# THE GREATER OMENTUM - ITS MORPHOLOGY AND FUNCTION.

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A THESIS PRESENTED FOR

THE DEGREE OF MASTER OF SURGERY,

UNIVERSITY OF CAPETOWN,

by

WILLIAM WILKIE,

M.B.,Ch.B.,

(University of Capetown).

1946

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# INTRODUCTION.

# INTRODUCTION.

The omentum has, from time to time, provoked sporadic reports on various aspects and, occasionally, a series of reports on one in particular.

Hitherto no comprehensive account of the omentum and its function has been given. This thesis was undertaken with a view to correlating the available information and, in addition, performing further investigations along lines that were indicated.

The Anatomy and Comparative Anatomy has received scant attention and the question of independent movement by the omentum has not yet been satisfactorily settled. These subjects have, therefore, been investigated and reported on at some length. In addition, some experiments of other observers have been repeated and a few original observations have been made and their significance discussed.

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# E M B R Y O L O G Y.

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## THE FORMATION OF THE COELOMIC CAVITY.

At the beginning of the third week of the development of the human embryo a cleft appears in the extra-embryonic mesoderm and extends to divide this into a somatic layer, lining the chorion, and a splanchnic layer, investing the yolk sac. The space so formed is the Extra-embryonic coelom, and the mesodermal cells which line it flatten into a limiting membrane called "mesothelium".

About one week later, at the beginning of somite formation numerous horizontal clefts appear in the unsegmented mesoderm of the embryo itself; these lie lateral to the mesodermal segments and begin to split the solid mesodermal sheet into a somatic and a splanchnic layer. (Fig. 1).

These spaces coalesce to form the intra-embryonic coelom, which appears first in the head region and does not communicate with the extra-embryonic coelom. The cranial ends of these two cavities become confluent in the midline to form an inverted U-shaped cavity. The broad apex of the U gives rise to the pericardial cavity and the two limbs to the pleural cavities. The peritoneal cavity

/develops

develops a little later, as the coelomic development progresses in a caudal direction simultaneously with further segmentation.

That part of the intra-embryonic coelom which is to form the peritoneal cavity at first communicates with the pleural cavities and extra-embryonic coelom around the base of the yolk sac. With the development of the septum transversum, and the constricting off of the embryo from the yolk sac, these communications are gradually closed off.

The early peritoneal cavity is thus constituted by the abdominal portions of the coelom on each side of the midline, with the primitive gut intervening. In this way a saggital septum is formed down the length of the peritoneal cavity. The primitive gut runs in the middle of this septum dividing it into a ventral, avascular portion, and a dorsal, vascular portion in which the splanchnic branches of the abdominal aorta run to the gut. (Fig. 2). This constitutes the ventral and dorsal mesenteries of the primitive gut.

The ventral mesentery of the primitive gut does not persist as does the dorsal mesentery, but disappears, except for a short portion proximally. In this way there is free communication across the midline in the peritoneal cavity, allowing for the later rotation of the gut.

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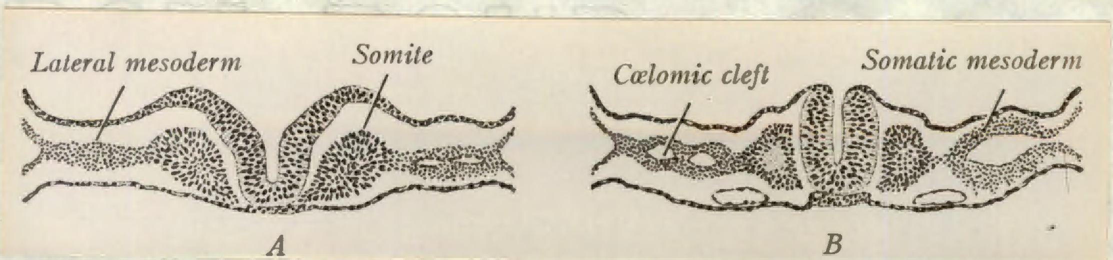


Fig. 1.

Origin of the human intra-embryonic coelom, shown by transverse sections. (X 65). The right half of each segment is somewhat more advanced than the left.

A. at two somites; B. at seven somites.

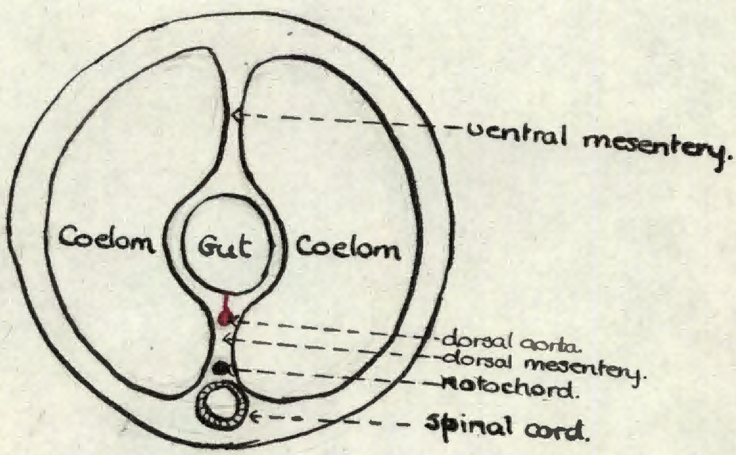


Fig. 2.

Diagram of human embryo showing primitive gut with ventral and dorsal mesentery.

## The Development of the Gut.

Early in the fourth week, owing to differences in the rate of growth of different parts of the embryo, it begins to assume its definite shape. This is brought about by the formation of four folds; the head fold, tail fold, and two lateral folds. These folds constrict the embryo from the yolk sac and, in so doing, form the primitive gut. Thus, the area enclosed by the head fold is termed the "fore-gut", and lies between the buccopharyngeal membrane and the pericardium ventrally, and the hind brain [redacted] dorsally; the area enclosed by the tail fold is the hind-gut, while the intervening portion which retains its connection with the yolk sac is the mid-gut. (Fig. 3).

As the omentum develops exclusively from the fore-gut, the further development of the mid- and hind-gut will not be discussed.

The part of the gut that succeeds the pharynx remains tubular and is the oesophagus. About the fourth week, a fusiform dilatation develops in the gut immediately distal to oesophagus, and proximal to the opening into the yolk sac. This is the stomach, and its further development is of the greatest importance in the development of the omentum. (Fig. 4).

As noted above, the primitive gut has originally

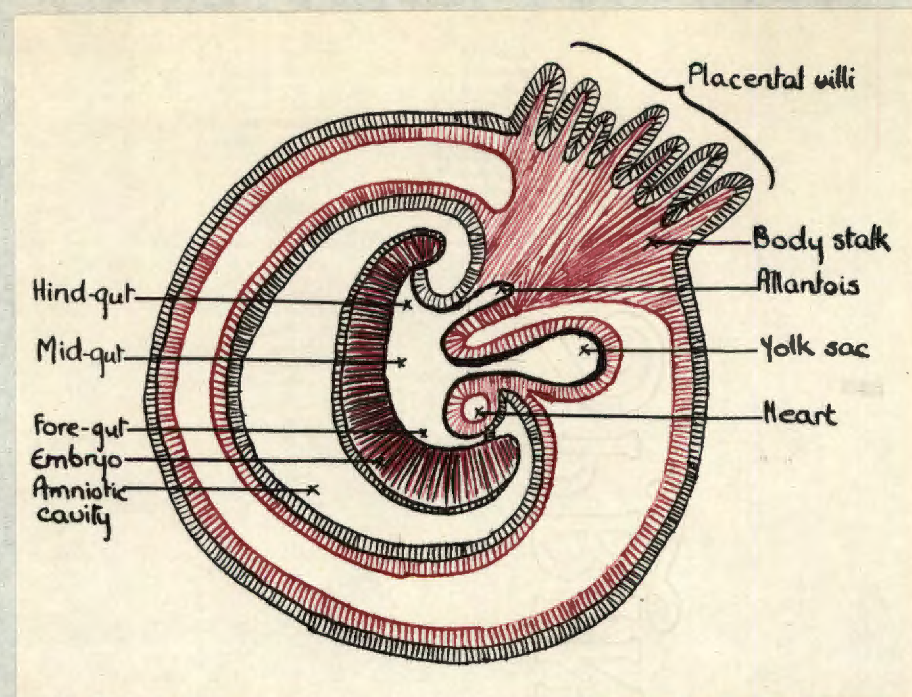


Fig.3.

A diagram to show the formation of the head and tail folds and the three divisions of the gut. (After Gray).


Fig. 4.

A diagram of the digestive tube of a human embryo 2.54 mm. long (Peter Thompson).

originally a dorsal and ventral mesentery and that the dorsal mesentery persists, while the ventral mesentery disappears, except the ventral mesentery of the fore-gut. This part of the ventral mesentery persists as the lesser omentum, or hepato-gastric ligament, and the falciform ligament of the liver, containing the umbilical vein. The liver develops as an outgrowth from the gut into the septum transversum, at the junction of the fore- and mid-gut. (Fig. 5).

At the 10 mm. stage, about 5½ weeks, differences in the rate of growth of the ventral and dorsal borders of the stomach become apparent, the dorsal border growing much faster than the ventral border, so that the greater and lesser curvatures are formed. (Fig. 6). The fundus arises as a local bulge near the cranial end, and so the adult shape of the stomach is established. As its two extremities are fixed, the oesophageal, by the hiatus in the diaphragm, and the pyloric by the bile duct and lesser omentum fixing it to the liver, the stomach rotates as its shape changes. As the liver occupies the whole of the right half of the upper abdomen, the stomach can only rotate to the left, which it does, and its left border now becomes anterior and its right border posterior. The right and left vagus nerves rotate with the stomach, and now come to supply the dorsal and ventral surfaces

/respectively.

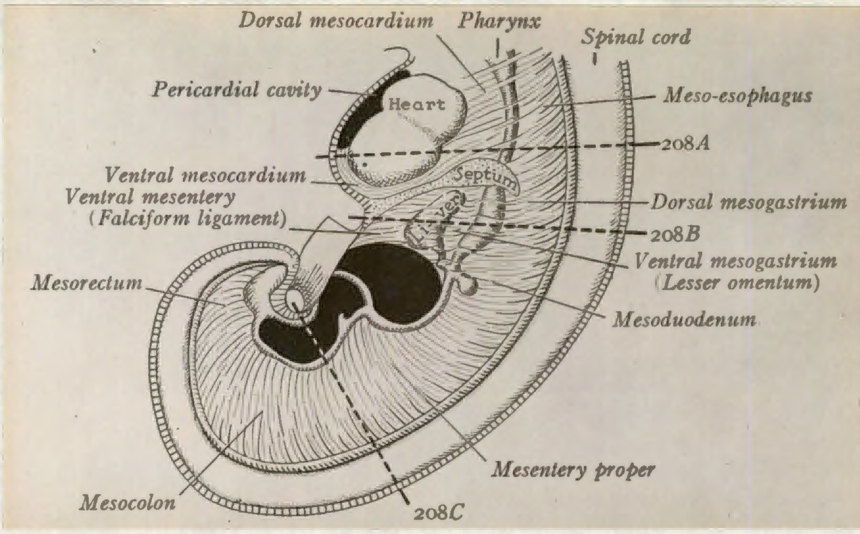


**Fig. 5.**

**Primitive human mesenteries, shown as diagram viewed from the left side. (Prentiss).**

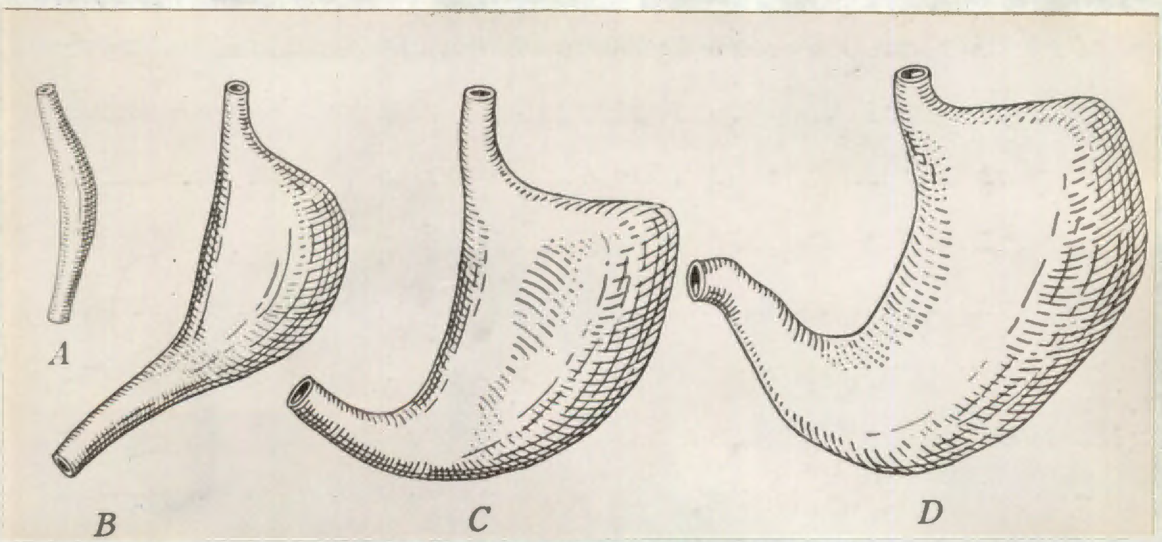


**Fig. 6.**

**Models of the human stomach. A. at 5.5 mm. (X 25); B. at 9 mm. (X 25); C. at 15 mm. (X 25); D. at 23 mm. (X 15). (Johnston).**

respectively.

The rotation of the stomach is also dependent on a difference in growth of its ventral and dorsal mesenteries; the dorsal growing faster than the ventral at the time that the omental bursa is forming, and so facilitates the rotation.

## The Development of the Omental Bursa and the Omentum.

It is an interesting fact that the omental bursa arises independently of the rotation of the stomach - the bursa begins to form at the 3 mm. stage, while the rotation of the stomach only begins at the 10 mm. stage. A study of comparative anatomy confirms this, as the omentum is present only in mammals, while the rotation of the stomach occurs much earlier, being found in reptiles. Further proof is found in a study of the tortoise [redacted] (Page 58) Here the stomach has rotated, and the pyloric end has become fused to the posterior abdominal wall, but the dorsal mesentery of the stomach remains separate from the posterior abdominal wall, so that a well-marked bursa is present behind the stomach, in the exact position of the omental bursa. There is, however, no epiploic foramen and no omentum, and, furthermore, the dorsal mesentery of the stomach has no blood supply of its own comparable to the omental arteries in mammals.

/At

At 3 mm. a diverticulum develops in the right surface of the dorsal mesentery of the stomach and burrows towards the left. It gives off two prolongations with relatively narrow necks: the one cranially between the oesophagus and the right lung bud, and the other continuing to the left in the dorsal mesentery of the stomach. (Fig. 7).

The main diverticulum persists as the vestibule of the omental bursa and communicates with the general peritoneal cavity by a relatively wide neck, the epiploic foramen, facing to the right.

The vestibule is bounded cranially and laterally by a lip-like fold of peritoneum that runs on the dorsal body wall. This is the caval mesentery in which the upper segment of the inferior vena cava develops, and into which part of the right lobe of the liver grows, so that it, too, comes to bound the vestibule on the right. (Fig. 8). On the left the vestibule is bounded by the stomach and its dorsal mesentery.

The cranial prolongation from the vestibule gets cut off by the development of the diaphragm, and often only its apex persists, as the infracardiac bursa (Fig. 7).

The prolongation of the vestibule that grows into the dorsal mesentery of the stomach continues to grow, but its neck remains relatively narrow - a point that is

/not

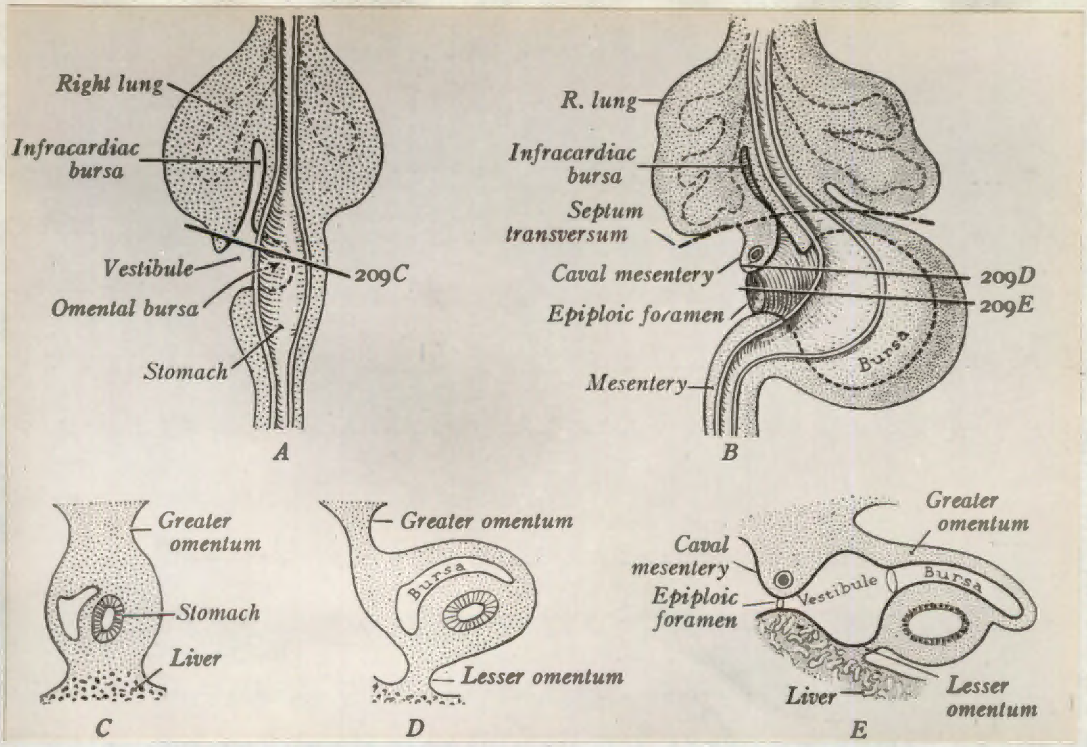


**Fig. 7.**

Early development of the omental bursa in human embryos (partly after Fraser). A.B. Ventral Views at 4 and 6 weeks; C-E. Transverse Sections at the levels indicated on A.B.

**Note:** That C.D. & E. are upside-down.

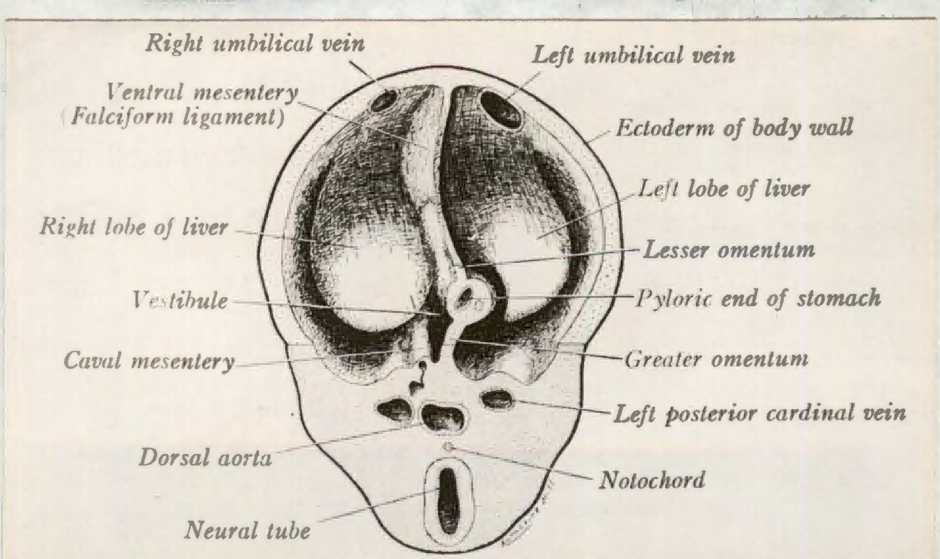


**Fig. 8.**

Early relations of the human omental bursa, shown in a simplified model at 8 mm. (Prentiss). The observer looks cephalad.

not well-illustrated by most diagrams. Fig. 9 shows clearly that this narrow neck is quite separate from the entrance to the vestibule, the epiploic foramen.

The omentum is developed solely from the dorsal mesentery of the stomach and is made up of the anterior and posterior walls of the diverticulum in the dorsal mesentery of the stomach. Its further growth and development is, therefore, dependent on that of the diverticulum.

With the rotation of the stomach, the bursa comes to lie dorsal to the stomach, and the ventral mesentery of the stomach, the lesser omentum, changes from a sagittal to a frontal plane. The epiploic foramen now presents a slit-like opening, leading from the general peritoneal cavity to the vestibule of the omental bursa, and bounded ventrally by the free border (originally caudal edge) of the lesser omentum; dorsally by the inferior vena cava; cranially by the caudate lobe of the liver; and caudally by the horizontal part of the duodenum.

In the third month, the posterior layers of the omental bursa begin to fuse with the underlying structures. The pancreas which had grown into these layers now fuses with the posterior abdominal wall - the line of fusion extending to its tail, where the posterior layers of the omental bursa fuse with the peritoneum overlying the upper

/pole

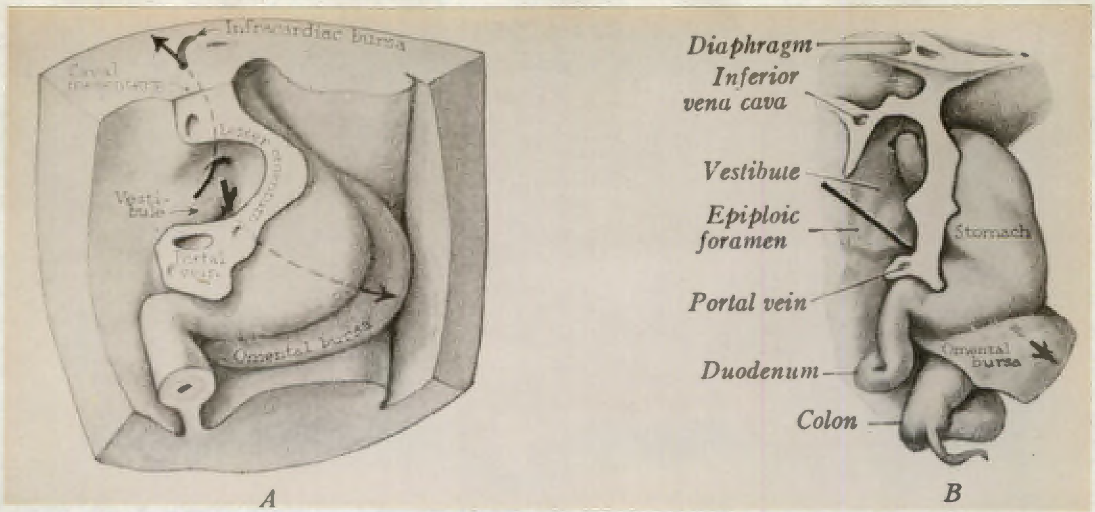


**Fig. 9.**

Early omental bursa of human embryos, in ventral view. A.at 6 weeks (After Fraser)(X 25); B. at 8 weeks (after Brauss)(X 5).

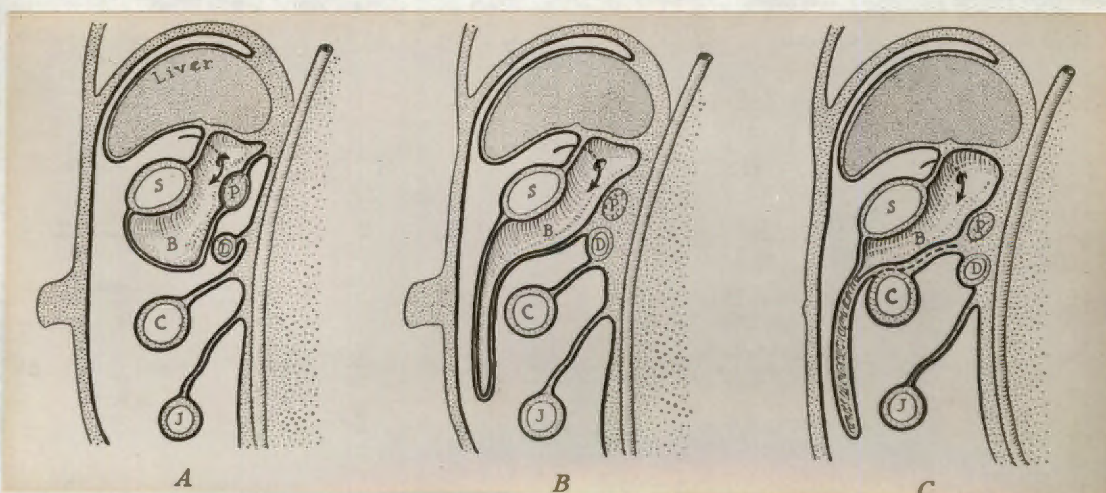


**Fig.10.**

Secondary fusions of the omental bursa. A. at two months; B. at four months; C. adult. (after Kollman). B. Omental Bursa; C. Transverse Colon; D. Duodenum; P. Pancreas; S. Stomach.

pole of the left kidney and the left adrenal. (Figs. 10, 11). The fusion continues caudally so that the transverse colon and transverse mesocolon are involved, the latter now consisting of two double layers of peritoneum (Fig. 12).

Finally, that part of the bursa extending caudally beyond the transverse colon becomes obliterated by fusion of the anterior and posterior layers, i.e., the omentum, and the transverse colon becomes attached to the stomach by this fused peritoneum known as the gastro-colic ligament.

Occasionally the fusion is incomplete and the bursa may extend down to the inferior free edge of the omentum, and more rarely the fusion with the transverse colon and transverse mesocolon may fail to develop when the foetal condition, shown in Fig. 10.B., persists.

The spleen develops in the cranial portion of the greater omentum. It grows into the outer of the two layers, the inner layer continuing in a smooth curve from the stomach to the kidney. The spleen divides this part of the greater omentum into the gastro-splenic and lieno-renal ligaments. (Fig. 11.B).

<u>The Development of the Blood Vessels.</u>

In the early embryo, before the two primitive

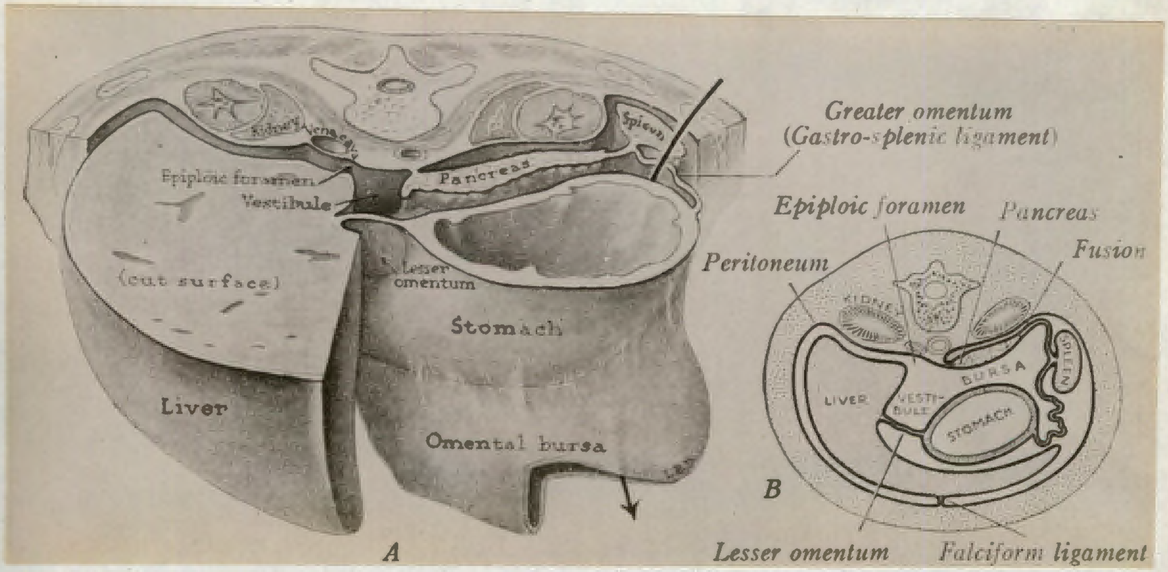


**Fig. 11.**

**Relations of the human omentum and general peritoneum at about four months (Arey).**
**A. Model cut transversely; B. transverse section.**

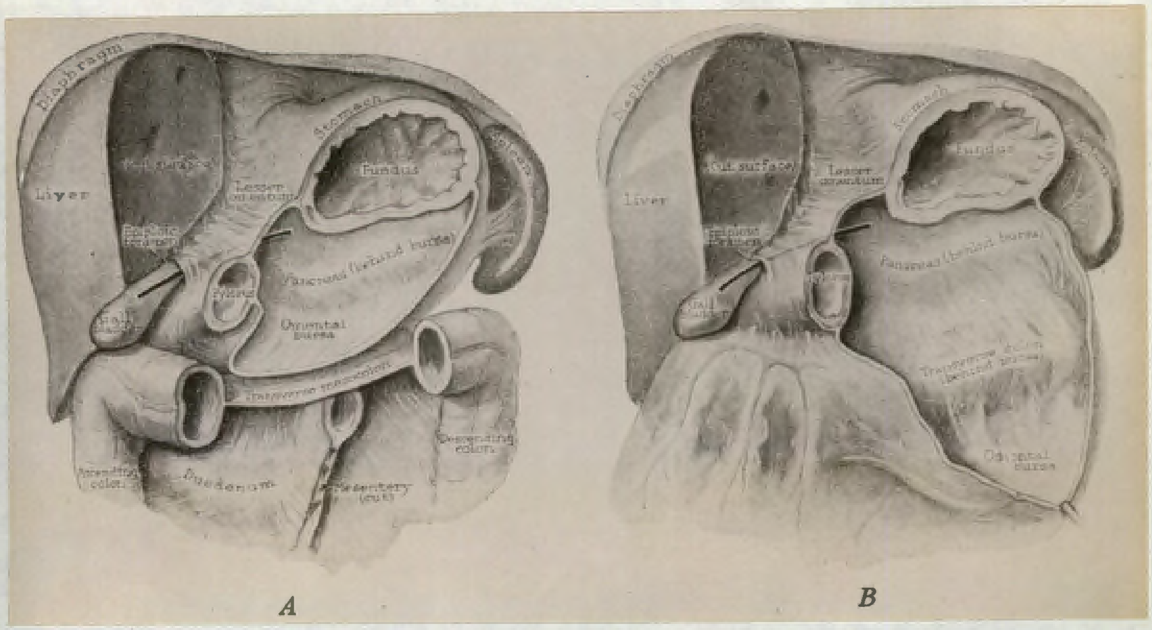


**Fig. 12.**

**Dissections showing the relations of the human omental bursa and the lesser omentum (Arey).**

**A. before union of the bursa and the transverse mesocolon; B. after union.**

dorsal aortae have fused to form the aorta, they give off three sets of paired vessels, as follows:-

1. Ventral paired vessels to the yolk sac - the Vitelline Arteries (Fig. 13);

2. Lateral paired vessels to the Wolffian ridge;

3. Lateral paired intersegmental vessels to the body wall.

With the fusion of the paired dorsal aortae to form the single dorsal aorta, the ventral paired vessels to the yolk sac fuse to form single trunks, while the other two sets of vessels persist as paired trunks. This gives rise to the following arrangement:

1. Ventral Splanchnic Arteries - ventral segmental unpaired vessels to the digestive tract;

2. Lateral Splanchnic Arteries - paired segmental arteries to the Wolffian ridge;

3. Somatic Arteries - paired intersegmental arteries to the body wall.

In the further development of the Ventral Splanchnic Arteries, these arteries become connected by longitudinal connecting vessels running on the ventral and dorsal borders of the gut, forming the ventral and dorsal splanchnic anastomoses (Fig. 14.A). This obviates the necessity for so many splanchnic vessels, and these are correspondingly reduced to three trunks - the coeliac to the fore-gut, the superior mesenteric to the mid-gut, and the inferior mesenteric to the hind-gut.

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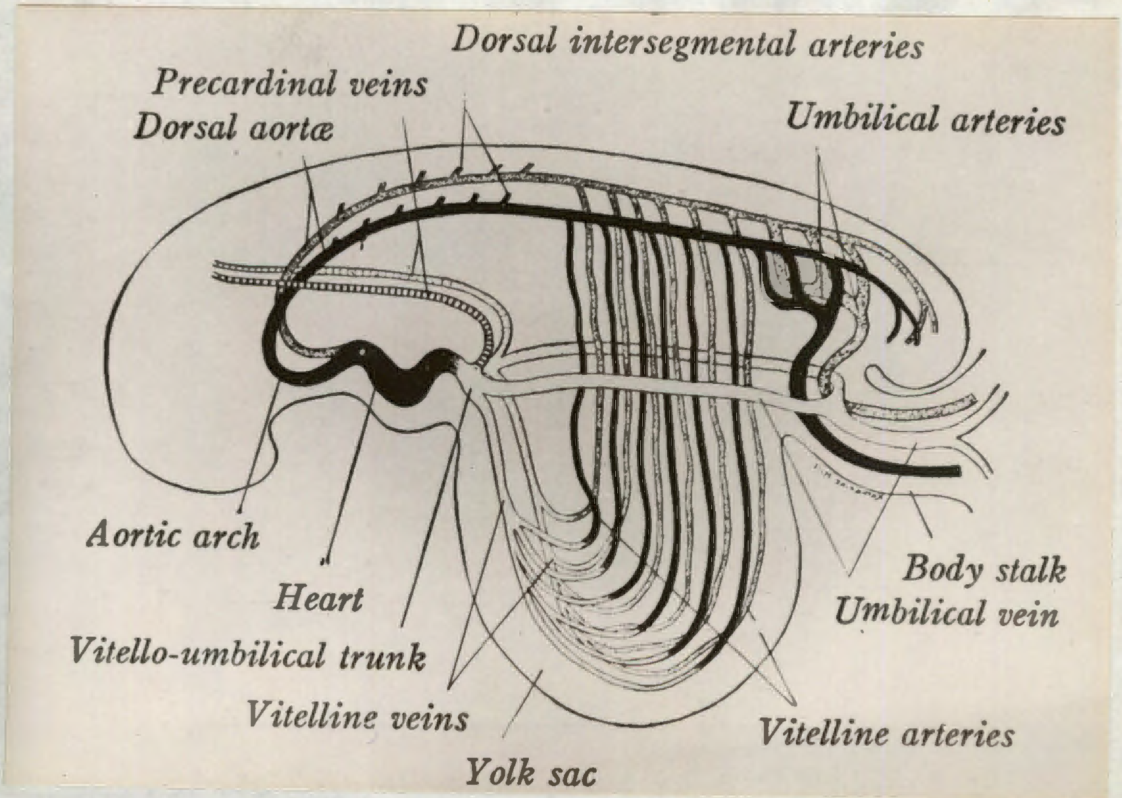


**Fig. 13.**

Arrangement of the blood vessels in lateral view in a human embryo of twelve somites. (Prentiss, after Felix).

With further development, part of the splanchnic anastomoses disappears, and all that persists from the ventral splanchnic anastomosis is the left and right gastric and the hepatic arteries; and from the dorsal anastomosis, the right and left gastro-epiploic, the pancreatico-duodenal arteries and the primary branches of the colic arteries. (Fig. 14.B.)

Arterial Developmental Anomalies:

Developmental anomalies occur but are not common. They are described in Harris' Treatise on Anatomy - any one of the three main divisions of the coeliac artery may arise from a common trunk with the phrenic artery.

This was observed in the 23 cm. foetus that was injected. The left gastric artery arose by a trunk common with the phrenic artery. (See Page 35, Plate 2).

The embryological explanation of how the left gastric, a splanchnic artery, comes to have a common origin with the phrenic, a somatic artery, is interesting.

There are originally three supra-renal arteries, branches of the abdominal aorta (lateral splanchnic arteries); superior, middle and inferior; the inferior becomes the renal artery, the middle becomes the artery of supply to the adrenal in the adult, and retains the name of middle supra-renal artery, while the superior

/becomes

becomes the inferior phrenic artery. So that the phrenic artery is not originally a somatic artery but a splanchnic artery, and any of the splanchnic branches of the coeliac axis can, therefore, easily arise with it from a common trunk.

## Suggested Theory of Development of Omental Blood Vessels.

An exhaustive search through the literature available in Cape Town failed to reveal any account of the development of the omental blood vessels.

The following account is purely theoretical and not based on any personal embryological research:

The omental blood vessels in the adult are described on Pages 31-47. From this it will be seen that the posterior layers are supplied separately from the anterior layers, although there is a free anastomosis.

As previously mentioned, the left and right gastro-epiploic arteries are developed from the dorsal splanchnic anastomosis (Fig. 14.B), into which the ventral splanchnic arteries originally ran.

These vessels all run in the primitive dorsal mesentery of the stomach, which gives rise to the omentum and its blood supply.

It is noteworthy that the general vascular plan for the anterior layers of the omentum differs from that of the primitive dorsal mesentery of the stomach only, in

/that

Fig 14a.

