

# MALE REPRODUCTIVE PHYSIOLOGY

*GUYTON & HALL,  
CHAPTER 81*

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# MALE REPRODUCTIVE SYSTEM

## OBJECTIVES:

- Explain how the hypothalamus and anterior pituitary gland regulate the male reproductive function
- Explain the *spermatogenesis* and the functions of the male reproductive organs and glands
- Describe the synthesis, secretion, metabolism and the effects of testosterone
- Describe the abnormalities of male sexual function

# Male Reproductive Organs

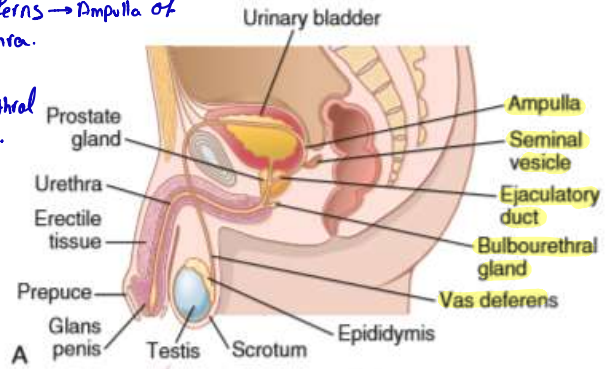
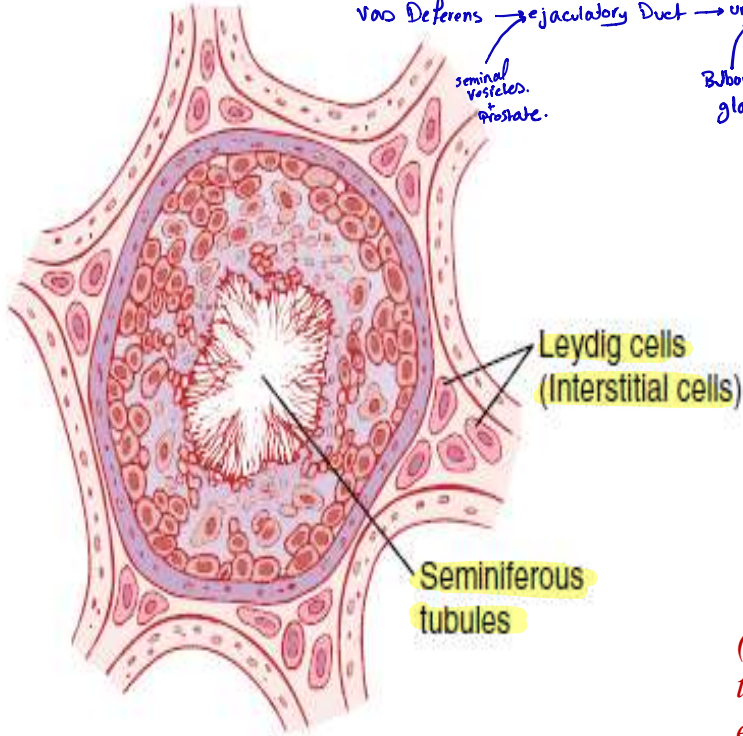
⇒ The Main organ of the Male Reproductive system is the testis (the gonads of the Male) where the Process of spermatogenesis takes Place.

Sperms:

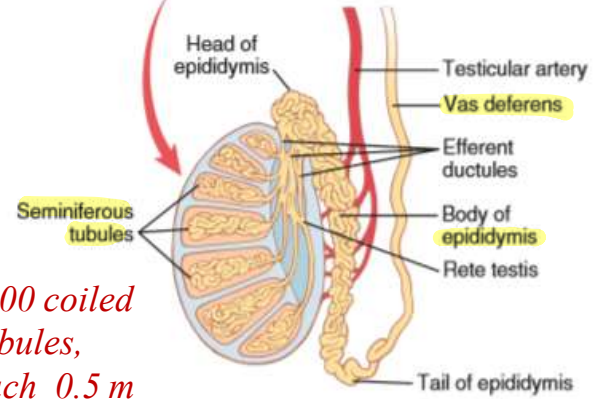
testes tubules → Epididymis → vas Deferens → Ampulla of vas Deferens → ejaculatory Duct → urethra.

seminal vesicles. prostate.

Bulbourethral gland.



(6 m long)



(900 coiled tubules, each 0.5 m long)

↙ Main function of the Male genital system.

# SPERMATOGENESIS

■ Formation of sperm from spermatogonia. (immature cells).

■ Occurs in seminiferous tubules influenced by GnRH.

■ Starts 10-13 years old > ↓ older people, climacteric

↘ The Process of spermatogenesis May ↓ with old Age and May Stop in the Age that is called climacteric.

1 ■ Sertoli cells: large with overflowing cytoplasmic envelopes that surround the developing spermatogonia around the central lumen of the seminiferous tubules. (nourish and support) (FSH)

↘ Present in the lumen of Seminiferous tubules.

↘ These cells work under the influence of FSH of Ant. Pituitary gland.

2 ■ Leydig cells: lie with interstitium between the seminiferous tubules. (LH → testosterone)

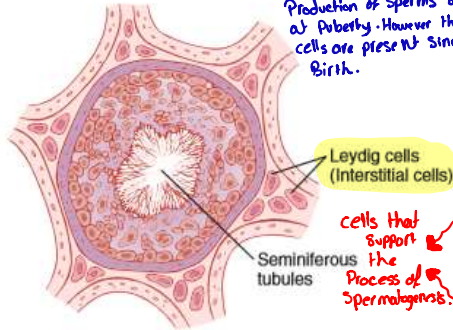
↘ The Function of these cells is to Produce testosterone, the Main Male Sex Hormone.

