Structures of the Reproductive System

- **Gonads**: organs that produce gametes and hormones
- **Ducts**: receive and transport gametes
- **Accessory glands**: secrete fluids into ducts
- **Perineal structures**: collectively known as external genitalia
Structures of the Reproductive System

- The Reproductive Tract
  - Includes all chambers and passageways that connect ducts to the exterior of the body
Structures of the Reproductive System

- Male and Female Reproductive Systems
  - Are functionally different
  - Female produces one gamete per month
    - Retains and nurtures zygote
  - Male disseminates large quantities of gametes
    - Produces 1/2 billion sperm per day
Structures of the Reproductive System

- The Male Reproductive System
  - **Testes** or male gonads
    - Secrete male sex hormones (androgens)
    - Produce male gametes (spermatozoa or sperm)
Structures of the Reproductive System

- **The Female Reproductive System**
  - **Ovaries** or female gonads
    - Release one immature gamete (**oocyte**) per month
    - Produce hormones
  - **Uterine tubes**
    - Carry oocytes to uterus:
      - if sperm reaches oocyte, fertilization is initiated and oocyte matures into **ovum**
  - **Uterus**
    - Encloses and supports developing embryo
  - **Vagina**
    - Connects uterus with exterior
Male Reproductive Functions

- **Pathway of Spermatozoa**
  - Testis
  - Epididymis
  - Ductus deferens (vas deferens)
  - Ejaculatory duct
  - Urethra
Male Reproductive Functions

- Accessory Organs
  - Secrete fluids into ejaculatory ducts and urethra
    - Seminal glands (vesicles)
    - Prostate gland
    - Bulbo-urethral glands
Male Reproductive Functions

- External Genitalia
  - Scrotum
    - Encloses testes
  - Penis
    - Erectile organ
    - Contains distal portion of urethra
Figure 28–1 The Male Reproductive System.
Male Reproductive Functions

- The Testes
  - Egg shaped
  - 5 cm long, 3 cm wide, 2.5 cm thick (2 in. x 1.2 in. x 1 in.)
  - Weighs 10–15 g (0.35-0.53 oz)
  - Hangs in scrotum
The Scrotum

- Is a fleshy pouch
- Suspended inferior to perineum
- Anterior to anus
- Posterior to base of penis
Male Reproductive Functions

- **Descent of the Testes**
  - Testes form inside body cavity
    - Are adjacent to kidneys
  - **Gubernaculum testis**
    - Is a bundle of connective tissue fibers
    - Extends from testis to pockets of peritoneum
    - Locks testes in position (near anterior abdominal wall) as fetus grows
Male Reproductive Functions

- Descent of the Testes
  - During seventh month
    - Fetus grows rapidly
  - Circulating hormones
    - Stimulate contraction of gubernaculum testis
  - Each testis
    - Moves through abdominal musculature
    - Is accompanied by pockets of peritoneal cavity
Male Reproductive Functions

Figure 28–2a The Descent of the Testes.
Male Reproductive Functions

Figure 28–2b The Descent of the Testes.
Figure 28–2b The Descent of the Testes.
Male Reproductive Functions

- Accessory Structures
  - Accompany testis during descent
  - Form body of **spermatic cord**
    - Ductus deferens
    - Testicular blood vessels, nerves, and lymphatic vessels
Male Reproductive Functions

- The Spermatic Cords
  - Extend between abdominopelvic cavity and testes
  - Consist of layers of fascia and muscle
  - Enclose ductus deferens, blood vessels, nerves, and lymphatic vessels of testes
  - Pass through **inguinal canal**
    - Are passageways through abdominal musculature
    - Form during development as testes descend into scrotum
  - Descend into scrotum
Male Reproductive Functions

- Blood Vessels of Testes
  - Deferential artery
  - Testicular artery
  - Pampiniform plexus of testicular vein

- Nerves of Testes
  - Branches of genitofemoral nerve
    - From lumbar plexus
Male Reproductive Functions

- **Male Inguinal Hernias**
  - Are protrusions of visceral tissues into inguinal canal
  - Spermatic cord (in closed inguinal canal)
    - Causes weak point in abdominal wall

- **Female Inguinal Canals**
  - Are very small
  - Contain ilioinguinal nerves and round ligaments of uterus
Male Reproductive Functions

Figure 28–3 The Male Reproductive System in Anterior View.
Male Reproductive Functions

- The Scrotum and the Position of the Testes
  - Is divided into two chambers, or **scrotal cavities**
  - Each testis lies in a separate scrotal chamber
- Raphe
  - Is a raised thickening in scrotal surface
  - Marks partition of two scrotal chambers
Male Reproductive Functions

- **Tunica Vaginalis**
  - Is a serous membrane
  - Lines scrotal cavity
  - Reduces friction between opposing surfaces
    - Parietal (scrotal)
    - Visceral (testicular)
Male Reproductive Functions

- **The Dartos Muscle**
  - Is a layer of smooth muscle in dermis of scrotum
  - Causes characteristic wrinkling of scrotal surface

- **The Cremaster Muscle**
  - Is a layer of skeletal muscle deep to dermis
  - Tenses scrotum and pulls testes closer to body
    (temperature regulation)
Male Reproductive Functions

- Temperature Regulation
  - Normal sperm development in testes
    - Requires temperatures 1.1°C (2°F) lower than body temperature
  - Muscles relax or contract
    - To move testes away or toward body
    - To maintain acceptable testicular temperatures
Male Reproductive Functions

- Structure of the Testes
  - Tunica Albuginea
    - Is deep to tunica vaginalis
    - A dense layer of connective tissue rich in collagen fibers
    - Continuous with fibers surrounding epididymis
    - Fibers extend into substance of testis and form fibrous partitions, or septa, that converge near entrance to epididymis
    - Supports blood and lymphatic vessels of testis and efferent ductules
Male Reproductive Functions

- Histology of the Testes
  - Septa subdivide testis into lobules
  - Lobules contain about 800 slender and tightly coiled seminiferous tubules
    - Produce sperm
    - Each is about 80 cm (32 in.) long
    - Testis contains about 1/2 mile of tightly coiled seminiferous tubules:
      - Form a loop connected to rete testis, a network of passageways
Male Reproductive Functions

- **Efferent Ductules**
  - 15–20 large *efferent ductules*
    - Connect rete testis to epididymis
Figure 28-4 The Structure of the Testes.
Male Reproductive Functions

- Connective Tissue Capsules
  - Surround tubules
  - Areolar tissue fills spaces between tubules
  - Within those spaces, there are
    - Blood vessels
    - Large **interstitial cells** (cells of Leydig):
      - produce androgens: dominant male sex hormones
      - testosterone is the most important androgen
Male Reproductive Functions

- **Spermatogenesis**
  - Is the process of sperm production
  - Begins at outermost cell layer in **seminiferous tubules**
  - Proceeds toward lumen
Male Reproductive Functions

Five Cells of Spermatogenesis

1. **Spermatogonia** (stem cells) divide by mitosis to produce two daughter cells:
   - One remains as spermatogonium
   - Second differentiates into primary spermatocyte

2. **Primary spermatocytes** begin meiosis and form secondary spermatocytes

3. **Secondary spermatocytes** differentiate into spermatids (immature gametes)
Male Reproductive Functions