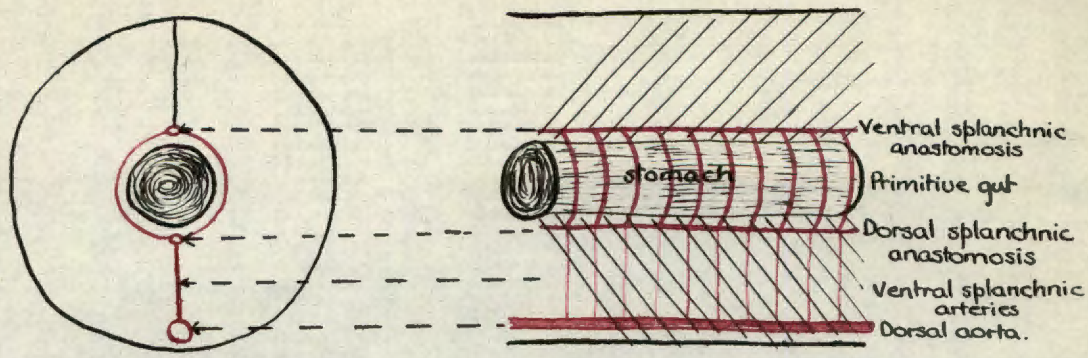


Fig. 14b.

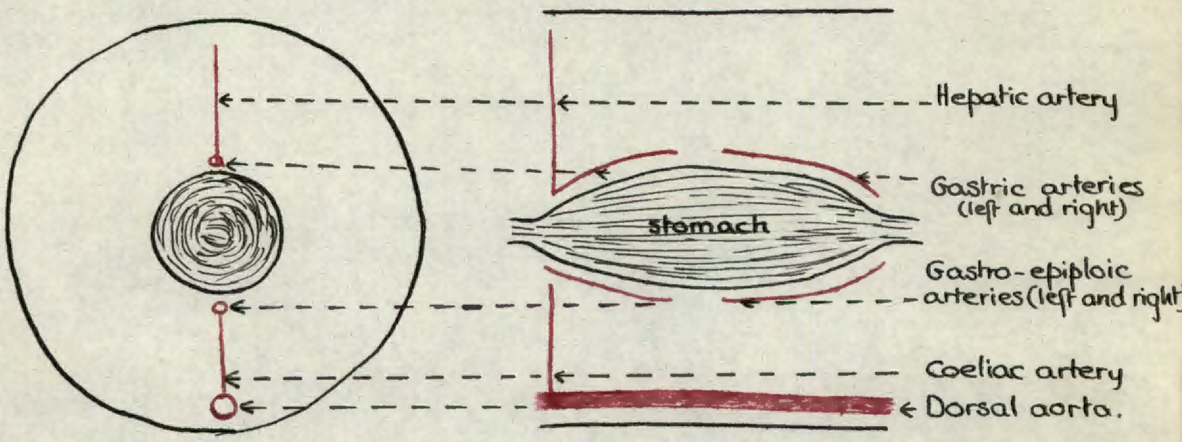


Fig. 14c.

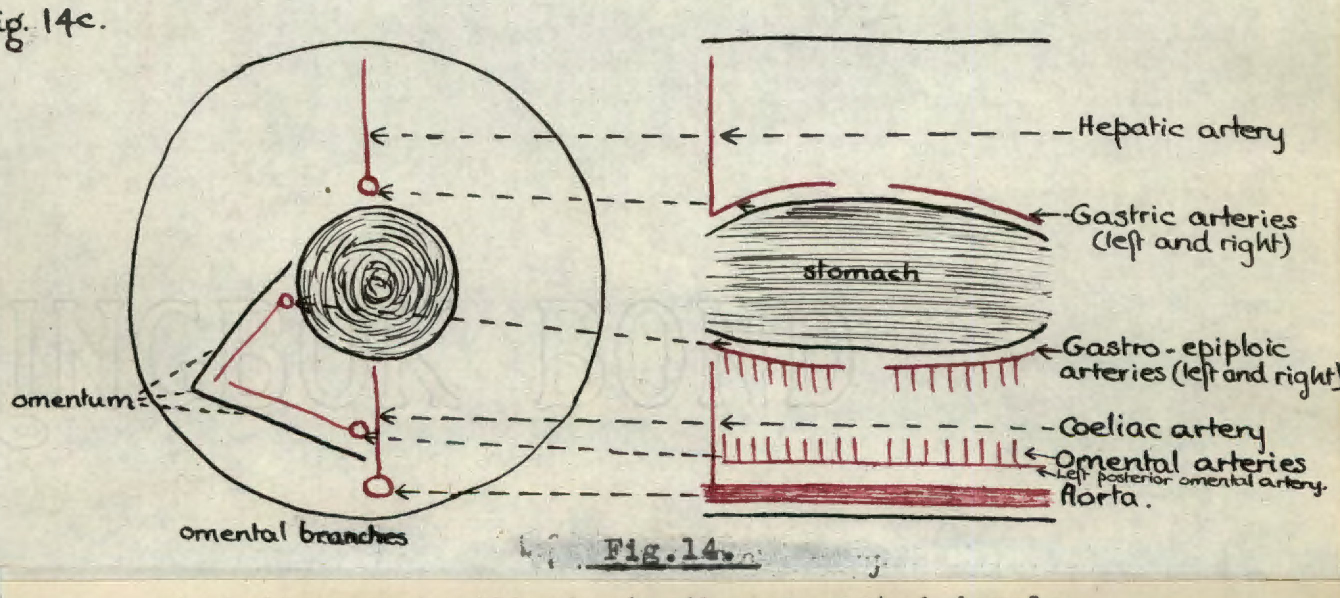


Fig.14.

A diagram to illustrate the suggested development of the omental arteries in the human embryo. The lefthand side shows the trunk in transverse section and the righthand side in sagittal section.
a.b. and c. represent different stages in development.

that the direction of flow in the omental vessels is the reverse of that in the ventral splanchnic arteries.

It is, therefore, suggested that the omental vessels in the anterior layers are developed from the primitive ventral splanchnic arteries. (Fig. 14.C).

The vascular plan for the posterior layers is not so constant, but, as a rule, it follows the same pattern as in the anterior layers: there is an arterial arcade running transversely, and from this branches are given off perpendicularly and run down to the inferior free border (Plate 1).

It is suggested that these omental arteries, like the anterior omental arteries, are developed from the ventral splanchnic arteries, but the direction of blood flow remains unchanged, and the arterial arcade (left and right posterior omental arteries) is developed as an anastomosing vessel in a manner similar to the formation of the dorsal splanchnic anastomosis. (Fig. 14.C).

Summary:

1. A description has been given of the embryological formation of the coelomic cavity, the omental bursa and omentum, the development of the foregut and its blood supply.

2. Developmental anomalies in the branches of

the coeliac axis have been discussed with reference to an anomaly observed in a 23 cm. foetus.

3. A theoretical account of the development of the omental blood vessels has been given.

# A N A T O M Y.

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## THE OMENTAL BURSA.

A description of the greater omentum includes the omental bursa, as the two are former together by the same embryological process and, furthermore, are closely related to each other - the omental bursa extending into the greater omentum for a variable distance.

The omental bursa is also called the lesser sac to distinguish it from the greater sac, or general peritoneal cavity. It is developed as a large diverticulum of the dorsal mesentery of the stomach into the upper righthand quadrant of the greater sac, and it lies behind the stomach.

The omental bursa has anterior and posterior walls and is bounded by irregular borders above, below and to left and right. It is completely shut off from the greater sac except at the epiploic foramen, or foramen of Winslow, which is a short, slit-like passage leading to the lesser sac from the greater sac.

The epiploic foramen is bounded anteriorly by the right free edge of the lesser omentum, containing the bile duct, portal vein and hepatic artery; posteriorly by the inferior vena cava covered by peritoneum, which is continuous to the left with the peritoneum of the

/posterior

posterior wall of the lesser sac; inferiorly by the first part of the duodenum; and superiorly by the caudate process of the caudate lobe of the liver, covered by the posterior layer of the lesser omentum.

The anterior wall is formed by the anterior two layers of the omentum starting at the lower free border of the omentum and extending upward to the greater curvature of the stomach, where they split to enclose the stomach, uniting again at the lesser curvature to form the lesser omentum. At the superior border of the lesser omentum the two layers enter the fossa for the ductus venosus and then double back on themselves, the posterior of the two covering the caudate lobe of the liver anteriorly, posteriorly and inferiorly, so that the caudate lobe actually projects into the omental bursa and does not form its superior boundary or roof, as it is sometimes described as doing, (Fig. 15). At the upper and posterior margin of the caudate lobe this layer of peritoneum is reflected back on itself downwards and is continuous with the peritoneum of the posterior wall of the bursa.

The posterior wall is formed from below upwards by the posterior two layers of the greater omentum, running up over the transverse colon and mesocolon, to the posterior

/abdominal

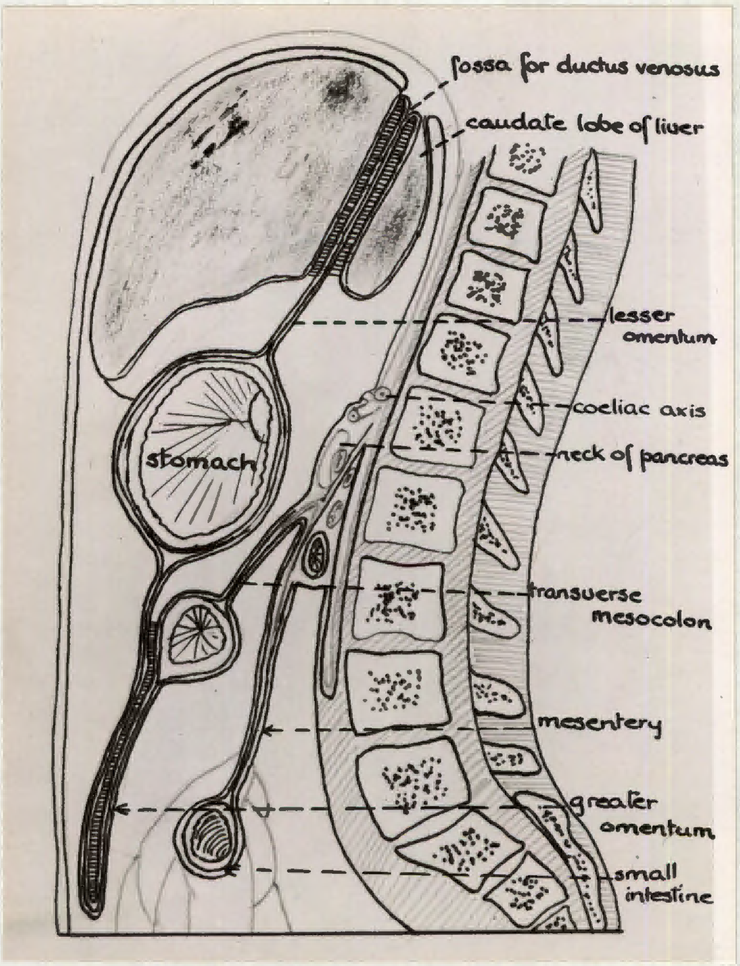



Fig. 15.

A sagittal section through the abdomen, approximately in the median plane. Diagramatic. (After Gray).

abdominal wall at the pancreas and the splenic artery, where they diverge - the posterior of the two passing downwards and the anterior passing upwards - to continue lining the posterior wall of the bursa, which is here formed by part of the head and the whole of the neck and body of the pancreas, the upper pole of the left kidney, most of the left adrenal and the greater part of the left half of the diaphragm. This is, in fact, the stomach bed. The coeliac axis lies just above the neck of the pancreas and its three branches, the left gastric, the hepatic and the splenic arteries run for varying distances behind this layer of peritoneum, (Fig. 16).

The anterior and posterior walls of the bursa are fused for a variable distance, the fusion starting at the inferior free border and usually extending as far as the transverse colon. This fusion limits the extent of the bursa downwards into the omentum. Poynter (73) examined 200 cadavers and found that the omental bursa extended downwards to the full extent of the omentum in 5%, and part of the way in another 10%.

The borders of the lesser sac are formed by the peritoneum of the posterior wall becoming reflected forward to become continuous with the peritoneum of the anterior wall.

The <u>lower border</u> is developmentally the lower

/free

free edge of the greater omentum, but in the adult it is much more proximal owing to the fusion between the anterior and posterior walls.

The upper border is narrow in extent and lies between the right side of the oesophagus and the fossa for the ductus venosus in the liver, and the peritoneal reflection from the diaphragm on to the liver at the left border of the inferior vena cava. Here the peritoneum of the posterior wall is reflected forward from the diaphragm to become the posterior layer of the lesser omentum.

The right border is formed from below upwards by the right free edge of the greater omentum up to the duodenum, where it is formed by the peritoneal reflection from the head and neck of the pancreas on to the posterior surface of the first part of the duodenum, and above this by the peritoneum of the posterior wall curving round the hepatic artery to become continuous with the peritoneum of the floor of the epiploic foramen.

The epiploic foramen interrupts the right border, but above this it is formed by the peritoneal reflection from the diaphragm on to the liver at the left border of the inferior vena cava, to form part of the posterior layer of the coronary ligament of the liver.

The left border is formed by the left free

/margin

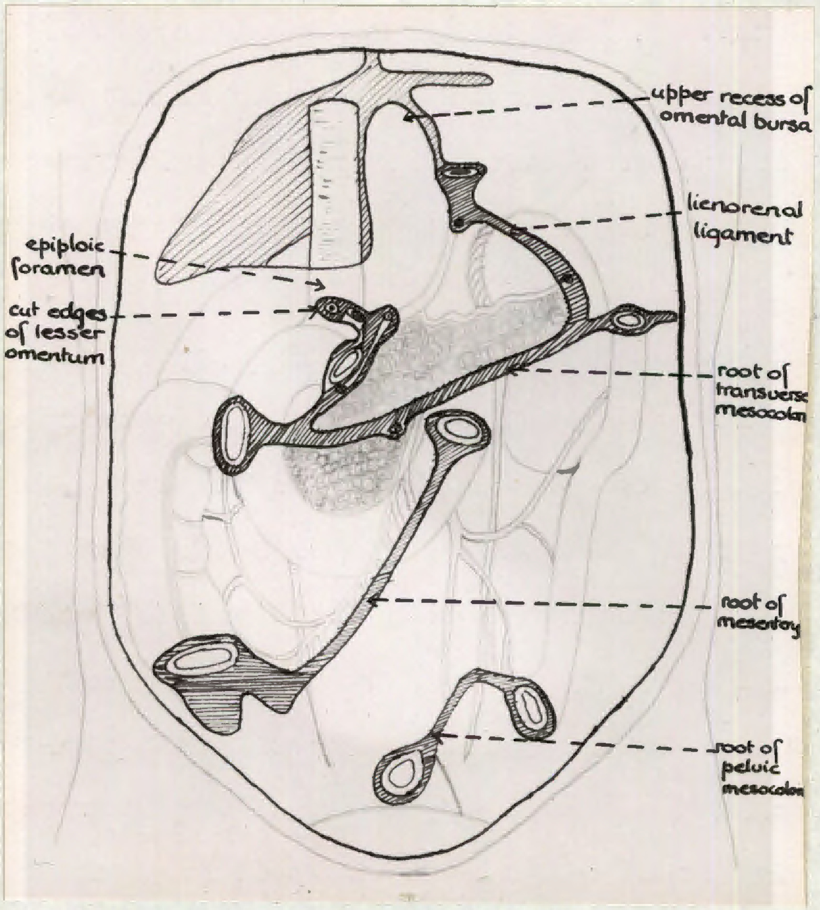



Fig. 16.

The posterior abdominal wall, showing the lines of peritoneal reflection. (Gray).

margin of the omentum up to the spleen, where it becomes much broader as it is formed by the inner peritoneal layer of the gastro-splenic and lieno-renal ligaments, the latter containing the splenic artery and vein, and the former the left gastro-epiploic and left posterior omental arteries, and, more proximally, the short gastric vessels. More proximally the left border is formed by the reflection of the peritoneum from the greater curvature of the fundus on to the diaphragm, to form the gastro-phrenic ligament. Here the upper end of the left border becomes continuous with the left end of the upper border of the bursa, and the left gastric artery raises a sickle-shaped fold of peritoneum as it runs forward from the posterior abdominal wall to gain the lesser curvature of the stomach. This fold of peritoneum is named the left gastro-pancreatic fold. The right gastro-pancreatic fold is a similar fold of peritoneum, raised off the floor of the bursa by the hepatic artery as it passes forward to gain the right free edge of the lesser omentum.

The Greater Omentum:

The greater omentum consists of a double layer of peritoneum that is folded on itself, so that four layers of peritoneum go to its formation - two anterior and two posterior layers. These layers become fused

/together

together just at the transverse colon and the posterior two layers fuse with the transverse mesocolon at this point, after which they lose their identity and are not considered as greater omentum but as transverse mesocolon.

Occasionally the posterior two layers of the omentum are not fused with the transverse mesocolon but run up separately from the latter to the posterior abdominal wall at the pancreas (Fig. 10b). This is what is found in the human embryo before three months and in all mammals except adult primates. (See Comparative Anatomy). No reference has been found in the literature to the incidence of this anomaly, but Poynter (73) has recorded that it did not occur in 200 consecutive autopsies.

Although the fusion between the posterior two layers of the omentum and the transverse mesocolon is very firm, it is by no means complete, as is described in the anatomy books (Fig. 10., C.), and, with a little patience, in a preserved specimen the omentum can be separated from the whole of the transverse mesocolon. That this is not a false line of cleavage is proved by the behaviour of the vessels in these two structures - the omental vessels coming away cleanly with the omentum, and the colic vessels remaining

/behind

behind with the transverse mesocolon. No vessels need be torn if the dissection is carefully done. (Page 39).

The greater omentum has an anterior and a posterior attachment which lie adjacent.

The <u>anterior attachment</u> is to the inferior aspect of the first inch of the duodenum, the whole of the greater curvature of the stomach and the gastrosplenic ligament, with which it is continuous.

The <u>posterior attachment</u> is to the inferior border of the transverse colon centrally, blending to the right with the anterior attachment to the duodenum, and to the left with the lieno-renal ligament with which it is continuous.

<u>The gastrocolic ligament:</u> The fusion of the anterior to posterior layers of the omentum, and the latter to the transverse mesocolon, leads to the formation of a ligament attaching the transverse colon to the greater curvature of the stomach. This is the gastro-colic ligament.

The greater omentum extends down between the coils of small gut and the anterior abdominal wall, and can usually be pulled down to the pelvic brim.

A variable amount of fat is contained between the layers of the omentum, depending on the state of

/nutrition

nutrition of the individual. The fat is collected in so-called "fat strips" along the larger blood vessels, giving the omentum a fenestrated or reticular appearance. The German name for it is "netz", meaning net.

The Blood Supply of the Greater Omentum:

The blood supply is of particular interest as it supports the suggestion that the omentum has been developed as a separate organ with its own blood supply, and is not merely a by-product of the process of development and rotation of the stomach.

The blood supply to the anterior and posterior two layers is separate and distinct. This is not evident in man unless the two layers are separated, but it is well seen in animals.

(i) Method of Study:

Thirty bodies were dissected.

Group 1. - one body. This was a preserved body in which the blood vessels had been injected with a red-lead suspension.

The abdomen was opened in the midline up to the xiphi-sternum. The diaphragmatic attachment to the inferior rib margin and xiphi-sternum was cut. The inferior vena cava and the aorta were cut above the diaphragm, the diaphragm, liver and stomach pulled downwards and the crura of the diaphragm and its origin from the lumbo-costal arches cut. The diaphragm

/and

and abdominal viscera, with the posterior parietal peritoneum, were then stripped off the posterior abdominal wall to the lower poles of the kidneys, where the posterior parietal peritoneum and adherent viscera and blood vessels were cut across and the specimen removed from the body.

The specimen consisted of diaphragm, liver, spleen, kidneys, stomach, duodenum, upper 2/3rds of intestine; ascending, transverse and descending colon, omentum, posterior parietal peritoneum and abdominal aorta with its visceral branches. The omentum was carefully separated from the transverse colon and then from the transverse mesocolon. The specimen had been well-injected and even the smaller arteries were shown. It was found that the omentum could be separated from the colon and mesocolon without tearing them, and that no blood vessels were torn in the dissection, i.e., no proof was found that the omentum supplied visible vessels to the colon. The possibility of a capillary anastomosis could not be excluded.

The anterior and posterior layers of the omentum were then separated from each other; this was more difficult - and, in places, impossible - without dividing blood vessels or peritoneum.

The abdominal aorta and the coeliac axis were

/dissected

dissected out and demonstrated.

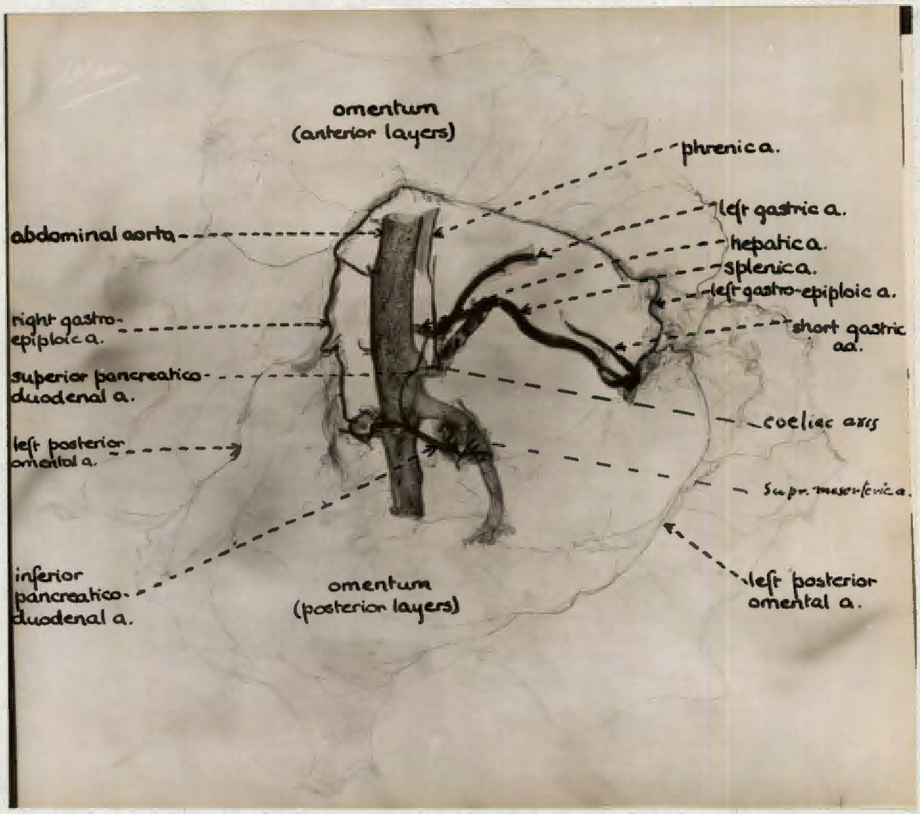
All the viscera, peritoneum and areolar tissue were then cut away, leaving only the abdominal aorta, superior mesenteric artery, coeliac axis with all its branches, and the omentum, separated into anterior and posterior layers.

The anterior layers of the omentum were then turned up, the posterior layers turned down and an X-ray (Plate 1.) taken.

The dissection showed clearly that the posterior layers were supplied separately from the anterior layers, although there were many anastomoses, chiefly around the left and right borders of the omentum, but also where the two layers were fused.

The anterior layers were supplied from the gastro-epiploic arch, which was formed by the left and right gastro-epiploic arteries - branches of the splenic, and superior pancreatico-duodenal arteries, respectively. The arch ran in the anterior layers of the omentum, about one finger's breadth below and parallel to the greater curvature of the stomach, and gave off branches upwards to the stomach, and downwards to the anterior layers of the omentum. These branches anastomosed freely with one another and with vessels in the posterior layers at points of fusion. They did not run round the inferior free margin to supply the posterior layers.

/The




## Plate 1.

X-ray of the coeliac axis, injected with red-lead, and the omentum (man). The anterior layers of the omentum have been separated from the posterior layers and turned up with the gastro-epiploic arch.

The posterior layers were supplied from an arterial arch that ran transversely between them at about the level of the transverse colon. Two arteries went to the formation of this arch: from the left an artery arose from the splenic at its bifurcation into this artery and the left gastro-epiploic artery; from the right a much smaller artery came off the superior pancreatico-duodenal artery. From this arch branches ran down perpendicularly to the inferior free margin of the omentum. (Plate 1. and Fig. 18.).

A few small arteries from the pancreas supplied the posterior layers in its vicinity.

Group 2 - one body, a 23 cm. foetus: The body had been preserved in 5% formalin for one month.

The abdomen was opened in the midline and the anterior half of the thorax cut away.

A canula was introduced into the left ventricle and tied in place by a ligature encircling both ventricles.

Metallic mercury was injected through the canula at low pressure. (See chapter on Comparative Anatomy, Page 49 for details of technique).

The abdomen was filled with saline to float the omentum and facilitate the dissection.

It was possible to dissect the omentum off the

/transverse

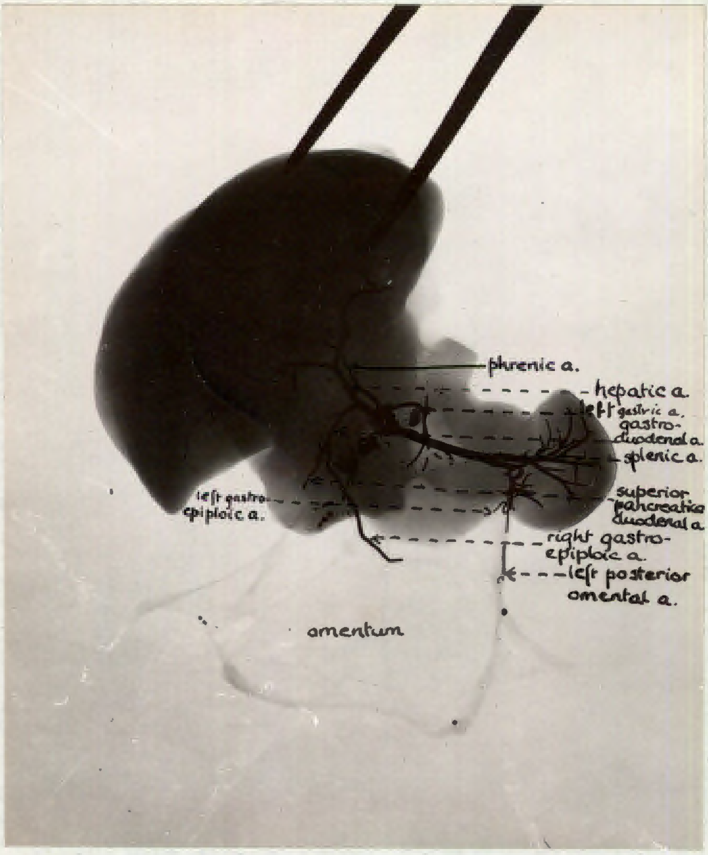



**Plate 2.**

X-ray of mercury-filled coeliac axis and its field of supply in a 23-cm. human foetus.

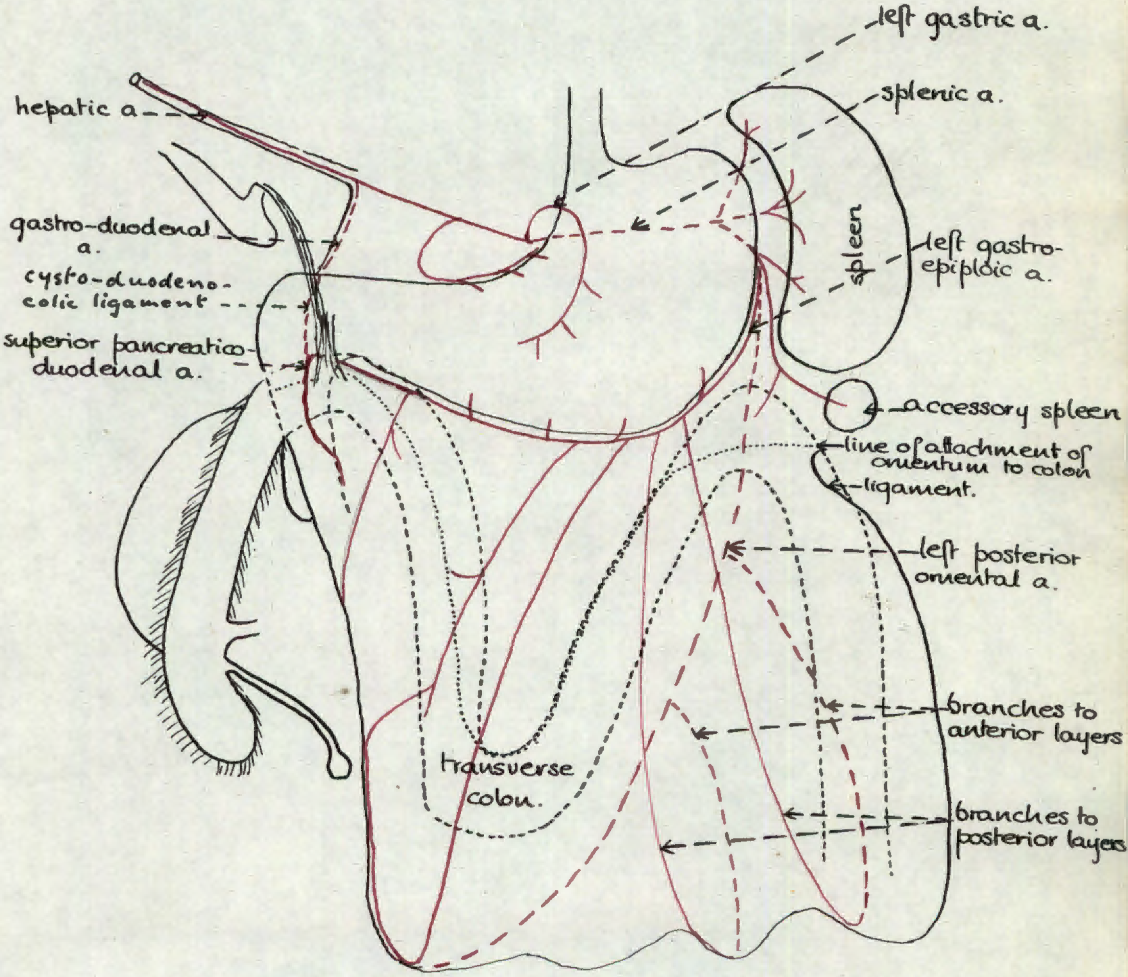



Fig. 17.

Diagram to show the blood vessels of the omentum and the stomach in a 23-cm. human foetus. Drawn from the dissection and the X-ray.

transverse colon and mesocolon, although it got slightly torn in the process. The line of adhesion is shown by a dotted line in Fig. 17.

The aorta was tied above and below the coeliac axis and the liver, stomach, spleen, omentum and coeliac axis were dissected out of the body in one piece.

An x-ray, which is reproduced in Plate 2, was taken of the specimen. Figure 17. is a diagrammatic representation of the dissection.

The following points are of interest:-

(a) The left gastric and inferior phrenic arteries arose by a common trunk from the aorta.

(b) The left gastro-epiploic artery and the left posterior omental artery arose by a common stem from the splenic artery.

(c) The relative sizes of these two arteries is indicated by the fact that the left posterior omental artery was filled with mercury for a longer distance than the left gastro-epiploic artery.

(d) The vessels in the anterior layers of the omentum were easily traced to the inferior free margin, where they anastomosed with vessels from the posterior layers. This was seen in adult dissections, described as having type b. vascular pattern (page 39).

<u>Group 3 - 15 preserved and injected bodies:</u> The omental arteries were dissected in 15 preserved adult bodies in which the blood vessels had been injected with a red-lead suspension.

/The

The arteries in the anterior layers were constant and conformed to the standard description given on page 33.

The arteries supplying the posterior layers followed one of three patterns:-

(a) In five bodies the left and right posterior omental arteries were present as described in Group 1. and illustrated by Fig. 18 and Plate 1.

(b) In eight bodies the left and right posterior omental arteries originated from the splenic artery and the pancreatico-duodenal artery, as in Group (a), but ran along the inferior free border of the omentum, or else an inch or two from it, in the anterior layers, giving branches to both anterior and posterior layers (Fig. 19).

(c) The posterior omental arteries were absent, in two bodies, the posterior layers being supplied by arteries from the anterior layers at areas of fusion between the two layers. There were no vessels running down to the inferior free border of the omentum and then doubling back in the posterior layers.

It is suggested that the name "Posterior Omental Arteries" should be retained for the arteries in Group *b*, in spite of their more frequent appearance in the anterior layers, because

(i) in the main they supply the posterior layers and

(ii) they would otherwise be confused with the omental branches of the gastro-epiploic arteries in the anterior layers.

In further discussing the blood supply of the omentum the term "type "a" ("b" or "c") vascular pattern"

/will

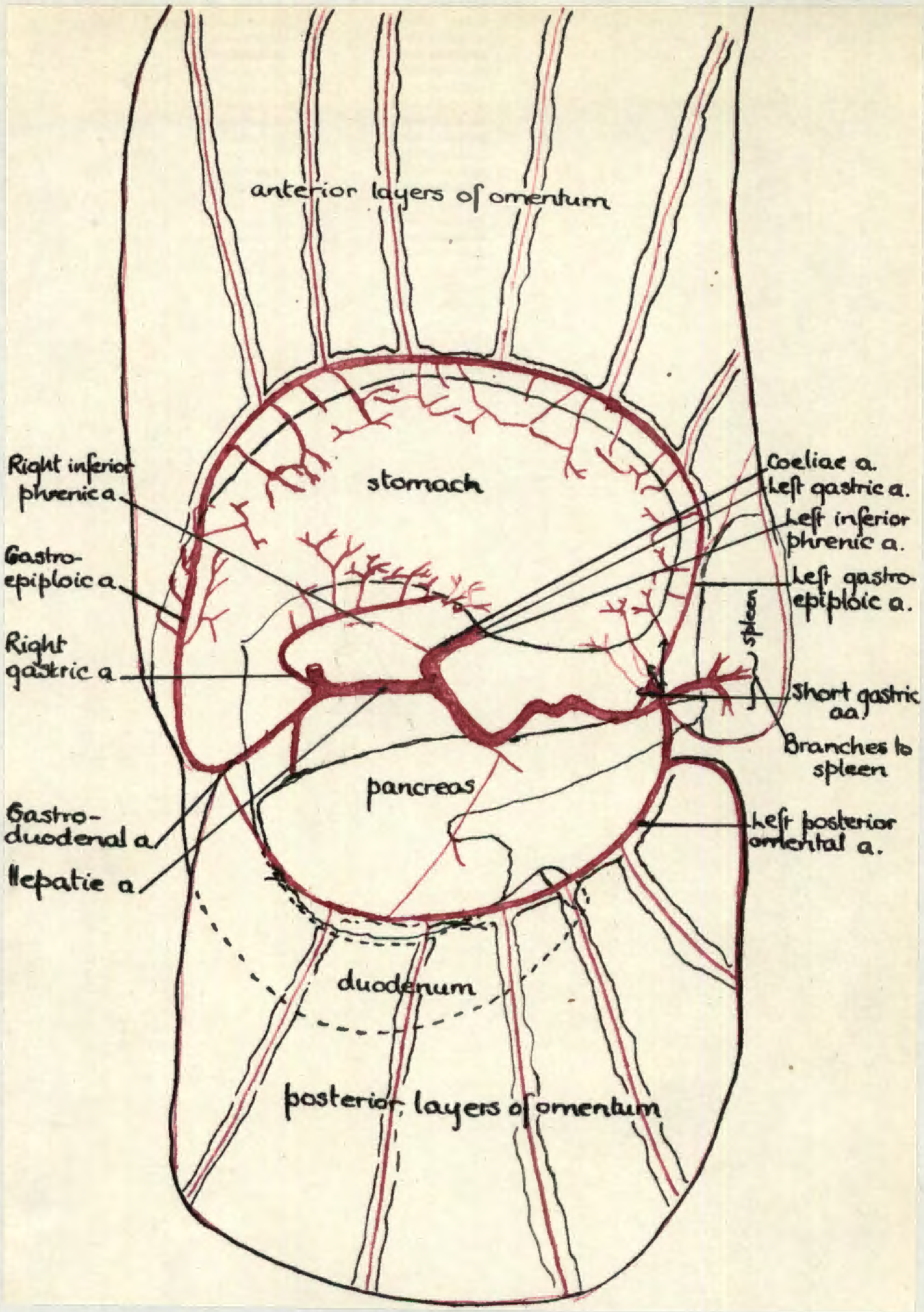



**Fig. 18.**

Diagram to show the blood supply of the omentum in man. Type "a", vascular pattern. The anterior layers and stomach have been turned up, leaving the posterior layers in their normal position.

