**The anatomy and physiology of the liver / by Francis Kiernan.**

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THE

# ANATOMY AND PHYSIOLOGY

OF

# THE LIVER.

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BY

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*From the* PHILOSOPHICAL TRANSACTIONS.

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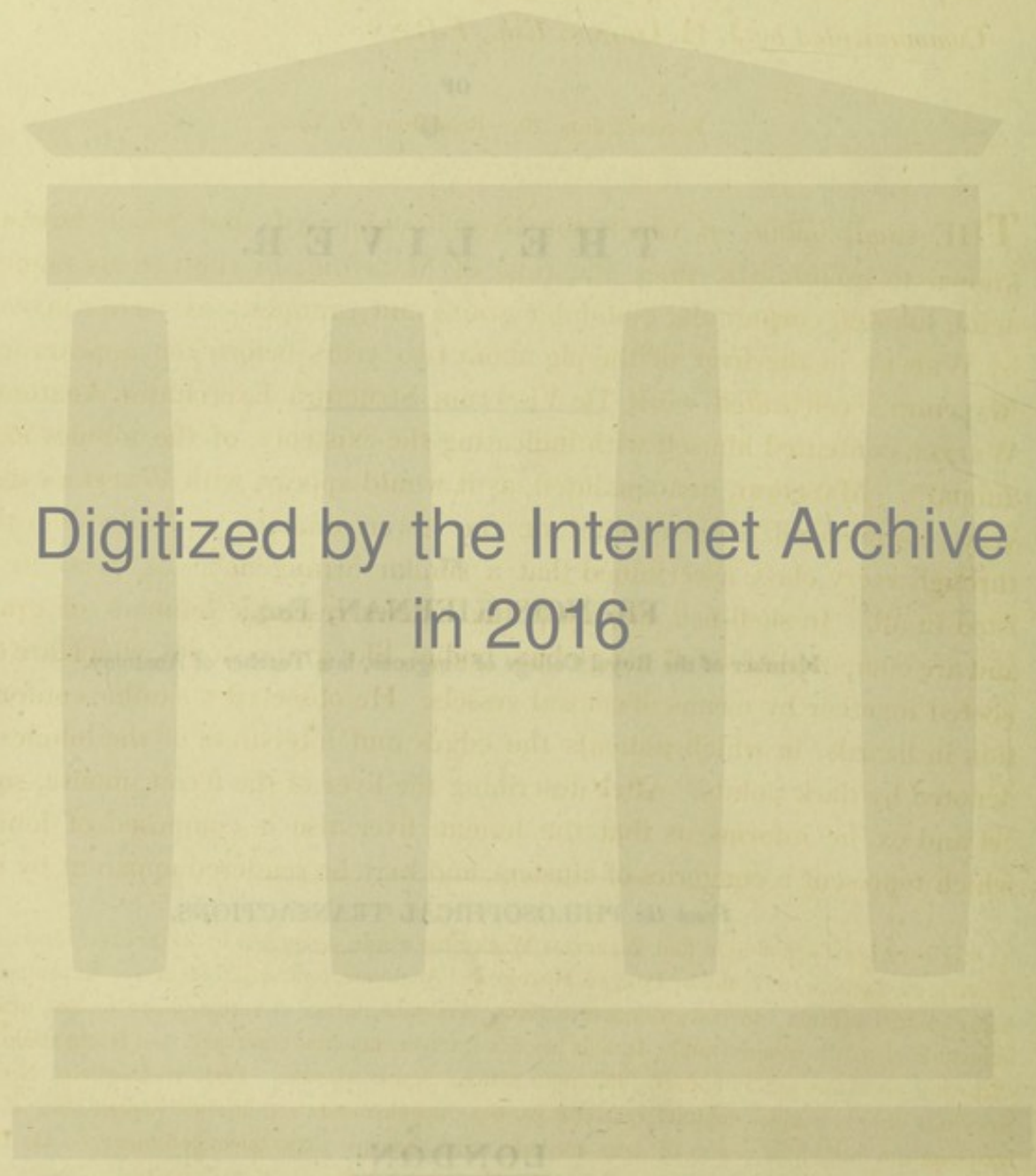

# XXIX. *The Anatomy and Physiology of the Liver.* *By* Francis Kiernan, *Esq., Member of the Royal College of Surgeons, late Teacher of Anatomy. Communicated by* J. H. Green, *Esq., F.R.S.*

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THE small bodies of which the liver is composed, and which have been known to anatomists, since the time of Malpighi, by the various names of acini, lobules, corpuscula, glandular grains and granulations, were discovered by Wepfer in the liver of the pig about two years before the appearance of Malpighi's celebrated work De Viscerum Structurâ Exercitatio Anatomica. Wepfer contented himself with indicating the existence of the lobules in one animal*. Malpighi, unacquainted, as it would appear, with Wepfer's discovery, commenced his researches on the lower animals, and pursuing them through every class, ascertained that a similar arrangement of structure existed in all. In shell-fish, he says†, the lobules resemble bunches of grapes, and are composed of small conglobate bodies, like grape-stones, which are connected together by means of central vessels. He observed a similar conformation in lizards, in which animals the edges and interstices of the lobules are denoted by dark points. After describing the liver of the ferret, mouse, squirrel and ox, he informs us that the human liver also is composed of lobules, which represent a congeries of clusters, and may be rendered apparent by boil-

* I have not been able to find Wepfer's Work: his words, as quoted by Malpighi, Opera Posthuma, p. 32, Londini 1697, and by Portal, Histoire de l'Anatomie, tom. iii. p. 243, are—"Expendas euge hepar suillum coctum: invenies detractâ extimâ membranâ, totam et vastem hanc molem, quasi ex innumeris glandulis combinatam. In aliis jecoribus, fateor, nondum observavi: sed fracto suillo bene cocto vidi glandulas quadrangulares, aliterque ratione figuræ affectas. Perlectis Clarissimi Nicolæi Stenonis observationibus cogitavi, quia et hepar quasi conglomerata est, an fortè hepatis officium foret lympham suo modo præparare ad usus corporis utiles, eamque juxta bilem secernere?"—De Dubiis Anatomicis, Epistola ad Jacob. Hen. Paulum. Norimberg 1664.

† De Hepate, cap. 2.

ing the organ and taking off its external coat. The lobules, he says, are appended to the extremities of the vessels contained in Glisson's capsule, and are invested in membranous tunics connected together by transverse bands. They vary in form in different animals: in fishes they resemble the leaf of the trefoil; in some animals they are pisiform; in the cat they have six or more sides; and they assume the hexagonal form in the human liver. Biliary calculi found in the liver were thought by MALPIGHI to be petrified lobules. Respecting the structure of the lobules, MALPIGHI informs us, that the glandular acini of which these bodies are composed have six or more sides; that they are connected by their vessels and bound together by proper membranes, the interstices between them being very apparent in the lower animals and in fishes, but obscure in the higher animals. MALPIGHI, having thus convinced himself of the existence of glandular acini in the liver, similar to those already known in the pancreas and thymus, classed this organ among the conglomerate glands*; but as he gave no representations by plates of the important discoveries he made, some difficulty has been experienced in understanding his descriptions †. Thus, he speaks of two kinds of bodies, of lobules and of acini: anatomists ‡, however, having used these terms indifferently to designate the same objects, have not understood them in the sense in which they were employed by MALPIGHI. MALPIGHI's discoveries in the anatomy of the liver are almost confined to the ascertaining its lobulated structure: he was unacquainted with the form of the lobules, with their peculiar arrangement around the hepatic veins, and with the manner in which the vessels are distributed; nor has much light been thrown on these points by the researches of more modern anatomists, although very considerable additions have been lately made to our knowledge of the ultimate

* De Hepate, cap. 3.

† The lobules and acini, as described by MALPIGHI, have been delineated by MASCAGNI, Prodromo della grande Anatomia, tab. vi. figg. 13, 14, 17. They have been also represented by BIDLOO, Anatomia Corporis Humani, tab. 38. fig. 1. The same figure will be found in COWPER's Anatomy of Humane Bodies.

‡ " On peut donner le nom de *lobules* (*acini*) aux petits amas de substance médullaire et de substance corticale réunies."—MECKEL, Anatomie Générale Descriptive et Pathologique, tom. iii. p. 453.

" M. FERREIN a trouvé dans chaque grain ou lobule du foye deux substances différentes."—Mémoires de l'Académie Royale des Sciences, Histoire. 1733. SŒMMERRING also, in speaking of the lobules, calls them *acini*.

structure of the liver and of other glands by the important discoveries of MÜLLER *.

The following pages contain an account of my own investigations of the structure of this organ. The description I propose to give will embrace, 1st, that of the lobules, the manner of their arrangement, their connexions with each other and with the vessels; 2ndly, the surfaces of the liver and the distribution of the vessels; and 3rdly, the structure of the lobules.

*Of the Lobules.*—The hepatic veins with the lobules present a tolerably accurate resemblance to the trunk, branches and leaves of a tree. (Plate XX. fig. 1.) The lobules may be compared to the leaves. The substance of the lobules is arranged around the minute branches of the veins in a manner which may be compared to the disposition of the parenchyma of a leaf around its fibres. The vessels in which the minute veins terminate may be compared to the branches of the tree, and these vessels by their junction form the trunks. The hepatic veins may be divided into two classes; into those veins contained in the lobules, and those contained in canals formed by the lobules. The first class is composed of the intralobular branches, one of which occupies the centre of each lobule, and receives the blood from a plexus formed in the lobule by the portal vein. (Plate XX. fig. 2, *a*.) The second class of hepatic veins is composed of all those vessels contained in canals formed by the lobules. Numerous small branches, as well as the large trunks which terminate in the inferior cava, are included in this class; they all resemble each other in being contained in canals, and they differ from the vessels of the first class which are contained in the lobules. The intralobular veins terminate in some of these vessels, and not in others; these vessels therefore admit of being divided into two sets; 1st, those in which the intralobular branches terminate (Plate XX. fig. 2, *b*.); 2nd, those in which no intralobulár branches terminate (Plate XX. fig. 2, *c*.). The lobules are arranged around the veins composing the first set, the bases of these bodies resting upon them; they may be called the sublobular-hepatic veins, this term being applied to them merely to distinguish them from the trunks which compose the second set, and on which the bases of the lobules do not rest. The branches of the second set are formed by the junc-

* De Glandularum secernentium Structurâ penitiori earumque primâ Formatione in Homine atque in Animalibus. Lipsiæ 1830.

tion of those of the first; the canals containing the former differ in the manner of their formation from those containing the latter. Every branch of the hepatic veins contained in the liver belongs to one of these two classes of vessels.

Each intralobular vein is composed of a central vessel, and of from four to six or eight smaller vessels, which terminate in the central vessel. (Plate XX. fig. 3, *e. f.*) The intralobular veins invariably correspond in form with the lobules, the substance of which is arranged around them; and as these vessels resemble in some degree the fibres of a leaf, so sections of the lobules made in the direction of the vessels assume a more or less foliated appearance. (Plate XX. fig. 3, *b.*) The lobules are not, however, flattened bodies like leaves; for, as the smaller veins enter the central vein in every direction, so small processes project in every direction from the lobules, the number of processes being equal to the number of veins terminating in the central vein. The form of the lobules will be now easily understood; their dimensions are known to all anatomists. They are small bodies, arranged in close contact around the sublobular-hepatic veins, each presenting two surfaces. One surface of every lobule, which may be called its base, rests upon a sublobular vein, to which it is connected by the intralobular vein running through its centre, the base of the lobule thus entering into the formation of the canal in which the sublobular vein is contained. (Plate XX. figg. 3. and 4, *c.*) The canals containing the hepatic veins may be called the hepatic-venous canals or surfaces; and as the base of every lobule rests on a sublobular vein, it is evident that the canals containing these veins are formed by the bases of all the lobules of the liver. (Plate XX. fig. 4, *h.*) The external or capsular surface of every lobule (Plate XX. figg. 3. and 4, *d.*) is covered by an expansion of Glisson's capsule, by which it is connected to, and separated from, the contiguous lobules, and in which branches of the hepatic duct, portal vein and hepatic artery ramify. All the lobules resemble each other in their general form, and they are all of nearly equal dimensions; they appear larger when the section is made in the direction of the hepatic veins, and smaller when in the transverse direction. This is most apparent in that state of the liver usually called the nutmeg liver. In a longitudinal section of a lobule, the intralobular vein is seen running through its centre; and if on the surface of the section five of the projecting

processes of the lobule be seen, five smaller veins will also be seen, one occupying the centre of each process, and all terminating in the central vein. (Plate XX. figg. 3. and 4, *f*.) In a transverse section of a lobule, the divided extremity of the intralobular vein is seen in the centre, and three or four processes of the lobule are seen shooting out in different directions. (Plate XX. fig. 6.) The vein being thus always situated in the centre, it sometimes happens that on the surface of a section of the liver, veins are seen in some lobules and not in others; this appearance is caused by the instrument, which, passing obliquely through these lobules, divides some vessels, which thus become apparent, and passes either above or below others.

The superficial differ in one respect from the internal lobules. In the latter, the intralobular veins commence at a certain distance from the surfaces of these bodies, the substance of which completely surrounds them, except at the bases of the lobules, where the veins make their exit to terminate in the sublobular veins. (Plate XX. fig. 5, *c*.) By superficial lobules are meant, not those only which form the convex and concave surfaces, but those also the capsular surfaces of which form the canals containing certain branches of the hepatic duct, portal vein, and hepatic artery, and the canals containing the trunks of the hepatic veins, all these canals being tubular inflections inwards of the superficies of the liver. In all the superficial lobules, the intralobular veins commence immediately at the surfaces; these lobules appearing less perfect in form, or less developed, than those of the interior, or as if their upper portions had been removed, giving to the surfaces of the organ the appearance of the surface of a section. (Plate XX. fig. 5, *d*.) The knowledge of this peculiar form of the superficial lobules enables us, in injecting the hepatic veins, to limit the injection to this system of vessels, which is effected by withdrawing the syringe when the injection appears in minute points on the surface of the liver. If the injection be propelled from the hepatic veins into those portions of the lobular venous plexuses immediately surrounding the intralobular veins, the first stage of hepatic venous congestion will be simulated; this is effected by withdrawing the syringe when the injection appears in small isolated patches on the surface. The next stage of congestion will be simulated by propelling the injection until the patches partially coalesce, and become continuous with each other; and finally, the appearance of general congestion is produced when the injection

passes into those branches of the portal vein which ramify in the interlobular fissures. Occasionally double lobules, or lobules having two intralobular veins, are observed on the surface. (Plate XX. fig. 7.)

Mascagni *, adopting Malpighi's view of the arrangement of the lobules, compares the liver to a bunch of grapes; and this anatomist and Bidloo have represented the lobules appended to the extremities of the vena portæ. As certain branches of this vein first ramify between the lobules, and finally enter them, these bodies may be represented as appended to its extremities: and although every lobule receives branches from this vein, yet a certain number only are clustered around its trunks, with which they have no immediate connexion; whereas the base of every lobule in the liver is in contact with, and connected to, an hepatic vein.

The essential part of a gland is undoubtedly its duct; vessels it possesses in common with every other organ; and it may be thought that in the above description too much importance is attached to the hepatic veins: but relations similar to those which exist between these veins and the lobules, do not exist between the latter and the ducts, or between them and any other set of vessels; nor is there the same exact relation between the ducts and lobules as between these bodies and the hepatic veins, for a lobule with six projecting processes may have three times that number of ducts ramifying on its external surface, whereas the same lobule will have but six minute veins, one in each process, all of which terminate in the central intralobular vein.

The foliated appearances delineated by Müller †, resemble very closely the lobules as I have described them; but they are not lobules, nor are they described as such by this anatomist. The figure representing the structure of the liver of the squirrel resembles longitudinal sections of lobules in some parts, and transverse sections in other parts. Vessels similar in their course to the intralobular branches of the hepatic veins are seen in this figure; but the vessels here represented are interlobular branches of the portal vein; and had the duct and artery been injected, small branches of these vessels also would have been seen accompanying the branches of the vein. The vein is seen occupying a fissure, which at intervals is dilated into spaces; these, as will be shown, are the interstices between the lobules. In those parts of the same figure which

* Prodromo, p. 142. tab. vi. fig. 17.

† Op. cit. tab. xi. figg. 8, 9, 11.

resemble transverse sections of lobules, the central dark spot is an interlobular space, occupied by branches of the duct, portal vein and hepatic artery. Had the animal died from hemorrhage, or had the portal vein and hepatic artery been tied in the living animal, so as to deprive the liver of its blood, no such appearances would have presented themselves, the arrangement of the structure of the liver in this, and in all the vertebrated animals, being much alike. I have preparations accurately exhibiting these appearances, which very commonly present themselves in the human liver, as well as in the liver of animals, and are produced by congestion, principally of the hepatic veins, the lobules being also congested except at their opposed margins. The same remarks apply to the delineations given by this anatomist of the liver of the quail, and to that of a portion of the human liver.

*Of the Surfaces of the Liver.*—The surfaces of the liver are, 1st, the external surface; 2ndly, the portal surfaces or canals, at which the vessels enter the organ; 3rdly, the hepatic-venous surfaces or canals, at which the vessels make their exit.

*Of the External Surface.*—Examined on the external surface of the liver, the lobules present every variety of form; but in one subject they may all be more or less angular, and in another rounded. They are separated from each other by fissures, which, at the angles of the lobules, dilate into small triangular spaces; they may be called the interlobular fissures and spaces; they contain the interlobular branches of the portal vein, hepatic artery and hepatic duct, ramifying in a fine cellular tissue continuous with Glisson's capsule, which, with the vessels, constitutes the capsules of the lobules. (Plate XXI. fig. 1, *b* and *c*.) The fissures and spaces were known to Malpighi: he was of opinion that by their means the liver is rendered flexible, and he tells us they are large in fishes, "qui flexuosè incedunt." He also informs us that the fissures were known to his predecessor Cortesius *, to Fernelius †, to Glisson ‡, and others.

* "Hic enim foramina quædam, seu rimulas in jecoris carne deprehendit."—De Hepate, cap. 2.

