Reproductive System

Chapter 26

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
• **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 $\rightarrow$ lactiferous ducts $\rightarrow$ lactiferous sinus $\rightarrow$ 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**
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______________ (2n) - stem cells in female complete mitosis

3-7th month of fetal development

______________ (2n) - about 2 million present at birth

- undergo____________ (degeneration) → 400,000 at puberty

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

______________ (n) - 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**

- ___________ – includes *monthly* series of events associated with maturation of an oocyte and its follicle in an ovary

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

- **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 increase 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. **function layer** (functional layer) detaches from uterine wall and is shed usually monthly during menstruation
  2. **basal layer** (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
27.1 Overview of Human Development

Prenatal Development

• **Pre-embryonic period** – lasts for first 2 weeks after fertilization; zygote divides that implants in endometrium

• **Fetal period** – extends from week 3 through 8 of gestation; **embryo** grows, folds, and forms rudimentary organ systems

• **Fetal 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

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**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 estrogen 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

    o As head of fetus pushes on and stretches cervix, more oxytocin is released

    o As more oxytocin is released, myometrium contracts more forcefully and placenta secretes more prostaglandins

    o 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