Male Reproductive System

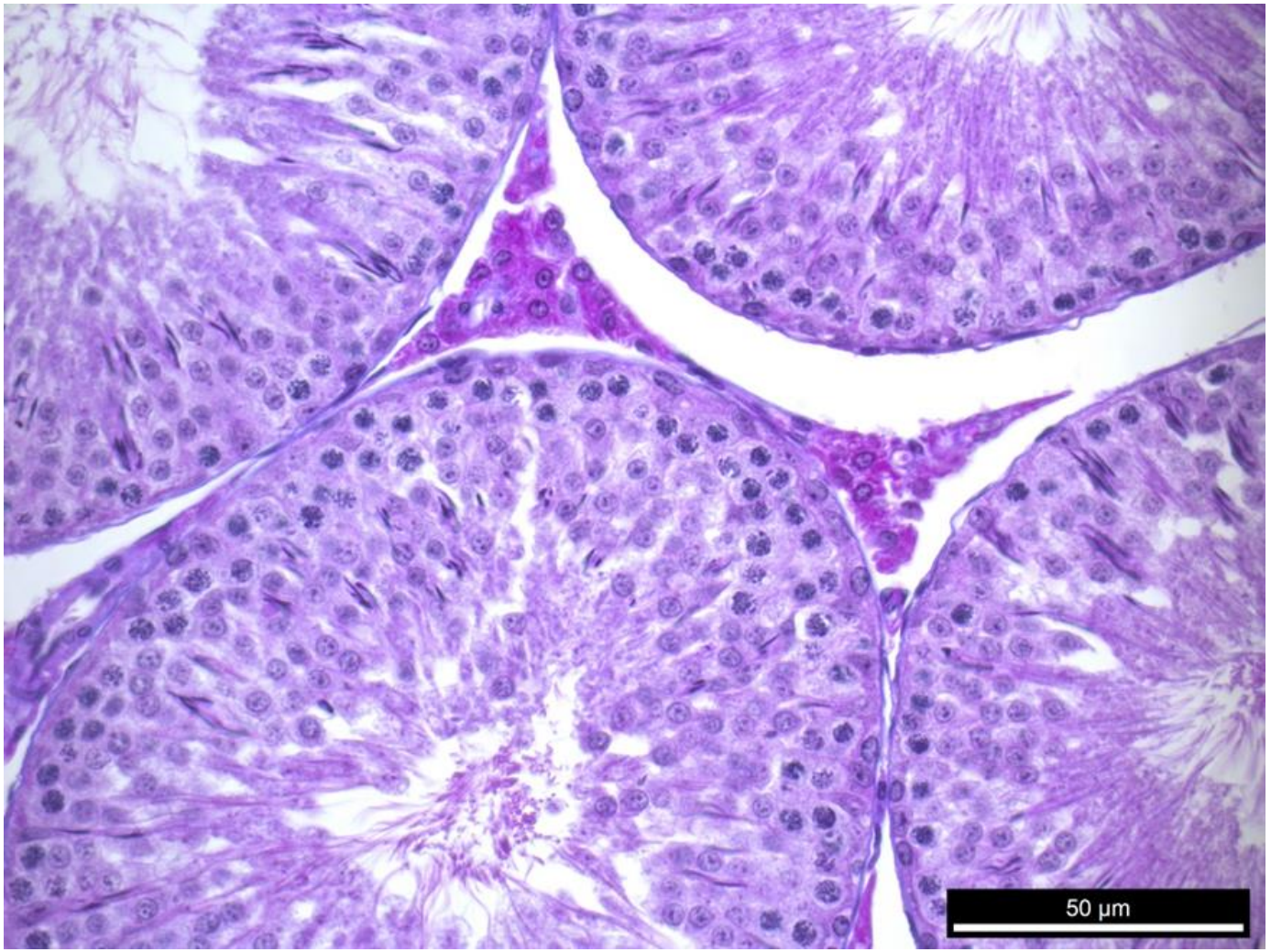
The male reproductive system consists of the testes, genital excurrent ducts, accessory glands, and penis.

The aim of this lesson to learn the histological structure and the histophysiology of male reproductive organs.

- The two primary functions of the testes are the production of sperm and the synthesis of androgens.
- Androgens, mainly testosterone, are essential for spermatogenesis.
- The male of each domestic mammal possesses a pair of testes that lie in a pouch of skin known as the scrotum.
- As the testes develop they evaginate from the abdominal cavity along its posterior wall, and in doing so, descend into the scrotum.
- Within the scrotum, the temperature of the testes is 2 to 3 °C below body temperature.
- This lower temperature is essential for spermatogenesis, but it is not required for hormone production, which can occur at normal body temperature.

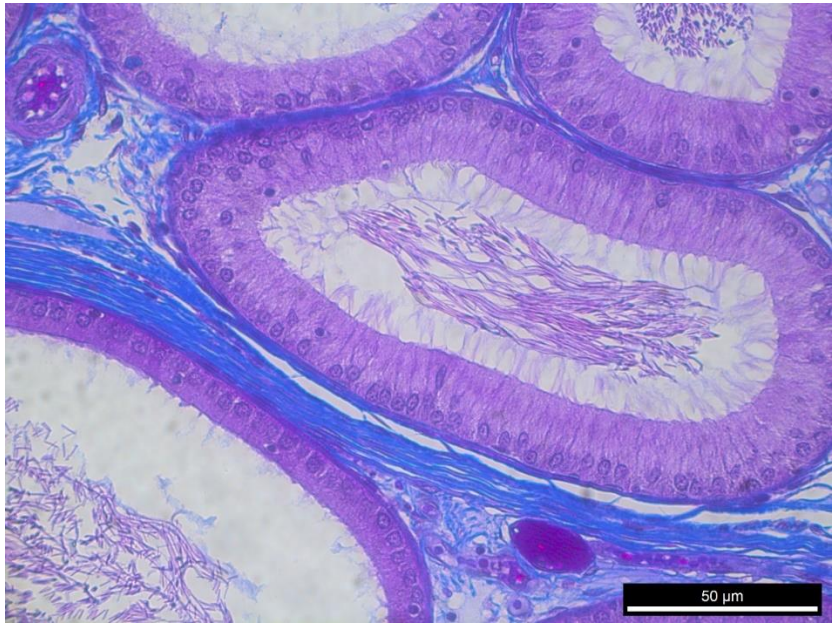
- Each testis is covered by a capsule of thick connective tissue called the **tunica albuginea (TA)**.
- The tunica albuginea houses a vascular bed that feeds and drains the testis.
- It is covered by peritoneum, the visceral layer of the tunica vaginalis.
- Each testis is divided into approximately 250 lobules by incomplete connective tissue septa that project from the capsule.
- These septa are thin in ruminants and thicker in the carnivore, stallion, and boar.
- Along the posterior surface of the testis, the tunica albuginea thickens and projects inward as the mediastinum testis.
- The mediastinum testis, which is actually a thickened portion of the tunica albuginea, contains the rete testis as well as larger lymphatic and vascular vessels.

The lobules of the testis vary in number according to species. Each lobule of the testis consists of 1 to 4 seminiferous tubules in which sperm are produced and a connective tissue stroma in which Leydig, or interstitial cells are contained.

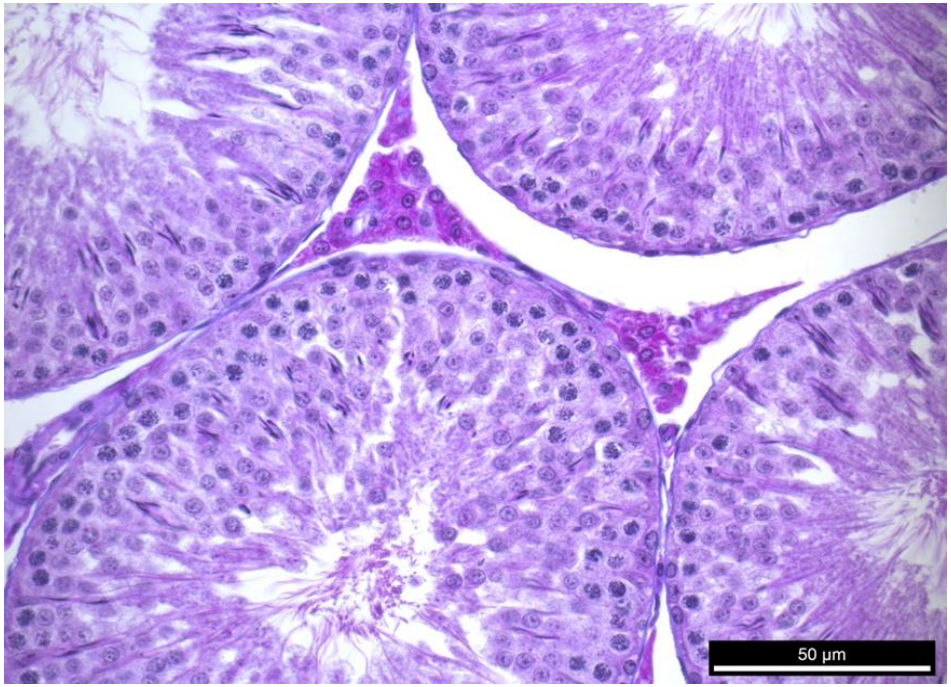


Seminiferous tubules are the site of spermatozoa production (spermatogenesis).
The ends of each tubule are connected to short, straight ducts called the **tubule recti** that guide the developing spermatozoa to the **rete testis**.
The rete testis is a labyrinth of anastomosing channels that collects spermatozoa from all of the seminiferous tubules and their respective tubule recti.
This rete, in turn, empties by way of short ducts (the **ductuli efferentes**) into a highly convoluted collecting channel, the **ductus epididymidis**.

- Together, the ductuli efferentes and the ductus epididymidis constitute the **epididymis**, which stores spermatozoa while they are fully mature.

