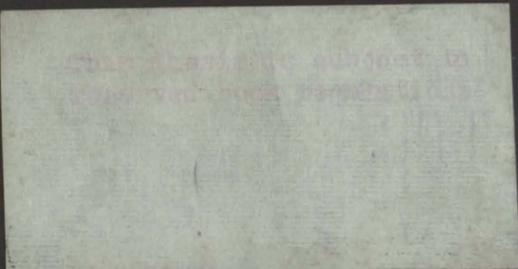
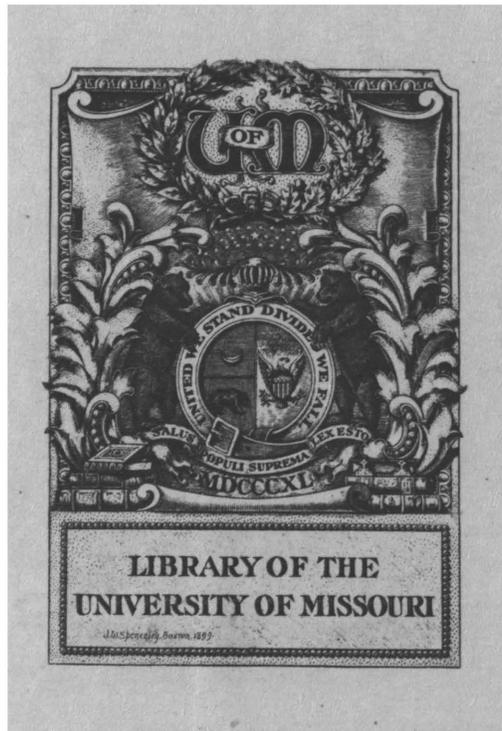


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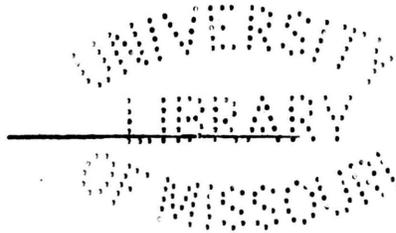
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THE UROGENITAL SYSTEM OF THE
20-MM. PIG EMBRYO

by

Frank Herbert Rose, A. B.



SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in the

GRADUATE SCHOOL

of the

UNIVERSITY OF MISSOURI

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PREFACE

The studies recorded in this dissertation were begun and largely carried out in the Department of Anatomy, University of Missouri Medical School, under the direction of Professor Franklin P. Johnson. They were completed in the Department of Anatomy, Harvard Medical School, as a special course under Professor Frederic T. Lewis. I am deeply indebted to Professors Johnson and Lewis for their valuable assistance.

F. H. R.

THE MESONEPHROS (WOLFFIAN BODY)

Upon exposure by ventral dissection, the mesonephroi of a 20-mm. pig embryo are found to be a pair of elongated bodies extending the whole length of the abdominal cavity. They lie against the dorsal body wall on either side of the vertebral column. Each organ is attached to the dorso-medial part of the body wall by its broad mesentery, which anteriorly is continued laterally to the diaphragm as a broad band - the phrenic ligament of the mesonephros. The mesonephroi are somewhat bean-shaped organs with medial hiluses. Their long axes diverge anteriorly and converge posteriorly. They are striated in appearance, the striae radiating from the hilus to the lateral surface. Hill ('05), using fresh tissues, measured the length of the mesonephros in three 20-mm. pigs and found it to be 7.3, 7.4, 7.2 mm. respectively.

The mesonephros consists of two parts, marked off on the exterior of the organ by the mesonephric duct. This duct passes posteriorly along the ventro-medial surface in a gradual curve, convex laterally and concave medially. The medial column - the part of the mesonephros which lies medial to the duct - contains mesonephric corpuscles. The larger lateral striated portion contains mesonephric tubules.

A mesonephric corpuscle is made up of a glomerulus, consisting of a tuft of capillaries covered by a film of simple flat epithelium, and a large outer capsule, lined by another layer of simple flat epithelium. This outer capsule is continuous both with the inner capsule and with the narrow

Fig I.

