Anatomy of the Male Reproductive System

- Urinary bladder
- Pubic symphysis
- Urethra
- Penis
- Ductus deferens
- Glans of penis
- Prepuce
- Epididymis
- Testis
- Scrotum
- Ampulla
- Ejaculatory duct
- Seminal vesicle
- Prostate gland
- Bulbourethral gland
- Rectum
Anatomy of the Male Reproductive System

- **External genitalia** (can be seen on the body surface)
  - penis
  - scrotum
- **Internal genitalia** (can’t be seen on the body surface)
  - sperm producing organs
    - testes
  - ducts that move sperm from the testes out of the body
    - epididymis
    - vas (ductus) deferens
    - ejaculatory duct
    - urethra
  - exocrine glands that secrete fluids into the ducts adding to the sperm to make semen
    - seminal vesicles
    - prostate gland
    - bulbourethral (Cowper’s) gland
Penis

- External penis consists of:
  - a shaft
  - a glans penis a prepuce (foreskin) covers the glans
- Internal penis consists of:
  - the urethra
    - transports urine and semen out of the body
  - three cylindrical bodies of **erectile tissue**, a spongy network of vascular sinuses (spaces) which fill with blood during sexual excitement
    - Corpora cavernosa
      - paired erectile bodies dorsal to the urethra which are responsible for erection
    - Corpus spongiosum
      - surrounds the urethra and prevents the collapse of the urethra during erection
Male Sexual Response: Erection

- Enlargement and stiffening of the penis due to the filling of erectile tissue with blood
- During sexual arousal, a Parasympathetic NS reflex promotes the vasodilation of penile arteries
  - blood fills the erectile tissue
- Expansion of the corpora cavernosa compresses the veins that drain blood out of the penis, preventing the flow of blood out of the erectile tissue
Scrotum

• Sac of skin and muscle that hangs outside the abdominal cavity which hold the testes
• Its external positioning keeps the testes at 34°C which is required for sperm production
• Two sets of muscles maintain testicular temperature:
  – dartos
    • a layer of smooth muscle deep to the skin
  – cremaster
    • smooth muscle surrounding the testes
• Contraction/relaxation of both muscles raise/lower the testes toward/away from the abdominal cavity increasing/decreasing testicular temperature
Testes

- Organs responsible for the production of:
  - male sex steroid hormone **testosterone**
  - sperm
- Organized into hundreds of sperm producing **seminiferous tubules**
  - the tubules are made of a simple columnar epithelium of **sertoli** (Nurse) cells
  - the **sperm** development (**spermatogenesis**) occurs between sertoli cells from the basal surface (inside the body) of the seminiferous tubule to the lumen (outside the body)
- **Interstitial** (Leydig) cells found between adjacent seminiferous tubules synthesize **testosterone**
- Fluid within the seminiferous tubules flows toward the epididymis carrying the sperm
Testes

- Spermatic cord
- Blood vessels and nerves
- Head of epididymis
- Ductus deferens
- Efferent ductule
- Rete testis
- Body of epididymis
- Tail of epididymis
- Seminiferous tubule
- Septum
- Lobule
- Tunica vaginalis
- Tunica albuginea
Seminiferous Tubule

- Blood vessel
- Seminiferous tubule
- Spermatids
- Sustentacular cells
- Tubule lumen
- Germ cells
- Connective tissue wall of tubule
- Interstitial cells
Hormonal Control of Testicular Function

- The secretion of testosterone is controlled by gonadotropin-releasing hormone (GnRH) and luteinizing hormone (LH) secreted from the hypothalamus and anterior pituitary gland, respectively.
- LH binds to receptors on Leydig cells which stimulates the synthesis of testosterone.
- Some of the testosterone leaves the testes causing effects in various locations in the body causing increase bone and muscle density; facial, axillary and genital hair growth, lengthening of vocal cords.
- Some of the testosterone remains in the testes to support spermatogenesis.
Epididymis

