Section of the History of Medicine.

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Malpighi's "De Pulmonibus."

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IT has often been observed, by men ill-versed in the history of scientific developments, that great new ideas, when developed, might easily have been inferred from others accepted long before. For example, when Erasistratos has told us that the heart's valves ensure a one-way course of the blood, and that all the blood of the body can be driven out by the opening of one artery by aid of the *horror vacui*, and Celsus has informed us that the heart is a muscular viscus, one might have inferred the circulation of the blood without waiting for Harvey. Even so one might imagine that Harvey, to complete his system, might have inferred the presence of definite vessels of communication between the arteries and the veins instead of an indefinite soakage through the "porosities of the tissues"—but he did not do so, nor did any one else for thirty years of keen discussion. The discovery of the capillaries was reserved for the work of Malpighi, who was trying to clear his views about the structure of the lungs. Since I have been unable to find an English translation of Malpighi's account of this discovery, and the letters in which he gives it are otherwise extremely interesting and important, I have endeavoured to make such a translation, and to make it literal. My English is certainly far from being elegant, but it is all the more in keeping with Malpighi's Latin composition.

These two letters, *De pulmonibus*, were written to Borelli, that *Praeclarissimus et eruditissimus virus*, whom the amiable author adored as his guiding star, although we may consider him much inferior to his correspondent in nearly every scientific qualification. Malpighi was a humble-minded man who accepted others at their own valuation. In the first letter he begins with an exordium on the supreme excellence of Borelli and the power of his "geometrical eye" to distinguish truth from error at a glance.

It is in the second letter that he gives an account of the discovery of the capillaries, but in the first is displayed the state of knowledge and belief about the lungs which had prevailed until Malpighi's time, as well as the careful and thorough method usually followed by this great anatomist.

EPISTLE I:—

ABOUT THE LUNGS

To that very famous and learned Man:—

ALPHONSUS BORELLIUS

Celebrated Professor of Science at Pisa.

by MARCELLUS MALPIGHIUS.

Professor of Medicine at Bologna.

It occurred to me that among the dissections which I prosecute from day to day I ought to examine the lungs more closely, for they seemed to me to be understood but hazily. All these matters should properly be communicated to you, for, by the talent in which you excel, you will be able to give these observations the geometrical eye, which at one glance collects from things their truth or falsity. It will be yours to direct these findings to better use, or to help my wavering mind with your discussion.

The substance of the lungs is commonly supposed to be fleshy because it owes its origin to the blood, and it is believed to be not unlike the liver or the spleen, and all agree that the lung in the fœtus is red when nourished by the blood alone, and consequently that it operates as a fleshy viscus of warm and humid temper. With greater care the senses and the reason seem to show an opposite nature of the substance. By diligent investigation I have found the whole mass of the lungs, with the vessels going out of it attached, to be an aggregate of very light and very thin membranes, which, tense and sinuous, form an almost infinite number of orbicular vesicles and cavities, such as we see in the honey-comb alveoli of bees, formed of wax spread out into partitions.

These (vesicles and cavities) have situation and connection as if there is an entrance into them from the trachea, directly from the one into the other; and at last they end in the containing membrane.

We see on the external surface of lungs recently removed from animals, when inflated with air, an almost infinite number of vesicles full of air. The same are to be seen, but less conspicuous, in the same lung divided through the middle and empty of air. But they are found more clearly and easily in the inflated lung after it is dried. Then they appear as little globules protuberant on the outer surface, and, on the divided part, little pits with sinuous offshoots. These are seen to be formed of thin, stretched membrane.

To bring certainty to the doubting mind, remove the lungs from a recently living animal, and by means of a syphon send water through the pulmonary artery. Thus you will drive out all the blood, and wash the pulmonary vessels by the water passing through them. All the lung substance reached by the water and emptied of blood will be made pale and almost transparent. If light compression is now made to drive the water out, and air is sent in by the trachea, let the still inflated lung be dried either in the shade or in the sun. Externally, with little exposure to light, it shows the small transparent globules, but internally the cut part easily shows to the eye the white mass of vesicles. I have produced a picture of these in the tables at the end, both the external and internal part of the lung, just as I could make them out by increased magnification. In the second picture, which, with greatest diligence I have been able to make out, those membranous vesicles seem to be formed out of the endings of the trachea, which goes away at the extremities and sides into ampullous cavities. From these the trachea is ended in the spaces and unequal cavities.

