *posterior apical*, a trunk 8 mm. in length; and the *mid-apical*, 1·2 cm. long, which continues the original direction with slightly increased outward bias.

Posterior apical (vj. asess). Mid-apical (vj. asese).

The Posterior Apical, overlapped in fig. 10 by the mid-apical and its bifurcation in the lower and outer corner of F iij, divides into an inner, and into an outer posterior apical trunk.

Inner postr. apical (vij. asesss). Outer postr. apical (vij. asesse).

The Inner Posterior Apical continues the vertical direction as far as its final bifurcation, 2·7 cm. above its origin, into an inward arching and an outward arching branch. Its most important branch is given early, straight inwards, facing at a distance the trachea, and crossing horizontally, at a high level, the direction of the left pulmonary arch. The distribution in question has the usual flattened **T** shape; the bronchus may be designated as the

Inner postr. apical (viij. asessss).

Posterior Apical Aortic Recurrent, in association with the aortic apical recurrent described above. It is well shown in column C of fig. 11, coinciding with line ij. Two ascending deep intra-pulmonary branches arise also from the trunk; of these the posterior is the more important.

Posterior apical aortic recurrent (viij. asesssi).

Of the two terminal arching branches, the inner bifurcates into an *anterior* and a *posterior* division, which respectively supply the posterior part of the inner superior margin, and the inner posterior angle of the apex (fig. 11, column C, line j).

Inner terminal (ix. asessssi). Outer terminal (ix. asessse).

The outer branch arches outwards (column B, line j) to the inner posterior half of the summit.

The Outer Posterior Apical has a posterior as well as an outward ascending tendency. It remains posterior to the outer branch of the mid-apical stem; and not reaching as high as the summit, it is overtopped by branches from that bronchus. At the same level as its twin-tube it yields a **T**-*shaped posterior marginal bronchus*, of which the descending branch assists in forming the posterior edge of the inferior lobe (fig. 11, line C).

Outer postr. apical (viij. asesses). T-shaped postr. marginal (viij. asessep).

After a further course of 1 cm. the trunk divides into an *ascending outer posterior apical* and a *horizontal outer posterior apical*, which are distributed to corresponding regions.

Ascg. outer posterior apical (ix. asessess). Horizontal outer postr. apical (ix. asessese).

The Mid-apical Stem is of much more important size than its fellow. Its two arching branches, the *inner mid-apical* and the *outer mid-apical* (ending in columns B and C of fig. 11 above line j), span the entire

Mid-apical trunk (vj. asese).

Inner mid-apical (vij. asesei). Outer mid-apical (vij. asesee).

width, and terminate respectively at the inner and at the outer surface of the apex. The inner surface however is only touched by a far-reaching branch, whereas the central apex, and the outer surface in its upper part, are entirely supplied from this source. Viewed from above, this district would take the shape of a pyramid inscribed in the curve of the pulmonary summit, and presenting its apex inwards, and its base outwards. In front of the apex of this pyramid would lie the apical district of the ascending apical bronchus; and behind it, the smaller inner-posterior apical district would complete the roughly quadrilateral outline of the total apex-district.

Inner mid-apical (vij. asesei).

The Inner Mid-apical is the longer, the more vertical at first, and subsequently the more curved of the two branches. Whilst ascending, as does its parent trunk, almost vertically, it reverses the outward tendency of the latter into an inward tendency with concavity inwards. As the summit is neared, this tendency develops into a strong curve inwards and upwards. (See fig. 11, square B ij.)

T-shaped deep pulmonary (viij. aseseia). Inner mid-apical (viij. aseseis).

The branches all take their origin upwards, from the outer or convex side of the bronchus, with one exception, that of the **T-shaped Deep Pulmonary** (see fig. 10, between squares F iij and G iij), a small branch arising forward from the early part of the trunk and facing the transverse apical bronchial interspace.

Outer central (ix. aseseise). Inner mid-apical (ix. aseseiss).

The next bifurcation provides an ascending **Outer Central Bronchus,** ending, in fig. 11, at the intersection of lines B and j; and the ensuing bifurcation an upright **Central Bronchus** which delivers a small **Anterior Mid-apical Bronchus** forwards to supply the upper surface not reached by the anterior inner apical. (See fig. 11, square B ij, near line C.)

Central aseg. (x. aseseisss). Inner mid-apical (x. aseseissi).

From the level of this bifurcation the mid-apical curves strongly inwards, and when near the inner upper margin divides into an anterior and a posterior branch, one of which (or both) reaches the margin. Descending intra-pulmonary branchlets are given by these bronchi.

Outer mid-apical (viij. aseseea). Outer postr. apical (viij. aseseep).

The Outer Mid-apical, which crosses diagonally, in fig. 10, the square G iij, almost strictly continues the outer ascending tendency of the common trunk, but it adds to it a strong backward element. It bifurcates into an anterior or *outer mid-apical* branch and into a larger *outer posterior apical branch.* In their branching their divisions are symmetrical, but of uneven size and slightly different level.

Superior outer mid-apical (ix. aseseeas). Inferior outer mid-apical (ix. aseseeae).

The Outer Mid-apical division, after yielding, near its point of origin, a downward T-shaped branch, divides into a *superior* and *inferior* branch of bifurcation for the upper outer slope of the apex exactly above the axillary apical.

Outer postr. apical (ix. aseseepe). Postr. outer central (ix. asese eps).

The much larger **Outer Posterior Apical** divides into a *posterior outer-central branch* and an *outer posterior apical.* The names of these bronchi sufficiently indicate their destination. The terminal branches from the posterior outer-central are purely superior. Those from the outer posterior-apical are partly bestowed upon the posterior, partly upon the outer upper margin of the apex.

Distribution of the Left Axillary Trunk.

Axillary stem.

The upward and outward course of the axillary stem is maintained for a distance of 1·1 cm. at the level of its second bifurcation where the two resulting divisions, especially the lower, assume a more horizontal course.

Axillary posterior interlobar. Axillary stem.

The first bifurcation yields an important **Axillary Posterior Interlobar** which faces the inner branch of the ascending oblique-dorsal trunk. From the front this is seen in fig. 10, close to intersection G iv. In fig. 11, it is hidden from view, except its origin in C iv.

Superior axillary (vij. asecee). Outer ascending apical (vij. asecees).

The axillary stem now divides into an outer almost horizontal trunk the *superior axillary*, and an anterior trunk the *outer ascending apical*. (See fig. 10, square G iv.)

The district corresponding to these trunks is analogous to the pyramidal ascending apical district, but the pyramid is here a low one, none of the branches rising to a high level.

Antr. axillary bronchus (viij. asecese). Outer ascg. apical (viij. asecess).

The Outer Ascending Apical soon gives an outward smaller branch, the **Anterior Axillary,** which is almost horizontal and lies in front of the superior axillary, assisting in forming the upper boundary of the infra-apical bronchial interspace. (See p. 108.)

Calvicular and other branches.

The outer ascending apical distributes a **T**-*shaped branchlet* towards the transverse apical bronchial interspace, a *posterior deep pulmonary*, and forwards a *clavicular* and an *ascending clavicular* branch. It terminates in an upper and a lower terminal branchlet, below and in front of the anterior division from the outer mid-apical.

Sup. axy. (viij. aseceee). **T**-shaped postr. interlobar (viij. aseceep).

The Superior Axillary, at first rising slightly, becomes horizontal, and gives horizontally outwards a **T**-shaped interlobar branch. The trunk, after a further outward course of 1 cm., divides into an *ascending*, and a slightly anterior *descending superior axillary*.

Descg. supr. axy. (ix. aseceeed). Ascg. supr. axy. (ix. aseceees).

The Descending Superior Axillary branch inclines slightly downwards and divides into an upper and a lower surface-branch for the anterior axillary district. This terminal fork is easily recognized in fig. 10, square H iv.

Axillary apical (x. aseceeess). Horizontal superior axillary (x. aseceeese).

The **Ascending Superior Axillary** branch divides into the **Horizontal Superior Axillary** and into the **Axillary Apical Bronchus.** Both these bronchi terminate, at different levels, in the mid-axillary line, by means of anterior and posterior branches of bifurcation.

The Left Infra-apical Interspace..

Left infra-apical space, analogous to right sterno-scapular space;

A well-defined, horizontal interspace, transverse to the axis of the body, which may be conveniently termed the left infra-apical interspace, is found between the bronchial stems which rise to the apex of the lung, and the horizontal bronchi destined for the pectoral distribution. This bronchial interspace is well shown in fig. 10, below line iv. It is analogous to the sterno-scapular interspace in the right bronchial tree, but differs from it in direction.

cause of their differences. Right apex receives several branches from pectoral trunk. Left apex only one.

The want of symmetry between the right and the left bronchial interspace is bound up with differences in the shape and relation of the two pectoral bronchial districts. On the right side of the chest, the pectoral trunk assists largely in the bronchial supply to the apex. In the left lung the apex is independent of any aid from the pectoral trunk, having derived its air-supply in great measure from behind, at the expense of the axillary distribution.

Upper boundary of left pectoral distribution is horizontal, on a level with right horizontal-sternal bronchus.

It results that the left pectoral district possesses an almost horizontal upper boundary, one twig only, the ascending mid-pectoral, rising to the level of the apex-bronchioles and terminating in the middle line of the lung, between the inner and the outer anterior apical distributions. Extending to the outer surface of the lung where it faces the posterior horizontal distribution, from that spot the boundary slopes downwards and inwards—forming the hypotenuse of a triangle, the right angle of which is formed by the sternal border and by the horizontal boundary.

The level of the horizontal boundary is the same as that of the right horizontal sternal bronchus.

The right pectoral district is mainly above this level.

The greater part of the right pectoral district is above this line, whereas the whole of the left pectoral district is inferior to it. This important point may be made out in fig. 10. Line v, in that drawing, is situated a little below the level in question.

RIGHT AXILLARY DISTRIBUTION.

Axillary trunk (iij. ee).

The Axillary Trunk, short and broad (little more than 1 cm. in length), is the direct continuation of the upper lobar bronchus. It is the outer division from the tripod described by Aeby (erroneously, as I have endeavoured to show) as a trifurcation of the "eparterial" bronchus. The apex-trunk and the axillary trunk should rather be regarded as bifurcated from a rudimentary internodium, of the same standing as the pectoral trunk, and with it derived by bifurcation from the upper lobar bronchus.

This rudimentary trunk has already been described under the name of axillary-apical (E ij).

The branches arising from the right axillary spread outwards, under repeated bifurcation, in the shape of a pyramid having its apex at the apparent trifurcation. The base of the pyramid is represented by the axillary and by the outer-posterior apical surfaces of the upper lobe.

General shape of axillary district.

The Central Axillary Interlobar is a short and relatively stout bronchus descending from the axillary immediately before its bifurcation. So close is this relation that, had this bronchus ever been previously described, it would probably have been regarded as forming part of a trifurcation. Its two branches, sloping respectively forwards, and backwards, end with T-shaped branchlets at the interlobar surface. Further reference will be made elsewhere to this distribution. This interesting bronchus and its branches are displayed in square H iv of fig. 11.

Axillary trunk (iv. eee). Central axillary interlobar (iv. eed).

Two slightly diverging trunks of almost equal size, the *axillary* and the *retro-axillary bronchi*, are the products of bifurcation from the main trunk, the faint upward tendency of which is assumed, in more marked degree, by its continuation and namesake (v. eeee).

The bifurcation in question is seen in fig. 10, just below the intersection of lines C and iij.

Axillary trunk (v. eeee). Retro-axillary trunk (v. eeep).

Distribution of the Right Axillary Division.

The Axillary Trunk is about 2 cm. in length. From its middle part arises obliquely downwards an **External Interlobar Branch.** Branchlets are distributed from this bronchus forwards and backwards.

Length of axillary trunk.

The final bifurcation of the axillary takes place in the same plane as the preceding one, the *anterior axillary-apical* and the *superior axillary* being the results. To the former reference has been made elsewhere (see "Apex"). They both possess a length of about 2 cm. and a symmetrical termination into an upper and a lower forking division. (Consult diagram fig. 9; but note that the axillary apical, as there shown, is too distant from the apex, and not sufficiently vertical in direction.)

Axillary trunk (vj. eeeee). External interlobar (vj. eeeed).

The Anterior Axillary Apical supplies a small branch forwards, and rises for a distance of 2 cm. before bifurcating. The upper of its forked terminal branches ends near the external surface of the apex at the level of the middle third; the lower third being supplied by the inferior branch.

The Superior Axillary presents exactly analogous branches, which provide for the aëration of the middle or external portion of the superior axillary region, the anterior and posterior aspects being otherwise supplied.

Anterior axillary apical (vij. eeeees). Superior axillary (vij. eeeeep).

Distribution of the Right Retro-axillary Division.

(This distribution can be best studied in fig. 10, squares H iij and I iij.)

Retro-axillary (vj. eeeps). Retro-axillary interlobar (vj. eeepd).

Singular among apex bronchi in possessing a posterior origin and a backward course, the *retro-axillary trunk* is of same size as its fellow, and likewise delivers a descending branch, the **Retro-axillary or Superior Dorsal Interlobar** which however quickly becomes horizontal, and with T-shaped bifurcation subtends the interlobar pleural surface. The two arms of the T are seen in fig. 10, above and almost parallel to line iij. The retro-axillary presents slight upward tendency and bifurcates into equal divisions, the *supra-spinate* and the *posterior axillary apical*.

Supra-spinate (vij. eeepsp). Posterior axillary apical (vij. eeepse).

The Supra-spinate Trunk continues the backward curve of the retro-axillary, and ends after a course of 1·5 cm. in an **Ascending Supra-spinate** and a **Retro-axillary Supra-spinate Branch**. Both these tubes contribute in the formation of the base of the pulmonary apex. They extend respectively outwards and backwards at the level of the scapular spine.

Ascending supra-spinate (viij. eeepsps). Retro-axillary supra-spinate (viij. eeepspp).

The **Posterior Axillary Apical Trunk**, moving outwards and upwards, bifurcates into the **Posterior Axillary Apical** and into the descending posterior axillary. The former is concerned in the supply to the outer posterior border of the apex. The **Descending Posterior Axillary**, inferior to the preceding bronchus, curves downwards, but previously sends an anterior descending branch to the axillary region.

Posterior axillary apical (viij. eeepses). Descending posterior axillary (viij. eeepsed).

The right axillary distribution, which has briefly been sketched, differs greatly from the left in the horizontal direction of its trunk and of most of its divisions, and in the more limited share which it takes in the formation of the apex proper. Shortened internodia and, as a result, apparent trifurcations are frequent in this distribution which thus rapidly acquires an extensive periphery.

THE PECTORAL REGION.

RIGHT PECTORAL DISTRIBUTION.

General Survey of this District.

The General Shape of the pectoral bronchial district is roughly that of an elongated pyramid, placed horizontally with its small end towards the root of the lung. The base of the pyramid corresponds to the anterior part of the surface of the chest, between the clavicular and the mammary level. The mesial surface is also posterior and is much bevelled. The lower surface, also bevelled posteriorly, is like the two preceding, invested by pleura. It forms the upper side of the short or transverse fissure. The outer side of the pyramid is interrupted by the oblique fissure, or great fissure of the lung. The upper side of the pyramid is continuous with the tissues of the apex, but in the bronchial cast it is formed by the sterno-scapular inter-bronchial space. General shape that of an elongated pyramid. The sides,

It will be understood from the previous description that there are but two free edges to the pectoral district, the mesial, or sternal, and the inferior edge, the former vertical, the latter horizontal, both being sharp. and the edges of the pyramid.

I have already stated that, in the right lung, the bronchi supplying the pectoral district send upwards branches which take a prominent part in the aëration of the anterior portion of the apex. In this sense the distribution which we are considering is not limited strictly to the pectoral region of the chest. Bronchi supplied to the apex.

The bronchi of this bronchial district are without exception derived from the pectoral stem, which is given off at the first bifurcation of the right upper lobar bronchus. A single stem, the pectoral.

The Bronchi of the Right Pectoral Distribution.

(This distribution can be followed in fig. 10, column B, where it extends between line ij and line vj—also in the diagram, fig. 9.)

The pectoral stem barely exceeds 1·3 cm. in length, but is of substantial thickness. Arising from the anterior extremity of the upper lobar bronchus, at the seat of the spurious trifurcation, it contributes the first part of the semicircular curve forwards and inwards which carries the termination of the Pectoral stem (ij. a).

horizontal sternal bronchus to a point in the anterior pulmonary fringe nearly opposite to the bifurcation of the trachea.

Sterno-pectoral (iij. aa). Mid-pectoral (iij. ae).

The two divisions from this stem lie side by side at their origin, not however in a strictly horizontal plane. The outer branch or *mid-pectoral* is slightly superior to the internal or *sterno-pectoral* bronchus. The same inclined plane continued upwards and backwards receives the divisions of the axillary stem. This imaginary plane defines the lower boundary or floor of the sterno-scapular inter-bronchial space or sulcus.

Distribution of the Right Sterno-pectoral Trunk.

Ascending sterno-pectoral (iv. aas). Horizontal sterno-pectoral (iv. aai).

The Sterno-pectoral Bronchus, of same length as its parent, continues the semicircular curve, and divides into the *ascending sterno-pectoral* and the *horizontal pectoral* bronchi.

Sterno-clavicular (v. aasi). Apical parasternal (v. aase).

Reference has been made to the **Ascending Sterno-pectoral** in connection with the apex. Suffice it to mention here that this trunk rises forwards and inwards for a distance of 1·5 cm. and bifurcates into the *sterno-clavicular* and the *apical parasternal bronchus* which occupy with their branches the regions indicated by their names. Both bronchi run an upward and ? inward course and remain within a transverse plane at least as far as the level of the clavicle.

Horizontal sterno-pectoral (v. aaii). Inner pectoral (v. aaia). Descending mid-sternal (vj. aaiid). Horizontal pectoral (vj. aaiii).

In contrast to its twin-bronchus **the Horizontal Sterno-pectoral** addresses itself to the supply of inferior districts. It is exceedingly short; and, bifurcating almost immediately, it yields the *inner-pectoral trunk,* and by a second bifurcation, 1 cm. distant from the first, the *descending mid-sternal.* Continuing its forward and inward curve the horizontal bronchus distributes a *descending parasternal* to the corresponding region of the anterior surface, and several marginal branchlets to the pulmonary fringe.

Descending parasternal (vij. aaiiid). Horizontal marginal (vij. aaiiii).

The Inner-pectoral Trunk, of smaller size than the horizontal pectoral, and not exceeding, in the cast, 1 cm. in length, proceeds forwards and a little downwards. After a bifurcation which gives rise to the *deep inner-pectoral interlobar,* it supplies branchlets to the inner portion of the upper lobe.

Inner-pectoral (vj. aaiaa). Deep inner-pectoral interlobar (vj. aaiad).

The Deep Inner-pectoral Interlobar deserves mention in connection with the **Central Inter-bronchial Space** (*cf.* p. 121) of the right lung, of which it forms one of the boundaries. Its branchlets are brought into relation with the upper division of the pulmonary vein, behind which descends the pulmonary artery.

Inner descending mid-sternal (vij. aaiidi). Outer descending mid-sternal (vij. aaiide).

The Descending Mid-sternal is easily identified as supplying the lower extremity of the sternal border. It lies at first nearer the posterior than the anterior surface of the fringe. Each of its divisions the *inner* and the *outer descending mid-sternal,* again subdivide.

From the inner division arise (1) a small T-shaped bronchus for the pericardial surface, and (2) marginal branches for the fringe of the lung.

The outer division provides anterior and posterior branches which, approaching the fringe, may be termed sub-marginal.

Distribution of the Right Mid-pectoral Trunk.

Mid-pectoral (iv. aea). Mid-pectoral apical (iv. aes).

A slightly ascending direction forwards and outwards rapidly removes the **Mid-pectoral** from the vicinity of its twin trunk the sterno-pectoral. After a course of 1·5 cm. it bifurcates, giving rise to the *mid-pectoral apical*, and by a second bifurcation to the *outer pectoral*.

Mid-pectoral apical (iv. aes). Infra-clavicular (v. aesa) (outer and inner branch). Mid-pectoral apical (vj. aesss). T-shaped posterior branch (vj. aessp.)

The Mid-pectoral Apical resembles the ascending sterno-pectoral in being distributed mainly above the level of the pectoral zone. In several particulars it contrasts with this bronchus. It is entirely an apex-bronchus, beginning to deliver branches at a height which almost corresponds to the summit of the distribution of the other bronchus. It arises 8 mm. higher and also further back than the latter, and, being at first vertical, maintains this deep situation for a distance of 5 mm. Then inclining forwards and very slightly outwards in its ascent, it supplies an **Infra-clavicular** horizontal bronchus, which bifurcates into an inner and an outer superficial branch. This is the most anterior and the lowermost of all the branches connected with the supply of the apex; and, in direction, it is the continuation of the second part of the mid-pectoral apical. The main trunk, now purely apical, ascends vertically from this point, giving a posterior and inner **T**-shaped bronchus which faces the anterior ascending apical trunk, and, 5 mm. higher up, **a Clavicular Branch**, outwards and forwards.

Mid-pectoral apical or external anterior-apical (vij. aessss). Clavicular branch (vij. aesssa). Anterior, (viij. aesssss), and lateral terminal bronchus (viij. aessssp).

From this point the mid-pectoral apical bronchus, whilst ascending almost vertically, shows a slight backward and outward inclination, in conformity with the dome-shaped surface of the district, and may be termed from its position the **External Anterior-apical** bronchus. Its small anterior terminal branch is in the same anterior transverse plane as the middle anterior-apical bronchus, a branch from the anterior ascending apical stem. Its posterior lateral terminal branch contributes to the supply of the external surface of the apex in its anterior portion.

The mid-pectoral apical distribution reviewed, in comparison with the ascending sterno-

In conclusion this bronchus, although originating from the pectoral stem, rises to the anterior external surface of the apex, falling short of the greater height attained by the more central air-tubes of the apex as a result of its own somewhat lateral position, and of the dome-like formation of the pulmonary summit. Whilst not approaching the surface excepting at its upper part, it is the most anterior of the apex-bronchi, being separated from the apical stem and its branches by the broad sterno-scapular inter-bronchial sulcus. Its distribution begins at the level of the clavicle; it is mainly anterior and superficial, and, in shape, pyramidal.

The distribution of the ascending sterno-pectoral, on the contrary, acquires breadth as it ascends, owing to the divergence of its two large branches. It supplies the inner third of the clavicular surface of the lung—

TABLE II.—LEFT PECTORAL DISTRIBUTION.

MIDDLE OUTER INTERLOBAR PECTORAL (viij. aaaceee). UPPER OUTER INTERLOBAR PECTORAL (viij. aaaeeee).

LOWER MARGINAL. LATERAL MARGINAL. LOWER MARGINAL. UPPER MARGINAL. POSTERIOR MID-PECTORAL INTERLOBAR (vij. aaaeep). HORIZONTAL PECTORAL (vij. aaaeee). INFERIOR OUTER INTERLOBAR PECTORAL (viij. aaaeaae). SUPERFICIAL MID-PECTORAL (viij. aaaeaaa).

DESCENDING STERNAL (viij. aaiiidd). LOWER PARASTERNAL (viij. aaiiida). HORIZONTAL STERNAL (viij. aaiiiii). UPPER PARASTERNAL (viij. aaiiiia).

DESCENDING STERNAL vij. aaiiid). HORIZONTAL STERNAL (vij. aaiiii). DESCENDING CENTRAL (vij. aaaead). SUPERFICIAL MID-PECTORAL (vij. aaaeaa).

STERNO-PECTORAL (vj. aaiii). ANTERIOR BRONCHUS OF THE ROOT (vj. aaiip). SUPERFICIAL DESCENDING INNER MID-PECTORAL (vj. aaiad). SUPERFICIAL ASCENDING INNER MID-PECTORAL (vj. aaias). HORIZONTAL OUTER PECTORAL (vj. aaaee). MID-PECTORAL (vj. aaaea).

STERNO-PECTORAL (v. aaii). INNER MID-PECTORAL (v. aaia). OUTER PECTORAL (v. aaae). ASCENDING MID-PECTORAL (v. aaas).

STERNO-PECTORAL (iv. aai). OUTER PECTORAL (iv. aaa).

Axillary-apical stem (iij. as). (See Table I.) PECTORAL STEM (iij. aa).

PECTORI-APICAL BRONCHUS (ij. a). Left cardiac stem (ij. d). (See Table III.)

LEFT UPPER LOBAR BRONCHUS (BRONCHUS IMPAR).

TABLE II.—RIGHT PECTORAL DISTRIBUTION.

RIGHT UPPER LOBAR OR PECTORI-APICAL BRONCHUS.

- Axillary Apical Stem (ij. e). (See Table I.)
- Pectoral stem (ij. a).
  - Sterno-pectoral (iij. aa).
    - Ascending sterno-pectoral (iv. aas).
      - Sterno-clavicular (v. aasi).
      - Apical para-sternal (v. aase).
    - Horizontal sterno-pectoral (iv. aai).
      - Hori-zontal pectoral (v. aaii).
        - Descending mid-sternal (vj. aaiid).
          - Outer de-scending mid-sternal (vij. aaiide).
          - Descend-ing mid-sternal (vij. aaiidi).
        - Horizontal pectoral (vj. aaiii).
          - Descending parasternal (vij. aaiiid).
          - Horizontal marginal (vij. aaiiii).
      - Inner pectoral (v. aaia).
        - Deep inter-lobar (vj. aaiad).
        - Inner pectoral (vj. aaiaa).
  - Mid-pectoral (iij. ae).
    - Mid-pectoral (iv. aea).
      - Outer pectoral (v. aeae).
        - Descending inter-lobar branch (vj. aeaed).
        - Outer pectoral (vj. aeaee).
          - Ascending outer pectoral (vij. aeaees).
          - Outer pectoral (vij. aeaeee).
            - Horizontal terminal (viij. aeaeeee).
            - Descending terminal (viij. aeaeeed).
      - Middle pectoral (v. aeaa).
        - Descend-ing inter-lobar branch (vj aeaad).
        - Middle pectoral (vj. aeaaa).
          - Ascending pectoral (vij. aeaaas).
          - Middle pectoral (vij. aeaaaa).
    - Mid-pectoral apical (iv. aes).
      - Mid-pectoral apical (v. aess).
        - T-shaped posterior branch (vj. aessp).
        - Mid-pectoral apical (vj. aesss).
          - Clavicular branch (vij. aesssa).
          - External anterior apical (vij. aessss).
            - Lateral terminal (viij. aesssssp).
            - Anterior terminal (viij. aesssss).
      - Infra-clavicular (v. aesa).

N.B.—*The meaning of the letters used as notation is explained on page 88.*

pectoral distribution.

the outer third of the same being furnished with air by the anterior axillary-apical bronchus.

Middle pectoral (v. aeaa). Outer pectoral (v. aeae).

After the origin of the apical division the mid-pectoral ceases to rise and is less outwards inclined. At first horizontal it assumes a slightly downward tendency which is continued in its branches and restores them to the original level of the pectoral stem. The bifurcation into the *middle pectoral* and the *outer pectoral* bronchus occurs 8 mm. in front of the previous bifurcation. The direction of the outer pectoral is chiefly and almost strictly external, that of the middle pectoral mainly anterior, and the two tubes diverge in a horizontal plane (slightly descending). From each arises, close to the bifurcation, a descending deep pectoral interlobar bronchus, directed towards the central root-space, and forming its anterior upper boundary. (See diagram, fig. 9; see also fig. 10, line B, between squares A iv and B iv.)

Middle pectoral (vj. aeaaa). Descending interlobar (vj. aeaad). Middle pectoral (vij. aeaaaa). Ascg. pectoral (vj. aeaaas).

The Middle Pectoral Bronchus, advancing almost straight, with very slight outward inclination is of short length. In addition to the **Interlobar Branch,** it supplies a small **Ascending Pectoral Branch** for the lung-tissue situated slightly higher. Its terminal bifurcation takes place at the anterior pectoral surface into an ascending and a descending branch.

Outer pectoral (vj. aeaee). Descending interlobar (vj. aeaed). Outer pectoral (vij. aeaeee). Ascending outer pectoral (vij. aeaees). Horizontal terminal (viij. aeeaeee). Descg. terminal (viij. aeaeeed).

The **Outer Pectoral Bronchus** has a longer course, almost strictly outwards. Its branches bear a close analogy to those of the preceding bronchus. The **Interlobar Branch** is an exact repetition of the interlobar from the middle pectoral, and is situated a little external and posterior to it. But the **Ascending Outer Pectoral** is not vertical, but inclined very obliquely upwards and outwards. And the two terminal branches are respectively horizontal and descending and are directed slightly backwards, approaching at their extremity the slightly superior and posterior distribution of the superior axillary trunk.

LEFT PECTORAL DISTRIBUTION.

(For the study of this distribution consult fig. 10; column E, and columns v and vj.)

Pectoral stem (iij. aa). Inner or sterno-pectoral (iv. aai). Outer pectoral (iv. aaa).

The Left Pectoral Stem, equal in thickness to the apical, has a length of 1·2 or 2·2 cm., according as it is measured along its upper or along its lower border, and a directly forward course. Its two horizontal divisions, the *inner*, or *sterno-pectoral*, and the *outer pectoral*, both possess at first an anterior direction. The inner or sterno-pectoral immediately turns inwards towards the pericardium. The outer pectoral breaks up before taking any departure from the sagittal direction; but its outer branch shows a rectangular outward bend, analogous to that seen in the sterno-pectoral bronchus.

Fig. 10.

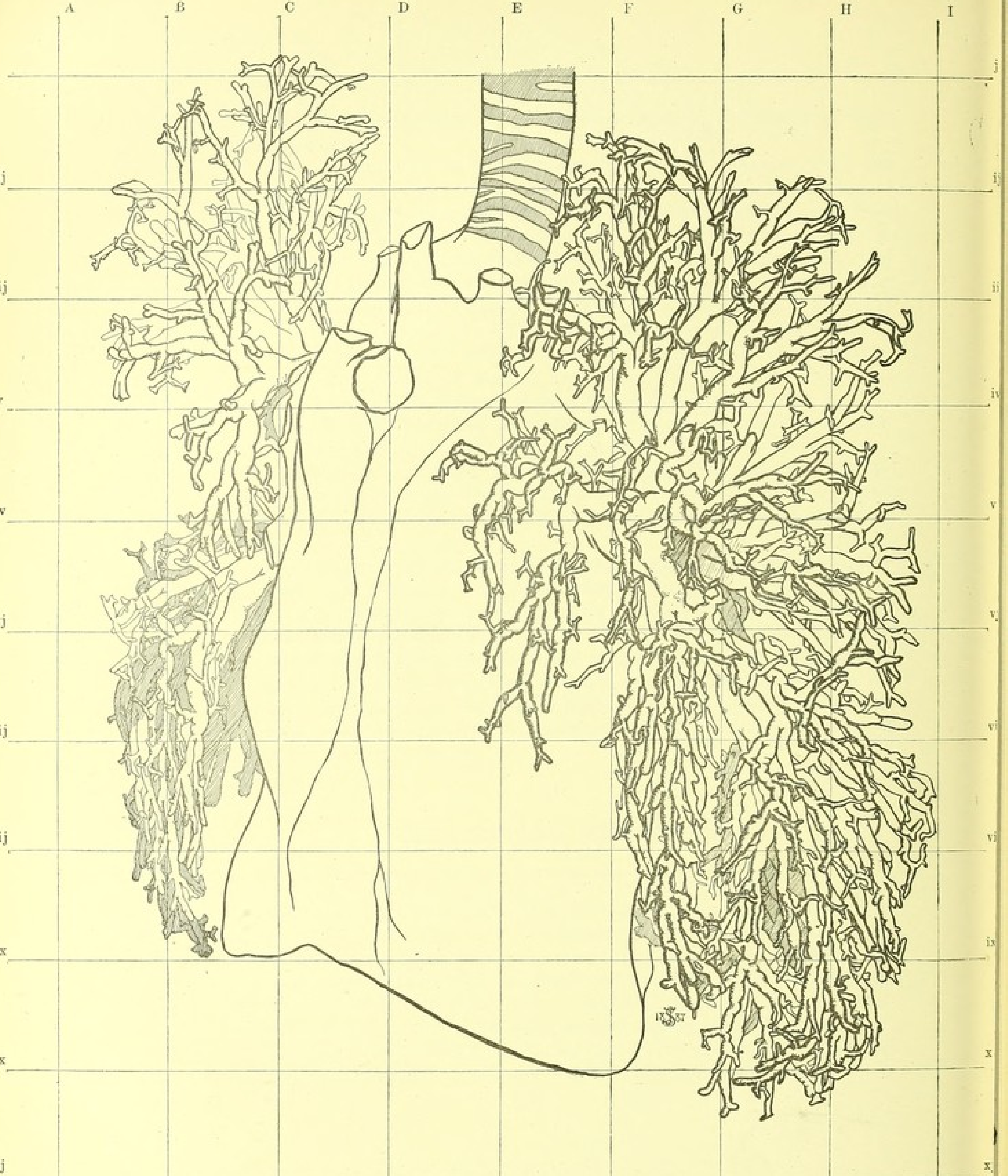


Fig. 10.

Drawing from a metallic cast of the Bronchi. Front view; from the left.

The soft parts and the bronchial membrane have been dissected away, except the trachea, the origin of the great vessels, and the pericardium, which are shown *in situ*.

EXPLANATIONS OF THE DRAWING.

1. Central Parts.

Above line iij, between this and the trachea: the divided orifices of the great arteries, and (at line D) of the vena azygos (raised).

Above line iv, below the V. azygos: the termination of the superior V. cava, dividing into right and left innominate veins.

Between line C and the V. cava:—the divided branches of the right superior pulmonary vein, and close behind this, within square B v: the inferior division of the right pulmonary artery.

2. Right Bronchial Tree.

Right Upper Lobe:

In square C iv, behind the right innominate V.:—the three apex-bronchi diverge, the pectoral stem horizontally forwards, its branches occupying a front plane,—the ascending-apical stem, upwards,—and the axillary stem, shown in weak outline, outwards.

Line C passes between the anterior and the posterior ascending-apical,* and the tracheal-apical bronchi. The superficial anterior-apical forms an angle, near the intersection B j with the external anterior-apical, from the mid-pectoral.

Square B iv contains the pectoral trunk dividing into its branches.

Right Middle and Lower Lobes:

In square B vj, behind the pulmonary vein, the cardiac stem gives rise to the mammary-cardiac, the sterno-cardiac and the posterior mammary-cardiac trunks.

Square B viij shows, in profile, the parallel-sternal branches, and between these and the pericardium two descending retro-cardiac branches in shaded outline.

3. Left Bronchial Tree.

Left Upper Lobe:

Square F vj contains the cardiac trunk (from the bronchus impar, which is not in view). The shaded trunk is the posterior-horizontal. Lower down the cardiac branches are seen in profile in column F.

In square F v the pectoral stem divides horizontally, along line v, into its conspicuous sterno-pectoral, and into the mid-pectoral divisions. The ascending mid-pectoral is cut short. The axillary-apical stem, partly disguised by the latter, bifurcates into the ascending-apical and the axillary trunk; and this again into the axillary and the posterior-axillary, thus imitating a trifurcation.

Into square H iij rises the axillary-apical.—Square G iij shows outer mid-apical branches above, outer ascending-apica branches below, and between the latter a twig from the outer posterior-apical.

Along line G the inner mid-apical bronchus rises into square F ij, concealing the inner posterior-apical branches.

In square E iv a letter H is imitated by branches of the apical sterno-clavicular, behind which are aortic branches of the posterior ascending-apical.

Left Lower Lobe:

Line G, below the posterior-horizontal (shaded), coincides with the interlobar fissure.

In square G vij the anterior-basic trunk bifurcates into the more vertical cardio-basic, and the widely branching mammary trunk.

In square G viij a shaded retro-cardiac branch is seen.

(The other basic distributions are better displayed in fig. 11.)

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* The right posterior ascending-apical bronchus will be seen if the two posterior branches terminating in square C j be followed downwards. Its external outline is hidden by the bronchus anterior to it.

Distribution of the Left Outer Pectoral Trunk.

The Outer Pectoral Trunk, immediately before dividing, yields an upward branch, **the Ascending Mid-pectoral Bronchus** which, after bending horizontally forwards, again assumes a rising tendency. This is the only derivative from the left pectoral stem which rises above the boundary of the broad horizontal *infra-apical inter-bronchial sulcus*. It may serve as a landmark dividing this space into an inner and an outer half. The ascending mid-pectoral distributes three small deep intra-pulmonary branches, and ends with an upward and a downward fork.

Outer pectoral trunk (v. aaae). Ascending mid-pectoral (v. aaas).

The bifurcation of the outer pectoral gives rise to the *mid-pectoral* and to the *horizontal outer pectoral trunk*. Both move outwards ultimately, but this movement is preceded, in the case of the **Mid-pectoral Bronchus**, by an initial forward course of 2 cm. which terminates with its bifurcation; at this point its inner division continues the forward direction, whilst the outer division carries out the outward bend just begun by the common trunk.

Horizontal outer pectoral (vj. aaaee). Mid-pectoral (vj. aaaea).

Immediately, or soon after its origin, the mid-pectoral bronchus sends a **Descending Central Bronchus** into the central *root-space*. This bronchus faces from above the cardiac trunk. The other branch of bifurcation is the **Superficial Mid-pectoral** which divides at the surface into an upper and a lower forking branch supplying the outer portion of the mid-pectoral region. The latter, or **Inferior Outer Interlobar Pectoral** possesses slight inclination downwards as well as a main outward tendency, which is soon interrupted by the pulmonary fissure. It aërates the interlobar subpleural tissue near the anterior surface, at the level of the third interspace between the ribs.

Descending central mid-pectoral (vij. aaaead). Superficial mid-pectoral (vij. aaaeaa). Superficial mid-pectoral (viij. aaaeaaa). Inferior outer (interlobar) pectoral (viij. aaaeaae).

The Horizontal Outer Pectoral is sufficiently localized by its name. It is mainly concerned with the anterior surface, but its early branch, the stout **Posterior Mid-pectoral Interlobar**, proceeds horizontally backwards to the interlobar surface, where it faces with its T-shaped bifurcation the posterior horizontal distribution. The horizontal outer pectoral divides into the **Upper Outer Interlobar Pectoral** supplying the interlobar tissue close to the outer fringe of the upper lobe and the **Middle Interlobar Outer Pectoral**, similarly distributed at a slightly lower level. The inferior interlobar outer pectoral, derived from the mid-pectoral has already been described. These three bronchi and their lobules form the outer edge of the upper lobe in the pectoral zone.

Horizontal outer pectoral (vij. aaaeee). Posterior mid-pectoral interlobar (vij. aaaeep). Upper outer interlobar pectoral (viij. aaaeeee). Middle outer interlobar pectoral (viij. aaaeeee).

Distribution of the Left Sterno-pectoral Trunk.

The Sterno-pectoral Stem, like a semi-flexed left elbow, bends horizontally inwards, so as almost to reach the pericardial surface. Its straight horizontal portion is continued forwards as **Inner Mid-pectoral**, a short

Sterno-pectoral stem (iv. aai).

Inner mid-pectoral (v. aaia). Sterno-pectoral (v. aaii).

stem with very open bifurcations. From this arise an ascending branch of small size, and a longer, almost vertical, descending branch. Both being superficial, are freely provided with ramifications.

Sterno-pectoral (vj. aaiii). Anterior bronchus of the root (vj. aaiip).

Beyond the angle (of 90°) which it forms with its previous direction, the second portion of the sterno-pectoral stem pursues its inward course for a distance of 1·7 cm., and gives an **Anterior Bronchus of the Root** to the internal or mesial surface just opposite the termination of the left main bronchus. In this situation the upper division of the pulmonary vein, enclosed between the main bronchus behind, and the elbow of the sterno-pectoral stem in front, rises into the horizontal inter-bronchial space which exists between the apical and the pectoral zone, and which I have termed the infra-apical sulcus. The ascending branch from the anterior bronchus of the root at this level is among the structures which lie in front of the vein.

Horizontal sternal (vij. aaiiii). Descending sternal (vij. aaiiid).

The final bifurcation of the sterno-pectoral gives origin to the *horizontal sternal* and to the *descending sternal*. Both trunks soon bend forwards at right angles with their previous directions and each of them, just before the bend, bestows a branch upon the neighbouring pericardial surface of the lung.

Horizontal sternal (viij. aaiiiii). Upper parasternal (viij. aaiiiia).

The Horizontal Sternal bifurcates into a small **Upper Parasternal** which lies to the right of the inner mid-pectoral bronchus between this and the sternal distribution, and into a continuation of the trunk. This ultimately breaks up into an **Upper**, almost horizontal, and a **Lower**, almost vertical **Marginal Bronchus.**

Upper (horizontal) marginal. Lower (vertical) marginal.

From the **Descending Sternal** arises likewise a **Lower Parasternal** which extends nearly to the lower boundary of the sternal distribution, and bears several branchlets.

Descending sternal (viij. aaiiidd). Lower parasternal (viij. aaiiida).

After some undulations, such as are common among the bronchi of the injected left lung, the descending sternal yields a **Lateral Marginal Branch**, and it terminates with a marginal bifurcation at the lower projection of the sternal fringe.

Lateral marginal. Lower marginal.

All the branches which have been described may be traced with tolerable ease in fig. 10 in the vertical columns D and E.

THE CARDIAC REGION.

BRONCHIAL SUPPLY TO THE RIGHT CARDIAC DISTRICT, OR RIGHT MIDDLE LOBE.

General Remarks concerning the Middle Lobe.

The middle lobe in great part internal to axis of bronchus intermedius.

General Shape and Relations.—Whereas the right upper lobe is situated, for the greater part, externally to the axis of the *intermediate bronchus*, the middle lobe is, at a lower level, in a large measure internal to the same axis continued.

Triangular outline.

Borders.

Viewed from the front the general outline of this lobe is triangular. The sternal and basic borders are gently curved, but the upper and outer boundaries are rectilinear, and they converge towards a point situated in the axillary region. The inner and lower margins are thin, the upper and outer possess considerable thickness.

Surfaces.

The anterior surface may be regarded as the base of a very shallow irregular pyramid, of which the apex would be formed by the attachment of the middle lobe to the pulmonary root.

Fissures.

The upper surface, forming part of the short, or transverse, fissure is of less extent than the inferior and outer surface, which forms one of the boundaries of the lower half of the great oblique fissure, and is in contact with the lower lobe. The inner or mesial surface is analogous to the inner surface of the pectoral district.

This lobe isolated except at root.

The cardiac stem.

In cases of normal development all these surfaces are lined by pleural membrane. It follows that, on all sides, the middle lobe is isolated from the remainder of the lung, excepting at its attachment to the root. The pedicle formed in this situation is tolerably broad and thick and surrounded by a rather loose fold of pleura. It contains the cardiac bronchus and blood-vessels and some glands, embedded in areolar tissue.

The superficial mammary-cardiac, the sterno-cardiac, and the deep mammary-cardiac divide the bronchial supply.

Bronchial Supply.—The middle lobe is entirely aërated through the branches of the cardiac stem. The apparent trifurcation of the latter stem at the upper and posterior part of the lobe is really a bifurcation into an outer or *superficial mammary-cardiac* trunk, and an inner, very short, although stout, stem, the *sterno-cardiac*, which immediately divides into an anterior, inner, *sterno-cardiac* and an outer, posterior, *deep mammary-cardiac* trunk. The supply of the lobe is divided between these three trunks.

