MALE REPRODUCTIVE SYSTEM

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INTRODUCTION

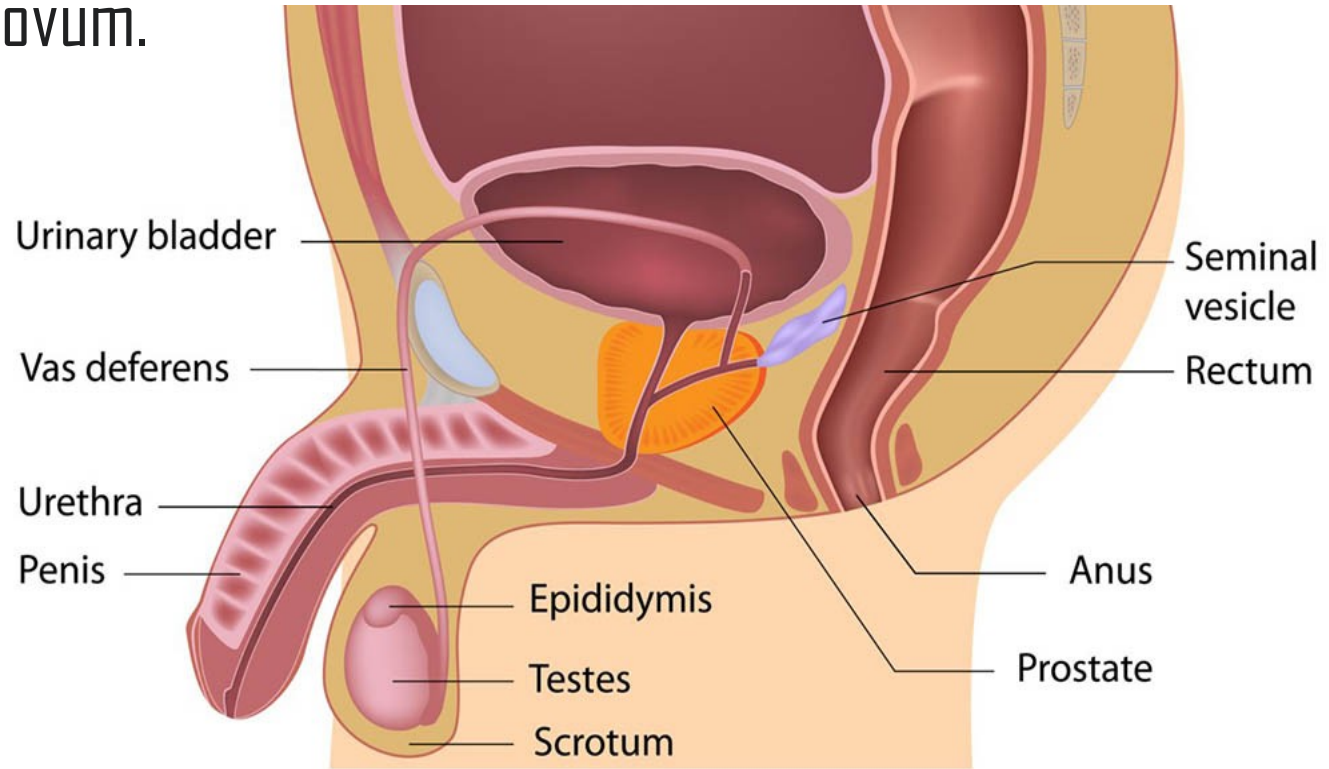
- The **reproductive system** of an organism is also known as the **genital system**.
- It is the biological system made up of all the anatomical organs involved in sexual reproduction.
- Many non-living substances such as fluids, hormones, and pheromones are also important accessories to the reproductive system.
- **Reproductive system** ensures the continuation of species.
- **Gonads** are the primary reproductive organs which produce the gametes (egg or ovum).
- A pair of testes (singular = testis) produces sperms in males and a pair of ovaries produces ovum in females.

- In humans and most of the higher animals, reproduction occurs by internal fertilization i.e. sexual intercourse or by mating.
- The **human reproductive system** includes the male reproductive system which functions to produce and deposit sperm.
- Along with the female reproductive system which functions to produce egg cells, and to protect and nourich the fetus until birth.
- Humans have a high level of sexual differentiation.
- In addition to differences in nearly every reproductive organ, there are numerous differences in typical secondary sex characteristics.

MALE REPRODUCTIVE SYSTEM

- The male reproductive system is a series of organs located outside the body and around the pelvis region of a male that contribute towards the reproduction process.
- The primary direct function of the male reproductive system is to provide the male sperm for fertilization of the ovum.
- Male Reproductive organs include:

1. PRIMARY SEX ORGANS
2. ACCESSORY SEX ORGANS



1. PRIMARY SEX ORGANS

- Testes are the primary sex organs or gonads in males.

2. ACCESSORY SEX ORGANS

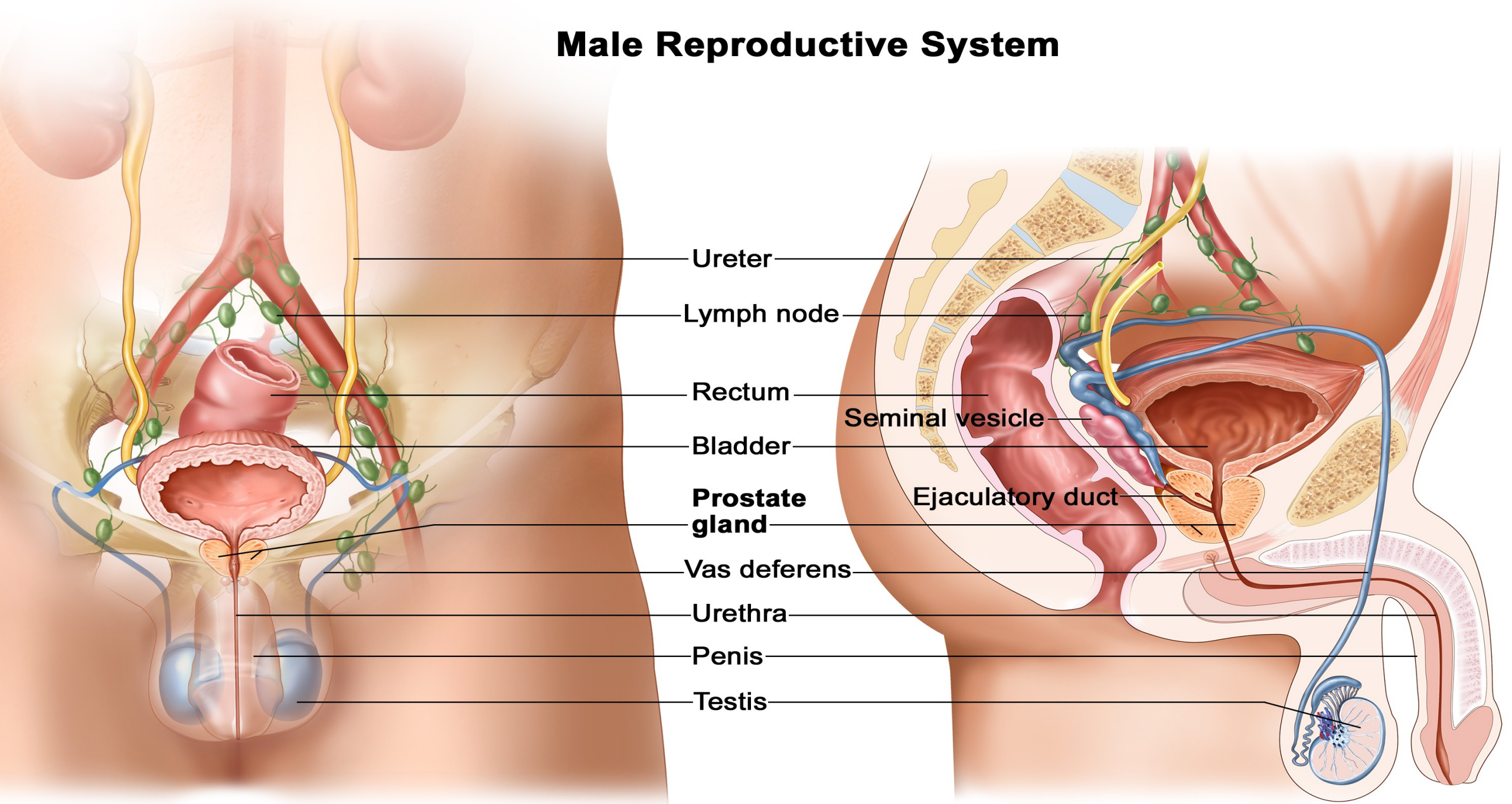
- Accessory sex organs in males are:

