

MALE REPRODUCTIVE SYSTEM

Male genital organs-

- The male reproductive organs & glands primarily resume the male gamete or sperm
- The male reproductive system of mammals consists of two testes (testicles) in the scrotum
- Scrotum is an accessory organ including ducts & glands, the urethra of the penis

Function of Testes & accessory genital glands-

Scrotum-

- It is a cutaneous sac that conforms their size & shape to the testes it contains
- The skin is thin, pliable & hairless next to skin, a layer of fibro-elastic tissue mixed with smooth muscle fibers called the **tunica dartos**
- The fibrous sheet of tunica dartos is present in between two testes to form scrotal septum which divides the scrotum into two compartments
- During cold exposure the muscle fibers of the tunica dartos contract & hold against the abdomen

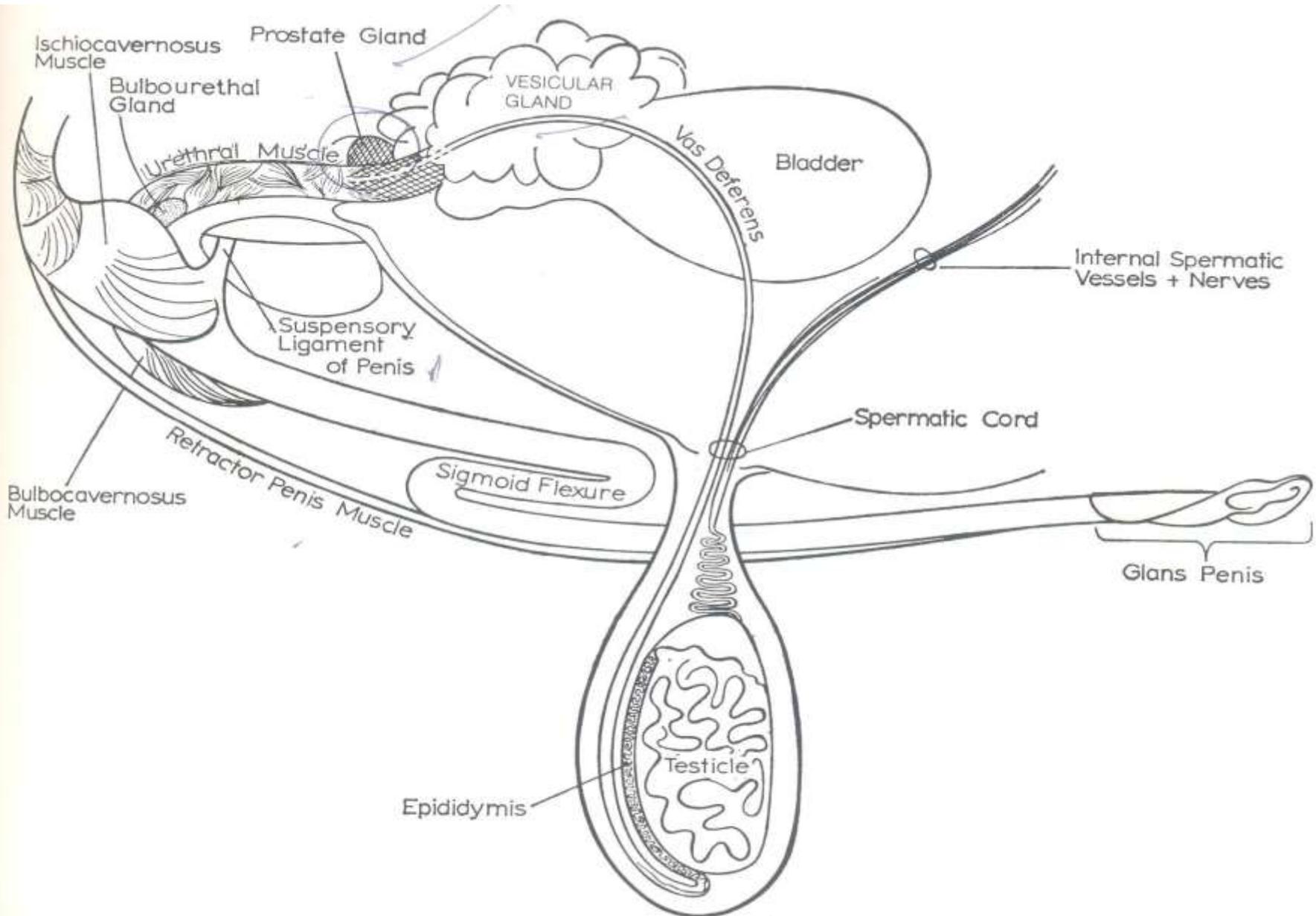
- **The cremaster muscle also contracts during cold exposure to assist the drawing of testes towards abdomen**
- Each testis consists of a mass of coiled seminiferous tubules surrounded by heavy fibrous capsule called tunica albuginea
- A number of fibrous septa dividing the testis into lobules & providing a framework for support of the seminiferous tubules & the interstitial cells that produce testosterone