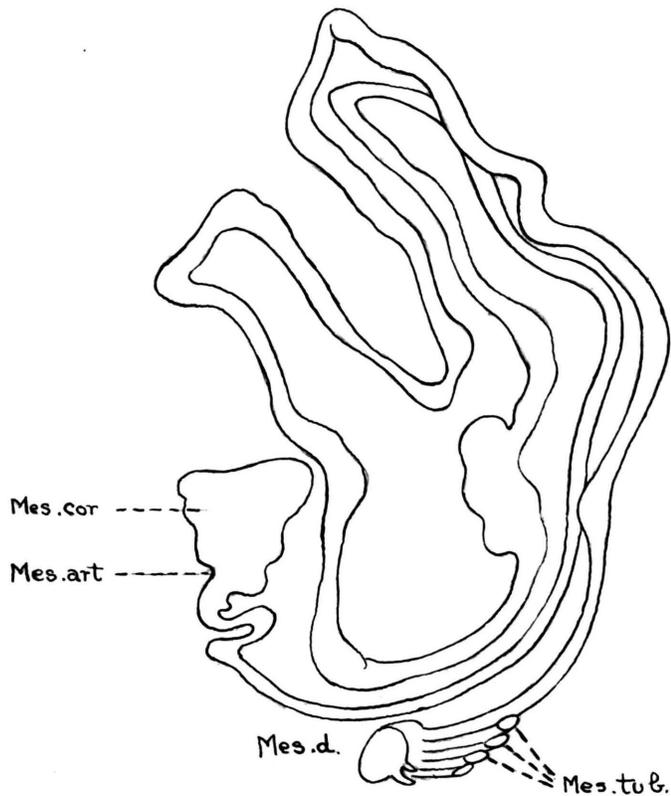


Fig. 1. Wax reconstruction of a mesonephric tubule of a 20-mm. pig embryo. No. 1.28 Univ. of Mo. E. C. Mes. art., site of entrance of mesonephric artery into the mesonephric corpuscle; Mes. cor., mesonephric corpuscle; Mes. d., mesonephric duct; Mes. tub., mesonephric tubules. (Model x 350 diam.; drawing x 150 diam.)
The magnification of the drawing in every case applies to the large finished picture and not to the pen and ink sketch used for labelling.

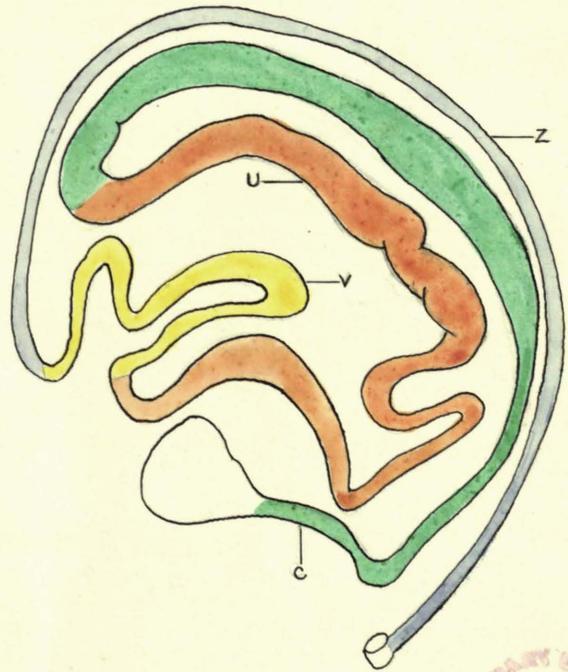
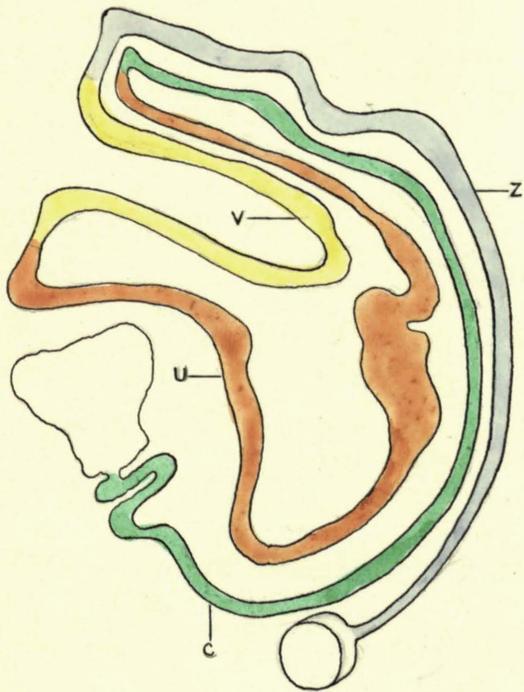
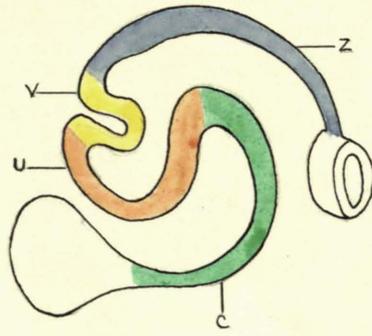
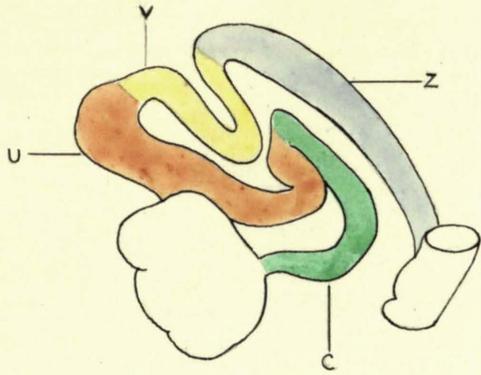
proximal end of the mesonephric tubule. In Fig. 1 (to be described presently) a notch in the capsule near the proximal end of the mesonephric tubule marks the place where a mesonephric arterial branch enters the corpuscle. The corpuscles tend to be spherical but are irregularly compressed. The number of corpuscles in one mesonephros, I found to be sixty-two. The diameter of the corpuscles was found by Bremer ('16) to be the same in 11-mm. pigs as in pigs larger than 11 mm., namely, 325 microns.

