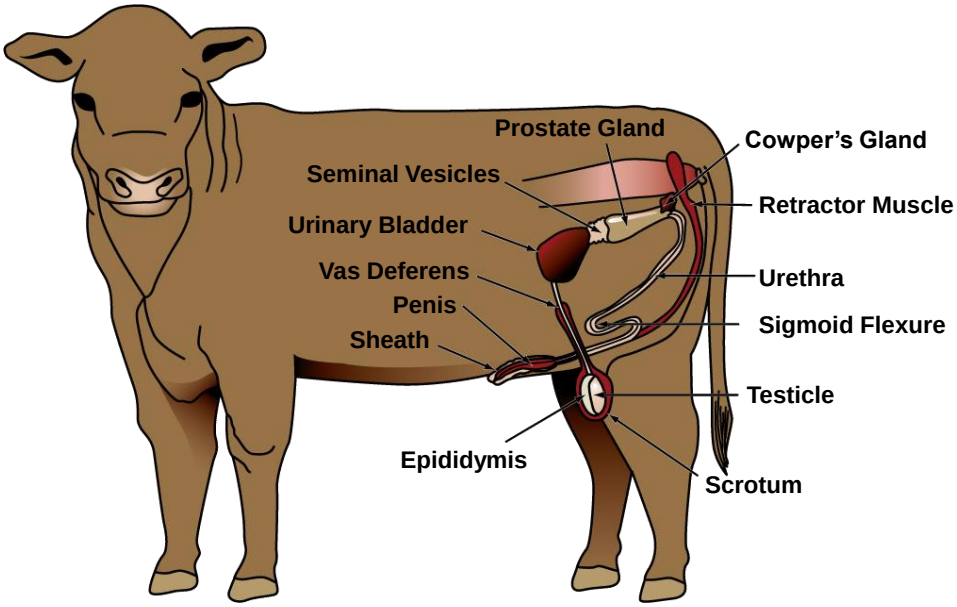
Gen 1: 22
God Blessed them and said "Be fruitful and increase in number and fill the water in the seas, and let the birds increase on the earth"…

