

LAB 8: THE REPRODUCTIVE SYSTEM

Protocol slides

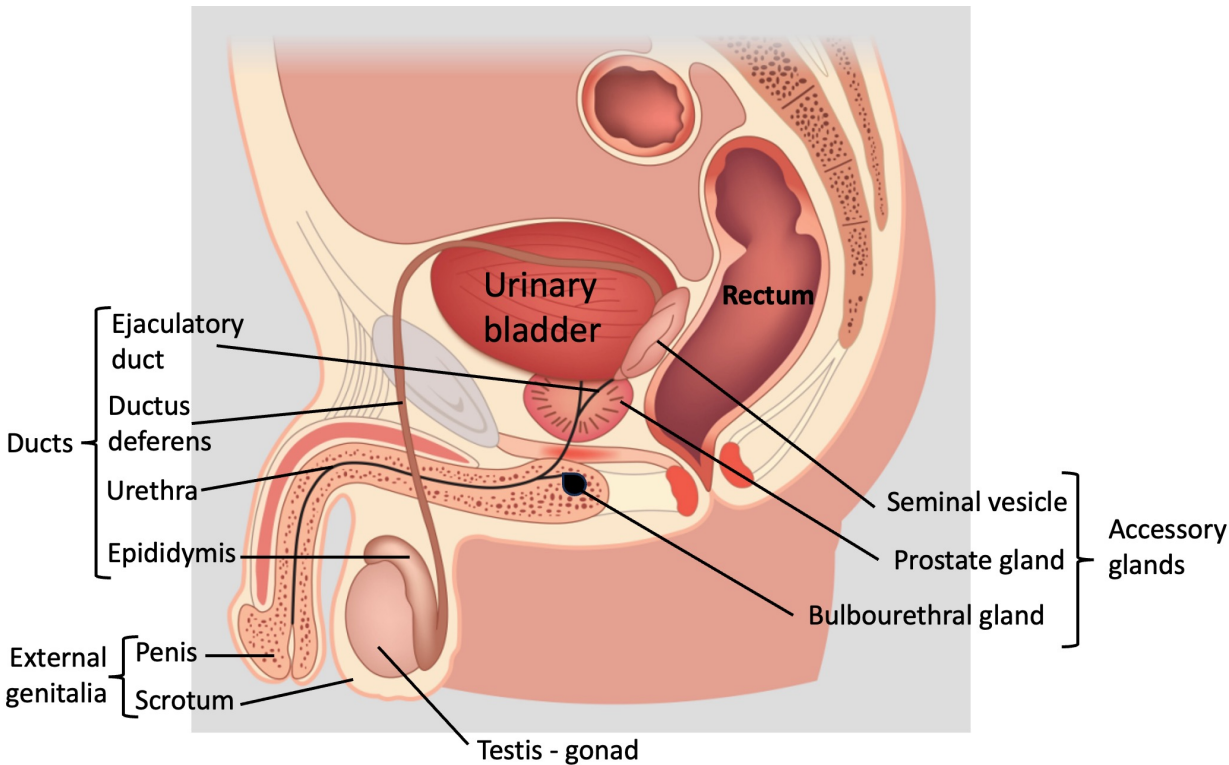
PCB 3702L

FIU

Lab 8 Protocol Objectives

- Identify male reproductive system structures and functions while performing dissection of bull testicle.

Male Reproductive Anatomy



Flow of Sperm: SEVEN UP!

**Seminiferous tubules (testes) → Epididymis →
Vas deferens → Ejaculatory Duct →
Urethra → Penis**

Testes

- Produce sperm
- Secrete the hormones testosterone and inhibin
- Covered by a capsule of connective tissue that extends inward and divides each testis into 200-300 internal compartments. Each compartment has 1-3 tightly coiled tubules, called seminiferous tubules

Scrotum

- Protects the testes
- Maintains the optimal temperature for sperm development (~2-3°C below core body temp.)

System of Ducts

- Includes the epididymis, vas deferens, ejaculatory duct, and urethra
- Assist in the maturation, storage, and transport of sperm cells

Accessory glands

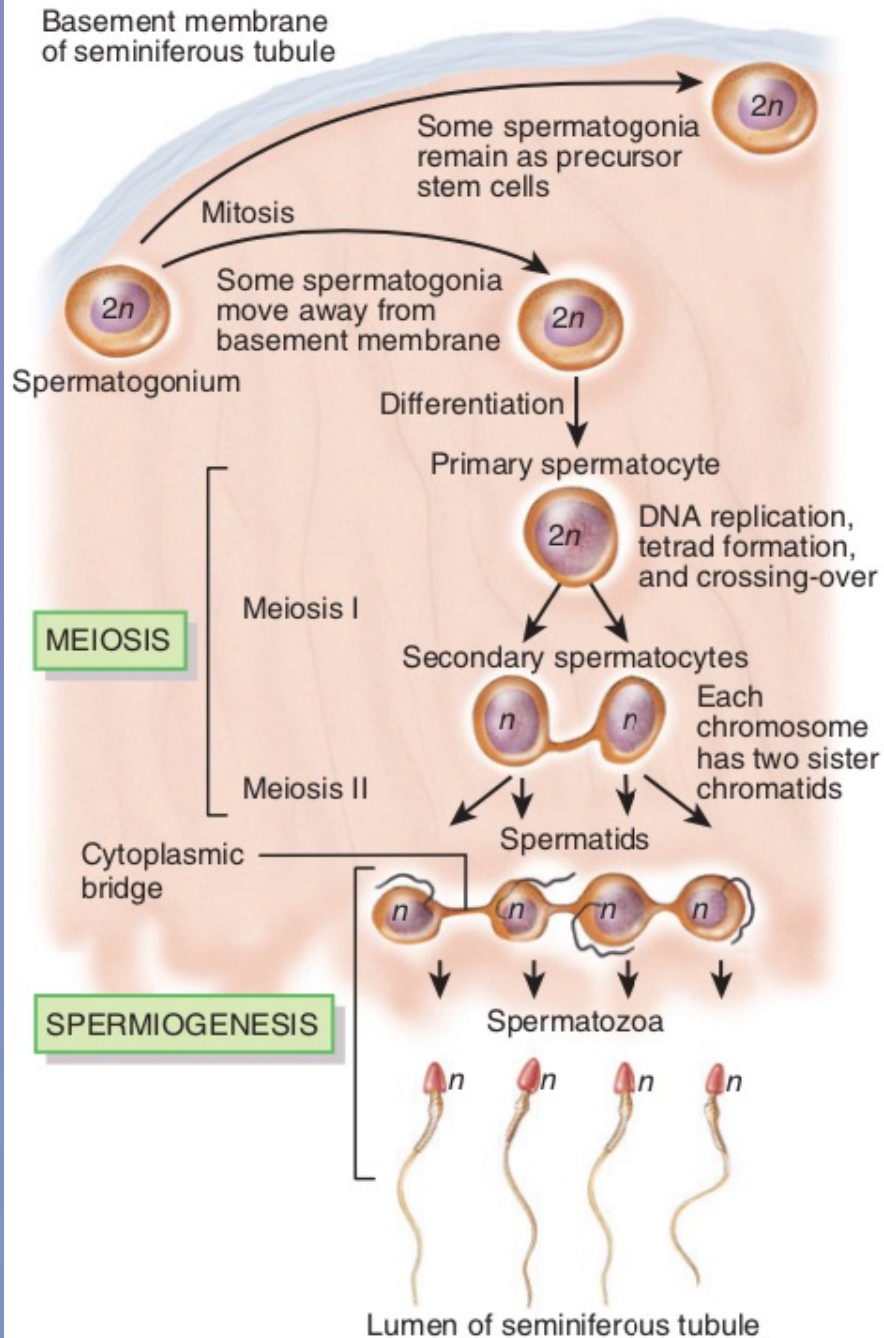
- Include the seminal vesicles, prostate gland, and bulbourethral glands
- Add secretions to sperm to form semen

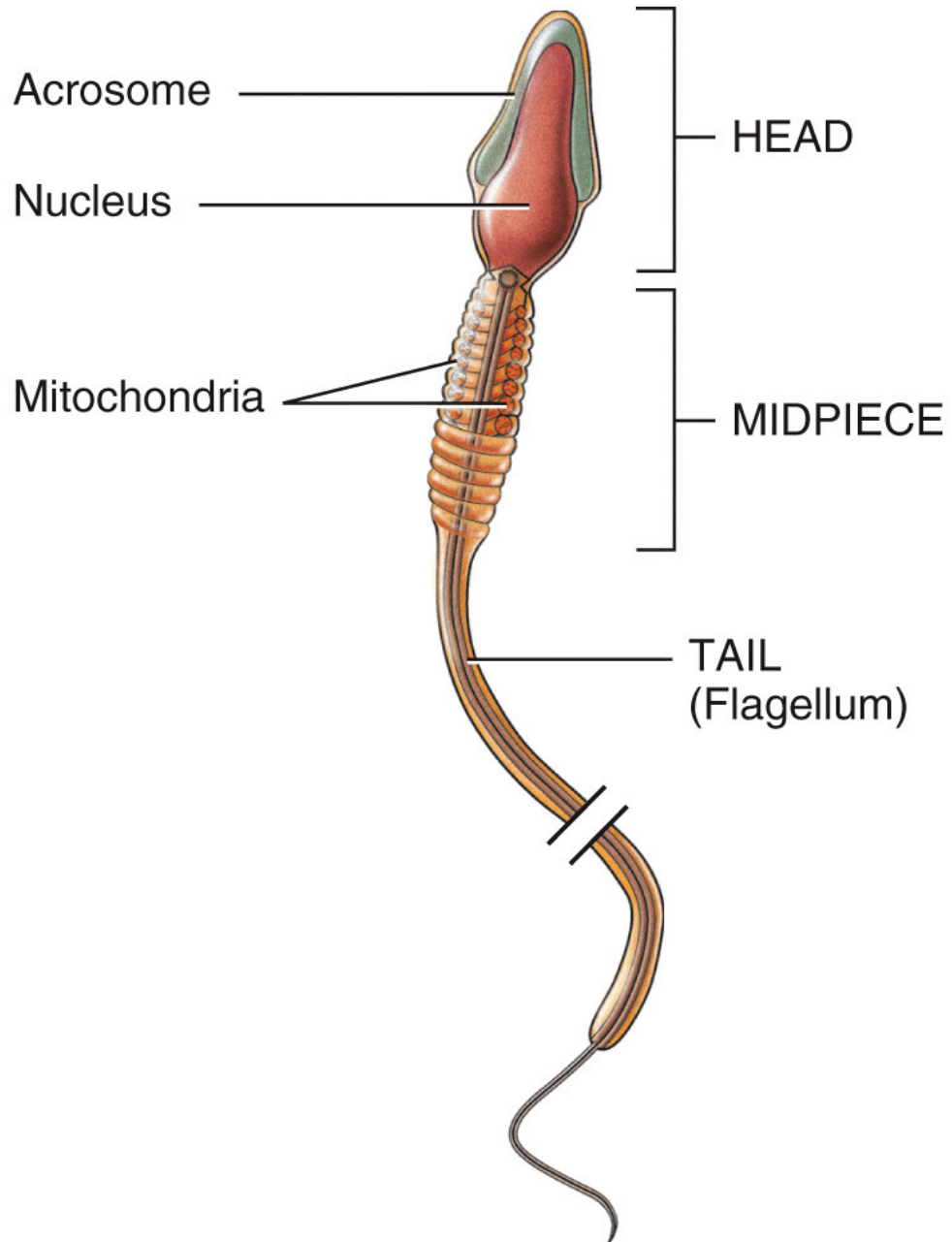
Penis

- Male copulatory organ

Spermatogenesis

- **Spermatogenesis:** beginning at puberty, it is the process by which sperm are produced in the **seminiferous tubules of the testes**
 - **Mitosis:** Spermatogonium differentiates into primary spermatocytes
 - Spermatogonia are the stem cells adjacent to the basement membrane. These cells remain dormant during childhood and actively begin producing sperm at puberty.
 - (1) spermatogonium gives rise to (4) spermatids
 - **Meiosis I:** Primary spermatocyte forms two haploid secondary spermatocytes
 - **Meiosis II:** The two secondary spermatocytes form four haploid spermatids
 - **Spermatogonia ($2n$) → primary spermatocyte ($2n$) → secondary spermatocyte (n) → spermatid (n) → sperm cell/spermatozoon (n)**
- **Spermiogenesis:** final stage of spermatogenesis which involves the maturation of spermatids into sperm
 - Once a sperm is formed, it is released into the lumen of the seminiferous tubule
 - Sperm cell = spermatozoon





Sperm

- **Head**

- Nucleus containing DNA
 - 23 chromosomes
- Acrosome containing digestive enzymes that assist the sperm in penetrating the oocyte cell membrane to bring about fertilization

- **Midpiece**

- Mitochondria that uses fructose secreted from the seminal vesicles to generate energy (ATP) for locomotion

- **Tail**

- Flagellum to propel the cell in a whip-like motion towards an oocyte
- Only flagellum in human body

