

The Urogenital System 🌙

Subsystem: physiology

Lecture Title: male reproductive system

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Intro:

Male reproductive system is composed of external and internal parts.

-The **external** male genitalia is composed of :penis and scrotum .

-the **internal** male genitalia are:

*testis: A testis is composed of seminiferous tubules that combine to form epididymis.

*epididymis :consists of a head,body and tail.

*vas deferens

* accessory glands

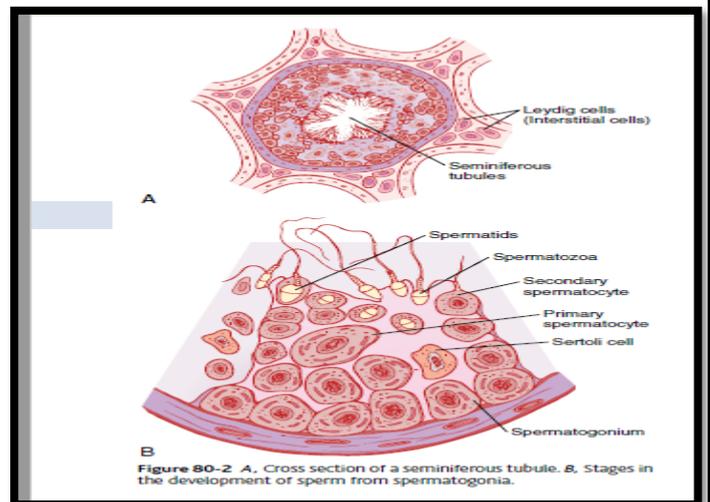
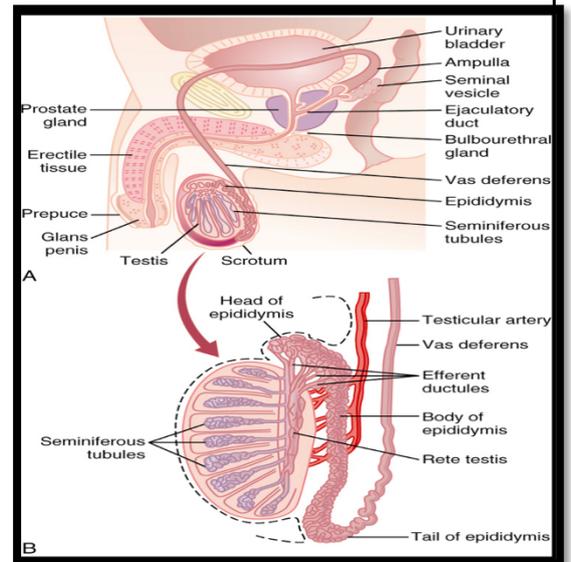
* seminal viscles

*prostate ,

* pulpourethral gland .

Figure (A) shows male reproductive system.

Figure (B) shows the internal structure of testis and epididymis.



In the cross section of the seminiferous tubule in the figure below we have interstitial cells called **leydig cells** that produce **testosterone**. Also, there are **sertoli cells** that provide **nutrients** for the maturing sperms.

SPERMATOGENESIS

During formation of embryo, the primordial germ cells migrate into testis and become immature germ cells called **spermatogonia**. #those cells stay in the testis until puberty

At **puberty** the spermatogonia begin to undergo mitotic division and continue to develop to form sperms.

