

MALE REPRODUCTIVE SYSTEM

MSC PHYSIOLOGY & PHARMACOLOGY

PHD PHARMACOLOGY

gaithali@yahoo.com

pharm.ghaithali@uomustansiriyah.edu.iq

<https://orcid.org/0000-0001-5153-4094>

Asst. Prof. Dr. Ghaith Ali Jasim Al-Zubaidy

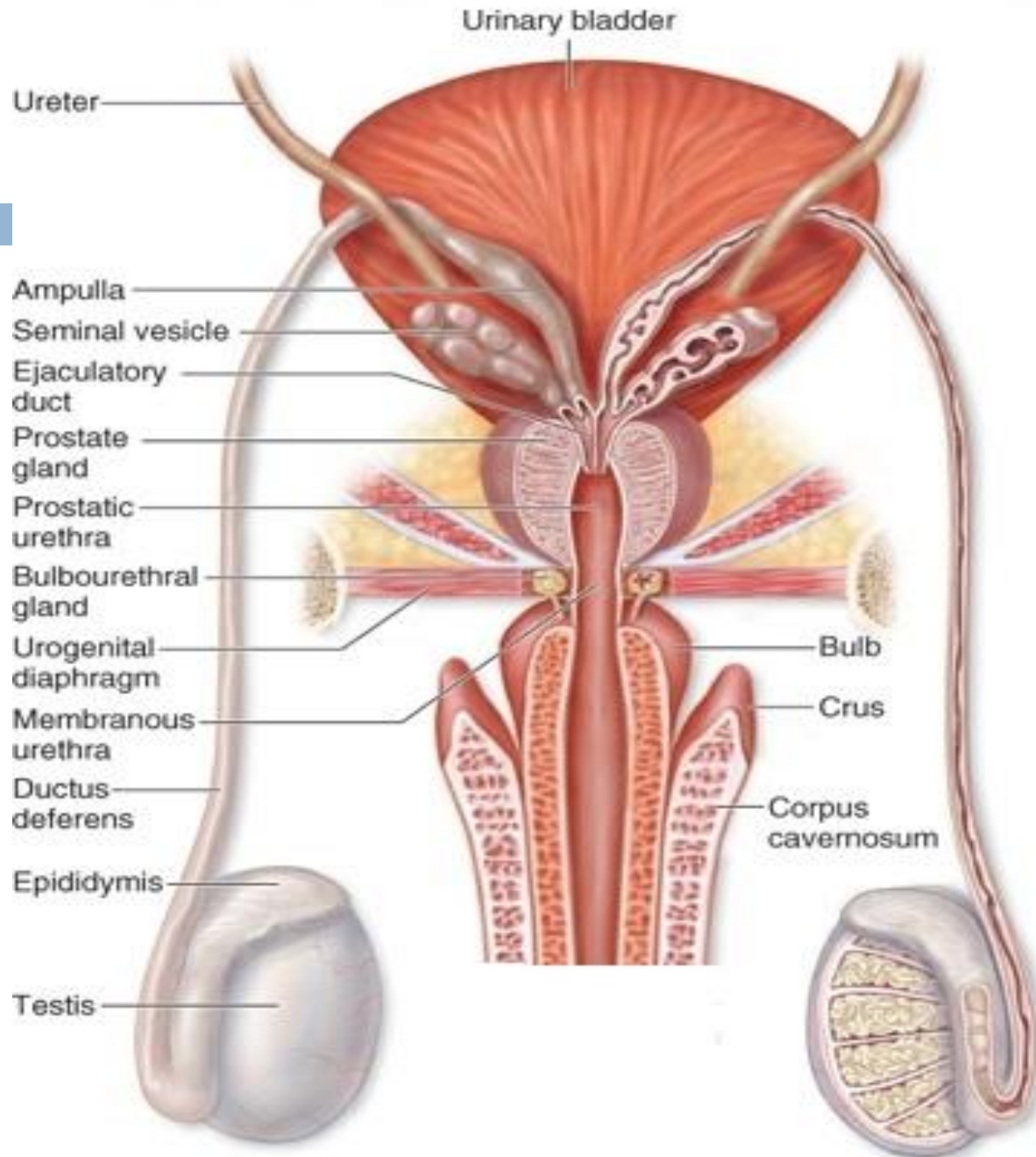
- The Reproductive system includes the following:
- Gonads: or reproductive organs that produce gametes & hormones.
- Ducts: that receive and transport the gametes.
- Accessory glands & organs that secrete fluids (into the same glands or other excretory ducts).
- External genitalia.

- The male and female reproductive systems are functionally deferent:
- *in an adult male, the testes or male gonads secrete sex hormones called androgens (**testosterone**) & produce **1/2 billion sperm each day.**
- *in an adult female the ovaries or female gonads, typically release **only one immature gamete** (called oocyte) **per month.**

The Male reproductive system:

