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GENEVA LITHIA SPRINGS.—Ontario County, New York.

POST-OFFICE.—Geneva.

LOCATION.—Geneva.

The well-known Geneva lithia water is obtained from an artesian well over eight hundred feet deep, which was bored in 1886. Issuing from a stratum of pervious rock defined by a layer of mediæval sandstone sixty feet thick and a deep substratum of hard slate, the water is forced up by an internal pressure of one hundred and twenty pounds to the square inch, and, if unimpeded at the surface, would form a fountain eighty feet high. The water is bright, clear, and sparkling, being agreeable to the palate and excellently adapted for table use. The following analysis was made by Prof. A. Auchie Cunningham, F.C.S.:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium sulphate	83.13
Magnesium carbonate	16.00
Potassium chloride	13.40
Sodium chloride	24.54
Sodium sulphate	17.64
Aluminum sulphate	8.75
Lithium bicarbonate	10.03
Lithium sulphate	4.10
Iron carbonate	2.15
Calcium sulphate	18.75
Calcium carbonate	35.84
Phosphoric acid	Trace.
Total	234.33

There is an entire absence of organic matter. The analysis shows a valuable lithia water, which possesses many excellent qualities. It may be classed as belonging to the lithiated-saline chalybeate variety. Aside from its strong impregnation with the bicarbonate and sulphate of lithia, it possesses enough of the sulphates of magnesium and sodium to give it laxative properties, and enough iron to make it a valuable ferruginous tonic when taken continuously. The water is used commercially, and has an extensive sale. It has the indorsement of many prominent physicians of the great Eastern cities. The water resembles that of a spring at Rippoldsau, in the Duchy of Baden, but is more heavily charged with iron and free phosphoric acid. It is extensively employed in anæmic states and general debility, and in many of the conditions resulting from the uric-acid diathesis, viz., gout, dyspepsia, rheumatism, renal and vesical calculus, Bright's disease, etc. *James K. Crook.*

GENITAL ORGANS, FEMALE. See *Sexual Organs, Female.*

GENITAL ORGANS, MALE.—EMBRYOLOGY OF THE GENITAL ORGANS.—In order to have a proper knowledge of the normal and at times abnormal anatomy of the human male genital organs, it is essential that a brief review of the main facts of their embryology should be presented.

That the higher types of vertebrates, during their development, pass through stages the essentials of which are permanent in some of the forms below them, is particularly well exemplified by a study of the embryology of the genital organs.

In the light of the theory of development many cases of anomaly of the genital organs will furnish striking evidence of either *atavism* or *arrested development*. In the growth of the embryo there is at first a period during which there is no indication of any provision either for a urinary or a generative function. A little later the rudiments of a urogenital apparatus are developed, but as yet there is no evidence of sexual differentiation.

In the course of embryological changes it will be observed that certain of the structures concerned appear and assume their permanent characters. Gradually and without modification of plan other structures, at first employed for purposes unrelated to the urogenital apparatus, become adapted, secondarily, for special purposes in this system; others, though belonging to this system from the first and attaining to a condition of functional activity in one direction, are later adapted to altogether different activities in another direction; lastly, other rudiments, according to the sex developed, either become elaborated into efficient and important parts of the reproductive organs, or dwindle into useless vestiges that never take any part in the normal work of the body.

In order that the reader may appreciate, to some extent, the significance of references to the lower animals, it may be well to state here that Tunicates are the lowest vertebrates known. Then, according to the grade of organization and from the simpler to the higher, come, in order, the Acrania (Amphioxus), Cyclostomes, Fishes, Amphibians, Reptiles and Birds, and, highest of all, the Mammals. The Mammals are further subdivided, according to grade of organization, into the Monotremes, Marsupials, and Placentals.

The common embryonic foundations of the sexual organs, male and female, are as follows, viz.: for the internal organs of generation they are the *germinal gland*, *the Wolffian duct*, the *mesonephros*, the *Müllerian duct*, a part of the *intra-embryonic allantois*, a part of the *cloaca*, and a part of the *proctodeum* (Figs. 2277 and 2278).

For the external organs of generation they are the *genital eminence*, *genital groove*, *genital folds*, and *genital ridges* (Figs. 2281 and 2282).

In intimate relation with the Wolffian duct arise, in orderly sequence, three important structures—viz., the *pronephros* or head kidney, *mesonephros* or Wolffian body (midkidney), and the *metanephros* or hind (permanent) kidney (Fig. 2277).

These nephric structures all lie in the dorsal wall of the embryo's abdominal cavity (cœlom) near the point where the somatic and splanchnic layers join (Fig. 2276); they extend, on either side of the notochord (primitive vertebral column), from the neighborhood of the heart to the tail end of the embryo, one behind the other in the order indicated by their names.

The intestinal, urinary, and reproductive organs are not only intimately related in the adult, but they are still more intimately related in the embryo (Fig. 2277), and therefore they must be referred to, in varying degrees, in describing the development of the male sexual apparatus.

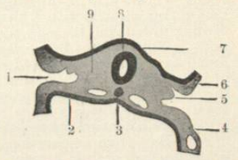

FIG. 2276.—Transverse Section of a Seventeen-Day Sheep Embryo. Diagrammatic. 1, Cœlom (pleuro-peritoneal cavity); 2, entoderm; 3, notochord; 4, splanchnic mesoderm or mesoblast; 5, middle plate; 6, somatic mesoderm or mesoblast; 7, ectoderm; 8, neural canal; 9, paraxial mesoblast.

At an early stage of the embryo an evagination occurs from the ventral surface of the hind gut near its caudal end to form the *allantois* (Fig. 2277, *A*). The part of the hind gut caudad of the allantois is the *cloaca* (*Cl*). The cloaca is present permanently in all vertebrates from Fishes to Monotremes.

Development of the Internal Genital Organs.—The pronephros and Wolffian duct are evolved as follows: the mesothelial cells of the *somatic mesoderm* (Fig. 2276, No. 6) near the *middle plate* (No. 5) evaginate on both sides, and form a cord of cells parallel with the notochord; at several points along the cephalic extremity of this longitudinal cord of cells it retains its connection with the lining cells of the cœlom (abdominal cavity) by short transverse cords of cells. Soon the cell cords are hollowed out, and thus are formed the segmental or Wolffian duct (Fig. 2277, *W*), which passes caudad and empties into the *cloaca* (*Cl*), and several short transverse *tubules* (Nos. 1, 1, 1), opening at one end into the cœlom and at the other extremity into the Wolffian duct. The transverse tubules in the immediate neighborhood of their cœlomic extremities are evaginated by a tuft of capillary blood-vessels from a branch of the adjacent axial blood-vessel (aorta), so that a series of *glomeruli* are formed. Through the physiological activity of the cells of the glomeruli the urinary constituents are eliminated in the Anamnia from the blood and passed along the transverse tubules into the Wolffian duct and cloaca and thence evacuated from the body. It is thus seen that the transverse tubules and their glomeruli constitute a segmental primitive kidney (pronephros). This pronephros (Fig. 2277, Nos. 1, 1, 1), though functional in Cyclostomes, Teleosts, and larval Amphibians, is vestigial in Selachians, Reptiles, Birds, and Mammals, and never functionates as a urinary organ; it soon gives place to the more important *mesonephros* (Fig. 2277, Nos. 2, 2, 2, 2).

Simultaneously with the segmentation of the paraxial mesoderm (Fig. 2276, No. 9) into the somites, the *middle plate* undergoes segmentation, and each segment is called a *nephrotome*. In the lower vertebrates each nephrotome is hollow and is formed by evagination of the cœlomic mesothelium; but in Reptiles, Birds, and Mammals the nephrotomes are at first solid cords of cells which subsequently become hollowed out and converted into a series of transverse, short canals situated behind, caudad of, the pronephros. They soon acquire connection with the previously formed Wolffian duct. Collectively they constitute the Wolffian body or *mesonephros*. At the cephalic end of the Wolffian duct, the now atrophied transverse tubules and glomeruli of the pronephros are still in connection with it. Embryologists usually compare the mesonephros with its Wolffian duct to a comb, the duct corresponding to the back of the comb, and the short transverse tubules representing the teeth.

In the further development of the mesonephros each transverse tubule becomes somewhat saccular midway between its two extremities, and then the sacculated portion is invaginated by a tuft of capillary blood-vessels derived from an arterial branch of the aorta. The invaginating tuft of capillaries is known as a Malpighian tuft, while the invaginated portion of the transverse tubule is called the Malpighian capsule; the two together constitute a primitive Malpighian body, analogous with the Malpighian bodies of the permanent kidney or metanephros. By the development of secondary tubules and Malpighian bodies the complexity of the mesonephros is greatly increased.

In those vertebrates in which the pronephros attains to a temporary functional activity, as in Cyclostomes, Teleosts, and Amphibians, the mesonephros appears relatively late; on the contrary, in those animals in which the pronephros remains rudimentary, as in Sharks, Reptiles, Birds, and Mammals, the mesonephros is developed early.

In the Anamnia (Fishes and Amphibians) the mesonephros not only acquires relations with the sexual apparatus, but also functionates as a urinary organ. Hence in these animals there is no metanephros. In the Amnia (Reptiles, Birds, and Mammals) the mesonephros functionates as a urinary organ only a short period during embryonic life; it undergoes profound retrograde and adaptive changes soon after its formation and enters into the exclusive service of the sexual apparatus, serving as channels to conduct the sexual cells from the germinal glands in the male, and becoming entirely vestigial in the female (parovarium and paroöphoron).

The transverse tubules of the mesonephros are divisible, in man, into an anterior or cephalic series and a posterior or caudal set. The former are the *sexual* set, and the latter become vestigial as the paradidymis and vas aberrans (homologous with the paroöphoron of woman) (Fig. 2279).

In the Amnia the permanent urinary organ is the metanephros. While the mesonephros and its Wolffian duct are temporarily functionating as a kidney, an evagination occurs from the caudal extremity of the duct.

