

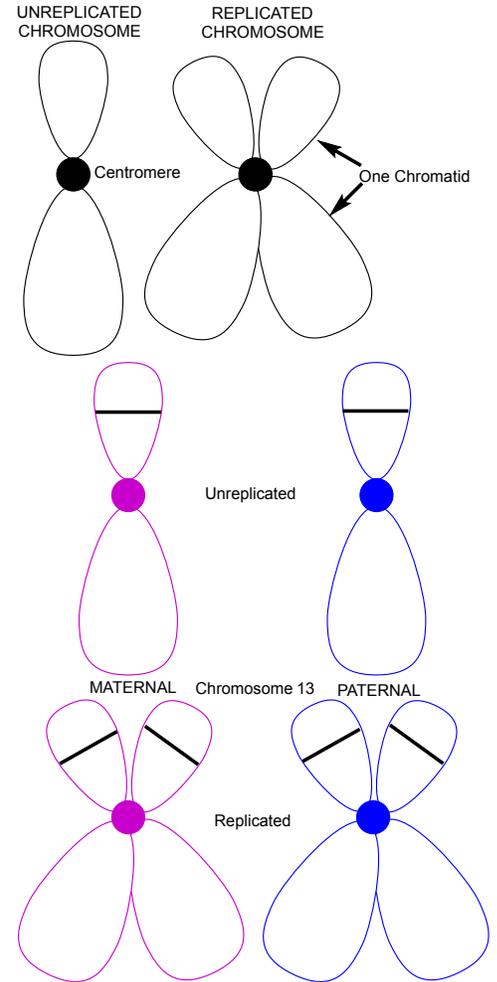
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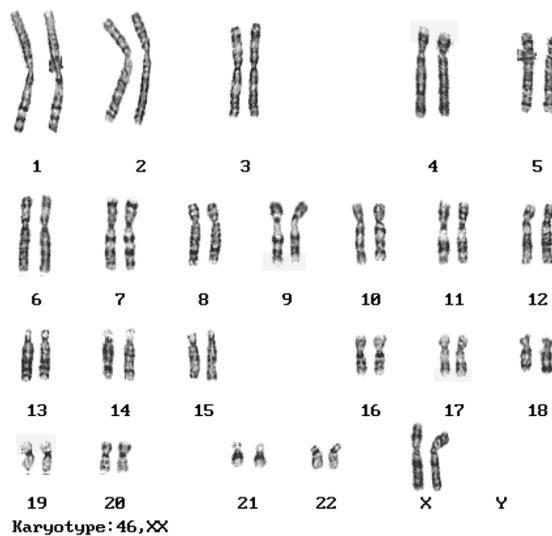
**CONCEPT: REVIEW OF MITOSIS AND MEIOSIS**

The Human Chromosome Complement:

- **Chromosome** is a bunch of DNA held on a **centromere** protein core.
  - **Unreplicated** chromosomes have 2 arms hanging off centromere.
- Each chromosome in a cell **replicates** before a cell divides.
  - Creates two identical **chromatids** held on the same centromere.
- Human body cells have \_\_\_\_\_ unique chromosomes.
  - But, total of 46 chromosomes—one from \_\_\_\_\_, one from \_\_\_\_\_.
  - **Homologous Chromosomes**- Two copies (maternal and paternal) of a chromosome.
- Can count chromosomes using terms *haploid* and *diploid*.
  - **Haploid (n)**= Number of *unique* chromosomes.
    - For humans,  $n=23$ .
  - **Diploid (2n)**= *Total* number of chromosomes, including maternal and paternal copies.
    - For humans,  $2n=46$ .
- The words *haploid* and *diploid* can also describe individual cells.
  - **Diploid Cell**- Has *two* copies of each chromosome, total=46.
  - **Haploid Cell**- Has *one* copy of each chromosome, total=23.

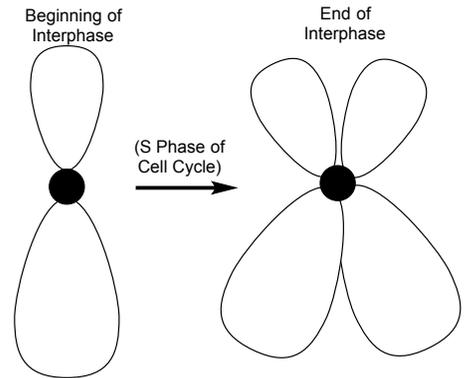


**EXAMPLE:** All the chromosomes pulled from a single human body cell.

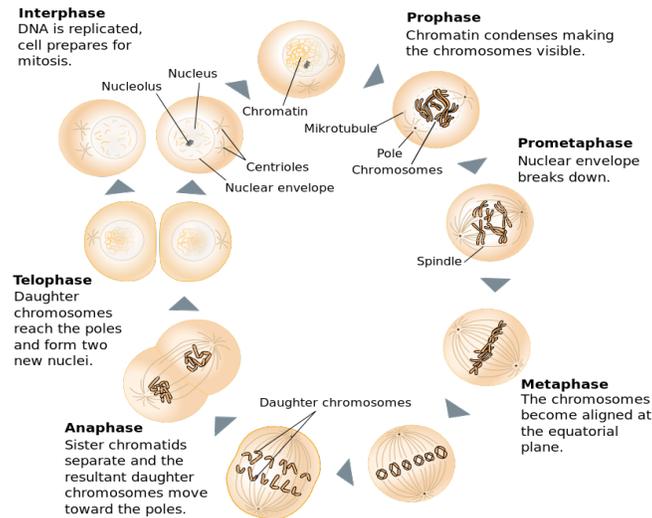


Review of Mitosis:

- **Mitosis**- Process of one cell dividing and making two *identical daughter cells*.
  - Each daughter cell has *exactly* the same chromosomes as parent: one  $2n=46$  parent → two  $2n=46$  daughters.
- **Interphase** is time between mitoses, when cell replicates its chromosomes.
  - Still 46 chromosomes, but each now has 2 sister chromatids.
- **Mitosis** consists of 4 phases:
  - **Prophase**- Membranes around nucleus break down.
  - **Metaphase**- All 46 chromosomes line up at middle of cell.

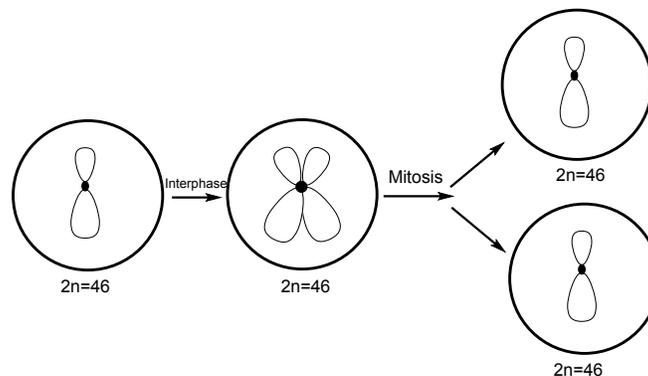


-**Spindles** from either side of cell connect to each \_\_\_\_\_.



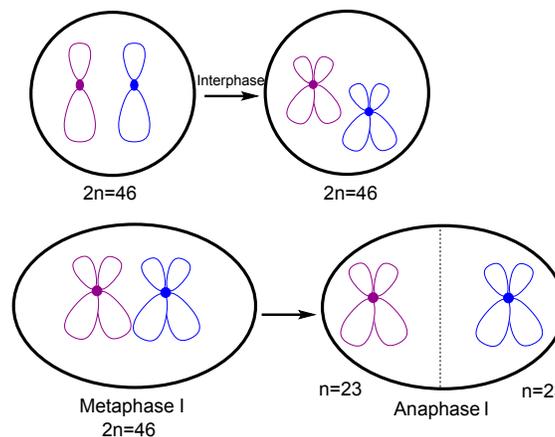
- **Anaphase**- Sister chromatids separate to opposite ends of cell.
- **Telophase**- Nucleus reforms.
- **Net Effect of Mitosis:** One  $2n$  parent with replicated chromosomes → two  $2n$  daughters with unreplicated chromosomes.

**EXAMPLE:** Summary of effects of interphase and mitosis on a cell and its chromosomes.



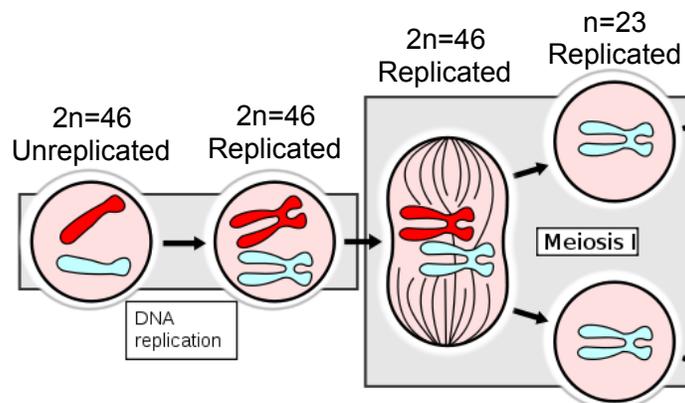
Review of Meiosis I:

- **Meiosis**- Process where one cell divides *twice* and makes *four haploid* daughter cells.
  - Each daughter has \_\_\_\_\_ the number of chromosomes as the parent.
  - Generates **gametes**—cells that can be combined with someone else’s gametes for reproduction.
- Meiosis happens in two steps, both very similar to a mitotic division: *Meiosis I* and *Meiosis II*.
- **Meiosis I (“Reduction Division”)** generates two *haploid* daughter cells from the parent cell.
  - During Metaphase I, homologous chromosomes pair up.
  - During Anaphase I, only one of each homologous pair goes to each daughter.



- Net Effect of Meiosis I: One  $2n$  parent with replicated chromosomes → two  $n$  daughters with replicated chromosomes.

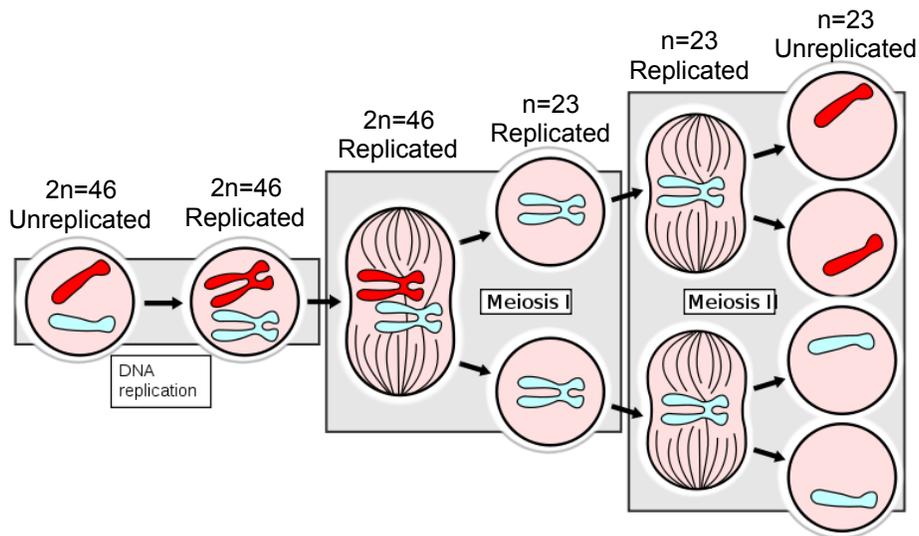
**EXAMPLE:** Summary of Meiosis I.



