VIII.—Description of a Reconstruction Model of a Horse Embryo Twenty-One Days Old.

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[Plate XIX, figs. 54–63. Text-figs. 22–26.]

[*Note.*—The following account of a horse embryo twenty-one days old is based upon a reconstruction and upon notes made by Mr A. GIBSON, M.B., F.R.C.S., etc., Professor of Anatomy in the Medical College, Winnipeg, when he was working in the Anatomical Department of the University of Edinburgh, and he, therefore, is responsible for everything except the mere writing.

When the reconstruction and the notes were completed, Professor COSSAR EWART, to whom the embryo belonged, was too fully occupied to proceed with his description of the embryo, consequently Mr GIBSON's notes were put aside for the time. Now, when circumstances permit Professor EWART to proceed with his part of the work, the services of Professor GIBSON are not available; therefore, with the aid of the reconstruction and Professor GIBSON's original notes, I have put together the following account of the embryo; but, as Professor GIBSON has not had the opportunity to revise his notes, I must be held entirely responsible for any errors of description or interpretation which may be found in the account.

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Feb. 1915.]

The embryo, as represented by the model, is bent upon itself, at the level of the cranial border of its umbilical orifice—that is, at the caudal end of the pericardial region; and, as a result of the bending, the general outline of the embryo, when viewed from the side, is hook-shaped.

The dorsal and longer limb of the hook is formed by the more caudal portion of the embryo—that is, the part which would lie caudal to the cranial margin of the umbilicus if the embryo were unbent.

The shorter limb of the hook is formed by the pericardial and cranial regions of the embryo with the included foregut and the stomatodæum. This part of the embryo is of course reversed so that its true dorsal surface is directed ventrally, and its ventral surface is turned dorsally and lies in relation with the ventral surface of the more caudal portion of the embryo (figs. 54, 55, 56, Pl. XIX*; and 8 and 11, Pl. IX).

When Professor EWART measured the embryo in the fresh condition, it was found to be 11 mm. total length, measured round the bend, whilst the distance from the bend to the most anterior part of the head was 3·25 mm. and the distance from the bend to the caudal extremity was 6·25 mm.

* Figs. referred to, other than those in Plate XIX, are in the Plates of Professor COSSAR EWART's paper.

The material given to Mr GIBSON, for reconstruction, was a series of 387 transverse sections, each section being 10μ thick; therefore the total length of the fixed and hardened embryo was 3·87 mm. Shrinkage, to the extent of about 40 per cent., must, therefore, have occurred during the preparation and embedding of the embryo.

That shrinkage has occurred is obvious from the condition of the heart and some of the other organs. Moreover, whilst the shrinkage does not appear to have altered the relative positions of the organs, it has altered the relative proportions of the two parts of the bent embryo; for whilst in the fresh embryo the total length was 11 mm., and the proportion of the shorter to the longer part was as 325 to 625, the total length of the reconstruction is 819 mm. and the proportion of the shorter to the longer segment is as 230 to 387. Nevertheless, the general appearance of the reconstruction and the drawings of the fresh embryo are essentially alike (figs. 54, 55, 56, Pl. XIX; 8, 11, Pl. IX; 27, Pl. XVI), except that the flexure in the model is more acute, on account of a certain amount of shrinkage of the heart, and that the curve of the head and the part of the body on the cranial side of the umbilicus is less rounded than it was in the fresh embryo.

The reconstruction was made by the ordinary wax-plate method, each section being enlarged 100 diameters on plates 1 mm. thick; the reconstruction is, therefore, one hundred times as large as the fixed and hardened embryo.

When the embryo was cut into sections, portions of the yolk-sac were still attached to it, and they are shown in the model (*Sp.*, figs. 54, 55, 56, Pl. XIX).

There was a completely closed amnion, which was removed from the model to expose the dorsal surface of the embryo.

The description of the appearance of the embryo and its appendages in the fresh condition has been given by Professor EWART in the preceding pages; what follows is a description based upon the reconstruction. In it the terms "cranial" and "caudal" portions of the embryo will be used respectively to refer to the shorter and more cranial, and the longer and more caudal parts of the bent embryo; whilst the term "the bend of the embryo" will refer to that part which connects the cranial and caudal portions together and forms the convex projection of the hook-shaped bend.

Surface Views.

When examined from above, from which aspect the cranial portion of the embryo is not visible, the caudal portion has an hour-glass-shaped outline (fig. 54, Pl. XIX), the constricted portion being a little nearer the caudal than the cranial end of the caudal portion of the embryo.

The constriction is not an artefact, but it is exaggerated by the shrinkage, for it is more marked in the reconstruction than in the fresh specimen (fig. 10, Pl. XIII; fig. 54, Pl. XIX).

In the region of the constriction the somatic wall of the embryo is definitely

folded upon itself, but neither the constriction nor the folding appears to be due to any external extra-embryonic cause.

An elevated ridge which marks the position of the neural tube runs along the median part of the dorsal region of the caudal portion of the embryo (fig. 54, Pl. XIX).

At the caudal end of the median ridge there is a narrow cleft, 100μ long in the embryo, which communicates with the central canal of the neural tube (figs. 54, 61, Pl. XIX, and text-fig. 22, p. 334), and constitutes the caudal neuropore.

In the cranial part of the caudal portion of the embryo there is, on each side of the median neural elevation ridge, an elevation which indicates the position of the subjacent pleuro-pericardial canal (figs. 55, 56, Pl. XIX).

When the model is examined from below, the dorsal surface of the cranial portion and the ventral surface of the more caudal part of the caudal portion of the embryo are seen (fig. 55, Pl. XIX). In the median line of the cranial portion the neural ridge, already noted on the caudal portion, extends cranially to the level of the dorsal end of the fourth branchial arch. There it terminates in a concavity which corresponds in position with the dorsal wall of the hind-brain (figs. 55, 57, 58, Pl. XIX).

Still more cranially is the convexity of the mid-brain; at that point the head bends towards the ventral surface of the embryo and it terminates in a rounded convexity, which forms the cranial boundary of the stomatodæum and which is bulged, on each side, by the projection of the rudimentary optic vesicle (fig. 57, Pl. XIX, and fig. 36, Pl. XV). There is no anterior neuropore.

