

Reproductive System Notes

Male Reproductive System:

Components:

- testes: produce **spermatozoa** (male reproductive cells) and **androgens** (male hormones)
- ducts: **epididymis**, **vas (ductus) deferens**, **urethra** (prostatic, membranous, spongy)
- accessory glands: **prostate**, **seminal vesicles**, **bulbourethral (Cowper's)**
- supporting structures: **scrotum**, **penis**

Development:

- testes **develop inside the abdominal cavity**; descend and exit via the **inguinal canals** prior to birth
- need to exit the abdominal cavity due to high temperature that prevents sperm formation
- failure to descend: **cryptorchidism**, causes sterility
- high temperature causes infertility; **pampiniform plexus** of testicular vein cools testis

Location after birth:

- located in the **scrotum** (sac attached to the **perineum**)
- cradled by **cremaster muscle** (extension of the internal oblique muscle)
- connected via **spermatic cord**: made of testicular artery and vein, vas deferens, nerves

Testicular Structure:

- fibrous **tunica albuginea** covers the outside; inward extensions, called septa, create **lobules** within the testes
- **seminiferous tubules** within the lobules produce **spermatozoa** (s. **spermatozoon**)
- **interstitial cells of Leydig** are found in the spaces between the seminiferous tubules

Spermatogenesis: process of sperm formation

- spermatogonium - primary spermatocyte (first meiotic division) - two secondary spermatocytes (second meiotic division) - four spermatids - four spermatozoa

Spermiogenesis: the process of differentiation of spermatids into spermatozoa

Path followed by spermatozoa:

- produced by cells inside the walls of the seminiferous tubules - move outside the testis in the **epididymis** (very long, thin, highly coiled tube) where they complete maturation in a few days - expelled into the **vas deferens** during ejaculation, travel out of scrotum via the inguinal canal into the pelvic cavity to the posterior side of the urinary bladder - joined by secretions via duct from the **seminal vesicle** - pass through prostate gland via **ejaculatory duct** which opens in the **prostatic urethra** (are joined by prostatic secretions) - now part of **semen** pass through the **membranous urethra** - then **spongy urethra** (joined by secretions of **bulbourethral glands**) - exit through the **urethral meatus** then through the **urethral orifice** to the outside.

Production of **androgens** (mainly **testosterone**):

- **testosterone is produced by the interstitial cells of Leydig**
- testosterone production, almost nil before puberty, increases dramatically at puberty

Some of the functions of testosterone:

- activates anabolic processes
- prior to birth, and after, controls development of male sexual structures
- controls behavior in both sexes
- supports sperm formation
- controls development of **male secondary sex characteristics**:
 - widening of shoulders
 - increased musculature
 - growth of facial hair, pubic and axillary hair
 - enlargement of larynx and vocal cords

Accessory glands:

- **prostate gland**
- **seminal vesicles**
- **bulbourethral (Cowper's glands)**
- produce fructose rich **alkaline secretions** (contain sodium bicarbonate meant to neutralize vaginal acidity)
- **semen**: spermatozoa + secretions of accessory glands

Structure of penis:

- **corpus spongiosum** around the urethra
- two **corpora cavernosa** on dorsal side
- **glans penis**: enlargement at distal end covered by **prepuce** (skin fold)

Erection: filling the corpora cavernosa and corpus spongiosum with blood by increased blood flow in the supply arterioles and decreased drainage through the venules. Controlled by parasympathetic system.

Ejaculation: peristaltic contractions in the walls of ducts (epididymis, vas deferens) propel spermatozoa and contractions of smooth muscle fibers in the walls of accessory glands squeeze out secretions. Controlled by sympathetic system.

