BACHELOR DEGREE IN BIOTECHNOLOGY
1° YEAR

PHYSIOLOGY OF THE MALE REPRODUCTIVE SYSTEM

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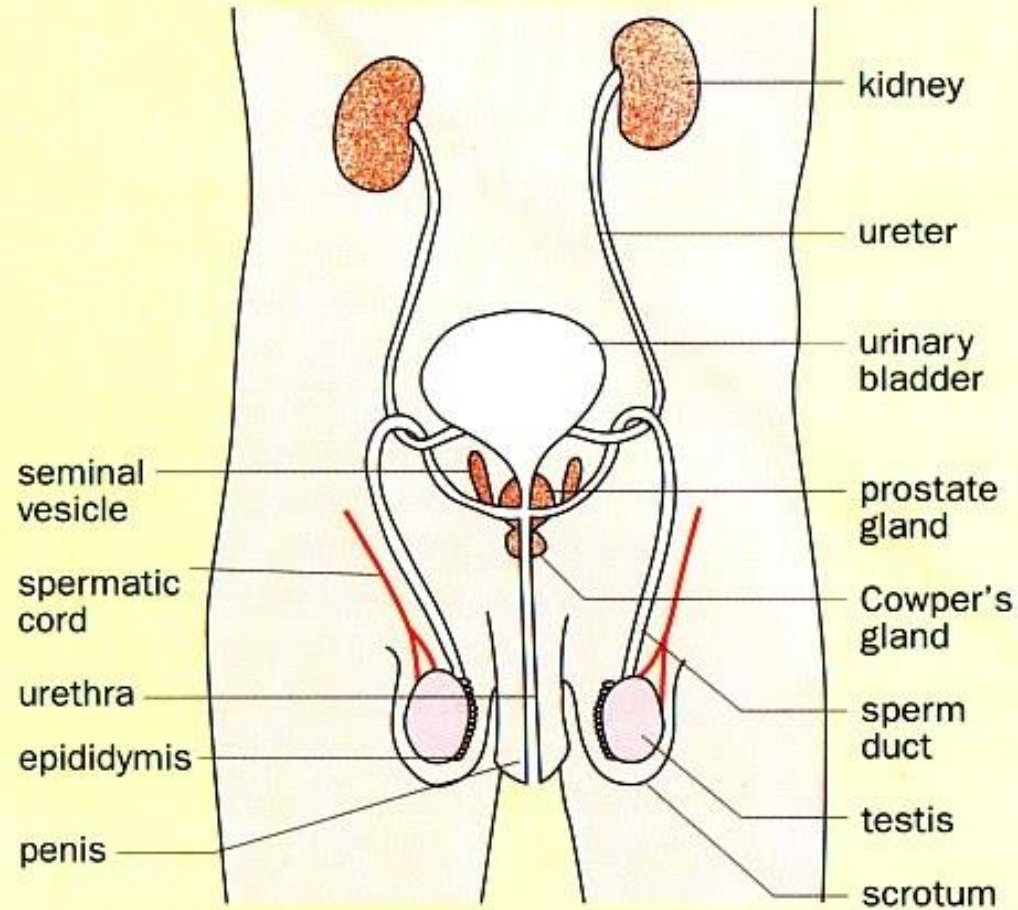
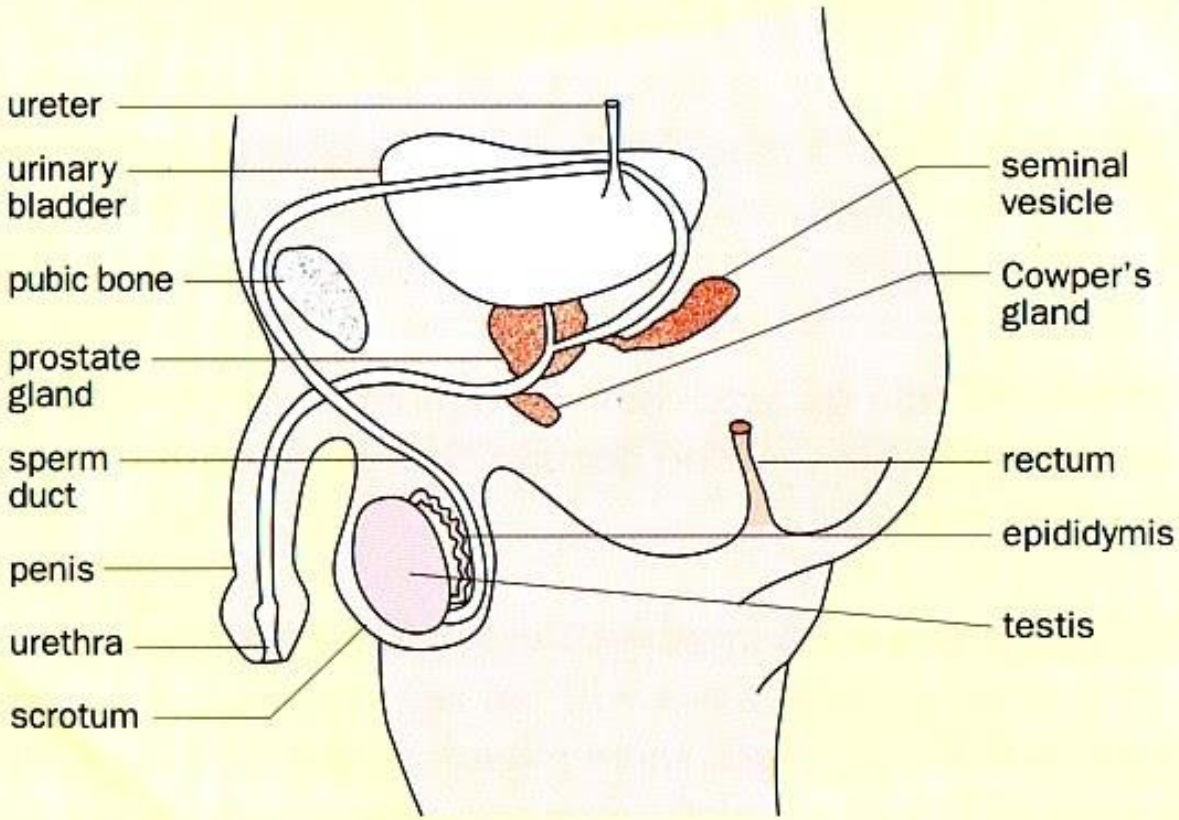
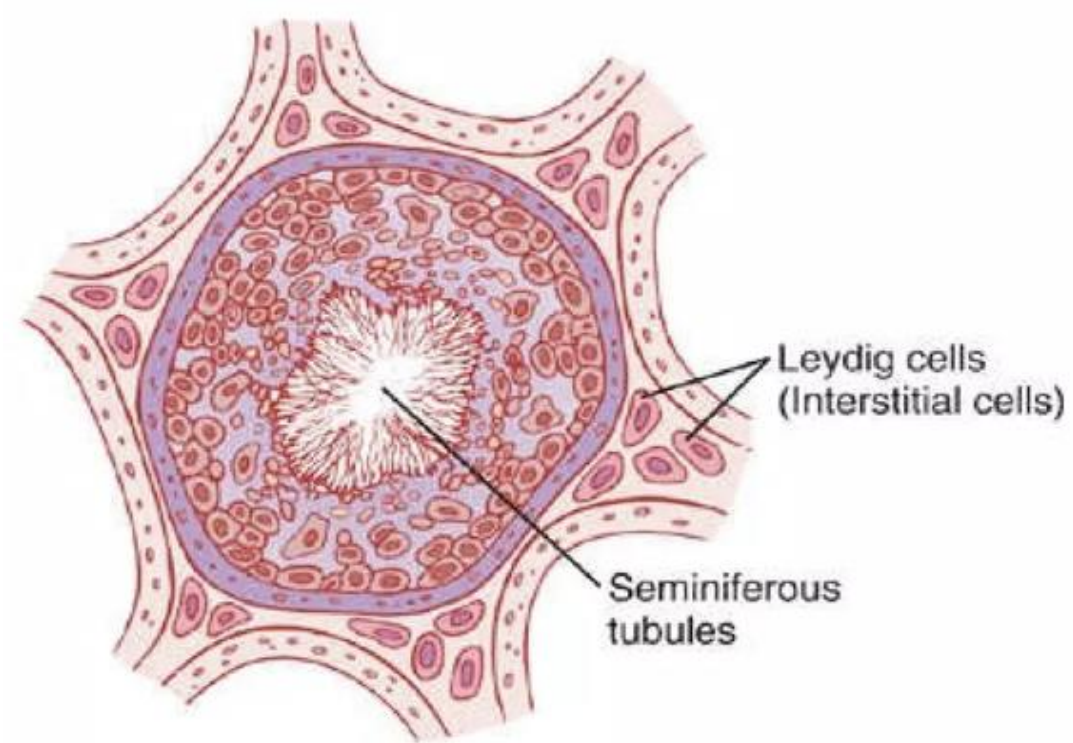


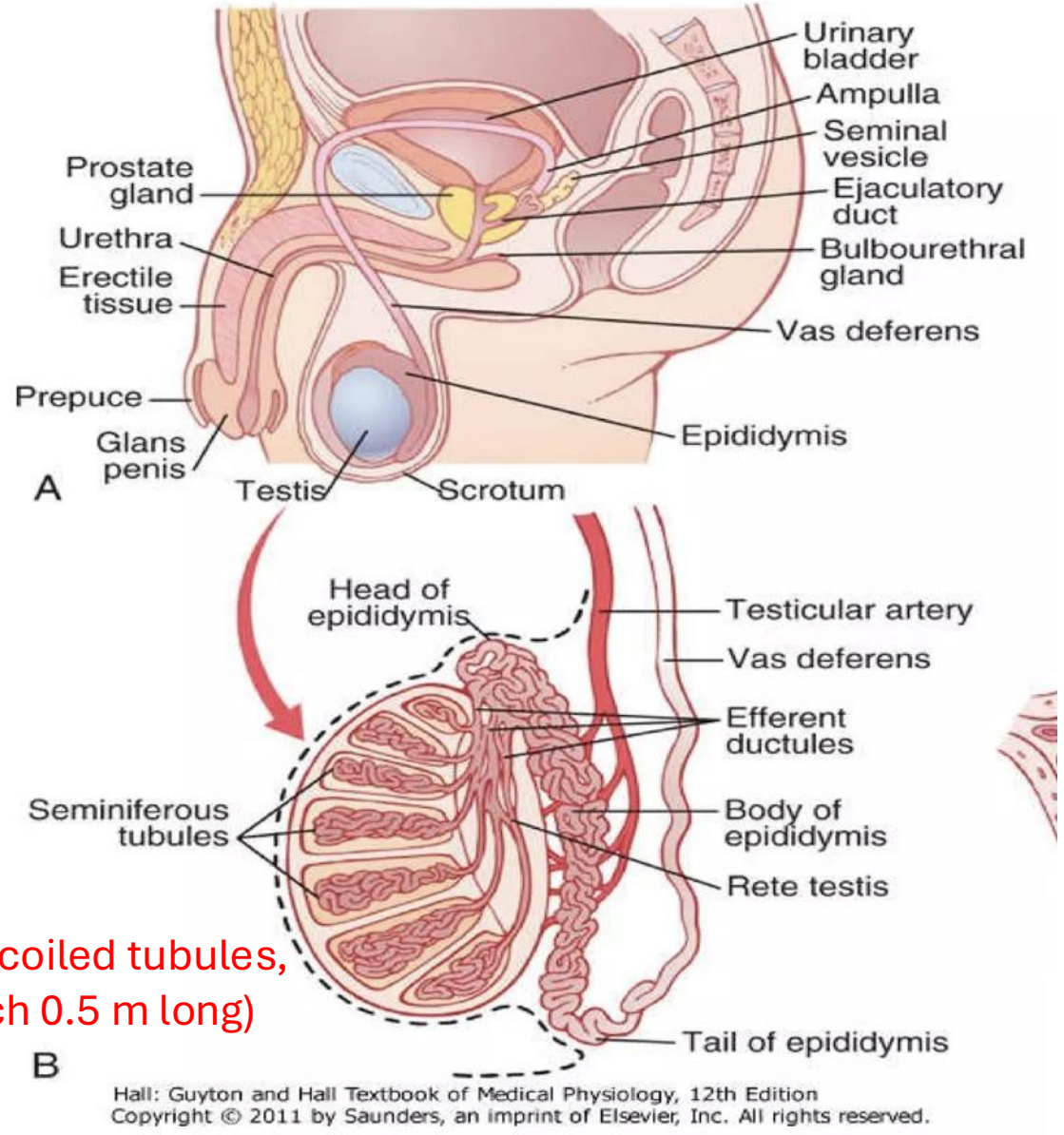
(a) Front view



(b) Left side view

1. Reproductive Organs Contributing to Semen Production





(900 coiled tubules,
each 0.5 m long)

