Anatomy of the Reproductive System

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The complexity of the organs that the mammalian reproductive system consists of, necessitates a general view of the systematization and short description of each structure involved. The following domestic mammals are subject of this chapter: cat (Felis catus), dog (Canis familiaris), pig (Sus scrofa domestica), large ruminant (Bos Taurus), sheep (Ovis aries), goat (Capra hircus), and horse (Equus caballus).

The anatomy of the reproductive system of laboratory animals and the nonmammalian animal models follow the description of domestic mammals’ anatomy (König and Liebich, 2004; Nickel et al., 1984). The laboratory animals are the rabbit (Oryctolagus cuniculus), the mouse (Mus musculus), and the rat (Rattus norvegicus). The nonmammalian animal models are the African clawed frog (Xenopus laevis L.) and the zebrafish (Brachidanio/Danio rerio).

The English anatomical terms are translated from Nomina Anatomica Veterinaria (NAV) (2012, op. cit. as ICVDGAN) and from Gheorghe M. Constantinescu and Oskar Schaller, Illustrated Veterinary Anatomical Nomenclature 4th edn, Thieme (2012, op. cit.). For the corresponding terms in humans, the following reference is suggested: Heinz Feneis and Wolfgang Dauber, Pocket Atlas of Human Anatomy Based on the International Nomenclature (2000, op. cit.).

1.1 Male Genital Organs in Domestic Mammals

The male reproductive system of all mammalian species, including the laboratory animals, consists of the paired testis, epididymis, ductus deferens, spermatic cord, accompanying tunics, accessory genital glands (single structures or pairs), the male urethra, the penis, and the prepuce.

Details of all components of the male reproductive system can be found in Schatten and Constantinescu (2007), Blackwell (op. cit.), Constantinescu and Constantinescu (2010), Omphaloskepsis (op. cit.), deLahunta and Habel (1986), Saunders (op. cit.), and Dyce (2010), 4th edn, Elsevier (op. cit.). For the laboratory animals except the rabbit, the details can be found in Constantinescu (2011) (a Color (water color) Atlas and Text, AALAS (op. cit.)). For the rabbit the details can be found in Barone (1973) Masson (op. cit.), and Barone (1978) École Nationale Vétérinaire Lyon (op. cit.).

1.1.1 The Testicle

The male gonad, with endocrine and exocrine functions, the testis, is the essential organ of the male reproductive system, producing testosterone and spermatozoa, respectively. It has an ovoid
shape, with the long axis species-specific oriented, a lateral and a medial surfaces, a free and an epididymal border, a head end, where the head of the epididymis is attached, and a tail end, where the tail of the epididymis is attached. (The body of the epididymis is not attached to the testicle.)

The testicle is intimately covered by a white and inextensible fibrous capsule called *Tunica albuginea*, which runs inside of the testicle walls, called *Septa* or *Septula*, which separate the testicular tissue into lobes (see Figure 1.1). Within the lobes, the testicular parenchyma, which is the functional tissue of the testis, consists of *seminiferous tubules*, *Leydig cells*, and *Sertoli cells*. The seminiferous tubules start as convoluted, and end as straight tubules that build up the *rete testis* within the *mediastinum testis*. The septa/septula converge into a structure called mediastinum testis.

### 1.1.2 The Epididymis, Ductus Deferens, and Spermatic Cord

The *epididymis* is the first excretory organ of the male reproductive system. It presents a head, a body, and a tail, all surrounded by the continuation of the testicular albuginea. The epididymis consists of *ductuli efferentes*—the continuation of the rete testis, and the *ductus epididymidis*.

The *ductus deferens* is the continuation of the ductus epididymidis and opens on the roof of the prostatic urethra at the level of colliculus seminalis. Within the spermatic cord it is connected to the *mesorchium* by the *mesoductus deferens*, whereas within the peritoneal cavity it is connected with the symmetrical duct and the paired ureter by the *genital fold*. An embryonic remnant of the fetal uterus (*uterus masculinus*) can be seen in some species within the genital fold.

![Figure 1.1 Internal organization of testicle and epididymis.](image)
The spermatic cord (Funiculus spermaticus) (see Figure 1.2) consists of the following:

- The ductus deferens with its blood and nerve supply surrounded and attached to the mesorchium by the mesoductus deferens
- The blood and lymphatic vessels and nerves supplying the testicle and the epididymis and smooth muscle fibers, all surrounded by the visceral lamina of the vaginal tunic and collectively called mesorchium.

The spermatic cord is connected to the parietal lamina of the vaginal tunic by the mesofuniculus.

1.1.3 The Descent of the Testicle

Starting its development on the roof of the abdominal cavity, the testicle with the epididymis is connected to the skin by a long mesenchymal tract (ligament) called gubernaculum testis, which runs within the inguinal canal. (The inguinal canal is outlined by the superficial and deep inguinal rings, the arcus inguinalis, and the internal abdominal oblique M. For details, see any veterinary anatomy book.) Pushing the transverse fascia and the parietal peritoneum through the deep inguinal ring, it will appear lined by the peritoneum under the name of vaginal ring. The space between the parietal and the visceral laminae of the vaginal tunic (continuation of peritoneum) within the inguinal canal is called vaginal canal, and that surrounding the testicle is

![Figure 1.2 Transverse section through the spermatic cord (outlined by the broken line).](image-url)
called vaginal cavity. Before the testicle passes through the inguinal canal surrounded by the intraabdominal tunics (see below), these tunics enclosing the gubernaculum testis protrude through the inguinal canal under the embryological term of vaginal process. By the retraction of gubernaculum testis, the testicle passes through the inguinal canal and establishes finally within the scrotum (see below). After birth, the gubernaculum testis is represented by three ligaments: proper ligament of testicle (between the tail head of the testicle and the tail of the epididymis), the ligament of the tail of the epididymis (between the tail of epididymis and the external spermatic fascia), and the scrotal ligament (between the external spermatic fascia and dartos).

1.1.4 The Tunics of the Spermatic Cord and the Testicle

The systematization of these tunics in intraabdominal and extraabdominal eases their comprehension.

1.1.4.1 The Intraabdominal Tunics

These are the structures that are brought by the testicle from the abdominal cavity during its descent. The internal spermatic fascia is the continuation of the transverse fascia. The vaginal tunic is the continuation of the peritoneum (see above). The cremaster M. protected by the cremasteric fascia is intimately attached to the internal spermatic fascia, as a bundle of fibers from the internal abdominal oblique M.

1.1.4.2 The Extraabdominal Tunics

These are structures outside of the inguinal canal. They consist of the external spermatic fascia, which continues the superficial fascia of the abdomen and the loose subcutaneous connective tissue, and the skin which in the testicular area duplicates in a skin layer, the scrotal skin, and a layer of smooth muscle fibers called Tunica dartos. Together the scrotal skin and the tunica dartos are called Scrotum. The symmetrical external spermatic fascia surrounds the penis as the superficial fascia of penis, and continues in the perineal region as the deep perineal fascia. Tunica dartos surrounds the penis as the deep fascia of penis and continues as the superficial perineal fascia.

1.1.5 The Accessory Genital Glands

The glands of the ampullae of the ductus deferens, the vesicular glands/semen vesicles, the prostate, and the bulbourethral glands differ from species to species in number and aspect, and from intact male to a sexually immature or an orchiectomized male.

There are no ampullae of the ductus deferens in the cat and in the pig. The vesicular glands are present in ungulates, but in the horse they are called seminal vesicles. The carnivores lack the vesicular glands. The prostate is the only accessory gland in the dog. In all species it consists of a body (surrounding the prostatic urethra) and a disseminate part (within the walls of the urethra). The latter is found in the pig, ox, and goat, is deficient ventrally in the sheep, and represented by a few lobules in carnivores. No disseminate part of prostate is found in the horse. The bulbourethral glands, absent only in the dog, are located symmetrically at the level of the curvature made by the urethral isthmus, between the pelvic and the penile parts of urethra.

1.1.6 The Penis and the Prepuce

The penis is an external genital, and the male organ of copulation. It consists of a root, a body, and a free part surrounded and protected by the prepuce, and the glans penis.
The root of the penis consists of two crura and the bulbus penis. The paired crus penis is the origin (proximal end) of corpus cavernosum penis. They are attached to the ischiatic arch covered by the ischiocavernosus muscles and join with each other in a “V”-shaped fashion to build up the corpus cavernosum penis. Between the two crura the bulbus penis is located. The latter is a proximal enlargement (at the origin) of spongy tissue that surrounds the penile urethra, spongy tissue called corpus spongiosum penis.