This evagination soon lengthens into a tube (Fig. 2277, *Met*), which extends cephalad, toward the caudal part of the mesonephros. The cephalic end of the rudimentary

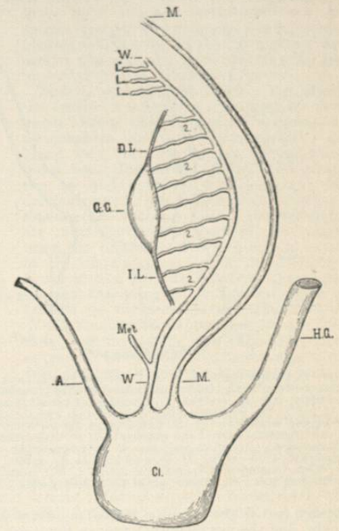

FIG. 2277.—Early Embryonic Condition of the Urogenital System. Diagrammatic. Sex undifferentiated. *A.*, Allantois; *Cl.*, cloaca; *H. G.*, hind gut; *W.*, Wolffian duct; *M.*, Müllerian duct; 1, 1, 1, pronephros; 2, 2, 2, 2, mesonephros (Wolffian body); *Met.*, metanephros (rudimentary permanent kidney); *G. G.*, germinal gland; *D. L.*, diaphragmatic ligament; *I. L.*, inguinal ligament.

metanephros branches freely to form a number of smaller tubes. The surrounding undifferentiated mesodermic cells form enveloping connective and vascular tissue. The blind end of each little tube becomes dilated and then invaginated by a tuft of capillary blood-vessels so that Malpighian bodies are formed analogous to those in the pro- and mesonephros. The tubules, owing to excessive growth in length, become tortuous and convoluted. The stalk of the diverticulum becomes the *ureter*, while the dilated part from which the branches are given off differentiates into the pelvis of the kidney with its infundibula and calyces.

Shortly after the formation of the mesonephros another tube (*Müllerian duct*) appears (Fig. 2277, *M.*). It lies close to the outer side of the Wolffian duct and parallel with it. It arises by evagination of the mesothelium of the cœlom in the form of a solid cord of cells and later acquires a lumen. The cephalic end of the duct, near the pronephros, maintains a communication with the cœlom by means of an expanded funnel-shaped mouth, while the caudal part empties into the cloaca. Its lower segment becomes closely associated with its fellow of the opposite side and with the two Wolffian ducts, thus forming the *genital cord*. The cloacal segments of the Müllerian ducts fuse early into a common tube, except in the Monotremes, where they remain permanently separate and empty into the urogenital sinus (Fig. 2278, *M.*). In all

other Mammals they fuse to a greater and greater degree in the ascending mammalian scale. Varying degrees of reversion to the more primitive types occur as instructive anomalies in human anatomy.

In the ascending vertebrate scale, the Wolffian duct

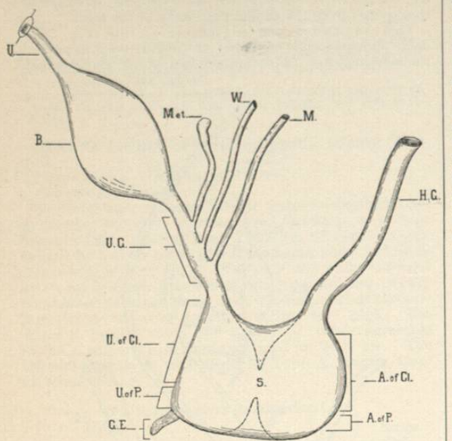

FIG. 2278.—Embryonic Condition of the Urogenital System Later than that Represented in Fig. 2277. Diagrammatic. The allantois has differentiated into the urachus (*U.*), bladder (*B.*), and urogenital sinus (*U. G.*). The proctodeum has appeared and, with the cloaca, is undergoing subdivision by the formation of the perineum (*S.*). *U. of Cl.*, Urogenital part of the cloaca; *U. of P.*, urogenital part of the proctodeum; *A. of P.*, anal part of the proctodeum; *A. of Cl.*, anal part of the cloaca; *H. G.*, hind gut; *G. E.*, genital eminence; *Met.*, metanephros (permanent kidney); *W.*, caudal part of the Wolffian duct; *M.*, caudal part of the Müllerian duct.

first appears in Cyclostomes, the Müllerian duct in Elasmobranchs, and the metanephric ureter in Reptiles.

This is a convenient place to state that the intra-embryonic portion of the allantois—in other words, that portion extending from the umbilicus to the cloaca—becomes differentiated into three segments as follows: The middle part dilates to form the *bladder* (Fig. 2278, *B.*), the umbilical portion becomes the *urachus* (*U.*), and the cloacal segment differentiates into the *urogenital sinus* (*U. G.*).

Through unequal growth of the parts the Wolffian and Müllerian ducts shift their positions from the cloaca to the urogenital sinus (Figs. 2277 and 2278), and also the duct (ureter) of the metanephros (permanent kidney) shifts its position from the Wolffian duct, first, to the urogenital sinus (Fig. 2278, *Met.*), and, finally, to the base of the bladder (Fig. 2279, *Met.*). Only in the Monotremes, among Mammals, do the ureters open permanently into the urogenital sinus.

In the twelfth week of the embryo the urogenital sinus acquires thick muscular walls, and the lining epithelial tube evaginates into the muscular tissue in the form of little sacs, the lining cells of which differentiate into secreting epithelium. Thus is formed the *prostate gland* enveloping the urogenital sinus or, as it is now designated, the *prostatic urethra*. The prostatic urethra is homologous with the *urethra* and the proximal part of the *internymphal space* of the adult female (Fig. 2280). The musculo-glandular part of the prostate is possibly homologous with the musculo-glandular part of the uterus. In this connection it is interesting to note that castration leads to atrophy of the prostate and removal of the ovaries induces atrophy of the uterus.

While the Müllerian duct is developing, a thickening of the mesothelial cells of the cœlom occurs close to the ventromesial portion of the mesonephros, thus forming an elongated swelling (*germinal ridge*) on the wall of the cœlom. By the proliferation of the mesoblastic tissue beneath the mesothelial cells the germinal ridge is still further enlarged, ultimately forming the *germinal gland* (Fig. 2277, *G. G.*). The gland becomes gradually pinched off from the mesonephros as the embryo grows, though still maintaining a connection with the vestige of this body by a fold of peritoneum (mesorchium or mesovarium).

In the differentiation of the male from the above-mentioned indifferent fundiments the following changes take place, viz.: columns of mesothelial cells of the germinal gland are evaginated into the mesoblastic tissue as *sperm tubes*, or sexual cords. By growths of the mesoblastic tissue the sexual cords are divided into roundish, follicle-like masses, which become hollowed out to constitute the *seminal ampullæ*. These, by further growth, are transformed into *seminiferous tubules* (Fig. 2288, No. 6), containing, among many smaller cells, a less number of large *sperm cells* (spermatogones) which develop into spermatozoa. By further transformations the characteristics of the adult testicle proper, or *didymis* (Fig. 2287, *Tunica vag. Vis.*), are developed. At the same time marked changes occur in the *mesonephros*, for from the sexual series of the transverse tubules of this organ cords of cells *penetrate* the germinal glands and fuse with the seminiferous tubules. The conversion of the cell cords into tubes produces the *coni vasculosi* of the *head* or globus major (Fig. 2288, No. 2; Fig. 2279, No. 8; Fig. 2287) of the epididymis, which are homologous with the parovarium of the female; the *vasa efferentia* (Fig. 2288, No. 3); the *rete testis* (No. 9); and the *vasa recta* (No. 7). The cephalic part of the Wolffian duct (from the mesonephros, Fig. 2277) develops into the *body* (Fig. 2288, No. 10) and *tail* or globus minor (Fig. 2288, No. 10; Fig. 2279, Nos. 4, 4, 4, 4) of the epididymis, while the caudal portion becomes the *vas deferens* (Fig. 2288, No. 12; Fig. 2279, W.) (homologous with the duct of Gärtner of the female). Near the extreme caudal portion of the Wolffian duct an evaginated pouch appears which develops into the *seminal bladder* (Fig. 2279, *V.*) and its duct. Caudad of this evagination the Wolffian duct becomes the *ejaculatory duct*.

The pronephros degenerates in both sexes into a vestige, *the stalked hydatid*, or hydatid of Morgagni, a little pedunculated sac attached to the upper part of the epididymis in the male (Fig. 2279, No. 7; Fig. 2287). The non-sexual, caudal series of mesonephric tubules likewise give rise to a vestigial structure, the paradidymis (Fig. 2279, Nos. 3, 3, 3), or organ of Giraldès, homologous with the paroöphoron in the female, lying among the convolutions of the tail of the adult epididymis. Primitively the germinal glands were arranged segmentally and extended along a greater number of somites as in Amphioxus at present. Each segment discharged its germ cells into an atrium and thence by an atriopore to the external water where impregnation took place; or, as in the higher Cyclostomes, the spermatozoa were discharged into the cœlom and made their way through the urogenital pores into the urogenital sinus and thence to the water. Then in Elasmobranchs the advance took place by which the spermatozoa are discharged along the Wolffian duct, a condition which persists in all the higher vertebrates.

In the male the Müllerian duct becomes vestigial throughout nearly its whole extent. Its cephalic extremity persists as the sessile or unstalked hydatid (Fig. 2279, No. 6), and is homologous with the fimbriated extremity of the Fallopian tube in the female. It is a small vesicle attached to the cephalic part of the testicle. The caudal part of the duct becomes the *uterus masculinus* (Fig. 2279, *M.*), and is homologous with the vagina and uterus. Should the intervening part of the duct persist in a patulous condition it is known as the *duct of Rathke* and is homologous with the oviduct of the female.

Testes. The testes in some Mammals, as in *Manis* among the Edentates, are subintegumental and lie in the inguinal canal. They remain normally in the abdomen

in many Mammals, as in Monotremes, most Edentates, and the Elephant.

