CHAPTER 19

The Reproductive System
Chapter 19 Learning Outcomes

• 19-1
  • List the basic components of the human reproductive system, and summarize the functions of each.

• 19-2
  • Describe the components of the male reproductive system; list the roles of the reproductive tract and accessory glands in producing spermatozoa; describe the composition of semen; and summarize the hormonal mechanisms that regulate male reproductive function.

• 19-3
  • Describe the components of the female reproductive system; explain the process of oogenesis in the ovary; discuss the ovarian and uterine cycles; and summarize the events of the female reproductive cycle.
Chapter 19 Learning Outcomes

• 19-4
  • Discuss the physiology of sexual intercourse in males and females.

• 19-5
  • Describe the age-related changes that occur in the reproductive system.

• 19-6
  • Give examples of interactions between the reproductive system and each of the other organ systems.
Basic Reproductive Structures (19-1)

- **Gonads**
  - **Testes** in males
  - **Ovaries** in females

- **Ducts**

- **Accessory glands**

- **External genitalia**
Gametes (19-1)

- Reproductive cells
  - **Spermatozoa** (or *sperm*) in males
  - Combine with secretions of accessory glands to form semen
  - **Oocyte** in females
    - An immature gamete
    - When fertilized by sperm becomes an **ovum**
Checkpoint (19-1)

1. Define gamete.

2. List the basic components of the reproductive system.

3. Define gonads.
The Scrotum (19-2)

• Location of primary male sex organs, the testes
  • Hang outside of pelvic cavity
  • Contains two chambers, the scrotal cavities

• Wall
  • *Dartos*, a thin smooth muscle layer, wrinkles the scrotal surface
  • *Cremaster muscle*, a skeletal muscle, pulls testes closer to body to ensure proper temperature for sperm
The Testes (19-2)

- **Tunica albuginea**
  - A dense fibrous capsule that surrounds each testis
  - Folds in to divide lobules

- **Seminiferous tubules**
  - Contain *nurse cells* (or *sustentacular cells*)
    - Support *spermatogenesis*, formation of sperm
  - Sperm pass through *rete testis* and *efferent ductules*
The Testes (19-2)

- **Interstitial cells**
  - Found between tubules
  - Produce testosterone

- **Epididymis**
  - Beginning of male reproductive tract
  - Sperm enter from rete testis
Figure 19-2a The Scrotum, Testes, and Seminiferous Tubules.

- Efferent ductule
- Ductus deferens
- Rete testis
- Epididymis
- Seminiferous tubule
- Skin
- Dartos muscle
- Cremaster muscle
- Scrotal cavity
- Tunica albuginea
- Septa

A horizontal section of the scrotum and testes
Figure 19-2b-c The Scrotum, Testes, and Seminiferous Tubules.

A section through a coiled seminiferous tubule

Seminiferous tubule containing late spermatids
Seminiferous tubule containing spermatozoa
Seminiferous tubule containing early spermatids

Spermatogonium
Spermatids
Capillary
Interstitial cells
Nurse cell nucleus

A diagrammatic sectional view showing the cellular organization of a seminiferous tubule

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Spermatogenesis (19-2)

- A series of cell divisions in seminiferous tubules

- Each division produces a daughter cell that is pushed toward the lumen of the tubule

- Includes:
  - *Mitosis* of stem cells, *spermatogonia*
  - *Meiosis*
  - *Spermiogenesis*
Mitosis (19-2)

- *Somatic* (or nonreproductive) cell division
- Two daughter cells contain same number of chromosomes
  - Forms primary spermatocyte
  - **Diploid** daughter cells
    - 23 pairs or 46 chromosomes
Meiosis I (19-2)

- Prophase I
  - **Synapsis** is pairing of chromosomes, with identical chromatids forming a **tetrad**
- Metaphase I
  - Tetrads line up
- Anaphase I
  - Tetrads are pulled apart
- Telophase I
  - Product is **secondary spermatocytes**, two daughter cells
Meiosis II (19-2)

• Prophase II
  • Spindle formation begins

• Metaphase II
  • Chromosomes line up

• Anaphase II
  • Chromatids are pulled apart

• Telophase II
  • Cytokinesis occurs

• At end of Meiosis I and II, one diploid primary spermatocyte produces four haploid spermatids
Figure 19-3 Spermatogenesis.