Supply to the outer corner; to the sternal, and to the mammary half.

The Outer Corner is served by the mammary-cardiac. A vertical line, drawn through the anterior surface, roughly divides **the Sternal or Inner Half**, supplied by the sterno-cardiac, from **the Outer Half**, which receives its supply from the deep mammary-cardiac. The latter, by its inner posterior cardiac branch, encroaches posteriorly beyond the imaginary middle-line and extends downwards to the extremity of the inferior fringe, which is not reached by the sterno-cardiac bronchi.

The Inner Border is parallel with the sternum, and the inner surface is in contact with the pericardium. These anatomical relations are turned to account in our nomenclature. The presence of the nipple not far from the upper outer boundary of the lobe is also a useful landmark.

The Right Cardiac Bronchial Distribution.

(This distribution is seen, in distant foreshortening, in columns A and B of fig. 10, being included between the horizontal lines v and ix. It is more clearly displayed in the diagram, fig. 9.)

Cardiac stem (ij. a).

The Cardiac or Middle Lobar Stem originates 2·8 cm. below the lower angle of origin of the upper lobar bronchus. Although undoubtedly ventral, it does not arise absolutely from the anterior surface of the bronchus intermedius. It is slightly internal as well as anterior. This circumstance assists in the production of the mesial position of the cardiac lobe in relation to the lower bronchial stem. But to the same result the inward curve of the sterno-cardiac and of the deep mammary trunks contributes yet more largely.

Its relations.

For a distance of 2 cm. the cardiac stem remains parallel to, and in posterior contact with, the descending bronchial stem. The lower, horizontal, division of the right pulmonary artery lies here across the anterior aspect of both these tubes, on its way to the various bronchial districts. The artery itself is situated behind the obliquely ascending upper pulmonary vein. Perhaps in consequence of these relations, the lower bronchial stem swerves faintly backwards at this level, whilst the cardiac stem presents a slight anterior concavity.

The pulmonary artery and vein.

Mammary-cardiac (iij. ae). Rudimentary inner-cardiac (iij. aa). Posterior mammary-cardiac (iv. aad). Sterno-cardiac (iv. aai).

The bifurcation into the forward tending *mammary-cardiac* and the **Rudimentary Inner-cardiac Stem** occurs immediately after the bend taken forwards by the cardiac stem. The inner-cardiac stem divides at once into a horizontal inward branch, the *sterno-cardiac*, and into the more posterior branch, descending obliquely forwards and slightly inwards, the *posterior mammary-cardiac.*

Distribution of the Right Mammary-cardiac Trunk.

The Mammary-cardiac Trunk, in its unbranched portion, has a length of 1·5 cm. and describes, in a horizontal forward direction, the same curve as the upper half of an elongated letter S; the second half of the curve is imperfectly, and with varying curvature, carried out by each of its two branches.

Superficial mammary-cardiac (iv. aed). Outer mammary-cardiac (iv. aee).

The inner or **Superficial Mammary-cardiac Division** preserves a main direction forwards, and, after distributing branchlets to the surrounding tissue, divides into two branches which bend downwards, near the anterior pulmonary surface, as **Inner** and **Outer Terminal** bronchi, and supply the upper part of the outer half of the lobe.

Outer mammary-cardiac (v. aeee). Ascending interlobar (v. aees).

The Outer Mammary-cardiac Bronchus completes the letter S with a long bold anterior curve extending to the axillary angle of the middle lobe. During this course small branches are given to the periphery. A bifurcation of this trunk takes place close to its origin, setting free the *ascending interlobar*, which helps to supply the upper septal surface of the middle lobe.

Three ascg. interlobars.

The Ascending Interlobar branch is analogous in position to two other interlobar bronchi between which it lies intermediate, namely, the ascending interlobar from the sterno-cardiac, and the ascending interlobar from the posterior-horizontal. All three rise to the same level—and their horizontal distance from the bronchial stem behind is almost the same (2·2 cm.). They thus form the anterior outer boundary of a **Central Root-space** defined above by the descending interlobars from the axillary and from the sterno-pectoral, and behind by the ascending mid-dorsal distribution from the posterior-horizontal. The space in question and the bronchi just enumerated are seen in fig. 10 and fig. 11, when inspected side by side. Diagrammatically, they are also shown in fig. 9.

Central root-space. Descending interlobars. Ascending mid-dorsal.

Sterno-cardiac trunk (iv. aaii). Ascending interlobar (iv. aais).

Distribution of the Right Sterno-cardiac Trunk.

Superficial sterno-cardiac (vj. aaiid). Posterior parasternal (vj. aaiip).

At the end of its horizontal inward course, **the Sterno-cardiac Trunk** furnishes a similar **Ascending Interlobar Bronchus**; and, bending downwards at a right angle, it breaks up into its anterior, or *superficial sterno-cardiac*, and into its *posterior parasternal division*.

Superficial sterno-cardiac (vij. aaiidd). Anterior parasternal (vij. aaiida).

By its first bifurcation **the Superficial Sterno-cardiac** gives rise to the *anterior parasternal*. This bronchus distributes small branches to the upper part of the parasternal surface of the cardiac lobe.

A subsequent bifurcation marks the origin of the **Anterior Pericardial**, a very short trunk, with vertically diverging arms, for the supply of the upper third of the sternal margin and internal surface of the middle lobe.

Superficial sterno-cardiac (viij. aaiiddd). Anterior pericardial (viij. aaiidda).

Descending slightly inwards, the continuation of the sterno-cardiac divides into the **Marginal Sterno-cardiac** (which bifurcates into the *first and second* **Parallel-sternal Cardiacs**), and into the **Third Parallel-sternal Cardiac.**

Marginal sterno-cardiac (ix. aaiidddd).

These parallel air-tubes form a symmetrical row extending outwards from the sternal margin. They do not reach to the lower extremity of the

TABLE III.—LEFT CARDIAC DISTRIBUTION.

- **LEFT UPPER LOBAR BRONCHUS (BRONCHUS IMPAR).**
  - Pectori-apical B. (ij. a). (See Table I.)
    - Axillary-apical (iij. as).
      - Ascending apical (iv.ass).
      - Axillary trunk (iv. ase).
    - Pectoral trunk (iij. aa).
      - Sterno-pectoral (iv. aai).
      - Outer pectoral (iv. aaa).
  - Left Cardiac Stem (ij. d).
    - Anterior Cardiac Trunk (iii. da).
      - Sterno-Cardiac (iv. dai).
        - Inner Sterno-Cardiac (v. daii).
          - Anterior Pericardial (vj. daiii).
          - Inner Sterno-Cardiac (vj. daiid).
            - Superficial Descending Cardiac Marginal (vij. daiida).
            - Deep Descending Cardiac Marginal (vij. daiidd).
        - Outer Sterno-Cardiac (v. daie).
          - Superficial Descending Cardiac Para-sternal (vj. daiea).
          - Deep Descending Cardiac Para-sternal (vj. daied).
          - Outer Superficial Mammary-Cardiac (vij. daeaee).
      - Mammary-Cardiac (iv. dae).
        - Mammary-Cardiac (v. daea).
          - Horizontal Mammary-Cardiac (vj. daeae).
            - Outer Superficial Mammary-Cardiac (vij. daeaee).
            - Inner Superficial Mammary-Cardiac (vij. daeaea).
          - Descending Mammary-Cardiac (vi. daead).
            - Outer Descending Mammary-Cardiac (vij. daeade).
            - Inner Descending Mammary-Cardiac (vij. daeadi).
        - Inter-lobar (v. daee).
    - Posterior Cardiac Trunk (iij. dd).
      - Posterior Pericardial (iv. ddi).
      - Posterior Cardiac (iv. dda).
        - Anterior Cardiac Lobular Trunk (v. ddaa).
          - Anterior Cardiac Lobular (vj. ddaad).
            - Small Lateral Branches.
              - Inner Anterior Lobular Bronchus (vij. ddaadi).
              - Outer Anterior Lobular Bronchus (vij. ddaade).
          - Inter-lobar (vj. ddaae).
        - Posterior Cardiac Lobular Trunk (v. ddad).
          - Inter-lobar (vj. ddade).
          - Posterior Cardiac Lobular (vj. ddadd).
            - Two Backward Branches.
              - Anterior Deep Lobular (vij. ddaddd).
              - Posterior Deep Lobular (vij. ddaddp).

TABLE III.—RIGHT CARDIAC DISTRIBUTION.

RIGHT INTERMEDIATE STEM.

- CARDIAC STEM (ij. a).
  - (RUDIMENTARY) INNER CARDIAC (iij. aa).
    - STERNO-CARDIAC (iv. aai).
      - ASCENDING INTERLOBAR (v. aais).
      - STERNO-CARDIAC (v. aaii).
        - POSTERIOR PARASTERNAL (vj. aaiip).
          - ANTERIOR DEEP (vij. aaiipa).
          - FOURTH PARALLEL STERNAL (vij. aaiipe).
            - POSTERIOR SUPERFICIAL TERMINAL.
            - FOURTH PARALLEL STERNAL.
        - SUPERFICIAL STERNO-CARDIAC (vj. aaiid).
          - ANTERIOR PARASTERNAL (vij. aaiida).
            - SUPERFICIAL BRANCHES.
          - SUPERFICIAL STERNO-CARDIAC (vij. aaiidd).
            - SUPERFICIAL STERNO-CARDIAC (viij. aaiiddd).
              - THIRD PARALLEL STERNAL (ix. aaiiddde).
              - MARGINAL STERNO-CARDIAC (ix. aaiidddd).
                - SECOND PARALLEL STERNAL.
                - FIRST PARALLEL STERNAL.
            - ANTERIOR T-SHAPED PERICARDIAL (viij. aaiidda).
    - POSTERIOR MAMMARY-CARDIAC (iv. aad).
      - INNER POSTERIOR CARDIAC (v. aadd).
        - INNER POSTERIOR CARDIAC (vj. aaddd).
          - INNER LOBULAR.
          - OUTER LOBULAR.
        - OUTER POSTERIOR CARDIAC (vj. aadde).
          - INTERLOBAR.
          - TERMINAL.
      - DESCENDING MAMMARY-CARDIAC (v. aada).
        - OUTER INTERLOBAR (vj. aadae).
        - DESCENDING MAMMARY-CARDIAC (vj. aadaa).
          - EXTERNAL MARGINAL (vij. aadaae).
            - OUTER INNER BRANCH.
          - LOWER EXTERNAL MARGINAL (vij. aadaad).
            - OUTER INNER BRANCH.
  - MAMMARY-CARDIAC (iij. ae).
    - SUPERFICIAL MAMMARY-CARDIAC (iv. aed).
      - INNER TERMINAL.
      - OUTER TERMINAL.
    - OUTER MAMMARY-CARDIAC (iv. aee).
      - ASCENDING INTERLOBAR (v. aees).
      - OUTER MAMMARY-CARDIAC (v. aeee).
        - SUPERFICIAL BRANCHES.
- Right lower lobar bronchus (ij. d). (See Table IV.)

N.B.—The meaning of the letters used as notation is explained on page 88.

Third parallel-sternal cardiac (ix. aaiiddde). Sternal bulge over the parallel-sternals.

lobe, but correspond, in the non-dissected lung, to a bulging usually seen at the lower part of the inner pulmonary border, and terminating a little way above the lower anterior angle. The parallel bronchi are readily seen in the diagram (fig. 9). They are also seen, in profile, in squares B vij and B viij of fig. 10.

Deep posterior parasternal (vij. aaiipa). Fourth parallel-sternal (vij. aaaipe).

A fourth or outermost parallel-sternal bronchus is supplied by the **Posterior Parasternal.** This trunk divides into a **Deep Posterior Parasternal** branch and into the fourth parallel-sternal. The **Fourth Parallel-sternal**, in its downward course, furnishes the posterior surface with a posterior superficial branch.

Distribution of the Right Posterior Mammary-cardiac Trunk.

Posterior mammary-cardiac (iv. aad).

The Posterior Mammary-cardiac Trunk is of short length (1·2 cm.), and descends obliquely forwards and slightly inwards. Lying behind the sterno-cardiac, it almost subtends the right angle described by the latter. It divides into the *inner posterior cardiac* and the *descending mammary-cardiac.*

Inner posterior cardiac (v. aadd). Descending mammary-cardiac (v. aada). Inner posterior cardiac (vj. aaddd). Outer posterior cardiac (vj. aadde).

The Inner Posterior Cardiac, a long and vertical bronchus, occupies the posterior plane of the lobar distribution, and almost bisects it into two lateral halves. It corresponds to the interval left between the more anteriorly placed descending mammary-cardiac and the superficial parasternal;—and it is parallel, in a slightly posterior plane, and external, to the fourth sternal-parallel bronchus. Its terminal bifurcation occurs a little above the lower end of the "parallel" distribution; and its two terminal branches, the inner and outer lobular, undertake, unassisted, the supply of the lower angle, or lobule, and of the lower margin of the middle lobe. In squares A ix, B ix of fig. 10, line B separates the two small tubes.

Inner lobular posterior cardiac (vij. aadddi). Outer lobular posterior cardiac (vij. aaddde).

The only branch of bifurcation from the inner posterior cardiac, viz., the **Outer Posterior Cardiac**, is given up high, and does not extend beyond the middle third of the lobe. It delivers backwards a small interlobar branch.

The Inner and Outer Lobular branches do not require any special description.

The descending mammary-cardiac (vj. aadaa). External interlobar (vj. aadae).

The Descending Mammary-cardiac Trunk assumes a downward, forward, and slightly outward course.

Its first branch, **the External Interlobar**, given backwards and outwards to the interlobar surface, presents the usual T-shape bifurcation.

Upper external marginal (vij. aadaae). Lower external marginal (vij. aadaad).

After a course of 1·2 cm., the trunk bifurcates into **the Upper External Marginal**, which distributes small branches to the outer margin and to the outer anterior surface of the cardiac lobe in its upper part; and into the **Inferior External Marginal**, or continuation of the descending mammary-cardiac, which supplies the outer external margin and the inferior external margin, and gives branchlets to the lower surface of the cardiac lobe in its external half.

Both bronchi are, in their first portion, covered by the superficial mammary-cardiac distribution; and in a similar manner, the branches of the upper external marginal are imbricated over the longer branches of the inferior external marginal. The descending branches of the latter bronchus, although not parallel, are arranged in lateral order,—somewhat resembling, in their mutual relations, the row of parallel-sternal bronchi described above.

BRONCHIAL SUPPLY TO THE LEFT CARDIAC DISTRICT.

General Survey of the Left Cardiac District.

Shape and Disposition.—The anterior surface of the cardiac distribution has an elongated triangular shape with almost horizontal base upwards. The inner, or pericardial, and the outer, or interlobar, surfaces slope backwards. If we could imagine this district disconnected at its upper part from the upper lobe, the free surface thus formed would be horizontal and the whole might be roughly compared to an inverted pyramid. This resemblance is more obvious in the metallic cast than in the fresh lung; for, although no interruption of surface defines, in the lung, the boundary between cardiac and pectoral distributions, a wide horizontal gap exists in the depth between the origin of the pectoral and the origin of the cardiac stem, analogous to the equally important gap situated below the apex and just above the horizontal range of the pectoral ramifications. The upper level of the cardiac region is the same in both lungs; but, externally and above, the left distribution does not extend as far as the right; and in its lower, pointed part it does not possess the same breadth as the right middle lobe.

Elongated triangular shape of the anterior surface.

Resemblance to an inverted pyramid, most marked in the bronchial cast.

Horizontal inter-bronchial space above this district.

General Plan of Bronchial Supply.—If a vertical sagittal plane be imagined, passing through the length of the left upper lobe, in this plane would lie the anterior and the posterior cardiac bronchus, the cardiac stem, and the ascending as well as the horizontal division of the pectori-apical bronchus. The general direction of the cardiac stem may be expressed by the words "downwards and forwards;" but its course cannot be figured by a straight line; for it possesses considerable curvature. The ordinary curved printer's bracket roughly represents the aperture of the great bifurcation of the left upper lobar bronchus. The bracket must be imagined to have its centre at the angle of bifurcation of the bronchus impar, and to face, or open forwards. One of the limbs would be constituted by the ascending pectori-apical stem, and by its continuation the axillary-apical stem; the cardiac stem would correspond, in general outline, to the lower limb of the bracket.

Bifurcation of bronchus impar resembles a bracket; the cardiac stem, its lower limb.

The Cardiac Stem, projecting forwards from the termination of the short bronchus impar, immediately bends downwards, and very slightly out-

Cardiac stem (ij. d).

Anterior-cardiac (iij. da). Posterior-cardiac (iij. dd).

wards (see diagram, fig. 9). During its descent, it bifurcates into the *anterior* and the *posterior cardiac*. Whilst the anterior cardiac assumes a horizontal direction forwards, its terminal branches become at first vertical; and subsequently they slant, in undulating fashion, forwards and downwards. The continuation of the cardiac stem as posterior-cardiac, taking a second bend, passes from the vertical into the oblique direction and thus becomes parallel with the anterior-cardiac divisions. At the same time its outward tendency is modified into a slightly internal one; and the extremity of the cardiac lobule receives its termination. It remains, throughout its course, posterior to the branches which it delivers.

Distribution of the Left Anterior-cardiac Trunk and of its Branches.

(For this distribution and the following, consult diagram (fig. 9); also, in fig. 10, the columns D, E, F, G, between lines iv and x.)

Sterno-cardiac trunk (iv. dai). Mammary-cardiac trunk (iv. dae).

Arising from the cardiac stem, 2·3 cm. from the origin of the latter, the **Anterior-cardiac Trunk** bifurcates, after a course of 1·3 cm., into an inner or *sternal*, and an outer or *mammary* division.

Mammary-cardiac (v. daea). Interlobar branch (v. daee).

The Mammary-cardiac, the smaller and shorter division, is almost horizontal in its distribution, and supplies the anterior external part of the base of the pyramid which has its apex at the cardiac lobule. By means of the **Interlobar Branch** which arises upwards and outwards from its first portion it also supplies the external face of the cardiac district. It bifurcates into a *descending mammary-cardiac* and a *horizontal mammary-cardiac bronchus*.

Horizontal, (vj. daeae) and Descending cardiac mammary (vj. daead).

The Horizontal Mammary-cardiac Bronchus assumes greater lateral extension than other branches of this distribution, and is devoted to the anterior surface of the outer corner of the cardiac district, to which it supplies an **Inner** and an **Outer Superficial Mammary-cardiac Bronchus**.

Inner, (vij. daeaaa) and Outer superficial mammary-cardiac (vij. daeaae).

The Descending Mammary-cardiac, slanting forwards, at first behind the horizontal branch, divides into an **Outer** and an **Inner Descending Mammary-cardiac** which supply the outer half of the middle third of the cardiac district.

Inner, (vij. daeadi) and Outer descending mammary-cardiac (vij. daeade).

The Sterno-cardiac, a larger trunk than its twin-tube, undertakes the supply of the sternal half of the district in its upper two thirds. By a bend analogous to that of the mammary cardiac it alters its original forwards and outwards direction into one forwards downwards and inwards; and its two main divisions, long parallel air-tubes, ultimately become vertical. From both divisions several short branches are distributed on both sides.

Inner, (v. daii) and Outer sterno-cardiac (v. daie).

The Inner Sterno-cardiac approaches the surface, and before bending downwards it gives an important outward rising T-shaped bronchus, **the Anterior Pericardial**, sufficiently described by its name.

Inner sterno-cardiac (vj. daiid). Anterior pericardial (vj. daiii).

Having reached the surface, the termination of the trunk divides into a **Superficial** and a **Deep Marginal Branch**, both of which end above the lower third of the cardiac district, at the sternal fringe.

Superficial, (vij.daiida) and Deep descending cardiac marginal (vij. daiidd).

The Outer Sterno-cardiac divides, at the same level as the preceding, into a superficial and a deep branch. Their position justifies their name of **Descending Cardiac Parasternals**; their distribution is parallel and external to that of the marginal branches.

Superficial, (vj. daiea) and Deep descending parasternal (vj daied).

Distribution of the Left Posterior-cardiac Trunk and of its Branches.

The Posterior-cardiac is a slightly larger trunk than the anterior cardiac; it forms the direct continuation of the cardiac stem. At first possessing some outward tendency, it subsequently moves forwards downwards and inwards, and for a length of 3 to 3·5 cm. carries no branches. Small bronchi are distributed by it to the posterior part of the cardiac district, in its middle third. But the two divisions arising from its main bifurcation are destined, as their name indicates, for the supply of the cardiac lobule.

A few millimetres above this bifurcation an important branch, **the Posterior Pericardial**, is given inwards, for the internal sub-pleural district facing the pericardium. This is a T-shaped bronchus, each of the arms of which also terminates with a T-shaped bifurcation. By its posterior extremity this small distribution is in relation with the inferior pulmonary vein, and no great interval separates it from the upper extremity of the inferior pericardial, a branch from the retro-cardiac trunk.

Posterior pericardial (iv. ddi). Posterior cardiac trunk (iv. dda).

Of the two lobular branches, **the Anterior Cardiac Lobular** becomes superficial at the lower third of the cardiac district and supplies part of its anterior surface. It provides an **Interlobar** branch outwards, for the septal surface, and several small lateral branches; and it splits up into an **Outer Anterior Lobular** and an **Inner Anterior Lobular**.

Anterior, (v. ddaa) and Posterior cardiac lobular (v. ddad).

Inner, (vij. ddaadi) and Outer anterior lobular (vij. ddaade).

The Posterior Cardiac Lobular likewise supplies a T-shaped **Interlobar** branch, which faces the cardio-basic trunk beyond the septum, and several short lateral branches. It also furnishes two good-sized posterior branches for the thin posterior edge of the lobular district. It terminates in an **Anterior** and a **Posterior Deep Lobular Division.**

Anterior, (vij. ddaddd) and Posterior deep lobular (vij. ddaddp).

THE POSTERIOR-HORIZONTAL REGION.

Preliminary Remarks.

Special features. Although not constituting in either lung a separate lobe, this distribution presents well-marked individuality. The following features will be easily recognized in the bronchial cast, or in dissections of the bronchial tree.

Shape not pyramidal. (1) The posterior-horizontal distribution is more conspicuous for lateral expansion than for depth. The terms "wedge" and "pyramid" which are suitable terms of comparison for the description of most dichotomous systems, are not here applicable owing to the relative width and thinness of the pulmonary slice under consideration.

Bronchi parallel to surface. (2) The posterior-horizontal bronchi are singular among bronchi in being parallel to the free pulmonary surface which they supply, instead of approaching it either perpendicularly or at a high gradient.

Horizontal course and origin. At right angles with the inferior lobar bronchus. (3) These are also the only large trunks which originate horizontally. The right upper lobar bronchus does indeed become horizontal during its short course, but it is not horizontal at its origin. Again, the posterior-horizontal forms a right angle with the descending bronchial stem, and this right angle occurs within the sagittal plane, which is perpendicular to the tracheo-bronchial plane. (Be it stated at once, however, that the origin of the right posterior-horizontal is not purely dorsal, but partly lateral.)

Shortest among primary bronchi. (4) The posterior-horizontal is the shortest among the primary trunks: some of its branches are therefore brought into unusual proximity to the lower bronchial stem.

Trifurcation apparent only. (5) The apparent tripartite division of the left posterior-horizontal will be shown to be really a modified bifurcation, by contrasting with it the genuine bifurcation of the right posterior-horizontal.

Want of symmetry, owing to pulmonary artery. (6) In other respects also the right and the left bronchial distribution fall short of absolute symmetry. Owing to the proximity of the pulmonary artery the symmetry of these two districts suffers as much as that of the two upper lobes from the unequal behaviour of the right and left divisions of that vessel.

Even development of the left bronchial branches. (7) As a consequence of the "high" passage of the left pulmonary artery and of the vertical direction assumed by the left axillary-apical bronchus in connection with this high passage, the left posterior-horizontal district escapes being encroached upon, and preserves an evenness of development in its subdivisions, which distinguishes it alike from the right distribution and from all other bronchial districts.

The right distribution uneven.

(8) On the contrary the "inferior" passage of the right pulmonary artery, and the horizontal position of the right axillary trunk bring about the following departures from symmetry:

Right bronchus lower and inclined downwards.

(i.) The right posterior-horizontal trunk is absolutely lower, and in addition has a faint downward bias instead of the upward bias noticed on the left side;

Other irregularities.

(ij.) The upper part of the distribution is stunted, and the symmetry of branching lost;

(iij.) The mid-axillary trunk and distribution are deflected slightly downwards;

(iv.) The right ascending and descending mid-dorsal branches, instead of being oblique and far-reaching, as in the left lung, are vertical and comparatively short.

THE RIGHT POSTERIOR-HORIZONTAL DISTRIBUTION.

(This distribution may readily be studied in the diagram (fig. 9) and in fig. 11.)

Origin of this stem; its relations to the cardiac stem and bronchus intermedius.

General Observations.—The first large air-tube which is supplied to the lower lobe is the posterior-horizontal stem. It arises slightly below the level of the cardiac stem, from the posterior (and slightly lateral) aspect of the inferior lobar bronchus. The latter name becomes applicable to the continuation of the bronchus intermedius from the level of the cardiac stem downwards. But no appreciable vertical interval exists between the right cardiac and the right posterior-horizontal bronchial origins; and the right inferior lobar bronchus does not therefore, practically speaking, begin above the level of the posterior-horizontal, as in the left lung. For a short distance above the level in question the intermediate bronchial stem, as stated elsewhere (see p. 76), and as may be gathered from the diagram (fig. 9) and from fig. 11, &c., is surrounded posteriorly by the pulmonary tissue of the inferior lobe; but its anterior surface is not buried within the latter, nor in the pulmonary tissue of the middle lobe, but corresponds to the bottom of the transverse fissure. This fact may be demonstrated by raising the overhanging flap of the upper lobe. For a distance of 3 cm. downwards from the same level, the lower lobar bronchus bends very slightly backwards previous to breaking up into the basic branches.

Relations of bronchus intermedius to the three pulmonary lobes.

Inferior lobar stem.

Situation and shape of the district.

The posterior-horizontal distribution corresponds in both lungs to the upper posterior and to the upper lateral part of the lower lobe. In the right lung it forms an horizontal elongated zone bevelled anteriorly. The dorsal part of this zone is supplied by the posterior-horizontal branch of the stem, the remainder by its mid-axillary horizontal branch.

Posterior-horizontal stem (iij. dp).

Mid-axillary horizontal (iv. dpe). Posterior-horizontal (iv. dpp).

The Posterior-horizontal Stem is remarkably short (only 0·6 cm.) and stout, being almost equal in diameter to the cardiac stem. Its direction is backwards and outwards. But this becomes converted, after bifurcation, into the outward direction and gentle downward slope of the *deep mid-axillary horizontal* trunk, which is destined for the middle third of the axillary region.

The rather smaller *posterior-horizontal* division, measuring only 6 mm. in length, arises straight backwards, with very slight upward tendency: it will be described further down. Its horizontal and ascending branches occupy a higher level than the branches from the mid-axillary horizontal: this circumstance gives rise to the downward and forward slope of the interlobar surface.

Right Mid-axillary Horizontal Distribution.

Horizontal or central axillary interlobar (v. dpea). Mid-axillary horizontal (v. dpee).

The undivided portion of the **Mid-axillary Horizontal** trunk measures 1 cm. in length. A slight curvature modifies its direction to one outwards and slightly downwards and forwards. Remaining within the plane of the previous bifurcation, it divides into the continuation of the same trunk, and into a smaller but important bronchus, the **Central or Horizontal Axillary Interlobar.** This bronchus advances straight forwards, almost vertically beneath the descending axillary interlobar from the axillary trunk, but at a much lower level than that branch, and terminates in two small branches fashioned to the respective surfaces of the upper and of the middle lobes, which they are destined to face.

Superior mid-axillary bronchus (vj. dpeee). Inferior mid-axillary bronchus (vj. dpeed).

A little further the mid-axillary horizontal gives rise to a *superior* (slightly anterior) *division* which follows the original direction and into an *inferior* (somewhat posterior) *division.* Both are distributed to the axillary region.

Superior mid-axillary (vij. dpeeee). Axillary mammary (vij. dpeeea).

The length of the **Superior Mid-axillary** bronchus is 1·5 cm. Its divisions are—an upper posterior and a lower anterior branch, termed respectively the *superior mid-axillary* and the **Axillary Mammary.** They are distributed to the districts indicated by their names.

Lower mid-axillary (vij. dpeede). Posterior horizontal axillary (vij. dpeedp).

The length of the **Inferior Mid-axillary** is 1·7 cm., and its direction outwards and downwards. It supplies a small **Central Descending Branch** to the space situated above the unbranched origin of the large basic bronchi; and it divides into the **Lower Mid-axillary** which is distributed below the superior mid-axillary; and into the **Posterior-horizontal Axillary** branch which bifurcates repeatedly and supplies the lower part of the middle third of the posterior axillary region.

The general drift of the mid-axillary distribution is slightly downwards and outwards. In the left lung this distribution rises much higher, not being materially curtailed by the great fissure, thanks to the almost vertical slant of the latter; but it also remains more posterior than in the right lung.

FIG. 11.

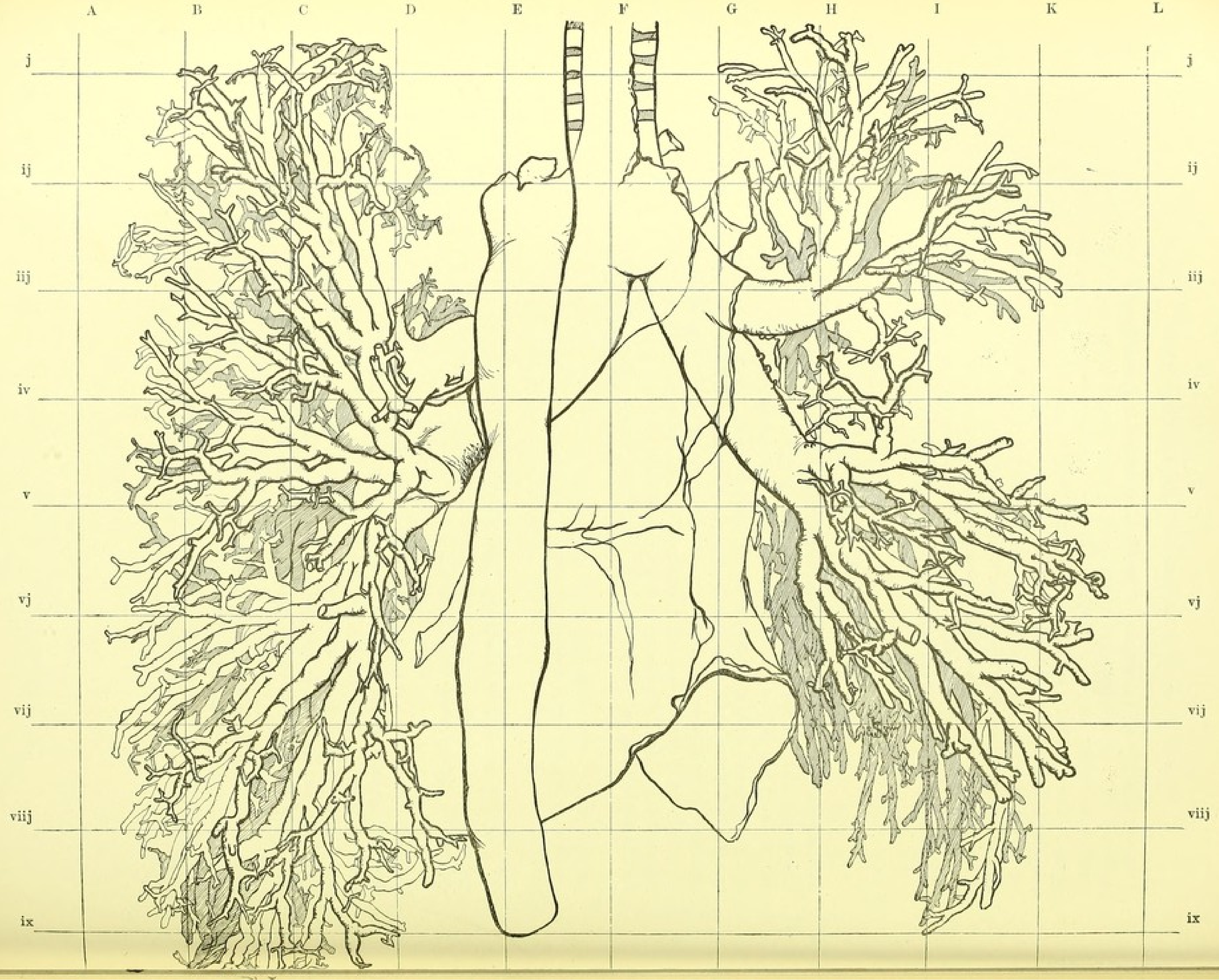


FIG. 11.

DRAWING FROM A METALLIC CAST OF THE BRONCHIAL TREE; POSTERIOR VIEW.

(As in fig. 10, the side of each square represents 20 mm.)

The outlines of several of the bronchial tubes have been interrupted, in order to show underlying parts.

EXPLANATION OF THE DRAWING.

1. MEDIASTINAL STRUCTURES.

The aorta, and its large branches, the vena azygos (divided and raised), the trachea and its bifurcation, the main bronchi and bronchus intermedius, the pericardium, and the cut edge of the pleura indicating the line of reflection of that membrane, will be all readily identified. Some of the pulmonary vessels, divided near their origin, are shown in squares G iv, G v, G vj and D vij. Square D iv is occupied by the descending portion of the arch of the left pulmonary artery and by the origins of its upper branches.

2. RIGHT BRONCHIAL TREE.

UPPER LOBE:

The shaded tubes belong to the distribution of the pectoral stem.

At intersection H iij the upper lobar, or pectori-apical stem divides into the ascending-apical, and the axillary trunks.

In square G iij the tracheal-apical diverges from the anterior ascending-apical, and ends, higher up, in the shape of a pitch-fork.

In square H ij the short posterior-apical (from the posterior ascending-apical) bifurcates into the posterior tracheal, (which covers the origin of the anterior inner-apical and of the superficial anterior-apical) and into the apical-supra-spinate. The axial-apical rises boldly in the same square.

In square H iv the central axillary interlobar bronchus faces the branches of the vertical ascending mid-dorsal.

In squares H iij and I iij are seen the axillary bronchi, and the stronger outlines of the retro-axillary branches.

LOWER LOBE:

The cardiac and the anterior-basic bronchi are shaded.

In square H v the superficial posterior-horizontal gives its vertical descending and its horizontal mid-dorsal branches; the deep posterior-horizontal bifurcates into its superior and inferior mid-axillary bronchi.

In squares G vj and H vj respectively originate the retro-cardiac and the lesser posterior-horizontal trunks.

In squares K vij and I ix are seen the terminal branches of the axillary-basic. The remaining non-shaded bronchi belong to the posterior-basic stem.

3. LEFT BRONCHIAL TREE.

UPPER LOBE:

The pectoral and the anterior ascending-apical bronchi are shaded.

In square D v, near intersection D iv, the small ascending aortic bronchus, and the descending pulmonary artery partly conceal the bronchus impar and its bifurcation (also hidden by the ascending mid-dorsal oblique). The cardiac division is shaded.

In square C iv the apparent trifurcation gives rise to the ascending-apical stem (the posterior division of which, alone, is seen), and by a common rudimentary stem to the axillary, and posterior axillary stems.

In square C iij the latter divides into posterior-apical and mid-apical; and the posterior-apical bifurcates into an outer and an ascending branch.

LOWER LOBE:

Horizontal column v contains the superior and the inferior mid-axillary horizontal distributions (arising from the deep posterior-horizontal) and the diverging mid-dorsal oblique divisions from the rudimentary superficial trunk.

Square C vj displays the apparent trifurcation into anterior-, axillary-, and posterior-basic stems and the origin of the small lesser posterior-horizontal.

Square C vij contains the descending oblique dorsal, and the dorsi-basic divisions of the posterior-basic; also the inferior descending aortic trunk.

Square C ix shows, in faint outline, the posterior inner angular branches, and the bolder lines of the superficial dorsi-basic bronchi.

Right Superficial Mid-dorsal Distribution.

The two divisions from the superficial horizontal are at right angles to each other, one being vertical, the other horizontal and transverse. Both these directions are also perpendicular upon the sagittal direction of the parent trunk. They are brought about by means of the rectangular curve exhibited by each of the bronchi in question at its origin. The *horizontal mid-dorsal* trunk distributes branches to the upper part of the mid-dorsal district; the *vertical descending mid-dorsal*, to the lower part.

Horizontal mid-dorsal (v. dppe). Vertical decending mid-dorsal (v. dppd).

The Horizontal Mid-dorsal Trunk, after a brief course of 6 mm., gives off by bifurcation the *vertical ascending mid-dorsal*, for the supply of the posterior upper fringe of the lower lobe; and continuing horizontally outwards for 2·5 cm., bifurcates into an *upper* and a *lower* branch which supply the upper half of the middle third of the posterior axillary region (the lower half being supplied by a posterior branch from the mid-axillary horizontal).

Horizontal mid-dorsal (vj. dppee). Vertical ascending mid-dorsal (vj. dppes).

Interlobar branch (vij. dppeea). Horizontal mid-dorsal (vij. dppeee).

Upper branch. Lower branch.

The Vertical Ascending Mid-dorsal gives up, by bifurcating almost immediately, a **Mid-dorsal Interlobar Bronchus.** A short distance further down arises from the same trunk, upwards and outwards, the **Ascending Oblique Dorsal,** which supplies the outer part of the posterior-upper fringe. Finally the vertical ascending mid-dorsal divides into two terminal lateral branches, provided with branchlets, for the respective supply of the anterior and of the posterior aspect of the thin pulmonary edge.

Mid-dorsal interlobar (vij. dppesa). Vertical ascg. mid-dorsal (vij. dppess).

A similar *interlobar branch* also arises from the horizontal mid-dorsal bronchus prior to its final bifurcation.

Ascending oblique dorsal (viij. dppesse). Vertical ascg. mid-dorsal (viij. dppesss).

The Vertical Descending Mid-dorsal does not exceed 6 mm. in length. It presents considerable analogy with the vertical ascending mid-dorsal. It bifurcates into a *small* anterior branch, **the Deep Descending Mid-dorsal,** which approaches the posterior aspect of the lower lobar bronchus, and into **the Superficial Descending Mid-dorsal,** in continuation of the original direction. The latter divides into a small **Mid-dorsal Vertebral Marginal,** of T shape, and into the **Mid-dorsal Oblique.** This branch curves downwards and outwards and bears small superficial branches at a distance of 2–3 cm. below the horizontal mid-dorsal.

Vertical descending mid-dorsal (v. dppd).

Superficial descending mid-dorsal (vj.dppdd). Deep desceg. mid-dorsal (vj. dppde).

The dorsal part of the posterior-horizontal distribution is much more restricted than in the left lung. It does not extend upwards as high as the level of the upper lobar bronchus, and inferiorly it is curtailed owing to the powerful development of the lesser horizontal mid-dorsal, a branch which, in the left lung, is of insignificant size.

Mid-dorsal inner marginal (vij. dppddi). Mid-dorsal oblique (vij. dppdde).

TABLE IV.—LEFT POSTERIOR-HORIZONTAL DISTRIBUTION.

LEFT LOWER LOBAR BRONCHUS.

- POSTERIOR-HORIZONTAL STEM (ii. p).
  - RUDIMENTARY SUPERFICIAL HORIZONTAL TRUNK (iij. pp).
    - ASCENDING MID-DORSAL OBLIQUE (iv. pps).
      - ASCENDING AORTIC (v. ppss).
        - T-SHAPED POSTERIOR BRANCH (vj. ppssp).
        - ASCENDING AORTIC (vj. ppsss).
      - ASCENDING MID-DORSAL OBLIQUE (v. ppse).
        - UPPER ASCENDING SUB-SCAPULAR (vj. ppses).
          - MARGINAL BRANCHES.
        - LOWER ASCENDING SUB-SCAPULAR (vj. ppsee).
          - DORSAL BRANCHES.
    - DESCENDING MID-DORSAL OBLIQUE (iv. ppd).
      - DESCENDING AORTIC (v. ppdd).
        - DESCENDING AORTIC (vj. ppddd).
          - INTERNAL BRANCH.
          - EXTERNAL BRANCH.
        - T-SHAPED SUB-PLEURAL BRANCH (vj. ppddp).
      - DESCENDING MID-DORSAL OBLIQUE (v. ppde).
        - HORIZONTAL SUPPLEMENTAL (vj. ppdee).
        - OBLIQUE BRANCH (vj. ppded).
  - DEEP POSTERIOR HORIZONTAL TRUNK (iij. pe).
    - SUPERIOR MID-AXILLARY HORIZONTAL (iv. pea).
      - ANTERIOR SUPERIOR MID-AXILLARY HORIZONTAL (v. peae)
        - TERMINAL BRANCH.
        - INTERLOBAR BRANCH.
      - POSTERIOR SUPERIOR MID-AXILLARY HORIZONTAL (v. peas).
        - TERMINAL BRANCH.
        - INTERLOBAR BRANCH.
    - INFERIOR MID-AXILLARY HORIZONTAL (iv. pep).
      - ANTERIOR INFERIOR MID-AXILLARY HORIZONTAL (v. pepd).
        - INTERLOBAR BRANCH (vj. pepde).
        - TERMINAL BRANCHES (vj. pepda).
      - POSTERIOR INFERIOR MID-AXILLARY HORIZONTAL (v. pepe).
        - POSTERIOR INFERIOR MID-AXILLARY HORIZONTAL (vj. pepee).
        - OBLIQUE DESCENDING (vj. peped).
- Lower bronchial stem (ij. d).
  - Anterior-basic stem (iij. da).
    - Mammary-basic.
    - Cardio-basic trunk.
      - Retro-cardiac trunk.
      - Cardio-basic trunk.
  - Lower bronchial stem (iij. d).
    - Axillary-basic.
    - Dorsi-basic trunk.
      - Inferior posterior-horizontal.
      - Dorsi-basic trunk.

TABLE IV.—RIGHT POSTERIOR-HORIZONTAL DISTRIBUTION.

RIGHT LOWER LOBAR BRONCHUS (ij. d).

