

The Male Reproductive System

Chapter 27

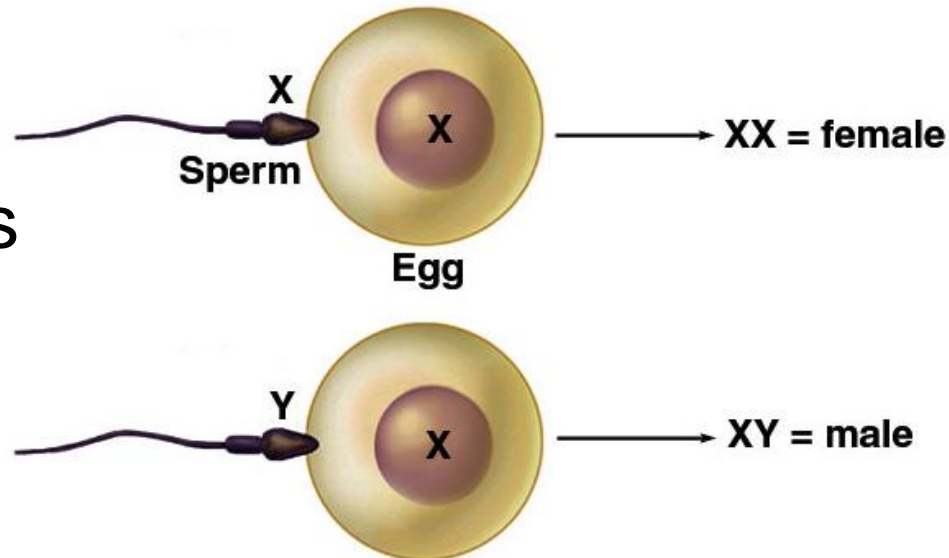
- Sexual reproduction
- Sex determination and development
- Male reproductive anatomy
- Spermatogenesis

Gametes and Sex Chromosomes

- Human cells contain 23 pairs of chromosomes
 - 22 pairs of autosomes
 - 1 pair of sex chromosomes (XY males: XX females)
 - Male gametes are sperm. Males produce 50% Y carrying sperm and 50% X carrying sperm.
 - Female gametes are eggs. Females produce eggs that only carry the X chromosome.

- Sex is determined by the sex chromosome carried by the sperm that fertilizes the egg.

- Fertilized egg is a zygote.



Overview of the Reproductive System

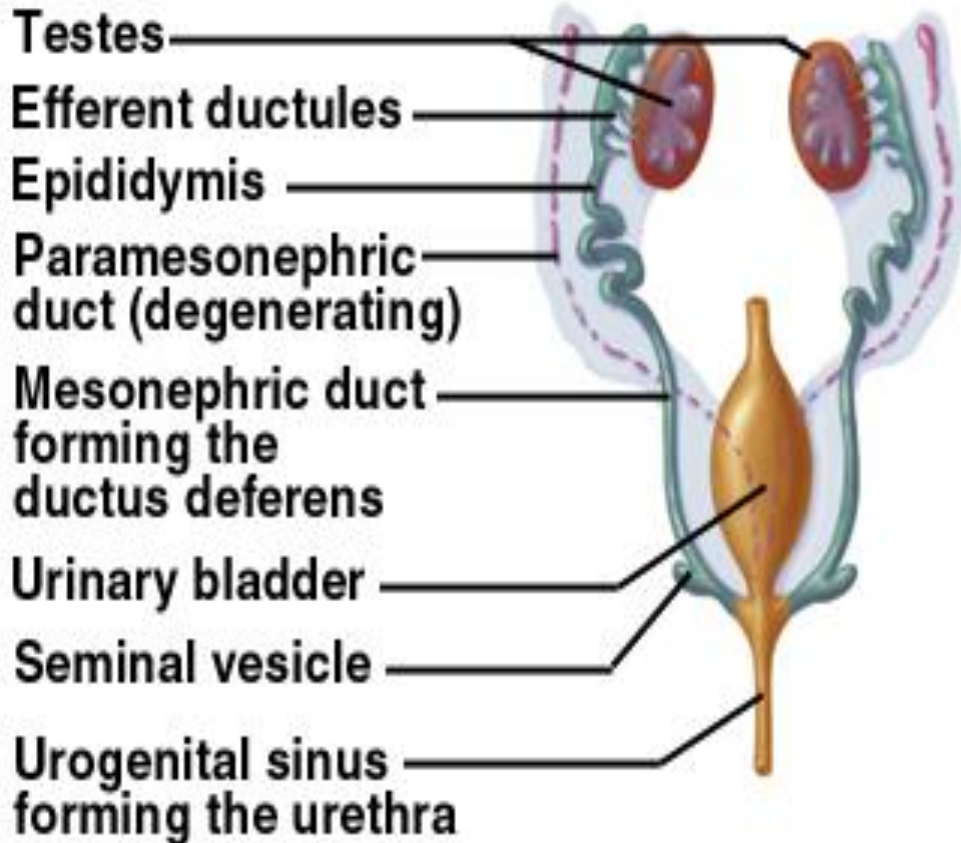
- Primary Sex Organs are the testes and ovaries that produce the gametes.
- Secondary Sex Organs
 - organs that do not produce gametes, but are essential for reproduction
 - male: ducts, accessory glands and penis that conduct the sperm through the male reproductive tract
 - female: uterine tubes, uterus and vagina that transport the egg, receive the sperm and nourish the developing fetus
- Secondary Sex Characteristics
 - features that indicate gender that mature at puberty
 - pubic hair, body morphology and voice pitch

Hormones and Sex Differentiation

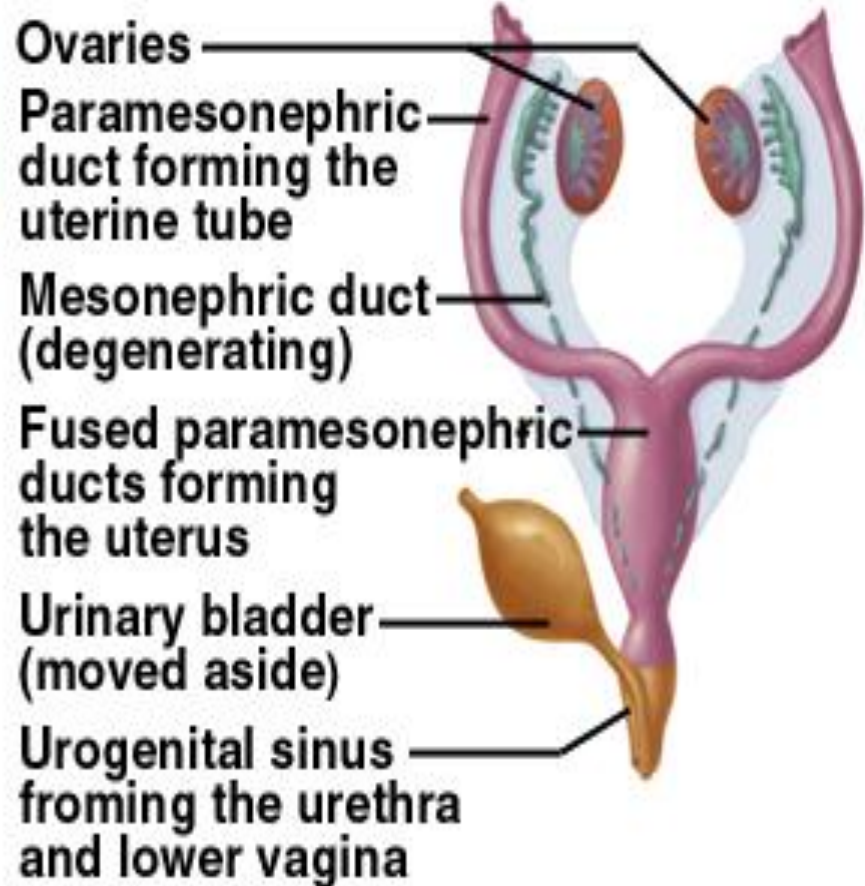
- Gonads begin to develop at 6 weeks from two ridges of gonadal tissues near the developing kidney called the mesonephros.
- 2 sets of ducts exist at that time in the embryo:
 - **mesonephric** duct can develop into **male** reproductive system (paramesonephric ducts degenerate in males)
 - **paramesonephric** ducts (Müllerian ducts) can develop into **female** reproductive tract (mesonephric ducts degenerate in females)
- **SRY** gene (**S**ex-determining **R**egion of the **Y** gene) in males, codes for a protein called the **testis determining factor** that causes development of testes.
 - testes secrete testosterone that directs development of male characteristics
 - testes also secrete müllerian-inhibiting factor that degenerates paramesonephric ducts
- Female development occurs in the absence of male or female hormones – female is the “default” human body plan.

