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HAS the umbilical cord at any period of its existence a tubular investment of the amnion?

The present investigation was undertaken in order to arrive at a satisfactory answer to this question; for on looking into the subject of the development of the umbilical cord in many of the recently published works relating to the science of midwifery, it was surprising to find how few of the authors of such

works agree on this question—many writers stating that the cord has a tubular sheath of the amnion, and they even describe the steps in the development whereby such an anatomical arrangement is brought about, and also give illustrations in support of their statements, while others, following the good work of Charles Sedgwick Minot, the Professor of Human Embryology in the Harvard Medical School, hold an entirely opposite view. Minot's large work on "Human Embryology" was published in New York in 1892. At page 357 in his book, when describing the development of the umbilical cord, he writes: "The development of the cord shows that it is never covered by the amnion, which, on the contrary, is always separate from the cord proper. This point is important to note because in most text-books the cord is erroneously described as covered by the amnion."

This clear and definite statement by Minot was published in 1892, yet many recent authors have either not noticed it or have passed over it as of no value. Minot's description, however, of the conversion of the ventral string, or Bauchstiel, into the umbilical cord is so difficult to follow that it is not unlikely that many authors have failed to interpret it. Here is Minot's description of the steps in development by which the Bauchstiel is converted into the umbilical cord. At page 357 in his book on "Human Embryology," he writes as follows:

"To convert the Bauchstiel into the umbilical cord, the somatopleure bends down on each side, and finally closing on the ventral side below the allantois, shutting in a portion of the cœlom, and becomes separated from the amnion. The amnion separates from the embryo first, then from the embryonic end of the Bauchstiel, and last of all from the distal end of the Bauchstiel; hence, when the closure of the somatopleure is completed, the amnion arises no longer from the embryo, but only from the end of the cord, where it joins the chorion. The closure of the Bauchstiel forms a long tube running from the embryo to the chorion. The cavity of the tube is part of cœlom, the whole tube is known as the umbilical cord." It must be confessed that it is difficult to follow Minot in this description. But it is quite evident that Minot's important conclusion regarding the relation of the amnion to the cord was the result of his careful observations concerning the development of the human embryo

from its earliest condition ; and it is only by a careful study of the development of embryos, both human and animal, that one can get at the truth regarding this interesting question of the relation of the amnion to the umbilical cord.

Unfortunately it is very difficult to obtain human embryos ; but such a study in embryology can be well carried out with the aid of embryos of deer, sheep, and pigs, which may be secured in all stages of development. The results obtained from the study of these particular embryos do not differ in any essential point from the results described by His and Minot in their work with human embryos.

My own work has been entirely carried out in connection with the embryos of deer and sheep and pigs, of which I secured a large number.

The first embryo examined by myself was one taken from the uterus of a large red deer. It reached me from the country on the 28th November 1899. As soon as it was removed from the uterus it was placed in a weak solution of bichloride of mercury. As to the age of this embryo it was difficult to speak accurately ; but the gamekeeper who sent it to me on my asking him as to its age, wrote as follows : " The chief 'rut' takes place here between the 25th October and 5th November ; but always a few does come earlier and a few later. The seasons do not differ much, not more than three or four days between an early and a late season. The does go with young eight months." The embryo measured just six mm. in length, not more, as it lay on its back in a weak solution of bichloride of mercury. It was placed under a specially prepared microscope and then drawn by a skilled artist.

It is represented in Fig. 1 Plate i. just as it appeared under the microscope—and every care was taken to represent all parts accurately as regards size and relation to each other.

The letters A and B point to its head, on which the cerebral vesicles were well marked. The head itself was enclosed in a globular amnion bag, O O, through which the head could be clearly seen. Immediately below the head and touching it, and extending away almost at right angles was the large collapsed yolk sac E, on whose surface numerous blood vessels could be seen.

The yolk sac E was seen to be attached to the primitive intestine by a narrow tube-like structure C, which was scarcely

thicker than the intestinal tube itself. The proximal end of the head within the amnion bag appeared to rest on the yolk sac just at the spot where the yolk sac itself was attached to the primitive intestine, as depicted in the figure.

Above and below the point of attachment of the yolk sac to the intestine the whole body cavity was widely open, and the primitive intestine was seen occupying the middle line as it passed downwards to the caudal end of the embryo, and it preserved the same thickness of tube the whole distance as far down as the origin of the allantois and the allantoic blood-vessels.

The length of the body cavity was about three times its greatest breadth, and at its margins it was boat-shaped.

At the sides of the intestinal tube in its course downwards towards the caudal end of the embryo could be seen two prominent ridge-like structures, F and G. In transverse sections of this embryo afterwards to be described, these ridges were found to be the Wolffian bodies, one on each side of the intestine.

At the extreme caudal end of the embryo the allantois, H H, with its large blood-vessels, K K, could be seen passing outwards over the ventral surface of the embryo on its way towards the chorion, and rapidly expanding transversely into a large bladder-like structure on whose surface could be seen numerous blood-vessels. The blood-vessels K K, and their numerous branches were gorged with embryonic blood-corpuscles.

The allantoic bladder was punctured with a fine needle and a quantity of clear fluid escaped. It is interesting to note in connection with this escape that the primitive intestinal tube and the genito-urinary ducts communicate with the allantoic bladder in such a young embryo. The large blood-vessels, K K, and the allantois itself were enclosed in thick embryonic vascular mesoblastic tissue, which thinned out over the greatly distended allantoic vesicle, as it expanded between the true and false amnion sacs. It was not possible to see any trace of limbs in this young embryo.

The most striking features in the view of this young embryo before us were the comparatively small size of the tubular connection between the yolk sac and the intestinal tube, and at same time, the extreme length of the intestinal

tube itself below that point of communication, and the large size of the open body cavity was very remarkable. The relative sizes and dimensions of all these parts and their proper relation to each other have been carefully preserved in the drawing.

Before proceeding further with our description of these young embryos it is necessary now to say something regarding the cleavage of the mesoblast and the formation of the large body cavity which we have just shortly described, in order that we may become better acquainted with the numerous terms and their significance, used in such an embryological study.

The description of the cleavage of the mesoblast as given in Quain's "Anatomy" at page 36, vol. i. part 1 (Embryology), is so excellent, that we cannot do better than give the very words, and at same time make use of an admirable diagram taken from Minot's work on "Human Embryology" to assist in the description.

At page 36 in Quain's "Anatomy" there is a drawing taken from Kölliker's work representing a transverse section of an embryo chick, in which are represented the medullary folds and the neural canal just closing, also the paraxial mesoblast, and the lateral mesoblast. There is also shown the epiblast, the hypoblast, the primitive aortæ, the notochord and the cœlomic cleavage of the lateral plate of mesoblast.

As regards the cleavage of the mesoblast and the formation of the body cavity, it is thus written : "At a very early period, soon, indeed, after the formation of the neural groove, two important changes begin in the mesoblast. One of these is the cleavage of the lateral mesoblast (which is at first a continuous sheet) into two plates, one of which clings to the epiblast and the other to the hypoblast. The cleft is at first small, but accumulation of fluid within it soon converts it into a cavity, which gradually spreads until the separation is very extensive. The layer of mesoblast which clings to the epiblast, eventually forms part of the body wall, and is known as the *somatopleure* : that which clings to the hypoblast forms eventually part of the wall of the alimentary tract, and is known as the *splanchnopleure*. The cavity between these, which is formed by the enlargement of the original cleft, is the cœlom, or body cavity (pleuroperitoneal cavity of authors)."

Fig. 3 shows the formation of the body cavity, Coe,

by the splitting of the lateral mesoblast into two layers, one of which joins with the epiblast to form the *somatopleure*, Som, while the other joins the hypoblast to form the *splanchnopleure* Spl, which encloses the intestinal tube In, and which

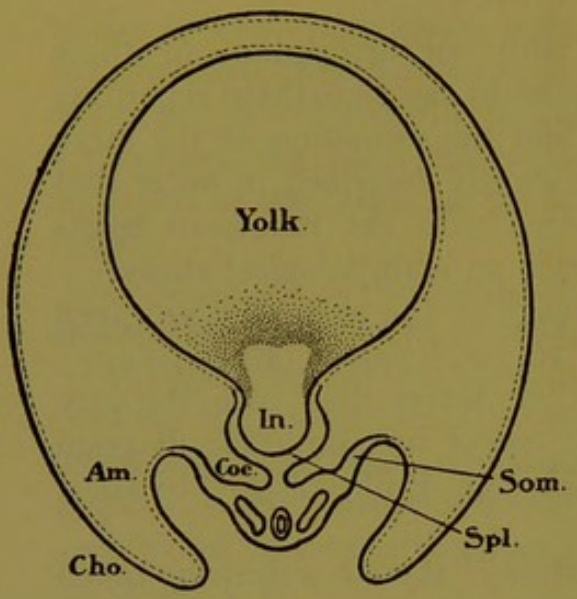


Fig. 3.

Am = Amnion.
Coe = Cœlom.
Cho = Chorion.
In = Intestine.

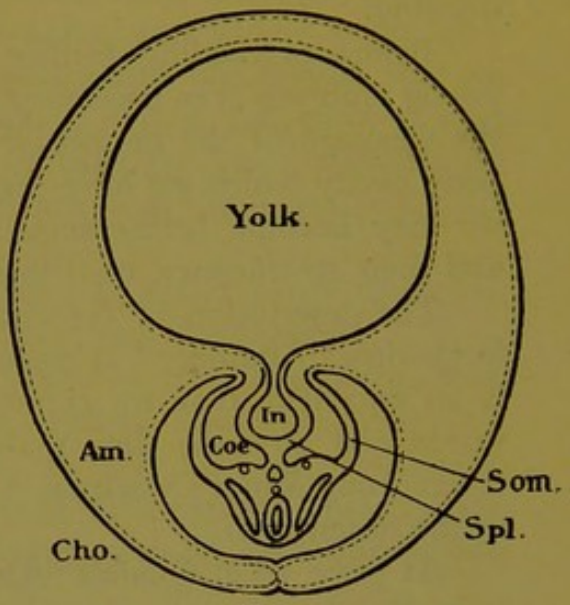


Fig. 4.

Som = Somatopleure.
Spl = Splanchnopleure.
Yolk = Yolk sac.

is still in communication with the yolk sac by the vitelline foramen.

In this figure the lateral somatopleure folds are seen rising up and closing over the dorsum of the embryo ; and in Fig. 4 they are represented as having come together in the middle line ; and as the line of junction gradually absorbs, the true and false amnion are thus formed. The true amnion, Am, immediately surrounds the embryo. Its cavity is lined by the epiblast. The outer or false amnion, or chorion, is lined by the mesoblast layer, while the epiblast is on the outside. In both figures the dotted lines represent the mesoblastic layers which are always opposed to each other in the encasing membranes. "The mesoblast of the one is separated from that of the other by a space occupied by fluid and continuous with the cœlom, with which, in fact, it remains continuous until the body walls of the embryo have entirely grown round and coalesced on the ventral surface, the final point of coalescence being the umbilicus."

"In the latter stages of gestation the space between the

amniotic and chorionic mesoblast disappears, and these two membranes become loosely united by a jelly-like connective tissue. When the body walls have thus closed in around the yolk sac the latter, greatly diminished in size, lies altogether outside the body of the young animal and is surrounded by the umbilical foramen and communicates with the primitive intestine by means of the vitelline duct, the orifice of communication being termed the vitelline foramen."

Regarding the formation of the allantois, at page 44 in Quain's "Anatomy" we read, "the time of development of the allantois seems to vary very much in mammals; and there is reason to believe that it is found in the human embryo at a very early period. Indeed, the earliest human embryos that have hitherto been described already possess an allantois. In most animals in which its development has been studied, the allantois has been found to begin as a hollow prolongation of the posterior end of the alimentary canal. It soon, however, becomes relatively shifted in position so as to come off from the ventral wall of the hind gut, growing into the posterior extension of the mesoblastic cleft, and eventually into the space between the true and false amnion and carrying along with it its mesoblastic covering.

It is therefore composed eventually of two parts (1) a hypoblastic sac which communicates, at first widely, but afterwards by a narrowed orifice, with the hind gut, and (2) an investment of mesoblast. This last is usually greatly thickened and very vascular, and is directly supplied with blood by two arteries (allantoic or umbilical arteries) which appear at first as a direct continuation of the primitive aortæ. As the allantoic vesicle expands into the cavity of the false amnion it carries the vascular mesoblast along with it, so that this mesoblast is thus brought to the inner surface of the chorion, over which the blood-vessels then spread, so as to convert this hitherto non-vascular membrane into one which is richly supplied with blood-vessels.

The chorion has grown in the form of ramified villi into the substance of the mucous membrane or decidua, even before this advent of the vascular tissue of the allantois, but the chorionic villi now receive blood-vessels, and thus become vascularised, the interchanges between the fœtal and maternal vascular systems, which are afterwards confined to one region only

of the chorion and decidua—that which forms the placenta—occurring in the first instance over the whole superficies of the ovum.

In the earliest human ova, in which the allantois has been investigated, it is already a tube of hypoblast which forms a direct prolongation of the posterior end of the alimentary canal, and is enclosed in a short stalk of mesoblast by which the posterior end of the embryo is attached to the chorion, and through which, by the allantoic (umbilical) blood-vessels, the chorionic villi are freely supplied with blood.

The stalk in question is not the umbilical cord, since it does not include the stalk of the yolk sac (vitelline duct), which only later becomes bound up with it.

This stalk is termed by His the abdominal stalk (Bauchstiel), the term allantois being by him restricted to the hypoblastic diverticulum."

In our further examination of this embryo, it was then turned over in such a way, that a good view was obtained of its dorsal parts. It was placed under a binocular microscope, and illuminated by means of concentrated light rays, and then drawn by the same skilled artist as before.

The appearance of the dorsal parts of this embryo is well shown in Fig. 2 Plate ii.

The head of the embryo could not be shown, but the globular bag-like amnion, O O, enclosing the head was well seen, and it was found to be continuous with the amnion, which closely invested the whole dorsal surface of the animal. The amnion everywhere as it passed off the dorsal surface was found to be attached to the margins of the large body cavity which was so well seen in the first view of this embryo. The embryo was again turned on to its back, and then the amnion could be traced coming off the dorsal surface everywhere to be attached to the margin of the widely open body cavity, or, as we shall now call it, the widely open umbilical foramen. The large but shrivelled-up yolk sac could be seen passing outwards from under the head towards the left of the animal. The amnion membrane as it covered the dorsal surface was almost transparent, and no blood-vessels could be seen in its substance.

A remarkable linear structure was seen in the substance of the left wall of the embryo. It is indicated by the letter G in

the drawing, and was found to be a large vein gorged with embryonic blood corpuscles coursing downwards from the region of the heart, in the substance of the lateral wall, to be continuous with the large allantoic vein, K, which was connected with the allantoic vascular circulation. On the right side a similar vein was seen. These allantoic or umbilical veins were found to lie external to the allantoic arteries, which are direct prolongations of the primitive aortæ, as they coursed over the allantois at its origin. As they left the lower end of the embryo with the allantois these blood-vessels were found to be encased in thick mesoblastic tissue derived from the lateral walls of the embryo.

It is necessary to direct special attention to the presence of these large veins in the side walls of the embryo. These side walls at this stage of development are known as the lateral somatopleure folds, and it is proper now to describe these large umbilical or allantoic veins as lying in the substance of the lateral somatopleure folds, as they pass downwards from the region of the heart towards the allantoic vesicle, over which they are distributed. In the transverse sections, to be described later on, it will be seen that these large umbilical veins lie in the substance of the somatopleure folds just at the line where the folds turn outwards and become continuous with the amnion as it passes over the dorsal surface of the embryo.

Another very important structure to direct attention to is the rump end of this little embryo, which projects considerably beyond the origin or root of the ventral string or allantoic outgrowth. In the Figure 2 Plate ii., the allantois H H has been drawn well away, so as to expose the rump of the little embryo. The ventral string, in the midst of which is the allantoic diverticulum from the intestine, is often described as a direct extension towards the chorion of the tail end of the embryo. A careful examination of this young embryo before us shows that its rump end projects considerably beyond the point at which the ventral string or Bauchstiel of His leaves the ventral surface of the embryo, and that the amnion membrane as it passes downwards over the dorsal surface embraces the rump end, and then turns forward round the rump to be attached to the very root of the ventral string or Bauchstiel at a point some distance from the distal end of the rump. At this stage there is no appearance of external genital organs, or anus, or tail; but the

whole rump end of such an embryo is tightly encased in the amnion.

