



# PHYSIOLOGY

- SHEET NO. 12
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Hey guys , long time no see ^^ ☀️

Let's start with the first lecture of the reproductive physiology .

## MALE REPRODUCTIVE SYSTEM

- The main organ of the male reproductive system is the **Testis** where the process of spermatogenesis takes place
- The **testis** is the gonads of the male
- The testis is **coiled organ** which contains 900 coiled tubules, each 0.5 m long

### The path of the sperms

Testicular tubules



Epididymis ( 6 m long )



Vas deference



Ampulla of Vas deference ( the enlarged part of vas deference)

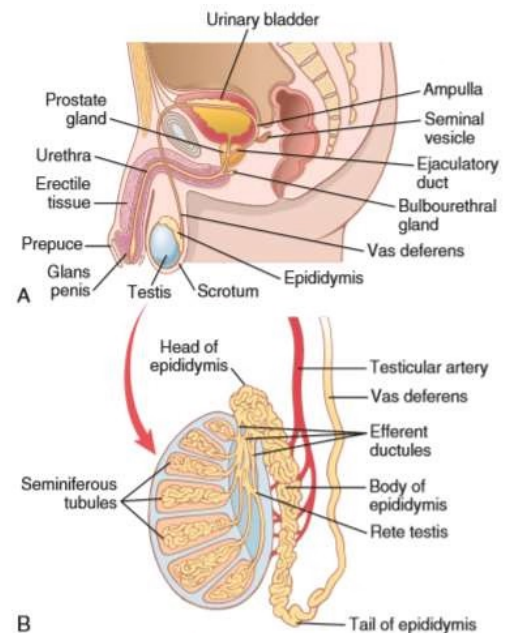


Ejaculatory duct ← 2 Seminal vesicles  
← Prostate



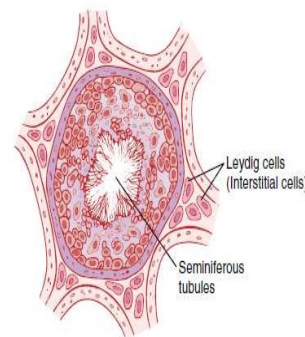
← Bulbourethral gland

Internal Urethra



### Spermatogenesis

- The main function of the male genital system
- Formation of **sperm** from **spermatogonia** ( immature sperms )  
That will fertilize the ovum in order to produce the **fertilized ovum** that will produce the offspring .
- The process occurs in seminiferous tubules influenced by **GnRH** which is secreted by hypothalamus
- The production of **sperms** starts at **puberty [10-13 years old ]**, however the **spermatogonia cells** are present since **birth** .
- The process of spermatogenesis may decrease with old age and may stop in the age that is called **climacteric** [ can happen in female as well ]



Corss section of seminiferous tubules where the sperm are formed

Extra || climacteric : the period of life when fertility and sexual activity are in decline

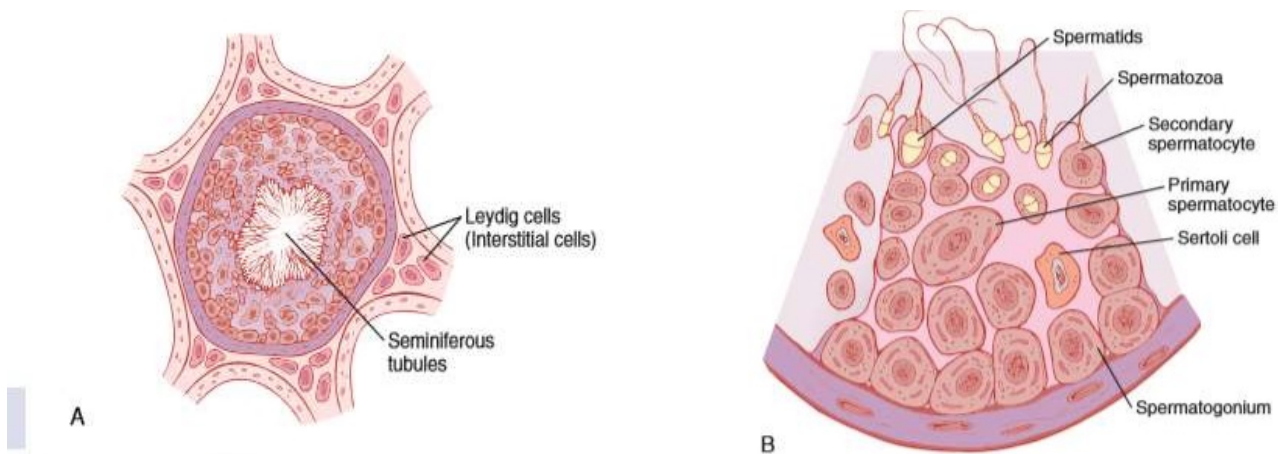
There are 2 type of cells that support this process :

