

**A preliminary note on the development of the clitoris, vagina, and hymen /  
by D. Berry Hart.**

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A PRELIMINARY NOTE  
ON THE  
DEVELOPMENT OF THE CLITORIS,  
VAGINA, AND HYMEN.

BY  
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# A PRELIMINARY NOTE

## ON THE

### DEVELOPMENT OF THE CLITORIS, VAGINA, AND HYMEN.<sup>1</sup>

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WHILE much has been done to put the development of the female genital organs on a satisfactory basis, there are certain points in which our knowledge is defective, as well as some outstanding facts which have not yet received a clear explanation, and can thus only be classed as anomalous. In the first place, so far as our present knowledge goes, it is remarkable that in the foetus at full time a hymen is always present; and still more remarkable that even in atresia vaginae the hymen, and occasionally a double hymen, is developed. Why should the hymen be always present in the full-time foetus? Why in atresia vaginae should the hymen escape the atresia?

Then, again, the structure of the vaginal mucous membrane is quite analogous to that of skin. We have many layers of a squamous and quite characteristic nature, the cells of the deeper layers being more oval and staining more deeply. The superficial layers desquamate like skin; there are practically no glands present, and in prolapsus uteri the everted mucous membrane takes on the appearance of the body skin. One would expect, therefore, an epiblastic origin for the lining of the vagina and the outer covering of the vaginal cervix. The genital tract is stated to be developed, however, from the ducts of Müller, the non-coalescing parts forming the Fallopian tubes, the coalescing portions the uterus and vagina. The ducts of Müller arise probably from the mesoblast, the Wolffian ducts from the epiblast. The received opinion is, therefore, that the vaginal lining is derived from Müller's ducts, a mesoblastic source, and that the Wolffian ducts and bodies have only an important excretory function in the early foetus until the permanent kidneys develop. Their importance as active organs then ceases,

<sup>1</sup> From the Laboratory of the Royal College of Physicians, Edinburgh.

and they are considered as possessing merely a pathological significance, as they provide the gynæcologist with the well-known parovarian cyst, with some of the papillomatous tumours of the ovary and broad ligament, as well as some of the rarer vaginal and broad ligament cysts. Some observers assert that the Wolffian ducts enter into the formation of the lower part of the vagina; and Pozzi, in a very acute and able manner, gives most excellent reasons for considering the hymen as not vaginal. Whether he is right in stating that it is to be considered vulvar remains to be seen.

For some time past I have had prepared for microscopical examination the pelves of early foetuses, male and female, the paraffin method being employed and the material cut serially. I examined them at first for my own information and for teaching purposes, but the remarkable developmental changes roused my interest and induced me to go more thoroughly into the matter than I had at first intended. From the published works and papers of His, Waldeyer, Dohrn, Nagel, v. Mihalkovics, Budin, Tourneux and Legay, Klein, Pozzi, Kollmann, Keibel, and from the suggestive text-book of Minot, I received much valuable information, but no answer to the initial difficulties I have stated. A prolonged and careful examination of my specimens seems to me to have cleared up these anomalous points, and this is my reason for publishing the present communication, and committing what the professed embryologist may consider a trespass.

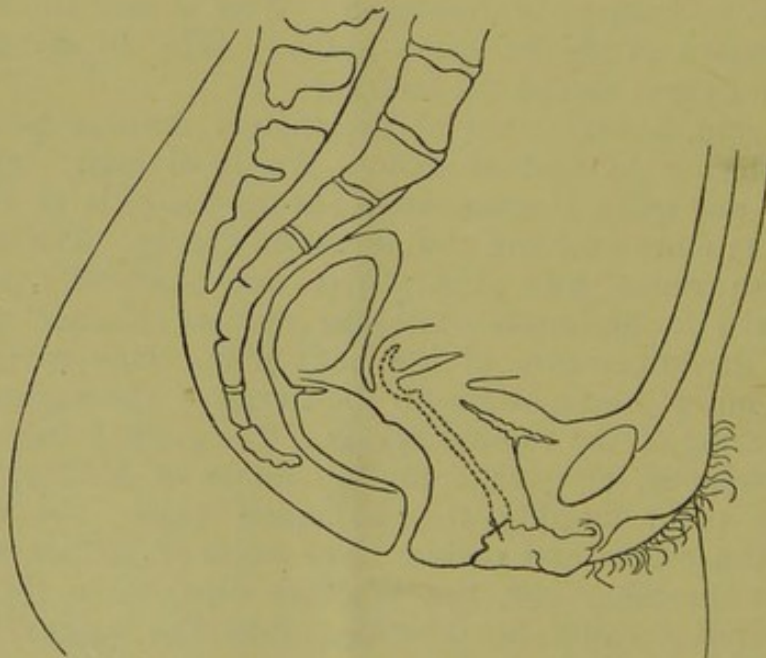


FIG. 1.—Vertical mesial section of the female pelvis (modified from Foster). A cross marks the site of the hymen, and the lining of the vagina derived from the Wolffian bulbs has a dotted outline.

The question to be considered will be clearly understood if Figs. 1 and 2 be first studied. Fig. 1 shows a vertical mesial

section of an adult pelvis. One sees the hymen on section, and the vagina with its outline dotted where its lining is derived, as I hope to show, from the Wolffian ducts, and therefore epiblastic.

Farre and Cullingworth accurately describe the hymen as a pouting vertical slit, and there is no doubt that some of its various shapes are made by the method of examination.

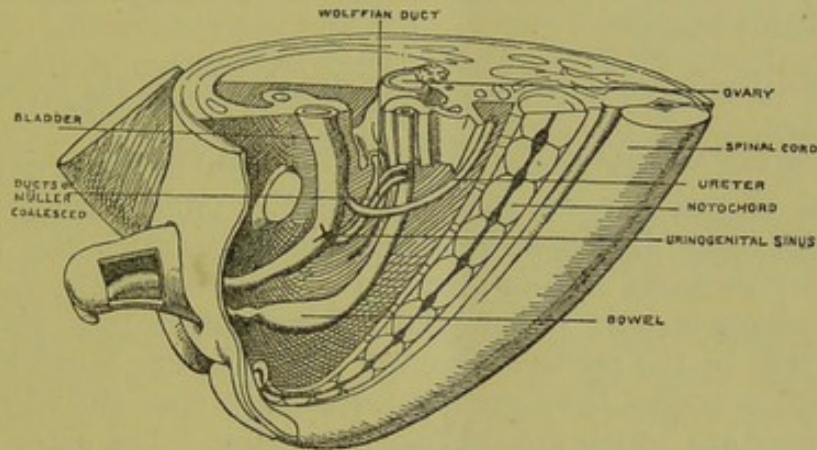


FIG 2.—From Keibel's model of organs in foetus at about eighth week. The eminence of Müller where the hymen will develop is marked with a cross, which also lies at the upper end of the sinus. (8.)

Fig. 2 shows Keibel's valuable model of the relations at the eighth week; it is practically the same as in the seven weeks' foetus, of which sections are given in the Plates. It is at Müller's eminence that the hymen is developed, and the main object of this note is to determine some of the changes transforming Fig. 2 into Fig. 1.