The Testes

- Within the **seminiferous tubules**, you will find:

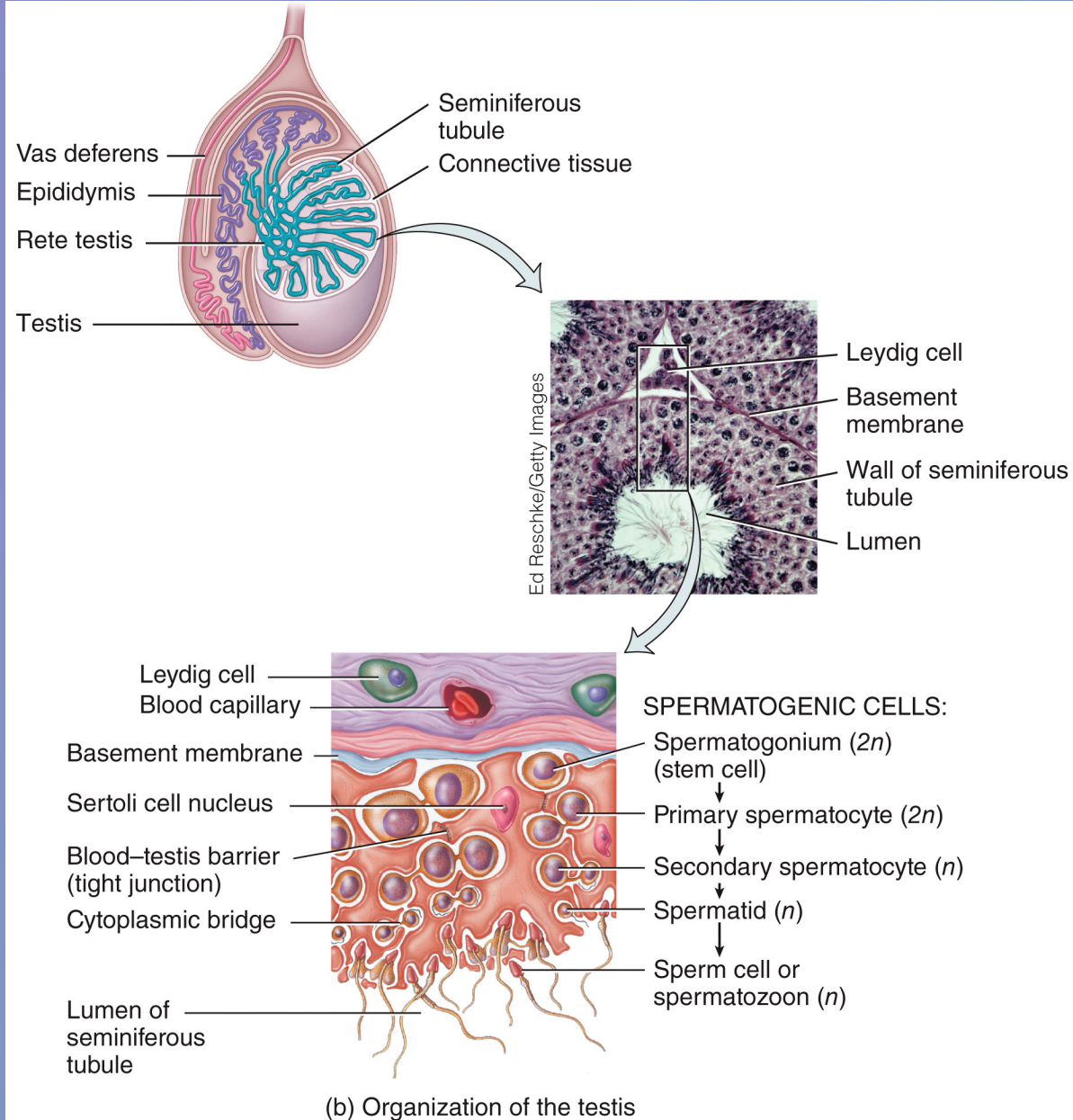
1. Spermatogenic cells

2. Sustentacular cells (Sertoli/Nurse cells)

- Found embedded among the spermatogenic cells; extend from the basement membrane to the lumen of the tubule
- Support, nourish, and protect developing sperm
 - Produce fluid for sperm transport
 - Secrete the hormone inhibin
 - Secrete ABP (androgen-binding protein)
 - Form blood-testis barrier

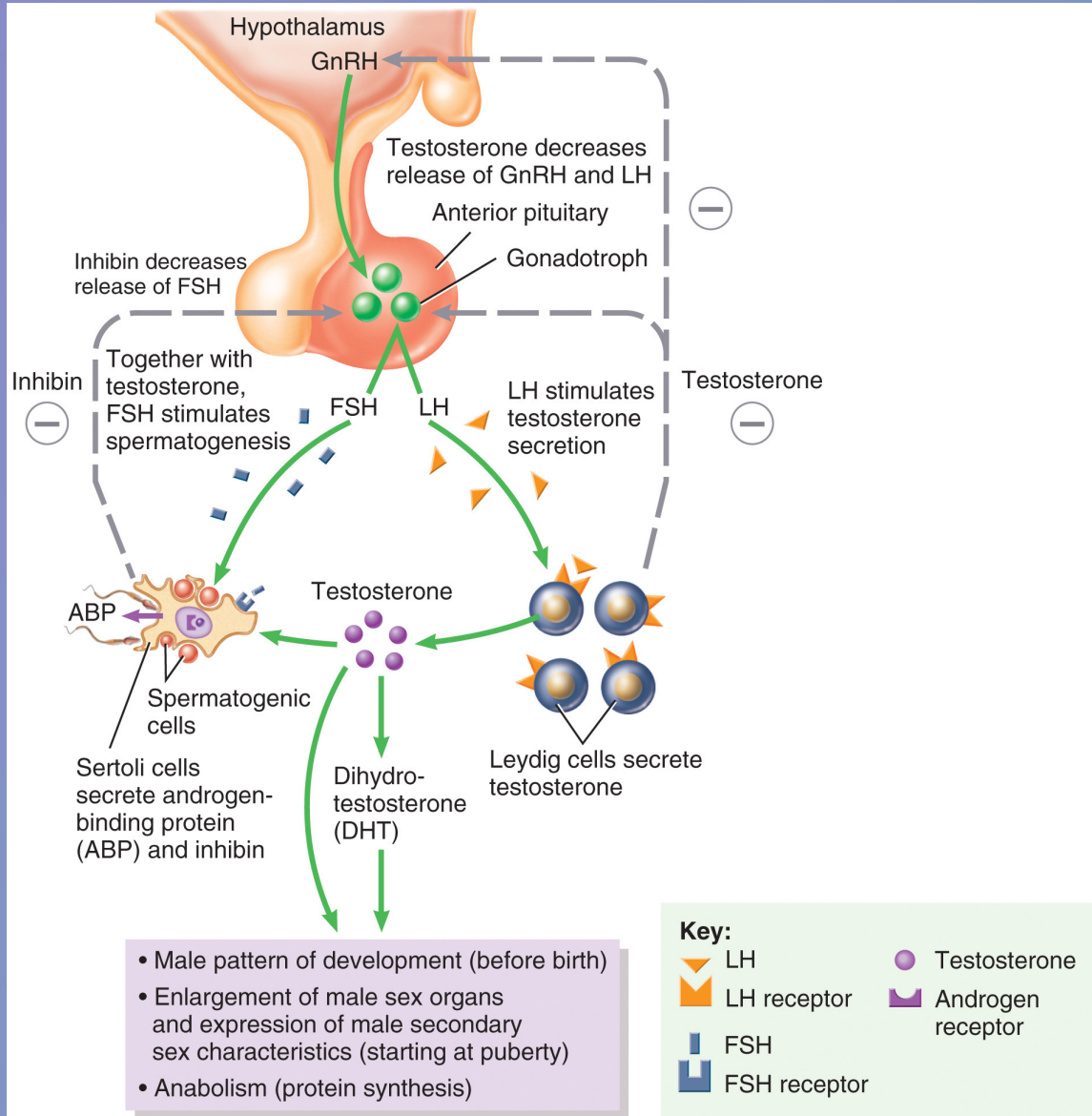
3. Leydig Cells (= interstitial cells)

- Clustered in the interstitial spaces between adjacent seminiferous tubules
- Secrete testosterone



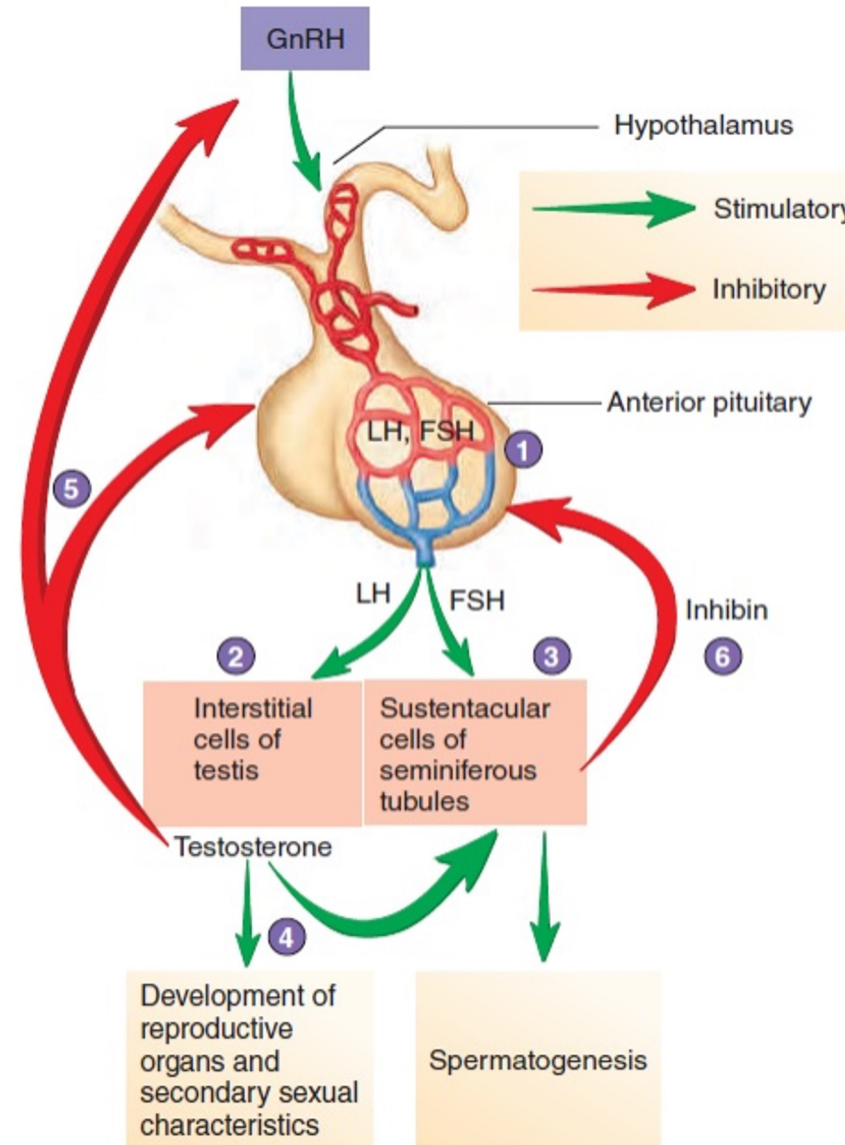
Male Reproductive Hormones

- **Gonadotropin-releasing Hormone (GnRH)**
 - Secreted by the **hypothalamus**
 - Once in the bloodstream, travels to the anterior pituitary to stimulate the secretion of follicle-stimulating hormone (FSH) and luteinizing hormone (LH)
- **FSH and LH**
 - Secreted by the **anterior pituitary gland**; targets the testes
 - **FSH** acts indirectly to stimulate the production of sperm within the seminiferous tubules
 - FSH and testosterone act synergistically on the **sustentacular cells (sertoli/nurse cells)** to stimulate the secretion of **androgen-binding protein (ABP)**. ABP binds to testosterone, keeping its concentration high
 - **LH** stimulates the secretion of testosterone from the **interstitial cells (leydig cells)**
 - Rising testosterone levels exert a negative feedback effect on the **anterior pituitary gland**, inhibiting the release of both FSH and LH
- **Inhibin**
 - Secreted by the Sertoli cells of the testes
 - Decreases the release of FSH