During ontogeny the testes arise in the same relative position as the ovaries in Mammals. Whereas normally, in man, the ovary never passes further caudad than the pelvis, the testis usually passes out of the abdomen through the *inguinal canal* into an evagination of the abdominal wall (*scrotal sac*) lined by evaginated peritoneum (*tunica vaginalis*). In some of the lower Mammals the two scrotal sacs continue separate, but in man they unite by a median raphe into a single scrotum. In man and

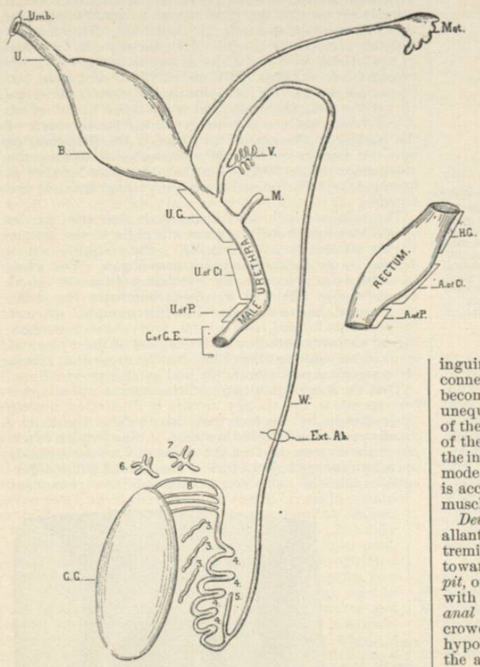

FIG. 2279.—Diagrammatic Representation of the Adult Male Urogenital System. Illustrating especially the embryonic elements that enter into the formation of the male urethra, the epididymis, and the rectum. The testicle (*G. G.*) and its related but much modified mesonephros (3, 3, 3, 4, 4, 4, 4, 4, 5, 8) have descended from the abdominal cavity into the scrotum. *Umb.*, Umbilicus; *U.*, urachus; *B.*, bladder; *U. G.*, prostatic urethra (urogenital sinus); *U. of Cl.*, together with *U. of P.*, form the membranous urethra (*U. of Cl.* is the urogenital part of the cloaca, and *U. of P.* is the urogenital part of the proctodeum); *C. of G. E.*, spongy urethra (canal of the genital eminence); *Met.*, permanent kidney (metanephros) and ureter; *V.*, vesicula seminalis; *M.*, uterus masculinus (distal vestige of Müllerian duct); *W.*, vas deferens (Wolffian duct); *Ext. Ab.*, external abdominal ring; 6, sessile hydatid (proximal vestige of Müllerian duct); 7, stalked hydatid (vestige of pronephros); 8, globus major of the epididymis; 4, 4, 4, 4, body and globus minor of the epididymis continued into the vas deferens (*W.*); 8, 4, 4, 4, 4, sexual adaptations of the mesonephros; 5, vas aberrans (vestige of mesonephros); 3, 3, 3, paradidymis (non-sexual vestige of mesonephros); *G. G.*, testicle or didymis (germinal gland); *A. of P.*, anal part of proctodeum; *A. of Cl.*, anal part of cloaca; *H. G.*, hind gut.

Compare the male urethra with the female urethro-internymphal channel (Fig. 2280, 1, 2, 4, 5, 6).

most Mammals the testes remain permanently in the scrotum by reason of the great reduction in size of the inguinal canal. Through arrest of development man's testicles may present all degrees of reversion in position to that of more primitive types.

The descent of the testes is a late development peculiar to Mammals. Primitively it was a periodic phenomenon occurring in the adult. At present, in the hedgehog, the testes retain their primitive cœlomic position up to the rutting period; but as the rut approaches they come to lie in evaginable portions of the abdominal wall in the inguinal region. After the rutting season they return to their abdominal position.

In their descent the testicles necessarily drag after them their attached structures, such as the spermatic artery and veins, the vas deferens, lymphatics, and nerves, all bound together by connective tissue, and thus constituting the *spermatic cord* (Fig. 2287, *Funiculus Sperm.*).

Mode of descent of the testicle. The descent of the testicle is a striking feature of its development. From the mode of development of the mesonephros and its ventro-median genital gland, they both are situated behind the peritoneal sac. Increasing in size they invaginate the sac and apparently project into the abdominal cavity, being held in position by peritoneum (mesorchium). Since the mid-kidney is the most conspicuous part of the projecting mass, the portion of the mesorchium extending to the diaphragm is called the *diaphragmatic ligament* (Fig. 2277, *D. L.*) of the kidney and the segment extending to the inguinal region is designated its *inguinal ligament* (Fig. 2277, *I. L.*). When the primitive kidney has become incorporated with the testicle as a part of its excretory apparatus, the inguinal ligament connects exclusively the testicle with the inguinal region. The inguinal ligament contains between its peritoneal folds connective tissue and unstriped muscular fibres, which become the *gubernaculum testis*. It is through processes of unequal growth of the body of the fœtus and the tissues of the ligament that the testicle is displaced from the side of the lumbar spine to the false pelvis and thence through the inguinal canal into the scrotum. The most primitive mode of descent is that observed in Insectivores, where it is accomplished through the agency of the cremasteric muscle.

Development of the External Genital Organs.—While the allantois is growing there is formed, near the caudal extremity of the embryo, a *surface depression* extending toward the cloaca. This depression is known as the *anal pit*, or *proctodeum*. The anal pit, though communicating with the surface, is partitioned off from the cloaca by the *anal membrane*. This membrane has its mesoblast crowded aside by the anal epiblast and the cloacal hypoblast growing together. By the breaking down of the anal membrane the cloaca is enlarged and communicates with the surface. Should the membrane fail of normal absorption a child would be born with *imperforate anus*.

In Fishes, Amphibians, Reptiles, Birds, and the lowest Mammals (*Monotremes*), the cloaca is a permanent structure through which the intestinal, urinary, and testicular secretions are voided. Man evolves first to and then beyond the cloacal state. In all mammals above Monotremes, and therefore in man, the *enlarged cloaca* (cloaca-proctodeum) undergoes division about the eighth week into a dorsal or *anorectal* cloaca (rectum and canal of the anus) and a ventral or *urogenital* cloaca (Fig. 2278, *U. of Cl.*, *A. of Cl.*, *U. of P.*, *A. of P.*). This division is accomplished by the growth and fusion of three ridges, one of which appears at the point of union of the gut and the urogenital sinus, while the other two extend, one from each lateral wall of the cloaca. The septum formed by the growth and fusion of the three ridges continues to thicken, especially near the surface, until it forms a pyramidal mass of tissue, called the perineum, or, preferably, *perineal body* (Fig. 2278, *S.*), since the urogenital portion of the outlet of the pelvis has been designated as the perineum. The urogenital portion of the cloaca-

proctodeum develops into the *membranous urethra* of the adult male.

Just ventral to the aperture of the cloaca (cloaca-protodeum), about the sixth week, appears the *genital eminence* (Fig. 2278, *G. E.*, Figs. 2281 and 2282), and soon both cloacal aperture and the eminence are surrounded by

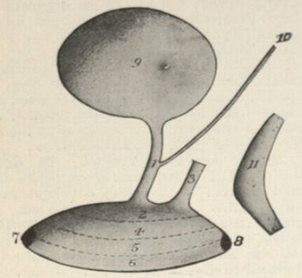

FIG. 2280.—Sagittal Section through the Adult Vulva, Vagina, Urethra, etc. Medial surface. Diagrammatic. 1, Urethra (proximal part of the urogenital sinus); 2, distal part of the urogenital sinus or proximal part of the internymphal cleft; 4, stratum of the internymphal cleft corresponding to the urogenital cloaca; 5, stratum of the cleft corresponding to the urogenital proctodeum; 6, stratum corresponding to the genital groove of the genital eminence; 2, 4, 5, 6, mesial surface of the right boundary of the internymphal cleft; 7, glans clitoridis; 8, fourchette; 9, bladder; 10, duct of Gärtner (persistent Wolffian duct); 3, vagina (enlarged Müllerian duct); 11, rectum; 1, 2, 4, 5, 6, urethro-internymphal channel and homologous with the entire male urethra. Compare with Fig. 2279.

the *genital ridges*. About the eighth week a groove (*genital groove*) appears on the under or cloacal surface of the genital eminence in *continuity with* the urogenital cloaca-proctodeum, and therefore with the urogenital sinus (Figs. 2279, 2281, and 2282). The groove becoming deeper is bounded laterally by projecting folds (Figs. 2281 and 2282) of skin (*genital folds*). For descriptive purposes, later, the genital folds may be divided into intra- and extraperineal portions. It is due to the growth of the perineal body that the anus is pushed entirely out of the field of the developed genital ridges (scrotum). The external genital organs of the male represent a further stage of development than the corresponding female parts. The genital eminence early acquires a knob-like extremity which develops into the *glans penis* (homologous with glans clitoridis) and its enveloping *prepuce*. The rest of the genital eminence, exclusive of the genital groove and genital folds, becomes developed into the corpora cavernosa of the clitoris or penis, and their enveloping tissues. The penis has well-marked intra- and extraperineal segments.

In both sexes, by further growth, the genital folds are extended along the sides of the outlet of the urogenital portion of the proctodeum dorsad toward the perineal body, so that a large part of the groove is caudad from, but continuous with, the outlet of the proctodeum (Fig. 2282). This portion of the genital folds may be spoken of as the *intraperineal* parts. By ventrad extension of the genital eminence and its glans penis, the *extraperineal* parts of the penis are formed. The extraperineal development of the genital eminence in the female is so slight that it scarcely exists,—in her the eminence is essentially intraperineal. In the female, through lack of fusion of the segments, the intraperineal parts form the *nymphæ* with their contained *bulbi vestibuli* and *pars intermedia* as the lateral boundaries of the genital groove, the *fourchette* as the dorsal boundary, and the *glans clitoridis* as the ventral boundary of the *genital groove*. The genital groove, caudad from the proctodeum, becomes in the adult the most caudal morphological element of the internymphal cleft (Figs. 2280, 2282). In the male development proceeds further than the stage represented in Fig. 2282. The genital folds bordering the outlet of the proctodeum fuse at their free margins and form the *intraperineal* portions of the corpus spongiosum (bulb and portion of the body), the intraperineal urethra, and the enveloping skin. This intraperineal portion of the corpus spongiosum is homologous with the bulbi vestibuli and pars intermedia of the female. By ventrad extension of the genital eminence and its genital folds and groove, and fusion of the fold margins, the extraperineal (pendulous) portion of the corpus spongiosum and its urethra are formed. The distal opening of the urethra is the *meatus urinarius*. It is generally stated in works on embryology, to the confusion of students of homology, that the urogenital sinus of the sexually undifferentiated embryo is homologous with the prostatic and membranous urethra of the male and with the vestibule of the female. But this certainly is incorrect. It seems to us far more in conformity with the facts to say that the *embryonic urogenital sinus* (Figs. 2278 and 2279, *U. G.*), plus the *urogenital cloaca* (*U. of Cl.*), plus the *urogenital proctodeum* (*U. of P.*), and plus the *genital groove* (*G. E.*, or *C. of G. E.*), differentiate into the *male urethra* from the neck of the bladder to the meatus urinarius on the one hand, or into the *female urethra and internymphal cleft* on the other hand (Fig. 2280). So that the male urethra is homologous with the urethro-internymphal space of the female.