- Posterior-horizontal trunk (iij. dp).
  - Short superficial posterior-horizontal trunk (iv. dpp).
    - Vertical descending mid-dorsal (v. dppd).
      - Superficial descending mid-dorsal (vj. dppdd).
        - Mid-dorsal oblique vij. dppdde).
        - Mid-dorsal inner marginal (vij. dppddi).
      - Deep vertical descending mid-dorsal (vj. dppda).
    - Horizontal mid-dorsal (v. dppe).
      - Vertical ascending mid-dorsal (vj. dppes).
        - Mid-dorsal inter-lobar (vij. dppesa).
          - Inner terminal.
          - Outer terminal.
        - Vertical ascending mid-dorsal (vij. dppess).
          - Ascending oblique dorsal (viij. dppesse).
          - Vertical ascending mid-dorsal (viij. dppesss).
            - Inner terminal.
            - Outer terminal.
      - Hori-zontal mid-dorsal (vj. dppee).
        - Inter-lobar (vij. dppeed).
        - Hori-zontal mid-dorsal (vij. dppeee).
          - Upper branch (for mid-axillary region).
          - Lower branch.
  - (Deep) mid-axillary posterior-horizontal (iv. dpe).
    - Central axillary interlobar (v. dpea).
    - Mid-axillary horizontal (v. dpee).
      - Superior mid-axillary (vj. dpeee).
        - Upper mid-axillary bronchus (vij. dpeeee).
        - Mammary axillary bronchus (vij. dpeeea).
      - Inferior mid-axillary (vj. dpeed).
        - Posterior-horizontal axillary (vij. dpeedp).
        - Lower mid-axillary (vij. dpeede).
- Lower bronchial stem (iij. dd).
  - Retro-cardiac trunk (iv. ddi).
  - Lower bronchial stem (iv. ddd).
    - Anterior-basic stem (v. ddda).
    - Lower bronchial stem (v. dddd).
      - Inferior posterior-horizontal (vj. ddddp).
      - Lower bronchial stem (vj. ddddd).
        - Axillary-basic stem (vij. dddddd).
        - Dorsi-basic stem (vij. dddddp).

N.B.—The meaning of the letters used as notation is explained on page 88.

THE LEFT POSTERIOR-HORIZONTAL DISTRIBUTION.

(For a study of this distribution consult the diagram (fig. 9) and fig. 11.)

General Survey of the District.

Differences between right and left. Symmetrical development. Horizontal extension and oblique extension of the bronchial tubes. Ascending and descending mid-dorsal oblique bronchi. Relative extent of the district. Its varying thickness. Upper and lower edge.

Viewed from behind, this distribution presents considerable symmetry. It consists of *a horizontal portion* which extends, with widening area, from the parent stem near the vertebral border to the upper part of the second third of the axillary and of the posterior axillary space; and of *a dorsal portion* represented by two long oblique branches. These arise from the same trunk as the horizontal bronchus, but from its posterior aspect, and equally diverge from the latter. Their own total divergence slightly exceeds 90°. By their branches, which are remarkably symmetrical, the ascending and descending mid-dorsal oblique bronchi form the vertebral border and aërate the posterior surface of the two middle fourths of the lung. In other words they span posteriorly the upper $\frac{2}{3}$ of the lower lobe, and they extend from the axillary line to the aortic border of the lung. The thin upper edge of the lower lobe and more than the upper $\frac{1}{3}$ of the same are exclusively supplied by branches from this distribution. The latter gains in thickness from above downwards, as far as the anterior horizontal axillary branch. This is the level of its maximum thickness, below which it wastes to a thin inferior edge. At this lower level the lateral branches from the basic trunks undertake, more anteriorly, the chief share in the bronchial supply.

The Bronchial Supply to the District.

Posterior-horizontal stem (ij.p). Relations to the pulmonary edge and fissure, to the aorta and left pulmonary artery, &c.

The left posterior-horizontal, a short and thick stem, possesses interesting anatomical relations. *Mesially* it lies close to the vertebral border of the lung and to the adjacent descending aorta; *anteriorly* it is in contact with the descending trunk of the pulmonary artery which separates it from the bronchus impar, or left upper lobar bronchus. The latter is situated more anteriorly and 0·9 cm. higher; whereas, in the right lung, the difference in level between the corresponding two bronchi is 3·25 cm. From *above* it is approached by the almost vertical interlobar fissure, from which it is separated by the descending pulmonary artery—and more internally by the end of the arch of the left pulmonary artery where the latter breaks up into descending pulmonary artery and into its apex-branches.

Deep posterior-horizontal (iij. pe). Rudimentary superficial posterior-horizontal' (iij. pp).

The thickness of the tube is considerable in proportion to its small length of only 8 mm.; but its diameter is abruptly bisected into an anterior and a posterior half. The anterior half only is continued as a single tube as "*deep posterior-horizontal trunk.*" The posterior half subdivides on the spot, and without the intervention of an internodium, into the *ascending* and *descending mid-dorsal oblique* bronchi.

Ascending mid-dorsal oblique (iv. pps). Descending mid-dorsal oblique (iv. ppd). Apparent trifurcation; test for its spuriousness. Analogy from the right lung.

This is probably the most perfect instance of an apparent, but spurious bronchial trifurcation to be found in the human lung. The real nature of the division is revealed by the following test. When viewed exactly from behind, the dividing tube does not present a continuous tripartite stellate line of intersection, but two separate lines, mutually perpendicular, and situated at separate levels. Analogy also strongly points to the conclusion that this is merely a double bifurcation. In the right lung, the diverging bronchi, which are vertical instead of oblique, arise, by bifurcation, from a definite stem capable of being measured. If from some cause, say from a more posterior position and greater length of the posterior-horizontal stem analogous to what is seen in the left lung, the trunk in question had, on the right side, become reduced to rudimentary proportions, the two bifurcations which are in the right lung quite distinct, and separated by an internodium, might, in this lung also, have become contiguous or even confluent.

Left Oblique Mid-dorsal Distribution.

Fan-shape,

Unlike the anteriorly placed deep posterior-horizontal, which divides, after a branchless course, into secondary trunks opposite the wide aperture of the angle formed by the divergence of the oblique mid-dorsal trunks, the latter distribute peripheral branches very early (within 2 or 3 cm. from the angles). Viewed from behind, the cast of this symmetrical angular distribution, filled in at the periphery by the later branching of the deep trunk, closely resembles an expanded lady's fan, the fully extended sides occupying the vertebral border, and the knob-like handle being represented by the posterior-horizontal stem itself.

and imbrication of this distribution.

It results from the posterior position of their origin and from their slight forward inclination that the oblique mid-dorsal trunks and divisions form from behind an imbrication for other dorsal bronchi, especially for the more anteriorly placed horizontal group, for the small inferior mid-dorsal horizontal and for the early divisions of the posterior-basic stem.

Ascending oblique mid-dorsal (v. ppse). Ascending aortic (v. ppss).

The Ascending Oblique Mid-dorsal Trunk slants upwards in a line which would probably, if continued, touch the acromion or the coracoid process; and under cover of the scapula it bifurcates into branches which supply the upper fringe of the lower lobe and terminate below the lower posterior border of the pulmonary apex. Previously, however, at a distance of 6 mm. from its origin, the trunk supplies an *ascending aortic bronchus* which rises vertically along the aortic border of the lung. The first part of this tube is visible in fig. 11, but as in many other cases, the bronchus has been interrupted in the drawing in order to display other structures. With these exceptions the whole posterior-horizontal distribution is well shown in fig. 11.

By means of anterior and of posterior branchlets the vertical **Ascending Aortic Trunk** supplies the sub-pleural surface facing the first part of the

Ascending aortic (vj. ppsss). Posterior sub-pleural branch (vj. ppssp).

descending aorta, and also comes into relation with the posterior aspect of the arch and of the descending division of the left pulmonary artery. Lying behind, and parallel to the ascending-apical stem, it forms the posterior boundary of the broad quadrilateral inter-bronchial space which constitutes the vertebral end of the interlobar space. A T-shaped **Posterior Sub-pleural** branch is supplied backwards by the ascending aortic, close to its origin.

The continuation of the *ascending oblique mid-dorsal* bifurcates, 2 cm. beyond its origin, into the *upper* and *lower ascending sub-scapular bronchi*.

Upper ascending sub-scapular (vj. ppses). Lower ascending sub-scapular (vj. ppsee). Short sub-pleural dorsal branches.

No departure from the original direction is made by the **Upper Oblique Sub-scapular** which gives upwards and forwards an interlobar branch (opposite the axillary interlobar) and bifurcates into marginal branches which terminate just below the middle of the posterior surface of the pulmonary apex, forming the fringe of the lower lobe in this situation.

The Lower Ascending Sub-scapular slopes rather less steeply upwards and outwards and gives posteriorly three successive short sub-pleural branches.

Descending oblique mid-dorsal (iv. ppd).

The Descending Oblique Mid-dorsal forms with its fellow-branch an angle of 110°. It has an unbranched length of 1·2 cm. only. Its bifurcation gives rise to the *descending aortic bronchus* which follows vertically the inner border of the lung.

Descending aortic (v. ppdd). Descending oblique mid-dorsal (v. ppde).

In close analogy with the ascending aortic, the **Descending Aortic** yields a T-shaped **Sub-pleural Dorsal** branch, and its continuation bifurcates just behind the origin of the lesser posterior-horizontal into two small *terminal bronchi, external* and *internal*, which bear deep branches as well as superficial dorsal ones.

T-shaped dorsal ranch (vj. ppdep.) Descending aortic (vj. ppded).

The continuation of the descending oblique mid-dorsal supplies upwards and outwards a small **Horizontal Sub-pleural** bronchus which distributes sub-pleural branches to the district contained in the great angle, and a *descending oblique bronchus* which supplies an anterior and a posterior branch and ends with a terminal fork immediately behind the level of the *inferior dorsal horizontal* bronchus.

Descending oblique (vj. ppded). Horizontal sub-pleural (vj. ppdee).

Left Mid-axillary Horizontal Distribution.

Superior mid-axillary horizontal (iv. pea). Inferior mid-axillary horizontal (iv. pep).

Of the two divisions from the *deep posterior-horizontal stem*, a short trunk measuring 1·2 cm. in length, the **Superior Mid-axillary Horizontal** not only is the higher but also, slightly, the anterior. It bifurcates, after a course of 8 mm., into a *posterior* and an *anterior upper mid-axillary horizontal* branch, which present very little divergence from the horizontal direction. Each of these delivers, close to its origin, an interlobar branch directed forwards.

Anterior superior mid-axillary hori-

The Posterior Upper Mid-axillary rises slightly outwards, and supplies to the posterior surface two small branches. It is situated at a slightly higher level than its fellow-branch. The branches of its terminal distribution are on a level with those of the outer pectoral bronchus, and would dove-tail with the latter, but for the intervening fissure.

zontal (v. peae). Posterior superior mid-axillary horizontal (v. peas).

The *anterior upper mid-axillary*, inferior to the preceding, and horizontal, is on a level with the angle of origin of the pectoral and cardiac bronchi, and reaches the surface at the mid-axillary line, or a little in advance of this line, opposite the interval between the outer pectoral distribution above, and the outer mammary distribution below.

The Inferior Mid-axillary Trunk, which is, in direction, slightly posterior, likewise divides into a *posterior inferior mid-axillary horizontal* and an *anterior inferior mid-axillary horizontal*.

Inferior mid-axillary horizontal (iv. pep).

The Posterior Inferior Mid-axillary Division is horizontal, and after a course of 1·6 cm., gives by bifurcation an **Oblique Descending Branch**. It finally bifurcates, in company with, and a little above the latter, at the mammary level, in the transverse posterior axillary vertical plane.

Posterior inferior mid-axillary horizontal (v. pepe). Anterior inferior mid-axillary horizontal (v. pepd).

Before finally bifurcating each of these tubes gives a **Sub-pleural Dorsal** and a small **Deep Dorsal Branch**.

The **Anterior Inferior Mid-axillary Horizontal** assumes a downward and forward direction: it approaches the septal surface to which it distributes two **Interlobar Branches**. Its terminal branches reach the axillary surface behind the mammary distribution.

Posterior inferior mid-axillary horizontal (vj. pepee). Descending oblique (vj. peped).

Anterior inferior mid-axillary horizontal (vj. pepda). Interlobar branches (vj. pepde).

THE RETRO-CARDIAC DISTRICT.

Preliminary Remarks.

Situation.

The district included between the downward and outward slope of the three basic bronchi and the posterior part of the inner surface of the lung is termed the retro-cardiac district and the bronchus supplying this district, the *retro-cardiac stem*. In the right lung this district is more extensive than in the left, and it includes the inner posterior corner of the base. In the left lung it is limited to the region first mentioned.

District larger in right than in left lung.

The bronchus, termed by Aeby "cardiac."

The right retro-cardiac stem was termed by Aeby the cardiac stem, a name more appropriately reserved for the right middle lobar bronchus, and for its left equivalent. Arising strictly from the inner surface of the lower lobar bronchus, it could find no place in the classification of bronchi into ventral and dorsal: it was therefore described by Aeby as an accessory bronchus. This designation is misleading;—it is fortunately unnecessary in the nomenclature here adopted.

The existence of a retro-cardiac stem in the left lung appears to have been overlooked by Aeby. In this lung it is not a primary, but a tertiary branch from the lower lobar bronchus, arising not above the origin of the anterior-basic stem as in the right lung, but from the cardio-basic branch of this stem.

THE RIGHT RETRO-CARDIAC DISTRICT.

(In connection with the description which follows, the diagram (fig. 9) and fig. 11 (columns G and H, between horizontal lines v and vij) should be consulted.)

Retro-cardiac stem (iv. ddi).

Anterior retro-cardiac (v. ddie).

Posterior retro-cardiac (v. ddip).

The Retro-cardiac Stem is rather smaller in calibre than the posterior-horizontal. It runs a vertical course, with slight inward convexity, for a distance of 1·5 cm., and then bifurcates into *the anterior and the posterior retro-cardiac*. It originates from the inner surface of the lower lobar bronchus, mid-way between the origin of the posterior-horizontal and that of the inferior posterior-horizontal.

Anterior retro-cardiac (vj. ddied).

Posterior pericardial (or retro-pericardial) (vj. ddiei).

The Anterior Retro-cardiac assumes a thoroughly downward and outward direction under the influence of the neighbourhood of the pericardium. After a course of 1·3 cm. it gives up inwards an important subpleural branch of bifurcation, the **Posterior Pericardial** a **T**-shaped bronchus extending its branches upwards and downwards in rectilinear order.

The continuation of the anterior retro-cardiac supplies a deep external branch for the tissue of the lower lobe, and ends by bifurcation for the supply of the inner surface and of the underlying pulmonary tissue of the base.

The Posterior Retro-cardiac, whilst remaining in the original sagittal plane, swerves backwards, with anterior concavity, so as to be slightly posterior to the pericardium. Posterior retro-cardiac (v. ddip).

It divides into an outer, deep; and an inner sub-pleural branch. The latter is analogous to, but smaller than, the posterior pericardial,—the outer branch, or continuation of the posterior pericardial, is distributed in a manner analogous to that of the anterior retro-cardiac bronchus. Inner, sub-pleural: Outer, deep branch.

LEFT RETRO-CARDIAC DISTRIBUTIION.

The Left Retro-cardiac Stem, not originating directly from the lower lobar bronchus, would not be included in a nomenclature confined to the consideration of the primary bronchial branches. In size however there is little to choose between this bronchus and the right retro-cardiac, which is a primary division;—and the pulmonary district on the left side is but little smaller than that on the right. We are therefore justified in undertaking their description in this place. Retro-cardiac stem (v. dadp).

The *ascendants* from the bronchus in question are (1) the cardio-basic stem, (2) the anterior-basic or cardio-mammary basic stem and (3) the lower bronchial stem.

Its *descendants* may be described as follows: **The Retro-pericardial** arises inwards within a few millimetres of the origin of the stem. Its two branches, anterior and posterior, descend at an acute angle. It is not therefore a T-shaped bronchus such as the posterior pericardial which is to be seen, in the metallic cast, a little above it, or as the pericardial branch from the descending aortic bronchus behind. At a distance of 1·5 cm. from its origin, the retro-cardiac stem subsequently divides into **Superficial and Deep Retro-cardiac Bronchi.** Retro-cardiac stem (vj.dadpd). Inferior posterior pericardial (or retro-pericardial) (vj. dadpi).

Both these air-tubes acquire considerable length, and, like their parent trunk, present some undulation. The superficial trunk is also anteriorly placed. They each divide into an anterior and a posterior branch. Superficial retro-cardiac (vij. dadpdi). Deep retro-cardiac (vij. dadpdd).

The anterior division from the *superficial retro-cardiac* is long and extends to the anterior lower border of the lower lobe, to a point situated 2 cm. above the anterior-basic angle: the posterior branch is much shorter. In the case of the deep retro-cardiac the conditions are reversed. The posterior branch is here the longer of the two, although it does not quite reach the vertebral border of the lung; the inner or deep branch is shorter. From each of these an anterior and a posterior branch;

Both trunks supply short outward branches for the deep pulmonary tissue, and the superficial retro-cardiac also furnishes a small sub-pleural branch resembling the retro-pericardial branch. and intra-pulmonary branchlets.

TABLE V.—LEFT RETRO-CARDIAC DISTRIBUTION.

SHORT INNER OR DEEP BRANCH. LONG POSTERIOR BRANCH.

SHORT POSTERIOR BRANCH. LONG ANTERIOR BRANCH.

(DEEP PULMONARY BRANCHLETS.)

(SUB-PLEURAL AND DEEP PULMONARY BRANCHLETS.)

Anterior TERMINAL. Posterior TERMINAL.

DEEP RETRO-CARDIAC (vij. dadpdd).

SUPERFICIAL RETRO-CARDIAC (vij. dadpda).

RETRO-PERICARDIAL BRONCHUS (vj. dadpi).

RETRO-CARDIAC TRUNK (vj. dadpd).

RETRO-CARDIAC TRUNK (v. dadp).

Cardio-basic trunk (v. dadd).

Cardio-basic trunk (iv. dad).

Mammary-basic trunk (iv. daa).

Dorsi-basic trunk (iv. ddp).

Axillary-basic trunk (iv. dde).

Anterior-basic trunk (iij. da).

Lower lobar stem (iij. dd).

Posterior-horizontal stem (ij. p).

Lower lobar stem (ij. d).

LEFT LOWER LOBAR BRONCHUS.

TABLE V.—RIGHT RETRO-CARDIAC DISTRIBUTION.

RIGHT LOWER LOBAR BRONCHUS
(ij. d).

- Posterior-horizontal stem (iij. dp).
- Lower bronchial stem (iij. dd).
  - RETRO-CARDIAC TRUNK (iv. ddi).
    - ANTERIOR RETRO-CARDIAC (v. ddie).
      - RETRO-PERICARDIAL (vj. ddiei).
        - ASCENDING TERMINAL.
        - DESCENDING TERMINAL.
      - ANTERIOR RETRO-CARDIAC (vj. ddied).
        - SUPERFICIAL BRANCH (vij. ddiedd).
          - ANTERIOR TERMINAL.
          - POSTERIOR TERMINAL.
        - DEEP BRANCH (vij. ddiede).
    - POSTERIOR RETRO-CARDIAC (v. ddip).
      - INNER SUB-PLEURAL (vj. ddipi).
        - ANTERIOR TERMINAL.
        - POSTERIOR TERMINAL.
      - POSTERIOR RETRO-CARDIAC (vj. ddipd).
        - ANTERIOR BRANCH.
        - POSTERIOR BRANCH.
  - Lower bronchial stem (iv. ddd).
    - Anterior-basic trunk (v. ddda).
    - Lower bronchial stem (v. ddde).

N.B.—The meaning of the letters used as notation is explained on page 88.

THE BASIC REGION.

REMARKS CONCERNING THE RIGHT AND THE LEFT PULMONARY BASE.

The base a conventional term,

The "Pulmonary Base" is an imaginary division of the lung, usually described for clinical rather than for anatomical purposes, and not corresponding to any outward line of separation, or to any perceptible landmark at the pulmonary surface. In spite of this absence of any delimitation, we all agree in understanding by the term "base" the broad lower extremity of the lung, including its inferior third. On each side the "base" mainly consists of part of the lower lobe, and, in speaking of the "pulmonary base," most clinical observers probably have in their mind the "base of the lower lobe" only. Yet the lower horizontal third or even fourth of the lung comprises part of another lobe, the middle lobe in the right, the upper lobe in the left lung. These lobes reach as far as the anterior pulmonary basic edge, which in varying proportions they help to form. The bronchial and the vascular supply of these inferior segments of lobes which are mainly situated higher up, have nothing in common with the bronchi and blood-vessels of the base of the inferior lobes, and we may, at any rate for the present, leave the higher lobes entirely aside.

usually means lower part of lower lobe.

The term justified by the shape of the district,

Turning to the bronchial tree as shown in the metallic cast, and confining our attention to the lower lobes, we discover both in the shape and in the mode of the bronchial distribution some justification for the use of the term base. **The Shape** of the bronchial district in question is analogous to that of the lower part of the lower lobe itself, which is described in the introductory section as roughly resembling the lateral half of an inverted cone.

and by its possessing special bronchi, the three basic trunks.

The Bronchial Supply to the lower horizontal third of the lower lobe is mainly derived from the three large terminal trunks of the bronchial system. These define the "base" as a special region in the bronchial tree, with much greater precision than this can be done from ordinary anatomical or clinical considerations. I therefore submit that they can, with great propriety be termed the three "basic bronchi." I have distinguished them as the anterior-basic, the axillary-basic, and the posterior-basic stems. To their number, as contributing to the basic supply, might also be added a fourth, the inferior, or lesser posterior-horizontal bronchus. The retro-cardiac distribution, which

The lesser posterior-horizontal,

has already been described, should also be mentioned as taking a share in the aëration of the base, although its origin which differs in the two lungs, is only in the left lung truly basic. The relations of these several tubes, on the right and on the left side, are very clearly shown in the drawing (fig. 11) representing the posterior aspect of the metallic bronchial cast.

and the retro-cardiac also assist.

General Survey of the Bronchial System of the Right Base.

Relative Situation of Aeby's "Bronchial Stem."—The "bronchial stem" described by Professor Aeby coincides, in its lower part, with the posterior-basic stem, and ends in one of the branches of the latter. Assuming for a moment the correctness of Aeby's views, which I have ventured to criticize in the introductory section, and the existence of a "bronchial stem," of which there seems to be insufficient evidence in man, I would point out that the "bronchial stem" would, at no part of its length, become anterior to the plane of the trachea; but would preserve to the last the outward and downward slope which eventually carries its termination into a position entirely posterior to the plane of the trachea. The same observation would also apply to the left "bronchial stem."

The "bronchial stem" never anterior, ultimately posterior to tracheal plane.

This difference in planes may be partly ascribed to the influence of the thickness of the bodies of the vertebræ which keeps the trachea well in front of the posterior thoracic plane, partly to that of the concavity of the posterior part of the thoracic cavity, which permits the lung to extend backwards.

Reasons why.

Relative Position of Basic Trunks.—Thus, at the base, the downward continuation of the main bronchus is decidedly posterior to the tracheal plane, and posterior also to the bulk of the lung. Indeed the only bronchi which occur in the bronchial tree behind the posterior-basic, are the posterior-horizontal, and the inferior or lesser posterior-horizontal; and of these two distributions the former does not belong to the base.

The posterior-basic posterior to tracheal plane and to most bronchi.

We are now enabled to determine the position of the basic bronchi and their mutual relations. These air-tubes are at first arranged in strict antero-posterior order, and possessing the same inclination outwards and downwards, they form a broadening plane, slanting in the same direction as that of the lower lobar stem. This may be seen at a glance, in fig. 11. A similar arrangement will be described in the left lung. There however the inferior posterior-horizontal is not in strict line with the other basic bronchi, neither is it as large as in the right lung, owing to the greater size acquired in the left lung by the posterior-horizontal distribution. In the right lung the order in which these bronchi occur, is, from before backwards:

Antero-posterior order of the three basic trunks and of the lesser posterior-horizontal.

(1) The anterior-basic stem
(2) The axillary-basic ,,
(3) The posterior-basic ,,
(4) The lesser posterior-horizontal stem.

The four origins occur at different levels.

Of these the first and the last diverge by an equal quantity from the line of the lower lobar stem, which, in the interval between them, bifurcates into its terminal trunks, the axillary-basic and the posterior-basic. On close inspection the anterior-basic is found to originate a little higher than the lesser posterior-horizontal, and the bifurcation just mentioned takes place about 1 cm. below the origin of the latter.

Analogy between anterior and axillary-basic;

Mode of Distribution of the Basic Bronchi.—Considerable analogy exists in the mode of distribution of the anterior-basic and of the axillary-basic, the former distribution being more extensive than the latter. Their branchings take place in two parallel, transverse, vertical planes, occupying together the anterior, half of the base. The axillary-basic distribution is limited to the lateral portion, whilst the other extends from the inner border of the base to the anterior axillary line. The bronchial district belonging to the posterior-basic will be described later. It is larger than either of the two preceding ones, and almost comprises the entire posterior half of the base.

Large size of posterior-basic distribution.

General Survey of the Bronchial System of the Left Base.

A "bronchial stem" even more doubtful in left lung than in right.

Apparent Trifurcation of Lower Lobar Bronchus.—The existence of any definite bronchial stem is yet more difficult to imagine in the left lower lobe than it is in the right; for the main bronchus appears here to terminate barely 2 cm. below the lower edge of the posterior-horizontal stem in three almost equal, and at first, almost parallel, trunks, which, in close antero-posterior order, continue the long downward and outward cardiac curve of this bronchus, and for a short distance also its slight backward bend.

Three basic bronchi parallel and almost equal.

Their three origins might, on superficial observation, be mistaken for a perfect trifurcation. A side view, however, shows that the anterior trunk originates at a slightly higher level than the others; moreover it protrudes relatively more from the main axis than does the posterior trunk. This is seen even more plainly from the inner aspect than from the outer. Here, therefore, is another instance of a bifurcation, unilaterally repeated, closely simulating a trifurcation.

Spurious trifurcation.

The axillary-basic coincides with the axis of the lobar bronchus.

Relative Situation of the Basic Bronchi.—The middle stem, or axillary-basic, which is a little smaller than either of the others, is, both as regards axis and direction, the apparent continuation of the lower lobar bronchus. The posterior-basic, owing to its bulging backwards, is out of line with the bronchus, and, in that respect, is less entitled to be regarded, as it seems to be by Professor Aeby, as the continuation of the "bronchial stem." Nevertheless its superior size may in itself constitute a sufficient claim.

At first parallel the three tubes gradually diverge.

Gradual Divergence.—Even during their short unbranched course of about 1 cm., the three trunks begin to lose their absolute parallelism. The three angles begin to vary, the posterior-basic trunk remaining almost vertical, the axillary-basic diagonal, and the anterior-basic displaying least obliquity, with more of the horizontal than of the vertical bias.

The Three Distributions are likewise almost parallel, their subdivisions occurring within transverse planes succeeding each other from before backwards. But, owing to the occurrence of antero-posterior bifurcations, in addition to those which are transverse, each of the three distributions gradually acquires thickness from above downwards. The thinnest of the three upright wedges thus formed is the axillary-basic, the thickest is the posterior-basic, which indeed forms the larger half of the base. The whole arrangement may, not inaptly, be compared to the common bellows, the sides and ribs of which, at first almost parallel, diverge more and more from the plane occupied by the nozzle.

The three basic distributions extend transversely, and are almost parallel; thin above, broad below—they, together, resemble the common "bellows."

Some Differences between the Right and the Left Base.

The spurious trifurcation observed at the left base presents with that seen at the right base the following features of contrast:

(1) It occurs decidedly higher (by about 8 mm.).

(2) Its slanting antero-posterior plane does not face purely upwards and outwards, as does the right, but upwards, outwards, and slightly backwards.

(3) Therefore, when viewed exactly from behind, the overlapping profiles of the two anteriorly placed trunks may still be seen, instead of being as in the right lung completely covered by the posterior trunk.

(4) Whereas the right basic trunks stretch outwards and downwards stiffly, the left basic trunks form together a long flexible spray, drooping with unequal curves, and thus gradually increasing their mutual distance.

(5) In consequence of their higher origin, the left basic trunks possess greater length, and they appear yet longer than they otherwise would appear, owing to their rather smaller diameter.

As may be observed in fig. 11, the left lesser posterior-horizontal is not only of smaller size but, at its origin, is more horizontal than the right.

Lastly, the retro-cardiac is not, in the left lung, a primary branch from the lobar bronchial stem, as it is in the right, although on both sides of the chest the same districts are supplied by these bronchi.

THE ANTERIOR-BASIC DISTRICT.

RIGHT ANTERIOR-BASIC DISTRIBUTION.

The District Supplied.

(The description given of this distribution may be best followed in the diagram, fig. 9.)

The right anterior-basic district smaller than the left, not including the retro-cardiac, and being kept back by the more oblique right fissure, and by the larger cardiac district.

The Anterior-basic Trunk arises, with strictly *ventral* origin, from the front of the lower lobar stem. In this respect it is in harmony with the left anterior-basic. The two districts have not, however, identical shape and extension. The right distribution is smaller than the left by the whole retro-cardiac district, which derives its bronchus directly from the lower lobar stem. It does not therefore extend its ramifications to the inner pulmonary surface beyond the anterior border of the lower lobe. Moreover, inasmuch as the right and the left anterior-basic districts underlie the septal surface of the lower lobe, they are influenced in their shape by the direction of the great fissure. Whereas the left fissure, in its lower part, is almost antero-posterior, the right is nearly transverse (with slight obliquity upwards and backwards). It results that, instead of facing inwards with its septal surface, the right distribution faces anteriorly. And since the cardiac lobe claims more than half the anterior-basic surface, the portion of this surface occupied by the anterior-basic distribution is much reduced. The left anterior-basic ramifications will be found to extend to the inner basic angle, of which they constitute the exclusive supply. In conclusion, the right anterior-basic distribution is less complicated and smaller than the left, and more restricted in its parietal sub-pleural extension.

Right Anterior-basic Distribution.

Its distribution resembles the axillary-basic distribution. In the left lung this resemblance is less.

The anterior-basic distribution resembles more faithfully than the left the axillary-basic distribution, not only in the arrangement of its parts, but also in the direction of its bronchi. Like the axillary-basic, the right anterior-basic trunk and its derivatives follow a straight course downwards and outwards, which is almost identical with the direction of the main bronchus and of the lower lobar stem, whereas the direction of the left anterior-basic trunk and of its branches is complicated by various bends and curves.

Anterior-basic stem (v. ddda).

The Anterior-basic Trunk originates at a very acute angle from the front of the lower lobar stem, about 8 mm. below the lower level of the retro-cardiac trunk. Its direction is altered from that of the parent trunk only to the extent of a slight obliquity forwards. In calibre it is about equal to the posterior-horizontal stem at its origin. Its distribution occupies a slice of the base parallel to the septum and extending from the anterior axillary line between its middle and its lower third, to the anterior fringe just external to the cardiac lobe.

Cardio-basic (vj. dddad). Lateral anterior-basic (vj. dddae).

The first bifurcation, into the *cardio-basic* and the *lateral anterior-basic trunks*, occurs after a course of 1·5 cm. Within a few millimetres from their origin each of these bears a large ⊤-shaped *interlobar branch*, the directions of which however are not identical.

⊤-shaped posterior pericardial (vij. dddadi). Cardio-basic trunk (vij. dddadd).

The Cardio-basic Trunk is the longer of the two divisions, and is destined for the extreme anterior base. It diverges slightly inwards from the original direction. Its final division into *inner anterior-basic* and *outer anterior-basic bronchi* takes place at a distance of 2·8 cm. from its origin, but its first branch is the **Posterior Pericardial**, a ⊤-shaped branch, occupying a position intermediate between that of the pericardial branches from the cardiac distribution and that of the retro-pericardial branch.

Inner anterior-basic (viij. dddaddi). Outer anterior-basic (viij. dddadde).

The Inner Anterior-basic, and the Outer Anterior-basic.— The two divisions of the cardio-basic trunk are provided with small branches, most of which are destined for the deepest tissues. Those from the internal division, also supply the anterior edge of the base. Each bronchus subsequently bifurcates into an inner and an outer terminal fork, which carry numerous branchlets.

Lateral anterior-basic (vj. dddae).

⊤-shaped interlobar branch (vij. dddaea). Infra-mammary (vij. dddaed).

The Lateral Anterior-basic Trunk is directly continuous with the direction of the common trunk. The ⊤-shaped **Interlobar Branch**, arising from its anterior surface, faces towards the cardiac lobe which lies in front of it. This trunk is much shorter than the cardio-basic, measuring only 1·1 cm. down to its chief bifurcation into the *external mammary* and *infra-mammary bronchi*. In Table VI. it is termed *infra-mammary*.

External mammary (viij. dddaede). Infra-mammary (viij. dddaedd).

The External Mammary Bronchus assumes a lateral direction inclined barely 20° below the horizontal. By its smaller *anterior branch* it partly supplies the surface external to the nipple. By its larger, *posterior branch*, which likewise possesses an upward and a downward terminal branch, it becomes associated with the axillary branch of the axillary-basic and assists in the supply of the upper part of the lower third of the anterior-axillary region.

Anterior infra-mammary (ix. dddaedda). External infra-mammary (ix. dddaedde).

The Infra-mammary Bronchus divides, after a course of 1·2 cm., into an anterior and an external branch. In general direction and in arrangement of branches this distribution resembles the more internally placed cardio-basic distribution. But the infra-mammary branches do not reach the base; they are supra-marginal, not marginal. The arches in which they

TABLE VI.—LEFT ANTERIOR-BASIC DISTRIBUTION.

LEFT LOWER LOBAR BRONCHUS.

- Posterior-horizontal trunk (ij. p). (See Table IV.)
- Lower lobar stem (ij. d).
  - Anterior-basic bronchus (iij. da).
    - Cardio-basic (iv. dad).
      - Retro-cardiac (v. dadp). (See Table V.)
      - Cardio-basic (v. dadd).
        - Superficial cardio-basic (vj. daddi).
          - Supra-marginal cardio-basic (vij. daddia).
            - Inner supra-marginal fork.
            - Outer supra-marginal fork.
          - Cardio-basic (vij. daddid).
            - Inner terminal.
              - Marginal arch.
            - Outer terminal.
              - Marginal arch.
        - Deep cardio-basic (vj. dadde).
          - Deep branches.
    - Mammary (iv. daa).
      - Horizontal mammary (v. daae).
        - Ascending central interlobar (vj. daaes).
        - Horizontal mammary (vj. daaea).
          - Internal superficial mammary (vij. daaeaa).
            - Superior terminal fork.
            - Inferior terminal fork.
          - External superficial mammary (vij. daaeae).
            - Superior branch.
              - Terminal fork.
            - Inferior branch.
              - Terminal fork.
      - Descending mammary (v. daad).
        - Outer descending mammary (vj. daade).
          - Outer descending mammary (vij. daaded).
            - Inner branch.
            - Outer branch.
          - Deep intra-pulmonary (vij. daadee).
        - Inner descending mammary (vj. daadi).
          - Inter-lobar branch (vij. daadii).
          - Inner descending mammary (vij. daadid).
            - Superior infra-mammary (viij. daadida).
              - Inner terminal fork.
              - Outer terminal fork.
            - Inferior infra-mammary (viij. daadidd).
              - Inner branch.
              - Outer branch.
  - Lower lobar stem (iij. dd).
    - Axillary-basic (iv. dde). (See Table VII.)
    - Posterior-basic (iv. ddp). (See Table VIII.)
      - Inferior posterior-horizontal (v. ddpe).
      - Posterior-basic (v. ddpd).

TABLE VI.—RIGHT ANTERIOR-BASIC DISTRIBUTION.

RIGHT LOWER LOBAR STEM (ij. d).

- Posterior-horizontal trunk (iij. dp). (See Table IV.)
- Lower bronchial stem (iij. dd).
  - Retro-cardiac trunk (iv. ddi). (See Table V.)
  - Lower bronchial stem (iv. ddd).
    - Anterior-basic stem (v. ddda).
      - Infra-mammary (vj. dddae).
        - T-shaped interlobar (vij. dddaea).
        - Infra-mammary (vij. dddaed).
          - External mammary (viij. dddaede).
            - Posterior external mammary.
              - Inferior terminal.
              - Superior terminal.
            - Anterior external mammary.
              - Inferior terminal.
              - Superior terminal.
          - Infra-mammary (viij. dddaedd).
            - External infra-mammary (ix. dddaedde).
            - Anterior infra-mammary (ix. dddaedda).
      - Cardio-basic (vj. dddad).
        - T-shaped pericardial (vij. dddadi).
        - Cardio-basic trunk (vij. dddadd).
          - Outer anterior-basic (viij. dddadde).
            - Outer marginal fork.
            - Inner marginal fork.
          - Inner anterior-basic (viij. dddaddi).
            - Outer marginal fork.
            - Inner marginal fork.
    - Lower bronchial stem (v. ddde).
      - Inferior posterior-horizontal (vj. dddep).
      - Lower bronchial stem (vj. ddded).
        - Axillary-basic trunk (vij. dddedd).
        - Posterior-basic trunk (vij. dddedp).

N.B.—The meaning of the letters used as notation is explained on page 88.

terminate remain about 2 cm. above the lower fringe. The inner and the outer division serve respectively as imbrications for the cardio-basic and for the axillary-basic terminal branches. Besides small branchlets to the deeper parts, and lateral branchlets, they supply, before their final division, two rows of anterior branches which overlap each other and are overlapped above by the external mammary branches.

LEFT ANTERIOR-BASIC DISTRIBUTION.

The District Supplied.

(Diagram (fig. 9) will show the air-tubes described in the text. They will also be recognized in fig. 10, between vertical lines G and I, and horizontal lines vj and x; part of the distribution is also shown in fig. 11 from behind.)

Situation and shape of district. The septal surface of lower lobe.

This distribution forms the almost vertical anterior and inner slice of the lower lobe. Its inclination is determined by the slope of the interlobar fissure, which is much more vertical in the left than in the right lung. The septal surface of the lower lobe receives its supply, above from the posterior-horizontal distribution, and, in its two lower thirds, from the distribution now under consideration, which moreover extends backwards, by means of the retro-cardiac branches, almost as far as the posterior pulmonary border, along the inner surface of the base.

Relations of the district to the axillary- and posterior-basic districts.

Viewed from its anterior aspect, the district in question slants from the mid-axillary region downwards and inwards to the anterior basic angle, passing obliquely across the lower mammary region. External, posterior and parallel to it lies the thinner segment of the lower lobe served by the axillary-basic trunk; and behind this is situated the more important posterior-basic district which represents almost a full half of the base of the lobe.

The Bronchial Supply.

Anterior-basic trunk (iij. da).

The Anterior-basic Trunk arises from the anterior aspect of the lower lobar bronchus, 1·4 cm. below the lower level of origin of the posterior-horizontal trunk. It preserves the main direction downwards and outwards, but combines with this a slight forward movement.

Mammary trunk (iv. daa). Cardio-basic trunk (iv. dad).

After a short course of 1·5 cm. it bifurcates into an upper and a lower branch which strongly diverge at first and subsequently converge. The lower or *cardio-basic trunk* is the almost direct continuation of the parent tube, of which the *mammary trunk* is also a modified continuation, occupying a rather higher level.

Left Mammary Bronchial Distribution.

Mammary trunk (iv. daa).

The Mammary Trunk presents a short curve with convexity upwards followed by considerable declivity. This brings the lower branches gradually nearer the anterior surface where they terminate 3 cm. above the lower fringe of the lung.

Horizontal mammary (v. daae). Descending mammary (v. daad).

The first branch, the *horizontal mammary bronchus*, is given off from the convexity of the curve. The bifurcation to which it owes its origin occurs in the same plane as the preceding one. The lower division is inferior, and assumes the name of *descending mammary* bronchus.

Ascending deep interlobar (vj. daaes). Horizontal mammary (vj. daaea).

The Horizontal Mammary Bronchus ascends for 2 or 3 mm. outwards and with a sharp bend becomes horizontal with forward direction. By this manœuvre its *inner* and *outer* branch of bifurcation reach the surface in the upper mammary and in the anterior mid-axillary regions.

An Ascending Deep Interlobar branch rises from the termination of the ascending portion just mentioned, and faces, beyond the great fissure, the deep interlobar bronchus from the superior branch of the cardiac stem.

Circle of deep interlobar bronchi defining the intra-pulmonary root-zone.

These two **T**-shaped tubes are the inferior constituents of a circle of deep interlobar bronchi which define the anterior limit of what may be termed the *intra-pulmonary root-zone*. The circle is completed above by smaller descending interlobar bronchi from the pectoral and from the horizontal axillary distribution; it is situated about 2·5 cm. in front of the angle formed by the pectori-apical stem with the main bronchus. No peripheral branches arise from the large air-tubes within the space thus defined, which is entirely occupied by blood-vessels, lymphatics, and fibrous tissue.

Internal superficial mammary (vij. daaeaa). External superficial mammary (vij. daaeae).

The Internal Superficial Mammary and the **External Superficial Mammary** bronchi divide symmetrically, each into an upper and a lower terminal fork. The two branches from the external bronchus are larger and further reaching than the internal branches, and they come respectively into anterior contact with the anterior inferior mid-axillary-horizontal, and with the upper mammary-axillary bronchus.

Descending mammary trunk (v. daad).

Inner, (vj. daadi) and Outer descending mammary (vj. daade).

The descending mammary or **Infra-mammary District** occupies the anterior surface of the lower lobe for a vertical distance of nearly 4 cm. between the preceding district and the basic zone.

Inner descending mammary (vij. daadid). Interlobar (vij. deadii).

The Descending Mammary Trunk after an unbranched course of 8 mm. divides, whilst still in the depth of the lung, into an *inner* and an *outer* trunk.

Inner supr., (viij. daadida). Inner inferior infra-mammary (viij. daadidd).

The inner trunk is rather more important than the outer by reason of the size and extent of its branches. A small **Interlobar Bronchus** is the product of its first bifurcation. After this it divides almost immediately, by a second bifurcation, into a **Superior Infra-mammary Bronchus** dis-

Inner and outer terminal branches from each of these.

tributing an *inner* and an *outer terminal* fork to the surface, and into an **Inferior Infra-mammary.**

Deep intra-pulmonary (vij. daadee). Outer descending mammary (vij. daaded). Inner and outer terminal external infra-mammary bronchi.

This bronchus, whilst still under cover of the former, divides into two diverging bronchi of good size, which ultimately become superficial after delivering deep and sub-pleural branchlets, and terminate by contiguous forkings 3 cm. above the fringe.

The Outer Descending Mammary follows with less symmetry the pattern just described. It supplies outwards a *deep* intra-pulmonary (vij. daadee), but no superior branch. It bifurcates like its fellow into *outer* and *inner* **External Infra-mammary Terminal** bronchi; the outer bronchus comes into anterior relation with the lower mammary-axillary bronchus.

Left Cardio-basic Distribution.

Cardio-basic stem (iv. dad).

The Cardio-basic Trunk, imitating in a reverse direction the initial curve of the mammary, presents at first a posterior and inferior convexity. Before this curve is completed the trunk undergoes a bifurcation in the same plane as the plane of bifurcation of the anterior-basic stem and of its mammary division, that is, in a direction almost parallel to the interlobar septum.

Cardio-basic stem (v. dadd). Retro-cardiac stem (v. dadp).

The two resulting trunks are the *cardio-basic* continued, and the **Retro-cardiac.** The latter has been made the subject of a separate description (see p. 139). It assumes a direction downwards, which is that of the early portion of the curve mentioned above.

Cardio-basic (vj. daddi). Deep cardio-basic (vj. dadde).

The Cardio-basic Trunk almost immediately returns to the original outward and downward direction of the anterior-basic stem. This direction it preserves for a few millimetres only; for another sharper bend downwards, forwards and inwards, brings it closer to the anterior border of the lower lobe and to the septal surface which it then follows, at a slight depth within the lung, as far as the anterior angle. The latter is exclusively supplied by its branches.

