Male reproductive function

BY

DR. NOUR A. MOHAMMED

Associate Professor Of Physiology

Faculty Of Medicine, Mutah University

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Structure of male reproductive system

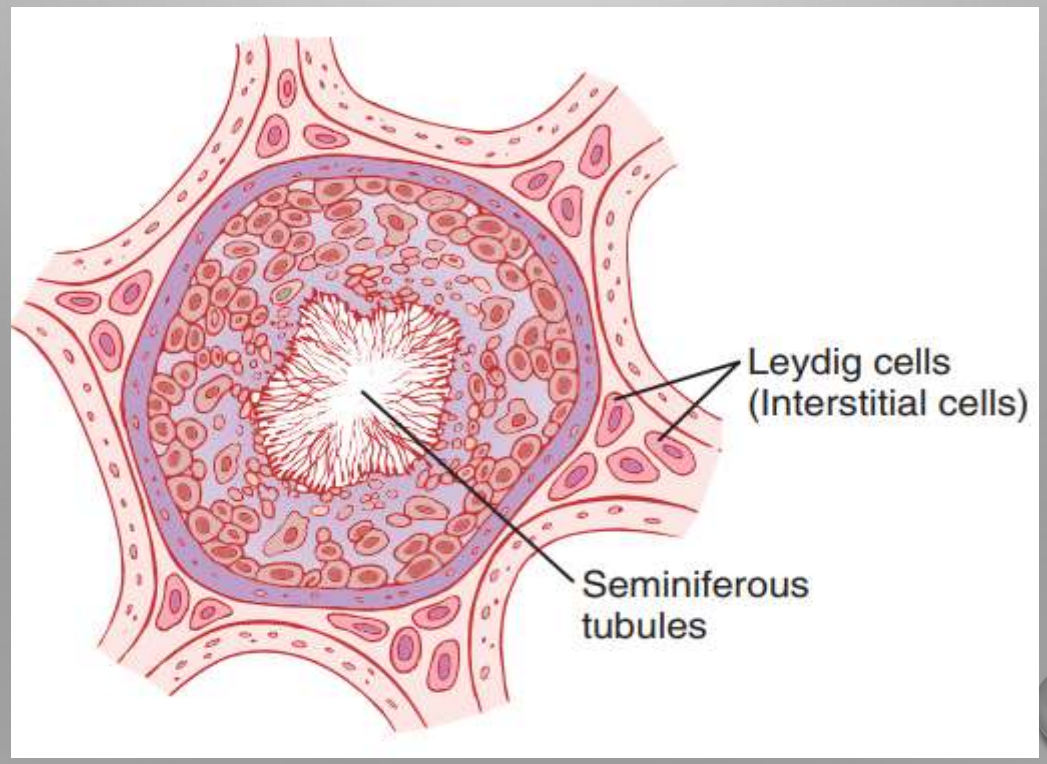
I. PRIMARY SEX ORGAN (TESTIS) !

1) Seminiferous tubules	Lined by Spermatogonia & contain Sertoli cells.
2) Interstitial cells of Leydig	Secrete testosterone.