The body of the penis is represented by the continuation of the two crura, distally, and is called corpus cavernosum penis. The penile urethra surrounded by the corpus spongiosum penis runs on the ventral side of it.

The free part of the penis includes the glans penis, distal to the attachment of the prepuce. The glans penis is the head of the penis, containing the corpus spongiosum glandis. In the tomcat a cartilage, and in the dog, mouse, and rat an os penis is included. Species-specific characteristics will be detailed later on.

The prepuce is the skin surrounding and protecting the free part of the penis in the resting position. It is a fold of skin consisting of an external and an internal laminae, continuous at the preputial ostium. The internal lamina attaches to the origin (proximal end, or base) of the free part of the penis, where it continues with the skin of the free part of the penis, visible when the penis is fully erect.

1.2 Female Genital Organs in Domestic Mammals

The female reproductive system of all mammalian species consists of the paired ovary, uterine, or fallopian tube (salpinx), and the uterus, the vagina, the vestibule, vulva, and clitoris. The mammary glands are associated with the female genital organs, and will be described in general terms.

Details of all components of the female reproductive system can be found in Schatten and Constantinescu (2007, op. cit.)

1.2.1 The Ovary

Similar to the male, the female gonad is a mixed gland with endocrine and exocrine functions. The ovary is the essential organ of the female genital system, producing progesterone, and estradiol, also oxytocin, relaxin, inhibin, and activin. As the exocrine function the ovary produces ovules (ovocytes, oocytes). Ovoid in shape, with a medial and a lateral surface, a free and mesovarian borders, tubal and uterine extremities, the ovary is provided with a hilus.

Notice that the mesovarium is attached to the mesovarian border, opposite to the free border, and the uterine extremity (toward the tip of the uterine horn) is opposite to the tubal extremity, in close proximity to the infundibulum of the uterine tube. Also, the hilus is the area of attachment of the mesovarium, and entrance of ovarian vessels.

A tunica albuginea intimately covers the ovary, similar to that of the testicle. In all species the stroma is the framework of the ovary (see Figures 1.3 and 1.4), consisting of fibrous tissue and smooth muscle, whereas the parenchyma is the functional tissue of the ovary. Except in the horse, the ovary consists of a peripheral cortex and a central medulla. In the mare the cortex is central, and the medulla is peripheral.

The cortex of the most mammals except the mare, which is also called the parenchymal zone, contains all categories of follicles: primary, secondary, tertiary (vesicular ovarian follicles), the
corpus luteum, the corpus albicans, and atretic ovarian follicles. A mature follicle liberates the ovule, which leaves the ovary through the cortex.

The medulla, also called the vascular zone, consists of vessels and nerves nourishing the ovary and is located in all species except the mare, after entering the hilus. In the mare, the free border of the ovary has an indentation/depression called the ovarian fossa, where the mature ovule leaves the ovary (the ovulation occurs), reason that some clinician call the ovarian fossa ovulation fossa.

Figure 1.3 Internal organization of the mare’s ovary.

Figure 1.4 Internal organization of the cow’s ovary.
The ovary is connected to the surrounding structures by the suspensory ligament (to the diaphragm), the proper ligament (to the apex of the uterine horn), and the mesovarium (which is the most cranial segment of the broad ligament). In a similar manner in which the mesepididymis separates the mesorchium in a proximal and a distal segment, the mesosalpinx separates the mesovarium into a proximal and distal segment.

Two groups of vestigial structures from the developmental life called epoöphoron and paroöphoron may be associated with the ovary after birth.

1.2.2 The Uterine Tube: Salpinx, Fallopian Tube

The uterine tube extends from the apex of the uterine horn (where it is attached to), and this is called the uterine end, to the vicinity of the ovary (and this is called the ovarian end) on the lateral side of the broad ligament. It is flexuous and has an uneven size, basically being divided into two distinct portions, the ampulla and the isthmus. We can distinguish two openings or ostia, the infundibulum, and the fimbriae, and in some species (carnivores, horse) the uterine part of the uterine tube, provided with a papilla.

The closest opening to the ovary is the abdominal ostium within the infundibulum. The latter is the funnel-shaped ovarian end of the tube. The infundibulum is provided with a fringe of processes called fimbriae, around the opening of the infundibulum. The fimbria, which is intimately attached to the ovary, is called ovarian fimbria. It is important to mention that the abdominal opening of the uterine tube corresponds to the peritoneal cavity, allowing the connection between the external environment (through the vagina) and the peritoneal cavity. The ampulla is the widest part of the tube, between the abdominal ostium and the isthmus. The isthmus is the narrow part of the salpinx, continuing with the uterine part of the tube. The uterine part of the salpinx is the shortest segment of the tube. It passes through the wall of the apex of the uterine horn and in some species (see above) ends on a papilla, whereas in the other species the salpinx gradually continues with the uterine horn. At this level, the salpinx opens into the uterus through the uterine ostium of the uterine tube.

As a part of the broad ligament, the mesosalpinx holds in place the uterine tube. The ovarian bursa is outlined by the distal mesovarium, the mesosalpinx, and the ovary. The entrance into the ovarian bursa is medially oriented.

1.2.3 The Uterus

The uterus is the organ of pregnancy, or gestation. In most mammals it consists of three major components: two horns, one body, and one cervix or neck, and it is called uterus bicornis. In the rabbit and the rat, the horns and cervix are paired, this type of uterus being called uterus duplex. In these two species the uterine horns run together side by side for a short distance caudally, and end by their own cervices. Therefore, there is no body of uterus in these two species. In primates, including humans, the uterus has only one body and the cervix, which is a characteristic of the uterus simplex. Nevertheless, Feneis and Dauber (2000) 5th edn Thieme (op. cit.) listed on p. 168.9 right and left uterine horns as “pointed extensions of the uterus at the entrance of the uterine tubes owing to the incomplete union of both paramesonephric ducts” (from the intrauterine development).

The uterine horns of the uterus bicornis and duplex expose mesometrial and free borders, and corresponding cavities. The uterine body and the cervix of the uterus bicornis have a right and a left mesometrial border, a dorsal and a ventral surface, and a cavity (for the cervix the cavity is called cervical canal). The cervices of the uterus duplex expose short right and left mesometrial
borders, dorsal and ventral surfaces, and their own, totally separated from each other, cervical canals. In all species the cervix has two openings: the internal uterine orifice opening toward the uterus and an external uterine orifice, between the cervix and the vagina.

The uterine horns vary from species to species in shape, size, and location. Each uterine horn has two openings: at the apex (tip) it communicates with the uterine tube through the uterine orifice of the tube, whereas caudally it opens into the body of the uterus. Here they are separated by a fold of mucosa called uterine velum, except in the mare. The mesometrial borders serve for the attachment of the mesometrium, the last component of the broad ligament.

The body of uterus is a unique compartment, where the embryo and the fetus develop before birth. In the mare, because of the lack of uterine velum, the caudal extent of the uterine body is called fundus. The mesometrium is provided with the round ligament of the uterus, which may extend from the apex of the uterine horn or uterine body to the deep inguinal ring enclosed in a lateral fold of the broad ligament. The round ligament of the uterus in carnivores will be described later.

The cervix has thick muscular walls and a narrow canal through which the fetus will exit the uterus. It has different species-specific structures, which make easy or complicate the birth and the artificial insemination (A.I.). It is important to note that the cervix has two distinct parts: a prevaginal and a vaginal part. The former is the part of the cervix cranial to the vagina, and the latter is the part that protrudes into the vagina. The more the cervix projects into the vagina, the deeper the vaginal fornix, the cranial blind pouch of the vagina surrounding the vaginal part of the cervix. Both vaginal part of the cervix and the fornix are very important structures in the mare and the female dog.

1.2.4 The Vagina and the Vestibule

The vagina is the canal located between the cervix and the external urethral orifice, or the hymen. The vaginal fornix has already been described. The hymen is a poorly developed transverse fold of the floor of the vagina just cranial to the external urethral ostium. The vagina opens into the vestibule through the vaginal ostium. Remnants of embryological structures can be seen on the floor of the vagina, on both sides of the external urethral orifice in the cow.

The last compartment of the female genital organs, the vestibule, communicates cranially with the vagina and caudally with one of the external parts of the female genital organ, the vulva. It is a very long canal in the domestic mammals in comparison to humans, and with the exception of the cat, shorter than the vagina. In the domestic mammals it is not considered an external organ, as it is considered in humans. On the lateral walls and the floor of the vestibule, an erectile tissue (the vestibular bulb) and several glands can be seen. The constrictor muscle of the vestibule and vagina is well developed in the female dog and the mare. A suburethral diverticulum is shown in the sow and the ruminants. In the female dog a urethral tubercle is seen at the vastibulovaginal junction.