Five Cells of Spermatogenesis

4. Spermatids:
   - Differentiate into spermatozoa

5. Spermatozoa:
   - Lose contact with wall of seminiferous tubule
   - Enter fluid in lumen
Male Reproductive Functions

Figure 28–5a The Seminiferous Tubules.
Male Reproductive Functions

Figure 28-5b The Seminiferous Tubules.
Figure 28–5c The Seminiferous Tubules: Stages in Spermatogenesis.
Male Reproductive Functions

Figure 28–5d The Seminiferous Tubules: Stages in Spermatogenesis.
Male Reproductive Functions

- Contents of Seminiferous Tubules
  - Spermatogonia
  - Spermatocytes at various stages of meiosis
  - Spermatids
  - Spermatozoa
  - Large nurse cells (also called sustentacular cells or Sertoli cells)
    - Are attached to tubular capsule
    - Extend to lumen between other types of cells
Male Reproductive Functions

- Spermatogenesis
  - Involves three integrated processes
    - Mitosis
    - Meiosis
    - Spermiogenesis
Male Reproductive Functions

- Mitosis
  - Is part of somatic cell division
  - Produces two diploid daughter cells
    - Both have identical pairs of chromosomes
Male Reproductive Functions

- **Meiosis**
  - Is a special form of cell division involved only in production of **gametes**
    - Spermatozoa in males
    - Oocytes in females
  - Gametes contain 23 chromosomes, half the normal amount
  - Fusion of male and female gametes produces **zygote** with 46 chromosomes
  - In seminiferous tubules
    - Begins with primary spermatocytes
    - Produces spermatids (undifferentiated male gametes)
Male Reproductive Functions

- Spermiogenesis
  - Begins with spermatids
    - Small, relatively unspecialized cells
  - Involves major structural changes
  - Spermatids differentiate into mature spermatozoa
    - Highly specialized cells
Male Reproductive Functions

- Mitosis and Meiosis
  - Meiosis I and meiosis II
    - Produce four \textbf{haploid} cells, each with 23 chromosomes
  - Prophase I
    - Chromosomes condense
    - Each chromosome has two chromatids
    - \textbf{Synapsis}:
      - maternal and paternal chromosomes come together
      - four matched chromatids form \textbf{tetrad}
    - Crossing over: exchange of genetic material that increases genetic variation among offspring
Male Reproductive Functions

- Mitosis and Meiosis
  - Metaphase I
    - Tetrads line up along metaphase plate
    - Independent assortment:
      - as each tetrad splits
      - maternal and paternal components are randomly distributed
  - Anaphase I
    - Maternal and paternal chromosomes separate
    - Each daughter cell receives whole chromosome:
      - maternal or paternal
Male Reproductive Functions

- Mitosis and Meiosis
  - Telophase I ends
    - With formation of two daughter cells
    - With unique combinations of chromosomes
  - Both cells contain 23 chromosomes with two chromatids each (reductional division)
Male Reproductive Functions

- Mitosis and Meiosis
  - Interphase
    - Separates meiosis I and meiosis II
    - Is very brief
    - DNA is not replicated
Male Reproductive Functions

- Mitosis and Meiosis
  - Meiosis II
    - Proceeds through prophase II and metaphase II
  - Anaphase II
    - Duplicate chromatids separate
  - Telophase II
    - Yields four cells, each containing 23 chromosomes
      (equational division)
Figure 28–6 Chromosomes in Mitosis and Meiosis.
Figure 28–7 Spermatogenesis.
Male Reproductive Functions

- Spermiogenesis
  - Is the last step of spermatogenesis
  - Each spermatid matures into one spermatozoon (sperm)
    - Attached to cytoplasm of nurse cells
Male Reproductive Functions

- **Spermiation**
  - At spermiation, a spermatozoon
    - Loses attachment to nurse cell
    - Enters lumen of seminiferous tubule
  - Spermatogonial division to spermiation
    - Takes about 9 weeks
Male Reproductive Functions

- Nurse Cells
  - Affect
    - Mitosis
    - Meiosis
    - Spermiogenesis in seminiferous tubules
Male Reproductive Functions

- Six Major Functions of Nurse Cells
  1. Maintain blood–testis barrier
  2. Support mitosis and meiosis
  3. Support spermiogenesis
  4. Secrete inhibin
  5. Secrete androgen—binding protein (ABP)
  6. Secrete Müllerian—inhibiting factor (MIF)
Male Reproductive Functions

- **Maintenance of Blood–Testis Barrier**
  - Blood–testis barrier isolates seminiferous tubules
  - Nurse cells are joined by tight junctions that divide seminiferous tubule into compartments
    - **Outer basal compartment** contains spermatogonia
    - **Inner lumenal compartment**, or adlumenal compartment, is where meiosis and spermiogenesis occur
Male Reproductive Functions

- Support of Mitosis and Meiosis
  - Nurse cells are stimulated by
    - Follicle-stimulating hormone (FSH)
    - Testosterone
  - Stimulated nurse cells promote
    - Division of spermatogonia
    - Meiotic divisions of spermatocytes
Male Reproductive Functions

- Support of Spermiogenesis
  - Nurse cells
    - Surround and enfold spermatids
    - Provide nutrients and chemical stimuli for development
    - Phagocytize cytoplasm shed by developing spermatids
Male Reproductive Functions

- **Inhibin**
  - Is a peptide hormone secreted by nurse cells in response to factors released by spermatozoa
  - Depresses
    - Pituitary production of FSH
    - Hypothalamic secretion of GnRH
  - Regulation of FSH and GnRH by Inhibin
    - Gives nurse cells feedback control of spermatogenesis
    - After division, increases inhibin production
Male Reproductive Functions

- Androgen-Binding Protein (ABP)
  - Binds androgens (primarily testosterone)
    - In seminiferous tubule fluid
  - Is important in
    - Elevating androgen in seminiferous tubules
    - Stimulating spermiogenesis
  - Production of ABP is stimulated by FSH
Male Reproductive Functions

- Müllerian-Inhibiting Factor (MIF)
  - Is secreted by nurse cells in developing testes
  - Causes regression of fetal Müllerian (paramesonephric) ducts
    - Help form uterine tubes and uterus in females
    - In males, inadequate MIF production leads to:
      - retention of ducts
      - failure of testes to descend into scrotum
Male Reproductive Functions

- Sperm Structure
  - Head
  - Neck (attaches head to middle piece)
  - Middle piece
  - Tail
Male Reproductive Functions

- Anatomy of a Spermatozoon
  - Head
    - A flattened ellipse that contains nucleus and chromosomes
    - Acrosomal cap at tip of head:
      - is a membranous compartment that contains enzymes essential to fertilization
      - made of fused saccules of spermatid’s Golgi apparatus
Male Reproductive Functions

- Anatomy of a Spermatozoon
  - Middle piece
    - Contains mitochondria:
      - in spiral around microtubules
      - activity provides ATP to move tail
Male Reproductive Functions

- Anatomy of a Spermatozoon
  - Tail
    - Is the only flagellum in the human body
      - is a whiplike organelle
      - moves cell from one place to another
      - has complex, corkscrew motion
Male Reproductive Functions

Figure 28–8a Spermiogenesis and Spermatozoon Structure.
Figure 28–8b Spermiogenesis and Spermatozoon Structure.
Male Reproductive Functions

- Mature spermatozoon lacks
  - Endoplasmic reticulum
  - Golgi apparatus
  - Lysosomes and peroxisomes
  - Inclusions and other intracellular structures

- Loss of these organelles reduces sperm size and mass

- Sperm must absorb nutrients (fructose) from surrounding fluid
Male Reproductive Functions

