Male reproductive system

Aleš Hampl

Key components & Gross anatomy

Paired gonads = testes

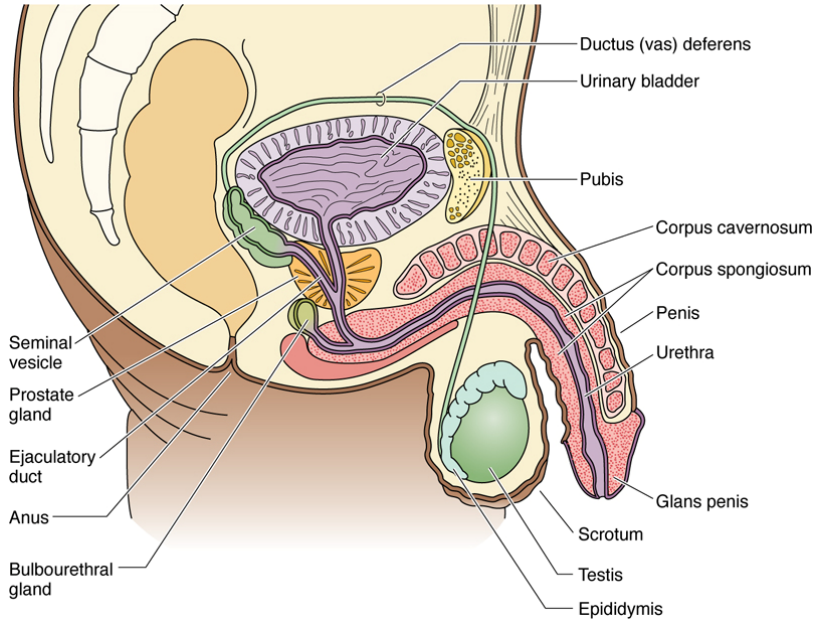
Genital ducts

Intratesticular
- Tubuli recti
- Rete testis
- Ductuli efferentes

Extratesticular
- Epididymis
- Ductus (vas) deferens
- Ejaculatory duct
- Urethra

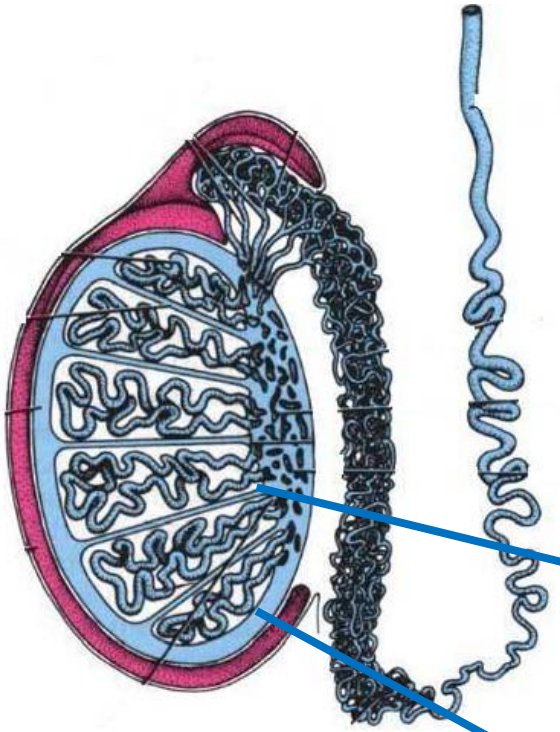
Associated glands
- Seminal vesicles (paired)
- Prostate
- Bulbourethral glands (paired)

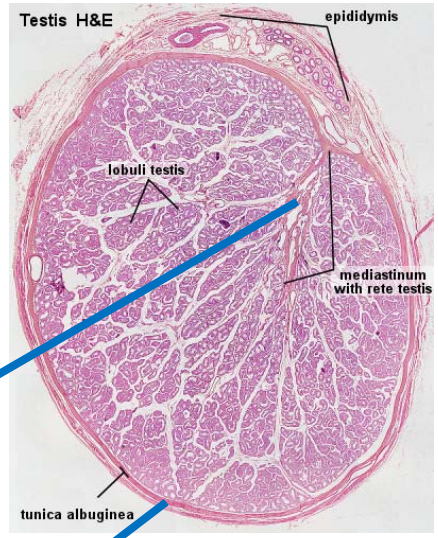
External genital organs
- Scrotum
- Penis



Testis - 1

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



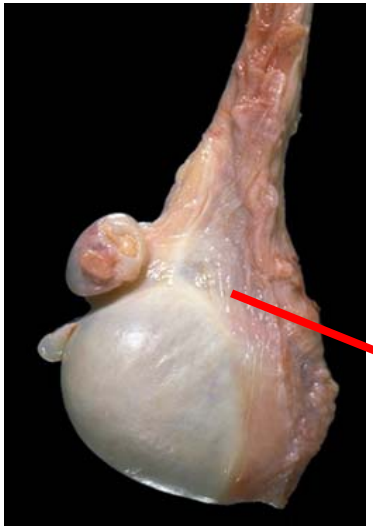


Mediastinum + Septa

- divide testis into **lobuli** (250-300)

Tunica albuginea - capsule

- dense connective collagenous tissue



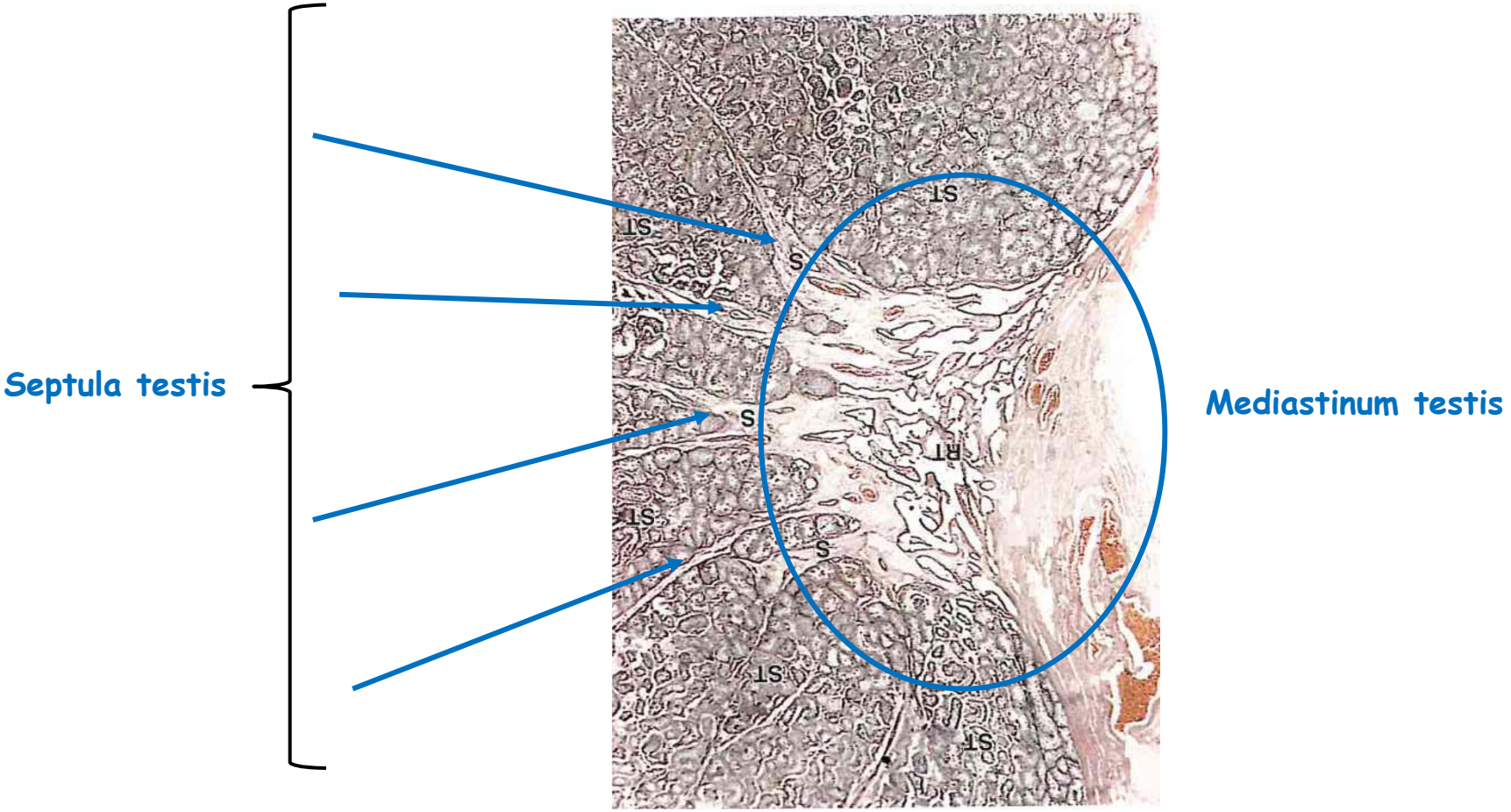
Tunica vasculosa

- inside of T. albuginea + adjacent to septa

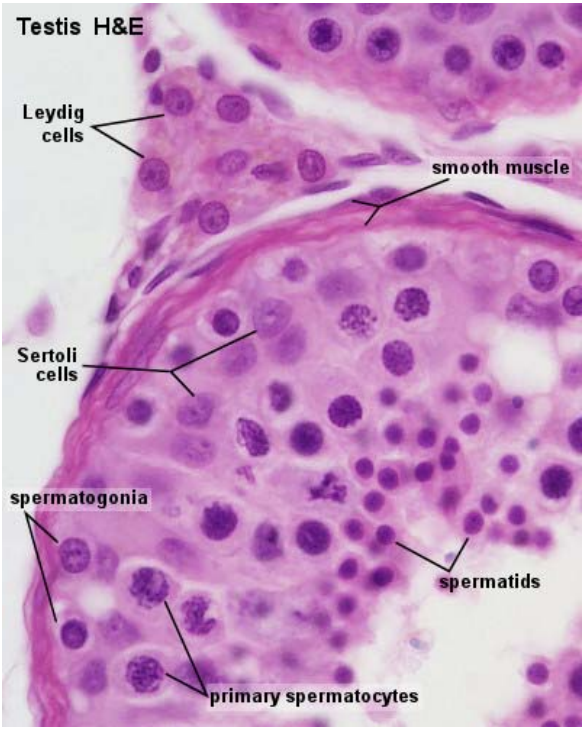
Tunica vaginalis

- serous, originates from peritoneum

Testis - 2



Testis - 3



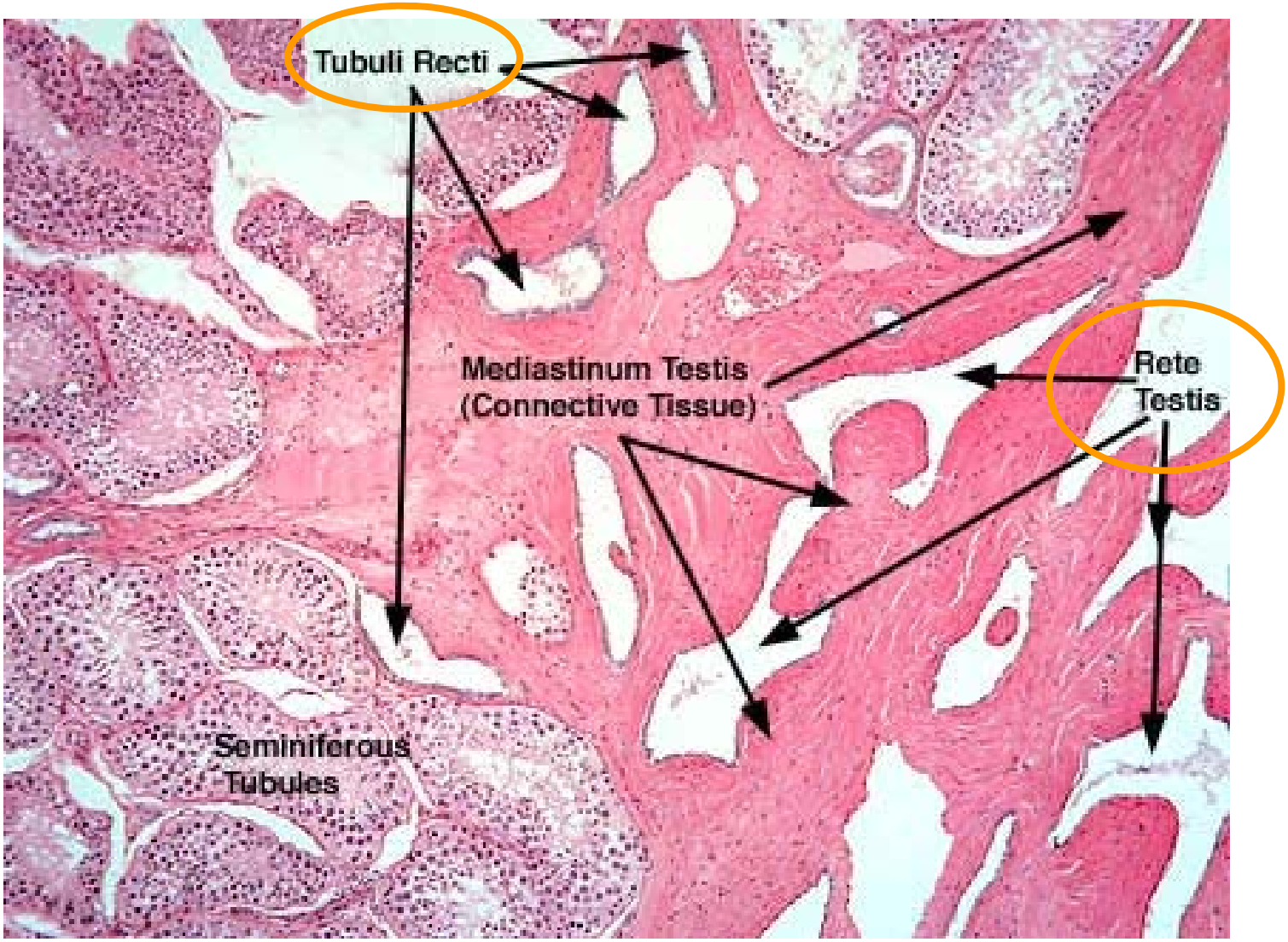
Seminiferous tubules

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

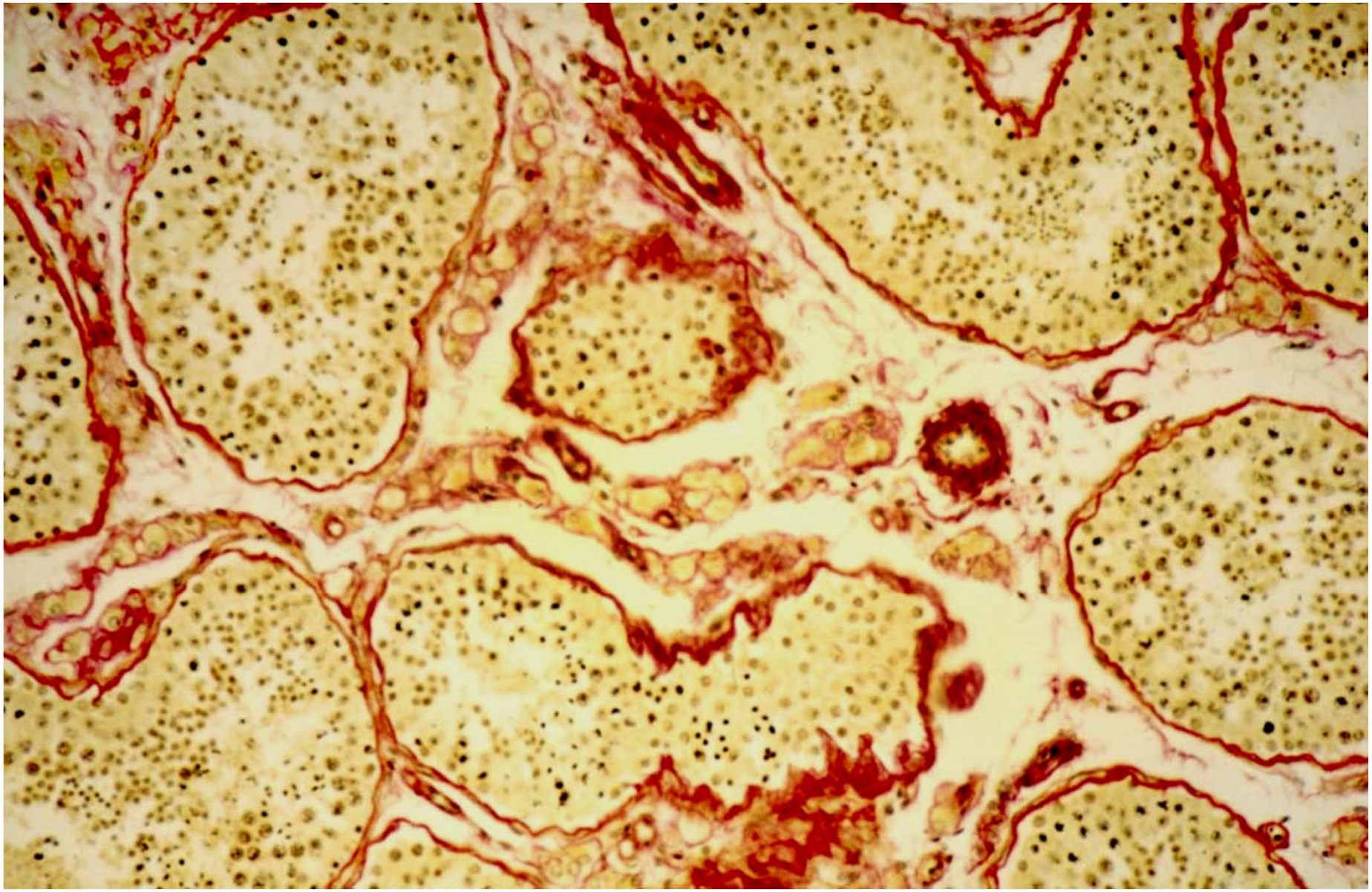
Interstitial tissue

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

Testis – 4 – continuation of seminiferous tubuli



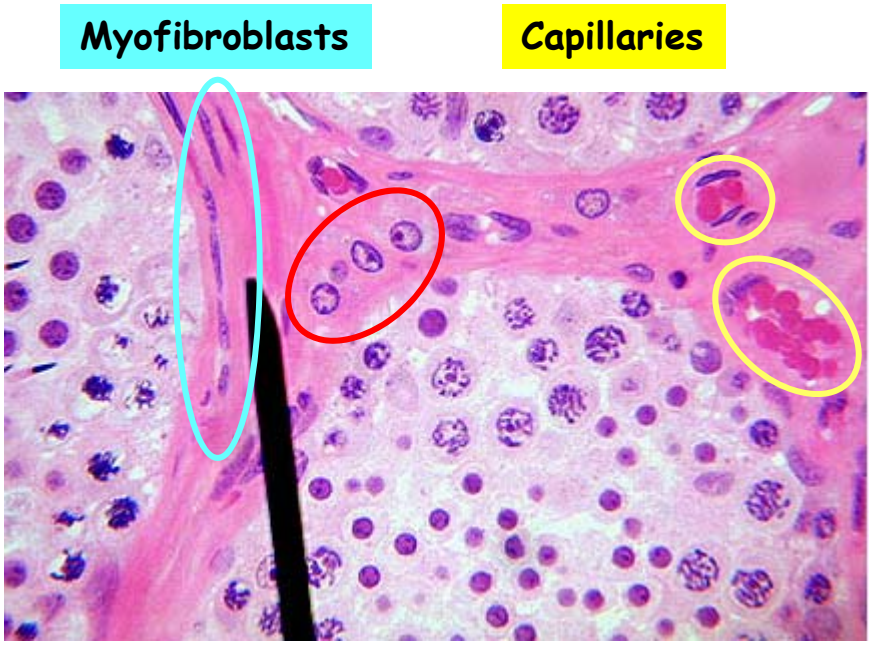
Testis - 5



Testis – 6 – interstitium – Leydig cells

Interstitium

- loose connective tissue
- fenestrated capillaries + lymphatics + nerves
- mast cells + macrphages + Lyedig cells



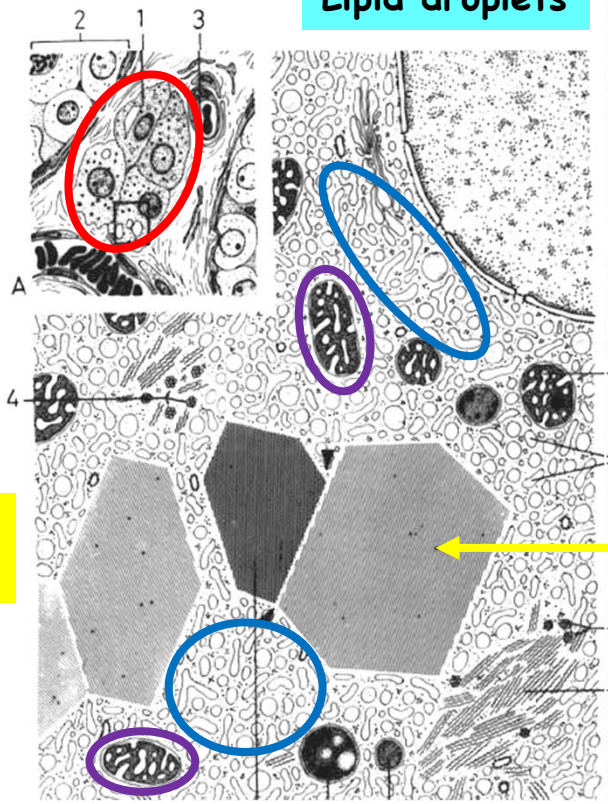
Leydig cells

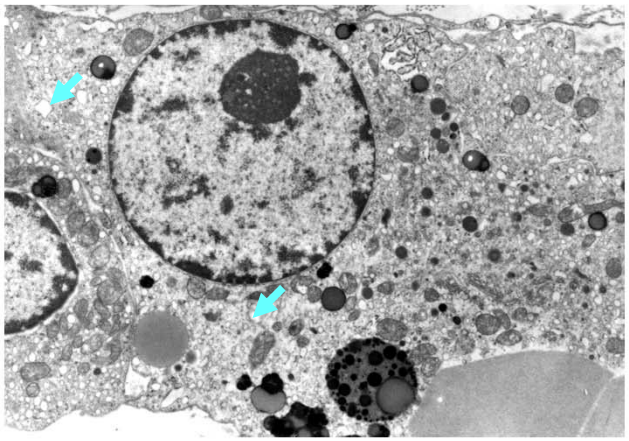
- round shaped
- large centrally located nuclei
- eosinophilic cytoplasm
- lipid droplets
- testosterone synthesis

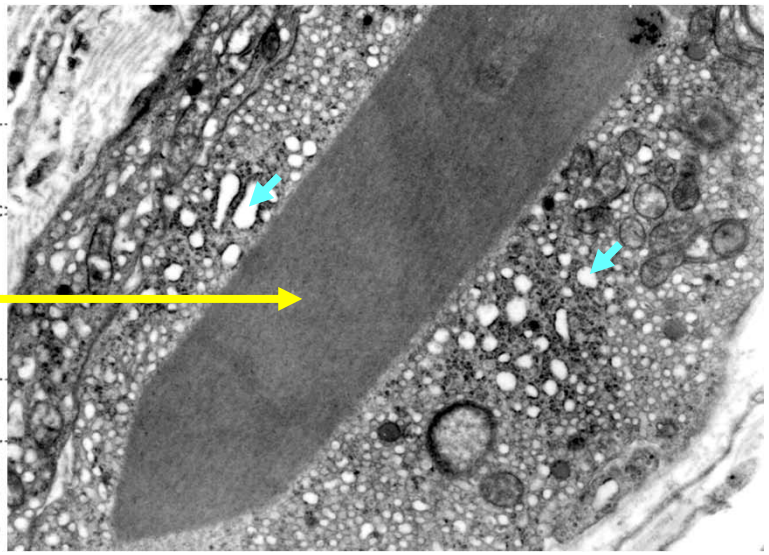
Testis – 7 – interstitium – Leydig cells

Mitochondria
+
Smooth ER
} Testosterone

Lipid droplets



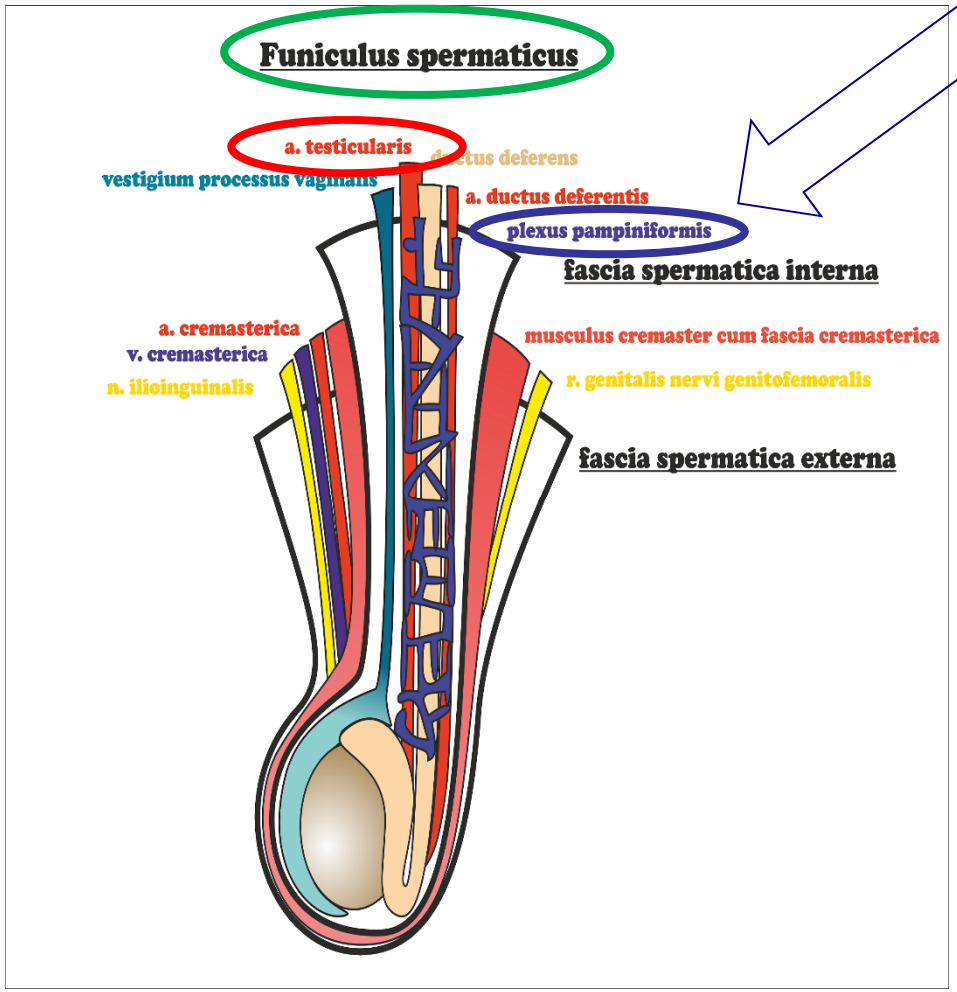


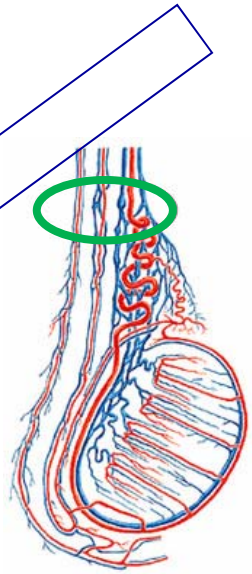


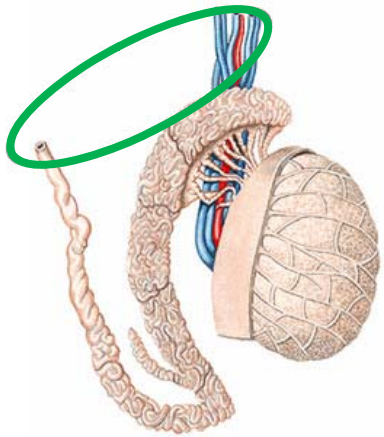
crystals of Reinke

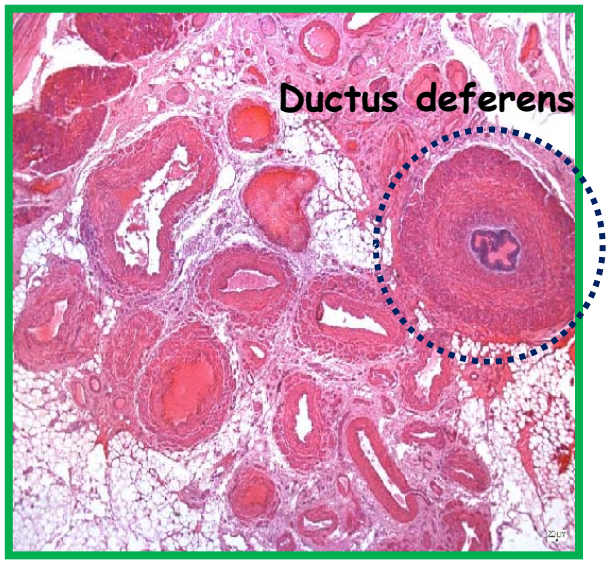
Testis – 8 – Blood supply – Plexus pampiniformis

