

# TESTIS

## TIG

### Location of the testes:

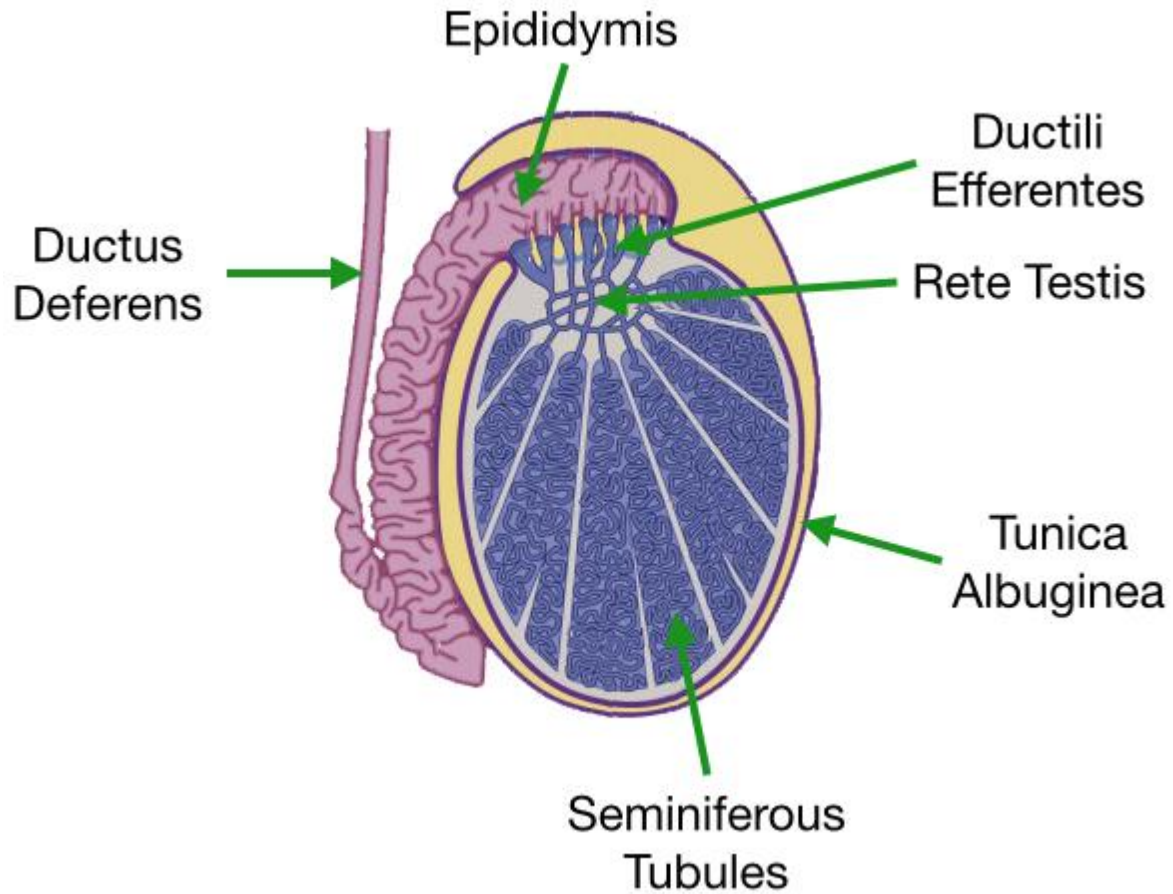
The two testes (testicles) are oval shaped glands that sit in a pouch of skin (the scrotum) behind the penis. In adult men, each testis is between 12-25 ml in size, growing from 1-3 ml in prepubertal children. It is normal for the size of each testis to differ slightly and for one to sit lower than the other. Each testis is attached to the body by the spermatic cord, which contains nerves, blood vessels and the vas deferens (which carries sperm from the testes to the urethra).

The location of the testes and scrotum on the outside of the body means that the testes can be kept cooler than normal body temperature. This is important for sperm production.

The testes are made up of 200-300 compartments called lobules. Each lobule contains several coiled structures called seminiferous tubules, where sperm are made. The seminiferous tubules then release the sperm into a series of ducts where they mature and pass to the urethra. Around the seminiferous tubules are the specialised cells that produce testosterone, called the Leydig Cells

**Testes are a source of gametes and steroid sex hormones.** Each testis is surrounded by a thick connective tissue coat called the **tunica albuginea**. The bulk of the gland contains **seminiferous tubules** that are the site of **sperm** production. The gland is divided into **lobules** by thin septa that radiate from the **tunica albuginea**. Each of these lobules contains between **one and four seminiferous tubules**.

Upon exiting a seminiferous tubule, sperm traverse the rete testis, ductus efferentes, and convoluted epididymis, visible on the dorsal aspect of the testis here.