The specimens I had for examination were as follows:—(1.) Serial sections of a five weeks' foetus, carefully prepared and stained, which I owe to the kindness of Dr H. J. Stiles. (2.) A seven weeks' foetus, also serially cut. This was from a cancerous seven weeks' pregnant uterus, successfully extirpated by me, and prepared and stained by Dr Lovell Gulland. (3.) A foetus at the third month, perfectly fresh and well preserved. (4.) A four and a half months' foetus, and (5.) one at full time. I also examined several male pelvises as well as those of foetal rabbits, but do not consider these at present.

The foetuses (3.) to (5.) were prepared by Mr Hume Patterson at the Laboratory of the Royal College of Physicians, where also the microphotographs and transparencies were made. I am greatly indebted to Mr Patterson for the skill he displayed in the preparation of the specimens and photographs.

The early foetuses were cut serially and transversely by the paraffin method; all the sections were mounted. The later foetuses were treated in the same way, but only every sixth could be mounted, and the sections were cut in the sagittal mesial plane. Mr Stiles' preparation had been stained in carmine in block; for all the rest, logwood and eosin were employed.

Based on this examination, and on the literature of the subject, I shall now consider—

(1.) *The development of the genital tract prior to the formation of the hymen.* This is well illustrated by the foetuses of the sixth and seventh week.

(2.) *The origin and development (a) of the prepuce of the clitoris, and (b) of the hymen.* The foetuses of the third and fourth month illustrate this stage.

(1.) *The development of the genital tract prior to the formation of the hymen.*

In the seven weeks' foetus one finds, in the abdominal cavity, the peritoneal ridges, one on each side of the middle line, with the Wolffian bodies. Lower down, the outer ridges with the Wolffian and Müllerian ducts appear; and at the lower levels, the ovary with its characteristic pedunculated form comes into view, lying on what will be the posterior lamina of the future broad ligament. The Wolffian bodies have greatly lessened in size, and at the level of the ovary are much diminished in section. The outer ridge is hour-glass shaped on transverse section. In the outer segment the ducts of Wolff and Müller develop: the inner one becomes the ovary. The outer joins its fellow to form the broad ligament in front of the ovarian part, which thus comes to lie behind.

In the broad ligament we have the Wolffian ducts and ducts of Müller, and at a lower level the genital cord of Thiersch. In the five weeks' foetus we find four canals in the genital cord, the two outer being the Wolffian ducts, the two inner the ducts of Müller. In the six weeks' foetus the ducts of Müller have coalesced into one canal, but the Wolffian ducts are distinct. Still lower we get the Wolffian ducts opening into the urino-genital sinus, while the ducts of Müller end in the eminence of Müller between these (v. Plates I. and III.).

Immediately before the Wolffian ducts so end they flatten out laterally, and with the Müllerian ducts form an H-shaped appearance on transverse section (Pl. III., Fig. 6). So far, then, it is certain that the Anlage of the greater part of the vagina is the ducts of Müller, with probably a part of the Wolffian ducts where the adult vagina is H-shaped on transverse section. (Hoffmann, quoted by Pozzi; but I have not been able to get the original paper.)

(2.) *The origin of (a) the prepuce of the clitoris and of (b) the hymen.*

In the four and a half months' foetus the coronal section of the glans clitoridis shows a remarkable horse-shoe like structure surrounding the glans tissue. The margins of the horse-shoe consist of a layer of active cells staining deeply, while between these we have less deeply stained cells (Pl. IV., Figs. 7 and 8). So far as one can determine, they are epithelial cells. Their origin and nature are clearly determined in the sagittal sections

of the glans in the three and a half months' foetus, where one sees, at the lower part of the clitoris apex, the epidermis sending in two sickle-shaped processes whose apices do not meet (Pl. IV., Fig. 7). This is really a thimble-like involution of epidermis, the open base of the thimble being at the corona. The superficial layers of the epidermis are necessarily in the centre of these involutions. The clitoris in the early foetus is bulbous and entire (Pl. V., Fig. 10). The involution, as already described, takes place at or about the third month, and the separability of the prepuce is formed by the central cells, which are really the superficial ones, desquamating; *i.e.*, the prepuce is now the movable hood we find in the adult.

To see the changes which bring about (b) *the development of the hymen*, we must examine sections at the third and fourth month respectively.

The specimens I examined were at the third and a half and fourth month, and the sections were cut sagittally in the former specimen, and in the axial transverse direction in the latter; *i.e.*, from side to side, and in the axis of the brim in the four and a half months' one.

Remarkable changes have taken place in the vagina. We have seen that in the early foetus the vagina was formed from the coalesced ducts of Müller, and that a lumen was present, the cavity being lined with a single layer of cells. What we now find is as follows:—At what we may term the site of the vaginal entrance one sees an ingrowth, the deeper layer of the vestibule lining passing in, and with it the superficial layers too. This passing in of the superficial layer is, as in the case of the clitoric prepuce, of great importance, as it is the desquamation of these superficial layers, however effected, that gives rise to a lumen. The passage is in the form of multiple tubular ingrowths, so that we see on section several canals the walls of which gradually disappear, and thus a single canal up to the outer aspect of the hymen is formed (Pl. IV., Fig. 7).

A little higher in the vaginal axis remarkable structures are now to be noted, *viz.*, two oval collections of cells from which cords of actively proliferating cells pass in several streams, as it were, to fill up the vaginal lumen as far as the cervix uteri, where in this specimen the posterior fornix is mapped out by a sickle-shaped prolongation of the cells. The vaginal lumen is solid below, but higher up a lumen has begun to form. The periphery of the bulbous collection of cells is mapped off by actively growing cells, while the mass of the bulb is made up of epithelial cells exactly similar to those of the epithelial lining of the fully developed vagina, the peripheric cells being the same as those in the deeper layers of the vaginal epithelium. In regard to this bulb an examination of all the sections shows that the following conditions are present:—At a little distance from the middle line it is solid;

in the middle line it has a lumen in the form of a vertical slit; while further out a second bulb is seen and with a duct, the Wolffian duct passing into it. One of the bulbs is the larger, and they lie laterally in relation to one another (Pl. VI., Fig. 12; and Pl. II., Figs. 3 and 4).

I may anticipate here, for convenience of terminology, one of the chief conclusions of my paper, by saying that these bulbs are Wolffian in their origin—*i.e.*, are derived from the Wolffian duct—and I shall now term them the Wolffian bulbs.

It is evident that we can now explain the hymeneal opening of the vagina, as we must distinguish between this and the formation of the fully developed hymen and its varieties. At present I only consider the former question.

The hymeneal opening is evidently formed by a vestibular involution from below meeting the bulbar distensions above, and causing a thinning, and ultimately a perforation, of the intervening tissue.

The four and a half months' pelvis shows the fully-formed and coalesced bulbs with a vertical slit, and according to the obliquity of the section we get either one bulb or both. Between the lower ends of the bulb is a vertical spur, the rudiment of the posterior vaginal column (Plate V., Fig. 9).

