with a greater or less increase in the quantity of vaginal mucus, which becomes brownish or rusty in color and has a peculiar odor. At this time, also, the breasts become slightly enlarged. This stage may continue for one or two days, although in many instances the first evidence of the access of a period is a discharge of blood.

When the symptoms above indicated occur, the general sense of uneasiness usually is relieved by the discharge of blood. During this, the second stage, blood flows from the vagina in variable quantity, and the discharge continues for three to five days. With regard to the duration of the flow there are great variations in different individuals. Some women present a flow of blood for only one or two days; while in others the flow continues for five to eight days, within the limits of health. A fair average, perhaps, is four days.

It is difficult to arrive at even an approximation of the total quantity of the menstrual flow. Burdach estimated it at five to six ounces (about 150 to 175 grammes). According to Longet this estimate is rather low, the quantity ordinarily ranging between ten and twelve ounces (300 and 350 grammes), occasionally amounting to seventeen ounces (500 grammes), or even more. It is well known that the quantity is very variable, as is the duration of the flow; and the difficulties in the way of estimating the total discharge are evident.

The characters of the menstrual flow are sufficiently simple. Supposing the discharge to continue for four days, on the first day the quantity is comparatively small; on the second and third the flow is at its height; and the quantity is diminished on the fourth day. During this, the second stage, the fluid has the appearance of pure, arterial blood, not coagulated, and mixed, as has been shown by microscopical examination, with epithelium from the vagina, cylindrical cells from the uterus, leucocytes and a certain quantity of sero-mucous secretion. Chemical examinations of the fluid have not shown any marked peculiarities, except that the quantity of fibrin is either not estimated or is given as much less than in ordinary blood.

The mechanism of the hæmorrhage is probably the same as in epistaxis. There is a rupture of small blood-vessels, probably capillaries, and blood is thus exuded from the entire surface of the membrane lining the uterus and sometimes from the membrane of the Fallopian tubes. The blood is then discharged into the vagina and is kept fluid by the vaginal mucus. The mucus of the body of the uterus is viscid and alkaline; the mucus secreted at the neck is gelatinous, viscid and tenacious, and is also alkaline; the vaginal mucus is decidedly acid, creamy and not viscid, containing epithelium and leucocytes.

The third stage, that of cessation of the menses, is very simple. During the latter part of the second stage the flow of blood gradually diminishes. The discharge becomes rusty, then lighter in color, and in the course of about twenty-four hours, it assumes the characters observed in the intermenstrual period.

When the menstrual flow has become fully established there is no very

marked general disturbance, except a sense of lassitude, which may become exaggerated if the discharge be unusually abundant. It has been noted, however, by Rabuteau, that during the menstrual period the production of urea is diminished more than twenty per cent., that the pulse becomes slower and that the temperature falls at least one degree Fahr. (about half a degree C.).

If the mucous membrane of the uterus be examined during the menstrual flow, it is found smeared with blood, which sometimes extends into the Fallopian tubes. It is then much thicker and softer than during the intermenstrual period. Instead of measuring about $\frac{1}{14}$ of an inch (1·8 mm.) in thickness, as it does under ordinary conditions, its thickness is $\frac{1}{8}$ to $\frac{1}{4}$ of an inch (4·2 to 6·4 mm.). It becomes more loosely attached to the subjacent parts, is somewhat rugous, and the glands are very much enlarged. At the same time there are developed, in the substance of the membrane, large numbers of spherical and fusiform cells. This condition probably precedes the discharge of blood by several days, during which time the membrane is gradually preparing for the reception of the ovum. There is also a fatty degeneration of the different elements entering into the structure of the mucous membrane, including the blood-vessels, this change being most marked at the surface; and it is on account of the weakened condition of the vascular walls that the hæmorrhage takes place. A short time after the flow has ceased, the mucous membrane returns to its ordinary condition. There is a considerable desquamation of epithelium from the uterus, with the flow of blood, during the menstrual period. Sometimes, in normal menstruation, the epithelium thrown off is in the form of patches.

Changes in the Graafian Follicles after their Rupture (*Corpus Luteum*).—After the discharge of an ovum, its Graafian follicle undergoes certain retrograde changes, involving the formation of what is called the corpus luteum. Even when the discharged ovum has not been fecundated, the corpus luteum persists for several weeks, so that, ovulation occurring every month, several of these bodies, in various stages of retrogression, may sometimes be seen in the ovaries.