The bifurcation of the cardio-basic trunk takes place about 1·5 cm. from its origin, and gives rise to a *superficial* and to a **Deep Cardio-basic Trunk.** The latter, smaller and much less branched than its twin-bronchus, is external and posterior to it, and preserves this relation. It does not become superficial, having for its special duty to supply the deep pulmonary tissue intervening between the descending and hitherto branchless trunks of the axillary and of the cardio-basic distributions.

Supra-marginal cardio-basic (vij. daddia). Cardio-basic bronchus (vij. daddid).

The distribution of the **Superficial Cardio-basic** is entirely symmetrical. A superior smaller division, the **Supra-marginal Cardio-basic,** arises anteriorly, which carries an *inner* and an *outer branch*. These are not destined to reach the extreme base, but they extend their terminal forks down to a level one or two centimetres above the fringe. The *supra-marginal cardio-basic* is itself covered above by the termination of the infra-mammary branches, and it furnishes an imbrication for the basic distribution below.

Inner and outer branch from the supra-marginal cardio-basic.

The cardio-basic bronchus divides into its *outer* and its *inner terminal* branch at the same level as the supra-marginal. These branches distribute several branchlets to the neighbourhood, and end at the extreme base by terminal angular arches, 1 cm. in height, and about 1 cm. broad at their lower extremity, or base. A succession of these arches lines the whole lower fringe of the lung. Both limbs of each of them bear laterally sub-lobular bifurcating branchlets, and finally become sub-lobular themselves.

Inner and outer terminal branch. Terminal arches.

THE AXILLARY-BASIC DISTRICT.

RIGHT AXILLARY-BASIC DISTRIBUTION.

The District Supplied.

(The diagram (fig. 9) will facilitate the study of the bronchi to be described.)

Situation of the district. General resemblance to the anterior-basic district. Smaller size of the right axillary-basic region.

This thin slice of the inferior lobe, included between the anterior-basic distribution in front and the posterior-basic behind, is parallel to the former rather than to the latter. Moreover it is planned on the model of the anterior-basic, and its branches display an arrangement symmetrical to that of the anterior-basic trunk.

For reasons already stated (see p. 146) the left axillary distribution is, just as the left anterior-basic, rather larger than the corresponding distribution on the right side. Indeed the right axillary-basic is reduced to the most simplified expression of what we recognize as a basic trunk. It consists of a single trunk of origin, bifurcating into a single lateral and a single basic trunk. The former is intended for the upper part of the lower axillary third, and the latter for the axillary border.

The Bronchial Supply.

Axillary-basic trunk (vij. dddedd).

Axillary-basic (viij. dddeddd). Retro-mammary-basic (viij. dddedde).

The Axillary-basic Stem is the anterior and smaller member arising from the final bifurcation which occurs 8 mm. to 1 cm. below the origin of the anterior-basic stem. Of rather smaller size than the latter, it remains strictly posterior to it, and posterior likewise, lower down, to the infra-mammary division. Near the base it emerges from under cover of the external infra-mammary bronchus. Its axillary branch is, in like manner, strictly posterior to the external mammary, branch for branch.

Axillary-basic (ix. dddedddd). External superficial branch (ix. dddeddde).

The axillary-basic stem pursues a branchless course for 1·5 cm., and bifurcates into a trunk possessing an identical direction, the axillary-basic continued, and into the axillary-retro-mammary trunk, which is parallel in direction to the external mammary, and therefore almost horizontal.

Deep branches

The Axillary-basic Division gives rise to an *external superficial branch*, which forms part of the system of imbricating branches observed around the whole surface of the lower lobe. It also distributes small *deep branches* to the pulmonary tissue and bifurcates into an *inner* and an *outer terminal*. Both latter bear sub-lobular twigs and end at the fringe with arches similar to those described above. and inner and outer terminals from the axillary-basic.

The External Superficial Axillary-basic supplies the lower axilla and ends in supra-marginal arches.

The Retro-mammary-axillary Division, following the example of the external mammary, breaks up after a course of 1·2 cm. into an *anterior* and a *posterior* branch, the posterior branch being the larger one. Each subsequently divides into an *upper* and a *lower superficial bronchus*. This distribution and that of the external mammary (which are depicted too low in the diagram) are covered at their origin by the last ramification from the axillary division of the posterior-horizontal stem. They form, below this, the next imbrication; and the same process is repeated downwards by a succession of imbricating rows of air-tubes, each of which is of rather more acute angle than its predecessor. Retro-mammary-axillary (viij. dddeddde). Anterior branch, posterior branch. Each of these bears an upper and a lower division. Successive imbrications from above downwards.

LEFT AXILLARY-BASIC DISTRIBUTION.

The Left Axillary-basic District compared with the Same District on the Right Side.

(The description of this district should be followed on the diagram (fig. 9) in conjunction with fig. 10 and with fig. 11. The bronchi are best displayed in the drawing last named.)

The differences noticed between the left axillary-basic distribution and the corresponding right one relate chiefly to size and to position. Whereas the right distribution was seen to be included between two almost strictly transverse planes, slight obliquity of the anterior and posterior boundaries is found on the left side, owing to the posterior position of the lower bronchial stem at the point where it divides into the axillary-basic and posterior-basic trunks, and owing also to the fact that a more anterior point of the basic fringe is reached by the left than by the right basic division. Thus the left distribution is rather more posterior in its axillary and rather more anterior in its basic section than the right. In addition the extent of surface supplied by it both in the axilla and especially at the base, is more considerable; and the bronchial ramifications are correspondingly more complicated. The exact parallelism observed on the right side between the axillary-basic branches and those of the anterior-basic trunk, are here, owing to the sinuous course of the latter, not so perfect. Differences in size and in position. Extent of the district greater on the left. Less symmetry with anterior-basic distribution.

TABLE VII.—LEFT AXILLARY-BASIC AND LESSER POSTERIOR-HORIZONTAL DISTRIBUTIONS.

LEFT LOWER LOBAR BRONCHUS.

- Posterior-horizontal trunk (ij. p). (See Table IV.)
- Lower lobar stem (ij. d).
  - Anterior-basic trunk (iij. da). (See Table VI.)
  - Lower lobar stem (iij. dd).
    - AXILLARY-BASIC TRUNK (iv. dde).
      - RETRO-MAMMARY-AXILLARY (v. ddee).
        - UPPER RETRO-MAMMARY-AXILLARY (vj. ddeea).
          - SUPERIOR BRANCH.
          - INFERIOR ANTERIOR BRANCH.
        - LOWER RETRO-MAMMARY-AXILLARY (vj. ddeee).
          - EXTERNAL BRANCH.
          - INTERNAL BRANCH.
      - AXILLARY-BASIC (v. dded).
        - ANTERIOR SUPERIOR AXILLARY-BASIC (vj. ddeda).
          - LATERAL SUPERFICIAL BRANCH (vij. ddedae).
          - SAME TRUNK (vij. ddedaa).
            - OUTER TERMINAL.
            - INNER TERMINAL.
              - SUPRA-MARGINAL ARCHES.
        - POSTERIOR INFERIOR AXILLARY-BASIC (vj. ddedd).
          - SAME TRUNK (vij. ddeddd).
            - AXILLARY-BASIC (viij. ddeddde).
            - ANTERO-LATERAL BASIC (viij. ddeddda).
              - MARGINAL ARCHES.
          - LATERAL INFERIOR AXILLARY BRANCHES (vij. ddedde).
            - DEEP PULMONARY AND IMBRICATING SUB-PLEURAL BRANCHES.
              - SUPRA-MARGINAL ARCHES.
    - POSTERIOR-BASIC TRUNK (iv. ddp). (See Table VIII.)
      - INFERIOR POSTERIOR-HORIZONTAL (v. ddpe).
      - DORSI-BASIC TRUNK (v. ddpd).

TABLE VII.—RIGHT AXILLARY-BASIC AND LESSER POSTERIOR-HORIZONTAL DISTRIBUTIONS.

RIGHT LOWER LOBAR STEM (ij. d).

- Posterior-horizontal (iij. dp). (See Table IV.)
- Lower bronchial stem (iij. d).
  - Retro-cardiac trunk (iv. ddi). (See Table V.)
  - Lower bronchial stem (iv. ddd).
    - Anterior-basic (v. ddda). (See Table VI.)
    - Lower bronchial stem (v. ddde).
      - LESSER POSTERIOR-HORIZONTAL (vj. dddep).
        - INFERIOR POSTERIOR-HORIZONTAL (vij. dddepe).
        - INFERIOR DESCENDING MID-DORSAL (vij. dddepd).
      - Lower bronchial stem (vj. ddded).
        - AXILLARY-BASIC TRUNK (vij. dddedd).
          - RETRO-MAMMARY-AXILLARY (viij. dddedde).
            - ANTERIOR BRANCH (ix. dddeddea).
              - TERMINAL BRANCHES.
            - POSTERIOR BRANCH (ix. dddeddep).
              - TERMINAL BRANCHES.
          - AXILLARY-BASIC (viij. dddeddd).
            - EXTERNAL SUPERFICIAL BRANCH (ix. dddeddde).
              - BRANCHES FOR LOWER AXILLA.
                - SUPRA-MARGINAL ARCHES.
            - AXILLARY-BASIC (ix. ddded ddd).
              - OUTER TERMINAL BRANCH.
                - MARGINAL ARCH.
              - INNER TERMINAL BRANCH.
                - MARGINAL ARCH.
        - Dorsi-basic trunk (vij. dddedp). (See Table VIII.)

N.B.—The meaning of the letters used as notation is explained on page 88.

Bronchial Supply to the District.

Axillary-basic trunk (iv. dde).

The Left Axillary-basic Trunk, in its non-branched portion, measures 1·5 cm. It ends in a bifurcation situated within the main transverse plane of the district.

Retro-mammary-axillary (v. ddee). Axillary-basic (v. dded). Three successive bifurcations in the same plane.

Of its two divisions, the outer and rather smaller **Retro-mammary-axillary Trunk,** adopts an inclination so much more outwards than downwards, that its upper branch is little removed from the horizontal. This trunk has a length of 1·5 cm., and it divides into a *superior* and an *inferior branch*, the latter being slightly posterior also, and its fellow slightly anterior. The plane of this bifurcation is the same as that of the preceding bifurcation and as that of the following one, for both divisions supply a small branch directed upwards and another, downwards, which are continued within the same original plane as the two previous bifurcations.

Upper, (vj. ddeea) and Lower retro-mammary-axillary (vj. ddeee). From the former a superior and an inferior branch; from the latter, a descending intra-pulmonary, and an internal and an external peripheral bronchus.

The Upper Retro-mammary-axillary division from the preceding trunk, is contiguous with the external mammary, which it approaches from behind and from below. It bifurcates into a *superior* and an *inferior branch;* and these bear small deep intra-pulmonary branches; as it draws near to the surface, the inferior branch becomes more and more anterior.

The Lower Retro-mammary-axillary gives a descending intra-pulmonary bronchus bearing recurrent branchlets and divides into an internal and an external peripheral bronchus, to be distributed at the junction of the middle and of the inferior axillary thirds.

Anterior superior axillary-basic (vj. ddeda). Posterior inferior axillary-basic (vj. ddedd).

The Axillary-basic Trunk, rather larger than its fellow, continues the direction of the common trunk, with a very faint increase in the forward tendency of the latter. For the relatively long interval of 2·2 cm., it remains undivided. Its bifurcation gives origin to an *anterior superior* and to a *posterior inferior axillary-basic bronchus.* These show little divergence in their direction, for they are both intended for the outer-anterior region of the base where the posterior division becomes external and superficial; but the anterior superior branch does not supply true marginal, but supra-marginal arches only. Both divisions have a branchless course of 1·2 cm.; and both are provided with an early *lateral branch*, bearing a *deep recurrent* branchlet.

The anterior superior axillary-basic gives a lateral branch, and inner and outer terminals.

The Anterior-superior Axillary-basic distributes its lateral branch to the anterior axillary region at the level of the infra-mammary branches. Its own division into an **Inner** and an **Outer Terminal** bronchus occurs at the lower extremity of the infra-mammary distribution. The terminal bronchi extend to within 2 to 3 cm. from the base forming supra-marginal arches. They provide a last imbrication for the branches of the inferior-axillary-basic.

Lateral inferior axillary branch (vij. ddedde). From this a deep re-

The Lateral-inferior Axillary Branch from the posterior-inferior axillary-basic is of some importance both in size and in position. It takes an outward direction towards the axillary fringe, which it does not quite reach. In addition to the **Deep Intra-pulmonary Recurrent** given high up, it supplies three superficial imbricating branches and ends by means of supra-marginal arches.

current, and three imbricating superficial branches.

The Posterior-inferior Axillary-basic Trunk continues a branchless course for 2·3 cm., and divides behind the imbrication of the supra-marginal distribution, into *outer* and *inner* branches which, becoming superficial, terminate in arches at the fringe. These branches may conveniently be termed the **Antero-lateral-basic** and **Axillary-basic Bronchi**.

Antero-lateral-basic (viij. ddeddda). Axillary-basic (viij. ddedddc).

THE LESSER POSTERIOR-HORIZONTAL DISTRICT.

RIGHT LESSER POSTERIOR-HORIZONTAL DISTRIBUTION.

Preliminary Remarks.

(Fig. 11 gives a good idea of the position and main branches of this distribution.)

Description deferred owing to difference of origin between right and left bronchi. Origin of this stem in the right lung.

For reasons of symmetry and of clearness of description the right lesser posterior-horizontal distribution must be considered in this place, although somewhat out of the order indicated by its bronchial origin. In the left lung the bronchial trunk in question originates from the posterior-basic stem, and will be described under that head. In the right lung its origin occurs above that of the posterior-basic stem and almost on the same level as that of the anterior-basic, which arises from the opposite side of the bronchial stem. For purposes of classification we may therefore admit that the lesser inferior-horizontal arises immediately below the anterior-basic, and from the posterior surface of the remaining stem which bifurcates into the axillary- and the posterior-basic trunks.

The district now under consideration occupies the upper third of the lower half of the lung and it is mainly superficial. Its bronchi are a reproduction, at a lower level (by 3 cm.), but with almost complete parallelism, of the horizontal mid-dorsal and of the vertical-descending mid-dorsal bronchi from the posterior-horizontal trunk.

The Bronchial Supply.

Lesser posterior-horizontal trunk (vj. dddep).

The Right Lesser Posterior-horizontal Trunk is not itself horizontal, but during its short course of 1·3 cm. proceeds downwards and outwards in a direction posterior and parallel to that of the lower lobar stem.

Inferior posterior-horizontal (vij. dddepe). Inferior descending mid-dorsal (vij. dddepd).

The Inferior Posterior-horizontal and the *inferior vertical-descending mid-dorsal* are the divisions arising from the bifurcation. The former assumes an outward direction with very slight inclination downwards, and soon gives by bifurcation an obliquely *ascending deep intra-pulmonary* branch. Continuing its course it divides into terminal branches behind the posterior axillary region.

The Inferior Vertical-descending Mid-dorsal has an unbranched length of 1·3 cent. and moves downwards and slightly backwards. It bifurcates into the *inferior oblique mid-dorsal* and the **Inferior Inner Marginal Mid-dorsal**. The latter divides into an *anterior* and a *posterior branch* and each of these repeatedly bifurcates, so as to supply the surface of the blunt vertebral edge of the lung at this level.

The Inferior Oblique Mid-dorsal is of rather larger size than the superior branch of the same name, of which it closely imitates the superficial outward descending course, and the branchings. It gives a *descending branch*, which is posterior to the posterior-basic division, and bifurcates outwards, at a point 1·5 to 2 cm. below the inferior posterior-horizontal stem.

The distribution which has been described furnishes the highest layer of the successive imbrications produced by the descending dorsal bronchi, inasmuch as the right posterior-horizontal distribution, situated above it, does not to any material extent overlap its branches.*

Ascending deep intra-pulmonary (viij. dddepes). Inferior posterior-horizontal (viij. dddeepe).

Inferior oblique mid-dorsal (viij. dddepde). Infr. inner marginal mid-dorsal (viij. dddepdi). Anterior and posterior branch from the latter.

* For an account of the left inferior or lesser posterior-horizontal distribution, see p. 167.

THE POSTERIOR-BASIC DISTRICT.

RIGHT POSTERIOR-BASIC, OR DORSI-BASIC DISTRIBUTION.

The District Supplied.

(The right posterior-basic and its branches, as far as they have been successfully injected in the metallic cast, come into full view in fig. 11.)

Extent of this district. THE distribution of the posterior-basic stem occupies the whole posterior half of the base and possesses therefore considerable breadth as well as depth, unlike the much more limited sections belonging to the other basic stems. First bifurcation sagittal. In contrast with the latter, the dorsi-basic stem undergoes its first bifurcation according to a plane which is almost sagittal, thus extending its ramifications backwards beyond the transverse plane which passes through the trachea and the right main bronchus.

The dorsi-basic stem viewed by Aeby as the continuation of the "bronchial stem." Of larger size than either of the other basic trunks, and corresponding in its direction with the axis of the "bronchial stem," the posterior-basic trunk claims according to Professor Aeby to be considered as a continuation of the latter. Even if that view should be adopted, it will be desirable to apply to this stem the name posterior-basic, which defines its function as the main supplying tube to an important pulmonary district.

The Bronchial Supply.

Posterior-basic stem (vij. dddedp). **The Posterior-basic Stem** is strictly posterior to the other two basic stems, and it remains, on the whole, part of the oblique, outward-inclined and outward-facing plane which contains them; but within that plane it swerves very slightly backwards. This tendency becomes more apparent in its posterior branch. The first bifurcation occurs 3 cm. below that which gave rise to the axillary-basic trunk, and its products are the *lateral dorsi-basic* division which is the direct continuation of the stem, and the *dorsi-basic* division, which diverging slightly backwards, probably corresponds to the third "hyparterial" dorsal branch, in Aeby's nomenclature. It provides the dorsal supply of the base as far as the neighbourhood of the vertebral margin, where the retro-cardiac distribution completes the circle of basic branches.

Lateral dorsi-basic (viij. dddedpe). Dorsi-basic (viij. dddedpd).

Right Lateral Dorsi-basic Distribution.

Lateral dorsi-basic (ix. dddedped). Inferior retro-axillary (ix. dddedpee). Superior and inferior branches from the latter.

The Lateral Dorsi-basic Trunk, rather larger than its fellow, has an unbranched course of 1 cm. The branch arising from its first bifurcation, **the Inferior Retro-axillary**, is comparatively small. It is analogous to, although originating at a lower level than, the retro-mammary branch of the axillary-basic; and it distributes its *superior* and *inferior branches*, belonging to the same level as those from the retro-mammary, to the outer-posterior surface of the lung, where it comes into contact with the inferior oblique mid-dorsal distribution.

Axillary dorsi-basic (x. dddedpede). Lateral dorsi-basic (x. dddedpedp).

Five millimetres lower the lateral dorsi-basic divides antero-posteriorly into a smaller anterior trunk the *axillary dorsi-basic*, and a posterior slightly more diverging trunk, the lateral dorsi-basic continued.*

The Axillary Dorsi-basic Trunk supplies the axillary and the retro-axillary region of the base. It has a length of 1·5 cm. and gives an anterior T-shaped *intra-pulmonary* branch of small size, and bifurcates into a *superficial* and a *deep division*.

Superficial, (xj. dddedpedee), and Deep axillary dorsi-basic (xj. dddedpeded).

The Superficial Axillary Dorsi-basic bifurcates, at a distance of 1·5 cm. from its origin, into a shorter *anterior* and a longer *posterior* bronchus, both of which subsequently divide into *terminal* branches, which do not reach to the extreme base, but are imbricated over the basic divisions from the deep branch.

Descending intra-pulmonary axillary dorsi-basic (xij. dddedpededd) Marginal axillary dorsi-basic (xij. dddedpedede). From the latter superficial and deep antr. and postr. terminal branches.

The Deep Axillary Dorsi-basic after a course of 1·5 cm. bifurcates into an internal **Descending Intra-pulmonary** division, presenting no large branches, and destined for the supply of the central parts of the base; and into the continuation of the *axillary dorsi-basic*. This trunk, with the exception of a few short *superficial and deep branches*, extends uninterruptedly downwards and outwards to the neighbourhood of the axillary fringe, there bifurcating into an *anterior* and a *posterior* division distributed to the axillary fringe.

The larger **Lateral Dorsi-basic Trunk** presents an arrangement analogous to that of the axillary dorsi-basic. It supplies the retro-axillary fringe and the outer dorsal fringe. From its point of origin it extends downwards outwards and slightly backwards, and it divides into a *superficial* and a *deep branch*.

Superficial, (xj. dddedpedpe), and Deep lateral dorsi-basic (xj. dddedpedpd).

The Superficial Lateral Dorsi-basic bifurcates into an *anterior* and a *posterior* bronchus, both of which supply supra-marginal arches imbricated above the deep distribution.

The Deep Lateral Dorsi-basic likewise gives rise to an anterior

* The lower portion of the posterior-basic distribution is incomplete in the metallic cast, owing to imperfect injection. The description given has been completed with the help of fresh dissections, and of dried specimens of the dissected bronchial tree.

TABLE VIII.—LEFT POSTERIOR-BASIC DISTRIBUTION.

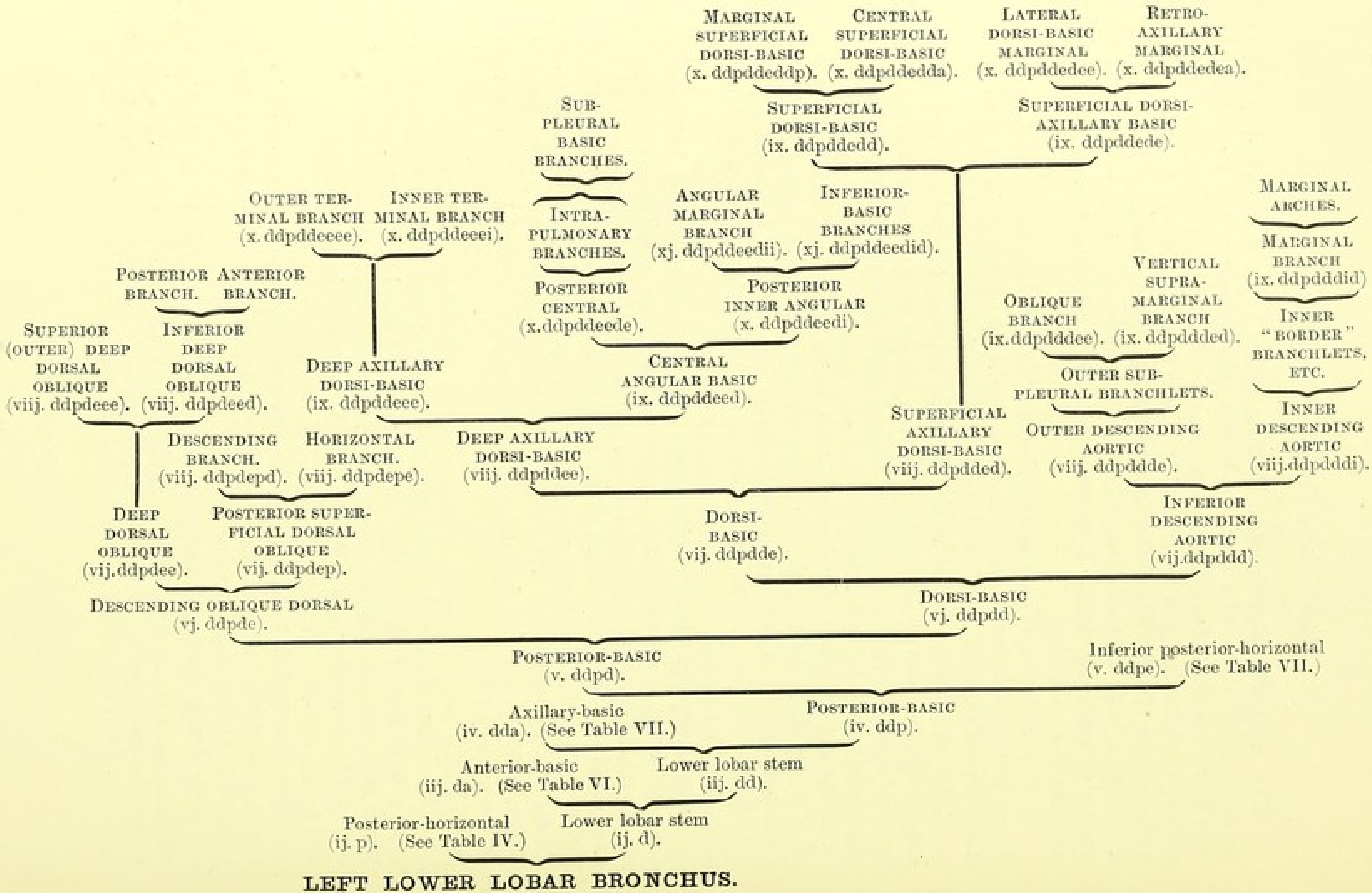


TABLE VIII.—RIGHT POSTERIOR-BASIC DISTRIBUTION.

RIGHT LOWER LOBAR STEM.

- Posterior-horizontal (iij. dp). (See Table IV.)
- Right lower bronchial stem (iij. dd).
  - Retro-cardiac (iv. ddi). (See Table V.)
  - Lower bronchial stem (iv. ddd).
    - Anterior-basic (v. ddda). (See Table VI.)
    - Lower bronchial stem (v. ddde).
      - Lesser posterior-horizontal (vj. dddep). (See Table VII.)
      - Lower bronchial stem (vj. ddded).
        - Axillary-basic stem (vij. dddedd). (See Table VII.)
        - Dorsi-basic stem (vij. dddedp).
          - Lateral dorsi-basic (viij. dddedpe).
            - Inferior retro-axillary (ix. dddedpee).
            - Lateral dorsi-basic (ix. dddedped).
              - Axillary dorsi-basic (x. dddedpede).
                - Superficial axillary dorsi-basic (xj. dddedpedee).
                - Axillary dorsi-basic (xj. dddedpeded).
                  - Descending intra-pulmonary axillary dorsi-basic (xij. dddedpededd).
                  - Marginal axillary dorsi-basic (xij. dddedpedede).
              - Lateral dorsi-basic (x. dddedpedp).
                - Superficial lateral dorsi-basic (xj. dddedpedpe).
                - Deep lateral dorsi-basic (xj. dddedpedpd).
                  - Anterior deep dorsi-basic (xij. dddedpedpda).
                  - Posterior deep lateral dorsi-basic (xij. dddedpedpdp).
          - Posterior dorsi-basic (viij. dddedpd).
            - Central dorsi-basic (ix. dddedpdd).
            - Posterior dorsi-basic (ix. dddedpdp).
              - Inferior dorsal (x. dddedpdpp).
                - Inner inferior dorsal (xj. dddedpdppi).
                - Outer inferior dorsal (xj. dddedpdppe).
              - Posterior dorsi-basic (x. dddedpdpd).
                - Superficial outer dorsi-basic (xj. dddedpdpde).
                - Dorsi-basic (xj. dddedpdpdd).
                  - Anterior deep marginal dorsi-basic (xij. dddedpdpdda).
                  - Posterior marginal dorsi-basic (xij. dddedpdpddp).

N.B.—The meaning of the letters used as notation is explained on page 88.

Anterior, (xij.ddded-pedpda), and Posterior deep lateral dorsi-basic (xij.ddded-pedpdp). From each of the latter a central and a peripheral or marginal bronchus.

and to a posterior division. Each of these supplies a superficial and a deep branch. The superficial branch of each is anterior, and it furnishes marginal arches to the fringe. The other branch, inclined backwards and inwards, is destined for the central portion of the base.

Right Dorsi-basic Distribution.

The Dorsi-basic Trunk, which diverges backwards from the main direction of the lower lobar stem, undertakes the aëration of the greater part of the posterior base, being assisted slightly on the outer side by the lateral dorsi-basic, and at the inner or vertebral border by the retro-cardiac. It also takes a chief share among the basic trunks in supplying the central base. For a distance of 8 mm. it bears no branches.

Central-basic trunk (ix. dddedpdd). Dorsi-basic trunk (ix. dddedpdp).

The first branch is given off, by bifurcation, straight downwards. It may be appropriately termed the **Central-basic Trunk.** It bifurcates into an *inner* and an *outer* division for the supply of the intra-pulmonary tissue. The latter is also largely supplied by the deep branches from the retro-cardiac distribution.

Inferior dorsal (x. ddded-pdpp). Dorsi-basic (x. ddded-pdpd). Inner, (xj. ddded-pdppi), and Outer inferior dorsal (xj. ddded-pdppe).

A second bifurcation occurs 8 mm. lower down into the **Inferior Dorsal Trunk** (which probably corresponds to the fourth hyparterial dorsal bronchus of Aeby), and into the continuation of the dorsi-basic. The latter does not alter its outward downward and backward direction. The inferior dorsal which arises from its posterior surface shows an inward and backward tendency: it divides into an *inner*, and into a more superficial *outer branch*, and supplies the inner posterior fringe and neighbouring surface.

Superficial outer dorsal (xj. ddded-pdpde). Dorsi-basic (xj. ddded-pdpdd).

The Dorsi-basic Trunk divides into an **Outer Superficial Branch** and into the continuation of the trunk. The outer branch again divides into an *inner* and an *outer* bronchus, which supply the parts above the base.

Anterior deep dorsi-basic (xij. ddded-pdpdda). Posterior dorsi-basic (xij ddded-pdpddp).

The dorsi-basic finally bifurcates into a **Deep Anterior** and a **Posterior Dorsi-basic**.

These bronchi present an arrangement similar to that which has been described at other parts of the basic fringe.

LEFT POSTERIOR-BASIC DISTRIBUTION.

The District Supplied.

This distribution can be readily studied in fig. 11; it will be noticed that the lesser posterior-horizontal trunk has been curtailed in the drawing.)

Extent and shape of the district.

The whole posterior half of the base is supplied by the dorsi-basic trunk which, by means of the lesser posterior-horizontal, also contributes to the aëration of the posterior middle third of the lung. In general shape this distribution almost exactly resembles the inferior lobe, and the same pyramidal outline repeats itself also in its subdivisions.

In consequence of the posterior divergence of its first portion (nearly equal to the anterior divergence of the cardio-basic trunk), the **Posterior-basic Stem** is, at the beginning of the lower third of the lung, the most superficial of all the large bronchi (with the exception of its own branch, the lesser posterior-horizontal). Alone, the lower ramifications from the posterior-horizontal distribution intervene between it and the posterior surface of the lung. Its great divisions, originating at this posterior level, must either descend vertically or else develop a forward tendency. Both these directions are represented (chiefly the latter) in the branchings from the left posterior-basic stem. It will be remembered that the right posterior-basic, in its own trunk and in all its branches, possesses a downward outward and backward movement. The left bronchi on the contrary present an outward and slightly forward tendency towards the axillary base; whilst a few, more superficially placed, descend vertically. Left posterior-basic stem (iv. ddp).

Left Lesser Posterior-horizontal Distribution.

The Inferior or Lesser Posterior-horizontal Trunk arises 4 mm. below the origin of the posterior-basic stem, and exactly behind the bifurcation of the left descending aortic bronchus, from the posterior surface of the stem. It takes its course almost horizontally outwards, keeping at a distance of 3·5 to 4 cm. below the posterior-horizontal trunk, and remaining under cover of the descending oblique from the latter. Both absolutely and relatively it is a little lower than the right lesser posterior-horizontal at its origin, being given off by the posterior-basic stem, instead of arising from the joint axillary-dorsal stem. It is of small size, and gives only small and unimportant branches downwards and anteriorly. Lesser posterior-horizontal (v. ddpe). Small branches downwards and forwards.

Together with the external mammary and with the mid-axillary bronchus, the lesser posterior-horizontal helps to form the floor of a **Central Lozenge-shaped Bronchial Interspace**, of which the inferior bronchus and its apparent trifurcation form the inner wall, and various **T**-shaped interlobar and deep bronchi the anterior and outer walls. Central lozenge-shaped inter-bronchial space.

The terminal bifurcation of this bronchus takes place in the posterior axillary region somewhat below the middle of the lung.

Left Posterior-basic Bronchial Supply.

The chief bifurcation of the posterior-basic stem occurs 2 cm. below the origin of the previous trunk, and gives rise to the *descending oblique dorsal*, and to the slightly larger *dorsi-basic division*. The latter supplies a pyramidal distribution, including the inner vertebral border and deeper parts, and the Descending oblique dorsal (vj. ddpde). Dorsi-basic trunk (vj. ddpdd).

Large extent of the latter's distribution. whole inferior border and lower basic surface, as far as the middle axillary line.

Smaller distribution from the descending oblique dorsal. The remainder of the posterior base,—viz., the outer and upper portion, is provided with bronchi by the descending oblique dorsal, a trunk inclined downwards and outwards, with slight forward tendency.

Left Descending Oblique Dorsal Distribution.

Posterior superficial dorsal oblique (vij. ddpdep). Deep dorsal oblique (vij. ddpdee). Horizontal branch (viij. ddpdepe). Descending branch (viij. ddpdepd).

The Descending Oblique Dorsal Trunk preserves the same direction as far as the lower axillary region, although it does not reach the basic margin. But it previously gives rise after a course of 1·5 cm. to the **Posterior Superficial Dorsal Oblique.** This short trunk bears the same relation to the outer base as the inferior aortic bronchus bears to the inner. It descends for 8 mm. exactly behind the deep oblique branch, and bifurcates into two superficial divisions provided with several sub-pleural branchlets. The *upper division* takes an outward direction towards the lower axillary region; the *lower*, or descending, descends almost vertically, but does not reach the edge of the lung. In the angle thus formed between these terminal branches, the deep portion ultimately comes to the surface about 3 cm. above the fringe.

Superior deep dorsal oblique (viij. ddpdeee). Inferior deep dorsal oblique (viij. ddpdeed).

The Deep Dorsal Oblique Trunk, whilst still under posterior cover of the superficial division, divides into an *upper* (or *outer*) and a *lower deep dorsal oblique*. After giving a deep intra-pulmonary bronchus forwards, the **Upper Deep Dorsal Oblique** again divides into an *anterior* and a *posterior* branch. The destination of these bronchi has already been mentioned. Branchlets from them are furnished respectively to the sub-pleural and to the intra-pulmonary tissue.

At a distance of 3 mm. below the descending dorsal oblique bronchus there arises from the posterior aspect of the trunk of the dorsi-basic an important minor trunk destined to supply the vertebral portion of the posterior pulmonary surface. The district in question is included between the lower limit of the distribution of the vertical descending aortic bronchus (derived from the posterior-horizontal trunk) and a level 2·5 cm. above the lower fringe of the lung. For the bronchus supplied to this district the name of **Inferior Descending Aortic** is almost indicated by the anatomical relations. It ramifies in a fan-shaped manner downwards, thus covering the posterior pulmonary surface from the scapular to the vertebral line, and leaving the outer half of the posterior surface to the descending oblique dorsal bronchus. Between the vertebral border of the lung and the direction of the dorsi-basic trunk, continued downwards, outwards, and slightly forwards, a space is left, the outline of which is triangular when viewed from behind. This space is filled by the almost completely symmetrical and equilateral-triangular outline of the inferior descending aortic distribution. The small bronchial trunk in question

Inferior descending aortic (vij. ddpddd). Dorsi-basic trunk (vij. ddpdde). Inverted fan-shaped and symmetrical distribution of the inferior descending aortic.

being at first absolutely vertical, forms at once an angle with the direction of the dorsi-basic trunk.

Inner descending aortic (viij. ddpdddi). Outer descending aortic (viij. ddpddde).

The branches of bifurcation of the inferior descending aortic are symmetrical and equal. The **Inner Descending Aortic** diverges slightly from the perpendicular, and ends above the inner posterior angle of the lung, completing a curve formed in succession by the main bronchus, by the inferior lobar bronchus and by the dorsi-basic, and resembling, when viewed from behind, a very open letter **C**. In the concavity of this curve, which constitutes as it were the inner edge of the bronchial tree, may be seen the pulmonary vein, the left pericardial surface, and quite anteriorly some of the sternal and cardiac bronchial tubes. From the concavity of this curve no inward branches are given excepting minute branches from the descending aortic bronchus.

C-shaped curve facing the pericardium.

The inferior pulmonary vein descends to the level of the bifurcation of the descending aortic: the inner division of this bronchus opposes to the vein a small **Anterior T-shaped Branch,** facing which, on the anterior side of the vein, is found a similar branch from the inferior pericardial bronchus.

Retro-venous T-shaped bronchus.

Other unimportant twigs are given off from the inner division, among them is an upper inward branchlet symmetrical with an outward branchlet from the outer division, and two inward branchlets intended for the lower part of the mesial border of the lung. The inner descending aortic finally supplies marginal arches which furnish the interval between the marginal branch from the superficial dorsi-basic and between the termination of the posterior angular bronchus at the inferior angle.

Marginal inner aortic branches.

The Outer Descending Aortic Bronchus is almost vertical. It supplies outwards a sub-pleural branchlet symmetrical with the small inward branch from its fellow bronchus; and it bifurcates after a course of 1 cm. into a *vertical supra-marginal branch* and an *oblique branch*, both of which are superficial.

Outer descending aortic (viij. ddpddde).

The Vertical Supra-marginal Bronchus lies parallel to and 5 mm. to the inner side of the inner division of the superficial dorsi-basic trunk, and thus separates this bronchus and its distribution from the inner border of the lung. It terminates in the same manner as other supra-marginal bronchi, and partly imbricates over the marginal branch from the superficial dorsi-basic trunk.

Vertical supra-marginal branch (ix. ddpdddedd). Oblique branch (ix. ddpdddee).

The Oblique Branch has a brief course downwards and outwards, supplying the sub-pleural tissue in the inferior mid-dorsal region.

Left Dorsi-basic Distribution.

The ensuing bifurcation of the dorsi-basic division of the posterior-basic stem gives rise to the *deep* and to the *superficial dorsi-basic trunks.*

The dorsi-basic trunk, in the interval of 1·3 cm. separating the origin of the descending aortic and the present bifurcation, has a direction parallel

Deep axillary dorsi-basic (viij. ddpddee). Superficial axillary dorsi-basic (viij. ddpdded).

to a line drawn from the posterior-horizontal stem to the lower extremity of the posterior axillary line.

The Deep Axillary Dorsi-basic Division follows the same direction, and may therefore be looked upon as the continuation of the posterior-basic stem. It traverses the depth of the outer portion of the lower lobe in front of the descending oblique distribution, and emerges above the posterior axillary fringe, to which it is distributed.

Deep axillary dorsi-basic (ix. ddpddeee). Central angular dorsi-basic (ix. ddpddeed).

The first bifurcation of the deep axillary dorsi-basic trunk gives rise to the *central angular dorsi-basic bronchus*, and to a continuation of the deep axillary dorsi-basic. The length of the undivided trunk above this bifurcation is 1 cm.; and between this and the subsequent bifurcation there is an unbranched length of 1·3 cm. The final breaking-up of the trunk is thus delayed until it has almost reached a superficial position in the posterior axillary region.

Inner, (x. ddpddeeei) and Outer terminal deep axillary-basic (x. ddpdd-eeee).

In its deep portion the deep axillary-basic gives rise to two or three stout and short **Intra-pulmonary Branches**; it finally divides into an **Inner** and into an **Outer Terminal** branch, which supply the tissue above the axillary fringe, and are therefore supra-marginal. Until close to the supra-marginal region they are covered by the imbrication of the inferior deep dorsal oblique bronchus.

Central angular dorsi-basic (ix. ddpdd-eed).

The internal branch of bifurcation, or **Central Angular Dorsi-basic**, is covered from behind by the superficial dorsi-basic, the general outline of which it repeats in a much more anterior or central plane. After a vertical course of 1·5 cm. it bifurcates into widely diverging branches.

Posterior inner angular (x. ddpdd-eedi). Posterior central (x. ddpdd-eede).

The branch to the posterior inner angle, or **Posterior Inner Angular**, which bears several deep *intra-pulmonary* branchlets, divides into an **Inferior-basic** bronchus and into an **Angular Marginal** bronchus. The latter furnishes a marginal arch for the posterior extremity of the inner fringe of the base.

Inferior-basic (xj. ddpdd-eedid). Angular marginal (xj. ddpdd-eedii).

The smaller, shorter, **Posterior Central Bronchus** extends outwards and downwards for the supply of the central zone above the posterior-outer pulmonary margin. It is anteriorly in relation with the central branches from the retro-cardiac bronchus, and parallel with them. It ends in subpleural basic branches.

Superficial axillary dorsi-basic (viij. ddpdded).

The Superficial Axillary Dorsi-basic Trunk and its distribution lie within a plane which passes through the inner posterior basic angle and along the posterior axillary line. After a course of 1·4 cm. this trunk divides into an outer and an inner branch, the former being slightly larger than its fellows.

Superficial dorsi-axillary-basic branch (ix. ddpdd-ede).

The outer division, or **Superficial Dorsi-axillary-basic**, is destined for the posterior axillary, and lateral dorsal fringe. Immediately above its bifurcation it supplies to the posterior pulmonary surface a branch of small size, which does not descend as far as the extreme fringe. It then divides into two branches, inner and outer, respectively termed **the Retro-axillary Marginal** and **Lateral Dorsal Marginal**, which terminate by means of small bifurcating branches at the surface.

Superficial dorsi-basic trunk (ix. ddpddedd).

Retro-axillary marginal (x. ddpdd-edea). Lateral dorsal marginal (x. ddpdd-edee).

The inner division, or **Superficial Dorsi-basic Trunk**, bifurcates after descending for 2·2 cm. vertically downwards, with slight inward bias. It divides into an *anterior* and a *posterior* branch. Each of these immediately bifurcates into two bronchi, *inner* and *outer*. The distribution is thus converted into a small pyramidal group which occupies the inner posterior angle of the base, and part of which is overlapped by the fringe of the descending aortic distribution.

Superficial dorsi-basic (ix. ddpddedd).

The branches from the posterior branch, or **Marginal Superficial Posterior-basic**, in addition to sub-pleural twigs, give rise to marginal arches for the fringe, and supply the fringe nearly as far as the angle. This distribution comes into contact with that of the posterior angular bronchus.

Marginal superficial posterior-basic (x. ddpddeddp). Central superficial posterior-basic (x. ddpddedda).

The branches arising from the **Central Superficial Posterior-basic** likewise supply branchlets to the intra-pulmonary tissue, and terminate at the basic surface in front of the marginal distribution just described.

SECTION III.

THE ANATOMY OF THE PULMONARY BLOOD-VESSELS, STUDIED FROM THE METALLIC CAST AND FROM DISSECTIONS.

GENERAL REMARKS ON THE PULMONARY BLOOD-VESSELS; THEIR RELATIONS TO EACH OTHER AND TO THE BRONCHI.

A.—General Relations of the Blood-vessels to the Bronchial Tree.

When the simple bronchial cast and the compound metallic cast of the bronchi and of the pulmonary blood-vessels are placed side by side, a striking contrast is presented by the unfurnished aspect of the first and by the fulness of the second. Indeed the great size of the injected blood-vessels is the first thing which arrests attention in the compound cast. Allowance must be made for the greater ease with which the walls of the blood-vessels, as compared with those of the bronchi, yield to the internal pressure exerted during injection. But even after this deduction, the calibre of the pulmonary vessels remains unusually large in proportion to their length, and reminds us of the fact that the amount of blood passing through them, to and from the lung, at each cardiac contraction, is exactly equal to the amount propelled into and derived from the general systemic circulation during the same interval of time.

