

THE PANCREATIC DUCTS IN THE DOG.

BY

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WITH 14 TEXT FIGURES.

Of recent years it has been established that in nearly all mammals the pancreas is double in origin, one anlage arising from the duodenum, dorsal and isolated, the other ventral and connected with the bile-duct. Correspondingly there are two ducts which nearly always intercommunicate within that part of the gland which is formed by the union of the two anlages. That part of either duct which lies between this communication and the bowel wall may remain small, or disappear either wholly or more usually only in part. As a rule the part that disappears is that adjoining the bowel and only one pancreatic orifice is then present in the adult type. All these modifications of the embryonic condition may occur even within one species of animal, but one of them is most frequent, and is known as the "normal" for that species. To determine this normal and also the occurrence and frequency of other types, it is necessary to examine many individuals, more or fewer according to the inconstancy or constancy of the normal. The curves (Fig. 3) of relative frequency of the various types observed in the instances examined by the author show how fallacious may be inferences drawn from meagre early statistics.

The beginnings of the duct-radicles in the acini have been carefully studied by many observers since Langerhans's publication in 1869, the findings of the various workers being reviewed by Oppel, 1900. Magiarski has reconstructed the lobule of the pancreas. Much attention has also been given to the development of the pancreas, by which the variations of the ducts are explained. The following communication deals with the two ducts, their relation and distribution in the dog.

METHODS.—The topography was studied in dissections¹ and trans-

¹ 75cc. of formalin injected in to the A. carotis communis when the dog is killed will so harden the tissues in two hours that the form and relations of the viscera can be readily ascertained by ordinary dissection, one examination made in this way giving clearer, more exact and correct knowledge than many made without hardening. The

verse sections of dogs. The ducts were studied by dissection of fresh, of hardened and of macerated material; in sections; and chiefly by celloidin corrosion preparations. Casts of the duodenal parts (within the wall of the duodenum) of the bile and pancreatic ducts are made by ligating off the part of the bowel which receives the ducts, filling it and the bile-ducts with celloidin solution injected *via* the latter,

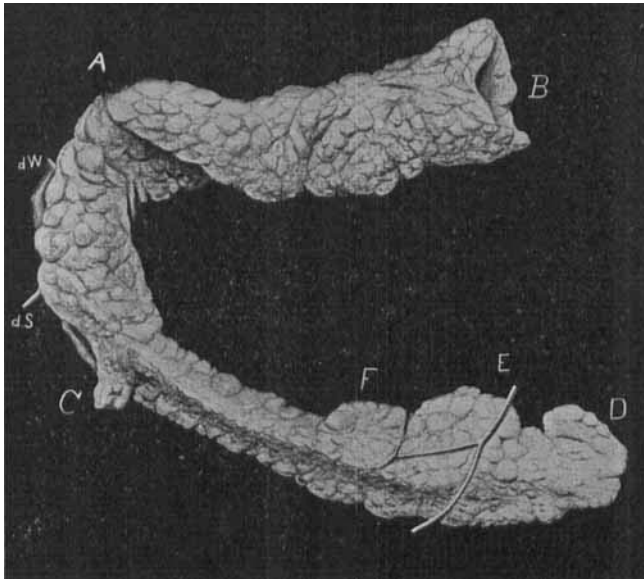


FIG. 1.—Pancreas of the dog with the parts brought into one plane. A B, omental or splenic portion, which lies nearly in a frontal plane and of which the expanded concave free end was applied to the left kidney; A C, epiduodenal or basal portion; C D, duodorsal portion. ACD, duodorsal division of Owen's description; this part lies nearly in a sagittal plane. E, branch from the arteria mesenterica superior crossing the left-hand surface of the pancreas on its way to the duodenum. F, lobe which is shown enlarged in Fig. 2.

then injecting the pancreatic ducts *via* the main duct within either the caput or the cauda pancreatis. These casts represent approximately

formalin may be diluted one-half with water and the last half of the solution may have starch or plaster of Paris and carmin added to it, giving a beautiful arterial injection. The abdominal viscera of the dog are so mobile that the animal should be placed in the ventral position before the injection, if the natural topography is to be studied. For the purposes of experimental operations done with the animal in the dorsal position, the topography of the organs in this position should be studied in material hardened with the animal on its back.

the lumina of the ducts within the bowel wall when the latter is stretched by distension. Casts of the lumina when the bowel is not distended are made by opening the first part of the duodenum along its ventral side to expose the orificial papillæ (vide infra), cleaning the mucous surface, dehydrating it with absolute alcohol and sealing up the orifices with celloidin, then injecting as above under low pressure. Or