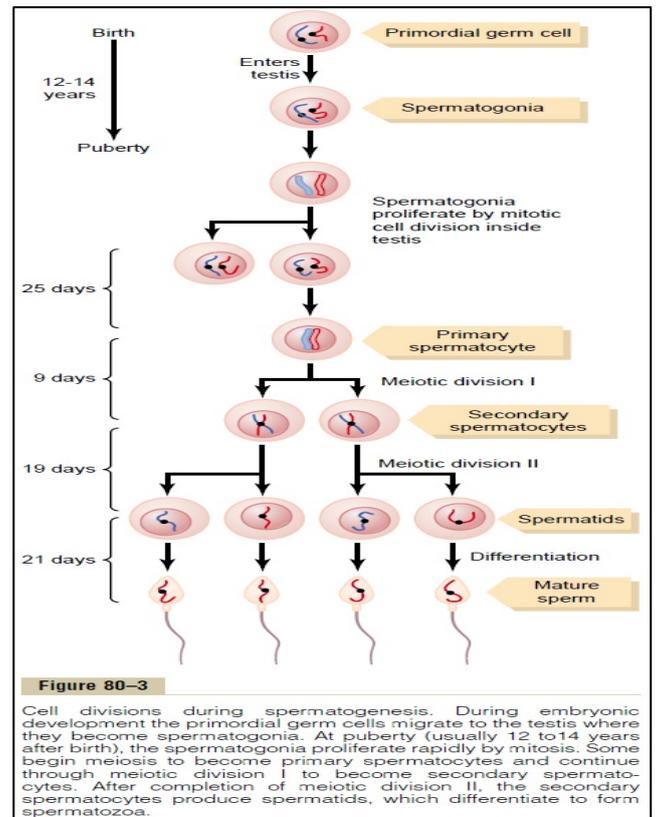
Spermatogenesis (74 days):

-Formation of sperm, it occurs in the seminiferous tubules during active sexual life, begins at age of **13 years**, continues throughout life & significantly decreases in old age.

-After formation in the seminiferous tubules, the sperm require several days to pass through the epididymis (still non-motile).

-After the sperms have been in the epididymis for some **18 to 24 hour**, they develop the capability of motility (some inhibitory proteins in the epididymal fluid prevent final motility until after ejaculation).

Primary spermatocytes goes through the first meiotic division from which secondary spermatocytes are formed. The latter goes through the second meiotic division to form spermatids and eventually mature sperms.



#please pay attention to the duration each stage takes.

Storage of sperm:

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

- Most of these sperms are **stored in the epididymis** .

Small quantity stored in the vas deferens.

They can remain stored and maintaining their fertility for at least a **month** .The sperms are kept inactive state by multiple inhibitory substances in the secretion of the ducts. But with high sexual activity they may store for **few days**.

-After ejaculation they become **motile** and capable of fertilization of the ovum (maturation).The sertoli cells and epithelium of epididymis secrete nutrient fluid ejaculate with the sperm contain **testosterone, estrogen, enzymes and special nutrients essential for sperm maturation.**

Physiology of mature sperm

Mature sperm are motile (velocity 1-4 mm/min) & capable of fertilizing the ovum & their activity is enhanced in a neutral & slightly alkaline medium & depressed in mildly acidic medium.

#The bulbourethral gland secretions neutralize acidic urine which remains in the urethra.

The activity & metabolism of the sperm increase with increase of temperature making short life of the sperm. The life expectancy of ejaculated sperm in the female genital tract is only 1 to 2 days.

Morphology of sperm

HEAD, NECK, BODY & TAIL

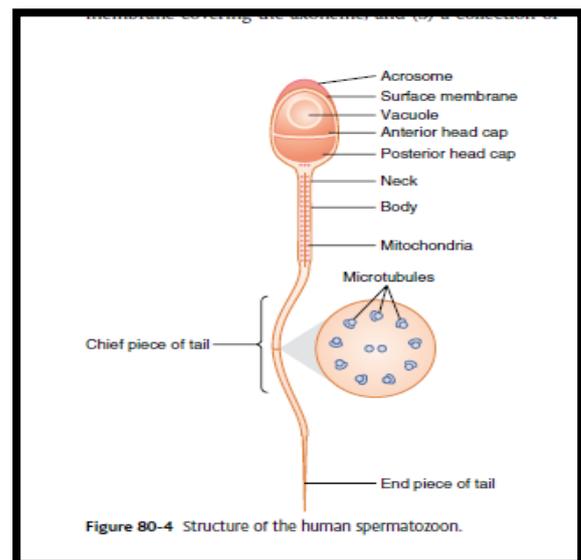
-Acrosome: cap at top of sperm head, contains

hyaluronidase and proteolytic enzymes, important in **penetration** into ovum

Mitochondria -- arranged around body

Tail – flagellum -- outgrowth of centriole -- two

microtubules in center, nine around the outside.



