26.1 Overview of the Reproductive System and Meiosis

Introduction to the Male and Female Reproductive Systems

Similarities between male and female reproductive organs:

- ________________ secrete sex hormones, including testosterone and estrogen

- Gonads produce ________________ by meiosis; male gametes are called sperm and female gametes are called ova, or egg cells

- Both genders have additional organs accessory reproductive organs

Cell division can occur either by mitosis that produces identical daughter cells or meiosis that produces sex cells

- Fertilization – process by which a sperm and egg cell fuse to form a new cell called a zygote
  - ________________ – cell that divides to produce all of cells in a new individual
  - Must contain correct number of chromosomes; half from ovum and half from sperm

Overview of Meiosis

- ________________ – process during which a cell divides to form daughter cells with half number of chromosomes; ensures correct number in gametes and eventually zygote
  - All human somatic cells have a nucleus with 46 chromosomes (23 pairs)
  - Somatic cells are ________________ (2n) because they have full paired set of chromosomes
Comparing Mitosis and Meiosis

- Mitosis occurs because new cells are needed for tissue growth or repair; new cells must be genetically identical to original
- Meiosis produces sperm and ova for reproduction; cells need to have half chromosome number of original cell

→ 26.2 Anatomy of the Male Reproductive System

Testes

Testes (testicles) – located outside abdominopelvic cavity in the scrotum
- Each testis is divided into ______________; contain tightly coiled loops called seminiferous tubules where sperm is produced
- Testes perform two important functions: sperm production and secretion of ______________________________

Seminiferous tubules contain two cell types:

1. _________________ (sperm-forming cells) and
2. _________________ cells; support sperm production

- Interstitial cells (Leydig cells) – found between seminiferous tubules

- Myoid cells, muscle-like cells that surround seminiferous tubules, contract to push sperm and testicular fluid through tubules

Seminiferous tubules →
______________________________ →
Rete testis →
Efferent ductules →
__________________________
Duct System

• **Epididymis** – filled with ductules; site of sperm __________ and __________

• **Ductus deferens** begins at end of epididymis
  - Travels with testicular arteries, veins, and nerves within a **spermatic cord** through the ___________ into pelvic cavity
  - Mucosa consists of PSCCE and smooth muscle, called **muscularis**
  - Ductus deferens can store sperm for months and reabsorb any sperm that has not been ejaculated

• ___________ – receives sperm from ductus deferens at the **seminal vesicle**

• _______________ – transports both urine and semen

The Penis

• ___________ – attaches to body wall
• ___________ or **shaft** – contains erectile tissue
• ___________ where external urethral orifice is located

Loose skin of penis forms a circular fold called **prepuce**, or **foreskin**; portion removed by **circumcision**

• **Internal penis** – includes three cylindrical **erectile bodies** (**corpora**)  
  - Each erectile body is a **spongy network** of connective tissue and smooth muscle with vascular spaces
  - _________________ – paired erectile bodies
  - _________________ at base
Accessory Sex Glands

- ________________ – found on posterior surface of urinary bladder meets with ductus deferens to form ejaculatory ducts

  - **Seminal fluid** –
    - Fructose – sugar that sperm utilize for ATP synthesis
    - Prostaglandins – stimulate smooth muscle contraction
    - pH of seminal fluid is alkaline to neutralize acids

- __________ – inferior to urinary bladder; surrounds urethra and ejaculatory ducts
  - Made up of 20–30 tubular glands and smooth muscle

- **Prostatic secretions** –
  - Citrate – sugar that sperm can utilize
  - **Prostate specific antigen (PSA)** – dissolve semen clot in female reproductive tract to allow sperm to proceed further into tract
  - Antimicrobial chemicals – inhibit some bacterial growth to decrease risk of infection in female reproductive system

Benign Prostatic Hyperplasia (BPH) and Prostate Cancer

- Enlargement of the prostate that is noncancerous but expands to point of compressing urethra, condition is called **benign prostatic hyperplasia**, or BPH
  - ________________; second most common cancer in U.S. men

