The Reproductive System: Female, Ch 20

After studying the male reproductive system you should be able to:
1. Identify the general structures of the female reproductive system.
2. Describe the structure and function of the ovaries.
3. Explain oogenesis and the development of oogonia.
4. Describe the ovarian cycle all the through to the formation/degeneration of the corpus luteum.
5. Describe the structure and function of the uterine (Fallopian) tubes.
7. Discuss the Clinical Applications from the study guide and be able to describe the disorders from the Applications to Health located at the end of this chapter.

Female Reproductive System
• Organs include:
  – **Ovaries**: Produce an immature egg (secondary oocytes) or **ova** and hormones: **Estrogen, progesterone, relaxin and inhibin**.
  – **Uterine (Fallopian) tubes** or **oviducts**: Transports ova to uterus;
  – **Uterus**: Site of embryonic and fetal development.
  – **Vagina**: Receives penis during intercourse and serves as birth canal during pregnancy.
  – **Vulva**: External genitalia
  – **Mammary glands**:

![Diagram of the female reproductive system](image-url)
Vagina

- **General Information:**
  - Fibromuscular tube ~4” long, that extends from the cervix to the vestibule and located between the urinary bladder and rectum.
  - **Functions:**
    - Receives semen from the penis during sexual intercourse
    - Passageway for menstrual flow
    - Passageway for

- **Vaginal wall components:**
  - Lined by nonkeratinized stratified squamous epithelium
  - Contains large stores of glycogen, the decomposition of which produces organic acids.
    - Acidic environment retards microbial growth, but is harmful to sperm.

External Genitalia (Vulva)

- **Mons Pubis:**
  - Subcutaneous layer of adipose tissue covered by skin and pubic hair lying over the pubic symphysis.

- **Labia Majora:**
  - Two longitudinal folds of skin that extend from the **mons pubis**
  - Are covered by pubic hair and contain adipose tissue, sebaceous (oil) and sudoriferous (sweat) glands
  - Are **homologous to scrotum**

- **Labia Minora:**
  - Two smaller longitudinal folds of hairless skin located medial to the labia majora and border the vestibule
  - Contain many sebaceous glands

- **Vestibule:** Region between the labia minora that contains the vaginal orifice, external urethral orifice, and openings to several glands
  - **Greater vestibular (Bartholin’s) glands:**
    - Paired mucus secreting glands located in the walls of vestibule; **homologous to Cowper’s glands**
    - Secrete
  - **Bulb of vestibule:** Consists of two elongated masses of erectile tissue just deep to the labia minora on either side of the vaginal orifice.
    - Becomes engorged with blood during sexual arousal, narrowing the vaginal orifice and placing pressure on the penis.
    - **Homologous to the corpus spongiosum** of the penis
- **Skene’s Glands:** Also known as the paraurethral glands or female prostate. Located on the anterior wall of the vagina, around the lower end of the urethra. They drain into the urethra near the urethral opening or just to the side of it.
  - These glands are surrounded with tissue (which includes the part of the clitoris) that reaches up inside the vagina and swells with blood during sexual arousal.
  - **Homologous with**
  - Has been suggested to be the source of female ejaculation, but their presence is variable as well as the amount of fluid they secrete.

- The **Gräfenberg Spot**, often called the **G-Spot**, is defined as a bean-shaped area of the vaginal wall. Some women report that it is an erogenous zone
  - Located one to three inches (2.5 to 7.6 cm) up the front (anterior) vaginal wall between the vaginal opening and the urethra.
  - Sensitive area that may be
  - Disagreement persists over its existence as a distinct structure, definition and location

- **Clitoris**
  - Located at the anterior junction of the labia minora
  - Consists of erectile tissue
  - Homologous to
Ovaries

- **Functions:**
  - Production of gametes (gametogenesis or oogenesis) called **ova**.
  - Production of hormones: **Estrogen, progesterone, relaxin** and **inhibit**.

Ovarian Cycle

- **Ovarian Cycle:** Series of events associated with the maturation of a **secondary oocyte** and alternates between two phases:
  - **Follicular phase:** Characterized by a maturing follicle which occurs in the first half of the cycle to produce a secondary oocyte ready for ovulation.
  - **Luteal phase:** Characterized by the presence of a corpus luteum that takes over during the last half of the cycle to prepare the female reproductive tract for pregnancy.

Oogenesis

- **Oogenesis:** Formation and development of female eggs (gametes).
  - Process begins before birth, accelerates at
  - Between puberty and menopause, completion of **oogenesis** occurs on a monthly basis.