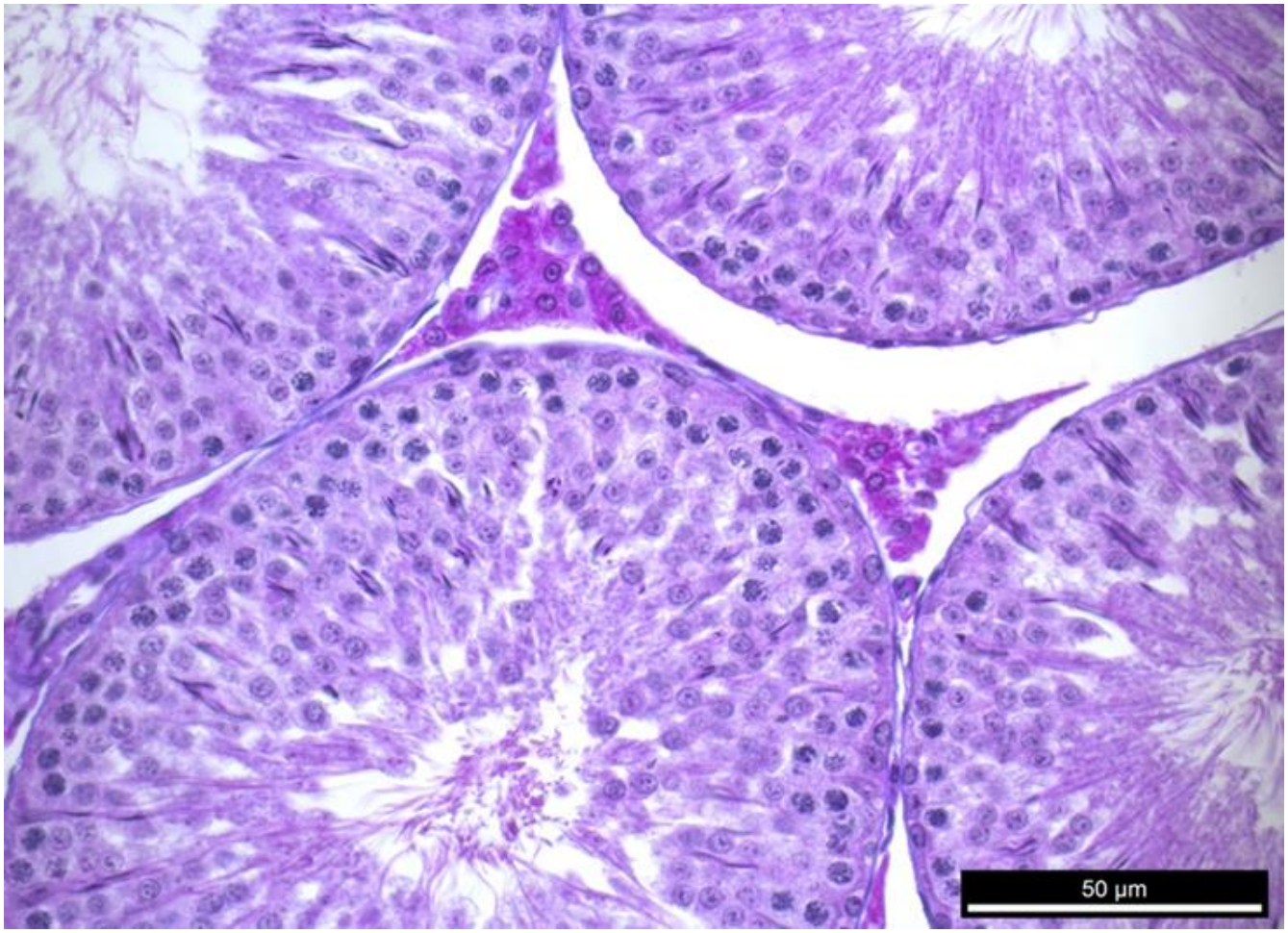


SEMINIFEROUS TUBULES

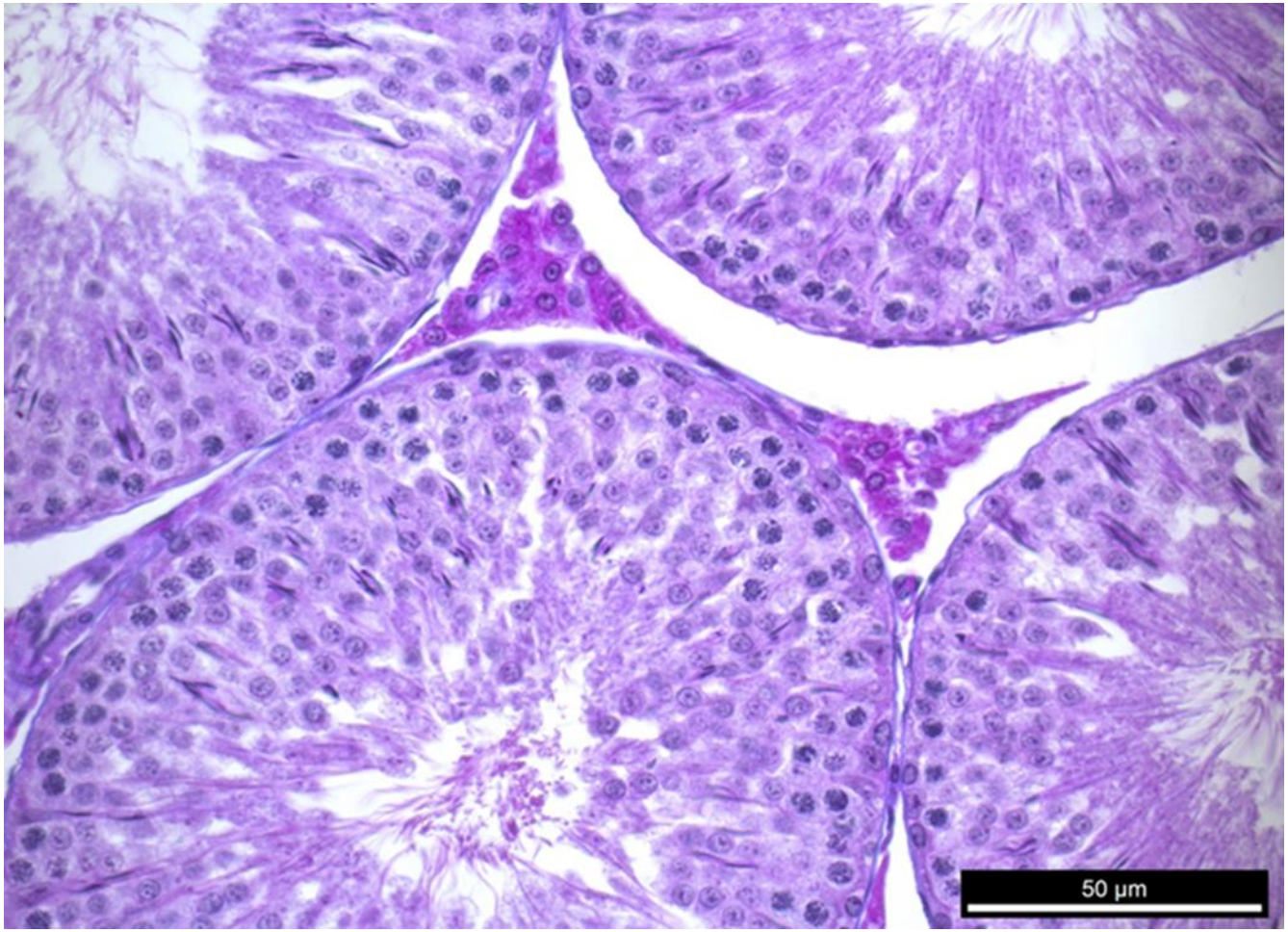


1. Spermatozoa
2. Spermatids
3. Spermatogonia
4. Sertoli cells

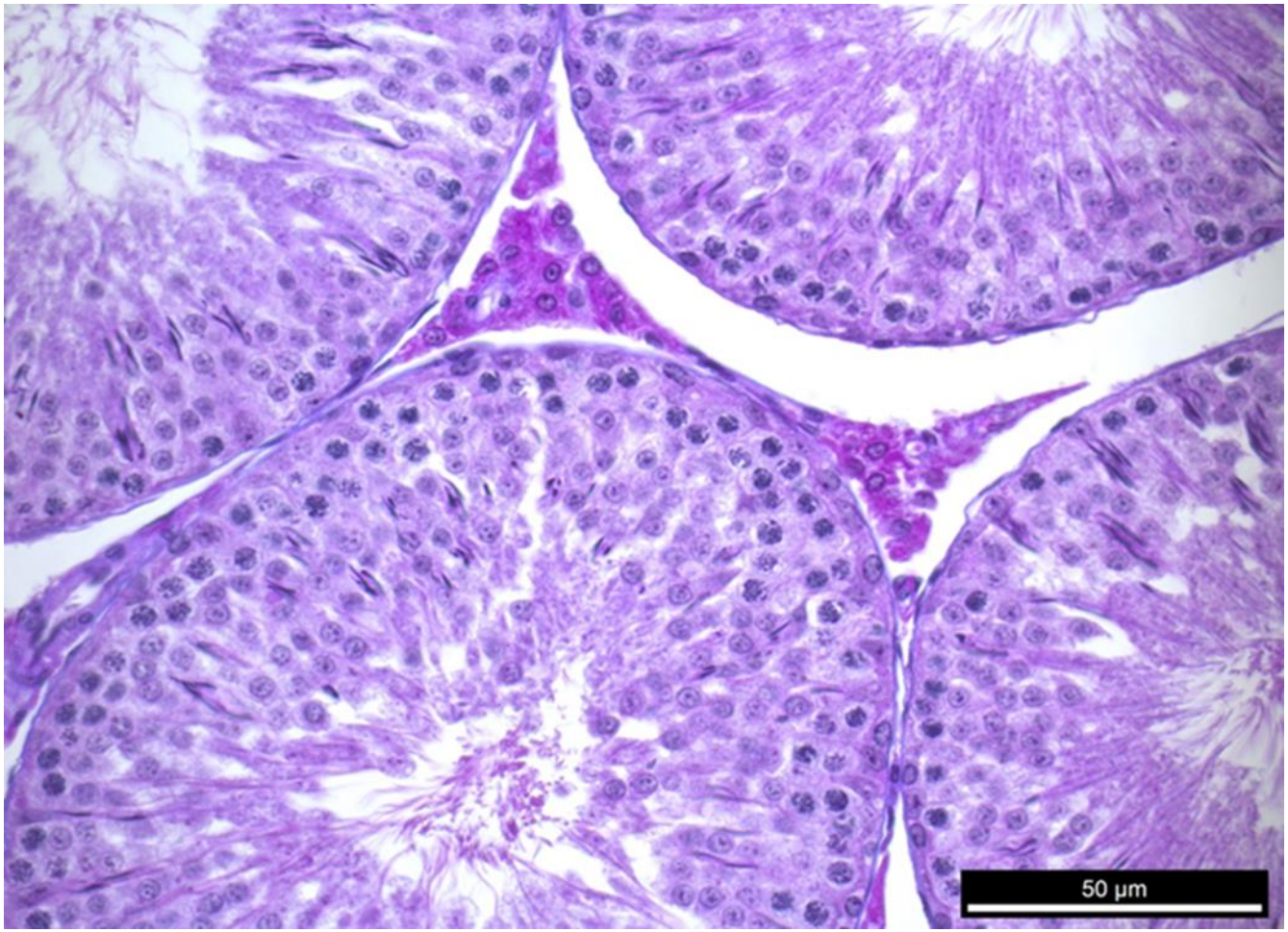
Each seminiferous tubule is lined by the seminiferous epithelium, a germinal stratified epithelium that is the site of spermatogenesis



- The seminiferous epithelium is composed of two cell types: Sertoli cells and the spermatogenic cells (Spermatogonia, spermatids, spermatozoa)



- The Sertoli cell is a support cell that extends from the basal lamina to the tubular lumen and occupies much of the volume of the seminiferous epithelium. These cells do not replicate after puberty.


50 µm

- Lateral and apical invaginations of Sertoli cell membranes embrace the differentiating spermatogenic cells. The lateral sides of adjacent Sertoli cells form numerous infoldings as well as tight junctions.
- Because of the presence of the tight junctions, the contents of the blood vessels beneath the basal lamina of the seminiferous epithelium cannot communicate with contents of the lumen of the seminiferous tubule without passing through the Sertoli cells.
- As a result, a blood-testis barrier is formed by Sertoli cells.

- Most importantly, the blood-testis barrier isolates the genetically different and therefore antigenic haploid germ cells (secondary spermatocytes, spermatids, and sperm) from the immune system of the adult male.
- Therefore, the blood-testis barrier serves an essential role in isolating the spermatogenic cells from the immune system.
- They are distinguished by a pale oval or triangular nucleus that has a prominent nucleolus.
- Sertoli cells are fewer in number than the spermatogenic cells.

- Sertoli cells ;

- form the blood-testis barrier.
- support, protection, and nutrition of developing sperm cells
- phagocytosis of excess cytoplasm of sperm
- release of spermatozoa into tubules.
- secrete inhibin which slows sperm production.
- secrete of androgen binding protein under control of FSH from the adenohypophysis.

Spermatogenic Cell

- The chief cell of the seminiferous epithelium is the spermatogenic cell.
- Spermatogenic cells, which regularly replicate and differentiate into mature sperm. The most immature spermatogenic cells, called spermatogonia, rest on the basal lamina.
- The most mature cells, called spermatids, are attached to the apical portion of the Sertoli cell, where they border the lumen of the tubule.
- Spermatogonium lies next to the basal lamina of the seminiferous epithelium between adjacent Sertoli cells. The blood-testis barrier lies adluminally to these cells, as tight junctions are formed above their apical boundary.

- The presence of these tight junctions distinguishes and divides the cytoplasm of the Sertoli cell into two regions:

  -The basal compartment

  -The adluminal compartment

  The ***basal compartment***, which lies beneath the tight junction and is reduced in height, and the ***adluminal (apical) compartment***, which extends to the lumen of the seminiferous tubule and is involved with the different stages of spermatogenic cell development.

- Cells derived from type B spermatogonia move from the basal compartment to the adluminal compartment.
- These cells are **primary spermatocytes,** and as they pass into the adluminal compartment, they form tight junctions with the Sertoli cells.

- The primary spermatocytes become the largest cells of the spermatogenic population.
- Soon after the primary spermatocyte has moved into the adluminal compartment, the diploid nucleus increases its deoxyribonucleic acid (DNA) content to 4N.
- Subsequent to further cell division, which occurs twice (both involving meiosis rather than mitosis), the primary spermatocytes remain primary spermatocytes for an extended period.

- The extended length of time is due to the prolonged prophase I of the first meiotic division, which includes four stages:

  leptotene, zygotene, pachytene, and diakinesis.