stem cell

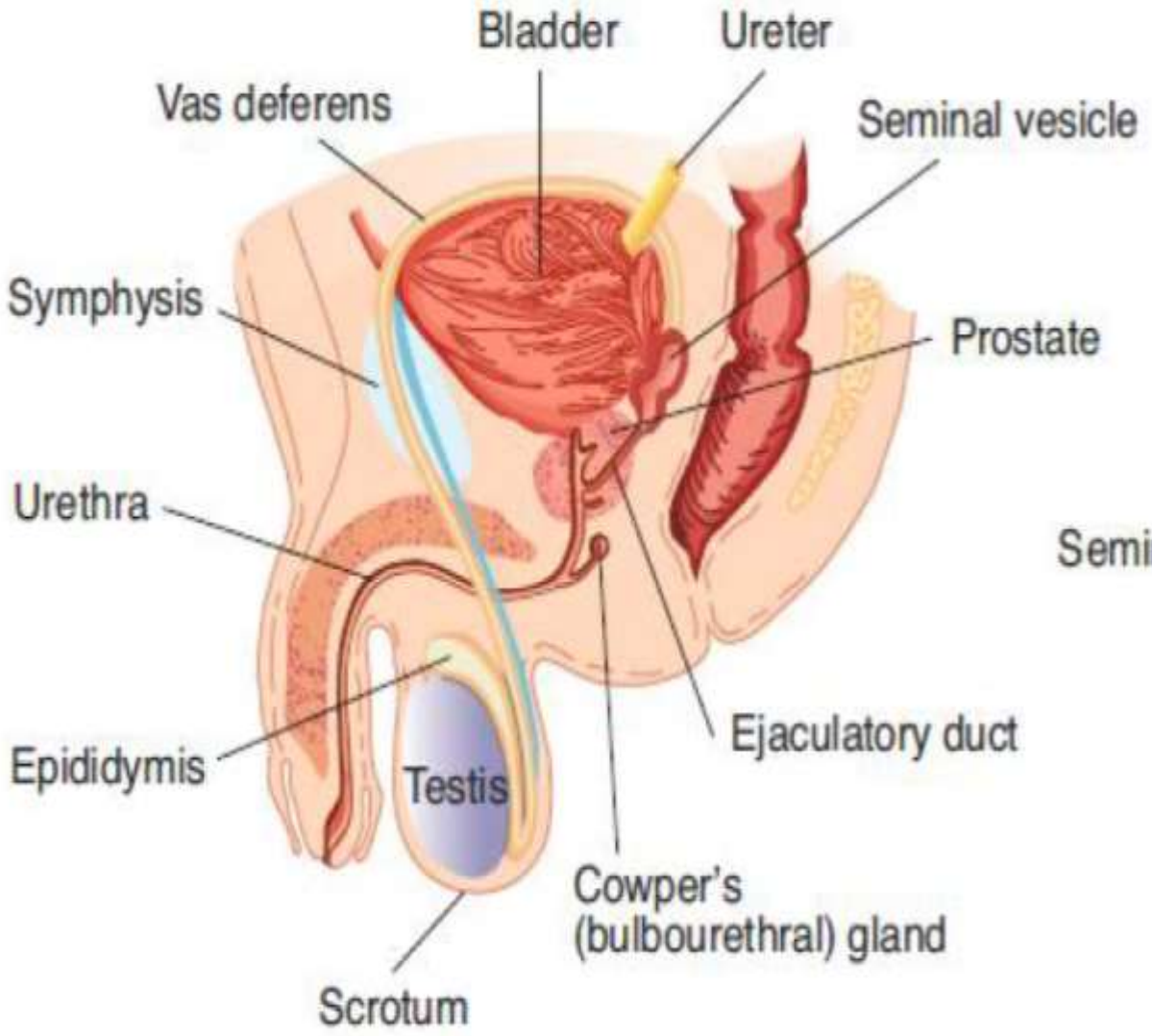
house cells

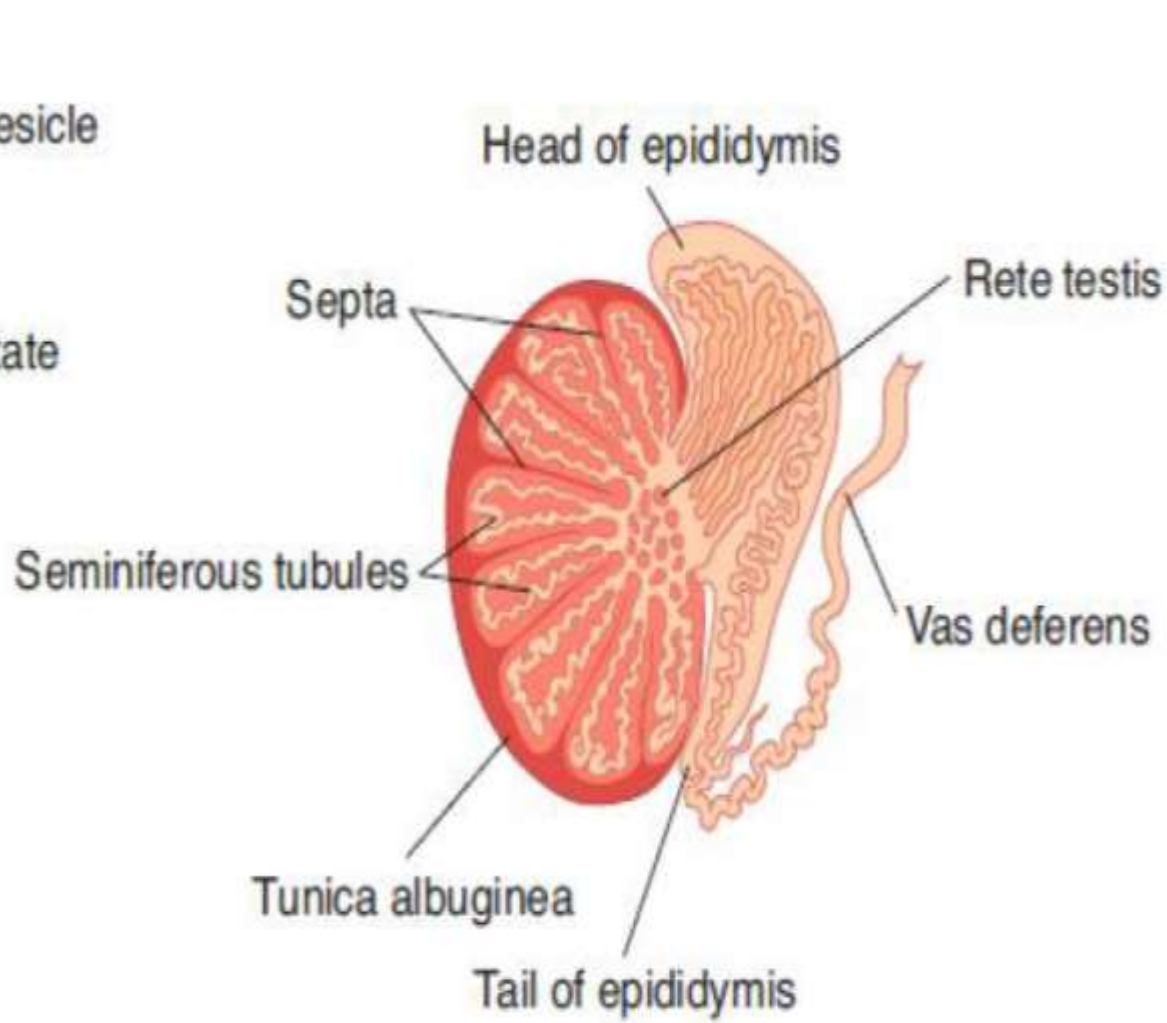
under effect of LH



II. SECONDARY SEX ORGANS

1) Epididymis & Vas deferens	- Site of Storage of Sperms. - Site of Maturation & Motility of sperms. - After remaining in epididymis for 18 hours - 10 days, sperms develop motility. - Sperms also become capable of fertilization (process called maturation.(- Most sperms are stored in vasdeferens & small amount in epididymis. - Sperms can remain stored and fertile for several months.
2) Seminal vesicles Secrete 60 - 80% of semen volume	- Secrete: a) Fructose: Fuel for the spermatozoa (200 - 800 mg %). b) Prostaglandins: help fertilization by: - Help the sperms to Penetrate the cervical mucus. - Cause reverse Peristaltic movement in uterus. c) Fibrinogen.
3) Prostate gland Secrete 13 - 33% of semen volume	- Secretes thin milky alkaline fluid to neutralizes the acidity of fluid of Vas deferens & Vagina. - Prostate secretion contain: a) Ca^{++} & Clotting enzymes & Citric acid. b) Fibrinolysin.
4) Bulbourethral gland (Cowper gland)	- Secret mucous to lubricate urethra. [male]
5) External genitalia	- Penis & scrotum.


Bladder
Ureter
Vas deferens
Seminal vesicle
Symphysis
Prostate
Urethra
Ejaculatory duct
Epididymis
Testis
Cowper's
(bulbourethral) gland
Scrotum


Head of epididymis
Septa
Rete testis
Seminiferous tubules
Vas deferens
Tunica albuginea
Tail of epididymis

SPERMATOGENESIS

📖 Phases of spermatogenesis:

- Spermatogonia present in seminiferous tubule are non-motile stem cells.
- **Spermatogonia** divide by **MITOSIS** to form two cellular pools:

A) **Additional stem cells:** for continuous renewal.

B) **Type A spermatogonia:** which enter the spermatogenesis:

1) TYPE A SPERMATOGONIA divide by **MITOSIS** to form **primary spermatocytes**.

- Primary spermatocyte contain 46 chromosomes.

2) 1RY SPERMATOCYTES divide by **MEIOSIS** to form two **Secondary spermatocytes.**

- Secondary spermatocyte contain 23 unpaired chromosomes.
- then, secondary spermatocytes divide to form spermatid.

3) Metamorphosis of spermatids to produce **Mature spermatozoa.**

- It is the morphological changes in spermatid without cell division.
- It is called spermiogenesis or spermeation .

📖 Duration of spermatogenesis: **64 – 74** days in human.

Role of sertoli cells in spermatogenesis

nurse / house cell

1. Provide a special environment for germinal cells development.

2. Secrete a fluid that supply nutrients for the developing sperm.

3. Spermiogenesis (Spermeation).

- It is the morphological changes in spermatid without cell division.

- Spermatids are attached to sertoli cells, which secrete digestive enzymes that remove most of the cytoplasm from the spermatids.

- Steps of spermiogenesis (Spermeation):

1. Losing some of the cytoplasm.
2. Condensation of the chromatic material of the nucleus to form head.
3. Collecting the remaining cytoplasm & cell membrane to form tail.
4. Play a physical role in shaping the head and tail of the sperm.