Large size of the pulmonary vessels:

Some of the peculiarities of the bronchial tree may be traced to the presence within it, and to the large calibre of the pulmonary arteries and of the pulmonary veins.

Peculiarities of the bronchial tree, connected therewith. They exclude the parenchyma from the root-zone.

In the first place these vessels so fill the interspaces left between the primary and the secondary branches of the main bronchus, that no room remains at the root for any pulmonary parenchyma; and in consequence, no lobular bronchioles arise from the central internodia of the bronchial tree, but their origin is relegated to more peripheral zones.

They modify the course of bronchi;

In some situations the large size of the vascular trunks and the claim which they make upon the intra-pulmonary space bring about the deflection of a large bronchus, or some important alterations in the structure or in the shape of the bronchial tree. The following are striking instances of this kind:

e.g., of the left main bronchus,

(1) The left main bronchus, longer than the right bronchus owing to the passage over it of the aorta, is still further elongated in order that it may afford support to the arch of the left pulmonary artery. Professor Aeby even goes so far as to suppose that the left upper lobe has been entirely sacrificed to the superior position of this vessel; a view which I cannot endorse.

and of the right cardiac bronchus.

(2) The right cardiac, or middle lobar, bronchus by the unusual course of its first portion, which descends in contact with the lower lobar bronchus, and by the curvature of its second portion, clearly bears witness to the lateral pressure from the transverse portion of the pulmonary artery, and of the superior pulmonary vein in front of the artery.

Different situation of the right and of the left "vessel-space" due to them.

(3) The large vacant space seen in the metallic bronchial cast, in the upper part of the middle third of the right lung, is mainly devoted to the large blood-vessels and strictly deserves to be termed "the intra-pulmonary vessel-space." This gap is analogous to the space which intervenes between the apex of the left lung and the trachea; but in consequence of the different course adopted by the pulmonary artery in the two lungs, the "vessel-space" occurs in different situations on the two sides, above the upper lobar bronchus on the left side, and on the right side below this air-tube.

Curvature of the left main bronchus connected with the pulmonary artery.

(4) Again the left main bronchus shows a slight depression of its oblique axis, near the pulmonary root, and a posterior sulcus at its termination. These correspond to the position of the arch of the left pulmonary artery on the one hand and to that of the left descending pulmonary artery on the other.

B.—General Relations of the Pulmonary Arteries to the Bronchi.

A single artery accompanies each bronchus.

The relations existing between the arterial channels and the air-tubes are extremely simple and very constant. Each bronchus is invariably accompanied by a single arterial branch. The association once established between them is never dissolved. Their directions undergo the same variations, and their bifurcations occur simultaneously. The only exceptions to this otherwise absolute uniformity are those which occur at the root of the lung before the arteries have succeeded in modifying their original direction in accordance with the very different direction presented by the larger bronchi.

Their bifurcations are simultaneous.

The arterial distribution is a duplicate of the bronchial.

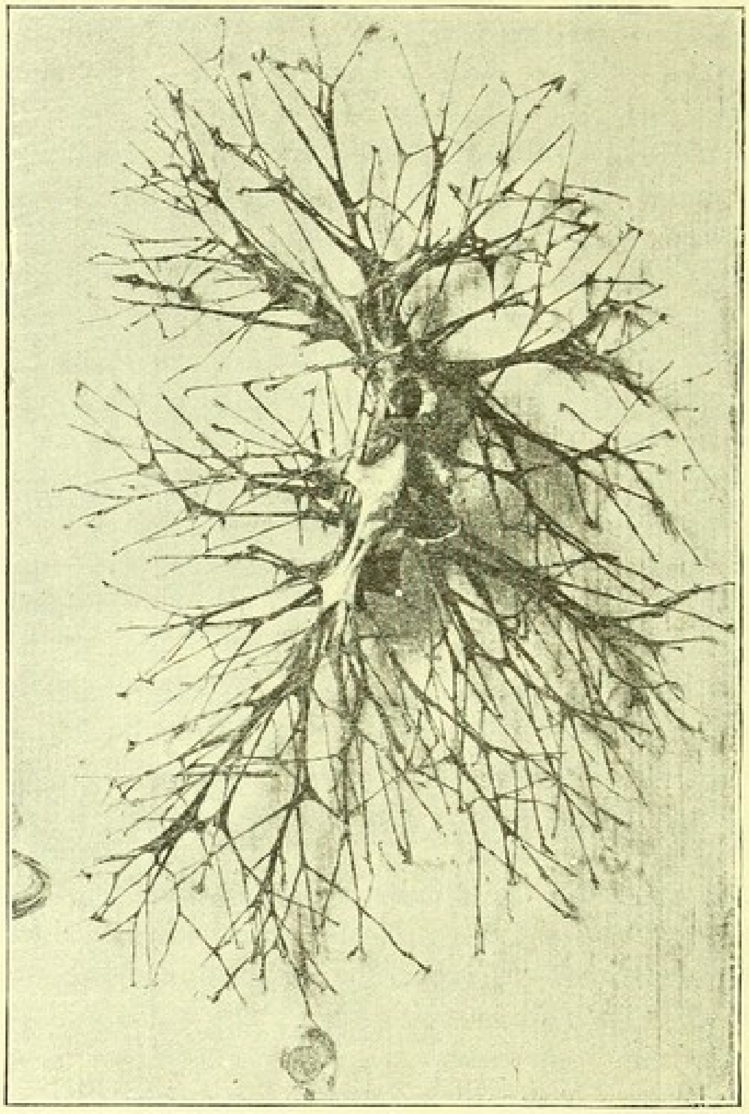
The arterial distribution is therefore a duplicate of the bronchial tree, and to describe the bronchial divisions is almost equivalent to describing the arteries. For this reason a separate diagram of the arterial ramifications will not be found necessary.

The relative position of artery and bronchus not the same throughout

But with regard to the relative positions assumed by each of the paired tubes, it is impossible to formulate a general rule applicable to all cases, as this has been attempted by Professor Aeby (*loc. cit.*, p. 4) and by Quain (*vide supra*, pp. 16, 17).

The aspect of the bronchial surface with which the accompanying artery is contiguous varies with the different districts of the same lung, and within the same district often varies with the individual bronchi. These relations will be in every case described in detail. There is however a rule capable of

Fig. 12.



Dissection of the Bronchi, of the Pulmonary Artery and of the Pulmonary Vein, dried. Right Lung—front view. (*From a Photograph,—considerably reduced.*)

The descending pulmonary artery is seen in the front plane, at the middle of the specimen. The details are not sufficiently clear to supply more than a general idea of the kind of dissections to which reference is made.

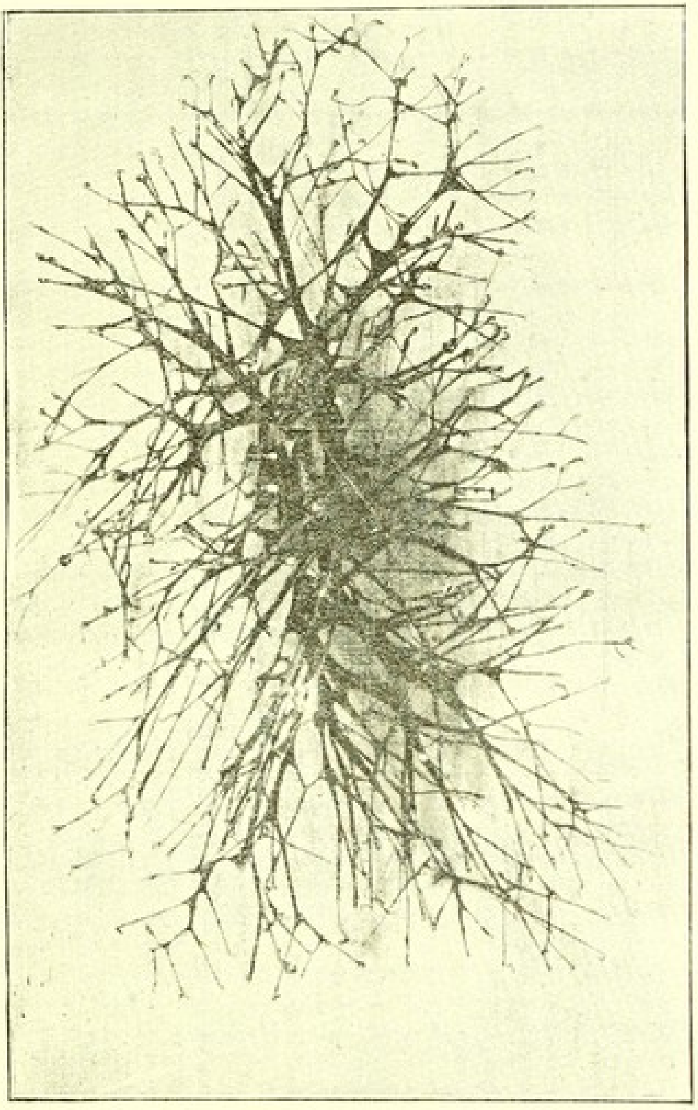
The arteries avoid the membranous sides of bronchi.

general application to those bronchi which possess a partly membranous wall. The artery is always associated with some portion of their cartilaginous surface, and not with the membranous portion.

C.—General Relations of the Pulmonary Veins to the Bronchi.

In direct opposition to the mutual behaviour of arteries and of bronchi, the relation of the pulmonary veins to the air-tubes is one of constant sepa- The veins remain at a distance

Fig. 13.



Dissection of the Bronchi, of the Pulmonary Artery and of the Pulmonary Vein, dried. Left Lung—front view. (*From a Photograph,—considerably reduced.*)

In this as in fig. 12 the photographic method has done scant justice to the specimen, the details of which are obscured. In both figures the venous branches may be recognized, in many places owing to the angles which they form with the direction of other vessels.

ration. Instead of clinging to the bronchial tubes, the veins usually ramify as far from them as it is possible. They generally select the middle of the interspace which intervenes between two or several bronchi. from the bronchi, in their interspaces.

Their mutual divergence persists.

Again instead of shaping their course in distant imitation of that of the bronchi, they retain their original divergence. In passing from one interspace into another their branches are of necessity otherwise than parallel to the bronchi. Nay, even during their course within the interspaces want of parallelism is the rule. The smaller veins approach the peripheral districts at an angle with the corresponding bronchi. Even when entering the lobule the two directions do not blend, and the venules are separated from the bronchiole by a considerable proportion of the thickness of the lobule. A study of the behaviour of the intra-lobular vessels within the lobule belongs to the province of histology and cannot be attempted here. But the description given of them by Sappey (*loc. cit.*, p. 470) favours the view that an analogous divergence exists between the most minute arterioles and venules.

They approach the lobules at an angle.

D.—General Relations of the Pulmonary Veins to the Pulmonary Arteries.

The veins remain independent of the arteries.

The mutual relations of the two sets of vessels within the lung, exclusive of their mediastinal portion, may be inferred from that which has been said concerning their individual relations to the bronchi. Throughout the lung the two blood-vessels follow an independent course. Between them there is neither symmetry of distribution, nor regularity of distance. They are rarely parallel. The veins do not, as in the systemic circulation, constitute a repetition of the arterial pattern. It is therefore impossible to gather from a description of the course followed by the pulmonary arteries more than an approximate idea of the direction taken by the pulmonary veins; and a separate diagram of the venous distribution is almost indispensable for reference, when specimens are not available for study (see fig. 18).

They are not parallel, nor similar.

Two rules regulate their mutual relations.

The chief features of contrast between the pulmonary arteries and the pulmonary veins may be summed up in the following rules:

(1) The two vessels are situated on opposite sides of the same bronchi, the artery clinging to the side of the bronchial wall, the vein keeping aloof.

(2) The arteries and the veins are not parallel, and they almost always cross each other at a considerable angle, often approaching, and sometimes equal to 90°.

Conclusions.

I cannot endeavour to discuss in these pages the important physiological considerations which a study of these relations has suggested; but within the range of pulmonary anatomy I have arrived at the following conclusions:

The veins connect divergent bronchial tracts.

(1) Inasmuch as the veins, occupying the bronchial interspaces, distribute their branches in various directions to two or to several bronchi, they establish an elastic link between the divergent bronchial tracts; and their ramifications throughout the lung constitute a connecting system for the pulmonary elements.

The intra-lobular arteries are

(2) From the persistent connection of the pulmonary arteries with the

bronchi, and from the fact that they enter the lobule in close association, it may be inferred that the same relation is continued yet further, and that the arterial element accompanies the bronchial element as far as the depth of the lobule. With regard to the pulmonary vein, a continued divergence would be suggested by the very distant behaviour of that vessel throughout the lung.

notably connected with the bronchioles; the venules are probably dissociated.

(3) At the surface the pulmonary vein is found to be intimately connected with the pleura; in its intra-pulmonary part it supports a continuous framework of connective tissue which extends between its branches; and lastly, close to the surface of the lobule, it undergoes division into two or more venules, which are at first superficial to the peri-lobular sheath, but which ultimately make their way into the lobule.

The pulmonary vein is connected with the pleura, with the intra-pulmonary framework, and with the peri-lobular membrane; it is peri-pneumonic, sustentacular, and peri-lobular, in addition to its vascular functions.

In these three successive stages of distribution, the pulmonary vein may be regarded, in a limited sense, as peri-pneumonic, as sustentacular, and as peri-lobular. The pulmonary artery on the contrary may be truly described as intra-pneumonic, as companion to the bronchus, and as intra-lobular. In other words, in addition to its vascular duty of conveying arterialized blood to the heart, the pulmonary vein would appear to discharge a supporting function in connection with the inter-bronchial and with the peri-lobular fibrous framework. The pulmonary artery would be, on the other hand, exclusively at the service of the blood-aërating function.

The pulmonary artery is restricted to the single function of respiration.

(4) According to all usual anatomical notions the term "artery" is synonymous with greater strength and elasticity than is understood under the term "vein." This difference in favour of the arteries is not perceptible within the lung, although it may be claimed for the pulmonary artery in its extra-pulmonary, and in its intra-radicular portions. The pulmonary vein is on the other hand remarkable for the toughness and for the elasticity as well as for the independence and for the unsupported condition of its ramifications.

Strength of wall and elasticity are not conspicuous in the small pulmonary arteries; they are more noticeable in the veins.

(5) Lastly, it may be argued, at least from a vascular standpoint, that the lung is a more direct extension of the pulmonary vein than of the pulmonary artery. Its connection with the left auricle is much more close and much more extensive than with the right ventricle; and whereas the pulmonary artery acts only as a loose link between the heart and the lung, the pulmonary veins firmly connect the two organs, as though by tight-drawn ligaments.

The lungs viewed as a vascular extension from the heart, and especially from the left auricle.

The veins viewed as ligaments.

E.—Differences between the Pulmonary and the Systemic Arteries.

The pulmonary artery is the only artery in the body which conveys venous blood. In spite of this contradiction in terms, it is, in its extra-pulmonary portion, and as far as its secondary divisions within the lung, unequivocally

The pulmonary artery conveys venous blood, but otherwise resembles the aorta at first. arterial in its structure and surroundings. Its origin from the right ventricle and its close resemblance to the aorta leave, on this point, no room for doubt. Nevertheless, it differs slightly from other arteries in the behaviour of its smaller branches. Its ramifications become intimately associated with the air-tubes; and, leaning upon them for lateral support, they appear to the naked eye to lose thickness of walls at an unusually rapid rate. Not only are the smaller branches thinner, they also seem to be of slightly softer texture, less extensile, and less elastic than systemic arteries.

Its smaller branches differ from other arteries; they have thinner, softer, less extensile and elastic walls.

In connection with this observation special interest attaches to the well-known fact that the pulmonary capillaries are unusually delicate, and narrow. These features would seem to point to their being structurally more closely allied to the pulmonary arterioles than to the venules.

The pulmonary capillaries resemble them rather than the veins.

In its distribution the pulmonary artery presents other peculiarities which distinguish it from systemic arteries:

(1) It is exclusively devoted to the respiratory function: its branches possess no other destination but the respiratory tissue; and the structures at the root of the lung, the pulmonary stroma, the pleura, and the bronchi (with the exception of the respiratory bronchioles) all remain outside the sphere of their distribution.

The pulmonary artery is purely respiratory in function.

(2) In becoming closely associated with the bronchi, it loses that independence which is common to most arteries, except the nutrient arteries of bone.

It is less independent in its course.

(3) In its systematic dissociation from the veins to which it corresponds, it departs from the usual arterial type.

It has no companion veins.

(4) Lastly, unlike the majority of systemic arteries, from its origin to its termination it presents no anastomoses.

It does not anastomose.

F.—Differences between the Pulmonary and the Systemic Veins.

Direct relation of the pulmonary veins to the heart.

The pulmonary veins stand in a more direct relation to the heart than any other veins except the cardiac veins. The four main pulmonary venous trunks are in effect diverticula from the cavity of the left auricle, and take a share in its rhythmical contractions, being supplied with a coat of cardiac striated fibres.

Rhythmical contraction.

Early subdivision.

In contrast with the pulmonary artery, which loops round into the pulmonary root, and whose breaking up is long delayed, the pulmonary veins, whilst still within the root, succeed in providing a complete set of diverging branches destined for the various parts of the lung. But in effecting this, the veins lose the appearances common to most systemic veins when undergoing division. Their general arrangement distantly resembles the divergence between the fingers of an outstretched hand. The radiating lines along which they extend to every point of the periphery meet centrally, close to the auricle, in the two short pulmonary veins on either side of the heart.

Very wide angles of divergence of its branches.

In their subsequent distribution the pulmonary veins assert the same tendency to early and wide-spreading ramification, in striking contrast to the behaviour of the arteries which are restricted to the rigid system of lobular distribution and of dichotomy.

The great length and the independent position thus assumed by veins of comparatively small calibre necessitate in them greater thickness and toughness than belong to most veins. In the possession of these qualities they may even be said to out-strip the arterial branches of corresponding size.

Great toughness and relative thickness of wall.

Yet more striking are their capacity for extension under linear traction, coupled with great resistance to ultimate disruption, and their remarkable power of recoil.

Great extensibility and elasticity.

The pulmonary veins do not anastomose during their course from the periphery to the root of the lung; but anastomoses occur between their smaller branches in the peripheral districts; and in this manner a connection is established between neighbouring lobules, the arterial supply to which is absolutely distinct.

No anastomoses at first. Frequent peripheral anastomoses.

In addition to this, during their intermediate course, and even within the zone of their secondary divisions they undergo extensive lateral branchings, and these place in communication large pulmonary districts which are contiguous, but otherwise separate.

Their anastomoses and wide-spreading branches connect the pulmonary districts.

Moreover it should be remembered that the bronchial venules (corresponding to bronchi smaller than those of third and fourth order: Sappey, *loc. cit.*, p. 456) empty themselves into the pulmonary veins as well as the pulmonary venules derived from the lobules of the lung.

They receive some of the bronchial venules.

All these circumstances render it highly probable that the pulmonary veins act not only as a medium of vascular connection, but as important factors in binding together the different districts of the lung and the different components of its tissue.

The pulmonary vein binds together the pulmonary districts and tissues.

The more definite points of contrast between the pulmonary and the systemic veins may be summed up as follows:

Summary of the differences between the pulmonary and the systemic veins.

(1) The pulmonary veins possess no valves.

(2) They do not accompany the arteries, but almost invariably keep at a distance from them.

(3) They are single, most probably not exceeding in number the pulmonary arteries, but in many situations appearing to be fewer than these, inasmuch as one peripheral venule often receives blood from two or more neighbouring arterioles.

(4) Their total capacity was considered by Winslow, by Santorini, by Haller and others (see Quain, vol. ii. p. 278, 1876) to be less than that of the corresponding arteries, instead of greater.

(5) Alone among veins they convey to the heart arterial blood. They derive their blood from two sets of capillaries which are in vascular connection respectively with the right and with the left ventricle, and which respectively

contain blood described as arterial and venous. It is obvious however that the ordinary meaning of the word venous cannot be applied to that portion of the bronchial blood which has been almost in direct contact with an abundant stream of air in the smaller bronchioles. Any contamination arising from the bronchial venous blood is both slight in extent and limited in kind, much carbonic anhydride not being included in its impurities.

(6) The pulmonary veins at their origin are contractile.

(7) The scheme of their distribution and the mechanism of their circulation are different from those of the veins of any other organ.

FIG. 14.

EXPLANATION OF THE DIAGRAM.

(The *figures* on either side refer to corresponding dots in the diagram. The figure corresponding to any given dot is determined by counting the dots *from within outwards*.)

The figure is purely diagrammatic as regards the blood-vessels and the bronchi. The latter present here the same arrangement as in fig. 9, which may with advantage be consulted. (Consult also the rough diagram of the isolated pulmonary veins, fig. 18.)

RIGHT LUNG.

1, Apical parasternal bronchus and artery.—2, Ascending-apical A.—3, Ascending-apical B.—4, Ascending-apical venous trunk.—5, Mid-pectoral apical B. and A.—6, Axillary B. and A.—7, Apical branch of the pulmonary axillary artery.—8, Posterior branch of the axillary-pectoral V. (The superior-dorsal V. is hidden from view.)

11, Descending parasternal B. and A.—12, Mid-sternal pectoral V.—13, Upper lobar venous trunk.—14, Inferior division of pulmonary A.—15, Horizontal mid-dorsal B. and A.—16, Corresponding vein.

j, Branch from sterno-cardiac V.—ij, Inner posterior-cardiac B. and A.—iij, Retro-cardiac B. and A.—iv, Outer posterior-cardiac B. and A.—v, Anterior-basic B. and A.—vj, Axillary-basic B. and A.—vij, Branch from lesser posterior-horizontal V.—viij, Lesser posterior-horizontal B. and A.

xj, Inner anterior-basic B. and A.—xij, Branch of anterior-basic V.—xiij, Anterior infra-mammary B. and A.—xiv, Axillary-basic B. and A. (both cut short at this spot).—xv, Inferior retro-axillary B. and A.

LEFT LUNG.

1′, Inner ascending-apical venous trunk.—2′, Ascending-apical B. and A.—3′, Transverse-apical vein, and divisions.—4′, Axillary-basic A.—5′, Axillary posterior interlobar B. and A.—6′, Ascending mid-pectoral B. and A.

11′, Posterior-cardiac B. and A.—12′, Lower lobar bronchus.—13′, Branch of mammary-cardiac vein.—14′, Inner descending mammary-cardiac B. and A.—15′, Outer descending mammary-cardiac B. and A.—16′, Anterior inferior mid-axillary horizontal B. and A.

j′, Retro-cardiac B. and A.—ij′, Superficial cardio-basic B. and A.—iij′, Inferior descending aortic B. and A.—iv′, Anterior superior axillary-basic B. and A.—v′, Inner descending mammary B. and A.—vj′, Outer descending mammary B. and A.—vij′, Posterior superficial oblique B. and A.

xj′, Deep cardio-basic B. and A.—xij′, Branch from descending posterior-basic V.—xiij′, Inferior basic B. and A.—xiv′, Posterior inferior axillary-basic B. and A.—xv′, Inner deep axillary dorsi-basic B. and A.—xvj′, Outer deep axillary dorsi-basic B. and A.

ERRATA: Although the relations of the right and of the left pulmonary artery to the common pulmonary A. and to the aorta are almost correctly given, the arch of the aorta does not rise as high as it should over the arch of the left pulmonary A.

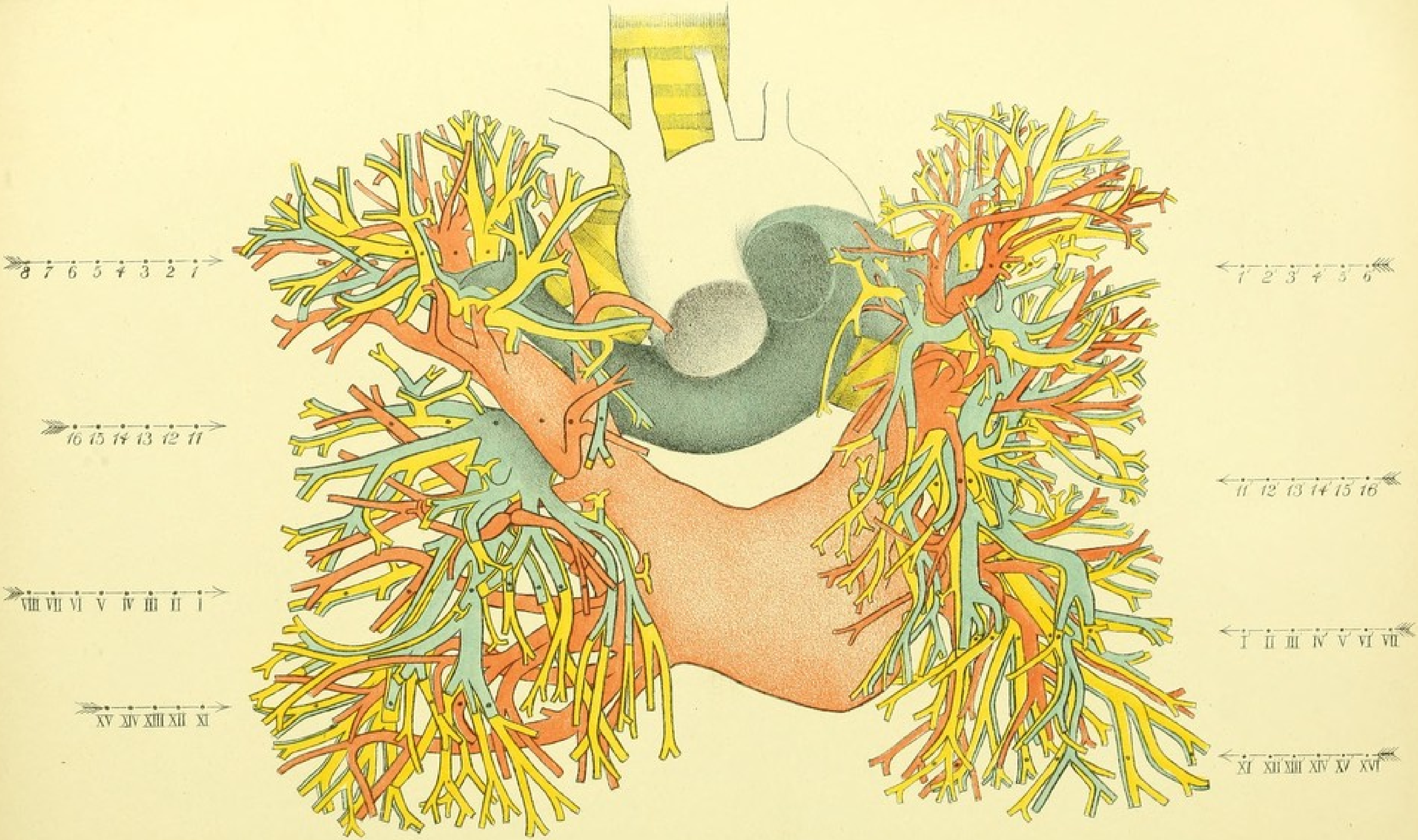
The right superior pulmonary vein should have presented greater curvature with spiral direction, and should have approached, at its termination, the origin of the bronchus intermedius.

The outline of the auricle is altered in the specimens from which the diagram was constructed, owing to the great distension of the upper part by the pressure of injection whilst the lower part was involved in the ligature securing the injecting cannula.

The left basic veins are depicted too small at their origin. The right basic veins are all shown, but the axillary-basic trunk should have arisen jointly with the posterior-basic, or close to the origin of the latter.

The right pulmonary-axillary artery has been drawn slightly out of position. It should have been nearer the bronchus and posterior to it.

Fig. 14



ROUGH COLOURED DIAGRAM OF THE BRONCHIAL
AND OF THE VASCULAR DISTRIBUTIONS.

Pulmonary Artery blue; Pulmonary Vein, and left Auricle, red; Bronchi, yellow.

DISTRIBUTION OF THE RIGHT PULMONARY ARTERY.

BROAD SKETCH OF THE RIGHT PULMONARY ARTERY AND OF ITS GREAT DIVISIONS WITHIN THE LUNG.

The Extra-pulmonary Portion of the right pulmonary artery is longer than the corresponding portion of the left pulmonary artery, owing to the common pulmonary artery being entirely to the left side of the middle line. It is crossed in front by the first portion of the aorta. In direction it is nearly horizontal. Immediately before entering the lung, the artery is situated behind the superior vena cava.

Long extra-pulmonary portion.

Relation to aorta and vena cava.

As it enters the Lung it lies in front of the bronchus intermedius and of the cardiac or middle lobar bronchus, being in immediate contact with the latter. At this stage it presents a very slight obliquity upwards; and it divides, whilst still in front of the bronchi into an ascending and into a descending portion for the upper lobe and for the lower lobes respectively. Before its division, it lies immediately above the superior pulmonary vein, which occupies a slightly anterior plane; but the internal ascending branch of the latter passes vertically in front of the termination of the main arterial trunk. It is behind this vein that arise the upper lobar pulmonary artery and the inferior axillary trunk.

Intra-pulmonary portion.

Its ascending and descending divisions.

Relations to veins.

Chief Branches, and their Directions.—Whilst the pectori-apical pulmonary artery ascends in front of the upper lobar bronchus, to the inner side of the apical trunk, delivering on its way the pectoral artery, and whilst the inferior axillary pulmonary artery very slantingly approaches from below the district of the same name, the descending division, which may be regarded as the continuation of the main artery, pursues an outward and downward course, at a level slightly beneath that of the horizontally placed pectoral stem of the upper lobar bronchus. The artery is here in close connection with important air-tubes and blood-vessels. Immediately in front is the superior pulmonary vein tending upwards and outwards in a direction almost at right angles to that of the artery. Behind is that portion of the continuation of the main bronchus which we have termed the intermediate bronchus; and, a little lower down, the two bronchi into which the intermediate bronchus divides. Of these the inferior lobar bronchus remains

The pectori-apical, the pectoral, the axillary pulmonary arteries.

Descending pulmonary artery.

Its important relations.

posterior to the artery, and the cardiac or middle lobar bronchus is slightly internal as well as posterior to it. In this portion of its course the descending artery, retaining some of the outward tendency which enabled it to cross the bronchus, is not yet quite parallel with the latter.

It is, at first, not parallel to bronchus.

Descending Trunk.—Behind the oblique lower border of the superior pulmonary vein, the descending artery undergoes a slight downward bend which renders it thenceforth parallel to the lower lobar bronchus, and it gives rise to three trunks :

Three divisions from it: descending, posterior-horizontal, cardiac.

(1) A middle, descending trunk;
(2) An outer, posterior-horizontal trunk;
(3) An anterior and inner, almost horizontal, but slightly descending trunk.

Of these divisions the first is the downwards continuation of the inferior lobar pulmonary artery, from which the other two arise almost in the shape of uplifted wings. The cardiac, or middle lobar artery, is the anterior division;—the other division has already been named.

The inferior pulmonary artery supplies retro-cardiac, anterior-basic, inferior dorsal, axillary-basic, posterior-basic trunks.

The Arteries of the Base.—Greatly diminished as a result of its branching, the descending or inferior pulmonary artery continues its course in anterior contact with the inferior lobar stem. It gradually becomes slightly external to it, and distributes a retro-cardiac, an anterior-basic, and an inferior dorsal branch. Finally, it divides into an axillary-basic and a posterior-basic trunk. The former preserves its anterior and outer relation to the bronchus. The latter becomes at once posterior, and in this relation its branches accompany the branches of the bronchial trunk to their termination.

Alone the last-named is posterior to its bronchi.

DETAILED ACCOUNT OF THE DISTRIBUTION OF THE RIGHT PULMONARY ARTERY.

ARTERIAL SUPPLY TO THE UPPER LOBE.

The Right Upper Lobe is supplied with venous blood by three large arterial trunks, which are analogous to the three great divisions of the upper lobar bronchus. The names proposed for them are, "ascending-apical artery;" "pectoral artery;" and "inferior or ascending axillary artery." These arteries become associated with the bronchi respectively bearing the same names. In this respect the arrangement is constant; but in other particulars variations occur.

Three large arteries: Ascending-apical, pectoral, inferior axillary.

The Size of the arterial trunks is apt to vary in accordance with differences in the mode of supply of peripheral districts, a peripheral district equally distant from two trunks being sometimes supplied by one, and sometimes by the other.

Variations in size,

and in origin.

In the Mode of Origin also abnormalities are seen. According to the usual arrangement a large pectori-apical trunk originates from the upper surface of the right pulmonary artery immediately after its entrance into the lung, namely from that part which may be called the transverse portion, and from this trunk or from the transverse portion just external to it, arises the inferior axillary artery. The latter arrangement obtains in the specimen depicted in figs. 19 and 20. But in the preparation represented in figs. 15 and 16, the three arteries have distinct origins, the first two arising side by side, and the inferior axillary, which is unusually large, springing from the extremity of the transverse portion just before its downward bend. From a comparison with other dissections, the arrangement last mentioned appears to be abnormal. In the following description we shall adhere to the first type.

The Right Pectori-apical Artery and its Branches.

Pectori-apical trunk.

The Pectori-apical Artery rises vertically behind the inner ascending trunk of the superior pulmonary vein, but owing to the inward swerving of the latter, the artery quickly becomes a little external as well as posterior to the vein. It is in contact posteriorly with the horizontal upper lobar bronchus, and externally with the origin of the inferior axillary artery, a vessel to which it may give origin. The pectori-apical trunk is a very short one, and divides almost immediately into the pectoral and the ascending-apical trunks.

Pectoral artery. Ascending-apical trunk.

Distribution of the Pectoral Artery.

Pectoral artery.

The Pectoral Artery, when arising from a common trunk with the ascending apical, is directed from the first outwards and forwards. In specimens where the pectoral artery independently arises from the transverse portion of the pulmonary artery the direction is at first upwards. Immediately before reaching the neighbourhood of the pectoral stem, to which it is slightly superior, it divides into an outer and an inner trunk, respectively termed the mid-pectoral and the sterno-pectoral artery.

Mid-pectoral, Sterno-pectoral arteries.

Usual relation to bronchi.

In the situation and relations of the main arterial trunk is foreshadowed the behaviour of most of its branches. They lie above and on the inner aspect of the air-tubes to which they are attached. To this rule there are two exceptions which will be presently mentioned.

Mid-pectoral artery.

The Mid-pectoral Artery passes outwards across and above the pectoral stem, immediately behind its bifurcation, and applies itself to the upper surface of the mid-pectoral bronchus. But the branch destined for the outer and inferior division of this bronchus reaches the air-tube from the outer side, having obliquely crossed the mid-pectoral bronchus. With this exception the arterial branches are internal as well as superior to the bronchial.

Sterno-pectoral artery. Usual relation to bronchi.

The Sterno-pectoral Artery divides into branches which apply themselves to as many bronchial tubes. Each artery adheres to the inner aspect of the corresponding bronchus. A slight deviation from this rule is observed in the case of the inner pectoral artery, which courses strictly along the upper surface of the air-tube and follows also in its ramifications the upper bronchial border.

Distribution of the Right Ascending-apical, or Axillary-apical, Artery.

Relation of ascending axillary-apical artery.

The Ascending-apical Artery follows the course and the distribution of the ascending-apical bronchus, to which it is internal and very slightly posterior. The posterior relation of the artery to the bronchus becomes more marked at a higher level, the inclination of the bronchus being slightly forward, that of the artery strictly vertical.

Relations of arteries and bronchi within the apex.

It results from this arrangement that the arterial branches are not only internal but posterior to the bronchial branches throughout the apical distribution; and further that the lateral arterial branches pass behind and never in front of any vertical bronchial tubes; and lastly that in any branchings occurring horizontally the artery would be posterior and superior to the bronchus.

Internal ascending pulmonary vein.

The internal ascending pulmonary vein which was at first situated in front of the pectori-apical artery, has, in its upward course, curved backwards, and now approaches the inner side of the ascending apical artery, being but slightly anterior to it.

Three parallel vertical vessels.

Thus, rising from the upper border of the pulmonary root, and within one transverse plane, is seen a row of three parallel and contiguous vessels:—a pulmonary vein, innermost; a pulmonary artery in the middle; and the pectori-apical bronchus externally.

Origin of superior axillary artery.

The Bifurcation of the ascending axillary-apical artery into apical artery and superior axillary artery takes place at a higher level than the bronchial bifurcation.

Superior axillary-trunk, better termed: Retro-apical artery.

The superior axillary arterial trunk is, in consequence, separated by a considerable vertical distance from the first part of the axillary bronchial stem, and has much less obliquity upwards than this bronchus. It should not be mistaken for an exact vascular equivalent of the latter. Its distribution is entirely restricted to the posterior apical bronchial district. It may therefore with propriety be termed the retro-apical artery.

Posterior axillary-apical artery: posterior and internal to bronchi. Supra-spinate pulmonary artery. Its branches are

The Retro-apical Artery, taking its course outwards, and very slightly backwards and upwards, delivers, before joining the retro-axillary bronchus, the ascending **Posterior Axillary-apical Artery,** which accompanies the bronchus of the same name and all its branches along their inner and posterior aspect, and the almost horizontal **Supra-spinate Pulmonary Artery.** The latter, passing behind the posterior axillary-apical bronchus, gains access to the posterior and upper border of the supra-spinate bronchus. Its branches accompany the divisions of the bronchus, preserving throughout the same anatomical relation to them. posterior and superior to the bronchi.

Distribution of the Right Pulmonary Axillary Artery.

The Pulmonary Axillary Artery may be of smaller or of larger size than the retro-apical artery, according to the share which it takes in the arterial supply to the axillary bronchial district. Usually being restricted to the supply of the lower portion of that district, it is of smaller diameter and it occupies an anterior plane. Its main level is about 3 cm. lower than that of the retro-apical artery. The pulmonary axillary artery takes its origin by the side of the pectori-apical arterial stem, from the upper surface of the transverse portion of the pulmonary artery. Passing upwards and outwards beneath the pectori-apical bronchus (a lymphatic gland intervening between them), it is received in the angle formed by the bifurcation of the superior pulmonary vein into the ascending apical vein and into the posteriorly placed superior dorsal vein. Beyond the fork thus produced it approaches by degrees the under and posterior surface of the axillary trunk, which it joins nearly at the point of bifurcation of that bronchus. The artery bifurcates behind the bronchus, and its branches are posterior and inferior to the air-tubes as far as their termination. In the diagram (fig. 17) and in the chromo-lithographed diagram one of its branches is erroneously depicted in front of the corresponding air-tube; and in addition an interval occurs between the vessels and the bronchi which does not exist in the specimens.

Pulmonary axillary artery.

Course and relations of the pulmonary axillary artery.

Its branches are posterior and inferior to bronchi.

Variation in Origin and Distribution.—Whenever the pulmonary axillary artery acquires greater development than the superior axillary trunk, this is due to its undertaking the partial supply of the retro-axillary bronchial district. It may even (as in fig. 16, square G iv) entirely supersede the superior axillary artery. In this case it forms the posterior division of a short arterial trunk (square G v) which arises from the transverse portion of the pulmonary artery close to the beginning of the descending portion. This short ascending trunk, not found in other specimens, bifurcates into an inner posterior division, or retro-axillary trunk and an outer anterior division or pulmonary axillary trunk.

Variation in its size and in its origin and distribution.

The short common axillary pulmonary trunk, when present, forms the upper arm of a complete arterial cross the long arm of which is represented by the descending pulmonary artery, the anterior arm by the cardiac artery and the posterior arm by the posterior-horizontal artery.

Complete arterial cross formed in some specimens.

The Relations of the arterial branches to the air-tubes differ in the two districts. The superior axillary trunk, or retro-apical artery approaches the corresponding bronchi from the inner side; its branches remain internal to the latter. In their vertical portions they become anterior and in their horizontal portions, superior to the bronchi which they accompany.* The same

The retro-apical branches are internal to bronchi; also anterior if vertical, and superior if horizontal.

* This relation is not accurately shown in the diagrams.

The axillary branches are posterior and inferior to bronchi.

tendency is also observed in the distribution of a retro-axillary artery originating abnormally from the transverse portion of the pulmonary artery.

On the contrary the pulmonary axillary arterial branches, which normally join their bronchi from the outer side and from below, become posterior as well as inferior to the latter.

ARTERIAL SUPPLY TO THE RIGHT MIDDLE LOBE.

Contact between superior pulmonary vein and descending pulmonary artery,

From what has preceded it is clear that the rising inferior pulmonary vein and the descending pulmonary artery are in contact in front of the intermediate bronchus and of the beginning of the middle and inferior lobar bronchi. Inasmuch as the vein is in this situation nearly horizontal in direction (although in the diagrams it appears to ascend), and inasmuch as the descending pulmonary artery sends out two almost horizontal lateral branches, the surface of contact between the two sets of vessels is much extended, and the line of contact is almost horizontal. This line exactly corresponds to that of the short or middle interlobar fissure which joins at its posterior extremity the great fissure. The two vessels are thus respectively covered by the upper and by the lower layer of the septal fold of the pleura. Under a different name the same fold may be traced posteriorly into the longitudinal fissure as far as the posterior surface of the intermediate bronchus.

at level of transverse fissure.

The cardiac or middle lobar artery.

The Cardiac or Middle Lobar Pulmonary Artery originates at a slightly lower level than the cardiac bronchus, which, in its beginning, is covered by the transverse portion of the pulmonary artery and by the obliquely ascending superior pulmonary vein in front of the latter. The origin of the cardiac artery is situated exactly below the vein.

Its branches are superior and external to bronchi.

The arterial branchings faithfully correspond with those of the bronchus, lying above the latter, and slightly external to them, in contrast with the sterno-pectoral arterial supply, which is inferior and internal to the air-tubes. The distribution in question is readily seen in figs. 15 and 19 and in the diagrams.

ARTERIAL SUPPLY TO THE RIGHT LOWER LOBE.

Descending pulmonary artery.

Owing to the great obliquity of its upper surface, the lower lobe, in its posterior part, attains a higher level than the middle lobe, and its first arterial trunk, the posterior-horizontal artery, is fractionally higher than the cardiac artery.

THE RIGHT DESCENDING PULMONARY ARTERY AND ITS BRANCHES.

Its direction

The Descending Pulmonary Artery is the sole source of venous blood for the lower lobe. From the point where its transverse portion comes to an end, at the bottom of the transverse fissure, the artery takes a direction downwards, outwards, and slightly backwards almost coinciding with that of the inferior lobar bronchial stem. Want of parallelism between the two tubes occurs only in the lower half of the lower lobe. Here the pulmonary artery becomes more and more external instead of anterior to the bronchus, and finally, in the posterior-basic division, entirely posterior to it. and relations.

The Branches of the descending pulmonary artery, enumerated from above downwards, are: (1) The posterior-horizontal artery; (2 and 3), arising by a common trunk of origin, the retro-cardiac and the anterior-basic arteries; (4) the lesser posterior-horizontal; (5) the axillary-basic and (6) the posterior-basic artery. Its branches.

Distribution of the Right Posterior-horizontal Artery.

The Posterior-horizontal Artery is true to its name, and diverges horizontally backwards and outwards from the external and posterior aspect of the pulmonary artery at the point where the latter bends downwards. It therefore continues the level, although not the direction, of the transverse portion of the trunk. It is situated exactly opposite the cardiac artery which takes its origin from the anterior and inner side of the large artery at its bend, with an obliquity downwards and forwards. Posterior-horizontal artery.

