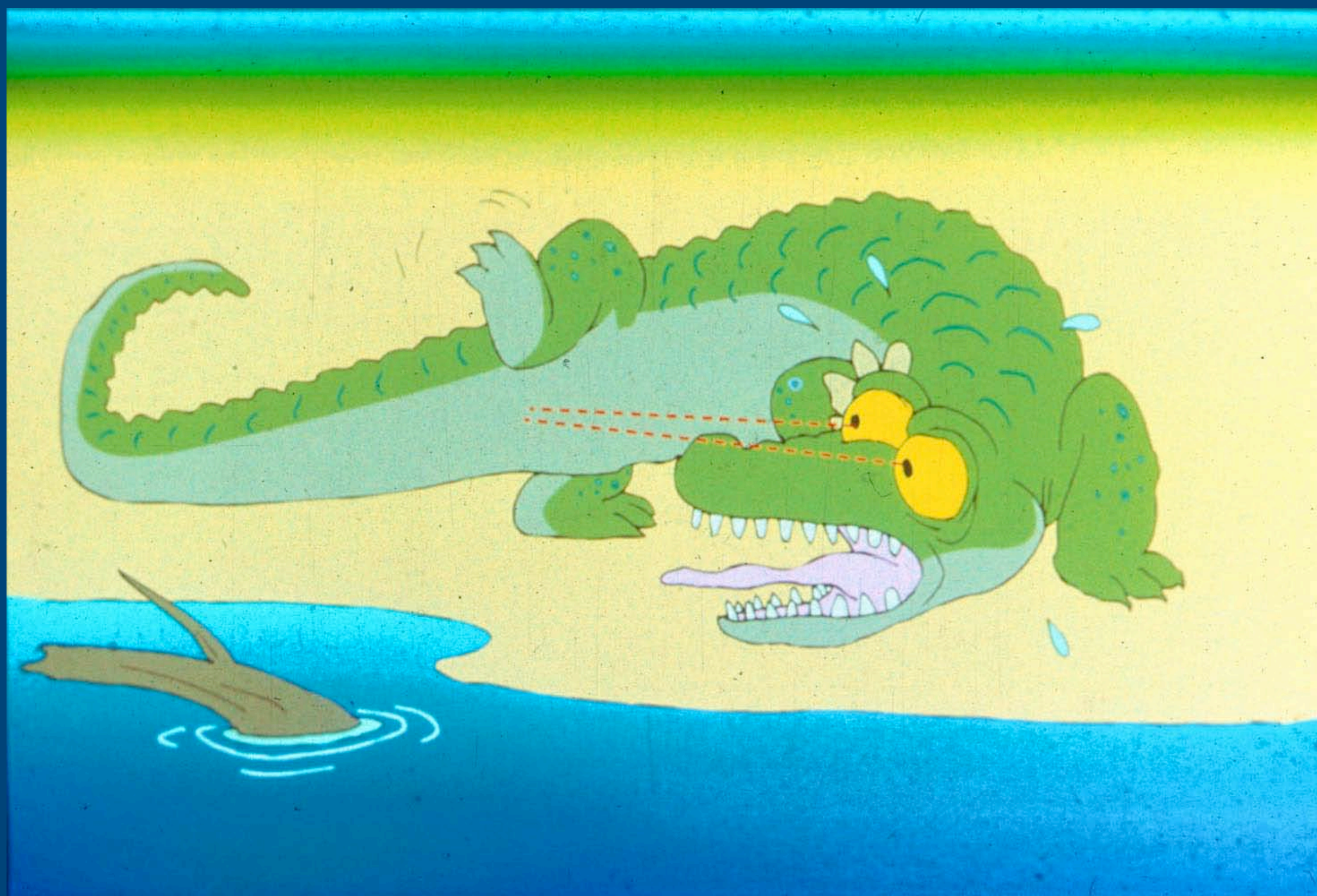
# Male Anatomy



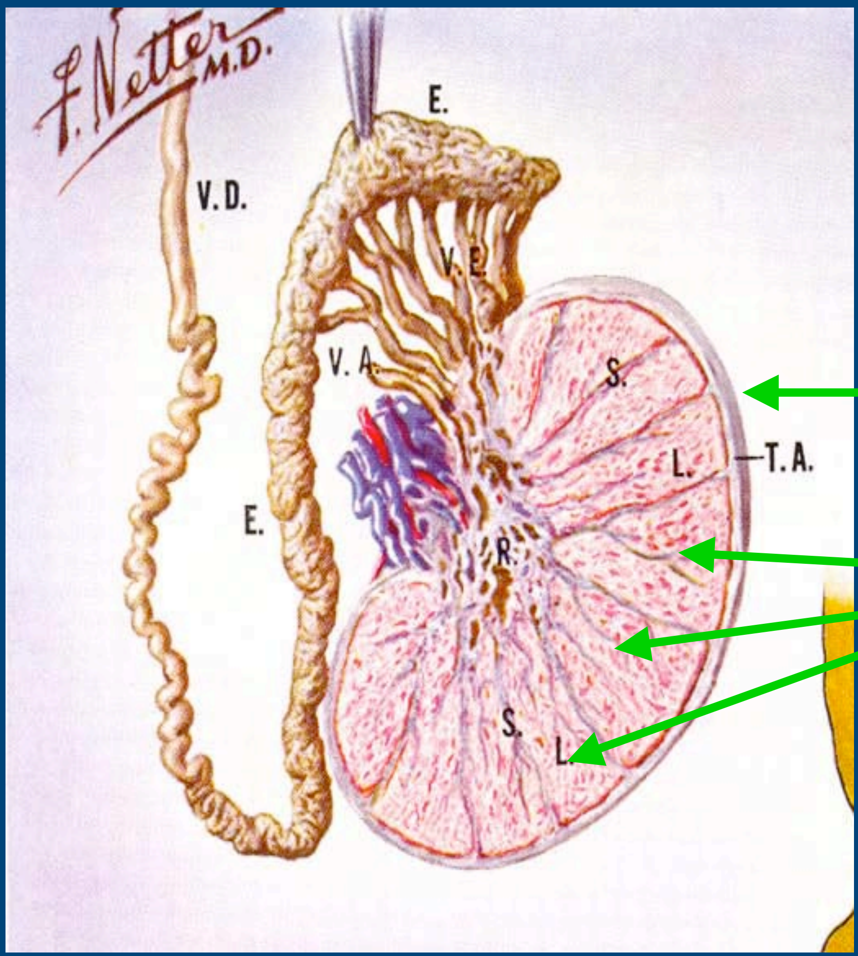
# Male Anatomy

- Primary Organ
  - testes, genetically determined in mammals
  - testis releases hormones that then control the development of secondary sex characteristics

1) Secondary Organs
   - internal duct system
     - e.g., vas deferens, epididymus
   - external genitalia

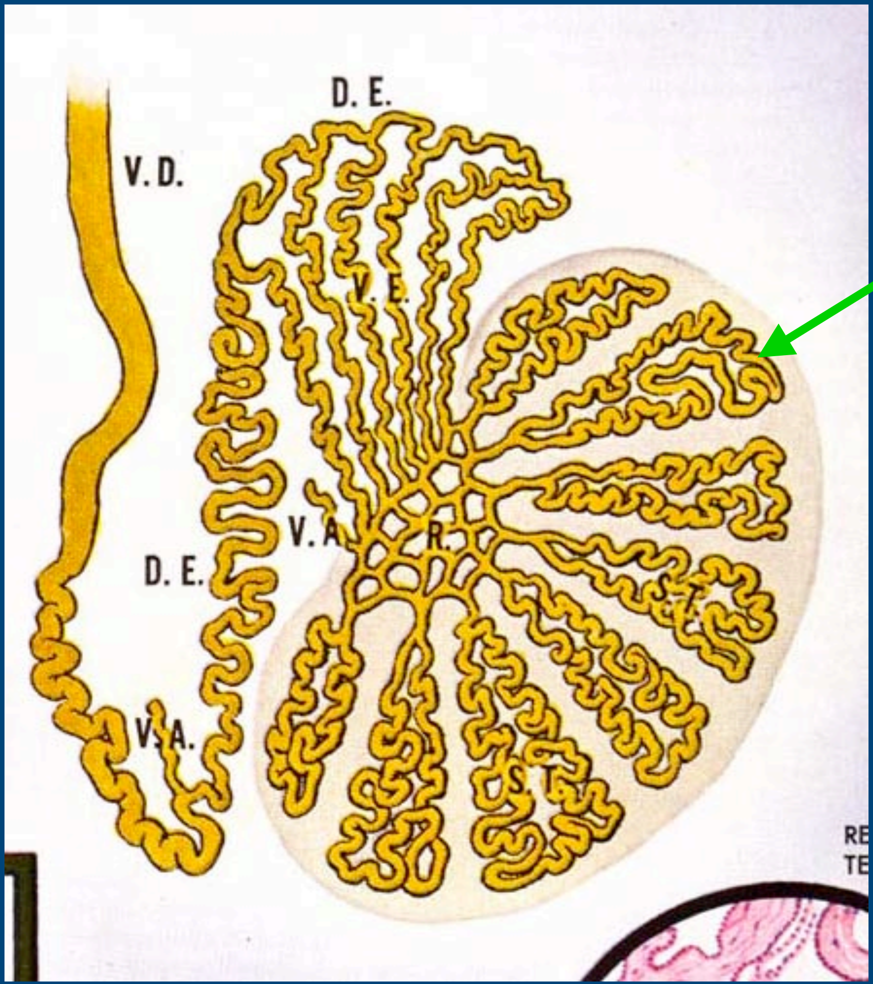
2) Secondary Sexual Characters
   - e.g., antlers, coloration, facial hair

