# THE DISCOVERY

OF THE

# NATURE OF THE SPLEEN,

FROM AN INVESTIGATION OF THE LATERAL HOMOLOGIES OF THE

## LIVER, STOMACH, AND INTESTINAL CANAL.

BY

HENRY R. SILVESTER, B.A., M.D.Lond.,

CLAPHAM COMMON, LONDON;

ASSOCIATE OF KING'S COLLEGE, LONDON; AND FORMERLY HUNTERIAN SCHOLAR IN HUMAN AND COMPARATIVE ANATOMY IN THE ROYAL COLLEGE OF SURGEONS OF ENGLAND.

Author of "The Discovery of the Physiological Method of inducing Respiration in Cases of Apparent Death from Drowning, Chloroform, Still-Birth, Noxious Gases."
"The Physiological Method of Treating Incipient Consumption, with Directions for its Prevention."
"A Contribution to the Science of Teratology," etc.



LONDON:
JOHN CHURCHILL & SONS, NEW BURLINGTON STREET.

MDCCCLXX.

"Thine eyes did see my substance, yet being unperfect; and in thy book all my members were written, which in continuance were fashioned, when as yet there was none of them."

Ps. cxxxix, 16.

"Ἔχει δ' ὁ ἄνθρωπος καὶ τὸ ἄνω καὶ τὸ κάτω, καὶ προσθία καὶ ὀπίσθία, καὶ δέξια και ἀρίστερα. τὰ μὲν οὖν δέξια καὶ ἀρίστερα ὅμοια σχεδὸν ἐν τοῖς μέρεσι καὶ ταῦτα πάντα, πλὴν ἀσθενέστερα τὰ ἀρίστερα."

ARISTOT.

# ON THE NATURE OF THE SPLEEN.

---

THE anatomy and physiology of the spleen have engaged the attention of philosophers from the days of Hippocrates down to the present time; there are, indeed, few parts of the human body on which more has been written than on the spleen, and none where the result has been more unsatisfactory. It becomes us, then, to approach this subject with due consideration. Haller, in beginning his observations, very sensibly admonishes his readers that "he is plunging into the region of mere conjecture, darker than in the case of any other viscus." A short historical recapitulation of the various theories respecting its functions will introduce us to some of the obscurities which require to be elucidated. It will, however, be unnecessary to dwell upon a vast number of hypotheses; for part of them are entirely destitute of anything like proof, and others are contradicted by experiment.

The most ancient opinion concerning the use of the spleen in the animal economy is that found in the writings attributed to Hippocrates, and is connected with the famous doctrine of the four humors (Hippocrates, 4th Book, *De Morb.*, tom. ii, page 325, ed. Kühn) *τῷ μὲν δὴ αἵματι ἡ καρδίη πηγὴ ἐστὶ τῷ δὲ φλέγματι ἡ κεφαλὴ τῷ δὲ ὕδατι ὁ σπλὴν. τῇ δὲ χολῇ τὸ χωρίον τὸ ἐπὶ τῷ ἥπατι αὐταὶ αἱ τέσσαρες τουτέοισιν εἰσί πήγαι ἄνευ τῆς κοιλίης.* The heart is the source of the blood, the head of the pituita, the spleen of the water, and the liver of the bile. The water was attracted by the spleen from the fluids received into the stomach, *φημὶ δὲ ἐπῆν ὁ ἄνθρωπος πίνῃ πλέον ἕλκειν ἐς ἑώυτον ἐκ τῆς κοιλίης τοῦ ὕδατος καὶ τὸ σῶμα κυὶ τὸν σπλήνα.* (*Ibid.*, p. 333.) In modern times, Charles Estienne supposed the vasa brevia distended with blood to be ducts proceeding from the spleen to the stomach, carrying fluid from one organ to the other. This opinion was soon afterwards set aside by the accurate observations of Vesalius, (*Opera omnia Anatomica*, Lugdun. Batav., 1725, pp. 437 to 440); and Sir Everard Home revived the old theory of Hippocrates, and made the spleen to receive a great portion of our drink from the cardiac extremity of the stomach. It was supposed to be transmitted directly from the stomach to the spleen by some unknown channel. This idea, however, after a series of experiments with coloured fluids, etc., he subsequently abandoned.

In another part of the Hippocratic collection (*De loc. in Hom.*, tom. ii, page 130) it is said that τοῖσι γὰρ αὔτοισιν ὅτεὸ σπλὴν θάλλει καὶ τὸ σῶμα φθίνει—those persons whose spleen is large have their bodies meagre—and which gave rise to the well-known comparison of Trajan, who said that the imperial treasury was like the spleen, because when that was rich the people were impoverished. "Namque ut ceteras omittam, Pompeia Plotina, incredibile dictu est, quanto auxerit gloriam Trajani; cujus procuratores cum provincias calumniis agitarent, adeo et unus ex iis diceretur locupletium quemque ita convenire, Quare habes? alter unde habes? tertius, Pone, quod habes; illa conjugem corripuit; atque increpans quod laudis suæ esset incuriosus, talem reddidit, ut postea exactiones improbas detestans, fiscum lienem vocaret, quod eo crescente, artus reliqui tabescunt." (Sexti Aurelii Victoris, epitom., cap. xlii, sec. 21.) The probable explanation of the observation, which has been confirmed in modern times, that the spleen is large when the stomach is filled with fluid, is to be found in the circumstance that the circulation through the spleen is liable to be obstructed by a congested condition of the portal system.

The symmetrical arrangement of the external organs of the body must be obvious to the most superficial observer. Symmetry expresses a fact; namely, that one half of an animal is usually an exact reversed copy of the other. The internal organs, also, are symmetrical. The term *azygos* (ἀζυγὸς) is applied by anatomical writers to certain parts of the body, which, being situated in or near the mesial line, appear singly and not symmetrically, or in pairs. This term, however (strictly speaking), is incorrectly applied; for each of these organs is composed of parts that were originally double or symmetrical, and which have coalesced in the middle line so completely as to appear single.

The celebrated Greek philosopher Aristotle draws attention to this arrangement of the animal body in his treatise *De Animalibus Historiæ*, lib. i, cap. xv: *Ἔχει δ' ὁ ἄνθρωπος καὶ τὸ ἄνω καὶ τὸ κάτω, καὶ πρόσθια καὶ ὀπίσθια, καὶ δέξια καὶ ἀρίστερα. τὰ μὲν οὖν δέξια καὶ ἀρίστερα ὅμοια σχεδὸν ἐν τοῖς μέρεσι καὶ ταυτα πάντα, πλὴν ἀσθενέστερα τὰ ἀρίστερα.* Man, however, has the parts of his body distinguished as the superior and inferior, the anterior and posterior, and the right and left. The right and the left parts, therefore, are similar and nearly the same, except that the left parts are less developed; and in *De Partibus Animalium*, lib. iii, cap. vii, Aristotle says: "*κατὰ δὲ τὸ ἧπαρ καὶ τὸν σπλῆνα δικαιῶς ἄν τις ἀπορήσειεν· τούτου δ' αἴτιον ὅτι ἐν μὲν τοῖς ἐξ ἀναγκῆς ἔχουσι σπλῆνα δόξειεν ἂν οἷον νόθον εἶναι ἧπαρ ὁ σπλήν.*" With respect, however, to the liver and spleen, it may be justly doubted whether they are bilateral or not, the cause of which is that in those animals that necessarily have the spleen, it may appear that the spleen itself is, as it were, a spurious liver. Again, in lib. iii, cap. iv, he says: *Ἧπαρ—ἔχει δ' ὥσπερ ἀντίζυγον ἐν τοῖς μάλιστ' ἀπηκριβωμενοῖς τὸν σπλῆνα.* The liver—but in the most accurately formed animals it has the spleen, as it were, opposite to it. If, then, the spleen is symmetrical with the liver, why is there any need of discussion about it? Why is this not conclusive evidence that the spleen is the undeveloped liver of the left side of the body, and if it is the undeveloped liver of the left side, may it not be supposed to assist in the function of the liver—namely, the secretion of bile? These questions, amongst others, will require our attention further on.

With regard to the function of the spleen, Aristotle says that "It is not an organ necessary for all animals, and that it assists the liver in performing the function of digestion; that the spleen attracts from the stomach the superfluous and excrementitious humours (chyle) and concocts them."

Plato, in the *Timæus*, makes mention of the spleen, and says: "On this account, when certain impurities are produced about the liver through bodily disease, then the spleen, purifying these by its rarity, receives them into itself, from its being a hollow and bloodless contexture."

Diocles of Caristus, who flourished a little time after Aristotle, confirmed the statements which his predecessor had advanced. A period of repose ensued for several centuries, until two celebrated anatomists arose in the Alexandrian school who, favoured by the permission of Ptolemy Lagus, the first of the Egyptian princes, with diligent research elaborately dissected the human body. These were the celebrated Herophilus, and Erasistratus, the pupil of Chrysippus, his contemporary, and were the means of giving to anatomy the rank of a true science. It is surprising that so eminent an anatomist as Erasistratus, notwithstanding these advantages, and while confessing that nature does nothing without a reason, should, nevertheless, consider the spleen to be a useless organ, an opinion adopted also by Rufus Ephesius, and apparently by Pliny, who says that runners used to have their spleen removed in order to increase their speed. The followers of Erasistratus dissented from this opinion of their master, and said that the spleen first prepared the chyle, which the liver afterwards turned into blood.

The opinion of Galen was that the humour called black bile is secreted by the spleen in the same way as the yellow bile is secreted by the liver, and it was from the supposed accumulation of this humour that persons affected with melancholy were believed to suffer. "Galen's opinions received universal assent, not only from the physiologists of his time and the Arabians, Avicenna, etc., but prevailed throughout the ages of darkness and barbarism, and were even defended by those anatomists who lived in the commencement of the sixteenth century at a time when science and literature were again revived, and when the intellectual powers became again roused after a repose of more than a thousand years" (Gray).

In the works of Aretæus, there is no fresh addition to our knowledge of the anatomy of the spleen; but his opinion, which is held in a modified form even at the present day, is that the spleen is nourished by black blood, of which it is the receptacle, and that, when it is diseased, this fluid is not elaborated by it, but is taken into the general circulation. He, in effect, separates the function of the spleen from that of the liver, and regards the spleen as a blood-gland.

Serenus Samonicus seems to consider the spleen as the organ of mirth, and that after its removal a person never laughed.

> "Splen tumidus nocet, et risum tamen addit ineptum,
> Ut mihi Sardois videatur proximus herbis,
> Irrita quæ miseris permiscent gaudia fatis.
> Dicitur exsectus faciles auferre cachinnos,
> Perpetuoque ævo frontem præstare severam."

It seems, at first sight, strange that, as the organ was considered to be the seat of mirth and laughter, the words *spleen*, *spleenful*, *splenetic*, etc., should be commonly used now to signify exactly the contrary state of mind. This opinion has probably arisen, first, from the spleen having been supposed to secrete the black bile, *μέλαινα χολή*, whence the word melancholy is derived; and secondly, from its having been considered as one of the causes of melancholy when "he doth not his duty in purging the liver as he ought, either too great or too little in drawing too much blood sometimes to it, and not expelling it" (see Burton's *Anatomy of Melancholy*, part i, sec. 2, men. v, sec. 4, and elsewhere). Oribasius, Alexander Trallianus, Paulus Ægineta, Joannes Actuarius, Haly Abbas, Theophilus Protospatharius, and Meletius agree with Galen concerning the functions of the spleen. According to Avicenna, the spleen by its vascularity imparts warmth to the stomach. Hofman mentions that some of the Arabic writers considered the office of the spleen to be to cool and refresh the heart. In other ancient writers, as, for example, St. Ambrose (*Hexaem.* lib. vi, sec. 71), "we find a slight modification of Galen's opinion; viz., that the spleen is placed near the liver in order to draw away the useless part of the aliment, and so, after retaining that which is necessary for its support, to transfer the purified and subtle remainder through the liver to the blood." (See *Penny Cyclopædia.*)

Joh. Guinterius follows Galen's description—"corpus hujus visceris, quod parenchyma vocant, rarum et laxum est spongiæ modo, ut facilius crassos humores et jecoris alliciat."

"Charles Estienne supposed the vasa brevia distended with blood to be ducts proceeding from the spleen to the stomach—an opinion soon afterwards set aside by the accurate observations of Vesalius. About 1578, a new theory of its use was suggested by Franciscus Ulmus in his Monograph, the first published on the anatomy of this gland, a theory, however, not founded on extended observations on the anatomy of the organ. He supposed that its office was to prepare blood for the heart and arteries, the material from which it is formed being the chyle, which is brought from the stomach by a large vein (the gastric) to the spleen by a branch of the vena portæ, the formed blood being returned to the heart by the splenic artery and aorta. Fel Plater also believed that its office was rather the elaboration of blood than the attraction of the melancholic juice, although he explained the method by which the blood was elaborated differently from Ulmus. He also argued that, as all azygos parts are placed in the median line of the body, the spleen cannot be one, as it corresponds in situation and structure with the liver, and therefore must be the liver of its own side, an opinion which he attempted to prove by many arguments." (Gray.)

It is unnecessary here to enumerate the various modern hypotheses, which are mostly fanciful and imaginary. It will be seen from the foregoing, that the more important theories concerning the nature of the spleen may be placed in two divisions:—in one in which the spleen is to be regarded as essentially connected with the liver, both functionally and anatomically, being the liver of the left side of the body, and this theory rests mainly for support upon the law of symmetry; and, in another division, where the spleen may be considered to be a blood-gland, having little or nothing to do with the liver either functionally or anatomically, its function being the elaboration of the sanguineous fluid. The liver in this case is regarded as an azygos and symmetrical organ, the left side being but slightly developed; and the spleen is looked upon as partaking of the nature of a lymphatic gland, not symmetrical with the liver, but a mesial organ, and as an appendage of the sanguiferous system.

One great difficulty in demonstrating that the spleen is the liver of the left side is, that the spleen cannot in any case be proved to secrete true bile; whilst the difficulty in the other supposition is, that the liver cannot be shown to be a symmetrical or azygos organ.

In modern times each division has found an advocate. Doellinger is in favour of the spleen's being regarded as symmetrical with the liver; and Müller regards it as a blood-gland. The greater number of modern physiologists appear to have followed Müller, and the study of the relative position and form of organs which had been the almost exclusive task of the elder school has now been thought to be of comparatively slight importance; whilst the intimate composition of all the organs has been investigated with unparalleled zeal and singular success.