### *Sertoli cells*

- large with overflowing cytoplasmic envelopes that surround the developing spermatogonia **around the central lumen** of the seminiferous tubules.
- work under the influence of **FSH** that secreted of anterior pituitary gland
- **Function** : nourish and support

### *Leydig cells*

- lie **within the interstitium** between the seminiferous tubules
- Work under the influence of **LH** that secreted of anterior pituitary gland
- Function** : produce **Testosterone** [ the main male sex hormone ]
- They are **Numerous** in the newborn male infants **ONLY** for the first few months of life **then** they disappear **until** the age of puberty where they become active again and stay active throughout adult life.



As you can see in the images , **spermatogonia** lie in the inner lining of the seminiferous tubules and they are actually originate from the **Primordial germ cell** that migrate into the seminiferous tubules during the 5th week of gestation.



# Hormonal factors that stimulate spermatogenesis

## 1-Testosterone

- **Secreted** by the **genital ridges** in the first 7 weeks of gestation & later by the **fetal testes** by the **Leydig cells**, & it has **2 functions**:

**1-Supporting effects during spermatogenesis**: growth and division of the testicular germinal cells.

**2-Androgenic effects**: growth of male primary sexual organs and development of primary & secondary characteristics of males

- Has *Negative feedback* on the anterior pituitary gland

[ When there is **increase** in testosterone secretion ➡ the **FSH**, **LH**, & **GnRH** secretion **decrease** ]

## 2-Luteinizing hormone [ LH ]

- **Secreted** from Anterior pituitary gland

- Has receptors in Leydig cells

- **Function**: stimulates the Leydig cells to secrete testosterone.

## 3-Follicle-stimulating hormone [ FSH ]

- **Secreted** from Anterior pituitary gland

- FSH secretion is stimulated by **GnRH** from the hypothalamus

- **Function**: Stimulates the Sertoli cells & supporting spermatogenesis; **without this, no spermatogenesis [ so it's essential for spermatogenesis ]**

## 4-Estrogens


- Formed from testosterone by the **Sertoli cells** when they are stimulated by **FSH** hormone