The full statement of the formation of the vagina and hymeneal opening seems to me to be as follows:—Up till the origin of the hymen the vagina is Müllerian and lacking its lower end. Then comes the formation of the Wolffian bulbs by a proliferation of the lower ends of the Wolffian ducts. The epithelium of these ducts, epiblastic in their origin, forms the Wolffian bulbs, and, proliferating, passes up into the vaginal canal, filling up its lumen, mapping out the fornices, covering the vaginal portion of the cervix, and passing at first into the lower part of the cervical canal. The central cells are the least active and become shed; that is, a lumen is formed. The vaginal entrance is formed where the epiblastic ingrowth from below meets the bulbar distension above, and this is the developmental definition of the hymen and the vaginal entrance.

The view so ably advocated by some authors, that the fully-formed vaginal lining is derived from the ducts of Müller, is full of difficulties. It would make the vaginal lining mesoblastic, and give no explanation of the remarkable blocking of the vagina with cells while the hymen is being formed, as well as no reason for the different lining of the adult vagina, uterus, and tubes. The lining of the uterus is Müllerian and mesoblastic, that of the vagina is Wolffian and epiblastic.

The question of the relation of these ducts to the germ layers is, however, much disputed. In the Elasmobranchs they appear to have a common origin. So far as my reading and examination of specimens go, I am of opinion that the Müllerian duct is

mesoblastic in the human foetus, but that at its very lowest part the vagina is Wolffian and therefore epiblastic, and that as the hymen is derived from the Wolffian bulbs, its inner surface is epiblastic. Its outer surface is really hypoblastic, being derived from the lining of the urino-genital sinus.

The view I advance seems to me to explain the development so far as the points stated in the beginning of the paper are concerned, and may be summed up as follows:—

1. Before the hymen is developed—*i.e.*, up till the second and third month of foetal life—the vagina is formed by the coalesced ducts of Müller, but no lower aperture and no hymen are present; the vagina is Müllerian and blind.

2. At the beginning of the third month two bulbs form from the lower ends of the Wolffian ducts, the periphery of these bulbs being formed from the more active cells, the central of cells of a more squamous type. The cells are, in fact, the same as those of the adult vagina.

3. By the proliferation and spread of these cells the Müllerian vagina has its lumen blocked, the fornices and vaginal portion of the cervix mapped out.

4. The Wolffian bulbs coalesce, break down in the centre, and as the Wolffian cells in the centre of the Müllerian vagina do the same, we get the normal vaginal lumen formed.

5. The hymeneal opening is brought about by the epithelial involution from below meeting the distending bulbs above.

6. The ducts of Müller determine the site of the vagina; the Wolffian ducts supply its lining and develop the hymen (*v.* also 5).

The bearing of these views on Atresia vaginae is as follows:—

1. Atresia vaginae is atresia of the Müllerian vagina, but the hymen, being Wolffian in origin, is present.

2. The reason a hymen is always present in the fully-formed foetus is as follows:—The Wolffian bulbs form the hymen and obliterate the lower ends of the ducts of the Wolffian bodies, and as these are the temporary kidneys of the foetus, they must of necessity have been present during the early life of a fully developed foetus.

3. The double hymen is not due to a permanent duplicity of the ducts of Müller, but to a non-coalescence of the Wolffian bulbs. The vertical slit of the hymen is due to the apposition of the lateral Wolffian bulbs.

4. In imperforate hymen the tissue between the involution from below and the Wolffian bulbs has not been perforated.

The real essence of all this development seems to be as follows:—In the fully-formed genital tract we have the lining of the uterus developed from the ducts of Müller, and having as its great function pregnancy and menstruation. Its single epithelial layer and delicate connective tissue fit it for these functions; but for the pressure of parturition which the vagina has to undergo,

we need a multiple, squamous, in fact, skin-like structure, such as is supplied from an epidermic source. One can see the great difference in the mucous membranes of, say, an inverted uterus and prolapsus uteri. In the one we have a raw, bleeding surface, quite unfitted for friction; in the other a structure that soon becomes skin-like and horny. To give the vagina this skin-like structure we get the Müllerian lining replaced from the epiblastic Wolffian bulbs; these at the same time taking a part in the formation of the hymen, as already described.

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- See Tourneux and Legay, and Hertwig’s text-book for full literature.

PLATE I.

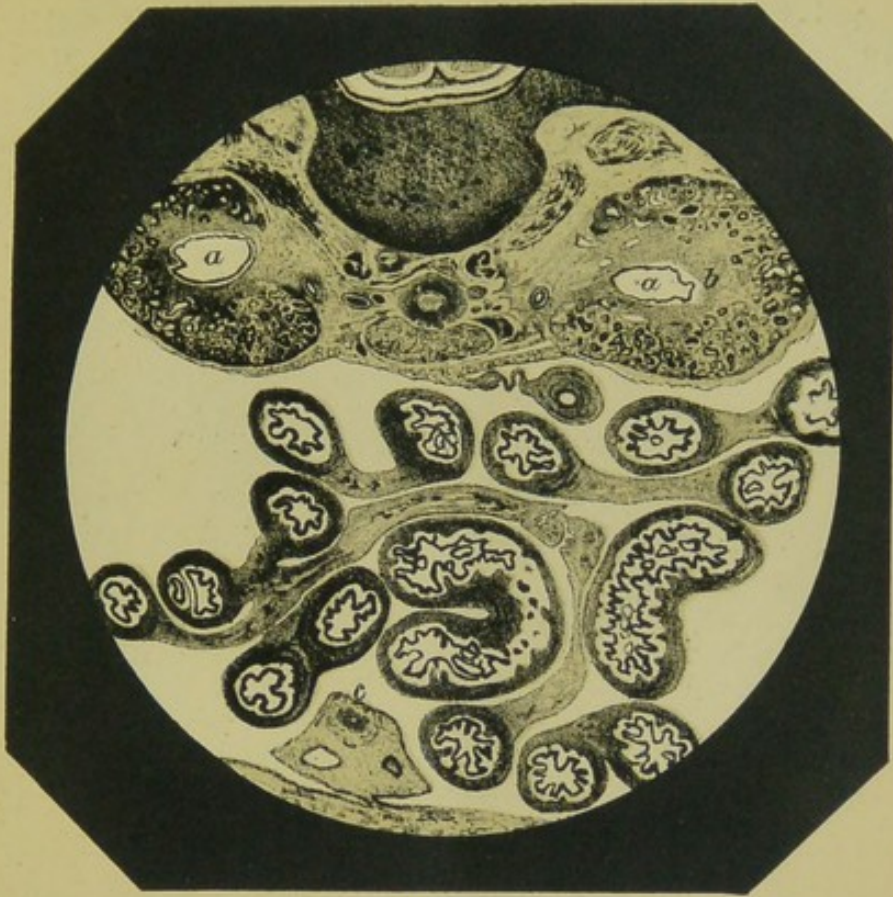
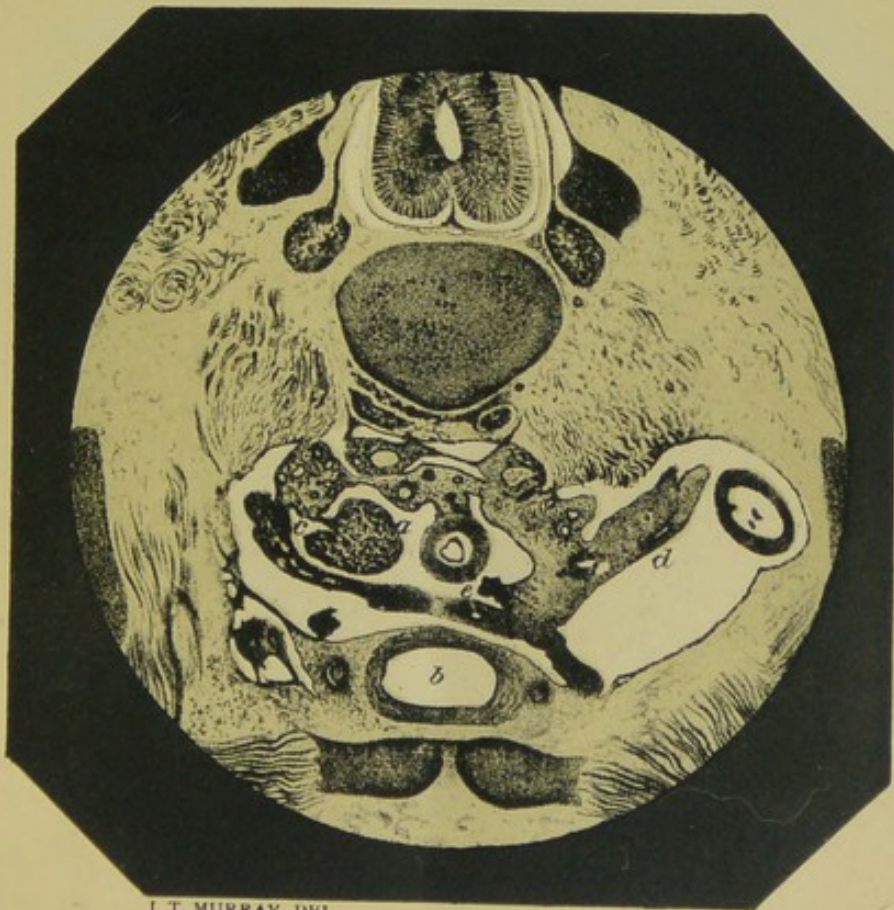