Infertility: < 20,000,000 spermatozoa/ml (normal 20,000,000 - 50,000,000)

Female Reproductive System:

Components:

- **ovaries:** produce precursors of ova (female reproductive cells)
- **Fallopian tubes** (uterine tubes, oviducts): carry female reproductive cells/zygote/mass of embryonic cells toward uterus
- **uterus:** holds, nourishes and protects developing embryo/fetus
- **vagina:** tubular structure connecting the uterus to the outside
- **vulva (pudendum):** external genitalia

Ovaries:

- almond sized and shaped, located against the lateral walls of the upper pelvic cavity
- supporting ligaments:
 - suspensory ligament: between ovary and lateral wall of pelvic cavity
 - ovarian ligament: between ovary and fundus of uterus
 - part of the sheet-like broad ligament (mesovarium)

Ovarian Structure:

- covered by germinal epithelium: layer of simple cuboidal epithelium
- surrounded by fibrous **tunica albuginea** (same as testes)
- two regions:
 - outer **cortex**
 - inner **medulla**
- ovarian follicles are found in the cortex:
 - follicle: central cell called **oocyte** surrounded by supporting **granulosa cells**
 - types of follicles (based on developmental stage):
 - **primordial:** primary oocyte surrounded by one layer of squamous cells
 - **primary:** primary oocyte surrounded by one layer of cuboidal cells
 - **secondary:** primary oocyte surrounded by two or more layers of cells
 - **Graafian:** very large with fluid filled space in the center; secondary oocyte pushed at the edge

Oogenesis:

Prior to birth

- **oogonia** multiply mitotically (about 3/4 million)
 - oogonia - become **primary oocytes** - start first meiotic div., stop at prophase
- Primordial follicles - Primary follicles

Birth

- female is born with ~ 3/4million primary follicles containing primary oocytes that have started the first meiotic division but **have stopped at the prophase**

Puberty

- each month ~24 follicles get activated, one survives (most follicles die by **atresia**); the primary oocyte completes the first meiotic division

- primary oocyte - **secondary oocyte** (and tiny, first polar body) - second meiotic div. starts but **stops at metaphase**

Primary follicle - Secondary follicle - Graafian follicle

- Graafian follicle ruptures at **ovulation** releasing the secondary oocyte in the pelvic cavity; the secondary oocyte is directed inside the Fallopian tube by the fimbriae and moves toward the uterus.

Possible outcomes:

- secondary oocyte is contacted by spermatozoa: the oocyte is activated and completes the second meiotic division forming an **ovum** (and a tiny, second polar body); the ovum and one of the spermatozoa unite (fertilization) to form the zygote (first cell of the new organism). The zygote starts to divide right away and by the time it reaches the uterine cavity it is a mass of cells that undergo **implantation** (attach to the uterine wall)

- secondary oocyte does not come in contact with spermatozoa: it will disintegrate on its way to the uterus

Fallopian tubes (uterine tubes, oviducts):

- have **fimbriae** (finger-like) surrounding funnel shaped opening next to the ovary
- attach to the **fundus** of the uterus

Uterus:

Parts:

- **fundus** (bottom): back (deep, proximal) part
- **corpus** (body): central part
- **cervix** (neck): end part that attaches to the vagina

Wall structure:

- **perimetrium**: thin outer layer
- **myometrium**: thick, middle muscular layer
- **endometrium**: thin inner lining
 - has two layers:
 - **endometrium basalis**: permanent, against the myometrium
 - **endometrium functionalis**: **shed during menstruation**; faces the uterine cavity

Supporting ligaments:

- part of sheet-like broad ligament (mesometrium)
- round ligament
- cardinal ligaments: lateral, main support
- utero-sacral ligament

Blood supply:

- uterine arteries branch from the internal iliac arteries
- the endometrium basalis is penetrated by **straight arterioles**
- from the straight arterioles branch **spiral arterioles** that enter the endometrium

functionalis; the spiral arterioles break during menstruation causing bleeding

Hormonal factors that control the menstrual cycle:

- **Follicle stimulating hormone (FSH)**: starting at puberty, activates a couple of dozens of primary follicles each month causing them to continue development

- **Luteinizing hormone (LH)**: triggers **ovulation** and, following that, it maintains the **corpus luteum**

- **Estrogen**:

- promotes tissue growth

- activates osteoblasts

- promotes the development of the **female secondary sex characteristics**:

- distribution of adipose tissue on the body with:

- enlargement of the breasts

- widening of the hips

- distribution of hair: axillary and pubic hair

- when at high levels in the blood, together with **progesterone**, inhibits the release of gonadotropic hormones by the pituitary gland and **prevents the start of a new menstrual cycle**

