

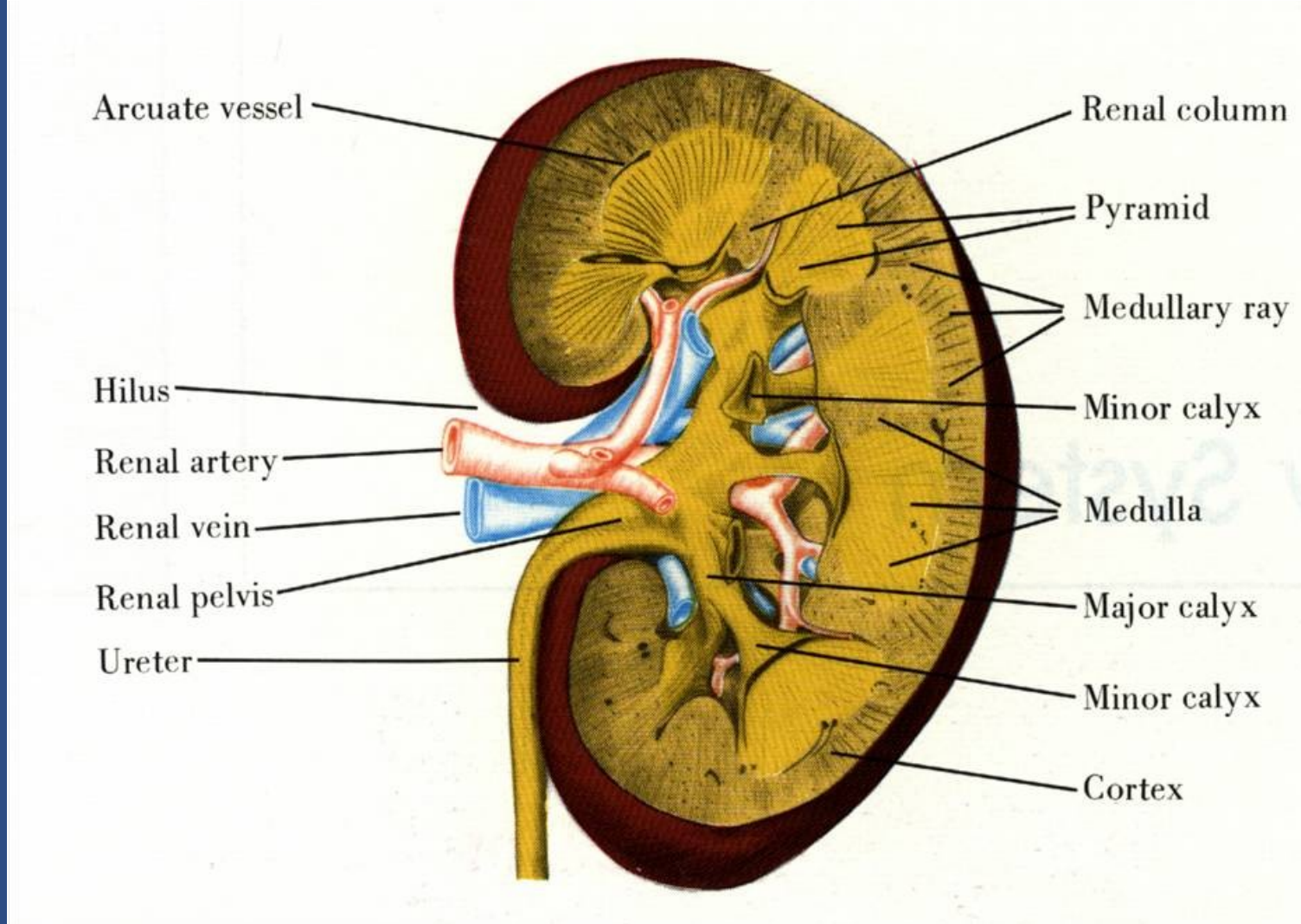
# THE URINARY SYSTEM

**Microscopic structure and development of urinary system**

- **Kidney: nephron –structure and function**
- **Urinary passages: ureter, urinary bladder, urethra**
- **Development of urinary system**

# THE URINARY SYSTEM

- **paired excretory gland – kidney**  
compound gland that secretes urine  
(connective tissue capsule and  
parenchyma)
- **excretory passages – ureter, urinary  
bladder, urethra**



2 distinct regions:

**cortex** and renal columns

**medulla**: 8-12 pyramids, apical portions project into minor calyces (papillae), bases face the cortex and medullary substance extends into cortex (medullary rays or striae medullares) = pars radiata corticis

# Nephron

a morphologic and functional unit of kidney (1-2 millions in each kidney)

## renal corpuscle of Malpighi (corpusculum renis)

- glomerulus of capillaries
- Bowman's capsule (2 sheets – parietal and visceral: podocytes)

## uriniferous tubule (tubulus renis)

- proximal tubule (convoluted and straight portion)
- loop of Henle (descending and ascending limb, thin and thick segment)
- distal tubule
- short connecting segment

# Histotopography of nephron

## cortex:

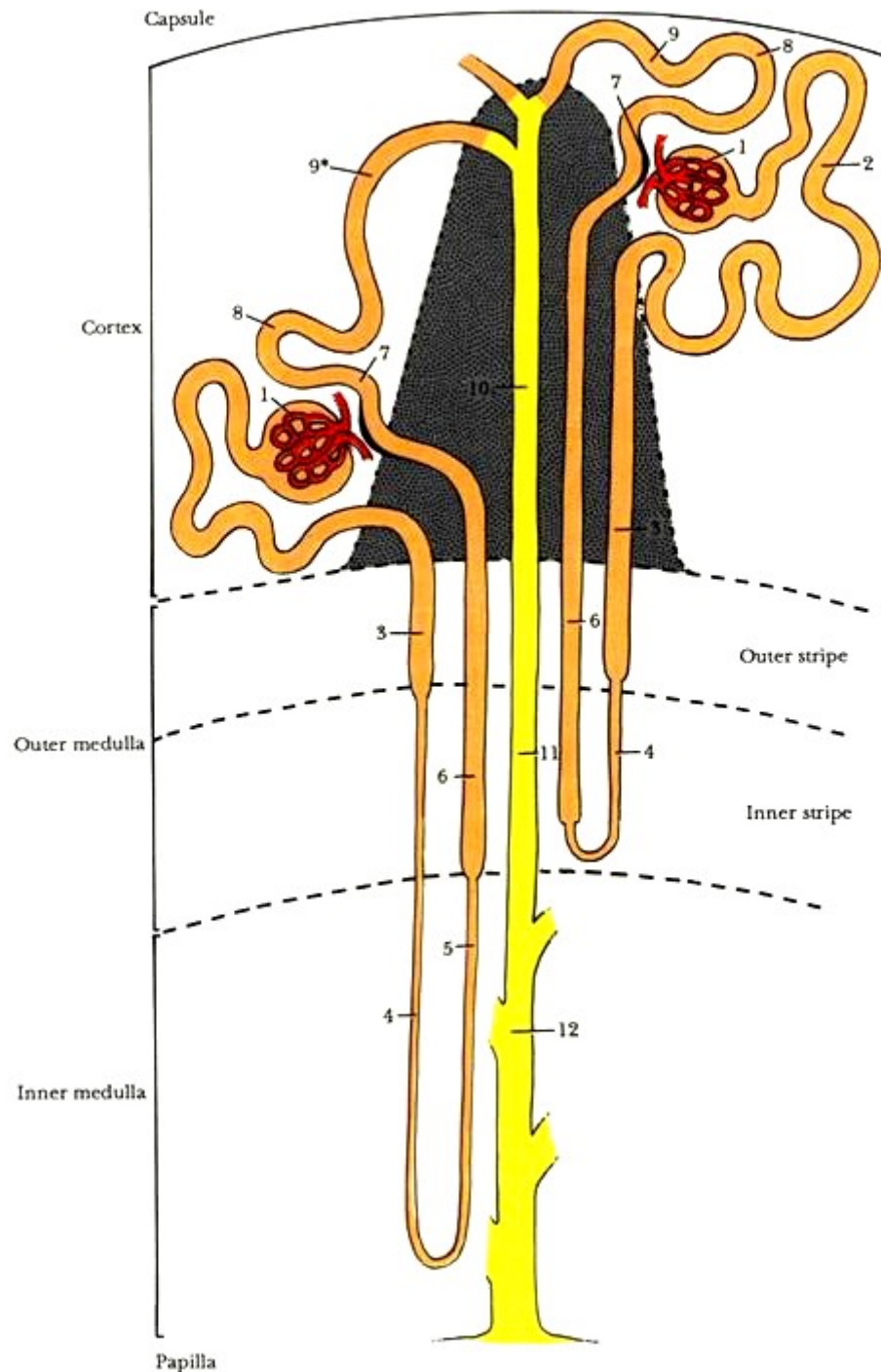
renal corpuscles  
convoluted parts of proximal and distal tubules

## medullary rays:

straight portions of proximal and distal tubules  
collecting tubules

## medulla:

loop of Henle  
collectin tubules  
papillary ducts



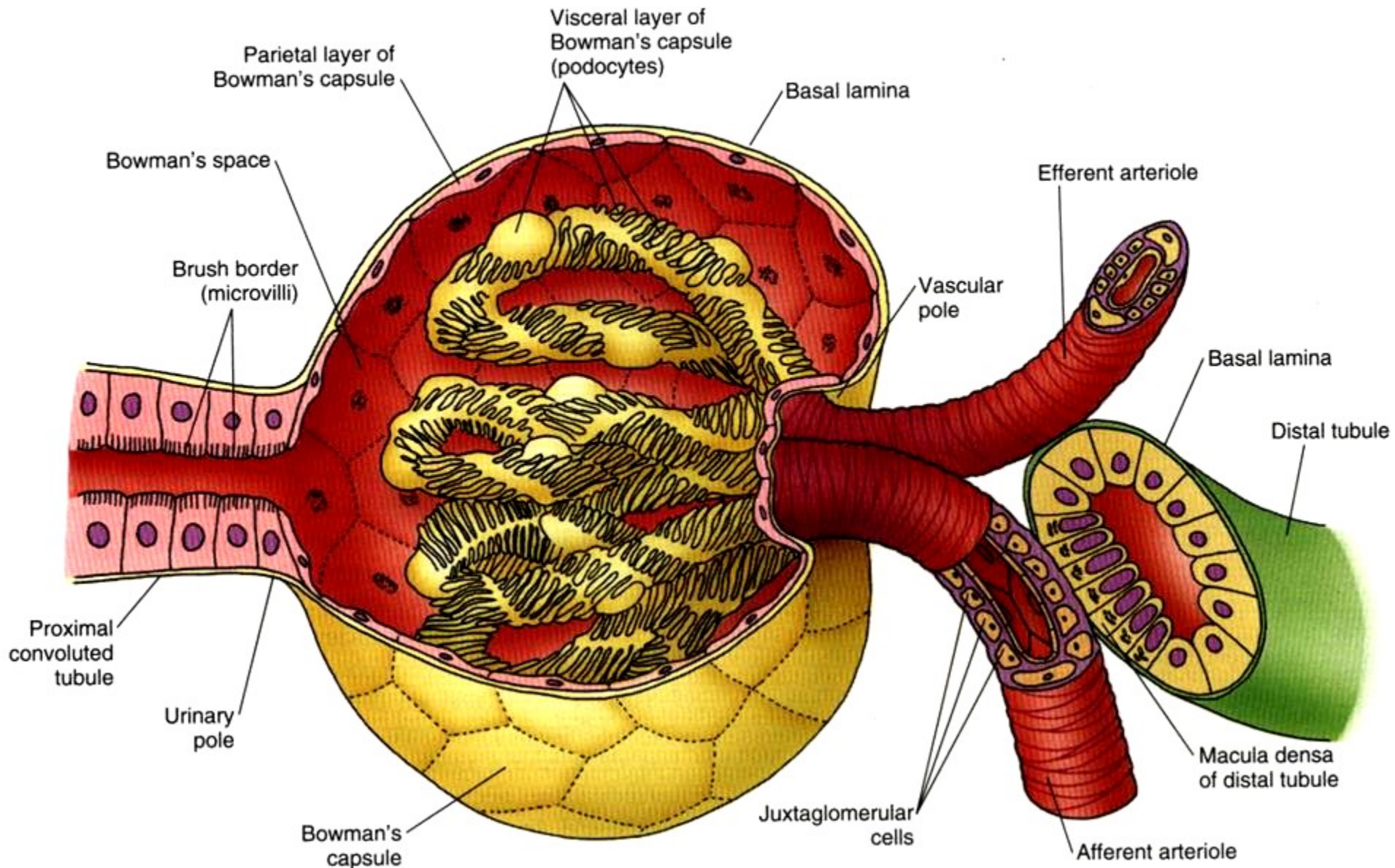
# RENAL CORPUSCLE

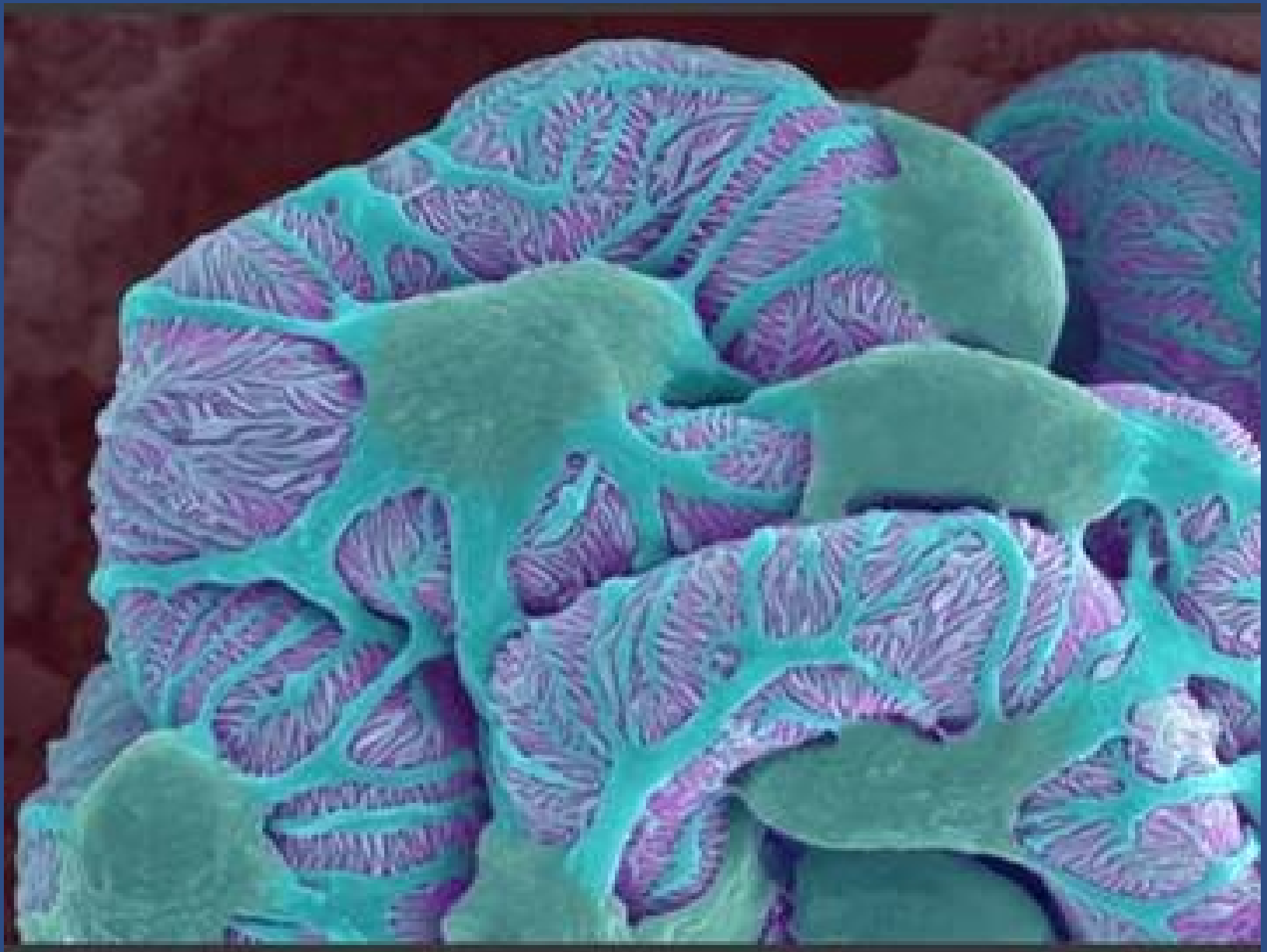
- glomerulus of fenestrated capillaries (between an afferent and efferent arterioles – **vascular pole**)
- Bowman's capsule – cup shaped, double wall: parietal and visceral layer, urinary space between them, it opens into proximal tubule at **urinary pole**