Review of Meiosis II:

- **Meiosis II (“Equational Division”)** is the same as a mitotic division, except with 23 chromosomes per cell.
  - During Metaphase II, all 23 chromosomes line up.
  - During Anaphase II, sister chromatids separate.
- Net Effect of Meiosis II: Two  $n$  parents with replicated chromosomes → four  $n$  daughters with *unreplicated* chromosomes.

**EXAMPLE:** Summary of Meiosis.



**PRACTICE 1:** A human cell undergoes mitosis. How many chromosomes are in each daughter cell?

- a) 12.
- b) 23.
- c) 46.
- d) 92.

**PRACTICE 2:** A human cell undergoes meiosis I. How many chromosomes are in each daughter cell?

- a) 12.
- b) 23.
- c) 46.
- d) 92.

**PRACTICE 3:** Trisomy 21 (Down Syndrome) is a genetic condition caused by “nondisjunction” during meiosis, causing one daughter cell (and, after fertilization, the resulting fetus) to have three copies of Chromosome 21. How many total chromosomes are in the body cells of a person with Trisomy 21?

- a) 23.
- b) 24.
- c) 46.
- d) 47.

**CONCEPT: MALE REPRODUCTION I: ANATOMY OF THE MALE REPRODUCTIVE SYSTEM**

The Male Reproductive System:

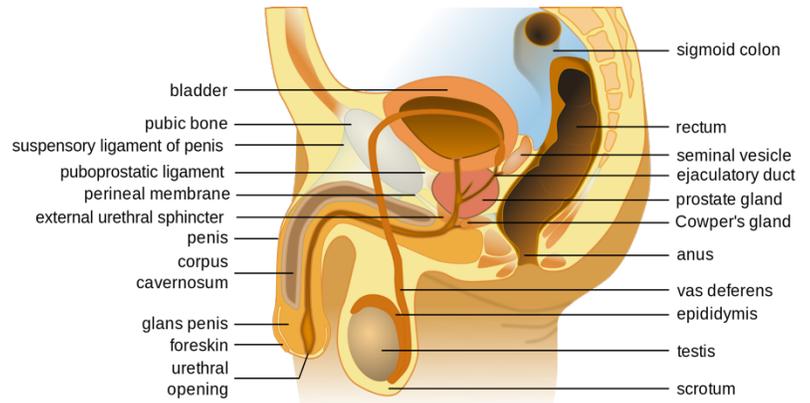
● **Penis and Scrotum with testis** are the two major parts of the male reproductive system. Within penis are:

- **Urethra**- Tube for urine and sperm.
- **Corpus Cavernosum**- Spongy tissue, fills with blood during **erection**.

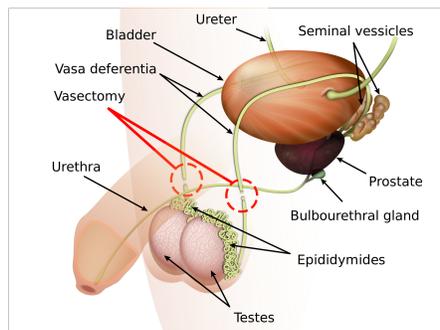
Following the path of sperm:

- **Testis**- Where \_\_\_\_\_ are first made.
- **Epididymis**- Stores/matures sperm.
- **Vas Deferens** carries sperm through the **prostate gland**, delivers it to \_\_\_\_\_.

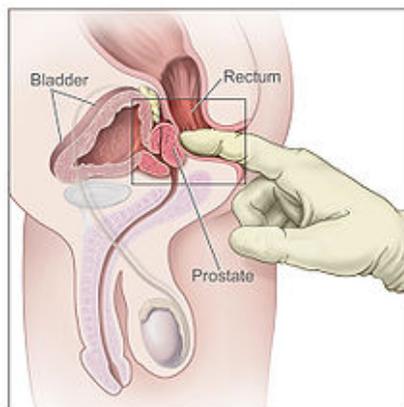
- Prostate gland adds fluids and nutrients, makes **semen**.
- Semen travels through **urethra** to get to outside world. (Urine also exits through the urethra.)



**EXAMPLE:** Vasectomies are procedures where the vas deferens is cut, eliminating a man's fertility.



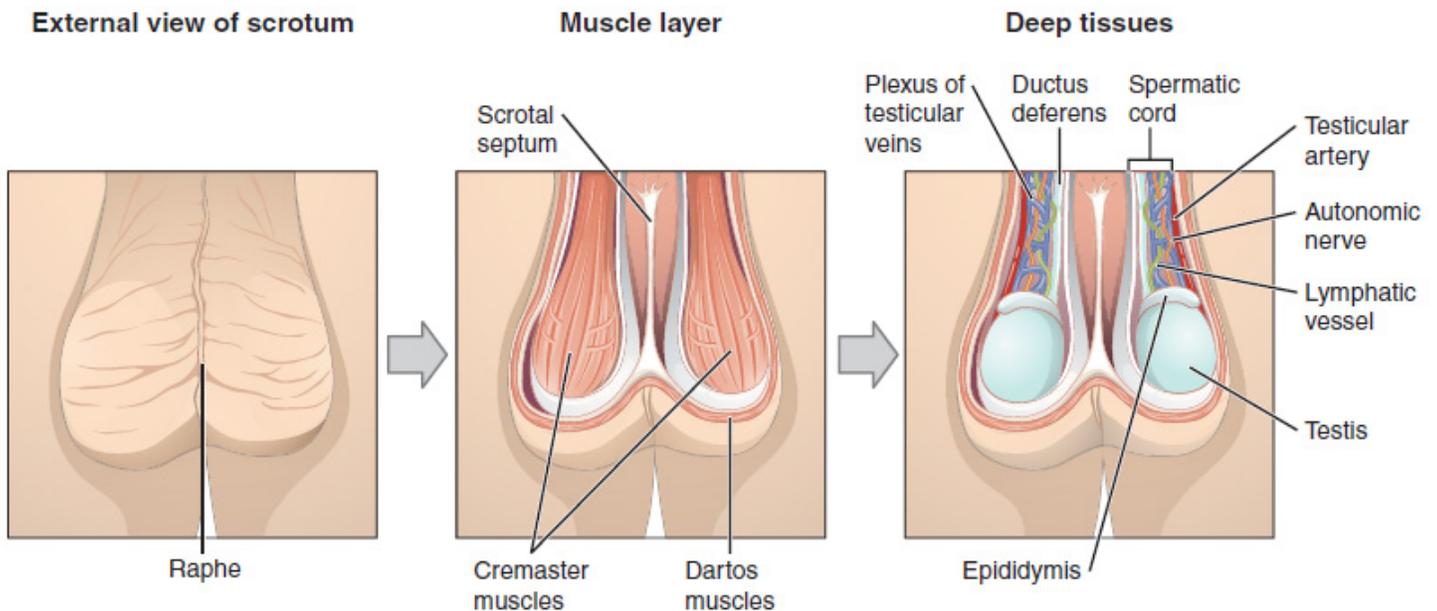
**EXAMPLE:** Prostate exams are performed by urologists to assess for enlargement of the prostate gland.



CONCEPT: SCROTUM AND TESTIS

- The **scrotum** is an external sac that contains the testis and epidymis
  - The scrotum is 2-3° \_\_\_\_\_ than the surrounding body, which is needed for proper sperm development
  - The external scrotum is divided in the midline by the **raphe** seam
  - Two sets of muscles control scrotum movement
    - The **dartos muscles** cause wrinkling and can elevate the testes
    - The **cremaster muscle** pulls the testes closer to the body
  - The scrotum is \_\_\_\_\_ with nerves and blood vessels through the **spermatic cord**; it contains...
    - **External spermatic fascia** formed by the fibrous sheet of the external oblique muscle
    - The *cremaster muscle* and **cremaster** fascia formed from the fibrous sheet of the internal oblique muscle
    - **Internal spermatic fascia** formed from the deep fascia of the abdominal muscles
    - A **testicular artery** to supply blood and the **pampiniform plexus** to cool the blood

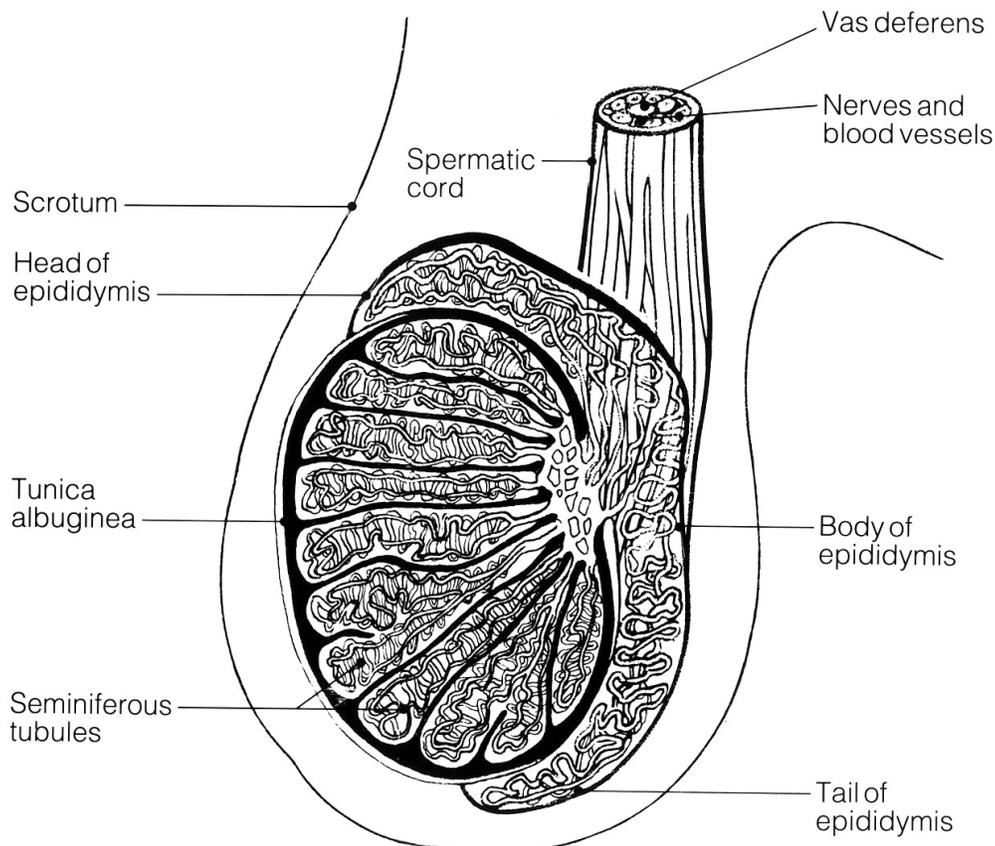
**EXAMPLE:**



- The **testis** are small organs found in the scrotum; they produce \_\_\_\_\_ and androgen hormones
  - The testis walls are made up of two layers
    - The **tunica vaginalis** is the outermost serous membrane, covers anteriorly and laterally
      - Has an outer **parietal layer** and inner **visceral layer**; in between is a serous-fluid filled cavity
    - The **tunica albuginea** is internal to the tunica vaginalis; covers the testis
      - The **mediastinum testis** sits at the posterior testis; is a thicker region of tunica albuginea
        - Where blood vessels, ducts, nerves, and lymph vessels are run
      - This projects internally and creates **septa** that divide the testis into ~250 **lobules**
        - Each lobule contains **seminiferous tubules**, which have cells that produce \_\_\_\_\_
        - The **interstitial space** surrounds the seminiferous tubules