- Screening for prostate cancer usually includes a digital rectal examination and assessment of blood **prostate-specific antigen** (______) levels
• ________________ glands (Cowper’s glands) – paired glands found at base of penis on either side of membranous urethra
  ▪ Secrete a thick, alkaline mucus-like fluid that helps neutralize
  ▪ Also lubricate glans penis during intercourse

Semen

Sperm – 5% of semen volume

• Typical ejaculate is between 2.5 and 5 ml in volume; contains between 40–750 million sperm cells

Male Infertility

• Infertility – inability to produce a pregnancy after one year of unprotected intercourse
  ▪ Approximately 40 percent of all infertility cases result from male infertility; usually due to a low sperm count
  • Low sperm count can result from any sort of damage to testis, such as physical trauma, exposure to radiation, or disease; could also be due to developmental defects
  ▪ During normal development, testes begin forming inside abdominopelvic cavity and then descend into scrotum
  ▪ If a testis does not descend into scrotum (disorder called cryptorchidism) sperm cells will not be produced
  ▪ In addition, inadequate secretion of GnRH, FSH, LH, or testosterone for any reason will also lower sperm count.
Support Structures: Scrotum and Spermatic Cord

- Midline _______ divides scrotum into two compartments,

- Scrotum wall contains a layer of smooth muscle called ________________

- ____________________ – tube extending from scrotum; contains ductus deferens, blood and lymph vessels, and nerves; leads to pelvic cavity
  
  ▪ **Inguinal canal** leads into abdominal cavity
  
  ▪ ____________________ – smooth muscle that controls height of testes

- Normal body temperature (37° C) is too warm for mass production of viable sperm cells; scrotum is generally 3° C cooler

→ 26.3 Physiology of the Male Reproductive System

Spermatogenesis

- Begins at **puberty** and continues for duration of lifespan

- Occurs in seminiferous tubules

  ________________ (2n) - stem cells

  -

  - some differentiate into →

  (1) ____________________ (2n)

  - meiosis I →

  (2) ____________________ (n)

  - meiosis II →

  (4) ________________ (n) → spermatozoa
**Sustentacular cells (nurse cells, Sertoli cells)**

- Provide nutrients for dividing cells and produce **inhibin**, which help regulate spermatogenesis
- Phagocytize damaged spermatogenic cells

**Sperm**

- Spermatids develop a head, midpiece, and tail as they mature into sperm cells
  - ___________ – contains nucleus and acrosome
  - _______________ – contains mitochondria
  - _____________ – flagellum
- Sperm are still nonmotile as they migrate to epididymis where they will complete maturation process
  - Trip takes about 12 days to reach epididymis and mature where sperm cells will remain viable for months
  - Entire process takes 60–70 days to complete

**Hormonal Control**

- **Gonadotropin-releasing hormone** (___________) – hypothalamus
- Anterior pituitary detects GnRH; stimulates secretion of **follicle-stimulating hormone** (__________) and **luteinizing hormone** (_______)
- FSH stimulates sustentacular cells to work and release _____________ hormone
- _________________ – main hormone involved in regulation of spermatogenesis and male reproductive physiology
Elevated testosterone and inhibin levels are sensed in hypothalamus and anterior pituitary causing negative feedback loop to close

Inhibin decreases release of FSH; testosterone reduces GnRH secretion

**Male Sexual Response**

- Erection and ejaculation are basic phases of male sexual response (similar affects in females)
  - Reflex triggers release of nitric oxide (NO) from blood vessels
  - Arterioles dilate in erectile tissue; allows for a large volume of blood to enter tissue
  - In non-aroused state penis is **flaccid** (relaxed) as blood vessels supplying penis are constricted

- Time period during which feelings of pleasure are experienced; coincides with ejaculation

- Process to expel semen from penis; under nervous system control that occurs in two stages:
  - Movement semen into urethra
  - Occurs as semen pushes from urethra

