I. The functions of the male reproductive system include:
   a. Production of male gametes (sperm)
   b. Synthesis of androgens (male sex hormones) such as testosterone.
   c. Delivery of sperm into the female reproductive tract.

II. Scrotum and Testes
   a. Scrotum = sac of skin and superficial fascia that hangs outside the abdominopelvic cavity at the root of the penis.
   b. Contains paired testes (male gonads or primary sex organs) separated by a CT septum. This location is 3°C lower than internal body T°, which enhances spermatogenesis.
   c. Cremaster muscle elevates the testes in response to cold T° & lowers them if T° rises.
   d. Darts muscle adjusts scrotal surface area in response to T°Δ. It contracts in response to a drop in T°. This decreases scrotal surface area and reduces heat loss. It relaxes in response to a rise in T°. This increases scrotal surface area and increases heat loss.
   e. 2 tunics surround each testis. Tunica vaginalis is the membranous outer layer derived from the parietal peritoneum. Tunica albuginea is the fibrous capsule directly apposed to the testis. The tunica albuginea extends inward to divide the testis into 250 lobules.
   f. Each lobule contains 1-4 coiled seminiferous tubules (the sites of spermatogenesis).
   g. Newly made sperm travel from the seminiferous tubules to a tubulus rectus to the rete testis and then on to an epididymis, which is the site of sperm maturation.
   h. W/i the CT btwn the seminiferous tubules are interstitial cells (a.k.a. Leydig cells) which secrete androgens (primarily testosterone) into the local interstitial fluid as well as the blood.
   i. Testicular arteries provide O₂-rich blood to the testes. As they approach the testes, each is surrounded by a pampiniform venous plexus, a network of veins that drain the testis and converge to form the testicular vein. This arrangement allows venous blood to absorb heat from arterial blood and helps to maintain the low scrotal temperature.
   j. The nerves, vessels (blood and lymphatic) and vas deferens associated with each testis are wrapped in a CT sheath known as the spermatic cord. Each spermatic cord penetrates the abdominal wall at an inguinal canal.

III. Penis
   a. Penis and the scrotum comprise the external genitalia.
   b. The penis functions to deliver sperm into the female reproductive tract.
   c. It consists of an attached root and a free shaft, which ends in an enlarged tip (glans penis). The loose cuff of skin around the glans is the prepuce/foreskin, and can be removed via circumcision.
   d. Internally, the penis contains a portion of the urethra (penile or spongy urethra) as well as 3 cylindrical erectile bodies. An erectile body is a network of connective tissue riddled with vascular sinuses and smooth muscle.
   e. A mid-ventral erectile body surrounds the penile urethra and is the corpus spongiosum. Distally, it expands forming the glans penis. Proximally the corpus spongiosum forms part of the root of the penis known as the bulb of the penis. It anchors the penis to the urogenital diaphragm.
   f. The 2 dorsal erectile bodies are the corpora cavernosa. Proximally the corpora cavernosa diverge and anchor the penis to the rami of the pubic arch. These portions of the corpora cavernosa are known as the crura of the penis.

IV. Epididymides
   a. 1st in a series of ducts thru which sperm travel on their way towards the body exterior.
   b. Each sits somewhat behind and above a testis within the scrotum.
   c. Sperm travel from seminiferous tubules to epididymides via tubuli recti and the rete testis.
   d. Sperm remain w/i the epididymis for about 3wks. During this time, they mature and acquire the ability to swim.
   e. During ejaculation, epididymal smooth muscle contracts forcing sperm into the vas deferentia.

V. Vas Deferentia (Ducts Deferentia) and Ejaculatory Ducts
   a. Each runs upward from an epididymis as part of a spermatic cord and then enters the pelvic cavity via an inguinal canal and passes over the bladder.
b. Distally, each widens (this portion is the **ampulla**) and joins the duct of the seminal vesicle to form an **ejaculatory duct**.

c. The 2 ejaculatory ducts pass thru the **prostate gland** and empty into the **prostatic urethra**.

d. During ejaculation, smooth muscle peristalsis propels sperm and testicular fluid thru the ductus deferentia and the ejaculatory ducts.

e. In a vasectomy, the scrotum is opened and each ductus deferens is cut and tied off.

**VI. Urethra**

a. Conveyance for both urine and semen.

b. Divided into 3 regions. The **prostatic urethra** is w/i the prostate gland. The **membranous urethra** is w/i the urogenital diaphragm. The **penile/spongy urethra** is w/i the corpus spongiosum.

c. The urethra is continuous with the lumen of the urinary bladder at the **internal urethral orifice** and opens to the exterior at the **external urethral orifice**.

**VII. Seminal Vesicles**

a. Paired glands on the posterior urinary bladder. They secrete 60% of semen volume.

b. **Seminal fluid** is a viscous alkaline fluid containing: **fructose** (provides energy for sperm), **prostaglandins** (alter the uterine environment to help sperm passage), and a **coagulating enzyme** (turns semen into a bolus that can be propelled during ejaculation).

c. Sperm, testicular fluid & seminal fluid mix within the ejaculatory duct during ejaculation.

**VIII. Prostate gland**

a. Doughnut-shaped, inferior to the urinary bladder and encircling the prostatic urethra.

b. Its secretions account for 30% of semen volume.

c. Multiple ducts from the prostate gland empty into the prostatic urethra.

d. **Prostatic fluid** contains: **citrate** (food source for sperm) and **prostate specific antigen** (liquefies the semen and allows sperm cells to swim freely). Prostatic secretions enter the prostatic urethra during ejaculation.

**IX. Bulbourethral glands**

a. Inferior to the prostate gland, w/i the urogenital diaphragm.

b. They produce thick clear alkaline mucus after erection but prior to ejaculation to neutralize the of acidic urine w/i the urethra and lubricate the glans penis.

**X. Semen**

a. Liquid transport medium for sperm.

b. It protects, activates, and facilitates the movement of sperm.

c. 10% is sperm and testicular fluid. 60% is seminal fluid. 30% is prostatic fluid.

**XI. Erectophysiology**

a. During sexual arousal, parasympathetic nerve signals are sent to the penis.

b. The ↑ parasympathetic nerve activity leads to formation of **nitric oxide**.

c. NO causes dilation of penile arterioles, which lets blood fill the erectile bodies. This compresses the veins draining the penis.

d. The result is more blood into the penis and less blood out – yielding an **erection**. Erection allows the penis to function as a copulatory organ.

e. Erection is a spinal reflex but it can be modified by cerebral input.

**XII. Physiology of Ejaculation**

a. When sexually arousing impulses reach a certain threshold level, a massive increase of penile sympathetic nerve activity occurs.

b. This sympathetic activity results in:
   1. Contraction of reproductive ducts/glands and emptying of their contents into the urethra;
   2. Closing of the internal urethral sphincter to prevent urine expulsion or semen reflux;
   3. Expulsion of semen from the urethra.

c. Ejaculation event is associated w/ generalized muscle contraction, ↑ HR, and ↑ BP.

**XIII. Sperm Production**

a. All body cells, except for sex cells (sperm and ova), are **diploid**. This means that they each have 2 copies of each **chromosome**. Each diploid cell has 23 pairs of chromosomes. One member of each pair came from mom and one came from dad.
b. Sperm and ova are **haploid**. Rather than having 23 pairs of chromosomes, they have only one of each – 23 single chromosomes.

c. When a sperm and egg combine during fertilization, a **zygote** is formed. This single cell is diploid and all other cells of the body derive from it.

d. The process by which the diploid zygote creates other diploid cells and these diploid cells create more diploid cells and so on is known as **mitosis**.

e. During development diploid cells known as **germ cells** are produced. The male germ cells are called **spermatogonia**.

f. The process by which these germ cells divide to become haploid and become sperm is **meiosis**.

g. **Spermatogenesis** is the total process of sperm formation. It consists of 2 phases: meiosis and **spermiogenesis**. It occurs in the seminiferous tubules.

h. Most of the cells that comprise the walls of the seminiferous tubules are in different stages of developing into sperm and are collectively known as **spermatogenic cells**.

i. The cells found in the outermost layer of the tubule are the **spermatogonia**. The spermatogonia divide continuously by mitosis to form 2 types – **type A** and **type B**. Type A spermatogonia stay in the peripheral rim of the seminiferous tubules to maintain the population of germ cells. Type B spermatogonia undergo meiosis and eventually become sperm.

j. Meiosis consists of 2 series of nuclear and cytoplasmic divisions that convert 1 diploid cell into 4 haploid cells. The first set of nuclear and cytoplasmic divisions is known as **meiosis I** and the second set is **meiosis II**.

k. Prior to meiosis I, the B type spermatogonium replicates its entire complement of DNA. It’s now a **primary spermatocyte** and moves slightly closer to the lumen of the tubule.

l. The primary spermatocyte undergoes meiosis I dividing its nucleus and cytoplasm. This yields 2 haploid **secondary spermatocytes**. They’re closer to the lumen than the primary spermatocytes.

m. Each secondary spermatocyte undergoes meiosis II dividing its nucleus and cytoplasm to yield 2 haploid **spermatids**. They’re closer to the lumen then the secondary spermatocytes.

n. At the end of meiosis I and II, one diploid spermatogonium has produced 4 haploid spermatids.

o. Spermatids do not physically resemble mature sperm. The process by which the spherical spermatids acquire the characteristic shape of adult sperm is known as **spermiogenesis**. Following spermiogenesis the 4 spermatids will have turned into 4 adult **spermatozoa**.

p. Both meiosis and spermiogenesis are assisted by another cell type found in the seminiferous tubules – the **sustentacular or Sertoli cells**.

q. Sustentacular cells help move, signal, and feed the developing sperm cells. They will also secrete the **testicular fluid** whose bulk flow will force sperm into the epididymis. Tight junctions between the sustentacular cells form the **blood–testis barrier** which prevents sperm cells from encountering cells of the immune system. Since sperm cells do not form until well after the immune system is established they would be recognized as foreign and destroyed.

### XIV. Sperm Structure

a. The adult sperm consists of 3 primary regions:

b. **Head** – contains the **nucleus** (with 23 chromosomes) and the **acrosome** (contains digestive enzymes that help sperm penetrate the cells surrounding the egg);

c. **Midpiece** – contains **mitochondria** to provide the ATP that power the sperm’s swimming;

d. **Flagellum** – the long tail that is used to propel the sperm.

### XV. Male Sex Hormones

a. Control of spermatogenesis & male sexual characteristics begins in the **hypothalamus**.

b. Post-puberty, the hypothalamus secretes pulses of **gonadotropin-releasing hormone (GnRH)**.

c. GnRH travels in the blood to the **anterior pituitary gland** and causes it to release the 2 **gonadotropins** – **follicle stimulating hormone** and **luteinizing hormone** (a.k.a. **interstitial cell-stimulating hormone**).

d. LH acts on interstitial cells and causes them to release **testosterone**. Testosterone has body wide effects, but some must remain within the seminiferous tubules to help promote spermatogenesis.

e. FSH causes sustentacular cells to secrete **androgen-binding protein**. **ABP** binds and concentrates testosterone within the seminiferous tubules.
f. If testosterone levels rise too high, it inhibits hypothalamic release of GnRH and pituitary release of FSH and LH.

g. If sperm count rises too high, the sustentacular cells will secrete the hormone inhibin, which inhibits anterior pituitary release of FSH and hypothalamic release of GnRH.

h. Testosterone is responsible for masculinization of embryonic genitalia and further development of reproductive structures at puberty. It induces features in nonreproductive organs. Such secondary sex characteristics include: appearance of pubic, axillary, and facial hair, enlargement of the larynx and deepening of the voice, thickening of the skin, development of bone and skeletal muscle mass, and boosting of metabolic rate.