Exercise 11: The Reproductive System

Figure 11.1 A human egg cell is fertilized in vitro using intracytoplasmic sperm injection. Image by Dr Elena Kontogianni - https://pixabay.com/en/ivf-fertility-infertility-icsi-1514174/ archive copy at the Wayback Machine (archived on 30 December 2018), CC0, https://commons.wikimedia.org/w/index.php?curid=57396823

Exercise 11 Learning Goals

After completing this lab you should be able to:

- Identify the internal and external organs of the male and female reproduction system on both the human models and the fetal pig dissection and describe their specialized features/structures
- Identify the three regions of the male urethra
- Describe the function of each reproductive system structure
- Describe the process/pathway of sperm, the development, composition and function of semen
- Describe the movement of an egg from the ovary to the external environment
- Describe the phases of the menstrual cycle
- Explain how lactation occurs and identify the structures of the mammary glands

Pre-Laboratory Exercise 11

Pre-Lab Activity 11.1 Introduction to Function

In the table below, describe the functions of the female reproductive system.

Web Resources:
https://cnx.org/contents/FPtK1zmh@15.2:IUrEdFyf@11/18-1-An-Overview-of-Blood
https://www.histology.leeds.ac.uk/tissue_types/index.php

Function	Description
Production	
Reception	
Transportation	
Protection and nourishment	
Delivery	

Pre-Lab Activity 11.2 Describe and Identify the Structures of both Female and Male Reproductive Systems.

Study the anatomical structures in the images and described in the charts below. Each chart provides a list of male and female genitalia with a description of function and physical appearance. Use the chart to answer the questions.

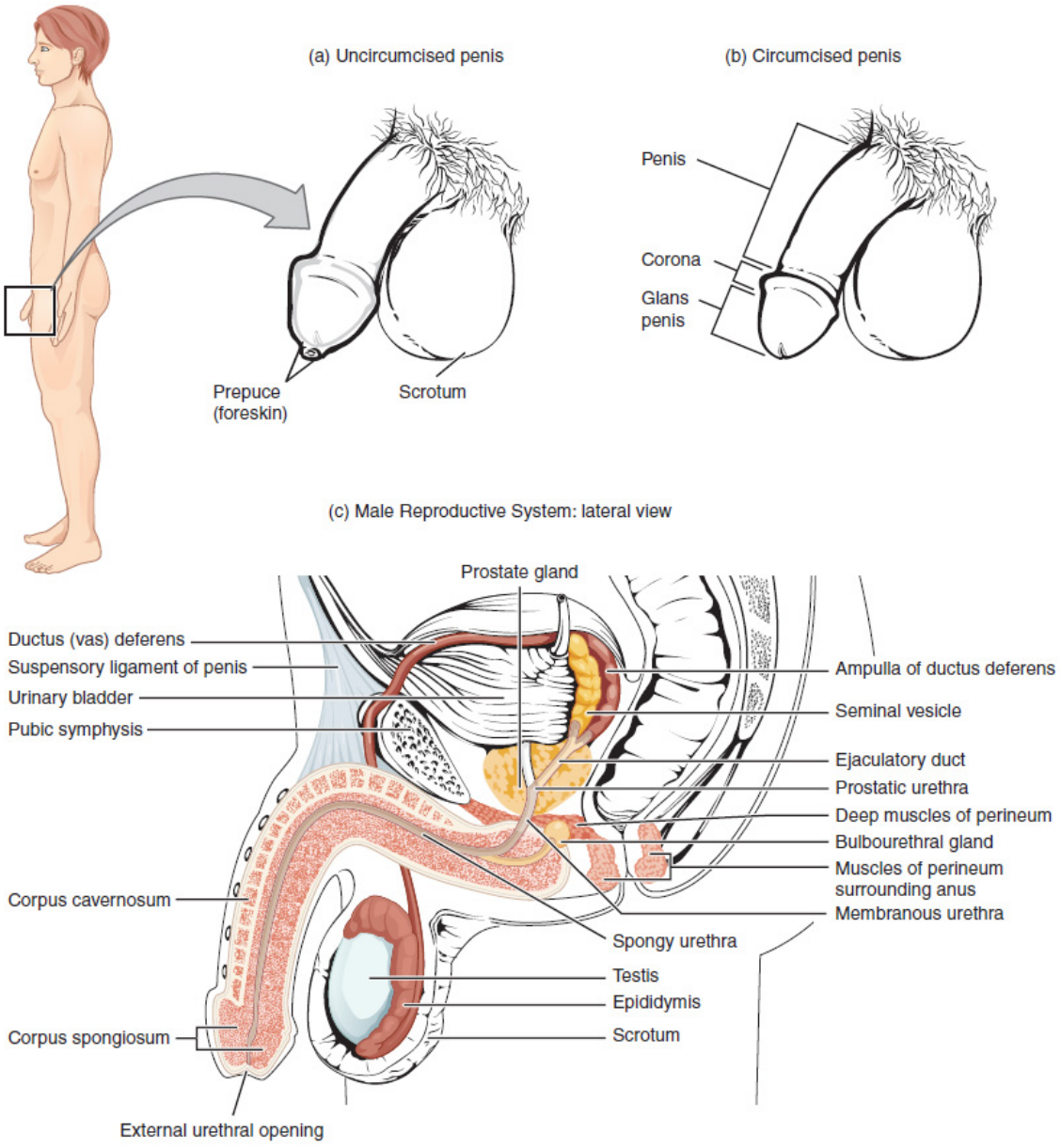

Figure 11.2 Male Reproductive System The structures of the male reproductive system include the testes, the epididymides, the penis, and the ducts and glands that produce and carry semen. Sperm exit the scrotum through the ductus deferens, which is bundled in the spermatic cord. The seminal vesicles and prostate gland add fluids to the sperm to create semen.