Hormonal Control of Spermatogenesis

- Formation of primary spermatocytes begins during **embryonic development**.

– Spermatogenesis **arrested until puberty**.

1. **Testosterone** by leydig cells (interstitial of testis)

2. **LH** from anterior pituitary to stimulate **leydig** cells to secrete testosterone.

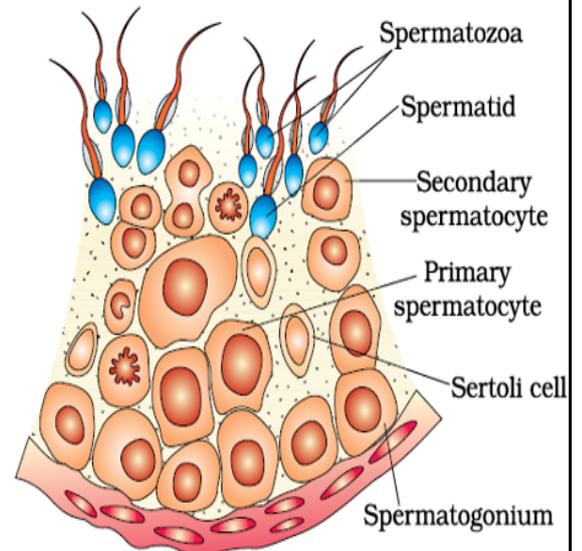
3. **FSH** from anterior pituitary, necessary in the later stages of spermatid maturation.

4. **Growth hormone** , controlling metabolic function of the testis.

5. **Estrogen** formed from testosterone by **Sertoli** cells when stimulated by FSH are probably also essential for spermatogenesis

Sertoli cells and their functions

- 1) Tight junctions between Sertoli cells form blood-testes barrier which maintains critical composition of tubular fluid for sperm maturation & prevents autoimmune destruction of sperm.
- 2) Secrete fluid for carrying sperm into the epididymis.
- 3) Provide nutrients for maturing sperm.
- 4) Secrete ABP (androgen-binding protein) that functions to maintain high levels of androgens in the tubular fluid.
- 5) Contain **aromatase** which converts androgens to estrogens.
- 6) Secrete **inhibin** (Negative feedback on FSH from ant pituitary)
- 7) Phagocytosis of residual bodies



Seminal vesicles and their functions

Secrete mucoid material containing fructose, citric acid & nutrient substances & large quantities of prostaglandins & fibrinogen.

The **prostaglandins aid fertilization:**

- 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. Few sperm reach upper end of fallopian tubes within 5 minutes.

Prostate glands and their function

The prostate gland secretes thin **milky fluid contains Ca²⁺ ion**, citrate ion, phosphate ion, a clotting enzyme & profibrinolysin. The alkaline prostatic fluid is important **for successful fertilization of the ovum**.

Functions of alkaline prostate fluid :

1. successful fertilization of the ovum by neutralizing the slightly acidic fluid of the vas deferens (due to the presence of citric acid and metabolic products of the sperm which inhibits sperm fertility). Also vaginal secretion of the female is acidic.
2. helps to neutralize the acidity of other seminal fluids during ejaculation & thus enhances motility & fertility **of sperm**.