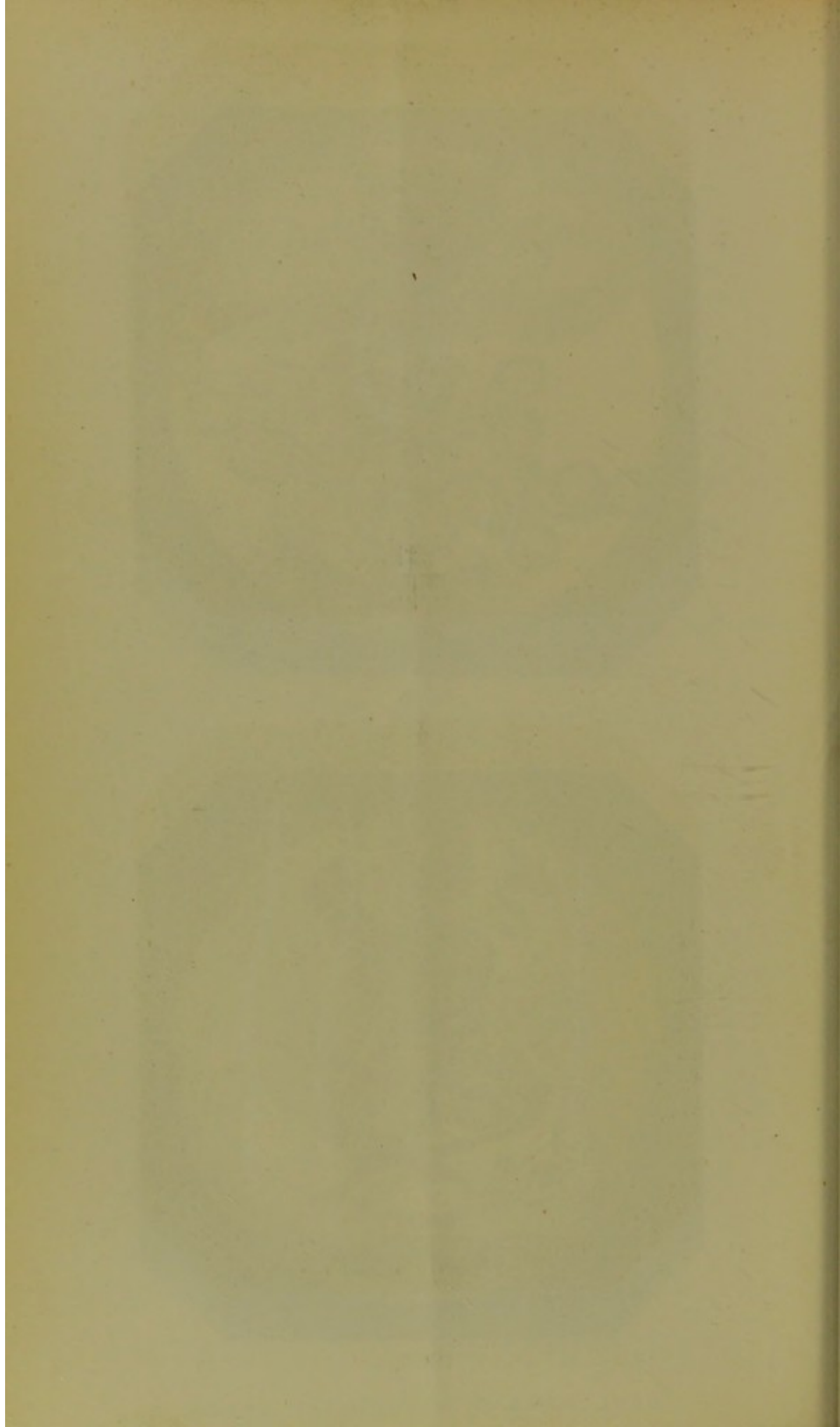
FIG. 1.



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FIG. 2.

DEVELOPMENT OF GENITAL TRACT.