1.1. Structure of the Testes

A. Seminiferous Tubules:

- The epithelial lining consists of three cell types: spermatogonia (stem cells), spermatocytes (immature sperm), and Sertoli cells

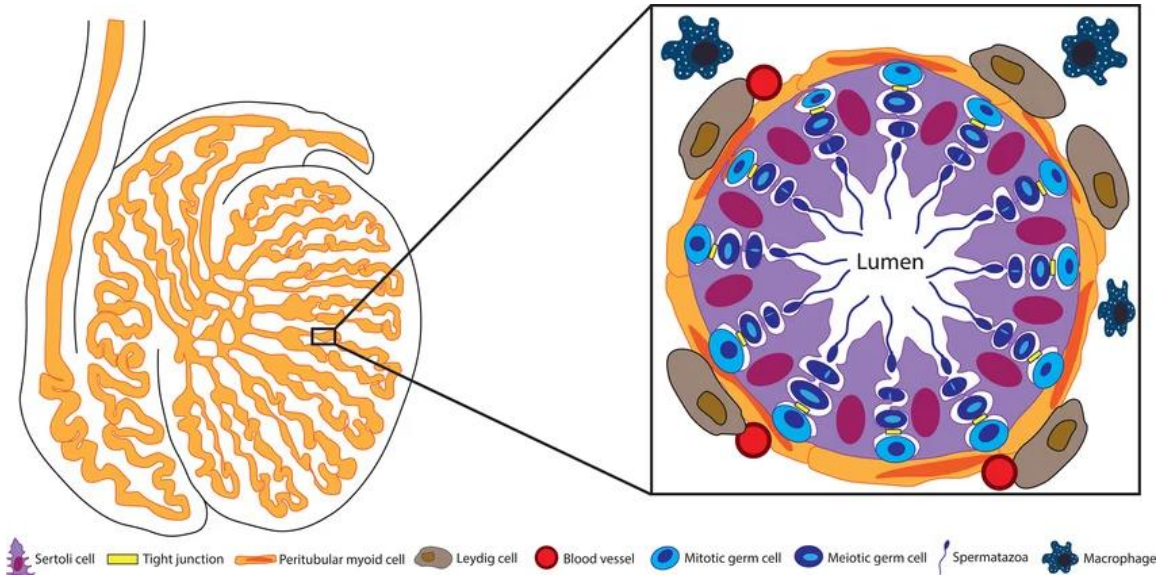
- Sertoli cells aid spermatogenesis:

1. Provide nutrients to developing sperm
2. Form blood-testes barrier
3. Secrete fluid into seminiferous tubule to help sperm transport

B. Leydig cells

	Seminiferous tubule		Leydig cells
% of testes	80		20
	Lobule	**Epithelial lining**	
Function	Spermatogenesis[1]	Support the developing sperm	Synthesis and secretion of testosterone
Location	Loops arranged in lobules surrounded by connective tissue	Lining of the seminiferous tubule	Cells surrounding the seminiferous tubule

[1]Production of sperm

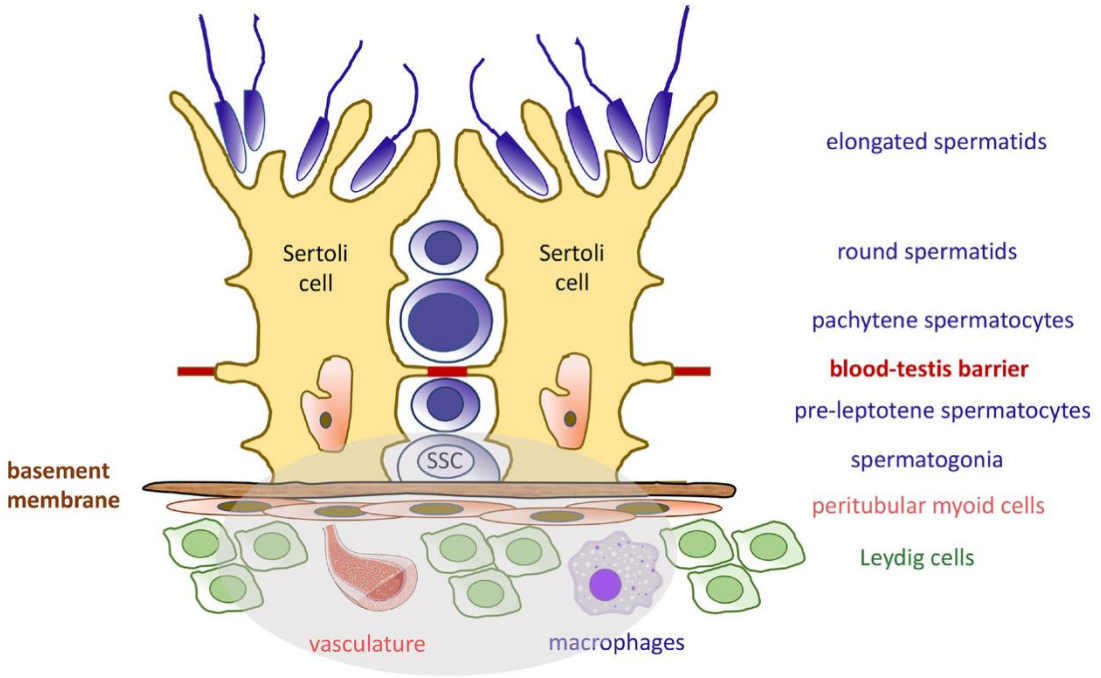


1.1. Structure of the Testes

C. Functions of Sertoli Cells

1) Blood-Testes Barrier:
Sertoli cells form tight junctions between each other, creating the blood-testes barrier. This barrier protects developing sperm cells from harmful substances and immune system attacks, maintaining a controlled environment essential for spermatogenesis.

2)Nourishment to Developing Sperm Cells:
Sertoli cells supply nutrients and metabolic support to the developing spermatozoa, ensuring their proper growth and maturation within the seminiferous tubules.



5) Androgen Binding Protein (ABP) Production:
Sertoli cells produce ABP, which binds testosterone and concentrates it within the seminiferous tubules, facilitating the hormonal regulation necessary for sperm development.

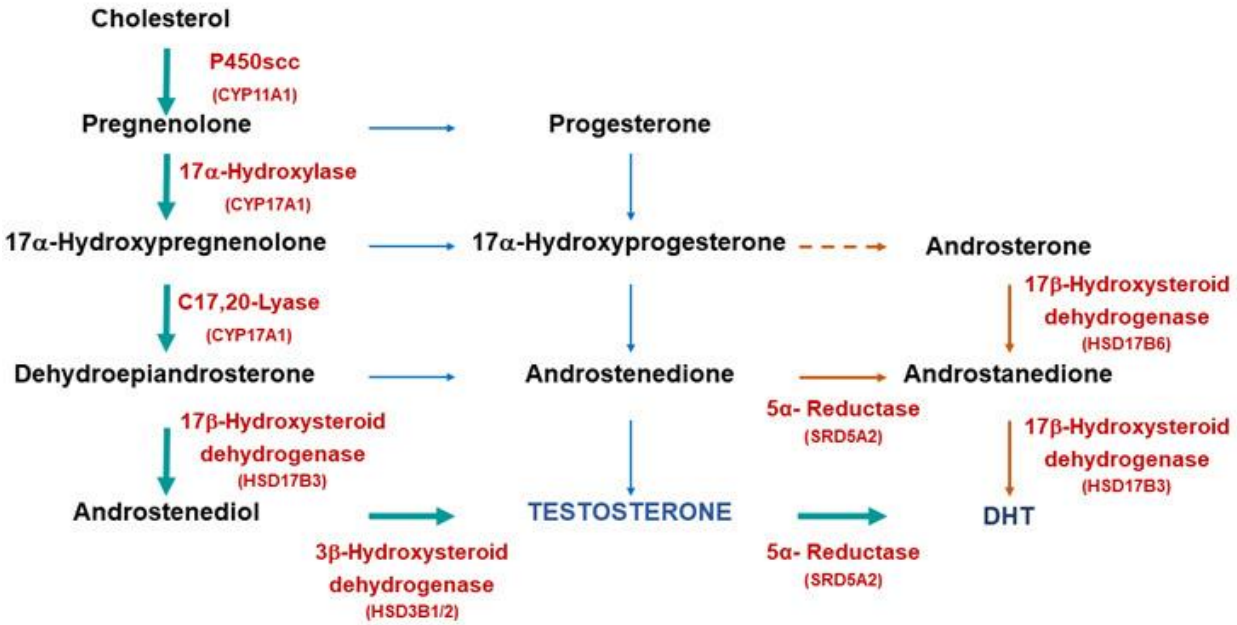
6) Inhibin Secretion:
Sertoli cells release inhibin, a hormone that provides negative feedback to the pituitary gland to regulate and decrease the secretion of follicle-stimulating hormone (FSH), thus controlling spermatogenesis.

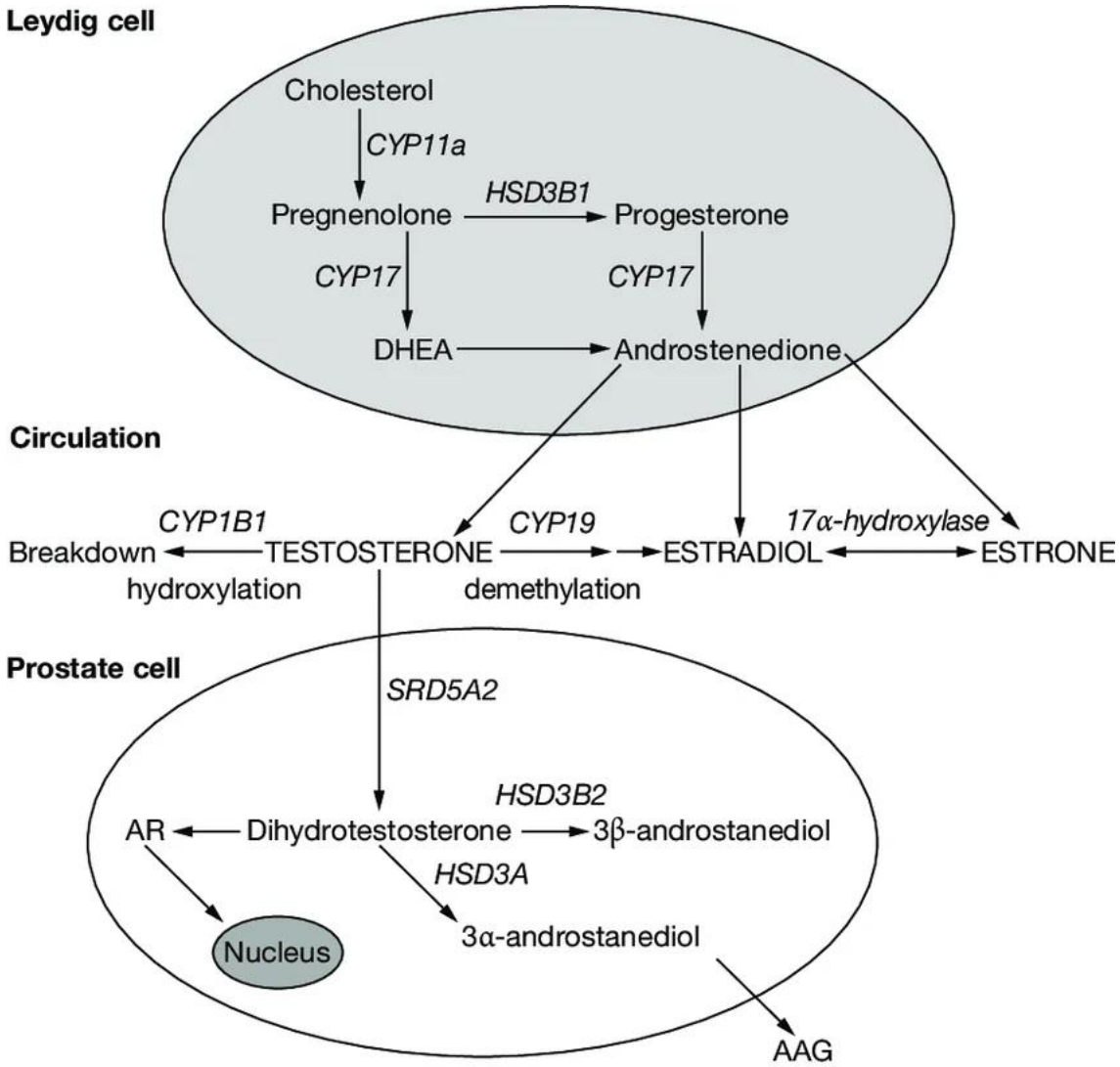
3) Phagocytosis:
These cells actively engulf and digest residual cytoplasm and damaged germ cells during sperm development, helping to maintain a healthy environment in the testes.