Reason seems to give power where the senses are deficient. Seeing that the air which rushes from the trachea into the lungs requires a continuous path for easy and rapid ingress and egress, whence possibly this internal tunic of the trachea, ended in sinuses and vesicles, makes a mass of vesicles like an imperfect sponge so to speak. This also the equal substance and colour seem to show in the dried lung; also the sheen which is reflected equally from the extreme canal of the trachea and from the appended little globules and sinuses. Nay, more, the internal surface of the trachea is smeared with a slight humidity, which should naturally be spread proportionally in the globules where the air is finally received and driven out, lest they be dried by the heat of the blood passing through (for the membranes are very thin and rare) and in order that they may be dilated into a larger mass and immediately compressed. This could not take place with dry membranes, as is known in states of disease.

Here one thing offers itself for investigation, for in the external part of the lungs, when exposed to light, a certain wonderful network seems to spread, by which you would say that emerging protuberant single bladders are bound together. The same is observed, obscurely, in the section of the lung inside. Whether this network is a vessel, or something nervous extended to the vesicles, or membranous walls themselves of the vesicles, terminating at the outermost investing membrane,

I am doubtful. For, in the interior cut part, certain nervous prolongations of this network seem to remain, either from particles turning out in drying, or lightly abraded by the knife, and in the outer part a certain shining, of the kind proper to the substance of nerves, seems to be observed. Hence I cannot deem it unlikely to be a nervous ligament of the vesicles united and mingled with the walls, as we see the semicircular cartilaginous prolongations in the trachea aspera, especially as it is probable, as I have said already, that those vesicles are continuations of the internal membrane of the trachea.

The division of the pulmonary mass is commonly taken from the form and situation: it has two parts, the mediastinum coming between them. The parts again are often divided—in man into two lobes, but these are multiplied in lower animals. I have observed a more wonderful and profound division, for the lung masses are produced by almost innumerable lobules surrounded by their own membrane, endowed with the common vessels, with allied prolongations of the arteria aspera. But the lobules can be reached if the semi-inflated lung be exposed to the solar rays or to light, when certain interstitia come out as if transparent. If you pursue these by a slight incision, you will bring out the lobules separate and adherent to the arteria aspera, and vessels wrapped in their own membrane. You test them by air blown in by the trachea. This membrane,—and it can be separated by careful dissection,—shines when exposed to light. These things will be seen better by a slight boiling of the lung and elaborate dissection of the interstitia.

In the tables at the end you will see the form of the lobules delineated. I have not been able to show altogether the insertion and various situation of these, for they vary under diverse circumstances. For the trachea, with its attached vessels, branches to all parts, and these ramifications end, now in the outer surface of the lungs which are smooth and level, now in the extreme corners; again, when they must be connected with neighbouring and surrounding ramifications, in order that the situation, connexion and capacity may be maintained, the lobules are placed in various ways, at the lower part of the trachea, at the side, at the apex. You will see the likeness of these processes outlined in the nut of the cypress. I have collected the principal and simpler in the tables at the end.

After the lobules, the interstitia mentioned above are to be observed. They are not bare vacuities and empty spaces shut off, for many have membranes spread out, some parallel, some at angles with one another, which are continued not only from the surface of the lobules laterally placed, but also from the inner substance of the lobules. Between these membranes there run out very many very small vessels from the lobules, which enter into those (lobules) opposite. By these membranes air is received or ejected as in the larger sinuses which have mutual communication so that air can be passed from one to the other. Thus, as the interstitia are the same as the membranous vesicles of the lungs, they are transparent and very thin.

As the interstitia have the same prolongation as is left by the lobules placed there, which in the larger animals almost equal the width of half a finger, I do not consider them to be only a separation and connection of the lobules, worked by Nature. Probably they compress the invested lobules with the intercepted air. Thus they multiply the force of the compression, and consequently aid the mixing of the blood mass. Further, I had frequently observed vesicles, which are called hydatids by the Greeks, in these interstitia, likewise both in old animals and in others dead by disease (I have observed) certain black points which mark out, as with a thin line, the whole extent of the interstitia. Probably I may regard them as diverticula, as if inflations of the smallest lobules. The same denigration is seen in the glands continued at the sides of the trachea aspera.