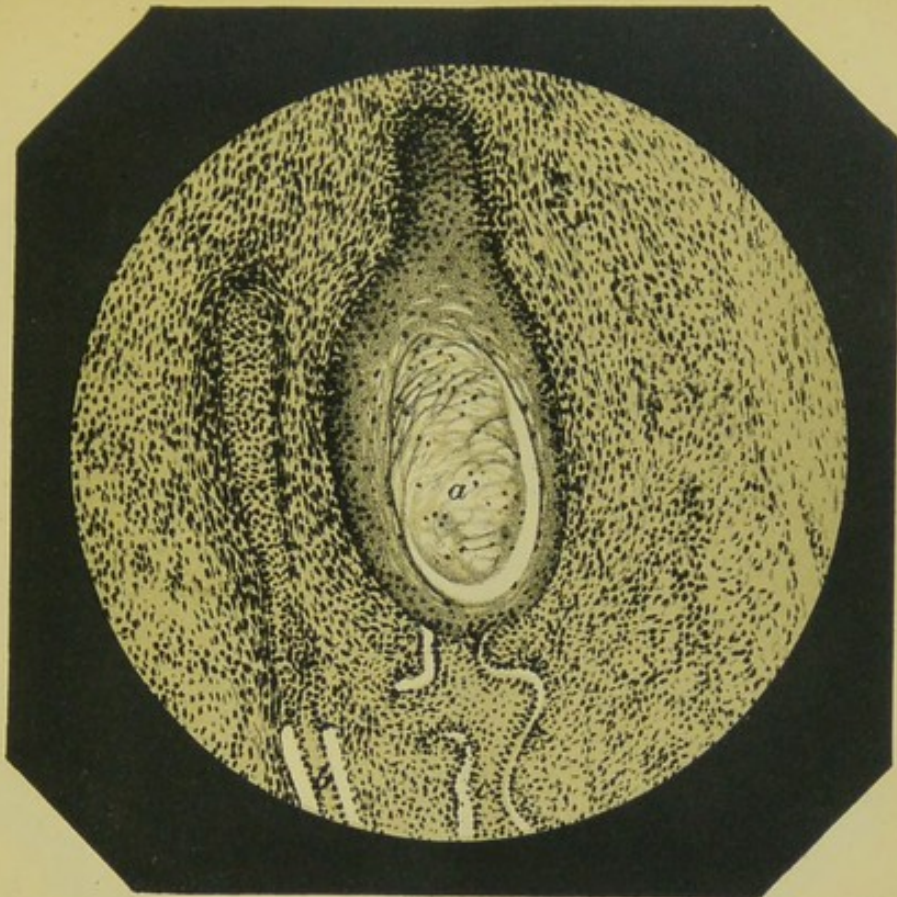
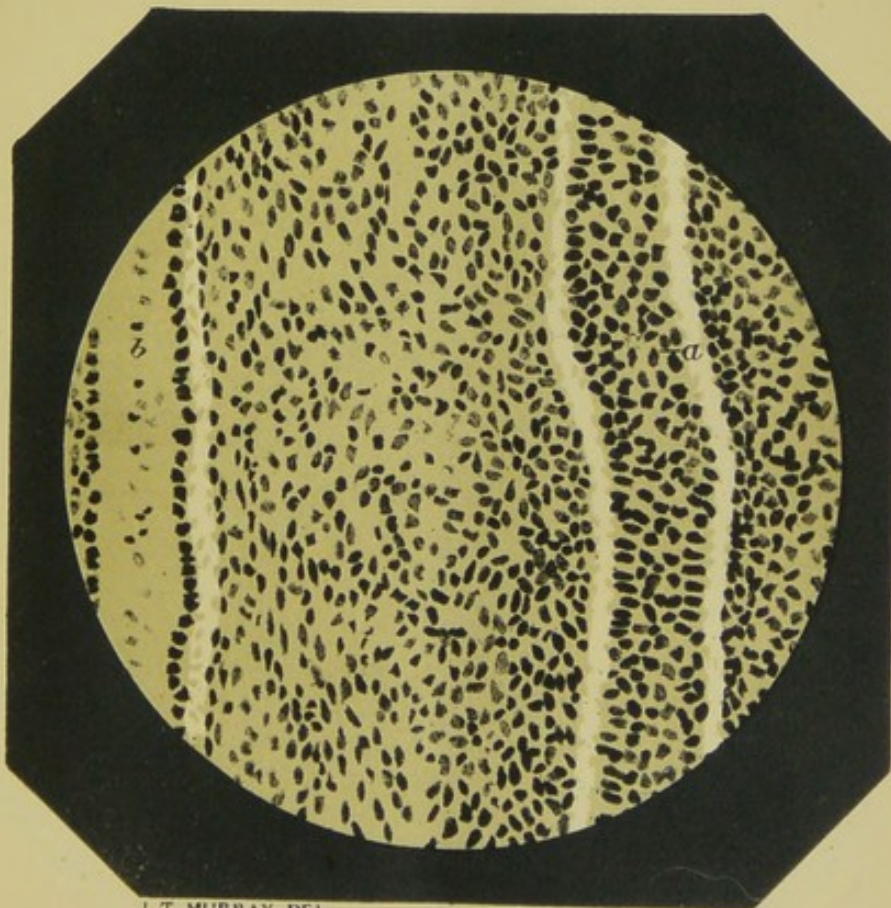


FIG. 3.



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FIG. 4.

DEVELOPMENT OF GENITAL TRACT.



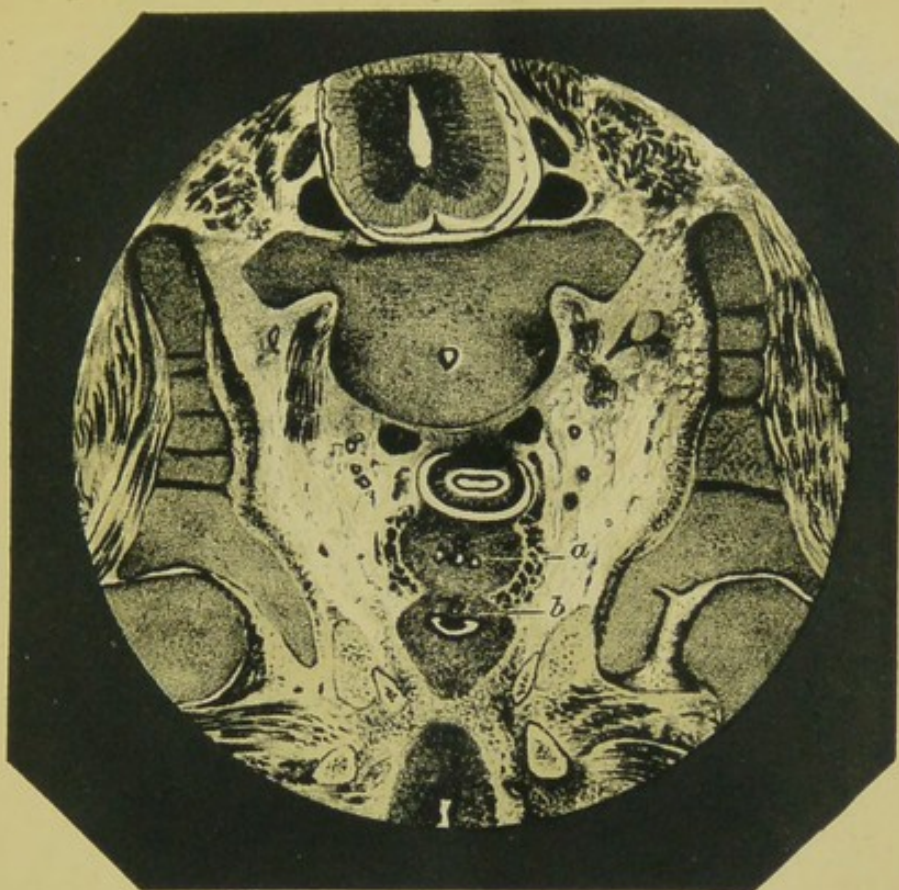
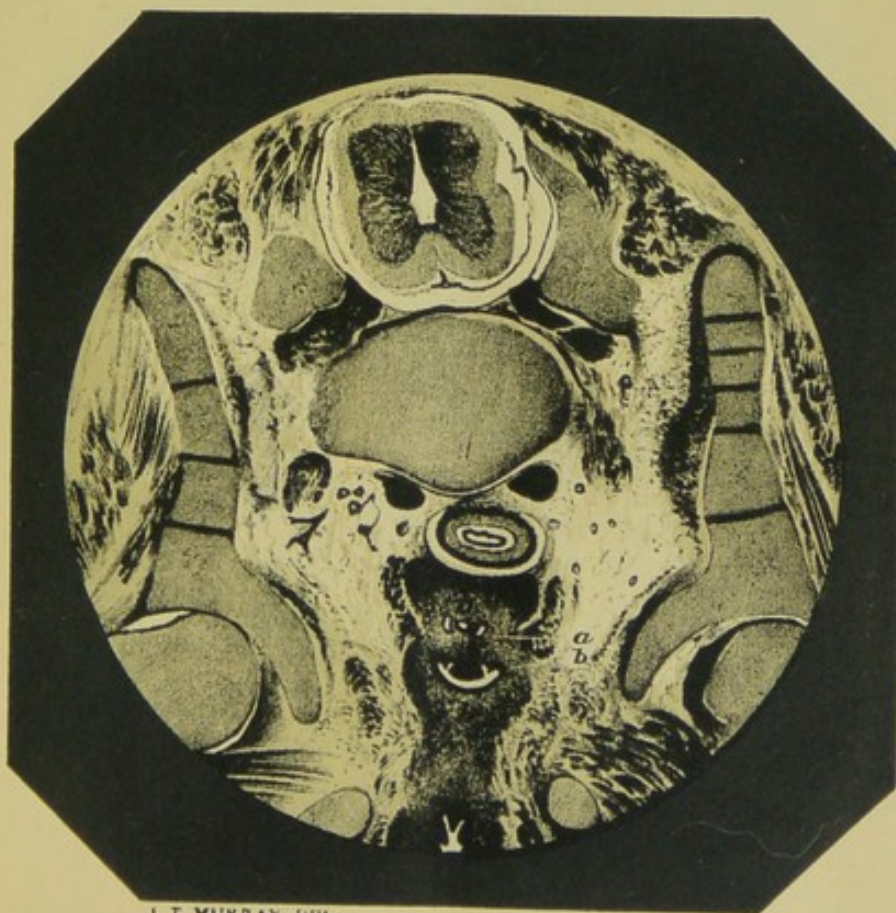


