

The Reproductive System

The Reproductive System

- Gonads—primary sex organs
 - Testes in males
 - Ovaries in females
- Gonads produce gametes (sex cells) and secrete hormones
 - Sperm—male gametes
 - Ova (eggs)—female gametes

Male Reproductive System Overview

- Testes
- Duct system
 - Epididymis
 - Ductus (vas) deferens
 - Urethra

Male Reproductive System Overview

- Accessory organs
 - Seminal vesicles
 - Prostate
 - Bulbourethral glands
- External genitalia
 - Penis
 - Scrotum

Male Reproductive System

Testes

- Coverings of the testes
 - Tunica albuginea—capsule that surrounds each testis
 - Septa—extensions of the capsule that extend into the testis and divide it into lobules
- Testes
- Each lobule contains one to four seminiferous tubules
 - Tightly coiled structures
 - Function as sperm-forming factories
 - Empty sperm into the rete testis (first part of the duct system)
- Sperm travels through the rete testis to the epididymis
- Interstitial cells in the seminiferous tubules produce androgens such as testosterone

Testes

Duct System

- Epididymis
- Ductus (vas) deferens
- Urethra
- Epididymis
 - Comma-shaped, tightly coiled tube
 - Found on the superior part of the testis and along the posterior lateral side
 - Functions to mature and store sperm cells (at least 20 days)
 - Expels sperm with the contraction of muscles in the epididymis walls to the vas deferens

Epididymis

Ductus Deferens (Vas Deferens)

- Carries sperm from the epididymis to the ejaculatory duct
- Passes through the inguinal canal and over the bladder
- Moves sperm by peristalsis
- Spermatic cord—ductus deferens, blood vessels, and nerves in a connective tissue sheath

Ductus Deferens (Vas Deferens)

- Ends in the ejaculatory duct which unites with the urethra
- Expanded end is called the ampulla
- Ejaculation—smooth muscle in the walls of the ductus deferens create peristaltic waves to squeeze sperm forward
- Vasectomy—cutting of the ductus deferens at the level of the testes to prevent transportation of sperm

Urethra

- Extends from the base of the urinary bladder to the tip of the penis
- Carries both urine and sperm
- Sperm enters from the ejaculatory duct

Urethra

- Regions of the urethra
 - Prostatic urethra—surrounded by prostate
 - Membranous urethra—from prostatic urethra to penis
 - Spongy (penile) urethra—runs the length of the penis

Urethra

Accessory Organs

- Seminal vesicles
- Prostate
- Bulbourethral glands

Accessory Organs

Seminal Vesicles

- Located at the base of the bladder
- Produces a thick, yellowish secretion (60% of semen)
 - Fructose (sugar)
 - Vitamin C
 - Prostaglandins
 - Other substances that nourish and activate sperm

Accessory Organs

Prostate

- Encircles the upper part of the urethra
- Secretes a milky fluid
 - Helps to activate sperm
 - Enters the urethra through several small ducts

Prostate

Bulbourethral Glands

- Pea-sized gland inferior to the prostate
- Produces a thick, clear mucus

- Cleanses the urethra of acidic urine
- Serves as a lubricant during sexual intercourse
- Secreted into the penile urethra

Semen

- Mixture of sperm and accessory gland secretions
- Advantages of accessory gland secretions
 - Fructose provides energy for sperm cells
 - Alkalinity of semen helps neutralize the acidic environment of vagina
 - Semen inhibits bacterial multiplication
 - Elements of semen enhance sperm motility

External Genitalia

- Scrotum
- Penis

External Genitalia

- Scrotum
 - Divided sac of skin outside the abdomen
 - Maintains testes at 3°C lower than normal body temperature to protect sperm viability

External Genitalia

- Penis
 - Delivers sperm into the female reproductive tract
 - Regions of the penis
 - Shaft
 - Glans penis (enlarged tip)
 - Prepuce (foreskin)
 - Folded cuff of skin around proximal end
 - Often removed by circumcision

