The Male Reproductive System
The male reproductive system

- Testes
- Genital ducts
- Accessory sex glands:
  - seminal vesicles
  - prostate
  - bulbourethral glands
- External genitalia:
  - penis
Structure of the Testis

- **Tunica albuginea** - connective tissue capsule.
- **Mediastinum testis** – thickening of the tunica albuginea on the posterior surface of testes.
- **Septa** – extensions of the tunica albuginea, dividing each testis into approximately 250 lobules.
- Each lobule consists of one to four **seminiferous tubules**, in which sperm are produced.
Structure of the Testis

- Each **seminiferous tubule** is approximately 50 cm long, within the lobule forms loops.

- The ends of the loop are called the **straight tubule (tubulus rectus)**.

- It continues into the **rete testis** - an anastomosing channel system within the mediastinum.
The seminiferous tubules are lined by the seminiferous epithelium

Two basic cell populations:

1. **Spermatogenic cells**, which regularly replicate and differentiate into mature sperm.

2. **Sertoli cells**, also known as supporting cells.
Spermatogenic cells

- Derive from the yolk sac and colonize the gonadal ridges during early development

  - **Spermatogonia** - the most immature cells, closest to the basal lamina, the only cell type present before puberty

  - **Primary spermatocytes** – the largest cells, closer to the lumen, 2n4N

  - **Secondary spermatocytes** – still closer to the lumen, rare on the slides since they immediately undergo second meiotic division, 1n2N

  - **Spermatids** - the most mature cells, next to the lumen, 1n1N, undergo differentiation to form mature sperm cells
Spermatogenesis

Divided into three phases:

1. **Spermatocytogenesis:** spermatogonia divide by mitosis. **Spermatogonia A** remain undifferentiated. **Spermatogonia B** can enter meiosis to form primary spermatocytes.

2. **Meiosis:** primary spermatocytes undergo two meiotic divisions to reduce both the chromosome number and amount of DNA to produce haploid cells called spermatids.

3. **Spermiogenesis:** spermatids undergo cytodifferentiation into mature spermatozoa.
Spermiogenesis

- **Nuclear condensation**: thickening and reduction of the nuclear size, condensation of the nuclear contents

- **Formation of acrosome**: a cap above the nucleus containing enzymes that play an important role in the penetration of the zona pellucid of the oocyte

- **Formation of flagella**: migration of centrioles backwards and mitochondria to the midpiece of tail

- **Discarding** the excess of cytoplasm
<table>
<thead>
<tr>
<th>Process</th>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitosis of spermatogonia</td>
<td>16 days</td>
<td>Formation of primary spermatocytes</td>
</tr>
<tr>
<td>Meiosis I</td>
<td>22-24 days</td>
<td>Division of primary spermatocytes with formation of secondary spermatocytes</td>
</tr>
<tr>
<td>Meiosis II</td>
<td>Several hours</td>
<td>Division of secondary spermatocytes with formation of spermatids</td>
</tr>
<tr>
<td>Spermiogenesis</td>
<td>24 days</td>
<td>Differentiation of spermatids into the spermatozoa</td>
</tr>
<tr>
<td>Total</td>
<td>~64 days</td>
<td></td>
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</tbody>
</table>
Spermatozoa

- Haploid nucleus contains male genetic information.
- Acrosome contains enzymes.
- Centriole.
- Spiral arrangement of mitochondria provides energy for swimming.
- Axial filament.
- Tail for propulsion.

Diagram showing the structure of a sperm cell, including the head, middle section, and tail.
Sertoli Cells

- Extend from the basal lamina to the lumen
- Have cytoplasmic infoldings embracing the developing spermatogenic cells
- Neighboring cells are connected by occluding junctions forming the **blood–testis barrier.**
Sertoli Cells functions:

- **Support** for spermatogenic cells
- **Nutrition** and metabolite exchange for the spermatogenic cells
- Secretion of **fluid for sperm transport**
- Secretion of **Androgen-binding protein (ABP)** which concentrates testosterone in the luminal compartment of the seminiferous tubule (essential for normal maturation of the developing sperm)
- Secretion of **Inhibin**, that inhibits follicle-stimulating hormone (FSH) release from the anterior pituitary gland.
- **Phagocytosis** of residual bodies shed by the maturing spermatozoa
- Blood-testis barrier **protects** from autoimmune attack
Blood Testis Barrier

- **Formed by** tight junctions between the Sertoli cells

- **Divides** the spermatogenic epithelium into two compartments:
  - **basal** (only spermatogonia)
  - **adluminal** (other spermatogenic types)

- **Protects** developing sperm cells from autoimmune response
  
  Spermatozoa and spermatogenic cells possess molecules that are unique to these cells and can be recognized as “foreigners” by the immune system.

  Autoimmune response will cause sterility.

- **Protects** developing sperm cells from harmful substances from circulation (toxins, drugs, etc.)
Leydig Cells

✓ Leydig cells (interstitial cells) are located outside the seminiferous tubules

✓ The main function - secretion of testosterone and other androgens:
  – In the embryo - essential for the normal development of the gonads in the male fetus
  – At puberty is responsible for the initiation of sperm production, accessory sex gland secretion, and development of secondary sex characteristics.
  – In the adult is essential for the maintenance of spermatogenesis, secondary sex characteristics, ducts, and accessory sex glands
Hormonal regulation of Testis

1. Hypothalamus secretes GnRH which stimulates the Anterior pituitary.
2. The Anterior pituitary secretes FSH and LH which target Sertoli cells and Leydig cells.
3. Sertoli cells produce Inhibin which has a negative feedback effect on the hypothalamus.
4. Leydig cells produce Testosterone which has a negative feedback effect on the hypothalamus.
5. LH stimulates Spermatogenesis which is inhibited by Inhibin.
Spermatic Ducts

Newly formed sperm cells travel through a series of ducts to reach the urethra.