# Eutherian Mammal Testes



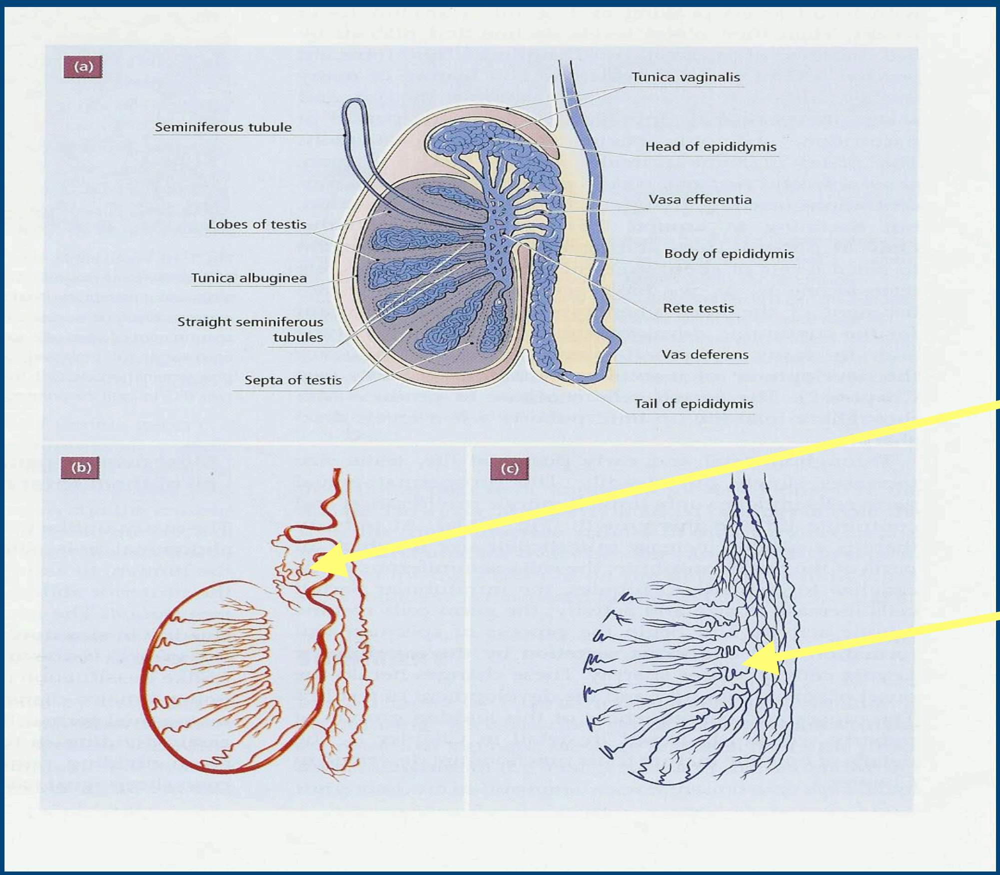

- Paired and oval shaped
- Shiny connective covering called the Tunica Albuginea
- Divided into testicular lobules
  - Approximately 250 in human testis

# Seminiferous tubules (ST)




- Each testicular lobule contains several coiled seminiferous tubules (ST)
  - ST site of sperm production
- Each ST ~ 1.3 ft in humans
- Total length of ST almost the length of a football field

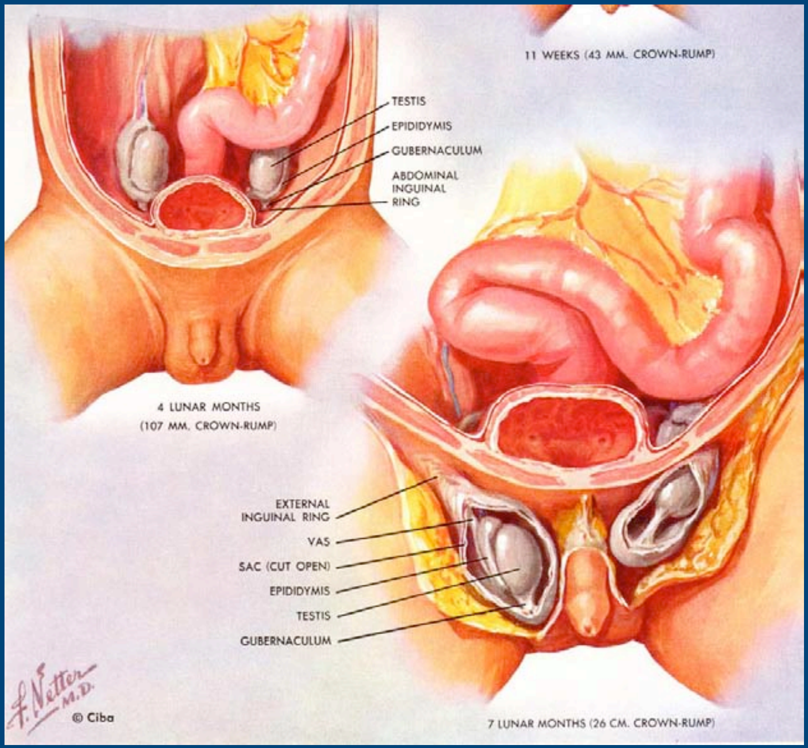
# Testis vascularization




Arterial supply

Venous supply

# Testicular development




- Develops in the abdominal cavity from the medulla of the primordial gonad

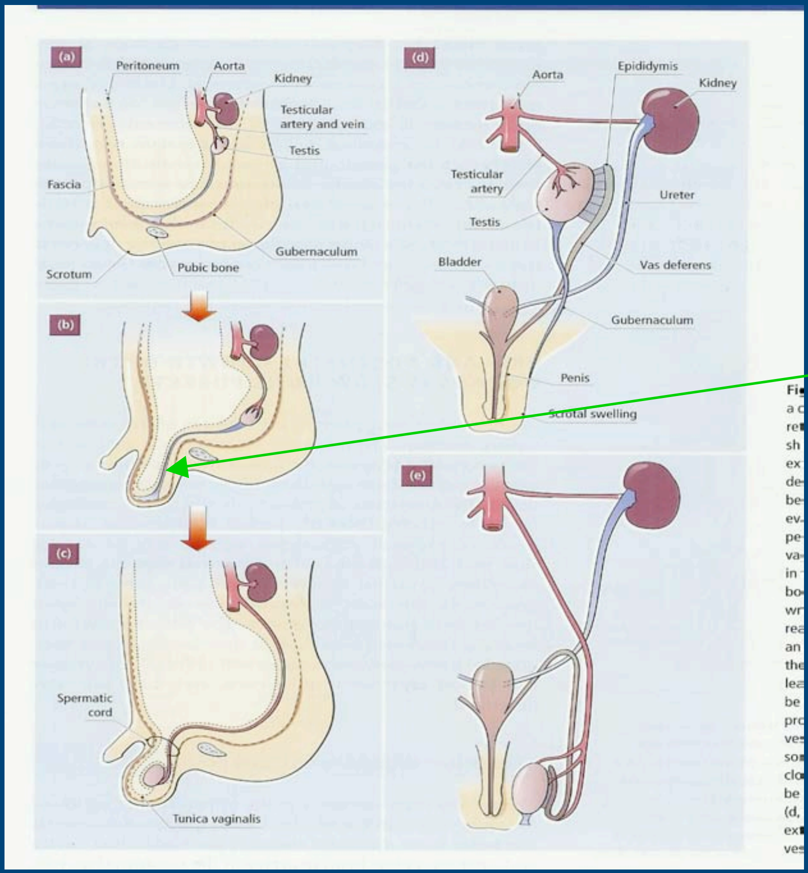
# Testicular location

- In most animals the testes lie in the scrotum
- Exceptions:
  - **Lumbar**: monotremes, elephants, hyraxes, reptiles, fishes
  - **Inguinal canal**: hedgehogs, moles, some seals
  - **Seasonal migration**: wild ungulates, most rodents

Reasons for scrotal position unclear

- sexual selection ?, cooling testis?

# Models for testicular migration




Johnson and Everitt 1.8

- Testis is firmly attached to abdominal wall by:

**1) <u>Posterior gonad ligament</u>**
**<u>(Gubernaculum)</u>** - as body grows the gubernaculum does not, thus testis is drawn downward

-in females gubernaculum grows

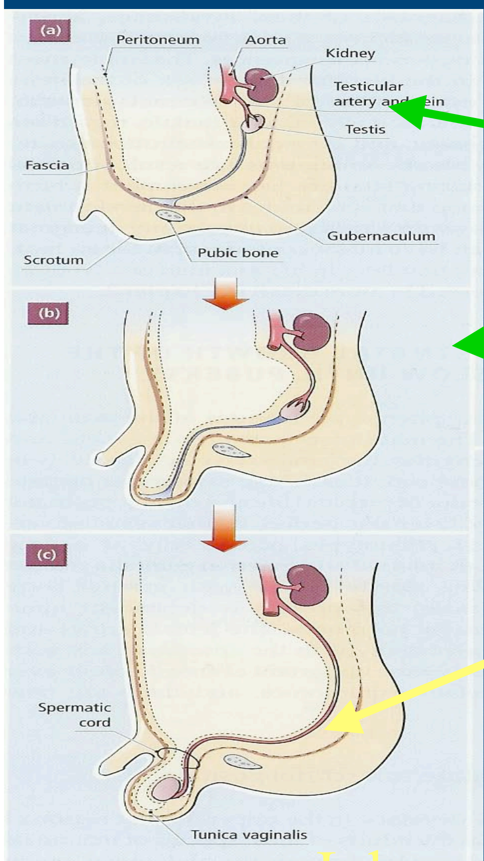
# Hormonal control of testicular migration

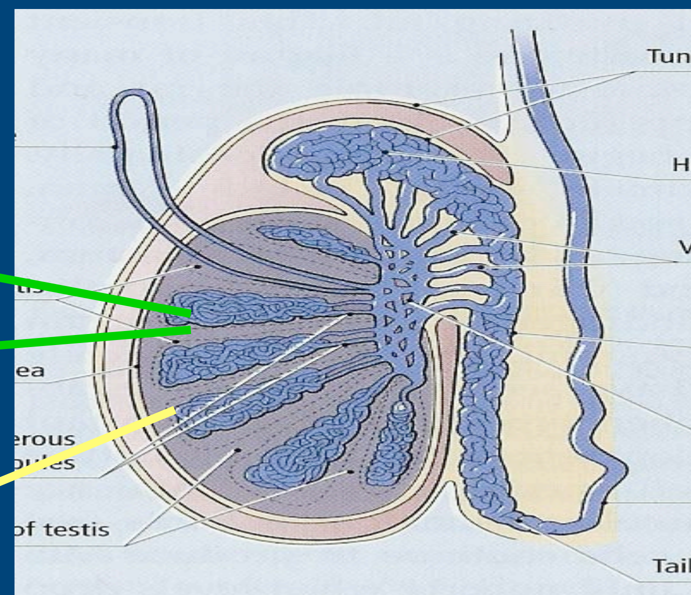
- Migration of testis thought to involve 2 hormones produced by testis