† "Fernelius rimulas in hepatis parenchymate observavit."—Ib.

‡ Glisson appears to allude to the clefts so frequently seen on the surface of the liver, and not to the interlobular fissures. "Vidi aliquando in gibba quorumdam jecinorum parte rimas et hiatus majusculos qui fortè à partium extremarum violentiore complicatione ortum duxerant: quemadmodum et panis frustrum nimiâ incurvatione diffringitur."—Anatomia Hepatis, cap. 9.

Mappes * has described the fissures and spaces; but this anatomist is mistaken in supposing that some of them contain hepatic veins alone, and that others contain hepatic veins, arteries and ducts. When there is but little cellular tissue in the capsules, the lobules are closely compacted together; they are therefore angular in form, and the fissures and spaces are less apparent. (Plate XXI. fig. 1.) Hence it is that these bodies have been described as having six or more sides by Malpighi, Sœmmerring †, and others. But when the cellular tissue composing the capsules is more abundant, the fissures, and particularly the spaces containing it, are wider and more apparent; the lobules are less closely connected, they touch each other by two or three points only, and consequently approach more or less to the circular or oval form. (Plate XXI. fig. 2.) Hence they have been described as, and present very much the appearance of, convolutions and undulating bands ‡. They are generally angular where they are most numerous, as in the thickest part of the liver; in these parts also they appear smaller, for being arranged vertically to the surface, their extremities alone are seen. At the edges of the liver, where they are fewer in number and less closely connected, they are rounded; and lying in an oblique or parallel direction to the surface, they appear larger. They are more angular in children than in adults: in some animals, as in the cat, they are always more angular than in others, as in the rabbit, hare and sheep; their angular or rounded form always depending on the quantity of cellular tissue composing Glisson's capsule. They appear smaller, are more equal in size and regular in form on the convex than on the concave surface of the liver, where they are arranged obliquely, the hepatic veins for the most part running nearer to this surface.

* "Au milieu de toutes les circonvolutions de cette substance (la substance jaune) se trouvent la plupart du temps des ouvertures triangulaires, ou un peu frangées, qui communiquent les unes avec les autres par de petites fentes."—Quelques Considérations sur la Structure du Foie,—Journal Complémentaire des Sciences Médicales, tom. xii. p. 223.

† "Idem, si in superficie aut in plagâ aliquâ dissectâ attentiùs consideraveris, ex acinis parvis quodammodo triquetris, tetragonis, pentagonis, hexagonis ac multangulis compositum videtur."—De Corporis Humani Fabricâ, vol. vi. p. 175.

‡ "L'une de ces substances, qu'on peut appeler granulée (médullaire suivant Autenrieth), forme des circonvolutions, tantôt semblables à celles des intestins, tantôt rameuses, plates et arrondies."—Mappes, loc. cit.

An intralobular hepatic vein occupies the centre of each superficial lobule *. If the extremity alone of a lobule reach the surface, a mere point will be seen in its centre; if a greater portion of the lobule be seen, two or three dark lines will be observed uniting together at a dark point; this point is the central intralobular vein in which the smaller veins terminate. (Plate XXI. fig. 1, *d* and *e*.) Frequently, lobules with eight or ten projecting processes are found on the surface, each process sending a vein to the intralobular vein running through the centre. It is evident that these superficial lobules are less perfect in form or less developed than the internal lobules, in which the veins are wholly surrounded by the substance (Plate XX. fig. 5, *d*.); and that a superficial lobule with eight or ten processes is, accurately speaking, half a lobule lying parallel to the surface. Lobules lying parallel to the surface may be always seen on the under and posterior part of the left lobe; such lobules are larger and more numerous in the liver of the sheep, rabbit, hare and squirrel than in the human liver. (Plate XX. fig. 1.) A striking difference will be observed if, in the liver of the sheep, these parallel lobules on the posterior part of the concave surface be contrasted with those forming the lobulus Spigelii. The difference between the superficial and internal lobules is satisfactorily proved by injections. If the hepatic veins be injected with blue size, and the portal vein with red, the blue will be found on the surface of every section, in the centres of the lobules, separated by the substance of these bodies from the portal veins occupying the interlobular fissures. If these lobules were, like those of the surfaces, perforated from one extremity to the other by the intralobular veins, the blue and red injection, or the intralobular hepatic veins and the interlobular portal

* These vessels, which are not mentioned by Ruysch, Haller, Morgagni, Ferrein, or by any other anatomist with whose works I am acquainted, did not escape the observation of Malpighi. "Ad singulos autem hosque minimos lobulos, proùt experiri licet, et ex pluribus etiam colligere, multiplices vasorum rami derivantur; nam surculi venæ cavæ, et portæ, porique biliarii indeficienter per totum hepatis corpus ramificantur, ut luculenter etiam Glissonius, in nondum satis laudato hepatis opere nobis indicat, et sanguineum vas in lobulis extimam hepatis superficiem constituentibus, *è centro ejusdem erumpens*, hinc inde ramificatur per totam periferiam bifidos promens ramos, à quo totus lobulus irrigatur."—De Hepate, cap. 2. And in his Opera Posthuma, p. 30, after speaking of the lobules, he says, "In horum centro scissura excitato sanguineo vasi extra erumpenti aditum præbet, quod in contiguas minimas glandulas, quibus lobuli quique integrantur, extremis finibus propagatur." It appears, however, that Malpighi mistook these branches of the hepatic vein for branches of the portal vein, and that he was acquainted with them in the superficial lobules only.

veins, would, in some places at least, be seen in contact, which is never the case.

The veins and fissures cannot be always seen without the aid of a magnifying glass; slight pressure, however, by which the blood is propelled into them, will generally make them visible. They may be always seen after a few hours maceration in water, or they may be shown by mercurial or size injections. For this purpose a liver containing the smallest quantity of blood should be chosen; and on this account the liver of the sheep is preferable to the human liver, the latter being generally in a state of congestion. The vena cava should be opened at its posterior part, and the mercury should be poured from a quill into the hepatic vein of the lobulus Spigelii. With slight pressure the mercury will appear in the centres of the lobules, in the form of lines, stellæ or points, surrounded by what has been called the red substance of the liver. If the liver contain much blood, the experiment may not succeed, for the blood will be propelled to the surface, and the vessels within the lobules will be no longer distinguishable from those between them. If the pressure be discontinued, the elasticity of the vessels will cause the mercury to retreat from the surface; if the pressure be renewed and slightly increased, the mercury will pass from the intralobular branches of the hepatic vein into the interlobular branches of the portal vein, and will be seen in the centre and at the circumference of every lobule. If the mercury be thrown into a branch of the portal vein, it will appear in the interlobular branches situated in the fissures and spaces. In the portal veins, which ramify in the cellulo-vascular capsules of the lobules, the mercury will have a dull appearance; it will be of its usual brilliancy in the intralobular veins, which, contained within the lobules, have no cellular tissue surrounding them.

*Of the Portal Canals.*—These canals commence at the transverse fissure, where they are continuous with the concave surface of the liver; they contain the hepatic ducts, the portal veins, the hepatic arteries, and the vaginal branches of all these vessels, with the nerves and absorbents, enveloped in a sheath of cellular tissue, first described by Glisson, and called Glisson's Capsule *. If

* The right edge of the lesser omentum is usually called Glisson's Capsule in this country. Glisson, after describing the suspensory ligament, says, "Ligamentum hoc non solùm extimæ hepatis

a longitudinal section of one of these canals be made, and the contents be dissected out, lobules, spaces and fissures will be seen, arranged in a precisely similar manner to those already described on the external surface. The lobules forming the parietes of the canals are similar to those of the surface, being, like them, perforated by the intralobular veins: they may be called the portal canals or surfaces, the portal vein being the largest vessel contained in them. (Plate XXII. fig. 1, *a*.) These canals, and those containing the large hepatic trunks, are formed by the capsular surfaces of a limited number of lobules; the canals containing the sublobular-hepatic veins are formed by the bases of all the lobules.

Glisson's capsule has attracted much of the attention of anatomists. It was known to Waleus* before it was described by Glisson; to the latter anatomist, however, who has given a detailed account of it, it owes all its celebrity. He describes it as a prolongation of the suspensory ligament, which enters the liver for the purpose of supporting its weight†; he says it arises from the peritoneum, and is of a particular structure‡; he considers it as the muscular coat of the portal vein, by which the blood is propelled through the liver§. Glisson supports his opinions respecting the structure and functions of the capsule with much ingenuity; they were admitted by Malpighi‖, were, according to Haller¶, strongly advocated by Pozzi, and generally adopted by anatomists until their fallacy was exposed by Fanton** and others. Haller†† and Sabatier‡‡ considered the capsule as a prolongation of the cellular tissue

membranæ affigitur, sed etiam parenchyma ejus penetrat, et communi vaginæ sive involucro rami venæ portæ (quà vena umbilicalis eidem continua est) validè adnectitur."—Anatomia Hepatis, cap. 2.

* "Imò in ipso hepate, tot rami arteriæ sunt, quot sunt rami venæ portæ, et totidem quoque sunt rami ductûs cholidochi. Quæ omnia hactenus ab anatomicis pro venis portæ habitæ sunt, quòd communi tunica tria illa vasorum genera in hepate includantur."—Jos. Waleus, De Motu Chyli et Sanguinis, ad T. Bartholinum Epistola Secunda: 1640.

† Op. cit. cap. 2. ‡ Ibid. cap. 28. § Ibid. cap. 42. ‖ De Hepate, cap. 2.

¶ "Josephus Pozzi in Commentariolo Epistolico pro glandulis hepatis, et Glissonianæ capsulæ carneis fibris, pugnat."—Methodus Studii Medici, vol. i. p. 373.

** Brevis Manuductio ad Historiam Anatomicam Corporis Humani, p. 109: Taurini 1699.—Dissertationes Anatomicæ, p. 135: 1701. Haller says, "G. Cowperus, capsulam Glissonii primus, ni fallor, demonstravit parvi momenti esse."—Methodus Studii.

†† "Nempe vena portarum multam cellulosam telam ex mesenterio et liene secum adfert."—Elementa Physiologiæ, vol. vi. lib. 23.

‡‡ Traité d'Anatomie, tom. iii. p. 350.

which surrounds the vessels in the mesentery and lesser omentum. LAENNEC *, after describing the proper capsule of the liver, which had been previously described by SABATIER † and SŒMMERRING ‡, the latter of whom calls it the *membrana cellulosa hepatis*, says, that this membrane, having covered the surfaces, enters the tissue of the liver, furnishing sheaths to all the vessels distributed to it, one of which, common to the vena portæ, biliary ducts and hepatic artery, constitutes Glisson's capsule. The capsule, he continues, is intimately connected with the substance of the liver, and is separated from the vessels by a loose and abundant cellular tissue, which is continuous with that surrounding the sinus of the vena portæ in the transverse fissure, and is connected with that of the mesentery; it is also continuous with that which connects the proper capsule with the peritoneum. LAENNEC is of opinion that Glisson's capsule allows the portal vein to yield and accommodate itself to the increased quantity of blood circulating through it during digestion. If it be true that more blood circulates through the liver during this period than at any other, which is denied by BICHAT §, yet LAENNEC's explanations of the function of the capsule cannot be admitted, for the hepatic veins would be equally subject with the portal vein to these variations in the circulation; the former vessels are, nevertheless, firmly connected to the substance of the liver, having no sheath of cellular tissue around them.

The cellular tissue of Glisson's capsule is undoubtedly continuous with that of the proper capsule of LAENNEC, and with the cellular tissue which surrounds the abdominal vena portæ, as described by HALLER and SABATIER; but, as M. ROUX ‖ observes, "il faut admettre quelque chose de plus dans ce qu'on nomme *capsule de Glisson*, puisqu'elle est tellement disposée que les vaisseaux qu'elle enveloppe sont lâchement unis à la substance du foie." Glisson's capsule is not mere cellular tissue: it is to the liver what the pia mater is to the brain; it is a cellulo-vascular membrane, in which the vessels divide and subdivide to an extreme degree of minuteness; which lines the portal canals, forming sheaths for the larger vessels contained in them, and a web in which the

* LAENNEC, Lettre sur des Tuniques qui enveloppent certains Viscères,—Journal de Médecine, par CORVISART, tom. v. p. 539.

† Traité d'Anatomie, tom. ii. p. 345 : 1791.

‡ De Corporis Humani Fabricâ, vol. vi. p. 168.

§ Anatomie Générale, tom. ii. p. 248.

‖ BICHAT, Anatomie Descriptive, tom. v. p. 98.

smaller vessels ramify; which enters the interlobular fissures, and, with the vessels, forms the capsules of the lobules; and which finally enters the lobules, and, with the blood-vessels, expands itself over the secreting biliary ducts. Hence arises a natural division of the capsule into three portions, a vaginal, an interlobular, and a lobular portion; and as the vessels ramify in the capsule, their branches admit of a similar division.

At the transverse fissure, the duct, vein and artery divide into branches, which enter the portal canals. These branches divide and subdivide into smaller branches, which enter smaller canals, and every canal, however small, contains one principal branch of each of these vessels; frequently, however, two ducts and two arteries are contained in the same canal. To these larger vessels the terms of hepatic ducts, portal veins and hepatic arteries may be confined, in order to distinguish them from the branches.

The excreting ducts are composed of the hepatic ducts, contained in the canals, of their vaginal branches, also contained in the canals, and of the interlobular branches, which, arising from the vaginal branches, ramify in the interlobular fissures. The interlobular ducts enter the lobules, in which they form plexuses. These plexuses may be called the lobular biliary, or secreting biliary plexuses, the ducts composing them being the secreting organs of the bile. The excreting ducts and their branches are invariably accompanied by the arteries and portal veins and their branches, the former conveying blood to their coats, the latter conveying it from them; a duct is never unaccompanied by an artery and vein, the vein being always a branch of the portal vein. The veins and arteries also enter the lobules. The veins form plexuses, the branches of which terminate in the intralobular hepatic veins; from the blood circulating through the plexuses, the bile is secreted. The lobular arteries are exceedingly minute, and few in number; they are the nutrient vessels of the lobules, and probably terminate in the plexuses formed by the portal vein. From the ducts, veins and arteries, therefore, three sets of branches arise, namely, the vaginal, the interlobular, and the lobular branches.

*Of the Vaginal Portion of Glisson's Capsule and of its Vessels.*—A branch of each vessel, contained in a portal canal, makes its exit from the canal at each interlobular space on its surface. The lobules being small bodies, the interlobular spaces are necessarily numerous and close together. The hepatic duct

and artery running together on one side of the canal, or winding spirally within it, are in apposition with but a very limited number of spaces; the two vessels are, however, brought into apposition with all the spaces by means of plexuses, from which the interlobular branches arise. (Plate XXI. fig. 5, *f. h.*) The portal vein also forms a plexus, being separated from the spaces by the duct and artery and their plexuses. (Plate XXI. fig. 5, *d.*) The branches forming these plexuses are the first which arise from the duct, artery and vein; they form a vascular sheath around these vessels, and may be called their vaginal branches; they ramify in a loose and fine cellular tissue, which, with them, constitutes the vaginal portion of Glisson's capsule. (Plate XXI. fig. 5, *j.*) This cellular tissue is continuous with that surrounding the vessels in the right edge of the lesser omentum, and with that of the proper capsule of Laennec. The internal surface of the cellulo-vascular sheath is in contact with the three principal vessels, and is composed of the largest branches arising from them. Its external surface is in contact with the parietes of the canal, and is composed of the smallest branches; these branches form a reticulated plexus, from which the interlobular branches shoot out, and entering every interlobular space, ramify between the lobules. (Plate XXI. fig. 5, *i.*) In the smaller canals, the fissures and spaces being less numerous, and the plexuses formed by the duct and artery being consequently less complicated, a great portion of the portal vein is in contact with the parietes of the canal. In these canals many of the interlobular veins arise immediately from the trunks, vaginal branches being given off, and forming a plexus, on that side only of the canal occupied by the duct and artery. In these canals we find the capsule, the essential part of which is the plexus, only on that side which is occupied by the duct and artery, the vein being in contact on the opposite side with the parietes of the canal. In the larger canals, in which the lobules and spaces are more numerous, and the plexuses necessarily more complicated, the sheath completely surrounds the three vessels. These two modes of arrangement of the capsule may be ascertained by making transverse sections of canals of different calibre. In a small canal in which the capsule is found only on that side occupied by the duct and artery, the portal vein should be laid open, and its internal surface examined. The fissures and lobules will be seen through the transparent coats of the vein on that side on which there is no capsule, and on the internal

surface of the vein numerous minute orifices will be observed, corresponding exactly to the interlobular spaces. These orifices are the mouths of interlobular veins, which enter the spaces without contributing to the formation of the plexus. (Plate XXI. fig. 6, *b*. Plate XXII. fig. 1, *c*.) A few larger orifices, not corresponding to the spaces, will also be seen: these are the mouths of vaginal branches, which divide in the canal into two, three, or more interlobular branches, and thus contribute partially to form the plexus. (Plate XXII. fig. 1, *d*.) On that side of the vein which is in contact with the artery and duct, and separated by them from the spaces, the orifices are larger and less numerous; these are the mouths of vaginal branches, which, ramifying in the canal, terminate in interlobular branches, which enter those spaces covered by the duct and artery. (Plate XXI. fig. 6, *c*. Plate XXII. fig. 1, *f*.)

From the above description it is evident that Glisson's capsule is a cellulo-vascular membrane, composed of the vaginal branches of the duct, vein and artery, ramifying in a layer of cellular tissue. Its existence around the three vessels in the larger canals, in which the vaginal plexus is most complicated; its existence on that side only of the smaller canals occupied by the duct and artery, and its almost total absence on the opposite side, sufficiently prove that by its means the three vessels are brought into apposition with all the interlobular spaces on the surfaces of the canals. The vaginal vessels are best seen by making longitudinal sections of canals, and dissecting out the three large vessels after having injected them. The mouths of the interlobular branches arising from the smaller portal veins may be shown by opening a vessel and removing the injection carefully from the trunk, leaving it in the branches. The internal surfaces of the ducts and arteries exhibit no orifices of interlobular branches, these branches always arising from the plexus which each duct and artery, however small, forms in the canal in which it is contained. The portal vein, like other vessels, occasionally varies in the manner in which it gives off its branches; thus, even in the smallest canals, it frequently happens that the three vessels are surrounded by the capsule. In this case the vein gives off vaginal branches only, and no interlobular branches, all the latter arising from the former.