The *vestibule* in human anatomy is described as the space extending from the glans clitoridis to the ostium vaginæ and between the nymphæ. The vestibule as thus defined is useless for studying homologies. The *whole space* between the nymphæ extending from the glans clitoridis (Fig. 2280, No. 7) to the fourchette (Fig. 2280, No. 8) must be considered. This internymphal space of the female is formed from several (four) distinct morphological elements, as follows—viz., a *part* of the urogenital sinus of the embryo (Fig. 2280, No. 2), urogenital cloaca (4), urogenital proctodeum (5), and genital groove (6).

That the most caudal part of the internymphal space corresponds to the spongy urethra is illustrated, among other things, by the fact that the ducts of Bartholin's glands open on the mesial surfaces of the nymphæ external to the hymen, just as the ducts of Cowper's glands open into the spongy urethra. The genital ridge differentiates into the mons veneris, and into two prominent

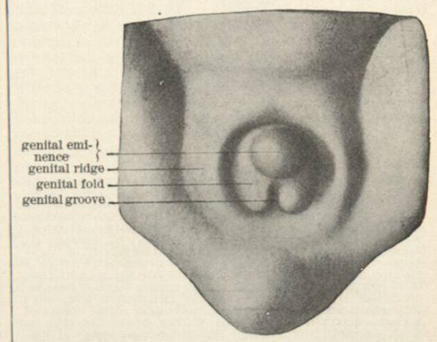

FIG. 2281.—Undifferentiated Stage in the Development of the External Genital Organs. Drawn from Ziegler wax model in United States Army Medical Museum. The genital groove is continuous with the undivided cloaca-proctodeal cavity.

pouches on either side of the penis, which become fused, by a median *raphe*, into the scrotum (homologous with labia majora of female).

By consequence of evaginations from the genital groove there are formed the glands of Cowper (homologous with the glands of Bartholin).

The differentiation of the genital ridges in the female into the *labia majora* enlarges the internymphal space into the interlabial space. In adult human anatomy the *vulval cleft* usually means the whole interlabial space. From the fact that the external fundiments of the sexual organs are exactly alike in both sexes, it is evident why, through abnormal ontogeny, forms come under observation occasionally which make it very difficult to decide whether they are male or female. These are the so-called cases of *hermaphroditism*. They arise either from the excessive development of certain fundiments or the interrupted development of other parts, in both the male and female. The male is most subject to those malformations which have led to the supposition that there may be hermaphroditism in man. They are due to the fact that the normal processes of fusion are interrupted in association with the interrupted development of other parts. For example, the genital ridges (Fig. 2282) may fail to unite into a scrotum and will simulate the labia majora of the female; the resemblance may be heightened by the failure of the testes to leave the abdominal cavity; and, further, the penis may be so rudimentary as closely to resemble a clitoris. Again, as I have seen, there may be a very noticeable depression between what seem to be incompletely fused genital folds (Fig. 2282) and every suggestion of a rudimentary *vagina*. The individual, though an adult, may be lacking in a growth of hair on the face; and, lastly, the mammary glands, as I have seen, may be as well developed as a woman's. But in spite of all these misleading features, the presence of *testes* in the abdominal cavity would stamp the individual as a man. In a case of this kind, unless a microscopic examination should reveal a seminal discharge, it would require an autopsy to ascertain whether testes or ovaries were in the abdomen.

Lack of fusion of the genital folds leads to various degrees of a pathological condition known as *hypospadias*.

Copulatory organs of various forms occur amongst the vertebrates, often morphologically distinct from one another.

A specially modified portion of each pelvic fin (clasper) occurs in male Sharks. Amongst the Teleosts the male Girardinus has the terminal portion of the anal fin modified for holding the female, and in many Cyprinoids the anal fin has modifications for a similar function. A marked swelling of the lips of the cloaca occurs in certain Amphibians, as the Urodeles, during the breeding season, by which internal impregnation may take place, but only in male Gymnophiona is a definite copulatory organ present in the form of an eversible cloaca, which is regulated by a well-developed musculature. Among Reptiles two kinds of copulatory organs exist, the one being seen in Crocodiles and Chelonians, and the other in Snakes and Lizards. In the former the organ is single and is a thickened portion of the ventral wall of the cloaca which is regulated by muscles and is protrusible. It consists of erectile tissue and has its dorsal surface grooved for the reception of the seminal fluid from the seminal ducts.

In Snakes and Lizards two copulatory sacs lie under the skin at the root of the tail and outside of the cloaca, which are regulated by a well-developed musculature and can be protruded through the cloacal opening and withdrawn. A spiral groove, for the transmission of semen, extends along each everted sac.

In most Birds the semen is expelled through a non-eversible cloaca, but in many, copulatory organs are present similar to those of Crocodiles and Chelonians.

In the males of all Mammals except the Monotremes, Marsupials, and some Edentates the *penis* consists of two *corpora cavernosa* attached proximally to the *ischia*, and a central portion, the *corpus spongiosum*, perforated by the urethral canal and expanded at the extremity to form the glans. The penis of Monotremes, decidedly reptilian, is situated in the cloaca and is indirectly in relation with the seminal ducts through the urogenital sinus. It consists of an unpaired corpus cavernosum (there is no corpus spongiosum) perforated with a canal in continuity with the urogenital sinus and the seminal ducts. It is only loosely surrounded by the mucous membrane of the cloaca, has a well-developed musculature, and can be protruded through the cloacal aperture.

The penis sheath, in Marsupials, opens directly on the surface of the body ventral to the anus, on account of the growth of the perineum. The two openings are surrounded by a common sphincter muscle. The erectile tissue is paired (two corpora cavernosa), but unconnected with the ischia.

The penis of Insectivores and Rodents, among Placental Mammals, approaches nearest that of Marsupials. In the ascending scale of Mammals the opening of the penis sheath is separated more and more from the anus and the

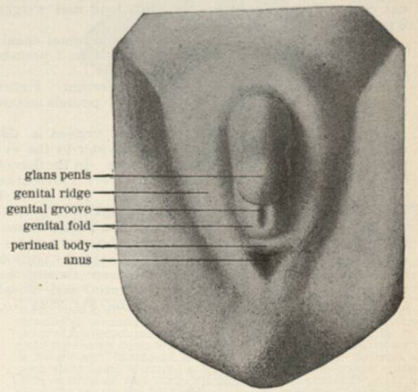

FIG. 2282.—Early Embryonic Stage of Male External Genital Organs. Drawn from Ziegler wax model in United States Army Medical Museum. Genital eminence projects so far dorsad and caudad as to conceal the genital folds and genital groove, which are continued to the under surface of the glans penis. The perineal body has formed and separates the cloaca-proctodeal cavity into a dorsal part having its outlet at the anus, and a ventral part having outlet at the genital groove, in virtue of the fact that the genital folds have extended dorsad and united to form the fourchette just ventrad of the perineal body. It will thus be observed that the genital folds and genital groove are practically divisible, even at this early stage, into intraperineal (root of penis) and extraperineal (pendulous part of penis) segments.

penis comes more and more to a ventral position, attaining a horizontal and fixed position along the abdomen. In the Apes the organ becomes more or less free from the body wall at its distal end, while in Man the whole of the distal end is free and the penis sheath forms a double integumentary tube-like investment (prepuce) over the glans.

During ontogeny, in Marsupials and Placental Mammals, the penis passes through stages that resemble successively those which are permanent in Crocodiles and Monotremes.

CHRONOLOGY OF UROGENITAL DEVELOPMENT.—*Third Week.*—About this time the Wolffian duct and pronephros are recognizable, the nephrotomes begin to develop and also the allantoic stalk appears.

Fifth Week.—The germinal ridges and the Müllerian duct appear and the fœtus is two-fifths of an inch (1 cm.) long.

Sixth Week.—The genital eminence, folds, groove, and ridge appear.

Seventh Week.—The mesonephros reaches its maximum development.

Eighth Week.—The caudal portions of the Müllerian ducts fuse, and the allantois presents a spindle-shaped dilatation in its middle forming the bladder.

Ninth Week.—The cloaca is divided into two parts. The permanent kidney has characteristic features. The testes are distinguishable from ovaries. The fundiments of the external genitals begin to show distinctions of sex.

The fœtus is one inch long (25 mm.) and weighs about 16 gm. (half ounce).

Third Month.—Prostate gland begins to develop. The union of the testes with the canals of the Wolffian body is complete. The testes are in the false pelvis. Fœtus is 2¾ inches long (7 cm.) and weighs 125 gm. (four ounces).

Fourth Month.—Sexual distinctions in external genitals are well marked. The genital groove is closed. The scrotum is formed, as also the prepuce. The prostate is well formed. Fœtus is 5 inches (13 cm.) long and weighs 240 gm., or 7½ ounces.

Seventh Month.—The testes are at the internal abdominal ring. Fœtus 14 inches (36 cm.) long and weighs 3 pounds (about 1.5 kgm.).

Eighth Month.—The testes are in the inguinal canal. Fœtus 16 inches (41 cm.) long. Weighs 4 to 5 pounds (about 2 to 2.5 kgm.).