The portion of the caudal part of the embryo which is seen when the model is viewed from below is a slightly concave and smooth area which forms a part of the wall of the yolk-sac; for although the area in question will eventually form part of the wall of the alimentary canal, the separation of the post-umbilical part of the alimentary canal from the yolk-sac has not yet commenced, except at the caudal end of the embryo; there a narrow, antero-posterior, cleft indicates the position of the already partially enclosed cloacal portion of the hind-gut (fig. 55, Pl. XIX).

When the model is examined from the side (figs. 56, 58, Pl. XIX) the cœlomic space is very obvious in the caudal portion of the embryo, where it intervenes between the splanchnopleure and the somatopleure, and the peculiar folding of the somatopleure, immediately before it becomes continuous with the amnion, is very noticeable. It is most obvious in the constricted region which was noted in the description of the dorsal aspect of the caudal portion (fig. 54, Pl. XIX).

On each side of the cranial portion of the embryo four branchial arches, with three intervening furrows, are easily recognised.

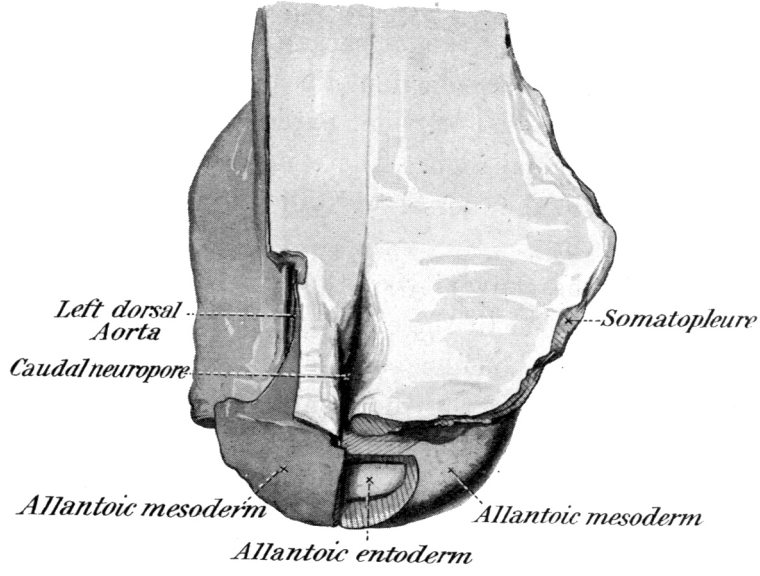
The ventral ends of the first arches are fused together at the cranial border of the pericardial region, which they separate from the stomatodæum; but the ventral ends of the three more caudally situated arches terminate on the dorsal border of

the more cranially situated portion of the bulging pericardial region. Extending caudally, from the dorsal border of the caudal part of the pericardial region, is the ridge, already noticed from the dorsal aspect, which curves round the bend of the embryo and indicates the position of the pleuro-pericardial canal of the corresponding side (fig. 56, Pl. XIX).

The Nervous System.

The neural tube is closed and it is separated from the surface ectoderm except at its caudal end. There it opens into the amniotic cavity through a narrow cleft-like caudal neuropore 100μ long (figs. 54, 57, 59, Pl. XIX, and text-fig. 22, below).

There is no sharp line of separation between the cerebral and spinal portions of



TEXT-FIG. 22.—Dorsal view of a dissection of the caudal end of the model of the embryo, showing the caudal neuropore, the terminal part of the left dorsal aorta, and the allantoic mesoderm and entoderm.

the tube, but the cerebral portion is clearly demarcated into hind-, mid-, and fore-brain sections, of which the hind-brain is the largest and the mid-brain the smallest. On account of the mid-brain flexure the fore-brain forms an obtuse angle with the hind-brain, and it lies in the anterior boundary of the fore-gut and the stomatodæum (fig. 57, Pl. XIX). It is separated from the mid-brain by a slight internal ridge and a less marked external sulcus. It shows no signs of segmentation; but from each side of its cranial end a primary optic vesicle bulges laterally, forming a projection which is visible from the external surface (fig. 36, Pl. XV).

The mid-brain also shows no signs of segmentation. It is a tube of fairly uniform calibre, and it passes without any sharp line of separation into the hind-brain.

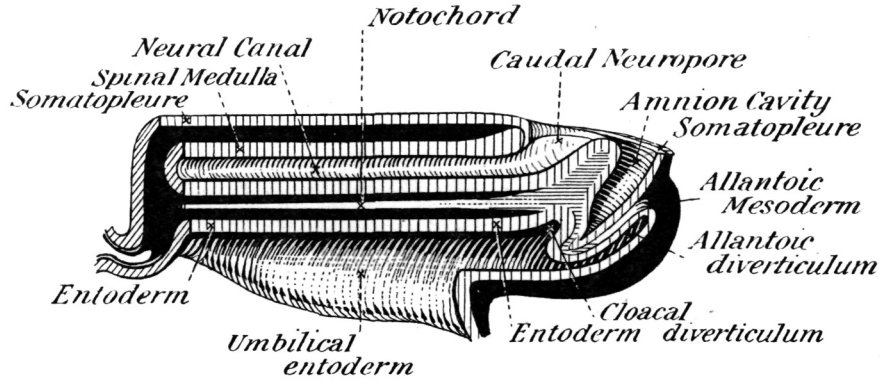
The hind-brain is curved on its long axis, the concavity of the curve being directed dorsally, and, as already stated, no definite line can be fixed at which it becomes continuous with the spinal medulla. Still, in the region immediately caudal

to the hind-brain curve there is a second curve, convex dorsally, which may be looked upon as the cervical curve; therefore the three primary flexures of the neural tube are all present: the cephalic flexure, in the mid-brain region, convex dorsally; the pontine flexure of the hind-brain, concave dorsally; and the dorsally convex cervical flexure at the region of junction of the hind-brain and the spinal medulla.

The spinal medulla runs from the hind-brain to the caudal end of the embryo, where it terminates in a mass of cells in which the hind-gut and the notochord also end (text-fig. 23, below).

Throughout its whole extent the dorsal surface of the spinal medulla lies close to the surface in the dorsal median line, and no mesoderm intervenes between it and the surface ectoderm.