- A mass of coiled tubes on the superficial surface of each testis that the sperm must pass through prior to ejaculation
- Sperm become mature (capable of fertilizing an ovum) as pass through its tubes toward the vas deferens
- During ejaculation, a layer of smooth muscle that surrounds the distal epididymis contracts, expelling sperm into the *vas deferens*
Ductus (Vas) Deferens and Ejaculatory Duct

- A duct that propels ejaculated sperm from the **epididymis** towards the **urethra**
- Its distal end merges with the duct of the exocrine seminal vesicle to give rise to the **ejaculatory duct**
- A **vasectomy** is an effective form of birth control whereby the vas deferens is cut and tied
Male Sexual Response: Ejaculation

- The propulsion of semen from the male duct system is coordinated by a Sympathetic NS reflex causing:
  - the smooth muscle surrounding the reproductive ducts and accessory glands to contract
- **Semen** is a fluid consisting of sperm and the exocrine secretions of the 3 accessory glands:
  - Seminal vesicles
  - Prostate gland
  - Bulbourethral glands
Seminal Vesicles

- 2 glands on the posterior wall of the bladder
- Secrete **seminal fluid** into ejaculatory duct
  - accounts for 60% of semen volume
  - alkaline
    - neutralizes the acidic environment of the vagina
  - contains **fructose**
    - energy source for the sperm
- Sperm and seminal fluid mix in the **ejaculatory duct** and move towards the urethra
Doughnut-shaped gland that encircles the urethra just inferior to the bladder secretes *prostate fluid* into the urethra

- accounts for 33% of semen volume
- contains enzymes that stimulate sperm movement in the vagina
Bulbourethral Glands (Cowper’s Glands)

• 2 pea-sized glands inferior to the prostate
• Produce thick, clear mucus during erection which:
  – neutralizes traces of acidic urine in the urethra
  – lubricates the urethra to facilitate the ejaculation of semen
Anatomy of the Female Reproductive System

• External genitalia (collectively referred to as vulva)
  – labia majora
  – labia minora
  – clitoris

• Internal genitalia
  – ova producing organs
    • ovaries
  – ducts/organs
    • uterine (fallopian) tubes
    • uterus
    • vagina
Female Internal Genitalia

- Infundibulum
- Ampulla
- Isthmus
- Fundus
- Body
- Ovarian ligament
- Mesosalpinx
- Mesovarium
- Uterine tube
- Ovarian artery
- Ovarian vein
- Suspensory ligament
- Ovary
- Mesometrium
- Round ligament
- Cardinal ligament
- Uterosacral ligament
- Myometrium
- Endometrium
- Internal os
- Cervical canal
- Lateral fornix
- Cervix
- External os
- Vagina
Ovaries

- Located on either side of the uterus
- Located in superficial surface of the ovary (cortex) are **primordial follicles** (200,000 per ovary)
- Each primordial follicle consists of:
  - an **oocyte** (immature egg cell) surrounded by a single layer of **follicular cells**
- Every 28 days the pituitary hormones FSH and LH stimulate the growth of one follicle and maturation of the oocyte within the follicle called the **ovarian cycle**
Uterine (Fallopian) Tubes

- Tubes lined with ciliated columnar epithelium create a flow of peritoneal fluid into the uterine tubes to “pull” the ovulated ovum into the uterine tube and moves it toward the uterus.

- The **fertilization** of an ovum by a sperm occurs within the distal ¼ of the tube (closest to the ovary).
Uterus

- Hollow, thick-walled organ located in the pelvis, superior to the vagina which provides an ideal location for the implantation and 9 month development of a fertilized ovum

There are 3 anatomical regions

- **Cervix**
  - narrow neck which connects to the vagina inferiorly
- **Body**
  - large middle portion of the uterus
- **Fundus**
  - rounded superior region that connects to the 2 uterine (fallopian) tubes
Uterine Wall

Composed of three layers

• Endometrium
  – a 2 layered lining consisting of:
    • a superficial simple columnar epithelium
    • a deep loose connective tissue containing blood vessels and uterine glands (exocrine)
  – changes in thickness during the 28 day uterine (menstrual) cycle