Reproductive System Early Development

Male

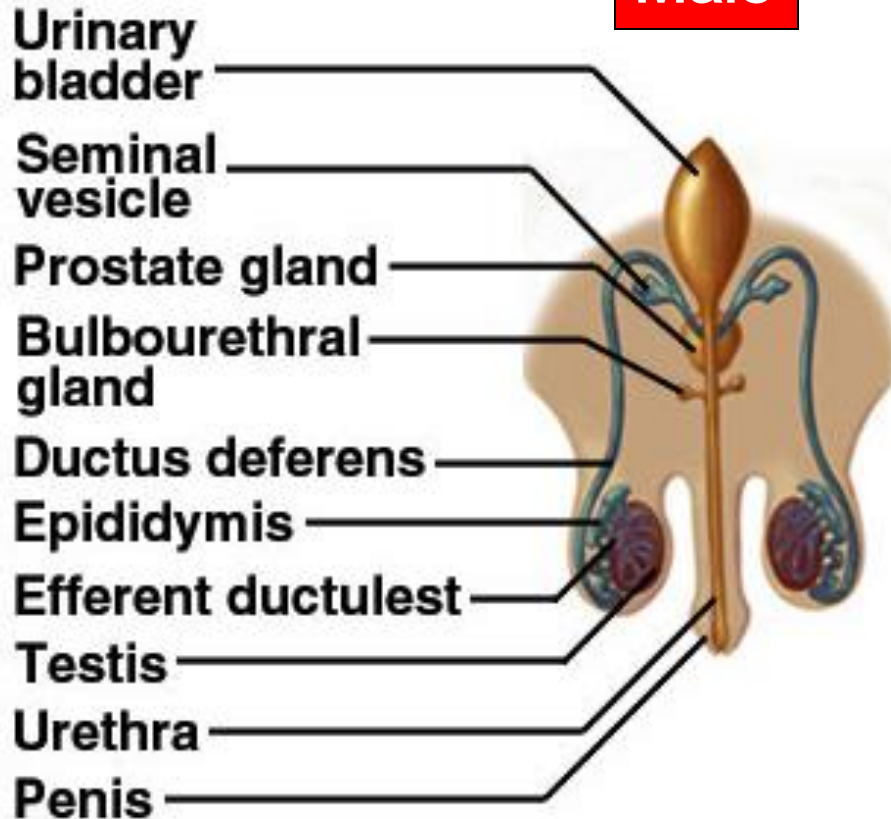


Female

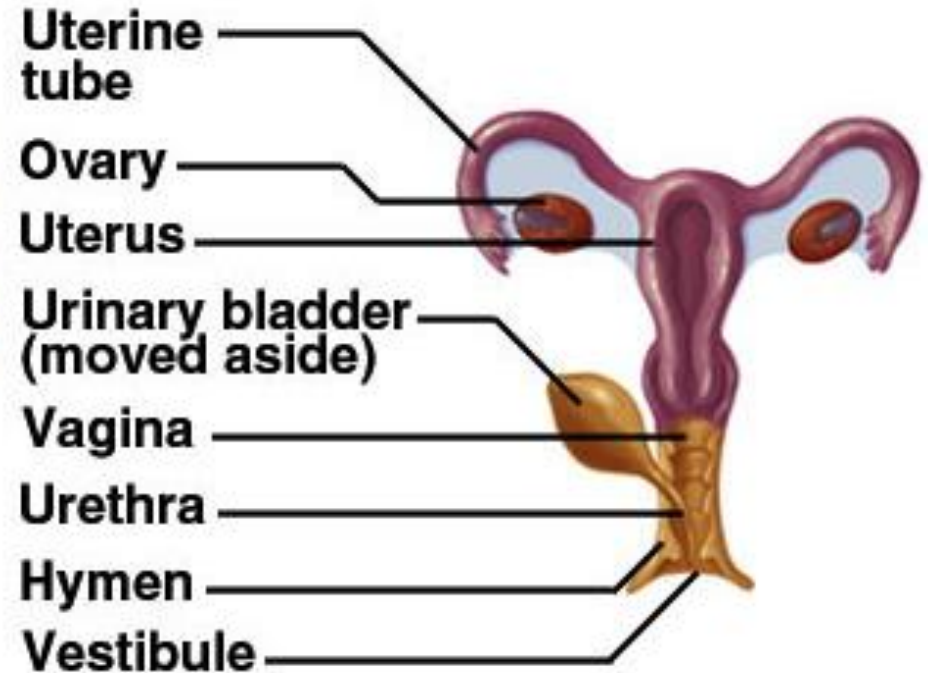


Reproductive System Anatomy at Birth

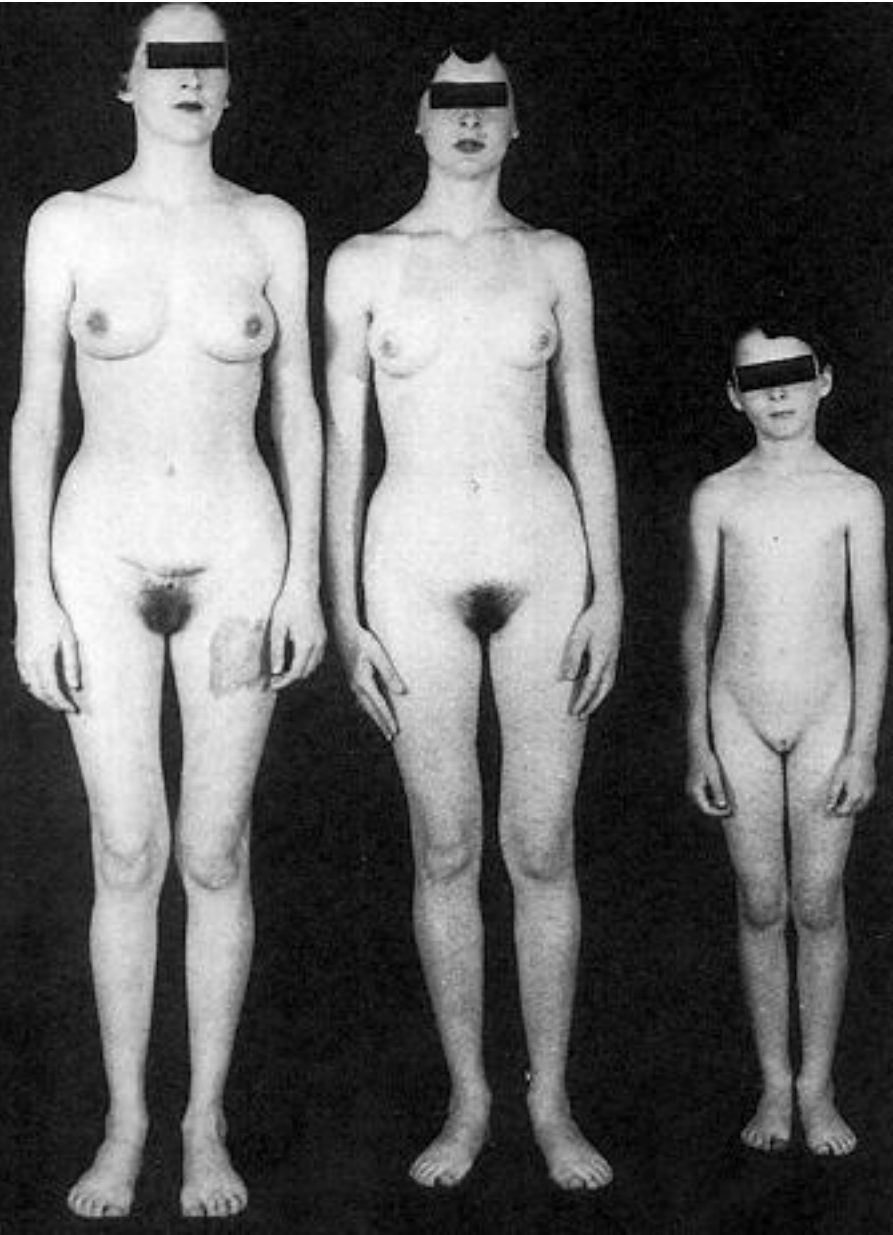
Male



Female

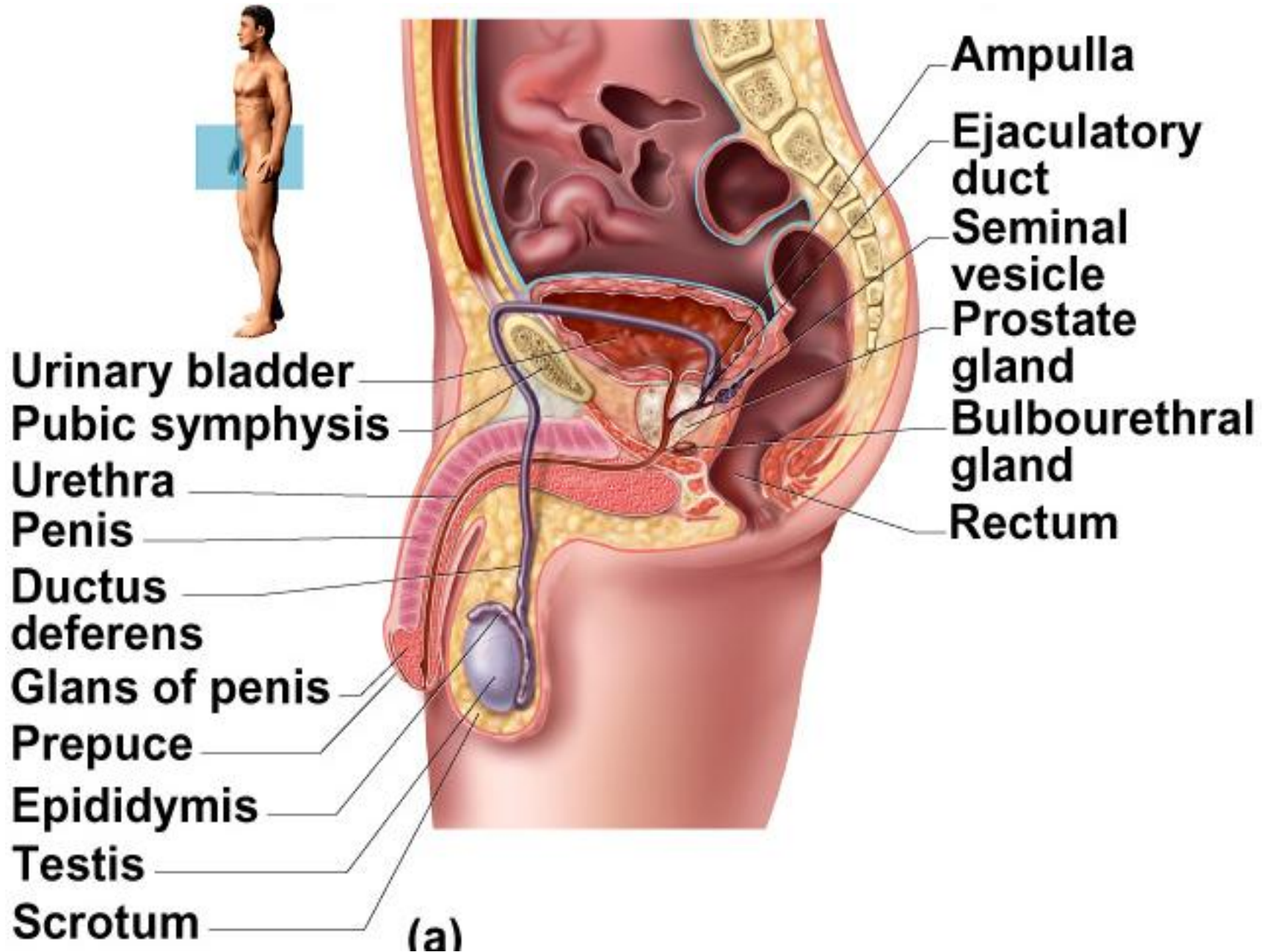


Androgen-Insensitivity Syndrome



- Three genetically male (XY) individuals
- Testes are present in the pelvis that may secrete the same amount of testosterone as a normal male.
- However, somatic cells lack receptors for testosterone.
- No masculinizing effects occur.
- No ovaries or uterus.
- About 100,000 babies are born per year in Arizona.
- Occurs in 1 out of 20,000 births or about 5 per year on average in Phoenix.