- **Sperm Maturation**
  - Testes produce physically mature spermatozoa that can NOT fertilize an oocyte
  - Other parts of the reproductive system are responsible for
    - Functional maturation, nourishment, storage, and transport
Male Reproductive Functions

- Sperm Maturation
  - Spermatozoa
    - Detach from nurse cells
    - Are free in lumen of seminiferous tubule
    - Are functionally immature:
      - are incapable of locomotion or fertilization
      - are moved by cilia lining efferent ductules into the epididymis
The **Epididymis**

- Is the start of male reproductive tract
- Is a coiled tube almost 7 m (23 ft) long
  - Bound to posterior border of testis
- Has a **head**, a **body**, and a **tail**
Male Reproductive Functions

- **Epididymis: Head**
  - Is proximal to the testis
  - Receives spermatozoa from efferent ductules

- **Epididymis: Body**
  - From last efferent ductule to posterior margin of testis

- **Epididymis: Tail**
  - Begins near inferior border of testis where number of coils decreases
  - Re-curves and ascends to connection with ductus deferens
  - Primary storage location of spermatozoa
Figure 28–9 The Epididymis.
Figure 28–9 The Epididymis.
Male Reproductive Functions

- Functions of the Epididymis
  1. Monitors and adjusts fluid produced by seminiferous tubules
  2. Recycles damaged spermatozoa
  3. Stores and protects spermatozoa
     - Facilitates functional maturation
Male Reproductive Functions

- Spermatozoa Leaving Epididymis
  - Are mature, but remain immobile
  - To become motile (actively swimming) and functional
    - Spermatozoa undergo **capacitation**
Male Reproductive Functions

- **Steps in Capacitation**
  1. Spermatozoa become motile:
     - When mixed with secretions of seminal glands
  2. Spermatozoa become capable of fertilization:
     - When exposed to female reproductive tract
The **Ductus Deferens** (or *vas deferens*)

- Is 40–45 cm (16-18 in.) long
- Begins at tail of the epididymis and, as part of spermatic cord, ascends through inguinal canal
- Curves inferiorly along urinary bladder
  - Toward prostate gland and seminal glands
- Lumen enlarges into **ampulla**
- Wall contains thick layer of smooth muscle
Male Reproductive Functions

- The Ductus Deferens
  - Is lined by ciliated epithelium
    - Peristaltic contractions propel spermatozoa and fluid
  - Can store spermatozoa for several months
    - In state of suspended animation (low metabolic rates)
Male Reproductive Functions

Figure 28–10a The Ductus Deferens and Accessory Glands
Figure 28–10b The Ductus Deferens and Accessory Glands

(b) Ductus deferens

Lumen of ductus deferens

Smooth muscle

SEM × 42

LM × 120

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Male Reproductive Functions

- The **Ejaculatory Duct**
  - Is a short passageway (2 cm; less than 1 in.)
    - At junction of ampulla and seminal gland duct
  - Penetrates wall of prostate gland
  - Empties into urethra
Male Reproductive Functions

- **The Male Urethra**
  - Is used by urinary and reproductive systems
  - Extends 18–20 cm (7-8 in.) from urinary bladder to tip of penis
  - Is divided into three regions:
    - Prostatic
    - Membranous
    - Spongy
Male Reproductive Functions

- **Seminal Fluid**
  - Is a mixture of secretions from many glands
    - Each with distinctive biochemical characteristics
  - Important glands include
    - Seminal glands
    - Prostate gland
    - Bulbo-urethral glands
Male Reproductive Functions

- 4 Major Functions of Male Glands
  1. Activating spermatozoa
  2. Providing nutrients spermatozoa need for motility
  3. Propelling spermatozoa and fluids along reproductive tract
    - Mainly by peristaltic contractions
  4. Producing buffers
    - To counteract acidity of urethral and vaginal environments
Male Reproductive Functions

- **The Seminal Glands**
  - Each gland is about 15 cm (6 in.) long with short side branches from body
  - Are tubular glands coiled and folded into 5 cm by 2.5 cm (2 in. x 1 in.) mass
  - Are extremely active secretory glands
  - Produce about 60% of semen volume
Male Reproductive Functions

- **Vesicular (Seminal) Fluid**
  - Has same osmotic concentration as blood plasma but different composition
    - High concentrations of fructose: easily metabolized by spermatozoa
    - Prostaglandins: stimulate smooth muscle contractions (male and female)
    - Fibrinogen: forms temporary clot in vagina
  - Is slightly alkaline
    - To neutralize acids in prostate gland and vagina
  - Initiates first step in capacitation
    - Spermatozoa begin beating flagella, become highly motile
Male Reproductive Functions

- Vesicular (Seminal) Fluid
  - Is discharged into **ejaculatory duct** at emission
    - When peristaltic contractions are underway
    - Contractions are controlled by sympathetic nervous system
Figure 28–10a The Ductus Deferens and Accessory Glands.
Male Reproductive Functions

Figure 28–10c The Ductus Deferens and Accessory Glands.

(c) Seminal gland

Secretory pockets
Lumen
Smooth muscle

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The **Prostate Gland**

- Is a small, muscular organ, about 4 cm (1.6 in.) in diameter
- Encircles proximal portion of urethra
  - Below urinary bladder
- Consists of 30–50 compound tubuloalveolar glands
- Surrounded by smooth muscle fibers
Male Reproductive Functions

- Prostatic Fluid
  - Is slightly acidic
  - Forms 20–30% of semen volume
  - Contains antibiotic *seminalplasmin*
  - Is ejected into prostatic urethra
    - By peristalsis of prostate wall
Figure 28–10a The Ductus Deferens and Accessory Glands
Male Reproductive Functions

(e) Prostate gland

Connective tissue and smooth muscle

Prostatic (tubuloalveolar) glands

Figure 28–10e The Ductus Deferens and Accessory Glands
The Bulbo-urethral Glands (or Cowper glands)

- Are compound, tubular mucous glands
- Round shaped, up to 10 mm (less than 0.5 in.) diameter
- Located at base of penis
- Covered by fascia of urogenital diaphragm
- Secrete thick, alkaline mucus
  - Helps neutralize urinary acids in urethra
  - Lubricates the **glans** (penis tip)
- Duct of each gland travels alongside penile urethra and empties into urethral lumen
Figure 28–10a The Ductus Deferens and Accessory Glands.
Figure 28–10d The Ductus Deferens and Accessory Glands.

(d) Bulbo-urethral gland

Smooth muscle
Capsule
Mucous glands

Lumen

LM × 175
Male Reproductive Functions

- **Semen**
  - Typical ejaculation releases 2–5 mL
  - Abnormally low volume may indicate problems
    - With prostate gland or seminal glands
  - Sperm count
    - Is taken of semen collected after 36 hours of sexual abstinence
    - Normal range: 20–100 million spermatozoa/mL of **ejaculate**
Male Reproductive Functions

- **Ejaculate**
  - Is the volume of fluid produced by ejaculation
  - Contains
    - Spermatozoa
    - Seminal fluid
    - Enzymes: including protease, seminalplasmin, prostatic enzyme, and fibrinolysin
Male Reproductive Functions

- Male External Genitalia
  - The *penis*
    - Is a tubular organ through which distal portion of urethra passes
    - Conducts urine to exterior
    - Introduces semen into female vagina
Male Reproductive Functions

- **The Penis**
  - **The root**
    - Is the fixed portion that attaches penis to body wall
    - Attachment occurs within urogenital triangle, inferior to pubic symphysis
  - **The body (shaft)**
    - Is the tubular, movable portion of the penis
    - Consists of three cylindrical columns of erectile tissue
  - **The glans**
    - Is the expanded distal end of penis that surrounds external urethral orifice
Figure 28–11a A Frontal Section through the Penis and Associated Organs.
Male Reproductive Functions

Figure 28–11b A Sectional View through the Penis.