parietal layer: simple squamous epithelium

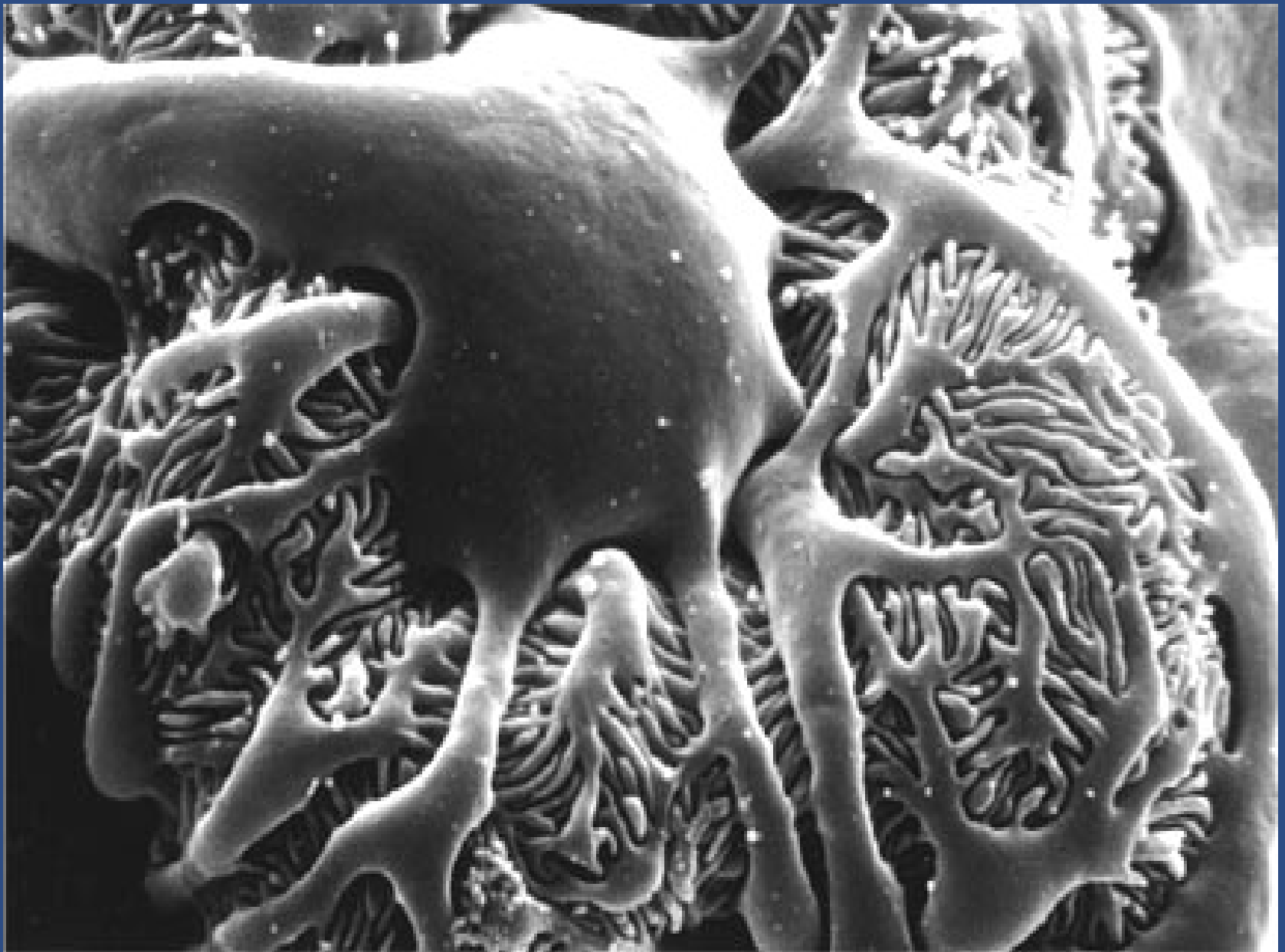
visceral layer: covers capillaries, the cells are modified – podocytes

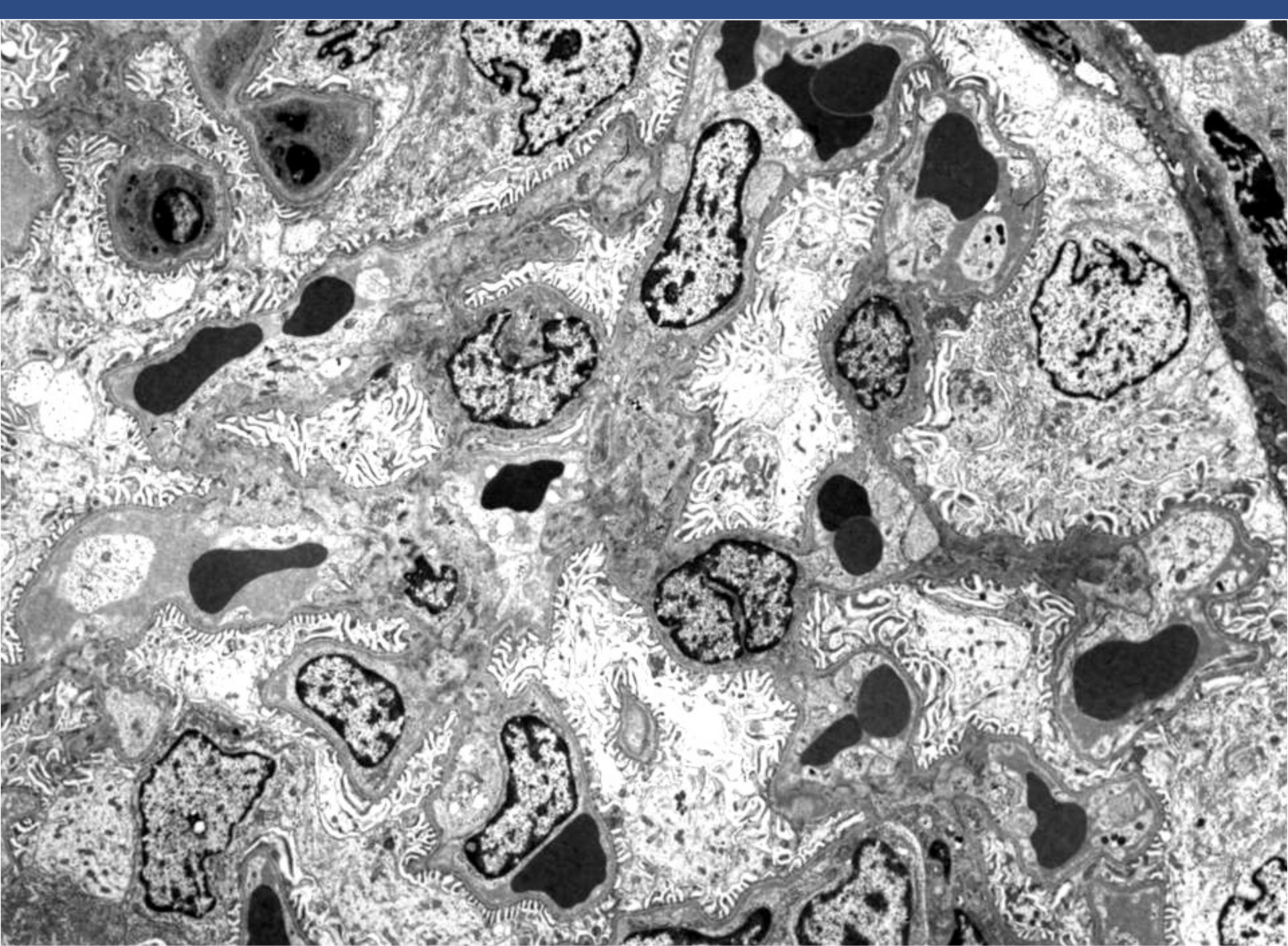
- **podocytes**: stellate, several primary processes extend into secondary processes = pedicles, which attach to the basal lamina), pedicles of adjacent cells interdigitate, between them = filtration slits spanned by a thin slit membrane (or diaphragm)
- the basal lamina of endothelium of capillaries and basal lamina of podocytes fuse into 3-layered complex: lamina rara subendothelialis, lamina densa and lamina rara subepithelialis





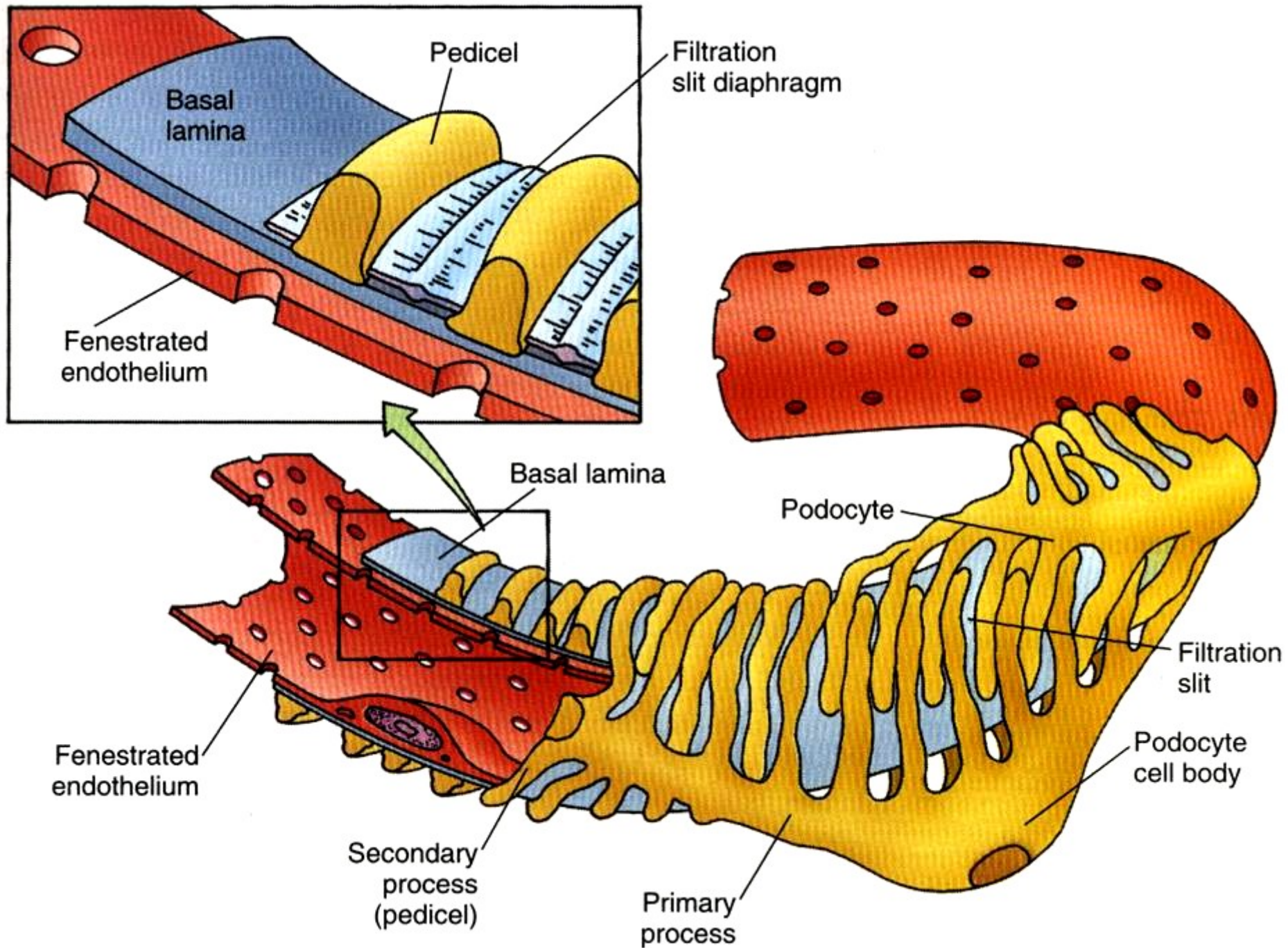


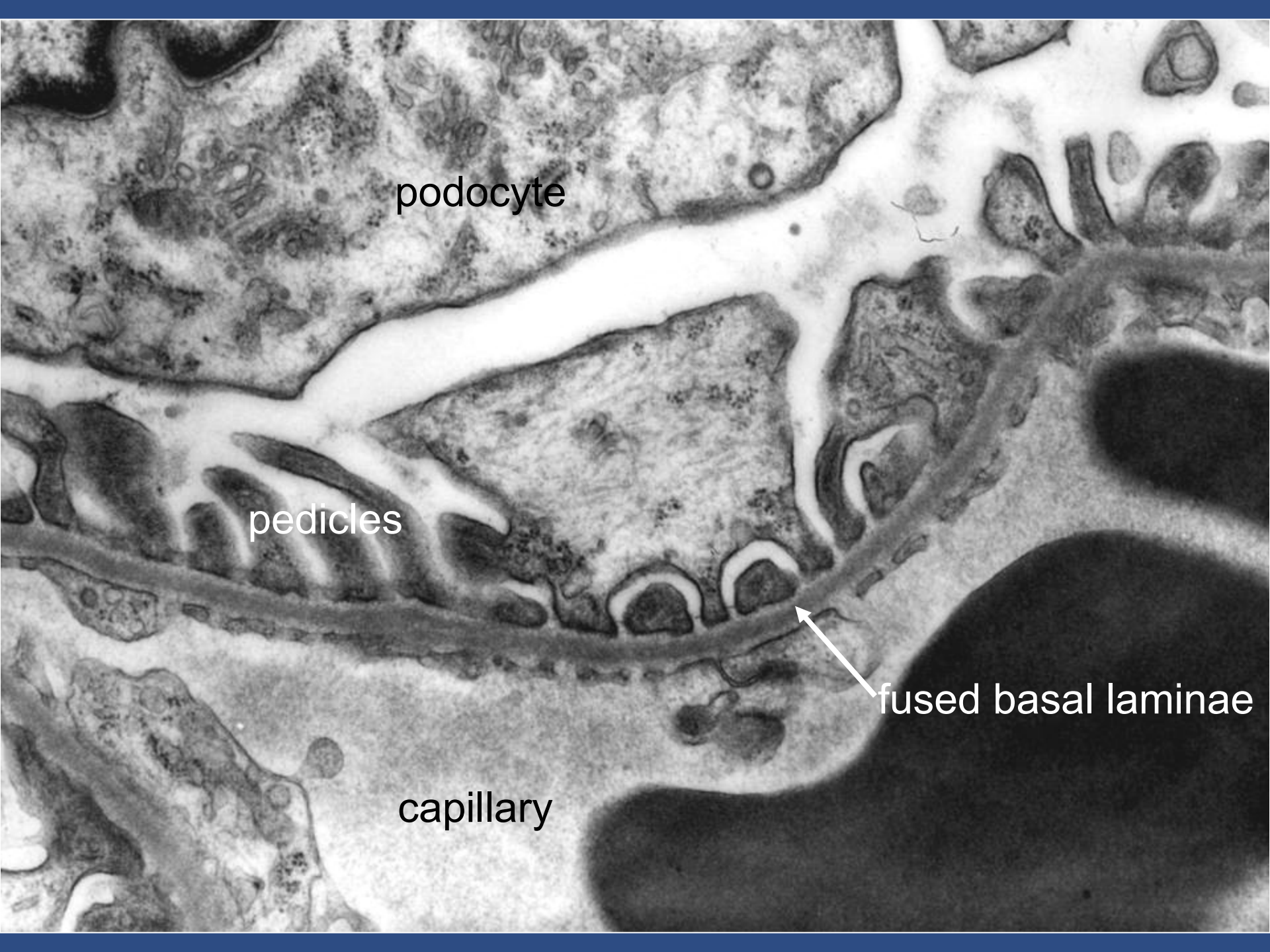




# Filtration's membrane

- endothelium of capillaries (fenestrations lack the diaphragm → in the fact – blood plasma flows through pores)
- complex of fused basal laminae of endothelium and podocytes = lamina rara subendothelialis, lamina densa (collagen IV → physical filter), lamina rara subepithelialis  
*laminae rariae contain heparansulfate (anion, it does not leak proteins with negative electric charge = ionic filter)*
- slit membrane between pedicles