The first vaginal branches of the ducts arise at nearly right angles with the trunks; they run in a transverse direction within the inner surface of the canal,

and terminate in branches which correspond to, and lie on, the fissures. Each transverse branch gives off one or two branches which ramify in the direction of the trunk, and one or two recurrent branches. All these branches run in the direction of the fissures, forming angles at the spaces over which they pass. At each angle a smaller branch is given off, which runs on a fissure leading from the space over which the angle in the vessel is formed. Thus, if the vessels be well injected, all the fissures and spaces will be covered by small ducts, which form a network of vessels corresponding in form to the fissures on which they lie. The transverse branches, and those which arise immediately from them, do not anastomose with each other, but the smaller branches sometimes appear to do so; I cannot, however, from dissection, affirm that they do, for those which appear to anastomose are exceedingly small vessels, and meet each other at the spaces; hence it is difficult to ascertain whether they really anastomose, or enter the spaces together without anastomosing. From the vaginal ducts spread over the surface of the canal, lobular and interlobular ducts arise; the former enter the lobules on the parietes of the canals; the latter leave the canals at the spaces to ramify between the lobules, which they finally enter. (Plate XXII. figg. 3. and 4.) The vaginal ducts are sometimes very tortuous in their course.

The coats of the ducts are highly vascular; the rugæ on their internal surface, and those on the internal surface of the gall-bladder, are formed by the ramifications of the larger blood-vessels, arteries as well as veins, covered by the mucous membrane. This membrane is studded with vascular papillæ, which become remarkably developed in the diseased ducts so frequently found in sheep and oxen. The smaller ducts are furnished with papillæ only, and to the rupture of the delicate vessels forming these papillæ is to be attributed the facility with which Sœmmerring and other anatomists injected the ducts from the arteries and veins, and not to any direct communication between the vessels and the ducts. This point has been particularly insisted upon by Müller, who, in speaking of Walter's experiments, says, "Itaque si in Walteri experimentis massa interdum ex vasis sanguiferis in ductum hepaticum transiit, certe non per minimos ductus biliferos transiit, sed in truncos ipsos ex vasculis sanguiferis erupit*." Mappes imagines that the hepatic artery is principally destined to

* Op. cit., p. 83.

supply the coats of the portal vein with blood: this is so far from being the case, that when the arteries are well injected, the larger ducts, from the extreme vascularity of their coats, may be mistaken for the injected arteries, whilst, in the coats of the vein, no vessels will be detected without the aid of the magnifying glass*. The coats of the ducts may be as highly injected from the portal vein as from the hepatic artery; but they cannot be injected from the hepatic veins, if the injection is confined to these vessels, and does not return by the portal vein. MAPPES could not inject the ducts from the portal or hepatic vein; he is nevertheless of opinion, "que la bile est tirée plutôt du sang déjà parvenu dans cette veine (la veine hépatique) que de celui qui se trouve encore dans les dernières extrémités de la veine porte." The ducts cannot be injected in a direct manner from the hepatic vein, no branches of this vein ramifying in their coats; fluid may indeed be made to pass from this vein into the ducts, but only through the medium of those branches of the portal vein which ramify in the coats of the ducts†. The ducts are injected from the portal vein and from the hepatic artery in the same manner as the fœtal intestine is frequently filled with injection from the umbilical vein or aorta, viz. by the rupture of the minute vessels of the mucous membrane. Hence it is evident that the ducts, so far as they have been yet traced, are abundantly supplied with arterial blood; that this blood returns into the branches of the portal, and not into those of the hepatic veins; and that the hepatic portal vein has branches of origin in the coats of the excreting ducts from the terminations of the hepatic artery, as the abdominal portal vein arises in the coats of the intestines, in the spleen and pancreas, from the arteries of these organs.

From their extreme vascularity alone we might infer, that the ducts serve

* MAPPES probably saw the vaginal arteries, which ramify on the parietes of the canal previously to entering the interlobular spaces, through the transparent coats of the veins, and concluded that they were ramifying in the coats of these vessels; or in making sections, this anatomist may have removed a portion of the parietes of a canal, leaving the arteries on the vein.

† By examining the surface of the liver after injecting the hepatic veins, we may ascertain in which parts the coats of the ducts are injected from these vessels, and in which they are not. If on one portion of the surface we see the interlobular portal veins injected from the hepatic veins, a few injected vessels will be found in the coats of the ducts of this part. In other parts of the liver, where the injection is confined to the centres of the lobules, and consequently to the hepatic veins, no injection will be found in the coats of the ducts, although the injected hepatic veins will be seen through them.

another purpose beside that of the conveyance of bile; and all anatomists are acquainted with the muciparous follicles of the lining membrane of their larger branches; in the smaller branches, the existence of the follicles has been denied*. In the former, they are irregularly distributed over the surface; in the latter, they are closely arranged in two longitudinal lines, occupying opposite sides of the ducts; and, arranged in this manner, they will be found in the smallest duct that can be examined. Mappes confounded the follicles with the orifices of vessels. Their number renders it probable that the fluid furnished by them serves another purpose beside that of rubricating the surfaces of the ducts†. Some estimate of the quantity of this fluid may be formed by examining the ducts, after having injected them with alcohol. These follicles are probably the secreting organs of all the mucus found in the bile. (Plate XXIII. fig. 1.)

The vaginal ducts are accompanied by the vaginal arteries; the latter, however, are more or less tortuous in their course, the former generally proceeding in the shortest direction to their destination. The vaginal arteries anastomose freely with each other, but their ramifications do not, like those of the ducts, correspond exactly to the fissures. If the left artery be injected in the transverse fissure, the injection will return by the right artery; this communication takes place by means of vaginal branches which the left artery gives off in the fissure, and which anastomose with similar branches of the right artery.

The vaginal branches of the vein anastomose with each other; they form a much more complicated plexus in the human liver than in the liver of most animals, and on this account the cellular tissue of Glisson's capsule is more abundant in the former, and greater difficulty is experienced in examining the plexuses formed by the ducts and arteries. In the sheep, portal veins of considerable size resemble the smaller portal veins in the human subject, vaginal branches arising from them on that side only of the canal occupied by the duct and artery, and interlobular branches on the other side. On this side,

* Meckel, Op. cit., tom. iii. p. 455.

† The internal surface of the pancreatic duct is studded with follicles similar to those of the hepatic ducts; they assume no particular arrangement. They are numerous and very apparent in some subjects; in others I have found no trace of them. The parotid and submaxillary ducts are not furnished with follicles.

therefore, we find the cellular tissue in small quantity, no venous plexus being formed, and the injected vaginal ducts and arteries may be seen without dissection through the transparent coats of the vein.

The nerves and deep-seated absorbents ramify in the portal canals; I have not been able to trace them into the interlobular fissures. The absorbents may be always injected from the duct, and the bile is frequently propelled into the former vessels by injecting the latter. Mascagni * found that injection thrown into the ducts returned colourless by the absorbents. I have frequently made the same observation, but I have as frequently found the injection in the absorbents of the same colour as that thrown into the duct, and have frequently filled all the absorbents of the right edge of the lesser omentum with red size from the duct. In one instance, and in the only one in which the trial was made, the thoracic duct was injected with mercury from the hepatic duct. Lippi asserts that "the lymphatics terminate not only, as has been hitherto supposed, in the thoracic duct and in the right subclavian vein, but that an infinite number of communications exist between the veins and lymphatics in other parts of the body†." Antommarchi‡ asserts that no such communications take place; and Lippi's opinions appear to have been satisfactorily refuted by Panizza§. No absorbents accompany the hepatic veins, and it is not probable that any of the absorbents of the liver terminate in the branches of the portal vein, the fluids in these two systems of vessels proceeding in different directions. The superficial absorbents ramify in the proper capsule. After injecting these vessels, the peritoneal coat may be removed without injuring them; or the peritoneal coat may be first removed, and the absorbents afterwards injected; and some few may be injected in the proper capsule after the separate removal of both. This can be done in the human subject and in the larger animals only, the proper capsule being of a much more delicate structure, or probably not existing, in the smaller animals, in which the liver appears to have no superficial absorbents. Injection sometimes passes from the arteries and portal veins into the absorbents.

*Of the Interlobular Portion of Glisson's Capsule and of its Vessels.*—As the interlobular ducts, veins and arteries arise from the vaginal ducts, veins and

* Prodromo della Grande Anatomia, p. 141.

† Illustrazioni del Sistema linfatico-chilifero, p. 10.

‡ Journal Hebdomadaire, tom. iv. p. 214.

§ Annali Universali di Medicina, vol. lvi. p. 225.

arteries, so the interlobular cellular tissue is continuous with the vaginal cellular tissue, the vessels and cellular tissue together constituting the interlobular portion of Glisson's capsule, which occupies the fissures and forms the capsules of the lobules *. The interlobular vessels, at their origin from the vaginal vessels, enter the spaces; in the spaces, therefore, we find the largest branches; these divide into smaller branches, which ramify in the fissures.

If the left hepatic duct be injected with size or mercury, the injection will return by the right duct, without extravasation and without passing into other vessels, and the injection will be found in the interlobular and vaginal ducts as well as in the trunks. This communication between the two ducts does not take place, like that which exists between the right and left arteries, through the medium of the vaginal branches of the transverse fissure, the injection being found in interlobular branches arising from the right duct. From this experiment, which I have frequently repeated with the same result, it appears that the right and left duct anastomose with each other through the medium of the interlobular ducts. This experiment does not always succeed, which probably arises from the quantity of bile contained in the ducts.

The interlobular branches of the portal vein cover, with their ramifications, the whole external surfaces of the lobules, with the exception of the bases of these bodies, and of those extremities of the superficial lobules which appear on the surfaces of the liver. The freest communications take place between these vessels; when successfully injected, which can be done with size only, the interlobular fissures in which they are contained, whether examined on the surfaces of the liver, or on the surface of a section, are coloured with the injection. Mercury thrown into a large branch of the portal vein returns by other large branches. This communication takes place through the medium of the interlobular branches, for though the vaginal branches in the same canal anastomose freely with each other, yet those of one canal communicate with those of another through the medium of the intervening interlobular branches alone. The interlobular veins also form communications between the lobular

* The interlobular portion of Glisson's capsule is thus accurately described by Malpighi: "Lobuli hi propriâ circumambiente membranâ vestiuntur, et continuatis per transversum membranosis nexibus firmantur, ita ut intermedia spatia, et rimulæ, minimæ tamen, inter lobulorum latera emergant." —De Hepate, cap. 2.

veins of a lobule, and those of the contiguous lobules. Hence it appears, contrary to the assertions of Bichat* and Mappes †, that the freest anastomoses exist between all the branches of the portal vein, and that the interlobular branches form the medium of communication.

When the portal vein is imperfectly injected, and the venous circles, formed by its interlobular branches around the lobules, are not brought into view, these branches are seen in the spaces, and three or four smaller branches are seen shooting into the fissures communicating with the spaces. These are the stellated vessels of anatomists. When the vessels are well injected, the stellæ are all continuous with each other, and the venous circles are formed; the stellated appearance, therefore, arises from the incomplete injection of the vessels. If the liver do not contain much blood, stellæ may be always produced on its surface by pressure.

No anastomoses can be shown to exist between the interlobular arteries, these vessels, even when most successfully injected, appearing like points, lines and stellæ in the fissures and spaces. The right artery may be injected from the left in the transverse fissure, and it has been shown that this communication takes place by means of the vaginal branches given off by the two arteries in the fissure; but if the left artery, or a branch of it, be injected at its entrance into its canal, after the vaginal branches of the fissure are given off, the injection will not return by the right artery. From this experiment it would appear that no anastomoses take place between the interlobular arteries; but as the vaginal arteries communicate freely with each other, and as the interlobular ducts also communicate with each other, and as the arteries ramify in the coats of the ducts, we may conclude that the interlobular arteries anastomose.

From the superficial interlobular fissures, small arteries emerge and ramify in the proper capsule on the convex and concave surfaces of the liver, and in the ligaments. These are the capsular arteries. They vary much in number in different subjects, being always most numerous in those in which the capsule is most developed. In those animals in which the liver has a peritoneal

* Speaking of the anastomoses of the portal vein, Bichat says, "Sa portion hépatique paraît en manquer: toutes les branches, rameaux et ramuscules, marchent isolément."—Anatomie Générale, tom. ii. p. 247.

† Loc. cit.

coat only, and no proper capsule, no capsular arteries can be shown by injection. In those subjects in which the capsular arteries are numerous, these vessels cover the surfaces of the liver with a beautiful plexus: those of the right lobe anastomose with those of the left, and both anastomose with branches of the phrenic, internal mammary and supra-renal arteries; some, leaving the liver, ramify under the peritoneum covering the right kidney; others pass along the ligamentum teres to the umbilicus, and anastomose with the epigastric arteries.

Walter did not distinguish the proper capsule, described by Sœmmerring and Laennec, from the peritoneal coat of the liver, the latter of which, he says, has no vascular connexions with the liver, but receives vessels from the vessels of the peritoneum, which, according to this anatomist, are branches of the internal mammary, epigastric, phrenic, intercostal and lumbar arteries. In his most successful injections of the vessels of the liver, Walter could detect no vessels in the peritoneal coat "nec nudo nec armato oculo, sed apparuit hæc membrana ut in hepatibus non injectis, alba neque vasis picta *." Walter erroneously concludes that this membrane has proper vessels, arising from the sources above enumerated, and having no connexion with those of the liver. All the capsular arteries, arising from whatever source, ramify in the proper capsule, and they may be all injected from the hepatic artery. I have never seen injected vessels in the peritoneum, but as recent adhesions between the liver and diaphragm may be injected from the hepatic artery, it appears evident that the peritoneal coat of the liver is nourished by this artery. That the proper vessels of the liver anastomose with those which Walter calls the proper vessels of the membrane, is proved by the fact, that recent adhesions between the right lung and the diaphragm may be injected from the hepatic artery, the injection passing from the capsular branches of this vessel into those of the phrenic, and thence into the phrenic arteries themselves †. The capsular veins are branches of the portal vein; these vessels communicate freely with branches of the phrenic veins. In some cases of atrophy of the liver, and in cases in which the circulation through the liver has been for some time obstructed, a

* De Hepate, p. 88.

† The capsular arteries have been well delineated by Ruysch, Thesaurus Anatomicus Decimus, No. 181. tab. 3. fig. 5.

collateral circulation is established by means of the communications which take place between the capsular branches of the hepatic artery and portal vein and those of the phrenic artery and vein.

All the *vasa vasorum* of the liver are branches of the hepatic artery and portal vein. Branches of the artery ramify in the coats of the duct, artery and portal vein; veins arise in the coats of all these vessels, and terminate in branches of the portal vein. In the hepatic-venous canals, and in the fissure of the inferior cava, small arteries issue from the interlobular fissures, and ramify in the coats of the hepatic veins and inferior cava; veins arise in the coats of these vessels, and entering the interlobular fissures, terminate in branches of the portal vein. All the veins arising in the coats of the vessels, and terminating in the portal vein, constitute the hepatic origin of this vein.

The trunks of the duct, vein and artery in each canal, terminate in interlobular branches. Vaginal vessels, giving off interlobular vessels, ramify in the transverse fissure, in the fissure of the gall-bladder, and in that containing the obliterated umbilical vein and ductus venosus; these fissures, therefore, must be considered as portions of portal canals.

*Of the Hepatic Veins, and of the Hepatic-venous Canals.*—The hepatic veins are contained in canals, which may be called the hepatic-venous canals; they commence in the interior of the liver, and terminate at the fissure of the inferior cava. Those containing the hepatic trunks are formed by the capsular surfaces of a limited number of lobules; those containing the sublobular-hepatic veins, are formed by the basis of all the lobules.

As three vessels are contained in each portal canal, and as a branch of each vessel makes its exit from the canal at each interlobular space, each vessel necessarily forms a plexus, by which it is brought into apposition with all the spaces on the surface of the canal: but one vessel only, an hepatic vein, being contained in each hepatic-venous canal, the external surface of the vein is in contact with, and connected to, all the lobules forming the parietes of the canal, the intralobular veins, at their exit from the lobules, entering the sublobular-hepatic veins without uniting in the canals to form branches similar to the vaginal branches of the portal vein, duct and artery. The interlobular branches of the vein and artery conveying blood to the lobules, correspond to the intralobular branches of the hepatic veins, which convey the blood from

the lobules; the former arise from the vaginal branches, the latter terminate in the sublobular-hepatic veins. Thus we find that the hepatic veins have no branches corresponding to the vaginal branches of the duct, portal vein and artery; and as Glisson's capsule is composed of the vaginal vessels ramifying in cellular tissue, we consequently find nothing similar to this capsule around the hepatic veins, these veins having no vaginal branches. In the smaller portal canals, in which the spaces are less numerous and the plexus less complicated, one side of the portal vein is in contact with the parietes of the canal. On this side the interlobular branches arise immediately from the vein, and the cellular tissue is in small quantity, forming a delicate membrane on the walls of the canal; on the opposite side, which is separated from the walls by the duct and artery, vaginal branches arise from the vein, and the cellular tissue is abundant. (Plate XXI. fig. 6.) These smaller portal veins resemble the hepatic veins on that side on which they are in contact with the walls of the canal, on which no vaginal branches are given off, on which the interlobular branches arise immediately from them, and on which there is no capsule; they resemble the larger portal veins on that side on which vaginal branches arise from them, and on which the capsule consequently exists. From the absence of vaginal branches on one side of these portal veins, it may be presumed, that should a portal vein be found entering the liver unaccompanied by a duct and artery, it would, like the hepatic veins, be connected to the parietes of its canal, and would, like these vessels, have no vaginal branches, and, consequently, no capsule. The structure and uses of Glisson's capsule are now fully explained, it being evident that the loose connexion of the ducts, portal veins, and hepatic arteries to the substance of the liver arises from the circumstance of the three vessels ramifying in the same canals; and that the adhesion of the hepatic veins to the substance depends on one vessel only being contained in each hepatic-venous canal.