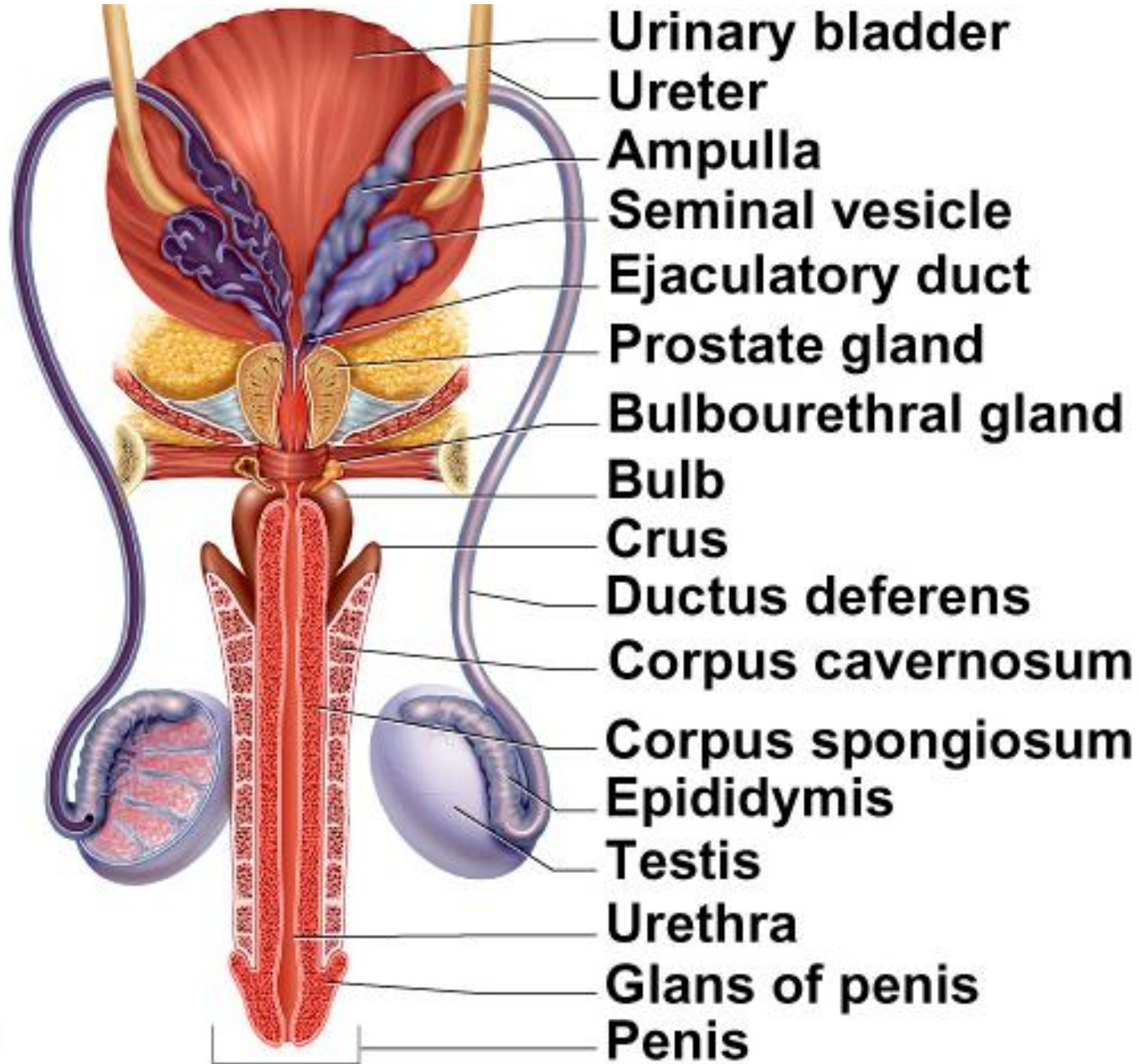
Adult Male Reproductive System



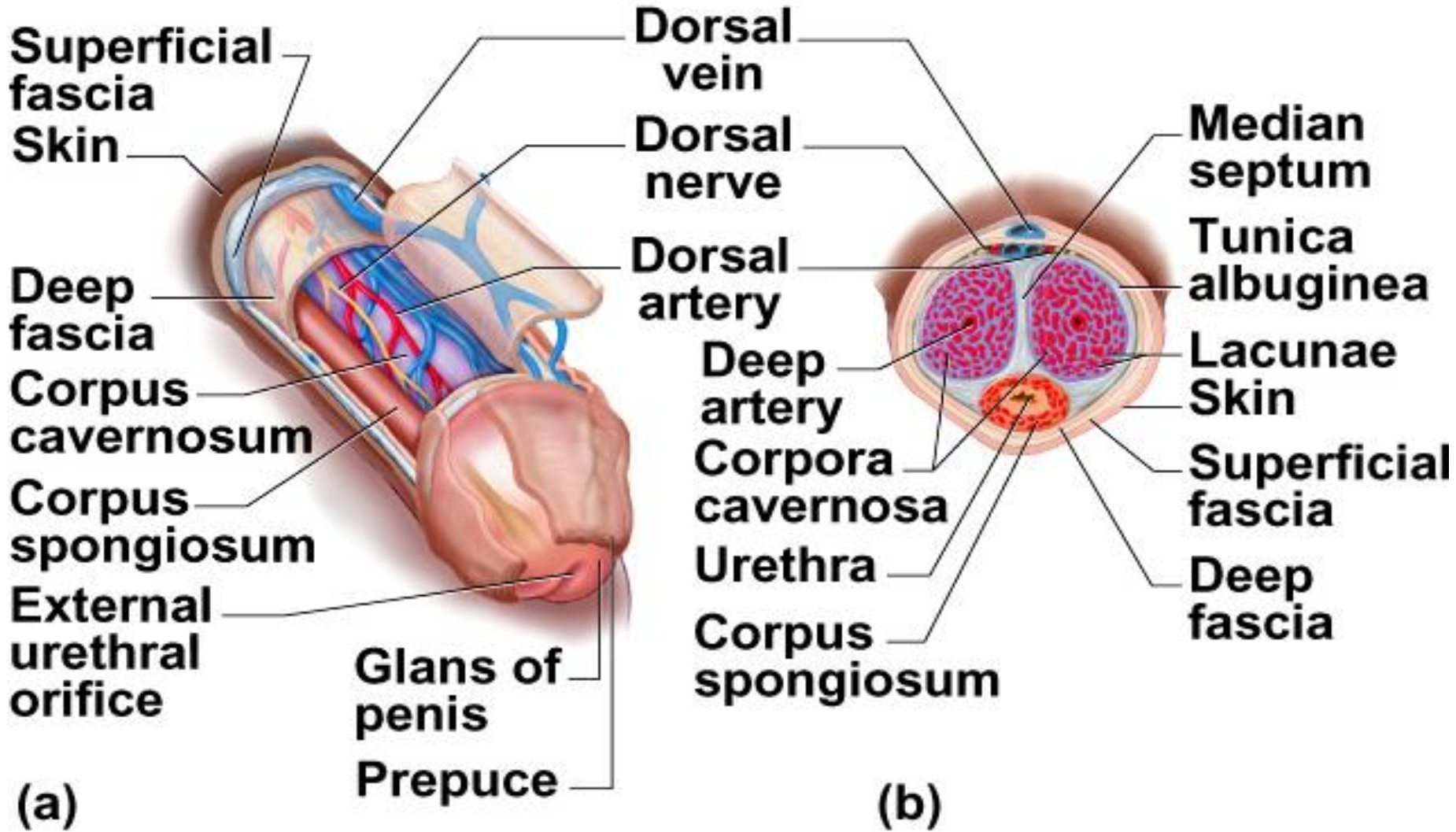
Anatomy of the Penis

- Three cylinders of erectile tissue are covered with connective tissue and loose skin.
- A single corpus spongiosum runs the length of the penis forming a bulb at the base and the glans at the tip. The corpus spongiosum surrounds the penile urethra. There is a corpus cavernosum on either side of the corpus spongiosum.
- Sexual stimulation causes release of nitric oxide from neurons that innervate the smooth muscle around arteries to the erectile tissue. The nitric oxide activates an enzyme that produces cGMP that relaxes the smooth muscle and increases blood flow into the erectile tissue leading to an erection. Another enzyme breaks down the cGMP which reduces blood flow and ends the erection.
- Erectile dysfunction occurs when cGMP is broken down too quickly. Drugs like Viagra, Levitra and Cialis inhibit the enzyme that breaks down cGMP.

Anatomy of the Penis