A study of transverse sections carried through the root of the ventral string, or Bauchstiel, and through the rump end of the embryo, makes it perfectly clear that it is a mistake to describe the ventral string as a continuation of the tail end of the embryo towards the chorion. The external genital organs, the anus, and tail develop in connection with this rump end of the embryo, but distally to the attachment of the amnion at the root of the Bauchstiel as the latter comes off from the ventral surface of the embryo. In all the early embryos examined, and they were many, this rump end was well marked, and in every case the amnion was found to embrace it closely, and then turn forward some distance to be attached to the root of the ventral string or Bauchstiel. This tail or rump end of the embryo is probably produced at an earlier stage when the *hind gut* is being formed. According to Quain, "all the three layers of the blastoderm are involved in the forward growth and overfolding which produces the head of the embryo, so that a prolongation from the blastoderm cavity, which is, of course, lined by hypoblast, becomes included in the head, and the anterior part of the primitive alimentary canal, or *fore gut*, is thereby produced. Formed in this way, its front end is necessarily blind, and for a long time there is no mouth nor any communication between the fore gut and the exterior of the embryo. The mouth becomes formed later by an invagination from the exterior. Lastly, at the tail end of the embryo a *hind gut* is produced. In most mammals and birds it is produced by a folding over of the tail end of the embryo like that which occurs at the head to enclose the fore gut. The hind gut remains for a considerable time blind, until the anus becomes formed by invagination from the exterior."

This explanation of the formation of the rump end of the embryo, namely, by a folding over of the blastodermic layers at an early stage to enclose a hypoblastic hind gut also explains how it is that the Bauchstiel which contains the tubular hypoblastic diverticulum from the intestine, comes off from the ventral surface of the embryo at some distance from its caudal or rump end, and we know that the external genital organs, the anus and the tail are formed externally to the root of the Bauchstiel; but it also explains how the amnion, after embracing the rump end of the embryo, appears to be

always attached to the very root of the Bauchstiel or ventral string. This rump end of the embryo is formed by the folding over of the caudal end of the embryo. It will be shown as we proceed that the amnion is everywhere an extension of the somatopleure folds, both at the sides, and at the tail and head ends of the embryo. The amnion which embraces the rump end of the embryo is simply an extension of the somatopleure fold in this region as will be afterwards explained.

At this early stage of development the Bauchstiel is entirely mesoblastic in structure; but, of course, has in its substance the hypoblastic tube of the allantois with the allantoic arteries and veins.

At first, as the Bauchstiel or ventral string grows outwards towards the chorion from the ventral surface of the embryo, its mesoblastic tissue and the mesoblastic tissue of the two lateral somatopleure folds are found to be in contact and fused together. The Bauchstiel with its allantoic tube and the vascular mesoblastic tissue of the somatopleure folds then grows outwards to the chorion, while from its root the somatopleure fold gives off the amnion membrane which now closely embraces the rump of the embryo, and which is pushed before it as the rump grows, and then becomes continuous with the amnion encasing the whole dorsal surface of the embryo. The amnion everywhere comes off from the somatopleure folds, both at the sides, and at the head and tail ends of the embryo. Whatever the appearances may be there is no exception to this rule. A study of the transverse sections of this embryo makes this point absolutely clear.

It is now possible to describe the transverse sections referred to. All these sections were carefully photographed, and they have been reproduced by the zinco-collotype process as the best means of giving to us an exact representation of the parts and their relations to each other, as in nature.

Plate iii. Fig. 5 is a transverse section through the young embryo just described, in such a way as to pass vertically down through the large yolk sac. It might be well here to mention that these figures can be seen to greater advantage if looked at through an ordinary hand lens. They come out much better for being thus magnified by a simple lens.

The neural canal, chorda dorsalis, and aorta are well shown. The aorta is almost double in this section. Immedi-

ately below the aorta a short mesentery can be seen attached to the splanchnopleure, which in section is seen to consist of splanchnic mesoblast lined with hypoblast, and the letter I points to the primitive intestine thus formed and still in communication with the yolk sac by a wide vitelline foramen. It is interesting to compare this section with the drawing of the young embryo as seen in Fig. 1 Plate i. The size of the tube of communication between the intestinal tube and the yolk sac is thus made clear. On each side of the mesentery and the intestinal tube, the large Wolffian bodies, W, can be seen, projecting into the cœlom, Coe, or body cavity, which is now widely open.

The genital ducts and glomeruli and tubules in the Wolffian bodies are well seen. The two lateral somatopleure folds, S, one on each side in the section, are beautifully brought out. These somatopleure folds, as we learn by a study of Figs. 3 and 4, are formed at an early stage of development when the lateral mesoblast splits into two layers. The external layer joins the epiblast, and the conjoined membranes now form the somatopleure fold which we see in the sections before us.

Looking carefully at these folds as they leave the body of the embryo to enclose the cœlom, or body cavity, it is easy to see that the somatic mesoblast is in more or less close contact and union with the epiblast. The letter S points to the somatic mesoblast of the somatopleure fold, and the letter E points to the epiblastic layer in union with the somatic mesoblast. In some parts as we follow the somatopleure folds, the epiblast is seen to be partly detached from the somatic mesoblast layer; so that it is perfectly clear that the lateral somatopleure folds now consist of two layers, the somatic mesoblast on the inner side and the epiblast on the outer or external side. Following these lateral somatopleure layers we come to a well-marked bulging out part on their mesoblastic surfaces, just at a point where these folds are about to turn outwards to become continuous with the amnion membrane, O, which can now be traced as passing entirely round the dorsal surface of the embryo. These bulging-out parts are the allantoic or umbilical veins, L, as seen in section. Through the whole series of sections from the head end of the embryo to its caudal extremity, these veins are found to lie in the same position in

the two lateral somatopleure folds. The mesoblastic tissue round these veins is much thickened, as seen in the figures; and just external to the veins, the somatopleure folds can be seen turning outwards and then downwards in such a way as to pass completely round the dorsal surface of the embryo; but it will be noticed that the somatopleure folds, though very thick in the neighbourhood of the umbilical veins, rapidly thin off and become continuous with what appears to be a thin membranous layer, the true amnion, O.

From this description of the manner in which the somatopleure folds are developed, it must be allowed that the amnion, which is a direct continuation of those folds, is morphologically a double layered membrane, consisting of somatic mesoblast and epiblast conjoined. A study of numerous sections of these young embryos makes it perfectly clear that the amnion sac is lined on its inner surface with epiblastic cells, while its outer layer consists of somatic mesoblast. It thus comes about that the true amnion sac is lined with epiblastic cells which are continuous with the epiblastic cells covering all parts of the body of the embryo. In connection with the sections through these umbilical veins it is interesting to observe that the left vein through the whole series of sections appears to be much the larger of the two.

Although the lateral somatopleure folds lie pretty close to the Wolffian bodies in this young embryo, it will be seen that their mesoblastic surfaces are as yet a long distance apart from the mesoblastic surface of the yolk sac with which they ultimately adhere when the cœlom or body cavity is shut off. The section before us shows how widely open is the body cavity, and how large is the umbilical foramen around the yolk sac at this stage of development, while the vitelline foramen is comparatively small.

Fig. 6 represents a section through this embryo in its lumbar region just above the situation where the allantoic outgrowth arises. The intestinal canal is now closed in, and there appears to be no mesentery, but the splanchnopleure, with its hypoblastic lining as the intestinal tube, is well seen in section. The Wolffian bodies are here small but their ducts are visible. The cœlom, or body cavity, is now very deep, but not very wide. The somatopleure folds have approached each other, and their mesoblastic surfaces are nearer

to each other than in the last section. There is no trace of a yolk sac. The umbilical veins, L L, in section are now very well marked, that on the left hand side being particularly so. The somatopleure folds appear to be very thick just as they turn round, external to the veins, to become continuous with the amnion membrane, which, with the aid of a small lens, can be seen to be a double layered membrane.

The next section, Fig. 7, is an important one as showing that the two somatopleure folds have now come in contact with each other, and have fused together around an elongated tubular structure which represents an almost vertical section through the allantoic tube, A, coming up from the cloacal end of the primitive intestine, I. The section has evidently passed vertically down through the allantoic tube as it was coming upwards to pass over the ventral surface of the caudal end of the embryo towards the chorion. This tube is lined with hypoblastic cells continuous with the cells lining the primitive intestine. Note how exceedingly thick is the mesoblastic tissue around the allantoic tube ; and with the aid of a small lens it is possible to see the allantoic arteries in section one on either side of the allantoic diverticulum ; and external to the arteries, the large umbilical veins are seen in the somatopleure folds in their usual situation. The somatopleure folds, although adhering and fused to the thick mesoblastic tissue around the allantoic tube, can be seen to turn round and outwards and to be continuous with the amnion membrane covering the dorsum of the embryo as before described.

In Fig. 8, which is a vertical section through the Bauchstiel or ventral string, the thick mesoblastic tissue surrounding the allantoic tube is well shown ; but the allantoic tube now as it runs horizontally outwards towards the chorion presents in section a tubular outline quite different from that presented in the last section.

The somatopleure folds here seem to be fused to the thick mesoblastic tissue surrounding the cloacal enlargement of the primitive intestine. The cœlom, or body cavity, is here remarkably small. The primitive intestine, I, with its cloacal enlargement and lined with hypoblastic cells, is well marked, and on either side of it there is a section of the large allantoic arteries N, N, which are again seen in the upper part of the figure, just below the section of the allantoic tube. The body of the

embryo has now a solid appearance and is almost nipped off from the Bauchstiel as the latter passes off from its ventral surface; but a study of the figure shows undoubtedly that the somatopleure folds still hold their morphological relation to each other and to other parts of the embryo. For on tracing up the somatopleure folds from their roots just outside the Wolffian bodies it is found that they bend inwards, first of all, and fuse with the mesoblastic tissue around the primitive intestine, in which the large allantoic arteries are seen; then they turn outwards, and in section present a remarkably thick mesoblastic mass, in the midst of which the allantoic arteries are seen just below the allantoic tube; and external to these arteries sections of the umbilical veins are seen in the substance of the true somatopleure folds, which now are just about to turn round and backwards in the usual way, and then thin off to become continuous with the amnion membrane. All this can be clearly made out in these sections; and it would appear as if the splanchnopleure and somatopleure folds at the caudal end of this embryo had never completely separated from each other, as the cœlom between them is reduced to a very small space, and these folds are continuous with each other round the cœlom, just below the situation of the allantoic arteries on either side of the cloacal end of the intestine. It is also very evident from this section that the Bauchstiel, or ventral string, consists for the most part of a thick central mass of vascular mesoblastic tissue surrounding the allantoic diverticulum, and that it is embraced on both sides by the very thick mesoblastic tissue of the two lateral somatopleure folds which then always turn outwards and backwards to give off the amnion membrane.

It is interesting to observe that while in the earlier sections the neural canal is completely closed, in the later ones it is still open, and the epiblast is everywhere seen continuous with its medullary folds.

In Fig. 9, which is a section vertically downwards and transversely through the Bauchstiel, or ventral string and rump end of the embryo, we find that the rump or body of the embryo at this situation is completely separated from the under surface of the Bauchstiel, and that the Bauchstiel is now considerably flattened out transversely. In the upper part of the Bauchstiel the cut tube of the allantois is seen, A. Below it and at each side of it

there is a great mass of vascular mesoblastic tissue. Just below the allantoic tube in the central region of the Bauchstiel are seen the two allantoic arteries, N N, while to the outside of these are seen the large umbilical veins, L L, in the substance of the lateral somatopleure folds just at the point where these folds turn round and backwards and thin off into the amnion membrane, O, which now closely embraces the rump end of the embryo.

Looking carefully at this and the following figure, it would appear as if the two lateral somatopleure folds were for the most part placed below the central mass of the Bauchstiel mesoblast. The apparent change in their morphological relation is probably due to the flattening out of the Bauchstiel; for it must not be forgotten that in the deer the allantoic tube with its thick mesoblastic vascular covering quickly spreads out transversely, between the true and false amnion sacs on its way to reach the chorionic cotyledons.

In this rump end of the embryo, the cœlom or body cavity between the lateral somatopleure folds and the splanchnopleure folds is hardly to be seen, and these folds themselves are united in one undivided mass around the cloacal end of the primitive intestine. In connection with this cloacal enlargement, I, as seen in this figure, it is evident that the hypoblastic lining at the upper part is in the act of forming two tubular structures by a process of invagination. These two tubular structures, completely closed in, are seen in the next figure 10, and, evidently, represent sections of the genito-urinary ducts, which are connected at this stage of development with this cloacal enlargement.

When describing the relation of the rump end of the embryo to the root and under surface of the Bauchstiel, we endeavoured to point out that the amnion membrane was not directly attached to the under surface of the Bauchstiel at its root after embracing the rump of the embryo; but that, embryologically, the mesoblastic surfaces of the two lateral somatopleure folds are fused to the sides and under surface of the mesoblastic Bauchstiel in such a way that the amnion membrane comes off from these folds at the root of the Bauchstiel, and then embraces the rump end of the embryo as a bag-like protrusion, and that morphologically, the amnion is everywhere a continuation of the lateral somatopleure folds. A glance at the figures 9 and 10 will make this statement clear and intelligible; for it is quite evident, from our examina-

tion of numerous sections, that as the lateral somatopleure folds are continued downwards they and the large veins in their substance become attached to and fused with the thick mesoblastic tissue of the Bauchstiel which encloses the allantoic diverticulum with the two allantoic arteries. It would, indeed, appear as if the Bauchstiel or ventral string was an outgrowth of a tubular diverticulum from the primitive intestine with the allantoic arteries in a mass of splanchnic mesoblast, and embraced at its side and under part by the two lateral somatopleure folds in which are the large umbilical veins.

An examination of a whole series of such sections of the caudal end of this embryo proves to us that though in the region of the yolk sac the body cavity or cœlom is very widely open, and that the splanchnopleure and somatopleure folds are widely distant and separate from each other, yet as we proceed in our sections towards the rump end of the embryo, we notice that the body cavity or cœlom becomes less and less wide, and that at last we reach a section in which the margins of the body cavity (see Fig. 7) are in contact and fused around the mesoblast surrounding the primitive intestine. In this case we find that the somatopleure folds are now in contact with the splanchnic mesoblastic tissue surrounding the intestine ; and so the cœlom is gradually shut in and reduced in size until we come to sections in which we find the cœlom has almost entirely disappeared.

In Fig. 11, which is a section through the rump end of the embryo at a considerable distance from the root of the Bauchstiel, the amnion membrane, O, or girdle of the somatopleure fold, is quite a thick structure as it passes round and embraces the rump. The epiblast is well-marked, and is seen in continuity with the medullary folds of the neural canal. In this section no trace of an intestine can be seen ; and only mesoblastic plates in an undivided condition are seen within the epiblastic ring. At this region the allantoic tube has flattened out transversely in the flattened ventral string, and there is no trace of the lateral somatopleure folds passing off into an amnion membrane. The ring of amnion around this section of the rump is without doubt a part of the amnion arising in connection with the caudal fold of the somatopleure at the root of the Bauchstiel in Figs. 9 and 10.

Though the somatopleure folds appear now to lie below the thick mesoblastic Bauchstiel owing to the great expanse

of the latter transversely, yet it can be seen in the sections, that these lateral somatopleure folds give off the amnion membrane in this region just as in other situations. It is in this region that the amnion is given off from the somatopleure fold at the root of the Bauchstiel, and it encases the whole rump and is pushed before it as the rump grows and becomes larger.

In Fig. 2 Plate ii. the rump end of the embryo from which these last sections have been prepared is well shown; and it will be at once seen that the ventral string or Bauchstiel is not a continuation of the tail end of the embryo, but that it is a mesoblastic out-growth from the ventral surface of the embryo with the allantoic arteries and tube within its central part. This mesoblastic out-growth is embraced by the two lateral somatopleure folds with the large allantoic veins in their substance. These somatopleure folds gradually come to lie at the side and under surface of the Bauchstiel as the ventral string or Bauchstiel expands laterally, and as it passes outwards over the ventral surface of the rump end of the embryo. The amnion membrane everywhere is an extension of these folds in all situations.

The last section, Fig. 12, which I shall describe is one of the last of the series. The section was made by the knife passing vertically downwards through the widely expanded Bauchstiel and through the very rump end of the embryo lying below it. A thick ring of somatopleure fold, O, is here seen around a shaving cut off the enclosed rump. This ring of somatopleure is part of the bag which surrounds the whole rump end of the embryo at this stage, and it is derived from the caudal somatopleure fold at the root and under surface of the Bauchstiel. As the general amnion sac later on becomes distended with fluid this bag of somatopleure fold round the rump is also distended, and the somatopleure fold is stretched out into the thin amnion membrane continuous with that which everywhere encloses the body of the embryo.