Spermatic cord

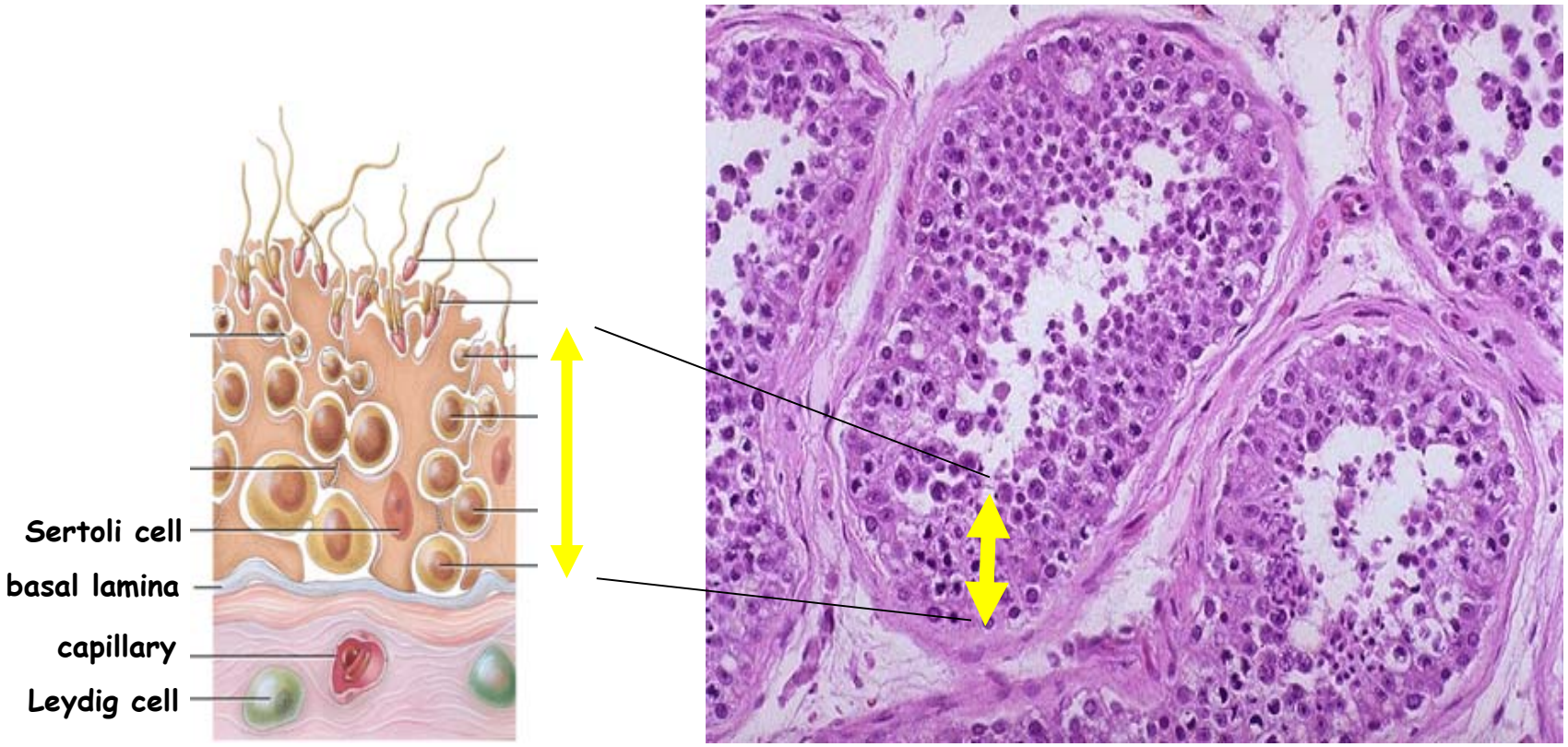








Testis – 9 – Seminiferous / Germinal epithelium



Testis – 10 – Sertoli cells

Morphology:

- tall, collumnar
- highly folded membranes, undistingushable boundaries
- hosts 30 to 50 germ cells
- abundant SER, minimal RER
- numerous mitochondria + well developed Golgi
- abundant cytoskeletal elements
- occluding + gap junctions

Function:

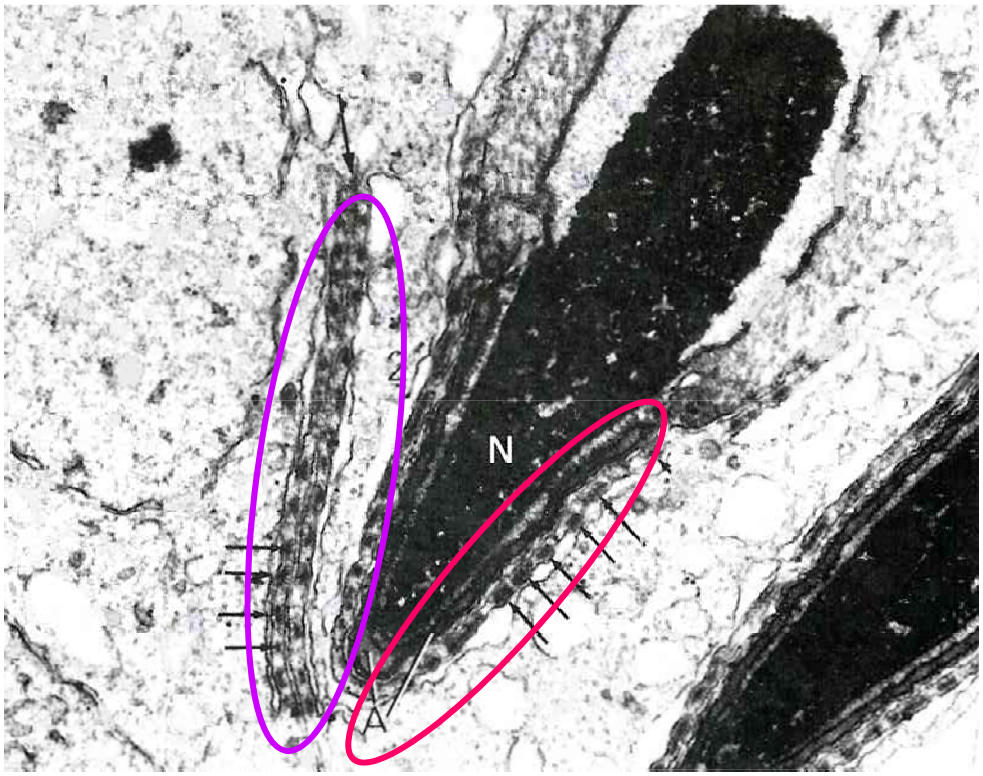
- support – physical + nutritional
- blood-testis barrier
- phagocytosis
- secretion of sperm transporting fluid + fructose
- endocrine: anti-Mullerian hormone + inhibin + androgen-binding protein

adluminal compartment

basal compartment

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

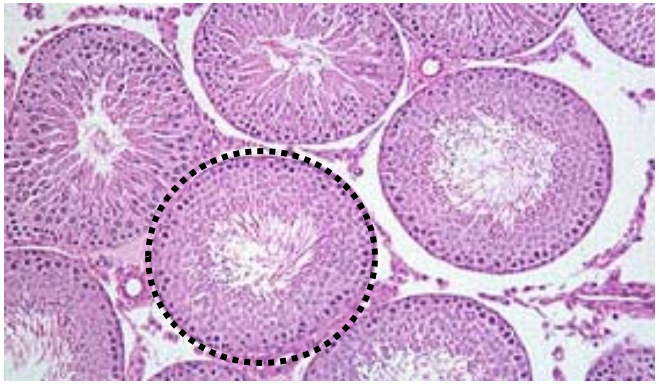
Testis – 11 – Sertoli cells – Junctional complexes



Sertoli-to-Sertoli

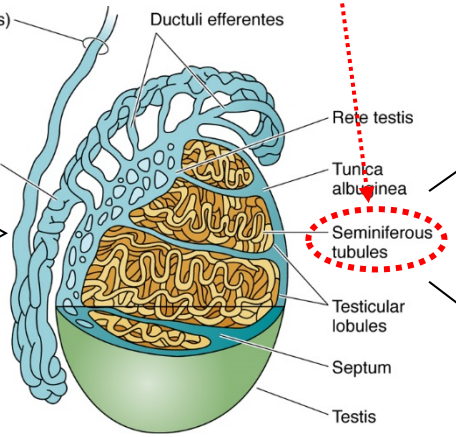
Sertoli-to-Spermatid

Spermatogenesis

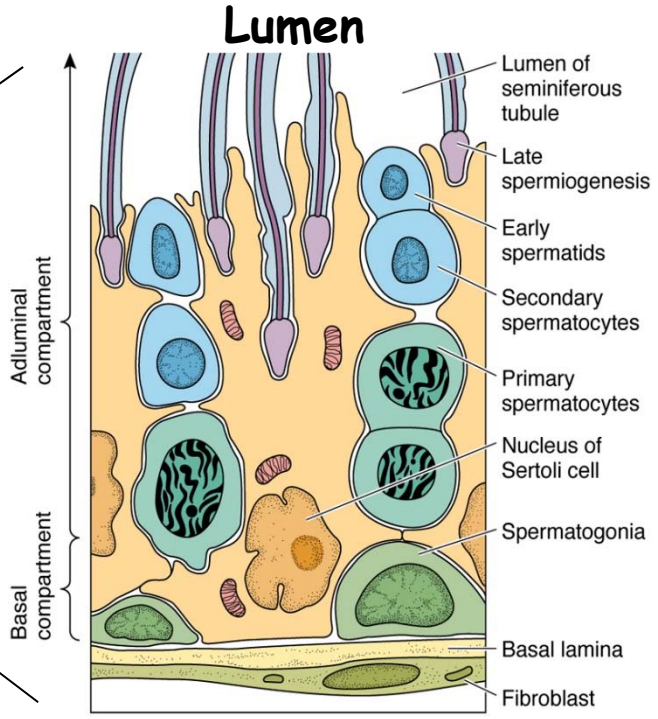


Before puberty → Slowly mitotically dividing spermatogonia in **genital ridges**

After puberty

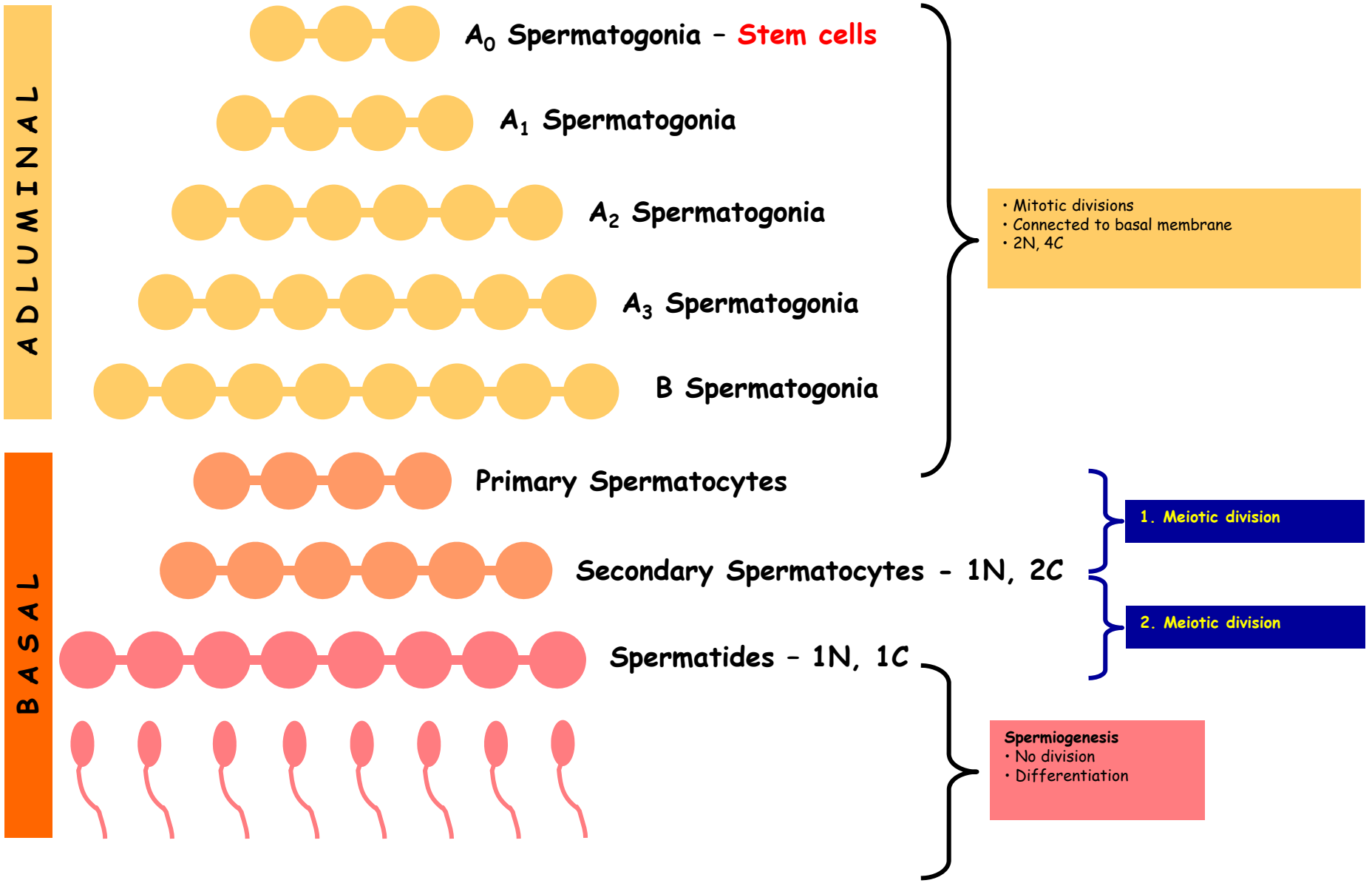


~0.25 mm
~0.5 km



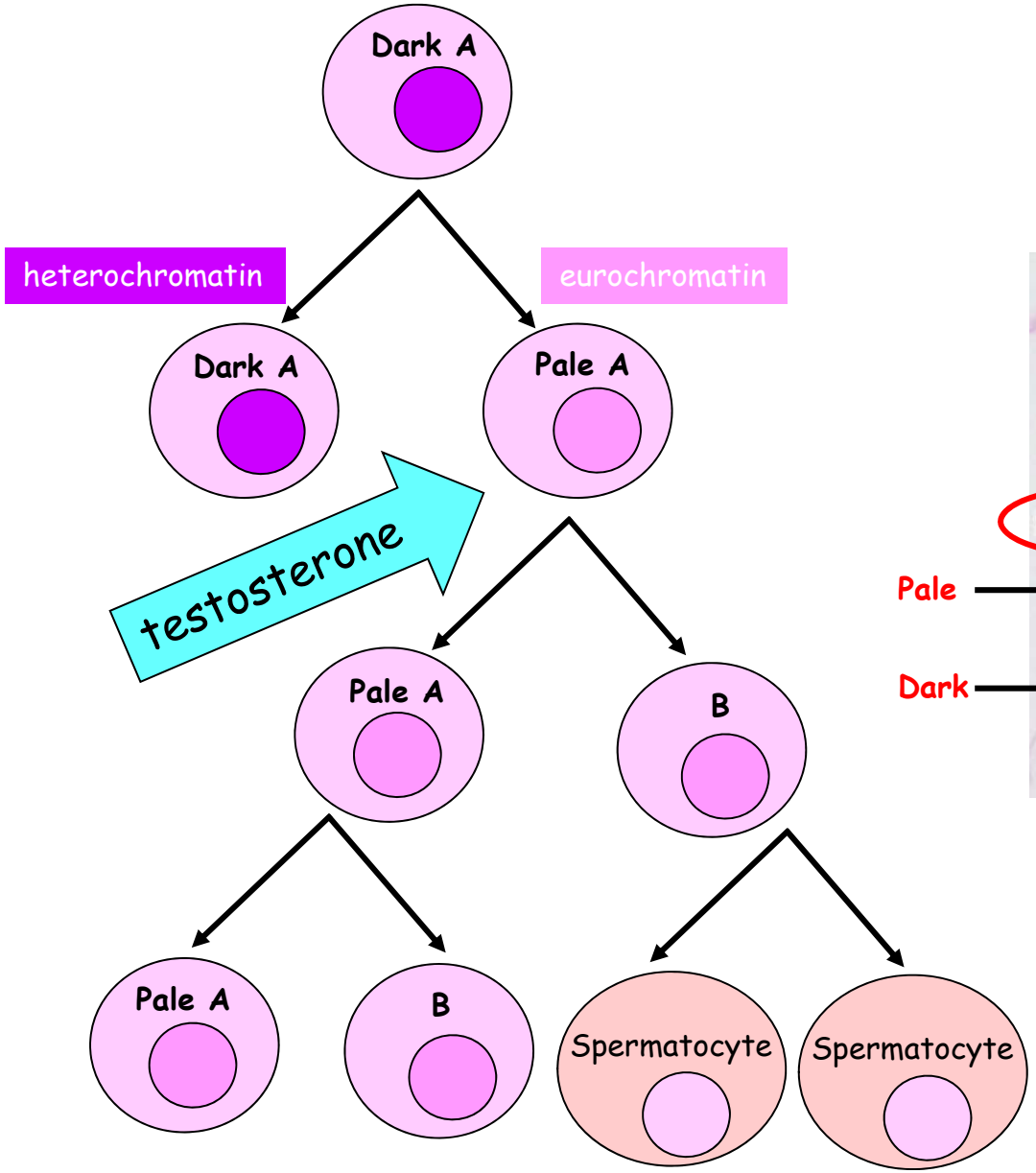
Spermatocytogenesis (mitotic) → **Meiotic phase** → **Spermiogenesis**

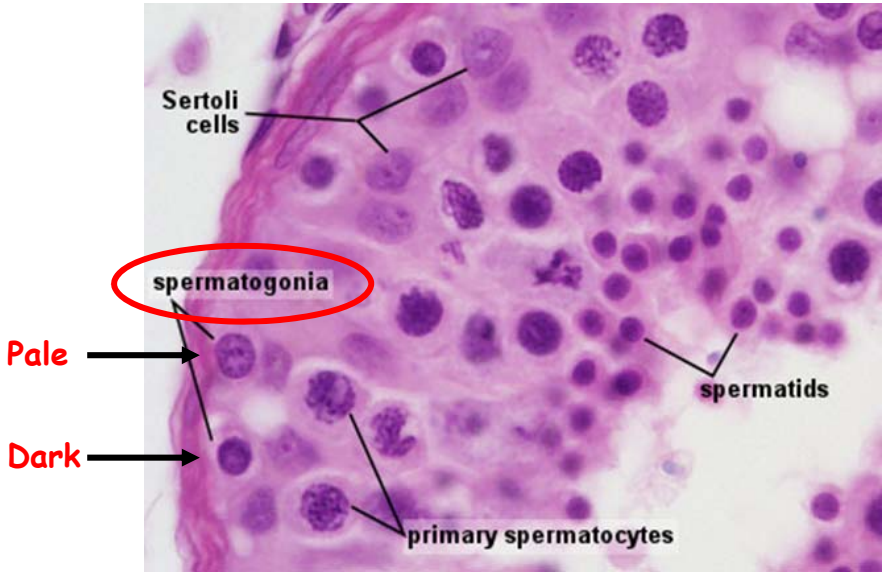
Spermatogenesis



Spermatogenesis - Spermatogonia

About 12 μm

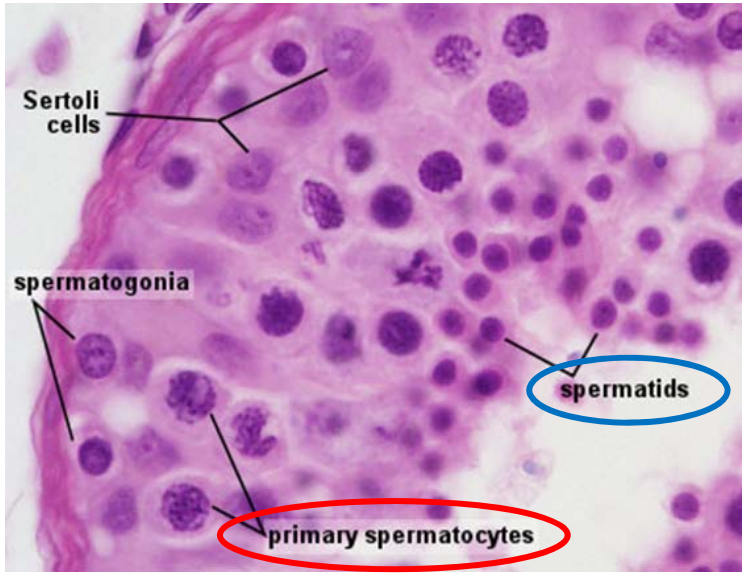




Spermatogenesis - Spermatocytes

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



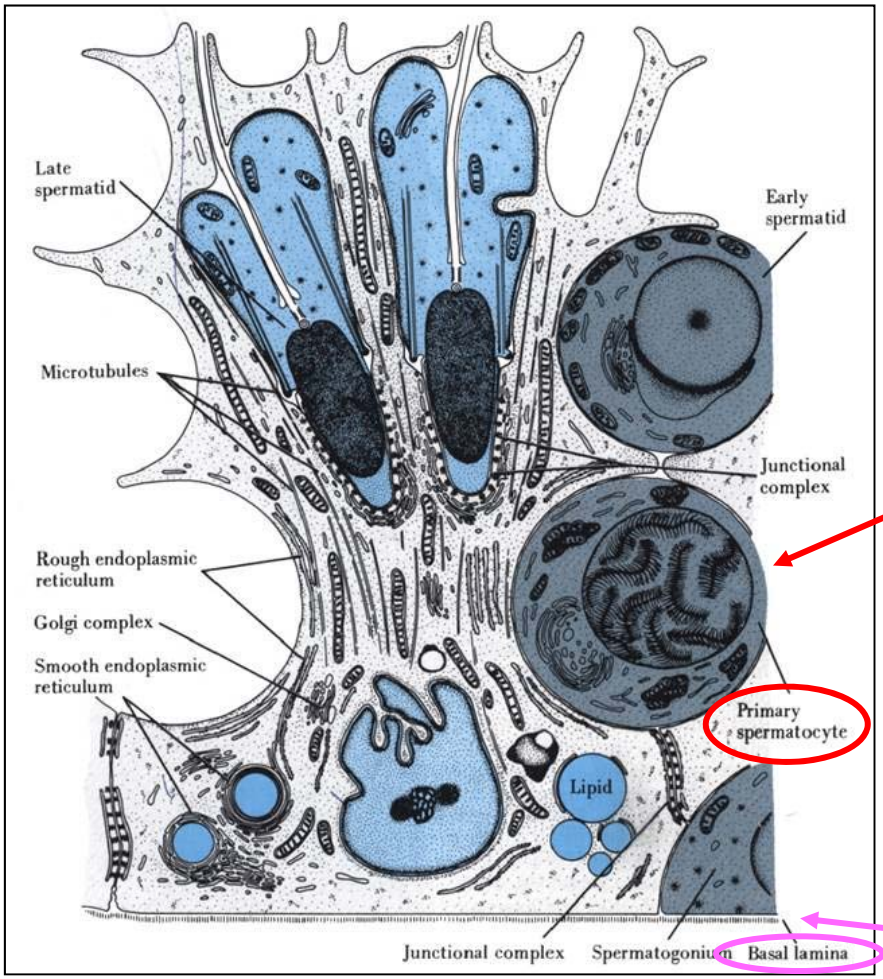
Secondary spermatocytes

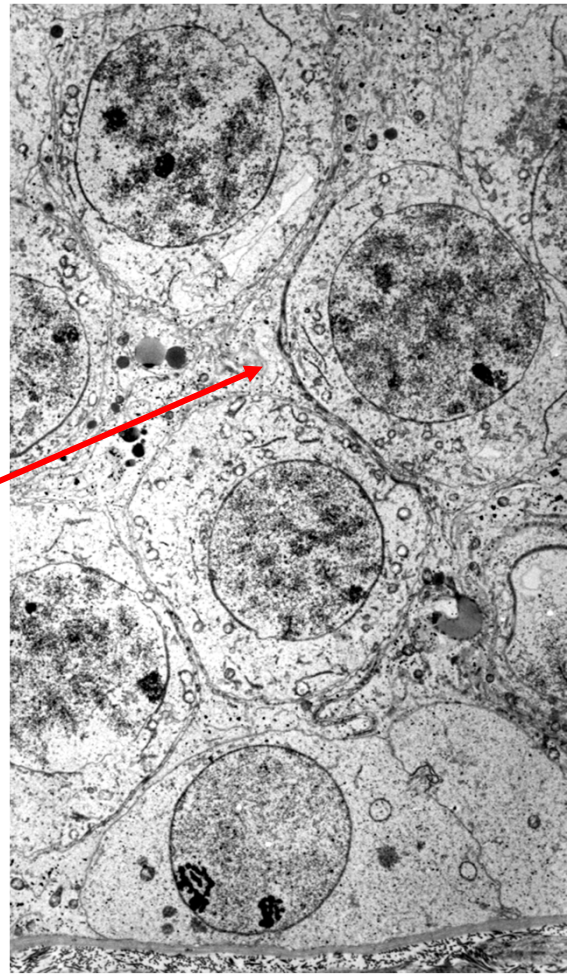
- smaller (12 μm)
- short living (~8 hrs)
- infrequently seen