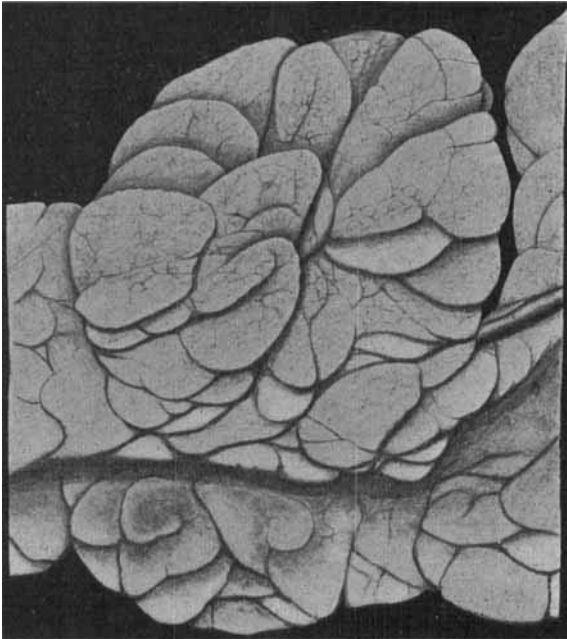


FIG. 2.—Enlarged view of lobe of pancreas of dog to show lobulation

the sealing up may be omitted and the relations of the bile-opening and Wirsung's can then be exactly determined as the injection solution and bile flow from the openings, pressure on the gall-bladder causing the bile to be expelled.

TOPOGRAPHY.—The pancreas in the dog is tongue-shaped, being 20-45 cm. long, 2-4 cm. wide and 1.5-2.5 cm. thick. Its size is quite variable, even in dogs of equal weight. It has three surfaces, of which two are broad and constant and one is narrow and may be discontinuous. The cross section is therefore like an isosceles triangle. The gland is somewhat loosely bound together by connective tissue into lobules and these again into larger lobules, until finally lobes of very

various sizes are formed. The free surfaces are nodulated and the margins are irregularly crenated. (See Figs. 1 and 2.)

The color is cream-pink to cream-red, varying according to the amount of venous engorgement in chloroformed animals. Usually several small lobes are much injected.

The gland is bent acutely on itself near its middle, giving it a \wedge shape. The left limb, *cauda pancreatis* (termed *splenic* by Owen), is the shorter; it runs in the dorsal wall of the bursa omentalis, caudo-sinistralward from the pylorus, dorsal to the stomach, toward or to the left kidney upon which it may abut with a broad concave end; the a. and v. lienalis groove, its anterior border and the colon transversum

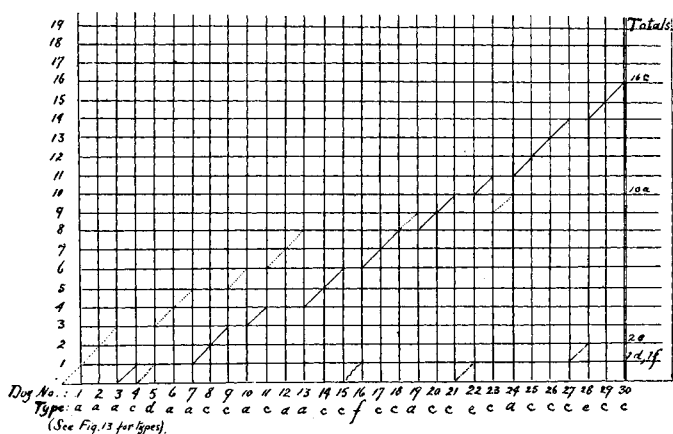


FIG. 3.—To show the frequency of occurrence of the types of the pancreatic ducts in the dog as observed in 30 consecutive cases.

is capped by its posterior surface. The right limb, *caput pancreatis* (termed *duodorsal* by Owen), extends in the mesoduodenum caudalward from the pylorus on the dorsal side of the duodenum nearly to the bend of the latter. It is longer, thinner and narrower than the left limb, and but for the influence of human anatomy, the terms "caput" and "cauda" pancreatis would here be reversely applied. The anterior 5-7 cm. rests on the duodenum, overlapping it somewhat on both sides; the remainder diverges dorsalward from the duodenum. The plane of this limb is sagittal while that of the left limb is principally frontal. At the apex of the \wedge the pancreas is folded or twisted on itself so that the left limb is turned on its main axis through nearly 180° . The probable origin of this twist and the relation of the pancreas to the peritoneum are shown in Fig. 4, which represents diagrammatically the

primitive embryonic and the derived adult condition in the dog. The right limb is in the mesoduodenum and retains this position. The left limb is contained in the mesogastrium and the whole gland may be regarded as in one plane (A). The bursa omentalis being formed by a pocketing of the mesogastrium between the stomach and the pancreas, and the dorsal margin of the left limb of the latter being fixed,