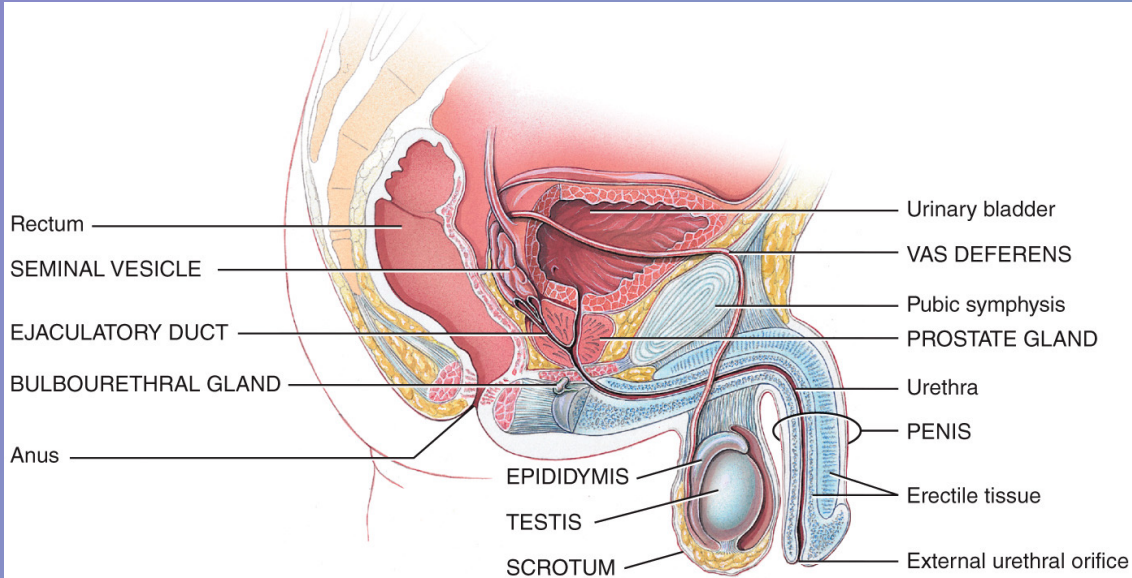


Male Reproductive Hormones Summary

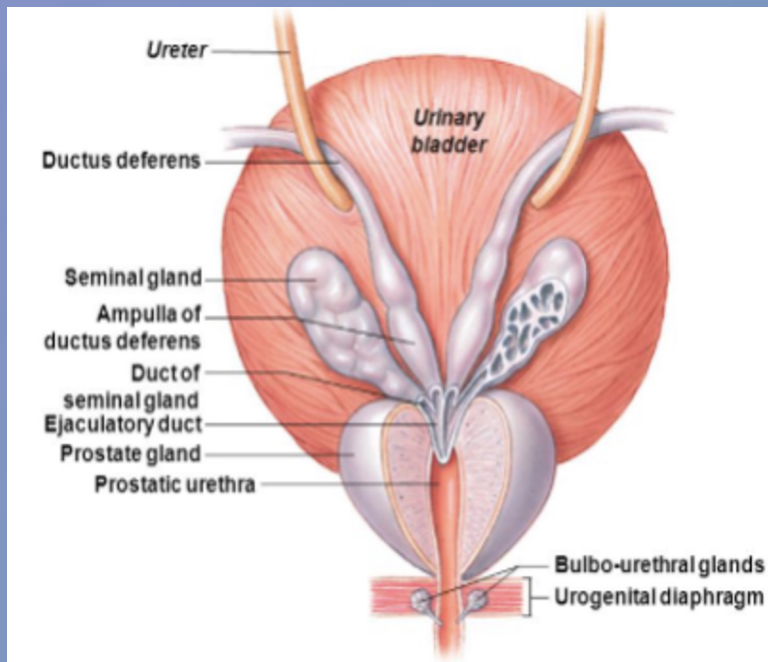
- 1 Gonadotropin-releasing hormone (GnRH) from the hypothalamus stimulates the secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the anterior pituitary.
- 2 LH stimulates testosterone secretion from the interstitial cells.
- 3 FSH stimulates sustentacular cells of the seminiferous tubules to increase spermatogenesis and to secrete inhibin.
- 4 Testosterone has a stimulatory effect on the sustentacular cells of the seminiferous tubules, as well as on the development of reproductive organs and secondary sexual characteristics.
- 5 Testosterone has a negative-feedback effect on the hypothalamus and pituitary to reduce GnRH, LH, and FSH secretion.
- 6 Inhibin has a negative-feedback effect on the anterior pituitary to reduce FSH secretion.



Male Accessory Glands

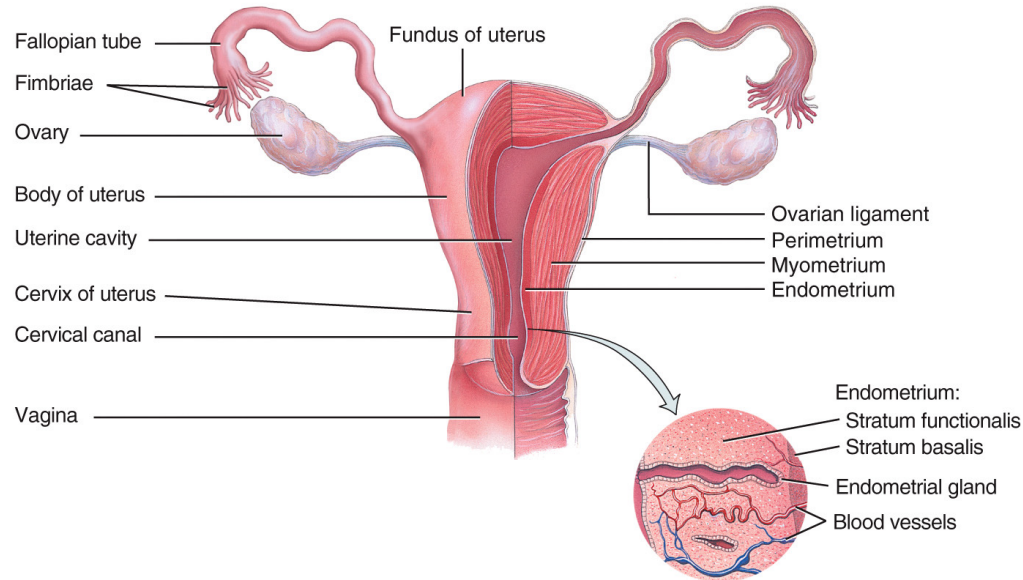
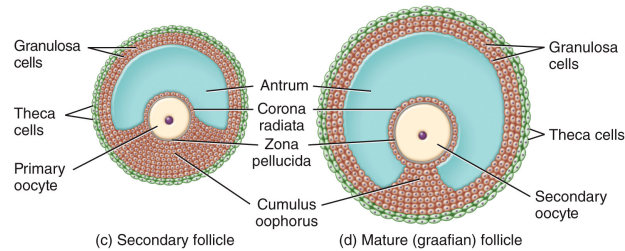
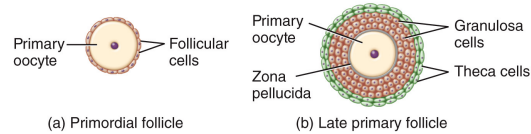
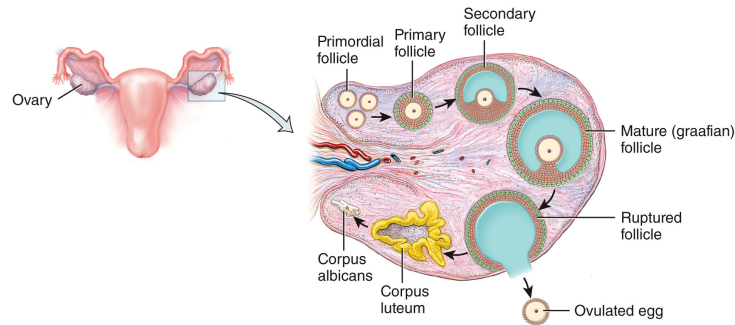


(a) Male organs of reproduction and surrounding structures



- **Seminal Vesicles:** Produces ~60-70% of seminal fluid
 - Paired structures located behind the urinary bladder and in front of the rectum
 - Secretes an alkaline, viscous fluid that contains **fructose** (monosaccharide sugar used for ATP production by the midpiece of sperm), **prostaglandins** (stimulates smooth muscle contractions within the female reproductive tract), and the **clotting protein fibrinogen** (helps semen coagulate after ejaculation).
- **Prostate gland:** Produces ~25% semen
 - Located below the urinary bladder and surrounds the upper portion of the urethra
 - Secretes a milky, slightly acidic secretion that plays a role in activating the sperm, contributing to sperm motility and viability
 - **Citric acid** (used by sperm for ATP production via the Krebs cycle), **clotting enzymes** (act on fibrinogen from the seminal vesicles to clot semen after ejaculation), **proteolytic enzymes** (such as prostate-specific antigen [PSA] that liquifies semen), **seminalplasmin** (antibiotic)
- **Bulbourethral glands:** Produces ~5% semen
 - Pea-sized structures located below the prostate gland on either side of the urethra
 - Produces a clear, alkaline mucous pre-ejaculate fluid that lubricates the tip of the penis and urethra, neutralizes acidity from urine, and creates a sperm-friendly environment, protecting the sperm and reducing the risk of damage during ejaculation

Female Reproductive Anatomy



(b) Relationship of the fallopian tubes to ovaries, uterus, and associated structures

Ovaries

- Produce oocytes (eggs)
- Secrete the hormones estrogen, progesterone, inhibin, and relaxin

Fallopian/Uterine Tubes

- Transport an oocyte from the ovary to the uterus
 - Fimbriae, cilia, and peristaltic contractions
- Successful fertilization typically occurs here within the ampulla region

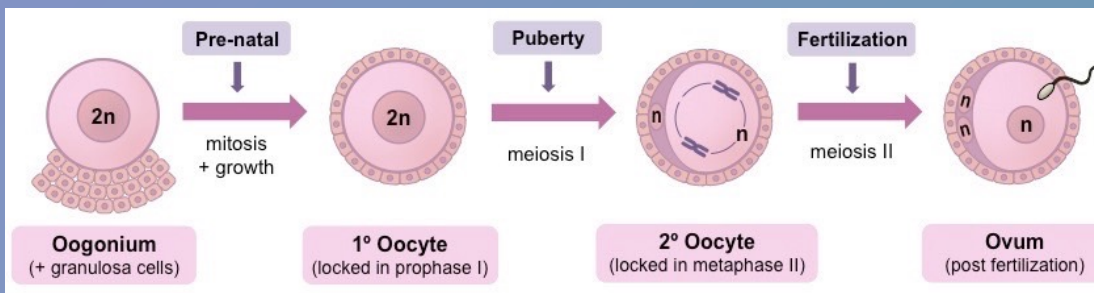
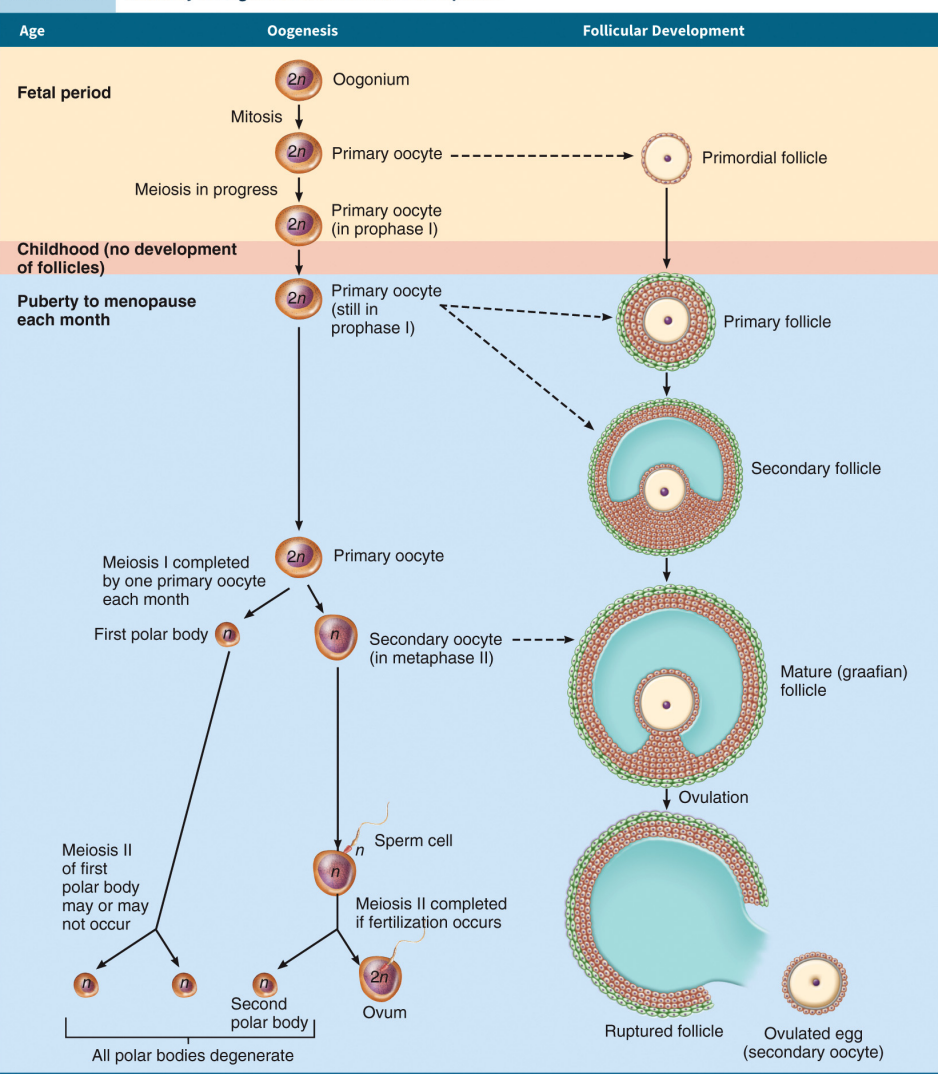
Uterus

