**Dr. Iman**

**THE MALE REPRODUCTIVE SYSTEM**

**The major components are:**

1. Testis

2. genital ducts

3. Accessory sex glands

4. Penis

All of these structures depend on the male hormones for proper function.

**The major functions are:**

1. Production of sperms

2. Production of hormones

3. Transfer of sperms to the female via the copulatory organ

**THE TESTIS:**

1. This is a compound gland with two major functions: as an exocrine cytogenic

 gland, it produces and releases sperms; as an endocrine gland, it produces hormones.

2. The testes are suspended in the scrotum outside the abdominal cavity at the end of the

 spermatic cords. Each testis carries with it a serous sac derived from the peritoneum

 called the tunica vaginalis (with an outer parietal and an inner visceral layer).

3. A thick, resistant connective tissue capsule called the tunica albuginea surrounds the

 testis. Underneath this, is a layer of loose connective tissue with blood vessels, the

 tunica vasculosa. The tunica albuginea may become thickened in the posterior region

 forming the mediastinum testis. Fibrous incomplete partitions (septula testis) divided the testis into numerous pyramidal, compartments called testicular lobules.

4. The septa are rather complete in the dog and boar. In other domestic animals, they are

 just inconspicuous connective tissue strands.

5. The location of the mediastinum testis varies in different species. In some animals

 , it is relatively small and is located in a posterior position , in others , it is centrally located in the testis.

6. Each testicular lobule is occupied by 1-4 U-shaped, double-ended seminiferous tubules.

7. Between the tubules is the interstitial tissue.

**Seminiferous Tubules:**

Each seminiferous tubule is U-shaped with the two ends opening in the rete testis.

A layered sheath of connective tissue surrounds each seminiferous tubule.

There may be peritubular cells present. They resemble smooth muscle cells in some

species (boar) and myofibroblast in others (bull). Rhythmic contractions of these cells

help to move the tubular contents.

The epithelium is a specialized, stratified epithelium, which contains two main cell types:

the Sertoli or supportive cells and the spermatogenic cells of the seminal lineage.

**Sertoli Cells, Structure:**

1. These are large cells that rest on the basal lamina and extend upward through the full

 thickness of the epithelium to the free surface at the lumen.

2. The nucleus is large and contains a prominent nucleolus. There are usually one or more indentations in the nucleus.

3. The apical and lateral plasma membranes have irregular “pockets” which house

 developing sperms.

4. There are a lot of microfilaments in the cytoplasm. These may be involved in

 changing the shape of the Sertoli cell and in sperm release.

5. Along the lateral surfaces of the Sertoli cells are elaborate intercellular junctions.

6. Before the animal reaches reproductive age, Sertoli cells are the predominant cells

 type of the seminiferous tubule. During the reproductive age, Sertoli cells make up

 about 10% of the population in the epithelium.

**Sertoli Cells Functions:**

1. During development, the Sertoli cells, produce Mullerian

 inhibiting substance (MIS). The latter inhibits the development of the embryonic

 mullerian duct derivatives (oviduct, uterus and cervix).

2. These columnar cells lie on the basal lamina and have cytoplasmic extension that

 wrap around the germ cell elements. The apical cytoplasm reaches the tubular lumen.

 The nucleus of a Sertoli is irregularly shaped, and contains a prominent

 nucleolus.

3. They form a support to the developing sperm cells.

4. They help to nourish the developing sperm cells. There are gap junctions between

 Sertoli cells as well as between Sertoli and developing sperm cells. Nutrients and

 other metabolites can pass from the Sertoli cells to the developing sperm cells.

5. They protect the developing sperm cells. Sertoli cells form the blood-testis barrier.

6. They secrete factors that are important in sperm development:

6.1. Androgen binding protein secreted by the Sertoli cells maintains a high

 concentration of the male hormone testosterone in the tubular lumens. This is

 critical for sperm development.

6.2. Potasium and bicarbonate secreted by the Sertoli cells into the testicular fluid

 help to propel the nonmotile sperms out of the testis.

6.3. Inhibin is a hormone that inhibits the secretion of FSH (follicle stimulating

 hormone) from the pituitary as well as gonadotropin releasing factor from the

 hypothalamus.