**Effects of Testosterone**

Testosterone levels increase dramatically at puberty typically between 12 and 14 years of age in males

- Increased testosterone levels trigger spermatogenesis and appearance of secondary sexual characteristics
  - Growth of pubic, axillary, chest, and facial hair
Skin thickens and sebaceous glands increase secretion

Erythrocyte production increases as testosterone increases erythropoietin secretion

Testosterone influences behavior; basis for male libido

Erectile Dysfunction

- Various psychological and physical factors may cause erectile dysfunction (ED)
  - Psychological influences include stress, depression, and anxiety;
  - Physical causes include cardiovascular disease and diabetes mellitus; obesity, tobacco, and alcohol use, and certain prescription medications
  - Older men have a greater risk because the amount of connective tissue in erectile tissue of penis increases with age, reducing blood flow to penis

26.4 Anatomy of the Female Reproductive System

Ovaries

- Secrete hormones: estradiol, estrone, and estriol, as well as progesterone, inhibin, and relaxin
- _____________ – superficial region where oogenesis (production of gametes) occurs within saclike follicles; develop and mature along with gametes
- _____________ – inner region where blood vessels, lymphatic vessels, and nerves are found
• Ovaries are held in place by three ligaments
  1. ______________ ligament – connects ovary to bony pelvis
  2. ______________ ligament – connects ovary to uterus
  3. ______________ ligament – connects ovary to pelvic wall

**Uterine tubes (fallopian tubes, or oviducts)**

• **Isthmus** – found at proximal end of tube, connects to uterus
• **Ampulla** – expansion at distal end that connects tube to infundibulum
• **Infundibulum** – funnel-shaped opening at distal end of uterine tube (*Fimbriae* – finger-like projections)
• _______________ – an oocyte is expelled from ovary; fimbriae sweep ovary surface to catch oocyte and direct it into uterine tube
  - Peristaltic contraction and ciliated cells work to move the oocyte toward uterus

**Uterus**

**Uterus (womb)** – hollow organ located in pelvis anterior to rectum and posterior to urinary bladder

• _______________ – main region
• _______________ – rounded region superior to entrance to uterine tubes
• _______________ – narrow neck
• Uterine wall is composed of three layers:
  1. _______________ – Outermost serous layer
2. _____________ – middle layer of smooth muscle

3. _____________ – innermost layer that lines uterine cavity; composed of simple columnar epithelium

**Vagina**

Organ of copulation; receives penis and semen during sexual intercourse; passageway for giving birth and for menstrual flow

- Parallel to urethra; lies between urinary bladder and rectum
- Vaginal wall is lined with transverse ridges called __________
- Mucosa is composed of stratified squamous epithelium
  - Epithelial cells secrete glycogen into vaginal lumen
  - Metabolized by bacteria
- _____________ – vascular partition of mucosa near distal vaginal orifice; commonly ruptured during first sexual intercourse

**Female External Genitalia**

- ___________ – external reproductive structures
- ___________ – rounded region overlying pubic symphysis
- ___________ – pair of elongated protective skin folds
- **Labia minora** – pair of thinner skin folds found enclosed within labia majora
  - ___________ – recess enclosed within labia minor contains **Vestibular glands** (Bartholin’s glands)
- ___________ – anterior to vestibule; small protrusion composed of erectile tissue
**Mammary Glands**

- Each mammary gland is found within hypodermis and enclosed within a rounded, skin-covered breast
- **Areola** – surrounds a **nipple** through which milk exits
- Each mammary gland is composed of 15–25 **lobes**
  - Each lobe is subdivided into smaller **lobules**; contain _________________ which produce milk when a woman is lactating
  - _________________ that surround alveoli helps propel milk toward nipple
  - Milk passes from alveoli → lactiferous ducts → lactiferous sinus → nipple

**Breast Cancer**

- **Breast cancer** – second most common type of cancer in women
- **Risk factors** for breast cancer include maternal relatives with breast cancer, longer reproductive span (early first menstrual cycle coupled with menstruation continuing until a later age), obesity, no pregnancies or first pregnancy at or after age of 35, and presence of breast cancer genes; two genes that increase susceptibility to breast cancer have been identified: **BRCA1** and **BRCA2**

