27

The Reproductive System

Objectives

Anatomy of the Male Reproductive System

1. Explain the structure and function of the testes.
2. Describe the structure and function of the penis.
3. List and discuss the location, structure, and function of the male accessory ducts and glands.

Physiology of the Male Reproductive System

4. Define the male sexual response.
5. Describe the process of spermatogenesis.
6. Identify the hormonal regulation of the male reproductive function.
7. Name the male secondary sex characteristics and explain the role of testosterone in their formation.

Anatomy of the Female Reproductive System

8. Indicate the structure and function of the ovaries.
9. Describe the structure, function, and location of the female reproductive duct system.
10. Identify the structures of the female external genitalia.
11. Discuss the mammary glands and breast cancer.

Physiology of the Female Reproductive System

12. Explain the process of oogenesis.

13. Discuss the ovarian cycle including its three phases and their major events.
14. Indicate the hormonal interactions of the ovarian cycle.
15. Describe the uterine cycle.
16. Identify the effects of estrogen and progesterone on the development of structures and physiological processes other than the ovarian cycle.

Sexually Transmitted Diseases

17. Discuss the causative agents and modes of transmission of gonorrhea, syphilis, chlamydia, genital warts, and genital herpes.

Developmental Aspects of the Reproductive System: Chronology of Sexual Development

18. Identify what determines sex.
19. Discuss the process of sexual differentiation as it occurs in the developing embryo.
20. Explain the descent of the gonads.
21. Define and discuss puberty and menopause.

Lecture Outline

I. Anatomy of the Male Reproductive System (pp. 1064–1070, Figs. 27.1–27.4)

A. The scrotum is a sac of skin and superficial fascia that hangs outside the abdominopelvic cavity at the root of the penis and houses the testes.
   1. Provides an environment three degrees below the core body temperature.
   2. Responds to temperature changes.

B. The testes are the primary reproductive organ of the male, producing both sperm and testosterone.
   1. The testes are divided into lobules with seminiferous tubules inside, where sperm are produced.
   2. Interstitial cells are found in the connective tissue surrounding the seminiferous tubules and produce testosterone.

C. The penis is the copulatory organ, designed to deliver sperm into the female reproductive tract.
   1. The penis is made of an attached root, a free shaft or body that ends in the glans.
   2. The prepuce, or foreskin, covers the penis and may be slipped back to form a cuff around the glans.
   3. Internally the penis contains the corpus spongiosum and the corpora cavernosum, two erectile tissues.

D. The Male Duct System
   1. The epididymis consists of a highly coiled tube that provides a place for immature sperm to mature and to be expelled during ejaculation.
   2. The ductus deferens, or vas deferens, carries sperm from storage sites in the epididymis, through the inguinal canal, over the bladder, and into the ejaculatory duct.
   3. The urethra is the terminal portion of the male duct system and carries both urine and sperm (not at the same time) to the exterior environment.

E. Accessory Glands
   1. The seminal vesicles lie on the posterior bladder wall and their alkaline secretion accounts for 60% of the volume of semen consisting of fructose, ascorbic acid, a coagulating enzyme (vesiculase), and prostaglandins.
   2. The prostate gland is responsible for producing a milky, slightly acidic fluid containing citrate, several enzymes, and prostate-specific antigen, making up about one-third of the semen.

3. The bulbourethral glands, or Cowper's glands, produce a thick, clear mucus prior to ejaculation that neutralizes any acidic urine in the urethra.

F. Semen is a milky white, somewhat sticky mixture of sperm and accessory gland secretions that provides a transport medium for sperm.

II. Physiology of the Male Reproductive System (pp. 1070–1079, Figs. 27.5–27.10)

A. Male Sexual Response
   1. Erection, enlargement, and stiffening of the penis results from the engorgement of the erectile tissues with blood triggered during sexual excitement.
   2. Ejaculation is the propulsion of semen from the male duct system triggered by the sympathetic nervous system.

B. Spermatogenesis is the series of events in the seminiferous tubules that produce male gametes (sperm or spermatozoa).
   1. Meiosis consists of two consecutive nuclear divisions and the production of four daughter cells with half as many cells as a normal body cell.
      a. Meiosis I reduces the number of chromosomes in a cell from 46 to 23 by separating homologous chromosomes into different cells.
      b. Meiosis II resembles mitosis in every way, except the chromatids are separated into four cells.
   2. Summary of Events in the Seminiferous Tubules
      a. Spermatogenesis begins when the spermatogonia divide to produce type A daughter cells that maintain the stem cell line, and type B daughter cells that get pushed toward the lumen to become primary spermatocytes and ultimately sperm.
      b. Each primary spermatocyte undergoes meiosis I to produce two secondary spermatocytes, which then undergo meiosis II to form spermatids.
      c. Spermiogenesis is a streamlining process that strips the spermatid of excess cytoplasm and forms a tail resulting in a sperm with a head, a midpiece, and a tail.
      d. The sustentacular cells, or Sertoli cells, form a blood-testis barrier that prevents membrane-bound antigens from escaping into the blood-stream.