It is interesting to note here the distance that exists between the under surface of the Bauchstiel and the mesoblastic ring surrounding the rump shaving. The Bauchstiel, or ventral string, as it lies above this ring is seen now to be very widely expanded and flattened out, and in the midst of it is seen (in section) the widely dilated allantoic tube

lined with hypoblastic cells. The mesoblastic tissue around this allantoic bladder is very vascular, and in it are seen numerous arteries and veins.

Let us now consider a little more carefully the origin and development of

The Bauchstiel, Abdominal Stalk or Ventral String, and its relation to the Somatopleure Folds and Amnion

One hundred and thirty-five photographs of sections through this young embryo were placed in their proper relation to each other, and fixed on a large piece of cardboard for study. The sections examined passed, first of all, through the yolk sac and its attachment to the primitive intestine, then through the middle part of the body, then through the lumbar region, and lastly through the Bauchstiel and rump end of the embryo.

The following conclusions were drawn from such a study.

At an earlier stage of development than this embryo presents, there must have been a folding over of the three primary layers of the embryo to produce the head fold by which the fore gut was included in the head region as a blind tube. The cephalic somatopleure fold can be traced in this region bending upwards and backwards over the head of the embryo to be continuous with the general amnion sac. This cephalic fold of somatopleure starts from the cephalic end of the umbilical foramen. The two lateral somatopleure folds can be traced bending back and then turning round the dorsal surface of the embryo as the amnion membrane. They border the lateral parts of the umbilical foramen. At the caudal end of the embryo there must also have been a folding over of the primary layers to produce the tail fold which encloses the blind hind gut; and in the sections it is easy to follow the bending back of the caudal somatopleure fold which, as a thick layer, turns backwards and downwards to embrace the rump end of the embryo produced by the tail fold. All these somatopleure folds, the cephalic, lateral, and caudal folds, are directly continuous with each other round the margin of the large umbilical foramen; and while the cephalic fold turns upwards and backwards to embrace the head, the somatopleure folds in all other parts turn downwards and backwards to embrace the dorsal surface and rump end of the embryo in one continuous sheet.

In the cleft, at the caudal end of the umbilical foramen, at the region where the caudal fold of somatopleure turns backwards to embrace the rump end, a tubular outgrowth from the primitive intestine makes its appearance. This tubular outgrowth, accompanied by the two prolongations of the primitive aortæ, and encased in a mass of mesoblastic tissue, grows outwards in this cleft between the margins of the umbilical foramen, and then turns backwards in such a way that the under surface of this mesoblastic outgrowth lies in contact with the upper mesoblastic surface of the caudal somatopleure fold to which it is attached. This mesoblastic vascular outgrowth is known as the Bauchstiel, or abdominal stalk of His. It is also called the ventral string. It has no epiblast covering at any part, and consists entirely of mesoblastic tissue.

The large allantoic or umbilical veins, in the sections, in the substance of the lateral somatopleure folds, are always seen just internal to that outward bend of the somatopleure folds which takes place when the folds turn round and backwards to pass round the dorsum of the embryo as the amnion membrane. The sections near the caudal cleft of the umbilical foramen show the folds are greatly thickened in this region, and that the large umbilical veins lie in a very thick mass of mesoblastic tissue. Following the sections onwards, it is seen that the thick mesoblastic tissue of these lateral somatopleure folds gradually approach and grasp and adhere to the thick splanchnic mesoblastic tissue surrounding the hypoblastic tubular outgrowth from the intestine; and the sections further show that the umbilical veins now pass inwards, and, lying external to the allantoic or umbilical arteries, become involved in the Bauchstiel or ventral string, as it grows outwards over the caudal somatopleure fold towards the chorion. While the allantoic or umbilical veins thus go inwards to form part of the Bauchstiel which is now like a tail prolongation of the embryo, but lying superficial to its rump end, the somatopleure folds which are very thick in this region, bend outwards and downwards, as in other parts, and being directly continuous with the caudal somatopleure fold they appear to sweep under the Bauchstiel, but it is clear that this appearance is caused by the Bauchstiel broadening out and then passing over the caudal fold of the somatopleure to which it is fused at this point. The caudal fold then separates from the Bauchstiel and passes at once

round the rump end, and is everywhere continuous with the amnion round the dorsal surface of the embryo.

In leading works on Embryology such as those of His and Minot, we read that the amnion is *attached* to the sides and to the root of the Bauchstiel. Whatever the appearances later on may be between the Bauchstiel and amnion membrane, they first come in contact and fuse to each other in the way I have described ; namely, by the under mesoblastic surface of the Bauchstiel attaching itself to the upper mesoblastic surface of the caudal fold of somatopleure, and this attachment takes place before the caudal fold is stretched out into the thin amnion membrane which it subsequently is. The caudal fold is at first quite a thick layer of somatopleure as it lies under the Bauchstiel and embraces the rump : all the folds are remarkably thick as they first come off from the margins of the umbilical foramen, and there is little space between them and the body of the embryo when first formed. This sac, which embraces the whole embryo, and known later on as the sac of the amnion, is attached only to the sides of the umbilical foramen and to the under surface of the Bauchstiel, in the way I have described. The attachment of the under surface of the Bauchstiel to the mesoblast of the caudal fold is not at first an extensive one ; for the fold quickly turns round and embraces the rump, while the vascular Bauchstiel with its allantoic tube passes straight out to reach the chorion ; but it is a most important one, as will be demonstrated when we are considering the conversion of the Bauchstiel into the true umbilical cord.

The outer surface of the amnion sac is entirely mesoblastic ; while the lining of the sac everywhere is epiblastic and is continuous with the epiblastic covering of the enclosed embryo.

The space between the two epiblastic surfaces is at first very slight, but as the fluid between them increases, not only does the space enlarge, but the margins of the umbilical foramen to which the amnion is attached are pulled upon and raised up in the form of a tubular prolongation of the body of the embryo ; and at this stage of development the umbilical foramen has considerably diminished in size around the yolk sac. While the outer surface of this tubular prolongation of the body wall is epiblastic and lies within the amnion sac, the inner surface which forms the wall of the cœlomic tube and encloses the yolk sac, or vitelline duct, is mesoblastic.

It is very important to notice that the surface of the Bauchstiel which lies in the caudal part of the umbilical foramen, and which faces the mesoblastic surface of the yolk sac at the cephalic end of the umbilical foramen, is entirely uncovered by amnion, and consists of splanchnic mesoblast. The amnion, as we have so often stated, is always continuous with the somatopleure folds at every part; and as the folds come off from the sides of the Bauchstiel, after the amnion sac is distended with liquid, by which means the Bauchstiel is drawn out, both at its sides, and lengthwise; so it is found by a careful study of the sections, that the amnion comes off from the sides of the Bauchstiel at a line external to the line of the umbilical veins as they course along the Bauchstiel towards the chorion; but the Bauchstiel in its middle part, within the line of the umbilical veins, is entirely uncovered by amnion.

Having thus described the young deer embryo, Plates i. and ii., and all its parts in their natural relation to each other, as seen in the front and dorsal aspects, and having directed special attention to the large widely open umbilical foramen, and to the comparatively small tubular connection between the yolk sac and the upper part of the primitive intestine; and, also, having described the rump end of the little embryo at this stage of development, we then shortly described several sections, in series, through its body, in order that we might bring out more clearly the origin, structure, and relations of the somatopleure folds to the amnion sac enclosing the body, and to the Bauchstiel, ventral string, or abdominal stalk, which connects the embryo to the maternal uterine surface.

We shall now, lastly, describe the steps in the further development by which the Bauchstiel or ventral string, is converted into the true umbilical cord

It will be necessary, however, in the first instance, to examine very shortly the appearances presented by two other deer embryos, as seen in Plates vii. and viii., which are somewhat older than the one already described.

The embryo first described, as seen in Plates i. and ii., as it lay on its back, was not in any way doubled up, so as to approximate its head and tail ends, although there was a marked head and tail fold enclosing the fore and hind gut:

but in the embryos as seen in Plates vii. and viii., there was a well marked approximation of the head and tail ends towards each other, as is well seen in Plate viii. where the embryo is lying on its side and the dorsal line is curved.

One of these embryos was placed on its back in such a way as to expose its ventral surface, which was then examined under a binocular microscope; and it was then possible to look down into the umbilical foramen. On comparing the umbilical foramen in this embryo, Fig. 13, with the umbilical foramen in the first embryo, Fig. 1, we see that in the first the foramen is very large and widely open, while in the second one it is closing in around the vitelline duct of the yolk sac, C. The whole animal is enclosed in an amnion bag which comes off from the umbilical foramen. In the drawing before us, Plate vii., it is difficult to see the amnion over the head region; but it can be seen somewhat distended with fluid between the letters M and D on the left side, and at the letter H on the right side of the animal, bulging out, as it were, and then passing inwards to the margin of the umbilical foramen on the one side, and then passing outwards over the whole body and rump end. As the amnion passes over the rump end, it turns forward, and appears to be attached to the sides and to the under surface of the Bauchstiel at its root. The letter M points to the first trace of a hind limb, and it is enclosed within the amnion sac. The large allantoic veins and arteries, as they course along the ventral surface of the Bauchstiel, H, are indicated by the letter K. Between the line of these blood-vessels, in the centre, can be seen the Bauchstiel mesoblastic surface which is uncovered by amnion.

The next embryo, Fig. 14, as seen in Plate viii., was a very beautiful object. The dorsal curve was very marked, as it lay on its side, and the head and tail ends were drawn towards each other. A good view was obtained of its head, A, and the branchial clefts were well marked, the heart, B, was quite distinct, and the large liver, D, could be traced bulging out the body of the embryo. The whole dorsal surface was encased in a tight-fitting amnion sac, which could be traced passing downwards over the head to be attached to the cephalic margin of the umbilical foramen. As it passed downwards this head fold of the amnion, N, was in contact with the shrivelled up yolk sac, C, whose vitelline duct could be

seen passing into the body of the embryo through the cœlomic opening of the umbilical foramen. The Bauchstiel, L, was a well-marked string-like structure. It was cut transversely across close to the rump end of the embryo; and then it was possible to see in the centre of the cut surface, as indicated by the letter M, the well-marked tubular orifice of the allantoic vesicle. The letter L points to the situation of the allantoic tube itself as it lies enveloped in a thick mesoblastic covering, between the line of the large blood vessels, veins and arteries, which go out towards the chorion, as indicated by the letters K K. The amnion membrane somewhat distended by fluid could be seen at the sides of the embryo, H, and then, after embracing the rump end, it turned sharply upwards to be attached to the under surface of the Bauchstiel at its root.

Between the letters H and K, this part of the amnion passing upwards to be attached to the under surface of the Bauchstiel at its root is well seen.

In Plate ix. we have very carefully represented the appearances seen in the case of a young sheep embryo, as it lies completely encased in the amnion sac which is everywhere distended with fluid.

The letter A points to the head. Below the head the heart and liver are seen. The letter B points to the true umbilical cord and to the large umbilical vein in its substance. The letter C points to the shrivelled up yolk sac which appears to pierce the umbilical cord at its front part. The yolk sac now lies quite outside the sac of the amnion. The letter N points to that part of the ventral string which is now entirely outside the amnion sac after the umbilical foramen has completely closed in around the vitelline duct of the yolk sac. The letter M points to the hind limb and tail within the amnion; and the letter O points to the general amnion sac filled with fluid to distension, and now attached to the embryo only at the distal end of the true umbilical cord at a point where the vitelline duct appears to pierce and enter the front part of the umbilical cord.

Looking at the figures in Plates i., ii., vii., viii., we may now ask, how is the Bauchstiel, or ventral string, whose origin, development and relations we have described, converted into the young umbilical cord, B, which is so well seen in the embryo before us, in Plate ix?

The Conversion of the Bauchstiel into the True Umbilical Cord

Bearing in mind all we have described regarding the origin, development and relations of the somatopleure folds to the umbilical foramen, and to the vascular Bauchstiel, or ventral string, it will be now easy to follow the steps in development which take place when the umbilical foramen closes in around the yolk sac and the mesoblastic Bauchstiel, and when the whole amnion sac is widely distended into a globular bag whose only attachment to the body of the embryo is at the margins of the umbilical foramen.

As the first result of the distension by fluid of the amnion sac, which is continuous everywhere with the somatopleure folds around the umbilical foramen, the amnion membrane is raised up from off the entire surface of the body of the embryo, and its attachment to the whole umbilical foramen is drawn out and put upon the stretch ; at the same time, explain it how we may, the head and tail ends of the embryo are approaching each other over the umbilical foramen, which is now gradually closing in around the yolk sac and the Bauchstiel, which are within its cœlomic tube, Plate x. The opposing cœlomic surfaces of the umbilical foramen are mesoblastic, and they adhere closely and tightly to each other where they come in contact, and to all parts within the tube ; and as the fluid distension proceeds, the amnion drags upon its attachment to the umbilical foramen in such a way that a distinct tubular process is drawn out from the body of the embryo below the amnion, and it embraces the vitelline duct and the Bauchstiel, which last contains in its mesoblastic substance the remains of the allantoic tube, the allantoic arteries and veins.

This Bauchstiel portion of the tubular process thus drawn out, forms a large part of the young umbilical cord thus produced. The umbilical cord thus formed is within the amnion sac, and the amnion sac is continuous with, and attached to the distal end of the cord. The cœlomic surface of the now closed-in umbilical foramen turns outwards as it is continuous with the outer mesoblastic surface of the amnion, while the epiblastic surface of the young umbilical cord is reflected over the inner surface of the amnion sac.

However long the true umbilical cord may ultimately become, it always lies within the amnion sac, and at its distal

end the outer mesoblastic surface of the amnion sac turns inwards to be continuous with the cœlomic surface of the original umbilical foramen, which now tightly grasps the much drawn-out and shrivelled-up yolk sac or vitelline duct.

However distant the amnion sac may be in the later stages of development from the body wall of the embryo, it arose at first in direct continuity with the somatopleure folds, which formed the margins of the umbilical foramen in the early embryo. The somatopleure folds at first, as they were continuous with the margins of the umbilical foramen, were very thick, and the amnion bag only becomes a large thin-walled membranous sac as the result of extreme stretching of the folds by fluid distension.

In connection with this origin of the amnion from the thick somatopleure folds, it is very interesting to observe that when we cut away the entire amnion bag from its attachment to the umbilical cord at its distal end, we find the amnion is very thick at the line of section, though the amnion bag elsewhere may be distended into a thin membranous sac.

Whatever prolongation there is of the vascular ventral string or Bauchstiel outside of the amnion sac, it is not the true umbilical cord which is always within the amnion sac.

The allantoic arteries and veins, along with the remains of the allantoic tube, as they lie in a mass of embryonic mesoblastic tissue are found in the posterior part of the young umbilical cord, and the mesoblastic tissue enclosing these structures is fused to and inseparable from the fold of somatopleure, which we described as the caudal somatopleure, and which is now continuous with the general somatopleure fold in the wall of the young umbilical cord.

However much the embryonic caudal fold of somatopleure, which was at first attached to the Bauchstiel at its root, and which is now recognisable as the amnion membrane coming off from the posterior part of the young umbilical cord, may appear to be drawn away from its original line of attachment (as in Plates ix. and xi.), such a change in position is only what was to be expected as the result of the distension of the amnion sac by fluid, and the consequent dragging outwards of all parts to which the early amnion bag was attached. Thus, if we look at the young umbilical cord, B, Fig. 15, Plate ix., we see the amnion membrane now comes off from it at a considerable distance from the body of the embryo, though, at first, the

amnion was attached to the embryo along the margin of the widely open umbilical foramen, where it was continuous with the early somatopleure folds, which now, of course, form part of the wall of the umbilical cord.

In a horizontal section through the young umbilical cord and amnion at its distal end, at a line where the amnion turns round from its attachment to the cord, the following appearances are presented. In outline the young cord is more or less oval, Fig. 18. On its outside is the epiblastic layer E, which is reflected over the entire inner surface of the amnion bag. At its front part the remains of the vascular yolk sac, K, with its hypoblastic lining, H, is well seen, and this is surrounded on all sides by the mesoblastic wall, D, or cœlomic surface of the original umbilical foramen, M. F points to the cephalic somatopleure. Posterior to the remains of the shrivelled-up yolk sac is a mass of thick embryonic mesoblastic tissue, B, in which are the remains of the allantoic tube, A, with its hypoblastic lining. Below and to the sides of this tube are the allantoic arteries, N, while external and slightly above them are the umbilical veins, L.

