Chapter 16
The Reproductive System

Slides 16.1 – 16.20

Lecture Slides in PowerPoint by Jerry L. Cook
The Reproductive System

- Gonads – primary sex organs
  - Testes in males
  - Ovaries in females
- Gonads produce gametes (sex cells) and secrete hormones
  - Sperm – male gametes
  - Ova (eggs) – female gametes
Male Reproductive System

- Testes
- Duct system
  - Epididymis
  - Ductus deferens
  - Urethra
Male Reproductive System

- Accessory organs
  - Seminal vesicle
  - Prostate gland
  - Bulbourethral gland
- External genitalia
  - Penis
  - Scrotum
Figure 16.2
Testes

- Coverings of the testes
  - Tunica albuginea – capsule that surrounds each testis
Testes

- Coverings of the testes (continued)

- Septa – extensions of the capsule that extend into the testis and divide it into lobules
Testes

- Each lobule contains one to four seminiferous tubules
  - Tightly coiled structures
  - Function as sperm-forming factories
  - Empty sperm into the rete testis
- Sperm travels through the rete testis to the epididymis
- Interstitial cells produce androgens such as testosterone
Epididymis

- Comma-shaped, tightly coiled tube
- Found on the superior part of the testis and along the posterior lateral side
- Functions to mature and store sperm cells (at least 20 days)
- Expels sperm with the contraction of muscles in the epididymis walls to the vas deferens
Ductus Deferens (Vas Deferens)

- Carries sperm from the epididymis to the ejaculatory duct
- Passes through the inguinal canal and over the bladder
- Moves sperm by peristalsis
- Spermatic cord – ductus deferens, blood vessels, and nerves in a connective tissue sheath
Ductus Deferens (Vas Deferens)

- Ends in the ejaculatory duct which unites with the urethra
- Vasectomy – cutting of the ductus deferens at the level of the testes to prevent transportation of sperm
Urethra

- Extends from the base of the urinary bladder to the tip of the penis
- Carries both urine and sperm
- Sperm enters from the ejaculatory duct
Urethra

- Regions of the urethra
  - Prostatic urethra – surrounded by prostate
  - Membranous urethra – from prostatic urethra to penis
  - Spongy (penile) urethra – runs the length of the penis
Seminal Vesicles

• Located at the base of the bladder
• Produces a thick, yellowish secretion (60% of semen)
  • Fructose (sugar)
  • Vitamin C
  • Prostaglandins
  • Other substances that nourish and activate sperm
Prostate Gland

- Encircles the upper part of the urethra
- Secretes a milky fluid
  - Helps to activate sperm
  - Enters the urethra through several small ducts
Bulbourethral Glands

- Pea-sized gland inferior to the prostate
- Produces a thick, clear mucus
  - Cleanses the urethra of acidic urine
  - Serves as a lubricant during sexual intercourse
- Secreted into the penile urethra
Semen

- Mixture of sperm and accessory gland secretions

- Advantages of accessory gland secretions
  - Fructose provides energy for sperm cells
  - Alkalinity of semen helps neutralize the acidic environment of vagina
  - Semen inhibits bacterial multiplication
  - Elements of semen enhance sperm motility
External Genitalia

• Scrotum
  • Divided sac of skin outside the abdomen
  • Maintains testes at 3°C lower than normal body temperature to protect sperm viability
External Genitalia

- Penis
  - Delivers sperm into the female reproductive tract
- Regions of the penis
  - Shaft
  - Glans penis (enlarged tip)
  - Prepuce (foreskin)
    - Folded cuff of skin around proximal end
    - Often removed by circumcision
External Genitalia

- Internally there are three areas of spongy erectile tissue around the urethra
Spermatogenesis

- Production of sperm cells
- Begins at puberty and continues throughout life
- Occurs in the seminiferous tubules
Processes of Spermatogenesis

- Spermatogonia (stem cells) undergo rapid mitosis to produce more stem cells before puberty
- Follicle stimulating hormone (FSH) modifies spermatogonia division
  - One cell produced is a stem cell
  - The other cell produced becomes a primary spermatocyte
Processes of Spermatogenesis

- Primary spermatocytes undergo meiosis
- Haploid spermatids are produced
Processes of Spermatogenesis