**EXAMPLE:**

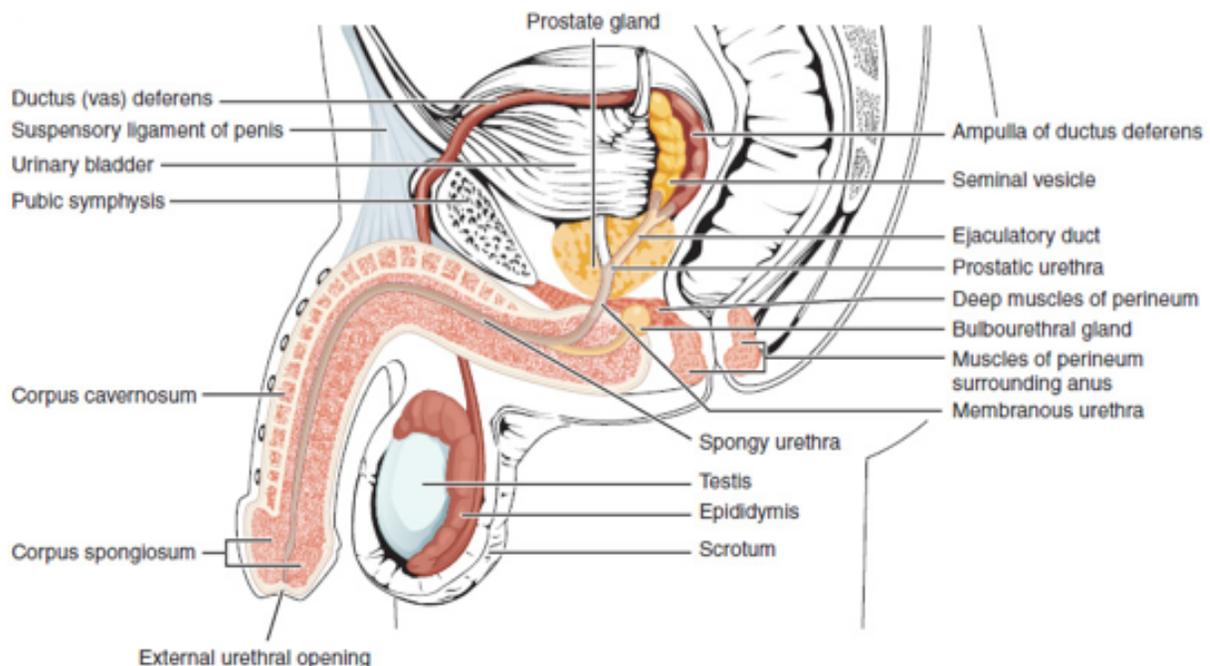
**Cross Section of Testicle**



CONCEPT: MALE REPRODUCTIVE DUCTS

- Male reproductive ducts are responsible for storing and \_\_\_\_\_ sperm
  - The **rete testis** receives sperm from seminiferous tubules; has multiple, interconnected channels
    - **Efferent ductules** (12-15) connect the rete testis to the epididymis head
  - The **epididymis** is a tube connecting the testis to the deferent duct; stores sperm for maturation; has three parts
    - The **head** (superior surface of testis), **body**, and **tail** (posterior surface of testis)
    - Inactive sperm remains here until they are fully \_\_\_\_\_ and ready to be ejaculated
  - The **ductus deferens** (*vas deferens*) travels between epididymis tail and ejaculatory duct in the spermatic cord
    - At the bladder, it separates from the spermatic cord and travels to the prostate gland
    - As the ductus deferens arrives at the superioposterior aspect of the prostate gland, an **ampulla** is created
  - The ampulla of ductus deferens and the seminal vesicle form the **ejaculatory duct**
    - Short passageway ~2cm that transports sperm, and seminal fluid from the ductus deferens to the urethra
  - The urethra transports semen from the ejaculatory ducts to the \_\_\_\_\_ of the body

**EXAMPLE:**

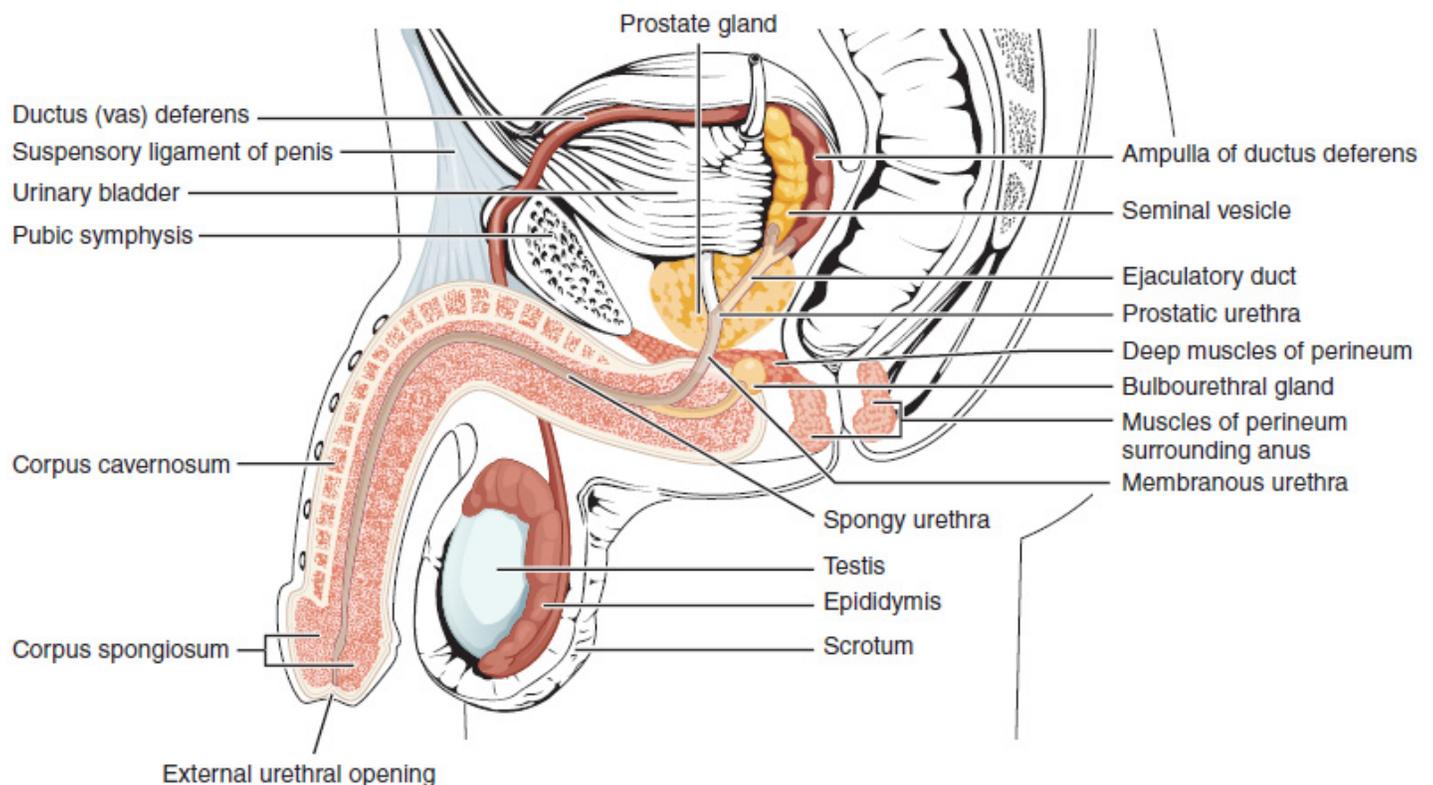




**CONCEPT: MALE ACCESSORY GLANDS**

- There are several glands that assist sperm survival by creating the different components of seminal fluid
  - Seminal fluid is a basic fluid that helps \_\_\_\_\_ sperm and protect it in the acidic vaginal environment
    - Releases its components into the ductus deferens during ejaculation; activating the sperm's flagellum
  - **Seminal vesicles** found lateral to ampulla of the ductus deferens; on the posterior surface of the urinary bladder
    - It gives a nutritional component to the seminal fluid as well as facilitates sperm entry into the uterus
  - The **prostate gland** is inferior to the bladder contains 30-50 mucosal glands that contribute to seminal fluid
    - Produces **prostatic fluid**, which gives nutrients essential for sperm health, also works as an \_\_\_\_\_
  - The **bulbourethral glands** (*Cowper glands*) are located at the penis base; produces mucin to coat the urethra
    - Provides \_\_\_\_\_ for the sperm to pass through the urethra during intercourse
  - **Semen** is sperm + seminal fluid; when released it is called **ejaculate**
    - Has between 200-500 million spermatozoa in 3-5 milliliters of fluid