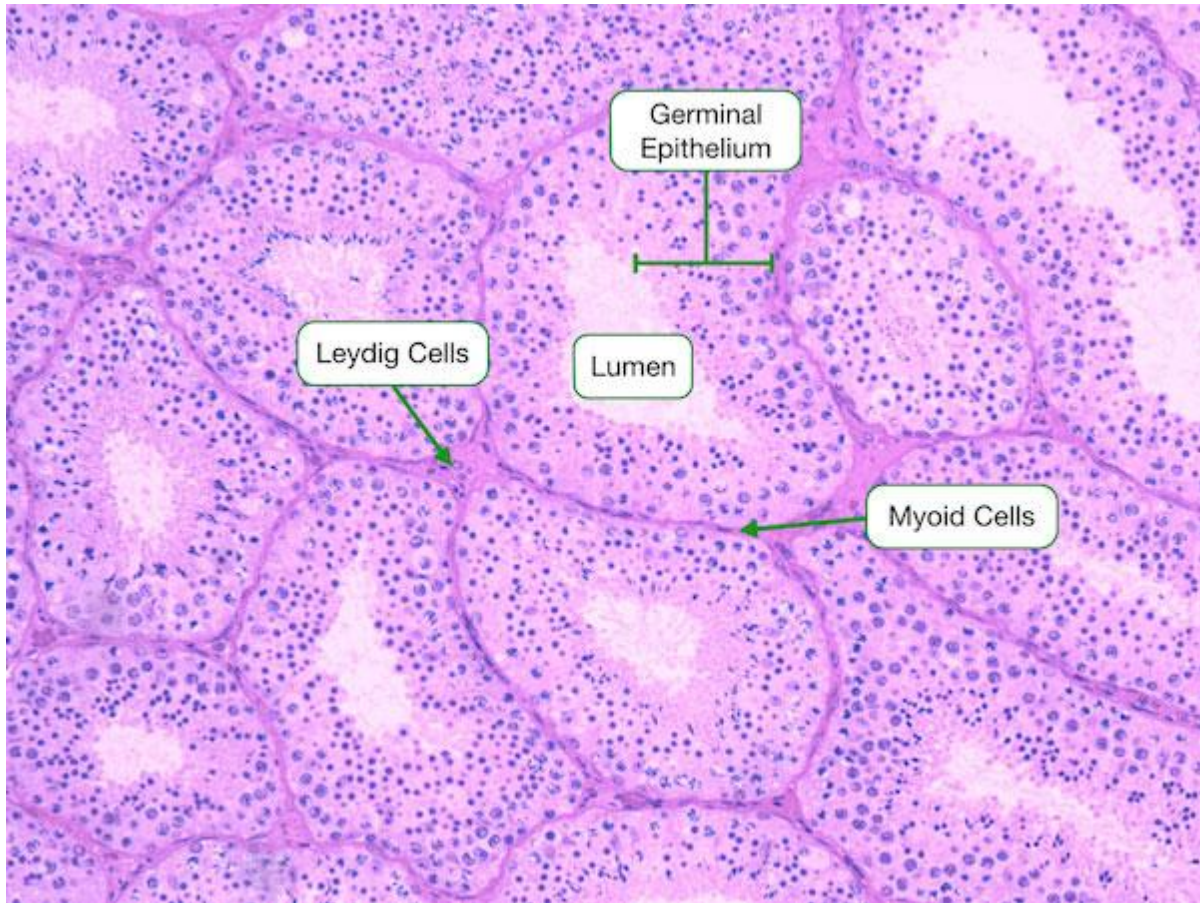




## Seminiferous Tubules:

Seminiferous tubules are the site of sperm production and consist of a germinal epithelium surrounding a central lumen. Uncommitted cells, called **spermatagonia**, reside along the basement membrane of the **germinal epithelium** and function as stem cells for sperm production. As spermatagonia mature into sperm, they migrate upwards through the epithelium and are finally released into the lumen.

The interstitium surrounding the germinal epithelium contains two notable cells. Myoid cells surround the tubules and generate rhythmic contractions to propel spermatozoa and fluid. They also synthesize collagen and other fibers of connective tissue. **Leydig cells** produce **testosterone** and localize in clumps.



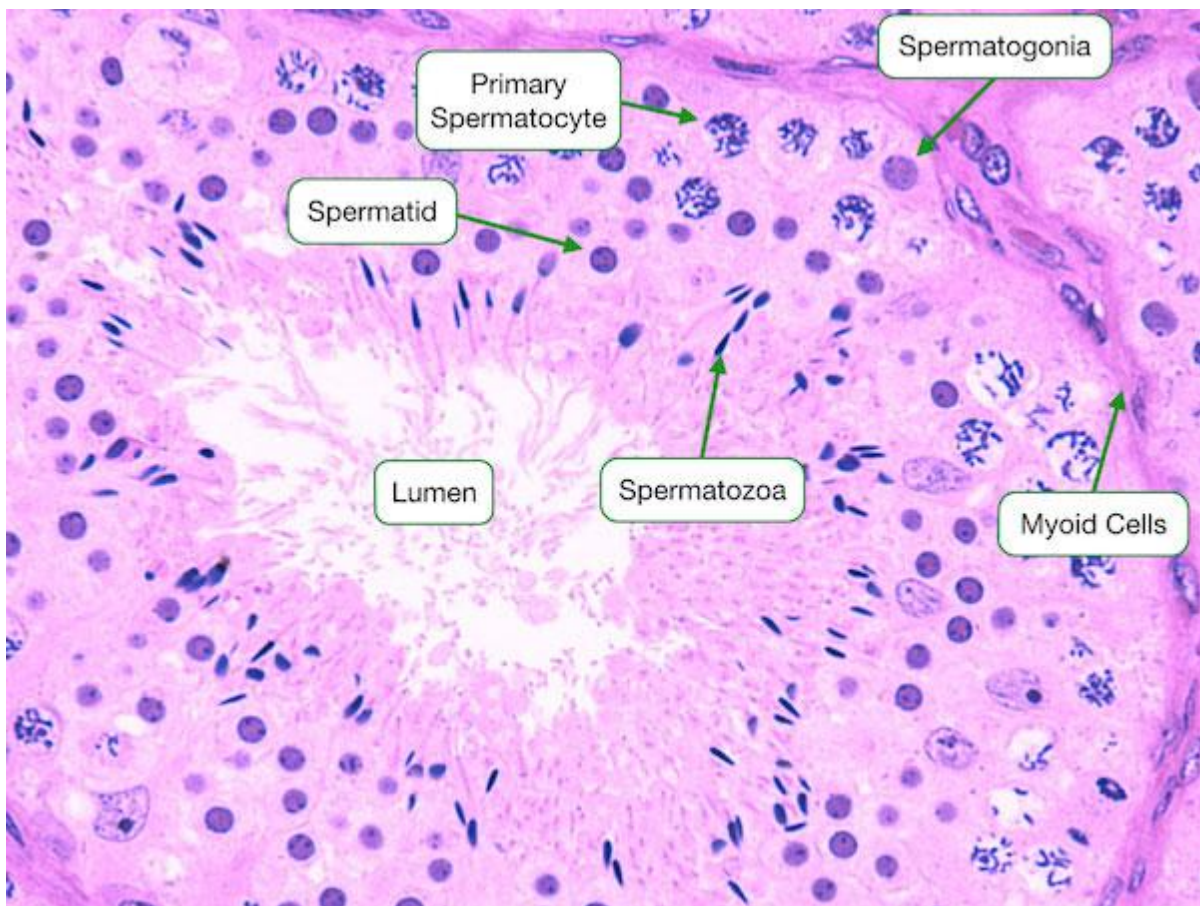
## Spermatogenesis:

Many stages of sperm development can be seen in a histological section of the seminiferous tubule. At the base of the germinal epithelium are spermatogonia which can divide to produce more **spermatogonia** or **primary spermatocytes** that are committed to developing into sperm.

**Primary spermatocytes** are located in the middle region of the seminiferous tubule. These cells have a prolonged prophase in **meiosis I** that allows for extensive time for crossovers to develop between homologous chromosomes. After completing meiosis I, primary spermatocytes give rise **secondary spermatocytes**.

Secondary spermatocytes proceed rapidly through meiosis II to produce spermatids. The short life-span of secondary spermatocytes means they are rarely found in the germinal epithelium.

Spermatids are the products of completed meiosis and are haploid. They remain connected to one another by cytoplasmic bridges which result from incomplete cytokinesis. The bridges mediate sharing of cytosolic components and communication between spermatids and allow for synchronous maturation. Note the condensed nucleus.



Spermatids mature into spermatozoa through a process called spermiogenesis that consists of the following changes:

- 1) **An acrosome**, containing hydrolytic enzymes, develops from the Golgi and overlies the dense, elongated nucleus.
- 2) **A flagellum** grows from the side opposite to the acrosome and extends into lumen of the seminiferous tubule.
- 3) **Mitochondria** aggregate around the flagellum.
- 4) **The bulk of the cytoplasm is cast off as a residual body**, leaving only a thin rim of cytoplasm around the nucleus.

## **Sertoli Cells:**

Sertoli cells extend from the basement membrane of the germinal epithelium to the lumen of the tubule and envelope the developing sperm cells. Sertoli cells are joined to one another by junctional complexes that form the blood-testis barrier. This barrier separates the germinal epithelium into a basal compartment and an adluminal compartment. Spermatogonia reside in the basal compartment but subsequent stages of sperm development reside in the adluminal compartment.