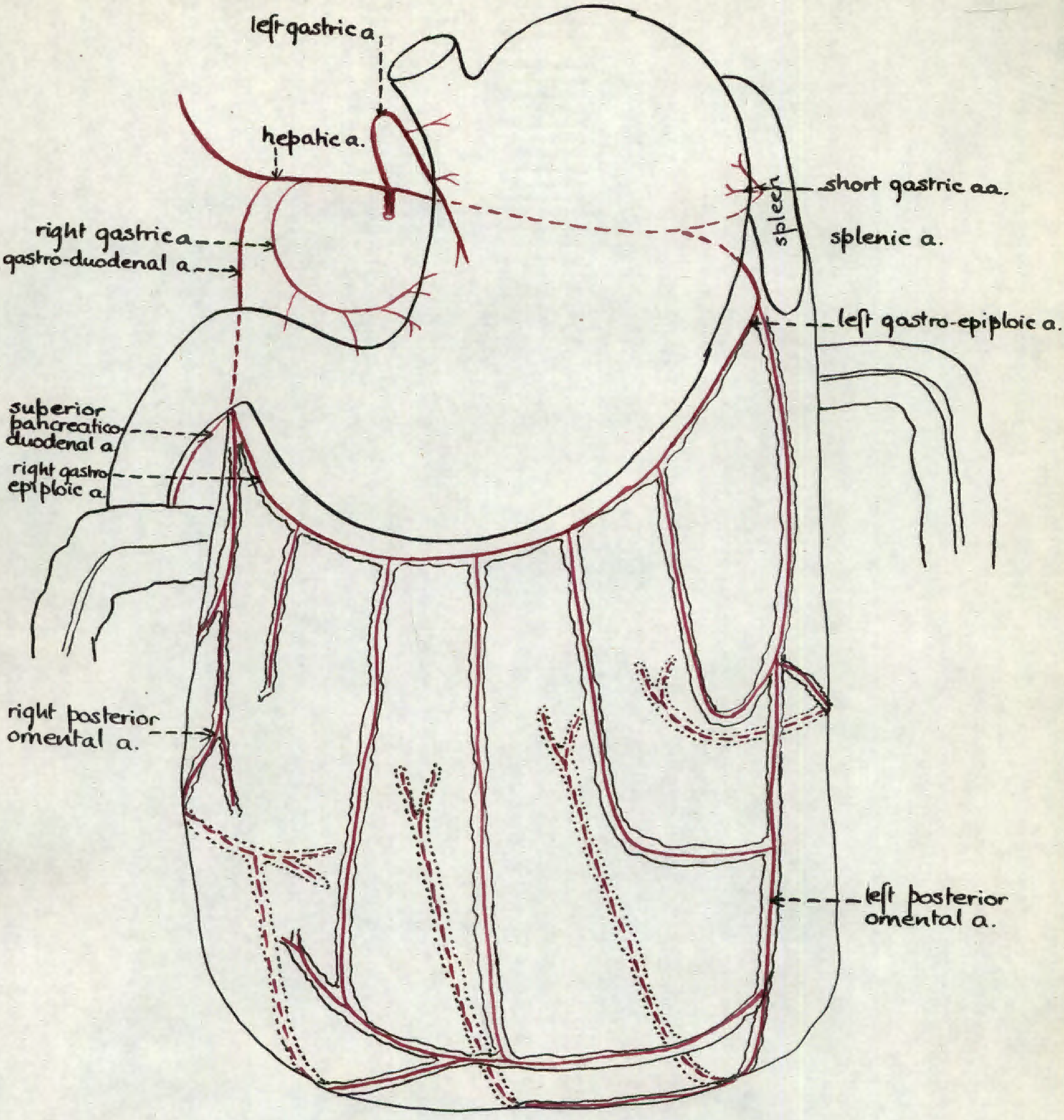



**Fig. 19.**

Diagram to show the blood supply of the omentum in man. Type "b" vascular pattern.

will be used, according as the blood supply conforms to the description given in paragraph a, b, or c. above.

Group 4 - 13 autopsy bodies dissected at the Police Mortuary.

There were 10 adults and 2 infants.

A dissection of the omental vessels was done and the results arranged according to the classification in Group 3, as follows:-

Type "a" vascular pattern ... 4 bodies,
Type "b" " " ... 7 bodies,
Type "c" " " ... 2 bodies.

Summary of Personal Observations:

The blood supply of the omentum was dissected in 30 bodies. The vascular pattern in the anterior layers was constant; in the posterior layers it took one of three forms. The vascular pattern of the omentum as a whole is, therefore, classified according to that of the posterior layers, into three types - "a", "b" and "c".

TABLE I.

| Vascular Pattern | No. of Cases |
|---|---|
| Type "a" | 10 |
| Type "b" | 16 |
| Type "c" | 4 |

(ii). Reports by other observers:

The following standard textbooks of Anatomy, Gray Cunningham, Morris and Howell (38, 22, 64, 44) do not distinguish between the blood supply of the two layers of the omentum, but describe it as coming from the gastro-epiploic arch. This corresponds to type "c" vascular pattern described in this investigation.

The literature available in Cape Town contains only two references to the anatomy of the omentum.

Dolgo and Saburoff (28) reported on a study of 25 persons (foetuses, children and adults). Unfortunately, the original article is not available. These authors claim that the posterior layers of the omentum are supplied by branches of the pancreatic arteries and branches of the middle colic artery. They also claim that the transverse colon is supplied by omental arteries.

Reid (76) reported on the omentum of a 17 cm. foetus. He was more concerned with the omentum as a fold of peritoneum, and mentioned the omental blood vessels merely to prove that the omentum had extended beyond the transverse colon - he was able to trace omental branches of the gastro-epiploic arteries to beyond the transverse colon. (Fig. 20).

/(iii)

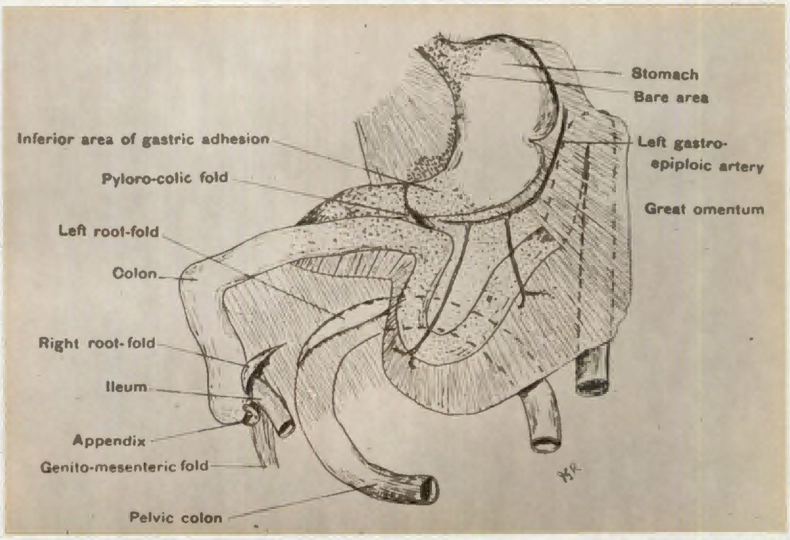



**Fig. 20.**

A diagram by Reid showing the omentum, its area of adhesion (area of stippling), and its blood vessels in a 17-cm. human foetus.

(iii) Discussion.

Dolgo and Saburoff (28) do not state whether the blood vessels received by the omentum from the middle colic artery, and the branches supplied by the omental arteries to the colon, are macroscopic or microscopic. The present investigation did not reveal any such vessels that were visible to the naked eye.

As the transverse colon and mesocolon are developed from the hind-gut, well away from the developing omentum, and fusion only occurs in the third foetal month, one would expect that these two structures should each retain an entirely separate blood supply, and that if any of the blood vessels did cross from one to the other, they would be small and of no consequence. This is what the present investigation suggests.

The observation that the posterior layers of the omentum have a distinct blood supply is confirmed by the comparative anatomy of the omentum. Thus, in the monkey and the dog they are supplied by branches from the pancreatico-duodenal and splenic arteries; in the cat and pig by branches of the splenic artery running through the pancreas; and in the dassie by branches of the splenic artery given off at the hilum of the spleen.

Page 47 follows. /[illegible]

Summary.

A description of the omental bursa and the greater omentum has been given.

A description of the blood supply of the omentum has been given. A separate arterial supply to the posterior layers of the omentum has been described, as far as is known, for the first time. The arteries concerned have been named and Right and Left Posterior Omental Arteries.

Three types of Vascular Pattern "a", "b" and "c" have been described for the omentum, based on variations in the arterial supply to its posterior layers.

C O M P A R A T I V E   A N A T O M Y.

INTRODUCTION.

# COMPARATIVE ANATOMY.

## Introduction:

The key to comparative anatomy is the vascular or nervous supply to the part being investigated.

This is particularly true of the omentum. The arteries are the paths along which investigations may logically be conducted - he who disregards them is lost in a "peritoneal desert", in which the omentum moves about and alters its shape like a sand dune; he who observes and charts them has a map of the elusive omentum and, by comparing the maps of different omenta, is able to follow their evolution.

To obtain the maximum of information from the map it is necessary to include the coeliac axis, whence the omental arteries originate.

The peritoneal relations are important but take second place to the blood supply. For this reason minor differences will not be stressed.

As the omentum develops from the dorsal mesentery of the stomach, the development of the alimentary canal as a whole, and of the stomach in particular, is likely to have a bearing on the deveopment of the omentum, and is, therefore, discussed.

## Method of Study:

It was considered desirable to have some accurate

/pictorial

pictorial record of the arterial systems investigated; X-rays were obviously superior to photographs, but considerable difficulty was experienced in finding a suitable contrast medium. Sodium Iodide, Uropac, Tincture of Iodine, and Bismuth emulsion were all tried and discarded because the shadow cast was not dense enough for the soft plate that had to be taken to show the omentum. Professor R. H. Goetz kindly drew attention to an old method of injecting metallic mercury. This was tried and proved an unqualified success:

(a) The mercury offered very little resistance to injection.

(b) It entered the smallest arterioles, but did not get into the capillaries, which would obscure the picture.

(c) Any leak was immediately seen, did not stain the tissues, and was easily stopped.

(d) The mercury in the vessels showed up very well to the naked eye and greatly simplified the dissection.

(e) Excellent X-rays were obtained because the density of the mercury enabled soft pictures to be taken to show up the omentum.

<u>Technique:</u>

The steps in the procedure were as follows:

1. The animal was anaesthetised.

2. In small animals the apex of the ventricles was cut off, a canula inserted through the left ventricle into the aorta and kept in place by a ligature tied round both ventricles.

/In

In larger animals the thoracic aorta was canulised above the diaphragm.

3. The inferior vena cava was cut between the diaphragm and the heart.

4. Saline was run through the canula until the arteries had been "cleared" of blood. If too much is introduced, the tissues become oedematous and this inferferes with the subsequent injection of mercury.

5. Mercury was injected, using a 5 cc. record syringe. Very little pressure was needed; it was kept up until a satisfactory filling of the arteries had been obtained. Any leaks were treated by ligature after picking up the artery in a pair of fine forceps.

In large animals the aorta was tied beyond the coeliac axis. It was advisable to start the injection first, so that the axis could be identified and not tied accidently. Once this had been done any mercury that had passed down the aorta could be aspirated back and the aorta tied.

It was also necessary in larger animals to tie off the superior pancreatico-duodenal artery, to avoid an unnecessary filling up of the superior mesenteric artery, via the pancreatico-duodenal anastomosis.

6. The liver, spleen, pancreas, stomach and coeliac axis were then dissected out of the body and suitably arranged for an X-ray to be taken.

/7.

7. The dissection of the coeliac axis and its branches was now completed with the X-ray as a guide.

Details of Radiography.

(a). Distance - 48",

(b). 400 M a. secs.

(c). 10 K.V.

Material used:

The omentum is known to be present only in mammals; nevertheless, it was decided to investigate the stomach and its dorsal mesentery in at least one species of every order of vertebrates available for study, in the hope that the earlier orders might throw some light on the development of the omentum. The investigation proved not altogether fruitless.

Starting with the most primitive of the Chordata, Amphioxus, a description of the gut and its mesenteries will be given of at least one species from each order of vertebrates.

Species in which no omentum occurs, or in which there is no point of interest, will not be discussed in detail.

The position that each order occupies in a classification of the Vertebrates (after Hayman) will be indicated.

/ACRANIA.

## ACRANIA.

### Amphioxus:

Serial transverse sections of Amphioxus were kindly lent by Prof. Day of the Zoology Department of the University of Capetown. An examination of these showed the gut was suspended from the mesentery. There was no suggestion of an omental bursa.

## CRANIATA.

### 1. Agnatha.

The lamprey (Petromyzon) was taken as an example of the class. The alimentary tract was simple and not convoluted. A piece of the dorsal mesentery of the gut, above the entrance of the bile duct, was taken for histological examination (See Histology, pg.148). There was no suggestion of an omental bursa.

### II. Gnathostomata.

These are divided into the Anamniota, comprising Pisces and Amphibia, and the Amniota, comprising Reptilia, Aves and Mammalia.

### (A) ANAMNIOTA.

#### 1. Pisces:

##### (a) Elasmobranchii.

/The

The Doogfish (Haploblepharsis edwarsii) was taken as an example of a cartilaginous fish. There was no omentum and no suggestion of an omental bursa.

Goodrich (37), however, states that in the dogfish embryo the development and rotation of the stomach leads to a depression on the right side of the dorsal mesentery, which is the first beginning of the Bursa Omentalis. He goes on to say, "In later development the mesentery becomes so defective that scarcely any trace of the bursa remains in the adult; and the same may be said of most of the Pisces."

The present investigation found no trace of the bursa and no defects in the mesentery in the two species examined.

(b) Teleostei.

The Red Roman (Pagrus laticeps) was taken as an example of a bony fish. There was no omentum and no suggestion of an omental bursa.

(c) Dipnoi.

These do not occur locally and none were available for dissection.

Goodrich (37), however, describes them as an example of early omental development. He says,

"Already in the Dipnoi, however, begin to "appear the important changes and complica- "tions characteristic of the Tetrapoda, and

/correlated

"correlated for the most part with the develop-
"ment of the lungs and the vena cava. In these
"higher vertebrates the stomach becomes more
"differentiated and more bent away from the middle
"line, and the bursa omentalis correspondingly
"enlarged and deepened. Pushing its way between
"the mesenteries and viscera, and tending to wrap
"round the alimentary canal, it forms special re-
"cesses which all communicate with the general
"trunk coelom on the right by an opening, the hiatus
"communis recessum (primitive Foramen of Winslow),
"behind the liver. Dorsally the recessus pancreaticus-
"entericus extends back into a blind pocket and
"spreading over the right surface of the stomach;
"ventrally a recessus hepato-entericus, bounded
"below by the lesser omentum, extends forward above
"the liver, where it passes into the right pneumato-
"enteric recess, the origin of which will be des-
"cribed below. The hiatus communis recessus or
"Primitive Foramen of Winslow is at first large and
"without definite posterior margin; but it gradually
"becomes constricted by surrounding structures.
"It is bounded in front by the liver, above by the
"plica mesogastrica, and below by the edge of the
"lesser omentum holding the hepatic artery, portal
"vein and bile duct. The plica mesogastrica contains

/the

"the vena cava inferior (thus forming the dorsal "fold called Holenvenengekrose by Hochstetter, and "Vena-cava-falte by Ravn), and as the right dorso- "lateral lobe of the liver grows backwards along the "vein into the fold, the opening becomes restricted "from in front. Further, in the amniota, the coeliac "artery and its branch, the hepatic artery, draw out "a fold from the mesentery projecting on the right "and from behind, so that the plica mesogastrica now "splits into an outer plica vena cavae and an inner "plica arteria coeliacae; a small cavo-coeliac recess "between them becomes the atrium or vestibulum bursa "omentalis, just within the foramen epiploicum Winslowi "in the mammal. The coeliac fold tends to separate "the bursa omenti majoris on the left from the bursa "omenti minoris on the right."

These statements cannot be accepted as they do not agree with the generally accepted embryological development of the omentum, and many of them have not been confirmed.

It is accepted that the omental bursa begins as a diverticulum in the dorsal mesentery of the stomach, before rotation of the stomach occurs. That the rotation of the stomach does not result in the formation of the omentum is shown by the fact that the omentum is found only in mammals, while the rotation of the stomach occurs in most orders higher than cyclostomata.

/In

In the tortoise (page 58 ), the rotation of the stomach has resulted in a well-marked bursa behind the stomach, in the position of the omental bursa in mammals. There is, however, no Foramen of Winslow and no omentum; nor has the dorsal mesentery of the stomach, corresponding to the omentum in mammals, any blood supply of its own. Finally, although the dorsal mesentery forms the anterior wall of the bursa, it remains intact and has no diverticulum, the whole of the bursa remaining proximal to it, so that the bursa has obviously not developed from it, as the omental bursa does, but has developed behind it.

For these reasons it may safely be concluded that this bursa bears no relation to the omental bursa of mammals.

The omentum is believed to exist only in mammals, and no report has been found in the literature of an omentum or omental bursa in Dipnoi or the lower Amniota, as is described by Goodrich. The present investigation did not show any suggestion of an omental bursa in orders below mammals, except in the tortoise, which has already been discussed.

The description of the formation of the vestibule to the omentum, given by Goodrich, does not agree with the embryological development of the omentum (page 8 ). It is accepted that the original diverticulum in the

/dorsal

dorsal mesentery becomes the vestibule, and from it a second diverticulum grows and develops into the omental bursa (Fig. 9).

For the reasons given, it must be concluded that there is no trace of an omental bursa in Dipnoi.

2. Amphibia.

The species examined was Xenopus laevus.

The stomach was simple, the gut short and not differentiated externally into small and large gut.

The stomach and gut were suspended from the posterior abdominal wall by a common dorsal mesentery in which the spleen and pancreas lay.

There was no trace of omentum or of omental bursa.

(B) AMNIOTA.

(1) Reptilia.

(i) Lacertilia - The Horny Lizard (Lacertilia sp.) and the Leguan (Veranus Albigularis) were dissected. They had no omentum, nor trace of an omental bursa. A piece of the dorsal mesentery of the stomach of the leguan was taken for histology (page 148).

(ii) Ophidia - The Mole Snake (Pseudaspis cana) was dissected. It had no omentum nor trace of an omental bursa. A piece of the dorsal mesentery of the stomach was taken for histology (page 148).

/(iii).

(iii) Chelonia - The Mountain Tortoise (Testudo geometricus) was dissected.

The intestinal tract was well differentiated into oesophagus, stomach, small gut, large gut and cloaca.

The Stomach was tubular and about twice the width of the oesophagus. It lay transversely across the abdomen and was differentiated from the small gut by a sphincter that was easily palpable, and visible from inside but not from the outside.

The Small Gut was about the length of the stomach and half its width. It ran downward in the form of an elongated "C" and ended in the dilated proximal part of the large gut, the caecum, a short distance caudal to the pylorus. It was shut off from the caecum by a well-marked sphincter.

The Large Gut was about twice the length and twice the diameter of the stomach. It had a short ascending part ending below the pylorus; a long transverse part running below and parallel to the stomach; and a long descending part that ended in the cloaca.

The Liver was a long, flattish, bi-lobed organ, lying along the top of the Stomach. The two lobes were connected by a narrow isthmus.

The Spleen was small and spherical. It lay between the caecum and the pylorus and was entirely extra-peritoneal.

/The

The pancreas was a small, compact, yellowish body lying between the spleen and the first part of the small gut. It was entirely extraperitoneal.

The Peritoneum:

The liver was partly intraperitoneal, with a broad coronary ligament. Only the terminal part of the small gut had a mesentery; the rest of the small gut and the large gut were fixed to the posterior abdominal wall.

The chief interest is in the peritoneal relations of the stomach. The stomach was attached to the liver by a short, strong fold of peritoneum, the gastro-hepatic ligament. This was obviously the ventral mesentery of the stomach. From its opposite border a double fold of peritoneum ran down to, and fused with, the peritoneum of the posterior abdominal wall, just proximal to the horizontal part of the large gut. This was, obviously, the dorsal mesentery of the stomach.

The stomach with its two mesenteries formed the anterior boundary of a peritoneum-lined space, bounded above, by the peritoneal reflection from the posterior abdominal wall on to the liver, which projected into this space; below by the peritoneum of the posterior abdominal wall, becoming continuous with the peritoneum of the dorsal mesentery of the stomach, just above the transverse part of the large gut; and at the sides by the continuation of this reflection. The posterior wall, or floor,

/was

was formed by the peritoneum of the posterior abdominal wall. The space extended to the right, to just short of the pylorus, and to the left to the left extremity of the stomach.

There was no communication between this space and the general peritoneal cavity.

There was no omentum. The dorsal mesentery of the stomach was actually a little redundant and did tend to bunch up very slightly along the "greater curvature" of the stomach, but this could, by no stretch of imagination, be called an omentum.

<u>The Blood Supply of the Stomach:</u> (Plate 3).

Two vessels supplied the stomach; they arose from the left arch of the aorta (the aorta was primitive and had still the two arches). The vessel supplying the proximal half of the stomach came off the aorta distal to the vessel that supplied the distal half of the stomach and the rest of the alimentary canal. It ran to the left, to the lower end of the oesophagus and ended by dividing into two branches which ran to the right along the greater and lesser curvatures of the stomach, in the dorsal and ventral mesenteries of the stomach. They ended by anastomosing with similar vessels from the pyloric end of the stomach.

The vessel supplying the distal half of the stomach was distributed in a similar manner and its

/branches

branches ran to the left from the region of the pylorus, in the ventral and dorsal mesenteries. It was a branch of the main vessel to the alimentary canal, which arose from the left aortic arch, proximal to the vessel to the proximal part of the stomach. It crossed anterior to the right aortic arch and gave off first, the artery to the distal half of the stomach, and then the hepatic artery, followed by the arteries to the rest of the gut.

The dorsal mesentery, like the ventral mesentery, had no special blood supply of its own, as is seen in the omentum; very small branches from the gastric arteries supplied it.

The tortoise is the only species below mammals in which a condition resembling an omental bursa was found.

The significance of this has been discussed in the chapter on Embryology (page 8 ) and on (page 56).

(2) <u>Aves.</u>

As the omentum is not present in birds, only one species, the Pigeon (Columbia livia) was dissected.

The peritoneal cavity was divided into a smaller left and a larger right compartment by a fold of peritoneum that ran from the gizzard to the ventral belly wall, and together with the falciform ligament of the liver, formed a complete saggital septum. This septum was avascular except for a small vein running in it from the mesentery to the liver.

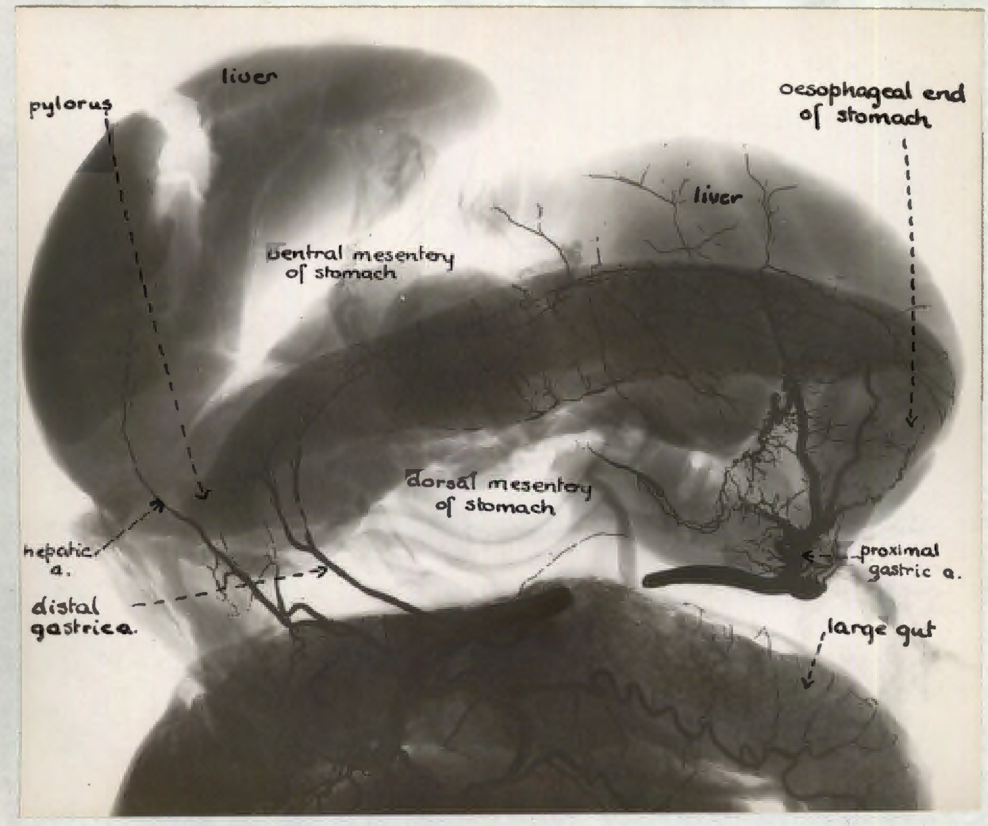



Plate 3.

Mercury-injected vessels of the Tortoise (Testudo geometricus). Note that there are no vessels large enough to be demonstrated in the dorsal mesentery of the stomach - the vessels seen in the righthand part of the mesentery were not in the mesentery but on the posterior abdominal wall.

Mesenteries:

The alimentary canal had a common mesentery: the mesentery of the distal oesophagus ran into the dorsal mesentery of the stomach and was continuous with the mesentery of the intestine. So that the common mesenterial attachment ran from the oesophageal opening in the diaphragm in a straight line to the midline of the pelvis. The Spleen lay behind the stomach attached to the common mesentery along the course of the coeliac artery. The Pancreas lay in the mesoduodenum between the two loops of the duodenum.

Ligaments of the Gizzard:

1. The Gastro-hepatic Ligament - ran from the gizzard to the ~~stomach~~ liver, and is developed from the ventral ligament of the stomach, as in all vertebrates.

2. The Dorsal Mesentery of the Stomach - formed part of the common mesentery and contained the coeliac artery. There was no bulge or diverticulum in it to suggest the beginning of an omentum.

3. The Ventral Ligament of the Gizzard - A fold of peritoneum ran from the gizzard to the ventral abdominal wall. It is sometimes referred to as the omentum, but Rubin (21) and Hyman (44) draw attention to this inaccuracy and point out that it develops as a result of the gizzard in the embryo bird becoming adherent to the ventral abdominal

/wall.

wall. With further development the gizzard recedes from the abdominal wall and, in so doing, draws out a double fold of peritoneum, which becomes the ventral ligament of the gizzard.

The function of this ligament is purely suspensory; it has no large blood vessels like the omentum.

There is thus no evidence that an omentum, or omental bursa, is present in the species dissected.

3. MAMMALIA.

The alimentary canal of mammals shows many developmental differences brought about by differences in diet and feeding habits. As a general rule, if the stomach is simple, the caecum and colon are complex, and vice versa.

The present investigation was undertaken in the hopes of being able to correlate the appearance and degree of development of the omentum with the complexity of the alimentary canal. This has not been successful - possibly because the survey did not include more of the primitive mammals which, unfortunately, were not available.

(i) Monotremata and Marsupialia.

Although monotremes are more primitive than marsupials, they have a more complicated alimentary tract than the very primitive marsupials, e.g., the Virginian Opossum (Figs. 21, 22). The higher marsupials, on the other hand, have either a complicated stomach, as in the Giant Kangaroo, or a complicated caecum as in the Koala Bear.

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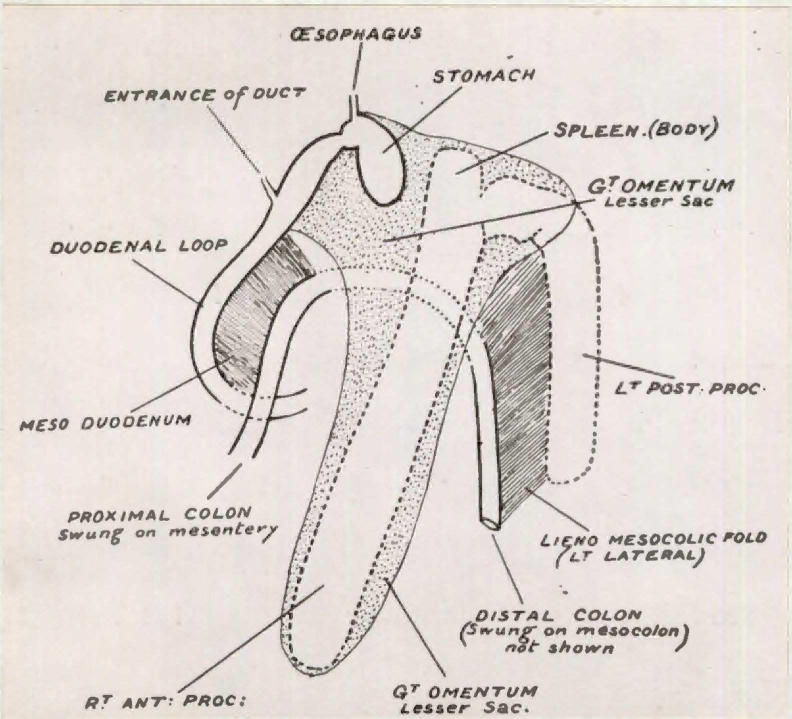


**Fig. 21.**

**Diagram showing the peritoneal relations of the spleen and the omentum in the Platypus. (Ornithorynchus sp.) (Mackenzie).**

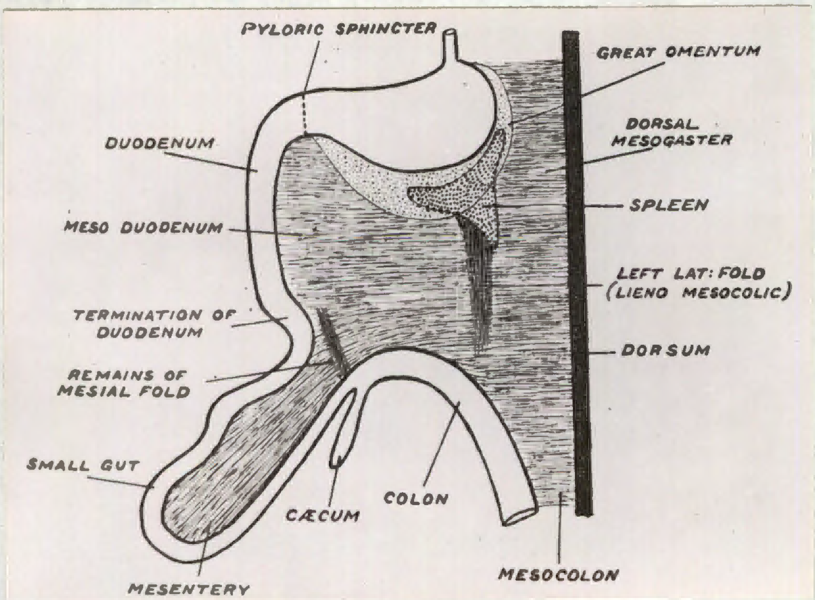


Fig. 22.

Intestinal plan of the American opossum (Didelphys marsupialis) showing the omentum and mesentery. (Mackenzie).

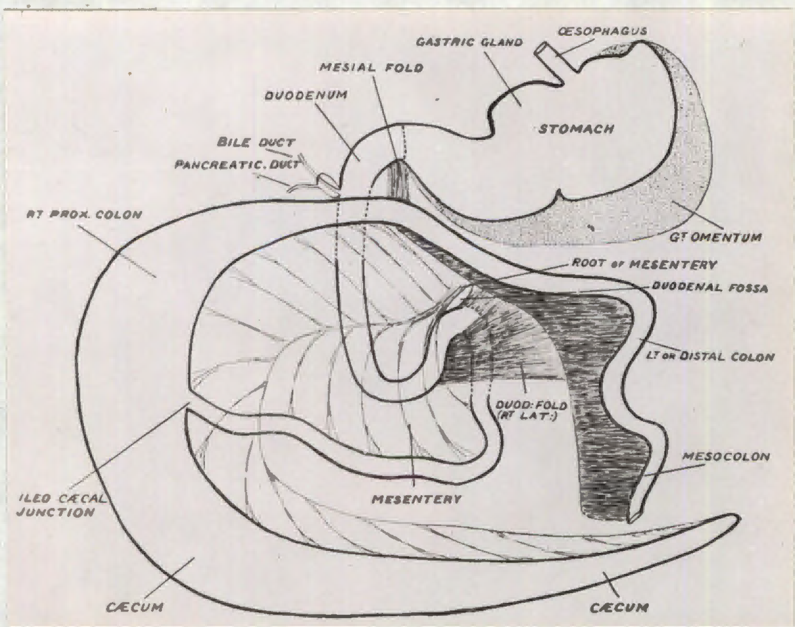


**Fig. 23.**

**The gastro-intestinal tract of the Koala (Phascolarctos cinereus), showing the omentum and the mesentery. (Mackenzie).**

In spite of these differences in the alimentary tract there appears to be little or no difference in the omentum, if the descriptions given in the literature are correct. The best of these is by MacKenzie (54), but as it does not include a description of the blood vessels, little is learned from it apart from the fact that an omentum is present in all marsupials and monotremes.

Figs. 21, 22, 23 are by MacKenzie (54) and show the alimentary canal and omentum of the Duck-billed Platypus (Ornithorhyncus sp.), Virginian Opossum (Didelphys marsupialis), and Koala (Phascolarctus cinereus) respectively. In spite of different degrees of development of the stomach and caecum, the omentum shows little variation except in the Platypus, where it is very large, due, obviously, to the enormous spleen.

In no other mammals examined was the spleen relatively as big, even when the omentum was very large; in the ox the spleen was not even situated in the omentum. The size of the spleen would not, therefore, appear to have any influence on the size of the omentum, except in the Platypus.

(ii) <u>Insectivora.</u>

The mole was the most primitive mammal dissected - it showed no distinction between large and small gut, which was surprising, as all other mammals, and even some of the reptiles, e.g., tortoise, and the birds, showed

/this

this distinction.

In both the mole and the shrew the coeliac and superior mesenteric arteries came off a common trunk, but the branches from this trunk in the mole showed a more primitive arrangement than in the shrew, where the arrangement was similar to that of the higher mammals.

The blood supply of the omentum was different in these two; in the mole it was primitive, while in the shrew it was more complicated.

(a) <u>The Cape Golden Mole</u> (Chrysochloris capensis).

The gut of the Cape Golden Mole was simple, the stomach only was differentiated, and there was no external or internal distinction between small and large gut.

The whole of the gut plus the pancreas and spleen was suspended from the posterior abdominal wall by a common mesentery that ran down the midline from just to the left of the aortic opening in the diaphragm to the pelvis. It was nowhere fused to the posterior abdominal wall or to itself.

The gut was supplied by two vessels, a coeliaco-mesenteric, that arose from the aorta just beyond the aortic opening in the diaphragm, and an inferior mesenteric artery that arose from the aorta beyond the renal arteries. In this it resembled the shrew.

<u>The Coeliaco-Mesenteric Artery.</u>

/The

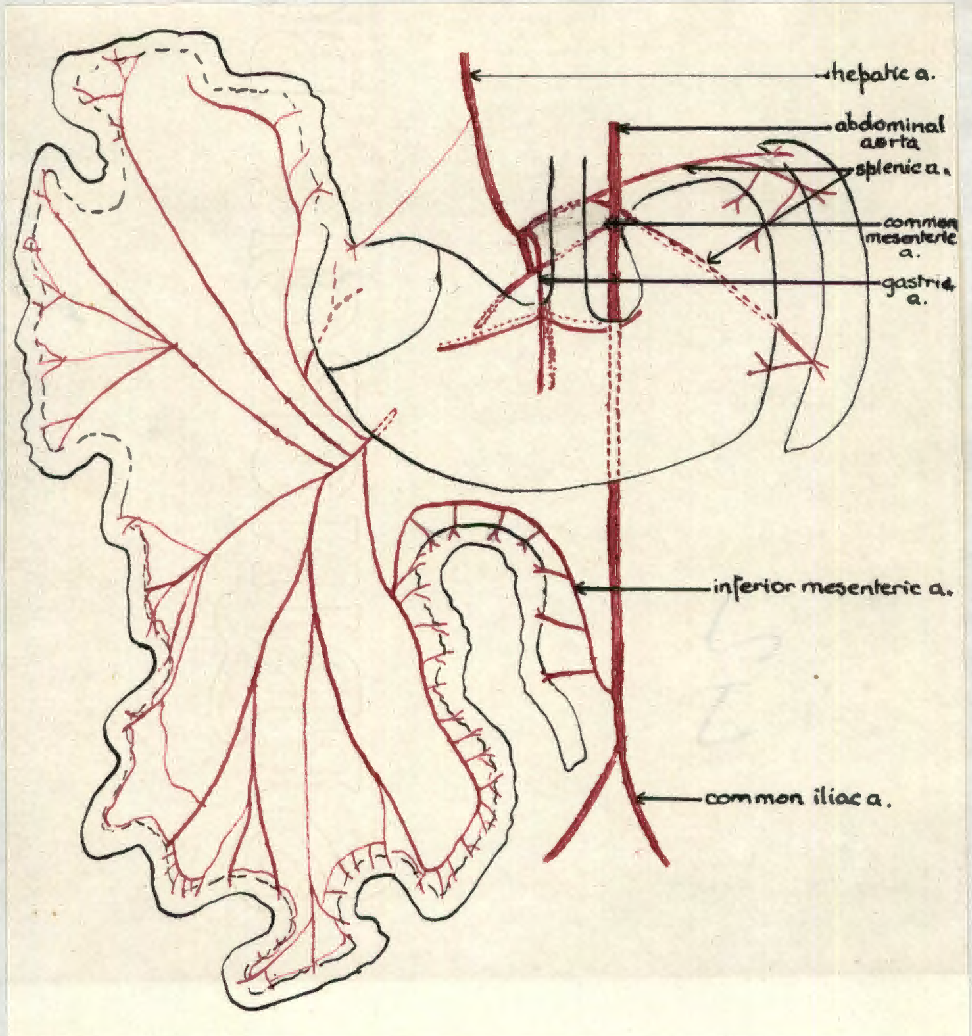


**Fig. 24.**

Sketch of the blood supply to the gut of a Cape Golden Mole (Chrysochloris capensis).
**Note**: The common stem to the hepatic, splenic and gastric arteries has been drawn too long and too far from the origin of the parent vessel. The arterial arcades to the gut have been drawn as nearly accurate as possible.
Note the absence of macroscopic gastro-epiploic vessels.