Numerous minute orifices are seen on the internal surface of the sublobular-hepatic veins; these orifices are the mouths of the intralobular veins, all of which terminate immediately in these vessels*. Every orifice corresponds to

* The orifices of the intralobular veins are most distinctly shown by injecting the hepatic veins with coloured size, by then making longitudinal sections of the veins and removing the injection from them, leaving it in the intralobular branches.

the centre of the base of a lobule; the number of orifices is therefore equal to the number of lobules forming the parietes of the canal in which the vein is contained. (Plate XXII. fig. 2, *e*.) As an intralobular vein makes its exit from the base of every lobule, and as every intralobular vein terminates in a sublobular vein, it is evident that the base of every lobule is in contact with a sublobular vein, and that the hepatic-venous canals containing these vessels are formed by the bases of all the lobules of the liver. The parietes of the portal canals are also composed of lobules; but they are composed of the capsular surfaces of lobules, and not of the bases, nor do all the lobules enter into their formation as into that of the hepatic-venous canals; for, as the interlobular ducts, veins and arteries ramify in fissures continuous with each other throughout the liver, many of these vessels terminate in lobules situated at a distance from the trunks from which they arise, these distant lobules not contributing to form the canals containing the trunks. As all the lobules unite to form the hepatic-venous canals, and as a certain number only enter into the formation of the portal canals, it is evident that the former are more numerous than the latter.

In the description of the lobules, the hepatic veins contained in canals were divided into two sets, into the sublobular-hepatic veins, and the hepatic trunks. The coats of the former are delicate in texture; they are transparent; the lobules and fissures are seen through them; their internal surface is studded with the orifices of intralobular veins; their canals, which are formed by the bases only of lobules, are not lined by prolongations of the proper capsule. (Plate XX. fig. 2, *b*. Plate XXII. fig. 2, *a*.) The trunks are more dense in structure; their external coat is composed of longitudinal bands; their canals are lined by prolongations of the proper capsule, which render them opake, the lobules and fissures not appearing through them; they receive no intralobular branches. Dense in structure, they are not adapted to receive these minute and delicate veins; their canals, therefore, unlike those containing the sublobular veins, are, like those containing the portal veins, composed of the capsular surfaces of lobules, the intralobular veins of which terminate in a neighbouring sublobular vein. (Plate XX. fig. 2, *c*. Plate XXII. fig. 2, *b*. *c*.)

If the internal surface of the large veins, which open into the trunks, be examined, and contrasted with the internal surface of a sublobular vein, the

orifices of the intralobular veins will be found less closely arranged in the former than in the latter. (Plate XXII. fig. 2, *g. h.*) This appearance arises from two causes. Two or three intralobular veins at their exit from the lobules, frequently unite and form one vein, which terminates in the large vein, on the internal surface of which will be seen one larger orifice, instead of three smaller orifices. Frequently also on the surfaces of these canals the capsular surfaces of lobules are seen, the bases of which enter into the formation of a neighbouring canal; no orifices, therefore, corresponding to the bases of these lobules are found in the veins under examination.

The intralobular veins will almost invariably be found entering the sublobular veins from the centre of what has been called the red substance of the liver. (Plate XXII. fig. 2, *e.*)

Of the formation of the hepatic-venous canals it may be said, that the smallest of the canals, and the greater number of them, are formed by the bases alone of lobules; that the next in dimensions are formed by the bases of some, and the capsular surfaces of other lobules; and that the largest are formed by the capsular surfaces only of these bodies. As the base of every lobule rests on a sublobular-hepatic vein, it is evident that those lobules, the capsular surfaces of which enter into the formation of canals, are in contact with two hepatic veins.

Ramifying in fissures which are continuous with each other throughout the whole liver, the interlobular branches of the portal vein anastomose freely with each other, enveloping every lobule in a venous web: the intralobular branches of the hepatic veins, on the contrary, confined within the lobules, have no direct communication with the corresponding branches of the surrounding lobules, from which they are separated by the substance of these bodies, and by the intervening interlobular ducts, veins and arteries, situated in the interlobular fissures; and one intralobular vein can be injected from another only through the medium of the intervening portal veins. When injected with mercury or size, the intralobular veins appear in the centres of the lobules in the form of points, stellæ, or twigs; these veins, therefore, unlike the interlobular portal veins, do not anastomose with each other. If, by means of a pipe and glass tube, mercury be thrown into a large hepatic vein on the surface of a section, it will return by several smaller neighbouring hepatic veins, which, generally, are

branches descending to terminate in the larger vessel in which the pipe is fixed. If these vessels be tied, the mercury will return by large hepatic veins, situated at a distance from the injected vessel, and not branches of it. In this experiment the force used is not sufficient to propel the mercury through the intervening intralobular, lobular and interlobular veins, and by such means to form a communication between the two hepatic veins; for if force sufficient to effect this were used, the mercury would return by portal as well as by hepatic veins, which is not the case. If the inferior cava be opened at its posterior part, and if by the same means mercury be thrown into a small hepatic vein, it will immediately return to the cava by other hepatic veins, without appearing in the superficial intralobular veins, and without passing into portal veins. From these experiments it appears that the sublobular veins anastomose with each other, and that their intralobular branches do not*.

By contrasting the hepatic veins with the portal vein, we find that no two intralobular branches of the former anastomose with each other; that the interlobular branches of the latter form one continuous plexus throughout the whole liver; that the sublobular veins anastomose directly, and not through the medium of the intralobular branches; that the portal veins have no direct communication with each other, but anastomose by means of their interlobular branches; that the hepatic veins, like the other veins of the body, proceed in a direct course to their termination in the cava; that the portal vein, accompanied by an artery, resembles an artery in its ramifications; that the larger hepatic veins, having longitudinal fibres in their coats, differ in structure from the portal vein; and that the blood contained in the liver after death is almost invariably found in the hepatic veins, the portal vein being usually empty.

The longitudinal fibres in the coat of the larger hepatic veins are similar to those in the coats of the iliacs and inferior cava, and to those which are occasionally seen in some superficial veins. Those of the iliacs and cava have been delineated by Senac†, who says they are composed of muscular fibres. This

* The most superficial vessel, the intralobular branches of which are seen on the surface, should be chosen for these experiments, and in order to ascertain that the mercury does not pass into the portal vein, a section of the liver should be made at some distance below the injected vessel. A glass tube and pipe, whereby the pressure may be graduated, should be always used in these experiments. Size injected into one hepatic vein will always, and wax will sometimes, return by other hepatic veins.

† Traité de la Structure du Cœur, tom. i. p. 254. Pl. IV. fig. 3.

opinion, which was adopted by PORTAL*, is sufficiently refuted by the existence of similar fibres in the hepatic veins, which, being firmly connected to the substance of the liver, admit of no motion.

The hepatic veins in the *Seal* differ in many respects from those of any other animal I have examined. The intralobular veins at their exit from the lobules do not, as in other animals, terminate immediately in the hepatic veins: these vessels enter the hepatic-venous canals, where they unite into branches, which, like the vaginal branches of the portal vein, are connected by a fine cellular tissue, with which they form around the hepatic veins a cellulo-vascular sheath, precisely similar to that surrounding the branches of the portal vein. The structure of the two sheaths is similar, but their uses are different. That of Glisson's capsule has been explained; the capsule of the hepatic veins in the seal appears destined to admit of the muscular contractions of these vessels. The posterior cava in this animal forms at the back part of the liver a large sinus in which the hepatic veins terminate, and which, according to CUVIER, "is connected with the power of diving, which these animals possess in a high degree†." The external coat of the hepatic veins is composed of circular fibres, which in the larger vessels form a complete tunic. In the smaller vessels the fibres are arranged in the form of circular fasciculi, which are connected with each other by oblique intermediate fibres. All the fasciculi do not extend completely round the veins; some, dividing into two portions, unite with fibres from those above and below, and form other fasciculi. (Plate XXIII. fig. 2.) By contrasting the hepatic veins in the seal with those in the human subject, it would appear that the circular bands in the former are composed of muscular fibres. In man, the fibres are longitudinal; in the seal, they are circular: in the former, the vessels adhere firmly to the parietes of their canals; in the latter, they are loosely connected by the cellulo-vascular sheath in which they are inclosed. The existence of the sinus in which these veins terminate, and in which the blood accumulates during the act of diving, appears to indicate the necessity of a muscular power to propel the blood onward to the heart. Had the intralobular veins in the seal terminated, as in other animals, immediately in the hepatic veins, these vessels would have been connected to every lobule forming the parietes of their canals, and their muscular contractions could not

* Anatomie Médicale, tom. iii. p. 348. † Leçons d'Anatomie Comparée, tom. iv. p. 265.

have taken place; the use of their sheaths is therefore evident, and different from that of the portal vein, hepatic duct and hepatic artery. No circular fibres exist in the coats of any of the other veins of this animal.

In the *Porpoise* the hepatic veins are connected to their canals; no circular fibres are seen in their coats. Their external surface is reticulated, the ridges corresponding to the interlobular fissures, where the interlobular cellular tissue is continuous with the cellular coat of the veins. The mouth of an intralobular vein occupies the centre of each space circumscribed by the ridges.

In diving birds, CUVIER says*, "all that portion of the vena cava inclosed in the liver is of very considerable diameter, and forms a kind of reservoir similar to that in the seal." I have examined some birds of this class, but have found no circular fibres in their hepatic veins.

*Of the Structure of the Lobules.*—The lobules constitute the secreting portion of the liver. Examined with the microscope, a lobule is apparently composed of numerous minute bodies, of a yellowish colour (imparted to them by the bile they contain) and of various forms, connected with each other by vessels. These minute bodies are the *acini* of MALPIGHI; his opinions respecting their structure and use are well known. RUYSCH† admitted the existence of the acini, and, more successful in his injections than MALPIGHI, he filled the minute vessels which are described by the latter anatomist as ramifying between these bodies; he thereby, probably, rendered the acini invisible, or less apparent than they present themselves in the natural state, in which they had been discovered by MALPIGHI, and he concluded that these minute bodies are composed of the terminal extremities of the vessels, with a certain number of which the ducts are continuous. BOERHAAVE‡ attempted to reconcile the contending opinions of the two great anatomists. FERREIN§ successfully opposed these opinions; he demonstrated the tubular structure of the kidney, and was the first who asserted that several other viscera, the liver, spleen and renal capsules, "sont un assemblage merveilleux de tuyaux blancs, cylindriques différemment repliés." MASCAGNI‖ says the liver is composed of cells, from which the minute biliary ducts arise, and this anatomist enters into a description of

* Op. cit., tom. iv. p. 274.

† Epistola Anatomica ad H. BOERHAAVE.

‡ Epistola Anatomica ad F. RUYSCH.

§ Mémoires de l'Académie Royale des Sciences, 1749.

‖ Prodromo, p. 142.

the various tunics of which these supposed cells are composed. To Müller, whose recent discoveries have thrown much light on the ultimate structure of glands, is due all the merit of the important discovery, that a gland is a duct, with blood-vessels ramifying on its parietes. This anatomist asserts, from analogy rather than from actual demonstration, that the biliary ducts in the vertebrated, like those in some of the invertebrated animals, terminate in cæcal extremities, which present certain differences in the manner of their arrangement in the different classes. The foliated and pinnate appearances delineated in Müller's 11th plate, and displaying, according to this anatomist, the manner in which the terminal extremities of the ducts are arranged, appear to me to result solely from partial congestion of the liver, the foliated portions being composed of the non-congested opposed edges of lobules, with the interlobular ducts, veins and arteries ramifying between them*. This state of the organ I have represented in Plate XXI. fig. 3. Appearances somewhat similar to those represented by Müller, Tab. XI. fig. 11, have been delineated by Dr. Hope in his valuable work on Morbid Anatomy. In describing figg. 104 and 105, Dr. Hope says†, "The acini or white substance of the liver displayed with singular and unusual distinctness: from a case in which the vena portæ was plugged with coagula and fibrinous concretions. The acini were very small, pale and collapsed, as if they had lost a portion of their supply of blood, thus allowing the red substance which occupied a preternatural space to encroach upon and compress them." The small bodies represented in these figures are composed of non-congested portions of three contiguous lobules, "the small puncta or depressions in the centre" being interlobular spaces, containing branches of the duct, portal vein and artery. These bodies being neither acini nor lobules, and the branches of the portal vein here represented being situated between, and not in, lobules, it cannot, from these appearances at least, be inferred, as Dr. Hope inquires, "that the principal part of the portal blood is distributed to the acini." MM. Boulland and Andral, Dr. Hope, and most other anatomists, are of opinion that the liver is composed of two substances,—of a red and a yellow substance: it will be shown hereafter that these two apparently different substances are identical in structure, the red colour resulting from congestion only.

* Op. cit. † Part V.

The portal vein enters the liver in all the vertebrated animals, in all of which the lobules are arranged around the hepatic veins as I have described them in man. Each lobule is composed of a plexus of biliary ducts, of a venous plexus formed by branches of the portal vein, of a branch of an hepatic vein, and of minute arteries; nerves and absorbents, it is to be presumed, also enter into their formation, but cannot be traced into them.

The hepatic ducts, commonly so called, and their vaginal and interlobular branches constitute the excreting portion of the biliary apparatus; they are also organs of mucous secretion, being furnished with mucous follicles: the secreting portion of the liver is also composed of ducts, which form a plexus in each lobule. These plexuses may be called the lobular biliary, or secreting biliary plexuses. The ducts composing them being exceedingly minute, and always containing bile, much greater difficulty is experienced in injecting them than in injecting the blood-vessels of the liver, even in the usual manner; and this difficulty is not so easily overcome as that occasioned by blood in the vessels, for the bile contained in the excreting ducts is propelled by the injection into the secreting ducts, from which it has no exit by other vessels, and consequently opposes the entrance of the injection. This process is, to a certain degree, facilitated by tying the portal vein and hepatic artery in the living animal, and thereby arresting the secretion of the bile *. If this operation be carefully performed, the animal will survive several hours, during which time the ducts will discharge much of the bile they contained, and the liver will sometimes become almost colourless. The experiment will probably be attended with more success if performed a few hours after feeding the animal. After preparing the liver in this manner, I have frequently succeeded in partially injecting the lobules from the hepatic duct; I have also injected these bodies from the duct in the human subject, but with less success. Examined with the microscope, the injected interlobular ducts are seen dividing into branches, which, entering the lobules, divide and subdivide into minute ducts; these ducts anastomose with each other, forming a reticulated plexus. (Plate XXIII. fig. 3.) If an uninjected lobule be examined and contrasted with an injected lobule, it will be found that the acini of MALPIGHI in the former are

* It is probable that the *tubuli seminiferi* might be injected with facility in animals after arresting the secretion, by dividing the blood-vessels of the cord several days before killing the animal.

identical with the injected lobular biliary plexus in the latter, and the blood-vessels in both will be easily distinguished from the ducts. The ducts forming the plexuses, when examined with the microscope, present very much the appearance of cells; and this appearance, which has been well delineated by Mascagni *, probably induced this anatomist to consider the liver as an assemblage of minute cavities, giving origin to the ducts. The form of the lobules bears no relation to the arrangement of the ducts, the form of each lobule being always correspondent to the branches of the intralobular hepatic vein occupying the centre of the lobule. The coats of the lobular ducts, on which the blood-vessels next to be described ramify, constitute the proper secreting substance of the liver, as the coats of the cortical ducts of the kidney, and those of the tubuli seminiferi, constitute the secreting substance of their respective organs.

The left lateral ligament may be considered as a rudimental liver, in which this organ presents itself to our examination in its simplest form. From that edge of the liver connected to the ligament, numerous ducts emerge, which ramify between the two layers of peritoneum of which the ligament is composed. These ducts were discovered by Ferrein, but this anatomist did not ascertain their termination. "A l'égard des vaisseaux biliaires, M. Ferrein en a observés de nouveaux, dont les uns reviennent du ligament gauche du foye, et qu'il a vûs quelquefois repandus sur la face inférieure du diaphragme †." These ducts, the smallest of which are very tortuous in their course, divide, subdivide and anastomose with each other. They are sometimes exceedingly numerous, two or three of them in such cases being of considerable size; some of them, as Ferrein says, frequently extend to the diaphragm and ramify on its inferior surface. They sometimes extend only half-way up the ligament, where they divide into branches, which, forming arches, return and descend towards the liver, anastomosing, or being continuous, with other ducts issuing from it. The spaces between the larger, or excreting, ducts are occupied by plexuses of minute, or secreting, ducts. (Plate XXIII. fig. 4.) I have injected the ducts on the inferior surface of the diaphragm, but have not succeeded in injecting them to their termination; we may however conclude,

* Prodromo, Tab. VI. figg. 13, 14.

