

I. Unit 16: The Reproductive System A. The Reproductive System 1. Gonads - primary sex organs a) Testes in males b) Ovaries in females 2. Gonads produce gametes (sex cells) and secrete hormones a) Sperm - male gametes b) Ova (eggs) - female gametes 3. Male Reproductive System Overview a) Testes (1) Each lobule contains one to four seminiferous tubules (a) Tightly coiled structures (b) Function as sperm-forming factories (c) Empty sperm into the rete testis (first part of the duct system) (d) Sperm travels through the rete testis to the epididymis (2) Duct system (a) Epididymis (i) Epididymis (a) Comma-shaped, tightly coiled tube (b) Found on the superior part of the testis and along the posterior lateral side (c) Functions to mature and store sperm cells (at least 20 days) (d) Expels sperm with the contraction of muscles in the epididymis walls to the vas deferens (b) Ductus (vas) deferens (i) Ductus Deferens (Vas Deferens) (a) Carries sperm from the epididymis to the ejaculatory duct (b) Passes through the inguinal canal and over the bladder (c) Moves sperm by peristalsis (d) Ends in the ejaculatory duct which unites with the urethra

- (e) Expanded end is called the ampulla
- (f) Ejaculation - smooth muscle in the walls of the ductus deferens create peristaltic waves to squeeze sperm forward
- (g) Vasectomy - cutting of the ductus deferens at the level of the testes to prevent transportation of sperm
- (c) Urethra
 - (i) Urethra
 - (a) Extends from the base of the urinary bladder to the tip of the penis
 - (b) Carries both urine and sperm
 - (c) Sperm enters from the ejaculatory duct
 - (d) Regions of the urethra
 - (i) Prostatic urethra - surrounded by prostate
 - (ii) Membranous urethra - from prostatic urethra to penis
 - (iii) Spongy (penile) urethra - runs the length of the penis
- (3) Coverings of the testes
 - (a) Tunica albuginea - capsule that surrounds each testis
 - (b) Septa - extensions of the capsule that extend into the testis and divide it into lobules
- b) Accessory organs
 - (1) Seminal vesicles
 - (a) Located at the base of the bladder
 - (b) Produces a thick, yellowish secretion (60% of semen)
 - (c) Fructose (sugar)
 - (d) Vitamin C
 - (e) Prostaglandins
 - (f) Other substances that nourish and activate sperm
 - (2) Prostate
 - (a) Encircles the upper part of the urethra
 - (b) Secretes a milky fluid
 - (c) Helps to activate sperm

- (d) Enters the urethra through several small ducts
- (3) Bulbourethral glands
 - (a) Pea-sized gland inferior to the prostate
 - (b) Produces a thick, clear mucus
 - (c) Cleanses the urethra of acidic urine
 - (d) Serves as a lubricant during sexual intercourse
 - (e) Secreted into the penile urethra
- c) External genitalia
 - (1) Penis
 - (a) Delivers sperm into the female reproductive tract
 - (b) Regions of the penis
 - (i) Shaft
 - (ii) Glans penis (enlarged tip)
 - (iii) Prepuce (foreskin)
 - (a) Folded cuff of skin around proximal end
 - (b) Often removed by circumcision
 - (c) Internally there are three areas of spongy erectile tissue around the urethra
 - (i) Erections occur when this erectile tissue fills with blood during sexual excitement
 - (2) Scrotum
 - (a) Divided sac of skin outside the abdomen
 - (b) Maintains testes at 3°C lower than normal body temperature to protect sperm viability
- d) Interstitial cells in the seminiferous tubules produce androgens such as testosterone
- e) Spermatic cord - ductus deferens, blood vessels, and nerves in a connective tissue sheath
- f) Semen
 - (1) Mixture of sperm and accessory gland secretions
 - (2) Advantages of accessory gland secretions