To give an idea of the structure of a mesonephric tubule and the course it takes in an embryo of 20 mm., a wax reconstruction was made. The tubule selected for modelling lay in the mid-portion of the gland, and the reconstruction of it is represented in Fig. 1. The tubule takes a very tortuous course from its beginning in the mesonephric corpuscle to its termination in the mesonephric duct, but lies throughout in approximately one plane. This plane is at right angles with the long axis of the gland. The outer capsule of the glomerulus becomes gradually narrowed ventrally, passing into a very slender tube. The tubule thus formed then takes a slightly convoluted course ventrally and laterally toward the mesonephric duct. Thus it comes quickly to lie immediately beneath the duct at the level where, after many convolutions, this particular tubule will eventually make its exit. After its first approach to the duct, the tubule continues its lateral course, following the outer surface of the gland to a very short distance from the dorsal border. Then it turns abruptly on itself, and, retracing its course in

a more medial position, follows the curve of the surface of the gland back to the ventral border where it again lies dorsal to the mesonephric duct. When about half way between the dorsal and ventral borders, this segment of the tubule becomes markedly increased in diameter, and is very convoluted and irregular in outline, but near the ventral border it tends to resume its former condition. Swinging on in its course beyond this point, the tubule bends dorsally, passing close to the lateral surface of its glomerulus, and so reaching the medial surface of the gland. In the dorso-medial position it turns laterally and sends a V-shaped loop to the center of the organ. The distal and lateral arm of this loop returns to the dorsal border. Thence, bending further laterally, it forms the terminal part of the tubule, which encloses all the rest as it follows the periphery of the organ to its termination in the mesonephric duct. In its final portion it becomes slightly reduced in calibre and empties, as seen in the figure, on the lateral side of the duct.

In a personal communication Dr. Lewis has proposed designating the several portions of the mesonephric tubule of the pig by letters, and his suggestion has been partially adopted in the foregoing account. He writes:

"A most interesting and important result of your work, taken in connection with that of MacCallum and of Mr. F. T. Kruser who studied in this laboratory in 1909, is the demonstration of a constant form for the mesonephric tubules, which for purposes of description may be divided into four parts. Beginning with the capsule of the corpuscle there is first loop C,



Drawn by M. Herford for Dr F. T. Lewis.

taking a crescentic course from the corpuscle to the dorsal part of the Wolffian body; then comes loop U, within the concavity of the C; thirdly, loop V, more or less within the U; and finally Z, a C-shaped terminal part tending to enclose all the rest as it passes from the dorsal surface to the Wolffian duct.