Male Genitalia		
Structure		**Description**
Testes		Paired, separated by the **Dartos** muscle; Produces spermatozoa and testosterone (interstitial cells); Lies in the scrotum outside the abdominopelvic cavity where the temperature is slightly lower than inside the body. The lower temperature optimizes the rate of sperm production; Each is covered by a dense connective tissue capsule called the **tunica albuginea** ("white tunic"); contain the seminiferous tubules.
Conducting System		System of tubules made up of epididymis, vas deferens, ejaculatory duct and urethra for the transport of spermatozoa from testes to the pelvic cavity. There they will be combined with the secretions of the accessory glands to form semen.
	Epididymis	An elongated structure on posterolateral surface of testis that caps on the superior side; First portion of duct system; Provides site for maturation of sperm.
	Ductus Deferens	Upon ejaculation, sperm is received here from the epididymis by peristalsis; passes through the inguinal canal into the pelvic cavity and superiorly over the bladder; enclosed with **spermatic cord** (a connective tissue sheath consisting of blood vessels, nerves and the **cremaster muscle** *(*This muscle encases the testes & elevates or lowers them to maintain the temperature needed to create sperm.); end is enlarged (called **ampulla***)*; empties into the ejaculatory duct.
	Ejaculatory Duct	During ejaculation, its contraction pushes sperm through the prostrate and to the **prostatic urethra** where it joins the **seminal vesicle.**
	Urethra	From the **prostatic urethra***,* sperm travels through the **membranous urethra** and then into the **spongy urethra** that runs the length of the penis.
Accessory Glands		Three accessory glands produce seminal fluids that nourish, protect and support the spermatozoa Combined with spermatozoa from the testes, these fluids form the ejaculate or **semen** Each gland contributes a certain percentage to the total volume of semen
	Seminal vesicles	Produces 60% of seminal fluid; lie close to end of ductus deferens; produce an alkaline secretion made of fructose and other fluids that provide ATP for the motion of the sperm tail and promotes fertility; duct merges with duct of ductus deferens to form ejaculatory duct (this allows sperm and seminal fluid to enter urethra together)
	Prostate	20-30% of fluid; circles around urethra and secretes a milky fluid that coagulates semen; This works to help activate the sperm; Because it encircles the urethra, if this structure becomes enlarged due to cancer or other facts, men will have a difficult time urinating
	Bulbourethral glands	Produces approx. 5% of fluid; pea shaped and very small; produce thick, clear alkaline secretion mucus that drains into the membranous urethra; this secretion is to intended to wash any urine out of the urethra when ejaculation of semen occurs as well as act as

		a buffer to the female reproductive tract (which is an acidic environment.); alkalinity neutralizes acidity of the male urethra and female vagina
Penis		The male copulatory organ; External (along with scrotum); Designed to deliver sperm to the female reproductive tract. (The **spongy urethra** transports both urine and semen through the penis); Consists of three main parts: ○ **shaft/body** ○ **glans** (large tip of the shaft) ○ **prepuce/foreskin** (loose skin of the penis which covers the glans and is often removed by a process called circumcision) The **body** consists of 3 cylinders of erectile tissue ○ A pair of **corpora cavernosa** on the dorsal side ○ A single **corpus spongiosum** on the ventral side During sexual arousal, the three cylinders become engorged with blood, causing an erection.

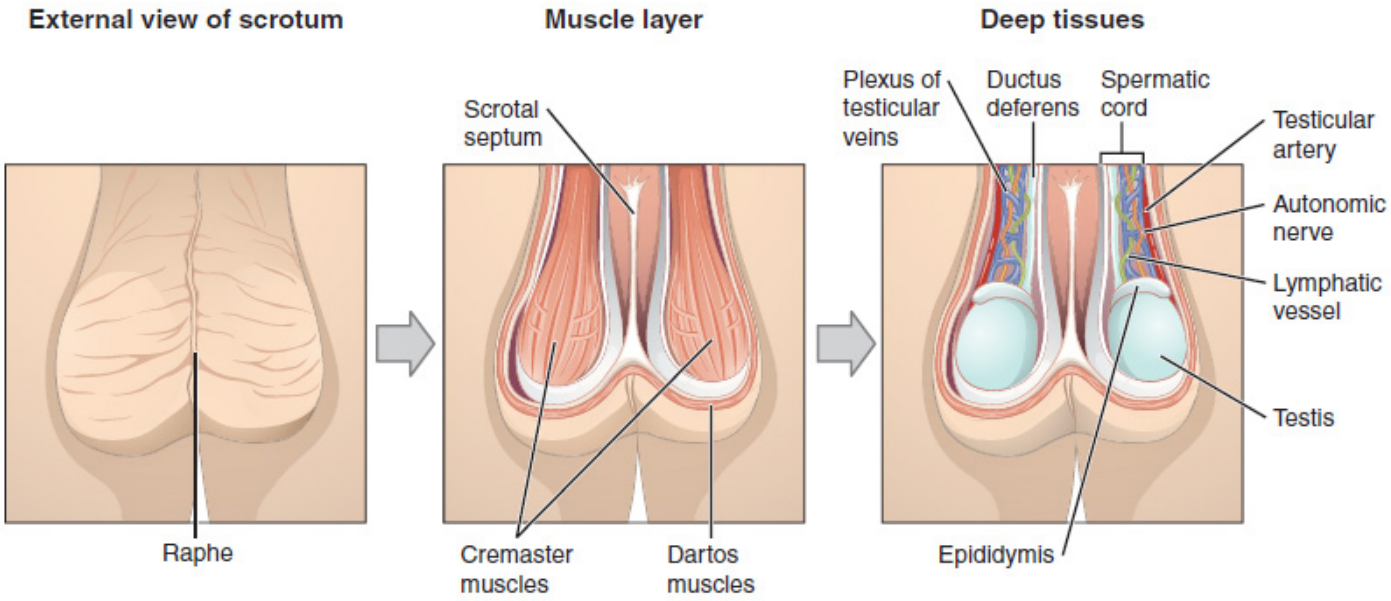

Figure 11.3 The Scrotum and Testes This anterior view shows the structures of the scrotum and testes.