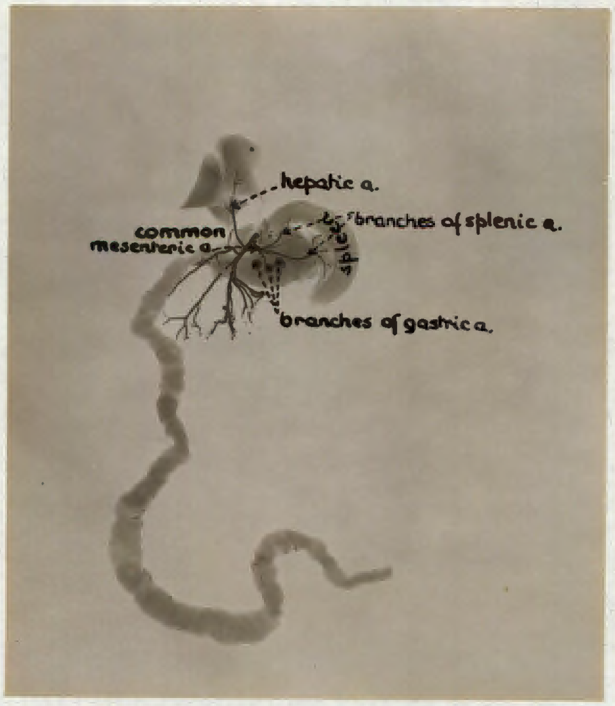


Plate 4.

X-ray of mercury-filled common mesenteric artery in the Cape Golden Mole. (Chrysochloris capensis). The mesentery has been cut at its attachment to the gut.

The coeliaco-mesenteric artery gave off, 1/4" from its origin, three vessels that came off a very short common stem - the hepatic, gastric and splenic arteries; it then gave off to the gut three branches on its right side, and two on its left side, and ended by supplying the middle of the gut. The three branches to the right supplied the proximal half of the gut, while the two to the left supplied the distal half of the gut (Fig. 24). (Note that the common trunk to the hepatic, gastric and splenic arteries has been drawn too long and too far away from the origin of the common mesenteric. Reference to Plate 4. will show the true relationship).

The first branch to the right supplied the first part of the gut after the stomach. It corresponded to the gastro-duodenal artery seen in higher mammals, and gave off a branch to the pylorus. This pyloric branch gave off a vessel that supplied the right half of the omentum - the right omental artery.

The last branch on the left side supplied the lower end of the gut up to 1½" from the anus, this terminal part of the gut being supplied by the inferior mesenteric artery, a branch of the abdominal aorta.

<u>The Hepatic Artery</u> ran upwards to supply the liver. It sent down a small branch that supplied the pylorus.

<u>The Gastric Artery</u> ran downward to supply the stomach. It divided into anterior and posterior branches,

/distributed

distributed to the respective surfaces of the stomach. It was the main vessel of supply to the stomach as there were no gastro-epiploic vessels visible to the naked eye, and the short gastric branches of the splenic artery were very small.

The Splenic Artery ran to the left in the pancreas, which it supplied. It divided into two branches, one to the upper and one to the lower pole of the spleen. It gave off the short gastric arteries and the lower branch also gave off a vessel that supplied the left half of the omentum - the left omental artery. There was no left gastro-epiploic branch visible to the naked eye.

The Omentum: The omentum was so thin that it was best examined floated in water, when it was seen to be a definite membrane hanging down from the greater curvature of the stomach. It contained no fat. The pancreas, which lay in the posterior layers and was entirely intraperitoneal, was easily pulled forward with the omentum and might be mistaken for it.

The spleen lay in its left border and was attached by the gastro-splenic ligament to the stomach. The spleen was relatively large, flattish and concave, and applied to the greater curvature of the fundus of the stomach.

The Foramen of Winslow was bounded anteriorly by the free edge of the lesser omentum containing the bile duct, portal vein and hepatic artery; posteriorly by the vena cava; superiorly by the liver, and inferiorly by the common

/mesenteric

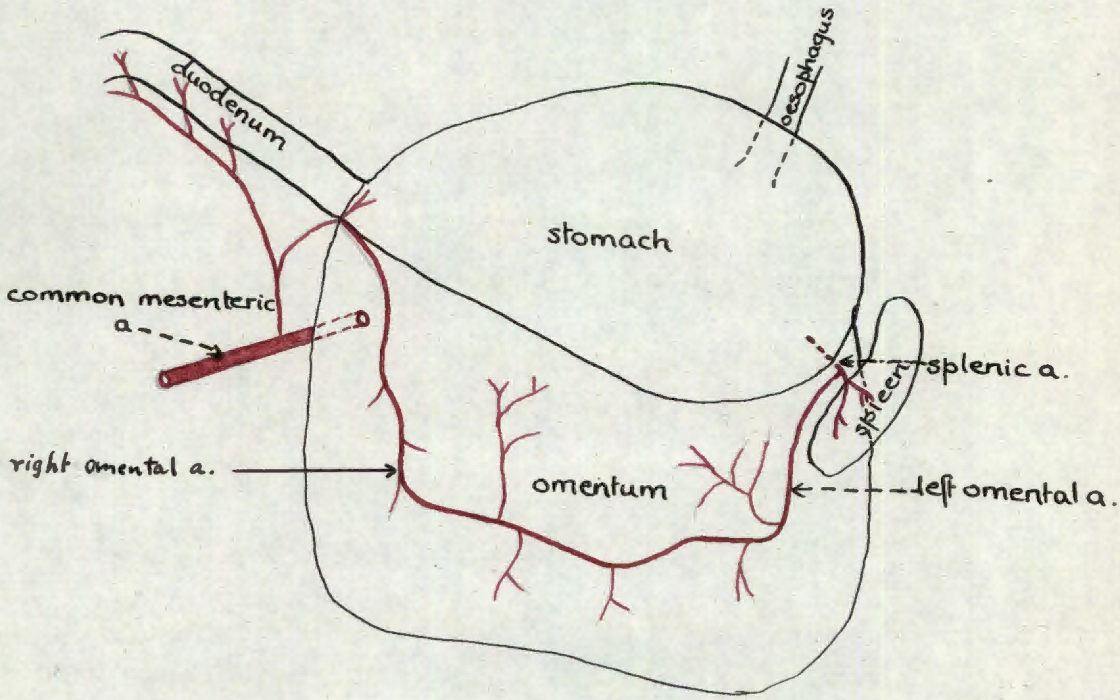


**Fig. 25.**

A diagram showing the blood supply of the omentum of the Cape Golden Mole. (<u>Chrysochloris capensis</u>). The stomach has been turned up.

mesenteric artery and the root of the mesentery.

The Blood Supply of the Omentum was from a definite arterial arch. (See Fig. 25). The artery on the left was a branch of the splenic, and the artery on the right a branch of the first branch of the common mesenteric artery to the gut beyond the stomach. From this arch vessels ran as indicated. No vessels were given off to the omentum from the pancreatic branches of the splenic artery.

This separate and distinct blood supply to the omentum was seen in no other mammal dissected. It is thought to be of considerable importance in indicating that the omentum arose as a separate organ, with its own blood supply.

(b) The Shrew. (Elephantulus myurus).

The shrew had a surprisingly well-developed alimentary canal considering it is an Insectivore.

The stomach was simple and to it was attached a well-developed omentum. The duodenum had a mesentery in which the head of the pancreas was situated. The small gut was long and coiled and had a mesentery; it ended in the large gut and at the site of junction there was a long caecum - about twice the length of the stomach. The colon made a small downward loop from the caecum and then ran up to the hepatic flexure, across to the splenic

/flexure

flexure and then down to the rectum. The ascending colon and the hepatic flexure with their mesenteries were fused to the medial aspect of the mesoduodenum. The transverse mesocolon had a common origin with the posterior layers of the omentum. The whole colon had a mesentery.

The head of the pancreas was in the mesoduodenum and the body was in the posterior layers of the omentum.

The spleen was situated in the left border of the greater omentum and divided off the gastro-splenic ligament from the rest of the omentum.

<u>The Blood Supply to the Alimentary Canal.</u>

The alimentary canal was supplied by two vessels: the coeliaco-mesenteric artery, which supplied the fore- and mid-gut, and the inferior mesenteric artery supplying the hind-gut.

<u>The Coeliac Axis</u> was a branch of the coeliaco-mesenteric artery, the other branch being the superior mesenteric artery. The coeliac artery divided into three branches:

1. Hepatic Artery which gave off the gastro-duodenal artery which divided into the supérior pancreatico-duodenal and the right gastro-epiploic artery, the latter supplying the greater curve of the stomach and the omentum.
2. Splenic Artery which supplied the spleen and gave off several large, short gastric arteries, the left gastro-epiploic artery and the left posterior omental artery.

/3.

3. Gastric Artery which ran down to the lesser curvature of the stomach and divided into anterior and posterior branches to the respective surfaces of the stomach.

The arterial supply to the gut resembled that of the mole, in having a coeliaco-mesenteric artery, but differed in having a gastro-duodenal artery - an artery present in all other mammals dissected.

<u>The Omentum</u> - To facilitate the dissection of the the omentum, the animal was immersed in saline after the abdomen had been opened, and the dissection was done under a dissecting microscope (16X).

The omentum was well-developed and extended ~~into the pelvis, lying~~ between the anterior abdominal wall and the coils of gut, about halfway down to the pelvis.

Its anterior layers were attached to the greater curvature of the stomach from the pylorus to the gastro-splenic ligament with which it was continuous. Its posterior layers were attached to the posterior abdominal wall at the coeliac axis.

They shared a common origin with the transverse mesocolon but were not adherent to it. The body of the pancreas was situated between the posterior layers.

<u>The Blood Supply of the Omentum:</u>

The omentum was well supplied with arteries.

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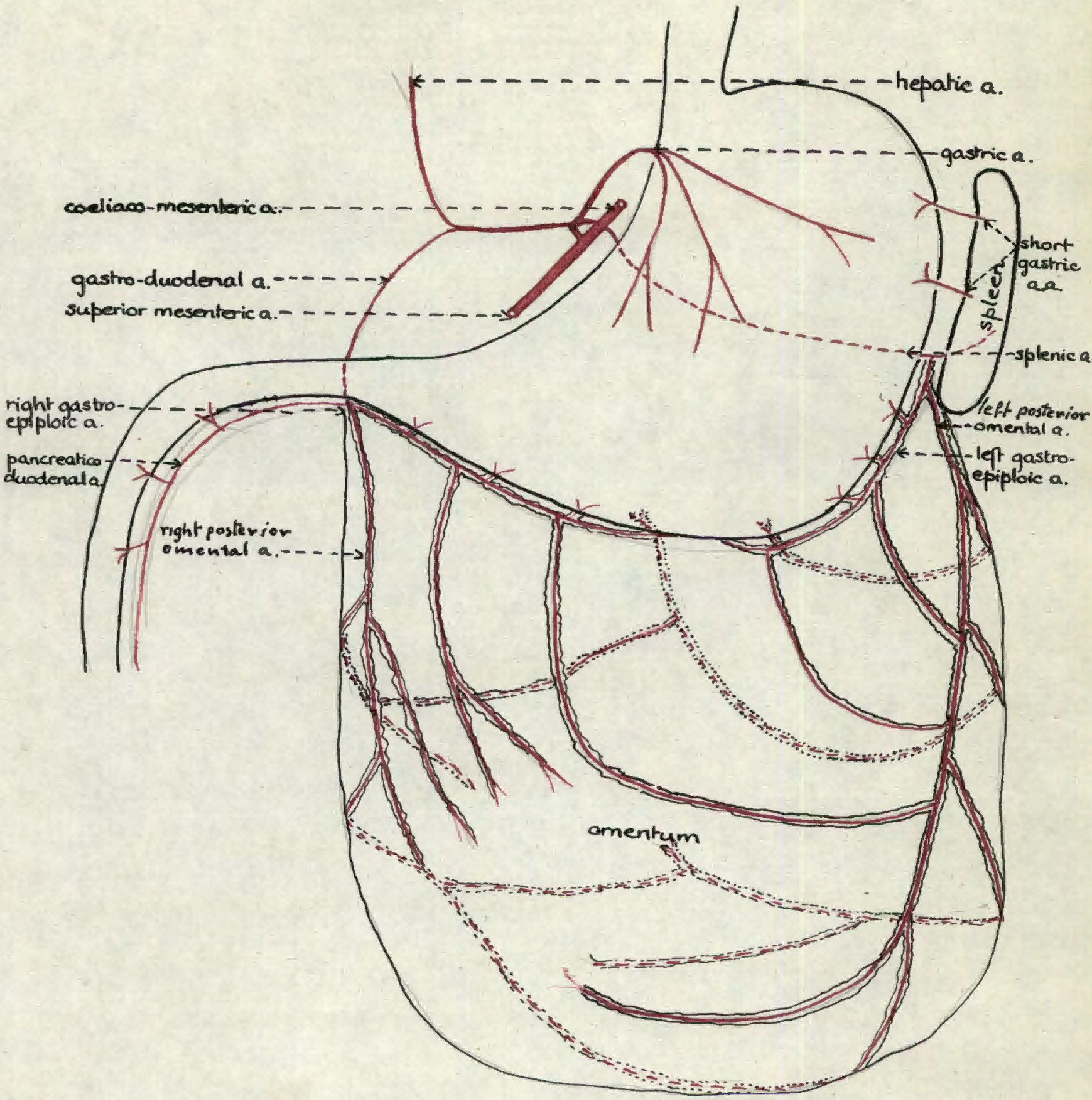


**Fig. 27.**

Diagram to show the blood supply of the stomach and omentum of the Shrew (Elephantulus myurus).

The anterior layers were supplied by the left and right gastro-epiploic arteries and by a large vessel that came off the splenic artery at the hilum of the spleen. This left posterior omental artery ran near the left margin of the omentum and gave branches to the anterior and the posterior layers. (Fig. 27).

The posterior layers were supplied by the omental artery described above, by small branches from the pancreatic arteries and by branches of the right gastro-epiploic artery running round the right free border of the omentum.

The similarity between Fig. 27 and Fig. 19, which depicts type "b" vascular pattern in the omentum in man, is striking.

(iii) Primates.

In primates the colon is fused to the posterior abdominal wall for a varying degree in different species. This is thought to result from the assumption of the erect posture, as it is not found in other mammals. The greatest degree of fusion is seen in man, where the ascending and descending colon have become fused to the posterior abdominal wall, while the transverse colon is suspended from the greater curvature of the stomach by the gastro-colic ligament (Page 30).

This fixation of the gut is less in the Blue Monkey and the Baboon, where only the ascending colon and the

/hepatic

hepatic flexure are adherent to the posterior abdominal wall, and only the hepatic flexure is attached to the stomach.

The omentum in man and the baboon is very similar, but in the blue monkey the right border of the omentum is fused with the peritoneum of the right paracolic gutter down to the pelvic brim.

The separate blood supply to the posterior layers of the omentum, described in man, is also seen in the monkey and the baboon.

(a) Man (Homo sapiens).

The omentum in man has been described in detail on pages 22-47.

(b) The Blue Monkey (Cercopithecus ethiops).

The general plan of the viscera of the blue monkey was similar to that found in man, except that the vermiform appendix was not developed and the caecum retained its foetal conical shape.

The Omental Bursa was large and extended from behind the stomach to the inferior free margin of the omentum. The condition found in the human embryo (Fig. 9) and in the pig - the omental bursa is separate from the vestibule to the bursa, but communicates through a well-marked foramen - was also found in the monkey.

/The

The Foramen of Winslow was patent and led into the vestibule to the omental bursa. It was bounded anteriorly by the free border of the lesser omentum, containing the bile duct, portal vein and hepatic artery; posteriorly by the peritoneum covering the inferior vena cava; superiorly by the liver, and inferiorly by the first part of the duodenum.

The Foramen into the Bursa was a well-marked triangular aperture formed by three folds of peritoneum with sharp crescentic free borders, each containing a blood vessel in its base. The left fold contained the gastric artery, the right fold the hepatic artery, and the superior fold the gastric vein curving over the top of the foramen to join the portal vein a little to the right of the hepatic artery.

The Coeliac Axis divided into three branches:

1. The Hepatic Artery, which gave off the gastro-duodenal artery that, in turn, divided into Pancreatico-duodenal, Right Gastro-epiploic and Omental Arteries.
2. The Gastric Artery, which ran to the lesser curvature of the stomach, raising up a fold of peritoneum off the posterior abdominal wall, to form the left border of the foramen into the omental bursa. At the lesser curvature it divided into anterior and posterior branches.

3. The Splenic Artery, which gave branches to the pancreas, and at the hilum of the spleen divided into splenic branches, short gastric arteries, left gastro-epiploic artery and four or five large branches which went into the anterior and posterior layers of the omentum.

The Omentum was voluminous and thin, contained no fat and was very vascular. It was found spread all over the abdominal viscera and extended into the pelvis. Its anterior layers took origin from the greater curvature of the stomach, from the pylorus to the gastro-splenic ligament, with which it was continuous; its posterior layers took origin from the posterior abdominal wall at the pancreas and coeliac artery. They were fused to the transverse mesocolon for a depth of two inches, the pancreas being situated intraperitoneally in the fusion.

The posterior layers also fused to the hepatic flexure, just below the pylorus, where, in addition, a strong ligament ran from the pylorus to the transverse colon. The fusion extended along the descending colon to the caecum; it was over a wide area, extending from the medial taenia to the right para-colic gutter.

The Blood Supply of the Omentum was from the Splenic and Gastro-duodenal Arteries (Figs.29 and 30).

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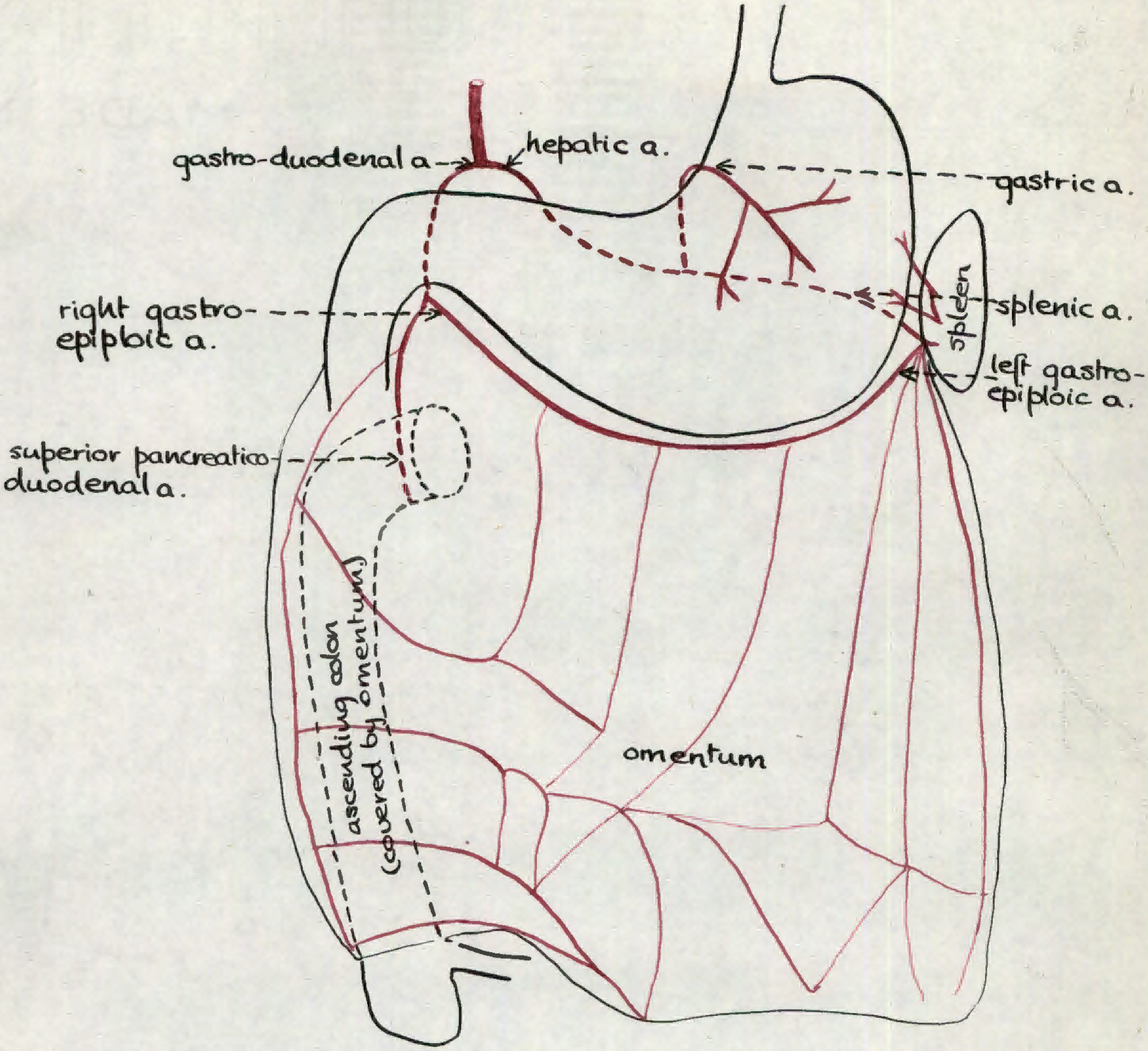
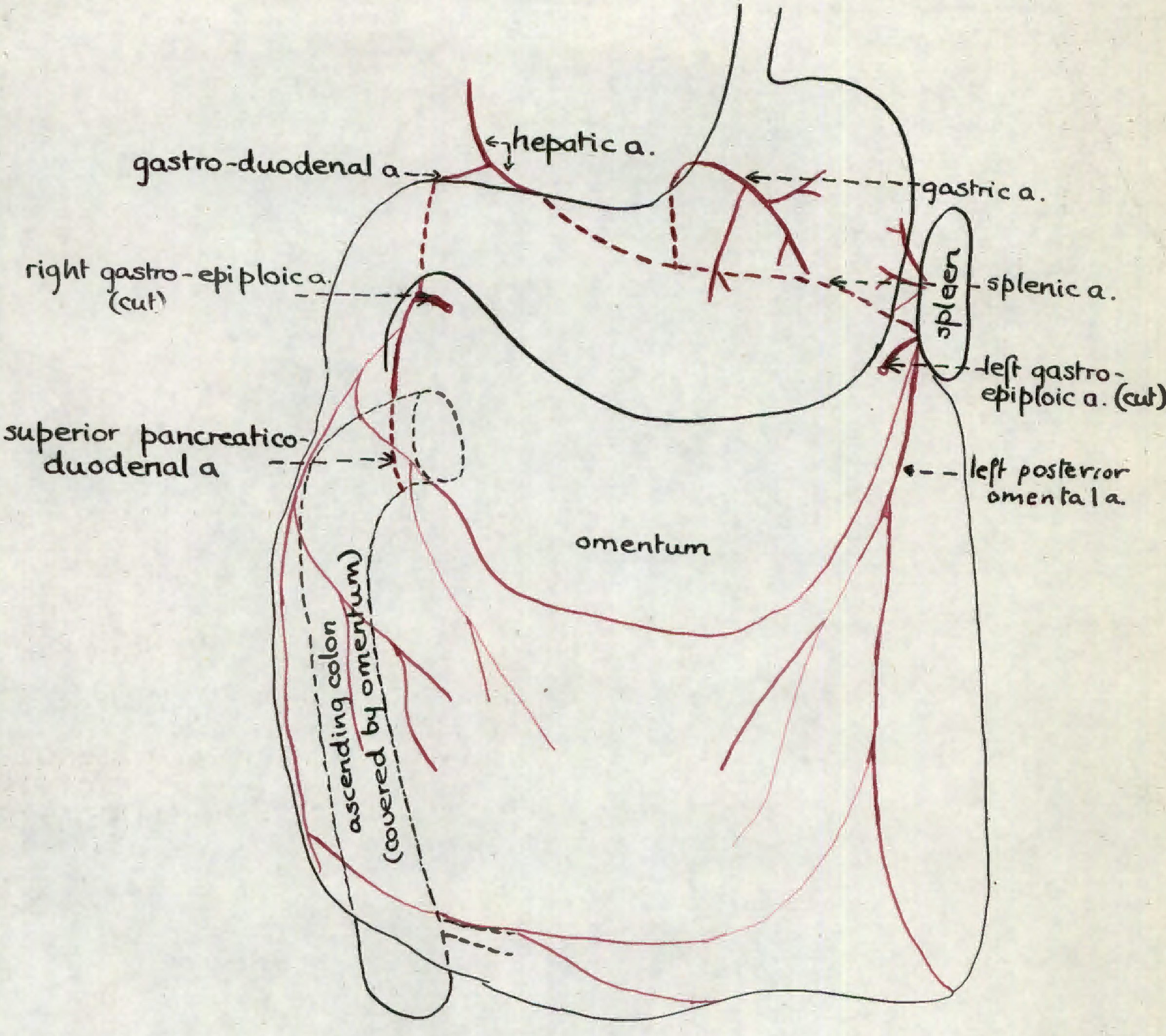



**Fig. 29.**

**Diagram to show the blood supply to the stomach and anterior layers of the omentum in the Blue Monkey (Cercopithecus ethiops).**




<u>Fig. 30.</u>

Diagram to show the blood supply to the stomach and posterior layers of the omentum in the Blue Monkey (Cercopithecus ethiops).

The anterior layers were more vascular than the posterior layers and were supplied by the gastro-epiploic arch, by three or four large vessels given off by the splenic artery at the hilum of the spleen, and by branches from the gastro-duodenal artery. This artery divided behind the duodenum into superior pancreatico-duodenal, right gastro-epiploic and a large artery that ran down in the omental attachment to the right paracolic gutter, and gave branches to the right half of the omentum. This latter artery, and the adhesion of the right border of the omentum to the right paracolic gutter, was seen in no other mammal.

The posterior layers were supplied by the branch of the gastro-duodenal artery that ran down in the right paracolic gutter and by left posterior omental branches from the splenic artery at the hilum of the spleen. There were no branches from the pancreatic vessels.

(c) <u>The Baboon</u> (Papio comatus).

One specimen of the baboon was examined. This was kindly lent by Professor M. R. Drennan, but as it was required for further dissection, a dissection of the coeliac axis was not possible.

The stomach was small and the duodenum had no mesentery. Unlike man and the blue monkey, the colon was very large and long, and the caecum well-developed.

/There

There was no vermifofm appendix.

The caecum had a mesentery, but the ascending colon and hepatic flexure were fixed to the posterior abdominal wall. The transverse and descending colon had a very long mesentery that formed a wide-mouthed cave opening distally in which the coils of small gut were found. The pelvic colon was long and had a long mesentery.

The omentum hung down from the greater curvature of the stomach. Its anterior and posterior layers were not fused. The posterior layers had a common origin with the transverse mesocolon, and were fused to the colon only at the hepatic flexure. This was similar to the condition found in the blue monkey, but the right border was free and not fused to the right paracolic gutter.

The omentum was extensive, being 24" long, compared to the crown-rump length of 36".

The Blood Supply of the Omentum: For the reasons given, this could not be thoroughly investigated but, from the examination that was possible, it appeared to conform to the type "b" vascular pattern of man (Fig. 19).

(iv). Carnivora.

The dog and cat were examined and furnished an interesting example of the difficulty of correlating the development of the omentum, with the complexity of the alimentary canal.

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The alimentary canal in these two carnivora was practically identical - neither the stomach nor the caecum was complicated, and the colon was short in both. Yet the omentum in the cat was proportionately many times larger than in the dog, and the blood supply to the posterior layers of the omentum was entirely different in the two.

(a) The Cat (Felix domestica).

The Alimentary Canal and Mesenteries:

The Stomach of the Cat was simple and had the omentum attached to its greater curvature. The duodenum had a mesentery in which hhe head of the pancreas was situated. The small gut was relatively short and thick-walled, its mesentery was continuous above with the root of the omentum and below with the mesentery of the colon. The colon was short: the caecum lay under the liver, from where the colon ran to the splenic flexure and then straight down to the rectum.

The Spleen lay in the omentum against the fundus of the stomach. In one specimen out of ten examined there were two small spleens of approximately equal size.

The Pancreas was intra-peritoneal, situated in the root of the posterior layers of the omentum.

The Coeliac Axis divided into three branches:

1. The Splenic Artery ran behind the peritoneum on the floor of the lesser sac just proximal to

/the

the pancreas. It divided into two main branches, one to the upper and one to the lower pole of the spleen. In addition, it gave off the following branches:

(a) Pancreatic artery that gave off three or four large branches that ran through the pancreas to supply the posterior layers of the omentum.

(b) Left gastro-epiploic artery supplying the greater curvature of the stomach and the left half of the anterior layers of the omentum.

(c) Short gastric arteries running to the fundus in the splenic omentum.

(d) Posterior gastric artery to the posterior surface of the body of the stomach. This artery was observed also in the pig.

2. Left or Anterior Gastric Artery ran down the left half of the lesser curvature and supplied the anterior surface of the stomach.

3. The Hepatic Artery ran to the liver in the free border of the lesser omentum and gave off the right gastric and gastro-duodenal artery, which divided into superior pancreatico-duodenal artery and right gastro-epiploic artery, the latter supplied the right half of the greater curvature of the stomach and the anterior layers of the omentum.

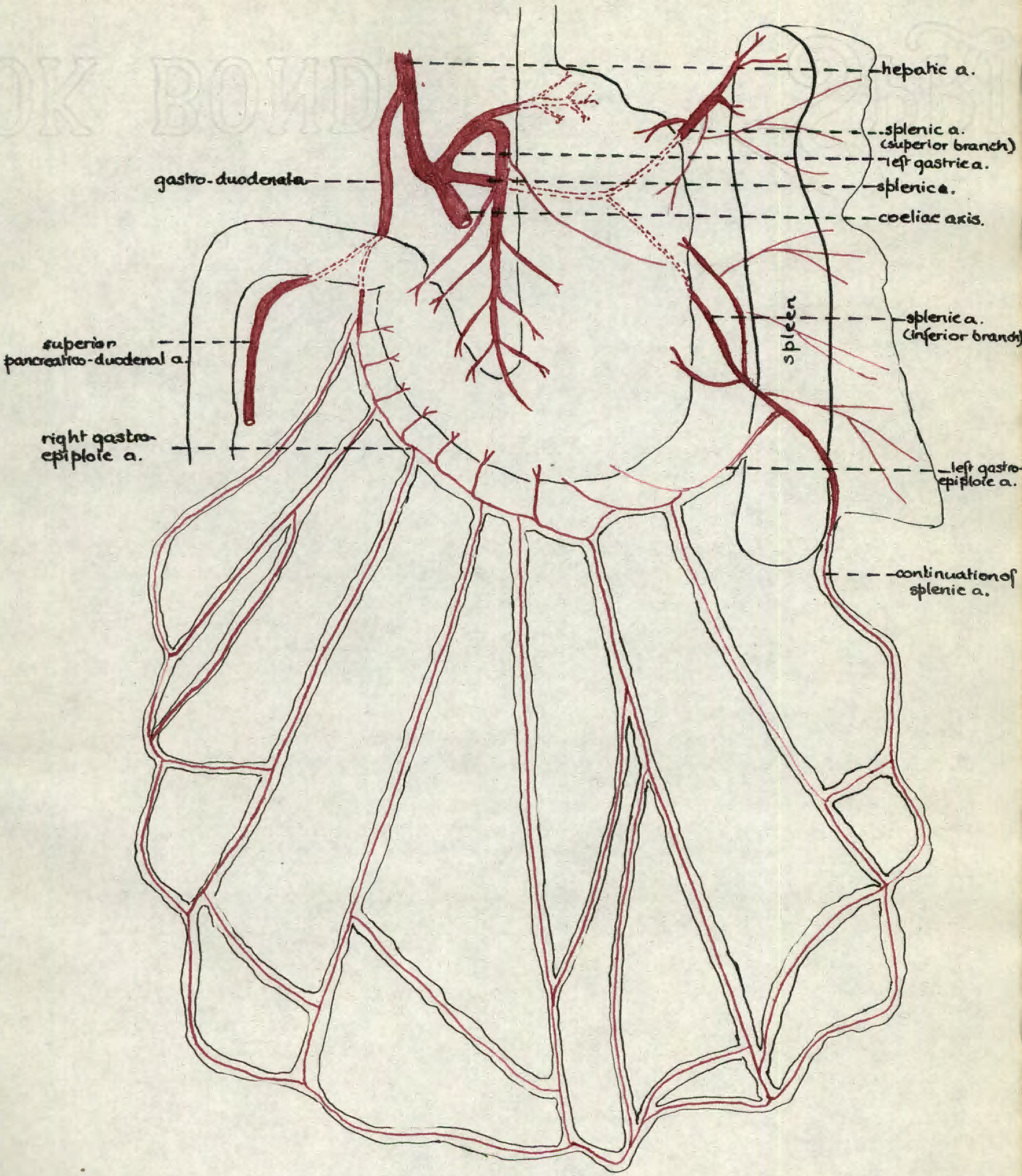
/The


Plate 5.

X-ray of mercury-filled coeliac axis of the cat (Felis domestica), showing the blood supply of the stomach and anterior layers of the omentum. The posterior layers have been turned upwards under the liver.

**Fig. 32.**

**Diagram of the blood supply of the stomach and anterior layers of the omentum in the cat (Felis domestica).**


hepatic a.
splenic a. (superior branch)
left gastric a.
splenic a.
coeliac axis.
gastro-duodenal a.
superior pancreatico-duodenal a.
spleen
splenic a. (inferior branch)
right gastro-epiploic a.
left gastro-epiploic a.
continuation of splenic a.

The Foramen of Winslow was patent and led into the lesser sac. It was bounded above by the right lobe of the liver; below by the portal vein as it curved forward to gain the lesser omentum; anteriorly by the free edge of the lesser omentum containing the hepatic artery, portal vein and bile duct; and posteriorly by the peritoneum covering the right crus of the diaphragm. The first part of the duodenum was not strictly related to the foramen as it did not curve backward but ran straight down. The inferior vena cava ran upwards into the liver about half an inch to the right of the foramen, on the posterior abdominal wall.

The Omentum was voluminous and contained many large blood vessels.

The anterior layers were attached to the first part of the duodenum and the greater curvature of the stomach as far as the fundus of the stomach. The spleen lay in the omentum adjacent to the fundus of the stomach. That part of the omentum between it and the stomach being named the gastro-splenic ligament. The omentum projected to the right beyond the spleen for a considerable distance (Fig.32).