- Are probably also essential

## 5-Growth hormone [ GH ]

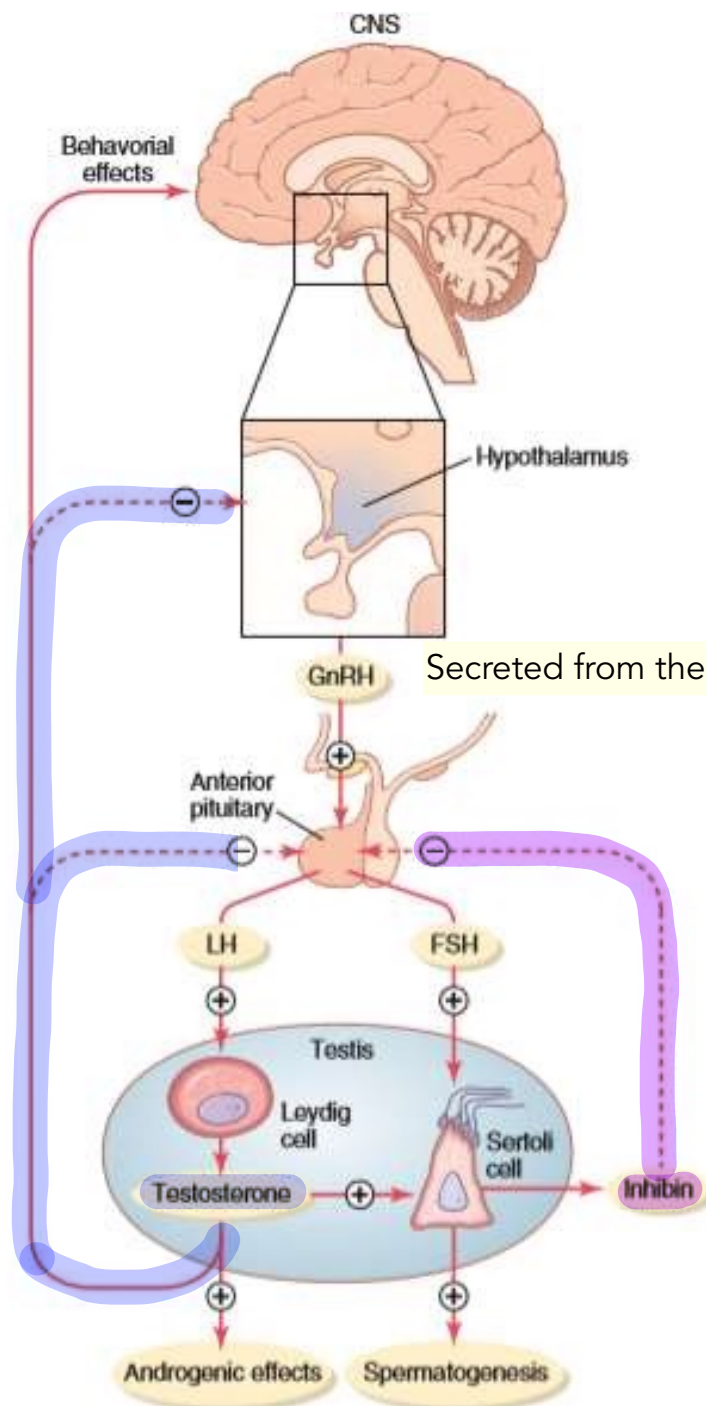
- **Secreted** from anterior pituitary gland

- **Function**: metabolic function in testes and promotes early division of the spermatogonia themselves

-  When there is lack of **pituitary GH** in case of *Pituitary dwarfs*, the spermatogenesis will be lacking [ **no GH, no spermatogenesis** ]

## Hypothalamic-anterior pituitary- gonad's axis

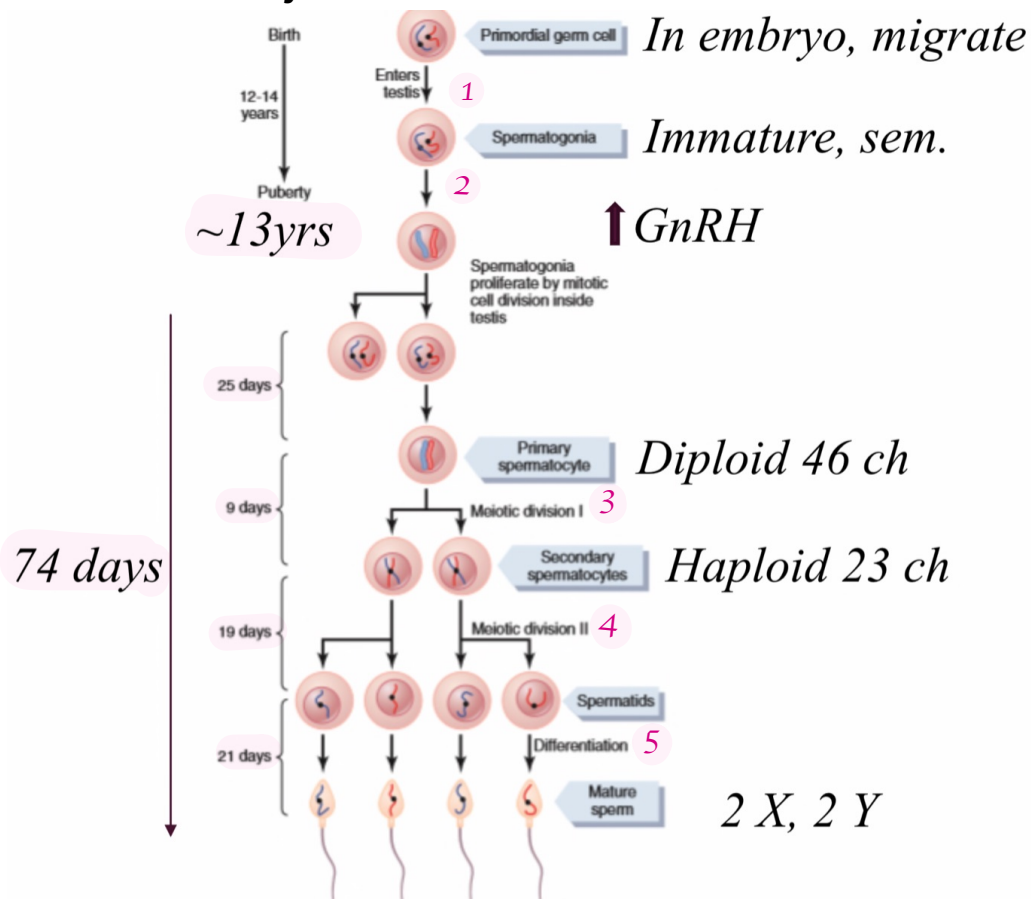
Don't worry , nothing is new here , just follow the diagram to make sure you understand the previous info 😊