"I append a series of drawings to show these features. Fig. 1 is sketched from Mr. Kruser's model of a 6-mm. pig; 2 is MacCallum's diagrammatic figure of a tubule at 8 mm., reversed for better comparison; 3 is from your model; and 4 is MacCallum's tubule of an 80-mm. pig, reversed and somewhat simplified. In all of these, the corresponding parts have been given distinctive colors, - C is green; U, orange; V, yellow; and Z, blue.

"As you may recall, MacCallum states that "special names might be given to the different parts of the tubule, but until their significance is more definitely known, this could be of little value." So he speaks merely of convoluted portions and of a "secretory loop" of large diameter which includes the distal half of C and the proximal half of U. This region of enlargement curiously does not agree with your findings and may be variable. Whether from his two figures (and perhaps other reconstructions) he recognized the fundamental plan which I have outlined seems uncertain. And I would differ from him as to the futility of naming these parts, since it enables one readily to recall and describe the complicated but surprisingly fixed course of these tubules. Heretofore this has not been possible so far as I am aware."

The number of tubules in the mesonephros of an 8-mm. pig embryo was found by MacCallum to be 42 on the left side and 40 on the right side. In the mesonephros of the 20-mm. pig used for the reconstruction, I found the number to be 56.

By ventral dissection, as already noted, the mesonephric duct is seen arching along the ventro-medial surface of the mesonephros. Its curve is gradual and the concavity is medial as far posteriorly as the hind end of the mesonephros. There the duct curves around the posterior pole of the mesonephros before bending forward to enter the base of the bladder. In the region of the anterior half of the mesonephros the mesonephric duct lies immediately dorsal to the Müllerian duct.

The mesonephros is supplied by ten or eleven pairs of mesonephric arteries (Hill '05), which are branches of the dorsal aorta.

The mesonephric veins are two in number, the posterior cardinal vein which courses along the dorso-lateral surface of the mesonephros, and the subcardialⁿ vein following its ventro-medial surface. A branching sinusoidal system exists between the two and is profusely distributed among the tubules throughout the gland. The mesonephric veins are connected posteriorly with the somatic veins of the pelvic region, and their contained blood drains anteriorly through the mesonephric sinusoidal system into the posterior cardinal vein proper.

THE URETER AND KIDNEY (METANEPHROS).

Immediately before the mesonephric duct enters the base of the bladder it gives off posteriorly the very slender ureter (Fig. 3). The ureter on leaving the mesonephric duct is directed downward, away from the kidney, but after taking this posterior and somewhat lateral course for a short distance it turns abruptly at an angle of eighty or ninety degrees (Fig. 3). After making this bend, it passes obliquely upward and outward on either side of the rectum until it enters the primitive pelvis of the metanephros.

At about ~~the~~ the mid-point in its course it reaches the posterior pole of the mesonephros. Here there is a characteristic bend, following one in relation with the umbilical arteries, so that it is at this stage a sinuous rather than a straight tube. In the upper fourth of its course it occupies a quadrilateral area which is bounded by the aorta medially, the kidney laterally, the posterior cardinal vein dorsally, and the subcardinal vein and mesonephros ventrally. The ureter in the particular embryo from which the wax reconstruction was made is 2.6 mm. in length. Its diameter is practically the same throughout, increasing very slightly for a short distance before it enters the pelvis of the kidney.

In the 20-mm. pig the kidney is 1.2 mm. in length. It is closely invested by a concentric arrangement of embryonic connective tissue which cannot be separated from the surrounding connective tissue, consequently, according to Felix, it is not the actual capsule of the kidney; the permanent