Leptotene, the first stage of prophase I, is recognized by the initial condensation of the chromosomes, which become threadlike in appearance.

- During zygotene the chromosomal homologs are now seen as pairs (four chromatids).
- As prophase continues into the pachytene stage, the chromosomal pairs condense further into shortened and thickened tetrads.
- After diplotene, prophase enters diakinesis and segments of the homologs are exchanged or crossing over, resulting in genetic recombination. As a result of the crossing over, each gamete receives a different, unique blend of genomic material.

- With the end of prophase the first meiosis enters **metaphase I** and the paired homologs move to the equatorial plate.
- During **anaphase I** the chromosomes migrate to each pole and enter **telophase I**, with the cell dividing into two but incompletely forming the same type of cytoplasmic bridge that occurred during previously mitotic divisions.
- The newly formed cells are **secondary spermatocytes**, and each cell now has one-half of the number of chromosomes that the primary spermatocyte possesses, but each chromosome consists of two chromatids.
- Within a short time the secondary spermatocytes enter the second meiotic division, which includes a relatively brief prophase II, followed by metaphase II, anaphase II, and telophase II.
- The subsequent cells formed from this division are **spermatids**, each containing a haploid complement of DNA.

- At the end of the second division, the newly formed spermatids undergo a remarkable transformation known as **spermiogenesis.** These cells are now located near the lumen of the seminiferous tubule.
- The spermatid metamorphoses into a spermatozoon by going through a four phase process that includes the Golgi phase, the cap phase, the acrosomal phase, and the maturation phase.

- The newly formed spermatozoa enter the lumen, unattached to the seminiferous epithelium.
- Each spermatozoon consists of a head and a tail.

INTERSTITIAL (Leydig) CELL

Within the lamina propria surrounding the seminiferous tubules are clusters of endocrine cells, the **interstitial (Leydig) cells**, that form the hormone, testosterone.

Leydig cells are large, polygonal, eosinophilic cells that typically contain lipid droplets.

The Leydig cells can be especially well developed in the stallion and the boar, occupying considerable portions of the interstitial tissue that lie between adjacent tubules.

Flattened, contractile myoid cells lie just outside the basement membrane of each seminiferous tubule.

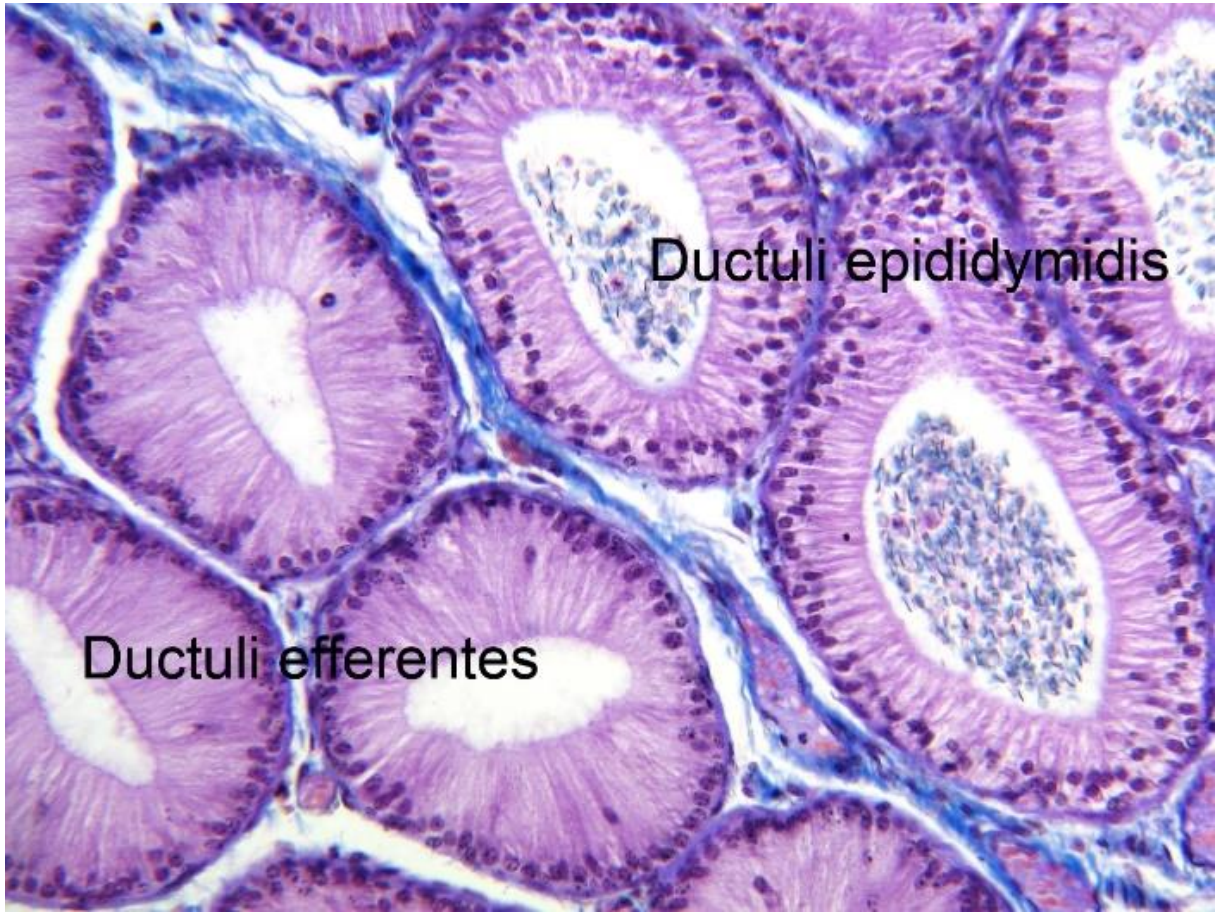
GENITAL DUCTS

- The seminiferous tubules empty into a system of ducts that exist within the testes, the **intratesticular ducts**, and outside the testes, the **extratesticular ducts**.
- The intratesticular ducts consist of the tubuli recti and the rete testis, and the extratesticular ducts consist of the ductuli efferentes, the ductus epididymis, and the ductus deferens.

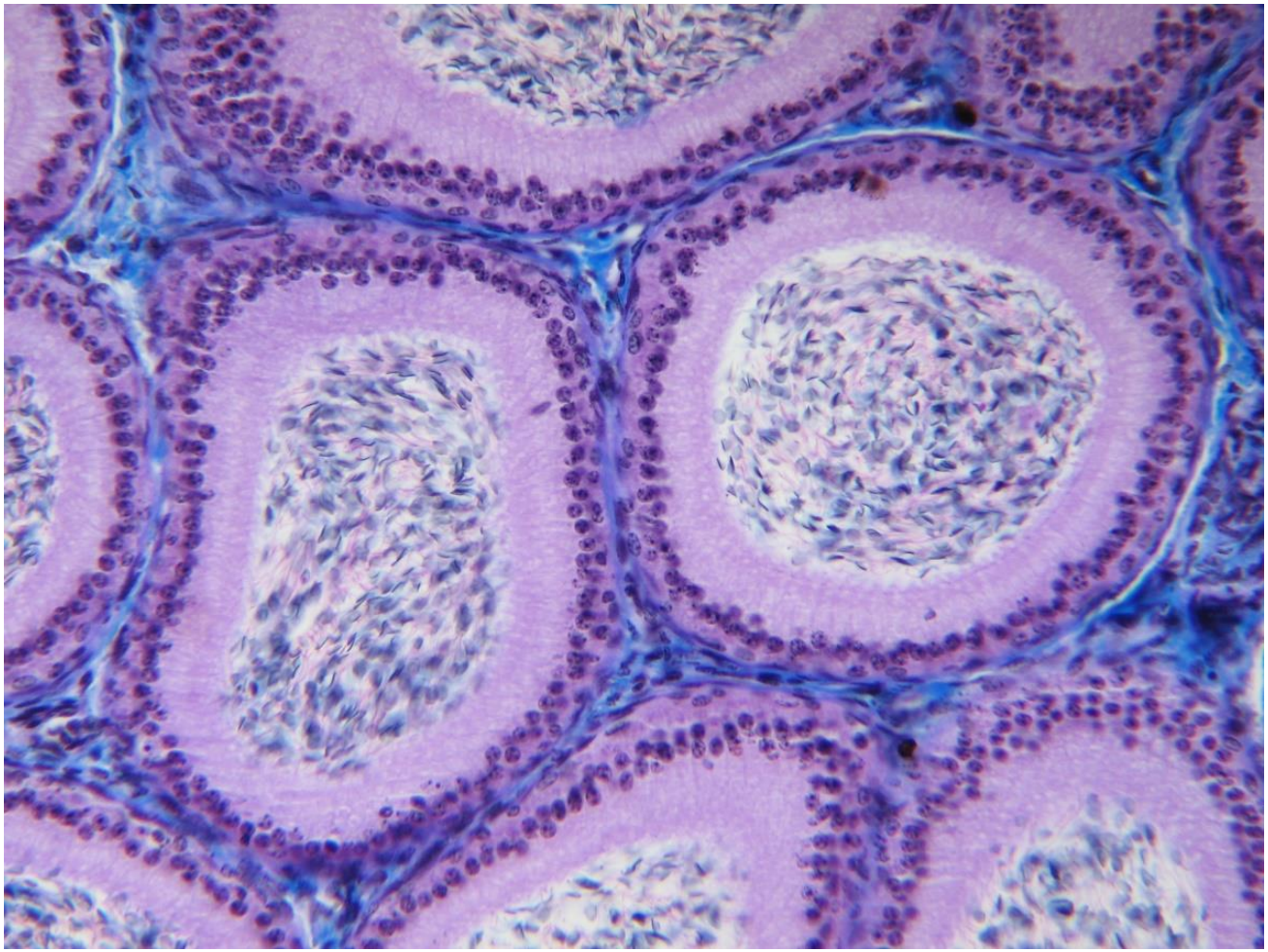
INTRATESTICULAR DUCTS

- The **tubuli recti** receive the spermatozoa formed by the seminiferous tubules and are lined by Sertoli cells.
- The tubuli recti empty into the **rete testis,** which as a labyrinth-like network of anastomosing channels.
- The rete testis possesses a simple squamous or cuboidal epithelium.
- Rete testis is surrounded by the loose connective tissue of the mediastinum testis.

EXTRATESTICULAR DUCTS



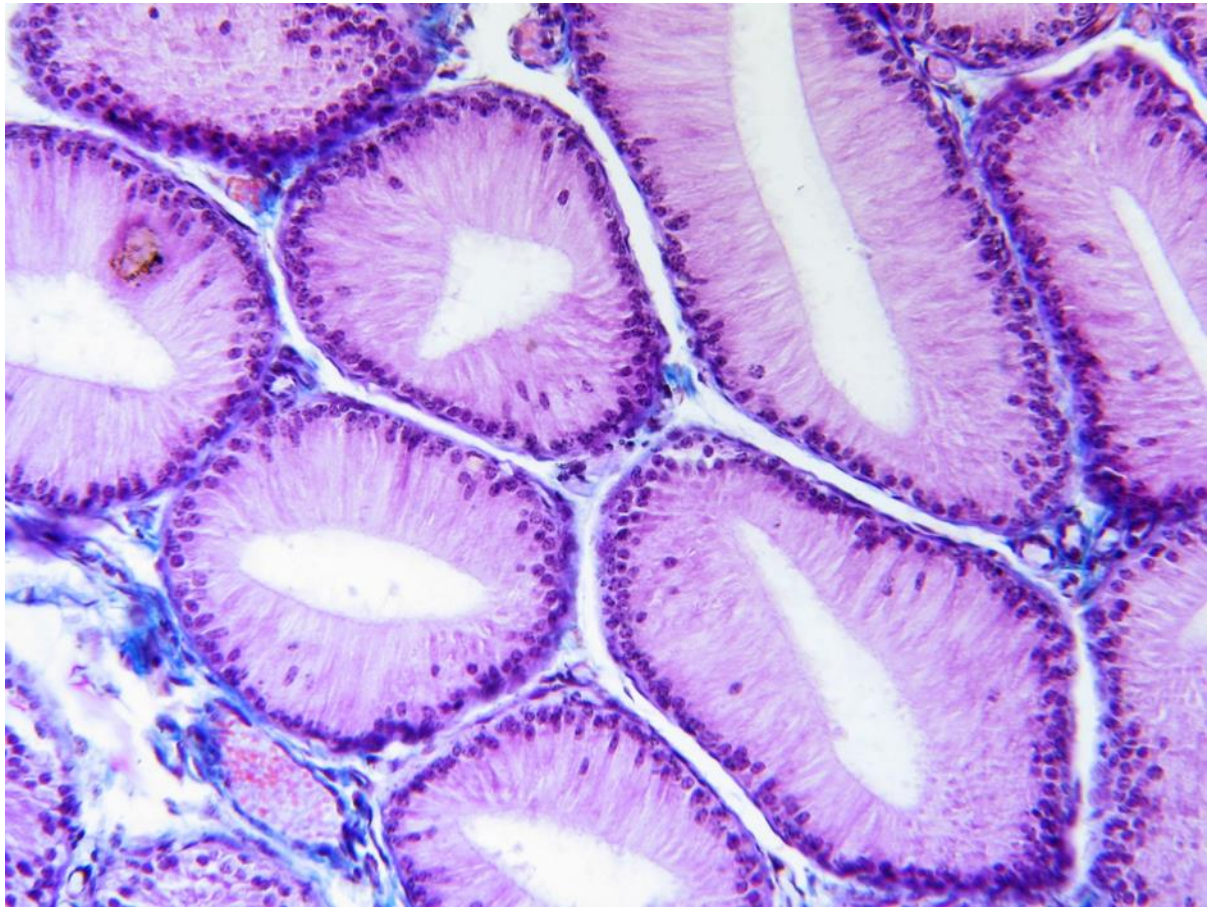
- The first two types of the extratesticular ducts, the ductuli efferentes and the ductus epididymis, form the accessory structure known as the **epididymis**.