1.2.5 The Vulva and the Clitoris

In the domestic mammals the vulva and the clitoris are considered the female external genital parts.

The vulva is located in a subanal position and is provided by two pairs of labia, major and minor, not easily distinguishable in the domestic mammals, as in humans, with some exceptions. Usually the vulva consists of two symmetrical labiae. The labiae meet in a dorsal and a ventral commissures, differently shaped in the domestic mammals. The contact borders of the two
labiae between the two commissures outline the **pudendal fissure**, the external urogenital opening.

Rudimentary partial homologue of the penis, the **clitoris** is located on the floor of the vestibule (some exceptions in laboratory animals). The only notable difference between the penis and the clitoris consists of the lack of urethra in the clitoris. The two **crura** and the **body with the corpus cavernosum**, the **glans with the corpus spongiosum**, and the **fascia of the clitoris** are the major components of this organ. The glans is protected within the **fossa of the clitoris**. The **prepuce** and the **frenulum** are also associated with the clitoris.

### 1.2.6 The Mammary Gland

The mammary gland(s) are associated with the female genital system. A detailed description for all species of domestic mammals with the blood supply, lymph drainage, and nerve supply is available in Schatten and Constantinescu (2007, *op. cit.*).

### 1.3 The Genital System in Domestic Mammals Species by Species

The male and the female genital systems in all species will follow the same step-by-step description as it was chosen for the general description, single or several structures under the same section.

In Section 1.3.1.1, the first section describes the testicle, epididymis, ductus deferens, spermatic cord, and investing tunics in the male. The second section describes the accessory genital glands, the third section describes the penis and the prepuce, and the fourth section describes the male urethra.

Section 1.3.1.2 consists of five sections providing a general description on female reproductive organs. No mammary glands will be described as a separate section. Illustrations are provided for the domestic mammals in Schatten and Constantinescu (2007, *op. cit.*), and for the laboratory animals (see Figures 1.68–1.70).

### 1.3.1 The Genital System in the Carnivores: Cat and Dog (Constantinescu, 2002)

#### 1.3.1.1 Male Genitalia

**The Testicle, Epididymis, Ductus Deferens, Spermatic Cord, Tunics**

The descent of the testicles occurs very late during the development (around the second week after birth). They reach the scrotum at the end of the third week.

The testicles are located just under the anus in the cat, and in the lower perineal region in the dog (between the two thighs). Globular in shape, the testicles of the cats and dogs are oblique, with the long axis cranioventrally oriented. The testicular artery running deep to the albuginea makes a species-specific characteristic design (see Figures 1.5 and 1.6). The average weight of testicles in the cat is 1.3 g, whereas in the dog it varies with the breeds between 7 and 20 g.

The epididymis is similar in cats and dogs, and it follows the general description. The ductus epididymidis is as long as 1.5–3 mm in the cat, and 5–8 mm in the dog.

The ductus deferens lack the ampulla in the cat, and in the dog is less distinct. Since there are no vesicular glands in both species, there is no ejaculatory duct.

The spermatic cord is the longest in the cat, because of the location of the testicles, and runs horizontally. In the dog it is slightly obliquely oriented in a dorsocranial direction.
The testicular tunics are similar to the general description, but the characteristic for both species is the fact that there is no ligament of the tail of the epididymis. The parietal lamina of the vaginal tunica and the internal spermatic fascia are adherent to the tail of the epididymis, which does not leave any space for the ligament of the tail of the epididymis. Instead, the scrotal ligament connects the tail of the epididymis directly to the tunica dartos.

**Accessory Genital Glands**

No ampullae of the ductus deferentes, no vesicular glands are present in both species.

The prostate (see Figure 1.7) is common to both species. In the cat the body of the prostate is bilobed, with a slightly lobulated surface, and does not completely surround the urethra, leaving ventrally a free space. The disseminate part is limited to the dorsal wall of the intrapelvic urethra. In the dog the body of the prostate is voluminous, bilobed, with a lobulated surface, and surrounds the urethra completely. The disseminate part is located similar to that of the cat.
The bulbourethral glands are present in the cat only. They are located dorsolateral to the urethral isthmus, spheroidal in shape, and pretty voluminous (5–6 mm in diameter).

**The Penis and the Prepuce**

The main characteristic of the carnivores penis is the fact that a cartilage in the cat, and a bone in the dog (Os penis) are found within the glans penis. The cartilage of the cat may ossify. The os penis of the dog is triangularly shaped on a transverse section and presents a ventral groove that protects the urethra and the corpus spongiosum glandis.

In the cat the location of the penis is just ventral to the testicles, and obliquely oriented in a ventrocaudal direction, with the urethral aspect in a dorsal position. During the erection it changes to a ventrocranial oblique position, with the urethral side ventral. The penis is provided with more erectile tissues than the penis of the dog. The glans penis is short and conique, and provided with numerous keratinized papillae oriented toward the base of the penis.

Figure 1.7 Accessory genital glands in the male dog: dorsal view.
In the dog the penis is located in a subabdominal position, parallel to the ventral contour of the abdominal wall. The crura of the corpus cavernosum are long and covered by strong and voluminous ischiocavernosus muscles. They connect with one another in the corpus cavernosum penis, which distinctly shows the separation between the two halves; even though they are fused, a thick septum separates the two halves. The corpus spongiosum penis, which continues with the corpus spongiosum glandis, is poorly developed in comparison to the cat. The former begins with the bulbus penis, which in the dog is paired and covered by the bulbospongiosus muscle. It is big, originates close to the ischial arch, and extends close to the scrotum. The corpus spongiosum glandis surrounds the penis urethra.

The body of the penis is short. Instead, the glans penis is voluminous and long, and consists of a bulb and a long part. The bulbus penis, which covers dorsally the proximal part of the os penis, is 2.5 cm in diameter in the resting functional status, whereas during the copulation it can reach 8 cm in diameter. With the help of the symmetrical constrictor muscle of bulbus vestibuli (of the female), and the slow engorgement of the bulb, the penis is “locked” and allows the male to perform the second time of copulation, which lasts approximately 20 min. For details, see Evans (1993), Saunders (op. cit.), and Evans and deLahunta (2013), Elsevier (op. cit.). The long part of the glans penis surrounds the “V”-shaped part of the os penis. A corona glandis is present in the dog (see Figure 1.8).

The prepuce of the cat is detached and placed under the scrotum. It is short and opens in a caudal direction. The preputial orifice is directed caudoventrally. In the dog the prepuce is long and in its cranial portion is attached to the ventral wall of the abdomen only by a fold of skin. The internal lamina is attached to the middle of bulbus glandis and covers the rest of the gland as the penis skin. The preputial cavity is wide. A pair of cranial preputial muscles is attached to the prepuce.

**The Male Urethra**

In the cat the preprostatic part of the pelvic urethra is much longer than that of the dog. In both species the prostatic part is associated with the prostate gland. The urethral crest and the colliculus seminalis are prominent in both species. There are only two symmetrical openings on both sides of colliculus seminalis for the ductus deferentes (no vesicular glands in carnivores). A spongy layer (cavernous tissue) surrounds the pelvic urethra and continues with the corpus spongiosum penis. The urethralis muscle surrounds the pelvic urethra, and continues as the bulbospongiosus muscle, which surrounds the penile urethra and the bulbus penis. The urethra opens distally by the external urethral orifice. The bulbo-urethralis muscles are present only in the cat.

![Figure 1.8 Penis of the dog.](image)
1.3.1.2 Female Genitalia (see Figure 1.9)

**The Ovary**
Bean shaped and flat, the ovaries are protected within the ovarian bursae. The entrance into the ovarian bursa of the dog is very narrow. The suspensory ligament is very long, while the proper ligament of the ovary is much shorter.

![Diagram of female genital apparatus](image)

**Figure 1.9** Genital apparatus of the female dog: dorsal aspect.
The Salpinx
Twice as long in the dog as in the cat, the uterine tubes are very narrow and each ends on a small uterine papilla. The flexuosity shown in the large mammals is almost absent.

The Uterus
Twice as long and wide in the dog as in the cat, the uterine horns have rounded cranial ends and they meet with each other to form the body of the uterus caudally.

The uterine body is also twice as long and wide in the dog as in the cat. Inside, it is provided with a uterine velum starting from the junction of the two horns, and which incompletely separates the uterine cavity.

