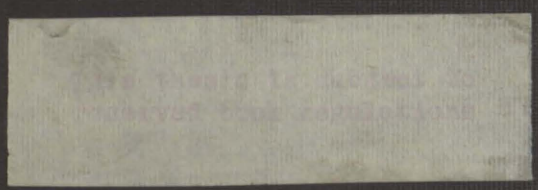

ON THE STRUCTURE OF A HUMAN EMBRYO EIGHTEEN MILLIMETERS IN LENGTH.

A DISSERTATION

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ON THE STRUCTURE OF A HUMAN EMBRYO ELEVEN MILLIMETERS IN LENGTH.

The purpose of this investigation is primarily to show the form and relations of the viscera in a human embryo eleven millimeters (neck-breech) ~~in~~ length and of the latter part of the fifth week of embryonal life.

The embryo is catalogued as No. 60 in the collection of human embryos in the Anatomical Laboratory of the University of Missouri. It was in excellent condition with the chorion, amnion, and yolk sac intact. After opening the membranes, the embryo was photographed, stained in bulk in alum-cochineal, embedded in paraffin, and cut in transverse serial sections 20 micra thick.

From these sections, a wax model was reconstructed (by Born's method) magnified seventy-five diameters. As may be seen in the accompanying photographs (Pl. I,II,III,IV), the model includes the cervical, thoracic, abdominal, and pelvic viscera, together with the large blood vessels. In addition, a portion of the body wall, including the lower extremity, is shown on the left side. The total height of the model is forty-seven centimeters. For convenience, it is made in two segments, the plane of division passing horizontally through the upper part of the liver.

In the following paper I will consider the various organs in the following order: (1) the vascular system; (2) the alimentary tract with the accessory glands; (3) the respiratory apparatus; (4) the urino-genital system; (5) the ductless glands.

The vascular system includes the heart, arteries, and veins.

1. Heart.

The heart (Pl.I,II,IV,H) at this stage is comparatively much larger than at later stages. The auriculoventricular and interventricular grooves are very distinct. The right side of the heart appears somewhat larger than the left. The heart is situated at the level opposite the sixth cervical to the fourth thoracic vertebrae, inclusive. Below, it rests upon a depression of the liver and slightly in front of it. Behind, it is in close relation to the anterior cardinal veins, ducts of Cuvier, sinus venosus, lungs, and trachea. In general form, the heart has already assumed the appearance of the adult structure.

2. Arteries.

The main trunk of the pulmonary artery (Pl. IV,pa) arises from the right ventricle as in the adult. On the left of the ascending aorta, it divides into two branches, representing the fifth pair of branchial arteries, which pass upward on either side of the trachea and oesoph-

agus to join the corresponding arches of the dorsal aortae. The left branch, of course, represents the ductus arteriosus (Botalli) (Pl. I,da).

The true pulmonary arteries are small vessels arising from these branchial trunks and passing down for a considerable distance just in front of the trachea on each side to join the corresponding lungs.

The ascending aorta (Pl. I,II,IV, A) arises from the left ventricle, much as in the adult, arching upward and forward (instead of backward), however. It divides into two pairs of branches; the posterior pair represents the fourth branchial arteries, the anterior pair the common trunk from which the first three branchial arteries (not shown in the model) arise.

As seen in the posterior view of the model, both aortic arches are still present. Just before uniting below, opposite the seventh cervical vertebra, a branch (Pl. I,II, IV, s c a) is given off dorso-laterally from each arch. These branches (the origins of which are indicated in the model) represent the common trunk of the subclavian and vertebral arteries of each side.

The dorsal aorta (Pl. II, III, Ad), formed by the union of the right and left aortic arches, descends nearly in the median line just in front of the vertebral column. In the lower dorsal and lumbar regions it gradually increases in caliber. It reaches its greatest dimensions (more than

doubled in diameter) opposite the third lumbar vertebra where the iliac arteries arise. Beyond this point the aorta diminishes rapidly to form the slender caudal artery (Pl. II, ca).

The iliac arteries are also very large near their origin (Pl. II, ia), but gradually taper down into smaller trunks, hypogastric arteries, extending upward and forward into the lower part of the wall of the umbilical cord on either side of the allantois (Pl. I,II,IV, ha).