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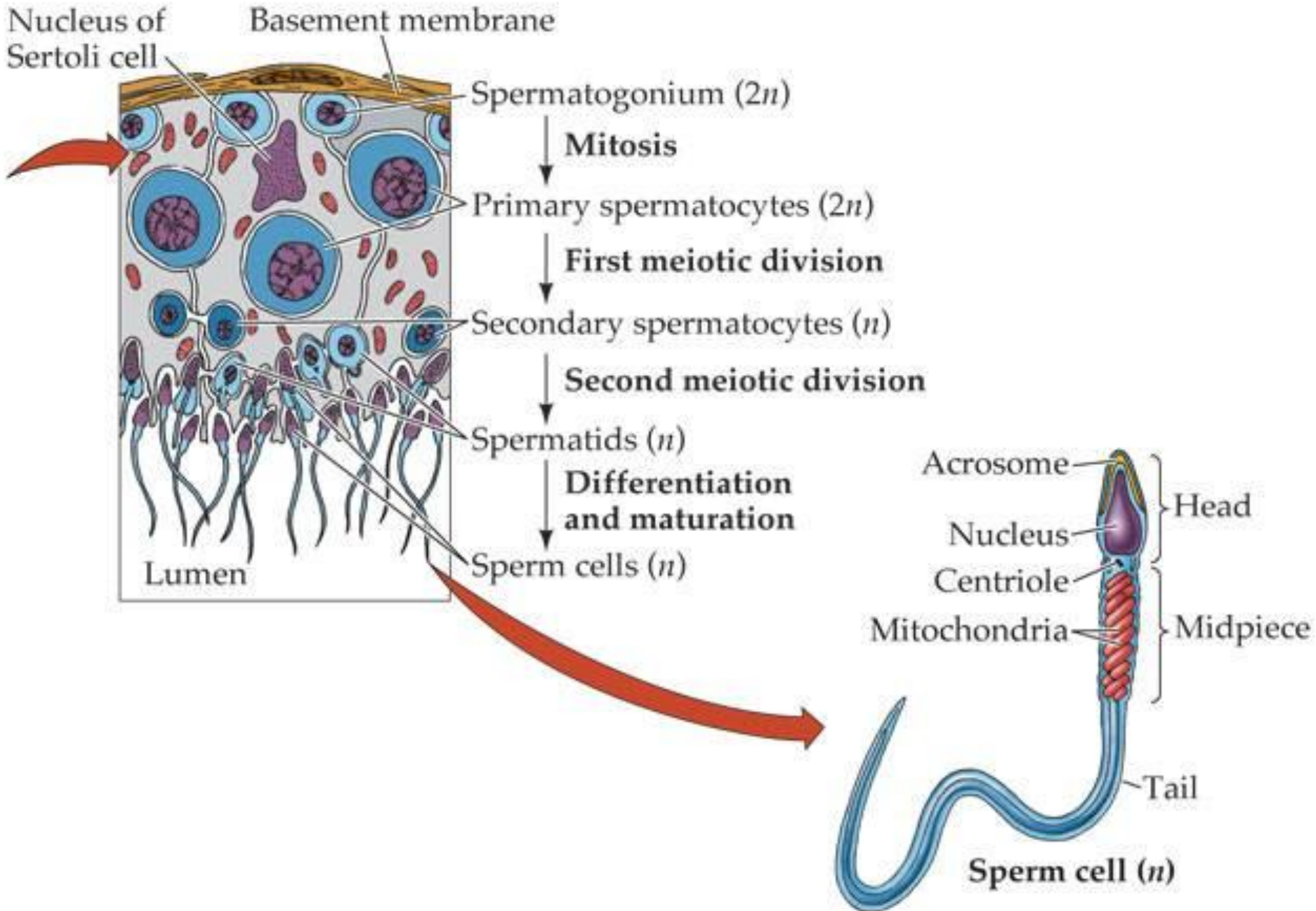
- In the testes the sperm cells or spermatozoa, travel within the epididymis→ the ductus deferens or vas deferens→ the ejaculatory duct→ &the urethra.
- Accessory organs: the seminal vesicles, the prostate gland & the bulbourethral glands secrete into the ejaculatory ducts & urethra. The external genitalia consist of the scrotum (which encloses the testes) & the penis.



Histology of the testes:

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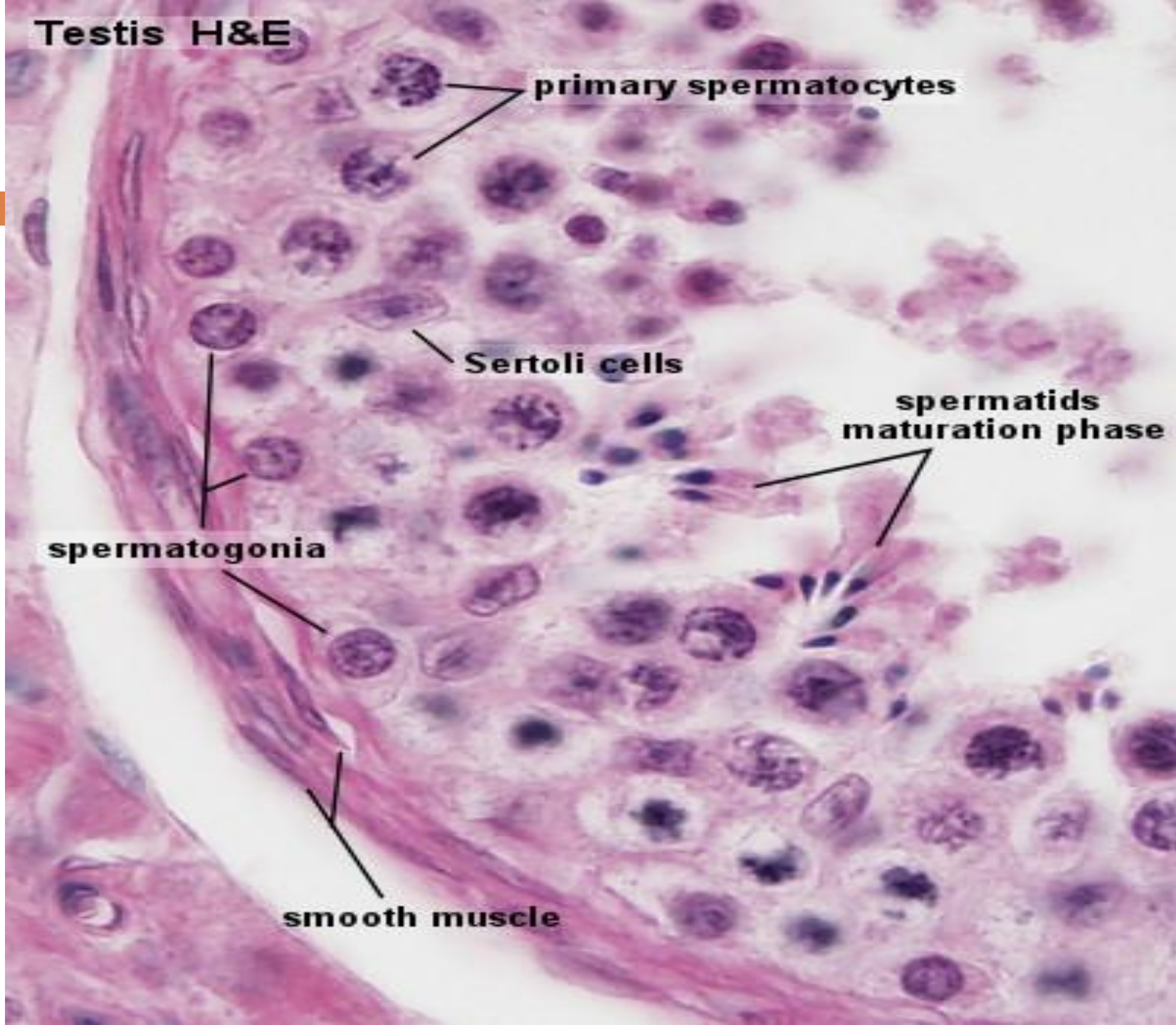
- The testes are subdivided by the **septa** to series of lobules, and **the seminiferous tubules** (which are tightly coiled) are distributed among the lobules. Typical testes contain nearly 1/2 mile of seminiferous tubules & the sperm production occurs within these tubules.
- Each seminiferous tubule is surrounded by delicate capsule, & loss connective tissue that fills the spaces between the tubules. Within those spaces are numerous blood vessels and large **interstitial cells (or Leydig cells)**, interstitial cells are responsible for the production of androgens (most important is testosterone).



LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 43.9 Seminiferous Tubules Are the Site of Spermatogenesis (Part 2)
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Testis H&E

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primary spermatocytes

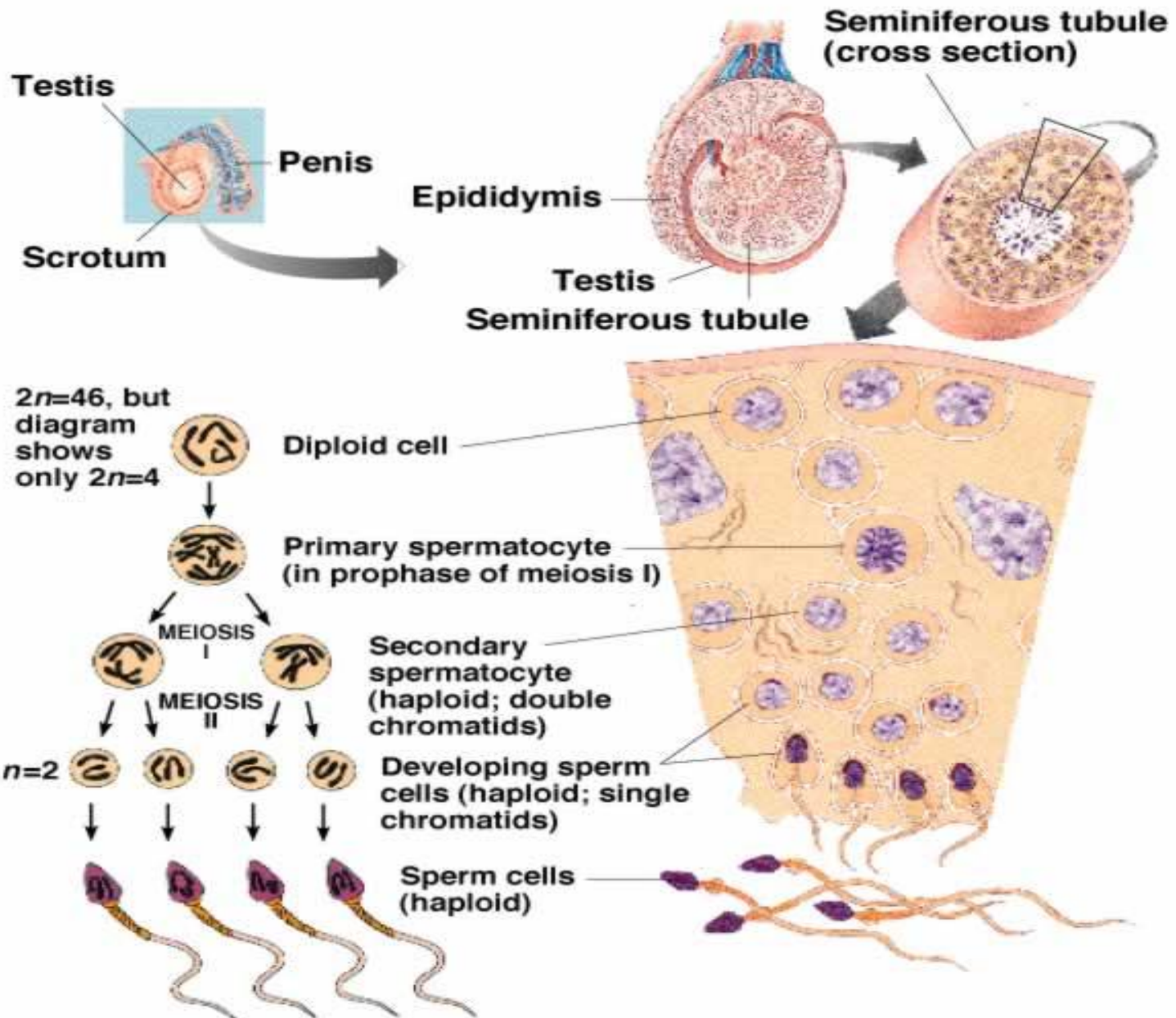
Sertoli cells

**spermatids
maturation phase**

spermatogonia

smooth muscle

- Sperm cells (or **spermatozoa**) are produced by the Spermatogenesis begins at the outer layer of cells in the seminiferous tubules & proceed towards the lumen.
- Stem cells called **spermatogonia** divided by **mitosis** to produce generations of daughter cells, some of which differentiate into spermatocytes, while **meiosis** is a specialized form of cell division involved only in the production of gametes (sperms & ovaries).
- *The spermatocytes give rise to the **spermatids**.*
- (at each step in this process, the daughter cells move closer to the lumen of the tubule. The spermatids differentiate into spermatozoa, this differentiation process is called Spermiogenesis & ends as a physically mature spermatozoa & spermoigenesis is the last step in spermatogenesis).