→ **26.5 Physiology of the Female Reproductive System**

**Oogenesis**

- Begins before female infant is born, then is suspended until puberty
- Once reactivated at ____________ continues until it ceases operation at ________________, somewhere between 45 and 55 years of age
- Occurs about once per month as a part of **ovarian cycle**
stem cells in female complete mitosis
3-7th month of fetal development

- about 2 million present at birth
- undergo (degeneration) \rightarrow 400,000 at puberty

ovulated mid-cycle each month, alternating ovaries (polar body formed)

completes meiosis II after fertilization

Spermatogenesis versus Oogenesis

- Spermatogenesis produces millions of sperm every day (in case they are needed), whereas oogenesis produces one viable secondary oocyte approximately once a month

Hormonal Control of Female Reproduction

- \text{Follicular phase (stages 1–4)}: During this phase follicles grow and develop:
  1. \text{single layer of squamous follicular cells surrounds primary oocyte}
  2. \text{follicle: follicular cells become grow around primary oocyte}
  3. \text{follicle: increases volume and size of follicle, small pockets of fluid form}
  4. \text{Vesicular (follicle): large cavity called antrum forms, primary oocyte, completes meiosis I to form a secondary oocyte and first polar body}

- \text{Ovulation phase (stage 5)}
• **Luteal phase (stages 6–7):**

6. _________________ is formed by the remaining follicle; secretes progesterone and some estrogen

7. _________________ – scar tissue that remains after corpus luteum is degraded

• Ovarian cycle averages about 28 days overall, with each stage accounting for following amount of time:
  - Follicular phase extends from day one to day 14
  - Luteal phase extends from day 14 to day 28

• Hormones of 28-day cycle:
  - Hypothalamus secretes __________ (gonadotropin-releasing hormone)
  - Anterior pituitary releases LH and FSH in response to GnRH
  - FSH stimulates follicle cells to secrete estrogens and secretes inhibin
  - Estrogens typically stimulate dominant follicle to continue developing into a vesicular follicle

  - Corpus luteum produces progesterone and estrogens
  - Increased levels of estrogen and inhibin exert negative feedback control on hypothalamus and pituitary
  - Estrogen inhibits GnRH and LH secretion

• Estrogen and progesterone stimulate development of **female sex characteristics:**
  - Maturation of sex organs and development of external genitalia
- Progesterone is responsible for maintenance of a pregnancy once fertilization has occurred

- Estrogens increases ______ density and increasing HDL cholesterol level

- Estrogen promotes blood coagulation that can lead to formation of blood clots in specific circumstances

- **Uterine cycle (menstrual cycle)** – series of cyclic events that uterine endometrium goes through each month
  - Uterine changes are coordinated with estrogen and progesterone levels released during ovarian cycle

- Endometrium is composed of two main layers:
  1. ________________ (functional layer) detaches from uterine wall and is shed usually monthly during menstruation
  2. ________________ (basal layer) does not thicken or shed, it replaces stratum functionalis at end of menstruation

  1. ________________ phase, days 1–5: uterus sheds stratum functionalis, resulting in menstruation

  2. ________________ (preovulatory) phase, days 6–14: stratum functionalis thicken; these glands enlarge and veins and arteries increase in number

  3. ________________ phase, days 15–28: arteries form in stratum functionalis and endometrial glands increase

- If pregnancy doesn’t occur, cells of stratum functionalis die and on day 28 menstrual phase begins
- If pregnancy occurs, secretory phase continues and uterus continues to develop in preparation for an embryo