- Dorsal artery (red), vein (blue), and nerve (yellow)
- Corpora cavernosa
- Dartos muscle
- Deep artery of penis
- Collagenous sheath
- Spongy urethra
- Corpus spongiosum
Male Reproductive Functions

Figure 28–11c An Anterior and Lateral View of the Penis.
Male Reproductive Functions

- Dermis of the Penis
  - Contains a layer of smooth muscle
    - A continuation of dartos muscle
  - Underlying areolar tissue
    - Allows skin to move freely
- Subcutaneous layer
  - Contains superficial arteries, veins, and lymphatic vessels
Male Reproductive Functions

- The **Prepuce** (or *foreskin*)
  - Is a fold of skin surrounding tip of penis
  - Attaches to neck and continues over glans
    - **Preputial glands:**
      - in skin of neck and inner surface of prepuce
      - secrete waxy material (**smegma**) that can support bacteria
      - **circumcision** can help prevent infection
Male Reproductive Functions

- Erectile Tissue
  - In body of penis
  - Located deep to areolar tissue
  - In dense network of elastic fibers
    - That encircles internal structures of penis
  - Consists of network of vascular channels
    - Incompletely separated by partitions of elastic connective tissue and smooth muscle fibers
  - In resting state
    - Arterial branches are constricted
    - Muscular partitions are tense
    - Blood flow into erectile tissue is restricted
The **Corpora Cavernosa**

- Two cylindrical masses of erectile tissue
  - Under anterior surface of flaccid penis
  - Separated by thin septum
  - Encircled by dense collagenous sheath
- Diverge at their bases, forming the **crura** of penis
- Each crus is bound to ramus of ischium and pubis
  - By tough connective tissue ligaments
- Extends to neck of penis
- Erectile tissue surrounds a central artery
Male Reproductive Functions

- The **Corpus Spongiosum**
  - Relatively slender erectile body that surrounds penile urethra
  - Extends from urogenital diaphragm to tip of penis and expands to form the glans
  - Is surrounded by a sheath
    - With more elastic fibers than corpora cavernosa
  - Erectile tissue contains a pair of small arteries
Male Reproductive Functions

- **Hormones and Male Reproductive Function**
  - Adenohypophysis releases:
    - Follicle—stimulating hormone (FSH)
    - Luteinizing hormone (LH)
  - In response to
    - Gonadotropin-releasing hormone (GnRH)
Male Reproductive Functions

- Gonadotropin-Releasing Hormone
  - Is synthesized in hypothalamus
    - Carried to pituitary by hypophyseal portal system
  - Is secreted in pulses
    - At 60–90 minute intervals
  - Controls rates of secretion of
    - FSH and LH
    - Testosterone (released in response to LH)
Male Reproductive Functions

- FSH and Testosterone
  - Target nurse cells of seminiferous tubules
  - Nurse cells
    - Promote spermatogenesis and spermiogenesis
    - Secrete androgen-binding protein (ABP)
Male Reproductive Functions

- **Negative Feedback**
  - Spermatogenesis is regulated by
    - GnRH, FSH, and inhibin
  - As spermatogenesis accelerates
    - Inhibin secretion increases
Male Reproductive Functions

- **Inhibin**
  - Inhibits FSH production
    - In adenohypophysis (anterior pituitary gland)
  - Suppresses secretion of GnRH
    - At hypothalamus
Male Reproductive Functions

- Inhibin and FSH
  - Elevated FSH levels
    - Increase inhibin production
    - Until FSH returns to normal
  - If FSH declines
    - Inhibin production falls
    - FSH production increases
Male Reproductive Functions

- Luteinizing Hormone
  - Targets interstitial cells of testes
  - Induces secretion of
    - Testosterone
    - Other androgens
Male Reproductive Functions

- **Testosterone**
  - Is the most important androgen
  - Stimulates spermatogenesis
    - Promoting functional maturation of spermatozoa
  - Affects CNS function
    - Libido (sexual drive) and related behaviors
  - Stimulates metabolism
    - Especially protein synthesis
    - Blood cell formation
    - Muscle growth
Male Reproductive Functions

- Testosterone
  - Establishes male secondary sex characteristics
    - Distribution of facial hair
    - Increased muscle mass and body size
    - Characteristic adipose tissue deposits
  - Maintains accessory glands and organs of male reproductive tract
Male Reproductive Functions

Figure 28–12 Hormonal Feedback and the Regulation of Male Reproductive Function.
Male Reproductive Functions

- **Testosterone**
  - Functions like other steroid hormones
    - Circulating in bloodstream
    - Bound to one of two types of transport proteins:
      - gonadal steroid-binding globulin (GBG):
        » carries 2/3 of circulating testosterone
      - albumins:
        » carry 1/3 of testosterone
Male Reproductive Functions

- Testosterone
  - Diffuses across target cell membrane
  - Binds to intracellular receptor
  - Hormone–receptor complex
    - Binds to DNA in nucleus
Male Reproductive Functions

- **Testosterone and development**
  - Production begins around seventh week of fetal development and reaches prenatal peak after 6 months
  - Secretion of Müllerian inhibiting factor by nurse cells leads to regression of Müllerian ducts
  - Early surge in testosterone levels stimulates differentiation of male duct system and accessory organs and affects CNS development
  - Testosterone programs hypothalamic centers that control:
    1. GnRH, FSH, and LH secretion
    2. Sexual behaviors
    3. Sexual drive
Male Reproductive Functions

- Estradiol
  - Is produced in relatively small amounts (2 ng/dL)
  - 70% is converted from circulating testosterone
    - By enzyme aromatase
  - 30% is secreted by interstitial and nurse cells of testes
The Female Reproductive System

- Produces sex hormones and functional gametes
- Protects and supports developing embryo
- Nourishes newborn infant
The Female Reproductive System

- Organs of the Female Reproductive System
  - Ovaries
  - Uterine tubes
  - Uterus
  - Vagina
  - External genitalia
Figure 28–13 The Female Reproductive System.
The Female Reproductive System

- **Structural Support**
  - Ovaries, uterine tubes, and uterus are enclosed in 
    **broad ligament**
  - **Uterine tubes**
    - Run along broad ligament
    - Open into pelvic cavity lateral to ovaries
  - **The mesovarium**
    - Stabilizes position of each ovary
Figure 28–14 The Ovaries and Their Relationships to the Uterine Tube and Uterus.
The Female Reproductive System

Figure 28–14 The Ovaries and Their Relationships to the Uterine Tube and Uterus.

