

Male reproductive system

Aleš Hampl

Key components & Gross anatomy

Paired gonads = testes

Associated glands

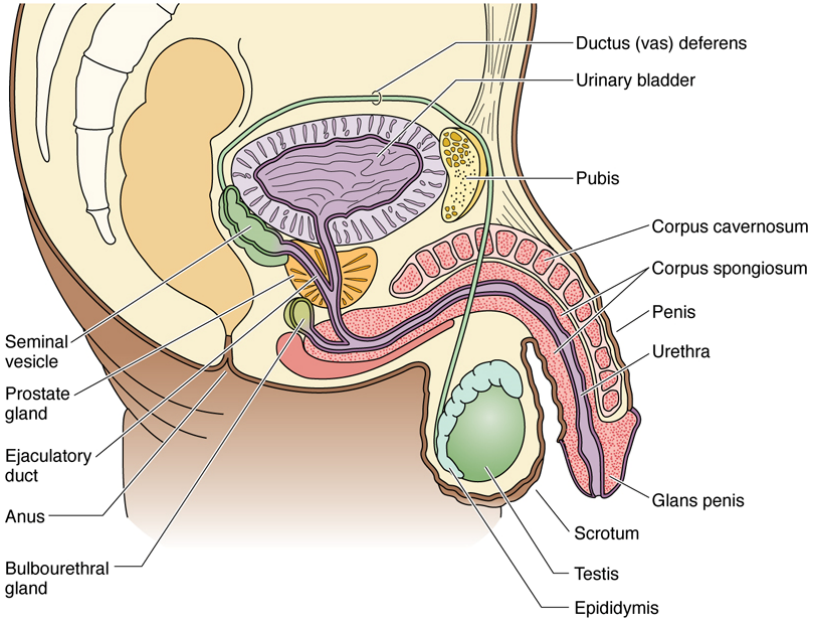
- Seminal vesicles (paired)
- Prostate
- Bulbourethral glands (paired)

Genital ducts	Intratesticular
	Extratesticular

- Tubuli recti
- Rete testis
- Ductuli efferentes
- Epididymis
- Ductus (vas) deferens
- Ejaculatory duct
- Urethra

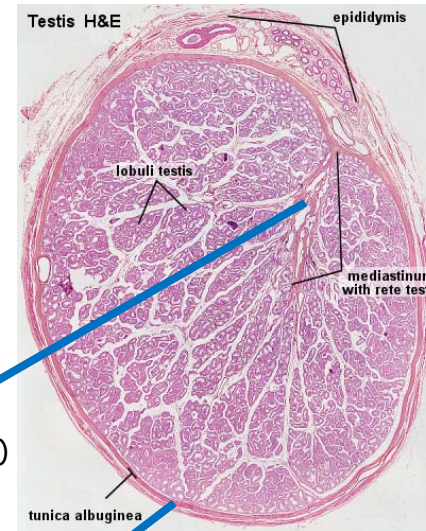
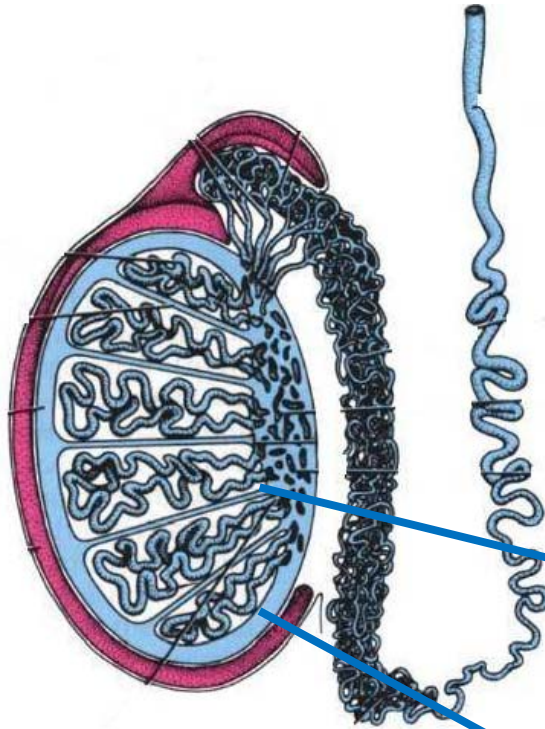
External genital organs

- Scrotum
- Penis



Testis - 1

Length: 4 cm
Width: 2-3 cm
Thickness: 3 cm



Mediastinum + Septa

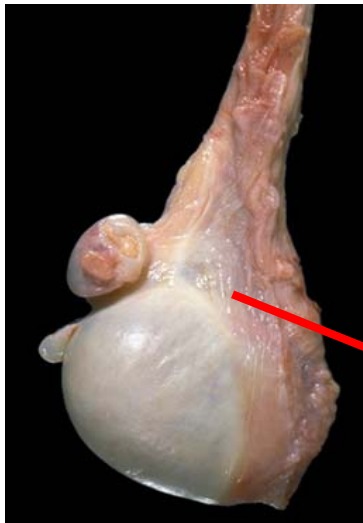
- divide testis into lobuli (250-300)

Tunica albuginea - capsule

- dense connective collagenous tissue

Tunica vasculosa

- inside of T. albuginea + adjacent to septa



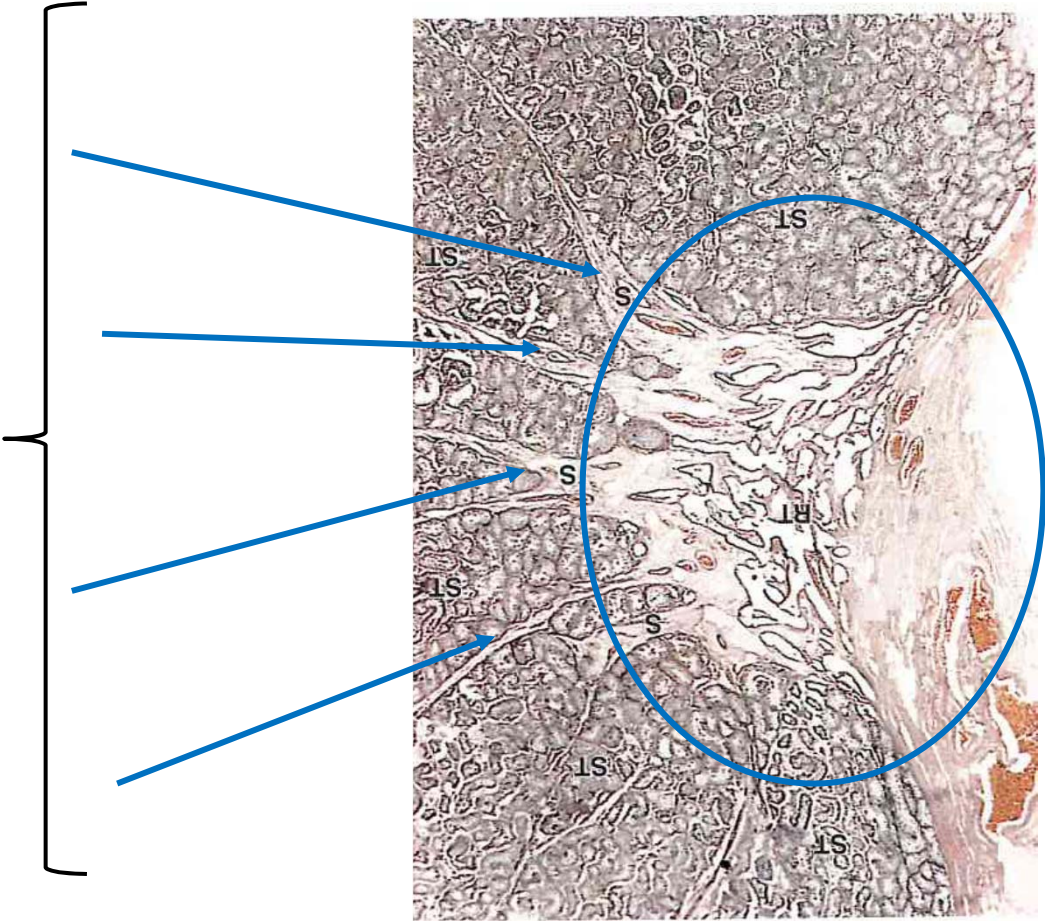
Tunica vaginalis

- serous, originates from peritoneum

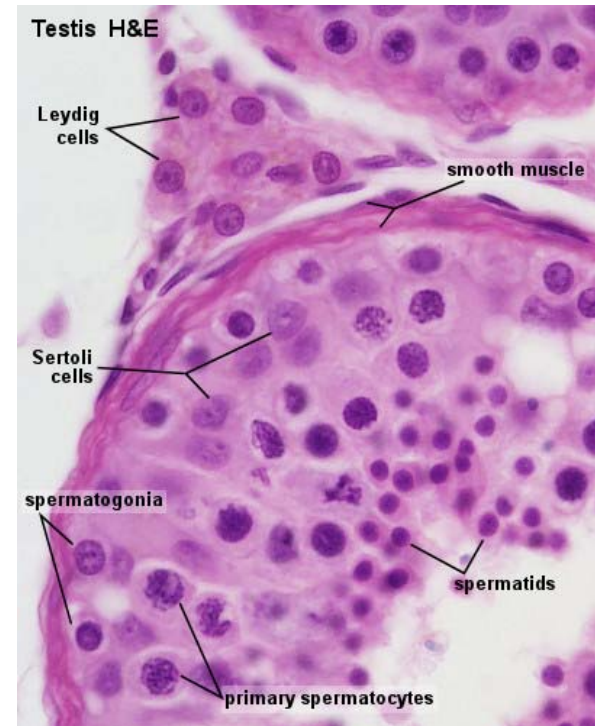
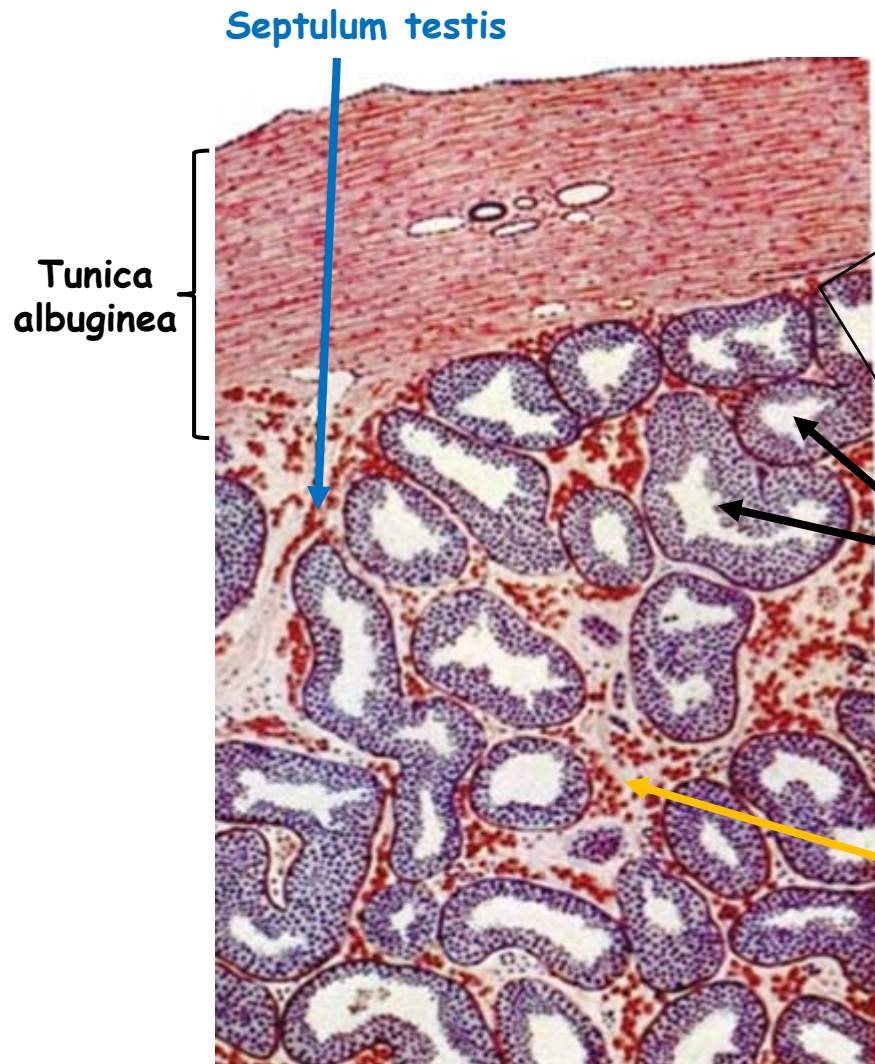
Testis - 2

Septula testis

Mediastinum testis



Testis - 3



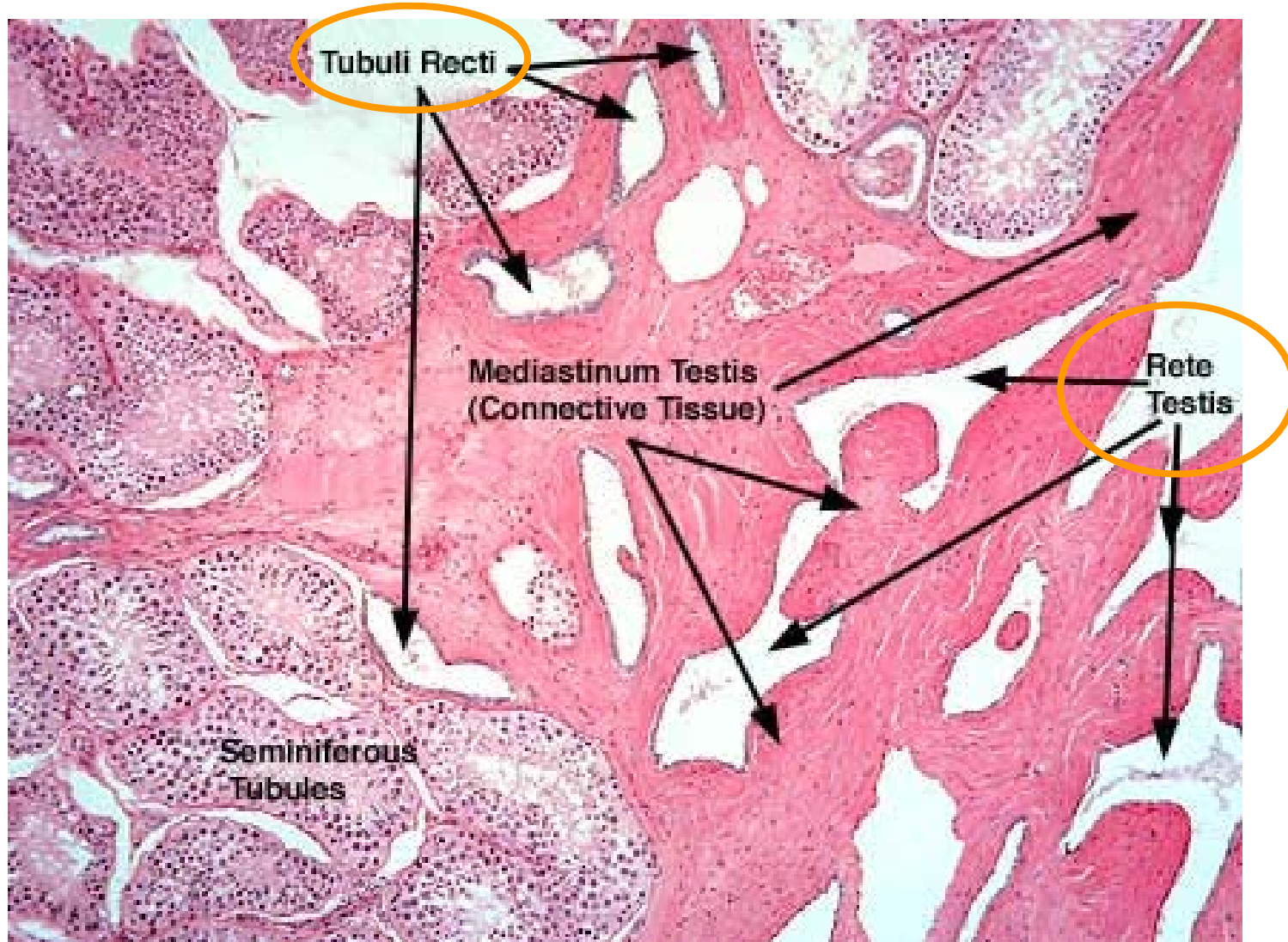
Seminiferous tubules

- 1 to 4 in one lobule
- 1 tubule - 30 to 70 cm in length
- total number about 1000
- total length about 500 m

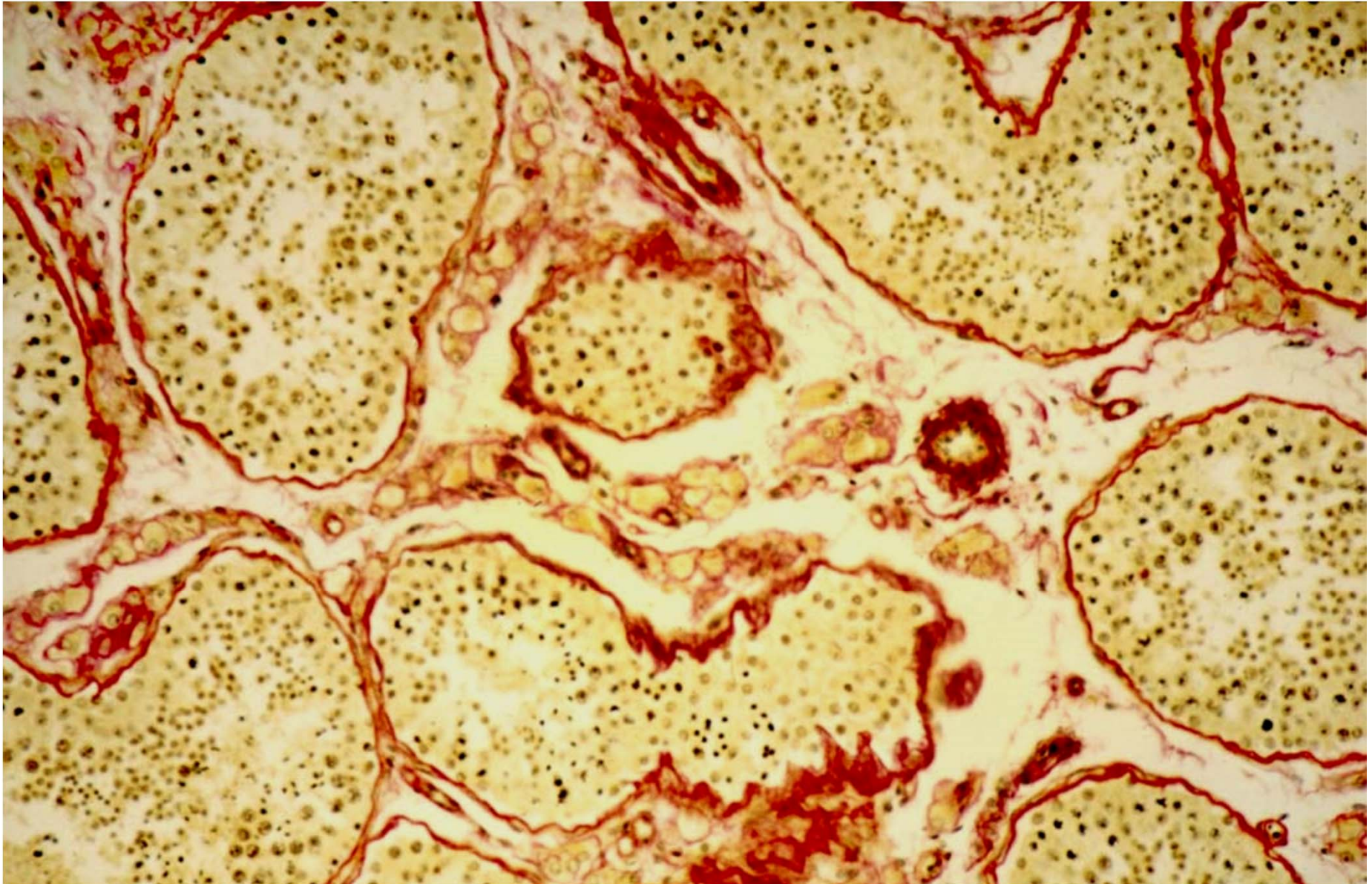
Interstitial tissue

- derived from T. vasculosa
- contains dispersed Leydig cells (brown)

Testis - 4 - continuation of seminiferous tubuli



Testis - 5



Testis - 6 - interstitium - Leydig cells

Interstitium

- loose connective tissue
- fenestrated capillaries + lymphatics + nerves
- mast cells + macrophages + **Leydig cells**

Myofibroblasts

Capillaries



Leydig cells

- round shaped
- large centrally located nuclei
- eosinophilic cytoplasm
- lipid droplets
- **testosterone** synthesis

Testis - 7 - interstitium - Leydig cells

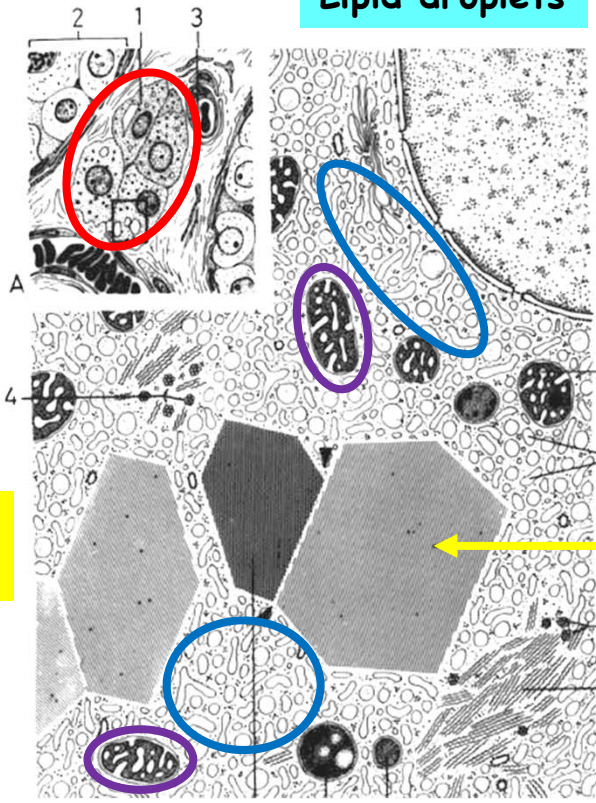
Mitochondria

+

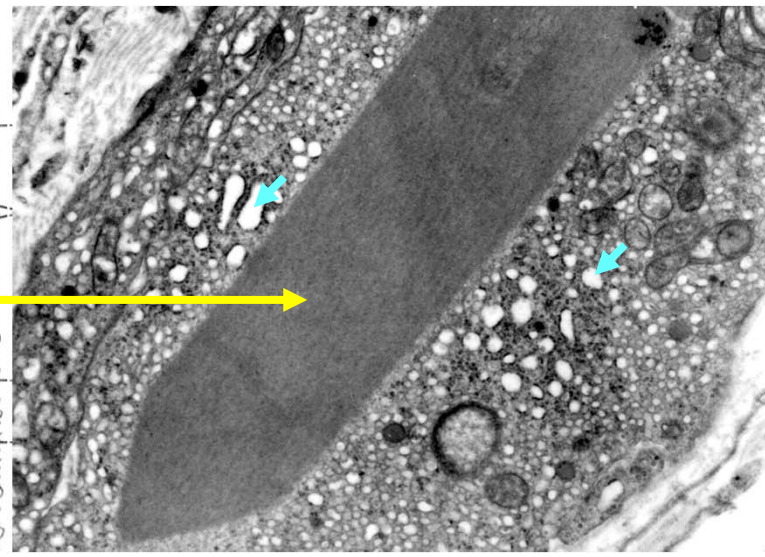
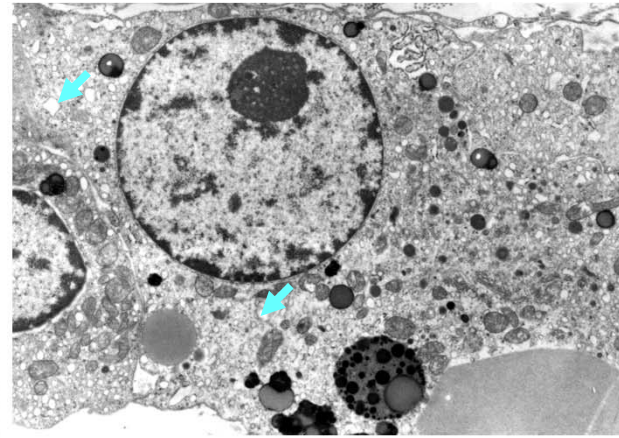
Smooth ER