I. Seminal vesicles
II. Prostate gland
III. Urethra
IV. Penis.

EXTERNAL AND INTERNAL GENITALIA

- Reproductive organs are generally classified into two groups, namely external genitalia (genital organs) and internal genitalia.
- External genital organs in males are scrotum, penis and urethra.
- Remaining sex organs constitute the internal genitalia.

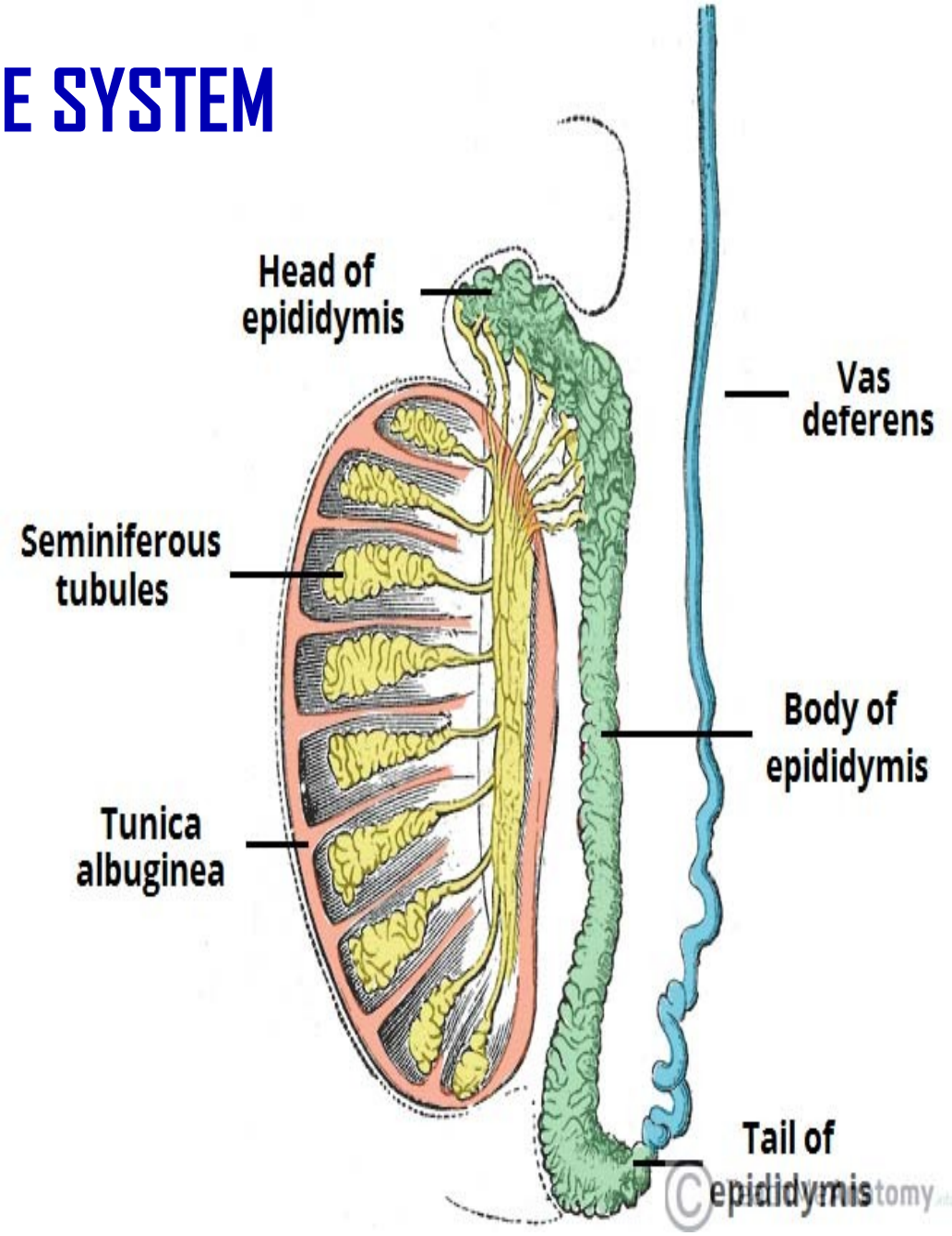
Male Reproductive System



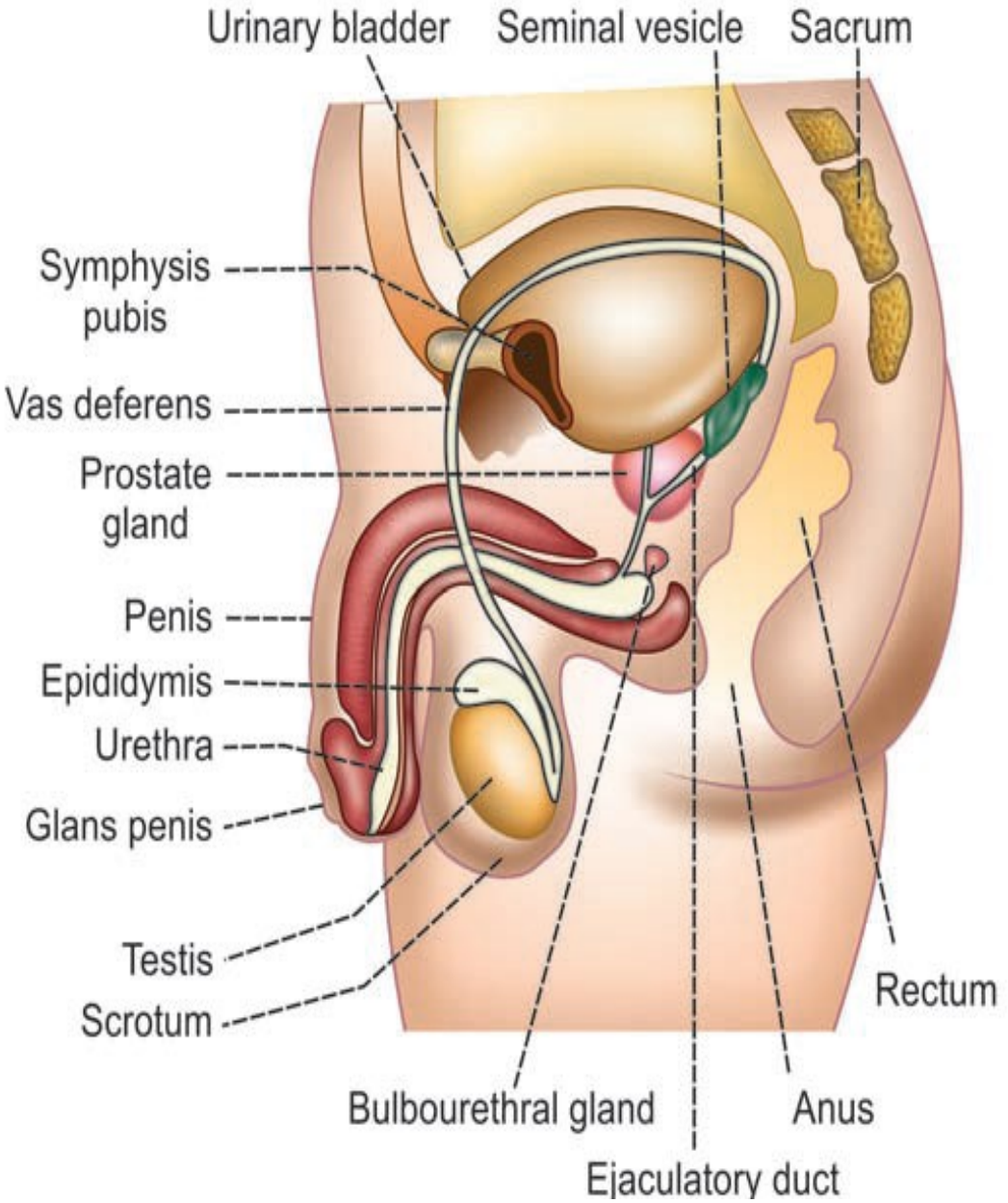
FUNCTIONAL ANATOMY OF MALE REPRODUCTIVE SYSTEM