(b) Ovary and mesenteries, sectional view
The Female Reproductive System

- **Ovaries**
  - Are small, almond-shaped organs near lateral walls of pelvic cavity
  - Three main functions
    - Production of immature female **gametes** (oocytes)
    - Secretion of female sex hormones (estrogens, progestins)
    - Secretion of inhibin, involved in feedback control of pituitary FSH
The Female Reproductive System

- **Ovary Support**
  - **Mesovarium**
  - Ovarian ligament extends from uterus to ovary
  - Suspensory ligament extends from ovary to pelvic wall
    - Contains the *ovarian artery* and *ovarian vein*
    - These vessels connect to ovary at *ovarian hilum*, where ovary attaches to mesovarium
The Female Reproductive System

- The Visceral Peritoneum of the Ovary
  - Also called germinal epithelium
  - Covers surface of ovary
  - Consists of columnar epithelial cells
  - Overlies *tunica albuginea*
The Female Reproductive System

- The **Stroma**
  - Are interior tissues of ovary
    - Superficial cortex
    - Deeper medulla
  - Gametes are produced in cortex
The Female Reproductive System

- **Oogenesis**
  - Also called ovum production
  - Begins before birth
  - Accelerates at puberty
  - Ends at menopause
The Female Reproductive System

Figure 28–15 Oogenesis.
The Female Reproductive System

- The Ovarian Cycle
  - Includes monthly oogenesis
    - Between puberty and menopause
The Female Reproductive System

- **Fetal Development**
  - Between third and seventh months
    - Primary oocytes prepare for meiosis
    - Stop at prophase of meiosis I

- **Atresia**
  - Is the degeneration of primordial follicles:
  - Ovaries have about 2 million primordial follicles at birth
    - Each containing a primary oocyte
  - By puberty
    - Number drops to about 400,000
The Female Reproductive System

- **Process of Oogenesis**
  - Primary oocytes remain in suspended development until puberty
  - At puberty
    - Rising FSH triggers start of ovarian cycle
  - Each month thereafter
    - Some primary oocytes are stimulated to develop further
The Female Reproductive System

- **Oogenesis: Two Characteristics of Meiosis**
  - Cytoplasm of primary oocyte divides unevenly
    - Producing one ovum (with original cytoplasm)
    - And two or three polar bodies (that disintegrate)
  - Ovary releases secondary oocyte (not mature ovum)
    - Suspended in metaphase of meiosis II
    - Meiosis is completed upon fertilization
The Female Reproductive System

- Ovarian Follicles
  - Are specialized structures in cortex of ovaries
    - Where oocyte growth and meiosis I occur
  - Primary oocytes
    - Are located in outer part of ovarian cortex:
      - near tunica albuginea
      - in clusters called egg nests
The Female Reproductive System

- **Primordial Follicle**
  - Each primary oocyte in an egg nest
    - Is surrounded by follicle cells
  - Primary oocyte and follicle cells form a **primordial follicle**
The Female Reproductive System

- **Ovarian Cycle**
  - After sexual maturation
    - A different group of primordial follicles is activated each month
  - Is divided into
    - **Follicular phase** (preovulatory phase)
    - **Luteal phase** (postovulatory phase)
The Female Reproductive System

Figure 28–16 The Ovarian Cycle.
Figure 28–16 The Ovarian Cycle.
Figure 28–16 The Ovarian Cycle.
Figure 28–16 The Ovarian Cycle.
The Female Reproductive System

Figure 28–16 The Ovarian Cycle.
The Female Reproductive System

Figure 28–16 The Ovarian Cycle.
Figure 28–16 The Ovarian Cycle.
The Female Reproductive System

- **The Uterine Tubes**
  - Fallopian tubes or oviducts
  - Are hollow, muscular tubes about 13 cm (5.2 in.) long
  - Transport oocyte from ovary to uterus
The Female Reproductive System

The Uterine Tubes

- **Infundibulum**
  - An expanded funnel near ovary
  - With *fimbriae* that extend into pelvic cavity
  - Inner surfaces lined with cilia that beat toward middle segment

- **Ampulla**
  - Middle segment
  - Smooth muscle layers in wall become thicker approaching uterus

- **Isthmus**
  - A short segment between ampulla and uterine wall
The Female Reproductive System

- Histology of the Uterine Tube
  - Epithelium lining uterine tube
    - Contains scattered mucin-secreting cells
  - Mucosa is surrounded by concentric layers of smooth muscle
Figure 28–17 The Uterine Tubes.
The Female Reproductive System

- Uterine Tube and Oocyte Transport
  - Involves ciliary movement and peristaltic contractions in walls of uterine tube
  - A few hours before ovulation, nerves from hypogastric plexus
    - “Turn on” beating pattern
    - Initiate peristalsis
  - From infundibulum to uterine cavity
    - Normally takes 3–4 days
The Female Reproductive System

- Uterine Tube and Fertilization
  - For fertilization to occur
    - Secondary oocyte must meet spermatozoa during first 12–24 hours
  - Fertilization typically occurs
    - Near boundary between ampulla and isthmus
Uterine Tube and Nutrients

- Uterine tube provides nutrient-rich environment
  - Containing lipids and glycogen
- Nutrients supply spermatozoa and developing pre-embryo
The Female Reproductive System

- The **Uterus**
  - Provides for developing embryo (weeks 1–8) and fetus (week 9 through delivery):
    1. Mechanical protection
    2. Nutritional support
    3. Waste removal
The Female Reproductive System

- The Uterus
  - Is pear-shaped
    - 7.5 cm long, 5 cm diameter (3 in. x 2 in.)
    - Weighs 30–40 g (1-1.4 oz)
  - Normally bends anteriorly near base (anteflexion)
    - In retroflexion, uterus bends backward
The Female Reproductive System

- Three Suspensory Ligaments of Uterus
  - Uterosacral ligaments
    - Prevent inferior–anterior movement
  - Round ligaments
    - Restrict posterior movement
  - Cardinal (lateral) ligaments
    - Prevent inferior movement
The Female Reproductive System

- **Uterine Body (or corpus)**
  - Is largest portion of uterus
  - Ends at isthmus

- **Fundus**
  - Is rounded portion of uterine body
    - Superior to attachment of uterine tubes
The Female Reproductive System

- **Cervix**
  - Is inferior portion of uterus
  - Extends from isthmus to vagina
  - Distal end projects about 1.25 cm (0.5 in.) into vagina

- **External os**
  - Also called external orifice of uterus
  - Is surrounded by distal end of cervix
  - Leads into *cervical canal*
The Female Reproductive System

- **Cervical Canal**
  - Is a constricted passageway opening to the uterine cavity of the body
  - At **internal os** (internal orifice)
The Female Reproductive System

- Blood Supply of the Uterus
  - Branches of uterine arteries
    - Arising from branches of internal iliac arteries
  - Ovarian arteries
    - Arising from abdominal aorta
  - Veins and lymphatic vessels
The Female Reproductive System

- Nerves of the Uterus
  - Autonomic fibers from hypogastric plexus (sympathetic)
  - Sacral segments $S_3$ and $S_4$ (parasympathetic)
- Segmental blocks
  - Anesthetic procedure used during labor
  - Target spinal nerves $T_{10}–L_1$
Figure 28–18a The Uterus.
Figure 28–18b The Uterus.
The Female Reproductive System

The Uterine Wall

- Has a thick, outer, muscular **myometrium**
- Has a thin, inner, glandular **endometrium** (mucosa)
The Perimetrium

- Is an incomplete serous membrane
  - Continuous with peritoneal lining

Covers

- Fundus
- Posterior surface of uterine body and isthmus
The Female Reproductive System

- **The Endometrium**
  - Contributes about 10% of uterine mass
  - Glandular and vascular tissues support physiological demands of growing fetus
- **Uterine glands**
  - Open onto endometrial surface
  - Extend deep into lamina propria
Figure 28–19 The Uterine Wall.
Figure 28–19 The Uterine Wall.
The Female Reproductive System

- Estrogen
  - Causes uterine glands, blood vessels, and epithelium to change with phases of monthly uterine cycle
The Female Reproductive System

