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 _______ and female gametes are called _______, or egg cells
  - Both genders have additional organs accessory reproductive organs

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

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

Cell division can occur either by mitosis that produces identical daughter cells or meiosis that produces sex cells
26.2 Anatomy of the Male Reproductive System

Testes

(testicles) – located outside abdominopelvic cavity in the scrotum

- Each testis is divided into lobules; 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. spermatogenic (sperm-forming cells) and
  2. ___________ cells; support sperm production
- Interstitial cells (Leydig cells) – found between seminiferous tubules
  - Produce testosterone
- Myoid cells, muscle-like cells that surround seminiferous tubules, contract to push sperm and testicular fluid through tubes
  - Seminiferous tubules ➔
  - Straight tubule ➔
  - Efferent ductules ➔
DUCT SYSTEM

• Epididymis – filled with ductules; site of sperm

• 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

• Ejaculatory duct – receives sperm from ductus deferens at the seminal vesicle
  • Joins urethra in the _________

• Urethra – transports both

THE PENIS

___________ – attaches to body wall

Body 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

(b) Cross-section of the penis with dorsal surface on top
### ACCESSORY SEX GLANDS

- **Seminal vesicles** – found on posterior surface of urinary bladder meets with ductus deferens to form ejaculatory ducts
- **Seminal fluid** – _______ of semen volume
  - _______ – sugar that sperm utilize for ATP synthesis
  - Prostaglandins – stimulate smooth muscle contraction
  - Coagulating proteins
  - pH of seminal fluid is _______ to neutralize acids

- Made up of 20–30 tubular glands and smooth muscle
- **Prostatic secretions** – _______ of semen volume
  - _______ – 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
- **Prostate cancer**; 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 (PSA) levels
- PSA blood levels below 2.5 ng/ml are considered normal

- Bulbourethral 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

- **Semen** – _______ 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
  - Less than 15 million sperm cells per milliliter of semen usually indicates infertility
  - 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
**MALE INFERTILITY**

- 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**

- Scrotum
  - Midline _______ divides scrotum into two compartments
  - Scrotum wall contains a layer of smooth muscle called _________

**Spermatic cord** – tube extending from scrotum; contains ductus deferens, blood and lymph vessels, and nerves; leads to pelvic cavity

- **Inguinal canal** leads into abdominal cavity
- _________ muscle – 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

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**SPERMATOGENESIS**

Spermatogenesis

- Begins at **puberty** and continues for duration of lifespan
- Occurs in seminiferous tubules
Spermatogonia (2n) - stem cells
- divide by ___________
- some differentiate into →
(1) Primary spermatocytes (2n) _________ →
(2) Secondary spermatocytes (n) _________ →
(4) Spermatids (n) → spermatozoa

**SUSTENTACULAR CELLS**
Sustentacular cells (nurse cells, Sertoli cells)
- Provide nutrients for dividing cells and produce __________, 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
- Sperm cells that are not ejaculated within a few months are reabsorbed
HORMONAL CONTROL

- Gonadotropin-releasing hormone (GnRH) – hypothalamus
- Anterior pituitary detects GnRH; stimulates secretion of follicle-stimulating hormone (FSH) and luteinizing hormone (LH)
- FSH stimulates sustentacular cells to work and release inhibin hormone
- LH stimulates interstitial cells to produce testosterone
- Testosterone – 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)
- Erection – 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

EFFECTS OF TESTOSTERONE

- Testosterone levels increase dramatically at puberty typically between 12 and 14 years of age in males
- Spermatogenesis begins
- 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
Bone density increases
Skeletal muscle mass increases
Erythrocyte production increases as testosterone increases 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
- Produce ova
- 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. Ovarian ligament – connects ovary to uterus
3. Suspensory ligament – connects ovary to pelvic wall
**Uterine Tubes**

Uterine tubes (fallopian tubes, or oviducts)

- Extend from ovary to; covered by peritoneum
- _______ – found at proximal end of tube, connects to uterus
- _______ – expansion at distal end that connects tube to infundibulum
- **Infundibulum** – funnel-shaped opening at distal end of uterine tube (Fimbriae – finger-like projections)

**Ovulation** – 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

**Vagina**

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

- Tube that extends from cervix to exterior of body
- Parallel to urethra; lies between urinary bladder and rectum
• Vaginal wall is lined with transverse ridges called **rugae**
• Mucosa is composed of stratified squamous epithelium
  • Epithelial cells secrete glycogen into vaginal lumen
  • Metabolized by bacteria
  • Generates lactic acid that helps maintain acidic pH
• __________ – vascular partition of mucosa near distal vaginal orifice; commonly ruptured during first sexual intercourse

### Female External Genitalia

**Vulva** – external reproductive structures
• **Mons pubis** – 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)
• **Clitoris** – anterior to vestibule; small protrusion composed of erectile tissue