Leydig cells

■ - numerous in the newborn male infants ONLY for the first few months of life,

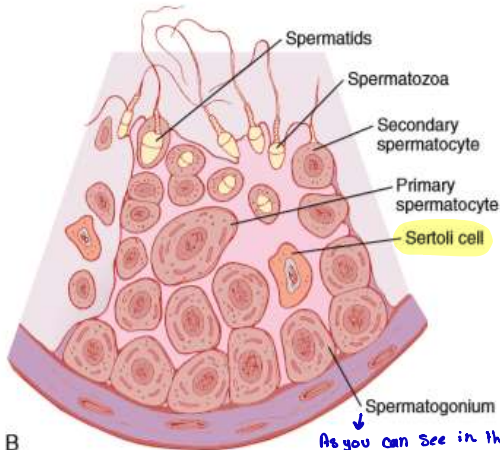
then they Disappear until the Age of Puberty where they Re-appear Again.

■ - active at puberty & throughout adult life & secrete testosterone.



cells that support the Process of Spermatogenesis.

A



B

As you can see in this image, Spermatogonia lie in the inner lining of the Seminiferous tubules and they actually originate from the Primordial germ cells that Migrate into the seminiferous tubules During the 5th week of gestation.

# Hormonal factors that stimulate spermatogenesis

**1-Testosterone**, there are other functions for this hormone that will be discussed later.

by the **Leydig cells** for **growth and division of the testicular germinal cells**.

**2-Luteinizing hormone**,

**stimulates the Leydig cells to secrete testosterone.**

**3-Follicle-stimulating hormone**,

**stimulates the Sertoli cells; without this, no spermatogenesis**

**4-Estrogens**

**formed from testosterone by the Sertoli cells when they are stimulated by FSH hormone, are probably also essential.**

**5-Growth hormone**,

**metabolic function in testes and promotes early division of the spermatogonia themselves; in pituitary dwarfs ? spermatogenesis?**

↳ when there is lack of pituitary GH in cases of pituitary dwarfs it has been noticed that spermatogenesis will be lacking.

So, if there is no growth hormone there will be no spermatogenesis

# Hypothalamic- anterior pituitary- gonad's axis

⇒ Both testosterone and FSH Play an important Role in supporting and stimulating Spermatogenesis

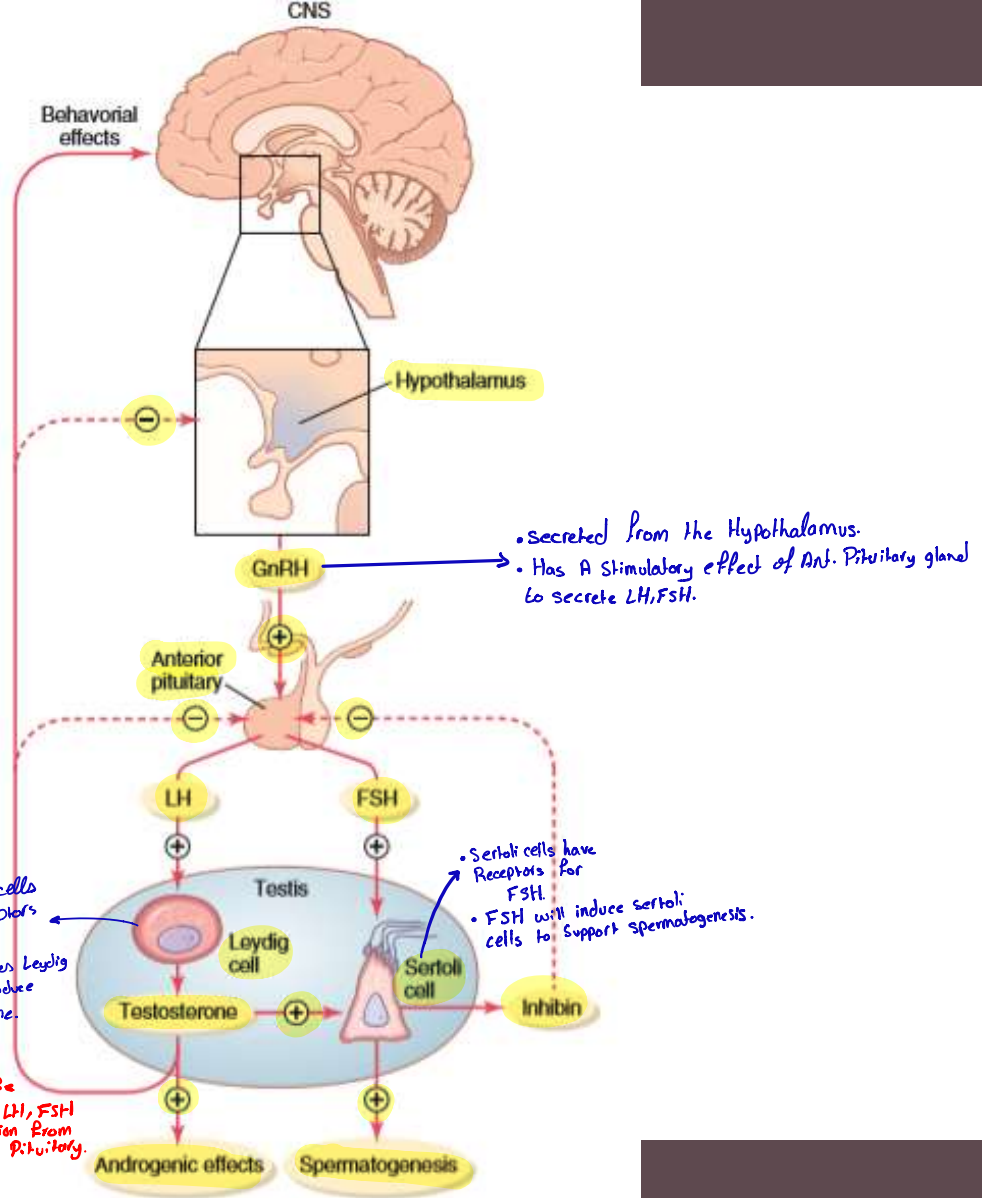
⇒ testosterone has Also other effects (Androgenic effects) that include:-  
Male Primary sexual organs growth and Development of Primary and Secondary characteristics of Males.