Testosterone

Lipid droplets

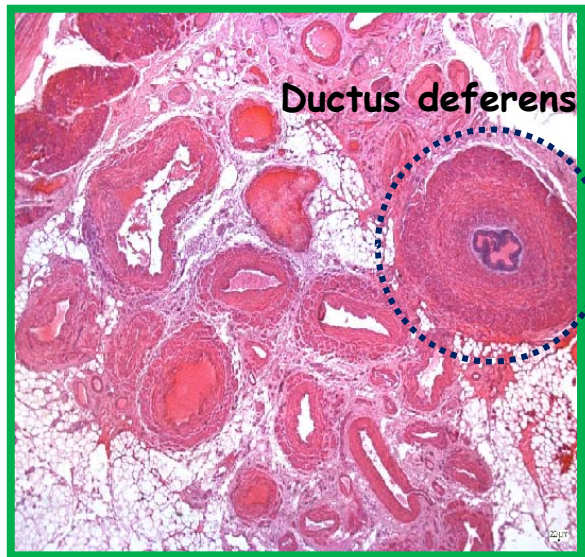
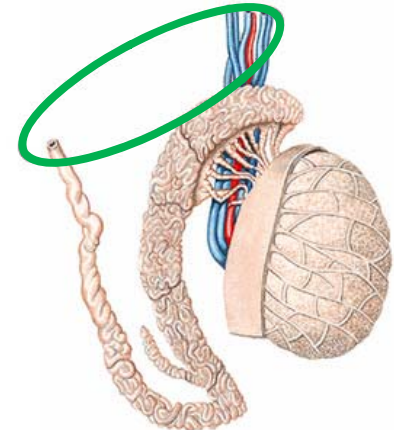
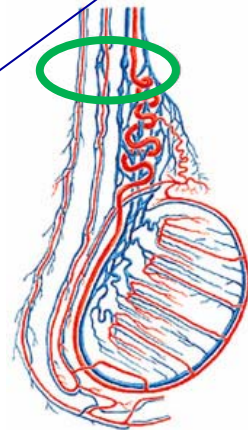
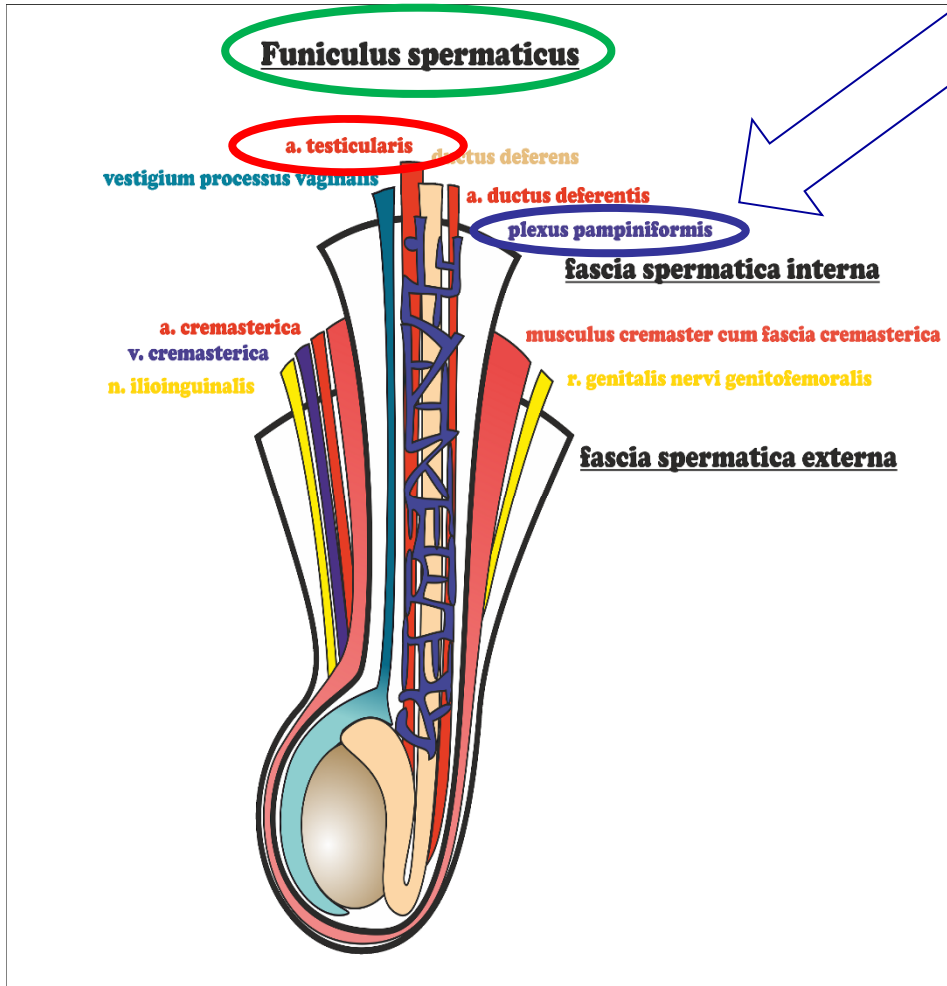


crystals of Reinke

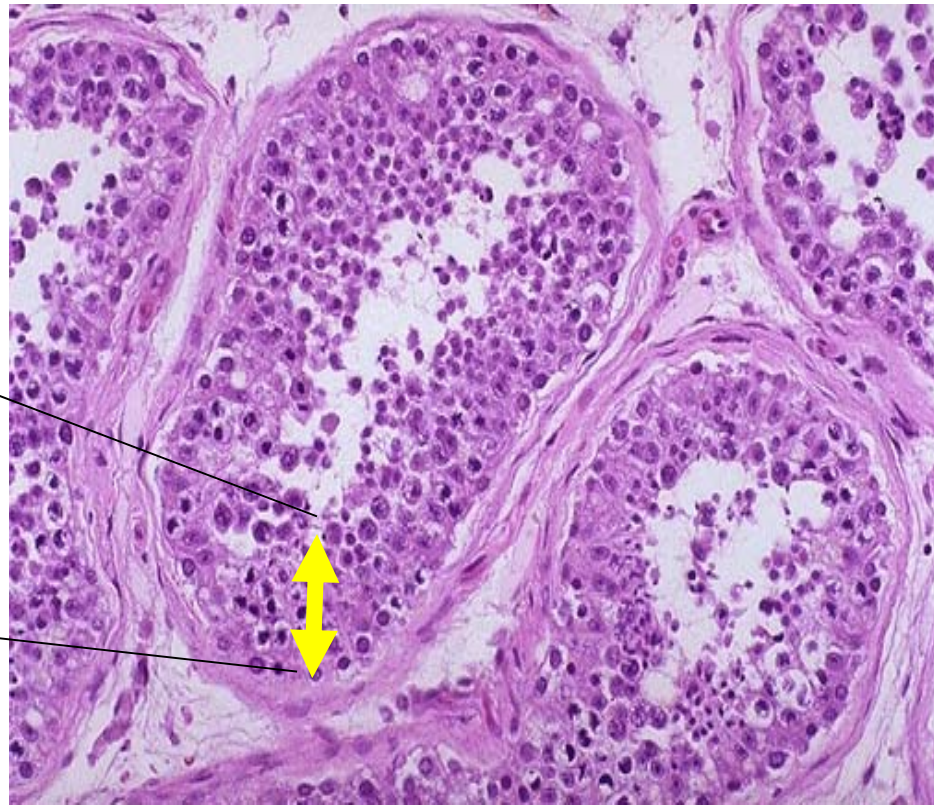
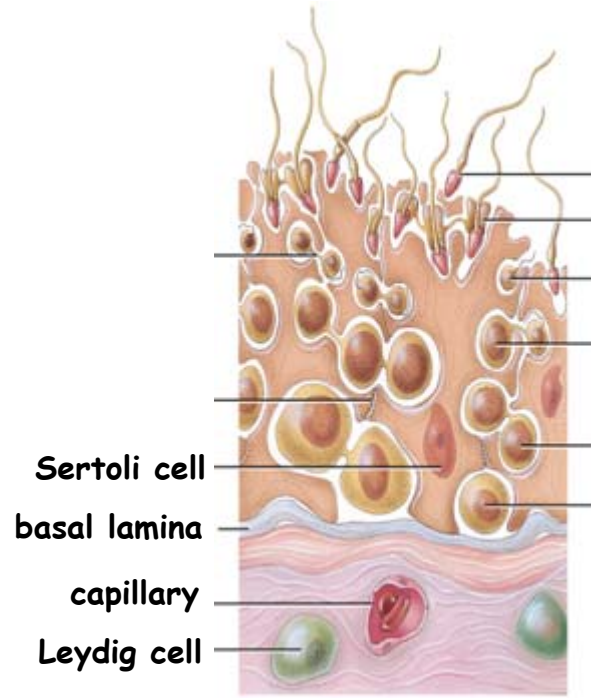


Testis - 8 - Blood supply - Plexus pampiniformis

Spermatic cord



Testis - 9 - Seminiferous / Germinal epithelium



Testis - 10 - Sertoli cells

Morphology:

- tall, columnar
- highly folded membranes, undistinguishable boundaries
- hosts 30 to 50 germ cells
- abundant SER, minimal RER
- numerous mitochondria + well developed Golgi
- abundant cytoskeletal elements
- occluding (zonulae occludentes) + gap junctions

Function:

- support - physical + nutritional
- blood-testis barrier
- phagocytosis
- secretion of sperm transporting fluid + fructose
- endocrine: **anti-Mullerian hormone** + **inhibin** + **androgen-binding protein**

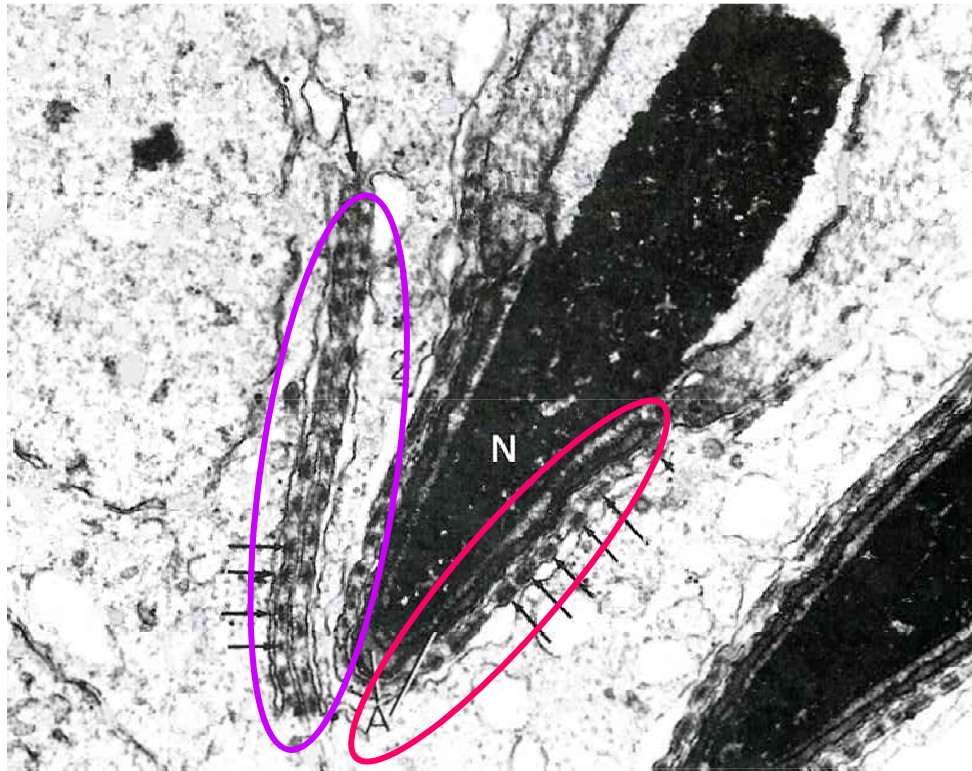


adluminal
compartment

basal
compartment

Sertoli-to-Sertoli
junctional complexes
=
blood-testis barrier
occluding + gap junctions

Testis - 11 - Sertoli cells - Junctional complexes



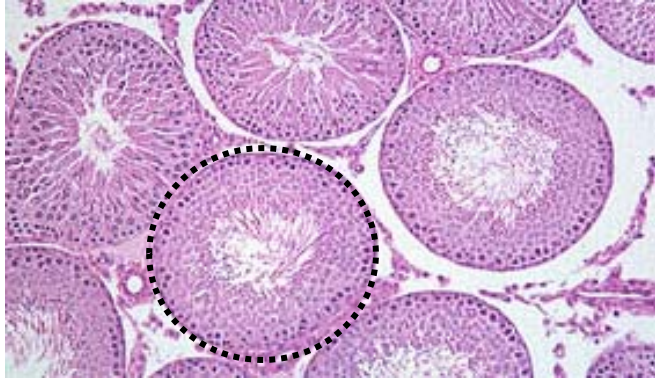
Sertoli-to-Sertoli

Sertoli-to-Spermatid

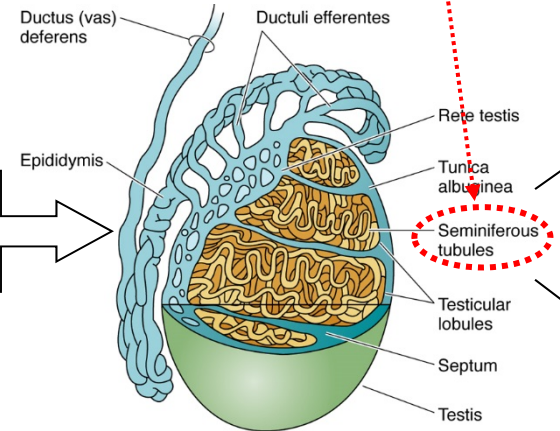
Spermatogenesis

Before puberty

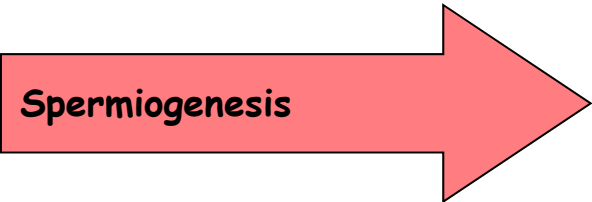
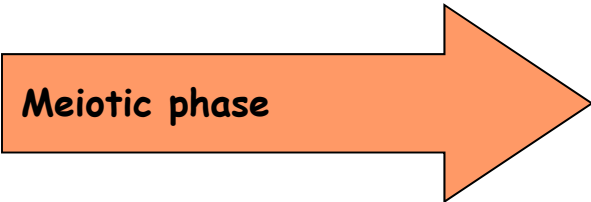
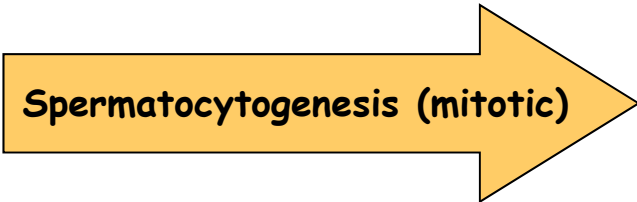
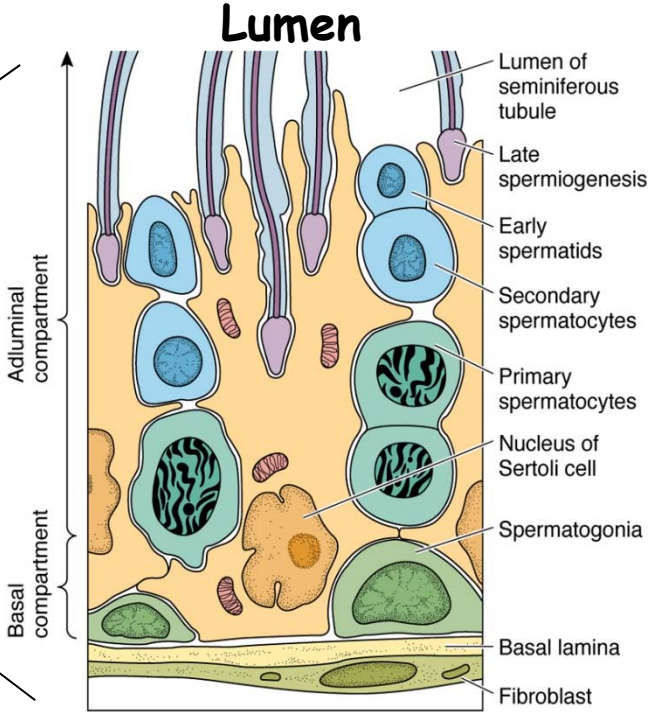
Slowly mitotically dividing spermatogonia in **genital ridges**



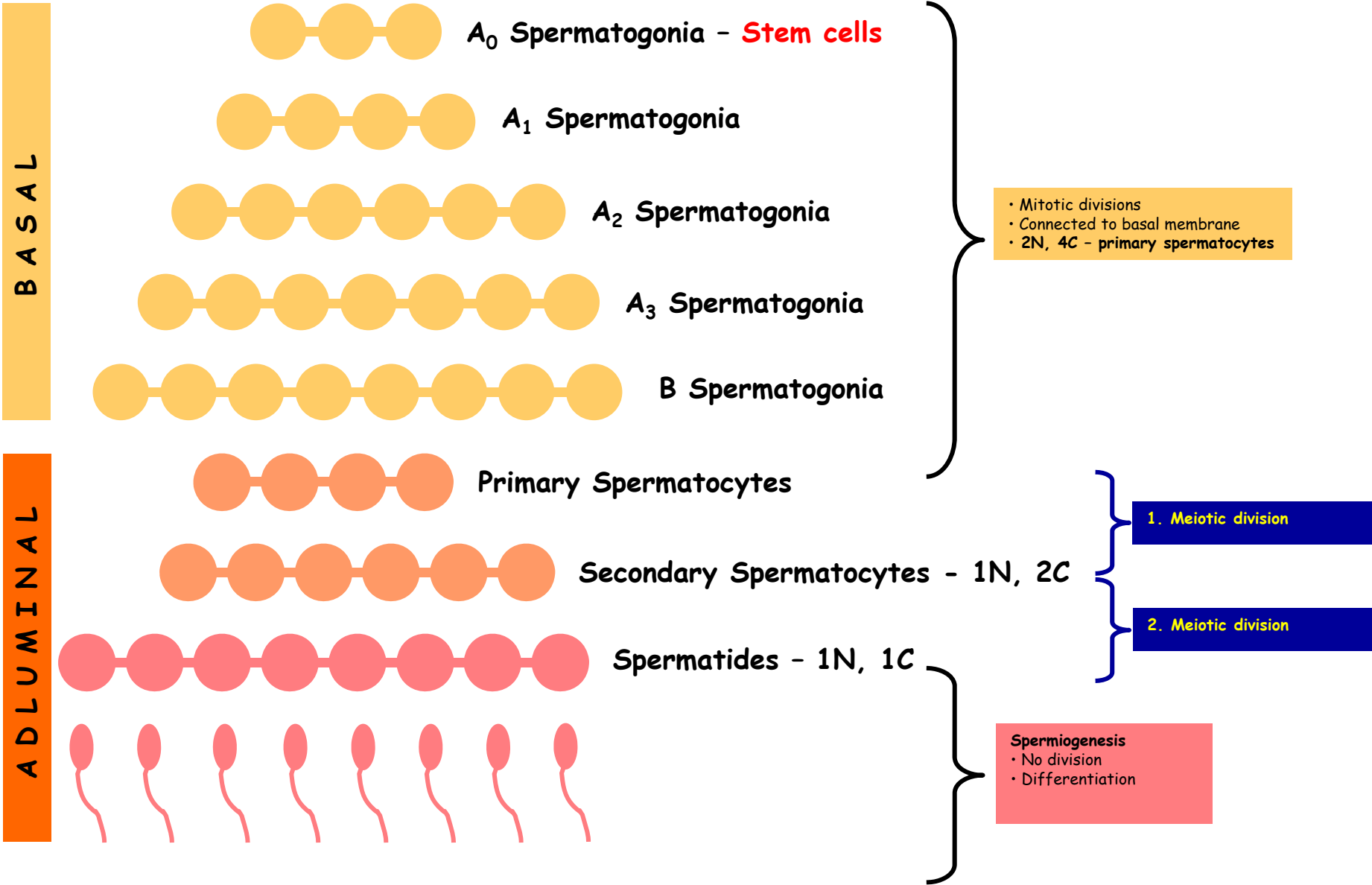
After puberty



~0.25 mm
~0.5 km

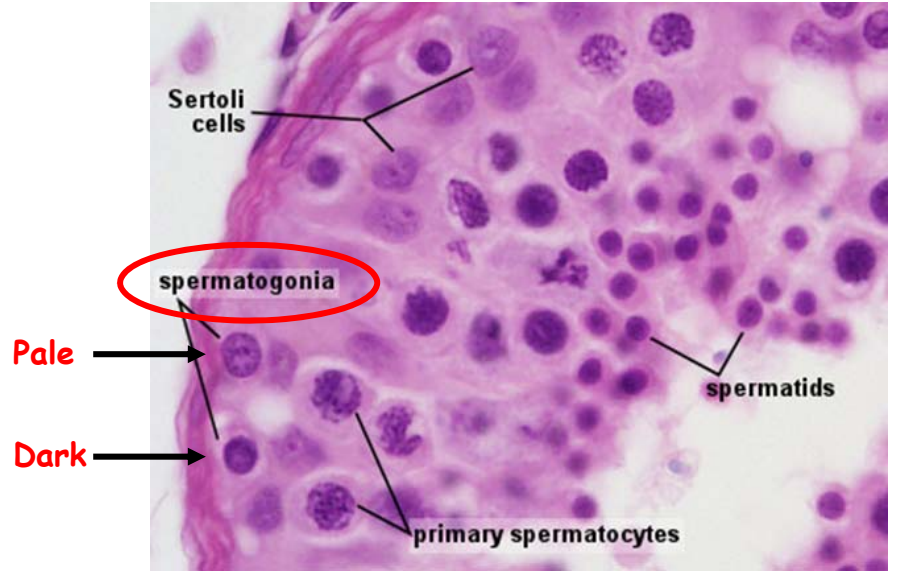
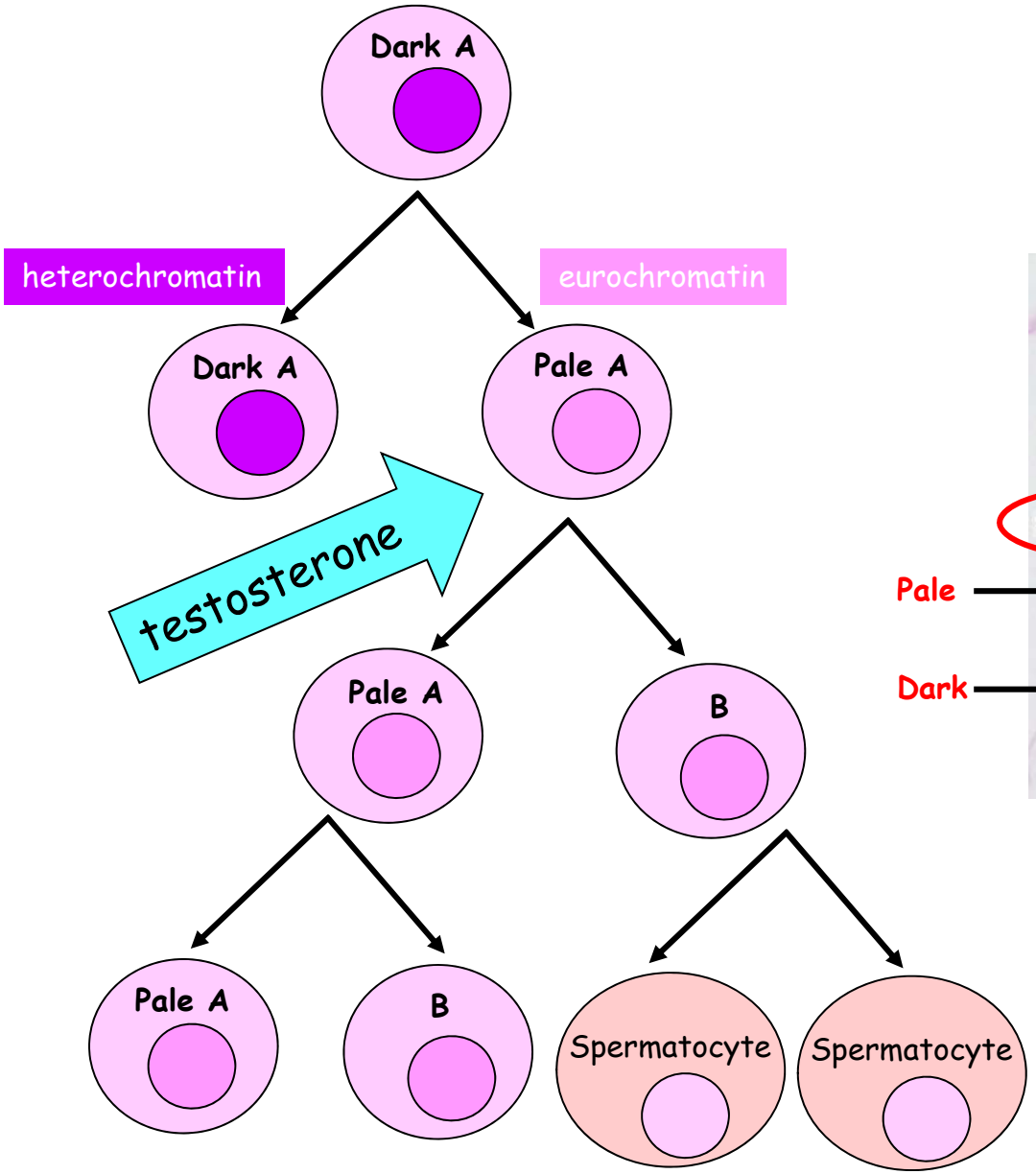


Spermatogenesis



Spermatogenesis - Spermatogonia

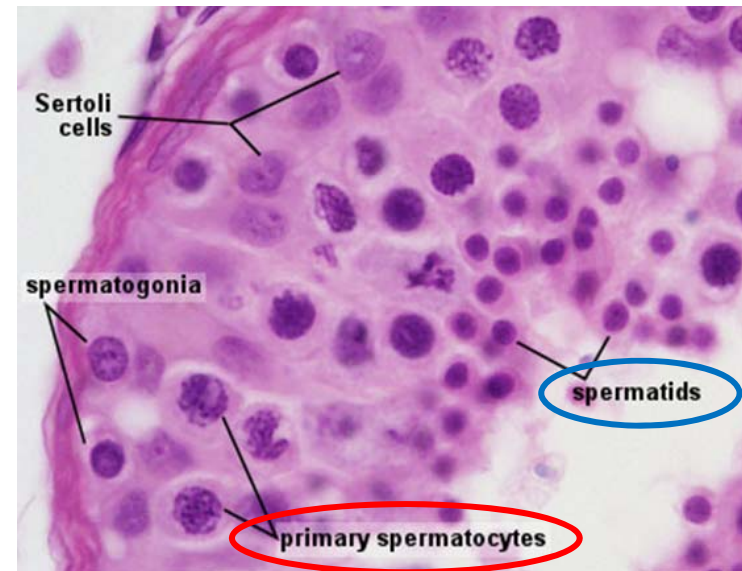
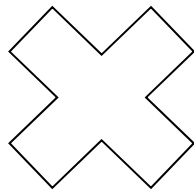
About 12 μm



Spermatogenesis - Spermatocytes

Primary spermatocytes

- largest germ cells (16 μm)
- at various stages of MeI 1 (~24 days)
- from basal to adluminal compartment
- occlusion junctions with Sertoli cells



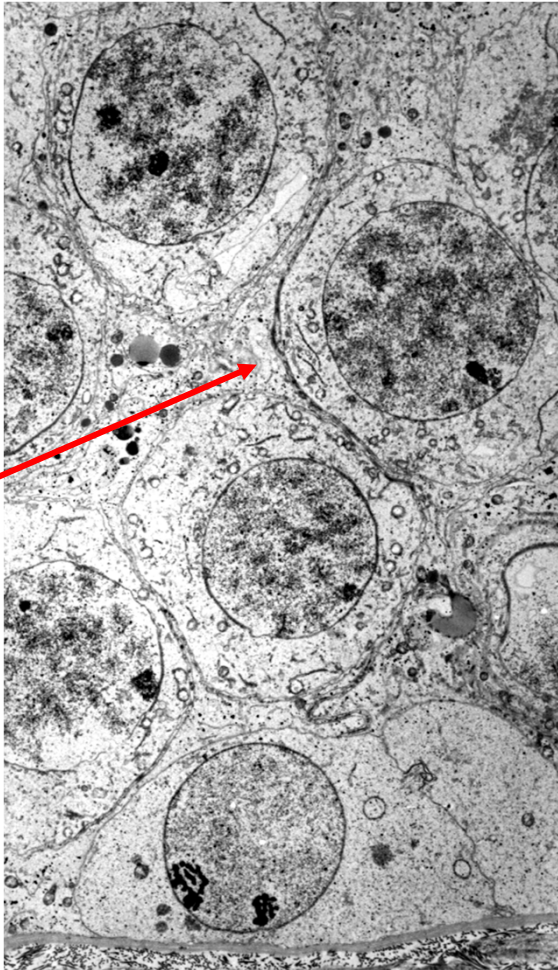
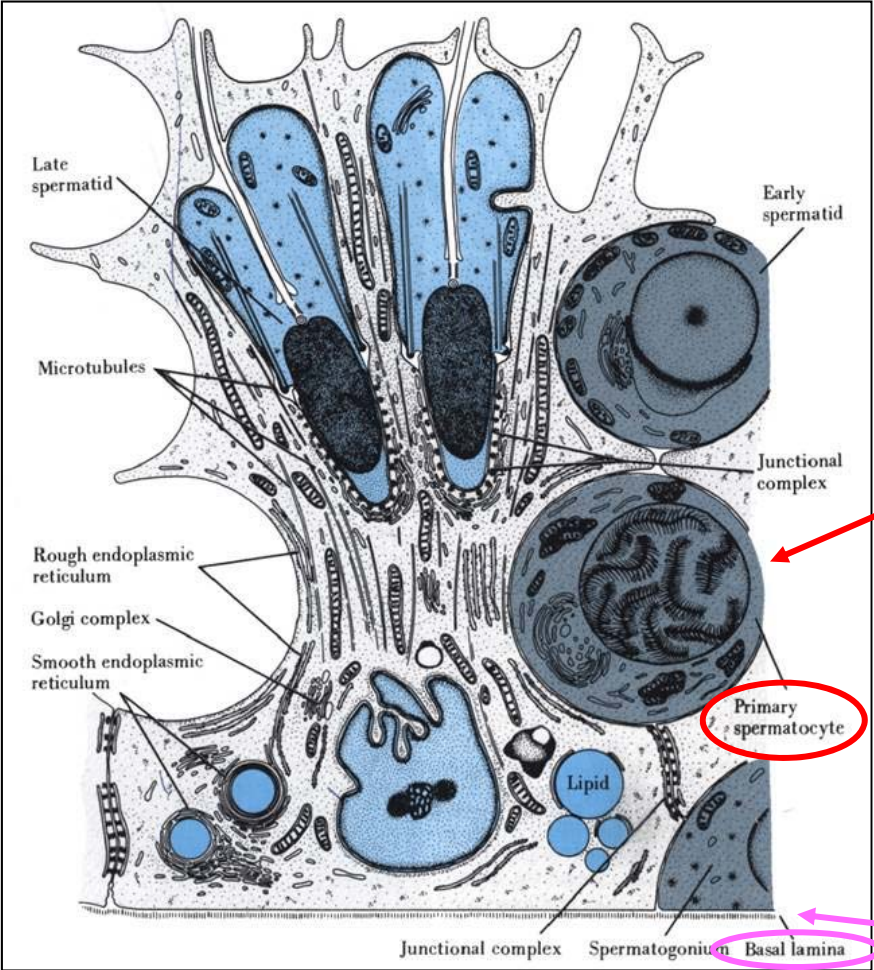
Secondary spermatocytes