A triplex of vessels is known to be disseminated through the lung substance; its use has been believed various. At present (the task) should be to find out the variety, length and irregularity of this, supposing it to be a prolongation of the trachea,

pulmonary artery and vein, which, with a certain intertwining by equal branching, run through the whole substance of the lungs. I thought to tell you this only, how to follow the genuine and obvious division of the vessels even to the smallest, which may be done otherwise obscurely by a light abrasion of the parenchyma. With the greatest delight I happened to get this. The small, thin and oblong lobe of a dog's lung is taken, and, exhausted of air by compression, exposed to the rays of the sun. The duct of the trachea is opened and the prolongations of the artery emptied of blood, all of which will give, with the attached lobules, the appearance of a polypodium. With a little pains and trouble, as vision is dull here, one can get a more exquisite delineation. But this will occur to you if you have inflated the pulmonary artery, through the trunk appearing at the beginning of the lobe, and have tied it with a knot, you will see the artery standing out as if having carved itself into very small pieces like an anaglypt, with all the vessels standing out in the form of the branches of a tree. If you want a more beautiful picture, introduce mercury and these branches will stand out silvery, even to the smallest.

Whether these vessels have mutual anastomosis in the sinuses or elsewhere, that thus the blood may be taken in by the vein by a continuous path, or whether they all gape into the substance of the lung, is doubtful and troubles my mind. For the unravelling of this I have endeavoured vainly with air, and with variously coloured fluids. Often have I seen black water, introduced by a syphon through the pulmonary artery, break out from several parts. On slight compression it used to sweat out from the investing membrane, partly also to be heaped up in the interstitia, but most of it, with blood commingled, breaks out by the pulmonary vein and, more wonderful still, through the trachea, but diluted and with light froth and less colour. However the lungs may be compressed, it goes out through the same passage. In the same lung when dried, the walls of all the vesicles and sinuses seem to be denigrated.

Something similar seems to happen when mercury is introduced, for by the full pulmonary artery, mercury runs to the utmost bifurcated prolongations, and, if they are compressed lightly outside, it is expelled from the investing membrane, and when an opening is made into the interstitia, almost the whole is collected there. In the dried lung also reddish vesicles are seen in varied and orderless manner—in some whitish. In all these circumstances the natural way is not followed, because the introduced fluid makes more ways for itself which are not usual in the state of health. Thus we are taught that the royal ways are broken by slight force and change of the humours. Wherefore it is not strange if hydrops, blood spittings, phthises, asthmas and emphysemata occur in the lungs from slight causes.

Concerning the use of the lungs I know that many views are held from the ancients onwards, and about them there is very much dispute—especially about the cooling, which is taken to be the principal purpose, when it strives with the imagined excessive heat of the heart which may require eventation; wherefore these things have made me diligently inquisitive in the investigation of another purpose, and from these things which I subjoin I can believe that the lungs are made by Nature for mixing the mass of blood. By *blood* I do not understand the aggregate of the four common humours—both biles, blood and pituita, but all that which flows continuously through the veins and arteries, and which consists of an almost infinite number of particles. All these seem to be comprehended in two parts, alike in some degree to our unaided sense—that is to say—the whitish part, commonly called the serum, and the red.

I need not persuade you by many words that, in Nature, there are bodies which were not originally endowed with fluidity but have their smallest parts ready for connection and union, so that, only with greatest force can they be separated, and, when separated, they endeavour to bring about mutual union. Again, these bodies, by admixture with another interposed body, become fluid. We see this in metals and other things fused by fire. Again, in pieces of tartar, spread out and mixed with

water they are fluid and inconspicuous, but when united are solid as stone. Again, with aqua regia, acids and the like disuniting things interposed, we render the more solid metals fluid. Nay, more, what is more wonderful still from the discontinuity of the parts alone, fluidity occurs in the driest things, e.g., in lead and tin burned in a mill by a potter and broken up. And the dullness of our sense is such that we may easily believe that the smallest grains of sand themselves flow like water.