- (a) Fructose provides energy for sperm cells
 - (b) Alkalinity of semen helps neutralize the acidic environment
 - (c) Semen inhibits bacterial multiplication
 - (d) Elements of semen enhance sperm motility
- g) Human Life Cycle
- (1) Union of a sperm (23 chromosomes) with an egg (23 chromosomes) creates a zygote (2n or 46 chromosomes)
 - (2) Spermatogenesis
 - (a) Production of sperm cells
 - (b) Begins at puberty and continues throughout life
 - (c) Occurs in the seminiferous tubules
 - (d) Spermatogonia (stem cells) undergo rapid mitosis to produce more stem cells before puberty
 - (i) Follicle-stimulating hormone (FSH) modifies spermatogonia division
 - (a) One cell produced is a stem cell, called a type A
 - (b) The other cell produced becomes a primary spermatocyte, called a type B daughter cell
 - (ii) Primary spermatocytes undergo meiosis
 - (iii) One primary spermatocyte produces four haploid spermatids
 - (iv) Spermatids - 23 chromosomes (half as much material as other body cells)
 - (e) Spermiogenesis
 - (i) Late spermatids are produced with distinct regions
 - (a) Head
 - (b) Midpiece
 - (c) Tail
 - (f) Sperm cells result after maturing of spermatids
 - (g) Spermatogenesis (entire process, including spermiogenesis) takes 64 to 72 days
 - (h) Structure of a Sperm

- (i) Anatomy of a Mature Sperm Cell
 - (a) The only human flagellated cell
 - (b) Head
 - (i) Contains DNA
 - (ii) Acrosome - "helmet" on the nucleus, similar to a large lysosome
 - (iii) Breaks down and releases enzymes to help the sperm penetrate an egg
 - (c) Midpiece
 - (i) Wrapped by mitochondria for ATP generation
- h) Testosterone Production
 - (1) The most important hormone of the testes
 - (2) Produced in interstitial cells
 - (3) During puberty, luteinizing hormone (LH) activate the interstitial cells
 - (4) In turn, testosterone is produced
 - (5) Functions of testosterone
 - (a) Stimulates reproductive organ development
 - (b) Underlies sex drive
 - (c) Causes secondary sex characteristics
 - (i) Deepening of voice
 - (ii) Increased hair growth
 - (iii) Enlargement of skeletal muscles
 - (iv) Thickening of bones
- 4. Female Reproductive System
 - a) Ovaries
 - (1) Composed of ovarian follicles (sac-like structures)
 - (2) Each follicle consists of
 - (a) Oocyte (immature egg)
 - (b) Follicular cells - surround the oocyte
 - (3) Ovarian Follicle Stages

- (a) Primary follicle - contains an immature oocyte
- (b) Graafian (vesicular) follicle - growing follicle with a maturing oocyte
- (c) Ovulation - when the egg is mature, the follicle ruptures; occurs about every 28 days
 - (i) The ruptured follicle is transformed into a corpus luteum
- (4) Support for Ovaries
 - (a) Suspensory ligaments - secure ovary to lateral walls of the pelvis
 - (b) Ovarian ligaments - attach to uterus
 - (c) Broad ligament - a fold of the peritoneum, encloses suspensory ligament
- b) Duct System
 - (1) Uterine tubes (fallopian tubes)
 - (a) Receive the ovulated oocyte
 - (b) Provide a site for fertilization
 - (c) Attach to the uterus
 - (d) Little or no contact between ovaries and uterine tubes
 - (e) Supported and enclosed by the broad ligament
 - (f) Uterine Tube Anatomy and Physiology
 - (i) Fimbriae
 - (a) Finger-like projections at the distal end of the uterine tube
 - (ii) Receive the oocyte from the ovary
 - (iii) Cilia
 - (a) Located inside the uterine tube
 - (b) Slowly move the oocyte towards the uterus (takes 3–4 days)
 - (iv) Fertilization occurs inside the uterine tube since oocyte lives about 24 hours
- (2) Uterus
 - (a) Located between the urinary bladder and rectum
 - (b) Hollow organ
 - (c) Functions of the uterus
 - (i) Receives a fertilized egg