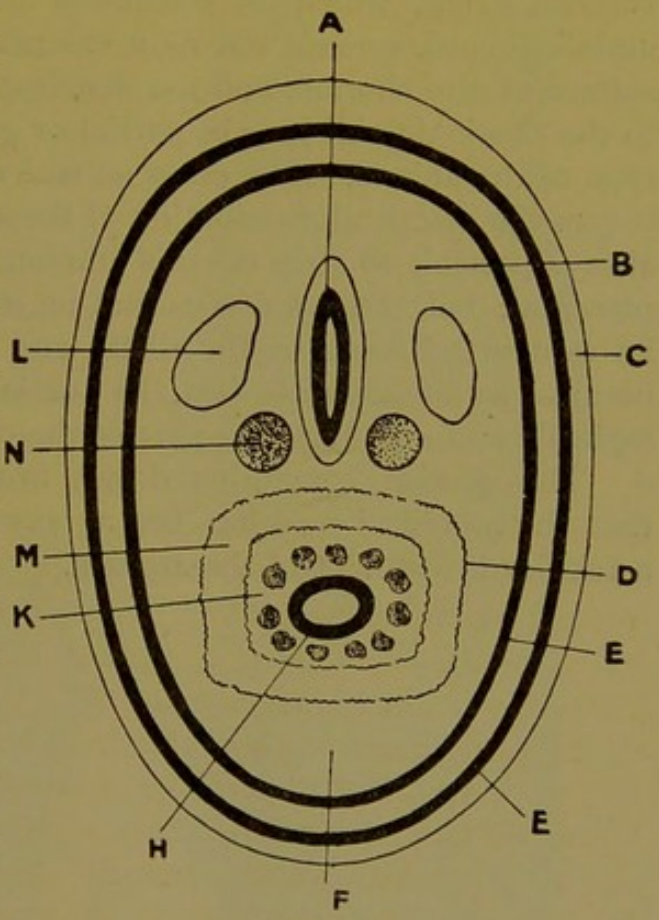


Fig. 18.
Horizontal section through the young umbilical cord and amnion at its distal end.

The vascular structures are enclosed in a thick mass of embryonic mesoblastic tissue which makes up the chief part of the young umbilical cord. It is not possible to detect any line of demarcation between this mass of Bauchstiel tissue and the mesoblastic surface of the embryonic caudal somatopleure fold which now forms the outer wall of the cord. In section, the amnion mem-

brane which here surrounds the cord, but which is altogether separate from it, consists of an epiblastic layer, E, on the inner side and of an outer mesoblastic layer, C, both of which are directly continuous with the same structures in the cord at its distal end. As development proceeds the mesoblastic outer surface of the amnion sac becomes gradually opposed to the inner mesoblastic surface of the chorion, with which it ultimately comes in contact, and to which it is attached by jelly-like connective tissue ; but from which it can at all times be easily separated.

Outside the true amnion sac, between it and the false amnion, or chorion, the vascular mesoblastic Bauchstiel, or ventral string, which is continued onwards from the true umbilical cord, spreads out as a vascular mass over the inner surface of the chorion, and the distribution of its blood vessels to the chorionic villi may be partial or general, according to the type of the animal. The outer surface of the true amnion thus covers the placental distribution of these blood vessels, and it is always possible to strip off this amnion membrane from such a placenta ; but the amnion cannot be stripped off further than its own attachment to the distal end of the umbilical cord, because, as already described, the amnion membrane is morphologically and structurally a part of the cord itself.

The general conclusion drawn from this investigation is, that the umbilical cord has not at any period of its existence a tubular investment of the amnion.

PLATE I.

FIG. 1.

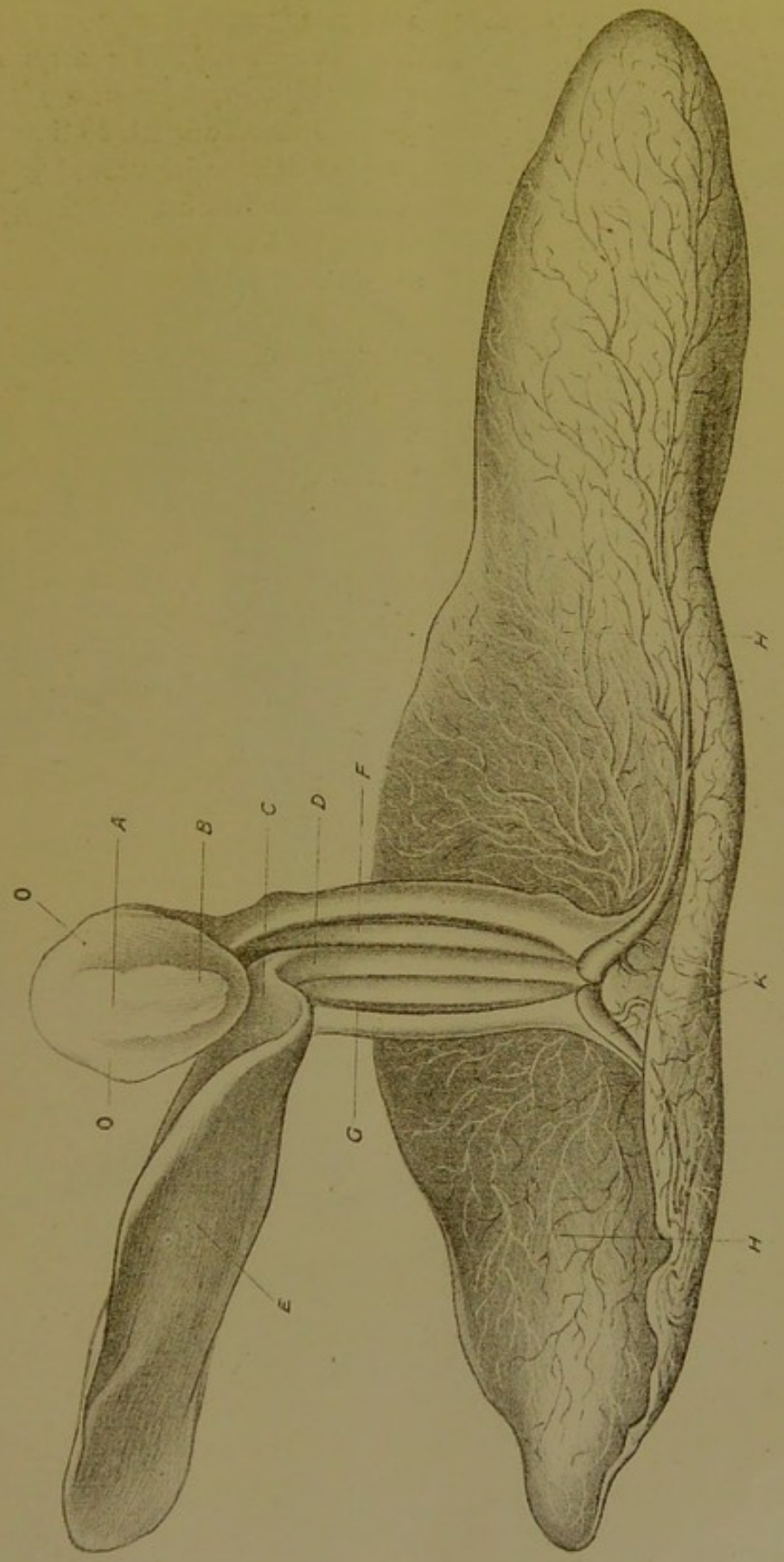


PLATE II.

FIG. 2.

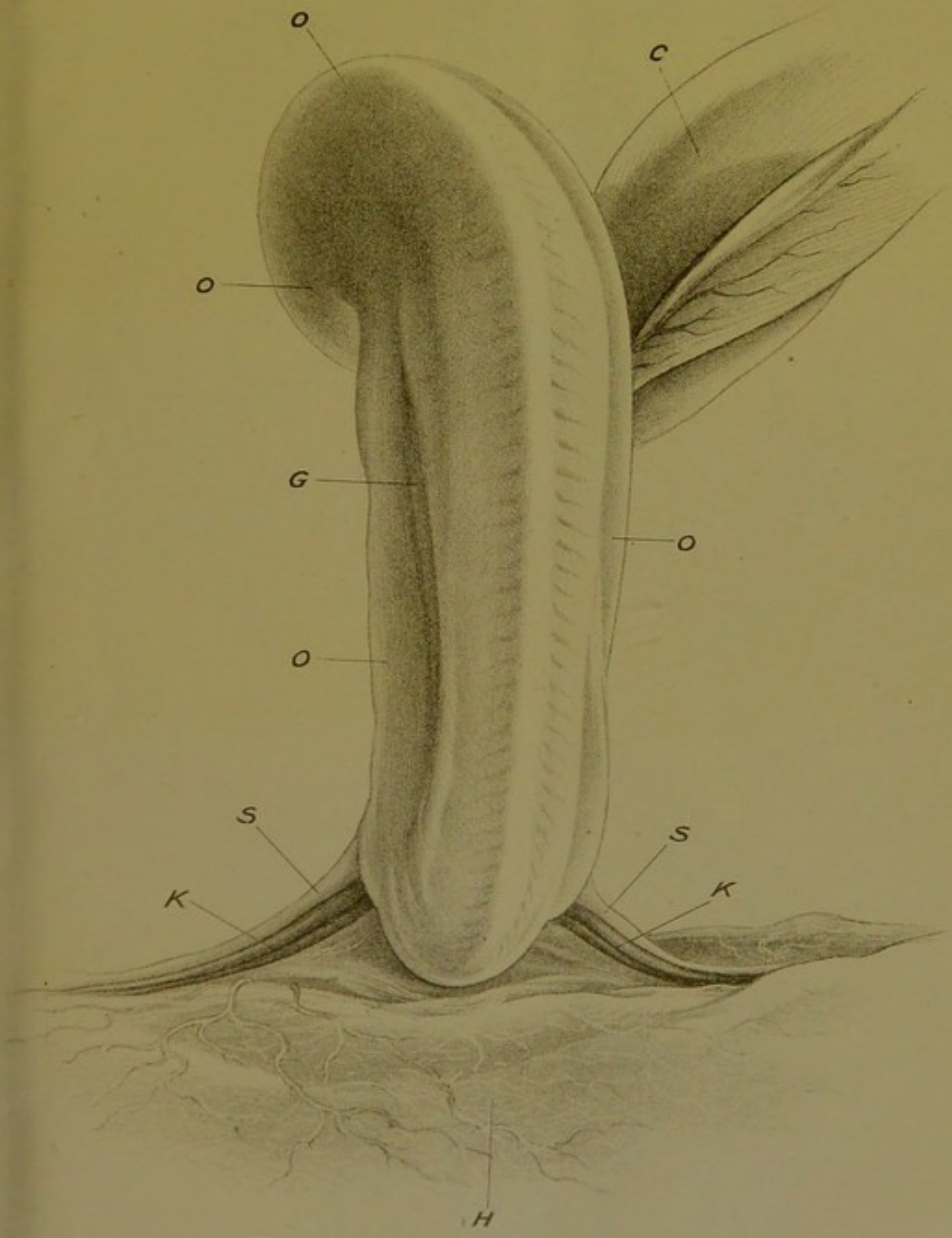


PLATE III.

FIG. 5.

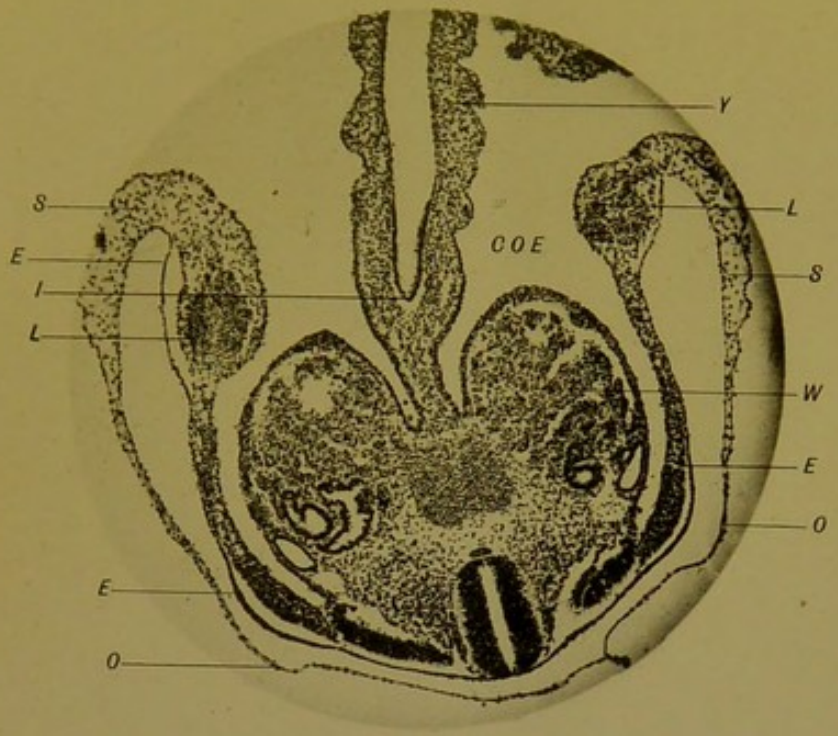
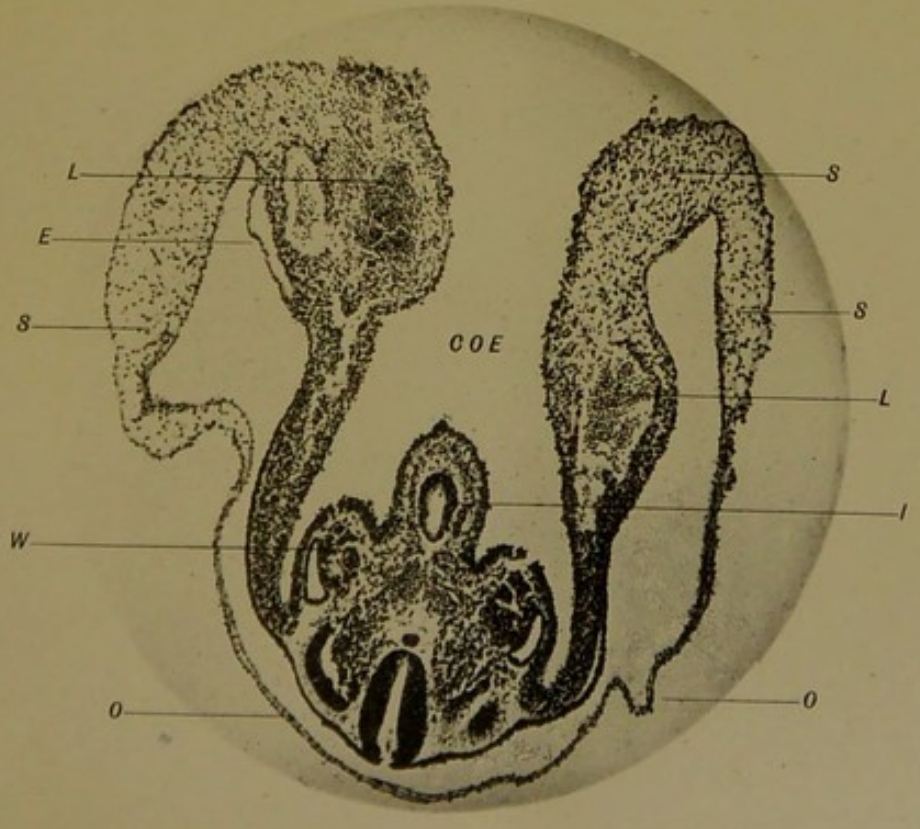


FIG. 6.