Nor is there a doubt that there are parts in the blood mass which are inclined to easy union, and may attain so much solidity that they rival a stone in hardness. The evidence of this is in the red part of the blood, which, separated from the serum and dried so that it bears the nature of a stone, can be rubbed down into small pieces of definite form. A portion of the light coloured serous substance condensed at the fire may become transparent, and bony by stronger union with advance of time. These particles therefore, duly mixed, form a certain fluid, for the serum is first fluid by admixture of watery substance. The visible evaporation of this issuing from the frying pan shows its existence while the serum condenses, and a certain humour, smelling and tasting like urine, is separated from the blood-serum in the middle of the alembic. This usually preserves a measure in proportion with the condensed serum. Bile and divers salts also are abundantly extracted from aqueous serum. For these, poured in and duly mixed with serum, produce a greater fluidity and solution of the parts. From the serous, or white part, the fluidity of the red part arises. We see this in the blood drawn from a divided vein. For, separated, the smallest red particles now mixed together, perhaps excited to movement by the warm particles issuing outside, are united to those like themselves, and the serous substance, pressed out all round on every side, is separated. This same process is observed in the living when scirrhous tumours are accumulated,—also black mucous tumours. The origin of these commonly calls to mind melancholia or black bile. All this is confirmed by common experience, for to prevent the blood issuing from the still living animal, from being divided into its parts by clotting, women are accustomed to crush it with the fingers or a rod and shake it up, i.e., in order that the thorough mixtures of the white and red be maintained.

Therefore, in order that this mixing may succeed best, and that the smallest part of the white may fall between and touch the smallest part of the red, and the mass of the blood be renewed and made by steady mixing, Nature has made the lungs. They bring light to those matters which are told us by the anatomists. It is known that the blood returning from the whole circuit, diluted by serum, is delivered into the lungs by means of the ordinary pulmonary artery, together with chylous matter from the common vessels of the thorax, and the lymph of Bartholin, which is the same as the white of the blood. All these can only undergo a rude mixing in the right ventricle of the heart. They are sent further into the adjoining lungs.

The structure of the lungs is such that it may be enabled to mix the blood more thoroughly. The branches of the vessels, even to the smallest, creep through the lung mass, so much so that when the included substances are thence sent on they are broken in the divisions and mingled at the divarications of the vessels as if by dashing together; at the same time they merge better into one nature, the air being wedged in the vesicles, agitating in a measure those substances. These (vesicles) pressing the vessels on all sides, while they are emptied and filled successively, are able to mix the whole material by pressure continued through their alternations. We see something like this when flour is kneaded into a mass; in order to mix it thoroughly we thump it frequently with the hand. We search for this truth in the lungs of fishes, which are formed into gills. The gills are composed of numerous semicircular rods leaning on one another; the pulmonary vessels with their very small prolongations run out to the very ends of the rods, which are so constituted that they receive water of greater density than the air around. This water, pressed by force of the bony operculum, crushes the rods together so that in the prolonged vessels and humours

sufficient mixing and motion may be had. Nay, more, because the mucus is always very easily rubbed off, it is not inconsistent to believe that substances, which in other cases go out through the kidney, may be driven out by this compression. In the same way when eggs are being hatched we have evidence, from the extreme branching of the umbilicus into the albumen and the yolk, which is so multiplied into very small ones that it marks out an elaborate network, indeed by this terminating by infinite branches in the humours of fluid a very small quantity of blood brought down is mixed with the juice brought to it.

These and similar matters I have explained to you in letters elsewhere when I saw the task of the lungs in the blood-bearing animals, and of those at rest in the fœtus, and when I saw in women a certain mass called the uterine placenta in which the umbilical vessels end. Not inconsistently, therefore, I believe the placenta to act vicariously for the lungs; through it the prolonged vessels run with similar ramification, and the white humour coming from the mother is mingled closely with abundant blood coming through the umbilical arteries, so that the blood now produced is carried back to the heart, and thence into the whole content of the body.