FIG. 5.



J. T. MURRAY, DEL.

FIG. 6.

DEVELOPMENT OF GENITAL TRACT.





FIG. 7.



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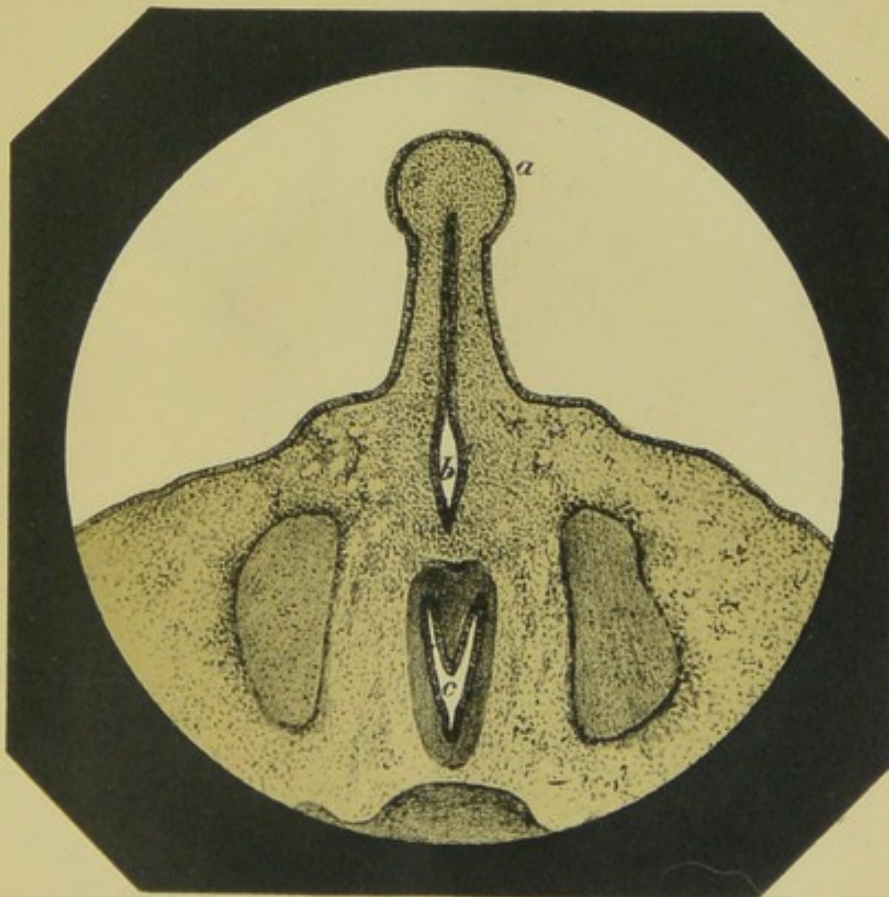
FIG. 8.

DEVELOPMENT OF GENITAL TRACT.





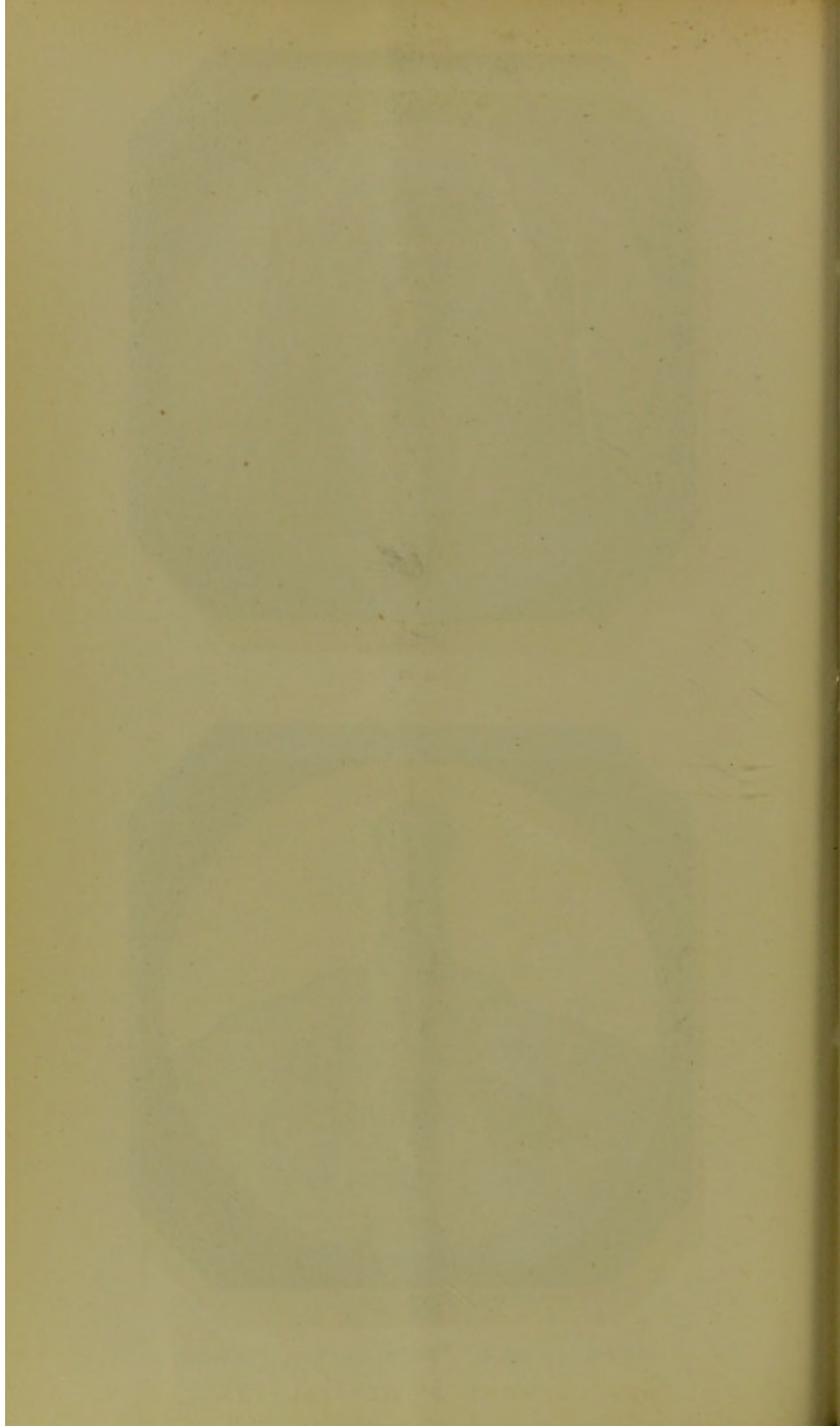
FIG. 9.