4. Formation of **BLOOD-TESTIS BARRIER** (**S**eparate between blood & testis).

Formed by:

- **Tight junction between adjacent sertoli cells** near the basal lamina.

Functions:

1) Protect the germ cells from blood-borne noxious agents (toxins).

2) Prevent antigenic products of germ cell division and maturation from entering the circulation ⇨ prevent autoimmune response.

5. Secrete some hormones & enzymes

1) **Androgen-binding protein (ABP):** → to maintain testosterone secretion ↑ in tubular for spermatogenesis

Maintain a high concentration of androgen in the tubular fluid.

2) **5 α reductase:** convert testosterone to more potent Dihydrotestosterone (DHT)

3) **Estradiol:** (source of 30% of male estrogen) ← Adrenal cortex → aromatization → estradiol

Estrogen is needed as stimulatory factors in spermatogenesis. FSH

low dose → ↑ FSH
high dose → ↓ FSH

4) **Inhibin:** has a **-ve feedback** inhibitory effect on the anterior pituitary

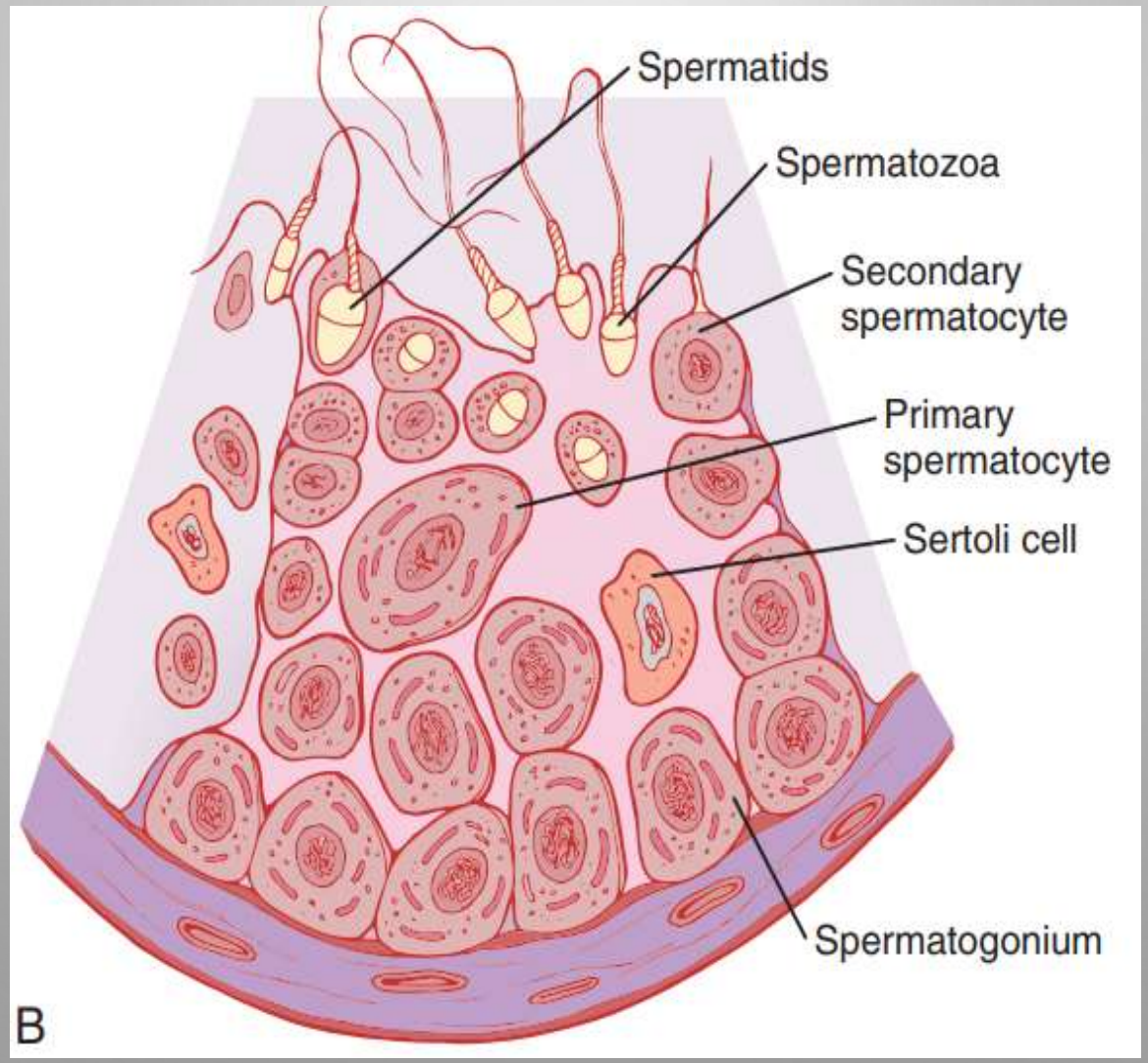
⇨ prevent over secretion of **FSH**.