The vitelline artery arises from the aorta at the level of the eighth thoracic vertebra; it runs forward and slightly downward in the mesentery of the small intestine. In the U-shaped intestinal loop extending out into the umbilical cord, the vitelline artery lies in the strip of mesentery between the intestines and near the inferior surface (where it is indicated on the model). On reaching the extremity of the intestinal loop, it divides into two branches which encircle the intestine and unite again into a single trunk on the outer side of the intestine at the attachment of the yolk stalk. In the cross section of the yolk stalk (Pl. IV, va) the vitelline artery is seen as a single trunk.

In the earlier embryonic stages, as ~~it~~ is well known, there are two distinct vitelline arteries passing out one on each side of the intestine to reach the yolk sac. One

of these (usually the left) is said to atrophy, leaving the other as a single vessel. The arterial ring surrounding the intestine in this case does not agree with this theory, however. Perhaps the single trunk is formed by a fusion of the two primitive arteries, except where they persist to form the ring.

3. Veins.

The anterior cardinal, or jugular veins (Pl.I, II, III, cv) are very large toward their terminations below, but smaller above. They pass down behind the corresponding auricles and terminate by joining the corresponding posterior cardinals to form the so-called ducts of Cuvier at the level of the seventh cervical vertebra.

The posterior cardinal veins (Pl. I, II, III, pcv) are two comparatively small veins. They lie on either side of the descending aorta separated from it by the sympathetic anlage, and from the third to the sixth thoracic vertebra by the suprarenal anlages. The posterior cardinal veins are closely related to the dorso-mesial aspect of the Wolffian bodies. Above the Wolffian bodies, they are related anteriorly to the lungs, above which they arch forward to join the corresponding ducts of Cuvier.

The left duct of Cuvier (Pl. I, dc) is formed at the level of the seventh cervical vertebra, and runs downward, forward, and inward in the inferior wall of the left aur-

icle, above the liver and in front of the left lung. It passes to the right side. After ascending a short distance, it finally opens into the sinus venosus in front of the inferior vena cava.

The right duct of Cuvier (Pl.II, d c) is very short. It runs downward and forward a short distance and joins the sinus venosus from which it is not distinguishable.

The left umbilical vein (Pl.I,II$^{IV}_{A}$, u v) is seen below the yolk stalk, where it lies in the lower part of the umbilical cord. Here it divides, the two branches immediately reuniting into a single trunk. Passing to the left, it runs horizontally backward in the lateral abdominal wall. Below the liver it again divides, this time into three branches, one large and two small, which soon reunite into a single trunk. At this point the umbilical vein turns vertically upward and passes into the liver in the umbilical notch.

The right umbilical vein has become rudimentary in this embryo, hence it is not represented in the model. It passes into the body wall on the right side of the umbilical cord, and its largest terminal branch passes to the left under the liver to join the left umbilical vein. A very small branch, however, evidently representing the primitive stem, continues upward and joins the liver in front of the gall bladder.

The amphalo-mesenteric, or vitelline vein, is seen in cross section of the yolk stalk (Pl. IV, vv) above the vitelline artery. It crosses the intestinal loop above the intestine at the point of attachment of the yolk stalk and passes backward in the mesentery of the loop, forming a prominent ridge on its upper (primitive left) surface. On approaching the duodenum this ridge becomes more prominent, and at one place the peritoneum entirely surrounds the vessel, so that it is here entirely free from the surface of the mesentery. The vein finally passes under the duodenum to enter the liver. The remainder of its course is not visible in the model.

Just as the vitelline vein reaches the duodenum it receives a small branch passing down the antero-superior duodenal wall. This may represent a persistant portion of the lower venous ring described by His[6] (for earlier stages).

Another branch may be seen entering the vitelline vein just below the duodenum. This branch extends out into the mesentery and in the sections may be traced to the vein accompanying the vitelline artery. This branch evidently represents the vessel which becomes the superior mesenteric vein. The vitelline vein already shows signs of involution. Its walls are much thickened, and the lumen is very narrow, in places almost obliterated. No such changes are seen in the vitelline artery, however.

The Alimentary Tract.