- smaller (12 μm)
- short living (~8 hrs)
- infrequently seen

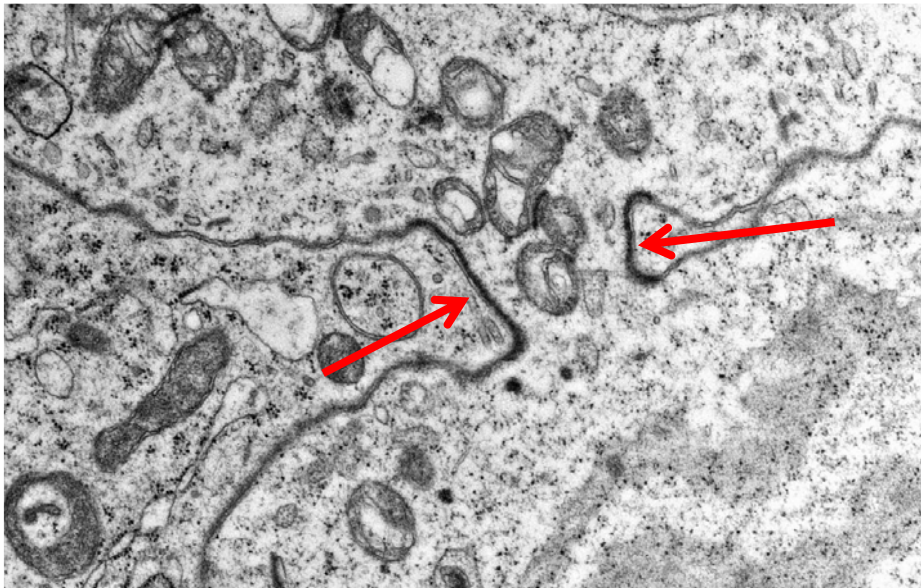
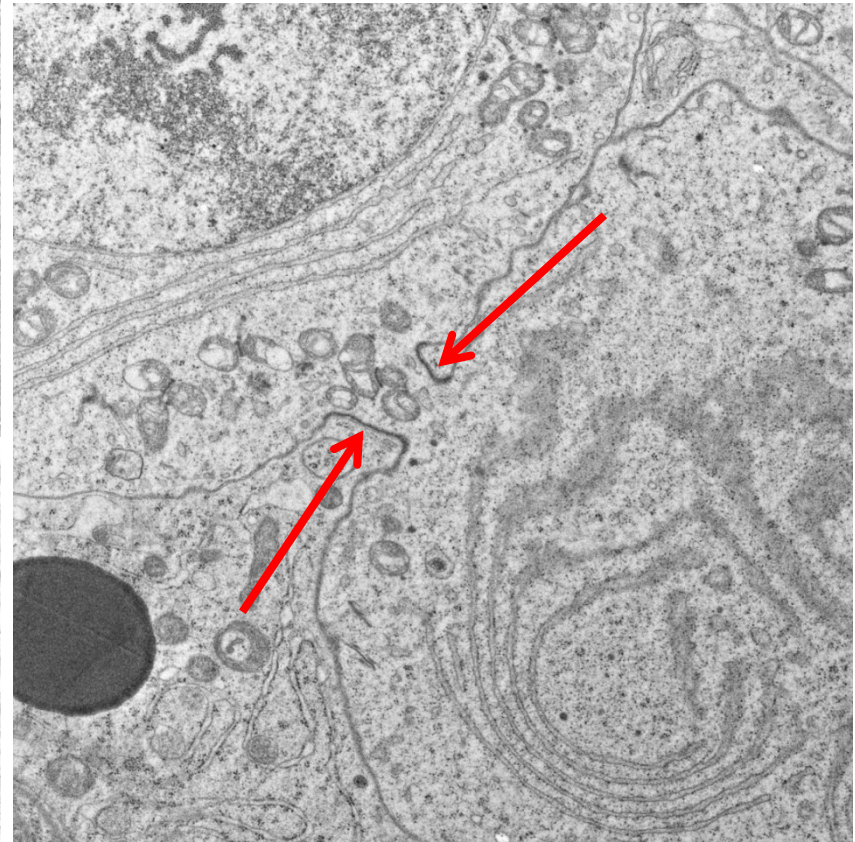
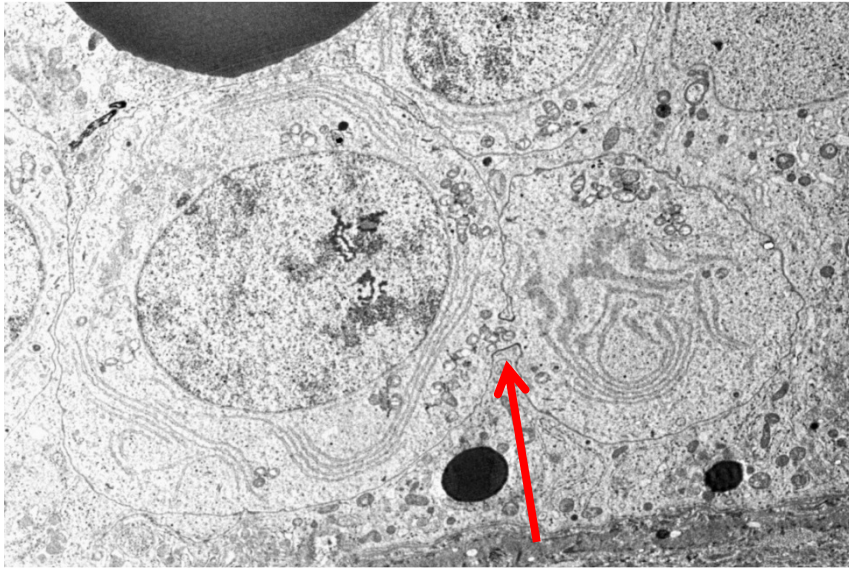
equatorial division - MeI 2

Spermatids

Spermatogenesis - Spermatoocytes



Spermatogenesis - Cytoplasmic bridges



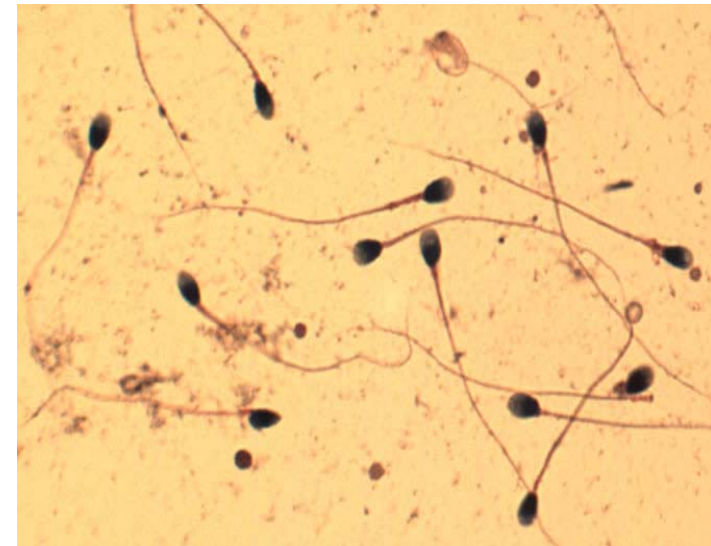
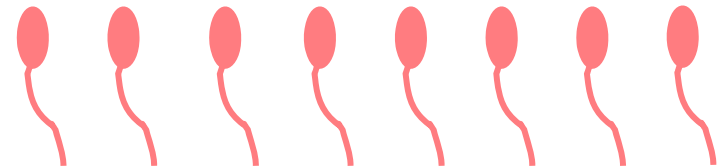
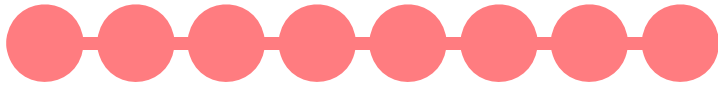
Spermatogenesis - Spermogenesis

Spermatides

- small germ cells (6-8 μm)
- cytoplasmic bridges

morphogenesis

Spermatozoa



Key elements

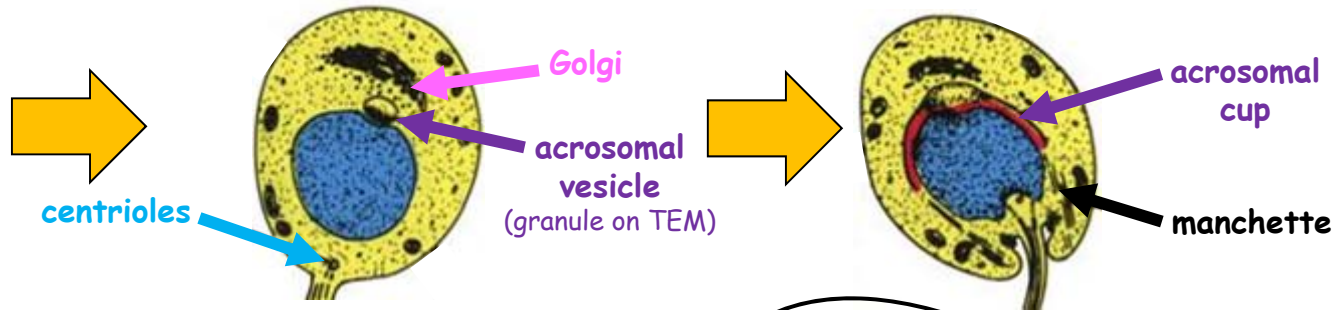
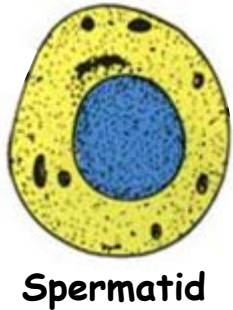
1. Formation of acrosome
2. Development of flagellum
3. Chromatin condensation + shaping the nucleus
4. Reduction of cytoplasm

Spermatogenesis - Spermogenesis

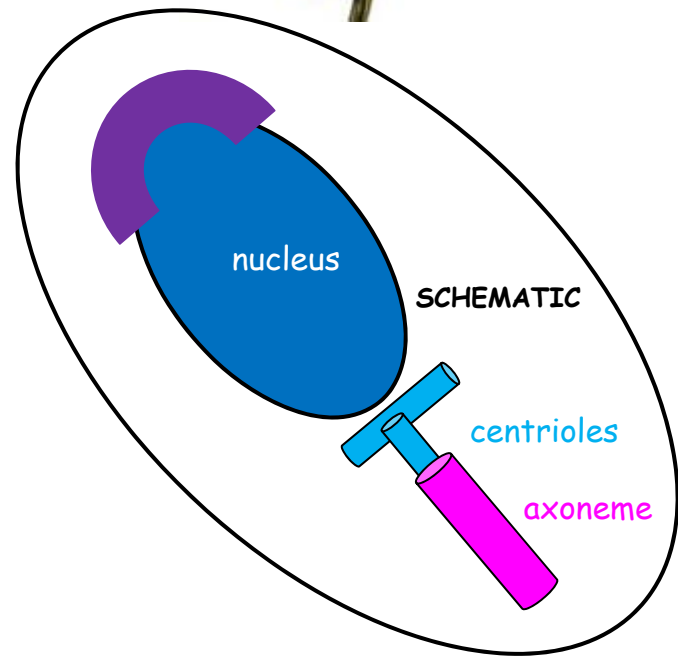
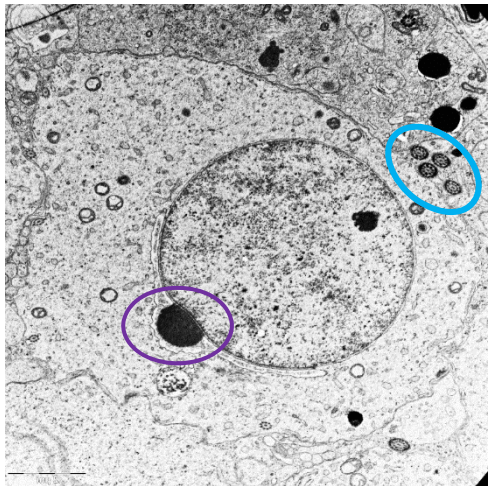
- Prominent Golgi complex
- Numerous mitochondria
- Pair of centrioles

- Transgolgi pathway produces granules
- Granules form **acrosomal vesicle**

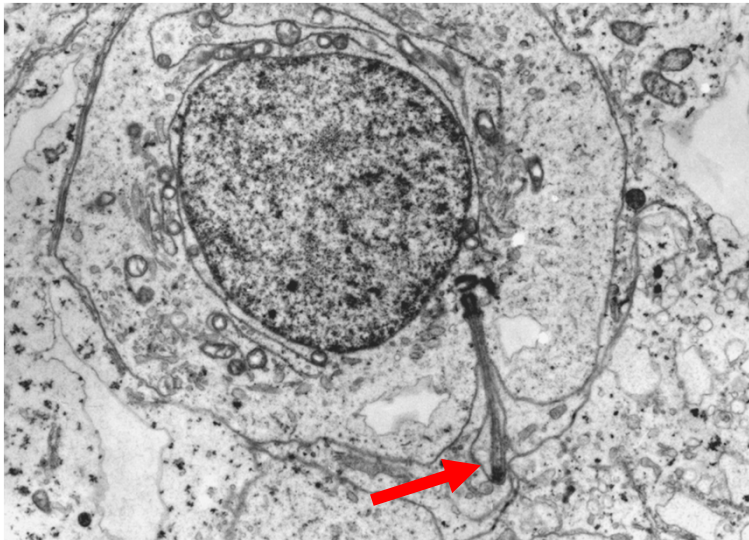
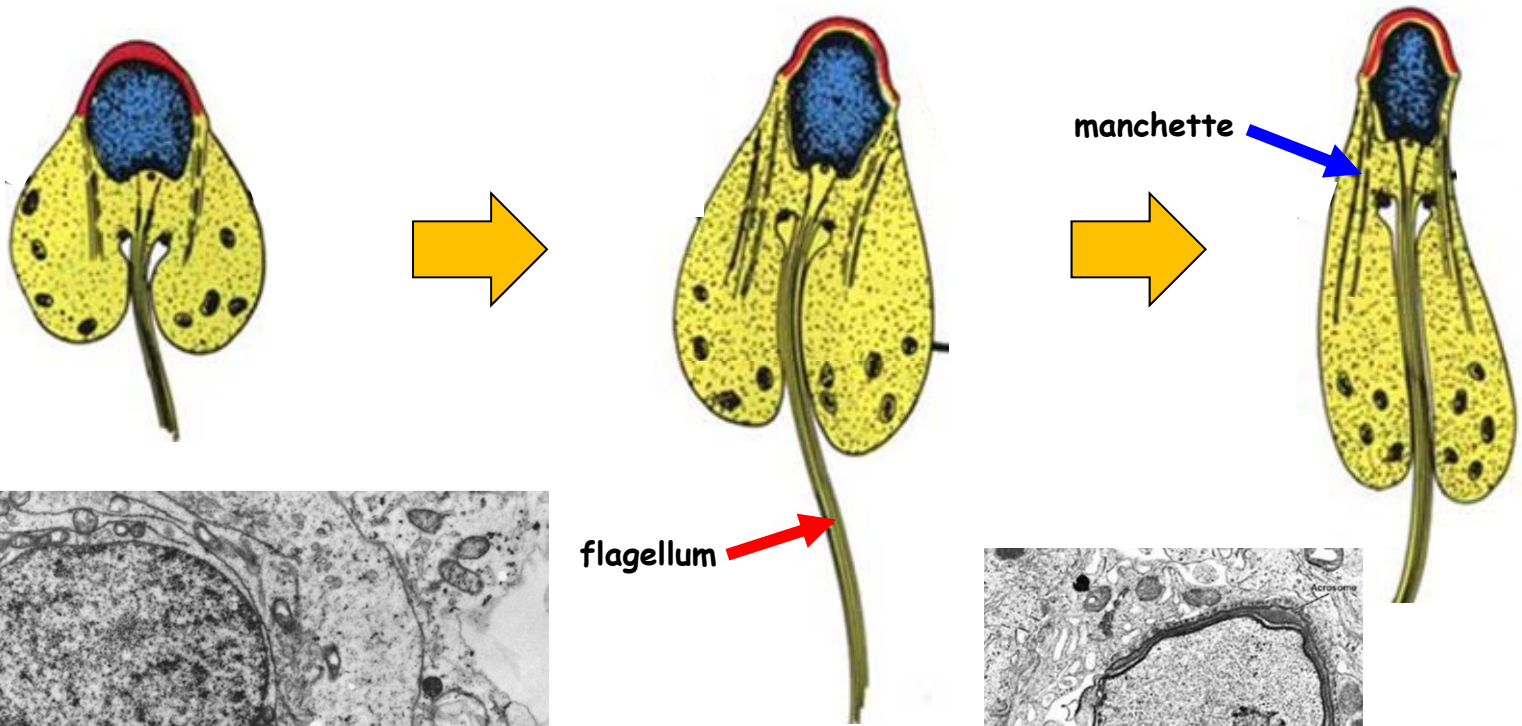
- Acrosomal vesicle flatten - **cup**
- Microtubules arrange into **manchette**
- Chromosomes begin to condense



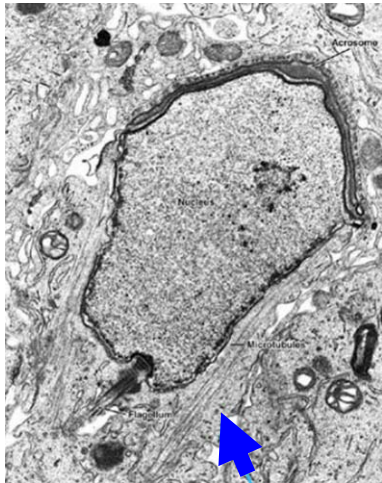
- Acrosomal enzymes**
- hyaluronidase
 - acrosin
 - acid phosphatase
 - neuraminidase



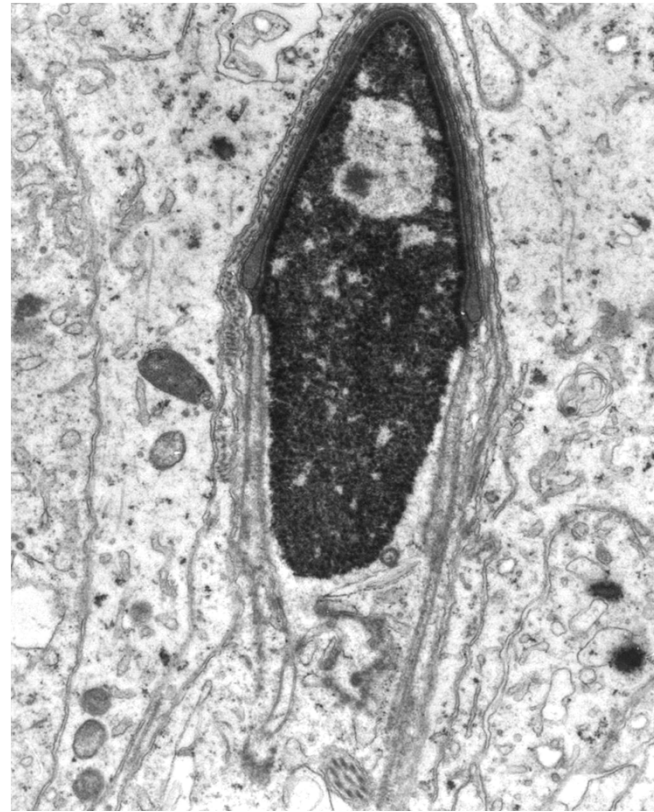
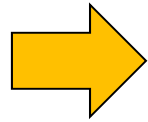
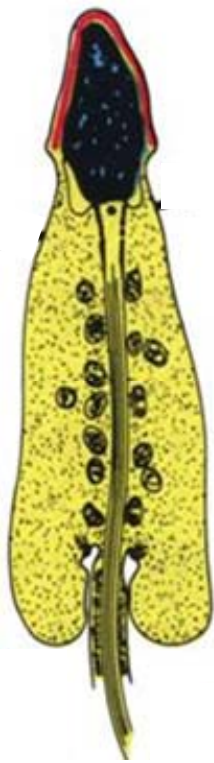
Spermatogenesis - Spermioogenesis



flagellum

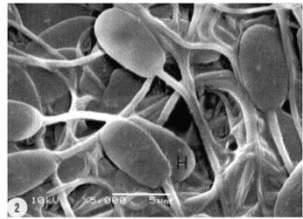
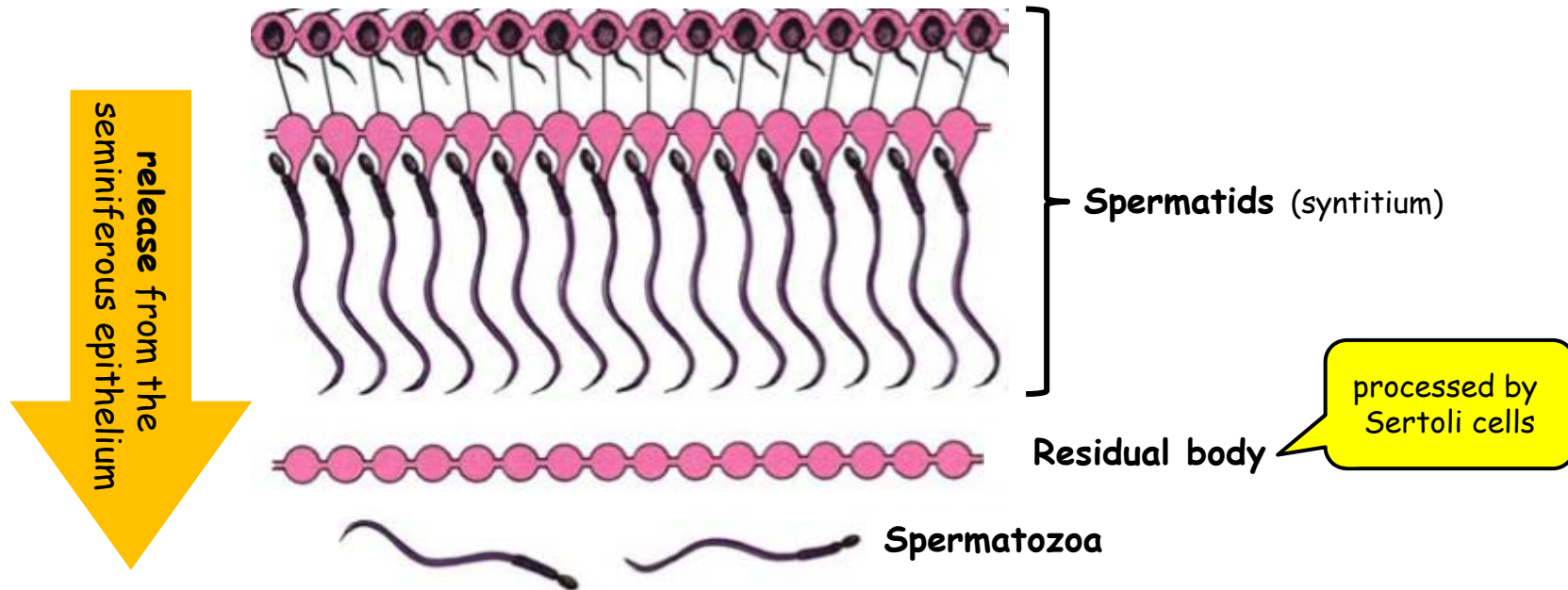


Spermatogenesis - Spermogenesis



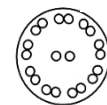
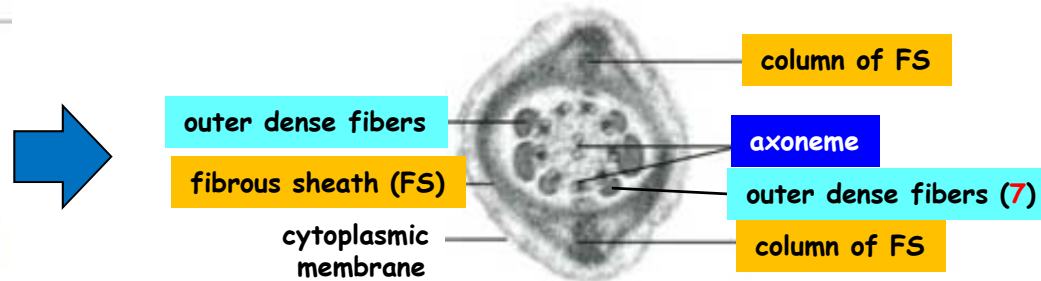
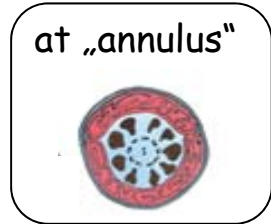
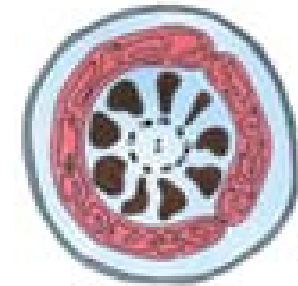
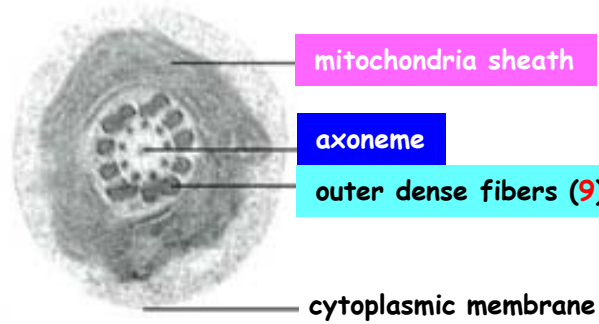
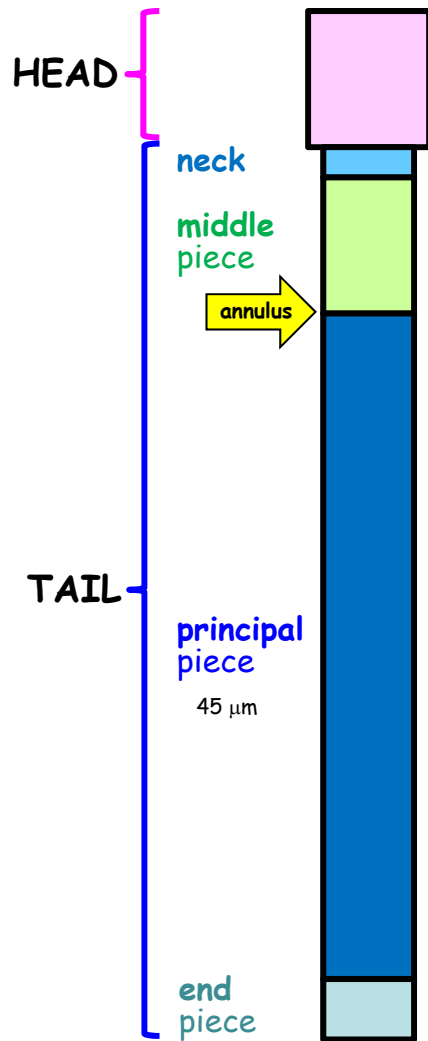
Spermatogenesis - **Spermiation**