5) **Mullerian inhibitory factor (MIF):**

During fetal development ⇨ Inhibit formation of fallopian tube from Mullerian duct in male fetus.

male fetus
/ mullerian → female ⊗
\ wolffian → male

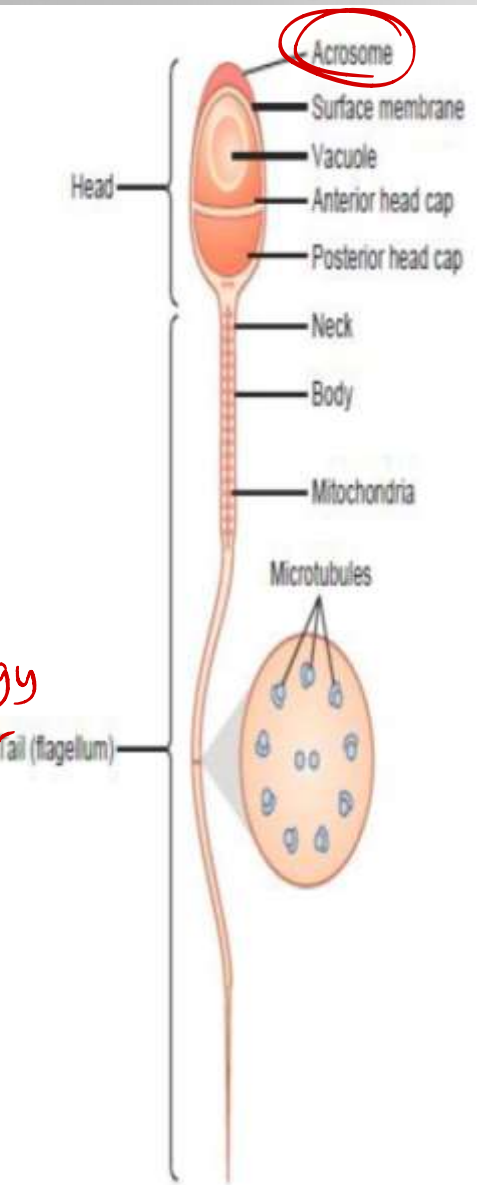
كل واحد يعمل development of diff gender



Stages in the development of sperm from spermatogonia

STRUCTURE OF MATURE SPERMATOZOA

A. Head	B. Tail
- Composed of the condensed nucleus. - The anterior part of the head is a thick cap called the acrosome. - Acrosome is formed from Golgi apparatus & contains some enzymes: a) **Hyaluronidase:** which digest proteoglycan filaments. b) **Proteolytic enzymes:** which digest proteins.	- Has three components a) Central skeleton formed of 11 Microtubules called the axoneme. b) Thin cell Membrane covering the axoneme. c) Collection of Mitochondria in the proximal portion of the tail. - Flagellar movement provides Motility for sperm at a velocity of 1 - 4 mm/minute.



Factors affecting spermatogenesis

1. HORMONAL FACTORS

1) FSH:

- Needed for growth and maturation of the testis.
- Needed for the normal functions of ***sertoli cells***.
- Help production of androgen binding protein by ***sertoli cells.***
- Help the last stages of spermatid maturation.

2) LH (ICSH):

- Needed for testosterone secretion by the ***leydig cells***.
- So, it is called **interstitial cells stimulating hormone** .

3) Testosterone:

- Needed for development & maintenance of germinal epithelium.
- Needed for complete meiosis.
- Needed for spermiogenesis (spermeation).

4) Estrogen:

- Needed for spermiogenesis (spermeation).

: ليش

low dose → ↑ FSH
high dose → ↓ FSH

- Formed by the sertoli cells by the effect of **FSH** stimulation.

- But, excessive estrogen (⇧ estrogen/androgen ratio) ⇨ ⇩ **FSH** secretion ⇨ depression of spermatogenesis.

5) Thyroxin:

- Stimulates spermatogenesis via stimulatory effect on cell **metabolism**.

- Its absence as in **cretinism** ⇨ deficient spermatogenesis

→ mentally retarded baby
[creative baby]

6) GROWTH HORMONE (GH):

- Promotes **early** division of the spermatogonia

- Its absence as in **pituitary dwarfism** ⇨ deficient spermatogenesis

2. Temperature

- Spermatogenesis requires lower temperature of about **32 o C**.