Doellinger says:—" Symmetrisch mit der Leber bildet sich das Milz, ein theils an und für sich, theils in seinem Verhältnisse zur Leber, besonders merkwürdiger Theil. Die in dem Sacke des Bauchfells eingeschlossenen Eingeweide zeichnen sich durch Mangel an Symmetrie aus, und so ist denn auch die Leber selbst unsymmetrisch gestaltet und insbesondere nicht gepaart. Der Leber gegenüber befindet sich das Milz und die Bauchspeicheldrüse, welche an die Stelle einer vollendet symmetrischen Paarung der Leber zu treten scheinen. Auf der linken Seite des Darmkanals wäre sohin in zwey Theile getrennt, was auf der rechten in ein Eingeweid vereinigt ist; eine Trennung wozu sich mehrere Beispiele auch an andern Theilen aus der vergleichenden Anatomie anführen lassen. Mann kann die Leber für eine Vereinigung des Milzes und einer Speicheldrüse ansehen, Mann kann aber auch sagen, es habe sich in der linken Seite der Unterleibshöle das Parenchyma der Leber und die ausfuhrungs-gänge derselben getrennt aus jenem sey das Milz, aus diesem die Bauchspeicheldrüse enstanden Wahrscheinlich giebt hierzu die herrschende Magenbildung den Anlass. An und für sich wäre also das Milz ein Product der unvollständig symmetrischen Bildung, und einer durch äussere Bestimmungen herbey geführten Trennung; woraus man einsieht, warum keine absonderung, wenigstens keine ausführung in ihm geschehen könne. Ist einmal das Milz enstanden so hat es zur Leber in so ferne die Milzvene als ein ast zur Bildung des Pfortaderstammes beyträgt, kein anderes Verhältniss als die übrigen Eingeweide des Unterleibs. Man denke sich doch keinen zweck wo keiner ist." *Grundriss der Naturlehre des Menschlichen Organismus.* Von Ignaz Doellinger, M.D., 1805.

Müller, in his *Elements of Physiology*, classifies the spleen with the suprarenal capsules, the thyroid and thymus gland, as was originally suggested by Ruysch, who also arranged the liver under the same category. He says:—" These are glands unprovided with an efficient duct; they agree in having the common function of impressing some change on the blood which circulates through them, or in yielding a lymph which plays a special part in the process of chylification and sanguification; for the venous blood and the lymph are the only matters returned by them into the general system."

" The spleen is met with only in the vertebrate classes, and in them it is nearly constant. In the cetacea the organ is divided into several smaller masses. In man and mammalia the spleen lies in the fold of peritonæum, which is continuous with the serous covering of the anterior and posterior surface of the stomach, and extends between the great curvature of the stomach, the diaphragm, and the transverse colon, and which at the part where it connects the stomach to the transverse colon is called the great omentum. This portion of peritonæum passes originally from the spinal column in the middle line to the great curvature of the stomach, forming a mesogastrium in which the spleen was developed. The spleen, therefore, is not an organ proper to the left side of the body, of which the fellow of the opposite side is wanting. It should be regarded as an organ originally situated in the middle line, just like the liver, which at first, when its two lobes were equal, did not belong to the right side more than to the left."

And again: " All the theories which regard the spleen as essentially connected in its function with the liver can be shown to be fallacious. Doellinger supposes the spleen to be formed merely for the sake of symmetry to be the fellow of the liver,—the rudimentary liver, as it were, of the left side. But the liver is originally symmetrical; and the spleen is, as we have already described, developed in the middle line—no greater value can be accorded to the circumstance that the splenic veins join the vena portæ, and the hypothesis thence deduced that the spleen prepares the blood for the secretion of the bile; for, in this respect, it does not differ from all the chylopoietic viscera, nor even from the inferior extremities in the lower vertebrata and the generative organs and air-bladder of fishes. We know that its importance in the economy is not great."

Müller's assertions appear to have obtained universal acceptance; though, on further inquiry, they will be found singularly unfortunate; and he concludes them by admitting that we are still ignorant of the office of the spleen. The inability to assign any function to this organ is, probably, a reason for grouping it with other ductless glands. Again, it is quite a different thing for an organ to be formed symmetrically with another and to be formed merely for the sake of conforming to the law of symmetry. In mammalia the large size of the splenic artery (frequently the larger branch of the cæliac axis) and vein, and the great pathological changes which are known to occur in the spleen, negative the idea of the spleen being formed merely for the sake of symmetry; moreover, that the spleen is an useless organ, or even one of little importance, is not established by the fact that important results do not follow upon its removal; for the removal of a kidney, a lymphatic gland, an ovary, a breast, an eye, an ear, etc., is not attended with serious consequences. Müller asserts that the liver itself is a symmetrical organ. Now, if this could be proved, nothing would be wanting to complete the idea of symmetry; but of this, more hereafter.

Again: the spleen, he attempts to show, is developed in the middle line; nevertheless, he groups it with the supra-renal capsules,—lateral organs,—and he brings to his aid for this purpose the dispositions of the peritonæum; he could not have chosen a more fallacious guide. The peritonæum itself is evidently unsymmetrical; moreover, the situation of the spleen varies considerably in the vertebrate series, being sometimes attached to the liver or to the pancreas or bound to the transverse arch of the colon or placed behind the stomach, etc. Again: if the spleen be, as he asserts, developed in the middle line of the body, it ought itself to exhibit a bilateral symmetry, which, however, it does not; and, Müller having claimed for the liver a mesial position, on the assumption that it is a symmetrical organ, it is incumbent upon him to show that the spleen is also symmetrical. With regard to the observation, that in the cetacea the organ is divided into several small masses, we have it on the authority of Gray, that, in the great northern whale (*Balena mysticetus*) this organ is single; in the porpoise, no doubt, there are several spleens; and in the dolphin the spleen has many lobes. Müller discredits the hypothesis that the spleen prepares the blood for the secretion of the bile on the ground that the splenic vein joins the vena portæ, as do also the veins of the inferior extremities, in the lower vertebrata; but why the spleen may not, on this account, aid in this function, does not appear; and its vein joining the vena portæ, which is admitted to be instrumental in the biliary function, is favourable to the view that it may, in common with it, assist in this important matter.

It must be evident, then, from the foregoing observations that, in order to elucidate the nature of this mysterious organ, two subjects must be investigated; namely, the symmetrical arrangement of the organs of the body and the nature of the function of the spleen.

Let us consider, in the first place, the question of symmetry. Pittard is an advocate in favour of the symmetry of the abdominal viscera. His views, indeed, appear almost identical with those of Müller. He says:—" The hepatic attachments of the falciform ligament and the gastro-splenic omentum land-mark the original median line of the liver, and that larger part of which is to the right of the ligament, and behind the omentum is the right lateral homologue of that lesser part which is to the left of the ligament and in front of the omentum. The anterior wall of the stomach is the left lateral homologue of the posterior wall. The spleen is an originally median organ, situated in the originally median meso-gastrium. The great omentum is a pouching out of the meso-gastrium towards the left; consequently, its outer surface is the left lateral homologue of its inner surface. The pancreas is an originally median organ, one end of which has been displaced along with the pylorus towards the right, so that its anterior aspect is the left lateral homologue of the posterior. Passing now from the regions of speculation, the intestinal canal can be witnessed in the embryo as a straight, uniform, mesial, and symmetrical tube, until its length, having become greater than that of the region which it is destined to occupy, it is compelled to arrange itself in gyrations and loops. The posterior and anterior walls of the stomach were originally, as indicated above, its right and left halves, and as to the other parts of the alimentary tube, whatever difficulty there is in recognizing the manner of their displacement in the human subject, is at once dispelled by examining their condition in the lower animals. No difficulty whatever is encountered in respect of the small intestine, for the mesentery is attached nearly in the median line. The bowels themselves, however, are continually varying their position, relative and positive, according to the manner of packing most convenient for their variable contents. Not so easy is it to understand the kind of displacement which has taken place in respect of the large intestine. The colon is curled back and crosses over the small intestine from right to left, forming a loop. In the human subject the true relation of these parts is further marked by the singular circumstance of this crossing over occurring just at the point where the meso-gastrium, after having descended as the great omental bag is returning to the spine, and the colon finding it there, so to speak, avails itself of it and uses it as a mesentery. Anatomists have named the borrowed portion of the meso-gastrium, the transverse meso-colon. In Ruminants, the colon being exceedingly long, avails itself also of the mesentery of the small intestine into which a loop of it is thrust further and further, until it makes three turns, so that in tracing the colon onwards with the finger, you make the spiral turns in the mesentery, and then double and return by the spiral turns placed between the former spirals. On the other hand, in the Carnivora, where the colon is very short, it crosses over the lower end of the ileum, so near its termination, that it is evident that the next degree of shortening must result in the continuation of the small and large intestine in a straight line. This actually takes place in the Reptilia, and then there is no longer any difficulty in recognizing the original mesial and symmetrical position of the intestinal tube, and its appendages, so displaced in the human subject as to make this recognition so extremely difficult."

It is only necessary to say here that the above speculations in favour of the symmetrical arrangement of the alimentary canal and its appendages rest too much upon the fallacious guide—the dispositions of the peritonæum; it must be evident that these dispositions vary in accordance with the variable situations of the organs it envelopes. The viscera being in all cases outside of the peritonæum, a much more trustworthy guide will be found in the structural form of the organs themselves, in their development, their vascular supply, their nerves and lymphatics, and their various forms in the vertebrate series.

Having presented to our readers the above views in support of the symmetry of the alimentary canal and its appendages, we now proceed to collect evidences of want of symmetry.

I may here just cite a few most notable exceptions, from comparative anatomy to symmetrical development.

*In Mammalia.*—In the male narwhal the left incisor tooth attains the enormous length of eight or ten feet; while the right one is found as a rudiment that never pierces the gum. The left nostril of most of the Cetacea is constantly much larger than the right.

In *Aves* a most remarkable exception to symmetrical development exists in the female generative organs. The left ovary and oviduct alone are functionally evolved; whilst the right, being atrophied at an early period, are barely appreciable in the adult animal.

*In Reptiles.*—The lungs of reptiles are usually two symmetrical organs; but in Ophidia the left lung, when it exists, is much shorter than the right; and, in some, as Coluber thiringicus, it is wanting altogether, the only vestige of it being a cæcal depression on the left side of the lower end of the trachæa; the absence of the left lung entails, of course, the loss of the left pulmonary vessels.

There can be no doubt that the left side of the human body is somewhat less fully developed than the right side. Again, the want of symmetry which is apparent in the great abdominal viscera and their appendages has been attempted to be explained by supposing that it depends entirely upon the lateral displacement and excess of growth of one side over the other, having reference to convenience of packing. This a-symmetry is greater in mammalia than in reptiles and fishes on account of the presence of the diaphragm which, so to speak, thrusts the abdominal viscera downwards, necessitating lateral displacement, &c. ; it attains its greatest acme in man, owing to the great lateral measurement compared with the antero-posterior distance which is so conspicuous in his figure when contrasted with that of the other animals. Now this idea will be entirely dispelled by an examination of the minute anatomy of the various organs, and by such an instance of want of symmetry as is presented by the gall-bladder, &c.

I conclude it will be conceded at once that the cerebro-spinal axis, the respiratory, urinary, generative and sanguineous systems are symmetrical.

It may, in the first place, be noted that those portions of the nervous, respiratory, uriniferous and reproductive systems which are situated at the sides of the body are represented by distinct unilateral organs, but those parts which are situated in the mesial line are bilateral and symmetrical, whether they are divided by a septum, or have their cavities freely opening into each other.

To proceed, then, with the anatomy of the digestive system. The upper part of the alimentary canal as far as the commencement of the stomach is strictly symmetrical. The frenum connects the lips with the gums, and marks the union of the two sides. The vertical line on the middle of the lower jaw indicates the original division of the bone into two lateral parts. The raphé along the middle of the whole length of the tongue indicates its bilateral symmetry, and at the base of the tongue, and in the midst of the muscular substance, will be found a vertical layer of fibrous tissue, which forms a partial septum between the two halves of the organ, and in the dog tribe a fusiform fibro-cartilage is known to exist in the middle of the tongue, near its under surface. The arteries of the tongue, derived from the linguales, are on each side of the septum. In the middle line of the hard palate is a ridge which marks the junction of the bones, and the soft palate is marked by a slight median ridge, which descends towards the uvula, and indicates the original separation of the velum into two lateral halves. The salivary glands also are similar, and the pharynx and œsophagus are each composed of two precisely similar lateral halves, and each side is supplied with vessels from the corresponding side of the body.

At the junction of the œsophagus with the stomach the symmetrical arrangement suddenly ceases. Some explanation is here required. It is to be noted that an organ may be apparently only developed symmetrically, that is to say, the anterior part may correspond with the posterior part, as, for instance, the anterior portion of the kidney may correspond with the posterior part of the same kidney; but the anterior part of the kidney is not the homologue of the posterior part; for the right kidney is the homologue of the left kidney. Just so in the stomach; the anterior wall of the stomach, even if corresponding accurately with the posterior wall, is not therefore the left lateral homologue of the posterior wall. It will be found, on examination of the process of development of the stomach, that the right or pyloric side of this organ goes on developing, whilst the left side or great end terminates in a large cul-de-sac; so that the œsophageal opening is much nearer the great than the pyloric end, and the stomach consequently extends across to the right side of the abdomen beneath the liver and the diaphragm. The muscular and mucous coats will be found developed accordingly, being thinnest in the great cul-de-sac and thickest at the pyloric end.

The outermost layers of muscular fibres radiate from the œsophageal orifice, and are found in greatest abundance along the lesser curvature towards the pylorus; they are arranged closely together and form a thick uniform layer, which becomes continuous with the longitudinal fibres of the duodenum; the second set, or the circular fibres, surround the body of the stomach with large circles, but at the left extremity of the great cul-de-sac they become small and thinly scattered rings; towards the pyloric end they again form smaller rings, and at the same time become much thicker and stronger than at any other point; at the pylorus itself they are gathered into an annular bundle, which forms the pyloric sphincter. The innermost layer, or the oblique fibres, descend obliquely upon the anterior and posterior surface of the stomach, where they spread out from one another, and gradually disappear. The gastric mucous membrane is thickest in the pyloric portion of the stomach, and thinnest in the great cul-de-sac, and the tubuli are shorter, and are simply tubular; but on approaching the pyloric portion they gradually become larger, and assume a more complicated form, for, though quite straight near the orifices, they are convoluted, or irregularly sacculated, towards their deep or closed extremities, and these characters are most perfect near the pylorus. The lenticular follicles, though found in greater or less numbers all over the stomach, are most numerous towards the pylorus.