- **Progesterone**:

- when at high levels in the blood, together with **estrogen**, inhibits the release of gonadotropic hormones by the pituitary gland and **prevents the start of a new menstrual cycle**

- maintains the **endometrium functionalis** and prevents its shedding

Menstrual cycle: consists of **two cycles**:

- **uterine cycle**: a series of monthly changes in the wall of the uterus of a nonpregnant female that prepare the **endometrium functionalis for implantation** and, if there is no implantation, the shedding of the endometrium functionalis

- **ovarian cycle**: monthly activation and the continued development into secondary follicles of about two dozens ovarian follicles, usually with only one surviving, completing development into a Graafian follicle and then rupturing **releasing a secondary oocyte in the pelvic cavity**.

Phases of the menstrual cycle:

- **Menstrual phase**

- **Preovulatory (postmenstrual) phase**

- **Ovulation**

- **Postovulatory (preremenstrual) phase**

Menstrual phase: last about 5 days

- **uterine cycle:** small patches of the **endometrium functionalis** get sloughed off from the uterine wall, one a time, with spiral arterioles rupturing and causing bleeding. By the end of the fifth day only a thin, smooth layer of endometrium, the endometrium basalis, is left.
- **ovarian cycle:** at this time the **levels of progesterone and estrogen in the blood are low** allowing the pituitary to release **follicle stimulating hormone (FSH)**. The FSH activates over twenty four primary follicles in the ovaries causing them to continue development. All but one follicle fail to complete development, undergo **atresia**, with the surviving follicle acquiring additional layers of supporting cells thus becoming a **secondary follicle**.

Preovulatory (postmenstrual) phase: variable in length; lasts from day 5 to about day 13

- **uterine cycle:** a new endometrium functionalis starts to grow out of the basalis layer.
- **ovarian cycle:** the surviving follicle becomes a Graafian follicle. The primary oocyte, within the follicle, completes the first meiotic division and produces two daughter cells, a tiny **first polar body**, which will be lost and a large **secondary oocyte**. The secondary oocyte **starts the second meiotic division but stops at metaphase**. Toward the end of this period there is a **sudden increase in the production of luteinizing hormone (LH)** by the pituitary gland causing the Graafian follicle to complete its maturation and to rupture.

Ovulation: occurs around day 14. The Graafian follicle ruptures releasing the secondary oocyte in the pelvic cavity. The secondary oocyte, in most instances, is directed inside the Fallopian tube (with help from the fimbriae) and starts traveling toward the uterus.

Postovulatory (premenstrual) phase:

- **ovarian cycle:** under the influence of the **luteinizing hormone (LH)** the mass of tissue of the former Graafian follicle that remained in the ovary is transformed into a yellow body called the **corpus luteum**. The **corpus luteum** starts producing large amounts of **progesterone and estrogen** causing their blood levels to increase dramatically.
- **uterine cycle:** under the influence of **progesterone** the **endometrium functionalis** layer continues its preparation for implantation: becomes thicker and accumulates large deposits of glycogen while numerous spiral arterioles grow into it from the endometrium basalis layer.

- if the secondary oocyte, while traveling toward the uterus, is met and contacted by spermatozoa then it will complete the second meiotic division and will form a second polar body and an **ovum (egg)**. Following fertilization the egg will form a **zygote** (first cell of the new organism), the zygote will start dividing mitotically right away and upon reaching the uterus the mass of cells will attach itself to the endometrium functionalis layer that lines the uterine cavity (**implantation**).

At the site of contact between the embryonic mass and the uterine wall a new structure,

called the **placenta**, will start growing immediately. The placenta will start producing **human chorionic gonadotropic hormone (HCGH)** which mimics in its effects the luteinizing hormone. HCGH will maintain the corpus luteum functional allowing it to continue to produce large amounts of progesterone and estrogen for several months. The high levels of progesterone and estrogen in the blood will inhibit the pituitary gland preventing it from releasing gonadotropic hormones (FSH and LH) thus the production and following that **the blood level of LH will decrease. However, since the HCGH is assuming the function of LH the corpus luteum will continue to function producing large amounts of progesterone and estrogen.**

The **high levels of progesterone** in the blood will maintain the endometrium functionalis layer in place preventing its shedding.