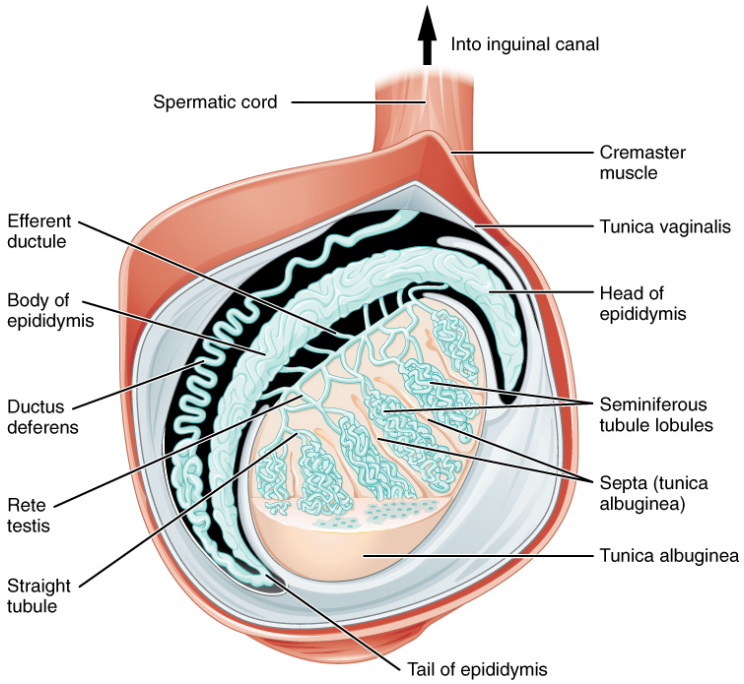

Figure 11.4 Anatomy of the Testis This sagittal view shows the seminiferous tubules, the site of sperm production. Formed sperm are transferred to the epididymis, where they mature. They leave the epididymis during an ejaculation via the ductus deferens.

Pre-Lab Exercise 11.2.1: Answer the following questions.

1. Which structures make up the conducting system component of the male reproductive system?

2. Which structure produces spermatozoa?

3. What is the function of the prostate?

4. Which structural feature of the penis is removed during a circumcision?

5. What is the name of the erectile tissue in the penis? Describe the shape and position of these tissues.

6. List the pathway of semen through the urethra:

7. What are the 3 accessory glands and what is there function?

8. Describe the difference between the Dartos muscle and the Cremaster muscle.

9. Describe the pathway of sperm from where it forms to where it exits the body.

The **female reproductive system** is composed of both internal (uterus, fallopian tubes, ovaries, cervix, and vaginal canal) and external (vulva) organs.

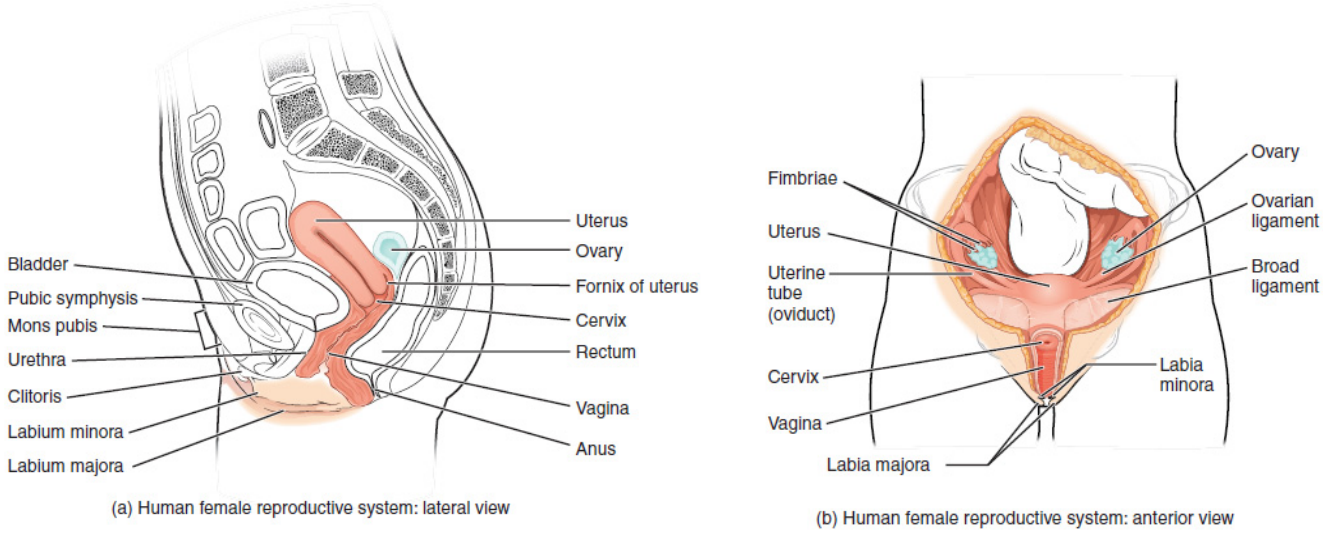

Figure 11.5 Female Reproductive System The major organs of the female reproductive system are located inside the pelvic cavity; Image Courtesy of Openstax Anatomy and Physiology.

Female Genitalia		
Structure		**Description**
Vulva		
	Mons pubis	Fatty pad that cushions and protects the pubic symphysis during sexual intercourse
	Labia majora	Two fatty folds that extend posteriorly from the mons pubis; homologous to the male scrotum; contains pubic hair, sudoriferous and sebaceous glands
	Labia minora	two smaller parallel folds, contain sebaceous glands but no hair, covers clitoris
	Clitoris	made of highly sensitive erectile tissue (same embryonic tissue that forms male penis), exposed region is called the glans
	Vestibule	between labia minora, contains vaginal orifice, hymen, the external urethra orifice (which has no reproductive function) and greater vestibular glands (secrete lubricant)
Vagina		Copulatory organ, birth canal, lined with stratified squamous epithelium, passageway for menstration
Ovaries		The primary reproductive organ of females; Produce endocrine (estrogen and progesterone) and exocrine (eggs, or ova) products; Supported by the *ovarian ligament,* the *suspensory ligaments* and the *mesovarium*; Houses the female gametes (eggs) in *follicles; Ovulation* is the ejection of the gametes from the ovary; NOT directed connected to uterus; instead *fimbriae* create fluid currents that "wave" the egg down the *fallopian tubes (uterine tubes)* and into the uterus
Fallopian (Uterine) tubes		Possesses the following structures: Fimbriae- fingerlike projections that move egg into tube; Infundibulum- expansion at beginning of tube, ciliated epithelium moves egg down tube, where most fertilization occurs; Ampulla- widened area of tube (majority of fertilizations occur here); Isthmus- last point of tube, narrow, connects to uterus
Uterus		Found between the bladder (anterior) and the rectum (posterior); site of implantation of the fertilized ovum; site of fetal development; contains 3 parts: Fundus, **cervix**, and body. The cervix is the opening to the vaginal canal. This is the structure that dilates (expands in size) during parturition.