When there is induction of spermatogenesis, **inhibin** will be released from sertoli cells and will have *negative feedback* on **LH** , **FSH** secretion from Anterior pituitary

## Spermatogenesis Steps

The total length of spermatogenesis - starting from spermatogonia and ending with mature sperms - , takes about **74 days**



**1** 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 Spermatogonium

**2** At puberty , GnRH level will be **↑**, then spermatogonia will start proliferating

-This step will take **25 days** to give rise to primary spermatocytes

-**Primary spermatocytes** are diploid cells [ 46 chromosomes ]

**3** Primary spermatocytes will enter the **first stage of meiosis** giving rise to **secondary spermatocytes** after **9 days**

- Secondary spermatocytes are haploid cells [ 23 chromosomes ]

**4** Secondary spermatocytes will enter the **second stage of meiosis** giving rise to **spermatids** after **19 days**

- **Spermatids** are haploid cells [ 23 chromosomes ]

## 5 Spermatids will differentiate into **Mature sperms**

- 1 Primary spermatocytes will give rise to **4 mature sperms** [ 2 sperms have X chromosomes, & the other 2 have Y chromosomes ]
- This step will take **21 days**

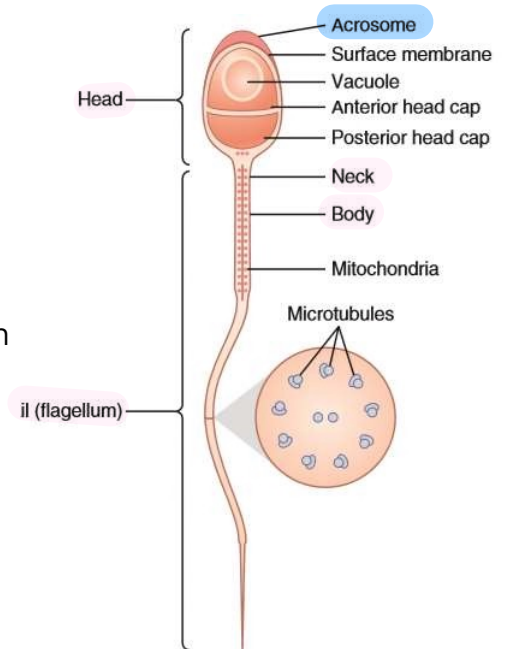
## Physiology of mature sperms

### Mature sperm composed of :

1. **Head**
  2. **Neck & body** ; contain mitochondria that facilitates the movement of the flagella
  3. **Tail [ flagellum ]**
- Mature sperm are **motile** & capable of **fertilizing** the ovum
  - Their activity is of them **enhanced** in a neutral & slightly alkaline medium & **depressed** in mildly acidic medium