4) Seminiferous Tubule Fluid Secretion:
Sertoli cells secrete fluid into the lumen of seminiferous tubules, which helps transport spermatozoa from the site of production towards the epididymis.

2. Testosterone

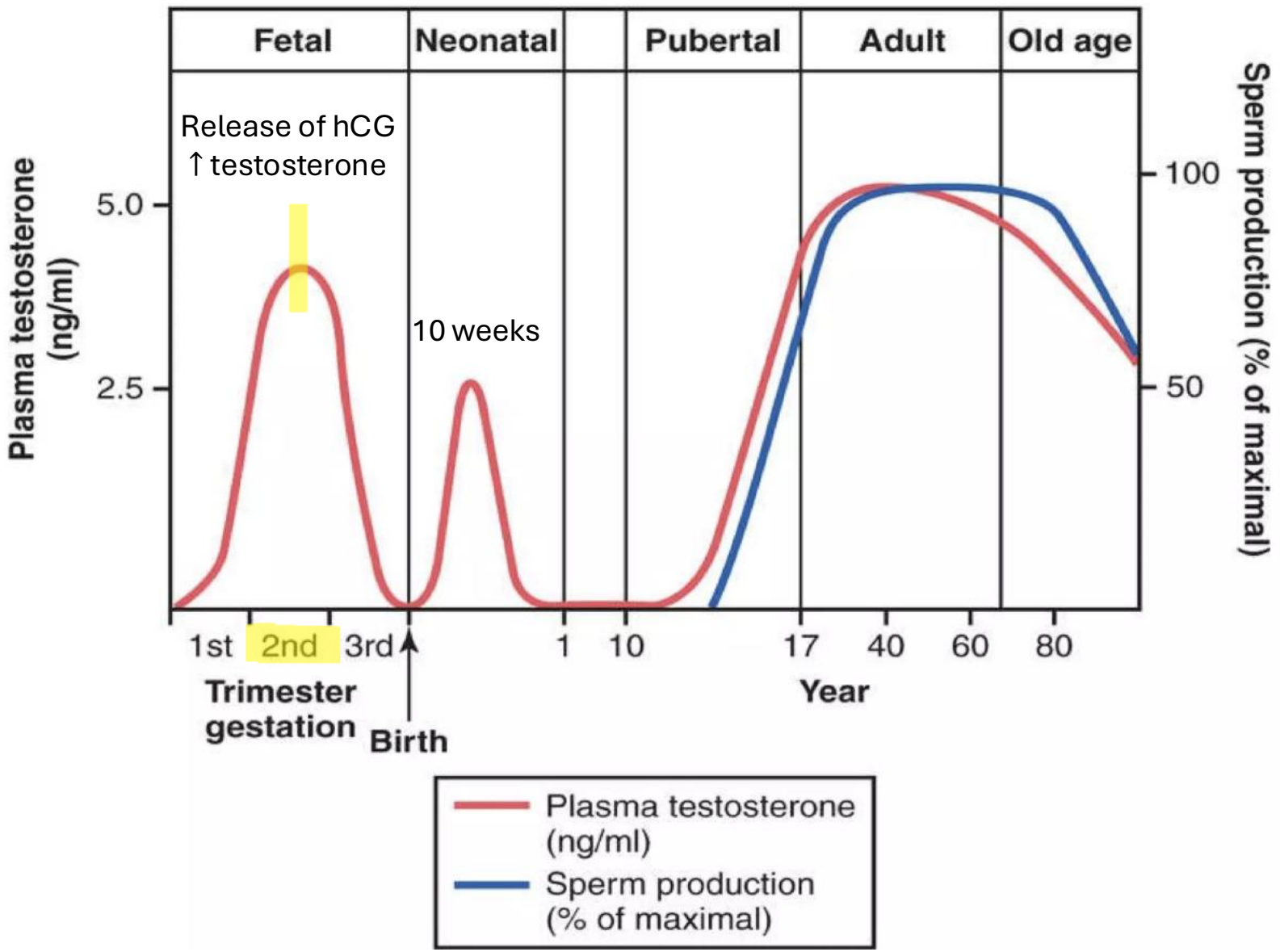
2.1. Biosynthesis of Testosterone





2. Testosterone

2.2. Plasma Testosterone Levels at Various Ages in Human Males

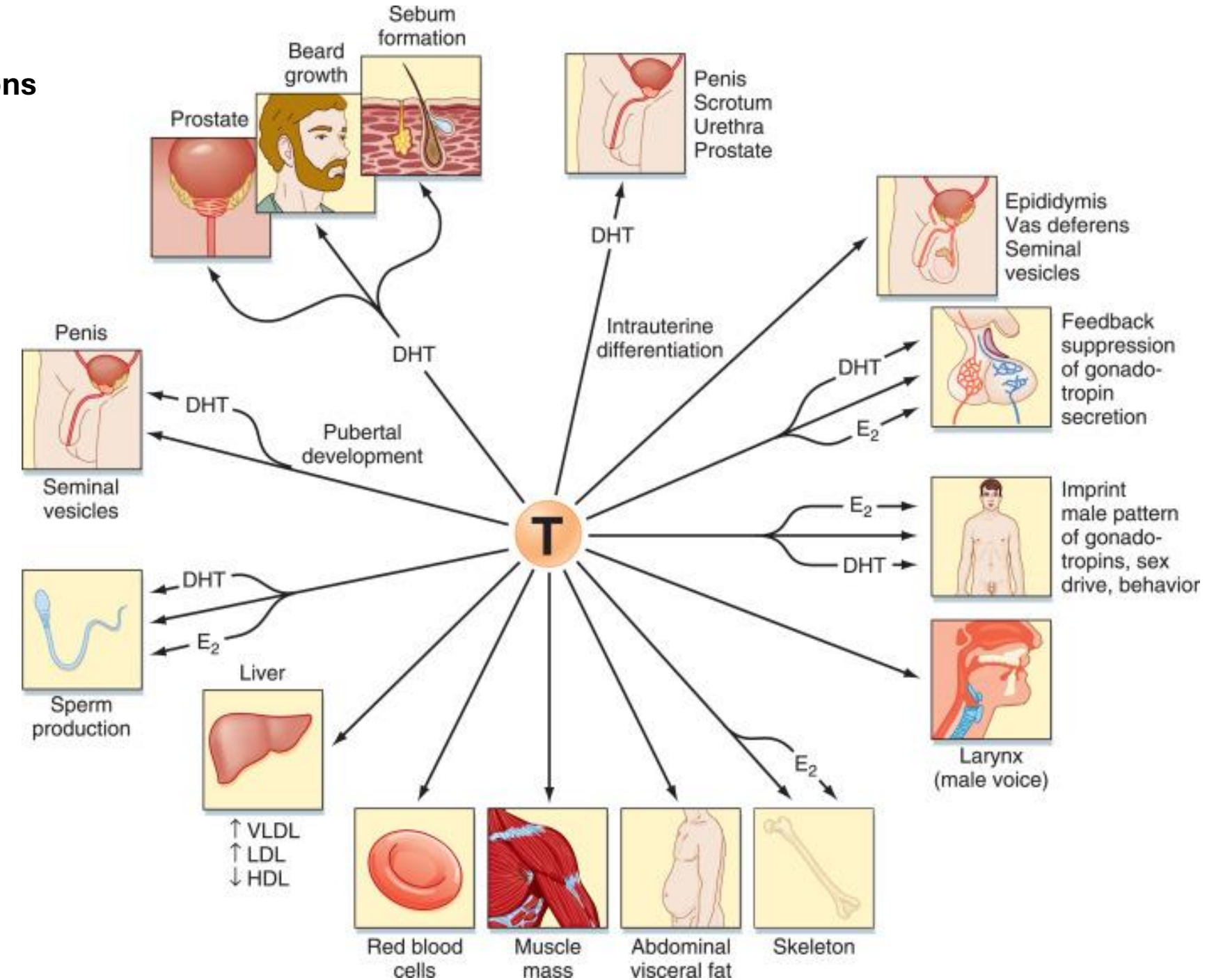


- Testosterone secreted by the genital ridges & later by the fetal testes is responsible for development of the male body characteristics including the formation of penis & scrotum & suppression of the formation of female genital organs.

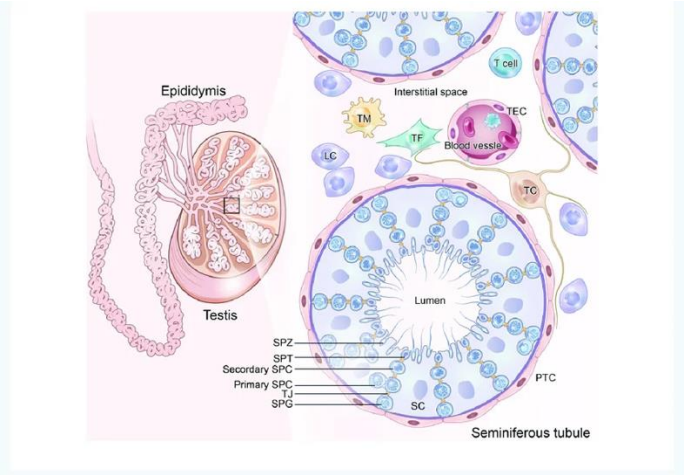
- The testes usually descend into the scrotum during the last 2 to 3 months of gestation when the testes begin secreting reasonable quantities of testosterone.