TESTES

- Testes are the **primary sex organs** or gonads in males.
- There are two testes in almost all the species.
- In human beings, both the testes are ovoid or walnut-shaped bodies that are located and suspended in a sac-like structure called **scrotum.**
- Each testis weighs about 15 to 19 g and measures about 5 × 3 cm.
- Testis is made up of about 900 coiled tubules known as **seminiferous tubules,** which produce sperms. Seminiferous tubules continue as the vas efferens, which form the **epididymis.**
- It is continued as **vas deferens.**



- Vas deferens is also called **ductus deferens, spermatic deferens** or **sperm duct.**
- From epididymis in scrotum, the vas deferens extends on its one side upwards into abdominal cavity via inguinal canal.
- Terminal portion of vas deferens is called **ampulla**. Ampulla of vas deferens joins ducts of seminal vesicle of same side, to form **ejaculatory duct.**
- Thus, there are two ejaculatory ducts each of which receives sperm from vas deferens and secretions of seminal vesicle on its own side.
- Both the ejaculatory ducts empty into a single **urethra.** Actually, ejaculatory ducts open into prostatic part of urethra.



LAYERS OF TESTIS

- Each testis is enclosed by three coverings.

1. TUNICA VASCULOSA

- Tunica vasculosa is the innermost covering.
- It is made up of connective tissue and it is rich in blood vessels

2. TUNICA ALBUGINEA

- Tunica albuginea is the middle covering. It is a dense fibrous capsule

3. TUNICA VAGINALIS

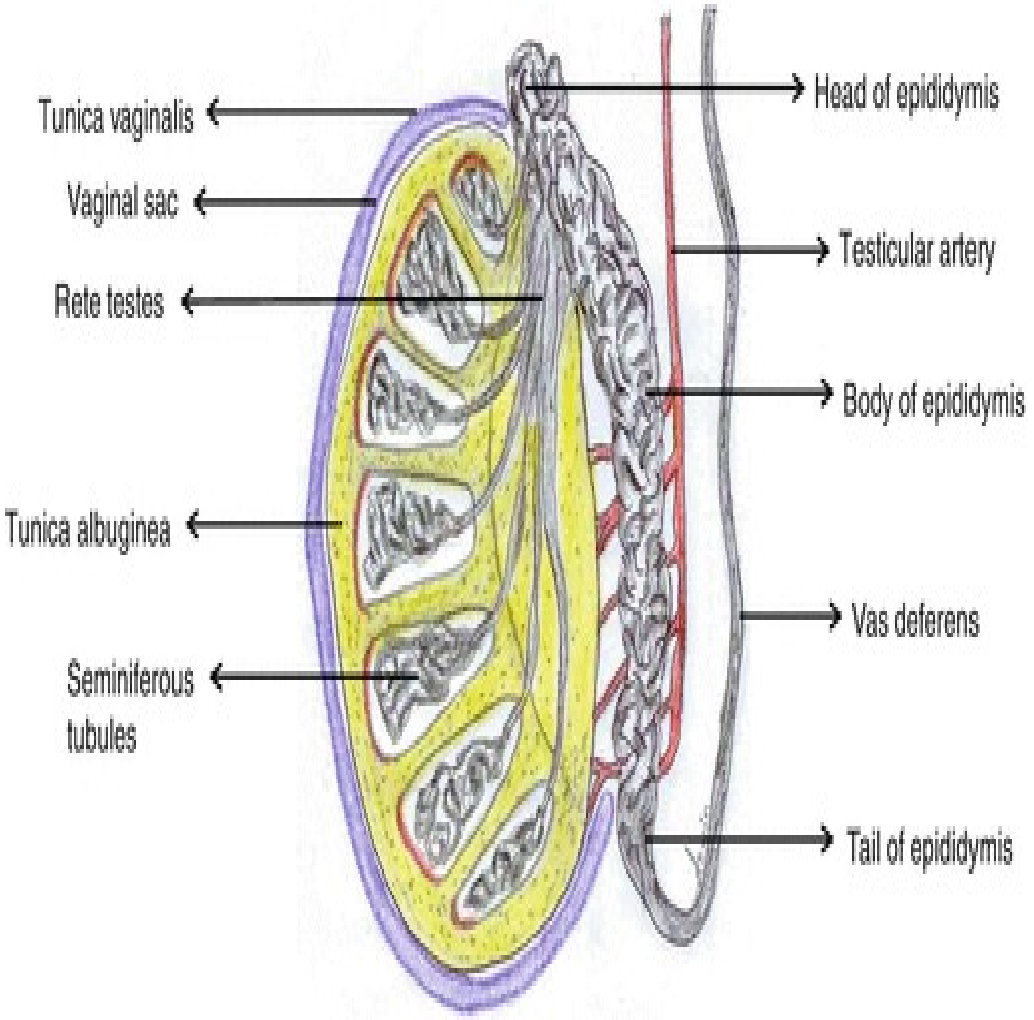
- Tunica vaginalis is the outermost closed cleft like covering, formed by **mesothelial cells.**
- It is formed by visceral and parietal layers, which glide on one another and allow free movement of testes.
- Visceral layer ofAnterior and lateral surfaces of testis are covered by all the three layers. Posterior surface is covered by tunica albuginea only.

PARENCHYMA OF TESTIS

- The functional portion of testis is called parenchyma, including the seminiferous tubules and interstitial cells located within the lobules.
- Parenchyma of testis consist of following parts:

1. LOBULES OF TESTIS

- Tunica albuginea on the posterior surface of testis is thickened to form the **mediastinum testis.**
- From this, the connective tissue septa called **septula testis** radiate into testis and bind with tunica albuginea at various points. Because of this, testis is divided into a number of **pyramidal lobules.**



- The septula do not form complete partition so the lobules of testis anastomose with one another at many places.
- Each testis has about 200 to 300 lobules.