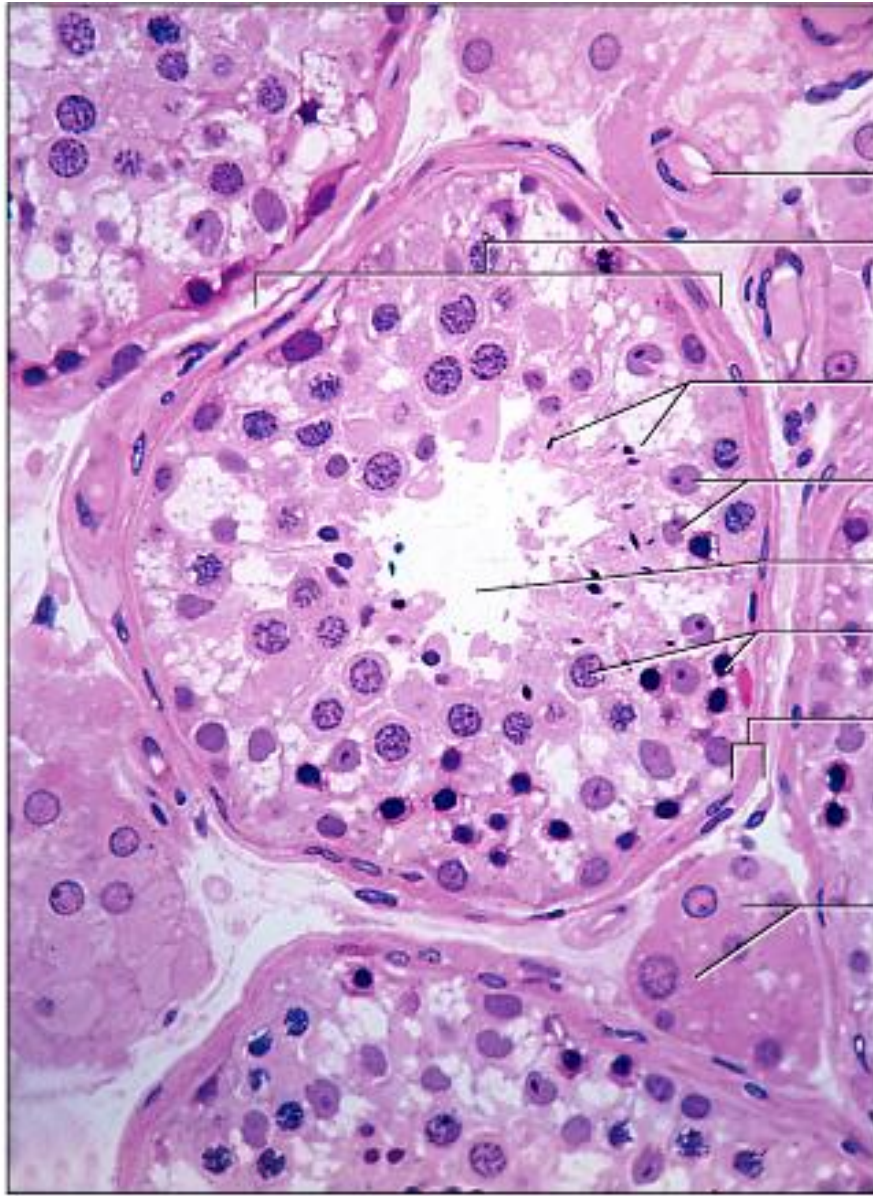
Anatomy of the Penis



Testes

- Testis = singular Testes = plural
- Testes contain millions of **seminiferous tubules** that produce sperm
 - each tubule is lined with a stratified epithelium composed of stem cells and sustentacular cells
- **stem cells** divide and differentiate into sperm cells
 - 300,000 cells per minute or about 400 million per day can be produced
 - normal sperm count is 50 million to 120 million cells/ml semen
 - sperm count below 20-25 million/ml is considered infertile
 - sperm cells account for only about 10% of semen volume
- **Sustentacular (Sertoli) cells** promote sperm cell development and form the blood-testis barrier that separates sperm from the immune system.
- **Interstitial (Leydig) Cells** produce testosterone.

Histology of the Testes



Blood vessel

Seminiferous tubule

Spermatids

Sustentacular cells (Sertoli)

Tubule lumen

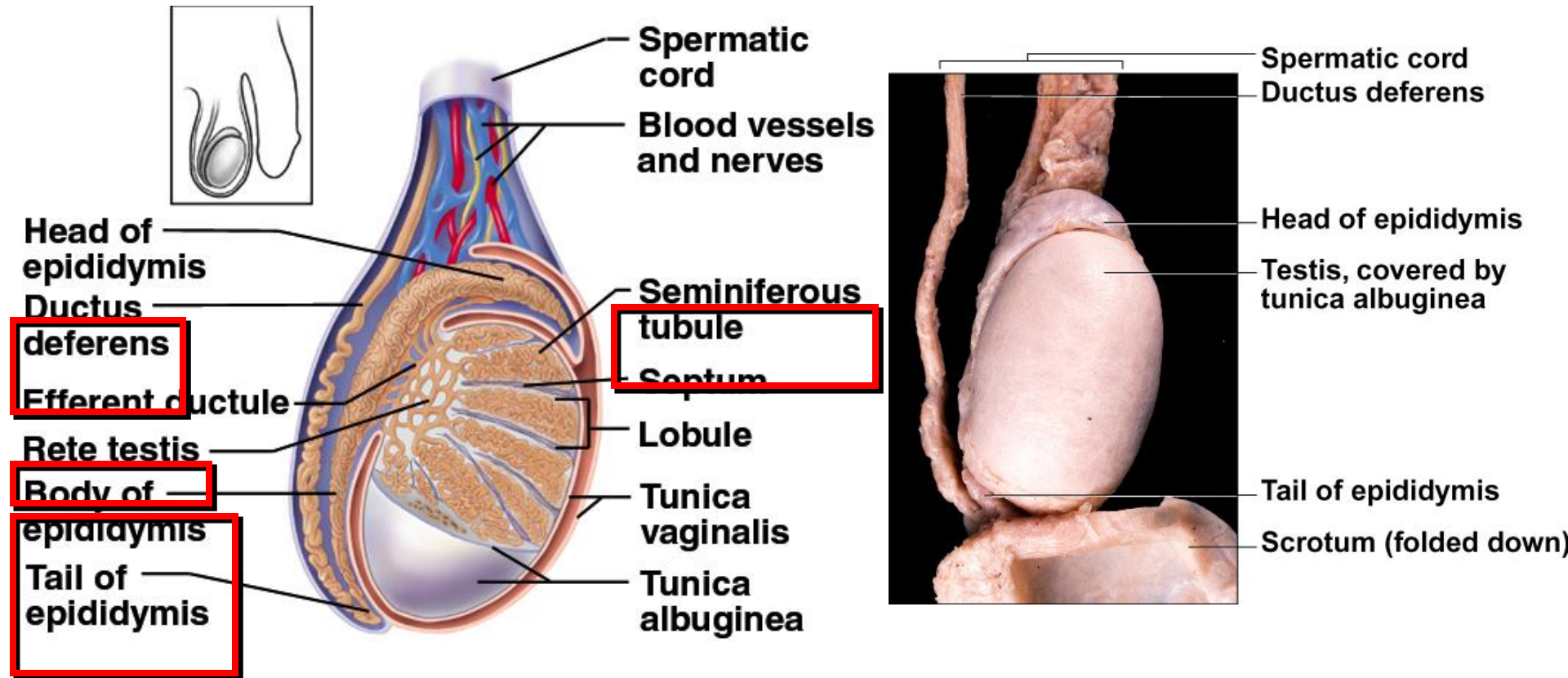
Germ cells

Connective tissue
wall of tubule

Interstitial cells (Leydig)