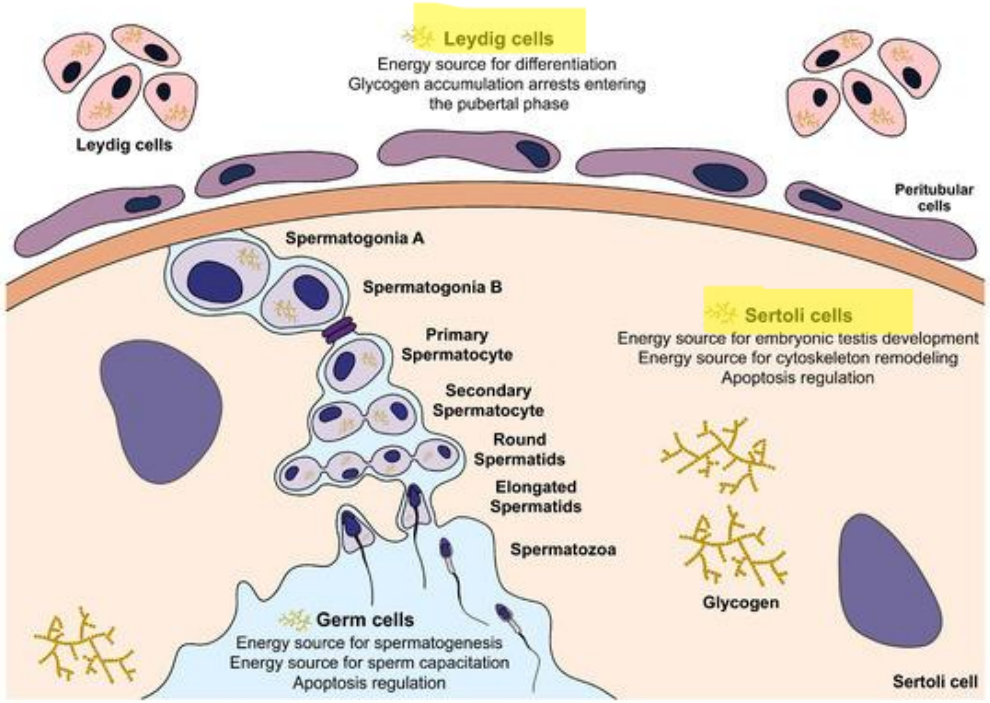
2. Testosterone

2.3. Testosterone Functions



3. Spermatogenesis





Duration ≈ 74 days

- Formation of sperm from spermatogonia.
- Occurs in seminiferous tubules influenced by GnRH.
- Starts 12-14 years old > ↓ older people, climacteric.
- Sertoli cells: large with overflowing cytoplasmic envelopes that surround the developing **spermatogonia** around the central lumen of the seminiferous tubules. (nourish and support) (FSH).
- Leydig cells: lie with the interstitium between the seminiferous tbues. (LH → testosterone).
  - Numerous in the new born male infants ONLY for the first few months of life.
  - Active at puberty & throughout adult life & secrete testosterone.

3. Spermatogenesis

3.1. Hormonal factors that stimulate spermatogenesis

A. Testosterone

- Secreted by the **Leydig cells**
- Essential for the **growth and division of testicular germinal cells**
- Maintains normal spermatogenesis

B. Luteinizing Hormone (LH)

- Secreted by the **anterior pituitary gland**
- Stimulates the **Leydig cells** to produce testosterone

C. Follicle-Stimulating Hormone (FSH)

- Acts on the **Sertoli cells**
- Supports nourishment and maturation of developing sperm cells
- Without FSH → normal spermatogenesis cannot occur

D. Estrogens

- Produced from testosterone by the **Sertoli cells**
- Formation occurs under FSH stimulation
- Likely contribute to normal sperm maturation and development

E. Growth Hormone (GH)

- Supports metabolic activity within the testes
- Promotes early division of spermatogonia
- GH deficiency may impair spermatogenesis

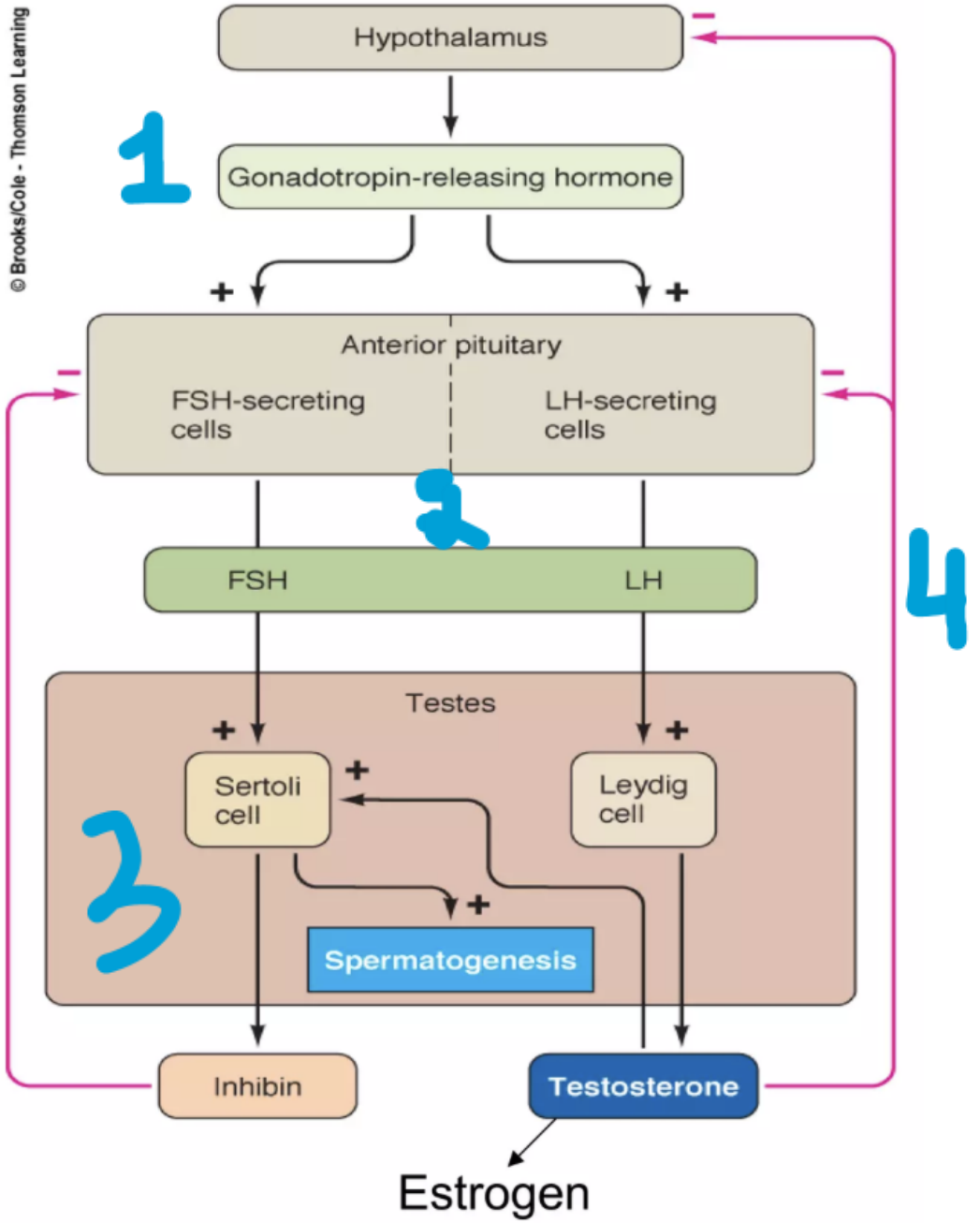
3. Spermatogenesis
3.2. Hypothalamic-anterior pituitary-gonad's axis

1. **GnRH** is secreted from the arcuate nucleus and travels to the anterior pituitary through the hypothalamic-hypophyseal portal blood

2. **LH** and **FSH** are secreted from the anterior pituitary in response to **GnRH** release, and are transported to the testes

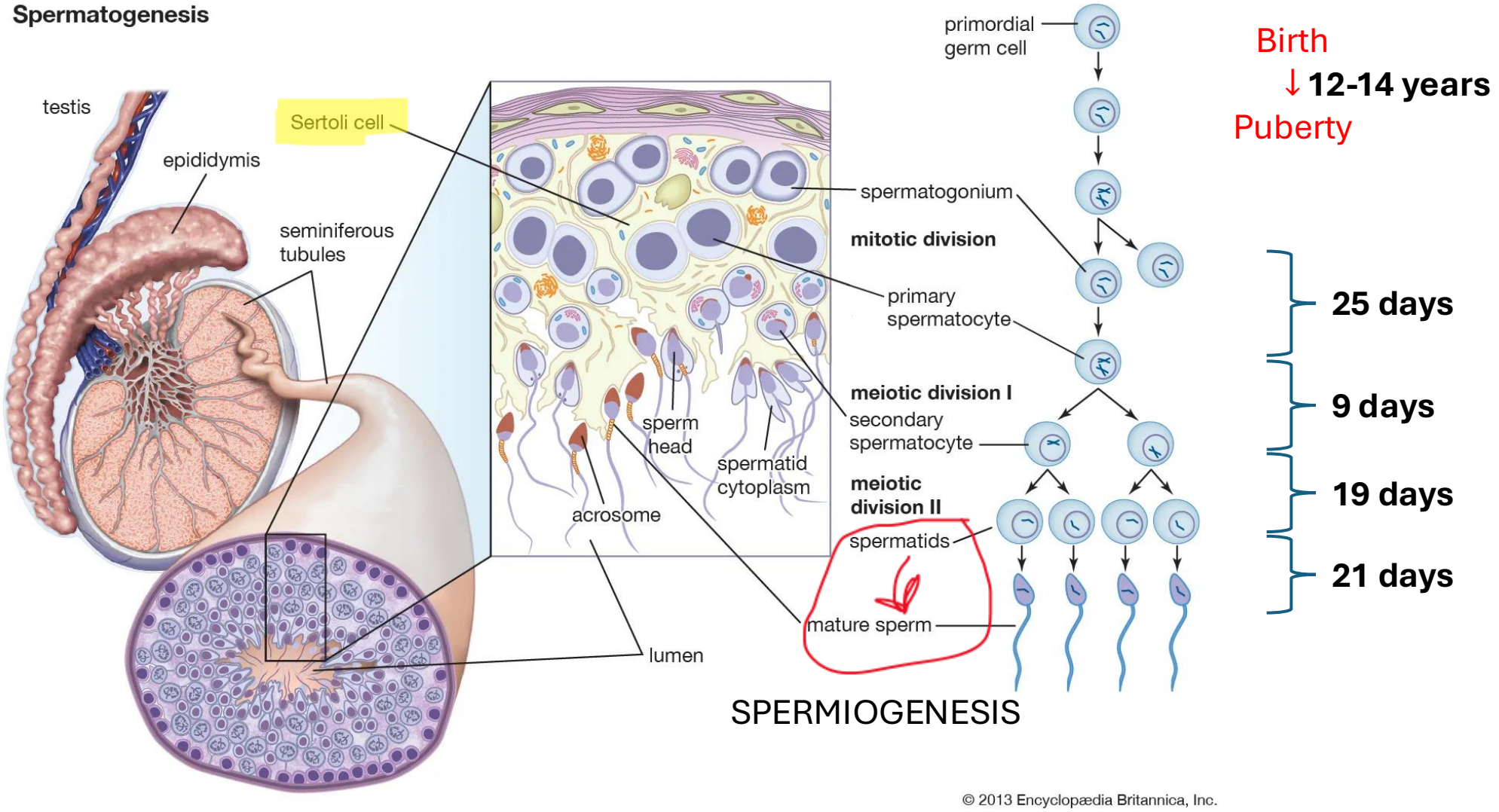
3. **FSH** directly stimulates the Sertoli cells in the testes to support spermatogonial development, while **LH** triggers testosterone production by Leydig cells, which is essential for the maturation of sperm cells. Together, these hormones coordinate to ensure efficient and continuous sperm production.

4. Testosterone is secreted into the circulation and elicits negative feedback on the anterior pituitary downregulating secretion of GnRH, LH and FSH.