⇒ testosterone has a -ve feedback on the Ant. Pituitary when there is ↑ testosterone Secretion, thereby ↓ the secretion of FSH/LH.  
Also testosterone has a -ve feedback on GnRH Secretion.

⇒ when there is ↑ induction of spermatogenesis, inhibin will Be Released from Sertoli cells and will have -ve feedback on LH, FSH secretion from Ant. Pituitary.

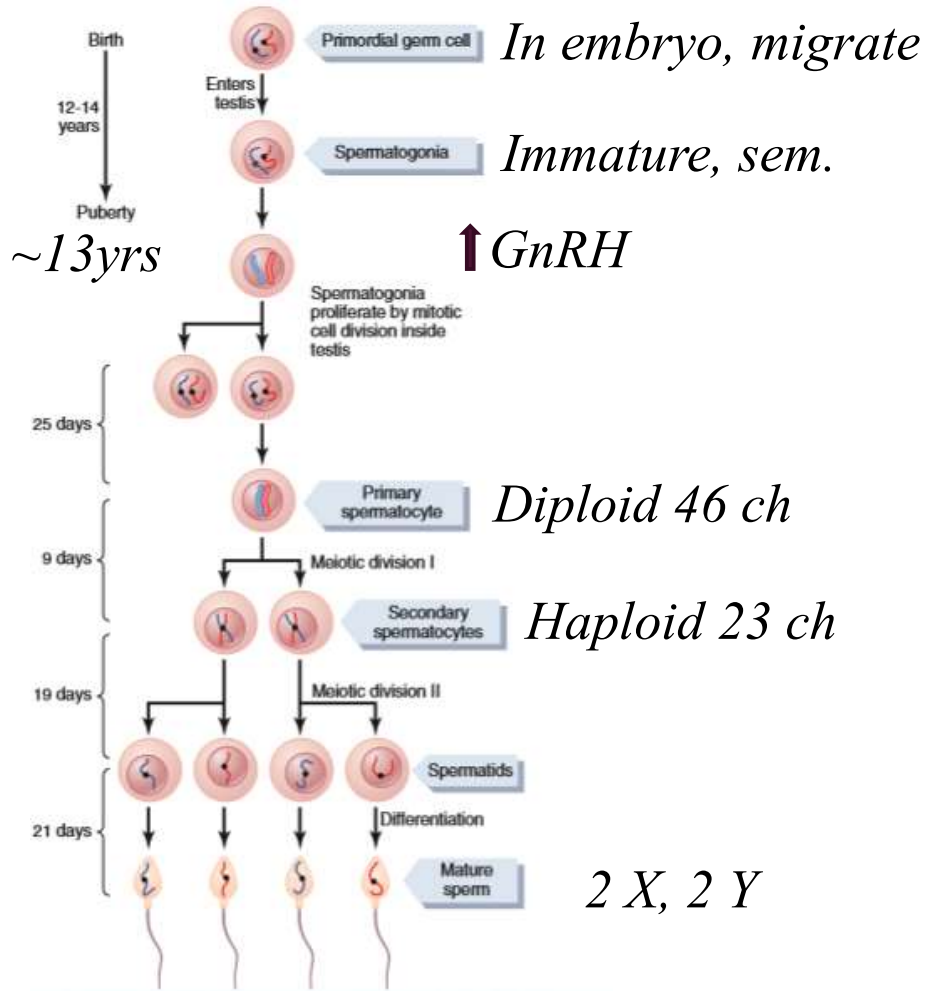
• Leydig cells have Receptors for LH.  
• LH induces Leydig cells to Produce testosterone.

• Sertoli cells have Receptors for FSH.  
• FSH will induce Sertoli cells to Support spermatogenesis.



See Next Page

74 days



• The sperm forming cells (Spermatogonia) are Derived from primordial germ cells.

So during embryogenesis, Primordial germ cells Migrate from the abdomen into the testis and line the Seminiferous tubules as spermatogonia.

Spermatogonia are immature cells.

• Until Puberty, there will be no further Division or Development of the spermatogonia.

At Puberty, GnRH levels will be ↑, then spermatogonia will start Proliferating. This process takes about 25 days to give Rise to 4 spermatocytes.

Primary spermatocytes are diploid cells (46 chromosomes).

Then the 4 spermatocytes will enter the first stage of Miosis giving Rise to Secondary Spermatocytes After 9 days.