50 μm

Testis and Associated Structures

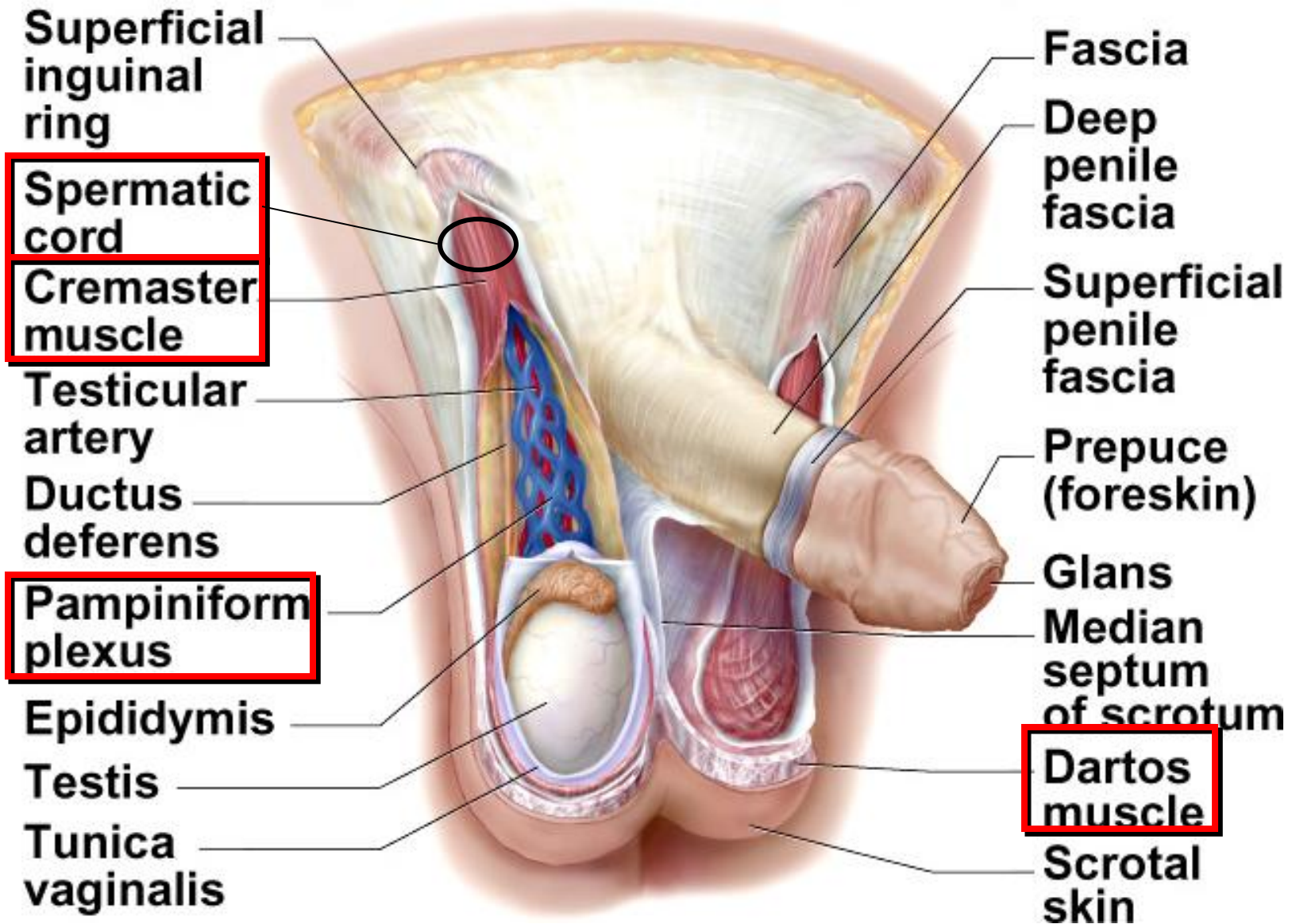


- **Seminiferous Tubules** drain into a network called the rete testis
- **Rete Testis** network of tubes that connects the seminiferous tubules and the epididymis.
- **Epididymis** network of tubes where sperm mature and leads to the **Ductus Deferens (vas deferens)**

Scrotum

- Scrotum is the pouch holding the testes
 - divided into 2 compartments
 - no fat in the hypodermis or fascia
- **Spermatic Cord** travels up from the scrotum to pass through the inguinal canal in the abdominal wall.
 - contains the ductus deferens, testicular artery, testicular vein, nerves and lymphatics
- Testicular thermoregulation is necessary since sperm are only produced at temperatures lower than core body temperature
 - **cremaster muscle** pulls testes closer to body when cold.
 - **dartos muscle** is composed of smooth muscle under the scrotal skin that can reduce the size of the scrotum when cold to reduce surface area.
 - **pampiniform plexus** is a network of veins around the testicular artery that exchange heat with incoming arterial blood resulting in cooler arterial blood entering the testis

Male Inguinal and Scrotal Region



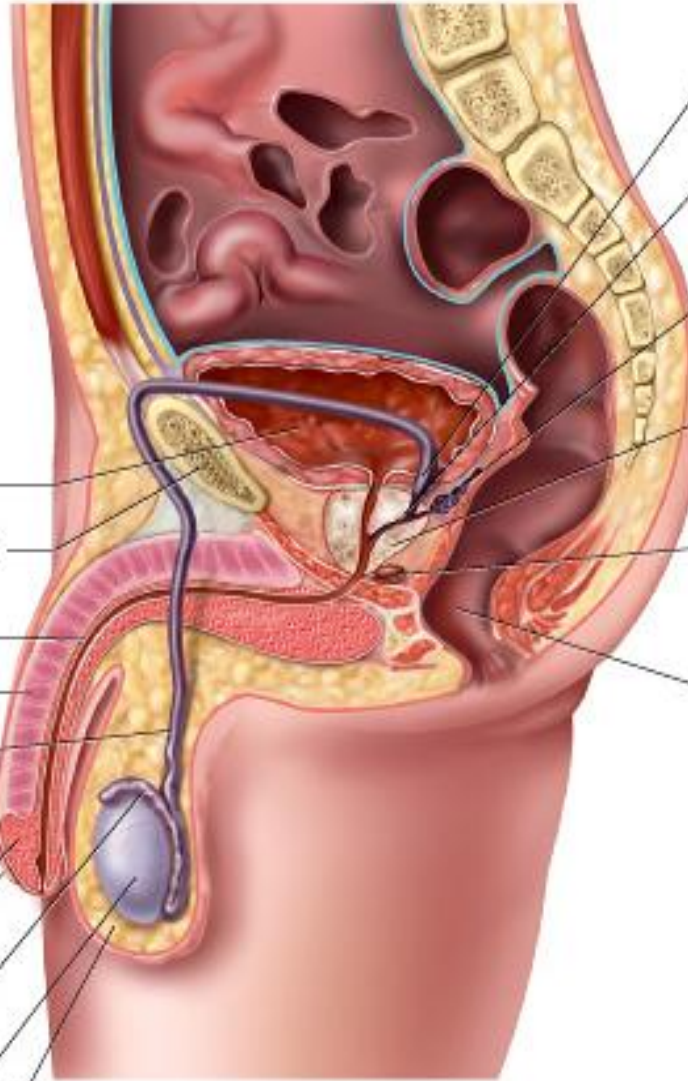
Male Accessory Glands

- Seminal Vesicles
 - ducts empty into the ejaculatory duct
 - viscous, yellowish secretion of fructose and other carbohydrates that nourishes sperm and sticky proteins that hold the sperm in the female reproductive tract.
 - also contains prostaglandins that may stimulate peristaltic contractions in the muscle of the female reproductive tract that help transport sperm through the female reproductive tract.
 - 60% of semen volume
- Prostate Gland
 - surrounds and empties into the urethra through about 20 pores
 - thin milky secretion that raises pH of male and female reproductive tract to a level optimal for sperm survival and activity.
 - 30% of semen volume
 - prostate gland can be palpated through rectal wall
- Bulbourethral (Cowper) Glands
 - produce a clear slippery fluid that provides initial lubrication for intercourse
 - neutralizes acidity of residual urine in male urethra that could kill sperm
 - contributes trace amounts to semen