Spermatogenesis involves three ***integrated processes:***

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1. ***Mitosis***
2. ***Meiosis***
3. ***Spermiogenesis***

1. **Mitosis:** is a process that separates the duplicated chromosomes of the original cells into two identical nuclei. The cell division produces daughter cells which are pushed toward the lumen of the tubule. These cells differentiate into spermatocytes that prepare to begin meiosis.

Mitosis is a part of the process of somatic cell division, which produces two daughter cells containing **46 chromosomes (23 pairs)**, called the **diploid cells** (because the daughter cells contain both members of each chromosome pair).

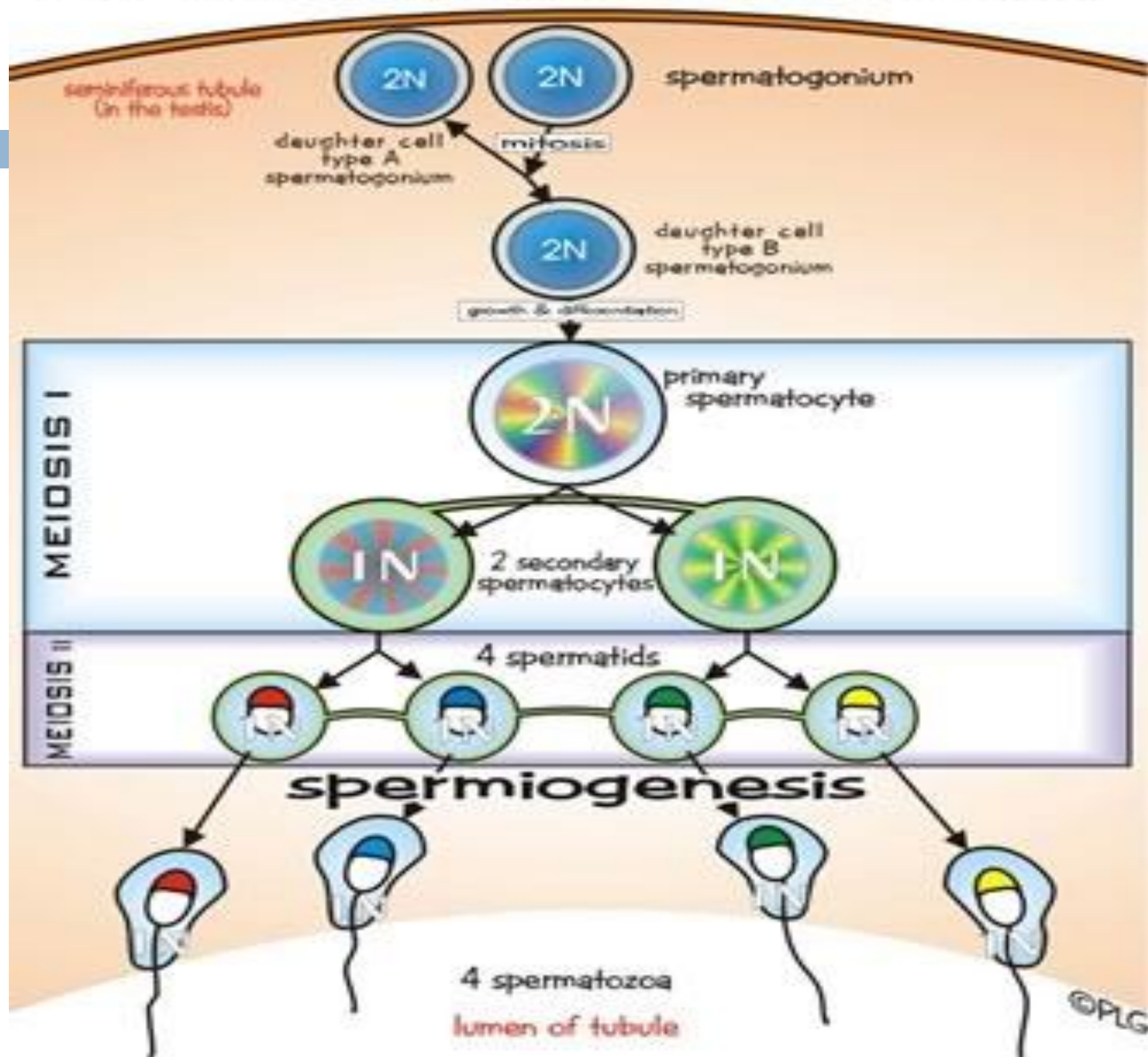
2. Meiosis: is a special form of cell division involved in gamete production (the **gametes contain half the normal chromosomes**), so the fusion of the nuclei of a sperm & an ovum produces a cell that has a normal number of chromosomes (46).

In the seminiferous tubules, the meiotic divisions of spermatocytes produce spermatids (*undifferentiated male gametes*).

Meiosis involves two cycles of cell division (meiosis I & II), and produce **four cells**, each contain **23 individual chromosomes** called **haploid cells** (because these cells contain only one member of each chromosome). These are the same in the formation of sperm & ova.

3. **Spermiogenesis** : spermatids are small & unspecialized cells in spermiogenesis the spermatids differentiate into a *physically mature spermatozoa*. (spermiogenesis involves major changes in spermatids internal & external structure).
- Spermatids undergoing spermiogenesis are not free in the seminiferous tubules but they are surrounded by the cytoplasm of the **Sustentacular cells**.
 - The process from spermatogonial division to Spermatation, takes approximately 9 weeks.

SPERMATOGENESIS



Spermatogenesis & Sustentacular cells function:

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- these cells have 6 functions that directly or indirectly affect mitosis, meiosis & spermiogenesis within the seminiferous tubules:

a- Maintenance of the blood – testes barrier:

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- the seminiferous tubules are isolated from the general circulation by a blood – testes barrier. **The sustentacular cells are joined by tight junctions forming a layer that divides the seminiferous tubules into an outer basal compartment (contains spermatogonia) and an inner luminal compartment (meiosis & spermiogenesis occurs).**
- (transport across the sustentacular cells is tightly regulated so that conditions in the luminal compartment remain very stable. And the fluid within the seminiferous tubules is produced by the sustentacular cells which also regulate the fluids composition.