† Mémoires de l'Académie Royale des Sciences, Histoire, 1733.

that, like those just described, they form arches, the branches returning towards the ligament, and being continuous with others ascending from it. Branches of the portal and hepatic veins, with arteries and absorbents, also ramify in the ligament, which, including between its layers a plexus of secreting and excreting ducts, with blood-vessels ramifying on their parietes, admirably displays the structure of the liver*. FERREIN speaks of other ducts; "d'autres reviennent de cette portion des parois de la veine cave, qui paroît hors de l'échancrure sigmoïde du foye quand on le regarde par derrière, d'autres enfin reviennent des membranes de la vésicule du fiel." The inferior cava usually occupies a fissure at the back part of the liver; this fissure is frequently converted into a canal by a portion of the liver, extending from the lobulus Spigelii to the right lobe; frequently, also, the fissure is converted into a canal by a band, apparently of ligamentous texture, varying in width in different subjects. This band is, like the left lateral ligament, a transparent portion of the liver, containing ducts and blood-vessels. In a preparation in my possession, in which the ducts in this band are injected, a few injected ducts are seen issuing from the right lobe and ramifying on the coats of the cava above the band. The umbilical vein is also contained in a fissure, which is frequently converted into a canal by a process of the liver, called the *pons hepatis*, extending from the *lobulus quadratus* to the left lobe; sometimes the two lobes are connected by a band only, which is similar in structure to that behind the cava. No ducts ramify in the coats of the gall-bladder. It is probable that FERREIN mistook the absorbents of the gall-bladder for ducts, this anatomist, probably, having injected some of the former vessels, as I have frequently done, from the hepatic duct: or FERREIN may allude to ducts which occasionally ramify between the liver and gall-bladder, and divide into interlobular branches, which enter the former, and which he may have removed with the latter and mistaken for ducts ramifying upon it. No branches of the hepatic veins ramify in the coats of the gall-bladder; and the absence of these vessels sufficiently proves the non-existence of ducts. The cystic veins are branches of the abdominal portal, and not of the hepatic portal or umbilical, vein: they are therefore efferent, and not afferent, vessels, conveying blood from, and not to, the

* A beautiful preparation is made by drying the ligament on glass, after having injected the ducts with size or mercury.

gall-bladder: it necessarily follows, that biliary ducts ramifying on the parietes of this receptacle would receive the materials of their secretion from arterial blood,—that of the cystic arteries. If in any case ducts should be found on the gall-bladder, I venture to assert, that branches of both the portal and hepatic veins will also be found; but the portal veins in such a case will be branches of the hepatic portal vein, will convey blood from the coats of the excreting ducts, and to the coats of the secreting ducts, and not from the gall-bladder. If ducts, arteries, and one set only of veins, terminating in either the portal or hepatic veins, should be found,—and this is always the case if FERREIN's assertion, that ducts ramify on the coats of the gall-bladder, be true,—then would the bile of these ducts at least be secreted, beyond dispute, from arterial blood.

Branches of the hepatic artery and portal vein accompany the ligamentum teres; these veins convey blood to the hepatic portal vein, and must therefore be considered as separate branches of the abdominal portal system.

*Of the Lobular Venous Plexuses.*—The interlobular branches of the portal vein, surrounding the lobules on every side except at their bases, divide into branches, which, entering these bodies, form in each of them a plexus, the branches of which terminate in the intralobular hepatic situated in the centre of the lobule. This plexus, interposed between the interlobular portal veins and the intralobular hepatic vein, constitutes the venous part of the lobule, and may be called the lobular venous plexus. Examined with a powerful microscope, the vessels constituting the plexus are seen converging from their origin at the circumference toward their termination at the centre of the lobule; they communicate with each other by smaller transverse branches, between which are seen minute circular, ovoid, or oblong spaces, occupied by portions of the lobular biliary plexus. (Plate XXIII. fig. 5.) Examined with a less powerful microscope, the vessels of the plexus appear arranged in circles. The circular, ovoid and oblong portions of the biliary plexus, seen between the branches of the venous plexus, are the acini of MALPIGHI. MÜLLER has delineated the converging vessels of the plexuses in the liver of the squirrel; but this anatomist did not ascertain whether they were branches of the portal vein or of the hepatic artery. "Præsertim examinare juvat, utrum vascula sanguinea descripta, inter acinos elongatos decurrentia, ad venam portarum an ad arterias pertineant, num sanguis inter acinos diffusus eadem ratione inferius

in venulas colligatur. Doleo, Sciurum hactenus novum defuisse, in quo quæstiones hæce vasis artificiose repletis possent extricari*." The venous plexus of one lobule communicates with the plexuses of the surrounding lobules by means of the intervening interlobular branches of the vena portæ, this vein thus forming one continuous plexus through the whole liver. The converging branches of each plexus unite at the centre of each lobule, and form an intralobular hepatic vein, this vein having no communication with the corresponding veins of the contiguous lobules, except through the medium of the intervening plexus and portal veins. No branches of the hepatic veins are found in any other part of the liver; occupying the centre alone of each lobule, their only office is to convey the blood from the lobular venous plexuses, and not from the arteries.

In consequence of its double venous circulation, the liver is naturally in a state of sanguineous congestion; hence arises the great difficulty of making successful injections of the human liver: the plexuses may, however, be frequently well, but seldom equally, injected, and always with greater success from the portal, than from the hepatic vein, the latter, and those portions of the plexuses immediately surrounding its intralobular branches, generally containing whatever blood may remain in the liver after death. The plexuses may be always injected with facility from the portal or hepatic veins, and the injection will pass freely from one vein into the other without extravasation, if the liver has been previously deprived of all its blood by the ligature of the portal vein and hepatic artery in the living animal†. Anatomists have consi-

* Op. cit., p. 80.

† I for some time experienced great difficulty in making successful injections of the minute vessels of the liver; and this difficulty, arising from the presence of blood in the vessels, was increased when my object was to inject the two veins in the same organ, no exit being then left for the blood. Very little advantage is gained by previously injecting warm water, a large portion of which remaining in the vessels dilutes the injection and obstructs its course. The object is to obtain a free passage for the injection through the minute vessels; this can be accomplished only by tying the portal vein and hepatic artery in the living animal, and thus depriving the liver of all its blood. In one minute after the application of the ligature, the liver becomes bloodless, and the sufferings of the animal may be abridged, and regurgitation into the hepatic veins prevented, by dividing the inferior cava near its termination in the right auricle. Before injecting, the body of the animal should be left in water during twenty-four hours, a ligature having been previously placed on the inferior cava above the diaphragm to prevent the entrance of the water into the hepatic veins. If the liver be previously prepared in this manner, all the intralobular hepatic veins may be injected with one colour, and all the interlobu-

dered, that the free communications which exist between the two vessels obviate the difficulty which would otherwise arise in the circulation through the liver, from the want of power consequent on the presence of the two veins*; and although the communications between these vessels appear, upon experiment, to be more free than those which exist between the hepatic artery and the portal vein, and between arteries and veins generally in other parts of the body, yet it appears that the arteries and veins in the spleen and kidney, and probably in all glands, communicate with equal freedom. The lobular venous plexus is best examined in the superficial lobules, but here again the human liver presents a difficulty, particularly in the adult, in consequence of the opacity of the proper capsule: the liver of the cat, and that of the smaller animals generally, appear to have no cellular capsule, and are consequently more favourable for this purpose.

The venous plexus ramifies on the biliary plexus: the blood circulating through it is composed of the portal blood, and certainly of that portion of the arterial blood which, having nourished the excreting ducts and supplied them with mucus, and having circulated through the vasa vasorum of all the vessels, becomes venous and is received into the branches of the portal vein, by which, with the portal blood, it is conveyed to the plexus; and from this mixed blood the bile is secreted.

The vessels of the plexus ramify on, or as MÜLLER says, between, the se-

lar portal veins with another, and the course and distribution of each set of vessels may be studied with facility. The various appearances produced by congestion of the liver may be imitated by injection. This method of injecting is equally applicable to every other organ. I made a very successful injection of the portal and hepatic veins in the exsanguine liver of a man, who died from the rupture of an aneurism of the abdominal aorta, under the care of Dr. HOPE, in the Marylebone Infirmary. In the preparations of this liver, as in those made by injecting the vessels after the ligature of the portal vein and hepatic artery in living animals, the central portions of the lobules are coloured with blue, and the marginal portions with red injection.

* The *vis à tergo* is removed by the ligature of the portal vein and hepatic artery; these vessels, nevertheless, disembarrass themselves perfectly of their blood, and no regurgitation takes place. In the sheep, the inferior cava runs in a direction parallel to the superior margin of the liver, a part of the right lobe of which is in front of this vein: the hepatic veins conveying the blood from this part terminate in the cava at obtuse angles; this blood consequently flows in an opposed direction to that passing through the cava. The collision of the two currents is prevented, and a septum is, to certain distance, formed between them by two valves, somewhat larger than those of the human aorta, situated at the orifices of the two right hepatic veins.

creting ducts; they are not continuous with the ducts as was imagined by Ruysch. On this subject Müller observes: "Itaque autopsia docet, vascula sanguifera tenuissima cum ductibus biliferis cæcis nullum commercium inire*.....Neque verò quisquam commercium inter fines ductuum biliferorum et vascula sanguifera unquam observavit. Quod jam Hallerus rectè monuit. Nemo vidit vasculum sanguiferum in finem ductûs biliferi usquam desinens†."

*Of the Lobular Arteries.*—The lobules are sparingly supplied with arterial blood. These bodies cannot be coloured with injection from the artery even in the young subject; in the adult, after the most successful injection, when the arteries of the cellular capsule, those of the excreting ducts and gall-bladder, and the vasa vasorum are minutely injected, a few injected vessels only are detected entering the lobules. I have frequently tied the thoracic aorta in living animals, thereby cutting off all supply of blood from the abdominal viscera; and in these animals, when injected from the aorta below the ligature forty-eight hours after death, the integuments, the secreting portions of the kidneys, the spleen, pancreas, intestines and pelvic viscera were coloured in a remarkable degree by the injection; on the surface of the liver a few vessels only could be discovered, this organ presenting a curious contrast with the surrounding coloured viscera. The gall-bladder and ducts were, however, equally well injected with the intestines; the vasa vasorum were also well injected. In these experiments it will be remarked, that the secreting portion alone of the kidney was highly injected; the excreting portion of this gland resembling the secreting portion of the liver in its supply of arterial blood, which it receives for nutrition only. Similar experiments were tried on birds, and in these animals all the viscera were highly injected, with the exception of the liver and kidneys, the latter organs in oviparous animals having, like the liver, a double venous circulation, the urine, as well as the bile, being secreted from venous blood‡. Whether the liver be injected from the aorta or from the hepatic artery, the appearances produced will be nearly the same. In

* Op. cit., p. 82. † Ibid. p. 83.

‡ Jacobson, De Systemate Venoso peculiari in permultis Animalibus observato. Hafniæ 1821. "On a peculiar Arrangement of the Venous System observed in many Animals," Edinburgh Medical and Surgical Journal, vol. xix. p. 78.

speaking of the excreting ducts, it was shown that these vessels are abundantly supplied with arterial blood, which is received by branches of the portal vein; the injection very commonly passes from the arteries into these branches, and thence into the trunks of the vein, and it occurred to me, that the injection thrown into the arteries was probably in this manner diverted from the lobules. To ascertain if such was the case, blue injection was first thrown into the portal vein; the arteries were then injected with red. On dissection, branches of the two sets of vessels were found in the coats of the vessels, and in those of the excreting ducts and gall-bladder; the lobules were coloured with the blue injection; the red was confined to their circumference, and appeared in points only. This experiment was varied by injecting the portal vein and its branches as far only as the entrance of the latter into the lobules, these bodies thus remaining uninjected. The injection propelled through the arteries had now free access to the uninjected lobules, and no exit by the injected portal vein; and the artery having no communication with the hepatic veins, the injection had no exit by these vessels: the lobules, however, were not better injected in this than in the preceding experiments. From these experiments I conclude, that the secreting portion of the liver, like the excreting portion of the kidney, is supplied with arterial blood for nutrition only. As all the branches of the artery of which we can ascertain the termination end in branches of the portal vein, it is probable that the lobular arteries terminate in the lobular venous plexuses formed by that vein, and not in the intralobular branches of the hepatic veins, which cannot be injected from the artery, the blood of these arteries, after having nourished the lobules, becoming venous, and thus contributing to the secretion of the bile.

Müller is also of opinion that the ultimate reticulated vessels of the liver receive blood from the artery as well as from the portal vein: "Vascula ultima reticulata sanguinem tam ab arteriis quam à venâ portarum accipere, venisque hepaticis reddere, ex hisce argumentis concludo: 1. Post injectionem in arteriam hepaticam non minùs quàm in venam portarum aut venas hepaticas factam, eadem communia vasculorum minimorum retia replentur, quod ex injectionibus exsiccatis Lieberkühnianis, Berolini asservatis, facilè quisquis sibi persuadebit:" from which it appears that Lieberkühn injected the lobules from the artery, as well as from the portal or hepatic veins. I have

shown that the ultimate reticulated vessels, or those I have called the lobular venous plexuses, are formed by the portal vein alone; that the branches of the artery ramify in the coats of all the vessels; and that these arteries terminate in the branches of the portal vein: it would appear, therefore, that LIEBERKÜHN, if he injected the lobules from the artery, must have previously filled all the branches of the portal vein from that vessel*. MÜLLER's second argument is: "Injecti liquores colorati ex alio vasorum ordine facilè in aliud transeunt, qualis frequens HALLERI veterumque, WALTERI denique et RUDOLPHII cet. extat experientia. Ipse equidem transitum aquæ limpidæ et coloratæ sæpius observavi†." MÜLLER coincides in opinion with those anatomists who suppose that all the blood-vessels communicate directly with each other. I have shown that no branches of the artery terminate in the hepatic veins, the latter vessels being injected from the former through the medium of the lobular venous plexuses of the portal vein.

*Of the Red and Yellow Substances of* FERREIN, *and of the Appearances produced in the Liver by Congestion.*—The structure of all the lobules is similar, and each lobule is of the same structure throughout; one part of a lobule is not more vascular than another; there is, therefore, no distinction of red and yellow substances in the liver; the red colour results from congestion only.

FERREIN first asserted the existence of two substances. "Sur la structure, il a trouvé dans chaque grain ou lobule du foye deux substances différentes; une qu'il appelle *corticale*, qui est extérieure, friable, et d'un rouge tirant sur le jaune; l'autre *médullaire*, ou intérieure, rouge, molle et pulpeuse, placée au centre de chaque grain, très-apparente dans plusieurs animaux, et souvent dans l'homme. Les conduits hépatiques traversent la substance corticale pour se rendre dans la substance médullaire, que M. FERREIN croit formée des extrémités pulpeuses de ces canaux‡." FERREIN's opinion respecting the existence of two substances has been very generally adopted by anatomists; some, however, have disagreed with him respecting their relative position to each other. Thus, AUTENRIETH says the yellow substance is medullary, and the red corti-

* LIEBERKÜHN used injection made of white wax, resin and Venice turpentine. "Sur les Moyens propres à découvrir la Construction des Viscères," Mémoires de l'Académie Royale des Sciences de Berlin, tom. iv. p. 28. 1748.

† Op. cit., p. 82.

‡ Mémoires de l'Académie Royale des Sciences, Histoire, 1733.

cal. MAPPES, who was unacquainted with the lobular structure of the liver, which was known to FERREIN, says, "l'une de ces substances, qu'on peut appeler granulée, (médullaire, suivant AUTENRIETH,) forme des circonvolutions, tantôt semblables à celles des intestins, tantôt rameuses, plates et arrondies, de couleur jaune et assez denses, qui laissent entre elles des espaces arrondies d'un quart ou d'un travers de ligne de diamètre, ou des fissures oblongues le tout rempli par la seconde substance, laquelle est brune et moins serrée et qu'on peut appeler cellulo-vasculaire (corticale, suivant AUTENRIETH) *." To MECKEL †, the view taken of the substances by AUTENRIETH and MAPPES appears more just than that taken by FERREIN. RUDOLPHI says the terms cortical and medullary are not applicable to the substances, one not forming a bark for the other. The attention of pathologists has been lately directed in a particular manner to these supposed elements of the liver by MM. BOULLAND and ANDRAL. BICHAT, who thought it "impossible that all the substance of the liver is destined to secrete bile," was of opinion that the bile is secreted from arterial blood alone, and that the liver fulfils another function connected with the existence of the vena portæ ‡. On this subject M. BOULLAND remarks, "Si cette opinion est vraie, elle doit s'accorder avec l'anatomie du foie, c'est-à-dire, que si cet organe est chargé d'une fonction de plus que celle de la sécrétion de la bile, et que cette fonction ait rapport à la circulation sanguine, ou doit y trouver un appareil vasculaire spécialement destiné à ce dernier usage, en outre de l'appareil sécréteur de la bile." In speaking of the substances, the same pathologist says, "La substance jaune se présente sous forme de granulations saillantes, dont la figure, la couleur et l'arrangement doivent les faire regarder comme les grains sécréteurs de la bile, connus depuis long-temps sous la dénomination d'*acini*.....Ces granulations sont entourées de toutes parts par la substance brune, qui affecte par cela même diverses formes angulaires..... Cette substance, qui est toujours déprimée au-dessous du niveau des granulations jaunes, n'est pas seulement formée de tissu cellulaire, mais encore d'un lacis vasculaire, qui peut être comparé au tissu érectile §." M. BOULLAND con-

* Loc. cit.

† Manuel d'Anatomie, tom. iii. p. 452.

‡ Anatomie Générale, tom. ii. p. 260.

§ "Considérations sur un Point d'Anatomie Pathologique du Foie," Mémoires de la Société Médicale d'Émulation, tom. ix. p. 177.

siders that the *Cirrhose* of LAENNEC depends on a disassociation of the two elements; the appearances he has represented in fig. 1, and which, as he remarks, are frequently observed in connexion with disease of the heart, resemble some of those delineated by MÜLLER in Tab. XI., and arise from sanguineous and biliary congestion. M. ANDRAL coincides with M. BOULLAND in his opinion of the two elements, and says, "Isolées, ou réunies et combinées de plusieurs manières, les altérations de ces deux substances produisent les diverses états morbides du parenchyme hépatique*." M. ANDRAL considers the red substance as "éminemment vasculaire†, .... où se ramifie surtout le système capillaire de l'organe‡." Opinions opposed to those just cited are entertained by PORTAL, MÜLLER, and M. CRUVEILHIER. PORTAL merely observes, that "FERREIN avait avancé gratuitement que les glandes du foie étoient composées de deux substances, l'une corticale, et l'autre médullaire§." M. CRUVEILHIER, in his admirable work on pathological anatomy, says, "Il n'existe pas deux substances dans le foie, soit qu'on admette deux espèces de granulations, soit qu'on admette que chaque granulation est composée des deux substances à la fois. Ce qui a pu en imposer à cet égard, c'est que la partie centrale de chaque granulation répond au radicule biliaire, et conséquemment est souvent teinte en jaune, et que la partie excentrique répond à l'élément vasculaire, et conséquemment est plus rouge que la partie centrale‖." MÜLLER gives the following account of the two substances. "Diversam substantiam hepatis, utpote medullarem et corticalem, quæ per hepar totum undique obveniunt, qualem AUTENRIETH, BICHAT, CLOQUET, MAPPES atque etiam J. FR. MECKEL admittunt, equidem neque in historia evolutionis amphibiorum et avium, neque in hepate adultorum microscopicè observato, conspexi. Historia evolutionis hanc quæstionem evidentissime illustrat. Systema nimirum ductuum biliferorum in embryone amphibiorum et avium liberis finibus in superficie hepatis prominulis conspicuum. Sarmentula illa foliatim et paniculatim divaricata, colore e gilvo candido nitent, magnopere ab interstitiis sanguinolentis distincta. Hinc sane duplicis substantiæ species exoritur, quoniam circum duc-

* Clinique Médicale, 2de Edition, tom. iv. p. 178.