Male Accessory Glands

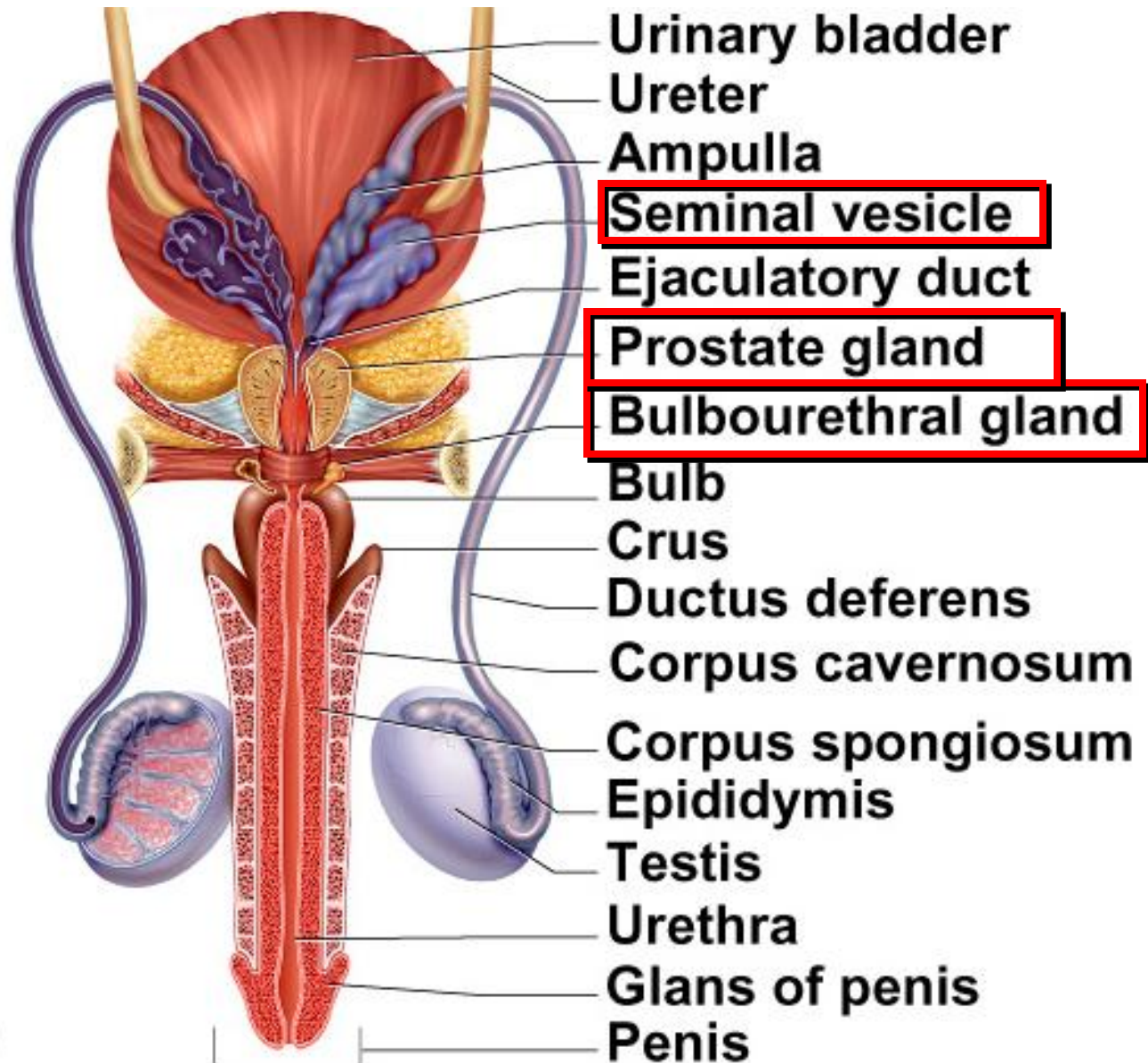


Urinary bladder
Pubic symphysis
Urethra
Penis
Ductus deferens
Glans of penis
Prepuce
Epididymis
Testis
Scrotum



Ampulla
Ejaculatory duct
Seminal vesicle
Prostate gland
Bulbourethral gland
Rectum

Male Accessory Glands

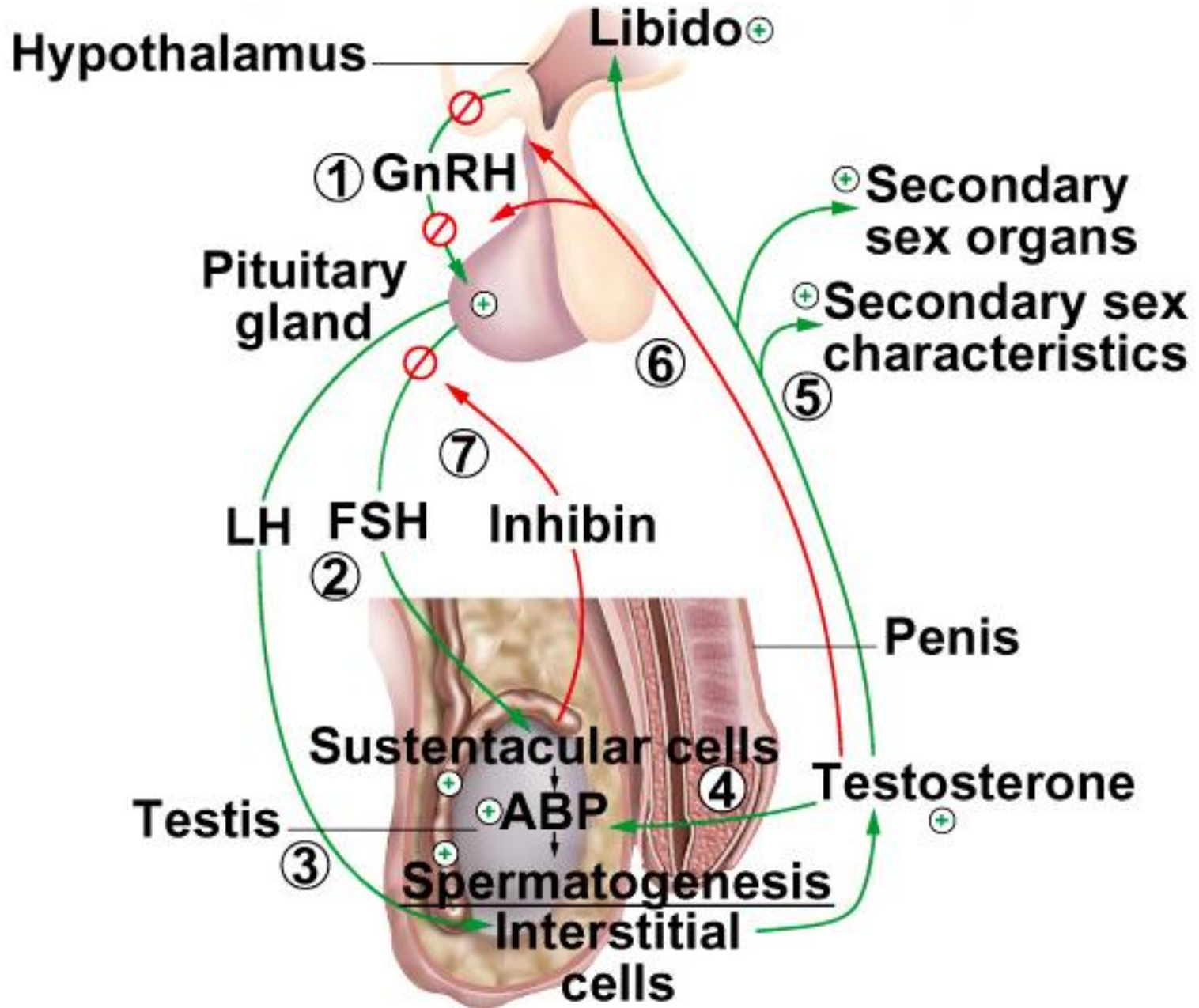


Brain-Testicular Hormone Axis

Arrows with plus signs indicate stimulatory effects; Arrows with bars indicate inhibitory effects.

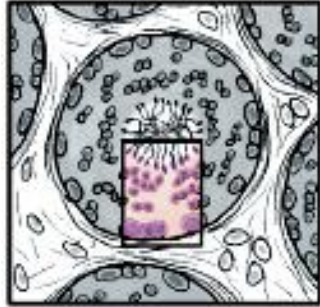
1. GnRH from hypothalamus stimulates the anterior lobe of pituitary to secrete FSH and LH.
2. FSH stimulates sustentacular cells to secrete androgen-binding protein (ABP).
3. LH stimulates interstitial cells to secrete testosterone.
4. In the presence of ABP, testosterone stimulates spermatogenesis.
5. Testosterone also stimulates development of secondary sex characteristics and stimulates libido (sex drive).
6. Testosterone has a negative feedback effect on the hypothalamus and pituitary which reduces GnRH secretion and pituitary sensitivity to GnRH.
7. To reduce sperm production without reducing testosterone secretion, the sustentacular cells also secrete inhibin, which selectively inhibits FSH secretion.

Brain-Testicular Hormone Axis



Spermatogenesis: Stem cells (spermatogonia) undergo meiotic divisions and differentiation while embraced by the sustentacular (Sertoli) Cells. It takes about 70 days for full maturation of spermatogonia into spermatozoa (sperm).