• Myometrium
  • thick middle layer consisting of smooth muscle
    – contracts during labor and childbirth

• Perimetrium
  – outermost layer consisting of elastic but tough connective tissue
    • similar to the visceral peritoneum
Vagina

• Thin-walled tube lying posterior to the bladder and anterior to the rectum
  – the organ of intercourse
  – connects the external environment to the **uterus**
  – provides a passageway for:
    • sperm
    • menstrual flow
    • birth
Ovarian and Uterine (Menstrual) Cycles

• Every 28 days in a non-pregnant female between puberty (first menstruation) and menopause (cessation of menstruation) there are changes that occur **SIMULTANEOUSLY** in one of the **ovaries** and the **uterus** of a non-pregnant female.

• Ovarian Cycle
  – controlled by GnRH, FSH and LH which target the ovaries and stimulate the secretion of estrogen and progesterone.

• Uterine Cycle
  – Estrogen and progesterone from the ovary target the endometrium (luminal wall) of the uterus causing it to grow and secrete **uterine milk** into the uterine lumen (exocrine).
(a) Ovarian cycle

- **Gonadotropin secretion**
  - LH (Luteinizing Hormone)
  - FSH (Follicle-Stimulating Hormone)

- **Ovarian events**
  - Developing follicle (from 2 months earlier)
  - Mature follicle
  - Ovulation
  - Corpus luteum
  - Involution
  - Corpus albicans

- **Days**
  - 1
  - 3
  - 5
  - 7
  - 9
  - 11
  - 13
  - 15
  - 17
  - 19
  - 21
  - 23
  - 25
  - 27
  - 1

- **Phases**
  - Preantral phase
  - Antral phase
  - Follicular phase
  - Luteal phase

(b) Menstrual cycle

- **Ovarian hormone secretion**
  - Estradiol
  - Progesterone

- **Thickness of endometrium**
  - Menstrual fluid

- **Days**
  - 1
  - 3
  - 5
  - 7
  - 9
  - 11
  - 13
  - 15
  - 17
  - 19
  - 21
  - 23
  - 25
  - 27
  - 1

- **Phases**
  - Menstrual phase
  - Proliferative phase
  - Secretory phase
  - Premenstrual phase
Ovarian Cycle

Follicular phase (days 1 – 14)

• GnRH from the hypothalamus stimulates FSH and LH secretion from the anterior pituitary gland
  – FSH stimulates the mitosis (growth) of the follicular cells of a primordial follicle developing into a primary follicle
  – LH stimulates estrogen secretion from follicular cells
  – follicular cells secrete a layer of proteins around the ova called the zona pellucida
  – continues to grow into a secondary follicle
    • develops a fluid filled antrum in the center
    • estrogen levels begin to rise steadily as the follicular cells continue secretion
  – continue growth into a Graafian (mature) follicle
Ovarian Cycle

- **Ovulation** (day 14)
  - The *rising levels estrogen* secreted from the Graafian follicle causes a *surge* (release) of LH (and FSH)
  - The LH surge stimulates a rapid production of antral fluid which fills the follicle beyond capacity causing it to rupture
  - The ruptured follicle ejects (ovulates) the *ovum* (with a few layers of surrounding follicular cells called the *corona radiata*) into the fallopian tube
  - Most of the follicular cells of the ruptured Graafian follicle remain in the ovary and organize into a *corpus luteum*
Ovarian Cycle

- **Luteal phase** (days 14 – 28)
  - period of *corpus luteum* activity
- LH from the surge:
  - transforms a ruptured follicle into a *corpus luteum*
  - stimulates the secretion of *estrogen* and *progesterone* from the corpus luteum
  - LH level decreases with time from LH surge
The Fate of Corpus Luteum Depends on LH

- If fertilization of the ovulated ovum by a sperm (pregnancy) **DOES NOT OCCUR**, the corpus luteum degenerates into a corpus albicans (small scar)
  - causes a reduction in estrogen and progesterone
  - causes the secretion of GnRH, FSH and LH allowing the cycle to begin again