The blood-testis barrier serves three important functions in sperm development:

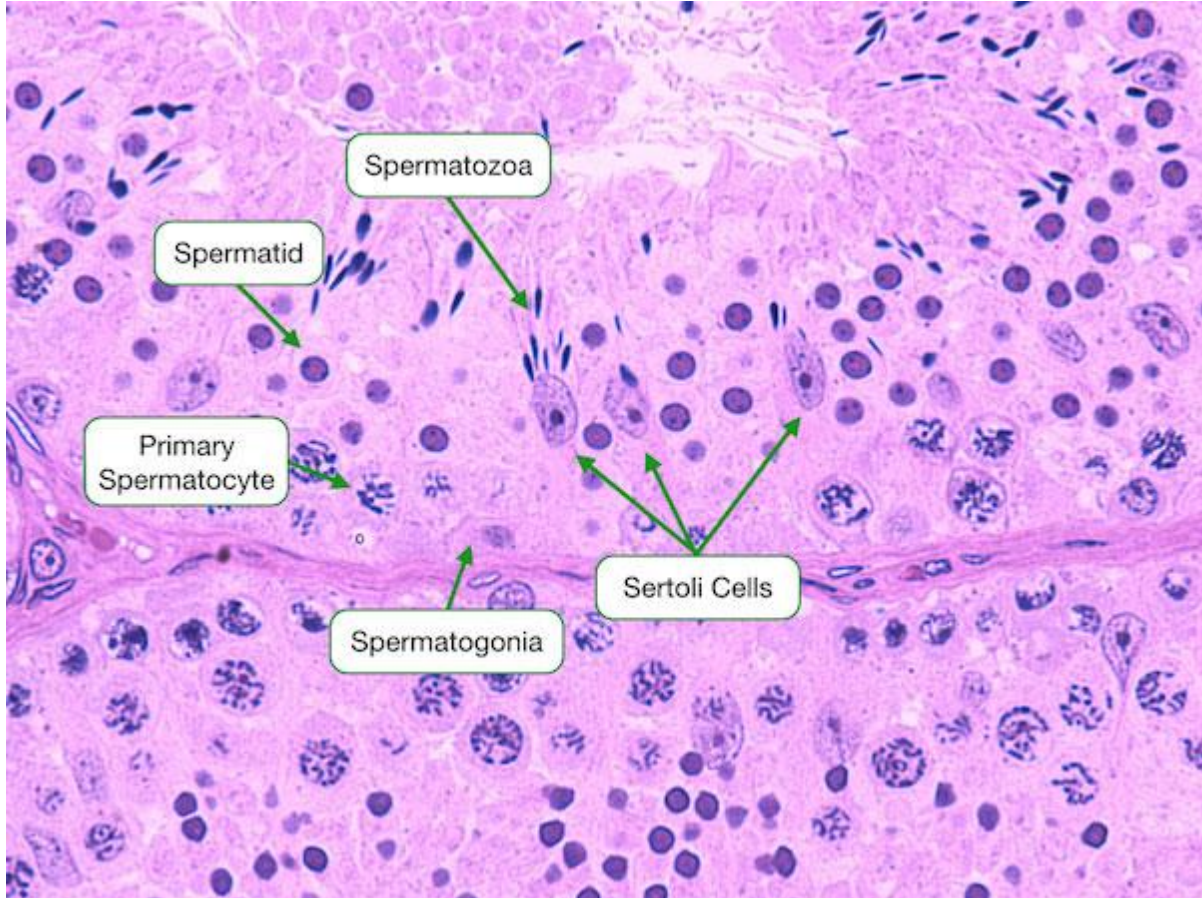
Allows Sertoli cells to create a unique chemical environment in the lumen of the tubule to facilitate sperm development

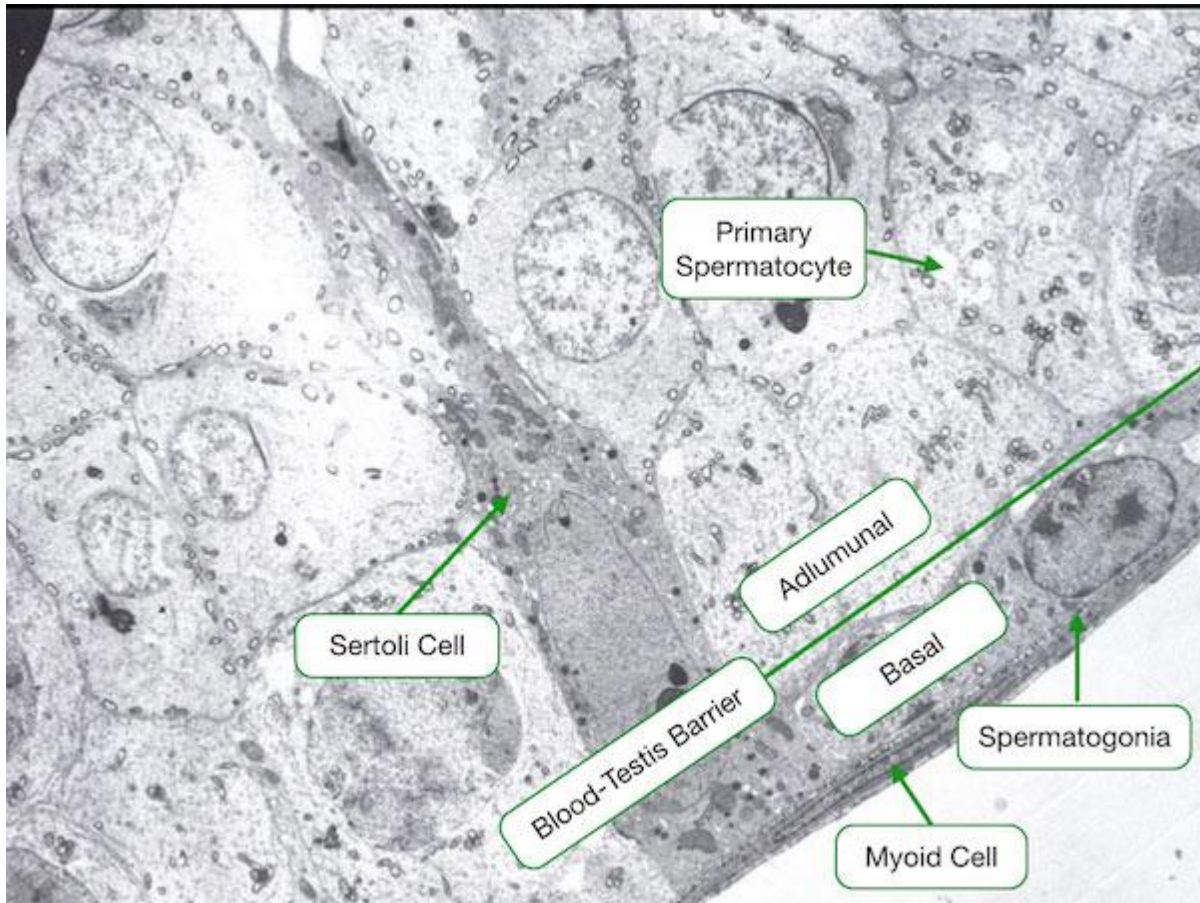
Prevents passage of cytotoxic agents into the seminiferous tubules

Prevents sperm from entering the blood stream and triggering an immune reaction to sperm. Generation of antibodies against sperm could reduce their ability to swim or fertilize an egg.