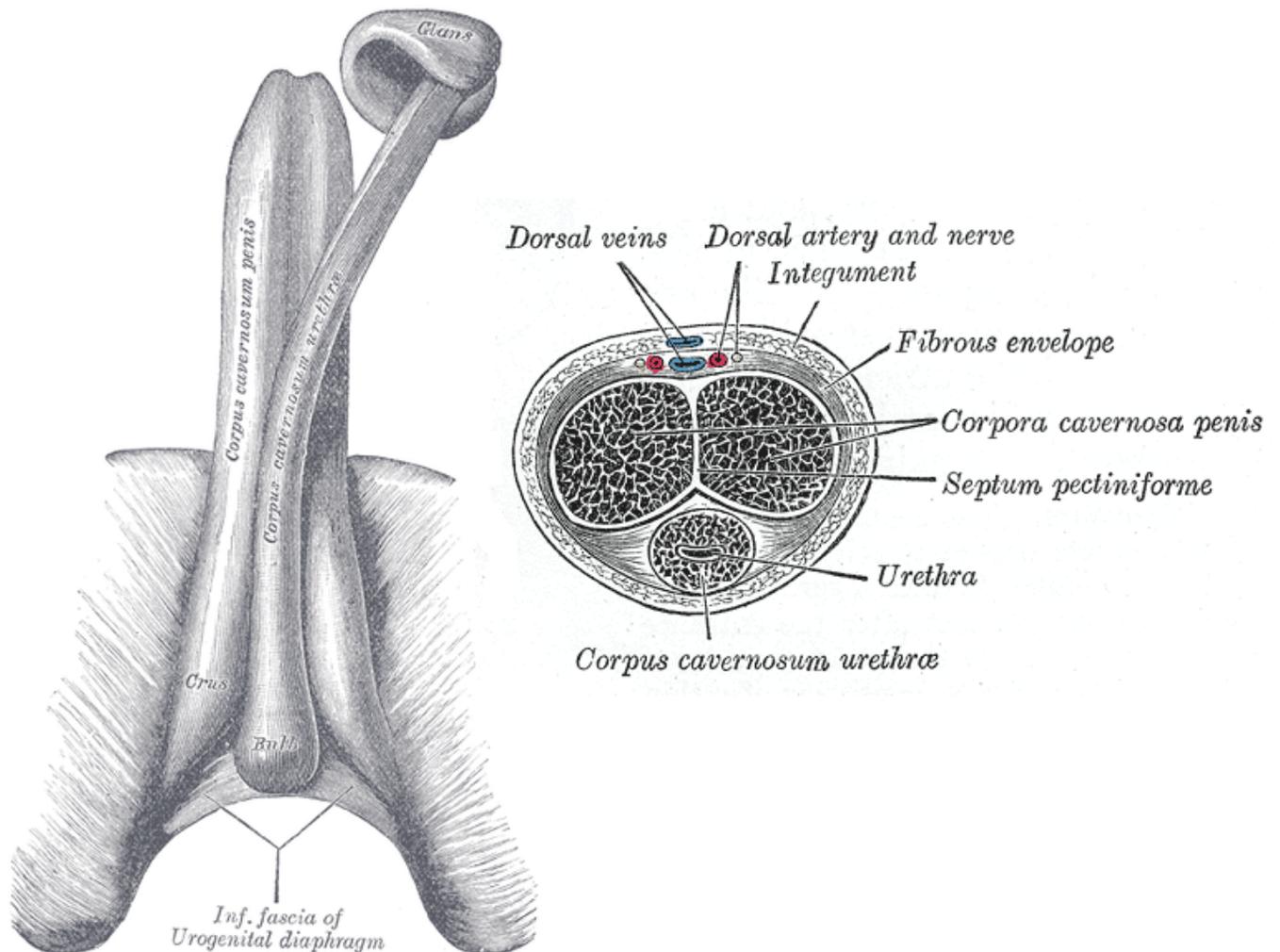
**EXAMPLE:**



CONCEPT: PENIS ANATOMY

- The **penis** + scrotum form the male external genitalia
  - The penis is internally divided into \_\_\_\_\_ sections: the **root**, the **bulb**, and the **crus**
  - The penis is externally divided into the **body** (*shaft*) and **glans** (tip)
    - The **external urethral orifice** is the opening on the penis glans
    - The **prepuce** (foreskin) is the distal skin attached to the glans, attaches to the **neck**
  - Three \_\_\_\_\_ tissues make up the penis body
    - The **corpora cavernosa** (paired) are posteriorly positioned; becomes the *crus*
    - The **corpus spongiosum** (single) is in the midline; becomes the *bulb*

**EXAMPLE:**



**CONCEPT: MALE REPRODUCTION II: SPERMATOGENESIS AND SPERMIOGENESIS**

Spermatogenesis and Spermiogenesis:

- **Spermatogenesis**- Process of making spermatids (male gametes) in the testis.

□ Making \_\_\_\_\_—uses two meiotic divisions to go from 2n parent cell to n daughter cell.

- **Spermatogonia**- “Germ cells,” undergo mitosis throughout a man’s life to provide cells for making sperm

□ Makes **Primary Spermatocytes**—the ones that will start meiosis.

- 1<sup>st</sup> Meiotic Division: Primary Spermatocytes→**Secondary**

**Spermatocytes.**

- 2<sup>nd</sup> Meiotic Division: Secondary Spermatocytes→*Spermatids*.

-**Spermatids**- Immature sperm.

- **Spermiogenesis**- Process of turning spermatids into mature *spermatozoa*.

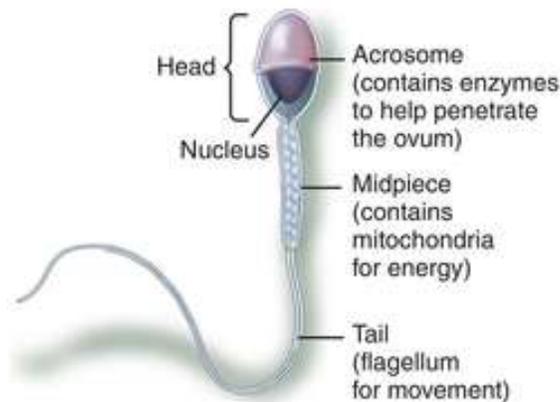
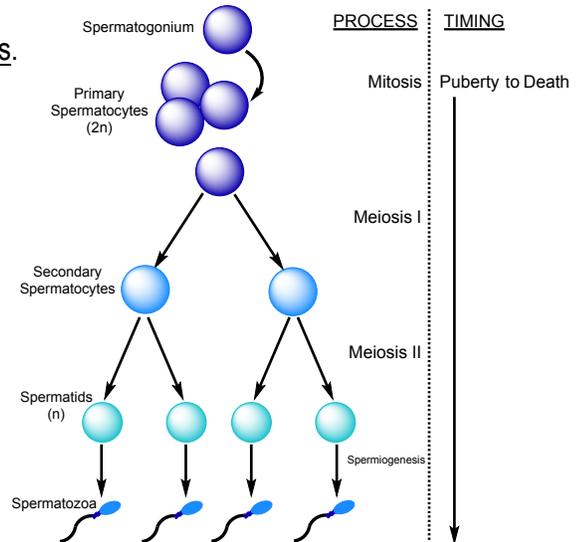
□ **Spermatozoa**- Gametes that are capable of swimming, fertilizing eggs.

- Spermiogenesis includes:

□ Elongation and formation of **flagellum** (for swimming).

□ Formation of **acrosome**—vesicle at tip, holds enzymes necessary for \_\_\_\_\_.

**EXAMPLE:** Mature spermatozoa have an acrosome and flagellum.





**PRACTICE 1:** Which of the following is the number of chromosomes present in a secondary spermatocyte?

- a) 12.
- b) 23.
- c) 46.
- d) 47.
- e) 92.

**PRACTICE 2:** Which of the following cell types secretes testosterone?

- a) Sertoli cells.
- b) Leydig cells.
- c) Anterior Pituitary cells.

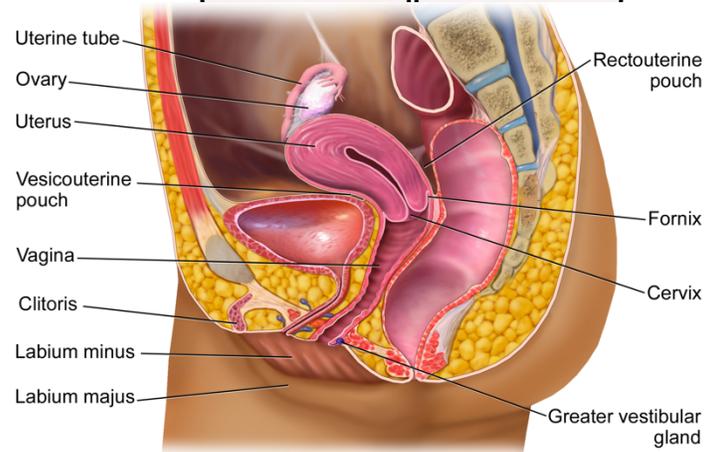
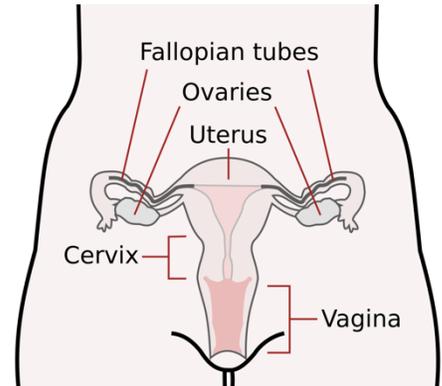
**PRACTICE 3:** Which of the following is the (indirect) effect of *increased luteinizing hormone (LH)* levels on the activity of Sertoli Cells?

- a) Increased Sertoli cell activity.
- b) Decreased Sertoli cell activity.
- c) No change in Sertoli cell activity.

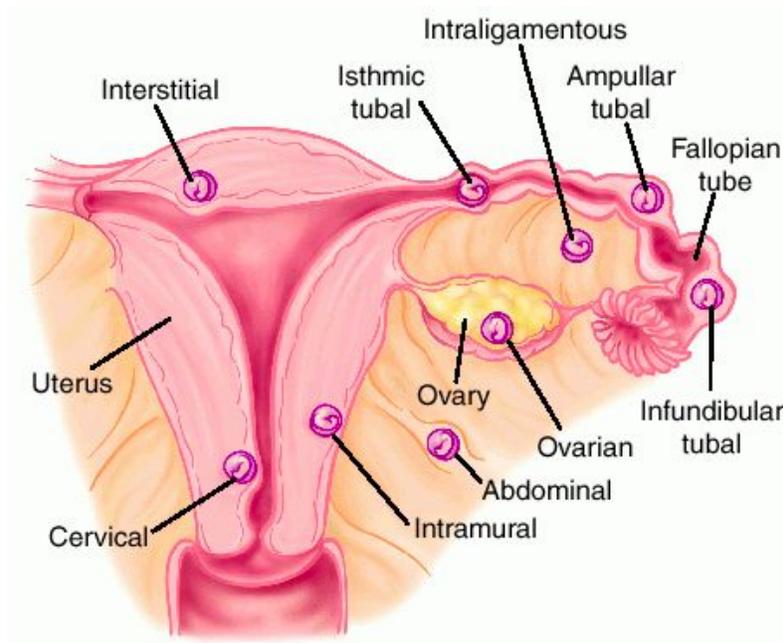
**CONCEPT: FEMALE REPRODUCTION I: ANATOMY OF THE FEMALE REPRODUCTIVE SYSTEM**

The Female Reproductive System:

- *Uterus* and *Vagina* are the two major parts of the female reproductive system.
  - **Uterus**- Muscle- and epithelium-lined pocket where babies grow.
  - **Vagina** (or **Vaginal Canal**)- Canal leading up to the \_\_\_\_\_.
  - Cervix**- Opening that separates uterus and vagina.
- *Fallopian Tubes* are connected to the uterus; *Ovaries* are very close to the other end of the Fallopian tubes.
  - **Ovaries** release eggs once per month into the Fallopian Tubes.
  - Eggs travel through **Fallopian Tubes** to arrive in uterus to (maybe) get fertilized by a sperm.