- Mitosis of spermatogonium (diploid)
  - Primary spermatocyte (diploid)
- Meiosis I
  - Synapsis and tetrad formation
    - DNA replication
    - Primary spermatocyte
      - Tetrad
      - Secondary spermatocytes
- Meiosis II
  - Spermatids (haploid)
  - Spermiation (physical maturation)
  - Spermatozoa (haploid)
Spermiogenesis (19-2)

- Final stage of sperm production
- Each spermatid matures into a **spermatozoon**
- Supported by actions of nurse cells
  - Control chemical environment for spermatogenesis
  - Secrete *inhibin*
Anatomy of a Spermatozoon (19-2)

- Three distinct regions

  1. **Head**
     - Contains nucleus with chromosomes
     - *Acrosome* tip has enzymes to penetrate oocyte
  
  2. **Middle piece**
     - A lot of mitochondria to provide energy for movement
  
  3. **Tail** or flagellum
     - Move sperm from one place to another
Figure 19-4 Spermatozoon Structure.

- Acrosome
- Nucleus
- Centrioles
- Mitochondrial spiral
- Cell membrane of flagellum
- Head
- Neck
- Middle piece
- Tail (flagellum)
Figure 19-1 The Male Reproductive System.

- Pubic symphysis
- Ductus deferens
- Urethra
- Penis
- Epididymis
- Glans
- Prepuce
- External urethral orifice
- Testis
- Scrotum

- Ureter
- Seminal gland
- Prostate gland
- Ejaculatory duct
- Bulbo-urethral gland
- Rectum
- Urinary bladder
The Epididymis (19-2)

- Where spermatozoa go to mature
  - Adjusts fluid produced by seminiferous tubules
  - Recycles damaged spermatozoa
  - Takes two weeks for spermatozoa to travel through epididymis
  - Are physically mature, but immobile
The Ductus Deferens (19-2)

- Also called the *vas deferens*
  - Goes into pelvic cavity through spermatic cord
    - Passes laterally to urinary bladder
    - Curves down past ureters toward prostate gland
  - *Ejaculatory duct*
    - Short passageway where seminal gland ducts merge with vas deferens
    - Goes into *prostate gland*, empties into urethra
Figure 19-5 The Ductus Deferens.

This posterior view shows the ductus deferens in relation to nearby structures.

This light micrograph shows the thick layers of smooth muscle in the wall of the ductus deferens.
The Urethra (19-2)

- A shared tube for both urine and semen
- Runs from urinary bladder to tip of penis
The Accessory Glands (19-2)

- Produce fluid component of semen

- Functions include:
  - Activating spermatozoa
  - Providing nutrients needed for motility
  - Generating peristaltic contractions to propel sperm and semen
  - Producing buffers to counteract acidic environment of urethra and vagina
The Seminal Glands (19-2)

- Contribute 60 percent of semen fluid
  - Fructose for metabolism by sperm
  - Prostaglandins stimulate smooth muscle in tract
  - Fibrinogen forms semen clot in vagina
  - Slightly alkaline to buffer acid environments
- Provide fluid that initiates **capacitation**
  - Development of motility of sperm tails
The Prostate Gland (19-2)

- Small, round organ surrounds urethra
- Prostatic fluid is about 20–30 percent of semen
  - **Seminalplasmin**
    - Protein with antibiotic properties
    - Appears to help prevent urinary tract infections (UTIs)
The Bulbo-urethral Glands (19-2)

- Also called Cowper’s glands
- Paired glands
- Secrete final amount of fluid in semen
  - Thick alkaline mucus
    - Buffers acidic environments
    - Lubricates glans of penis
Ejaculate is 2–5 mL of semen containing:

1. Spermatozoa
   - From 20–100 million/mL

2. Seminal fluid
   - Contains glandular secretions, ions, nutrients

3. Enzymes
   - Protease dissolves mucus in vagina
   - Enzymes that clot semen, and enzymes that liquefy it
The Penis (19-2)