The cervix in carnivores (see Figure 1.10) has unique characteristics, very important during the performing of the A.I. (see McCarthy (2005), p. 414, Elsevier op. cit.). The cervical canal is short, and communicates with the uterine body by the internal uterine orifice. The vaginal part of cervix protrudes into the vagina on the roof as a rounded cervical tubercle, which continues as a very developed dorsal median fold. Thus, the external uterine orifice opens on the ventral aspect of the cervical tubercle, and is directed toward the vaginal floor. The vaginal fornix is located only on the ventral side of the tubercle—the external uterine orifice is not surrounded by the fornix as it is in the large mammals. In the cat the cervical tubercle has fine folds.

The broad ligament consists of the mesovarium, mesosalpinx, and mesometrium. The round ligament of the uterus originates from the lateral surface of mesometrium and in the dog it is enclosed in a fold of the broad ligament and passes through the inguinal canal accompanied by the transverse fascia and the parietal peritoneum collectively known as the vaginal process. The round ligament of the uterus concealed within the vaginal process exits the inguinal canal and can be felt under the skin as far as close to the vulva. In the cat the round ligament of the uterus is not accompanied by the vaginal process (see Watson, 2009, op. cit.).

Figure 1.10 Sagittal section through the uterus and vagina of the dog. (Modified and redrawn from Evans (1993).)
The Vagina and the Vestibule

The vagina is a very long canal in the dog as against that in the cat, and lasts from the external uterine ostium to the external urethral ostium, located on the floor between the vagina and the vestibule. The most important structures of the mucosa are the cervical tubercle and the dorsal median fold. Along with the other smaller longitudinal mucosal folds, the urethral tubercle (in the dog only), and the shallow transversal ridge of the mucosa (the potential hymen) cranial to the external urethral orifice, these are the most relevant structures of the vagina in both species.

The last of the internal genital organs, the vestibule, has a very peculiar position—it is caudoventrally obliquely oriented, which makes the A.I. technique difficult, especially for the beginners. In length the vestibule of the cat is proportionately much longer than that of the dog, and seems to have the same length as the vagina. The external urethral orifice opens in a deep mucosal groove—there is no urethral tubercle. The vestibular bulb, involved in the mating process, is present only in the dog, surrounded by a rich venous plexus. In the cat only the venous plexus persists, richer and denser than in the dog. The minor vestibular glands are present in both species, whereas the major glands are present only in the cat.

The Vulva and the Clitoris

Together with the clitoris, the vulva is a part of the external genital organs. The vulvar labiae are thick in both species, and sometimes the major labiae can be differentiated from the minor labiae, especially in the dog. The dorsal commissure of the vulva is rounded in the dog and pointed in the cat, whereas the ventral commissure is pointed in the dog and rounded in the cat.

Very large in both species especially in the dog, the clitoris consists of two crura (2–3 cm in the dog), a body (4 cm in the dog), and the glans. The crura and the body lie on the floor of the vestibule, whereas the glans (less visible in the cat than in the dog) lies on the floor of the clitoral fossa. The cat clitoral glans includes a small cartilage that resembles the os penis of the male. In the resting position the clitoris of the dog lies in the clitoral fossa with the glans down as shown on page 428, Fig. 13–6 in McCarthy (2005, op. cit.). During copulation, the clitoris becomes erect and takes a considerable role in the process.

1.3.2 The Genital System in the Pig

1.3.2.1 Male Genitalia

The Testicle, Epididymis, Ductus Deferens, Spermatic Cord, and Tunics

In the pig the descent of the testicles occurs several days before birth (around the 110th day of gestation). The cryptorchidism is relatively frequent in this species.

The long and elliptical testicles are very large in the boar. They are located in a subanal position, close to the anus, with the tail ends oriented dorsocaudally. The location of the testicles pulls the spermatic cords far caudally. They are very long, and the inguinal canal is very much obliquely oriented, which causes frequent inguinal herniae. The species-specific design of the testicular artery is shown in Figures 1.11 and 1.12.

The epididymis is voluminous. Its tail is so much detached that it looks like an appendix to the testicle. The epididymal duct is long and tortuous. The proper ligament of the testicle and the ligament of the tail of the epididymis are strong.

The ductus deferens is as long as the spermatic cord. It is not provided with an ampulla. After exiting the vaginal canal it changes the direction in a sharp caudal angle, crosses the direction of the corresponding ureter and ventral to it in its way to the prostatic urethra, covered by the vesicular gland. In castrated males the entire abdominal route of the ductus deferent is exposed. The genital fold binds down the paired ureters, the ductus deferentes, and the cranial extents of
the vesicular glands. In the final leg of its journey, the ductus deferens passes through the prostate gland and opens on the corresponding side of the colliculus seminalis.

The spermatic cord is slightly different from the other species in that the mesofuniculus is in a vertical position and attached to the dorsal wall of the vaginal canal.

The testicular tunics are thicker than in the carnivores, especially the extraabdominal tunics, as follows: The scrotum is divided into two halves by a deep scrotal raphe. The scrotal ligament is strong to maintain the testicle suspended within the scrotum. The external spermatic fascia is thick.

**Accessory Genital Glands (see Figure 1.13)**

The ampulla of the ductus deferens is provided with glands.
The *vesicular gland* is enormous in the boar, and gradually regresses after castration. It is pyramidal in shape, with the base of the pyramid cranially oriented and dropped into the abdominal cavity over the neck of the urinary bladder. The symmetrical glands touch each other in the median plane, covering and hiding the small prostate gland. The surface of the vesicular...
gland is lobulated. The unique excretory canal of each gland opens on the ipsilateral side of the ductus deferens, lateral to the colliculus seminalis.

The prostate gland has a very small compact part, and a widely disseminated part. The former consists of two symmetrical lobes and is overlapped by the vesicular glands, whereas the latter completely surrounds the urethra.

The bulbourethral glands are very large and cover almost completely the pelvic urethra from the cranial extent of the pelvic floor to the bulbus penis. Completely surrounded by the bulboglandularis muscles, the glands touch each other by the medial borders. One excretory canal of each gland opens into the penile urethra ventral to the urethral recess (specific to the pig and ruminants only) (see Constantinescu and Schaller, 2007, pp. 210–211, op. cit.; Garrett, 1987, op. cit.).

The Penis and the Prepuce (see Figure 1.14)
A fibroelastic type, the penis of the pig is very long, with a wide and thick root (the bulbus penis is voluminous). Its body is provided with a sigmoid flexure, starting after the two crura form the corpus cavernosum penis. The corpus spongiosum penis and the bulbus spongiosus muscle are limited to the bulbus penis. The ischiocavernosus muscles are attached to the proximal curve of the sigmoid flexure. The retractor penis muscles extend cranial to the distal flexure of the sigmoid flexure. The glans penis is very reduced, and the apex of penis is cylindrical and spiraled first to the right, then dorsally, and finally to the left. This shape is due to the asymmetry of the corpora cavernosa before fusing with each other, and to the albuginea. A raphe penis joins the glans to the free part of the penis (see Figure 1.14).

The prepuce is divided into two uneven compartments by a circular fold of the internal lamina, which separates the preputial cavity into a very long caudal compartment (20–25 cm) and a very short cranial compartment. The latter is provided with a preputial diverticulum, a large dorsal bilobed sac, specific to the pig, with approximately 135 ml capacity. The two symmetrical halves of the diverticulum are separated by a median fold of the roof. The strong cranial preputial muscles cover the preputial diverticulum helping to empty it, and fuse with each other on the ventral aspect of the prepuce. The caudal preputial muscles are thin and extend from the superficial inguinal ring to the lateral borders of the prepuce. They do not reach the preputial orifice.

Figure 1.14 The pig’s penis within the prepuce: lateral view.
The Male Urethra

The *male urethra* in the pig (and in the ruminants) is unique in terms of the presence of a urethral recess. This structure is described in Section 1.3.3 (see Figure 1.22).

1.3.2.2 Female Genitalia

The Ovary, Salpinx, Uterus, Vagina, Vestibule, Vulva, and Clitoris (Figures 1.15 and 1.16)

In the sow the *ovaries* are berry shaped, each *follicle* or *corpus luteum* being exposed on the ovarian surface, separated from each other by deep grooves. The *ovarian hilus* is easily depicted on the mesovarian border. The uterus is as long in this species as the ovaries are hanging inside of the abdominal cavity mingled with the intestinal loops. The ovary is totally enveloped in the infundibulum of the salpinx. The *ovarian bursa* is very large and wide.

Suspended by a short mesosalpinx, the *uterine tube* opens on the inner side of the mesosalpinx facing the ovary. The *infundibulum* completely surrounds the ovary. The uterine ostium is surrounded by numerous little endometrial tubercles disposed in a double/triple rosette.