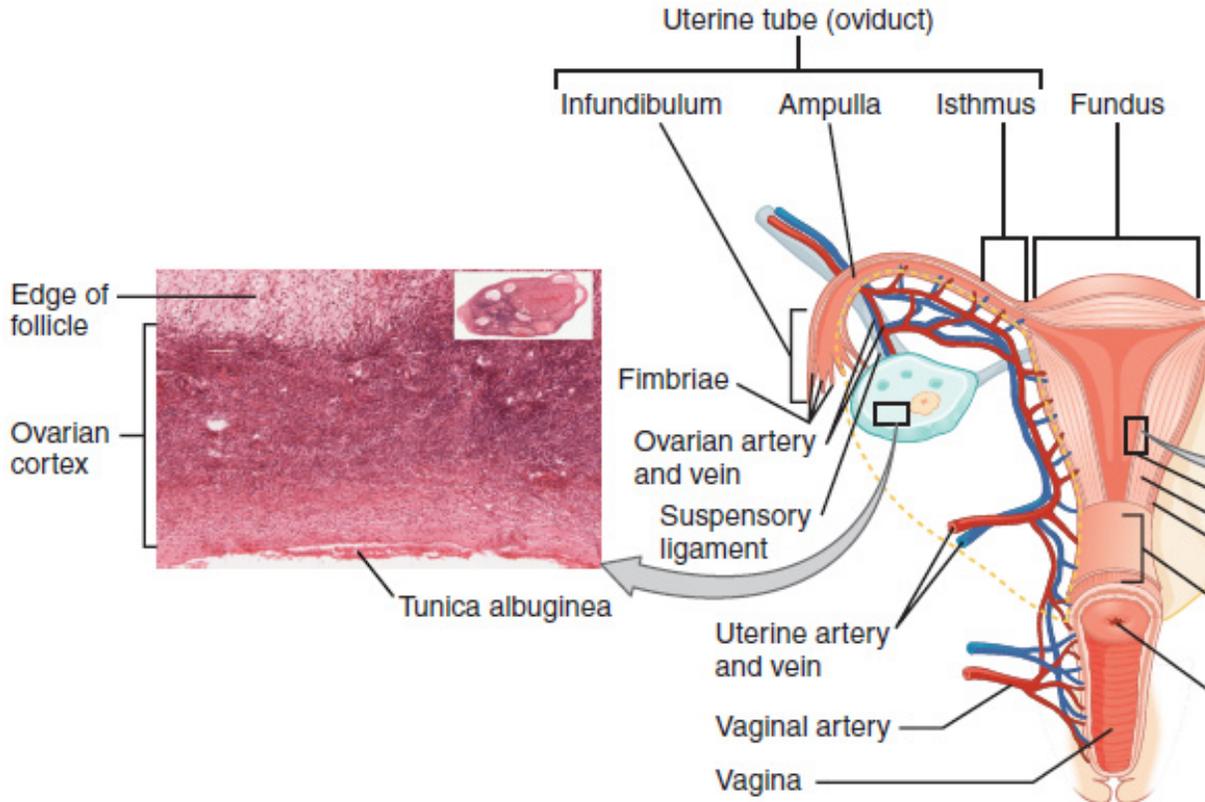
**EXAMPLE:** Ectopic pregnancy is when a fertilized egg implants in the Fallopian tube (or elsewhere) instead of the uterus.





- The ovaries have a \_\_\_\_\_ consistency and is divided into four layers
  - The outermost **germinal epithelium** is the visceral peritoneum that has a single cuboidal epithelial layer
  - The **tunica albuginea** is the middle layer, a dense connective tissue capsule covering
  - The interior cavity of the ovary has:
    - The superficial **cortex** contains ovarian follicles
    - The deep **medulla** is the innermost region; contain blood and lymph vessels, and nerves

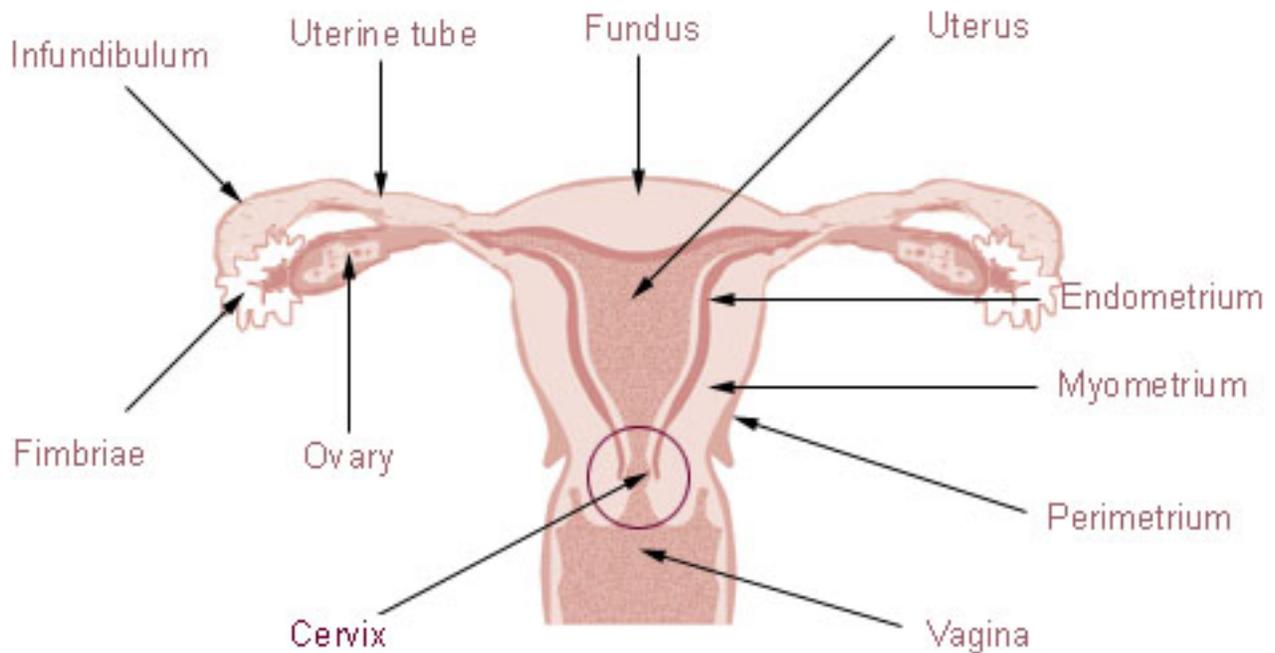
**EXAMPLE:**



CONCEPT: UTERINE TUBES

- **Uterine tubes** (*fallopian tubes*): hollow, muscular tube; laterally extend from the uterus to the ovaries for oocyte transport
  - The uterine tubes are divided into \_\_\_\_\_ segments
    - The **infundibulum** is the funnel-shaped lateral free area of the uterine tube
      - The **fimbriae** are the fingerlike folds that extend to the ovary during ovulation
    - The **ampulla** is medial to the infundibulum; where fertilization occurs
    - The **isthmus** is the region between the ampulla and uterus
    - The **uterine part** penetrates into the uterine wall

**EXAMPLE:**



- The tube wall is composed of several layers
  - The **mesosalpinx** is the outermost covering surrounding the uterine tube wall, suspending the tubes
  - The **serosa** is the outermost area of the uterine wall; serous membrane covering the tubes
  - The **muscularis** has two layers of smooth muscles – an inner circular layer and outer longitudinal layer
    - Helps \_\_\_\_\_ the oocyte with peristaltic contractions
  - The **mucosa** is the innermost layer formed from simple ciliated columnar epithelium
    - It is shaped into linear folds, with cilia in its apical surface beating in the directing of the uterus