Development of Oogonia

- During embryonic development, germ cells multiply and differentiate within the ovaries into **oogonia**.
  - **Oogonia** are diploid (2n) stem cells that
  - **Primary oocytes** are cells that begin meiosis and are arrested in **prophase I of meiosis**-homologous chromosomes are paired but do not separate.
    - Occurs during the
  - **Primary oocytes** remain in a state of suspended development until puberty.
    - At birth, there are ~1 million **primary oocytes** present in each ovary (2 million total)
      - Each **primary oocyte** is contained within
        - At puberty, ~200,000 remain in each ovary and of these, around 400 will mature during a females reproductive years
          - One **primordial follicle** containing a **primary oocyte** completely matures per
• **Primordial Follicle**: Composed of a primary oocyte (2n) surrounded by a single layer of follicular (or granulosa) cells.
  
  • At puberty, different groups of primordial follicles are stimulated by follicle stimulating hormone (FSH), to develop into primary follicles.
    • Signals the

**Primary Follicle**

• Within the primary follicle, the primary oocyte enlarges and the follicular cells divide forming multiple layers (6-7) of cells known as granulosa cells.

**Secondary Follicle**

• **Secondary follicle** forms when the granulosa cells secrete follicular fluid, which builds up in a cavity called the antrum.
  
  • Granulosa cells produce a clear glycoprotein layer called the zona pellucida, between the primary oocyte and the granulosa cells.
    • Zona pellucida is the barrier that sperm will

• Even though there are a few secondary follicles developing, usually only one secondary follicle develops to complete maturity – known as a mature (Graafian) follicle.
  
  • FSH influences a group of secondary follicles to grow and

  • By day 6 of the ovarian cycle, one follicle in one ovary has outgrown all the others and is considered the dominant follicle.
  
  • Estrogen and inhibin secreted by the dominant follicle decrease the secretion of FSH, which causes the other less well-developed follicles to stop growing and undergo atresia (degenerate).
  
  • Fraternal (nonidentical) twins result if two secondary follicles achieve
Mature (Graafian) Follicle
- Formed by the 10th to 14th day of ovarian cycle.
- Primary oocyte completes meiosis I to form 2 haploid secondary oocytes \((n)\) which are arrested in **metaphase II of meiosis**.
  - Will complete

- One secondary oocyte contains the majority of cytoplasm while the other daughter cell known as the **first polar body**, is discarded genetic material and contains very little cytoplasm.

Ovulation
- **Ovulation**: Process by which the secondary oocyte and 1st polar body is released from the mature follicle into the pelvic cavity on day 14.
  - Surge in the release of LH (luteinizing hormone) from the anterior pituitary gland stimulates **ovulation**.
- **Secondary oocyte** enters the uterine (Fallopian) tube
  - Fluid currents established by the ciliated epithelium of the fimбриae transfer the secondary oocyte to the uterine tube.
  - If fertilization does not occur, the

Fertilization
- If fertilization of the secondary oocyte does occur, **meiosis II** resumes and the secondary oocyte divides into two haploid \((n)\) cells, one of which is a **polar body**
  - Fertilization usually occurs in the fallopian tube.
  - **Zygote**:
Summary of Hormonal Regulation of Ovarian Cycle

- Control of ovulation
  - Gonadotropin-releasing hormone (GnRH):
    - Secreted by the hypothalamus
    - Stimulates the release of FSH and LH
  - FSH:
    - Stimulates the growth and development of the primary and secondary ovarian follicles
    - Stimulates the
  - LH:
    - Stimulates further development of ovarian follicles and their estrogen secretion
    - At Midcycle (14th day), estrogen levels are high enough to cause a brief surge of LH which triggers ovulation of the secondary oocyte from the Graafian follicle.
    - Promotes formation of the corpus luteum
  - Luteal phase is characterized by the corpus luteum

- Corpus Luteum (yellow body): Functions to prepare the uterus for pregnancy by stimulating the growth and secretory activity of the uterine lining (endometrium).
- Corpus luteum secretes estrogen, progesterone, relaxin, and inhibin.
  - Estrogen and Progesterone:
    - Inhibits GnRH and thus the release of FSH and LH which prevents development of new follicles
    - Promotes development of the endometrium for pregnancy
  - Relaxin:
    - Relaxes the uterus by inhibiting
    - During pregnancy the placenta produces large quantities of relaxin which helps relax the uterus and dilate the uterine cervix
  - Inhibin: Inhibits the secretion of FSH and LH.