For a certain time anterior to the discharge of the ovum, there is a cell-proliferation from the proper coat of the Graafian follicle, and probably from the membrana granulosa, with a projection of looped blood-vessels into the interior of the follicle. This is the first formation of the corpus luteum. At the time of rupture of the follicle, the ovum, with a great part of the membrana granulosa, is discharged. Usually, at the time of rupture of the follicle, there is a discharge of blood into its interior; but this is not invaria-

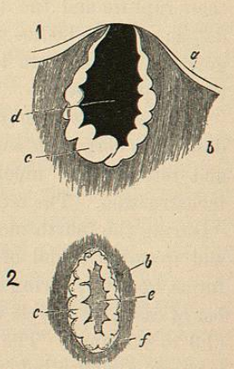

FIG. 285.—*Sections of two corpora lutea; natural size* (Kölliker).

1, corpus luteum eight days after conception; *a*, external coat of the ovary; *b*, stroma of the ovary; *c*, convoluted wall of the Graafian follicle; *d*, clot of blood.

2, corpus luteum at the fifth month of pregnancy; *b*, stroma of the ovary; *c*, convoluted wall of the Graafian follicle; *e*, decolorized clot; *f*, fibrous envelope of the corpus luteum.

ble, although there is always a gelatinous exudation more or less colored with blood. At the same time the follicular wall undergoes hypertrophy, and it becomes convoluted, or folded, and highly vascular. This convoluted wall, formed by the proper coat of the follicle, is surrounded by the fibrous tunic, and its thickening is most marked at the deepest portion of the follicle. At the end of about three weeks, the body—which is now called the corpus luteum, on account of its yellowish or reddish-yellow color—has arrived at its maximum of development and measures about half an inch (12·7 mm.) in depth, by about three-quarters of an inch (19·1 mm.) in length, its form being ovoid. The convoluted wall then contains a layer of large, pale, finely granular cells, which are internal and are supposed to be the remains of the epithelium of the follicle. The great mass of this wall, however, is composed of large, nucleated cells, containing fatty globules and granules of reddish or yellowish pigmentary matter. The thickness of the wall is about one-eighth of an inch (3·2 mm.) at its deepest portion.

After about the third week the corpus luteum begins to contract; its central portion and the convoluted wall become paler; and at the end of seven or eight weeks, a small cicatrix marks the point of rupture of the follicle.

The above are the changes which occur in the Graafian follicles after their rupture and the discharge of ova, when the ova have not been fecundated; and the bodies thus produced are called false corpora lutea, as distinguished from corpora lutea formed after conception, which latter are called true corpora lutea.

Corpus Luteum of Pregnancy.—When a discharged ovum has been fecundated, the corpus luteum passes through its various stages of development and retrogression much more slowly than the ordinary corpus luteum of menstruation. The retrogression begins toward the end of the third month. "During the fourth month, the corpus luteum diminishes by nearly a third, and toward the end of the fifth, it ordinarily is reduced one-half. It still forms, however, during the first days after parturition, and in the greatest number of cases, a tubercle which has a diameter of not less than $\frac{2}{7}$ to $\frac{1}{3}$ of an inch (7·3 to 8·5 mm.). The tubercle afterward diminishes quite rapidly; but it is nearly a month before it is reduced to the condition of a little, hardened nucleus, which persists more or less as the last vestige of a process so slow in arriving at its final term. Nevertheless, there is nothing absolute in the retrograde progress of this phenomenon. I have seen women, dead at the sixth and even the eighth month of pregnancy, present corpora lutea as voluminous as others at the fourth month" (Coste, 1849). The differences between the corpora lutea of pregnancy and of menstruation were accurately described by Dalton, in 1851 and 1877.

Male Organs of Generation.

The chief physiological interest attached to the anatomy of the male organs of generation relates to the testicles, which are the organs in which the male element of generation is developed. As regards the penis, it will be necessary to do little more than describe the mechanism of erection and of the ejaculation of semen.

The Testicles.—The testicles are two symmetrical organs, situated, during a certain period of intraüterine life, in the abdominal cavity, but finally descending into the scrotum. Immediately beneath the skin of the scrotum, is a loose, reddish, contractile tissue, called the dartos, which forms two distinct sacs, one enveloping each testicle, the inner portion of these sacs fusing in the median line, to form a septum. Within these two sacs the coverings of each testicle are distinct. These organs are suspended in the scrotum, by the spermatic cords, the left usually hanging a little lower than the right. The coverings for each testicle, in addition to those just mentioned, are the intercolumnar fascia, the cremaster muscle, the infundibuliform fascia, the tunica vaginalis and the proper, fibrous coat.