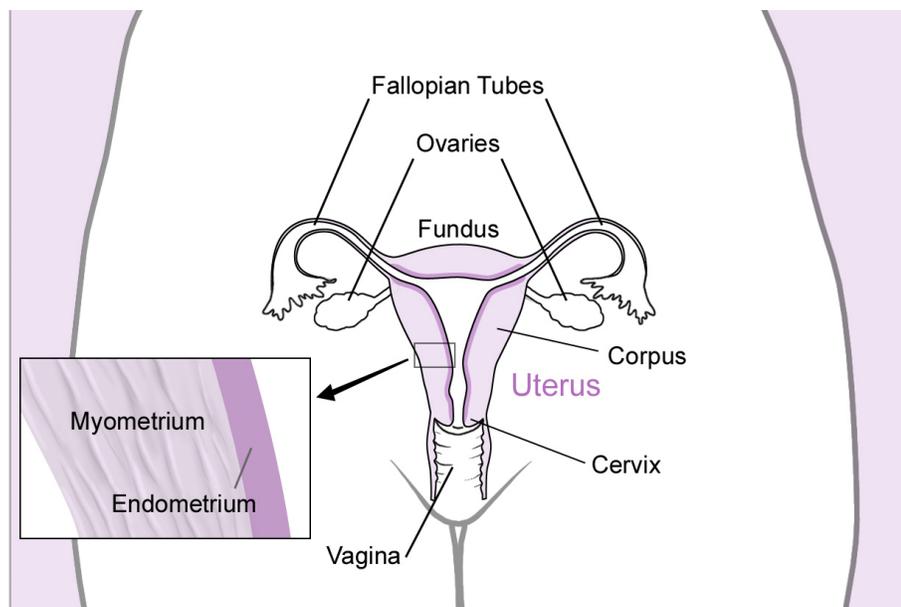
**EXAMPLE:**



CONCEPT: UTERUS

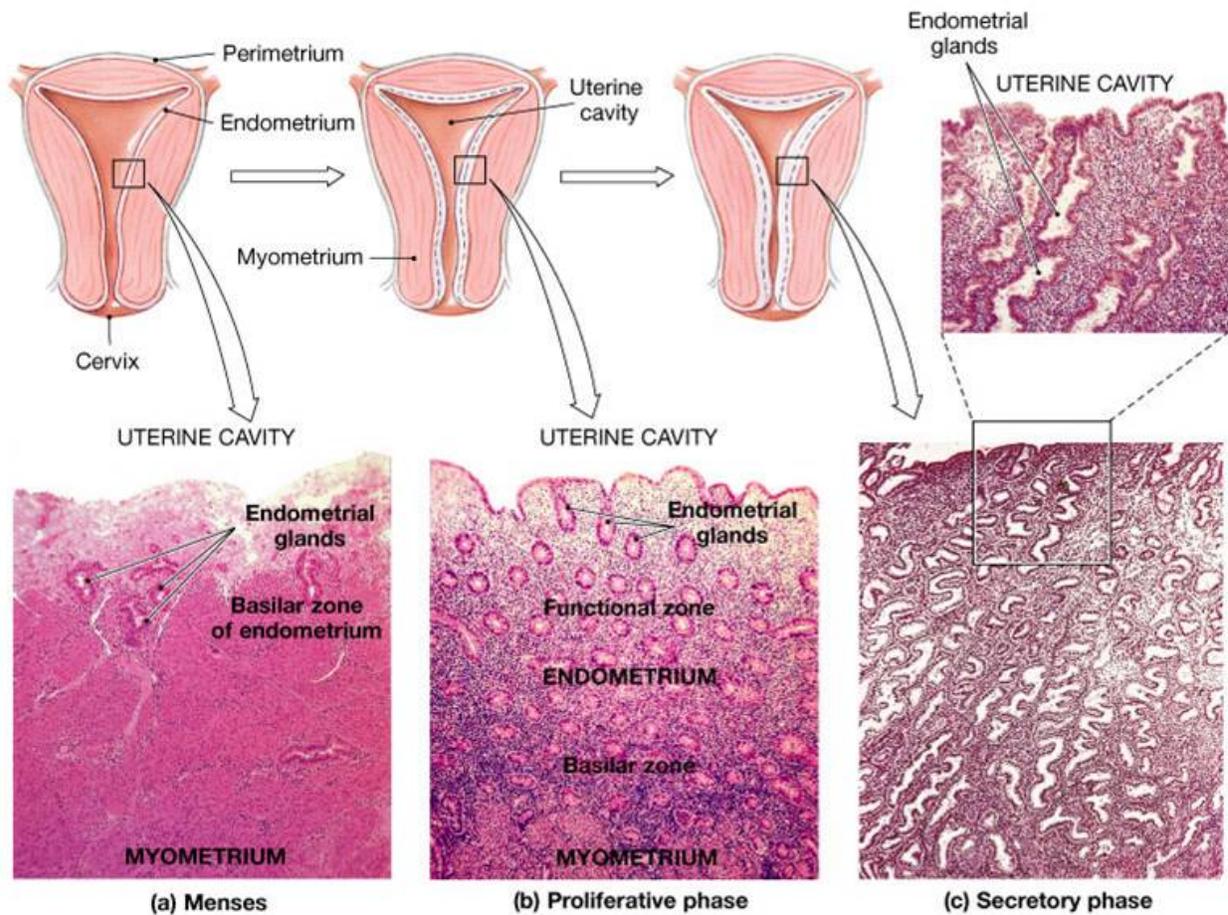
- The **uterus** is a small, pear-shaped muscular organ that connects the uterine tubes to the vagina
  - It provides \_\_\_\_\_, nutrition, and waste removal for a developing embryo
  - Is an **anteverted** organ as it is angled anterosuperiorly across the superior bladder
  - The uterus is divided into the following regions
    - The **fundus** is rounded and broad; sits in between both uterine tubes
    - The **body** is the majority of the uterus, and is made of thick smooth muscle
    - The **isthmus** is the constricted passage that leads to the cervix
    - The **cervix** is a narrow projection that extends into the vagina; within the vagina:
      - The **external os** leads into the **cervical canal** and opens at the **internal os**
  - A **mucus plug** sits at the external os to prevent \_\_\_\_\_
  - Several structures hold the uterus in place; **prolapse** of the uterus into the vagina occurs if these are weakened
    - The **urogenital diaphragm** (pelvic floor muscles) resist intr-abdominal pressure; hold uterus in place
    - The **round ligaments** laterally attaches to the uterus; goes through the inguinal canal to labia majora
    - The **transverse cervical ligaments** attach the cervix and vagina to the pelvic wall
    - The **uterosacral ligaments** attach the inferior uterus to the sacrum

**EXAMPLE:**



- The uterine wall is composed of three regions
  - The **perimetrium** is the outermost tunic; is an incomplete serosa layer; continuous with broad ligament
    - Covers the anterior and posterior surfaces of the uterine body as well as the \_\_\_\_\_
    - Contains uterine glands used in the uterine cycle
  - The **myometrium** is the middle tunic; made of smooth muscle
  - The **endometrium** is the innermost tunic; it is made of mucosa
    - The **basal layer** (*stratum basalis*) is the permanent layer, gives rise to functional layer
    - The **functional layer** (*stratum functionalis*) is the layer shed each month if no fertilization occurs

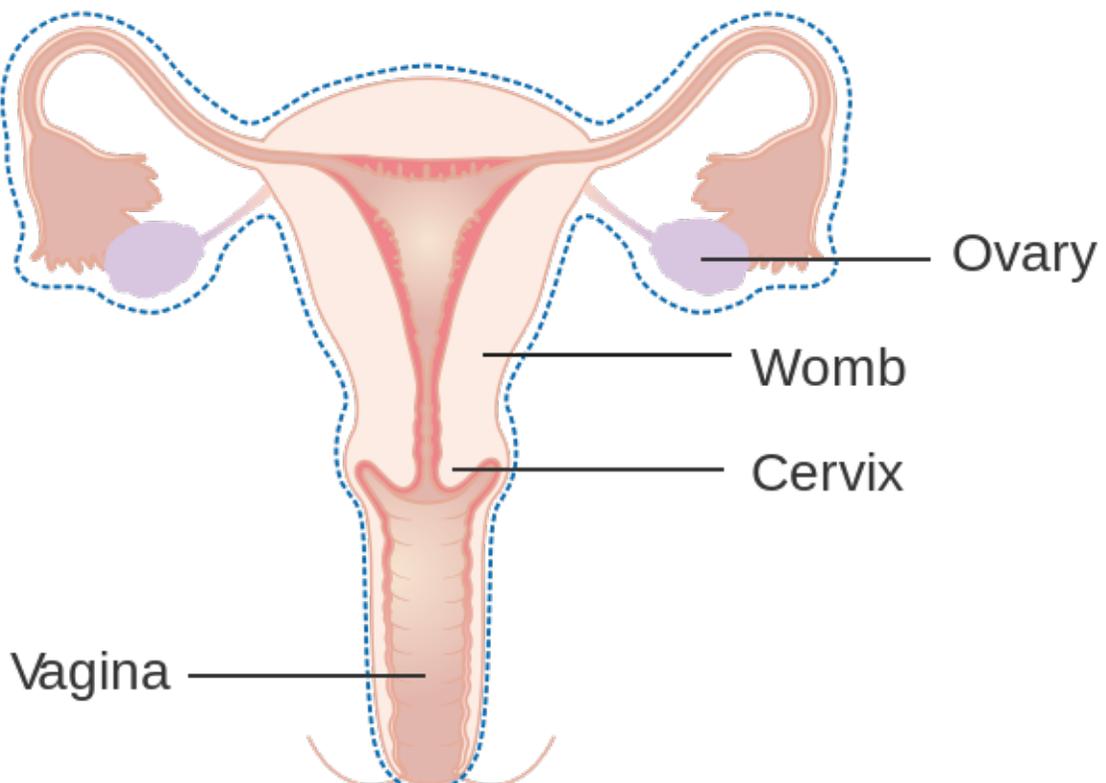
EXAMPLE:



CONCEPT: VAGINA

- The **vagina** is the elastic, muscular tube forming in the inferior region of the female reproductive anatomy
  - It is the copulating organ of females and the \_\_\_\_\_ canal, as it connects outside of the body
  - The primary blood supply comes from:
    - Internal iliac arteries → vaginal branch
    - Venous drainage by vaginal vein
  - The vaginal wall is composed of three tunics:
    - The **adventita** is the outermost layer of areolar connective tissue
    - The **muscularis** has two layers of smooth muscle
    - The **mucosa** is the innermost layer; highly vascularized
      - Epithelial cells secrete an \_\_\_\_\_ substance to prevent infection
      - Near the **vaginal orifice** opening, several folds form the **hymen** (vascularized membrane)