- Site of implantation of a fertilized egg, the development of the fetus during pregnancy, and the contractions that push the fetus out of a woman's body during childbirth
- Implantation of a fertilized egg occurs within the endometrium. Exceptions in the case of ectopic pregnancy.
- Composed of 3 layers, namely the endometrium, myometrium, and perimetrium

Vagina

- Female copulatory organ
- Outlet for menstrual flow and birth canal
- Acidic pH (<4.5)

TABLE 23.1 Summary of Oogenesis and Follicular Development



Oogenesis

Oogenesis: process by which female gametes (oocytes) are produced

Before birth:

- All the oogonia a woman will ever have are formed.
 - Oogonia ($2n$)** are stem cells that divide via **mitosis** to produce million of germ cells
 - Many of these germ cells degenerate but others develop into primary oocytes
 - These **primary oocytes ($2n$)** begin to undergo **meiosis I** but are arrested at **prophase I** until puberty

At Puberty:

- Each month until menopause, several primordial follicles start to mature in response to FSH; one dominates (usually) and becomes the Graafian follicle
 - exception: fraternal twins, triplets, etc.
 - other secondary follicles regress and become atretic (a type of apoptosis)
- The **primary oocyte ($2n$)** completes **meiosis I** to form a secondary oocyte and polar body
- The **secondary oocyte (n)** begins meiosis II, but is arrested at **metaphase II**
 - The secondary oocyte is ovulated from the Graafian follicle and will only complete meiosis II to form a mature ovum if fertilization occurs

The Ovarian Cycle

❖ Follicular Phase

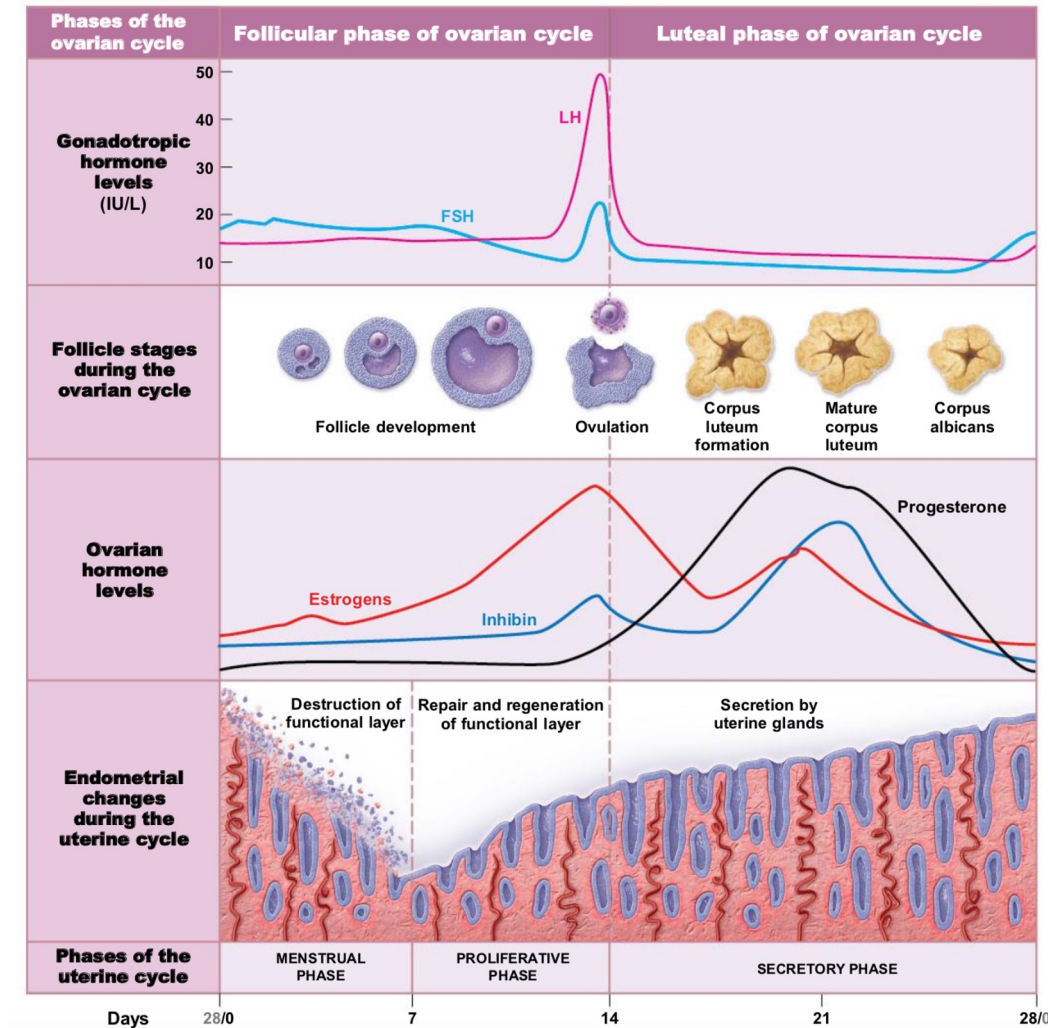
- Initiated by FSH
- Primary follicles -> Secondary follicles -> Graafian follicle
- Growing follicle produces increasing levels of estrogen

❖ Ovulation

- Graafian follicle bulges out of ovarian wall
- Positive feedback by estrogen on LH causes LH surge
 - LH surge determines the timing of ovulation
- LH stimulates the rupture of the Graafian follicle, leading to the release of the secondary oocyte (ovulation) into the pelvic cavity. The fimbriae pick up this egg, and it will reach the endometrium of the uterus after passing through the fallopian tubes

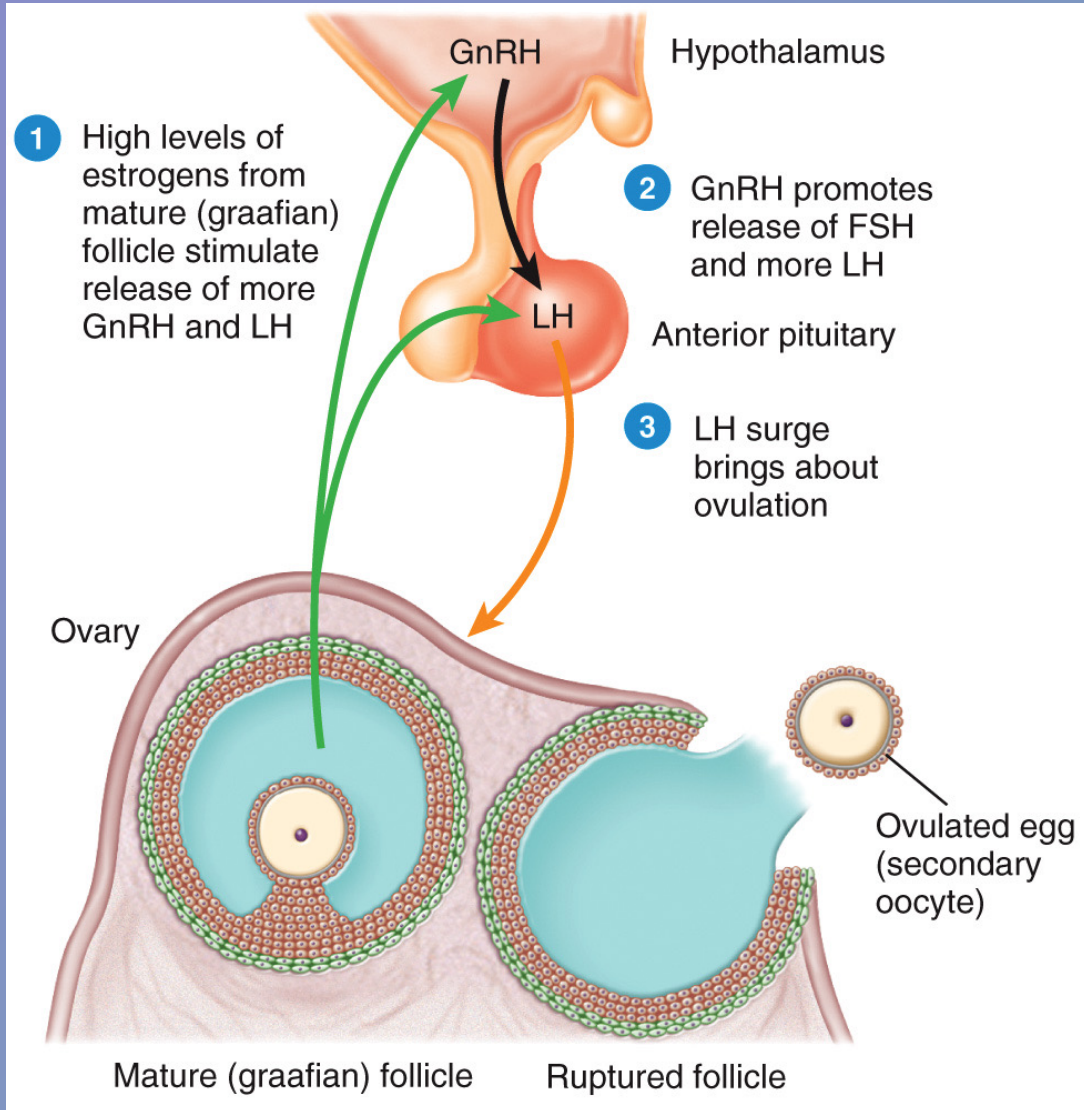
❖ Luteal Phase

- LH stimulates the ruptured follicle to become a corpus luteum
- The corpus luteum secretes estrogen and progesterone, which inhibit FSH and LH secretion from the anterior pituitary, and inhibin, which inhibits FSH
- If fertilization does not occur, the corpus luteum degenerates into the corpus albicans (scar tissue)
 - Causes estrogen, progesterone, and inhibin levels to fall allowing the cycle to repeat