- Introduces semen to vagina during intercourse
  - Also conducts urine to the exterior through urethra
- Three regions
  1. **Root** is the fixed portion connected to body wall
  2. **Body** (or **shaft**) contains erectile tissue
  3. **Glans** expanded distal end with *external urethral orifice*
- **Prepuce**, fold of skin over glans, often removed
Erectile Tissue of the Penis (19-2)

- Maze of vascular channels, elastic connective tissue, and smooth muscle
  - Anterior of flaccid penis covers two *corpora cavernosa*
  - *Corpus spongiosum* surrounds urethra
- In resting state:
  - Little blood flow, arterial branches constricted
- During *erection*:
  - Parasympathetic neurons release NO, a vasodilator
An anterior and lateral view of a penis showing the positions of the erectile tissues.

- Urethra
- Root of penis
- Ischial ramus
- Corpus spongiosum
- Corpora cavernosa (erectile tissue)
- Pubic symphysis
- Body (shaft of penis)
- Glans
- Scrotum
- External urethral orifice
Figure 19-6b–c The Penis.

- **Ureter**
- **Trigone of urinary bladder**
- **Prostate gland**
- **Urethra**
- **Corpus spongiosum**
- **Corpora cavernosa**
- **Urethra**
- **Glans**
- **Prepuce**
- **Opening of duct from bulbo-urethral gland**
- **Corpus spongiosum**
- **Corpora cavernosa**
- **Dorsal blood vessels**
- **Seminal gland**
- **Opening of ejaculatory duct**
- **Ductus deferens**
- **Bulbo-urethral gland**
- **External urethral orifice**

**b** A frontal section through the penis and associated organs

**c** A sectional view through the penis
Male Reproductive Hormones (19-2)

- **GnRH** secreted by hypothalamus triggers release of **FSH** and **LH** from anterior pituitary
- FSH targets nurse cells to trigger spermatogenesis
- LH causes interstitial cells to secrete testosterone
  - Stimulates differentiation of male reproductive tract
  - Initiates sexual maturity, development of secondary sex characteristics
Figure 19-7 Regulation of Male Reproduction

SPOTLIGHT

FIGURE 19-7
Regulation of Male Reproduction

HYPOTHALAMUS

Release of Gonadotropin-Releasing Hormone (GnRH)
The hypothalamus secretes the hormone GnRH.

Negative feedback:
High testosterone levels inhibit the release of GnRH by the hypothalamus, causing a reduction in LH secretion and lowering testosterone levels to normal levels.

When stimulated by GnRH, the anterior lobe of the pituitary gland releases luteinizing hormone (LH) and follicle-stimulating hormone (FSH).

SECRETION OF FOLLICLE-STIMULATING HORMONE (FSH)

FSH targets primarily the nurse cells of the seminiferous tubules.

Inhibin depresses the pituitary production of FSH, and perhaps the hypothalamic secretion of gonadotropin-releasing hormone (GnRH). The faster the rate of sperm production, the more inhibin is secreted. By regulating FSH and GnRH secretion, nurse cells provide feedback control of spermatogenesis.

ANTERIOR LOBE OF THE PITUITARY GLAND

Secretion of Luteinizing Hormone (LH)

LH targets the interstitial cells of the testes.

Interstitial Cell Stimulation

LH induces the secretion of testosterone and other androgens by the interstitial cells of the testes.

SECRETION OF TESTOSTERONE

Testosterone

Under FSH stimulation, and in the presence of the testosterone from the interstitial cells, nurse cells promote spermatogenesis and spermiogenesis, and secrete inhibin in response to factors released by developing spermatozoa.

Peripheral Effects of Testosterone

Maintains libido (sexual drive) and related behaviors
Stimulates bone and muscle growth
Establishes and maintains male secondary sex characteristics
Maintains accessory glands and organs of the male reproductive system

Nurse cell environment aids both spermatogenesis and spermiogenesis.
4. List the male reproductive structures.

5. On a warm day, would the cremaster muscle be contracted or relaxed? Why?

6. What happens when arteries within the penis dilate?

7. What effect would low FSH levels have on sperm production?
The Female Reproductive Tract (19-3)

• Functions
  • Produce sex hormones
  • Produce gametes
  • Support and protect developing embryo
  • Nourish newborn infant
The Ovaries (19-3)

- Located near lateral walls of pelvic cavity
  - Stabilized by broad ligament and supporting ligaments
- Responsible for:
  - Production of immature gametes, **ova**
  - Secretion of female sex hormones
    - **Estrogens**
    - **Progestins**
  - Secretion of inhibin
Figure 19-8a The Female Reproductive System.