- Spermiogenesis
  - Late spermatids are produced with distinct regions
    - Head – contains DNA covered by the acrosome
    - Midpiece
    - Tail
    - Sperm cells result after maturing of spermatids
  - Spermatogenesis takes 64 to 72 days
Processes of Spermatogenesis

Figure 16.3
Anatomy of a Mature Sperm Cell

- The only human flagellated cell
- DNA is found in the head

Figure 16.5
Testosterone Production

- The most important hormone of the testes
- Produced in interstitial cells
Testosterone Production

- Functions of testosterone
  - Stimulates reproductive organ development
  - Underlies sex drive
  - Causes secondary sex characteristics
    - Deepening of voice
    - Increased hair growth
    - Enlargement of skeletal muscles
    - Thickening of bones
Regulation of Male Androgens (Sex Hormones)

Figure 16.6

Stimuli from other areas in the brain

Hypothalamus

Releasing hormone

Anterior pituitary

FSH

LH

Testosterone production

Testis

Sperm production

Negative feedback

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Female Reproductive System

- Ovaries
- Duct System
  - Uterine tubes (fallopian tubes)
  - Uterus
  - Vagina
- External genitalia
Female Reproductive System

Figure 16.8a

(a)

Suspensory ligament
Ovary
Uterine (fallopian) tube
Fimbriae
Ovarian ligament
Round ligament
Fundus
Body
Uterus
Urinary bladder
Symphysis pubis
Urethra
Vagina
Clitoris
Labium minus
Labium majus
Ovaries

- Composed of ovarian follicles (sac-like structures)
- Structure of an ovarian follicle
  - Oocyte
  - Follicular cells
Ovarian Follicle Stages

- Primary follicle – contains an immature oocyte
- Graafian (vesicular) follicle – growing follicle with a maturing oocyte
- Ovulation – when the egg is mature the follicle ruptures
  - Occurs about every 28 days
- The ruptured follicle is transformed into a corpus luteum
Support for Ovaries

- Suspensory ligaments – secure ovary to lateral walls of the pelvis
- Ovarian ligaments – attach to uterus
- Broad ligament – a fold of the peritoneum, encloses suspensory ligament
Support for Ovaries

Figure 16.8b

(a) Lineweight. (b) Lineweight.

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Uterine (Fallopian) Tubes

- Receive the ovulated oocyte
- Provide a site for fertilization
- Attaches to the uterus
- Does not physically attach to the ovary
- Supported by the broad ligament
Uterine Tube Function

- Fimbriae – finger-like projections at the distal end that receive the oocyte
- Cilia inside the uterine tube slowly move the oocyte towards the uterus (takes 3–4 days)
- Fertilization occurs inside the uterine tube
Uterus

- Located between the urinary bladder and rectum
- Hollow organ
- Functions of the uterus
  - Receives a fertilized egg
  - Retains the fertilized egg
  - Nourishes the fertilized egg
Support for the Uterus

- Broad ligament – attached to the pelvis
- Round ligament – anchored interiorly
- Uterosacral ligaments – anchored posteriorly
Support for the Uterus

Figure 16.8b
Regions of the Uterus

- **Body** – main portion
- **Fundus** – area where uterine tube enters
- **Cervix** – narrow outlet that protrudes into the vagina
Walls of the Uterus

- Endometrium
  - Inner layer
  - Allows for implantation of a fertilized egg
  - Sloughs off if no pregnancy occurs (menses)
- Myometrium – middle layer of smooth muscle
- Serous layer – outer visceral peritoneum
Vagina

- Extends from cervix to exterior of body
- Behind bladder and in front of rectum
- Serves as the birth canal
- Receives the penis during sexual intercourse
- Hymen – partially closes the vagina until it is ruptured
External Genitalia (Vulva)

- Mons pubis
- Fatty area overlying the pubic symphysis
- Covered with pubic hair after puberty
External Genitalia (Vulva)

- Labia – skin folds
  - Labia majora
  - Labia minora
External Genitalia

- Vestibule
  - Enclosed by labia majora
  - Contains opening of the urethra and the greater vestibular glands (produce mucus)

- Clitoris
  - Contains erectile tissue
  - Corresponds to the male penis
Oogenesis

- The total supply of eggs are present at birth
- Ability to release eggs begins at puberty
- Reproductive ability ends at menopause
- Oocytes are matured in developing ovarian follicles
Oogenesis