3. Spermatogenesis

3.3. Process



Birth

↓ **12-14 years**

Puberty

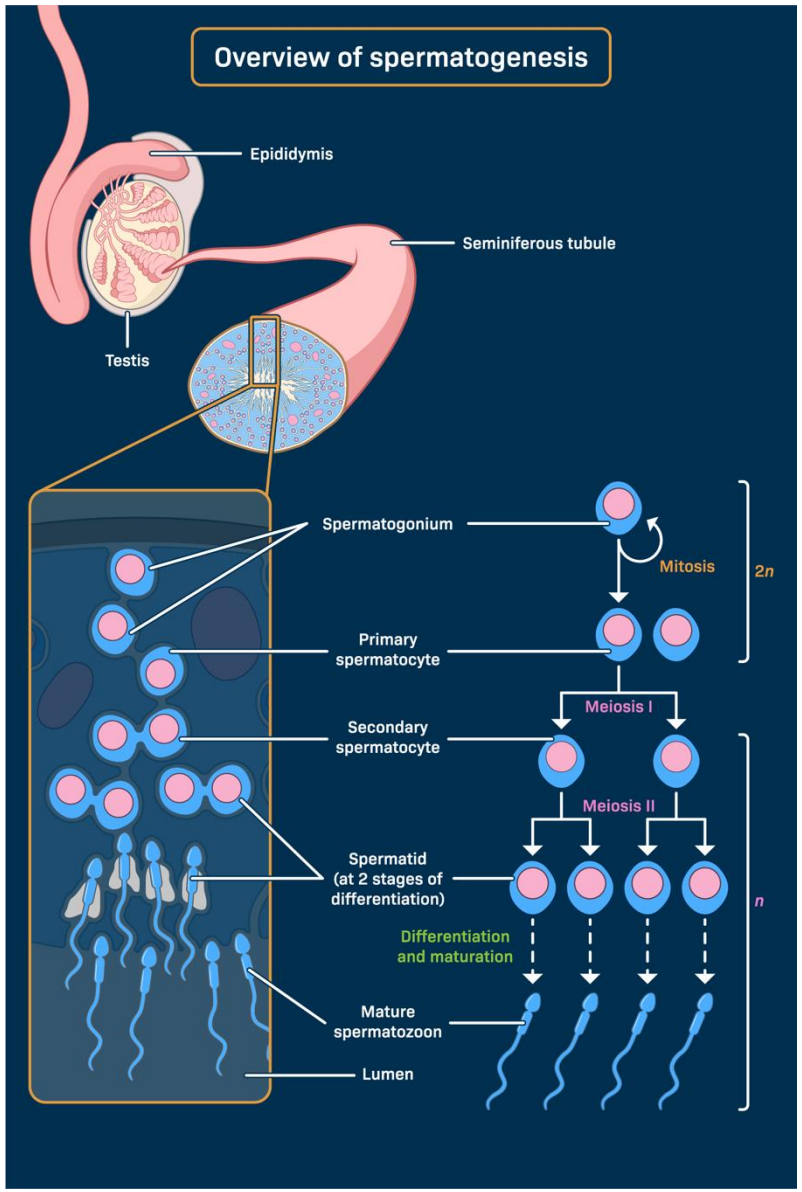
25 days

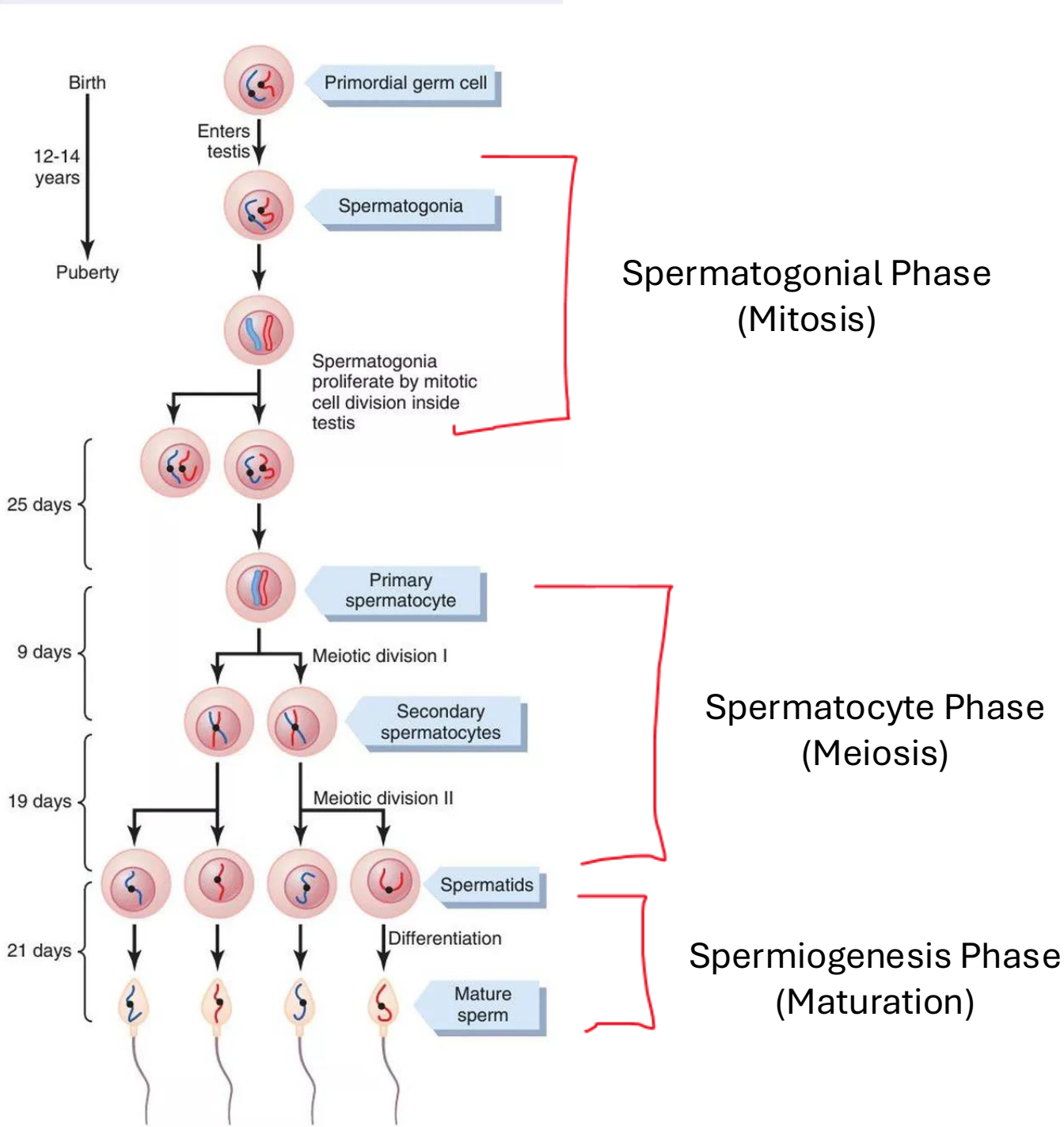
9 days

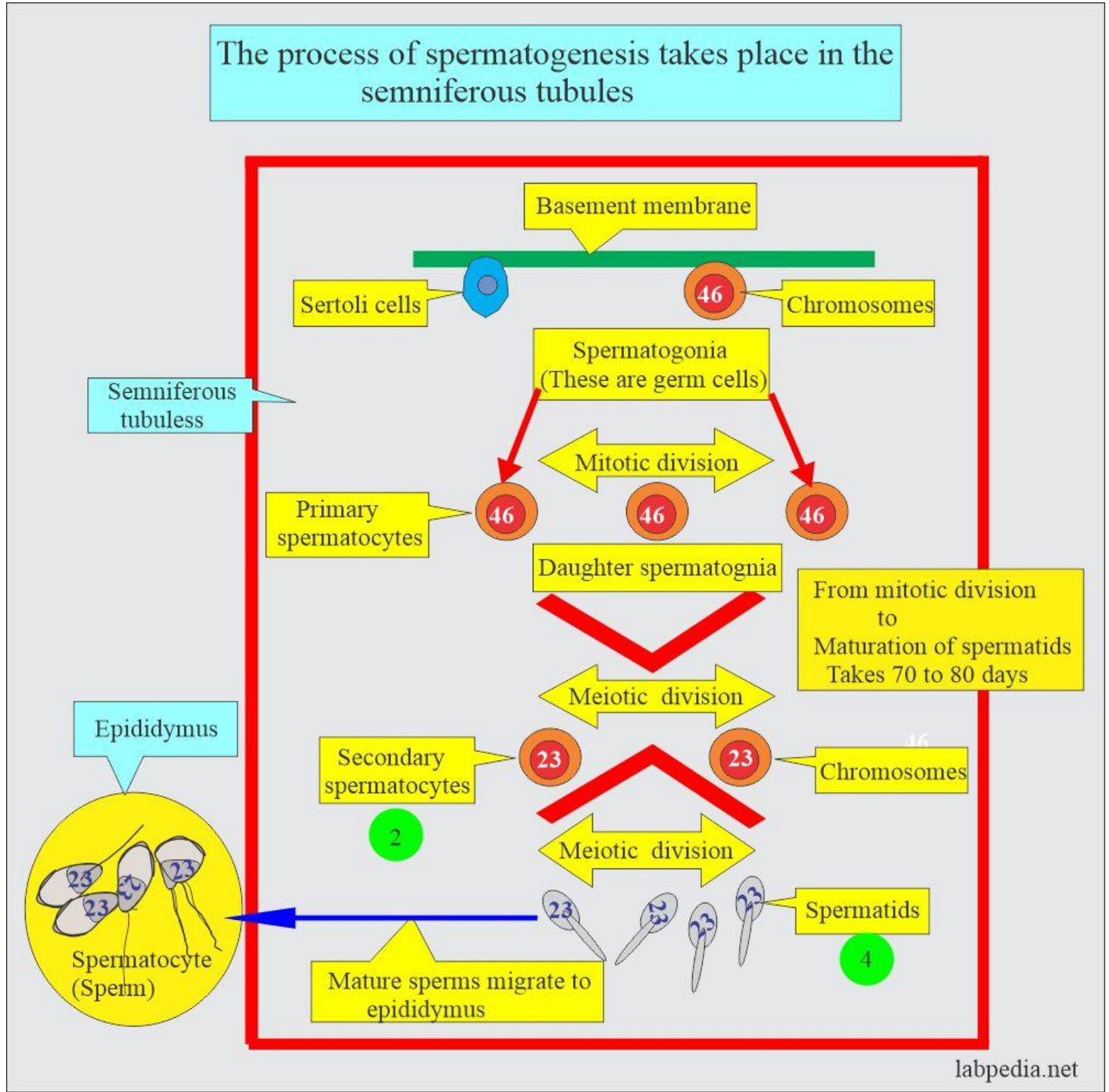
19 days

21 days

3. Spermatogenesis
3.3. Process

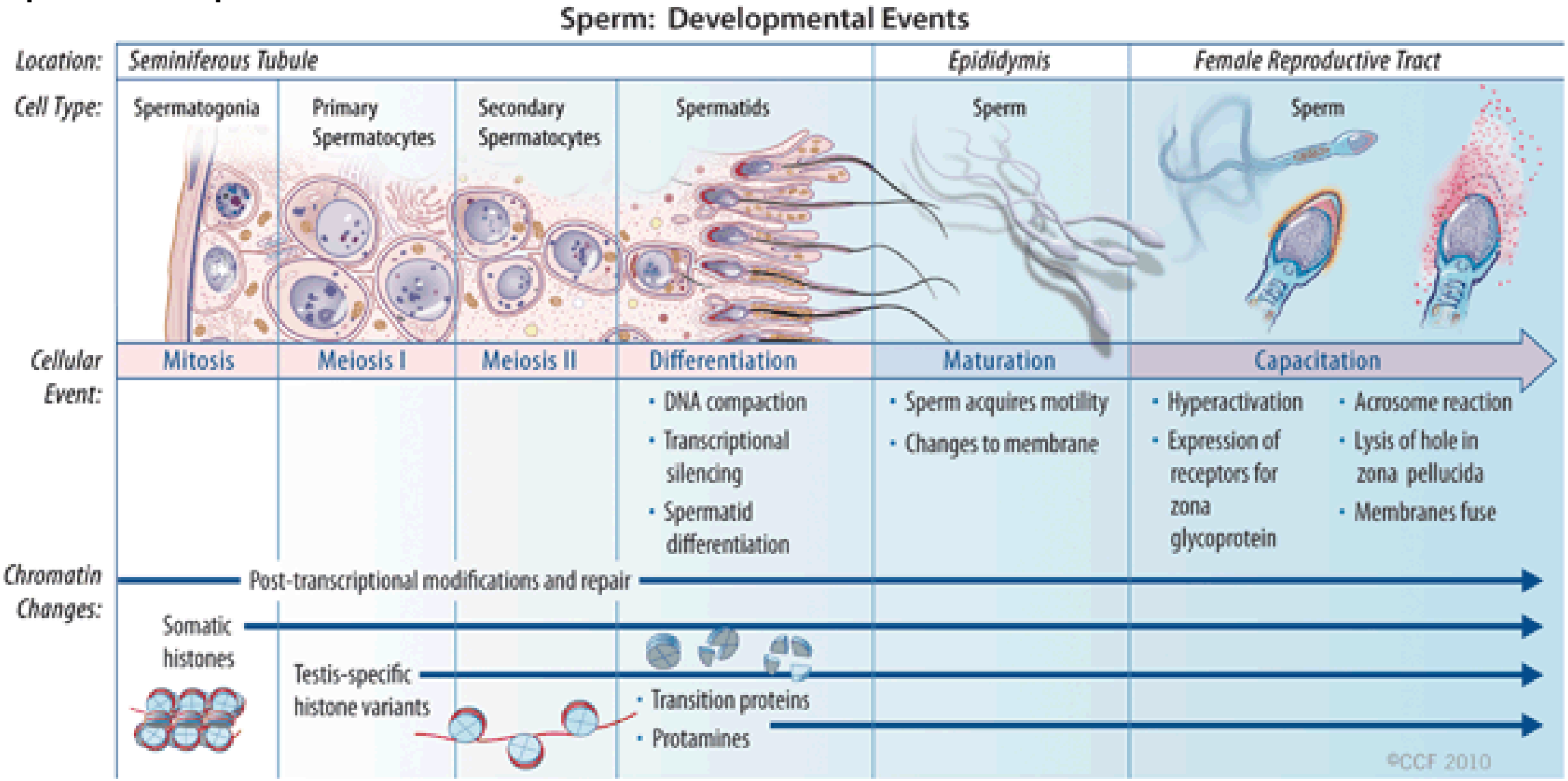





The process of spermatogenesis takes place in the semniferous tubules
Basement membrane
Sertoli cells
46
Chromosomes
Spermatogonia (These are germ cells)
Semniferous tubuless
Mitotic division
Primary spermatocytes
46
46
46
Daughter spermatognia
From mitotic division to Maturation of spermatids Takes 70 to 80 days
Meiotic division
Epididymus
Secondary spermatocytes
23
23
Chromosomes
2
Meiotic division
23
Spermatids
4
Spermatocyte (Sperm)
Mature sperms migrate to epididymus
labpedia.net

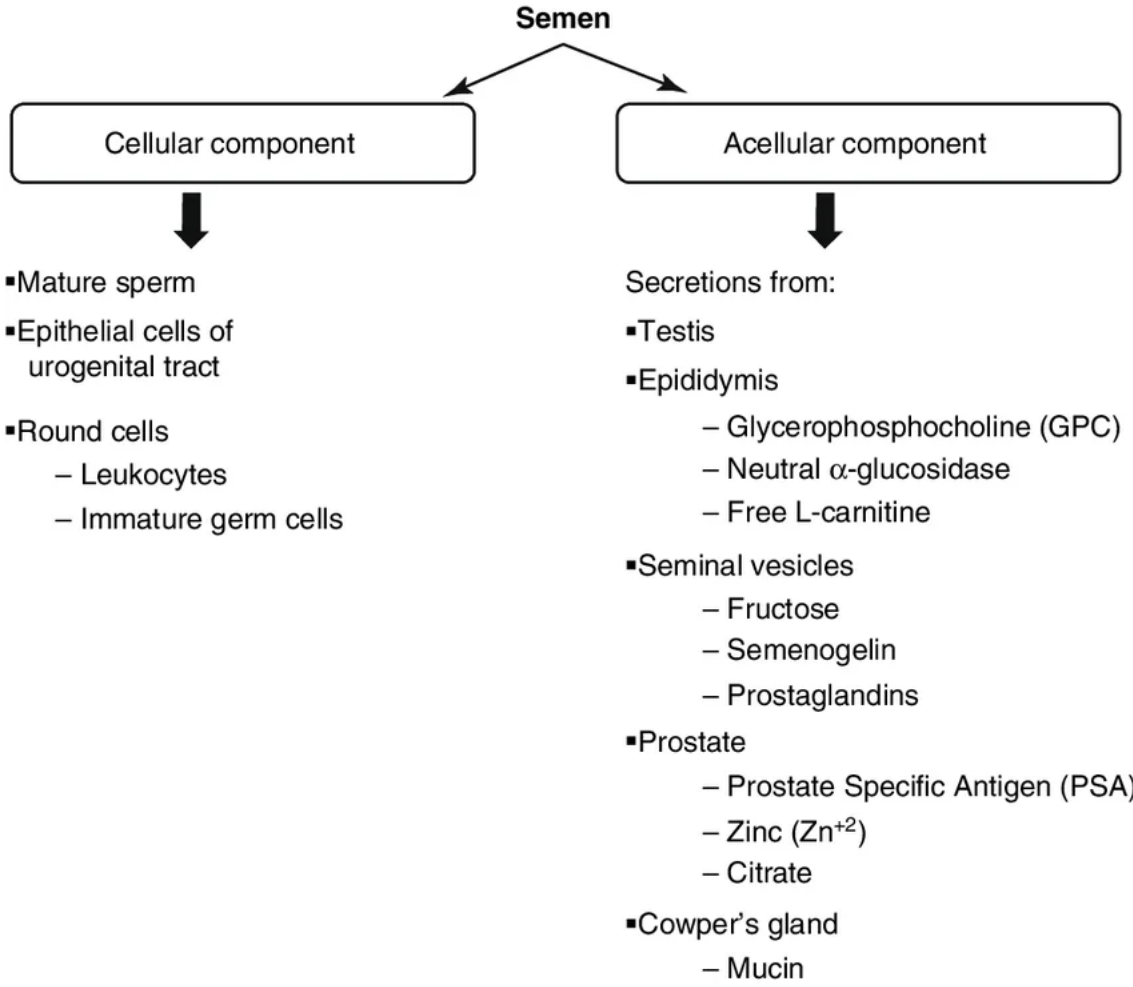
3. Spermatogenesis

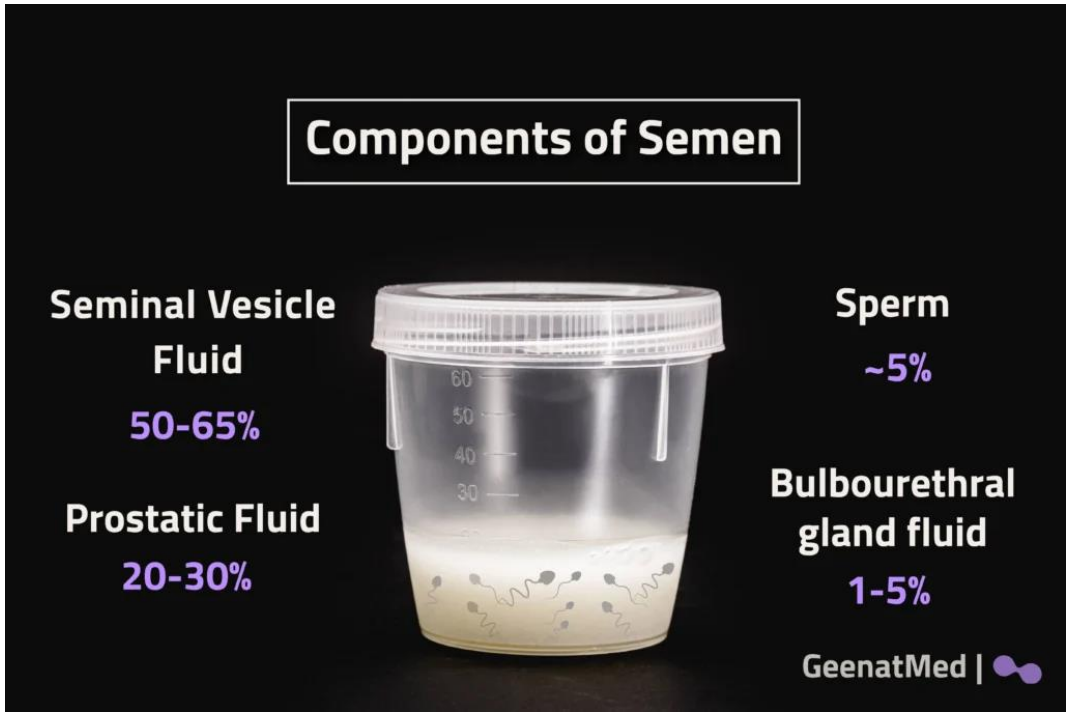
3.4. Sperm Developmental Events



4. Semen

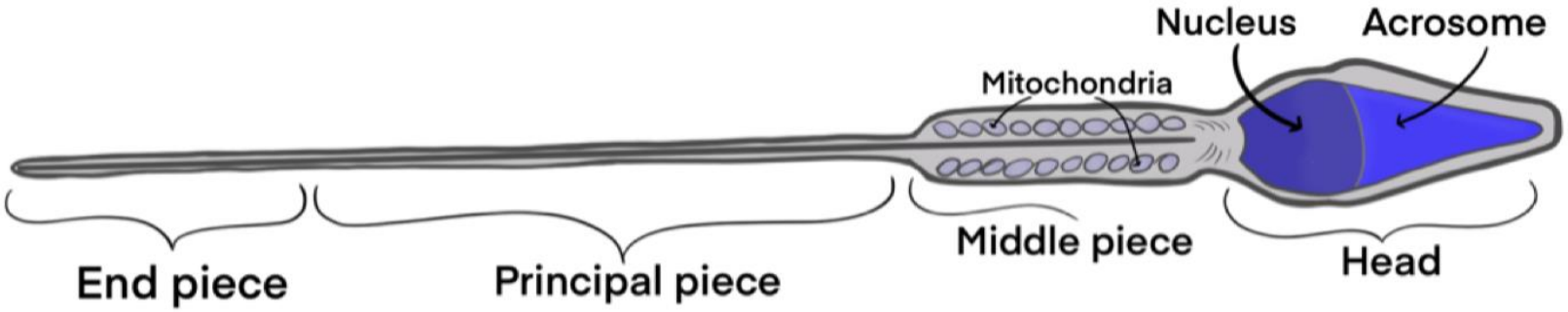
•**Semen composition:** 10% sperm and fluid from vas deferens.
• **Semen volume:** Seminal vesicles contribute 60% + Prostate gland adds 30%.
•Mucus glands, especially bulbourethral glands, also contribute.





4. Semen

4.1. Structure of a spermatozoan



- The head contains the nucleus covered by the acrosome. The acrosome contains enzymes necessary for penetration of the ovum in the female.
- The tail is composed of a principal and an end piece. It is responsible for sperm motility.

- **Maturation:** Sperm undergo maturation primarily in the epididymis, where they gain motility and the ability to fertilize an egg. This process involves biochemical and structural changes that prepare the sperm for successful fertilization.
- **Storage:** After maturation, sperm are stored in the epididymis until ejaculation. Propert storage conditions are crucial to maintain sperm viability and function.
- **Physiology:** The physiology of sperm includes their motility mechanisms, energy metabolism, and response to environmental factors such as pH and temperature, all of which influence their fertilizing capability.
- **Speed = 1-4 mm/min:** Sperm typically swim at speeds ranging from 1 to 4 millimeters per minute, which is sufficient to navigate the female reproductive tract toward the egg.
- **pH of Medium:** The pH of the surrounding medium affects sperm motility and viability. Optimal pH levels are usually slightly alkaline, around 7.2 to 8.0, which supports sperm function.
- **Temperature:** Temperature plays a critical role in sperm health. The testes are located outside the body to maintain a temperature slightly lower than core body temperature, which is essential for proper sperm development and function.
- **Life Expectancy** Sperm life expectancy varies depending on the environment. Inside the female reproductive tract, sperm can survive up to 5 days under optimal conditions, whereas outside the body, their lifespan is significantly shorter.