The stout horizontal trunk, measuring in length from 2·5 to 3 cm. finds itself placed in front of, and at a higher level than the bronchus with which it is associated. It bifurcates almost immediately into a *smaller posterior* and a *larger lateral* division.

The Vertical Descending Mid-dorsal Artery, a short trunk for the supply of the middle third of the vertebral border of the lung, takes at first a horizontal direction backwards, and crossing from above the posterior-horizontal bronchus attaches itself to the upper surface of the air-tube to which it belongs. It ultimately descends along the vertebral border of the latter. The artery in its course gives a branch upwards which accompanies the vertical ascending mid-dorsal bronchus. Vertical descending mid-dorsal artery.

The Larger, Lateral Division may be regarded as the continuation of the posterior-horizontal artery, of which it maintains the direction for a short distance. Before it has acquired a length of 2 cm., it bifurcates horizontally into a *posterior* and a *lateral* trunk, destined respectively for the sub-scapular and for the mid-axillary districts of the bronchial tree.

The posterior, or **Horizontal Mid-dorsal Artery** passes horizontally backwards and outwards to the angle formed by the horizontal mid-dorsal, and by the ascending oblique dorsal bronchus; and bifurcating within the bronchial bifurcation, it supplies companion arteries to the opposite sides of the two air-tubes; these arteries gradually become posterior. Horizontal mid-dorsal artery. Its branches become posterior to bronchi.

The Lateral or Mid-axillary Posterior-horizontal Trunk joins the bronchus of the same name and follows its divisions, remaining throughout superior, and sometimes becoming anterior to the bronchial tubes. Mid-axillary posterior-horizontal artery. Its branches are superior.

Distributions of the Right Lesser Posterior-horizontal, Retro-cardiac, and Basic Arteries.

Common origin of retro-cardiac and of anterior-basic arteries. Their branches are anterior and external to the bronchi.

The Retro-cardiac and the Anterior-basic Arteries arise by a common short trunk situated half-way between, and a little externally, as well as anteriorly to, the two bronchial origins. In this situation it bifurcates; and the two arteries, diverging equally from the perpendicular direction of their common trunk, apply themselves to the anterior and external aspect of the corresponding bronchi, for the ramifications of which they supply arterial branches preserving to the end the same relation.

Lesser posterior-horizontal. Its branches are superior to the air-tubes.

The Lesser Posterior-horizontal Artery.—This is a stout horizontal vessel, which arises a very short distance below the level of the preceding trunk, and distributes its branches in contact with the upper wall of the corresponding bronchial tubes.

Axillary-basic artery. Its branches are anterior to the bronchi.

The Axillary-basic Artery.—Of the two terminal divisicns of the descending pulmonary artery the axillary-basic is the more direct continuation of the arterial trunk;—but in size it is much inferior to the posterior-basic. It is, at its origin, superior, and it becomes also anterior to the axillary-basic bronchus. Its divisions remain throughout the distribution anterior to the bronchi which they accompany.

Posterior-basic artery. Posterior relation of this stem and of its divisions to the air-tubes.

The Posterior-basic Artery represents the lowest as well as the most posterior extension of the pulmonary artery. It departs from the lateral position previously occupied by the arterial trunk, and becomes posterior to its accompanying bronchial tubes. This is an important peculiarity, which readily distinguishes the posterior-basic distribution from that of other basic arteries. There is however one exception to the posterior position assumed by the arterial branches:

Lateral dorsi-basic artery.

The Lateral Dorsi-basic Artery passes in front of the corresponding bronchus. But its branches ultimately show a tendency to become posterior.

Fig. 15.

Drawing from a metallic cast of the Bronchi, Pulmonary Arteries and Pulmonary Veins—obtained in a somewhat obese, female subject; isolated by dissection. (*Cf.* figs. 19 and 20.)

Front view, from the right.

(The side of each square represents 20 mm.)

EXPLANATION OF THE DRAWING.

Many peripheral tubes are soft and twisted, not having been filled with metal. The left auricle is distorted from pressure of injection. Below the auricle, on either side of the aorta, a strip of pleura indicates the line of reflection of the membrane; above it, part of the aorta, of the common pulmonary A. and of the superior V. cava are in view.

Left Lung.

In square F vj, the lower division of the left superior pulmonary V. gives rise to the pectoral veins (line v) as well as to the superior and inferior cardiac veins; the veins occupying the interspaces below the corresponding bronchi.

In square F vij, the three left basic veins separate the anterior-basic bronchi above (arteries superior) from the posterior-basic B. below (arteries posterior).

In squares F v and iv, to the inner side of the pectoral bronchi and arteries the superficial internal ascending pulmonary vein rises to supply the inner apex. A small portion of the transverse pulmonary V. is seen in middle of square F iv, in front of the ascending-apical B.

Right Lung.

In the middle third the superior pulmonary vein and the descending pulmonary artery are in close contact. In the upper lobe the veins are relatively more in view. In the middle and lower lobes the arteries to a great extent cover from the front and from above the other structures. A cross-shaped division of the vessels occurs repeatedly in this specimen: *e.g.*, at intersections E iv and C iv, also at C v (large arterial cross).

Below the innominate artery are seen the sub-pleural sterno-pectoral V.; at line iv, the pectoral arteries and bronchi; at line v, the mid-sternal pectoral V.; at line vj, the cardiac arteries and bronchi (the ascending branch of the central cardiac V. separating their two sets at point D vj).

Along line D, crossed by line iij, are grouped the ascending-apical artery, bronchus, and V.—and below line iv rises the ascending mid-pectoral V.

At junction C iv the axillary-pectoral V. is seen in front of the axillary bronchus and artery, the divisions of which occupy the external portion of the upper lobe.

At junction C v, the horizontal vein appearing to belong to the middle lobe probably belongs to the upper. Below this vessel, the posterior-horizontal artery, bronchus, and V. are easily found.

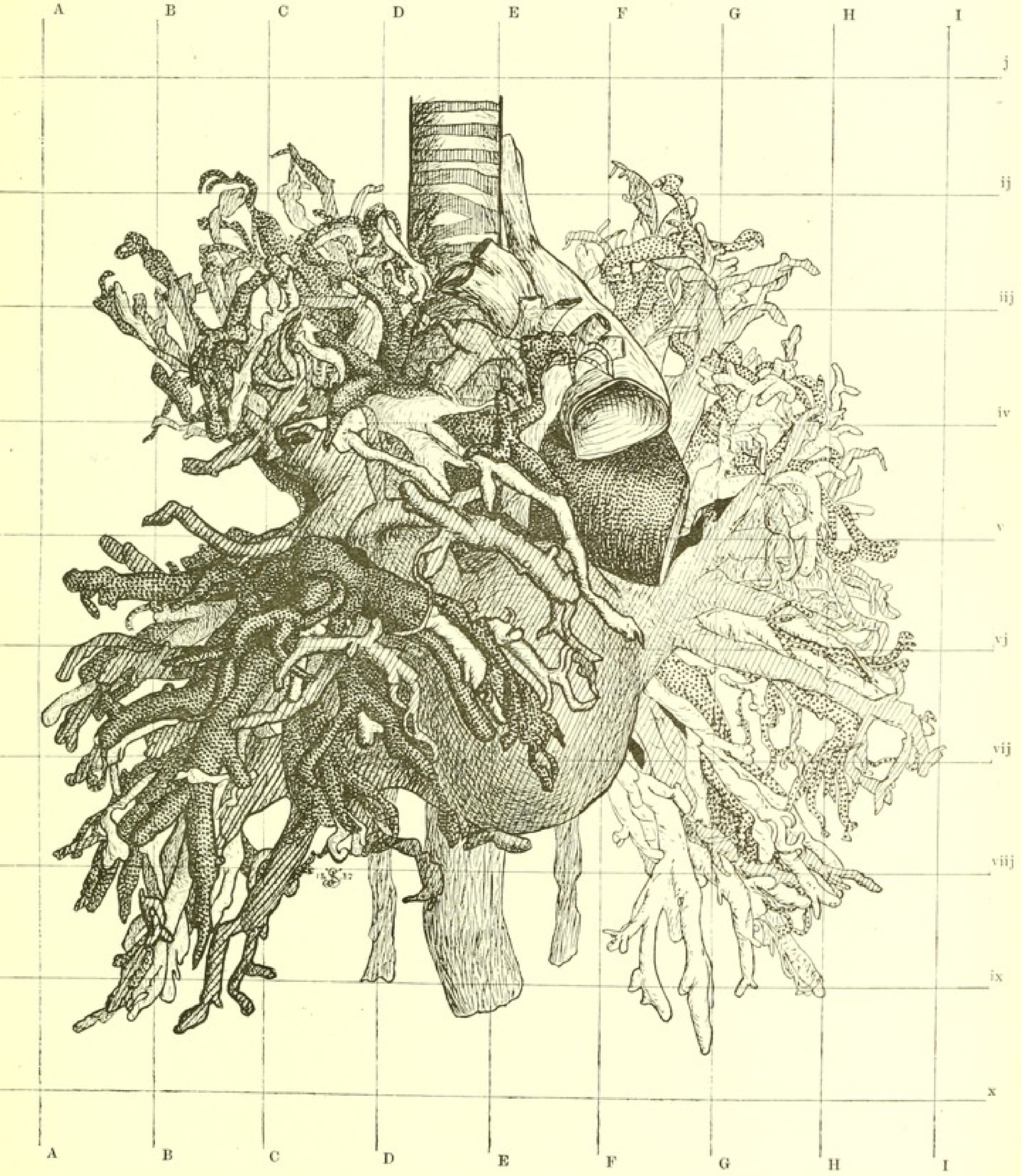
At junction C vj the anterior-basic artery is seen below the cross-shaped mammary-cardiac A. It soon divides into its lateral anterior-basic, and its cardio-basic trunk. The pointed termination of the latter is much anterior to the posterior-basic bronchi seen on either side of it.

At junction B vij the axillary-basic artery and bronchus appear below the lateral anterior-basic trunk.

At junction C vij a large venous trunk from the inferior pulmonary V. divides into its branches, anterior- and axillary-basic. The retro-cardiac vessels and bronchi are situated above the artist's subscription; and externally to the same, in a posterior plane, descends the posterior-basic vein.

Fig. 15.

Pulmonary arteries, dotted; pulmonary veins, shaded; bronchi, blank; black patches indicate lymphatic glands.



DISTRIBUTION OF THE LEFT PULMONARY ARTERY.

General Remarks on the Mode of Distribution of the Left Pulmonary Artery.

The extra-pulmonary course of the left pulmonary artery has already been described. Having risen in front of the left bronchus, and partly arched over it, the artery enters the upper part of the root of the lung at its posterior aspect, with a direction forwards, outwards, and slightly downwards. Extra-pulmonary portion;

The supply to the apical region of the upper lobe is given at the higher level reached by the artery. Subsequently the diminished arterial trunk descends behind the large bronchia, following a course to be hereafter described, and after supplying, at the upper level of the middle third of the lung, the cardiac trunk, it terminates lower down in a manner similar to that of the inferior lobar bronchus. Intra-pulmonary course. Resemblance to the right in the lower lobe.

Inasmuch as the upper lobe does not receive its supply from a large single trunk, analogous to the upper lobar bronchus, but from three trunks, the lobar nomenclature is of less avail for purposes of description than in the right lung, and we must adopt a regional nomenclature in its stead. The apical, the pectoral, and the cardiac regions, each receiving a separate artery, will be described in succession. Of these arteries, the two upper arise in close proximity to each other; the third, at a considerable distance further down. Upper lobe supplied by three distinct trunks.

ARTERIAL SUPPLY TO THE LEFT UPPER LOBE.

(Consult for the study of this distribution the diagrams 14 and 17 and figs. 16 and 20.)

A separate name need hardly be given to the broad, massive, **Sessile Trunk** which serves as origin to the arteries of the apex (but which is sometimes nothing more than a mere bulging of the wall of the pulmonary artery). Indeed all appearances of a special trunk may be absent, and the several vessels may originate separately and in close succession, from the smooth convexity of the posterior part of the arch of the pulmonary artery. Sessile trunk of origin; may be absent.

When present the trunk is situated on the left side of the pulmonary arch immediately beyond its downward bend. It is apt to display, in the injected specimen, a transverse furrow. The upper and lower segments defined by the latter, are destined respectively for the supply of the pectoral Its situation, when present.

region and of the inner-anterior group of apex-bronchi and for that of the outer and posterior group.

Arterial Supply to the Inner and Central District of the Left Apex.

The Left Pectori-apical Trunk and its Apical Branches.

Pectori-apical trunk. Ascending-apical trunk; Pectoral trunk.

The superior segment of the sessile trunk, although it does not accompany the bronchus bearing that name, may be termed the *pectori-apical artery* since it divides into the ascending-apical and pectoral trunks. The direction of this important vessel is almost horizontally forwards and slightly outwards and downwards. Its bifurcation occurs at the foot of the ascending-apical bronchial trunk.

Distribution of the Left Ascending-apical Trunk.

Ascending-apical trunk.

The Ascending-apical Trunk, the larger of the two branches of bifurcation, rises into the apex with a direction upwards and forwards, and adheres to the posterior and inner side of the ascending-apical bronchus. It divides in faithful imitation of the bronchus, and its divisions follow the inner side of the bronchial branches.

Anterior ascending-apical artery.

The Anterior Ascending-apical Artery is, in its relations, analogous to the vessel of the same name in the right lung; but, instead of lying tolerably close to the outer wall of the trachea, it is separated from it by the aggregate thickness of the trunk of the left pulmonary artery, of the aortic arch, and of the subclavian artery.

Its divisions are internal to bronchi, and above slightly anterior.

The artery moves for a short distance forwards, in order to reach the inner border of the corresponding bronchus, which it approaches from behind. As it rises, it becomes strictly internal to the bronchus, and in its upper divisions slightly anterior to the corresponding bronchial branches.

Posterior ascending-apical artery. Its divisions are posterior.

The Posterior Ascending-apical Artery is situated almost immediately behind the posterior ascending-apical bronchus, and its smaller branches preserve the same name and assume the same direction as the bronchus, accompanying its divisions *from behind*.

Arterial Supply to the Posterior and Outer District of the Left Apex.

The Left Axillary Pulmonary Artery.

Posterior apical artery from the axillary pulmonary artery.

The Left Axillary Pulmonary Artery arises from the lower segment of the sessile trunk and distributes branches within the posterior zone in which it originates. The posterior apical bronchus (from the posterior axillary stem) and the other branches of the axillary stem receive their attendant arteries from this source. The arterial branches remain in contact with the inner posterior side of the bronchial divisions. The arteries are internal and posterior to the bronchi.

Summary.—What has been said concerning the arterial distribution to the left apex may be briefly summed up as follows: Relations between bronchi and arteries at the apex.

The arteries arise at a higher level than the bronchi, and posteriorly and internally to the latter.

They generally preserve a posterior relation to the air-tubes. Some of the outward branches become external to the bronchial ramifications. But the majority of the arteries are internal as well as posterior. Arteries posterior to bronchi; also usually internal.

There is however one exception to the otherwise constant rule as to the posterior position of the arteries: Exception to the rule:

The Outer Ascending-apical Artery, a branch of small size, arises from the pulmonary artery immediately below the sessile trunk, and curving underneath the axillary bronchial stem (the interlobar branch of which receives from it a posterior arteriole), reaches the anterior surface of the outer ascending-apical bronchus, the distribution of which it accompanies. The outer ascending-apical artery. Its branches are anterior to the bronchi.

The Pulmonary Veins.—It is the rule for pulmonary veins not to occur on the same side of bronchi as the arteries, and the veins within the left apex are almost exclusively anterior. The space in front of the ascending bronchi is reserved for the distribution of the upper transverse pulmonary vein. The posterior branches from this vein, reversing the course followed by the arteries, traverse the apex from before backwards, and thus reach its posterior surface, to which they are distributed. Relations between the arteries and the pulmonary veins.

ARTERIAL SUPPLY TO THE LEFT PECTORAL DISTRICT.

The Pectoral Artery, almost equal to the ascending-apical, its twin-vessel, continues the course of the pectori-apical trunk (*vide supra*). Pectoral artery;

The direction of this important artery is sagittal from behind forwards; and although some of its branches are deflected upwards or downwards, the trunk is strictly horizontal. Applying itself exactly to the upper surface of the pectoral bronchus, the artery becomes anterior to the bronchi in all its descending divisions, and posterior to the bronchi in its ascending branches. Some of the branches show an inclination towards the inner side, others towards the outer side of the corresponding bronchial tubes. its direction and relations. The descending arteries are anterior to the bronchi; the ascending arteries are posterior.

In the injected specimen the artery occupies a conspicuous position, but its origin is anteriorly hidden by the rising trunk of the mid-apical pulmonary vein; and the transverse-apical vein (from which the latter originates) lies across its first part.

Having emerged from behind the vein, the artery comes well into view from the front, and assumes a slightly ascending direction. It bifurcates The arterial branches remain superior to the bronchi.

twice in rapid succession, and it furnishes each of the pectoral bronchi with a companion artery, which remains superior to the air-tube.

The pectoral distribution being mainly horizontal, ample room is afforded below its level for the ramifications of pectoral veins.

ARTERIAL SUPPLY TO THE LEFT CARDIAC REGION.

Cardic artery.

The left cardiac district equivalent to the right middle lobe.

The Cardiac Artery, a bulky and short trunk, springing horizontally forwards from the antero-lateral aspect of the pulmonary artery, at the level of the cardiac bronchus, supplies all the blood to be distributed to the cardiac district, which is the equivalent of the right middle lobe. If any doubt were possible as to the relative value of the right and of the left cardiac districts, it would be set at rest by comparing the almost identical behaviour of the arterial supply to this region on the right side of the chest, and on the left side.

The short cardiac arterial trunk almost immediately splits into an *inner* and an *outer* division. The inner division is inferior and posterior, the outer division is superior and anterior.

External relation to air-tubes (occasionally inferior).

The upper level of the cardiac artery is faintly superior to that of the posterior-horizontal artery, and to the level of the cardiac bronchus. The artery is strictly external and parallel to the bronchus, and this relation is preserved with great constancy throughout the distribution. Any departure from the rule is almost invariably in the sense of an inferior position of the arterial branches.

Inner or posterior cardiac artery.

Its relation to the bronchi is external and inferior.

The Inner or Posterior Cardiac Artery is slightly lower than the outer. This is due to the fact that it has to cross beneath the anterior division of the cardiac bronchus and subsequently beneath the cardiac vein, situated between the bronchi, before it can reach the outer surface of the posterior cardiac bronchus, its companion air-tube. Throughout its ramifications it remains external and slightly inferior to the bronchial twigs, the vein lying near the inner side of the latter.

Anterior cardiac artery.

The Outer or Anterior Cardiac Artery is much shorter than its fellow, to which it is superior as well as anterior. It immediately bifurcates into an inner and an outer trunk, respectively termed the sterno-cardiac and the mammary-cardiac artery.

Sterno-cardiac artery; external relation to bronchi.

The Sterno-cardiac Artery crosses inwards above the mammary-cardiac bronchus and applies itself to the outer side of the sterno-cardiac bronchus, supplying each division of the latter with a separate companion-artery.

Mammary-cardiac artery;

The Mammary-cardiac Artery, much shorter than the preceding, finds itself almost at its origin in contact with the outer bronchial wall which

FIG. 16.

DRAWING FROM THE SAME SPECIMEN AS FIG. 15: THE VARIOUS TUBES WILL BE RECOGNIZED BY THE SAME FEATURES AS IN FIG. 15. (*Cf.* figs. 19 and 20.) BACK VIEW, FROM THE LEFT.

(The side of each square represents 20 mm.)

EXPLANATION OF THE DRAWING.

The thoracic aorta is interrupted in the drawing. Two thin strips of membrane have been preserved in the specimen, indicating the position of the pleural reflection. The arch of the aorta (above which are the left carotid and subclavian arteries) is seen to rest upon the arch of the left pulmonary artery. The position of the descending portion of the latter is well shown.—The right pulmonary artery comes into view beneath the bifurcation of the trachea and is continued into the great vascular gap (column v).

RIGHT LUNG.

Square G v: A common axillary pulmonary A. supplies (in this specimen) a large retro-axillary as well as an axillary arterial trunk. Between the retro-axillary and the ascending-apical A. (in column F) lie the upper lobar bronchus (with axillary and apical divisions) and the intervening axial apical vein. In front of the retro-axillary A. are the corresponding bronchus and V.

In square H v: tips of the axillary-pectoral vein, superior dorsal vein, and ascending oblique dorsal vein.

Square G vj contains in a group the posterior-horizontal arteries, bronchi, and veins; affords a glimpse of the descending pulmonary A.; and at line G shows the vertical descending mid-dorsal A., and further inward, the interval between the superior pulmonary V. and the posterior-horizontal division of the inferior pulmonary V.

In square G vij the transverse-basic venous trunk divides, covered from behind by the posterior-basic artery and bronchus; and the posterior-basic vein descends towards point H viij. The smaller posterior veins are seen near line G.

LEFT LUNG.

Column D, at the apex, shows the posterior ascending bronchus, and its aortic branch beneath the corresponding vein which separates them from the anterior ascending-apical bronchi and arteries in column C.

Line D traverses, below point D iij, the posterior-apical A., a branch from the axillary A., which latter is seen at and below line iv. (The posterior ascending-apical A. appears in square D iij, but the common apical trunk is partly concealed.)

In squares C iv and v, the posterior-apical bronchus and the axillary bronchus, (with superior arteries) diverge above and below line iv. At their angle are seen their veins—together with larger veins showing through from the front.

In square C v, the axillary-apical bronchus diverges vertically upwards from the pectoral B. and A. The pectoral veins, below, ramify between pectoral and cardiac planes.

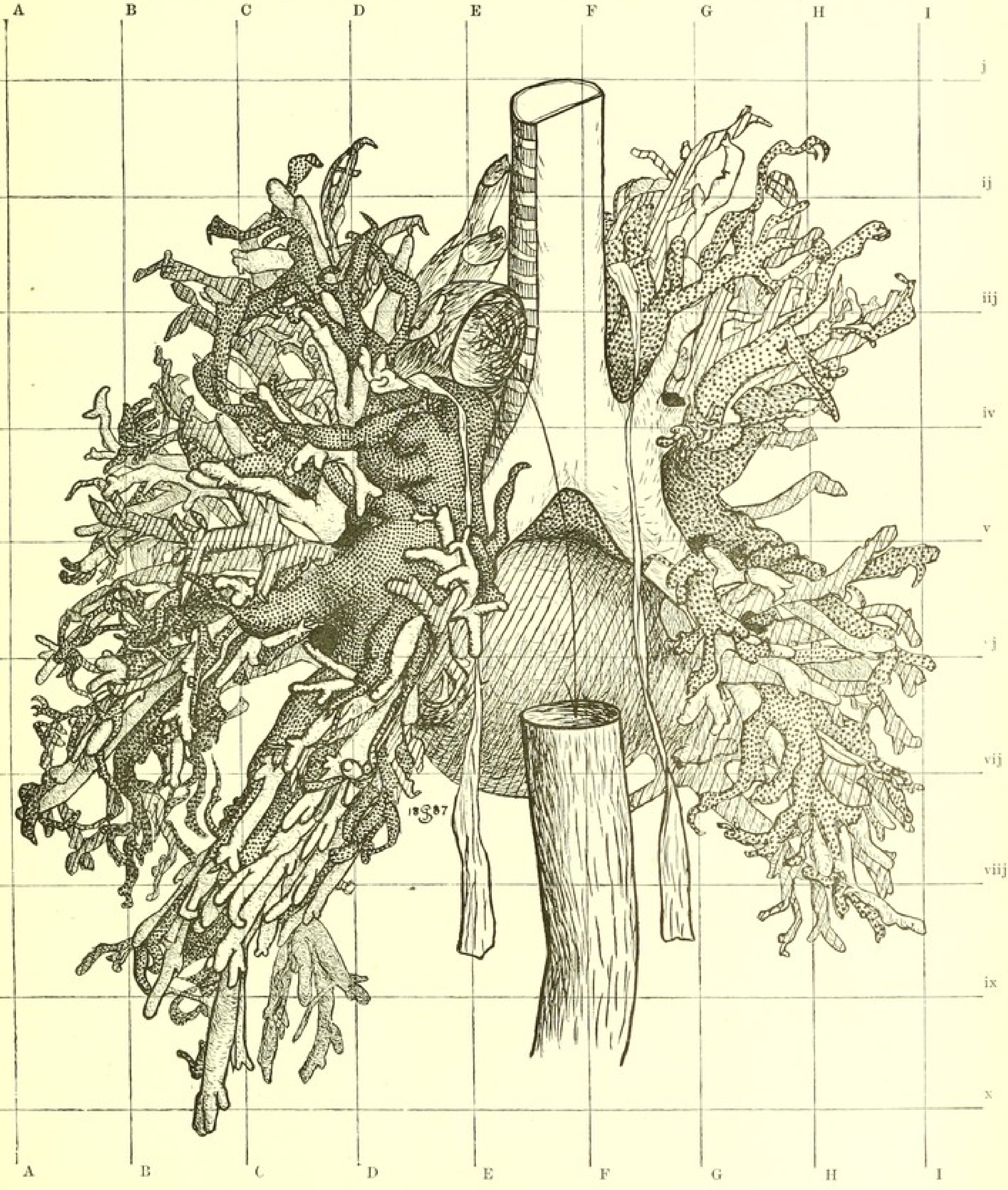
In square C vj, the inferior cardiac V., in column C, forms the upper side of the angle contained in square C vij, and the stout outer mammary-cardiac A. and B. are in view.

The inferior lobe is imperfectly injected, and is seen in profile; it may be noticed however that the anterior- and axillary-basic arteries lie chiefly in front of, and the posterior-basic arteries chiefly behind their respective bronchi.

In square D vj the posterior-horizontal A. arises in front of and above, and the vein below and behind the bronchial trunk.

FIG. 16.

Pulmonary arteries, dotted; pulmonary veins, shaded; bronchi, blank; black patches indicate lymphatic glands.



it is destined to follow. Its ramifications faithfully accompany those of the mammary-cardiac bronchus. same relation.

ARTERIAL SUPPLY TO THE LEFT LOWER LOBE.

The Left Descending Pulmonary Artery.

In connection with the description given of the upper lobar arterial supply, and before entering upon that of the lower lobe, it is necessary to refer briefly to the anatomy of the main arterial stem.

The name "descending pulmonary" applicable from an early stage.

Since the left pulmonary begins its downward course immediately below the summit of the arch, and before any branches have arisen from it, the name "descending pulmonary" applies in the left lung to the whole intra-pulmonary portion of the artery, and the sessile apical trunk, where it exists, may be regarded as one of its branches. The outer ascending-apical artery and the cardiac trunk undoubtedly take their origin from it, although they are included within the upper lobe.

Direction of the descending pulmonary artery.

The cardiac and the posterior-horizontal arteries arise at same level, yet belong to different lobes.

This fact explained.

The direction of the descending pulmonary is at first slightly outwards and very slightly forwards as well as downwards. At the level of the cardiac origin, it becomes more vertical. The lower lobar bronchus having assumed from its origin, a more vertical course than that which belonged to the main bronchus, it results that the pulmonary artery, which was posterior to the plane of the main bronchus above, becomes external to the inferior lobar bronchus. In this manner it comes to lie between the latter and the fold of pleura which lines the bottom of the great fissure. This observation renders intelligible the fact that the cardiac artery and the posterior-horizontal artery should originate from the same trunk within the same horizontal plane, and yet should belong to separate lobes. The position assumed by the artery is but slightly lateral. Below the level mentioned the name "inferior lobar artery" becomes applicable to the arterial trunk.

Close agreement between arteries and bronchi in left lower lobe; except in the posterior-horizontal district.

In the left lower lobe the arrangement of the bronchial tree is copied by the pulmonary artery with greater accuracy than in the upper lobe. The agreement between the bronchial and the arterial divisions is not limited to a similarity of origin. In position the two sets of branches are also closely associated from the first, owing to the intimate relation existing between the main artery and the main bronchus special to the lower lobe. In the posterior-horizontal district, however, some discrepancies are found.

Differences between the right and the left distribution:

Distribution of the Left Posterior-horizontal Artery.

The left arterial trunk shorter than the bronchial;

The leading features of difference between this arterial distribution and the right posterior-horizontal distribution, are due on the one hand to the greater size of the left district, and on the other to the fact that the descending pulmonary artery, from which the arterial supply is derived, is not anterior, *it may even be rudimentary or absent.*

The descending pulmonary artery is posterior to the main bronchus, but anterior to the posterior-horizontal.

as in the right lung, but posterior (as well as external) to the lower lobar bronchus. Instead of being rather longer, as on the right side, the left arterial trunk is much shorter than the posterior-horizontal bronchial stem. Sometimes it does not provide all the arteries for the district; but one or two of the latter may arise independently directly from the descending pulmonary artery. Nay, a collective arterial trunk may be entirely absent, or as in the specimen depicted in fig. 20, only represented by a faint bulging of the posterior wall of the pulmonary artery.

The posterior-horizontal arterial stem is superior and external to the bronchial.

It should be understood that although the descending pulmonary artery is posterior to the main left bronchus above the level of the posterior-horizontal bronchus, the latter passes behind and to the mesial side of the artery, which is thus included between the posterior-horizontal bronchial distribution behind, and the upper lobe, thus forming the floor or groove, of the longitudinal fissure.

Deep posterior-horizontal artery.

Where it exists, the common posterior-horizontal arterial stem arises on the outer and anterior side of, and a little above the corresponding bronchial stem and divides in a manner analogous to the latter. But in any case, whether arising jointly or separately, the following arteries are supplied to the district:

Its branches are posterior and superior to the bronchi.

The branches of the inferior mid-axillary artery are anterior.

(1) **A Deep Posterior-horizontal Artery**, which shows a marked tendency to an independent origin (see fig. 20, square C vj). This artery at its origin is anterior and superior to the bronchus of same name, but gradually allows the air-tube to become anterior. The relation of the arterial branches to the bronchial is thus posterior and superior. Where, as in the specimen (fig. 20), the deep air-trunk bifurcates almost immediately, the two attendant arteries may originate separately from the descending pulmonary artery, and the branches of the lower division or **Inferior Mid-axillary Artery**, may remain anterior to the corresponding bronchial branches.

Ascending mid-dorsal oblique artery, anterior and external to its bronchus.

Its branches become posterior to the air-tubes.

(2) **An Ascending Mid-dorsal Oblique Artery** arises, either as a branch of bifurcation from a rudimentary superficial posterior-horizontal stem, or as an independent branch from the descending pulmonary artery, In either case it adheres to the anterior and external face of the ascending bronchial stem and bifurcates later than the latter, well within the diverging bronchial angle. Its branches show a tendency to become posterior to the air-tubes to which they correspond.

Varying origin of the ascending aortic bronchus.

The ascending aortic bronchus may receive a separate artery arising from the mesial aspect of the arterial stem. It may however in other cases be the first branch of the descending mid-dorsal oblique artery.

Descending mid-dorsal oblique artery, posterior to the bronchus.

(3) **The Descending Mid-dorsal Oblique Artery** and its branches become in all cases posterior to their accompanying bronchi, but the road by which this position is gained differs according to the two types already described.

Its normal origin from a rudi-

In the first type the artery originates from the rudimentary superficial trunk, and descends along the outer side of the bronchus, lying at first across and between the deep posterior-horizontal bronchus in front, and the ascending mid-dorsal oblique vein posteriorly.

mentary superficial trunk.

In the second type, in which no common arterial trunk exists, the vein last-mentioned and the artery exchange sides. The vein becomes anterior and deep, ascending between the deep posterior-horizontal and the descending oblique bronchi—and the artery becomes entirely posterior and arises high up from the pulmonary artery, and immediately supplies a small ascending aortic branch mentioned above for the supply of that bronchial district.

Other mode of origin. The artery is a branch of the descending pulmonary artery, and supplies the ascending aortic artery.

Its subsequent course is at first vertical (see fig. 20, square D vj), posterior and at right angles to the direction of the posterior-horizontal bronchus. Having reached the upper level of the descending mid-dorsal bronchus, it bifurcates into a **Descending Mid-dorsal Oblique** and a **Descending Aortic Artery**. To both sets of air-tubes these arteries are posterior throughout, but to the former, slightly superior also.

Its branches are throughout posterior to the bronchi.

In conclusion it may be stated of the left posterior-horizontal distribution that the arteries are, almost without exception, posterior to the air-tubes in their branchings, although some of them are at their origin anterior to the bronchi.

In general the arteries are posterior in this distribution.

Arterial Distribution to the Left Base.

Distribution of the Left Anterior-basic Artery.

The Anterior-basic Artery arises from the anterior aspect of the descending pulmonary artery at the level of origin of the bronchial trunk, viz., 1·6 cm. below the cardiac artery. It curves slightly inwards and forwards to reach the superior and outward surface of the bronchus, and does not subsequently forsake this surface throughout the distribution.

Anterior-basic artery superior and external to bronchi.

The Retro-cardiac Artery.—In cases where the retro-cardiac bronchus originates from the inner division of the anterior-basic, the artery belonging to this division after being superior, becomes internal; it is thus brought into contact with the retro-cardiac bronchus, to which it furnishes an anterior arterial supply.

But the origin of the retro-cardiac bronchus may not take place from the inner division, but higher up from the stem of the anterior-basic bronchus. In such a case it is joined by a special artery derived from the descending pulmonary artery. This artery, passing underneath the anterior-basic bronchus, becomes external and slightly anterior to the retro-cardiac bronchial tube.

The retro-cardiac artery may arise from the inner anterior-basic division or from the descending pulmonary artery; and is respectively pre-bronchial or post-bronchial.

Distribution of the Left Axillary-basic Artery.

The regularity of the relations existing between artery and bronchus in the axillary-basic region obviates the necessity for a lengthy description. **The Axillary-basic Artery** arises laterally and slightly posteriorly from

The axillary-basic arterial branches

anterior and superior to the bronchial.

the descending pulmonary artery, which, at this level, is lateral to the bronchial stem, or slightly anterior. It is joined from below and from behind by the axillary-basic bronchus; and remaining slightly anterior, but chiefly superior to the bronchus, it accompanies the air-channels without any material modification in its relations.

Distribution of the Left Posterior-basic Artery.

The posterior-basic artery. Varying origin; posterior relation to the bronchi.

This large trunk may arise above or below the level of the origin of the axillary-bronchus. In the former case it applies itself from the first to the posterior surface of the posterior-basic bronchus. But, when it happens to originate below the axillary-basic bronchus, it lies in front of this air-tube, as terminal trunk of the pulmonary artery. In such a case it would immediately join the outer side of the posterior-basic bronchus, to which it ultimately becomes posterior.

The length of the artery is never considerable; it varies slightly, however, in these two types of distribution. The arterial branches arise relatively higher than the corresponding air-tubes and join these from above. They almost invariably are posterior and external to the bronchi.

Inferior posterior-horizontal artery.

The Lesser Posterior-horizontal Artery is merely one of the early branches from the posterior-basic artery; it rests upon the *posterior surface* of the posterior-horizontal bronchus.

The Right and the Left Pulmonary Arteries contrasted.

Left pulmonary artery more vertical and posterior.

The most striking features of the left pulmonary artery are its vertical course and absolutely posterior position. In both these particulars it strongly contrasts with the right pulmonary artery.

Similarity in the lower thirds.

On the other hand, within their lower two thirds, the two arteries acquire much similarity. Viewed from the outer side, just below the upper third, they both present two lateral branches and a downward continuation—which are respectively the posterior-horizontal, the cardiac, and the descending pulmonary arteries.

The posterior-horizontal arteries; points of agreement.

The two posterior-horizontal arterial distributions are not quite symmetrical. On both sides, however, a descending branch is apt to cross the posterior surface of the bronchial stem and to assume a position more internal and more posterior than that occupied by any air or blood-vessel in the lung.

General agreement in the basic supply.

In the region of the pulmonary base the arterial supply shows tolerable equality on both sides.

The right and the left cardiac arteries correspond.

Lastly, and most important, the two cardiac arteries unmistakably agree in their behaviour. Their origin is symmetrical on both sides; and takes place directly from the pulmonary artery. It is interesting to find that the level of origin of the left cardiac artery is slightly inferior to that of the right cardiac. The morphological value of these trunks runs therefore little risk of being overlooked, and the left artery is not likely to be mistaken, as happened in the case of the left cardiac bronchus, for an unimportant branch in an "hyparterial" upper lobe.

By inference, the arteries distributed within the upper third of the two lungs are equivalent, if not similar—and it is difficult to resist the further inference that inasmuch as on both sides they are closely associated with the bronchi in their ramifications—these bronchi also are, if not morphologically identical, at least morphologically analogous.

Inferentially the arteries in the two upper lobes are also equivalent.

In the pectoral region the practical identity existing between the two sides may be seen at a glance. Elsewhere it lies under disguise. But by careful scrutiny more and more instances of resemblance are brought to light. Indeed resemblance is the rule, even in the upper third of the lung; it is want of agreement which is exceptional.

The pectoral distributions are almost identical.

In conclusion, the general resemblance exhibited by the right and by the left arterial distributions is sufficiently strong to act as a crucial test for the correctness of the doctrine of similarity of the two bronchial systems—and it might alone be argued as an adequate proof against the theory of bronchial asymmetry, advanced by Professor Aeby.

The arterial resemblances are a sufficient proof against Aeby's bronchial theory

THE PULMONARY VEINS.

Mode of Origin and of Distribution, and General Relations of the Pulmonary Veins.

(*Important general remarks occur on pp.* 175-180.)

Isolated position and special characters of the pulmonary veins.

The pulmonary venous system, unlike the pulmonary arterial system, is not a mere copy of the bronchial tree. In a diagram representing the venous ramifications (see fig. 18) it is difficult to recognize any trace of the general arrangement special to the other tubes. With these the veins show no tendency to associate, but they remain solitary from one end of their course to the other. They are not even parallel to the bronchial tracks, but they seem to seek for themselves a path entirely different from that of other vessels. Indeed it is rather direction than distance which separates them from the bronchi and from the pulmonary arteries.

They are never parallel to, but cross and recross, the bronchial tracts.

This estrangement is noticeable even at their origin. The artery and the bronchus enter the lung from above; the vein approaches it from below. The two sets of vessels cross each other within the root of the lung: at the periphery they cross and cross again, as though their initial divergence could never be rectified. Even between the lobular vessels the divergence is as marked as elsewhere. The thin end of the lobule serves for the entrance of the bronchiole and of the arteriole; but the venules pass in at its sides, two or more venules entering each lobule.

Similar behaviour in the lobules.

The left auricle viewed as a common trunk of origin.

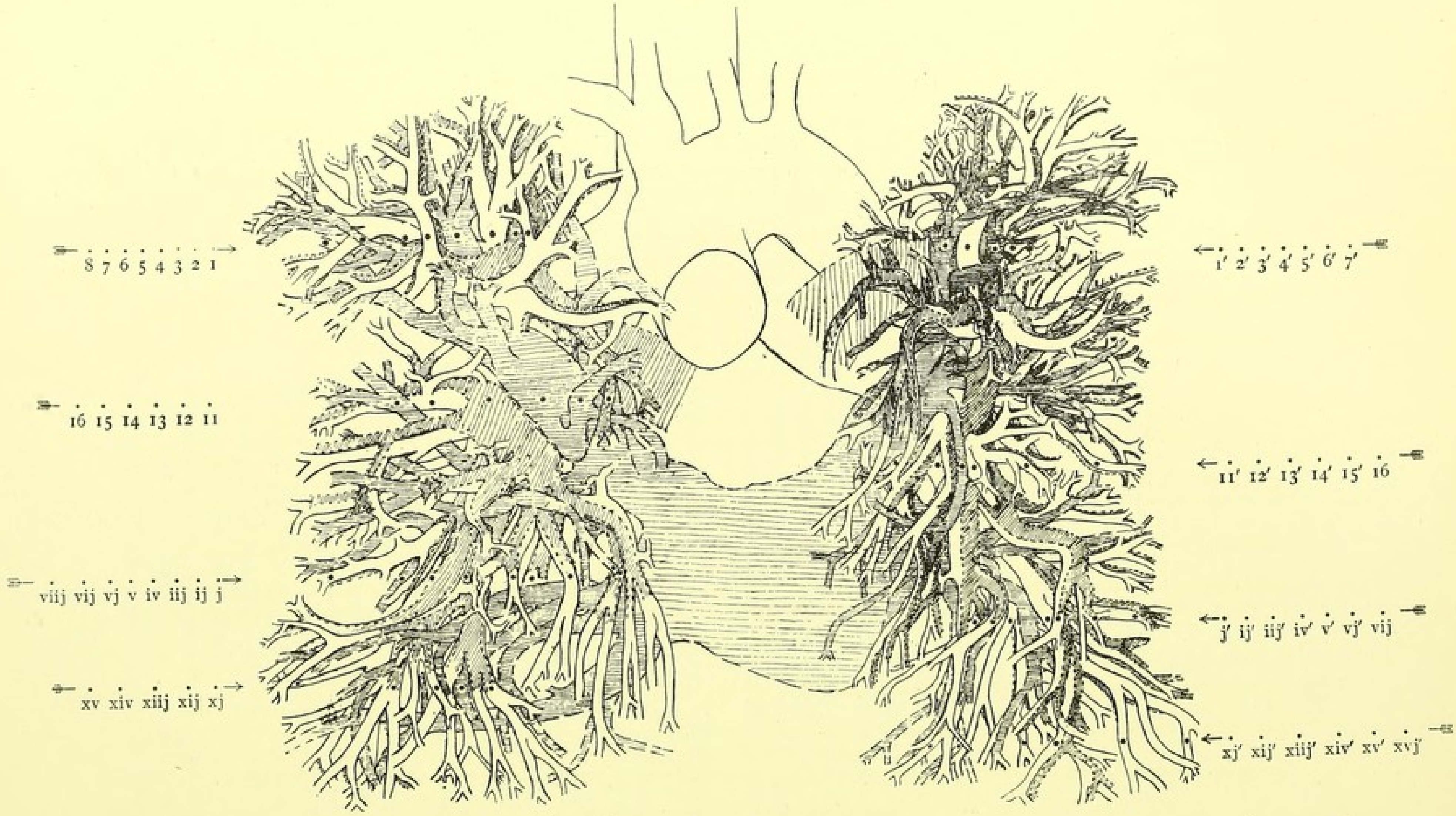
The Left Auricle, giving rise directly to the two pulmonary veins of both lungs, may be regarded as the common parent-trunk of each set of veins, and of both sets together. As a trunk of origin, it combines functions resembling those which belong to the common pulmonary artery and to the right and to the left pulmonary arteries. Unlike the arteries, the veins, which converge from all parts of the pulmonary periphery, do not become unified until they are merged into the heart. Through them the heart and the lung are placed in direct relation; and they are the chief agents in bringing about the mutual support which these two organs afford to each other.

The veins establish direct relations between heart and lungs, and contribute to their mutual support.

Sub-pleural veins and venules;

The Pulmonary Pleura and the sub-pleural and interlobar tissues bear important relations to the pulmonary veins (*cf.* p. 176 and p. 177). The close connection subsisting between the sub-pleural connective layer and the

FIG. 17.



ROUGH DIAGRAM OF THE BRONCHIAL, ARTERIAL AND VENOUS RAMIFICATIONS.