6.4. Activin is a hormone that exerts a positive feedback on the secretion of FSH.

7. The Sertoli cells phagocytize defective sperms and residual bodies.

8. By changing their surface contours (with the help of microfilaments and

 microtubules) the Sertoli cells release sperms into the lumen.

**The Spermatogenic Cells:**

The germ cells are derived from tissues in the yolk sac and migrate in embryonic life to

the gonadal ridges. They comprise the bulk of the cells in the adult seminiferous tubule.

These form the other major category of cell types in the seminiferous tubules and include:

1. Stem cells

2. Proliferating cells

3. Differentiating cells

**Spermatogenesis:** is the process by which the stem cells are transformed into spermatozoa.

This is subdivided into three phases:

Spermatocytogenesis, production

Meiosis, division

Spermiogenesis, differentiation

**Spermatogonia**

These are the stem cells of the seminal lineage.

**Spermatocytogenesis:**  is the process during which spermatogonia develop into spermatocytes.

1. The spermatogonia are found in direct contact (“sitting”) on the basal lamina.

1. A number of species-specific mitosis takes place with the stem spermatogonia , resulting in Type A and then Type B spermatogonia.

 3. The division of a stem spermatogonium produces two daughter cells: another stem

 cell that continues the line of reserved stem cells, and a Type A spermatogonium.

 4. The Type A spermatogonia divides further to finally form Type B spermatogonia.

 5. The Type A spermatogonia are usually oval shaped and sit on the basal lamina.

 6. The Type B spermatogonia are more spherical and begin to move away from the

 basal lamina.

 7. Type B spermatogonia undergo mitosis and form primary spermatocytes.

 **Primary Spermatocytes**

 1. The primary spermatocytes gradually lose contact with the basal lamina and move

 into the adluminal tubular compartment.

 2.The nuclear DNA is replicated and all chromosomes consist of two sister chromatids.

 3. The primary spermatocyte goes into the prophase of the first meiotic division. This prophase is quite prolonged and primary spermatocytes are found in large numbers.

 They can be identified by the thickened chromosomes in their nuclei.

 4. The prophase of the first meiotic division is subdivided into the leptotene, zygotene,

 pachytene, diplotene, and diakineses stages.

 5. During the pachytene stage, crossing-over occurs between the non-sister chromatids

 of the paired chromosomes. The result is the appearance of new unique chromosomes

 that are different from both the maternal and paternal chromosomes.

 6. At the end of the prophase the nuclear membrane disappears.

 7. The metaphase, anaphase, and telophase occur rapidly.

 8. At the end of the first meiotic division (reductional division), secondary

 spermatocytes are produced.

**Secondary Spermatocytes**

1. The secondary spermatocyte has only half the number of chromosomes.

2. These are short-lived, intermediate in size between primary spermatocytes and

 spermatids. They may not be easily identified in a histological section.

3. The secondary spermatocytes enter the second meiotic division

 resulting in spermatids.

**Spermatids**

1-These daughter cells of the secondary spermatocytes do NOT divide.

2. Each spermatid contains a haploid set of chromosomes.

3. They are small in size, have nuclei with areas of condensed chromatin and are located

 near the center of the seminiferous tubule epithelium.

4- These cells then undergo spermiogenesis.

**Spermiogenesis:**

This is the process by which spermatids undergo a series of changes and differentiate into

individual spermatozoa. This is a process of cyto differentiation in which the cells are

extensively modified but no cell division is involved.

There are four phases: Golgi phase, cap phase, acrosomal phase, and maturation phase.

**Spermiation:** Spermatids are released as spermatozoa into the lumens of the seminiferous tubules.

**Structure of the Spermatozoon**

Spermatozoa vary in length between 60 μm (boar, stallion) to 75 μm (ruminants).

* In the light microscope the spermatozoon appears to have only two parts: the head and

 the tail.

* In the electron microscope, the tail can be subdivided further into the neck, the middle

 piece, the principal piece, and the end piece.

**Head**:

The shape of the head is species-dependent and subject to great variations. The

acrosomal cap covers the anterior portion of the nucleus. The nucleus is greatly condensed.

**Neck:**

 also called the connecting piece. This is a short and narrow structure between the

head and the middle piece. It consists of two centrioles with the centrally located

centriole giving rise to the axoneme. There are also nine peripheral, longitudinally

oriented coarse fibers that are continuous with the outer fibers of the middle piece.