The posterior layers were entirely separate from the anterior layers and not so vascular. They arose from the posterior abdominal wall at the coeliac axis and were

/continuous

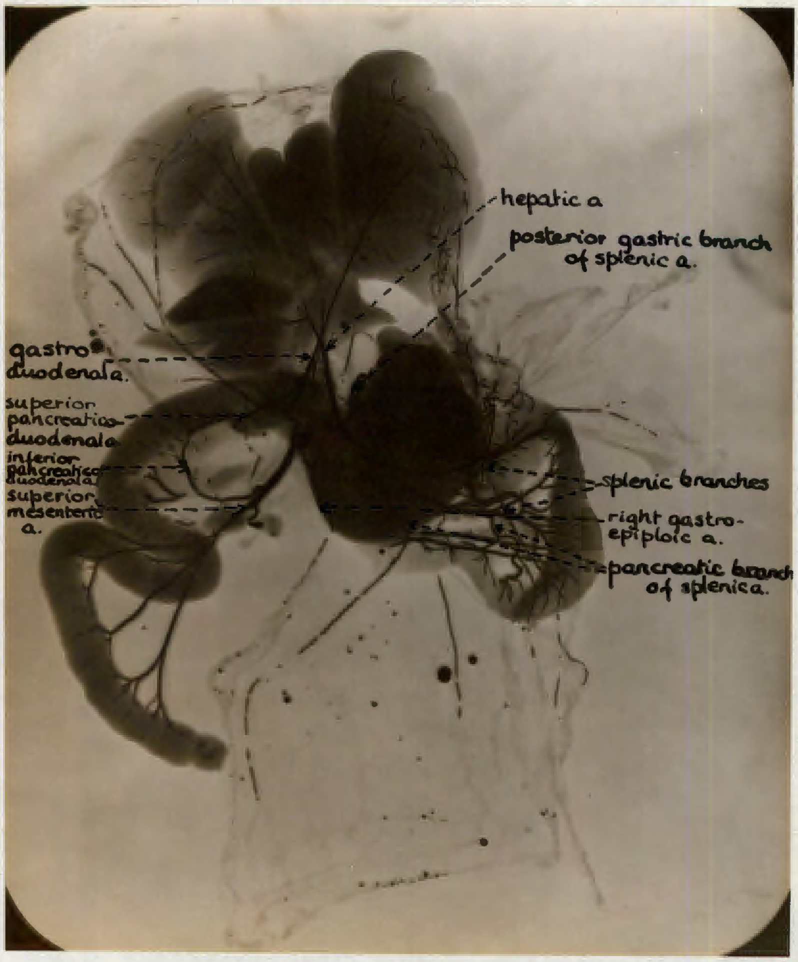
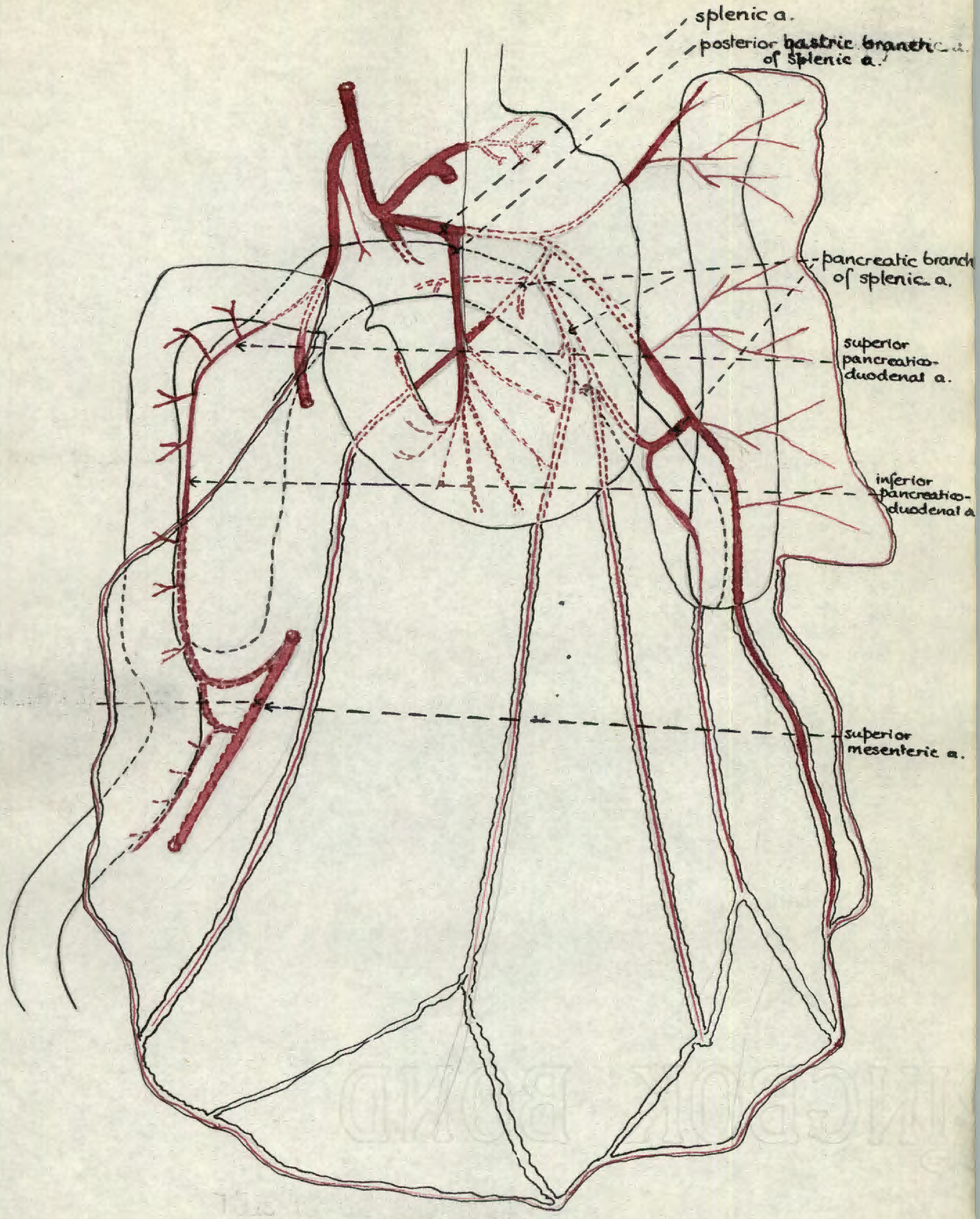



Plate 6.

X-ray of mercury-filled coeliac axis in the Cat (Felis domestica), showing the blood supply of the posterior layers of the omentum. The anterior layers have been turned back over the liver.

Fig. 33.

Diagram of the blood supply of the stomach and pesterior layers of the omentum in the cat (Felis domestica).


splenic a.
posterior gastric branch of splenic a.
pancreatic branch of splenic a.
superior pancreatico-duodenal a.
inferior pancreatico-duodenal a.
superior mesenteric a.

continuous on the right with the mesentery of the duodenum. Except for a common origin, they were quite separate from the mesentery of the transverse colon.

<u>The Blood Supply of the Omentum:</u>

The anterior and posterior layers of the omentum each had their own blood supply, which was quite separate but anastomosed around the free borders of the omentum.

The anterior layers were supplied by numerous long branches coming off at right angles to the left and right gastro-epiploic arteries and running down to the inferior free margin (Fig. 32 and Plate 5).

The posterior layers were supplied by the pancreatic branch of the splenic artery. This artery divided into pancreatic branches and three or four fairly large arteries that ran through the pancreas to supply the posterior layers of the omentum. (Fig.33 and Plate 6).

(b) <u>The Dog</u> (Canis domestica).

<u>The Alimentary Canal and Mesenteries</u> - These resemble those of the cat so closely that a description of them is unnecessary.

<u>The Coeliac Axis</u> - Like in the cat and most mammals, divided into Gastric, Hepatic and Splenic arteries. The Gastric artery supplied the anterior and posterior surfaces of the stomach; the Hepatic artery divided as in the cat, and the Splenic artery divided into two

/branches

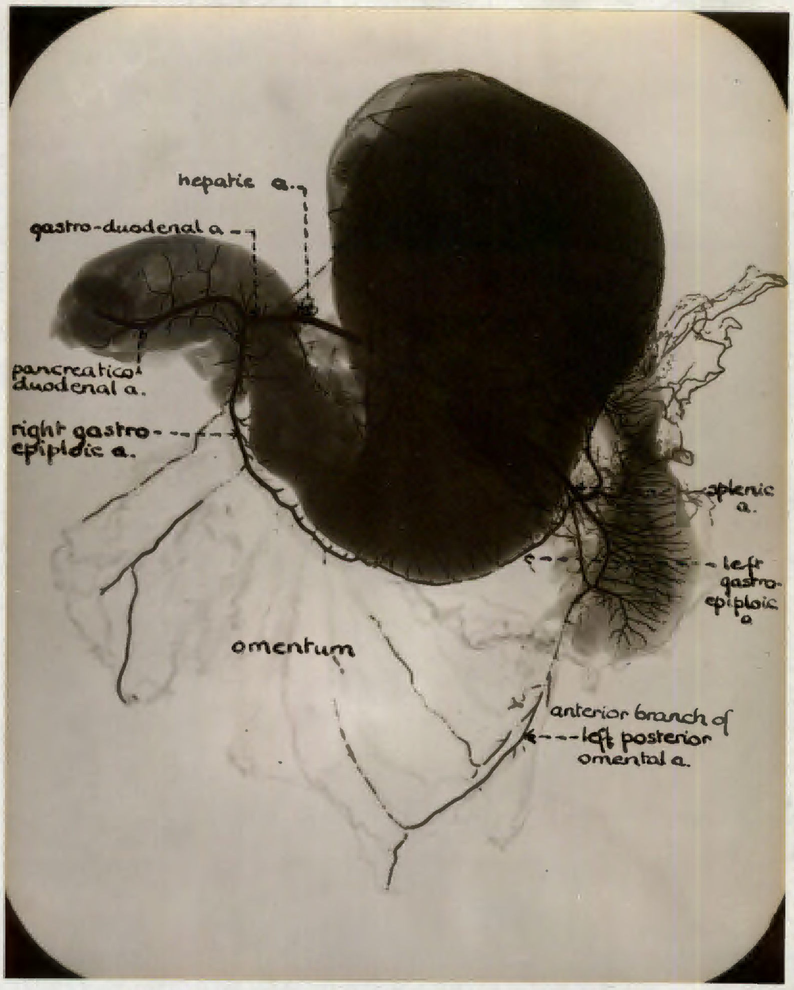



**Plate 7.**

X-ray of a mercury-filled coeliac axis of the Dog (Canis domestica), showing the blood supply of the stomach and anterior layers of the omentum.

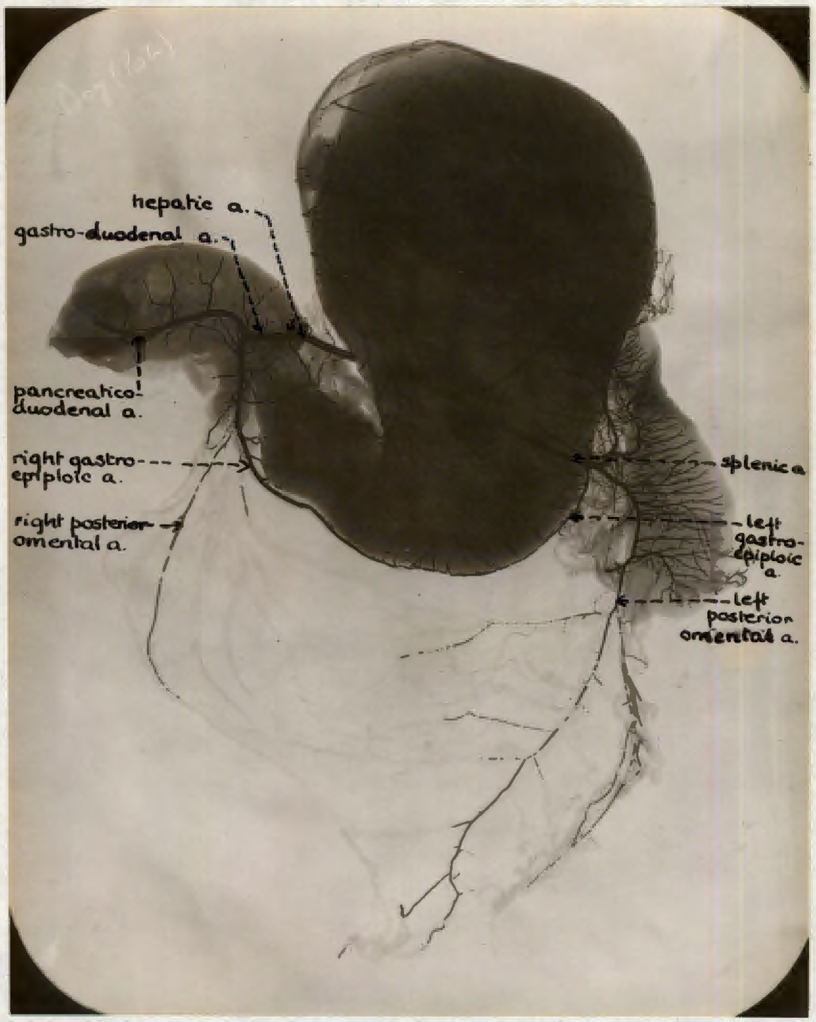



**Plate 8.**

X-ray of a mercury-filled coeliac axis of the Dog (Canis domestica), showing the blood supply of the stomach and the posterior layers of the mentum.

branches, one to each of the upper and lower poles of the Spleen, and, in addition, supplied branches to the pancreas, the short gastric arteries, the left gastro-epiploic artery and the left posterior omental artery which divided into anterior and posterior branches. The posterior gastric artery and the omental arteries via the pancreas were not present as in the cat.

The Omentum was much smaller than in the cat. The attachment of the anterior and posterior layers was as in the cat; the left border, however, ran from the tail of the spleen to fuse with the descending mesocolon as far as the pelvic brim. This fold of peritoneum was relatively avascular.

The Blood Supply of the Omentum: The anterior layers, as in most mammals, were supplied by branches from the gastro-epiploic arch; in addition, the left posterior omental artery gave off an anterior branch that anastomosed with the branches of the left gastro-epiploic artery (Plate 7).

The posterior layers received no branches from the pancreatic arteries, but were supplied by a series of arches between the left and right posterior omental arteries, branches of the splenic and right gastro-epiploic arteries respectively.

This vascular pattern corresponds quite closely to type "b" in man (Fig.19).

/ry.

V. <u>Artiodactyla.</u>

This order is characterised by having complicated stomachs, simple caeca and a coiled colon.

The pig illustrates the simplest type of stomach found in the order - it is incompletely divided into two, and, by means of the canalis gastricus, food is passed into the right half of the stomach, by-passing the left half.

The ox illustrates the most complicated stomach found in the sub-order, Pecora (Ruminants), of this order. Here the stomach is divided into four chambers.

The omentum of the pig was simple and its vascular pattern most resembled that of the cat, in receiving large branches from the pancreatic arteries. The omental bursa was interesting in that the foramen leading from the vestibule into the bursa had persisted. This was also seen in the monkey.

The omentum of the ox was complicated by the addition of the rumen to the stomach. It is as if the rumen had grown into the posterior layers of the omentum, so that the ventral sac of the rumen projects into the omental bursa, and the posterior sac of the rumen into the general ~~fu~~ peritoneal cavity behind the bursa (Figs.34 and 37). The omental bursa thus still lay behind the homologue of the primitive stomach, the abdmasum, but not behind the stomach as a whole; instead, it

(page 97 follows)

it was enclosed between the abomasum anteriorly and the rumen posteriorly. The prolongation down to the right iliac fossa along the superior pancreatico-duodenal artery, of the attachment of the omentum resembled the condition described in the Blue Monkey, but here the attachment was to the right paracolic gutter, and the vessel running in the line of attachment was a branch of the superior pancreatico-duodenal artery. (Fig. 29).

The blood supply to the posterior layers of the omentum, from the left and right ruminal and superior pancreatico-duodenal arteries, is peculiar to ruminants, as is also the fact of the spleen not being in the omentum, and the splenic artery, therefore, not supplying the omentum.

(a) The Pig. (Sus scrofa domestica).

The Coeliac Axis: The coeliac axis in the Pig had only two branches, the hepatic and splenic arteries. The gastric artery did not arise from the coeliac as in other mammals but came off in two branches, one from each of the main divisions of the coeliac artery.

The Splenic Artery divided into the following branches:-

(a) Pancreatic arteries,

(b) Posterior gastric artery which ran up in a thick fold of peritoneum to the posterior surface of the fundus of the stomach, (c.f., the Cat, page 88).

/(c)

(c) Short gastric branches to the fundus, running in the gastro-splenic omentum.

(d) Branches to the spleen.

(e) Left gastro-epiploic artery.

(f) Branches to the left half of the omentum.

The Hepatic Artery divided into the following branches:

(a) Pancreatic branches.

(b) Anterior gastric artery.

(c) Pyloric artery.

(d) Gastro-duodenal artery, which divided into the pancreatico-duodenal artery and the right gastro-epiploic artery. The latter gave off branches to the omentum.

The Omentum: The omentum was thin and contained hardly any fat; in this it resembled the monkey and horse. It extended down to just beyond the middle of the abdomen. The anterior and posterior layers were not fused; they arose from the greater curvature of the stomach and the posterior abdominal wall around the origin of the coeliac axis, respectively. The posterior layer was not fused on to the transverse colon or mesocolon, although it had a common origin with the mesocolon.

The Omental Bursa: The omental bursa was particularly interesting in that the vestibule to the omental bursa was clearly seen and in its posterior wall was seen a well-marked foramen leading into the lesser sac. This and the monkey are the only animals in which this condition - a persistence of the foetal condition

/described

described on page 8 and illustrated in Fig. 9., was found.

The foramen admitted two fingers and was bounded by two crescentic folds of tough peritoneum. The free margin of these folds was about 1/3" in width and contained no other structure. The posterior gastric artery, a branch of the splenic artery, ran up in the base of the posterior fold, while the pancreas abutted on the base of the anterior fold. This was quite definitely the only opening into the lesser sac.

The Foramen of Winslow was situated in the usual position and admitted three fingers easily. It was bounded anteriorly by the right free border of the lesser omentum containing the portal vein, the bile duct and the hepatic artery; posteriorly by the inferior vena cava lying on the left crus of the diaphragm; superiorly by the right lobe of the liver containing the inferior vena cava, and inferiorly by the pancreas.

The inferior vena cava took a somewhat peculiar course that was interesting: It approached the liver towards its right inferior extremity and gained this in the floor of the èpiploic foramen. It then entered a tongue-like prolongation of this lobe of the liver and ran upwards, forwards, and to the left/in it, so that it came to form part of the superior boundary of the foramen.

The Blood Supply of the Omentum: The pig was the only

/animal

animal in which the posterior layers of the omentum were more vascular than the anterior layers.

The anterior layers were supplied from the gastro-epiploic arch and also vessels from the hilum of the spleen.

The posterior layers were supplied by several big branches from the pancreatic branches of the splenic artery and also by vessels from the hilum of the spleen (cf. Cat, Fig. 33).

(b) The Ox. (Bos taurus).

The stomach of the ox was very large and occupied over half of the abdominal cavity. It completely filled the left half, except for the spleen, and extended over to the right of the midline for a considerable distance. It was compound, being composed of four divisions, viz., rumen, reticulum, omasum and abomasum. The rumen was further incompletely subdivided into dorsal and ventral sacs by the pillars, which are folds of the wall composed of mucous membrane and muscle (Fig. 34).

The duodenum was long and thin and made a long sweep down on the right of the midline to the pelvic brim, before it ascended to the duodeno-jejunal junction. It had a mesentery.

The spleen was firmly attached to the left crus of the diaphragm and the posterior surface of the dorsal sac of the rumen, which was outside the omental bursa. The spleen was, therefore, not attached to the omentum.

/The

The Pancreas was a compact organ, roughly quadrilateral in shape. It lay in the mesoduodenum and formed part of the ventral boundary of the foramen of Winslow.

The Foramen of Winslow was long and narrow. It was bounded superiorly by the liver; posteriorly by the peritoneum covering the inferior vena cava; inferiorly by the terminal colon and superior mesenteric artery, and anteriorly by the duodenum, mesoduodenum, pancreas and portal vein, hepatic artery and bile duct.

The Omental Bursa was situated between the omasum, abomasum and reticulum anteriorly, and the rumen posteriorly. Proximally it extended up between the lesser omentum and the peritoneum overlying the ventral surface of the dorsal sac of the rumen; distally it extended down to the lower border of the omentum, as the anterior and posterior layers were nowhere fused.

It will be noticed that no part of the bursa lay behind the stomach as a whole, as is found in other mammals.

The Omentum was thick and tough, and of considerable extent. The anterior and posterior layers were not adherent. Starting on the right, the origin of the anterior layers was from the posterior abdominal wall at the brim of the pelvis, then proximally along the mesoduodenum to the greater curvature of the abomasum, which it followed to where the omasum overlay the greater curvature. Here it became

/continuous

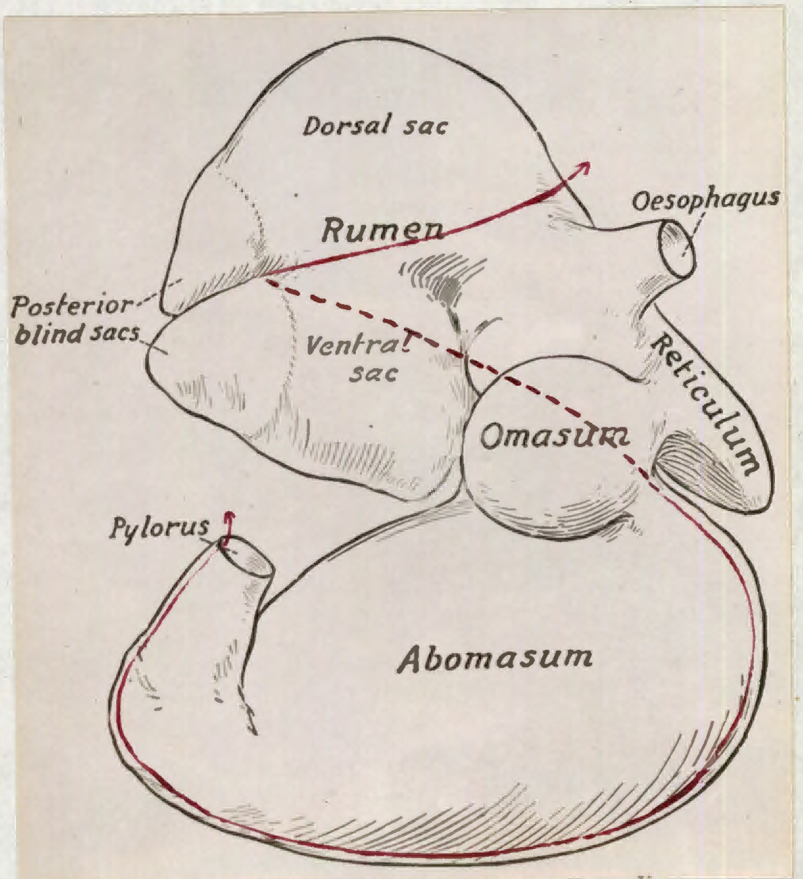



**Fig. 34.**

A diagram of the stomach of a calf (Bos taurus), with the rumen lifted up. (Sisson).
The line of omental attachment has been drawn in.

continuous with the line of attachment of the posterior layers. From here the line of the posterior layers followed the left ruminal artery to its anastomosis with the right ruminal artery, and then followed this artery off the rumen on to the posterior abdominal wall at the origin of the coeliac artery. (Fig. 37).

<u>The Blood Supply of the Stomach:</u> The stomach was supplied by the coeliac artery, which differed from the usual arrangement in mammals in that it had five branches (93):

1. <u>The Hepatic Artery</u> divided into the following branches:

   (a) Pancreatic.

   (b) Dorsal and ventral branches to the liver. The latter was the larger and gave off the right gastric artery which ran along the lesser curvature in the lesser omentum to supply the first part of the duodenum and the pylorus. It anastomosed with the dorsal branch of the omaso-abomasal artery.

   (c) Cystic artery to the gall bladder.

   (d) The gastro-duodenal artery, which divided into right gastro-epiploic and pancreatico-duodenal arteries. The gastro-epiploic artery ran along the greater curvature of the abomasum, supplied branches to the abomasum and the omentum, and ended by anastomosing with the left gastro-epiploic artery. The pancreatico-duodenal artery ran between the head of the pancreas and the duodenum, supplying them and giving branches to the anterior and posterior layers of the omentum.

2. <u>The Right Ruminal Artery</u> ran on the anterior surface of dorsal sac of the rumen. It supplied this, the pancreas and gave branches to the posterior layers of the

/omentum.

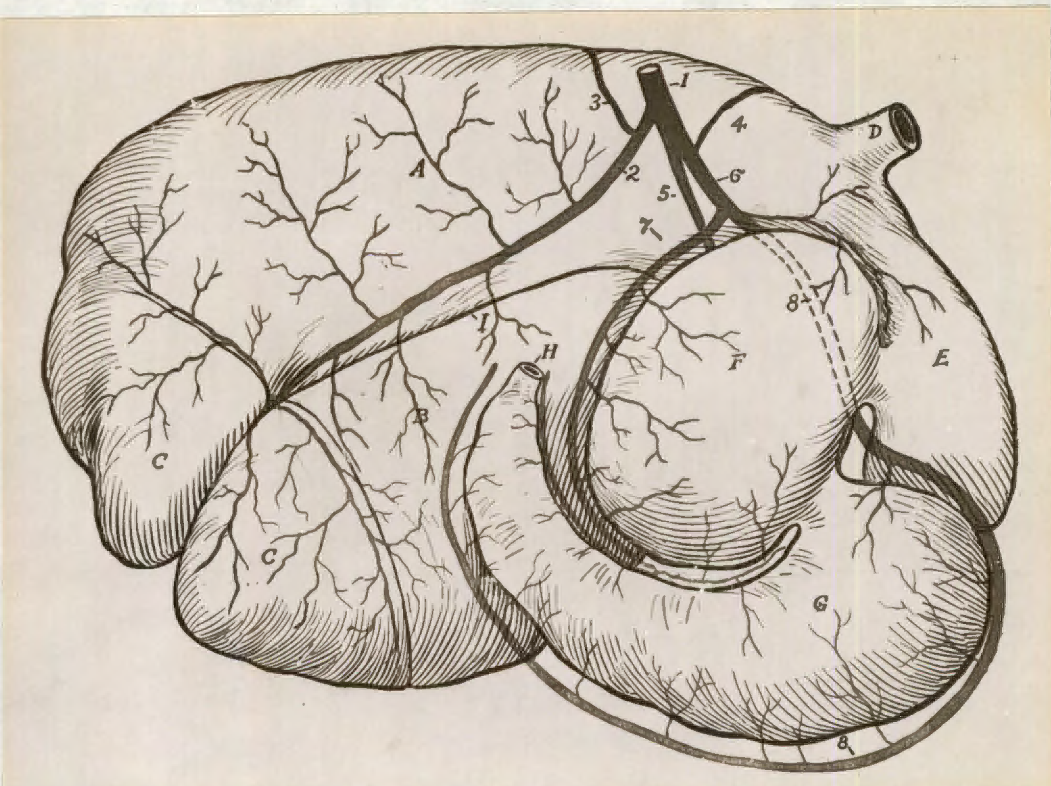



**Fig. 35.**

The blood supply of the stomach of the ox (Box taurus).
1. Coeliac artery; 2. right ruminal; 3. splenic; 4. reticular; 5. left ruminal; 6. omaso-abomasal; 7. dorsal branch of 6; 8. ventral branch of 6 (left gastro-epiploic); A. dorsal sac of rumen; B. ventral sac of rumen; C.C. posterior blind sacs; D. oesophagus; E. reticulum; F. omasum; G. abomasum; H. duodenum; I. right longitudinal furrow of rumen. By an oversight the reticular artery is shown as arising from the omaso-abomasal.
(Sisson).

omentum. It ended by anastomosing with the left ruminal artery.

3. The Left Ruminal Artery ran on the left surface of the surface of the ventral sac of the rumen which it supplied, in addition to giving a branch to the reticulum and branches to the posterior layers of the omentum.

4. The Omaso-abomasal Artery, (A. Gastrica Sinistra), ran behind the omasum, where it divided into two branches. The dorsal branch curved sharply back on the dorsal surface of the omasum to reach the lesser curvature of the abomasum, along which it ran to anastomose with the right gastric artery. The ventral branch (A. Gastro-epiploica Sinistra) ran down to the greater curvature of the abomasum, and along it to the right, where it anastomosed with the right gastro-epiploic artery. It supplied branches to the greater curvature of the abomasum and the omentum.

5. The Splenic Artery supplied only the spleen. It gave no branches to the omentum.

The Blood Supply of the Omentum: The omentum was supplied by the arteries along whose course it was attached. Thus, the anterior layers were supplied by the pancreatico-duodenal branch of the gastro-duodenal artery, and the right and left gastro-epiploic arteries; and the posterior layers were supplied by the pancreatico-duodenal artery and the left and right ruminal arteries (Fig. 36 and 37).

/(vi)

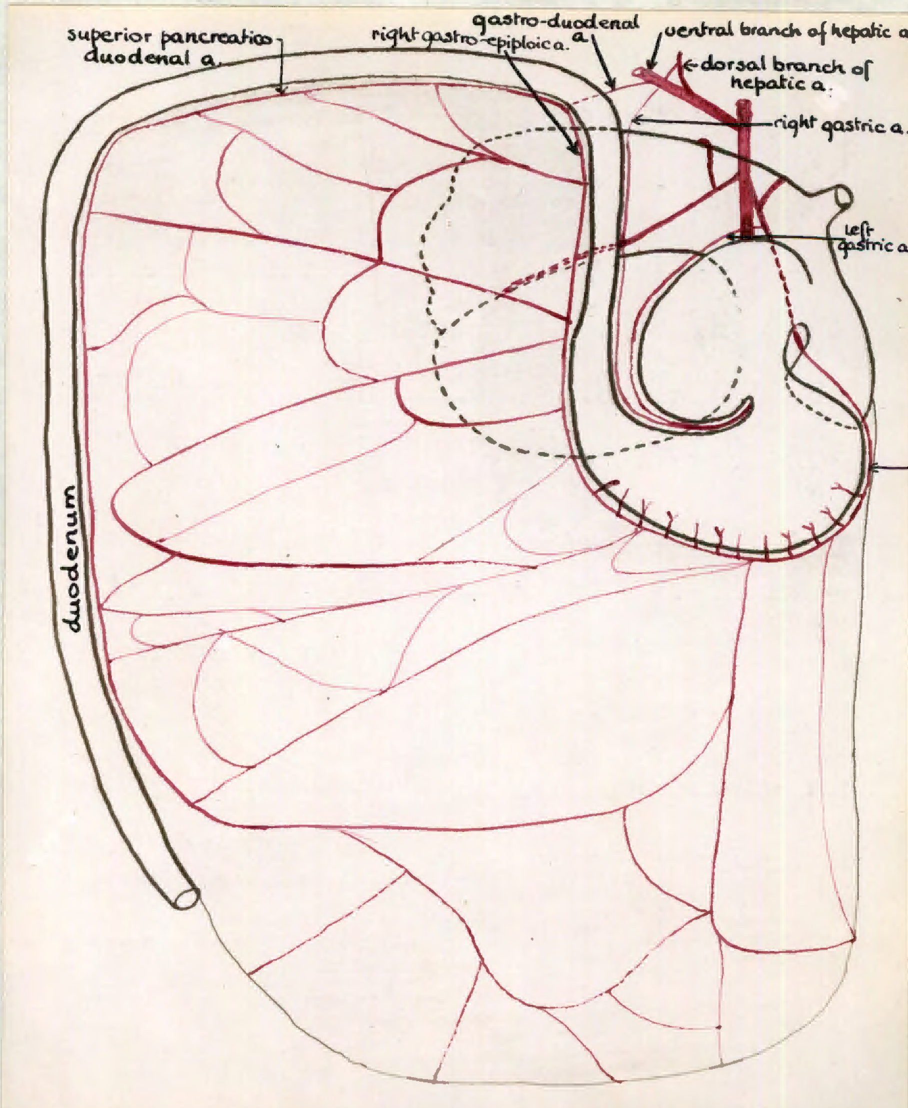



Fig. 36.

Diagram showing the anterior layers of the omentum in the Calf (Bos taurus) and their blood supply.

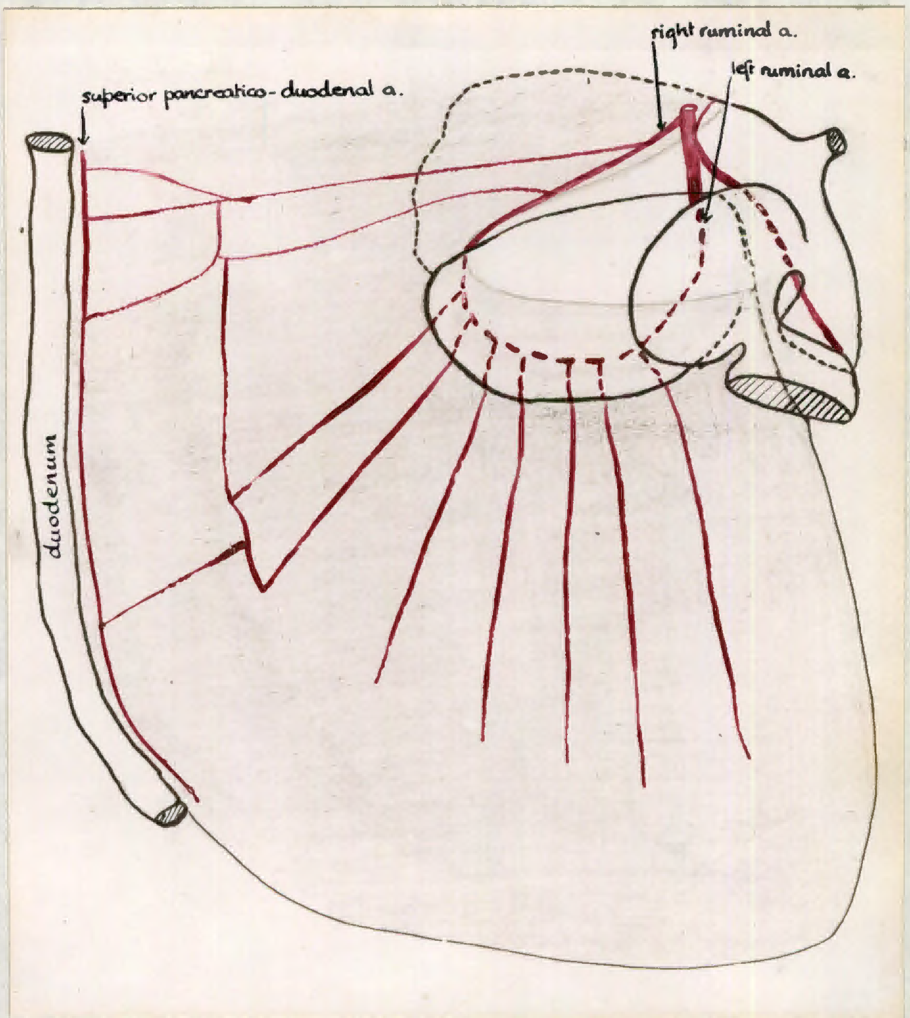



Fig. 37.

Diagram to show the posterior layers of the omentum in the Calf (Bos taurus) and their blood supply.
The abomasum and first part of the duodenum have been cut away.

(vi) Perissodactyla.

The Horse (Equus caballus) was taken as an example of this order, which is characterised by having a relatively small, fairly simple stomach and an enormous caecum and colon.

The left half of the stomach was lined by squamous epithelium and was devoid of glands; the right half was lined by mucous membrane and was glandular.

The duodenum had no mesentery - in this it resembled the primates. The small intestine was long and had a mesentery.

The caecum was very large and had a capacity of 6-8 gallons; the colon was divided into large and small colon. The former was long and looped and had a long mesentery, the latter being short and having a very short mesentery.

The Coeliac Axis - divided into 3 branches (Fig. 38).

(a) The Gastric Artery, which ~~is~~ divided into anterior and posterior branches. (Anomalies: It may arise from the splenic artery; the anterior branch may come off the splenic, and the posterior off the hepatic artery - Sisson (93).

(b) The hepatic Artery gave off pyloric, pancreatic and gastro-duodenal branches, the latter dividing behind the first part of the duodenum into superior pancreatico-duodenal and right gastro-epiploic arteries.

/(c).

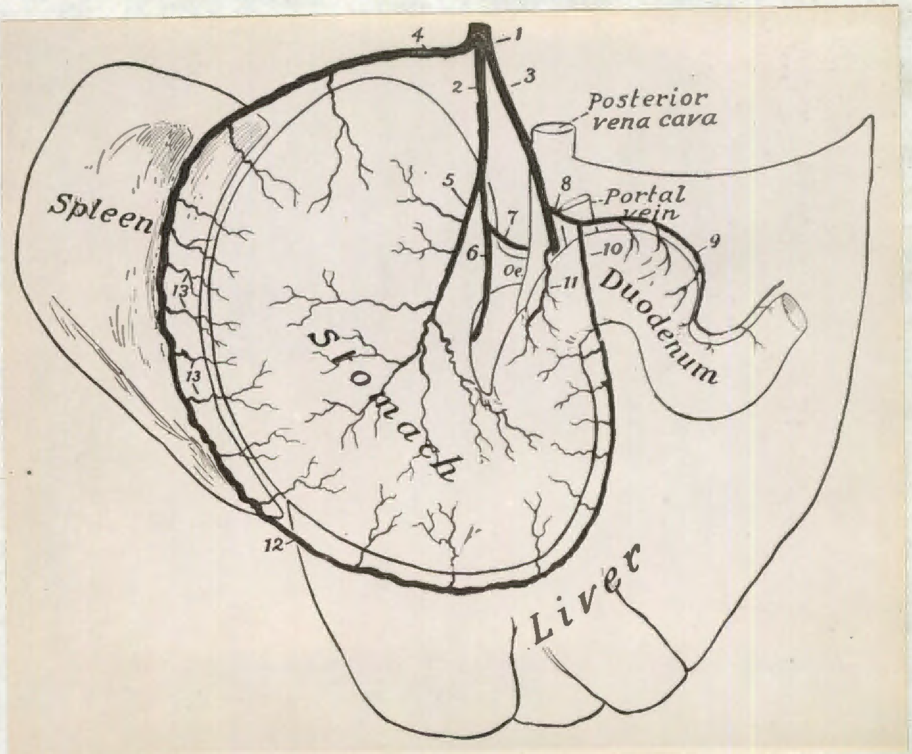



**Fig. 38.**

Branches of Coeliac Artery of Horse.
(Equus caballus).
1. coeliac artery; 2. gastric artery; 3. hepatic artery; 4. splenic artery; 5. posterior gastric artery; 6. anterior gastric artery; 7. oesophageal branch; 8. gastro-duodenal artery; 9. pancreatico-duodenal artery; 10. right gastro-epiploic artery; 12. left gastro-epiploic artery; 13. short gastric branches of splenic.
(Sisson).

