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
-

- _____ **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 bodytemperature (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**

_____ **(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 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