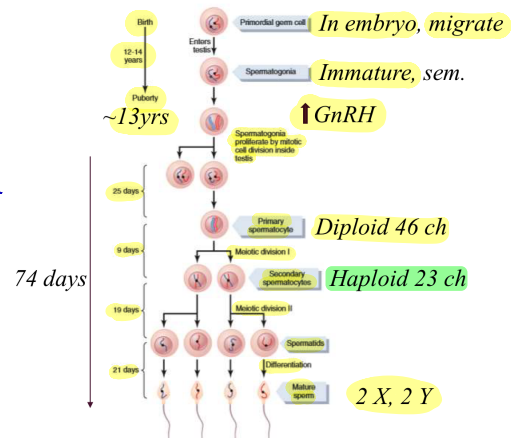
Secondary spermatocytes are haploid cells (23 chromosomes) → The Doctor said they have 46 chromosomes but this is wrong.

2nd spermatocytes enter the 2nd Stage of Miosis to give Rise to spermatids After 14 days.

Spermatids are haploid as well.

Spermatids further differentiate into Mature sperms, so 1 primary spermatocyte will give Rise to 4 Mature sperms, 2 of these 4 have an "X" chromosome and the other two will have "Y" chromosome.

⇒ The total length of Spermatogenesis Starting from spermatogonia and ending with Mature sperms, takes about 74 days.



# PHYSIOLOGY OF MATURE SPERM:

Composed of:-

Head

Tail (Flagella)

- Mature sperm are motile & capable of fertilizing the ovum & their activity is enhanced in a neutral & slightly alkaline medium & depressed in mildly acidic medium.

- ejaculated sperm live in the female genital tract for only 1 to 2 days

→ located in the sperm's head.

- The acrosome stores large quantities of <sup>1</sup>hyaluronidase (to digest <sup>2</sup>proteoglycans) and proteolytic enzymes (to digest proteins).

⇒ These enzymes are imp. so that the sperm can penetrate the ovum.

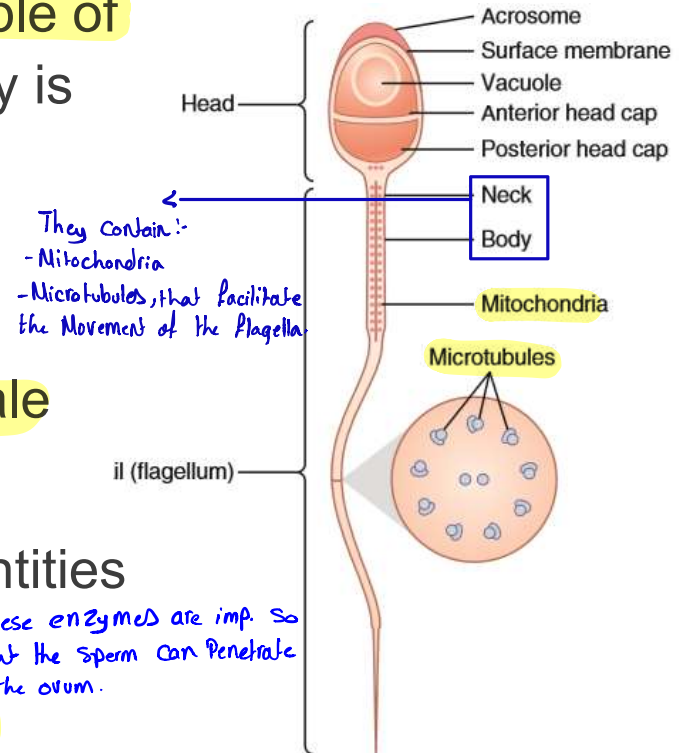


Figure 81-4. Structure of the human spermatozoon.

# MATURATION OF SPERM IN THE EPIDIDYMIS

- After their formation in the seminiferous tubules, sperms require several days to pass through the epididymis (non-motile).  $\Rightarrow$  when sperms are first produced in the epididymis, they are non-motile.

- After <sup>within 2 days</sup> 18 to 24 hrs <sup>sperms</sup>  $\rightarrow$  they develop the capability of motility in epididymis

- (some inhibitory proteins in the epididymal fluid prevent final motility until after ejaculation).

even though sperms acquire motility within the epididymis, they still cannot move due to the presence of inhibitory proteins in the epididymal fluid that restrict or prevent sperms from moving.

$\Rightarrow$  so sperms inside epididymis are CAPABLE of moving, however they are INHIBITED from moving around until ejaculation.