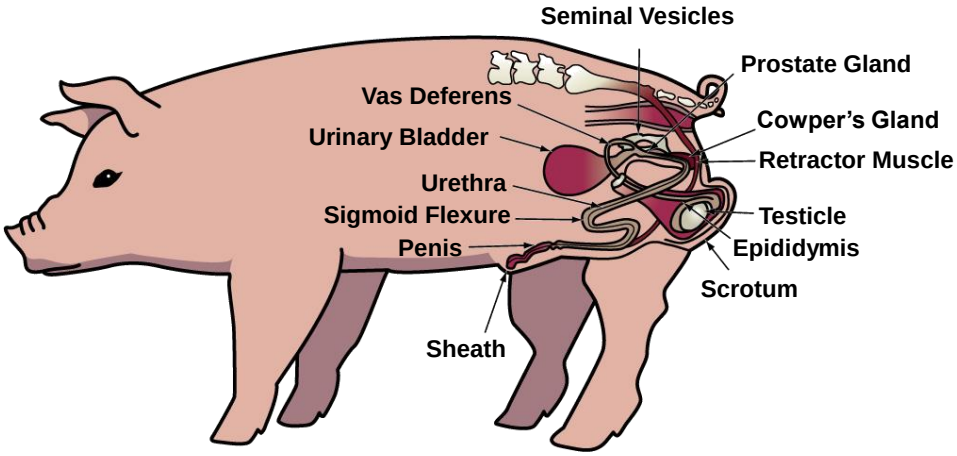
Anatomy of the Male Reproductive System

By PC Sianangama, PhD
Department of Animal Science
University of Zambia

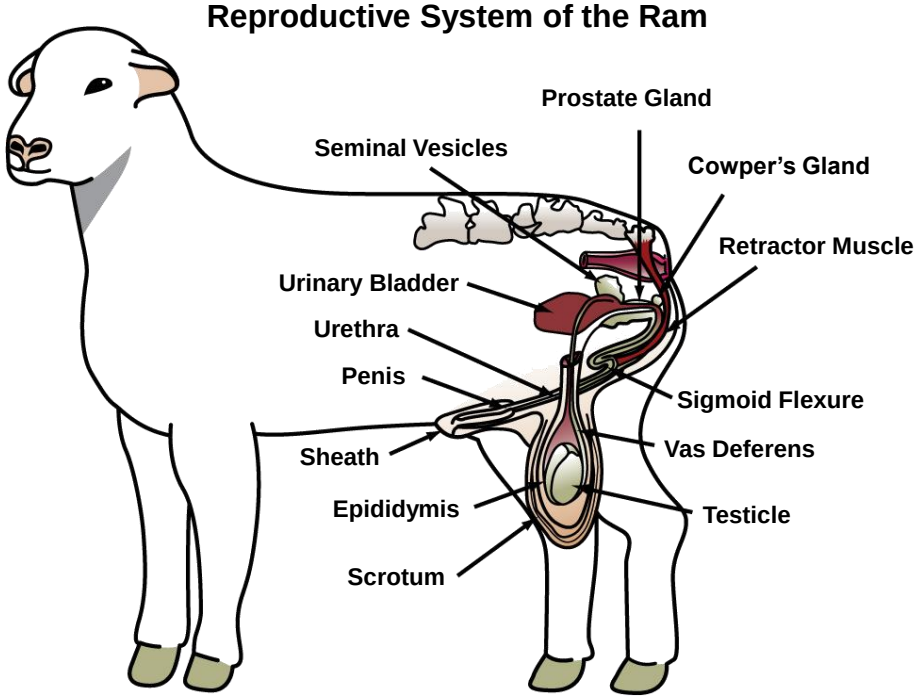
Reproductive System of the Bull



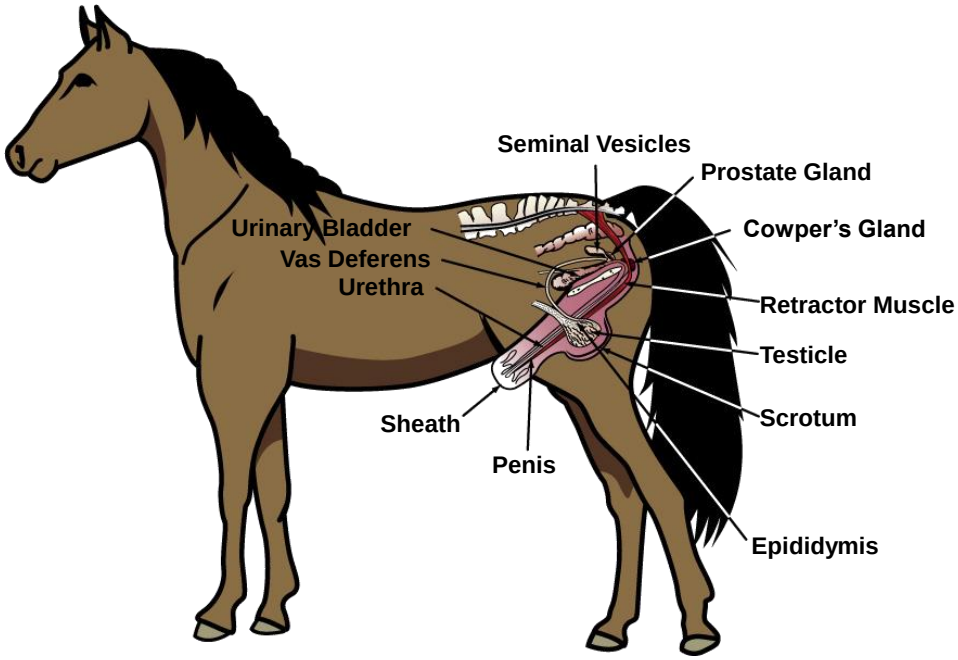
Reproductive System of the Boar



Reproductive System of the Ram



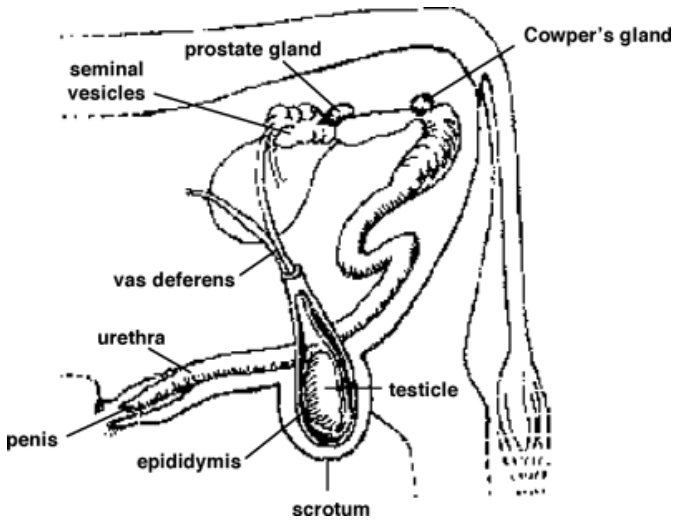
Reproductive System of the Stallion



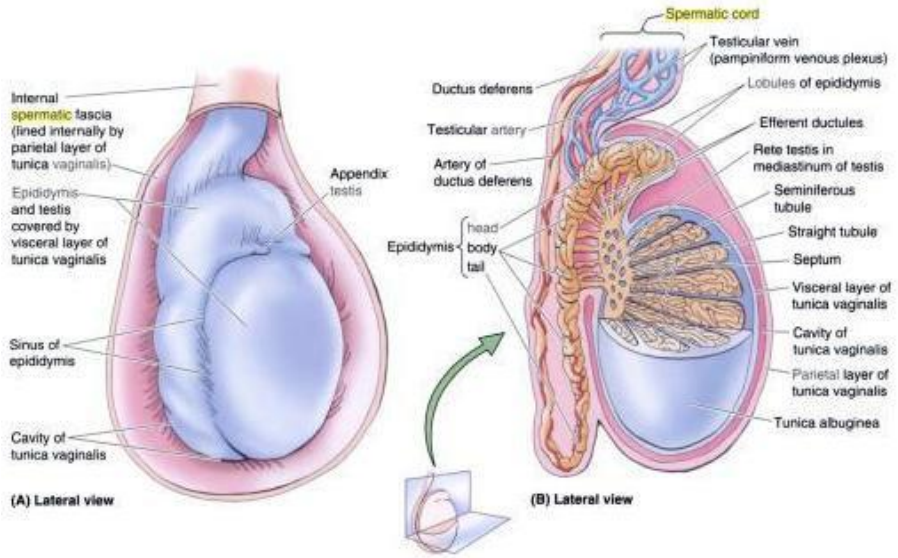
Reproductive parts continued…

- Retractor Muscle – pulls penis back into the body
- Penis – deposits semen into female and excretes urine
- Sheath/Prepuse – external skin which protects the penis

