

Urinary system
Systema urinarium

Excretory system

David Kachlík

Overview of urinary excretory system

Upper urinary system

- Kidney (*Ren*)
 - Nephron
 - Collecting ducts (*Ductus colligentes*)
 - Major and minor renal calices (*Calices renales majores et minores*)
 - Renal pelvis (*Pelvis renalis*)
- Ureter

Lower urinary system

- Urinary bladder (*Vesica urinaria*)
- Urethra

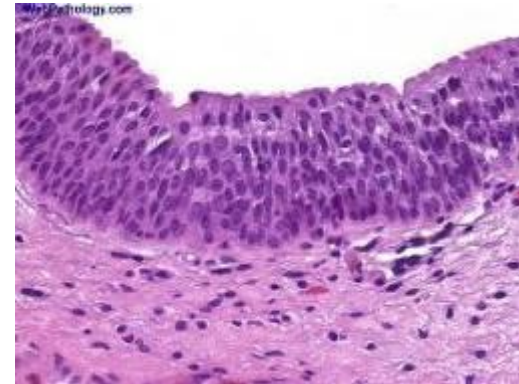
Excretory system

general structure

- mucosa (*tunica mucosa*)
 - transitional epithelium = urothelium (*epithelium transitionale; urothelium*)
 - exception: terminal part of urethra
 - lamina propria mucosae
- muscular layer (*tunica muscularis*) – smooth
 - inner longitudinal (*stratum internum longitudinale*)
 - outer circular (*stratum externum circulare*)
 - exception: urinary bladder has 3 layers
- adventitia (*tunica adventitia*)
 - exception: serosa on upper surface of urinary bladder

Transitional epithelium = Urothelium (*Epithelium transitionale* = Urothelium)

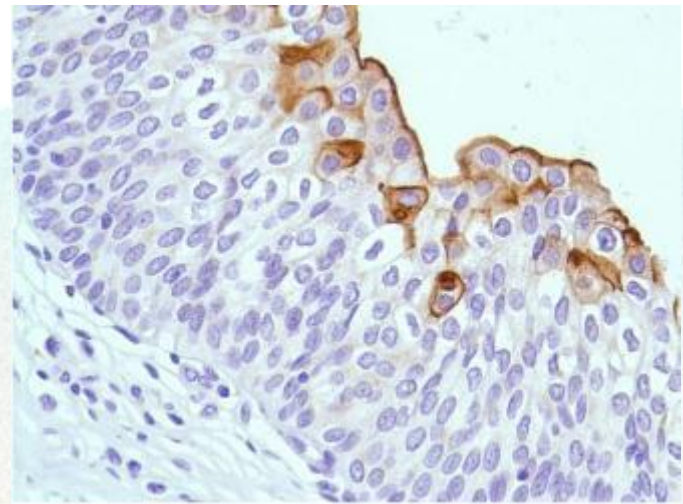
- renal calices and pelvis, ureter, urinary bladder, proximal part of urethra
- pseudostratified epithelium
 - **changing height and shape of cells**
 - depending on content
 - empty = 5-7 layers
 - full = 3 layers
- cells: basal, intermediate, superficial
 - umbrella cells (*urotheliocytus superficialis*; *umbellocytus*)
 - larger, polyploid, flat on surface, extensible
 - urothelial plaque (*crusta urothelialis*) – glycoproteins (uroplakins)



<http://www.webpathology.com/image.asp?case=49&n=1>

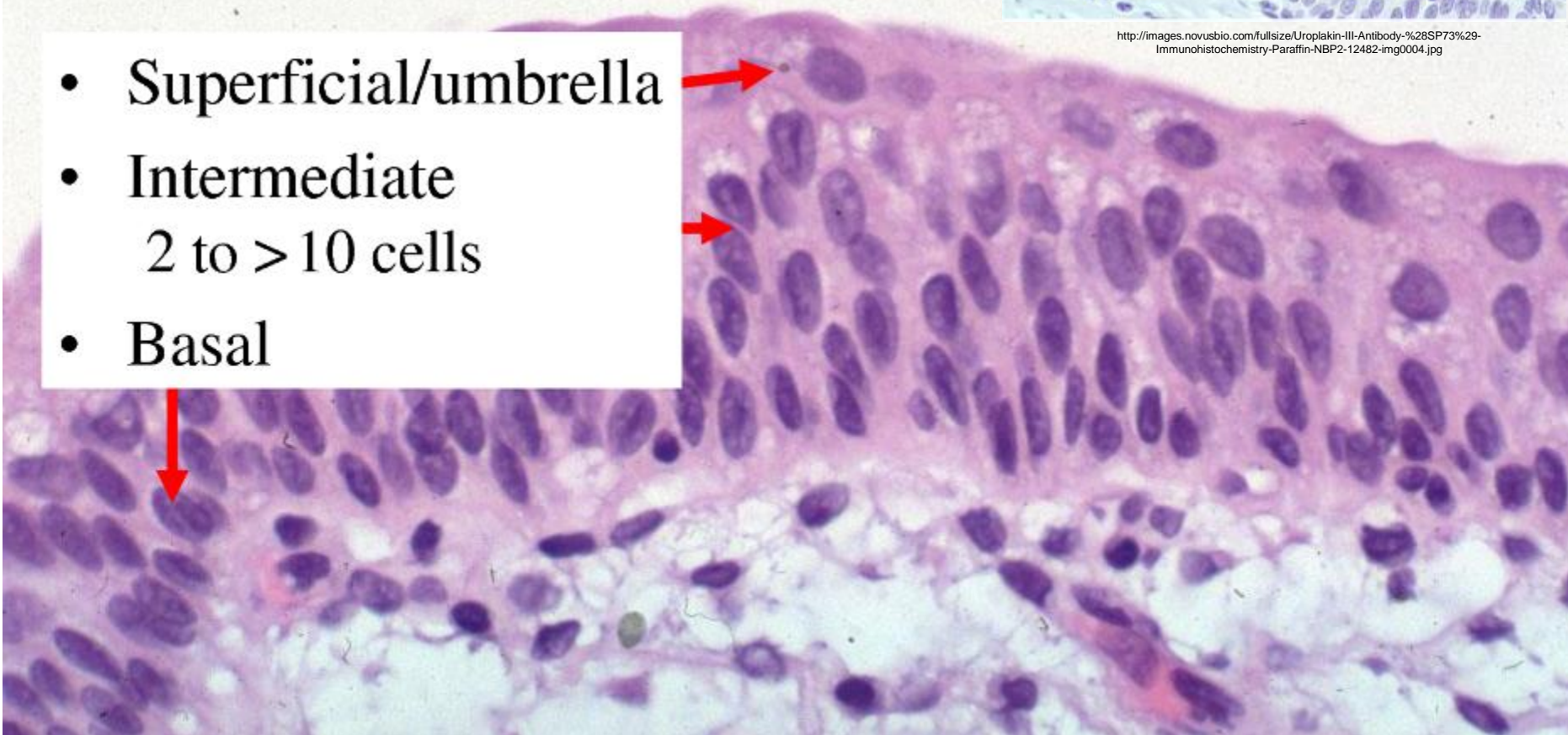
Normal urothelium

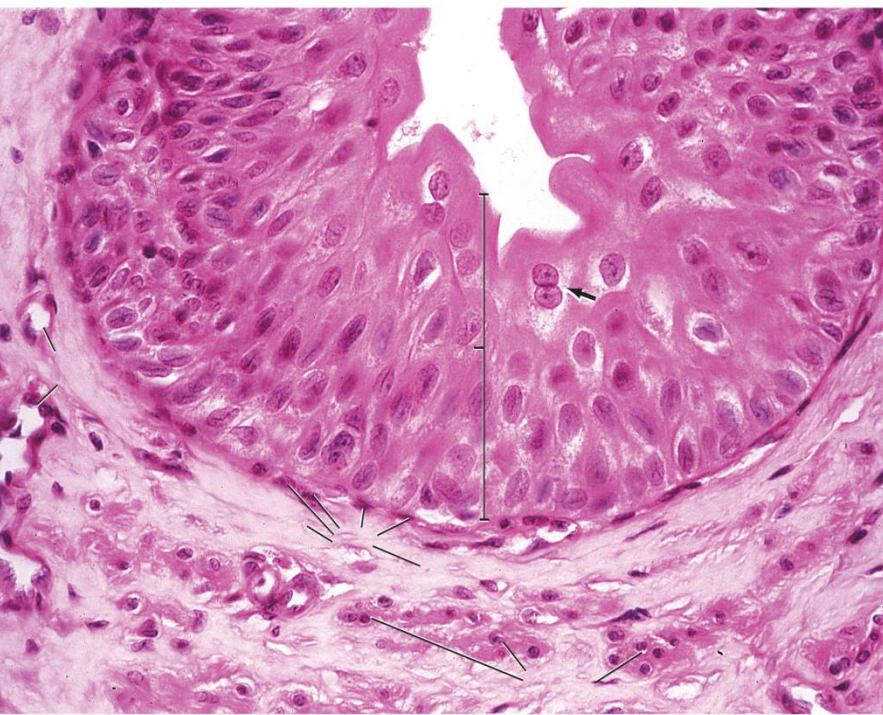
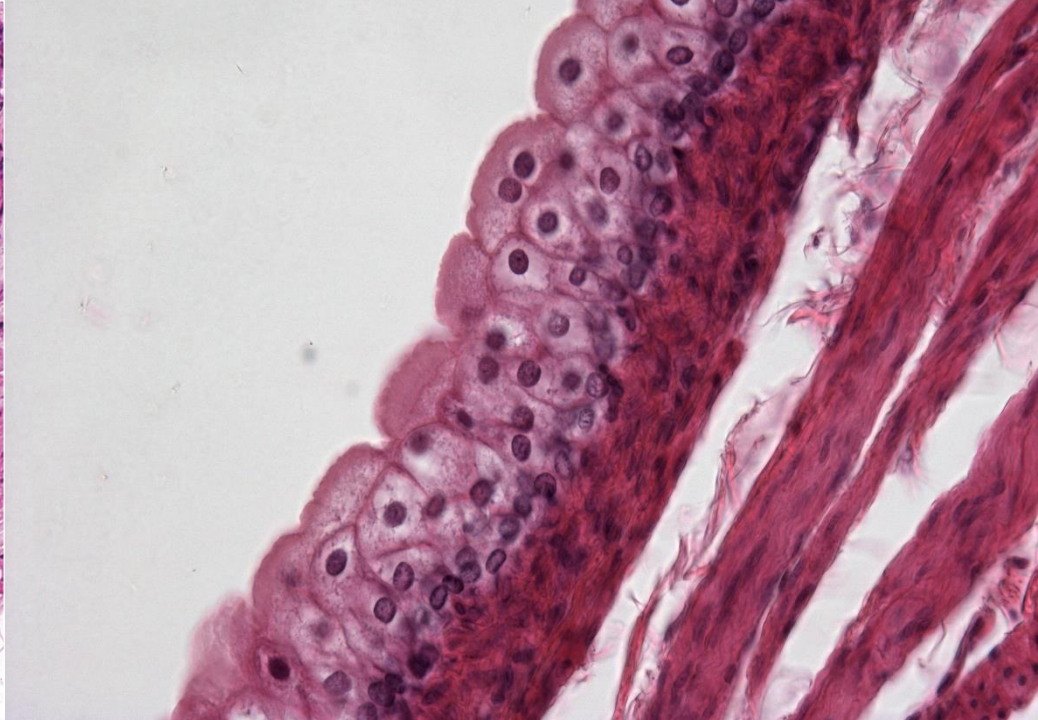
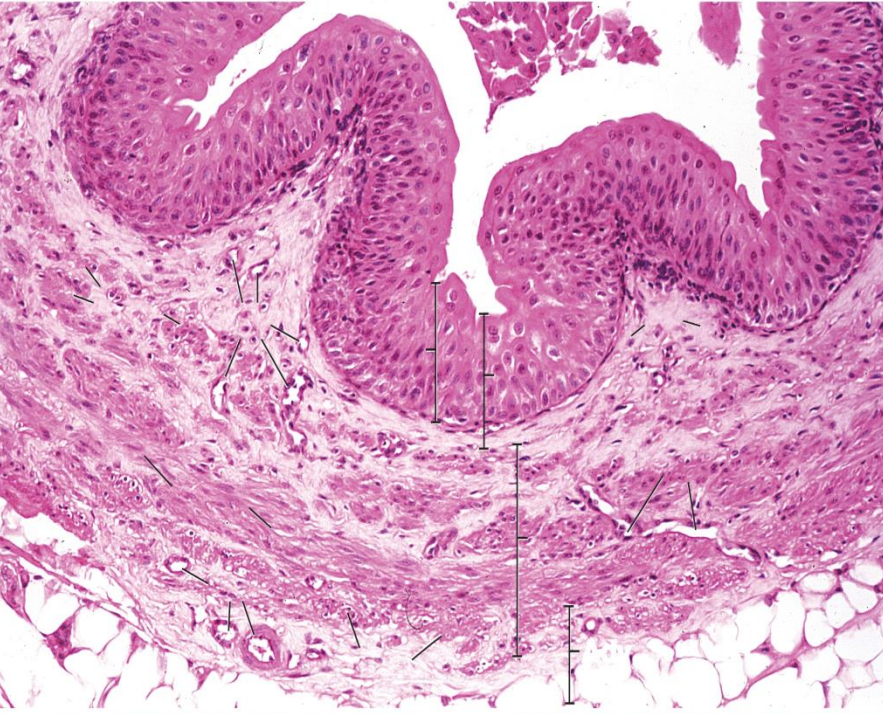
Urothelium = all epithelial cells



<http://images.novusbio.com/fullsize/Uroplakin-III-Antibody-%28SP73%29-Immunohistochemistry-Paraffin-NBP2-12482-img0004.jpg>

- Superficial/umbrella
- Intermediate
2 to > 10 cells
- Basal





Renal pelvis (*Pelvis renalis*, gr. pyelos)

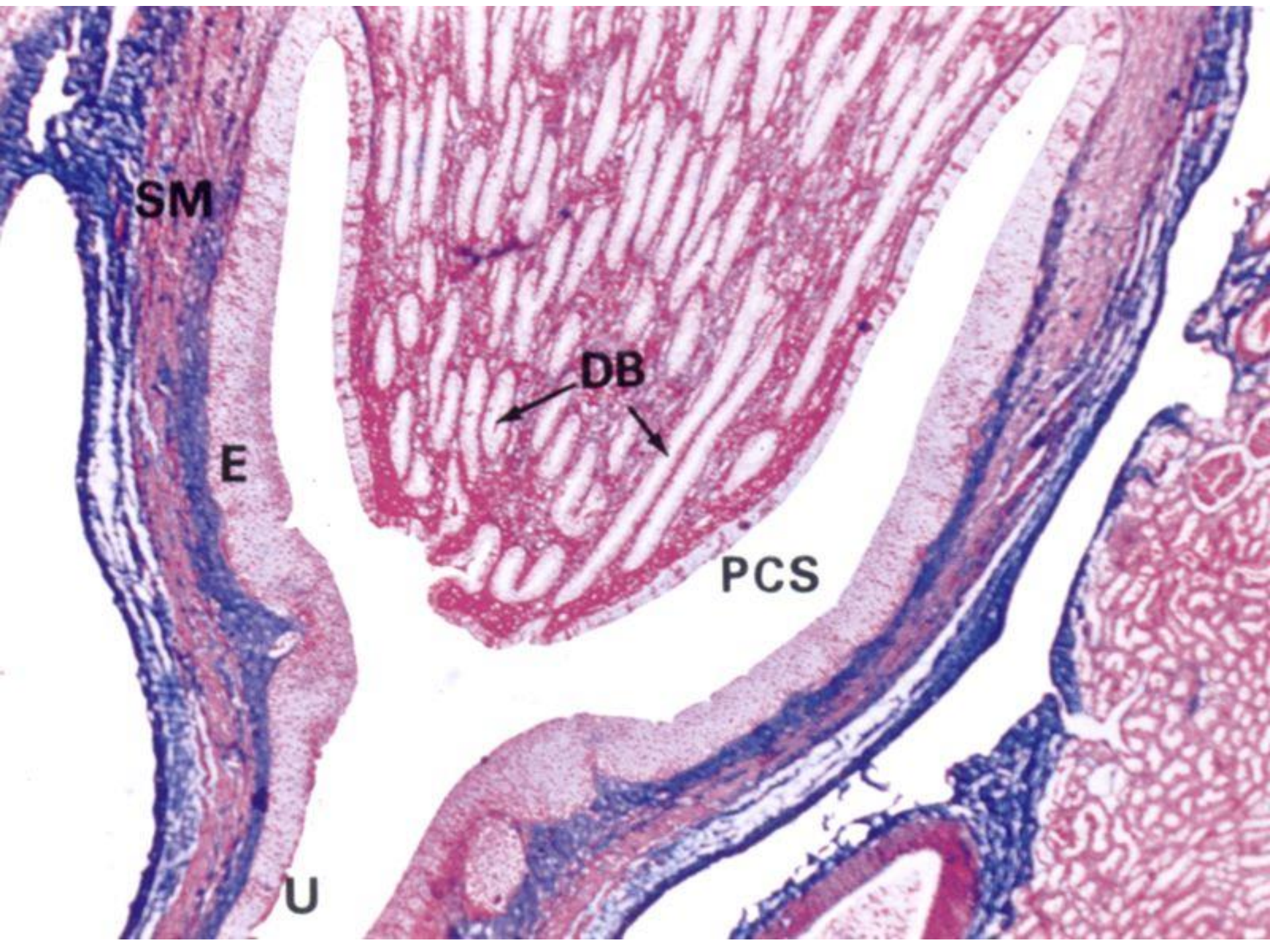
Renal calices (*Calices renales*)

- 7-14 **minor calices** (*calices minores*) around papillae → 2-3 **major calices** (*calices majores*) → **pelvis** → ureter
- ampullar / dendritic type
- 2-3 layers of urothelium
- tunica muscularis – spirally organized cells
 - thicker circular layer around papillae
 - urinary pacemaker cells (*myocyti stimulantés*)
- projection: processus costalis L1
- vessels: branches from a. renalis