Ninth Month.—The testes are in the scrotum. Fœtus 20 inches (50 cm.) long. Weighs 6 to 7 pounds (about 3 to 3.5 kgm.).

Adult Genital Organs.—The *male urethra* is the urogenital canal extending from the bladder to the extremity of the penis (Figs. 2279 and 2283). In the flaccid state it forms a double curve, but when erect it presents a single curve with the concavity ventrad. It is about 7 inches (19 cm.) in length when flaccid, but during erections greatly elongated. It is divided in a prostatic portion (1½ in. or 32 mm. long), membranous part (three-quarters of an inch or 20 mm. long), and a spongy portion (5 in. or 14 cm. long). The urethra, except during the passage of urine or semen, has the ventral and dorsal surfaces in contact. The prostatic portion (Fig. 2283, No.

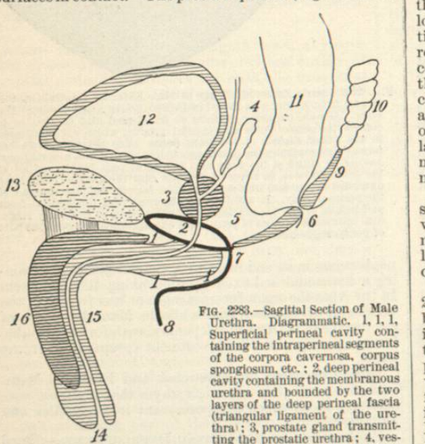

Fig. 2283.—Sagittal Section of Male Urethra. Diagrammatic. 1, 1, 1, Superficial perineal cavity containing the intraperineal segments of the corpora cavernosa, corpus spongiosum, etc.; 2, deep perineal cavity containing the membranous urethra and bounded by the two layers of the deep perineal fascia (triangular ligament of the urethra); 3, prostate gland transmitting the prostatic urethra; 4, vesiculæ seminalis and vas deferens emptying through the ejaculatory duct into prostatic urethra; 5, site of perineal body; 6, anal portion of rectum (11) passing through the sphincter ani muscle (9); 7, central tendon of perineum whence starts Colles' fascia to continue into the dartos (8) of the scrotum; 10, coccyx; 12, bladder; 13, symphysis pubis; 15, extraperineal portion of corpus spongiosum; the spongy urethra is seen traversing the corpus spongiosum and terminating at the meatus urinarius in the glans penis (14); the bulb of the corpus spongiosum is seen in the superficial perineal cavity, resting against the perineal layer of triangular ligament; the prostate is in the pelvic cavity, resting against the pelvic layer of triangular ligament; 16, extraperineal portion of corpus cavernosum; extending between the symphysis and corpus cavernosum is seen the suspensory ligament of the penis.

3) is spindle shaped and is the most dilatable and widest part of the canal. A narrow longitudinal ridge (*verumontanum*), three-quarters of an inch (20 mm.) in length, exists upon the dorsal wall. It is formed by the projecting mucous membrane and contains muscular and erectile tissue. It serves, when distended, to prevent the semen passing back into the bladder. There is a slightly depressed fossa (*prostatic sinus*) on either side of the verumontanum. A depression (*uterus masculinus*) exists at its distal part (Fig. 2279, *M*). It is a *cul-de-sac* about a quarter of an inch (6 mm.) in length extending dorso-cephalad in the substance of an organ (*prostate gland*), which envelops the prostatic urethra (Fig. 2283, No. 3). Its walls are composed of mucous, connective, and muscular tissue, and the ducts of numerous small glands open upon its mucous surface. The uterus masculinus is homologous with the vagina and uterus of the female. The membranous urethra (Fig. 2283, No. 2) is the narrowest part of the canal except at its termination in the penis. Its ventral surface is concave and is placed about an inch dorso-caudad from the subpubic arch. Its dorsal surface is separated from the rectum by the perineal body (Fig. 2283, No. 5).

The spongy urethra (Fig. 2283, No. 15) is the longest. Its calibre is intermediate between the other segments, and uniform except at either extremity. For half an inch (13 mm.) behind the terminal opening it is dilated and forms the *fossa navicularis*, while behind, for an inch (25 mm.), it widens in every direction and is called the *pars bulbosa*.

The urethra is composed of three coats: mucous, areolar, and muscular. The inner, or mucous, coat is continuous at its proximal end with the mucous coat of the bladder and at its distal end with the integument of the penis. It is also continuous with the ducts of the several glands opening into it. Its epithelial lining consists of columnar cells, except at the distal opening, where the cells are squamous. The mucous coat is arranged in longitudinal folds in the membranous and spongy portions when the urethra is empty. The orifices of numerous mucous glands occur on the surface of the mucous coat, especially on the spongy portion, while the glands themselves (glands of Littré) are situated in the submucous connective tissue. The orifices are directed distally and vary in size, and some may easily intercept the point of a small instrument. One of these orifices, much larger than the rest (*lacuna magna*), is situated in the fossa navicularis on its dorsal surface, about half an inch (13 mm.) or so from the outlet.

The areolar coat is rich in elastic fibres, and its interstices are plentifully supplied with convoluted vessels which serve the purpose of erectile tissue. The outer or muscular coat consists of two layers of unstriped muscular fibres, the outer being longitudinal and the inner circular.

The Perineum and Penis.—The male perineum (Fig. 2284), or urogenital region of the outlet of the pelvis, is bounded by the subpubic arch (Nos. 1, 1), the pubo-ischiatic rami (No. 4), the ischial tuberosities (No. 7), and the transversus perinei muscles. The arch and rami present two lips and an intermediate space. The transversus perinei muscles, one on either side, arise laterally from the ischial tuberosities and are inserted medianly into the central tendinous point (No. 6) of the perineum. Each is innervated by the perineal branch of the internal pudic nerve. Their action is to fix the central tendinous point of the perineum.

Extending from fixed attachments—viz., from the dorsal (posterior) border of the muscles and the central tendon, along their deep (pelvic) surfaces, and thence along the deep (pelvic) lips of the pubo-ischiatic rami, and subpubic arch—is a triangular-shaped fascia (Fig. 2284, No. 5). At the points of attachment the fascia is single, but across the triangular interval which it occupies it divides into two layers, a superficial or perineal layer and a deep or pelvic one. Between the two layers, therefore, exists a space called the *deep perineal cavity* (Fig. 2283, No. 2), which contains a number of structures, viz., the membranous portion of the urethra (whence the name of triangular ligament of urethra for the double-layered fascia), Cowper's glands, the compressor urethræ muscle, subpubic ligament, the internal pudic vessels, the dorsal

nerve and vein of the penis, the artery and nerve of the bulb, and a plexus of veins, all bound together by very delicate connective tissue.

The deep or pelvic layer of the triangular ligament is continuous with the pelvic fascia. The superficial layer is the *deep floor* of a second perineal cavity, *the superficial perineal cavity* (Fig. 2283, Nos. 1, 1, 1). The perineum has another important fascia (superficial perineal fascia) which, like the triangular ligament or deep perineal fascia, is divisible into two layers. The deeper layer is the *fascia of Colles*. It is continuous, at the posterior border of the transversus perinei muscles, with the triangular ligament (Fig. 2283, No. 7). It passes superficial to the muscles and is attached firmly to the superficial lips of the pubo-ischiatic rami and the adjacent ischial tuberosities, but is *not attached* to the superficial lip of the subpubic arch, for the corpora cavernosa and the corpus spongiosum intervene (Fig. 2284, Nos. 1, 1). Colles' fascia, in this region, is continuous with the dartos of the scrotum (Fig. 2283, Nos. 7, 8).

This *superficial perineal cavity* is bounded thus on the pelvic side by the triangular ligament (Fig. 2283, No. 2), on the cutaneous side with the fascia of Colles (Nos. 7, 8), laterally by the intermediate surface of each pubo-ischiatic ramus (Fig. 2284, No. 4), and dorsally (posteriorly) by the line of junction of Colles' fascia and the triangular ligament (Fig. 2283, No. 7). The superficial perineal space is continuous ventrally with the *sub-dartos* space of the scrotum and penis (Fig 2283, No. 8; Fig. 2284, Nos. 1, 1).

It is in the superficial perineal cavity that extravasation of urine most frequently takes place in cases of rupture of the urethra. From the nature of the fascial attachments, it is clear that the only direction in which the fluid can make its way is ventrad along the scrotum and penis and thence on the ventral part of the abdomen.

This superficial perineal space contains the following *intraperineal* segments of the penis, viz.: the crura penis (Fig. 2284, No. 2; Fig. 2283) partly covered by the erector penis muscle, the bulb and part of the body of the corpus spongiosum (Fig. 2283, Nos. 1, 1, 1; Fig. 2284, No. 3) hidden by the accelerator urinæ muscle, the transversus perinei muscles, and the superficial perineal blood-vessels and nerves.

The crura penis (homologous with the crura clitoridis of the female) are the intraperineal and diverging parts of two fibrous cylindrical tubes called the corpora cavernosa. The latter are placed side by side and intimately connected by the septum pectiniforme along the median plane for their anterior (extraperineal) three-fourths (Figs. 2284 and 2285); the posterior (intraperineal) fourth of each corpus cavernosum diverges from its fellow to form a strong tapering fibrous process firmly connected to the pubo-ischiatic ramus. In many mammals (*e.g.*, lemurs and apes), a bone, the *os penis*, is developed in the septum between the corpora cavernosa.

The corpus spongiosum, a single, bilaterally symmetrical structure, is composed also of two parts, an intra- and an extraperineal portion.

The intraperineal portion commences between the diverging crura penis, where it forms an enlargement, the *bulb*, and then narrowing forms a part of the body (Fig. 2283, Nos. 1, 1, 1; Fig. 2284, No. 3). The extraperineal part is composed of two segments, the remaining portion of the body (Fig. 2283, No. 15) and the *glans penis* (No. 14). The body is cylindrical and situated in a groove on the ventral surface of the corpora cavernosa (Fig. 2285, No. 10). The glans penis overlaps the rounded extremities of the corpora cavernosa and presents the form of an obtuse cone flattened dorso-ventrally (Fig. 2283, No. 14). At its summit is a vertical opening, the meatus urinarius. The base forms a projecting rounded border (corona), behind which is a constriction (neck). Both these parts have numerous sebaceous glands secreting a cheesy matter of peculiar odor.