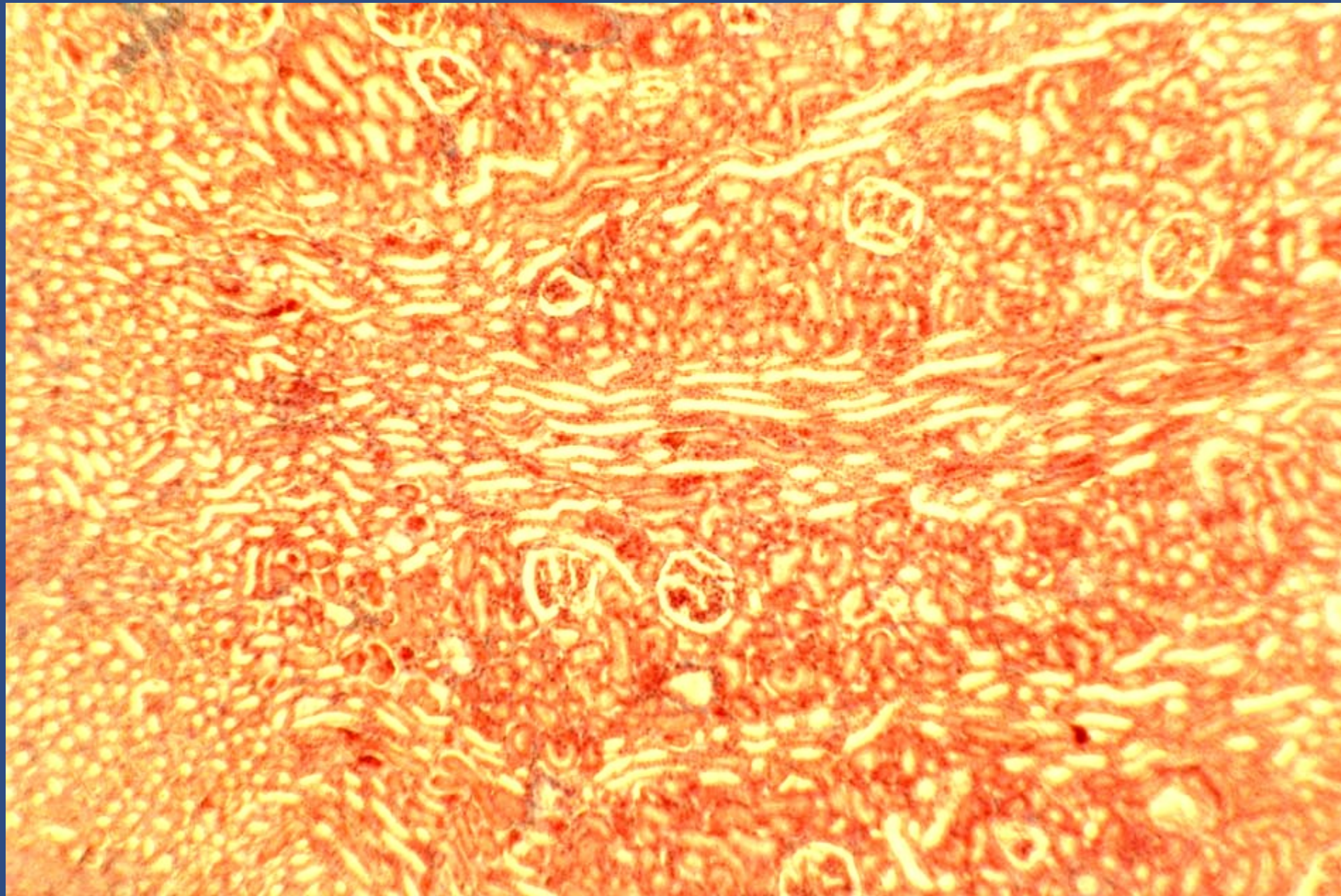
podocyte

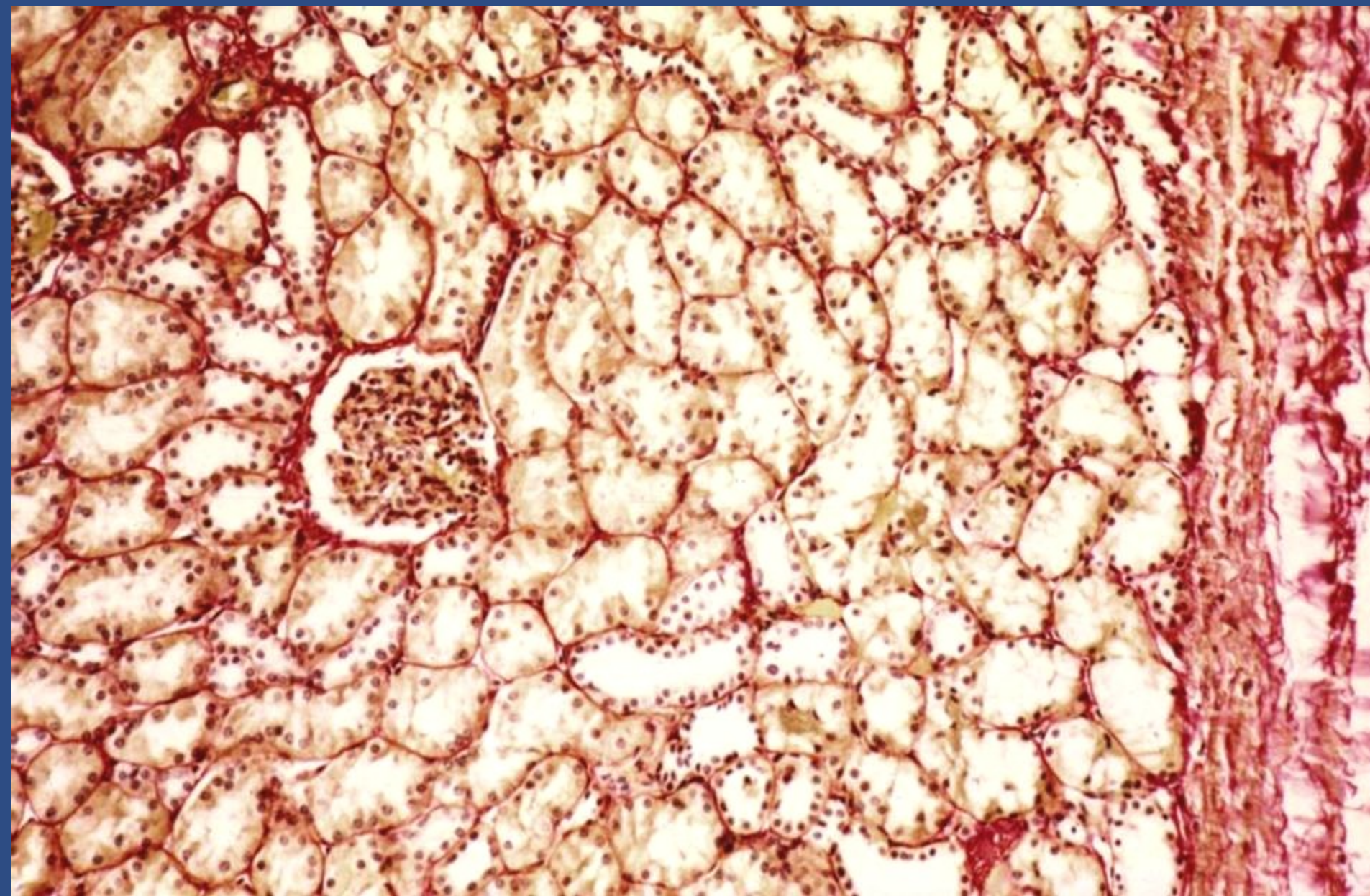
pedicles

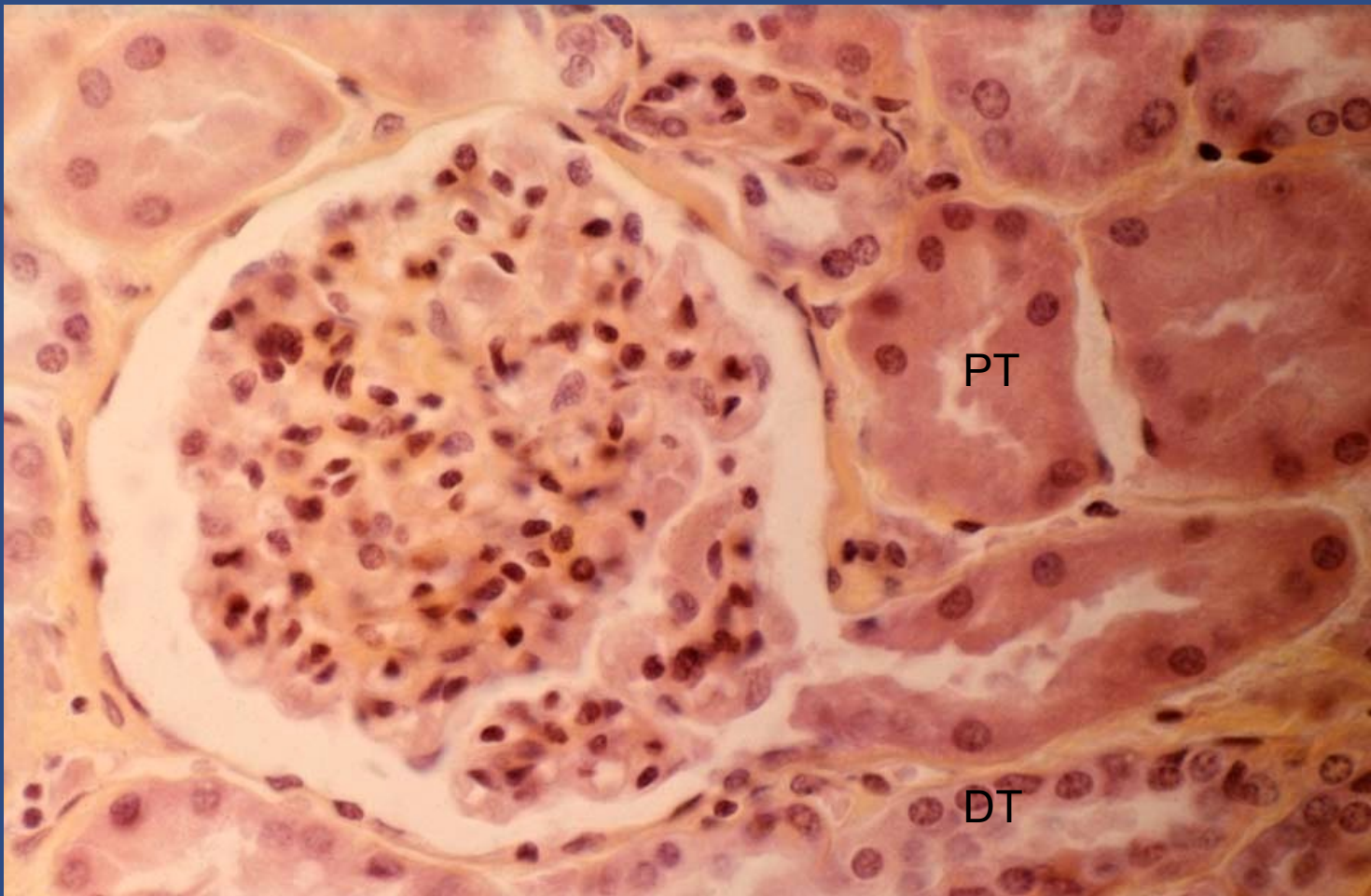
fused basal laminae

capillary

medullary rays = striae medullares







PT

DT

**PROXIMAL TUBULE (PT)**

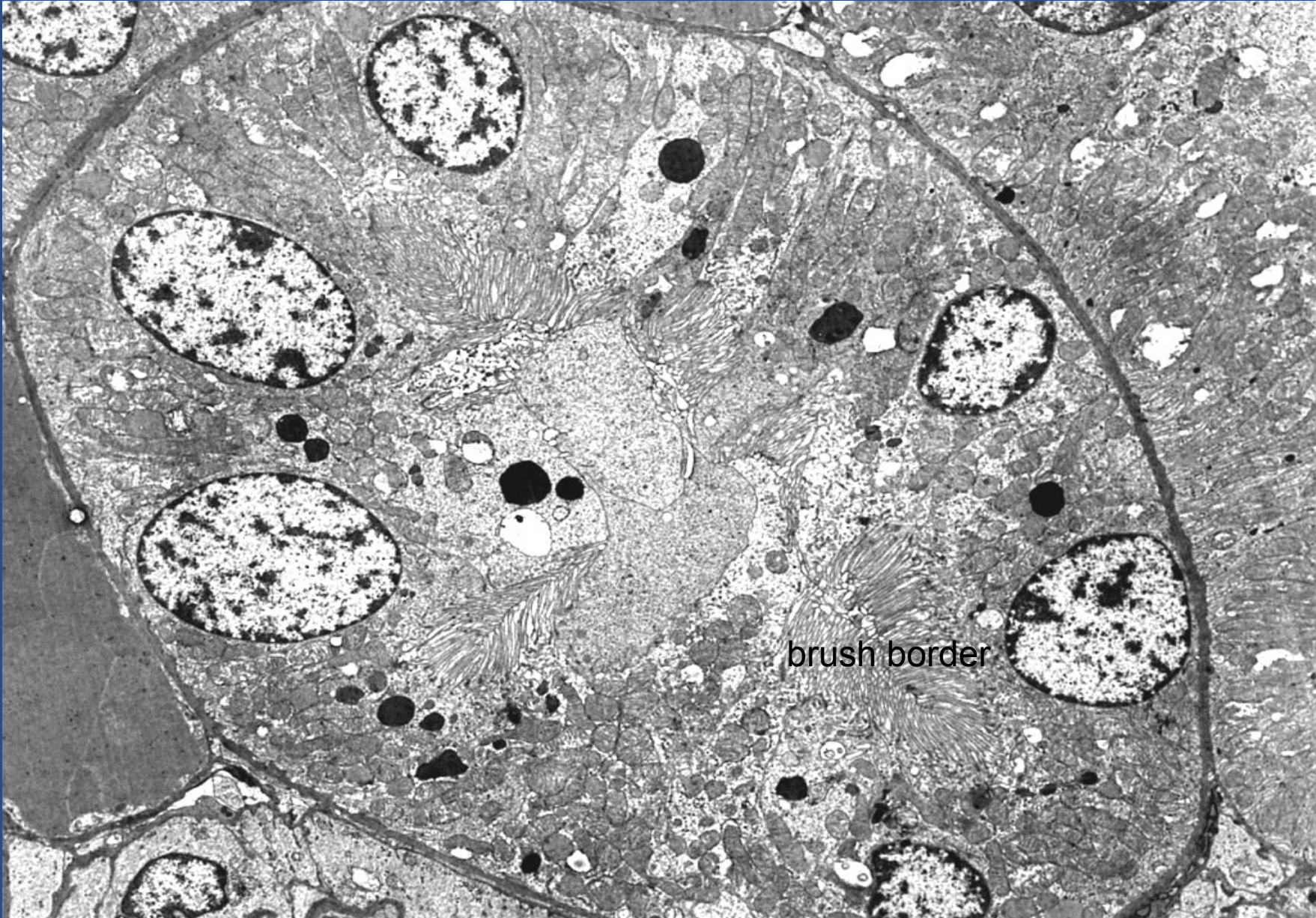
- convoluted portion in cortex
- straight portion in medullary rays
- simple low columnar epithelium
- eosinophilic cytoplasm
- brush border at apical surface (irregular outline of lumen)
- basal striation, dark nuclei in irregular distances