The *uterine horns* are extremely long and flexuous, intermingling with the jejunal loops. They open separately into the *body*, which is short. The *cervix* is proportionately long and is provided with endometrial cushion-like prominences called *pulvini*, which interdigitate with each other occluding the cervical canal.

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**Figure 1.15** The ovary of the sow.
There is no fornix in the sow. The vagina is almost as long as the cervix, and is provided with prominent longitudinal folds and a hymen in very young animals.

Shorter than the vagina, the vestibule is provided with a reduced suburethral diverticulum, minor vestibular glands, and a vestibular bulb.

The two labiae of the vulva are thick, and the ventral commissure is pointed. The clitoris is very long and flexuous, and the preputial cavity (fossa of the clitoris) is shallow.

1.3.3 The Genital System in the Ruminants (Constantinescu, 2001, 2004a)

1.3.3.1 Male Genitalia
For details of the male urethra, major muscles, blood supply, lymph drainage, and nerve supply to the male genital system, see Schatten and Constantinescu (2007, op. cit.).

The Testicle, Epididymis, Ductus Deferens, Spermatic Cord, and Tunics (See Figures 1.17–1.20)
In the ruminants, the testicles are ovoid shaped, and in a vertical position, with the head of the epididymis proximal, and the tail distal. The epididymal canal is as long as 40–60 m, and the ductus deferens is provided with an ampulla. With species-specific design of the testicular artery and the
Figure 1.17 The left testicle and epididymis of the bull: lateral aspect.

Figure 1.18 The left testicle and epididymis of the bull: medial aspect.

Figure 1.19 The left testicle and epididymis of the bull: the free border.
presence of the ligament of the tail of the epididymis in addition to the proper ligament of the testicle and the scrotal ligament, there are no notable differences from the general description of structures listed above. There is a short ejaculatory duct in ruminants. A reduced uterus masculinus can be seen in the bull. The spermatic cord and the tunics do not differ from the other species.

The Accessory Genital Glands (Figures 1.21 and 1.22)
The vesicular glands are elongated and large in the bull, rounded and much smaller in the buck and the ram. The surface of the glands is uneven and lobulated. The common excretory duct joins the ductus deferens in a short ejaculatory duct before opening into the urethra.
Only in the bull, the prostate has a reduced body on the dorsal aspect of the urethra. The body lacks in the small ruminants. The disseminated part is present in all ruminants, fully extended in the bull and the buck, and only on the dorsal wall of the urethra in the ram.

The bulbourethral glands, elliptical in the bull and spherical in the ram and buck, are located symmetrically on both sides of the urethral isthmus. They are covered by the bulboglandularis muscles. The excretory canal opens into the urethra via the urethral recess, common to the pig and all ruminants (see Figure 1.22).

**The Penis and the Prepuce (Figures 1.23–1.25)**

The penis in ruminants is fibroelastic, very long, but with a reduced diameter. The tunica albuginea is very thick. The body of the penis is provided with a sigmoid flexure, similar to that of...
the pig, but relative to its position it is located caudal to the testicles. The free part of the penis differs within these three species (see Figures 1.23–1.25). For details, see Schatten and Constantinescu (2007, op. cit.).

The prepuce is long and narrow, as the preputial orifice is (see Figure 1.25). Both cranial and caudal preputial muscles are present in ruminants.

Blocking the nerve supply to some of the most clinically important male (and female) genital organs, the easiest method is suggested and illustrated in Schatten and Constantinescu (2007, op. cit.), pp. 39–41, Figure 1.54.

1.3.3.2 Female Genitalia (Constantinescu et al., 1969, 1977; Constantinescu and Theodorescu, 1977)

The Ovary, Salpinx, Uterus, Vagina, Vestibule, Vulva, and Clitoris (Figures 1.26–1.31)

The ovary is relatively small in comparison to the size of the species. Ovoidal and flattened, the ovary looks like an almond. Most of the surface is uneven, as a result of numerous follicles and corpora lutea in various stages of development. These structures are as big as to be easily palpable by rectal palpation. The ovarian hilus is distinct and located on the mesovarian border.

In nulliparous and primiparous individuals, the ovaries can be palpated within the pelvic inlet. The more pregnancies the animal has had, the more cranially the ovaries are located. They drop within the abdominal cavity pulled by the increasingly larger pregnant uterus, and in the cow they are more and more difficult to be palpated by rectal exploration.
The salpinx or uterine tube is flexuous, mobile, and twice as long in the cow as in the small ruminants (20–28 versus 10–16 cm). The infundibulum surrounds and covers the ovary, outlining a wide ovarian bursa.

The uterus is a classical type of uterus bicornis. The uterine horns are three times longer in the cow (35–45 cm) versus 12–15 cm in the small ruminants. The tips of the horns are progressively increased in volume and take a spiral shape, similar to the ram’s horns. Before they approach to each other to continue as the uterine body, the two horns are attached by the intercornual ligament, double in the cow. This is a clinically important structure for establishing the age of...
Figure 1.25 The penis and the left testicle—left lateral aspect—of the buck.

Figure 1.26 The uterus, vagina, and vestibulum of the cow: dorsal view.
gestation, or any anomalies of the ovaries by rectal palpation, pulling the entire uterus from the abdominal cavity into the pelvic cavity to ease the investigation. The uterine horns are separated inside of the uterus by the uterine velum, similar to the carnivores and the sow; therefore, they open inside of the body independent from each other. The body of the uterus is short, and provided with a very large mesometrium. The round ligament of the uterus is small. The
Figure 1.28 The genital tract of the female goat: dorsal aspect.

Figure 1.29 Uterine caruncles in ruminants: cow.
endometrium is provided with elevations of the mucosa of different size and shape called **caruncles**, all pediculated. The shape of the caruncles differs slightly among ruminants, but the surface has a spongy aspect, with crypts in which the villi of the **cotyledons** of the placenta implant. Each caruncle and the corresponding cotyledon make a **placentome**. The **cervix** is as long as 10 cm in the cow, and 4 cm in small ruminants. It is rigid and easy to identify by rectal palpation in the cow. The cervical canal is irregular, with four circular folds that interdigitate with each other. The last fold protrudes within the vagina, and is provided with additional longitudinal folds, giving to the vaginal part of the cervix the aspect of an open flower.

The **vagina** in the cow is long (~30 cm) and wide, whereas in the small ruminants it measures only 10 cm. Folds of the mucosa as annular ridges are prominent. The **fornix** is deeper dorsally (see Figures 1.26–1.28). A small **hymen** may be observed in some cows.

The **vestibule** continues the vagina caudal to the external urethral ostium. It is caudoventrally oriented, hanging over the ischial arch. A **suburethral diverticulum** (present only in the sow and the ruminants) opens into the **external urethral orifice**. **Minor and major vestibular glands**, as well as two symmetrical **Gärtner’s ducts**, are observed on the floor of the vestibule. No major or minor vestibular glands are present in the goat, occasionally they are present in the ewe (see Figures 1.26–1.28).

The **vulva** is similar in all three species. The **clitoris** is located in a shallow fossa, is flexuous, provided with a very small **glans** or no glans, with the **prepuce** less evident.
1.3.4 The Genital System in the Horse

1.3.4.1 Male Genitalia
For details of the male urethra, major muscles, blood supply, lymph drainage, and nerve supply to the male genital system, see Schatten and Constantinescu (2007, op. cit.).

*The Testicle, Epididymis, Ductus Deferens, Spermatocord, and Tunics (Figures 1.32–1.35)*
Ovoidal shaped, the **testicle** of the horse is horizontally positioned, with the head cranially, and the tail caudally. The mediastinum testis is small and pushed to the periphery of the testicle. The **epididymis** covers the dorsal border of the testicle; the head of it does not exceed the head of the testicle, whereas the tail of the epididymis is very detached. The **epididymal canal (85 m)**

![Figure 1.32](image1.png) The left testicle of the stallion: lateral aspect.

![Figure 1.33](image2.png) The left testicle of the stallion: medial aspect.
is the longest in the domestic species. The testicular bursa, the proper ligament of the testicle, the ligament of the tail of the epididymis, and the scrotal ligament are all well defined.

Each ductus deferens is provided with an ampulla. The ampullae, the seminal vesicles, and the two ureters are all together connected by the genital fold, in the middle of which the uterus masculinus is visible.

The spermatic cord is short but voluminous, and in a vertical position.

The tunics and the cremaster muscle are strong, some tunics very thick, but similar to those of the other species.

The Accessory Genital Glands (see Figure 1.35)
The vesicular glands called in the horse also seminal vesicles because they look like small bladders join their excretory ducts with the ampullae of the ductus deferentes in the ejaculatory ducts.

