The functions of the male reproductive system include:

- Production of male **gametes** (**sperm**)
- Synthesis of **androgens** (male sex hormones) such as **testosterone**.
- Delivery of sperm into the female reproductive tract.

The **scrotum** is a sac of skin and superficial fascia that hangs outside the abdominopelvic cavity at the root of the penis. The paired **testes** (male **gonads** or **primary sex organs**) are suspended w/i the scrotum, separated by a connective tissue septum. This location provides a temperature 3°C lower than internal body T°, which enhances sperm production. The **cremaster muscle** elevates the testes in response to cold T° and lowers them when T° rises. The **dartos muscle** adjusts the scrotal surface area in response to changes in T°. The dartos contracts in response to a drop in T°. This decreases scrotal surface area and reduces heat loss. The dartos relaxes in response to a rise in T°.

2 tunics surround each testis. The **tunica vaginalis** is the membranous outer layer derived from the parietal peritoneum. The **tunica albuginea** is the fibrous capsule directly surrounding the testis. The tunica albuginea extends inward to divide the testis into 250 **lobules**. Each lobule contains 1-4 coiled **seminiferous tubules**. These are the sites of sperm synthesis. Each seminiferous tubule is surrounded by several layers of **myoid cells** which contract to propel sperm and testicular fluid out of the testis. Newly made sperm travel from the seminiferous tubules to a **tubulus rectus** to the **rete testis** and then on to the **epididymis**, which is the site of sperm maturation. W/i the connective tissue btwn the seminiferous tubules are **interstitial cells** which secrete androgens (primarily testosterone) into the local interstitial fluid as well as the blood.

Testicular arteries provide O_2-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.

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**.

The **penis** and the scrotum comprise the **external genitalia**. The penis functions to deliver sperm into the female reproductive tract. 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 penis is known as the **prepuce**/**foreskin**, and is removed via **circumcision**.

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. A mid-ventral erectile body surrounds the penile urethra and is known as the **corpus spongiosum**. Distally, it expands forming the glans penis. Proximally the corpous spongiosum forms part of the root of the penis known as the **bulb of the penis**. It anchors the penis to the urogenital diaphragm. 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**.

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

The vas deferentia are also known as the **ductus deferentia**. 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. Distally, each widens (this portion is the **ampulla**) and joins the **duct of the seminal vesicle** to form an **ejaculatory duct**. The ejaculatory ducts pass thru the **prostate gland** and empty into the prostatic urethra. During ejaculation, smooth muscle peristalsis propels sperm and testicular fluid thru the ductus deferentia and the ejaculatory ducts. In a **vasectomy**, the scrotum is surgically opened and each ductus deferens is cut and tied off.

The **urethra** serves as a conveyance for both urine and semen. It's divided into 3 regions. The **prostatic urethra** is w/i the prostate gland. The **membranous urethra** is w/i the **urogenital diaphragm**. The **penile** or **spongy urethra** is w/i the corpus spongiosum. 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**.

The seminal vesicles are large paired glands on the posterior bladder. Their secretions account for 60% of semen volume. **Seminal fluid** is a viscous alkaline fluid containing: **fructose** (to provide energy for sperm), **prostaglandins** (which alter the uterine environment to help sperm passage), and a **coagulating enzyme** (which turns semen into a bolus that can be propelled during ejaculation). Sperm, testicular fluid and seminal fluid mix within the ejaculatory duct during ejaculation.

The prostate gland is a doughnut-shaped gland inferior to the urinary bladder and completely encircling the prostatic urethra. Its secretions account for 30% of semen volume. Multiple ducts from the prostate gland empty into the prostatic urethra. **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.

The **bulbourethral glands** are found inferior to the prostate gland, w/i the urogenital diaphragm. 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.

Semen is the liquid transport medium for sperm. It protects, activates, and facilitates the movement of sperm. 10% is sperm and testicular fluid. 60% is seminal fluid. 30% is prostatic fluid.

During sexual arousal, parasympathetic nerve signals are sent to the penis. The ↑ parasympathetic nerve activity leads to formation of **nitric oxide**. NO causes dilation of penile arterioles, which lets blood fill the erectile bodies. This compresses the veins draining the penis. 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. Erection is a spinal reflex but it can be modified by cerebral input.

When sexually arousing impulses reach a certain threshold level, a massive increase of penile sympathetic nerve activity occurs. This sympathetic activity results in: (1) Contraction of reproductive ducts and glands and the emptying of their contents into the urethra; (2) Closing of the internal urethral sphincter to prevent urine expulsion or semen reflux; and (3) Expulsion of semen from the urethra. The entire ejaculatory event is associated w/ generalized muscle contraction, increased HR, and increased BP.

All body cells, except for sex cells (sperm and eggs), are **diploid**. This means that they each have 2 copies of each **chromosome**. Each diploid body cell has 23 pairs of chromosomes. One member of each pair came from mom and one member came from dad. Sperm and eggs are **haploid**. Rather than having 23 pairs of chromosomes, they have only one of each – 23 single chromosomes. 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. 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**. During the developmental process, eventually, diploid cells known as **germ cells** are produced. The process by which these diploid germ cells divide to become haploid and start to become sperm (and eggs) is known as **meiosis**.

Spermatogenesis is the total process of sperm formation. It consists of 2 phases: meiosis and **spermiogenesis**. It occurs in the seminiferous tubules. 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**. The cells found in the outermost layer of the tubule are diploid germ cells known as **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. 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**. Prior to meiosis I, the B type spermatogonium replicates its entire complement of DNA. It is now known as a **primary spermatocyte** and moves slightly closer to the lumen of the tubule. The primary spermatocyte then undergoes meiosis I dividing its nucleus and cytoplasm. This results in 2 haploid **secondary spermatocytes**. They are found slightly closer to the lumen than the primary spermatocytes. Each secondary spermatocyte then undergoes meiosis II dividing its nucleus and cytoplasm to become 2 haploid **spermatids**. The spermatids are slightly closer to the lumen then the secondary spermatocytes. At the completion of both stages of meiosis, one diploid spermatogonium has produced 4

haploid spermatids. 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**.

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

The adult sperm consists of 3 primary regions: **Head** – contains the **nucleus** (with 23 chromosomes) and the **acrosome** (contains digestive enzymes that help sperm penetrate the cells surrounding the egg); **Midpiece** – contains multiple **mitochondria** to provide the ATP that powers the sperm's swimming; and the **Flagellum** – the long tail that is used to propel the sperm.

Control of spermatogenesis and male sexual behavior and characteristics begins in the **hypothalamus**.

1. The hypothalamus continuously secretes pulses of **gonadotropin-releasing hormone** (**GnRH**).
2. 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**).
3. 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.
4. FSH causes sustentacular cells to secrete **androgen-binding protein**. **ABP** binds and concentrates testosterone within the seminiferous tubules.

If testosterone levels rise too high, it inhibits hypothalamic release of GnRH and pituitary release of FSH and LH.

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.

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.