# STORAGE OF SPERMS

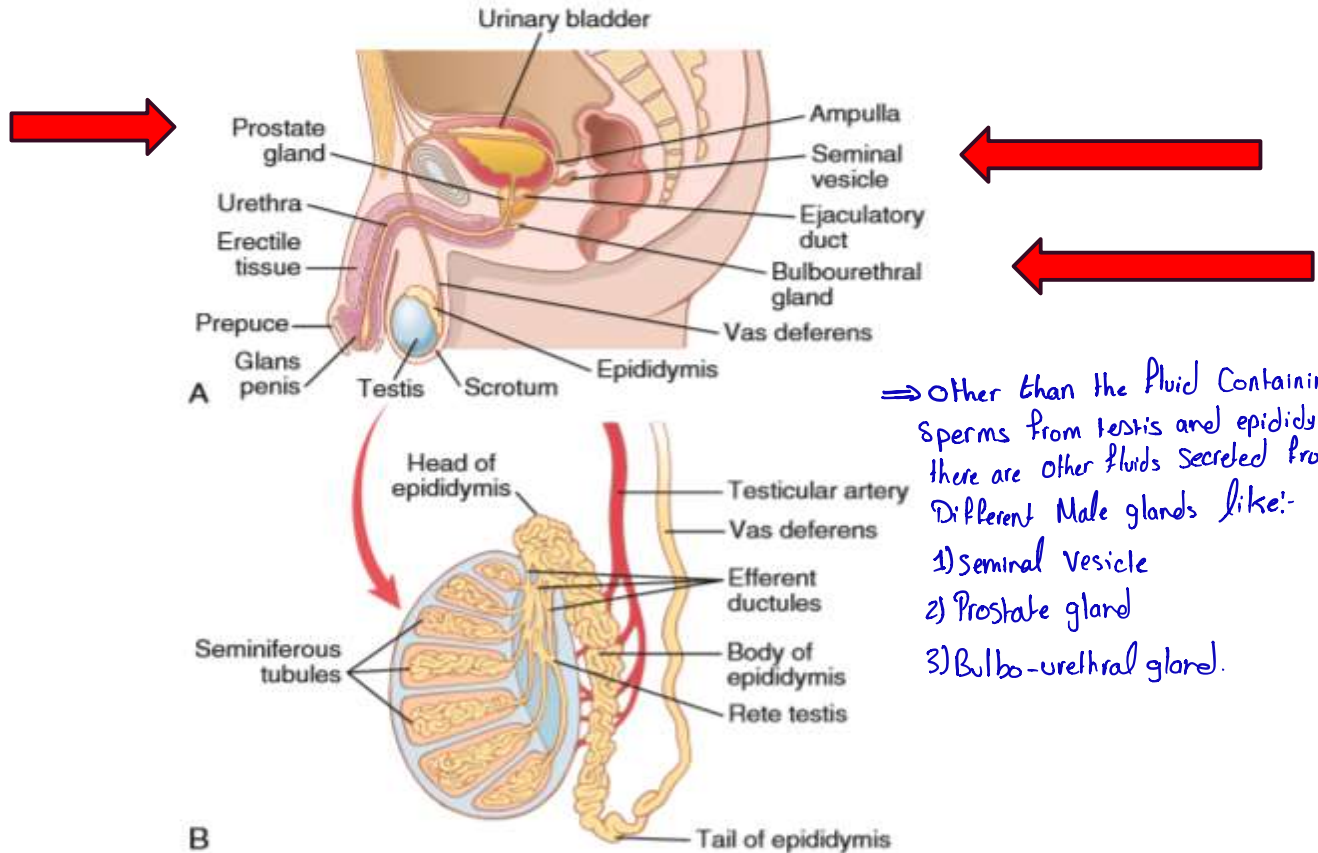
The 2 testes of adult human form up to 120 million sperms each day.

- Small amount are stored in the epididymis
- The majority are stored in the vas deferens (month).  
↳ life expectancy of Matured Formed sperms is only 1 Month.

After ejaculation, the sperm becomes motile & capable of fertilizing the ovum "maturation"  
↳ Because the inhibitory factors are washed away.

- The sertoli cells and epithelium of the epididymis secrete nutrient fluid which contains (testosterone & estrogens), enzymes & nutrients essential for sperm maturation.

# SECRETION OF MALE GLANDS



⇒ Other than the fluid containing sperms from testis and epididymis there are other fluids secreted from different male glands like:-

- 1) Seminal vesicle
- 2) Prostate gland
- 3) Bulbo-urethral gland.

A

# Seminal Vesicles Function

⇒ The secretions from the seminal vesicles form about 70% of the total volume of the semen.

Components of the fluid secreted from seminal vesicles

1 mucoïd material containing fructose, citric acid & nutrient substances & large quantities of prostaglandins & fibrinogen.

2  
3  
4  
5

Secretions of seminal vesicles is Acidic.

This gives viscosity to the semen.  
↳ Fibrinogen is needed for coagulation, since coagulation is imp. for the movement of sperms inside the female genitalia.

The prostaglandins help in fertilization in two ways:

1- by reacting with the female cervical mucus making it more receptive to sperm movement.

2- by causing backward reverse peristaltic contractions of the uterus & fallopian tubes to move the ejaculated sperm toward the ovaries.

3- Reduce the immune response in the female genital system against sperms.

# Prostate Gland Function

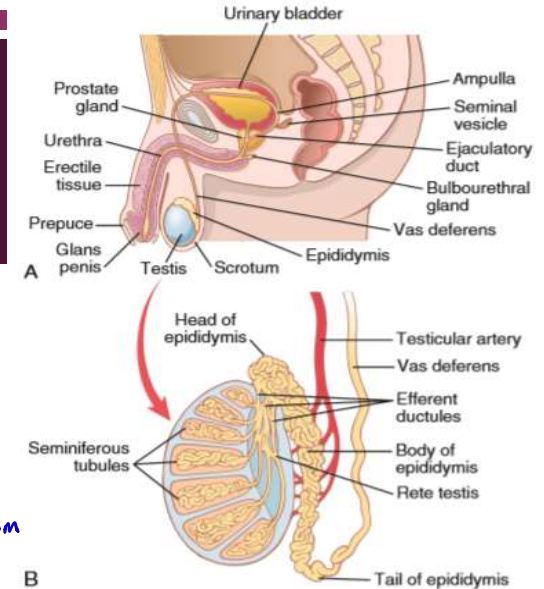
The prostate gland secretes **thin milky fluid** containing; **Ca<sup>2+</sup>**, **citrate ion**, **phosphate ion**, a **clotting enzyme** & **profibrinolysin**. The **alkaline prostatic fluid** is important for successful fertilization of the ovum.