### Mammary Glands

Modified sweat glands of the integumentary system to produce milk
• 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
  • **Myoepithelial cells** 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**

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**OOGENESIS**

- Begins before female infant is born, then is suspended until puberty
- Once reactivated at puberty continues until it ceases operation at **menopause**, somewhere between 45 and 55 years of age
- Occurs about once per month as a part of__________

- **Oogonia (2n)** - stem cells in female complete mitosis 3-7th month of fetal development
- **Primary oocytes (2n)** - about 2 million present at birth - undergo _________ (degeneration) → 400,000 at puberty
- **Secondary oocyte (n)** - ovulated mid-cycle each month, alternating ovaries (polar body formed)
- _________ (n) - completes meiosis II after fertilization

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**26.5 PHYSIOLOGY OF THE FEMALE REPRODUCTIVE SYSTEM**

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**OGOGENESIS (development of an ovary)**

- **Oogonia (2n)**
- **Primary oocyte**
- **Secondary oocytes** (degeneration)
- **Secondary oocytes** (completion meiosis II)
- **Ovulated secondary oocyte**
- **Corpus luteum**

**DEVELOPMENT OF A FOLLCLE**

- **Oogonia**
- **Primary oocyte**
- **Secondary oocyte**
- **Ovulated secondary oocyte**
- **Corpus luteum**

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** развития яйцеклетки**

- **Оогонии (2n)**
- **Первичный яйцеклетка**
- **Вторичные яйцеклетки** (дегенерация)
- **Вторичные яйцеклетки** (комплет мейоз II)
- **Овулированный вторичный яйцеклетка**
- **Корpus luteum**

**развитие фолликула**

- **Оогонии**
- **Первичный яйцеклетка**
- **Вторичные яйцеклетки**
- **Овулированный вторичный яйцеклетка**
- **Корpus luteum**
**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**

- **Ovarian cycle** – 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. **Primordial follicle** – 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 (tertiary) follicle:** large cavity called antrum forms, primary oocyte, completes meiosis I to form a secondary oocyte and first polar body

**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 **GnRH** (gonadotropin-releasing hormone)
- Anterior pituitary releases _____ and _____ 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

LH triggers _________
- Corpus luteum produces progesterone and estrogens
- Increased levels of estrogen and inhibin exert negative feedback control on hypothalamus and pituitary
- Estrogen inhibits _______ and _______ secretion
- Inhibin inhibits _______ 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 bone 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. Stratum functionalis (functional layer) detaches from uterine wall and is shed usually monthly during ____________
  2. Stratum basalis (basal layer) does not thicken or shed, it replaces stratum functionalis at end of menstruation

1. Menstrual phase, days 1–5:

2. Proliferative (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
    • Appearance of pubic and axillary hair and an increase in secretions from sebaceous glands
    • Adipose tissue increases in subcutaneous layer throughout body, with additional deposits in hips, thighs, and breasts
    • Individual’s height increases; ________
Menstruation

- first episode of menstrual bleeding; occurs approximately two years after onset of puberty
- Will not occur unless a girl has at least 15–17% body fat
- Leptin – hormone secreted by adipocytes; stimulates gonadotropin secretion

Menopause

- 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
  - Bone density may decrease
  - Hot flashes 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 external os of 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

Cervical Cancer - Development and Heredity
27.1 OVERVIEW OF HUMAN DEVELOPMENT

Prenatal Development

- **Pre-embryonic period** – lasts for first 2 weeks after fertilization; zygote divides that implants in endometrium
- **Embryonic period** – extends from week 3 through week 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**

Cleavage - 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 ____________:
- An outer layer of cells, called *trophoblast cells*, participate in forming ____________
- 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

- Nutrition uptake
- Storage and removal of waste

Extraembryonic Membranes

- 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 chorionic villi

Extraembryonic Membranes

- 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 chorionic villi
**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 **gastrula**
- 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

**ORGANOGENESIS**

**PLACENTATION**

**27.4 FETAL PERIOD: WEEK 9 UNTIL BIRTH (ABOUT WEEK 38)**

- **Placenta** – 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 ____________ to support pregnancy
  - Blood separated by ____________ ____________
**Umbilical cord** connects center of placenta to fetus umbilicus

- **Umbilical arteries** - carry deoxygenated to __________
- **Umbilical vein** - carries oxygen and nutrients to __________

**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

**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
  - Genitalia are distinguishable as male or female
  - Heartbeat can be heard with a stethoscope
  - **Lanugo** and **vernix caseosa** 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
  - ______ hormone
  - ________ 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 (positive feedback)

**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

**PRENATAL AND NEWBORN GENETIC SCREENING**

- **Amniocentesis** – done between 14 and 20 weeks of pregnancy; amniotic fluid is withdrawn using a needle inserted into amniotic cavity, as shown
  - **Chorionic villi sampling**, withdraws chorionic villi tissue