The prostate shows only the compact part, with two lobes connected by an isthmus, and located on the dorsal side of the urethra.
The bulbourethral glands are ovoidal in shape, located on the dorsal aspect of the urethral isthmus, covered by the bulboglandularis muscles and each gland provided with several (6–8) excretory ducts.

**The Penis and the Prepuce (Figures 1.36 and 1.37)**
The musculocavernous type of the horse penis (see Figure 1.36) is provided with numerous cavernous spaces and less trabeculae. During the erection its length increases by 60% and is fully used in the long-lasting mating process. The root of the penis is well represented, and the crura are covered by strong ischiocavernosus muscles. The body of the penis is suspended to the pelvic symphysis by a ligament. The urethral groove is wide and protects the urethra surrounded by the corpus spongiosum penis. The glans penis contains the corpus spongiosum penis, is voluminous, and during the erection the corona glandis can reach 13–16 cm in diameter. The glans penis is,
in the horse, a very complex and unique structure, with its corona glandis, collum glandis, fossa glandis, the urethral sinus, and the septum glandis.

The prepuce is also unique in the horse, with the external and internal laminae, the preputial fold and ring, the corresponding cavities and orifices (see Figure 1.37).

1.3.4.2 Female Genitalia

The Ovary, Salpinx, Uterus, Vagina, Vestibule, Vulva, and Clitoris (Figure 1.38)

The ovary of the mare is a unique structure. The uniqueness comes from the fact that the cortex and the medulla of the other species are, in the mare, reversed. Thus, the cortex with the follicles is central, and the vascular medulla is peripheral. Consequently, there is one ovarian fossa located on the free border of each ovary, close to the abdominal ostium of the uterine tube (salpinx). The opposite border of the ovary is connected to the mesovarium. The ovaries are located caudal to the kidney and are palpable by rectum.

Figure 1.36 The penis of the horse.

Figure 1.37 Median section through the free part of the penis and of the prepuce in the horse.
The salpinx (see Figure 1.38) is very flexuous, with abundant fimbriae surrounding the infundibulum, with the abdominal ostium in the center of it. In the mare only, the uterine tube opens into the uterine horn in the center of a small papilla provided with a sphincter.

The uterus (see Figure 1.39) has a relatively short, but large body. Not being divided as in the other species by the uterine velum, the cranial end of the body is called uterine fundus. The two uterine horns are slightly curved ventrally. Centered by a straight cervical canal, the cervix opens into the vagina by a very prominent and plicated portion. This vaginal portion of the cervix is anchored to the walls of the vagina by vertical folds called frenula (singular frenulum). During diestrus, estrus, and pregnancy, the vaginal part of the cervix and its relationships with the vagina are different from each other as they are shown in Figures 1.40–1.45. The broad ligaments are strong, and as long as from near the tip of the uterine horns to the deep inguinal rings; each ligament is provided with a short round ligament.

The vagina is long and wide, to accommodate the impressive size of the penis. Just in front of the large external urethral orifice, on the floor of the vagina a sort of transversal fold of the mucosa can be seen, similar to the hymen.

The vestibule and the vulva hung over the ischial arch. Only the minor vestibular glands are present. The vestibular bulb is very developed, playing an essential role in copulation.

The vulva and the clitoris are strongly connected (see Figure 1.39). The vulva has two pigmented labiae, whose ventral commissure is rounded ventrally and pointed dorsally. The 7–9 cm long clitoris exposes a very voluminous glans located within the clitoral fossa. The frenulum of the clitoris, the recesses, and the sinuses are shown in Figures 1.46 and 1.47 and
are of an extremely high importance in the mare theriogenology (Youngquist and Threffall, 2007).

1.4 Genital Organs in Laboratory Mammals

(See text and figures in Constantinescu (2011).)

The genital organs in laboratory animals will be described species by species, both male and female. At the end, the mammary glands of all of the three mammalian species (rabbit, mouse, and rat) will be described in separate sections.
Figure 1.40 The vaginal part of the cervix in the mare during diestrus, estrus, and pregnancy (also see Figure 1.41–1.45). Diestrus: the cervix—caudal view.

Figure 1.41 Diestrus: the vaginal portion of the cervix—median section.

Figure 1.42 Estrus: the cervix—caudal view.
Figure 1.43 Estrus: the vaginal portion of the cervix—median section.

Figure 1.44 Pregnancy: the cervix—caudal view.

Figure 1.45 Pregnancy: the vaginal portion of the cervix: median section.
1.4.1 The Genital System in the Rabbit (Barone et al., 1973; Barone, 1978; Constantinescu, 2004b)

1.4.1.1 Male Genitalia (Figures 1.48–1.51)

**The Testicle, Epididymis, Ductus Deferens, Spermatic Cord, and Tunics**

The testicle (see Figures 1.48 and 1.49) is small, oval shaped and elongated, 3–3.5 cm long and 1–1.5 cm wide, located almost in a horizontal position in the scrotum, with the head cranially oriented and abundantly covered by the head of the epididymis. The location of the scrotum is ventral to the prepuce and the anus. Remember in the tomcat the scrotum is located between the prepuce (ventrally) and the anus (dorsally).

The epididymis has a voluminous head that covers almost completely the head of the testicle, a slender body, and a round, long, and mobile tail. The proper ligament of the testicle and the ligament of the tail of the epididymis are present as common to all species except the carnivores.
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(remember the latter are not provided with the ligament of the tail of the epididymis). In addition, there is a scrotal ligament in the rabbit. The ductus deferens is flexuous, runs within the spermatic cord very similar to the other species, and ends with an ampulla. The ampulla insinuates under the seminal vesicle and the vesicular gland and joins the ducts of the latter before opening together in the corresponding colliculus seminalis. Though very short, the joined ducts can be considered as the ejaculatory ducts.

The spermatic cord is long and voluminous. The internal spermatic fascia is completely surrounded by a strong and thick cremaster muscle, which is able to retract the testicle within the peritoneal cavity completely. This happens during the fights among males to dominate the females in heat. The fights of the males target the testicles of the opponent, trying to castrate, therefore eliminate him from the competition. The retraction of the testicles within the peritoneal cavity is possible because the spermatic cord is horizontally positioned, and the deep inguinal ring is very large, particularities of the rabbit.

The testicular tunics are similar to the other species.

Accessory Genital Glands (Figures 1.50 and 1.51)
The accessory genital glands in the male rabbit are different from any other species, yet controversial by different anatomists. We can distinguish an impair seminal vesicle, an impair vesicular gland, an impair (dorsal) prostate, a pair of paraprostatic glands ventral to the latter, and a pair of bulbourethral glands.

The seminal vesicle, impair and bilobed, called by Popesko et al. (2002, op. cit.) as the vesicular part of the vesicular gland, located at the level of the neck of the urinary bladder covers the ampullae of the ductus deferentes and the ureters. The vesicular gland, called by Popesko et al. (2002, op. cit.) as the compact part of the vesicular gland, partially covers the seminal vesicle and the ampullae of the ductus deferentes. According to Barone et al. (1973, op. cit.), the prostate consists of three glands: the cranial prostate, which is the vesicular gland, the prostate (the dorsal or caudal prostate), and a paired paraprostatic glands (the ventral prostate) located ventral to the previous gland. The true (caudal or dorsal) prostate, called also by Popesko et al. (2002) as impair, is located caudal to the vesicular gland. The paraprostatic glands are very small, rounded, and located ventral to the dorsal prostate. The bulbourethral glands located at the
isthmus of the urethra and separated from the prostate are connected by a bridge that gives the glands the appearance of a voluminous bilobed mass.

**The Penis and the Prepuce (See Figure 1.50)**

The *penis* is as long as 8 cm and oriented caudally, similar to that of the tomcat. The free part is not provided with spicules, like that of the tomcat, but there is a longitudinal raphe visible. The glans penis is small. The ischiocavernosus muscles are strong. There is no retractor penis muscle, but a symmetrical subischiocavernosus muscle instead, a characteristic of this species.

**Figure 1.50** Male genital apparatus in the rabbit: left lateral view. (Redrawn and modified from Barone *et al.* (1973).)

**Figure 1.51** Accessory genital glands in the male rabbit: dorsal aspect. (Adapted from Barone *et al.* (1973), and redrawn from Constantinescu (2004b).)
The prepuce consists of the internal lamina—without preputial glands—and the external lamina provided with long hairs. Between the prepuce and the anus a symmetrical perineal sinus is present. Two pairs of major and minor perineal glands located caudal to the ischiocavernosus muscles open into the perineal sinuses.