C. Hormonal Regulation of Male Reproductive Function
   1. Brain-testicular axis refers to the relationship and interactions between the hypothalamus, anterior pituitary gland, and the testes.
      a. The hypothalamus releases gonadotropin-releasing hormone (GnRH), which controls the release of the anterior pituitary hormones follicle-stimulating hormone (FSH) and luteinizing hormone (LH) in males.
      b. FSH indirectly stimulates spermatogenesis.
      c. LH, also called interstitial cell-stimulating hormone (ICSH), stimulates the interstitial cells to produce testosterone.
      d. Locally testosterone acts as a final trigger for spermatogenesis.
      e. Testosterone inhibits hypothalamic release of GnRH and acts directly on the anterior pituitary gland to inhibit gonadotropin release
      f. Inhibin is produced by the sustentacular cells and released when sperm count is high.
   2. Mechanism and Effects of Testosterone Activity
      a. Testosterone is synthesized from cholesterol and exerts its effects by activating specific genes to be transcribed.
      b. Testosterone targets accessory organs (ducts, glands, and penis) causing them to grow and assume adult size and function.

c. Testosterone induces male secondary sex characteristics: pubic, axillary, and facial hair, deepening of the voice, thickening of the skin and increase in oil production, and an increase in bone and skeletal muscle size and mass.

III. Anatomy of the Female Reproductive System (pp. 1079–1087, Figs. 27.11–27.18)

A. The ovaries are the primary reproductive organs of the female.
   1. The ovaries produce the female gametes (ova or egg) and the sex hormones (estrogens and progesterone).
   2. The paired ovaries are found on either side of the uterus and are held in place by several ligaments.
   3. Saclike structures called ovarian follicles consist of an immature egg, called an oocyte, encased by one or more layers of different cells.
   4. Follicles at different stages are distinguished by their structure as primordial follicles, primary follicles, secondary follicles, and Graafian or vesicular follicles.
   5. Ovulation occurs each month in adult women when one of the maturing follicles ejects its oocyte from the ovary.
   6. The ruptured follicle transforms into a glandular structure called the corpus luteum, which eventually degenerates.

B. The Female Duct System
   1. The uterine tubes, or fallopian tubes or oviducts, form the beginning of the female duct system, receive the ovulated oocyte, and provide a site for fertilization to take place.
   2. The uterus is a hollow, thick-walled muscular organ that functions to receive, retain, and nourish a fertilized ovum.
      a. The uterus is supported by the mesometrium, the lateral cervical ligaments, the uterosacral ligaments, and the round ligaments.
      b. The wall of the uterus is composed of three layers: the perimetrium, the myometrium, and the endometrium.
   3. The vagina provides a passageway for delivery of an infant and for menstrual blood, and also receives the penis and semen during sexual intercourse.

C. The external genitalia, also called the vulva or pudendum, include the mons pubis, labia, clitoris, and structures associated with the vestibule.

D. Mammary glands are present in both sexes but usually function only in females to produce milk to nourish a newborn baby.
   1. Mammary glands are modified sweat glands that are really part of the integumentary system.
   2. Breast cancer usually arises from the epithelial cells of the ducts and grows into a lump in the breast from which cells eventually metastasize.

IV. Physiology of the Female Reproductive System (pp. 1088–1096, Figs. 27.19–27.22, Table 27.1)

A. Oogenesis is the production of female gametes called oocytes, ova, or eggs.
   1. A female's total egg supply is determined at birth and the time in which she releases them extends from puberty to menopause.
   2. In the fetal period the oogonia multiply rapidly by mitosis, become primordial follicles, and then become primary follicles that begin the first meiotic division.
   3. After puberty a few oocytes are activated each month, but only one will continue meiosis I, ultimately producing two haploid cells, a polar body, and a secondary oocyte.

4. The secondary oocyte stops in metaphase II and if a sperm penetrates it, it will complete meiosis II, producing a second polar body and a large ovum.

B. The ovarian cycle is the monthly series of events associated with the maturation of the egg.
   1. The follicular phase is the period of follicle growth typically lasting from day 1 to 14.
   2. Ovulation occurs when the ovary wall ruptures and the secondary oocyte is expelled.
   3. The luteal phase is the period of corpus luteum activity, days 14–28.

C. Hormonal Regulation of the Ovarian Cycle
   1. During childhood, the ovaries grow and secrete small amounts of estrogen that inhibit the release of GnRH until puberty, when the hypothalamus becomes less sensitive to estrogen and begins to release GnRH in a rhythmic manner.
   2. Hormonal Interactions During the Ovarian Cycle
      a. On day 1 of the cycle, levels of GnRH rise and stimulate increased production and release of FSH and LH.
      b. FSH and LH stimulate follicle growth and maturation, and estrogen secretion.
      c. Rising levels of estrogen in the plasma exert negative feedback on the anterior pituitary, inhibiting release of FSH and LH.
      d. Estrogen exerts positive feedback on the anterior pituitary resulting in a burst of LH triggering ovulation and transforming the ruptured follicle into the corpus luteum.
      e. Rising plasma levels of progesterone and estrogen exert a negative feedback on LH and FSH release.
      f. LH levels fall and luteal activity ends; the corpus luteum degenerates dropping the levels of estrogen and progesterone and the cycle starts again.