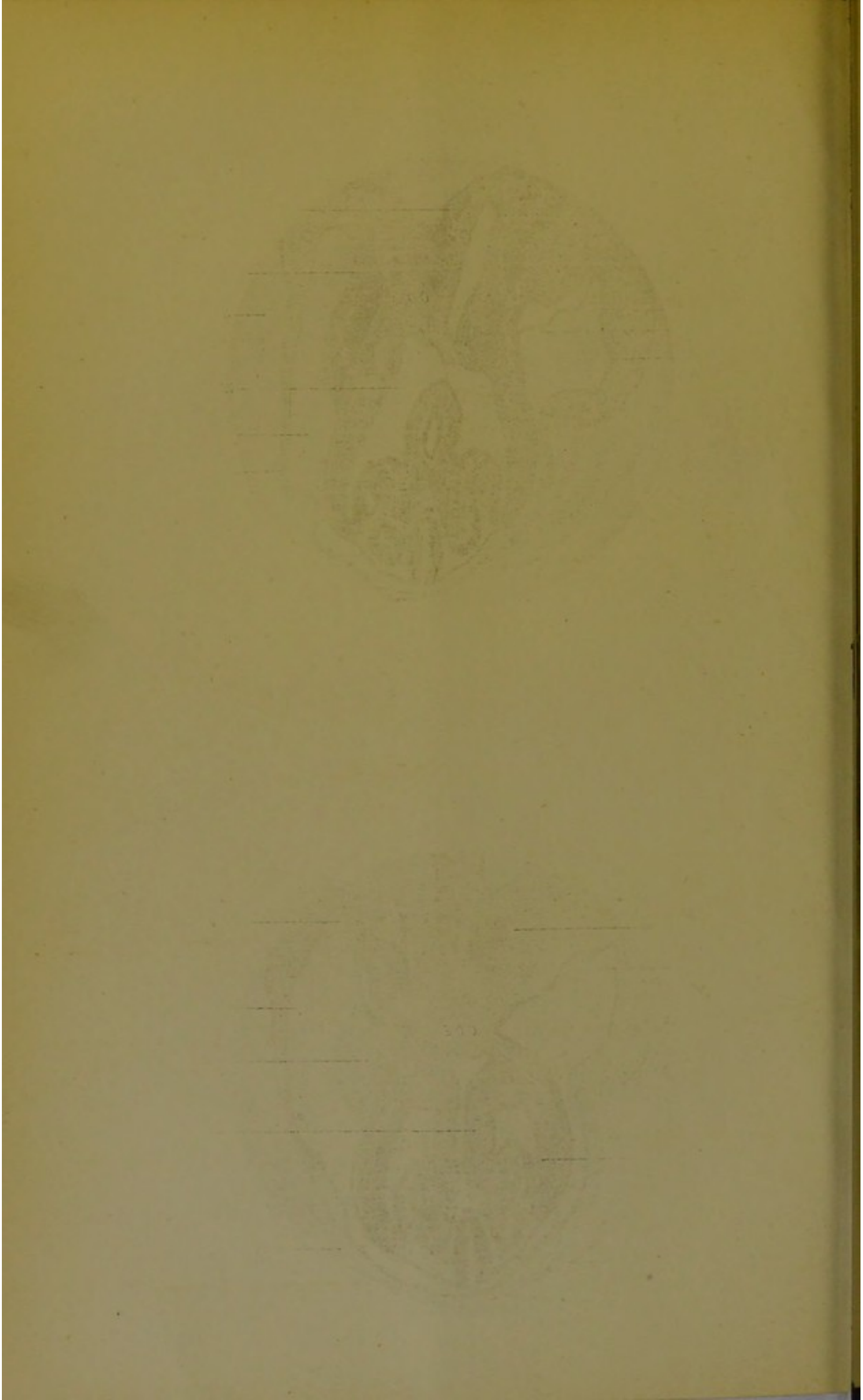


PLATE IV.

FIG. 7.

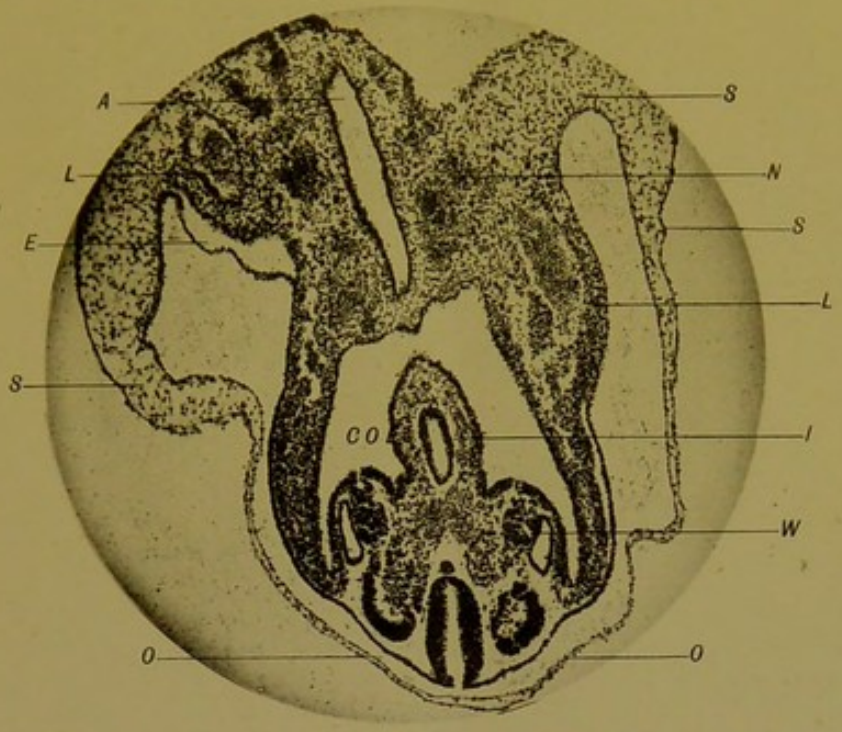
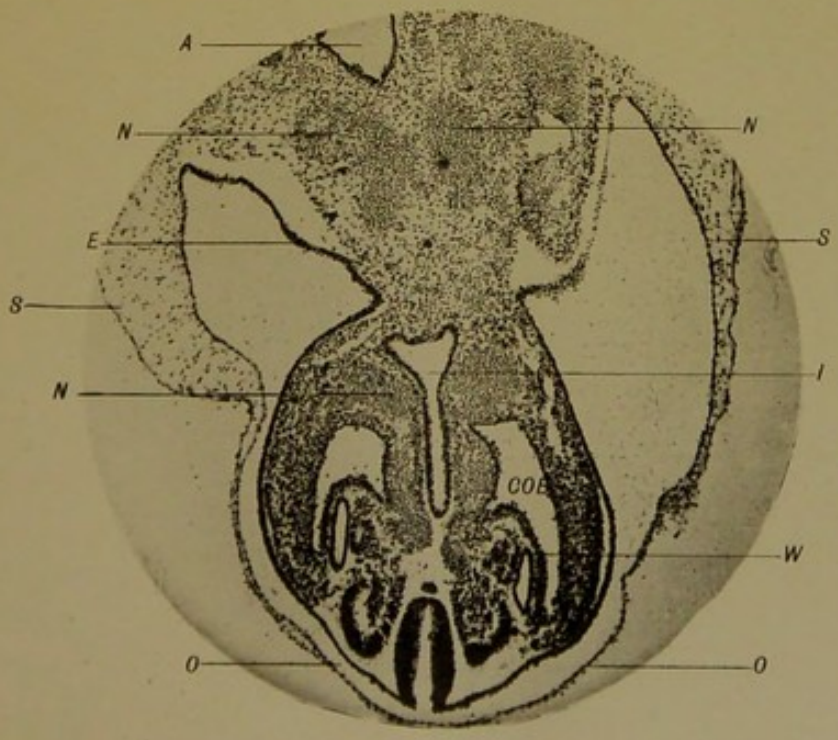


FIG. 8.



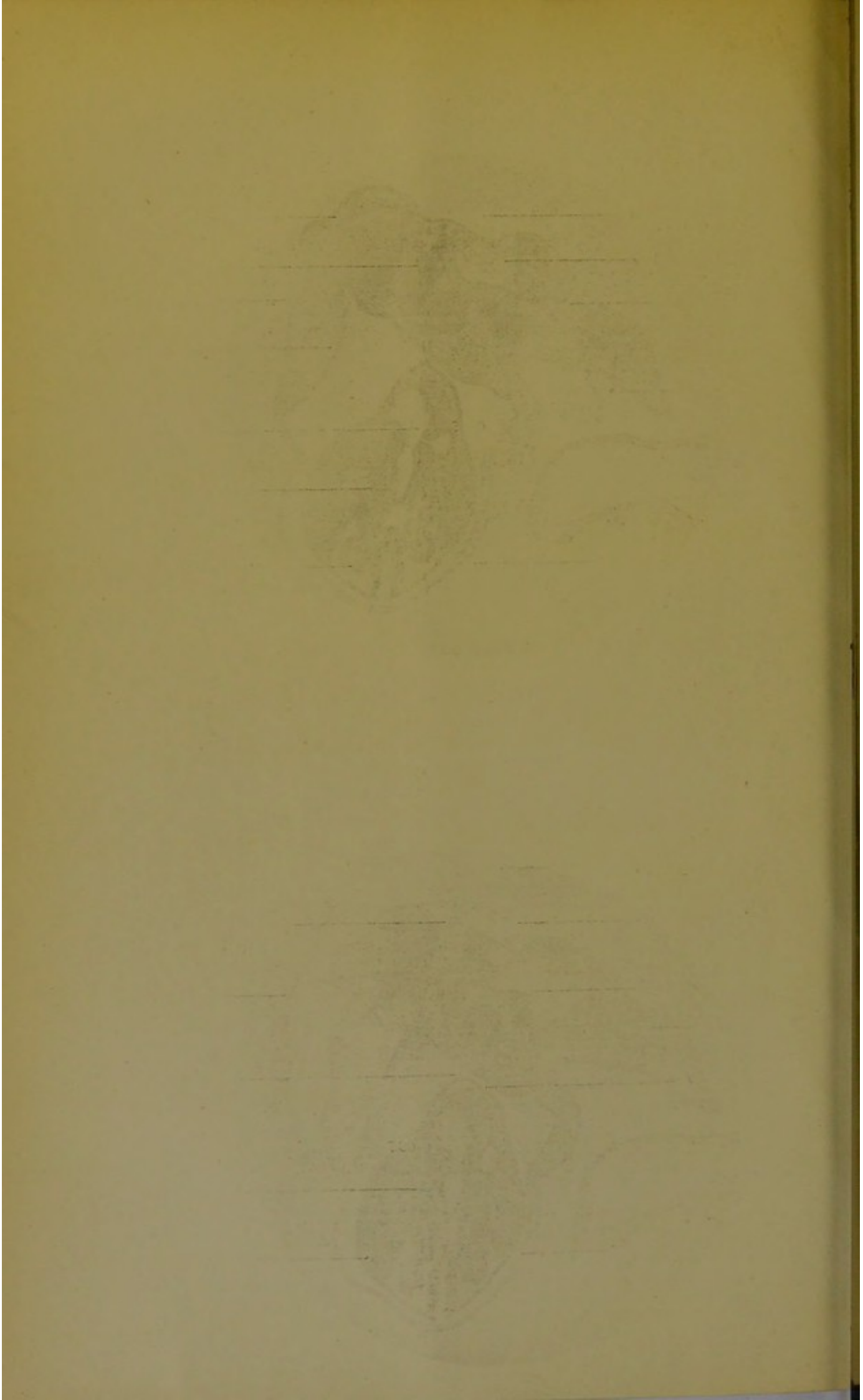


PLATE V.

FIG. 9.

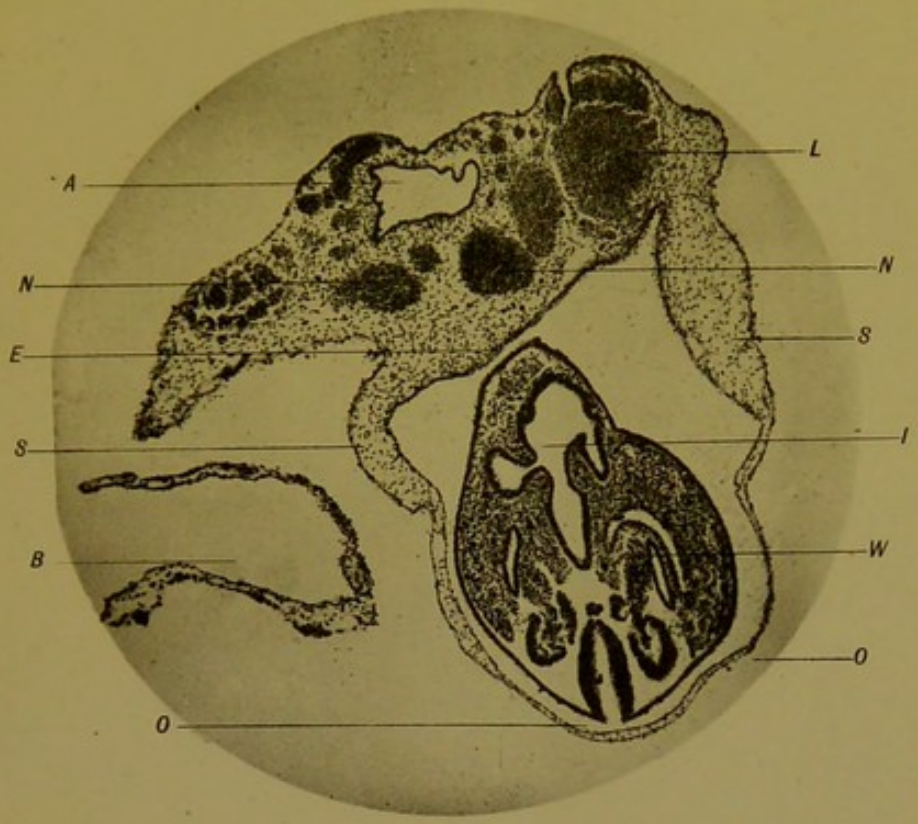
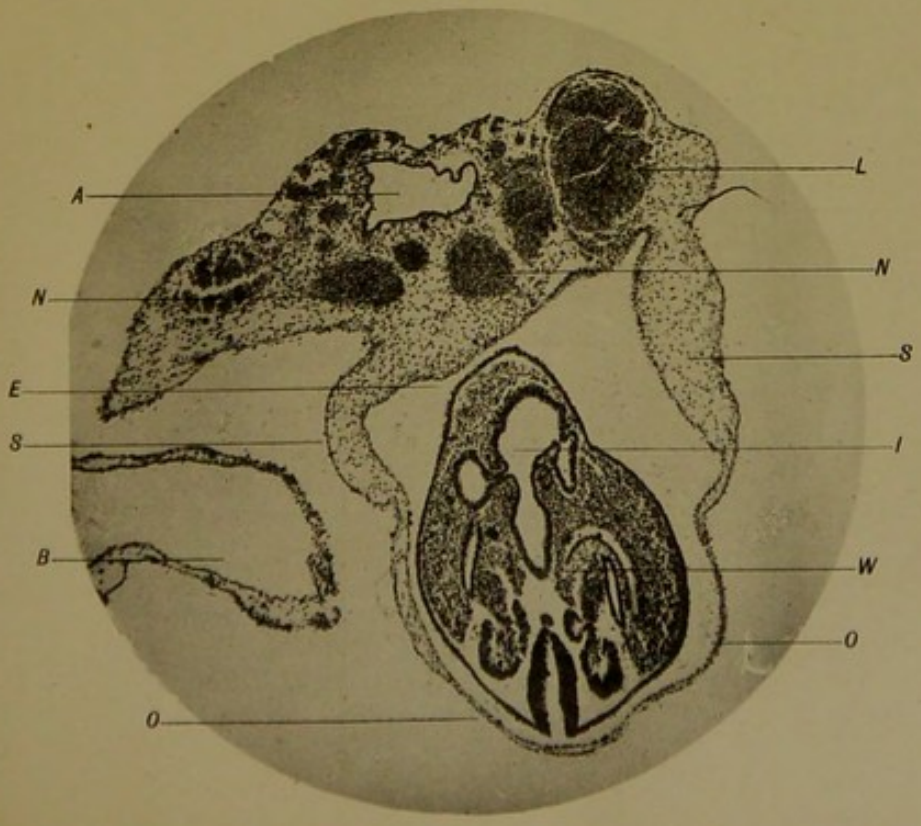


FIG. 10.