- The epididymis stores the spermatozoa, which continue to remain inactive within the male reproduction tract, and provides its own substance, replacing the testicular fluid formed by the rete testis.

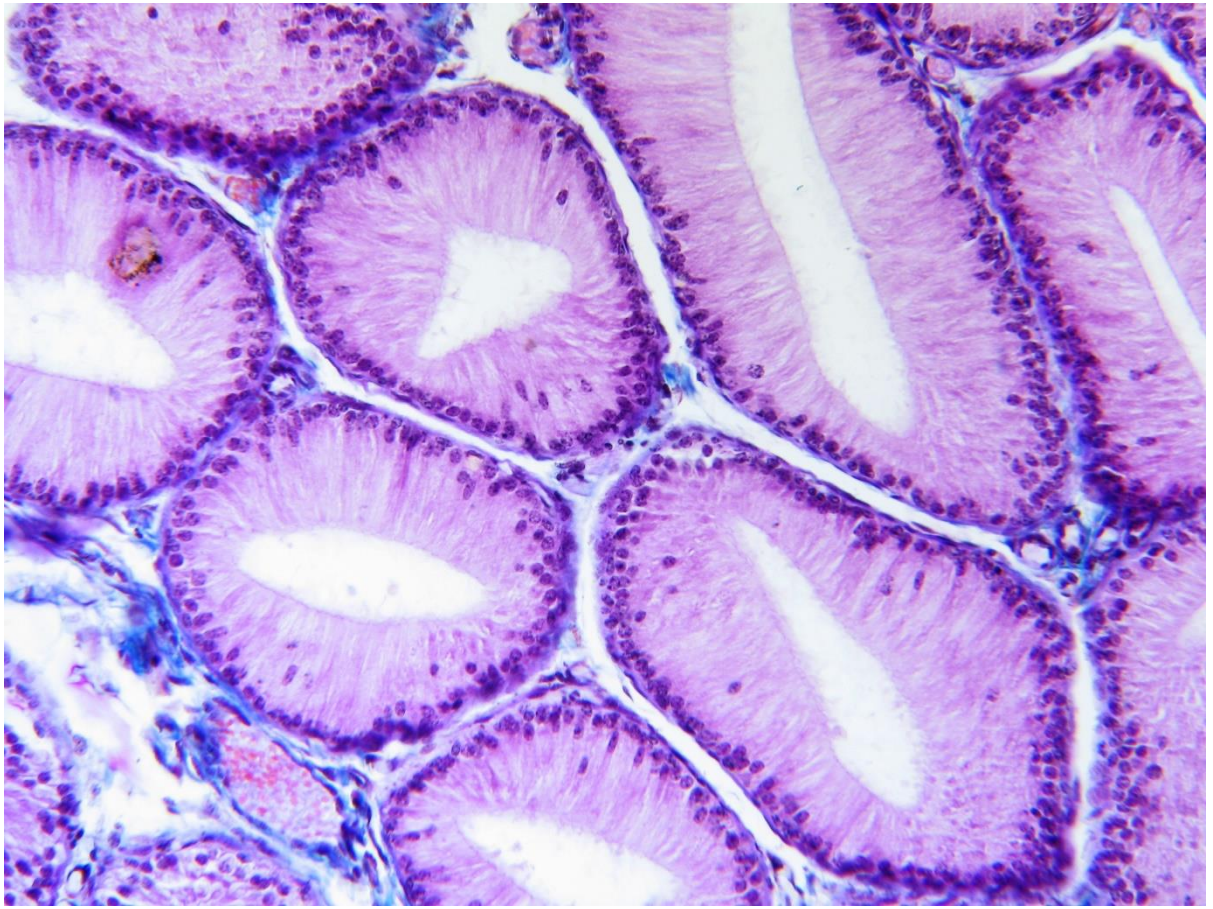
Ductuli Efferentes

- From the rete testis, 8 to 20 or so short tubules, known collectively as the ductuli efferentes, lead the spermatozoa to the ductus epididymis.



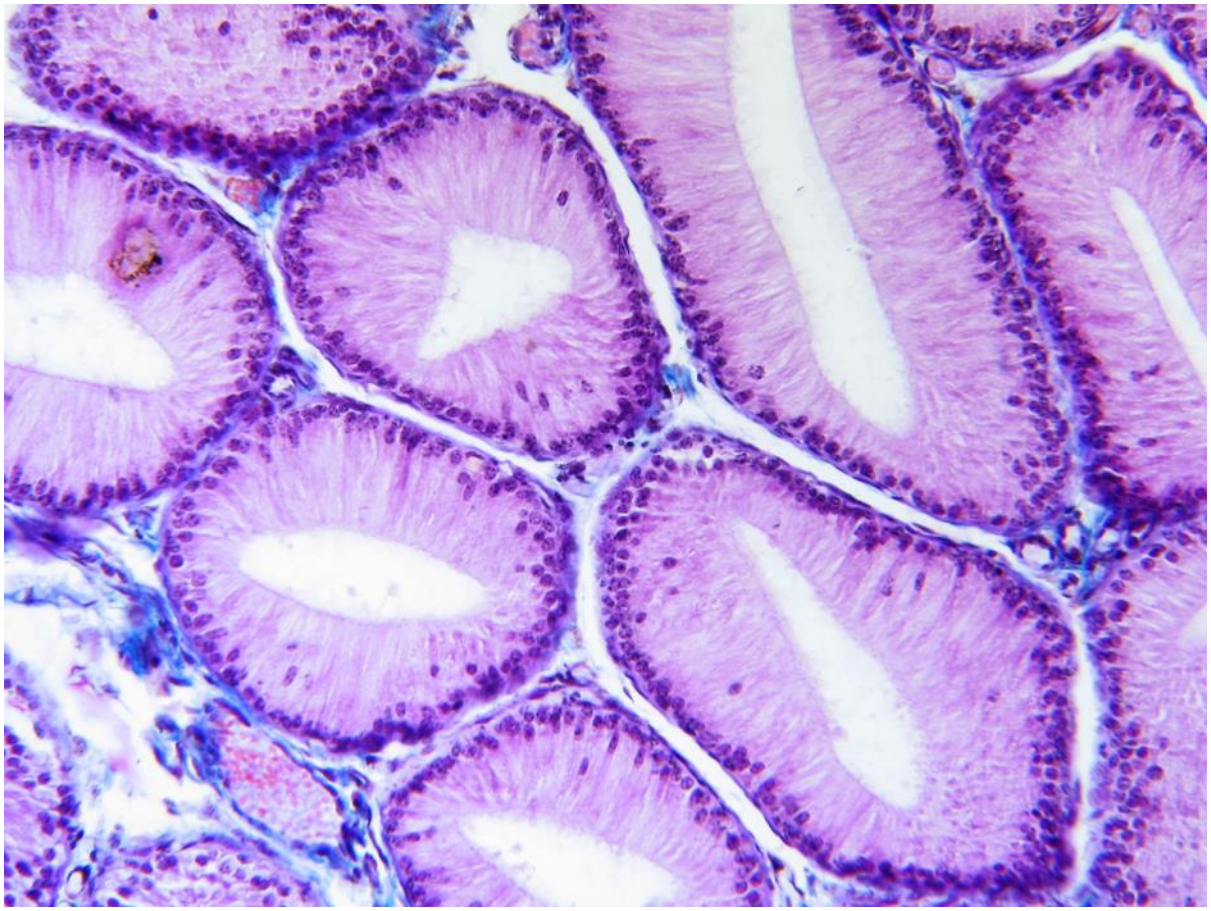
Ductuli Efferentes

- These tubules are lined by a simple columnar or a pseudostratified epithelium, that is either ciliated or nonciliated.Those that are nonciliated are usually equipped apically with microvilli.