**Intratesticular ducts:**
- **Straight tubules** – Sertoli cells, simple cuboidal epithelium
- **Rete testis** – low cuboidal epithelium
- **Efferent ductules** – simple cuboidal (absorption of fluid) and ciliated columnar cells (sweeping of sperm cells to the epididymis)

**Excretory ducts:**
- **Ductus epididymis**
- **Ductus deferens**
- **Ejaculatory duct**
Spermatic ducts

- ductus deferens
- ejaculatory duct

- efferent ductules
- duct of the epididymis
**Epididymis**

- Contains the efferent ductules and the duct of the epididymis
- Lined by the pseudostratified epithelium, cells are characterized by stereocilia
- Cells are capable of both absorption and secretion
- Smooth muscle cells underline the BM help to propel spermatozoa toward the ductus deferens
- A site of spermatozoa maturation
Ductus Deferens and Ejaculatory Duct

• DD is the longest part of the excretory system
• A direct continuation of the tail of the epididymis
• Within the spermatic cord through the inguinal canal ascends into the abdominal cavity
• **Pseudostratified columnar epithelium, few stereocilia, longitudinal folds**
• **Three layers of smooth muscles** – peristaltic contraction during **ejaculation**
• Distal end forms the **ampulla of ductus deferens**
• The ampulla joins the **duct of the seminal vesicle**, continues through the prostate gland as the **ejaculatory duct** and empties into the prostatic urethra.
Accessory Genital Glands

- seminal vesicles
- prostate
- bulbourethral glands
Seminal vesicles

- Highly coiled tubes
- Many folds in the mucosa
- Smooth muscle contract during ejaculation
- The secret is rich in fructose, and other simple sugars, amino acids, citrate and prostaglandins
- Fluid of seminal vesicles is the principal metabolic substrate for sperm cells
- 70% of human ejaculate
- Under the control of testosterone
PROSTATE GLAND

• Surrounds the origin of the urethra
• Consists of 30 to 50 tubuloalveolar glands arranged in three concentric layers:
  - an inner mucosal layer,
  - an intermediate submucosal layer,
  - a peripheral layer
• The mucosa is folded, epithelium from tall cuboidal to pseudostratified columnar
• Surrounded by fibromascular capsule with smooth muscle cells that contract during ejaculation
• secrete a clear fluid rich in citric acid and acid phosphatase, that contributes to the formation of seminal fluid
• Ducts open into the prostatic urethra
• Corpora amilacea – glycoprotein spheres in the gland’s lumen. Enlarge and calcify with age.
The adult prostatic parenchyma is divided into four anatomically and clinically distinct zones:

1. The central zone
2. The peripheral zone
3. The transitional zone

The peripheral zone comprises 70% of the glandular tissue of the prostate. It surrounds the central zone and occupies posterior and lateral parts of the gland. **Most prostatic carcinomas arise from the peripheral zone of the prostate gland.** The peripheral zone is palpable during digital examination of the rectum. This zone is also the most susceptible to inflammation.
Bulbourethral Glands

✓ The paired **bulbourethral glands** (Cowper’s glands) are pea-sized structures located in the urogenital diaphragm

✓ The glands are compound **tubuloalveolar glands** that structurally resemble mucus secretory glands

✓ The clear, mucus-like glandular secretion contains considerable amounts of galactose and galactosamine, galacturonic acid, sialic acid.

Sexual stimulation causes release of this secretion, which constitutes the major portion of the **preseminal fluid** and probably serves to lubricate the penile urethra.
SEMEN

Semen contains fluids and sperm from the testis and secretory products from the epididymis, ductus deferens, prostate, seminal vesicles, and bulbourethral glands.

It is alkaline and may help to neutralize the acid environment of the urethra and the vagina.

Semen also contains prostaglandins that may influence sperm transit in both the male and female reproductive ducts.

The average ejaculate of semen has a volume of about 3 mL and normally contains up to 100 million sperm per milliliter.
Urethra

✓ Conducts both urine and seminal fluid

✓ 3 parts:

1. **Prostatic part** – surrounded by the prostate, lined by transitional epithelium, receives prostatic and ejaculatory ducts

2. **Membranous part** – surrounded by skeletal muscles of urogenital diaphragm, which form voluntary external sphincter. Lined by pseudostratified columnar epithelium

3. **Spongy part** – passes through the corpus spongiosum of the penis, epithelium changes from pseudostratified columnar to stratified squamous towards the distal end (fossa navicularis).

✓ Numerous **glands of Littre** empty mucous secretion into the lumen
**PENIS**

**Corpora cavernosa** (two) – dorsal position, dense CT sheath – **tunica albuginea**

**Corpus spongiosum** – ventral position, distal end – **glans penis**, penetrated by the urethra

**Erectile tissue** – numerous interconnecting lacunae, lined by endothelium, surrounded by connective tissue trabeculae

**Erection of the penis** involves the filling of the vascular spaces of the corpora cavernosa and corpus spongiosum under the parasympathetic stimulation.
Thank you for attention