equatorial division - Mei 2

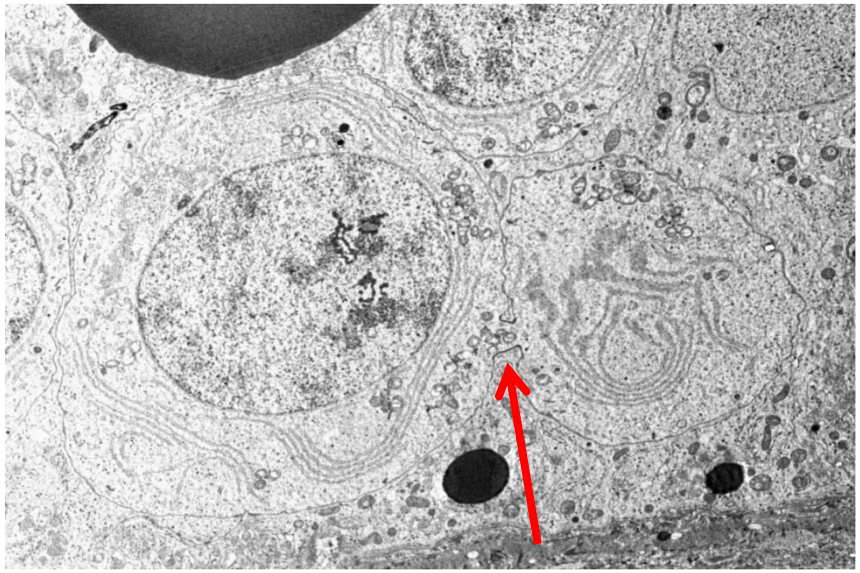
Spermatids

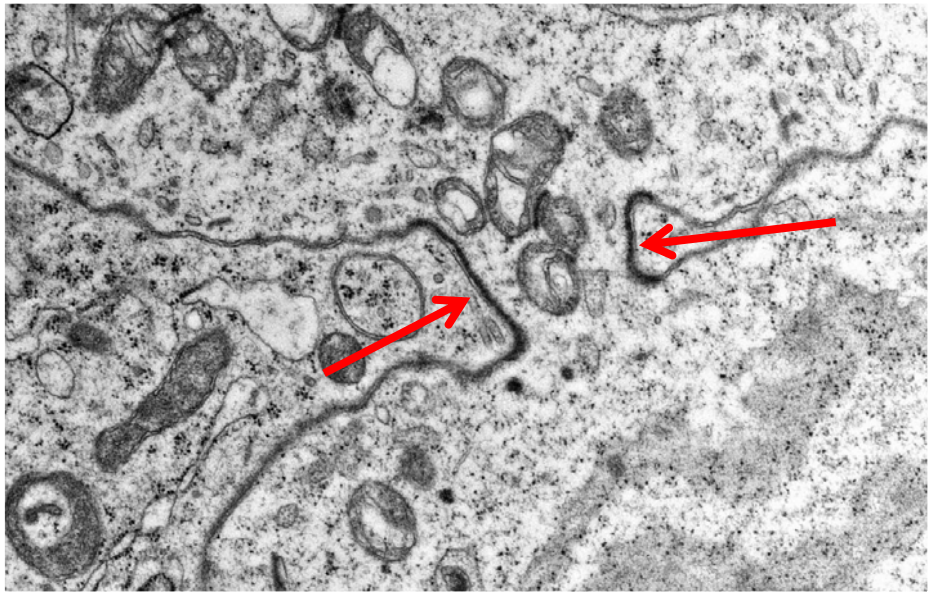
Spermatogenesis - Spermatocytes

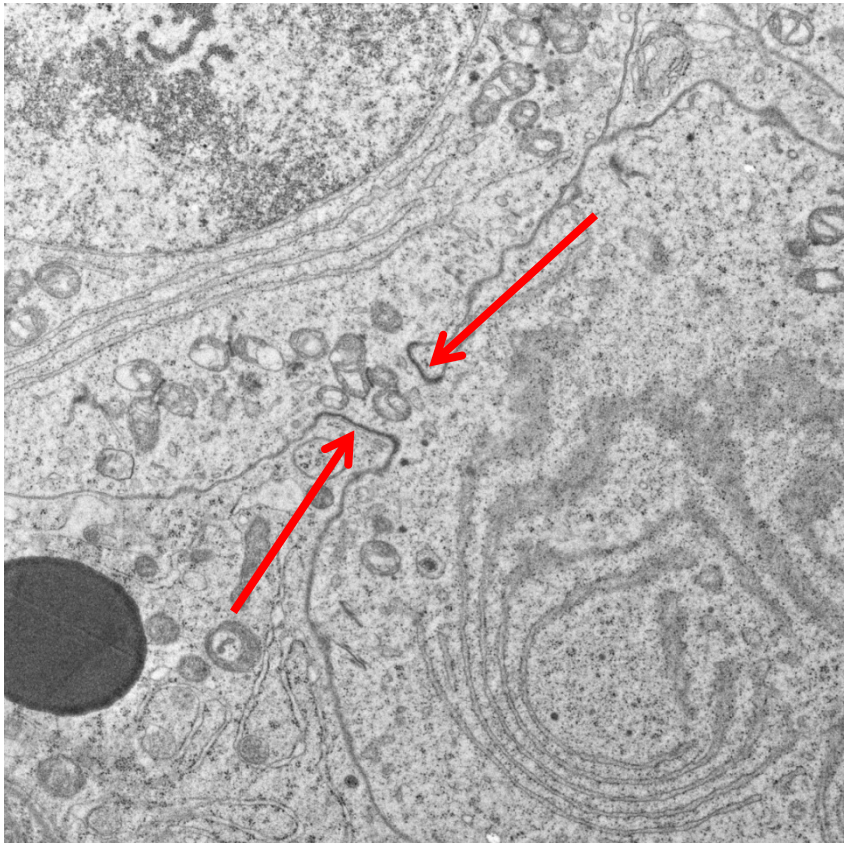




Spermatogenesis – Cytoplasmic bridges



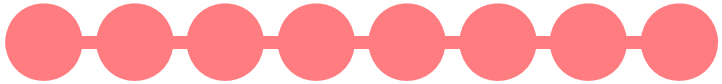




Spermatogenesis – Spermiogenesis

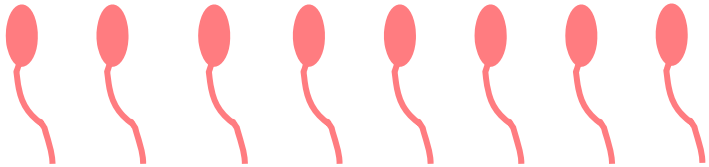
Spermatides

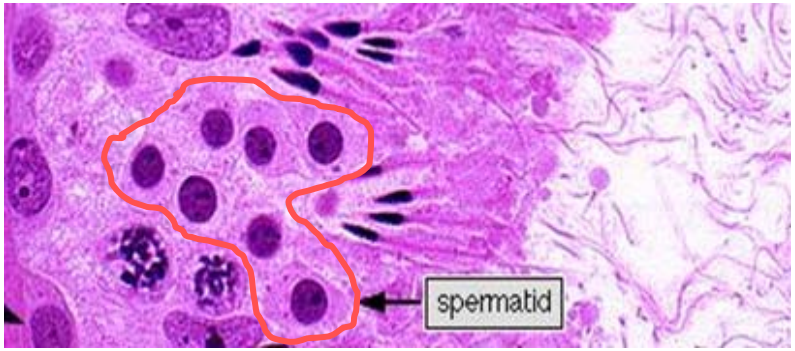
- small germ cells (6-8 μm)
- cytoplasmic bridges

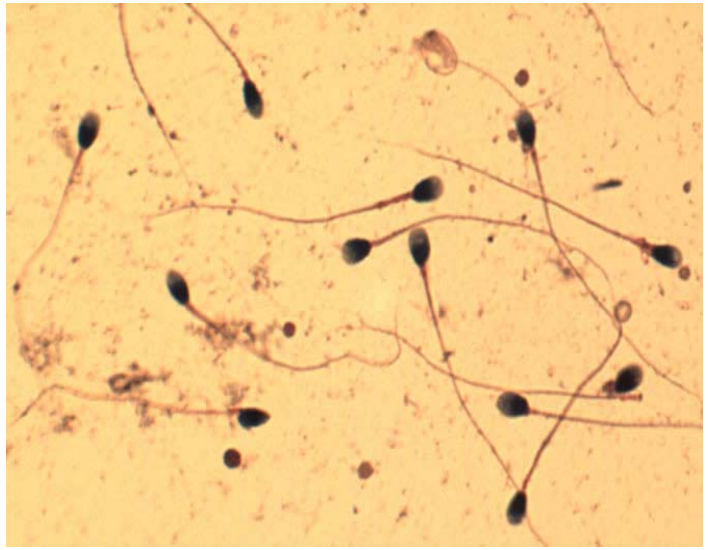


morphogenesis

Spermatozoa







Key elements

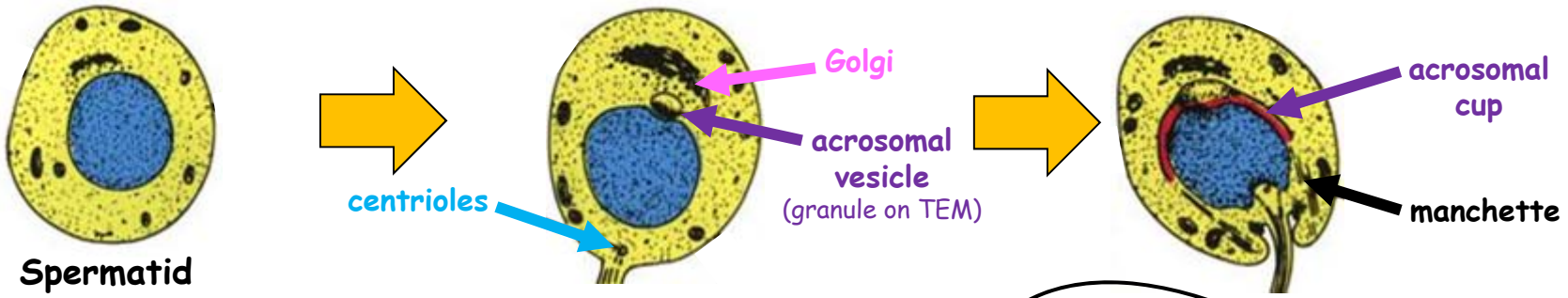
1. Formation of acrosome
2. Development of flagellum
3. Chromatin condensation + shaping the nucleus
4. Reduction of cytoplasm

Spermatogenesis – Spermiogenesis

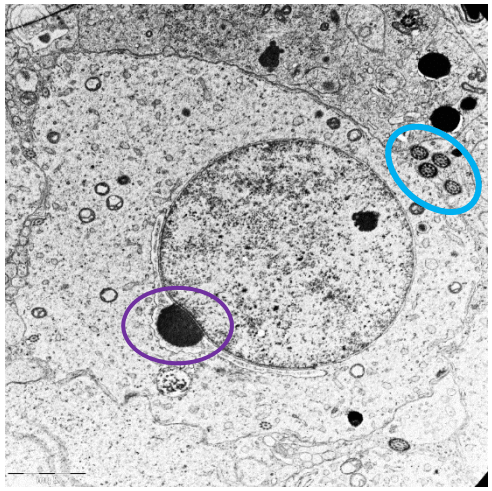
- Prominent Golgi complex
- Numerous mitochondria
- Pair of centrioles

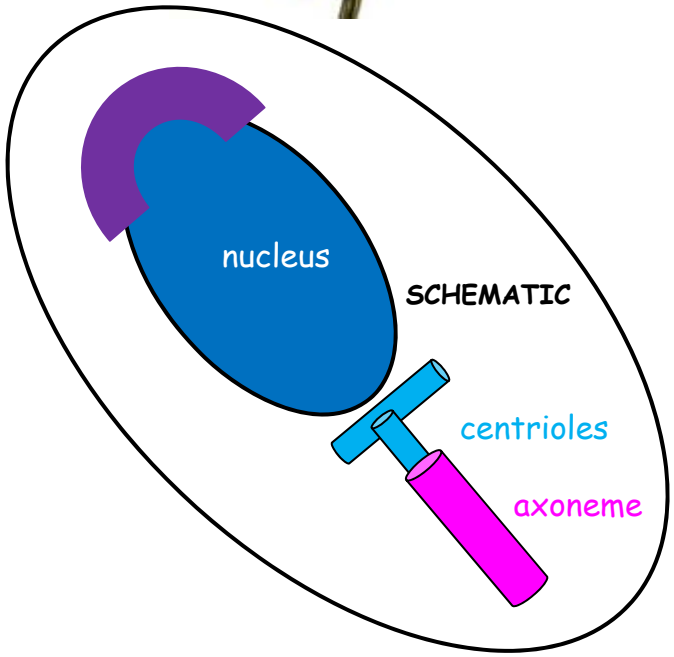
- Transgolgi pathway produces granules
- Granules form **acrosomal vesicle**

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

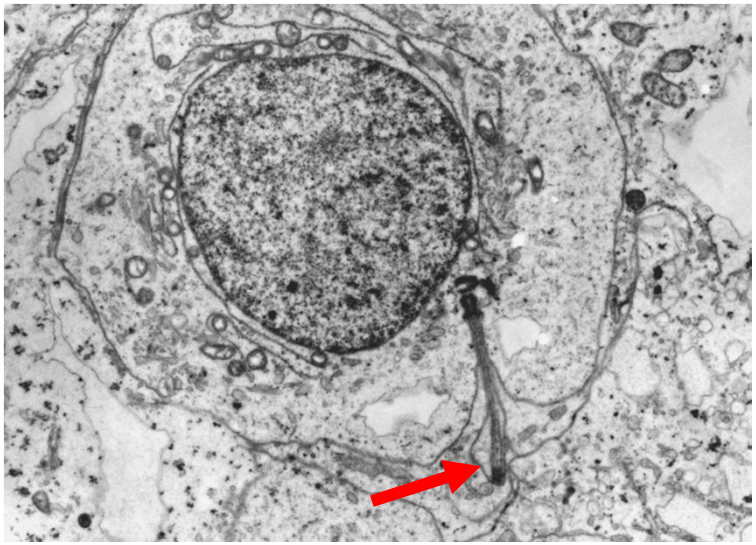


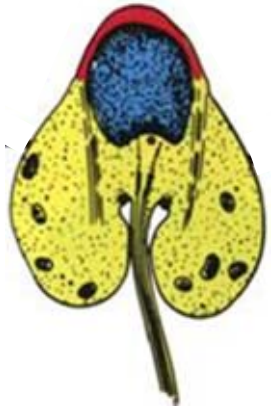
Acrosomal enzymes
- hyaluronidase
- acrosin
- acid phosphatase
- neuraminidase

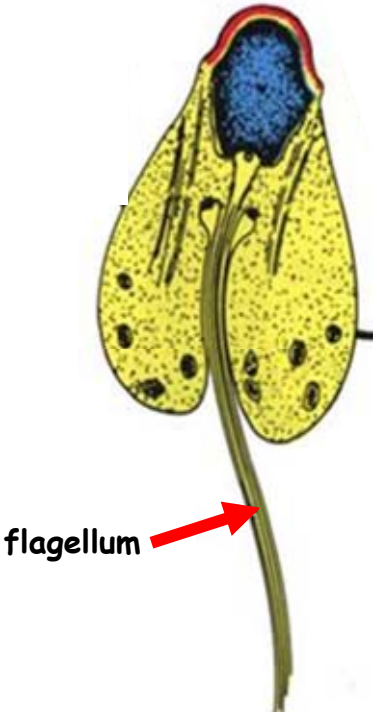


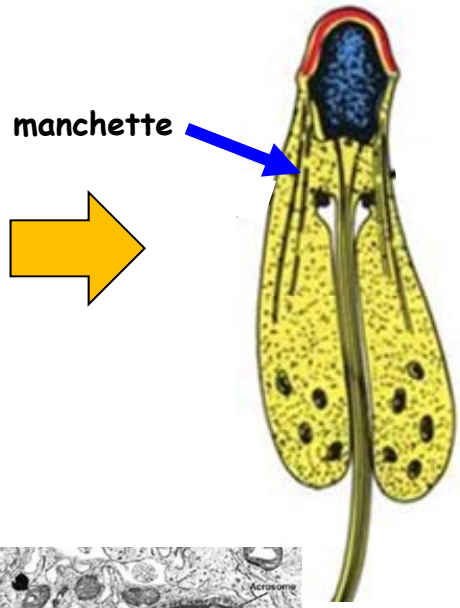


Spermatogenesis – Spermiogenesis

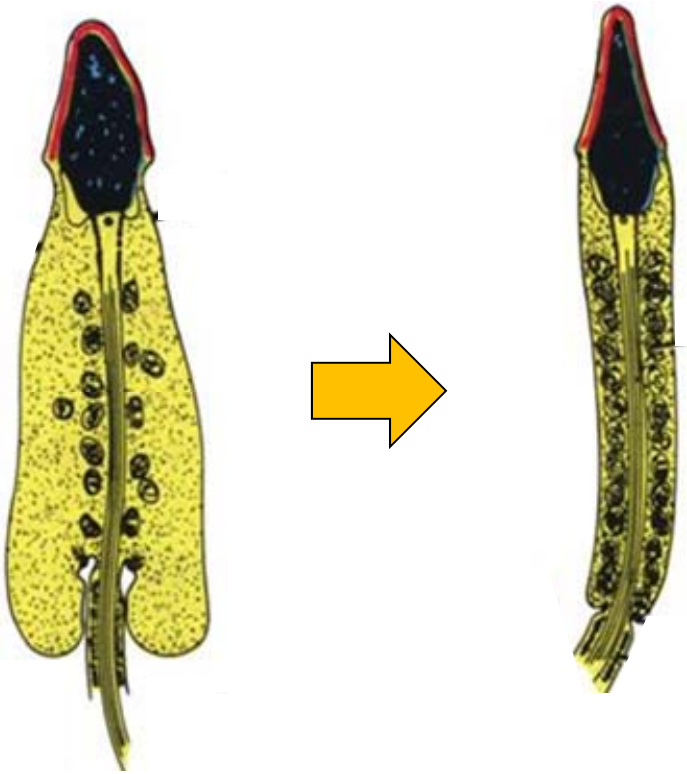


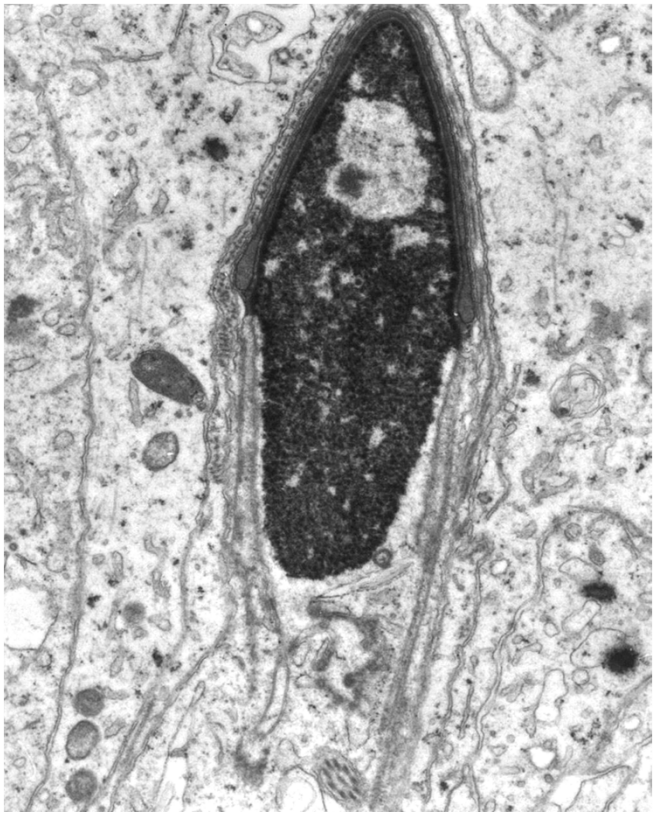






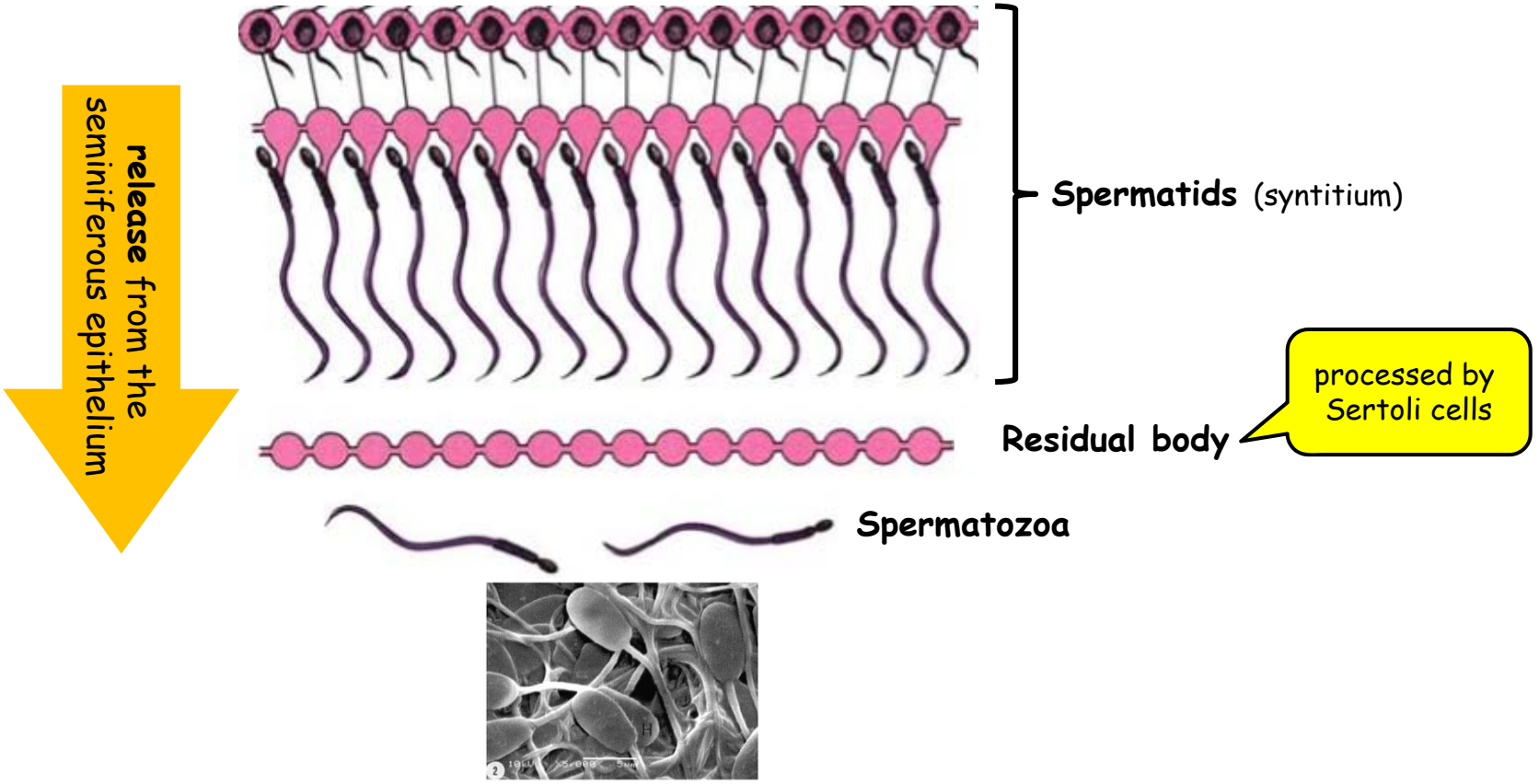
Spermatogenesis – Spermiogenesis





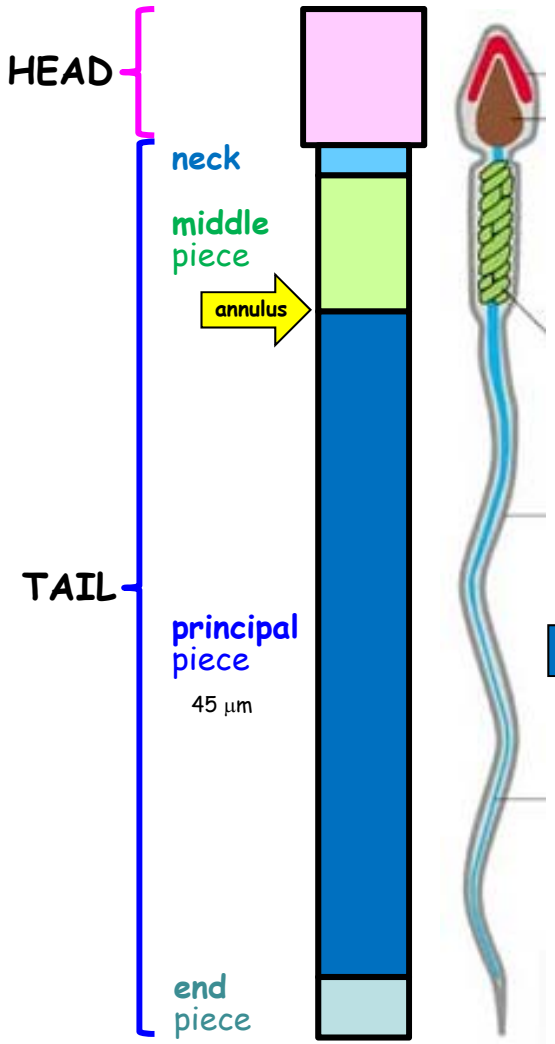
Spermatogenesis – Spermiation

= final stage of spermiogenesis

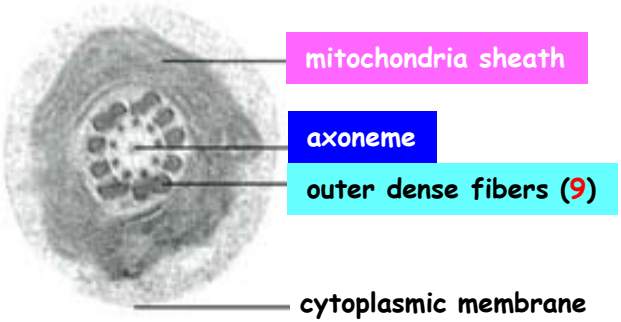


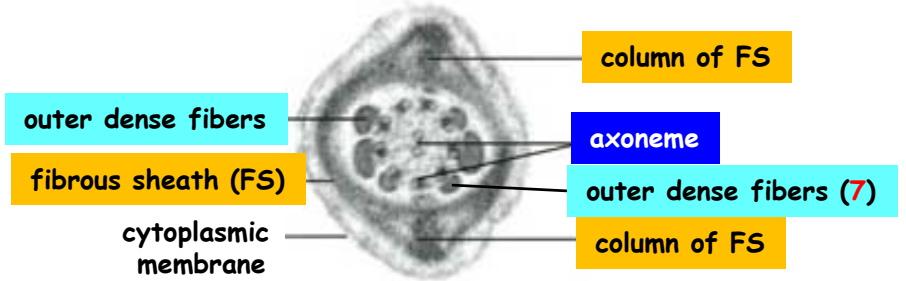
Spermatozoon

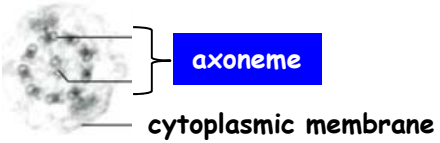
Total length = 65 μm

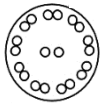


at „annulus"