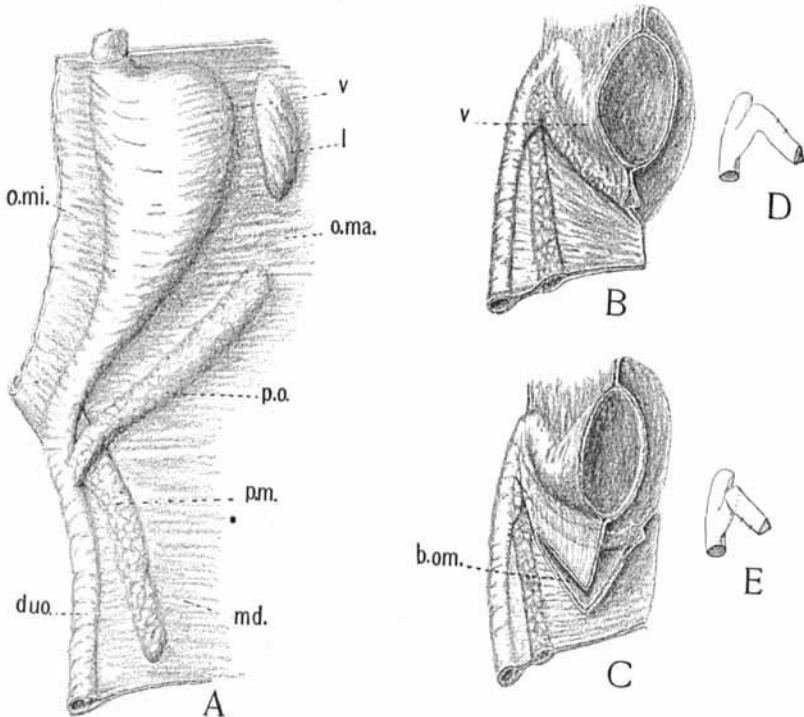


FIG. 4.—Scheme of development of the peritoneal relations of the pancreas in dog. In D and E are shown the part of the splenic division adjacent to the bowel. xx indicates the same border in each.

while the ventral margin is carried caudalward by the omentum majus, the twist results (C). The duodenal end is fixed or probably carried cranialward with the pylorus, while the splenic end is carried caudalward as the alimentary canal elongates and is thrown into curves. Thus the left limb becomes directed caudo-sinistralward. Except where it is in contact with the duodenum, the pancreas has everywhere a free surface covered by peritoneum.

OBSERVATIONS.—Pancreatic Orifices. Figs 5 and 6. There are two pancreatic orifices in the dog. One is in or close beside the terminal part of the ductus choledochus, this relation identifying it as the opening of the ductus Wirsungianus. It is about 0.3 mm. in diameter and is situated on the summit of a papilla in the mucosa of the dorsal wall of the duodenum, 3-5 cm. from the pylorus. It looks either into the ductus choledochus near the opening of the latter or caudalward on the free surface of the papilla, about 2 mm. from the bile-opening. In one instance celloidin injected into the bile-duct towards the bowel passed freely into the ductus Wirsungianus, having first closed the common orifice by precipitating in it.²

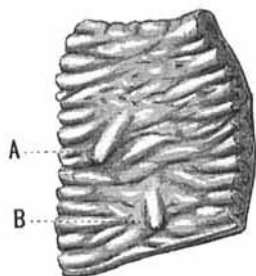


FIG. 5.

FIG. 5.—Part of dorsal wall of dog's duodenum, with orificial papillae, A, of ductus choledochus; B, of ductus Santorini. The bowel-wall was contracted and the mucosa much wrinkled.

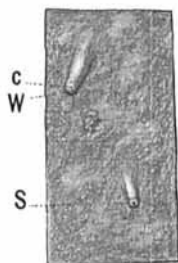


FIG. 6.

FIG. 6.—Dorsal wall of dog's duodenum and orificial papillae. C, orifice of ductus choledochus; W, of ductus Wirsungianus; S, of ductus Santorini. The bowel-wall was relaxed.