External Genitalia

- Internally there are three areas of spongy erectile tissue around the urethra
- Erections occur when this erectile tissue fills with blood during sexual excitement

Spermatogenesis

- Production of sperm cells
- Begins at puberty and continues throughout life
- Occurs in the seminiferous tubules

Spermatogenesis

- Spermatogonia (stem cells) undergo rapid mitosis to produce more stem cells before puberty
- Follicle-stimulating hormone (FSH) modifies spermatogonia division
 - One cell produced is a stem cell, called a type A daughter cell
 - The other cell produced becomes a primary spermatocyte, called a type B daughter cell

Spermatogenesis

- Primary spermatocytes undergo meiosis
- One primary spermatocyte produces four haploid spermatids
 - Spermatids—23 chromosomes (half as much material as other body cells)

Human Life Cycle

- Union of a sperm (23 chromosomes) with an egg (23 chromosomes) creates a zygote (2n or 46 chromosomes)

Spermiogenesis

- Late spermatids are produced with distinct regions
 - Head
 - Midpiece
 - Tail
- Sperm cells result after maturing of spermatids
- Spermatogenesis (entire process, including spermiogenesis) takes 64 to 72 days

Structure of a Sperm

Anatomy of a Mature Sperm Cell

- The only human flagellated cell
- Head
 - Contains DNA
 - Acrosome—“helmet” on the nucleus, similar to a large lysosome
 - Breaks down and releases enzymes to help the sperm penetrate an egg
- Midpiece
 - Wrapped by mitochondria for ATP generation

Testosterone Production

- The most important hormone of the testes
- Produced in interstitial cells
- During puberty, luteinizing hormone (LH) activate the interstitial cells
- In turn, testosterone is produced

Testosterone Production

- Functions of testosterone
 - Stimulates reproductive organ development
 - Underlies sex drive
 - Causes secondary sex characteristics
 - Deepening of voice
 - Increased hair growth
 - Enlargement of skeletal muscles
 - Thickening of bones

Hormonal Control of the Testis

Female Reproductive System

- Ovaries
- Duct System
 - Uterine tubes (fallopian tubes)
 - Uterus
 - Vagina
- External genitalia
 - Female Reproductive System
 - Ovaries
- Composed of ovarian follicles (sac-like structures)
- Each follicle consists of
 - Oocyte (immature egg)

- Follicular cells—surround the oocyte

Ovaries

Ovarian Follicle Stages

- Primary follicle—contains an immature oocyte
- Graafian (vesicular) follicle—growing follicle with a maturing oocyte
- Ovulation—when the egg is mature, the follicle ruptures; occurs about every 28 days
- The ruptured follicle is transformed into a corpus luteum

Support for Ovaries

- Suspensory ligaments—secure ovary to lateral walls of the pelvis
- Ovarian ligaments—attach to uterus
- Broad ligament—a fold of the peritoneum, encloses suspensory ligament

Female Reproductive System

Duct System

- Uterine tubes (fallopian tubes)
- Uterus
- Vagina

Uterine (Fallopian) Tubes

- Receive the ovulated oocyte
- Provide a site for fertilization
- Attach to the uterus
- Little or no contact between ovaries and uterine tubes
- Supported and enclosed by the broad ligament

Uterine Tube Anatomy and Physiology

- Fimbriae
 - Finger-like projections at the distal end of the uterine tube
 - Receive the oocyte from the ovary
- Cilia
 - Located inside the uterine tube
 - Slowly move the oocyte towards the uterus (takes 3–4 days)
- Fertilization occurs inside the uterine tube since oocyte lives about 24 hours

Female Reproductive System

Uterus

- Located between the urinary bladder and rectum
- Hollow organ
- Functions of the uterus
 - Receives a fertilized egg
 - Retains the fertilized egg
 - Nourishes the fertilized egg

Support for the Uterus

- Broad ligament—attached to the pelvis
- Round ligament—anchored anteriorly
- Uterosacral ligaments—anchored posteriorly