- Ovary
- Uterine tube
- Urinary bladder
- Pubic symphysis
- Urethra
- Greater vestibular gland
- Clitoris
- Labium minus
- Labium majus
- Uterus
- Sigmoid colon
- Fornix
- Cervix
- Vagina
- Rectum
- Anus

A sagittal section showing the female reproductive organs
A posterior view of the uterus, uterine tubes, and ovaries.
Oogenesis (19-3)

- Ovum production begins in utero, ends at menopause

- **Oogonia**
  - Stem cells undergo mitosis before birth producing:

- **Primary oocytes**
  - Undergo meiosis I producing:

- **Secondary oocytes**
  - Do not undergo meiosis II until fertilized by sperm
Oogenesis

Mitosis of oogonium
- Completed before birth

- Oogonium

Meiosis I
- Begins before birth

- DNA replication

- Primary oocyte (diploid)

- Synapsis and tetrad formation

- First polar body

- Completed after puberty

- First polar body may not complete meiosis II

- Secondary oocyte (haploid)

Meiosis II
- Begun in the tertiary follicle and completed only if fertilization occurs.

- Secondary oocyte released in metaphase of meiosis II

- If fertilization occurs after ovulation, meiosis II is completed

- Second polar body

- Mature ovum (haploid)
Ovarian Follicle Development (19-3)

• Site of oocyte growth and meiosis I
  • **Primordial follicle**
    • Primary oocyte surrounded by single layer of follicle cells
  • **Primary follicle**
    • Cells enlarge, divide, produce estrogens
  • **Secondary follicle**
    • Wall of follicle thickens, secretes fluid
    • Fluid accumulates in pockets
The Ovarian Cycle (19-3)

- Secondary follicle matures through a 28-day cycle
  
  - Follicular phase
    - Takes about 14 days
  
- Ovulation
  - Occurs in an instant

- Luteal phase
  - Takes about 14 days

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The Follicular Phase of the Ovarian Cycle (19-3)

- FSH stimulates formation of tertiary follicle
- Increases in LH prompt completion of meiosis I
  - Produces secondary oocyte and a polar body
- Oocyte projects into central chamber of follicle, the antrum
The Ovulation Phase of the Ovarian Cycle (19-3)

- Tertiary follicle bursts
- Releases secondary oocyte into pelvic cavity
- Oocyte enters uterine tube
The Luteal Phase of the Ovarian Cycle (19-3)

- Empty follicle collapses
- Develops into endocrine structure, corpus luteum
- Corpus luteum secretes progesterone
- Without fertilization of the ovum:
  - Corpus luteum degenerates into corpus albicans
  - Marks the end of full ovarian cycle
  - FSH will rise to initiate another ovarian cycle
Figure 19-10 Follicle Development and the Ovarian Cycle.

1. **Primordial follicles before puberty**
   - Primary oocyte
   - Follicle cells
   - LM x 1440

2. **Formation of primary follicle**
   - Follicle cells
   - Primary oocyte
   - Zona pellucida
   - LM x 1092

3. **Formation of secondary follicle**
   - Zona pellucida
   - Nucleus of primary oocyte
   - LM x 1052

4. **Formation of tertiary follicle**
   - Antrum containing follicular fluid
   - Corona radiata
   - Secondary oocyte
   - LM x 136

5. **Ovulation**
   - Follicular fluid
   - Secondary oocyte within corona radiata
   - Ruptured follicle wall
   - Outer surface of ovary
   - LM x 208
The Uterine Tubes (19-3)

• Also called *Fallopian tubes*, or *oviducts*

• **Infundibulum** is expanded end closest to ovary

• **Fimbriae** are fingerlike projections of infundibulum
  - Cilia help propel oocyte into uterine tube

• **Walls of tube move oocytes toward uterus**
  - Use ciliary movement and peristalsis
The Uterus (19-3)