- - the blood – testes barrier is essential for **preserving the differences** between the tubular fluid & interstitial fluid.
- - developing spermatozoa contain sperm-specific antigens in their cell membrane & these antigens are not found in the **somatic cell membrane**, so they would be attacked by the immune system if blood – testes barrier did not prevent being detected.

b- Support of mitosis & meiosis:

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- spermatogenesis depends on the stimulation of sustentacular cells by circulating follicle-stimulating hormone (FSH) & testosterone.
- -stimulated sustentacular cells then promote the division of spermatogonia & the meiotic divisions of spermatocytes.

c- Support of spermiogenesis:

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- the sustentacular cells surround & enfold the spermatids providing nutrients & chemical stimulation that spermatids providing nutrients & chemical stimulation that promote development.

d- Secretion of inhibin:

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- inhibin is a peptide hormone secreted in response to factors released by the developing sperm.
- -inhibin depresses the pituitary production of (FSH) from pituitary & gonadotropin-releasing hormone (GnRH) from the hypothalamus.
- -the faster the rate of sperm production, the greater the amount of inhibin secreted. So sustentacular cells provide a feed back control of spermatogenesis.

e- Secretion of androgen-binding protein:

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- androgen-binding protein(ABP) binds androgen (testosterone) in the fluid contents of the seminiferous tubules, this protein is important in elevating the concentration of androgens within the tubules & stimulated spermiogenesis(the production of ABP is stimulated by FSH).

f- Secretion of Mullerian-inhibiting factor:

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- MIF is secreted by sustentacular cells in the developing testes (this hormone causes regression of the fetal mullerian duct). Inadequate MIF production leads to failure of the testes to descend into the scrotum.

The Reproductive Tract:

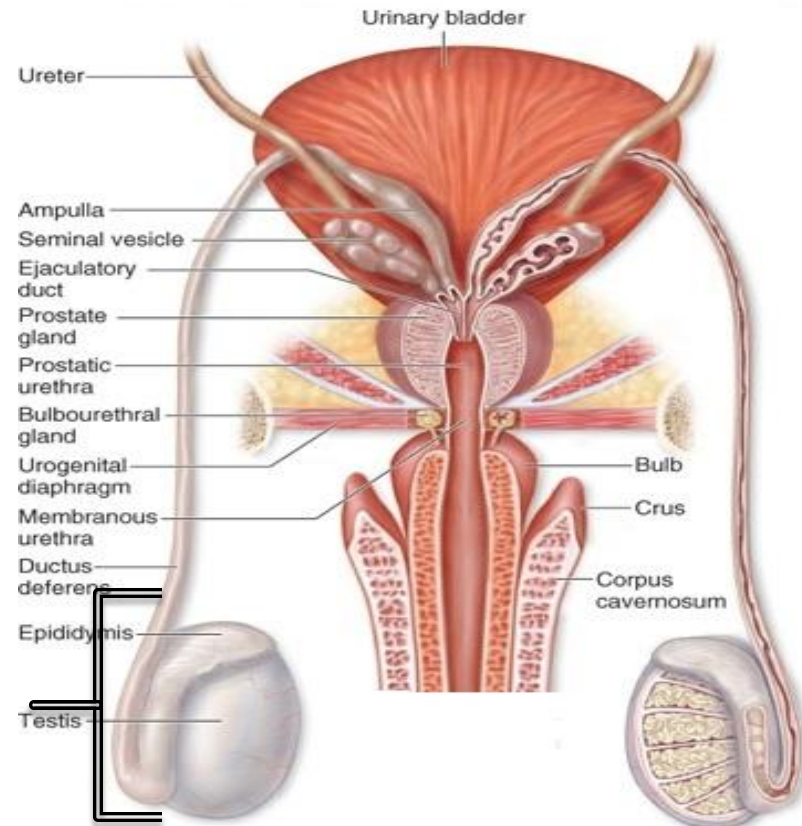
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- The testes produce physically mature spermatozoa (but they are incapable of successful fertilization). The other proteins of the male reproductive system are responsible for the functional maturation (nourishment, storage & transport of spermatozoa).

The Epididymis:

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- It lies along the posterior border of the testis, the epididymis has a head, body & a tail.



The functions of Epididymis :

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- 1-**it monitors & adjusts the composition of the tubular fluid (epididymis is lined by a pseudo stratified columnar epithelium so the cilia increase the surface area available for absorption & secretion into the fluid in tubule).
- 2-**it acts as a recycling center for damaged spermatozoa (cellular debris & damaged spermatozoa are absorbed in the epididymis).

functions..cont..

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3-it stores spermatozoa & facilitates their functional maturation: it takes about two weeks for a spermatozoon to pass through the epididymis, during this period the **spermatozoon completes its functional maturation.**

Spermatozoa leaving the epididymis are mature but they remain immobile. So to become active, motile & fully functional they must undergo **Capacitation** which occurs in two steps:

- Spermatozoa become motile when mixed with secretions of seminal vesicles.
- Spermatozoa become capable of fertilization when exposed to conditions inside the female reproductive system.

functions..cont..