We find that the azygos, or mesial organs, are supplied by two vessels from the corresponding sides of the body; but when we examine the stomach we at once detect an exception, for although it is a highly vascular organ, the aorta gives off only one artery to the stomach, the coronary; when, however, this artery is not given off directly from the aorta, it is associated in its origin with the hepatic on the right to the liver, and the splenic artery on the left to the spleen.

The lymphatics of the stomach may be arranged in three sets: one set accompanies the coronary vessels, and receiving, as it runs from left to right, branches from both surfaces of the organ, turns backwards near the pylorus to join some of the larger trunks; another series of lymphatics, from the left end of the stomach, takes a different course, and follows the vasa brevia, and unites with the lymphatics of the spleen; whilst the third set inclines from left to right, along the great curvature of the stomach, from which it passes backwards, and terminates in one of the principal lacteal vessels.

The prevertebral portion of the sympathetic system of nerves comprises three large aggregations of nerves, or nerves and ganglia, situated in front of the spine; they are single or unsymmetrical. The coronary, or stomachic plexus, consists of numerous filaments, which are enclosed within the small omentum, and are guided by the coronary artery to the stomach. They form an interlacement by branches of communication one with another, also with the terminal branches of the pneumogastric nerves, and finally spread out on *both* surfaces of the stomach.

We must now direct attention to the state of the stomach in the vertebrate series, from which it will be apparent that, whilst the pyloric portion remains pretty constant in form, it is distinct from the cardiac end, both anatomically and physiologically.

*In mammalia.* In the quadrumana the stomach often resembles that of man, but it is sometimes globular, or elongated, sacculated, constricted, or bent on itself; but whatever is the shape, a distinction between a cardiac and a pyloric portion is always recognisable.

In the carnivora the stomach also presents the human shape, but the cardiac pouch is larger. In the insectivorous cheiroptera the stomach is globular. In the vampire, although it is long and conical, the cardiac end is the larger. In the frugivorous species it is still longer; the cardiac pouch is constricted in its middle, and the pyloric portion is bent. In the proper insectivora this organ is elongated.

In the edentata it is usually simple; but in the genus manis the cardiac and pyloric portions are marked off by an internal fold, and in one species a long sac extends from the pyloric portion. In the sloth the stomach is first divided into a cardiac pouch and a pyloric portion, the former has a dense epithelium, and is again subdivided into two parts, one ending in a blind canal. The pyloric portion has thick walls and a soft mucous membrane, and is subdivided into parts which might be compared with the third and fourth stomachs of ruminants. In the ant-eater the cardiac part of the stomach constitutes a kind of crop, whilst a second chamber, having thick walls and a hard gristly lining, somewhat resembles the gizzard of the bird, and compensating for the want of teeth, crushes the ants by aid of the sand swallowed with them.

In ruminants the stomach presents the most remarkable complications. The cardiac end, variously subdivided and modified, is often lined by a thicker epithelium, but as it has been regarded as a dilatation of the œsophagus, we shall not dwell upon the description.

In the pachydermata, the stomach is more simple: thus it is elongated, and possesses a long cardiac pouch in the elephant and rhinoceros; but in the former it presents numerous internal transverse folds; the hippopotamus has two cardiac pouches opening widely into the rest of the stomach. In the tapir and hyrax this organ forms two cavities. In the pig the stomach resembles that of man, though the cardiac end is more projecting, and a considerable extent of the lining membrane, near the œsophageal opening, is covered with thick epithelium. In the peccary still more of the cardiac portion is lined with a dense epithelium. In the solipeds the stomach is rounder, the œsophageal and pyloric openings are near to each other, and the cardiac portion is lined by a thick epithelium, which terminates in a dentated margin. In the rodentia the stomach is often marked off by a cardiac, and a pyloric portion, often indicated by an external constriction.

Marsupials have a simple, somewhat elongated stomach. In the kangaroo the stomach is as long as the body, and the middle portion is sacculated, and marked by three longitudinal folds. It has three compartments, two being cardiac pouches, and also three rows of large crypts, along the bands.

Among cetacea the dugong has this organ elongated, and marked off into a cardiac and a pyloric portion by a constriction, from near which two blind pouches proceed.

*In Birds.*—The digestive canal is usually complex; the œsophagus being more or less dilated near its lower end to form the crop to which succeeds the proventriculus, or proper secreting stomach, and beyond this is a third cavity, forming the gizzard. The crop is most developed in the grain-eating gallinacea, forming a dependent bag connected with one side of the œsophagus, as in the fowl, or as in pigeons, consisting even of two lateral oval sacs. The second, or lower œsophagus, has no constricted cardiac orifice. The proventriculus, the true glandular stomach, varies in form, being sometimes wide and straight, sometimes round. The gizzard is the third, or muscular stomach of birds. A pyloric valve usually exists in birds.

*In Reptiles.*—The alimentary canal in this class is more simple than in birds, to which, however, it approaches more nearly than to that of fish. The œsophagus, as in birds, joins the stomach without any constriction or cardiac orifice. In the large saurians, the first part of the stomach has the form and structure of the gizzard. The pyloric part is more decidedly glandular, and corresponds with the short portion sometimes found between the gizzard and the duodenum in birds. In the serpents the cardiac part of the stomach is long, slightly sacculated, and highly dilatable, whilst the pyloric portion is narrower, and very muscular, being the only part like a gizzard. In the chelonians the stomach is curved, and larger at the cardiac than at the pyloric end. The pyloric valve is usually present in reptiles, though not very distinct. In amphibia the stomach is fish-like, being tubular, wider at the cardiac than at the pyloric end, and placed transversely or curved upon itself.

*In Fishes.*—The alimentary canal presents its most simple vertebrate form, being wide and short. The œsophagus, short, wide, and muscular, sometimes passes so evenly into the stomach, that the structure of the mucous membrane alone distinguishes them. In the cyclostomata it forms only a dilated portion of the nearly straight canal. In the osseous fishes it is usually tubular, bent once upon itself, and narrower towards the pylorus, sometimes it becomes flask-shaped, or globular, with its cardiac and pyloric openings placed near together; the cardiac orifice is large, and sometimes provided with a valvular fold; the pyloric part is sometimes so muscular as to resemble an imperfectly developed gizzard; a pyloric valve nearly always exists. In the singular amphyoxus the alimentary canal is short, and nearly straight, the stomach being scarcely dilated. (Marshall).

All through the vertebrate series there are clear indications that the stomach is composed of two parts, physiologically distinct from each other, a cardiac and a pyloric stomach, more or less united in the mesial line. The pyloric stomach remains in a very uniform condition, whilst the cardiac stomach assumes various forms. The cardiac stomach we regard as the homologue of the pyloric stomach, but remaining in a condition of incomplete development—the cardiac stomach being unprovided, at its left extremity, with a valvular apparatus resembling the pylorus.

We now pass on to the consideration of the anatomy of the intestinal canal. The small intestine is usually regarded as occupying normally a mesial position, and this is supposed to be rendered certain by the consideration that the mesentery is attached *nearly* in the middle line. There is nothing, however, in the small intestine which indicates a symmetrical arrangement of its parts; the patches of Peyer's glands are placed lengthways in the intestine, at that part of the tube most distant from the mesentery; but the patches are never placed symmetrically on each lateral aspect of the bowel, and the other glandular structures are scattered freely all over the mucous membrane. If the stomach is to be regarded as a mesial organ, it follows that the small intestine which is a continuation of it, is also a mesial organ, but this view affords no explanation of the stomach's projecting to the right lateral region, nor of the small intestine's describing a large curve from the right side towards the middle line of the abdomen; but if we assume that the stomach is fully developed towards the right side, the course both of the stomach and the intestine becomes at once perfectly clear, and the direction of this portion of the alimentary canal from the right side to a median position is further explained by its course being directed to join the large intestine, which we regard as a mesial and symmetrical organ.

This view of the nature of the small intestine is further confirmed by the circumstance that this portion of the digestive canal, instead of being supplied by an artery from each side of the body, as is the case in azygos organs generally, is supplied by one vessel, the superior mesenteric, which arises from the side of the aorta a little below the cœliac axis.

The stomach and bowels of chelonia are nearly as much laterally displaced as in the human subject. In the other reptiles they are not much out of the median line, yet in none are they exactly mesial, except towards the termination. The cardiac end of the stomach tends, though often but a little, towards the left, but the pyloric is free, and can be brought without much violence to the middle line, but yet it is always found leaning to the right.

The large intestine in man describes the greater part of a circle. The explanation of its various turns before it finally dips into the pelvis to gain the middle line of the sacrum has been given above. It differs from the small intestine both in its outward form and in its internal structure, and the opening leading from the ileum into the large intestine is guarded by a valve. The cæcum, which is double in many animals, is the widest part of the large intestine.

The symmetrical and mesial character of the large intestine is borne out by the arrangements of arterial supply; for instead of having one vessel, the cæcum, and ascending and transverse colon, receive their vessels from the right side of the superior mesenteric artery, and the descending colon and sigmoid flexure and rectum from the inferior mesenteric.

*The Intestinal Canal in the Vertebrata.*—The intestinal canal in all *mammalia* is marked off from the stomach by a pyloric valve. Except in cetacea and a few edentata and cheiroptera, the division into a small and large intestine prevails throughout. At the junction of the small with the large intestine a more or less perfect ileo-cæcal valve is found, except in the monotremata, cetacea, and certain edentata and cheiroptera. A cæcum nearly always exists. It is absent in all insectivora, in cheiroptera, in some of the edentata, and in certain cetacea. In the carnivora it is short and narrow; absent in bears and weasles, present in quadrumana. In all ruminants it is capacious; larger in solipeds; in the horse three times as large as the stomach, being two feet long; in the pachyderms somewhat smaller. In the hyrax there are two cæca; in rodents it is absent; in the dormouse short and small; in the rat of great size; in rabbit and hare eight times as capacious as the stomach. In carnivorous cetacea there is no cæcum, but in balena a small one; in herbivorous species sometimes a very large one, sometimes short and bifid; in carnivorous marsupials there is no cæcum, in insectivorous marsupials a small one; in the frugivorous it is wide, twice as long as the body, and in the herbivorous species three times as long. In monotremata there is a small cæcum. *In Birds.*—A pyloric valve usually exists in birds. The intestine of birds is shorter than that of mammalia, but longer, relatively to that of the body, than that of reptilia. The duodenum always forms a large loop, embracing the pancreas; the remaining portion is variously folded in different birds, the convolutions being spiral, concentric, or irregular. The distinction between the small and the large intestine now becomes less marked, there being no ileo-cæcal valve, and villi being found on the mucous membrane of both; this place of junction is, however, frequently indicated by the presence of a cæcum, or rather of two cæca, for this diverticulum is most commonly double. The cæca are wanting in some vultures; in the cormorant, wryneck, and toucan, and in many carnivorous, insectivorous, and frugivorous birds. They are small and short in other vultures, in the eagles, and solan goose, and also when they exist in the insessorial tribes; they are longer in the nocturnal than in the diurnal birds of prey. Among the rasores, they are short in pigeons, but very long in the grouse, each measuring three feet, or thrice the length of the body. In other rasores they are of moderate length. In the cursorial birds the intestinal canal approaches more nearly the mammalian character. The cæca, however, are absent in the cassowary, whilst in the ostrich they are wide, about two feet long, and have an internal spiral fold, like that of the hare. The large intestine beyond the cæca is large and mammalia-like in the ostrich, but usually is relatively short, straight, and not very wide. It terminates by an imperfect valved circular opening in the dilated cavity called the cloaca, into which also the ureters and the ducts of the reproductive organs open.

*In Reptiles.*—The pyloric valve is usually present in reptiles, though not very distinct; the intestine is shorter and wider than in birds. In saurians there is mostly an ileo-colic valve; the crocodile has no cæcum. In the chelonians the intestine is long and muscular; an ileo-cæcal valve usually exists, and also frequently a cæcum. In serpents the small intestine is elongated, the ileo-colic valve is indistinct, the large intestine sometimes has transverse folds in its interior analogous with the spiral valve in the same part in the cartilaginous fishes. The lower end of the larger intestine forms a cloaca, receiving the ducts of the urinary and reproductive organs. The presence of a cæcum in certain chelonia is associated with the use of a vegetable diet. In the more fish-like batrachians the division into small and large intestine is imperceptible; the latter ends in a cloaca. *In Fishes.*—The intestine is short and wide, and is distinguished into a large and small intestine by a slight constriction only; there is no distinct ileo-colic valve, but sometimes a short cæcum exists. The small intestine has usually connected with it, immediately below the pylorus, the appendices pyloricæ; the large intestine is often, as in sharks, provided with internal folds, or a spiral valve.—(Marshall.)

From the above considerations we conclude that the small intestine is a lateral unsymmetrical organ, that its left lateral homologue is undeveloped, and that the cæcum and large intestine are mesial, bilateral, and symmetrical, and that the vermiform appendix is the only remaining vestige of the left small intestine.

To recapitulate. We regard the stomach as a mesial organ, composed of a right and a left portion, the pyloric and the cardiac; that one is the lateral homologue of the other; that the left, or cardiac, instead of being developed, terminates in a cul-de-sac; that the right, or pyloric portion, is developed, communicating with the small intestine by means of the pylorus; that the small intestine is developed on the right side of the body only, and is unsymmetrical and lateral, and having passed from the right lateral region, it communicates with the large intestine in the middle line of the body; that the left lateral homologue of the right small intestine is so far undeveloped that the only vestige found of it is the vermiform appendage; that the cæcum and the large intestine are each double, or symmetrical organs, occupying the median line of the body; in short, that the alimentary canal is symmetrical from its commencement at the mouth down to the stomach; that in the middle of its course, that is to say, from the stomach to the end of the small intestine, the symmetry is not carried out, but that from the cæcum to the termination of the large intestine the alimentary canal is as symmetrical as it is at its commencement.

A sketch of the development of the alimentary canal will elucidate this subject. The alimentary canal commences in the mucous layer of the blastoderm, in form of a groove, which is soon changed into a tube at each end, but is left open in the middle, upon the ventral aspect, and communicates by means of a tube, named the omphalo-enteric canal, or vitelline duct, with the vitelline sac; this duct is soon obliterated, and the vitelline sac becomes the umbilical vesicle, which is henceforth connected with the embryo only by a slender elongated pedicle, containing the omphalo-mesenteric vessels, and is finally atrophied.