As the spinal medulla passes caudally it gradually diminishes in size, and at its



TEXT-FIG. 23.—Diagram representing a medial sagittal section of the caudal end of the embryo.

caudal end, where it is not yet separated from the surface ectoderm, its central canal opens on the surface through the caudal neuropore previously mentioned (figs. 54 and 59, Pl. XIX; text-fig. 23, above).

Nerve ganglia and nerves were present, but no attempt was made to reconstruct them.

The Otic Vesicle.

Each otic vesicle is of ovoid form, but somewhat compressed in the cranio-caudal direction. It opens on the surface, at its dorsal apex, between the median plane and the dorsal end of the second visceral arch (fig. 55, Pl. XIX).

It is situated opposite the middle of the concavity of the hind-brain to the medial side of the second branchial pouch, at the level of the cranial border of the pouch (figs. 55, 58, Pl. XIX), and very distinctly caudal to the dorsal end of the first branchial pouch.

The greatest cranio-caudal length of the vesicle, in the embryo, is 150μ. Its immediate relations are: medially, the hind-brain; ventrally, the corresponding dorsal aorta; and ventro-laterally, the anterior cardinal vein.

The Alimentary Canal.

The alimentary canal comprises an ectodermal stomatodæum, an entodermal fore-gut, and a partially enclosed hind-gut. The mid-gut is not yet separated from the yolk-sac.

The Stomatodæum.

The stomatodæum is best seen from the ventral aspect. It is a relatively wide and deep recess overhung on the cranial side by the massive fronto-nasal process, and bounded laterally and caudally by the mandibular arches (figs. 56, 57, 58, Pl. XIX).

Maxillary processes of the mandibular arches and Rathke's pouch are not yet formed.

Bucco-pharyngeal Membrane.

The bucco-pharyngeal membrane is still present. It consists of ectoderm and entoderm alone. Dorsally it is attached to the ventral surface of the head, where its entodermal layer is fused with the cranial end of the notochord. Laterally and ventrally it is connected with the cranial borders of the mandibular arches (fig. 57, Pl. XIX).

Seessel's Pouch.

Immediately caudal to the dorsal end of the bucco-pharyngeal membrane there is a small dorsal diverticulum of the cranial end of the fore-gut. It obviously corresponds in position to Seessel's pouch (fig. 57, Pl. XIX).

The Fore-gut.

The dorsal wall of the fore-gut follows the contour of the ventral walls of the mid- and hind-brains (fig. 57, Pl. XIX).

In the ventral wall of the fore-gut, immediately caudal to the fused ventral ends of the mandibular arches, there is an eminence of triangular outline. It is formed by a mass of entodermal epithelium which lies immediately dorsal to the cranial end of the truncus aorticus, and it probably represents the tuberculum impar. Along each cranio-lateral border of the tuberculum impar there is a slight ridge on the ventral end of the corresponding mandibular arch; therefore at this stage there are present, already, three rudiments of the tongue (fig. 63, Pl XIX).

The median part of the caudal border of the tuberculum impar is connected, by a median ridge, with a transverse elevation which unites the ventral ends of the second branchial arches across the ventral wall of the pharynx (fig. 63, Pl. XIX).

Branchial Pouches.

Four branchial pouches are present (figs. 57, 58, Pl. XIX). The first and second are relatively voluminous. They communicate with the cavity of the pharynx by wide apertures, which are situated immediately ventral to the dorsal aorta, and

they are separated from one another by the second aortic arch. Each is provided with a dorsal and a ventral diverticulum.

The ventral ends of the first pair of branchial pouches are continuous with transverse grooves in the ventral wall of the pharynx, which are separated from one another by the median longitudinal ridge which unites the tuberculum impar with the transverse ridge between the second arches (fig. 63, Pl. XIX).

The ventral ends of the second branchial pouches are connected together by a transverse sulcus which crosses the ventral wall of the pharynx immediately caudal to the second arches (fig. 63, Pl. XIX).

The third branchial pouch is a shallow cranio-caudal evagination of the corresponding ventro-lateral border of the triangular pharyngeal cavity, and the fourth pouch is of similar character but of much smaller size (fig. 57, Pl. XIX).

The lateral borders of the third and fourth pouches can be seen in fig. 58, Pl. XIX, lying between the dorsal aorta and the dorsal wall of the right atrium immediately cranial to the duct of Cuvier.

Caudal to the region of the fourth branchial pouches the gut rapidly expands, and immediately dorsal to the cranial end of the sinus venosus its ventral wall dips slightly in the median plane, whilst, at the same level, the ventral part of each lateral wall expands into a shallow pouch. It is probable that the median depression and the lateral diverticulæ represent the rudiments of the respiratory system. This supposition is supported by the fact that each lateral diverticulum abuts against the ventro-medial wall of the corresponding pleuro-pericardial canal (text-fig. 26, p. 342, and fig. 57, Pl. XIX).

The cavities of the first and second branchial pouches are separated from the corresponding branchial cleft by ectoderm and entoderm only, but between the cavities of the third and fourth pouches and the exterior there is mesoderm as well as ectoderm and entoderm.

The Branchial Clefts.

Three branchial clefts are visible on the surface (fig. 56, Pl. XIX). They are vertical clefts, broadest and deepest at their ventral ends, which lie quite close to the pericardium, but the depth of the clefts is considerably less than that of the corresponding pouches (fig. 63, Pl. XIX).

The Branchial Arches.

Four arches are visible on the exterior aspect of the pharyngeal region, but only three on the inner aspect. On the outer aspect the first three form vertical ridges, of which the first is the longest and most massive, whilst the fourth is a rounded eminence (fig. 56, Pl. XIX). The ventral ends of the first arches are joined together in front of the cranial border of the pericardium. The ventral ends of the three posterior arches abut against the dorsal border of the bulging pericardial region.

The dorsal ends of all four arches fade away, on the dorsal aspect of the hind-brain region of the head.

On the inner surface of the ventral end of each first arch there is a slight ledge-like projection which runs along the corresponding cranio-lateral border of the tuberculum impar and fuses in front of the tuberculum with its fellow of the opposite side. These ledges probably represent the rudiments of the lateral borders and the tip of the tongue (fig. 63, Pl. XIX).