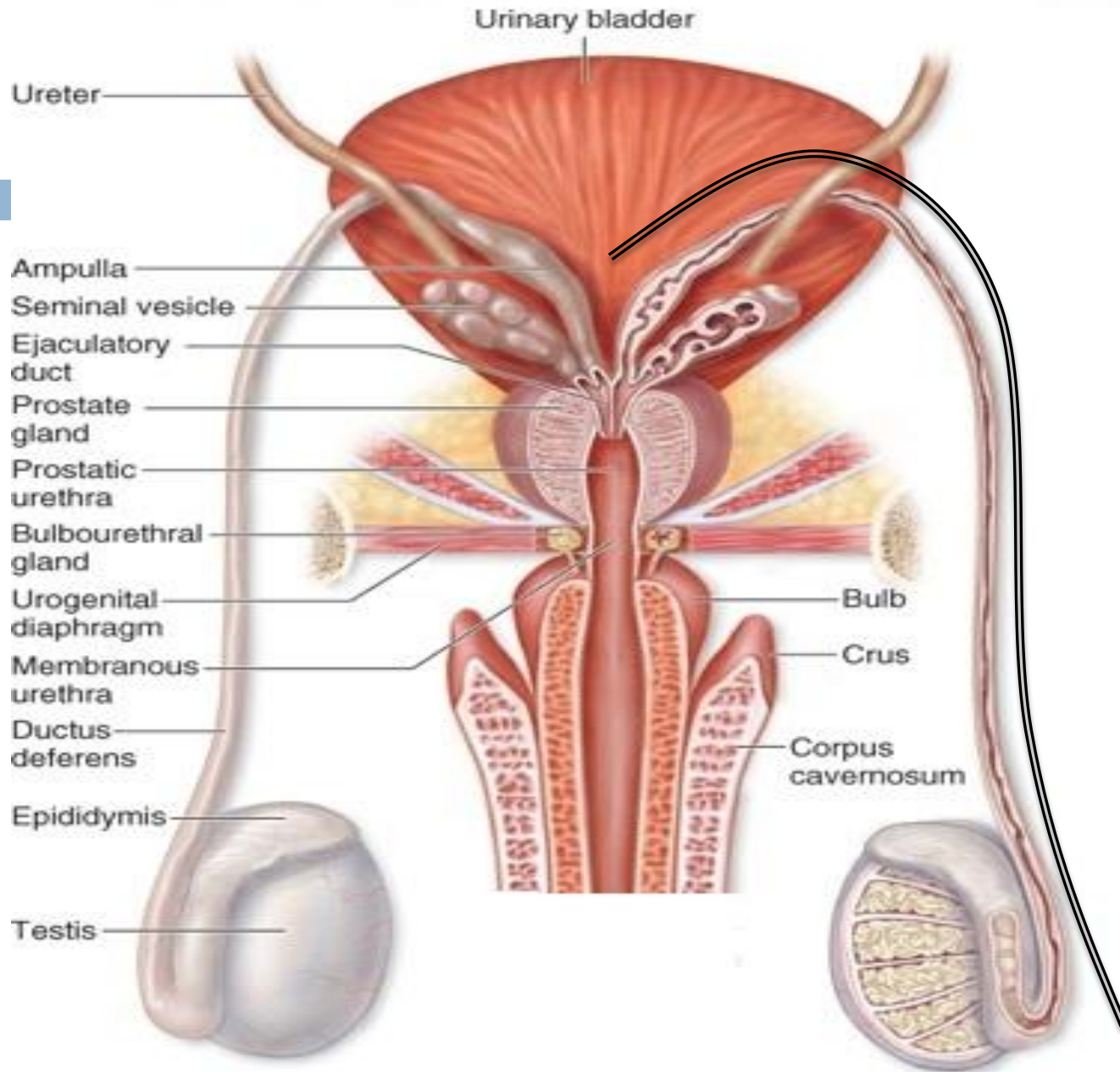
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4-the epididymis secretes a substance that prevents premature capacitation.

5-transport along the epididymis involves some combination of fluid movement & peristaltic contractions of smooth muscles.

The Ductus Deferens:

- Vas deferens 40-45cm long begins at the tail of the epididymis. The vas deferens is part of the spermatic cord & before the vas deference reaches the prostate gland & seminal vesicles its lumen enlarges & called the **ampulla**.
- The vas deferens contain a thick layer of smooth muscle which function in transporting the sperms by the peristaltic contractions which propel spermatozoa & fluid along the duct, also the vas deference can store spermatozoa for several months.



The Accessory Glands:

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- Fluids of the seminiferous tubules & the epididymis are only 5% of the volume of semen, so the fluid components of semen is a mixture of the secretions of many different glands. **Seminal vesicles, prostate gland & the bulbourethral glands.**

Major functions of male accessory glands:

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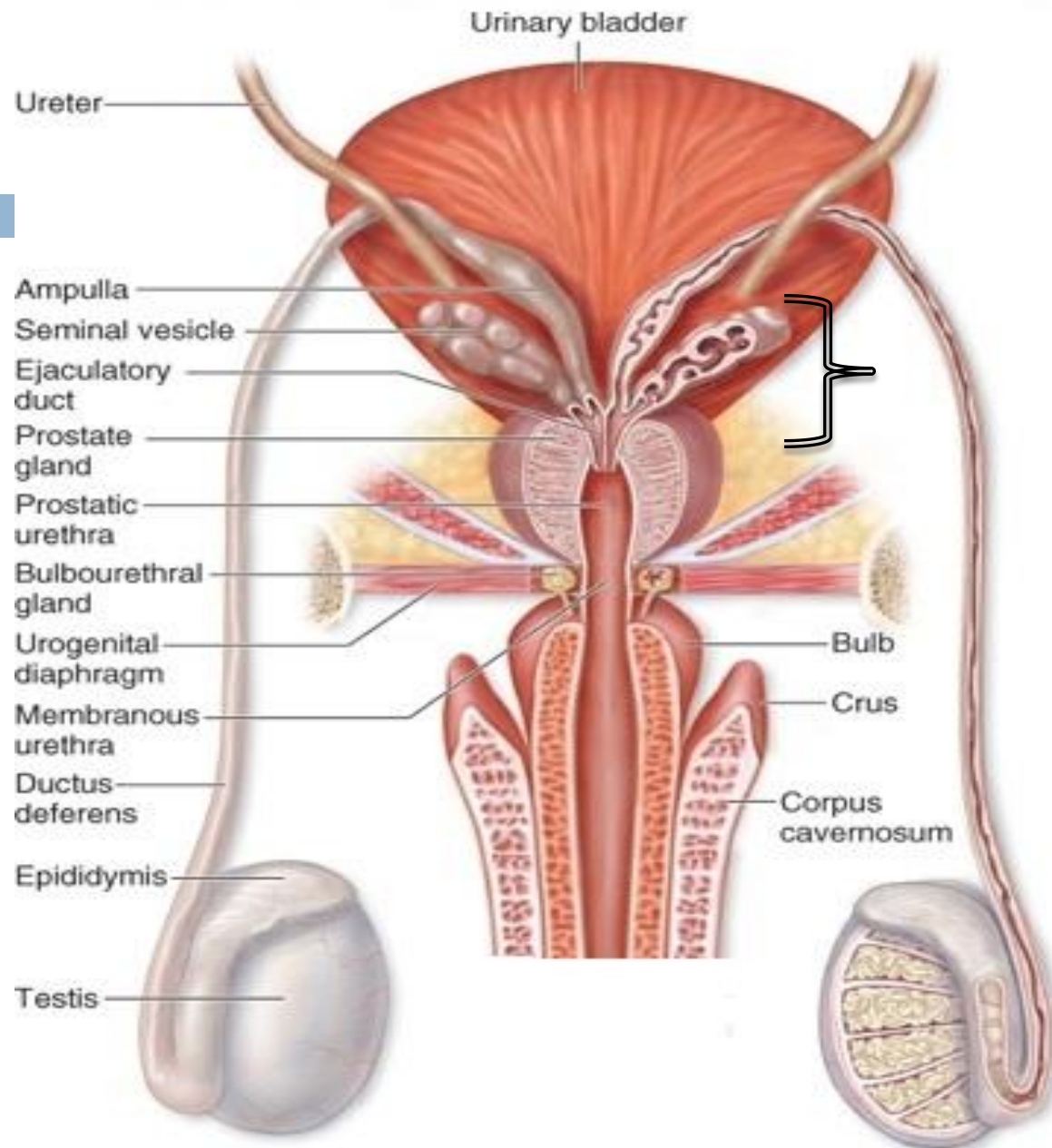
- 1-Activating spermatozoa.
- 2-Providing the nutrients spermatozoa needs for motility.
- 3-Propelling spermatozoa & fluids along the reproductive tract by peristaltic contractions.
- 4-Producing buffers that counteract the acidity of urethral & vaginal contents.