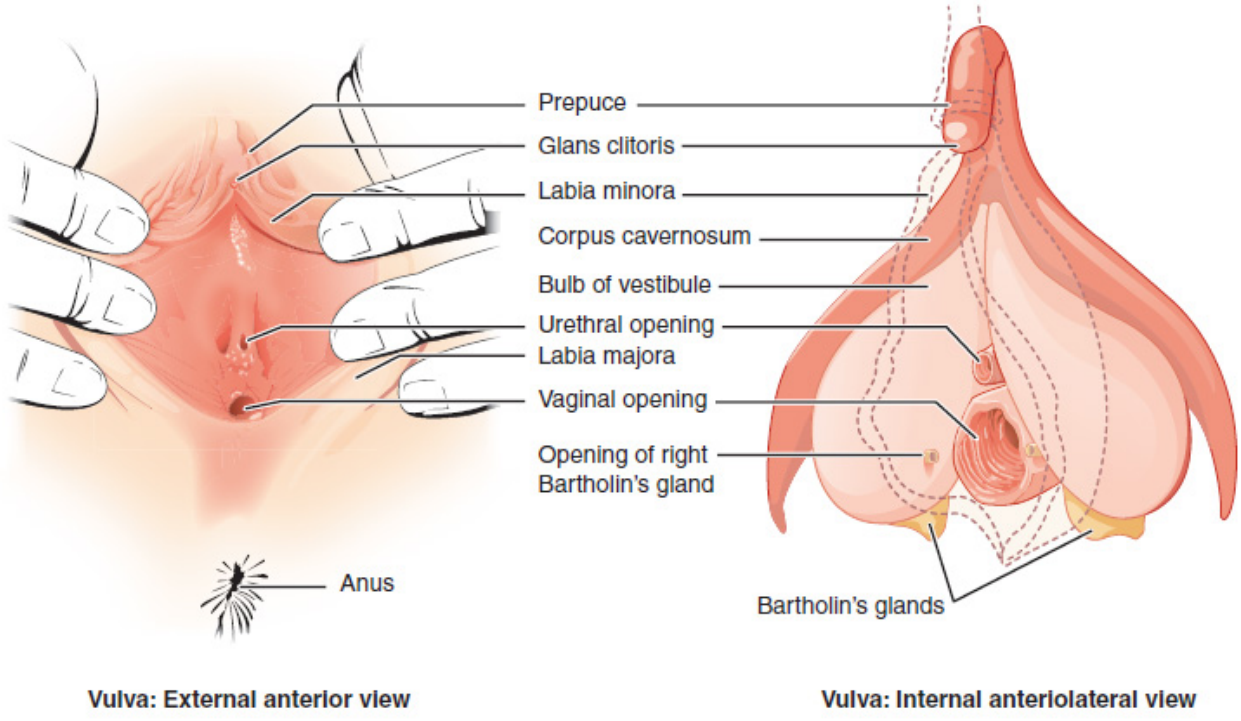

Figure 11.6 The Vulva The external female genitalia are referred to collectively as the vulva. Image Courtesy of OpenStax.

Pre-Lab Exercise 11.2.2: Answer the following questions.

1. What structure in the female reproductive system is made of erectile tissue?

2. Describe the location of the uterus within the pelvic cavity. Which structure sits anterior to it and which sits posterior to it? What are the three main parts of the uterus?

3. What are fimbriae and where are they located?

4. What type of tissue lines the vaginal canal?

5. Where is the cervix located?

6. What is the female external genitalia called?

7. Where do you find the hymen?

Pre-Lab Activity 11.2 The Ovarian Cycle

The **ovarian cycle** is a cycle of maturation of a female's oocytes and ovarian follicles. Similar to the menstrual cycle, this process takes roughly 28-days and corresponds to the menstrual cycle. The ovarian cycle involves the processes of **oogenesis** (the production of female gametes) and **folliculogenesis** (the growth and development of ovarian follicles) which happen in concert with one another. These processes are followed by a luteal phase. All are governed by the secretion of hormones from the hypothalamus and the pituitary gland (See figure below).

Oogonia are ovarian stem cells that form during female fetal development and ultimately give rise to female egg cells (oocytes). Gametogenesis, or more specifically, oogenesis, is the name of this maturation process. Mitotic division of oogonia form primary oocytes in the fetal ovary prior to birth. Primary oocytes remain arrested in stage of meiosis I until puberty, when the female will undergo her first ovulation, or release of an oocyte from the ovary. From this point on, ovulation is triggered by a surge of luteinizing hormone and will continue throughout the life of the female until menopause.

With the surge of luteinizing hormone, primary oocytes divide into a secondary oocyte and a polar body. The secondary oocyte is the larger of the two cells that will go on to be released from the ovary into the fallopian tube.

While oogenesis produces the egg cells that has the potential for life, folliculogenesis prepares that cell for ovulation. Small **primordial follicles** have a single layer of support cells (granulosa cells) surrounding a oocyte. They are found in the ovary of both newborn and adult females. These resting state follicles change when the granulosa cells transition from squamous cells to cuboidal cells and dividing. This marks the transition into the secondary follicle. The primary oocyte residing in this secondary follicle will secrete a thin membrane called the zona pellucida. This membrane is important as it aids in fertilization of the oocyte. Futhermore, the appearance of a thick follicular fluid, or antrum, marks the transition of the secondary follicle into a tertiary follicle (antral follicle). Not all tertiary follicles are predestined for ovulation. As this process is

occurring in several follicles at once, only one follicle will survive, continuing to grow until ovulation. The rupturing of the follicle to expel the oocyte, marks the beginning of ovulation.

In the final phase of ovulation (luteal phase), lutenizing hormone from the pituitary gland stimulates the formation of a corpus luteum (luteal body) from the remaining follicular tissue.