  1) MIH – mullerian inhibiting hormone
     1) Involved in transabdominal migration

  – **Testosterone**- stimulates genitofemoral nerve to produce nueropeptide calcitonin gene-related peptide (CGRP)
     – CGRP stimulates transinguinal and scrotal migration

# Hormonal control of testicular migration (2)




MIS

Androgens

Johnson and Everitt 1.8 & 1.9

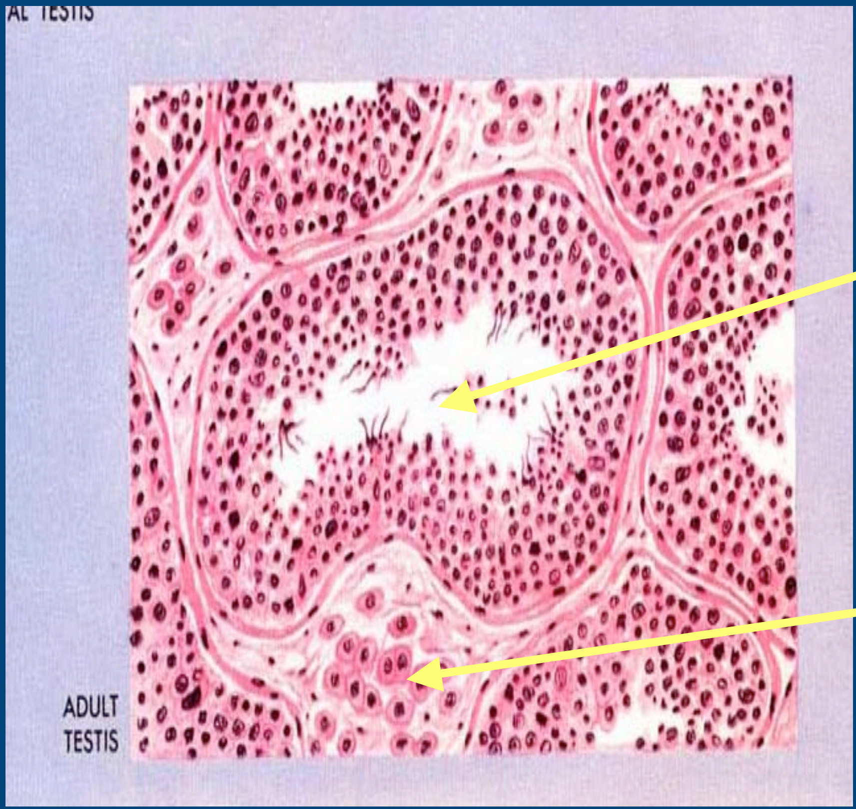
# Abnormalities in testis migration

1) **<u>Cryptorchism</u>** "abdominal" testis

   -testis does not descend properly

   - detrimental to spermatogenesis and normal testicular metabolism
   - Rise in humans in US and Europe by about 250% in the last 30-40 years
   - Leads to arrested spermatogenesis
     - 4-7 degrees C below body temp ideal

# Testicular Histology




Testis is made up of 2 major compartments

1) **Region inside seminiferous tubules**

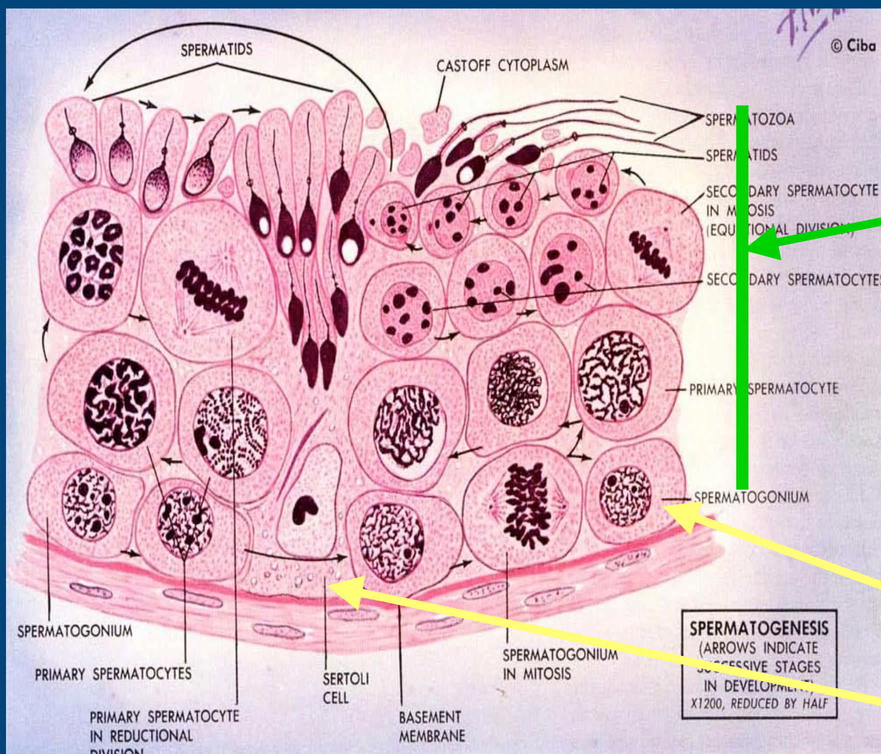
   **Spermatozoa development**

2) **Interstitial space outside ST**

   **- Leydig cells,**

   **- Androgen Production**

# Seminiferous Tubules

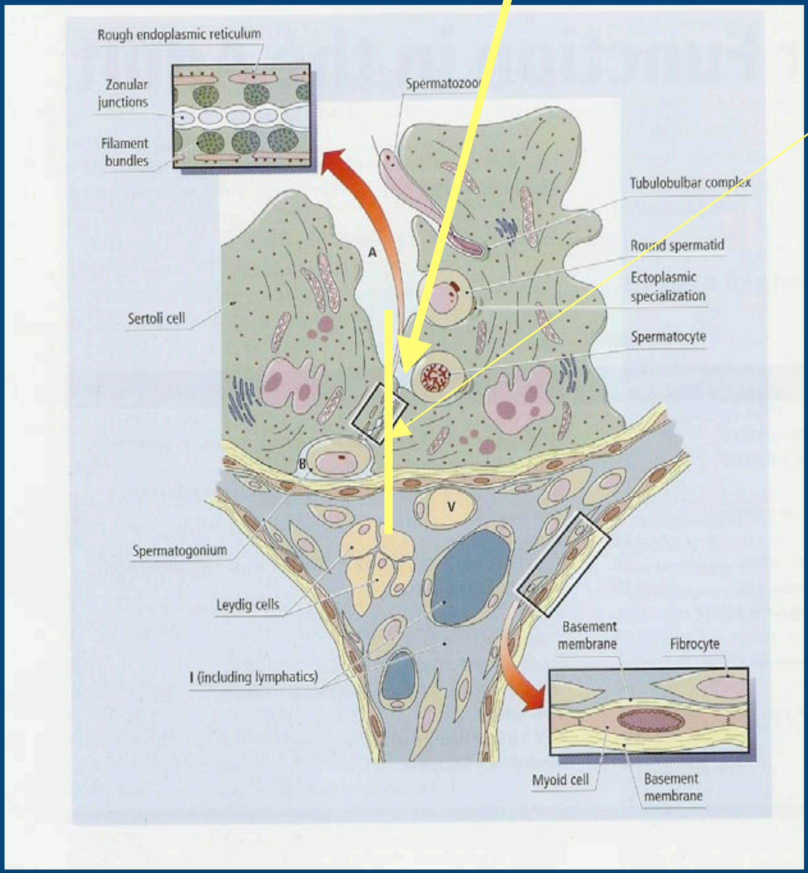



- Seminiferous tubules are lined by a <u>germinal epithelium</u>
- Primary product is spermatozoa
- Two cell types are found within ST
  - Germ cells
  - Sertoli cells

# Interstitial space


- Outside the ST lie Leydig cells
  - Responsible for androgen production in response to LH

# Blood testis barrier




Johnson and Everitt 4.1

Limits fluid transfer between adluminal and basal and interstitial compartments

Prevents gametes entering interstitial space

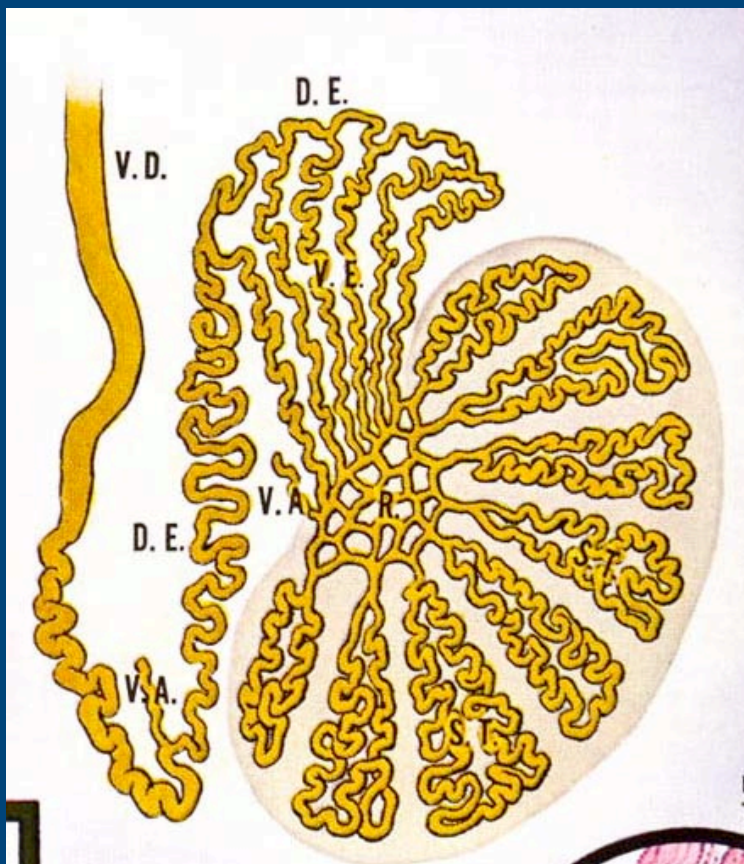
# Blood testis barrier 2

- The two compartments are separated by a blood testis barrier
  - Consists of a series of gap and tight junctions that serve as a physiological barrier separating the sertoli cells from the capillaries located in the interstitial space.
  - **Function**: prevents immune response to "foreign" protein of gametes
    - Sperm granuloma