The Seminal Vesicles:

The seminal vesicles are extremely active secretory glands with an epithelial lining that contains extensive folds. And the seminal vesicles contribute about **60 %** of the volume of semen. The composition of the secretion contains:

- 1 - High concentrations of fructose (which is easily metabolized by spermatozoa).
- 2- Fibrinogen (which form a temporary clot after ejaculation).

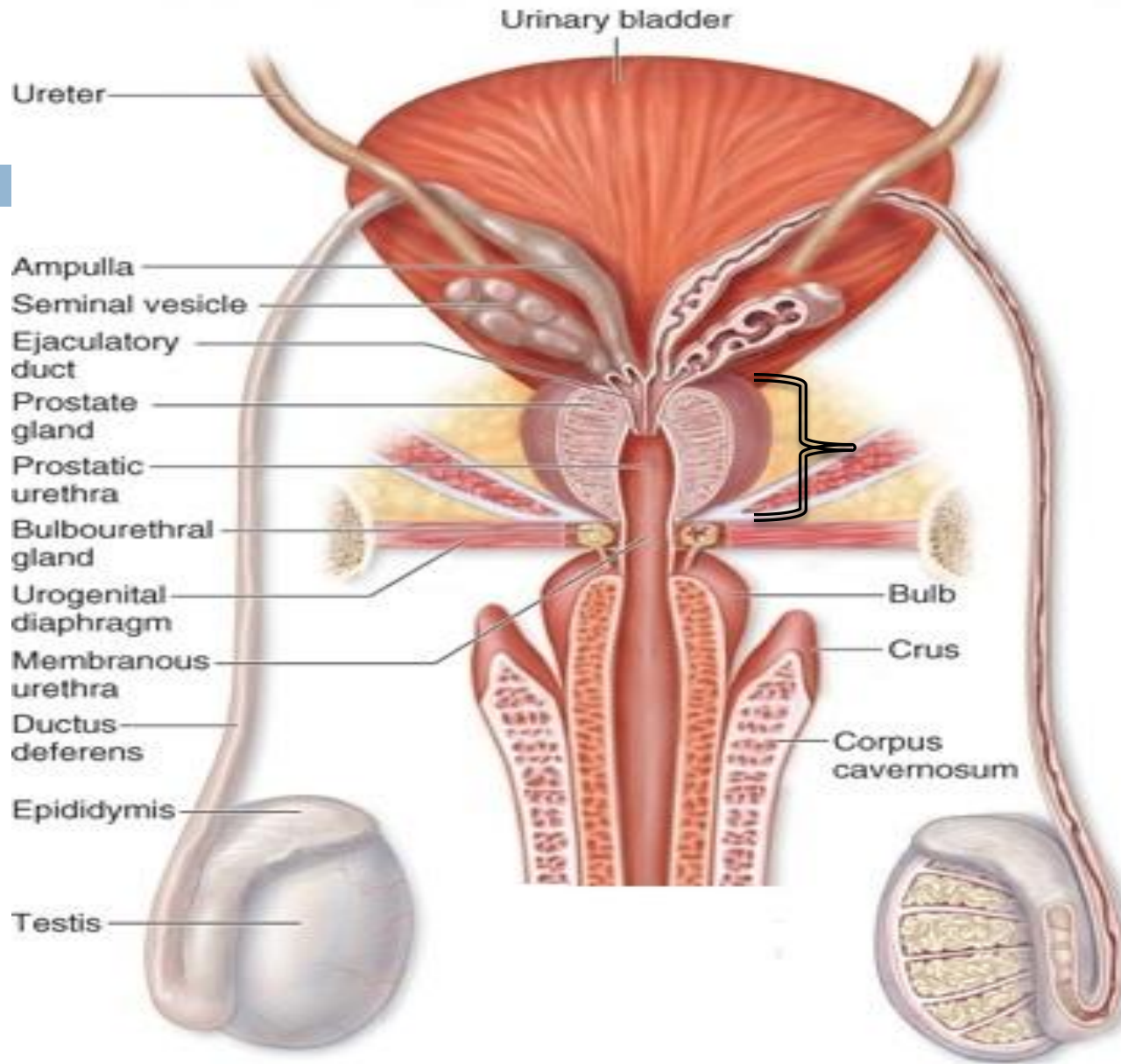
- 3- Secretion of the seminal vesicles are slightly alkaline which helps neutralize acids in the prostatic secretions & within the vagina.
- 4- Inactive but functional spermatozoa begin beating their flagella when mixed with the secretions of the seminal vesicles & become highly mobile.