Female Reproductive System

Regions of the Uterus

- Body—main portion

- Fundus—superior rounded region above where uterine tube enters
- Cervix—narrow outlet that protrudes into the vagina
 - Walls of the Uterus
- Endometrium
 - Inner layer
 - Allows for implantation of a fertilized egg
 - Sloughs off if no pregnancy occurs (menses)
- Myometrium—middle layer of smooth muscle
- Perimetrium (visceral peritoneum)—outermost serous layer of the uterus
- Female Reproductive System
 - Vagina
 - Extends from cervix to exterior of body
 - Located between bladder and rectum
 - Serves as the birth canal
 - Receives the penis during sexual intercourse
 - Hymen—partially closes the vagina until it is ruptured
- External Genitalia (Vulva)
 - Mons pubis
 - Labia
 - Clitoris
 - Urethral orifice
 - Vaginal orifice
 - Greater vestibular glands
 - External Genitalia (Vulva)
 - Mons Pubis
 - Fatty area overlying the pubic symphysis
 - Covered with pubic hair after puberty
 - Labia
 - Labia—skin folds
 - Labia majora—hair-covered skin folds
 - Labia minora—delicate, hair-free folds of skin
- Vestibule and Greater Vestibular Glands
 - Vestibule
 - Enclosed by labia majora
 - Contains external openings of the urethra, vagina
 - Greater vestibular glands
 - One is found on each side of the vagina
 - Secretes lubricant during intercourse
- Vestibule and Orifice of Vestibular Gland
 - Clitoris
 - Contains erectile tissue
 - Corresponds to the male penis
 - The clitoris is similar to the penis in that it is
 - Hooded by a prepuce
 - Composed of sensitive erectile tissue

- Becomes swollen with blood during sexual excitement

Perineum

- Diamond-shaped region between the anterior ends of the labial folds, anus posteriorly, and ischial tuberosities laterally

Oogenesis and the Ovarian Cycle

- The total supply of eggs are present at birth
- Ability to release eggs begins at puberty
- Reproductive ability ends at menopause
- Oocytes are matured in developing ovarian follicles

Oogenesis and the Ovarian Cycle

- Oogonia—female stem cells found in a developing fetus
- Oogonia undergo mitosis to produce primary oocytes
- Primary oocytes are surrounded by cells that form primary follicles in the ovary
- Oogonia no longer exist by the time of birth

Oogenesis and the Ovarian Cycle

- Primary oocytes are inactive until puberty
- Follicle stimulating hormone (FSH) causes some primary follicles to mature each month
- Cyclic monthly changes constitute the ovarian cycle

Oogenesis and the Ovarian Cycle

- Meiosis starts inside maturing follicle
- Produces a secondary oocyte and the first polar body
- Follicle development to the stage of a vesicular follicle takes about 14 days
- Ovulation of a secondary oocyte occurs with the release of luteinizing hormone (LH)
- Secondary oocyte is released and surrounded by a corona radiata

Ovulation

Oogenesis and the Ovarian Cycle

- Meiosis is completed after ovulation *only if* sperm penetrates
 - Ovum is produced
 - Two additional polar bodies are produced
- Once ovum is formed, the 23 chromosomes can be combined with those of the sperm to form the fertilized egg (zygote)
- If the secondary oocyte is *not* penetrated by a sperm, it dies and does not complete meiosis to form an ovum

Male and Female Differences

- Meiosis
 - Males—produces four functional sperm
 - Females—produces one functional ovum and three polar bodies
- Sex cell size and structure
 - Sperm are tiny, motile, and equipped with nutrients in seminal fluid
 - Egg is large, non-motile, and has nutrient reserves to nourish the embryo until implantation

Oogenesis

Uterine (Menstrual) Cycle

- Cyclic changes of the endometrium
- Regulated by cyclic production of estrogens and progesterone