Sertoli cells synthesize **androgen-binding protein (ABP)** that keeps **testosterone levels high in the seminiferous tubules**. They also produce

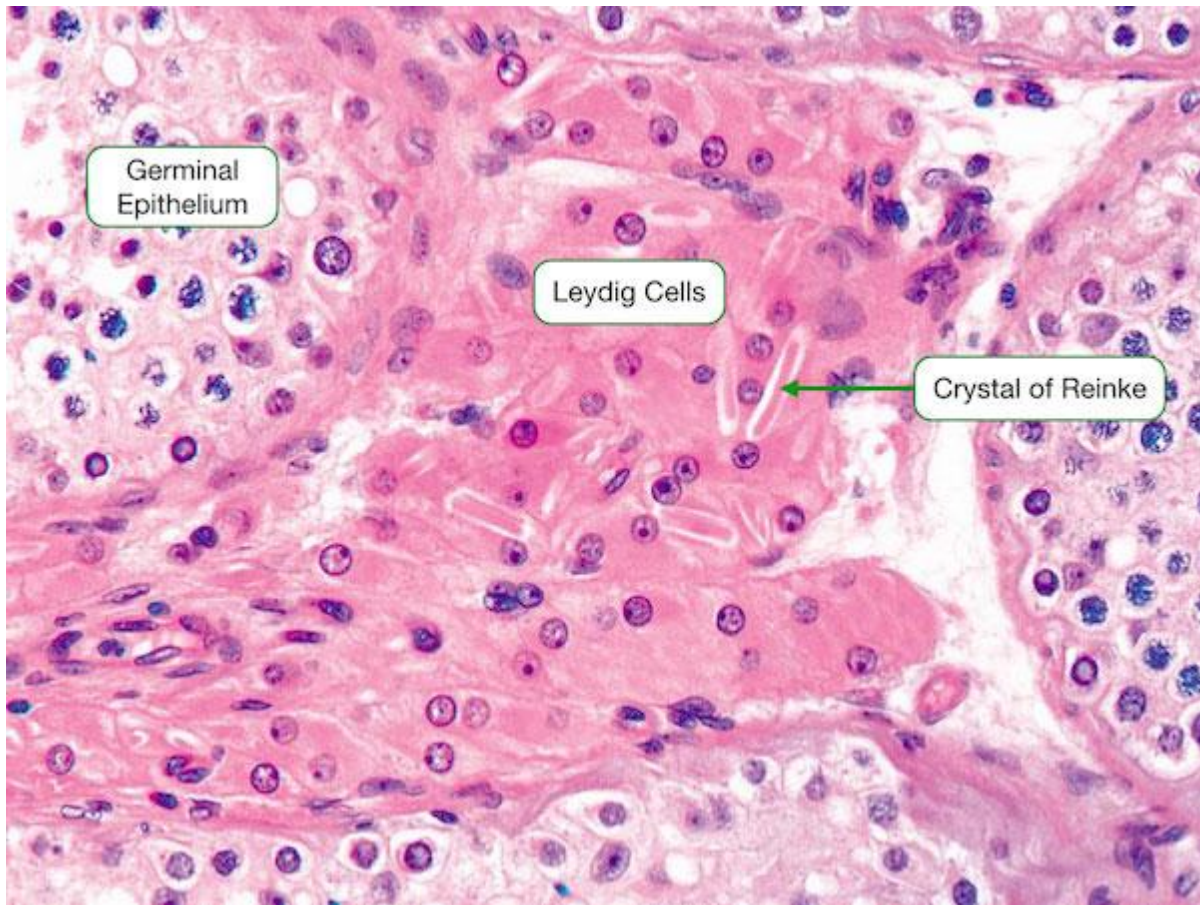
growth factors that support sperm cells and spermatogenesis. Follicle-stimulating hormone (FSH) increases production of ABP and growth factors. **Inhibin**, produced by Sertoli cells, reduces production of FSH.





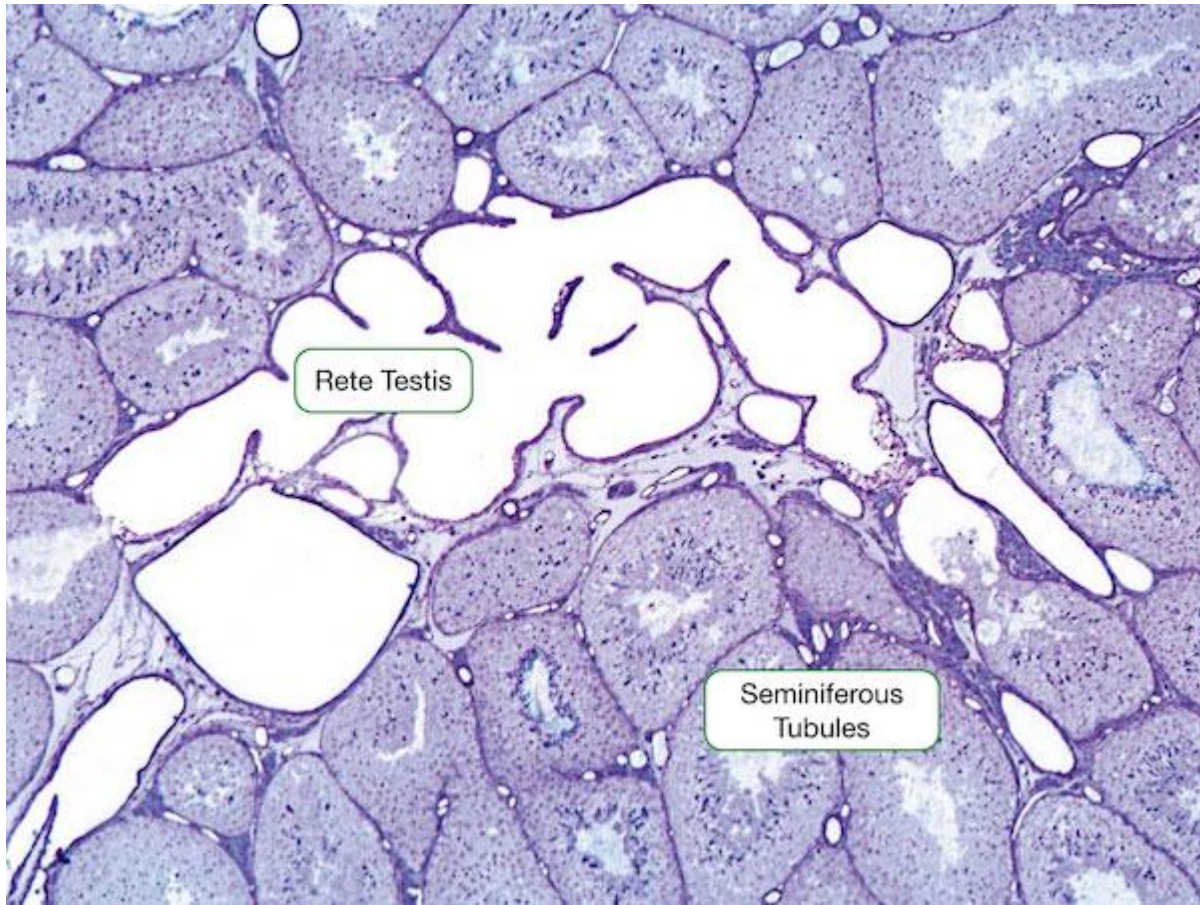
## Leydig Cells:

Leydig (interstitial) cells are located within the loose connective tissue surrounding the seminiferous tubules. They appear pale due to their high cholesterol content and often contain crystals of Reinke, which have an unknown function. Leydig cells produce testosterone which is responsible for male secondary sexual characteristics and the maintenance of the germinal epithelium. Leutenizing hormone (LH), released by cells in the anterior pituitary, stimulates production of testosterone in Leydig cells.



