The functions of the female reproductive system include:

- Production of female gametes (**ova**).
- Production of female sex hormones (**estrogens** and **progesterone**).
- Reception and maintenance of a developing **embryo** and **fetus**.

The **ovaries** flank the **uterus** laterally and are held in place by several ligaments. The **ovarian ligament** anchors the ovary medially to the uterus. The **suspensory ligament** anchors it laterally to the pelvic wall. The **mesovarium** anchors the ovary to the uterus and abdominal wall and lies btwn the ovarian ligament and fallopian tube. The suspensory ligament and mesovarium are part of the **broad ligament**. The broad ligament is a fold of peritoneum that drapes over the uterus, uterine tubes, and ovaries and supports them. The **ovarian arteries** and **ovarian veins** are the major blood vessels of the ovaries. Each ovary is surrounded by a fibrous **tunica albuginea**. The tunica albuginea is surrounded by a layer of simple cuboidal epithelium called **germinal epithelium**. The **ovarian cortex** is the site of **ovarian follicles**, which house and support the developing **gametes**. The **ovarian medulla** primarily contains blood vessels and nerves.

Each ovarian follicle consists of a developing egg, called an **oocyte**, surrounded by one or more layers of **supporting cells**. These supporting cells are known as **follicle cells** if there is only a single layer and as **granulosa cells** if there are multiple layers. There are 4 basic stages of follicular development. A **primordial follicle** consists of a single layer of squamous follicle cells surrounding an oocyte. A **primary follicle** consists of one or more layers of cuboidal follicle cells surrounding an oocyte. A **secondary follicle** is similar to a primary follicle except that fluid-filled spaces exist btwn the surrounding granulosa cells. A **graafian follicle** contains a huge fluid-filled cavity called an **antrum** that dominates the whole structure. It's a.k.a. a **vesicular follicle**. Each month, one graafian follicle (on average) will undergo **ovulation** and the oocyte will be ejected from the ovary into the peritoneal cavity. The remaining granulosa cells transform into a short-lived endocrine structure known as the **corpus luteum**.

The **uterine** or **fallopian tubes** are the initial part of the female duct system. They receive the ovulated oocyte and transport it to the uterus. Each is 4" long and extends medially from the ovary to the uterus. The uterine tube is primarily supported by the broad ligament. It has 4 regions. At the end are the **fimbriae**, ciliated fingerlike extensions that drape over the ovary. The **infundibulum** is an open funnel-shaped structure from which the fimbriae extend. The **ampulla** is the portion that curves around the ovary. The **isthmus** is the constricted region where the tube joins the uterus. When an ovulated oocyte is cast into the peritoneal cavity, the cilia on the fimbriae beat creating a current of fluid that draws the oocyte into the infundibulum. The uterine tube contains a smooth muscle layer and a ciliated epithelium. These both assist in moving an oocyte towards the uterus. Fertilization usually occurs in the ampulla. The developing blastocyst is then propelled towards the uterus.

The **uterus** is a hollow, thick-walled organ that receives, retains, and nourishes a developing embryo and fetus. It's located anterior to the rectum and posterosuperior to

the bladder. It's continuous with the vagina. In most women, the uterus flexes anteriorly where it joins the vagina and is thus **anteverted**. In older women, it may flex posteriorly instead and be **retroverted**. There uterus has 3 major regions. The **body** is the large midportion. The **fundus** is the rounded portion just superior to the entrances of the uterine tubes. The **cervix** is the neck that projects into the vagina inferiorly. The cavity of the cervix is the **cervical canal**. It communicates with the **uterine cavity** (w/i the body of the uterus) via the **internal os**. It communicates with the vaginal cavity via the **external os**. The cervical mucosa contains mucus-secreting **cervical glands**. Cervical mucus plays an important role in timing of fertilization as well as preventing pathogens from accessing the uterus. The uterus is supported laterally by the broad ligament, anteriorly by the **round ligament**, as well as the **cervical ligaments** laterally and the **uterosacral ligaments** posteriorly. Another important source of uterine support is the muscles of the pelvic floor – i.e., the muscles of the **urogenital** and **pelvic diaphragms**. The wall of the uterus has 3 layers. The **perimetrium** is the outermost layer and is mostly visceral peritoneum. The **myometrium** is the middle layer and is made of smooth muscle bundles. The **endometrium** is the inner layer and is lined by a simple columnar epithelium underlain by a thick lamina propria. The endometrium is divided into 2 sublayers. The **stratum functionalis** is superficial and undergoes cyclic changes in response to ovarian hormones and is shed during menstruation; The **stratum basalis** is the thinner and deeper layer and is unresponsive to ovarian hormones and forms a new stratum functionalis after menstruation ends.