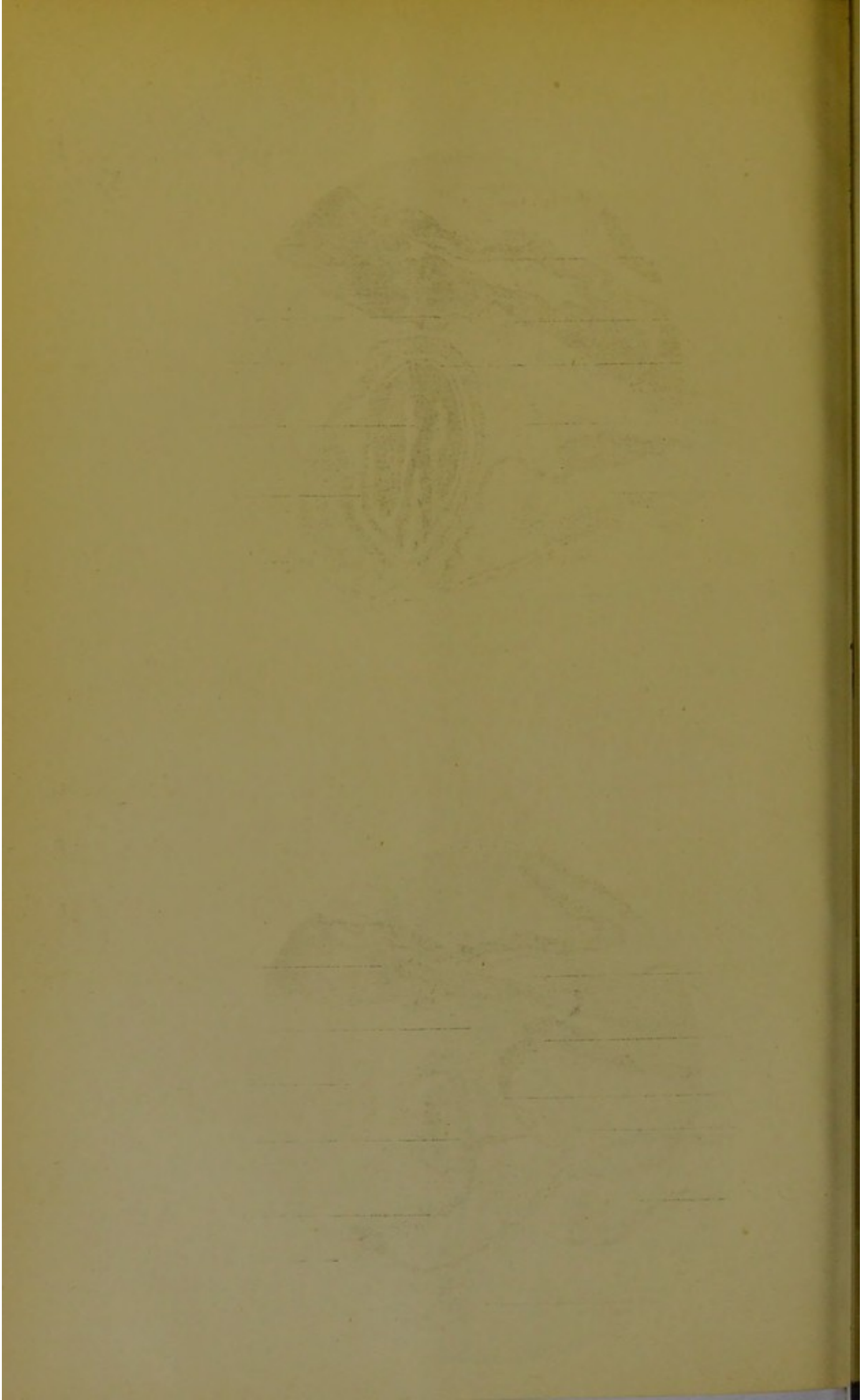


PLATE VI.

FIG. 11.

FIG. 12.

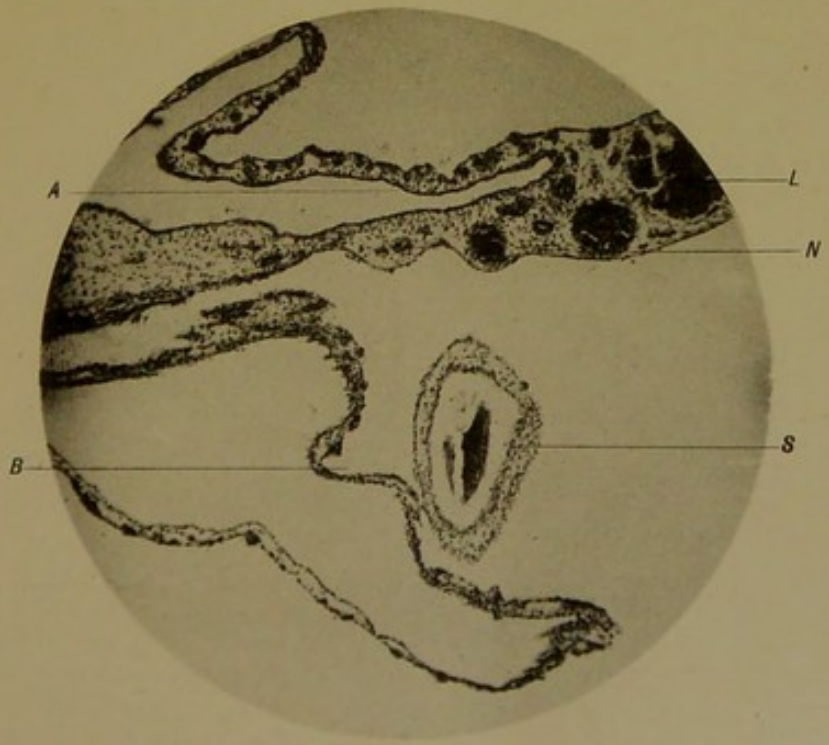


PLATE VII.

FIG. 13.

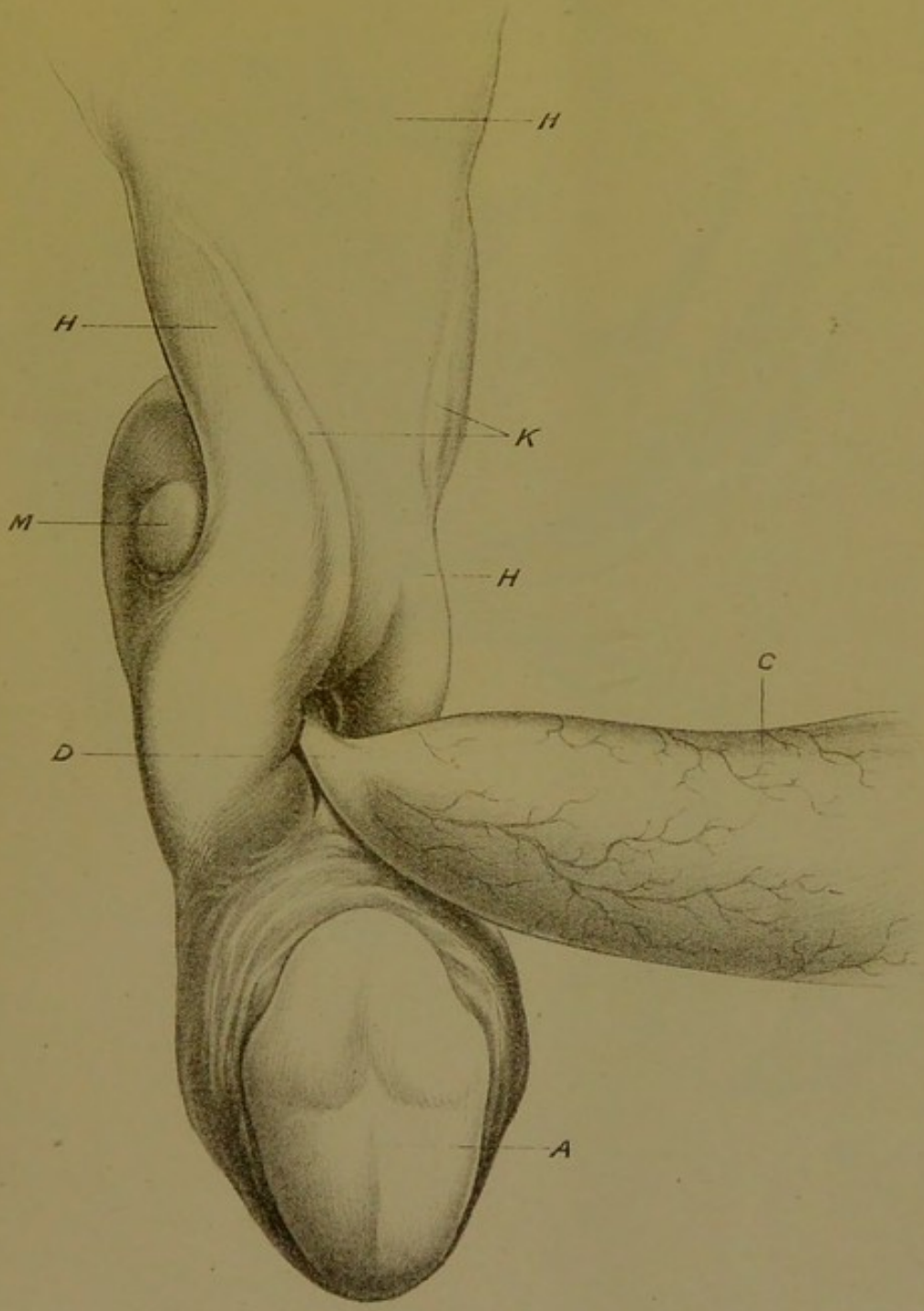


PLATE VIII.

FIG. 14.

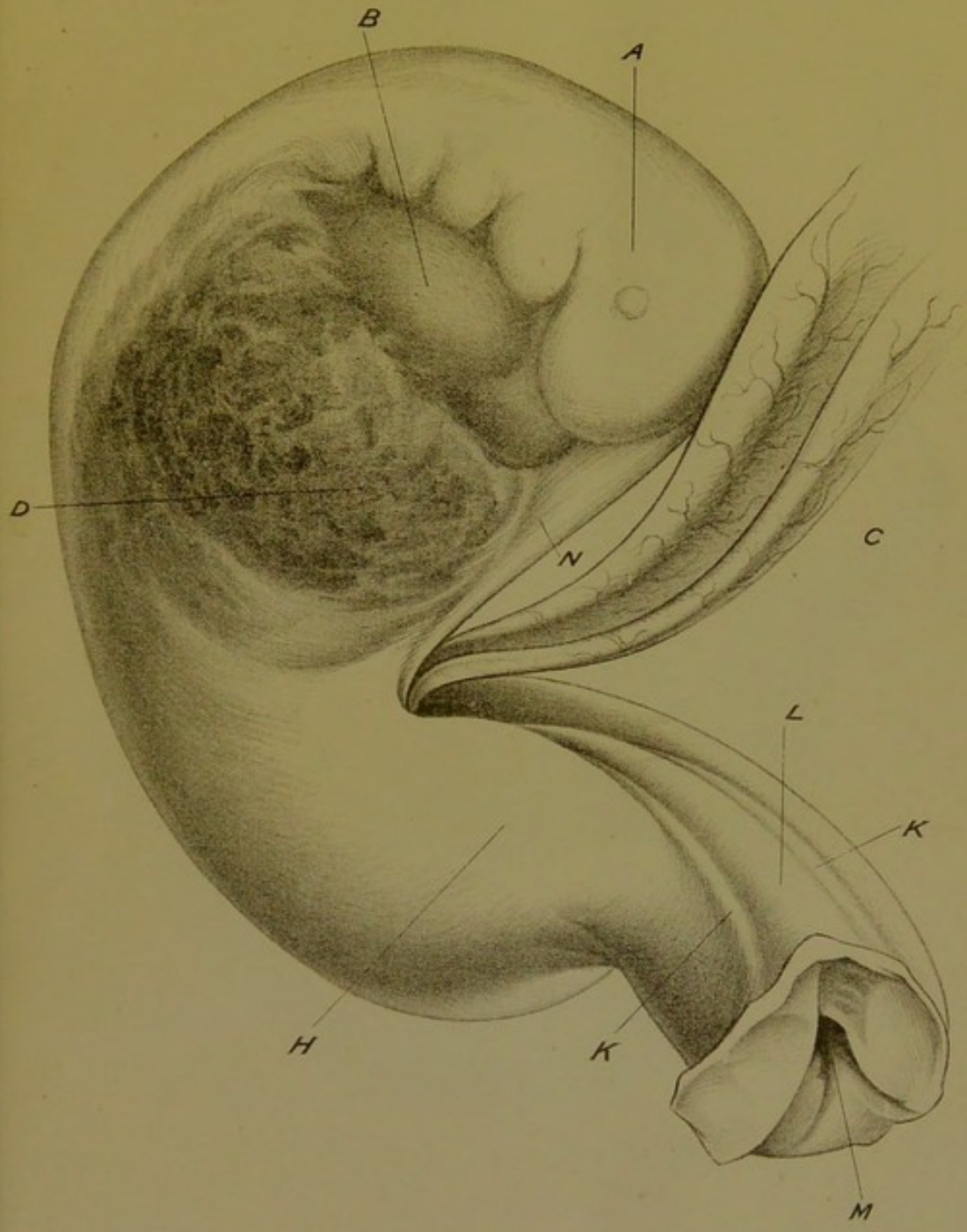


PLATE IX.

FIG. 15.

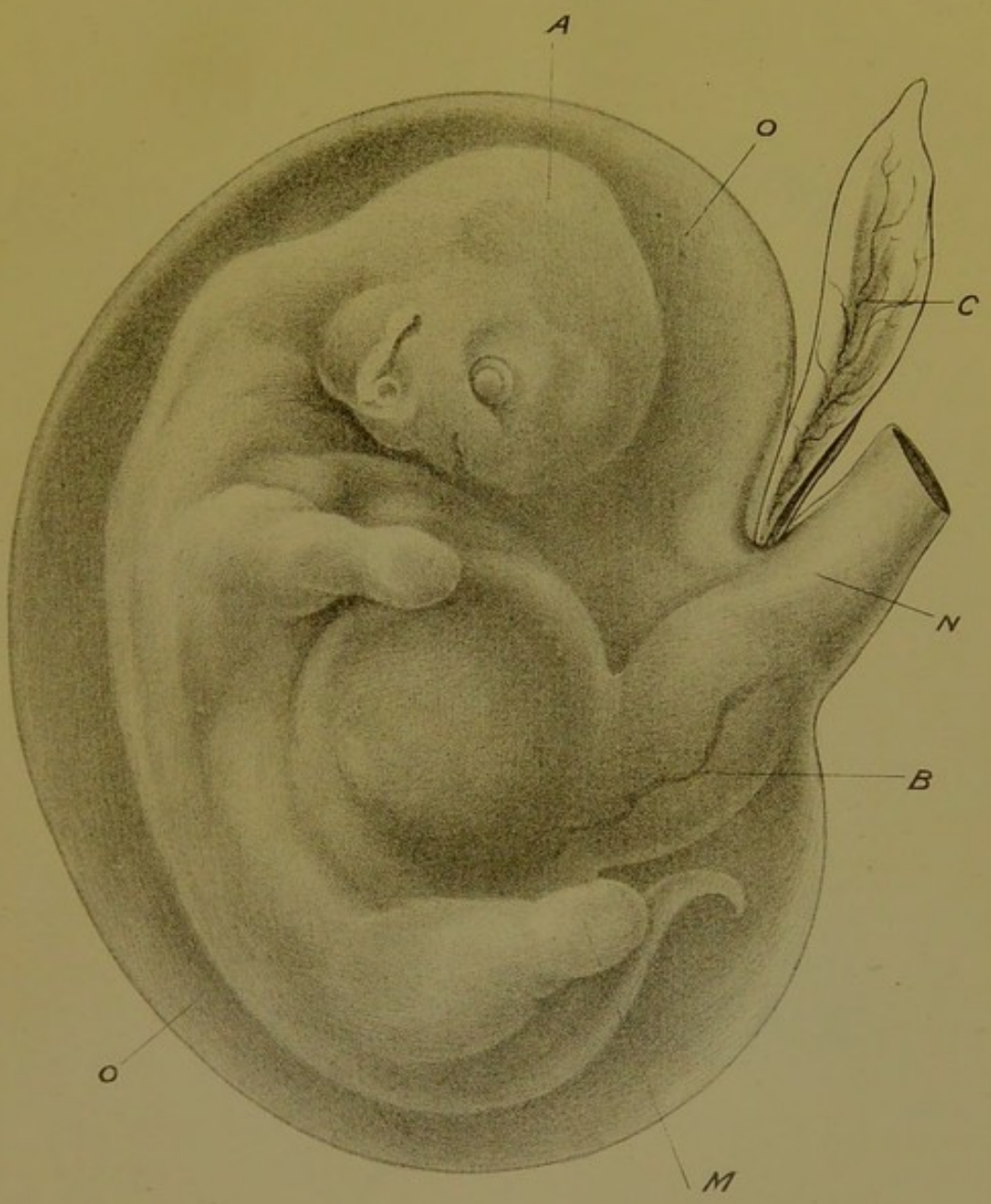


PLATE X.

FIG. 16.