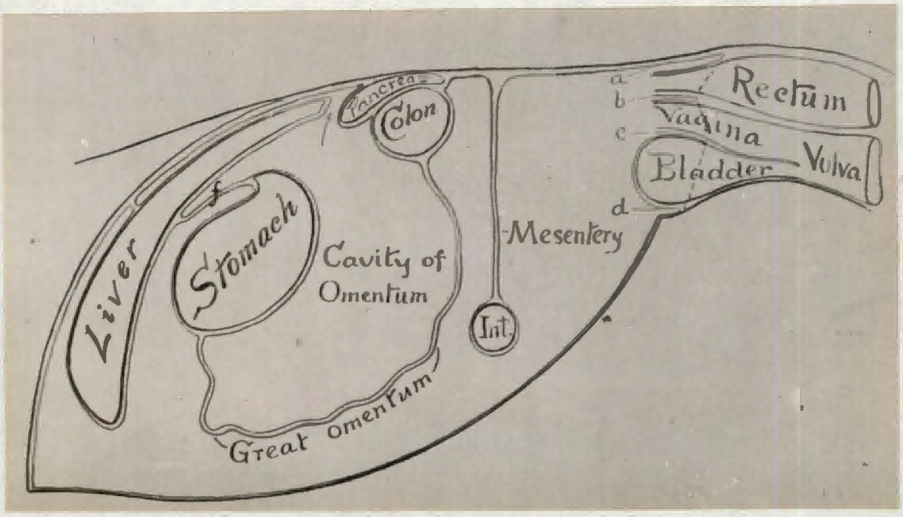



**Fig. 39.**

Sagittal section of a mare (Equus caballus) showing the lines of peritoneal reflection. (After Sisson).

(c) The Splenic Artery, in addition to supplying the spleen, gave off pancreatic, short gastric and left gastro-epiploic arteries.

The Omentum was relatively small and avascular (Fig. 39). It had not the same structure throughout: the part that formed the gastro-splenic ligament and the part that ran down from the spleen to the small colon were thick and strong, while the rest of the omentum was thin and fenestrated.

It was relatively avascular and contâined no fat strips, resembling the pig and the monkey.

The anterior and posterior layers of the omentum were not fused. The posterior layers were fused to the small colon and its short mesocolon. This fusion of the omentum to part of the colon was seen also in primates, the Rabbit and Dassie, but in no other mammals.

Blood Vessels in the Omentum:

Apart from the short gastric and gastro-epiploic vessels that ran in the omentum but did not supply many branches to it, the omentum was relatively avascular. Its anterior layers received branches from the gastro-epiploic arch, while the posterior layers were supplied by small vessels from the splenic running to the right from the hilum of the spleen, and by a small vessel that came off the pancreatico-duodenal artery.

/This

This conformed to the blood supply of the omentum in man, type "b", but the vessels were not so well-marked, in particular the vessels to the posterior layers.

(vii) Hyracoidia.

The Dassie (Procavia capensis) was taken as an example of this order, which is characterised by having a most complicated caecum and colon (Plate 9) with a relatively simple stomach.

The stomach resembled that of the horse and the rodents in that the cardiac pouch was lined by squamous epithelium.

The Duodenum had a mesentery which was continuous with that of the small gut.

The Caecum was large and sacculated. The colon distal to the caecum had the diameter of the small gut for about six inches and then dilated into a second caecum that had two long pointed processes (Plate 9). From the apex of this caecum the ascending colon originated. The whole of the colon, including the two caeca, had a mesentery.

The Pancreas was a small, compact, pinkish organ situated retroperitoneally along the splenic artery.

The Spleen was situated as usual in the great omentum, adjacent to the fundus of the stomach.

The Coeliac Axis divided into gastric, hepatic and splenic arteries. Except that there was no left gastro-epiploic

/artery,

artery, the branches of these arteries were similar to those of other mammals. (Plate 10).

The Omentum was well-developed, as is seen in Plate 10.

The anterior and posterior layers were not fused. The attachment of the anterior layers extended from the first part of the duodenum on the right, along the greater curvature of the stomach, to the gastro-splenic ligament on the left. The posterior layers arose from the posterior abdominal wall in the region of the splenic artery. They were attached to the anterior aspect of the transverse colon and mesocolon by a few thin folds of peritoneum. By cutting these bands it was possible to separate them entirely. The transverse mesocolon was very short so that the transverse colon lay up against the root of the omentum.

This fusion of the posterior layers to the transverse colon is not comparable to what is found in man and the horse, where it was more complete.

The Blood Supply of the Omentum. The omentum was well supplied by two vessels - the right gastro-epiploic, from the gastro-duodenal, and the left posterior omental artery, from the splenic. The left posterior omental artery divided into anterior and posterior branches that ran to the left in the respective layers of the omentum (Plate 10).

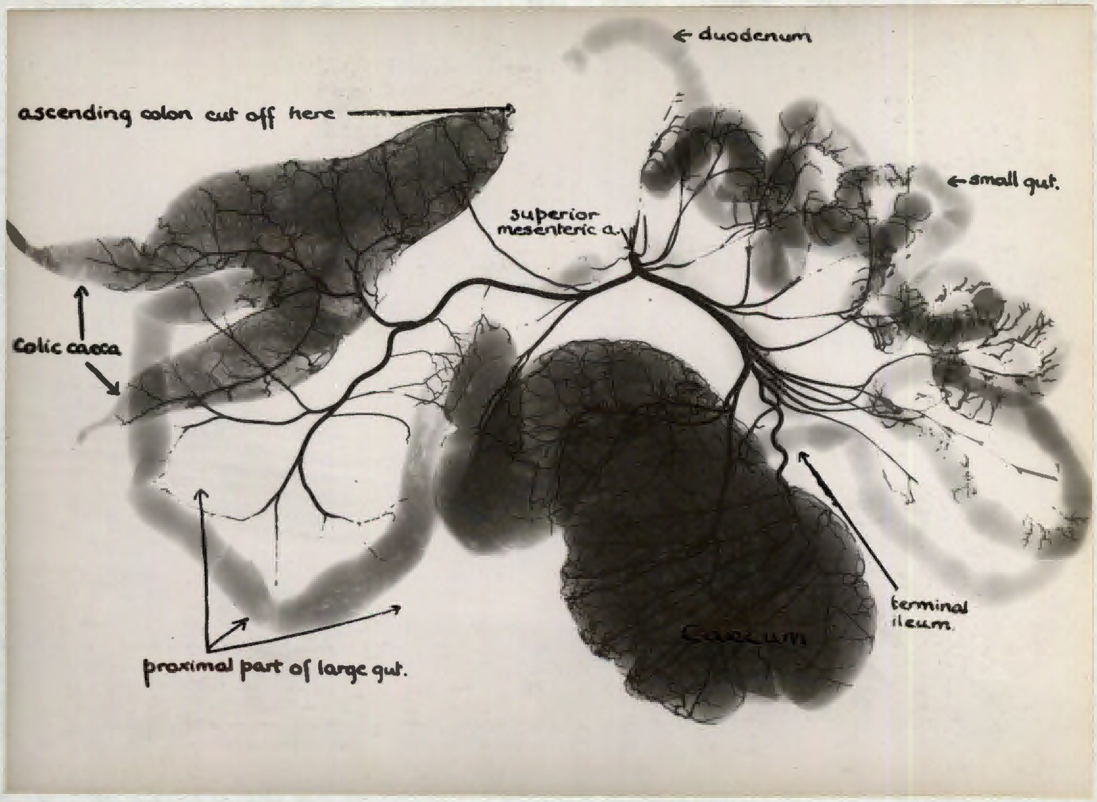



**Plate 9.**

X-ray of a mercury-filled Superior Mesenteric Artery, the small gut and part of the large gut in the Dassie (Procavia capensis).

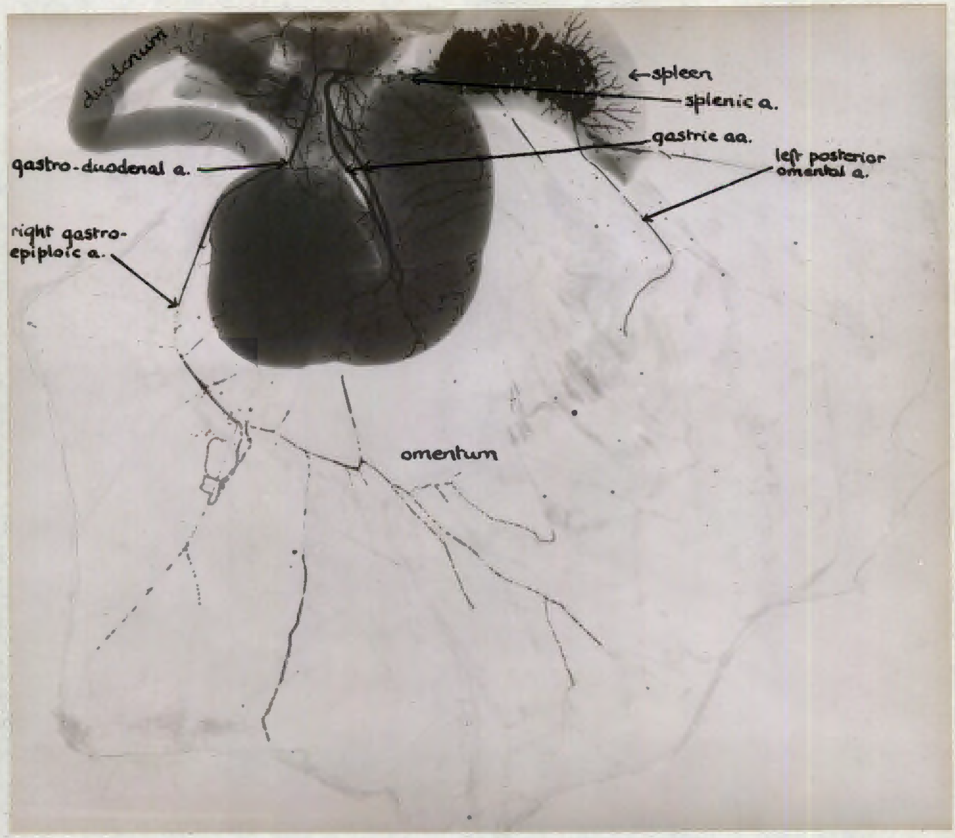



Plate 10.

X-ray of mercury-filled coeliac axis in the Dassie (Procavia capensis), showing the omentum and its blood supply.
Note: The left gastro-epiploic artery is absent.

The anterior layers of the omentum were thus supplied by the right gastro-epiploic artery and the anterior branches of the left posterior omental artery.

The left half of the posterior layers were supplied by the posterior branches of the left posterior omental artery; the right half was relatively avascular.

In the Rat (Plate 11) the left gastro-epiploic artery was also absent, but the vascular pattern was marginal, whereas in the Dassie the vessels radiated from the right gastro-epiploic and splenic arteries.

Description by other observers:

Only one reference to the omentum of the dassie was found in the literature. It was by Beddard (9). The following extract is quoted and Fig.40 reproduced from it:

"As is the case in all of the more specialised "mammalia, the omentum is attached to the trans- "verse colon. And the mode of its attachment is "very interesting. The colon where it leaves the "region of the two paired caeca is attached to the "stomach by a fold of omentum. After this follows "a section of the colon to which there is no such "omental attachment, and again at the commencement "of the descending colon the omentum is for a second "time inserted upon it." (Fig. 40).

/The

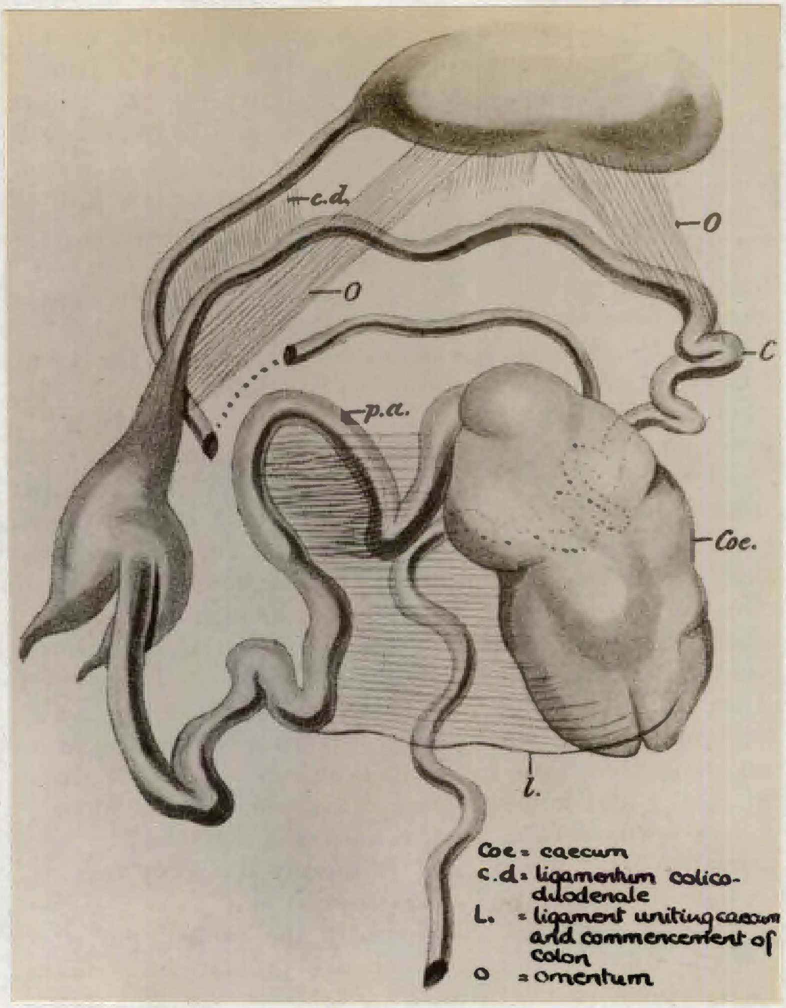



**Fig. 40.**

Diagram by Beddard to show the alimentary tract and omentum of the Dassie (Procavia capensis).

The present investigation is unable to confirm his description of the method of attachment of the omentum to the colon, nor does it agree that the omentum is attached to the colon in all of the more specialised mammals.

(viii) Rodentia.

The alimentary canal of this order is characterised by having a relatively simple stomach and a complicated caecum.

The fundic portion of the stomach is usually lined by squamous epithelium, and the muscular coat is very thin. This was best seen in the rat.

The caecum is most complicated in the rabbit, where it is about a foot in length, and terminates in a vermiform appendix about six inches long.

In the three species examined, rat, guinea pig and rabbit, the alimentary canal from the pylorus to the rectum had a mesentery.

The Coeliac Axis in Rodentia - divided into Gastric, Hepatic and Splenic arteries (Plates 11, 12, 13).

The hepatic artery gave off the gastroduodenal artery, which divided behind the first part of the duodenum, into superior pancreatico-duodenal and right gastro-epiploic arteries.

The splenic artery supplied the pancreas and spleen, and gave off a branch to the fundus of the stomach,

/the

the left gastro-epiploic and short gastric arteries, and continued on into the omentum as the left posterior omental artery.

In the rat the left gastro-epiploic and the short gastric arteries were absent.

The gastric artery divided into anterior and posterior branches opposite the mid-gastric sphincter. In the rabbit an additional artery arose adjacent to the gastric artery and supplied the anterior and posterior surfaces of the fundus.

The Omentum: The relative sizes is indicated by Plates 11, 12 and 13. The anterior layers of the omentum originated from the first part of the duodenum and the greater curvature of the stomach as far as the spleen, when they became continuous with the gastro-splenic ligament.

The posterior layers of the omentum arose from the posterior abdominal wall in the region of the coeliac axis, and had a common origin with the transverse meso-colon, which was very short. Only in the rabbit were the posterior layers of the omentum adherent to the transverse colon. This was also seen in the horse and partly in the dassie and monkey.

The anterior and posterior layers were not adherent, except in the guinea pig, where the left posterior omental artery passed from the tail of the

/pancreas

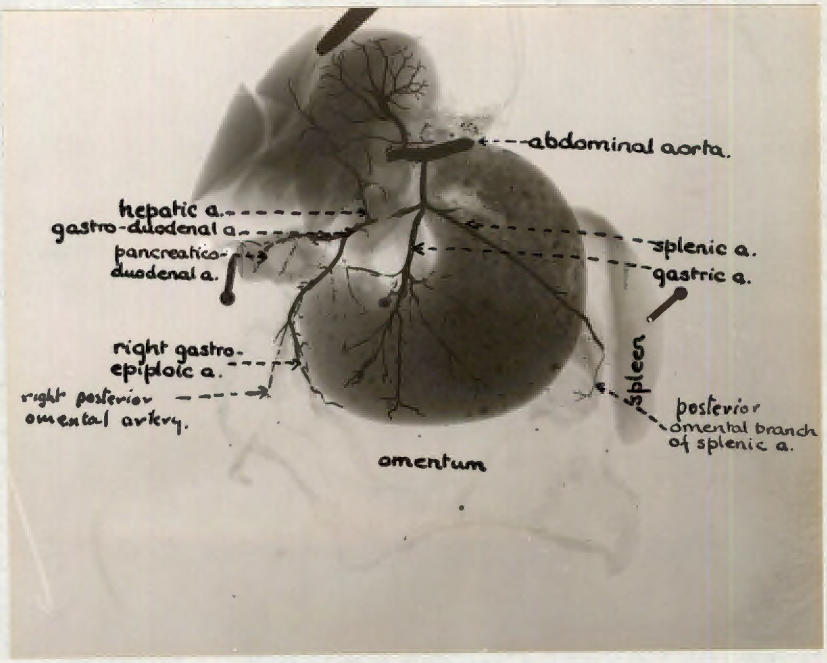



**Plate 11.**

X-ray of mercury-filled coeliac axis in the White Rat (Rat rattus).

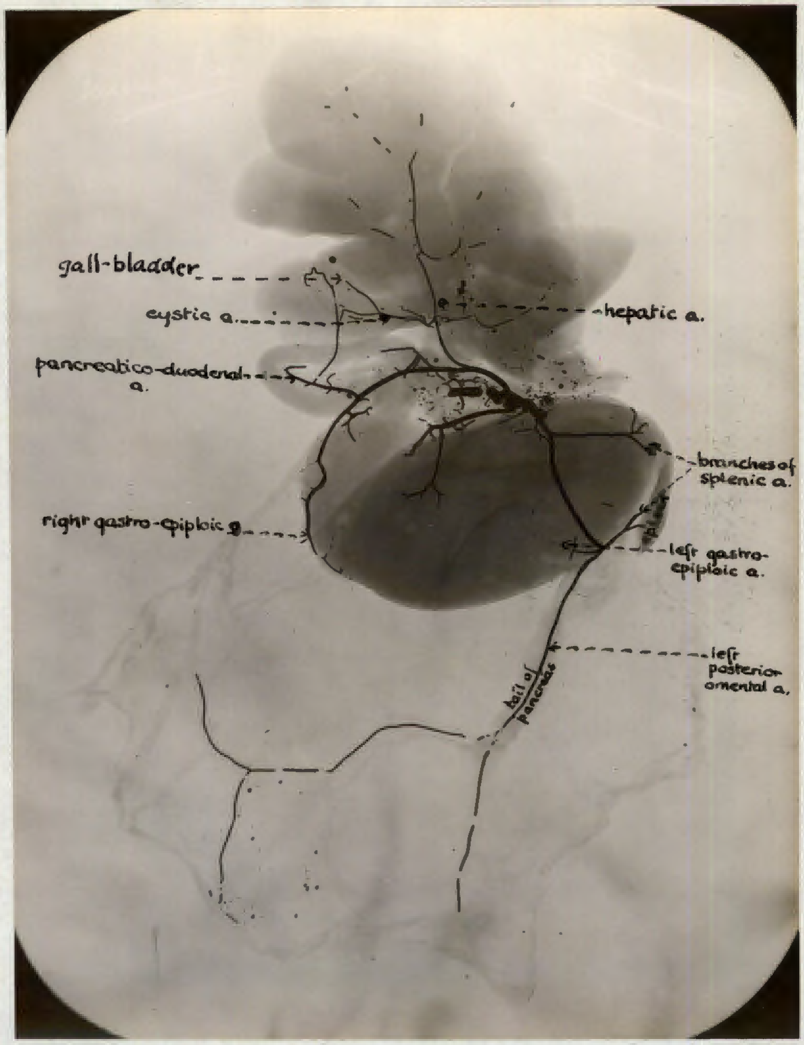
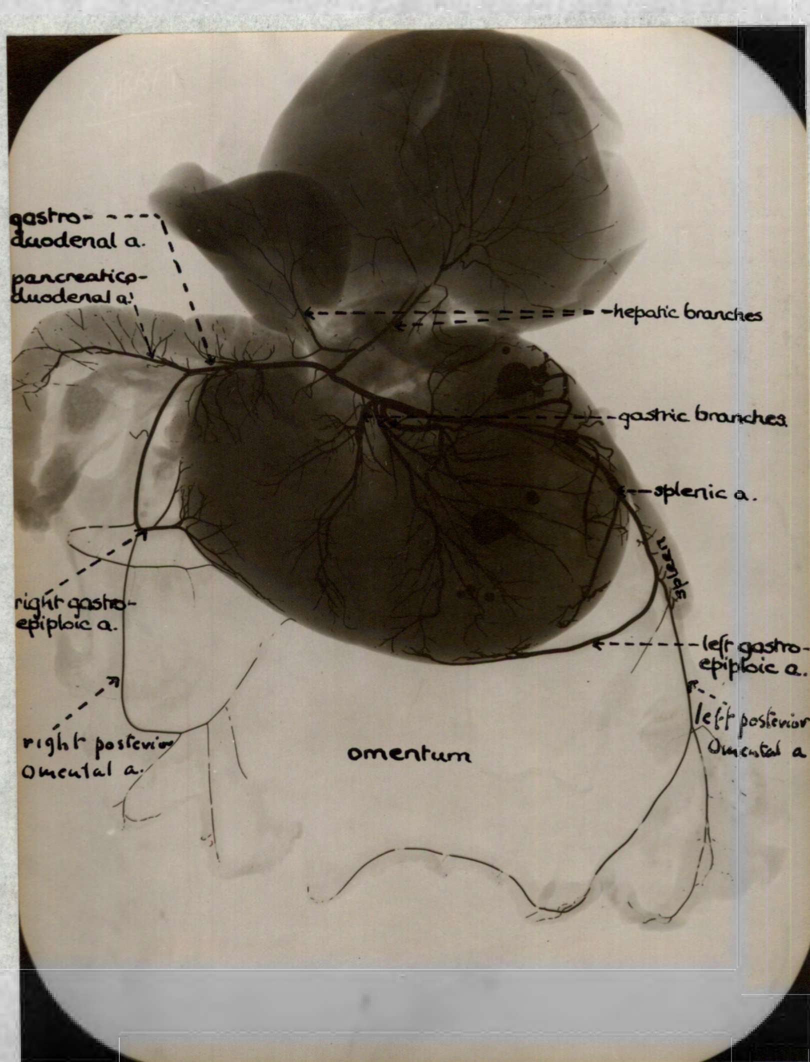



**Plate 12.**

X-ray of the mercury-filled coeliac axis of the Guinea Pig (Cavia porcellus). The liver has been turned up. Note that the left and right gastro-epiploic arteries are not very large and do not give any big branches to the omentum.
Note also the tail of the pancreas lying in the omentum and the continuation of the splenic artery, being the chief vessel of supply to the omentum.




## Plate 13.

X-ray of a mercury-filled coeliac axis in the Rabbit (Lepus cuniculus), showing the blood supply to the stomach and omentum.

pancreas in the posterior layers to the anterior layers.

In the rat and rabbit the pancreas lay in the root of the posterior layers, enclosed between them and extending from the concavity of the duodenum to the hilum of the spleen. The guinea pig was peculiar in that the tail of the pancreas swung away from the spleen and ran forward well into the omentum, carrying with it the continuation of the splenic artery. (Fig. 42 - Plate 12).

The Blood Supply of the Omentum in Rodents is characteristically marginal, i.e., the gastro-epiploic vessels play only a minor role, as in the Rabbit and Guinea Pig, or one may be absent, as in the rat; the main blood supply coming from a single artery, or a leash of arteries, running down in the left and right omental borders from the splenic and right gastro-epiploic arteries respectively, and meeting in the inferior border of the omentum, to complete the marginal arch, from which branches run to the anterior and posterior layers of the omentum. There was no separate blood supply to the anterior and posterior layers, as was seen in all other mammals except the mole.

The fat strips accompanying the arteries accentuate this pattern, which is well seen in Plates 11 and 13, of the Rat and Rabbit respectively.

The similarity between this marginal blood supply of Rodents and the arterial arch seen in the mole

/(Fig.25)

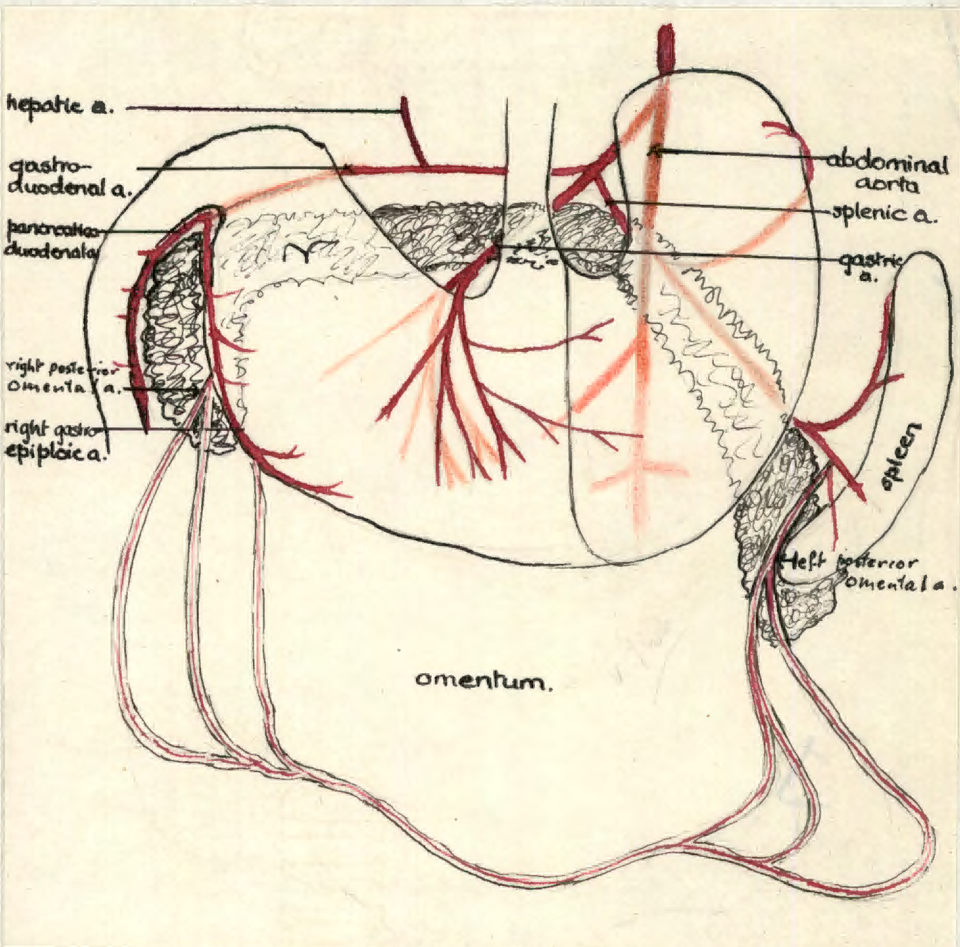



**Fig. 41.**

Diagram to show the blood vessels of the omentum and the stomach in the White Rat (Rat rattus). Note the absence of the left gastro-epiploic artery and the short gastric arteries.
Drawn from the dissection and the X-ray.

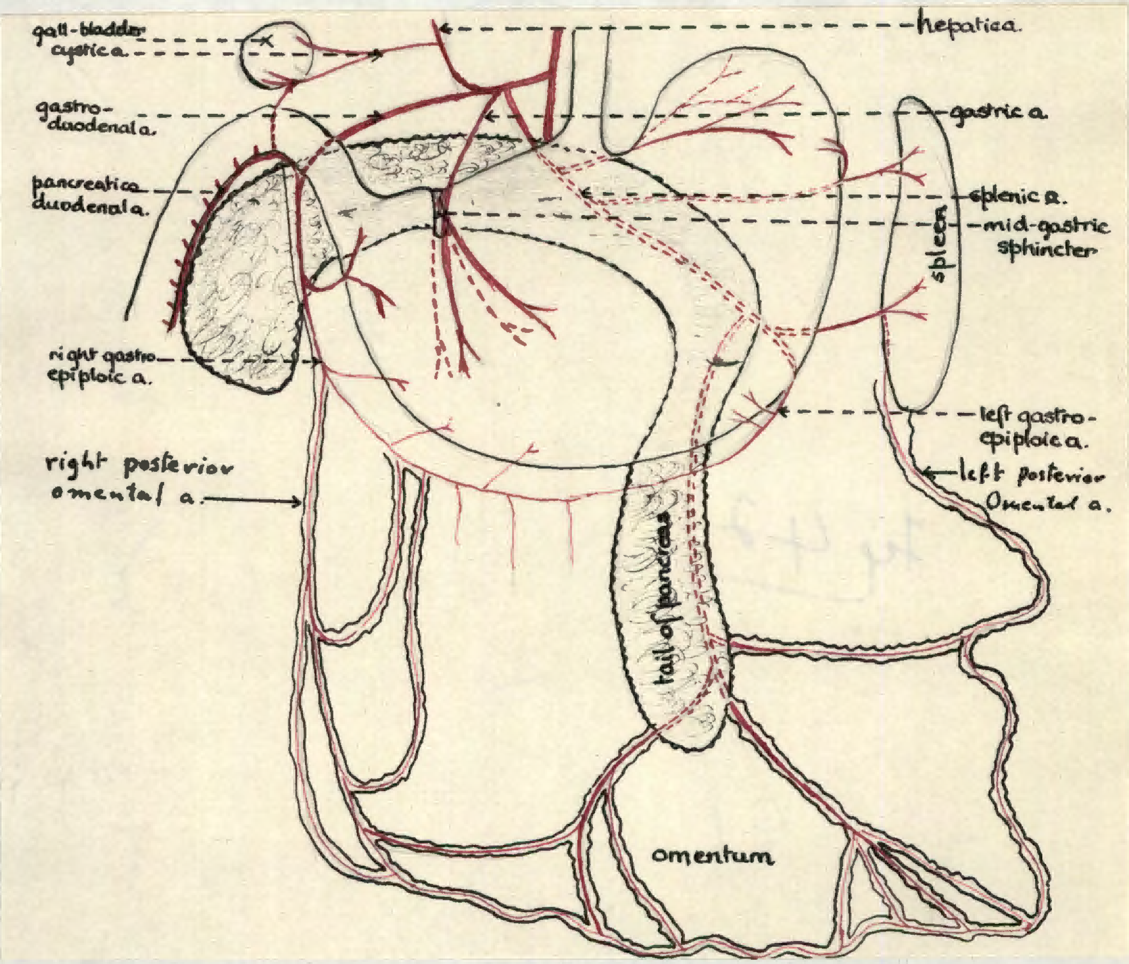



**Fig. 42.**

Diagram to show the blood vessels of the omentum and the stomach in the Guinea Pig (Cavia porcellus). Drawn from the dissection and the X-ray.

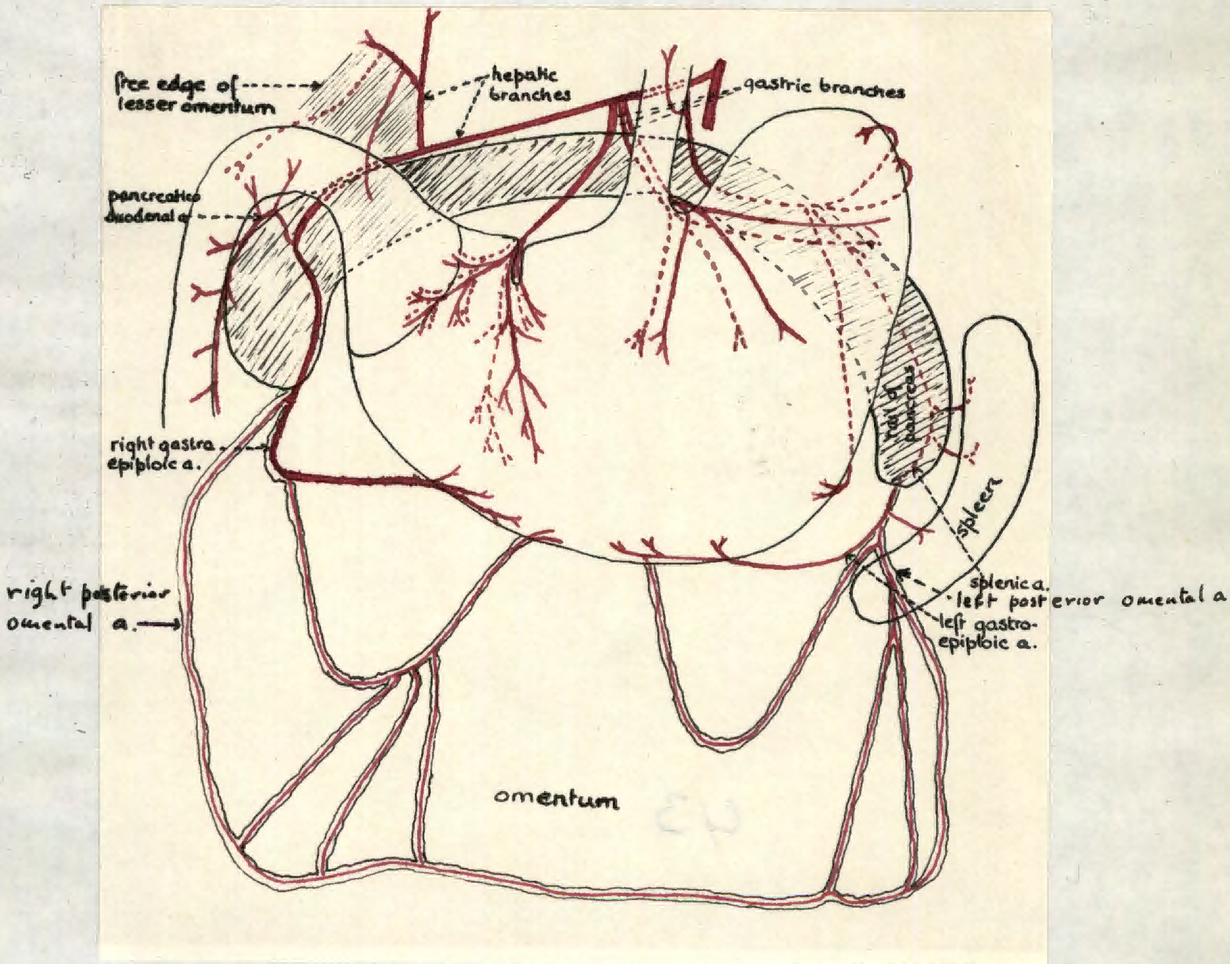



**Fig. 43.**

A diagram showing the blood supply of the stomach and omentum in the Rabbit. (Lepus cuniculus).

(Fig. 25) is striking, and suggests that the marginal vessels are developed first, and are followed by the gastro-epiploic arteries. In the Rat the left gastro-epiploic artery has not yet appeared.

The similarity the left posterior omental artery in the Guinea Pig has to the same artery in man is seen by comparing Plate 12 with Fig. 16. and Plate I.

## SUMMARY AND CONCLUSIONS:

1. The comparative anatomy of the dorsal mesentery of the stomach in Amphioxus, Cyclostome, Pisces, Amphibia, Reptilia and Aves, and of the omentum in nine Mammalian orders, has been studied with special reference to the blood supply.

2. X-ray records have been kept of the arteries filled with mercury. The technique is described.

3. There was no omentum nor trace of an omental bursa in orders below Mammalia, but the Tortoise had a bursa between the stomach and its dorsal mesentery, and the posterior abdominal wall.

4. The significance of this bursa has been discussed with reference to the embryological development of the omental bursa.

5. A number of isolated anatomical facts, variations in different species, was observed:-

(a) In the Pig and Monkey the vestibule to the omental bursa was well-defined, with a foramen leading from it into the omental bursa. This resembles the condition found in the human embryo.

(b) Fat strips were absent in the Monkey, Pig, and Horse.

/(c).