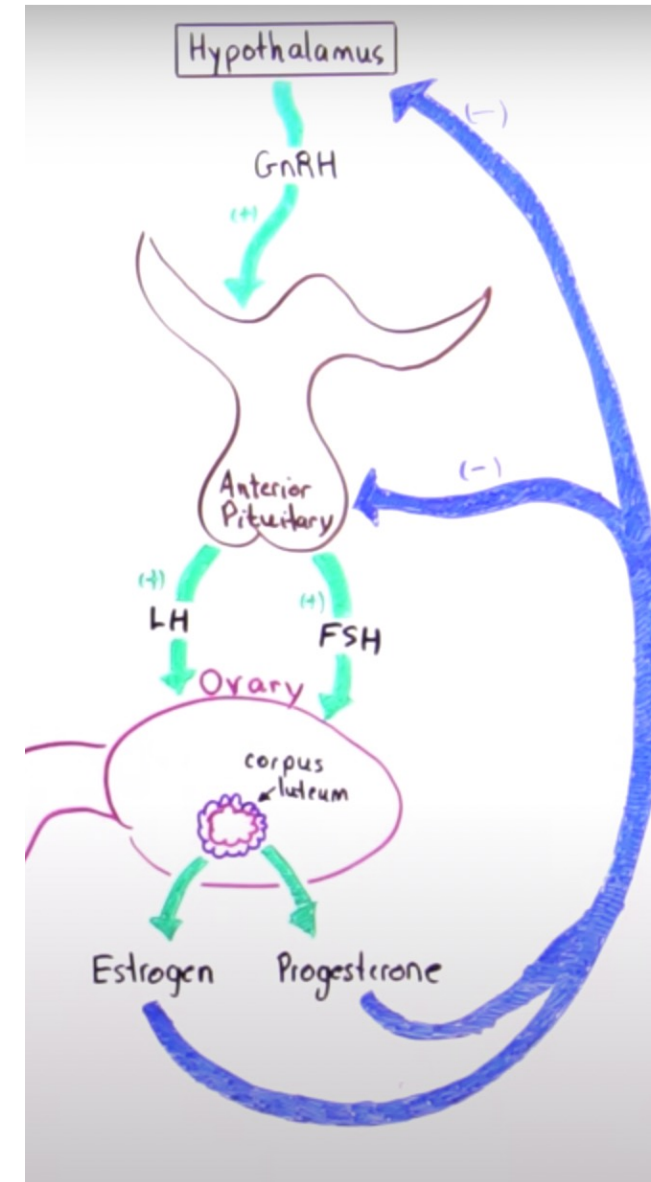


Helpful video: <https://youtu.be/X-d5fE-pAME>

Positive Feedback Allows Ovulation to Occur



After Ovulation



The Uterine Cycle

❖ Menstrual Phase

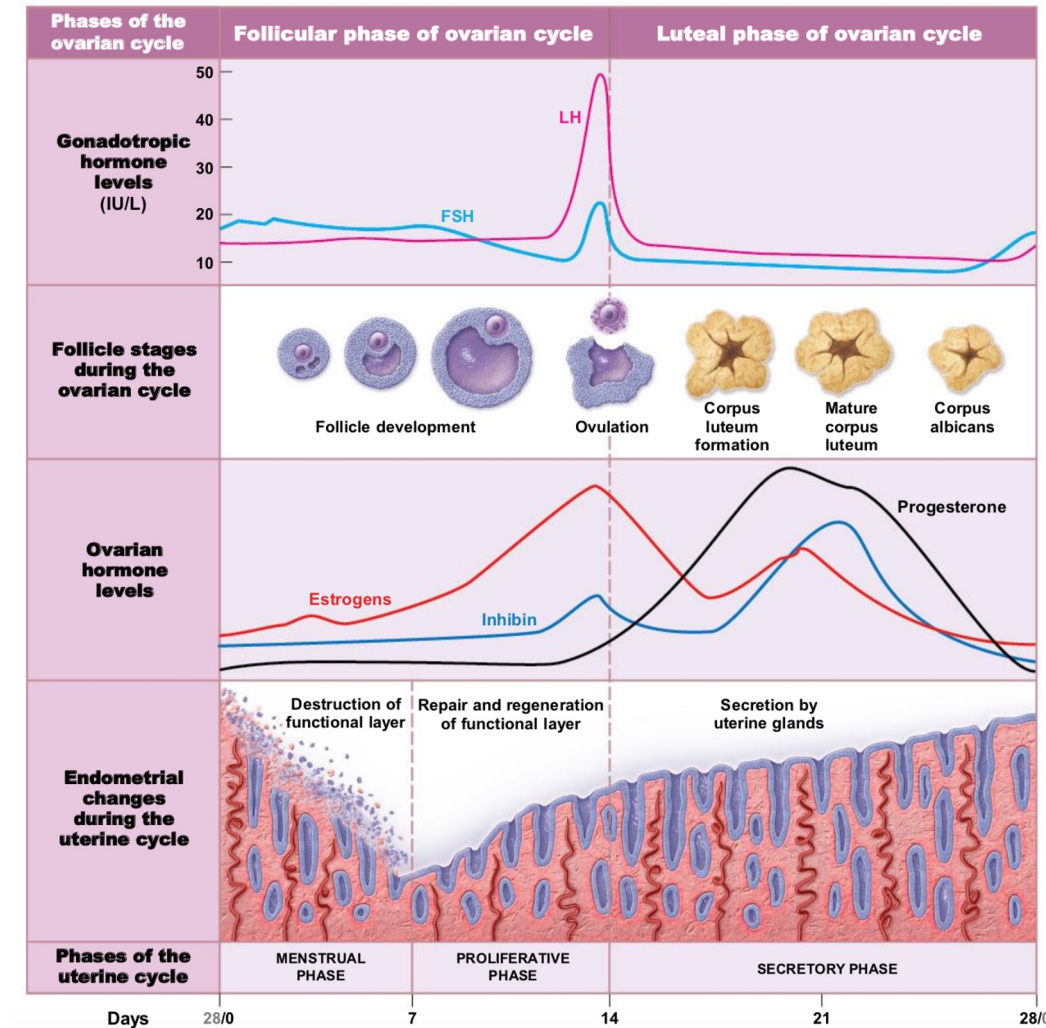
- ❖ Begins due to a decrease in progesterone and estrogen levels
 - ❖ This reduces blood flow to endometrium, causing tissue of the functional layer to die and be discharged as menstruation
 - ❖ Can last from 2 to 7 days

❖ Proliferative Phase

- ❖ Increased estrogen stimulates the thickening of the endometrial lining, creating a new functional layer and allowing it to rebuild
- ❖ Prepares the body for the implantation of a fertilized egg

❖ Secretory Phase

- ❖ Progesterone and estrogen secretion by the corpus luteum continues to stimulate endometrial growth and secretion
- ❖ The functional layer of the uterus is now ready for a fertilized egg to implant...if fertilization does not occur, the decline of progesterone and estrogen triggers the shedding of the endometrium leading to menstruation



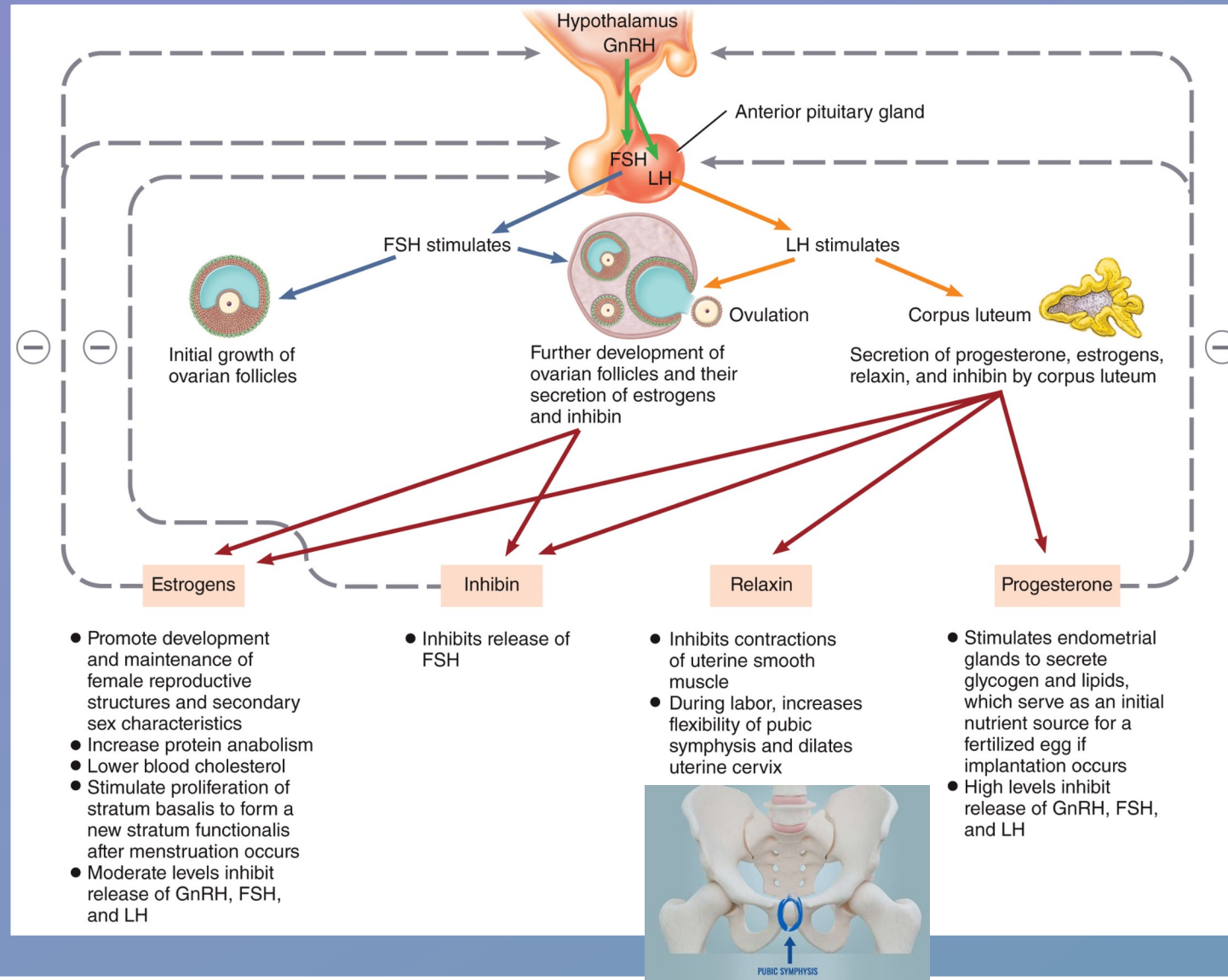
FEMALE HORMONES – Part One

HORMONE	FUNCTION	SECRETED FROM
Gonadotrophin Releasing Hormone (GnRH)	Responsible for stimulating the release of FSH and LH from the anterior pituitary gland.	Hypothalamus
FSH	Stimulates follicular growth.	Anterior Pituitary
LH	Determines the time of ovulation (therefore the hormone tested in ovulation test kits); Stimulates the formation of corpus luteum.	Anterior Pituitary
Estrogen	Promotes the development and maintenance of female reproductive structures and secondary female characteristics, in addition, it helps to build strong bones; Estrogen thickens the uterine lining, preparing the uterus for pregnancy if fertilization occurs.	Follicle & Corpus Luteum
Progesterone	Prepares and maintains the endometrium of the uterus to receive a fertilized egg	Corpus Luteum

FEMALE HORMONES – Part Two

HORMONE	FUNCTION	SECRETED FROM
Inhibin	Inhibits the secretion of FSH after ovulation	Follicle & Corpus luteum
Relaxin	At low levels, relaxin relaxes the uterus by inhibiting contractions of the myometrium; At high levels, relaxin increases the flexibility of the pubic symphysis and helps dilate the uterine cervix at the end of pregnancy	Corpus luteum & Placenta
Prolactin	Stimulates milk production (lactation) in the mammary glands	Anterior Pituitary
Oxytocin	Stimulates uterine contractions during labor, and milk let-down during breastfeeding	Produced → Hypothalamus; Secreted → Posterior Pituitary
hCG (Human Chorionic Gonadotropin)	Maintains the corpus luteum until the placenta can take over secreting progesterone. As a result of this increased production, hCG accumulates in the maternal bloodstream and is excreted in the urine. Thus, pregnancy tests measure this hormone.	Conceptus (embryo) Placenta

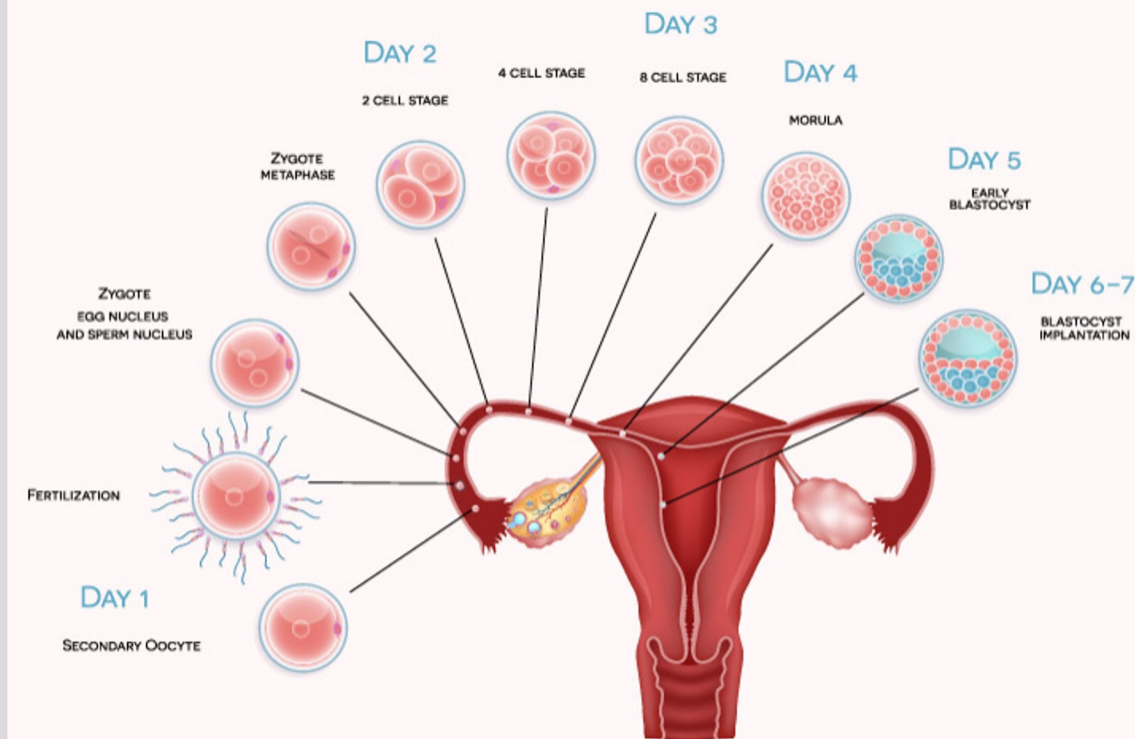
HORMONES OF THE FEMALE REPRODUCTIVE SYSTEM