The alimentary canal itself is at first a straight tube closed at each end, and placed along the front of the vertebral column, to which it is closely attached above and below (supposing the embryo to be placed in an erect position), whilst in the middle of its course it is connected by a median membraneous fold, or rudimentary mesentery. Soon, however, it advances from the spine and forms a simple bend in the middle of the body, with a straight portion at its upper and lower end. The middle, or apex of the bend, advances to the umbilicus, where it is connected with the umbilical vesicle by the pedicle, and also by the omphalo-mesenteric vessels, which pass out there to the vesicle. By the early appearance of a slight dilatation which forms the future stomach, the primitive simple tube is divided into an upper and a lower portion. *a.* From the upper portion, besides the œsophagus which is formed by a gradual elongation of the part, there are ultimately developed the mouth, tongue, and salivary glands, the pharynx, larynx, trachea, and lungs. At first the upper end is closed; at length a wide aperture appears which is not the mouth properly so called, but an opening upon which the mouth and lips are subsequently developed as superadded parts, commencing after the eighth or ninth week. *b.* The dilated portion of the tube which forms the stomach turns over on its right side, so that the border which is connected to the vertebral column by the membraneous fold (or true mesogastrium), comes to be turned to the left, the position of the tube being vertical, like the stomach of some animals. *By degrees it becomes more dilated, chiefly on what is now the left border, but subsequently the great curvature, and assumes first an oblique, and finally a transverse position*, carrying with it the mesogastrium, from which the great omentum is afterwards produced. The pylorus is seen at the third month, but is very slightly marked. Immediately below the stomach the duodenum is formed, and upon this part of the canal commence the rudiments of the liver and pancreas, both having protrusions of the mucous membrane growing into their blastemic mass. *c.* In the meantime the part below the stomach becomes the intestinal canal; that portion of it which is suspended by a mesentery forming, besides the duodenum, the jejunum, the ileum, the cæcum, and the colon, whilst the lower and attached part constitutes the rectum. The place of distinction between the small and large intestine, which is soon indicated by the protrusion of the cæcum, is at a point just below the apex, or middle of the simple bend already mentioned. As the small intestine grows, the part below the duodenum forms a coil, which at first lies in the commencing umbilical cord, but retires again into the abdomen; about the tenth week afterwards it continues to elongate, and its convolutions become more and more numerous. The diverticula, sometimes found projecting from the small intestine, are supposed to be developed from a persistent portion of the vitelline duct, which continues to grow with the rest of the bowel; the large intestine is, at first, less in calibre than the small. The cæcum appears as a protrusion a little below the apex in the primitive intestinal tube, and, as well as the commencing colon, is at first lodged in the umbilicus with the coil of the small intestine; the appendix is at first of equal width. The ileo-cæcal valve appears at the commencement of the third month, when the coils of intestine and cæcum have retired from the umbilicus into the abdomen; the colon is at first to the left of the convolutions of the small intestine, but then, together with the meso-colon, crosses over its upper part, at the junction of the duodenum and jejunum. The cæcum and transverse colon are then found just below the liver; finally, the cæcum descends to the right iliac fossa. At the fourth or fifth month the parts are in the same position as in the adult. The lower straight and attached portion of the tube eventually forms the rectum; the anal orifice does not exist at first, but appears a week or so later than the oral opening. (Quain and Sharpey.)

*The Liver.*—We have just seen that upon the duodenum commence the rudiments of the liver and pancreas, both having protrusions of the mucous membrane growing into their blastemic mass. In the chick, the liver consists of a cluster of isolated follicles, not lodged in the walls of the intestine, as is the case in some of the invertebrata, but clustered round a sort of diverticulum of the intestinal tube, which is the first condition of the hepatic duct, and into which they discharge themselves. Its development has been traced in the bird from a conical protrusion of the intestinal canal, surrounded by a soft mass of blastema, in which, by a subsequent process of growth, the ducts are formed. In the mammalian embryo, it has been found to commence by a double mass of blastema attached to the outer wall of the intestinal tube, and having a conical protrusion of the internal membrane passing into each lobe of the mass. In the early fœtus the right and left lobes of the liver are of equal, or nearly equal, size, and in consequence of the greater equality as to size between the two lobes, the position of the fœtal liver in the abdomen is more symmetrical as regards the middle line of the body. In the very early fœtus it occupies nearly the whole abdominal cavity, and at a full period it still descends an inch and a half below the margin of the thorax, overlaps the spleen on the left side, and reaches down to the crest of the ilium on the right side. In the adult human subject it is situated in the upper part of the abdominal cavity, occupying the right hypochondriac region, and extending across the epigastric region into a part of the left hypochondrium. On the upper surface the line of attachment of a fold of peritonæum, named the broad or falciform ligament of the liver, marks off the surface unequally into a right and a left portion; the right portion is much larger and more convex than the left. This ligament contains between its folds the round ligament which ascends from the umbilicus to enter the longitudinal fissure on the under surface of the liver. It is the remains of the umbilical vein of the fœtus. The liver is composed of a large number of lobes; five are enumerated in the human subject, but they are only apparent on the under surface. In some animals the whole surface is divided by a deep fissure into angular masses. In fact, anatomists have made the most of these lobes of the liver in their attempts to claim a symmetrical figure for this organ. Thus: "In the carnivora and rodentia, which present the most complex form of liver that we meet with among mammalia, there are five distinct parts; namely, a 'central', or principal lobe, and a right and left 'lateral' lobe, each with its 'lobular appendage.' The whole mass of the liver in man which we are accustomed to describe as consisting of a 'right' and 'left' lobe does in reality form but one (there being no real division between its two portions), which must be regarded as the 'central' lobe; the 'lobulus Spigelii' is the rudiment of the right 'lateral' lobe, and the 'lobulus caudatus' is its 'lobular appendage,' but the left 'lateral' lobe, with its lobular appendage,' is altogether undeveloped." There is only one hilum to the liver, which is transverse; and, as a rule, the gall-bladder is a simple organ. The liver is supplied by one artery—the hepatic—and not by one from each side of the body. The large size of this organ, and the peculiarities of its circulation, etc., will demand our attention at a later stage. We will now trace the liver in the vertebrate series.

"Among the vertebrata the liver, proportionately to the body, becomes progressively larger; in passing from the mammal to the fish its general form corresponds with that of the abdominal cavity. Thus, it is broad in the apes and in the carnivora; longer in the larger ruminants and long-bodied animals; of moderate length in birds; broader in the comparatively short chelonia and sauria, but long in the elongated ophidia; broad and short in the frogs and toads, but long in the newts, stretching widely into the abdomen of the broad-shaped skates and rays, but lengthened out in the eel. Its position is usually somewhat mesial, but in the mammalia with large compressed stomachs it is placed more towards the right side, as is also the case in the anthropoid apes. In fishes it generally lies more on the left side of the body. In birds in which the diaphragm is complete, the liver is notched for the reception of the heart and pericardium. In reptiles, amphibia, and fishes which have no diaphragm, the liver also reaches up to the pericardium, except when the body is very long, as in the serpents and eels. The liver in the mammalia generally is very simple, its lobes being only slightly marked. In the ruminants it is subdivided into three lobes; in the rodentia and carnivora there are from three to five lobes; in the llama, amongst ruminants, the under surface—and in the capromys, a rodent animal, the whole surface—is divided by a deep fissure into angular masses, resembling those of the kidney of the bear. In birds the lobes are two, and of equal size; in reptiles and amphibia the lobes are generally two, but the liver is undivided in the ophidia; in fishes the liver is often more subdivided. The microscopic structure of this gland in all the vertebrata resembles that of the human liver. In mammalia a gall-bladder is sometimes present and sometimes absent amongst the herbivorous kinds; it is present in nearly all ruminants, as in oxen, sheep, goats, and antelopes, but not in the camels and stags. It is also present in solipeds and in most pachydermata, as in the horse and tapir, peccary, and elephant, but not in the pig. In the elephant the hepatic duct is dilated and thickened, and has a spiral fold within. The gall-bladder is wanting in mice and hamsters amongst rodentia, also in the sloths amongst the edentata, and in true cetacea. In the carnivorous and insectivorous kinds the gall-bladder is present. In the cat and a few other animals it is sometimes found double, and there are sometimes three. When the gall-bladder is present, a cystic, hepatic, and common bile-duct exist. In birds the gall-bladder is generally present, but is wanting in certain species of a particular genus without obvious relation to the habits or food. It is absent in the ostrich, pigeons, toucans, and many parrots. Proceeding from the liver in birds are two ducts—one hepatic to the duodenum, the other to the gall-bladder—from which a cystic duct runs on to the duodenum; there is, therefore, no common bile-duct: when the gall-bladder is wanting, the two hepatic ducts open separately into the intestine. In reptiles a gall-bladder always exists, but it varies in form. It is placed at a distance from the liver, and has a long cystic duct in the ophidians, but it is imbedded in the substance of that gland. In the chelonians there is either a common bile-duct, or the cystic duct and hepatic duct open separately into the duodenum. The gall-bladder invariably exists in amphibia. In fishes this receptacle is usually present, though it is absent in many genera, being then replaced by a dilatation upon one of the hepatic ducts, which are here usually numerous.

*The Blood-vessels of the Liver.*—In all the vertebrata the liver receives blood both from the hepatic artery and the portal vein. In the mammalia this vein, as in man, has only a few communications with the lumbar and pelvic systemic veins. In birds and reptiles the communications between the pelvic and portal vein is such that a part of the blood from the lower extremities and from the tail joins the portal blood, and passes into the liver. In fishes the caudal veins, and sometimes those from the reproductive organs and the air-bladder, are connected with the portal system." (Marshall).

From the above it must be apparent that although the liver may be composed of almost any number of lobes, aggregated together, and may vary in shape and have any number of ducts, yet in no case are there two livers, two gall-bladders, two hepatic arteries, and two portal systems, either united or otherwise, in the median line of the body. There is reason to conclude that the biliary apparatus of the left side of the body is undeveloped; and since the biliary apparatus is developed in connection with the small intestine, the absence of that organ on the left side of the body confirms the hypotheses of the absence of the left small intestine. These views receive remarkable confirmation from a review of the portal and umbilical circulation, and their anomalies are immediately explained. If, for the sake of argument, we suppose that the liver is a median and symmetrical organ, composed of a right and a left liver, conjoined in the mesial line of the body, there ought, then, to be two portal veins—one collecting the blood for the chylopoietic viscera of the right side of the alimentary canal and its appendages, and the other on the left side collecting its blood from the chylopoietic viscera of the left side of the alimentary canal, and these vessels ought to be symmetrical in size and position, etc. Now, what we actually do find is quite a different state of things. The superior mesenteric vein on the right side of the body collects and returns the blood from the small intestine, and from one-half of the large intestine, namely, from the ascending and transverse colon. The trunk formed by the union of its several branches inclines upwards, and on the right side passes into the liver as the portal vein. Now, on the left side of the body the difference is very striking. The inferior mesenteric vein commences at the rectum by branches, which unite with those from the remaining portion of the large intestine, namely, the descending colon, and passes upwards on the left side of the body, terminating by falling into a large vessel which has been inappropriately called the splenic vein, and which collects the blood from the great end of the stomach and the spleen. This large *union vein* is directed from left to right, imbedded in the substance of the pancreas, crosses over the front of the spine to the other side of the body, and terminates by joining the superior mesenteric vein, which, as we have mentioned above, passes into the liver as the portal vein. The absence of both the biliary apparatus and the small intestine on the left side of the body completely explains the anomalous absence of symmetrical arrangement.

A notable exception to the law of symmetry in connection with the fœtal circulation cannot be satisfactorily elucidated on the supposition that the liver is a symmetrical organ, composed of a right and left liver, united in the median line; but receives a ready solution if we regard the liver as a-symmetrical.

It will be remembered that there is but one umbilical vein to carry the placental blood to the liver, whilst there are two umbilical arteries. An explanation is afforded by the fact that there are not two livers; for, as there is but one liver, there is but one umbilical vein. The umbilical arteries are two and have nothing to do with the liver, being the continuations of the common iliac arteries, into which the aorta divides.

The Pancreas, as is the case with the liver, is developed in connection with the small intestine; it commences in the form of a small bud from the left side of the intestinal tube, having a protrusion of the mucous membrane growing into its blastemic mass. In the adult it is embraced by the curvature of the duodenum, and extends across the epigastric into both hypochondriac regions. Its intimate structure closely resembles that of the salivary glands. The pancreatic duct sometimes opens into the intestine by a common orifice with the common bile-duct, and sometimes separately. The number of ducts is uncertain—one, two, or three—and like the salivary glands, the pancreas receives its blood-vessels at all points and from various sources—the hepatic, splenic, and superior mesenteric—and its blood is returned by the splenic and superior mesenteric veins.

"The pancreas is present only in the vertebrata and the higher mollusca; it is not so widely distributed amongst animals as the liver, and it assumes a rudimentary form in fishes. In mammalia, birds, and reptiles, the pancreas occupies the concavity of the constantly present curvature of the duodenum. *In mammalia*, when the duodenal mesentery is short or absent, as in the quadrumana, carnivora, ruminants and solipeds, the pancreas is compact and elongated, with a portion extending towards the spleen, so that it may seem bilobed, as in the carnivora and ruminantia, or even trilobed, as in the horse, the splenic portion being double; when, however, the duodenum has a wide mesentery, as in rodentia, the pancreas forms an arborescent mass between two layers of the mesentery, as seen in the rabbit and rat. The typical number of ducts in the mammalia appears to be two, as indeed is the case in the early condition in man, the upper and larger duct alone persisting. In the horse and dog there are also two ducts, the lower one being the larger in the dog; the latter opens separately into the duodenum by a common orifice. In the rabbit, the upper duct is very minute, and the chief duct opens from nine to twelve inches below the pylorus. In all cases the pancreatic fluid is discharged into the duodenum. In certain carnivora, as in the seal, and sometimes in the cat, the chief duct dilates into a reservoir previously to entering the intestine.

*In birds*, the pancreas is proportionally larger than in other vertebrata; it usually consists of from two to six elongated portions, attached as usual to the much bent duodenum. Each portion of the gland has a duct generally opening separately into the intestine. There are six ducts in the vulture, fowl, heron, and grebe; three in the crow, pigeon, grouse, and duck; but only one in the eagle, ostrich, and stork. In the stork alone, the single pancreatic duct opens by a common orifice, with a single hepatic duct. Usually one at least of the pancreatic ducts in birds opens above the bile duct, but this is not constant; when several ducts exist, they usually open alternately with other hepatic or cystic ducts; the cystic duct generally opens lowest. In the ostrich, the bile escapes through the single hepatic duct close to the pylorus, and the pancreatic juice also by a single duct three feet lower down.