- **The Myometrium**
  - The thickest portion of the uterine wall
  - Constitutes almost 90% of the mass of the uterus
  - Arranged into longitudinal, circular, and oblique layers
  - Provides force to move fetus out of uterus into vagina
Two Divisions of Endometrium

- Functional zone
  - Layer closest to uterine cavity

- Basilar zone
  - Adjacent to myometrium
The Female Reproductive System

- The Functional Zone
  - Contains most of the uterine glands
  - Contributes most of endometrial thickness
  - Undergoes dramatic changes in thickness and structure during menstrual cycle
The Female Reproductive System

- The Basilar Zone
  - Attaches endometrium to myometrium
  - Contains terminal branches of tubular endometrial glands
The Female Reproductive System

- Blood Supply of Endometrium
  - Arcuate arteries
    - Encircle endometrium
  - Radial arteries
    - Supply straight arteries (to basilar zone)
    - Supply spiral arteries (to functional zone)
The Female Reproductive System

- Cyclical Changes in Endometrium
  - Basilar zone remains relatively constant
  - Functional zone undergoes cyclical changes
    - In response to sex hormone levels
    - Produce characteristic features of uterine cycle
The Female Reproductive System

- The **Uterine Cycle** (or *menstrual cycle*)
  - Is a repeating series of changes in endometrium
  - Lasts from 21 to 35 days
    - Average 28 days
The Female Reproductive System

- Uterine Cycle
  - Responds to hormones of ovarian cycle
  - Menses and proliferative phase
    - Occur during ovarian follicular phase
  - Secretory phase
    - Occurs during ovarian luteal phase
The Female Reproductive System

- **Menses**
  - Is the degeneration of functional zone
    - Occurs in patches
  - Is caused by constriction of spiral arteries
    - Reducing blood flow, oxygen, and nutrients
  - Weakened arterial walls rupture
    - Releasing blood into connective tissues of functional zone
The Female Reproductive System

- Menses
  - Degenerating tissues break away, enter uterine lumen
  - Entire functional zone is lost
    - Through external os and vagina
  - Only functional zone is affected
    - Deeper, basilar zone is supplied by straight arteries
Figure 28–20a The Appearance of the Endometrium during the Uterine Cycle.
The Female Reproductive System

- **Menstruation**
  - Is the process of endometrial sloughing
  - Lasts 1–7 days
  - Sheds 35–50 mL (1.2-1.7 oz) blood
The Female Reproductive System

- **The Proliferative Phase**
  - Epithelial cells of uterine glands
    - Multiply and spread across endometrial surface
    - Restore integrity of uterine epithelium
  - Further growth and vascularization
    - Completely restores functional zone
  - Occurs at same time as
    - Enlargement of primary and secondary follicles in ovary
The Female Reproductive System

- The **Proliferative Phase**
  - Is stimulated and sustained by
    - Estrogens secreted by developing ovarian follicles
  - Entire functional zone is highly vascularized
  - Small arteries
    - Spiral toward inner surface
    - From larger arteries in myometrium
The Female Reproductive System

Figure 28–20b The Appearance of the Endometrium during the Uterine Cycle.
The Female Reproductive System

- **The Secretory Phase**
  - Endometrial glands enlarge, increasing rate of secretion
  - Arteries of uterine wall
    - Elongate and spiral through functional zone
  - Begins at ovulation and persists as long as corpus luteum remains intact
  - Peaks about 12 days after ovulation
    - Glandular activity declines
  - Generally lasts 14 days
Figure 28–20c The Appearance of the Endometrium during the Uterine Cycle.
The Female Reproductive System

- The Uterine Cycle
  - Ends as corpus luteum stops producing stimulatory hormones
The Female Reproductive System

- **Menarche**
  - The first uterine cycle
  - Begins at puberty (age 11–12)

- **Menopause**
  - The termination of uterine cycles
  - Age 45–55
The Female Reproductive System

- Amenorrhea
  - Primary amenorrhea
    - Failure to initiate menses
  - Transient secondary amenorrhea
    - Interruption of 6 months or more
    - Caused by physical or emotional stresses
The Female Reproductive System

- The **Vagina**
  - Is an elastic, muscular tube
  - Extends between cervix and vestibule
  - 7.5–9 cm (3-3.6 in.) long
  - Highly distensible
The Female Reproductive System

The Vagina

- Cervix projects into *vaginal canal*
- **Fornix** is shallow recess surrounding cervical protrusion
- Lies parallel to
  - Rectum, posteriorly
  - Urethra, anteriorly
Blood Supply of the Vagina

- Is through **vaginal branches** of internal iliac (uterine) arteries and veins
The Female Reproductive System

- Innervation of the Vagina
  - Hypogastric plexus
  - Sacral nerves
  - Branches of pudendal nerve
Three Functions of the Vagina

1. Passageway for elimination of menstrual fluids
2. Receives spermatozoa during sexual intercourse
3. Forms inferior portion of birth canal
The Vaginal Wall

- Contains a network of blood vessels and layers of smooth muscle
- Is moistened by
  - Secretions of cervical glands
  - Water movement across permeable epithelium
The Female Reproductive System

- **The Hymen**
  - Is an elastic epithelial fold
    - That partially blocks entrance to vagina
    - Ruptured by sexual intercourse or tampon usage
Vaginal Muscles

- Two bulbospongiosus muscles extend along either side of vaginal entrance

  - Vestibular bulbs:
    - masses of erectile tissue that lie beneath the muscles
    - have same embryological origins as corpus spongiosum of penis
The Female Reproductive System

- The Vaginal Epithelium
  - Is nonkeratinized, stratified, and squamous
  - Forms folds (rugae)
  - Changes with ovarian cycle
The Female Reproductive System

- Vaginal Lamina Propria
  - Is thick and elastic
  - Contains small blood vessels, nerves, and lymph nodes
The Female Reproductive System

- The Vaginal Mucosa
  - Is surrounded by elastic muscularis layer
    - Layers of smooth muscle fibers
    - Arranged in circular and longitudinal bundles
    - Continuous with uterine myometrium
Figure 28–21 The Histology of the Vagina.
The Female Reproductive System

- Vaginal Bacteria
  - A population of harmless resident bacteria
    - Supported by nutrients in cervical mucus
    - Creates acidic environment
    - Restricts growth of many pathogens
The Female Reproductive System

- A Vaginal Smear
  - Is a sample of epithelial cells shed at surface of vagina
  - Used to estimate stage in ovarian and uterine cycles
The Female Reproductive System

- **Vulva** (or *pudendum*)
  - Area containing female external genitalia

- **Vestibule**
  - A central space bounded by small folds (*labia minora*)
    - Covered with smooth, hairless skin
  - Urethra opens into vestibule
    - Anterior to vaginal entrance
Paraurethral Glands

- Also called Skene glands
- Discharge into urethra near external opening
The Female Reproductive System

- The **Clitoris**
  - A small protruberance in vestibule
  - Has same embryonic structures as penis
  - Extensions of labia minora
    - Form **prepuce** or hood
Vestibular Glands

- Lesser vestibular glands
  - Secrete onto exposed surface of vestibule

- Greater vestibular glands (Bartholin glands)
  - Secrete into vestibule near vaginal entrance
Mons Pubis and Labia Majora

- Form outer limits of vulva
  - Protect and cover inner structures
  - Contain adipose tissue
- Sebaceous glands and apocrine sweat glands
  - Secrete onto inner surface of labia majora
Figure 28–22 The Female External Genitalia.
The Female Reproductive System