- (i) Receives a fertilized egg
- (ii) Retains the fertilized egg
- (iii) Nourishes the fertilized egg
- (d) Support for the Uterus
 - (i) Broad ligament - attached to the pelvis
 - (ii) Round ligament - anchored anteriorly
 - (iii) Uterosacral ligaments - anchored posteriorly
- (e) Regions of the Uterus
 - (i) Body - main portion
 - (ii) Fundus - superior rounded region above where uterine
 - (iii) Cervix - narrow outlet that protrudes into the vagina
- (f) Walls of the Uterus
 - (i) Endometrium
 - (a) Inner layer
 - (b) Allows for implantation of a fertilized egg
 - (c) Sloughs off if no pregnancy occurs (menses)
 - (ii) Myometrium - middle layer of smooth muscle
 - (iii) Perimetrium (visceral peritoneum) - outermost serous layer of the uterus
- (3) Vagina
 - (a) Extends from cervix to exterior of body
 - (b) Located between bladder and rectum
 - (c) Serves as the birth canal
 - (d) Receives the penis during sexual intercourse
 - (e) Hymen - partially closes the vagina until it is ruptured
- c) Female Reproductive System
 - (1) External Genitalia (Vulva)
 - (2) Mons pubis
 - (a) Fatty area overlying the pubic symphysis
 - (b) Covered with pubic hair after puberty

- (3) Labia
 - (a) Labia - skin folds
 - (i) Labia majora - hair-covered skin folds
 - (ii) Labia minora - delicate, hair-free folds of skin
 - (4) Clitoris
 - (a) Contains erectile tissue
 - (b) Corresponds to the male penis
 - (i) The clitoris is similar to the penis in that it is
 - (a) Hooded by a prepuce
 - (b) Composed of sensitive erectile tissue
 - (c) Becomes swollen with blood during sexual excitement
 - (5) Urethral orifice
 - (6) Vaginal orifice
 - (7) Vestibule and Greater Vestibular Glands
 - (a) Enclosed by labia majora
 - (b) Contains external openings of the urethra, vagina
 - (c) Greater vestibular glands
 - (i) One is found on each side of the vagina
 - (ii) Secretes lubricant during intercourse
 - (8) Perineum
 - (a) Diamond-shaped region between the anterior ends of the labial folds, anus posteriorly, and ischial tuberosities laterally
5. Oogenesis and the Ovarian Cycle
- a) The total supply of eggs are present at birth
 - b) Ability to release eggs begins at puberty
 - c) Reproductive ability ends at menopause
 - d) Oocytes are matured in developing ovarian follicles
 - e) Oogonia - female stem cells found in a developing fetus
 - (1) Oogonia undergo mitosis to produce primary oocytes

- (2) Primary oocytes are surrounded by cells that form primary follicles in the ovary
- (3) Oogonia no longer exist by the time of birth
- f) Primary oocytes are inactive until puberty
 - (1) Follicle stimulating hormone (FSH) causes some primary follicles to mature each month
 - (2) Cyclic monthly changes constitute the ovarian cycle
 - (3) Meiosis starts inside maturing follicle
 - (a) Produces a secondary oocyte and the first polar body
 - (b) Follicle development to the stage of a vesicular follicle takes about 14 days
- g) Ovulation of a secondary oocyte occurs with the release of luteinizing hormone (LH)
 - (1) Secondary oocyte is released and surrounded by a corona radiata
- h) Meiosis is completed after ovulation only if sperm penetrates
 - (1) Ovum is produced
 - (a) Two additional polar bodies are produced
 - (b) Once ovum is formed, the 23 chromosomes can be combined with those of the sperm to form the fertilized egg (zygote)
 - (2) If the secondary oocyte is not penetrated by a sperm, it dies and does not complete meiosis to form an ovum
- 6. Male and Female Differences
 - a) Meiosis
 - (1) Males - produces four functional sperm
 - (2) Females - produces one functional ovum and three polar bodies
 - b) Sex cell size and structure
 - (1) Sperm are tiny, motile, and equipped with nutrients in seminal fluid
 - (2) Egg is large, non-motile, and has nutrient reserves to nourish the embryo until implantation
- B. Uterine (Menstrual) Cycle
 - 1. Cyclic changes of the endometrium