The inner portions of the ventral ends of the second arches are fused with one another across the floor of the pharynx, and the ventral ends of the inner portions of the third arches end in slight elevations, on the floor of the pharynx, but they are not yet united together in the median plane (fig. 63, Pl. XIX).

Each first and second branchial arch is traversed by the corresponding aortic arch, but no definite blood-vessels are present in the third and fourth arches. Their cores are formed by thickened bars of undifferentiated mesoderm interposed between the ectodermal and entodermal layers.

Mid-gut and Hind-gut.

There is no definite mid-gut, and only a small part of defined hind-gut. For a distance corresponding with two and a half millimetres of the embryo, caudal to the cranial border of the umbilicus—that is, caudal to the posterior border of the pericardial region—there is no trace of demarcation of gut from yolk-sac, but more caudally there is a cleft 400μ long, in the embryo, which leads into a definitely enclosed hind-gut (fig. 55, Pl. XIX).

It should be noted that the cleft is caused by infolding of the lateral parts of the splanchnopleure, and that the small cloacal chamber and the allantoic diverticulum have either been enclosed by the meeting and fusion of the lateral folds or they are diverticula from the yolk-sac, for there is no trace of any caudal fold.

There can be scarcely any doubt that, of the two diverticula from the caudal end of the hind-gut, the one which runs caudally is the allantoic diverticulum, and that which passes dorsally is either a part or the whole of the rudiment of the cloacal chamber; but it is noteworthy that, of the two, the allantoic diverticulum at this stage approaches nearer to the amnion cavity than does the cloacal diverticulum, and that the cloacal membrane is a comparatively thick mass of tissue, with but small transverse or cranio-caudal extension (text-fig. 23, p. 335, and fig. 57, Pl. XIX).

The Entodermal Cloaca.

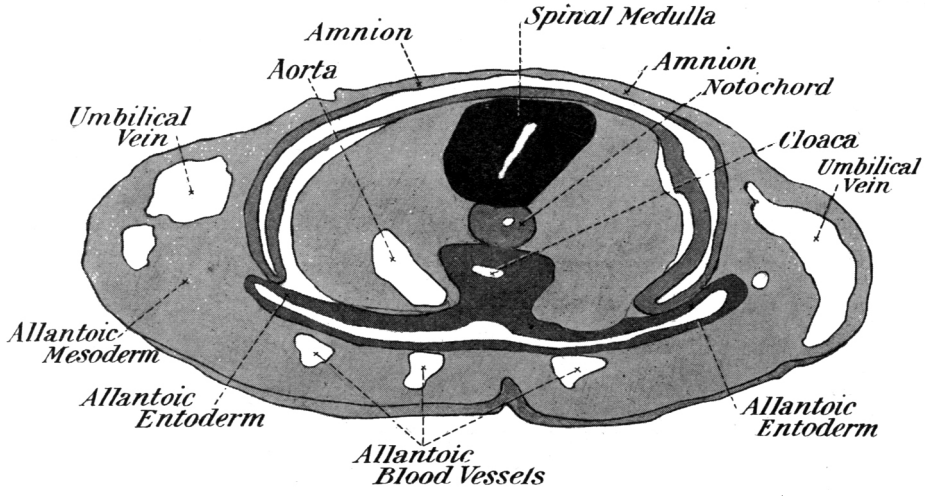
The pouch-like diverticulum from the dorsal wall of the caudal portion of the gut which represents part or the whole of the rudiment of the cloacal chamber has a cavity which is only 30μ long in the embryo. Its entodermal epithelial wall is thick, and at its caudal end it fuses, dorsally, with a terminal mass of cells in which end the

epithelium of the gut wall, the spinal medulla, and the cells of the caudal end of the notochord. In other words, the epithelium of the dorsal end of the cloacal diverticulum fuses with the longitudinal growth centre of the embryo; but the epithelium which forms the caudal boundary of the diverticulum abuts against the surface ectoderm of the tail amnion fold, from which it is separated, in places, by a very thin layer of cells which appear to be of mesodermal nature. This portion of the epithelial wall of the cloacal chamber, therefore, takes part in the formation of the very small cloacal membrane which separates the cloacal chamber from the amniotic cavity (text-fig. 23, p. 335, and fig. 57, Pl. XIX).

The Allantois and its Blood-vessels.

The allantois is of small size (text-fig. 24, below, and figs. 55, 56, 57, 61, Pl. XIX). It consists of the allantoic diverticulum from the hind-gut and the somatic mesoderm which covers it.

The allantoic diverticulum is a narrow-necked sac so flattened dorso-ventrally that



TEXT-FIG. 24.—Slightly oblique section through the caudal end of the embryo immediately posterior to the angle between the cloacal chamber and the allantoic diverticulum. The section shows the small cloacal chamber, the flattened allantoic diverticulum, and the hollow notochord.

its cavity is reduced to the dimensions of a narrow cleft (text-fig. 23, p. 335, and fig. 57, Pl. XIX).

The diverticulum commences by a narrow neck 50μ wide, but, as it passes caudally, into the somatic mesoderm beneath the caudal part of the amnion, it expands till it attains, in the embryo, a width of 235μ (fig. 61, Pl. XIX). The entodermal diverticulum is surrounded laterally, ventrally, and caudally with mesoderm, but dorsally it lies in relation with the ectoderm in the region of the caudal end of the amnion. It is possible, therefore, that both the dorsal and the ventral diverticula are portions of the common cloacal chamber, and that the portion of the embryo

between their extremities which lies immediately adjacent to the amnion cavity is part of the cloacal membrane; in that case the entodermal allantoic diverticulum has not yet formed, and the allantois is merely represented by the vascular mesoderm which covers the posterior part of the cloacal chamber. Which of the two views is the more correct can only be decided by the examination of somewhat older specimens, and they are not at present available. In the meantime the indications are that the caudal diverticulum is allantoic on account of its narrow communication with the remainder of the hind-gut and its relation to a capillary plexus of blood-vessels which communicate on the one hand with the dorsal aortæ and on the other with the umbilical veins (figs. 60, 61, Pl. XIX).