† Ibid., p. 176.

‡ Précis d'Anatomie Pathologique, tom. ii. p. 584.

§ Anatomie Médicale, tom. v. p. 277.

‖ Anatomie Pathologique du Corps Humain, Livr. xii. "Foie granuleux."

tuum biliferorum surculos et fines undique tela vasculosa subtilis sanguifera disponitur, ita ut interstitia ductuum biliferorum a tela conjunctiva expleantur, quæ et subtilissimis fere constat vasculorum sanguiferorum retibus, in quibus arteriæ et venulæ advehentes in revehentes venas transeunt. Atque hæc sola est utriusque substantiæ notio. Sed in omnibus organis glandulosis fere idem obvenit *."

My attention was first directed to the anatomy of the liver by the study of the admirable works of M. Andral. In the first organs I examined, I found the small branches of the hepatic veins ramifying exclusively in the red, and those of the portal vein in the yellow substance. I concluded that the liver was composed of two venous trees, a portal and an hepatic tree, the former having a cortex of yellow, the latter of red substance; and with M. Boulland I thought it probable that the red substance was the organ of the function imagined by Bichat. I next ascertained the lobular structure, and concluded with Ferrein that the red substance was medullary, and the yellow cortical. Subsequent dissections, in which I found branches of both the portal and hepatic veins ramifying in the red substance, tended to unsettle the opinions I had formed respecting the anatomy and physiology of the two substances; and these opinions were finally overturned by the examination of a liver in which I found the branches of the portal vein alone ramifying in the red, and those of the hepatic veins in the yellow substance. The only conclusion that could be drawn was, that the red colour resulted from congestion; that it was medullary, occupying the centre of each lobule, when the hepatic, and cortical, forming the circumference, when the portal vein, was congested. It occurred to me that the kidneys of birds having, like the liver, a double venous circulation, were equally subject to congestion, and would, like it, present an appearance of two substances. Dissection verified this conjecture; but the apparently two substances are red, one, however, being of a much deeper colour than the other. I have satisfied myself by repeated injections, by examination with the microscope, and by experiments on living animals, that the lobules are of the same structure throughout; that one portion of a lobule is not more vascular than another; that the acini of Malpighi, by contrast with the congested vessels, are even more apparent in the red than in the yellow

* Op. cit., p. 83.

substance; and that these supposed two substances are consequently identical in structure. That secreting biliary ducts are contained in the red as well as in the yellow substance, is proved by the relation given by M. Andral of a case of jaundice with "coloration insolite du foie." "Foie volumineux, pesant, très-dur, se déchirant difficilement, offrant une teinte générale d'un brun verdâtre. En l'examinant avec plus d'attention, on trouve que cette teinte n'est pas uniforme, et que le parenchyme du foie est formé, 1°. par un tissu d'un blanc verdâtre, disposé sous forme de lignes ou de plaques irregulières (c'est le tissu blanc ordinaire hypertrophié); 2°. par un tissu d'un vert brun foncé, duquel dépend la couleur générale que présente le foie, et qui est l'analogue du tissu rouge ordinaire*." This was a case of vitiated biliary secretion, with general biliary and partial sanguineous congestion. The ordinarily yellow substance was of a greenish white colour, being congested with greenish bile only; the ordinarily red substance was of a deep brownish green, this colour evidently resulting from biliary and sanguineous congestion combined. I have met with more than one case of this kind; I have also seen cases of jaundice in which there was no biliary congestion of the liver, and the highest state of biliary congestion without jaundice. In attempting to estimate the causes of the various shades of colour observed in the liver, it is not sufficient to examine the cystic bile alone; the hepatic bile should be also examined, and it will be generally found, as in the above case, that these shades of colour depend either on biliary or sanguineous congestion alone, or on the various combinations of both.

Sanguineous congestion of the liver is either general or partial. In general congestion the whole liver is of a red colour (Plate XXI. fig. 6.), but the central portions of the lobules are usually of a deeper hue than the marginal portions. (Plate XXI. fig. 5.) Partial congestion is of two kinds, hepatic-venous and portal-venous congestion. Of the first kind there are two stages. In the first and most common stage, the hepatic veins, their intralobular branches and the central portions of the plexuses are congested. The congested substance is in small isolated patches of a red colour, and, occupying the centres of the lobules, it is medullary; the non-congested substance is of a yellowish white, yellow or greenish colour, according to the quantity and quality of the bile it contains:

* Clinique Médicale, 1ère Edition, tom. iv. p. 169.

it is continuous throughout the liver, and, forming the marginal portions of the lobules, is cortical. (Plate XXI. fig. 2.) This is passive congestion of the liver; it is the usual and natural state of the organ after death, and probably arises from its double venous circulation. In the second stage, the congestion extends through the plexuses to those branches of the portal vein situated in the interlobular fissures, but not to those in the spaces, which being larger than, and giving origin to, those in the fissures, are the last to be congested; when these vessels contain blood, the congestion is general, and the whole liver is red. In this second stage, the non-congested substance appears in isolated circular and ramous patches, in the centres of which the spaces and fissures are seen. (Plate XXI. fig. 3.) This is active congestion of the liver; it very commonly attends disease of the heart, and acute disease of the lungs or pleuræ: the liver is larger than usual in consequence of the quantity of blood it contains, and is frequently at the same time in a state of biliary congestion, which probably arises from the sanguineous congestion. Although in the first stage, the central portions of the plexuses, and in the second, the greater portion of each plexus and those branches of the portal vein occupying the fissures, are congested, and although the plexuses are formed by the portal vein; yet, as this form of congestion commences in the hepatic veins and extends towards the portal vein, and as it is necessary to distinguish this form from that commencing in the portal vein, the term of hepatic-venous congestion will not probably be deemed inapplicable to it. Portal-venous congestion is of very rare occurrence; I have seen it in children only. In this form, the congested substance never assumes the deep red colour which characterizes hepatic-venous congestion; the interlobular fissures and spaces and the marginal portions of the lobules are of a deeper colour than usual; the congested substance is continuous and cortical, the non-congested substance being medullary and occupying the centres of the lobules. (Plate XXI. fig. 4.) The second stage of hepatic-venous congestion, in which the congested substance appears, but is not, cortical, may be easily confounded with portal-venous congestion.

The physiological deductions arising out of the preceding anatomical facts are extremely simple. If it could be shown that two substances exist in the liver, it might be fairly presumed that this organ executes two functions; but each lobule being, in itself, a perfect gland, and of the same structure through-

out, each lobule, and consequently the whole liver, executes but one function, the secretion of bile*.

It has been shown that all the vasa vasorum of the liver are branches of the hepatic artery and portal vein; that branches of the portal vein arise in the coats of the hepatic veins themselves; and that the veins of the coats of the vessels constitute the hepatic origin of the portal vein. The arterial blood having circulated through the coats of the vessels, becomes venous, and is conveyed by the veins arising in the coats of the vessels into those branches of the portal vein which correspond to the vessels in the coats of which the veins arise: thus, from the coats of the vaginal ducts, veins and arteries they convey the blood into the vaginal veins; and from the coats of the interlobular ducts, veins and arteries into the interlobular veins. From the coats of the hepatic veins and inferior cava, the blood is conveyed into the interlobular portal veins. In the vaginal and interlobular veins, the blood conveyed from the coats of the vessels becomes mingled with the proper portal blood. This mixed blood is conveyed by the interlobular veins into the lobular venous plexuses, in which the lobular arteries probably terminate, after having nourished the secreting ducts. From the mixed blood circulating through the plexuses, the bile is secreted by the lobular or secreting biliary plexuses.

* M. Voisin (Nouvel Aperçu sur la Physiologie du Foie) has lately revived an old opinion respecting the physiology of the liver. The absorbents of the liver are, according to M. Voisin, of two kinds, the lymphatics and the chyliferous vessels: the former arise in the tissue of the liver and ramify on its surfaces; the latter are continuous with the chyliferous vessels of the intestines; they accompany the portal vein, and convey a portion of the chyle into the liver, in which, according to M. Voisin, it undergoes a certain change, and is conveyed from the liver into the receptaculum chyli by (as it would appear from M. Voisin's description) the same vessels. M. Voisin makes no mention of the valves of his chyliferous vessels, or of the impossibility of injecting these vessels, except by rupturing the valves, from the lesser omentum upwards towards the liver; but he asks, "S'il n'en était pas ainsi de l'origine et du trajet de ces vaisseaux lactés, d'où viendraient ceux qu'on remarque dans le foie, de quelle utilité lui seraient-ils?" If the abdomen of a dog be opened during the period of the absorption of the chyle, no part of this fluid will be found in the absorbents (the chyliferous vessels of M. Voisin), which leave the liver at the transverse fissure and descend, covered by the peritoneum of the right edge of the lesser omentum, to enter a lymphatic gland situated near the duodenum. If a ligature be placed on the vessels near the duodenum, the absorbents above the ligature will, in a few minutes, become turgid; if the ligature be loosened, the turgid vessels will soon resume their natural appearance. If the ligature be placed on the vessels near the transverse fissure, the absorbents below the ligature, being no longer supplied with fluid from the liver, will collapse and be no longer perceptible.

The blood which enters the liver by the hepatic artery fulfils three functions: it nourishes the liver; it supplies the excreting ducts with mucus; and, having performed these purposes, it becomes venous, enters the branches of the portal vein, and contributes to the secretion of the bile. The portal vein fulfils two functions; it conveys the blood from the artery, and the mixed blood to the coats of the excreting ducts. It has been called the *vena arteriosa*, because it ramifies like an artery, and conveys blood for secretion; but it is an arterial vein in another sense, being a vein to the hepatic artery, and an artery to the hepatic vein. The hepatic veins convey the blood from the lobular venous plexuses into the vena cava inferior.

Ferrein was evidently well acquainted with the hepatic circulation; it is to be regretted that his "Mémoire sur la Structure et les Vaisseaux du Foye" was not published. The following account of the vessels is given from his description of them. "A' l'égard des vaisseaux sanguins, il a observé que les divisions et les subdivisions de la veine-porte donnent deux sortes de rameaux, les uns veineux et les autres artériels: il nomme rameaux artériels ceux qui sont connus par leur fonction de porter le sang de la veine-porte dans le foye: il a découvert les veineux, et ceux-ci reçoivent le sang de l'artère hépatique, et le conduisent dans les rameaux artériels de la veine-porte, de ceux-ci dans la substance médullaire des lobules, et de-là dans les branches de la veine-cave*." It does not appear that Walter ascertained the termination of any of the branches of the artery; he supposed that some branches of this vessel pour arterial blood into the portal vein; he says, "Extremitates ultimæ arteriarum in hepate evanescunt, ita, ut nonnullæ earum, partim in cellulosa hepatis interna terminentur, hinc illam nutriant, partim sub forma fasciculorum florum, vel potius in directione fere stellari in reliquam hepatis sustantiam se dispergentes, ramulos venæ portarum perforent, in eorum cavum sese aperiant, ibique tandem liquidum quoddam ad bilem idoneum magis perficiendam secernunt: reliqui rami, ramos venæ cavæ et ductus hepatici elegantissimo reticulo vasculoso, irretiunt†." Of the functions of the artery, the same anatomist says, "Officium ergo arteriæ hepaticæ duplex erit, vel substantiam cellulosam

* Mémoires de l'Académie Royale des Sciences, Histoire, 1733.

† De Hepate, p. 96, in Annotationes Academicæ, Berolini 1786.

membranasque vasorum hepatis nutrire, vel partem aliquam bili necessariam secernere et in ipsam venam portarum deponere *."

M. SIMON† concluded from his interesting and ably conducted experiments, that the bile is secreted from the portal blood alone; and Mr. PHILLIPS arrived at the same conclusion from the issue of two experiments in which he tied the hepatic artery, the details of which are in the possession of the Royal Society. From the issue of three experiments in which the portal vein was tied, and in in which bile was secreted, and from the cases related by Mr. ABERNETHY and Mr. LAWRENCE, Mr. PHILLIPS concluded that bile might be secreted from arterial blood alone‡. I have shown that the bile is secreted from venous blood alone, this blood being composed of the two streams which enter the liver by the portal vein and hepatic artery; and from the anatomical details into which I have entered, it is evident that bile will be secreted, but in different quantity, whether the vein or the artery be tied, and from venous blood in both cases. The quantity of arterial blood conveyed to the liver is so small, and death so soon follows the ligature of the vein, that in experiments on rabbits and kittens, in which I tied the vein, I cannot say that bile was secreted.

It appears to have been satisfactorily ascertained by TIEDEMANN and GMELIN §, and by M. VOISIN‖, that the bile is a purely excrementitious fluid, stimulating the intestinal canal, but having no influence on the formation of the chyle. The lungs separate from venous blood an excrementitious matter in a gaseous form; the liver, extracting from venous blood an excrementitious fluid, may be considered as the abdominal lung.

A few eminent physiologists, founding their opinion on false anatomical data, on the cases related by Mr. ABERNETHY and Mr. LAWRENCE, and on the absence of the hepatic-portal vein in the invertebrated animals, in which the liver is supplied with arterial blood only, maintain that the bile is secreted from arterial blood. Since the conclusions contained in this paper respecting the

* De Hepate, p. 105, in Annotationes Academicæ, Berolini 1786.

† Nouveau Bulletin des Sciences par la Société Philomatique de Paris, 1825. Edinburgh Journal of Medical Science, No. 1. p. 229. Birds are better adapted for these experiments than the mammiferous animals, the portal vein in the former animals communicating freely with the posterior cava. M. SIMON performed his experiments on pigeons.

‡ London Medical Gazette, June 29, 1833.

§ Recherches sur la Digestion, 2de Partie, p. 58.

‖ Op. cit.

physiology of the liver were first submitted to the Society, I have been enabled, through the kindness of Mr. STANLEY, to examine the liver of the child in which Mr. ABERNETHY found that the portal vein terminated in the inferior cava. Mr. ABERNETHY's account of the case is contained in the Philosophical Transactions for 1793. Mr. GREEN, in his anatomical lectures, had always described this case, as presenting less anomaly than was commonly supposed. He considered that the umbilical vein ramified through the liver, that the artery probably terminated in it, and that the vein and not the artery conveyed the blood to the secreting part of the liver. Sir CHARLES BELL also, in speaking of this case, makes the following highly interesting observations: "We may observe on this case, that it does not prove the bile to be, in the natural economy, secreted by the arteries and not by the vena portæ; for the artery here was unusually large, so that it performed a function in this instance which it does not usually perform. Had the artery been of the usual size, we might then have concluded that the vena portæ was distributed to the liver to serve some lesser use in the economy of the system, and that it did not secrete the bile. The liver, it is said, was of the ordinary size. Now as the bulk of the liver is, in its natural state, made up of the dilated veins, it is some proof of what I should imagine had taken place here, that by some provision of the vessels, the arterial blood had been diffused, and the celerity of its motion checked previous to its ultimate distribution. Nay, it may have opened into the branches of veins answering to the extremities of the vena portæ. I conclude, that this singular and interesting case may strengthen the opinion which some have entertained, that the extreme branches of the hepatic artery pour blood into the extremities of the vena portæ previous to this formation of the bile by these veins; but it still leaves us with the general conclusion, that the peculiarities in the distribution of the vena portæ are a provision for the secretion of the bile, and that the branch of the aortic system, the hepatic artery, is otherwise necessary to the support of the function of the liver *."

I examined the liver of this child, which had not been examined by Mr. ABERNETHY, in the presence of Mr. STANLEY, Mr. MAYO, and several other gentlemen, in the Museum of Saint Bartholomew's Hospital. Mr. ABERNETHY had injected the arteries with red, and the hepatic veins with yellow size. As had

* The Anatomy and Physiology of the Human Body, vol. iii. p. 330.

been happily conjectured by Mr. Green and Sir Charles Bell, we found the open and uninjected ramifications of the umbilical vein (the hepatic-portal vein) accompanying, as usual, the branches of the hepatic artery and duct. By making sections of portal canals, we found the arteries, as Mr. Abernethy had described them, much larger than usual. In ordinary cases one principal artery is found in each canal; in this case two, and in some places three arteries of equal calibre were found in each canal. The branches of the umbilical or portal vein, which are usually so much larger than those of the artery, were found, on the surfaces of sections of this liver, to be, as nearly as we could judge, equal in calibre to the united dimensions of the two or three arteries which accompanied each branch of the vein. Bichat, in support of his opinion that the bile is secreted from arterial blood, says, "On dit que le volume du foie est considérable, à proportion de l'artère hépatique: cela est vrai; mais ce n'est pas au volume de ce viscère qu'il faut comparer celui de cette artère pour savoir si elle fournit les matériaux de la sécrétion, puisque nous avons vu qu'il est impossible que toute sa substance soit destinée à séparer la bile. C'est avec les conduits biliaires et leur réservoir qu'il faut établir la comparaison: or, cette artère est exactement proportionée à ces conduits; il y a entre eux à-peu-près même rapport qu'entre la rénale et l'uretère; au contaire, les conduits biliaires sont bien manifestement disproportionnés à la veine porte *." Bichat's opinion, and the argument here offered in support of it, are completely refuted by the dissection of the liver in this case. The branches of the duct were much smaller than those of the artery; in one canal, in which there were three arteries of equal dimensions, the duct was of about half the size of one artery. (Plate XXI. fig. 6.) This case, therefore, does not establish an analogy between the biliary organs of the vertebrated and invertebrated animals; but, on the contrary, it shows that the class of monstrosities to which it belongs, forms a much slighter deviation from the ordinary vertebrated type than was imagined†. Nor does it militate against the conclusions maintained in this paper upon the physiology of the liver; although, as Mr. Mayo observed, it cannot be supposed that the arterial blood, in its passage through the vasa vasorum into the branches of the umbilical vein, underwent the usual change into venous blood; and it

* Anatomie Générale, tom. ii. p. 260.