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FIG. 10.

DEVELOPMENT OF GENITAL TRACT.



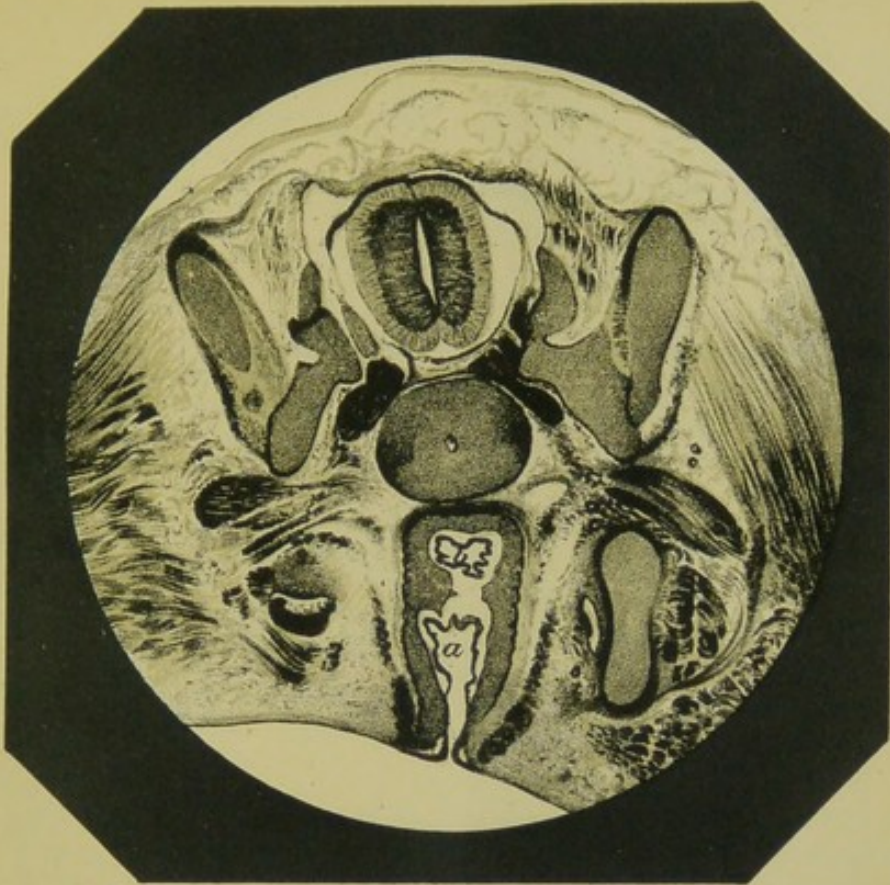
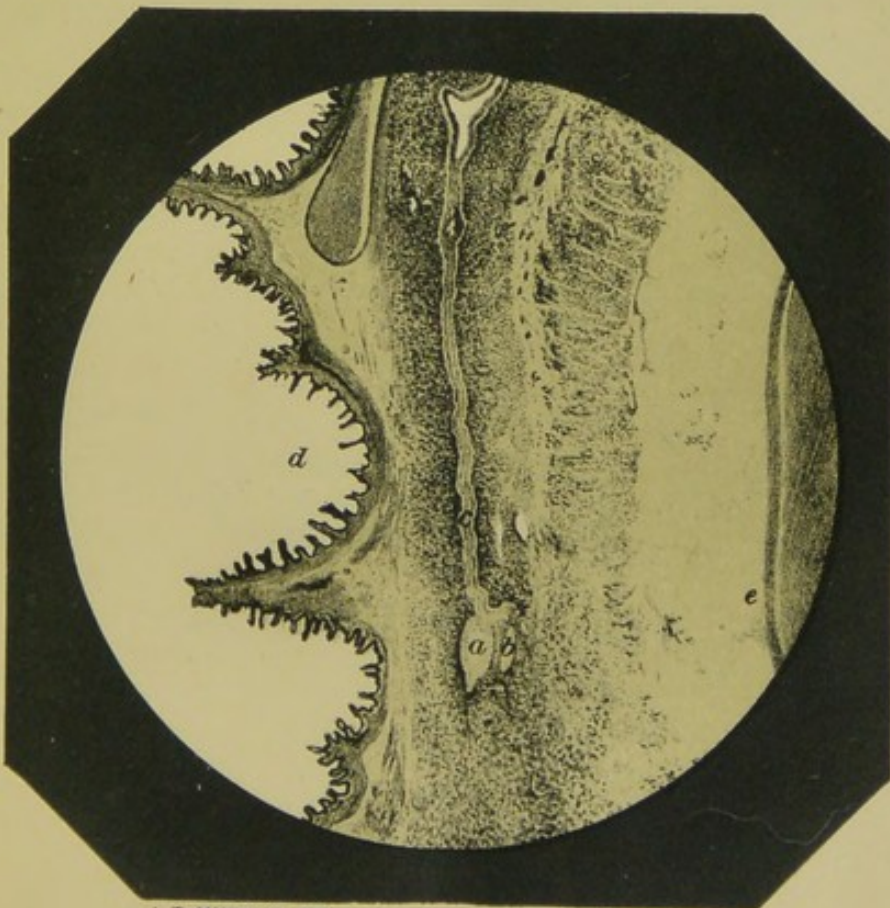
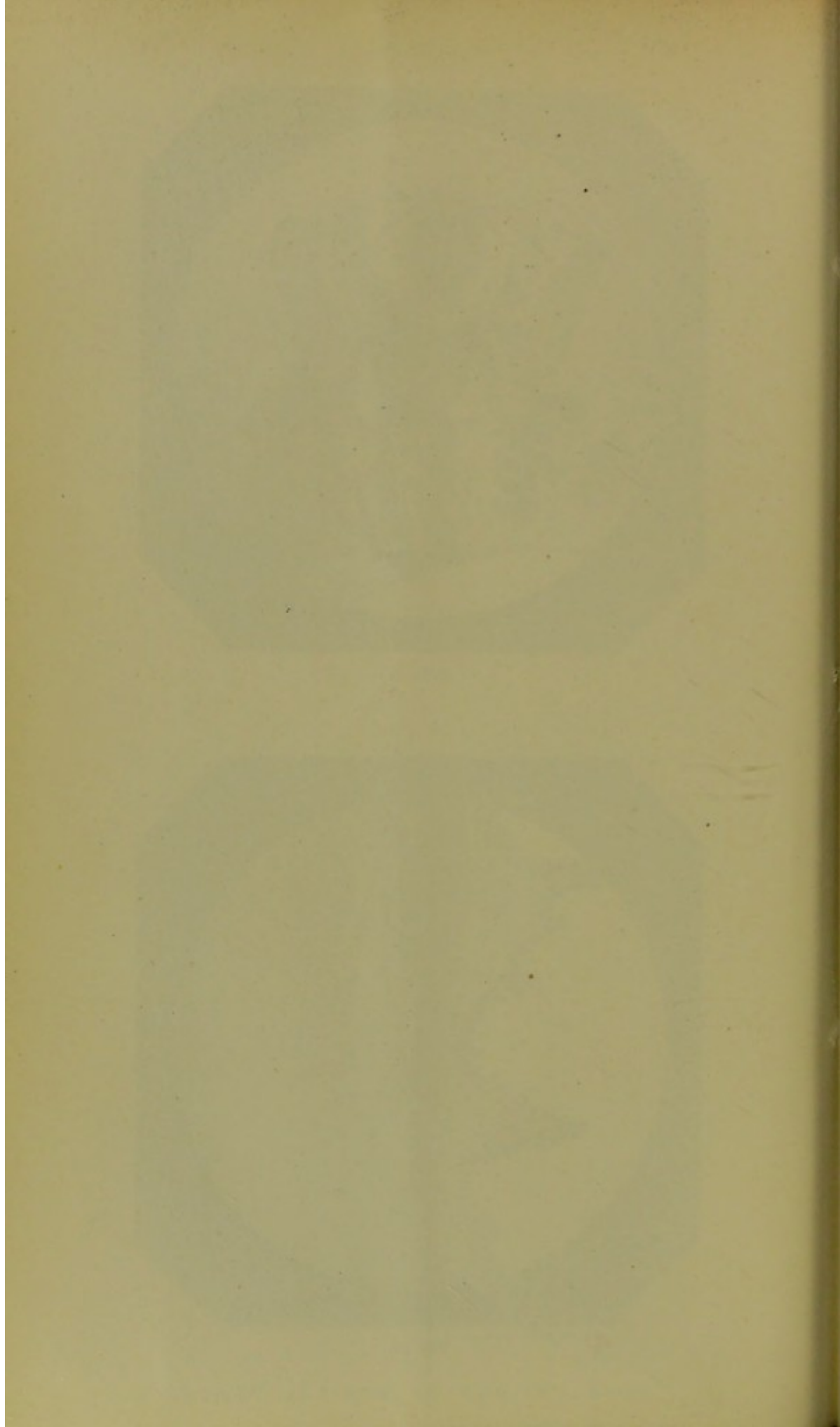