- FSH and LH regulate the production of estrogens and progesterone
- Both female cycles are about 28 days in length
- Ovulation typically occurs about midway through cycle on day 14
- Uterine (Menstrual) Cycle
- Stages of the menstrual cycle
 - Menstrual phase
 - Proliferative stage
 - Secretory stage
- Uterine (Menstrual) Cycle
- Menstrual phase
 - Days 1–5
 - Functional layer of the endometrium is sloughed
 - Bleeding occurs for 3–5 days
 - By day 5, growing ovarian follicles are producing more estrogen
- Uterine (Menstrual) Cycle
- Proliferative stage
 - Days 6–14
 - Regeneration of functional layer of the endometrium
 - Estrogen levels rise
 - Ovulation occurs in the ovary at the end of this stage
- Uterine (Menstrual) Cycle
- Secretory stage
 - Days 15–28
 - Levels of progesterone rise and increase the blood supply to the endometrium
 - Endometrium increases in size and readies for implantation
- Uterine (Menstrual) Cycle
- Secretory stage (continued)
 - If fertilization does occur
 - Embryo produces a hormone that causes the corpus luteum to continue producing its hormones
 - If fertilization does NOT occur
 - Corpus luteum degenerates as LH blood levels decline
- Fluctuation of Gonadotropin Levels
- Fluctuation of Ovarian Hormone Levels
- Ovarian Cycle
- Uterine (Menstrual) Cycle
- Hormone Production by the Ovaries
- Estrogens
 - Produced by follicle cells
 - Cause secondary sex characteristics
 - Enlargement of accessory organs
 - Development of breasts
 - Appearance of axillary and pubic hair
 - Increase in fat beneath the skin, particularly in hips and breasts
 - Widening and lightening of the pelvis
 - Onset of menses (menstrual cycle)

Hormone Production by the Ovaries

- Progesterone
 - Produced by the corpus luteum
 - Production continues until LH diminishes in the blood
 - Does not contribute to the appearance of secondary sex characteristics
 - Other major effects
 - Helps maintain pregnancy
 - Prepare the breasts for milk production

Female Reproductive System Overview

Developmental Stages of Ovarian Follicle

Mammary Glands

- Present in both sexes, but only function in females
 - Modified sweat glands
 - Function is to produce milk
 - Stimulated by sex hormones (mostly estrogens) to increase in size
- ### Anatomy of Mammary Glands
- Areola—central pigmented area
 - Nipple—protruding central area of areola
 - Lobes—internal structures that radiate around nipple
 - Lobules—located within each lobe and contain clusters of alveolar glands
 - Alveolar glands—produce milk when a woman is lactating (producing milk)
 - Lactiferous ducts—connect alveolar glands to nipple

Female Mammary Glands

Mammography

- X-ray examination that detects breast cancers too small to feel
- Recommended every 2 years for women between 40 and 49 years old and yearly thereafter

Mammograms

Stages of Pregnancy and Development

- Fertilization
- Embryonic development
- Fetal development
- Childbirth

Fertilization

- The oocyte is viable for 12 to 24 hours after ovulation
- Sperm are viable for 24 to 48 hours after ejaculation
- For fertilization to occur, sexual intercourse must occur no more than 2 days before ovulation and no later than 24 hours after
- Sperm cells must make their way to the uterine tube for fertilization to be possible

Mechanisms of Fertilization

- When sperm reach the oocyte, enzymes break down the follicle cells of the corona radiata around the oocyte
- Once a path is cleared, sperm undergo an acrosomal reaction (acrosomal membranes break down and enzymes digest holes in the oocyte membrane)
- Membrane receptors on an oocyte pull in the head of the first sperm cell to make contact

Mechanisms of Fertilization

- The membrane of the oocyte does not permit a second sperm head to enter
- The oocyte then undergoes its second meiotic division to form the ovum and a polar body
- Fertilization occurs when the genetic material of a sperm combines with that of an oocyte to form a zygote