The lower portion of the pharynx is shown in the upper part of the model (Pl. I, II, III, IV, Ph). Below and in front of the pharynx is the anlage of the larynx. Laterally are the third and fourth branchial pouches, with their corresponding derivatives (thymus and lateral thyroid) and branchial arteries.

The thymus anlage (Pl. I, II, III, IV, tm) of each side is composed of a vertical elongated anterior portion, derived from the inner segment of the branchial pouch (still connected with the pharynx), and an oval portion, situated above and behind the anterior portion, and derived from the outer part of the third branchial cleft. The anlage of the thymus is situated in the interval between the third and fourth branchial arteries of each side.

The thyroid gland (Pl. I, II, IV, tr) is still divided into three portions, two lateral and one median anlage. The median anlage (Pl. IV, tr) is a triangular mass, flattened dorso-ventrally, situated in front of the termination of the ascending aorta. No ductus thyreoglossus was found in this embryo.

The lateral thyroid anlage of each side is seen as an enlargement in the wall of the inner portion of the fourth gill cleft. It is situated between the fourth and fifth branchial arteries of each side, and is still connected with the pharynx.

The oesophagus (Pl.III, oe) extends from the level of about the fourth cervical vertebra to the third thoracic. It is rather large above but becomes smaller as it approaches the stomach. Its antero-posterior curvature conforms with the curvature of the body down to the level of the second thoracic vertebra, where it turns forward to its termination. Its lateral curvatures are first slightly to the left opposite the seventh cervical vertebra and then slightly to the right at the level of the first thoracic vertebra, and finally slightly to the left at its termination.

The stomach is somewhat spindle-shaped, and more vertically placed than in the adult. No fundus is present. The stomach is not well shown in the model, being excluded from the left body wall by the thick layer of posterior mesogastrium (great omentum). A window is cut through this into the bursa omentalis on the left side (Pl.III, w) showing the great thickness of the omental wall and giving a limited view of the posterior wall of the stomach.

Anteriorly and to the right, the stomach is related to the liver. Externally it is in contact with the body wall above but separated from it by the bursa omentalis below. Posteriorly, it is related to the supra-renal body and the Wolffian body above, being separated from the latter by the thick posterior mesogastrium below. The anlage of the spleen also lies in the thick mesogastrium postero-external to the stomach, and just behind the window (w). The cardiac orifice lies at about the

level of the third thoracic vertebra, the pylorus opposite the seventh, slightly to the left of the median line.

The duodenum (Pl. II, du) is composed of two portions. The first portion extends from the pylorus almost horizontally to the right, slightly convex anteriorly, to the right side of the liver; here it turns at a sharp angle to join the second portion which extends downward and forward to terminate in the duodeno-jejunal angle. The first portion is immediately below the liver, being in contact with the quadrate lobe, neck of the gall bladder and right lobe. The second portion rests upon the anterior surface of the sexual anlage.

Following the duodenum, the intestinal canal forms a U-shaped loop extending out into a peritoneal diverticulum in the umbilical cord (Pl. I, II, IV, in). The jejuno-ileum forms the proximal limb and the turn of this loop. The proximal limb (Pl. II, in) extends forward and slightly upwards on the right side. The turn of the loop is convex forward. At this point the intestine is surrounded by the ring of the vitelline artery and crossed above by the vitelline vein. The yolk stalk (Pl. I, II, IV, y s) is attached to the convexity of the intestine here. In the cut end (Pl. IV), the vitelline vein is seen above, the artery below and the cavity of the yolk stalk (which does not communicate with the lumen of the intestine) to the right side of the stalk.

The colon forms the distal limb of the loop. Beginning

with the caecum (scarcely indicated on the external intestinal wall, though provided with a distinct caecal cavity internally) which lies just behind the turn of the intestinal loop (Pl. I, cae) the colon passes backward and downward on the left side, parallel with the proximal limb. The colon decreases in caliber from the caecum onward, and re-enters the general body cavity nearly in the midplane. Here it turns sharply downward and forward; and passing between the hypogastric arteries, Wolffian ducts and ureters, of each side joins the rectum which opens into the cloaca dorsal to the urethra (Pl. II, r). There is no indication of the tail gut in this embryo. The intestinal canal is covered with peritoneum from the cordiac end of the stomach to the point where it passes between the hypogastric arteries, with the exception of the posterior wall of the duodenum, where it is in contact with the pancreas.