4. Semen
4.2. Functions of accessory glands

- **Accessory reproductive organs** accounts for 90% of the semen volume, and sperm the remaining 10%
- The main function of the fluid secreted together with the sperm is **to promote sperm survival.**

	Prostate	Seminal vesicle
Composition of fluid secreted	Citrate, calcium and enzymes	Fructose, citrate, prostaglandins and fibrinogen
Function of fluid secreted	Increase sperm motility	- Nourishment of ejaculated sperm - Prostaglandin secretion

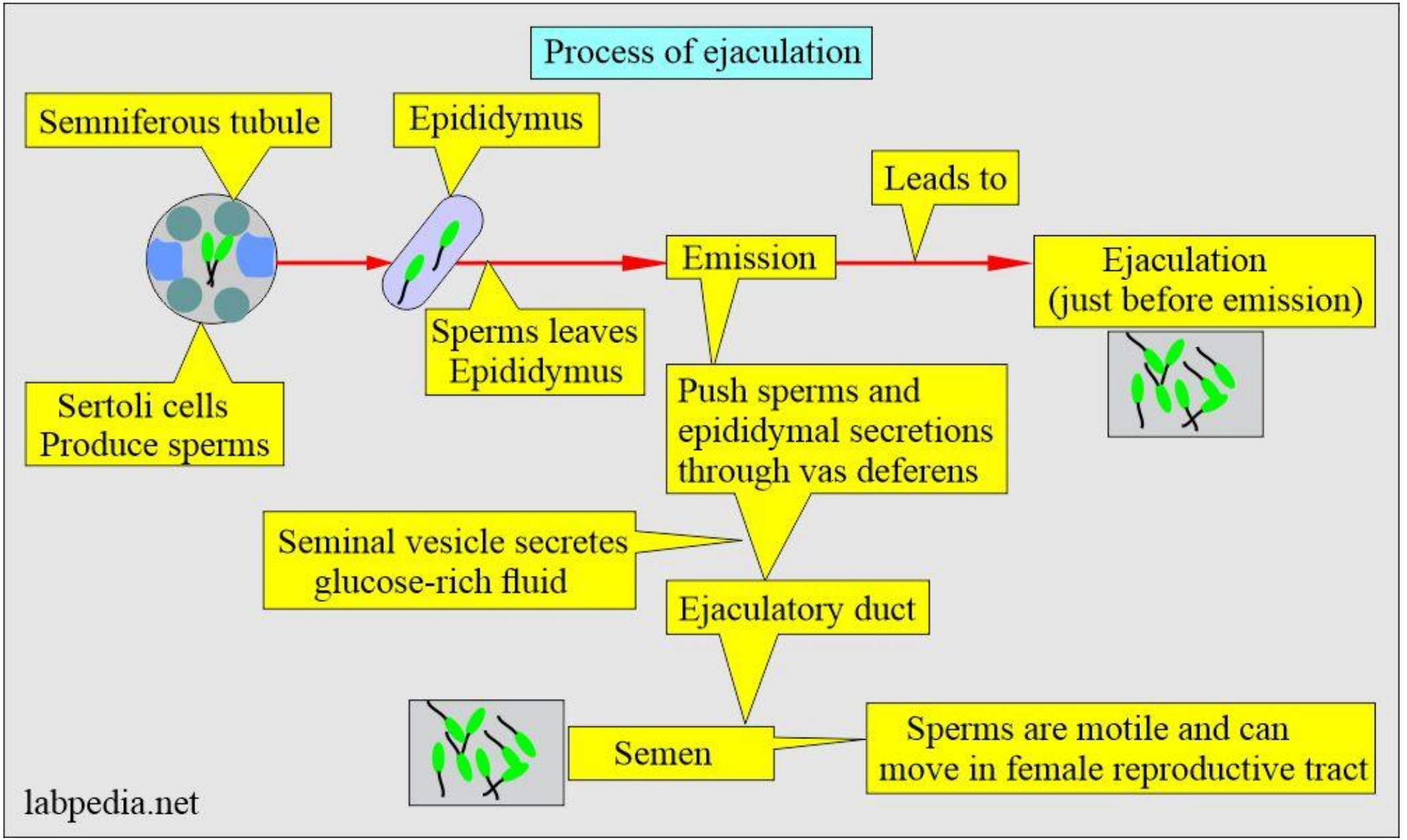
Prostate

- **Milky fluid** is slightly **alkaline** to neutralize acidic vaginal secretions, and it subsequently aids in fertilization.
- Contains calcium, citrate, and phosphate ions
- Produces a clotting enzyme that acts on fibrinogen from the seminal vesicle
- Releases profibrinolysin to break down seminal clot, freeing mobile sperm

Seminal vesicle

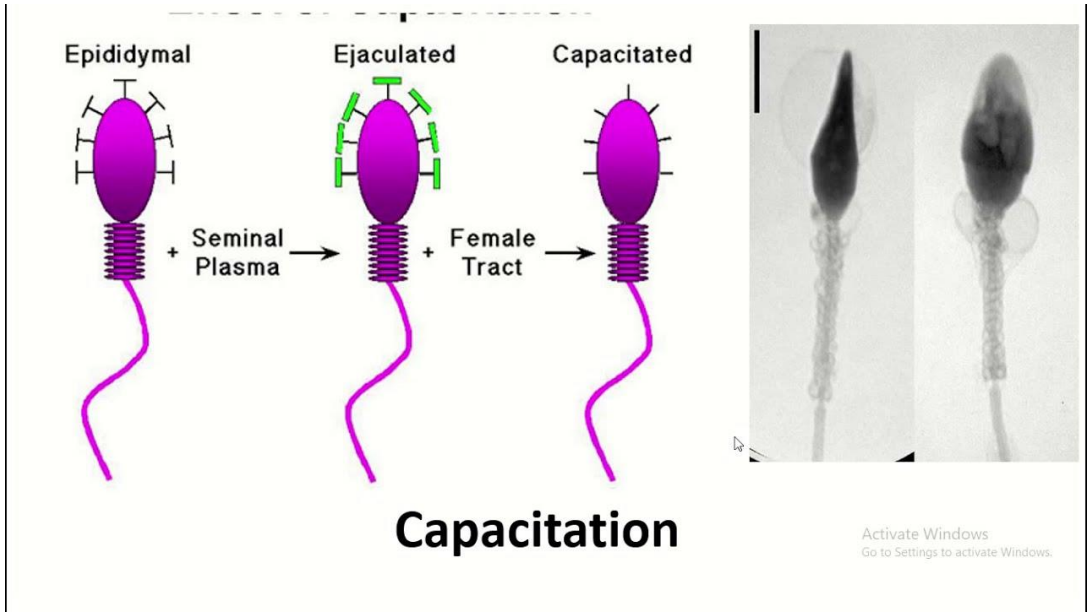
- Provide fructose and citric acid as nutrients for sperm motility and viability.
- Produce prostaglandins that enhance female cervical mucus receptivity to sperm.
- Induce backward peristaltic contractions in the uterus and fallopian tubes to aid sperm movement.
- Secrete fibrinogen to form a meshwork clot.

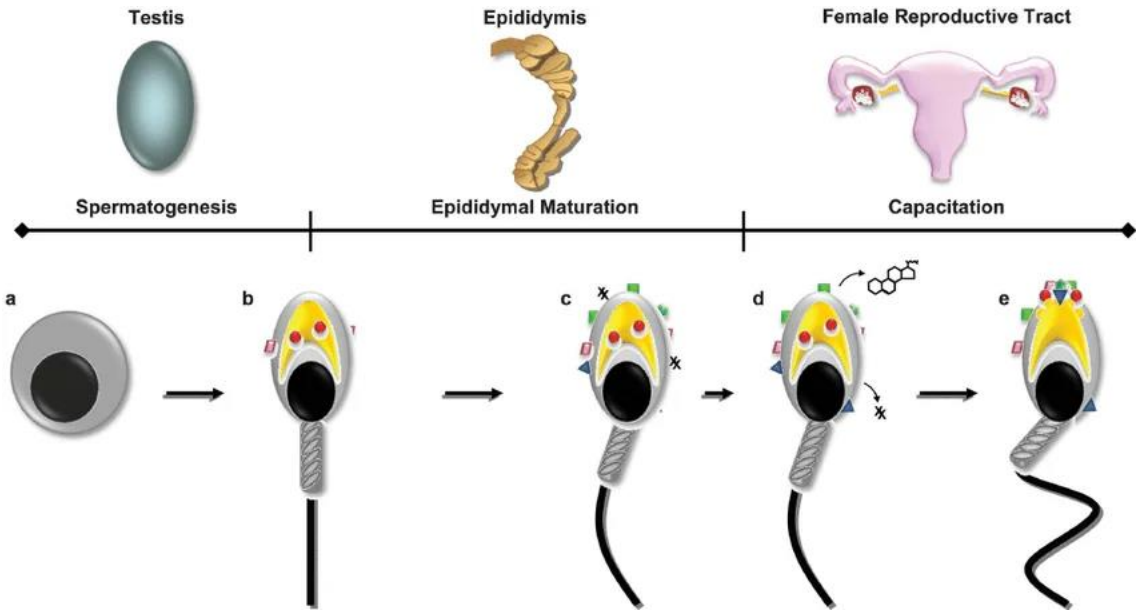
5. Emission & Ejaculation



6. Capacitation

- Capacitation occurs in uterine and fallopian tube fluids within 1-10 hours after ejaculation.
- **Floating vesicles** from seminiferous tubules contain cholesterol.
- **Cholesterol** is added to the acrosomal part of the sperm
- Sperm membrane becomes permeable to calcium ions
- Increased calcium triggers flagellum activity
- Acrosomal contents are released during the process

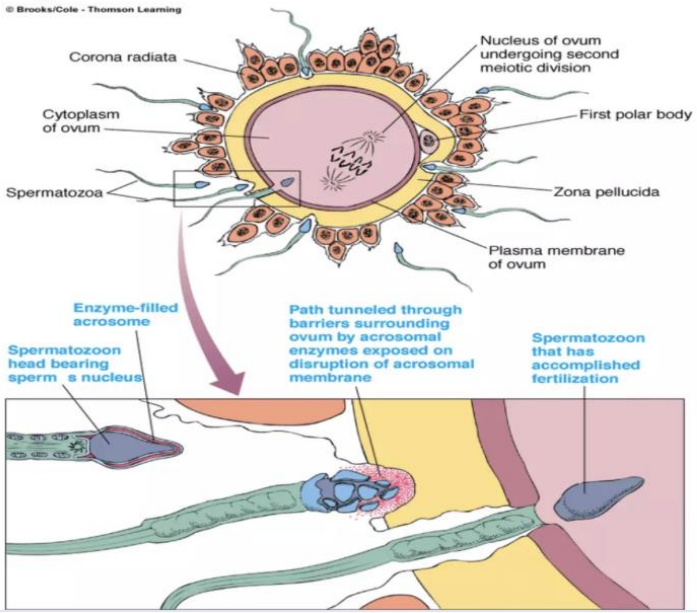


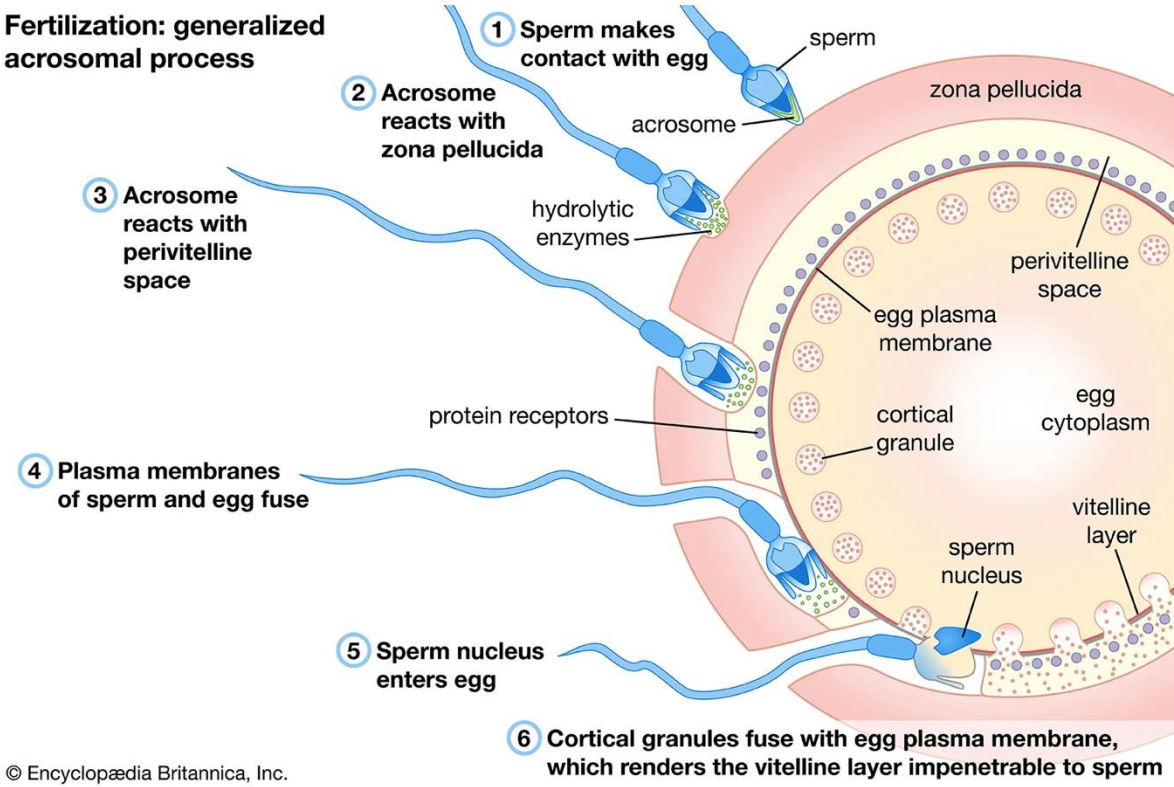


7. Acrosome Reaction

Hyaluronidase → Depolymerizes hyaluronic acid polymers in the intercellular cement that hold the ovarian granulosa cell together