The tunica vaginalis is a shut sac of serous membrane, covering the testicle and epididymis and reflected from the posterior border of the testicle to the wall of the scrotum, lining the cavity occupied by the testicle on either side and also extending over the spermatic cord. This tunic is really a process of peritoneum, which has become shut off from the general lining of the abdominal cavity. The spermatic cord is composed of the vas deferens, blood-vessels, lymphatics and nerves, with the coverings already described which expand and surround the testicle.

Beneath the tunica vaginalis are the testicles, with their proper, fibrous coat. These organs are ovoid, and flattened laterally and posteriorly. "They are an inch and a half to two inches (38·1 to 50·8 mm.) long, about an inch and a quarter (31·8 mm.) from the anterior to the posterior border, and nearly an inch (25·4 mm.) from side to side. The weight of each varies from three-quarters of an ounce to an ounce (21·2 to 28·3 grammes), and the left is often a little the larger of the two" (Quain). The proper, fibrous coat is everywhere covered by the closely adherent tunica vaginalis, except at the posterior border, where the vessels enter and the duct passes out. At the outer edge of this border, is the epididymis, formed of convoluted tubes, presenting a superior enlargement, called the globus major, a long mass running the length of the testicle, called the body, and a smaller, inferior enlargement, called the globus minor. This too is covered with the tunica vaginalis. Between the membrane covering the testicle and epididymis and the layer lining the scrotal cavity, is a small quantity of serum, just enough to moisten the serous surfaces. At the superior portion of the testicle are one or more small, ovoid bodies, called the hydatids of Morgagni, each attached to the testicle, by short, constricted processes. These have no physiological importance and are supposed to be the remains of fœtal structures.

The proper, fibrous coat of the testicle is called the tunica albuginea. It is white, dense, inelastic, measures about $\frac{1}{25}$ of an inch (1 mm.) in thickness, and is simply for the protection of the contained structures. Sections of the testicle, made in various directions, show an incomplete, vertical process of the tunica albuginea, called the corpus Highmorianum or the mediastinum testis. This is wedge-shaped, about $\frac{1}{6}$ of an inch (4·2 mm.) wide at its su-

perior and thickest portion, is pierced by a number of openings, and lodges blood-vessels and seminiferous tubes. From the mediastinum, delicate, radiating processes of connective tissue pass to the inner surface of the tunica albuginea, dividing the substance of the testicle into imperfect lobules, which lodge the seminiferous tubes. The number of these lobules has been estimated at one hundred and fifty to two hundred. Their shape is pyramidal, the larger extremities presenting toward the surface, with the pointed extremities situated at the mediastinum.

Lining the tunica albuginea and following the mediastinum and the processes which penetrate the testicle, is a tunic, composed of blood-vessels and delicate, connective tissue, called the tunica vasculosa, or pia mater testis.

Lodged in the cavities formed by the trabeculæ of connective tissue, are the seminiferous tubes, in which the male elements of generation are developed. These tubes exist to the number of about eight hundred and forty in each testicle and constitute almost the entire substance of the lobules. The larger lobules contain five or six tubes, the lobules of median size, three or four, and the smallest enclose sometimes but a single tube. Each tube presents a convoluted mass, which can be disentangled under water, particularly if the testicle be macerated for several months in water with a little nitric acid. The entire length of the tube when thus unravelled is about thirty inches (7·6 decimetres), and its diameter is $\frac{1}{200}$ to $\frac{1}{100}$ of an inch (125 to 166 μ). It begins by two to seven short, blind extremities and sometimes by anastomosing loops. The cæcal diverticula are usually found in the external half of the tube, and their length is $\frac{1}{12}$ to $\frac{1}{8}$ of an inch (2·1 to 3·2 mm.). The anastomoses are sometimes between the tubes of different lobules, sometimes between tubes in the same lobule and sometimes between different points in the same tube. As the tubes pass toward the posterior portion of the testicle, they unite into about twenty straight canals, called the vasa recta, about $\frac{1}{75}$ of an inch (0·33 mm.) in diameter, which penetrate the mediastinum testis. In the mediastinum the tubes form a close net-work, called the rete testis; and at the upper

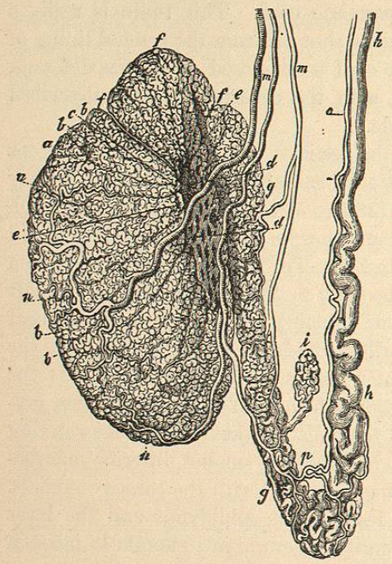

FIG. 286.—*Testicle and epididymis of the human subject* (Arnold).