- Oogonia – female stem cells found in a developing fetus
- Oogonia undergo mitosis to produce primary oocytes
- Primary oocytes are surrounded by cells that form primary follicles in the ovary
- Oogonia no longer exist by the time of birth
Oogenesis

- Primary oocytes are inactive until puberty
- Follicle stimulating hormone (FSH) causes some primary follicles to mature
  - Meiosis starts inside maturing follicle
    - Produces a secondary oocyte and the first polar body
  - Meiosis is completed after ovulation only if sperm penetrates
    - Two additional polar bodies are produced
Oogenesis

Figure 16.10

Before birth
- Meiotic Events
  - 2n Oogonium (stem cell)
  - Mitosis
  - Growth
  - Primary oocyte
  - Primary oocyte (arrested in prophase I; present at birth)

Childhood
- Each month from puberty to menopause
  - Primary oocyte (still arrested in prophase I)

Meiotic Events
- Meiosis I (completed by one primary oocyte each month)
  - First polar body
  - Meiosis II of polar body (may or may not occur)
  - Polar bodies (all polar bodies degenerate)

Follicle Development in Ovary
- Follicle cells
  - Oocyte
  - Primary follicle

Growing follicle
- Secondary oocyte (arrested in metaphase II)
- Ovulation
- Ovulated secondary oocyte

Mature vesicular (Graafian) follicle
- Ovum
- Sperm

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Menstrual (Uterine) Cycle

- Cyclic changes of the endometrium
- Regulated by cyclic production of estrogens and progesterone

Stages of the menstrual cycle

- **Menses** – functional layer of the endometrium is sloughed
- **Proliferative stage** – regeneration of functional layer
- **Secretory stage** – endometrium increases in size and readies for implantation
Hormonal Control of the Ovarian and Uterine Cycles

(a) Fluctuation of gonadotropin levels

(b) Fluctuation of ovarian hormone levels
Hormonal Control of the Ovarian and Uterine Cycles

(c) Ovarian cycle

(d) Uterine cycle

Figure 16.12c, d
Hormone Production by the Ovaries

- Estrogens
  - Produced by follicle cells
  - Cause secondary sex characteristics
    - Enlargement of accessory organs
    - Development of breasts
    - Appearance of pubic hair
    - Increase in fat beneath the skin
    - Widening and lightening of the pelvis
    - Onset of menses
Hormone Production by the Ovaries

- Progesterone
  - Produced by the corpus luteum
  - Production continues until LH diminishes in the blood
  - Helps maintain pregnancy
Mammary Glands

- Present in both sexes, but only function in females
  - Modified sweat glands
- Function is to produce milk
- Stimulated by sex hormones (mostly estrogens) to increase in size
Anatomy of Mammary Glands

- **Areola** – central pigmented area
- **Nipple** – protruding central area of areola
- **Lobes** – internal structures that radiate around nipple
- **Alveolar glands** – clusters of milk producing glands within lobules
- **Lactiferous ducts** – connect alveolar glands to nipple
Stages of Pregnancy and Development

- Fertilization
- Embryonic development
- Fetal development
- Childbirth
Fertilization

- The oocyte is viable for 12 to 24 hours after ovulation
- Sperm are viable for 12 to 48 hours after ejaculation
- Sperm cells must make their way to the uterine tube for fertilization to be possible
Mechanisms of Fertilization

- Membrane receptors on an oocyte pulls in the head of the first sperm cell to make contact
- The membrane of the oocyte does not permit a second sperm head to enter
- The oocyte then undergoes its second meiotic division
- Fertilization occurs when the genetic material of a sperm combines with that of an oocyte to form a zygote
The Zygote

- First cell of a new individual
- The result of the fusion of DNA from sperm and egg
- The zygote begins rapid mitotic cell divisions
- The zygote stage is in the uterine tube, moving toward the uterus
The Embryo

- Developmental stage from the start of cleavage until the ninth week
- The embryo first undergoes division without growth
- The embryo enters the uterus at the 16-cell state
- The embryo floats free in the uterus temporarily
- Uterine secretions are used for nourishment
The Blastocyst

- Ball-like circle of cells
- Begins at about the 100 cell stage
- Secretes human chorionic gonadotropin (hCG) to produce the corpus luteum to continue producing hormones
- Functional areas of the blastocyst
  - Trophoblast – large fluid-filled sphere
  - Inner cell mass
The Blastocyst