- **The acrosome** [ located at the sperm head as a CAP 🧢 ] stores large quantities of ;

1. **Hyaluronidase**: to digest proteoglycans
  2. **Proteolytic enzymes** : to digest proteins
- these enzymes Facilitate the fertilization process



## Maturation of sperms in the Epididymis

- After their formation in the seminiferous tubules, sperms require several days to pass through the epididymis [ **non-motile** ]
- After 18 to 24 hrs , sperms develop the **capability** of motility in epididymis [ **capable to move but still not motile** ]

[ **Sperm** inside the epididymis are capable to move but they are inhibited by some inhibitory proteins in the epididymal fluid that prevent final motility **until after ejaculation** ]

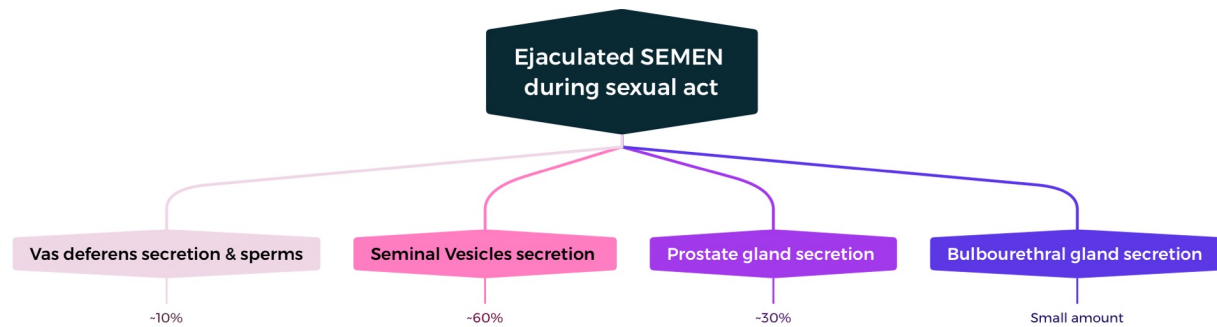
- **After ejaculation**, the sperm becomes **motile** & capable of **fertilizing** the ovum , so the **sperm is mature** 🧐

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

## 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 & life expectancy of mature sperms is only 1 month



## Sertoli cells and epithelium of the epididymis secretion

nutrient fluid which contains (testosterone & estrogens), enzymes & nutrients essential for sperm maturation

## Seminal Vesicles secretion

PH ( 7.2 - 8 ) & Composed of :

- 1-mucoid material containing fructose : give the viscosity of the semen
- 2- citric acid
- 3-nutrient substances
- 4-fibrinogen
- 5-large quantities of prostaglandins :

prostaglandins Help in fertilization in 3 ways

- A]** by reacting with the female cervical mucus making it more receptive to sperm movement
- B]** by causing backward reverse peristaltic contractions of the uterus & fallopian tubes to move the ejaculated sperm toward the ovaries
- C]** by reducing the immune response in the female genital system against sperms

## Prostate Gland Secretion

The prostate gland secretes thin milky **alkaline** fluid , composed of :

- 1-**Ca<sup>2+</sup>**
- 2-citrate ion
- 3-phosphate ion
- 4-clotting enzyme
- 5-Profibrinolysin

Functions :

- A]** The alkaline prostatic fluid is important for successful fertilization of the ovum
- B]** 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)
- C]** helps to neutralize the acidic vaginal secretions (pH 3.5-4.0) to optimize it for better sperm motility (pH 6.0-6.5)

## Bulbourethral glands secretion

Mucous secretion 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 take place within **1-10 hours**

*What happens in this capacitation ?*

1. inhibitory factors [ **that inhibit the sperms motility** ] are washed out by uterine and fallopian fluids
  2. the sperm swims away from cholesterol vesicles (acrosome gets thinner)
  3. the membrane of the sperms becomes more permeable to  $\text{Ca}^{++}$
- This step is important for the fertilization process

## Testosterone and other male sex hormones

- **Androgen** : Any steroid hormone that has masculinizing effects [ related to male characteristics ]