# Ducts in males

- All ducts in human **males** are derived from the primitive kidney
  - termed the **Wolffian ducts (or archinephric duct)**

# Ducts in males




1) **Seminiferous tubules** –

2)**Tubuli recti** (straight tubules)

3) **Rete testis**- branched network of ducts

4) **Vasa efferentia**- carry to single common duct

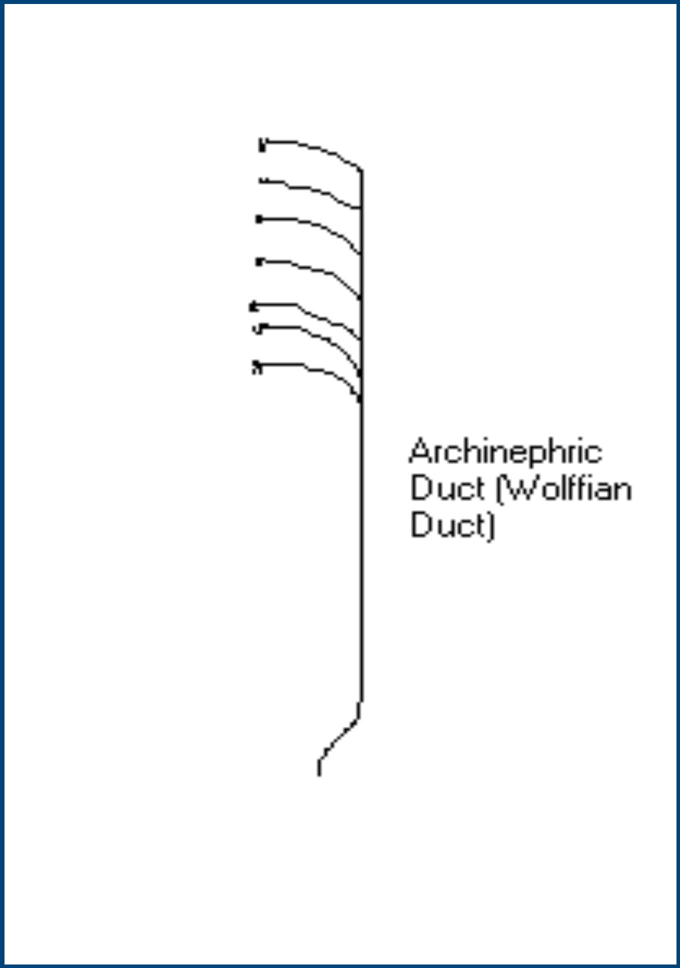
5) **Epidydmis**- single duct (>15 ft in human male)

6) **Vas deferens** pass out scrotum through inguinal canal to the urethra.

Evolution and Embryonic development of the duct system in males

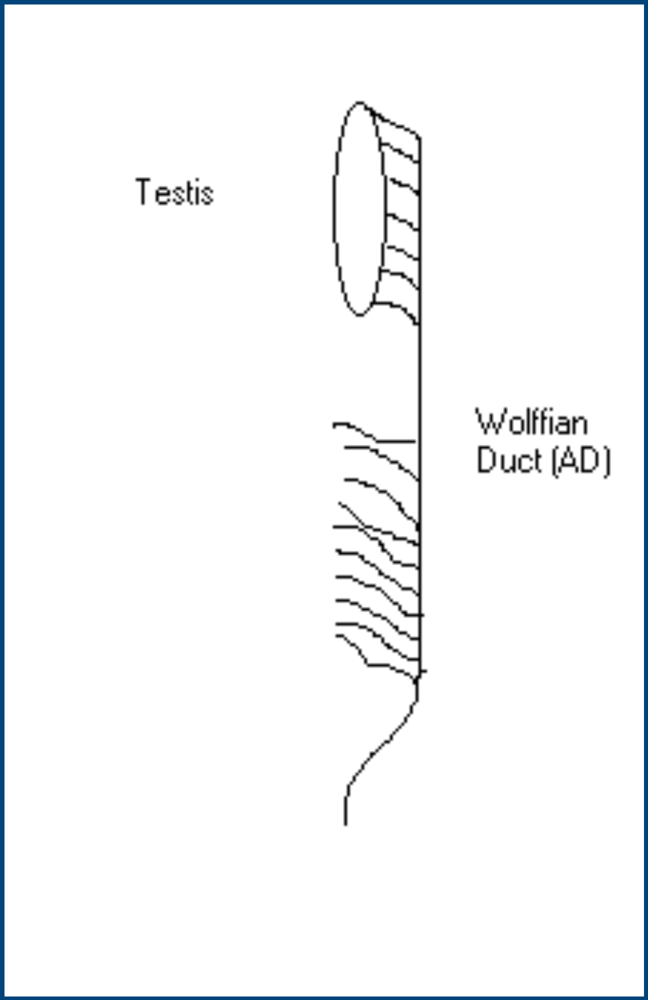
- pronephric kidney
-mesonephric kidney
- metanephric kidney

# Pronephric kidney



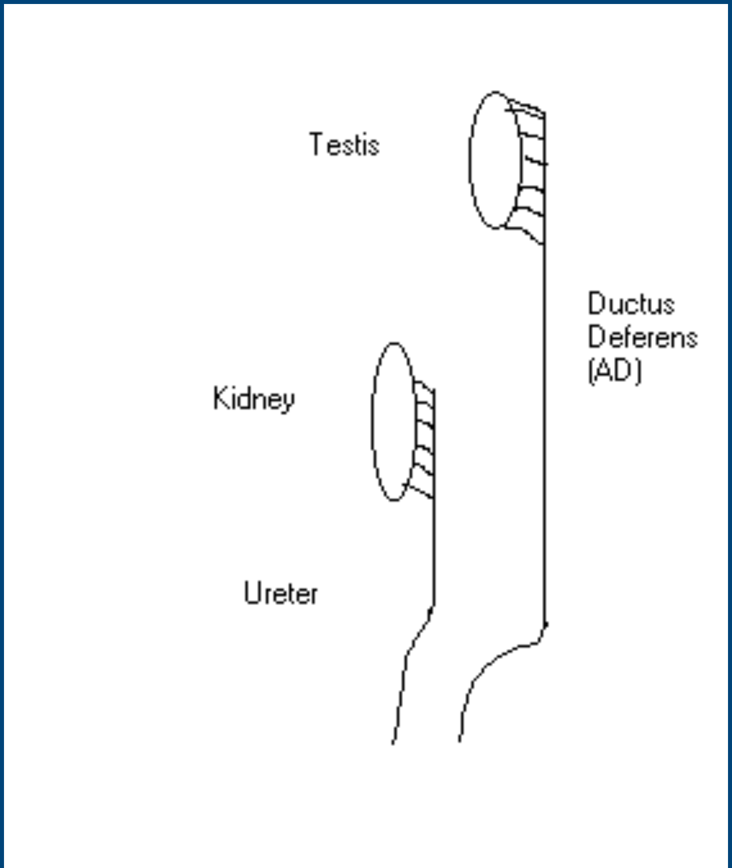

- **1st kidney to form in humans**
  * It is the **functional kidney** of fish and larval amphibians
- Develops anteriorly then degenerates in amniotes
- Remaining duct called the Wolffian Duct (AD)
  – Sperm transport in amniotes

# Mesonephric Kidney



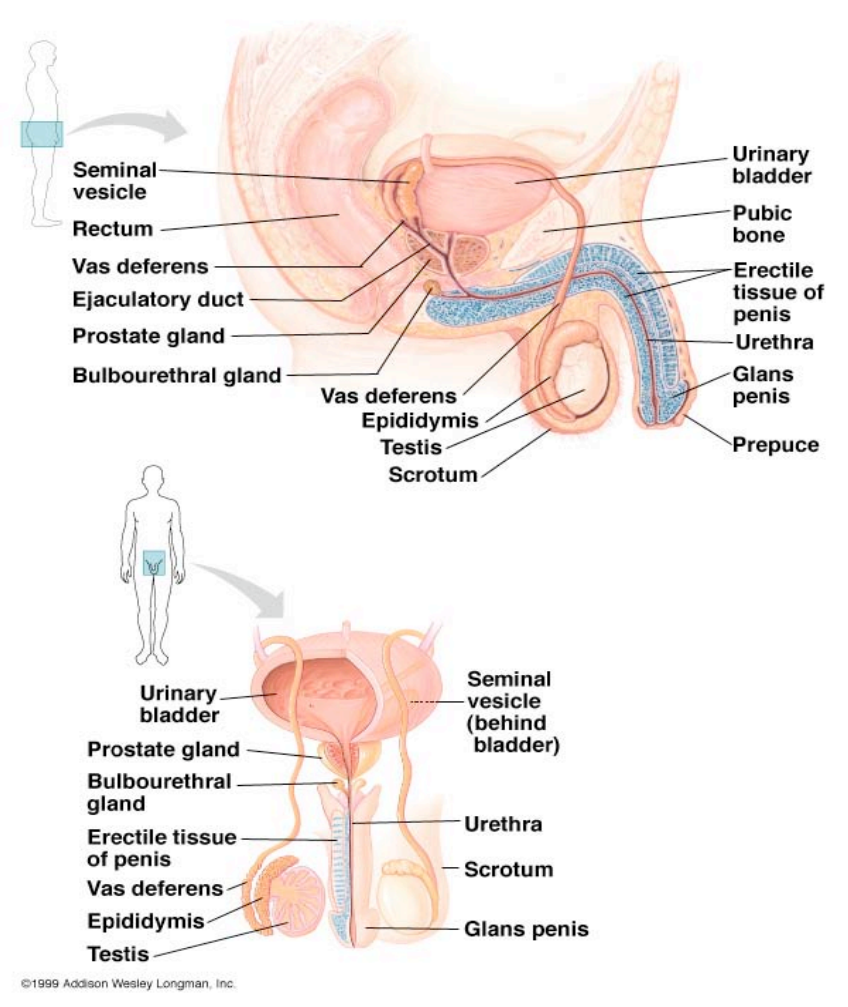

- $2^{nd}$ kidney
- 30 tubules form in humans
- As tubules form caudally the anterior ones die off
- Female mammals- all tubules die
- Male mammals- tubules become sperm ducts of testis
- Functional Kidney: anamniotes