*In reptiles*, the pancreas is usually large. It is larger in the herbivorous than in the carnivorous saurians, being largest in the iguanas. In the chelonians, the gland is even ramified as in the rodents. In the ophidians, it is either long and bifid, pyramidal, or round. The duct is nearly always single, and enters the duodenum separately but sometimes with the bile duct. In the serpents, the pancreas is joined to the spleen, and has even been confounded with it. In the amphibia, the pancreas is found in the mesentery, between the stomach and the duodenum. In the lowest amphibia, as in the siren, the pancreas is much subdivided, so as to approximate to the form of the pyloric appendages in the fishes. Its ducts form numerous parallel canals, opening separately into the duodenum. In fishes, the pancreas is a small gland sometimes found attached to the liver. The trout possesses this organ as well as the pyloric appendages." (Marshall.)

From this description it will be seen that the pancreas is composed of an indefinite multiplication of lobes, communicating with numerous ducts, opening separately or in conjunction with the common bile duct into the small intestine; that there is no appearance of symmetry in its construction, and that it has not two arteries direct from the aorta specially devoted to it.

*The Absorbent System.*—The want of symmetry existing on the opposite sides of the abdominal cavity is further evidenced by a brief consideration of the absorbent system. The thoracic duct is a mesial organ, not, however, always a single trunk throughout its whole extent, for it frequently divides opposite the seventh or eighth dorsal vertebra into two trunks, which soon join again. It has indeed been found by Cruikshank double in its entire length. The thoracic duct is the common trunk. The lacteals which commence in the coats of the intestine extend to the thoracic duct in which they all terminate; they are derived in far larger numbers from the small than from the large intestine. Having passed through the lymphatic glands the lacteals gradually unite as they approach the attached border of the mesentery, two or three perhaps joining to form one; and so they become diminished in number, until at length, near the root of the superior mesenteric artery, only two or three trunks remain, which end in the thoracic duct. In this way the lacteals from the whole of the small intestine, from the cæcum and from the ascending and transverse parts of the colon, terminate. But the trunk from the left side of the body, instead of receiving its share of branches from the small intestine and being of equal size and importance with that on the right side, is a small trunk, which having received branches from the descending colon, and its sigmoid flexure, turns upwards and opens by a separate trunk into the lower end of the thoracic duct. The small size of this trunk, and the fact of its receiving so few branches, and these from the left side of the large intestine, are explained by the absence of the small intestine on the left side of the abdominal cavity.

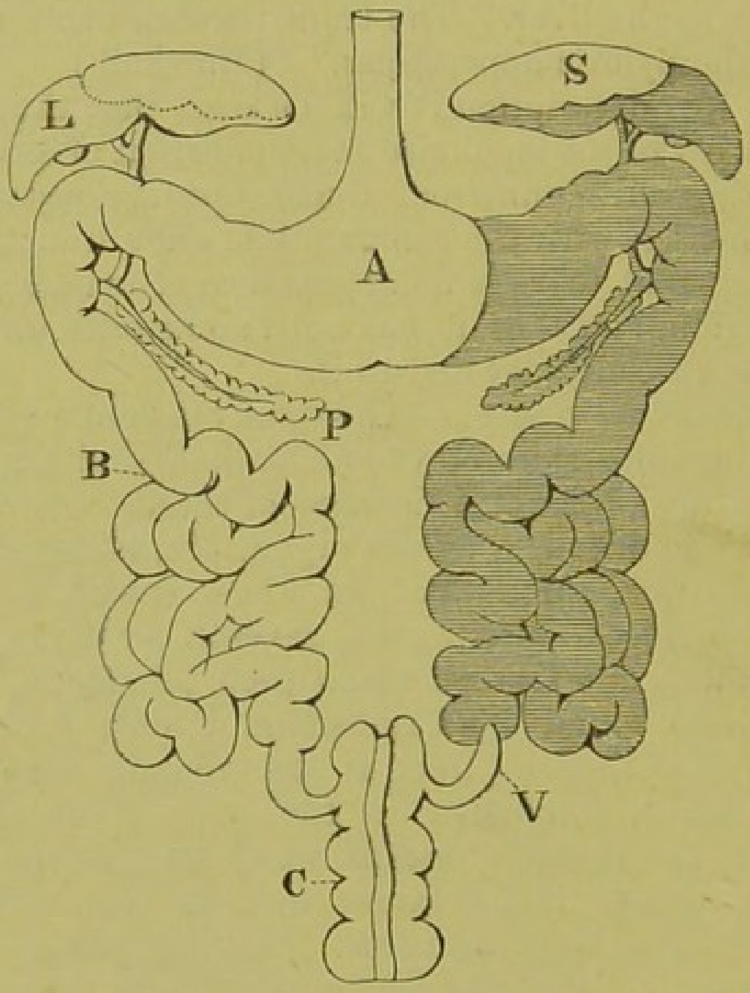


DIAGRAM TO ILLUSTRATE THE SYMMETRICAL ARRANGEMENT OF THE ABDOMINAL VISCERA.

A. The Stomach. B. The Small Intestine. C. The Large Intestine. V. The Vermiform Appendix. L. The Liver. S. The Spleen. P. The Pancreas.

The shaded portion represents those parts of the abdominal viscera which are undeveloped on the left side of the body.

Having given a slight sketch of those portions of the alimentary canal and their appendages, which occupy the right side of the abdominal cavity, we now pass on to the consideration of their lateral homologues, which are situated on the left side of the body. We may enumerate these as the following—the cardiac stomach, only partially developed; the vermiform appendix, the only remnant of the small intestine; the left half of the cæcum and of the large intestine, and finally the spleen.

We have described above the condition of the stomach in the vertebrate series. It is only necessary to add here, that pain in the left side of the stomach is frequently referred to the left side of the head, and that pain in the right side is referred to the right side of the head; and that during the progress of the digestive process in some animals, a constriction is observed partially dividing the right from the left stomach; and there are certain other pathological conditions which elucidate this subject. In man the great cul-de-sac of the stomach projects beyond the œsophagus to the left for about two or three inches, and all the structures entering into its formation bear evidence of an arrest of development, whilst in the lower animals this part of the stomach is not only to some extent distinct from the pyloric stomach, but is completely different in structure, and, failing its due physiological function, it is appropriated to other purposes. The pylorus on the right side never has a left lateral homologue in a valvular orifice, viz., a left pylorus.

The representative of the right small intestine is the Vermiform appendix. Proceeding from the inner and back part of the cæcum, at its lower end, is a narrow, round, and tapering portion of intestine, named appendix vermiformis. This process is usually about the width of a long quill, and varies from three to six inches in length, differing much in its dimensions in different cases. Its general direction is upwards and inwards behind the cæcum, and after describing a few slight turns it ends in a blind point. It is retained in its position by a small fold of peritonæum, which forms a mesentery for it; this cæcal appendix is hollow down to the extremity, and its cavity communicates with that of the cæcum by a small orifice, sometimes guarded by a fold of mucous membrane. Its coats are the same as those of the cæcum, but the longitudinal muscular fibres, which are continuous with those of the three bands upon the cæcum and colon, form a uniform layer round the appendix just as in the small intestine. The vermiform appendix is developed from the cæcum. A distinct appendix exists in man, in the ourang-outang, and in the wombat, but apparently in no other animal. As is well known, the vermiform appendix is usually considered to be a part of the cæcum arrested in its growth, and is usually regarded as the rudiment of the long cæcum found in mammalia. But there are strong reasons for looking upon it as the representative of the undeveloped small intestine of the left side of the body; the left lateral homologue of the right small intestine; and the character of its mucous membrane is not an insuperable objection to this view.

We must refer to what we have said above about the large intestine and its condition in the vertebrate series for the evidence in favour of its double nature, and the frequent occurrence of two cæca will explain its true state in man. The only remaining organ is the spleen.

There are two opinions held with regard to the Spleen. One opinion is, that it is the left lateral homologue of the liver, and is situated on the left side of the body; and the other opinion is, that it is a mesial or azygos organ, occupying the median line of the body, and having no lateral homologous relationship to the liver. Müller, as we have seen above, advocates the second opinion in the following words: "In man and mammalia the spleen lies in the fold of peritonæum, which is continuous with the serous covering of the anterior and posterior surface of the stomach, and extends between the great curvature of the stomach, the diaphragm, and the transverse colon; and which at the part where it connects the stomach to the transverse colon is called the great omentum. This portion of peritonæum passes originally from the spinal column in the middle line to the great curvature of the stomach, forming a meso-gastrium in which the spleen was developed. The spleen, therefore, is not an organ proper to the left side of the body of which the fellow of the opposite side is wanting." Müller omits to state that several other organs are also contained in the same fold of peritonæum which cannot all be regarded as median organs, namely, the pancreas, close to which the spleen is developed, and the duodenum. Moreover, due allowance has not been made for the arrest of development of the great cul-de-sac of the stomach, and for the absence of the small intestine on the left side of the body; nor can the dispositions of the folds of the peritonæum be regarded as a guide in a question of symmetry. Again he says, "The spleen should be regarded as an organ originally situated in the middle line, just like the liver, which at first, when its two lobes were equal, did not belong to the right side more than to the left," and "Doellinger supposes the spleen to be formed merely for the sake of symmetry, to be the fellow of the liver; the rudimentary liver as it were, of the left side. But the liver is originally symmetrical"—consequently the presence of the spleen is not required to complete the idea of symmetry. Here again Müller has derived his inference from circumstances which are not conclusive. The number of the lobes of the liver is a matter of uncertainty. Almost any number of lobes may be aggregated together, and has nothing to do with the question of symmetry; and if, as there is reason to believe, the small intestine itself is a lateral organ, the liver which is developed in connection with it must be a lateral organ also. Müller having proved to his satisfaction that the liver is a median organ on the ground that it is symmetrical in its form, would have increased the weight of his argument had he been able to add that the spleen also is symmetrical in form. This, however, he has been unable to do, as it presents no appearance of symmetry, and it is supplied by one arterial trunk instead of two. The difficulty with regard to the relationship of the liver and spleen has not arisen so much from the apparent want of symmetry in the situation of the spleen with respect to the liver, but rather from its failing to exhibit any trace of the function which is performed by the liver; and since the spleen has never been found to secrete bile itself, the ancients endeavoured to overcome the difficulty by supposing that the spleen aided the liver in that operation, and this view has, in modern times, received support from the observation that the splenic vein is one of the largest sources of supply to the portal system. Of this, however, more hereafter.

The Spleen is situated in the left hypochondrium, at the cardiac end of the stomach, between that viscus and the diaphragm. It is a highly vascular and easily distensible organ, and has no excretory duct. It is unsymmetrical in form, and somewhat lobular; the external free convex face of the spleen is smooth and covered by the peritonæum, but the internal concave face is irregular, and presents a vertical fissure, named the hilum, which transmits the blood-vessels and nerves. The fissure is not always present. Two layers of peritonæum reflected from the spleen, at the borders of the hilum, on the great cul-de-sac of the stomach, and containing between them the splenic vessels and nerves, and the vasa brevia, constitute the gastro-splenic omentum, which thus serves to attach the spleen to the cardiac end of the stomach. The tail of the pancreas touches the lower end of the inner surface of the spleen. To the diaphragm the spleen is attached by a reflection of the peritonæum, named the suspensory ligament. The lower end is in contact with the left end of the arch of the colon, or with the transverse meso-colon. Its weight fluctuates usually between four and ten ounces. In intermittent fever it is much distended and enlarged, weighing as much as eighteen or twenty pounds.

It is unnecessary here to describe the structure of the spleen. We must refer the reader to the works of Sœmmering, Kölliker, Krause, Gray, and W. Müller. The splenic artery in man, the largest branch of the cœliac axis, is directed horizontally towards the left side, together with the splenic vein behind the upper border of the pancreas, and divides near the spleen into several branches: some of these enter the fissure in this organ. The pancreatic branches supply the pancreas. The gastric branches, vasa brevia, enclosed within the gastro-splenic omentum, passing from left to right, reach the left extremity of the stomach. The gastro-epiploic artery runs along the great curvature of the stomach. In some animals the splenic artery is smaller than the other branches of the cœliac axis. In some birds the blood-vessels are derived from one of the branches of the gastric previous to its distribution to the stomach, liver, duodenum, and pancreas. The vasa brevia, when distended with blood, have been mistaken for ducts proceeding from the stomach to the spleen, and *vice versa*. The splenic vein is of very considerable size; considerably larger than the splenic artery. It commences by five or six branches which issue separately from the fissure of the spleen, but soon join to form a single trunk It is directed from left to right, embedded in the substance of the pancreas. It is joined by the inferior mesenteric vein, when a large trunk is formed, which is inaptly also called the splenic vein. This trunk, which unites the venous system of the two sides of the body, and might be more appropriately named the *union vein*, crosses the front of the spine to the right side of the body, and falls into the superior mesenteric vein nearly at right angles. These two trunks form the portal vein. The splenic vein receives in its course veins from the neighbouring parts. When the circulation in the liver is obstructed, this *union vein* transmits the congestion across to the opposite side of the body directly to the spleen. "In the amphibia the large size of the spleen, and its peculiarly lax and distensile texture, are in perfect harmony with the requirements of the animals of this class, and it is peculiarly adapted as a reservoir for the blood, which accumulates in the portal system, inferior vena cava, and the hepatic reservoir, during the suspension of the respiration." (Gray.)

It has been mentioned that the splenic vein is the largest of the constituent channels of the portal system, and probably the above remarks afford some explanation of this fact. If we regard the spleen as an organ proper to the left side of the body, the course of the blood in the splenic vein to the opposite side of the body, namely, to the liver, is altogether anomalous, and is the only instance of the kind in the body. But if we regard the biliary apparatus and portal system as absent on the left side, the explanation is at once evident, and affords another argument in support of our view of the subject. There is a similarity in the course of the blood conveyed by the splenic artery and hepatic artery; for the blood from the splenic artery having passed through the spleen, is conveyed to the portal vein, and the blood of the hepatic artery is also believed to be conveyed into the portal system before gaining the hepatic veins and vena cava.

The Spleen appears in the fœtus about the seventh or eighth week, on the left side of the dilated part of the alimentary tube or stomach, and close to the rudiment of the pancreas, at its distal end, but perfectly separate from this body. This distinct separation of the spleen and pancreas is most evident at this period, for a distinct granular membrane divides them, whilst also the dark granular traces of the pancreatic mass, and the lighter colour of the rudimentary spleen, make this distinction more manifest. The spleen does not, as Arnold states, arise like the pancreas from the duodenum, and exist at first as a common mass with that gland. (Gray.)