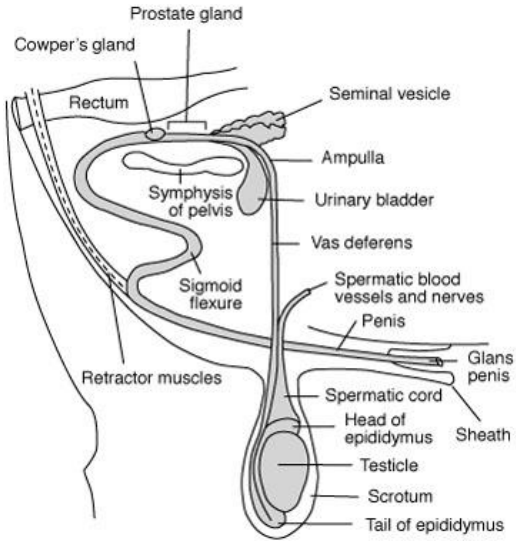
Bull Reproductive Tract

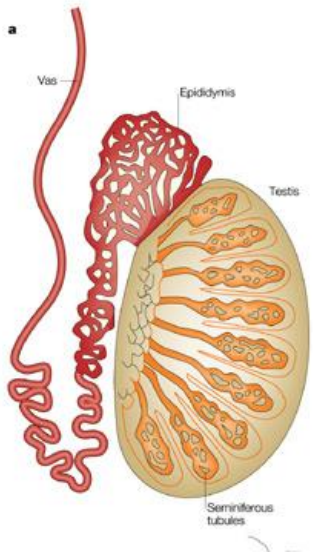


Testis



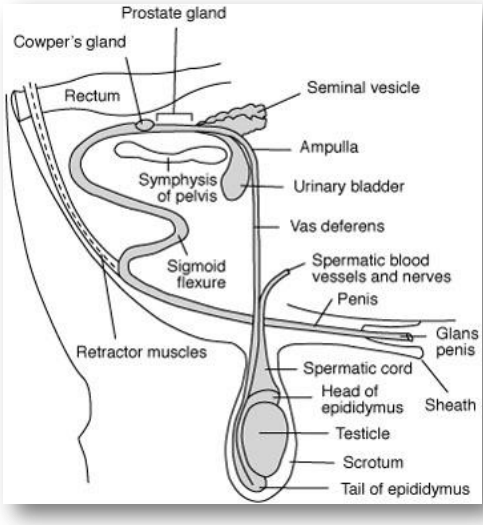
Testis and Accessory Glands





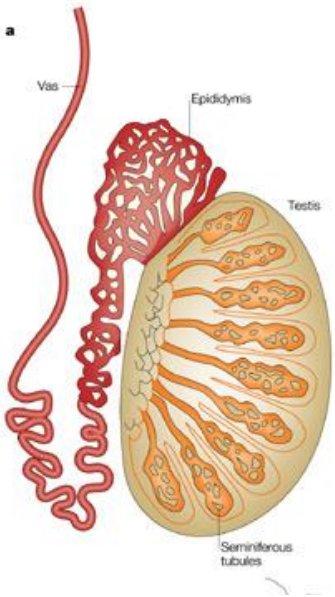
The Male Reproductive Tract - Overview

- **The reproductive tract of a bull has two parts –**
- **1. The <u>testicles</u>, including**
  - **Seminiferous Tubules made of Leydig Cells and Sertoli Cells**
- **2. The <u>secondary sex organs</u>, including…**
  - **Epididymis**
  - **Vas Deferens**
  - **Seminal Vesicle**
  - **Prostate Gland**
  - **Cowper's Gland**
  - **Urethra and Penis**



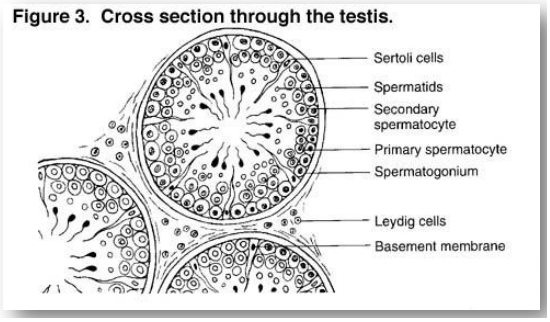
The TestEs

- The testicles have two functions:
- 1. Production of the spermatozoa that will become the sperm cells
- 2. Production of testosterone, the 'male' hormone
- The testicle is the entire organ, consisting of the testis (plural: testes), the scrotum (outer covering of skin), and beginning of the epididymis