= final stage of spermiogenesis

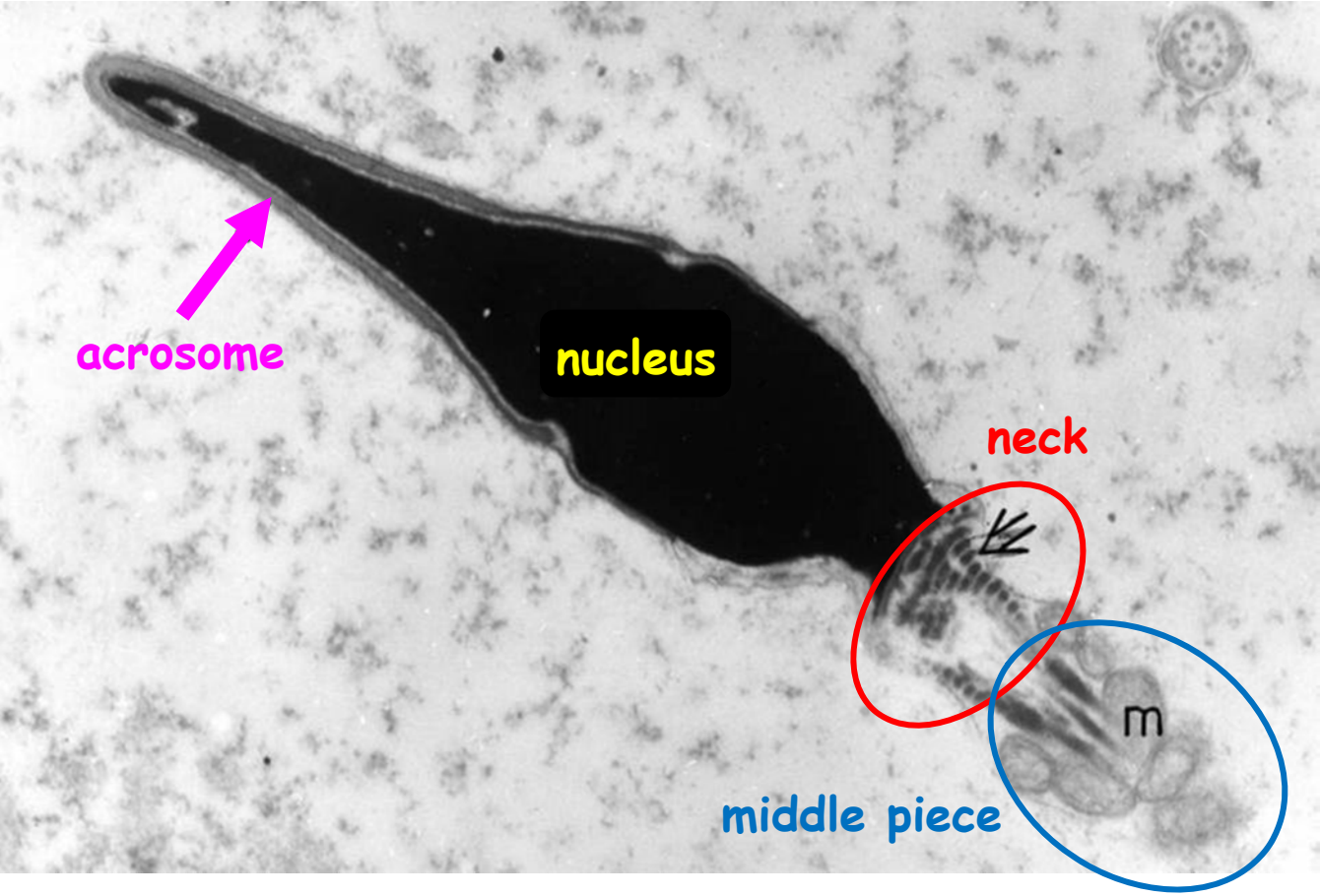


Spermatozoon

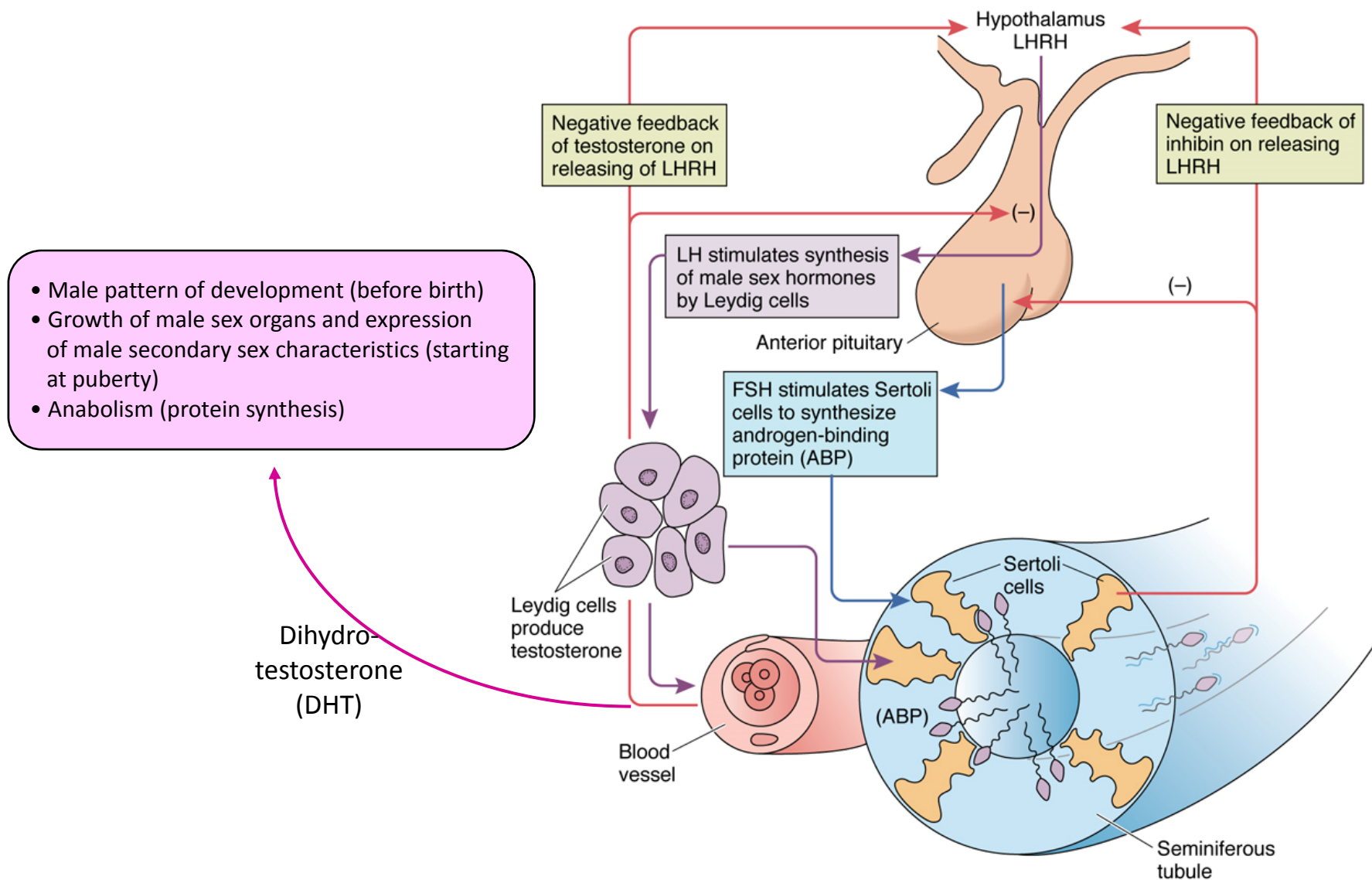
Total length = 65 μm



Spermatozoon



Spermatogenesis - Hormonal regulation



- Male pattern of development (before birth)
- Growth of male sex organs and expression of male secondary sex characteristics (starting at puberty)
- Anabolism (protein synthesis)

Spermatozoa + Ejaculate

Properties of spermatozoa

- life-span: 2 to 3 dys in female reproductive tract
several weeks in epididymis
- fertilising ability: up to 2 days
- velocity: 3-5 mm/min.
- 2 types of spermatozoa: with X or Y chromosome

Composition of ejaculate

Corpuscular:

- spermatozoa (40-100 mil./1ml)
- desquamated epithelia
- residual bodies
- prostatic concretions

Seminal plasma:

- secretions of seminal vesicles, prostate, bulbourethral, and Littré's glands
- testicular fluid
- secretions of epithelia of excretory ducts

Spermatozoa + Ejaculate

Normozoospermia - WHO standard

- **volume** of ejaculate: 2,0 ml and more
- **pH** of ejaculate: 7,2-7,8
- **sperm concentration**: minimally 20 mil. spermatozoa/1ml, total at least 40 mil./ejaculate
- **movability**: min. 50 % movable with 25 % quickly and progressively moving
- **morphology**: min. 30 % normal spermatozoa
- **vital spermatozoa**: minimally 50 %

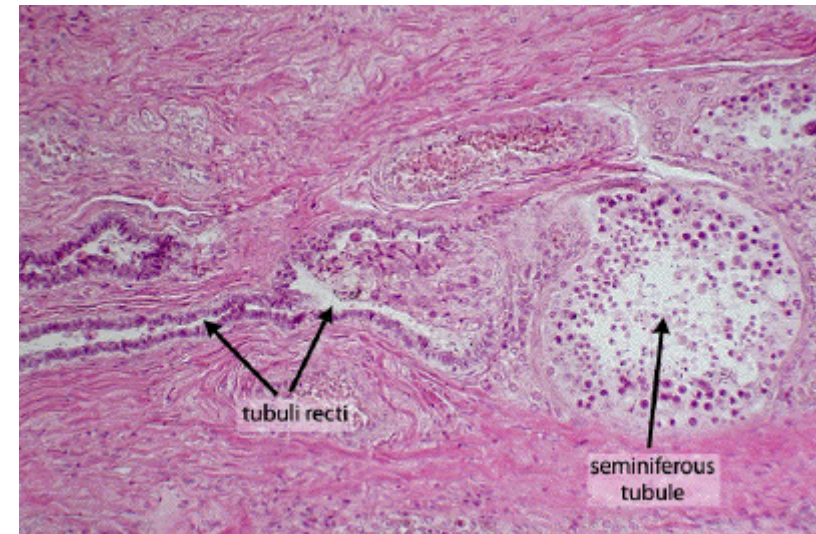
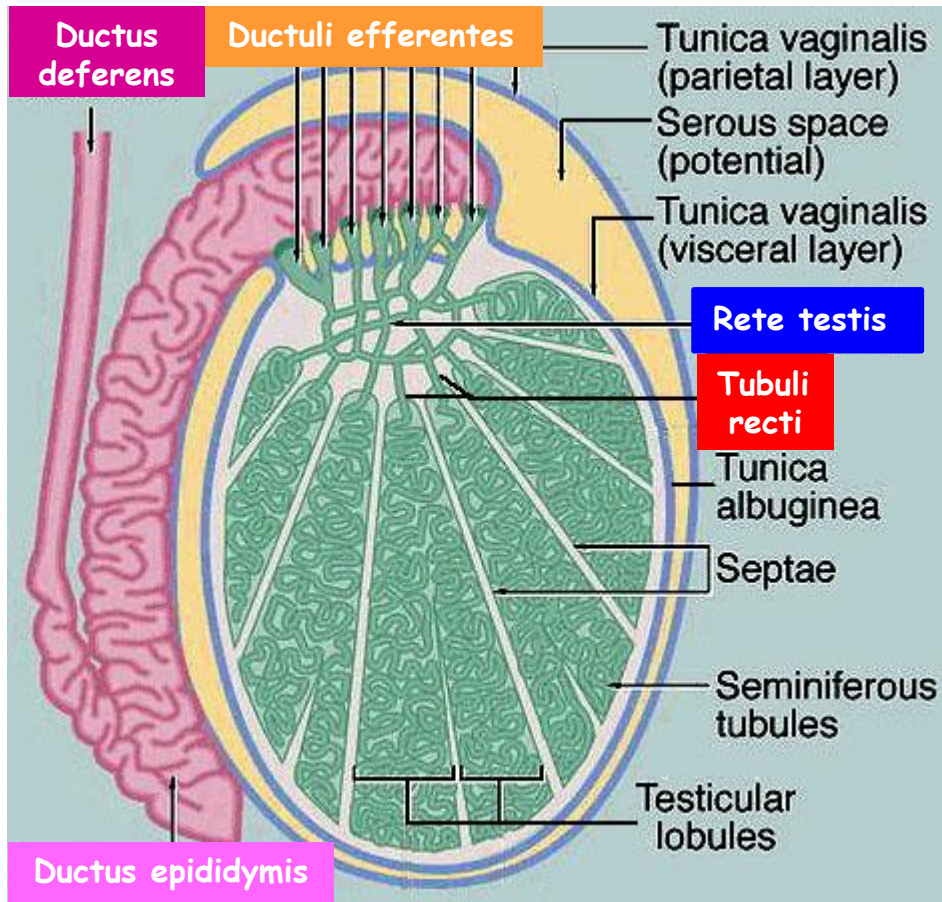
Abnormal spermiogram - Nomenclature

- **Asthenozoospermia**: reduced sperm motility
- **Oligozoospermia**: reduced sperm concentration in ejaculate
- **Teratozoospermia**: large numbers of morphologically abnormal sperm
- **Oligoastenoteratospermia**: combined abnormality in numbers, motility, and morphology of sperm
- **Azoospermia**: complete absence of sperm in ejaculate
- **Necrozoospermia**: high percentage of dead sperm (norm = minimum 50%)
- **Pyospermia**: unusually high numbers of leukocytes in ejaculate (norm = max. 1 million)

Male efferent passages = Genital ducts

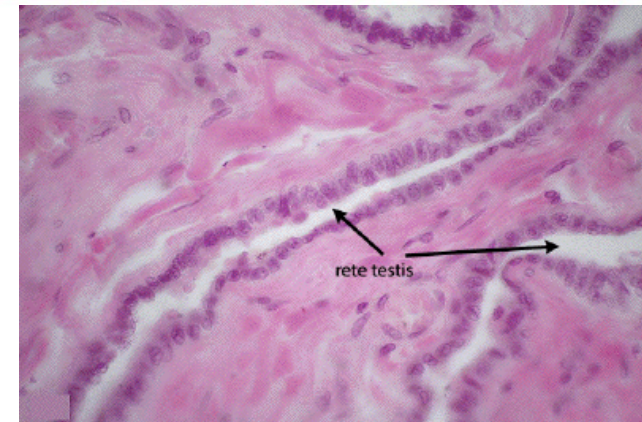
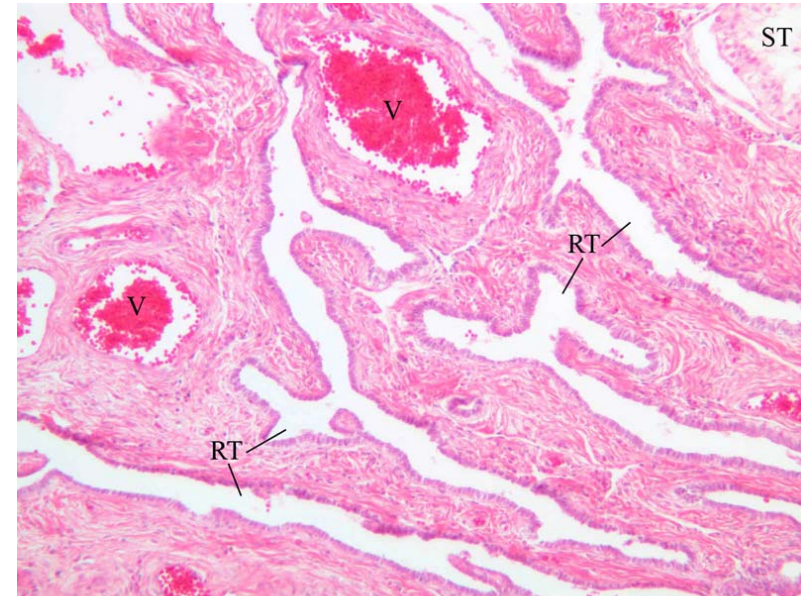
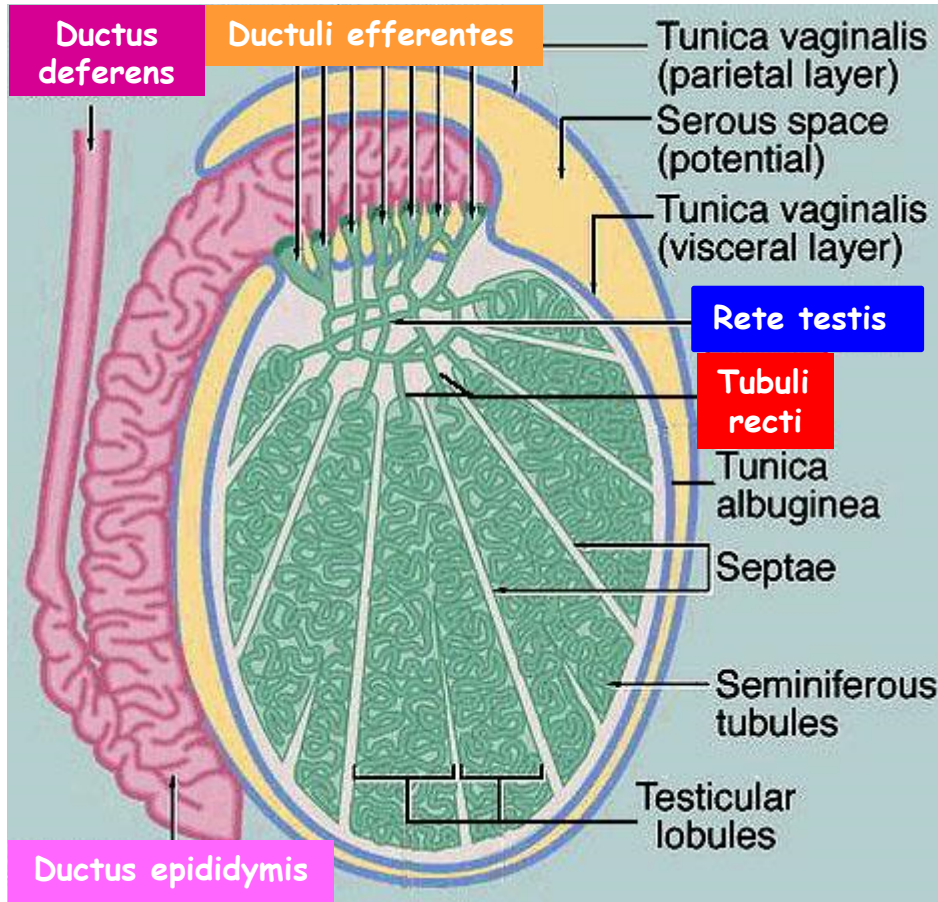
Genital ducts	Intratesticular <ul style="list-style-type: none">• Tubuli recti• Rete testis• Ductuli efferentes
	Extratesticular <ul style="list-style-type: none">• Epididymis• Ductus (vas) deferens• Ejaculatory duct• Urethra

Intartatesticular genital ducts - **Tubuli recti**



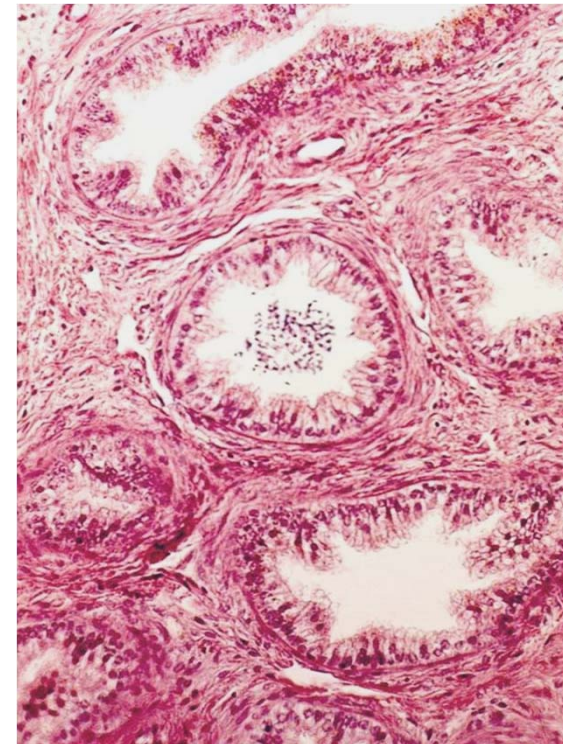
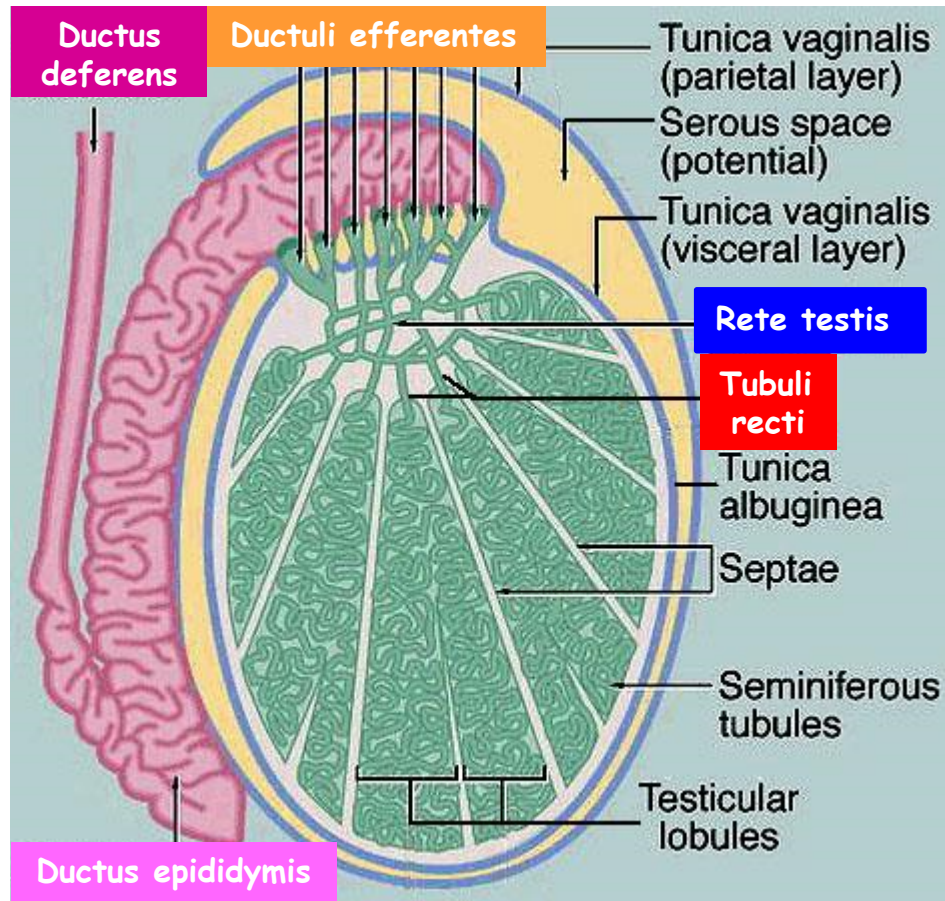
- short - about 1 mm
- in septula
- proximal part: Sertoli cells
- distal part: simple cuboidal epithelium
(short microvilli + cilium)

Intartatesticular genital ducts - Rete testis



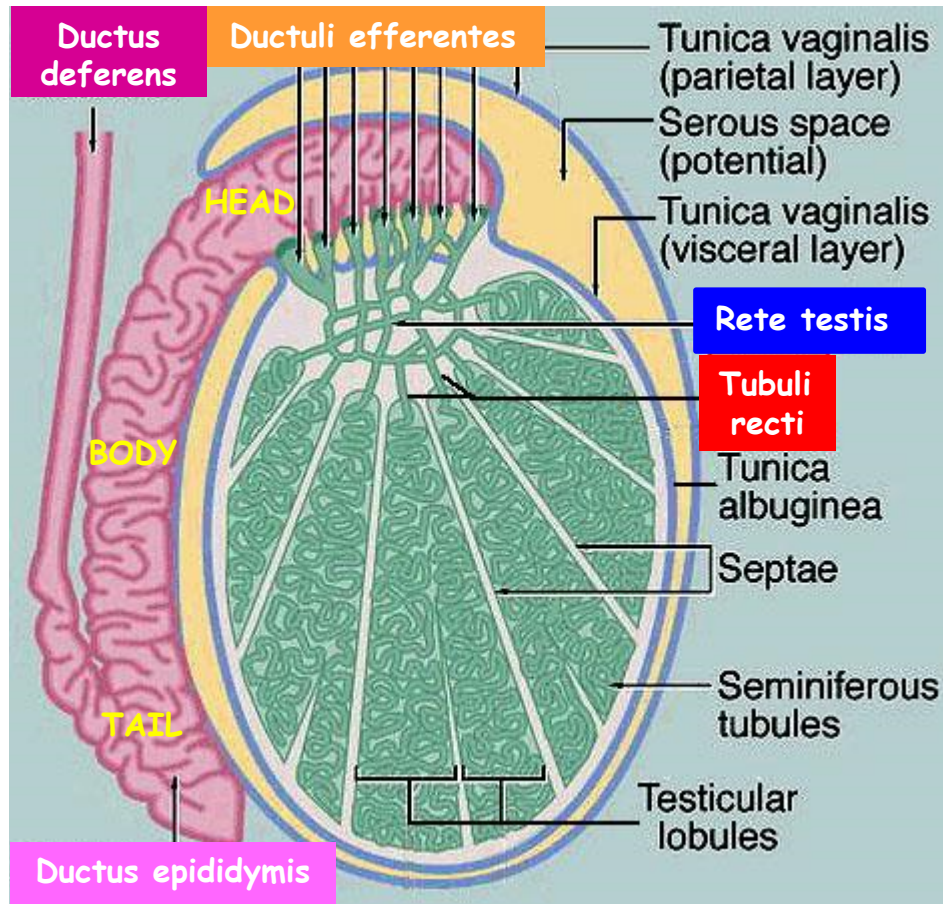
- labyrinth - interconnected channels
- in mediastinum
- simple cuboidal epithelium (as in Tubuli recti)
(with microvili + cilium)
- circular smooth muscle cells