To the union of the smallest (ingredients) there follows not only thorough mixing and fluidity in the blood, but also at the same time a renewal of the blood-mass occurs from the materials brought into it; by fermentation intervening heat arises and a greater and greater freedom of the particles is induced. Evidence of these things may be the "colliquatio" and swelling at one time in the white, and at another in the yolk, of hatching eggs by the mixing of the blood introduced through the umbilical vessels. In the meanderings of these vessels new blood is generated by means of the blood brought in and fermenting, the liver not yet being active. We experience the same motion in ourselves, when shortly after food we feel a swelling in the lungs from the aliment flowing in, with subsequent heat, increased pulse, and frequent respiration. In my own especial case I feel such tension from vegetables and legumes, from which (tension) with a certain acrid swelling humour, I predict to myself and to bystanders a fit of palpitation about to occur in the heart: this having taken place, the stray seizure is removed. This fermentation shows itself more clearly in "hectics" when the blood is more acrid, so that what is brought may loosen and scatter, not only the parts into which it flows through the arteries, but also, the ferment going further may bring such freedom and motion to the parts of the blood that, after union and nutrition, innumerable particles fly out insensibly through the skin, the kidneys, the nose, and the bowels by sensible and copious evacuation. Nay, more, the lungs themselves are the first in which this business is carried out; they feel its severity deeply; therefore it is not strange, they being exceedingly swollen and restricting motion, that it may be feasible, with milk, barley water, snails, baths, oil and the like, to repress the activity of this ferment. In these individuals therefore, the heat increases as the food,—the chyle,—comes into the lungs, so that they become sensibly feverish, and, the attenuated blood insinuating itself more, the cheeks especially become red. At length, as happens in such cases, the structures and channels of the lungs are eroded or are opened, gaping into the cavity of the chest, or into the trachea, and then sometimes the blood, sometimes only the white part of it, condensed by heat, breaks out by the sputum or is collected in the thorax. So great is the necessity of this fermentation and its benefit, that in certain women in whom for some cause it is not excited properly, the white serous part of the blood, not without affection of the lungs, may increase so much that the red almost vanishes. Anyone can test this by examination of the blood from a divided vein and confirm it also by the colour, the torpor and cachexia of the body. Nay, more, at the time of nature fixed and instituted, healthy women swell each month and, for the opening of the menstrual ways, practise purgation. From all these things it is not hard to recognize the origin of the actual heat, when we know that, from another source, separate particles excited to motion induce in us the actual feeling of warmth.

To these uses (of the lungs) I could add another necessary thing—that the lungs are made by Nature as if for a storehouse of blood, so that it may constantly in turns give forth blood to the heart, which, thence driven into the whole body by continual circulation, may impart life and motion to everything. Nevertheless since this is dealt with by others I will only add in passing—

If the collapsed lungs of animals living up to the time of opening the thorax, are filled again with air introduced by a pipe, the movement of the heart is restored (it was almost extinguished) by the blood breaking into the left ventricle owing to the pressure made by the air.

Practice also helps us to prove this, for when the vessels of the lungs are obstructed, inequality of the pulse appears at first, then finally, death. The lungs are so important to life in living animals that it is a fact always that diseases come to an end either from the lungs themselves or in them.

I have been able to collect these things from observations made for anatomical purposes. I might have determined them more surely if the work had not been in very small things, almost escaping vision—

Follow me with your usual kindness, and may you reach the years of Nestor.

Epistle II.—About the Lungs.

There is this difficulty and obscurity to be met with in natural things, that there seems to be something in them that is not to be determined altogether by our senses. And so, steadfastly working with very great labour, we may contemplate Nature showing herself in her beginnings, as it were in a volume elaborated through mysteries. And when we try to unravel the obscure things in the viscera of animals, at length by our efforts, and only with great weariness, we conclude that the truth of our observations is made out. We borrow illumination, as if by degrees, from dissection, sometimes of insects, sometimes of perfect animals. For Nature is accustomed to rehearse with certain large, perhaps baser, and all classes of wild (animals), and to place in the imperfect the rudiments of the perfect animals.

And now, most famous man, I will handle the matter more closely. There were two things which, in my epistle about observation on the lungs, I left as doubtful and to be investigated with more exact study.

(1) The first was what may be the network described therein, where certain bladders and sinuses are bound together in a certain way in the lungs.

(2) The other was whether the vessels of the lungs are connected by mutual anastomosis, or gape into the common substance of the lungs and sinuses.

The solution of these problems may prepare the way for greater things and will place the operations of nature more clearly before the eyes. For the unloosing of these knots I have destroyed almost the whole race of frogs, which does not happen in that savage Batrachomyomachia of Homer. For in the anatomy of frogs, which, by favour of my very excellent colleague D. Carolo Fracassato, I had set on foot in order to become more certain about the membranous substance of the lungs, it happened to me to see such things that not undeservedly I can better make use of that (saying) of Homer for the present matter—

"I see with my eyes a work trusty and great."