**DISTAL TUBULE (DT)**

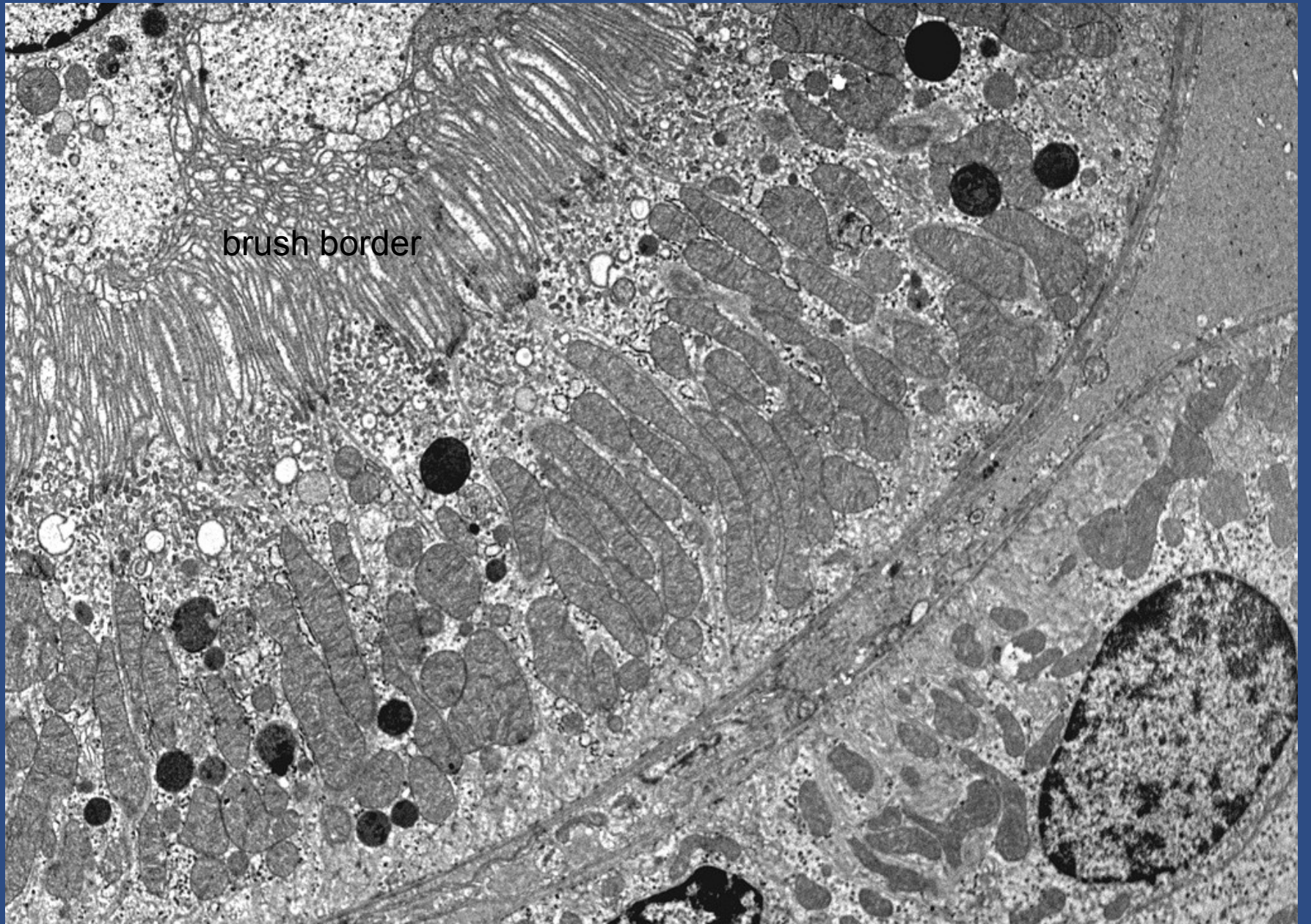
- convoluted portion in cortex
- straight portion in medullary rays
- simple cuboidal epithelium without brush border (wider lumen)
- less stained cytoplasm, regularly arranged spherical nuclei



Proximal tubule



brush border

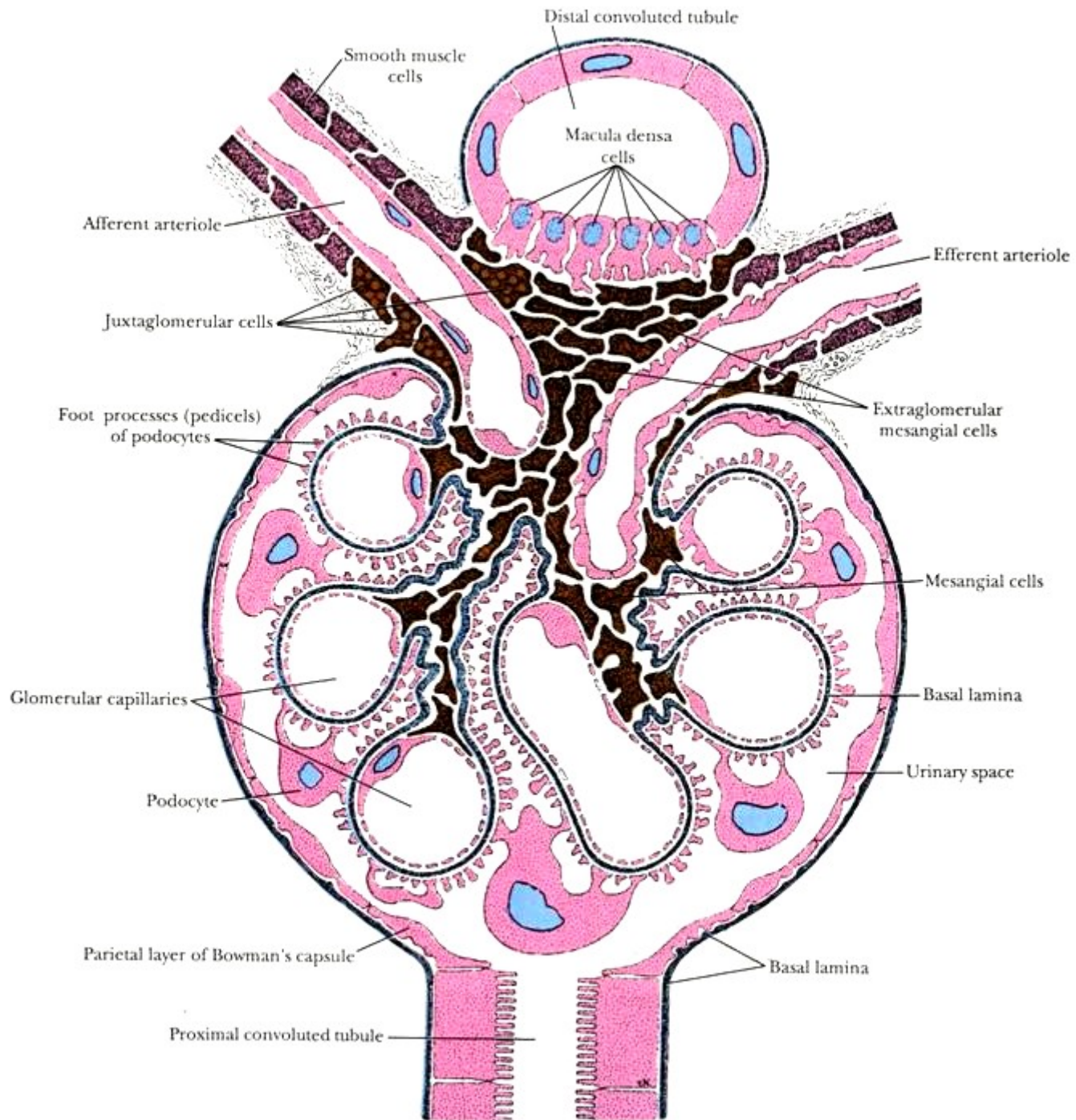


brush border

# Juxtaglomerular apparatus

## (renin production)

- **juxtaglomerular cells** (modified smooth muscle cells of tunica media of afferent arteriole) produce renin, it catalyses the cleavage of angiotensinogen to angiotensin I and II, which causes vasoconstriction resulting in increase of blood pressure
- **macula densa**: specialized region of distal tubule adjacent to the afferent arteriole, cells are packed in palisade manner (high columnar cells)
- **mesangial cells** (extraglomerular mesangium – modified fibroblasts at vascular pole) (*intraglomerular mesangium – in pathologic conditions – inflammation – lay down collagen*)



## MEDULLA OF KIDNEY (CROSS SECTION)

- **Loop of Henle**

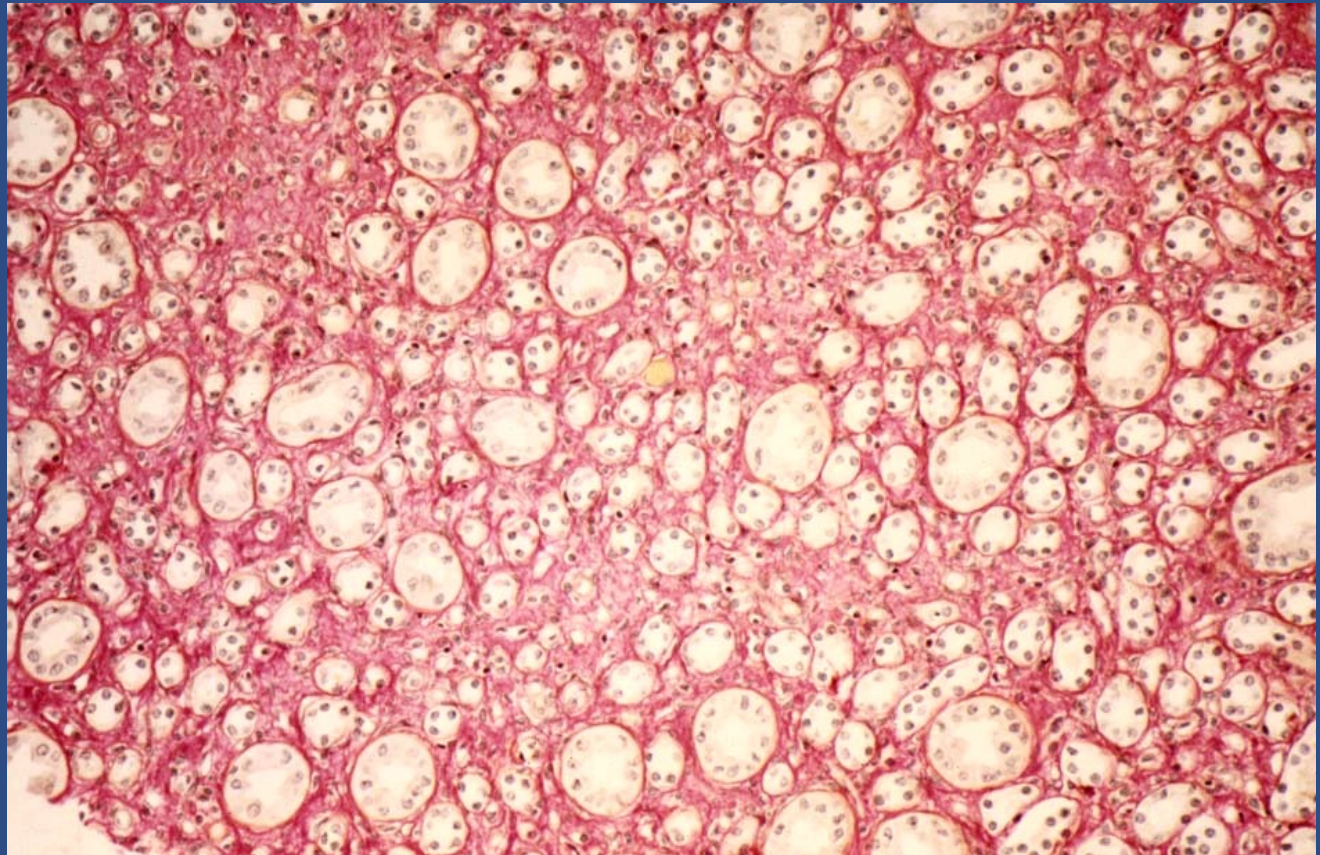
thin segment – simple squamous epithelium