Fig II

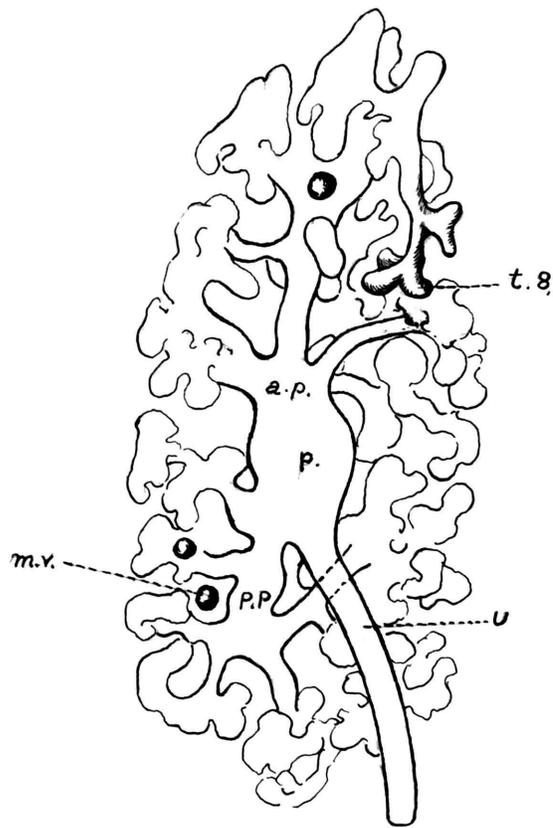


Fig. 2. Wax reconstruction of the kidney of a 20-mm. pig embryo. No. 1.15 Univ. of Mo. E. C. A.p., anterior pole; p.p., posterior pole; p, primitive pelvis; m.v., metanephric vesicle; t.8, terminal collecting tubule of the eighth order; u, ureter. (Model x $87\frac{1}{2}$ diam.; drawing same enlargement as the model.)

capsule must therefore develop at a later stage.

The kidney lies between the posterior cardinal and subcardinal veins, immediately dorsal to the middle portion of the posterior half of the mesonephros. At the anterior end of the kidney a medial fold of peritoneum separates the kidney and mesonephros laterally.

The upper end of the ureter becomes flattened dorso-ventrally and broadened medio-laterally just before passing abruptly into the larger primitive renal pelvis. The pelvis, like the upper end of the ureter, is flattened dorso-ventrally; its greatest diameter is vertical, producing the well defined anterior and posterior poles. The particular model I made of the kidney of a 20-mm. pig shows five secondary collecting tubules arising from the anterior pole of the pelvis and four from the posterior pole. This model is represented in Fig. 2. It shows no dorsal and ventral tubules arising from the primitive pelvis, and the same is true in human embryos. The terminal collecting tubules at this stage are in most cases of the fifth and sixth orders, but in the region of the anterior pole, where the tubules of the second order have grown forward for a comparatively long distance, some of the tubules of the higher orders have arched backward as far as the anterior pole of the primitive pelvis, forming tubules of the eighth order.

The primitive uriniferous tubules showing the greatest development are situated near the primitive renal pelvis, and they are connected with the distal ends of collecting tubules of the first few orders. They show only one or two convolutions before becoming enlarged distally as the primitive

renal corpuscles. Metanephric vesicles are present in great numbers near the periphery of the kidney, and are found in relation to the enlarged tips of the terminal collecting tubules. At the periphery of the kidney is a cap of undifferentiated metanephrogenic tissue in relation to the highest orders of collecting tubules, and arranged in lobules.

From the six or seven pairs of small segmental arteries which are given off from the dorsal surface of the aorta opposite the embryonic kidney, minute arterial twigs branch off laterally. They run to the ventral and dorsal surfaces of the thin connective tissue covering of the kidney. Arterial blood thus enters the kidney through its periphery, the renal artery proper having not yet been developed.

The veins of the kidney, poorly developed at this stage, empty directly into the posterior cardinal system.

THE GENITAL GLANDS.

In 20-mm. pig embryos the ovary and testis can be distinguished from one another, though they contain essentially the same structures, namely, germinal epithelium and tunica albuginea, genital cords and stroma. In the following description these structures are considered in turn, with notes as to the sexual difference which each presents.

As seen in ventral dissections, the genital glands are small elongated bodies lying medial to the middle third of the mesonephros. They are attached to the ventral side of the broad mesonephric mesentery by markedly constricted mesenteries of their own,- the mesorchium in the male and the mesovarium in the female. The glands become narrow anteriorly passing into the rete, which extends forward to the region of the anterior pole of the mesonephros. Posteriorly they pass into the "mesenteric ridge," a name suggested by Allen ('04).

The epithelium covering the genital glands as well as that of the remainder of the genital ridge is continuous with the lining epithelium of the peritoneal cavity. Its component cells are closely crowded together. The epithelial covering of the ovary is extremely high, and its component cells are columnar, while that of the testis is comparatively low, and its component cells tend to be flat.