The allantoic blood-vessels consist of a number of dilated capillaries which form a coarse network on each side. Each lateral network receives two branches from the caudal end of the dorsal aorta of the same side, and it terminates, at the caudal end of the allantoic mass, in a terminal transverse sinus from which the umbilical veins take their origin (figs. 59, 60, 61, Pl. XIX). But, in addition to the connection with both umbilical veins through the terminal sinus, each vascular network also communicates directly with the umbilical vein of the same side (fig. 60, Pl. XIX).

The Notochord.

The notochord extends from the dorsal end of the bucco-pharyngeal membrane, with which it is continuous, to the growing point at the caudal extremity of the embryo, where it fuses with the mass of cells in which the spinal medulla and the entoderm of the caudal end of the alimentary canal also end.

In the greater part of its extent it is a rounded cord of cells, but the cranial and caudal portions differ from the longer intermediate part, which intervenes between them.

Where it lies ventral to the adjacent parts of the hind- and mid-brain it is triangular in outline, in transverse section. Nearer the cranial extremity of the embryo it is flattened and forms a strap-like strand, with a dorsal and ventral edge and right and left surfaces. The dorsal edge lies free, ventral to the brain, whilst the ventral border is fused with the entoderm of the dorsal wall of the fore-gut. Its cranial extremity is fused, as previously stated, with the dorsal border of the entodermal layer of the bucco-pharyngeal membrane.

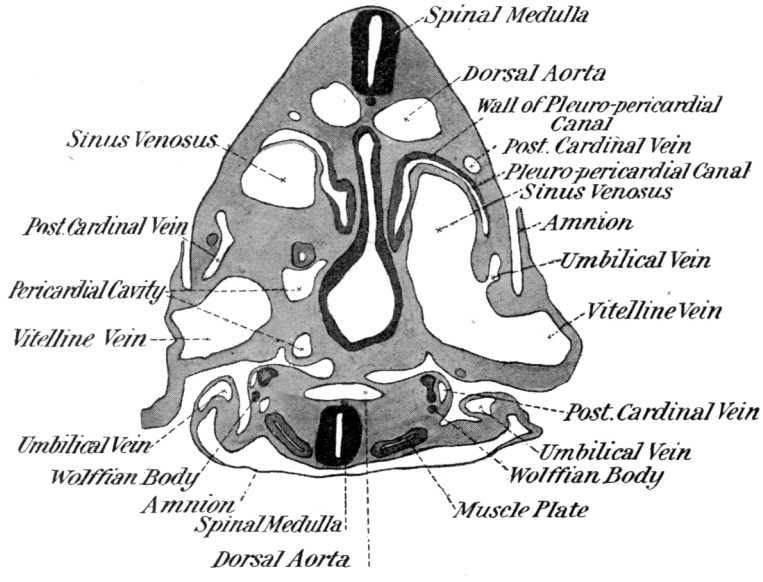
The caudal portion of the notochord is also cylindrical, but it is of considerably greater diameter than the more cranially situated part. Shortly before it reaches its caudal end, for a distance of 110μ, in the embryo, it becomes a hollow tube (text-fig. 24, p. 339, and fig. 52, Pl. XVIII), and this portion is bent slightly towards the left side of the embryo. Its caudal extremity fuses with the mass of cells which forms the growth centre at the caudal end of the body.

The Vascular System.

The Heart.—The heart includes (1) a large sinus venosus; (2) a sinu-atrial canal; (3) a ventricle; (4) an atrio-ventricular canal; (5) a bulbus cordis; and (6) a truncus aorticus.

The sinus venosus is large. It forms the most caudal part of the heart, and lies in the curve of the bent embryo.

It is somewhat cuboidal in form. It is in relation dorsally, and near the median plane, with the ventral wall of the fore-gut, and, on each side, with the ventral wall of the corresponding pleuro-pericardial canal, into which it bulges (text-figs. 25, 26, below and p. 342, and fig. 58, Pl. XIX).

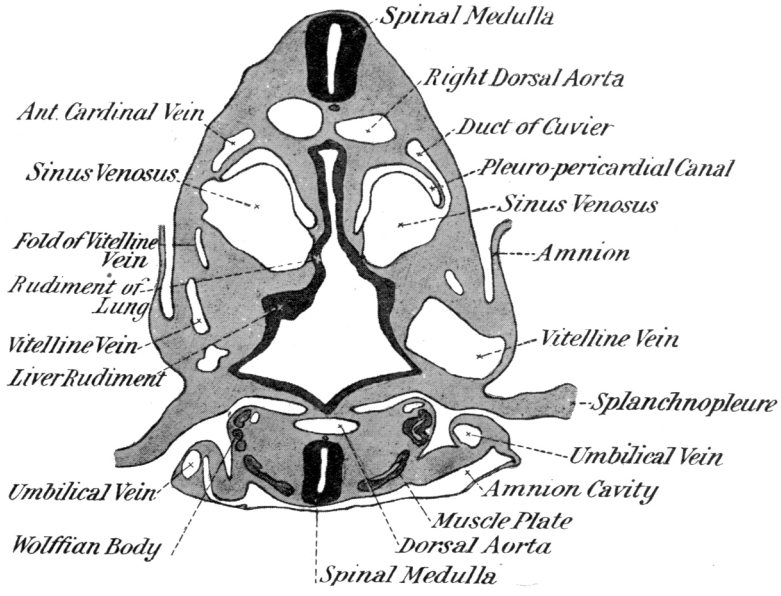


TEXT-FIG. 25.—Oblique section through the embryo along the line 1, fig. 58, Pl. XIX.

On account of the curvature of the embryo the ventral part of the sinus venosus has a comparatively reduced cranio-caudal extent, as contrasted with the dorsal part; and at its caudal end, near the median plane there is a slight evagination which may possibly be the rudiment of the cranial end of the inferior vena cava, but at this stage the evagination in question has no connection with any venous channel in the liver region. The cephalic end of the sinus opens through a short and wide sinu-atrial canal into the caudal part of the atrium. The position of this canal is marked on the exterior, on each side, by a very definite sulcus (fig. 57, Pl. XIX).

The tributaries which open into the sinus are the two vitelline veins, the two umbilical veins, and the two ducts of Cuvier. Each vitelline vein enters at the caudal end of the corresponding lateral border of the sinus. The terminations of the umbilical veins are close to those of the vitelline veins, but are situated a little more medially and more dorsally. The short duct of Cuvier, on each side, enters the cranial end of the sinus on its dorsal aspect and near the lateral border (fig. 58, Pl. XIX).