PYELOGRAM





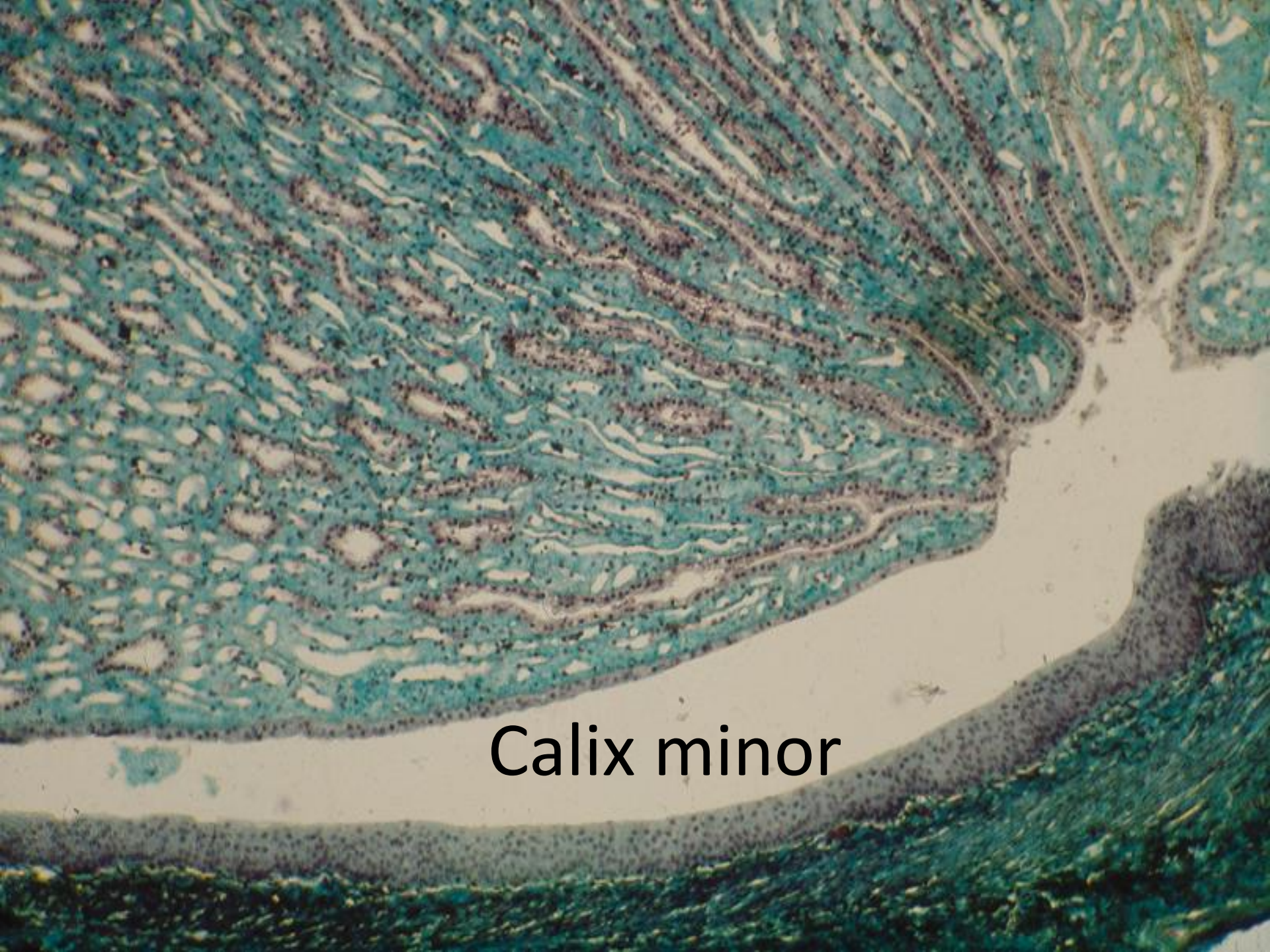
SM

E

DB

PCS

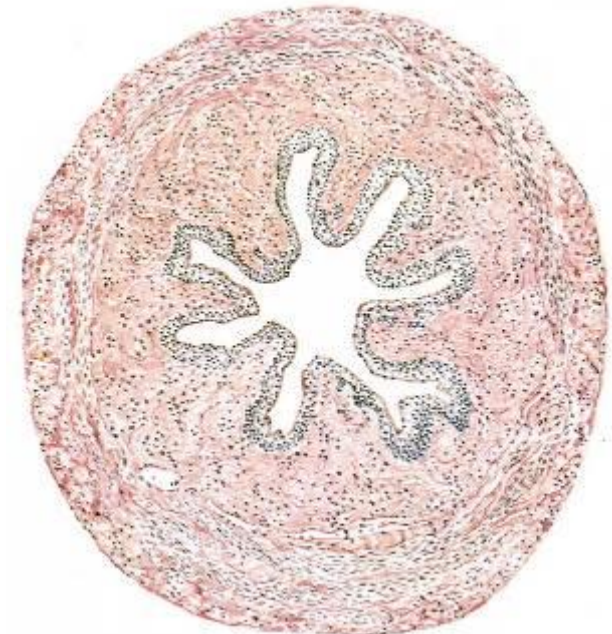
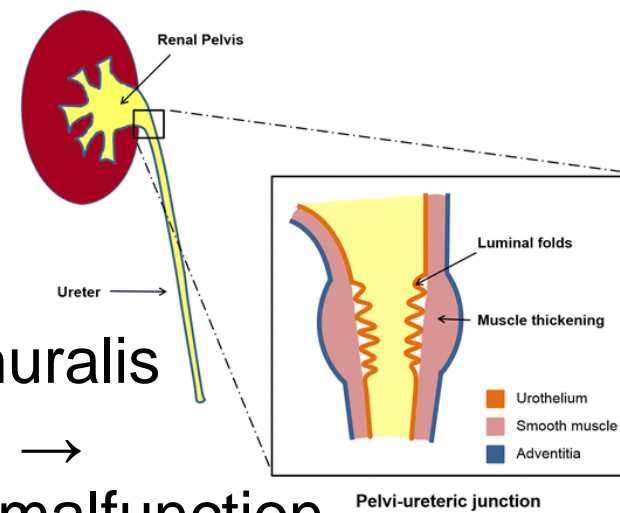
U



Calix minor

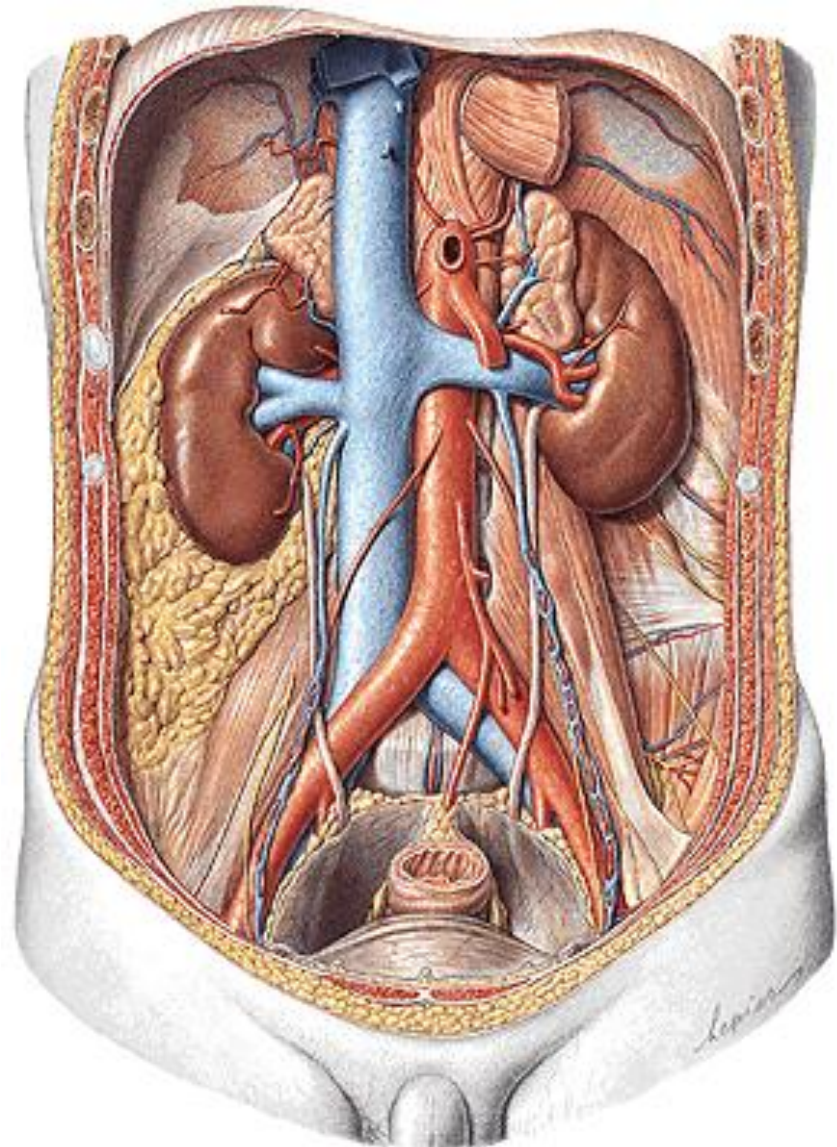
Ureter

- 25-30 cm, width 4-7 mm
- 3 parts: pars abdominalis, pelvica, intramuralis
- 3 narrowings – danger of stone blockage → obstruction → hydronephrosis → kidney malfunction
 - at the exit from pelvis
 - at the crossing of vasa iliaca communia (left) / externa (right)
 - when entering the urinary bladder (pars intramuralis)
- folded mucosa → starshape lumen
 - lamina propria contains soft tissue
- *Waldeyer's* ureteric sheath
- retroperitoneal organ
 - adventitia contains adipose tissue
- peristaltic transport of urine to bladder
- crosses many structures



Ureter – syntopy

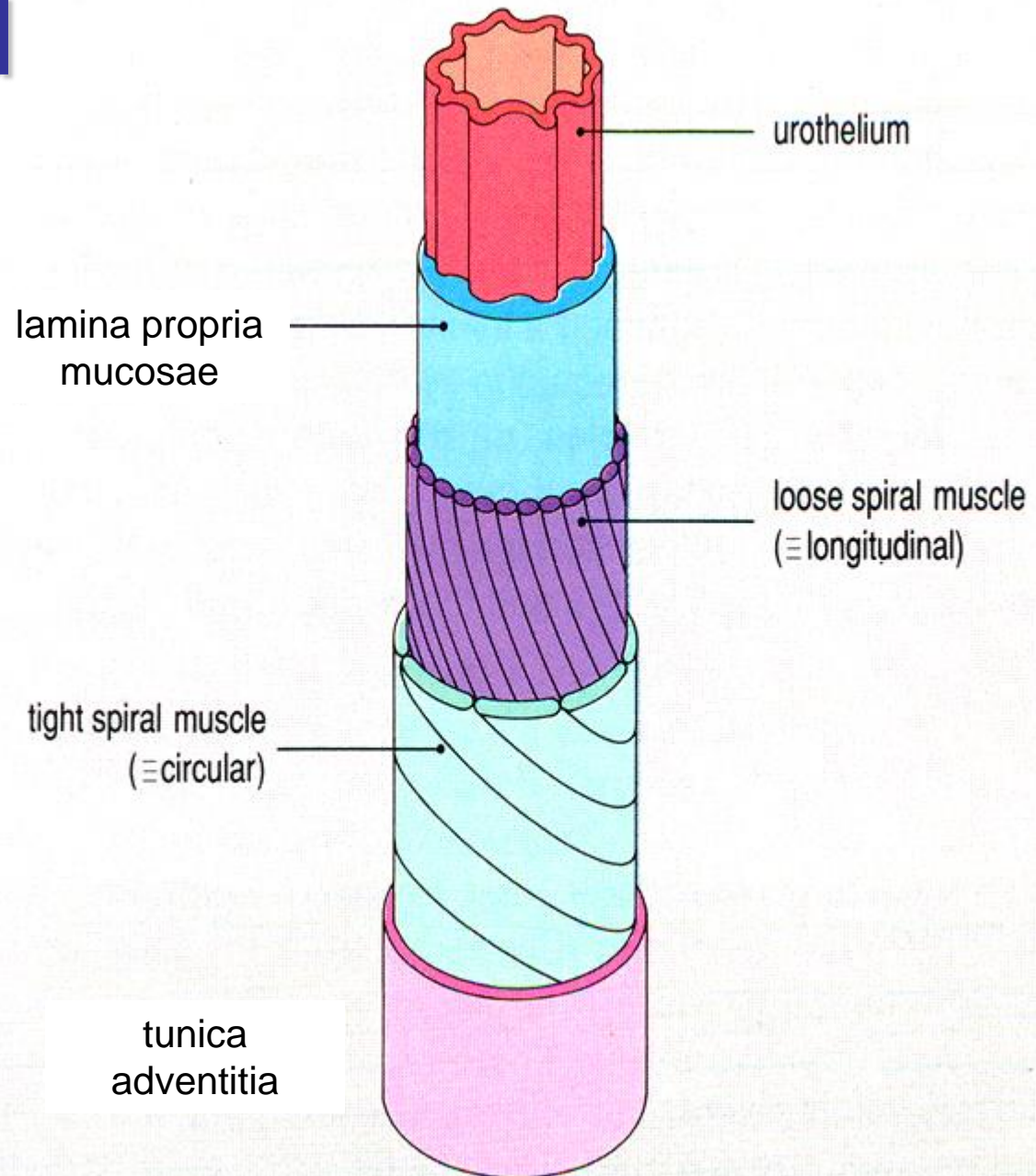
- retroperitoneal organ
- *origin*: dorsally to vasa renalia
- *dorsally* to vasa testicularia♂ / ovarica♀
- *ventrally* to m. psoas major and n. genitofemoralis
- *ventrally* to vasa iliaca communia sinistra / externa dextra
- *dorsally* to urinary bladder
- *dorsally* to ductus deferens♂ / a. uterina♀



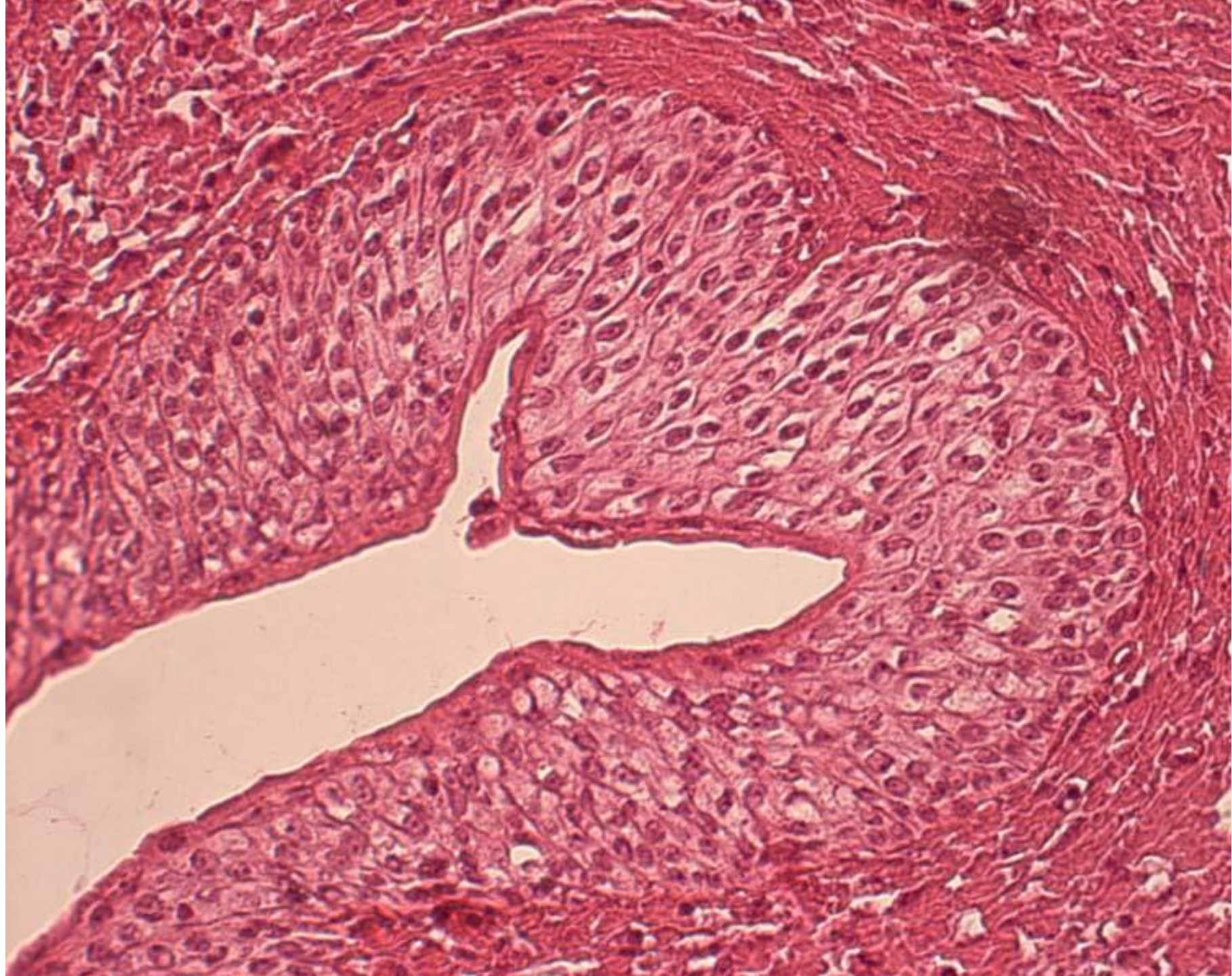
Ureter – *supply*

- arteries: a. renalis, aorta abdominalis, a. testicularis/ovarica, a. ductus deferentis / uterina, a. vesicalis inf. → **rr. ureterici**
- veins correspond to arteries
- lymph: n.l. lumbales (aortici lat.), n.l. iliaci int.+ ext.+ communes
- nerves: n.X + truncus sympathicus
 - plexus renalis, aorticus abdominalis, hypogastricus sup.+ inf. → plexus uretericus

Močovod (ureter)