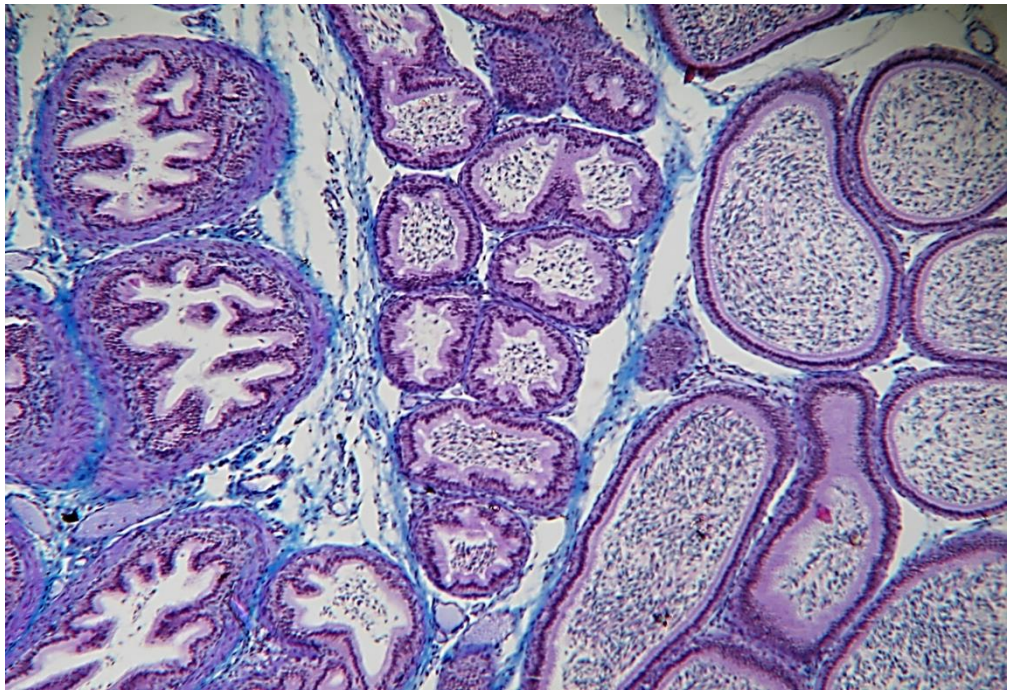
Ductuli Efferentes

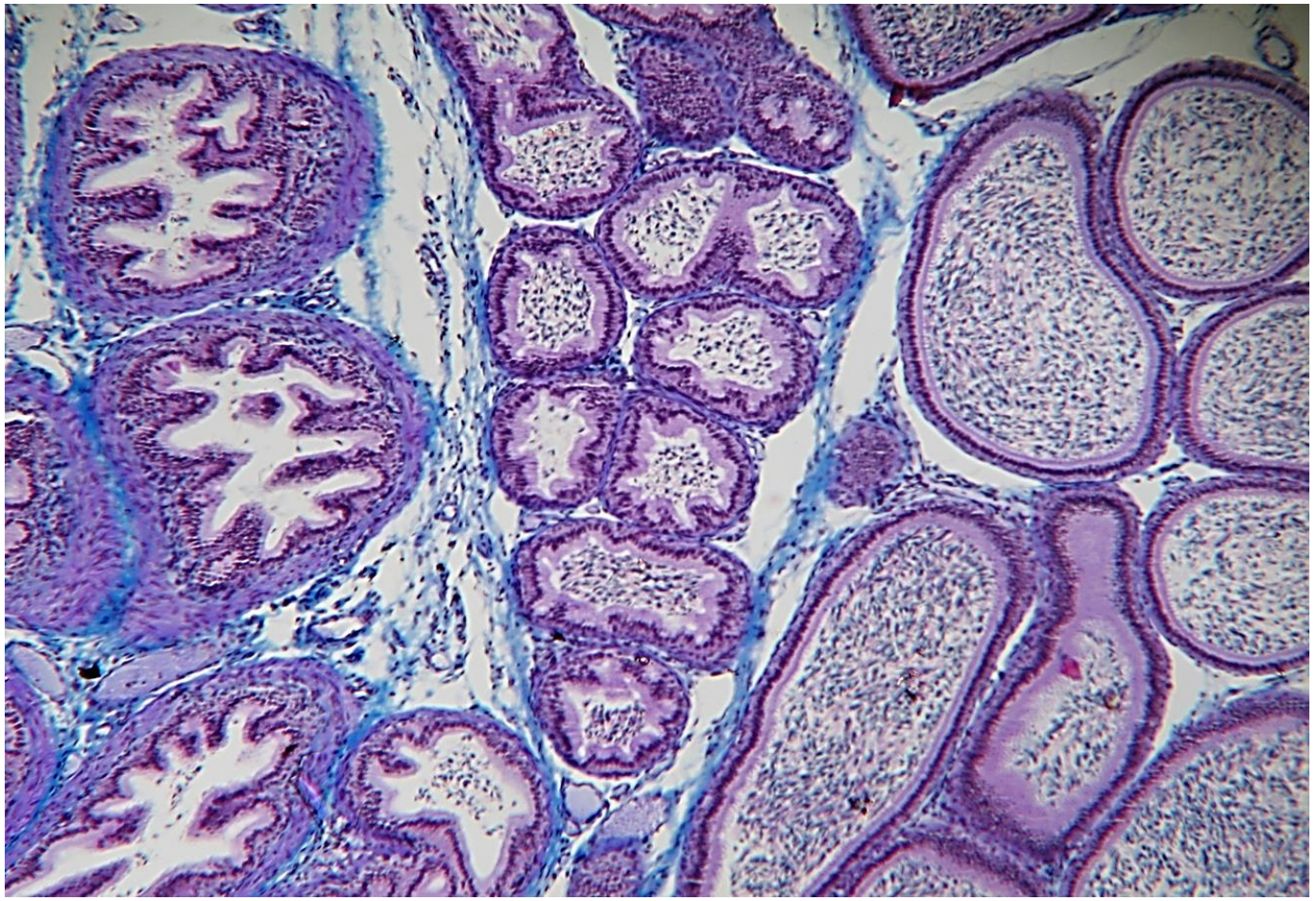
- The nonciliated portions are most likely involved in the absorption of the testicular fluid, whereas the ciliated portions facilitate the movement of the spermatozoa toward the ductus epididymis.



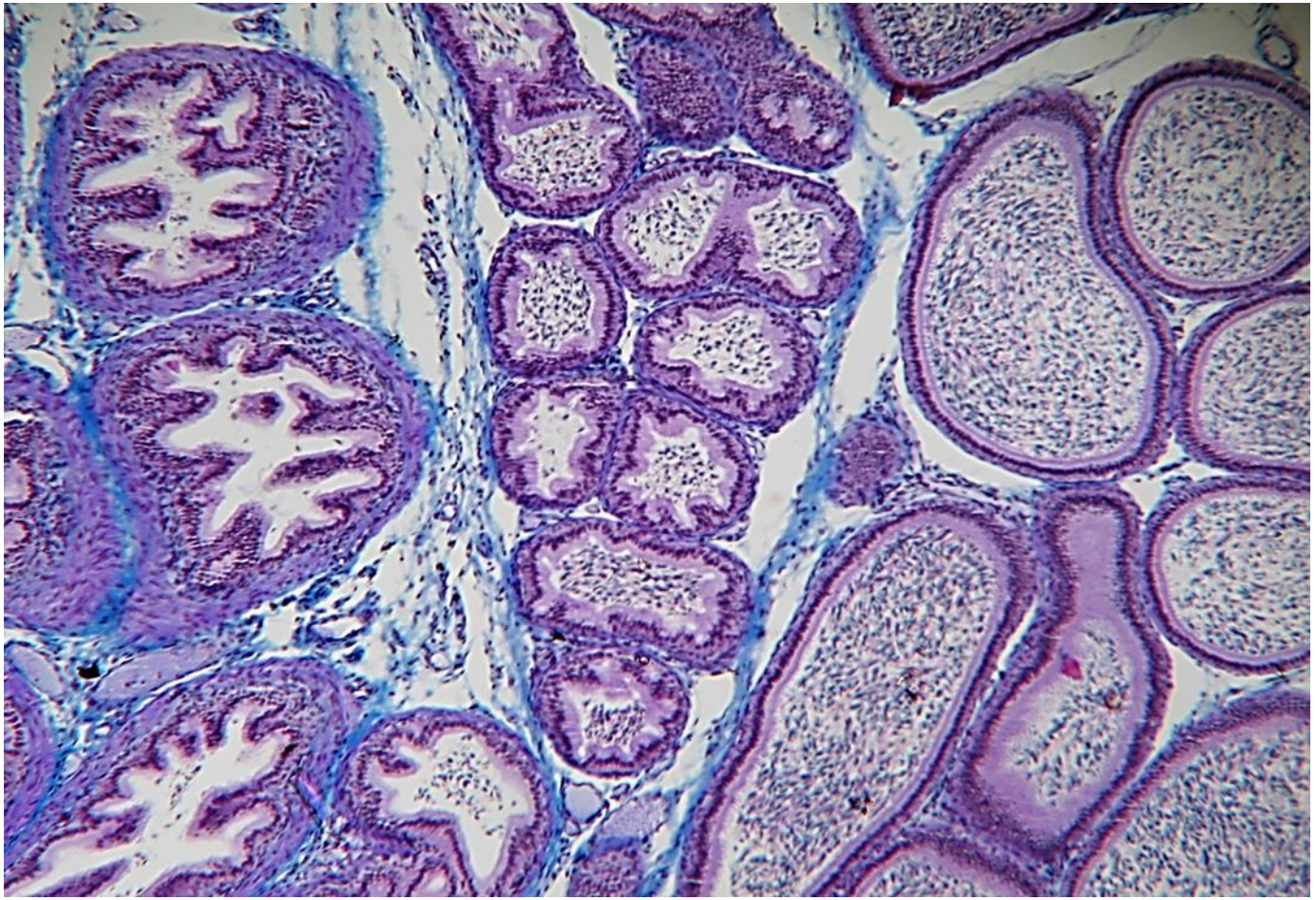
Ductus Epididymis

- The ductus epididymis consists of a long, highly convoluted tubule that is subdivided into three portions: the head (**caput**), body (**corpus**), and tail (**cauda**). The length of the entire duct varies greatly among domestic species.