**Middle Piece:**

The core of the middle piece is the characteristic structure of a flagellum:

axoneme of 9 (doublets) + 2 microtubules. These are surrounded by 9 longitudinally

oriented, tapered outer fibers that are connected to the fibers of the connecting piece.

These are in turn surrounded by the mitochondria in a helicoidal arrangement.

**Principal Piece**:

 This is the longest portion of the spermatozoon. The central axoneme is

surrounded by outer dense fibers. Two of the outer fibers fuse to form a characteristic

peripheral fibrous sheath.

**End Piece:**

 The termination of the fibrous sheath marks the beginning of the end piece,

which contains only the axial filament complex.

**The Interstitial Tissue:**

1. Between the seminiferous tubules the interstitial spaces contain loose connective

 tissue, blood and lymph vessels, free mononuclear cells, and interstitial endocrine(Leydig) cells.

2. The cells of Leydig produce testicular androgen and, in the boar, large amounts of

 Estrogens.

3-These cells are under the influence of luteinizing hormone from the pituitary.

4. The cells of Leydig have ultrastructure of steroid synthesizing/metabolizing cells with

 a lot of smooth endoplasmic reticulum and mitochondria with tubular cristae. Lipid

 droplets are found in the cytoplasm of Leydig cells in all species.

6. In a routine histological section stained with H&E, the Leydig cells have eosinophilic

 cytoplasm with small, clear lipid droplets.

7. Thus high concentrations of testosterone are delivered to the tubules and the

 testosterone that diffused into the blood reaches the rest of the body.

**THE BLOOD TESTIS BARRIER**:

1. During sperm development new genetic combinations appeared a result of crossing

over. Since sexual maturity occurs long after the development of immune competence,

the differentiating sperm cells can be recognized as ‘foreign’ and provoke an immune

response that will destroy the sperms.

2. This does not happen because a blood-testis barrier protects the developing sperms.

3. Very elaborate occluding or tight junctions make up the blood-testis barrier between

 Sertoli cells. The junctions divide the seminiferous epithelium into a basal

 compartment and an ad luminal compartment.

4. Large molecules such as immune globulins cannot penetrate the tight junctions and

 thus are unable to reach the developing sperms.

5. Note that the spermatogonia are located outside the barrier (they are genetically

 identical to the somatic cells) and can respond to various factors. The spermatocytes

 are inside the barrier and they may express novel proteins on their surfaces.

**The genital ducts: Intratesticular& Extratesticular ducts:**

**Intra testicular ducts**

Tubuli recti, rete testis, ductuli efferentes

**Tubuli Recti and Rete Testis**

1. The last segment of the seminiferous tubule opens into a short, straight duct that is

 lined with simple cuboidal cells, this is the tubuli recti.

2. The tubuli recti connect to a vast network of tubules, the rete testis, which occupies

 most of the space within the mediastinum testis. These channels are lined with a

 simple cuboidal epithelium.

3-The epithelial cells secrete fluid, which helps the non motile sperms to move along.

4. Connecting and draining the rete testis channels are 10-15 convoluted ducts called the ductuli efferentes.

**Ductuli Efferentes:**

1. The epithelium of the ductuli efferentes is pseudostratified columnar epithelium. The lumen is scalloped or stellate in outline due to alternating patches of cuboidal and columnar cells.

2. Some of the cells are ciliated and are involved in moving sperms forward. Other cells

 do not have cilia and are involved with fluid absorption.

3-Much of the testicular fluid is absorbed here and new fluid secreted into the lumen.

4. The epithelium rests upon a distinct basal lamina and there is a layer of smooth

muscle cells around the tubule.

**Extra testicular ducts**

**Ductus epididymis**

**Structures**

1. The ductuli efferentes empty their contents into the ductus epididymis, which is a

 single tube. This is highly coiled and tortuous so that you will see multiple cross

 sectional profiles of the same tube in a histological section. The total length of the

 ductus is about 40 m in the bull and boar, up to 70 m in the stallion.

2. The duct can be divided into three regions: the caput ( head), the corpus( body) and

 the cauda ( tail).

3. The epithelium is pseudostratified columnar. There are tall principal cells with

 stereocilia, which are long, branched, non motile microvilli. Small basal reserve cells sit on the basal lamina.