The Atrium.—Even when the shrinkage (figs. 57, 62, Pl. XIX) which the atrium has undergone has been fully taken into account, it is obviously a smaller chamber than the sinus venosus. It lies more towards the left than the right side of the embryo, cranial to the sinus venosus and dorsal to the left portion of the ventricular chamber (figs. 57, 58, 62, Pl. XIX). Its dorsal wall lies close to the ventral wall of the fore-gut, in the region of the ventral ends of the second and third branchial pouches, and, as it bulges towards the fore-gut, it is largely responsible for the elevation which forms the ridge-like caudal boundary of the groove which connects the ventral ends of the second branchial pouches together (figs. 57, 63, Pl. XIX). The ventral wall of the atrium lies in relation with the dorsal wall of the left portion of the ventricle, into which it opens through a short but distinct atrio-ventricular canal (fig. 62, Pl. XIX).



TEXT-FIG. 26.—Oblique section through the embryo along the line 2, fig. 58, Pl. XIX.

To the left of the atrio-ventricular canal the left margin of the atrium projects ventrally, forming the rudiment of the left auricle. The right auricular portion of the atrium which lies medial and caudal to the bulbus cordis is not so distinctly deliminated.

The Ventricle.—The ventricle forms the most ventral portion of the heart. It crosses the median plane from left to right, but lies more to the right than to the left side (figs. 55, 56, 62, Pl. XIX). Its ventral wall, on the left side, is deeply invaginated, a condition obviously due to shrinkage, for in the drawings of the fresh specimen the ventricular area is uniformly convex. There is already definite surface indication of the separation of the ventricle into right and left portions (fig. 62, Pl. XIX).

The bulbus cordis commences at the cranial end of the right segment of the ventricle and it runs medially and dorsally till it reaches the median plane, where it

terminates in a short truncus aorticus (figs. 58, 62, Pl. XIX). The truncus aorticus lies dorsal to the ventricle, cranial to the atrium, and, at its termination, it is on the right side of the atrio-ventricular canal (fig. 62, Pl. XIX).

Truncus Aorticus.—The short truncus aorticus extends from the bulbus cordis to the ventral wall of the fore-gut, where, immediately ventral to the ventral ends of the first branchial pouches, it terminates by dividing into four branches, two on each side. The more cranially situated branches are the ventral roots of the first aortic arches; the more caudally situated branches are the second aortic arches.

The Aortic Arches.—Two aortic arches are present on each side.

The ventral root of the first arch runs cranialwards from the truncus aorticus, below the aperture of the first branchial pouch, to the ventral end of the mandibular arch; there it turns dorsally and becomes the first aortic arch.

The first aortic arch runs dorsally, along the cranial border of the aperture by which the first branchial pouch communicates with the pharynx (figs. 58, 63, Pl. XIX), and at the level of the dorsal margin of the aperture it turns caudally and becomes the dorsal root of the first arch. The dorsal root of the first arch terminates by joining the dorsal end of the second arch at the level of the otic vesicle and ventral to the anterior cardinal vein (fig. 58, Pl. XIX).

The second aortic arch runs directly dorsally, through the second branchial arch, from the truncus aorticus to the caudal end of the dorsal root of the first aortic arch, with which it unites to form the commencement of the dorsal aorta (fig. 58, Pl. XIX).

The Dorsal Aortæ.—The dorsal aortæ run from the dorsal ends of the second aortic arches to the caudal end of the embryo, where they terminate by breaking up into branches which join the capillary plexus of the allantois (figs. 58, 59, 60, 61, Pl. XIX). In the head region each dorsal aorta lies medial to the dorsal extension of the second branchial pouch of the same side, and then along the dorsal surface of the lateral margin of the more caudal part of the pharynx. In the thoracic region it is run along the dorso-lateral border of the gut, dorsal to the pleuro-pericardial canal of the same side (text-figs. 25 and 26, pp. 341, 342). Near the caudal end of the fore-gut, and in the transverse plane in which the vitelline veins join the sinus venosus, the two dorsal aortæ fuse together to form a single trunk. This trunk lies in the median plane, dorsal to the yolk-sac and ventral to the notochord, until within a short distance from a point near the cranial end of the cleft which indicates the position of the hind-gut. There it separates again into a right and a left dorsal aorta which run caudally, in the angles between the spinal medulla and the dorsal wall of the hind-gut, to their terminations in the allantoic region (figs. 58, 59, 60, 61, Pl. XIX). A short distance from its termination the caudal portion of each dorsal aorta gives off large branches to the wall of the yolk-sac, and a number of branches which pass ventrally to the allantoic capillary plexus already described (p. 340).

The Anterior Cardinal Veins.—Each anterior cardinal vein commences near the

dorsal end of the mandibular arch by the union of a number of radicles. From its commencement, it runs, first caudally and then ventrally, to its termination in the duct of Cuvier of the same side. In the cranial part of its course it lies dorsal to the dorsal root of the first aortic arch and the most cranial part of the dorsal aorta, ventral to the otic vesicle, and medial to the dorsal extensions of the first and second branchial pouches. As it reaches the thorax it turns ventrally and crosses the lateral side of the dorsal aorta a short distance caudal to the fourth branchial pouch (fig. 58, Pl. XIX).

The Posterior Cardinal Veins.—Each posterior cardinal vein commences in the mesoderm near the caudal end of the embryo, and, as it runs towards the cranial end of the body, it lies at first ventral to the corresponding Wolffian duct, then dorso-lateral to the duct, and next on the ventro-lateral aspect of the more cranially situated portion of the Wolffian body. After leaving the Wolffian body it runs along the dorso-lateral wall of the pleuro-pericardial canal (fig. 58, Pl. XIX), and, shortly before its termination in the duct of Cuvier, it lies dorsal to the more caudal part of the sinus venosus (fig. 58, Pl. XIX).

Ducts of Cuvier.—Each duct of Cuvier is formed by the union of the anterior and posterior cardinal veins of the same side opposite the cranial end of the dorsal wall of the sinus venosus, and a short distance caudal to the fourth branchial pouch (fig. 58, Pl. XIX). It is quite a short vessel, which is compressed from side to side, and which runs ventrally and somewhat caudally round the lateral wall of the pleuro-pericardial canal, to its termination in the sinus venosus (text-figs. 25 and 26, pp. 341, 342).