- Primary germ layers are eventually formed
  - Ectoderm – outside layer
  - Mesoderm – middle layer
  - Endoderm – inside layer
- The late blastocyst implants in the wall of the uterus (by day 14)
Derivatives of Germ Layers

- Ectoderm
  - Nervous system
  - Epidermis of the skin
- Endoderm
  - Mucosae
  - Glands
- Mesoderm
  - Everything else
Development from Ovulation to Implantation

Figure 16.15

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Development After Implantation

- Chorionic villi (projections of the blastocyst) develop
  - Cooperate with cells of the uterus to form the placenta
- The embryo is surrounded by the amnion (a fluid filled sac)
- An umbilical cord forms to attach the embryo to the placenta
Development After Implantation

Figure 16.16
Functions of the Placenta

- Forms a barrier between mother and embryo (blood is not exchanged)
- Delivers nutrients and oxygen
- Removes waste from embryonic blood
- Becomes an endocrine organ (produces hormones) and takes over for the corpus luteum
  - Estrogen
  - Progesterone
  - Other hormones that maintain pregnancy
The Fetus (Beginning of the Ninth Week)

- All organ systems are formed by the end of the eighth week
- Activities of the fetus are growth and organ specialization
- A stage of tremendous growth and change in appearance
The Effects of Pregnancy on the Mother

- Pregnancy – period from conception until birth

- Anatomical changes
  - Enlargements of the uterus
  - Accentuated lumbar curvature
  - Relaxation of the pelvic ligaments and pubic symphysis due to production of relaxin
Effects of Pregnancy on the Mother

- Physiological changes
  - Gastrointestinal system
    - Morning sickness is common due to elevated progesterone
    - Heartburn is common because of organ crowding by the fetus
    - Constipation is caused by declining motility of the digestive tract
Effects of Pregnancy on the Mother

- Physiological changes
  - Urinary System
    - Kidneys have additional burden and produce more urine
    - The uterus compresses the bladder
Effects of Pregnancy on the Mother

- Physiological changes
  - Respiratory System
    - Nasal mucosa becomes congested and swollen
    - Vital capacity and respiratory rate increase
Effects of Pregnancy on the Mother

- Physiological changes
  - Cardiovascular system
    - Body water rises
    - Blood volume increases by 25 to 40 percent
    - Blood pressure and pulse increase
    - Varicose veins are common
Childbirth (Partition)

- Labor – the series of events that expel the infant from the uterus

- Initiation of labor
  - Estrogen levels rise
  - Uterine contractions begin
  - The placenta releases prostaglandins
  - Oxytocin is released by the pituitary
  - Combination of these hormones produces contractions
Initiation of Labor

1. Baby moves deeper into mother’s birth canal
2. Pressoreceptors in cervix of uterus excited
3. Afferent impulses to hypothalamus
4. Hypothalamus sends efferent impulses to posterior pituitary, where oxytocin is stored
5. Posterior pituitary releases oxytocin to blood; oxytocin targets mother’s uterine muscle
6. Uterus responds by contracting more vigorously

Positive feedback mechanism continues to cycle until interrupted by birth of baby

Figure 16.18
Stages of Labor

- **Dilation**
  - Cervix becomes dilated
  - Uterine contractions begin and increase
  - The amnion ruptures
Stages of Labor

- Expulsion
  - Infant passes through the cervix and vagina
  - Normal delivery is head first
- Placental stage
  - Delivery of the placenta
Stages of Labor

1. Dilation of the cervix
2. Expulsion: delivery of the infant
3. Delivery of the placenta

Figure 16.19
Developmental Aspects of the Reproductive System

- Gender is determined at fertilization
  - Males have XY sex chromosomes
  - Females have XX sex chromosomes
- Gonads do not begin to form until the eighth week
Developmental Aspects of the Reproductive System

- Testes form in the abdominal cavity and descend to the scrotum one month before birth
- The determining factor for gonad differentiation is testosterone
Developmental Aspects of the Reproductive System

- Reproductive system organs do not function until puberty
- Puberty usually begins between ages 10 and 15
- The first menses usually occurs about two years after the start of puberty
- Most women reach peak reproductive ability in their late 20s
Developmental Aspects of the Reproductive System

- Menopause occurs when ovulation and menses cease entirely
  - Ovaries stop functioning as endocrine organs
- There is no equivalent of menopause in males, but there is a steady decline in testosterone