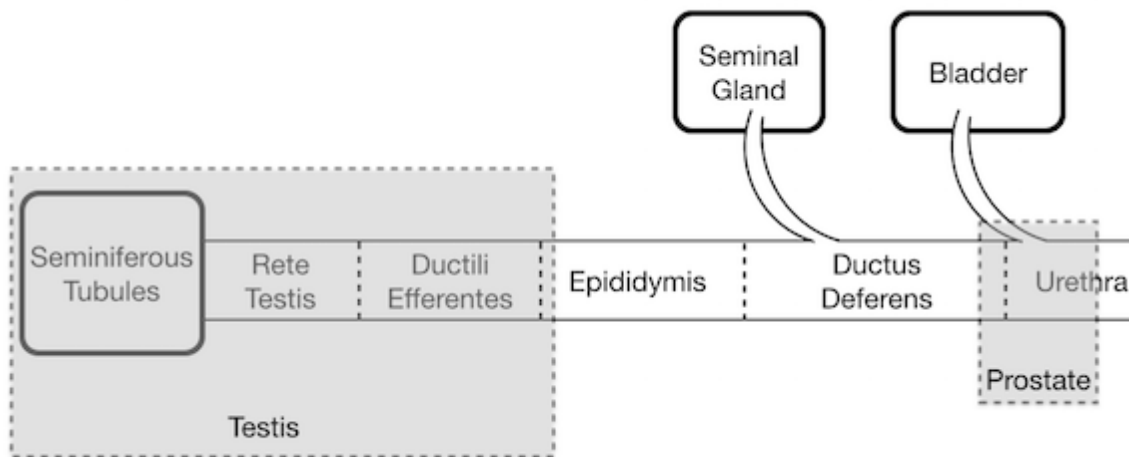
## Rete Testis:

The rete testis connects the seminiferous tubules to the ductus efferentes. It is lined by ciliated cuboidal epithelial cells that also contain microvilli. The activity of the cilia helps to move the spermatozoa along the tube, as they are immobile until they reach the epididymis. The microvilli absorb excess materials, including protein and potassium, from the seminal fluid.



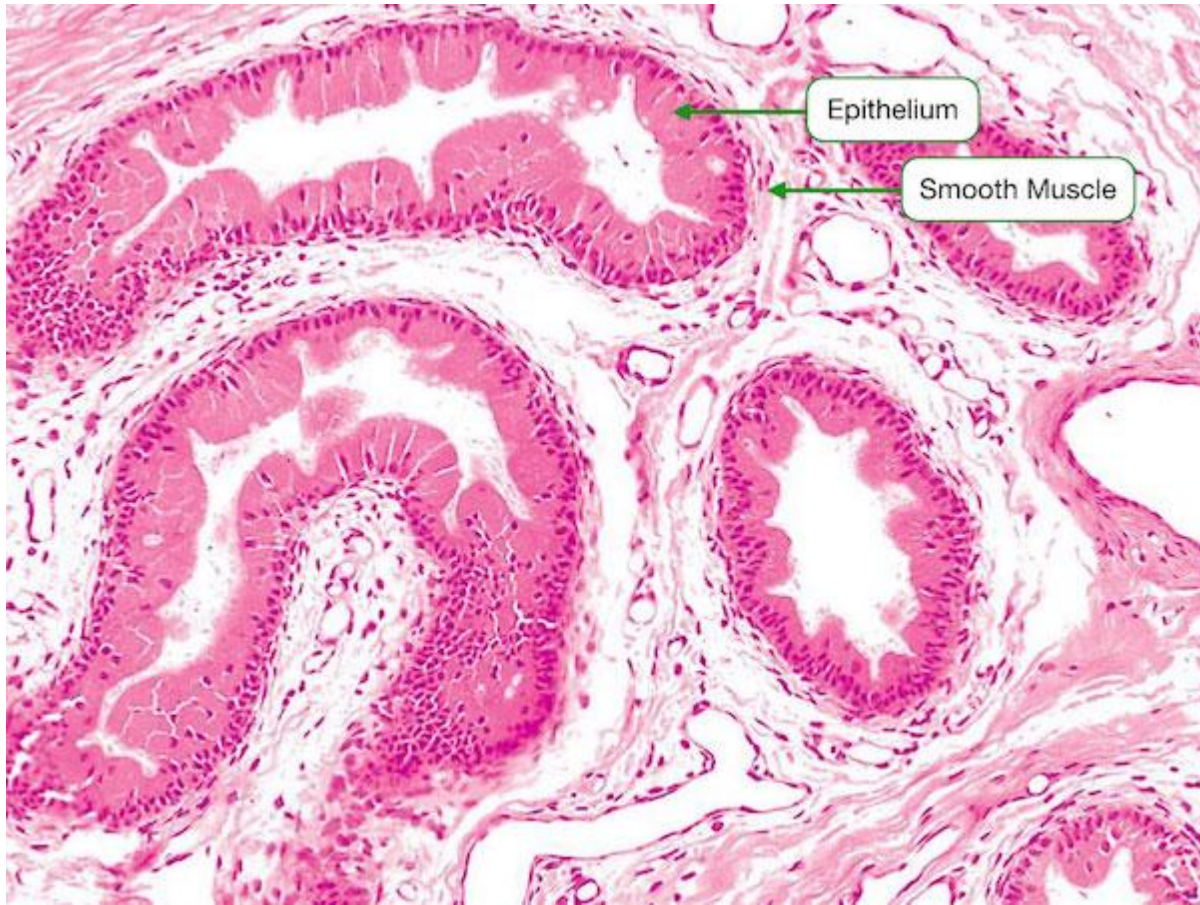
## Conduction of Sperm:

The male reproductive tract is a long tube that brings the spermatozoa from the testes to the outside of the body. The tract comprises several segments with different structures and functions. As discussed previously, spermatozoa are produced in the seminiferous tubules in the testis. Spermatozoa flow from the seminiferous tubules into the rete testis and then the ductuli efferentes. The ductuli efferentes merge to form the epididymis which is the site where spermatozoa gain motility. The epididymis transitions into the ductus deferens which receives secretions from the seminal gland and prostate. The ductus deferens from each side merge with the urethra.