- Provides:
  - Mechanical protection
  - Nutritional support for embryonic and fetal development
- Pear-shaped, muscular organ
  - Tips anteriorly over urinary bladder
- Two regions, the **body** and the **cervix**
The Uterus (19-3)

• **Body**
  - Fundus is area above attachments of uterine tubes
  - **Isthmus** is narrowing of body at inferior end

• **Cervix**
  - Projects into vagina
  - **Internal os** is the opening between body and cervix
  - **External os** is the opening into vagina
The Uterine Wall (19-3)

- **Endometrium**
  - Functional zone of epithelial lining undergoes changes
    - Is sloughed off as part of uterine cycle
  - Basilar layer remains intact

- **Myometrium**
  - Muscle layer contracts during labor and delivery

- **Perimetrium**
  - Visceral peritoneum
Figure 19-11 The Uterus.

- Infundibulum
- Ampulla
- Isthmus
- Fundus of uterus
- Uterine tube
- Uterine cavity
- Body of uterus
- Ovary
- Ovarian artery and vein
- Ovarian ligament
- Round ligament of uterus
- Perimetrium
- Myometrium
- Endometrium
- Uterine artery and vein
- Internal os of uterus
- Isthmus of uterus
- Cervical canal
- External os of uterus
- Vagina
- Cervix
- Broad ligament
- Round ligament of uterus
The Uterine Cycle (19-3)

- First cycle, **menarche**, begins at puberty
- Continues until **menopause**
  - Interrupted by illness, stress, starvation, pregnancy
- Functions
  - Prepare uterine lining for implantation of fertilized ovum, called a zygote
Menses (19-3)

- Degeneration of functional zone of endometrium
  - Arteries constrict
  - Secretory glands and epithelial cells die
- Triggered by drop in progesterone and estrogen
- **Menstruation**
  - Blood and dead cells pass through and out the vagina
The Proliferative Phase of the Uterine Cycle (19-3)

- Begins at completion of menses
- Increases in ovarian estrogen trigger repair and growth of endometrium
- Increases in vascularization
- Development of nutritional secretory glands
- Functional zone becomes several mm thick
The Secretory Phase of the Uterine Cycle (19-3)

- Begins at ovulation
- Uterine glands enlarge
- Prepares endometrium for a developing embryo
- Stimulated by progestins and estrogens from corpus luteum
- As corpus luteum degenerates, uterine cycle ends
- Menses will begin again
The Vagina (19-3)

• An elastic muscular tube that is parallel and anterior to rectum, posterior to the urethra

• Fornix
  • Shallow recess surrounding base of cervix

• Hymen
  • Epithelial fold partially blocks vaginal entrance

• Functions
  • Passageway for menstrual fluid
  • Receives penis and holds semen during intercourse
  • Lower portion of birth canal
Female External Genitalia of the Vulva (19-3)

- Vagina opens into **vestibule**
  - Urethral opening is anterior to vaginal opening
  - Clitoris, erectile tissue, is anterior to urethral opening
- Vestibule bound by the **labia minora**
  - Covered with smooth, hairless skin
  - Extension covers clitoris with *prepuce, hood*
- **Lesser and greater vestibular glands** moisten and lubricate
- **Mons pubis** and **labia majora**, outer area that protects vestibule
Figure 19-12 The Female External Genitalia.

- Mons pubis
- Labia minora
- Labia majora
- Prepuce of clitoris
- Glans of clitoris
- Urethral opening
- Vestibule
- Vestibular bulb
- Greater vestibular gland
- Hymen (torn)
- Vaginal entrance
- Anus
The Mammary Glands (19-3)

• Located in breasts

• Function in **lactation**, milk production
  
  • Gland surrounded by adipose tissue and supported by ligaments
  
  • Secrete into ductules, converge into **lactiferous duct**
  
  • Drains into **lactiferous sinus**
  
  • Opens onto body surface of **nipple**
  
  • **Areola** is brownish skin surrounding nipple
Figure 19-13  The Mammary Gland of the Left Breast.