Intartatesticular genital ducts - **Ductuli efferentes**



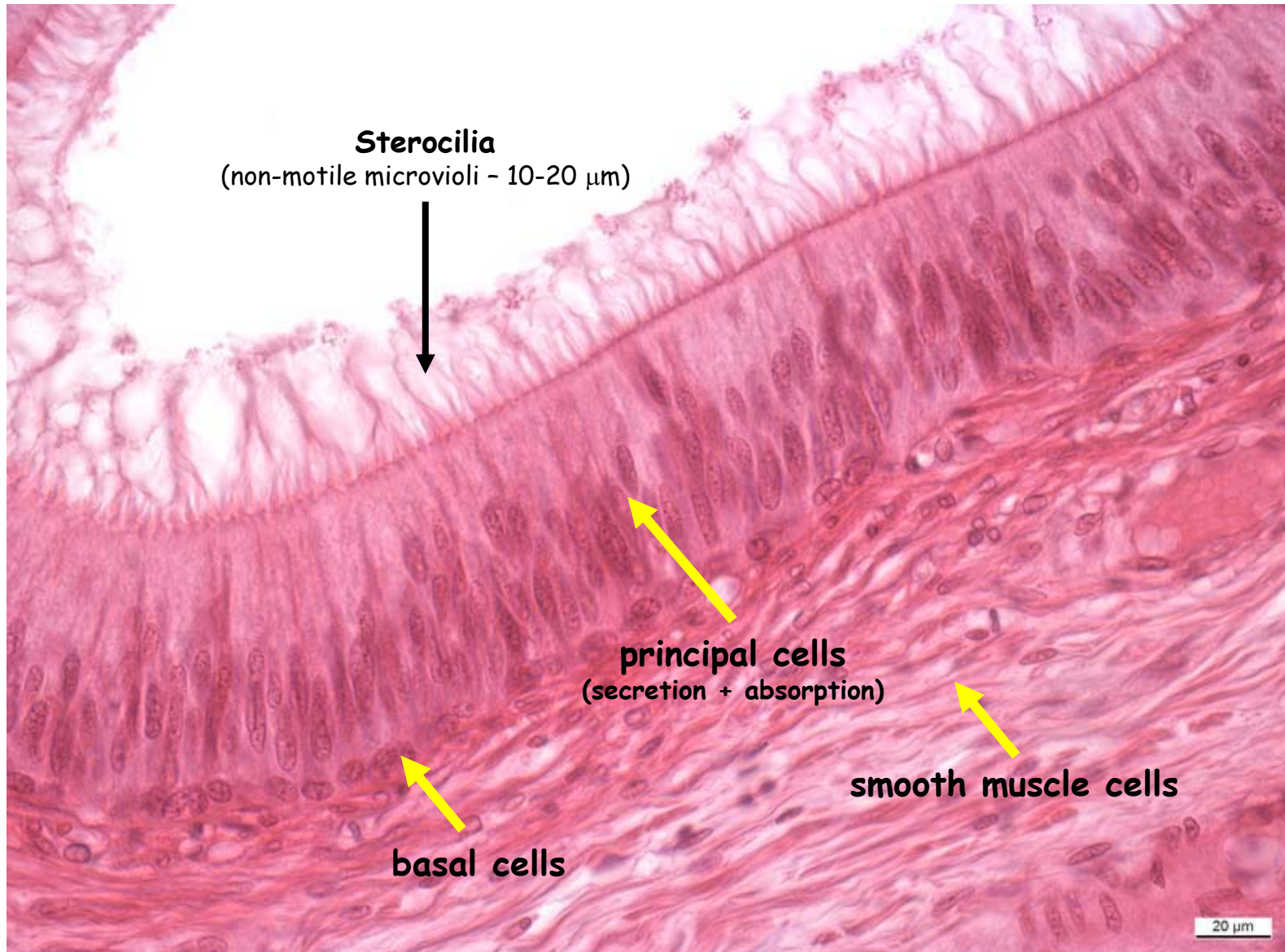
- 10 to 20
- penetrate tunica albuginea
- cuboidal + columnar cells (patches)
- **non-ciliated + ciliated** - sperm passage
- microvilli + lysosomes - absorption of luminal fluid
- **smooth muscle cells** - passage of sperm

Extratesticular genital ducts - Ductus epididymis 1

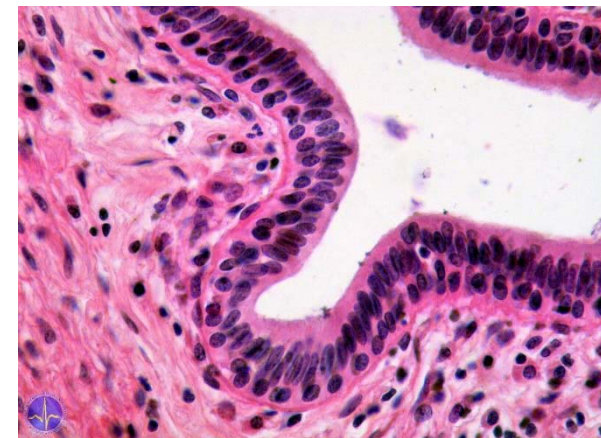
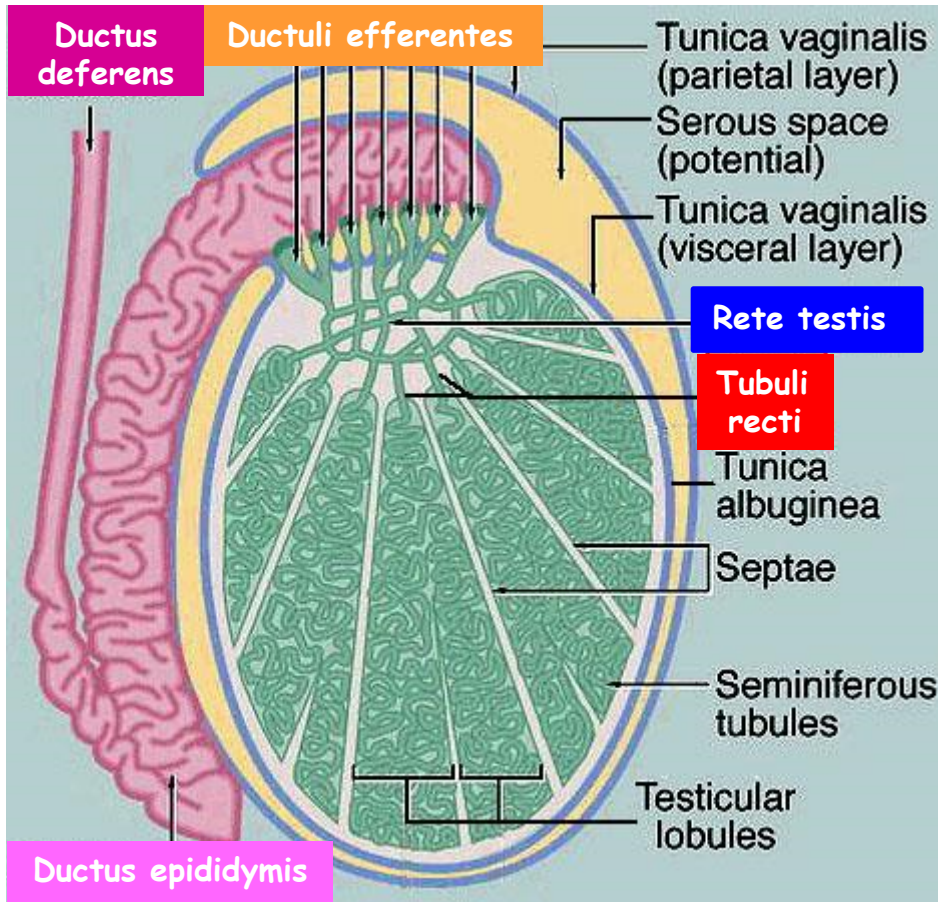


- about 5 meters long
- highly convoluted (head + body)
- tail (cauda) straight - sperm storage + maturation (under hormonal influence)
- columnar pseudostratified lining: **basal cells** (polyhedral) + **principal cells** (columnar)
- principal cells with **stereocilia**
- surrounded by circular **smooth muscle** layer (peristaltic motion)

Extratesticular genital ducts - Ductus epididymis 2

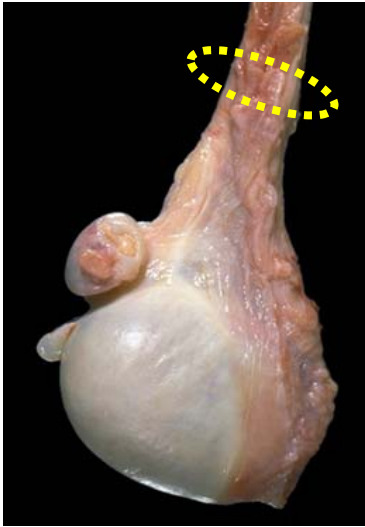


Extratesticular genital ducts - Ductus deferens 1

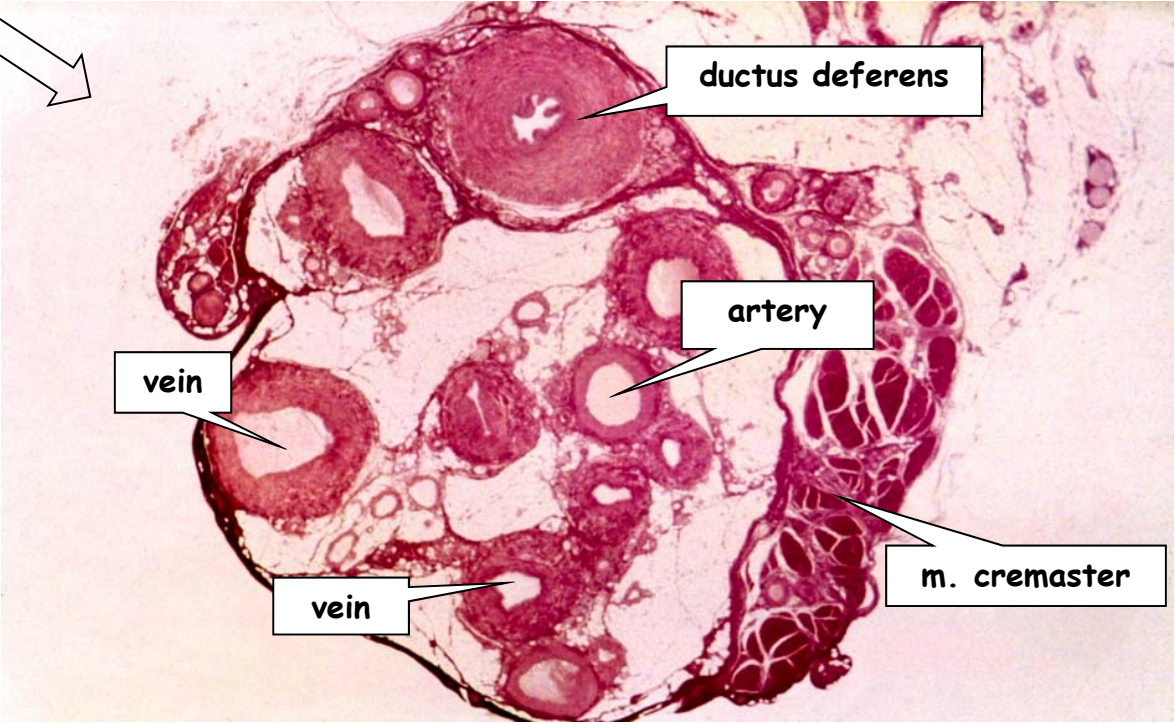


- thick walled + folded lumen
- epithelia similar to D. epididymis - columnar pseudostratified (basal cells + principal cells)
- surrounded by three layers of smooth muscle layer (circ+long+long)
- sympathetic innervation - initiate ejaculation

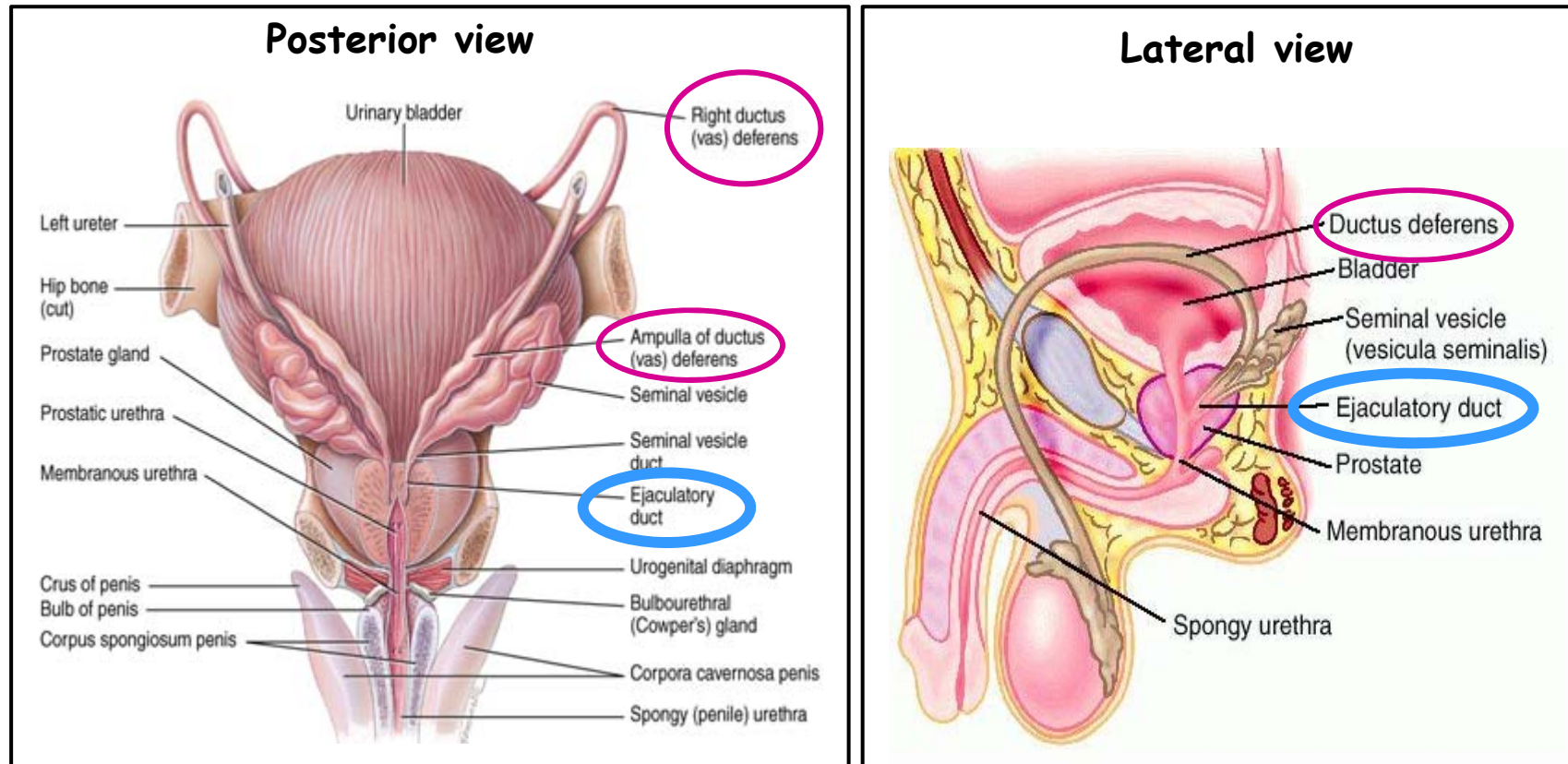
Extratesticular genital ducts - Ductus deferens 2



Funiculus spermaticus

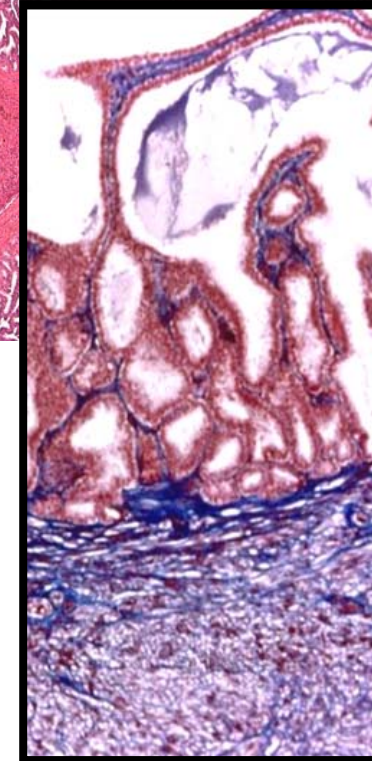
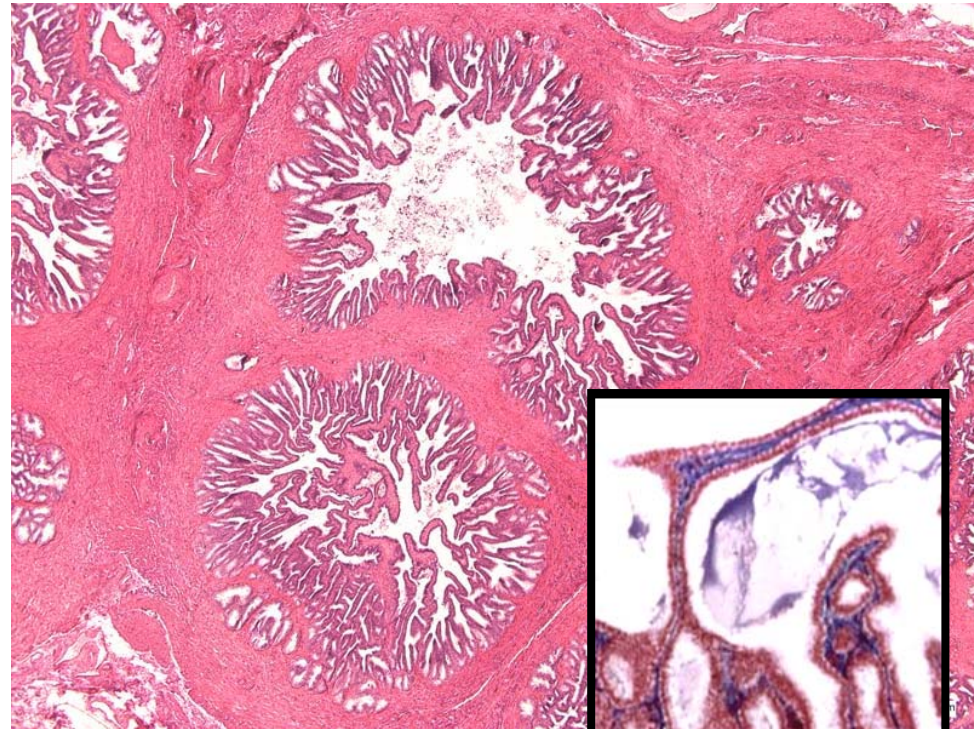
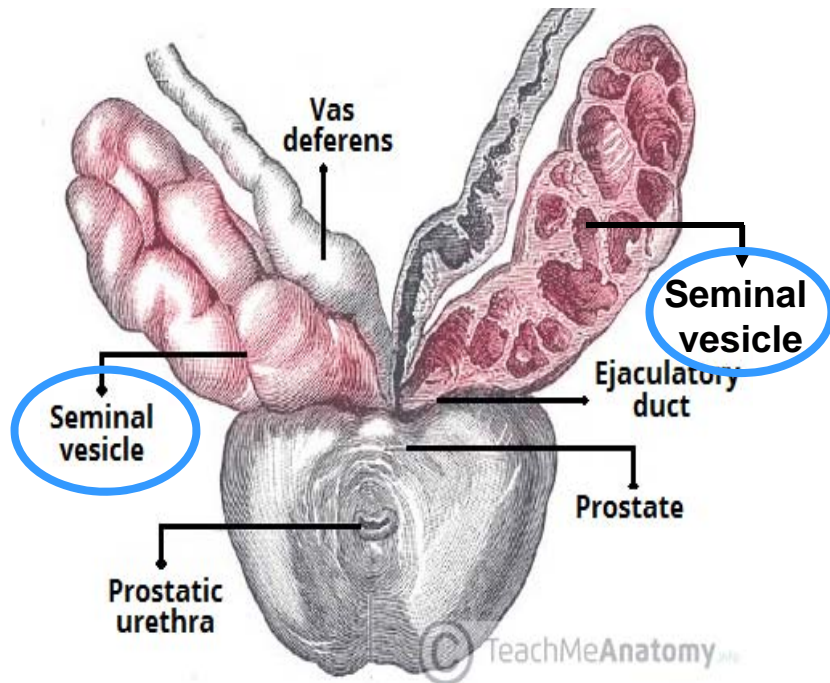


Extratesticular genital ducts - Ejaculatory duct



- short + straight
- portion after entry of seminal vesicle duct
- surrounded by prostate
- enters urethra at the **colliculus seminalis** (verumontanum)
- lined with **simple columnar epithelium**
- **NO smooth muscle laeyer**

Accessory genital glands - Seminal vesicles



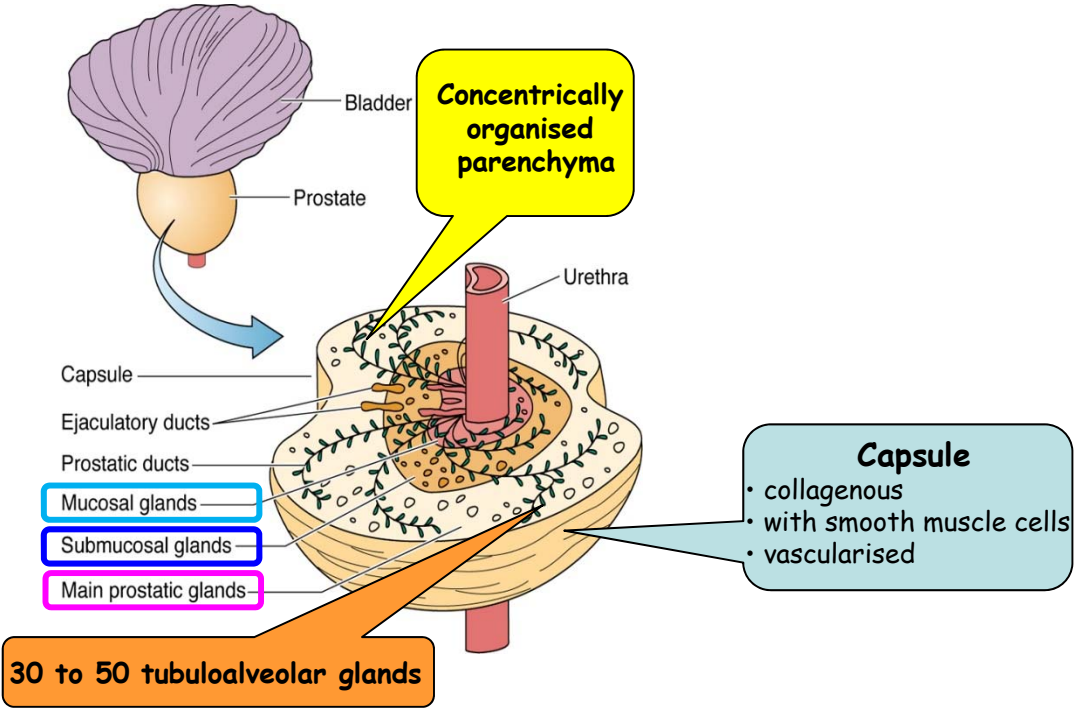
- develops from ductus deferens
- about 15 cm long snaking tube - **tubular gland**
- highly folded mucosa - labyrinthous cul-de-sac with openings to lumen
- **pseudostratified epithelium** - **basal** + **principal** cells (with microvilli+ cilium)
- **fibroelastic submucosa** + **smooth muscle layer**
- **seminal fluid** - constitutes about 70 of ejaculate (rich for **fructose**)

Accessory genital glands - Prostate gland 1

Mucosal
 • closest to the urethra
 = shortest

Submucosal
 • larger than mucosal

Main
 • largest
 • most abundant

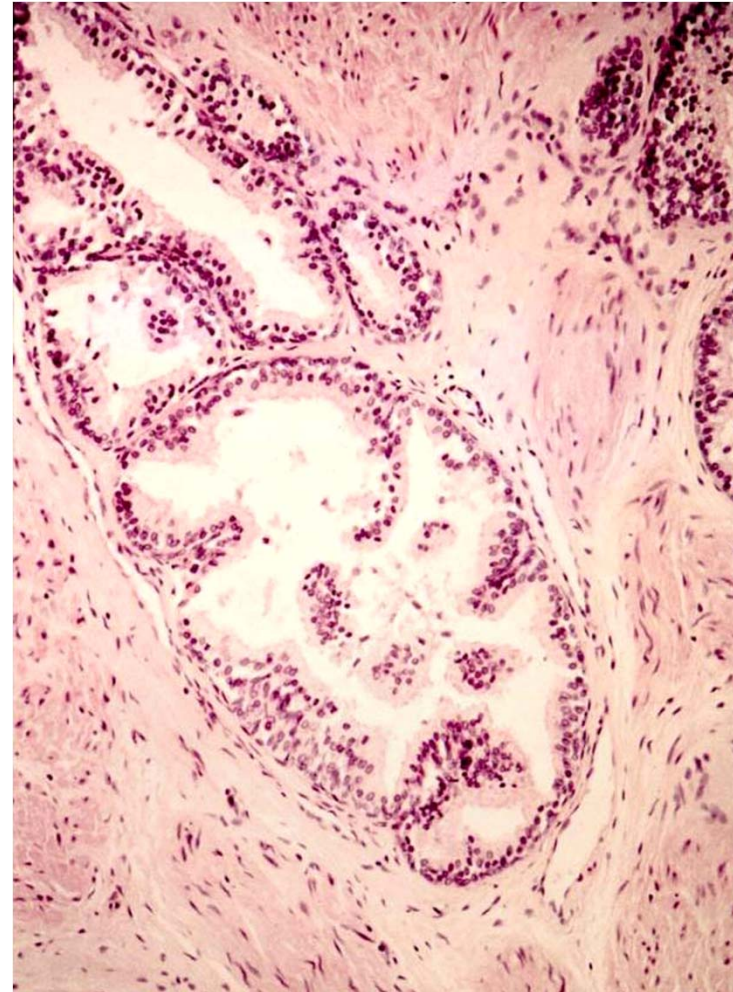
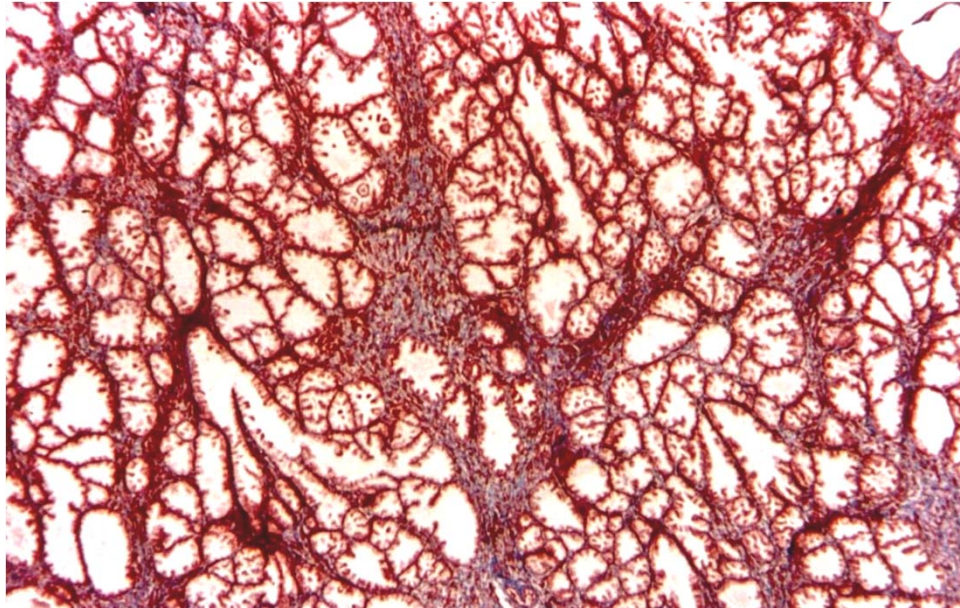