2. SEMINIFEROUS TUBULES

- Each lobule contains 1 to 4 coiled tubules known as the seminiferous tubules, which are surrounded and supported by interlobular connective tissue.
- Seminiferous tubules do not end bluntly, but form single, double or triple arches.

3. RETE TESTIS

- Rete testis is a network of thin-walled channels present in mediastinum.
- All the seminiferous tubules open into the rete testis.

4. VAS EFFERENS

- From rete testis, 8 to 15 tubules called vas efferens arise.
- Vas efferens join together and form the head of epididymis and then converge to form the duct of epididymis.

5. EPIDIDYMIS

- Duct of epididymis is an enormously convoluted tubule, with a length of about 4 meter. It begins at head, where it receives vas efferens.

6. VAS DEFERENS

- At the caudal pole of testis, epididymis turns sharply upon itself and continues as vas deferens, without any definite demarcation.

7. INTERSTITIAL CELLS OF LEYDIG

- Interstitial cells of Leydig are the hormone secreting cells of testis, lying in between the seminiferous tubules.

SEMINIFEROUS TUBULES

- Seminiferous tubules are thread-like convoluted tubular structures which produce the spermatozoa or sperms.
- There are about 400 to 600 seminiferous tubules in each testis.
- Each tubule is 30 to 70 cm long with a diameter of 150 to 300 μ.
- Wall of the seminiferous tubule is formed by three layers:

1. **Outer capsule or tunica propria, formed by fibroelastic connective tissue**
2. **Thin homogeneous basement membrane**
3. **Complex stratified epithelium, which consists of two types of cells:**
   i. Spermatogenic cells or germ cells
   ii. Sertoli cells or supporting cells.

SPERMATOGENIC CELLS

- Spermatogenic cells or germ cells present in seminiferous tubules are **precursor cells** of spermatozoa. These cells lie in between **Sertoli cells.**
- In children, the **spermatogenic cells** are in primitive stage called **spermatogonia.**
- With the onset of puberty, spermatogonia develop into sperms through different stages.

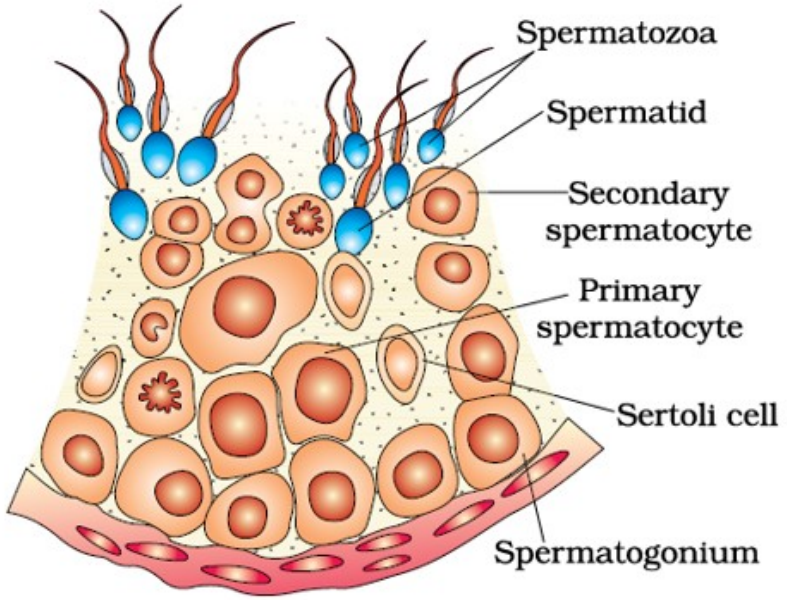
STAGES OF SPERMATOGENIC CELLS

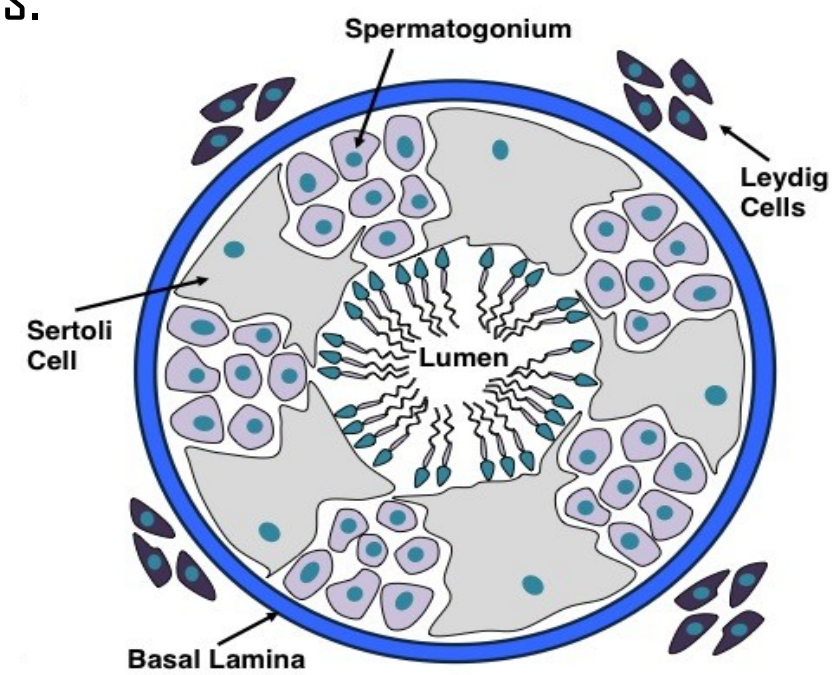
- Different stages of spermatogenic cells seen from periphery to the lumen of seminiferous tubules are:

1. Spermatogonium
2. Primary spermatocyte
3. Secondary spermatocyte
4. Spermatid.

SERTOLI CELLS

- Sertoli cells are the **supporting cells** for spermatogenic cells.
- These cells are also called **sustentacular cells** or **nurse cells.**
- Sertoli cells are the large and tall irregular columnar cells, extending from basement membrane to lumen of the tubule.
- Germ cells are attached to the Sertoli cells by means of cytoplasmic connection.
- This attachment between germ cells and Sertoli cells exists till the matured spermatozoa are released into the lumen of seminiferous tubules.





FUNCTIONS OF SERTOLI CELLS

1. Sertoli cells provide support, protection and nourishment for the spermatogenic cells present in seminiferous tubules till the spermatozoa are released.
2. Secrete the enzyme **aromatase,** which converts androgens into estrogen.
3. Secrete **androgen-binding protein** (ABP), which is essential for testosterone activity, especially during spermatogenesis.
4. Secrete **inhibin,** which inhibits FSH release from anterior pituitary.

BLOOD-TESTES BARRIER

- Blood-testes barrier is a mechanical barrier that separates blood from seminiferous tubules.
- Formed by tight junctions between the adjacent Sertoli cells, near the basal membrane of seminiferous tubule.

FUNCTIONS OF BLOOD-TESTES BARRIER

1. PROTECTION OF SEMINIFEROUS TUBULES

- Blood-testes barrier preventing the entry of toxic substances from blood into the lumen of seminiferous tubules.
- However, blood-testes barrier permits essential substances for spermatogenic cells.
- It prevents Large molecules including proteins, galactose polysaccharides and cytotoxic substances.
- It permits Nutritive substances essential for spermatogenic cells, necessary hormones and water.

2. PREVENTION OF AUTOIMMUNE DISORDERS

- Blood-testes barrier also prevents the development of autoimmune disorders by inhibiting the movement of antigenic products of spermatogenesis, from testis into blood.