Cross section of seminiferous tubules



Spermiogenesis

Spermatozoa

Spermatids

Secondary spermatocytes

Primary spermatocyte

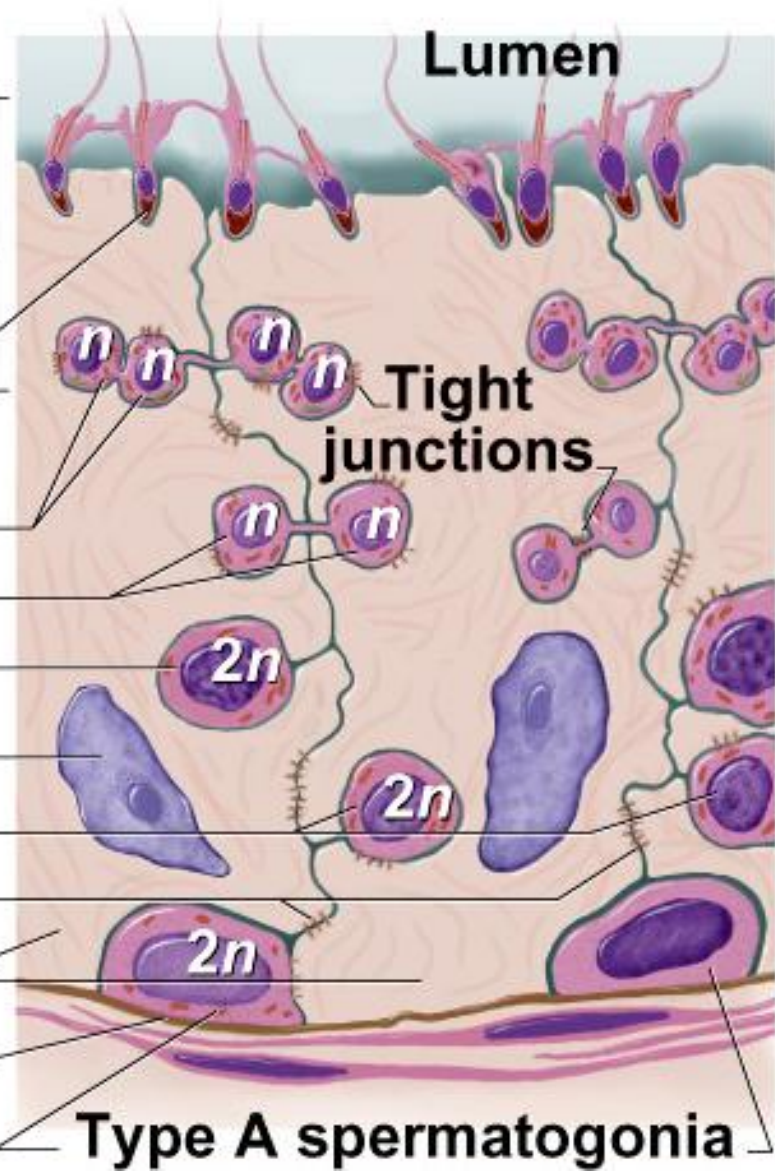
Sustentacular cell nucleus

Type B spermatogonia

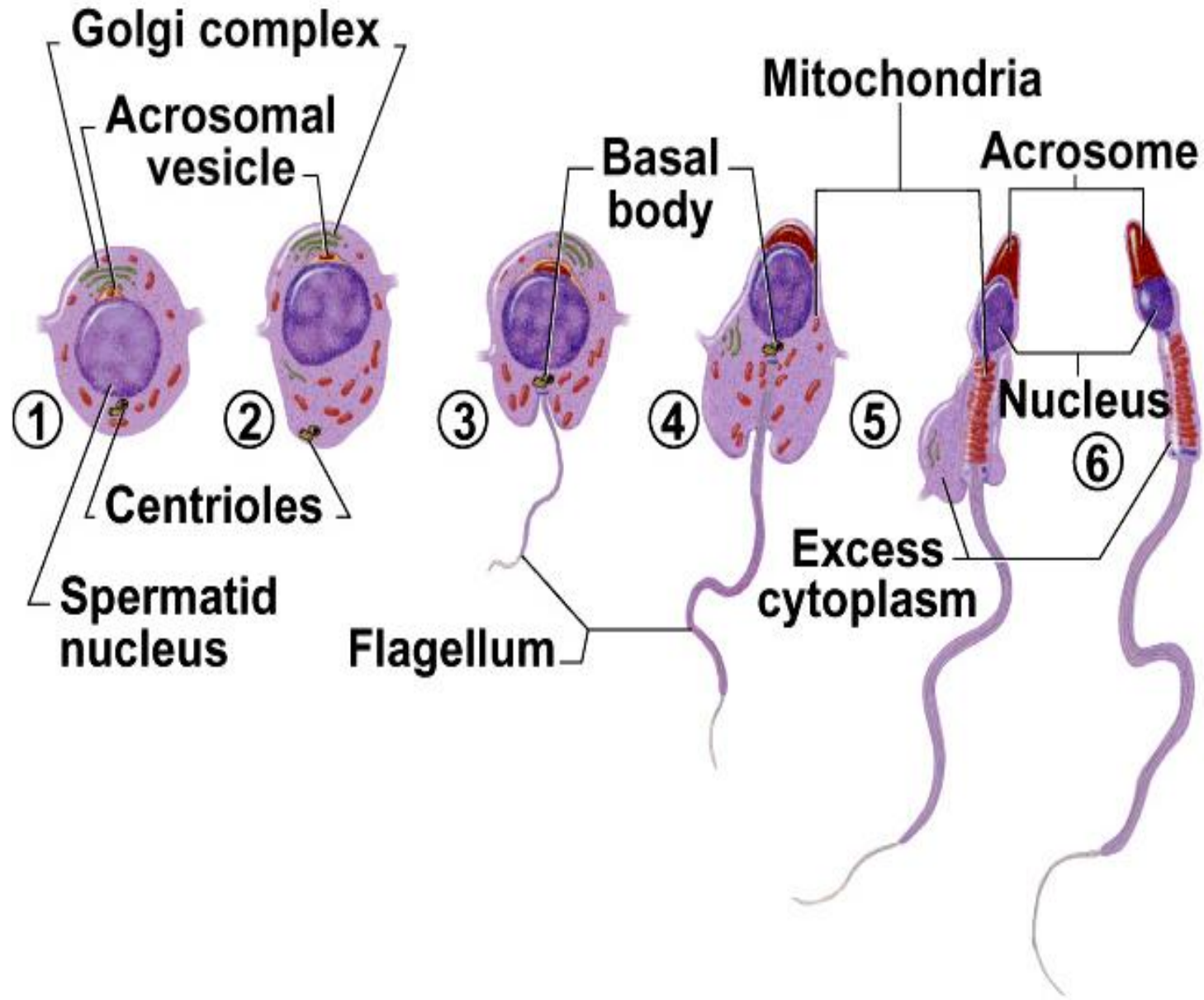
Blood-testis barrier

Sustentacular cells

Basement membrane



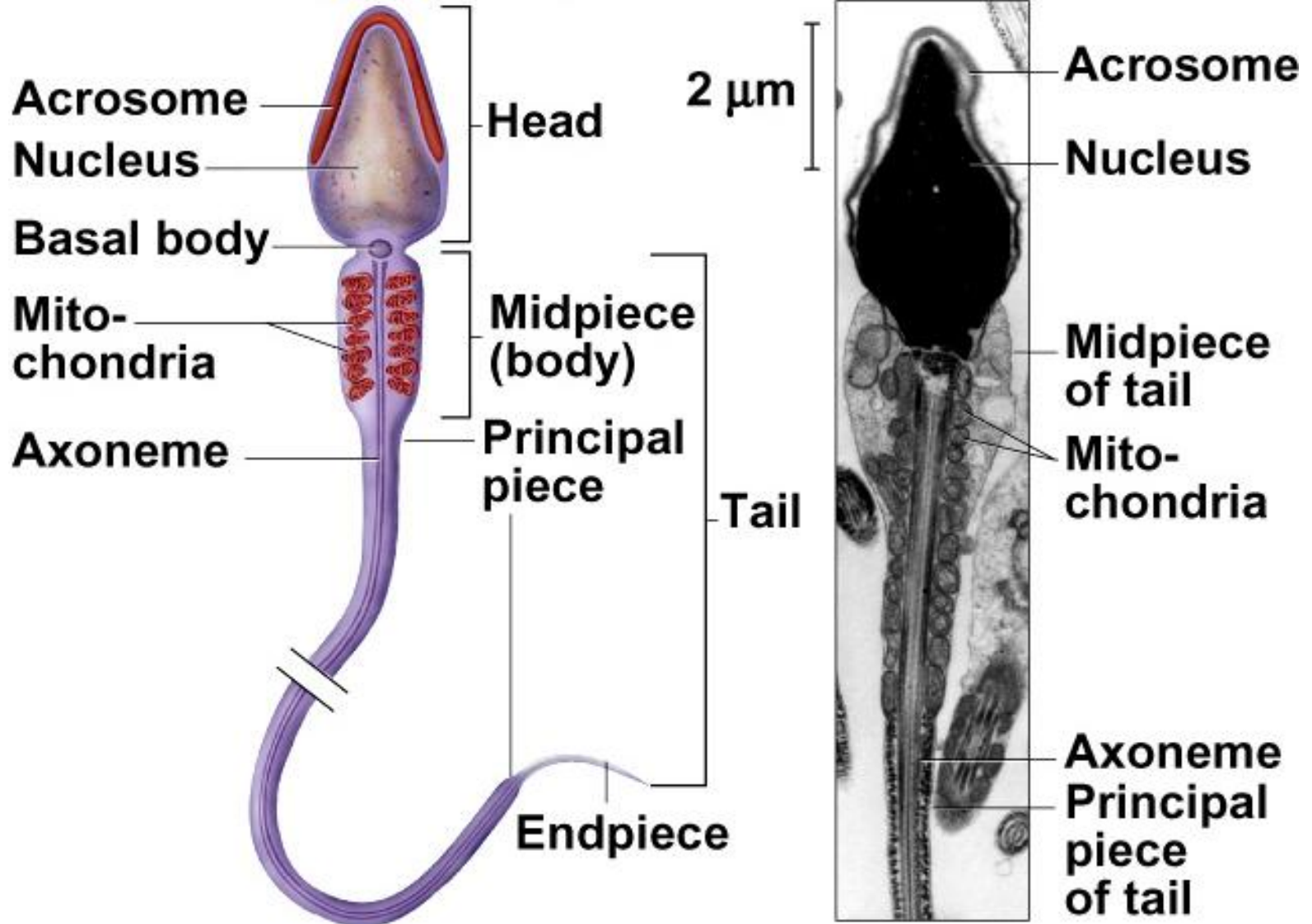
Spermiogenesis is the gradual transformation of a spermatid into a flagellated spermatozoon

