

PHYSIOLOGY

Sheet

Slide

Handout

Number

1

Subject

The Male Reproductive system

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The Male Reproductive System

This sheet was written according to the recording of section 3, the contents of this lecture are very simple and most of the ideas were covered in the midterm Anatomy.

❖ Spermatogenesis

- Generally, when we discuss the reproductive system, we are mainly talking about the **endocrine** functions of these systems. i.e. When the hormonal function is normal, then the production of sperms/ova is normal.
- In the male reproductive system, the endocrine functions reside in 2 cells that work together as one functional unit, none of which can function alone and these cells are:
 - Leydig cells
 - Sertoli cells
- The anterior pituitary releases Gonadotropins;
 - LH (Luteinizing hormone)
 - FSH (Follicle-stimulating hormone)
- LH acts on Leydig cells, increasing the production of androgens (testosterone).
- FSH acts on Sertoli cells, testosterone then enters these cells and is converted into Estradiol by the use of the enzyme **aromatase**.
- For normal production of sperms, Sertoli cells must release factors, including:
 - **Blood hormones** (e.g. Follistatins, Activins, Inhibins; there're subtypes of each)
 - **Androgen-Binding Protein (ABP)** – These bind androgen in order for the sertoli cells to be able to make use of the body androgen, or else the presence of testosterone in the body will be of no use.
 - **Estradiol** (by the aid of aromatase).
 - **Growth factors and other products**.
- Inhibins have both endocrine & paracrine functions.
- LH & FSH produce factors such as:-
Steroidogenic factor 1 (SF1) and cAMP response element binding protein (CREB).
These factors activate enzymes that control testosterone production by Leydig cells.
- LH alone also stimulates the synthesis of sterol carrier proteins (SCP) and sterol activating proteins (SAP) important for the production of testosterone.

Ps.) Testosterone is the most potent androgen.

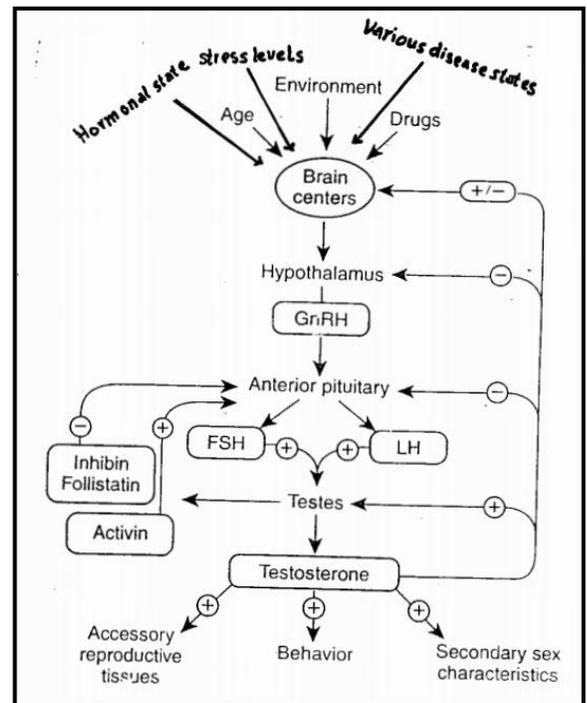
- Leydig cells of testes produce 95% (No no 96% :o!! -Dr.saleem) of body testosterone. Although testosterone is the main secreted product, testes also secrete:-
 - Pregnenolone
 - Progesterone
 - 17-hydroxyprogesterone
 - Dihydrotestosterone
 - Androsterone
 - Androstenedione – serves as precursor for extraglandular **estrogen** formation.
- Prolactin has receptors on Leydig cells. Normally, prolactin synergizes with LH to increase the production of testosterone from Leydig cells.

➔ In cases of over-production of prolactin (e.g. Prolactinoma; a pituitary tumor) prolactin will **decrease the level of testosterone** by 2 ways:

- 1) By occupying all the receptors on Leydig cells, preventing LH from binding.
- 2) By inhibiting the pulsatile secretion of LH by anterior pituitary.

➤ Regulation of spermatogenesis

- Brain centers respond to several factors including: Hormonal state, Age, Drugs, Stress levels, Various disease states, Environment, and Genetic factors.
- These centers stimulate the hypothalamus to produce Gonadotropin-Releasing hormone (GnRH).
- GnRH stimulates the anterior pituitary to release LH & FSH.
- LH & FSH act on Leydig & Sertoli cells in the testes in order to produce testosterone.
- Testosterone affects the Behavior, Accessory reproductive tissues & Secondary sex characteristics.
- Testosterone sends –ve feedback to levels of Ant. pituitary, Hypothalamus & Brain centers therefore reducing the secretion of LH, FSH, GnRH and factors from brain centers.
- Testosterone, Estradiol, Activins, Inhibins & Follistatins are the major hormones that regulate secretion of gonadotropins (LH & FSH) from Anterior pituitary.
- Generally, Testosterone, Estradiol, Inhibin inhibits secretion of males' LH & FSH.



- Activins stimulate the secretion of FSH.
 - Follistatins inhibit the secretion of FSH.
 - Inhibins directly inhibit the secretion of FSH, but NOT LH.
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✚ **Functions of Sertoli cells:** (Critical to germ cell as indicated by their close contact)

- 1- Sertoli cells also produce glycoprotein hormones; inhibins, activins & follistatins that regulate the secretion of FSH.
- 2- They can phagocytose damaged germ cells and also residual bodies (excess cytoplasm resulting from the transformation of spermatids to spermatozoa)
- 3- They provide structural support and nutrition for germ cells, secrete fluids and assist in **spermeation**; (which is the final detachment of spermatozoa from sertoli cells into the lumen of seminiferous tubules).