FUNCTIONS OF TESTES

Testes performs two functions:

1. Gametogenic function: Spermatogenesis
2. Endocrine function: Secretion of hormones

GAMETOGENIC FUNCTIONS OF TESTES – SPERMATOGENESIS

- Spermatogenesis is the process by which the male gametes called **spermatozoa** (sperms) are formed from the primitive **spermatogenic cells** (spermatogonia) in the testis.
- It takes 74 days for the formation of sperm from a **primitive germ cell.**
- Throughout the process of spermatogenesis, the spermatogenic cells have cytoplasmic attachment with Sertoli cells.
- **Sertoli cells** supply all the necessary materials for spermatogenesis through the cytoplasmic attachment.

STAGES OF SPERMATOGENESIS

Spermatogenesis occurs in four stages:

1. Stage of proliferation
2. Stage of growth
3. Stage of maturation
4. Stage of transformation

1. STAGE OF PROLIFERATION

- Each **spermatogonium** contains **diploid number** (23 pairs) of chromosomes.
- The 23 pairs include 22 pairs of **autosomal chromosomes** and one pair of **sex chromosomes (X,Y).**
- During the proliferative stage, spermatogonia divide by mitosis, without any change in chromosomal number.
- During this stage, the spermatogonia migrate along with Sertoli cells towards the lumen of seminiferous tubule.

2. STAGE OF GROWTH

- In this stage, the primary spermatocyte grows into a large cell.
- Apart from growth, there is no other change in spermatocyte during this stage.

3. STAGE OF MATURATION

- After reaching the full size, each primary spermatocyte quickly undergoes meiotic or maturation division, which occurs in two phases:

FIRST PHASE

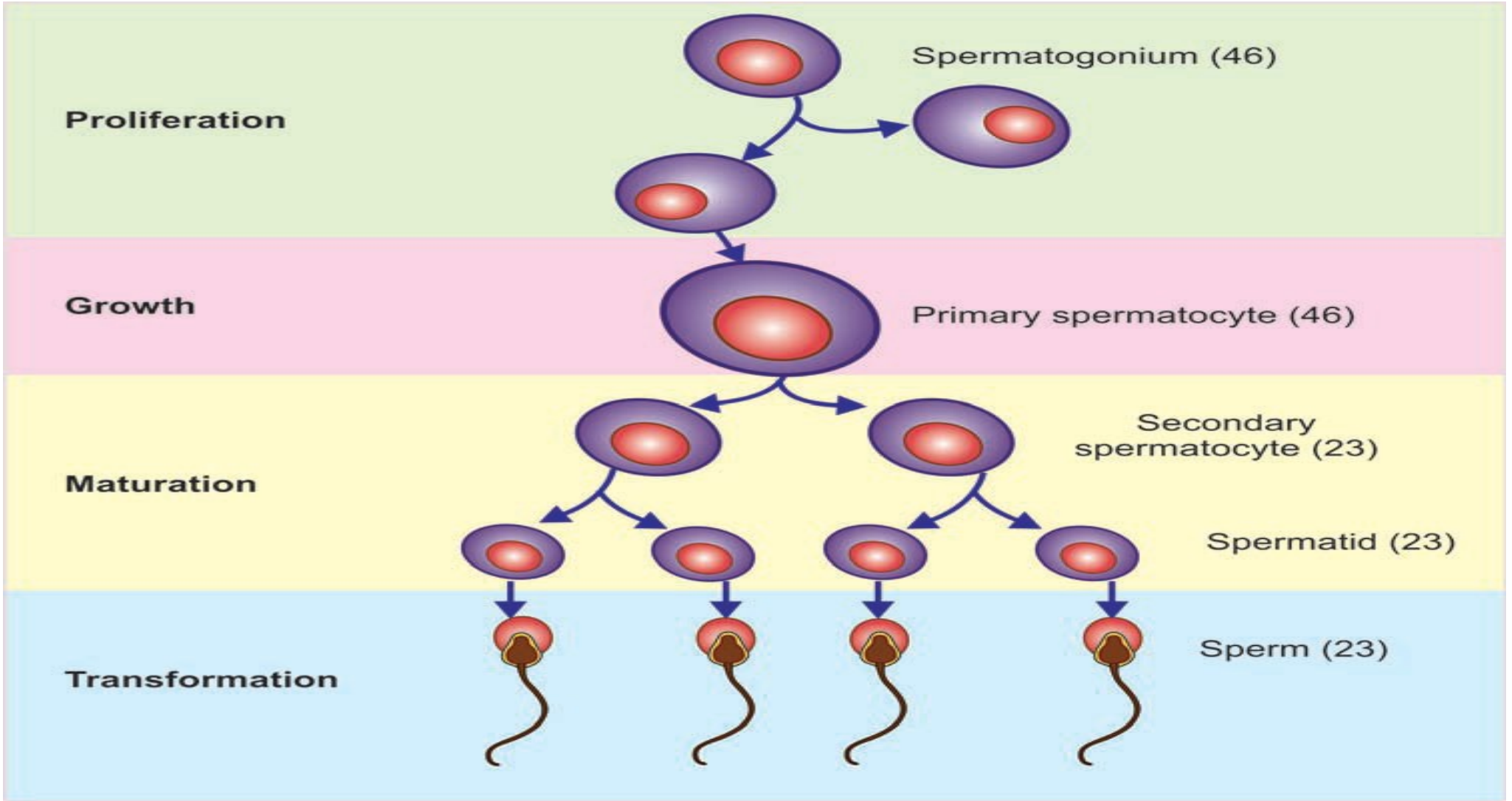
- In the first phase, each **primary spermatocyte** divides into two **secondary spermatocytes.**
- The significance of the first meiotic division is that each secondary spermatocyte receives only the **haploid** or **half the number of chromosomes (**22+X or Y).

SECOND PHASE

- During this phase, each secondary spermatocyte undergoes second meiotic division, resulting in two smaller cells called **spermatids.**
- Each spermatid has **haploid** number of chromosomes.

4. STAGE OF TRANSFORMATION

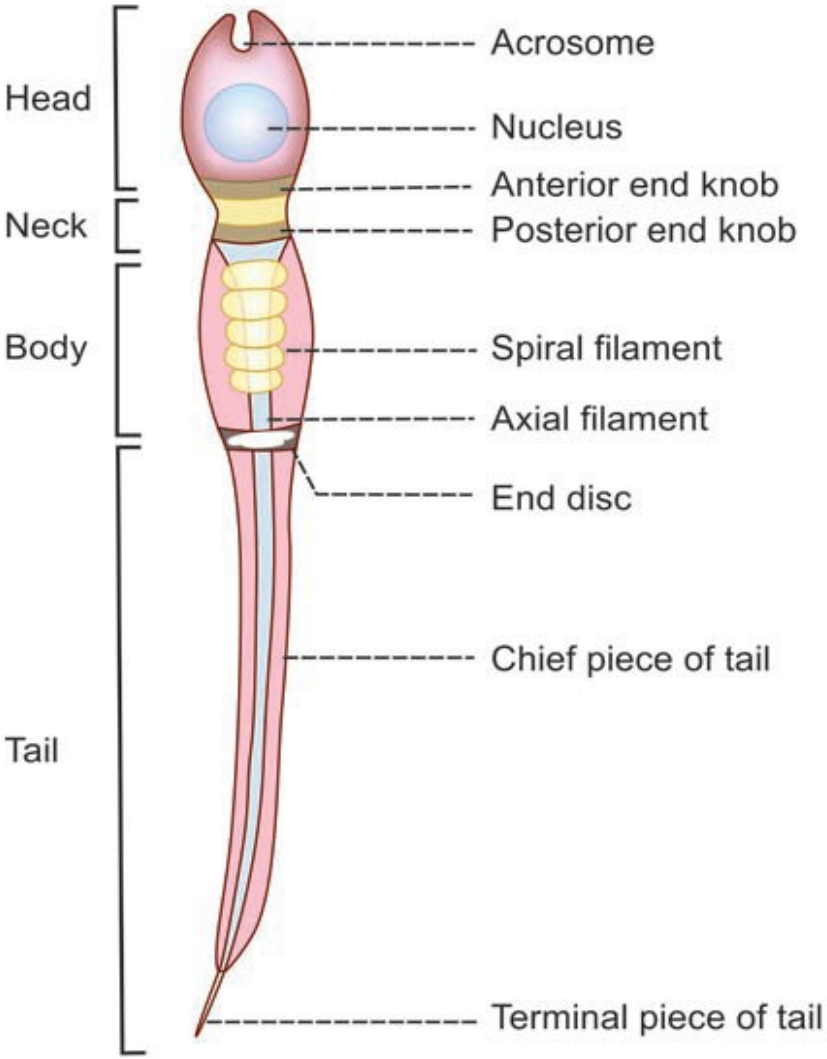
- There is no further division. Spermatids are transformed into matured **spermatozoa** (sperms), by means of **spermeogenesis** and released by **spermination.**