- 2. Regulated by cyclic production of estrogens and progesterone
- 3. FSH and LH regulate the production of estrogens and progesterone
- 4. Both female cycles are about 28 days in length
 - a) Ovulation typically occurs about midway through cycle on day 14
- 5. Stages of the menstrual cycle
 - a) Menstrual phase
 - (1) Days 1–5
 - (2) Functional layer of the endometrium is sloughed
 - (3) Bleeding occurs for 3–5 days
 - (4) By day 5, growing ovarian follicles are producing more estrogen
 - b) Proliferative stage
 - (1) Days 6–14
 - (2) Regeneration of functional layer of the endometrium
 - (3) Estrogen levels rise
 - (4) Ovulation occurs in the ovary at the end of this stage
 - c) Secretory stage
 - (1) Days 15–28
 - (2) Levels of progesterone rise and increase the blood supply to the endometrium
 - (3) Endometrium increases in size and readies for implantation
 - (4) If fertilization does occur
 - (a) Embryo produces a hormone that causes the corpus luteum to continue producing its hormones
 - (5) If fertilization does NOT occur
 - (a) Corpus luteum degenerates as LH blood levels decline
- 6. Hormone Production by the Ovaries
 - a) Estrogens
 - (1) Produced by follicle cells
 - (2) Cause secondary sex characteristics
 - (a) Enlargement of accessory organs

- (i) Development of breasts
 - (b) Appearance of axillary and pubic hair
 - (c) Increase in fat beneath the skin, particularly in hips and breasts
 - (d) Widening and lightening of the pelvis
 - (e) Onset of menses (menstrual cycle)
- b) Progesterone
- (1) Produced by the corpus luteum
 - (2) Production continues until LH diminishes in the blood
 - (3) Does not contribute to the appearance of secondary sex characteristics
 - (4) Other major effects
 - (a) Helps maintain pregnancy
 - (b) Prepare the breasts for milk production
7. Mammary Glands
- a) Present in both sexes, but only function in females
 - (1) Modified sweat glands
 - b) Function is to produce milk
 - c) Stimulated by sex hormones (mostly estrogens) to increase in size
 - d) Anatomy of Mammary Glands
 - (1) Areola - central pigmented area
 - (2) Nipple - protruding central area of areola
 - (3) Lobes - internal structures that radiate around nipple
 - (4) Lobules - located within each lobe and contain clusters of
 - (5) Alveolar glands - produce milk when a woman is lactating
 - (6) Lactiferous ducts - connect alveolar glands to nipple
 - e) Mammography
 - (1) X-ray examination that detects breast cancers too small to feel
 - (2) Recommended every 2 years for women between 40 and 49 years old and yearly thereafter
- C. Stages of Pregnancy and Development
- 1. Fertilization

- a) The oocyte is viable for 12 to 24 hours after ovulation
- b) Sperm are viable for 24 to 48 hours after ejaculation
- c) For fertilization to occur, sexual intercourse must occur no more than 2 days before ovulation and no later than 24 hours after
- d) Sperm cells must make their way to the uterine tube for fertilization to be possible
- e) Mechanisms of Fertilization
 - (1) When sperm reach the oocyte, enzymes break down the follicle cells of the corona radiata around the oocyte
 - (2) Once a path is cleared, sperm undergo an acrosomal reaction (acrosomal membranes break down and enzymes digest holes in the oocyte membrane)
 - (3) Membrane receptors on an oocyte pull in the head of the first sperm cell to make contact
 - (4) The membrane of the oocyte does not permit a second sperm head to enter
 - (5) The oocyte then undergoes its second meiotic division to form the ovum and a polar body
 - (6) Fertilization occurs when the genetic material of a sperm combines with that of an oocyte to form a zygote
- 2. Embryonic development
 - a) The Zygote
 - (1) First cell of a new individual
 - (2) The result of the fusion of DNA from sperm and egg
 - (3) The zygote begins rapid mitotic cell divisions
 - (4) The zygote stage is in the uterine tube, moving toward the uterus
 - b) Cleavage
 - (1) Rapid series of mitotic divisions that begins with the zygote and ends with the blastocyst
 - (2) Zygote begins to divide 24 hours after fertilization
 - (3) Three to 4 days after ovulation, the preembryo reaches the uterus and floats freely for 2–3 days