Accessory Glands.

Of the accessory glands of the digestive tract only the liver is seen, the pancreas being hidden behind the duodenum and stomach. The liver (Pl. I,II,III,IV, L) is the largest organ of the body, yet at this stage it is not as large relatively as it is in the older stages. It is situated at a level opposite the third to the seventh thoracic vertebrae, inclusive. Its left lobe is nearly as large as the right, being only slightly displaced by the stomach.

The liver is flattened from above downward, measuring in the model 22 centimeters transversely, 18 centimeters antero-posteriorly, but on the average only about 9 centimeters vertically. The liver is rounded below but above it has a large depression for the heart.

Above, the liver is related to the heart antero-superiorly, and to the lungs posteriorly. Behind, it is related to the stomach, and to the right suprarenal and Wolffian bodies. A small area below is related to the proximal portion of the duodenum. The remainder of the external surface of the liver is in contact with the abdominal wall.

The Respiratory Apparatus.

The anlage of the larynx is visible below and in front of the pharynx, with which it communicates (Pl.IV, lr).

The trachea begins at about the level of the fifth cervical vertebra and bifurcates at the level of the first thoracic vertebra.

The lungs are situated at a level corresponding to the first, second and third thoracic vertebrae. They are very small in size. They show only slight indication of lobes. The lungs are each related posteriorly to the corresponding posterior cardinal vein and the upper part of the Wolffian body. Internally they are in close contact with the oesophagus. Anteriorly they are related to the ducts of Cuvier and the auricular portion of the heart above, and to the liver below.

The Urinogenital System.

The urinogenital system is composed of the Wolffian bodies with the sexual anlage; the kidneys and ureters; the bladder, allanlois, and cloaca.

The Wolffian bodies (Pl.I,II,III,wl) are the largest organs of this system, narrow above, they become much larger below. They are situated on either side of the dorsal aorta, from the second thoracic to the first lumbar vertebra. The suprarenal bodies separate the Wolffian bodies from the aorta, from the third to the sixth thoracic vertebra, however. Posteriorly, the Wolffian bodies are in contact with the body wall, and are intimately related throughout their whole length to the posterior cardinal veins. Anteriorly they are closely connected, in their lower two-fifths to the sexual anlage. Above this the right Wolffian body is related anteriorly to the liver, and the left to the stomach and posterior mesogastrium. In the uppermost portion, each Wolffian body is in contact with the posterior aspect of the corresponding lung.

The Wolffian duct forms a ridge on the lateral surface of each Wolffian body. At the lower end of the Wolffian body it extends forward, internal to the corresponding hypogastric artery, and then joins the bladder-urethra anlage just internal to the ureter.

The sexual anlages (Pl.I,II,sa) appear as two elongated, flattened plates lying upon the anterior surfaces of

the lower portions of the corresponding Wolffian bodies, and closely related to them. The right sexual anlage lies behind the descending portion of the duodenum.

The right ureter (Pl.II, ur) is seen extending downward and backward from the bladder. Its bifurcated extremity represents the anlage of the kidney which lies internal to the wide beginning of the hypogastric artery.

The allantois (Pl.II,al) extends upward from the anlage of the bladder, then forward in the ventral wall of the umbilical cord, between the two hypogastric (umbilical) arteries.

The lower expanded extremity of the allantois represents the anlage of the bladder and is continuous anteriorly with the narrow anlage of the urethra (Pl.II,u). This in turn soon opens into the cloaca (Pl. II, cl).

The cloaca receives the urethra ventrally and the rectum dorsally. It lies near the surface of the urinogenital papilla (Pl.II,up), but does not yet open externally.

The Ductless Glands.

The ductless glands reconstructed are the spleen and suprarenal bodies. The location of the splenic anlage is indicated by a thickening of the mesogastrium, posteroexternal to the stomach, just behind the quadrangular window cut in the model (Pl.I,w), and anterior to the left Wolffian body. The tissue of the spleen is not yet sharply

differentiated from the surrounding tissue of the mesogastrium.

The anlages of the suprarenal bodies (Pl.III, s) are at a level between the third and sixth thoracic vertebrae. Each lies between the superior part of the Wolffian body and ~~the~~ posterior cardinal vein externally and the aorta internally. The suprarenal anlages are as yet not very sharply differentiated from the surrounding anlage of the sypathetic system.