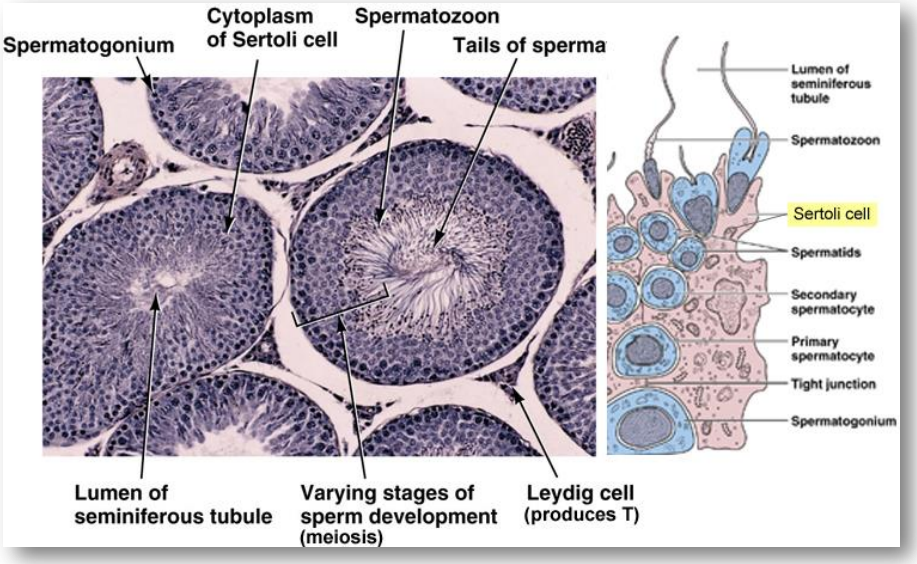


Seminiferous tubules & Sertoli Cells

- Each testis is comprised of long, coiling structures called Seminiferous Tubules
- Each seminiferous tubule is comprised of connected Sertoli cells
- The Sertoli cells are what produce and nurture developing sperm

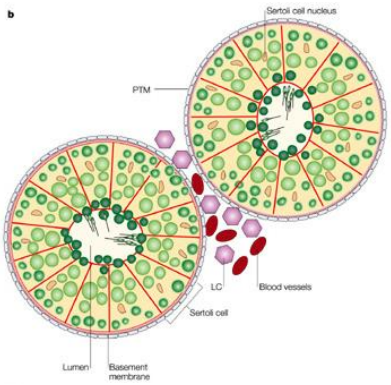


Seminiferous tubules and sertoli cells



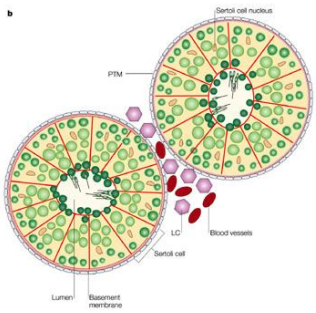
Blood Testis Barrier

- Sertoli cells have a "tight junction" barrier which serves to prevent the body from destroying the sperm.
  - Why would the body destroy sperm?
  - HINT: Chromosome #'s and types
- The BTB is a physical barrier between the testes and the seminiferous tubules.
  - Think of an Orange! ~



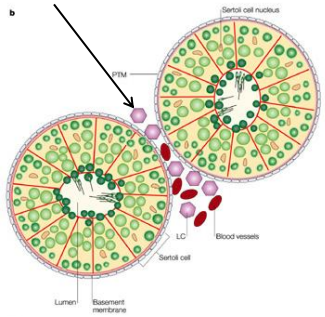
BTB

- The Sertoli cells form a barrier that prevents blood from accessing the lumen of the seminiferous tubules.
  - How is this a good thing?
  - How is this a bad thing?
- What would happen if the BTB were breached?



Leydig Cells

- Leydig cells/interstitial cells are dispersed throughout the testes and produce male hormones (androgens)
  - Testosterone is considered the primary male hormone
  - Testosterone is released under the influence of LH from the pituitary gland.
  - Both LH and FSH are needed for sperm production ~

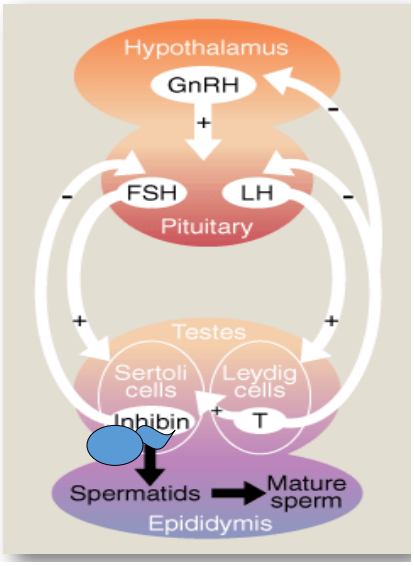


Male Hormones

- Male Hormones are necessary for:
  - Onset and maintenance of sperm production
  - Sex drive (libido)
  - Development and maintenance of secondary sex characteristics (organs and features) ~
- After puberty, spermatozoa formation is a continuous process.
  - This process is controlled by the endocrine system.
- FSH and LH are important in stimulating the testes to produce spermatozoa and testosterone. ~

Male Hormone Loop

- Hypothalamus releases GnRH, which signals pituitary to release FSH, LH
- LH tells Leydig cells to release testosterone, which stimulates production of sperm.
  - *note negative feedback!*
    - Testosterone also slows the release of LH (as does Inhibin for FSH)
    - What would injections of testosterone do to sperm production?

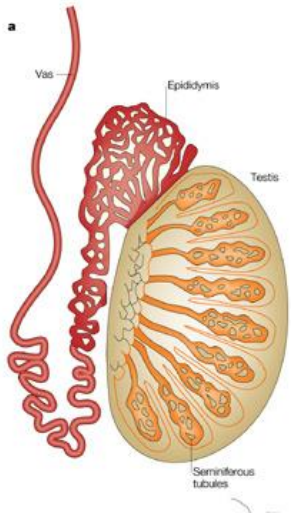


Male Hormone Cycle

- 1. Brain releases GnRH
- 2. GnRH causes release of LH, FSH
- 3. LH causes release of testosterone from Leydig Cells
- 4. Testosterone causes production of sperm in Sertoli Cells (as well as production of Inhibin)
- 5. Testosterone reduces production of LH; Inhibin reduces production of FSH