- c) Late blastocyst stage - embryo implants in endometrium (day 7 after ovulation)
- d) Developmental Stages
 - (1) Embryo - developmental stage until ninth week
 - (2) Morula - 16-cell stage
 - (3) Blastocyst - about 100 cells
- 3. Fetal development
 - a) Fetus - beginning in ninth week of development
 - (1) The Embryo
 - (a) The embryo first undergoes division without growth
 - (b) The embryo enters the uterus at the 16-cell state (called a morula) about 3 days after ovulation
 - (i) The embryo floats free in the uterus temporarily
 - (ii) Uterine secretions are used for nourishment
 - (c) The Blastocyst (Chorionic Vesicle)
 - (i) Ball-like circle of cells
 - (ii) Begins at about the 100-cell stage
 - (iii) Secretes human chorionic gonadotropin (hCG) to induce the corpus luteum to continue producing hormones
 - (iv) Functional areas of the blastocyst
 - (a) Trophoblast - large fluid-filled sphere
 - (b) Inner cell mass - cluster of cells to one side
 - (v) Primary germ layers are eventually formed
 - (a) Ectoderm - outside layer
 - (b) Mesoderm - middle layer
 - (c) Endoderm - inside layer
 - (d) Derivatives of Germ Layers
 - (i) Ectoderm
 - (a) Nervous system
 - (b) Epidermis of the skin
 - (ii) Endoderm

- (ii) Endoderm
 - (a) Mucosae
 - (b) Glands
- (iii) Mesoderm
 - (a) Everything else
- (vi) The late blastocyst implants in the wall of the uterus (by day 14)
- (d) Embryo of Approximately 18 Days
 - (i) Development After Implantation
 - (ii) Chorionic villi (projections of the blastocyst) develop
 - (a) Cooperate with cells of the uterus to form the placenta
 - (iii) Amnion - fluid-filled sac that surrounds the embryo
 - (iv) Umbilical cord
 - (a) Blood-vessel containing stalk of tissue
 - (b) Attaches the embryo to the placenta
 - (v) Functions of the Placenta
 - (a) Forms a barrier between mother and embryo (blood is not exchanged)
 - (b) Delivers nutrients and oxygen
 - (c) Removes waste from embryonic blood
 - (d) Becomes an endocrine organ (produces hormones) and takes over for the corpus luteum (by end of second month) by producing
 - (i) Estrogen
 - (ii) Progesterone
 - (iii) Other hormones that maintain pregnancy
- (e) The Fetus (Beginning of the Ninth Week)
 - (i) All organ systems are formed by the end of the eighth week
 - (ii) Activities of the fetus are growth and organ specialization
 - (iii) This is a stage of tremendous growth and change
- 4. Childbirth
 - a) Effects of Pregnancy on the Mother

- a) Effects of Pregnancy on the Mother
 - (1) Pregnancy - period from conception until birth
 - (2) Anatomical changes
 - (a) Enlargement of the uterus
 - (b) Accentuated lumbar curvature (lordosis)
 - (c) Relaxation of the pelvic ligaments and pubic symphysis due to production of relaxin
 - (3) Physiological changes
 - (a) Gastrointestinal system
 - (i) Morning sickness is common due to elevated progesterone and estrogens
 - (ii) Heartburn is common because of organ crowding by the fetus
 - (iii) Constipation is caused by declining motility of the
 - (b) Urinary system
 - (i) Kidneys have additional burden and produce more urine
 - (ii) The uterus compresses the bladder, causing stress incontinence
 - (c) Respiratory system
 - (i) Nasal mucosa becomes congested and swollen
 - (ii) Vital capacity and respiratory rate increase
 - (iii) Dyspnea (difficult breathing) occurs during later stages of pregnancy
 - (d) Cardiovascular system
 - (i) Blood volume increases by 25–40%
 - (ii) Blood pressure and pulse increase
 - (iii) Varicose veins are common
- b) Childbirth (Parturition)
 - (1) Labor - the series of events that expel the infant from the uterus
 - (a) Rhythmic, expulsive contractions
 - (b) Operates by the positive feedback mechanism
 - (c) False labor - Braxton Hicks contractions are weak, irregular uterine contractions