For in this (frog anatomy) owing to the simplicity of the structure, and the almost complete transparency of the vessels which admits the eye into the interior, things are more clearly shown so that they will bring the light to other more obscure matters.

In the frog, therefore, the abdomen being laid open lengthwise, the lungs, adhering on each side to the heart, come forth. They are not slack as in other animals, but remain tense for the animal's requirements. They are nothing more than a membranous bladder, which at first sight seems to be spattered with very small spots, arranged in order after the fashion of the skin of the dogfish—

commonly called Sagrino. In form and surface protuberances it resembles the cone of a pine: but internally and externally a certain texture of vessels diversely prolonged is connected together, which, by the pulse, by contrary movement, and the insertion of the vein, are pulmonary arteries. In the concave and interior part of this (bladder) it almost fades into an empty space devoted to the reception of air, but it is not everywhere smooth but is interrupted by the occurrence of alveoli. These are produced by membranous walls raised to a little height. They are not all of this shape, but when the walls are produced out in length and width and connected together, the bays (sinuses) are formed almost into hexagons; and bent at the corners of the sinuses the membrane is extended a little as an infundibulum is constituted; and thus the lungs of the smaller frogs are fashioned. But in those which are larger, the walls are raised higher, and from the middle of the enclosed floor three come out very visibly increasing. The partitions in the smaller frogs are almost unobservable, but those in the bigger ones are bound into three other sinuses as they divide the greater sinus very much. The area, or the floor of the sinuses, admits the vessels spoken of above, and the artery itself sometimes ends inconspicuously, fork-like in the middle, but further on is spread out at the greater passage and sometimes manifestly produces another branch, but the vein glides down the inner slopes of the walls and is mingled with these, and, the branches having been sent down through the walls, at length runs into the area.

Observation by means of the microscope will reveal more wonderful things than those viewed in regard to mere structure and connection: for while the heart is still beating the contrary (i.e., in opposite directions in the different vessels) movement of the blood is observed in the vessels,—though with difficulty,—so that the circulation of the blood is clearly exposed. This is more clearly recognized in the mesentery and in the other greater veins contained in the abdomen.

Thus by this impulse the blood is driven in very small (streams) through the arteries like a flood into the several cells, one or other branch clearly passing through or ending there. Thus the blood, much divided, puts off its red colour, and, carried round in a winding way, is poured out on all sides till at length it may reach the walls, the angles, and the absorbing branches of the veins.

The power of the eye could not be extended further in the opened living animal, hence I had believed that this body of the blood breaks into the empty space, and is collected again by a gaping vessel and by the structure of the walls. The tortuous and diffused motion of the blood in divers directions, and its union at a determinate place offered a handle to this. But the dried lung of the frog made my belief dubious. This lung had, by chance, preserved the redness of the blood in (what afterwards proved to be) the smallest vessels, where by means of a more perfect lens, no more there met the eye the points forming the skin called Sagrino, but vessels mingled annularly. And, so great is the divarication of these vessels as they go out, here from a vein, there from an artery, that order is no longer preserved, but a network appears made up of the prolongations of both vessels. This network occupies not only the whole floor, but extends also to the walls, and is attached to the outgoing vessel, as I could see with greater difficulty but more abundantly in the oblong lung of a tortoise, which is similarly membranous and transparent. Here it was clear to sense that the blood flows away through the tortuous vessels, that it is not poured into spaces but always works through tubules, and is dispersed by the multiplex winding of the vessels. Nor is it a new practice of Nature to join together the extremities of vessels, since the same holds in the intestines and other parts; nay, what seems more wonderful, she joins the upper and the lower ends of veins to one another by visible anastomosis, as the most learned Fallopius has very well observed.