SPERMEOGENESIS

- Spermeogenesis is the process by which spermatids become matured spermatozoa.
- Changes taking place during spermeogenesis:

i. Condensation of nuclear material
ii. Formation of acrosome, mitochondrial spiral filament and tail structures
iii. Removal of extraneous (extra volume of nonessential) cytoplasm.



SPERMINATION

- spermination is the process by which the matured sperms are released from sertoli cells into the lumen of seminiferous tubules.

FACTORS AFFECTING SPERMATOGENESIS

Spermatogenesis is influenced by:

1. Sertoli cells
2. Hormones
3. Other factors.

4. ROLE OF SERTOLI CELL IN SPERMATOGENESIS

- Sertoli cells influence spermatogenesis by:

i. Supporting and nourishing the germ cells.
ii. Providing hormonal substances necessary for spermatogenesis.
iii. Secreting androgen-binding protein (ABP), which is essential for testosterone activity.
iv. Releasing sperms into the lumen of seminiferous tubules (spermination).

2. ROLE OF HORMONES IN SPERMATOGENESIS

- Spermatogenesis is influenced by many hormones, which act either directly or indirectly.
- Hormones necessary for spermatogenesis are:

i. Follicle-stimulating hormone (FSH)
ii. Testosterone
iii. Estrogen
iv. Luteinizing hormone (LH)
v. Growth hormone (GH)
vi. Inhibin
vii. Activin.

I. FOLLICULE-STIMULATING HORMONE

- It is responsible for the **initiation of spermatogenesis.**
- It binds with Sertoli cells and spermatogonia and induces the proliferation of spermatogonia.

II. TESTOSTERONE

- Testosterone is responsible for the sequence of remaining stages in spermatogenesis.
- Also responsible for the **maintenance of spermatogenesis.**
- Testosterone activity is largely influenced by androgen-binding protein.

III. ESTROGEN

- Estrogen is formed from testosterone in Sertoli cells.
- It is necessary for **spermeogenesis.**

IV. LUTEINIZING HORMONE

- In males, this hormone is called **interstitial cell stimulating hormone** (ICSH).
- It is essential for the **secretion of testosterone** from Leydig cells.

V. GROWTH HORMONE

- Growth hormone is essential for the **general metabolic processes** in testis.
- It is also necessary for the proliferation of spermatogonia.

VI. INHIBIN

- Inhibin is a peptide hormone and secreted by Sertoli cells.
- Its secretion is stimulated by FSH.
- Inhibin plays an important role in the **regulation of spermatogenesis** by inhibiting FSH secretion through feedback mechanism.

3. ROLE OF OTHER FACTORS IN SPERMATOGENESIS

I. INCREASE IN BODY TEMPERATURE

- Increase in body temperature prevents spermatogenesis.
- Normally, the temperature in scrotum is about 2°C less than the body temperature.
- When the temperature increases, the spermatogenesis stops.

II. DISEASES

- Infectious diseases such as mumps cause degeneration of seminiferous tubules and stoppage of spermatogenesis.

ACCESSORY SEX ORGANS IN MALES

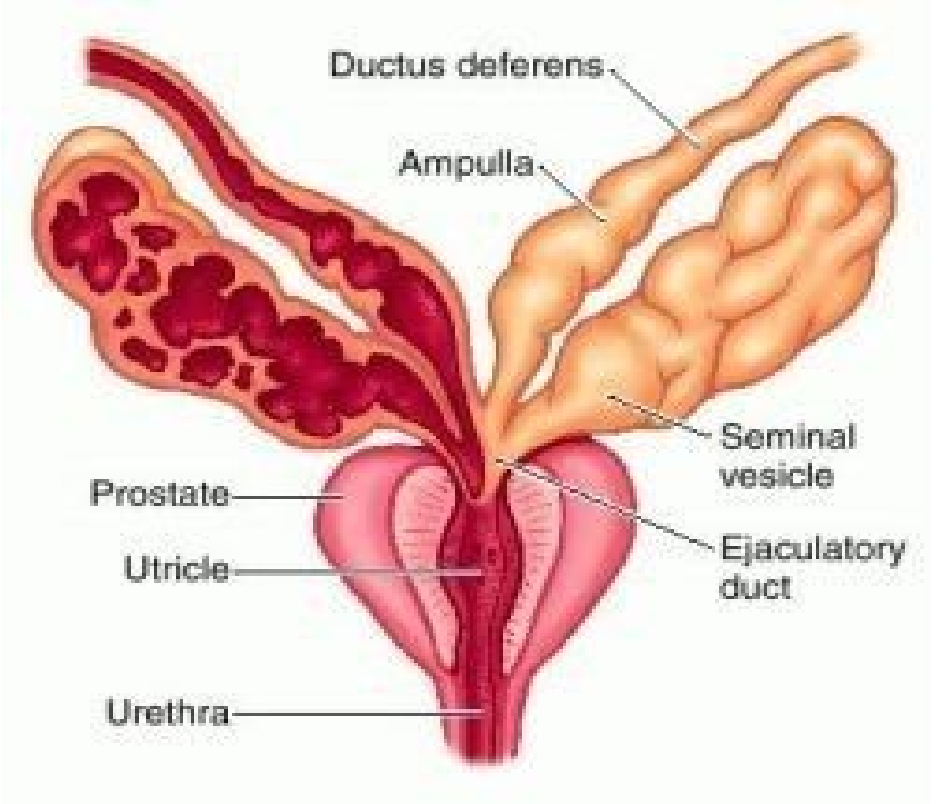
1. SEMINAL VESICLES

- Seminal vesicles are the paired glands situated in lower abdomen on either side of prostate gland behind urinary bladder.
- Each seminal vesicle is a hollow sac of irregular shape and is lined by mucous membrane.
- Epithelial cells of the mucous membrane are secretory in nature and secrete seminal fluid.
- Duct of seminal vesicle from each side joins with **ampulla of vas deferens** to form **ejactulatory duct.**
- Thus seminal fluid is emptied into ejaculatory ducts, which open into urethra.

Seminal vesicles secrete several important substances.

Products from seminal vesicles – 60%

1. Ascorbic acid
2. Fibrinogen
3. Flavin
4. Fructose
5. Inositol
6. Pepsinogen
7. Phosphorylcholine
8. Prostaglandin (PGE_2)
9. Citrate
10. Citric acid



FUNCTIONS OF SEMINAL FLUID

I. NUTRITION TO SPERMS

- **Fructose** and other nutritive substances in seminal fluid are providing nutrition and energy to the sperm.