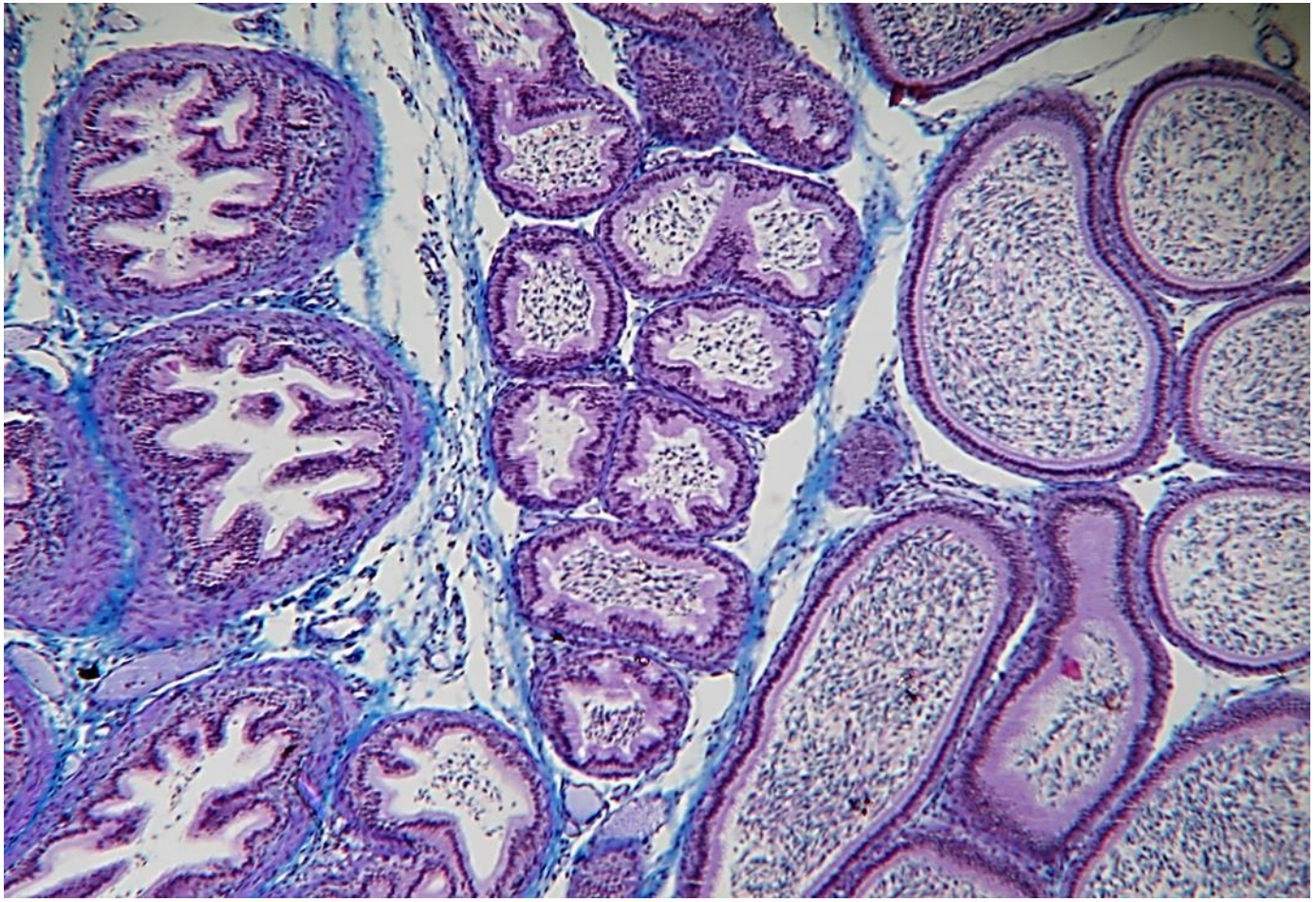




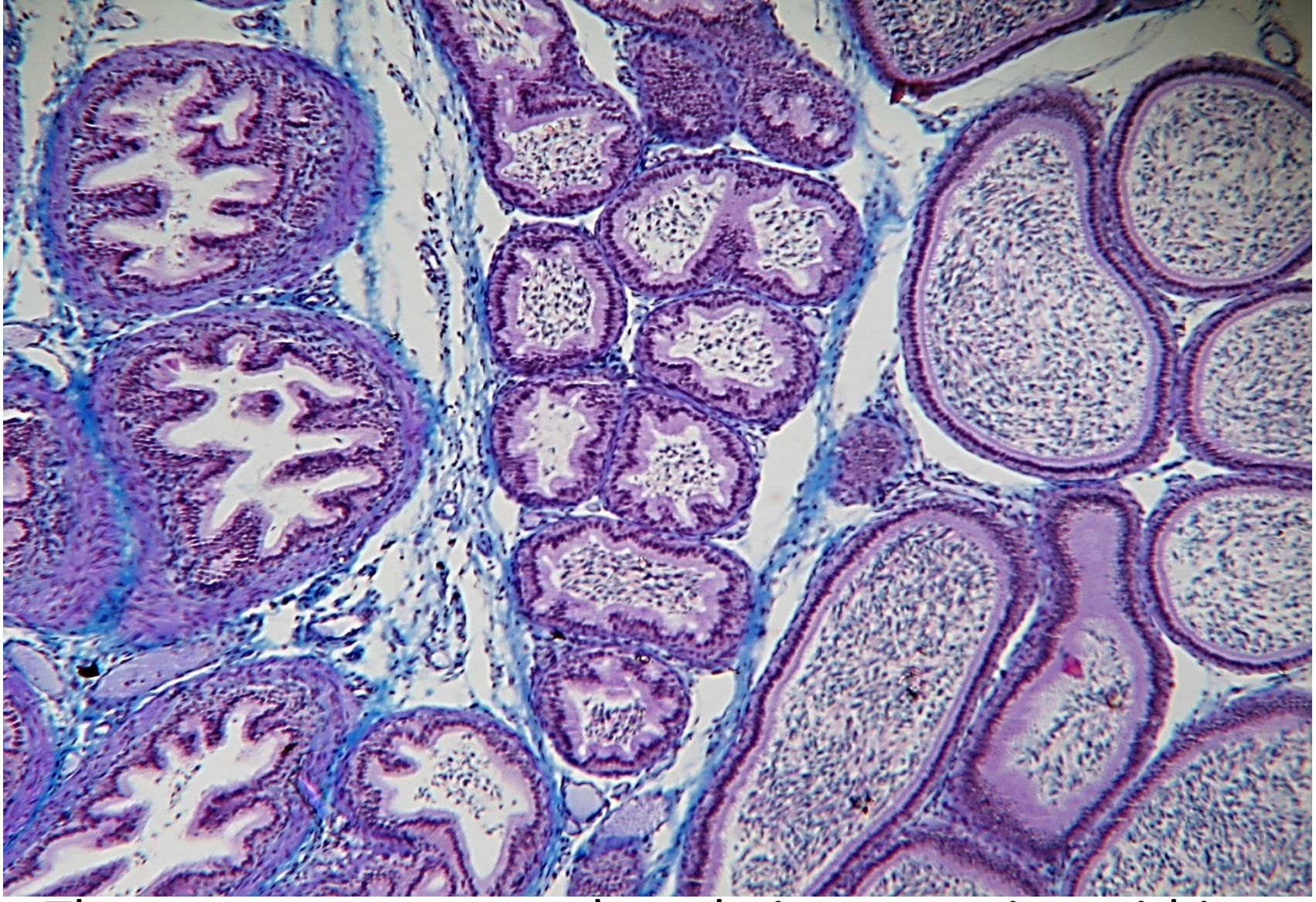
The head (caput) is the portion that receives the contents contained within the ductuli efferentes.



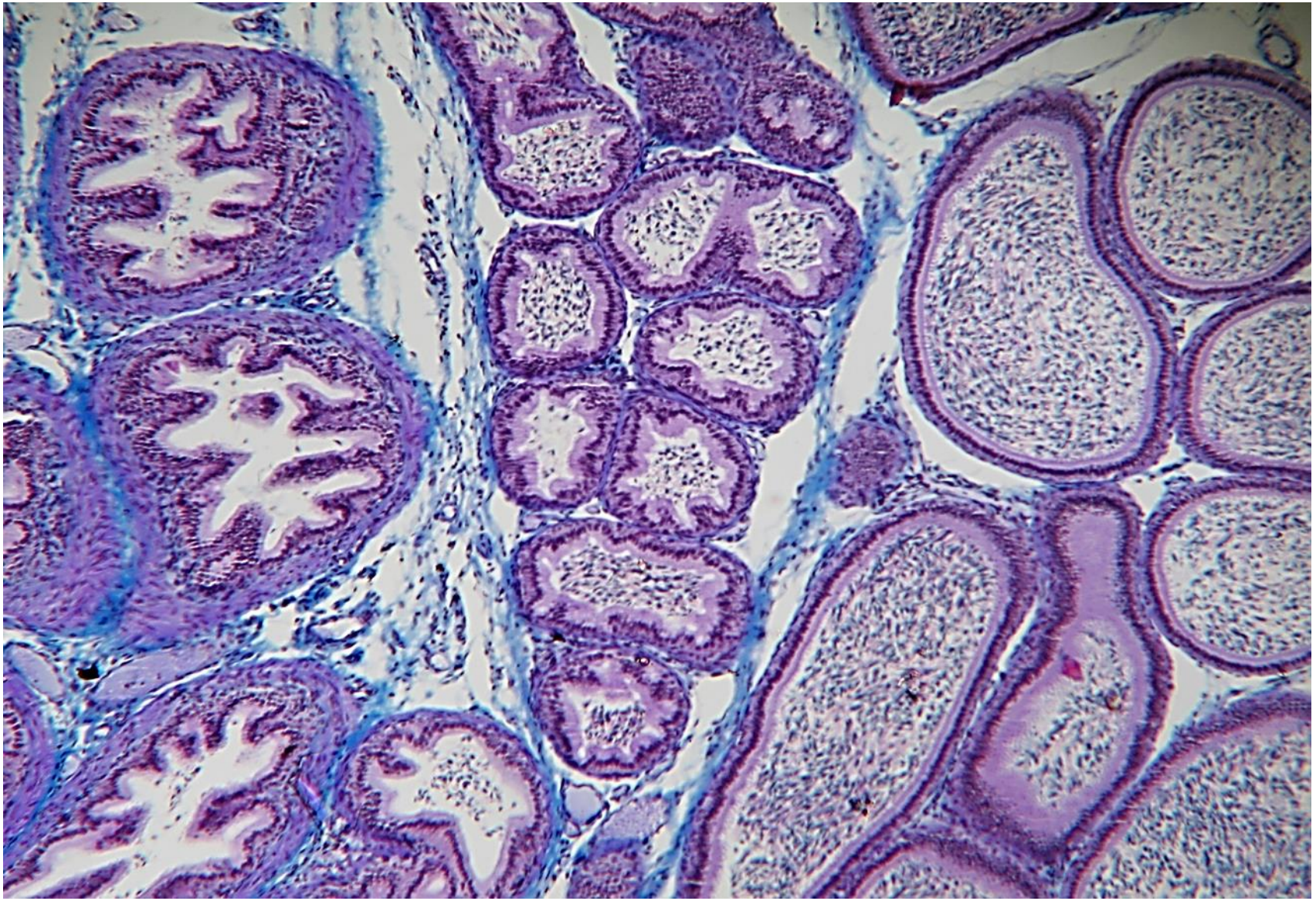
- The body (corpus) possess pseudostratified columnar epithelium, having at least two cell types: the tall columnar principal cell and the short polygonal basal cell.



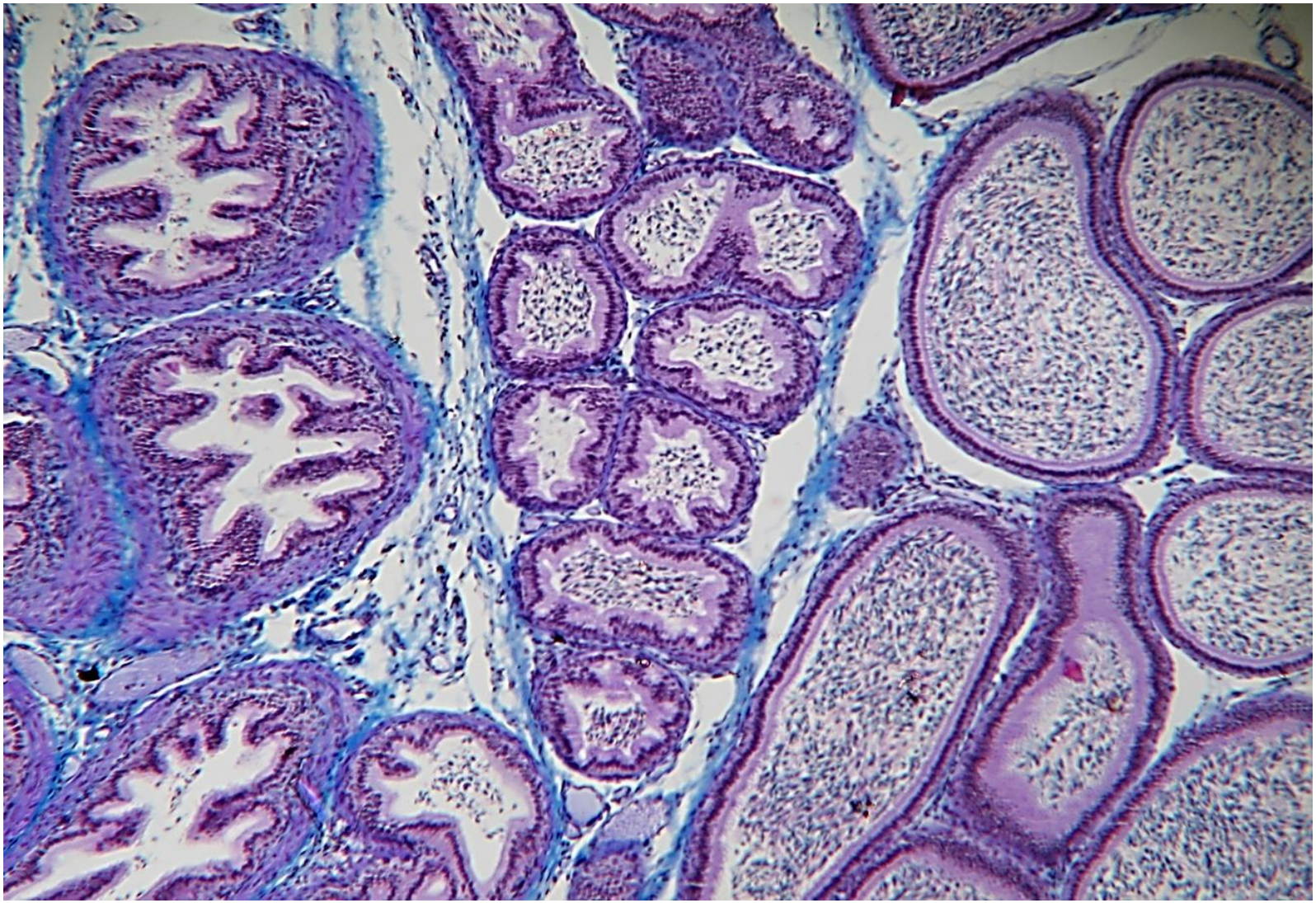
- The principal cells of this pseudostratified columnar epithelium form stereocilia.