Semen

- Ejaculated semen during sexual act is composed of fluid & sperm fluid from the **vas deferens (~10%)**,
+fluid from the **prostate gland (~30%)**,
+fluid from the **seminal vesicles (~60%)**,
+ small amounts from the mucous glands the **bulbourethral glands**.
- The average pH is about 7.5, the alkaline **prostatic fluid** helps to neutralize the mild acidity of other portions of the semen & **gives the semen a milky appearance**.
- Fluid from the **seminal vesicles & mucous glands** gives the semen its **mucoid consistency**.

Effect of sperm count on fertility:

- The quantity of ejaculated semen during coitus about 3-5 ml, each milliliter contains about 120 million sperm (normal male count vary between 35 million to 200 million sperm). Average of 400 millions in each ejaculation. **Sperm count below 20 million leads to infertility**.

Effect of sperm morphology and motility on fertility:

- Sometimes sperm count is normal but still *infertile* when about one half of the sperm having *abnormal shape*.
- Sometimes the shape of the sperm is normal but they either relatively non-motile or entirely non-motile which causes infertility.

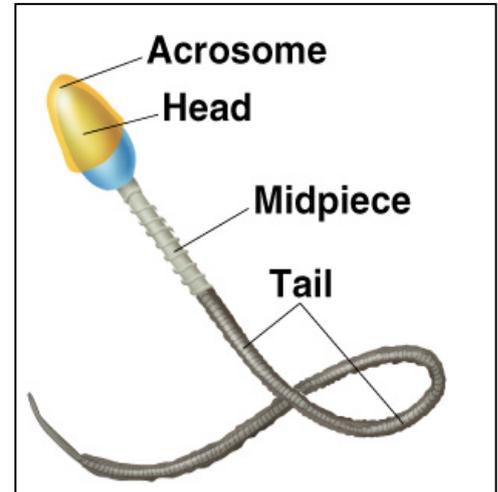
Capacitation of the spermatozoa

Making it possible for them to penetrate the ovum:

- Sperm in the epididymis is kept inactive by multiple inhibitory factors secreted by the genital duct epithelia & they are activated in female genital tract, for the final processes of fertilization. These **activation changes** are called capacitation of the spermatozoa (require **1 to 10 hrs**).

-Uterine & fallopian fluids wash away the inhibitory factors which suppress the sperm activity in the male genital ducts.

-The membrane of the sperm becomes permeable to **Ca** to enter to the sperm and becomes powerful in motion and to penetrates the ovum.



Acrosome enzymes, the “Acrosome Reaction” and penetration of the ovum:

The acrosome of the sperm stores large quantities of **hyaluronidase** and **proteolytic enzymes**.

Hyaluronidase depolarizes hyaluronic acid polymers in the intracellular cement that hold the ovarian granulosa cells together. Also the **proteolytic enzymes** digest the proteins that adhere to ovum.

When the sperm inside the ovum within 30 minutes, the membrane of sperm head fuse together to form single cell (fertilization) containing equal number of chromosomes and genes from mother and father.

Why one sperm enter the oocytes??

The reason is not entirely known. After penetrating the ovum, Ca diffuse inward through the oocyte membrane and release cortical granules from the oocyte. These granules contain substances that prevent binding of additional sperms.

*Don't stop
when you are
tired.
Stop when you
are done!*

SPERMATOGENESIS AND MALE FERTILITY

1-Abnormal spermatogenesis : **Orchitis & mumps.**

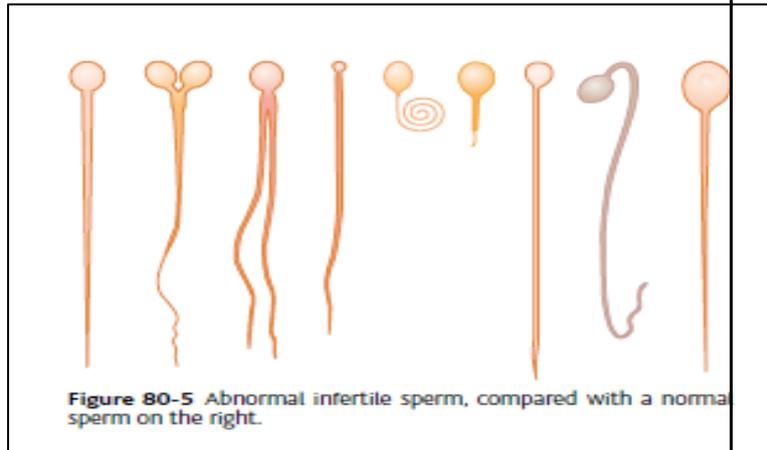
2- Effect of **temperature** #the testes need lower temperature than the body's hence they're located outside of the body.