Comparison with Observations found in the Literature.

This embryo with a few exceptions corresponds, in general, to embryos previously described by various authors. Certain features, however, I have not been able to find mentioned in the literature at hand.

One feature of interest is the splitting of the umbilical vein into branches which soon reunite. Another is that the lateral anlages of the thyroid gland are not so well formed and not so closely related to the median anlage as in the embryos of ten and twelve millimeters described by His (6) and Sudler (13). Moreover, they are differently located with respect to the thymus. In this embryo the thymus is situated between the lateral and median thyroid anlages instead of being external to the lateral anlages as described and figured by these authors.

The intestinal ring formed by the vitelline artery, though described by Hochstetter (7a) for mammals (cat), has

not been previously observed in the human embryo, so far as I know.

That the vitelline (omphalo-mesenteric) vein does not persist as the superior mesenteric vein was long ago observed by Luschka (9). He states that the omphalo-mesenteric vein, (also the artery), disappears in man in embryos of the third month, but can still be injected through the heart at birth in the carnivora, which are born blind (dog, cat, etc.). Allen (1) confirmed these results in the dog, cat, lion, and guinea pig.

These results, however, have evidently been overlooked by some modern writers. His (6) makes no mention of them in his elaborate work. He claims that the omphalo-mesenteric becomes the superior mesenteric and portal vein. The omphalo-mesenteric becomes the portal vein but evidently only a very short portion of it becomes the superior mesenteric (i.e. from the point where it is joined by the (distal) superior mesenteric vein up to the point where it unites with the splenic vein to form the portal).

Minot (12) does not make a clear statement as to the relation of the vitelline vein to the superior mesenteric, and does not mention the atrophy of the vitelline vein. The same may be said of Marshall (10), McMurrich (11), Young (5), and Robinson (14), Hertwig and others.

Dexter (3) describes, apparently as an original observation, the atrophy of the omphalo-mesenteric vein in the

foetal cat, and an independent formation of the superior mesenteric. Lewis (8) later verified this condition in the pig, crediting Dexter with the original discovery.

Foster and Belfour (4), however, describe the superior mesenteric vein in mammals as eventually joining the vitelline to form the portal. Charpy (2) also states the relation correctly and credits Luschka with the discovery. Hochstetter (7) cites and endorses the statements of Allen (1).

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EXPLANATION OF PLATES.

PLATE I. Photograph of left view of model, showing the cervical, thoracic, abdominal, and pelvic viscera, as well as a side view of the branchial arches, descending aorta, anterior and posterior cardinal veins, duct of Cuvier, and the umbilical veins and arteries. In the lower fourth the external body wall including the tail, hind limb, and a part of three or four somites are shown.

A. Ascending aorta; Ad, Descending aorta; Bw, Body wall; cae, Caecum; cv, Cardinal vein; da, Ductus arteriosus; dc, Duct of Cuvier; hl, Hind limb; L, Liver; la, Left auricle; lu, Lung; lv, left ventricle; pcv, posterior cardinal vein; sa, sexual anlage; sca, subclavian artery; ta, tail; tm, thymus; tr, thyroid gland; uv, umbilical vein; w, window cut in mesogastrium; WI, Wolffian body; ys, Yolk stalk.

PLATE II. Photograph of the right view of the model. On this side the lower part of the body wall seen on the left side of the model is not reproduced, but has been dissected out to the mid-sagittal plane, giving a side view of the spinal cord, notochord, and the descending aorta with its branches.

A, ascending aorta; Ad, descending aorta; al, allantois; ca, caudal artery; cl, cloaca; cv, anterior cardinal vein; du, duodenum; hl, hind limb; ha, hypo-