**Puberty and Menopause**

- **Puberty** – typically begins between 9 and 11 years old for females with increase in estrogen and progesterone resulting secondary sex characteristics
- Breasts development begins
- Appearance of pubic and axillary hair and an increase in secretions from sebaceous glands
- ______________ tissue increases in subcutaneous layer throughout body, with additional deposits in hips, thighs, and breasts
- 
- ___________ – first episode of menstrual bleeding; occurs approximately two years after onset of puberty
  - Will not occur unless a girl has at least ______________ body fat
  - **Leptin** – hormone secreted by adipocytes; stimulates gonadotropin secretion
- ______________ – point when menstruation has not occurred for at least one year
  - Number of primary follicles left that can respond to LH and FSH is diminished after thirty or more years of ovarian cycles
- Reduced levels of estrogens and progesterone may alter female secondary sex characteristics
  - Breasts, uterus, and uterine tubes may shrink, while pubic and axillary hair may thin
- ___________ may occur due to changes in rhythmic secretion of GnRH

**Cervical Cancer**

- **Cervical cancer** occurs most often in women between the ages of 30 and 50
- Frequently caused by human papillomavirus (HPV), which is transmitted sexually
• The number of cases and number of deaths from cervical cancer have decreased significantly; projected to decrease further as **HPV vaccine** becomes more widespread

• Cervical Cancer

• Decline is due in large part to **Pap (Papanicolaou) smear test**; detects precancerous cells and early-stage cancers before symptoms are noticeable; involves scraping loose cells from cervix and examining them microscopically

• Cells showing signs of abnormal development (**dysplasia**) warrant further investigation, including visual examination of cervix or a **biopsy** to determine if cancerous cells are present
Development and Heredity

Chapter 27

27.1 Overview of Human Development

Prenatal Development

- **Pre-embryonic period** – lasts for first 2 weeks after fertilization; zygote divides that implants in endometrium
- **________ period** – extends from week 3 through 8 of gestation; embryo grows, folds, and forms rudimentary organ systems
- **_______ period** – lasts from week 9 until birth; fetus grows larger and continues to develop until its organ systems can function without assistance from mother

27.2 Pre-embryonic Period: Fertilization through Implantation

Fertilization

- Fusion of **sperm cell** and **secondary oocyte** to form a __________

Cleavage and Blastocyst Formation

_________ - series of rapid mitotic divisions that produce genetically identical cells called At this stage, cells start to differentiate known as a __________

Cell division continues producing a **blastocyst** (___________):

- An outer layer of cells, called **trophoblast cells**, participate in forming **placenta**
- **Inner cell mass**, or embryoblasts, form embryo
Implantation

Implantation occurs approximately 4 – 7 days after fertilization when blastocyst begins to attach to endometrium

• Trophoblast secretes human chorionic gonadotropin (__________)
  ▪ Stimulates corpus luteum in ovary to secrete estrogen and progesterone
  ▪ Progesterone maintains endometrium

Development of Extraembryonic Membranes

Extraembryonic membranes first appear during second week of development, continue to develop during embryonic and fetal periods

• Protecting embryo
• Nutrition uptake
• Gas exchange
• Storage and removal of waste

• Encloses embryo in fluid-filled amniotic cavity; penetrated only by umbilical cord
  ▪ Secretes amniotic fluid into cavity
  ▪ Protects embryo from trauma and drying out

• _____________ – outermost extraembryonic membrane
  ▪ Forms _____________________
Ectopic Pregnancy

• In an **ectopic pregnancy**, implantation and growth in any location other than endometrium (1–2% of all pregnancies are ectopic)

• Almost all of these are “**tubal pregnancies**” but can occur in other locations (abdominal cavity, ovary, or cervix)

• Presents a large risk to mother, as only uterus is able to expand and sustain the pregnancy

→ 27.3 *Embryonic Period: Week 3 through Week 8*

Embryonic Period

• **Embryonic period** - starts with formation of ____________

• Three germ layers develop during this period that will become all of major organ systems in process of ____________
  
  ▪ Placenta forms during this period and begins to provide nutrition and oxygen to embryo and remove wastes

27.4 *Fetal Period: Week 9 until Birth (about Week 38)*

Placentation

• **Placentation** – formation of placenta; attaches to uterine wall and to embryo/fetus through umbilical cord