4. There are layers of smooth muscles outside the epithelium. In the head region, the

 layer is circumferential. In the body there are two layers, inner circular and outer

 longitudinal. In the tail there are three layers, circular, oblique and longitudinal. The

 muscle layers exhibit peristaltic movements and propel and sperms along the ductus

 epididymis.

**Ductus deferens:**

1. The end of the epididymis enlarges into the ductus deferens, also known as the vas

deferens.

2. It transverse the inguinal canal and courses behind the peritoneum toward the urethra.

 In the inguinal canal and the scrotum the ductus deferens courses with the spermatic

 cord (ductus deferens, testicular artery, pampiniform plexus of veins, lymphatic

 vessels and nerves).

3. Fascia and the striated cremaster muscle enclose the spermatic cord.

4. The epithelium of the ductus deferens is pseudostratified columnar with variable

 distribution of stereocilia.

5. The columnar cells secrete a fluid rich in carbohydrates and amino acids.

6. The muscular layers outside the epithelium are thick and are arranged into three

 layers: thin inner longitudinal, robust middle circular, and thick outer longitudinal.

 Strong contractions of the muscular layers expel the sperms in ejaculation.

7. The ductus deferens ends in a short, dilated segment (in the stallion, ruminants, dog)

 or as a straight tube (boar, cat) near the prostate. This segment is known as the

 ampulla. The lumen becomes larger and there is a vastly increased infolding of the

 mucosa into many long, complicated and anastomosing ridges.

**The ejaculatory ducts:**

1. After the ampulla, the excurrent duct becomes the short, straight ejaculatory duct,

 which pieces the body of the prostate at the base of the urinary bladder.

2. The opening is like a small slit into the prostatic part of the urethra, on a small

 thickening of its dorsal wall, the colliculus seminalis (also known as the

 verumontanum).

3. The slit-like openings of the ejaculatory ducts are located to the right and left of a

 blind invagination on the summit of the colliculus, the utriculus masculinus (utriculus

 prostaticus) that is the vestigial homolog of the uterus.

4. The ejaculatory duct is lined by simple or pseudostratified columnar epithelium. Near

 the urethra, the epithelium becomes transitional.

5. The wall of the ejaculatory ducts is formed by fibrous tissue only. There are no muscular layers.

6. In the stallion and ruminants, the ductus deferens unites with the excretory duct of the

 seminal vesicle to form a short ejaculatory duct. In carnivores, the ductus deferens

 joins the urethra alone because the seminal vesicle is absent.

**The accessory sex glands: Seminal vesicles, prostate, and bulbourethral**

**glands.**

**The seminal vesicles, The Vesicular Gland**

1. Stallions: true vesicles, with wide central lumen into which open short, branched

tubulo- alveolar glands, in most domestic animals, this gland of lubulated compound gland has a central duct surrounded radially by branching tubular to tubular adenomers.

1. In the bull, the vesicular gland is a compact, lobular organ.
2. Carnivores do not have vesicular glands.

5. The epithelium is pseudostratified with columnar secretory cells and basal reserve

 cells. The cytoplasm of the columnar cells contain a large amount of lipid droplets.

 6.Well vascularized lamina propria submucosa that can develop into stromal position for lobe and lobule formation; secretory ducts empty centrally .

7. The muscular tunic consist of two layers of smooth muscles but they are not organized into distinct layers.

8. The secretion is rich in fructose.

9. Secretions from the seminal vesicles help to coagulate the semen.

**The prostate:**

1-This is the largest of the accessory sex glands. It is present in all domestic animals.

2. It is composed of 30-50 tubulo-alveolar glands with 16-32 excretory ducts opening

 into the urethra to the left and right of the colliculus seminalis.

3. The glands are embedded in a fibromuscular ( fibroelastic& smooth muscle)

capsule that continues into stromal septa; the glandular parenchyma consist of compound tubuloalveolar gland that comprise two portions; the body(external portion) and the disseminate(internal portion).

4.The epithelium is pseudostratified columnar with secretory and basal cells or simple columnar cells.

6. Most of the columnar cells secrete a proteinaceous material. Some mucus secreting

cells may also be present.

7. Corpora amylacea (prostatic concretions) are laminated bodies in the acini. These

structures may be calcified.

**The Bulbourethral Glands of Cowper:**

1-These are small glands with ducts that enter the membranous urethra.