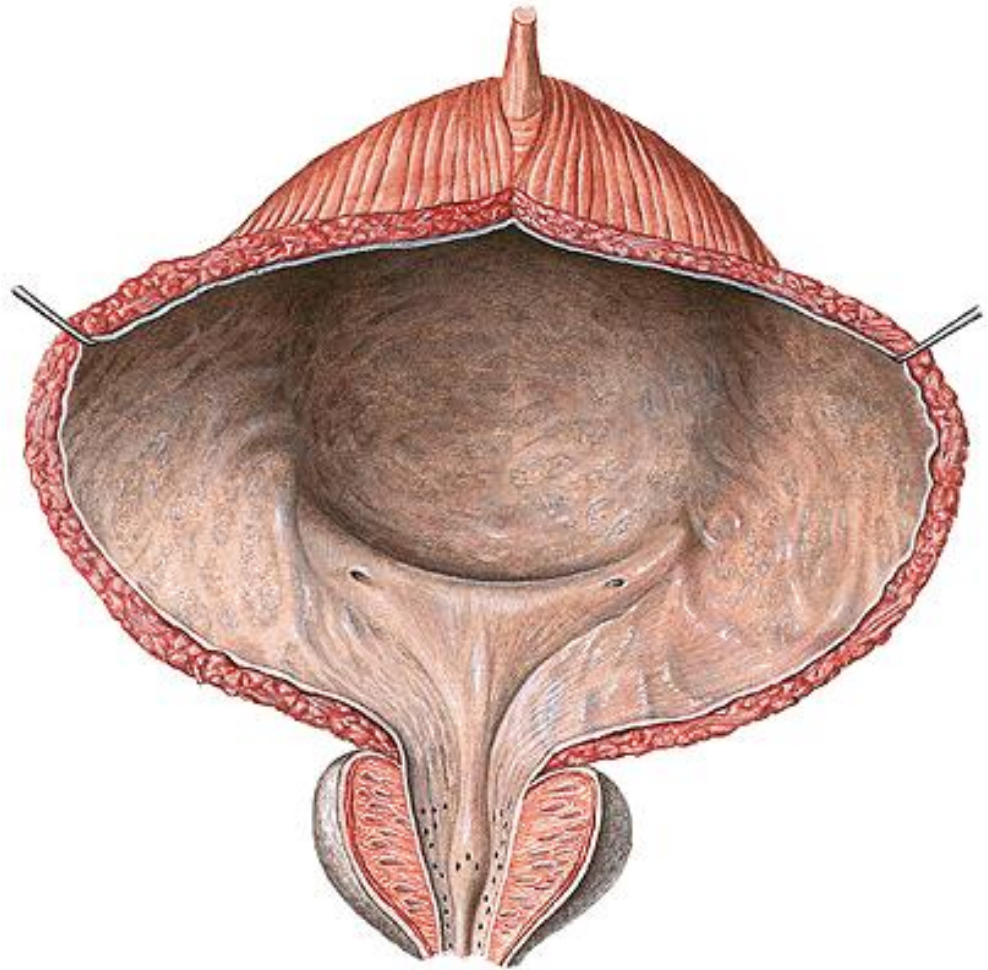
Transplantation of kidney

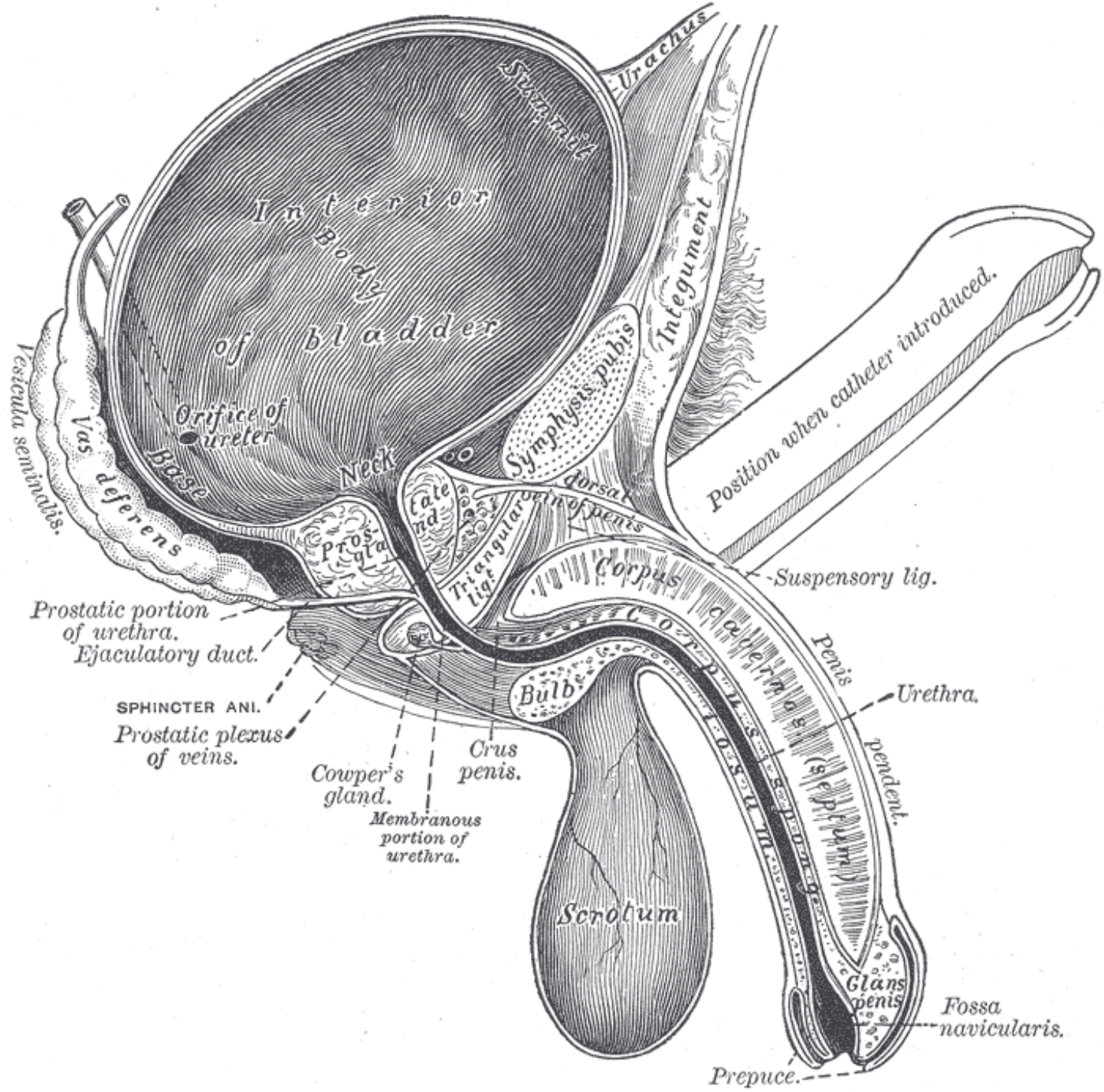
- since the end of 50th
- 5-year graft survival – 70%
- necessary to transfer the kidney including the proximal part of ureter and its vessels (branches of a. renalis)
- placement into fossa iliaca and connection of artery onto a. iliaca externa (*end-to-side*) or onto terminal part of a. iliaca interna (*end-to-end*)
- eventual a. renalis accessoria is connected onto a. epigastrica inferior

Urinary bladder

(*Vesica urinaria*, gr. *Urokystis*)

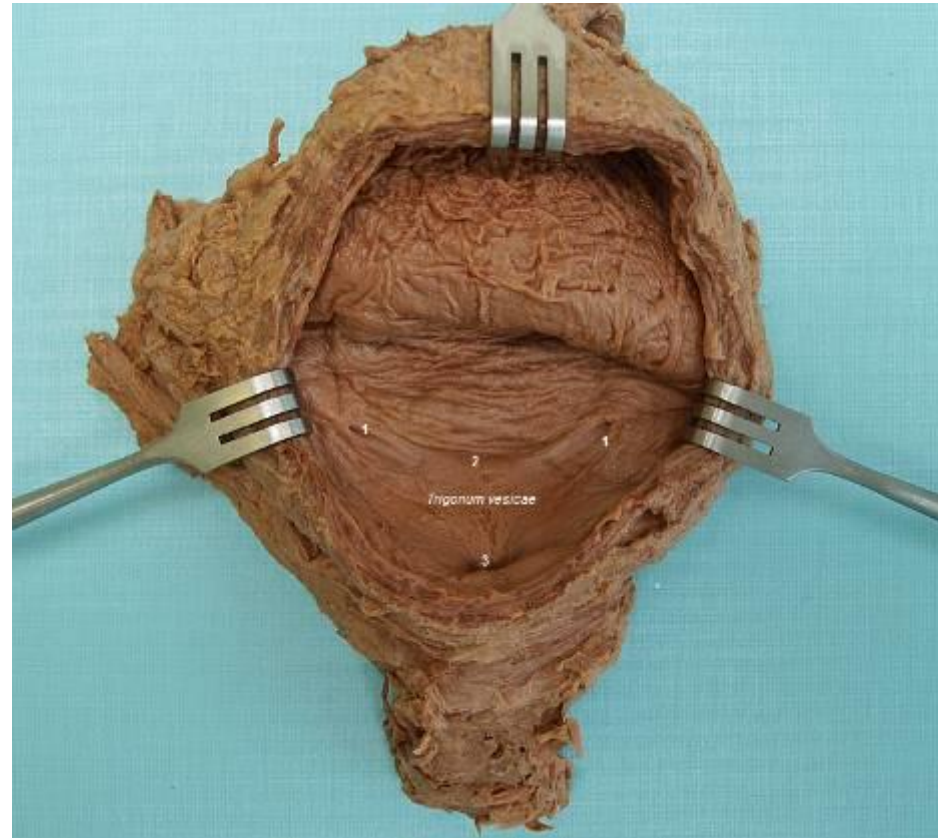
- apex, corpus, fundus, cervix, *uvula*, (*vertex*)
- trigonum vesicae
- muscles: smooth
 - m. detrusor (*parasympathetic*)
 - m. trigoni vesicae
 - ♂ m. sphincter vesicae (*sympathetic*)
- projection: behind symphysis pubica
 - in children above





Trigonum vesicae *Lieutaudi*

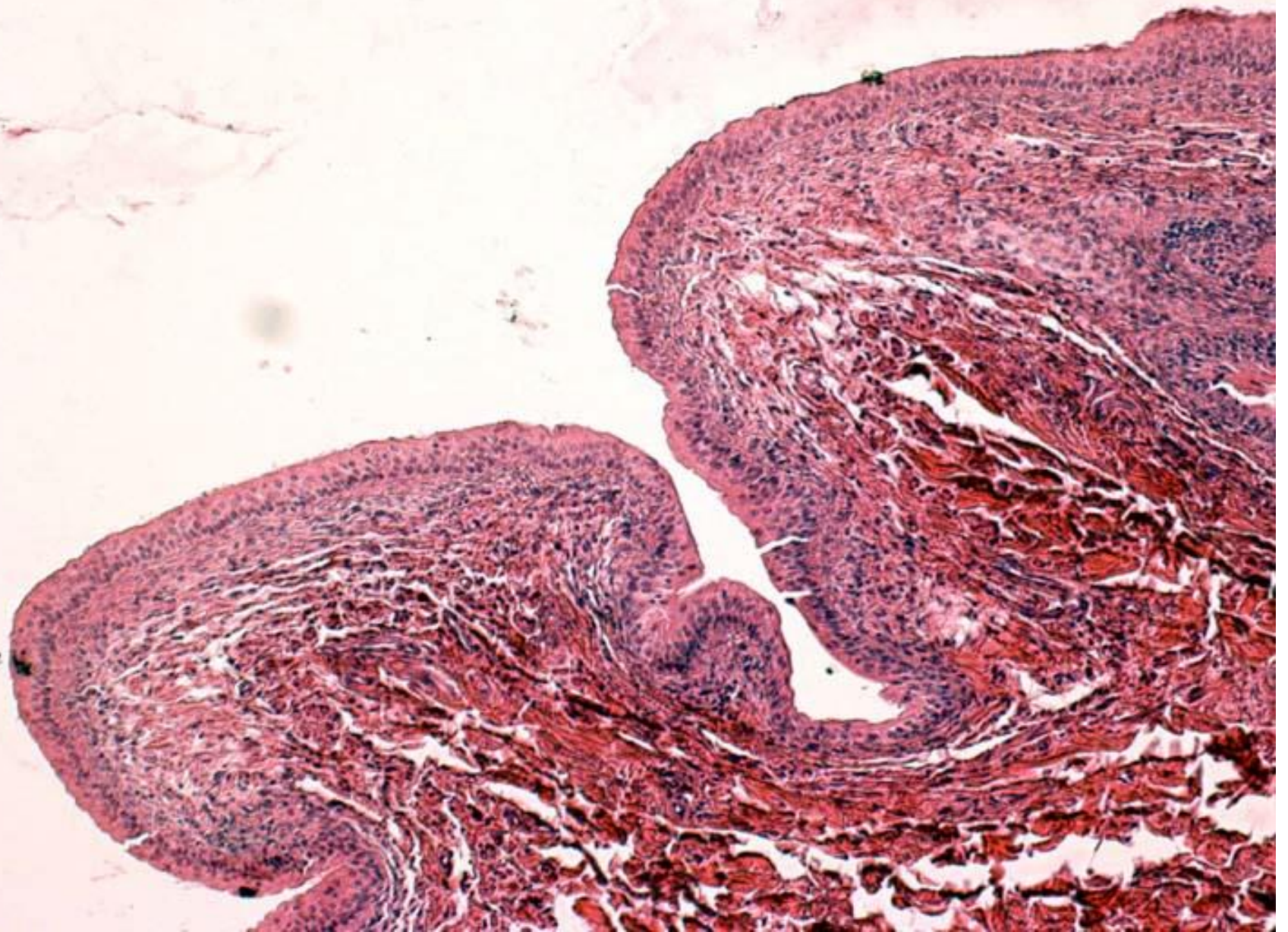
- ostia ureterum (2)
- ostium urethrae internum
- cranially: plica interureterica *Mercieri*
 - fossa retrotrigonalis
- laterocaudally: Bell's fibers
- *no folds*
- *its underlay derived from Wolffian duct*



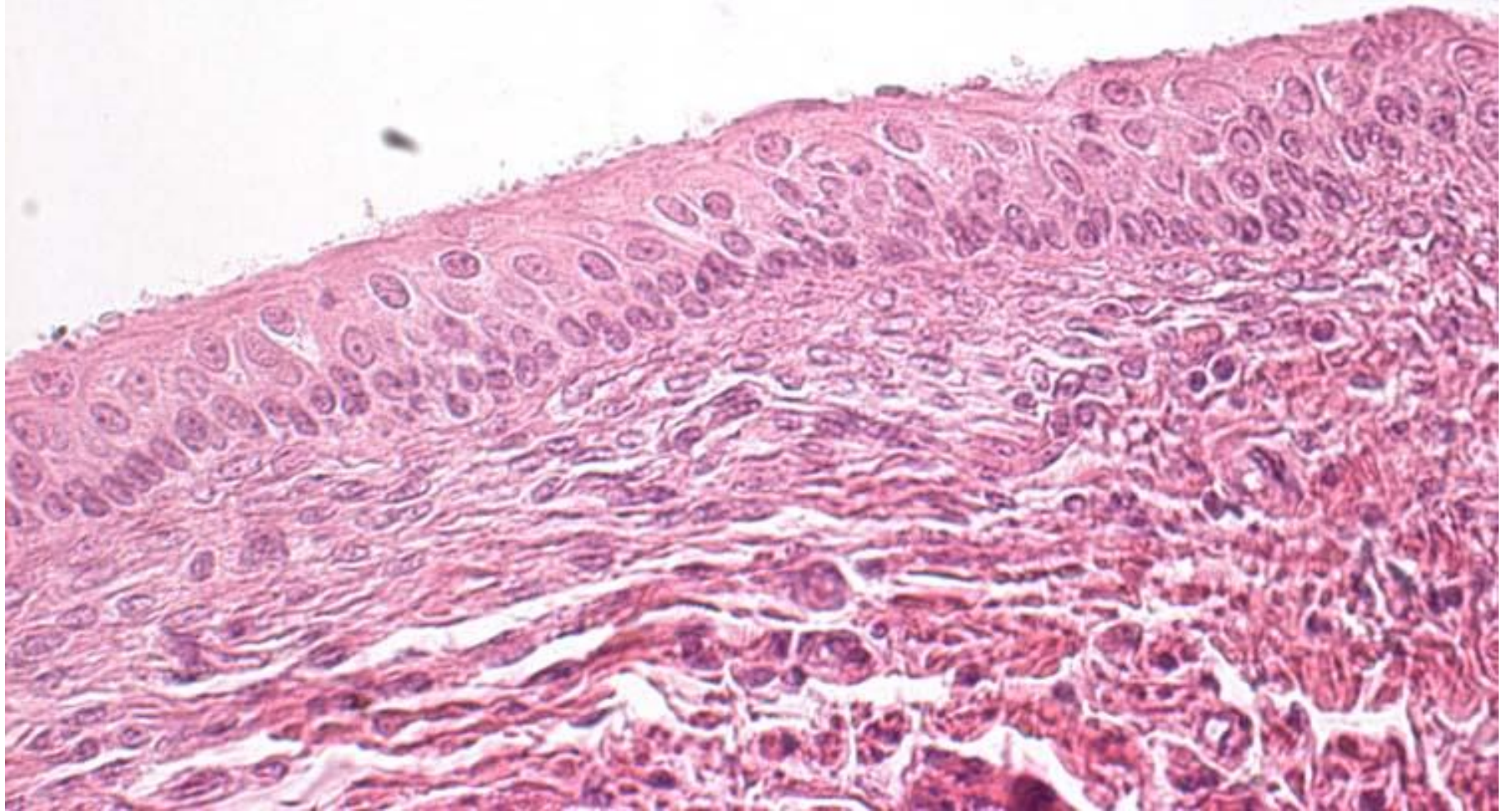
Urinary bladder – *structure*

- folded mucosa except for trigonum vesicae
- plica ureterica runs laterally from the ostium ureteris
- smooth tunica muscularis forms 3 irregular layers:
 - inner plexiform (till longitudinal)
 - middle circular (→ m. sphincter vesicae only in males !)
 - external longitudinal
- tunica serosa (= peritoneum) covers:
 - upper part of urinary bladder in females (excavatio vesicouterina)
 - upper and posterior surface in male (excavatio rectovesicalis)