Proteolytic enzymes → Digest proteins in the structural elements of tissue cells that still adhere to ovum





8. Abnormal Spermatogenesis

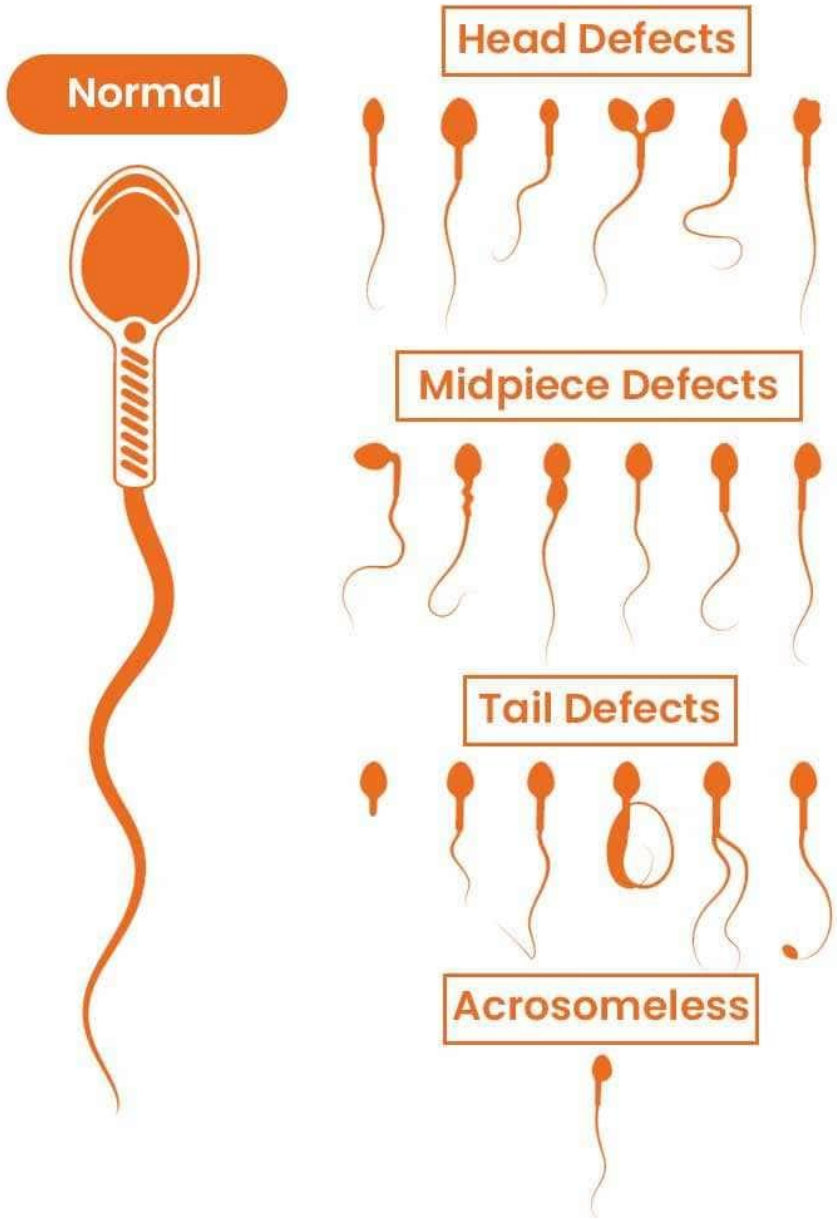
- Abnormal spermatogenesis can be caused by infections and temperature changes
- **Cryptorchidism:** failure of testes to descend into the scrotum near birth.

- Normal sperm count ranges from 35 to 200 million/ml, with an average of 120 million/ml

- Typical ejaculate volume is 3.5 ml.
- Sperm count directly affects fertility potential

1.Aspermia (azoospermia): When there is no sperm.
2.Oligospermia is when the count is <20 million/mL.
3.Asthenospermia is low sperm motility.
4.Necrospermia is the Normal count of the sperm but is non-motile.
5.Hemospermia is when there are abundant RBCs in the ejaculate.

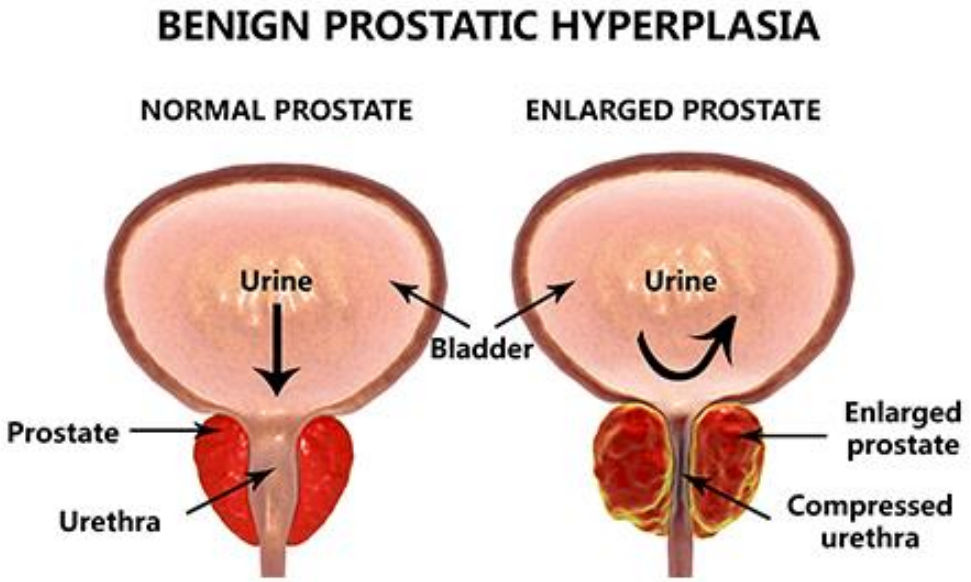
9. Effect of Sperm Morphology and Motility on Fertility



10. Related Abnormalities to Prostate Gland

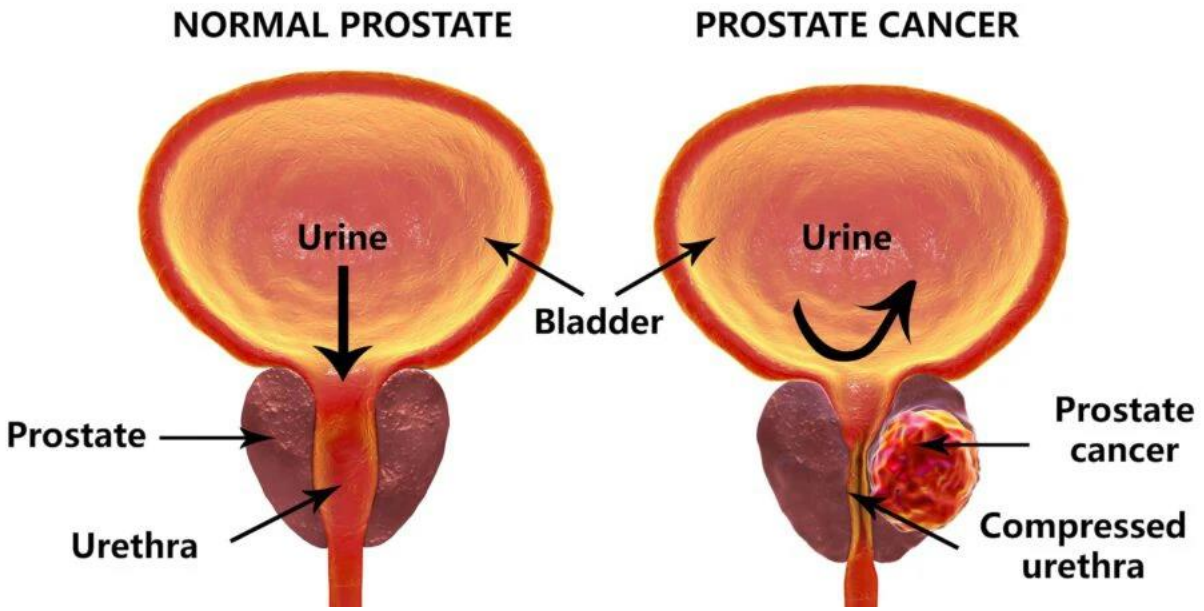
A) Benign prostatic enlargement

•Common in older men due to overgrowth of prostatic tissue.
•Not considered a direct effect of testosterone alone.
•May compress the urethra and cause urinary symptoms.



B) Prostate cancer

•Malignant growth of prostate cells.
•Testosterone can stimulate the growth of androgen-sensitive cancer cells.



10. Related Abnormalities to Prostate Gland

C. Male hypogonadism

•Reduced or absent testicular function.

•During fetal life: lack of functional testes prevents normal male sexual differentiation, leading to development of female internal/external characteristics.

•Before puberty: loss of testes causes eunuchism, with infantile sex organs and absence of secondary sexual characteristics.

•After puberty: castration causes regression of sexual organs and reduced male secondary characteristics.

D. Adiposogenital syndrome / Fröhlich syndrome

•Form of hypothalamic hypogonadism.

•Caused by reduced GnRH secretion from the hypothalamus.

•Associated with obesity due to hypothalamic feeding-center dysfunction and eunuchoid features.

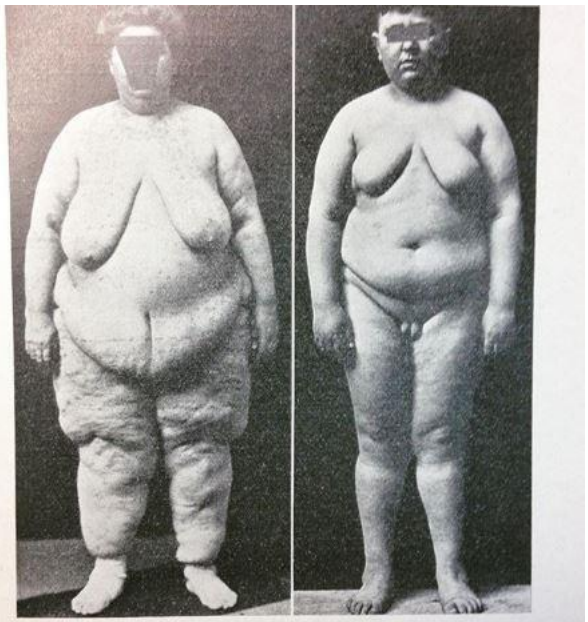


Fig. 134. Fig. 135.

Fig. 134.—Fröhlich syndrome. Aged fifty, weight 362 pounds, height 62 inches, blood pressure 210/120. The blood pressure fell during three weeks of treatment to 145/80. Catamenia normal. Hands and feet very small with tapering digits.

Fig. 135.—Fröhlich syndrome. Boy of sixteen. Note fat distribution and delayed sexual development. The knock knees, small hands, and small feet are characteristic.