GLANDS

• simple pseudostratified columnar epithelium
 • abundant RER + Golgi + secretory granules

- size and shape of **chestnut** (the largest accessory gland)
- **stroma** (derives from the capsule): fibroelastic elements, many **smooth muscle cells**
- **prostatic secretion**: lipids, acid phosphatase, proteolytic enzymes, citric acid, fibrinolysin (liquifies semen)

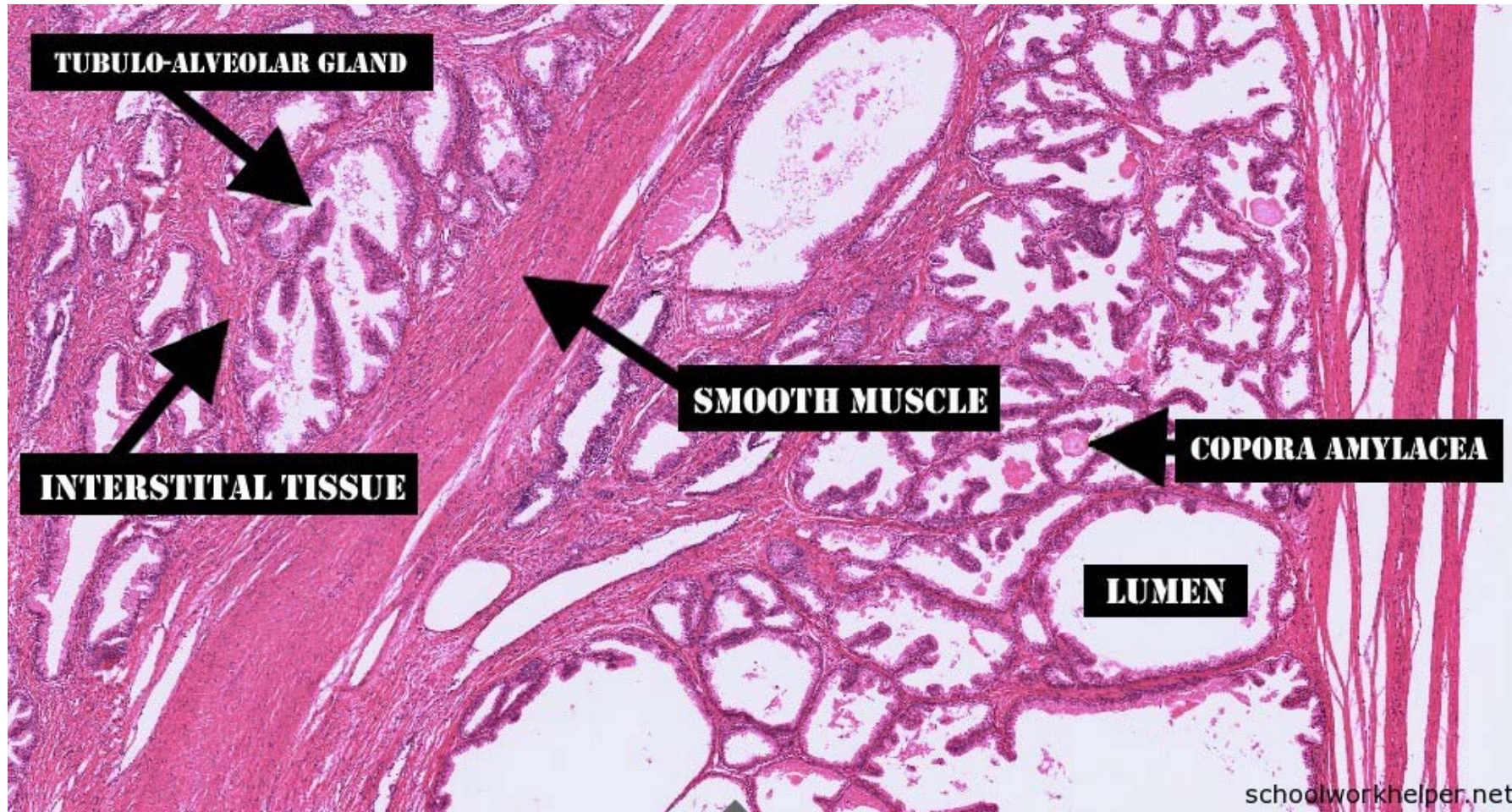
Accessory genital glands - Prostate gland 2



- Corpora amylacea**
= prostate concretions
- increase with age
 - may calcify
 - size even 1 mm

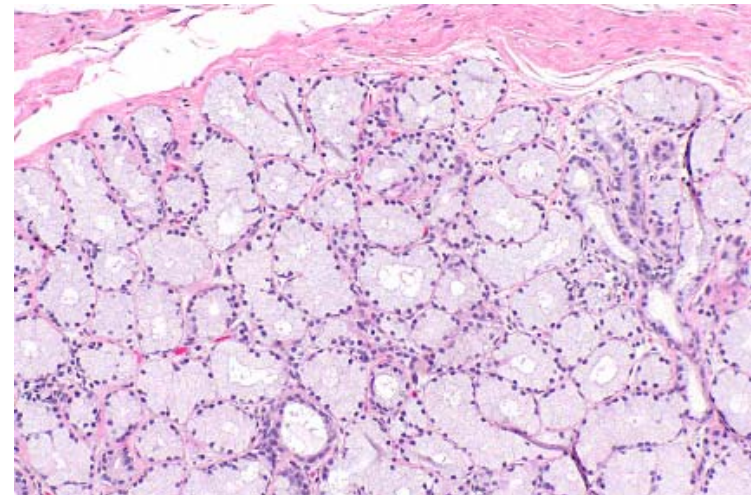
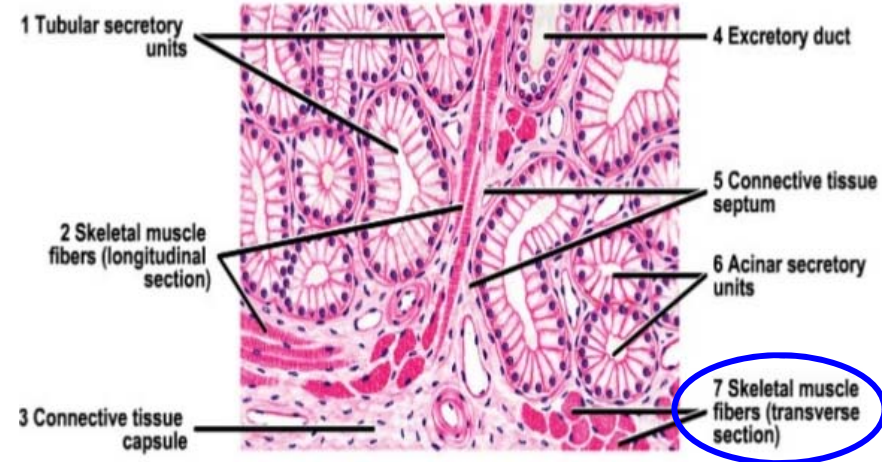
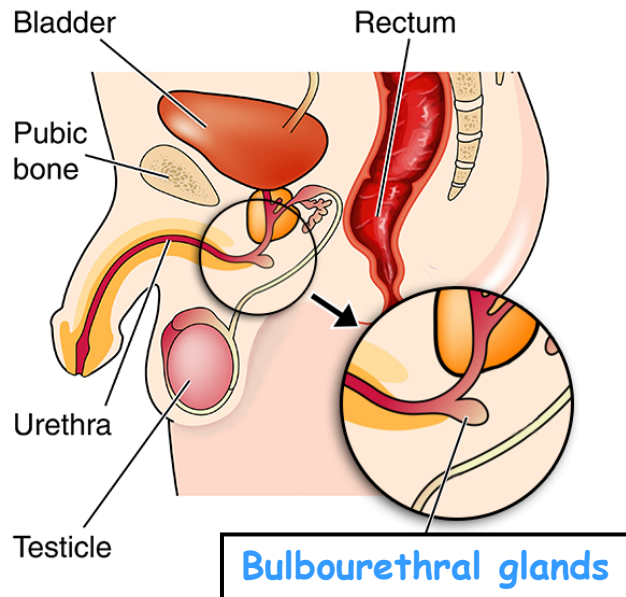


Accessory genital glands - Prostate gland 3



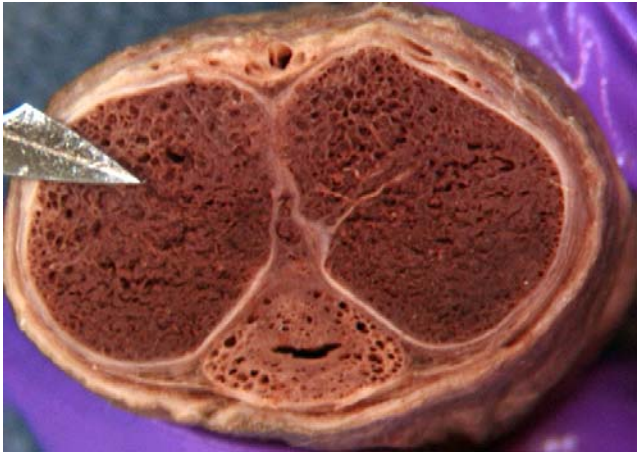
Accessory genital glands - **Bulbourethral glands**

Lateral view



- small - 3 to 5 mm
- at the root of the penis
- lobular structure (septa)
- **skeletal muscle fibers** (derived from urogenital diaphragm)
- simple cuboidal epithelium
- lubricating fluid (sialic acid + galactose)

Penis - 1



Superficial dorsal vein
Deep dorsal vein
Dorsal artery
Dorsal nerve
Deep artery

Tunica albuginea

Septum
(discontinuus)

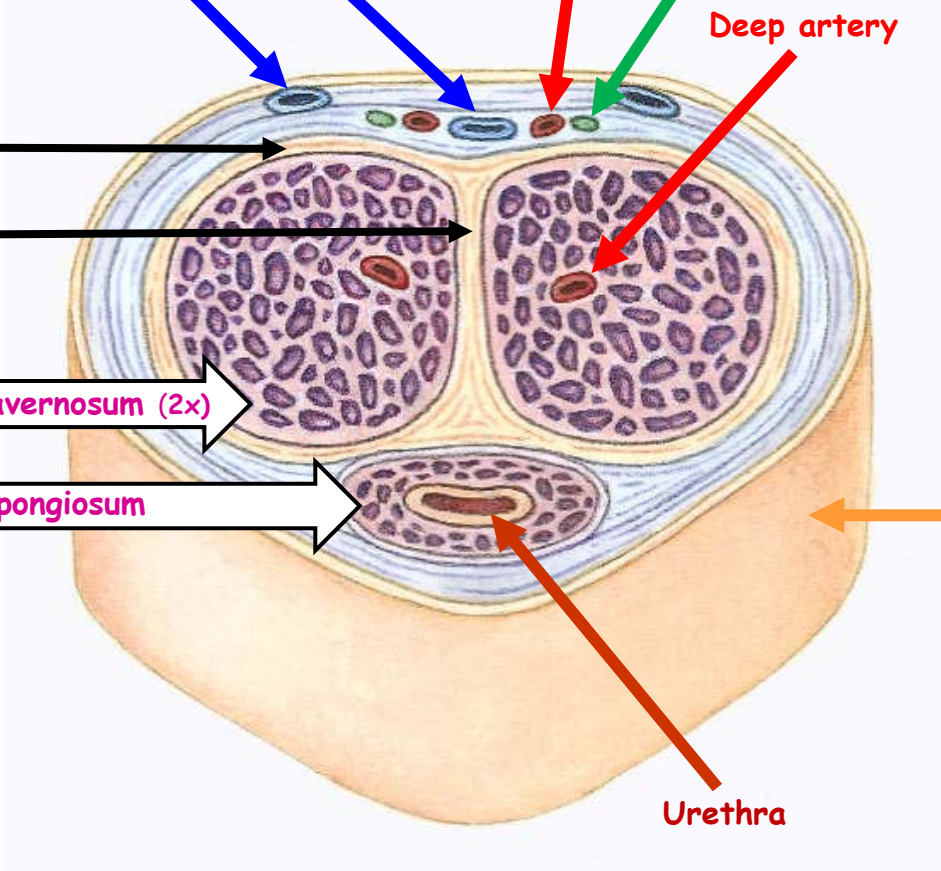
Erectile tissue

Corpus cavernosum (2x)

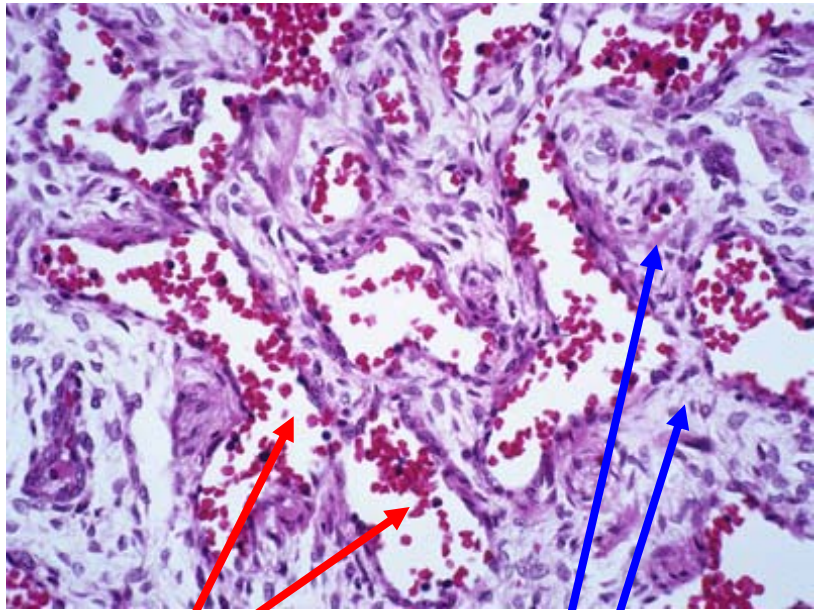
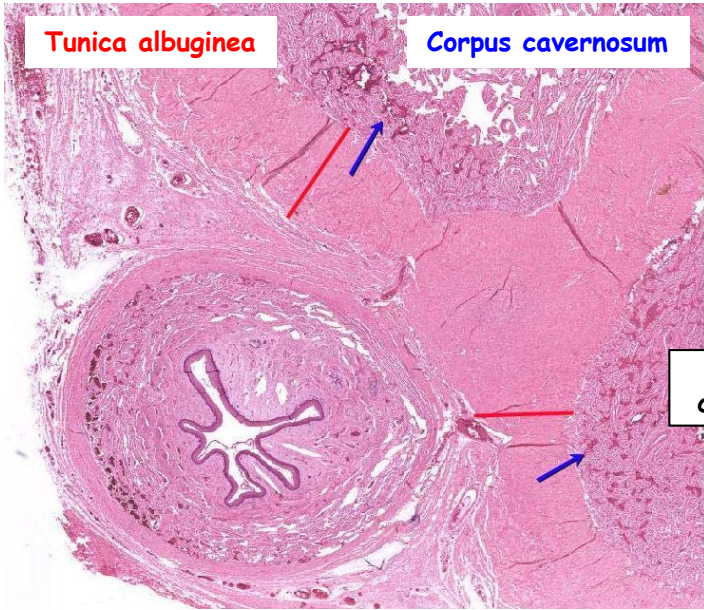
Corpus spongiosum

Skin

Urethra

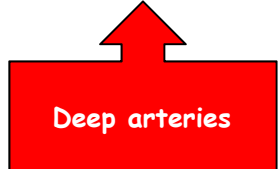
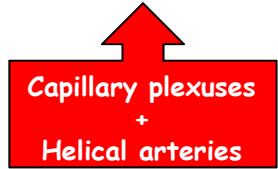
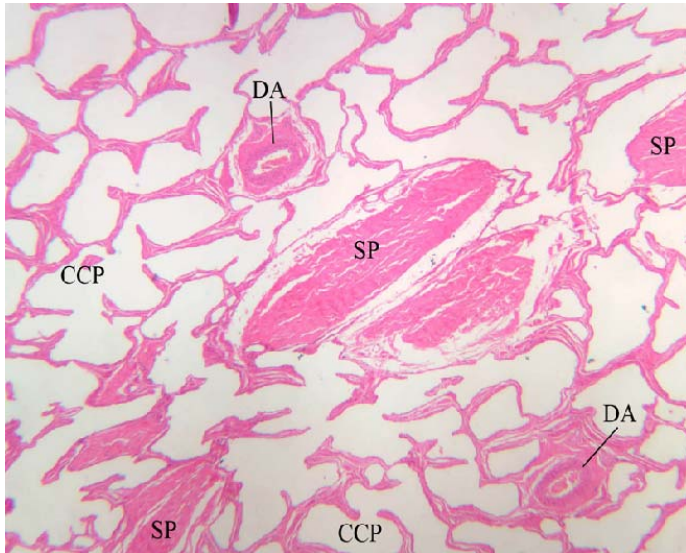


Penis - 2



Vascular spaces
 • lined by endothelia

Trabeculae
 • elastic fibers
 • smooth muscle cells

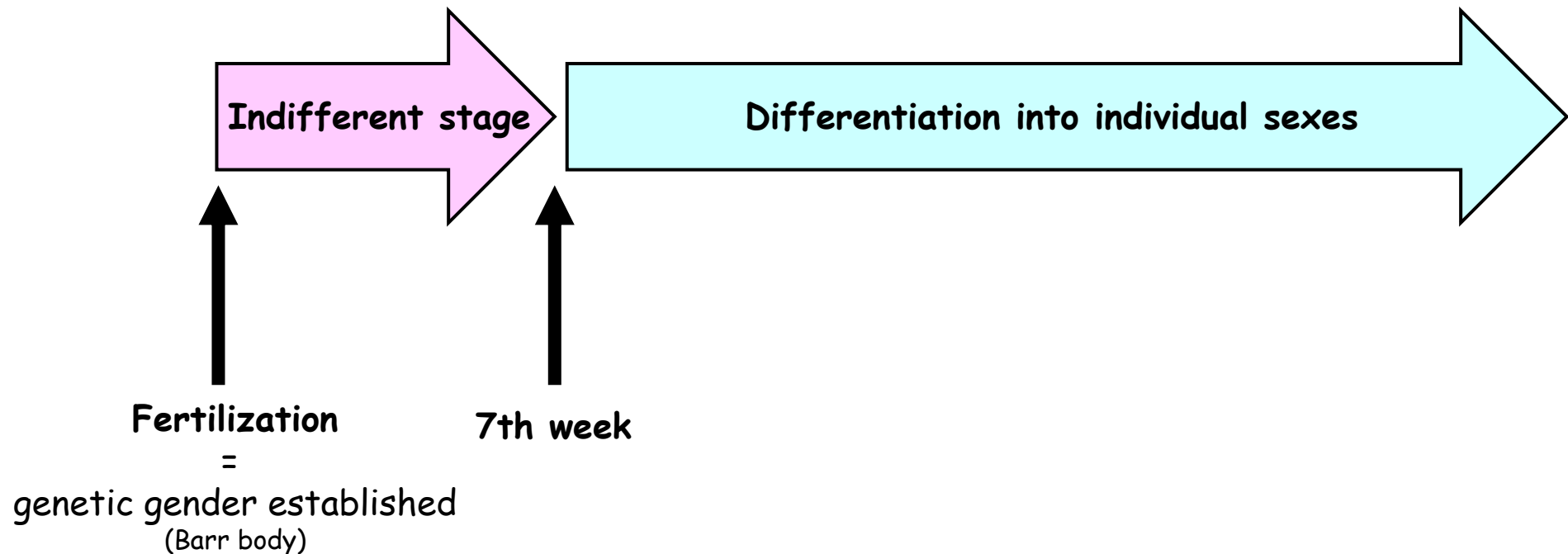


Genital system

Sexual dimorfism - individual can only have one type of genital organs

Genetic determination:

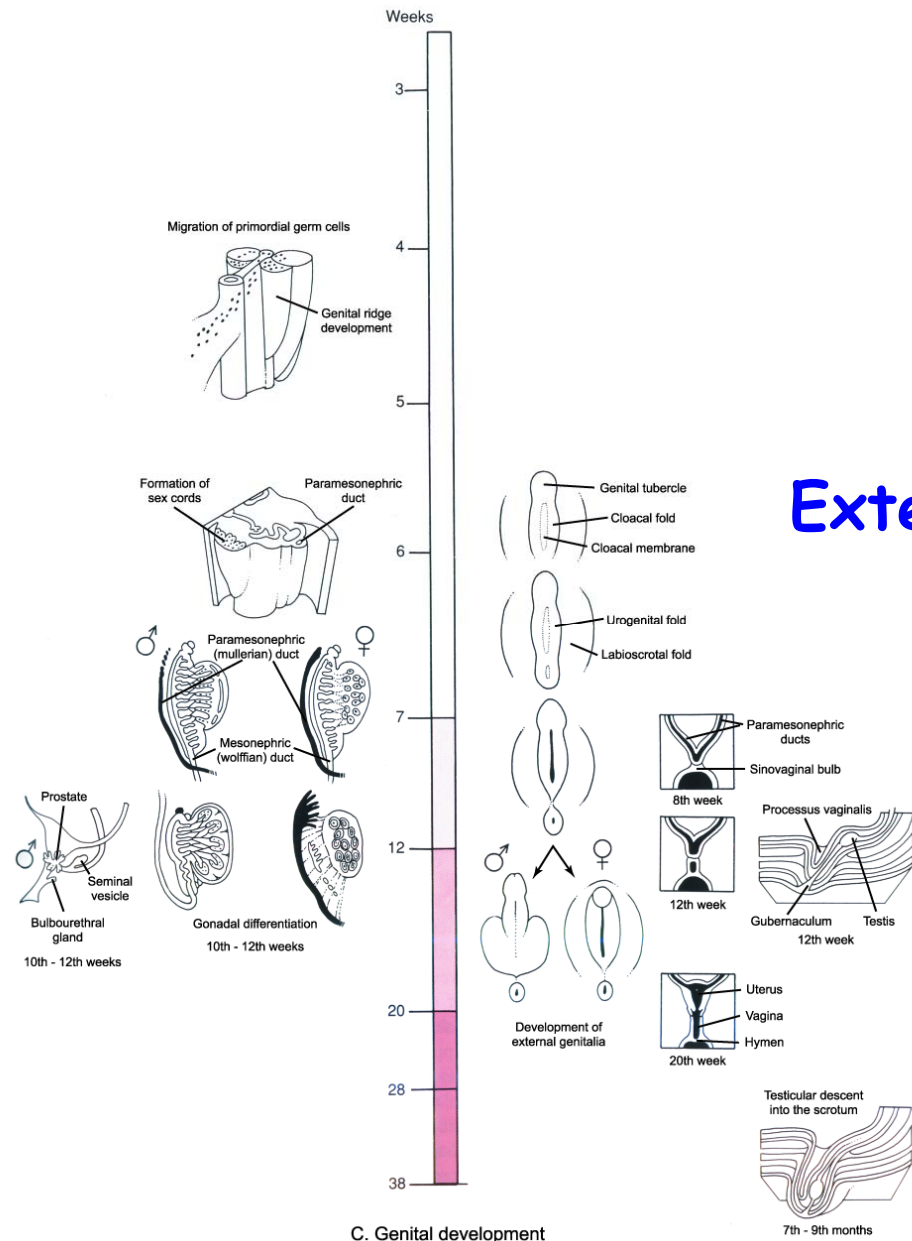
- Heterogametic (XY) - male
- Homogametic (XX) - female