† Meckel, Manuel d'Anatomie, tom. ii. p. 538. I. Geoffroy Saint-Hilaire, Histoire des Anomalies, tom. i. p. 456.

was still, he contended, arterial blood, though less pure in character, which was conveyed through venous canals into the secreting part of the liver.

A case, similar to Mr. ABERNETHY'S, which was met with by the late Mr. WILSON, is mentioned by Mr. LAWRENCE * and Dr. MONRO †. The history of this case was lately read at a Meeting at the College of Physicians, by Dr. WILSON, to whom I am indebted for the following particulars. The subject was a girl, thirteen years of age, who met with her death from an injury of the head. The vena portæ terminated in the inferior cava; there were two splenic veins, one of which entered the portal vein, and the other the cava near the point where it becomes surrounded by the liver. Mr. WILSON says, "I could trace no vein passing into the liver at the cavity of the portæ; the remains of the umbilical vein were impervious; I traced them to the entrance of the portæ, *and now regret that I had not traced them sufficiently far to see with what set of vessels they were united*..... The hepatic artery," Mr. WILSON continues, "came off in a distinct trunk from the aorta, and ran directly to the liver: it was much larger than it usually is, but not so large as the trunk of the vena portarum; it entered the liver as usual. The gall-bladder had nothing remarkable in its appearance: it was of a size proportioned to that of the liver, and contained more than half an ounce of bright yellow fluid, similar in appearance to the bile; it was not, however, submitted to any other test but that of sight." The umbilical vein in this case was obliterated as far as it was traced by Mr. WILSON; but, as in Mr. ABERNETHY'S case, its hepatic branches were doubtlessly open, and received the blood from the artery, which they conveyed to the coats of the secreting ducts. No portion of the liver was preserved ‡.

While engaged in the examination of the natural structure of the Liver, I have not been inattentive to the changes produced in it by disease; and, with the permission of the Society, I propose submitting to its consideration a paper on the Morbid Anatomy of this organ.

* Medico-Chirurgical Transactions, vol. v. p. 174.

† Elements of Anatomy, vol. ii. p. 564. 1825.

‡ In the case related by LIEUTAUD after BAUHIN (Historia Anatomico-Medica), the liver and spleen, it is said, were wanting, the portal vein terminating in the inferior cava. The case related by HUBER (Programma sistens Observationes aliquot Anatomicas), which, in the Index to SANDIFORT'S Thesaurus Dissertationum, is entitled "Diaphragmatis Habitus singularis," was, as MECKEL and RUDOLPHI observe, probably a case in which the hepatic veins perforated the diaphragm previously to entering the cava, and not an unusual termination of the portal vein, as has been supposed by some anatomists.

## *Explanation of the* PLATES.

### PLATE XX.

Fig. 1. A. An hepatic vein.

B. Lobules arranged around the intralobular branches of the hepatic veins, as they are frequently seen at the posterior part of the concave surface of the liver. This arrangement is more distinctly seen in the liver of the sheep than in the human liver. These lobules are parallel to the surface.

Fig. 2. Displays the three sets of branches constituting the hepatic veins.

A, A, A. The intralobular hepatic veins.

B, B. The sublobular-hepatic veins, in which the intralobular veins terminate.

C, C. Hepatic trunks, in which no intralobular veins terminate.

D. The mouths of intralobular veins opening into the sublobular veins.

E. The mouths of small sublobular veins.

F. The mouths of large sublobular veins.

Fig. 3. A longitudinal section of sublobular-hepatic veins, with lobules arranged around them.

A, A. Sublobular-hepatic veins.

B, B. Longitudinal sections of lobules, presenting a foliated appearance.

C, C. The bases of the lobules resting on the sublobular veins, and forming the canals containing them. The bases of the lobules are connected to the sublobular veins by the intralobular veins.

D. The external or capsular surfaces of the lobules.

E, E. The intralobular veins running through the centres of the lobules.

F. The projecting processes of the lobules, with their veins terminating in the central vein. The intralobular veins correspond in form with the lobules, the number of smaller veins being equal to the number of processes.

G. The mouths of intralobular veins opening into the sublobular vein.

Fig. 4. A. An oblique section of a sublobular-hepatic vein.

B, C, D, E, F, G. As in the preceding figure.

H. The bases of other lobules seen through the coats of the vein, and forming the canal in which the vein is contained. The centre of the base of each lobule is occupied by an intralobular vein.

I. The interlobular fissures seen through the coats of the vein.

Fig. 5. Longitudinal sections of an internal, and of two superficial lobules.

A. A sublobular-hepatic vein.

B. The convex surface of the liver.

C. An internal lobule, in which the smaller veins are seen commencing about the middle of the processes of the lobule, the substance of which completely surrounds them. The intralobular vein is also surrounded, except at the base of the lobule, where it makes its exit to terminate in the sublobular vein.

D. Two superficial lobules.

E. An intralobular vein commencing at the surface of the liver.

F, F. Two smaller veins, commencing at the surface and terminating in

G. An intralobular vein commencing at the surface. The superficial lobules are perforated by the intralobular veins, and when compared with the internal lobules, appear as if their upper portions had been removed.

H, H. The substance of the liver, formed by other lobules.

Fig. 6. A. A transverse section of a lobule.

B. The divided central intralobular vein.

C. The smaller veins, terminating in the central vein.

Fig. 7. A. A transverse section of a double lobule.

B, B. The smaller veins, terminating in

C. The divided central veins.

## Plate XXI.

Fig. 1. A. Angular lobules in a state of anæmia, as they appear on the external surface of the liver.

B. The interlobular spaces containing the larger interlobular branches of the hepatic duct, portal vein and hepatic artery.

C. The interlobular fissures, in which the smaller interlobular branches of the hepatic duct, portal vein and hepatic artery ramify.

D. Intralobular veins, occupying the centres of the lobules.

E. Smaller veins, terminating in the central veins.

Fig. 2. A. Rounded lobules in the first stage of hepatic-venous congestion, as they appear on the external surface of the liver.

B & C. The interlobular spaces and fissures; they are larger than those represented in the preceding figure, and contain more cellular tissue.

D. The congested intralobular veins.

E. Appearances produced by congestion of the intralobular hepatic veins, and of the central portions of the lobular venous plexuses, and constituting the medullary substance of FERREIN, the cortical substance of AUTENRIETH, the red substance of MM. BOULLAND, ANDRAL and other anatomists, and the cellulo-vascular substance of MAPPES. These appearances may be produced by injecting the central portions of the plexuses from the hepatic veins.

F. The non-congested marginal portions of the lobules, constituting the cortical substance of FERREIN, the medullary substance of AUTENRIETH, the yellow substance of MM. BOULLAND and ANDRAL, and the granular substance of MAPPES.

Fig. 3. A. Lobules in the second stage of hepatic-venous congestion, as they appear on the external surface of the liver.

B & C. Interlobular spaces and fissures.

D. The congested intralobular veins.

E. Appearances produced by more extensive congestion of the lobular venous plexuses. It will be remarked that in this, as in the preceding, figure, the intralobular veins and the central portions of the lobules are congested, but that, in this figure, the congestion is not confined to the centres of the lobules; that it extends to their margins and to those branches of the portal vein which ramify in the interlobular fissures; the congested substance is

consequently continuous, and the non-congested substance is in isolated patches. As the congestion extends from the hepatic to the portal vein, and as those branches of the portal vein contained in the fissures are smaller than those contained in the spaces, those in the fissures are congested before those in the spaces; the fissures are, therefore, in many parts rendered obscure, in consequence of the congested state of the smaller interlobular portal veins contained in them, and of the corresponding marginal portions of the lobules: the congestion not having extended to the veins in the spaces, those portions of the lobules immediately surrounding them are not congested. This is the red or medullary substance of FERREIN, now appearing cortical; in the preceding figure it appeared medullary; in this, it is continuous throughout the liver; in the preceding figure it was in isolated patches. This appearance also may be produced by injecting the plexuses from the hepatic veins.

F. Non-congested portions of lobules, much resembling, in some parts, transverse sections, and, in other parts, longitudinal sections of single lobules. These apparently whole bodies are composed of the non-congested, opposite, marginal portions of three or four contiguous lobules, the congestion not having extended to the portal veins ramifying in the spaces and fissures which are seen between the different portions of which they are formed. They are of a yellowish white or yellow colour, according to the quantity and quality of the bile they contain. These are the bodies represented by MÜLLER, Tab. XI. fig. 11, by M. BOULLAND, Plate II. fig. 1. and by Dr. HOPE, figg. 104 and 105. This is the non-congested, or yellow, substance now appearing medullary, and in isolated patches; in the preceding figure it appeared cortical and continuous. This is the nutmeg liver of pathologists, the hypertrophy of the red substance of M. ANDRAL.

Fig. 4. A. The lobules as they appear on the surface in a state of portal-venous congestion.

B. The interlobular spaces and fissures; they are of a darker colour than those represented in fig. 2, in consequence of the congested state of the interlobular branches of the portal vein.

C. The intralobular hepatic veins; containing no blood, they are smaller, and of a lighter colour than those represented in figg. 2 and 3.

D. The central portions of the lobules in a state of anæmia. This is the yellow or non-congested substance appearing medullary, and arising from non-congestion of the intralobular veins, and of the central portions of the lobular venous plexuses.

E. The marginal portions of the lobules in a congested state. This is the congested substance appearing cortical and continuous, as in the preceding figure, but arising from a different cause,—from congestion of the interlobular branches of the portal vein and of the marginal portions of the lobules. This appearance may be produced by injecting the marginal portions of the lobular venous plexuses from the portal vein.

Fig. 5. A transverse section of a large portal canal and its vessels. The lobules are in a state of general congestion, their central portions being more congested than their marginal portions.

A. Superficial lobules forming the parietes of the canal. They are similar to those of the external surface, being perforated by their intralobular veins. Some are observed in which these veins do not extend to the capsular surfaces of the lobules, this appearance depending on the direction in which the incision is made.

B. Internal lobules not entering into the formation of the parietes of the canal. In these lobules the intralobular veins are completely surrounded by the substance.

C. A transverse section of a portal vein.

D. Vaginal branches arising from the vein, and dividing into interlobular branches, which enter the interlobular spaces.

E. A transverse section of an hepatic duct.

F. A vaginal branch arising from the duct, and dividing into interlobular branches which enter the spaces.

G. The artery.

H. A vaginal branch arising from the artery, and dividing into interlobular branches which enter the spaces.

I. Three interlobular vessels, a duct, vein and artery entering each interlobular space.

J. The vaginal plexus, formed by the vaginal branches of the duct, vein and artery. The internal surface of the plexus is in contact with the large vessels; its external surface is in contact with the parietes of the canal. The vessels forming the plexus ramify in cellular tissue, which, with the vessels, constitutes the vaginal portion of Glisson's capsule. The capsule in these larger canals completely surrounds the three vessels.

Fig. 6. Represents a transverse section of a small portal canal and its vessels. The lobules are in a state of general congestion.

*a*. The portal vein, a great portion of which is in apposition with the interlobular spaces on the parietes of the canal.

*b*. The interlobular branches arising from the trunk and entering the spaces, with the branches of the duct and artery, without ramifying in the canal. On this side the vein resembles an hepatic vein in having no vaginal branches.

*c*. Two vaginal branches arising from the vein, and dividing into interlobular branches on that side of the canal on which the vein is separated from the spaces by the duct and artery. On this side, the vein, giving off vaginal branches, and being separated from the parietes of the canal by the capsule and vessels, resembles the larger portal veins.

*d*. The duct giving off vaginal branches.

*e*. The artery giving off vaginal branches.

*f*. Three vessels, a duct, vein and artery, entering each interlobular space on the surface of the canal.

## Plate XXII.

Fig. 1. A longitudinal section of a small portal vein and canal; the lobules are in a state of anæmia.

A, A. Portions of the portal canals, from which the vein has been removed. The parietes are composed of lobules, similar to those of the external surface of the liver, separated from each other by fissures and spaces.

B. The portal vein; the lobules and fissures are seen through its coats.

C. Mouths of interlobular veins, which, arising immediately from the portal vein, enter the spaces without forming a plexus. This portion of the vein, giving off no vaginal branches, and consequently having no capsule, resembles in these respects an hepatic vein.

D. Two larger orifices. These are the mouths of vaginal veins which enter the canal, and divide into two, three, or more interlobular branches.

E, E. The orifices of small portal veins, which enter other canals.

F. Vaginal branches arising from the vein and forming a plexus on that side of the canal occupied by the duct and artery. These branches are seen dividing into branches, which enter the spaces covered by the duct and artery.

G. The hepatic duct, giving off vaginal branches.

H. The hepatic artery, giving off vaginal branches.

Fig. 2. A longitudinal section of an hepatic vein. The lobules are in the first stage of hepatic-venous congestion.

A, A, A. Sublobular-hepatic veins, terminating in

B. An hepatic trunk. No intralobular veins terminate in this vein; its coats are not transparent; the hepatic-venous canal containing it is lined by a prolongation of the proper capsule.

C. The capsular surfaces of the lobules forming the canal, in which the venous trunk is contained. The veins of these lobules terminate in a neighbouring sublobular vein.

D, D. The parietes of the hepatic-venous canals, a portion of the vein having been removed.

E, E. The orifices of the intralobular veins, which enter the sublobular veins from the centres of the bases of the lobules forming the parietes of the canal containing the veins. Each orifice is situated in the centre of the congested portion (the red substance of FERREIN) of each lobule.

F. Longitudinal sections of lobules, the intralobular veins of which are seen terminating in the sublobular vein.

G. The orifices of intralobular veins less closely arranged than at E, E.

H. The capsular surfaces of lobules, which, with the bases of other lobules, form these canals.

I. The parietes of the canal containing this vein are formed by the bases alone of lobules.

Fig. 3. A. An hepatic duct.

B, B. The transverse branches of the duct.

C, C. Branches which ramify in the direction of the trunk.

D, D. Recurrent branches.

E. Smaller branches arising at the angles formed by the preceding branches.

Fig. 4. A longitudinal section of a portal canal, with an hepatic duct and its vaginal branches ramifying on the parietes of the canal. The lobules are angular and in a state of anæmia.

A, B, C, D, E. As in the preceding figure.

*f*. A vaginal duct leaving the canal and dividing into interlobular branches.

G, G. Ducts entering smaller portal canals.

## PLATE XXIII.

Fig. 1. Represents the internal surface of a small hepatic duct, with its follicles aranged in two longitudinal lines.

Fig. 2. An hepatic vein of the *Seal* laid open, and showing the circular fibres of which its external coat is composed.

Fig. 3. Represents the interlobular ducts entering the lobules, and forming the lobular biliary plexuses.

*a*. Two lobules.

*b, b, b*. Interlobular ducts.

*c, c, c*. The interlobular cellular tissue.

*d, d*. The external portions of the lobular biliary plexuses injected.

*e, e*. The intralobular branches of the hepatic vein.

*f, f*. The uninjected central portions of the lobules.

No such view of the ducts as that represented in this figure can be obtained in the liver. The interlobular ducts are, in the figure, seen anastomosing with each other: I have never seen these anastomoses, but I have seen the anastomoses of the ducts in the left lateral ligament, and, from the results of experiments related in this paper, I believe the interlobular ducts anastomose. I have never injected the lobular biliary plexuses to the extent represented in the figure.

Fig. 4. Represents the biliary ducts ramifying in the left lateral ligament of the liver.

*a*. The left lateral ligament of the liver.

*b*. The posterior edge of the left lobe of the liver.

*c*. The loose edge of the ligament.

*d*. That edge of the ligament which is connected to the diaphragm.

*e, e*. Biliary ducts emerging from the liver and ascending to ramify in the ligament.

*f*. Arches formed by the ducts towards the upper part of the ligament.

*g*. The plexuses formed by the minute ducts.

Fig. 5. Representing the interlobular branches of the portal vein, the lobular venous plexuses, and the intralobular branches of the hepatic veins of three lobules.

*a, a, a*. The interlobular veins contained in the spaces.

*b, b, b*. The interlobular veins which occupy the fissures, and which, with the veins in the spaces, form venous circles around the lobules. This is the appearance which the venous circles present when

examined with a common magnifying glass; they are, however, formed by numerous, and not by single, branches, as represented in the figure.

*c*, *c*, *c*. The lobular venous plexuses, the branches of which, communicating with each other by intermediate vessels, terminate in the intralobular veins. The circular and ovoid spaces, seen between the branches of the plexuses, are occupied by portions of the biliary plexuses, constituting the acini of MALPIGHI.

*d*, *d*, *d*. The intralobular branches of the hepatic veins, in which the vessels of the plexuses terminate.

Fig. 6. A transverse section of a portal canal, showing the relative dimensions of the vessels in the liver of the child, in which the portal vein terminated in the inferior cava.

*a*. The umbilical, or hepatic-portal vein.

*b*. Three arteries contained in the same canal.

*c*. The duct.

*a*. An hepatic vein.