- (2) Initiation of labor
 - (a) Estrogen levels rise
 - (i) Uterine contractions begin
 - (b) The placenta releases prostaglandins
 - (c) Oxytocin is released by the pituitary
 - (d) Combination of these hormones oxytocin and prostaglandins produces contractions
 - (3) Stages of Labor
 - (a) Dilation
 - (i) Cervix becomes dilated
 - (ii) Full dilation is 10 cm
 - (iii) Uterine contractions begin and increase
 - (iv) Cervix softens and effaces (thins)
 - (v) The amnion ruptures (“breaking the water”)
 - (vi) Longest stage at 6–12 hours
 - (b) Expulsion
 - (i) Infant passes through the cervix and vagina
 - (ii) Can last as long as 2 hours, but typically is 50 minutes in the first birth and 20 minutes in subsequent births
 - (iii) Normal delivery is head first (vertex position)
 - (iv) Breech presentation is buttocks-first
 - (c) Placental stage
 - (i) Delivery of the placenta
 - (ii) Usually accomplished within 15 minutes after birth of infant
 - (iii) Afterbirth - placenta and attached fetal membranes
 - (a) All placental fragments should be removed to avoid postpartum bleeding
- D. Developmental Aspects of the Reproductive System
 - 1. Gender is determined at fertilization
 - a) Males have XY sex chromosomes
 - b) Females have XX sex chromosomes

- b) Females have XX sex chromosomes
- 2. Gonads do not begin to form until the eighth week
 - a) Testosterone determines whether male or female structures will form
- 3. Reproductive system organs do not function until puberty
 - a) Puberty usually begins between ages 10 and 15
- 4. Males
 - a) Enlargement of testes and scrotum signals onset of puberty (often around age 13)
- 5. Females
 - a) Budding breasts signal puberty (often around age 11)
 - b) Menarche - first menstrual period
 - c) Menopause - a whole year has passed without menstruation
 - (1) Ovaries stop functioning as endocrine organs
 - (2) Childbearing ability ends
 - (3) There is a no equivalent of menopause in males, but there is a steady decline in testosterone
- E. Contraception - birth control
 - 1. Birth control pill - most-used contraceptive
 - a) Relatively constant supply of ovarian hormones from pill is similar to pregnancy
 - b) Ovarian follicles do not mature, ovulation ceases, menstrual flow is reduced
 - 2. Morning-after pill (MAP)
 - a) Taken within 3 days of unprotected intercourse
 - b) Disrupts normal hormonal signals to the point that fertilization is prevented
 - c) Other hormonal birth control devices cause cervical mucus to thicken
 - d) Minepill (tablet)
 - e) Norplant (rods placed under the skin)
 - 3. Intrauterine device (IUD)
 - a) Plastic or metal device inserted into uterus
 - b) Prevents implantation of fertilized egg
 - 4. Sterilization

- 4. Sterilization
 - a) Tubal ligation (females) - cut or cauterize uterine tubes
 - b) Vasectomy (males) - cut or cauterize the ductus deferens
- 5. Coitus interruptus - withdrawal of penis prior to ejaculation
- 6. Rhythm (fertility awareness) - avoid intercourse during period of ovulation or fertility
 - a) Record daily basal temperature (body temperature rises after ovulation)
 - b) Record changes in pattern of salivary mucus
- 7. Barrier methods
 - a) Diaphragms
 - b) Cervical caps
 - c) Condoms
- 8. Spermicidal foams
 - a) Gels
 - b) Sponges
- 9. Abortion - termination of pregnancy
 - a) Miscarriage - spontaneous abortion is common and frequently occurs before a woman knows she is pregnant
- 10. RU486 or “abortion pill” - induces miscarriage during first 7 weeks