The three fibro-elastic tubes (viz., the corpus spongiosum and the corpora cavernosa) enclose a fibrous trabecular structure whose meshes lodge the erectile tissue. The trabeculæ are more delicate and the meshes smaller in the corpus spongiosum. The meshes or areolæ of the corpus spongiosum freely communicate with one another. The areolæ of the corpora cavernosa freely communicate with one another on each side, and also with those of the

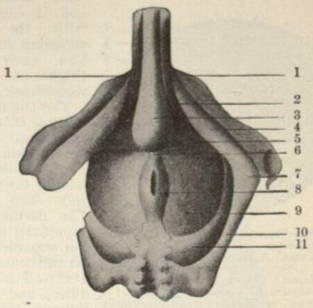

Fig. 2284.—Male Perineum, Showing Triangular Ligament and the Intra- and Extraperineal Portions of the Penis. Colles' fascia and the superjacent parts have been removed. 1, 1, Region of subpubic arch hidden by penis; 4, rami of pubes and ischium (pubo-ischiatic rami); 7, tuberosity of ischium (drawn much too far dorsad); 6, central tendon of the perineum, between which and the tuberosities of the ischium extend the transversus perinei muscles (omitted in the drawing); 5, triangular ligament or deep perineal fascia, on the superficial or perineal layer of which are shown the following structures, viz.: 3, the bulb of the corpus spongiosum from which the enveloping accelerator urinæ muscle has been removed; 2, crus penis of the corpus cavernosum, from which on either side the enveloping erector penis muscle has been removed. 8, Sphincter ani; 9, levator ani. The dorsal boundary of the triangular ligament is seen in the figure to extend as far back as the central tendon, where it is continuous with Colles' fascia. The triangular ligament is shown to be attached to the deep or pelvic lip of the pubo-ischiatic rami and subpubic arch; Colles' fascia has been removed from the superficial lip of the rami. The portions of the penis dorsad from the subpubic arch are intraperineal portions, while the parts ventrad of the arch are extraperineal.

opposite side through fissures in the fibrous septum between them. The areolæ are lined with epithelial cells and are comparable to widely dilated capillaries. At several points in their walls arteries communicate with them; they give origin to the veins. Blood rushing into, and being retained in the, areolæ causes erection of the penis.

The corpus spongiosum and the corpora cavernosa, with their envelopes, constitute the penis. The intraperineal segments of the penis converge at the apex (ventral part) of the superficial perineal cavity and, passing out of the cavity beneath the symphysis pubis (Figs. 2283 and 2284, Nos. 1, 1), form the pendulous body (extraperineal portion) of the penis. A strong band of fibrous tissue (the suspensory ligament of the penis) passes downward from the symphysis and blends with the fibrous cylinders of the corpora cavernosa (Fig. 2283).

The urethra (spongy portion) extends throughout the length of the corpus spongiosum and terminates at the meatus urinarius.

The erector penis muscle (homologous with the erector clitoridis) embraces the crus penis and arises from the intermediate space of the pubo-ischiatic ramus and the ischial tuberosity. It is inserted into the sides and ventral surface of the crus. By compressing the crus it assists in causing and maintaining erection. The accelerator urinæ muscle is bilaterally symmetrical. It is also called the ejaculator seminis. It is homologous with the sphincter vaginæ or bulbo-cavernosus of the female. It arises from the central tendinous point and from the median raphe in front. From these points its fibres diverge like the plumes of a feather. The greater number course around the sides and are inserted into the dorsum of the intraperineal part of the corpus spongiosum, while the foremost fibres extend around the lateral part of each corpus cavernosum and are inserted into the midline of

the dorsum of the two bodies, covering the dorsal vessels. By compressing the latter it helps to cause and maintain erection. The superficial layer of the superficial perineal fascia acquires no bony attachments and is continuous with the corresponding fasciæ of the scrotum, thighs, and ischio-rectal fossæ.

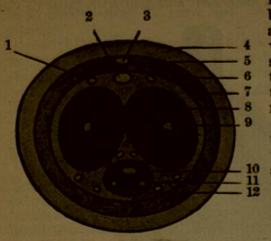

FIG. 2285.—Transverse Section of the Penis. Diagrammatic. 1, Dorsal artery; 2, deep dorsal vein; 3, superficial dorsal vein; 4, skin; 5, dartos (superficial layer of superficial fascia); 6, deep layer (areolar tissue) of the superficial fascia; 7, deep fascia; 8, cylindrical membrane containing erectile tissue of corpus cavernosum; 9, artery of corpus cavernosum; 10, spongy urethra in corpus spongiosum; 11, branch of artery of bulb supplying corpus cavernosum; 12, cylindrical membrane containing erectile tissue of corpus spongiosum; surrounding the latter are several blood-vessels.

The common envelopes of the extraperineal penis are the skin, superficial fascia (containing the dartos), and deep fascia. The dartos is the superficial layer of the superficial fascia and contains unstriped muscular fibres, and is continuous with the dartos of the scrotum. When contracted, it compresses the veins of the penis and favors erection. The skin is remarkably thin, is loosely connected with the deeper parts, is dark in color, and free from adipose tissue.

The erectile structures receive sympathetic nerves from the pelvic plexus and spinal nerves from the superficial perineal and the dorsal nerve of the penis. The coverings of the penis receive nerves from the inferior perineal of the internal pudic and from the genital branch of the genito-crural nerve. They receive *blood* from the external pubic artery, and from the superficial perineal and dorsal artery of the penis, branches of the internal pudic. The bulb and body of the corpus spongiosum are supplied by a branch (artery of the bulb) of the internal pudic. Each corpus cavernosum receives the cavernous branch of the internal pudic. The glans is mostly supplied by the dorsal artery of the penis (Fig. 2285).

The *veins* from the envelopes of the penis converge to the dorsum of the organ and empty into the superficial dorsal vein, lying in the areolar tissue beneath the dartos along the median line and emptying into the obturator and external pudic veins. The veins from the glans emerge at its neck and form the deep dorsal vein which runs in the median groove on the cavernous bodies beneath the deep fascia (Fig. 2285). It perforates the triangular ligament and empties into the prostatic plexus. Those from the body and bulb enter the same plexus or the internal pudic vein. Small veins emerge from the ventral and dorsal surfaces of the corpora cavernosa. They empty into the deep dorsal vein, the former circling around the sides of the bodies. The principal vein comes from the posterior part of each cavernous body, and, perforating the triangular ligament, enters the prostatic plexus.

The superficial lymphatics of the penis empty into the superficial inguinal glands, while the deep lymphatics empty into the pelvic glands about the internal iliac artery.

The Testicle, Spermatic Cord, and their Envelopes.—The testicle is the gland that secretes the male germ cells or spermatozoa (Figs. 2286 and 2287). It is supplied with arteries, veins, lymphatics, nerves, and an excretory duct (vas deferens). In migrating, during development, from the abdomen it evaginates a portion of the peritoneum (visceral and parietal layers, which subsequently become pinched off and form the *tunica vaginalis*) and all the layers of the abdominal wall in the inguinal region. It pushes in front of it, hernia-like, the following layers in addition to the peritoneum—viz., first, the *subperitoneal connective tissue*, and then, in order, the *infundibuliform fascia* (portion of transversalis fascia), some of the fibres of the [illegible] oblique muscle thus forming the *cremasteric fascia*, the *intercolumnar fascia*, the *dartos* (superficial fascia rich in unstriped muscular fibres), and, finally, the *skin* (Fig. 2286). The path of the testicle through the abdominal wall is the *inguinal canal*; the evaginated, many-layered pouch is the *scrotal sac*, one on either side. By fusion the skin forms a common covering for both testicles, the line of fusion being indicated by the raphe; but the remaining layers meet in the median plane to form the *septum scroti*. All the envelopes of the two glands together form the *scrotum*. The deep "opening" of the inguinal canal is the *internal abdominal ring*; the superficial or subcutaneous end is the *external abdominal ring* (Fig. 2279, *Ext. Ab.*).

The inguinal canal is oblique and runs parallel with Poupart's ligament. It is about an inch and a half in length. It commences near the middle of Poupart's ligament and half an inch cephalad from it, and extends to the spine of the pubis. Its cephalic boundary is the arched fibres of the internal oblique and transversalis muscles; its caudal boundary is formed by the union of Poupart's ligament with the transversalis fascia; the ventral boundary is the skin, superficial fascia, aponeurosis of the external oblique, and partly by the internal oblique; the dorsal boundary is the triangular fascia, the conjoined tendon of the internal oblique and transversalis muscles, the subperitoneal connective tissue, and peritoneum.

The testicle, in migrating from the abdomen into the distal part of the scrotum, carries with it its tributary structures, such as the vas deferens, arteries, veins, lymphatics, and nerves, all bound together with connective tissue into a *spermatic cord* (Fig. 2287). The spermatic cord extends from the testicle to the internal abdominal ring, and is therefore divisible into a scrotal and an inguinal portion.