D. The uterine (menstrual) cycle is a series of cyclic changes that the uterine endometrium goes through each month in response to changing levels of ovarian hormones in the blood.
   1. The menstrual phase takes place on days 1–5 typically, and is the time when the endometrium is shed from the uterus.
   2. The proliferation phase (days 6–14) is the time in which the endometrium is rebuilt once again becoming velvety, thick, and well vascularized.
   3. The secretory phase (days 15–28) is the phase in which the endometrium prepares for implantation of an embryo.

E. Extrauterine Effects of Estrogens and Progesterone
   1. Rising estrogen levels promote oogenesis and follicle growth in the ovary, as well as growth and function of the female reproductive structures.
   2. Estrogens also cause the epiphyses of the long bones to close during growth spurts in puberty.
   3. The estrogen-induced secondary sex characteristics of females include growth of breasts, increased deposition of subcutaneous fat in the hips and breast, widening and lightening of the pelvis, growth of pubic and axillary hair, and metabolic changes.
   4. Progesterone works with estrogen to establish and help regulate the uterine cycle, and promotes changes in cervical mucus.

F. In the female sexual response, the clitoris, vaginal mucosa, and breasts become engorged with blood; the nipples erect; vestibular glands increase in activity; and the final phase is orgasm.

V. Sexually Transmitted Diseases (pp. 1096–1097, Fig. 27.23)

A. Gonorrhea is caused by Neisseria gonorrhoeae bacteria, which invade the mucosae of the reproductive and urinary tracts.

B. Syphilis is caused by Treponema pallidum, a bacteria that easily penetrate intact mucosae and abraded skin, and enter the lymphatics and the bloodstream.
C. Chlamydia is the most common sexually transmitted disease in the U.S. and is caused by the bacteria Chlamydia trachomatis.
D. Genital warts are caused by a group of about 60 viruses known as the human papillomavirus (HPV).
E. Genital herpes is generally caused by the herpes simplex virus type 2, which is transferred via infectious secretions.

VI. Developmental Aspects of the Reproductive System: Chronology of Sexual Development (pp. 1097–1102, Figs. 27.24–27.26)

A. Embryological and Fetal Events
   1. Sex is determined by the sex chromosomes at conception; females have two X chromosomes and males have an X and a Y chromosome.
   2. Sexual Differentiation of the Reproductive System
      a. The gonads of both males and females begin to develop during week 5 of gestation.
      b. During week 7 the gonads begin to become testes in males, and in week 8 they begin to form ovaries in females.
      c. The external genitalia arise from the same structures in both sexes, with differentiation occurring in week 8.
   3. About two months before birth the testes begin their descent toward the scrotum, dragging their nerve supply and blood supply with them.

B. Puberty is the period of life, generally between the ages of 10 and 15 years, when the reproductive organs grow to adult size and become functional.
C. Ovarian function declines gradually with age; menstrual cycles become more erratic and shorter until menopause, when ovulation and menstruation stop entirely.

Cross References

Additional information on topics covered in Chapter 27 can be found in the chapters listed below.

1. Chapter 3: Cell division; tight junctions; organelles; microvilli
2. Chapter 4: Pseudostratified epithelium; tubuloalveolar glands
3. Chapter 9: Peristalsis (smooth muscle contraction)
4. Chapter 10: Male and female perineum; muscles of the pelvic floor
5. Chapter 12: Testosterone and brain anatomy
6. Chapter 13: Reflex activity
7. Chapter 14: Sympathetic and parasympathetic effects
8. Chapter 16: Brain-testicular axis; prostaglandins; testosterone; FSH and LH; ovaries and estrogen
9. Chapter 25: Male urethra
10. Chapter 28: Fertilization; vaginal environment and sperm viability; passage of sperm through the female reproductive tract in preparation of fertilization; relationship of spermatozoon and oocyte structure related to fertilization; uterine function in reproduction; interruption of uterine and ovarian cycles by pregnancy; completion of meiosis II
11. Chapter 29: Meiosis as related to genetics; importance of tetrad formation and recombination

Laboratory Correlations

1. Marieb, E. N. Human Anatomy & Physiology Laboratory Manual: Cat and Fetal Pig Versions. Seventh Edition Updates. Benjamin Cummings, 2002.

Exercise 42: Anatomy of the Reproductive System

Exercise 43: Physiology of Reproduction: Gametogenesis and the Female Cycles

2. Marieb, E. N. Human Anatomy & Physiology Laboratory Manual: Main Version. Sixth Edition Update. Benjamin Cummings, 2002.

   Exercise 42: Anatomy of the Reproductive System

   Exercise 43: Physiology of Reproduction: Gametogenesis and the Female Cycles