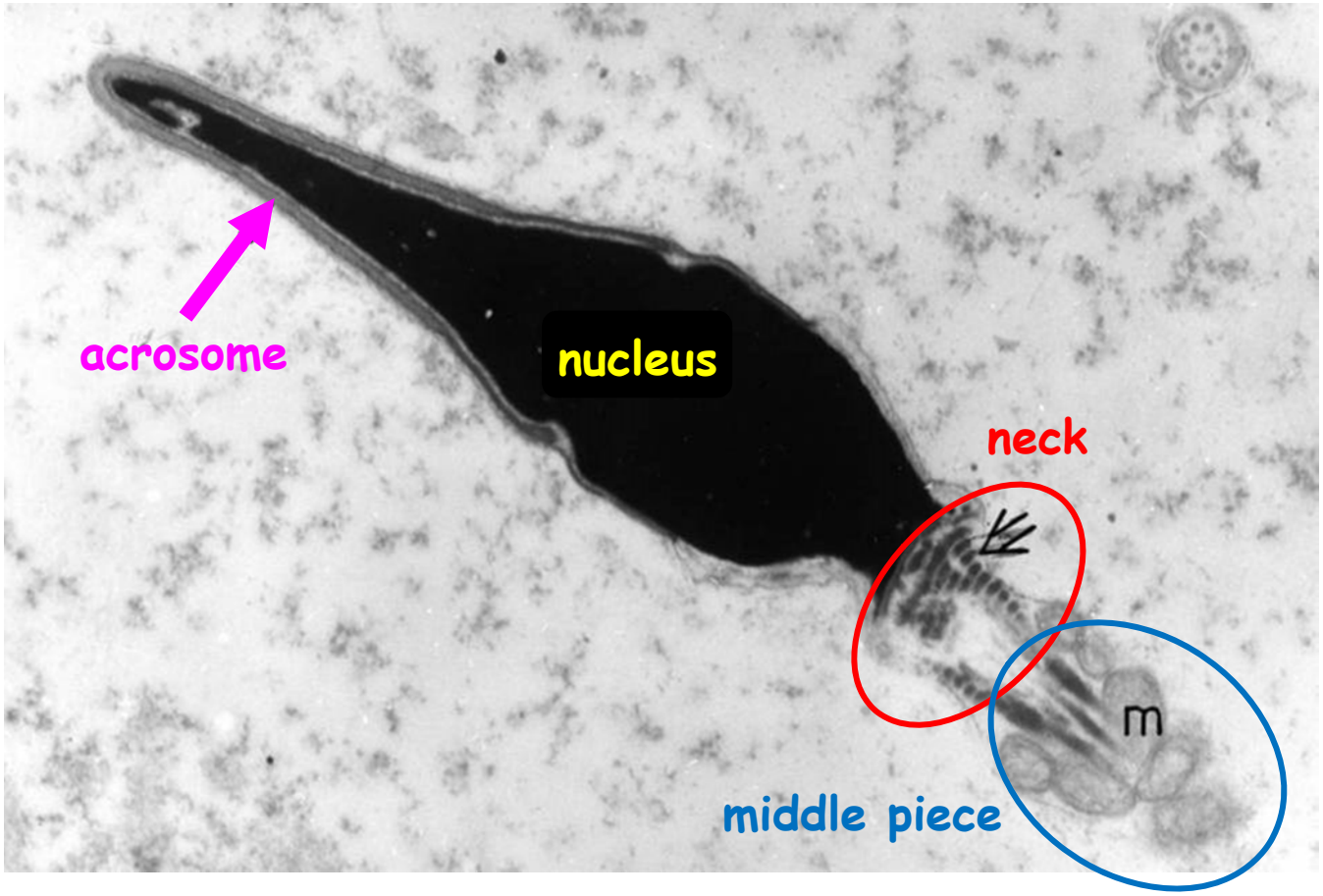






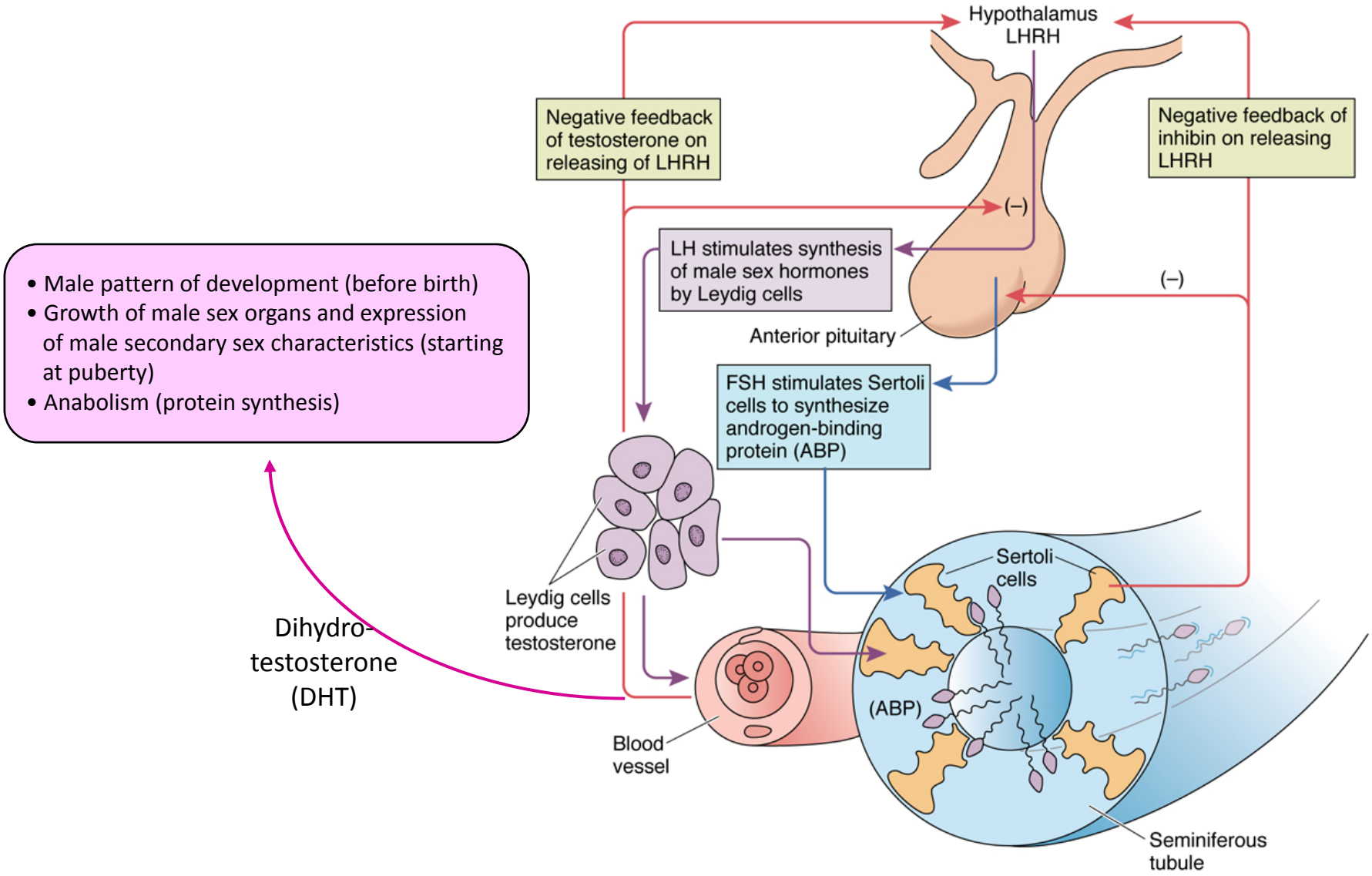


Spermatozoon



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 epidydimis
- 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 concrements

Seminal plasma:

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

Spermatozoa + Ejaculate

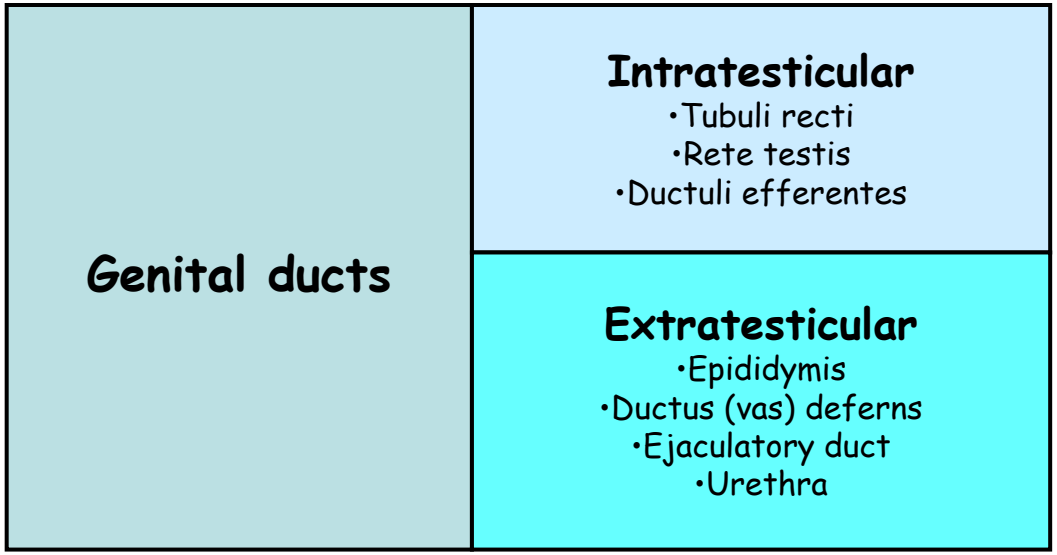
Normozoospermia – WHO standard

- **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 %

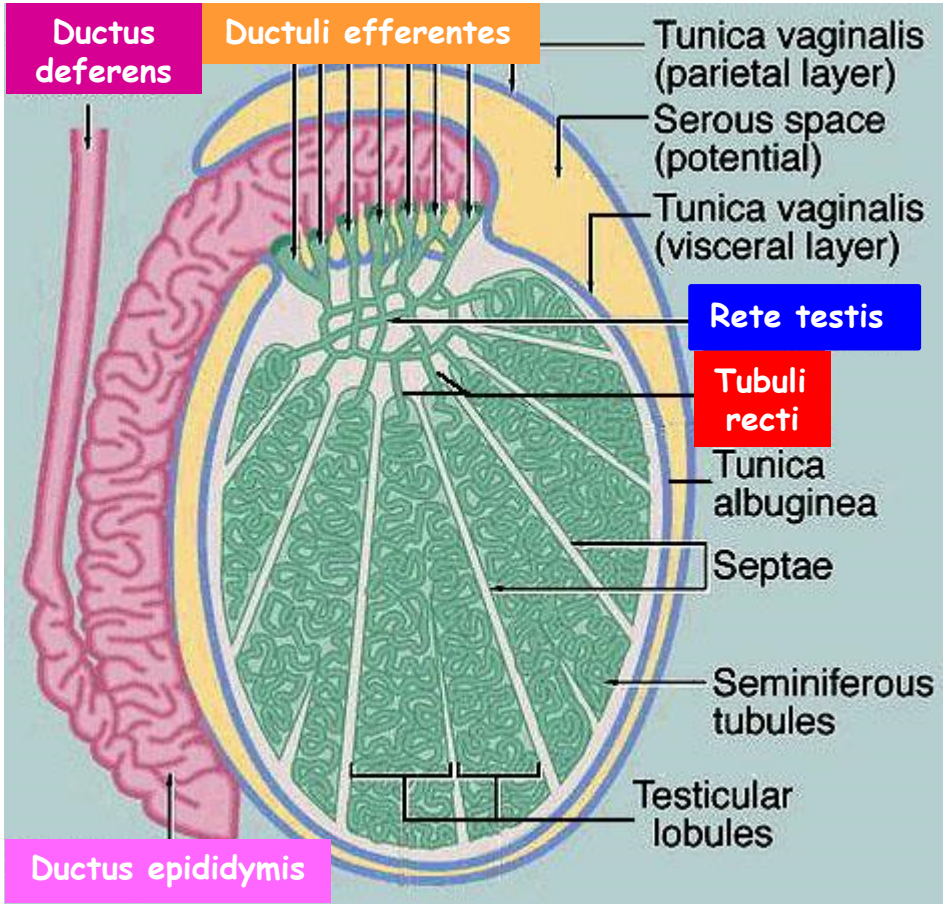
Abnormal spermiogram - Nomeclature

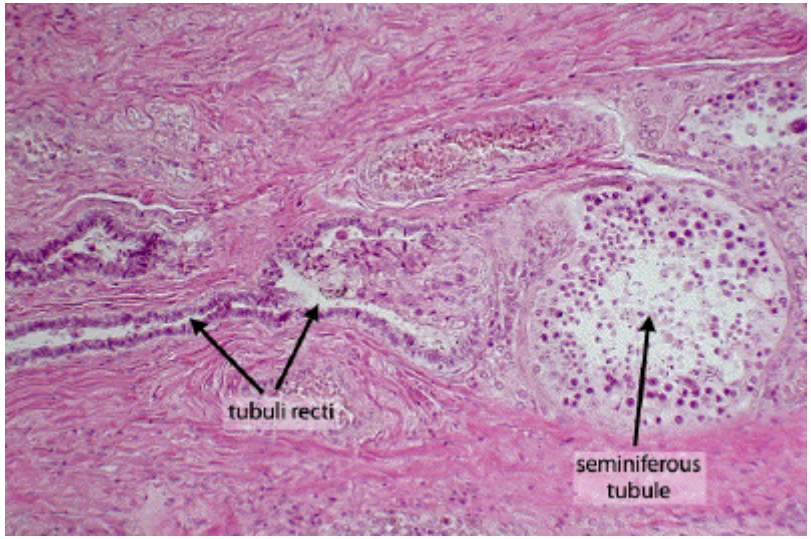
- **Asthenozoospermia**: reduced sperm motility
- **Oligozoospermia**: reduced sperm concentration in ejaculate
- **Teratozoospermia**: large numbers of morphologically abnormal sperm
- **Oligoastenoteratospermia**: combined abnormality in numbers, motility, and morphology of sperm
- **Azoospermia**: 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



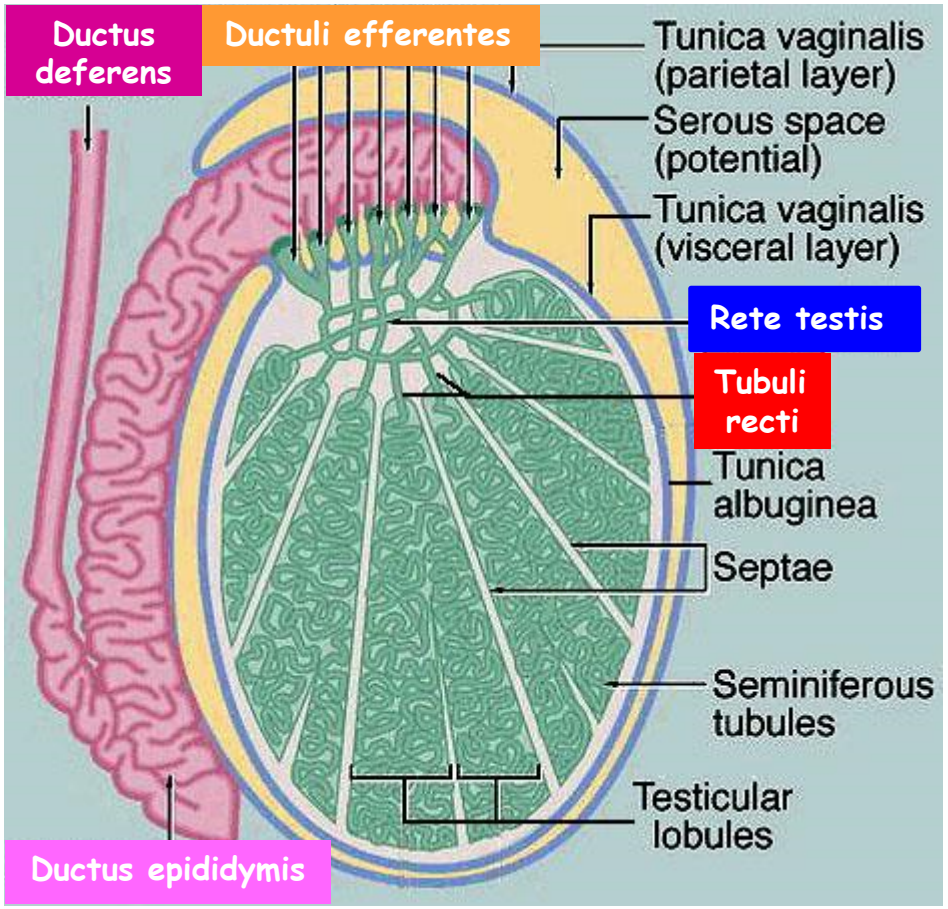
Intartatesticular genital ducts – Tubuli recti

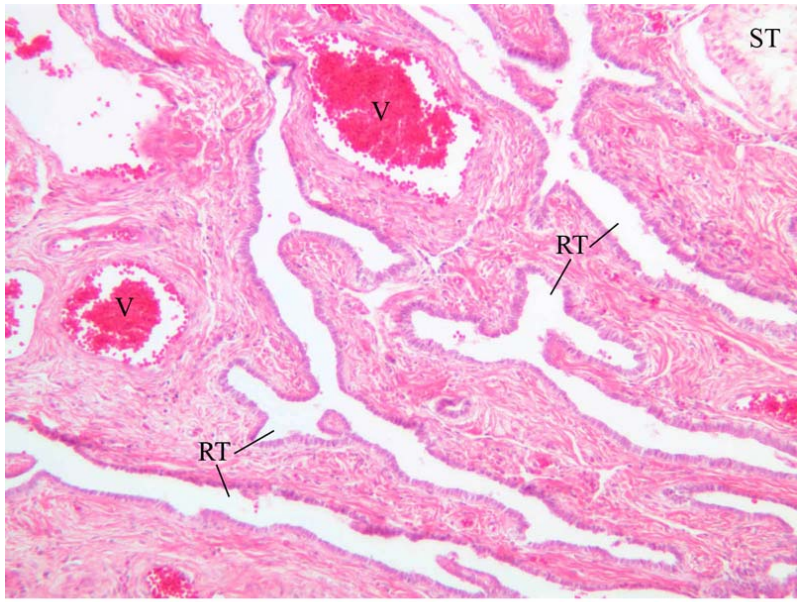


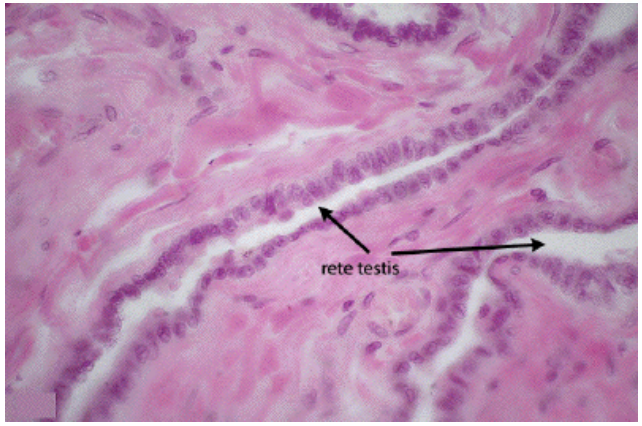


- short – about 1 mm
- in septula
- proximal part: Sertoli cells
- distal part: simple cuboidal epithelium

Intartatesticular genital ducts – Rete testis

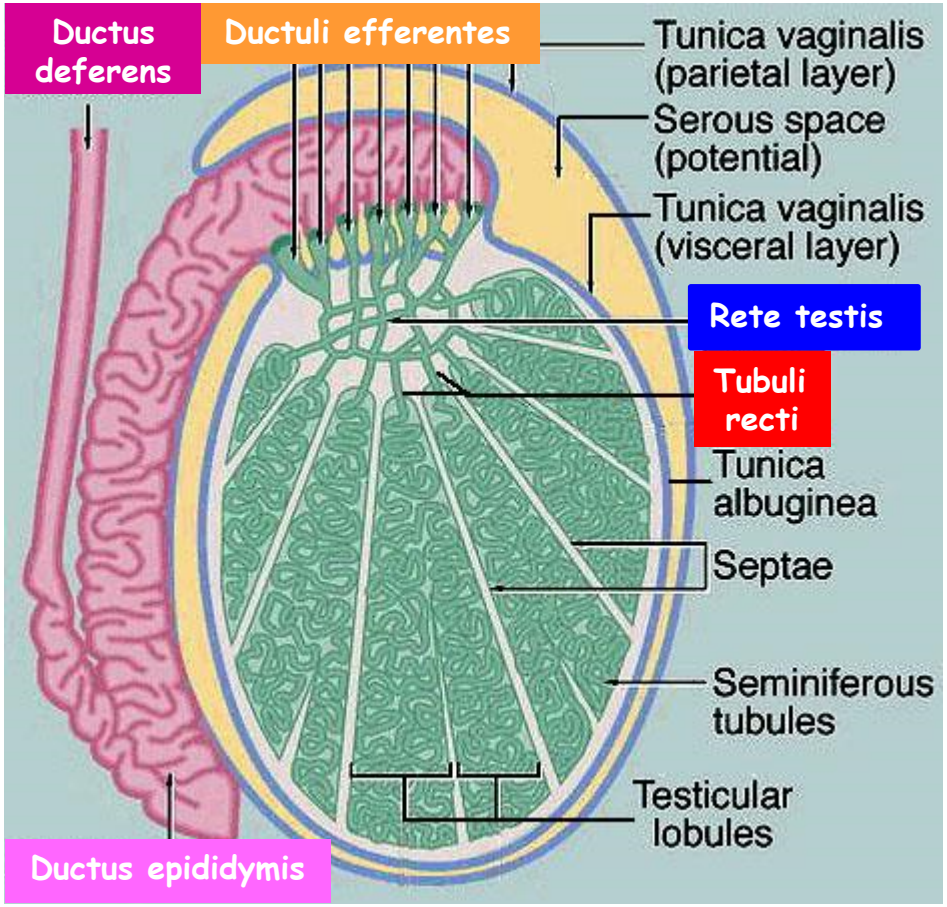






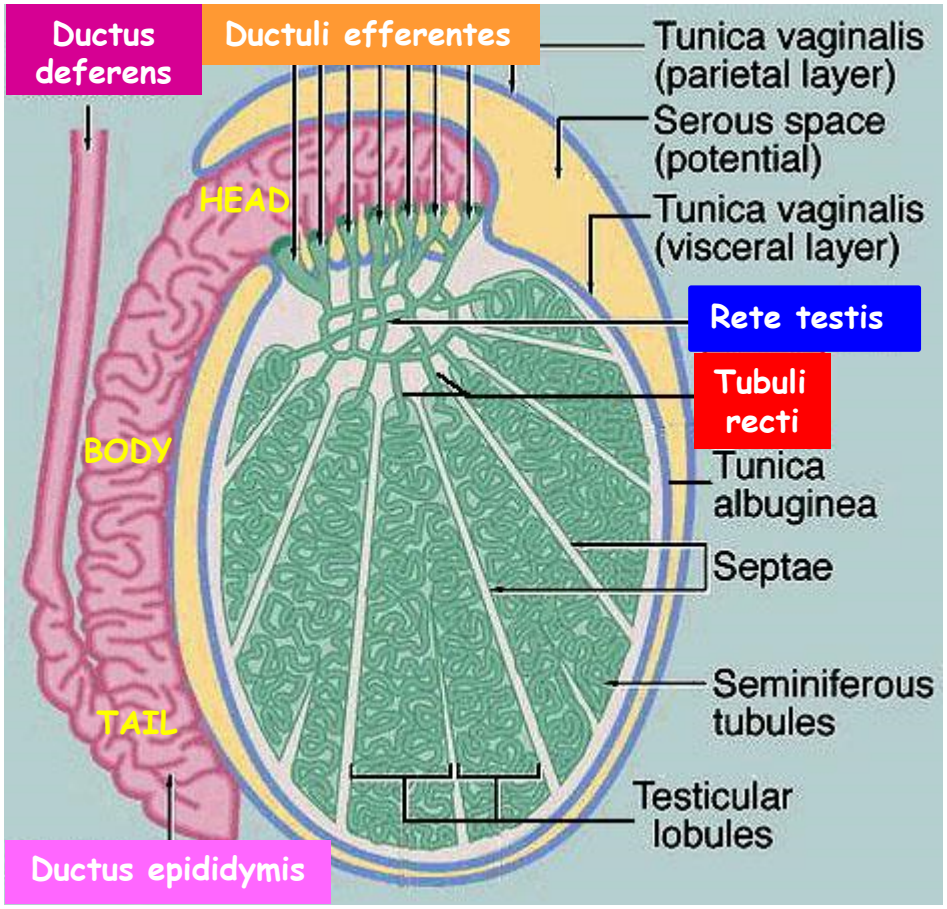
- labyrinth – interconnected channels
- in mediastinum
- simple cuboidal epithelium (as in Tubuli recti)
  (with microvili + cilium)
- circular smooth muscle cells