#Taxi drives are more liable to infertility than other people because they spend more hours sitting allowing scrotal temperature to rise.

3- **Cryptorchidism** : #not descended testes that needs surgical intervention الخصية المهاجرة

4- Effect of sperm **count.**

5-Effect of sperm **morphology** and motility



MALE SEXUAL ACT

1-Neuronal stimulus

A- Glans penis : sensory end organs – slippery massaging action of intercourse on the glans stimulate sensory end organ then sexual signal through pudendal nerve-sacral portion of spinal cord → ? Undefined areas in the brain .

B-Others : Scrotum, perineum, prostate, testes, vas deferens, mild infection and vascular congestion, aphrodisiac drugs .

2- **Psychic element** : Thinking and dreams.

Stages of the Male sexual act

1-**Erection**: controlled by **parasympathetic** nervous system

Increase Parasympathetic and decrease sympathetic activity to penile arterioles → vasodilation of the arterioles and erection

Parasympathetic postganglionic fibers release Ach

- muscarinic receptors on endothelium -- produce NO

-arteriolar dilatation → veins are compressed causing reduction in venous return.

*Erectile tissue : Corpus cavernosa(CC)& spongiosum fill of blood under pressure & venous outflow partially occluded.

...Erectile bodies mainly (CC) surrounded by strong fibrous coat which causes ballooning to extent that the penis becomes hard and elongated.

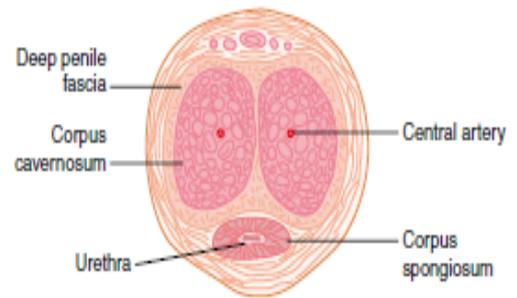


Figure 80-6 Erectile tissue of the penis.

2-Lubrication: A **parasympathetic** function causes secretion of urethral and **bulbourethral** glands to secrete mucus for lubrication during coitus.

3-Emission: Movement of ejaculate into proximal part of urethra under **sympathetic** control by hypogastric & pelvic sympathetic nerve fibers -- causes sequential peristaltic contraction of smooth muscle of vas deferens -- closing of bladder sphincter

4-Ejaculation: spinal reflex -- under **sympathetic** control triggered by entry of semen into urethra causes nerve impulses to activate contraction of ischiocavernosus & bulbocavernosus muscles which increase the pressure in the erectile tissue and the genital duct and urethra which ejaculate semen from urethra to the exterior. At the same time rhythmic contraction of pelvic muscles and some muscle of body trunk cause thrusting movement of pelvis and penis to help propel the semen deeper in the vagina.

Orgasm: The entire period of sexual excitation (**Emission and ejaculation**)

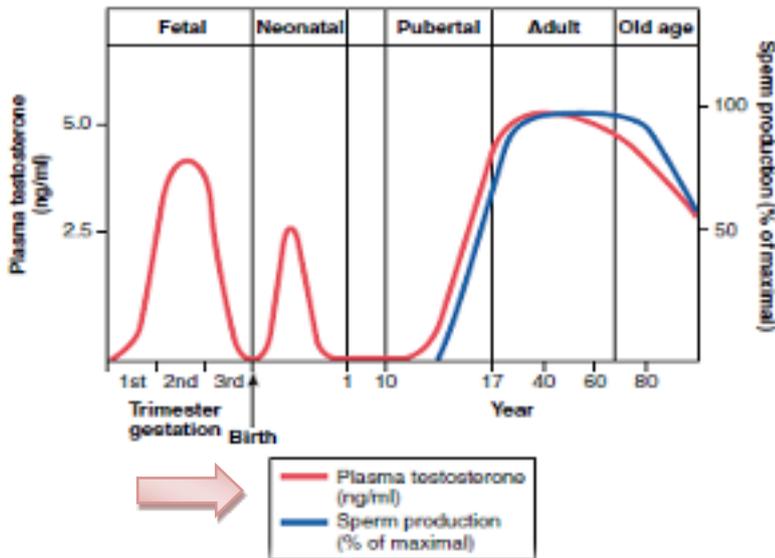


Figure 80-9 The different stages of male sexual function as reflected by average plasma testosterone concentrations (red line) and sperm production (blue line) at different ages. (Modified from Griffin JF, Wilson JD: The testis. In: Bondy PK, Rosenberg LE [eds]: Metabolic Control and Disease, 8th ed. Philadelphia: WB Saunders, 1980.)

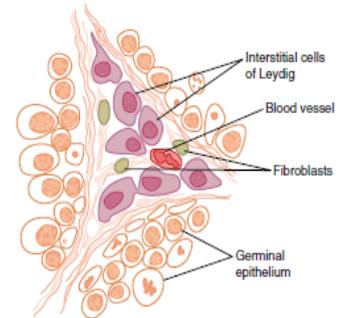


Figure 80-7 Interstitial cells of Leydig, the cells that secrete testosterone, located in the interstices between the seminiferous tubules.

Resolution: The male sexual excitement disappear within 1-2 minutes and erection ceased.

ANDROGENS

- 1-Testosterone , abundant
- 2-Dihydrotestosterone
- 3-Androstenedione

Much of testosterone converted to more active one **dihydrotestosterone** into **target cells**.

Testosterone secreted from leydig cells which are not exist during childhood. Small amount of androgen from adrenal glands
About five percent of androgens in the body secreted by adrenal glands

Some **estrogen** also formed in the male (source not clear) :

- 1-By **sertoli** cells by converting testosterone to estradiol
- 2- Much larger by converting testosterone to estrogen by the **liver(80%)**