II. CLOTTING OF SEMEN

- Immediately after ejaculation, semen **clots** because of the conversion of fibrinogen from seminal fluid into fibrin.

III. FERTILIZATION

- Prostaglandin of seminal fluid enhances fertilization of ovum by Initiating **reverse peristaltic movement** of uterus and fallopian tubes.

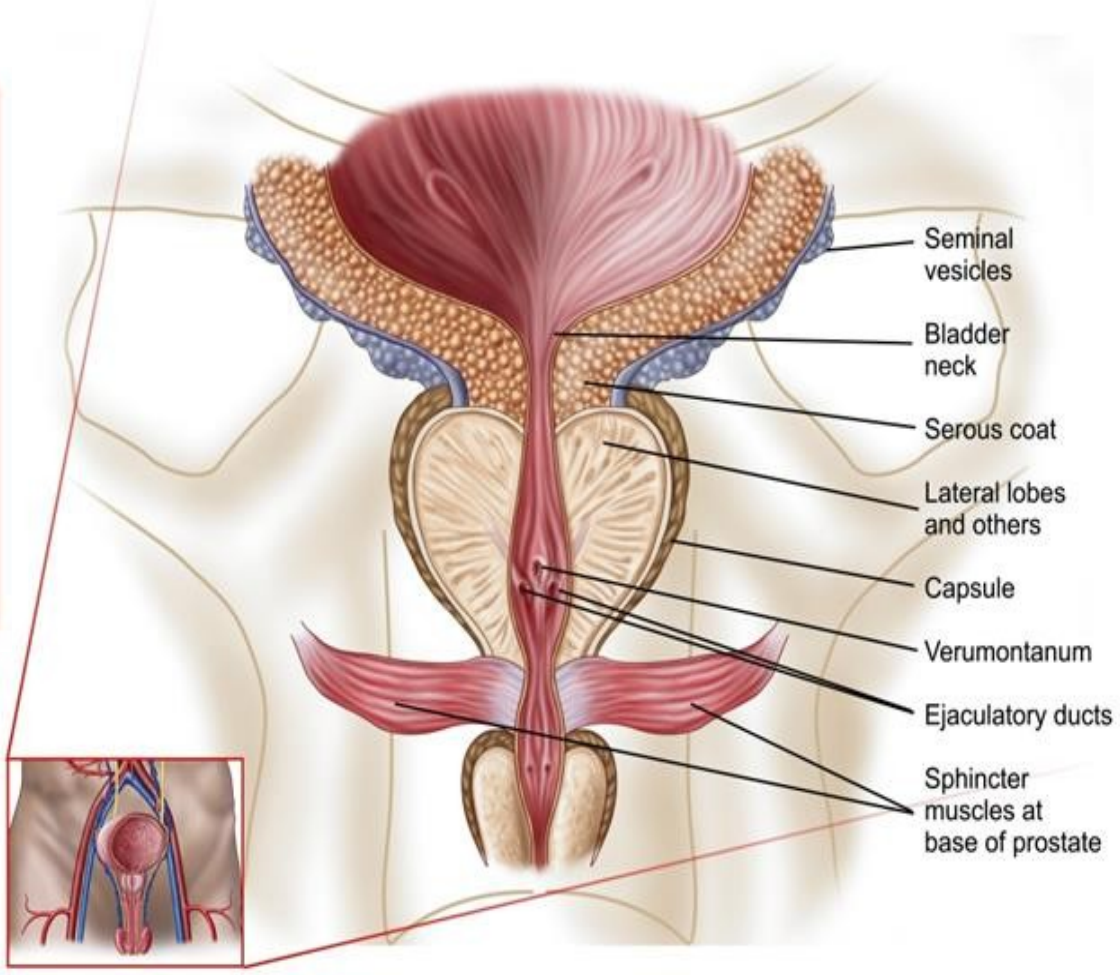
2. PROSTATE GLAND

- Human prostate gland weighs about 40 g.
- It consists of 20 to 30 separate glands, which open separately into the urethra.
- Prostate secretes **prostatic fluid,** which is emptied into **prostatic urethra** through **prostatic sinuses**.
- Prostate fluid is a thin, milky and alkaline fluid. It forms 30% of total semen.

- The products secreted by prostate gland are given in table.

Products from prostate gland – 30%

1. Acid phosphatase
2. Cholesterol
3. Clotting enzymes
4. Fibrinolysin
5. Glucose
6. Lactate dehydrogenase
7. Phospholipids
8. Plasminogen activator
9. Seminin
10. Spermine
11. Bicarbonate
12. Calcium
13. Citrate
14. Sodium
15. Zinc



FUNCTIONS OF PROSTATIC FLUID

1. MAINTENANCE OF SPERM MOTILITY

- Prostatic fluid provides optimum pH for the motility of sperms.
- Generally, sperms are nonmotile at a pH of less than 6.0.

2. CLOTTING OF SEMEN

- The clotting enzymes present in prostatic fluid convert fibrinogen (from seminal vesicles) into **coagulum.**
- It is essential for holding the sperms in uterine cervix.

3. LYSIS OF COAGULUM

- The coagulum is dissolved by fibrinolysin of prostatic fluid, so that the sperms become motile.

APPLIED PHYSIOLOGY – ENLARGEMENT OF PROSTATE GLAND

- Enlargement of prostate gland is of two types:

A. Benign enlargement
B. Malignant enlargement.

A. BENIGN ENLARGEMENT

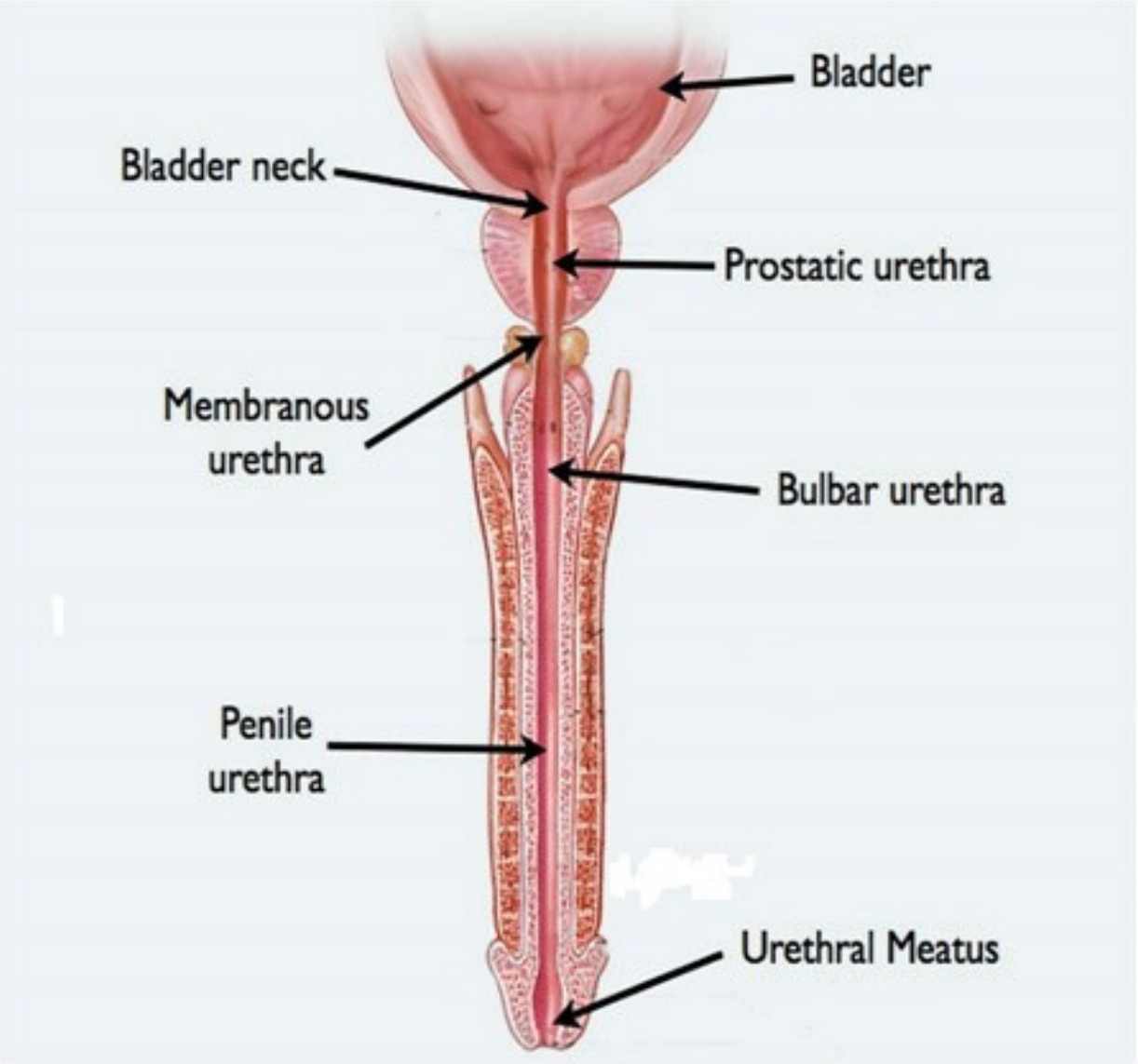
- Hyperplasia of glandular structures and connective tissues causes benign **(nonmalignant)** enlargement of prostate gland.
- It occurs in some men after 60 years of age, due to unknown causes.
- Enlarged prostate gland stretches the urethra and obstructs urine outflow from bladder.
- Common symptoms are increase in the frequency, difficulty in urination and dribbling of urine after urination.

B. MALIGNANT ENLARGEMENT

- Malignant enlargement **(cancer)** of prostate gland also causes obstruction of urinary passage.
- In addition, the **metastasis** (spread of cancer from primary site to other places) affects the other tissues, particularly bones.

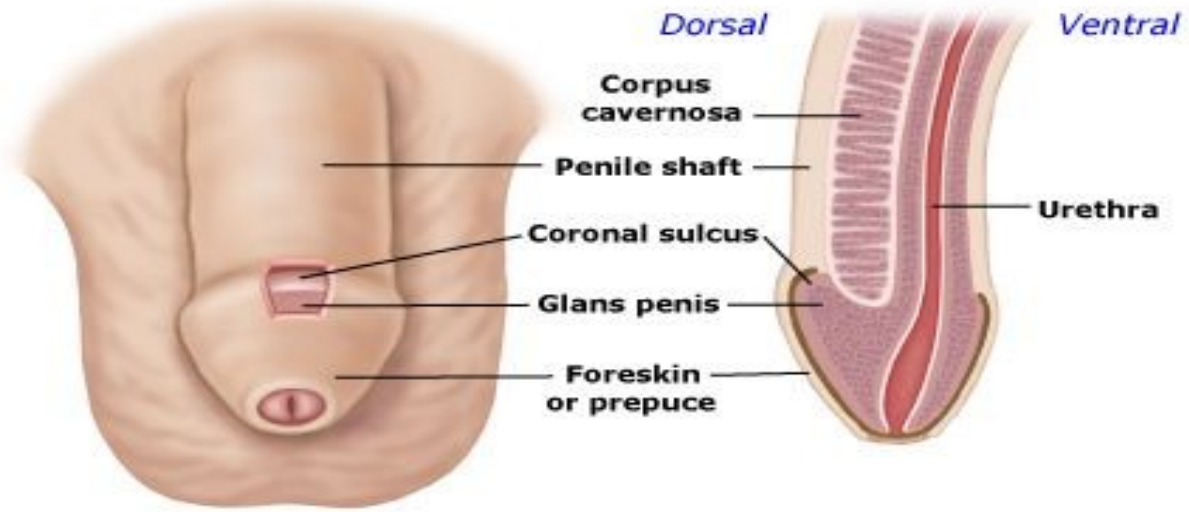
3. URETHRA

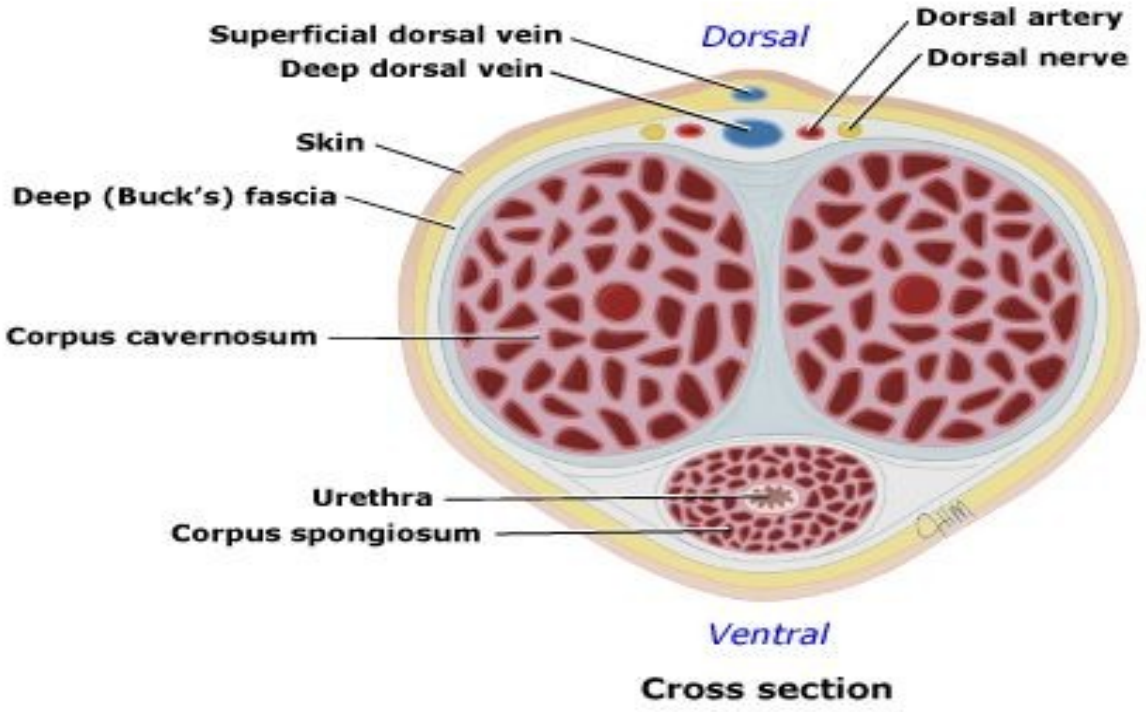
- Urethra in male has both reproductive and urinary functions.
- contains mucus glands throughout its length, which are called **glands of Littre.**
- The bilateral **bulbourethral glands** or **Cowper** glands also open into the urethra.



4. PENIS

- Penis is the male genital organ. Urethra passes through penis and opens to the exterior.
- Penis is formed by three erectile tissue masses, i.e. a paired **corpora cavernosa** and an unpaired **corpus spongiosum.**
- Corpus spongiosum surrounds the urethra and terminates distally to form **glans penis.**





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