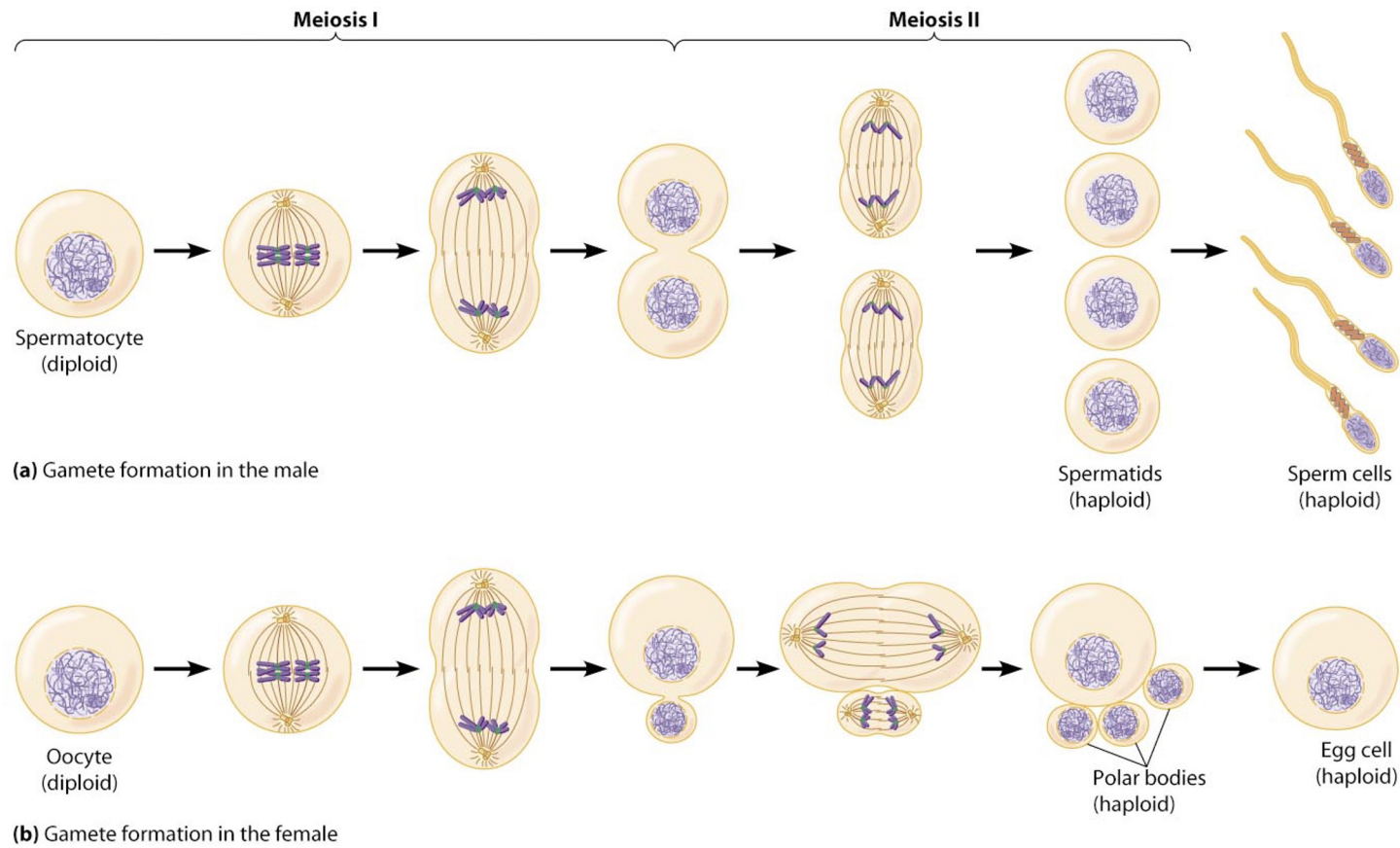


*Note that estrogen can have negative or positive feedback. Positive feedback is responsible for the LH surge that occurs prior to ovulation.

FERTILIZATION

- ❖ Once the egg is fertilized, the secondary oocyte completes Meiosis II and becomes a mature ovum.
- ❖ The female and male nuclei fuse to restore the diploid chromosome number (46), and the fertilized ovum is now called a **zygote**.
 - Dizygotic (fraternal) twins are produced from the release of two secondary oocytes and the fertilization of each by different sperm.
 - Monozygotic (identical) twins develop from a single fertilized ovum that splits into two embryos, which in 99% of the cases occurs before 8 days have passed.
 - ❏ Separations that occur later than 8 days are likely to produce **conjoined twins**
- ❖ The zygote undergoes cleavage (rapid mitotic cells divisions) and eventually implants in the endometrium ~7 days after fertilization.

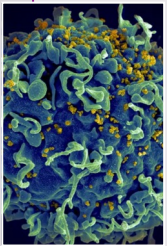




Each round of spermatogenesis produces 4 sperm while each round of oogenesis produces 1 egg

Copyright © 2009 Pearson Education, Inc.

SPERMATOGENESIS VS. OOGENESIS



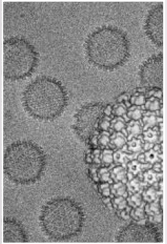
The virus that attacks the body's immune system, specifically the CD4 cells, is known as the _____ and it eventually leads to _____, a condition in which the infected person has a CD4 cell count less than 200 cells/mm³.



STD, also known as “the clap,” caused by bacteria; the clap is a euphemism for _____ because of the theory that men with this STD would slap both hands forcefully on both sides of their genitalia to expel pus and cure the infection.



This common STD is caused by an infection with a protozoan parasite with the species name of vaginalis and is called _____.



This disease is caused by HSV and causes itching, patching, ulcers, and scabs in the genitalia. _____



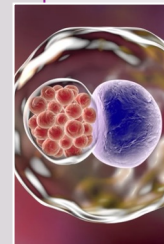
Humans infected by the bacteria *Treponema pallidum* suffer from symptoms that consist of small PAINLESS ulcers on the genitals or around mouth area, this infection is known as _____.



This disease can be transmitted via skin-to-skin contact or by sexual exposure but in women it has been shown to cause cervical cancer. _____



When a patient who is sick comes after contracting this STD, they have symptoms of yellowing eyes, abdominal pain, and dark urine. This patient has some scarring in their liver. They have _____.



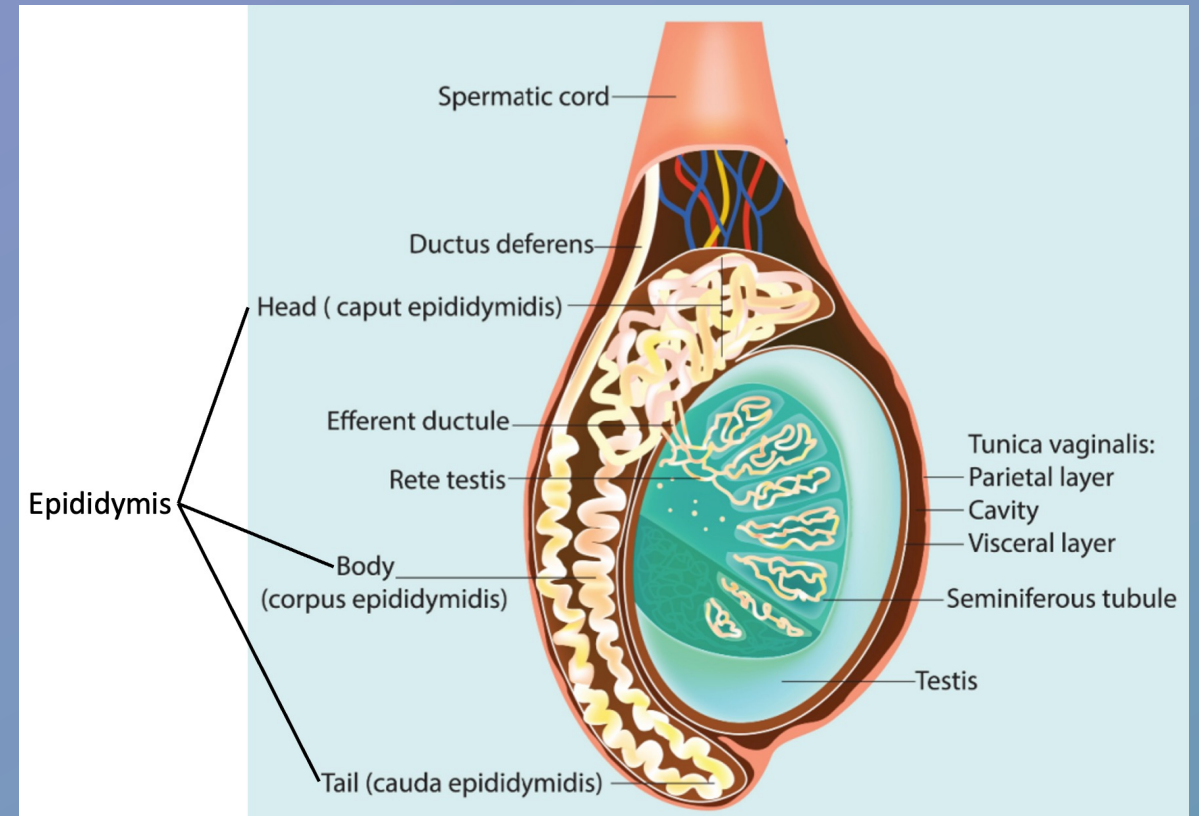
This STI primarily manifests as urethritis in men and endocervicitis in females; this bacterial species is known as *trachomatis*; this disease is known as _____.

Which STDs/STIs can be cured? Three bacterial STIs (chlamydia, gonorrhea and syphilis) and one parasitic STI (trichomoniasis) are generally curable with single-dose regimens of antibiotics.

SEXUALLY-TRANSMITTED INFECTIONS/DISEASES

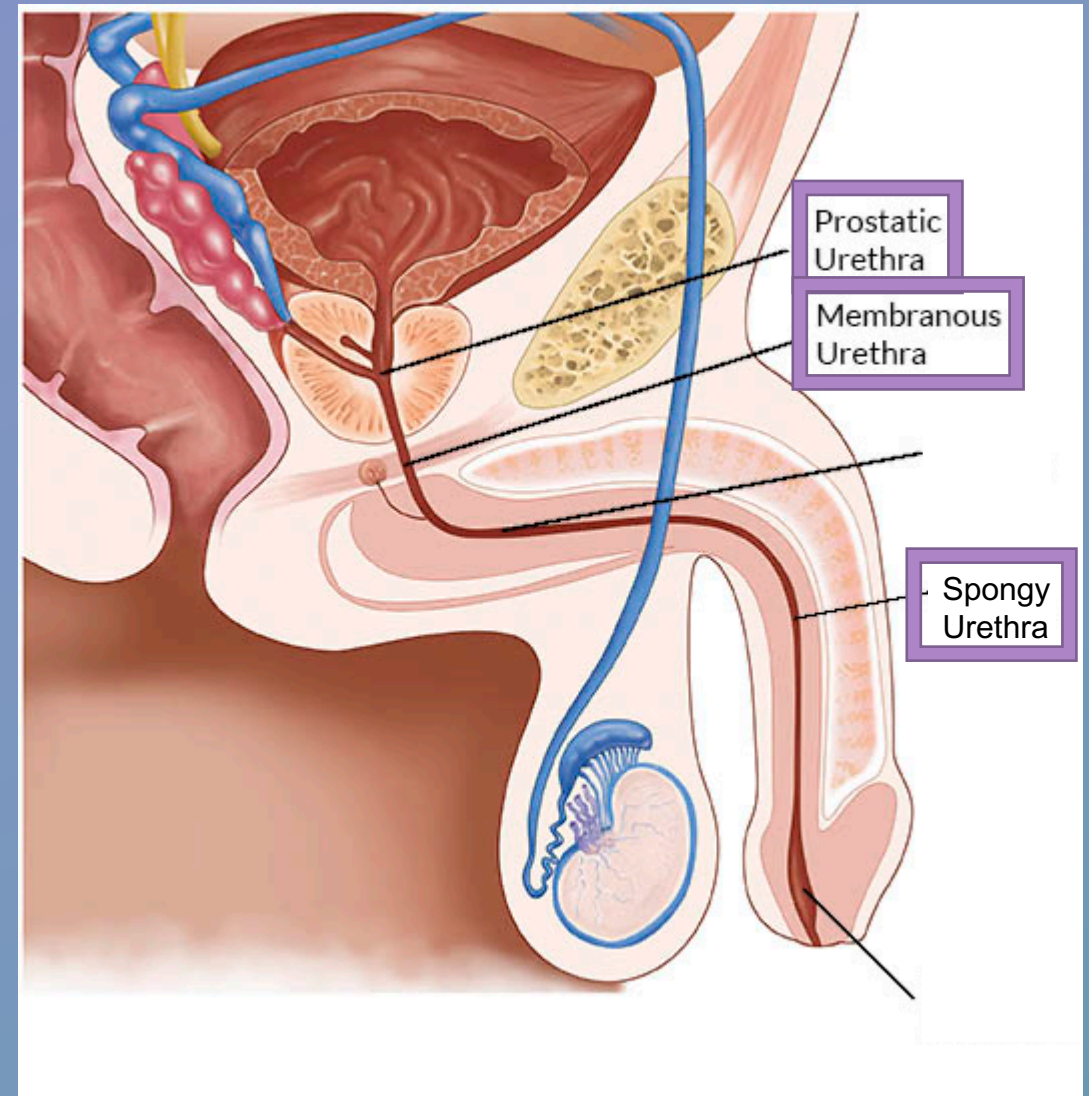
Matching Word Bank: AIDS, Chlamydia, Hepatitis B, HIV, HPV, Gonorrhea, Genital Herpes, Syphilis, Trichomoniasis.