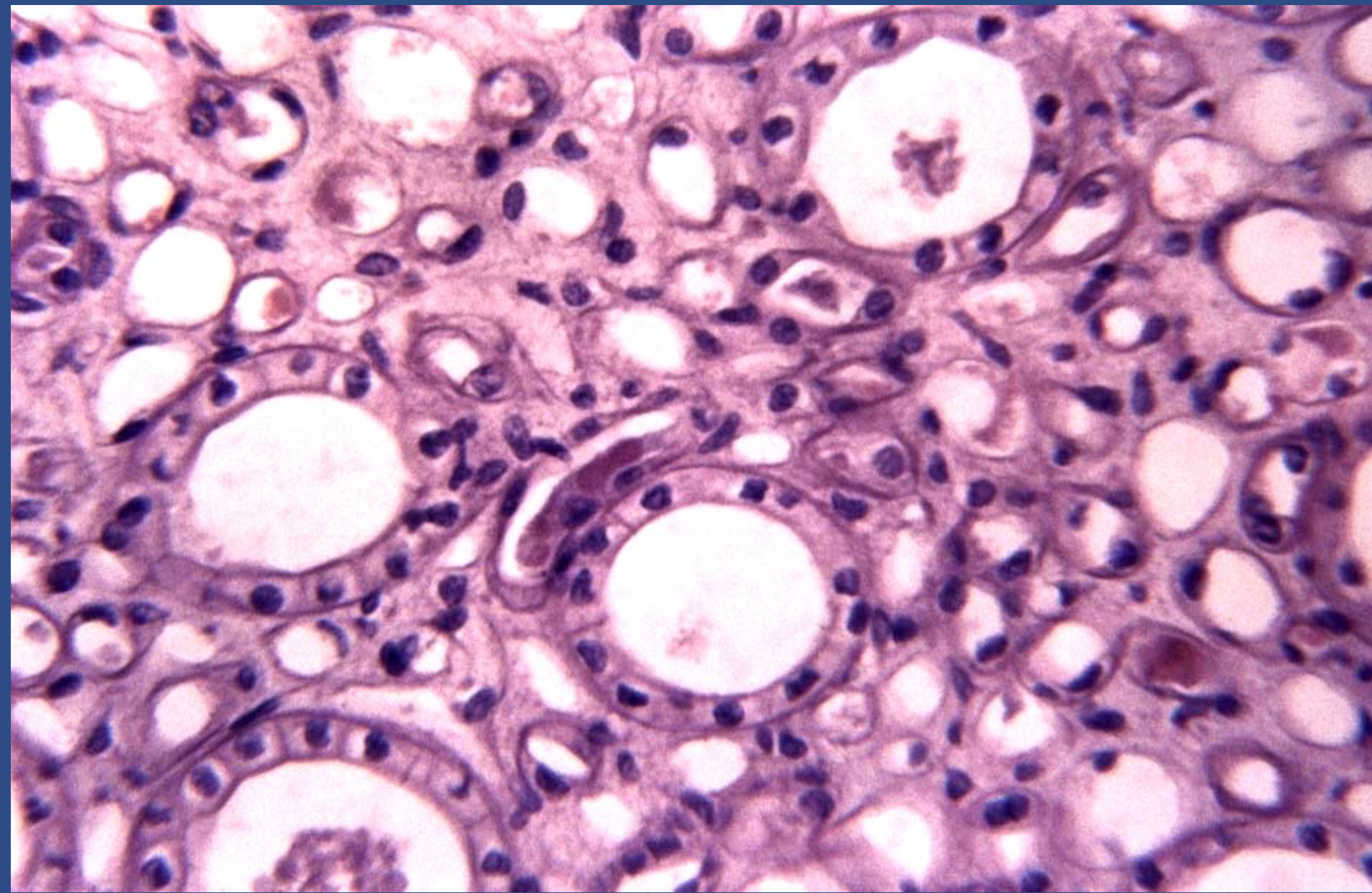
thick segment – similar epithelium as in distal tubule

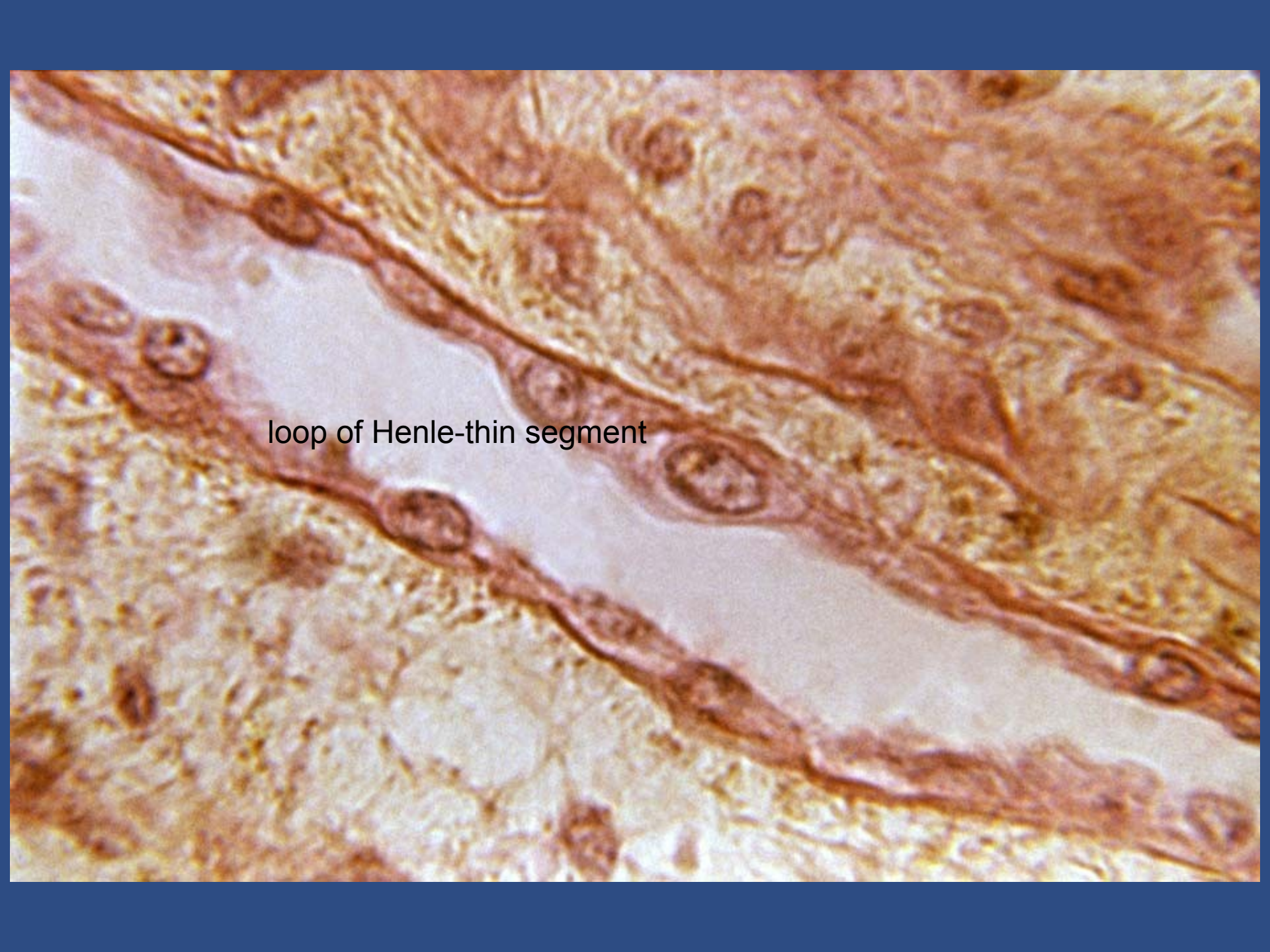
- **Collecting tubules**

pass down in a medullary rays and through the outer zone of medullary pyramids, converge and join to form large ducts of Bellini (ductus papillares) which open on the area cribrosa at apex of each papilla

epithelium simple cuboidal to columnar, pale stained cytoplasm, apical convexity of the surface

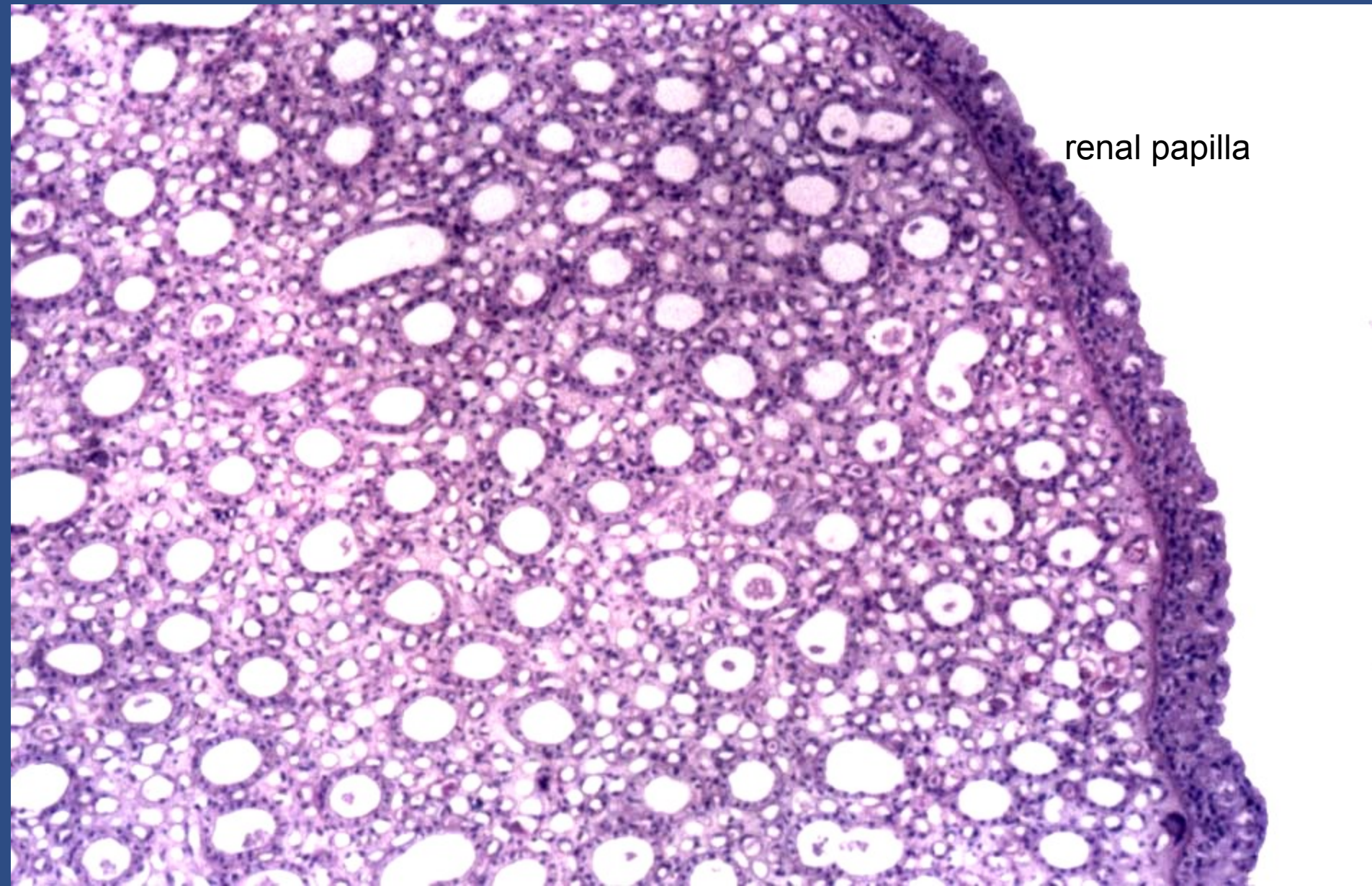




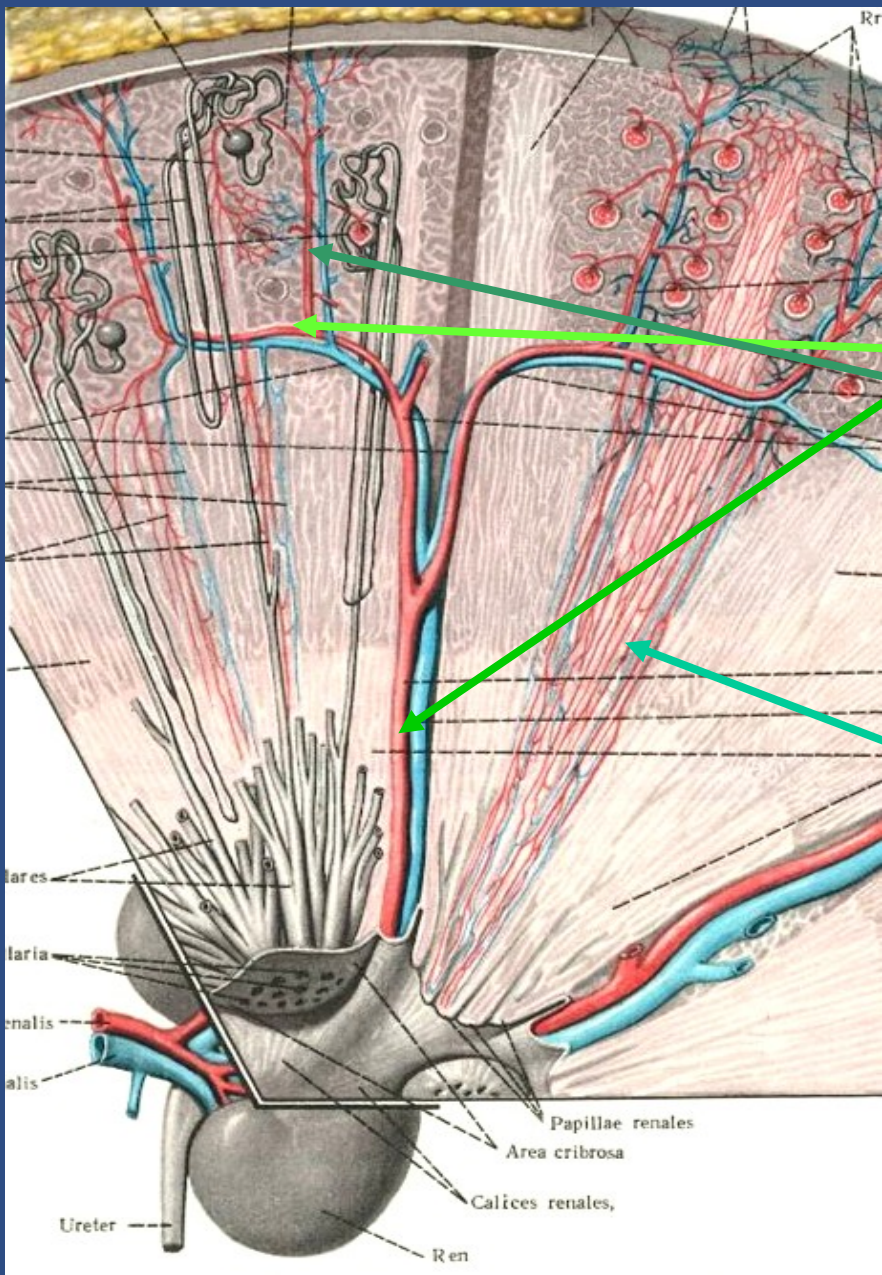
A light micrograph of a kidney section stained with hematoxylin and eosin (H&E). The image shows a cross-section of the renal cortex. A prominent feature is the loop of Henle, which is a U-shaped structure. The thick part of the loop is the descending limb, and the thin part is the ascending limb. The thin segment is characterized by a simple cuboidal epithelium. The surrounding tissue is the renal interstitium, which contains various cells and blood vessels. The overall color is a mix of pink and purple.

loop of Henle-thin segment

renal papilla







## Blood circulation in kidney:

- a. renalis
- aa. interlobares
- aa. arcuatae
- aa. interlobulares
- afferent arteriole
- glomerulus
- efferent arteriole
- capillary bed peritubular+  
vasa recta
- vv. interlobulares
- vv. arcuatae
- vv. interlobares
- vv. renales

**Portal system of kidney – 2 following capillary beds !!!**

# Urinary passages

## ● **intrarenal:**

collecting tubules and ducts (tubuli colligentes and ductus colligentes)  
papillary ducts (ductus papillares)