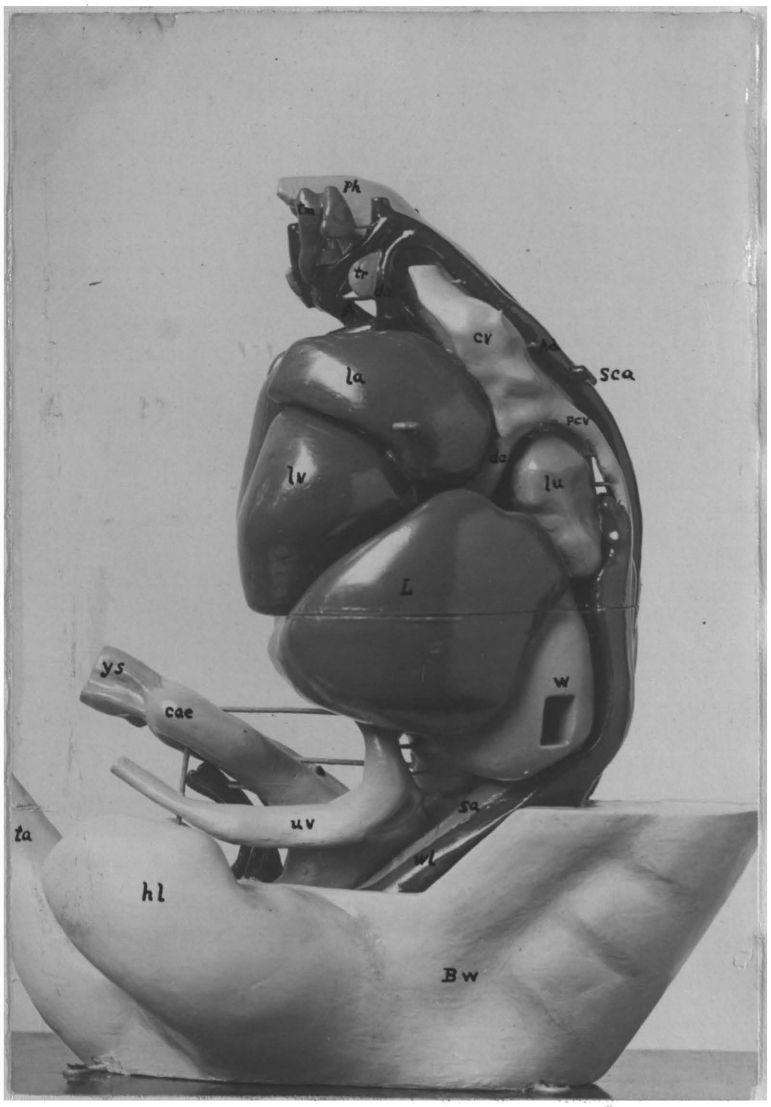
gastric artery; ia, iliac artery; in, intestine; L, liver; lu, lung; n, notochord; pcv, posterior cardinal vein; ph, pharynx; r, rectum; ra, right auricle; rv, right ventricle; sa, sexual anlage; sca, subclavian artery; spc, spinal cord; sv, sinus venosus; tm, thymus; tr, thyroid; u, urethra; ur, ureter; up, urinogenital papilla; uv, umbilical vein; vv, vitelline vein; wl, Wolffian body; ys, yolk stalk.

PLATE III. Photograph of the posterior view of the model, showing the descending aorta, the cardinal veins, the thoracic and abdominal viscera. In this view the levels of the spinal nerve roots are indicated by short transverse stripes on the oesophagus and descending aorta.

Ad, descending aorta; cv, anterior cardinal veins; hl, hind limb; la, left auricle; L, liver; lu, lung; oe, oesophagus; pcv, posterior cardinal veins; ph, pharynx; ra, right auricle; s, suprarenals; sv, sinus venosus; V, level of fifth spinal nerve. w, window cut in mesogastrium; wl, Wolffian bodies.

PLATE IV. Photograph of the anterior view of the model. The small upper part shows the pharynx and its appendages, and the branchial arches. The large middle part of the model represents the heart above and the liver below. Below the liver are the intestines, yolk stalk and umbilical vessels.

A, ascending aorta; cae, caecum; cv, anterior cardinal veins; H, heart; ha, hypogastric artery; hl, hind limb; ia, iliac artery; in, intestine; L, liver; la, left auricle; lr, larynx; lv, left ventricle; pa, pulmonary artery; ph, pharynx; ra, right auricle; rv, right ventricle; sa, sexual anlage; t, tongue; ta, tail; tm, thymus; tr, thyroid gland; up, urinogenital papilla; uv, umbilical vein; va, vitelline artery; vd, vitelline duct; vv, vitelline vein; Wl, Wolffian body.