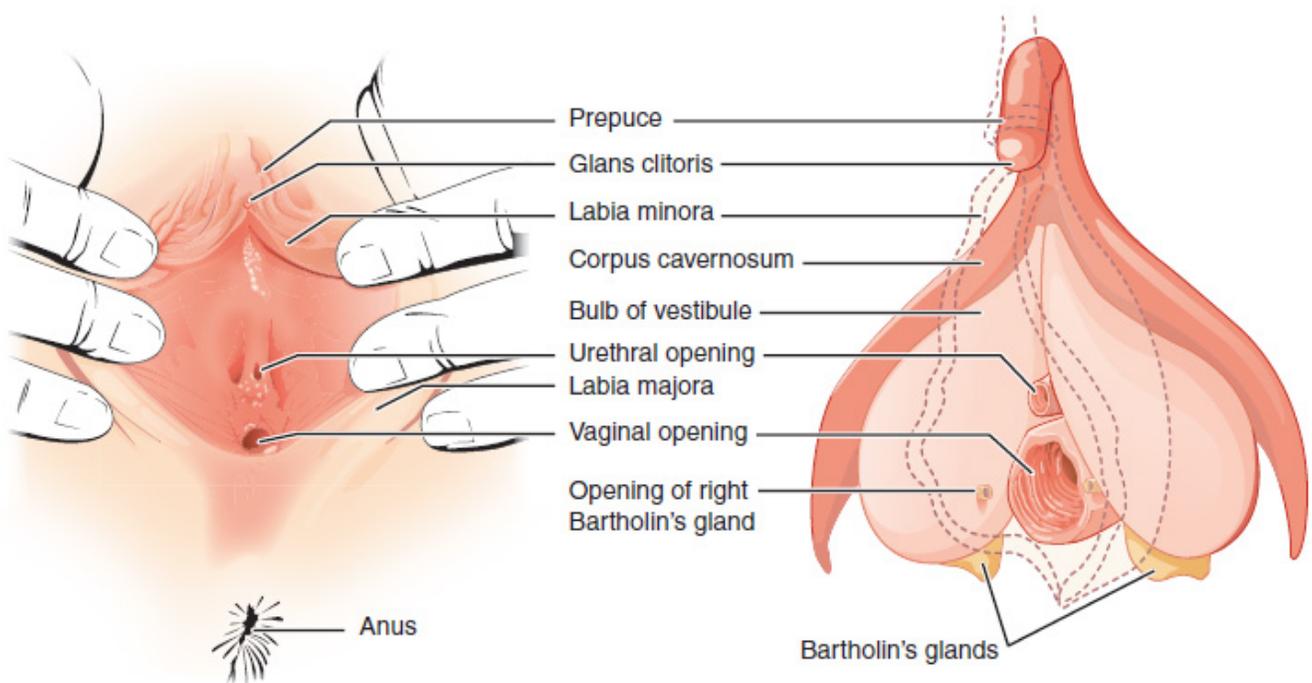
**EXAMPLE:**



CONCEPT: EXTERNAL FEMALE ANATOMY

- Female external genitalia are \_\_\_\_\_ by the **vulva**
  - Anterior to the pubic symphysis is the **mons pubis** formed by skin, fat, connective tissue, and hair
  - The **labia majora** (latera) and **labia minora** (medial) are two pairs of skin folds
    - The labia majora are paired, thick folds; has hair, sweat, and sebaceous glands
    - The labia minora are paired, \_\_\_\_\_, and has sebaceous glands, and melanocytes
  - The **vestibule** is the space between the labia minora; it contains the...
    - Urethral opening, vaginal orifice and lateral **bulb of the vestibule**
    - The **lesser** and **greater vestibular glands** secrete mucin for lubrication
  - The **clitoris** is located near the anterior labia minora; projects into the vestibule; swells during arousal
    - The **corpora cavernosa** (2) are erectile projections that become sensitive during sex
    - The **crus** extend posteriorly from the corpora cavernosa and attach to the pubic arch
    - The **glans** caps the clitoris; it contains lots of nerve receptors for sensitivity and pleasure during sex
    - The **prepuce** is a labia minora fold that covers the clitoris

**EXAMPLE:**



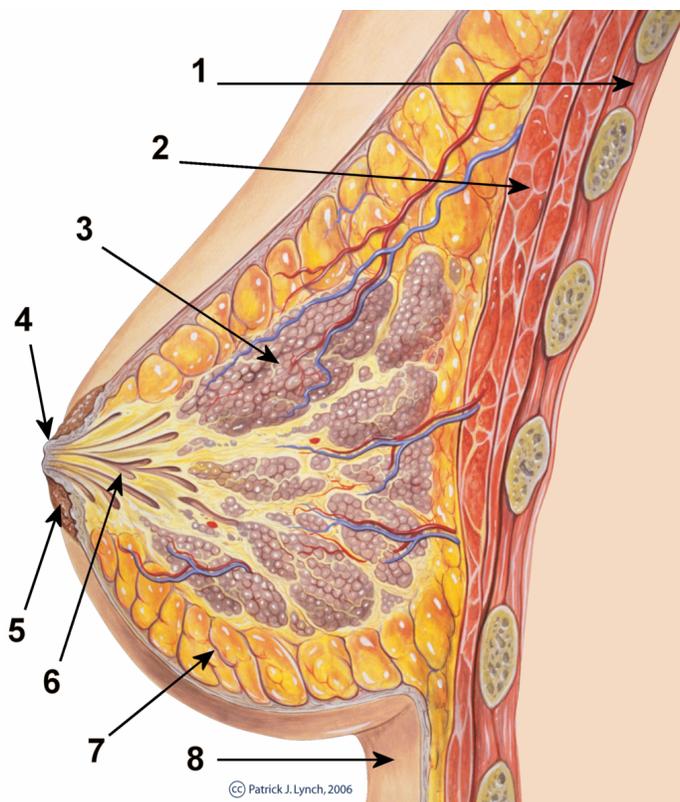
Vulva: External anterior view

Vulva: Internal anteriolateral view

CONCEPT: MAMMARY GLANDS

- The **mammary glands** (*breasts*) are in the anterior thoracic wall; contain several exocrine glands
  - Produce and secretes \_\_\_\_\_ with protein, fat, and lactose for infant nutrition
  - The external structures of the mammary glands include:
    - The **nipple** contains tiny openings to transport breast milk to the infant
    - The **areola** is the brown area surrounding the nipple; contains **areolar glands** (*sebaceous*)
      - It is \_\_\_\_\_ in women who have given birth (**parous**) than women who haven't (**nulliparous**)
  - The internal structure of the mammary glands includes:
    - **Suspensory ligaments** are fibrous connective tissue bands that provide support; skin → deep fascia
      - Structurally linked to the pectoralis major muscle by these ligaments
    - **Lobes** divide the mammary glands
    - **Lobules** further divide each lobe; contain **alveoli** that produce and secrete milk
    - **Lactiferous** are channels formed from alveoli and lobule ducts that later form lactiferous ducts
      - Drain into **lactiferous sinus**, which is where milk \_\_\_\_\_ occurs before release

**EXAMPLE:**



**CONCEPT: FEMALE REPRODUCTION II: OOGENESIS AND FOLLICULOGENESIS**

Oogenesis:

- **Oogenesis**- Process of making **ova** (eggs; female gametes) in the ovaries.
  - Making gametes—requires 2 meiotic divisions *that are spaced pretty far apart in time.*

- **Oogonia**- Female germ cells that eventually under meiosis to become eggs.

- Undergo \_\_\_\_\_ too, *but only during prenatal development (before birth).*

Oogenesis is two meiotic divisions *that stop and start.*

- Before birth:

- **Primary Oocytes** are made by oogonia doing *mitosis*.
- Primary oocytes *start* Meiosis I, *arrest* at Prophase I.

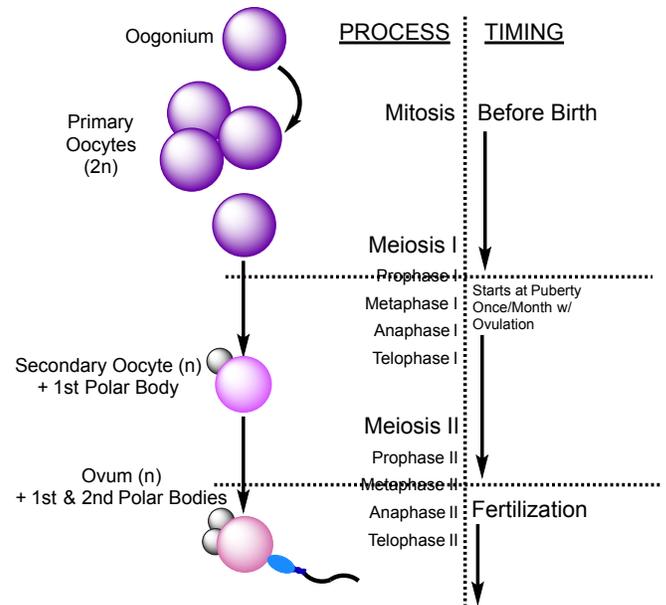
-“Girl is born with all the eggs she’ll ever have.”

- Starting at puberty, one primary oocyte per \_\_\_\_\_ restarts:

- Finishes Meiosis I, but it’s an “unequal” division:
  - Primary Oocyte→**Secondary Oocyte**+a **Polar Body**.
  - Secondary Oocyte gets way more cytoplasm and organelles.
- Secondary oocyte *starts* Meiosis II, but *arrests* at Metaphase II.

- Secondary oocyte is **ovulated** (released from ovary into Fallopian tube→uterus; more later).

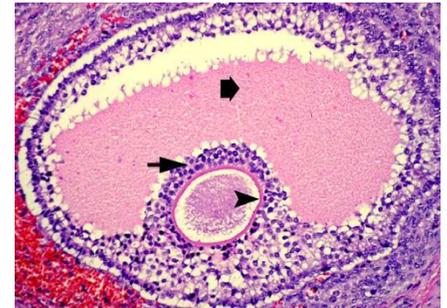
- *If* secondary oocyte is *fertilized*, finishes Meiosis II.
  - Secondary Oocyte→**Ovum**+a second polar body.



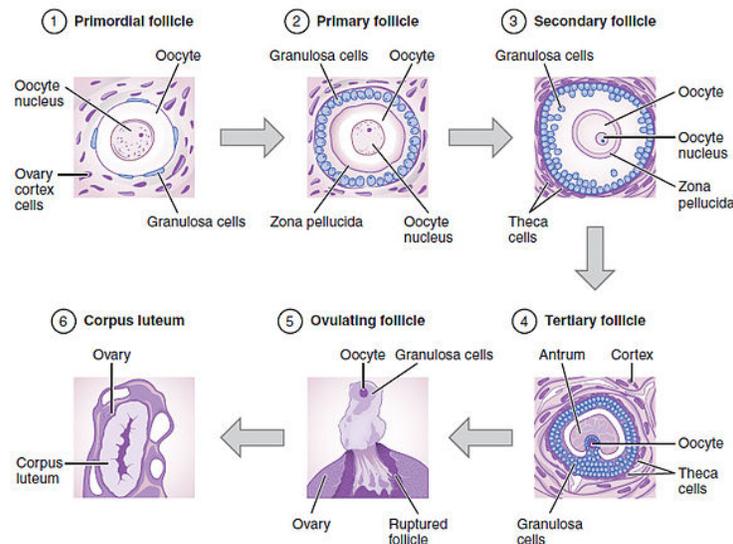
Folliculogenesis—Follicular Development:

- **Follicle**- Larger structure encasing the egg.
  - **Folliculogenesis**- Process of developing the \_\_\_\_\_ -- happens during the month leading up to ovulation.

- Follicle consists of two layers of stuff wrapped around the egg.
  - **Zona Pellucida**- Layer of glycoproteins (just proteins with sugars).
  - **Granulosa Cells**- Cells wrap around oocyte to protect, help nourish.



- Folliculogenesis occurs in stages:
  - 1) **Primordial Follicle**- Just the oocyte with a couple thin granulosa cells.
  - 2) **Primary Follicle**- Zona pellucida develops, granulosa cell layer gets thicker.
  - 3) **Secondary Follicle**- More growth of zona pellucida and granulosa cells.



- 4) **Tertiary Follicle**- More growth of zona pellucida and granulosa cells.
  - Antrum** forms—granulosa cells still wrap around oocyte+zona pellucida, but get an *additional layer* of granulosa cells with empty space between.
- 5) **Ovulation**- Oocyte+zona pellucida+inner layer of granulosa cells break out of ovary→Fallopian tube.
  - Corona Radiata**- Layer of granulosa cells still around oocyte.
- 6) **Corpus Luteum**- Leftovers of the follicle still in the \_\_\_\_\_ .
  - Important in regulating menstrual cycle—more later.