The other pancreatic orifice is about 0.8 mm. in diameter, and is situated at the summit of a similar but smaller papilla 2-5 cm. caudo-sinistralward from the first. This is the opening of the ductus Santorini, distinguished by its isolation from the bile-duct.

These orificial papillae are 3-5 mm. high and are really the enlarged terminal part of ridges of the mucosa due to the duodenal parts of the

ducts. Each ridge begins cranialward, culminates and terminates caudalward in the papilla. That nearer the pylorus is 7-10 mm. long and 2-3 mm. wide, and runs caudo-dextralward. The other is about 5 mm. long, 2 mm. wide and runs caudo-sinistralward.

The crests of the ridges and especially of the papillae are usually reddish owing to congestion of the blood-vessels there. The anterior papilla is often bilestained.

The real form of the papillae and ridges is seen only in sections of the duodenum. Fig. 7. As the bowel contracts, the ridges enlarge and numerous false rugae appear.

²This simulates injection of the pancreas by bile when the common orifice is obstructed by a gallstone.

DUCTS (Figs. 8, 9, 10).—The ducts are conveniently described in three parts: (a) *intraglandular*, (b) *free*, between the gland and the bowel wall, and (c) *duodenal*, in the wall of the duodenum.

Ductus pancreaticus Figs. 8, 9, 10.—(a) Intraglandular part. The ducts arise in the lobules as the intercalated ducts into which the alveoli open. The interlobular ducts unite usually like a broad Y; one arm of the Y is usually short. The stems of the Y's in turn form arms of larger similar Y's. The planes of successive Y's tend to be at right angles. Occasionally instead of a Y-form the ducts unite T-like and the arms of the T's may even be bent down a little. Each lobar duct originates by the union of the interlobular, and runs near the axis of the lobe toward the axis of the gland, being joined usually on all sides by various-sized lobular branches by which its caliber is continually augmented. In short broad lobes which do not extend far from the axial duct, the interlobular ducts unite Y-like nearly to the hilus of the lobe. Fig. 10. (The branching is dichotomous.)

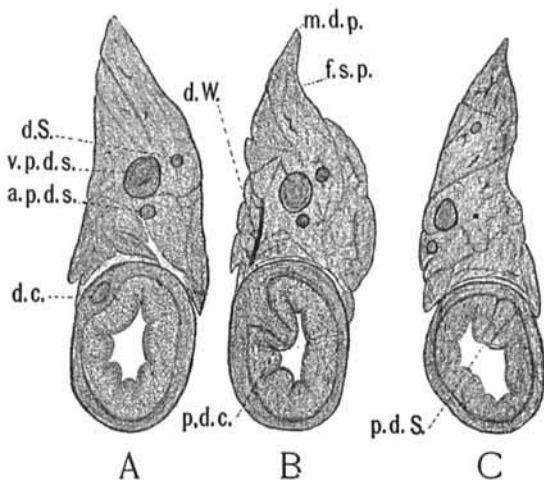


FIG. 7.—Sections of the duodenum and pancreas, to show the orificial papillae.

In or near the axis of each limb of the pancreas runs the main or axial duct. It arises in the free extremity of the limb by the union of the lobar ducts there. In its course towards the duodenum it receives lobar ducts on all sides, at wide angles of junction. The axial duct from the caput pancreatis meets and joins that from the cauda, near the duodenum, adjacent to the lower pancreatic orifice. Thence the main duct passes to the duodenum as:

(ii) Free part of ductus Santorini. This is most readily found on the left side of the duodenum. It is near the posterior part of that portion of the pancreas which is directly applied to the duodenum. The edge of the pancreas overlaps it and lobules of fat usually conceal its continuation into the bowel wall. Near it there is generally a large blood-vessel on the surface of the bowel. The duct can be located with-

out injury to the peritoneum by pushing back the edge of the pancreas, testing the fixity of the latter adjacent to the bowel, and looking for a whitish band sinking into the pale pink wall of the duodenum. This