## Alkaline prostate fluid function:

- 1- helps to neutralize the slightly acidic fluid of the vas deferens (due to the presence of citric acid and metabolic product of the sperm which inhibits its fertility).
- 2- helps to neutralize the acidic vaginal secretions (pH 3.5-4.0) to optimize it for better sperm motility (pH 6.0-6.5)

Since as we mentioned before, acidic media ↓ the activity of sperms and inhibits fertility as well as ↓ like expectancy for sperms.

# SEMEN



Ejaculated semen during sexual act

is composed of :

*which originally come from  
testis + epididymis.*

- the fluid & sperm from the **vas deferens** (~10%)
- fluid from the **seminal vesicles** (~60%) Majority.
- fluid from the **prostate gland** (~30%)
- small amounts from the mucous glands the **bulbourethral glands**.

*↳ They produce mucous secretions that facilitates and lubricates the movement of the secreted fluid.*

# Capacitation of the Spermatozoa

⇒ In the female genital tract, freshly ejaculated semen undergo a process called capacitation which takes place within 1-10 hours after the sperms enter the female genital tract.

- Freshly ejaculated semen undergoes “**capacitation**” within **1-10 hours**. What happens in this Capacitation Process?

1. **inhibitory factors are washed out by uterine and fallopian fluids**  
↳ That inhibit sperms movement.

2. **the sperm swims away from cholesterol vesicles (acrosome gets thinner)**

3. **the membrane of the sperms becomes more permeable to  $Ca^{++}$**  This step is important for fertilization process later on.

# TESTOSTERONE AND OTHER MALE SEX

A steroid Hormone.

■ The testis secretes several male sex hormones called **androgens**;  
1 **testosterone**, 2 **dihydrotestosterone** and 3 **androstenedione**.

■ Testosterone is the more abundant form while **dihydrotestosterone** is the more active form. (More Potent)

■ The term “androgen” means any steroid hormone that has masculinizing effects.

■ From the testes and adrenal glands. Synthesized either from cholesterol or directly from acetylcoenzyme A.

- Testosterone is secreted from the testis mainly.
- Androgens can be secreted from testis and adrenal gland. (Small amounts of testosterone can be secreted from the adrenal gland in both sexes.)
- Androgens are derived from either from cholesterol or directly from acetyl CoA.

The Hormones that are Related to Male Characteristics.

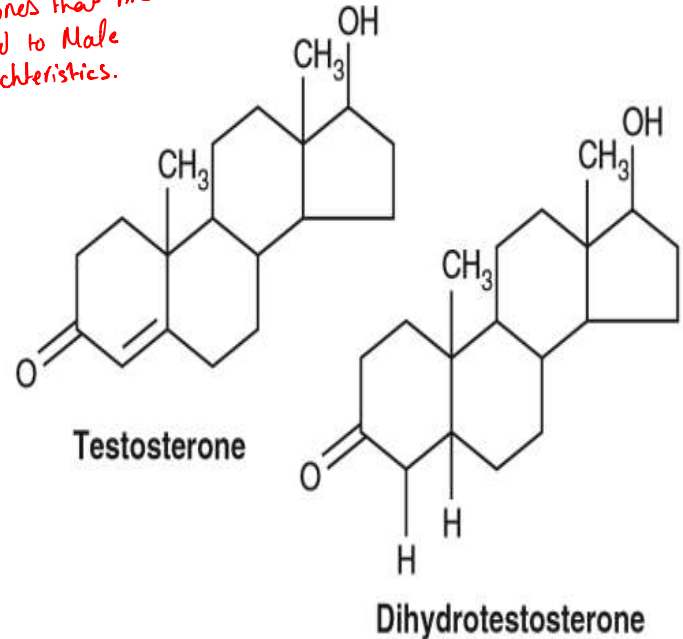


Figure 81-8. Testosterone and dihydrotestosterone.

\* since As we know, testosterone is a steroid hormone, it can freely Diffuse through the cell Membrane of the target cell.

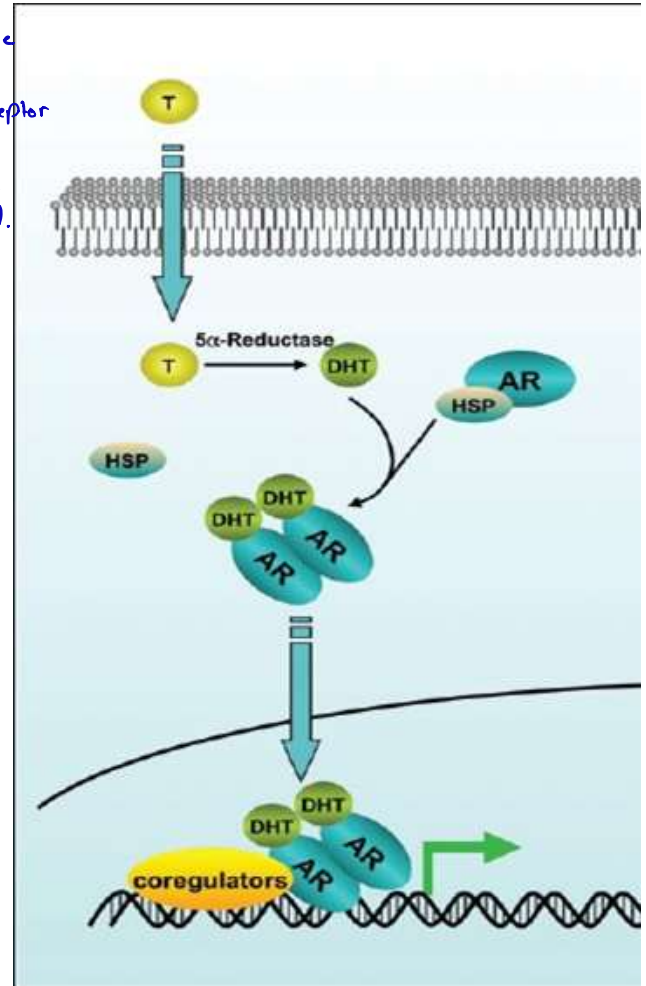
Then it will get converted to Dihydrotestosterone (DHT) By 5- $\alpha$  Reductase enzyme.