But in order that you may more easily get hold of what I have said, and follow it with your own sight, tie with a thread, just where it joins the heart, the projecting

swollen lung of an opened frog while it is bathed on every side with abundant blood. This, when dried, will preserve the vessels turgid with blood. You will see this very well if you examine it by the microscope of one lens against the horizontal sun. Or you may institute another method of seeing these things. Place the lung on a crystal plate illuminated below through a tube by a lighted candle. To it bring a microscope of two lenses, and thus the vessels distributed in a ring-like fashion will be disclosed to you. By the same arrangement of the instruments and light, you will observe the movement of the blood through the vessels in question. You will yourself be able to contrive it by different degrees of light, which escape description by the pen. About the movement of the blood, however, one thing shows itself, worthy of your speculation. The auricle and the heart being ligatured, and thus deprived of motion and the impulse which might be derived from the heart into the connected vessels, the blood is still moved by the veins toward the heart so that it distends the vessels by its effort and copious flow. This lasts several hours. At the end, however, especially if it is exposed to the solar rays, it is agitated, not by the same continued motion, but, as if impelled by changing impulses, it advances and recedes fluctuating along the same way. This takes place when the heart and auricle are removed from the body.

From these things, therefore, as to the first problems to be solved, from analogy and the simplicity which Nature uses in all her operations, it can be inferred that that network which formerly I believed to be nervous in nature, mingled in the bladders and sinuses, is (really) a vessel carrying the body of blood thither or carrying it away. Also that, although in the lungs of perfect animals the vessels seem sometimes to gape and end in the midst of the network of rings, nevertheless, it is likely that, as in the cells of frogs and tortoises, that vessel is prolonged further into very small vessels in the form of a network, and these escape the senses on account of their exquisite smallness.

Also from these things can be solved with the greatest probability the question of the mutual union and anastomosis of the vessels. For if Nature turns the blood about in vessels, and combines the ends of the vessels in a network, it is likely that in other cases an anastomosis joins them ; this is clearly recognized in the bladder of frogs swollen with urine, in which the above described motion of the blood is observed through the transparent vessels joined together by anastomosis, and not that those vessels have received that connection and course which the veins or fibres mark out in the leaves of nearly all trees.

To what purpose all these things may be made, beyond those which I dealt with in the last letter concerning the pulmonary mixing of the blood, you yourself seemed to recognize readily, nor is the opinion to be lessened by your very famous device, because by your kindness you have entrusted me with elaborate letters in which you philosophised subtly by observing the strange portents of Nature in vegetables, when we wonder that apples hang from trunks not their own, and that by grafting of plants the processes have produced bastards in happy association with legitimates. We see that one and the same tree has assumed diverse fashions in its branches,—while here the hanging fruits please the taste by a grateful acidity, there they fulfil every desire by their nectar-like sweetness, and you furnish credibility to the truth at which you wondered when in Rome, that the vine and the jasmine had come forth from the bole of the Massilian apple. He who cultivated the gardens with a light inserted fork made these clever things with bigger branches, and he taught the unreluctant trees the bringing forth of divers things. About this matter Virgil in the Georgics fitly sang :—

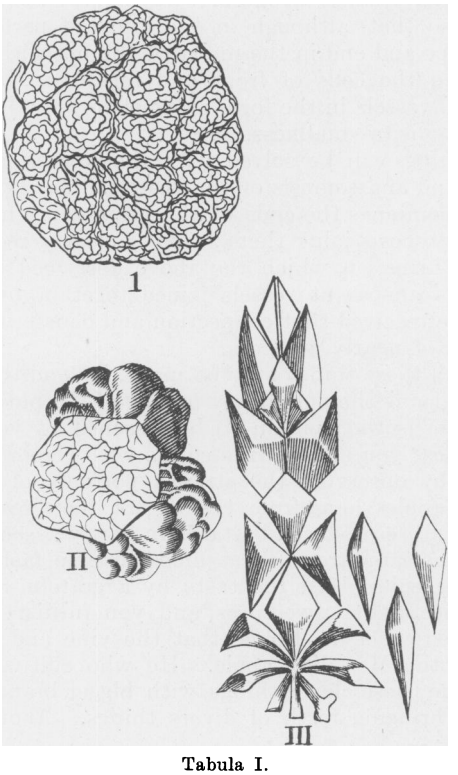
> " They ingraft the sprout from the alien tree
> And teach it to grow from the moist inner bark."