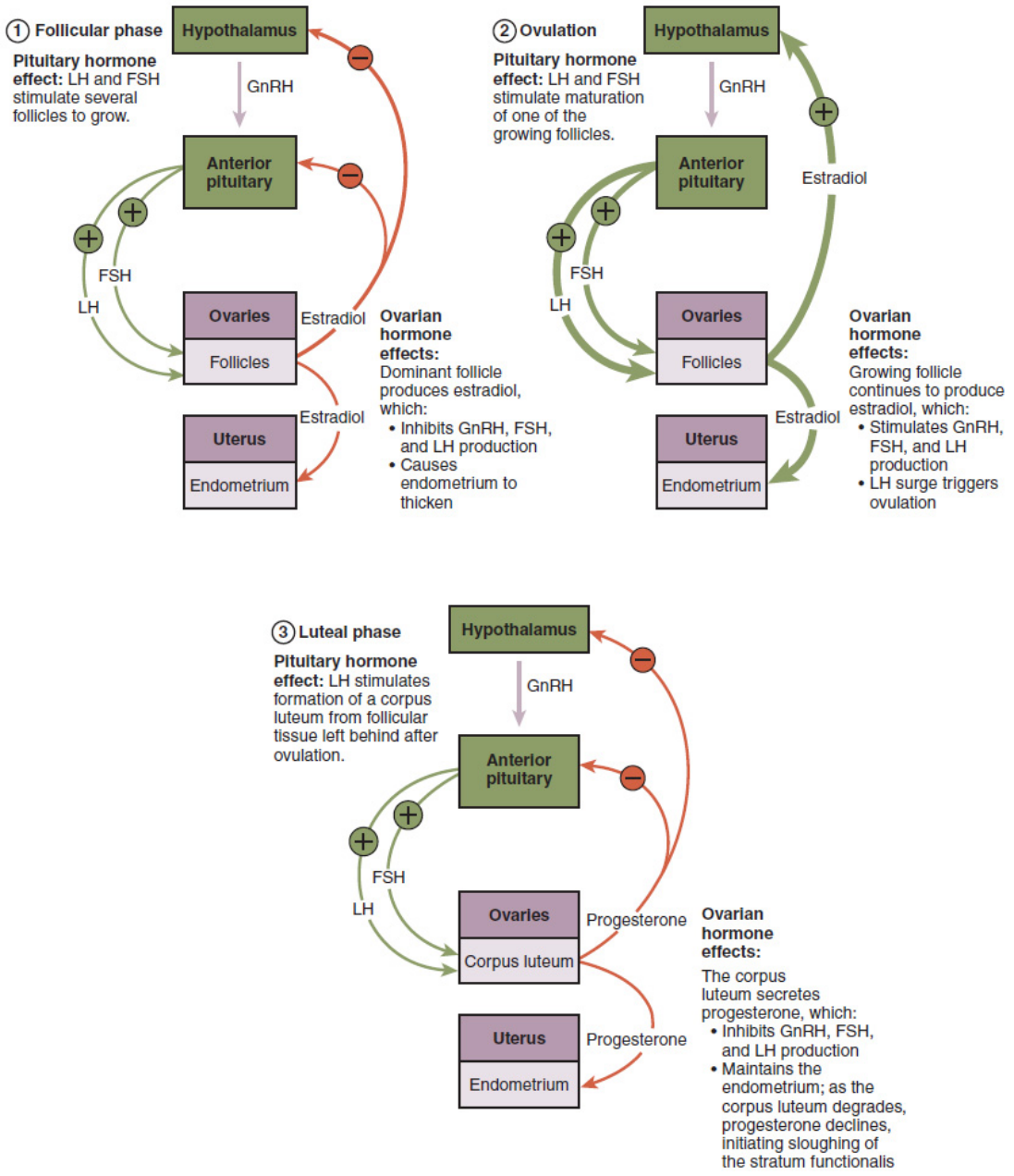

Figure 27.13 Hormonal Regulation of Ovulation The hypothalamus and pituitary gland regulate the ovarian cycle and ovulation. GnRH activates the anterior pituitary to produce LH and FSH, which stimulate the production of estrogen and progesterone by the ovaries.