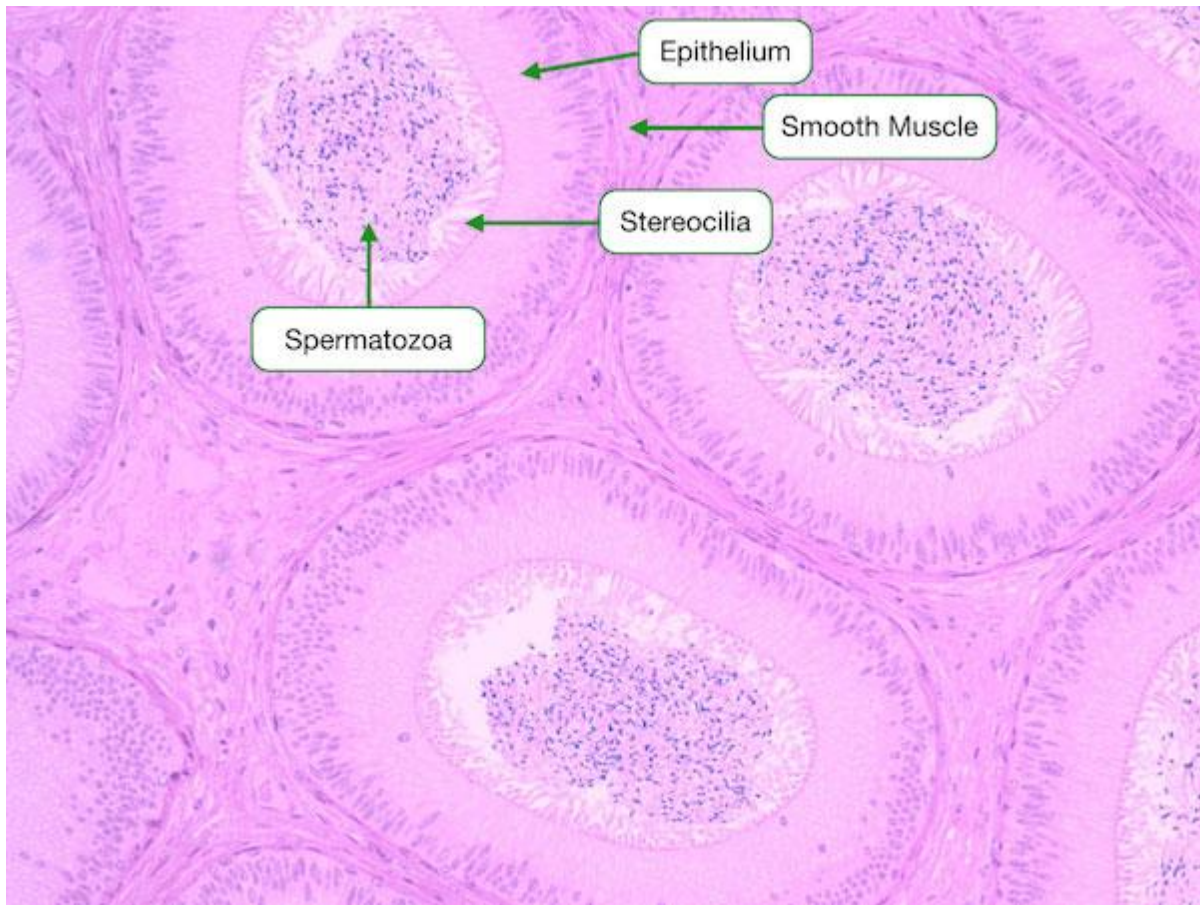
## Ductuli Efferentes

The ductuli efferentes emerge from the dorso-superior margin of each testis. They originate from the rete testis and gradually fuse to form the ductus epididymis. The epithelium has a characteristic scalloped appearance that results from a lining that contains both cuboidal and columnar epithelial cells. A layer of smooth muscle surrounds the walls. The non-ciliated cells reabsorb testicular fluid, while the ciliated cells propel the immobile sperm to the epididymis, where they gain the ability to swim.



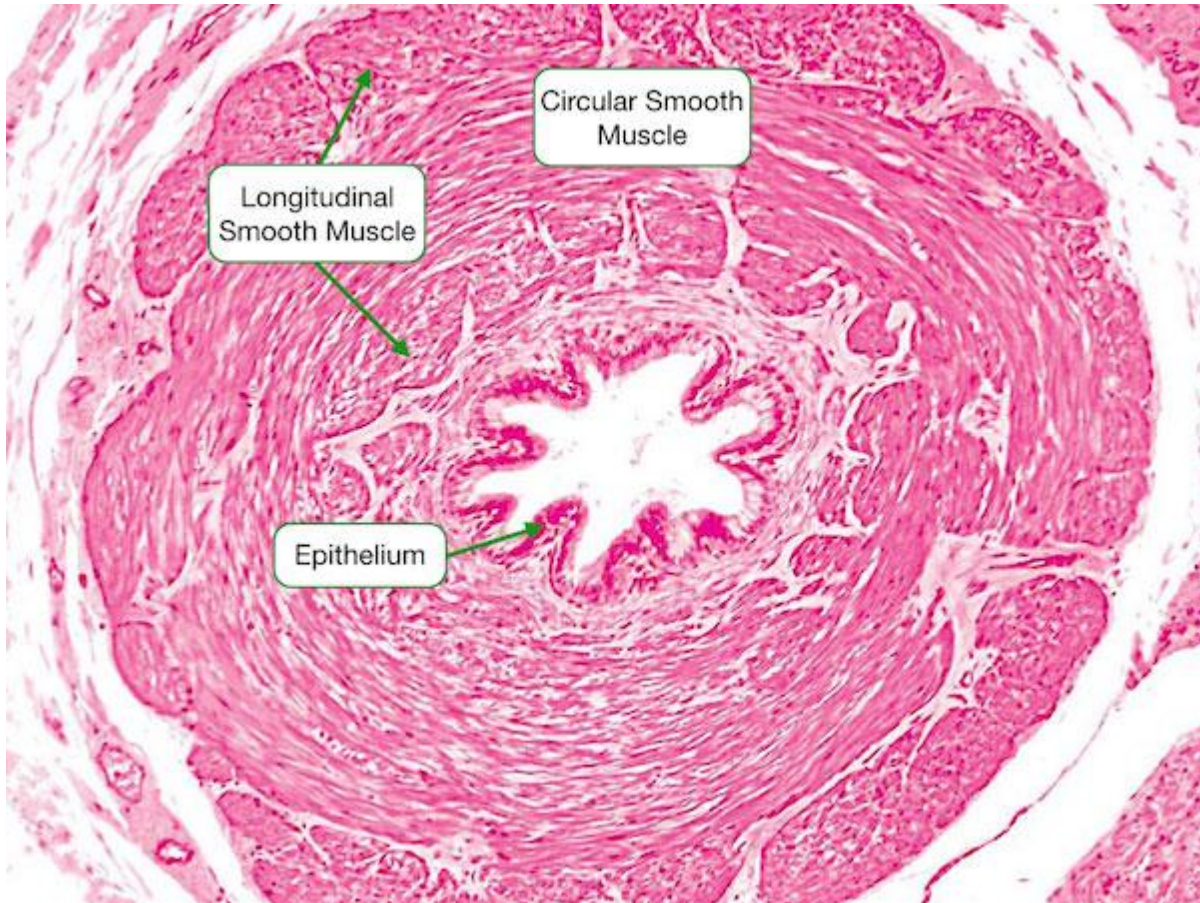
## Epididymis:

The epididymis is a muscular, convoluted tubule that stores spermatozoa and is the site at which they acquire their motility. It is lined by a pseudostratified epithelium whose cells contain non-motile stereocilia. These stereocilia absorb much of the excess fluid containing the spermatozoa. The epithelium of the epididymis also contains mitotic basal cells. In this section, the spermatozoa can be seen in the lumen throughout the epididymis.