**PRACTICE 1:** Which of the following is the type of cell that gets released into the Fallopian tube during ovulation?

- a) Primary oocyte.
- b) Secondary oocyte.
- c) Ovum.
- d) Spermatozoa.

**PRACTICE 2:** Which of the following is made of a thin layer of glycoproteins?

- a) Granulosa cell layer.
- b) Zona pellucida.
- c) Follicle.
- d) Oocyte.

**CONCEPT: FEMALE REPRODUCTION III: THE MENSTRUAL CYCLE**

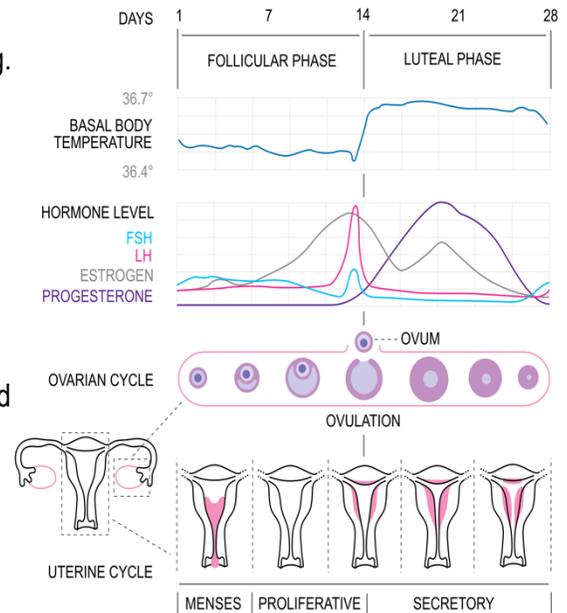
Overview of the Menstrual Cycle:

- **Menstrual Cycle**- Predictable, repeating changes in a woman's hormones, uterine lining, and ovaries.
  - Happen over a ~28 day cycle.
- **Ovarian Cycle**- Menstrual Cycle can be broken into two phases based on what's happening in the \_\_\_\_\_.

- **Follicular Phase**= First half of ovarian cycle.
  - Single follicle doing folliculogenesis—an egg is maturing.
- **Luteal Phase**= Second half of ovarian cycle.
  - Egg has been **ovulated** from ovary, now traveling into Fallopian tubes/uterus.
  - Corpus Luteum**- Leftovers of follicle in ovary.

- **Uterine Cycle**- Menstrual Cycle can be broken into three phases based on what's happening in the \_\_\_\_\_.

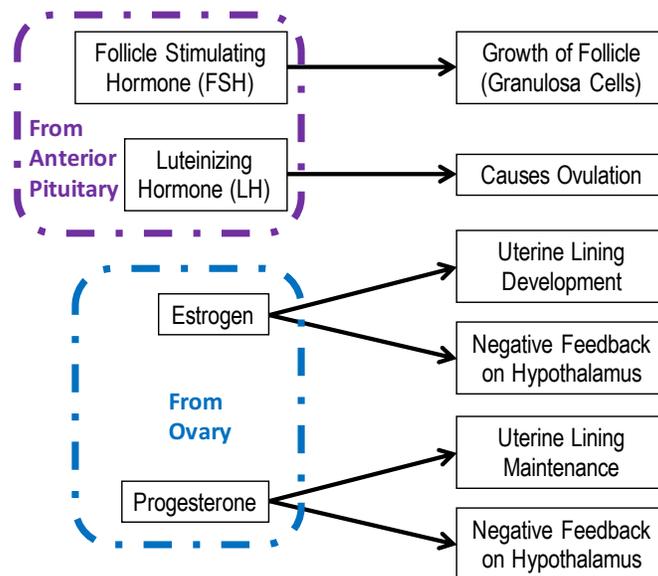
- **Menstruation/Menses**= First ~5 days of uterine cycle.
  - Getting rid of old uterine lining.
- **Proliferative Phase**= Rest of first half (~10 days).
  - Building up new uterine lining.
- **Secretory Phase**= Second half of uterine cycle.
  - Uterine lining waiting for possible fertilization and implantation.



Hormones of the Menstrual Cycle—FSH, LH, Estrogen, and Progesterone:

- Four major hormones secreted from two locations in the body control changes during the menstrual cycle.
- *Anterior Pituitary* secretes *follicle-stimulating hormone (FSH)* and *luteinizing hormone (LH)*.
  - **FSH** stimulates **granulosa cells** in the \_\_\_\_\_.
    - Causes the follicle and egg to mature.
  - **LH** rises very sharply halfway through the ovarian cycle, causing **ovulation** (release of \_\_\_\_\_ from ovary).
  - (Reminder: **Gonadotrophin Releasing Hormone (GnRH)** from hypothalamus causes secretion of FSH and LH from anterior pituitary)
- The *ovary* itself, as the follicle matures, secretes *estrogen* and *progesterone*.
  - **Estrogen** causes the uterine lining to develop.
    - Also helps control/regulate FSH and LH secretion from the anterior pituitary.
  - **Progesterone** keeps the uterus in the secretory phase.

**EXAMPLE:** Summary of menstrual cycle's four major hormones and their effects.



The Menstrual Cycle in Detail—Effects and Control of FSH, LH, Estrogen, and Progesterone:

● **Follicular Phase** features ~steady release of FSH and rising levels of estrogen.

- FSH stimulates the granulosa cells, causing the follicle to grow/mature.
- Estrogen secreted by follicle—↑Estrogen as follicle gets bigger.
  - Estrogen exerts negative feedback on the hypothalamus:
    - ↑Estrogen→↓GnRH→↓FSH.

- **Menstruation** is early in the follicular phase.
  - Later, ↑Estrogen→**Proliferative Phase**.

● **Ovulation** is caused by a change in how the hypothalamus responds to estrogen.

- **LH Surge**- High Estrogen levels→↑↑LH (and FSH) release.
  - ↑↑LH→**Ovulation**—Ovum released from follicle into Fallopian.

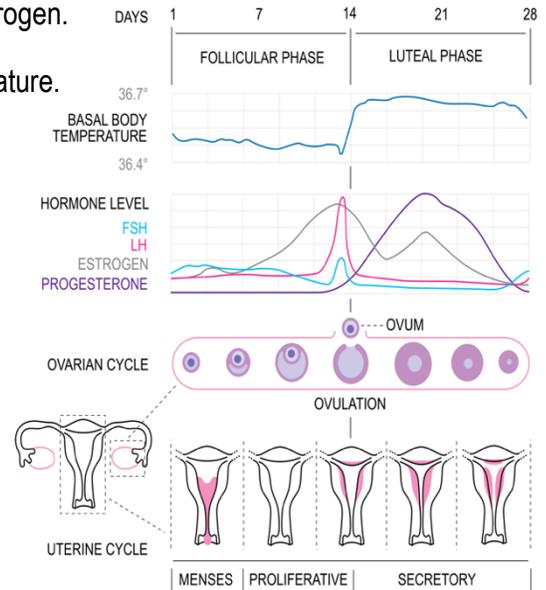
- **Corpus Luteum**- Leftover follicular cells in the ovary—secretes **progesterone**.

● **Luteal Phase** is dominated by progesterone secreted from the corpus luteum.

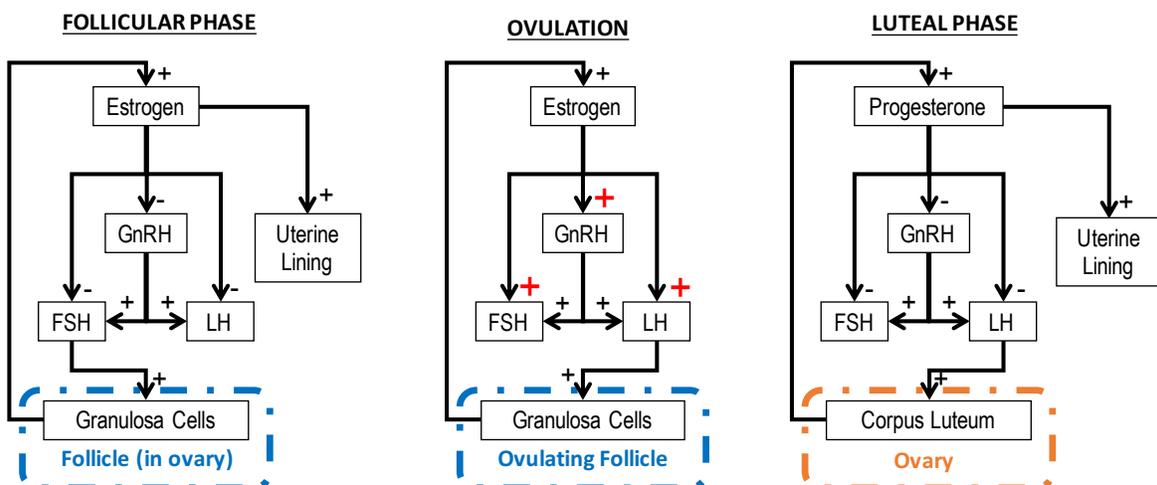
- Progesterone keeps the uterine lining thick and healthy—ready for possible baby.
- Progesterone also has negative feedback on hypothalamus→↓FSH and LH.

● If no baby: Corpus Luteum decays and dies→↓Progesterone→No stimulation of uterine lining→Menstruation.

- ↓Progesterone→↑FSH and LH—the cycle restarts.



**EXAMPLE:** Feedback loop summary of the menstrual cycle.



**PRACTICE 1:** Which of the following describes the (indirect) effects of follicle-stimulating hormone (FSH) on the development/proliferation of the uterine lining?

- a) Increased uterine lining proliferation.
- b) Decreased uterine lining proliferation.
- c) No effect on uterine lining proliferation.

**PRACTICE 2:** Which of the following describes the cause of ovulation?

- a) Negative feedback of progesterone on the anterior pituitary.
- b) Moderate levels of estrogen inhibiting the release of gonadotrophin-releasing hormone (GnRH).
- c) High levels of estrogen stimulating the release of gonadotrophin-releasing hormone (GnRH).
- d) Decay of the corpus luteum.

**PRACTICE 3:** Which of the following describes the cause of menstruation?

- a) Negative feedback of progesterone on the anterior pituitary.
- b) Moderate levels of estrogen inhibiting the release of gonadotrophin-releasing hormone (GnRH).
- c) High levels of estrogen stimulating the release of gonadotrophin-releasing hormone (GnRH).
- d) Decay of the corpus luteum.

**PRACTICE 4:** Ovulation sticks are a product that allow a woman to identify the day(s) on which she begins ovulating, allowing her to plan her sexual activity accordingly. Ovulation sticks detect the hormone that most directly causes ovulation. Which of the following is the hormone likely detected by ovulation sticks?

- a) Follicle-stimulating hormone (FSH).
- b) Luteinizing hormone (LH).
- c) Estrogen.
- d) Progesterone.