# Metanephric kidney (metanephros)



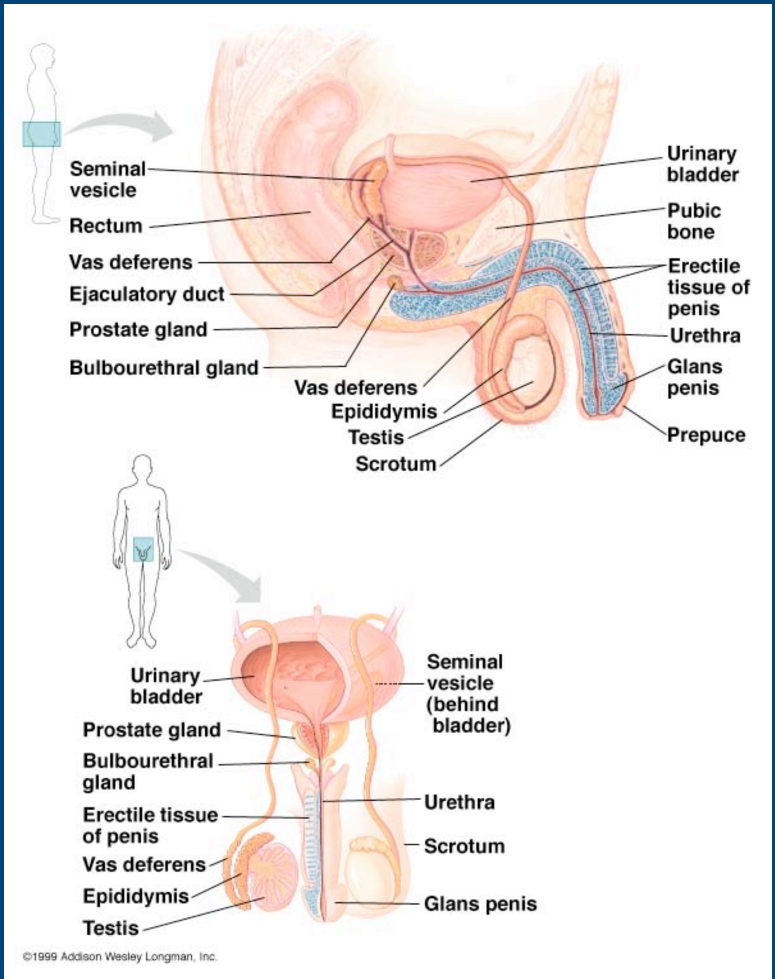

- Permanent kidney of amniotes
- Serves both as an excretory and osmoregulatory organ
- Ureter transports urine
- Ductus Deferens (AD)transports sperm

# Accessory Glands



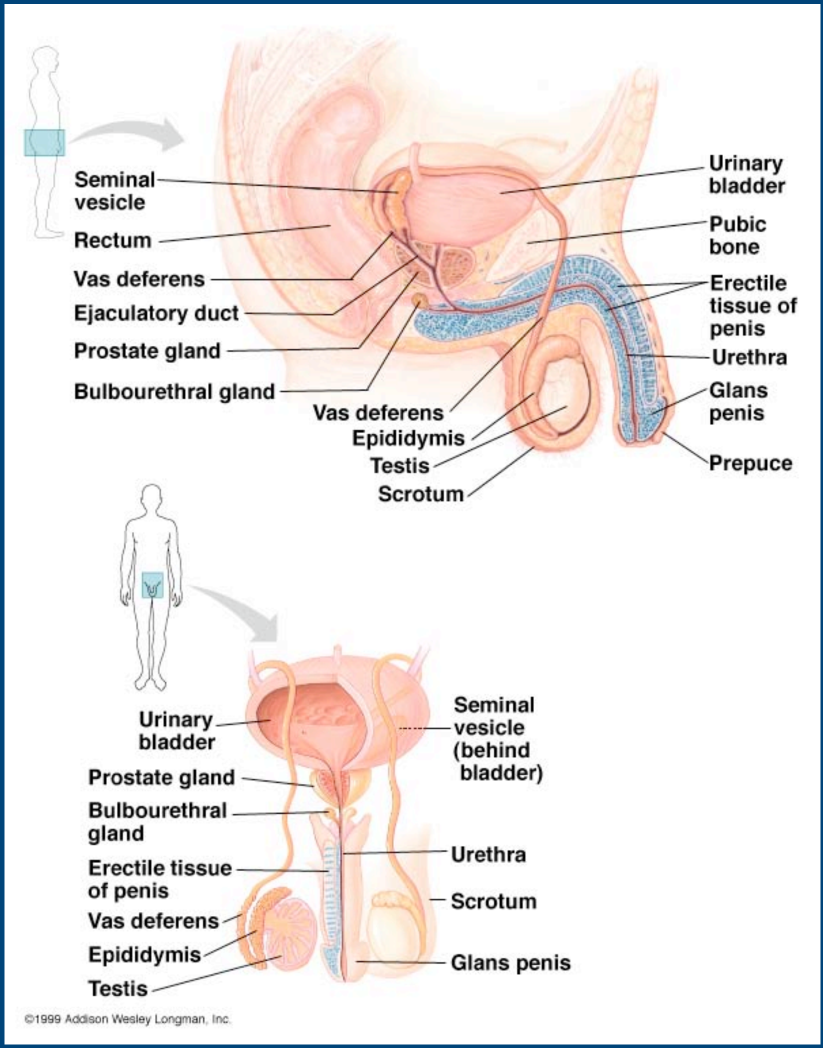

- Seminal Vessicles
- Prostate gland
- Bulbourethral glands
- Involved in the production of semen

# Seminal Vesicles



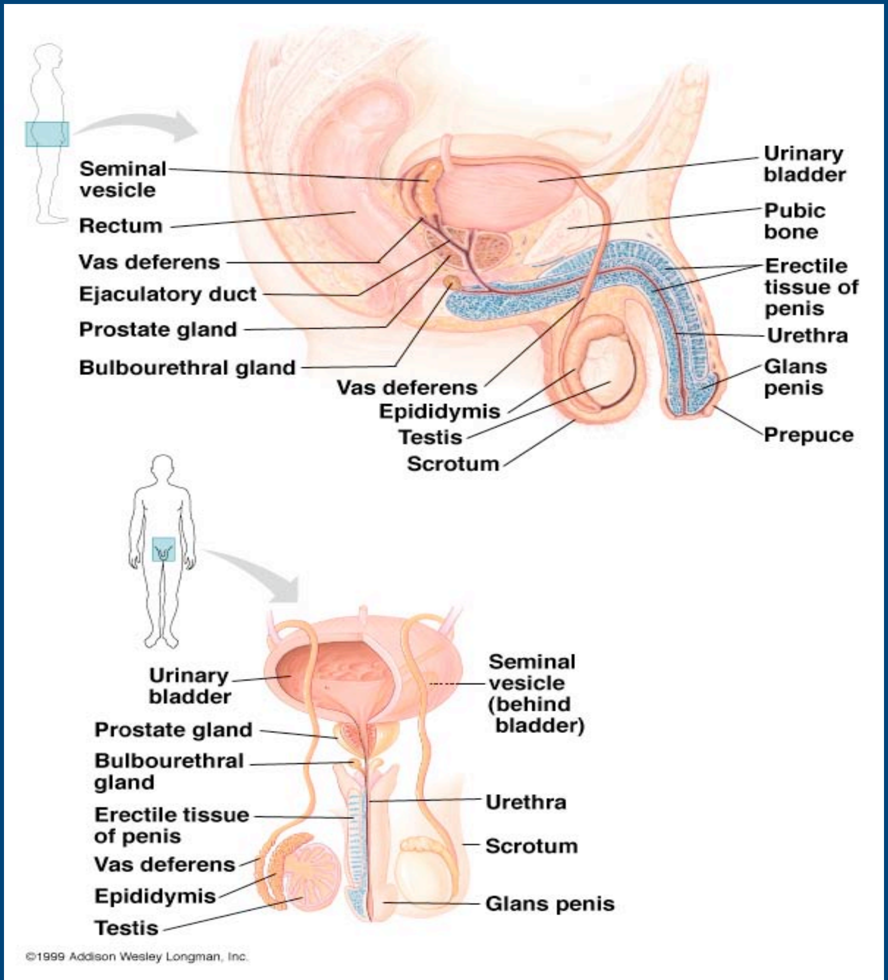

- Secrete alkaline, viscous fluid
- High fructose content
- Comprises the majority of semen

# Prostate Gland




- Adds an alkaline solution to semen
- Facilitates a favorable environment for sperm in the more acidic vagina and female reproductive tract
- 13-33% of semen