The **vagina** is the thin walled tube that sits btwn the bladder and rectum and extends from the cervix to the body exterior. It receives the penis and semen during sexual intercourse and provides a delivery route for an infant and for menstrual flow. The vaginal wall contains a mucosa, smooth muscle muscularis, and an adventitia. The mucosa is lined by stratified squamous epithelium and contains rugae, but no glands. Cervical mucous glands provide lubrication for sexual intercourse. The opening of the vagina is the **external vaginal orifice**. The opening between the **vaginal canal** and the cervical canal is the external os. In virgins, the vaginal mucosa partially covers the external vaginal orifice. This partition is called the **hymen**. Because the cervix projects into the vagina, there is a recess around the neck of the cervix called the **vaginal fornix**. There are lateral, posterior, and anterior portions of the fornix.

The ovaries, uterine tubes, uterus, and vagina constitute the **internal genitalia**. The **external genitalia**, or **vulva**, include the **mons pubis**, **labia**, **clitoris**, and structures associated with the **vestibule**. The mons pubis is a fatty rounded area overlying the **pubic symphysis**. Running posteriorly from the mons pubis are two elongated skin folds, the **labia majora**. The labia majora enclose the **labia minora**, two smaller folds of skin. The labia minora enclose a recess called the **vestibule**, which contains the external urethral and vaginal orifices. Lateral to the vaginal opening are the **greater vestibular glands**. They release mucus for lubrication during intercourse. Anterior to the vestibule is the **clitoris**, a small protruding structure composed largely of erectile tissue and covered by a **prepuce**. The female **perineum** is a diamond shaped area bounded laterally by the ischial tuberosities, posteriorly by the coccyx, and anteriorly by the pubic arch. It contains the anus and vulva.

Mammary glands are found in both sexes, but function only in females. They produce milk to nourish a newborn baby. Each mammary gland is contained within the superficial fascia of the breast anterior to the pectoral muscle. Internally, each mammary gland consists of 15-25 **lobes** that radiate around and open at the **nipple**. Surrounding the nipple is a ring of pigmented skin called the **areola**. Within the breast, the lobes are separated by fibrous connective tissue and fat. This CT constitutes the **suspensory ligament of the breast**. Within the lobes are smaller units called **lobules**, which contain glandular **alveoli** that contain milk when a woman is lactating. These alveolar glands pass milk into **lactiferous ducts**, which open to the outside at the nipple. Within each lactiferous duct is a dilated region called the **lactiferous sinus**, where milk accumulates during nursing (**lactation**).

Oogenesis is the meiotic process in females in which diploid germ cells produce haploid gametes. During the fetal period, **oogonia** (diploid germ cells) multiply by mitosis. The oogonia replicate their DNA and become **primary oocytes**. At this point, they are surrounded by a single layer of simple squamous follicle cells – yielding **primordial follicles**. Primary oocytes begin meiosis I but become "stuck" and do no further division until they receive the appropriate hormonal signal during each menstrual cycle. By birth, there are approximately two million primordial follicles, each containing a single primary oocyte, present in the ovarian cortex. At puberty, about 80 percent of these follicles have degenerated and only about 250,000 remain. Each month, one follicle will complete the long process of becoming a graafian follicle and its contained oocyte will complete meiosis I. At the end of meiosis I, the single primary oocyte has divided into two dissimilar cells, a tiny haploid cell called the **first polar body** and a large haploid **secondary oocyte**. The secondary oocyte is the cell that will actually be ovulated. The first polar body will die (although it may divide before dying). Think of the polar body as a means of getting rid of chromosomes on the way to becoming haploid. The large size of the secondary oocyte is advantageous b/c it makes it easier for the sperm cell to find it. If and only if a sperm fertilizes the secondary oocyte, will the secondary oocyte complete meiosis II. If fertilization does not occur, the secondary oocyte will die. Meiosis II results in a large **ovum** and another tiny polar body – the **second polar body**. The large size of the ovum is advantageous b/c it allows for the retention of nutrients as well as proteins and other molecules involved in development. The ovum will contain 2 sets of haploid **pronuclei** – its own and that of the sperm that fertilized it. When these 2 pronuclei fuse, the cell is now diploid and is now known as a **zygote**. The second polar body will die.

The **ovarian cycle** is the monthly series of events associated with the release of a secondary oocyte and the "just-in-case" preparation for its fertilization and implantation. It consists of 2 consecutive phases: the **follicular phase** is the period during which follicle growth is hormonally stimulated (typically days 1-14 of the cycle); the **luteal phase** is the period of corpus luteum activity, during which the uterus is prepared for pregnancy (typically days 15-28 of the cycle).