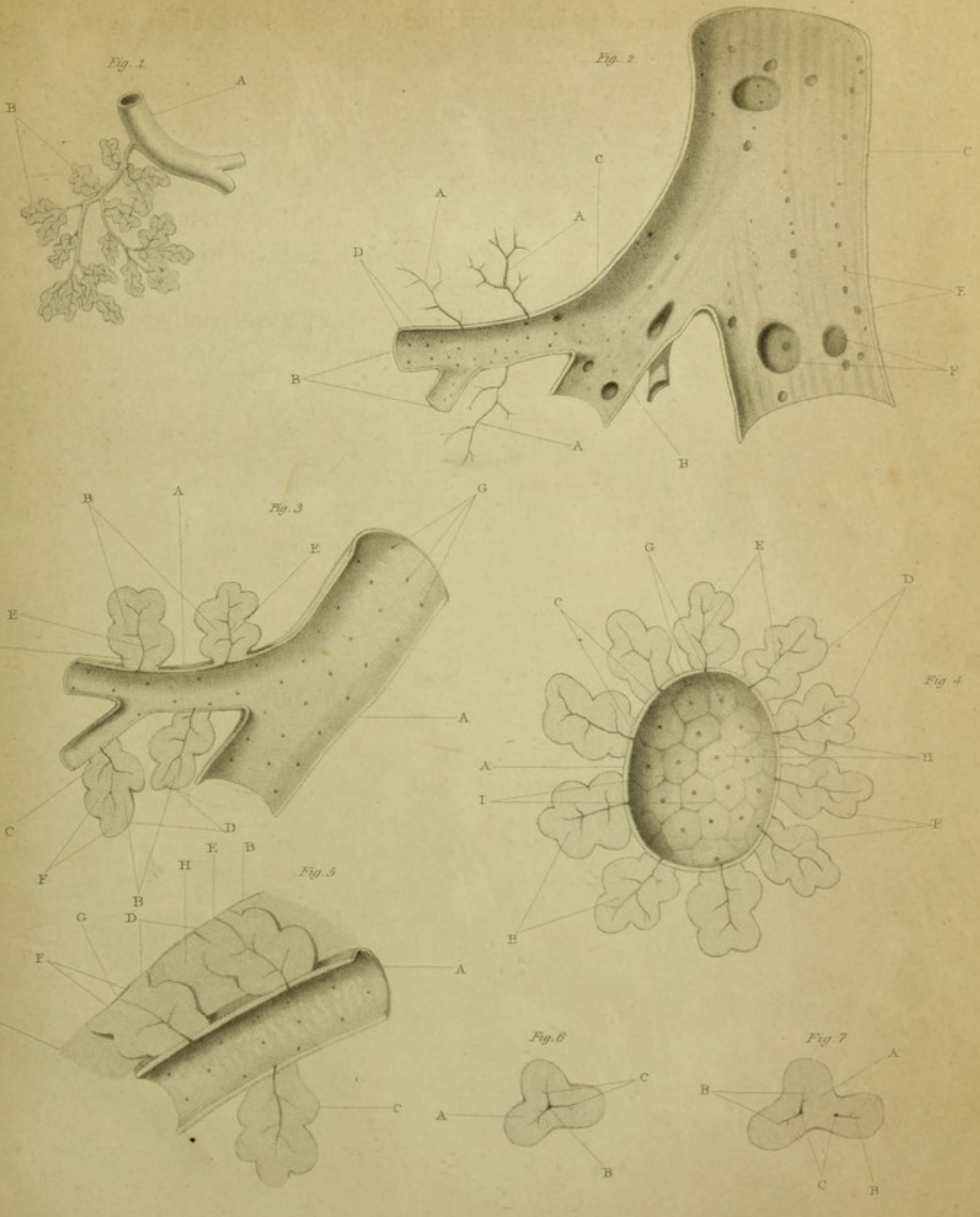
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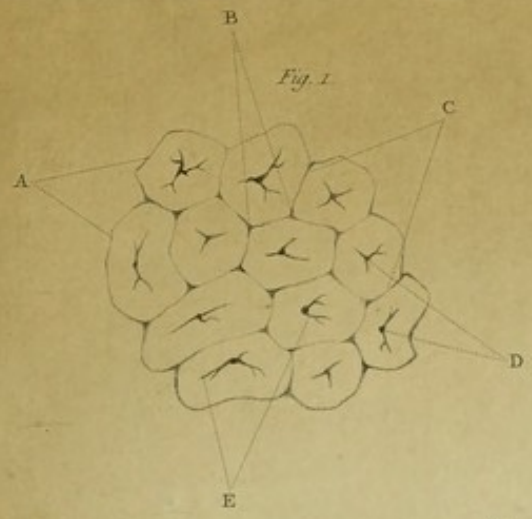
Fig. 1.

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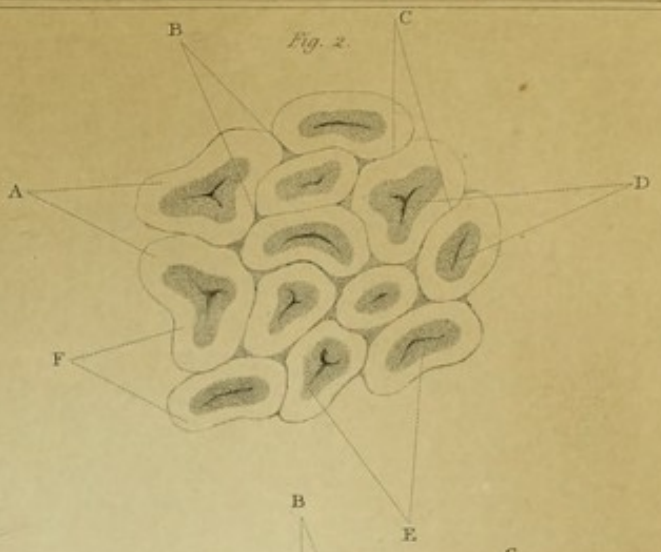


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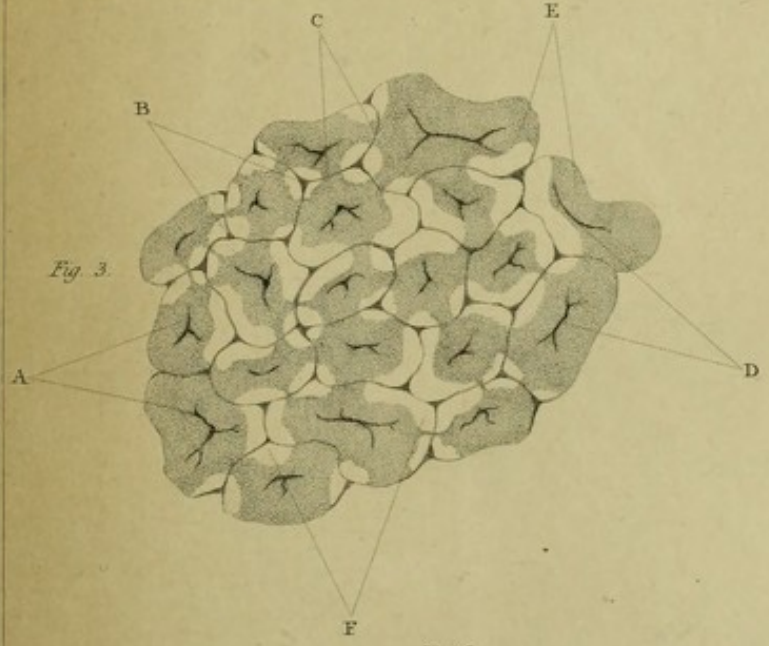


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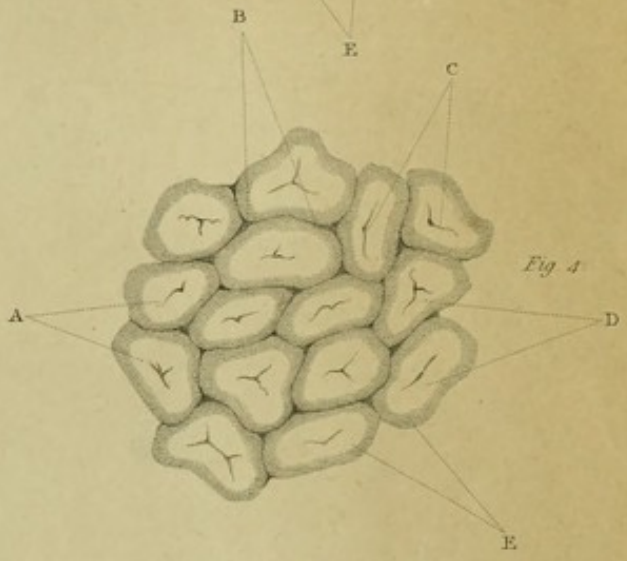


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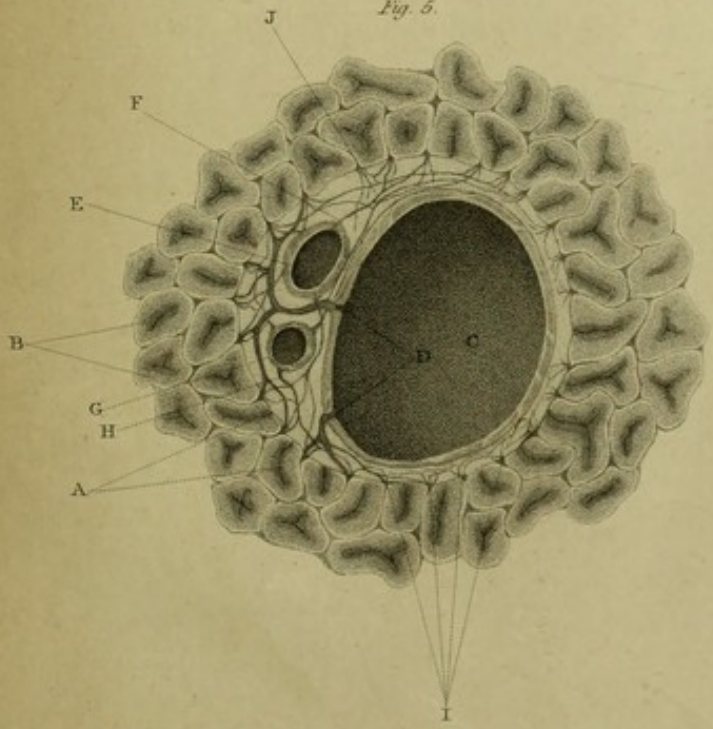


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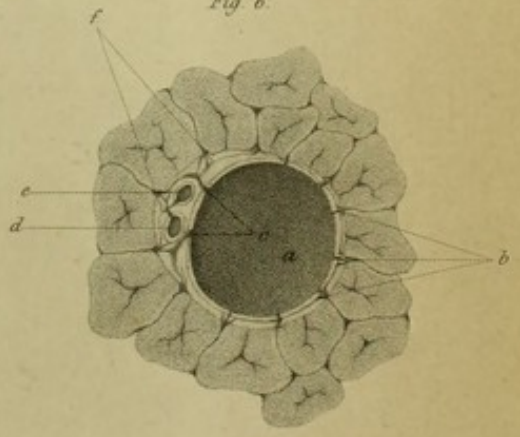

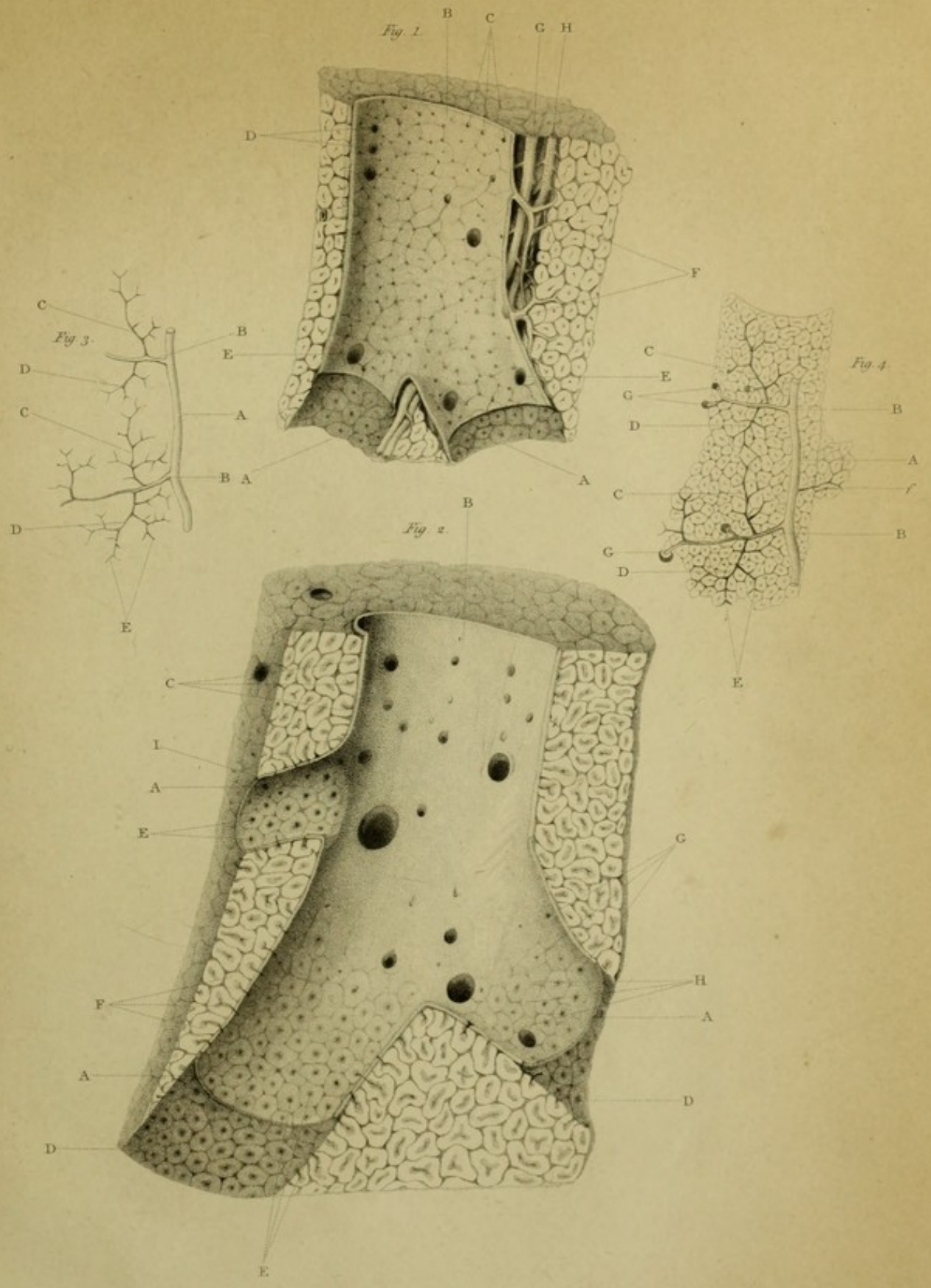
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Fig. 1.

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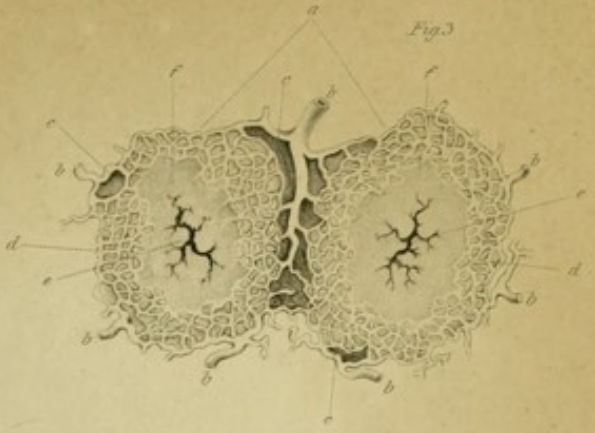
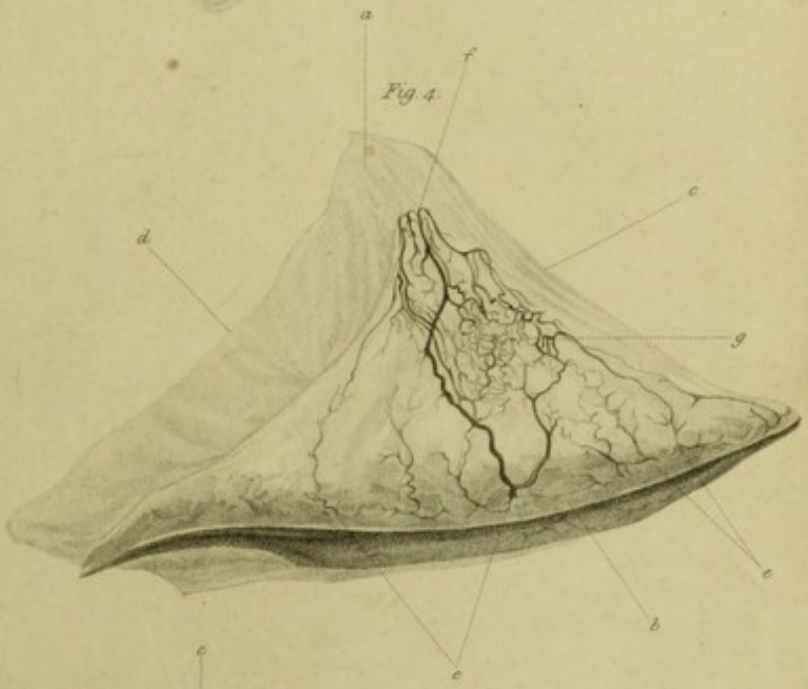



Fig. 4.

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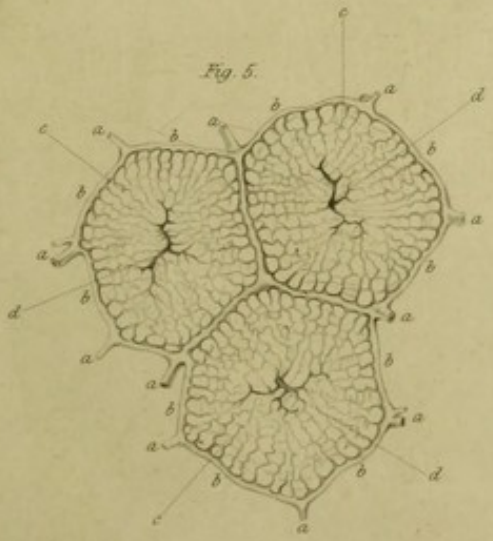


Fig. 6.