Intartatesticular genital ducts – Ductuli efferentes



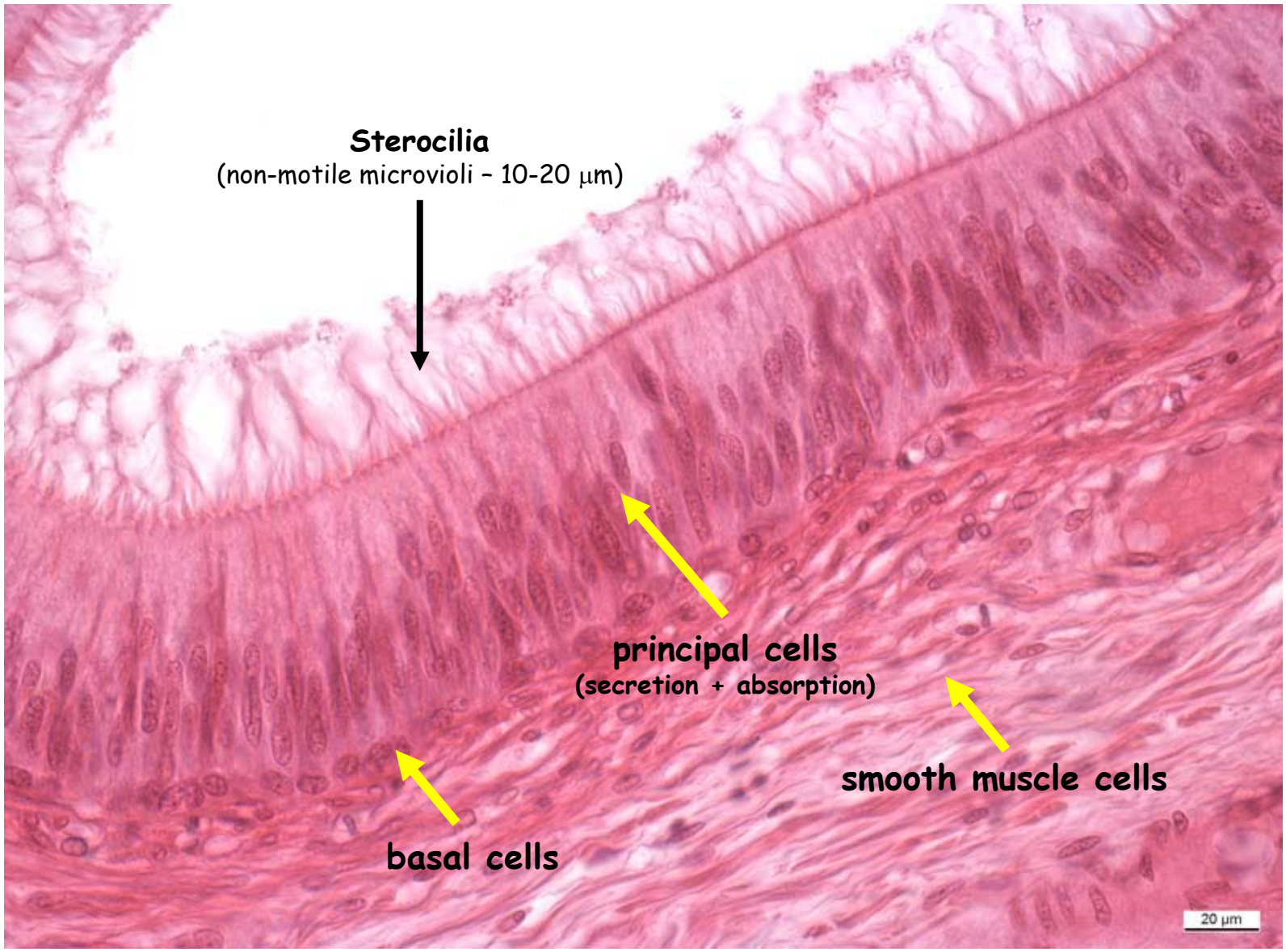
- 10 to 20
- penetrate tunica albuginea
- cuboidal + collumnar cells (patches)
- non-ciliated + ciliated – sperm passage
- microvili + lysosomes – absoption of luminal fluid
- smooth muscle cells – passage of sperm

Extratesticular genital ducts – Ductus epididymis 1

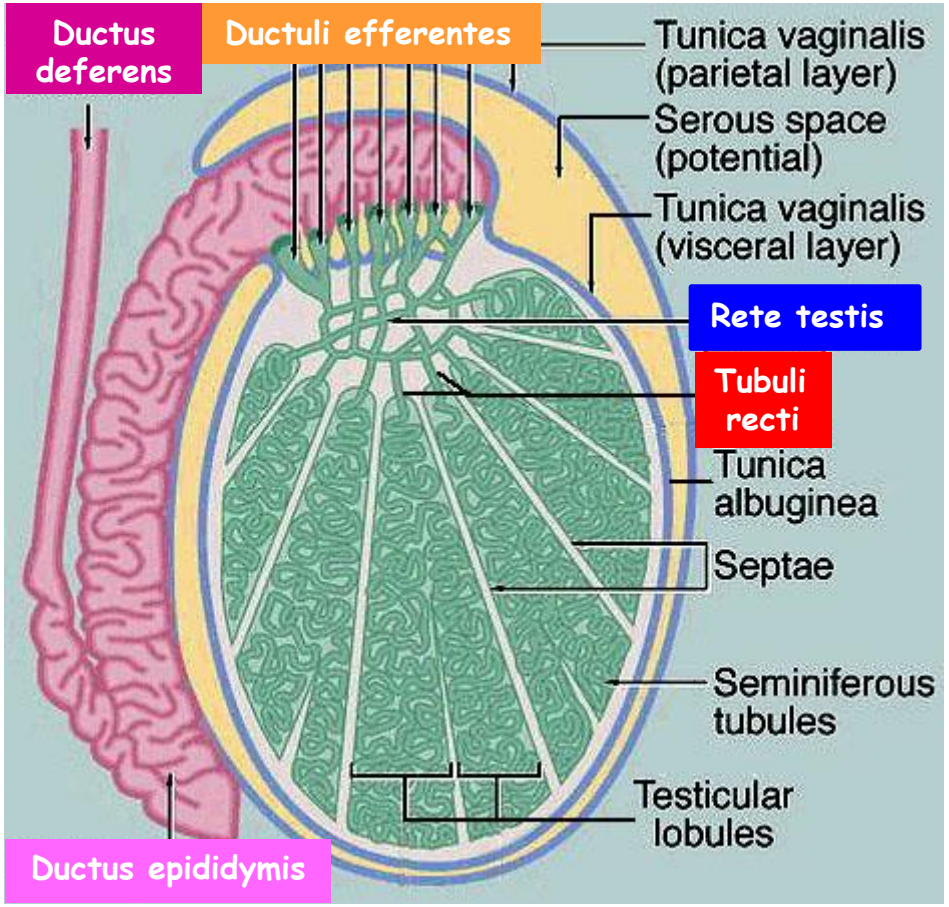


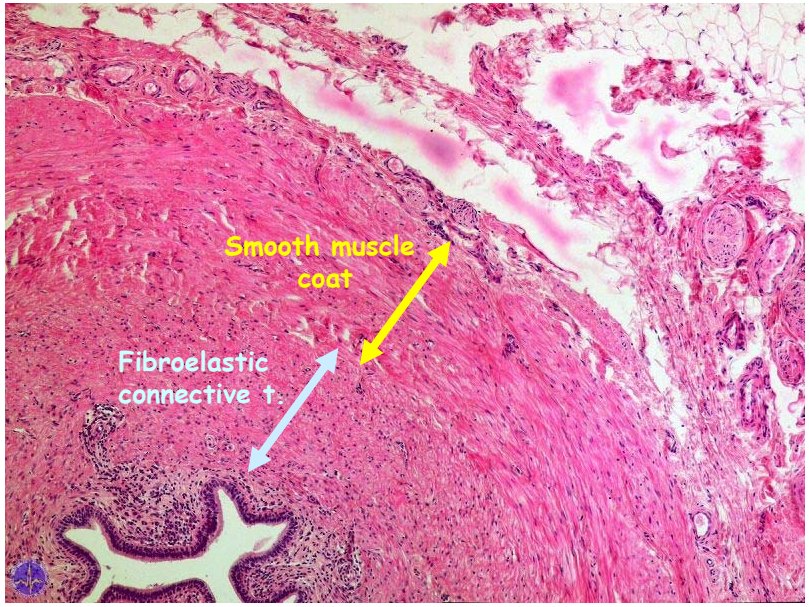
- about 5 meters long
- highly convoluted (head + body)
- tail (cauda) straight – sperm storage + maturation (under hormonal influence)
- collumnar pseudostratified lining: basal cells (polyhedral) + principal cells (collumnar)
- principal cells with stereocilia
- surrounded by circular smooth muscle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

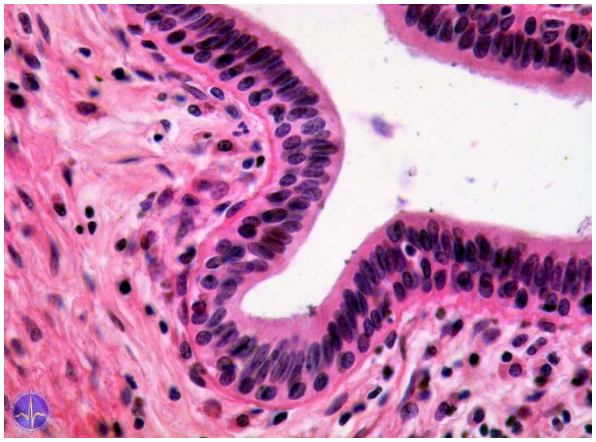
Extratesticular genital ducts – Ductus epididymis 2



Extratesticular genital ducts – Ductus deferens 1

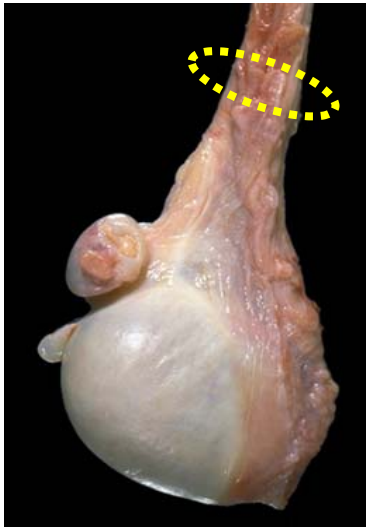




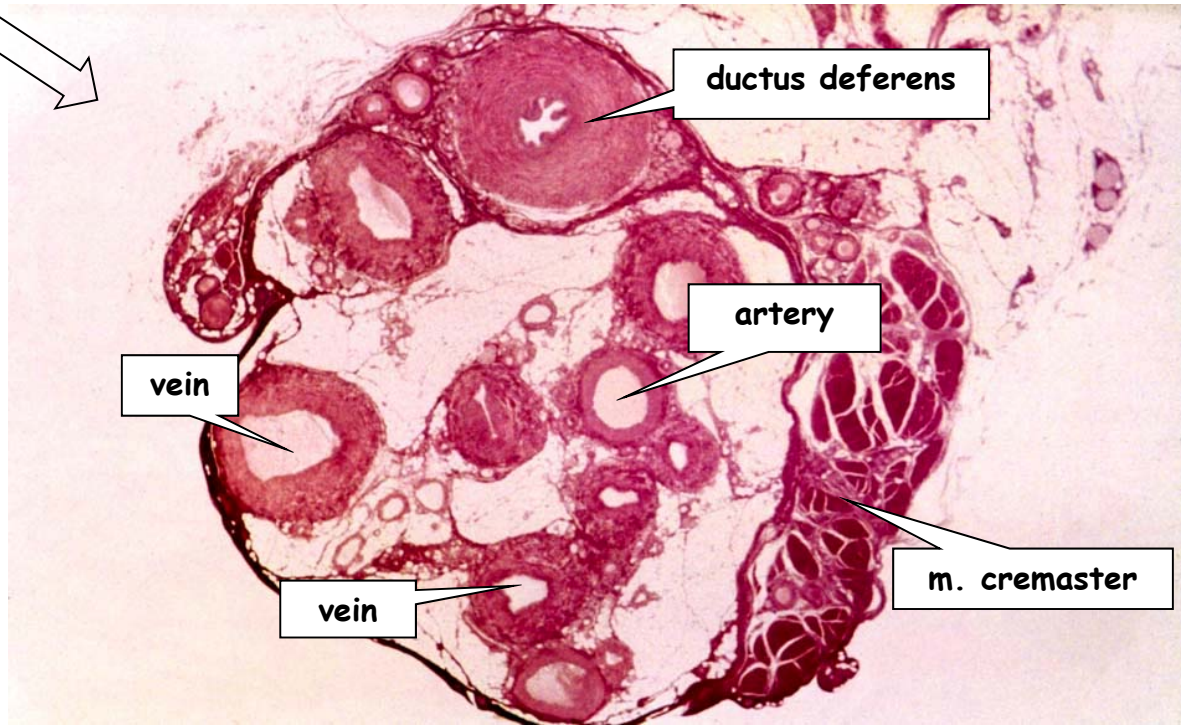


- thick walled + folded lumen
- epithelia similar to D. epididimis – collumnar pseudostratified (basal cells + principal cells)
- surrounded by three layers of smooth muscle layer (circ+long+long)
- sympathetic inervation – initiate ejaculation

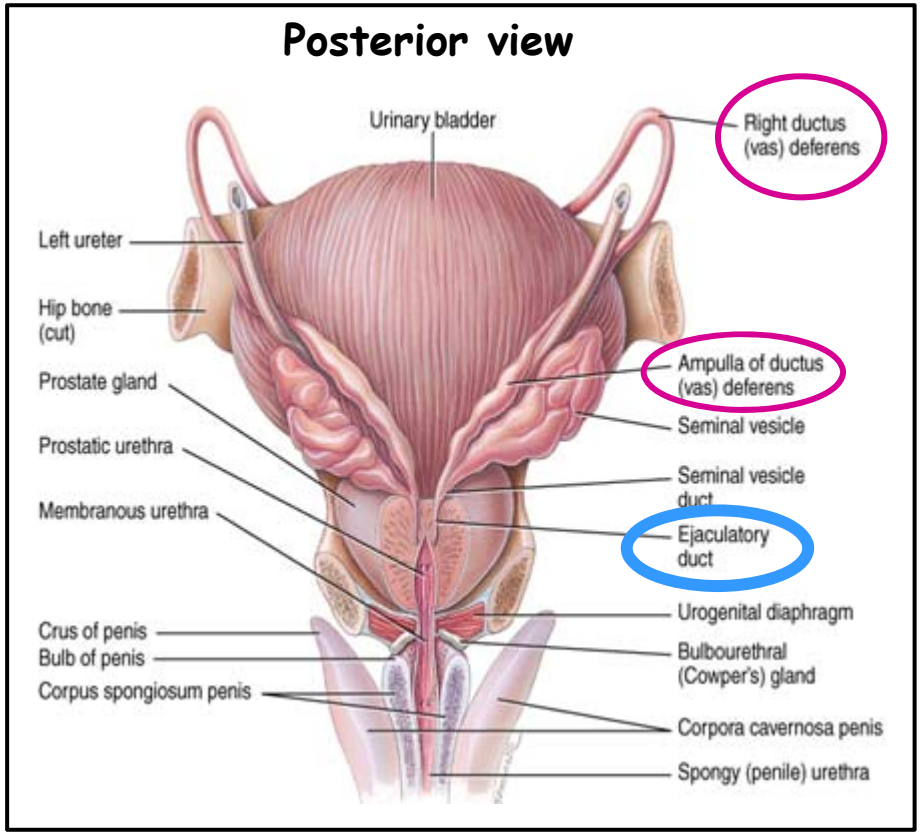
Extratesticular genital ducts – Ductus deferens 2

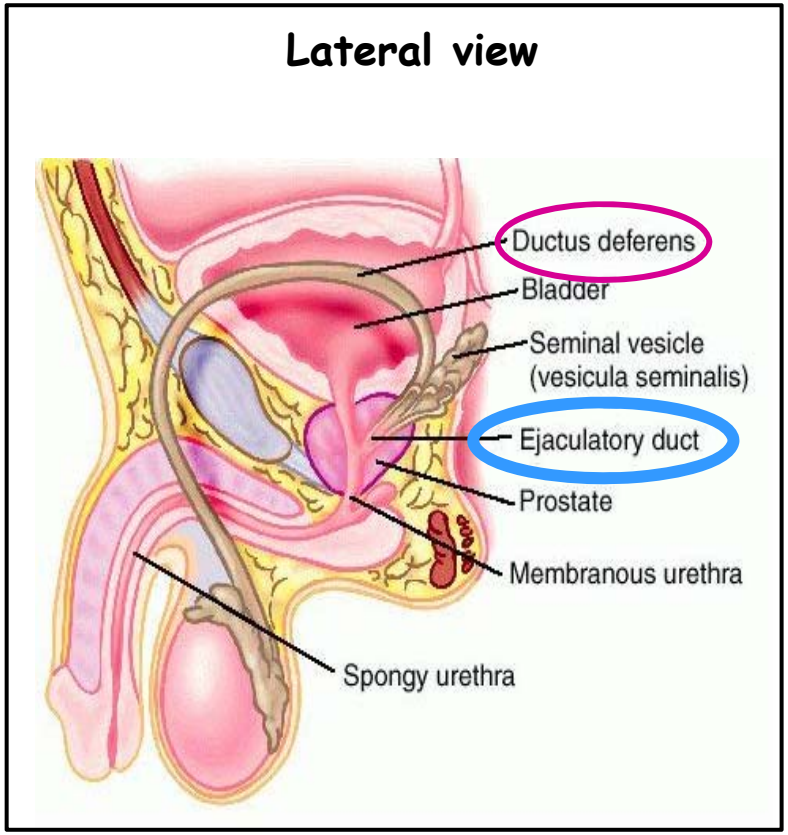


Funiculus spermaticus



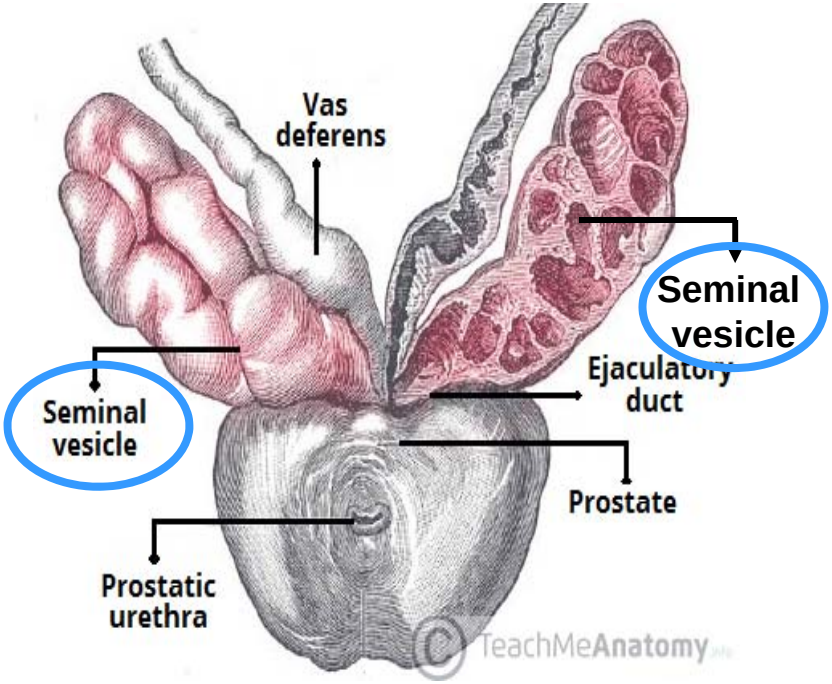
Extratesticular genital ducts – Ejaculatory duct

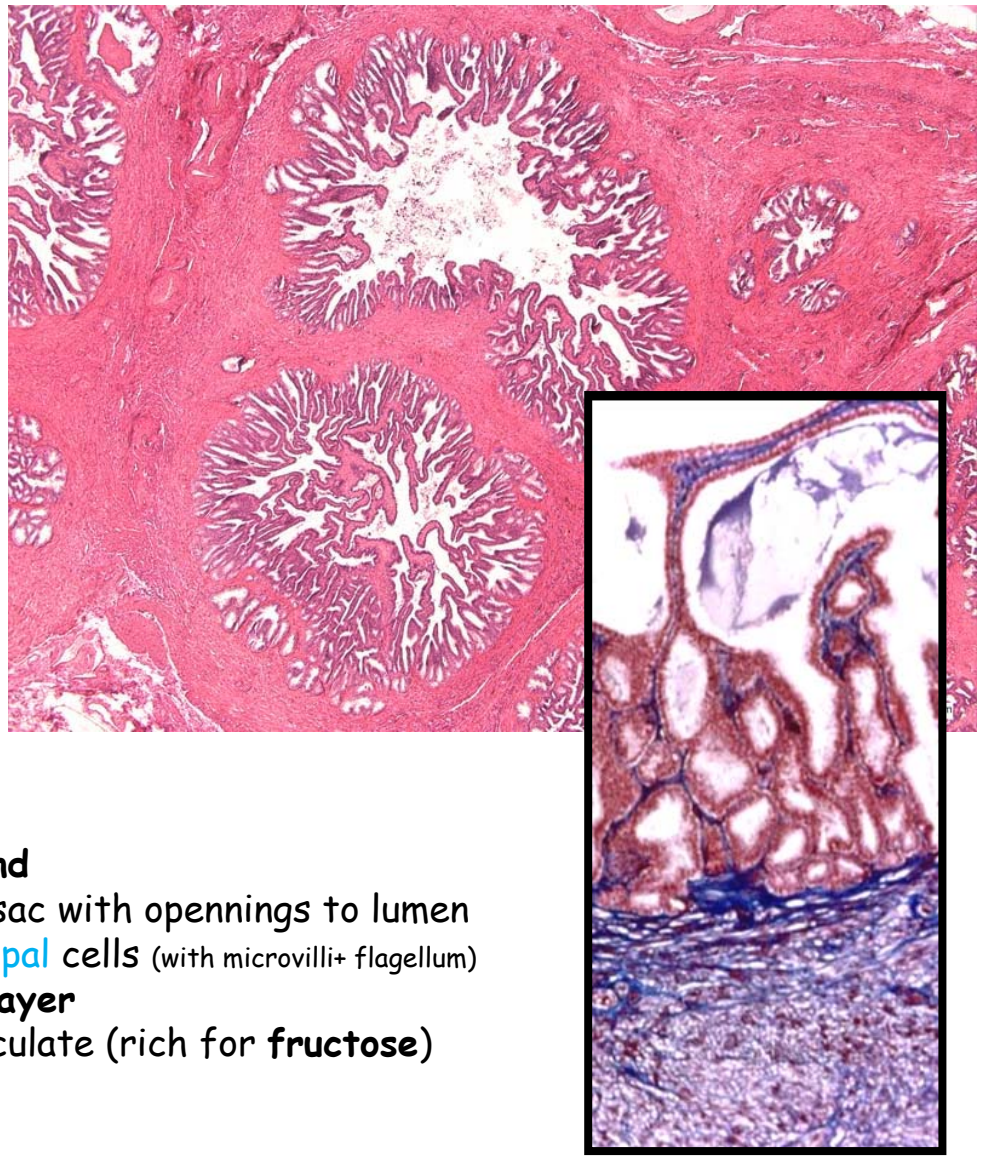




- short + straight
- portion after entry of seminal vesicle duct
- surrounded by prostate
- enters urethra at the **colliculus seminalis** (verumontanum)
- lined with **simple collumnar epithelium**
- **NO smooth muscle laeyer**

Accessory genital glands – Seminal vesicles





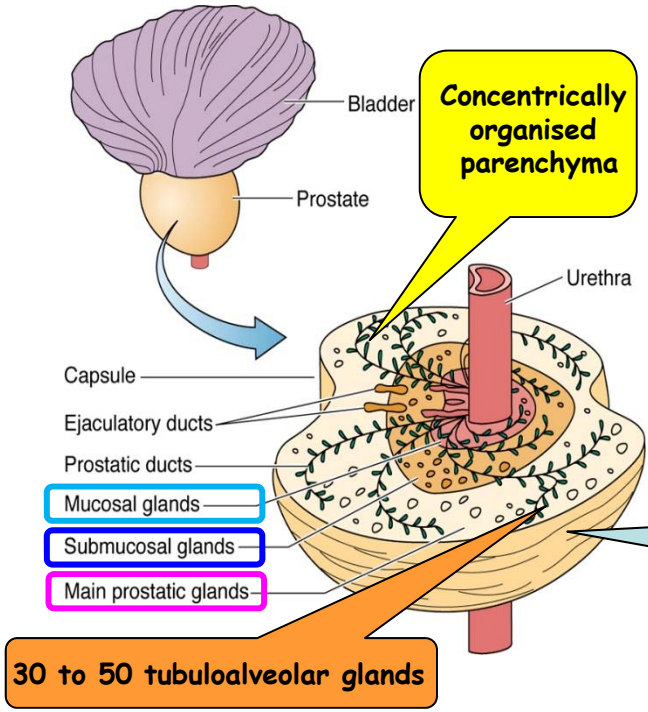
- develops from ductus deferens
- about 15 cm long snaking tube – **tubular gland**
- highly folded mucosa – labyrinthous cul-de-sac with openings to lumen
- **pseudostratified epithelium** - basal + principal cells (with microvilli+ flagellum)
- **fibroelastic submucosa + smooth muscle layer**
- **seminal 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



Concentrically organised parenchyma

Capsule
- collagenous
- with smooth muscle cells
- vascularised

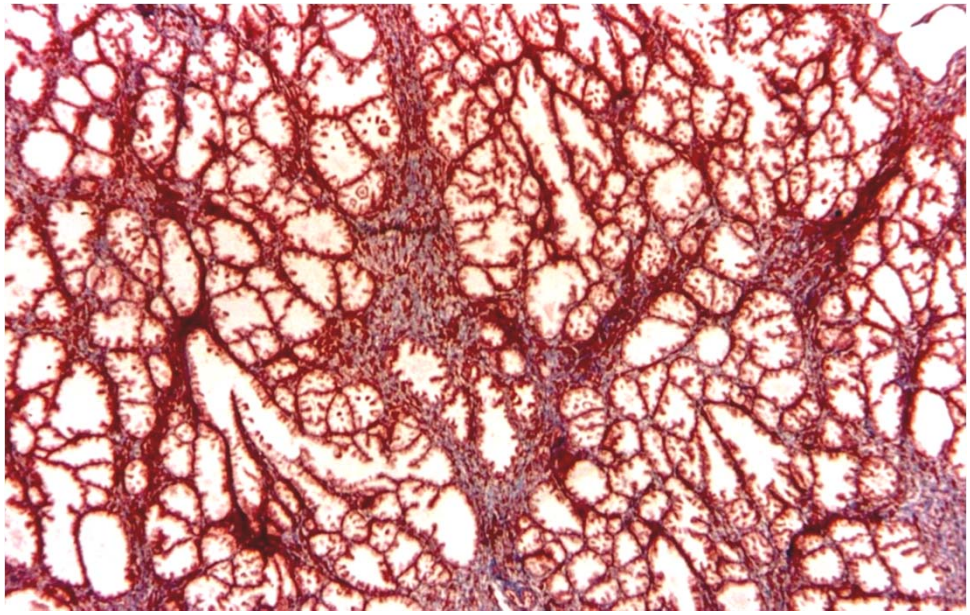
30 to 50 tubuloalveolar glands

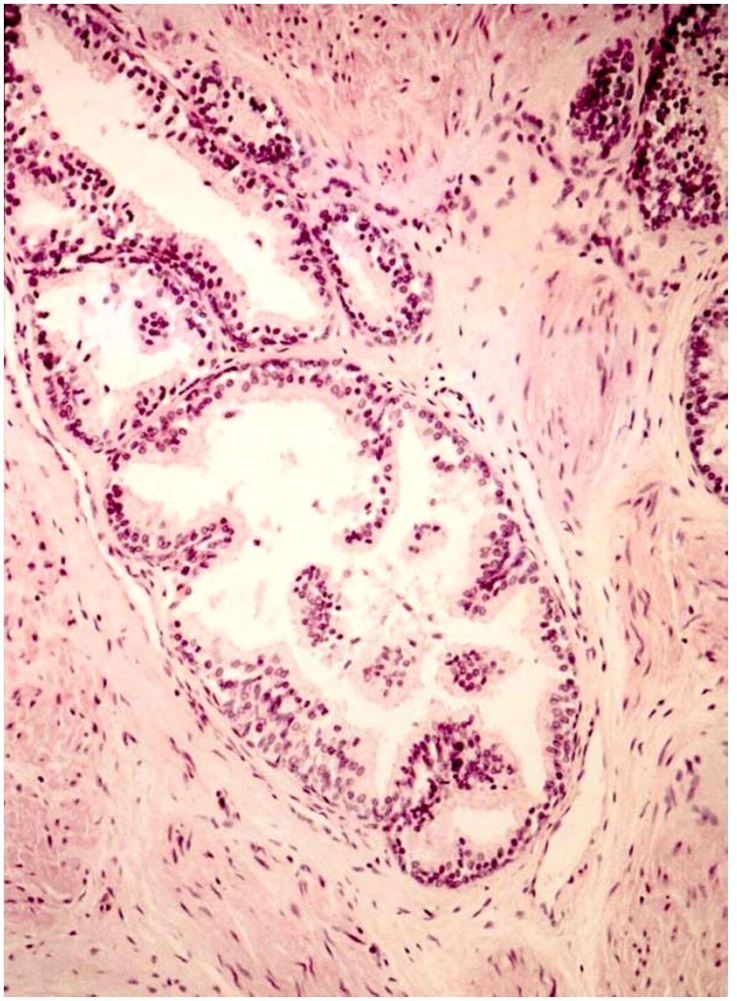
GLANDS

- simple pseudostratified collumnar epithelium
- abundant RER + Golgi + secretory granules