Genital system - 7 weeks at indifferent stage

Gonads

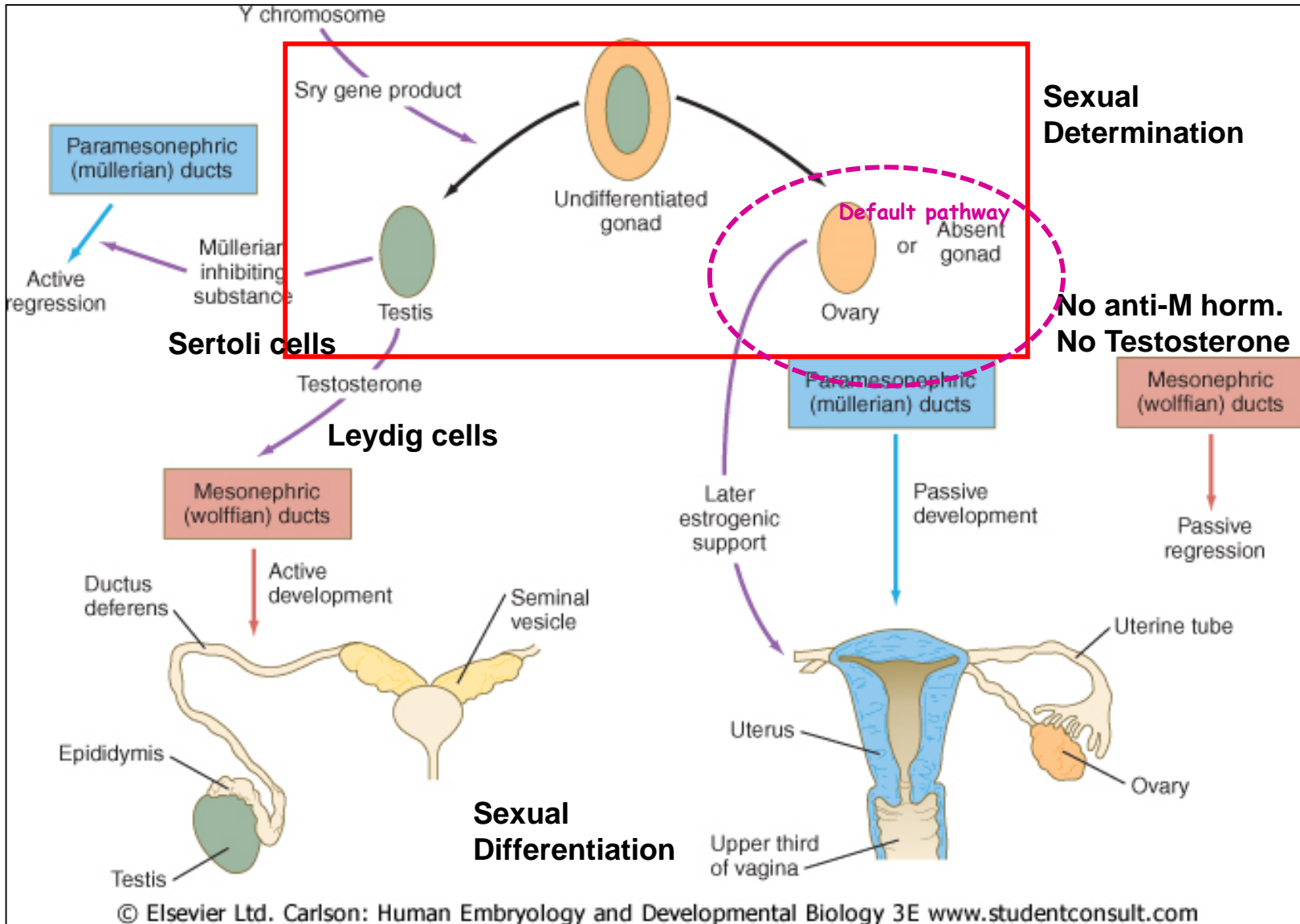
External genitalia



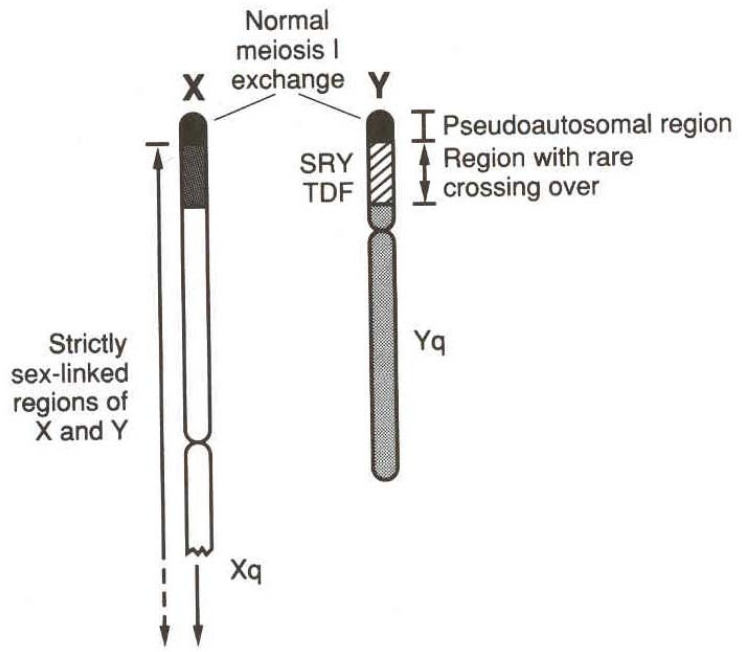
Genital system - Sry gene

Y chromosome decides
 XXY - male
 XO - female

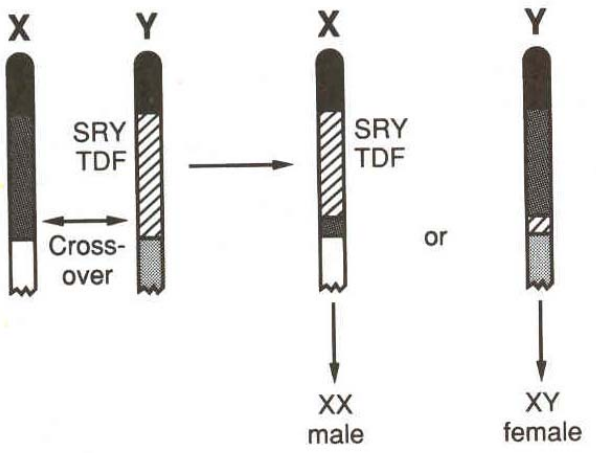
Sry gene - Sox family TF - on short arm of Y chromosome



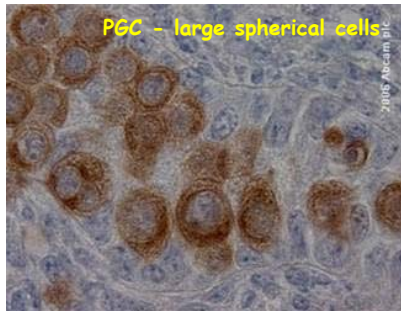
Genital system - Sry gene



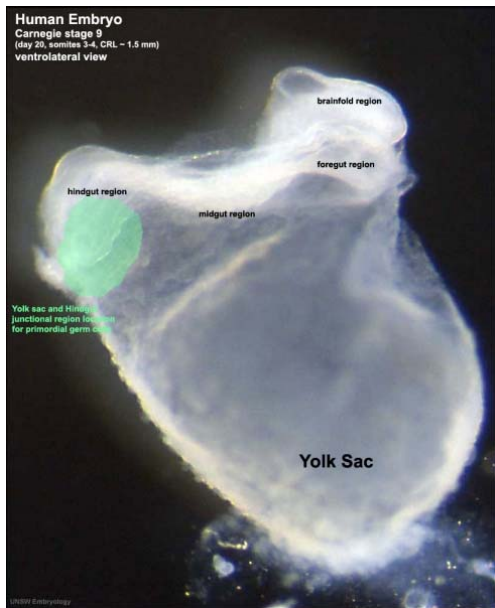
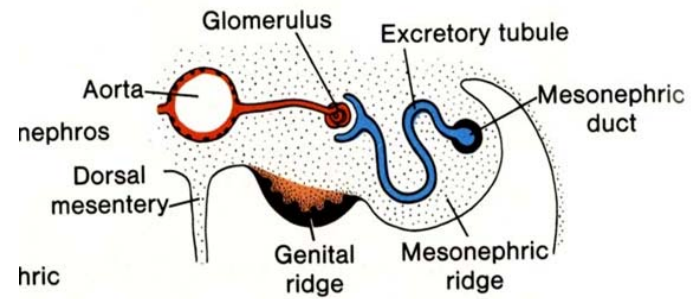
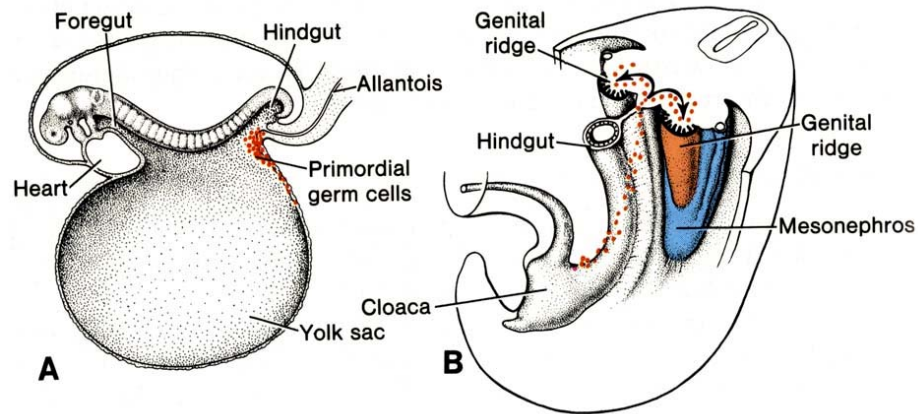
Pairing of X and Y chromosomes in pseudoautosomal region during meiosis



Rare crossing-over causes translocation of SRY to X chromosome: XY females or XX males

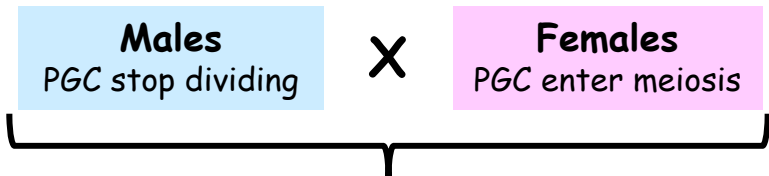


Genital system - Primordial germ cells



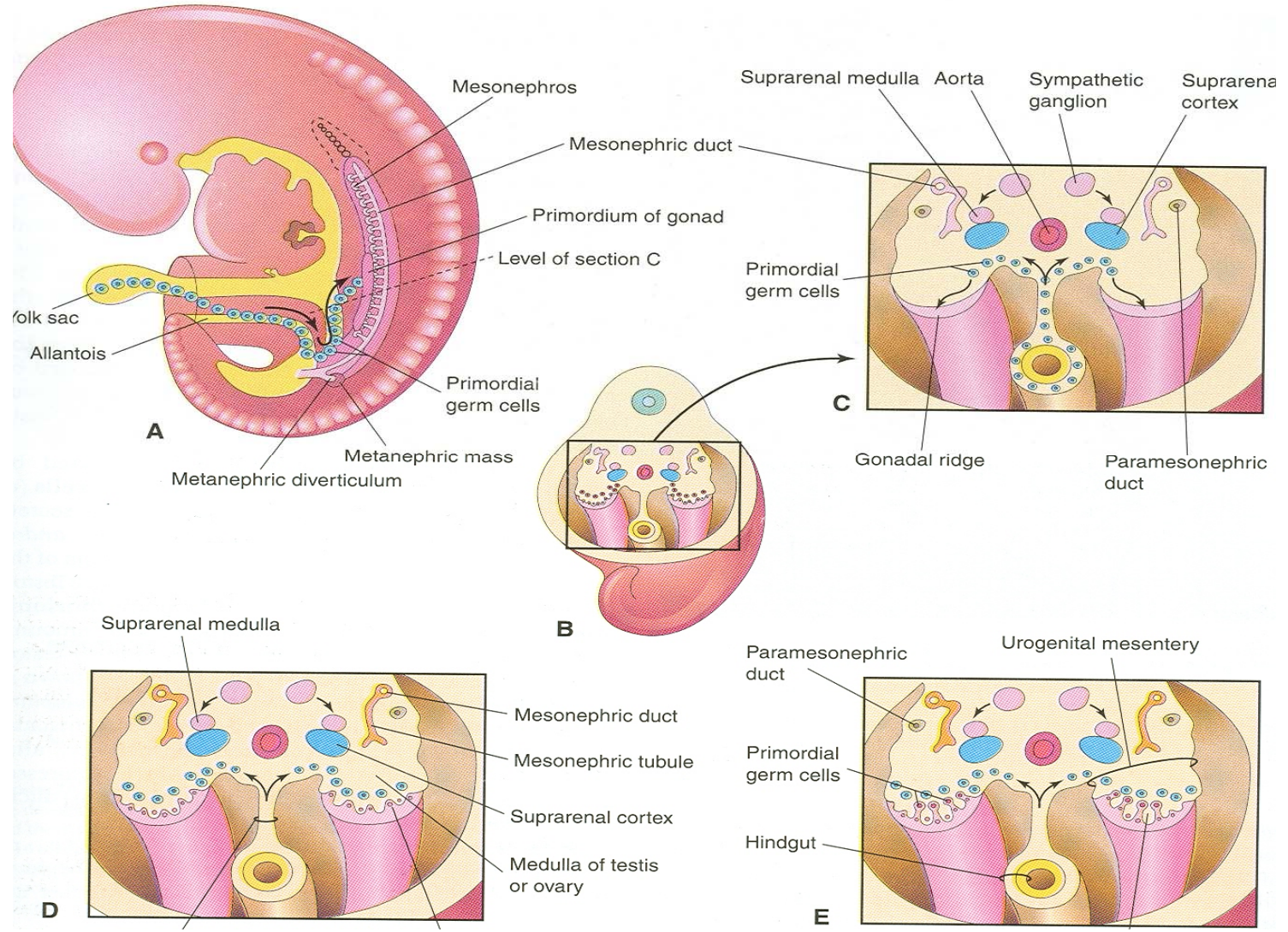
Primordial germ cells (PGC)

- first recognizable at day 24
- from epiblast-derived extraembryonic mesoderm
- few cells among endodermal cells of the yolk sac
- they migrate through the dorsal mesentery of the hindgut
- migrate towards genital ridges (plicae genitales)
- proliferate during migration
- reach (1-2 thousands) genital ridges on week 6 of gestation



decided by somatic cells in the genital ridges

Genital system - migration of PGC into gonadal anlagen



Genital system - gonadal anlagen

Steroidogenic mesoderm
along the ventromedial border of the mesonephros

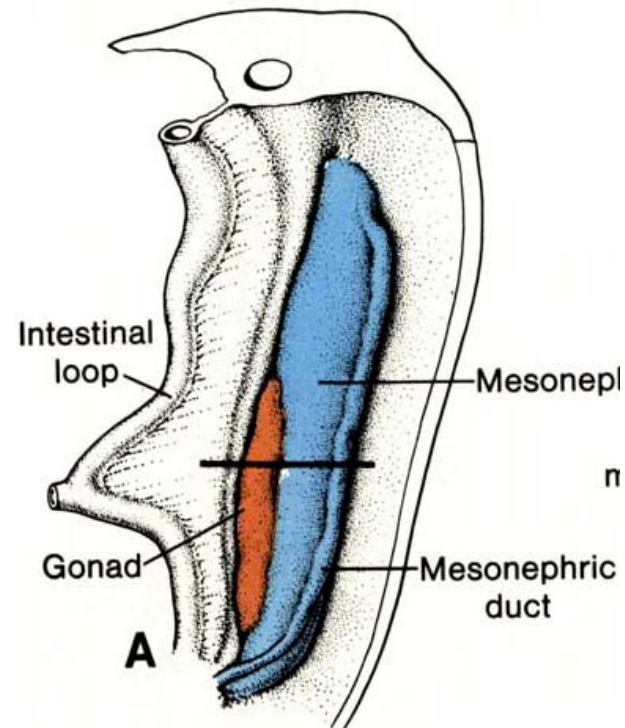
cranial region
Adrenocortical primordia

caudal region
=
Genital ridges

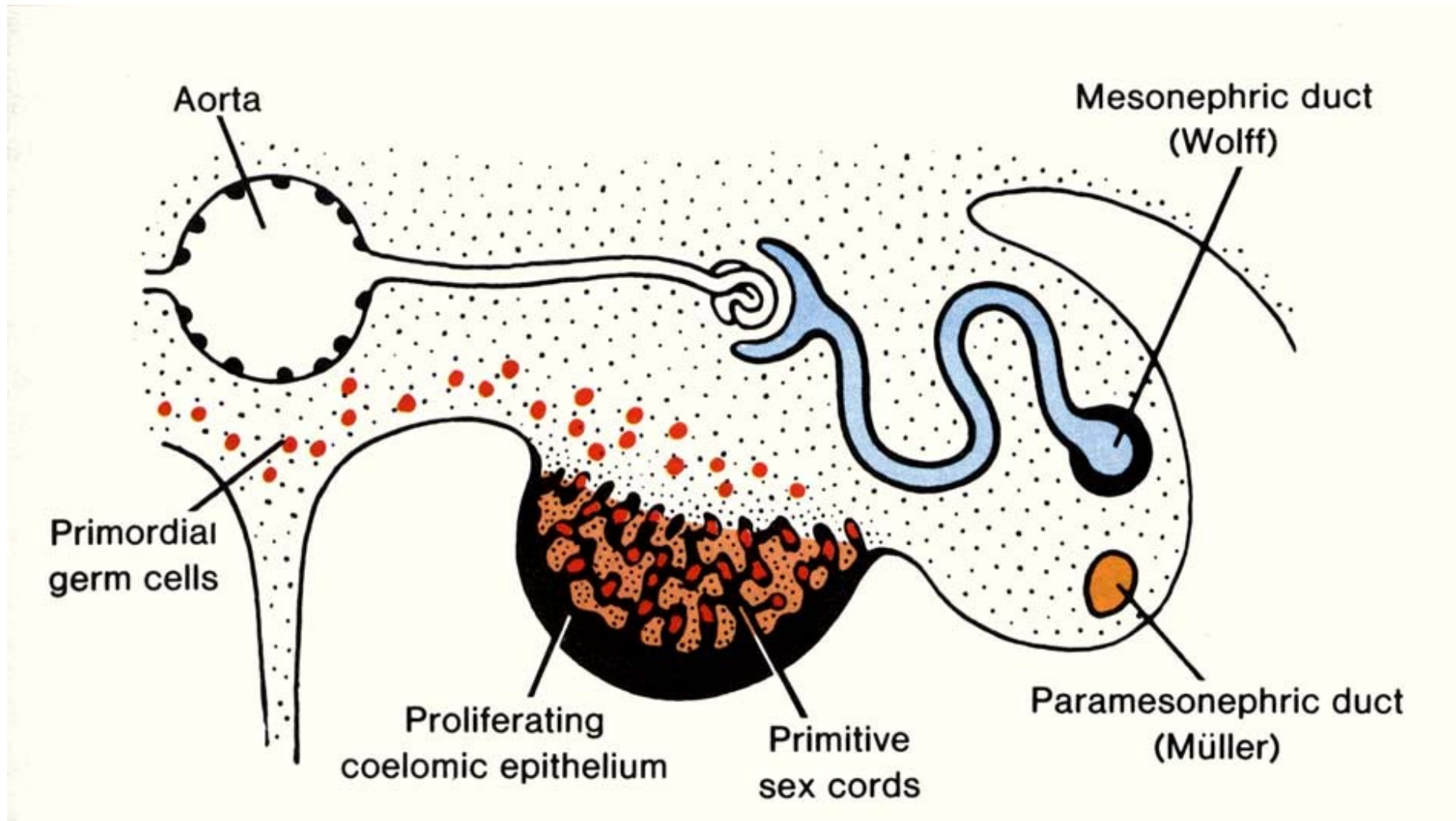
cells of **coelomic epithelium**
+
cells from **mesonephric ridge**

Week 4 - Th6 to S2
cranial + caudal parts involute
Week 6 - L3 to L5

become populated by PGC at week 6



Genital system - indifferent gonade (week 6)



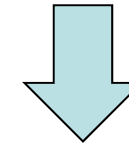
Genital system - Descent of the testes

„Prerequisites + driving forces“ for the descent of testes:

- testes enlargement
- atrophy of mesonephros - allows for caudal movement
- tension of gubernaculum
- atrophy of paramesonephric ducts - move to unguinal canal
- enlargement of processus vaginalis peritonei (6th month)
- increased intraabdominal pressure ?

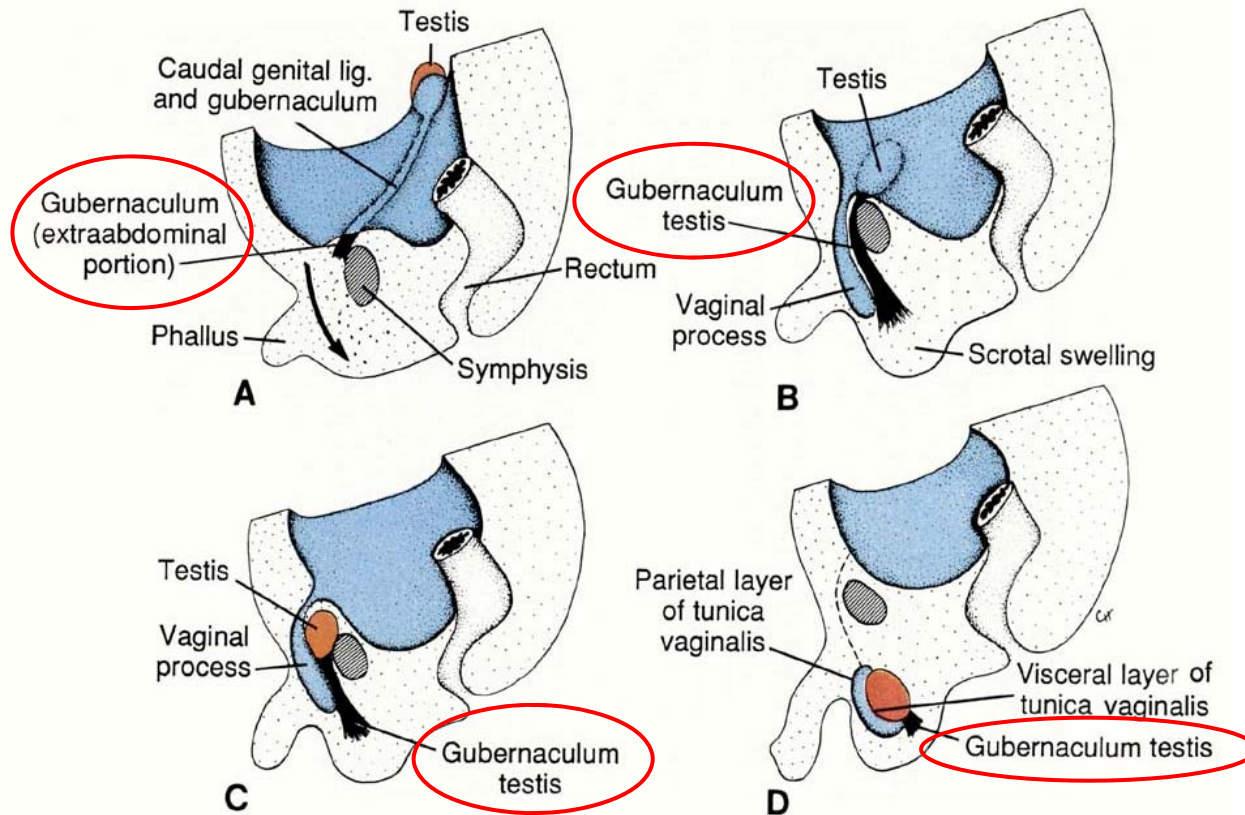
By 26 weeks

- the testes have descended retroperitoneally to the deep **inguinal rings**



During 26th week

- final descent through the **inguinal canals** into the scrotum - 2 to 3 days



NOTES

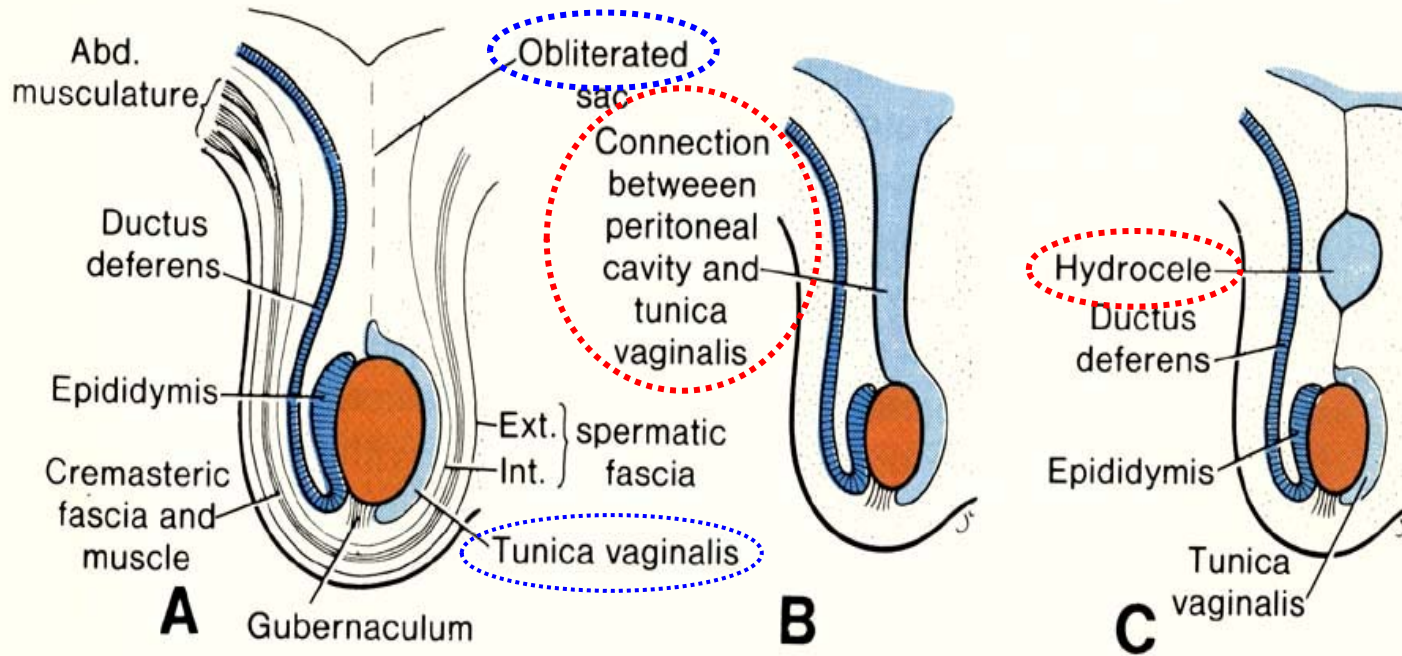
More than 97% of full-term newborn males have both testes in the scrotum

During the first 3 months after birth, most undescended testes descend into the scrotum

Spontaneous testicular descent does not occur after the age of one year

Gubernaculum - originates from caudal portion of genital ridge

Genital system - Descent of the testes



Processus vaginalis obliterated
NORMAL

Remaning connection = Risk of hernia
ABNORMAL

Remaing cyst = Hydrocele
ABNORMAL

Genital system - Differentiation of the testes

Late 6th week

Cord cells differentiate to Sertoli cells

(meiosis-inhibiting factor, anti-mullerian substance, androgen binding factor)

Tunica albuginea develops

(sets barrier between coelomic epithelium and testis cords)

Cord cells form seminiferous tubuli, tubuli recti, and rete testis

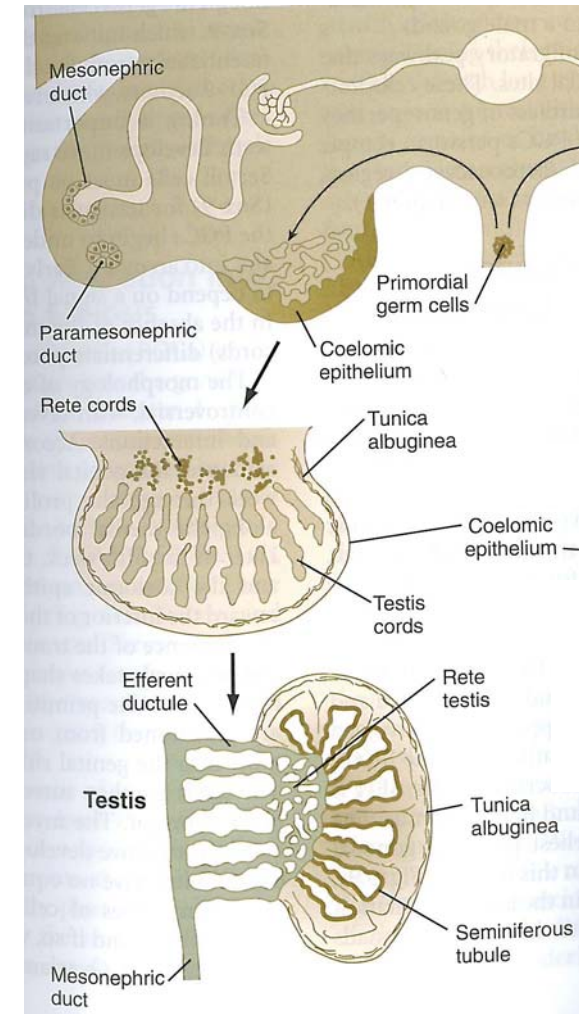
Rete testis joins ductuli efferentes that are derived from mesonephric ducts

(5th to 12th)