DHT will combine with Cytosolic Receptors (Androgen Receptors) and then the Receptor

- Hormone complex will be translocated As dimers into the Nucleus to Bind to hormone Response element (DNA sequence) as dimers as well , and then induce gene expression  $\rightarrow$  Protein synthesis. (Testosterone is an Anabolic Hormone).

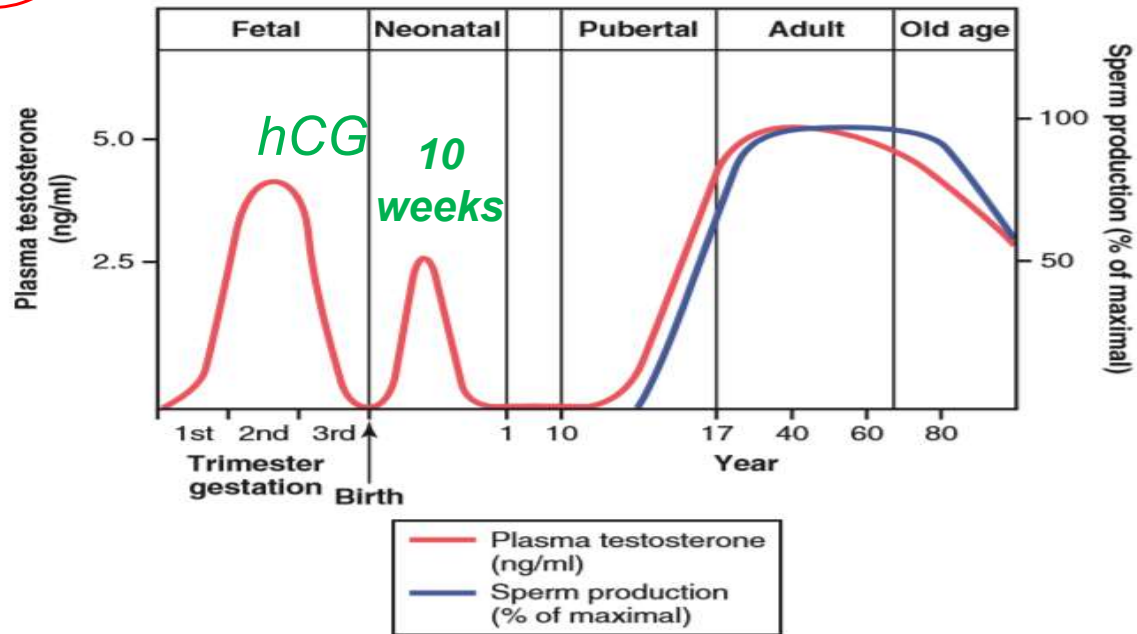
## The Intracellular mechanism of action of testosterone

*It increases the rate of protein synthesis in target cells.*



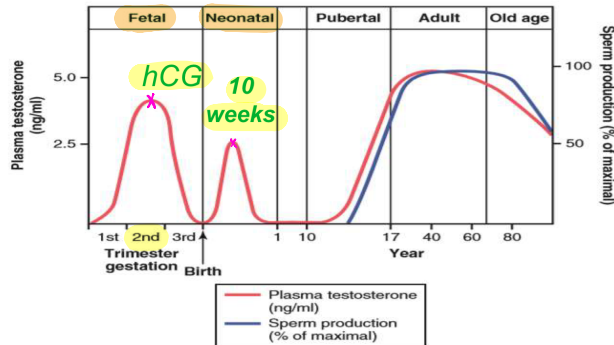
# Functions of testosterone

*See Next Page*



- It is responsible for the characteristic masculine body of a male.

- Testosterone is Not only secreted After puberty in males to induce spermatogenesis and enhance the Male characteristics, but it is Also secreted in the Fetal and Neonatal life.



- As we can see from the figure above, in the middle trimester of gestation there will be a peak increase in plasma levels of testosterone that is induced by "hCG"

↳ have similar effects to LH in stimulating testosterone secretion.

- In the Neonatal life (10 weeks after birth) testosterone levels will be high although at this <sup>stage</sup> there is no spermatogenesis taking place. These high levels of testosterone at this age are responsible for developing male reproductive organs.

# FUNCTIONS OF TESTOSTERONE DURING FETAL DEVELOPMENT

↓  
and Neonatal.

→ in the first 7 weeks of gestation.

Testosterone secreted by the genital ridges & later by the fetal testes is responsible for development of the male body characteristics including the formation of penis & scrotum & suppression of the formation of female genital organs.

A Male with No testosterone secretion will develop female sex organs.

## Effect of testosterone on descending the testis:

↳ Testosterone is important for descending the testis from the abdomen down into the scrotum.

The testes usually descend into the scrotum during the last 2 to 3 months of gestation when the testes begin secreting reasonable quantities of testosterone.

if a baby was born with undescended testis  
⇒ hormonal injection of testosterone can be used as a method of treatment instead of using surgical approaches.