1.4.1.2 Female Genitalia (Figures 1.52 and 1.53)

The Ovary, Salpinx, Uterus, Vagina, Vestibule, Vulva, and Clitoris

The ovary is long, thin, and flat, with an uneven surface due to the follicles. The cranial pole is surrounded by an adipose body. Topographically, they are far caudal from the kidneys, at the level of the fifth lumbar vertebra. The proper ligaments of the ovaries are very long, thus the ovaries are not as close to the tips of the uterine horns as in the other species. The ovarian bursa is deep and wide.

The uterine tube is relatively long, with the ampulla three times wider than the isthmus. The infundibulum is provided with a multitude of small fimbriae. The uterine ostium of the salpinx is surrounded by small caruncles of the uterine mucosa, which are disposed in four divergent directions (Barone et al., 1973, op. cit.; Barone, 1978, op. cit.)

The uterus is a duplex type of uterus. This means that the two horns come close to each other at the caudal end, but they do not open into a uterine body. Instead, they open separately into the vagina by two distinct side by side cervicis (sing. cervix), similar to the rat. There is no body of uterus in the rabbit (and the rat). The uterine horns are flexuous and attached to long broad ligaments. The round ligament of the uterus is as long as it penetrates within the inguinal canal accompanied by the vaginal process, similar to the female dog. The cervix protrudes into the

Figure 1.52 Genital apparatus in the female rabbit: ventral aspect. (Redrawn and modified from Barone et al. (1973), and redrawn from Constantinescu (2004b).)
The vagina with its **vaginal portion**, provided with involute folds of the mucosa resembling a flower in full bloom. There is a **uterine velum** between the vaginal portions of the cervices.

The **vagina** is very long, filling almost the entire pelvic canal. The **vaginal fornix** is very deep, and surrounds both vaginal portions of the two cervices. The **hymen** is rudimentary.

The **vestibule** is topographically located caudal to the ischial arch, on the ventral aspect of the rectum. The **external urethral ostium** is very wide. **Major vestibular glands** are present on the floor, lateral to the projection of the body of clitoris. The **vestibular bulb** and the **constrictor muscle of the vestibule and vagina** are well represented.

The **vulva** is provided with **major and minor symmetrical labiae**. The **clitoris** is strong, and long up to 4 cm. It shows a small **glans** and is located in a deep **clitoral fossa**, protected by the **clitoral prepuce**. As in the male, the **subischiocavernosus muscle** is also present in the female rabbit. Within the clitoral fossa, very well-developed **preputial glands** can be observed. **Major and minor perineal glands** are lining the symmetrical **perineal sinus**.

### 1.4.2 The Genital System in the Mouse (Constantinescu, 2006)

#### 1.4.2.1 Male Genitalia

**The Testicle, Epididymis, Ductus Deferens, Spermatic Cord, and Tunics (Figures 1.54 and 1.55)**

The **testicle** is round, and covered on both head and tail by the epididymis. It is located similar to the rabbit, between the anus and the prepuce, with the long axis parallel to the rectum. The **proper ligament of the testis** is well represented.
The epididymis is enormous, especially its head. With the head, body, and tail, the entire epididymis covers intimately the testicle. The ligament of the tail of the epididymis is short and covered by the tail of the epididymis.

The ductus deferens is very long, and together with the rest of the spermatic cord and the endoabdominal testicular tunics are enclosed in an abundant amount of fat. The ampullae of the ductus deferentes are very well developed, connected by the genital fold, and provided with an unpaired ampullary gland. The extraabdominal testicular tunics are not different from those of the rabbit or the domestic mammals. The scrotal ligament is present. The cremaster muscle is not as well developed as in the rabbit, but still strong.

The spermatic cord and the tunics do not show anything in particular.

Accessory Genital Glands (Figure 1.56)
The accessory genital glands of the mouse and the rat have particularities that put them in a different category.

The ampullary gland is small, elongated, and located between the ducts of the vesicular glands and fully shown on the dorsal aspect. Its caudal extent is covered by the dorsal prostate gland. The entire surface is slightly lobulated.
The vesicular glands are enormous, mostly located within the peritoneal cavity, in a shape resembling the ram’s horns. With the surface lobulated and very well supplied by blood, they parallel the curvature of the ampullae of the ductus deferentes in their way to the prostatic urethra, running on both sides of the ampullary gland. The ducts enter under the dorsal prostate before reaching the urethra.

The coagulating glands common to the mouse and the rat are much smaller than the vesicular glands, still with an uneven surface, and are located and protected in the lesser curvature of the vesicular glands.

The prostate consists of two separate glands: a dorsal, and a ventral prostate. The dorsal prostate is the largest, resembling a butterfly, having two symmetrical lobes connected by an isthmus, and with an uneven surface. The ventral prostate is much smaller, consisting of two lobes and is provided with an even surface.

The bulbourethral glands are big, rounded, and with a lobulated surface. They are covered by the respective bulboglandularis muscles, and their ducts are running in front of the ducts of two symmetrical bulbourethral diverticula. The latter are specific to the mouse, have a smooth surface, and have the role of temporary deposit of the glands’ secretion. However, their ducts do not communicate with each other and open separately into the urethral recess, specific to the mouse, rat, pig, and ruminants. The cast of the pelvic urethra clearly shows separate ducts of the bulbourethral diverticula and of the bulbourethral glands. The urethral isthmus is shown in the

Figure 1.56 Accessory gental glands in the male mouse: dorsal aspect. (Redrawn and adapted from Constantinescu (2011) with permission from the American Association for Laboratory Animal Science (AALAS).)
cast between the ducts of the bulbourethral diverticula and the urethral recess, where inside of the urethra a fibrocartilaginous plate can be seen.

The Penis and the Prepuce (Figure 1.57)
The penis of the mouse is ventrally oriented, and slightly bent horizontally. Thus, it is caudally oriented at the level of the glans penis/os penis, in continuation to the strong corpus cavernosum penis. A median section through the penis shows, in addition, the conical-shaped cartilage, which covers the distal end of the os penis; the urethra, which is positioned dorsally in the resting sexual activity, and the external urethral ostium; the corpus spongiosum penis, and the corpus spongiosum glandis. Note that the glans penis is provided with small spines. The cartilage on the tip of the os penis will ossify and fuse with the os penis. The prepuce with the ostium and the fornice are also shown in this median section.

1.4.2.2 Female Genitalia

The Ovary, Salpinx, Uterus, Vagina, Vestibule, Vulva, and Clitoris (Figures 1.58 and 1.59)
The ovary is small, elliptically shaped, smooth, and located in the proximity of the corresponding kidney, anchored by a long suspensory ligament and a fairly long mesovarium.

The salpinx is very flexuous and short, and the ampulla and the infundibulum surround the ovary from the caudal to the cranial pole. It is suspended by a short mesosalpinx.
Figure 1.58 Genital apparatus in the female mouse: ventral aspect.

Figure 1.59 Genital apparatus in the female mouse in situ: left lateral aspect. (Redrawn and adapted from Constantinescu (2011) with permission from the American Association for Laboratory Animal Science (AALAS).)
The uterus has two long horns bent ventrally, flexuous, and suspended by a long mesometrium embedded in a large amount of fat. The round ligament of the uterus accompanied by the mesometrium penetrates the vaginal ring and passes through the inguinal canal, accompanied by the external pudendal artery and vein. The body of uterus is short, and the mouse is provided by one cervical canal and uterine ostium. The vaginal part of the cervix protrudes significantly into the vagina and has longitudinal striations.

The vagina is long, uniform as lumen, with longitudinal folds and very deep fornices around the vaginal part of the cervix. There is a hymen at the end of the vagina, at the transition to the vestibule, but no external urethral ostium is present in the vagina. Instead, the urethra is as long as paralleling the vagina, vestibule, and vulva, and opening by the external urethral orifice immediately ventral to the vulva.

The vestibule is very short and provides support for the vulva.

The clitoris is not associated with the vestibulum or the vulva, but with the external urethral ostium. The urethra passes through the corpus cavernosum clitoridis before opening through the external urethral ostium. We can say that the vulva consists of the vaginal orifice, and the external urethral orifice, to which the clitoris is associated (the latter is located at the base of the clitoris). There is a pair of preputial glands symmetrically located ventral to the external urethral ostium.

1.4.3 The Genital System in the Rat (Constantinescu, 2007)

(See text and figures in Constantinescu (2011).)

1.4.3.1 Male Genitalia

The Testicle, Epididymis, Ductus Deferens, Spermatic Cord, and Tunics (Figures 1.60 and 1.61)

The testicle is similar to that of the mouse, the only noticeable difference being that the tail of the epididymis is very long, detached from the caudal pole of the testicle, and separated from the latter by a big amount of fat. The scrotum extends caudally between the anus and the prepuce, so that it is very apparent and rounded.