The Vitelline Veins.—The right and left vitelline veins are the largest blood-vessels of the embryo, and each terminates in the corresponding ventro-lateral angle of the caudal portion of the sinus venosus. The orifice of termination of each vein is quite distinct from that of its fellow of the opposite side.

The Umbilical Veins.—Each umbilical vein takes origin from the transverse sinus which lies in the allantoic mesoderm at the caudal end of the body of the embryo, and it receives a number of additional tributaries from the capillary plexus in the allantoic mesoderm (figs. 59, 60, 61, Pl. XIX). As it passes towards the heart each vein lies in the most lateral part of the body wall of the corresponding side, and it terminates, in the dorsal wall of the caudal part of the sinus venosus, a little dorsal and medial to the termination of the vitelline vein (text-figs. 25, 26, pp. 341, 342, and fig. 58, Pl. XIX).

The Cœlom.—The greater part of the intra-embryonic portion of the cœlom is a narrow cleft, which communicates freely with the extra-embryonic cœlom at the margins of the embryo and at its caudal end. The more cranially situated portion of the cœlom is enclosed, and it forms a pericardial cavity and two pleuro-pericardial canals.

The pericardium surrounds the heart. Its cranial extremity is situated at the level of the second branchial arch. The caudal end lies at the cranial border of the

umbilicus, where the cavity of the pericardium is separated from the extra-embryonic cœlom by the mesodermal septum transversum.

At its dorsal boundary on each side, at the level of the fourth branchial pouch and the cranial border of the duct of Cuvier, the pericardium communicates with a pleuro-pericardial canal (fig. 58, Pl. XIX).

The Pleuro-pericardial Canals.—Each pleuro-pericardial canal commences from the dorsal part of the pericardial cavity, at the level of the cranial border of the duct of Cuvier. It runs from the more cranially situated to the more caudally situated end of the bend of the embryo, terminating, in the latter situation, in what will eventually be the peritoneal portion of the cœlom. As it passes between its two terminations it lies medial to the duct of Cuvier; dorsal to the sinus venosus, by which its ventral boundary is invaginated; and ventral to the dorsal aorta and the posterior cardinal vein of the same side (text-figs. 25, 26, pp. 341, 342, and fig. 58, Pl. XIX).

DESCRIPTION OF FIGURES ON PLATE XIX.

Fig. 54. Dorsal view of the caudal portion of a reconstruction of a horse embryo 11 mm. long.

Fig. 55. Dorsal view of the cranial portion of the reconstruction, and ventral view of the most caudal part of the caudal portion, of a horse embryo 11 mm. long. Both portions have been partially dissected.

Fig. 56. Left lateral view of a reconstruction of a horse embryo 11 mm. long. A portion of the heart is shown, and the lines of incision for the removal of the ventral wall of the pharynx and the dorso-lateral wall of the left pleuro-pericardial canal are shown.

Fig. 57. View of a median section of a reconstruction of a horse embryo 11 mm. long. The heart has not been divided, and its left side is shown.

Fig. 58. Right lateral view of a reconstruction of a horse embryo 11 mm. long. The reconstruction has been dissected to show the relations of the branchial pouches and the otic vesicle to the blood-vessels and the heart.

Fig. 59. Dorsal view of the caudal end of a reconstruction of a horse embryo 11 mm. long. Dissected to show terminal part of right dorsal aorta.

Fig. 60. Ventral view of the caudal end of a reconstruction of a horse embryo 11 mm. long, showing the blood-vessels.

Fig. 61. Dissection of the ventral portion of the caudal end of a reconstruction of a horse embryo 11 mm. long, showing cavities of allantoic diverticulum and hind-gut.

Fig. 62. Ventral view of a reconstruction of the heart of a horse embryo 11 mm. long.

Fig. 63. View of the dorsal aspect of the ventral wall of the pharynx of a horse embryo 11 mm. long, showing section of the first three branchial arches and sections of the first and second aortic arches.

Note.—Figs. referred to, other than those on Plate XIX, are in the Plates of Professor Cossar Ewart's paper.

[Key to Lettering

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KEY TO LETTERING OF FIGURES ON PLATE XIX.

1AA. First aortic arch.
2AA. Second aortic arch.
Al. Allantois.
Alb. Allantoic branches of aorta.
AlD. Allantoic diverticulum.
AlM. Allantoic mesoderm.
Am. Amnion.
ACV. Anterior cardinal vein.
Ana. Anastomoses, between allantoic arteries and umbilical veins.
APpC. Arrow in pleuro-pericardial canal.
AT. Atrium.
AVC. Atrio-ventricular canal.

1BA. 1st branchial arch
2BA. 2nd ,, ,,
3BA. 3rd ,, ,,
4BA. 4th ,, ,,
BC. Bulbus cordis.
1BC. 1st branchial cleft.
2BC. 2nd branchial cleft.

BM. Bucco-pharyngeal membrane.
1BP. 1st branchial pouch.
2BP. 2nd ,, ,,
3BP. 3rd ,, ,,
4BP. 4th ,, ,,

Cl. Cloaca.
CN. Caudal neuropore.

DA. Dorsal aorta.
DC. Duct of Cuvier.

FB. Fore-brain.

HB. Hind-brain.
HG. Hind-gut.

Lu. Rudiment of lungs.

MB. Mid-brain.

Nc. Notochord.
NeC. Neural canal.

OV. Otic vesicle.
OtV. Otic vesicle.

PCV. Posterior cardinal vein.
PoV. Primary optic vesicle.
Ppr. Pleuro-pericardial ridge.

Sm. Somatopleure.
Sp. Splanchnopleure.
SpM. Spinal medulla.
SV. Sinus venosus.

TA. Truncus aorticus.
TI. Tuberculum impar.
TS. Terminal sinus.

UV. Umbilical vein.

V. Ventricle.
VV. Vitelline vein.

For ZBP, fig. 55, *read* 2BP.