BULL TESTICLE DISSECTION



THE MALE URETHRA

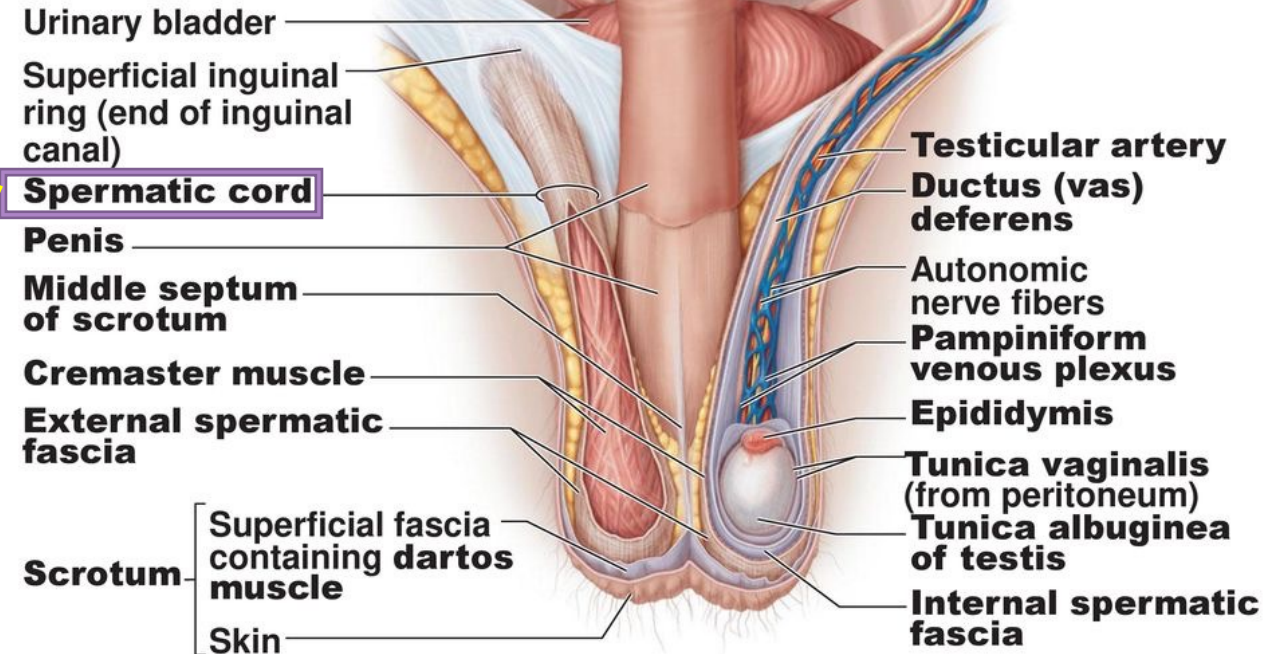
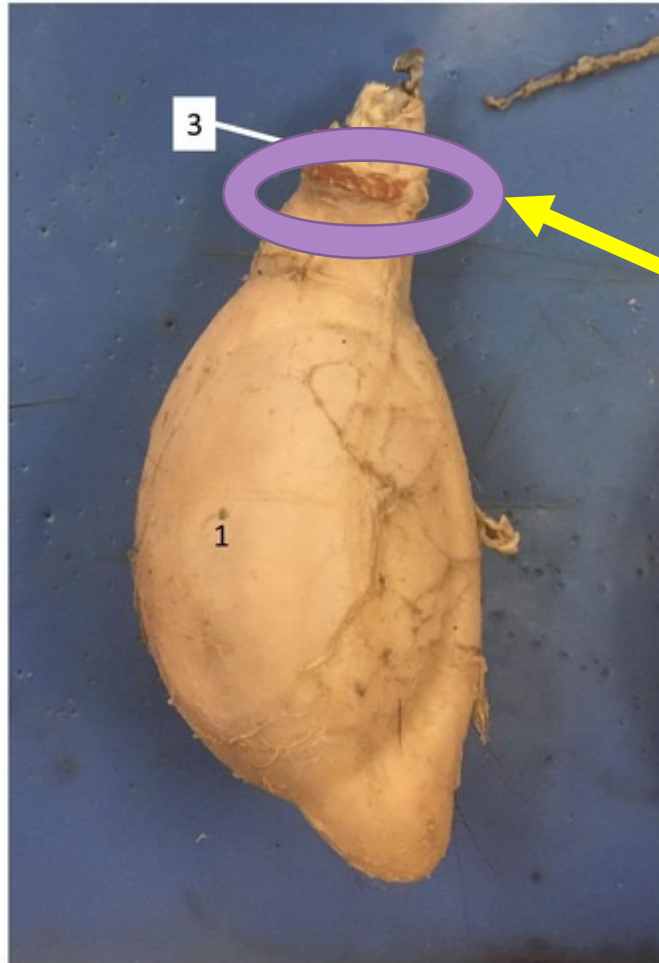
- The male urethra is subdivided to form the **prostatic urethra**, **membranous urethra**, and the **spongy urethra**
- The male urethra allows the passage of both urine & sperm



The Spermatic Cord

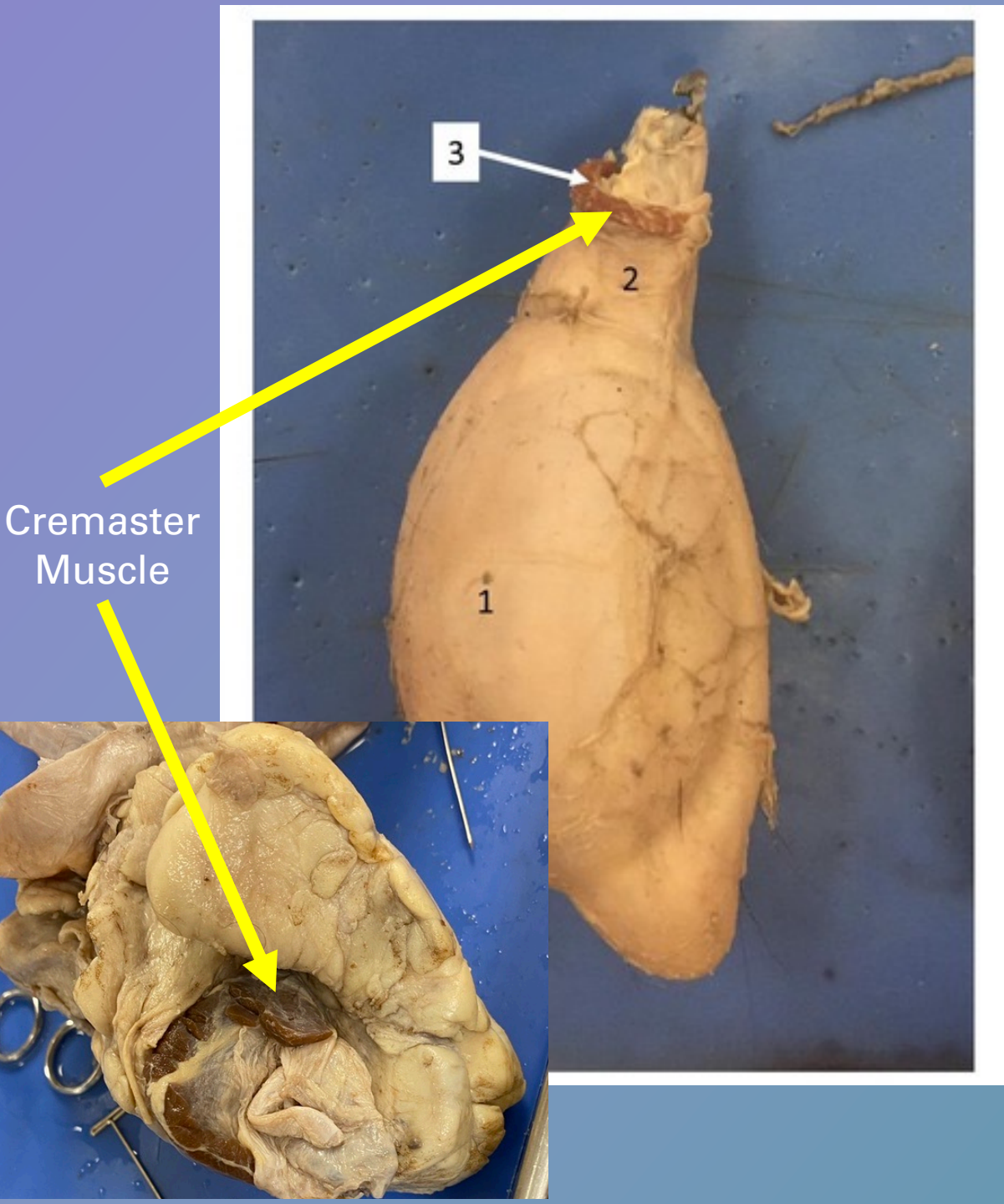
The spermatic cord consists of the ductus deferens, cremaster muscle, blood vessels (deferential artery, testicular artery, pampiniform plexus of the testicular vein), lymphatic vessels and autonomic nerves.

***Underlined structures above were discussed during class, and you are required to know.**



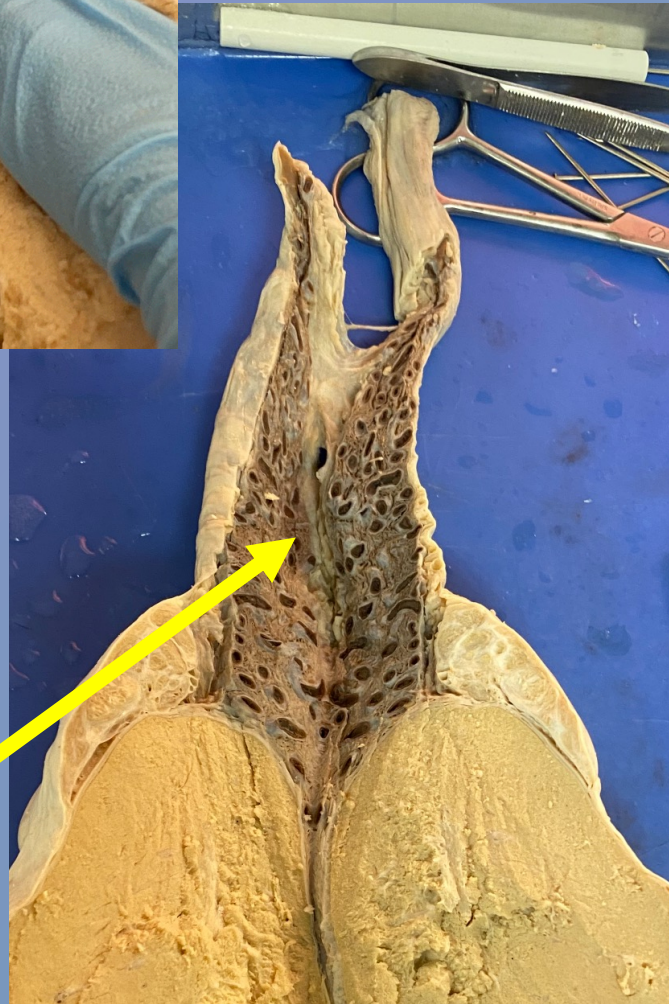
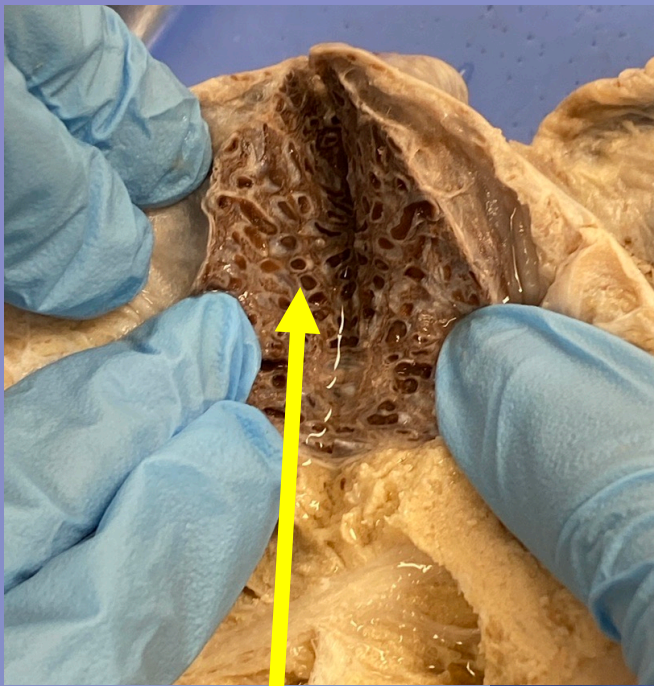
Cremaster Muscle

- The cremaster muscle is a paired structure made of thin layers of striated and smooth muscle
- Functions to regulate the temperature of the testes
 - Contracts when it is cold outside, bringing the testes closer to the body, which facilitates the absorption of body heat
- This muscle can be found in the spermatic cord