TESTOSTERONE

Effect of  
Testosterone on  
Development of  
Adult Primary and  
Secondary Sexual  
Characteristics

**1- After puberty,** the increasing amounts of testosterone cause enlargement of the penis, scrotum & testis & secondary sexual characteristics.

## **2- Effect on the distribution of body hair:**

Testosterone causes growth of hair over the pubis and on the face

## **3- Baldness:**

Testosterone decreases the growth of hair on the top of the head (two factors

1) genetic background; 2) large quantities of androgenic hormones.

## **4- Effect on voice:**

It causes hypertrophy of the laryngeal mucosa, enlargement of the larynx (typical adult masculine voice)

**5- Testosterone increases thickness of the skin and can contribute to development of acne** *testosterone ↑ secretions from sebaceous glands.*

**6- Testosterone increases protein formation and muscle development**  
*↳ Anabolic Actions of testosterone.*

**7- Testosterone increases bone matrix and causes Ca<sup>2+</sup> retention:**

Bones grown thicker & deposit additional Ca<sup>2+</sup>. Thus it increases the total quantity of bone matrix & causes Ca<sup>2+</sup> retention (anabolic effect).

**8- Testosterone increases basal metabolism:**

It increases the basal metabolic rate by about 15% (indirectly as a result of the anabolic effect).

**9- Effect on red blood cells:**

It increases red blood cells 15-20% (due to increased metabolic rate).

*↳ Not Related to EPO levels.*

**10- Effect on electrolyte and water balance:**

It increase the reabsorption of Na<sup>+</sup> in the distal tubules of the kidneys.

*↳ and thus water*

MALE  
REPRODUCTIVE  
SYSTEM

Abnormalities of  
spermatogenesis and  
male sexual function

\* Fertility Depends on:-  
1) sperm count 2) shape of sperms. 3) Motility of sperm cells.

## Effect of sperm count on fertility:

- The quantity of ejaculated semen during coitus is about 3-5 ml  
*in each 1 ml of semen, there is 120 M Sperm cells on Avg.*
- 1ml >>> 120 million sperm (normal sperm count 35 - 200 million sperm/ml).

## Effect of sperm morphology and motility on fertility:

- Sperm count is normal but infertile? *This is Due to:-* abnormal shape.
- Shape of the sperm is normal but relatively non-motile or entirely non-motile which causes infertility.



Figure 81-5. Abnormal infertile sperm, compared with a normal sperm on the right.

## Prostate gland and its abnormalities

- Benign prostatic fibroadenoma in older age due to overgrowth of prostate tissue (not caused by testosterone).
- Cancer of the prostate gland caused by stimulation of cancerous cells by testosterone.

## Hypogonadism in male: Hypogonadism

- During fetal life when the (testes are nonfunctional) none of the male sexual characteristics develop in the fetus. Instead female organs are formed.
- If the boy loses his testes before puberty → eunuchism (infantile sex organs & infantile sexual characteristics) is developed ↳ The boy will have infant sex organs and infant sexual characteristics.
- If a man is castrated after puberty, sexual organ regress in size and voice regress However, the main male secondary characteristics will remain.

## Adiposogenital syndrome, Fröhlich syndrome, or hypothalamic eunuchism: \*Hypogonadism can be due to genetic inability of the hypothalamus to secrete GnRH.

- Hypogonadism due to genetic inability of the hypothalamus to secrete normal amount of GnRH & abnormality of the feeding center of the hypothalamus resulting in obesity with eunuchism. Adiposogenital Syndrome.

## Cryptorchidism:

Failure of the testes to descend in the scrotum which normally occurs during fetal life.

## Testicular tumors and hypergonadism in male:

Interstitial leydig cell tumors (rare), overproduction of testosterone.

In children, causes rapid growth of the musculature and bones and early uniting of the epiphyses and causes excessive development of male sexual organs.

⇒ if Hypergonadism took place in Adults, it might be able hard to see the effect of ↑ testosterone levels.



# SELF STUDY

MALE SEXUAL ACT



## Stages of male sexual act:

1- Penile erection. by parasympathetic impulses.

2- Lubrication, Parasympathetic impulses cause the urethral glands & bulbourethral glands to secrete mucous.

3- Emission and ejaculation. Function of the sympathetic nerves.

Contraction of the vas deferens & ampulla to cause expulsion of the sperm in the internal urethra. Contraction of the prostate & seminal vesicles to expel their fluid in the urethra. All these fluid mix in the internal urethra with the mucous secreted by the bulbourethral glands to form the semen. This process at this point is called emission

- Filling of the internal urethra with semen causes sensory impulses through pudendal nerves to the sacral region of the cord. Fullness of the internal urethra causes rhythmical contractions of the internal genital organs which increases their pressure to ejaculate the semen to the outside called ejaculation

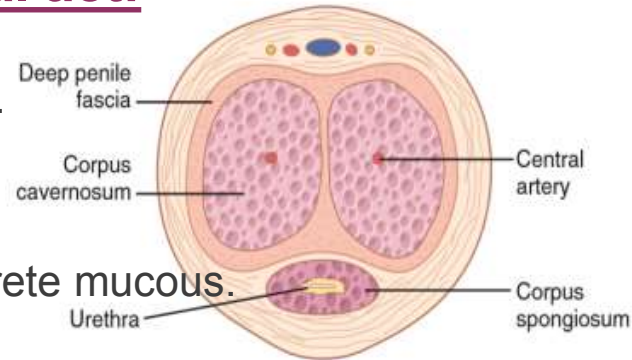


Figure 81-6 Erectile tissue of the penis.