By the tenth week the spleen forms a distinct lobulated body, placed at the great end of the stomach. After birth it increases rapidly in size, and in comparison with the weight of the body, it is as heavy a few weeks after birth as in the adult. This organ is peculiar to vertebrate animals. Separate splenculi, which are sometimes found in the human subject, bring to mind the multiple condition of the spleen in some animals, and also the notching, often deep, of the anterior margin of this organ in man. The spleen exists, without exception, in all the vertebrate animals. It varies much in shape even in mammalia; being, in different cases, round, oval, much elongated, lobulated, and even multiple. The latter condition is seen in the dolphin. It is largest in the bats, and smallest in the cetacea. The spleen presents its maximum of development in mammalia in connection with the greater general completeness and requirements of their organization. In the amphibia it is peculiarly lax and distensible. In birds the spleen is generally small as compared with the body; much smaller than in mammalia; its shape is either round, oval, fusiform, or flat. In reptiles it is of variable size, and differs in form according to the general shape of the body. As we descend in the scale of the vertebrate series, the function of the spleen appears to be considerably reduced in importance, as shown by the extreme diminution in its size; a diminution more marked in some of the orders of this class than in any other of the vertebrata. In fishes the spleen is universally present, but its small size in proportion to the body shows that it is an organ of less functional importance than in the mammalia. In birds and reptiles this organ is usually attached to the pancreas. In reptiles and fishes it is rather connected with the intestine than with the stomach, as in the mammalia.

To recapitulate. We have seen that two theories have been entertained with regard to the spleen. In one, both the liver and the spleen are regarded as mesial organs, and the spleen is looked upon as a blood-gland, having nothing to do with the liver. In the other, the liver and spleen are both held to be lateral organs, symmetrical with each other, and the spleen as an undeveloped liver of the left side, and aiding the liver in its biliary function. The only argument in favour of the spleen's being a mesial organ is derived from the situation of its development. There can be no doubt that in the bird the spleen is developed in the meso-gastrium; that is, between layers of peritonæum, which originally pass from the spinal column in the middle line, to the great curvature of the stomach. This appears, in modern times, to have settled the question as to the mesial nature of the spleen, but upon a careful inquiry this is found to be capable of explanation; for that portion of the peritonæum which should correspond on the left side of the body with that fold of peritonæum which on the right side is associated with the pylorus and duodenum, is altogether absent, on account of the undeveloped state of these parts on the left side of the abdomen. Moreover, the peritonæum cannot be considered a satisfactory guide, for it is itself unsymmetrical, and the various organs are outside it, and it envelopes in the same folds parts which are most dissimilar in their nature. It will be also borne in mind that the spleen originates close to the pancreas, which cannot be supposed to be a symmetrical organ. The situation of the spleen, in close proximity to the pancreas and the small intestine, is in perfect accordance with the idea of its homologous relationship with the liver, which is really connected with those parts rather than with the stomach to which it is attached by peritonæum.

Again, the liver has been supposed to be itself symmetrical and mesial, and consequently no organ is required to fulfil the idea of symmetry; but an examination of the liver in the vertebrate classes shows that the liver, although its lobular structure may give rise to that appearance, is never really a symmetrical organ, and a similar remark would apply to the spleen.

Again, the hypothesis that the spleen assists in the function of the liver is usually regarded as untenable, because the blood of all the chylo-poietic viscera, and even that from the inferior extremities in the lower vertebrata, enters the vena portæ. Hence it is inferred that there is nothing peculiar in the fact of the splenic blood going to the liver. But the course of the splenic vein is most abnormal, and can only be sufficiently accounted for by the hypothesis of the absence of a special portal system on the left side of the body.

The absence of bilateral symmetry in the liver, and also in the spleen; their symmetrical situation with respect to each other; their being each supplied by a corresponding trunk from the aorta, together with the want of symmetry in that portion of the abdominal viscera with which the liver is connected, all confirm the opinion which has been held, though vaguely, from the earliest times, that the spleen is symmetrical with the liver, and negative the modern idea that the spleen is a mesial organ.

There is, however, another and greater difficulty, namely, what is the function of the spleen, and if it is anatomically symmetrical with the liver, how is it connected with this organ physiologically?

The philosophers of antiquity, when regarding the spleen as symmetrical with the liver, endeavoured, by various suggestions, to connect them in function; but since it was apparent that bile was not immediately secreted by the spleen, they concluded either that this organ was an undeveloped liver, or that it prepared the blood during its passage through its substance for the elaboration of bile in the liver, or that black bile was secreted by the spleen in the same way as the yellow bile was secreted by the liver; but actual experiment has demonstrated that bile is secreted where the spleen has been removed, and the splenic blood, by going to the vena portæ, does not differ in this respect from that from all the chylo-poietic viscera.

The modern opinion, with regard to the spleen, is that it is unsymmetrical with the liver; that it is a blood-gland, having nothing to do with the function of the liver; and that it produces certain changes in the properties of the blood as it passes through its tissues. The assigned function of this organ has of course changed in accordance with these views, and the spleen is now believed by some persons to supply the germs of those cells, which are ultimately to become blood corpuscles, and for the following reasons:—

1. There is no difficulty in the admission of such corpuscles into the smaller veins of the spleen.

2. There is an unusual proportion of colourless corpuscles in the blood of the splenic vein.

3. The period of greatest functional activity of the gland generally is during the state of early childhood, when the formative processes are going on with extraordinary activity, and there is at the time a larger proportion of colourless corpuscles in the blood than at any subsequent period.

4. The state of blood when there is a multiplication of its colourless corpuscles, is almost always associated with hypertrophy of this body.

It must be admitted the above reasons are not very powerful. The hypothesis is most conclusively answered by Professor Owen.

"The splenic artery," he remarks, "must pour more blood into the splenic reservoir than is needed for the mere nutrition of the organ, and consequently the blood must there undergo change. But the spleen receives too small a portion of the circulating mass to have any definite influence on the manufacture, or general condition, of the blood. Such changes as are effected in the splenic locality more probably relate to the function of the gland to which the altered blood is exclusively carried, and it is to be noted that the splenic vein is the largest of the constituent channels of the portal one. With reference to the hypothesis of sanguification, it may be remarked that in no mammalian order is the mass of blood so great, or so full of blood discs, as in the cetacea; yet in them the spleen has its relative least size."

The fact that the spleen is remarkably small in the fœtus, and excessively large during the prevalence of certain fevers, the result of blood poisoning, is favourable to the view that at least one of the alterations effected in the blood has reference to the removal of some of the effete constituents of the circulation; the decomposed elements passing from the spleen, by the splenic vein, to be eliminated by the liver from the system. Nor is it necessary to suppose, as we shall see hereafter, that the formation of the bile is solely dependent upon this supply.

It may be objected to the theory that, the blood, either by its retarded motion through the serpentine splenic vessels, or by its stagnation in the splenic cells, or by changes wrought in it by some action of the spleen, is rendered fit for the secretion of bile in the liver; and to the theory that, the splenic blood is loaded with properties which the action of the liver separates from it; that we do not usually meet with such arrangements as these in the animal economy—indeed, no instance could be adduced of a like nature—one organ elaborating properties in the blood that they may be removed by another; or a part producing changes in the blood fitting it for the secretion which is to be performed by another. The tissue of each gland has the power of extracting its peculiar secretion from the common mass. Further, bile is secreted when the spleen has been removed, and it is secreted in those cases in which the vena portæ empties its blood directly into the inferior cava. Moreover, it has been ascertained that bile is produced in the liver from the blood distributed to its substance by the portal vein and the hepatic artery, and not from either of these vessels exclusively, and that the bile may continue to be secreted even if either of these vessels be obliterated, provided the supply of blood be sufficient.

The anatomical details we have given above afford at once a clue to the solution of this difficulty. We have shown that the spleen has no biliary apparatus associated with it. We have also pointed out that the course of the splenic blood is across the mesial line of the body, and falls into the portal system of the liver, an organ proper to the opposite side of the abdomen, this course being altogether exceptional and different from what occurs in the case of any other viscus. Now, since the spleen is unprovided with a biliary apparatus of its own, and it makes use, so to speak, of the biliary apparatus of the liver, an organ on the opposite side of the body; and since, as we have shown, the liver is symmetrical with the spleen, and all symmetrical organs are similar, we are led to conjecture that the liver is composed of an organ similar to the spleen, combined with a biliary apparatus.

We pass on, then, to the consideration of the question whether the liver may not in reality be regarded as a combination of two organs; viz., a blood-gland, similar to the spleen, and a biliary apparatus combined together.

Ruysch appears to have been one of the first anatomists who classified the liver with the thyroid, supra-renal capsules, and lymphatic glands as a vascular or blood-gland —'glandula sanguinea.' "The action of the ductless glands —that of extracting material from the blood elaborating it, and, instead of eliminating it by ducts, returning it into the blood by means of a venous or lymphatic absorption is no doubt, to a certain extent, imitated by the liver, the largest secreting gland in the body; for in the embryo the liver is indeed a true blood-gland." (Carpenter and Power).

Without laying much stress here upon the comparative size of this gland, which is by far the most bulky of the abdominal viscera, we shall pass on to consider its anatomical and physiological characteristics so far as they elucidate our subject; and the first thing which attracts attention when considering the liver is its double vascular supply, and this alone is sufficient to lead to the conjecture that it is compound in its nature, for it differs in this respect from all the other abdominal viscera.

It will be remembered that the hepatic artery, the branch of the cœliac axis which corresponds with the splenic, is distributed to the proper coat of the liver, to the coats of the various ducts and vessels, and to the capsule of Glisson, and forms plexuses upon the elaborate interlobular cellular structure; and that it probably terminates in the portal vein by the intervention of a capillary network; and that, in addition to this, the portal vein is distributed to the hepatic lobules after the manner of an artery; and that it is the portal vein which, under ordinary circumstances, is the main source of the biliary supply. It may, however, here be suggested that this is not conclusive; for there is another organ in the body, namely, the lung, which also has an arterial and a venous circulation, the venous circulation being distributed after the manner of an arterial. Now, the objection may be answered, and be made to give additional weight to the theory of the compound nature of the liver, by considering the nature of the lung, and tracing its progressive development in the animal series. The bronchial vessels which supply the cellular tissue of the lung, forming plexuses in the interlobular cellular tissue, and spreading out upon the surface of the lung beneath the pleura, may be compared with the hepatic arteries, and the pulmonary vessels which convey the blood sent through the lung by the heart for aëration may be compared with the portal vein.

Without going at great length into the comparative anatomy of the lung, we may note that in fishes the air-bladder formed by a prolongation of the internal tegumentary membrane constitutes a rudimentary lung, and exists at the same time that the lung-function is being performed by the gills. The air-bladder is, in fact, acknowledged to be an accessory respiratory organ. In some fishes the resemblance of the air-bladder to a lung is very decided, and its connection with the function of respiration is evidently most important. The canal by which it communicates with the alimentary canal opens, in some instances, at the back of the mouth ; so that a gradual approach is seen to the arrangement which exists in air-breathing animals. In these fishes, as in the amphibia that retain their gills, it would appear that the respiration is accomplished partly by the lungs, and partly by the gills. There can be no doubt that the lung may be regarded as a combination of the air-bladder and the gills, and that however perfectly the union is accomplished, it is in reality a combination of two distinct organs, and there are not indeed wanting indications in the mammalian lung of the combined function of the two organs of which it was originally composed. With regard to the liver, the evidence is more conclusive ; for the function of each portion can be readily detected, notwithstanding that, as in the case of the lung, the structural union is complete.

From time to time, various attempts have been made to separate, anatomically, the substance of the liver into two distinct portions, and this in consequence of two distinct functions of the liver having been recognized by many physiologists.

Ferrein went so far as to describe the medullary substance as being red in colour and of a pulpy consistence, and the cortical as friable in its structure and of a yellowish red colour ; and Müller distinctly admits a kind of double substance, although he objects to its designation, medullary and cortical. In his physiology, however, he is disposed to modify his previous idea of two substances, for he says: "From my researches, however, it results that there is but one kind of *real* hepatic substance formed of agglomerated biliary canals, but the ramified divisions of this substance being connected by a *vascular cellular tissue* which is often of a dark colour, a contrast between this and the yellow substance of the acini is produced." A similar relation of the constituent parts of the liver exists in the embryo of the bird in the yellowish twig-like ramifications of the biliary canals, as seen on the surface of the organ rising out of a reddish vascular tissue.

Robin goes yet further: he recognizes two distinct parts in the liver—a biliary organ and a glycogenic organ. He regards the lobules with the liver-cells and blood-vessels as the parts concerned in the glycogenic function of the liver, and the little glands which open into the biliary ducts all along their course, and are arranged on the duct in the form of fronds of a fern, as the biliary organ. It is only necessary to say in answer, that there is no direct evidence that the racemose glands (vestiges of Malpighian bodies?) attached to the excretory biliary passages (?) have anything to do with the secretion of the essential constituents of the bile; and, as they are not even found in some animals that produce a considerable quantity of bile, we may regard the fact of the isolation of two organs in the liver—one for the secretion of bile, and the other for the production of sugar, as still unsettled. (Flint.)

What we are in quest of is a fibro-cellular structure, supporting a close arterial and venous plexus, similar to that found in the spleen; and pathology points out this more distinctly. For in cirrhosis of the liver, when there is undoubtedly a partial atrophy of the biliary secreting portion of the liver with hypertrophy of the cellular substance, the distinction is very evident. But as we see in the case of the lung, organs combined together by nature cannot easily be separated by art.

It is worthy of remark, that in the mammalian embryo (the dog) the liver has been found by Bischoff to commence by a double mass of blastema attached to the outer wall of the intestinal tube immediately beneath the dilatation for the stomach.

It was formerly supposed that the chief and only important office of the liver was to produce bile, and all physiological researches into the function of this organ were then directed to the question of the uses of the biliary secretion; but in 1848 it was announced by Bernard that he had discovered in the liver a new and important function; and he proceeded to show, by an ingeniously conceived series of experiments, that the liver is constantly producing sugar of the variety that had long been recognized in the urine of persons suffering from diabetes mellitus. The great physiological and pathological importance of the discovery, attested as it was by experiments which seemed to be positively conclusive in their results, excited the most profound scientific interest.