Urinary bladder – HE

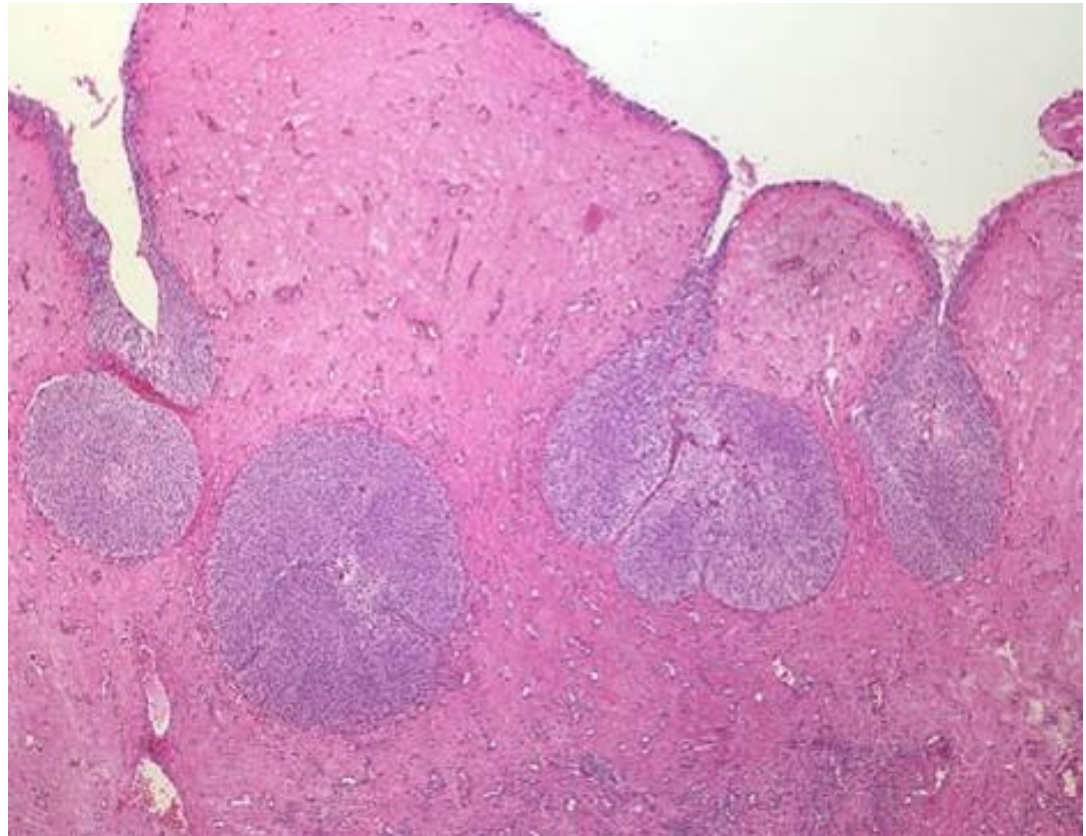


Urinary bladder – HE



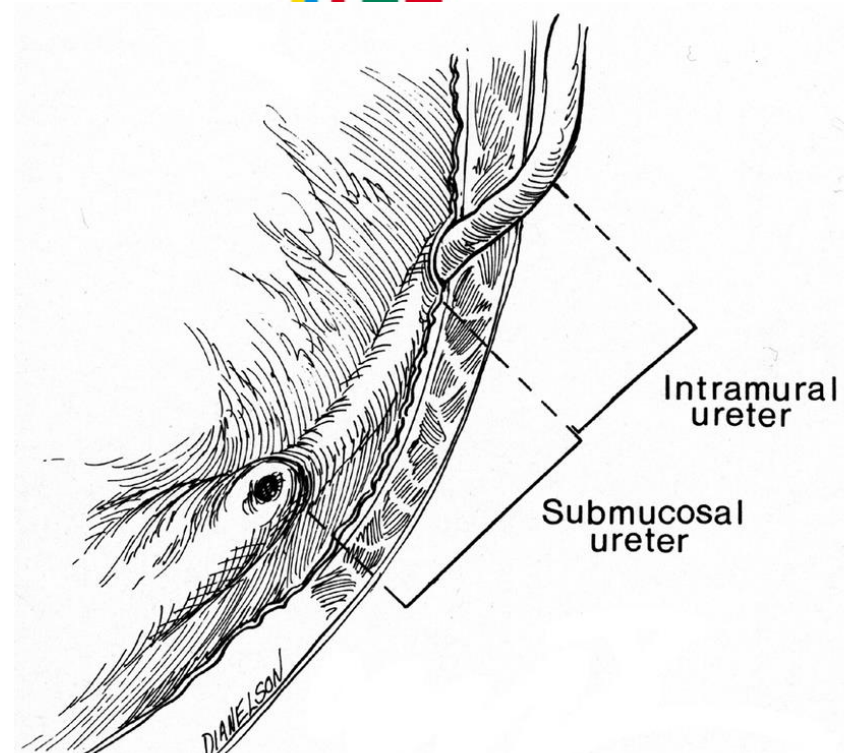
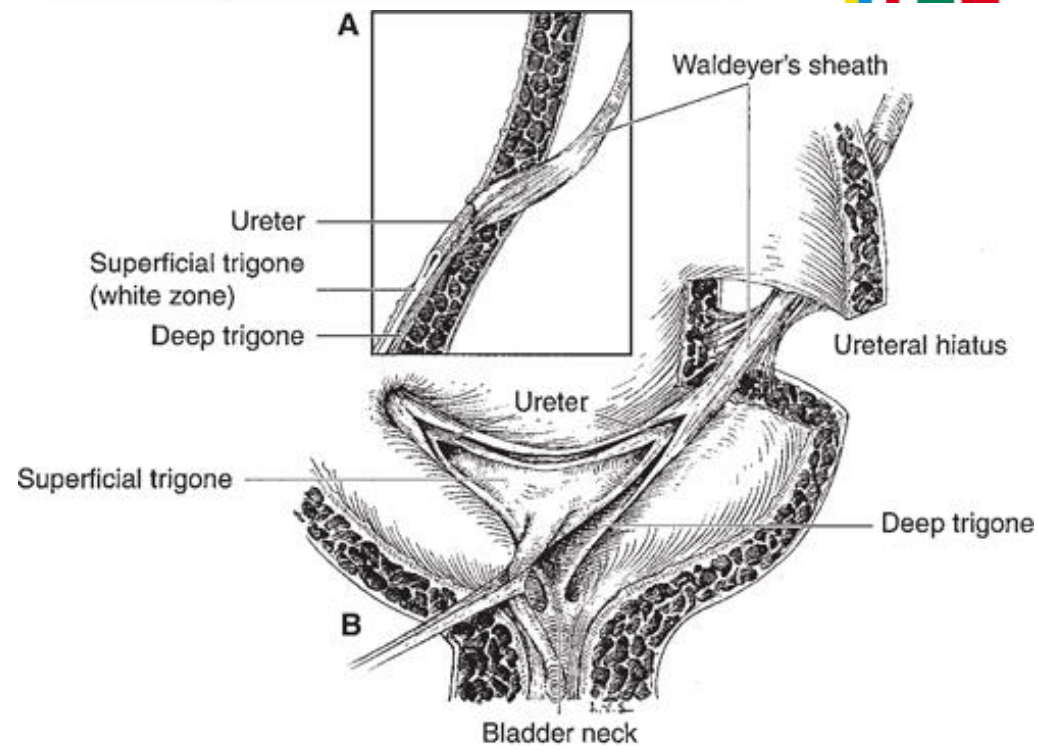
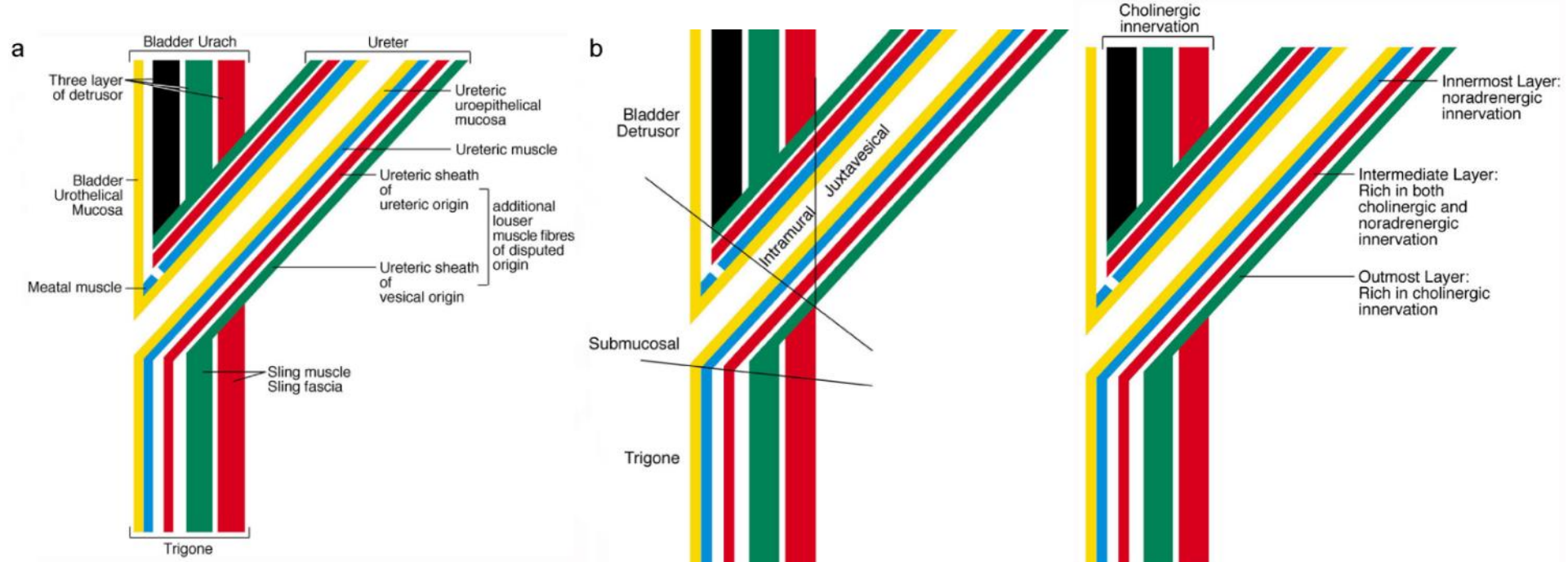
Von Brunn's nests

- groups of proliferating cells of urothelium in lamina propria mucosae of urinary bladder
- benign reactive changes present in 85-90%
- connection with surface epithelium may not be preserved

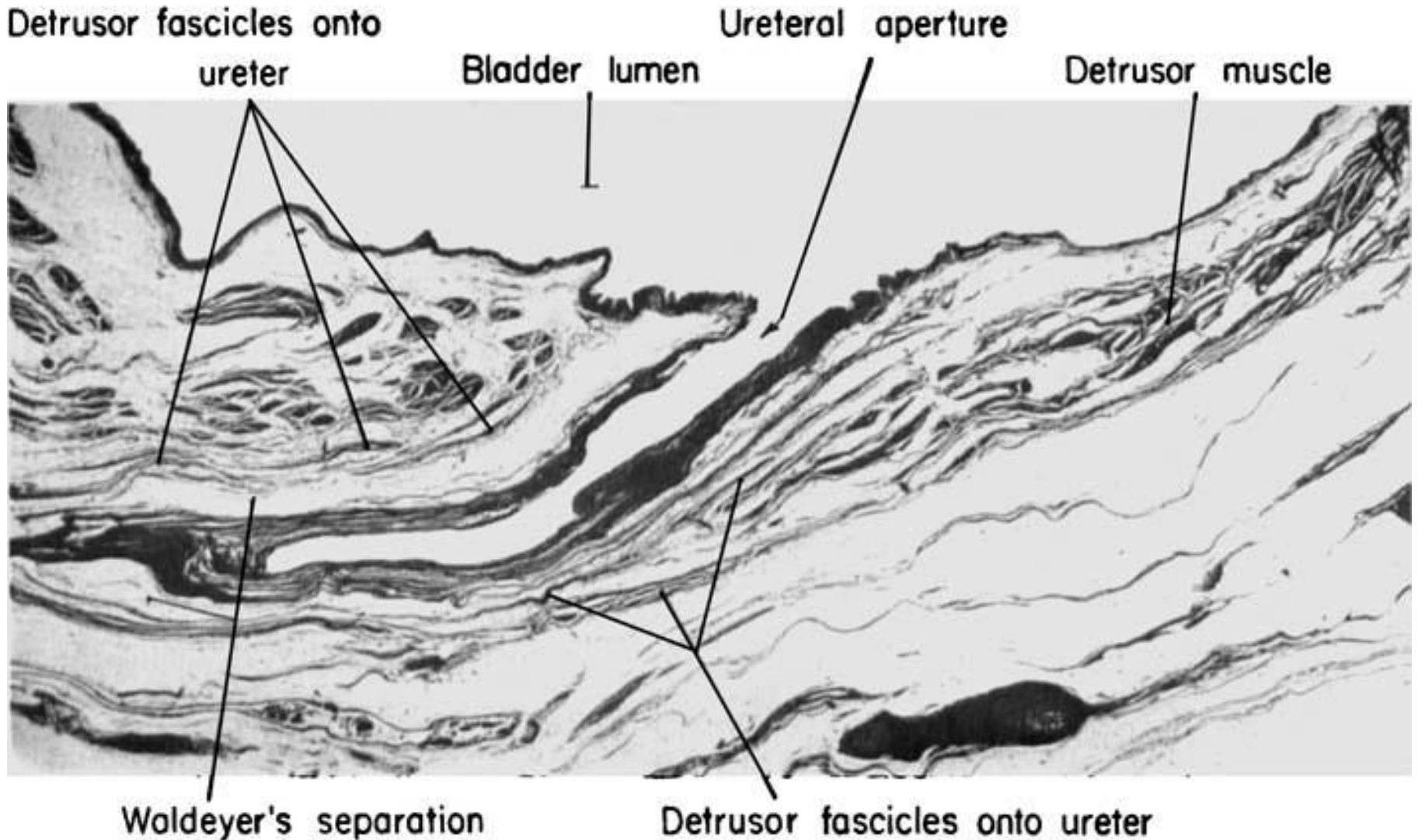


Notes for histology lovers 😊

- glandulae mucosae
 - not constant
 - simple or branched
 - mucinous
 - close to the ostia ureterum and ostium urethrae internum
- scattered cells of DNES
- MALT (mucosa-associated lymphoid tissue)



Waldeyer's ureteric sheath



Fixation of urinary bladder

ligaments + smooth muscles from surrounding structures

- ligamentum umbilicale medianum (chorda urachi)

– fascia vesicoumbilicalis *Delbeti*

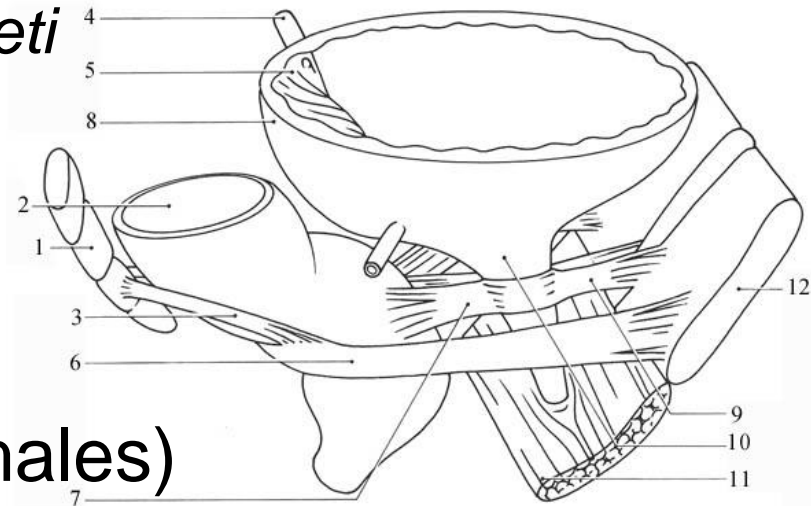
- ligg. et m. rectovesicalis

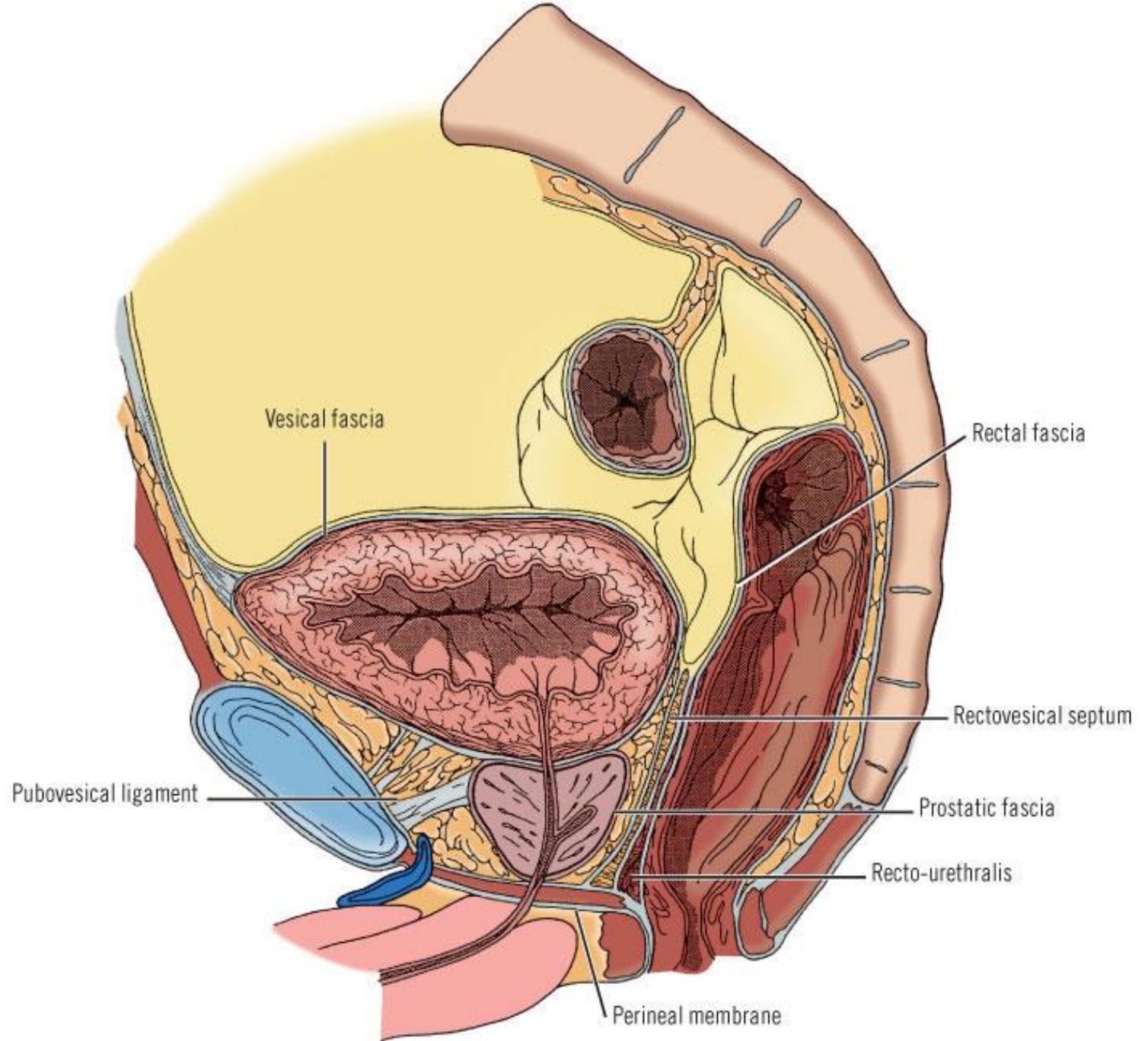
- ligg. et m. pubovesicalis

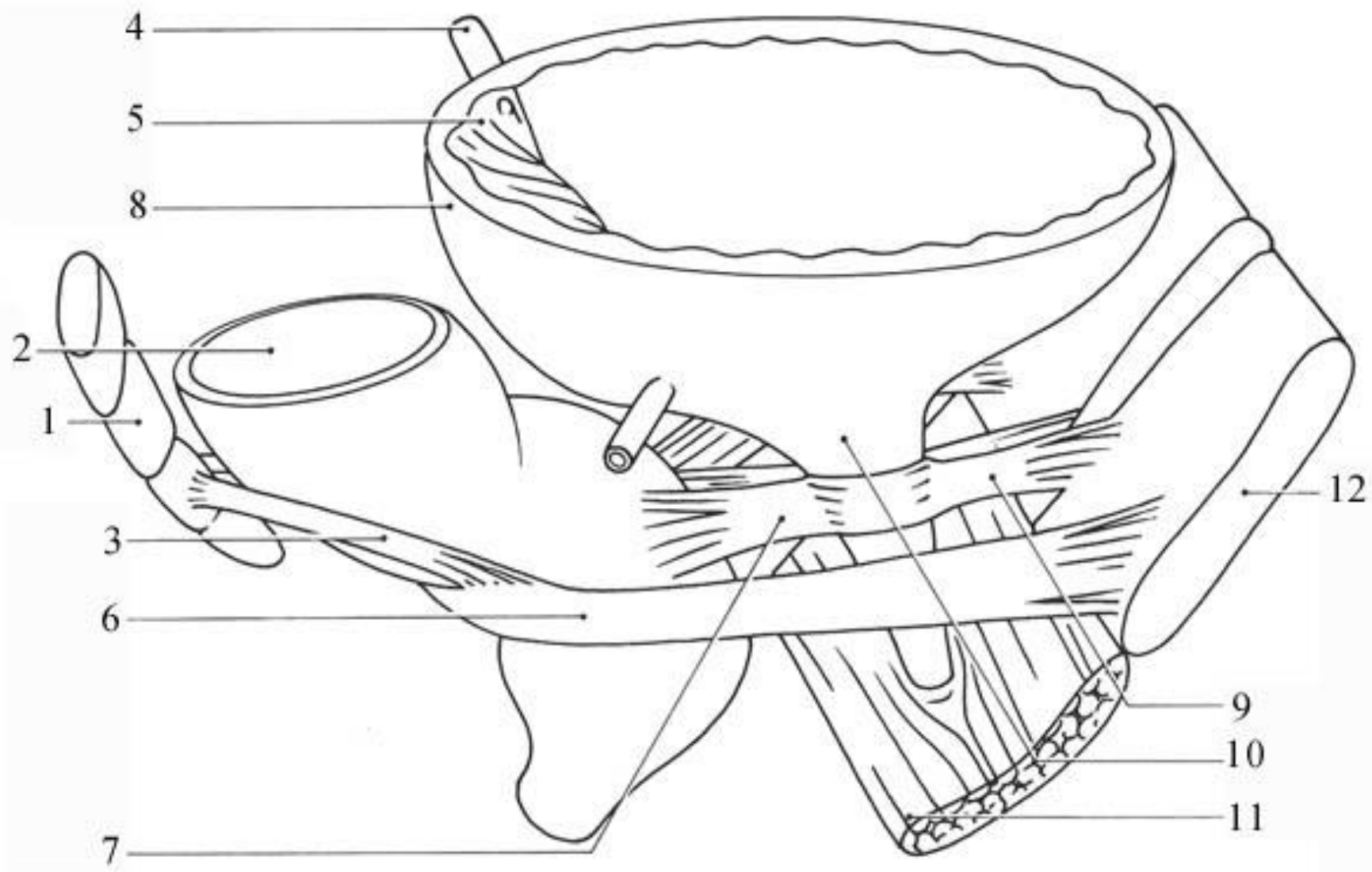
- m. rectourethralis (only in males)

- ligg. vesicouterina (only in females)

- ligg. et m. puboprostaticus (only in males)







Urinary bladder – *blood supply*

- Arteries: a. iliaca int.
 - a. umbilicalis → **aa. vesicales sup.**
 - **a. vesicalis inf.**
 - (→ a. obturatoria, a. glutea inf., a. uterina, a. vaginalis → rr. vesicales)
- Veins: **plexus venosus vesicalis**
(connection to *plexus venosus prostaticus/vaginalis*) → vv. vesicales → v. iliaca int.