## ● **extrarenal:**

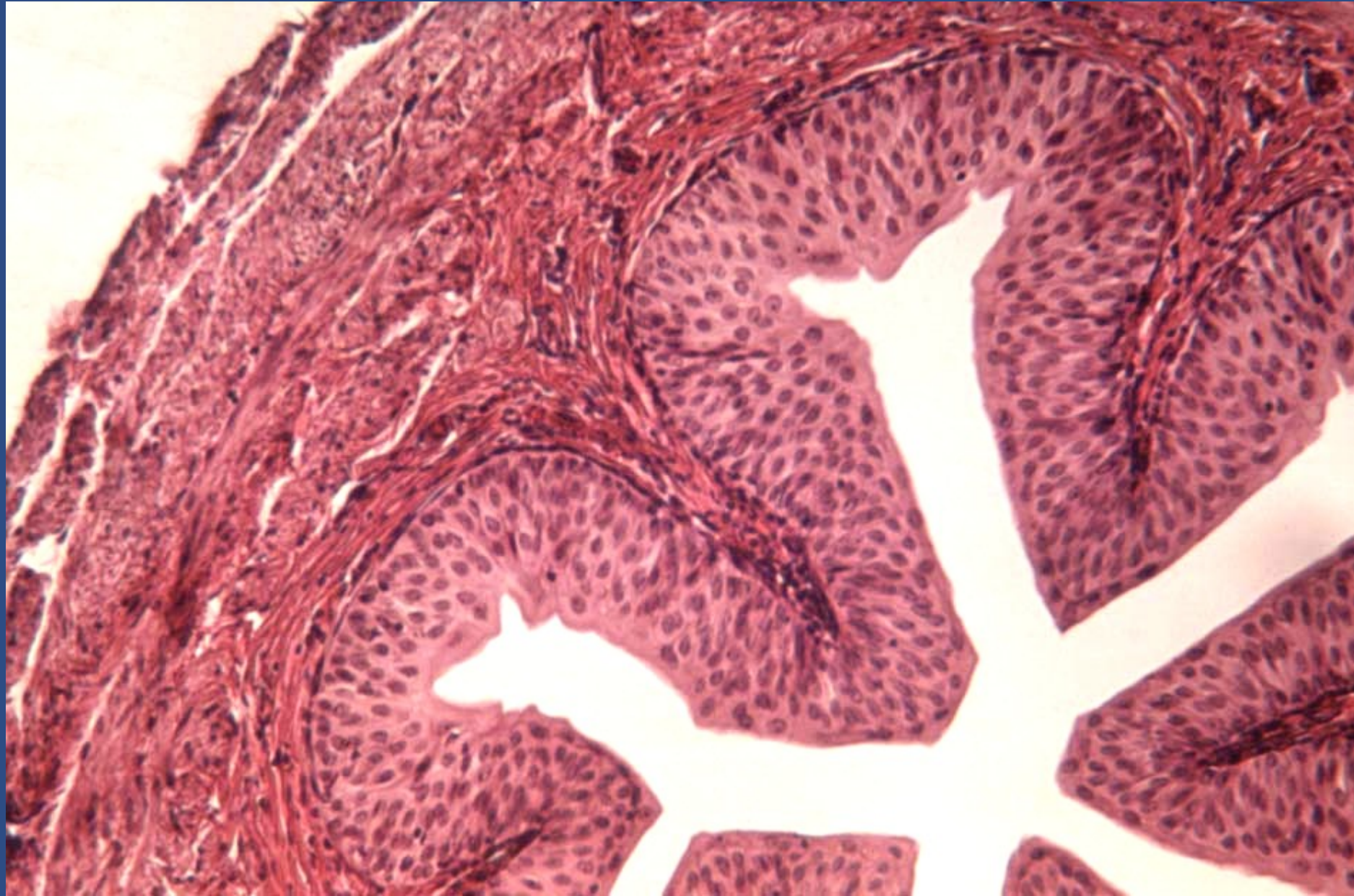
minor calyces (calyces minores)  
major calyces (calyces majores)  
renal pelvis (pelvis renalis)  
ureter  
urinary bladder (vesica urinalis)  
urethra (feminina, masculina)

# Extrarenal urinary passages

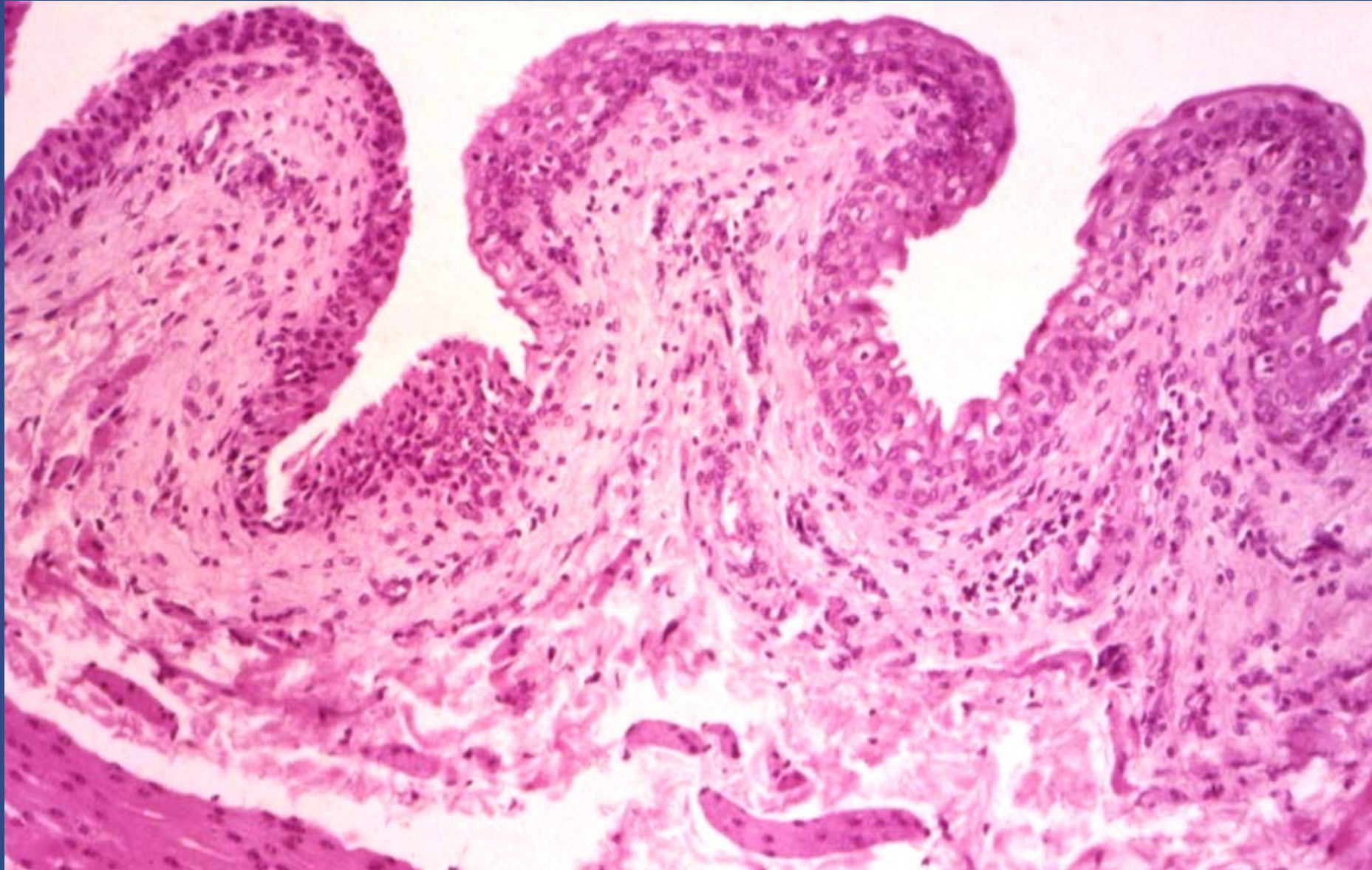
The wall consists of (general structure of hollow organs):

- ❶ **tunica mucosa:** epithelium (transitional), lamina propria mucosae
- ❷ **tunica muscularis:** smooth muscle tissue arranged into 2 or 3 (lower 1/3 of ureter, urinary bladder) layers, inner longitudinal, outer circular
- ❸ **adventitia** (urinary bladder – partly serosa)

# Ureter



# Urinary bladder



# URETHRA

**MALE:** long (15-20 cm)

**pars intramuralis, prostatica, membranacea, spongiosa (cavernosa)**

- **tunica mucosa** (longitudinal folds) – epithelium and lamina propria (transitional epithelium in intramural and prostatic part, pseudostratified or stratified columnar epithelium in remainder parts, stratified squamous in fossa navicularis)  
**glands:** mucous (endoepithelial: lacunae Morgagni, exoepithelial: paraurethral glands of Littre in lamina propria), lamina propria – numerous venous plexuses
- **tunica muscularis externa:** inner longitudinal, outer circular
- **adventitia**

**FEMALE:** shorter (3-4 cm)

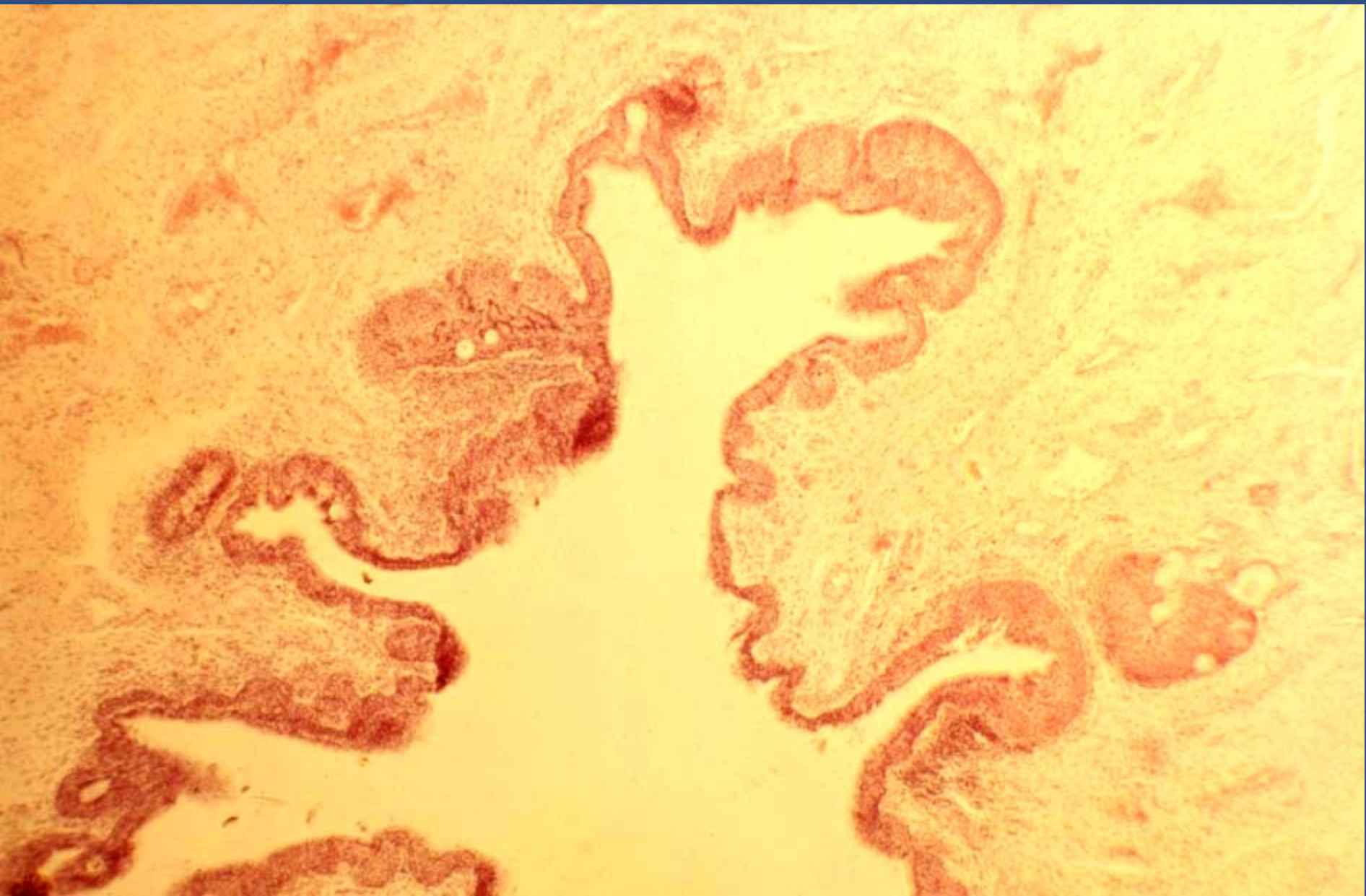
- **tunica mucosa** (longitudinal folds) – epithelium and lamina propria (transitional epithelium in short intramural part, stratified squamous in remainder parts), mucous **glands of Littre** in lamina propria
- **tunica muscularis externa**
- **adventitia**