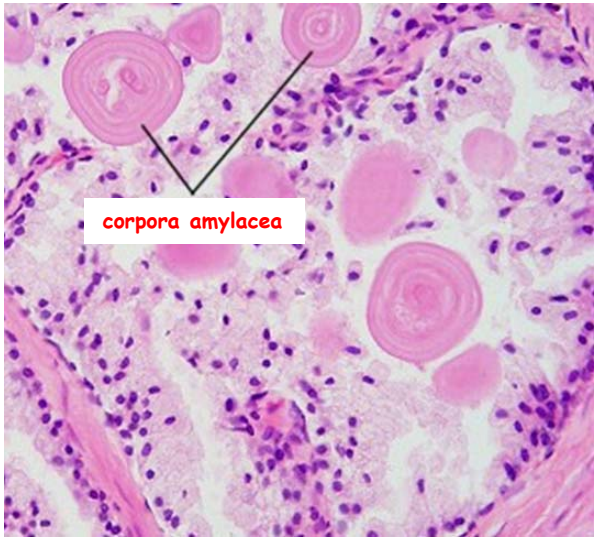
- size and shape of **chesnut** (the largest accesory gland)
- stroma (derives from the capsule): fibroelastic elements, many **smooth muscle cells**
- **prostatic secretion**: lipids, acid phosphatase, proteolytic enzymes, citric acid, fibrinolysin (liquifies semen)

Accessory genital glands – Prostate gland 2

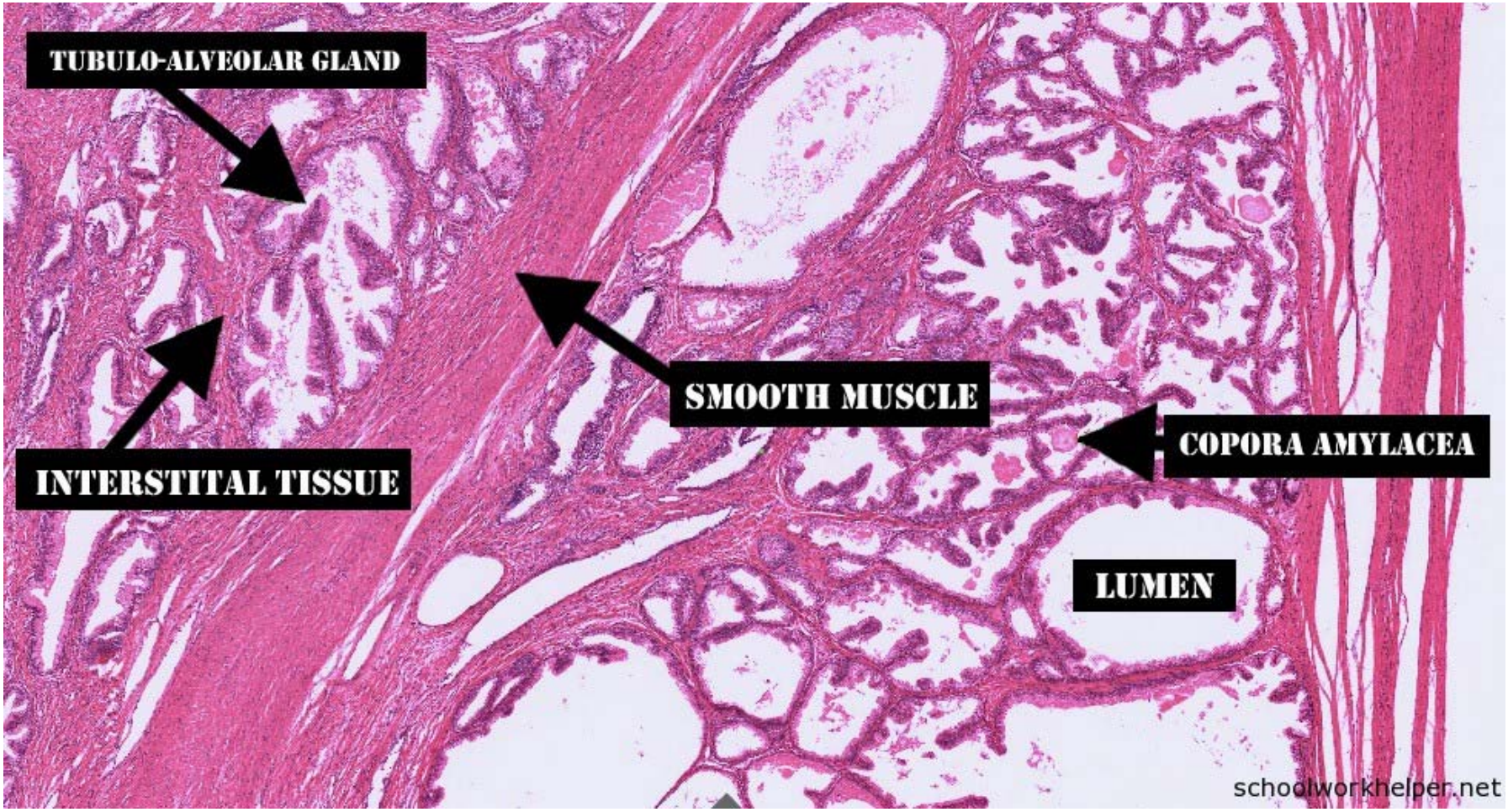




Corpora amylacea
= prostate concretions
- increase with age
- may calcify
- size even 1 mm

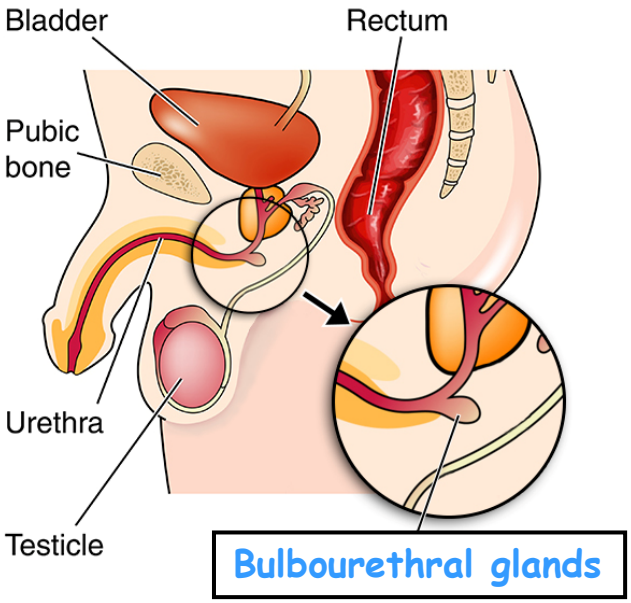


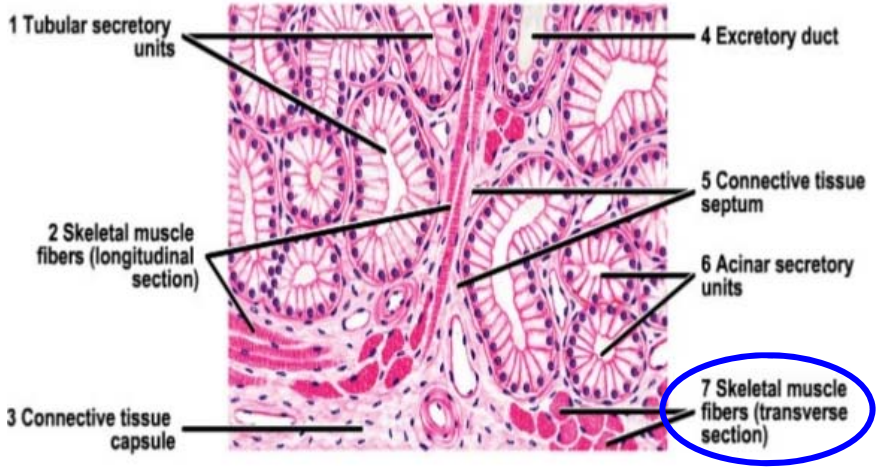
Accessory genital glands – Prostate gland 3

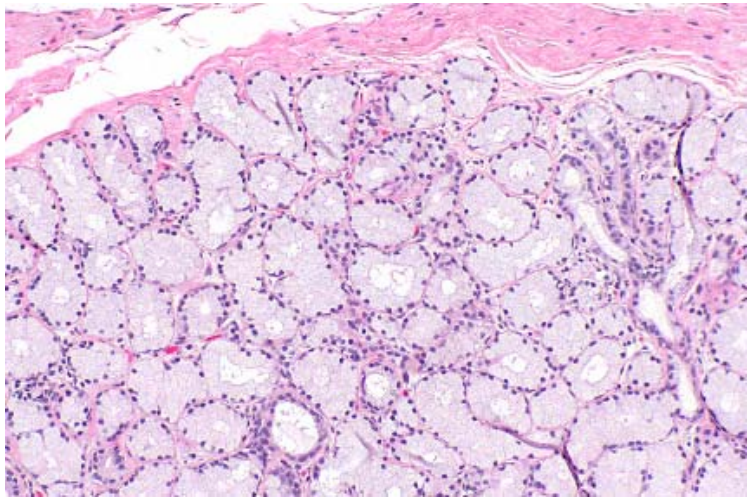


Accessory genital glands – Bulbourethral glands

Lateral view

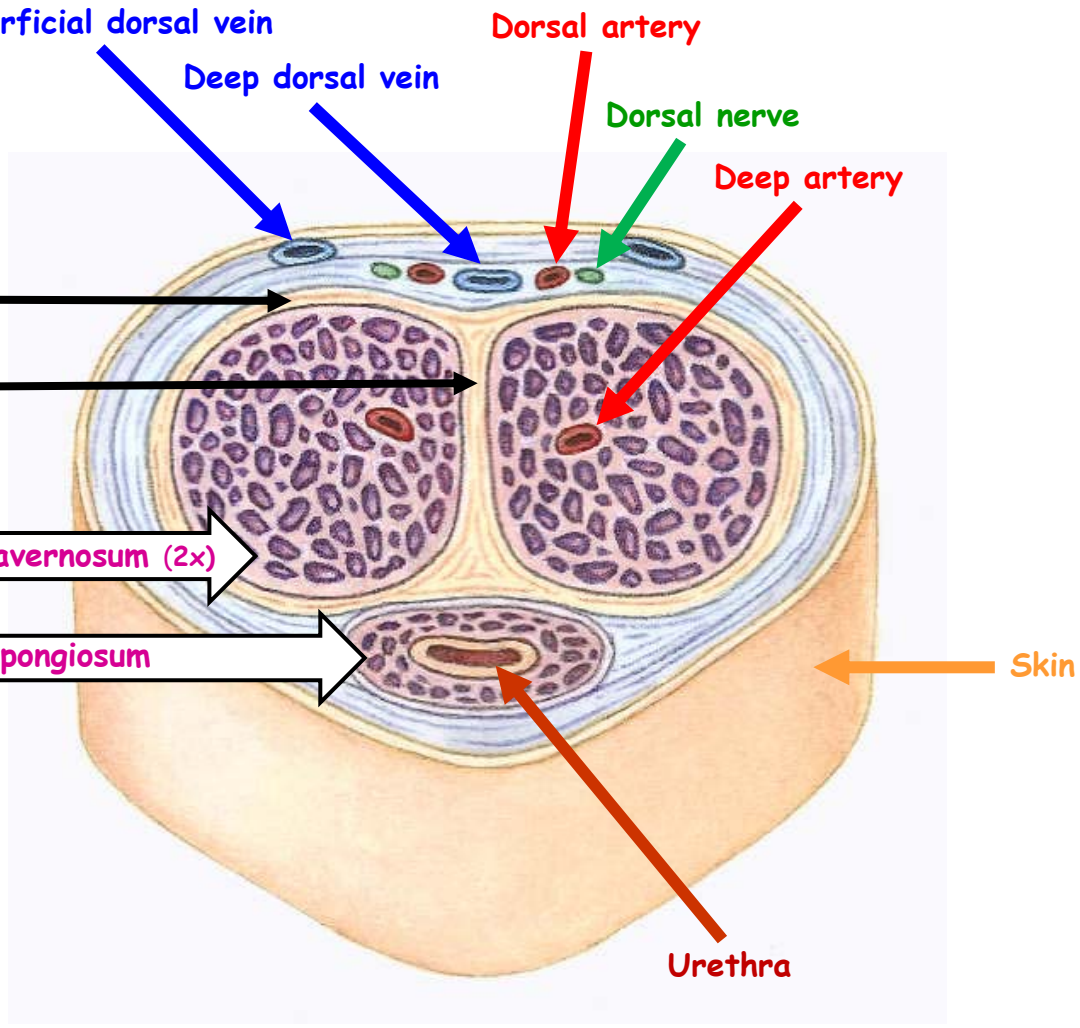




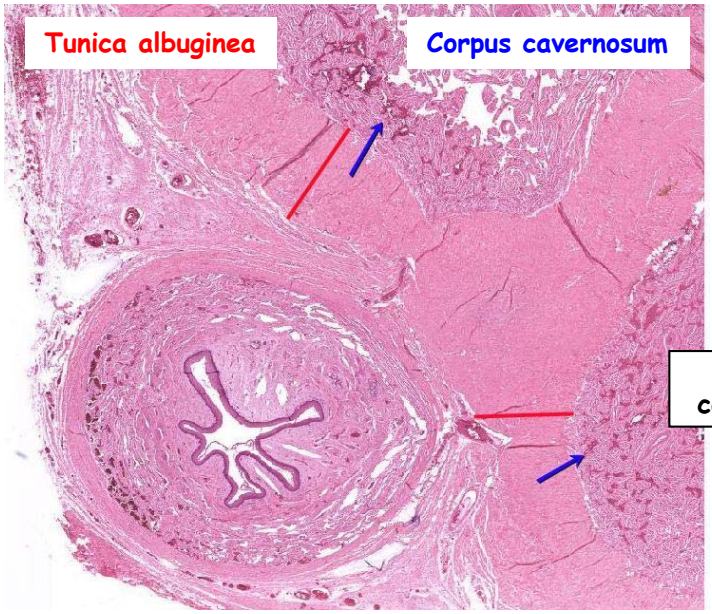


- small – 3 to 5 mm
- at the root of the penis
- lobular structure (septa)
- **skeletal muscle fibers** (derived from urogenital diaphragm)
- simple cuboidal epithelium
- lubricating fluid (sialic acid + galactose)

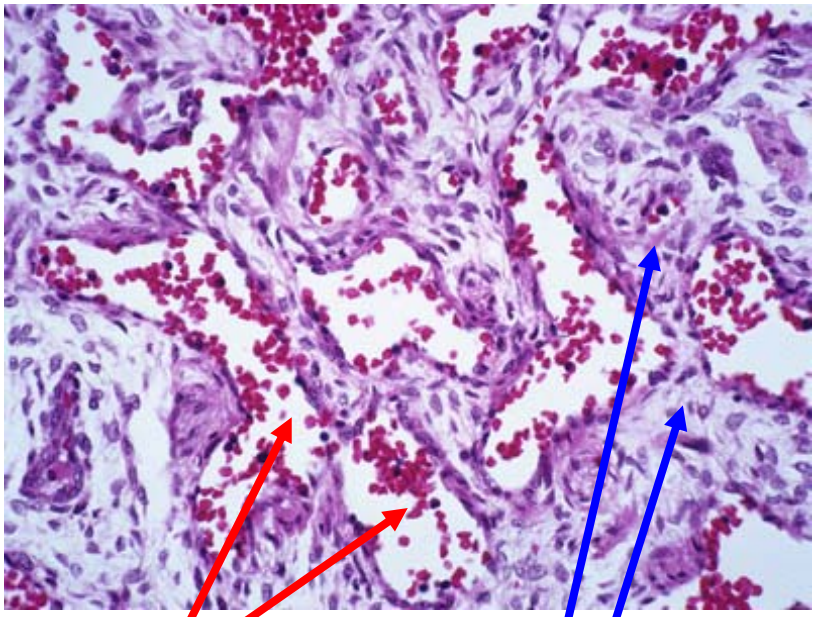
Penis - 1


Superficial dorsal vein
Deep dorsal vein
Dorsal artery
Dorsal nerve
Deep artery
Tunica albuginea
Septum
(discontinuos)
Erectile tissue
Corpus cavernosum (2x)
Corpus spongiosum
Skin
Urethra

Penis - 2



Corpus cavernosum

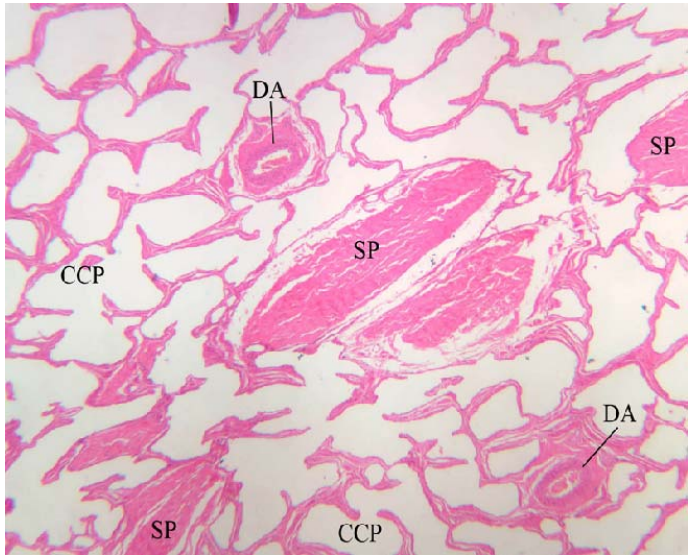


Vascular spaces

- lined by endothelia

Trabeculae

- elastic fibers
- smooth muscle cells



Capillary plexuses
+
Helical arteries

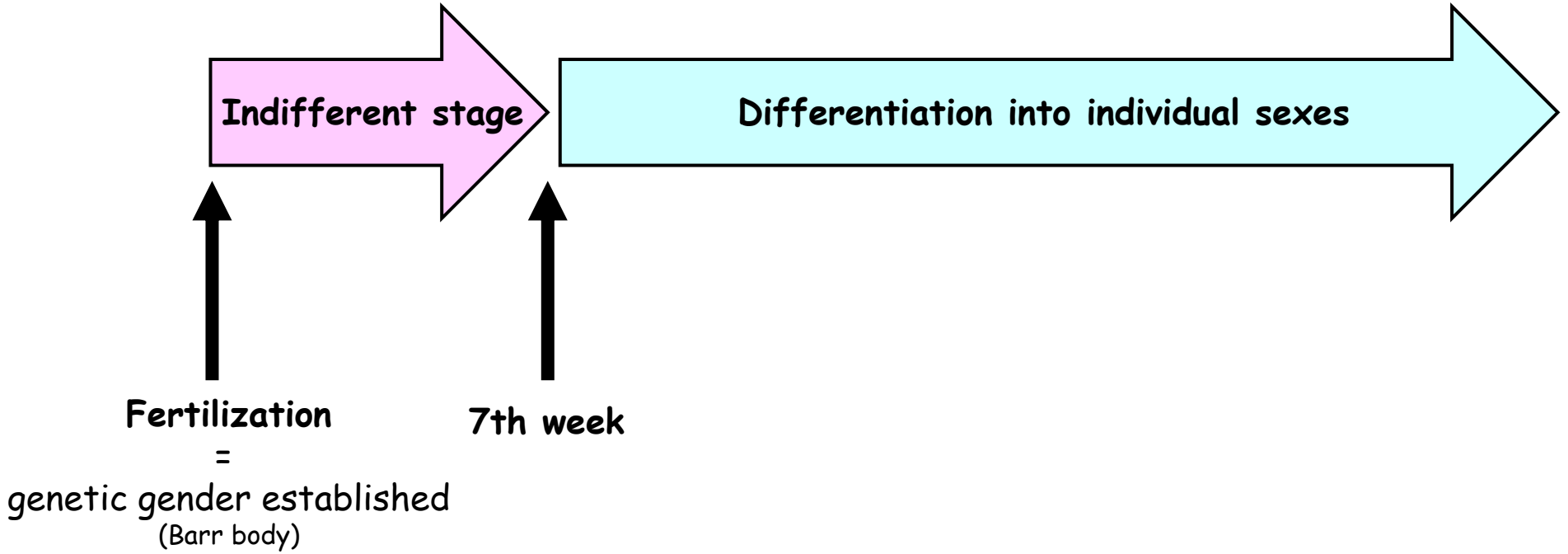
Deep arteries

Genital system

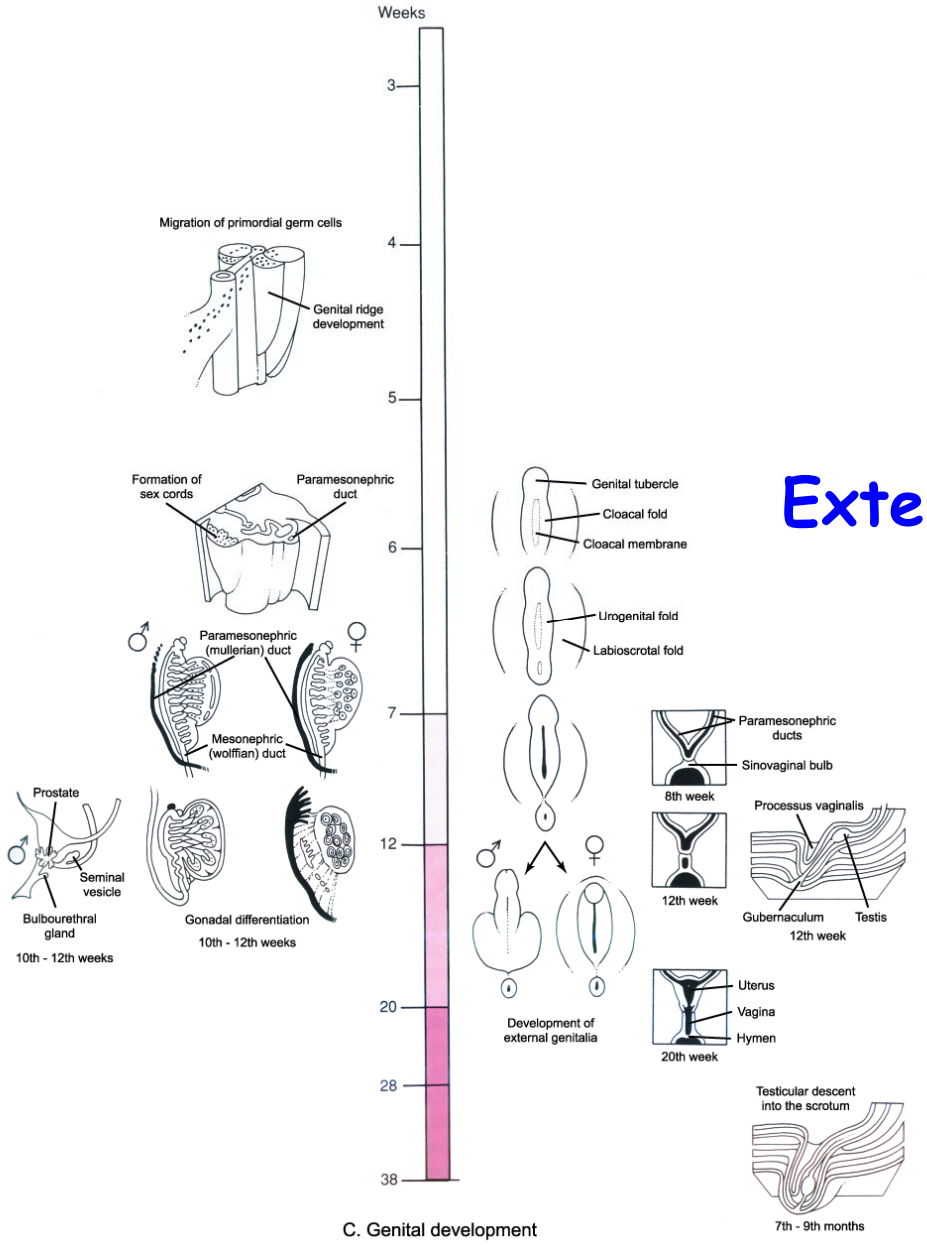
Sexual dimorfism – individual can only have one type of genital organs

Genetic determination:

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



Genital system – 7 weeks at indifferent stage



C. Genital development

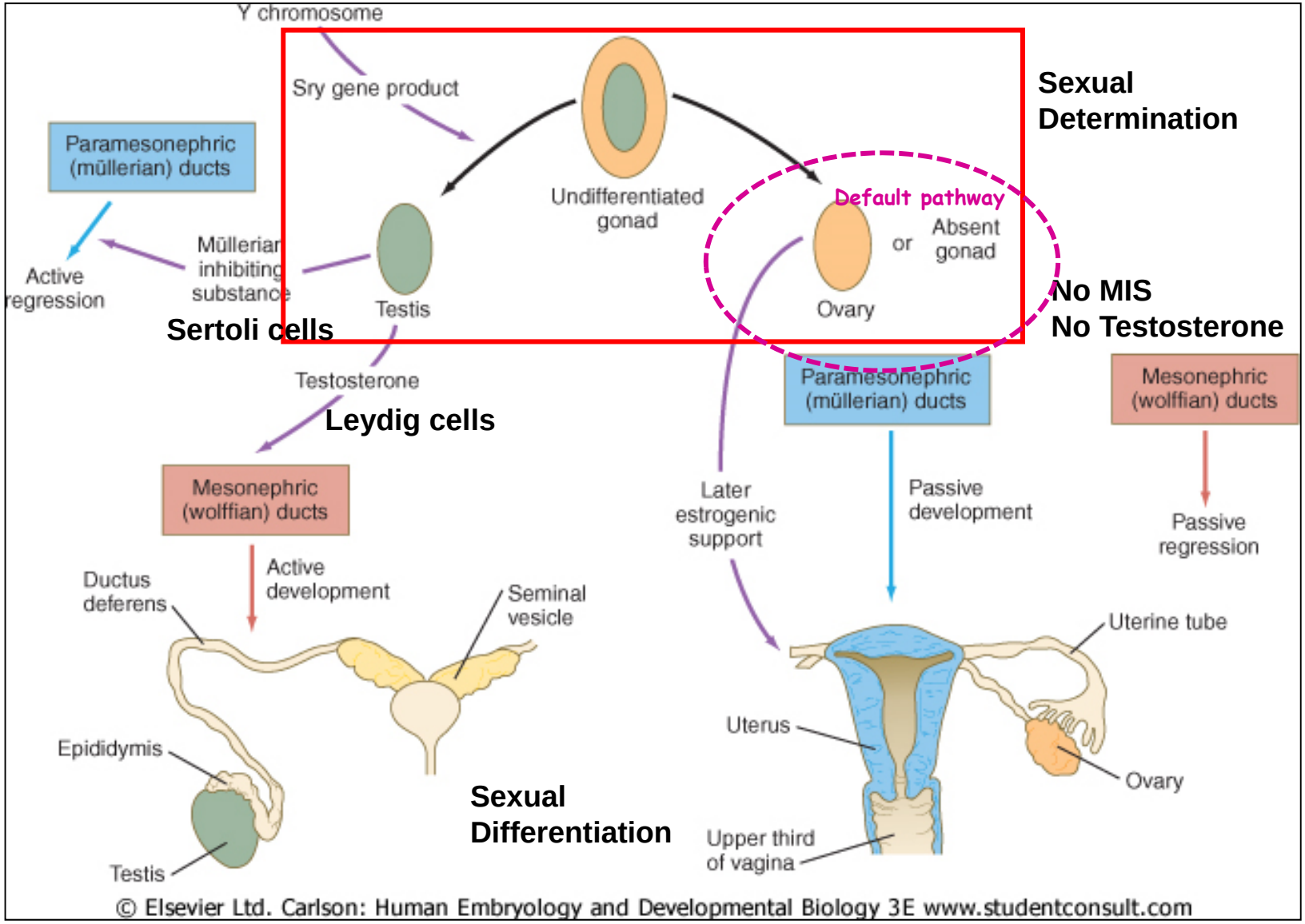
Gonads

External genitalia

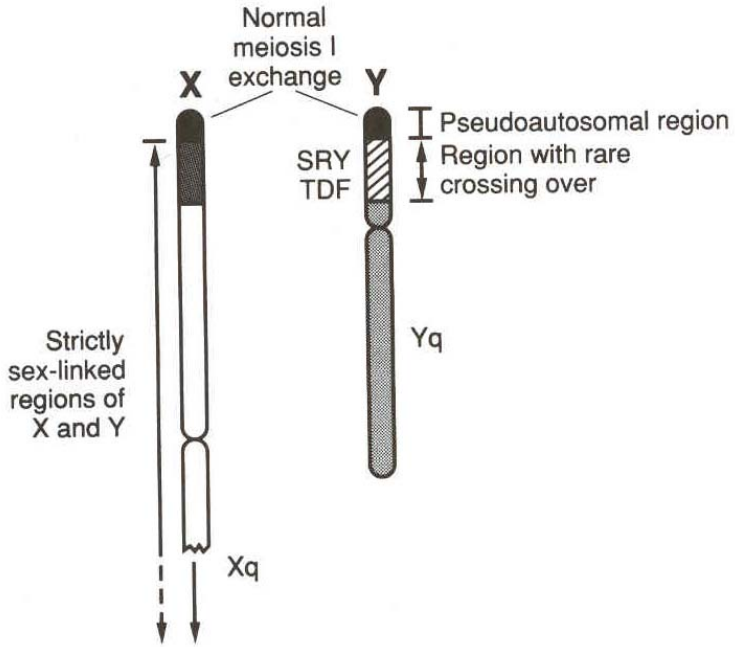
Genital system – Sry gene

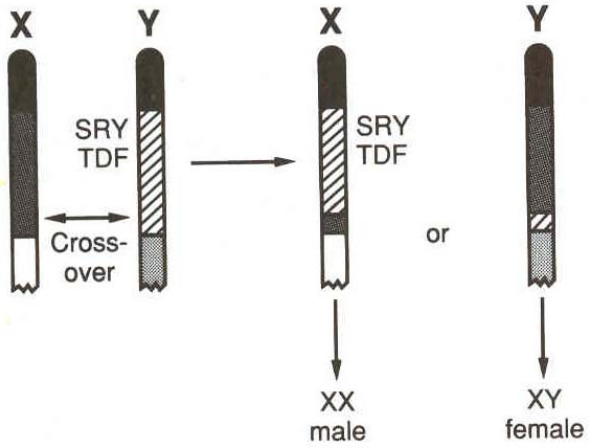
Sry gene – Sox family TF – on short arm of Y chromosome

Y chromosome decides
XXY – male
XO – female



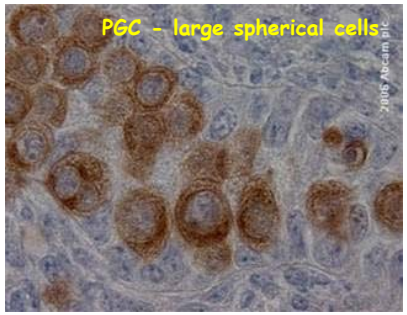
Genital system – Sry gene



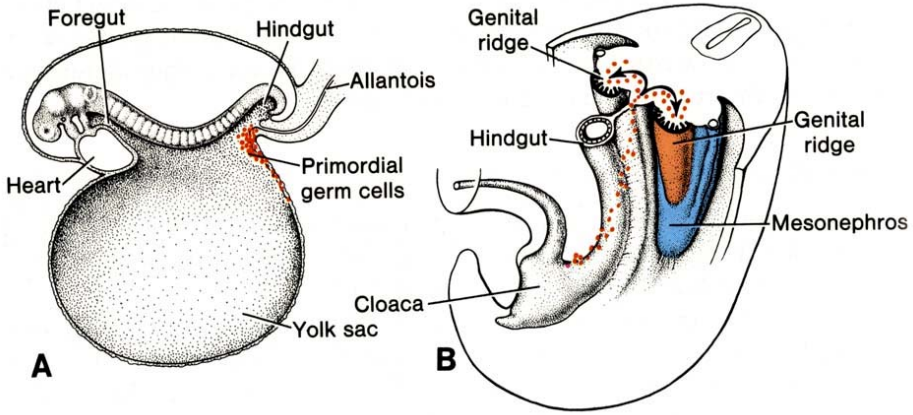


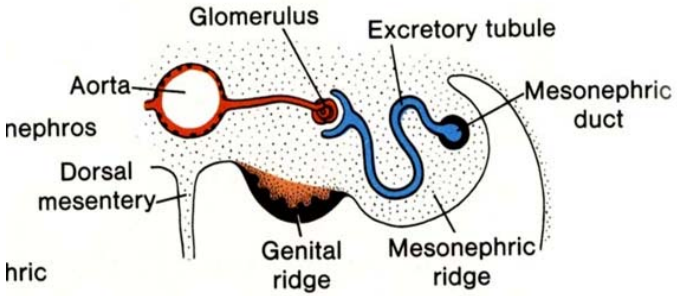
Pairing of X and Y chromosomes in pseudoautosomal region during meiosis

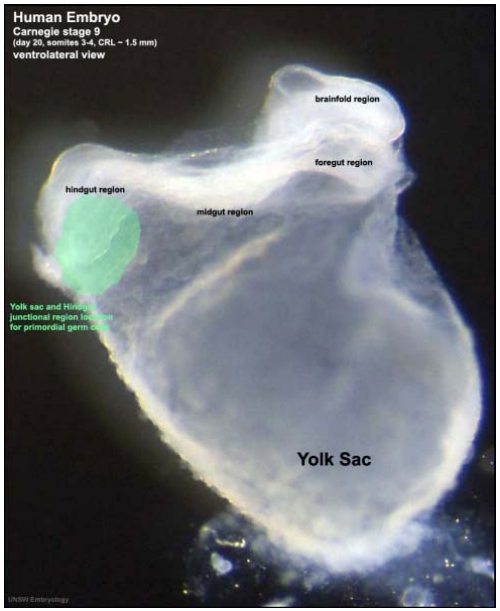
Rare crossing-over causes translocation of SRY to X chromosome:
XY females or XX males



Genital system – Primordial germ cells







Primordial germ cells (PGC)

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

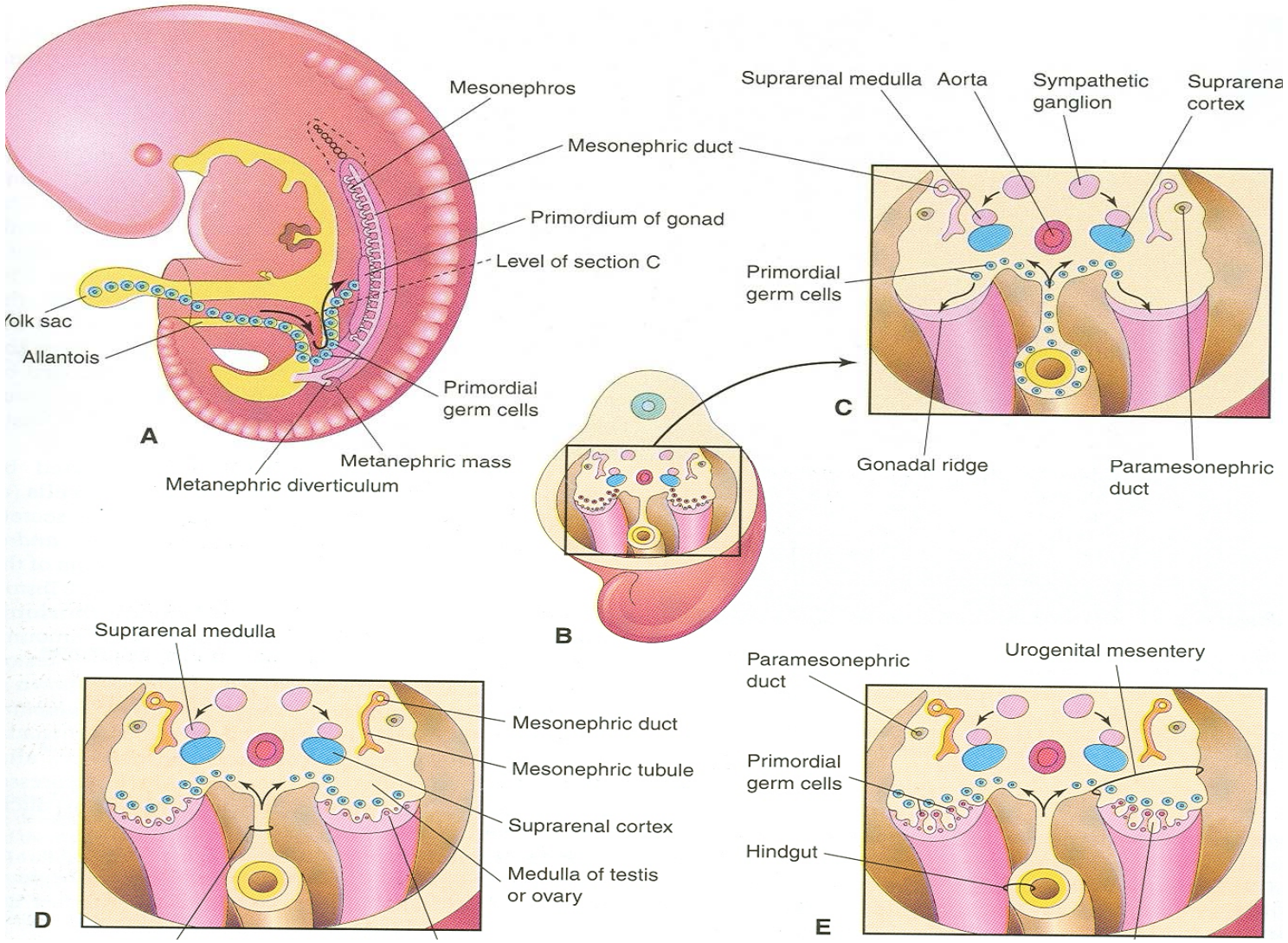
Males
PGC stop dividing

X

Females
PGC enter meiosis

decided by somatic cells in the genital ridges

Genital system – migration of PGC into gonadal anlagen



Genital system – gonadal anlagen

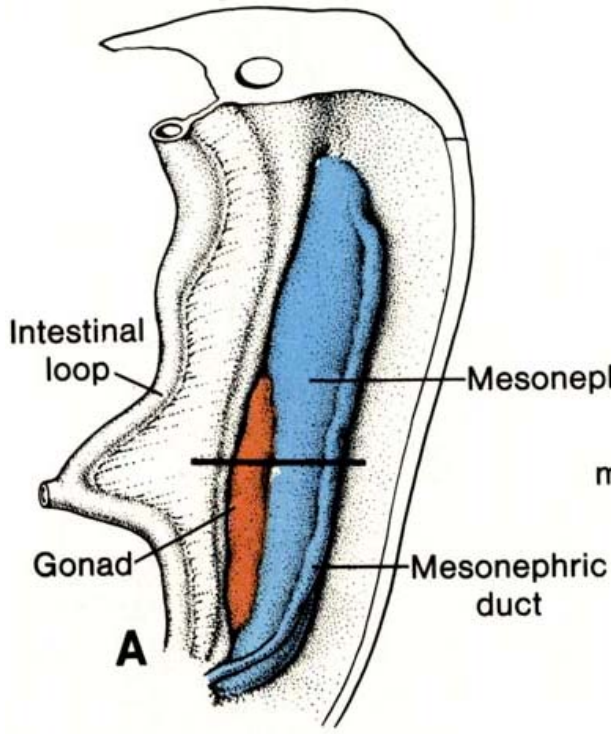
Steroidogenic mesoderm
along the ventromedial border of the mesonephros

cranial region
=
Adrenocortical primordia

caudal region
=
Genital ridges

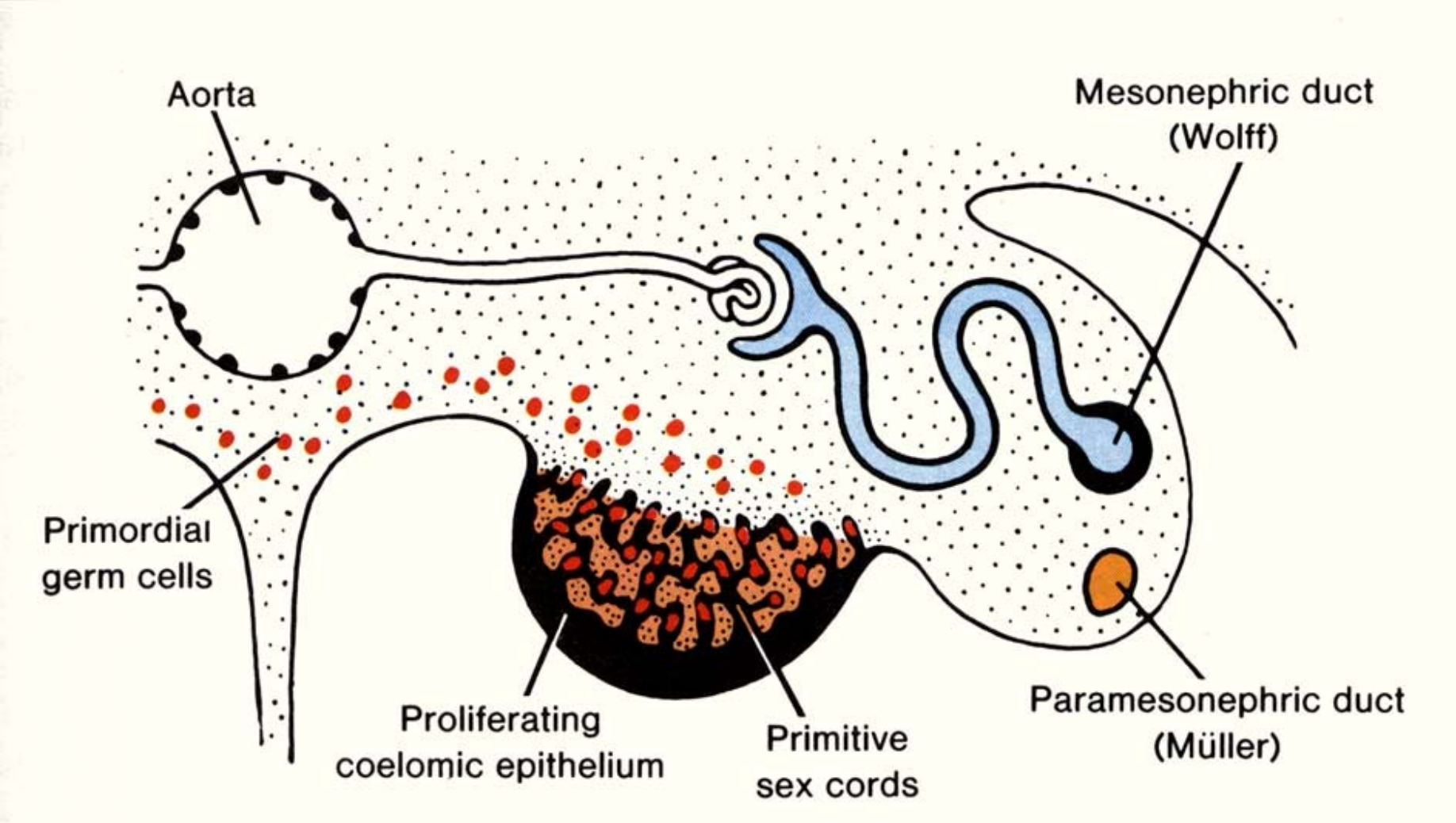
cells of **coelomic epithelium**
+
cells from **mesonephric ridge**

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



become populated by PGC at week 6

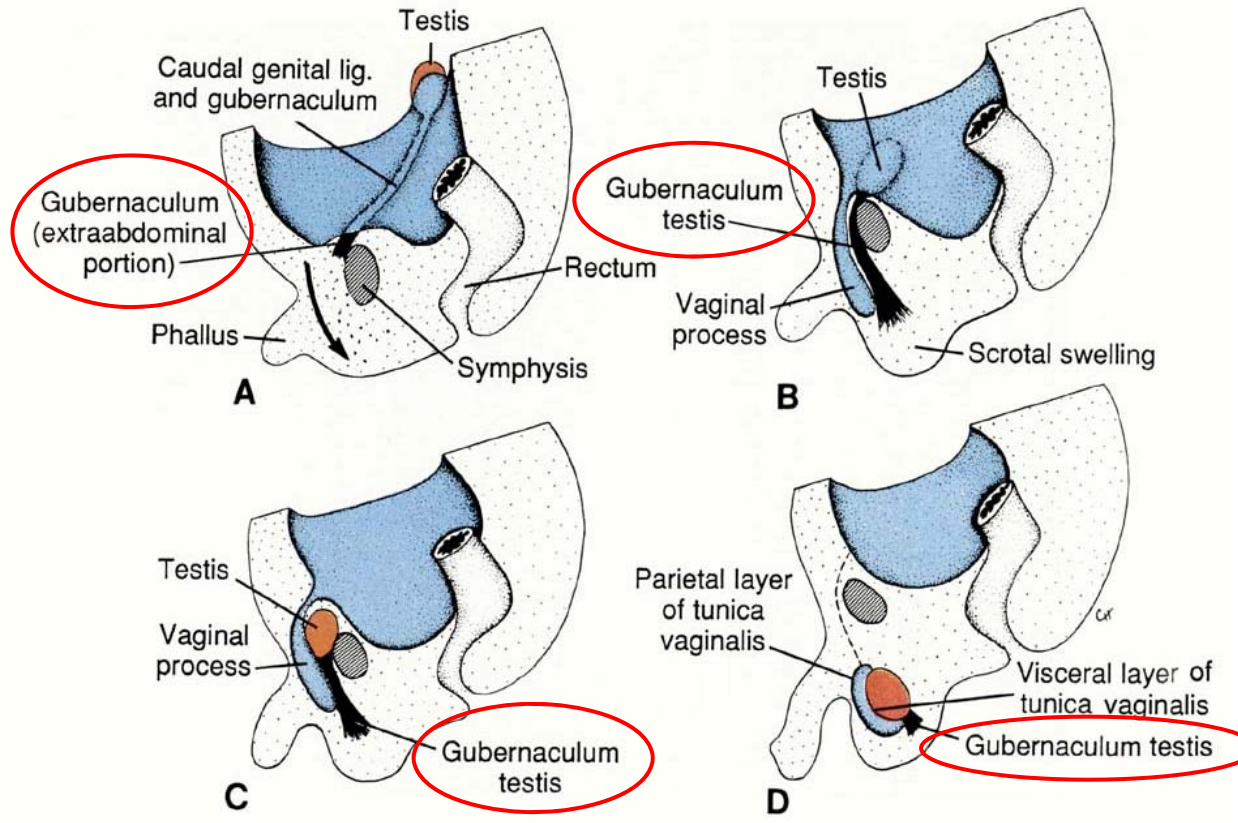
Genital system – indifferent gonade (week 6)



Genital system – Descent of the testes

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

- testes enlargement
- atrophy of mesonphros – allows for caudal movement
- tension of gubernaculum
- atrophy of paramesonephric ducts – move to unquinal 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

Gubernaculum – originates from caudal portion of genital ridge

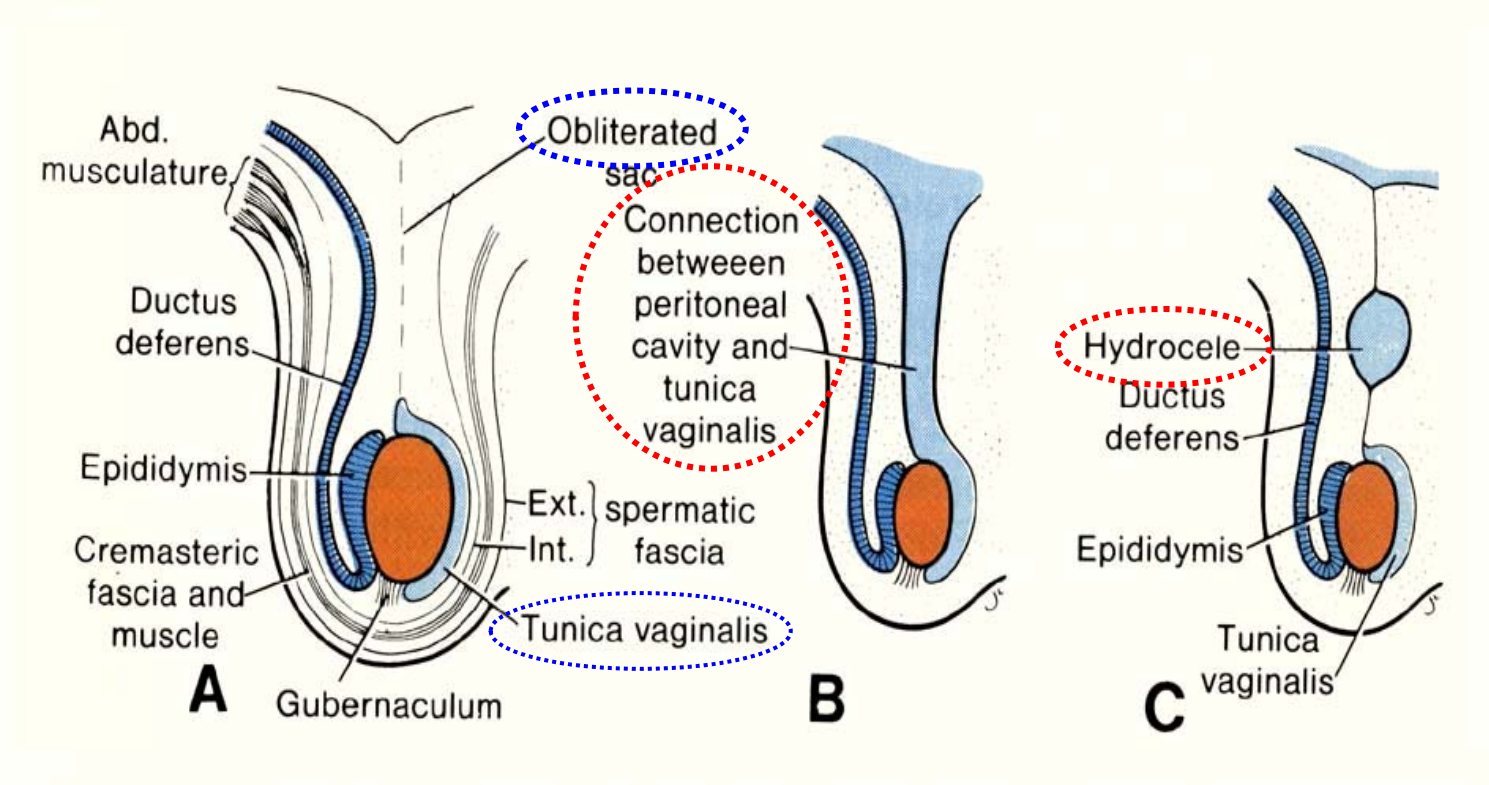
NOTES

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

Genital system – Descent of the testes



Processus vaginalis obliterated

NORMAL

Remanining 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)