## Ductus Deferens:

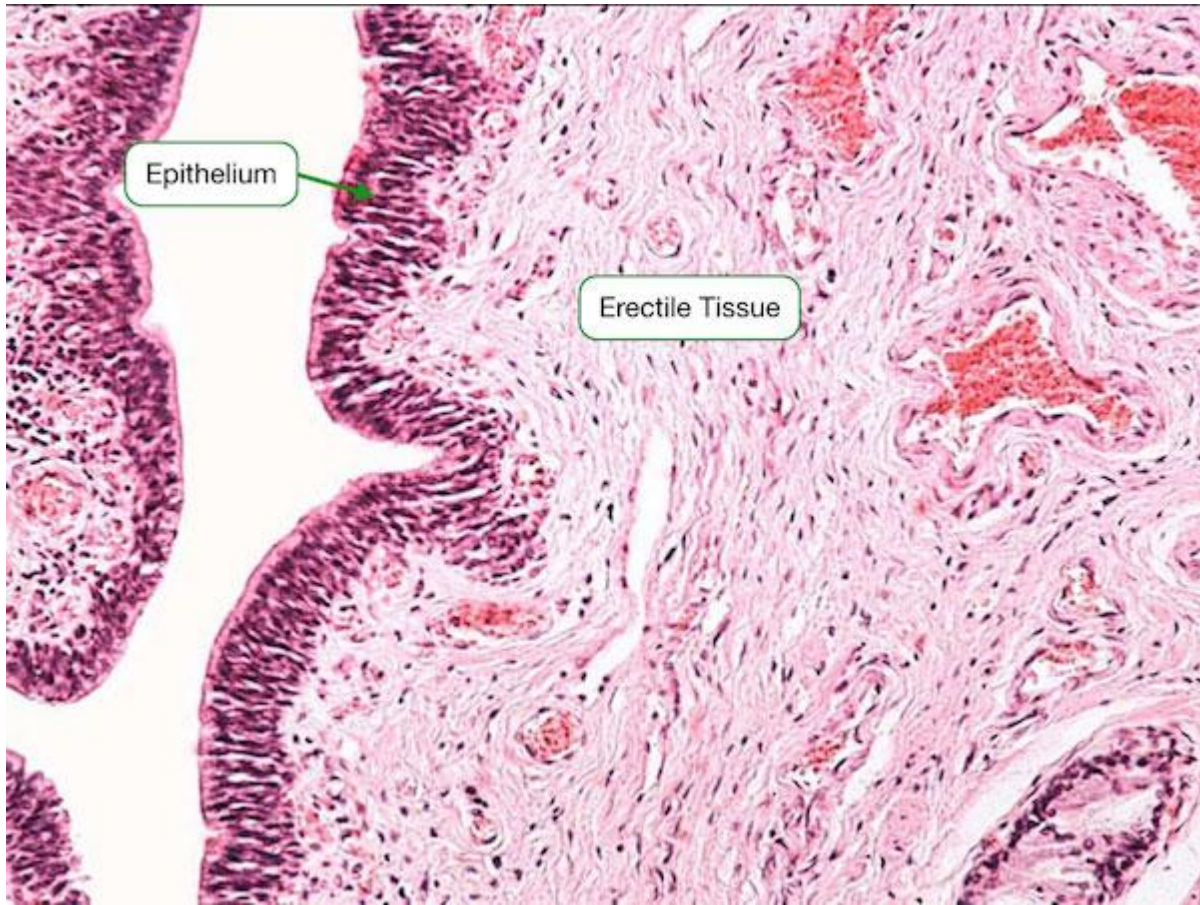
The ductus deferens is another muscular tubule that carries sperm downstream from the epididymis. Its wall is thicker than that of the epididymis and contains three muscular layers: inner longitudinal, middle circular, and outer longitudinal. The epithelium of the ductus deferens is similar to that of the epididymis, with pseudostratified cells bearing stereocilia.



The distal portion of the ductus deferens is called the ampulla and receives secretions from the seminal vesicles. The duct is now referred to as the ejaculatory duct and ducts from each side will merge and join the urethra as it runs through prostate gland.

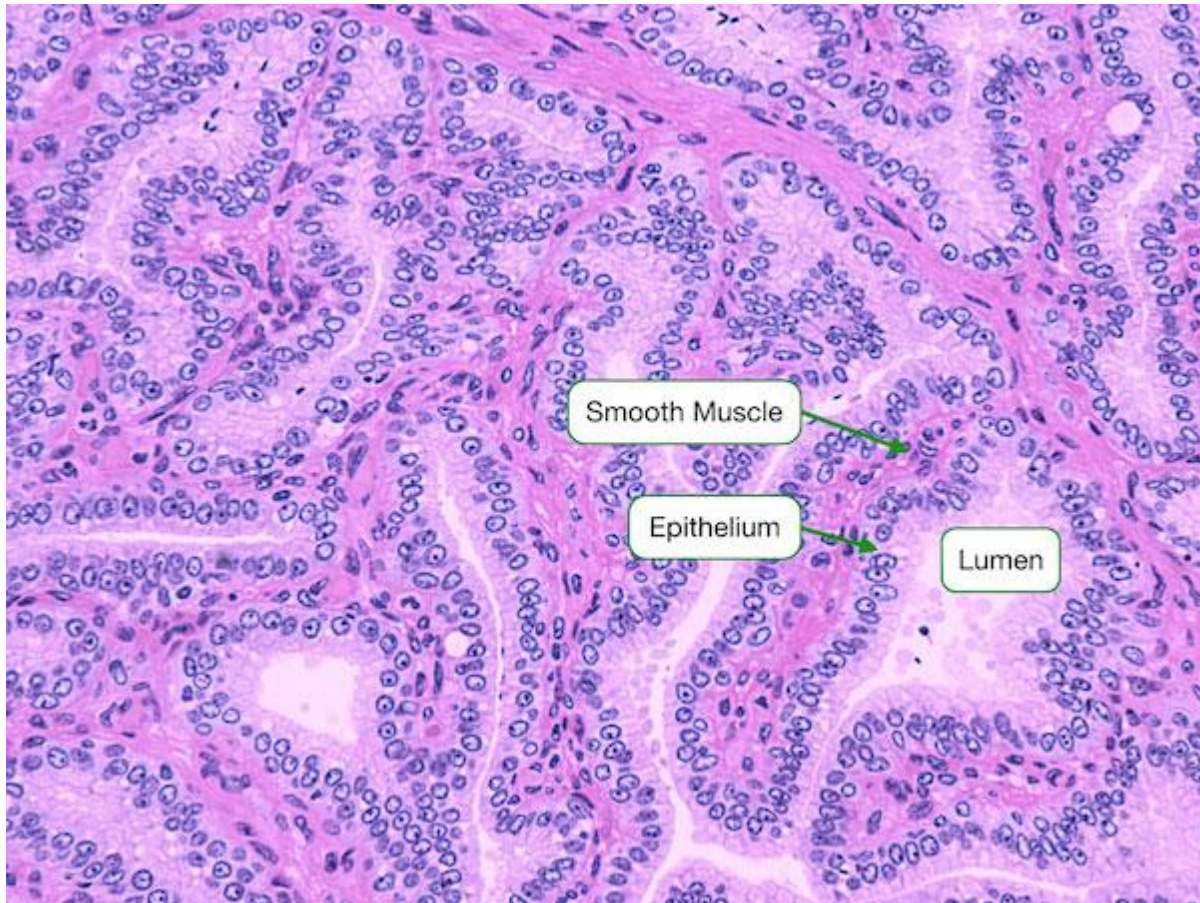
### Urethra:

The urethra is lined primarily by stratified or psueodstratified columnar epithelial cells, but its opening displays a stratified squamous epithelium. Erectile tissue surrounds the urethra and contains numerous blood vessels. During an erection, the arteries dilate to fill the sinuses, which obstruct venous outflow and traps blood in the penis.