# Bulbourethral Glands

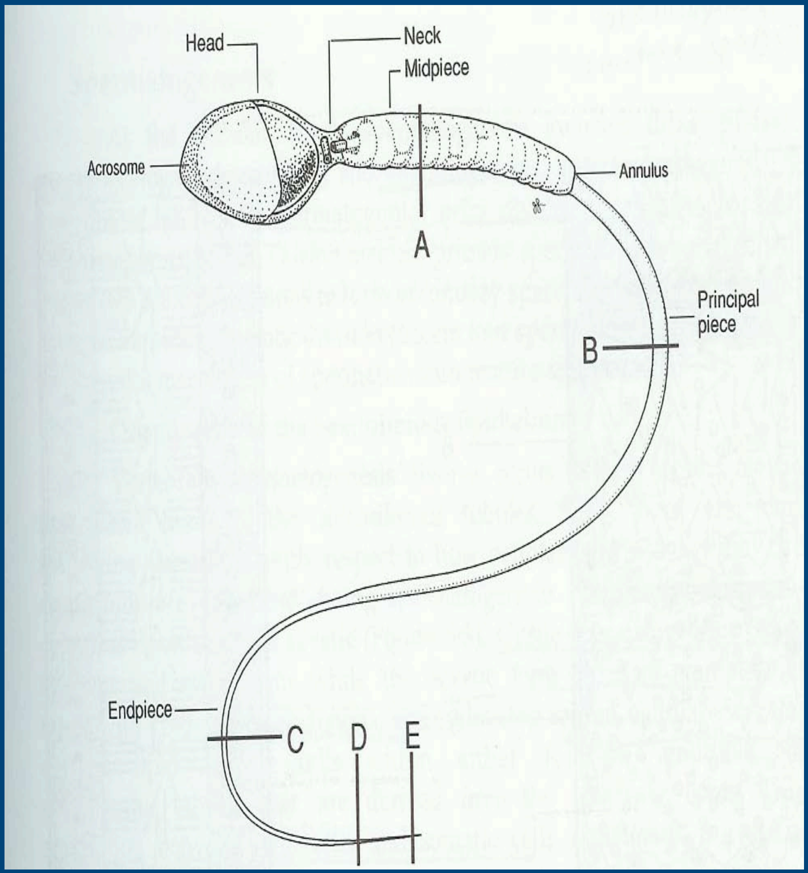



- Secrete lubricant

# Function of Ducts and Accessory Glands

- Sperm transport
- Sperm Storage
- Sperm maturation
- Production of semen

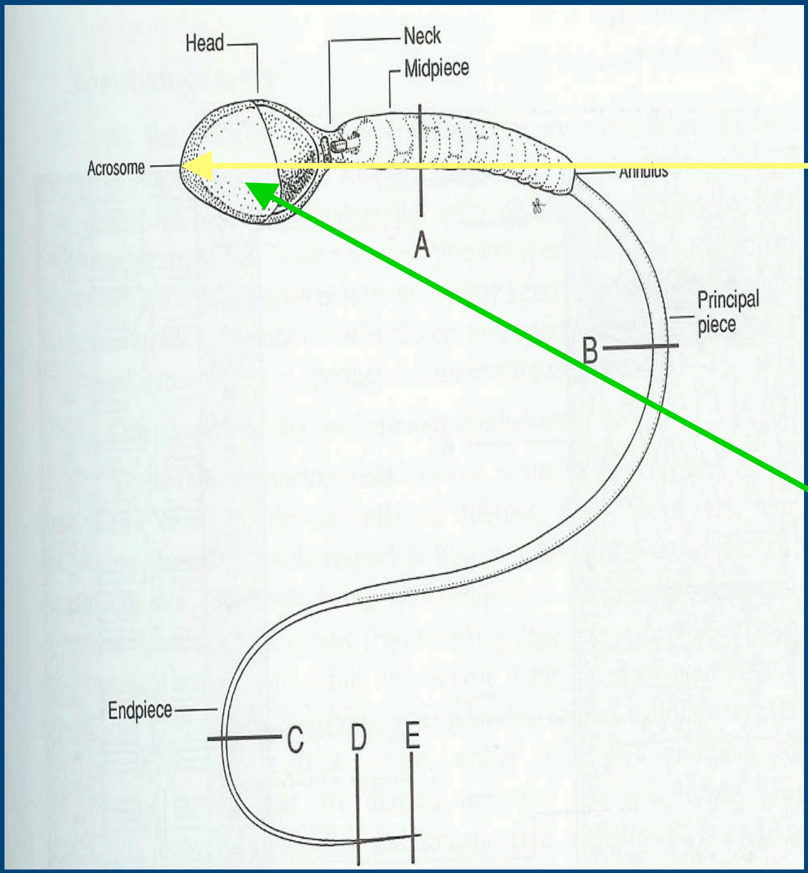
# Sperm anatomy




Lombardi 5-2

- Head and tail components of mature spermatozoan
  - Head contains genetic material (1N)
  - Tail responsible for generating propulsive forces

# Sperm Anatomy 2




Lombardi 5-2

- Sperm head
  - Lysosomal cap containing hydrolytic enzymes': acrosome cap
  - Nucleus containing chromatin

# Sperm structures vary widely



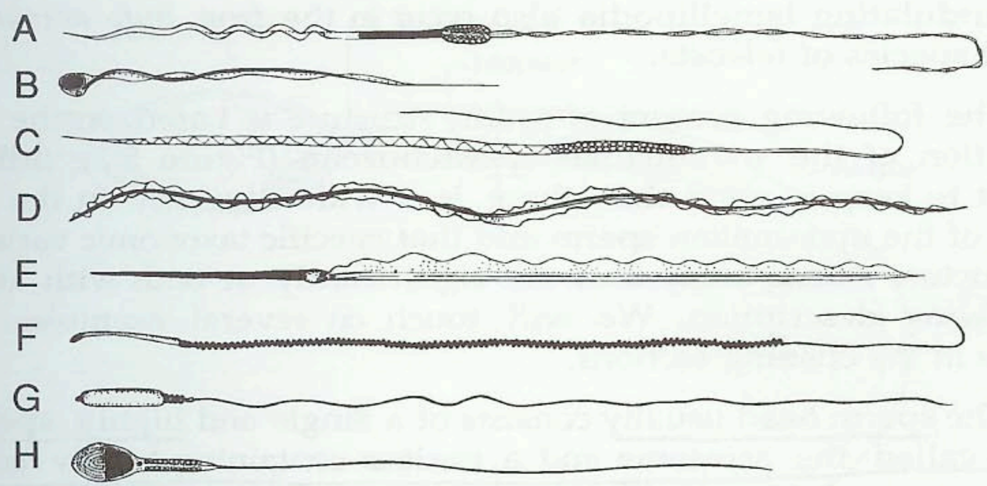
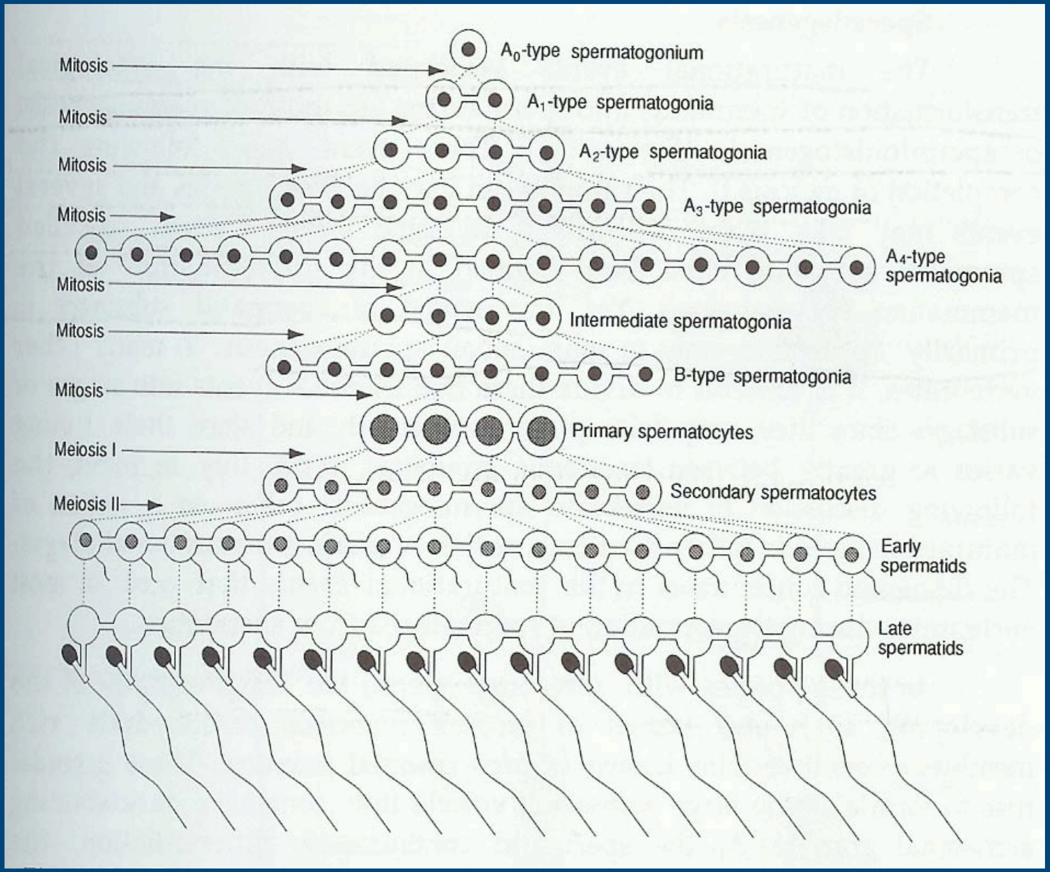



*Figure 5.1* Variation in the structure of vertebrate spermatozoa. A,B,C, fishes; D, amphibian (*Pseudobranchus striatus*)(after Noble); E, amphibian (*Triturus marmoratus*)(after Angel); F, G, birds; H, mammal (*Homo*). Sperm are not to scale.