[Diagram of ovarian cycle]
**Uterine Tubes**

- **Uterine (Fallopian) Tubes or oviducts**: Transmit ova from ovary to uterus, and provide necessary environment for fertilization.
- **Contains the following regions:**
  - **Infundibulum**: Funnel-shaped segment that contains a fringe fingerlike fimbriae.
  - **Ampulla**: The widest and longest portion;
    - Implantation of the embryo in the uterine tube rather than the uterus can cause an **ectopic pregnancy**.
- **Wall of tube consists epithelial cells that include:**
  - **Ciliated cells** that transport (like a “conveyor belt”) the fertilized ovum or secondary oocyte to the uterus.
  - **Peg cells**: Secrete a nutrient-rich medium that nourishes the

**Uterus (Womb)**

- **Uterus**: Hollow pear-shaped organ located in pelvis between the urinary bladder an rectum.
- **Site of the following major events:**
  - Implantation of fertilized egg
  - Development of fetus
  - Pathway for sperm to enter the uterine tubes
  - Labor
Menstrual Cycle

- Menstrual or uterine cycle is typically ~28 days and can be divided into 3 phases:
  - Menstrual phase
  - Proliferative Phase
  - Secretory Phase

Menstrual Phase (day 1-5)

- **Menstrual (Uterine) cycle** begins on the 1st day of menstrual bleeding (menses)
- Triggered by low levels of estrogen and progesterone that cause vasoconstriction of arteries supplying the outer layer of the endometrium (stratum functionalis).

Proliferative Phase (day 5-14)

- Rising estrogen levels stimulate regeneration of the **functional zone** of the endometrium by mitosis.
  - Estrogen is secreted from the **granulosa cells** of the developing ovarian follicles.
  - Proliferation occurs at the same time as the development/enlargement of the

Secretory Phase (day 15-28)

- **Secretory phase**: Begins at ovulation and is marked by enlargement and increased secretions by the endometrial glands that provide a fluid rich in nutrients such as glycogen.
  - The secretory phase lasts approximately

- **Progesterone** and **estrogen** from the corpus luteum stimulate the growth and secretion of the secretory phase.
- **Human chorionic gonadotropin (hCG)** secreted by the implanted embryo stimulates the continued development of the corpus luteum and secretion of progesterone/estrogen.
  - Absence of hCG results in decreased levels of

Contraceptive Pill
- Oral contraceptives usually consist of a synthetic estrogen/progesterone mix that is taken once a day for 3 weeks after the last day of a menstrual period.
- Causes an immediate increase in blood levels of estrogen/progesterone that inhibits the release of

  - Because the pill contains ovarian steroid hormones, the endometrium proliferates
  - In order to prevent an abnormal growth of the endometrium, women stop taking the pills after three weeks and placebo pills are taken during the fourth week.
  - This causes estrogen and progesterone levels to

  - The pill is then taken raising the estrogen/progesterone levels and preventing FSH from being released and starting the ovarian cycle.

RU 486 (Mifepristone)
- Blocks the action of progesterone by binding to and blocking progesterone receptors.
  - The endometrium starts to degenerate and slough off within 48-72 hours.
  - A type of prostaglandin (misoprostol) that stimulates uterine contractions is given after RU 486 to aid in the expulsion of the endometrium

Correlation between hormonal levels and cyclic ovarian and uterine changes
During the first half of the ovarian cycle, known as the follicular phase (step 1), the ovarian follicle (2) secretes estrogen (3) under the influence of FSH (4) and LH (5). The rising levels of estrogen inhibit FSH secretion, which declines (6) during the last part of the follicular phase. LH continues to rise slowly (7) throughout the follicular phase. When the follicular output of estrogen reaches its peak (8), the high levels of estrogen trigger a surge in LH secretion at midcycle (9). This LH surge brings about ovulation of the mature follicle (10). Estrogen secretion plummets (11) when the follicle releases its egg at ovulation.

  The old follicular cells are transformed into the corpus luteum (12), which secretes progesterone (13) as well as estrogen (14) during the last half of the ovarian cycle, known as the luteal phase (15). Progesterone strongly inhibits both FSH (16) and LH (17), which continues to decrease throughout the luteal phase. The corpus luteum degenerates (18) in about two weeks if the released ovum has not been fertilized and implanted into the uterus. Progesterone (19) and estrogen (20) levels sharply decrease when the corpus luteum degenerates, removing the inhibitory influences on FSH and LH. As these anterior pituitary hormone levels start to rise again (21 and 22) on the withdrawal of inhibition, they stimulate the development of a new batch of follicles as a new follicular phase is ushered in (1 and 2).

  Concurrent uterine phases reflect the influences of the ovarian hormones on the uterus. Early in the follicular phase, the highly vascularized, nutrient rich endometrial lining is sloughed off (the uterine menstrual phase (23). This sloughing results from the withdrawal of estrogen and progesterone (19 and 20) when the old corpus luteum degenerated at the end of the preceding luteal phase (18). Late in the follicular phase, the rising levels of estrogen (3) cause the endometrium to thicken (the uterine proliferative phase) (24). After ovulation (10), progesterone from the corpus luteum (13) brings about vascular and secretory changes in the estrogen-primed endometrium to produce a suitable environment for implantation (the uterine secretory phase) (25). When the corpus luteum degenerates (18), a new ovarian follicular phase (1 and 2) and uterine menstrual phase (23) begin.