- If fertilization of the ovulated ovum by a sperm (pregnancy) **DOES OCCUR**, the fertilized egg secretes a hormone called human chorionic gonadotropin (hCG) which stimulates the anterior pituitary gland for continued secretion of LH
  - prevents the degeneration of the corpus luteum
Uterine (Menstrual) Cycle

- **Menstrual** phase (days 1 – 5)
  - menstrual bleeding causes the endometrium to shed (decrease thickness)
  - flows out of the vagina
    - caused by the decrease in estrogen levels from the degeneration of the corpus luteum during the previous cycle
- **Proliferative** phase (days 6 – 14)
  - an increase in estrogen levels during the follicular phase stimulates endometrium growth (thickness)
  - increase in vascular supply and develops exocrine secreting uterine glands
- **Secretory** phase (days 14 – 28)
  - uterine glands secrete uterine milk into the uterus
    - stimulated by an increase in progesterone levels during the luteal phase
Endometrium

– decreases in thickness (sheds) at the beginning of the cycle
– increases in thickness during the middle of the cycle
– secretes uterine milk at the end of the cycle that nourish a developing fertilized egg
• contains many blood vessels to supply a developing embryo and fetus
  – develops into the placenta
Endometrium

(a) Proliferative phase

(b) Secretory phase

(c) Menstrual phase

- Endometrial gland
- Stratum functionalis
- Spiral artery
- Stratum basalis
- Myometrium
- Secration
Fertilization

- The first sperm to reach the ovum exocytoses the proteases of the acrosome which digest a layer of proteins around the ovum—the zona pellucida surrounding the egg to gain access to the cell membrane.
  - the sperm and ovum cell membranes fuse together to create a single cell (zygote).
  - the zygote begins a period of rapid mitotic divisions (cleavage) which increases the number of cells as it continues to travel towards the uterus.
Fertilization and Preembryonic Development

- Fertilization (0 hours)
- Sperm cell
- First polar body
- Secondary oocyte
- Egg pronucleus
- Sperm pronucleus
- Zona pellucida
- Zygote
- 2-celled stage (30 hours)
- 4-celled stage
- 8-celled stage
- Morula (72 hours)
- Cleavage
- Blastomeres
- Ovary
- Maturing follicle
- Corpus luteum
- Ovulation
- Implanted blastocyst (6 days)
- Blastocyst
Placenta

- A temporary organ made of embryonic and maternal tissue 2 layers that allows for the exchange of substances between maternal and embryonic/fetal blood without physical contact between these separate circulatory systems
  - At the end of the 1\textsuperscript{st} trimester it takes over the secretion of \textit{estrogen} and \textit{progesterone} from the corpus luteum causing a rapid increase in both hormones for the remainder of pregnancy
- An increase in estrogen levels in the mother stimulates:
  - breasts enlargement
  - the synthesis of \textit{oxytocin receptors} on the \textit{myometrium} of the \textit{uterus} in preparation for labor and child birth
Structure of Mammary Glands

(a) Sagittal section
(b) Anterior view
Lactation

- During the later stages of pregnancy, estrogen and progesterone levels are very high which stimulates the hypothalamus to secrete prolactin-releasing hormone (PRH) which targets the anterior pituitary
  - the anterior pituitary responds by secreting prolactin
    - stimulates the production of milk in the alveoli in the breasts
Lactation

• After birth, prolactin levels decrease due to the decline estrogen and progesterone levels
• The stimulation for prolactin secretion comes from suckling (activates mechanoreceptors in breast)
• Suckling has 2 main effects:
  – stimulate prolactin secretion to continue milk production
  – stimulate oxytocin secretion to stimulate contraction of smooth muscle around the alveolar ducts in the breast to move milk towards the nipple
    • reduces the size of the uterus by stimulating contraction
Lactation

Prolactin surges

Feedings

Pregnancy

Lactation