The **lack of FSH production due to the inhibition of the pituitary** prevents the start of a new ovarian cycle.

The high levels of progesterone help maintain the endometrium functionalis layer thus preventing the start of a new uterine cycle.

Thus, the high blood levels of progesterone and estrogen prevent the start of a new menstrual cycle during pregnancy.

The corpus luteum stops functioning during the second half of pregnancy, at that time the **production of estrogen and progesterone is taken over by the placenta.**

- if the secondary oocyte is not met by spermatozoa it will soon disintegrate while traveling toward the uterus. The **high levels of progesterone and estrogen in the blood will inhibit the pituitary gland** and prevent the release of **LH**. Without LH the corpus luteum can not continue to function and it starts to degenerate. It stops producing the progesterone and estrogen, changes to a whitish color, it is now called the **corpus albicans**, and shrinks to a small scar that is left in the mass of the ovary.

The levels of progesterone and estrogen in the blood decline with the following consequences:

- the endometrium functionalis layer can not be sustained, due to lack of progesterone, and starts to shed on piece at a time: **a new uterine cycle begins.**
- the low blood levels of estrogen and progesterone allow the pituitary to become disinhibited and to start releasing FSH. The FSH activates a couple of dozens of ovarian follicle thus **starting a new ovarian cycle.**
- this way **a new menstrual cycle begins.**

- **climacteric** : period of irregular menstrual cycling that precedes menopause.

- **menopause**: complete cessation of menstrual cycles; associated with aging.

- **amenorrhea**: lack of menstrual cycles; often caused by insufficient adipose tissue in the body resulting from starvation or excessive physical exercise.

Vagina: tubular structure that connects the uterus to the outside. Attaches to the **cervix** of the uterus at the proximal end. Forms an attachment fold called the **fornix**. The vaginal mucosa has folds (**rugae**). The mucosa stores significant amounts of glycogen which, following processing, produces **lactic acid**. The **lactic acid** makes the vaginal environment acidic this way preventing the growth of pathogens. The acidic environment is inhospitable, however, to the spermatozoa and has to be neutralized by the **alkaline semen**.

The distal end of the vagina opens, through the **vaginal orifice** in the **vestibule** of the **vulva** (pudendum).

Vulva (pudendum): external female genitalia

Structure:

- **mons pubis (mons veneris):** pad of adipose tissue located anterior to the symphysis pubis.
- two pairs of folds:
 - **labia majora:** lateral, large, filled with adipose tissue, covered with hair
 - **labia minora:** medial, thin, hairless
- **clitoris:** small, penis-like structure containing two **corpora cavernosa**, covered by a prepuce-like skin fold. Located at the anterior end of the **labia minora**. The **urethra does not pass through it** and it has **no corpus spongiosum**.
- **vestibule:** space bordered by the labia minora; its walls contain glands that produce lubricating secretions:
 - many small, **lesser vestibular glands**
 - a couple of large, **greater vestibular glands (Bartholin's glands)**

Mammary glands:

- located in the pectoral region superficial to the pectoralis major muscles.
- supported by strands of connective tissue called suspensory ligaments (Cooper's ligaments; 'Cooper's droop': sagging of the breasts due to stretching of the Cooper's ligaments.
- made of 15 - 20 functional masses of milk producing tissue (**lobes**) separated by masses of adipose tissue.
 - inside the **lobes** there are **lobules** that contain grape-like masses of secretory cells called **alveoli which produce milk**.
 - the milk flows to wide ducts, **lactiferous ducts (sinuses)**, where it is **stored before release**.
 - the **lactiferous ducts** open through the **papilla** (nipple) to the outside; the **papilla** is surrounded by the **areola**, a dark, pigmented area.
- **lactation:** production and release of milk
 - **milk production is controlled by the hormone prolactin**
 - **milk release from the lactiferous ducts is controlled by the hormone oxytocin;** when there is tactile stimulation of the breast by the infant trying to feed, the stimulation causes the release of oxytocin from the neurohypophysis; the oxytocin travels via the blood the walls of the lactiferous ducts causing their constriction thus expelling the milk (milk let down) from the breast.