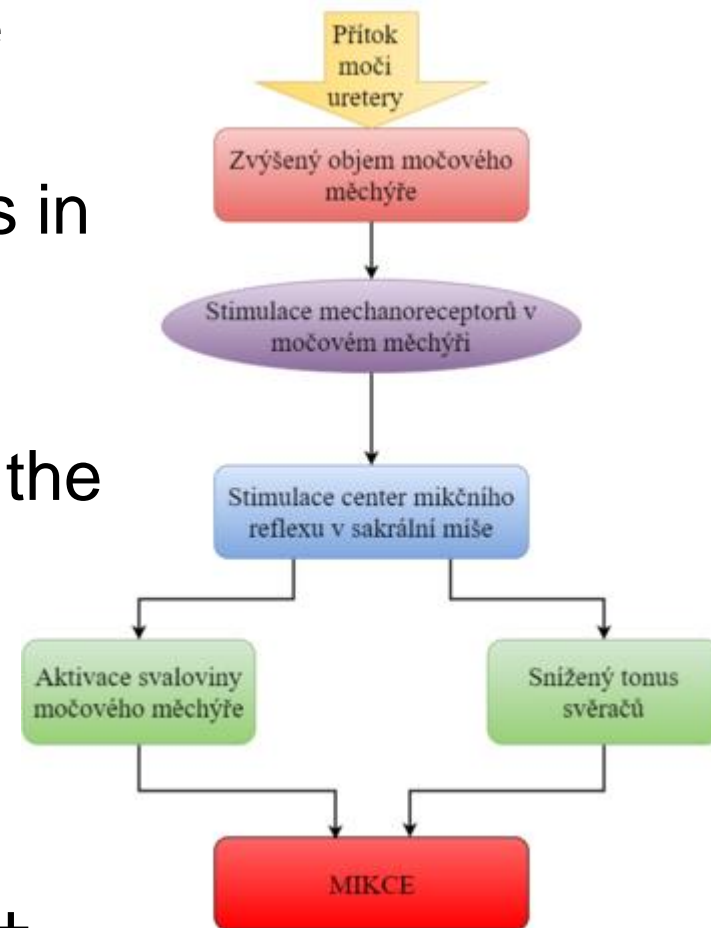
Urinary bladder

lymph and innervation

- Lymph: n.l. paravesicales → nodi **iliaci int.** et **ext.** → nodi iliaci comunes
- Nerves: plexus hypogastricus inf. → **plexus vesicalis** (autonomic + viscerosensory)
 - parasympathetic fibers (segment S2-S4 – Onuf's sacral miction center) → contraction of m. detrusor
 - sympathetic fibers (segment T11-L3) → contraction of m. sphincter vesicae

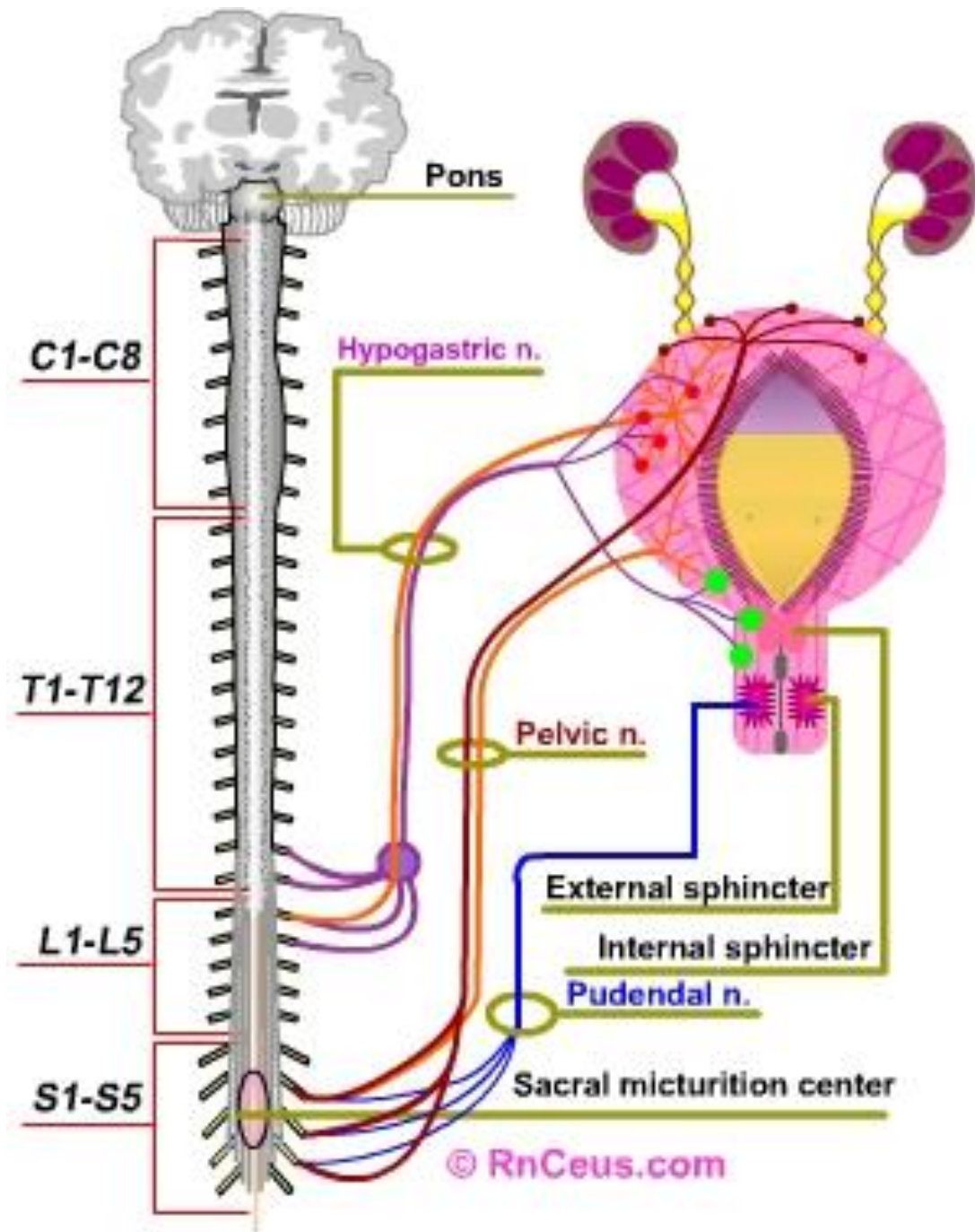
Micturition reflex

- receptor: mechanoreceptors in the wall of urinary bladder
- afferent limb: viscerosensory fibres in plexus hypogastricus inferior
- centre: ncl. nervi pudendi (Onuf's sacral micturition centre) S2-S4 in the spinal cord
- efferent limb: visceromotor parasympathetic fibres in plexus hypogastricus inferior
- effector: m. detrusor (contraction) + m. sphincter urethrae int. (relaxation)

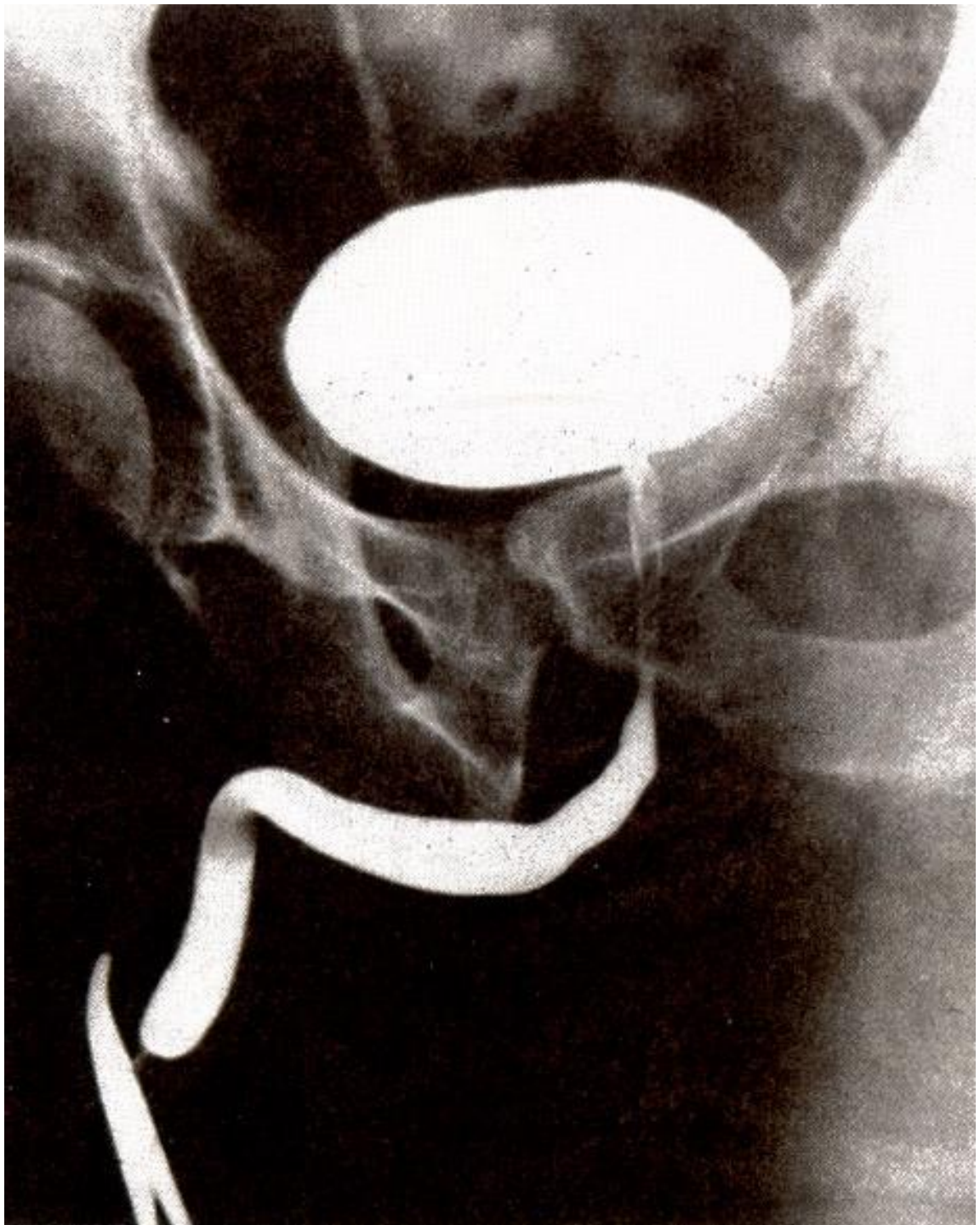


Micturition centers

- **pontine**
(Barrington's nucleus; *centrum micturitionis*)
 - release of sphincter and miction (excretory period)
- **spinal** (sacral; Onuf's nucleus; *nucleus nervi pudendi*)
 - S2-S4

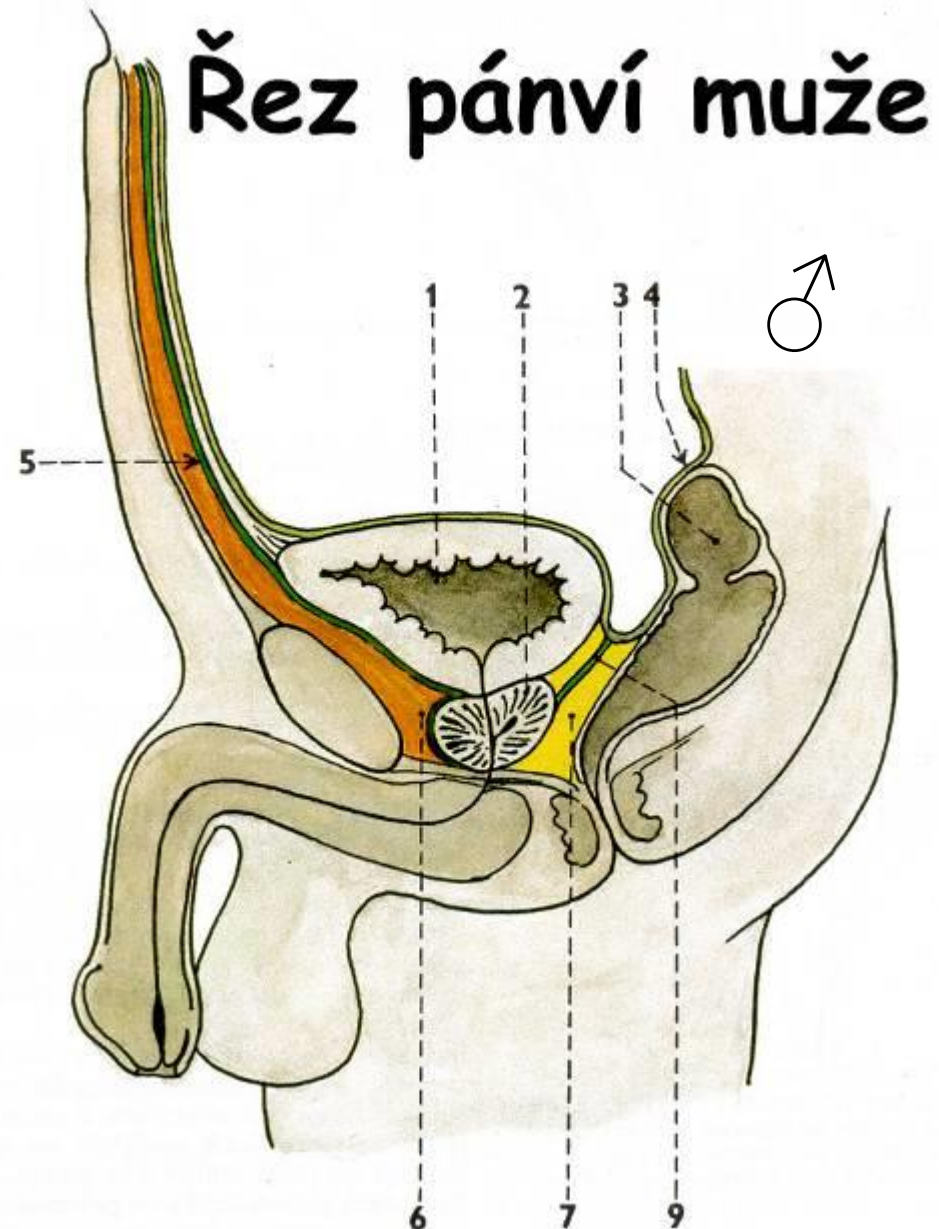


Cystography



Urinary bladder – syntopy

- ligamentum umbilicale medianum (= chorda urachi)
- fascia vesicoumbilicalis *Delbeti*
- ♂ septum rectovesicale *Denonvilliersi*
- ♀ septum vesicovaginale
- spatium retropubicum *Reztii*
 - *epicystostomy*



Urinary bladder – *peritoneum*

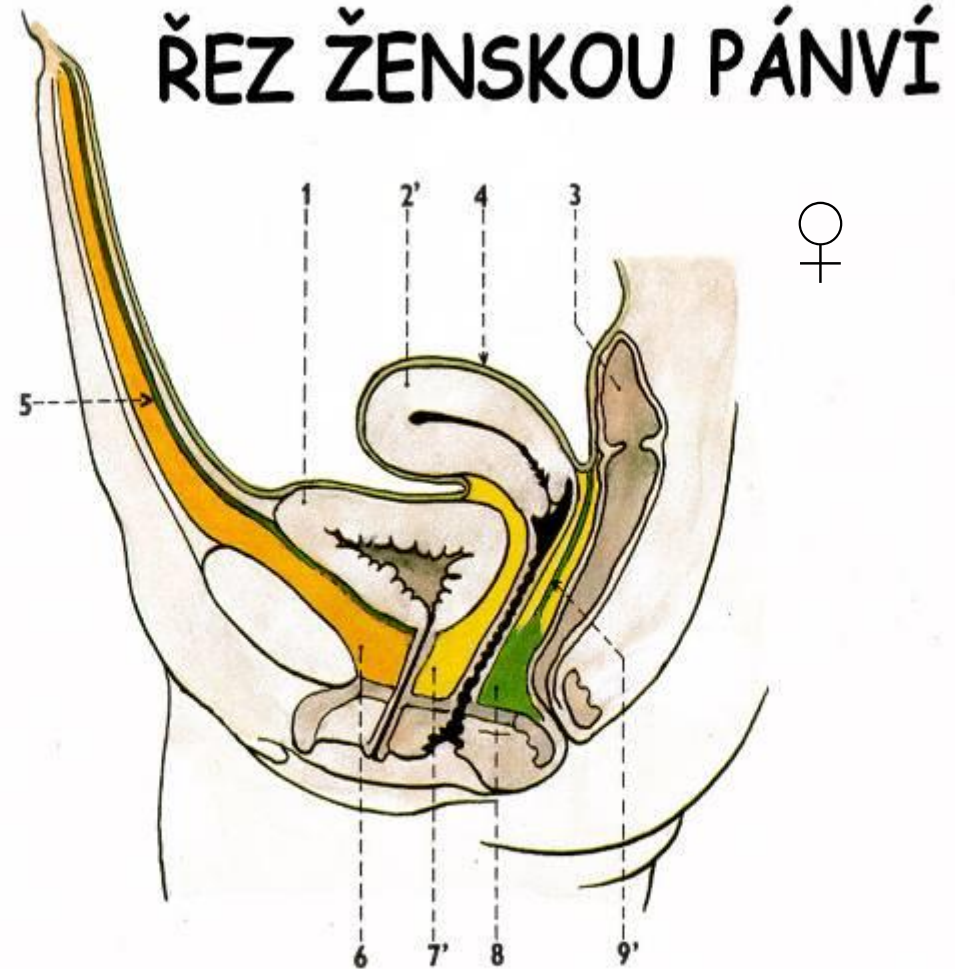
- fossae paravesicales
- ♂ excavatio rectovesicalis (*Prousti*)
 - **deepest recess** of abdominal cavity in **male**
 - in contact with the tip of vesiculous glands

- ♀ excavatio vesicouterina (*Dunni; Meiringi*)

- ♀ excavatio rectouterina (*Douglasi*)
 - **deepest recess** of abdominal cavity in **female**

- in contact posterior vaginal fornix
- puncture via vagina

ŘEZ ŽENSKOU PÁNVÍ



1 / močový měchýř
 2 / prostata
 2' / děloha
 3 / vaječník
 4 / peritoneum
 5 / fascia vesicoumbilicalis

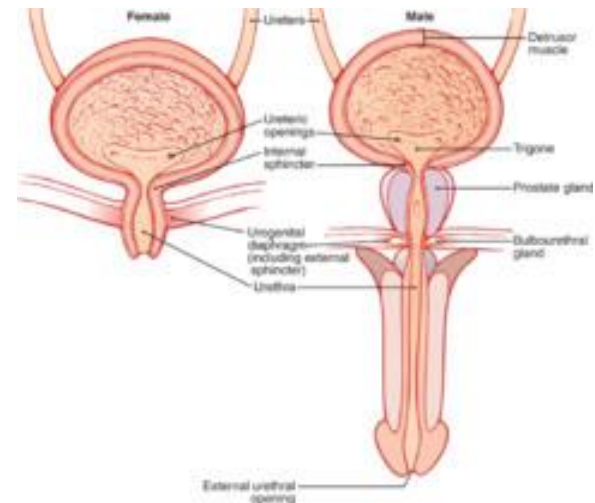
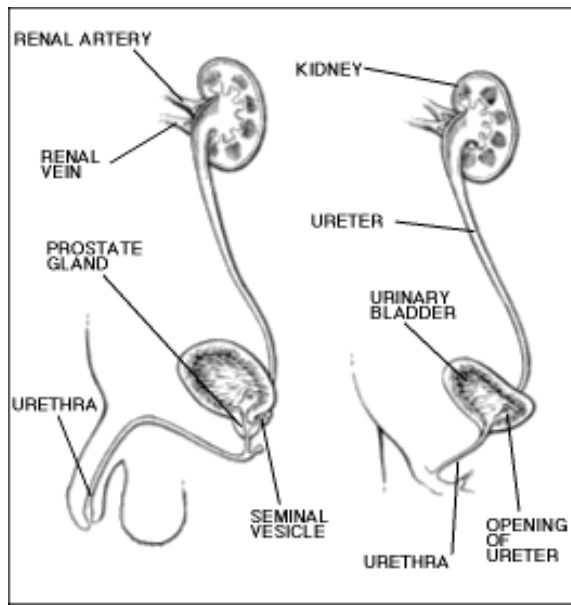
6 / spatium retropubicum (praevesicale)
 7 / vazivo za močovým měchýřem a prostatou u muže
 7' / vazivo za močovým měchýřem a urethrou u ženy
 8 / vazivo tzv. perineálního klínu u ženy (mezi zadní stěnou vaginy a rektem)
 9 / septum rectovesicale u muže
 9' / septum rectovaginale u ženy