a, testicle; *b*, *b*, *b*, *b*, lobules of the testicle; *c*, *c*, vasa recta; *d*, *d*, rete testis; *e*, *e*, vasa efferentia; *f*, *f*, *f*, cones of the globus major of the epididymis; *g*, *g*, epididymis; *h*, *h*, vas deferens; *i*, vas aberrans; *m*, *m*, branches of the spermatic artery, to the testicle and epididymis; *n*, *n*, *n*, ramification of the artery upon the testicle; *o*, deferential artery; *p*, anastomosis of the deferential with the spermatic artery.

portion of the posterior border they pass out of the testicle, by twelve to fifteen openings, and are here called the vasa efferentia.

Having passed out of the testicle, the vasa efferentia form a series of small, conical masses, which together constitute the globus major, or head of the epididymis. Each of these tubes when unravelled is six to eight inches (15 to 20 centimetres) long, gradually increasing in diameter, until they all unite into a single, convoluted tube, which forms the body and the globus minor of the epididymis. This single tube of the epididymis, when unravelled, is about twenty feet (6 metres) in length.

The walls of the seminiferous tubes in the testicle itself are composed of connective tissue and of peculiar structures which will be fully described in connection with the processes of development of the spermatozoids. In the rete testis it is uncertain whether the tubes have a special fibrous coat or are simple channels in the fibrous structure. They are here lined with pavement-epithelium. In the vasa efferentia and the epididymis, there is a fibrous membrane, with longitudinal and circular fibres of non-striated muscular tissue and a lining of ciliated epithelium. The movements of the cilia are toward the vas deferens. In the lower portion of the epididymis the cilia are absent. The tubular structures of the testicle, the epididymis and the beginning of the vas deferens are shown in Fig. 286.

At the lower portion of the epididymis, communicating with the canal, there usually is found a small mass, formed of a convoluted tube of variable length, called the vas aberrans of Haller (*i*, Fig. 286). This is sometimes wanting.

Vas Deferens.—The excretory duct of the testicle extends from the epididymis to the prostatic portion of the urethra and is a continuation of the single tube which forms the body and globus minor of the epididymis. It is somewhat tortuous near its origin, and it becomes larger at the base of the bladder, just before it is joined by the duct of the seminal vesicle. Near its point of junction with this duct it becomes narrower. Its entire length is nearly two feet (about 6 decimetres).

The course of the vas deferens is in the spermatic cord, to the external abdominal ring, through the inguinal canal, to the internal ring, where it leaves the blood-vessels, passes beneath the peritoneum, to the side of the bladder, then along the base of the bladder, by the inner side of the seminal vesicle, finally joining the duct of the seminal vesicle, the common tube forming the ejaculatory duct, which opens into the prostatic portion of the urethra.

The walls of the vas deferens are thick, abundantly supplied with vessels and nerves, and provided with an external, fibrous, a middle, muscular, and an internal, mucous coat. The greater part of that portion of the tube which is connected with the bladder is dilated and sacculated. The fibrous coat is composed of strong, connective tissue. The muscular coat presents three layers; an external, rather thick layer of longitudinal fibres, a thin, middle layer of circular fibres, and a thin, internal layer of longitudinal fibres, all of the non-striated variety. By the action of these fibres the ves-

sel may be made to undergo energetic, peristaltic movements, and this has followed stimulation of that portion of the spinal cord corresponding to the fourth lumbar vertebra, which is described by Budge as the genito-spinal centre.

The mucous membrane of the vas deferens is pale, thrown into longitudinal folds in the greatest part of the canal, and presents a number of additional rugæ in the sacculated portion, these rugæ enclosing little, irregularly polygonal spaces. The membrane is covered with columnar epithelium, which is not ciliated. In the sacculated portion are large numbers of mucous glands.

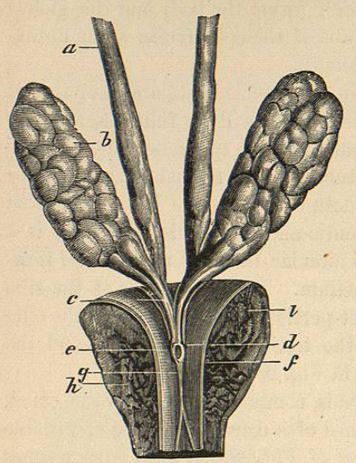

FIG. 287.—*Vas deferens, vesiculæ seminales and ejaculatory ducts* (Liégeois).
a, vas deferens; *b*, seminal vesicle; *c*, ejaculatory duct; *d*, termination of the ejaculatory duct; *e*, opening of the prostatic utricle; *f*, *g*, veru montanum; *h*, *l*, prostate.