Lombardi 5-1

# Spermatogenesis

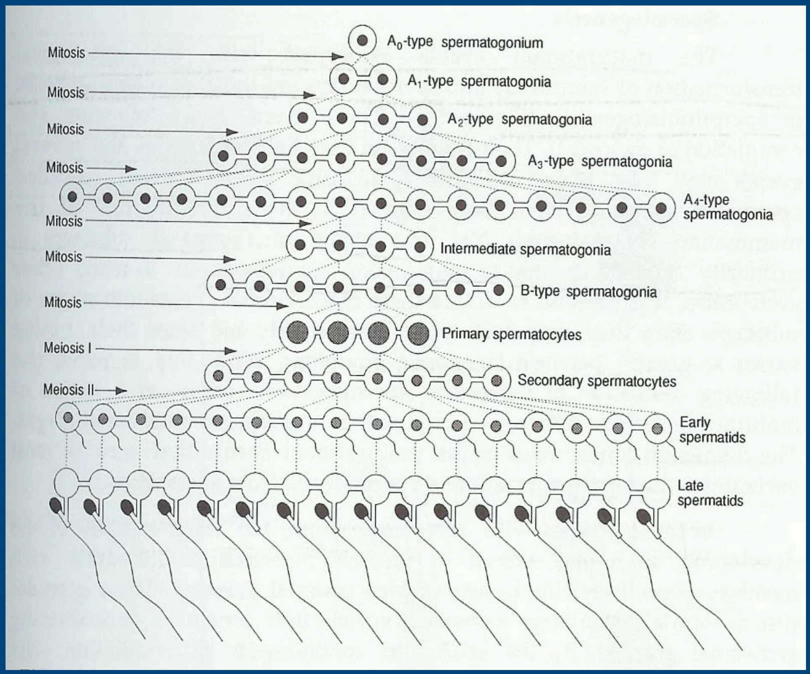



4 spermatids (1N) per meiotic cycle

Lombardi 5-5

# 3 phases of spermatogenesis

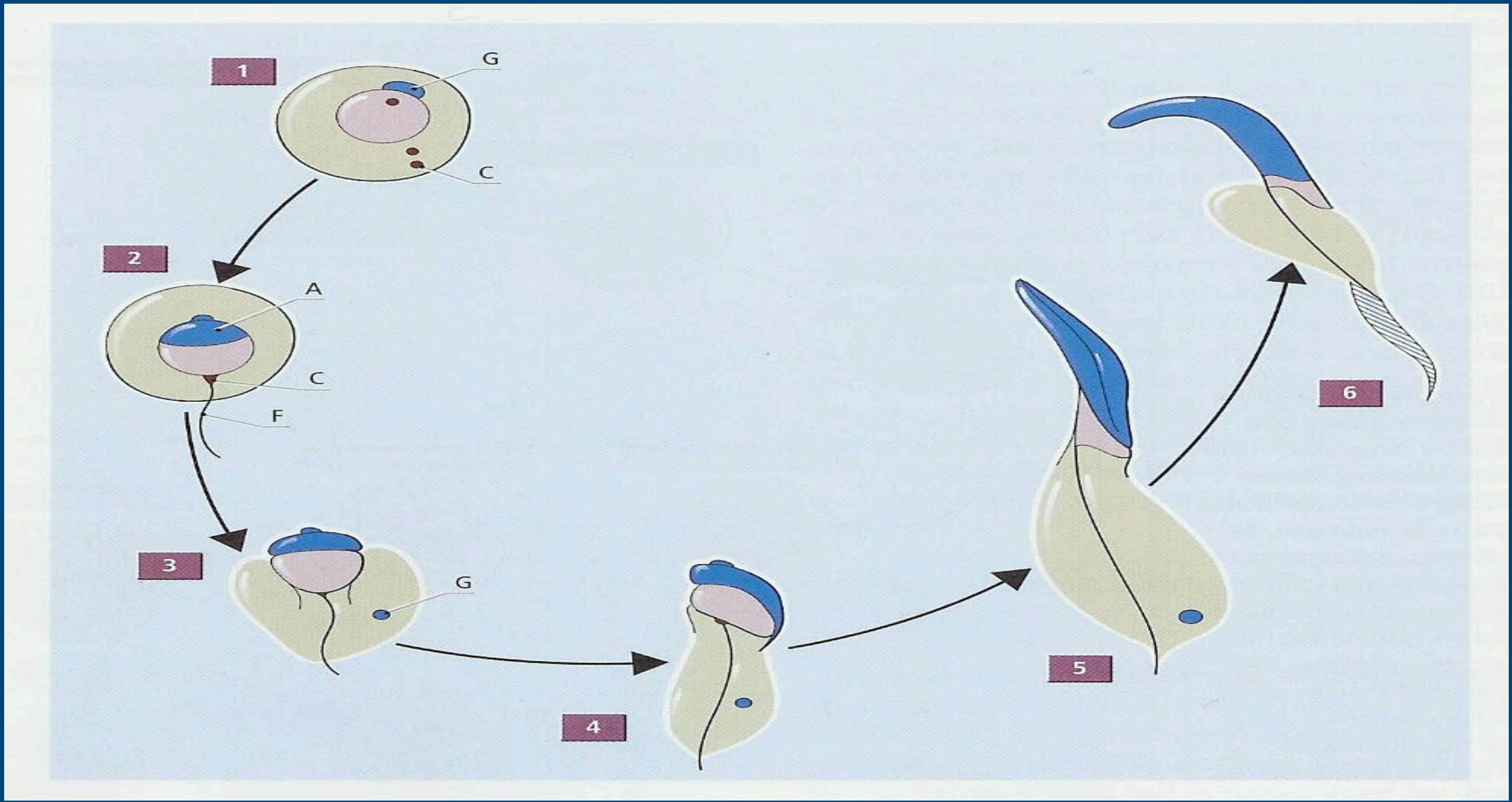
1
2
3.




1) Mitotic proliferation
2) Meiosis
3) Codifferentiation

Lombardi 5-5

# Codifferentiation




Johnson and Everitt 4.5

# Temporal organization of spermatogenesis

Table 4.1 Kinetics of spermatogenesis.

| Species | Time for completion of spermatogenesis (days) | Duration of cycle of the seminiferous epithelium (days) |
|---|---|---|
| Man | 64 | 16 |
| Bull | 54 | 13.5 |
| Ram | 49 | 12.25 |
| Boar | 34 | 8.5 |
| Rat | 48 | 12 |

Johnson and Everitt Table 4.1

**Spermatogenic cycle**:

-Time for the completion of spermatogenesis very consistent within a species

Individual Spermatogonium begin to divide mitotically and meiotically at regular time interval for a given species

# Temporal organization of spermatogenesis (2)

Table 4.1 Kinetics of spermatogenesis.

| Species | Time for completion of spermatogenesis (days) | Duration of cycle of the seminiferous epithelium (days) |
|---|---|---|
| Man | 64 | 16 |
| Bull | 54 | 13.5 |
| Ram | 49 | 12.25 |
| Boar | 34 | 8.5 |
| Rat | 48 | 12 |

Johnson and Everitt Table 4.1

Duration of cycle of the seminiferous epithelium:

- spermatagonium starts to undergo new cycle after aprox. ¼ of the time for complete spermatogenesis has passed

# Temporal organization of spermatogenesis (3)

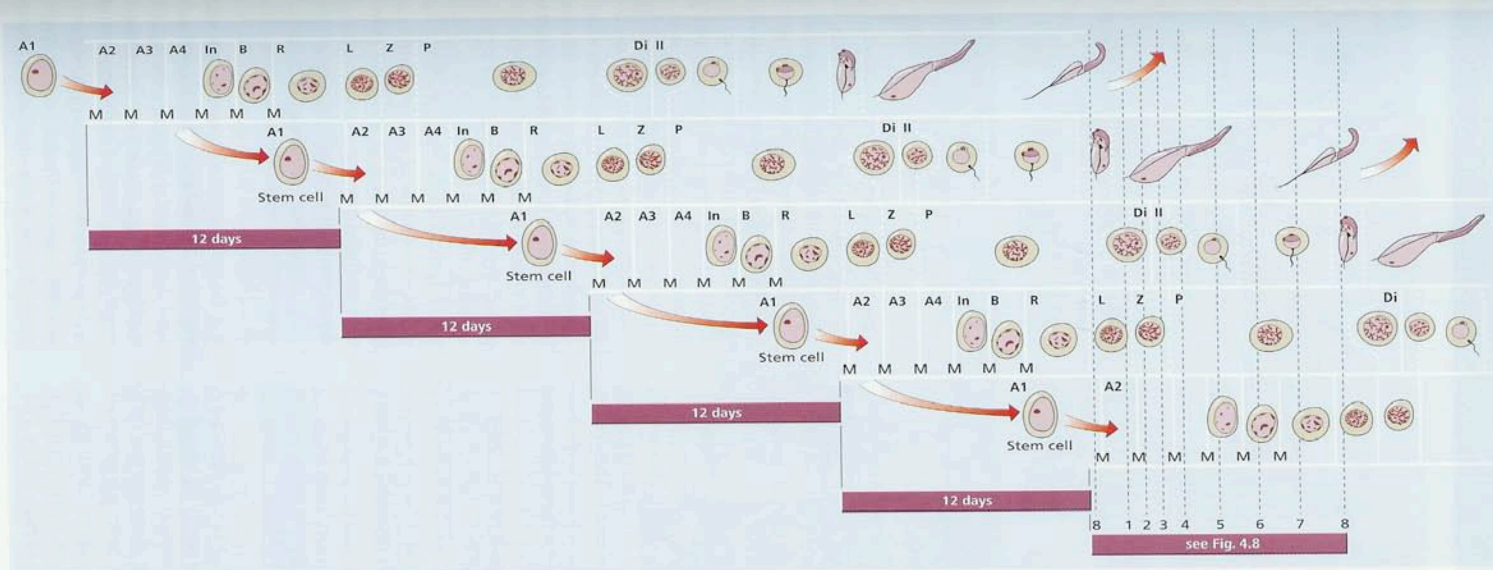
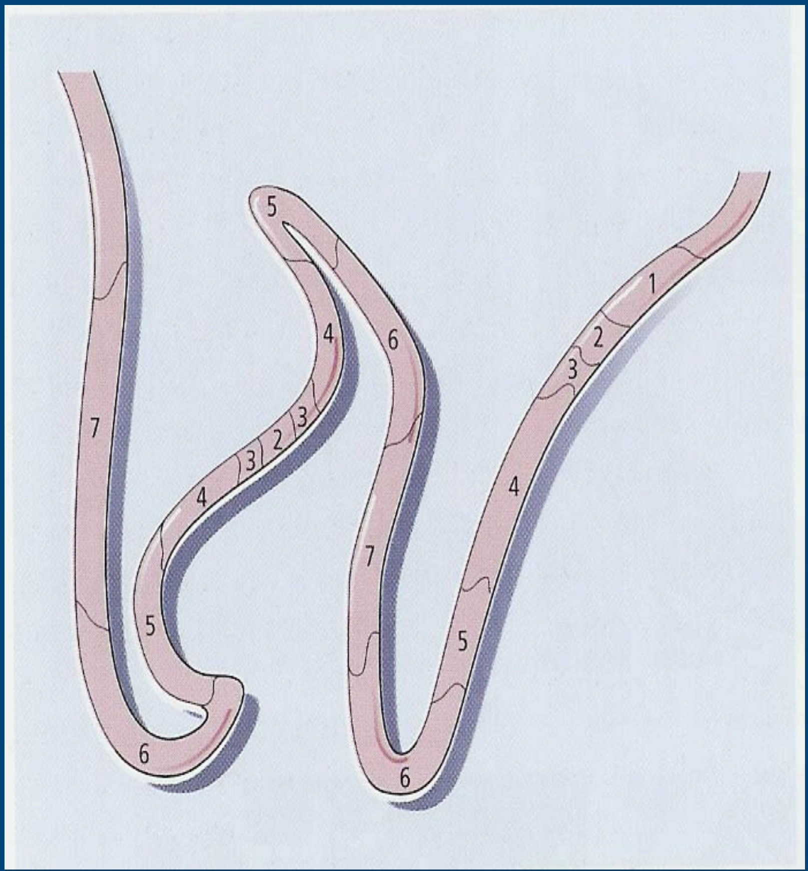