(c) The transverse colon was fused for varying distances to the posterior layers of the omentum near their origin in Primates, the Horse, Dassie and Rabbit.

(d) In the Monkey the right border of the omentum was fused to the ascending colon and the right paracolic gutter. A large branch of the right gastro-epiploic artery ran down in this line of fusion and supplied branches to the omentum.

(e) In the Dog, an avascular fold of omentum ran from the lower pole of the spleen to fuse with the descending mesocolon.

(f) Only in the Pig did the Coeliac Axis divide into two instead of three branches.

6. Except in the Mole and Rodents, the anterior and posterior layers of the omentum were separately supplied with blood vessels, which did, however, anastomose round the free borders of the omentum.

7. The relation between the degree of development of the omentum and the alimentary canal has not been clarified, possibly because the survey has not been wide enough.

It is, however, suggested that the mole, which has the most primitive gut, also has the most primitive omentum, as judged by its blood supply; furthermore, that Rodents, who have a marginal blood supply to the

/omentum,

omentum, represent the next stage in omental development, i.e., the appearance of the gastro-epiploic arteries which gradually take over the vascularisation of the omentum. And finally, it is suggested that the highest stage in omental development is reached when the anterior and posterior layers are separately supplied by radiating branches from vessels which run in the attachment of these layers. This is seen in the ox and corresponds well with the highly-developed stomach; it is, however, also seen in the cat where the stomach is simple.

It is obvious that many more orders and species must be examined before this tentative suggestion of omental development can be confirmed.

8. In the shrew, monkey, dog, dassie and in rodents the arteries supplying the posterior layers of the omentum have been named the Right and Left Posterior Omental Arteries because of the resemblance they have to the corresponding arteries in man described on pages 31-46 and depicted in Figs. 18 and 19.

9. It is suggested that the omentum develops in mammals as a special organ. In support of this is the absence of any precursor in lower vertebrates, and the fact of the omentum having its own blood supply, the development of which can be traced in successive mammalian orders.

# H I S T O L O G Y.

# HISTOLOGY.

## Introduction:

The account of the histology of the omentum given by Cappell (17) is very good and the following extract from it is given both for its content and to serve as a starting point for a discussion of the histology.

"The structure of the omentum varies considerably "in different animals, but the differences are "quantitative rather than qualitative, and, in spite "of the apparent dissimilarity, the organ presents "the same essential histological features in all the "mammals I have studied. Structurally the omentum "consists of a framework of connective tissue, carry- "ing a rich plexus of blood and lymph vessels, en- "closed between two sheets of mesothelial cells. "Over the main trabeculae of the omentum the meso- "thelium forms a continuous sheet, but between these "strands the organ presents the structure of a net, "the cords and intersections of which are clothed "on all sides by mesothelial cells.
"Along the main vessels adipose tissue tends to "collect in well-nourished animals, while from the "main trunks numerous small vessels and capillaries "arise and form a complicated anastomotic network "around and throughout the strands of the framework.
"The larger blood vessels are generally accompanied "by lymphatic vessels which drain into lymph nodes "along the stomach and colon.
"The mesentery is of a similar structure but there are "no net portions and the membranes form a thin con- "tinuous sheet.
"In many animals histiocytes tend to be aggregated, "particularly in the neighbourhood of vessels and "nerves, where they are included in the term 'adventitial "cells'. Many of these adventitial cells are small "and round with darkly staining nuclei and closely "resemble lymphocytes. Among these are a few larger "cells with paler staining nuclei, whose protoplasm "at the periphery forms blunt pseudopods. The latter "are the fully-developed histiocytes, the former are "believed to be reserves of primitive cells, but

/intermediate

"intermediate form are of frequent occurrence.
"In the omentum and mesentery these adventitial "cells are more numerous than elsewhere, and in "rodents they form especially pronounced peri-"vascular aggregations. In the rabbit and mouse "large collectionsof these cells also occur scattered throughout the omental and mesenteric tissues, without related blood vessels, but frequently connected with finer lymph channels; these form the so-called 'taches laiteuses', or milk spots."

Reports by Other Observers and Discussion.

1. Lymphatics:

Lymphatics, it is now certain, do exist in the omentum, but their presence was controversial for a long time.

The following authors denied their presence:

Casparis (18) quotes Ranvier as having first demonstrated them in the kitten in 1896, but he believed they were only present up to three months of age, after which they disappeared.

Shipley and Cunningham (84, 1916) denied their presence in laboratory animals.

Wojciechowski (101, 1927), after a careful study of 400 omenta of all ages, embryonic and adult, denied their presence.

Poynter (73, 1938) found them in the child at birth, but was unable to demonstrate them after the third month.

Fischer (32-1936), by using a special technique, demonstrated them in young rabbits by microphotographs, but at two years they were either absent or obscured by

/connective

connective tissue or fat. In man he did not see them in the foetus but did in the adult. In adult laboratory animals he demonstrated their presence only in the thinnest areas, running along the blood vessels.

The following authors claim to have demonstrated lymphatics:

Casparis (18 - 1918) claimed to have been the first to demonstrate them in the rabbit, dog, cat and man. He was able to recover particulate matter introduced intraperitoneally, from the cysterna chyli and thoracic duct, but not from the mediastinal glands.

On the other hand, Adams (1) quotes Buxton and Torrey as having first demonstrated the presence of lymphatics in 1906.

Simer began working on the lymphatics of the omentum in 1934 and has published 7 papers, the last in 1942 (86-92) in which he proves conclusively that lymphatics are present in the omentum of the dog, cat and man; in man from the fourth foetal month. He stresses how difficult it is to demonstrate them in man in either fresh or stained preparations, as they are deeply embedded in the fat strips. It was only by adopting a special method of injection with india ink, which he describes, that he was able to demonstrate their presence for certain.

<u>Omental Lymphatics in Man (Simer).</u>

Lymph vessels in the omentum are divided into a

/Central

Central Plexus and Lateral Collecting Channels (88).

Central Plexus: This accompanies the arteries (Figs. 44 and 45). There are usually two main vessels 15-150 µ in diameter, one on each side of the artery. They are thin-walled. The large vessels contain numerous valves, while the small vessels have few valves. These vessels are obscured by the fat and are difficult to demonstrate.

Lateral Collecting Channels: These run on the periphery of the fat strips; they are thick walled and resemble veins. Valves occur regularly every 1 - 2 mm.

Transverse Plexiform Lymph Channel: This runs to right and left between the greater curvature of the stomach and the gastro-epiploic vessels, and drains into the gastro-epiploic and splenic glands respectively, and then to the coeliac and hepatic glands, and thence to the cysterna chyli. There is no evidence that the diaphragmatic lymphatics play any part in the lymph drainage of the omentum of the dog or cat.

Lymphatics in Omento-jejunal Adhesions:

Simer (91) demonstrated these by the ingenious method of feeding animals on fat stained with Sudan IV, when the lymphatics appeared as pink, meandering lines near the surface of the fat strip. He was actually able to trace the fat from the mucosa of the gut to the omentum and through it to the duodenal lymph node (Fig. 46).

He makes a very interesting observation in

/relation

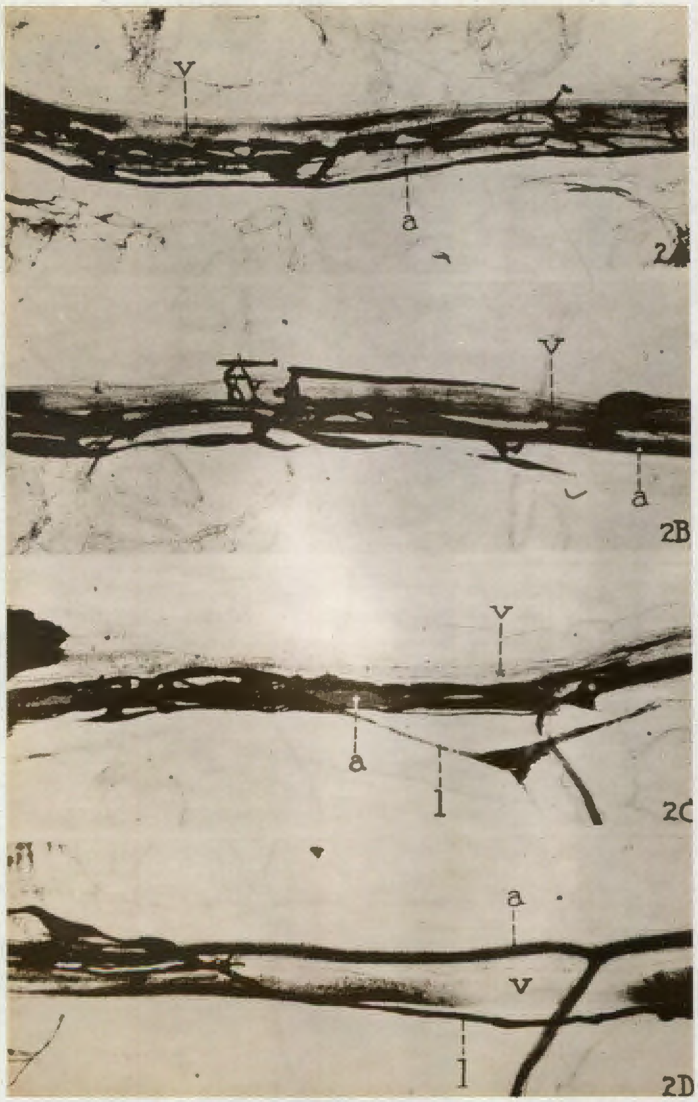



**Fig. 44.**

Photomicrofotographs of portions of omenta in which the lymph vessels are injected. (man) X10. In A. and B. a dense lymphatic plexus surrounds the artery, a. The vein, v, lies above. In C. and D. the central plexus of lymph vessels unites with a longitudinal collecting vessel, l.
(Simer).

Fig. 45.

Drawing of a wax reconstruction of an area 5 by 6 mm., from an adult human omentum. Black indicates veins; horizontal lines arteries; stipple, nerves; and white, lymphatics. The circles indicate the position of valves, thirty-two of which were counted in the lymph channels, and three in the veins of this area.

(Simer).

relation to the physiology of lymphatics: animals without adhesions, who were fed on this dye, showed the fat coloration only in the duodenal pole of the gland and not in the omental pole as did animals who had adhesions. This indicates that lymph is not pooled on reaching a gland but keeps to the path appropriate to the area it drains from.

Lymphatics in 'Milk Spots'.

Webb and Simer (97) demonstrated lymphatics in 'milk spots' and showed that they communicated with the central perivascular lymph channels, and had valves which indicated that the direction of flow was away from the milk spots.

The Path taken by Lymph from the Omentum:

There is no reason to expect that the lymphatics of the omentum should differ from the lymphatics elsewhere in the body by not following the arteries of supply to the part. The description given by Simer (88) (Fig.47) confirms this scheme. Higgins and Bain (43), however, have described a different course for the lymphatics of the omentum. According to them, the lymphatics follow the inner mesothelial layer of the omental bursa, i.e., the vessels of the anterior layers of the omentum run along the posterior of the two anterior layers of peritoneum, along the dorsal surface of the stomach and the lesser omentum, to the caudate lobe of the liver and to

/the

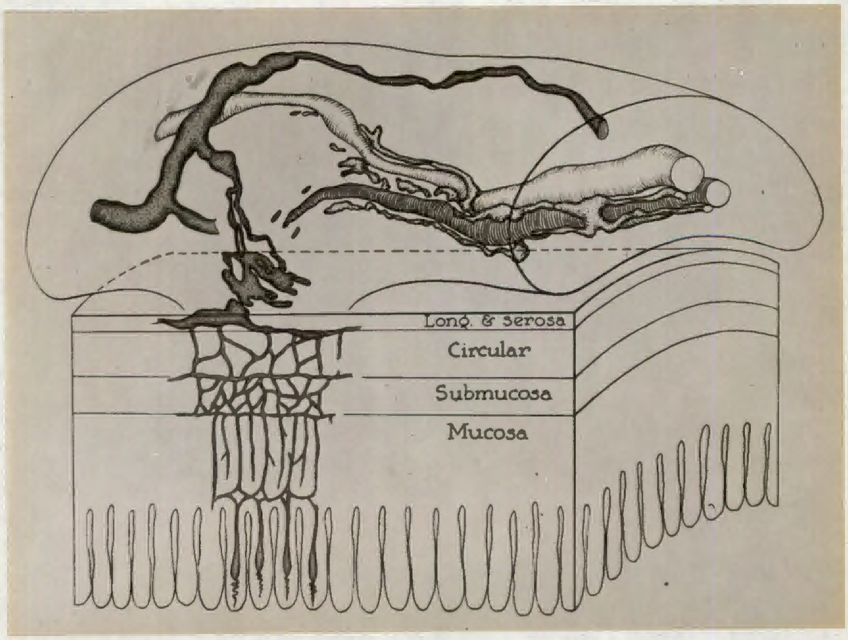



Fig. 46.

Diagram showing the relations of portions of the jejunum and omentum involved in an adhesion. Lymphatics are indicated by stippling and blood vessels by vertical lines. Fat (heavy stippling) absorbed by mucosa passes from the intestinal lymphatic plexuses through newly-formed connections in the adhesion into an omental lymphatic.

(Simer).

the posterior layer of the coronary ligament of the liver. While the lymphatics of the posterior layers run along the anterior of the two posterior layers of peritoneum, across the pancreas, to the crura of the diaphragm. From here all the vessels pass to the pleural surface of the diaphragm, thence to the anterior mediastinal lymphatics and so to the cervical lymph trunks. They stress that the stomach, in contradistinction, drains to the coelaic glands and so the thoracic duct.

No worker has confirmed this work, and nobody has questioned these unusual statements. As there is no embryological explanation for the omental lymphatics not following the omental arteries, it is felt that this observation is faulty.

For the same reason, and because the colic arteries are believed not to supply the omentum, the statement by Cappell on page 129 that omental lymphatics drain to lymph glands of the colon is questioned.

Crous in 1912 (quoted by Casparis (181), thought the lymph drainage was via the posterior mediastinal glands. The arguments against Higgins' and Bain's claim can be applied to this claim.

The path described by Simer (88) will be taken to be the correct one, as it is the logical path for the lymph to take, and the numerous investigations that he reports fully support this. The right 2/3 of the greater omentum drains to the right to a large node situated below the

/pylorus,

pylorus and named by him the 'Duodenal Node'. From here the lymph passes to the intestinal lymph trunk and so to the cysterna chyli. The left 1/3 of the greater omentum drains to the left to the splenic node (Figs.47 & 48). There is no evidence that the lymphatics of the diaphragm play any part in the lymph drainage of the greater omentum, although they are of definite importance in the lymph drainage of the peritoneal cavity.

The Function of Omental Lymphatics:

Simer (92), is the only one to discuss this, and points out that particulate matter is not removed from the omentum by the lymphatics to any extent, but that it remains encapsulated by the reticulo-endothelial cells for many years.

What then is the function of the omental lymphatics ? Before suggesting an answer it is as well to ask if there is any need to suggest a special function for these lymphatics other than the function of lymphatics in general - that of removing tissue fluid as it accumulates. There is no reason to suggest a special function, and it must be assumed that the function of the omental lymphatics, together with the lymphatics of the rest of the abdomen, is to remove fluid as it accumulates in the peritoneal cavity. Numerous experiments have been done to show that fluid absorption from the belly is decreased if the omentum is excised. Thus D.P.D.Wilkie (99) showed there is a 50% decrease in fluid absorption in cats when the

/omentum

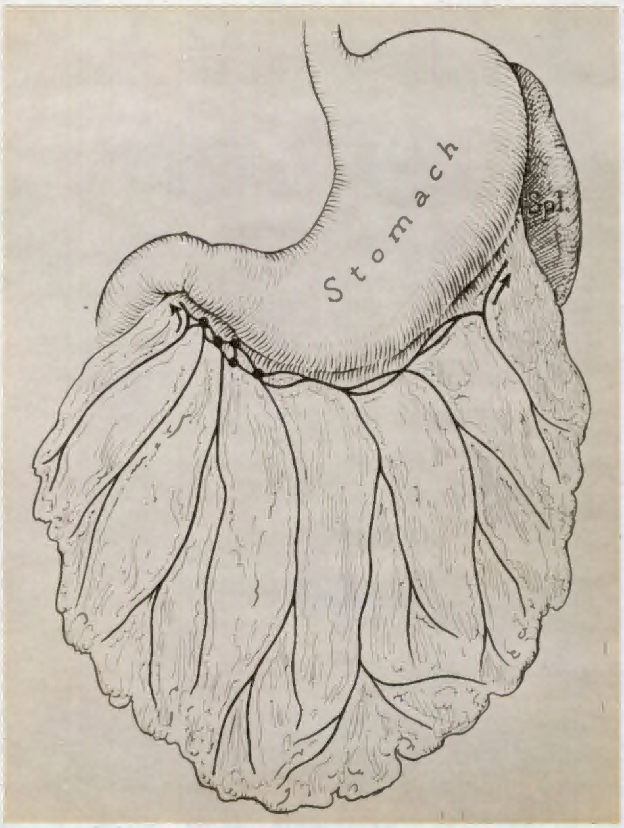



**Fig. 47.**

Drawing showing the proximal connections of omental lymphatics in man. The arrows indicate lymph flow to the splenic nodes on the left, and the coeliac nodes on the right.

(Simer).

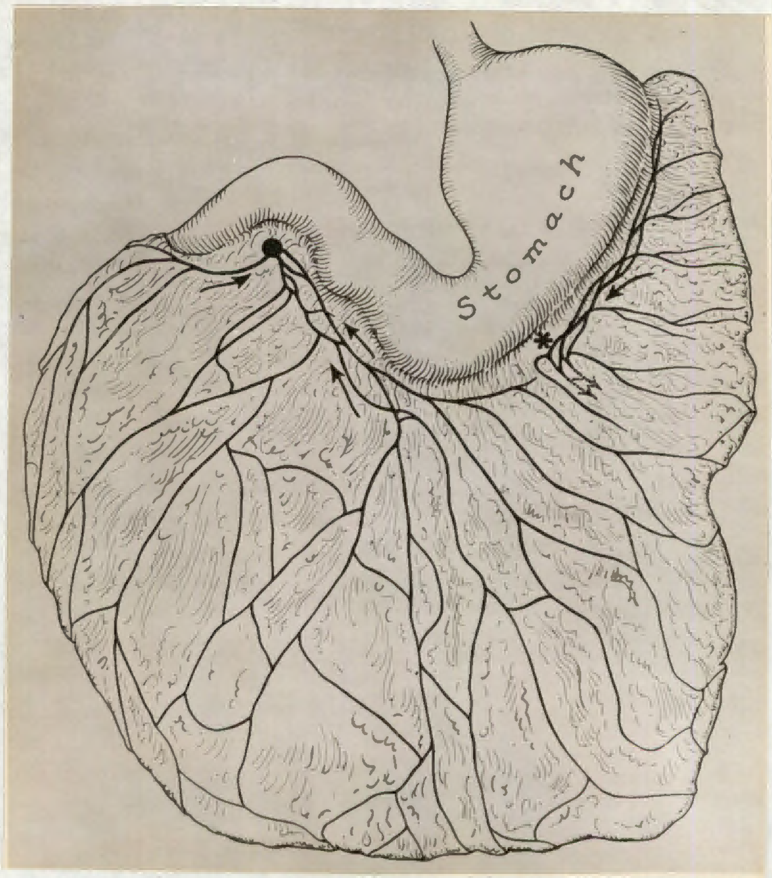



**Fig. 48.**

Lymphatics in the ventral leaf of the omentum in the dog omentum. The black dot is the duodenal node and the asterisk indicates the spot where the lymph vessels of the left half pass dorsally to the splenic nodes.
(Simer).

omentum is excised, and Dunsmore, quoted by Adams (1), stated that the omentum was capable of absorbing 0.5% of the body weight of fluids per hour.

Summary:

1. Lymphatics are present in the omentum of man and many mammals, at all ages.

2. Lymphatic drainage is along the omental arteries to the Duodenal and Splenic nodes, thence to the intestinal lymph trunk via the coeliac glands.

3. Lymphatics are not concerned with transporting particulate matter. Their function is probably to remove peritoneal fluid as it accumulates.

2. Reticulo-Endothelial Cells:

The presence of Reticulo-endothelial cells in the omentum has been described by numerous observers, some of whom have even described the omentum as a reticulo-endothelial organ.

Wojciechowski (102 - 1927) declared that the omentum was a reticulo-endothelial organ and that its function was protective through the milk spot cells. The summary of his article in Biological Abstracts does not include his description of the milk spot cells, but undoubtedly these were histiocytes.

Hamazaki (41 - 1927), working on rats, decided on

/histological

histological evidence that the milk spots were very similar to the spleen in structure and in function, and that they were part of the reticulo-endothelial system. He confirmed this by doing splenectomies in young rats, and then, observing the milk spot cells. He found that these hypertrophied due to an increase in histiocytes, and that the number of milk spots increased. He also noted a tremendous increase in the haemosiderin in the milk spots. He concluded that the compensatory function of the milk spots of destroying effete red cells exceeded that of the liver, and that, histologically as well as functionally, the milk spots came to resemble the spleen.

Cappell (17 - 1929), by intravitam and supravital staining, demonstrated histiocytes in the omentum and also in the mesentery. Repeated injections of dye caused a marked increase in the number of histiocytes.

Fieschi et al (30 - 1929) demonstrated vitally staining cells accompanying capillaries in the omenta of dogs, rats and guinea pigs. They also demonstrated the pericytes, or cells of Rouget, with chromic silver impregnation. They neither supported or questioned the view that the pericytes and reticulo-endothelial cells were one and the same structure.

Lowenthal (53 - 1926) was able to isolate clasmatocytes (histiocytes) from the milk spots of rats, by culturing in serum and transplanting repeatedly on to fresh /cultures.

Redi (74 - 1929) claimed that intramuscular injections of epiploic extract increased the number of histiocytes in the omentum. This he demonstrated by the omentum taking up an increased amount of trypan blue following a subcutaneous injection of epiploic extract.

Detlefsen (26 - 1939) reported on the histology of the developing omentum in meercats, and confirmed the presence of histiocytes, but reported that they decreased and gradually disappeared as the animals matured and the fat strips developed. As there is no reason to expect an atrophy of the reticulo-endothelial system as the animal matures, and as this disappearance occurs simultaneously with the development of the fat strips, it is likely that the histiocytes are merely being obscured by the fat strips, exactly as happens with the lymphatics.

Mixter (60 - 1941) described in detail the histology of the milk spots of the pleura, and concluded that besides the supporting framework of connective tissue they represent primarily accumulations of histiocytes (macrophages) mingled with a few lymphocytes, some mast cells and a few eosinophiles. The macrophages are recognised not only by their microscopic appearance but also by their avid ingestion of carbon particles or trypan blue, introduced into the pleural cavity. He suggests the name Macrophagal Foci in place of Milk Spots (Taches Laiteuses) given by Ranvier in 1874, before their significance was known. He found evidence that the milk spot cells can

/be

be formed by proliferation of the overlying mesothelial lining of the pleura.

<u>Summary:</u>

1. The presence of large numbers of Reticulo-endothelial cells - Histiocytes - in the omentum has been confirmed by vital staining.

2. Stimulation by various means leads to an increase in these histiocytes.

<u>3. Histology of Blood Vessels:</u>

Hamazaki (40) described the blood vessels in milk spots: there are many capillaries and many of them dilate to form sinusoids, as in the spleen. The endothelium of these capillaries allows a free passage for the migration of wandering cells, red blood cells, etc.

Cappell (17) has shown that the capillaries of the omentum share with the capillaries of the bone marrow the property of being permeable to certain substances, in particular saccharated iron oxide.

Rogers (79) investigated the pericapillary cells in the omentum of the cat in order to confirm the statement made by Bensley and Vintrup (1928) that in the frog stimulation of these pericapillary cells caused contraction of the cell, and so constriction of the capillary. He found that stimulation of these cells caused no contraction, either of the cell or of the

/capillary,

capillary, whereas stimulation of the endothelial cell caused a definite though transient and localised constriction of the capillary. He concluded that the pericapillary cells bore no structural or functional resemblance to smooth muscle.

Summary:

1. The capillary endothelium of omental vessels is permeable to histiocytes and to certain crystalloid solutions, the latter function is shared by capillaries in bone marrow.

2. The pericapillary cells do not resemble smooth muscle structurally or functionally.

4. Nerves:

Michels (59) described a plexus of non-medullated nerve fibres in relation to the capillaries. There is a free plexus of non-medullated nerves distributed about the capillaries, in intimate contact with the capillary wall, running parallel to it, crossing over or under, and often becoming lost in the wall. The nerves are extremely narrow plasmodial strands (1$\mu$), which intermittently (100 - 200$\mu$) show oval, Schwannian nuclei, and at intervals exhibit branching. Many capillaries contain no nerves, and terminal, knob-like endings are nowhere present. The pericapillary reticulum by which

/every

every capillary is supposedly innervated is not a nervous structure at all but represents argentophile adventitial reticular fibres.

Simer (86, 87) reports nerves accompanying the arteries.

5. Muscle.

The categorical denial by D.P.D.Wilkie (99) that muscle exists in the omentum, apart from the blood vessels, has been confirmed repeatedly.

The work of Rogers is quoted above. He investigated the pericapillary cells and decided they bore no structural or functional resemblance to muscle.

Anderson (72) misquotes Schonbauer and Schintzen from the J.A.M.A. 1924.83:311. as having said that muscle exists in omental adhesions, whereas they said that smooth muscle existed in adhesions between gut and parietal peritoneum, and was probably due to muscle having been pulled into the adhesion from the gut wall.

Cappel's description of the histology of the omentum (page 129) makes no reference to muscle being present.

6. The Peritoneal Covering of the Omentum:

It is generally accepted that the omentum is covered by peritoneum, but it is not generally realised that there is evidence to show that histologically and functionally

/there

there is a difference between the cells covering the omentum and the rest of the peritoneum, visceral and parietal.

Poynter (73) drew attention to the fact that silver staining showed that the covering of the omentum differed from that of the general peritoneal cavity, and, furthermore, there were distinct differences in the covering cells of the fat strips and of the spaces between.

The most striking evidence of this fact is afforded by Poynter's experiments of injecting india ink intraperitoneally in animals, and after five minutes opening the belly and washing under running water. The ink is easily washed off the gut, mesentery and parietal peritoneum but cannot be washed off the omentum.

## PERSONAL OBSERVATIONS.

### (A) EFFORTS TO DEMONSTRATE MUSCLE IN THE OMENTUM:

#### (1) Histological Examination.

(i) Method: Attempts to stain and examine the material "on the flat" in the form of "spreads" proved unsuccessful and had to be abandoned.

It was clear that unless a longitudinal section of a single sheet of the material was examined, there would be no means, except by cutting serial sections, of

/ascertaining

ascertaining whether any muscle that might be encountered came from a blood vessel or not. A technique was accordingly evolved by Mr. W. Taylor of the Department of Pathology of the University of Capetown.

The material was stretched out and pinned on to a piece of cardboard, so that it was about 1/8" above the surface. It was then fixed in formalin, and dehydrated in alcohol. Finally it was unpinned and carefully, without crumpling, embedded in paraffin wax for section.

Two stains were used - Haematoxylin and Eosin, and Mallory's stain for muscle and connective tissue.

(ii) Material: The omentum and its precursor, the dorsal mesentery of the stomach, were examined in a number of mammals and lower forms of Chordates, including full-grown, half-grown and foetal specimens, as tabulated:-

| Full Grown | Half Grown | Foetuses. |
|---|---|---|
| Cyclostome (Petromyzon) | Kitten (2 days) (Felis domestica) | Rat (20 days (Mus rattus) |
| Mole Snake (Pseudaspis cana) | | |
| Tortoise (Testudo geometrica) | Calf (4 days) (Bos taurus) | Man (24 weeks) |
| Leguan (Veranus albigularis) | | Man (10 weeks) (Homo sapiens) |
| Bat (Rhinolophus capensis) | | |
| Mole Rat (Bathyergus capensis) | | |
| Dassie (Procavia capensis) | | |
| Cat (Felis domestica) | | |
| Man (Homo sapiens). | | |

TABLE II.

(iii) Results: No muscle, apart from that of the blood vessels, was seen in any of the sections. It was thought at first that the section from the mole snake showed muscle apart from the blood vessels, but it was finally concluded that this was not so.

(iv) Conclusions: The absence of muscle in the omentum is generally taken as a point against the omentum being able to move itself. It is suggested that if muscle were present it could only approximate the free border of the omentum to the attached border, i.e., the greater curvature of the stomach, and could in no way have the opposite action - that of causing the free border to move away from the stomach.

Therefore, the absence of muscle in the omentum cannot be advanced as an argument against independent movement.

(2) Direct Electrical Stimulation:

(i) Method: The omentum had to be kept moist and in an atmosphere of carbondioxide to approach natural conditions as nearly as possible.

(a) The omentum was excised from a living, anaesthetised animal and immediately put into a bath of saline. From a Kipp's apparatus a constant stream of carbon-dioxide was kept bubbling through the saline.

/Being

Being heavier than air the carbon dioxide would displace all the air above the water in the bath.

(b) The animal was anaesthetised, placed on its back and its belly cut open in the midline. The belly wall was held up by means of hooks, so that it formed a small bath containing the viscera. This was half-filled with saline and carbon dioxide bubbled through it as in (a).

The omentum was then stimulated electrically by electrodes applied directly to it. It was observed with a dissecting microscope (X16).

(ii) Material: Four guinea pigs were used - two for part (a) and two for part (b).

(iii) Results: No contraction or movement was observed even when the stimulus was so powerful that generalised muscular twitching in the animal was produced. The gut when stimulated directly contracted locally at the site of stimulation.

(B) INTRAPERITONEAL INJECTION OF INDIA INK.

This was done to confirm and illustrate Poynter's experiments (73).

A rat, a guinea pig and a cat were used. 2 cc. india ink was injected intraperitoneally into the rat

/and

and the guinea pig, and 5 cc. into the cat. The animal was alternately flexed and extended for five minutes and then killed, the abdomen opened and washed under running water for 5 minutes.

The results are shown in Plates 14, 15 and 16, which are photographs of the animals, showing clearly that the india ink adhered only to the omentum.

(C) HISTOLOGY OF THE OMENTUM IN ACHOLURIC JAUNDICE.

The histology of the omentum in a patient with congenital acholuric jaundice was compared with that of the omentum of a normal patient. The specimens were taken at the operations for splenectomy and appendicectomy respectively.

Haematoxylin and Eosin, and Prussian Blue (for iron) stains were done.

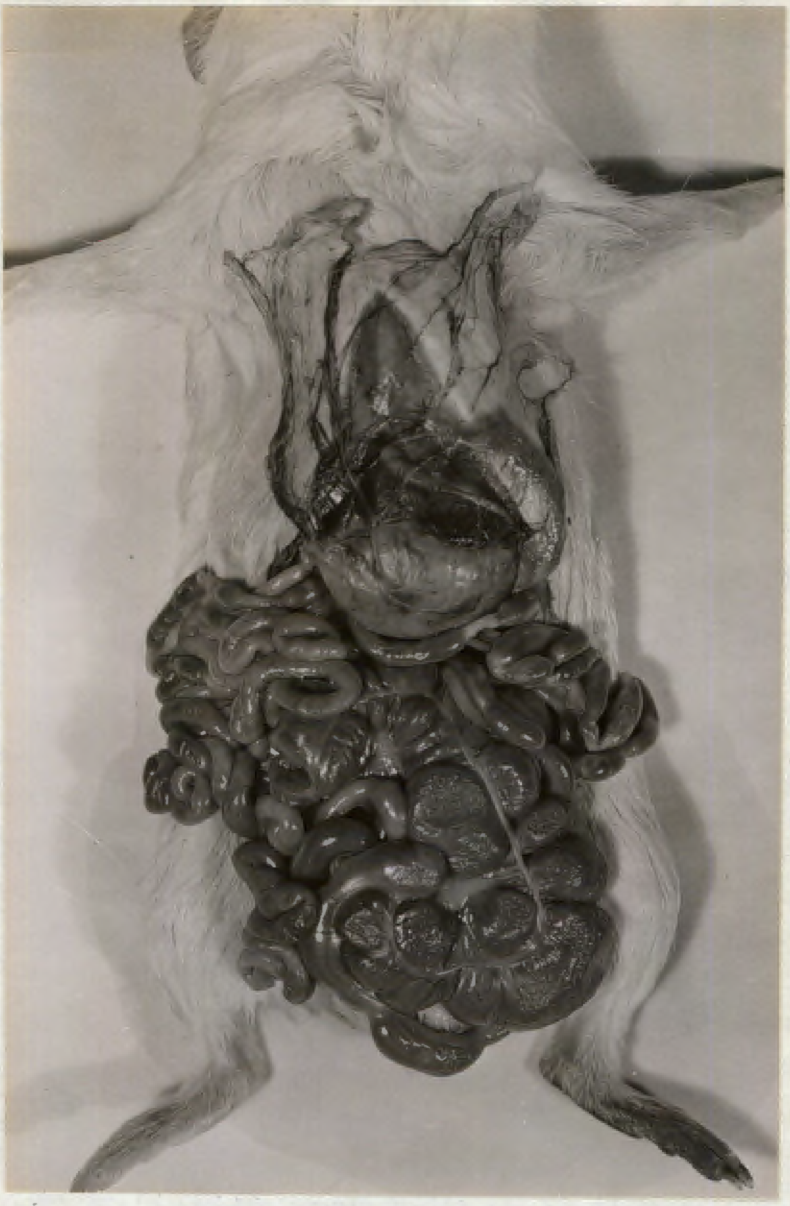
The investigation was prompted by the work of Hamazaki (41) referred to on page 141.

It was argued that, as he had shown that the omentum, through its reticulo-endothelial cells, was able to deputise for the spleen in the function of destroying red cells, it might conceivably assist the spleen when the latter was destroying red cells in excess of normal. If this happened it would be shown by an increase in iron pigment in the omentum, similar to that which Hamazaki found in the rat.

/Results:

Plate 14.

White rat. Showing india ink on omentum and none on the viscera. (Photograph).



<u>Plate 15.</u>

Guinea Pig. Showing india ink on omentum and none on the viscera. (Photograph).

Plate 16.

Cat. Showing india ink on the omentum and none on the viscera. (Photograph).

<u>Results:</u> The omentum from the patient with acholuric jaundice showed no increase in iron pigment.

<u>Conclusions:</u>

There is no evidence that the increased destruction of red cells in acholuric jaundice is carried on by the reticulo-endothelial cells of the omentum.

<u>SUMMARY:</u>

1. The presence of lymphatics in the omentum is accepted; their paths of drainage and their function is discussed.

2. The presence of large numbers of reticulo-endothelial cells in the omentum is accepted. They increase in response to stimulation.

3. This investigation found no evidence that the reticulo-endothelial cells of the omentum shared in the excessive destruction of red cells that occurs in alholuric jaundice.

4. Omental capillaries share with those of the bone marrow the property of differential permeability to certain crystalloids.

5. Non-medullated nerves occur in plexuses along the blood vessels of the omentum.

6. This investigation found no muscle in the omentum or in the dorsal mesentery of vertebrates. The material was taken from embryos, half-grown and

/full

full-grown animals.

7. Electrical stimulation of the omentum of guinea pigs caused no contraction (present investigation).

8. The cells covering the omentum differ in structure and function from those of the rest of the peritoneum.

# PHARMACOLOGY.

## PHARMACOLOGY.

REPORTS BY OTHER OBSERVERS:

The only report in the literature on the action of drugs on the omentum is by Neissing and his co-workers (66). The original article is, unfortunately, not available. They report that the fibrocytes in the omentum are capable of contraction and relaxation in response to pharmacological stimulation. They took avascular pieces of guinea pig omentum and laid them over the small open end of a short conical glass tube, then completely immersed in Ringer's Solution and examined under a Zeiss dissecting microscope (216X), and noted the reponse to solutions of drugs.

They report that adrenaline and ergotamine, among others, caused a contraction of the fibrocytes, which, in extreme cases, completely closed the holes of the network and produced a cross striation in the protoplasm of the fibrocytes.

Atropine and acetylcholine, on the other hand, produced as an end effect a relaxation of the omentum with an enlargement of some of its meshes. The reactions, they claim, are reversible and do not damage the omentum; they are produced by "changes in the protoplasm of the mesothelial cells and not of the fibres."

/Personal

Personal Investigations:

An attempt was made to repeat the work of Neissing.

Material:

(a) Freshly-excised omentum from anaesthetised white rats,

(b) Freshly-excised omentum from anaesthetised guinea pigs,

(c) Omentum in vivo in anaesthetised guinea pigs.

Method:

The method described by Neissing is not clear from the abstract of his article in the journal "Biological Abstracts", and could not, therefore, be repeated.

It was felt, however, that his requirements, viz., freshly-excised omentum examined in Ringer's Solution, could easily be conformed with.

(a) A layer of plasticine ¼" thick was put in the bottom of a petri dish, a window 1" x ½" cut in the plasticine, and the dish filled with Ringer's Solution to the level of the plasticine. The excised piece of omentum was then laid across the window and kept taut by means of pins stuck into the plasticine. It was then examined under the low and high power of the microscope.

