

• **IMPORTANT TERMS THAT REFER TO THE REPRODUCTIVE SYSTEM**

asexual reproduction = the creation of offspring by a single parent, without the participation of sperm and egg (fission or budding are examples of asexual reproduction)

sexual reproduction = the creation of offspring by the fusion of two haploid sex cells (gametes), forming a diploid zygote. All vertebrates perform sexual reproduction.

gametes = a sex cell; a haploid sperm or egg. The union of two gametes of opposite sex (fertilization) produces a zygote.

sperm = a male gamete. The sperm of most animals has a head that contains the cell nucleus and a whip-like tail that allows them to swim.

ovum (egg) = a female gamete. The ovum is often the largest cell in the body of most organisms.

zygote = a fertilized egg, which is diploid, that results from the union of a sperm and an egg (ovum).

hermaphroditism = a condition in which an individual has both female and male gonads and functions as both a male and female in sexual reproduction by producing both sperm and eggs (very, very rare).

• MALE REPRODUCTIVE ANATOMY

- The primary goal of the male reproductive system is the continual production of millions of **spermatozoa** from the time of puberty to death. A man must produce **20 - 50 million sperm per milliliter (cc) of ejaculate in order to be fertile**. The average ejaculate volume is about 2-3 cc, so about 150 to 200 million sperm are deposited in the vagina during intercourse.

- **The sperm is the male gamete (or sex cell)**. So, the **testis is the primary sex organ** in the male because the testis performs **gametogenesis (the formation of the gametes)**. In the human male, sperm are produced continually after puberty through a process known as **spermatogenesis**. The entire process of spermatogenesis takes about 72 days in humans and normally occurs continually and uninterrupted from puberty until death. **Spermatogenesis** involves the production of a number of different sperm cell types: **spermatogonia (least mature), primary spermatocytes, secondary spermatocytes and spermatids (most mature)**.

- **The male reproductive system is well designed for the following functions:**

1. the production of sperm (**spermatogenesis**). **Spermatogenesis** refers to gametogenesis in the male. This is the **GAMETOGENIC FUNCTION** of the testes. Sperm are small cells consisting of a **head** (contains the cell nucleus = genes; DNA), **midpiece** (contains mitochondria for energy production) and **flagella** (tail)
2. the transportation of sperm from the testes through a series of ducts to be stored until ejaculation.
3. ejaculation of the sperm into the female reproductive system.
3. the production of steroid hormones (**androgens such as testosterone**) that are required for the development and maintenance of the male secondary sexual organs and secondary sexual characteristics. This is the **ENDOCRINE FUNCTION** of the testes.

- Some of the male reproductive organs lie within the pelvic cavity (e.g. the seminal vesicles, prostate). However, in order to function normally, the testes must lie within a muscular sac known as the **scrotum**. The scrotum is made of smooth muscle, connective tissue and skin and it is an active **thermoregulatory organ**. The scrotal muscles (**cremaster muscle**) can contract to bring the testes closer to the abdomen and thus warm the testes or the scrotal muscles can relax and drop the testes away from the abdomen to cool them. **The testes must reside at a temperature a few degrees below abdominal temperature in order for normal spermatogenesis to proceed**. That is, if the testes become too warm, there is a decrease in sperm production.

- **Originally, the testes are formed from tissue near the kidneys in the abdominal cavity during gestation**. The testes start to form during the 7th week of gestation. Testosterone production causes the testes to descend. Normally, during the third trimester of gestation, the testes descend from their starting position in the abdomen to the scrotum. The **gubernaculum** (a fibromuscular band) shortens at about 7 months causing the testes and the spermatic cord to migrate. When the testes descend they pick up some fibers of the external oblique muscle to become the **cremaster muscle** (to regulate testes temperature).

The spermatic cord is comprised of: the cremaster muscle, the vas deferens, the testicular artery, the testicular veins, autonomic nerves, lymphatic vessels and the tunica vaginalis (portion of the peritoneum).

- A failure of the testes to descend into the scrotum before birth is called **cryptorchidism**. Cryptorchidism occurs in about 1% of newborn males. Usually cryptorchidism is caused by an anatomical blockage that prevents the testes from migrating through the **inguinal canal**. The inguinal canal is the passageway between the abdomen and the scrotum. Sometimes cryptorchidism is caused by an insufficient testosterone secretion during gestation. Surgery soon after birth or testosterone administration at puberty can usually correct cryptorchidism.
- Normally, once the testes have descended into the scrotum, the inguinal canal is sealed up so that there is no longer an opening between the abdominal cavity and the scrotum in the adult human male. In other animals (e.g. rats), the inguinal canal remains open so that the male can retract their testes back into the abdomen as a defense mechanism. Unfortunately, human males cannot do this!

• **THE MALE REPRODUCTIVE ORGANS**

Testis = the male gonad = has two functions:

1. **Spermatogenesis**, the maturation and production of sperm.
2. **Endocrine function = steroidogenesis** (makes steroids). The testis makes the male sex steroids that are called androgens. Testosterone is the most potent and most important androgen that is made by the testes.

Seminiferous Tubules = the hollow, fluid filled, small tubes within the testes which produce sperm. There are several meters of seminiferous tubules packed into each testis. *There are no blood vessels or nerves in the seminiferous tubules.* The sperm mature in their own special environment protected from harmful substances in the blood by the **blood-testis barrier**. That is, only certain small substances in the blood can gain access to the seminiferous tubules.

Interstitial Tissue = the tissue that lies between the seminiferous tubules in the testes. The interstitial tissue contains the nerves and blood vessels that supply the testes as well as the lymphatic vessels which help protect the testes from foreign invaders. Additionally, there are special cells called **Leydig cells** within the interstitial tissue which produce the androgen, **testosterone**.

Rete Testis = the collecting area inside the testis which receives sperm that were produced in the seminiferous tubules.

Vasa Efferentia (Efferent Ducts) = these are small ducts that carry sperm from the rete testis to the epididymis. As the sperm travel through the vasa efferentia, much of the fluid in which they are carried is reabsorbed by the vasa efferentia so that the sperm are concentrated as they enter the epididymis.

Epididymis = the epididymis receives the sperm from the vasa efferentia. *It takes about two weeks for the sperm to travel through the twisted epididymis during which time they undergo further maturation and gain the ability to swim (the sperm become motile).* Sperm are stored in the tail of the epididymis previous to ejaculation.

Vas Deferens = a tube which is surrounded with smooth muscle that pumps the sperm from the tail of the epididymis to the urethra. There are two vas deferens that carry sperm, one from each of the right and left testes. The vas deferens are the tubes which are cut and tied off during a **vasectomy**.

Urethra = the tube which runs through the penis that carries both urine from the urinary bladder and semen from the reproductive ducts.

Seminal Vesicles = are two glands which supply fructose (an energy source for the swimming sperm) and other substances that make up about half of the volume of the semen.

Prostate = a gland which surrounds the urethra. The prostate secretes an alkaline fluid that neutralizes the acidic vaginal secretions as well as other substances that encourage sperm survival in the female reproductive tract. Unfortunately, the prostate grows in response to testosterone stimulation. During old age, many men experience **Benign Prostatic Hyperplasia (BPH)**. BPH refers to the non-cancerous overgrowth of the prostate that can lead to many side effects including a difficult or frequent need to urinate or incontinence as the prostate squeezes down on the urethra. BPH can usually be effectively treated with drugs (Proscar) or surgery, although some surgical techniques can cause impotence in some of these men.

Penis = an organ that contains spongy erectile tissue that can fill with blood. Arterioles in the penis vasodilate while the veins become compressed to cause an erection. The penis delivers the semen into the vagina of the female during intercourse.

- **Specifics about the Penis**

Parts of the penis

glans penis = head of the penis

penile shaft = body of the penis

corona glandis = rounded ridge at back end of the glans penis

penile prepuce (foreskin) = not present in circumcised men; small glands under the foreskin secrete oil which when mixed with skin cells produces **smegma**
Retraction of the foreskin to remove smegma with soap and water is important to prevent bacterial infection.

Penile shaft contains three cylindrical spongy tissue masses, two of which are the **corpus cavernosa** on the top of the shaft and the **corpus spongiosum** on the bottom of the shaft (through which the urethra runs).

- Length of non-erect (flaccid) penis is usually between 8.5 to 10.5 cm (3.3 to 4.1 inches) with an average of 9.5 cm (3.7 inches)
- The average length of an erect penis is 16 cm (6.3 inches) with a range of 12 cm to 23.5 cm (4.7 to 9.2 inches).
- Average circumference of an erect penis at its thickest point is 13.2 cm (5.2 inches)
- There is no correlation between skeletal system make-up and penis size. A smaller non-erect penis will enlarge more during erection than a larger non-erect penis.

Scrotum = an active thermoregulatory organ that contains smooth muscle, connective tissue and skin. The testes normally reside in the scrotum. Within the scrotum are the **visceral and parietal layers of the tunica vaginalis** (the peritoneum that lubricates and lines the spermatic cord and testes).

Bulbourethral (or Cowper's) Gland = a gland beneath the prostate that lubricates and "washes out" the urethra previous to ejaculation. Previous to ejaculation, the Cowper's gland secretes an alkaline fluid (which may or may not contain sperm from a previous ejaculation) that clears the urethra of any urine.

- **COMPOSITION OF SEMEN**

- about 1% of semen by volume is sperm
- about 99% of semen by volume is secretions containing fructose and alkaline substances produced by the prostate gland and seminal vesicles.
- There are two basic tissue compartments within the testes:

1. THE SEMINIFEROUS TUBULES

- There are no blood vessels or nerves in the seminiferous tubules. The seminiferous tubules contain the developing sperm cell types (**spermatogonia, spermatocytes, spermatids**) and the **Sertoli cells**. The Sertoli cells are found interspersed between the developing sperm cells. As spermatids mature into sperm, they are carried through the seminiferous tubules to the rete testis by a fluid that is produced by the Sertoli cells. The Sertoli cells provide the developing sperm cells with the nutrients and hormones that they need in order to mature into spermatozoa.

2. THE INTERSTITIAL TISSUE

- The interstitial tissue in the testes contains all the blood vessels, nerves and lymphatics that supply the testes. A special cell type in the interstitial tissue called a **Leydig cell** is responsible for producing **testosterone**.

While both men and women produce both testosterone and estrogen, men produce more testosterone and women produce more estrogen.

- Testosterone has the following effects in males:

1. maintenance and development of the secondary (accessory) sexual organs (e.g. the penis, scrotum, seminal vesicles, bulbourethral gland, prostate, vas deferens, epididymis)
 2. maintenance and development of the secondary sexual characteristics (e.g. hair growth on the face and chest, skeletal muscle growth, deeper voice, etc)
 3. travels to the seminiferous tubules to help stimulate spermatogenesis
1. inhibits the release of LH from the anterior pituitary (adenohypophysis)
 2. responsible for libido (sex drive)

- Estrogen has the following effects in males: (from Sertoli cells)

1. regulates functions of Leydig cells
2. may have central nervous system effects at specific sites in brain (eg. hypothalamus)
3. may be important for spermatogenesis

MALE INFERTILITY

- A male is considered sub or infertile if he produces fewer than 50 million sperm per milliliter of ejaculate. The first test performed to determine whether a male is infertile is to do a **sperm count** (count the number of sperm per cc in the ejaculate).

Male infertility is usually caused by one of two basic reasons:

1. ANATOMICAL OBSTRUCTION IN THE DUCTS THAT CARRY SPERM OUT OF THE TESTES.

This can be congenital or caused by trauma to the male reproductive tract and can sometimes be corrected surgically.

2. A DEFICIENCY IN THE PRODUCTION OF SPERM BY THE TESTES.

This can also be congenital or caused by exposure to environmental toxins or radiation and is usually not treatable.

- **STERILIZATION OF THE HUMAN MALE = VASECTOMY** = the cutting (ligating) and stapling or tying off of the vas deferens to prevent the sperm from becoming a component of the semen.