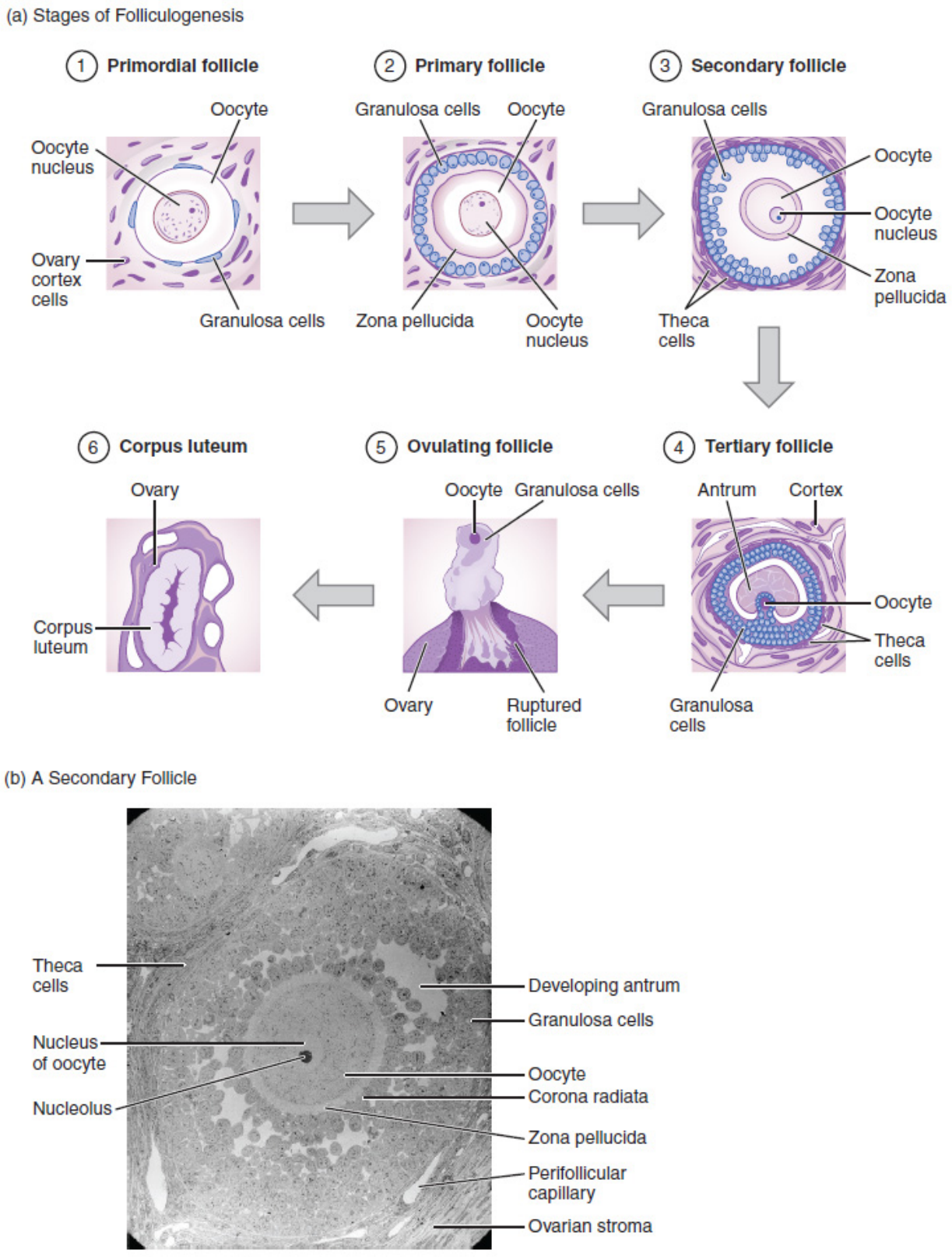

Figure 11.7 Folliculogenesis (a) The maturation of a follicle is shown in a clockwise direction proceeding from the primordial follicles. FSH stimulates the growth of a tertiary follicle, and LH stimulates the production of estrogen by granulosa and theca cells. Once the follicle is mature, it ruptures and releases the oocyte. Cells remaining in the follicle then develop into the corpus luteum. (b) In this electron micrograph of a secondary follicle, the oocyte, theca cells (thecae folliculi), and developing antrum are clearly visible. EM × 1100. (Micrograph provided by the Regents of University of Michigan Medical School © 2012)

Pre-Lab Exercise 11.2.1: Answer the following question.

1. Describe the phases of ovulation including the hormones that are released in each phase.

Pre-Lab Activity 11.3 The Uterine Wall and the Menstrual Cycle

The uterine wall consists of 3 layers:

1. **Perimetrium**- outer layer, continuous with the visceral peritoneum, also called the serosa
2. **Myometrium**- muscular middle layer (3 layers of smooth muscle), responsible for labor contractions
3. **Endometrium**- two layers
   - ***stratum basalis*** - covers myometrium and produces new functional zone each month
   - ***stratum functionalis*** - very glandular and vascularized, supports embryo, sheds monthly during menstruation do to changes in ovarian hormone levels

The female menstrual cycle is hormonally regulated by FSH and LH from the anterior pituitary and by estrogen and progesterone from the ovaries. The fluctuations in these hormones produces 3 phases:

1. Menstrual phase (menses): approx. day 1-5, "sloughing off" of lining, accompanied with bleeding
2. Proliferative phase: approx. day 6-14, due to estrogen: endometrium is repaired, glands and vessels proliferate, and endometrium thickens. Ovulation occurs during this phase (ovulation is caused by LH from the pituitary)
3. Secretory phase: approx. day 15-28, due to progesterone: vascular supply further increases, size of glands increases and secrete nutrients for sustaining an embryo if present. If there is not an embryo present- the corpus luteum deteriorates, endometrium becomes spastic and menses will occur.

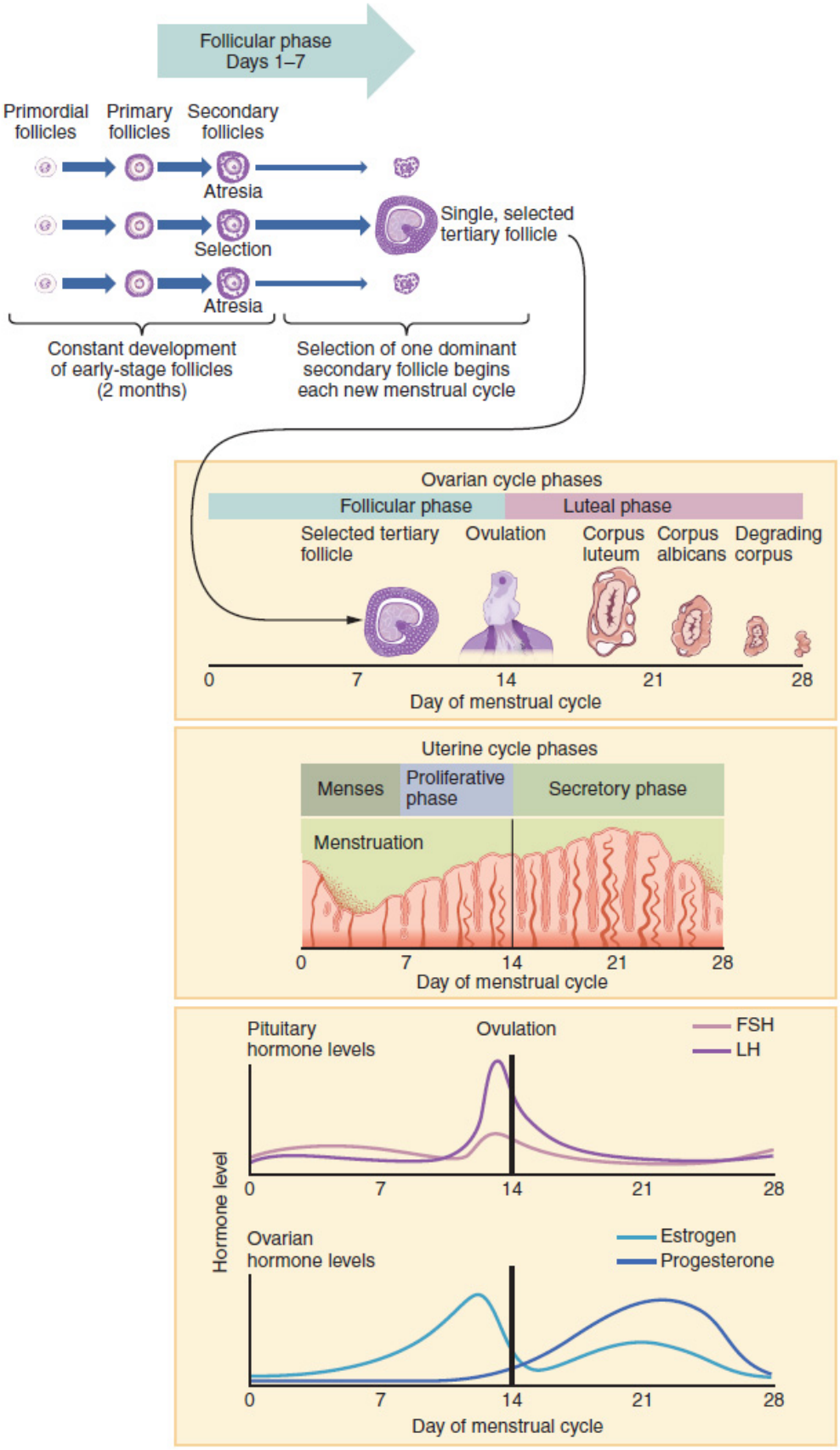

Figure 11.8 Hormone Levels in Ovarian and Menstrual Cycles The correlation of the hormone levels and their effects on the female reproductive system is shown in this timeline of the ovarian and menstrual cycles. The menstrual cycle begins at day one with the start of menses. Ovulation occurs around day 14 of a 28-day cycle, triggered by the LH surge.