Spermatogenesis- It occurs in the Seminiferous tubules (formation of spermatozoa)

Seminiferous Tubules-

- The seminiferous tubules lined with epithelium consists of two cell types, the sustentacular or sertoli cells & germ cells
- The sustentacular (sertoli) cells are irregular in shape & they nourish the developing sperm & mediates the effects of FSH & testosterone on the germ cells
- The sustentacular cells produce a fluid along with the spermatozoa for transportation from the tubules to the rete-testis

Male genital organs:



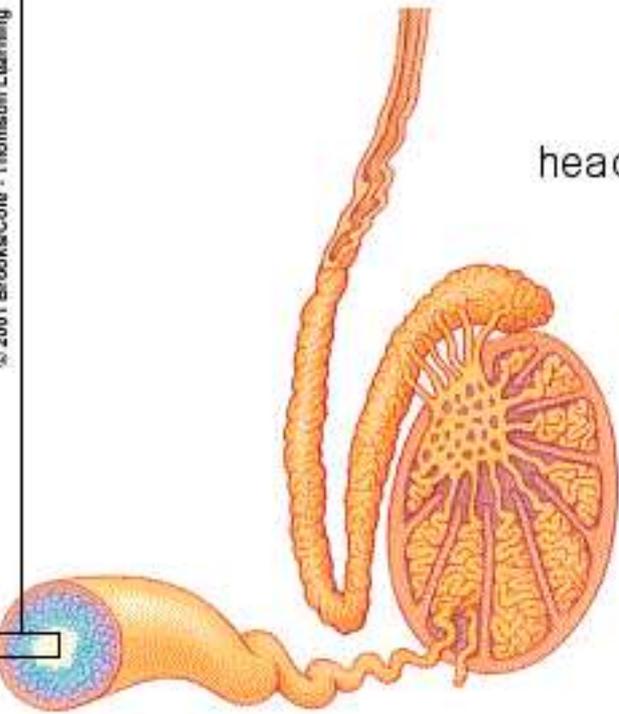
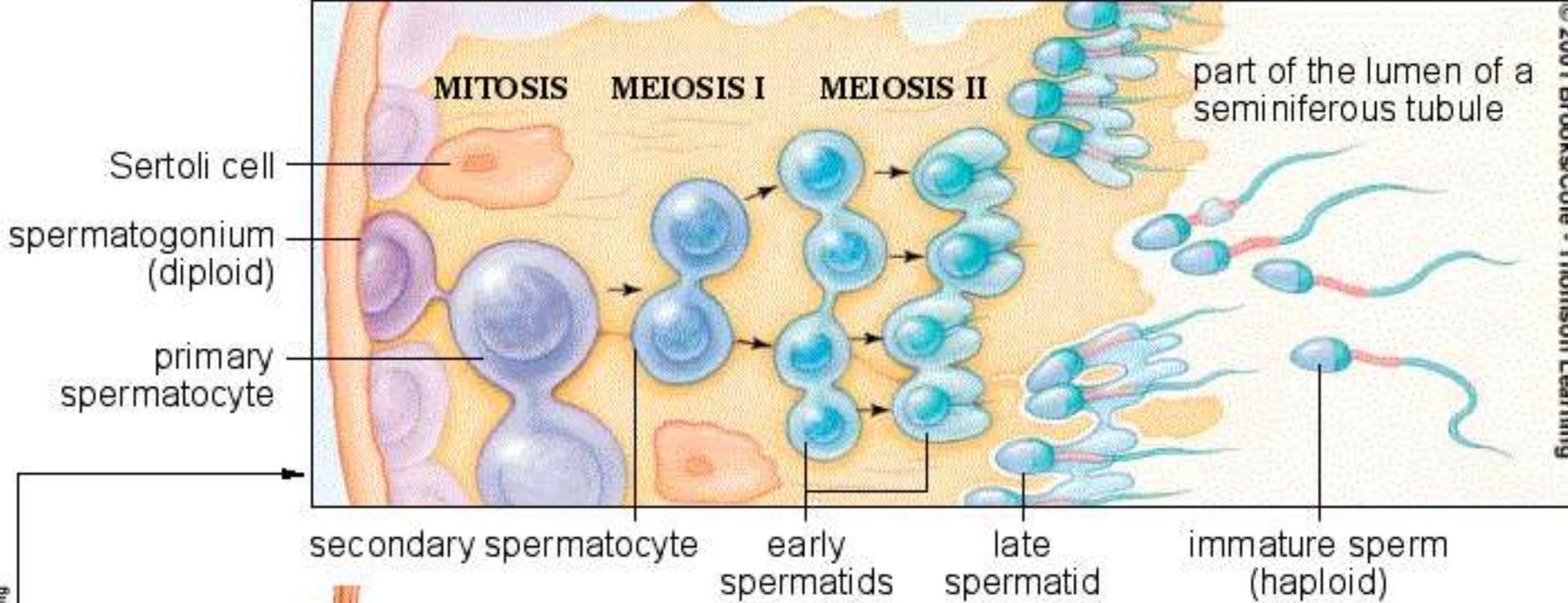
- One of the fluid component, androgen binding protein, transports androgen from their site of synthesis in the testis to the epididymis to get maturation of spermatozoa
- Interstitial cell (leydig cell) lies between the CT of seminiferous tubules secrete Testosterone
- The interstitial fluid between sertoli cells & within the lumen of the seminiferous tubules differs from typical interstitial fluid due a permeable barrier (blood testis barrier) between these fluids & fluid outside of the tubules