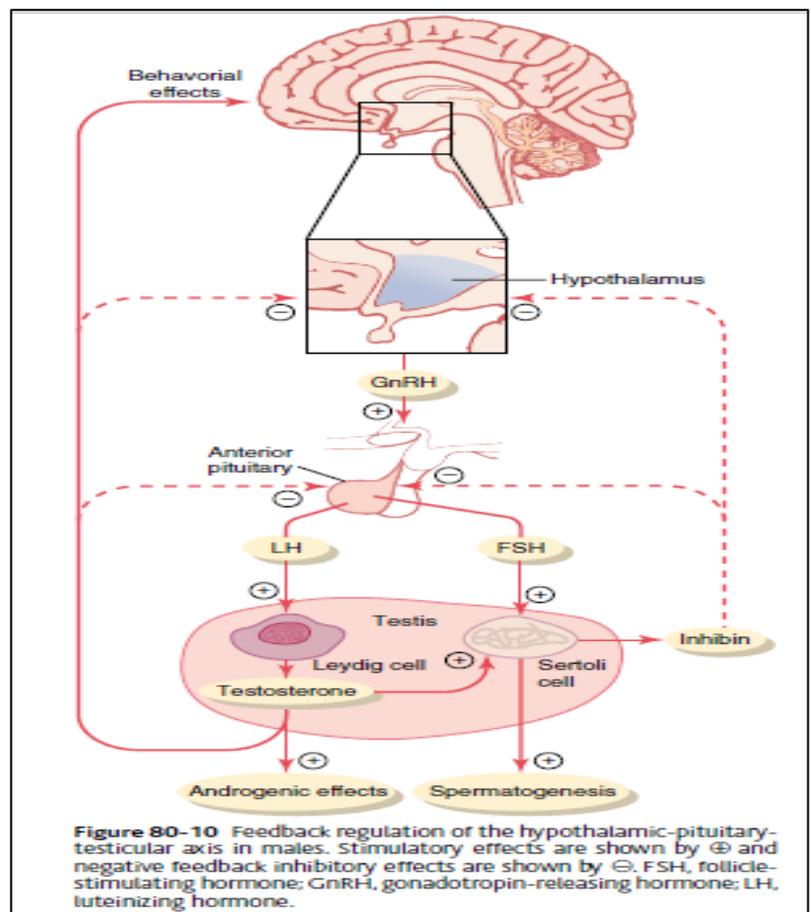
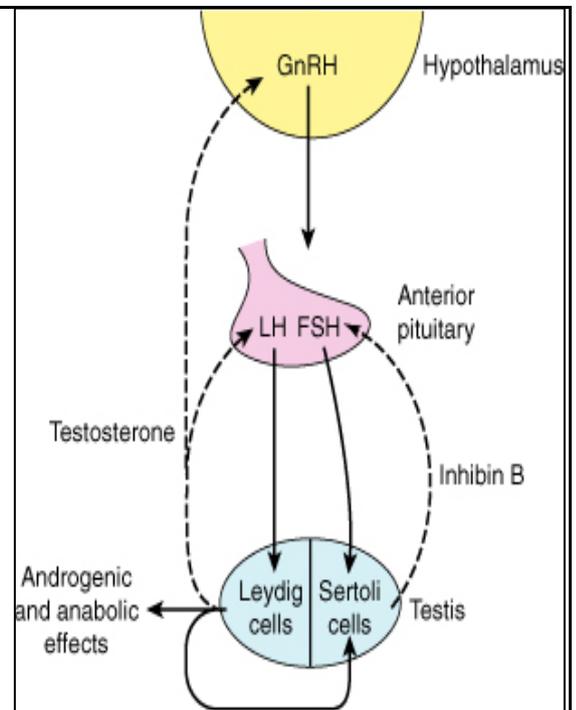


Figure 80-10 Feedback regulation of the hypothalamic-pituitary-testicular axis in males. Stimulatory effects are shown by ⊕ and negative feedback inhibitory effects are shown by ⊖. FSH, follicle-stimulating hormone; GnRH, gonadotropin-releasing hormone; LH, luteinizing hormone.

Functions of testosterone

Adult primary and secondary characteristics:

- 1) body **hair** distribution (pubis, face, chest, back, etc)
- 2) **voice**: hypertrophy of laryngeal mucosa and larynx
male = deep voice
- 3) **skin**: thickens skin and increases ruggedness of subcutaneous tissues, sebaceous glands (acne) and oil production
- 4) Protein formation and **muscle** development
- 5) **Bone growth** and calcium retention: thought to inhibit production of osteoclasts. Tall, Castrated male.
- 6) Increase **basal metabolic rate**.
- 7) Red blood cells -- causes increases in erythropoietin -- **stimulates RBC production**
- 8) Stimulates **sodium and water reabsorption** in proximal tubule of kidney (some effect on distal?)
- 9) Development of behavioral aspects characteristic for the "male brain".
- 10) Development of **♂ 2° sex characteristics** (male sex drive & libido)
- 11) ↑ protein formation & ↑ Ca²⁺ deposition
- 12) It has growth promoting effects, however ↑ testosterone levels lead to a decrease in final height because testosterone causes premature closure of epiphyseal plates.
- 13) Testosterone → male pelvis (load-bearing with narrow outlet).
- 14) ↑ MR (Metabolic rate) by 15% due to its protein anabolism.
- 15) Maintains **spermatogenesis** (with FSH)
- 16) Fetal development: present at 2nd month of embryonic life presence or absence of testosterone determines development of genital organs and characteristics