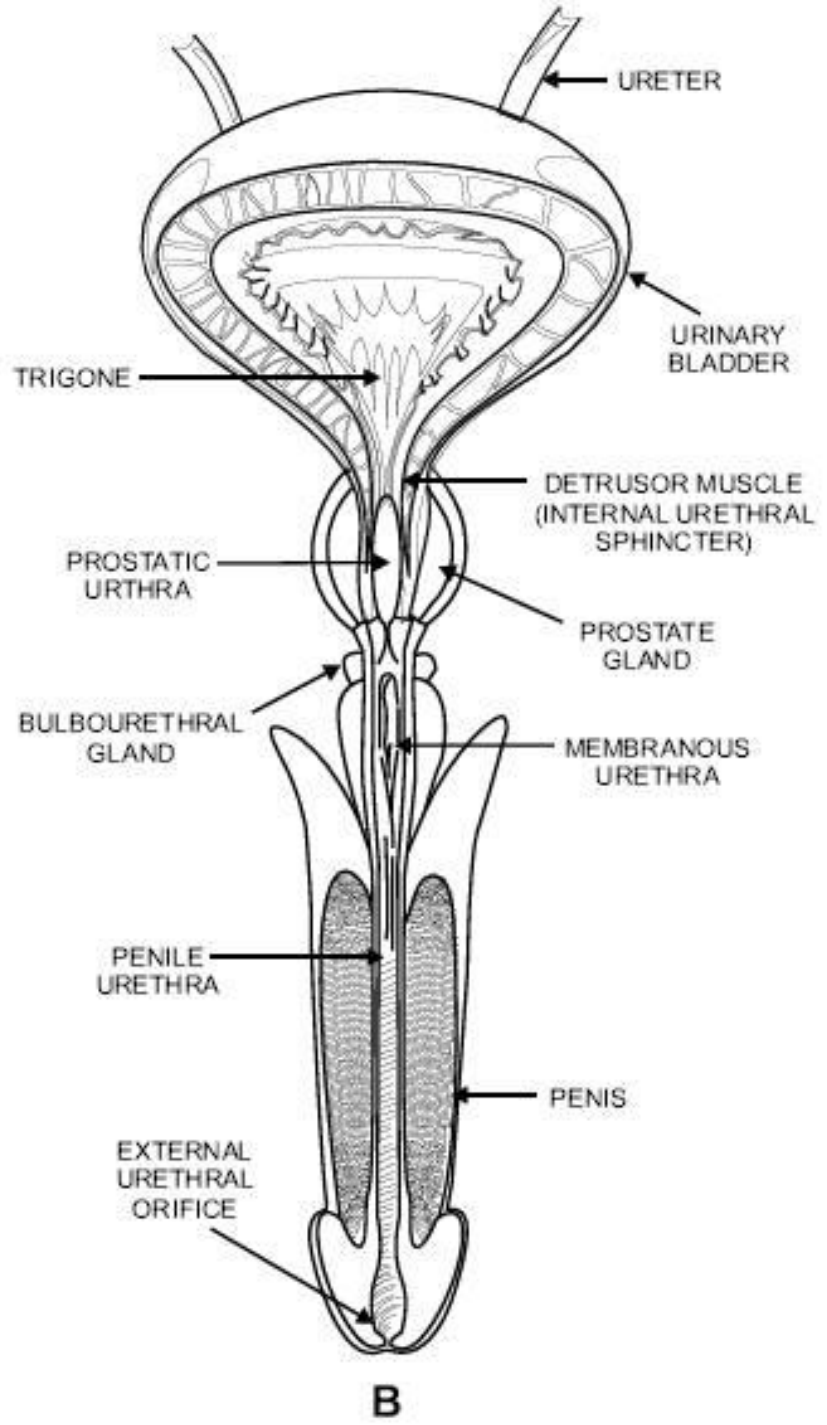
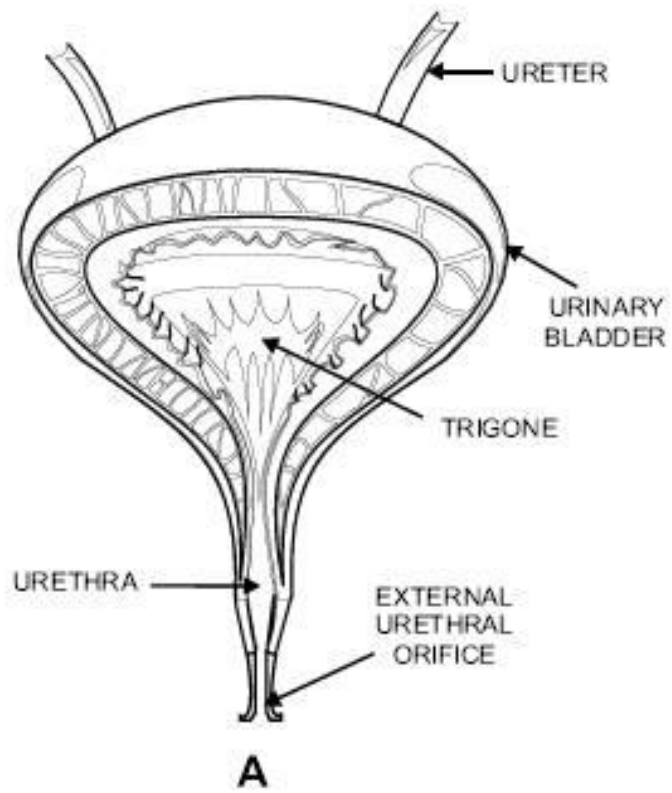
Urethrae



- longer (20 cm)
- narrower
- 2x bent (*curvatura*)
- 4 narrowings
- 4 parts

- shorter (4 cm)
- wider (6-8 mm)
- straight
- prone to infection
- easier catheterization
- 3 parts





Urethrae

- ♀
 - intramural part - transitional epithelium (urothelium)
 - further continues as non-keratinizing stratified squamous epithelium

- ♂
 - first 2 parts transitional epithelium (urothelium)
 - next 2 parts stratified columnar epithelium
 - in fossa navicularis non-keratinizing stratified squamous epithelium
 - In external ostium keratinizing stratified squamous epithelium

Female urethra

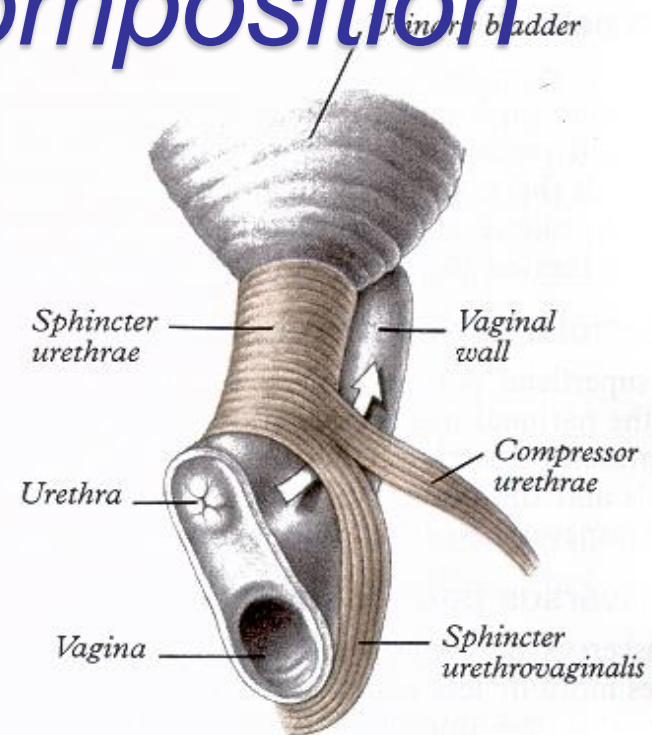
Urethra feminina

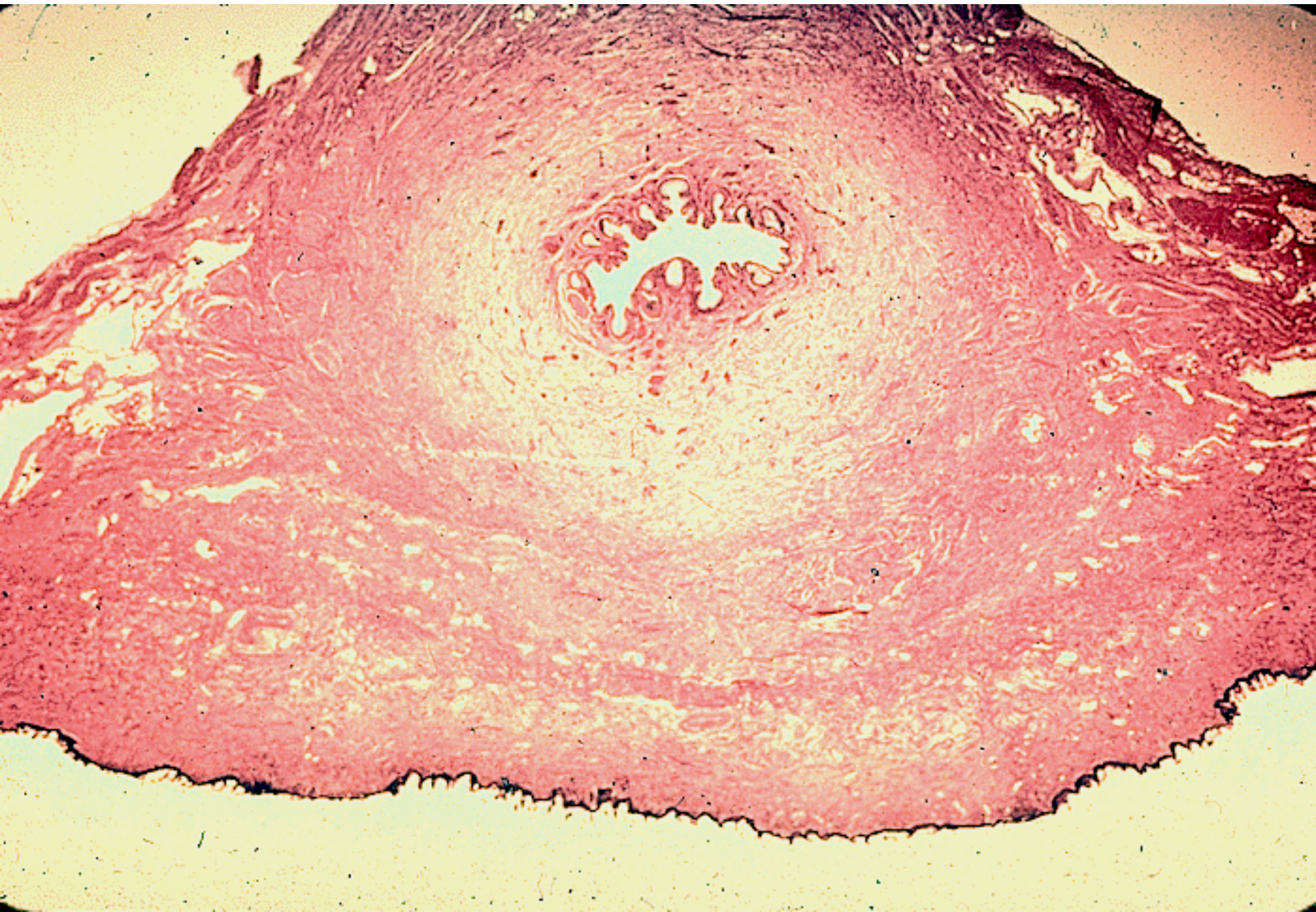
- ostium urethrae **internum** (trigonum vesicae)
 - accipiens, evacuans
- pars **intramuralis** – within the wall of urinary bladder
 - transitional epithelium (urothelium)
- pars **pelvica**
- pars **perinealis** – in hiatus urogenitalis of pelvic floor
 - non-keratinizing stratified squamous epithelium
- ostium urethrae externum – in vestibulum vaginae on papilla urethralis
- elevates carina urethralis on anterior vaginal wall

Svaly močopoavniho dna ženy

Female urethra – composition

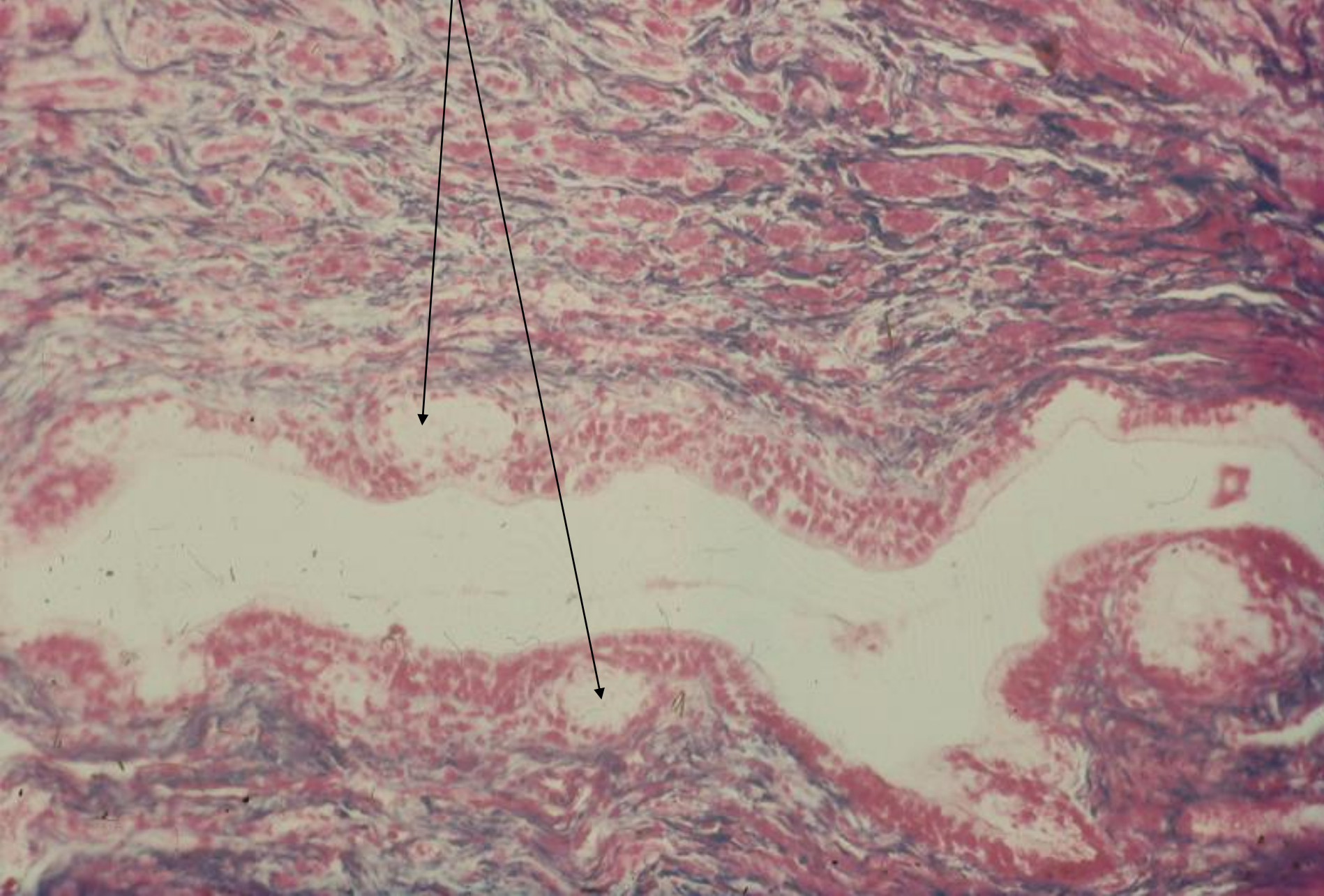
- longitudinal low folds
 - crista urethralis on posterior wall
- tunica mucosa
 - lacunae urethrales (*Morgagni*)
 - glandulae urethrales – mucinous
- tunica spongiosa
 - **venous plexus, elastic fibers**
 - glandulae et ductus paraurethrales (*Skenei-Schülleri*)
- tunica muscularis
 - **inner longitudinal smooth muscle**
 - **outer circular skeletal muscle** (m. sphincter urethrae, m. compressor urethrae, m. sphincter urethrovaginalis)







Lacunae urethrales Morgagni



Female urethra – *supply*

- Arteries: branches from a. vesicalis inf. et a. vaginalis
- Veins: → plexus venosus vesicalis
→ plexus venosus vaginalis
→ vv. pudendae int.
- Lymph: n.l. iliaci int. + ext.
- Nerves:
 - autonomic and viscerosensory: plexus hypogastricus inf.
→ plexus vesicalis, plexus uterovaginalis → nn. vaginales
 - somatomotor fibers: from S2-S3 via n. pudendus for skeletal sphincters

Continence in female

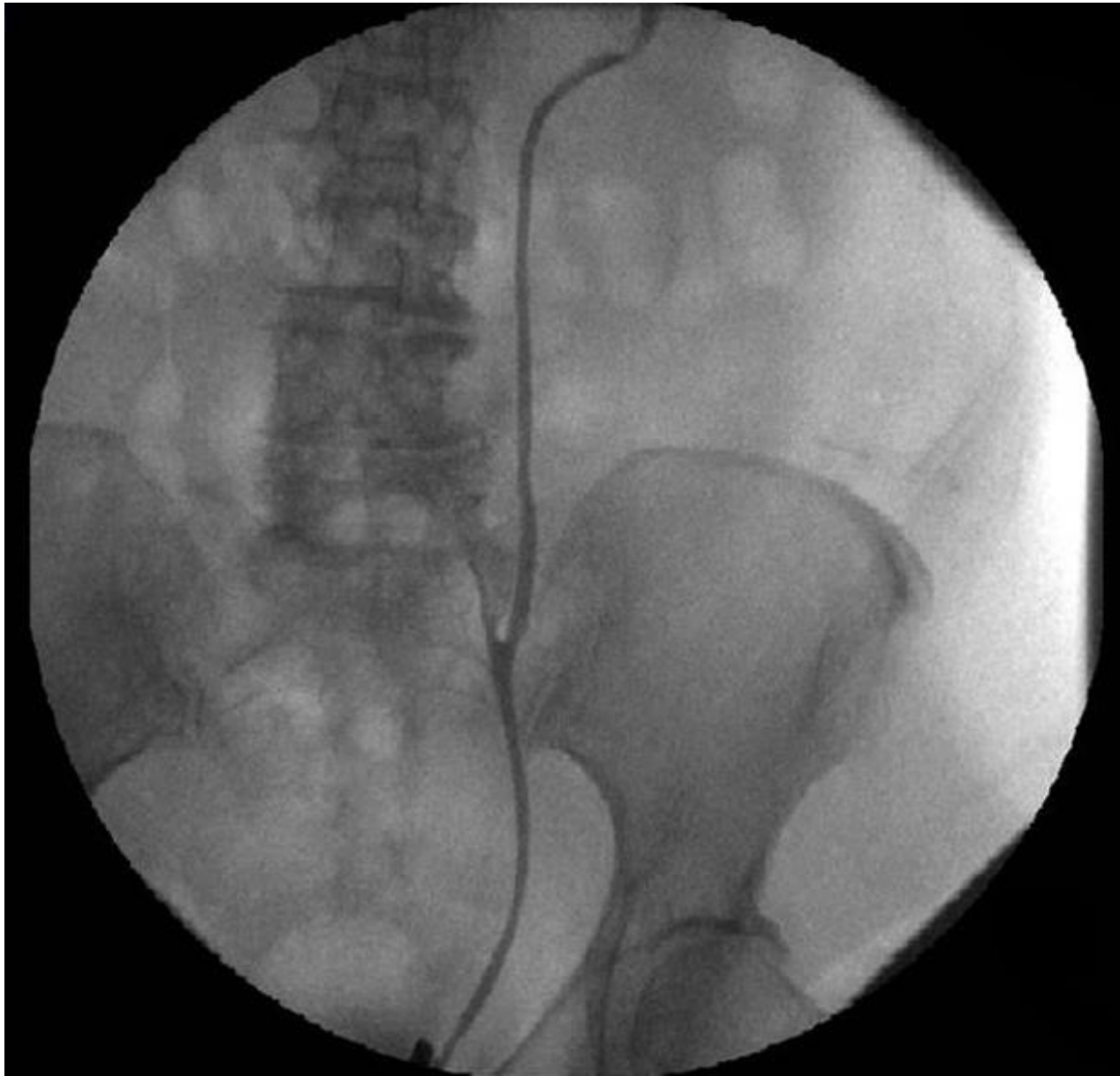
- **no smooth sphincter** in urinary bladder
- 3 components:
 - **elastic fibers** in tunica spongiosa
 - large amount of **veins** in tunica spongiosa
 - **striated sphincter** of urethra
- so-called „*periurethral musculature* “ in fast retention of urine and at the end of urination
 - m. levator ani (S3-S4)
 - m. bulbospongiosus (n. pudendus)