✓ testicles outside body

Factors that maintain low testicular temperature:

1. The scrotum is **outside** the abdominal cavity.
2. Absence of **subcutaneous fat** in the scrotum.
3. **Dartos muscle**:
   - Relax in hot weather ⇨ draw the testis away from warm abdomen.
   - Contract in cold weather ⇨ attract the testis near warm abdomen.
4. **Counter-current heat exchanger** in Pampiniform plexus:
   - The warm blood in **spermatic arteries** runs parallel but in the opposite direction to the cold blood in the **spermatic veins.**
   - This allow counter-current exchange of heat from warm arterial blood to cold venous blood.

! ✓ cold blood to testis

Increase testicular temperature ⇨ ⇩ sperm count

1. Hot baths (45 ºC for 30 min/day) as in sauna.
2. Insulated athletic supporters.

normal
last 2m of gestation
↓
descend to scrotum

3. Cryptorchidism

- Failure of testicular descend in the scrotum. (Un-descended testis).
- ***CAUSES:*** A) Obstruction of the inguinal canal.

  B) Testosterone deficiency. growth deficiency ↓ weight
- ***EFFECT:*** A) Complete failure of spermatogenesis with sterility.

  B) Mild impairment of endocrine function of testis.
- ***TREATMENT:*** (Must start as **early** as possible)

A) Surgical dilatation of the inguinal canal.

B) Testosterone administration.

3. DIET

1) PROTEIN:

- Needed for synthesis of sperms & pituitary gonadotropin.
- Complete protein starvation ⇨ arrest of spermatogenesis.

2) VITAMIN E:

- ⇩ vitamin E ⇨ irreversible tubular degeneration (in animals).
- This is not proved in human.

3) VITAMIN A:

- ⇩ vitamin A ⇨ keratinization & atrophy of germinal epithelium.

4) VITAMIN B:

- Vit. B act as catalyst for metabolic processes in tubular germ cells.

5) VITAMIN C:

- Vit. C is needed in testosterone synthesis
- ⇩ vitamin C ⇨ inhibition of spermatogenesis.

4. CENTRAL NERVOUS SYSTEM

- The hypothalamus contains dopaminergic & noradrenergic neurons.
- Stimulation of these neurons ⇨ ⇧ release of gonadotropin releasing factor (FSH / LH)

⇨ stimulation of anterior pituitary ⇨ ⇧ gonadotropins secretions.

- So, **psychic** stimuli affecting hypothalamus ⇨ excitatory or inhibitory effect on Gonadotropin secretion ⇨ changes in the degree of fertility.
- e.g. Stress ⇨ ⇩ dopamine ⇨ ⇩ gonadotropin & ⇧ prolactin.

5. IRRADIATION

- Irradiation ⇨ destruction of germinal epithelium (⇩ spermatogenesis).
- Certain doses of radiation spare sertoli cells & leydig cells. So, spare the endocrine functions of the testis.

6. HYPOXIA & TOXINS:

- Hypoxia & ischemia ⇨ depress spermatogenesis.
- Bacterial or chemical toxins ⇨ depress spermatogenesis.

Endocrine function of the testis

1. Testosterone(T)

It is a steroid hormone

- It is secreted by the leydig cells under the control of LH

- LH ⇨ ⇧ cAMP via LH receptors on cell membrane of leydig cells.

- Testosterone is formed also in the adrenal cortex.

Metabolism

1) most of the (T) is converted to 17-ketosteroid and excreted in urine.

But, 2/3 of the urinary 17-ketosteroid are of adrenal origin and 1/3 of

Urinary 17-ketosteroid are of testicular origin.

2) small amount of (T) is converted to estrogen (by aromatization).

3) conjugation of (T) with glucuronic acid or sulfate in liver.

Mechanism of action: like other steroids

1. The hormone passes the cell membrane, enter the cell and bind to specific ***Cytoplasmic*** receptors.

2. The resulting complex (steroid - receptor complex) enters the nucleus ⇨

Facilitate transcription of various genes ⇨ production of mRNA

⇨ new protein formation (testosterone induced protein).

3. The new proteins perform the actions of the hormone.

↑ testosterone

! Similar to thyroxin but it enters cyto where as testos enters as complex & NOT alone

Actions of testosterone

I. During fetal life

1. **D**evelopment of male sex organs: **(internal genitalia**).

2. **D**i hydro testosterone is essential for development of **external genitalia & prostate**.

3. **D**escend of testis into scrotum: during the **last 2** months of gestation . ↓ = crypto [no - descend]

II. At puberty

A. On the primary sex organ

- Essential for spermatogenesis .

- Essential for growth & maturation & maintenance of testis.

B. On the secondary sex organs

- Essential for growth & maturation & maintenance of:

- Epididymis & vas deferens & seminal vesicles & bulbourethral glands.