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

### Androgens Types

1-**testosterone** : the more abundant form secreted mainly from the testis  
[ small amount can be secreted from the adrenal gland in both sexes ]

2- **dihydrotestosterone** :  
the more active form [ more potent , less abundant ]

3-**androstenedione**

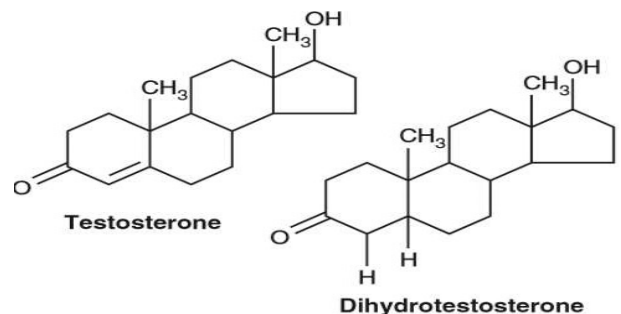


Figure 81-8. Testosterone and dihydrotestosterone.

## The Intracellular mechanism of action of testosterone

- Testosterone is Anabolic hormone
- It increases the rate of protein synthesis in target cells

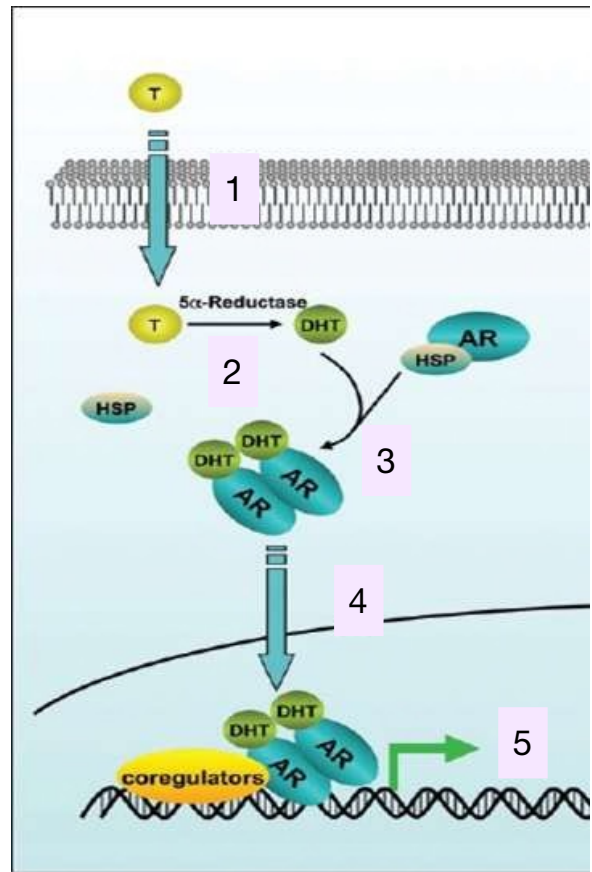
1. Testosterone is a steroid hormone, so it can freely **diffuse** through the cell membrane of the target cell

2. Then it will get **converted** to DHT by **5-alpha reductase** enzyme

3. DHT will combine with cytosolic receptors (androgen receptors)

4. the receptor-hormone complex will be **translocated** as a dimer into the **Nucleus**

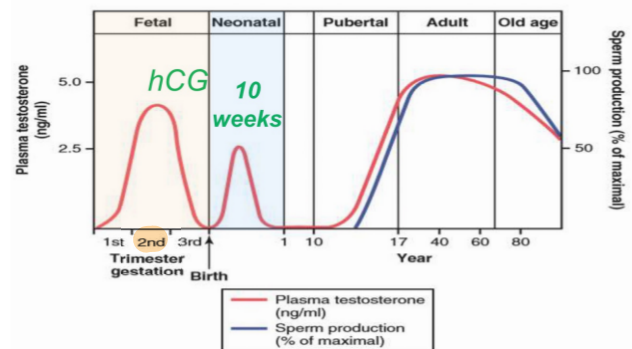
5. The receptor-hormone complex binds to **hormone response element [DNA sequence]** as a dimer as well, and induce gene expression & **protein synthesis**.