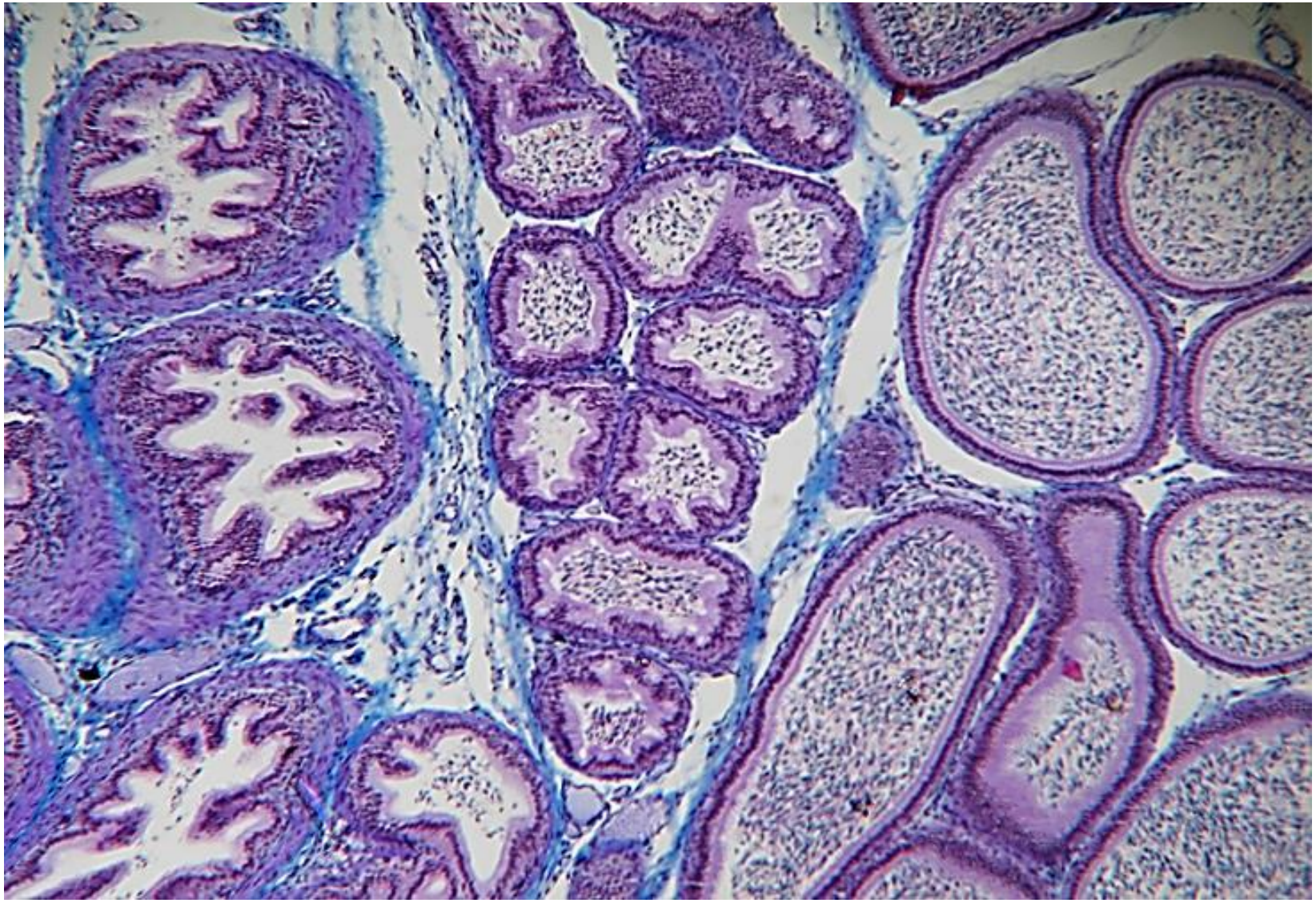
- The spermatozoa complete their maturation within the head and the body of the ductus epididymis.



- The epithelial basement membrane of the ductus epididymis is attached to a thin layer of connective tissue which is encircled by a thin layer of smooth muscle.



- Contraction of the smooth muscle assists in moving the maturing spermatozoa to the caudal portion (tail) of the ductus epididymis.
- The tail stores the mature spermatozoa for extended periods if necessary.

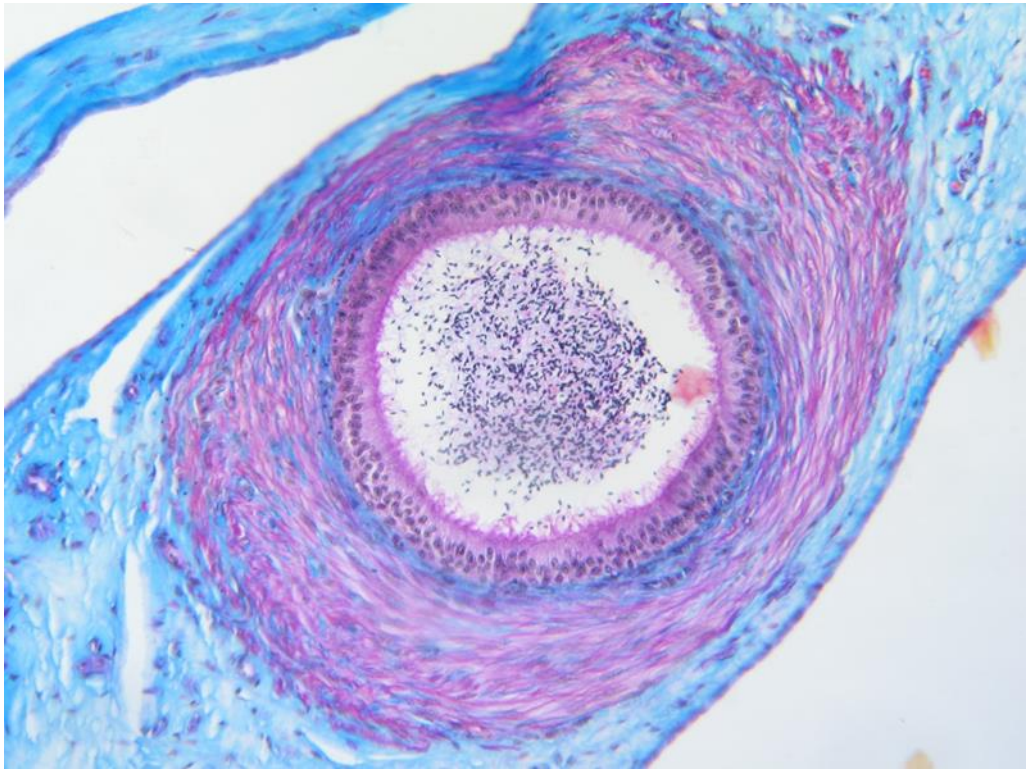


The height of the principal cells becomes reduced as the tail moves toward the ductus deferens.

The surrounding smooth muscle thickens.

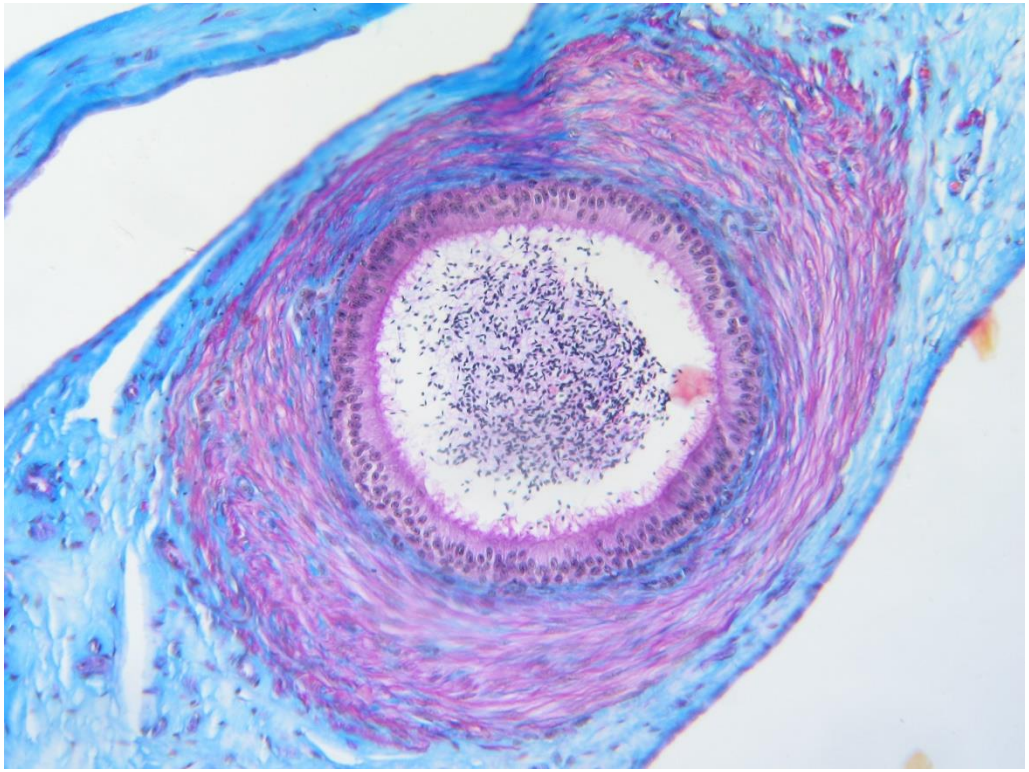
Ductus Deferens

- The ductus epididymis ends, emptying into the **ductus deferens**.
- The epithelial lining continues to be pseudostratified columnar with short stereociliated principal cells.

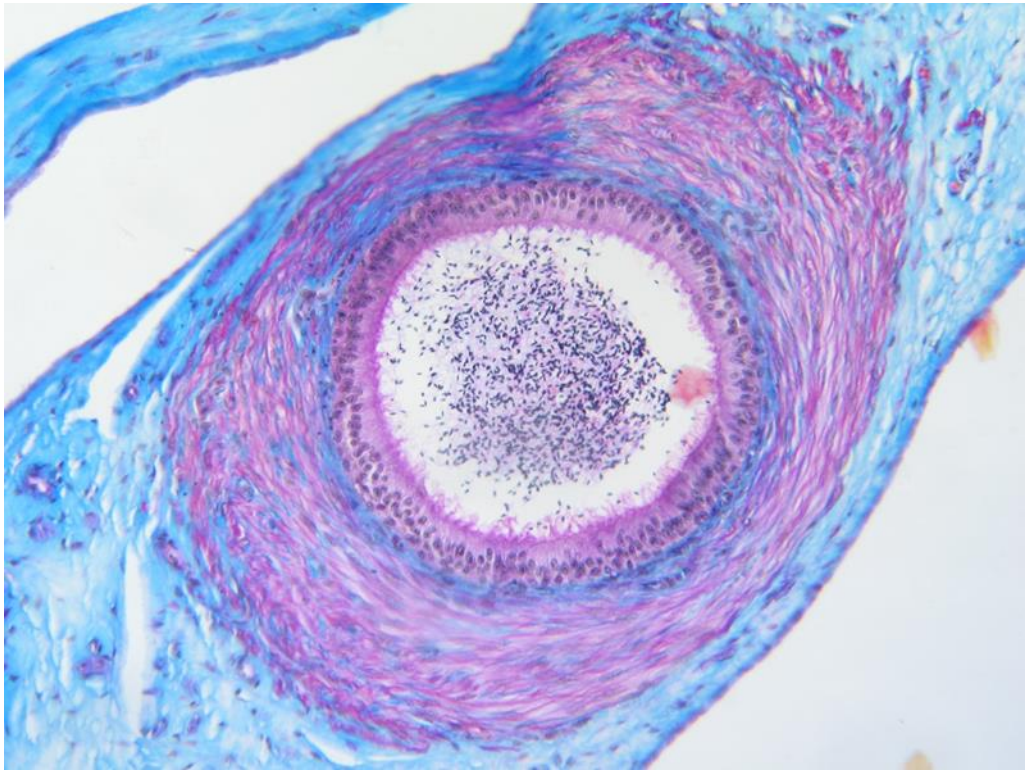


Ductus Deferens

- Like the ductus epididymis, the base of the epithelium is attached to a thin layer of a well-vascularized loose connective tissue.

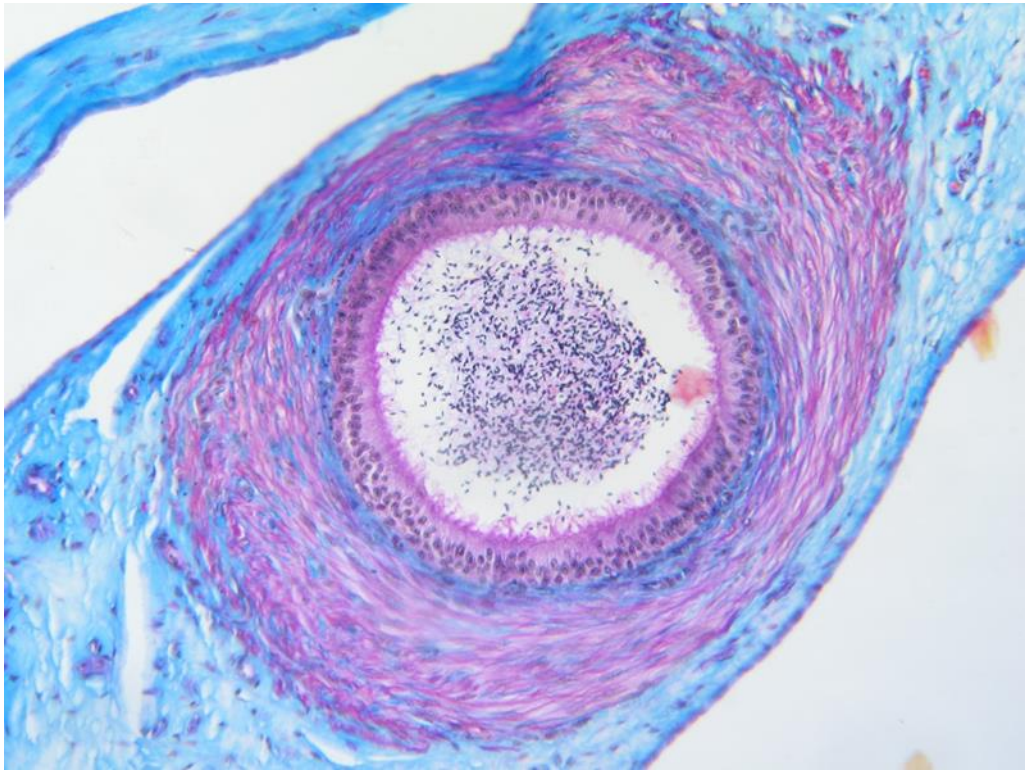


Ductus Deferens



- This tissue is encircled by a very well developed layer of smooth muscle that is additionally lined by another, external layer of smooth muscle oriented along the longitudinal axis of the ductus deferens; together they comprise a well-developed tunica muscularis.

Ductus Deferens



- Near its junction with the urethra, the ductus deferens forms a dilated ampulla whose lamina propria and submucosa are filled with glandular secretory units.
- The ampulla is absent in the cat.

The termination of the ductus deferens varies from species to species.

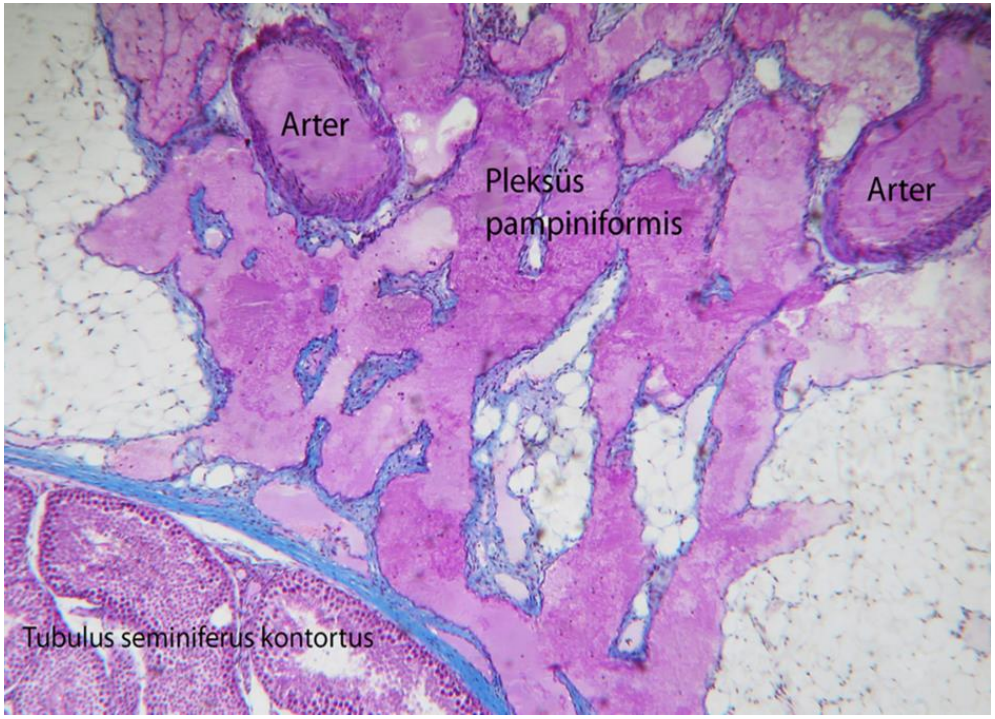
In the bull, ram and stallion, the ductus deferens joins the excretory duct of the vesicular gland to become an ejaculatory duct that empties into the urethra.

In the boar, the ductus deferens does not join the excretory duct of the vesicular gland because each duct empties into the urethra separately.

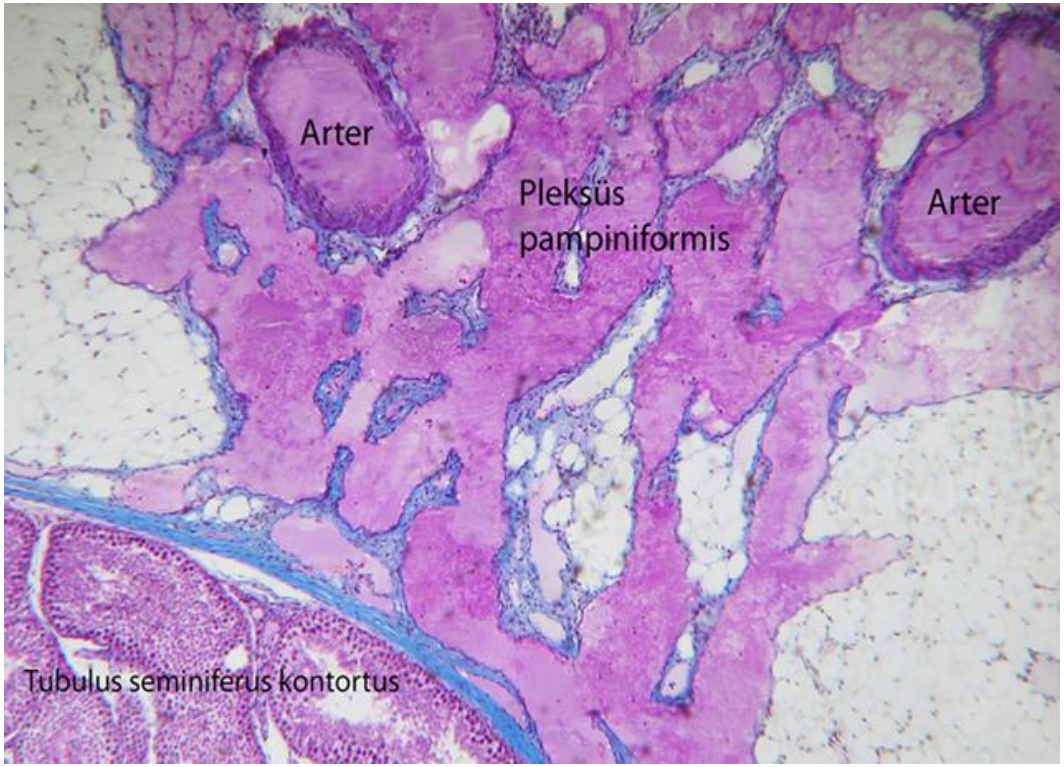
In the dog and cat, the ductus deferens leads directly to the urethra as well, but for a different reason than that of boars. Male carnivores do not form vesicular glands.

- Spermatogenesis requires that the testes be maintained below normal body temperature.
- As the testes descend from the abdominal cavity into the scrotum, they carry with them blood vessels, lymphatic vessels autonomic nerves, and an extension of the abdominal peritoneum called the tunica vaginalis, which covers their anterolateral surface.
- Within the scrotum, the temperature of the testes is 2 to 3 °C below body temperature.
- This lower temperature is essential for spermatogenesis but is not required for hormone production (steroidogenesis), which can occur at normal body temperature.
- If the testes are maintained at higher temperatures (e.g., because of fever) or if they fail to descend into the scrotum, sperm are not produced.

- Each testis receives blood through a testicular artery, a direct branch of the abdominal aorta. It is highly convoluted near the testis, where it is surrounded by the pampiniform venous plexus, which carries blood from the testis to the abdominal veins.



- This arrangement allows head exchange between the blood vessels and helps maintain the testes at a lower temperature.
- The cooler venous blood returning from the testis cools the arterial blood before it enters the testis through a countercurrent heat exchange mechanism.



- In addition, the cremaster muscle, whose fibers originate from the internal abdominal oblique muscle of the anterior abdominal wall, responds to changes in ambient temperature. Its contraction moves the testes closer to the abdominal wall, and its relaxation lowers the testes within the scrotum.

Accessory Glands

- In most domestic animals, the seminal plasma is made by the accessory glands, which include the vesicular gland, the prostate, and the bulbourethral gland.

- Only carnivores lack the vesicular gland, and the dog lacks the bulbourethral gland as well.
- The seminal plasma is both mucous and serous in composition and functions to nourish and provide the necessary energy source for spermatozoa motility, lubricate the urethra, and create a volume of ejaculate that helps move the spermatozoa.

VESICULAR GLAND

- Anatomically, boars form a pair of vesicular glands, whereas carnivores lack this gland.
- The glandular epithelium is pseudostratified columnar with round, short basal cells scattered between the columnar cells. The columnar cells secrete large amounts of fructose that provides energy for the spermatozoa.

PROSTATE GLAND

- The **prostate gland** produces an alkaline secretion that neutralizes the acidity of the male urethra and female vagina.
- The prostate surrounds the pelvic urethra in two parts: an outer, compact **body (corpus prostate)** that completely or partially covers an inner **disseminate part (disseminate prostate**).
- Much of the glandular parenchyma of the prostate is located within the body, consisting of multiple compound tubuloalveolar secretory segments .
- The disseminate part is much like the body, but only less so, having fewer tubuloalveolar segments.
- The glandular epithelium as well as the ducts can range from cuboidal to columnar in shape.
- The prostate gland is a seromucous gland except in the dog, where it is entirely serous.
- The carnivorous prostate is well developed.

BULBOURETHRAL (Cowper's) GLAND

- The bulbourethral gland, which consists of a paired structure that lies dorsolaterally to the pelvic urethra.
- The secretory units are arranged as either compound tubuloalveoli (in the stallion and ruminants) or compound tubuli (in the cat and the boar), being absent in the dog.
- The secretory epithelia are generally simple columnar and produce a mucus-rich product in most species, but can contain serous material in ruminants as well.
- The secretion of the cowper gland, which is released before ejaculation, serves initially to clear the urethra of urine and subsequently aid in lubricating the vagina.

URETHRA

- The male urethra, which carries both urine and semen, can be divided into a pelvic and a penile portion.
- The pelvic urethra is lined by a transitional epithelium.
- Along the entire length of the urethra, the connective tissue below the mucosa contains erectile tissue with thin-walled cavernous spaces (veins).
- In the pelvic urethra this erectile tissue forms the stratum cavernosum.
- The penile urethra, which courses through the ventral region of the penis, is lined by a mixture of transitional, stratified cuboidal, stratified columnar, or simple columnar epithelium.
- The larger, more abundant cavernous spaces of the penile urethra form the corpus spongiosum (corpus cavernosum urethra), which is surrounded by a tunica albuginea.

PENIS

- Although shared by urinary and reproductive systems, the penis is designed for the copulatory ejaculation of semen and spermatozoa. For that reason, much of the penis consists of erectile tissues required for copulation.
- This structure is composed of the paired corpora cavernosa penis, the corpus spongiosum penis (corpus cavernosum urethra**)**, and the glans penis.
- This structure is composed of the paired corpora cavernosa penis, the corpus spongiosum penis (corpus cavernosum urethra), and the glans penis.

- The corpora cavernosa penis, which makes up much of the body of the penis, consists of two dorsal columns of erectile tissue that are lined by a dense connective tissue, the tunica albuginea.
- The tunica albuginea may become discontinuous and allow the vascular cavernous spaces to join one another or, in the dog and stallion, form a connective tissue septum.
- The erectile tissue consists primarily of vascularized connective tissue that can be ladened with elastic fibers.
- The vasculature is composed of sinuses that become engorged during erection, especially within a vascular-type penis, in cats, dogs and horses.

- In pigs and ruminants, the penis enlarges to some extent with vascular engorgement. However, in these animals the tunica albuginea is well developed, consisting of dense connective tissue and forming a fibrous-type penis.
- **The glans**, which is best developed in the dog and the stallion, contains a variety of tissues, depending on the species. In carnivores, the glans consists of erectile tissue, bone, os penis, and fibrocartilage, whereas in the bull it consists of dense connective tissue with an erectile venous plexus that surrounds the urethra, as well as forms much of the tunica albuginea.
- **The prepuce** is an external layer of integument.

Semen, seminal fluid or Ejakulate

- Semen contain fluids and sperm from the testis and secretory products from the epididymis, ductus deferens, prostate, seminal vesicles, and bulbourethral glands. It is alkaline and may help to neutralize the acid environment of the urethra and the vagina. Semen also contains prostoglandins that may influence sperm transit in both the male and female reproductive ducts and that may have a role in implantation of a fertilized ovum.

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