Pre-Lab Activity 11.4 Mammary Glands and Lactation

The *mammary glands* are modified sweat glands that produce milk in a process called *Lactation.*
Each breast consists of:

- ***Lobes*** (15-20) Separated by fat and CT
- ***Lobules*** –contain alveoli
- ***Alveoli*** –milk secreting cells
- ***Lactiferous Duct-*** Site of milk expression; drain milk from lobules
- ***Lactiferous* Sinus -**empty milk into nipples
- ***Nipple*** –surrounded by pigmented *areola*

Milk secreting cells (alveoli) produce milk, which enters into the lactiferous ducts. Myoepithlelial cells of the alveoli contract, pushing the milk into connecting lactiferous sinuses. Milk is further pulled from these sinuses by suckling of an infant who has latched on to the areola (pigmented region around the nipple).

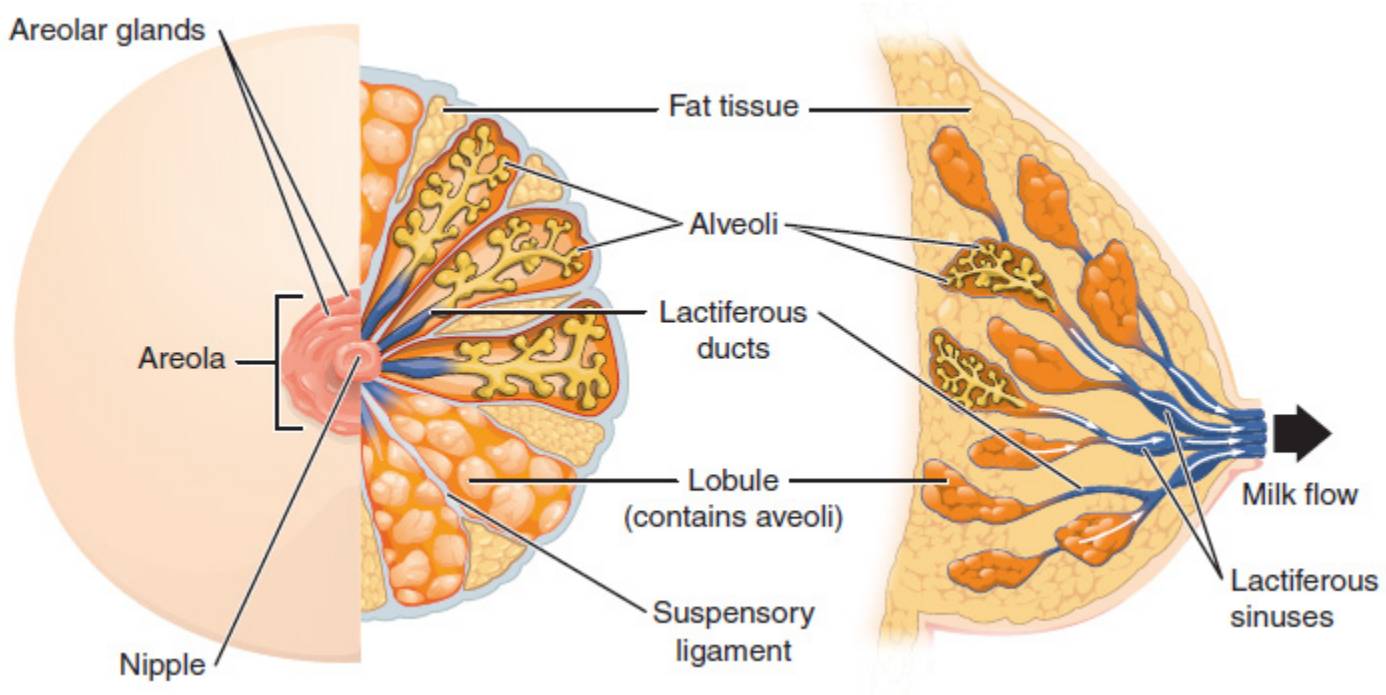

Figure 11.9 Anatomy of the Breast during lactation, milk moves from the alveoli through the lactiferous ducts to the nipple.

Pre-Lab Exercise 11.4.1: Answer the following question.

2. Describe the production and flow of milk in the process of lactation. Which hormone is involved with milk production?

Lab Exercise 11: Reproductive System

Activity 11.1: Table-Top models

Before beginning the dissection, identify the following structures on the table-top models.

Male	Female
☐ Bulbourethral gland (Cowper's)	☐ Broad ligament (R &L)
☐ Epididymis (R &L)	☐ Fallopian tubes (R &L)
☐ Inguinal canal	☐ Ovaries (R &L)
☐ Penis	☐ Uterus
☐ Preputial orifice (foreskin)	☐ Vagina canal
☐ Scrotum	☐ Cervix
☐ Testes (R & L)	☐ Vulva
☐ Vas deferens (R & L)	☐ Urethra
☐ Prostate	☐

Activity 11.2: Fetal Pig Dissection

Supplies needed: Gloves, scalpel/scissors, blunt probe, tweezers

Use human terminology where ever terms for the pig may differ.

For the FEMALE fetal pig reproductive system:

1. Locate the left and right **ovaries**, the small, pea-shaped structures at the base of the abdominal cavity.
2. Note the very small, convoluted tubules next to each ovary. These are the **fallopian tubes**.
3. The fallopian tubes connect to the much larger tubes that extend to the base of the bladder. These larger tubes are the uterine horns, not present in humans. These allow animals like pigs, dogs, etc. to have large multiple pregnancies (litters).