(*Should be compared with the coloured diagram, fig.* 14.)

FIG. 17.

EXPLANATION OF THE DIAGRAM.

The *shading* is horizontal for the left auricle and for the pulmonary veins; oblique for the pulmonary arteries: (many of the latter are purposely cut short in the diagram).—The aorta and the air-tubes are not shaded.

The *outline* is continuous for the bronchi, and interrupted for the blood-vessels; short lines have been used for the arteries, and longer lines for the veins.

The *figures* on either side refer to corresponding dots in the diagram. The figure corresponding to any given dot is determined by counting the dots *from within outwards.*

RIGHT LUNG.

1, Apical parasternal B. and A.—2, Ascending-apical artery.—3, Ascending-apical bronchus.—4, Ascending-apical venous trunk.—5, Mid-pectoral apical B. and A.—6, Axillary B. and A.—7, Apical branch of pulmonary axillary artery.—8, Posterior branch of the axillary-pectoral V. (the superior-dorsal V. is hidden from view).

11, Descending parasternal B. and A.—12, Mid-sternal pectoral V.—13, Upper lobar venous trunk.—14, Inferior division of pulmonary A.—15, Horizontal mid-dorsal B. and A.—16, Corresponding vein.

j, Branch from sterno-cardiac V.—ij, Inner posterior-cardiac B. and A.—iij, Retro-cardiac B. and A.—iv, Outer posterior-cardiac B. and A.—v, Anterior-basic B. and A.—vj, Axillary-basic B. and A.—vij, Branch from lesser posterior-horizontal V.—viij, Lesser posterior-horizontal B. and A.

xj, Inner anterior-basic B. and A.—xij, Branch from anterior-basic V.—xiij, Anterior infra-mammary B. and A.—xiv, Axillary-basic B. and A. (both cut short at this spot).—xv, Inferior retro-axillary B. and A.

LEFT LUNG.

1′, Inner ascending-apical venous trunk.—2′, Ascending-apical B. and A.—3′, Transverse-apical V. and divisions.—4′, Axillary B. and A.—5′, Axillary posterior interlobar B. and A.—6′, Ascending mid-pectoral B. and A.

11′, Posterior-cardiac B. and A.—12′, Lower lobar bronchus.—13′, Branch of mammary-cardiac V.—14′, Inner descending mammary-cardiac B. and A.—15′, Outer descending mammary-cardiac B. and A.—16′, Anterior inferior mid-axillary horizontal B. and A.

j′, Retro-cardiac B. and A.—ij′, Superficial cardio-basic B. and A.—iij′, Inferior descending aortic B. and A.—iv′, Anterior superior axillary-basic B. and A.—v′, Inner descending mammary B. and A.—vj′, Outer descending mammary B. and A.—vij′, Posterior superficial oblique B. and A.

xj′, Deep cardio-basic B. and A.—xij′, Branch from descending posterior-basic V.—xiij′, Inferior basic B. and A.—xiv′, Posterior inferior axillary-basic B. and A.—xv′, Inner deep axillary dorsi-basic B. and A.—xvj′, Outer deep axillary dorsi-basic B. and A.

ERRATA: *The right superior pulmonary vein extends too far outwards and fails to approach the angle formed by the origin of the upper lobar bronchus and by the bronchus intermedius, as described in the text.*

The divisions of the right inferior pulmonary vein likewise differ from the description given. (*Consult figs.* 15, 16, 19, 20.)

The right axillary pulmonary artery (7) *has received horizontal shading; this should have been oblique. The position of this vessel is also wrong* (*see text*).

pulmonary venules could probably be demonstrated at any point of the pulmonary surface. It is however specially obvious in two situations: (1) At the pulmonary fringe, venules of relatively larger size become absolutely sub-pleural, and extend almost as far as the sharp edge of the fringe. They clearly add strength to the frail pulmonary structures and to their investing membrane. (2) The whole mesial, or mediastinal surface of the lung is connected not only with venules, but with large sub-pleural veins. To these veins, along a great portion of their length, the pleural membrane is intimately adherent; it thereby becomes relatively fixed, and loses pliability whilst it gains in resistance. In extreme inflation of the lung these lines of attachment would become visible as slight depressions between freely bulging portions of the pleura. That this peculiarity should be restricted to the mesial surface is partly the result of the anatomical disposition of parts, the vessels assuming directions which are nearly perpendicular to most of the other surfaces. But the arrangement described may also be connected with definite physiological purposes. It is, for instance, conceivable that the entire pulmonary framework, if requiring to be fixed by limited attachments, would most readily be fixed at the expense of the surface which is nearest the heart, and which is least affected by the respiratory movements of the thorax.

at pulmonary fringe and at mesial surface.

Their anatomical and physiological significance.

The Main Pulmonary Veins, of which there are two on either side, arise directly from the auricle, where their entrance is not guarded by any valve. Both veins take their origin from the upper-posterior corner of the auricle in close mutual proximity, one being slightly posterior as well as inferior to the other. In the drawings this relation is disturbed as a result of the intra-auricular pressure set up during the injection. They immediately diverge. **The Descending or Inferior** pulmonary vein follows a direction downwards and outwards, and the **Ascending or Superior** pulmonary vein assumes an upward and outward course.

The main pulmonary veins; their origin.

Descending, or inferior, ascending, or superior, pulmonary vein.

It is noteworthy that the three pulmonary lobes of the right lung are not represented in the venous distribution by three vessels; both lungs alike possess two main pulmonary veins only.

No third vein in the right lung.

From their early divergence it may at once be gathered that the two pulmonary veins on each side are meant for different parts of the same lung, and are not a mere reduplication of the venous path, such as normally occurs at the systemic periphery. Pulmonary veins differ from systemic veins in being single. Moreover, they do not possess valves, and their aggregate calibre has been found not to exceed, but to be rather less than the aggregate calibre of the pulmonary arteries.

Pulmonary veins never double; no valves; their total calibre less than the arterial.

DISTRIBUTION OF THE RIGHT PULMONARY VEINS.

VENOUS DISTRIBUTION TO THE RIGHT UPPER LOBE.

Right Superior, or Ascending, or Anterior Pulmonary Vein.

(Consult for the study of the venous distribution the diagram (fig. 18). Also the diagrams (figs. 14 and 17), and the drawings (figs. 15 and 16, 19 and 20).)

The right superior pulmonary vein.

The Right Superior, or Ascending, or Anterior Pulmonary Vein originates from the upper and anterior corner of the auricle with a direction upwards and outwards, and slightly forwards at first, but subsequently backwards.

Forward curve.

The short forward curve which it presents at its entrance into the lung is caused by its crossing at right angles in front of the descending artery and bronchi.

Spiral course backwards and upwards.

Beyond this point the vein moves spirally upwards, encircling, from the front and from the outer side, the descending vessels, and ending as superior dorsal vein in contact with the upper pleural fold of the great fissure.

Relation to the fissures and to the central inter-bronchial space.

Although it terminates in the great fissure, its course lies along the groove of the transverse or short fissure. It occupies the upper half of the great central inter-bronchial space of the right lung, which has been described above and which is well displayed in fig. 9.

It rests upon the cardiac, descending pulmonary, and posterior-horizontal arteries, and beneath the horizontal bronchial tubes of the upper lobe.

The outer part of the spiral curve (the curvature of which is not well given in the diagrams) rests, from before backwards, upon the cardiac arterial trunk, upon the descending pulmonary artery, and upon the posterior-horizontal trunk, these three vessels being confluent in this situation. This is also the site of the downward bend of the descending pulmonary artery.

The venous trunk is thus included between the broad arterial surface below and the horizontal pectoral bronchia above. In this situation it delivers upwards, between the pectoral and the axillary bronchial stems, its largest branch, the ascending-apical vein, which rises, with slight divergence, to the right side of, but not in contact with, the apical bronchial stem.

Its branches.

The only other branch arising from the upper surface of the spiral is the important inner superficial ascending vein.

The lower and anterior surface of the spiral curve furnishes in succession the cardiac veins, the pectoral mid-sternal, the mid-pectoral, and the external, or axillary pectoral vein.

The Anatomical Relations presented by the ascending or superior pulmonary vein are the following:

Its relations to

In front of its origin lies the beginning of the ascending vena cava and the right auricle.

the vena cava,

Above and slightly overlapped by it, the right pulmonary artery pursues its course downwards and outwards.

the pulmonary artery,

Behind it, glands are found along the inner border of the intermediate bronchus;—and at a higher level, the cardiac bronchus, which lies in front of the bronchus intermedius, and the descending pulmonary artery present a slight anterior concavity which receives the backward concavity of this part of the vein—just as the two semiflexed and opposed index-fingers may be made to cross and to interlock. At this spot however the vein has already given up its earliest branches, viz., the inner superficial ascending vein and the inferior deep veins which descend to the middle lobe, behind and below the cardiac arteries and bronchi.

the bronchus intermedius, the cardiac bronchus, and the descending pulmonary artery.

Thus there is no horizontal part to this trunk and its subdivision begins almost before it has reached the pulmonary root, and at a point immediately external to the vertical outer border of the superior vena cava.

Its subdivision begins early.

The Early Branches of the superior pulmonary vein take four principal directions,

Early branches: their directions,

(1) vertically upwards;
(2) obliquely upwards and outwards along the depth of the middle or short interlobar fissure, and for some way along the great fissure;
(3) downwards and outwards;
(4) forwards and inwards.

The divisions corresponding to these directions are:

their names.

(1) The superficial inner ascending trunk;
(2) The oblique continuation of the venous stem;
(3) The cardiac veins, an anterior or horizontal cardiac vein; and a posterior, descending, deep cardiac vein, two vessels arising jointly or separately from the lower surface of the pulmonary vein close to the auricle.
(4) The pectoral mid-sternal vein, the lowermost, and in its origin the most anterior among the vessels and bronchi of the upper lobe.

The Later Branches have already been mentioned. They consist of:

Later branches:

(5) The mid-pectoral vein;
(6) The external or axillary pectoral vein;
(7) The ascending-apical trunk;
(8) The termination of the trunk as superior dorsal vein.

Venous Supply to the Right Inner-apical District.

Superficial inner ascending vein; its internal and superficial position. Its relations.

The Superficial Inner Ascending Trunk is the most superficial and the most internal of all the vessels of the root. It is strictly vertical. It is of large diameter and presents in its undivided portion a length of 2 cm. It lies between the superior vena cava internally—the sterno-pectoral bronchus and artery externally, the right pulmonary artery and its pectori-apical division posteriorly. Anteriorly and along its inner side it is covered by the pulmonary pleura at the line of reflection from the pericardium.

Its branches are: (*a*) an anterior, horizontal, sterno-pectoral vein; (*b*) a larger ascending trunk.

Sub-pleural sterno-pectoral vein, remains wholly sub-pleural.

(*a*) **The Sub-pleural Sterno-pectoral Vein,** arising slightly above the level of the artery and bronchus of the same name, and at first in contact with the internal face of the artery, gradually becomes separated from them, because not following their somewhat downward direction, and because remaining wholly sub-pleural. Its branches diverge widely along the mediastinal surface of the lung, and are intimately connected with the pleural membrane. They extend to the extreme pulmonary margin. See diagram (fig. 18, *S. P.*).

Its branches support and fix the pulmonary pleura.

The sub-pleural branches just described may be taken as typical of the behaviour of the peripheral veins in various situations, but especially at the mesial, mediastinal or pericardial surface. The sustentacular character of the pulmonary vein is here emphasized by its close connection with the sub-pleural tissue. The vein serves as a support for the pleura itself, and renders impossible a loosening or a shifting of the membrane beyond definite limits.

A complete system of sub-pleural branches of the same kind lines the mesial surface from above downwards.

Sub-pleural ascending-apical vein;

(*b*) **The Sub-pleural Ascending-apical Trunk,** or continuation of the trunk, shows a slight leaning backwards in its vertical ascent. After a course of 6 mm., it divides into the *sub-pleural anterior ascending-apical vein* and into the *sub-pleural posterior ascending-apical vein.* Both these vessels are posterior to, and form angles with, the arteries and bronchi of corresponding name.

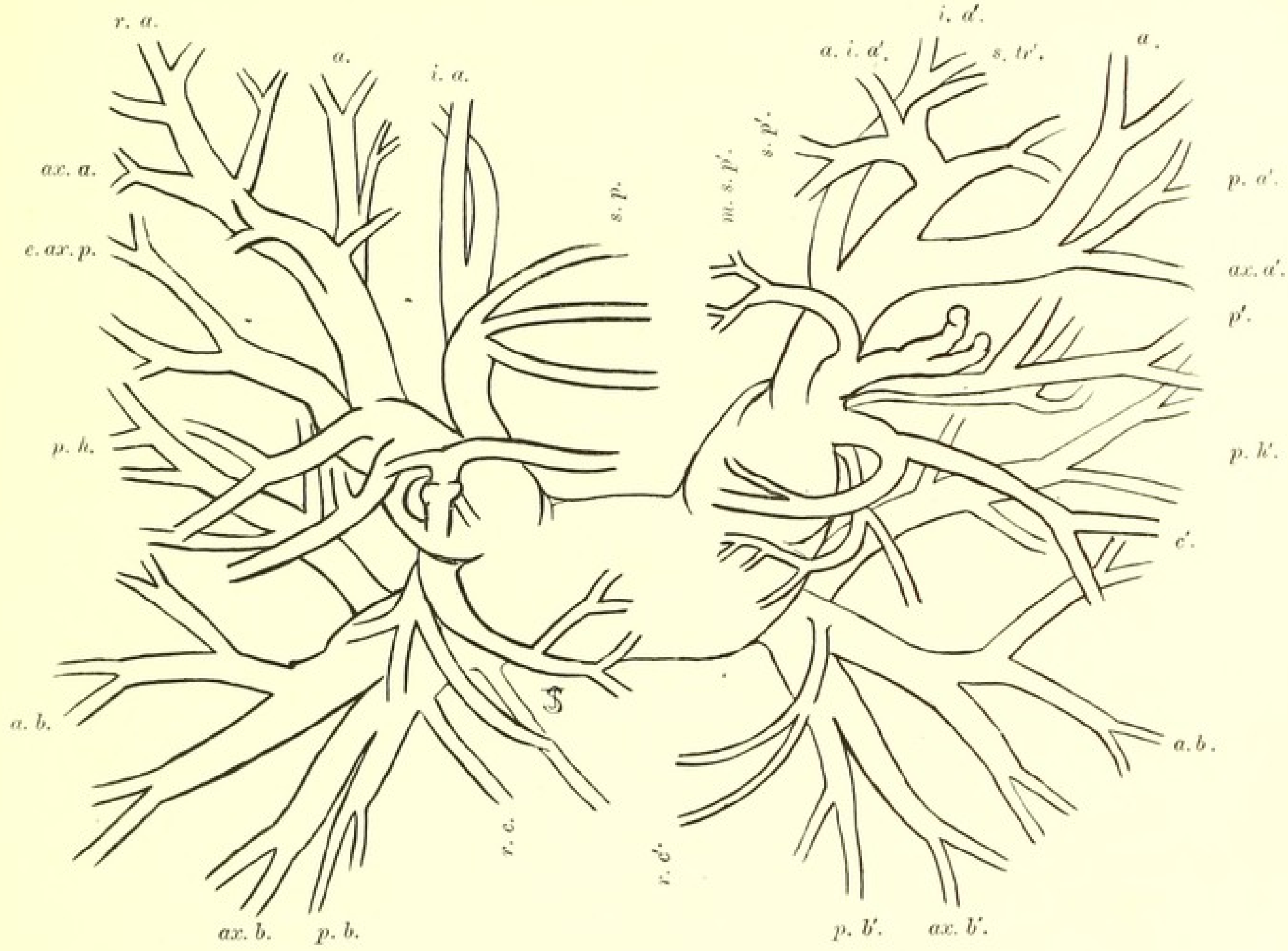
its relations.

The sub-pleural ascending-apical trunk lies upon the anterior surface of the pectori-apical artery (at the level of its bifurcation), in front of the outer border of the vena cava.

Sub-pleural anterior ascending-apical vein.

The Sub-pleural Anterior Ascending-apical Vein (as well as the posterior vein, in its first portion) rests upon the inner surface of the ascending-apical artery and faces the convexity of the first bend of the aorta, at its posterior part. The ascending vein shows comparatively slight backward tendency. It remains sub-pleural mainly, and supplies the inner surface of the apex.

FIG. 18.



ROUGH DIAGRAM OF THE CHIEF PULMONARY VEINS AND OF THE UPPER PART OF THE LEFT AURICLE;

FRONT VIEW.

The left auricle (of which the lower half is not shown) and the superior and inferior pulmonary veins are readily recognized. Between the two latter, on either side, are seen the cardiac veins (lower on the right side than on the left). The right mammary-cardiac branch, corresponding to *c'* on the left, has been depicted too small.

The right pectoral branches, corresponding to the group opposite *p'* on the left, are arranged in oblique scale between *c. ax. p.** (right external axillary-pectoral V.) and the origin of the right superior pulmonary V. *s. p.* and *s. p'.* (right and left sub-pleural sterno-pectoral veins) should have been of same size and arrangement.—*m. s. p'.* : left mid-sternal-pectoral V. (sub-pleural branch); the analogous vein on the right side is seen just above the auricle.

a. : Right central-apical V.—*a'.* : left outer ascending-apical vein (depicted too large), from the transverse-apical trunk. *p. a'.*, and *ax. a'.*, the posterior-apical V. and the axillary-apical V., arise from the same trunk.—*r. a.*, the right retro-axillary trunk, and *ax. a.*, the right axillary-apical V., arise jointly from the ascending-apical stem, which also yields the outer central-apical V.

i. a. ; *i. a'.*, right and left posterior sub-pleural ascending-apical V. (the anterior division on the right side is sub-pleural likewise—on the left side, it is more deeply situated and of much larger size, supplying *s. p'.* (see above), *s. tr'.* the superior transverse-apical trunk, *a. i. a'.* the left anterior sub-pleural ascending apical V., &c.).

p. h. ; *p. h'.*, right and left posterior-horizontal distribution. (The lesser posterior-horizontal V. is not depicted.)

a. b. ; *a. b'.*, right and left anterior- or transverse-basic distribution.—*r. c.** ; *r. c'.*, anterior retro-cardiac V.

ax. b. ; *ax. b'.*, right and left axillary-basic V.*—*p. b.* ; *p. b'.*, right and left descending posterior-basic V.

* ERRATA : *c. ax. p. (see above) extends too high, and its lower branch (crossing p. h.) too low; the latter moreover appears, wrongly, to possess an independent origin.—r. c. should have been made to arise from a. b. as in the left lung.—ax. b.; ax. b'. The separation of these trunks from p. b.; p. b'. should have been carried higher (cf. fig.* 19, *square* F viij).

The Sub-pleural Posterior Ascending-apical Vein lies behind the preceding vein, and, instead of being, like it, almost vertical, arches backwards across the inner surface of the rising apical arterial stem, just above the line of pleural reflection which is seen on this surface, and slightly above the arch of the azygos vein. It distributes superficial veins to the internal base and to the posterior base of the apex.

Sub-pleural posterior ascending-apical vein—supplies the posterior inferior part of the inner surface of apex.

The vertical line of the superficial inner ascending pulmonary vein and of its branches defines with precision the anterior boundary of the root of the lung, and also, higher up, the internal boundary of the apex. At the level of the upper lobar bronchus, just before it finally bifurcates, the vein is the innermost of a row of four large apical ascending trunks, the second trunk being the ascending-apical artery, the third the bronchus, and the fourth the intra-apical ascending-apical vein. The close proximity and parallelism of the vein to the artery in this case constitutes an interesting exception to the rule of dissociation which usually governs the relations of the two vessels.

The superficial inner ascending vein is innermost of four parallel apical trunks.

The terminations of the two superior divisions of the vein are chiefly subpleural. They may however to a slight depth supply the pulmonary tissue also. Their injection has unfortunately been incomplete in the metallic casts. But in the latter the two bronchial districts in question are seen to receive their deep venous supply mainly from branches of the intra-apical ascending vein.

Terminal branches chiefly sub-pleural.

Venous Supply to the Right Pectoral Region.

The remaining branches of the superior pulmonary vein, with the exception of the deep ascending apical trunk, are situated very superficially, close to the inferior surface of the upper lobe, and to the upper pleural lining of the transverse fissure and of the superior part of the longitudinal fissure respectively. Thus three of the sides of the upper lobe are outlined by pulmonary veins, the bronchial and arterial tree being contained within them as an outer framework connected with the pulmonary pleura.

The other branches of superior pulmonary vein form an outer frame for the upper lobe on three sides.

The Mid-sternal Pectoral Vein is a stout vessel, 1·8 cm. in length, originating straight forward from the inferior and anterior aspect of the convexity of the superior pulmonary vein. In the metallic cast it forms the anterior inferior angle of the upper lobe, at a distance of 1·8 cm. below the level of the sterno-pectoral bronchus, for the district of which its ascending branch is destined.

Mid-sternal pectoral vein, isolated at anterior inferior angle, supplies the district of sterno-pectoral bronchus.

Occupying a solitary and peripheral position in the midst of the spongy tissue of the pulmonary angle above described, it distributes numerous vessels perpendicular to the surface and through them it enters into relation with three pleural surfaces, the mesial or mediastinal, the anterior or thoracic, and the inferior or interlobar surface of the upper lobe.

It is in connection with three pleural surfaces. Its branches.

In addition to these branchlets, it gives rise to three important veins:

(*a*) a small sub-pleural sternal vein;
(*b*) a larger sub-pleural interlobar vein;
(*c*) a large ascending sterno-pectoral vein.

Sub-pleural sternal. Sub-pleural interlobar. Ascending sterno-pectoral for the districts of the marginal and parasternal bronchi.

(*a*) and (*b*) **The Sub-pleural Sternal, and the Sub-pleural Interlobar Veins** are almost horizontal and distributed in close connection with the pulmonary surface of the pleura, respectively along the inner and along the inferior surface of the upper lobe.

(*c*) **The Ascending Sterno-pectoral Vein** takes a direction upwards and forwards and passes, almost at a right angle, the outer side of the descending mid-sternal bronchus (to the district of which it gives a branch), on its way to the horizontal marginal and parasternal distributions which it supplies from below with pulmonary veins.

Mid-pectoral vein. Direction and branches.

The Mid-pectoral Vein arises 1·5 cm. external to, and 1·5 cm. higher than, the preceding vein, from the convexity of the venous trunk. Its direction is forwards and slightly outwards. It is a little internal to the mid-pectoral bronchus and situated at a lower level (about 1 cm. distant). It divides at a point 1·3 cm. beyond its origin into a horizontal branch, directed forwards and outwards, and into an obliquely forward ascending branch.

Ascending mid-pectoral vein for inner mid-pectoral district. Interlobar mid-pectoral vein.

The Ascending Mid-pectoral Vein is situated almost at an equal distance from the mid-pectoral and from the inner pectoral bronchus, and probably undertakes the supply of both these distributions.

The Interlobar Mid-pectoral follows from below the direction of the mid-pectoral bronchus, whilst remaining in close proximity to the septal pleura.

External or axillary-pectoral vein.

The External or Axillary-pectoral Vein is normally given off from the foot of the central ascending-apical trunk, but it may (as in fig. 15, at the intersection of the lines C and iv) arise directly from the superior pulmonary vein. Its direction is horizontally outwards. Its original longitude from the mid-pectoral vein is rather more than 1 cm., and its level is about 1 cm. higher than the level of the latter. It is about half-way between the two neighbouring bronchi, the outer pectoral and the superior axillary, but both vertically and horizontally rather nearer the outer pectoral. Nevertheless, the vein is specially distributed in the district of the superior axillary bronchus, in spite of a distance of 1·5 cm. occurring between their horizontal trunks. But at the parietal periphery this distance is lessened by the gradual approximation of their branches. Sub-pleural venules arise from this venous trunk as well as from the interlobar mid-pectoral. Its final divisions are analogous to those of the superior axillary bronchus. Its branches however originate by a more rapid bifurcating process, and they are apt to assume a tetrapodic or rosette-like arrangement, as in fig. 15.

Nearer to the outer pectoral bronchus, but its branches are supplied to the superior axillary district.

Its branching sometimes tetrapodic.

The main trunk of this vein does not remain in contact with the pleural surface of the septum, but lies at a rather higher level and supplies to it sub-pleural branchlets.

Venous Supply to the Right Central- and Outer-apical District.

The Deep or Ascending-apical Trunk, which is either the parent-trunk of, or almost simultaneous in its origin with the preceding vein, is the largest branch from the superior pulmonary vein. It may be looked upon as the anterior branch of the final bifurcation of the latter, the superior dorsal vein being the posterior branch. This bifurcation may be delayed, as in the specimen depicted in figs. 15 and 16, and take place in the centre of the upper lobe instead of its base. Under these circumstances the termination of the superior pulmonary vein foregoes entering the longitudinal fissure, but becomes identified with the ascending-apical trunk, and the superior dorsal, now a mere branch from this vein, reaches its posterior district above the superior axillary bronchus instead of passing beneath it.

Deep or central ascending-apical trunk. Its relation to the superior pulmonary and to the superior dorsal veins, variable.

The central ascending-apical trunk presents an almost vertical non-branched length of upwards of 2 cm., situated in the angle between the horizontal stem of the pectoral and the slightly oblique stem of the axillary bronchus. Its normal termination occurs a little in front, to the inner side and above the level of the axillary bifurcation, in an apparently tripodic fashion. Its three branches may be designated by the following names:

Vertical portion.

Apparent tripodic division into vertical central, outer central, and axillary-apical veins.

(*a*) Vertical, central, or axial vein;
(*b*) Outer central-apical vein;
(*c*) Axillary-apical vein.

(*a*) **The Central or Axial Apical Vein** ascends externally to and slightly behind the posterior ascending-apical bronchus, occupying an intermediate position in the interval between the bronchi belonging to the apical stem and to the axillary stem respectively. It preserves an ascending vertical direction as far as the posterior internal portion of the apex, where its branches are distributed to the neighbouring bronchial districts. It may be of smaller size than the outer central-apical vein, as in the specimen depicted in figs. 19 and 20. In this case it does not supply any other districts. Or as in the other specimen (figs. 15 and 16) it may far surpass in size the outer central vein, and send a large branch to the interspace in front of the posterior ascending-apical bronchial stem for the supply of the anterior and inner portion of the apex.

Central or axial apical vein distributed to posterior internal portion of apex; alternating with the outer central-apical, in size and in the anterior inner supply of apex.

The central-apical vein also delivers low down a small vein, with direction upwards, inwards, and backwards, for the supply of that portion of the base of the pulmonary apex which is situated immediately opposite the trachea.

Small branch to inner posterior base of the apex.

(*b*) **The Outer Central-apical Vein** follows an upward, outward, Outer central-apical vein mainly distributed to outer apical district; complementary to the central-apical vein, as regards branch to anterior or inner district.

and forward course, half-way between the outer apical and the superior axillary bronchus, roughly parallel to both ; but it approaches more and more the former, for the district of which its branches are specially meant. In size and in distribution it bears a complementary relation to the central-apical vein. Probably the more normal type is that according to which the outer central vein is the larger, and sends an internal branch, passing in front of the posterior ascending-apical bronchial stem, to the anterior inner apical district.

In all cases this vein is mainly concerned with the supply to the outer anterior apical region, its branches interlacing with the outer apical bronchial tubes from below, and from the outer side.

Axillary-apical vein for the posterior and outer apex.

(*c*) **The Axillary-apical Vein** is of large size, and of considerable length. Upon its supply is dependent the large posterior and outer apical district. Its direction is, at first, backwards and upwards and strongly outwards. Passing backwards between the horizontal retro-axillary stem and the ascending posterior axillary stem, it becomes more vertical, and assumes a central position between the retro-axillary system and the posterior-apical system. To both of these it distributes large veins corresponding to their several bronchi but forming with the latter repeated angles, and separated from them by clear intervals.

When the superior dorsal vein is derived from the central-apical vein, it ultimately arises as a branch of the axillary-apical vein, which is then correspondingly larger.

Superior dorsal vein; relation to upper lobar bronchus and bronchus intermedius.

The Superior Dorsal Vein may be seen, in fig. 20 (at the intersection of the lines F and v), to arise within the angle formed by the upper lobar bronchus above, and the bronchus intermedius below. This is the terminal point reached by the spiral curve described by the superior pulmonary vein. The alternate mode of origin of this vein has already been described in connection with the central-apical vein and with the outer central-apical vein. It will here suffice to refer to the more normal arrangement.

Relation to axillary pulmonary artery.

From its point of origin the vein takes a direction slightly backwards and upwards, and strongly outwards. At the outset it is in inferior, and slightly posterior, contact with the axillary pulmonary artery, which separates it from the bronchial wall. The artery soon rises away from it, to join the superior axillary bronchus, and leaves it an isolated vessel, half-way distant from the axillary, and from the posterior-horizontal bronchi.

It is the most inferior and posterior of vessels and bronchi to upper lobe.

In spite of its faintly ascending direction, this venous trunk remains the most inferior of the large channels of the upper lobe, lying close to the interlobar surface. It presents numerous branchlets, and breaks up into a posterior ascending, and an outer horizontal branch situated at first far below the corresponding bronchi—viz., the supra-spinate, and the retro-axillary-apical trunk, the subdivisions of which it repeats at a distance, but subsequently approximating to their distributions at the periphery.

It serves the supra-spinate and the posterior axillary-apical districts.

Summary.—In reviewing the upper lobar venous distribution it may be pointed out:

(1) That in most cases the veins are external or posterior, as well as inferior to the bronchi, to which they correspond; The relation to bronchi is posterior, distant,

(2) That the venous trunks lie at a considerable distance from the bronchi, and often in the centre of the inter-bronchial spaces;

(3) That the pulmonary veins, thus situated, often send branches to otherwise distinct bronchial districts. and multiple.

Lastly, the superior pulmonary vein rises, under cover of the pulmonary tissue, and of peripheral bronchi, obliquely across the face of the upper lobe, and is throughout inferior to the bronchial, and to the arterial tree. Oblique anterior and inferior course of the pulmonary vein.

VENOUS DISTRIBUTION TO THE RIGHT MIDDLE LOBE.

The middle lobe is furnished with two pulmonary veins, arising close to each other in the vertical, sagittal plane, which passes through the superficial inner ascending vein. They spring from the inferior surface of the superior pulmonary vein, close to the left auricle, with directions respectively downwards and forwards, and downwards and outwards. These veins are the inner anterior, almost horizontal, sub-pleural cardiac vein; and the posterior, or inferior, deep cardiac vein. The cardiac veins: mode of origin and direction.

The Inner Anterior, Sub-pleural Cardiac Vein extends its long diverging arms across the mediastinal surface of the middle lobe, and is, throughout, intimately adherent to the pleura, being apparently analogous to the sub-pleural sternal vein, described in the upper lobe. Inner sub-pleural cardiac vein.

It arises on a level with the origin of the inner division of the cardiac bronchus, and for a short distance lies close to the inner surface of this tube, separating it from the pulmonary pleura and from the auricle. It soon however breaks up into its branches which diverge upwards and downwards. Proximity to bronchus and to auricle. Its branches sub-pleural.

The Posterior or Inferior Deep Cardiac Vein, a short trunk given off from the under surface of the superior pulmonary vein, takes a direction downwards and slightly forwards. It soon distributes an *ascending* and a *descending vein*—and further down a short horizontal trunk, which divides into an *outer cardiac* and a *central cardiac* branch. Its terminal branch the *posterior cardiac* is continued in the original direction downwards and slightly forwards, remaining near the posterior surface of the lobe and well behind the arteries and bronchi. At its origin the deep cardiac vein lies for a short distance beneath the outer division of the cardiac bronchus, the corresponding artery being above the latter. Posterior or inferior deep cardiac. Ascending, descending, outer cardiac, central cardiac, and posterior cardiac branches. Termination as posterior cardiac.

The Ascending-cardiac Branch passes forwards and upwards beneath the cardiac bronchus, and between the cardiac artery and the descending pulmonary artery at their angle of divergence, and supplies the upper outer district of the middle lobe. This branch as well as the following arises Ascending-cardiac vein.

from the trunk of the posterior or deep cardiac vein very near the origin of this vessel.

Descending-cardiac.

The Small Descending Branch remains within the root of the middle lobe, and is unimportant.

Horizontal trunk of origin of the central and outer cardiac veins.

The Short Horizontal Trunk moves straight forwards, and quickly divides. Its two branches soon become superior to the bronchus, and to its divisions, passing respectively to the inner and to the outer side of the latter towards the anterior surface of the lobe.

Central cardiac vein.

The Central Cardiac Vein is chiefly devoted to the supply of the deep pulmonary tissue. It assumes an almost central position in the middle of the interspace produced in the bronchial cast by the divergence of the inner, outer and posterior cardiac bronchi. Its branches follow various directions, inwards, outwards, downwards and upwards. The superior branch comes into close relation with the pleura covering the inferior surface of the transverse fissure. The inner and the outer branch are termed, in connection with the bronchi which they approach, the **Sterno-cardiac** and the **Mammary-cardiac** veins. These are conspicuous objects in figs. 14 and 17.

Its superior branch partly subpleural.

Sterno-, and mammary-cardiac veins.

Outer cardiac vein; sub-pleural, and deep branch.

The Outer Cardiac Vein is, from the first, situated close to the great longitudinal fissure, and to the pleural lining of the middle lobar surface of this fissure. It divides into a *sub-pleural* and into a *deep branch*. The former appears to remain within the vicinity of the pleura, as far as the imperfect injection has enabled its course to be followed. The deep branch supplies the outer cardiac district.

VENOUS DISTRIBUTION TO THE RIGHT LOWER LOBE.

The Right Inferior or Posterior Pulmonary Vein.

The Inferior or Posterior Pulmonary Vein is almost equal in diameter to the superior vein, but much shorter. Originating from the posterior upper corner of the left auricle, it proceeds almost horizontally outwards and slightly backwards. Its chief branches arise early and mainly from its posterior aspect, which is made to appear yet shorter than the anterior.

Superior division: the posterior-horizontal vein.

A superior, ascending division is given off from the upper and posterior aspect of the vein immediately after its origin from the auricle and close to the line of reflection of the pleura pulmonalis. This vessel, which is of large size, rises obliquely to the space immediately beneath the posterior-horizontal bronchus and is termed the *posterior-horizontal vein*.

Inferior division: three trunks, transverse-basic,

The larger inferior division breaks up just behind the retro-cardiac vessels into three important trunks of which two are posterior, and the third, less posterior, corresponds to the interval between the anterior-basic and the axillary-basic bronchial distributions, and may be termed the *deep transverse-basic vein*.

Fig. 19.

Drawing from a metallic cast of the Bronchi, Pulmonary Arteries and Pulmonary Veins, isolated by dissection. (*Cf.* figs. 15 and 16.) Front view, from the right.

(The side of each square represents 20 mm.)

EXPLANATION OF THE DRAWING.

Some peripheral tubes are not well injected. In the middle line are seen the orifice for the cannula, the left auricle, and above, the aorta and pulmonary A.

Right Lung.

Right Upper Lobe:

In contrast with figs. 15 and 17 here the retro-axillary artery arises from the apical not from the axillary pulmonary A., which is here smaller (seen at upper part of square C vj, behind axillary bronchus).

Line D, along which rises the mid-apical venous stem, separates the axillary vessels and bronchi externally, from the apical and pectoral.

In square E v the inner superficial ascending-apical vein is seen. The other divisions of the superior pulmonary vein may readily be followed in E vij, D vj, and C vj.

Right Middle and Lower Lobe:

The cardiac veins, unfilled and torn, show as small stumps (square E viij near line E, square D vij, below black gland). Similarly the retro-cardiac vein (square D viij).

In square C ix the anterior-basic vein abruptly terminates in the angle formed by the branches of the anterior-basic bronchi and arteries, and the axillary- and posterior-basic veins are continued into square B x.

The posterior-horizontal artery extends along line vj, and the axillary artery and bronchus above line viij,—and the posterior-basic bronchial divisions occupy square B ix.

Left Lung.

The large venous trunks are clearly shown—

In square F vj the left apical venous trunk, and diverging from it the posterior superficial ascending-apical trunk.

In square G iv: from the former arise, at right angles, the anterior ascending-apical trunk, and the transverse-apical trunk.

In square G vj, between the pectoral and the mammary-cardiac bronchi ramify the pectoral veins; and the two cardiac veins spread outwards below their bronchi.

Close to line G, arising from the anterior-basic bronchus, the retro-cardiac bronchus and artery descend in front of the two upper divisions from the inferior pulmonary V. 10 mm. external to the small retro-cardiac vein. Lastly, the posterior descending-basic venous trunk, internal to a division of the posterior-basic bronchus, is overlapped by the outlines of bronchi from the right cardiac distribution.

In squares G ix and H ix the cardio-basic bronchi form a group hiding from view the basic structures beyond.

Fig. 19.

Pulmonary arteries, dotted; pulmonary veins, shaded; bronchi, blank; black patches indicate lymphatic glands.

Of the two posterior trunks one, the *lesser posterior-horizontal vein*, follows an outward course immediately beneath the lesser posterior-horizontal distribution. The other descends obliquely outwards and downwards towards the outer inferior edge of the lung, as *descending posterior-basic vein.* lesser posterior-horizontal, and descending posterior-basic.

A small *retro-cardiac vein* descends vertically from the inferior surface of the inferior division, and parallel to this vein a second *retro-cardiac vein* takes its origin from the beginning of the descending posterior-basic vein. These two small vessels are posterior, although not contiguous to the branches of the retro-cardiac bronchus. Inferior retro-cardiac vein.

None of the branches from the inferior pulmonary vein are strictly superficial, but from each of its posterior trunks small veins originate at the inner edge of the lung, with direction backwards. These probably become subpleural. Small posterior subpleural veins.

In conclusion, the venous supply to the lower lobe may be summed up as consisting of the following vessels in downward succession:— Summary of branches.

(1) Posterior-horizontal trunk;
(2) Lesser posterior-horizontal trunk;
(3) Deep transverse-basic trunk, or anterior-basic vein (from this arises the anterior retro-cardiac);
(4) Descending posterior-basic trunk, dividing into an anterior upper or axillary-basic and a posterior-basic portion (from the origin of (4) arises one of the posterior retro-cardiac veins);
(5) Small inner posterior retro-cardiac vein.

The Anatomical Relations which the inferior pulmonary vein bears to the bronchial tree, are: firstly, an *inferior* relation. With the exception of the posterior-horizontal vein, both its trunk and its branches are situated below the level of the final division of the lower lobar bronchus into the great basic air-tubes, and its branches remain inferior to the bronchial districts; Relations to the bronchial tree it is inferior,

Secondly, it is *posterior* at its origin and in its large branches. The posterior surface of the inferior pulmonary vein is in the same transverse vertical plane as the posterior-horizontal, and posterior-basic trunks, and therefore posterior slightly to the tracheal plane. From this it may be gathered that the vein is in close relation to the spinal column. The most anterior of its divisions, the deep transverse-basic, remains posterior to the anterior-basic bronchus; posterior,

Thirdly, it is *internal*. This applies not only to its origin, but to the first part of its large branches. Putting aside the short trunk itself which is horizontal, and the posterior-horizontal vein which ascends, the general drift of the branches is slightly downwards as well as outwards, a direction analogous to that of the inferior lobar bronchus and of its branches, but departing much less from the horizontal than the latter. An acute angle is thus formed between the main venous and the main bronchial direction, and internal. Angle between the main bronchial and venous directions. the several venous branches meet the bronchial and the arterial branches at angles varying with the inclination of each.

Its branches are transverse to bronchi. Fourthly, its branches are, roughly speaking, *transverse* (although not usually in a rectangular manner) to the bronchial directions; and their position is inferior to that of the bronchi.

Interspace between descending bronchus and the auricle and the veins, From behind, an elongated interspace may be recognized between the outer border of the left auricle and of the continuation of the inferior pulmonary vein as descending posterior-basic vein, and the inner border of the inferior lobar stem continued as posterior-basic bronchus. This oblique interspace comes to an acute angle low down. From above it is limited by the trunk of the superior pulmonary vein just before it crosses to the front of the bronchus.

crossed by various structures. The interspace is crossed by various structures, viz.: posteriorly, by the posterior-horizontal and the lesser posterior-horizontal veins, with directions which have been described; anteriorly, by the deep transverse-basic vein and, in an opposite direction (downwards and inwards), by the retro-cardiac bronchus, which covers the termination of the main venous trunk, and conceals its apparently tripodic division.

Distribution of the Right Posterior-horizontal Vein.

"Posterior-horizontal" a misnomer, as applied to this trunk, although applicable to some of its branches. **The Posterior-horizontal Vein** is not accurately described by its name, in its first portion; nevertheless there is perhaps no better way of shortly expressing the relation which subsists between the vein and the upper district of the lower lobe, than to give to this vein the same name as that which identifies the bronchus and the artery of that district. It is part of the general scheme of dissociation, described on p. 176, that those of its branches should become horizontal which correspond to oblique bronchial branches, and *vice versâ*.

Course of the venous trunk. The venous trunk itself is clearly not horizontal, but rises outwards with gentle upward convexity as far as the vertical line passing through the bifurcation of the posterior-horizontal bronchus; remaining inferior to that tube, it divides into its branches at that spot.

Measurement. It measures 3 cm., a great length in comparison to the very small measurement of the bronchus and of the artery. Within 5 mm. from its

Ascending and posterior small branches. origin it gives an **Upward Branch** and two small **Posterior Branches** for the supply of the tissues of the vertebral border of the lung.

Small ascending mid-dorsal vein. Passing in front of the vertical descending mid-dorsal bronchus for which it provides a short vein, it supplies a small rising trunk, **the Ascending Mid-dorsal Vein**, which occupies the angle between the vertical-ascending and the vertical-descending mid-dorsal bronchi, of which the former receives its entire venous supply from this source.

Superficial posterior-horizontal trunk. At a point immediately below the posterior-horizontal bronchus, but sometimes originating in common with the preceding, **the Superficial**

Posterior-horizontal trunk separates from the deep posterior-horizontal vein, with backward and outward tendency and soon divides into an **Ascending Oblique** and a **Horizontal Branch,** respectively destined for the bronchial districts bearing the same names, to which they remain inferior and slightly posterior.

Becoming relatively anterior, **the Deep Posterior-horizontal Trunk** penetrates with slightly upward course into the interspace between the superficial posterior-horizontal and the mid-axillary-horizontal bronchi. It divides into a large ascending and a large descending branch which ramify in the same vertical transverse plane, distributing veins to both bronchial districts. Deep posterior-horizontal trunk. Ascending branch, descending branch.

Distribution of the Right Lesser Posterior-horizontal Vein.

The Lesser Posterior-horizontal Vein arises 1·5 cm. below the preceding, from the posterior aspect of the inferior division of the lower pulmonary vein, immediately above the descending posterior-basic vein. It is apt however to originate at a higher level from the trunk of the preceding vein, its subsequent course not being affected thereby. It is strictly horizontal and transverse, and passes straight outwards beneath the posterior curves formed by the descending branches of the corresponding bronchus. To these it distributes venous branches which follow directions analogous to those of the bronchi, whilst remaining in an inferior and anterior plane. Lesser posterior-horizontal vein; horizontal course.

In addition to these branches of distribution, a small **Posterior Sub-pleural** branch arises from the trunk close to its origin, in a vertical line with the sub-pleural branch from the preceding vein. Posterior sub-pleural branch.