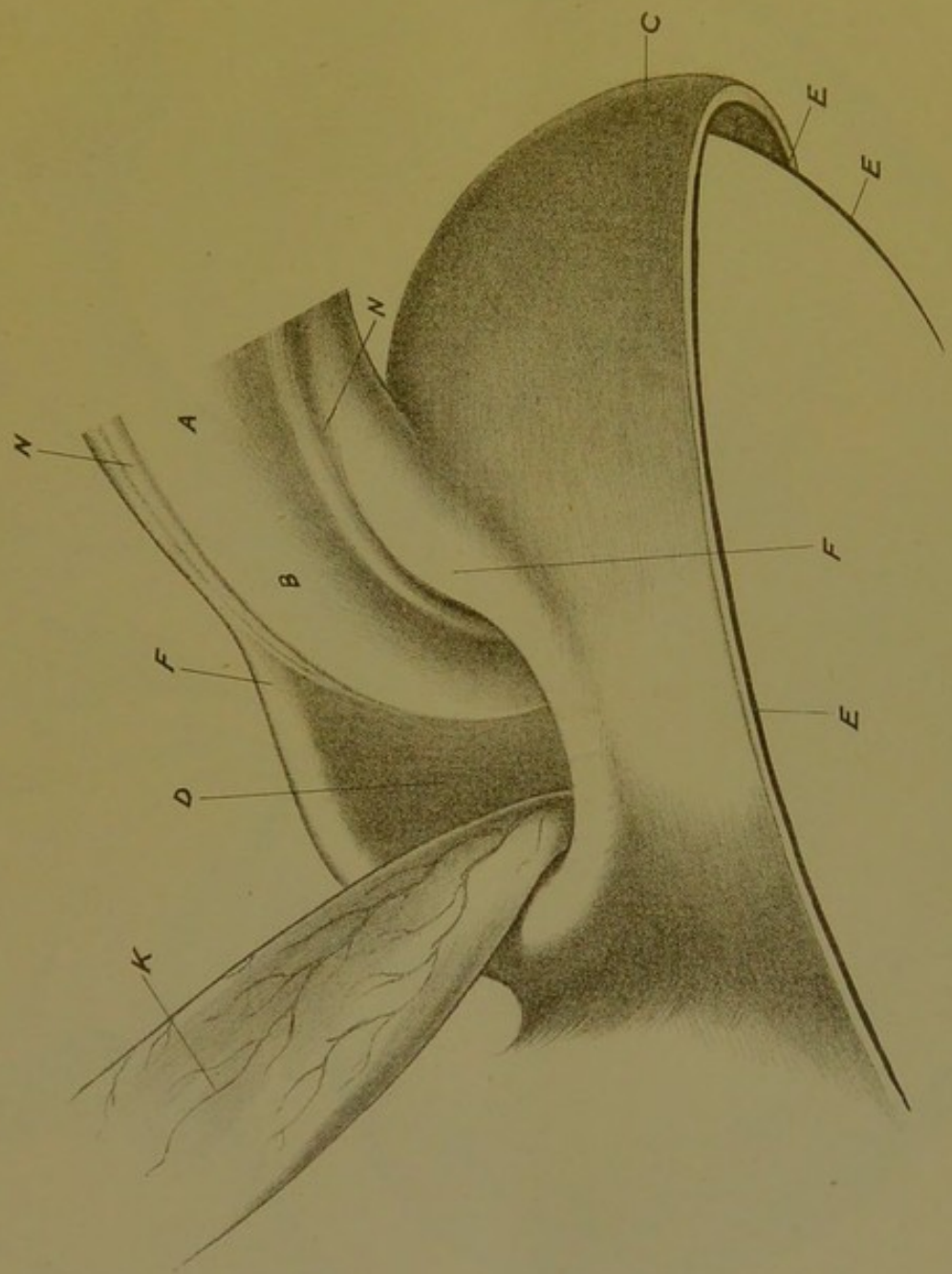


PLATE XI.

FIG. 17.

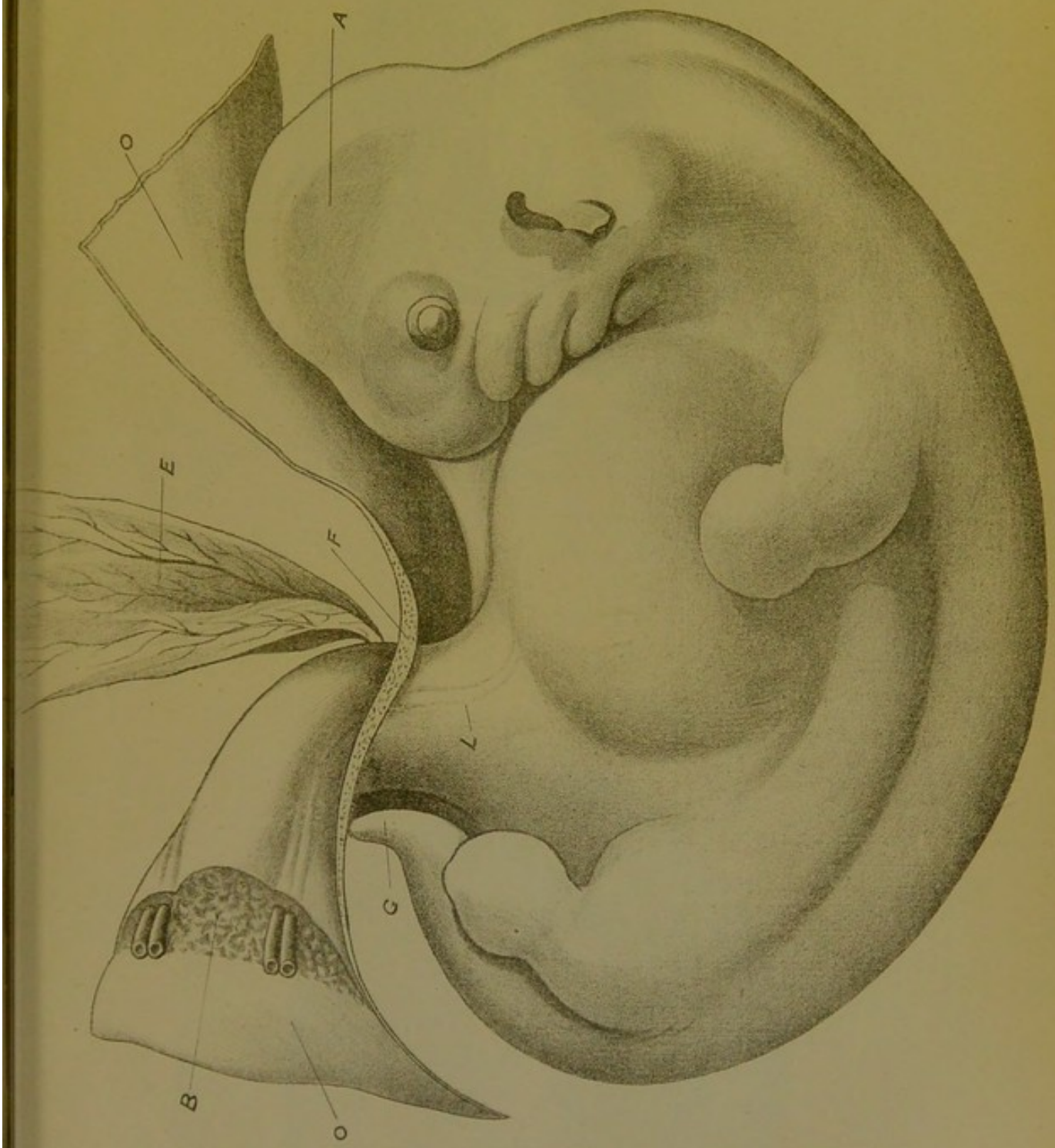


PLATE XII.

FIG. 19.

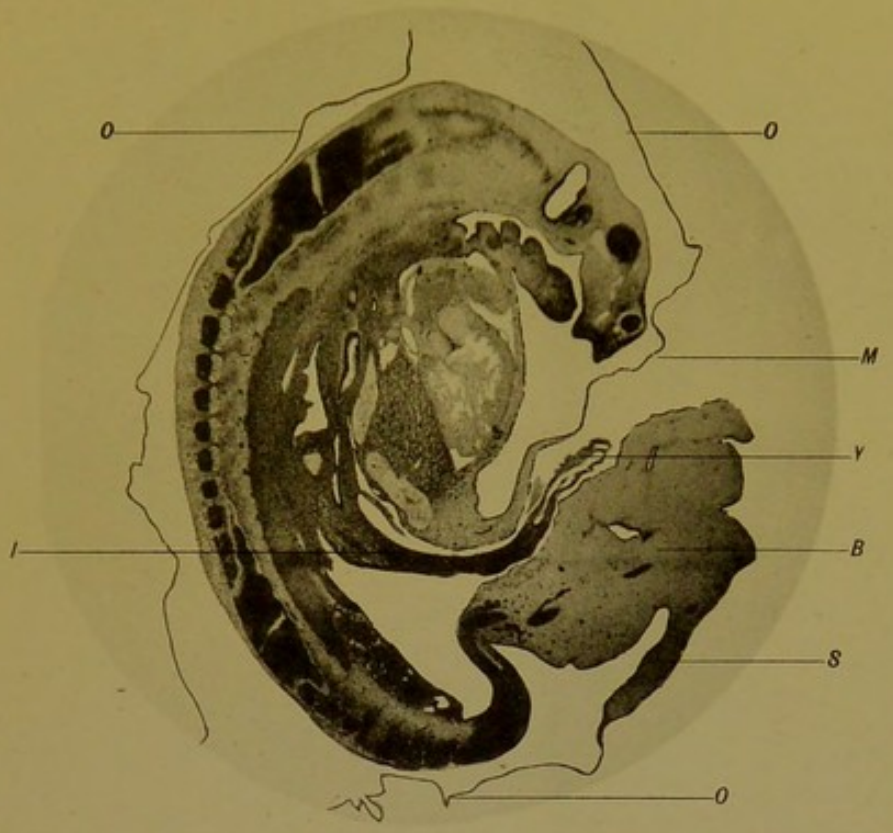
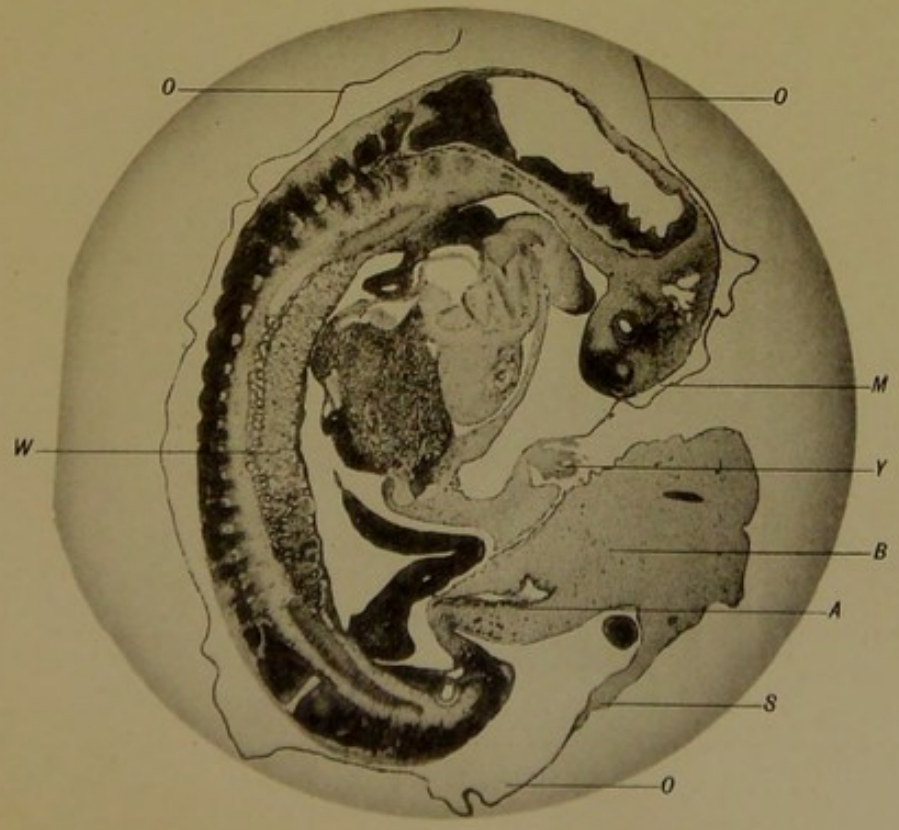


FIG. 20.



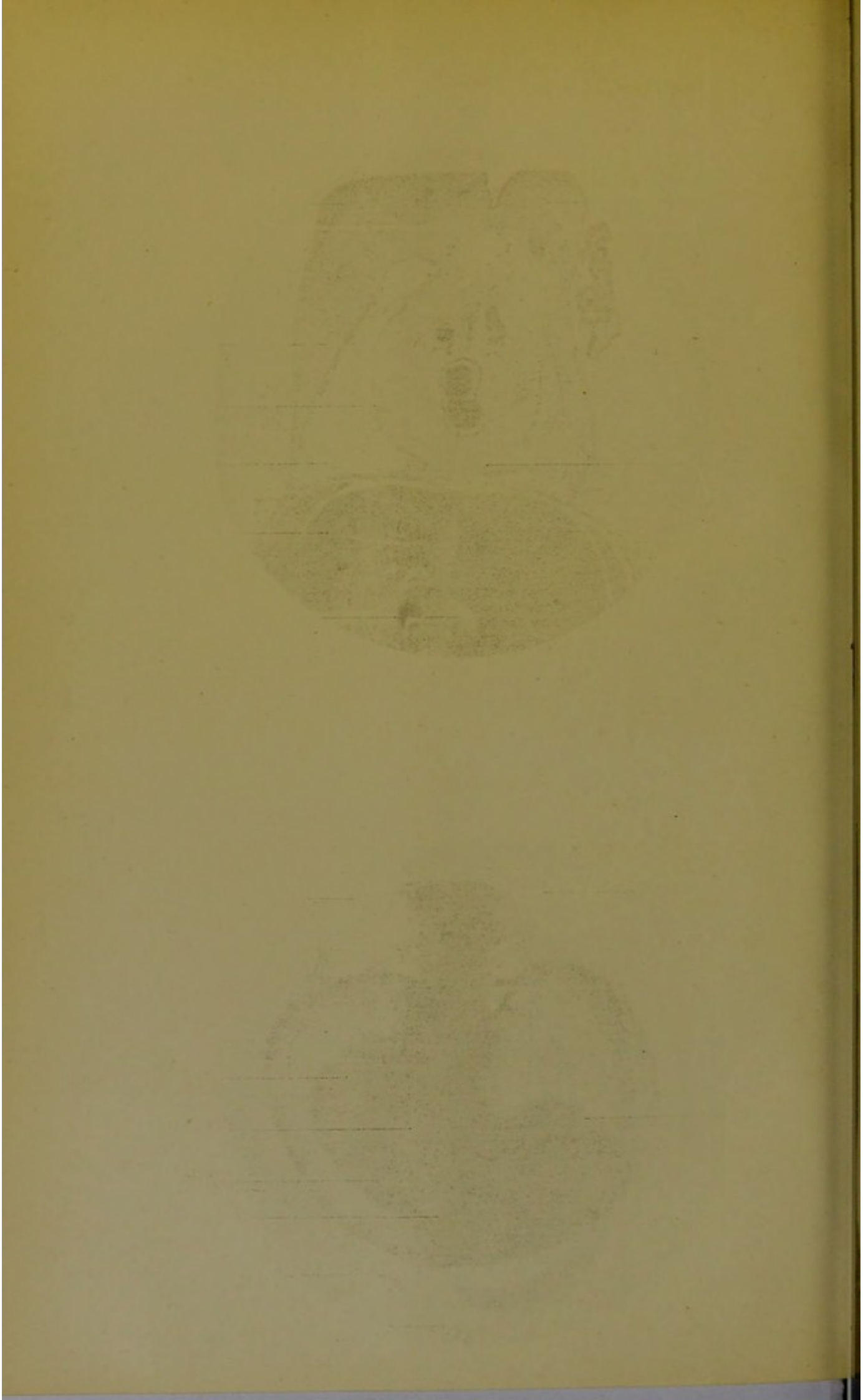


PLATE XIII.

FIG. 21.