# Male urethra



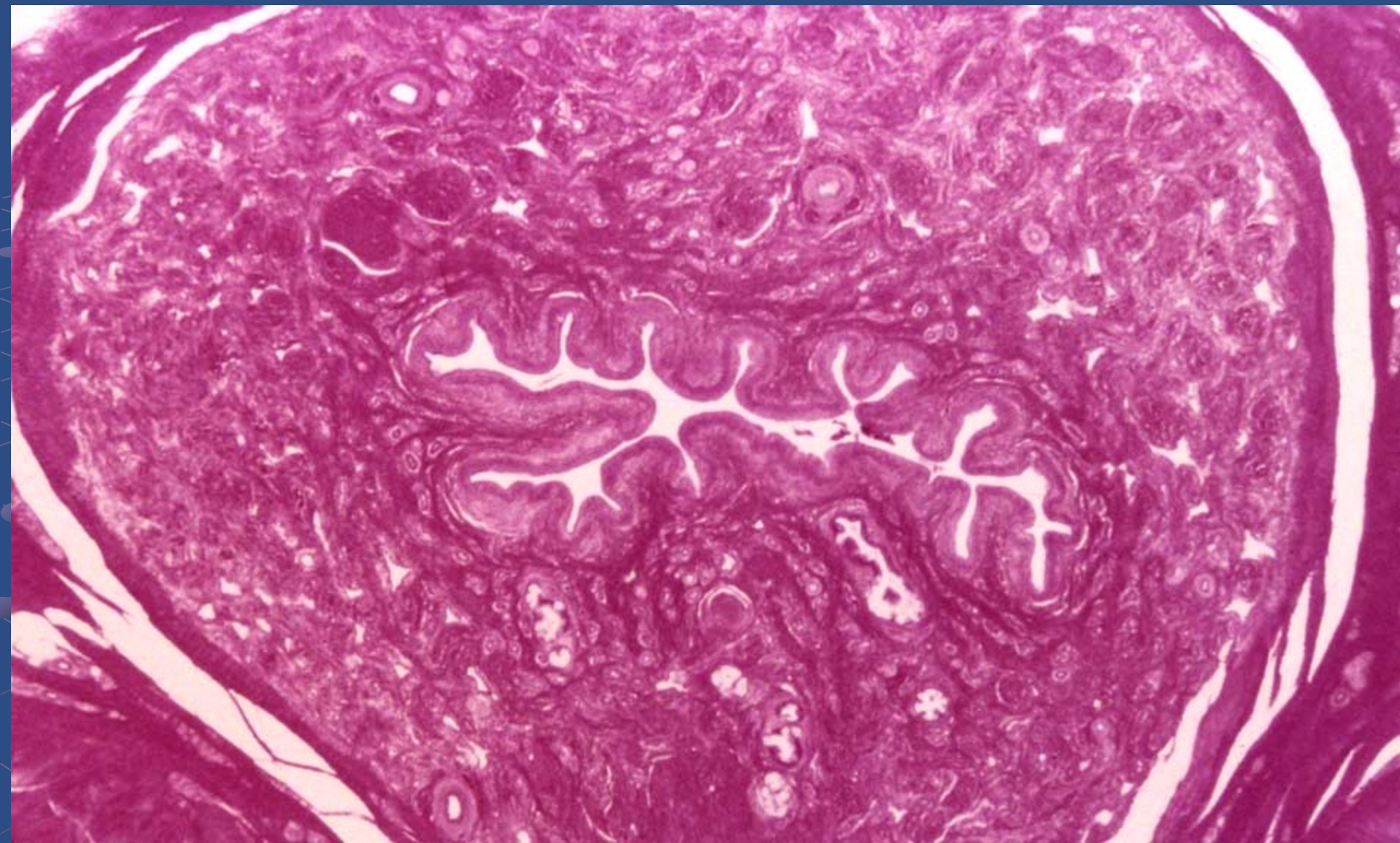
**lacunae Morgagni**

# Male urethra





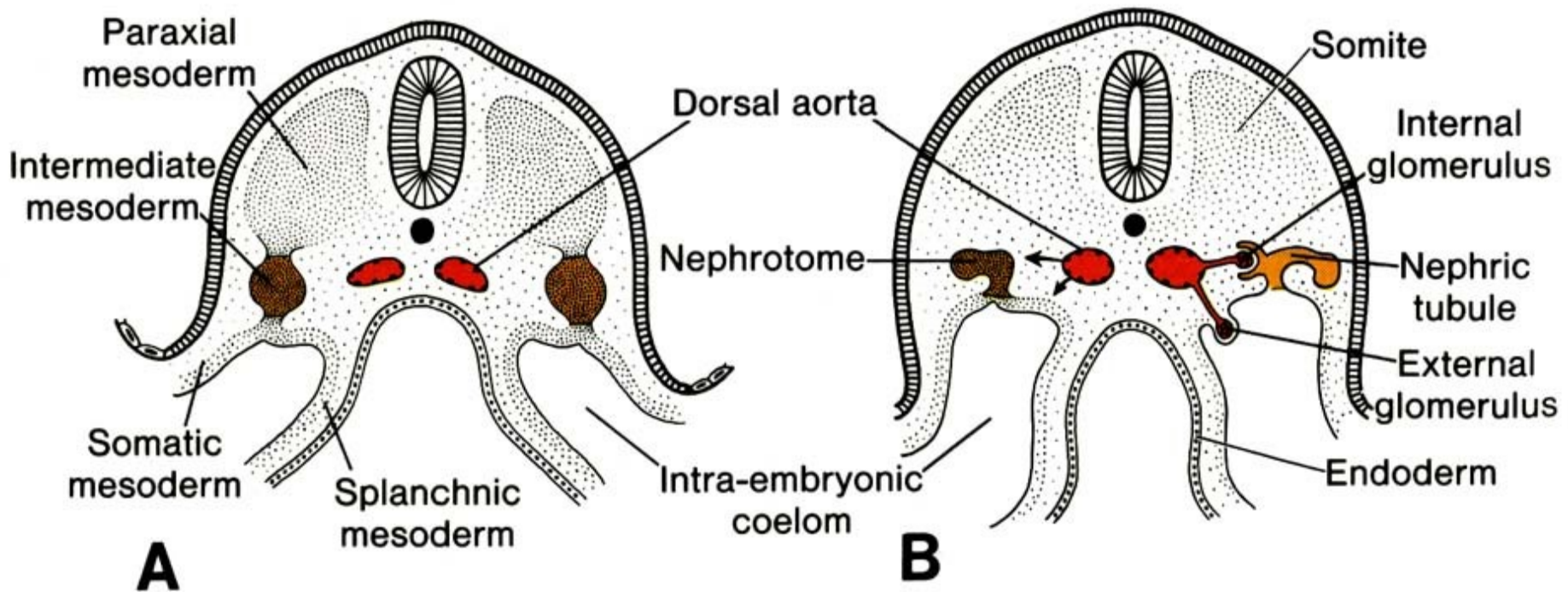
# Male urethra



# Development of urinary system

- Is bound with development of genital tract
- Excretory component: mesoderm of nephrotomes
- Urinary passages: mesoderm of nephrotomes and endoderm of cloaca
- 3 temporary (slightly overlapping), anatomically and functionally defined stages:
  1. Pronephros
  2. Mesonephros
  3. Metanephros

Nephrotomes: intermediate mesoderm loses contact with somite and forms segmentally arranged cell clusters, they obtain a lumen and establish nephric tubules. Medial ends are in contact with arteries (glomeruli), lateral ends grow caudally to form longitudinal duct (Wolffian duct)

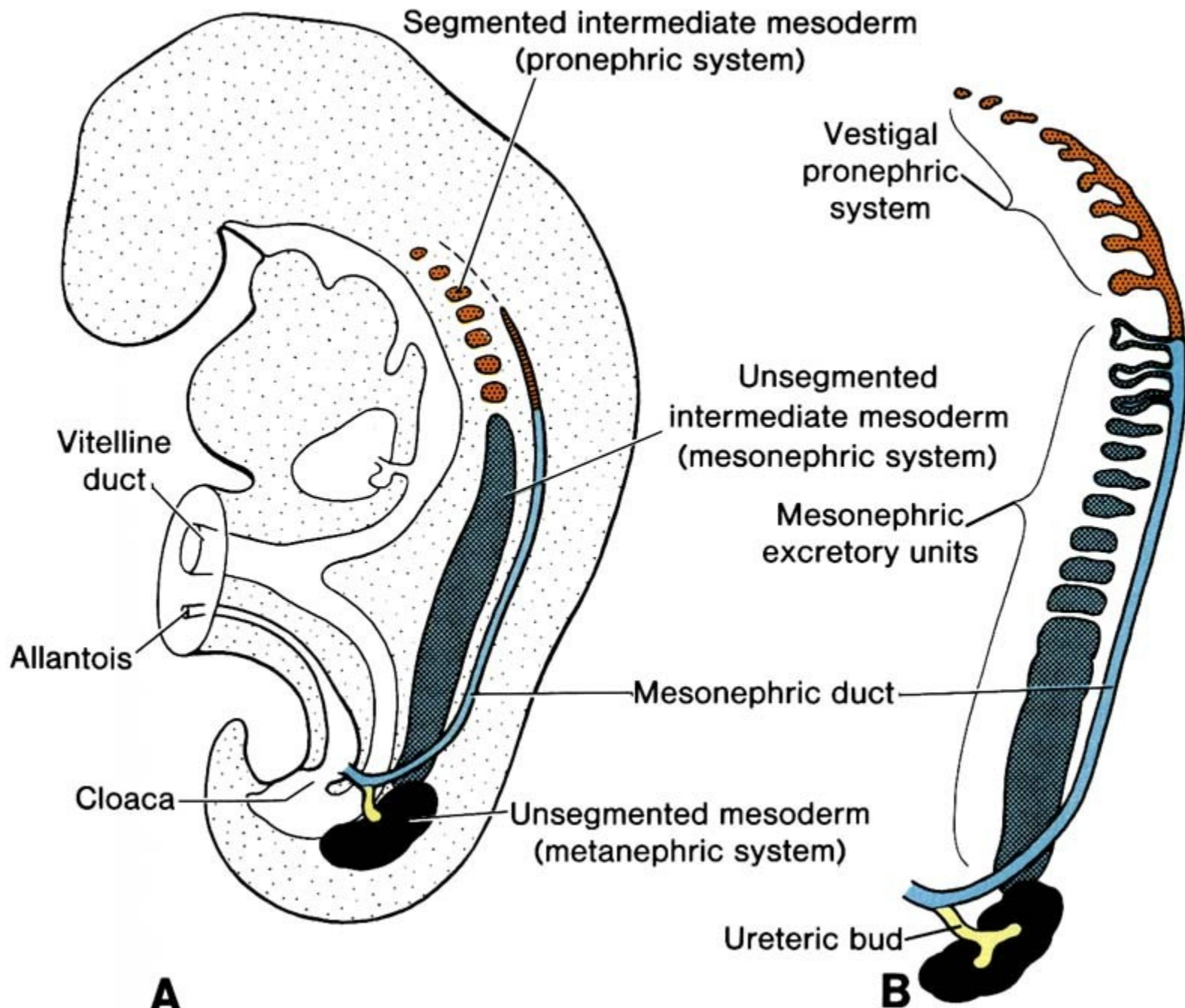


■ **Pronephros** (rudimentary, nonfunctional) – at the end of 3rd week of development, cervical region (cranial 10-12 somites), disappearance at the end of 4th week, Wolffian duct remains – ductus mesonephricus)

■ **Mesonephros** (Wolffian body) – during 4th week (day 22 to day 23), C6 – L3, maximal extent at the beginning of 2nd month

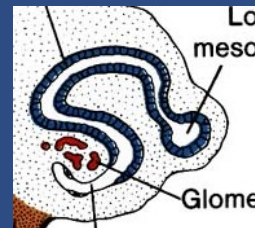
■ **Metanephros** (permanent kidney) – during 5th week, L4 – L5

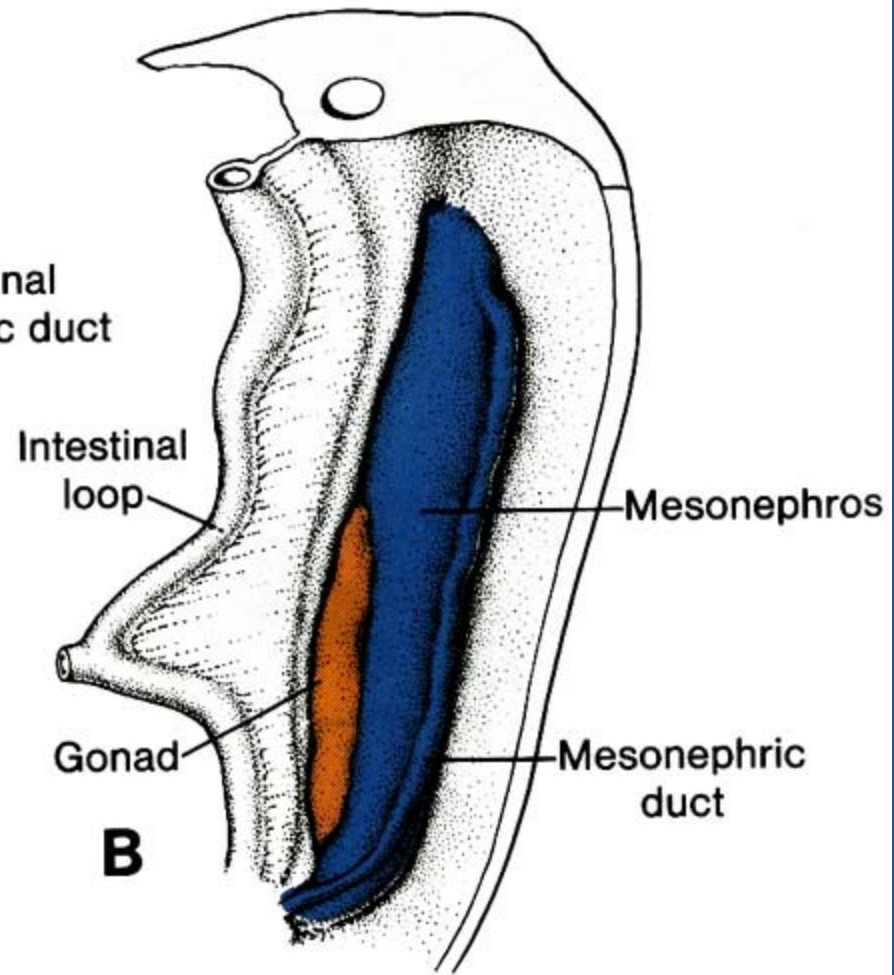
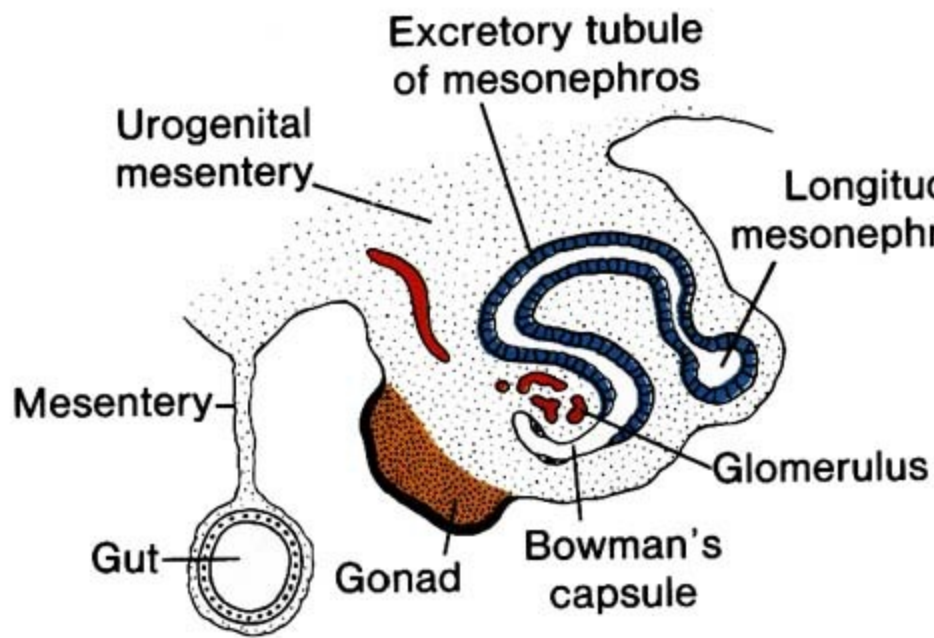
*Ureteric bud – from caudal end of Wolffian duct*



# Mesonephros

- During regression of pronephros, the first excretory tubules of mesonephros appear.
- Nephrotomes C6-L3 fuse and divide into secondary clumps (about 50).
- They luminize, lengthen, form S-shaped tubules and acquire glomeruli (Bowman's capsule → renal corpuscle).
- The opposite ends open into mesonephric duct (Wolffian).
- Large ovoid body on each side of the midline – urogenital ridge.
- While caudal units differentiate, the cranial disappear.
- A few caudal tubules persist in the male.