The Zygote

- First cell of a new individual
- The result of the fusion of DNA from sperm and egg
- The zygote begins rapid mitotic cell divisions
- The zygote stage is in the uterine tube, moving toward the uterus

Cleavage

- Rapid series of mitotic divisions that begins with the zygote and ends with the blastocyst
- Zygote begins to divide 24 hours after fertilization
- Three to 4 days after ovulation, the preembryo reaches the uterus and floats freely for 2–3 days
- Late blastocyst stage—embryo implants in endometrium (day 7 after ovulation)

Cleavage

Developmental Stages

- Embryo—developmental stage until ninth week
 - Morula—16-cell stage
 - Blastocyst—about 100 cells
- Fetus—beginning in ninth week of development

The Embryo

- The embryo first undergoes division without growth
- The embryo enters the uterus at the 16-cell state (called a morula) about 3 days after ovulation
- The embryo floats free in the uterus temporarily
- Uterine secretions are used for nourishment

The Blastocyst (Chorionic Vesicle)

- Ball-like circle of cells
- Begins at about the 100-cell stage
- Secretes human chorionic gonadotropin (hCG) to induce the corpus luteum to continue producing hormones
- Functional areas of the blastocyst
 - Trophoblast—large fluid-filled sphere
 - Inner cell mass—cluster of cells to one side

The Blastocyst (Chorionic Vesicle)

- Primary germ layers are eventually formed
 - Ectoderm—outside layer
 - Mesoderm—middle layer
 - Endoderm—inside layer
- The late blastocyst implants in the wall of the uterus (by day 14)

Derivatives of Germ Layers

- Ectoderm

- Nervous system
 - Epidermis of the skin
 - Endoderm
 - Mucosae
 - Glands
 - Mesoderm
 - Everything else
- Embryo of Approximately 18 Days
Development After Implantation
- Chorionic villi (projections of the blastocyst) develop
 - Cooperate with cells of the uterus to form the placenta
 - Amnion—fluid-filled sac that surrounds the embryo
 - Umbilical cord
 - Blood-vessel containing stalk of tissue
 - Attaches the embryo to the placenta
- Embryo of Approximately 18 Days
The 7-week Embryo
Functions of the Placenta
- Forms a barrier between mother and embryo (blood is not exchanged)
 - Delivers nutrients and oxygen
 - Removes waste from embryonic blood
 - Becomes an endocrine organ (produces hormones) and takes over for the corpus luteum (by end of second month) by producing
 - Estrogen
 - Progesterone
 - Other hormones that maintain pregnancy
- The Fetus (Beginning of the Ninth Week)
- All organ systems are formed by the end of the eighth week
 - Activities of the fetus are growth and organ specialization
 - This is a stage of tremendous growth and change in appearance
 - Photographs of a Developing Fetus
 - Development of the Human Fetus
 - Effects of Pregnancy on the Mother
 - Pregnancy—period from conception until birth
 - Anatomical changes
 - Enlargement of the uterus
 - Accentuated lumbar curvature (lordosis)
 - Relaxation of the pelvic ligaments and pubic symphysis due to production of relaxin
- Effects of Pregnancy on the Mother
- Physiological changes
 - Gastrointestinal system
 - Morning sickness is common due to elevated progesterone and estrogens
 - Heartburn is common because of organ crowding by the fetus
 - Constipation is caused by declining motility of the digestive tract
- Effects of Pregnancy on the Mother