## Functions of testosterone

Testosterone is not only secreted after puberty in male to induce spermatogenesis, and enhance male characteristics, but also it is secreted in **fetal** and **neonatal life**

**In the middle trimester of gestation**, there will be a peak increase in plasma level of testosterone that is induced by **HCG** - **HCG**; has similar effects of LH in **stimulating testosterone secretion**



**In the neonatal life** [ 10 weeks after birth ], testosterone level will be high although there is no spermatogenesis taking place at this stage.

- The high level of testosterone at this stage are responsible for **the development of male reproductive organs**

# Testosterone functions

## DURING FETAL DEVELOPMENT

- development of the male body characteristics including the formation of penis & scrotum
- suppression of the formation of female genital organs
- when the testes begin secreting reasonable quantities of testosterone , it usually descend into the scrotum during the last 2 to 3 months of gestation

- A male without testosterone , will develop female sex organs
- If baby was born with undescended testis, hormonal injections of testosterone can be used as a method of treatment instead of using surgical approach

## During Adult development

- After puberty
- Effect on the distribution of body hair
- Baldness
- Effect on voice
- Testosterone increases thickness of the skin and can contribute to development of acne
- Testosterone increases protein formation and muscle development
- Testosterone increases bone matrix and causes  $\text{Ca}^{2+}$  retention
- Testosterone increases basal metabolism
- Effect on red blood cells
- Effect on electrolyte and water balance

- increasing amounts of testosterone cause enlargement of the penis, scrotum & testis & secondary sexual characteristics
- Testosterone causes growth of hair over the pubis and on the face
- Testosterone decreases the growth of hair on the top of the head
- causes hypertrophy of the laryngeal mucosa, enlargement of the larynx (typical adult masculine voice)
- By increase the secretion from sebaceous glands
- Anabolic effect
- Bones grown thicker & deposit additional  $\text{Ca}^{2+}$
- it increases the total quantity of bone matrix & causes  $\text{Ca}^{2+}$  retention
- anabolic effect
- increases the basal metabolic rate by about 15%
- indirectly as a result of the anabolic effect
- It increases red blood cells 15-20%
- due to increased metabolic rate
- It increase the reabsorption of  $\text{Na}^{+}$  & water in the distal tubules of the kidneys

- genetic background
- large quantities of androgenic hormones

## *Abnormalities of spermatogenesis and male sexual function*

Fertility depends on :

### *1-sperm count*

The quantity of ejaculated semen during coitus is about 3-5 ml

in each 1ml of semen >>>120 million sperm (normal sperm count 35 - 200 million sperm/ml).

### *2-sperm shape*

If the Sperm count is normal but infertile , this is due to **abnormal shape** of sperm

### *3-Motility of the sperm*

If the Shape of the sperm is normal but relatively non-motile or entirely non-motile , this will cause infertility

## *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*

- 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** (the boy infantile sex organs & infantile sexual characteristics is **developed** )
- If a man is castrated after puberty, sexual organ regress in size and voice regress , but the main male secondary characteristics will remain

## *Adiposogenital syndrome, Fröhlich syndrome, or hypothalamic eunuchism*

- 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**.

## *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

**In Adult** 🧑, it might be hard to see the effect of testosterone elevation

## SELF STUDY - 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**

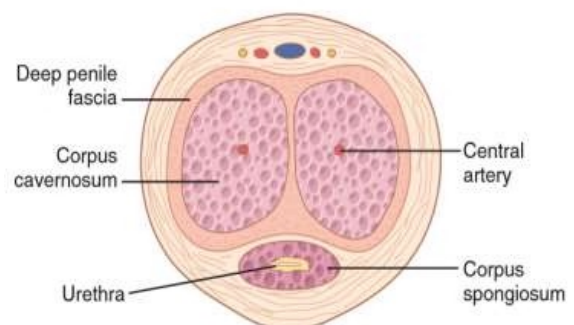


Figure 81-6. Erectile tissue of the penis.

تخليلوا صرنا سنة رابعة ؟ 🍀💜

" وَقَالَ رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ  
عَلَيَّ وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ  
وَأَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ "

