INTRODUCTION:

The function of the human reproductive system is somewhat unique. Rather than sustaining the individual, its primary function is to perpetuate the species and it is the only system in which the two sexes have completely different organs. The ovaries and testicles (collectively called the *gonads*) are the only organs in which cell division by *meiosis* occurs to produce oocytes and sperm (collectively called *gametes*) with only half the full number of chromosomes found in other cells. They have 23 chromosomes, termed *haploid* by geneticists, while all of the other cells in your body contain 46 chromosomes, referred to as *diploid* cells. When the two haploid gametes (one egg and one sperm) fuse, the resulting *zygote* is again diploid with 46 chromosomes arranged as 23 pairs.

Producing those gametes, of course, is only part of the function of the reproductive system. The sperm must be transported to where they can be ejaculated into the reproductive system of the female; they must reach the proper location to fertilize the oocyte; the resulting zygote must reach the uterus and implant itself there; pregnancy must be maintained for nine months; and childbirth must successfully occur.

Embryologically, the human reproductive system is one of the last systems to begin formation, and hence one of the last to become mature. In fact, it is the only human system that does not mature and reach full function until ten or more years after birth. In both sexes, it develops as three parts:

a) The testicles (testes) or ovaries, collectively called gonads;

b) A series of ducts or tubes; and

c) The external genitalia.

The *male* reproductive system is probably the more simple of the two. Sperm are produced in the testicles, mature and are temporarily stored in the epididymis, then are transported through the vas deferens and urethra via contractions of smooth muscle to be deposited in the vagina of the female reproductive tract during sexual intercourse. Specialized cells in the testes also produce testosterone. Seminal vesicles and the prostate gland secrete the fluids which together with the sperm will form the semen. The penis contains erectile bodies that harden when they fill with blood, allowing the semen to be deposited deeply within the vagina of the female during intercourse. Millions of sperm are produced every day under the stimulus of follicle stimulating hormone from the anterior pituitary gland, and if ejaculation does not occur they are reabsorbed by the epididymis or simply lost into the urine.

The *female* reproductive system is functionally more complex. The ovaries produce oocytes (eggs) and secrete estrogen and progesterone which stimulate changes in the uterus and other organs in preparation for fertilization and pregnancy. At ovulation, one (or occasionally two) oocytes are released from the surface of the ovary and transported into the uterine tubes (also called oviducts or Fallopian tubes). During sexual intercourse, sperm which are deposited in the vagina are transported through the uterus and uterine tubes to where one of them can fertilize the oocyte. The resulting zygote and early embryo is then transported by the uterine tube to the uterus, where it implants for continued development. The placenta develops to nourish and support the growing fetus before being expelled during childbirth.
Unlike that of the male, the female reproductive system has a distinct cyclical pattern to its function. Under the stimulation of follicle stimulating hormone from the anterior pituitary gland, only one or two oocytes are produced each month within follicles of the ovaries, which also produce estrogen. Luteinizing hormone from the anterior pituitary gland helps trigger ovulation of mature oocytes, after which some of the remaining follicle cells develop into a separate endocrine tissue called the corpus luteum (meaning “yellow body” in Latin), that secrete progesterone as well as some estrogen. If fertilization and subsequent pregnancy do not occur, the corpus luteum stops its secretion of progesterone and the inner lining of the uterus, where the embryo would have implanted, is sloughed off during menstruation.

Another significant difference between the male and female reproductive systems is a rather abrupt cessation of reproductive function which occurs in woman at menopause as the pituitary stops secreting its stimulatory hormones. The reproductive systems of men, in contrast, continue to function throughout life.

Before you begin this exercise, be sure you have a moderately good understanding of how the male and female reproductive systems work: formation and transport of sperm and oocytes, sexual arousal and intercourse, ejaculation, the menstrual cycle, pregnancy, and childbirth.

LEARNING OBJECTIVES:
At the end of this exercise, students should be able to:
- Identify the organs of the human reproductive system, both male and female
- Describe the functions of these reproductive organs
- Describe the histology of the testis, epididymis, penis, ovary, and uterine tube
- Correlate the physiological phases of the ovary with those of the uterus
- Describe the pathway of sperm from their production in the testicles until they may fertilize an oocyte, and the pathway that the resulting embryo will follow to the uterus
- Identify the organs of the reproductive system on living humans

GROSS ANATOMY OF THE MALE REPRODUCTIVE SYSTEM

Exercise 1: Using Figures 27.7, 27.10, and 27.11 in your Saladin text, we will identify organs of the male reproductive system on the isolated models (not the full torso models) of male reproductive organs in a sequence that follows the pathway of sperm. Remember: “right” and “left” refer to the person (or parts of a person) being examined, never the observer’s right or left.

Identify the testis or testicle in the skin-covered sac called the scrotum. A part of the scrotum is shown on each half of the model, and a part of the medial partition between the testes is shown on the right side. The testis on the left side of the model is shown with its surrounding membranes removed, exposing the tunica albuginea that surrounds it.

The epididymis can be seen superior and medial to the testis on the left side. It is held tightly against the testis by a complicated set of membranes that surround both organs. The pink vas deferens can be seen attached to the inferior, medial tail of the epididymis.
Questions for discussion:

What artery supplies blood to the testicle on each side?

The testicles develop within the abdomen of the fetus, then descend into the scrotum. When does this occur?

What changes occur in sperm as they pass through the epididymis? What would happen if the epididymis could no longer carry out this function?

Next, find the spermatic cord on this model. It is a complicated structure that contains the vas deferens, a network of veins and arteries, a nerve, and some other structures. The spermatic cord continues upward and passes through the inguinal canal, a reinforced opening through the lower abdominal wall. On the right side, parts of the abdominal wall are removed so that the passage of the spermatic cord through the inguinal canal can be followed.

The sperm-transporting structure within the spermatic cord is the vas deferens, also known as the ductus deferens. Trace this muscular tube from its origin on the epididymis, through the spermatic cord, through the inguinal canal and into the abdominal cavity. From the inguinal canal, trace it across the superior surface of the bladder, over the ureter (another pink tube) and down the posterior surface of the bladder to where it joins with the seminal vesicle.

Now split the model in half and remove the left side of the bladder and attached structures. The seminal vesicles can again be located on the posterior surface of the bladder. Each seminal vesicle is a multi-lobed gland whose duct joins with the vas deferens. Inferior to the seminal vesicle and bladder, find the prostate gland. Note that the urethra passes through it. The tiny ejaculatory duct does not show up well on this model, but may be seen in Fig. 27.10. It originates where the seminal vesicle and vas deferens merge and is contained within the prostate gland. Its termination in the urethra is shown inside the prostate gland.

Questions for discussion:

Which tube is cut during a vasectomy?
Where is this tube most easily isolated to be identified and cut?

What happens to the sperm after a vasectomy, since their movement through this tube is blocked?

Besides this tube, what other structures are found in the human spermatic cord?

What percentage of human semen consists of fluids produced by the prostate and seminal vesicles?
What percentage of it consists of sperm?

What do the fluids produced by the seminal vesicles and prostate contain?

Where are sperm "stored" before ejaculation?
Find the three parts of the urethra on this model.

The **prostatic urethra** runs through the prostate gland.

The **membranous urethra** is a short segment between the prostate gland and the base of the penis.

The **spongy or penile urethra** is the segment of the urethra inside the penis.

Note the position of the base of the penis near the prostate gland. The spongy urethra traverses the entire penis through a column of spongy erectile tissue called the **corpus spongiosum**.

The **penis** originates near the prostate gland. Note that the proximal root of the penis runs through muscles and ligaments, and only the distal, pendulous **shaft** of the penis extends from the surface of the body. The expanded distal end of the penis is called its **glans**, which is covered by the **prepuce** or foreskin (commonly removed in infant males by circumcision). During erection, the erectile bodies fill with blood and cause the shaft of the penis to align with the internal, more proximal root - notice in Figure 27.10 and on the model how this would occur.

Examine the penis in cross section by putting the two detachable pelvic pieces together with the shaft of the penis removed. Three columns of the erectile tissue are visible. The inferior one, containing the urethra, is the **corpus spongiosum** ("spongy body"). The two superior columns are named the **corpora** (that's the pleural of corpus) **cavernosa** ("cavernous bodies"). Follow these into the shaft of the penis, noting how the corpus spongiosum contains the urethra and expands to form the **glans**.

**Exercise 2:** Explain to other members of your lab group where and how sperm are produced within the testis, and the parts of the testis through which they must pass to get to the epididymis. If other members of your lab group are not explaining this correctly, be sure to help them understand. You will only hurt them and yourself if you let them give a poor explanation. Do not give up until every single person in the lab group can do this from memory.

**Exercise 3:** Examine the torso model in which male genitalia can be inserted or removed. With these in place, identify each of the structures described in Exercise 1 above. Note the location of the bladder and reproductive structures near it relative to the intestines and other abdominal organs.

**Exercise 4:** In the space below, trace the pathway of sperm from where it is produced in the testes to where it exits through the glans of the penis during ejaculation. One possible difficulty you might encounter is the role of the seminal vesicle. Sperm never pass through or enter this gland. It merely produces a mucus secretion that contributes to the formation of semen.

**HISTOLOGY OF THE MALE REPRODUCTIVE SYSTEM**

**Exercise 5:** Under low power of the microscope, examine slide #12. This shows a portion of a testis. Identify the **tunica albuginea** and connective tissue **septa** that separate the testis into **lobules** (see Figure 27.9 in Saladin). Notice most of the testis consists of **seminiferous tubules** that have been cut in many different orientations as they coil within each lobule.
Switch to high power and examine the **seminiferous tubules** (Figure 27.9 in your Saladin text). Note the large cells on the outside of each tubule, with smaller cells toward the center. As sperm develop and mature they move from the outside, just deep to the tunica albuginea, to the inside of each tubule. In most of the tubules you should be able to identify the tails of sperm. These sperm are almost ready to be released into the lumen, and you may be able to see some that have already been released.

Identify **interstitial cells** (i.e. Leydig cells) in the spaces between the seminiferous tubules. These are the cells that respond to LH to produce testosterone.

**Questions for discussion:**

*Development of sperm in the seminiferous tubules is stimulated by which hormone from the pituitary gland?*

*Secretion of testosterone by the interstitial cells of the testis is stimulated by which hormone from the pituitary gland?*

**Exercise 6:** Under low power of the microscope, examine slide #29 of the **epididymis**. Note the appearance of many tubules in the center - this is actually a single tube tightly coiled up and thus cut many times on this slide. Superficially, note the dense irregular connective tissue which surrounds the epididymis. This contains many blood vessels, reflecting the large blood supply that this organ has.

Switch to higher power and examine one or two of the sectioned tubules. These are lined by a **pseudostratified columnar epithelium** supported by a looser connective tissue in which many smaller blood vessels are evident. In some regions of the tubules you will note sperm.

**Question for discussion:**

*What is the function of the epididymis?*
Exercise 7: Examine slide #27 of the penis (from a nonhuman primate) under low power. The penis is covered with skin – the epidermis is a cornified/keratinized stratified squamous epithelium while the dermis is formed by a dense irregular connective tissue. In most of the slides, the penis still has its prepuce (foreskin), so another layer of stratified squamous epithelium appears deeper within the organ: be sure you understand how this occurs (Figure 5.1 in your Saladin text describes the sectioned appearance of three-dimensional structures, and Figure 27.11 may help).

Within the section of the penis on this slide, identify two erectile bodies: the larger one that occupies approximately half of the penis is the corpus cavernosum. The smaller, less distinct one is the corpus spongiosum containing the urethra, which appears as a collapsed tube lined by epithelium. Note that this structure is different from the human penis which contains two corpora cavernosa (that's plural of "corpus cavernosum") rather than the single structure shown here, but if you divided the single corpus cavernosum on this slide into two side-by-side erectile bodies you would have the appearance of the human penis. Note the many small blood vessels (arterioles and venules) that surround the erectile bodies. These, as you would expect, are involved in the flow of blood into and out of the erectile bodies during erection.

Under high power, examine the epithelium of the urethra. This is a columnar epithelium, but its exact structure is not clear on the slide. In fact, the penis is one of the few places in the body where a stratified columnar epithelium is found. (Review Chapter 5 in your Saladin text if you do not understand what this type of epithelium should look like). Also examine the corpus cavernosum under high power and note the large number of arterioles.

Questions for discussion:

What causes the erectile bodies of the penis to fill with blood during erection?

Why does the erect penis assume the angle it does (pointing somewhat superiorly)?

GROSS ANATOMY OF THE FEMALE REPRODUCTIVE SYSTEM

Exercise 8: Use the independent plastic model of the female pelvis (not the torso model) for this section. Figures 28.1, 28.3, and 28.8 in your Saladin text will serve as references. On the midsagittal view of one-half of the model, locate the rectum, anus, urinary bladder, urethra and urethral opening and note their positions relative to the uterus, vagina and vaginal opening.

Identify the ovaries on each side of this model. Two tubular structures connect the ovary to the uterus. The inferior one is a ligament that helps support the ovary. The pink/red one, with the expanded end near the ovary, is the uterine tube, also called the oviduct or Fallopian tube. The expanded, funnel-like end of the uterine tube, which partly surrounds the
ovary, is called its **infundibulum**. Finger-like **fimbriae** can be seen attached to the edge of the infundibulum. Proximal to this (nearer the uterus) is the **ampulla**, then the narrower **isthmus** of the oviduct that penetrates the wall of the uterus.

On Figure 28.3 of your Saladin text, identify the **infundibulum, fimbriae, ampulla**, and **isthmus** of the uterine tube.

On the model, examine the **uterus** which consists of three parts. The **fundus** of the uterus is superior to the entry point of the uterine tubes. The middle, and largest region of the uterus is the **body**. The third, most inferior part of the uterus is the narrow **cervix** which projects inferiorly into the vagina. The recessed grooves between the cervix and vaginal wall (like a moat around a castle) are called **fornices** (singular = fornix). Find the position of the **anterior fornix** and the **posterior fornix**.

Internally, note that the uterus shows two different textures and colors. The thinner striated zone on the inside represents the **endometrium**. External to this is a thicker, lighter red layer called the **myometrium**. The smooth, pink outermost layer is its **serosa**.

Most of the time, the uterus lies in the position shown on this model - tipped anteriorly to rest on the superior surface of the urinary bladder. It assumes a more upright position during orgasm and during pregnancy. Between the uterus and bladder is a peritoneum-lined **vesicouterine pouch** (not open on the model.) Between the uterus and rectum, find the **rectouterine pouch**. These two pouches are of medical significance because they are "low points" for the drainage of abdominal cavity infections. Note that the rectouterine pouch can be easily drained through the vagina by means of an incision in the posterior fornix.

Reassemble the model, placing the inner piece inside the rest of the pelvis so you can examine the external genitalia. Note both the **urethra** and **vagina** open into a narrow space called the **vestibule**, while the anus opens much more posteriorly. Lateral to the vestibule are two folds of skin on each side. The inner, smaller folds are named the **labia minora** ("small lips"). Lateral to them are thicker folds called the **labia majora** ("large lips").

At the anterior part of the vestibule between the two labia minora, identify the **clitoris**. This develops from the same embryonic structure in the female as the penis in the male, and it also consists of erectile tissue that fills with blood during sexual excitement. Near the opening of the vagina, a small, horizontal fold of mucous membrane represents the **hymen**. The vestibule, labia majora and minora, urethral and vaginal orifices, hymen, and clitoris are collectively called the **vulva** or the **pudenda**.

**Exercise 9:** Place the female genitalia into the appropriate torso model. Identify the structures described in Exercise 8 above. Note the location of the bladder, uterus, ovaries, and oviducts relative to the intestines (including the rectum) and other abdominal organs.
**Exercise 10:** Examine the model representing half of an ovary with different stages of development of the follicles. At the middle bottom is a mature or vesicular follicle that is in the process of ovulation: rupturing to release its egg, or oocyte (sometimes, although not quite correctly, called the ovum). To the left of the mature follicle is a large, yellow, scalloped structure, a corpus luteum ("yellow body"). It formed from a previously ovulated mature follicle. Between the mature follicle and corpus luteum is one of three corpus albicans ("white body"). These are the remnant scars of previous corpora lutea (that's the plural of "corpus luteum"). To the left of the mature follicle are three medium-sized, immature, secondary follicles that may someday become mature follicles. With the aid of Figure 28.2 in your Saladin text, be sure you can identify these structures.

**Exercise 11:** Examine the figure shown here (this is similar to figure Figure 28.14 in your Saladin text) which correlates the phases of the ovarian cycle and the phases of the menstrual cycle. Identify what is happening in the ovary during its follicular phase, ovulation, and luteal phase. Identify what is happening to the endometrium of the uterus during its menstrual phase, proliferative phase, and secretory phase.

**Questions for discussion:**

The early stages of follicle development, before ovulation, occur under the stimulation of which hormone from the anterior pituitary gland?

During which part of the menstrual cycle is this occurring?

The conversion of a follicle to a corpus luteum, after ovulation, occurs under the stimulation of which hormone from the anterior pituitary gland?

During which part of the menstrual cycle is this occurring?

If the oocyte is fertilized by sperm, where (which part of which organ) in the female reproductive system will this occur?

During which part of the menstrual cycle is this most likely to occur?
Exercise 12: Explain to other members of your lab group the pathway that sperm will follow from the vagina to where fertilization will occur, the pathway that the resulting embryo will follow to the uterus, and how it will embed itself within the endometrium. Be sure to help other members of your lab group understand this if necessary - you only hurt them and yourself by accepting a poor explanation. Do not give up until every single person in the lab group can do this from memory.

HISTOLOGY OF THE FEMALE REPRODUCTIVE SYSTEM

Exercise 13: Examine slide #40 of the ovary under low power. This slide is not from a human - it is from an animal that gives birth to many young at a time since it shows many follicles developing simultaneously. Identify its cortex, medulla, and tunica albuginea. Identify follicles in different stages of development, including large fluid-filled mature follicles. Identify a corpus luteum, in which cells have filled in the central region of the follicle.

Exercise 14: Examine slide #19 of the uterine tube (also called the oviduct or Fallopian tube) under low power. Note this is a tube with very a very thick muscularis, within which many blood vessels are easily identified. Notice how the mucosa is thrown into very long folds extending far into the lumen.

Under high power, examine the mucosa of the uterine tube. The epithelium varies from simple squamous to simple columnar in form, with the latter representing more active regions of the organ. You may or may not be able to identify brush-like projections extending from the apical surface of the columnar cells - these are the cilia which help propel sperm toward the oocyte and later help propel the oocyte or developing embryo toward the uterus (see Figure 28.4 in your Saladin text). Identify the connective tissue lamina propria within the folds.

Exercise 15: Explain to the other members of your lab group the sequence of development from a primordial follicle in the ovary, through ovulation and the formation of a corpus luteum, to the corpus albicans. Include hormones from the pituitary gland that stimulate this process and hormones that are produced by the follicle and corpus luteum, including the functions of the latter. Be sure to help other members of your lab group understand this if necessary. Don’t give up until every single person in the lab group can do this from memory.

Exercise 16: Explain to the other members of your lab group the changes which occur in the endometrium of the uterus in one menstrual cycle, including what hormones (or lack thereof) are causing these changes and where the hormones are being produced. Don’t give up until everyone can do this from memory.
Exercise 17: This exercise will require you to take off most of your clothing, so you should obviously do this exercise at home.

On yourself or another person, identify the location of the bladder, urethra, ovaries, oviducts, uterus, vagina, testes, spermatic cord, seminal vesicles, and prostate. Obviously, you (or the person you are examining) will not have all of these organs, but you may be able to note their location on another person of the other sex. Use a pen (preferably water soluble) to draw these structures on the skin.

If you are female (or if you have a willing female partner) identify your labia majora, labia minora, vestibule, clitoris, urethral orifice, and vaginal orifice – you may need to use a mirror to do this on yourself. Notice that pubic hair grows on the lateral surfaces of the labia majora but not on their medial surface or on the labia minora. Use a finger to feel the transition from the keratinized (dry) form of stratified squamous epithelium on the skin to the nonkeratinized (wet) form as you enter the vagina.

If you are male (or if you have a willing male partner) identify the scrotum, noticing that it is thin with little connective tissue deep to the skin. Feel the testes and epididymis on both sides. Identify the location of the inguinal canal, which runs inside the inguinal ligament. Identify the shaft of the penis and its glans. If you were not circumcised, you will still have a prepuce or foreskin. With the penis erect, identify the corpora cavernosa and corpus spongiosum of the shaft and follow them back to where you can also feel the root of the penis posterior to the scrotum. Identify the external urethral orifice.