The epididymis doesn’t surround the testicle as that of the mouse. The ligament of the tail of the epididymis is very long.

The ductus deferens is proportionally longer than that of the mouse, and together with the intraabdominal testicular tunics is surrounded by a less abundant amount of fat. The ampullae are less developed as in the mouse.

The spermatic cord and the tunics are similar to those of the mouse.

Figure 1.60 Testicle of the rat: left, lateral aspect. (Redrawn and adapted from Constantinescu (2011) with permission from the American Association for Laboratory Animal Science (AALAS).)
Accessory Genital Glands (Figures 1.62 and 1.63)
The ampullary gland located on the dorsal aspect is flat, rectangular, with irregular borders, and covers the last segments of ductus deferentes and vesicular glands.

The vesicular glands are very large, but not as big as those of the mouse. Their curvature may be inward oriented. They are also lobulated and well supplied by blood. The genital fold is present.

The coagulating glands are located in the same place, and larger than in the mouse. Their surface is between smooth and slightly lobulated.

The dorsal prostate consists of two symmetrical spheroidal-shaped, smooth lobes, which originate from the ventral aspect, just caudal to the ventral prostate (see Figure 1.62). The ventral prostate consists of two symmetrical elongated, slightly lobulated sacs that drop within the peritoneal cavity, just caudal to the urinary bladder (see Figure 1.63). They can be seen also on the dorsal aspect (see Figure 1.62). The genital fold interconnect the two ventral lobes, leaving a triangular space in between.

The bulbourethral glands are spheroidal shaped, smooth, and covered by the bulboglandularis muscles (see Figure 1.62). There are no bulbourethral diverticula, as in the mouse. The urethral recess is present (Figure 1.64).

The Penis and the Prepuce (Figure 1.65)
The penis of the rat has many similarities with the penis of the mouse. It is bent at 90° angle, with the proximal (longer part) vertical, and the distal (shorter part) horizontal. The latter contains the os penis. A median section through the penis shows the cartilage fused with the distal end of the os penis, the corpus cavernosum penis, corpus spongiosum penis, corpus spongiosum glandis, the urethra with the external urethral ostium, and the glans penis with the spines. The cartilage on the distal end of the os penis will ossify later. The prepuce exposes the external and internal laminae, the fornix, and the preputial ostium. The preputial glands are present, as in the mouse.

1.4.3.2 Female Genitalia

The Ovary, Salpinx, Uterus, Vagina, Vestibule, Vulva, and Clitoris (Figures 1.66 and 1.67)
The ovaries are small and similar to those of the mouse.

The salpinx is also similar to that of the mouse.
Figure 1.62 Accessory genital glands in the male rat: dorsal aspect. Figure 1.63 Accessory genital glands in the male rat: ventral aspect.
The *uterus duplex* of the rat (similar to that of the rabbit) has in general a reduced volume. The *uterine horns* are not flexuous like in the mouse; they connect to each other to continue with their own *cervix*; therefore, apparently *there is no uterine body* in the rat. However, the body of uterus is listed on Fig. 1.66 and 1.67. The two cervices open separate from each other into the *vagina*—the *vaginal parts* of the *two cervixes* have two *external uterine ostia*. The *broad ligament* and the *round ligament of the uterus* are similar to those of the mouse.

The *vagina* is similar to that of the mouse, except that there are two external uterine openings surrounded by a deep *vaginal fornix*.

The *vestibule*, the *vulva*, the *clitoris*, the *urethra* and external urethral orifice, and the *preputial glands* are similar to those of the mouse.

### 1.4.4 The Mammary Glands in Laboratory Animals (Figures 1.68–1.70)

There are four or five pairs of mammary glands in the female *rabbit* (*one axillary* and *one thoracique*, or *two thoracique*—cranial and caudal, *one or two abdominal*—cranial and caudal, and *one inguinal*). The papillae are visible and their tips are provided with 8–10 papillary openings versus 5–7 in the cat, 8–14 in the dog, 2–3 in the sow, 1 in all ruminants, and 2 in the mare. The openings correspond to the number of glandular complexes.

There are five pairs of mammary glands in the mouse (*axillary, cranial and caudal thoracic, abdominal*, and *inguinal*) and six pairs in the rat (*one more abdominal pair*).

In the *mouse* the axillary glands are separated from the thoracic glands (both cranial and caudal) on the lateral and ventral aspects of the body, whereas on the dorsal aspect all these symmetrical glands are fused by a median bridge. The abdominal and inguinal glands extend to the dorsum. The inguinal glands extend laterally from the perineal area and completely encircle the external genitalia ventrally, but they do not extend dorsally.

In the *rat* none of the mammary glands reaches the dorsum. The axillary and the thoracic glands are fused ventrally ipsilaterally, whereas the axillary and the cranial thoracic glands are shown as a unique structure on the lateral side. The caudal thoracic and the cranial abdominal glands are connected laterally by a narrow glandular bridge. The symmetrical inguinal mammary glands surround, but do not reach, the external genitalia.
1.4.5 The Genital System in the *Xenopus laevis*: African Clawed Frog (Constantinescu, 2005a)

1.4.5.1 Male Genitalia (Figure 1.71)

The male reproductive organs of this frog consist of two intraabdominal testicles with the pair mesorchium and efferent vessels, attached to the kidneys, in the cranial proximity to the adrenal glands (see Figure 1.71). The semen passes into the kidneys through these fine efferent ducts. From here, the semen passes with the urine through the urogenital ducts into the cloaca. There

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**Figure 1.65** Rat. Penis (median section), stained by hematoxylin eosin. (Redrawn and adapted from Constantinescu (2011) with permission from the American Association for Laboratory Animal Science (AALAS).)
Figure 1.66 Genital apparatus in the female rat: ventral aspect. (Redrawn and adapted from Constantinescu (2007 and 2011) with permission from the American Association for Laboratory Animal Science (AALAS).)

Figure 1.67 Genital apparatus in the female rat: left lateral aspect. (Redrawn and adapted from Constantinescu (2011) with permission from the American Association for Laboratory Animal Science (AALAS).)
Figure 1.68 Rabbit. Mammary glands: ventral aspect. (Redrawn and modified from Barone (1978).)

Figure 1.69 Mouse. Mammary glands in lateral (a), ventral (b), and dorsal (c) aspects. (Redrawn and adapted from Constantinescu (2006 and 2011) with permission from the American Association for Laboratory Animal Science (AALAS).)
Figure 1.70  Rat. Mammary glands in left lateral (a) and ventra (b) aspects. (Redrawn and adapted from Constantinescu (2007 and 2011) with permission from the American Association for Laboratory Animal Science (AALAS).)

Figure 1.71  Male genital apparatus in the Xenopus laevis in situ: ventral aspect. (Redrawn and adapted from Constantinescu (2005a) with permission from the American Association for Laboratory Animal Science (AALAS).)
is no penis in the *Xenopus laevis*. Instead, during the mating process (embracement/amplexus), which may last several days, the grip of the male stimulates the releasing of eggs wrapped in a jelly substance looking like a spawn. The sperm fertilizes the eggs outside the body.

1.4.5.2 Female Genitalia

The female reproductive organs consist of two ovaries, two oviducts, and two ovisacs. The ovisacs open into the cloaca, common to the urinary system (see Figure 1.72).

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**Figure 1.72** Female genital apparatus in the *Xenopus laevis in situ*: ventral aspect. (Redrawn and adapted from Constantinescu (2005a) with permission from the American Association for Laboratory Animal Science (AALAS).)

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**Figure 1.73** Male genital apparatus in the Zebrafish *in situ*: left lateral aspect. (Redrawn and adapted from Constantinescu (2005b) with permission from the American Association for Laboratory Animal Science (AALAS).)
1.4.6 The Genital System in the Brachidanio rerio (Zebrafish) (Constantinescu, 2005b)

1.4.6.1 Male Genitalia
The male reproductive organs in zebrafish consist of two intraabdominal testicles located in close proximity to the swim bladder, the intestine, and the kidneys (see Figures 1.73 and 1.74). The sperm is ejected through the cloaca.

1.4.6.2 Female Genitalia
The female reproductive organs consist of two large ovaries. The eggs are expelled through the urogenital/anal pore (see Figure 1.75).

References
ICVGAN (International Committee on Veterinary Gross Anatomical Nomenclature) (2012) *Nomina Anatomica Veterinaria*, 5th edn (revised version), published on the website of the World Association of Veterinary Anatomists (http://www.wava=amav.org), the Editorial Committee, Hannover (Germany), Columbia, MO (USA), Ghent (Belgium), Sapporo (Japan).