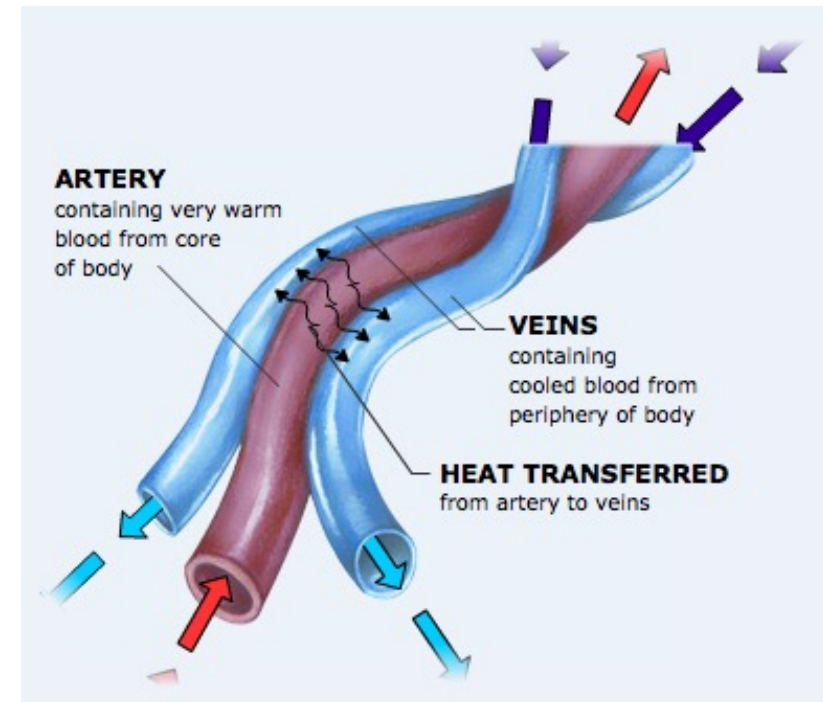


Pampiniform Plexus

- Network of many small veins found in the spermatic cord
- Eventually gives rise to the testicular veins, aiding in venous return from the testes
- Acts as a heat exchanger by cooling blood from the adjacent testicular artery
- Enlargement of the pampiniform plexus is called varicocele



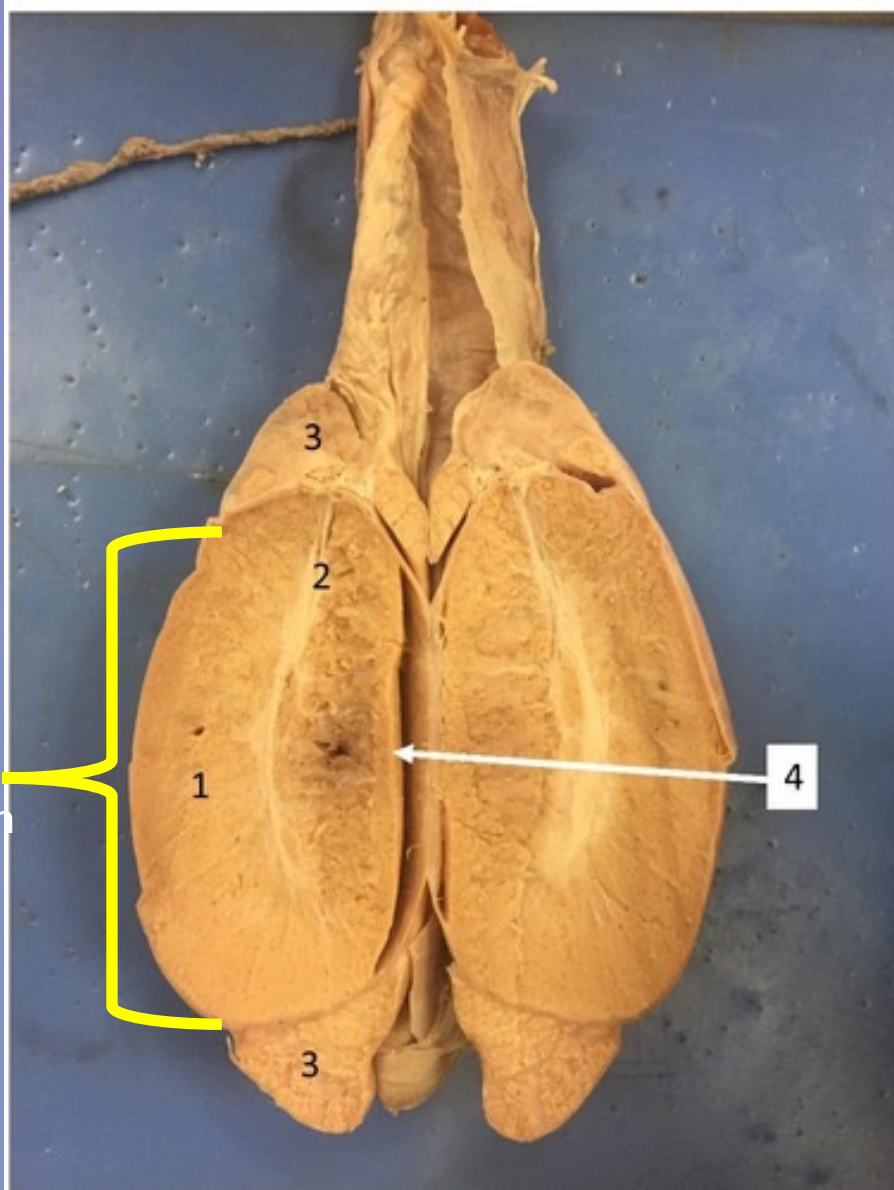
Blood Vessels of the Spermatic Cord



Seminiferous Tubules

- Narrow, microscopic coiled tubules that produce sperm in the **testes**
- Seminiferous tubules interconnect with each other forming the **rete testis** within the mediastinum. The rete testis connects to the **efferent ductules**. These efferent ductules lead to the epididymis

Seminiferous
Tubules Within
Testis



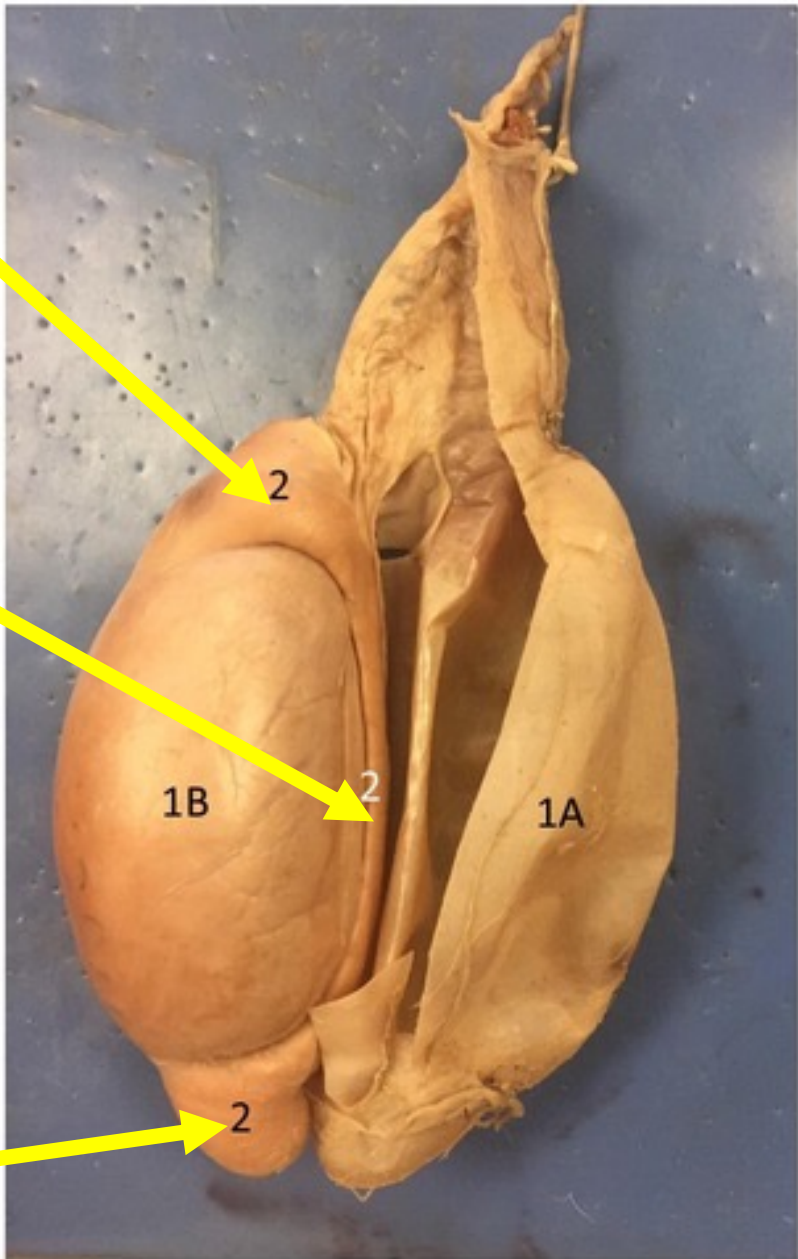
Epididymis

- A long, coiled duct on the outside of the testis in which sperm mature.
- **Be able to identify the head, body and tail.**
 - **Head:** receives spermatozoa via the efferent ductules and sends to the body. Closer in proximity to the spermatic cord (in comparison to the tail).
 - **Body:** receives sperm from head and sends to the tail.
 - **Tail:** receives sperm from body and sends to the vas deferens.

Head

Body

Tail



Vas Deferens/Ductus Deferens

- Conveys sperm from the epididymis to the urethra via peristaltic contractions
- Found posteriorly to the testis and medial to the epididymis
- The vas deferens is one component of the spermatic cord



Vas Deferens/Ductus Deferens

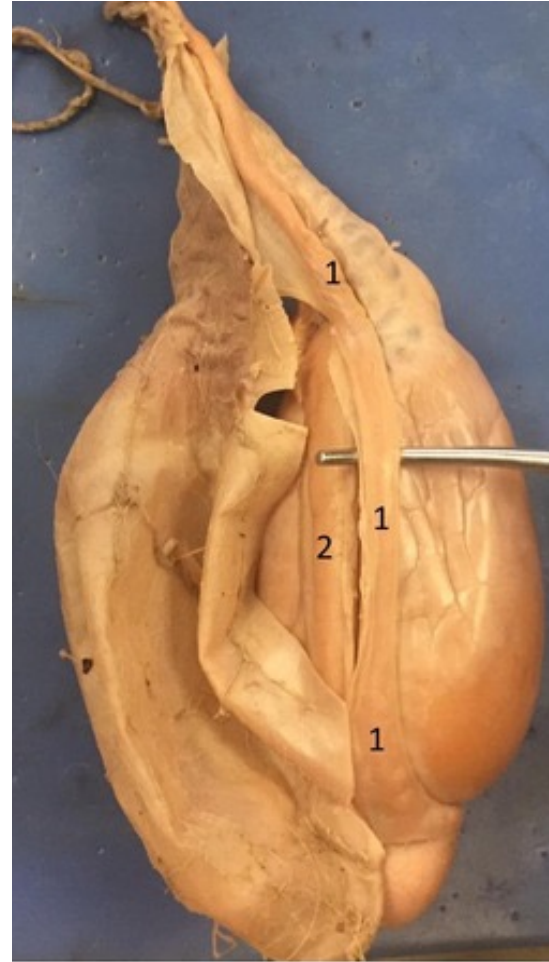
Practice Identifying:



2 = Spermatic Cord
3 = Cremaster Muscle



2 = Epididymis



1 = Vas (ductus) Deferens
2 = Epididymis



1 = Seminiferous Tubules,
3 = Epididymis

Bull Testicle Dissection Protocol Questions

Flow of Sperm: SEVEN UP!

- Seminiferous tubules (testes) → Epididymis → Vas deferens → Ejaculatory Duct → Urethra → Penis

How would damage to the Dartos and Cremaster muscle reduce sperm count?

- The dartos and cremaster muscles are found externally to the testis, and their function is to aid in the thermoregulation necessary to maintain spermatogenesis
- If either or both muscles were to be damaged, then the testis would be exposed to temperatures higher/lower than their optimum and it would inhibit spermatogenesis
- Cremaster Muscle: Transient retraction of the testis out of the scrotum is a normal reflex caused by contraction of the cremaster muscle. This muscle functions to regulate the temperature of the testis and to protect it from extrinsic trauma
 - Contraction tenses the scrotal sac and pulls it closer to the body
 - If it is cold outside the testes move closer to the abdomen to maintain the proper temperature
- Dartos Muscle: The dartos muscle is the scrotal part of the dartos fascia, composed of smooth muscle cells. In the scrotum, the tunica dartos act to regulate the temperature of the testicles, which promotes spermatogenesis. It does this by expanding or contracting to wrinkle the scrotal skin.
 - Superficial smooth muscle
 - The contraction causes the wrinkling of the scrotal surface. This contraction reduces the surface area available for heat loss
- Both the cremaster & the dartos muscles contract if it is too cold outside