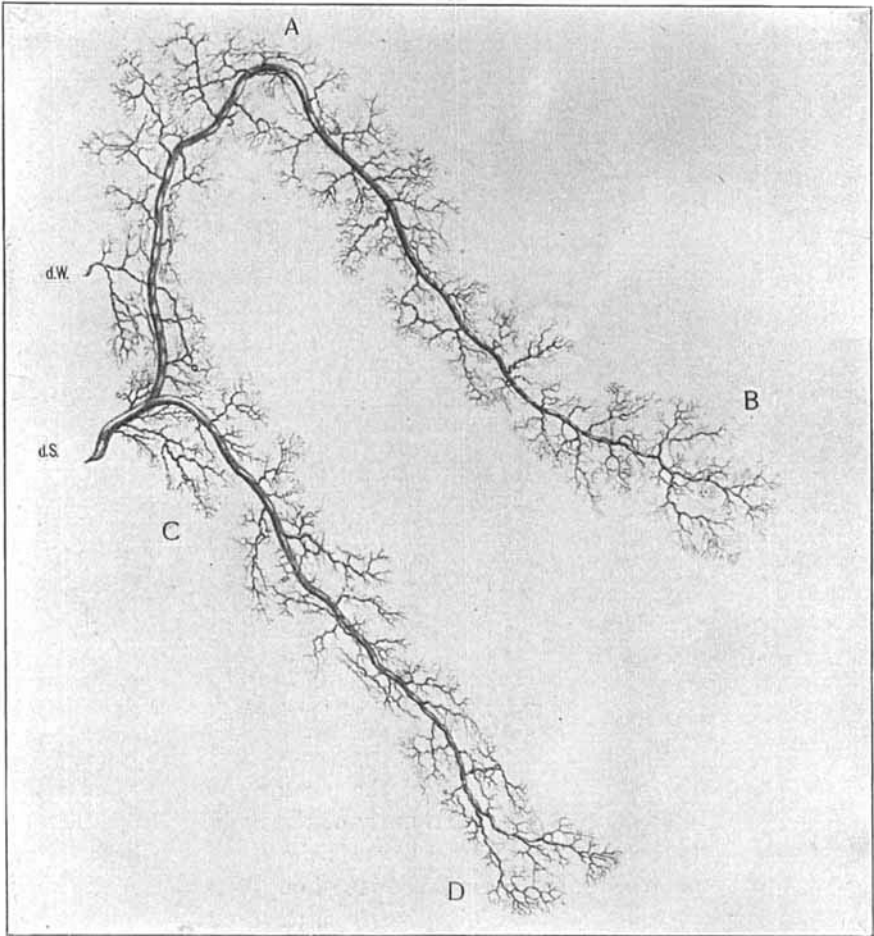


FIG. 8.—The pancreatic ducts in the dog. A B, omental portion; A C, epiduodenal; and C D, duodorsal portion.

part of the duct is directed somewhat caudalward, is about 2 mm. wide and 3-4 mm. long. It is flattened as it approaches the bowel. The union of the two axial ducts is within the gland as a rule, but may be at any point up to the surface of the duodenum.