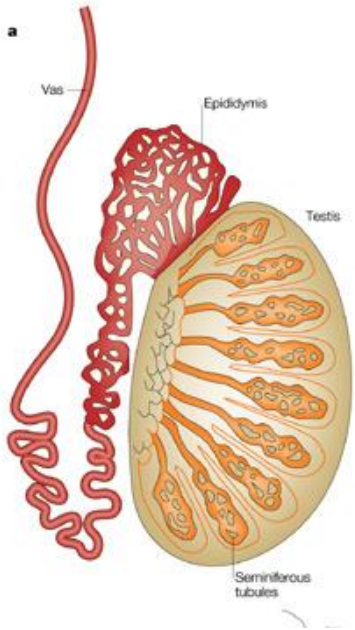
Epididymis

- After leaving the testes through ducts in the seminiferous tubules, sperm enter the epididymis.
- The epididymis is a tubular structure located on one side of the testes.
- It is packed with a milky nutritive substance as well as spermatozoa from the testes.
- Spermatozoa mature in the epididymis
  - *Principally An assembly line, not a storage unit!~*



Vas Deferens

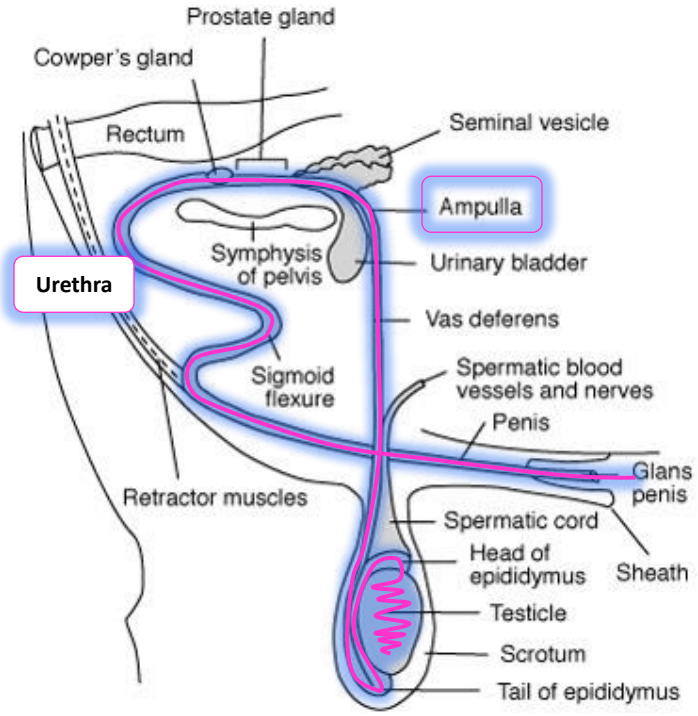
- From the epididymis, spermatozoa enter the vas deferens.
- This carries the spermatozoa into the body cavity towards the urethra
- It is surrounded by muscles that contract during ejaculation. ~



Ampullae of Henle, Urethra

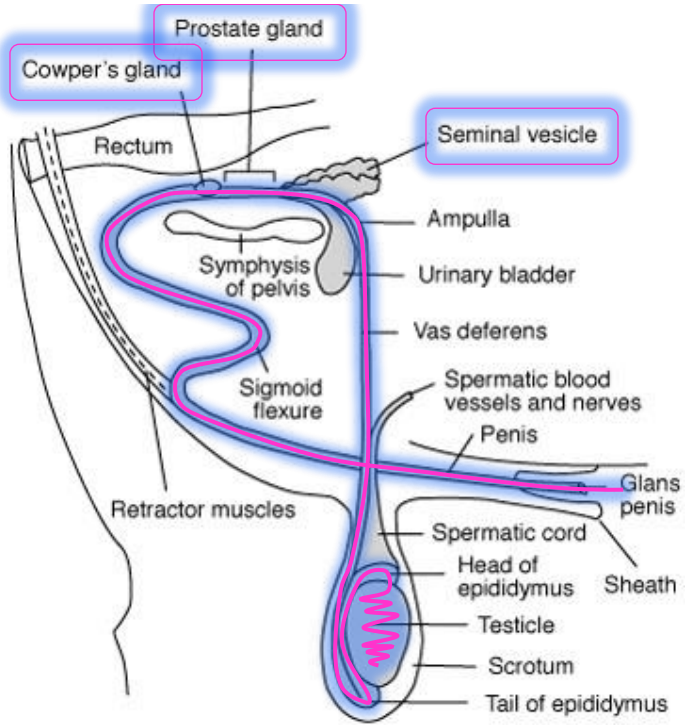
- The vas deferens enlarges inside the pelvis to form the ampullae
  - Where spermatozoa are stored and mixed with a nutritive substance.