A zone of connective tissue, the tunica albuginea, separates the epithelial covering from the genital cords contained in the gland and is continuous with the stroma. It is narrow and compact in the testis, broad and loose in the ovary.

The genital cords at this stage are fairly well

developed in the testis. They appear to branch and anastomose freely. In the ovary they are very poorly developed. The egg-tubes of Pflüger have not yet appeared.

The rete extends anteriorly from the genital gland in a low ridge which terminates in the region of the anterior pole of the mesonephros as a broad, low plate of thickened epithelium. At the ventro-posterior angle of this plate lies the opening of the Müllerian duct. The rete consists of a few poorly developed cords imbedded in loose stroma. They are continuous with the peritoneal epithelium and run for a short distance posteriorly and laterally to end, in most cases, in the stroma. Rarely one is seen to be in direct connection with a mesonephric corpuscle.

The mesenteric ridge at this stage is poorly developed and extends only a very short distance beyond the posterior pole of the genital gland. The covering of the mesenteric ridge is like that covering the rete including its anterior plate, namely, thickened ~~p~~eritoneum with closely crowded cells.

THE MÜLLERIAN DUCT.

In the 20-mm. pig the Müllerian duct is a slender tube which lies directly ventral to the anterior end of the mesonephric duct, forming a low slender ridge on the surface of the mesonephros.

The peritoneum covering the ridge made by the Müllerian duct is similar to that covering the genital ridge proper, with which it is continuous anteriorly.

The Müllerian duct is a little further developed in the female embryo than in the male. Thus in two male embryos it measured 0.3 mm. and 0.2 mm. in length, respectively. In two female embryos it was 0.9 mm. and 0.7 mm., respectively.

Posteriorly the Müllerian duct ends blindly. It opens anteriorly as the primitive infundibulum of the uterine tube, directly ventral to the anterior end of the mesonephric duct. The epithelium lining the Müllerian duct is similar to the thickened peritoneal epithelium covering the anterior portion of the genital ridge, with which it is continuous.

Fig III

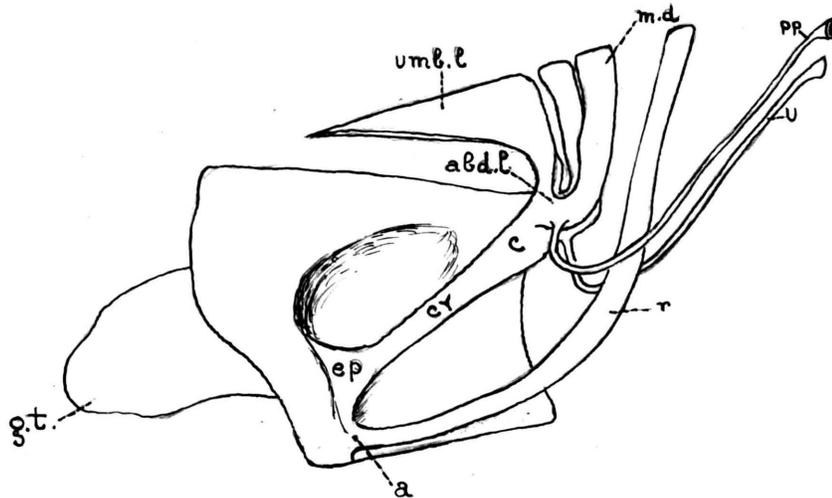


Fig. 3. Wax reconstruction of the urogenital sinus of a 20-mm. pig embryo. No. 1.15 Univ. of Mo. E. C. A, anus; abd.l., bladder or abdominal limb of allantoic stalk; c, crescent shaped proximal part of urogenital sinus; cy, middle portion of urogenital sinus; ep, distal epithelial plate; g.t., genital tubercle; m.d., mesonephric duct; p.p., primitive pelvis of kidney; r, rectum; u, ureter. (Model x 250 diam.; drawing x 125 diam.)

THE UROGENITAL SINUS, ALLANTOIS, AND
GENITAL TUBERCLE.