Attached to the vas deferens, near the head of the epididymis, is a little mass of convoluted and sacculated tubes, called the organ of Giraldès, or the corpus innominatum. The body is $\frac{1}{6}$ to $\frac{1}{3}$ of an inch (4·2 to 8·5 mm.) long and $\frac{1}{12}$ of an inch (2·1 mm.) broad. Its tubes are lined with cells of pavement-epithelium, which often are filled with fatty granules. Generally the tubes present only blind extremities, but some of them occasionally communicate with the tubes of the epididymis. This part has no physiological importance. It was regarded by Giraldès as the remnant of the Wolffian body, analogous to the parovarium.

Vesiculæ Seminales.—Attached to the base of the bladder and situated externally to the vasa deferentia, are the two vesiculæ seminales. These bodies are each composed of a coiled and sacculated tube, four to six inches (10 to 15 centimetres) in length when unravelled, and somewhat convoluted, in the natural state, into an ovoid mass which is firmly bound to the vesical wall. The structure of the seminal vesicles is not very unlike that of the sacculated portion of the vasa deferentia. They have an external, fibrous coat, a middle coat of muscular fibres, and a mucous lining. Muscular fibres pass over these vesicles from the bladder, both in a longitudinal and in a circular direction, and serve as compressors, by the action of which their contents may be discharged. The mucous coat is pale, finely reticulated, and covered with cells of polygonal epithelium, which are nucleated and contain brownish granules. The vesiculæ seminales undoubtedly serve, in part at least, as receptacles for the seminal fluid, as their contents often present a greater or less number of spermatozoids. Although the membrane of the vesicles seems to produce an independent secretion, the presence of mucous glands has not been demonstrated.

The ejaculatory ducts are formed by the union of the vasa deferentia with the ducts of the vesiculæ seminales on either side, and they open into the prostatic portion of the urethra. Except that their coats are much thinner, they have essentially the same structure as the vasa deferentia.

Prostate.—Surrounding the vesical extremity of the urethra, including what is known as its prostatic portion, is the prostate gland, or body. This organ, except as it secretes a fluid which forms a part of the ejaculated semen, has chiefly a surgical interest, so that it is unnecessary to describe minutely its form and relations. It is enveloped in a very dense, fibrous coat, contains many glandular structures opening into the urethra, and presents a great number of non-striated, with a few striated muscular fibres, some just beneath the fibrous coat and others penetrating its substance and surrounding the glands.

The glands of the prostate are most distinct at that portion which lies behind the urethra. In the posterior portion of this canal are found about twenty openings, which lead to tubes ramifying in the glandular substance. These tubes are formed of a structureless membrane branching as it penetrates the gland. They present hemispherical diverticula in their course, and terminate in dilated extremities, which are looped and coiled. In the deeper portions of the tubes, the epithelium is columnar or cubical, becoming tessellated near their openings, and sometimes laminated.

The prostatic fluid probably is secreted only at the moment of ejaculation. Its characters will be considered in connection with the composition of the seminal fluid. According to Kraus the prostatic fluid has an important office in maintaining the vitality of the spermatozoids. "The spermatozoa, in the absence of the prostatic fluid, can not live in the mucous membrane of the uterus of mammalia; but with its aid they may live for a long time in the uterine mucus, often more than thirty-six hours."

Glands of the Urethra.—In front of the prostate, opening into the bulbous portion of the urethra, are two small, racemose glands, called the glands of Méry or of Cowper. These have each a single excretory duct, are lined throughout with cylindrical epithelium, and secrete a viscid, mucus-like fluid, which forms a part of the ejaculated semen. Sometimes there exists only a single gland, and occasionally, though rarely, both are absent. Their uses are probably not very important.

The glands of Littre, found throughout the entire urethra and most abundant on its anterior surface, are simple racemose glands, extending beneath the mucous membrane into the muscular structure, presenting here four or five acini. As these acini are surrounded by muscular fibres, it is easy to understand how their secretion may be pressed out during erection of the penis. They are lined throughout with columnar or conoidal epithelium, and secrete a clear and somewhat viscid mucus, which is mixed with the ejaculated semen.

Male Elements of Generation.

The spermatozoids are the essential, male elements of generation, and these are produced in the substance of the testicle, by a process analogous to