Spermatogenesis-

- It involves in the formation of mature male gametes from the most undifferentiated germ cells along with the several mitotic cell divisions consisting the mitotic cell division during which the chromosome number is reduced from diploid to haploid
- Meiosis entails two cell divisions & occurs only during the development of gametes in the testis & ovary

- Beyond 1st division, the DNA is replicated to that of mitotic cell division
- This replication results in chromosomes, consists two identical chromatids
- In preparing 1st mitotic division, homologous chromosomes pair up along the middle of the cell
- During the 1st meiotic division, one chromosome of each homologous pair moves into each daughter cell
- The individual homologous pair moves randomly to the daughter cell
- This mixing is done for the genetic variation among the offsprings
- After the 1st meiotic division, each daughter cell has a haploid number of chromosome but each chromosome consists of two chromatids
- During the 2nd meiotic division of the two daughter cells each of the resulting four cells receives one of the chromatids

- The overall result of meiosis is the production of four daughter cells, each of which has a haploid number of chromosomes
 - In case of mammals, male produce when (XY) chromosome superior
 - But when (XX) chromosome united the female offspring will produce
 - But in case of avian, there is opposite, female avian contains (ZW) chromosome where as in male, it consists both (ZZ) chromosomes
 - When homologous chromosomes are paired in preparation for the 1st meiotic division, crossing over may occur
 - The chromosomes may be exchanged between homologous chromosomes
 - These exchanges ↑ genetic variability among the offspring
- Spermiogenesis-** Spermatids undergo a series of functional & structural changes to become spermatozoa & this process is termed spermiogenesis



Bulbourethral gland (Cowpers gland)- These are paired glands on either side of the pelvic urethra cranial to the ischial arch caudal to other accessory glands

Penis:

- It is the male secondary sex organ of copulation
- It is divided into glans or free extremity, the body or main portion & the 2 crura or root attaches with the ischial arch of the pelvis
- It is derived or surrounded by fibro-elastic capsule, tunica albuginea
- Tunica albuginea surrounds the bulk of penile body's internal structure composed of paired columns of erectile tissue, the corpora cavernosa
- Each corpora cavernosa is replete with blood sinusoids divided by sheets of CT called Trabeculae
- In swine & ruminants the penis is firm when not erect
- In horse it is musculo-cavernous penis with flaccid

- The ventral midline groove between the corpora cavernosa contains the penile urethra & an associated unpaired body of erectile tissue, the corpus spongiosus