- **Mammary Glands**
  - Secrete milk to nourish an infant (*lactation*)
  - Are specialized organs of the integumentary system
  - Are controlled by hormones of the reproductive system and the placenta
  - Lie in **pectoral fat pads** deep to the skin of the chest
  - **Nipple** on each breast
    - Contains ducts from mammary glands to surface
  - **Areola**
    - Reddish-brown skin around each nipple
The Female Reproductive System

- Mammary Glands
  - Consist of lobes
    - Each containing several secretory lobules
    - Separated by dense connective tissue
The Female Reproductive System

- **Suspensory Ligaments of the Breast**
  - Bands of connective tissue
  - Originate in dermis of overlying skin
  - Areolar tissue separates mammary gland complex from underlying pectoralis muscles

- **Blood Supply of Mammary Glands**
  - Branches of internal thoracic artery
The Female Reproductive System

- **Mammary Gland Ducts**
  - Leave lobules
  - Converge
  - Form single *lactiferous duct* in each lobe
Lactiferous Duct

- Enlarges
- Forms expanded chamber (lactiferous sinus)
- 15–20 lactiferous sinuses open to each nipple
The Female Reproductive System

- An Active Mammary Gland
  - Is a tubuloalveolar gland
    - Consisting of multiple glandular tubes
    - Ending in secretory alveoli
  - Does not complete development unless pregnancy occurs
Figure 28–23a The Mammary Glands.
The Female Reproductive System

Figure 28–23b, c The Mammary Glands.
The Female Reproductive System

- Hormones and the **Female Reproductive Cycle**
  - Involves secretions of pituitary gland and gonads
  - Forms a complex pattern that coordinates ovarian and uterine cycles
The Female Reproductive System

- Circulating Hormones
  - Control female reproductive cycle
  - Coordinate ovulation and uterus preparation
The Female Reproductive System

- GnRH from the hypothalamus regulates reproductive function
- GnRH pulse frequency and amplitude change over course of ovarian cycle
  - Changes in GnRH pulse frequency are controlled by
    - Estrogens that increase pulse frequency
    - Progestins that decrease pulse frequency
The Female Reproductive System

- The Endocrine Cells
  - Of adenohypophysis
  - Each group of endocrine cells
    - Responds to different GnRH pulse frequencies
    - Is sensitive to some frequencies, insensitive to others
Hormones and the Follicular Phase

- Begins with FSH stimulation
- Monthly
  - Some primordial follicles develop into primary follicles
- As follicles enlarge
  - Thecal cells produce androstenedione
The Female Reproductive System

- Androstenedione
  - Is a steroid hormone
  - Is an intermediate in synthesis of estrogens and androgens
  - Is absorbed by granulosa cells and converted to estrogens
The Female Reproductive System

- Interstitial Cells
  - Scattered throughout ovarian stroma
  - Also secrete small amounts of estrogens
The Female Reproductive System

- Circulating Estrogens
  - Are bound primarily to albumins
    - Lesser amounts carried by gonadal steroid-binding globulin (GBG)
  - Three types: estradiol, estrone, and estriol
The Female Reproductive System

- Estradiol
  - Is most abundant
  - Has most pronounced effects on target tissues
  - Is dominant hormone prior to ovulation
Estrogen Synthesis

- Androstenedione is converted to testosterone
- Enzyme aromatase converts testosterone to estradiol
- Estrone and estriol are synthesized from androstenedione
The Female Reproductive System

Figure 28–24 Pathways of Steroid Hormone Synthesis in Males and Females.
Figure 28–25 The Hormonal Regulation of Ovarian Activity.
Five Functions of Estrogen

1. Stimulates bone and muscle growth
2. Maintains female secondary sex characteristics
   - Such as body hair distribution and adipose tissue deposits
3. Affects central nervous system (CNS) activity
   - Especially in the hypothalamus, where estrogens increase the sexual drive
4. Maintains functional accessory reproductive glands and organs
5. Initiates repair and growth of endometrium
Early in **follicular phase** of ovarian cycle

- Estrogen levels are low
- GnRH pulse frequency is 16–24/day (1 per 60–90 minutes)
- As tertiary follicles form, concentration of circulating estrogens rises steeply and GnRH pulse frequency increases to 36/day (1 per 30–60 minutes)
In follicular phase

- Switchover occurs
  - When estrogen levels exceed threshold value for about 36 hours
  - Resulting in massive release of LH from adenohypophysis
In follicular phase

- Sudden surge in LH concentration triggers:
  1. Completion of meiosis I by primary oocyte
  2. Rupture of follicular wall
  3. Ovulation

- Ovulation occurs 34–38 hrs after LH surge begins
  (9 hrs after LH peak)
In **luteal phase** of ovarian cycle

- High LH levels trigger ovulation
  - Promote progesterone secretion
  - Trigger formation of corpus luteum
- Frequency of GnRH pulses stimulates LH more than FSH:
  - LH maintains structure and secretory function of corpus luteum
The Female Reproductive System

- **Luteal Phase**
  - Progesterone levels remain high for 1 week
  - Unless pregnancy occurs, corpus luteum begins to degenerate
  - Progesterone and estrogen levels drop
  - GnRH pulse frequency increases
    - Stimulating FSH secretion
    - Ovarian cycle begins again
The Female Reproductive System

- **Hormones and the Uterine Cycle**
  - Corpus luteum degenerates
  - Progesterone and estrogen levels decline
    - Resulting in menses
  - Endometrial tissue sheds several days
    - Until rising estrogen stimulates regeneration of functional zone
  - Proliferative phase continues
    - Until rising progesterone starts secretory phase
  - Increase in estrogen and progesterone
    - Causes enlargement of endometrial glands
    - And increase in secretory activities
The Female Reproductive System

Figure 28–26 The Hormonal Regulation of the Female Reproductive Cycle.
Figure 28–26 The Hormonal Regulation of the Female Reproductive Cycle.
Hormones and Body Temperature

- Monthly hormonal fluctuations affect core body temperature
  - During luteal phase: progesterone dominates
  - During follicular phase: estrogen dominates and basal body temperature decreases about 0.3°C
- Upon ovulation: basal body temperature declines noticeably
- Day after ovulation: temperature rises
Sexual Function

- Coitus (Copulation)
  - Sexual intercourse
    - Introduces semen into female reproductive tract
Sexual Function

- **Male Sexual Function**
  - Is coordinated by complex neural reflexes
    - Using sympathetic and parasympathetic divisions of ANS
- **Male Sexual Arousal**
  - Leads to increase in parasympathetic outflow over pelvic nerves, which leads to erection
Sexual Function

- Male Sexual Stimulation
  - Initiates secretion of bulbo-urethral glands
  - **Lubricates** penile urethra and surface of glans
  - Leads to coordinated processes of emission and ejaculation
Sexual Function

- **Emission**
  - Occurs under sympathetic stimulation
  - Peristaltic contractions of ampulla
    - Push fluid and spermatozoa into prostatic urethra
  - Seminal glands contract
    - Increasing in force and duration
  - Peristaltic contractions in prostate gland
    - Move seminal mixture into urethra
  - Sympathetic contraction of urinary bladder and internal urethral sphincter
    - Prevents passage of semen into bladder
Sexual Function