The Testicles. Each testicle consists of two separate but closely related parts, viz., the testicle proper, or

FIG. 2286.—Transverse Section of the Testicle and its Scrotum. Diagrammatic. For the sake of clearness the individual layers of the scrotum are represented as widely separated. 1, Skin; 2, dartos (superficial fascia); 3, intercolumnar fascia; 4, cremasteric fascia; 5, infundibuliform fascia; 6, subperitoneal fascia; 7, parietal layer of the tunica vaginalis; 8, cavity of the tunica vaginalis; 9, visceral layer of the tunica vaginalis connected by subserous areolar tissue to the tunica albuginea (10); 11, the mediastinum giving off trabeculæ to the tunica albuginea; 12, epididymis.

didymis (Fig. 2287, *Tunica vag. Vis*), and an epididymis (*globus major, globus minor*). Each didymis is compressed laterally and is oval in form. It is one and a half

to two inches long (38 to 50 mm.), an inch and a quarter (30 mm.) dorso-ventrally, and one inch (25 mm.) in breadth. It weighs about six drachms (24 gm.). It has a lateral, convex surface looking outward and a little backward; a median, flat surface looking inward and a little forward. The dorsal border, nearly straight, is directed backward and upward and has attached upon its entire length, nearer its lateral than its median part, a structure composed of convoluted tubules and called the *epididymis*. The ventral border of the testicle looks forward and slightly downward. The inferior or caudal extremity is pointed and occupies a plane postero-internal to the more rounded upper or cephalic extremity. The epididymis consists of an enlarged cephalic *head* (*globus major*), a central portion or *body*, and a caudal, pointed *tail* (*globus minor*). The tubules of the globus major are continuous directly with those of the testicle (Fig. 2288, No. 3), but the body and globus minor are connected to the testicle by the tunica vaginalis and its subserous connective tissue. In horizontal section the body resembles a comma, and therefore it shows it to possess a ventral and dorsal surface, as well as lateral and median borders. The dorsal surface is convex, the ventral is concave. Between the concave surface and the testicle is a blind depression (*digital fossa*) opening laterally. The median border corresponds to the tail of the comma.

There are found connected with the globus major and neighboring part of the testicle two small bodies (*hydatids of Morgagni*), one of which is sessile and the other pedunculated (Fig. 2287). The former, one-eighth to one-third of an inch (3 to 8 mm.) in length, is flattened or rounded, and situated ventrally either on the globus major, the adjacent part of the testicle, or between the two; the latter, about the same size, is attached to the globus major. The hydatids are fœtal vestiges.

The testicle proper (didymis), as distinguished from its epididymis, is a fibro-glandular structure (Fig. 2288). The outermost part (*tunica albuginea*) is a dense connective-tissue membrane, which at the dorsal border is reflected ventrally into the gland and forms an incomplete vertical septum (*mediastinum*). From the sides and front of the mediastinum numerous connective-tissue cords and laminæ (*trabeculæ*) radiate to the inner surface of the tunica albuginea. Thus the interior of the gland is divided into a number (about two hundred) of incomplete cone-shaped spaces (*loculi*), which have their bases at the inner surface of the tunica albuginea and their apices at the mediastinum. In the cone-shaped loculi and lining the tunica albuginea and trabeculæ is a vascular layer (*tunica vasculosa*) consisting of a network of minute blood-vessels held together by delicate connective tissue. The true glandular tissue (seminiferous tubules) occupies the loculi. Each loculus contains two or three seminiferous tubules (*tubuli seminiferi*), commencing at the base of the space by blind extremities and taking a very convoluted course to the apex of the loculus. In their course toward the mediastinum they give off two or three blind pouches, and not only make anastomoses with one another, but also with the tubules in adjacent loculi. The tubules of each loculus, near its apex, unite together and form a single, straight, excretory tube (*tubulus rectus*) which enters the mediastinum. The tubules of a single loculus are bound together by a delicate interstitial connective tissue, rich in minute blood-vessels, and make a cone-shaped body (*lobule*) with the apex at the mediastinum. Each little tube in a lobule is about $\frac{1}{110}$ in. ($\frac{1}{4}$ mm.) in diameter, and when uncoiled its length is increased about thirty times (about 2 ft. or 62 cm.). The tubuli recti, formed as already described at the apices of the lobules, are smaller in diameter than the convoluted tubules of the lobules. They enter the mediastinum and form throughout that structure a network of anastomosing tubules (*rete testis*) of varying diameter, but always larger than the tubuli recti or convoluted tubules of a lobule. They have no proper wall, but are excavations in the mediastinum lined by epithelium of varying character. At the dorso-cephalic part of the testicle these channels finally unite to form about twelve tubes (*vasa efferentia*), which escape almost immediately through the tunica albuginea and enter into the globus major of the epididymis. The vasa efferentia, shortly after piercing

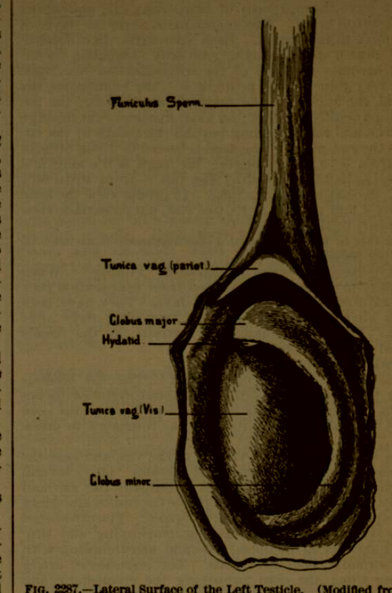

FIG. 2287.—Lateral Surface of the Left Testicle. (Modified from Gegenbaur.) All the layers of the scrotum down to and including the parietal layer of the tunica vaginalis, cut through and turned aside, thus exposing the cavity and the visceral layer of the tunica vaginalis; the latter enveloping the didymis (*Tunica vag. Vis.*), the epididymis (*Globus major, Globus minor*), and the hydatid.

the tunica albuginea, become greatly convoluted and form about twelve cone-shaped bodies (*coni vasculosi*) with their bases turned away from the tunica albuginea. They are each about one-third of an inch (or 8 mm.) long and enter a common duct and together constitute the globus major. This common duct extends downward, as the *tube of the epididymis*, and, greatly convoluted, forms the body and globus minor. The coils are held together by connective tissue. The length of the tube when uncoiled is about 15 ft., or 4.5 metres. Its diameter above is about $\frac{1}{10}$ in., or $\frac{2}{3}$ mm., but gradually decreases toward the globus minor and then enlarges beyond that structure. The tube consists of an inner mucous coat lined with ciliated columnar cells, and an outer coat of unstriped muscular fibres. The tube of the epididymis emerges from the globus minor as a constituent (*vas deferens*) of the spermatic cord (Figs. 2279 and 2288).

Spermatogenesis.—The male germ cells are formed only in the convoluted tubes of the lobules of the testis. The process is homologous with oögenesis (maturation of the ovum) in the female. If a section of a seminiferous tubule be examined, the following arrangement will be observed: Each tubule presents several layers of cells. The layer furthest from the lumen of the tube is formed principally by a number of cells called *spermatogones*. Each of these, from time to time, divides into two daughter cells, one of which persists as a spermatogone, while the other differentiates into a *primary spermatocyte*, thus forming a layer nearer the lumen. This latter cell divides into two cells, the *secondary spermatocytes*, thus

forming a layer still nearer the lumen. These undergoing division present a layer of *spermatids*, each one of which develops into a *spermatozoon*. In addition to the preceding cells there are others, found in all the layers, which serve the purposes of supporting and nourishing cells (Sertoli cells). The spermatozoa form the layer of cells next to the lumen. Each spermatid, in differentiating into a spermatozoon, gradually elongates; its nucleus becomes the head of the spermatozoon enveloped by a very thin film of protoplasm; the centrosome lies behind the nucleus in the middle piece or neck; the tail develops behind the neck; an axial filament runs through the neck and tail extending beyond the sheath of the latter as the end-piece. The head is from 2 to 3 μ in breadth and from 3 to 5 μ in length; the neck is 6 μ long and 1 μ ($\frac{1}{25000}$ inch) in breadth; the tail is from 40 to 60 μ long; the end-piece is 6 μ long. In profile view the head is narrow and pointed at its free end, but on surface view it appears oval in shape.

The rate of progression of a spermatozoon is about 0.05 mm. per second.

Spermatozoa possess remarkable vitality. When mounted on a slide and protected from evaporation they have exhibited motility for nine days. They have been found alive in the male genital tract four days after death. They may retain their activity in the female genital tract for several weeks.

Weak acid solutions kill them.

Structure of the Spermatic Cord. The *vas deferens* forms the axis of the cord and is about eighteen inches (46 cm.) in length. It is in the dorsal part of the cord and is recognizable from its cord-like resistance to pressure.

The *spermatic artery* is ventral to the vas, and near the testicle becomes tortuous and divides into several branches, two or three of which accompany the vas and supply the epididymis; others pierce the tunica albuginea and supply the testicle proper (*didymis*). The *deferential artery* is a long, slender vessel accompanying and supplying the vas on its dorsal side and anastomosing with the spermatic near the testis. The *cremasteric artery* courses along the cord supplying the cremasteric and other coverings. Seven or eight *spermatic veins* emerge from the dorsal surface of the testis median to the epididymis, and unite to form the *pampiniform plexus* passing mostly along the ventral plane of the vas and constituting the bulk of the cord. Farther up the cord they are reduced to two or three in number; at the internal abdominal ring they have united into one or two spermatic veins. *Lymphatic vessels* accompany the veins. Plexuses of *sympathetic nerves* accompany the arteries.

Except for a short distance above the testicle, the scrotal portion of the spermatic cord is lacking in the serous envelope; otherwise the coverings are identical with those of the testis. The inguinal part of the cord has only the following coverings, viz., the subserous connective tissue, the infundibuliform fascia, and cremasteric fascia.

At the internal abdominal ring the constituents of the spermatic cord separate and course in different directions. The vas deferens, after winding around the outer side of the deep epigastric artery, and crossing the external iliac vessels, descends at the side of the bladder into the pelvis. It arches downward and backward to its base, crossing the vestigial hypogastric artery to reach the median side of the ureter. At this point it is sacculated and enlarged, forming the *ampulla*, which extends to the base of the prostate gland (Fig. 2283, No. 3). The ampullæ are median from the vesiculæ seminales, and are between the bladder and the second part of the rectum. They constitute the lateral boundaries of the external trigone of the bladder. At the base of the prostate gland the vas deferens becomes narrowed and, uniting here with the duct from the seminal bladder, forms the *ejaculatory duct* (Fig. 2283). The vas deferens is about two feet (61 cm.) in length and about a line and a quarter (3 mm.) in diameter. The spermatic artery can be traced crossing obliquely the external iliac artery and ureter to the aorta a little below the renal artery. It rests on the psoas magnus muscle behind the peritoneum. The right one passes across the inferior vena cava.