Distribution of the Right Descending Posterior-basic Vein.

The Descending Posterior-basic Vein follows a downward and outward direction, with slight tendency backwards, and traverses the posterior part of the base of the lung in front of the more posterior branches descending from the posterior-basic bronchus. Posterior descending-basic vein.

Its first branch, which is comparatively small, and belongs to the earliest part of the trunk, is delivered backwards, and corresponds in situation with the vertical line passing above through the sub-pleural branches from the two preceding veins, and passing below, through the outer division from the retro-cardiac bronchus, which descends vertically in front of the venous trunk. This vein is intended for the posterior sub-pleural district and for the **Outer Retro-cardiac** district. Posterior branch: sub-pleural and retro-cardiac division.

Immediately before its passage across the inner division of the posterior-basic bronchus, the vein bifurcates into a straight continuation, and into a rather smaller trunk, which becomes slightly anterior to the main branch. To this trunk may be given the name of **Axillary-basic Vein**. It is Axillary-basic vein.

parallel to the anterior-basic vein, but situated at a higher level (rather more than 1 cm. higher). It becomes inferior to the axillary-basic bronchus.

Terminal divisions to outer posterior base.

The continuation of the trunk, crossing the interspace between the two branches of the posterior-basic bronchus, 2·5 cm. below the bifurcation of the latter, divides, whilst in that interspace, into its two terminal veins :— one of these is bestowed upon the outer side of the dorsal distribution (from the posterior-basic bronchus); the other supplies by its subdivisions the entire **Lateral Dorsi-basic District** from its anterior aspect.

Distribution of the Right Deep Transverse- or Anterior-basic Vein.

Deep transverse-basic vein.

The Deep Transverse-basic, or Anterior-basic Vein, is the most anterior of the three large veins which originate from the inferior pulmonary vein, in the shape of a tripod. Its direction lies forwards and outwards, and slightly downwards. It is crossed in front at its origin by the trunk and bifurcation of the retro-cardiac bronchus. To this distribution it gives an **Anterior Retro-cardiac Vein** which descends in the interval between the two bronchi. Continuing its course, the trunk passes behind the anterior-basic bronchus and distributes to its two divisions inferior branches which are also slightly posterior.

Anterior retro-cardiac vein.

Distribution of the Right Retro-cardiac Veins.

Anterior and two posterior retro-cardiac veins.

The Retro-cardiac Veins are three in number, an anterior and two posterior. Each of them has received a passing mention in the foregoing description. They are all three of small size and follow a downward course.

Their relation to bronchi is posterior.

The *inner posterior* retro-cardiac branch originates from the under-surface of the inferior division of the infra-pulmonary vein. The *outer posterior* arises in common with a posterior, sub-pleural, branch, from the descending posterior-basic trunk; it is parallel to and only 5 mm. distant from the preceding vein.

The *anterior retro-cardiac vein* is derived from the deep transverse-basic trunk, or anterior-basic vein, as the bronchus descends in front of this vein.

Although parallel in direction to the bronchial tubes, the veins in question are not in contact with the bronchi.

Concluding Remarks concerning the Left Auricle and the Right Inferior Pulmonary Vein and its Branches.

The inferior pulmonary vein in relation to the pleural reflection.

In reviewing the venous supply to the lower lobe attention should be called to the trunk of the inferior pulmonary vein, an important structure in connection with the pulmonary root of which it forms part, and of which it defines the inferior-posterior boundary. It gives attachment to the pulmonary pleura by nearly three-fourths of its circumference, the anterior aspect alone being free from membranous investment. The line of pleural attachment approaches very closely the boundary of the auricle itself; and excludes from the pericardium the large veins which have been described above.

Owing to the posterior position of the vein, its branches penetrate the lung from behind, and would all be posterior to their corresponding bronchial tracts but for the fact that, at this low level, the bronchus has become sufficiently posterior to pass behind them.

The veins generally anterior;

Owing, on the other hand, to the inferior position of the vein, the venous branches are inferior to the bronchi and, in some cases, rise to meet them; others again descend towards the bronchial districts; whilst a few remain horizontal. In general terms, a transverse tendency of distribution prevails and the veins meet most of the bronchial tracts at considerable angles.

general transverse tendency, at angles with bronchi.

The rule that arteries and veins occupy different aspects of the bronchi also receives very constant confirmation in the lower lobe.

Veins and arteries on opposite sides of bronchi.

The basic veins of the right lung do not always follow the plan of distribution which has been described. Variations are specially observed in the mode of grouping of the vessels at their origin. But the leading features of the peripheral ramifications will be found, in most specimens, to coincide with those which have been detailed.

Variability in their origin or in their grouping.

DISTRIBUTION OF THE LEFT PULMONARY VEINS.

Preliminary Remarks on some of the Differences between the Right and the Left Pulmonary Veins.

Two left veins, superior and inferior.

The left lung normally presents two pulmonary veins analogous to the right superior and inferior veins, and these veins occupy the same relative positions in connection with the lung and with the heart as on the right side. The two veins originate in close proximity to each other from the upper outer corner of the left auricle, the superior vein being anterior to the inferior.

Occasionally a single trunk from the auricle.

Occasionally as in the specimen from which the drawings in figs. 15 and 16 were made, they leave the auricle in the shape of a single large trunk, which does not divide until it has entered within the pulmonary root.

Differences between right and left veins due to asymmetry of heart.

Important differences may be observed as regards shape, direction, and mode of branching, when the veins are compared on the two sides. Most of these differences find their explanation in the asymmetrical position of the heart; and to this subject it is essential to devote a few words.

Left auricle the least asymmetrical cavity,

The degree of asymmetry of position is not the same for all the cavities of the heart, it varies with each of them, and it is probably least in the left auricle. Nevertheless even here will be found a very marked departure from bilateral evenness of parts.

yet it is not central,

The middle line of the left auricle does not coincide with the mesial line, or tracheal line continued, but lies a little to the left of it.

not transverse,

Again the transverse vertical plane of the auricle is not parallel with the transverse vertical planes of the body but is set with slight obliquity backwards, and towards the left.

not horizontal.

Lastly the transverse axis of the auricle is not perfectly horizontal, but is directed slightly upwards as well as backwards, towards the left.

The discrepancies between the two sets of pulmonary veins are exactly those which might be theoretically inferred from the anatomical disparities just mentioned.

Hence the left veins are shorter,

(1) Because the left auricle is brought nearer to the left pulmonary root than to the right, the left pulmonary veins are, in an equivalent measure, shorter than the right veins, and generally present no horizontal extra-pulmonary portion.

higher,

(2) On the left side the veins take their origin at a slightly higher level than on the right side; and

posterior,

(3) They also arise in a plane slightly posterior to that of the origin of the right veins.

steeper.

(4) A steeper course of the left veins is another direct consequence of the almost immediate contact of the left pulmonary root with the auricle.

Mode of distribution influenced by bronchus and pulmonary artery.

The differences presented by the left veins in respect of their mode of distribution are to a great extent governed by the peculiarities of the left pulmonary artery and of the left bronchus; and these have already been stated to depend ultimately upon the one-sided situation of the heart.

Curve of left bronchus, different from course of right bronchus.

The left main bronchus, which in its first part is to a very slight extent posterior to the right, ceases after its entrance into the pulmonary root to incline backwards, and even displays a slight tendency forwards. The right bronchus on the contrary moves steadily backwards downwards and outwards.

Left pulmonary artery not visible in front.

Again whereas the right pulmonary artery occupies a very prominent place among the structures lying in front of the tracheo-bronchial plane, the trunk of the left pulmonary artery is from the first posterior to the left bronchus and is not visible from the anterior aspect of the root of the left lung.

The left superior pulmonary vein in close contact with bronchial tree.

It follows that on the left side nothing intervenes between the superior pulmonary vein and the front of the bronchial tree; but that the right superior pulmonary vein is lifted by the pulmonary artery from direct contact with the large bronchi.

Unlike the right, the left pulmonary vein is posterior to bronchi.

Hence a forward, downward, and outward course.

On the other hand the right inferior pulmonary vein is, to say the least, not posterior to the lowermost bronchial divisions; but the left inferior pulmonary vein is at first decidedly posterior to the planes of its distribution, and therefore, instead of following, as the right, an almost straight outward tendency in its main branches, exhibits in their first part, a forward and outward direction. This direction is in addition strongly inclined downwards, not only because the left inferior vein occupies at first a higher level, but also because it is from the first in the immediate vicinity of the descending bronchi.

Origins of right upper, and middle lobar veins differ owing to transverse artery.

The left upper, and cardiac veins alike enter interspaces directly.

Left Superior Pulmonary Vein.—In the right lung the mode of origin of the upper lobar and that of the cardiac veins are rendered different by the transverse portion of the pulmonary artery, which lies between them. On the left side this cause of disparity does not exist. The long spiral curve which has been described in connection with the right superior vein, is not here required; but the veins of the upper lobe are enabled to pass into the successive bronchial interspaces with as much directness as obtains with respect to the right cardiac veins.

At the apex transversely

Within the interspaces the veins ramify with varying direction according to the course followed by the bronchi. Among the upright air-tubes of the apex, interspaces and veins alike become somewhat vertical. The conveyance of the veins to the outlying interspaces in the outer and posterior placed veins are necessary. zones of the upper lobe is effected, in the right lung, by the spiral curve of the superior pulmonary vein. In the left lung the same purpose is served by the occurrence of a rectangular bend in the vertical course of the chief venous trunk or trunks of the apex. From this bend a horizontal, transverse portion extends across the breadth of the lower part of the apex, for the supply of the distant interspaces.

The left cardiac veins have higher origins, because no transverse fissure exists.

In addition to the influences which have been enumerated, the absence of a transverse fissure, and of a separate middle lobe, and the joint origin from a single trunk (the bronchus impar) of the pectori-apical and of the cardiac bronchial supply enable the cardiac veins to arise at a much higher level (more than 2 cm. higher) on the left side than on the right. The left cardiac veins arise immediately beneath the apical and pectoral veins. Thus the great distance which separates the ascending-apical branch and the inferior cardiac branch of the right vein is reduced in the left vein to insignificant proportions. The veins, for the left upper lobe, to use a homely but practical illustration, arise in a tuft from the upper and anterior aspect of this vein, instead of occupying at their origin an area of divergence of 180°, as on the right side.

The left upper lobar veins all arise in a tuft; the right veins with great divergence.

Differences in shape and direction. The right vein broad and horizontal.

The differences in shape between the two superior pulmonary veins are readily gathered from the foregoing description. The right vein which arises almost horizontally outwards is broad and almost cylindrical in aspect. Upon its origin rests from above and from behind the transverse extra-pulmonary portion of the right pulmonary artery.

The left vein vertical and coniform.

The left vein, which arises almost vertically, with faint direction forwards and outwards, is parallel, but not in immediate contact with the first or descending extra-pulmonary portion of the right pulmonary artery. Its shape is that of a somewhat irregular inverted cone, the apex of which is branched, whilst the base is free from any branches.

Its relations to the pulmonary arteries.

The direction of the left vein crosses (as occurs in the right lung) the direction of the left pulmonary artery, but between these two structures the main bronchus intervenes. A slight lateral contact does however occur high up, between the inner ascending-apical vein and the first part of the left pulmonary artery, and between the same vein and the termination of the common arterial trunk;—and at its summit the superior pulmonary vein rises nearly into the angle formed by the bifurcation of the common pulmonary artery, and occupied by the left bronchus.

Left inferior pulmonary vein. Greater size of the left posterior-horizontal vein.

The Left Inferior Pulmonary Vein is not only more posterior and higher in its origin, and more forward and more abrupt in its downward course, but the relative size and the arrangement of its branches are also rather different from those of the right inferior veins. Owing to the greater extent of the left posterior-horizontal district, the left vein is relatively larger than the right. The inferior division of the left inferior pulmonary vein is for the same reason absolutely smaller than the right inferior division. The three trunks which in both lungs arise from this division are not in the left lung arranged in the shape of a regular tripod, but in parallel finger-like order, forming at first a compact flattened prolongation of the inferior division, and continuing its direction. Divergence, however, soon occurs between these trunks, but mainly upwards and downwards within the original, vertical, axillary-vertebral plane.

Smaller size of the left inferior division of the inferior vein. Hand-like arrangement of its branches.

VENOUS DISTRIBUTION TO THE LEFT UPPER LOBE.

THE LEFT SUPERIOR, OR ASCENDING, OR ANTERIOR PULMONARY VEIN.

The Superior Pulmonary Vein is the only channel through which the left auricle receives the arterial blood derived from the left upper lobe. Its undivided portion, of coniform shape, and of nearly vertical direction, has a length of about 2 cm. The first important structure with which it comes into contact is the left main bronchus, at its termination, and the bronchus impar, both of which it crosses anteriorly. Its oblique right border is separated by an interval of barely 1 cm. from the inferior border of the right pulmonary artery, which is parallel to this border. Its left border is in close relation with the two divisions of the bronchus impar, the cardiac veins lying, at their origin, along the anterior inner surface of the cardiac bronchus, and the pectoral veins arising almost in contact with the pectori-apical trunk, and passing below the pectoral bronchus. The *superficial posterior ascending trunk*, one of the upward continuations of the vein, extends upwards between the apical arterial trunk on the left, and the anterior part of the arch of the left pulmonary artery on the right. *The apical trunk*, the other and more direct continuation, is in relation with the artery of the same name, and with the pectoral artery.

Superior pulmonary vein. Shape, length and direction. Relation to left bronchus and bronchus impar, to right pulmonary artery, to cardiac veins, to pectoral bronchi,

The vein terminates above on a level with the angle of bifurcation of the common pulmonary artery which is situated, on its right side, at a slight distance.

to common pulmonary artery.

The Branches of the superior pulmonary vein, although arising in close proximity to one another, are readily distinguished into three sets in connection with their varying directions :

Branches:

(1) The ascending-apical trunk follows, as its name indicates, a vertical course in continuation of that of the parent stem.

ascending-apical,

(2) The pectoral trunk which almost immediately subdivides, is directed nearly horizontally outwards.

pectoral,

(3) The cardiac vein or veins show from the first a strong downward and forward tendency. The two cardiac veins may arise from a common trunk, and this trunk may give origin to the pectoral vein. In this case the cleavage of the superior pulmonary vein would take place primarily into two, an upper or apical, and a lower, or pectori-cardiac division. In more normal specimens

and cardiac veins. Two primary divisions of superior pulmonary vein.

The pectoral vein sometimes included in the lower; normally in the upper.

the cardiac supply separates singly, as the lowest detachment; and the upper division or remainder of the superior pulmonary vein contains the elements of the pectoral as well as of the apical supply. In the coloured diagram the abnormal arrangement has been depicted.

The Venous Distribution to the Left Apex.

Apical trunk.

Relation to bronchus impar and descending pulmonary artery, and to apical artery and bronchus.

Length.

Highest, most anterior and internal structure of root.

The Left Apical Venous Trunk.—This vessel is much superior in size to the other two divisions from the superior pulmonary vein, and transmits the entire blood supply from the apex. It arises straight upwards from the termination of the vein, at the upper level of the bronchus impar and of the main bronchus, and it is almost from the first in contact with the external surface of the arch of the left pulmonary artery, the second portion of which descends outwards behind it. In its unbranched vertical course of 2 cm. it is therefore surrounded as it were on its inner and posterior aspect by the left pulmonary artery, and externally it is separated from the apical bronchial stem by the corresponding arterial division. It is the highest, the most anterior, and the most internal of all the tubular structures contained in the pulmonary root. It divides into a larger, *apical*, and a smaller, *posterior sub-pleural ascending-apical vein.*

Branches. Posterior sub-pleural ascending-apical vein.

Occasionally not sub-pleural, but deep.

The Posterior Sub-pleural Ascending-apical Vein, rising above the arch of the left pulmonary artery, passes backwards, and subsequently outwards, to the interval between the ascending-apical and the axillary posterior-apical bronchi, where it ascends and distributes branches. During the greater part of its course this vessel is superficial and sub-pleural. It may, however, forsaking its sub-pleural situation, follow an abnormal course, through the thickness of the apex. In this case it is a mere branch from the transverse portion of the apical trunk, and the sub-pleural supply is derived from the anterior-apical division of the same trunk.

Backward curve of this vein, to inner side of apical artery at its origin.

Under normal conditions the backward curve of the posterior sub-pleural ascending vein takes place immediately above the convexity of the arch, and the vein lies across the inner side of the apical artery, or more strictly of its ascending-apical branch, which separates the vein from the posterior ascending-apical bronchus.

Apical trunk; length and direction.

Relation to pectoral bronchus; to infra-apical interspace, to pectoral artery, to apical artery, to sterno-pectoral artery,

The Apical Venous Trunk, little diminished in size by the delivery of the preceding vein, continues its upward course for a distance of 1·8 cm., and during that interval presents most important relations. The bifurcation which gives origin to it occurs just above the level of the pectoral bronchus, opposite the large transverse infra-apical inter-bronchial space into the mouth of which it is conveyed by its inclination outwards and upwards. The horizontal pectoral artery makes its way forwards across, and in contact with the inner surface of the vein. The posterior surface of the vein is separated from the preceding vein by the left apical artery, which moves close up to its posterior outer side. The internal, or sterno-pectoral division of the pectoral artery, touches its anterior outer surface on its way outwards and forwards. The inner surface is situated immediately beneath the pleura and faces the termination of the common pulmonary artery, from which it diverges outwards.

to pleura, and to common pulmonary artery.

Immediately above the level of the horizontal pectoral artery it bifurcates into two large divisions, forming with each other a right angle, viz., the *transverse-apical trunk* which proceeds horizontally outwards, and the *anterior ascending-apical* which continues the previous direction upwards, occupying an intermediate position between the ascending-apical bronchi and the sterno-pectoral distribution.

Rectangular bifurcation.

Distribution of the Left Transverse-apical Vein.

The Transverse-apical Trunk lies in contact, at its origin, with two arteries. It rests upon the horizontal trunk of the pectoral artery, which bifurcates, beneath and in front of it, into its inner and its outer branch; and posteriorly it leans against the vertical ascending-apical artery. In other words, it is wedged into the right angle formed by the ascending-apical and by the pectoral artery. Pursuing its course outwards, it passes in front of the ascending-apical bronchial trunk, which is coupled with the ascending-apical artery; and immediately in front of the interspace between this bronchus and the axillary bronchus, it divides into its branches, the *central-apical vein*, the *pulmonary axillary vein*, and the *posterior-apical vein*.

Transverse-apical trunk arises in contact with pectoral and ascending-apical artery. Crosses in front of ascending-apical artery and bronchus.

The Central-apical Vein rises upwards and slightly outwards in the interspace between the outer ascending-apical bronchus from the axillary trunk, and the inner anterior-apical bronchus from the apical trunk. It is anterior and external to the distribution of the latter air-tube.

Central-apical vein. It is anterior and external to the bronchi.

The Pulmonary Axillary Vein is the direct continuation outwards of the transverse-apical trunk and passes in front of, and beneath the axillary bronchus, distributing anterior and inferior branches to its two divisions, the outer ascending-apical and the superior axillary bronchus.

Pulmonary axillary vein. It is anterior and inferior to the bronchi.

The Posterior-apical Vein proceeds straight backwards, at first almost horizontally; and, immediately in front of the posterior-apical bronchus, it divides into two veins which extend respectively into the interspaces occurring between the posterior-apical and the axillary, and between the posterior-apical and the vertical apical distributions. These veins also are anterior and slightly external to the corresponding bronchi.

Posterior-apical vein. Its course and mode of division. Its branches are anterior and external to the bronchi.

Distribution of the Left Anterior Ascending-apical Trunk.

The Anterior Ascending-apical Trunk, rather smaller than the transverse-apical, rises for a distance of 8 mm. within the infra-apical interspace, at its inner extremity, and divides into an *anterior sub-pleural ascending* and an *upper transverse-apical vein*.

Anterior ascending-apical trunk.

Anterior sub-pleural ascending vein.

The Anterior Sub-pleural Ascending-apical Vein, remaining sub-pleural, supplies the highest members of the series of sub-pleural veins which are associated with the inner mediastinal surface of the pulmonary pleura. It also furnishes veins to the two bronchial districts between which it is placed.

Upper transverse-apical at a higher level, more superficial and more anterior than the transverse trunk. Its branches are inferior to the apical air-tubes.

The Upper Transverse-apical Vein adopts, as its name indicates, a course analogous to that of the transverse-apical trunk, but at a higher level, immediately under the zone of the smaller peripheral apical ramifications. It is directed outwards and forwards, and is not therefore parallel to the larger transverse trunk, the course of which is either strictly outwards, or even slightly inclined backwards. Thus it is not only much less deeply situated, but its branches are directed towards the anterior, and towards the antero-external regions of the apex at the clavicular level. Its ramifications are chiefly devoted to the service of the apical sterno-clavicular, and of the inner anterior-apical bronchial districts and they remain inferior to these bronchi, whilst also bestowing branches upon those air-tubes which rise from the pectoral distribution as far as the upper zone of the infra-apical bronchial interspace.

General analogy between right and left veins. In the right lung the transverse channel is below the pectoral zone, through which the ascending veins rise. The posterior sub-pleural apical and the axillary veins are respectively alike.

A Comparison between the right and the left apical venous supply enables us to trace between the two distributions a general analogy in spite of much divergence in details. The most striking difference between them is that in the right lung the transverse supplying channel is inferior to the pectoral bronchial range, but that it is superior to the latter in the left lung. Hence it follows that the veins ascending to the right apex pass upwards between the pectoral bronchi, whereas in the left lung they arise altogether above the pectoral zone. Great resemblance exists between the two sides, in respect of the posterior sub-pleural apical and of the axillary venous supply. But, on the left side, the posterior sub-pleural vein does not arise from a separate division, but from the main apical venous stem, which supplies the transverse-apical, and the anterior ascending-apical trunk, and through this ultimately the anterior sub-pleural ascending-apical vein. The rectangular bifurcations which give rise to the transverse-apical trunk and to the upper transverse vein are remarkable departures from the usual type of division of the pulmonary blood-vessels.

The Left Pectoral Venous Distribution.

Pectoral trunk; its four divisions. Varying origin and share in the cardiac distribution.

The Four Pectoral Veins usually arise from the upper division of the superior pulmonary vein by means of a very short trunk of origin. Occasionally as in one of the specimens depicted (figs. 15 and 16) this trunk is given off from the inferior division. In that specimen the pectoral veins are of large size and take more than the usual share in the supply of the cardiac district. Being situated below the pectoral bronchi, in the inter-bronchial space between this distribution and the cardiac, these veins normally participate in the cardiac venous supply.

The four veins spread in a horizontal fan-shaped manner, anteriorly and outwards, with slight convexity upwards. They originate by means of bifurcations. The first one gives rise to the **Mid-sternal** and to the **Mid-pectoral** and the second to the *posterior* and to the *outer pectoral vein.* Horizontal fan-shaped branching. Two successive bifurcations.

Although this resemblance is not well displayed in the diagram (fig. 18), **the Sub-pleural Sterno-pectoral Vein** is in every way analogous to that found on the right side. Sub-pleural sterno-pectoral vein.

The Outer- and the Posterior-pectoral Veins subdivide in the horizontal plane situated immediately beneath the pectoral bronchi. Their ascending branches approach the bronchi on the inner side. Their horizontal branches remain below the pectoral bronchi, and send small vessels to the upper boundary of the cardiac bronchial zone. Mid-sternal and mid-pectoral; postr. and outer pectoral veins. They are inferior and internal to the bronchi.

The left posterior-pectoral corresponds to the right superior-dorsal vein, but is stopped in its backward course, by the longitudinal fissure. It delivers a **Posterior Interlobar Pectoral Vein** opposite the descending pulmonary artery.

The left pectoral venous trunk lies in the angle between the cardiac trunk and the pectori-apical bronchus, being exactly in front of the origin of the latter.

Venous Supply to the Left Cardiac Region.

The Cardiac Venous Trunk, as short as the preceding, overlaps from below the inner aspect of the cardiac bronchus. Its two divisions, the *superior* and the *inferior cardiac vein* have different downward obliquity, the superior closely approaching to the horizontal direction. The cardiac venous trunk.

The Superior or Deep Cardiac Vein, remaining at first superficial with direction forwards, swerves faintly outwards to a position almost immediately below that of the anterior cardiac bronchus. Its **Sterno-cardiac** and its **Mammary-cardiac** branch respectively approach the inner and the inferior aspect of the corresponding bronchi, and supply their bronchial districts. Superior or deep cardiac trunk. Sterno-cardiac vein internal, mammary-cardiac vein inferior to the bronchi.

The Inferior or Sub-pleural Cardiac Vein immediately divides into a *sub-pleural cardio-sternal* branch, analogous to that found on the right side, and into an *inferior cardiac branch* which follows the inferior and inner aspect of the corresponding bronchi. Inferior cardiac trunk. Sub-pleural cardio-sternal, and inferior cardiac vein.

Remarks on the Left Upper Lobar Venous Supply.

In reviewing the venous distribution of the left upper lobe, it is important to remember that this lobe is the equivalent of the right upper and of the right middle lobe. Review of the upper lobar supply.

Horizontal transverse inter-bronchial spaces: apical, infra-apical, infra-pectoral, and infra-mammary.

The spreading of the venous distribution in horizontal tiers is a striking feature of the left upper lobe. It is correlated with the peculiarities of the bronchial tree, and of the arterial distribution, and with the existence of three transverse inter-bronchial spaces,—the apical, the infra-apical, and the infra-pectoral interspace. To these might be added a fourth, the infra-mammary, corresponding to the interval between the superior and the inferior cardiac bronchi.

The veins in this lobe are closer, and more parallel to bronchi at first than in other parts; subsequently they follow the two rules of venous distribution.

It results from this disposition, and also from the close proximity of the superior pulmonary vein to the bronchial tree, that several of the venous branches possess, in this part of the lung, a course more parallel to, and, in many cases, less distant from the air-tubes, than is to be observed in any other part of either lung. This closer relationship is however restricted entirely to the early venous trunks. As they approach the peripheral zones, and undergo subdivision, they conform to the two rules which have been found applicable to all other veins, viz. the rule that the veins occupy the bronchial interspaces, and from this independent position send branches more or less transverse to the direction of the arterio-bronchial tracts;—and the rule that they select that side of the bronchi which is opposite to the bronchial surface followed by the pulmonary artery.

The ascending-apical veins a striking exception.

One of the very rare exceptions to the latter rule, is presented by the ascending-apical veins, the behaviour of which has been fully described.

VENOUS DISTRIBUTION TO THE LEFT LOWER LOBE.

Left Inferior or Posterior Pulmonary Vein.

The inferior pulmonary vein;

its branches and its anatomical relations.

The peculiarities of origin, of size, and of direction of the inferior pulmonary vein have already been given with sufficient detail (see p. 216); and it has been pointed out that its superior division, the *posterior-horizontal vein*, originates in immediate proximity to the left auricle, whereas the inferior division proceeds downwards outwards and forwards for a distance of 1·5 cm. before subdividing into the *anterior-basic*, the *axillary-basic*, and the *posterior-basic* veins. The inferior pulmonary vein and its large branches are in close relation with the descending aorta, the pleural reflection passing from the outer surface of this vessel to their posterior surface.

Venous Supply to the Left Posterior-horizontal District.

The posterior-horizontal vein.

Length and direction.

The Posterior-horizontal Trunk resembles in all essential particulars the same vein in the right lung. It is somewhat stouter and much shorter than the right vein. It extends upwards outwards and very slightly forwards, for a distance of 2 cm., covered from behind by the small descending aortic branches, as far as the lower border of the descending

FIG. 20.

SAME SPECIMEN AS FIG. 19; LEFT LATERAL AND POSTERIOR VIEW.

(*Cf.* figs. 15 and 16.)

(The side of each square represents 20 mm.)

EXPLANATION OF THE DRAWING.

The middle vertical third of the drawing shows the termination of the common pulmonary A., the arch of the aorta, and the arch of the left pulmonary A., and the sub-tracheal part of the right pulmonary A. The kink in the left descending pulmonary A. is accidental, probably the result of pressure during the injection. The solitary twigs, above and below, belong to the right lung. The origin of the four pulmonary veins from the auricle is seen distinctly.

RIGHT LUNG.

The upper lobar bronchus is foreshortened; the ascending-apical bronchus, out of sight; the axillary bronchus and its two large divisions, in view. In the angle to right of trachea, the mid-apical V. divides, far away from, but apparently close beneath the transverse portion of the posterior division of the apical artery, which accompanies the retro-axillary as well as the posterior-axillary-apical bronchi.

At intersection F v: the termination of the superior pulmonary V. as superior dorsal V., below which, the posterior-horizontal arterial and bronchial trunk.

Column vj—contains the posterior-horizontal bronchi and vessels.

At line vij, column G, the lesser posterior-horizontal A. is accidentally fused, in the drawing, with the underlying posterior-basic A., which bends downwards at this level. At the same level the inferior posterior-horizontal vein and the descending posterior-basic vein have taken the injection for a short distance only.

LEFT LUNG.

In square C v, the apex derives its arterial supply from the axillary trunk (dividing into posterior-apical, and axillary pulmonary arteries), and from the larger ascending-apical trunk arising out of sight between the axillary trunk and the posterior superficial ascending-apical vein. The posterior-apical bronchi are seen in the same square, terminating at line iij, and the axillary bronchi in square B v.

Above line iv, the anterior and posterior ascending-apical arteries and bronchi extend to the apex.

At junction C iv, a branch from the transverse-apical V. penetrates the interval between the posterior-apical and axillary bronchi. (The veins to the apex are mainly anterior.)

Between lines v and vij, the posterior-horizontal distribution is included. The vein may be followed as far as point D vj, beyond which the injection has failed.

Just below point D v, originates the superficial arterial supply;

At D vj, begins the deep posterior-horizontal bronchus; the corresponding artery arises anteriorly to it from the descending pulmonary A.

In square A vij ends the mammary-cardiac distribution.

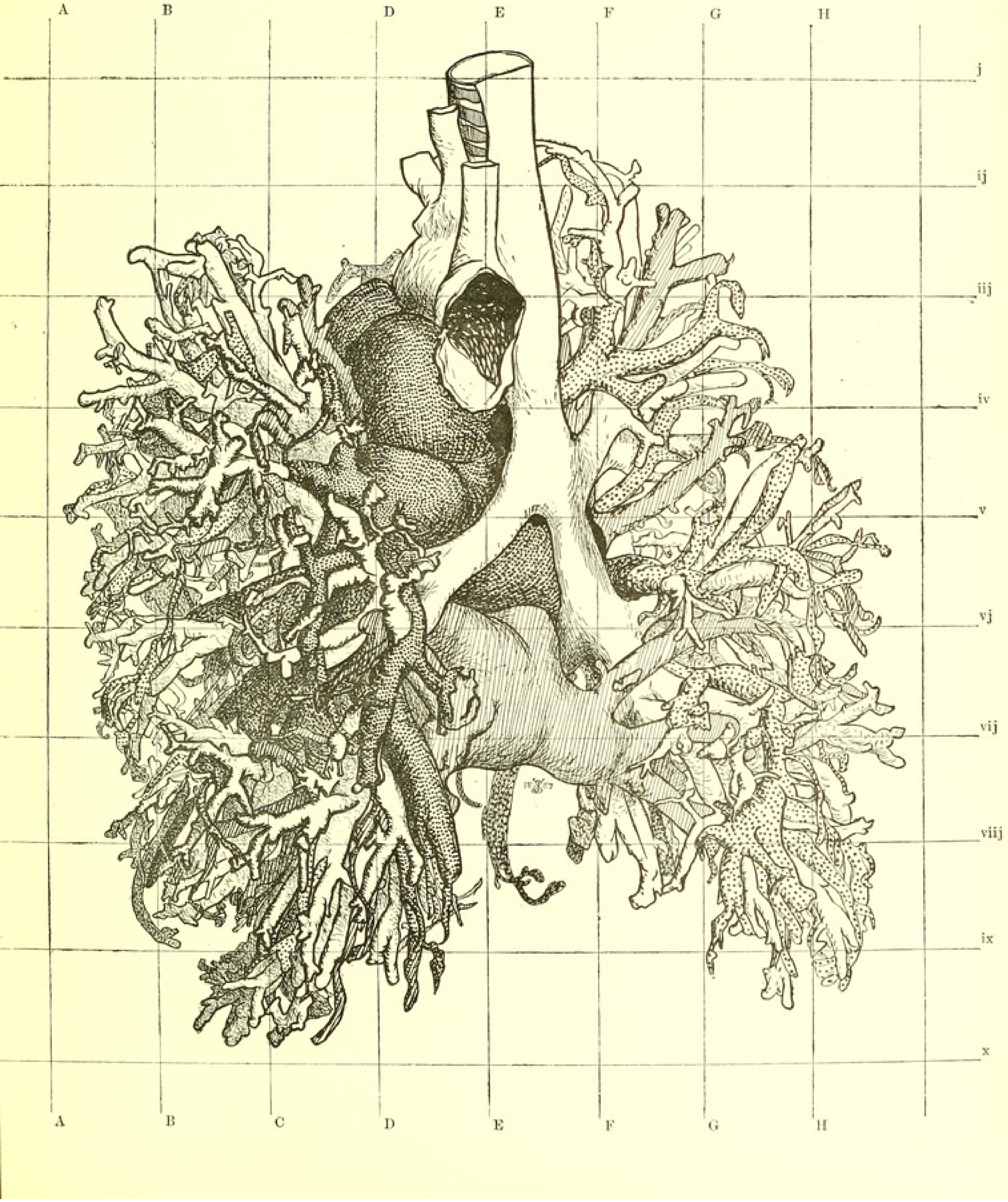
In square C viij the anterior-basic veins separate the anterior-basic from the axillary-basic bronchi; the two corresponding arteries are dimly seen in square C vij.

Just above point D viij the axillary-basic vein intervenes between two posterior-basic bronchi.

In column D the termination of the descending pulmonary artery, posterior to its bronchus, covers the breaking-up of the inferior pulmonary V. and of its descending posterior-basic division, the lowermost branch of which ends in D x.

FIG. 20.

Pulmonary arteries, dotted; left auric'e and pulmonary veins, shaded; bronchi, blank; black patches indicate lymphatic g'ands.



mid-dorsal oblique bronchus. Passing to the ventral side of this air-tube, it divides into its chief tributary-veins.

Its first branches are given off, however, at a much earlier stage, from its posterior aspect, almost immediately in front of the aorta. Their direction is respectively upwards and downwards. They bear the names of **Ascending** and of **Descending Aortic Veins.** These veins are a little anterior to, and a little nearer the middle line than the air-tubes. They distribute subpleural branchlets to the vertebral aspect of the lung in its middle portion. Small ascending and descending aortic veins, anterior and internal to bronchi.

The Descending Mid-dorsal Oblique Vein descends in front of, and slightly below the bronchial distribution, which shares with it the same name. Descending mid-dorsal oblique vein, inferior and anterior to the bronchi.

A second bifurcation of the continuation of the trunk occurs just below the level of the deep posterior-horizontal bronchus. The two resulting branches take the names of the neighbouring bronchi.

The Ascending Mid-dorsal Oblique Vein is inferior and slightly anterior to the bronchial path; its branches become more decidedly anterior. Sometimes, as in the specimen of which fig. 16 is a posterior view, the ascending oblique vein arises independently from the posterior-horizontal trunk close to its origin. It then replaces the small ascending aortic branch, and it passes upwards and outwards, behind instead of in front of the descending mid-dorsal oblique bronchus. Ascending mid-dorsal oblique vein, inferior and anterior to the bronchi, occasional irregular origin.

The Deep Posterior-horizontal Vein is at first inferior and posterior to the corresponding bronchus; but rising to the level of the bifurcation of the latter, it passes between its diverging limbs to the front of the air-tubes, and there breaks up into its branches; or it may divide before having become anterior. Deep posterior-horizontal vein, at first posterior, then anterior to the bronchi.

The general tendency of the left posterior-horizontal venous distribution is towards an anterior and inferior position of the veins, in opposition to that of the arteries, which pursue a downward and backward course. Very little therefore is seen of these veins from behind, although they arise in a plane posterior to that of most of the pulmonary vessels and bronchi. When the ascending mid-dorsal oblique vein takes an abnormal origin from the horizontal trunk it remains for some distance posterior, being covered only by the small descending aortic distribution. Review of this district. The veins have a tendency downwards and forwards.

Another posteriorly placed vein may abnormally arise from the posterior-horizontal trunk. The small descending aortic branch is sometimes replaced by a good-sized vessel, posterior to the artery which descends behind the inner descending aortic branches from the posterior-basic bronchus, and therefore superficial as well as posterior. Occasional descending posterior branch.

Venous Supply to the Left Pulmonary Base.

Inferior division of inferior pulmonary vein.

The Inferior Division of the inferior pulmonary vein, arising almost in front of the aorta, proceeds for a short distance downwards outwards and slightly forwards, before approaching the innermost of the descending basic bronchi. During this interval it divides into its three basic branches, which keeping at first side by side, resemble the adducted fingers of a hand; and it also delivers, from its lower portion, a posterior branch, the **Descending Aortic-basic Vein**, for the supply of the aortic district of the posterior-basic distribution. This vein sometimes is a branch from the posterior-horizontal trunk.

Descending aortic-basic vein.

Relations and direction of the three basic veins.

Viewed from the front, the termination of the inferior pulmonary, and its three divisions arranged side by side from above downwards, in parallel order, with direction downwards, outwards and forwards, are situated 1 cm. below the level of the subdivision of the inferior lobar bronchus into its basic branches. The veins pass outwards in front of the posterior-basic bronchial trunk, and behind the inner, or cardio-basic, division of the anterior-basic bronchus. They are within the same vertical axillary-vertebral plane as the lower lobar bronchus; but their upper border forms with the direction of the latter a considerable angle.

The Left Anterior-basic Vein.

Anterior-basic vein.

Origin.

The Anterior-basic Venous Trunk is the uppermost of the three parallel basic bronchi. Its origin is best studied from the anterior aspect. (See fig. 19, column F, middle of line vij.) The three trunks do not arise simultaneously, but by two successive bifurcations. As in the right lung, the anterior-basic trunk is also here the first product of bifurcation.

Anterior retro-cardiac vein,

internal to the bronchi.

A small **Anterior Retro-cardiac Vein** immediately descends from its anterior surface, in front of the angle of bifurcation between it and the still undivided remainder of the inferior pulmonary vein. In fig. 19 this small vein lies obliquely across the line of bifurcation and conceals from view its inner portion. It is separated from the inner side of the retro-cardiac bronchus by a distance of 1 cm., and converges towards the lower extremity of the latter. It probably assists in the sub-pleural supply of this zone.

Cardio-basic and infra-mammary veins.

Assuming a slightly less descending course than the axillary-basic, and becoming slightly anterior to the plane of that vessel, the anterior-basic vein divides into its two large branches, the *cardio-basic* and the *infra-mammary* trunk, below the angle of bifurcation which gives rise to the anterior-basic bronchus. Both these veins pass outwards behind the cardio-basic bronchus, but only one of them, the infra-mammary, crosses the infra-mammary-basic bronchus from behind.

The Cardio-basic Vein follows the posterior and inner aspect of the bronchus and of its branches. The cardio-basic vein, internal and posterior to the bronchi.

The Infra-mammary Vein divides almost immediately into a superior, horizontal, and an inferior, oblique branch. The infra-mammary veins:

The inferior branch, or **Descending Infra-mammary Vein,** remains below the corresponding bronchus, the direction of which downwards outwards and forwards, it follows at a distance. One of its branches is distributed forwards and downwards to the interspace between this bronchus and the cardio-basic bronchus, the other branch backwards to the interspace in front of the axillary-basic bronchial trunk. (1) Descending infra-mammary,

The superior branch, or **Horizontal Infra-mammary Venous Trunk,** passes between the infra-mammary bronchus in front, and the axillary-basic and posterior-basic bronchi behind, and divides into a *horizontal* and an *ascending infra-mammary vein.* (2) Horizontal infra-mammary trunk.

The Horizontal Infra-mammary Vein passing outwards transversely, towards the lower axillary third of the pulmonary surface, along the interspace between the descending and the horizontal division of the corresponding air-tube, distributes branches to both these bronchial districts. Horizontal infra-mammary vein.

The Ascending Infra-mammary Vein is directed upwards, outwards and backwards, towards the posterior axillary middle third of the pulmonary periphery. It separates the horizontal bronchial distribution derived from the mammary-basic trunk, from the horizontal distribution, arising from the axillary-basic and posterior-basic trunks, and is situated immediately beneath, and a little in front of the deep posterior-horizontal distribution. To these several districts it supplies branches. Ascending infra-mammary vein. Its relation to neighbouring bronchial districts,

Above, it is in close relation, through its branches, with the mid-axillary pleural membrane, and, at the level of the interspace between the posterior-horizontal and the basic distributions, with the interlobar pleural fold. and to the axillary and interlobar pleura.

The three large veins which have been described in the preceding paragraphs form a broad, fan-shaped distribution, which occupies a great part of the long, oblique, interspace occurring in front of the posterior-horizontal, of the axillary-basic, and of the posterior-basic distributions, and probably serve the additional purpose of binding together these distributions with that of the anterior-basic trunk. General relations of the anterior-basic venous system.

The Left Axillary-basic Vein.

The Axillary-basic Vein, parallel, and in contact with the anterior-basic above, and the posterior-basic below, is the upper branch of bifurcation of the remainder of the inferior pulmonary vein, left by the separation of the anterior-basic trunk. Its original direction is soon modified into a downward and outward curve, with convexity upwards and outwards, Axillary-basic vein, internal and inferior to bronchi and in imitation of the curve described by the bronchial trunk. It lies to the inner and inferior side of the latter.

largely distributed to posterior-basic district; it is of considerable size.

Occupying the interspace between the axillary-basic and the posterior-basic distributions, it is concerned with the supply of both, but more specially of the latter. This circumstance explains its large size, which equals that of the anterior-basic, and exceeds noticeably that of the posterior-basic vein.

The Left Posterior-basic Vein.

Posterior-basic trunk. Its inner and anterior relation to the bronchi.

The Posterior-basic Trunk is the lowermost of the constituents of the pulmonary root, and in its first portion is therefore visible from the front as well as from the back of the metallic cast. In its subsequent course it does not penetrate deeply into the lung, but remains in inner and in anterior contact with the posterior-basic bronchus. For this reason, and owing also to the fact that the left extremity of the left auricle is tilted upwards and backwards, the course of the vein is a very rapid one downwards and slightly outwards.

Branches of distribution.

Branches of distribution pass outwards backwards and downwards, to the lateral, to the posterior and to the central parts of the base of the lung.

From its origin arise a posterior branch;

Two veins arise from the first part of the trunk, close to its origin. Indeed one of these, the posterior and larger branch, may be considered to arise from the posterior part of the common trunk giving origin to the axillary-basic and to the posterior-basic vein. It has already been described, under the name of descending aortic-basic vein, on p. 224.

and a small descending sub-pleural branch.

The other branch, a small and unimportant vein, arises with direction downwards and slightly forwards, from the inferior surface of the venous trunk. Its destination is the inner and inferior surface of the pulmonary base. Beyond the analogy which exists between it and the descending sub-pleural branch, supplied in a similar situation by the right posterior-basic vein, it presents no feature of interest.

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