- During copulation, sperm is moved into the urethra.
  - This is a common pathway for both urine and semen (the mix of the products of the testes and accessory glands.) ~



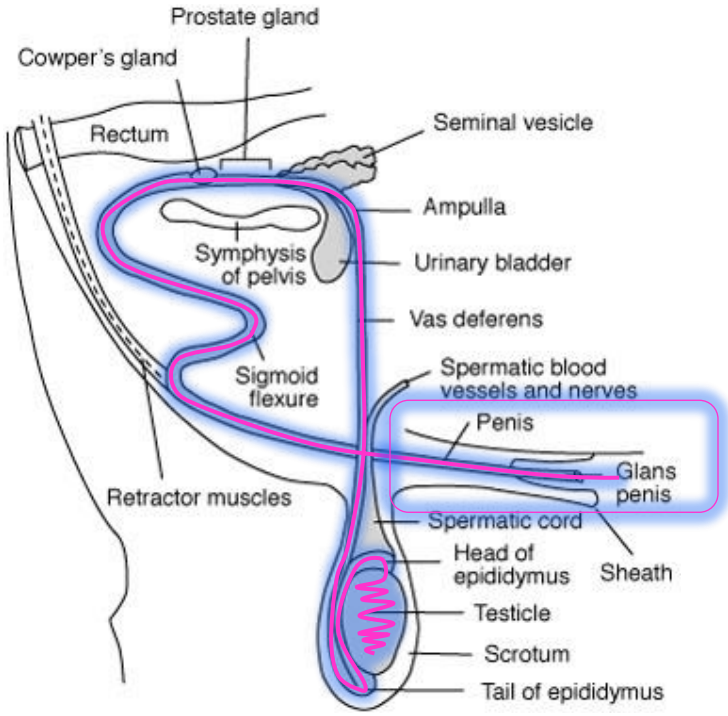
Accessory Glands (3)

- There are three accessory glands:
  - 1. Seminal Vesicles – secrete a fluid high in sugars (fructose) to nourish the spermatozoa – feels like a bag of grapes (palpation)
    - This fluid also dilutes sperm at ejaculation and serves to activate motility – the bulk of fluid production occurs here
    - Rich in proteins, fructose, enzymes.
    - Secretes prostaglandins, causing uterine contractions
  - 2. Prostate glands – Creates a basic pH of 7.5-8 – protects sperm
  - 3. Cowper's gland – lubricating & cleansing substance
    - Cleanse male and female reproductive tracts prior to passage of spermatozoa (King Sperm's archers)
- These secretions are released almost instantaneously
- Yellowed cloudy semen secretions may indicated an infection in these glands

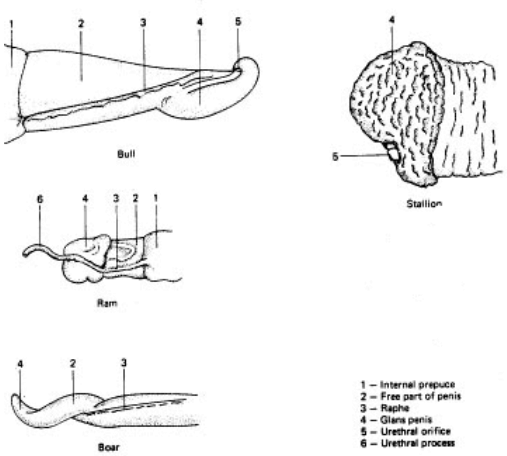


Urethra and Penis

- The urethra extends to the tip of the penis (phallus), where it exits the body.
- Urethra surrounded by smooth muscle – crucial for ejaculation.
- Penis is composed of sponge-like blood tissue
- Under sexual stimulation, this tissue fills with blood, enlarging it and enabling it to be inserted into a female's vagina.
  - Otherwise, it is kept inside the body cavity in most species



Structure of the Penis



What causes ejaculation?

- Bull – temperature
- Ram - ??
- Boar – pressure
- Stallion – nerves

Sperm SUSCEPTIBILITY

- Sperm are not hardy; they are rather fragile cells
- They are very susceptible to:
  - Heat
  - Jarring (Shock)
  - Radiation
  - Poor Nutrition
  - Infrequent ejaculation (increases abnormalities)
    - A mature bull can ejaculate as much as 7 consecutive times without a severe reduction in spermatozoa

Infertility

- Infertility is not immediately recognizable!
  - Symptoms may show 2.5-3 mo's after!
  - It takes ~70 days to produce sperm, and over two weeks to travel through the epididymus.
- A mature bull should produce 70 billion sperm/week.
  - The heavier the testes, the more sperm is produced.

Briefly – EDC's

- Endocrine Disrupting Chemicals are a serious concern today.
- These chemicals have similar chemical conformations to sex hormones and mimic their effects in the body.
- What impact would this have on a body; remember negative feedback! ~

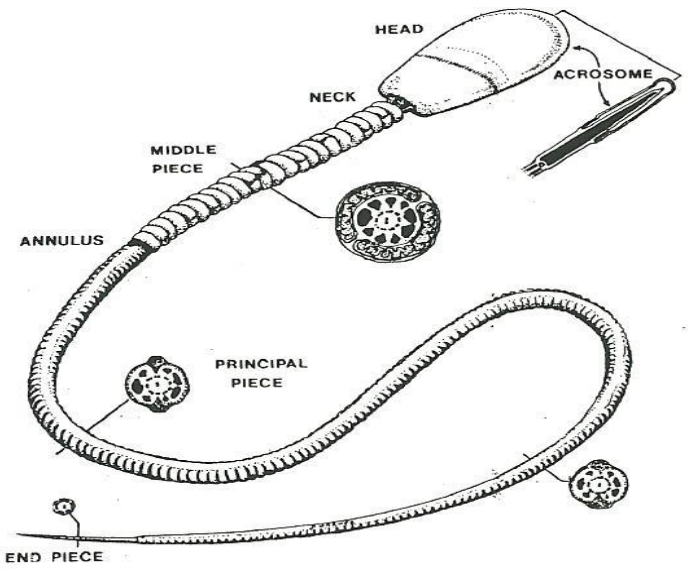
EDC's

- "To date, in vitro and in vivo studies have identified several antiandrogenic toxicants including vinclozolin, procymidone, linuron, several phthalate esters, and *p,p*'-DDE, all of which alter male rat sex differentiation."
  - Emerging Issues Related to Endocrine Disrupting Chemicals and Environmental Androgens and Antiandrogens
  - Gray, et. al. , US Environmental Protection Agency ~