On either side two spermatic veins generally accompany each spermatic artery for a distance and then fuse into a single vein. The right one opens obliquely into

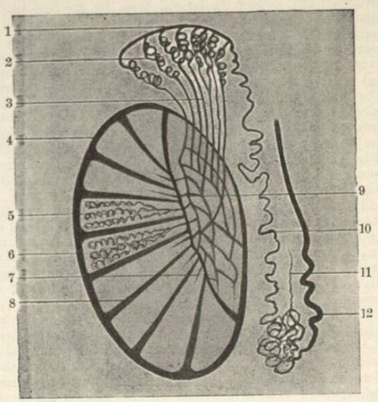

FIG. 2288.—Diagram of testicular tubules. 1, Collecting tube of the epididymis; 2, coni vasculosi; 3, vasa efferentia; 1, 2, and 3 form the globus major; 4, tunica albuginea; 5, loculus containing a lobule; 6, lobule; 7, one of the vasa recta; 8, trabecula; 9, rete testis in the mediastinum; 10, tube of the epididymis forming the body and globus minor; 11, vas aberrans; 12, vas deferens.

the inferior vena cava, the left one into the left renal vein at a right angle. The left spermatic veins pass behind the sigmoid colon with their artery. The deferential artery can be traced to the superior vesical artery at the side of the bladder. The cremasteric is a branch of the deep epigastric artery. The lymphatic vessels terminate in the lumbar glands. The sympathetic nerves are the spermatic plexus derived mostly from the renal, but partly from the aortic plexus. The plexus is re-enforced through the deferential from the pelvic plexus.

Dorsal to the spermatic cord is the internal branch of the genito-crural nerve from the lumbar plexus. It innervates the cremaster muscle. The ilio-inguinal nerve from the lumbar plexus enters the inguinal canal at varying points and appears at the external abdominal ring ventral to the cord. It gives sensibility to the scrotum.

Tunica Vaginalis (Fig. 2287). As already stated, the tunica vaginalis is the innermost of the scrotal coats of the testis, derived from the peritoneum during the descent of the testis. At birth the cavity of the tunica is directly continuous with that of the peritoneum, so that the tunica consists of inguinal, scrotal, and testicular segments. But, usually, a short time after birth, the inguinal and upper scrotal parts are reduced to a fibrocellular thread lying in the loose connective tissue around the spermatic cord; so that the tunica vaginalis is reduced to a testicular portion. There are all grades of variation between a tunica vaginalis whose cavity is freely continuous with the cavity of the abdominal peritoneum and one whose cavity is absolutely shut off from that of the abdomen, and without even the presence of a vestigial connective-tissue thread.

The *visceral layer* of the tunica is closely adherent to the testicle proper, and to the globus major and lateral part of the body of the epididymis, and is prolonged upward upon the spermatic cord for half an inch (12 mm.). It extends into the digital fossa between the epididymis and testicle. It leaves uncovered nearly all the posterointernal part of the body and the globus minor of the epi-

didymis. It is in those uncovered parts that extensive vascular communication is established between the testicle and its coverings and the cord. The *parietal layer* is continuous with the visceral layer at the point of reflection from the spermatic cord, and at the postero-inferior parts of the testicle. It is loosely connected with the infundibuliform fascia by the subserous connective tissue. The two layers are in contact normally except for a very thin film of serous fluid secreted by the endothelial cells of the tunica.

The Seminal Vesicles (Fig. 2283, No. 4). These reservoirs for the semen, to which they add their own secretion, are situated between the bladder and the rectum. They are lobulated pouches of pyramidal shape placed one on either side external to the ampullæ of the vasa deferentia, and are two inches (50 mm.) long and a half-inch (12 mm.) wide at the base. They present rectal and bladder surfaces, median and lateral borders, a base and an apex. The ventral surface is attached to the base of the bladder overlapping the ureter. The rectal surface is covered above by the recto-vesical pouch of the peritoneum, but below is separated from the rectum only by the recto-vesical fascia. The bases are widely separated, but the apices converge and narrowing into straight ducts unite, near the base of the prostate gland, with the corresponding vasa deferentia to form the ejaculatory ducts.

Each vesicle consists of a single tube coiled upon itself and giving off many blind diverticula, all bound together firmly by fibrous tissue. When uncoiled the main tube is about five inches (125 mm.) in length and of the diameter of a quill.

Each ejaculatory duct is about three-quarters of an inch (19 mm.) long, and commencing at the base of the prostate it runs downward and forward between the lateral and middle lobes to empty into the urethra, near or through the uterus masculinus. The seminal vesicles and ejaculatory ducts have three coats: an inner or mucous one, a middle or muscular one, and an outer or areolar one.

The nerves of the vesicles and ducts are derived from the pelvic plexus. The middle hemorrhoidal and the vesical arteries supply the vesicles and the extraprostatic portion of the duct. The intraprostatic portion receives its nutriment from the prostatic vessels. Veins and lymphatics accompany the arteries, emptying into the vesico-prostatic plexus.

Prostate Gland (Fig. 2283, No. 3). The prostate is a musculo-glandular body surrounding the proximal urethra and the neck of the bladder. It is in the pelvic cavity behind the lower part of the symphysis pubis. It is cephalad from the deep layer of the triangular ligament of the urethra (deep perineal fascia). It is about the shape and size of a large chestnut. It develops at puberty and atrophies after castration. It presents a base, an apex, a ventral, a dorsal, and two lateral surfaces. The base is situated immediately below the bladder; the apex rests upon the pelvic side of the triangular ligament; the dorsal surface rests on the rectum, distant about one inch and a half (37 mm.) from the anus; the ventral surface, about three-quarters of an inch (19 mm.) behind the symphysis, has some loose fat and a plexus of veins in front of it, and is connected on either side to the pubic bone by the pubo-prostatic ligaments; the lateral surfaces are in relation with the anterior portions of the levator ani muscles, the vesico-prostatic plexus of veins intervening. The prostate consists of a median and two lateral lobes. The lateral lobes are separated by a deep notch at the base and by a slight furrow on the ventral and dorsal surfaces. The middle lobe, variable in shape, is a small transverse band, placed between the two lobes at the posterior part of the gland, behind the proximal urethra. The ejaculatory ducts pass between the middle and lateral lobes. The prostate is enveloped by a thin but firm fibrous capsule continuous with the pelvic layer of the triangular ligament and the recto-vesical fascia. It consists of stroma (mostly muscular) and glandular tissue. Immediately beneath the fibrous capsule is a thick muscular layer, and around the prostatic urethra is another strong, circular, muscular layer; extending between the two are a series of decussating muscular trabeculæ, forming interstices that contain the glandular tissue. The tubular glands are arranged around the urethra in a radiating manner, and their ducts (about thirty in number) communicate by minute orifices with the prostatic sinus on either side. They are lined with columnar epithelium and secrete a milky fluid, which is added to the seminal fluid at the moment of ejaculation.

The prostate is supplied by the internal pudic, vesical, and hemorrhoidal arteries. The veins empty into the vesico-prostatic plexus surrounding the organ, and thence into the internal iliac vein. The nerves are derived from the pelvic plexus.

Cowper's Glands. These glands are two firm lobulated bodies about the size of peas and situated, one on either side of the membranous urethra, between the two layers of the triangular ligament (Fig. 2283, No. 2). They lie close above the bulb among the fibres of the compressor urethræ muscle. Each body is a compound racemose gland, and its duct, lined by columnar epithelium, pierces the perineal layer of the triangular ligament and runs forward for about an inch (25 mm.) under the mucous membrane, finally emptying into the spongy urethra. The viscid, albuminoid, transparent secretion of these glands is mixed with the seminal fluid at the moment of ejaculation.

Daniel Kerfoot Shute.

GENTIAN.—GENTIANA. "The dried rhizome and root of *Gentiana lutea* L. (fam. *Gentianaceæ*)," U. S. P. This, the yellow gentian, is one of the largest and showiest species of the genus. It is a tall, sturdy, mountain perennial, arising from a thick, fleshy, slightly branching or simple, and sometimes very long (from half a metre to one metre or more), yellowish-brown root, and is a yard or more high. It grows abundantly in the elevated and mountainous parts of Southern and Middle Europe, Asia Minor, etc. In Switzerland, Southern France, and the hilly parts of Germany, it is collected for use. Although sometimes cultivated for ornament, it does not thrive well, and rarely flowers except in its native pastures.

DESCRIPTION.—In cylindraceous, usually slightly flattened, curved or crooked pieces of indefinite length, and from 0.5 to 3.5 cm. ($\frac{1}{4}$ to nearly $1\frac{1}{2}$ in.) thick, or in longitudinal slices of the same thickness; externally yellowish-brown to dark brown, strongly and crookedly longitudinally wrinkled, and marked with lighter-colored circular root scars, the rhizome finely or heavily annulate; somewhat tough and flexible when damp, rather brittle when dry, the fracture short but uneven, the bark thick, reddish-brown, separated by a dark brown line from the yellowish or reddish-yellow inner portion; free from starch; odor strong, characteristic; taste very bitter, slightly sweetish. The roots of other species are distinguished by their smaller size and tendency to divide into numerous branches at the top. Their introduction is to be regarded as only technically an adulteration, as their properties are identical with those of the official root.

COMPOSITION.—The principal constituent of this and other gentians is the peculiar, intensely bitter, crystalline glucoside, *gentiopicrin*, first obtained in a state of purity in 1868, by Kromeyer, from fresh gentian root. It cannot, so it is said, be made to crystallize from that which has been dried. It forms clear, radiate, or clustered needles; is soluble in water and diluted alcohol, but not in ether; and by means of diluted acids it is separated into sugar and *gentiogenin*, a yellow, bitter, neutral powder. The yield is about one and two-thirds *per mille*. *Gentisic acid* is more abundant. It is in large needle-shaped crystals, tasteless, and almost insoluble in water and ether, but slightly soluble in alcohol. It is not an active substance. The root also contains a good deal of pectic matters, sugar (gentianose), etc., but no starch, and probably no tannic acid, unless the gentisic acid be considered a form of tannin.

ACTION AND USE.—Gentian is the most perfect type at our command of the class of medicines called "simple bit-