2. They are compound tubular glands in the boar, cat, and buck. They are tubuloalveolar

 in the stallion, bull and ram.

3. Dogs do not have bulbourethral glands.

4. The secretory epithelium is simple columnar, the adenomeres empty in a duct system, which lined by simple cuboidal or simple columnar epithelia linning the collecting ducts ,when these joined the linning become pseudostratified columnar then become transitional in single large duct before connecting with the urethra.

5. Secretion from the glands is clear, viscous, mucus-like and is rich in sialo proteins.

6. The secretion may serve as lubricant for the urethra.

**Penis, the copulatory organ:**

Basic architecture

1-Three cylinders of erectile tissues and the penile urethra.

2. The cylinders of erectile tissues are enclosed by connective tissue and then by skin.

3. The single corpus spongiosum encloses the urethra and enlarges terminally into the

 glans penis.

4. The paired, parallel and dorsal cylinders of erectile tissues are the corpora cavernosa,

 extending only as far as the glans.

 Corpora Cavernosa

1. Two cylinders of erectile tissue. The caudal ends are called crura penis. The rostral

 ends stop at the glans penis.

2. Each cylinder is enclosed by thick, dense, fibroelastic connective tissue, the tunica

 albuginea. The partition between the two cylinders is incomplete, allowing vascular

 spaces to communicate.

3. Erectile tissue is made up of a vast honey comb-like system or irregular cavernous

 blood spaces. The walls of the spaces, trabeculae, are made up of smooth muscles,

 nerves and dense connective tissue. Endothelial cells line the surfaces of the walls.

4. Deep artery runs through the center of each cylinder.

5. The major veins are at the periphery, beneath the tunica albuginea.

6. This erectile tissue is similar to the crura of the clitoris in the female.

Corpus Spongiosum.

1. Single cylinder of erectile tissue, which is blunt at both ends: rostral – glans penis,

caudal – bulbus penis.

2. A thin tunica albuginea surrounds the cylinder.

3. The trabeculae have more elastic tissue and less smooth muscle.

4. In the center of the cylinder is the urethra.

Peri cavernous Tissues of the Penis

1. There are considerable differences in these tissues among species.

2. Vascular-Type Penis, as found in stallions, contain bundles of smooth muscle

 interspersed with a small amount of connective tissue which run parallel to the

 longitudinal axis of the organ.

3. Fibrous-Type Penis, as found in ruminants and boars, has a predominance of

 connective tissue, and little or no smooth muscle is present.

4. Intermediate-Type Penis, as found in carnivores, has more connective tissue and less

 smooth muscle bundles as compared to a vascular-type penis.

5. An os penis (in dogs) or an os glandis (in cats) is continuous with the cranial corpus

 cavernosum.

**The urethra:**

The urethra extends from the bladder through the penis. It can be subdivided into

different sections, depending on the structure it is coursing through.

**Prostatic urethra**

1. Passes through the prostate.

2. It is in this portion that you find the colliculus seminalis and the utriculus masculinus.

3. The ejaculatory ducts and prostatic ducts open into the prostatic urethra.

4. The epithelium is mainly transitional but becomes pseudostratified or stratified

columnar at the distal portion.

There are two layers of smooth muscles around the prostatic urethra, inner longitudinal

and outer circumferential. The outer layer is highly developed at the internal urethral

orifice, where it becomes part of the internal sphincter of the bladder.

**Membranous urethra**

1. Very short structure line by stratified columnar epithelium.

2. Smooth muscle layer thinner.

3. It is in the membranous urethra that striated muscle fibers of the urogenital diaphragm

surround the urethra. These fibers comprise the sphincter muscle of the urethra, forming

the external sphincter of the bladder.

Cavernous urethra spongiose or penile urethra

1. The longest portion of the urethra expands at the bulb of the corpus spongiosum (bulb

of the urethra) and expands again in the glans penis (terminal fossa).

2. Epithelium is stratified columnar. At the distal portion, from the fossa outward, it

becomes stratified squamous nonkeratinized and in turn becomes continuous with the

stratified squamous keratinized epithelium that covers the glans penis.

3. Located in the penile periurethral tissue are many small glands that contain mucus

secretory cells. These are the glands of Littre and the secretion helps to lubricate the urethra.