You lay bare the secret of this wonderful result by your philosophising method, for we might consider the acid juice of the Massilian apple sweetens to the nature of pure wine as far as the particles of that juice may run through the small openings of the

trunk proper, but not in the same way can they come up into the continued tubules of the vine. Here, stirred by their own motion, and torn away beyond their usual order by the impulse of those following after, and broken up, they must conform themselves to the superinduced form of the passage, and put on the new nature by which the vine or the jasmine is brought forth. Nature pursues a like mode of operation in the lungs, for the turbid blood returns from the ambit of the body, widowed elsewhere of particles, to which a new humour from the subclavian vein is added to be perfected by the further action of Nature. This happens in order that it may be arranged and prepared into the nature of particles of flesh, bone, nerve, etc., while it enters the myriad vessels of the lungs. It is conducted into divers very small threads. Thus a new form, situation, and motion is prepared for the particles of the blood, from which flesh, bone, and spirits may be formed. The trustworthiness of your saying is increased by the like structure of the seminal vessels as if a certain nutrition of the living animal were also its regeneration.

I have put these few little observations into a letter that I might increase the things found out about the lungs. If I have set in motion all the point of my observations I have owed the addition to the frog. You will bring out the truth and dignity of these matters by your authority and contrivance. Meantime, apply yourself happily to philosophy, and may you go on to render me altogether happy by increasing a little my very unimportant thoughts of your writings "De Animalium Motu."

Farewell! Bologna, 1661.

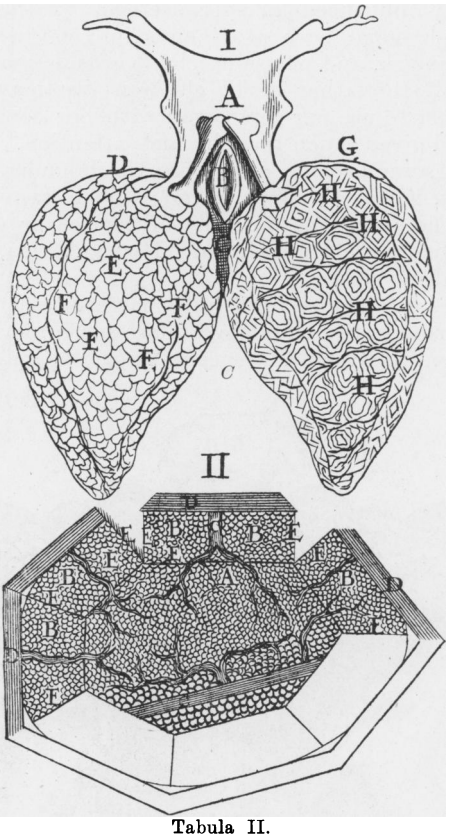


Tabula I.

FIG. I.—Outermost piece of dried lung showing the rete.

FIG. II.—Interior vesicles and sinuses sketched with portion of the interstitium in the upper part. The beginning and complete prolongation could not be exhibited to the eye by the picture.

FIG. III.—Adaptation over the trachea and the pulmonary vessels which also, parted from their usual site, are shown for easier understanding.



Tabula II.

FIG. I.—Showing lungs of frogs with trachea attached. (*A*) Larynx, which is semi-cartilaginous. (*B*) Rima, which is accurately closed and opened at the animal's need. Air being enclosed it keeps the lungs expanded. (*C*) Site of the heart. (*D*) External part of the lung. (*E*) Prolonged rete of the cells. (*F*) Prolongation of the pulmonary artery. (*G*) Concave part of the lung divided through the middle. (*H*) Prolongation of the pulmonary vein running through the apices.

FIG. II.—Containing the most simple cell without the intermediate walls (magnified). (*A*) Interior floor of the cell. (*B*) Parietes separated and bent. (*C*) Trunk of pulmonary artery with attached branches, as if ending in a network. (*D*) Trunk of pulmonary vein wandering with its branches over the slopes of the walls. (*E*) Vessel in the bottom and corners of the walls with the ramifications of the rete continued.

The Armorial Bearings of the Worshipful Society of Apothecaries.

By T. VINCENT DICKINSON, M.D.

WHEN James the First of England finally "disunited, disjoined and separated" the Apothecaries from the Grocers and Pepperers in 1617 and granted them a Charter, he called their Guild a *Society* instead of a Company, for, as he remarked, the Grocers were merely merchants and "not competent judges of the practice of medicine," whereas the Apothecaries practised an art as well as mystery. And he chose this appellation of *Society* in imitation of and modelled on a similar Association, the "Société scientifique" of Naples, founded in 1540, and also to give emphasis to his conception of a Guild composed of men who exercised an art in distinction to those who plied a trade.