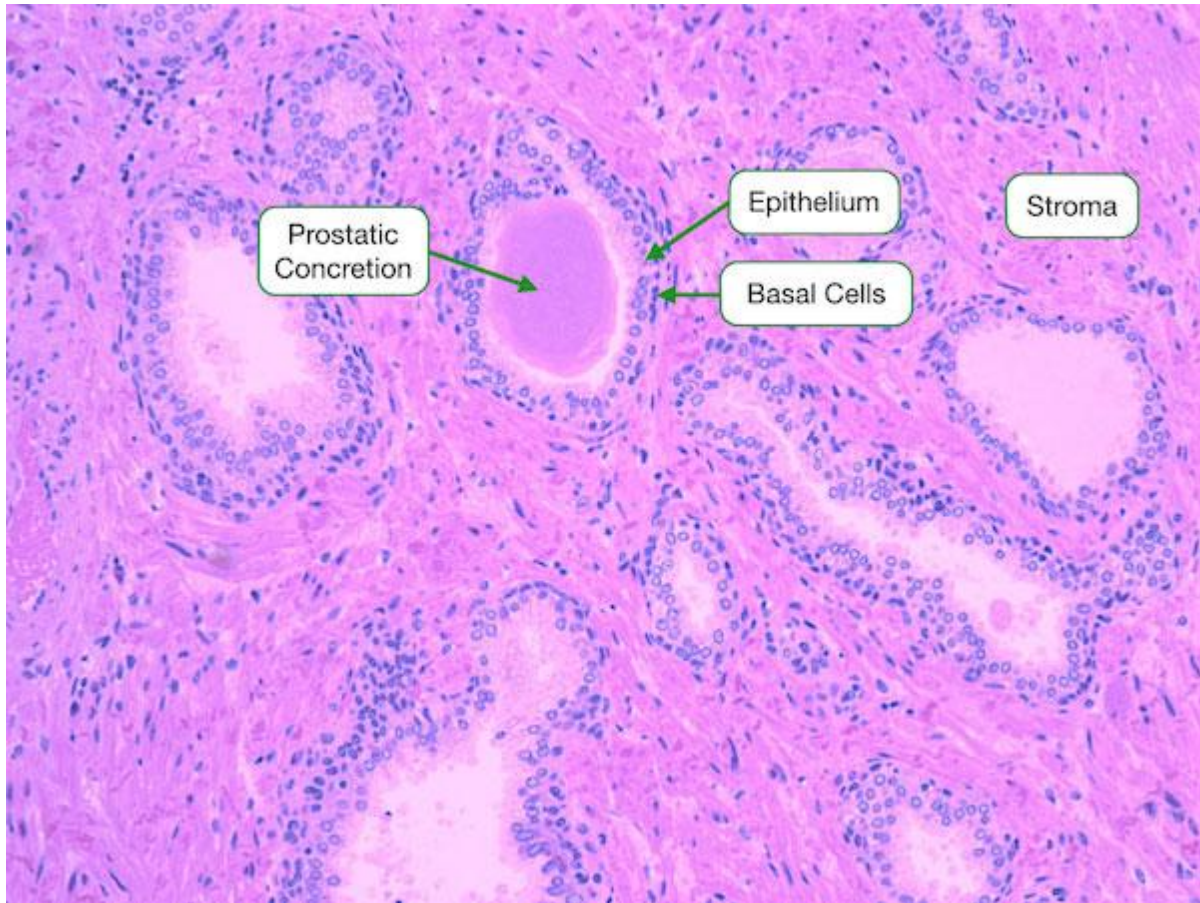
## Seminal Vesicle:

Seminal vesicles are glandular sacs that produce a secretion that composes 80% of the seminal fluid and contains fructose, fibrinogen, and prostaglandins. The secretion empties via a short duct into the ampulla of the ductus deferens. The seminal vesicles appear as honeycombed saccules with thin, highly branched folds of mucosa, lined by a pseudo stratified columnar epithelium. Observe the coat of smooth muscle surrounding the saccular dilation of the gland. Its contraction expels the accumulated secretion during ejaculation.



## Prostate Gland:

The prostate is a walnut-sized conglomeration of tubulo-acinar glands that surrounds the initial segment of the urethra. This gland produces a secretory product containing citric acid and proteolytic enzymes that prevent coagulation of semen. The epithelium that lines the glands is usually columnar with numerous flattened basal cells also visible. The lumen of the glands often contain prostatic concretions that accumulate over time. Their significance is unknown but they make a useful marker for identifying the prostate. The glands are surrounded by a stroma that contains connective tissue and smooth muscle.



## Functions/Roles of the testes:

The two main functions of the testes are to produce sperm and to produce the male sex hormones (androgens). This makes the testis both an endocrine and exocrine gland (which release substances into a duct rather than directly into the blood like endocrine glands).

## Testosterone has many functions including:

Growth and development of male reproductive organs (penis and testes)

Growth spurt at puberty

Production and maturation of sperm

Growth of facial and body hair

Deepening voice

Growth of the Adam's apple

Sex drive/libido

Maintenance of bone density

Maintenance of muscle mass and strength

Fetal development of male reproductive organs

Increasing red blood cell count

## Hormones produced by the testes:

### Testosterone

Testosterone is the main hormone that promotes the development and maintenance of male characteristics. Testosterone can be converted into a more active male sex hormone, called dihydrotestosterone (DHT).

### Anti-Mullerian hormone (AMH)

Anti-Mullerian hormone (AMH) is important for sex differentiation in the unborn baby during early pregnancy. It is produced in male babies by the testes, where it shuts down the development of Mullerian (female) ducts. These ducts would otherwise develop into parts of the female reproductive tract (fallopian tubes, uterus and vagina). This allows the development of the epididymis, vas deferens and the seminal vesicles of the testes.

## Estradiol:

Estradiol is produced in small amounts in men by the Leydig cells of the testes. Levels of estradiol in the blood of men are similar to (in fact slightly higher than) those in women after menopause. In men, estradiol contributes to bone health and the maturation of sperm.

## Inhibin B

Inhibin B is released from the Sertoli cells in the seminiferous tubules of the testes. It plays a key role in regulating follicle stimulating hormone (FSH) release from the pituitary gland.

## Keeping testis hormone levels in balance

### Testosterone

Testosterone levels are controlled through a negative feedback loop. The hypothalamus releases gonadotrophin releasing hormone (GnRH) which signals the pituitary gland to release luteinising hormone (LH). LH signals the testes to produce testosterone. When testosterone levels reach a threshold, the hypothalamus makes less GnRH. This loop keeps testosterone levels within a normal range.

### Inhibin B

Inhibin B levels are controlled through a negative feedback loop. In fertile men, follicle stimulating hormone (FSH) released from the pituitary gland signals the testes to make inhibin B. This increase in inhibin B signals the pituitary to decrease FSH production. This loop keeps inhibin B levels within a normal range.