FIG. 11.



J. T. MURRAY, DEL.

FIG. 12.



## DESCRIPTION OF PLATES.

Pl. I., Fig. 1.—T. S. of seven weeks' foetus; *a* is in Wolffian duct; *c* points to summit of bladder. ( $\frac{8}{1}$ .)

Fig. 2.—T. S. at level where broad ligaments have formed. *a* is ovary; *c* points to Wolffian relics; *d* is Wolffian duct; *e*, duct of Müller. In both figures the spinal cord lies behind. ( $\frac{8}{1}$ .)

Pl. II., Fig. 3.—Shows Wolffian bulbs. The larger one shows the epithelium proliferating into the Müllerian vagina; at the side is seen the second Wolffian bulb at its outer aspect, with the Wolffian duct passing into it. Wolffian duct has *b* in its lumen; *a* is larger Wolffian bulb. ( $\frac{200}{1}$ .)

Fig. 4.—Wolffian duct and Müllerian vagina. Müllerian vagina, *a*; Wolffian duct, *b*. ( $\frac{200}{1}$ .)

Pl. III., Fig. 5.—T. S. showing genital cord. *a* points to the three canals in it; the central one is the coalesced Müllerian ducts; the outer are the Wolffian ducts. *b* points to the eminence of Müller in the urino-genital sinus. It is at the eminence of Müller that the hymen forms. ( $\frac{8}{1}$ .)

Fig. 6.—T. S. shows genital cord as in fig. 5. In the urino-genital sinus the openings of the Wolffian ducts can be seen; *a* points to genital cord; *b* to urino-genital sinus. ( $\frac{8}{1}$ .)

Pl. IV., Fig. 7.—Sagittal mesial section of pelvis of three and a half months' female foetus, showing development of hymen and formation of prepuce of clitoris. *e* is epidermis passing to map out glans; *a* is on Wolffian bulb, which is breaking down centrally; and *b* is involution from urino-genital sinus to meet distending Wolffian bulbs and make hymeneal opening. ( $\frac{8}{1}$ .)

Fig. 8.—Coronal section of four and a half months' foetus to show passing of epidermis to form prepuce. *b*, glans clitoridis; *a* points to active layer of epidermis. ( $\frac{8}{1}$ .)

Pl. V., Fig. 9.—Coronal section of pubic arch of four and a half months' foetus between the layers of triangular ligament. *a* is lower end of urino-genital sinus; *c* is at upper end; *b* is the lateral half of the hymen developed from one of the Wolffian bulbs; the section has missed the other half, but one can see the spur representing the posterior column of the vagina. *d* is on Bartholinian gland. ( $\frac{8}{1}$ .)

Fig. 10.—T. S. six weeks' foetus (Stiles). Shows early clitoris and urino-genital sinus, *a*, *b*. ( $\frac{8}{1}$ .)

Pl. VI., Fig. 11.—T. S. seven weeks' foetus showing cloaca. Rectum, *b*; urino-genital sinus, *a*. ( $\frac{8}{1}$ .)

Fig. 12.—Vertical mesial section of three and a half months' foetus. Wolffian bulbs, *a*, *b*; *c* is Müllerian vagina, with epithelial proliferation in it, and posterior fornix mapped out. Rectum, *d*; symphysis, *e*. ( $\frac{8}{1}$ .)

THE HISTORY OF THE  
CITY OF BOSTON  
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TO THE PRESENT TIME  
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