Examination *

- endoscopy
- urethrocytography
- cystoscopy
- urodynamic examination



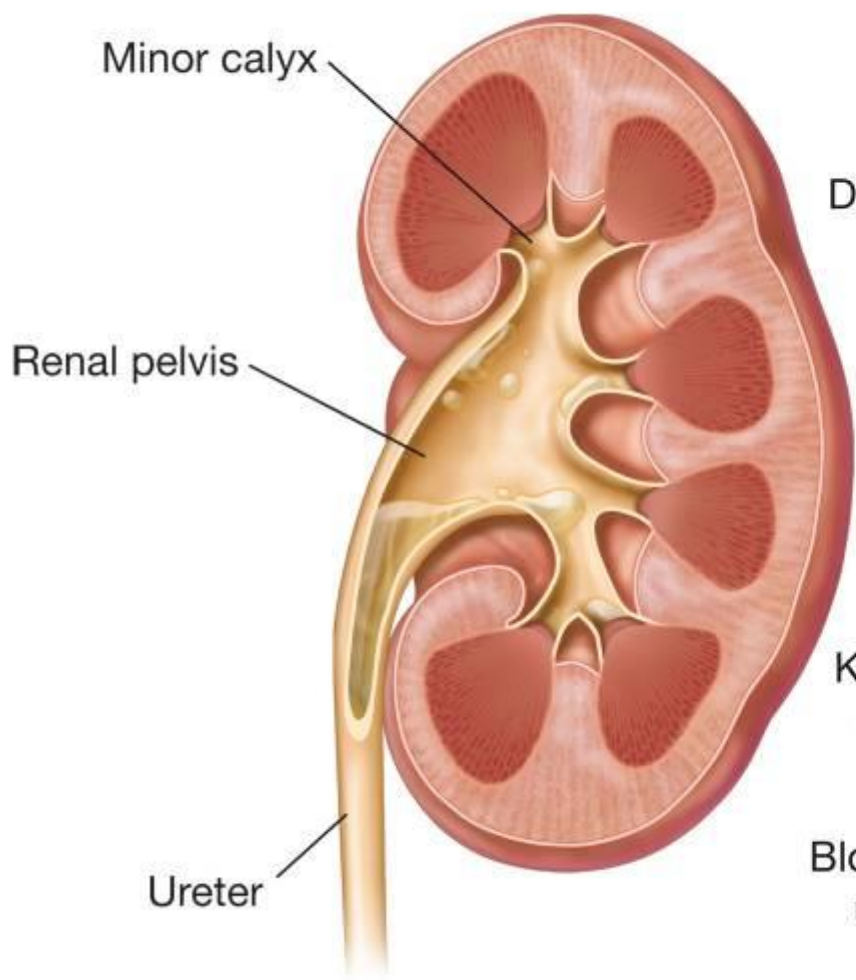
Ureter fissus



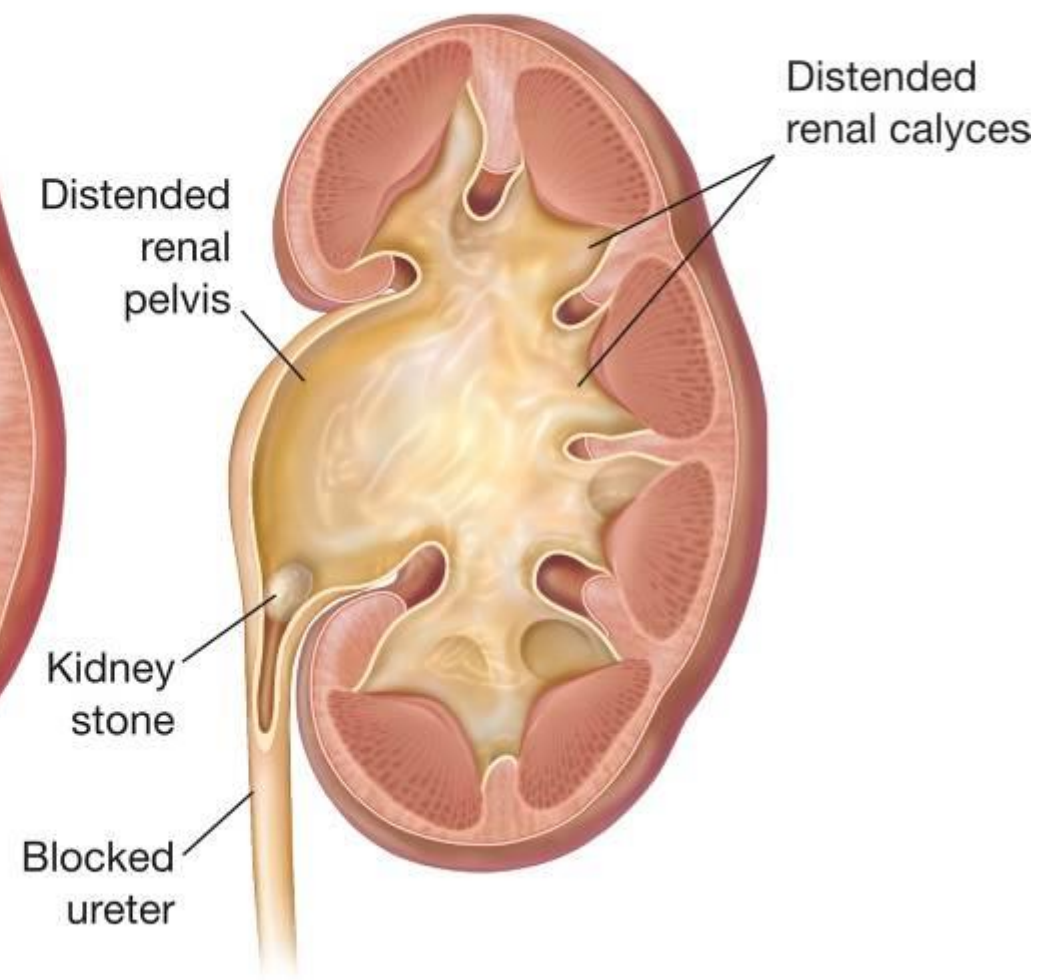
Diseases of excretory tract *

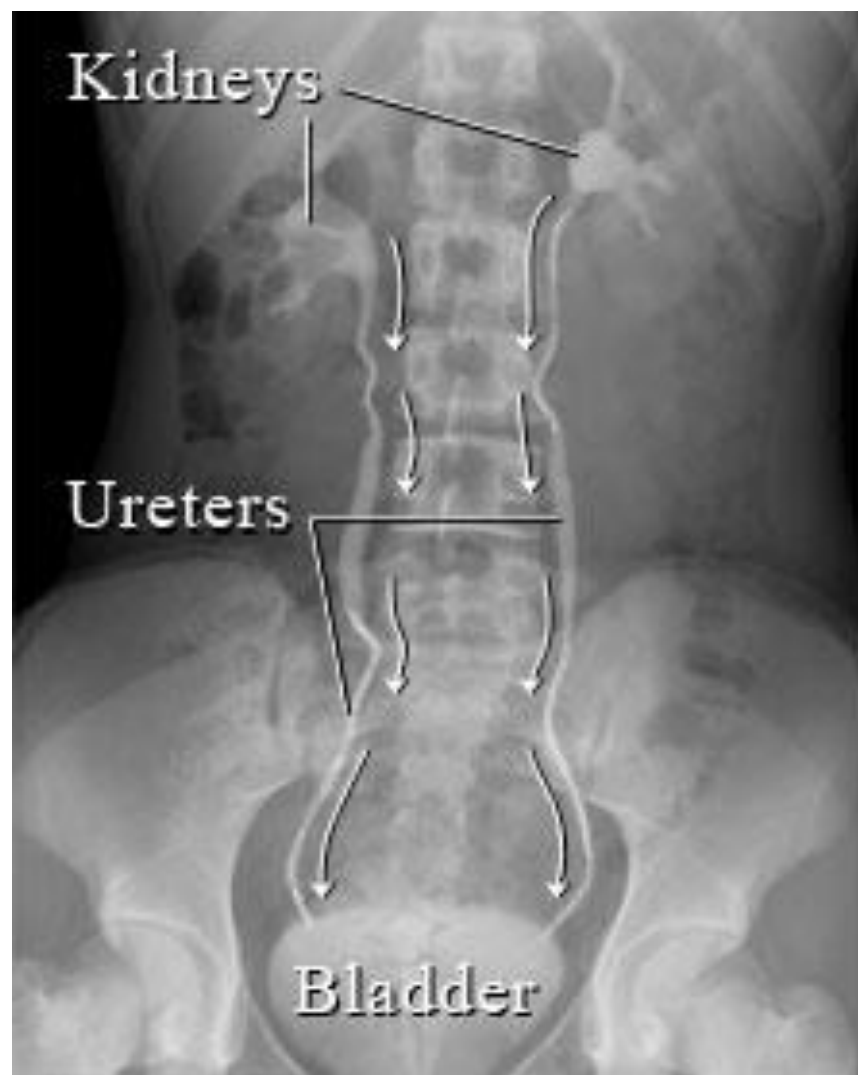
- **nephrolithiasis**
- **hydronephrosis**
- rupture of renal pelvis
- **vesicoureteral reflux**
- uroinfection
- urolithiasis + renal colic
- diverticle
- tumors (papilloma, papilocarcinoma)

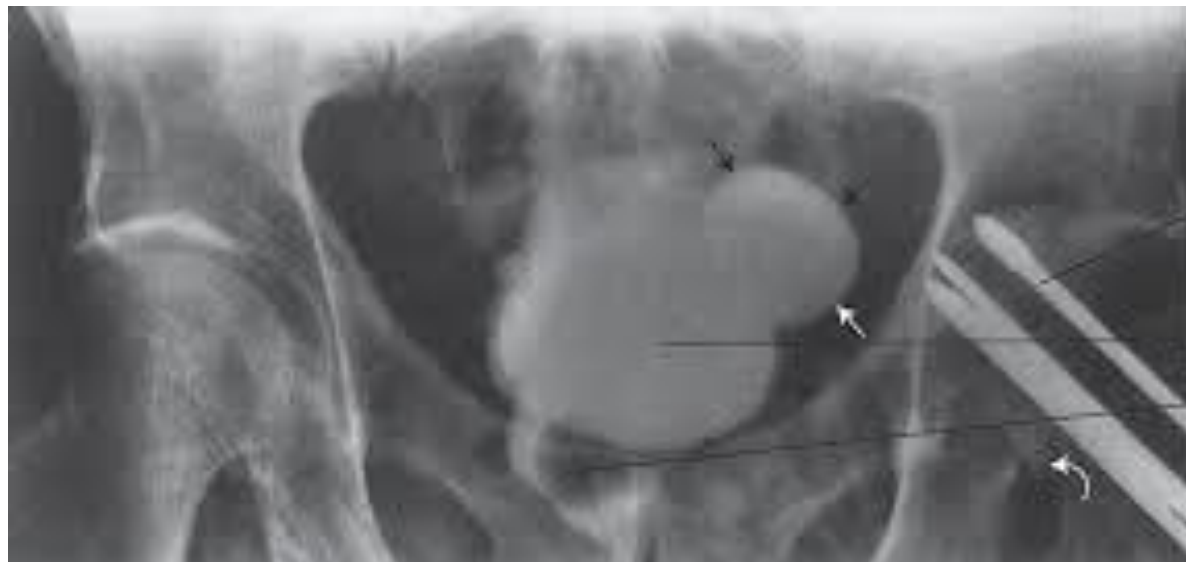
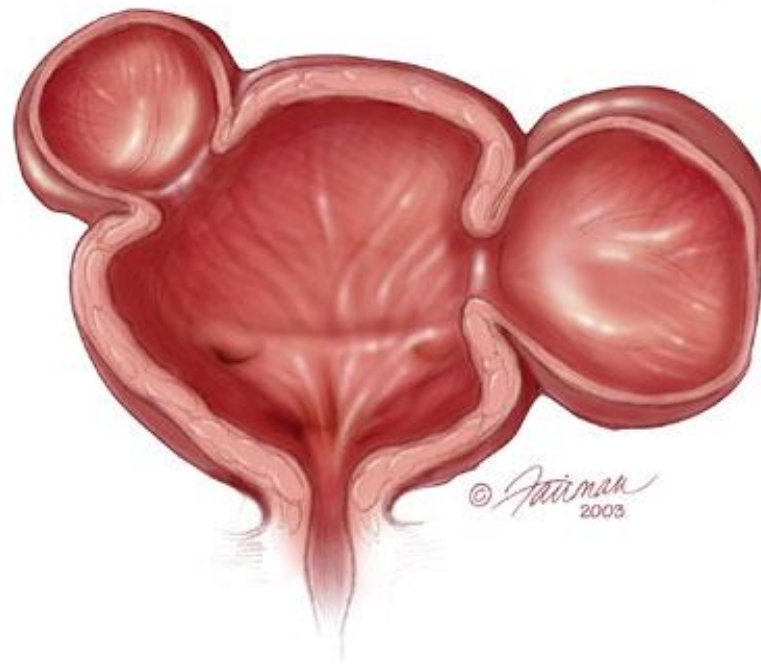
Normal kidney



Hydronephrosis







Metallic orthopedic pins

Urinary bladder

Foley catheter balloon

Treatment methods

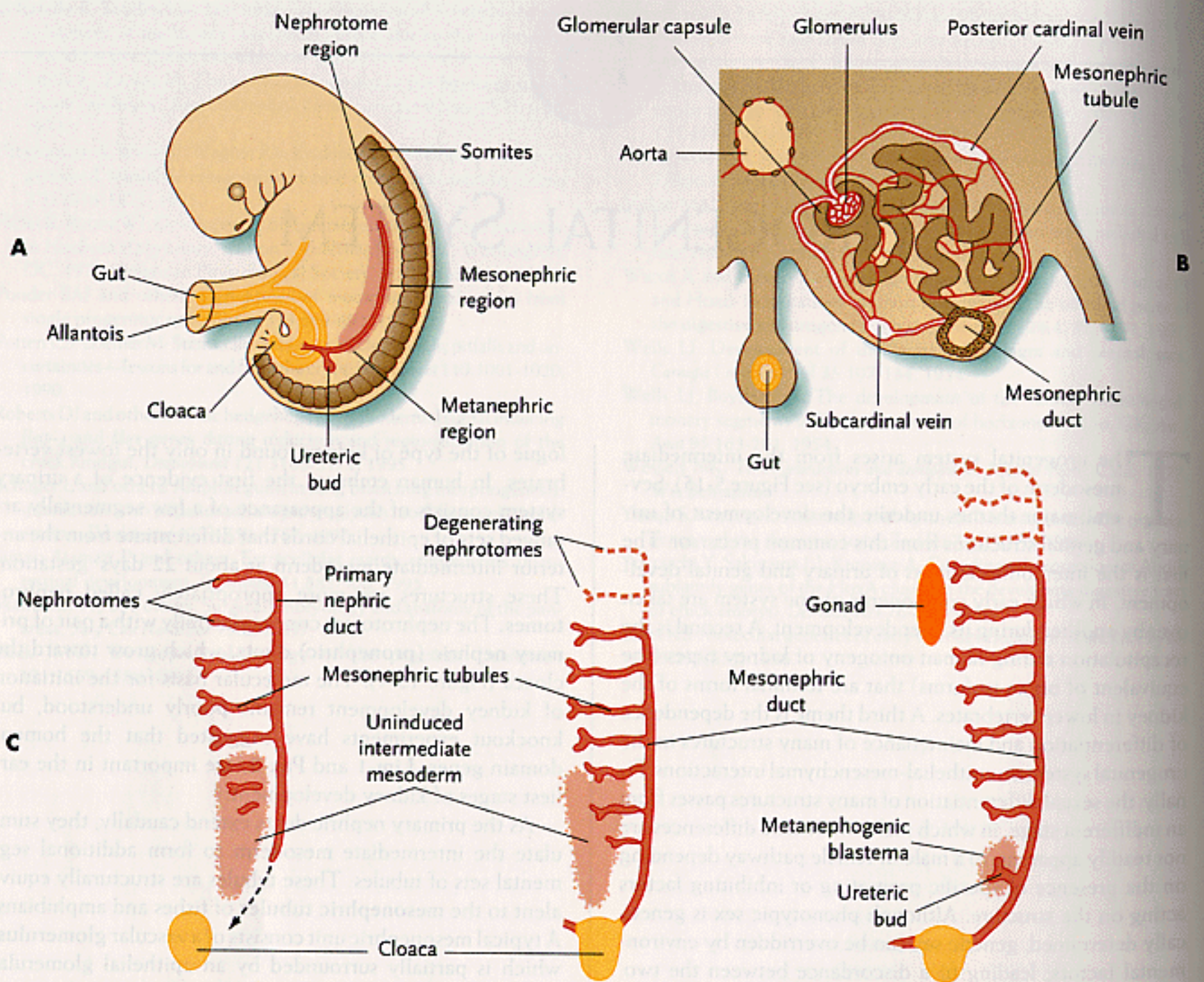
- ESWL = extracorporeal shock wave lithotripsy



- URS = ureteroscopic lithotripsy
- endoscopy of ureter (endoscopic introduction of stent)