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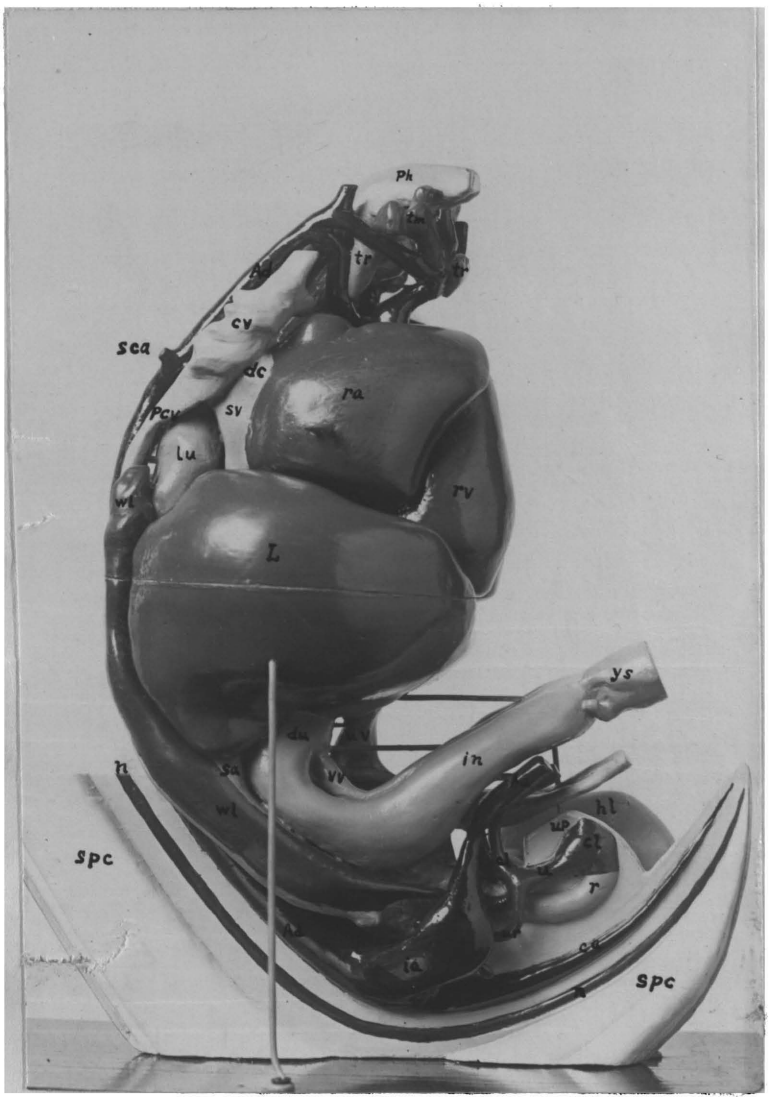
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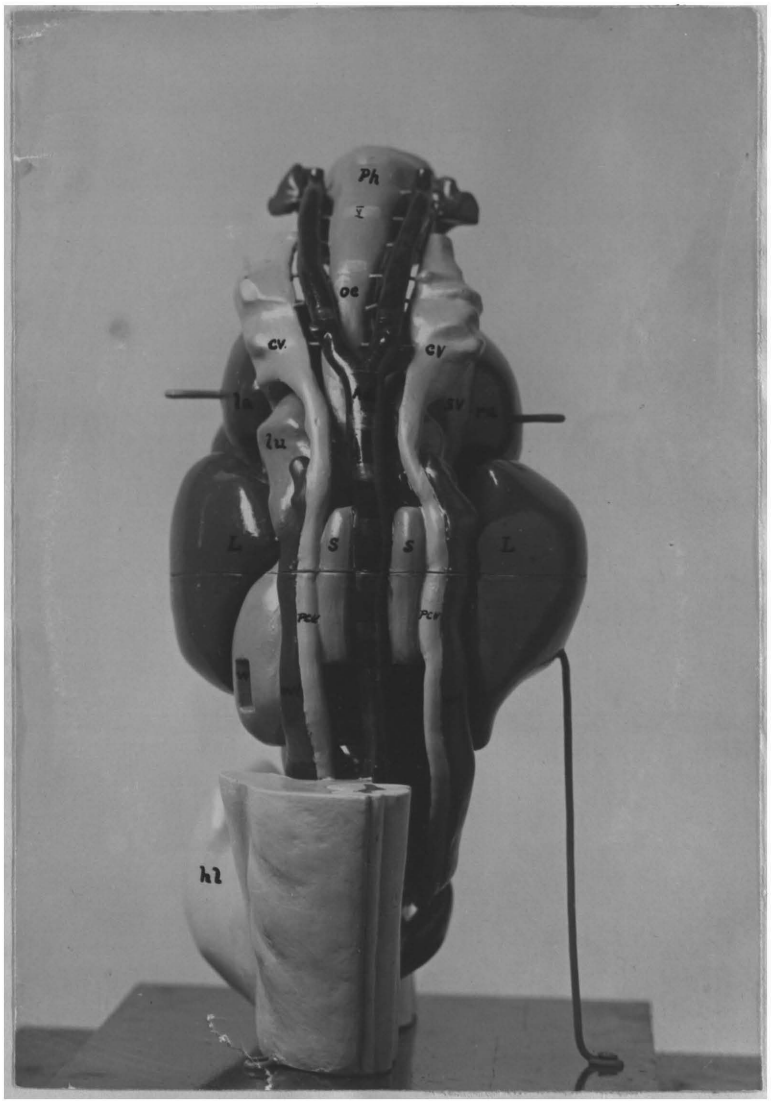
PLATE II