• ____________ – organ that is shed after infant is born develops from both fetal (chorionic villi) and maternal (decidua basalis) structures
  
  ▪ Site of exchange of oxygen, nutrients, and waste between mother and fetus
  
  ▪ Produces hormones to support pregnancy
• **Umbilical cord** connects center of placenta to fetus **umbilicus**
  - ________________ - carry deoxygenated to placenta
  - ________________ - carries oxygen and nutrients toward fetal
  - Deoxygenated fetal blood in umbilical arteries → placenta into chorionic villi
  - Fetal blood then picks up oxygen and nutrients and delivers waste by diffusion
  - Oxygenated blood leaves placenta → umbilical vein

• **Fetal circulation** and **cardiovascular system**
  - Unique cardiovascular structures present during prenatal development:
    - umbilical arteries
    - umbilical vein

3 vascular shunts
  - Blood from umbilical vein bypasses liver via ________________; connected to inferior vena cava and flows into right atrium of heart
  - ________________ – hole in interatrial septum that directly connects right and left atria; bypasses lungs
  - ________________ – short passage that connects pulmonary trunk to aorta; bypasses lungs

**Premature Infants**

• An infant is considered **premature** if it is born more than 3 weeks before full-term (38 weeks); more than 12% of babies born in United States each year are premature
• The earlier the birth, the more complications infant is likely to experience; most commonly, premature infants suffer from respiratory, digestive, and thermoregulatory difficulties

Module 27.5 Pregnancy and Childbirth

Changes during Pregnancy

• **First trimester (months 1–3)** pre-embryonic and embryonic development is completed and fetal development begins
  - By end of first trimester, basis of all of major organ systems are present making it most critical stage of development

• **Second trimester (months 4–6)** fetus continues to grow and develop; pregnancy usually becomes obvious as uterus and abdomen expand
  - Ossification begins in most bones
  - Genitals are distinguishable as male or female
  - Heartbeat can be heard with a stethoscope
  - ___________ and ___________ present
  - Skeletal muscles begin to contract

• **Third trimester (months 7–9)** fetus grows rapidly and gains a significant amount of weight
  - Woman’s uterus and abdomen enlarge further and many women exhibit new symptoms related to size of the fetus
  - Eyelids open completely
  - Fetus usually turns upside down
  - In males, testes begin to descend through inguinal canal
  - Fetal neurons form networks
Placenta also functions as an endocrine organ:

- Corpus luteum relinquishes production of progesterone and estrogens to placenta by end of third month of gestation
- **Human placental lactogen** and **placental prolactin** - prepare mammary glands for milk production
- **Relaxin** - relaxes body's muscles, joints, and ligaments

- **Oxytocin** from fetal and maternal hypothalamus is secreted during second and third trimesters and peaks during labor to stimulate uterine contractions and allow milk release from mammary glands

**Childbirth (Parturition)**

- Series of events collectively called **labor**
  - Both fetal and maternal hypothalamus secrete oxytocin; stimulates placenta to secrete prostaglandins
  - Prostaglandins dilate cervix and with oxytocin, increase strength of uterine contractions
    - As head of fetus pushes on and stretches cervix, more oxytocin is released
    - As more oxytocin is released, myometrium contracts more forcefully and placenta secretes more prostaglandins
    - Both effects cause cervix to stretch more, which stimulates release of more oxytocin (**_______________**)
Prenatal and Newborn Genetic Screening

- Cells and amniotic fluid may be withdrawn and analyzed to test for chromosomal abnormalities.

- Usually recommended for women 35 years or older at delivery, as their oocytes are older; increases risk of chromosomal abnormalities; also recommended for women who know they or father are carriers of inherited diseases, or when possible fetal abnormalities are discovered on ultrasound

  - _______________ – done between 14 and 20 weeks of pregnancy; amniotic fluid is withdrawn using a needle inserted into amniotic cavity, as shown

  - _______________ – withdraws chorionic villi tissue