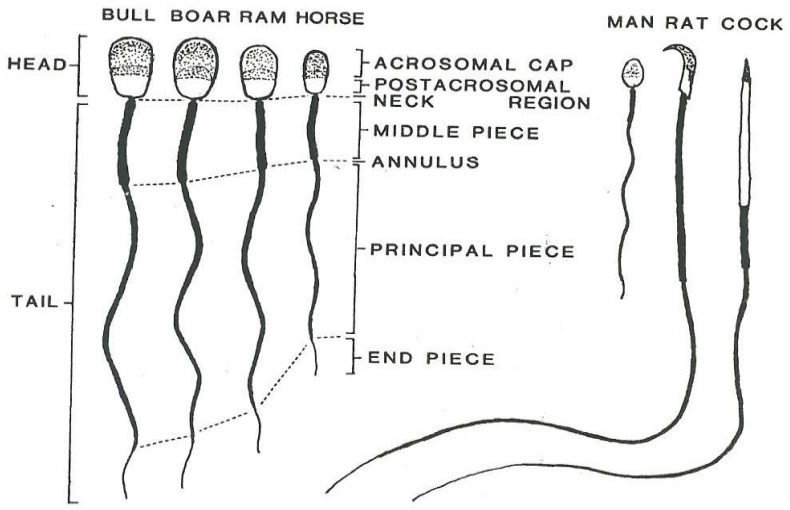
A Concern

- In humans and other mammals, male fertility has dropped significantly.
- This has also been seen in cattle; it is much harder to breed a cow today than it was 50 years ago.
- Furthermore, cases of sexual abnormalities have increased in amphibians and reptiles.
- Is this genetic or environmental? ~

SPERMATOZOON



SPERMATOZOA



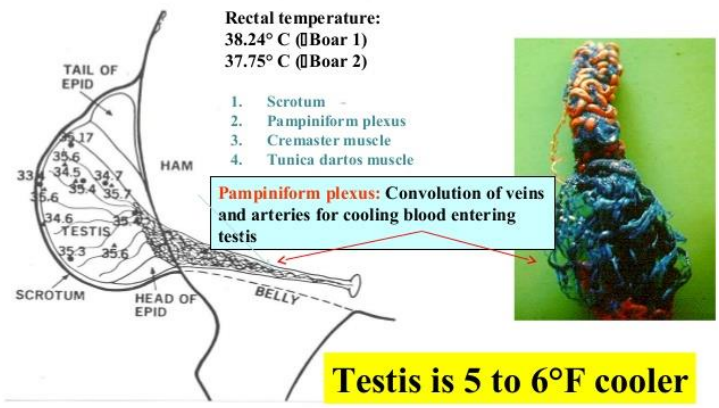
§ Testicular Thermoregulation

- **Sperm cannot be produced at core body temperature (too warm):**
  - **1. pampiniform plexus** = near testicular artery, a network of veins– forming countercurrent heat exchanger that cools arterial blood entering testis by 1-2 degree Celsius (Fig. 27.8)
- **When Cold:**
  - **2. cremaster muscle** = pulls testes close to body when cold
  - **3. dartos muscle--**
    - Contracts and scrotum becomes taut
    - wrinkles skin reducing surface area of scrotum

27-17

Temperature Control

Thermoregulatory Mechanism of Testis



Levis

Temperature Control (Thermoregulation)

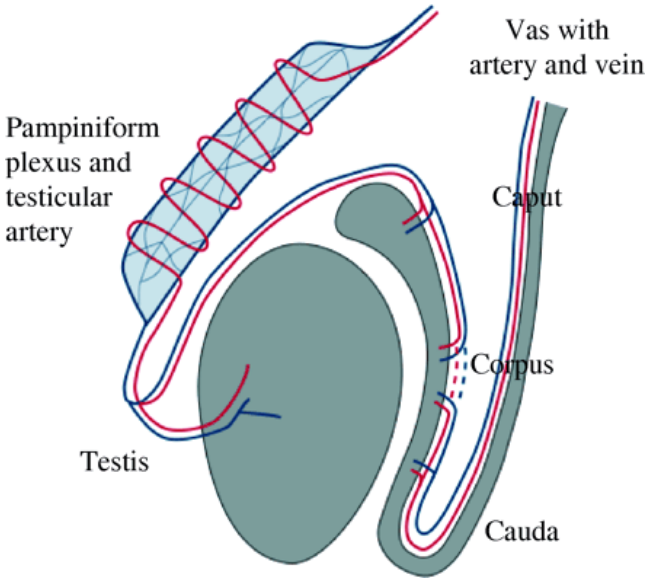
Effect of season on percent discarded ejaculates

Stud[2]	Winter (%)	Summer (%)
A	6.7 ± 1.0	21.4 ± 3.4
B	8.2 ± 1.3	10.7 ± 2.8
C	2.4 ± 0.9	18.8 ± 3.7
D	4.5 ± 1.1	35.4 ± 8.9

[1]% motility or % normal morphology was < 70% in ejaculates not used.
[2]means are from ~ 2000 ejaculates / stud / season.