The separation of the rectum from the ventral portion of the cloaca by the downward growth of the perineal septum has just been completed in the 20-mm. pig, as shown in Fig. 3. The deep portion of the urogenital sinus is continuous anteriorly with the bladder or abdominal limb of the allantois duct just below the outlets of the mesonephric ducts. This deep or upper part of the urogenital sinus is crescent-shaped, with a dorsal concavity and ventral convexity. Passing from the bladder toward the exterior, the crescentic part gradually decreases in width, forming a narrow cylindrical middle portion. This in turn becomes laterally compressed, forming a long vertical epithelial plate. The plate is attached along the mid-ventral line of the genital tubercle, beginning at a point just in front of the anus and extending to almost the summit of the genital tubercle.

The lumen of the urogenital sinus extends only a short distance into this compressed terminal part of the urogenital sinus, occurring as a very narrow cleft toward the unattached border.

The cleavage of the closing plate has been described by Dürbeck ('07) who found that "when the anal membrane ruptures (embryos 1.95 - 2 cm.) the urogenital epithelial plate begins a splitting open at the caudal limit of the urogenital orifice, whereby the closed end of the lumen of the urogenital canal is opened to the outside." In the 20-mm.

male embryo this opening is a very small narrow slit; in the female it is considerably larger and is more or less round.

The allantoic duct may be said to consist of two limbs: the abdominal limb which lies within the body of the embryo and forms the bladder; and the umbilical limb which passes out through the umbilical opening to the allantoic sac (Minot). The abdominal limb is continuous with the deep part of the urogenital sinus, and where they meet both are crescentic in section. The concave dorsal side receives the outlets of the mesonephric ducts, which are at the same level on either side of the mid-line. Just above the outlets of the mesonephric ducts the abdominal limb of the allantoic duct curves forward toward the ventral abdominal wall and passes out the umbilical opening becoming the umbilical limb. The umbilical limb in its proximal part, in addition to being compressed dorso-ventrally, is also compressed laterally, by the accompanying pair of umbilical arteries. It is therefore a structure of four sides; all of which are somewhat crescentic, being convex toward the lumen of the duct. More distally the duct becomes smaller and cylindrical.

The abdominal limb of the allantoic duct is attached to the ventral abdominal wall; this line of attachment of the duct is continued out along its umbilical limb. The mesothelium covering the umbilical limb is thrown into a number of irregular papillary projections, - the mesothelial villi of the allantois. "At this stage (20 mm.) the villi are little more than large vesicles of mesothelium, which contain in their interior some coagulum and a very few mesenchymal cells, asso-

ciated with which are a few fibres - but whether true connective tissue fibres or not is undetermined. The mesothelium of the villi is a very thin layer of flattened cells." (Minot)

The genital tubercle at this stage is very prominent, and equally so in both sexes. It protrudes forward between the base of the tail posteriorly, the umbilical cord anteriorly, and the posterior limb-buds laterally; almost concealing from view the portion of the ventral abdominal wall posterior to the umbilicus. The tubercle is somewhat conical but presents certain marked irregularities which are constant in both sexes. Its lateral slopes are more gradual than those toward the anus and umbilicus, the umbilical surface being almost perpendicular. There is a definite constriction around the mid-portion of the tubercle and a shallow less obvious depression just proximal to the blunt summit. On the anal side of the tubercle the latter constriction is continuous with a narrow furrow which extends along the mid-line as far back as the urogenital orifice,- just in front of the anus. The urogenital sinus is attached along the raphe of this furrow. At the base of the tubercle on its anterior side is a large dome-shaped prominence which reaches almost to the umbilicus.

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June 5, 1919

My dear Dean Miller,

In accordance with your request
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degree, & recommend its acceptance.

Its brevity does not indicate the
amount of work done in the investi-
gation, which seems to have been
carried out carefully & intelligently.

Sincerely yours,

George Beeson

1508 John St.,
Baltimore, Md.,
May 12, 1919.

To the Graduate School,
University of Missouri,
Columbia, Missouri.

This is to certify that
I have read the thesis entitled " The uro-
genital system of the 20 mm. pig embryo"
written by Frank Herbert Rose, A.B., and
submitted in partial fulfilment of the re-
quirements for the degree of Master of Arts,
and that it meets with my approval.



Associate Professor of Anatomy,
University of Missouri.
(On leave of absence)

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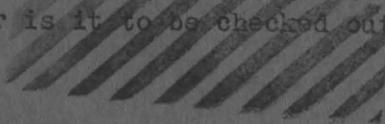


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