In 1857 Bernard discovered a sugar-forming material in the liver analogous in its composition and properties to starch; and this seemed to complete the history of glycogenesis. Shortly after the publication of the glycogenic theory, it was found that other changes were effected in the blood in its passage through the liver, and physiologists then understood, for the first time, how glandular organs might produce secretions and yet not discharge them into excretory ducts, and this indeed pointed the way to the explanation of the function of the ductless glands. (Flint.)

The production of glycogenic matter is, however, not peculiar to the liver; for before birth the placenta performs a similar function, and at about the time that glycogenic matter begins to appear in the liver, the glycogenic organs of the placenta become atrophied, and are lost some time before birth.

It is, then, rather with the changes effected in the blood in its passage through the liver, as compared with those effected in the blood in its passage through the spleen, that we are especially concerned. Some very curious observations were made by Lehmann upon the corpuscles in the hepatic vessels. He estimated that the proportion of white corpuscles in the blood of the hepatic vein was at least five-fold the proportion in the portal blood. He also noted certain differences in the appearance of the red corpuscles, which he explained by the supposition that the liver was the seat of development of these elements, which were formed from the white corpuscles and that the blood of the hepatic veins contained a greater number of newly formed, or rejuvenescent, blood corpuscles.

This at once connects the function of a portion of the liver with that of the spleen. For it has been ascertained that there are similar established points of difference between the blood of the splenic artery and of the splenic vein. There can be no doubt of the fact that the blood coming from the spleen contains a large excess of white corpuscles. Donné was the first to call attention to this fact, and his observations have been confirmed by Gray and many others.

There is another fact connected with the liver which cannot be satisfactorily accounted for except on the supposition that the liver is a compound organ, namely, its immense size in the fœtus—being at the third or fourth week so large as to constitute one half the weight of the body—for the amount of bile secreted by the fœtal liver is insignificant, and bears no proportion to the vascularity of this organ. It will be recollected that in the fœtus, up to the moment of birth, most of the blood returned from the placenta by the umbilical vein passes through the liver before it reaches the heart. The blood of the umbilical vein reaches the ascending vena cava to gain the heart in three different ways. Some passes directly into the vena cava by the ductus venosus; another, and the principal portion, passes first through the portal veins, and then through the hepatic veins, whilst a third portion enters the liver directly, and is ultimately returned to the vena cava by the hepatic veins. The biliary function of the liver is essentially connected with that of the intestine, and hence it is in abeyance in the fœtus while the function of a ductless blood-gland is alone performed. Immediately after birth, and concurrently with the sudden arrest of the passage of placental blood through the liver, this organ, notwithstanding that it assumes its biliary function, at first, becomes absolutely lighter, and although the rest of the body grows rapidly, this decrease in weight is not recovered from until the conclusion of the first year. After this period the liver, though it increases in size, grows more slowly than the body, so that its relative weight, in regard to the body, which was one to eighteen just before birth, becomes gradually less and less. At about five or six years of age it has reached the proportion maintained during the rest of life, viz., one to thirty-six; and it is worthy of remark that the relative weight of the left lobe to that of the right, which is about one to one and a half immediately before birth, undergoes a diminution afterwards. Thus at a month old it has been found to be as one to three; and in after life the proportion is generally one to five. This decrease in size takes place at the same time that the biliary function is on the increase, and is sufficiently accounted for by the cessation of the blood-gland function of a portion of the liver. After birth, as the liver decreases in size, so the spleen as rapidly increases in size, and in comparison with the weight of the body, is as heavy a few weeks after birth as in the adult.

Evidence in favour of the liver's supplementing the function of the spleen may be obtained from the experiment of removing the spleen. The experiment of removing the spleen seems to have been performed in very early times. Pliny says—"That animals will live after this part has been torn out" (Lib. xi, c. 30); and the same fact is noticed in the Talmud, (Ginzburger, Medic. Talmud. p. 11). Haller cites various instances in which the spleen has been lost in the human subject; particularly Leon. Fioravanti, Tesoro della Vita Umana, b. ii, c. 8, *Phil. Trans.*, No. 451. The removal of it from the dog is an experiment which has been repeated over and over again, (see Haller, t. vi, p. 421. We find that animals, and even human subjects, have lived without the spleen, and enjoyed tolerable health. Sometimes the experiment has been fatal; but not from the loss or interruption of any function, that could be ascribed to the spleen. We find that dogs have been lively, fat, and even plethoric; that they have had good appetites; in short, imperfection in the digestive process is the only thing noticeable, and the liver is the only organ which has suffered, and that in only a few instances.

The inference usually drawn from these experiments is, that the spleen is a useless organ; or that the function of the spleen is of little importance in the economy. Such an inference is of course absurd. The more correct interpretation would probably be, that some other organ supplements the function of the spleen, just as one kidney can accomplish the function of urinary excretion after the other has been removed. Moreover, in this case the single organ remaining does not apparently undergo enlargement; and there can be no reason why the liver may not accomplish the function of the spleen after the removal of this organ, and without undergoing any enlargement, except, as mentioned, in a few instances.

To return to the liver. Having shown above that the liver may be regarded as a union of two organs, and that it performs two functions—one function being similar to that of the spleen, and exhibited in the altered condition of the blood of the hepatic veins—we now draw attention to its remaining function, namely, the biliary, in order to connect this office of the liver with that of the alimentary canal, and to account for the absence of that function on the left side of the body, in connection with the spleen.

The first point which claims our attention is, that no liver exists in those annulida which are destitute of a distinct alimentary canal, such as the trematoda, tæniada, and acanthocephala; nor yet in the cœlenterata, much less in the protozoa. The liver, in its simplest condition, is a mere inflection of the mucous lining of the alimentary canal, forming a small cæcal recess, or follicle. The capillary vessels ramify upon the parietes of the follicles, which pour their secretion into their internal surface, whence it is conveyed to the alimentary canal to be mingled with the ingesta. In this, its most rudimentary form, the liver would appear to be present in the languinella, a small ciliobrachiate polypus. The next most elementary form of the hepatic cæcum is seen in the single lengthened follicle discovered by Owen in the ascaris halicornis. The follicle opens into the alimentary canal at about one third from its oral extremity. Among the annelida, as the medicinal leech, the liver is represented by numerous simple cæcal pouches, appended to each side of the digestive canal. The next step in the complication of the organ is observed in the lengthened filiform tubercles, which are connected with the sides of the canal in the aphrodita. They terminate in a small oval sac. In other species of the same genus, and in the arenicola, they display a tendency to ramify by developing small cæcal pouches from their sides. In the class insecta the hepatic cæca vary in progressive development from the simple vascular dilatations observed in the digestive canal of the lampyrus splendidula, or the simple cæcal tubules of the carnivorous cicindela to the numerous cæcal follicles of the dytiscus, or to the more lengthened tubuli of the blatta orientalis. Throughout the whole class, the character of the liver is tubular. In arachnida the cæcal follicles are short, and terminate at their extremities in a cluster of numerous rounded vesicles, which give to the organ a lobulated appearance. In the class crustacea the simple cæcal follicle of insecta becomes branched and ramified, of which we have an example in argulus foliaceus. In astacus fluviatilis it is more branched; and in the pagurus striatus the liver is composed of an extraordinary assemblage of ramified follicles. In the hepatic organ of the squilla mantis we perceive a remarkable transition from the simple branched and ramified follicle of the lower crustacea, to the higher forms of the organ in the molluscous classes in which it is solid and symmetrical. In vertebrata the liver is close and complex in its structure, and always directly connected with the alimentary canal. This intimate connection is best seen during the period of the development of this organ. Its development has been frequently traced from a conical protrusion of the intestinal canal, surrounded by a soft mass, or blastema, in which, by a subsequent process of growth, the ducts are formed.

Through the whole of the vertebrate series the biliary apparatus is so intimately connected in its origin with the alimentary canal, that the absence of the alimentary canal from any cause would necessarily entail the absence of the biliary apparatus. Now if, as we have shown above, there is reason to believe that the small intestine of the left side of the body is undeveloped, the absence of the biliary apparatus on that side is fully accounted for.

But as we have explained, there is also reason to regard the liver in the vertebrata as a combination or union of two organs, a biliary apparatus and a blood-gland. Hence, on the left side of the body, the non-development of the alimentary canal, together with the absence of the biliary apparatus, gives rise to the separate existence of the blood-gland, the spleen. These two organs are not essentially connected in the animal series, for we know that the biliary apparatus may exist independently of the spleen, for such a condition is maintained throughout the invertebrate classes.

The term blood-gland has been frequently used in these pages when speaking of the spleen, and its lateral homologue, a portion of the liver, in accordance with the nomenclature of recognised authorities. The term, it must be confessed, has been used by them rather from the circumstance that the spleen is intimately connected with the sanguiferous system, and that it is unprovided with a special duct, than from any definite views with regard to its office. The function of the liver, in its capacity of a blood-gland, is performed in its highest degree in the fœtal condition, when much of the blood from the placenta passes through its substance. The nature of this office may be the more readily explained by referring, by way of analogy, to the lymphatic system of vessels. It is well known that for the most part the lacteals and lymphatics, which may be regarded as constituents of the vascular system, pass through certain small vascular bodies named lymphatic glands, so that both the chyle and lymph are sent through these glands before being mixed with the blood. It is found, moreover, that the lymph and chyle contain a greater proportion of fibrine, and are consequently more perfectly coagulable after passing through these glands, and it is also observable that the proper corpuscles of the chyle and lymph are most abundant in that which is obtained from the lacteals, or lymphatics, which have just passed through these glands. From this latter circumstance, it has been supposed that these corpuscles, though probably also generated elsewhere, in the lymphatic and lacteal vessels, are principally produced in these glands. In a gland a large number of plexiform lymphatic vessels are collected into a compact mass of small compass. A system of lymphatic vessels is superadded in all classes of vertebrate animals. Such, however, is not the case in the invertebrata.

When we compare with the above description some points connected with the course of the circulation in the fœtal condition, the structure of the spleen, and the composition of splenic and hepatic blood, a remarkable coincidence will be apparent. It will be remembered that the blood from the placenta, after proceeding by the umbilical vein, mostly passes through the blood gland, the liver, before it is mixed with the blood of the general circulation of the body, so that this organ holds the same position in relation to the sanguiferous system that the lymphatic gland does to the lymphatic system ; and the total absence of lymphatic glands in the placenta appears to account for the presence of this gland at the point of ingress of the placental blood into the general circulation. A gland for the passage of blood so situated would both obstruct the entrance of injurious elements into the body, and impress new characters upon the placental blood, fitting it for the purposes of the circulation. Although the combination of the blood-gland with the biliary apparatus, in the case of the liver, renders the structure obscure, yet in its lateral homologue the spleen, the structure is quite in harmony with the view that the spleen is a highly developed glandular structure, analogous to the lymphatic gland, but differing as much from a lymphatic gland as an arterial trunk differs from a lymphatic vessel. By its higher degree of development the spleen is adapted to the requirements of the arterial and venous systems. The spleen then is to be regarded as a *sanguiferous gland* attached to the sanguiferous system, and performing a similar function for the arterial to that performed by the lymphatic gland for the lymphatic system. With regard to the hypothesis of sanguification, the spleen probably has no more power of sanguification than a lymphatic gland has of manufacturing lymph, although in both cases they are capable of impressing definite characters upon the fluid passing through them. There are three functions, at least, we may expect from the spleen, if regarded as a *sanguiferous gland*, namely, the arresting of effete or injurious elements in the blood, the adding of leucocytes, or white corpuscles, and the increasing of the fibrine and albumen of the blood. Now the investigations of Lehmann, Béclard, Gray, and others, have shown undoubtedly, although its significance has not hitherto been understood, that the blood of the splenic vein differs from that of the splenic artery, in having a large excess of white corpuscles, a diminution in the proportion of red corpuscles, and an increase in the fibrine and albumen. Although the blood of the hepatic veins originates from a more complicated source, we may still expect to find a large excess in the white corpuscles, and it does show an excess of these corpuscles, at least fivefold the proportion found in the portal blood. Pathological investigations strongly corroborate the above views as to the nature of the spleen.

The irregularity in the *situation* of the Spleen has never been satisfactorily accounted for. In the chelonia the spleen is bound to the commencement of the transverse arch of the colon ; and amongst the sauria, in the crocodile it is placed behind the stomach, at the back part of the abdomen, but on the left side of the mesial line ; and in ophidia this organ, in the large boa for instance, is found at the left side of the pylorus, just at the commencement of the intestine and intimately connected with the pancreas. In pisces the position is similar in nearly all families, being placed in apposition to the side of the stomach, or to some part of the intestinal canal, by means of a fold of the mesentery. In some few fish, as in the tench, it is in intimate connection with the left lobe of the liver. May not this want of regularity in the situation of the spleen be accounted for by its having missed its connection with the biliary apparatus of its own side of the body? In the higher mammalia, in which it presents by far its greatest development, it maintains a position symmetrical with, and laterally homologous with, the liver. The separate splenculi, and also the deep notching of the anterior margin of the spleen, in the human subject, bring to mind the multiple condition of this organ in some animals, as, for instance, in the porpoise. In the dolphin there are many lobes. Both these conditions are liable to occur in the case of all lobular organs, and are noticed in the liver, pancreas, and kidney, in various animals.

The *size* of the Spleen in proportion to the size of the body is a subject which has engaged the attention of many observers, and without any satisfactory conclusion. As we have before mentioned, in the cetacea, in which the bulk of the blood is larger, the size of the spleen is smaller in proportion to the size of the body than in any other of the mammalia; whilst in the cheiroptera, as, for instance, in the bat, it is larger in proportion to the body than in any other order of this class. It is much larger in felidæ than in the other orders of the carnivora; whilst in the kangaroo it is small. In birds the spleen is generally of small size as compared with the body; much smaller than in the mammalia. It is large in the cormorant and small in the puffin and ostrich. Descending in the vertebrate series, in reptilia the spleen appears considerably reduced in size and importance. In the crocodile it is of larger size than in any other reptilia. In the ophidia this organ is very small, being reduced to its minimum of development in this class. Moreover, the Malpighian bodies which form so important an element of the spleen in the mammalia and birds, are absent in the reptiles. In pisces the spleen is generally present, but is of small size; in the lepidosiren it is exceedingly small; in the lamprey its presence has been thought doubtful; and in the lancelet, the most lowly organised of the vertebrata, it seems to be absent.