- Pectoralis major muscle
- Pectoral fat pad
- Suspensory ligaments
- Lobules of two lobes of the mammary gland
- Lactiferous duct
- Areola
- Nipple
- Lactiferous sinus
Female Reproductive Hormones (19-3)

- Hormones of the anterior pituitary
  - Govern ovarian cycles
  - Regulate secretions of ovarian hormones
  - Provide feedback to hypothalamus

- Hormones of the ovaries
  - Govern uterine cycles
  - Provide feedback to hypothalamus and pituitary
• Onset triggered by increase in FSH of pituitary

• Growing follicular cells secrete **estrogens**
  - Most important estrogen is **estradiol**
  - Stimulate bone and muscle growth
  - Establishes and maintains secondary sex characteristics
  - Increases sex drive in CNS
  - Maintains accessory organ function
  - Initiates repair and growth of endometrium
Hormones and the Follicular Phase (19-3)

- Early follicular phase
  - Estrogen and inhibin levels are low

- Late follicular phase
  - Estrogens and inhibin increase
    - At about day 12 they trigger surge of LH
    - At about day 13 they trigger rise in FSH
  - LH surge triggers ovulation
Hormones and the Luteal Phase (19-3)

- Corpus luteum develops and secretes progesterone
  - Prepares endometrium for implantation of embryo
- If pregnancy doesn't occur, drop in progesterone and estrogen
  - Feeds back to hypothalamus
  - Removes inhibition of GnRH
  - GnRH stimulates FSH production
Hormones and the Uterine Cycle (19-3)

- Drop in progesterone and estrogen:
  - Triggers degeneration of endometrium and menses

- Rise in estrogen:
  - Stimulates proliferative phase

- Rise in progesterone:
  - Stimulates secretory phase
Hormones and Body Temperature (19-3)

- **Follicular phase**
  - Temperature is lower

- **Ovulation**
  - Temperature drops sharply

- **Secretory phase**
  - Temperature rises

- **Temperature cycles can predict ovulation**
The ovarian cycle begins with the release of GnRH, which stimulates the production and secretion of FSH and the production—but not the secretion—of LH.

**Follicular Phase of the Ovarian Cycle**
- The follicular phase begins when FSH stimulates some secondary follicles to develop into a tertiary follicle.
- As secondary follicles develop, FSH levels decline due to the negative feedback effects of inhibin.
- Developing follicles also secrete estrogens, especially estradiol (estr-ah-di-ohl), the dominant hormone prior to ovulation.
- In low concentrations, estrogens inhibit LH secretion. This inhibition gradually decreases as estrogen levels climb.

**Luteal Phase of the Ovarian Cycle**
- Elevated estrogen levels stimulate LH secretion.
- On or around day 14, a massive surge in LH level triggers (1) the completion of meiosis I by the primary oocyte, (2) the forceful rupture of the follicular wall, (3) ovulation, roughly 9 hours after the LH peak, and (4) formation of the corpus luteum.
- The corpus luteum secretes progesterone, which stimulates and sustains endometrial development.
- After ovulation, progesterone levels rise and estrogen levels fall. This suppresses GnRH secretion. If pregnancy does not occur, the corpus luteum will degenerate after 12 days, and as progesterone levels decline, GnRH secretion increases, and a new cycle begins.
Figure 19-14 Regulation of Female Reproduction. (2 of 2)

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<tr>
<th>Gonadotropic hormone levels (IU/L)</th>
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<th>LUTEAL PHASE OF OVARIAN CYCLE</th>
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<td>Mature corpus luteum</td>
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<td>Corpus albicans</td>
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DAYS 28/0 7 14 21 28/0
8. Name the structures of the female reproductive system.

9. As the result of infections such as gonorrhea, scar tissue can block both uterine tubes. How would this blockage affect a woman's ability to conceive?