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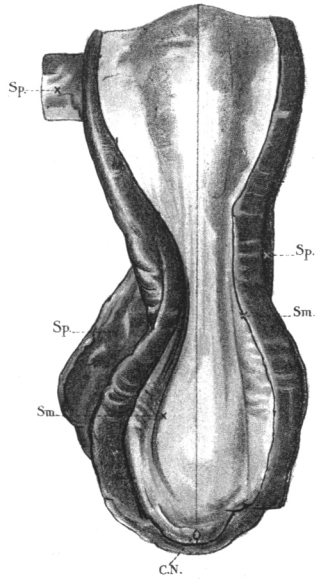
GIBSON AND ROBINSON: MODEL OF HORSE EMBRYO.—PL. XIX.

54



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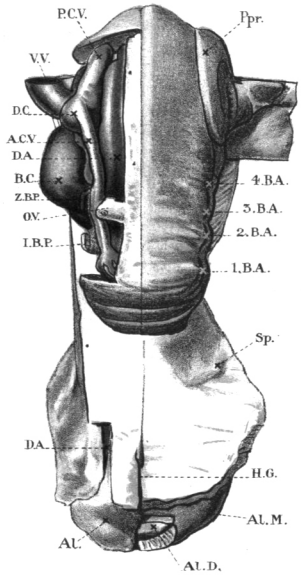

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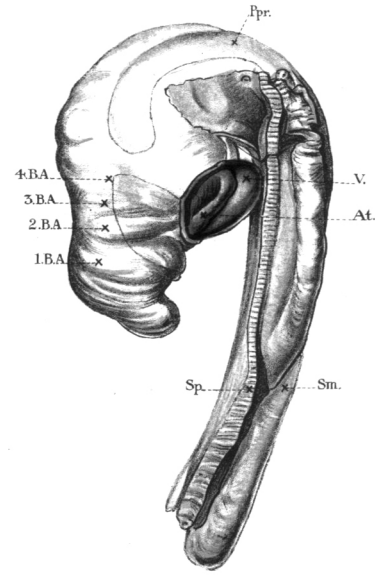

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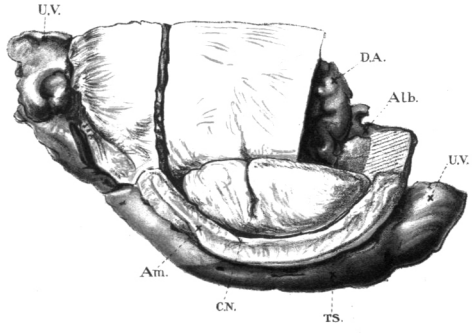

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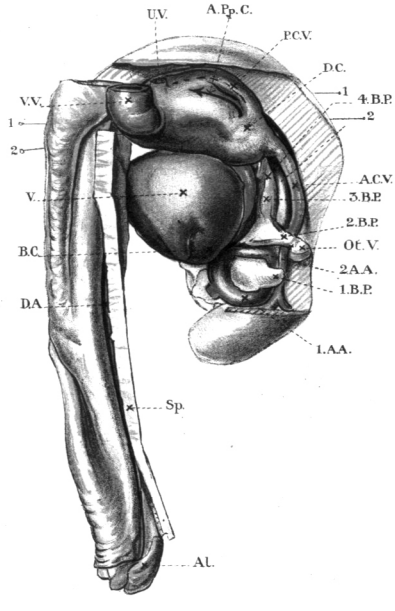

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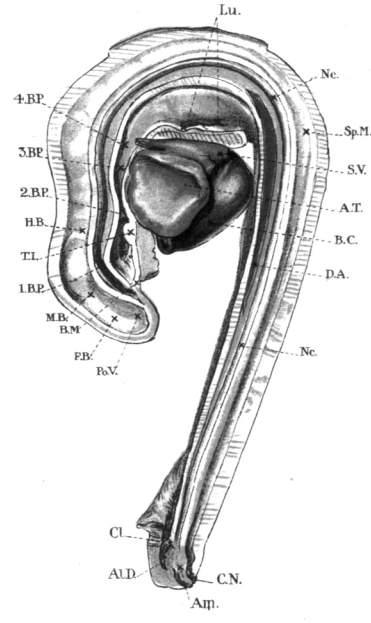

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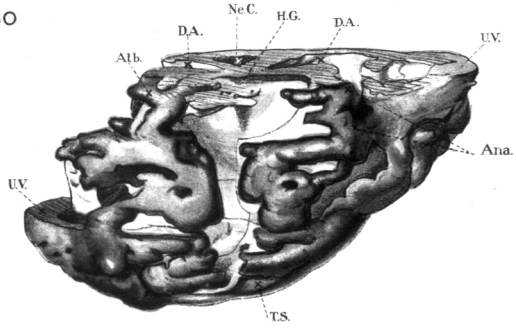

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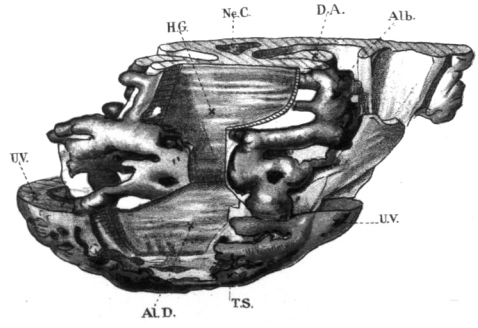

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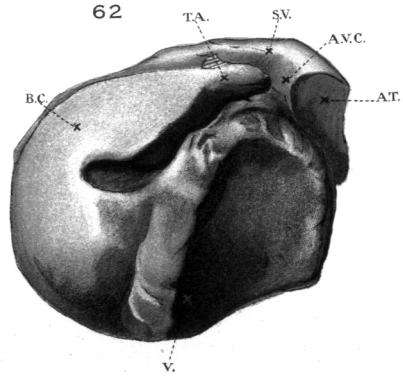

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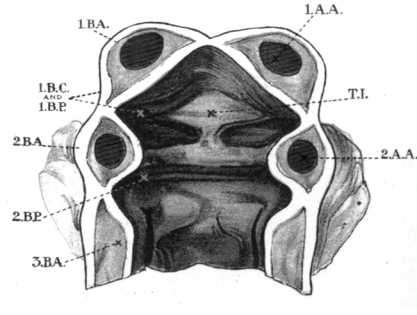

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