**Fig. 4.7** The top panel illustrates the passage of one rat spermatogonium through the spermatogenic process. The length of the block illustrating each cellular stage is proportional to the amount of time spent in that stage. When a new cell type arises by division, solid bars separate adjacent blocks (M, mitosis). During meiotic prophase and spermiogenesis, however, cells change morphology by progressive differentiation, not quantal jumps. This continuum of change is indicated by the use of broken lines to delineate blocks. A, In and B, spermatogonia; R, L, Z, P and Di, resting, leptotene, zygotene, pachytene and diplotene primary spermatocytes; II, secondary spermatocytes. Each of the lower panels shows the history of other spermatozoa, which commenced development by cyclic generation of new type A spermatogonia from the stem cell population at progressively later time intervals. The interval between each of these events is about 12 days. Note that four such events occur before the upper spermatozoon (and its siblings in the family) has completed development and been released. Thus, several different cell types will be present in one cross-section of a tubule at the same time, although at different points on the radial axis through the tubule. This feature is illustrated more compactly in Fig. 4.8, in which the sections indicated by the dashed lines numbered 1–8 are summarized.

Johnson and Everitt Figure 4.7

# Spatial organization of spermatogenesis



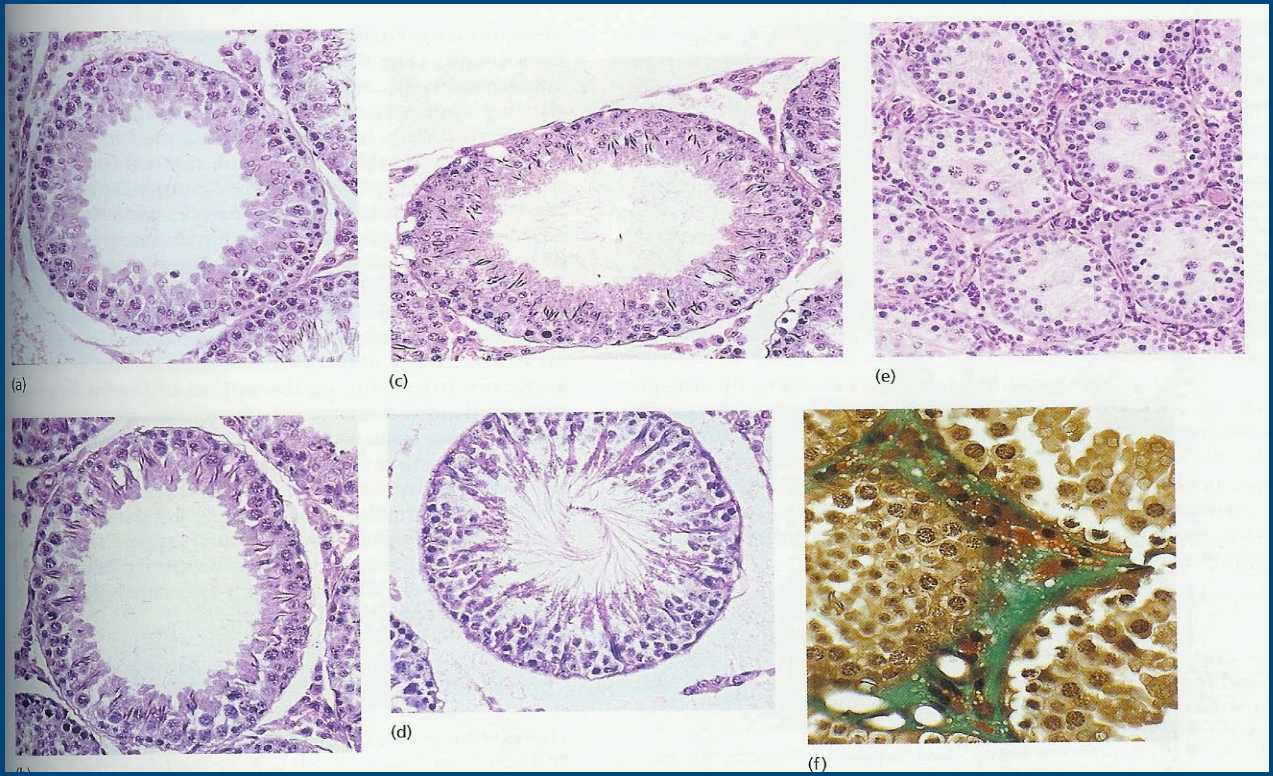

**Spermatogenic wave**:

Each region of seminiferous tubule at a slightly different stage of spermatogenesis

-aids in providing a steady supply of sperm

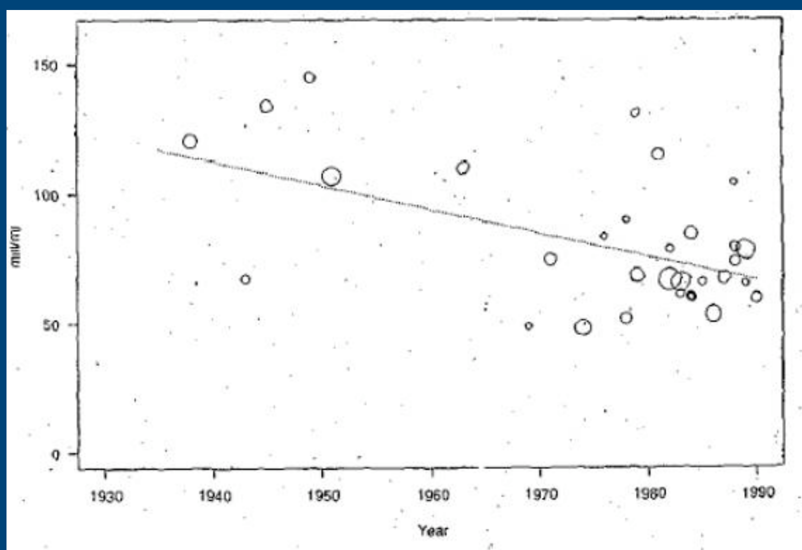
Johnson and Everitt Figure 4.10

# Spatial organization of spermatogenesis (2)




Johnson and Everitt Figure 4.9

# Disruption of spermatogenesis?




Declining sperm counts since 1930s

Graph from report " Male Reproductive Health and Environmental Chemicals with Estrogenic Effects" 1995 report by Danish EPA (students.whitman.edu/~cushinda/ mentrends.htm)

# How might contaminants disrupt spermatogenesis?

# Testicular Cancer

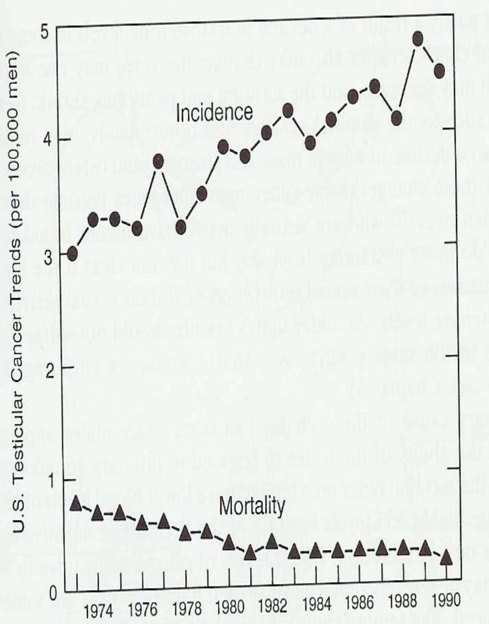



**Figure 4-8** Trends in the incidence and deaths from testicular cancer in the United States (per 100,000 men). Note that, although the incidence has increased, the mortality has decreased, both mainly because of earlier detection. Adapted from Raloff (1994).

3 fold increase since 1940

Leading cancer in American males 15-35

# Disruption of spermatogenesis?

Scientific reaction to the news of declining sperm-counts was mixed.

http://www.nearingzero.net/screen_res/nz071.jpg