Prepuce:

- It is an invaginated fold of skin surrounding the free extremity of the penis
- The outer surface consists of typical skin while inner mucous membrane consists of a preputial layer lining the prepuce
- It accumulates urine, secretions & dead cells which contribute to the typical odor of a mature boar

Erection & Ejaculation:

- Penile erection is a neural reflex initiated by appropriate tactile stimulation of the penis, visual or environmental stimuli (estrus)
- Penile erection requires vasodilation within the penis

- Parasympathetic nerves releases Ach, which stimulates endothelial cells lining the blood vessels to release nitric oxide & acts directly on smooth muscle to bring about vasodilation
- Prior to ejaculation, spermatozoa are moved from epididymis through the ductus deferentia to the pelvic urethra termed as **emission**
- Emission & ejaculation are autonomic reflexes involving both sympathetic & parasympathetic divisions
- Ejaculation of semen through the penile urethra is associated with more contractions of the epididymis, ductus deferentia & additional contractions by muscles of the penis surrounding the penile urethra

Spermatozoa morphology-

- The spermatozoa consists of a head & tail
- The head contains the nucleus, primarily consisting of condensed genetic material & an acrosome, membrane sac

- The tail has a central core of microtubules & filaments for providing motility
- The middle piece of the tail contains a dense collection of mitochondria for energy provision
- The acrosome is a sac of hydrolytic enzymes including acrosin & hyaluronidase
- These enzymes facilitate the fusion of the male & female gametes

Epididymis:

- It composed of a long convulated tube that connects the efferent ductules of the testis with the ductus deferens
- The spermatozoa released from seminiferous tubules pass through the rete testis into the epididymis
- The tail of epididymis contains these spermatozoa's

- During passage of spermatozoa into epididymis, spermatozoa that are immotile & incapable of fertilization comes in touch with epididymal secretions & testosterone
- Hence, there is a functional change associated with these spermatozoas & are become motile & capable of fertilization

Semen & Semen technology- Semen acts as transport medium for the spermatozoa & it contains a variety of substances including various electrolytes, fructose, citric acid & sorbitol provides source of energy for spermatozoa

Characteristics of Semen-

- Concentration of spermatozoa per ml of semen
- Motility characteristics of spermatozoa
- Shape of the spermatozoa

Semen is also collected & used for breeding technologies such as AI & in vitro fertilization. It can also be frozen & used for years

Sperms of different species:

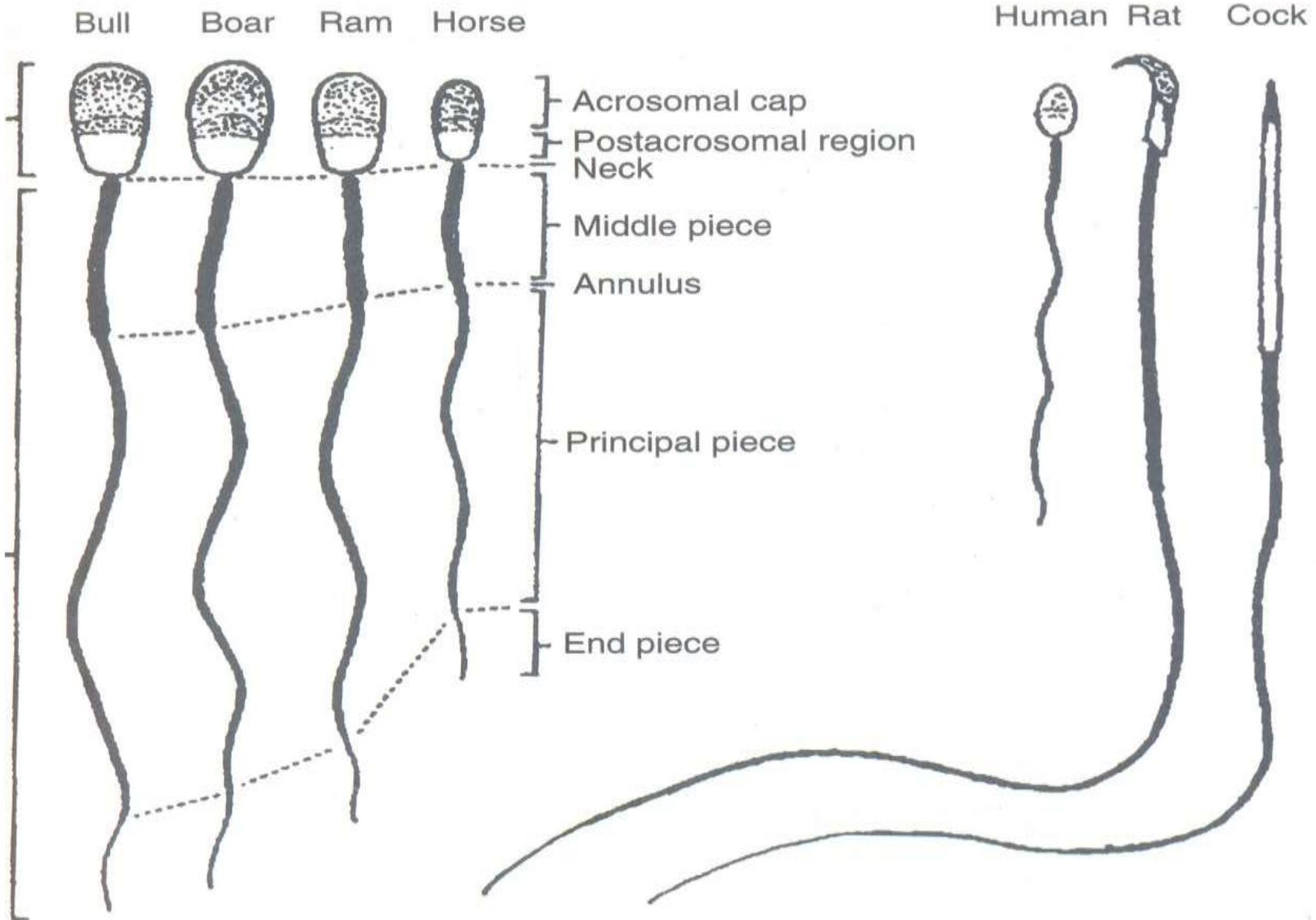


Figure of far structure: Garner eds., Lippi p. 97

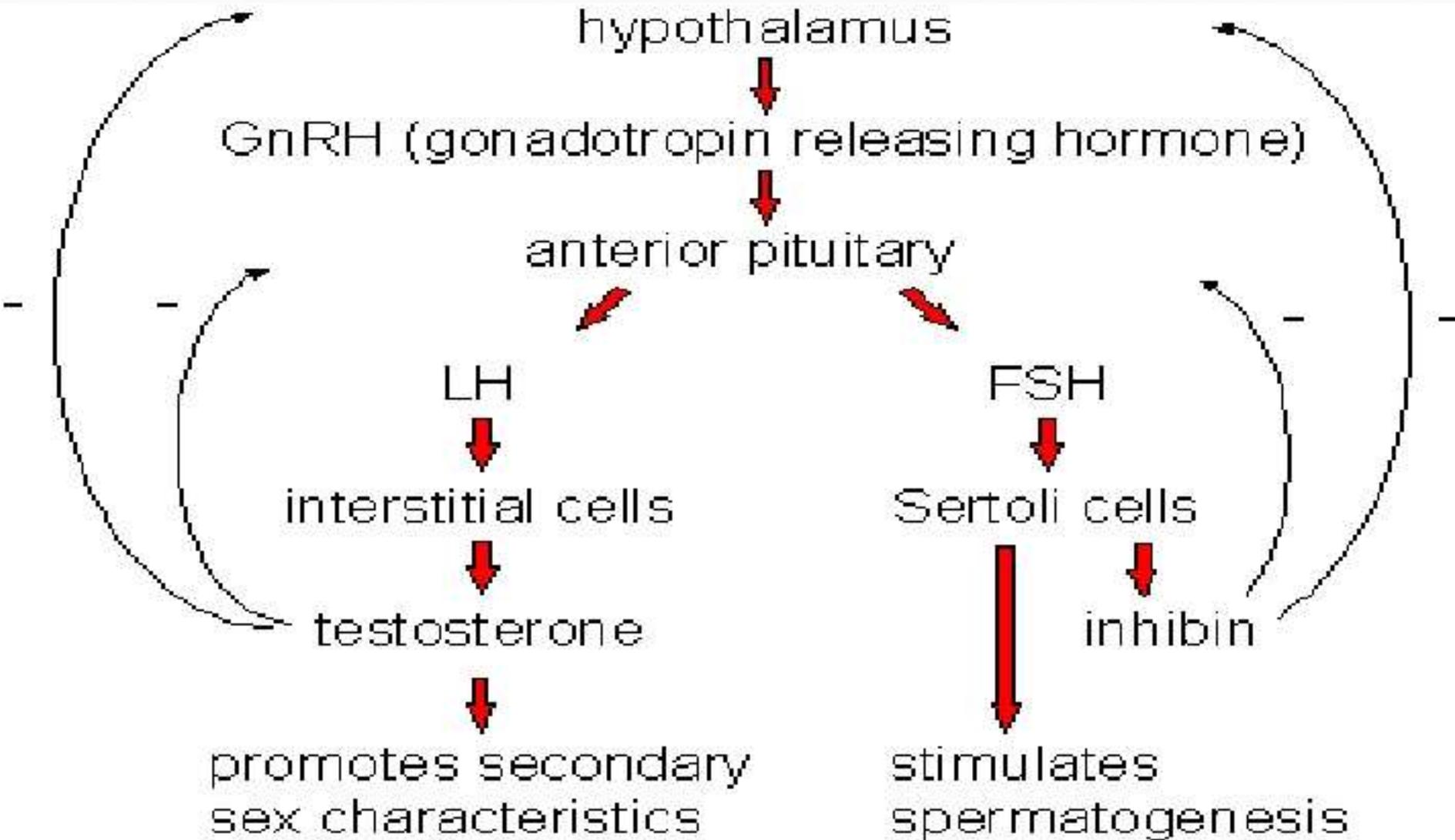
Sperm concentration in different species:

Species	Ejaculate volume (ml)		Sperm concentration ($\times 10^6$ /ml)	
	Range	Average	Range	Average
Boar	150–500	250	25–300	100
Buffalo	0.5–4.5	2.5	200–800	600
Bull	2–10	4.0	300–2000	1000
Camel	4–12	8.0	100–700	400
Cat	0.02–0.12	0.03	100–2600	1700
Deer	2–20	4.0	100–1300	200
Dog	2–15	9.0	60–300	300
Goat	0.2–2.5	1.0	1000–5000	3000
Guinea pig	0.4–0.8	0.6	5–17	10
Human	2–6	3.0	50–350	80
Rabbit	0.4–6.0	1.0	50–350	150
Ram	0.7–2.0	1.0	2000–5000	3000
Stallion	30–300	70	30–800	120

Hormones of male reproduction:

- The gonadotrophins (FSH & LH), protein hormones stimulate testicular function from the adenohypophysis
- FSH promotes spermatogenesis by its action on the germ cells in the seminiferous tubules & sertoli cells that support the development of the spermatozoa
- LH acts on testicular interstitial cells to promote the secretion of androgens primarily testosterone
- Gonadotrophin releasing hormone (GnRH) from the hypothalamus stimulates the release of both FSH & LH from the adenohypophysis
- Testosterone has direct effect on the adenohypophysis to suppress LH release directly
- When stimulated by FSH, sustentacular cells produce inhibin
- Inhibin has a –ve feedback effect on the adenohypophysis to suppress further release of FSH

In male animals-



Testosterone; its function & regulation:

- It is a steroid hormone when enters to the target cells it converts into dihydrotestosterone which binds to intracellular receptors
- It matures the spermatozoa within the testis & promotes the development & function of male accessory sex organs causes development of secondary sex characteristics & promotes male sexual behavior
- For normal libido (sex desire) is necessary develop by the testosterone which affects neurons within the brain
- In castrated male, libido may continue, because within neurons, testosterone converts into estradiol

Accessory sex glands: Semen provides favorable conditions for nutrition of sperm & acts as a buffer against the acidity of the female genital tract

Ampullae- These are glandular enlargements associated with the terminal parts of the ductus deferentia. They contribute volume to the semen & well developed in stallion, bull & ram. It is absent in boar

Vesicular glands (Seminal vesicles)- These are paired glands associated with the genital fold. These gland merges with the ductus deferentia creating the ejaculatory duct

Prostrate gland- This is a paired gland surrounds the pelvic urethra under cover of the urethral muscle. The prostrate produces an alkaline secretion which gives semen its characteristics odor. In older animals, the prostrate gland may become enlarged & interfere with urination