(iii) Duodenal part of ductus Santorini (Fig. 12) is 5-7 mm. long,

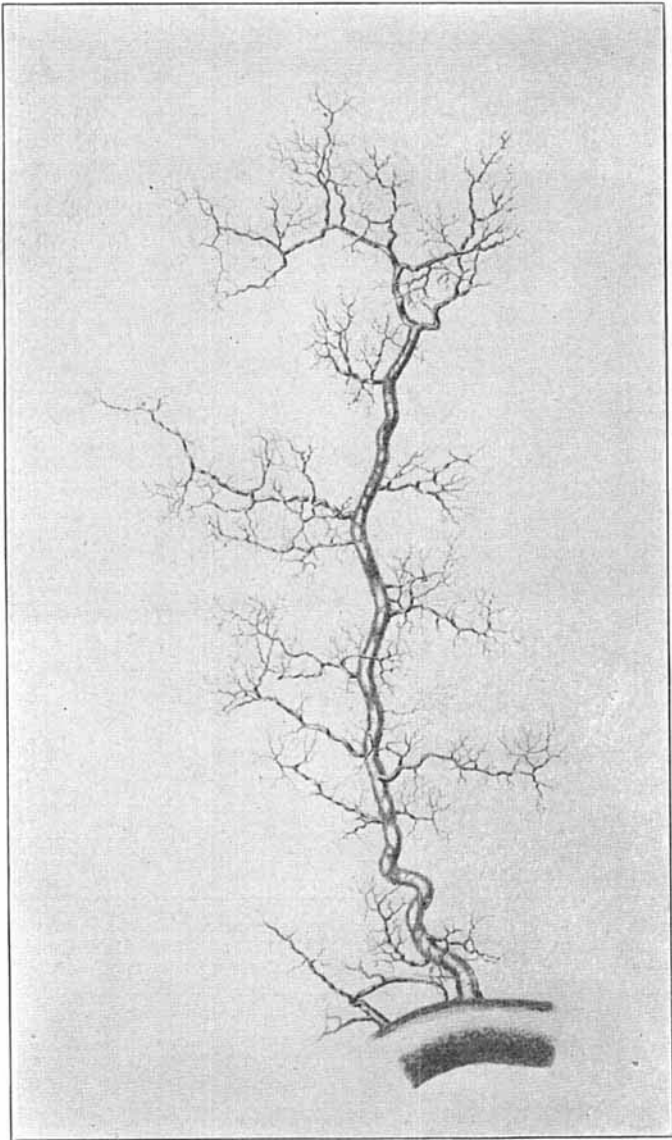


FIG. 9.—A lobular duct and its branches, from pancreas of dog.

2 mm. wide, and runs obliquely through the muscle-coats of the bowel, entering at an angle of 30° - 60° with the longitudinal muscle fibres but curving so that this angle diminishes in the further course to the papilla.

Towards the base of the latter it is broadened in the plane of the muscle layers; the papillary part rises at an obtuse angle and tapers to the orifice.

Ductus pancreaticus accessorius (Ductus Wirsungianus).—(i) Intra-glandular part lies in the right-hand part of the epiduodenal (*vide* summary) part of the pancreas, being directed cranio-dextralward, i. e. as if it came from the caput pancreatis. It is 1.5 cm. long and has as a rule the form of a side-channel from the main duct to the bowel (*vide infra*, Communications). It receives several branches, some medium-

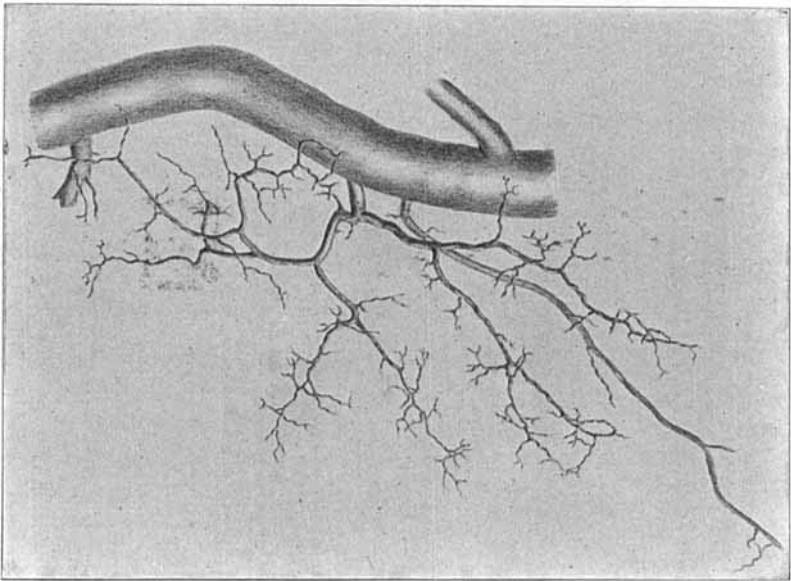


FIG. 10.—A lobar duct, showing dichotomous branching throughout. From pancreas of dog.

sized, but most are small. It is narrower in its middle part and wider towards its ends. It is like an interlobular duct and cannot be dissected out as clean and free as the axial ducts.

(ii) Free part of ductus Wirsungianus is to be sought on the right side of the duodenum. It is hidden under the pancreas and the best guide to it is the ductus choledochus. This passes under the pancreas for some distance before sinking into the duodenum, and is readily distinguished by its dusky orange-brown color, due to the bile in it and the vascularity of its walls. Its duodenal part shines through the bowel wall and can be traced nearly to its end, fading and finally disap-

pearing as it sinks deeper. A short distance caudalward and further under the pancreas from this point where the ductus choledochus disappears (1-2 cm. from the entrance of the latter into the bowel wall) the ductus Wirsungianus may be found. Its free part is 3-5 mm. long and usually 0.5-1 mm. wide. It may be known from a blood-vessel by its fixity, by its whiteness (or other color when artificially injected from the main duct) also by its sinking into the bowel wall and forming there a whitish area. It usually runs cranio-dextralward.

(iii) Duodenal part of ductus Wirsungianus (Fig. 11, D, E, F) is 3-5 mm. long, varies greatly in its direction, but generally runs cranio-dextralward at first, then curves so as to be parallel with the ductus choledochus. Its terminal part is very similar to that of the ductus Santorini (q. v.).