(Flowers,NCR-57,2002, unpublished)

Temperature Control (Thermal Regulation)

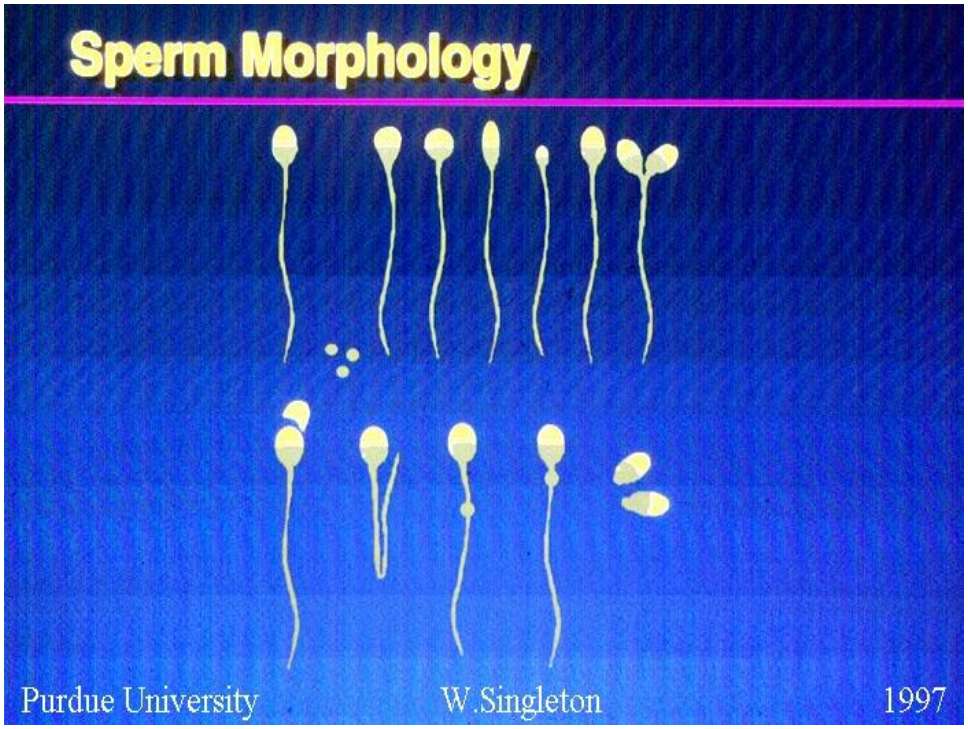


Temperature Control

- The testicles must located outside of the male's body as normal sperm formation occurs at a temperature several degrees below normal body temperature
  - Very cold temperatures can also damage the scrotum.
- To keep the testicles at the proper temperature, the cremaster muscle suspends or retracts to move the testicles closer to or further from the body
  - Testosterone causes this response; no testosterone, no cremaster function
- This muscle can be damaged or other injury or malformation can prevent one or both testicles from descending. This condition is called cryptorchidism
- An individual with this condition will be partially or fully sterile and this individual should not be allowed to breed.

Semen Characteristics

Species	Ejaculate vol. (mL)	Sperm Conc. (millions/mL)	Sperm # per ejaculate (Billions)
Bull	5-8	800-2,000	5-10
Ram	0.8-1.2	2,000-3,000	1.6-3.6
Boar	150-500	200-300	30-60
Stallion	60-100	150-300	5-10
Cock	0.2-0.5	3,000-7,000	0.6-3.5
Human	2-5	100-1,000	0.1-2.0



How much semen is produced & useable during AI

TABLE 11-2 Characteristics of Semen from Farm Animals

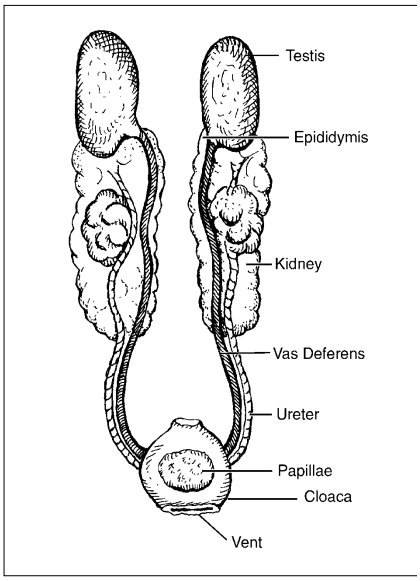
Characteristics	Cattle	Goats	Horses	Sheep	Swine
Volume of ejaculate (ml)	5	0.8	30	1	225
Sperm concentration (10^9/ml)	1.1	2.4	0.15	3.0	0.2
Motile sperm (%)	70	80	70	75	60
Ejaculates/week	4	20	3	20	3
Motile sperm (AI)	10	60	100	120	1,200
Females inseminated/ejaculate (AI)	350	25	60	20	20

SOURCE: Compiled from Bearden and Fuquay, 1997, and Cole and Garrett, 1980.

POULTRY Reproductive System

Papillae – located at the end of the vas deferens and on the floor of the cloaca, the papillae emit semen into the cloaca of the female.

Phallus – a rudimentary copulatory organ that becomes engorged with lymph during mating, which allows semen to be deposited onto the female's everted cloaca; the phallus is more developed in ducks and geese.



Causes of sterility

- Conditions other than cryptorchidism can also cause sterility in males, including
- - excessive fat deposits in the scrotum
- - a very high fever or high fever over several days
- - very hot weather for an extended period of time

- If the male was producing sperm prior to these occurrences, sperm production may resume after 6-10 weeks.