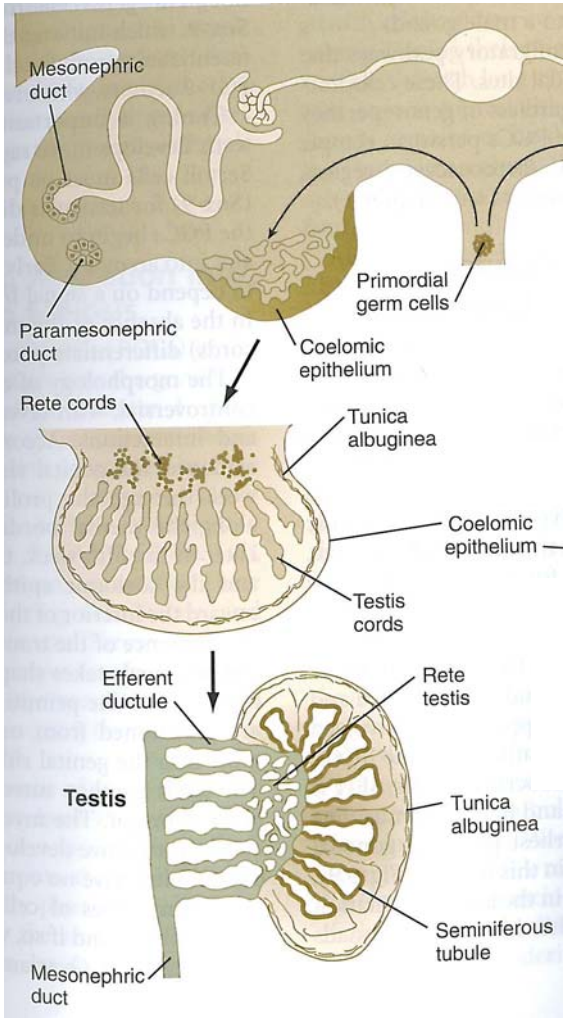
Tunica albuginea develops
(sets barrier between coelomic epithelium and testis cords)

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

Rete testis joints ductuli efferentes that are derived from mesonephric ducts
(5th to 12th)

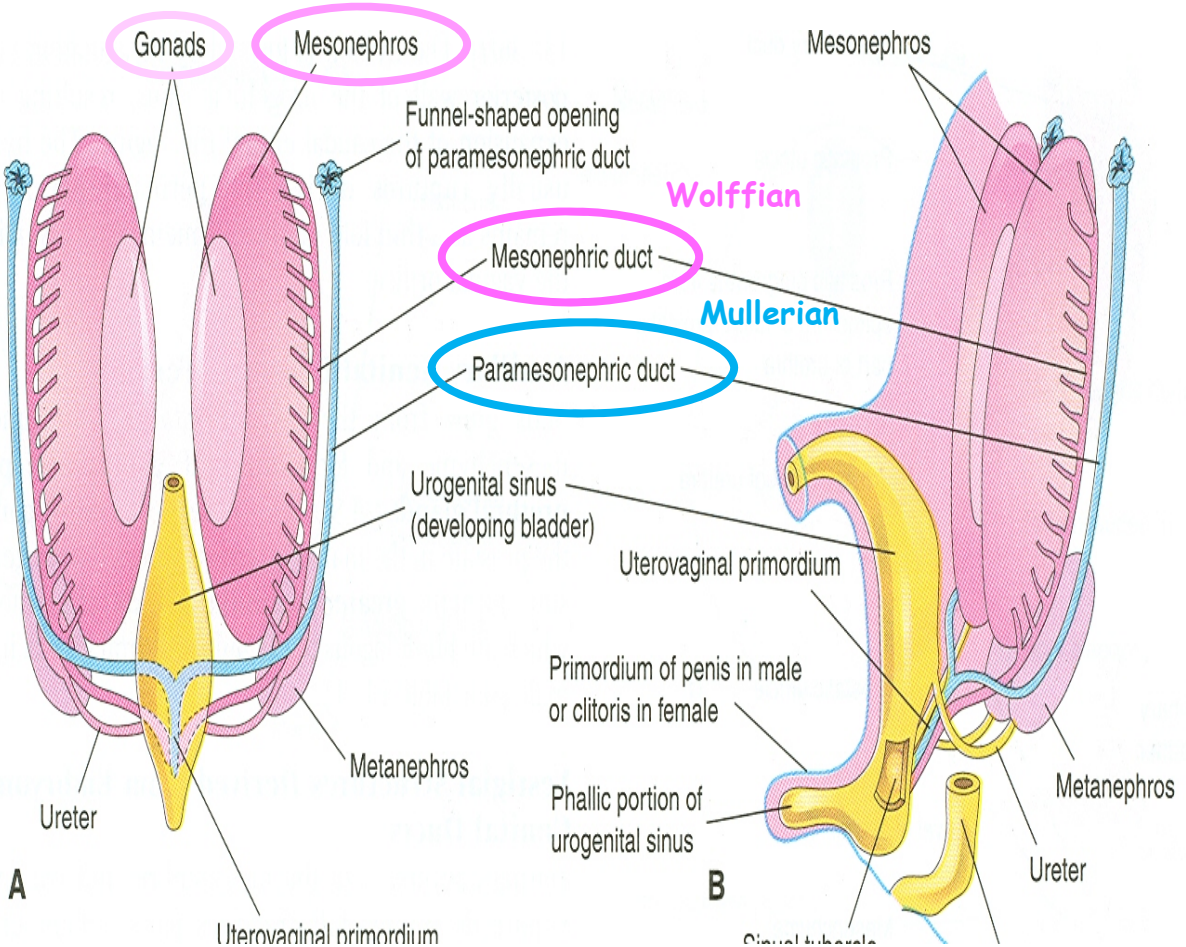
Week 8 to 18

Leydig cells develop and function in developing testis
- from coelomic epithelia and mesonphros
- produce testosteron
- support development of Wolfian (mesonephric) duct
- support development of external genitalia



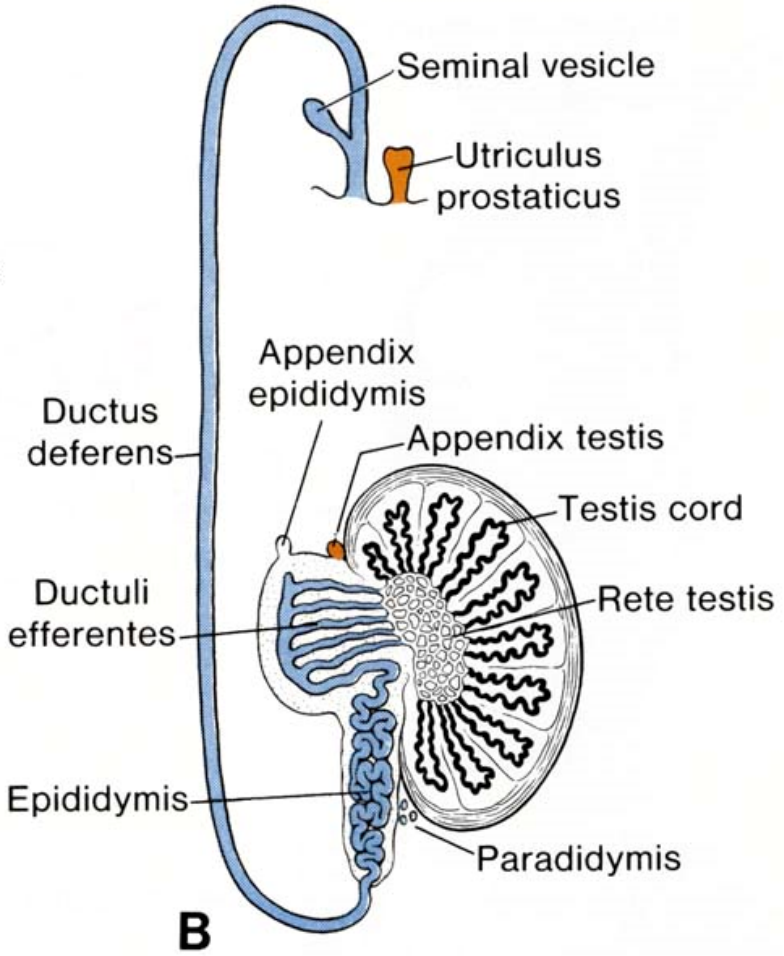
Genital system – Sexual duct system – Indifferent stage

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)

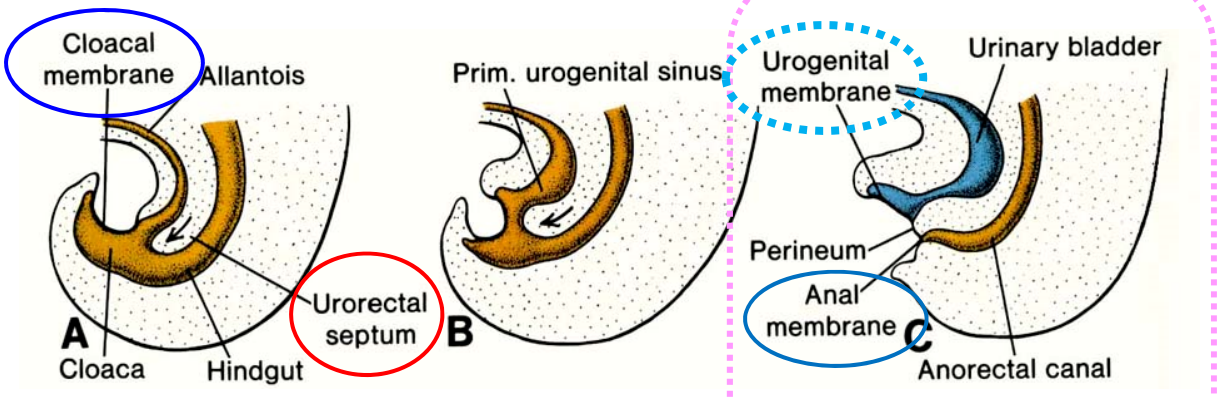
Mesonephros
- **Ductuli efferentes**
- **Paradidymis** (under the testis, nonfunctional)

Genital system – External genitalia - Indifferent stage

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

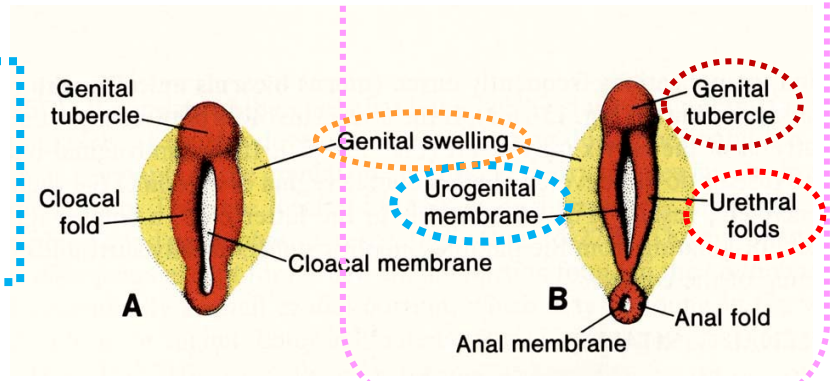
HORMONE-INDEPENDENT

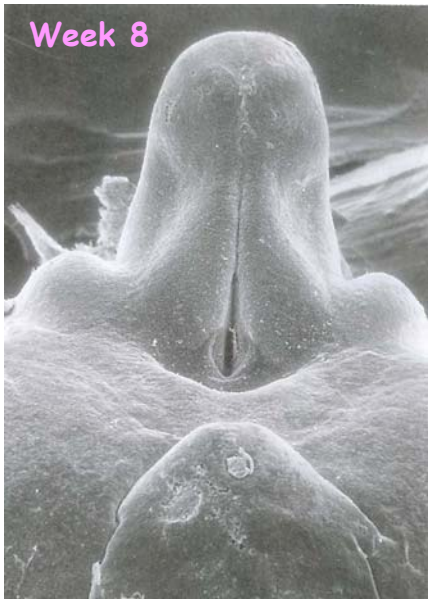
Week 6 to 8



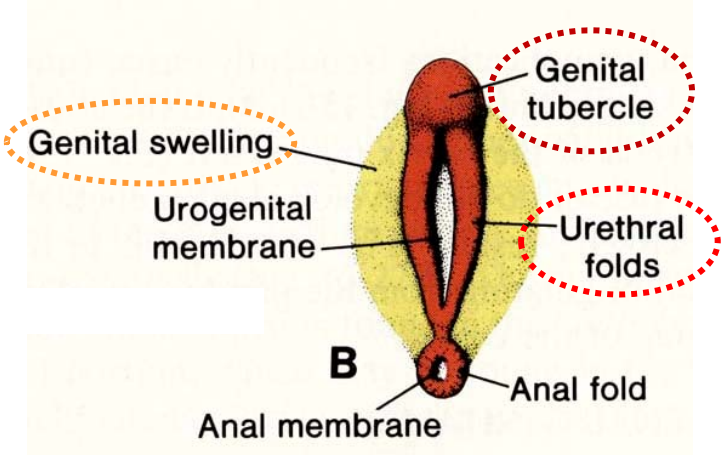
Orificium urogenitale primitivum demarcated by:

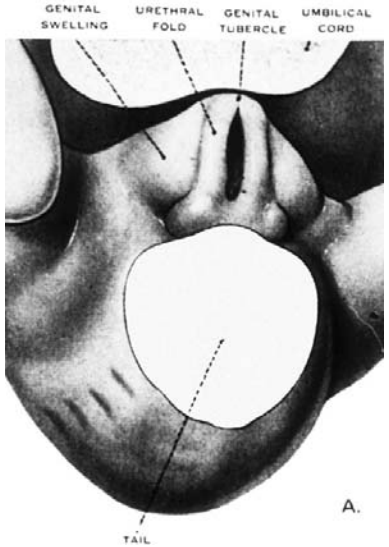
- Genital tubercle – Phallus
- Urethral (genital) folds – Plicae urogenitales
- Genital swellings – Tori genitales





Genital system – External genitalia - Dimorphism





Week 9 to 13

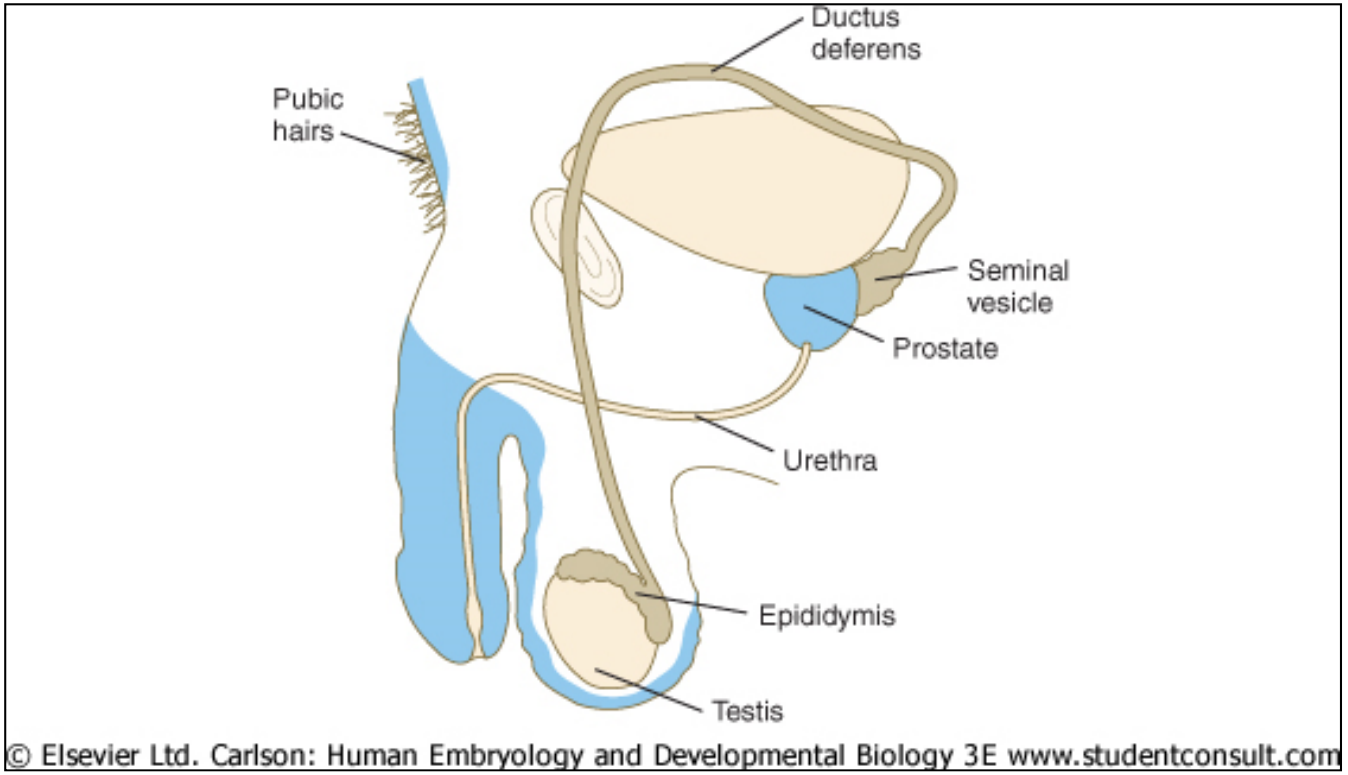
Weeks 12 + 13 are particularly critical
=
fusing of urethral folds

MALE		FEMALE
Penis	Genital tubercle	Clitoris
Urethra	Genital (urethral) folds	Labia minora
Scrotum	Genital swellings	Labia majora

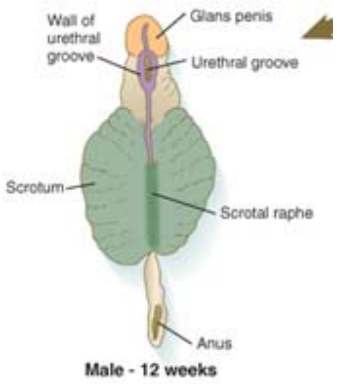
Genital system – External genitalia - Male

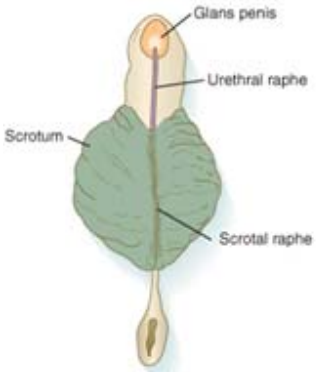
Influenced by dihydrotestosterone

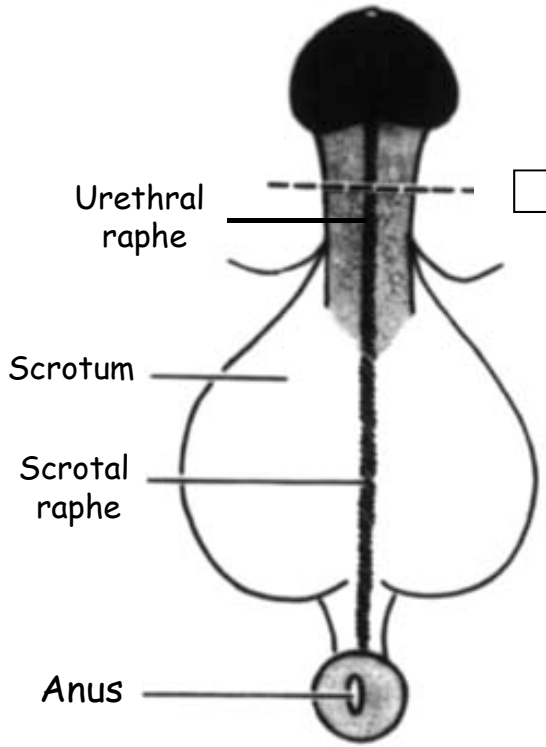
Influenced by testosterone

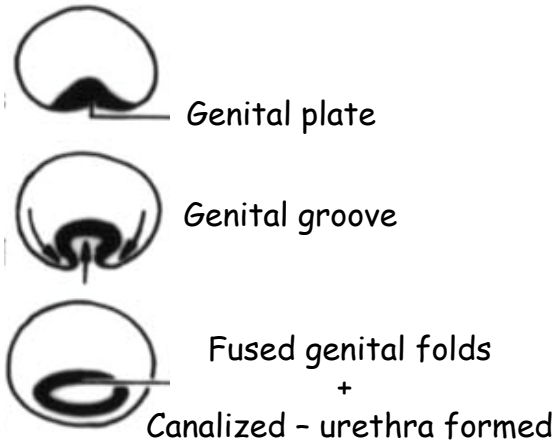


Genital system – External genitalia - Male









Genital tubercle elongates – penis (phallus)

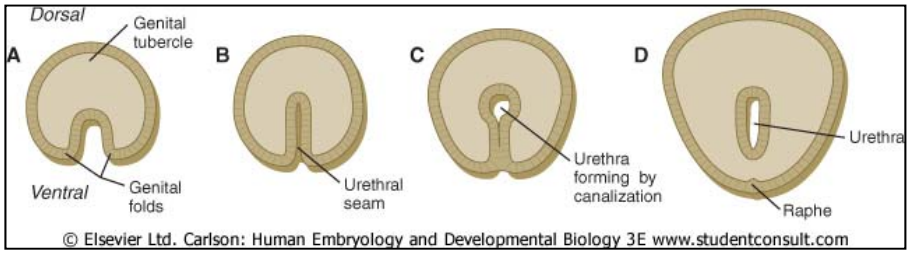
Genital swellings enlarge – scrotum

Genital folds form the lateral walls of the urethral groove

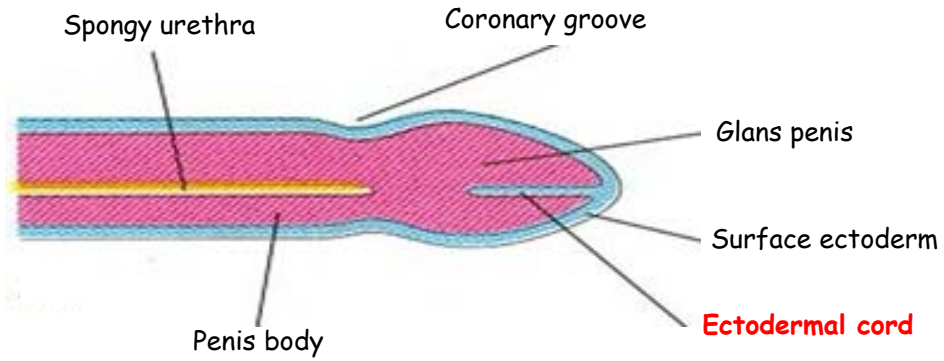
Genital folds form the spongy urethra

Ventral epithelium of genital folds – urethra proper

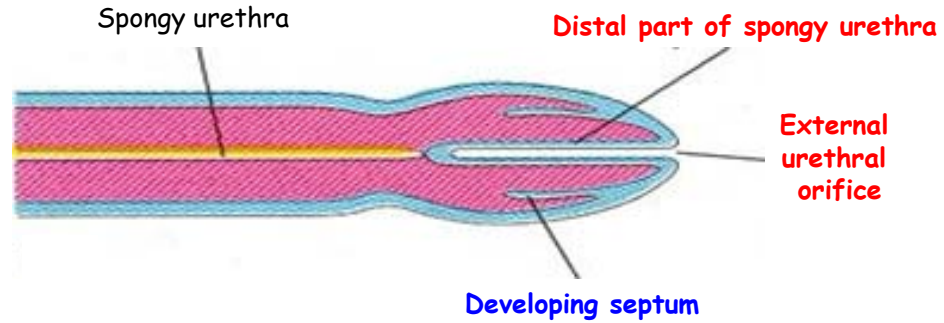
Corpora cavernosa develop from mesenchyme



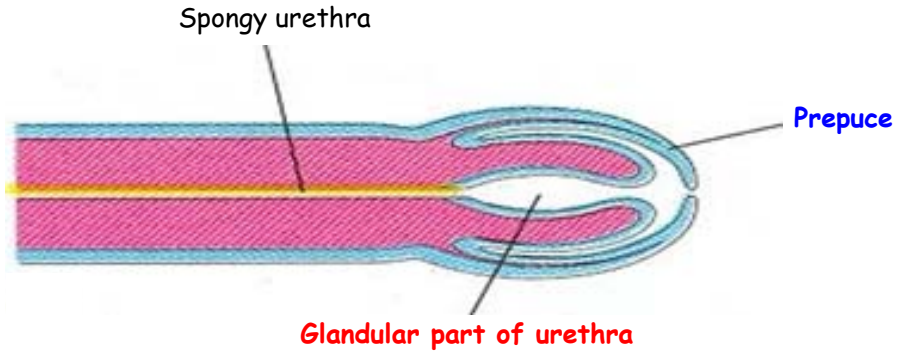
Genital system – External genitalia – Urethral orifice



- ectodermal ingrowth forms a cellular ectodermal cord

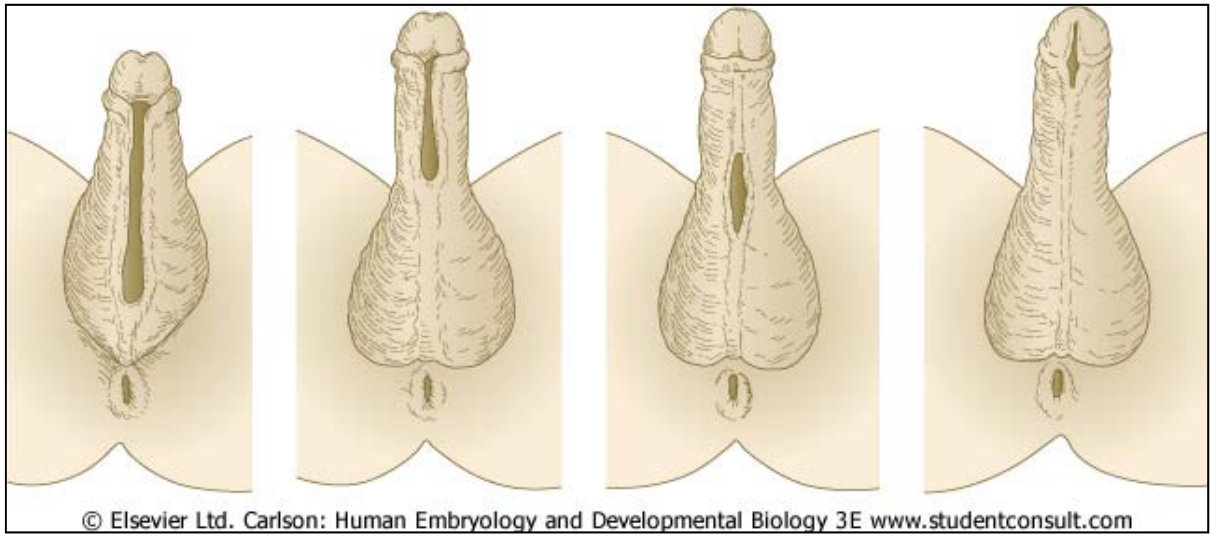


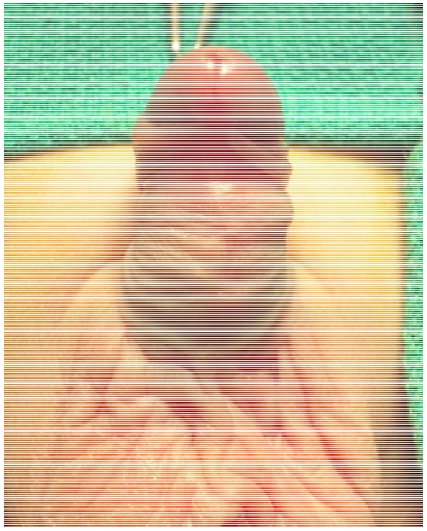
- the cord grows towards the root of the penis to meet the spongy urethra
- the cord canalizes
- circular ingrowth of ectoderm occurs at the periphery of the glans penis (week 12)



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

Genital system – External genitalia – Male hypospadia





Normal midline raphe

Raphe off center

Thank you for your attention !

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