Various hypotheses have been put forth in explanation. It has been suggested that the size of the spleen might bear some relation to the nature of the animal's food. Thus in mammalia, the spleen is found to have a much larger proportional size in carnivora and insectivora than in the remaining orders. It is consequently largest when the intestinal canal presents the least complex structure, where the digestion is most rapidly performed, and consequently when the new material is more suddenly added to the blood; and we have seen above how congestion of the portal system may impede the passage of the blood through the spleen. It is quite possible that this may, to some extent, influence the size of the spleen; and there can be little doubt but that "in the amphibia its large size and its peculiar lax and distensile texture are in perfect harmony with the requirements of the animals of this class, being peculiarly adapted as a reservoir for the blood, which accumulates in the venous system during the suspension of respiration." (Gray.)

These explanations are not sufficient to meet all cases. It is probable that a clue is to be found in the application of some general law of nature, modified to some extent by the habits of each race of animals. We find, in fact, that, if we may judge from its size, the importance of the spleen seems to diminish successively from mammalia to birds, then to reptiles, and from them to fishes; and we also find that the liver among the vertebrata, proportionately to the body, becomes progressively larger in passing from the mammal to the fish. For instance, in the mammalia the spleen presents by far its greatest development of structure, and this, no doubt, partly depends upon the greater general completeness and requirements of their organization. But the liver in mammalia is very much reduced in size, and is more compact and firm than in the lower vertebrata; and may not the small size of the liver be to some extent accounted for by the compensating function of the largely developed spleen?

Although the above may afford sufficient explanation of the fact that the spleen is larger in the mammal than in the fish, it does not account for the difference of size in the various orders of each class. But may not the proportional size of the spleen in each order be also a question of development? for, on examination, it will be found that the proportional size of this organ frequently bears some relation to the development of the lateral organs, as exhibited in the size and complex structure of the limbs, especially of the upper extremities If we take extreme cases, this will be more apparent; in the mammalia, by way of illustration, the largest proportional size of the spleen is to be found in the bats, and the smallest in the whales; whilst it is in the bats we meet with the highest development of the upper extremities, and in the whales the lowest.

In the *Felidæ*, with highly developed claws, as, for example, in the lion, the spleen is of much larger size than in other orders of the carnivora; whilst in the kangaroo the spleen is proportionately small, this reduced bulk coexisting with the diminished size of the upper extremities. The small size of the spleen in the marsupials and monotremes is, however, capable of another explanation.

In the *Pachydermata*, as a rule, the spleen is small. The seal, phoca vitulina, would, at first sight, appear to be an exception; but as explained above, in amphibia and other animals of allied habits, the spleen, by its large size and distensile structure, serves as a reservoir for the blood which naturally accumulates in the inferior cava and the hepatic reservoir, and passes through the channel in the portal system to the spleen, when the venous system is obstructed as a result of suspended respiration.

In the class *Aves* the spleen is generally of small size, as compared with the body—much smaller than in the mammalia—in accordance with the descending scale of general development. The liver, moreover, is more largely developed than in the mammal. The spleen is large in the cormorant, and small in the ostrich and puffin, and large, as may be expected, in the diving moor-hen.

In the *Reptilia*, as we descend in the scale of the vertebrate series, the function of the spleen appears to be considerably reduced in importance, as shown by the extreme diminution in its size. The liver is larger than in birds. The crocodile, as compared with the serpents, affords another example of the larger size of the spleen, coexisting with the higher development of the limbs. This organ is larger in the crocodiles than in any other reptile; and in the ophidia the spleen is very small: its size has been estimated, as compared with the body, at 1 to 11.150. In the boa it hardly exceeds in size a common pea. The most prominent structural difference in the reptilia is the absence of Malpighian bodies, which form so important an element of the spleen in the mammalia and birds. In *Pisces* the spleen is universally present, but its small size in proportion to the body confirms this view and shows that it is an organ of less functional importance than in the mammalia. The liver is larger than in birds.

Having shown above that the spleen is, anatomically, the left lateral homologue of the liver, we now recapitulate the various considerations for regarding the spleen and liver as mutually related, physiologically.

From independent investigation, physiologists have come to regard the spleen as a blood-gland; that is to say, an organ devoid of any proper duct, and whose office is to impress certain characters upon the blood in its passage through its tissues. There has, however, been much difference of opinion with regard to the precise nature of the change effected in the sanguineous fluid. Some have gone so far as to believe that it supplies all the germs which are ultimately to become blood-corpuscles; but, as Professor Owen has pointed out, although the spleen receives more blood than is needed for its nutrition, it yet receives too small a portion of the circulating mass to have any very definite influence on the manufacture of the blood. Since, however, the splenic vein is the largest constituent channel of the portal vein, it is inferred that such changes as are effected in the splenic locality probably relate to the function of the liver, to which the altered blood is exclusively carried.

To this it has been objected that, no instance of an arrangement of a like nature can be adduced, of one organ's elaborating properties that they may be removed by another ; and also that the splenic blood does not differ in its destination from the blood of all the chylopoietic viscera. What, however, is exceptional is this, that the splenic blood is poured into the portal system of the opposite side of the body, and this fact leads to the conjecture that not only is the biliary apparatus absent on the left side of the abdomen, but that the liver itself is a combination of two organs, one resembling its lateral homologue, the spleen—a blood-gland—and the other a biliary organ.

Now, upon an examination of the liver, we find that it has a double vascular supply, differing in this respect from all the other abdominal viscera. It is supplied by the hepatic artery, a vessel corresponding with the splenic artery, and also by the portal vein, which is distributed after the manner of an artery; and the blood from the hepatic artery, as is also the case with that from the splenic artery, falls ultimately into the portal system before gaining the hepatic veins. The tissues supplied by the hepatic artery differ from those supplied by the portal vein, which is distributed exclusively to the hepatic lobules. It may be objected that this double vascular supply is not conclusive evidence as to the double nature of the liver, for a similar arrangement exists in the case of the lung, which is supplied by an artery and a vein, and the vein is distributed to the pulmonary lobules after the manner of an artery.

An examination of the nature of the lung will dispose at once of this objection; for the lung is a compound organ, and is to be regarded as a combination of the air bladder and the gills ; and there are not wanting indications of the combination of their separate functions; and in the case of the liver, the function of each of its component parts can be recognised.

The discovery of the glycogenic function of the liver has directed the attention of physiologists to the liver, in order to detect the existence of two distinct portions; but their labours have not been attended with any very satisfactory results, so far as the isolation of two organs is concerned; and since the glycogenic function is also performed in other parts, and the spleen itself does not perform a similar office, we seek in the liver some vestige of a fibro-cellular structure, supporting an arterial and venous plexus, similar to that found in the spleen. Now in the disease of the liver known as cirrhosis, in which there is a partial atrophy of the biliary secreting portion of the liver, this tissue becomes evident. But it is in the blood of the hepatic veins that we find the greatest evidence of the liver's performing a similar function to that of the spleen. Lehmann has detected the presence of white corpuscles in the blood of the hepatic vein, and has estimated that their proportion is at least fivefold the proportion in the portal blood; and Donné has called attention to the fact, and his observations have been confirmed by Gray and others, that the blood coming from the spleen also contains a large excess of white corpuscles.

That the liver has other functions in addition to that of secreting bile, is apparent from its condition in the fœtus; for at an early period of fœtal existence it is so large as to constitute one half the weight of the whole body, and the amount of bile secreted is quite insignificant, and bears no proportion to its vascularity. A large portion of the blood from the placenta passes through this organ before entering the general circulation. At birth, notwithstanding that it assumes its biliary function concurrently with the establishment of the office of the intestine, it becomes considerably lighter, and up to the age of five or six years, although the secretion of bile is largely on the increase, it becomes gradually less and less. This is sufficiently accounted for by the cessation of its blood-gland function; moreover, the spleen after birth as rapidly increases in size as the liver diminishes, and in comparison with the weight of the body is as heavy a few weeks after birth as in the adult.

Further evidence of the liver's supplementing the function of the spleen may be obtained from the experiment of removing the spleen; for the inference drawn from the fact of the small amount of disturbance to the system following this operation at once points to the conclusion that some other organ carries on its function, just as one kidney can accomplish the function of urinary excretion after the other has been removed, and without any apparent enlargement; and the only organ which has suffered after removal of the spleen has been the liver. All these circumstances, taken in combination with the anatomical position of the liver and spleen, explain the mutual physiological relationship of these two organs.

It is now necessary to account for the absence of the biliary apparatus on the left side of the body in connection with the spleen. No liver exists in those animals which have no alimentary canal. In all animals having a liver this organ is intimately connected with the alimentary canal, and during the period of development this organ cań be traced to a conical protrusion of the mucous membrane of the intestinal canal, surrounded by a soft mass, or blastema. Through the whole of the vertebrate series the biliary apparatus is so intimately connected with the alimentary canal, that the absence of one would necessarily entail the absence of the other; so that the undeveloped condition of the small intestine on the left side of the body fully accounts for the absence of the biliary apparatus on this side; and since, on the right side, the biliary apparatus is connected with the blood-gland, the two together constituting the liver, the cause of its absence, in combination with the spleen, is sufficiently clear, and these two organs are not necessarily connected together, for the biliary apparatus exists without the spleen throughout the invertebrate series.

The pancreas has nothing whatever to do with the spleen. It is situated on the right side of the mesial line of the body, on the same side as the liver, with which it is functionally connected. The liver is not the result of the union of a pancreas with a spleen, nor would the spleen, if united with the pancreas, form a liver.

We have, in the next place, to consider the nature of the function of the spleen. It has been denominated a "blood-gland," but with very vague notions with regard to its functions. The liver, as we have seen, is composed of a blood-gland and a biliary apparatus; but its office as a blood-gland is performed in its highest degree in the fœtal condition, when much of the blood from the placenta passes through it. It is well known that in the lacteal and lymphatic systems both chyle and lymph are for the most part sent through small vascular glands before being mixed with the blood. Just in the same way the blood from the placenta passes through the blood-gland connected with the liver, before it is mixed with the blood of the general circulation; so that this organ bears the same anatomical relationship to the sanguiferous system that the lymphatic gland does to the lymphatic system; and the entire absence of lymphatic glands in the placenta appears to account for the presence of this gland at the point of ingress of the placental blood into the general circulation of the fœtus.

Although the combination of the blood-gland with the biliary apparatus, and the ultimate arrest of its function, obscure its structure, in the case of the liver, its lateral homologue the spleen presents a structure in harmony with the view that it is a highly developed glandular organ, attached to the arterial system, somewhat analogous to a lymphatic gland, but differing as much from an ordinary lymphatic gland as an arterial trunk differs from a lymphatic vessel. The lymph, or chyle, after passing through a gland, contains a greater proportion of fibrine, and a larger number of proper white corpuscles; moreover these glands appear to have the power of obstructing the entrance of injurious elements into the blood. Now the investigations of Lehmann, Béclard, Gray, and W. Müller, have shown undoubtedly that the blood of the splenic vein presents a very large excess of white corpuscles, a diminution in the proportion of red corpuscles, and an increase in the fibrine and albumen; and that the blood of the hepatic veins also shows a large excess of white corpuscles, at least five-fold the proportion found in the blood of the portal veins. Diminution in the proportion of effete corpuscles in the blood in passing through the spleen, in a very marked degree, has been noted. Enlargement of the Spleen, as the result of blood-diseases, corroborates these views.

The small size of the spleen, as compared with the liver, in the fœtal state, is to be explained by the fact that the umbilical vein exists only on the right side of the body. The lobed and multiple condition of the spleen in some animals, is nothing more than what occurs in the case of other lobular organs, such as the liver, kidney, pancreas, etc. The size of the spleen, in proportion to the size of the body, is a question of development, modified by the habits of the animal, the size of the liver, and the degree of development of the lateral organs, etc.

The Spleen is not the undeveloped liver of the left side of the body, nor is it the parenchyma of the liver disunited from the pancreas; nor is it a blood-gland in the mesial line of the body, having no homologous relationship with the liver.

The Spleen is a sanguiferous gland, situated on the left side of the abdominal cavity. It is the left lateral homologue of a portion of the liver; the liver being a combination of a sanguiferous gland and a biliary apparatus.

In the course of this investigation the following points in human anatomy receive elucidation.

The peculiar shape of the stomach, terminating at one end in a cul-de-sac, and at the other in the pylorus. The opening for the œsophagus not being in the centre, but much nearer the great end of the stomach. The direction of this organ, stretching into the right lateral region. The marked difference which exists in its various coats, and their undeveloped condition as they approach the great cul-de-sac.

The stomach being supplied by one artery instead of by two vessels, one on each side; so that it depends upon neighbouring organs for its vascular supply. The lymphatic vessels at the cul-de-sac forming a distinct set from those belonging to the rest of the stomach. The sympathetic system of nerves supplying both surfaces.

The contraction which exists during the process of digestion more or less dividing the stomach into two cavities; and the fact that pain at the left end of the stomach is felt on the left side of the head, and that at the right side of the stomach on the right side of the head.

The situation of the small intestine, commencing at the upper part of the right lateral region, and passing to the middle line before joining the large intestine. That the various glands, Peyer's glands in particular, are not placed symmetrically on each lateral half of the bowel. That this intestine is supplied by one artery and vein.

That the large intestine, instead of being supplied by one vessel, as in the case of the small intestine, is supplied by two vessels; and that its situation is in the mesial line of the body. The nature of the vermiform appendix.

The large size of the fœtal liver; its diminution after birth. That it is situated in the right hypochondriac region, rather than in the mesial line. The nature of its lobes. That although the largest viscus in the abdominal cavity, it is supplied by only one artery from the aorta, instead of by two. That there are not two portal systems, one for each side of the abdomen. That the umbilical vein is connected with the liver in the fœtal condition. That there is but one umbilical vein instead of two, whilst there are two umbilical arteries. That there is no biliary apparatus, nor small intestine, on the left side of the body. That the lacteal system is much smaller on the left side of the abdomen than on the right, and is not connected with the small intestine.

The small size of the spleen before birth, and its rapid increase afterwards. Its distension in cases of internal congestion. The large size and peculiar course of the splenic vein. That there is one splenic artery instead of two. The unsymmetrical form of the spleen, and its lobular condition. That the spleen has no biliary function.

Enlargement of the Spleen results from an abnormal condition of the blood, as in Typhus, Typhoid, Cholera, Pyæmia, Erysipelas, Scarlatina, Measles, Dyscrasia, Ague, Scurvy, Purpura, Chlorosis, Rheumatism, and Tuberculosis.

In conclusion, it may be added that the foregoing investigations into the anatomy and physiology of the abdominal viscera afford many suggestions as to the appropriate treatment for the relief of various affections of the Stomach, Liver, and Spleen.