4. Attached to each uterine horn is a large, membranous sheet of tissue. This is the **broad ligament**.
5. To see the rest of the uterus and the rest of the female reproductive system, make a medial incision through the pubis bone. You can feel the cavity where the reproductive structures lie by placing your blunt probe into the opening at the base of the bladder. You need to cut through the bone down to your probe in order to see the remaining structures.
6. Observe the body of the **uterus** after you have made your incision. Note also the urethra coming from the base of the bladder.
7. The **vagina** attaches to the base of the uterus. Note also the rectum lying underneath (posteriorly to) the vagina.
8. Trace the vagina down to the point at which it merges with the urethra. This last section, which provides a common opening to the outside for both the vagina and urethra, is called the *urogential sinus*, not present in humans. The urinary and reproductive systems remain separate in a human female.
9. Once you have completed this dissection find a male specimen and identify the components of that system.

For the MALE fetal pig reproductive system:

1. Locate the **scrotum**, the sac of tissue lying outside the abdominal cavity between the legs.
2. Within the abdominal cavity, locate the gonadal arteries. Trace these arteries to the point where they go through the abdominal wall. The opening where the gonadal arteries go through the abdominal wall is the beginning of the **inguinal canal**. Note also that another tube is coming out of the inguinal canal at the same point where the gonadal artery is going in. This other tube is the **vas deferens**.
3. Make a small incision along one inguinal canal so that you can expose the testis.
4. Note the membranous tube that covers all of the structures. This is the rest of the inguinal canal. Peel off this membrane so that you can see the structures within.
5. The **testis** is the small, dark, bean-shaped structure at the end of the inguinal canal.
6. The **epididymis** is the tightly coiled tube on one side of the testis. Trace the epididymis around to the other side of the testis. Note the tube becomes uncoiled and extends up through the inguinal canal to the bladder. This is the **vas deferens**.
7. To see the rest of the male reproductive system, make a medial incision through the pubis bone. You can feel the cavity where the reproductive structures lie by placing your blunt probe into the opening at the base of the bladder. You need to cut through the bone down to your probe in order to see the remaining structures.

8. Find the **urethra** coming off the base of the bladder. Note also the rectum lying underneath the urethra.
9. Trace the urethra down until you see a small white bulge of tissue on each side of it. These bulges of tissue are the **bulbourethral (Cowper's) gland**.
10. Continue to trace the urethra down through the rest of the body. Note that at the base, the urethra bends and continues on up toward the umbilical cord. Beyond this bend, the urethra is now the **penis**.
11. Locate the **preputial orifice**, the external opening of the penis located just below the umbilical cord.
12. Once you have completed this dissection find a female specimen and identify the components of that system.

Activity 11.3 Spermatogenesis

Spermatogenesis is the production of sperm cells that occurs in the seminiferous tubules of the testes. Mitosis of the diploid spermatogonia is the first step in spermatogenesis. Spermatagonia are diploid cells, which means they have a complete set of the individual's chromosomes.

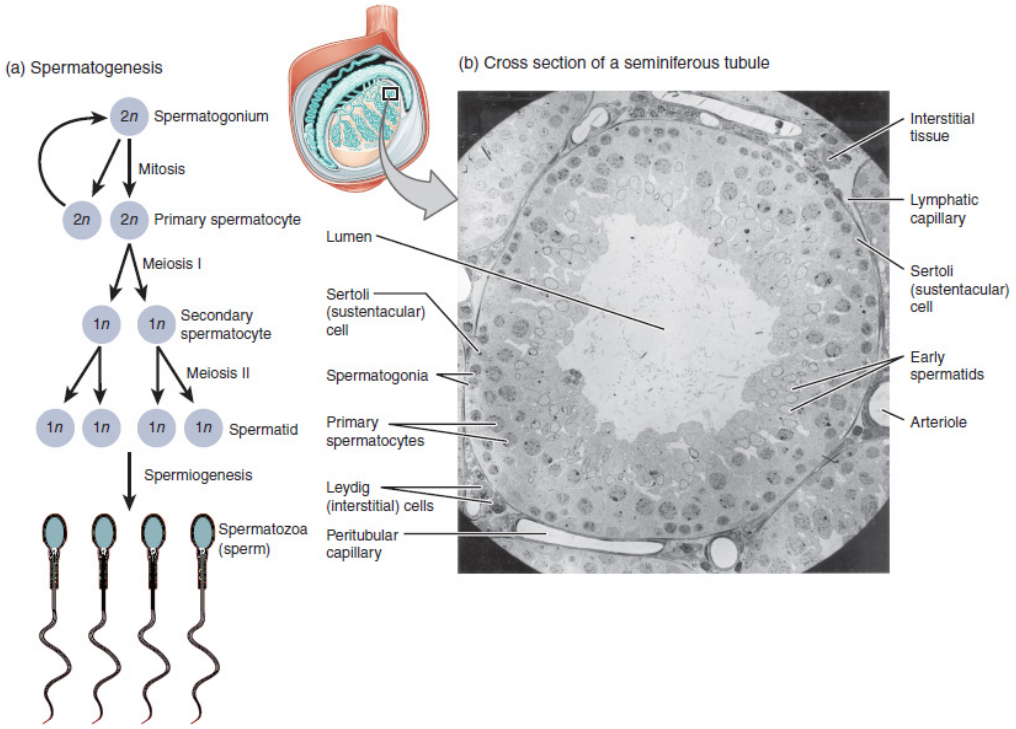

Figure 11.10 Spermatogenesis (a) Mitosis of a spermatogonial stem cell involves a single cell division that results in two identical, diploid daughter cells (spermatogonia to primary spermatocyte). Meiosis has two rounds of cell division: primary spermatocyte to secondary spermatocyte, and then secondary spermatocyte to spermatid. This produces four haploid daughter cells (spermatids). (b) In this electron micrograph of a cross-section of a seminiferous tubule from a rat, the lumen is the light-shaded area in the center of the image. The location of the primary spermatocytes is near the basement membrane, and the early spermatids are approaching the lumen (tissue source: rat). EM × 900. (Micrograph provided by the Regents of University of Michigan Medical School © 2012)

Exercise 11.4.1: Answer the following question.

1. Using the image above, describe the divisions that take place during spermatogenesis, including the name of the sperm intermediates and whether or not they are diploid or haploid. Start with **Spermatagonium** and end with **Spermatozoa**.

Activity 11.4: Histological Observation of Reproductive Tissues

View each slide provided by your instructor, identifying important features of each tissue.

Exercise 11.4.1: Describe or Draw the structures that you see for the following tissues.

Tissue	Description/Drawing
Uterus Human Prograviid Phase Sec	
Penis Mammal C.S.	
Human Epididymus Sec	
Fallopian Tube Fimbriated End Human C.S.	