C. On the secondary sex characters

1. **The distribution of body hair** ← testo. dihyd. test.

- General body hair increases.
- Beard appears.
- Hairline on scalp recedes antro-laterally.
- Baldness: decrease the growth of hair on the top of the head.
- Pubic hair grows with male pattern (triangle with apex up).

2. **Voice**

- Hypertrophy of the laryngeal mucosa and enlargement of the larynx ⇨ Deeper voice (low pitch voice).

3. **SKIN:**

- Increases thickness of the skin.
- Increases secretion of the sebaceous glands ⇨ **acne** formation.

4. **Bone building: Wide shoulder & narrow pelvis.**

5. **Increased muscle bulk.**

D. On the behavior

- Regulation of behavioral effects, boys becomes aggressive, develop interest in sex, increased libido.

E. General metabolic effects:

- ⇧ **P**roteins synthesis (anabolic).
- ⇧ Quantity of **b**one matrix & causes ca^{++} retention.
- ⇧ **B**asal metabolic rate.
  ⇧ Food intake
- ⇧ R**BC**s number, by stimulating erythropoietin synthesis.
- ⇧ Na^{+} reabsorption in the distal convoluted tubules ⇨ Slight increase in the extracellular fluid & A**B**P.

Di hydro testosterone (DHT):

- About 20 % of plasma DHT is synthesized by the testis by the action of **5α− reductase** on testosterone.
- The remainder is derived from the peripheral conversion of testosterone to DHT by **5α− reductase** in some target cells.
- DHT circulates in blood, with a plasma level that is 10 % of the testosterone level.
- DHT -receptor complexes are **more stable** than testosterone - receptor complexes in the target cells. Thus DHT is **more potent** than testosterone.

Functions of DHT

A. Fetus:

- Development of prostate and external genital organs.

B. At puberty:

1. Enlargement of prostate and external genitalia.
2. Hair growth all over the body.
3. Fall of scalp hair and bilateral temporal recession of frontal scalp hairline.
4. Increased secretion of sebaceous glands and acne formation.

- Congenital 5α–reductase deficiency produces **male pseudo-hermaphroditism.**

in fetal life

sex organ is not clear to distinguish gender

XY

no testosterone issue, internal genetalia is OK
external ♂ → confused as female

endocrine function

(II) Estrogens

- 80-90 % of estrogens in males are formed by action of aromatase on circulating testosterone.
- The remainder is secreted by the testes, some from **Leydig cells** and some from **Sertoli** cells.
- Very small amount secreted by the adrenal cortex.
- The plasma **estrogen** level **in males** is 20-50 pg. /ml.
- Elevation in the ratio of plasma estrogens to androgens→ some feminization of the male body may occur as **gynecomastia**.

⊕ ↓ FSH

(III)Inhibin

- Polypeptide hormone secreted by **Sertoli** cells in males.
- Inhibit FSH secretion by a direct negative feedback action on anterior pituitary gland. So, depress spermatogenesis.

Hormonal control of testicular functions

Hypothalamic-hypo-physeal testicular axis

cyclic → female
continuous → male

1-*gonadotropin- releasing hormone(Gn-RH)*:

- peptide secreted by the hypothalamus →to the anterior lobe of the pituitary gland, through the hypophyseal portal circulation → release of **FSH** and **LH** hormones.
- The secretion of *(Gn-RH)* is continuous in male not cyclic as in female. This known as sexual differentiation of the hypothalamus.
- *(Gn-RH)* stimulates the release of gonadotropin hormones through **Cyclic AMP.**