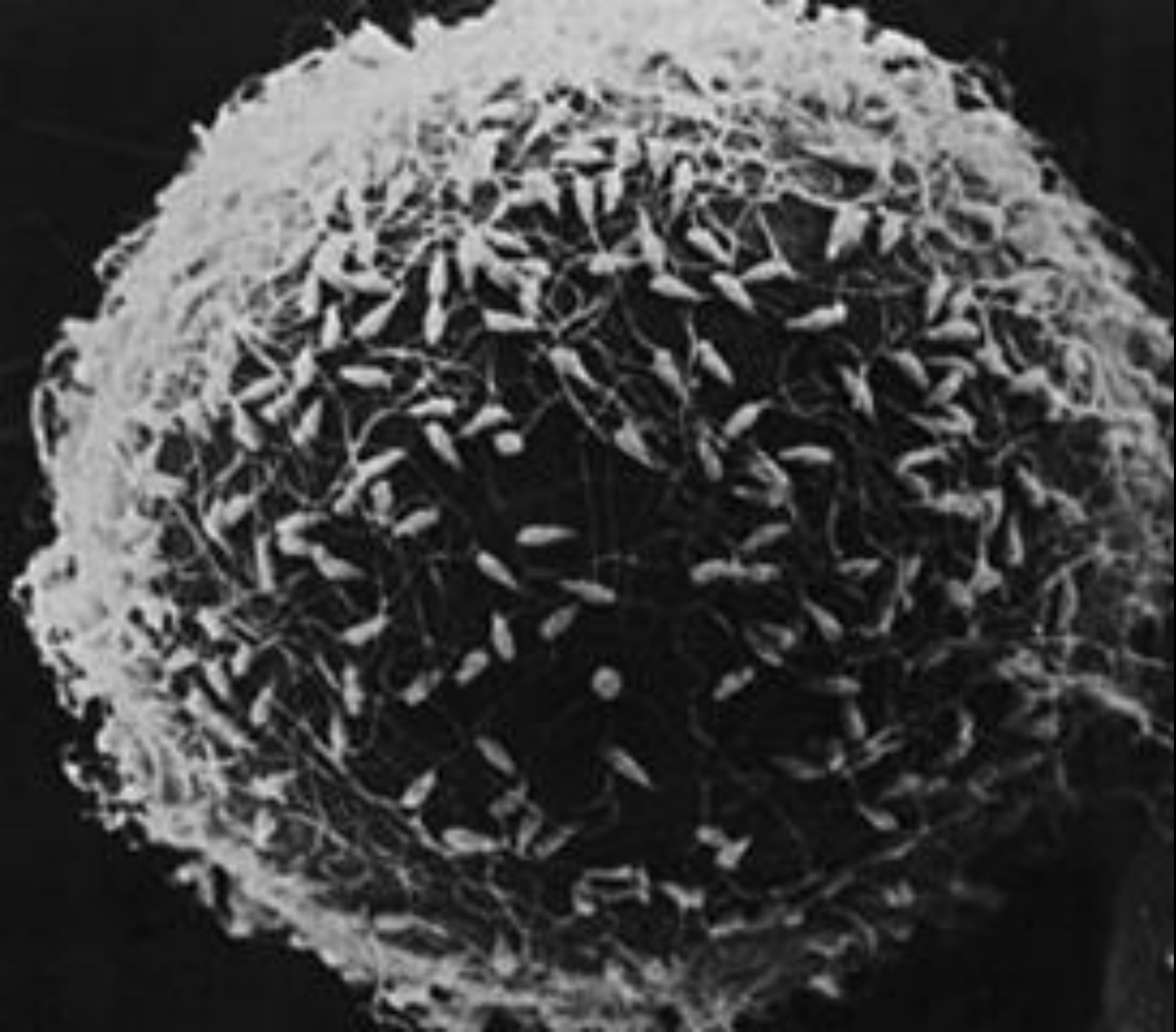


Spermatozoa (plural) Spermatozoon (singular)

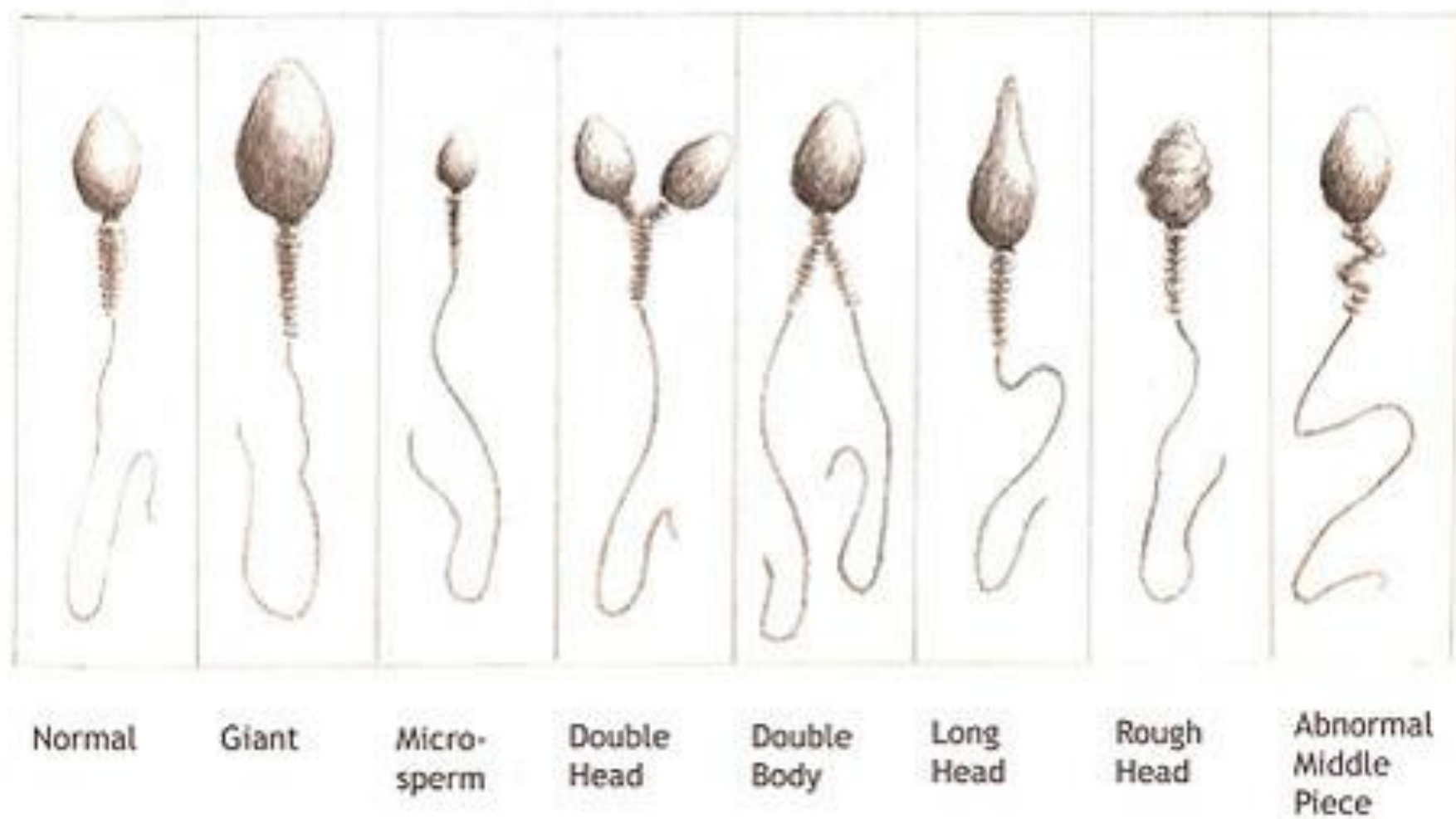
- Head
 - contains the nucleus, acrosome and basal body of the tail flagella
 - acrosome contains enzymes that penetrate the egg
 - nucleus contains haploid set of chromosomes that complements completes the genome of the egg
 - basal body supports the flagellum
- Tail is the flagellum of the cell and is divided into 3 regions:
 - Midpiece contains mitochondria around axoneme of the flagella. Mitochondria produce ATP for flagellar movement.
 - Principal Piece is the long, major portion of the flagellum.
 - Endpiece is the very narrow tip of the flagella.

Mature Spermatozoon





Sperm Morphology



END