10. What benefit does the acidic pH of the vagina provide?

11. Which layer of the uterus is sloughed off, or shed, during menstruation?

13. What changes would you expect to observe in the ovarian cycle if the LH surge did not occur?

14. What effect would blockage of progesterone receptors in the uterus have on the endometrium?

15. What event in the uterine cycle occurs when estrogen and progesterone levels decline?
ANS Influence on Sexual Function (19-4)

- Sexual intercourse (also coitus, or copulation)
  - Introduces semen into female reproductive tract
  - Requires coordination of reflexes of autonomic nervous system (ANS)
Male Sexual Function (19-4)

• **Arousal**
  - Triggered by thoughts or genital stimulation
  - Parasympathetic activity leads to erection due to engorgement of erectile tissue

• **Emission**
  - Sympathetic activity leads to emission
  - Moves semen through tract
    - Peristalsis and contraction of accessory glands
Male Sexual Function (19-4)

- **Ejaculation**
  - Results from contraction of skeletal pelvic floor muscles

- **Orgasm**
  - Pleasurable sensation associated with ejaculation

- **Impotence**
  - Inability to achieve or maintain an erection
Female Sexual Function (19-4)

- Comparable to that in males

- Arousal
  - Parasympathetic activity leads to engorgement of clitoris and vestibular bulbs

- Orgasm
  - Accompanied by contraction of skeletal pelvic floor muscles
16. List the physiological events of sexual intercourse in both sexes, and indicate those that occur in males but not in females.

17. An inability to contract the ischiocavernosus and bulbospongiosus muscles would interfere with which part of the sexual response in males?

18. What changes occur in females during sexual arousal as the result of increased parasympathetic stimulation?
Menopause (19-5)

• When ovulation and menses cease:
  • Decline in estrogen and progesterone
  • Reduces size of female reproductive structures
  • Linked to osteoporosis

• Perimenopause
  • Precedes menopause
    • Uterine cycles become irregular
The Male Climacteric (19-5)

• Age-related changes in males are more gradual
• Levels of testosterone decline
• Sperm production continues
  • Sperm may lose viability

20. Why does the level of FSH rise and remain high during menopause?

21. What is the male climacteric?
Reproductive Hormones Affect All Body Systems (19-6)

- Reproduction depends on coordination of the following factors:
  - Physical
  - Psychological
  - Physiological
<table>
<thead>
<tr>
<th>HORMONE</th>
<th>SOURCE</th>
<th>REGULATION OF SECRETION</th>
<th>PRIMARY EFFECTS</th>
</tr>
</thead>
</table>
| GONADOTROPIN-RELEASING HORMONE (GnRH) | Hypothalamus            | Males: inhibited by testosterone  
Females: inhibited by estrogens and/or progestins                 | Stimulates FSH secretion and LH synthesis in males and females                  |
| FOLLICLE-STIMULATING HORMONE (FSH)  | Anterior lobe of the pituitary gland | Males: stimulated by GnRH, inhibited by inhibin and testosterone  
Females: stimulated by GnRH, inhibited by inhibin, estrogens, and/or progestins | Males: stimulates spermatogenesis and spermiogenesis through effects on nurse cells  
Females: stimulates follicle development, estrogen production, and oocyte maturation |
| LUTEINIZING HORMONE (LH)       | Anterior lobe of pituitary gland | Males: stimulated by GnRH  
Females: production stimulated by GnRH and secretion by estrogens    | Males: stimulates interstitial cells to secrete testosterone  
Females: stimulates ovulation, formation of corpus luteum, and progestin secretion |
| ANDROGENS (Primarily Testosterone) | Interstitial cells of testes | Stimulated by LH                                                  | Establish and maintain secondary sex characteristics and sexual behavior; promote maturation of spermatozoa; inhibit GnRH secretion |
| ESTROGENS (Primarily Estradiol) | Follicle cells of ovaries; corpus luteum | Stimulated by FSH                                                  | Stimulate LH secretion (at high levels); establish and maintain secondary sex characteristics and behavior; stimulate repair and growth of endometrium; inhibit secretion of GnRH |
| PROGESTINS (Primarily Progesterone) | Corpus luteum           | Stimulated by LH                                                  | Stimulate endometrial growth and glandular secretion; inhibit GnRH secretion     |
| INHIBIN                       | Nurse cells of testes and follicle cells of ovaries | Stimulated by factors released by developing sperm (male) or developing follicles (female) | Inhibits secretion of FSH (and possibly GnRH)                                   |
Figure 19-16

The REPRODUCTIVE System

FIGURE 19-16 diagrams the functional relationships between the reproductive system and the other body systems.
22. Describe the interactions between the reproductive system and the cardiovascular system.

23. Describe the interactions between the reproductive system and the skeletal system.