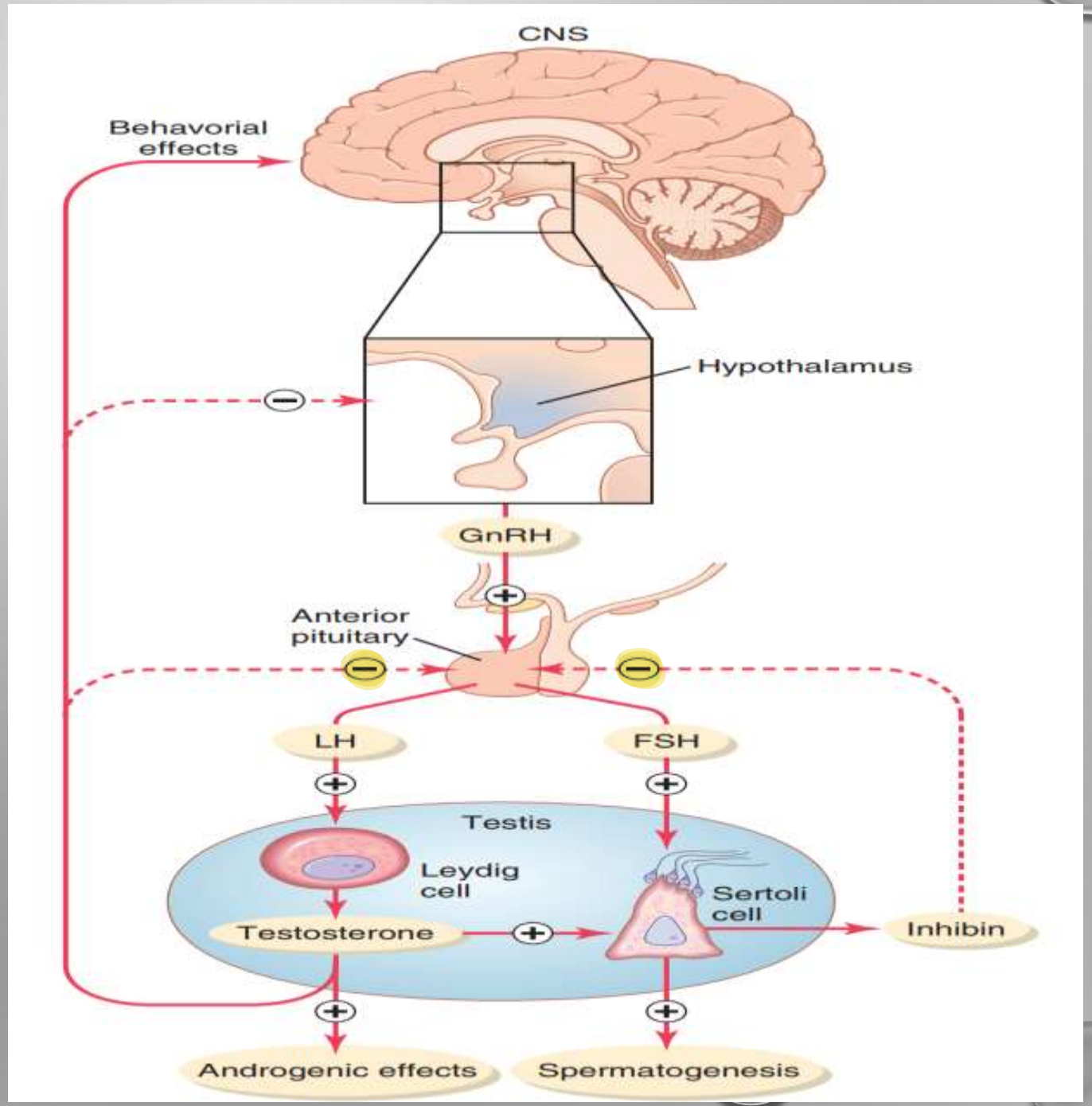
CONTROL OF Gn-RH

read but imp

(A) Feedback control

1. **Long loop** between testosterone , hypothalamus and anterior pituitary gland.
2. **Short loop** between FSH and LH and the hypothalamus (negative feedback).

(B) nervous factors: e.g. Emotional and physical stress act on the hypothalamus leading to decrease *(Gn-RH)* secretion →decreased secretion of pituitary gonadotropin and decrease fertility in men.


CNS
Behavorial effects
Hypothalamus
GnRH
Anterior pituitary
LH
FSH
Testis
Leydig cell
Sertoli cell
Testosterone
Inhibin
Androgenic effects
Spermatogenesis

read but imp

2- Pituitary gonadotropin (FSH & LH):

LH: tropic to ***Leydig cells*** → stimulates testosterone secretion. So called **ICSH**.

FSH: tropic to ***Sertoli cells*** → stimulates spermatogenesis, maintains high concentration of testosterone in seminiferous tubular fluid, and stimulates secretion of inhibin and estrogen.

- LH and FSH are *glycoproteins*. They exert their effects on their target tissues in the testis mainly by activating **cyclic AMP**, which in turn activates specific enzyme systems in the respective target cells.
- High testosterone blood level → **-ve** feedback inhibition of **LH secretion** at both hypothalamic and pituitary levels, and vice versa.
- High inhibin blood level → **-ve** feedback inhibition of FSH secretion from the anterior pituitary, and vice versa.

Testicular function tests

1- Estimation of urinary gonadotropins: they increase in primary hypogonadism and decrease in secondary hypogonadism.

2- Estimation of 17-ketosteroids in urine :they decrease in testicular disease. It reflects mainly adrenocortical secretion activity.

3- Semen analysis.

4- Testicular biopsy: may be in **azospermic patients**. A sample of testicular tissue is taken by a needle to show whether male sterility is due to defect in spermatogenesis or due to obstruction of the duct system. Testicular biopsy may be done also to exclude testicular carcinoma.


THank you