“Plasminogen activator” converts plasminogen to plasmin; a proteolytic enzyme that assists in the release of mature sperms into the lumen (spermeation)

- 4- They synthesize large amounts of transferrin; an iron transport protein important for sperm development.
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- There are 4 hormones:- LH, FSH, hCG (human chorionic gonadotropin) & TSH (thyroid-stimulating hormone)
 - ➔ These hormones have the same alpha subunit, what is specific for each hormone is the **beta** subunit.
 - ➔ LH & hCG are administered to increase the number of sperms in cases of Azoospermia (no sperms production) or Oligospermia (low number of sperms).
- The difference between a male and a female is 1 single chromosome (Y chromosome) and a pair of endocrine glands (testes/ovaries).
- The differentiation of primitive gonads into testes/ovaries is genetically determined, but the development of a mature ovary/testis requires certain concentrations of sex hormones (i.e. estrogen & testosterone).
- Sex organs (testes/ovaries) have 2 main functions:-
 - 1) Production of hormones (i.e. androgens in case of testes).
 - 2) Production of sex cells (sperms/ova).
- ✓ Production of sex cells requires normal pituitary, hypothalamus and brain centers.
- Spermatogenesis occurs in all seminiferous tubules inside the testes.

- Secondary sex characteristics in men (hardening of voice, facial hair, etc...) appear mainly at puberty when testosterone secretion is at its highest.
 - Accessory (secondary) sex organs are the penis, epididymis, vas deferens, prostate, bulbourethral gland and the seminal vesicles.
Ps.) Any enlargement in the prostate might cause difficulty in urination.
 - The sperms are produced in the testis, mature in the epididymis and then are transferred via the vas deferens to the urethra.
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✚ Stages of spermatogenesis:-

- 1) **Mitosis** – Production of primary spermatocytes, same number of chromosomes (46).
- 2) **Meiosis** – Production of spermatids, with half the number of chromosomes (23).
- 3) **Spermiogenesis** – Spermatid development into a sperm (23 chromosomes).

These phases are regular, ordered (affected by some chemicals or factors), sequential and have different durations.

- The duration of spermatogenesis ranges from 70 to 75 days.
- Hormones are essential for normal spermatogenesis, can alter the number of sperms and can cause chromosomal abnormalities but they cannot alter its duration.
- Because sperm cells are rapidly dividing and undergoing meiosis, spermatogenesis is very sensitive to external agents that alter cell division; **Chemical carcinogens, chemotherapeutic agents, certain drugs, environmental toxins, irradiation and extreme temperatures** can reduce the number of replicating germ cells.
- New cycles of spermatogenesis are initiated every 2-3 weeks at puberty and approximately 200 million sperms are produced daily in adulthood by both testes; therefore **one testis is sufficient**.
- If testes were exposed to infection **or** physical injury, antibodies might be produced against sperms and may cause infertility ONLY if they were **very high** in number.
 - ⇒ Sometimes, although very rare, antibodies against sperms may also be found in both the female and the male and this definitely leads to infertility.
- Summary for hormones affecting spermatogenesis
 - Testosterone (essential for meiosis)
 - FSH, LH, Estrogen
 - Growth hormone & almost all other hormones, especially thyroid hormones.

- ⊖ In growth hormone deficiency, e.g. Dwarfs; they are mentally normal but some may have sexual-infertility.
- ⊖ While in cripples(?), they are both mentally-ill & sexually-infertile.
- ⊖ Thyroid cancer patients are infertile, with azoospermia or oligospermia.

✚ Maturation of spermatozoa

Maturation of sperms involves becoming motile and able to fertilize an ovum.

Maturation begins in the **body of epididymis**; 50% of maturation occurs in there, while the other 50 % matures in the **tail of epididymis**.

⇒ So, If you take a sample from the lumen of seminiferous tubules in the testes or from the head of epididymis, you'll see 0% of motile sperms.

➤ The process of maturation lasts for 10-24 days.

➔ The ability to gain this motility (mechanism of maturation) in the epididymis involves the activation of a unique protein called **CatSper** (**cation channels of sperms**).

It is a calcium ion channel that permits cAMP generalized Ca^{++} influx and this permits the sperms to become motile and move forward.

➤ The epididymis stores little amount of sperms, while the main storage reservoir is in the vas deferens, especially in the ampulla.

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✚ Capacitation

After ejaculation of sperms to the female reproductive tract, they move upward to the uterine tube where they slow down and undergo capacitation; a process which is essential for the sperm to fertilize the ovum.

➤ It lasts from 1 hour to several hours.

➤ It consists of two things:

- Increasing the motility of the sperm
- Facilitating the penetration of acrosomal cap into the ovum.

➔ However, the role of capacitation appears to be facilitatory rather than obligatory, because fertilization is readily produced in vitro, so there has to be extensive regulation in order for it to happen in vivo.

⊛ **Chemotaxis theory:** Some researches tell that sperms express olfactory receptors, while eggs produce odorant-like molecules and chemotaxis occurs.

➤ Sperms can be stored for several weeks in the male reproductive tract, but can survive for only for 1-2 days in the female reproductive tract.

The sheet is dedicated to Laith Shlash <3

Best of luck.

Hala Madrid <333