- Physiological changes (continued)
 - Urinary system
 - Kidneys have additional burden and produce more urine
 - The uterus compresses the bladder, causing stress incontinence
- Effects of Pregnancy on the Mother
- Physiological changes (continued)
- Respiratory system
 - Nasal mucosa becomes congested and swollen
 - Vital capacity and respiratory rate increase
 - Dyspnea (difficult breathing) occurs during later stages of pregnancy
- Effects of Pregnancy on the Mother
- Physiological changes (continued)
 - Cardiovascular system
 - Blood volume increases by 25–40%
 - Blood pressure and pulse increase
 - Varicose veins are common
- Childbirth (Parturition)
- Labor—the series of events that expel the infant from the uterus
 - Rhythmic, expulsive contractions
 - Operates by the positive feedback mechanism
- False labor—Braxton Hicks contractions are weak, irregular uterine contractions
- Childbirth (Parturition)
- Initiation of labor
 - Estrogen levels rise
 - Uterine contractions begin
 - The placenta releases prostaglandins
 - Oxytocin is released by the pituitary
 - Combination of these hormones oxytocin and prostaglandins produces contractions
- Initiation of Labor
- Stages of Labor
- Dilation
 - Cervix becomes dilated
 - Full dilation is 10 cm
 - Uterine contractions begin and increase
 - Cervix softens and effaces (thins)
 - The amnion ruptures (“breaking the water”)
 - Longest stage at 6–12 hours
- Stages of Labor
- Expulsion
 - Infant passes through the cervix and vagina
 - Can last as long as 2 hours, but typically is 50 minutes in the first birth and 20 minutes in subsequent births
 - Normal delivery is head first (vertex position)
 - Breech presentation is buttocks-first
- Stages of Labor
- Stages of Labor

- Placental stage
 - Delivery of the placenta
 - Usually accomplished within 15 minutes after birth of infant
 - Afterbirth—placenta and attached fetal membranes
 - All placental fragments should be removed to avoid postpartum bleeding

Stages of Labor

Developmental Aspects of the Reproductive System

- Gender is determined at fertilization
 - Males have XY sex chromosomes
 - Females have XX sex chromosomes
- Gonads do not begin to form until the eighth week
- Testosterone determines whether male or female structures will form

Developmental Aspects of the Reproductive System

- Reproductive system organs do not function until puberty
- Puberty usually begins between ages 10 and 15

Developmental Aspects of the Reproductive System

- Males
 - Enlargement of testes and scrotum signals onset of puberty (often around age 13)
- Females

- Budding breasts signal puberty (often around age 11)
- Menarche—first menstrual period

Developmental Aspects of the Reproductive System

- Menopause—a whole year has passed without menstruation
 - Ovaries stop functioning as endocrine organs
 - Childbearing ability ends
- There is a no equivalent of menopause in males, but there is a steady decline in testosterone

A Closer Look: Contraception

- Contraception—birth control
- Birth control pill—most-used contraceptive
 - Relatively constant supply of ovarian hormones from pill is similar to pregnancy
 - Ovarian follicles do not mature, ovulation ceases, menstrual flow is reduced

A Closer Look: Contraception

- Morning-after pill (MAP)
 - Taken within 3 days of unprotected intercourse
 - Disrupts normal hormonal signals to the point that fertilization is prevented
- Other hormonal birth control devices cause cervical mucus to thicken
 - Minepill (tablet)
 - Norplant (rods placed under the skin)

A Closer Look: Contraception

- Intrauterine device (IUD)
 - Plastic or metal device inserted into uterus
 - Prevents implantation of fertilized egg

- Sterilization
 - Tubal ligation (females)—cut or cauterize uterine tubes
 - Vasectomy (males)—cut or cauterize the ductus deferens

A Closer Look: Contraception
- Coitus interruptus—withdrawal of penis prior to ejaculation
- Rhythm (fertility awareness)—avoid intercourse during period of ovulation or fertility
 - Record daily basal temperature (body temperature rises after ovulation)
 - Record changes in pattern of salivary mucus

A Closer Look: Contraception
- Barrier methods
 - Diaphragms
 - Cervical caps
 - Condoms
 - Spermicidal foams
 - Gels
 - Sponges

A Closer Look: Contraception
- Abortion—termination of pregnancy
- Miscarriage—spontaneous abortion is common and frequently occurs before a woman knows she is pregnant
- RU486 or “abortion pill”—induces miscarriage during first 7 weeks of pregnancy
 - Flow Chart of Events that Must Occur to Produce a Baby
 - Some Contraceptive Devices