- **Ejaculation**
  - Occurs as powerful, rhythmic contractions
    - In ischiocavernosus and bulbospongiosus muscles
    - That stiffen penis
    - Push semen toward external urethral opening
  - Causes pleasurable sensations (orgasm)
  - Followed by subsidence of erectile tissue (detumescence)
Sexual Function

- **Impotence**
  - Also called **male sexual dysfunction**
    - Is an inability to achieve or maintain an erection
    - Caused by physical or psychological factors
Sexual Function

- Female Sexual Arousal
  - Parasympathetic activation leads to
    - Engorgement of erectile tissues
    - Increased secretion of cervical mucous glands and greater vestibular glands
  - Blood vessels in vaginal walls fill with blood
  - Fluid moves from underlying connective tissues
    - To vaginal surfaces
Sexual Function

- Female Orgasm
  - Is accompanied by
    - Peristaltic contractions of uterine and vaginal walls
    - Rhythmic contractions of bulbospongiosus and ischiocavernosus muscles
Sexuality Transmitted Diseases (STDs)

- Are transferred by sexual intercourse
- Include bacterial, viral, and fungal infections
  - Pelvic inflammatory disease (PID)
  - AIDS
  - Gonorrhea
  - Syphilis
  - Herpes
  - Genital warts
  - Chancroid
Aging and the Reproductive System

- Female reproductive system
  - Changes associated with **menopause**

- Male reproductive system
  - Changes associated with **male climacteric** (andropause)
  - Occur gradually, over longer time period
Menopause

- Is the time that ovulation and menstruation cease
- Typically occurs around age 45–55
- Circulating concentrations of estrogens and progesterone decline
- Production of GnRH, FSH, and LH rises sharply
Aging and the Reproductive System

- **Perimenopause**
  - The interval immediately preceding menopause
  - Ovarian and uterine cycles become irregular
    - Due to shortage of primordial follicles
    - Estrogen levels decline
    - Ovulation is not triggered
Aging and the Reproductive System

- Decline in Estrogen Levels
  - Leads to
    - Reduction in uterus and breast size
    - Thinning of urethral and vaginal epithelia
    - Reduction in bone deposition (osteoporosis)
Aging and the Reproductive System

- **The Male Climacteric (andropause)**
  - Is the period of declining reproductive function
  - Circulating testosterone begins to decline
    - Between ages 50 and 60
  - Circulating FSH and LH increase
  - Sperm production continues
  - Sexual activity gradually decreases
    - With declining testosterone levels
Sex Hormones and Homeostasis

- Males
  - Sperm count must be adequate
  - Semen must have correct pH and nutrients
  - Erection and ejaculation must function properly
Sex Hormones and Homeostasis

- Females
  - Ovarian and uterine cycles must coordinate properly
  - Ovulation and oocyte transport must occur normally
  - Environment of reproductive tract must support
    - Survival and movement of sperm
    - Fertilization of oocyte
### SUMMARY TABLE 28–1  Hormones of the Reproductive System

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Source</th>
<th>Regulation of Secretion</th>
<th>Primary Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonadotropin-releasing hormone (GnRH)</td>
<td>Hypothalamus</td>
<td>Males: inhibited by testosterone and possibly by inhibin</td>
<td>Stimulates FSH secretion and LH synthesis in males and females</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females: GnRH pulse frequency increased by estrogens, decreased by progestins</td>
<td></td>
</tr>
<tr>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Adenohypophysis</td>
<td>Males: stimulated by GnRH, inhibited by inhibin</td>
<td>Males: stimulates spermatogenesis and spermiogenesis through effects on nurse cells</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females: stimulated by GnRH, inhibited by inhibin</td>
<td>Females: stimulates follicle development, estrogen production, and oocyte maturation</td>
</tr>
<tr>
<td>Luteinizing hormone (LH)</td>
<td>Adenohypophysis</td>
<td>Males: stimulated by GnRH, production stimulated by GnRH, secretion by the combination of high GnRH pulse frequencies and high estrogen levels</td>
<td>Males: stimulates interstitial cells to secrete testosterone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females: stimulation of corpus luteum, formation of corpus luteum, and progestin secretion</td>
<td></td>
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<td>Androgens (primarily testosterone and dihydrotestosterone)</td>
<td>Interstitial cells of testes</td>
<td>Stimulated by LH</td>
<td>Establish and maintain secondary sex characteristics and sexual behavior; promote maturation of spermatozoa; inhibit GnRH secretion</td>
</tr>
<tr>
<td>Estrogens (primarily estradiol)</td>
<td>Granulosa and thecal cells of developing follicles; corpus luteum</td>
<td>Stimulated by FSH</td>
<td>Stimulate LH secretion (at high levels); establish and maintain secondary sex characteristics and sexual behavior; stimulate repair and growth of endometrium; increase frequency of GnRH pulses</td>
</tr>
<tr>
<td>Progestins (primarily progesterone)</td>
<td>Granulosa cells from midcycle through functional life of corpus luteum</td>
<td>Stimulated by LH</td>
<td>Stimulate endometrial growth and glandular secretion; reduce frequency of GnRH pulses</td>
</tr>
<tr>
<td>Inhibin</td>
<td>Nurse cells of testes and granulosa cells of ovaries</td>
<td>Stimulated by factors released by developing spermatozoa (male) and developing follicles (female)</td>
<td>Inhibits secretion of FSH (and possibly of GnRH)</td>
</tr>
</tbody>
</table>
Integration with Other Systems

- Human reproduction requires normal function of multiple systems
  - Reproductive system
  - Digestive system
  - Endocrine system
  - Nervous system
  - Cardiovascular system
  - Urinary system
### Functional Relationships between the Reproductive System and Other Systems

#### THE REPRODUCTIVE SYSTEM IN PERSPECTIVE

**Integumentary System**
- Covers external genitalia; provides sensations that stimulate sexual behaviors; mammary gland secretions provide nourishment for newborns
- Reproductive hormones affect distribution of body hair and subcutaneous fat deposits

**Skeletal System**
- Pelvis protects reproductive organs of females, portion of ductus deferens, and accessory glands in males
- Sex hormones stimulate growth and maintenance of bone; sex hormones at puberty accelerate growth and closure of epiphyseal cartilages

**Muscular System**
- Contraction of skeletal muscles eject semen from male reproductive tract; muscle contractions during sexual intercourse produce pleasurable sensations in both sexes
- Reproductive hormones, especially testosterone, accelerate skeletal muscle growth

**FIGURE 28–27** Functional Relationships between the Reproductive System and Other Systems.
### Integration with Other Systems

#### The Reproductive System in Perspective

<table>
<thead>
<tr>
<th>Nervous System</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Controls sexual behaviors and sexual function</td>
</tr>
<tr>
<td>• Sex hormones affect CNS development and sexual behaviors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Endocrine System</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hypothalamic regulatory hormones and pituitary hormones regulate sexual development and function; oxytocin stimulates smooth muscle contractions in uterus and mammary glands</td>
</tr>
<tr>
<td>• Steroid sex hormones and inhibin inhibit secretory activities of hypothalamus and pituitary gland</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cardiovascular System</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Distributes reproductive hormones; provides nutrients, oxygen, and waste removal for fetus; local blood pressure changes responsible for physical changes during sexual arousal</td>
</tr>
<tr>
<td>• Estrogens may help maintain healthy vessels and slow development of atherosclerosis</td>
</tr>
</tbody>
</table>

**FIGURE 28–27** Functional Relationships between the Reproductive System and Other Systems.
Integration with Other Systems

FIGURE 28–27 Functional Relationships between the Reproductive System and Other Systems.