Casts of the lumen of the main duct often show numerous small knobbed projections from the surface. These can be best seen in injected sections. They are due to the small glands in the duct wall.

It will be seen (Figs. 1, 2, 8, 9, 10) that there is necessarily a close correspondence between the form and size of the ducts and the shape and lobulation of the gland. The gland and the main ducts are long: the gland is narrow and the largest duct branches are relatively short; the lobes and lobules are very various in size, as are also the duct branches.

It may also be observed (Figs 5 and 6) that the free and duodenal parts of the ducts run outward from under the pancreas. Or stating this fact from the standpoint of development, and considering the ducts to run *from* the bowel, the two ducts are directed toward each other as they go to the pancreas, this direction giving a reminiscence of the approaching, crossing and fusing of the two original parts of the gland.

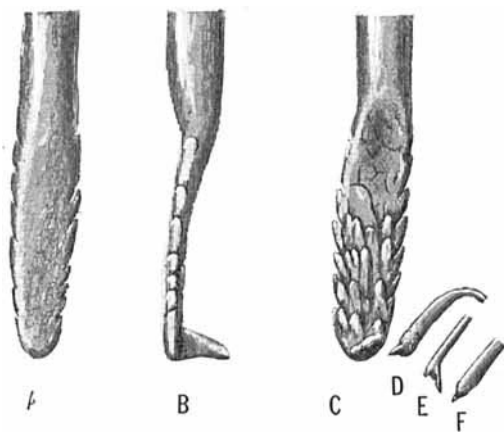


FIG. 11.—Celloidin casts of the duodenal part of the ductus choledochus (A, B and C) and of the ductus Wirsungianus (D, E and F), made with the duodenum distended. C and D, ventral aspect; B and E, seen from the left; A and F, dorsal aspect. The scale-like appearance in A, B and C is due to the crypts.

C. COMMUNICATIONS BETWEEN THE TWO PANCREATIC DUCTS.—In no instance of about 40 determinations was either duct absent. The relation between the ducts was exactly determined in thirty cases, the



FIG. 12.—Cast of the duodenal part of the ductus Santorini, A, seen from the dorsal side; B, from the right; C, from the ventral side. The duodenal wall was stretched by distension of the bowel.

findings being reducible to five types, diagrammatically represented in Fig. 13; A and B belong to one type but differ in that in A the ductus Wirsungianus has a longer and more tortuous course and joins the main duct nearer its bifurcation. A is more frequent than B. This type (A or B) occurred sixteen times in the thirty; type C, ten times; D, once; E, twice; and F, once. When the preliminary examination of the free part of the ductus shows that the ductus Wirsungianus is large, type E or F is very probably present, and should be carefully examined for.

In the instance in which the two ducts were not in communication, the pancreas was readily separable into two parts, one passing from near

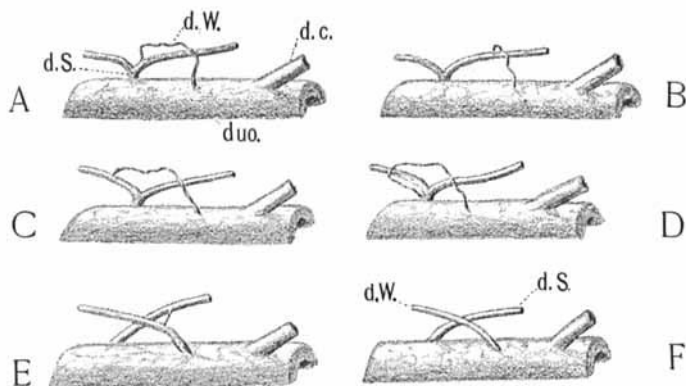


FIG. 13.—The terminal parts of the bile and the pancreatic ducts, and the dorsal wall of the duodenum. From dog. Diagrammatic. In A and B the ductus Wirsungianus joins the main duct from the cauda pancreatis; in C, it joins the duct from the caput pancreatis; and in D it joins the main duct. In E and F the two pancreatic ducts are about equal in size. In F, they do not communicate and each is confined to its embryonal field.

the pylorus caudalward (caput pancreatis), containing the ductus Wirsungianus, while the other extended cranialward along the duodenum from the lower pancreatic orifice to the pylorus and then bending to the

left formed the left (splenic or omental) limb (cauda pancreatis); it contained the ductus Santorini, which did not bifurcate. The pancreatico-duodenal vessels ran between the two divisions of the pancreas. There were in fact two pancreatic glands present, (caput pancreatis) right, the other (cauda pancreatis) to the left. In all the other instances, in which the ducts were united, the loop formed by the ducts from one orifice to the other arched over the pancreatico-duodenal vessels (Fig. 14).