(b) The guinea pig was anaesthetised, its belly opened in the midline and the omentum delivered. The animal was held up to the stage of the miscoscope and the omentum placed on a slide

/moistened

moistened with saline and examined under high and low power.

Results:

A 1/1000 solution of Adrenaline was dropped on to the preparation while observing it under, first, the low and then the high-power lens. No contraction of the fibrocytes or alteration in size or shape of the net spaces was observed. The total amount of Adrenaline used each time was 1 cc.

The experiment was repeated using Atropine with the same results.

CONCLUSIONS:

As far as can be ascertained, the observations of Neissing and his co-workers, that fibrocytes are capable of contraction and relaxation, has not been commented upon in the literature. This property they claim for fibrocytes is extraordinary and lacks confirmation.

The present investigation was unable to supply this confirmation.

FUNCTION.

INTRODUCTION.

INVESTIGATIONS BY OTHER OBSERVERS.



PERSONAL INVESTIGATIONS.

# FUNCTION.

## Introduction:

A brief historical survey of the theories of the function of the omentum indicates that it has interested medical men from the earliest times.

Hippocrates (460 - 355 A.D.) made the observation that if the omentum protrude it necessarily mortifies and drops off. He thought it regulated the amount of peritoneal fluid. As will be shown later, this probably is one of the functions of the omentum.

Aristotle (384 - 322 A.D.) believed the omentum kept the intestines warm; in this he was supported by Galen, who recorded that a gladiator who had lost his omentum through a wound always felt cold in his belly afterwards.

Malpighii (1628-1694) thought it was a storehouse for fat and that it was the cause of ascites. It is recognised to-day that the omentum is one of the fat depots in the body and has to do with peritoneal absorption.

Fabricus: ascribed ~~it~~ to it the origin of those winds that so torture hypochondriacs.

Vesalius believed it was a ligament to support the transverse colon.

Verhagen believed that it protected the viscera from sudden jars and friction.

/Hansen

Hansen postulated that it pulled the stomach down when full so that it should not embarrass respiration.

Owen (1866) thought it was a provision to enable the digestive cavity to encroach between its two layers during expansion.

It was not until abdominal surgery became routine that surgeons were afforded the opportunity of studying the normal omentum and its reaction to disease processes in the abdomen.

Rutherford Morison was particularly interested in the function of the omentum and drew attention to how frequently it was found in the neighbourhood of intra-abdominal disease. "There can be little doubt", he wrote, "that it travels about the abdomen with considerable rapadity and is attracted by some sort of information to the neighbourhood where mischief is brewing. There is something more than a mechanical causation in the movement of the omentum, which can be likened to that of a jelly fish" (63).

He named it the "Abdominal Policeman" and drew attention to the way it cured a hernia by plugging its orifice; to the way it protected strangulated gut from rupture when the gut was returned to the belly at operation; to the ability it had of forming new blood vessels and revascularising an organ whose nutrition

/was

was impaired - a huge ovarian fibroid that was receiving almost all its blood supply from half a dozen omental arteries, each the size of the brachial; and, finally, the way it covered up and localised foci of suppuration, e.g., acute appendicitis, perforated ulcer, perforated carcinoma of a hollow viscus (62) (Fig. 49-56).

Numerous attempts have been made to prove experimentally in animals that the omentum does move towards a "neighbourhood where mischief is brewing." These experiments have not been successful and the reasons will be discussed below.

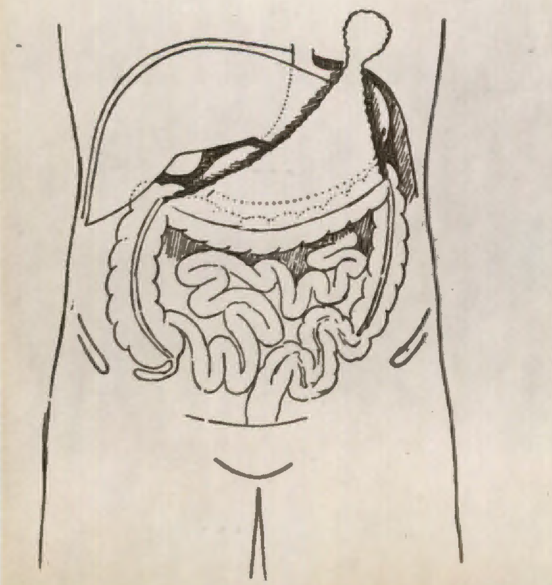
In addition to these experiments concerned with movement of the omentum, others have been performed to investigate other functions of the omentum.

INVESTIGATIONS BY OTHER OBSERVERS:

1. Movement.

(i) Irritation of the parietal peritoneum has been unsuccessful in causing the omentum to move. Thus, Rubin (83) killed an animal with anaesthetic and then removed the anterior abdominal wall down to the parietal peritoneum, which he irritated. He observed no movement of the omentum. Rothenberg and Rosenblat (82) inserted radio-opaque substances (Michel clips, leaded glass silk, silver brain clips) into the omenta of dogs and, after an interval of two weeks, introduced a sterile needle into the abdomen in the right iliac fossa.

/Ne



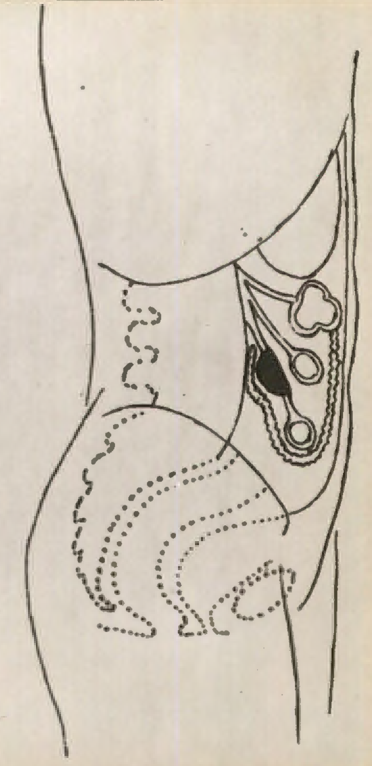


**Fig. 49.**

Omentum occluding a hole in the diaphragm caused by injury.

**Fig. 50.**

Omentum guarding a suppurating gland in the mesentery of the small intestine.

(Morison and Saint).

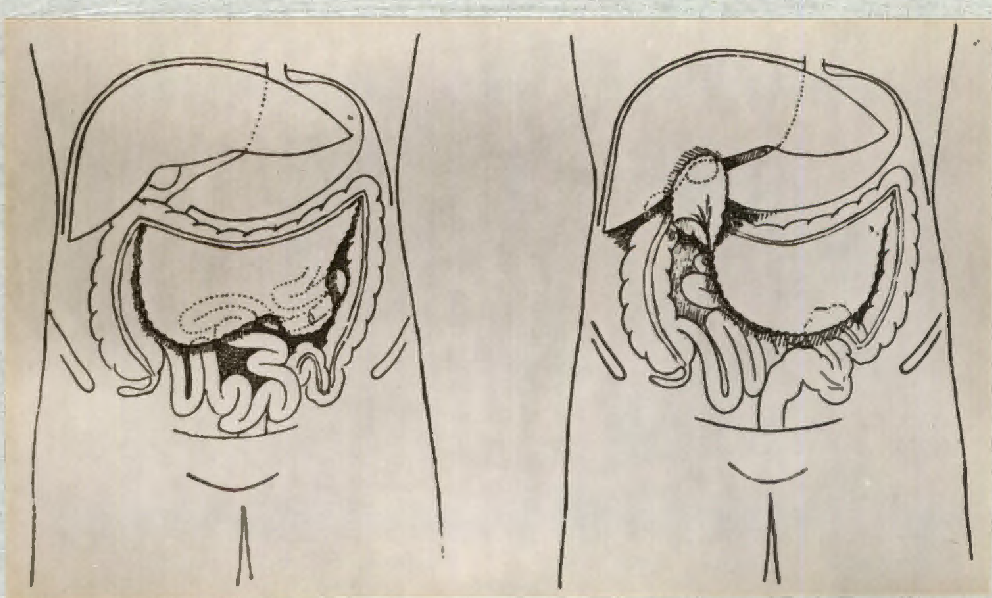


**Fig. 51.**

Omentum surrounding an injured piece of small intestine.

**Fig. 52.**

Omentum isolating a suppurating or gangrenous gall-bladder.

(Morison and Saint).

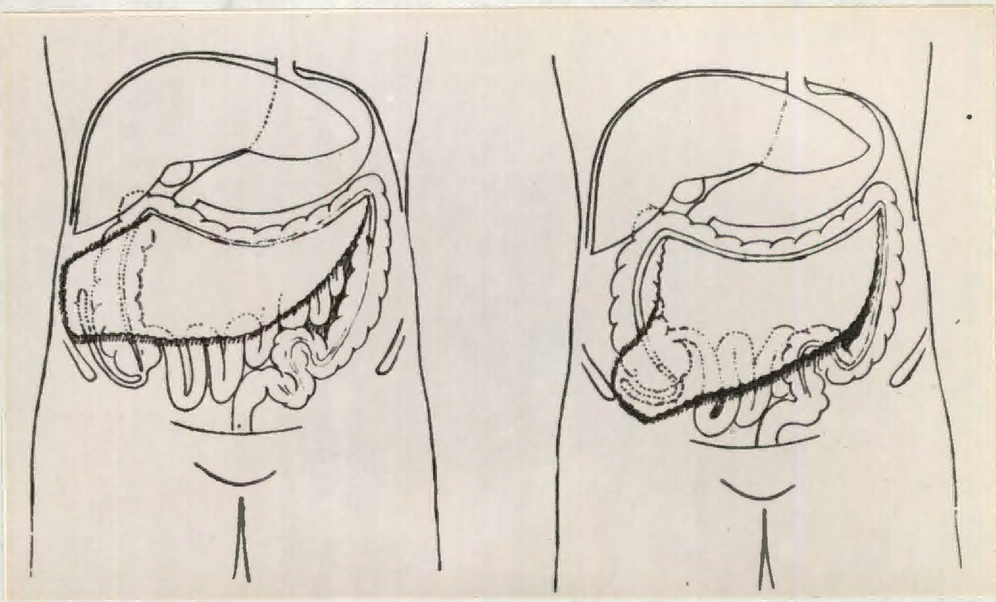


**Fig. 53.**

Omentum isolating the appendix in the flank.

**Fig. 54.**

Omentum isolating the appendix in the iliac fossa.

(Morison and Saint).

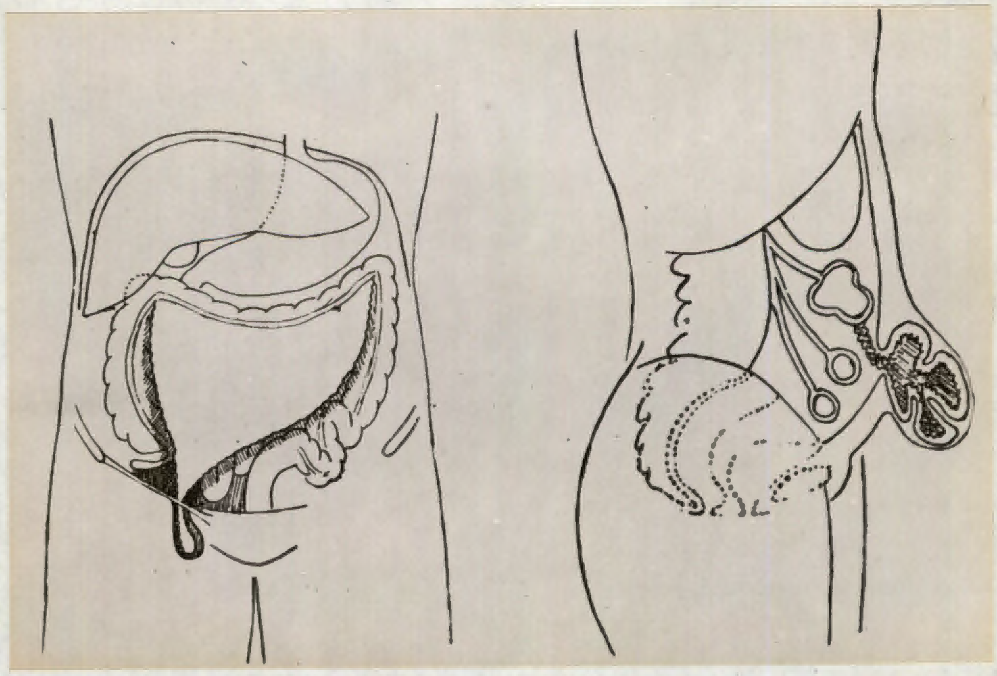


Fig. 55.

Omentum occluding a femoral hernial sac.

Fig. 56.

Omentum occluding the sac of an umbilical hernia.

(Morison and Saint).

No movement was seen.

(ii). <u>Sterile Particles</u> introduced into the peritoneal cavity resulted in conflicting reports: Adams (1) introduced sterile cotton wool sponges and found they were always adherent to the omentum in guinea pigs, and "nearly always" in rabbits. If placed between the liver and diaphragm, or in the pelvis, they did not adhere to the omentum. Florey (34) sewed sterile pieces of pith on to the parietal peritoneum of cats, and found that unless they were placed in contact with the omentum the latter did not become adherent to them. Using decerebrate cats he placed a suspension of indigo carmine on the posterior abdominal wall and kept the animal flat on its back for two days. The omentum did not take up the suspension, whereas it did in control animals, who were allowed to run about. D.P.D.Wilkie (99) introduced sterile powdered charcoal intraperitoneally into two cats; in one the omentum was first excised. The latter cat died in two days (cause not stated) and the gut was coated with charcoal. The former was killed: the omentum had taken up all the carbon and the gut remained white and glistening.

(iii). <u>Localised Peritonitis.</u> - D.P.D.Wilkie (99) produced a staphylococcal appendicitis in one rabbit and reported that the omentum ignored it. Florey (34) tied a ligature round a small part of the upper rectum in

/one

one decerebrate cat. The cat died in 15 hours (cause not stated) and the omentum had not moved down to the rectum. In another experiment, again using decerebrate cats kept flat on their backs, he produced small abscesses in the wall of the gut and on the surface of the liver. They were ignored by the omentum.

(iv) General Peritonitis - Rothenberg and Rosenblat (82) injected ½ cc. (3,000,000 organisms) of virulent B. Coli suspension intraperitoneally in dogs. The omentum was observed radiographically in the method described above. It did not move. (No details given of the peritonitis and if it had, in fact, been produced. Postmortem after two weeks showed no trace of inflammation).

(v) Respiration, Peristalsis and Body Movements.

Rothenberg and Rosenblat (82) observed the omentum by the method described above, and decided that respiratory movements and peristalsis of the gut were the only factors in moving the omentum. Florey (34) observed the omentum through "windows" made in the abdominal wall and concluded that bending and stretching movements of the body produced most movement of the omentum; next in importance was peristalsis and, lastly, diaphragmatic movements.

(vi) Hyperaemia of Omental Arteries - Schutz (85) /perfused

perfused under pressure omental arteries of animals (dogs) and two human omenta excised at postmortem. By causing the vessels to straighten out he was able to produce movement of the whole omentum, "mass movement". As a control he tied the omental branches of the right gastro-epiploic artery, and produced peritonitis by a swab soaked in turpentine placed in the peritoneal cavity. The omentum did not move. (No mention is made of the omentum moving in response to turpentine peritonitis, when the omental arteries were not tied).

2. PROTECTION AGAINST INFECTION.

Linton (52) produced hyperplasia of the omentum in rabbits by peritoneal injections of alineurot and starch. He then transplanted these omenta to normal rabbits, and found it protected 60% against 15-100X the minimum lethal dose of streptococci injected intraperitoneally. Control animals who had normal omenta transplanted received no such protection.

Redi (75) found that intramuscular injections of omental extracts had a beneficial effect on peritonitis in animals. (An extract of the original article only is available and no figures or details are given).

D.P.D.Wilkie (99) excised the omenta in seven rabbits, and three weeks later injected sublethal doses

/of

of Staphylococcus Aureus. Five died. In seven controls only two died. He observed that the cell response in the peritoneal fluid was better than in the control animals, but there were more organisms. The omenta in the control animals were heavily coated with bacteria.

3. PROTECTION AGAINST TOXINS.

Ueda and Mabuchi (95) injected typhoid bacillus toxin into rabbits who had had their omenta excised: 12 out of 17 died compared with 3 out of 18 control animals.

4. FLUID ABSORPTION.

Dunsmore, quoted by Adams (1) reported that the omentum could absorb 0.5% of the body weight of fluids per hour.

Rubin (83) injected a solution of indigo carmine intraperitoneally in cats and recovered it from the urine in 12 - 15 minutes. When the omentum was excised the dye only appeared in the urine after 40 - 60 minutes.

D.P.D.Wilkie (99) reported the ratio of absorption of fluid from the peritoneal cavity in cats with and without the omentum was 3:2 respectively.

5. REGENERATION.

Arnaud, quoted by Higgins and Bain (43), claimed that the omentum regenerated in 5 - 6 weeks if excised.

Webb and Simer (98) excised the omentum in a dog and found no regeneration after 2¼ years (Figs.57 A & B).

/6.

6. REVASCULARISING ISCHAEMIC ORGANS.

D.P.D.Wilkie (99) repeated and confirmed the work of de Renzi. He tied the splenic vessels in 5 cats and 3-10 weeks later found the spleen was small and shrunken and covered by omentum; its centre was necrotic but there was a thin outer shell of normal spleen. One cat died and the omentum was found adherent to the scar, away from the spleen.

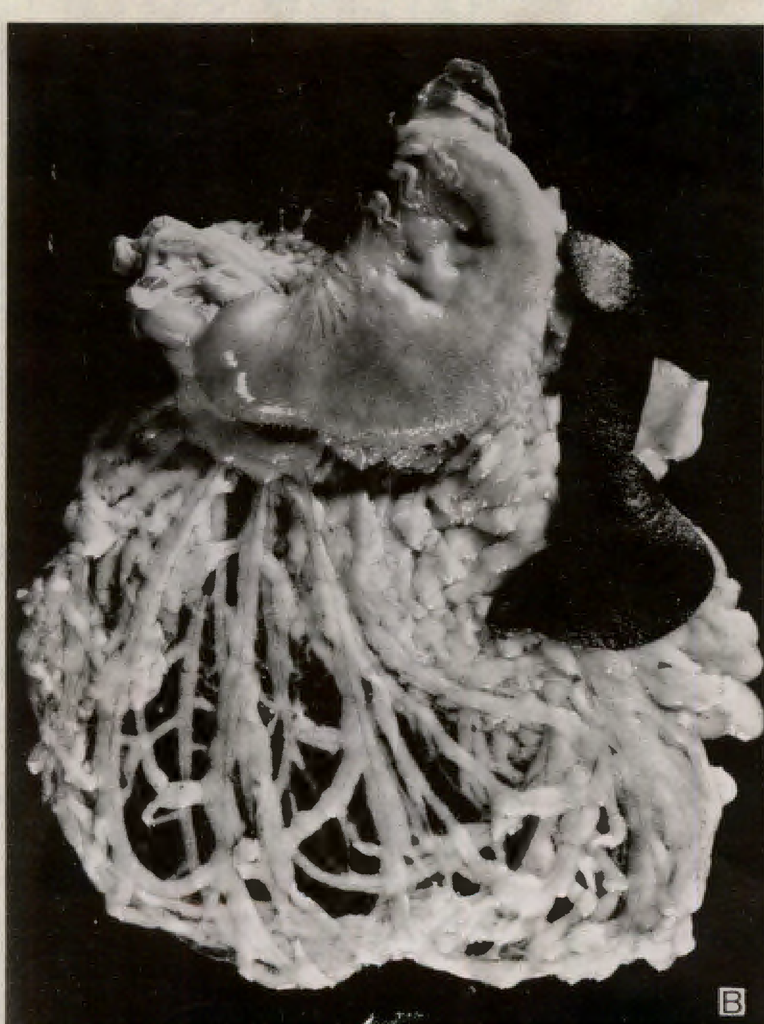
In 8 controls 5 died 2-16 days later and 3 lived in ill health for one month till they were killed. The spleen in all these animals was a bag of necrotic pus.

Paunts (71) transplanted the omentum into the pulp of a decapsulated kidney. Six weeks later he was able to tie either the renal artery or vein and excise the opposite kidney with no ill effects.

7. EXCISION OF THE OMENTUM.

Ueda and Mabuchi (95) report on widespread histological and serological changes following excision of the omentum in rabbits.

The liver showed cloudy swelling, fatty infiltration, loss of glycogen and enlargement of the Kupfer cells; the kidneys interstitial haemorrhages and proliferation of histiocytes; the spleen enlargement of the endothelial cells of the sinus walls and the pulp; the lymph glands an increase in histiocytes; the stomach ulcers in 6 out of 14 animals; the blood leucopaemia and /and



<u>Fig. 57.B.</u>

Photograph of the normal
omentum of a dog. (Simer).


**Fig. 57.A.**

A photograph of the stomach and spleen of a dog 2¼ years after the omentum had been excised. (Simer).

and anaemia and an increase in fasting blood sugar.

No record is made of control animals for the above investigations.

Blood protein and cholesterol was increased but not in control animals.

Draper and Johnson (29) report that they have excised the omentum in 200 patients, chiefly children, with no fatalities and no ill effects, on the grounds that toxins were absorbed from the gut via the omentum. It is felt that the operation is quite unjustifiable.

PERSONAL OBSERVATIONS.

Some experiments by other observers were repeated and three experiments performed in an attempt to show that the omentum moved in response to stimuli.

EXPERIMENT NO.1.

This was undertaken in an attempt to repeat the observation of Arnaud that the omentum was capable of regeneration.

Six rats and six half-grown guinea pigs were used.

Method: The animal was anaesthetised with ether. The hair was clipped short and the skin painted with tincture of iodine. The abdomen was opened in the midline and the omentum delivered, caught at intervals next to the greater curvature of the stomach with artery

/forceps

forceps and cut away with the diathermy. In the guinea pig the tail of the pancreas, coming into the omentum, was not excised. There was no bleeding. The abdomen was closed in two layers with continuous cotton sutures, the peritoneum and muscles being taken together.

There were no deaths.

The animals remained healthy and gained weight.

Results: After 6 weeks the animals were killed and the stomach excised with the pancreas and spleen. There was no sign of regeneration of the omentum as can be seen from Plates 17 and 18.

EXPERIMENT No.2.

This experiment was designed to repeat the experiments of Schutz (85).

Two dogs were used.

Method: The dogs were killed by gassing. The abdomen and left half of the thorax was opened, the coeliac axis canulised, and cleared of blood by saline infusion. The omentum was floated in a flat dish of saline held against the greater curvature of the stomach. In one dog normal saline was used for perfusion, and in the other human serum. Perfusion was done under pressure with a Higginson's syringe.

/Results:

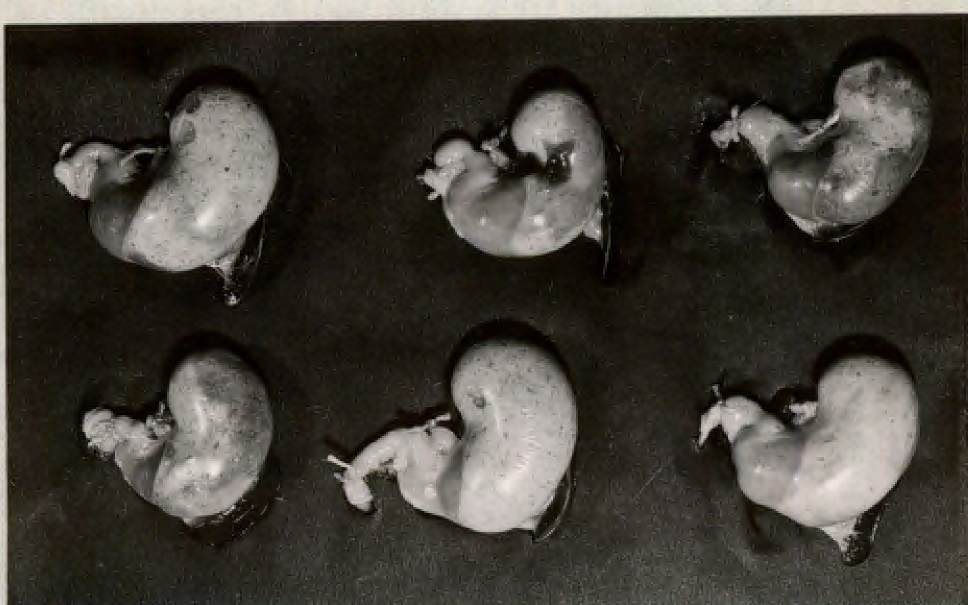


Plate 17.

Photograph of the stomachs of 6 rats 6 weeks after excision of the omentum.

Plate.18.

Photographs of the stomachs of 6 guinea pigs 6 weeks after excision of the omentum. The omentum in the angle between the tail of the pancreas and the greater curvature of the stomach was not excised.

Results: Perfusion under pressure resulted in only about 1" of movement.

When the superior mesenteric vein, the portal vein and the hepatic artery were ligatured and the pressure in the omental vessels correspondingly increased, it was possible to make the omentum move away from the greater curvature of the stomach for about 3 inches. It could, however, be pulled down another 3 inches.

EXPERIMENT No.3.

This experiment was designed to repeat the observation made by D.P.D.Wilkie (99) that excision of the omentum lowers the resistance of the animal to infection.

Cats were chosen because they have a very large and vascular omentum and a high resistance to peritonitis. It was hoped that excision of the omentum would appreciably lower this resistance. 10 cats were used.

Method:

(a) It was decided to use a culture of Staphylococcus Pyogenes Aureus. This was kindly prepared by Dr. P. Don of the Department of Bacteriology.

To determine the dosage Cat No.1 was injected intraperitoneally with 1 cc. of the culture. It died in 12 hours of septicaemia, the organism being recovered from the peritoneal and pleural fluid and the heart blood.

/Cat

Cat No.2. was then injected with ½ cc. of the culture and developed a peritonitis from which it recovered.

(b) The omentum was excised in six cats (Nos. 3-8), using the following technique: The cats were anaesthetised with Nembutal by mouth - one grain per kilo of body weight. The hair on the abdomen was cut short, the skin painted with tincture of iodine and the abdomen opened in the mid-line. The omentum was delivered and excised between cotton ligatures. The abdomen was closed in two layers with continuous cotton sutures, the peritoneum and muscles being taken together.

Cat No.3 recovered but escaped after 14 days,

Cat No.4 died on the 7th day of secondary haemorrhage,

" " 5 died of the anaesthetic

" " 6 " " " "

" " 7 recovered

" " 8 "

(c). Cats Nos. 7 and 8 and two controls (Nos. 9 and 10) were used for the experiment four weeks later.

Each was given 1½ grains of Nembutal by mouth so that they could be handled easier. When this had taken effect each was injected with ½ cc. of the culture intraperitoneally. The subsequent course is shown in Table III. below.

/Time

| Time after Injection. | Number of pus cells per cu.mm. of peritoneal fluid. | | | |
|---|---|---|---|---|
| | No.7. | No.8. | No.9. | No.10. |
| 8 hours | 108,000 | 56,000 | No fluid | No fluid |
| 24 hours | 88,000 | 24,000 | No fluid | 52,000 |
| 48 hours | Recovered | 30,000 | Recovered | Recovered |
| 72 hours | | died. | | |

TABLE III.

SUMMARY:

Two cats were injected intraperitoneally with Staphylococcus Aureus culture four weeks after their omenta had been excised. Both developed peritonitis and one died. Of the two controls, one developed peritonitis but it recovered.

EXPERIMENT NO.4.

4 cc. of a sterile 20% Barium Sulphate emulsion was injected intraperitoneally into two cats. It was thought the Barium would not irritate the peritoneum and would be taken up by the omentum, rendering it radio-opaque and suitable for further study.

An X-ray (Plate 19) was taken after four days and a laparotomy performed. The former showed up the Barium in the omentum very plainly and the latter confirmed

/that

that the omentum had taken up nine-tenths of the barium, but revealed that the omentum was grossly abnormal. It was thickened and matted together and adherent to the abdominal wall in two places.

After four weeks another laparotomy was done. The omentum was still thickened and adherent. Histology of the omentum showed amorphous aggregations of Barium encapsulated by histiocytes and large numbers of histiocytes crammed full with Barium.

As there seemed no prospect of the omentum ever functioning normally after this, the experiment was abandoned.

EXPERIMENT No.5.

It was decided that to demonstrate movement, the omentum should not be so large that it covered the whole peritoneal cavity. For this reason rabbits were chosen in preference to cats.

The omentum was visualised by inserting three small pieces of Tantallum wire, one into the middle of each free border and then taking an X-ray photograph.

Tantallum wire was chosen because it produces no irritation in the tissues and is obtainable in very thin gauge (0.005 inch). The weight was 5.8 mg. per inch.

Ten rabbits were used.

Plate 19.

X-ray of a cat showing the Barium practically all taken up by the Omentum.

Method:

(a) The anaesthetic was 7-10 cc. of a 25% of Urethane injected into the marginal vein of the ear.

The technique was the same as in Experiment No.3. up to the delivery of the omentum. Half-inch lengths of tantallum wire were now inserted into the omentum, one in the middle of each free border. By tying one and two knots in two out of the three pieces before insertion it was possible to recognise each on the X-ray (Plate 20).

(b) The rabbits were numbered from one to ten, and odd numbers had the omental vessels ligated as well. These were to serve as controls, but at the subsequent postmortem the omentum was found to be so pathological - in one there was actually fat necrosis - that no conclusions about movement can be drawn from them.

Rabbits Nos. 2 and 3 died two days after the operation, from peritonitis and cellulitis of the wound respectively.

The remaining rabbits were arranged in four pairs (a-d), each comprising an odd and even number.

(b) The animal was anaesthetised and an X-ray taken. It was then alternately flexed and extended for two minutes and a second picture taken.

Local peritonitis was produced by placing an irritant on a swab in contact with the parietal

/peritoneum

peritoneum just below the umbilicus for 24 hours.

In two pairs an incision was made down to the peritoneum, the swab put in place and the wound closed over it. In the other two pairs the peritoneum was incised and the swab stitched into the peritoneum.

In Pair "a2 the irritant was turpentine, in "b" and "c" tincture of iodine, and in "d" barium sulphate suspension.

After 24 hours a third X-ray was taken.

A general peritonitis was then produced by injecting 2 cc. of the respective irritant intraperitoneally (4 cc. of barium) and the last X-ray taken after 6 hours.

The animals were then killed and an autopsy performed.

<u>Details of Radiography:</u>

| | |
|---|---|
| Exposure: | Small focus, |
| Distance: | 35" |
| K.V.: | 65 |
| Ma: | 200 |
| Time: | $^{1}/_{20}$ sec. |

<u>Results:</u> In all the experiments the omentum remained tucked up against the stomach.

In all those in which the omental arteries had been tied it was adherent to the scar and to the gut in several places, and was grossly pathological.

In the four in which the omental vessels were not tied the omentum was adherent to the scar in one, but it

/could

could reach the area of local peritonitis.

The area of local peritonitis was adherent to the colon in all cases.

90% of the wires were still in situ and had caused no reaction to their presence.

The X-rays showed the wires distinctly but there was no movement of the omentum.

Plate 20 shows how easily the wires are seen.

SUMMARY OF PERSONAL OBSERVATIONS.

1. There was no regeneration of the omentum six weeks after excision in guinea pigs and rats.

2. By perfusing the omental arteries under pressure the omentum was made to move.

3. Excision of the omentum rendered cats more susceptible to peritonitis. It would be advisable to repeat the experiment using a larger number of cats.

4. A suspension of barium sulphate introduced intraperitoneally in cats was taken up by the omentum, but it produced so much reaction in the omentum as to render it unfit for further studies on movement.

5. Alternate flexing and extending of the body, local peritoneal irritation and generalised peritonitis failed to cause significant movement in the omentum, as shown on X-ray, and confirmed at autopsy.

Plate 20.

An X-ray of a Rabbit, No.4., showing the tantallum wires in the omentum. Note the distinguishing knots in the wires.

GENERAL CONCLUSIONS:

It may be fairly stated that experimental work on the omentum has not been of a high standard. A few serious criticisms are:

(a) The conditions of the experiment become too artificial;

(b) The groups of animals are far too small for statistical conclusions to be drawn, e.g., D.P.D. Wilkie, Schutz, and Webb and Simer report experiments on one or two animals (the present investigation has the same shortcoming);

(c) Controls are often not mentioned;

(d) Only a very small proportion of the work reported has been repeated by independent observers.

1. Movement. While no experiment has so far been designed to prove conclusively that the omentum is capable of moving in response to stimulation, it is felt that the experiments have not been entirely satisfactory. Thus, Rubin (83) used animals killed by anaesthetic; Florey (34) used decerebrate cats; the radio-opaque substances introduced with the omentum by different observers were possibly too heavy, e.g., lead shot, glass beads, silver brain clips.

The work of Schutz opens up an interesting and hopeful

/field

field of research. The experiments done hitherto introduce too many artificial factors, and it remains to be seen if hyperaemia of the omental vessels under normal conditions will result in movement of the omentum. It is felt that experiments designed to abolish vasomotor tone of these vessels selectively will have the greatest likelihood of success.

The structural difference of the omentum in different animals may be of importance. The rabbit, for example, has a primitive omentum as judged by its vascular pattern, and it is possible that the function of movement has not yet been fully developed.

There is wide scope for research on comparative physiology of the omentum.

2. Protection against Peritoneal Infection. This is born out by experimental work, which confirms clinical observations.

3. Effects of Excision. It seems unlikely that the changes in other organs reported by Ueda and Mabuchi (9 5) were due solely to the effects of excision and confirmation by an independent observer is awaited.

4. Regeneration. The fact that the omentum does not regenerate after excision cannot be taken as proof that it serves no useful function, when an organ as important as the stomach does not regenerate.

5. <u>Fluid Absorption.</u> The omentum is able to absorb large amounts of fluid from the peritoneal cavity. The significance of this is not understood.

6. The omentum is able to supply blood vessels to ischaemic viscera. This is the underlying principle of the omentopexy operations for cirrhosis of the liver and angina pectoris.

# GENERAL SUMMARY AND CONCLUSIONS.

# GENERAL SUMMARY AND CONCLUSIONS

## Morphology

The Anatomy and Comparative Anatomy of the omentum has been investigated with special reference to the blood supply. The method of investigation has been described.

A theory has been advanced to explain the development of the omental blood vessels; The embryology of a particular developmental anomaly of the coeliac axis has been discussed.

The suggestion has been made that the omentum develops as a separate organ with its own blood supply, the evolution of which has been discussed.

In man, a separate blood supply to the posterior layers of the omentum by the left and right posterior omental arteries has been described, it is believed for the first time, and confirmed by finding it in other mammals.

The histology of the omentum with reference to the lymphatics, the reticulo-endothelial system, the capillaries, the nerves and the presence of muscle has been discussed.

## Function.

There is little doubt that the omentum is of tremendous value in intraperitoneal infections. In generalised

/peritonitis

peritonitis it acts like a large spiders net, to use D.P.D. Wilkie's apt simile, the organisms sticking to its surface in the same way that any particulate matter would, and then being engulfed by the wandering histiocytes and either destroyed or encapsulated. In localised peritonitis it helps to keep the infection localised, and by virtue of its vascularity is a valuable ally to the peritoneum involved. That this happens is not questioned, but the manner in which it reaches the site of trouble is controversial. In interpreting results of animal experiments, there is a tendency to ignore the critisims that have been made against the artificial conditions of the experiments, and to interpret the negative results as meaning that the omentum has no power of independant movement. It is felt that before this can be accepted, more convincing experiments should be performed, under conditions that as far as possible approach the natural, and the number of animals should be such that the experiments have a definite statistical value.

Page 193 follows.

## ASPECTS SUGGESTED FOR FURTHER STUDY.

An examination of the mammalian orders not available at the time of this investigation, would complete the picture of the comparative anatomy and possibly throw further light on the development of the omentum.

A study of the comparative physiology of the omentum might furnish further interesting information on its development.

Cappell (17) has observed that the capillaries of the omentum are permeable to saccharated iron oxide. By injecting this intravenously it might be possible to render the omentum radio-opaque and so study its movements radiographically.

It is felt that the method of inserting tantallum wire and observing the omentum radiographically, warrants a more extensive trial with different methods of stimulation and in different animals.

The effects of abolishing vasomotor tone in the omental arteries is suggested for study in relation to movement.

## ACKNOWLEDGMENTS

I am grateful to Professors C.F.M. Saint, R.H. Goetz, B.J. Ryrie, M.v.d. Ende, M.R. Drennan and Dr N Sapieka for suggestions and encouragement and facilities in their respective departments.

I wish to thank Dr R. Turner for the facilities granted at the Government Pathology Laboratory, and the staff, in particular Mr Hollow and Mr Ray, for their help.

I am indebted to Dr J. Grieve for facilities in the X-Ray Department at the Groote Schuur Hospital, and to the radiographers, in particular Miss Mackie, for their assistance.

I wish to thank Miss E. Scholtz for the illustrations, Mr W. Taylor for the histology and Mr G. McManus for the photographic work.

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