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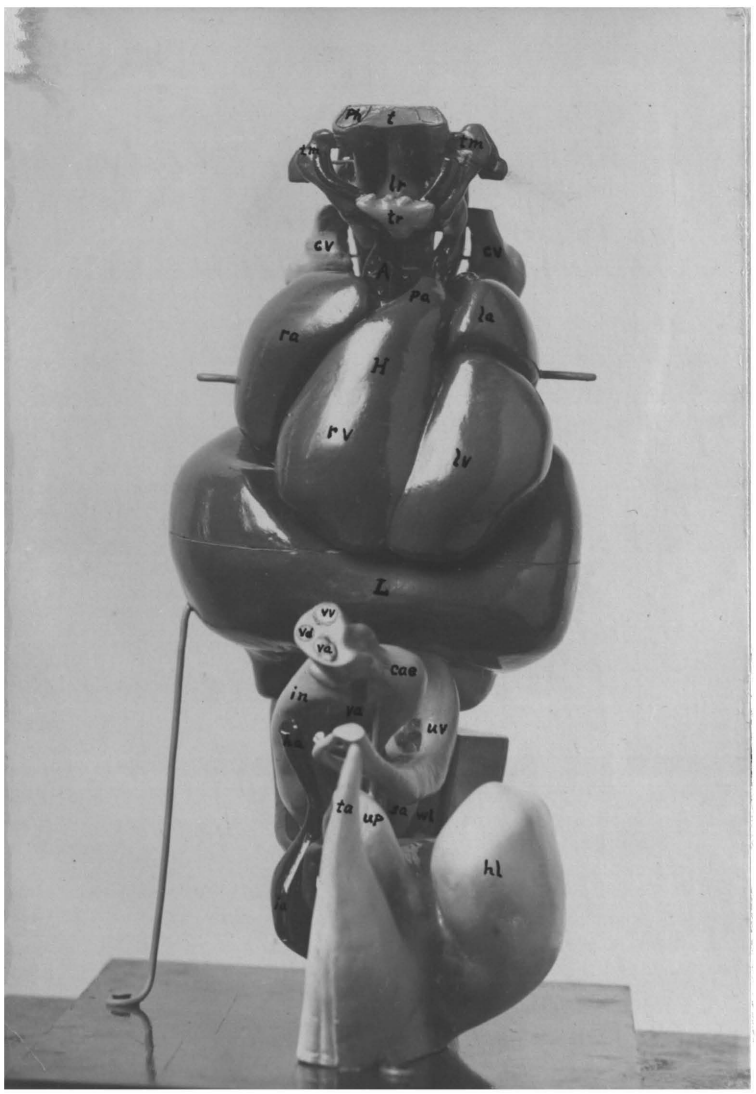
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PLATE IV