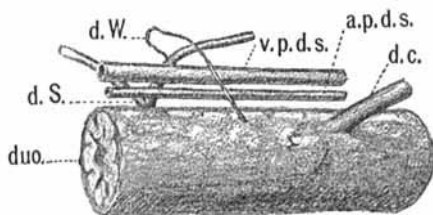


FIG. 14.—Part of the duodenum, ductus choledochus, pancreatic ducts and superior pancreatico-duodenal vessels, seen from the right side.

Types not met with but which are possible are:

- (a) Ductus Wirsungianus the larger.
- (b) Either duct absent.
- (c) Only one pancreatic orifice.

The varying size of the ductus Wirsungianus indicates that all these types will be met with in a sufficiently large series.

REMARKS.—1. A consideration of the types (Fig. 13) of the ducts in the adult leads to the following conclusions regarding the pancreas of the dog:

(a) The pancreas has a double origin, arising from at least two anlagen, which are placed on opposite sides of the pancreatico-duodenal vessels, but unite beyond these so as to form an arch over them. (Fig. 14).

(b) The original fields of the two ducts (and of the two anlagen) are: (i) ductus Wirsungianus (ventral anlage), the caput pancreatis (duo-dorsal segment) and the right half of the basal or epiduodenal (*vide infra*) segment; (ii) ductus Santorini (dorsal anlage), the remainder of the gland.³ By the anastomosis which occurs where these two fields are contiguous, the ductus Santorini takes over the drainage of the field of the ductus Wirsungianus beyond the anastomosis.

(c) These facts justify giving distinctive names to the two segments of the right limb of the pancreas: the anterior part, applied to the duodenum consists of the proximal or basal part of the product of each

³ This accounts for Flexner's observations in his study of experimental pancreatitis. He injected the ductus Santorini—not the ductus Wirsungianus—with various fluids, and observed immediate and subsequent effects most marked in the *splenic* and *basal* parts of the gland.

anlage, and may be termed *basal* (portio basalis); the part that diverges from the duodenum may be designated *duodorsal* (portio duodorsalis) (making a restricted application of Owen's term).

The left limb of the pancreas, from its position, may be termed omental (portio omentalis).

2. The names "ductus pancreaticus" and "ductus pancreaticus accessorius" do not always coincide with "ductus Wirsungianus" and "ductus Santorini." The latter are applied with reference to relation with the ductus choledochus, which is constant. The former are applied with reference to relative size of the pancreatic ducts, which varies. For the purposes of human anatomy, of comparative anatomy, and of embryology, it is desirable to have exact names. The modification which the ducts and parts of the pancreas undergo seems to necessitate the retention of two pairs of terms, one pair based on organogeny, the other on the morphology of the adult gland. Instead of the indefinite and unscientific eponymic terms "Wirsungianus" and "Santorini" there may be used:

(1). *Ductus hepatopancreatis* seu *ventropancreatis*—the duct arising only from the ventral or hepatopancreatic anlage.

(2). *Ductus dorsopancreatis*—the duct derived only from the dorsal pancreatic anlage.

The *ductus pancreaticus* is the main duct (in the adult gland) whether simple or compound in origin. The *ductus pancreaticus accessorius* is the smaller or subsidiary duct, or residue of a duct, when two are present in the adult gland.

In conclusion, it is a pleasure to thank Professor L. F. Barker and Professor J. M. Flint for many kind suggestions throughout the course of this work.

ABBREVIATIONS USED IN THE FIGURES.

- a. p. d. s.*, arteria pancreatico-duodenalis superior.
- v. p. d. s.*, vena pancreatico-duodenalis superior.
- b. om.*, bursa omentalis.
- duo.*, duodenum.
- d. c.*, ductus choledochus.
- d. S.*, ductus Santorini.
- d. W.*, ductus Wirsungianus.
- f. s. p.*, facies pancreatis sinistra.
- m. d. p.*, margo pancreatis dorsalis
- md.*, mesoduodenum.
- o. ma.*, omentum majus.
- o. mi.*, omentum minus.

- p. m.*, pancreas from dorsal anlage.
p. v., pancreas from ventral anlage.
p. d. c., papilla of ductus choledochus.
p. d. S., papilla of ductus Santorini.
l., lien.
v., ventriculus.

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