+ testosterone = male external genitalia

- testosterone = female external genitalia

17) causes **descent of testes into scrotum** during last 2-3 months of pregnancy
(Failure of testicular descent = cryptorchidism)

18) Fetal **development of epididymis**, vas deferens, seminal vesicles

19) **Pubertal growth** of penis, seminal vesicles, musculature, skeleton, larynx, Spermatogenesis

Functions of DHT

1. Fetal development of penis, penile urethra, scrotum, prostate
2. Pubertal growth of scrotum, prostate, sexual hair, sebaceous glands
3. Prostatic secretion
4. Development of ♂ 2 sex characteristics:

(facial hair, acne, temporal recession of hair line, baldness, enlargement of prostate & ♂ sex organ)

BASIC INTRACELLULAR MECHANISM OF ACTION OF TESTOSTERONE:

Converted intracellular

5 α -reductase

Testosterone  **dihydrotestosterone (DHT)**

and Stimulates rate of protein formation virtually every where in the body and more specific on target cells responsible for development of sexual character

5 α -reductase :Intracellular enzymes

Hypothalamus and anterior pituitary for control of male sexual hormones

1-Gonadotropin releasing hormone (**GnRH**) from hypo stimulate :

2-**LH and FSH** from ant pituitary : LH stimulate secretion of testosterone from testes & FSH stimulate spermatogenesis

During pregnancy : If the fetus is male hCG from the placenta cause the testes of the fetus to secrete testosterone for the formation of male sexual organs.

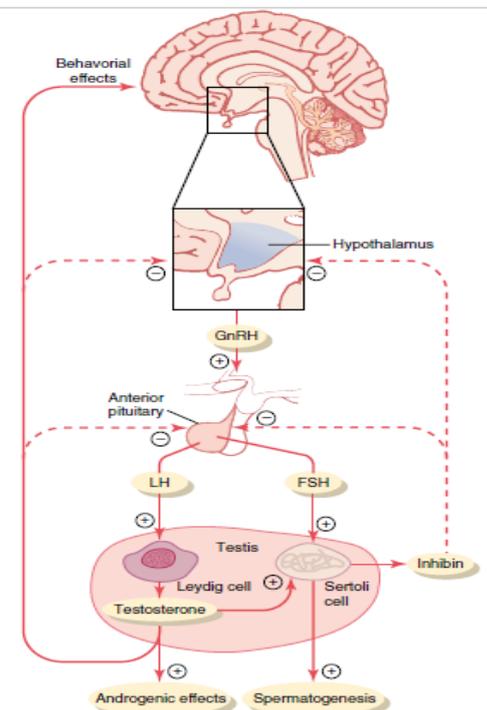


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Male sexual life

- 1-**normal** sexual function till about 50yr then decreases gradually
- 2-Male **climacteric** : As menopause in female
- 3-**Prostate** gland : Hypertrophy , cancer which is stimulated by testosterone and can be treated by estrogen

Erectile dysfunction (Impotence)

#losing the ability of erection

- 1-Trauma as prostate surgery
- 2-Decrease testosterone
- 3-Drugs : Nicotine, alcohol, antidepressants
- 4-Vascular diseases as :
Hypertension, DM, atherosclerosis

#treatment (viagra and cialis)

Manufactured nitric oxides that work as vasodilators to increase blood flow to help or maintain erection.

PINEAL GLAND ??

- 1.Pineal gland play some role in sexual and reproductive function in some animals
- 2.Perhaps(not certain) it plays at least some role in controlling sexual drive and reproduction in humans

THE END