At the beginning of the follicular phase, the **hypothalamus** begins to secrete increasing amounts of **gonadotropin releasing hormone** (**GnRH**). GnRH acts on the **anterior pituitary**, making it secrete **follicle stimulating hormone** (**FSH**) and **luteinizing hormone** (**LH**). The combination of FSH and LH stimulates follicle growth. (NOTE – a primordial follicle will not mature into a graafian follicle during the 2 weeks of the follicular phase. This takes months to occur but growth occurs during the follicular phase of each cycle.) As follicles mature and grow during the follicular phase, they secrete **estrogen**. Estrogen prepares the uterus for a possible pregnancy. Estrogen feeds back and prevents the release of FSH and LH from the anterior pituitary but at the same time causes the anterior pituitary to stockpile LH and FSH. As follicle growth continues and estrogen levels rise and FSH and LH levels decline. Primary oocytes within late primary follicles secrete a thick sugar/protein matrix called the **zona pellucida** that surrounds the oocyte. Some primary follicles develop **antrums** and become **secondary follicles**. A single layer of follicle cells (the **corona radiata**) still surrounds the oocyte. Eventually only one follicle becomes a mature **graafian follicle** and is ready for ovulation. Remember – it took months for the graafian follicle to develop. On or around day 14, estrogen levels reach a threshold level and the anterior pituitary releases its stored FSH and more importantly its LH. A massive surge in plasma LH occurs. This LH surge:

- Causes the primary oocyte (w/i the graafian follicle) to complete Meiosis I forming a secondary oocyte and the first polar body.
- Causes **ovulation**. The secondary oocyte is cast into the peritoneal cavity where it will be swept into the uterine tube and towards the uterus, where along the way it may or may not get fertilized by a sperm.
- Causes the follicle cells that remain to turn into an endocrine structure – the **corpus luteum**.

Following ovulation, the luteal phase commences. The corpus luteum begins to secrete **progesterone** as well as a small amount of estrogen. Progesterone maintains the uterus in a state ready to receive and nourish an embryo (if fertilization has occurred). Progesterone also inhibits any further pituitary release of FSH or LH. This prevents any further follicle growth or ovulation during the next 2 weeks– in case fertilization has occurred. If fertilization does not occur, then LH levels will become quite low due to the inhibitory effect of progesterone. LH is necessary for maintenance of the corpus luteum. As LH levels diminish past a threshold level, the corpus luteum begins to degenerate. It will gradually turns into a whitish mass of scar tissue known as a **corpus albicans**. As the corpus luteum degenerates, progesterone levels fall and the inhibition of pituitary FSH and LH is removed. LH and FSH levels begin to rise again and the cycle will begin anew. However if pregnancy does occur, then the soon-to-be **placenta** will produce a hormone known as **human chorionic gonadotropin** (**HCG**). It will maintain the corpus luteum and prevent its degeneration even as LH levels plummet.

The **uterine cycle** refers to the cyclical changes that occur in the uterus in response to ovarian hormones. Days 1-5 are the **menstrual phase**, during which plasma progesterone will plummet and the stimulus for maintaining the thick endometrium will disappear. In response to this, the stratum functionalis will be shed and detached tissue and blood (**menses**) will slough out the vagina. Days 6-14 are the **proliferative phase**,

during which plasma estrogen is rising. This causes the stratum functionalis to grow thicker and become more vascular and glandular. This is in preparation for the possibility of fertilization and pregnancy. Estrogen also causes cervical mucus to become less viscous. This will facilitate sperm entry. Days 14-28 are the **secretory phase**, during which plasma progesterone rises to its peak during this period of corpus luteum activity. Progesterone causes even more vascularization of the stratum functionalis and causes the endometrial glands to twist, coil, and enlarge. Progesterone will cause cervical mucus to become more viscous (i.e., it creates a **cervical plug**). This helps prevent the (potential) embryo from being attacked by any pathogens that may migrate from the vagina.

There are myriad extrauterine effects of estrogen and progesterone. Estrogen:

- Promotes bone lengthening and epiphyseal plate closure in adolescents
- Inhibits bone resorption
- Promotes skin hydration
- Stimulates female pattern of fat deposit and growth of axillary and pubic hair
- Increases renal retention of sodium and consequently of water
- Enhances HDL cholesterol ("good cholesterol") and reduces LDL cholesterol ("bad cholesterol").

Progesterone increases body T° and promotes urination.

The female sexual response is somewhat similar to the male response. The vaginal mucosa, clitoris, and breasts engorge with blood – analogous to erection. Orgasm is not typically accompanied by ejaculation, but muscular tension, BP, and HR all increase.

Other important terms and events include:

- **Puberty** → period of life (typically btwn 10y and 15y) during which the reproductive organs grow to adult size and become functional.
- **Menarche** → first menstrual period.
- **Menopause** → normal cessation of menstrual function that typically occurs btwn ages 46 and 54.