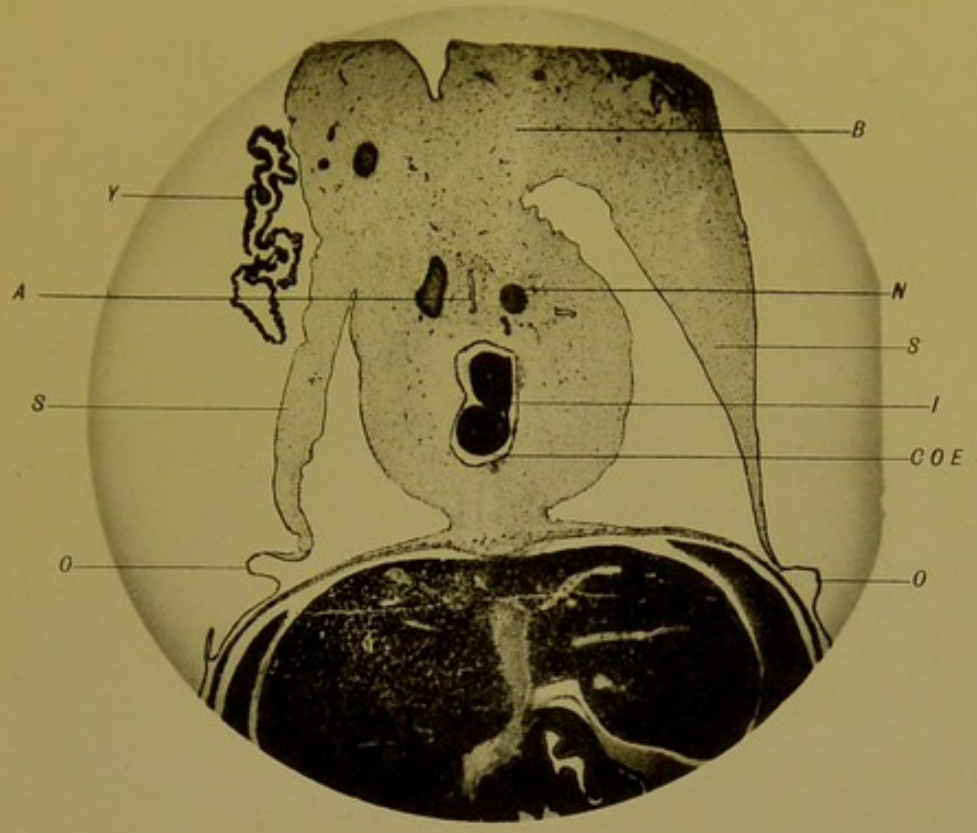
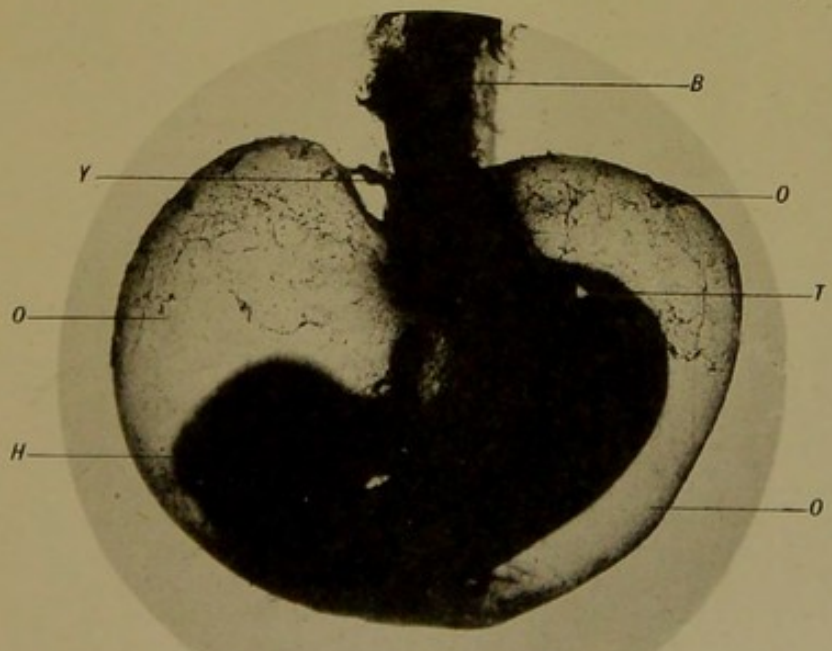


FIG. 22.



Description of Plates and Figures.

PLATE I.

Fig. 1.—An embryo deer, 6 mm. in length, lying on its back.

A B Head
C Yolk sac, joining the intestine.
D Intestinal tube at point of junction.
E Large collapsed yolk sac.
G F Wolffian bodies.
H H Large allantoic bladder, covered with vascular mesoblast.
K K Allantoic blood-vessels.
O Amnion.

Note the large widely open umbilical foramen and the small tubular communication between the yolk sac and the primitive intestine at this stage of development, and the length of the intestinal tube.

PLATE II.

Fig. 2.—The same embryo. Its dorsal surface is now seen.

C Collapsed yolk sac.
G Large vein gorged with embryonic blood corpuscles, in the left lateral somatopleure.
H Allantois with blood-vessels, drawn well away from the rump end of the embryo.
K K Large allantoic blood-vessels.
O Amnion.
S Somatopleure tissue covering the allantoic blood-vessels.

Note the rump end of the embryo projecting considerably beyond the point at which the ventral string, or allantoic outgrowth, leaves the ventral surface of the body. The rump end is tightly encased in the amnion.

PLATE III.

Fig. 5.—Microphotograph of section through this embryo at the point where the yolk sac joins the intestine (see Fig. 1).

C O E The cœlom, or body cavity.
E Epiblast detached in some places from somatic mesoblast.
I Primitive intestine lined with hypoblastic cells and in communication with the yolk sac.
L Large umbilical vein in lateral somatopleure, on both sides.
O Amnion—the direct continuation of the somatopleure folds.
S Somatopleure folds continuous with amnion passing round embryo.
W Wolffian body.
Y Yolk sac.

Fig. 6.—Microphotograph of section which passed transversely through the lumbar region of this embryo.

C O E The cœlom, or body cavity.
E Epiblast.
I Primitive intestine lined with hypoblastic cells. There is little or no mesentery here.
L Large vein in the lateral somatopleure. The left vein is very large.
O Amnion.
S Somatopleure fold. Just external to the vein on each side the fold is very thick.
W Wolffian body.

Note—the somatopleure folds in this section are close to each other.

PLATE IV.

Fig. 7.—Microphotograph of section passing vertically downwards through the allantoic outgrowth, and through the body of the embryo at the point where the tube of the allantois comes upwards out of the body.

A Allantoic tube lined with hypoblastic cells.
C O E The cœlom, or body cavity, here closed in.
E Epiblast.
I Primitive intestine lined with hypoblastic cells.
L Allantoic, or umbilical veins, in the wall of the lateral somatopleure folds.
N Allantoic artery—one on each side of the allantoic tube.
S Somatopleure folds. Their thick somatic mesoblastic surfaces in this region have now fused with the thick vascular mesoblast (splanchnic) enclosing the allantoic tube, thus shutting in the cœlom in this region.
O Amnion.
W Wolffian body. Small in this region.

FIG. 8.—Microphotograph of section passing vertically downwards through the Bauchstiel, or ventral string, and through the body of the embryo.

A Allantoic tube, lined with hypoblastic cells, passing out horizontally towards the chorion.
C O E Cœlom, here very small.
E Epiblast.
I Intestinal tube, lined with hypoblastic cells.
N N Allantoic arteries, just below allantoic tube.
O Amnion.
S Somatopleure folds.
W Wolffian body.

Note.—The Bauchstiel in this section consists of the allantoic tube, with allantoic arteries, in the midst of a mass of splanchnic mesoblastic tissue embraced on both sides by the thick lateral somatopleure folds in which are the allantoic veins.

PLATE V.

FIG. 9.—Microphotograph of section through the Bauchstiel and rump end of the embryo, just at the point where the caudal somatopleure fold, under the Bauchstiel, turns round to embrace the rump end of the embryo. The epiblastic surface of the rump, as seen in the section, is here separated from the epiblast lining the inner surface of the caudal somatopleure fold.

A Allantoic tube in section.
B Part of allantoic bladder.
E Epiblastic lining of amnion sac. The letter also points to epiblast on the rump.
I Cloacal enlargement of intestinal tube in which an invagination of the hypoblast is taking place to form two tubes—genital ducts.
L Allantoic vein.
N N Allantoic arteries just below allantoic tube.
S S Somatopleure folds.
O Amnion.
W Wolffian body.

FIG. 10.—Microphotograph of section through Bauchstiel and body of the embryo at rump end—very much the same as in section, Fig. 9, but in Fig. 10 the invagination of the hypoblast in cloacal enlargement of intestinal tube is completed, and two tubes in section are seen.

A Allantoic tube lined with hypoblast cells.
B Part of allantoic bladder.
E Epiblast lining amnion sac and covering body of embryo.
I Intestine.
L Large allantoic vein.
N N Allantoic arteries, just below allantoic tube.
O Amnion.
S S Somatopleure folds forming amnion sac and lined with epiblast.
W Wolffian body.

PLATE VI.

FIG. 11.—Microphotograph of section through flattened out or expanded Bauchstiel, and rump end of embryo, which is surrounded with a thick covering of somatopleure fold, or amnion membrane.

A Expanded allantoic tube.
B Part of allantoic bladder.
E Epiblast on surface of rump section. The epiblast also lines the ring of amnion round this rump section.
L Allantoic vein.
N N Allantoic arteries.
O Amnion.
S Ring of somatopleure, or amnion, round the section of the rump. It is very thick.

FIG. 12.—Microphotograph of section through Bauchstiel and rump, at the extreme end of the embryo—only a shaving of the rump end is seen within the amnion covering which is here very thick.

A Allantoic tube widely expanded.
B Part of allantoic bladder.
L Allantoic vein.
N Allantoic artery.
S Ring of somatopleure round the end of the rump of embryo.

PLATE VII.

FIG. 13.—A deer embryo lying on its back, and so placed as to show the Bauchstiel or ventral string and umbilical foramen now rapidly closing in round the vitelline duct of the yolk sac.

A Head, covered by amnion membrane.
C Yolk sac, the vitelline duct is seen passing into the cœlom or body cavity through the closing in umbilical foramen.
D The vitelline duct entering the umbilical foramen.
H H The Bauchstiel or ventral string.
K K Umbillical blood-vessels, in the ventral string.
M First trace of a hind limb, enclosed by the amnion.

PLATE VIII.

FIG. 14.—A deer embryo placed on its side so as to show the marked dorsal curve which takes place when the head and tail ends approximate over the umbilical foramen.

A Head.
B Heart.
C Yolk sac whose vitelline duct can be seen entering the umbilical foramen.
D Liver.
H Amnion on the side of the embryo.
K K Umbilical blood-vessels of the Bauchstiel. Between the line of these blood-vessels the Bauchstiel in the centre is uncovered by amnion.
L The Bauchstiel.
M Cut allantoic tube in centre of Bauchstiel.
N Amnion membrane covering the head, and attached to embryo at the cephalic margin of the umbilical foramen.

PLATE IX.

FIG. 15.—The embryo of a sheep. The amnion sac round the embryo is distended with fluid, and it is attached only to the distal end of the true umbilical cord, while the ventral string, outside the amnion sac, with its umbilical blood-vessels passes onwards to the mesoblastic surface of the chorion.

The young umbilical cord is seen within the amnion sac, and the vitelline duct appears to pierce the amnion on the anterior surface of the young umbilical cord.

A Head of embryo.
B The young umbilical cord. The letter *B* points to a large umbilical vein in the cord, seen through the amnion.
C Yolk sac. The vitelline duct is embraced by the closed in umbilical foramen at the front part of the umbilical cord at its distal end. The yolk sac now lies entirely outside the amnion sac.
M Hind limb.
N The ventral string outside amnion sac, consisting of mesoblastic tissue with the umbilical blood-vessels and remains of allantoic tube, passing out towards the chorionic villi.
O Amnion sac tightly distended with fluid, and attached only to the distal end of the true umbilical cord.

PLATE X.

FIG. 16.—This drawing, as the result of many observations, was designed to show the manner in which the umbilical foramen closes in around the yolk sac and the root of the Bauchstiel, both of which structures are within the cœlomic tube of the umbilical foramen. The Bauchstiel in the centre, within the line of the umbilical blood-vessels, is mesoblastic, and is uncovered by amnion. The amnion is in connection with the somatopleure folds attached to the embryo only at the margin of the umbilical foramen, and to the side and under surface of the Bauchstiel at its root, as already described.

As the cœlomic tube gradually closes in on the yolk sac and the Bauchstiel, the amnion membrane is at same time raised off the surface of the embryo by fluid distension, and there results a tubular process of somatopleure, below the raised up amnion, around the margin of the umbilical foramen, whose outer surface is epiblastic. This tubular process whose outer surface is epiblastic, as it lies below the distended amnion, is the first trace of the true umbilical cord ; and at its distal end the amnion is attached to and continuous with the somatopleure folds which constitute its walls.

A Allantoic tube in centre of vascular Bauchstiel.
B Bauchstiel. The central part between the line of blood-vessels is uncovered by amnion.
C Amnion sac encasing the whole embryo and attached to the embryo only at the margin of the umbilical foramen, and to the sides and under surface of the Bauchstiel at its root.
D Cœlomic mesoblastic surface of the umbilical foramen continuous with the outer mesoblastic surface of the amnion.
E Epiblast covering entire surface of the embryo and then reflected, at the umbilical foramen, over the entire inner surface of the amnion sac.
F F Outer mesoblastic surface of amnion.
K Yolk sac with vitelline duct.
N Umbilical blood-vessels.

PLATE XI.

FIG. 17.—Drawing of a sheep's embryo so prepared as to show the relation between the young umbilical cord and the amnion, the Bauchstiel and yolk sac. The entire amnion membrane has been cut away except a long narrow strip *O O*, which is attached to the distal end of the umbilical cord.

A Head of embryo.
B Bauchstiel outside the amnion sac, with the umbilical blood-vessels, on its way to the chorion. Attached to the under surface and to the sides of the Bauchstiel at this part is the caudal fold of the somatopleure, known now as the amnion, whose under surface is covered with the epiblastic layer reflected from off the umbilical cord which is within the sac.
E Yolk sac whose vitelline duct is tightly embraced by the cœlomic mesoblastic surface of the closed in umbilical foramen. The vitelline duct in the umbilical tube lies against that surface of the Bauchstiel, in the centre, which is uncovered by amnion membrane.
F points to the thick edge of the cut amnion membrane, which is always thick near to its attachment to the distal end of the cord, because the amnion here is a continuation of the thick somatopleure folds, which form the wall of the umbilical foramen.
G The tail of the embryo, in this case lying in a vertical groove on the posterior wall of the umbilical cord.
L The umbilical cord, whose outer epiblastic surface is reflected over the entire inner surface of the amnion. The letter points to vein.
O O Amnion membrane attached to the umbilical cord at its distal end.

PLATE XII.

FIG. 19.—Microphotograph of vertical mesial section through a deer embryo to show the vitelline duct and intestinal tube in the centre of the young umbilical cord, which is within the amnion sac.

B Bauchstiel outside amnion sac with its blood-vessels passing out to the chorion.
I Intestinal tube in connection with vitelline duct, in the umbilical cord.
M Cephalic fold of amnion in direct continuity with the cephalic fold of the somatopleure.
O Amnion passing round the embryo.
S Caudal fold of somatopleure at under-surface of Bauchstiel continuous with the amnion.
Y Vitelline duct.

FIG. 20.—Microphotograph of vertical mesial section through a deer embryo.

A Allantoic tube remains.
B Bauchstiel.
M Cephalic fold of amnion continuous with the cephalic fold of somatopleure.
O Amnion sac round embryo.
S Caudal fold of somatopleure, below Bauchstiel, continuous with the amnion.
Y Yolk sac, vitelline duct.
W Vertical section of Wolffian body.

Note the line of adhesion between the somatic mesoblast of the cephalic somatopleure fold and the anterior surface of Bauchstiel in this section of the young umbilical cord. A fold of the intestine points to it.

PLATE XIII.

FIG. 21.—Microphotograph of section which passed horizontally through the body and umbilical cord of sheep's embryo.

A Remains of allantoic tube.
B Bauchstiel, outside amnion sac.
C O E Cœlom.
I Folds of intestine in the cœlom.
N Allantoic artery.
O Amnion membrane passing round body of embryo and continuous with the thick lateral somatopleure folds from the distal end of the cord.
S Lateral somatopleure folds turning round and backwards after closure of the umbilical foramen, to become continuous with amnion membrane.
Y Yolk sac outside amnion sac.

FIG. 22.—Deer embryo enclosed within the tightly distended amnion sac, almost natural size. The amnion is tightly distended with fluid, and is attached only to the distal end of the umblical cord, while the vascular ventral string or Bauchstiel, outside the amnion sac, spreads out over the inner surface of the chorion to distribute its blood vessels to the chorionic cotyledons.

B Bauchstiel or vascular ventral string.
H Head of embryo within the amnion sac.
O O Tightly distended amnion sac.
T Tail of embryo.
Y Vitelline duct outside the amnion sac at front part of umbilical cord.