The Prostate Glands:

The prostate gland is a small, muscular, rounded organ & it encloses the proximal portion of the urethra as it leaves the urinary bladder.

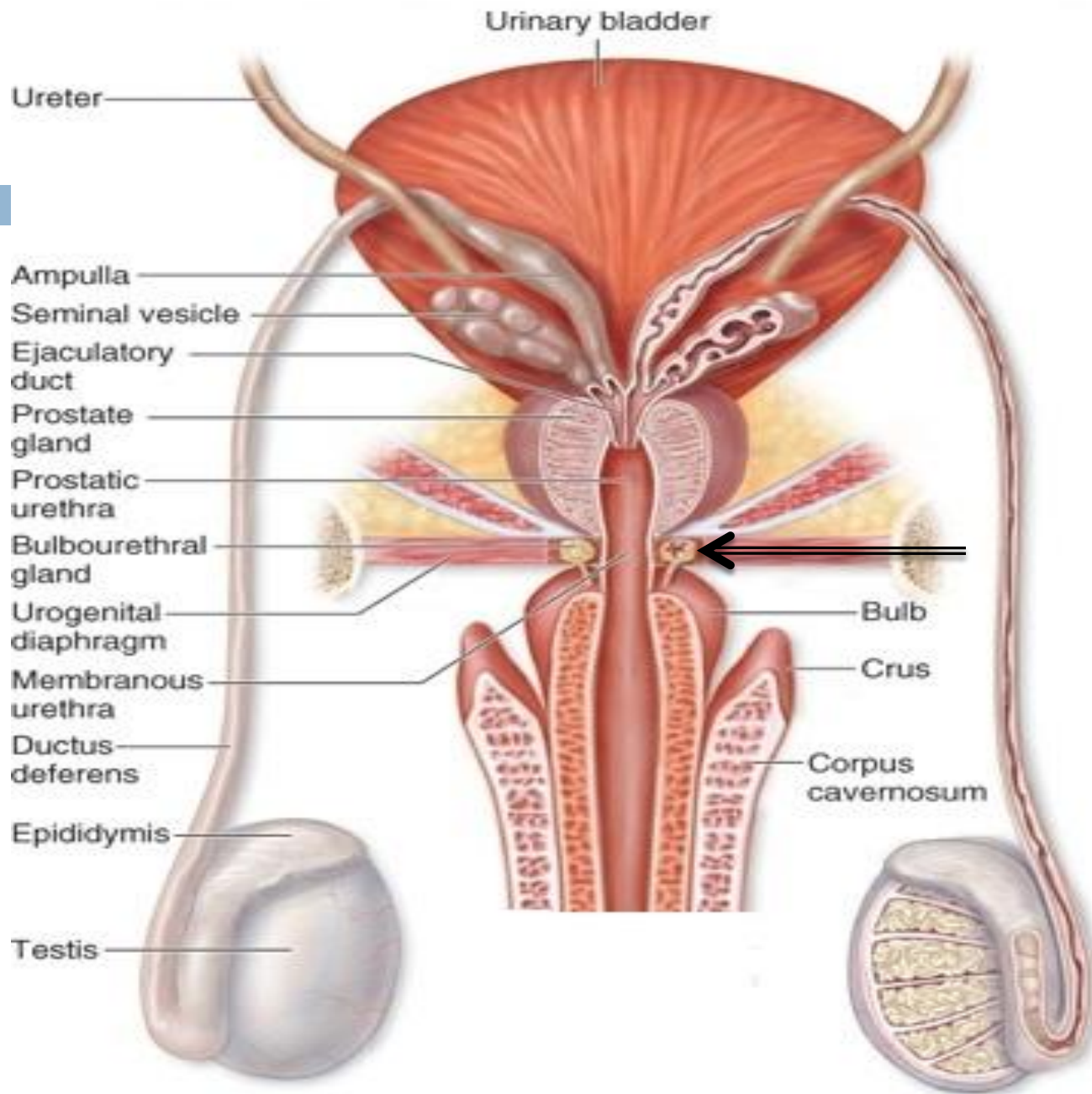
- Prostate glands produce prostatic fluid a slightly acidic solution that contributes **20-30 %** of the volume of semen.
- The prostatic secretions contain **seminalplasmin** an antibiotic that may help prevent urinary tract infections in males.



The Bulbourethral Glands: (or Cowper's Glands)

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- Are stimulated at the base of the penis, they secrete a thick, **alkaline mucus**. the secretion helps neutralization any urinary acids that may remain in the urethra.



Hormones of the Male Reproductive Function:

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- The anterior pituitary release Follicle-Stimulating Hormone(FSH) & Luteinizing hormone(LH), under the effect of Gonadotropein Releasing Hormone(GnRH).

=FSH and Spermatogenesis=

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- In males, FSH targets primarily the sustentacular cells in the seminiferous tubules.
- Under FSH stimulation & in the presence of testosterone from interstitial cells, the sustentacular cells:
 - **-promote spermatogenesis & spermiogenesis.**
 - **-secrete androgen-binding protein (ABP).**
- The rate of spermatogenesis is regulated by a negative feed back mechanism involving GnRH, FSH & inhibin.
- **-FSH levels elevated → inhibin production ↑ es → FSH levels to normal.**
- **-FSH levels decline → inhibin production falls → FSH production accelerate.**

=LH & Androgen production=

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LH causes the secretion of testosterone by interstitial cells in testes.

Testosterone has many functions:

- Stimulating spermatogenesis & promoting the functional maturation of spermatozoa.
- Affecting CNS function.
- Stimulating metabolism throughout the body specially protein synthesis & muscle growth
- Establishing & maintaining the secondary sex characteristics (facial hair, increased muscle mass).
- Maintaining the accessory glands of the male reproductive tract.