Week 8 to 18

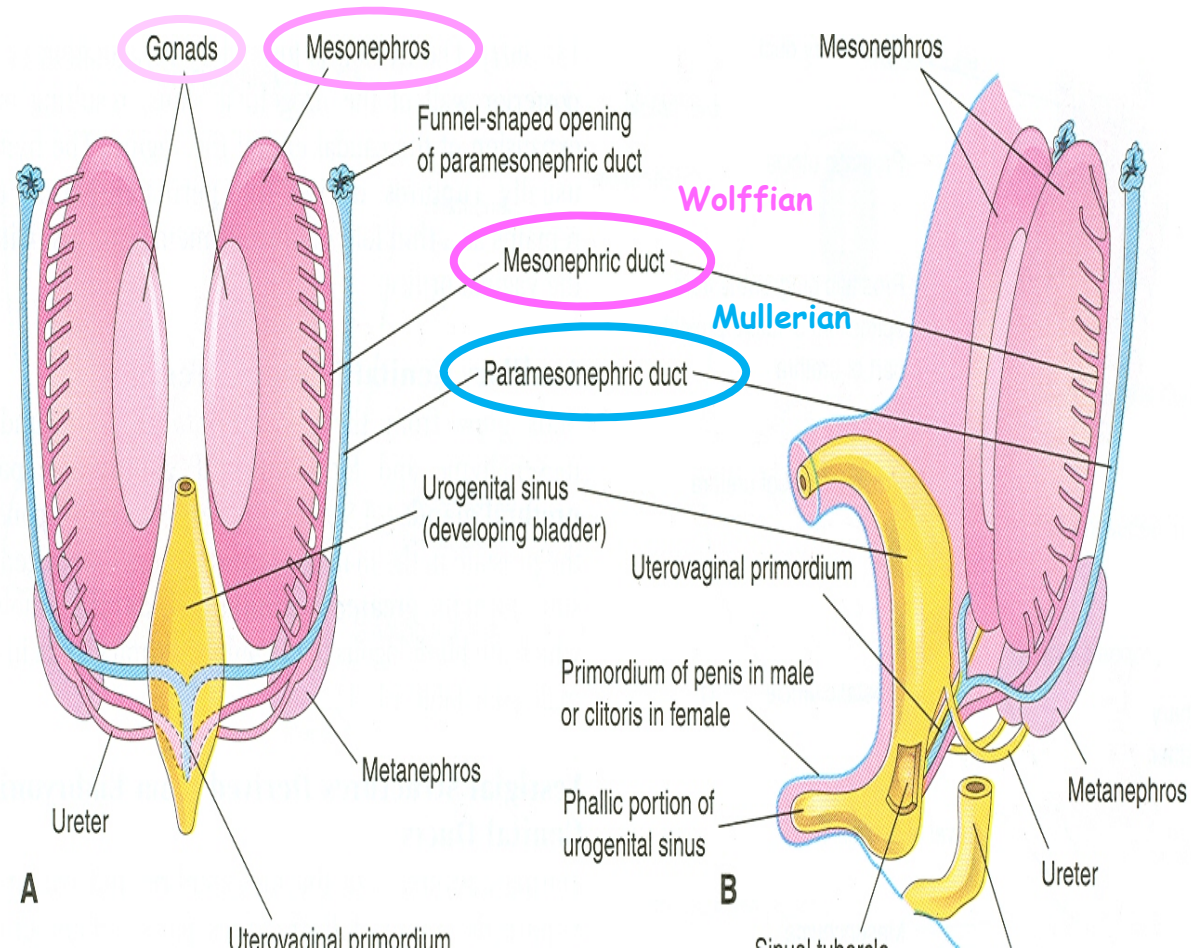
Leydig cells develop and function in developing testis

- from coelomic epithelia and mesonephros
- produce testosterone
- support development of Wolfian (mesonephric) duct
- support development of external genitalia



Genital system - Sexual duct system - Indifferent stage

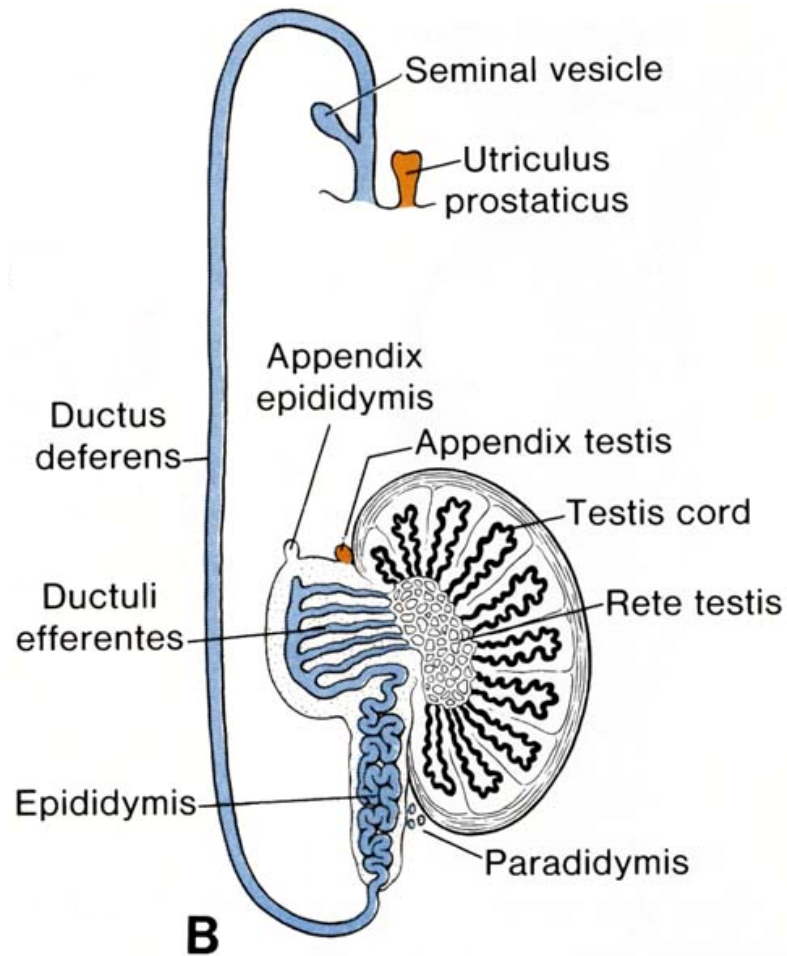
Week 7



Paramesonephric duct

Develops at days 44 to 48
Cranially opens to coelomic cavity

Genital system - Sexual duct system - **Male**



Mesonephric ducts (Wolffian)

- Ductus epididymis
- Ductus deferens
- Ductus ejaculatorius
- Seminal vesicle

Paramesonephric ducts (Mullerian) regresses in week 8 (anti-M hormone)

- Appendix testis (cranial part)
- Utriculus prostaticus (caudal part)

Mesonephros

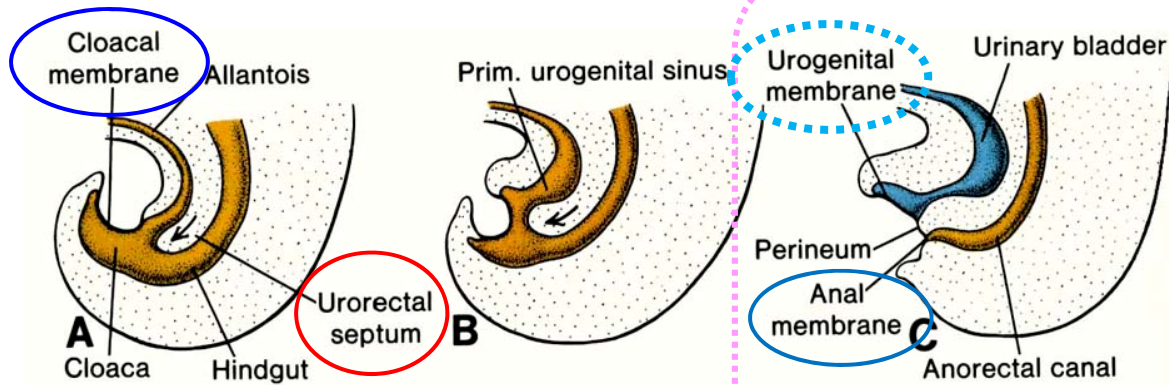
- Ductuli efferentes
- Paradidymis (under the testis, nonfunctional)

Genital system - External genitalia - Indifferent stage

They are derived from a complex mesodermal tissue located around cloaca.

HORMONE-INDEPENDENT

Week 6 to 8

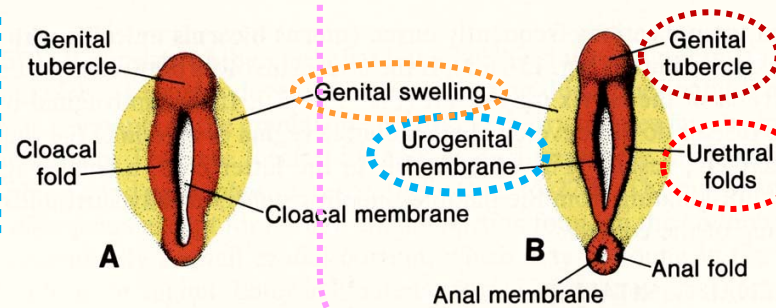


Orificium urogenitale primitivum
demarcated by:

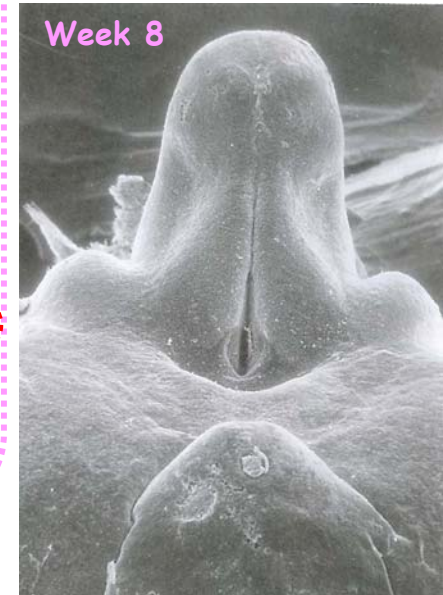
Genital tubercle - Phallus

Urethral (genital) folds - Plicae urogenitales

Genital swellings - Tori genitales



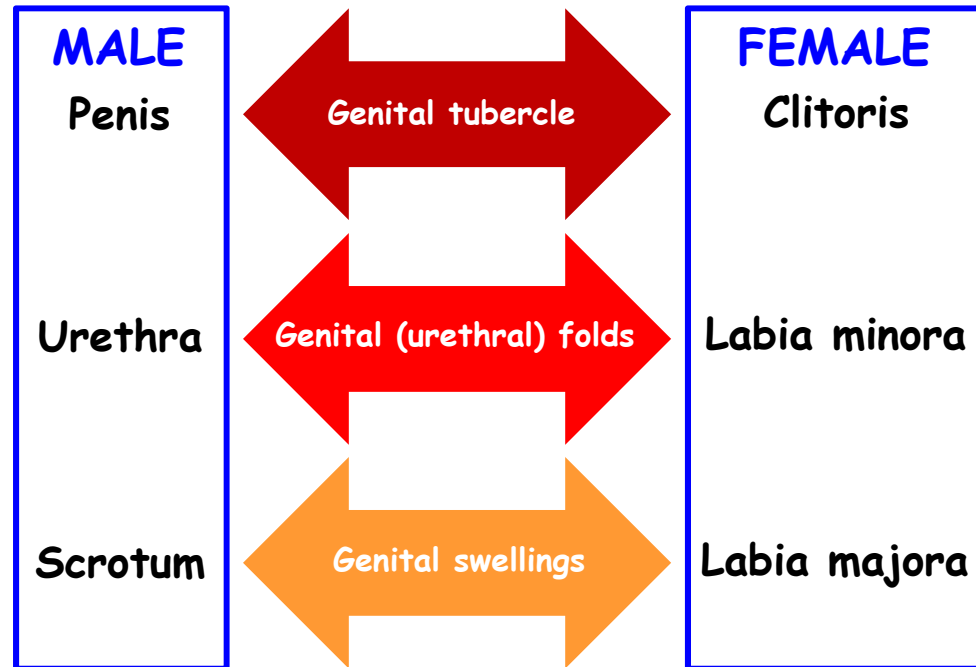
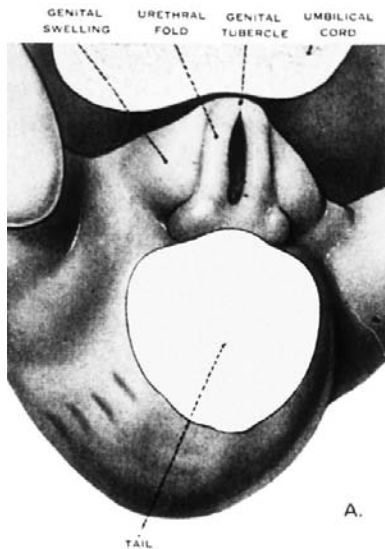
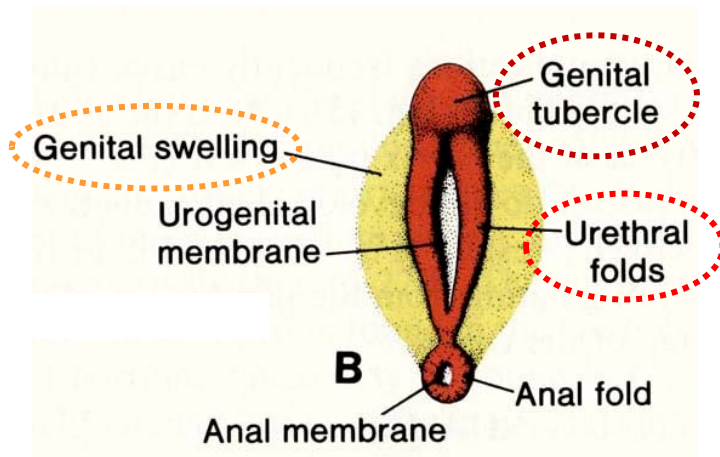
Week 8



Genital system - External genitalia - Dimorphism

Week 9 to 13

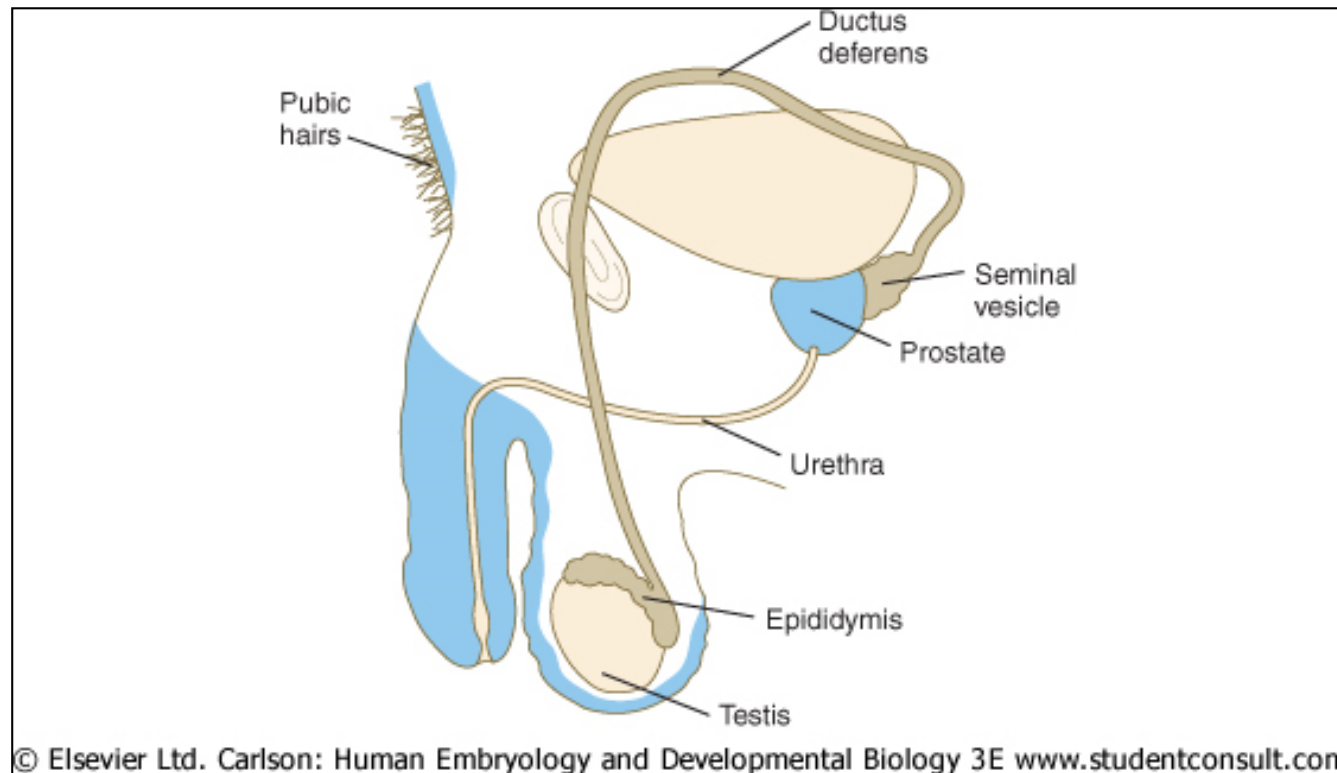
Weeks 12 + 13 are particularly critical
= fusing of urethral folds



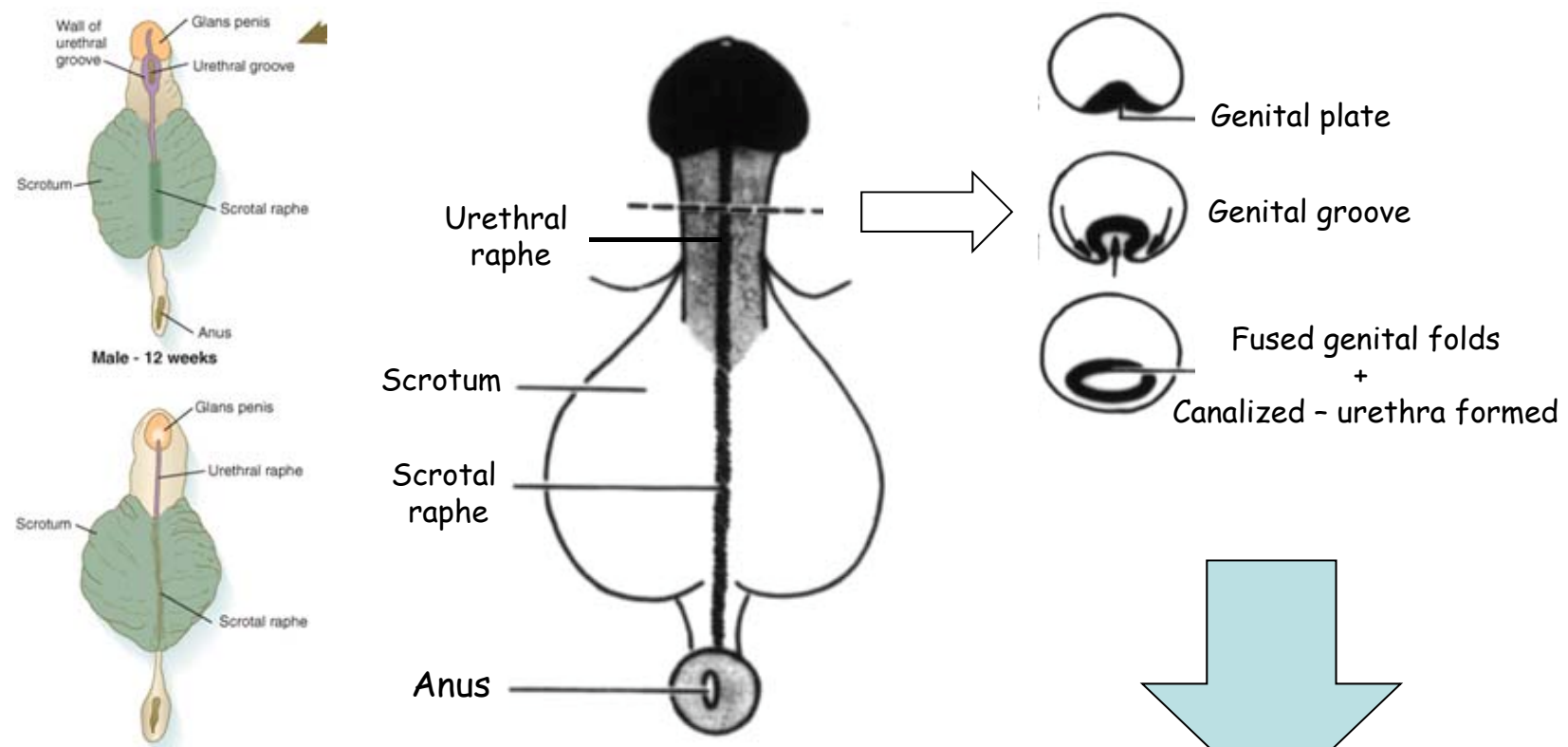
Genital system - External genitalia - Male

Influenced by dihydrotestosterone

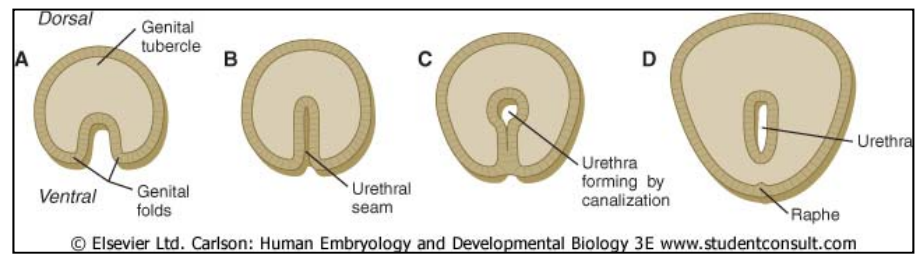
Influenced by testosterone



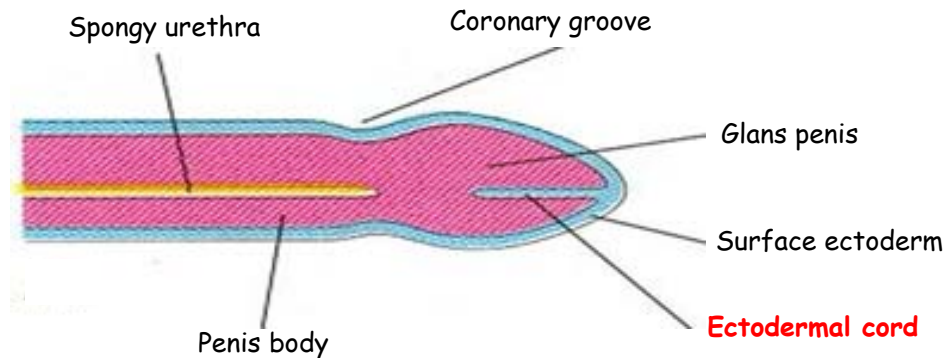
Genital system - External genitalia - Male



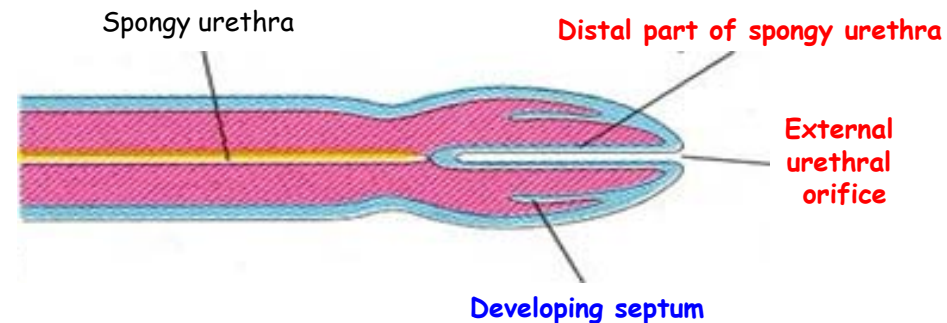
Genital tubercle elongates - penis (phallus)
 Genital swellings enlarge - scrotum
 Genital folds form the lateral walls of the urethral groove
 Genital folds form the spongy urethra
 Ventral epithelium of genital folds - urethra proper
 Corpora cavernosa develop from mesenchyme



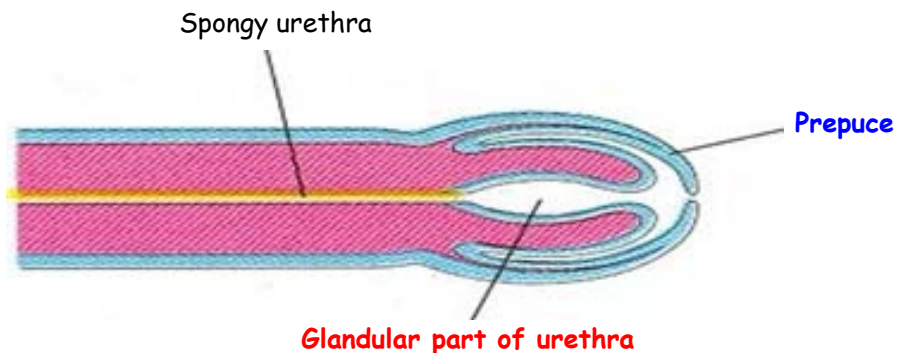
Genital system - External genitalia - Urethral orifice



- ectodermal ingrowth forms a cellular **ectodermal cord**

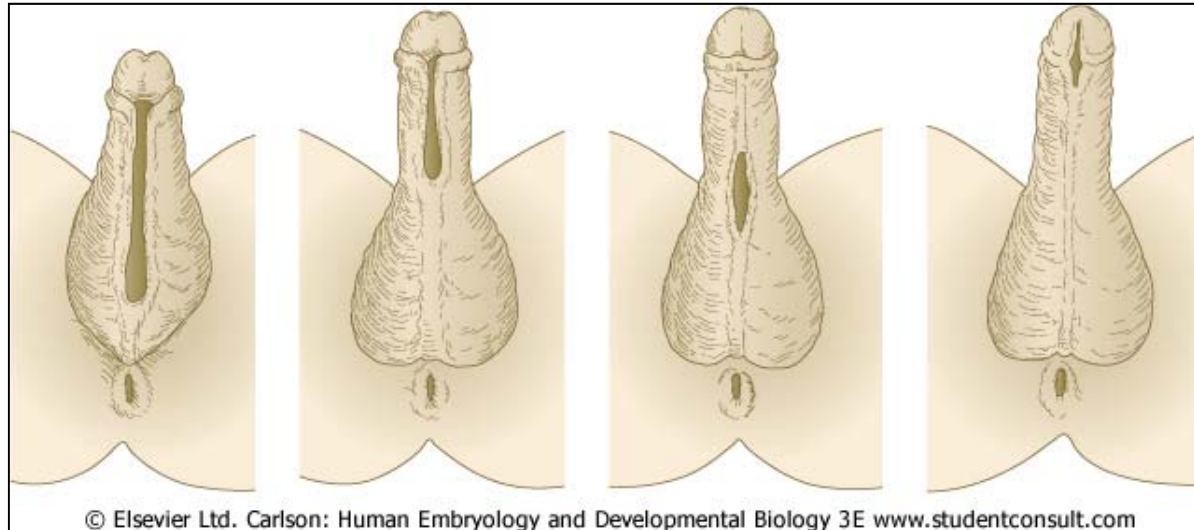


- the **cord** grows towards the root of the penis to meet the spongy urethra
- the **cord** canalizes
- **circular ingrowth** of ectoderm occurs at the periphery of the glans penis (week 12)



- **circular ingrowth** breaks down forming **prepuce** (for some time adherent to the glans penis, hard to retract at birth)

Genital system - External genitalia - Male hypospadias



Normal midline raphe



Raphe off center

Thank you for your attention !

Questions and comments at:
ahampl@med.muni.cz