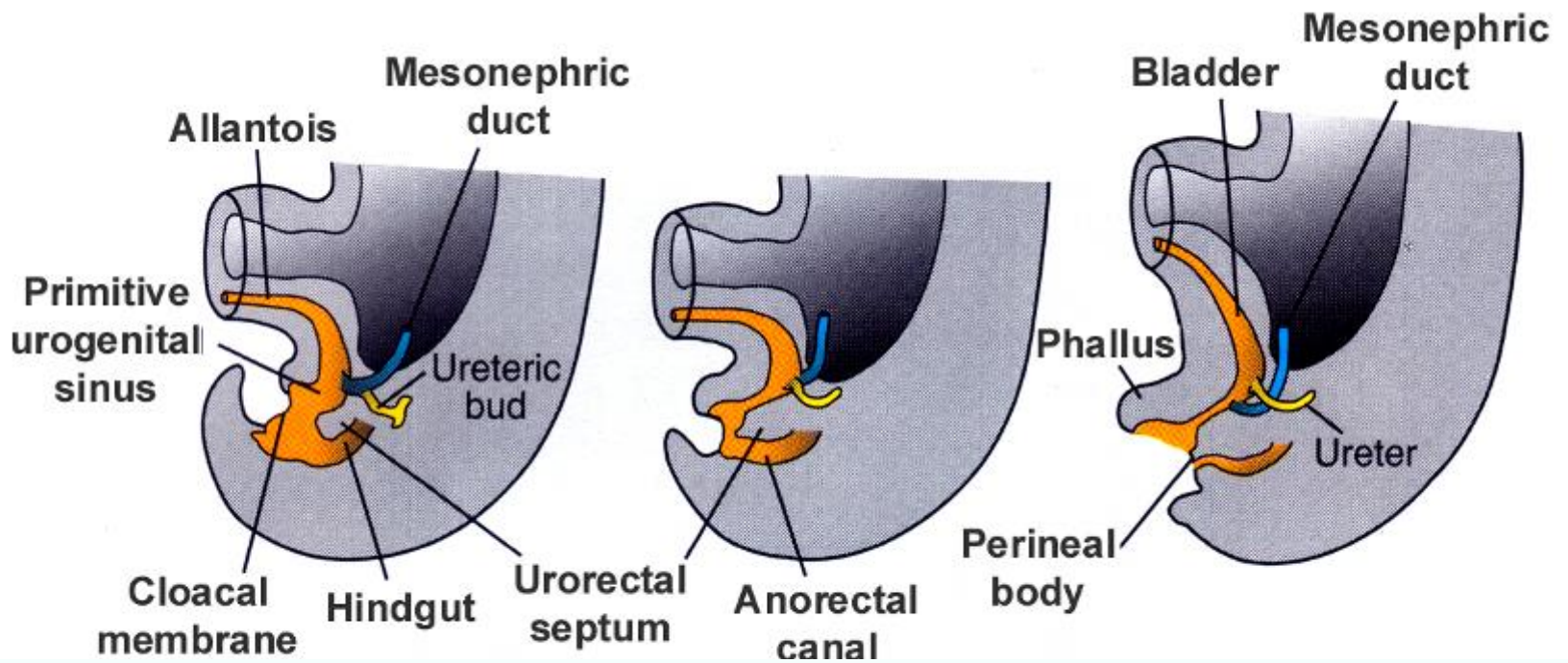
Development of urinary excretory system

- origin is intermediate mesoderm
- vacuolization → canal
- ductus pronephricus
- ductus mesonephricus *Wolffi*
 - in the stage of 27-28 nephrotomes connects to the cloaca
- ureteric bud grows into metanephrogenic blastema → ureter, renal pelvis, major calices, minor calices, papillary ducts down to collecting tubules



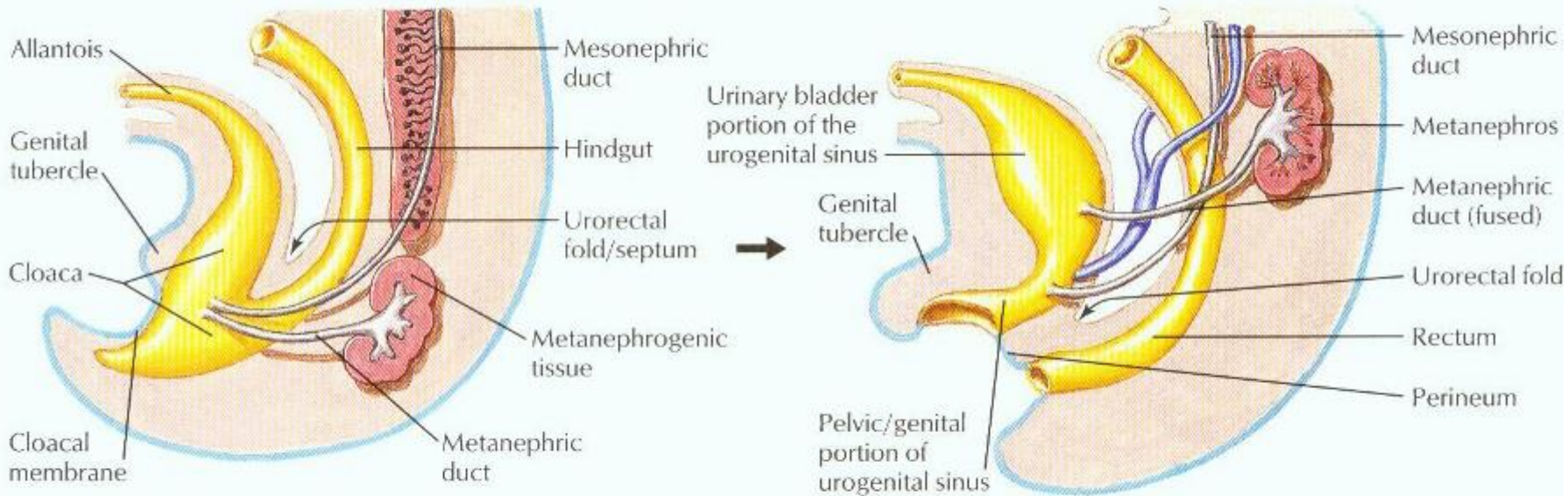
Urogenital sinus (*Sinus urogenitalis*)

- 8th week: fusion of septum urorectale and membrana cloacalis →
 - membrana urogenitalis (urogenital membrane)
 - membrana analis (anal membrane)
- sinus urogenitalis primordialis (primordial urogenital sinus)
 - canalis vesicourethralis (vesico-urethral canal)
- sinus urogenitalis definitivus (definitive urogenital sinus)
 - pars pelvica (pelvic part)
 - pars phallica (phallic part)



Division of the cloaca by the urorectal septum

Urogenital sinus and rectum



Functional classification of **sinus urogenitalis**

3 parts:

- upper (*pars allantoica*) → urachus → disappears
- middle (*canalis vesicourethralis*) → urinary bladder + female urethra
- lower (*pars pelvica et pars phallica*) → female urethra / most of male urethra + prostate gland and bulbourethral gland

Development of urinary excretory system

Urinary bladder

- epithelium from endoderm of sinus urogenitalis → pars vesicalis canalis vesicourethralis
- other layers derived from adjacent splanchnic mesoderm
- urachus
- separation of urinary and genital excretory tract
- material of trigonum vesicae derived from tissue of Wolffian duct

Development of urinary excretory system

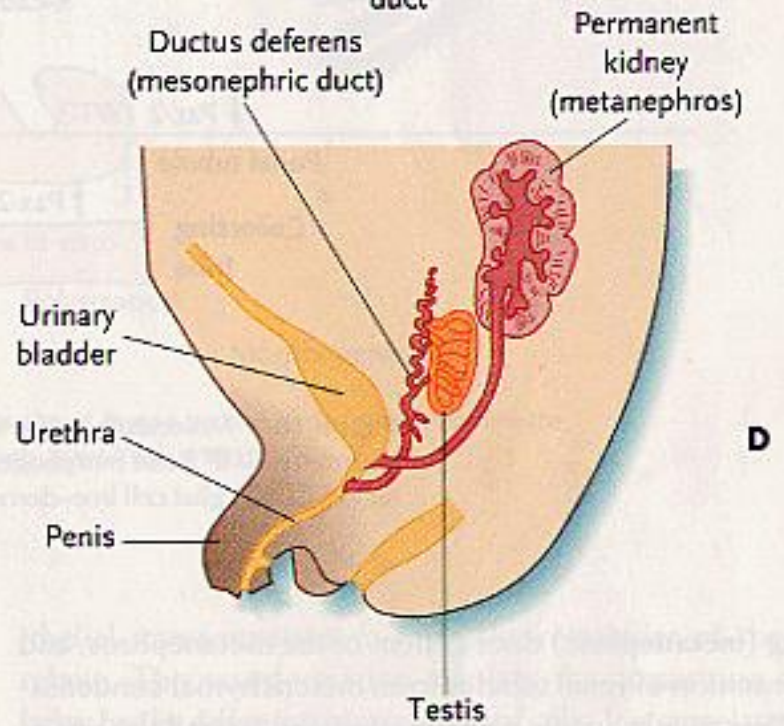
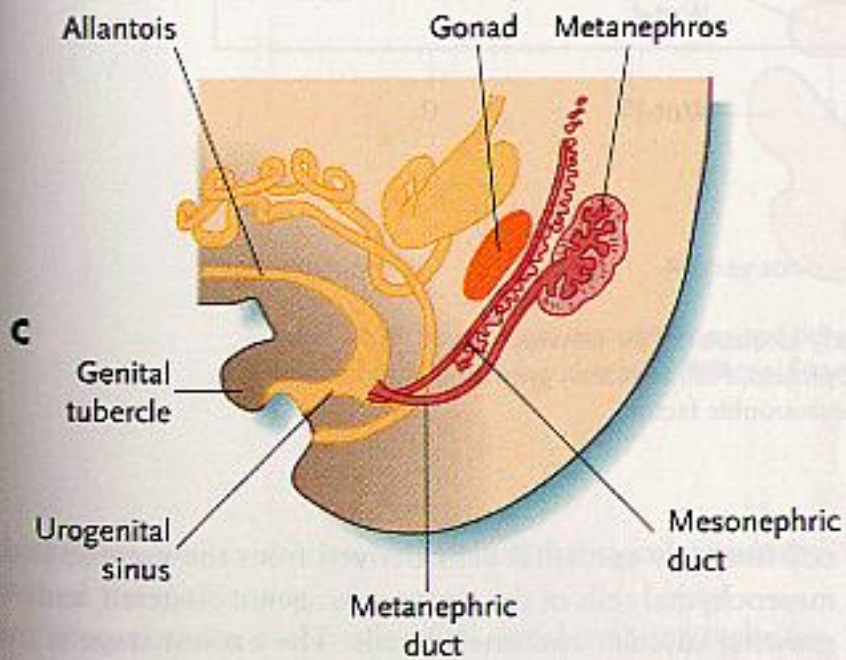
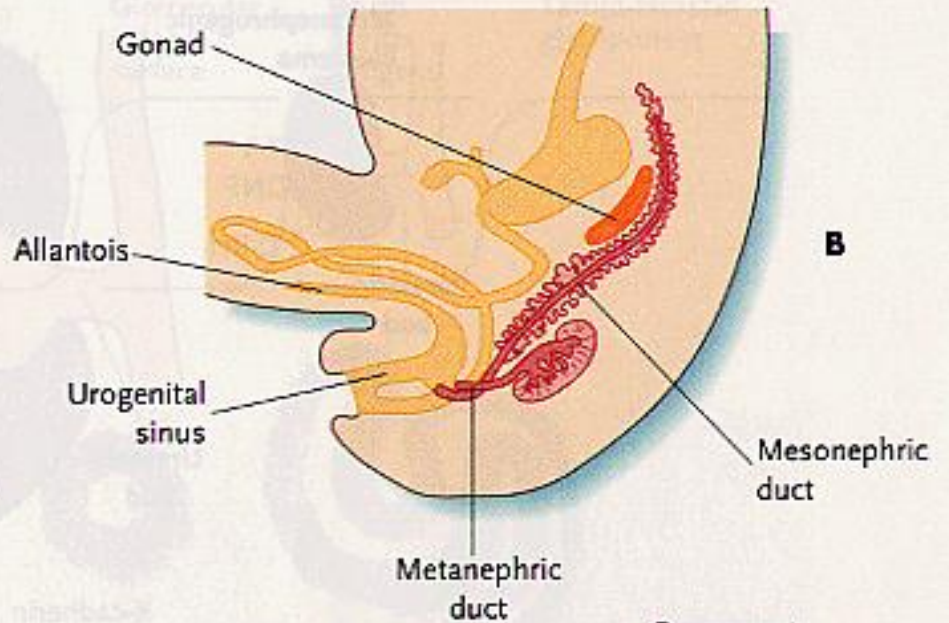
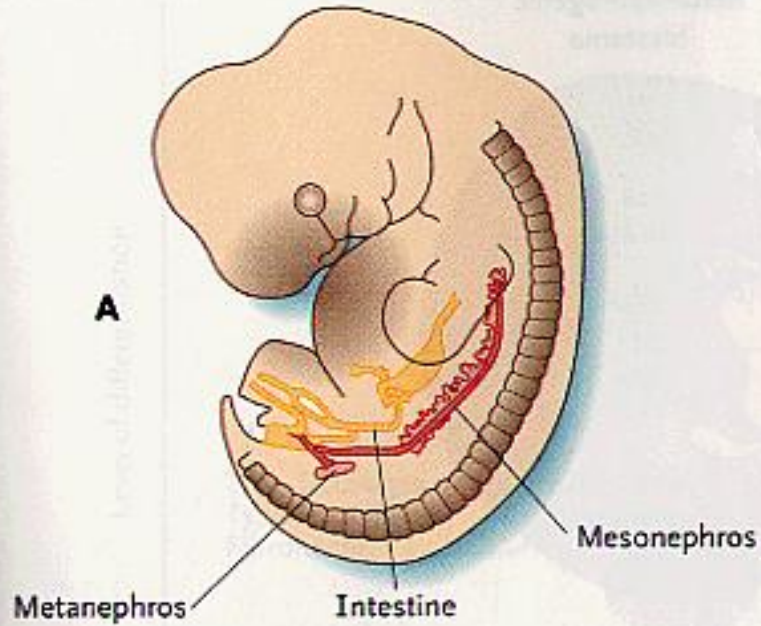
Female urethra

- epithelium derived from endoderm
- other layers derived from adjacent splanchnic mesoderm
- larger proximal portion from pars urethralis canalis vesicourethralis – lined by transitional epithelium
- smaller distal portion from pars pelvica sinus urogenitalis – lined by nonkeratinized stratified squamous epithelium

Development of urinary excretory system

Male urethra

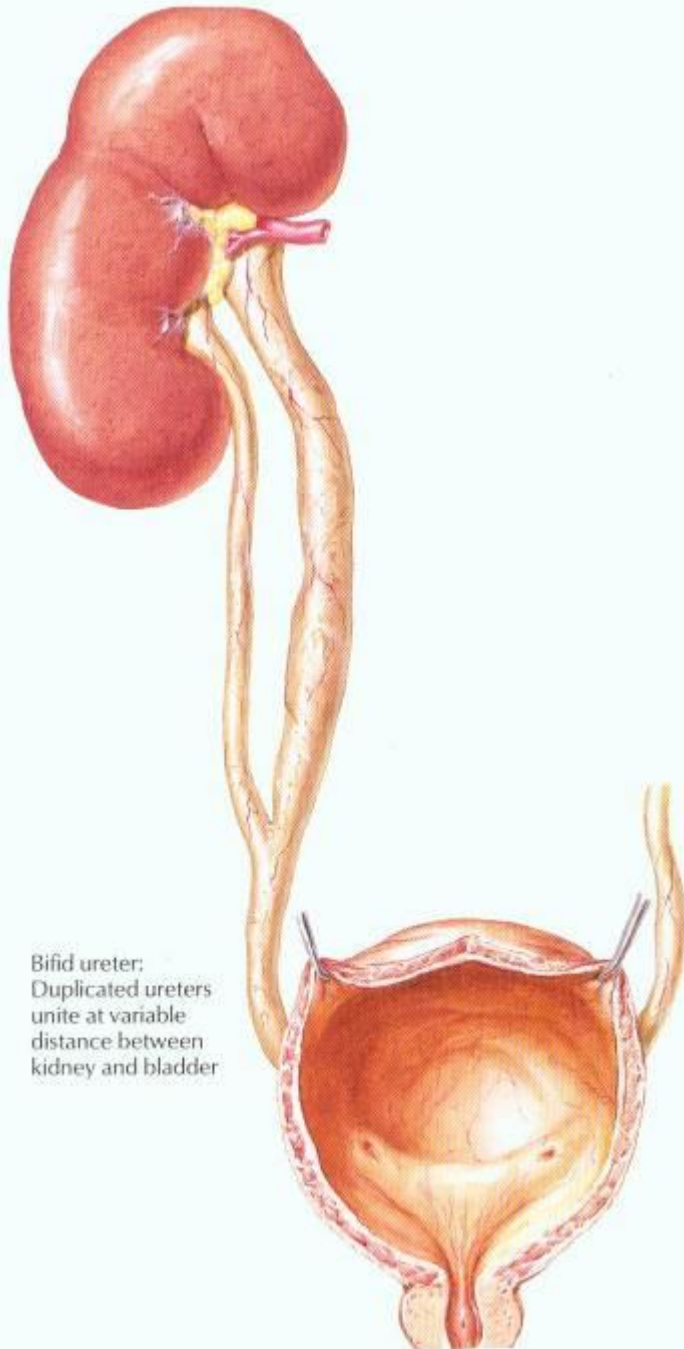
- epithelium derived from endoderm
- posterior wall of pars intramuralis + upper half of pars prostatica (cranially to orifice of genital system) derived from tissue of Wolffian duct
- lower half of pars prostatica + pars intermedia in male from pars pelvica of sinus urogenitalis
- pars spongiosa u.m. + gl. bulbourethralis *Cowperi* from pars phallica sinus urogenitalis
- distal part on the top of glans penis derived from ectodermal glandular plate (*lamella glandularis*) → fossa navicularis
- other layers derived from adjacent splanchnic mesoderm



Developmental defects

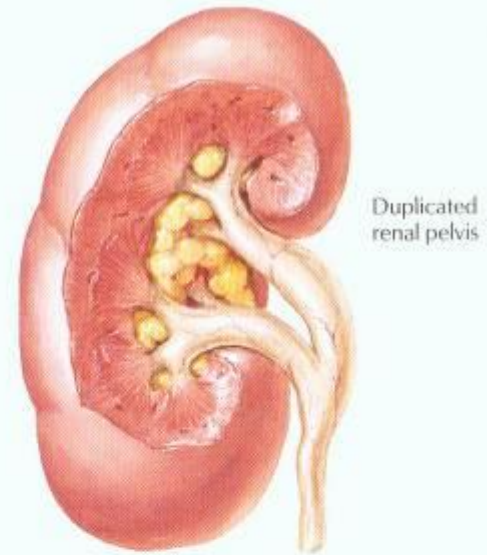
- uterine duplex (double ureter), ureter fissus
- exstrophy of urinary bladder (*exstrophia v.u.*)
- agenesis of urinary bladder
- ectopic urinary bladder
- double urinary bladder
- fistula congenita vesicouterina / vesicovaginalis
- urachal cyst
- urachal sinus
- urachal fistula
- hypospadias / epispadias

Incomplete duplication of ureter



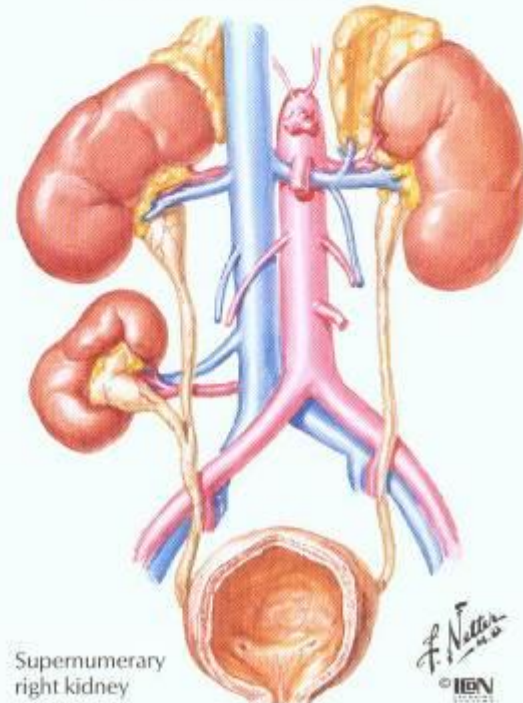
Bifid ureter:
Duplicated ureters
unite at variable
distance between
kidney and bladder

Anomalies of renal pelvis and calyces



Duplicated
renal pelvis

Anomalies in number of kidneys



Supernumerary
right kidney

F. Netter
© IGV