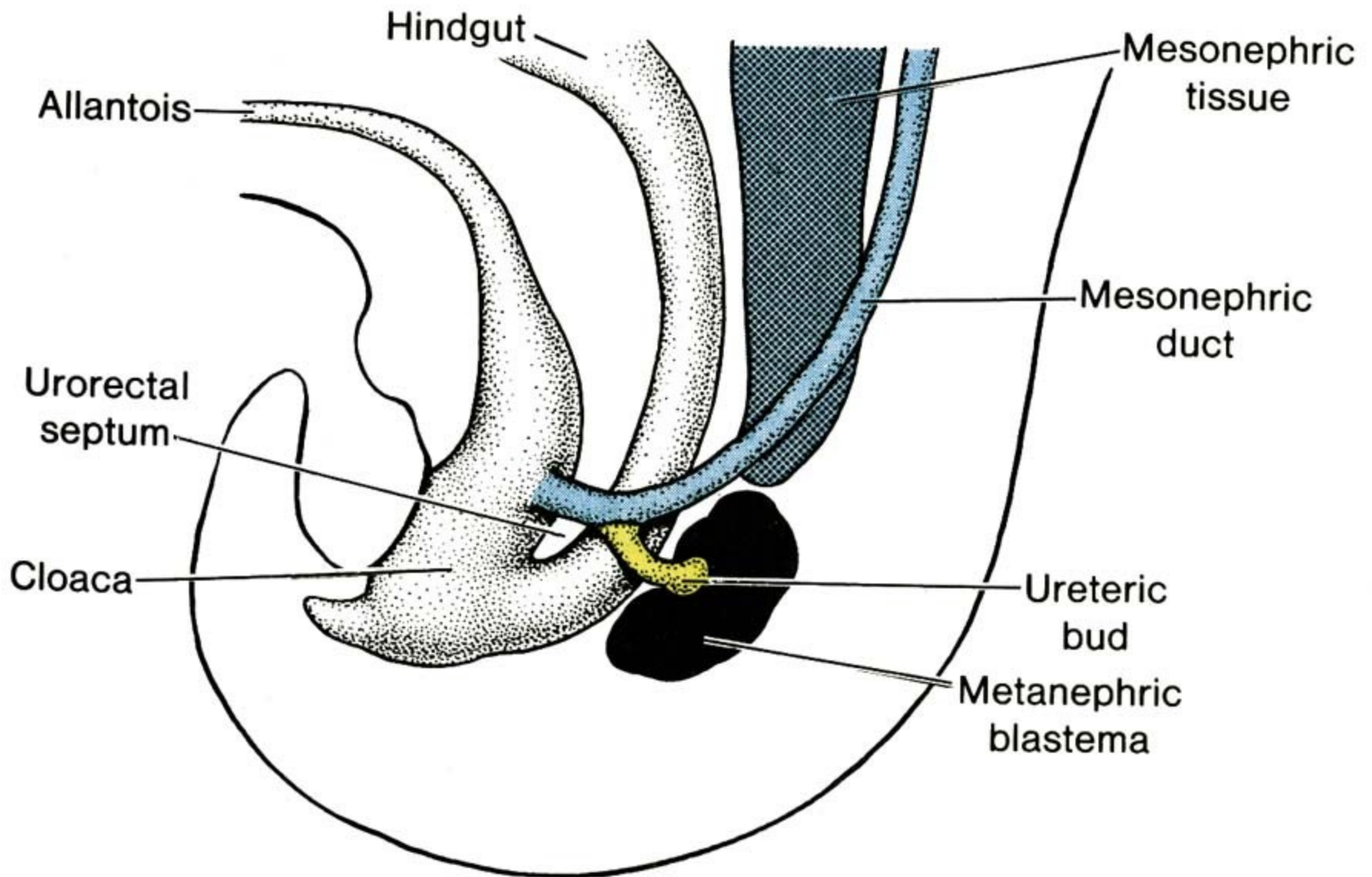




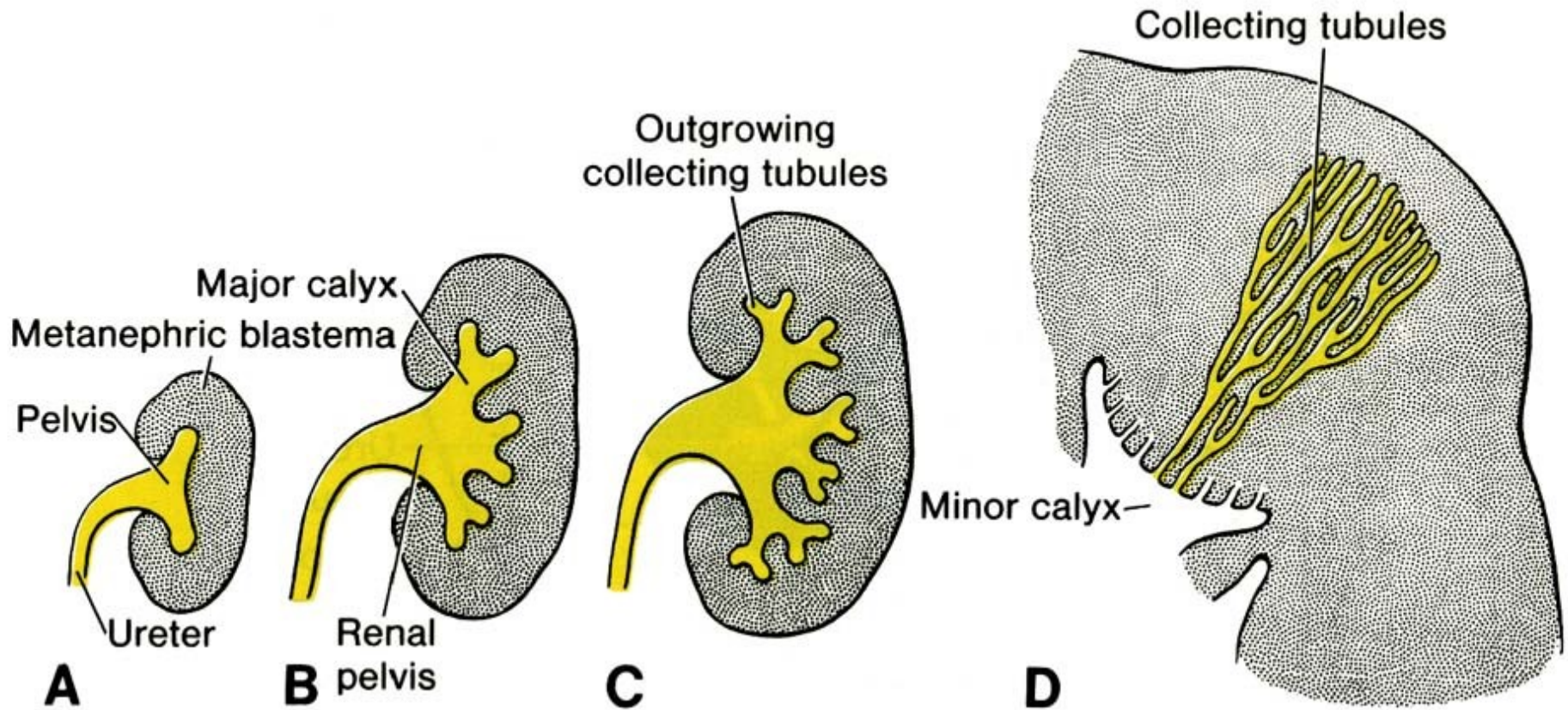
# Metanephros (permanent kidney)

- During 5th week.
- Excretory units - similar manner as mesonephric system.
- Collecting ducts develop from ureteric bud (metanephric diverticulum) – an outgrowth of mesonephric duct close to the cloaca.
- Bud penetrates the metanephric tissue, dilates (to form renal pelvis) and splits into cranial and caudal portion (major calyces).
- Each calyx forms two new buds and continue to subdivide until 12 or more generations of tubules have been formed.
- Derivatives of ureteric bud: ureter, renal pelvis, major and minor calyces, 1 to 3 million collecting tubules



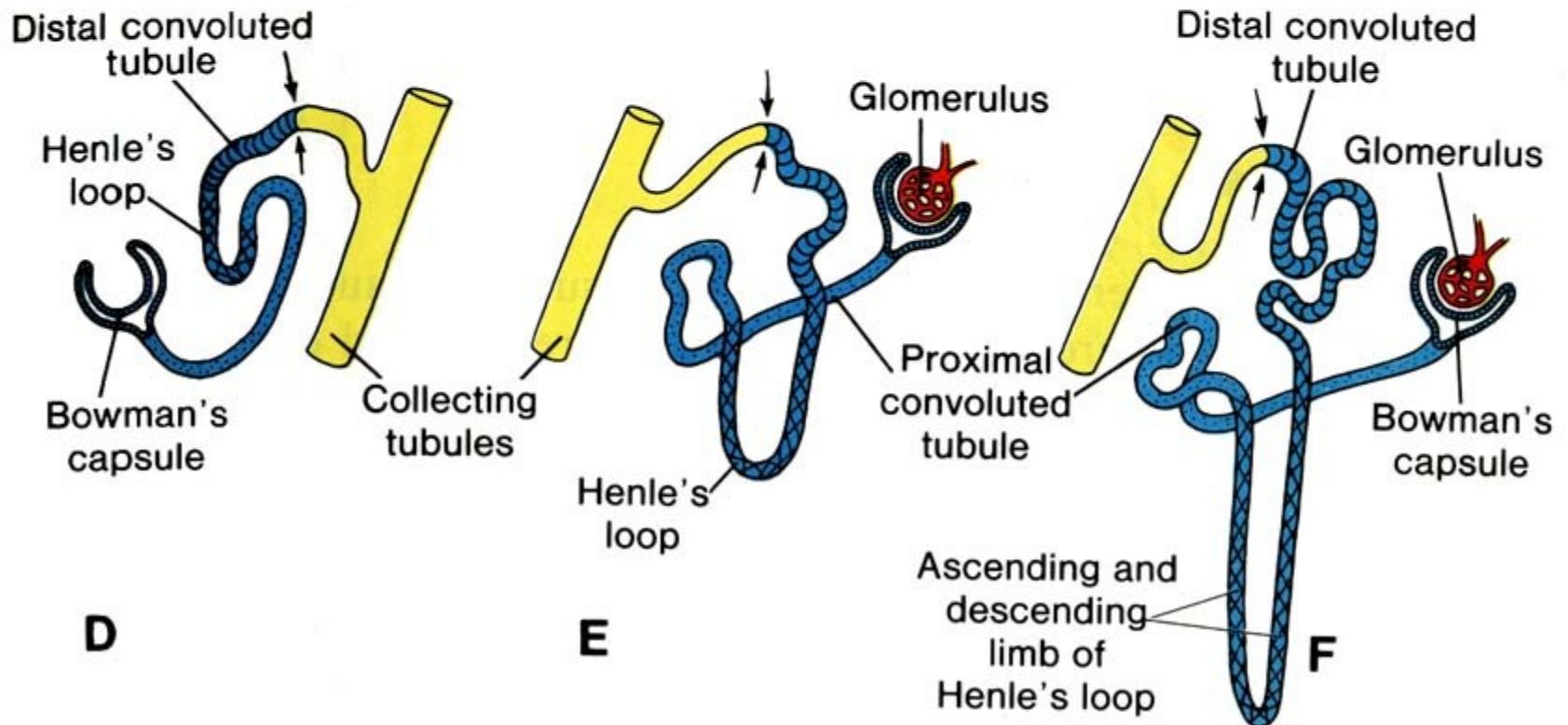
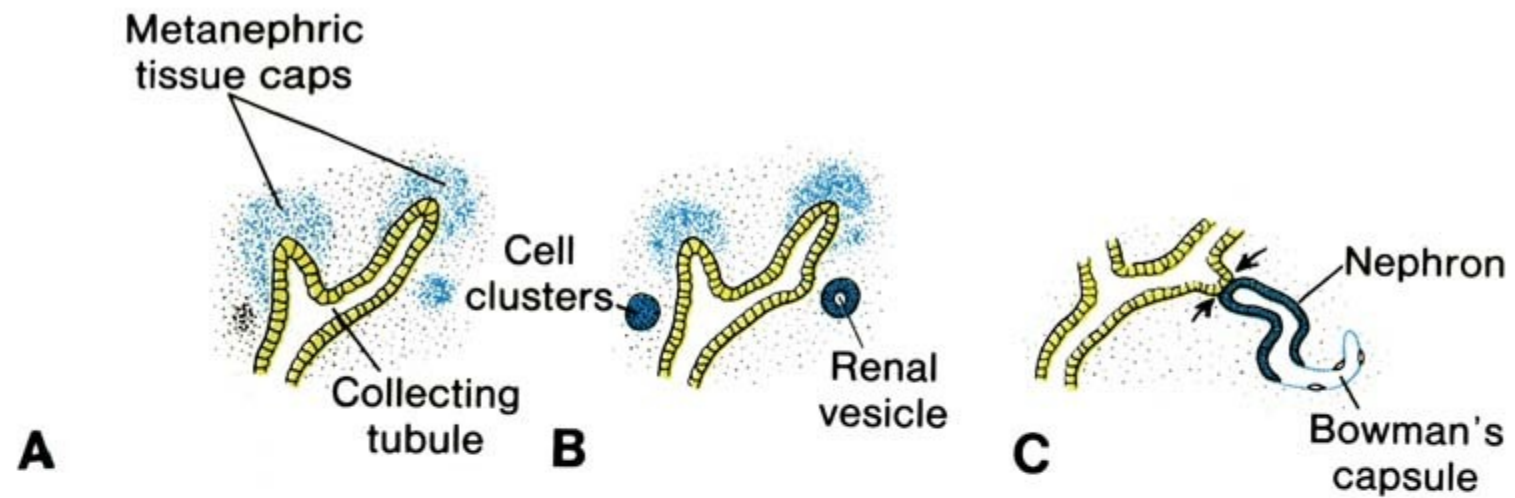


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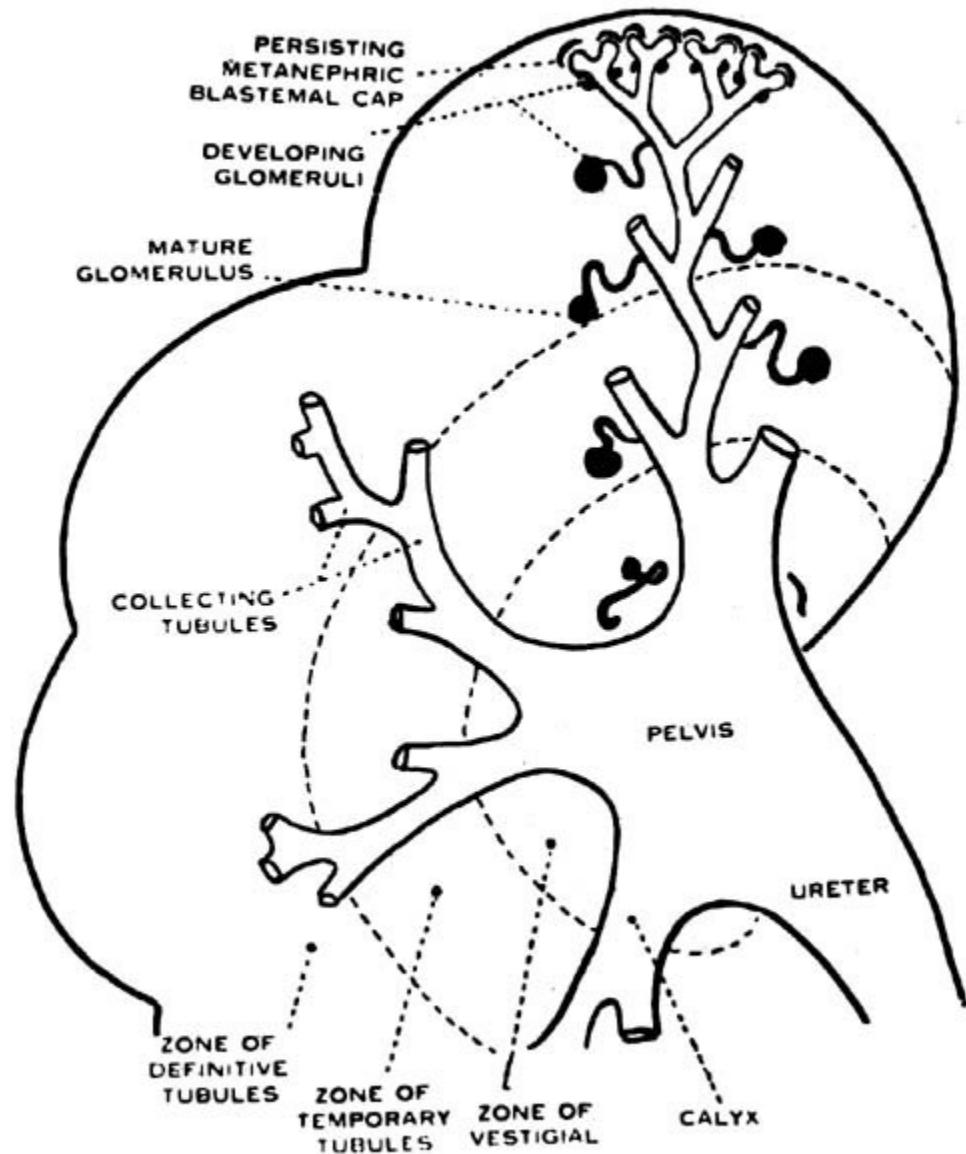
# Excretory system of metanephros

- Each collecting tubule is covered by a metanephric tissue cap.
- Inductive influence of tubule → cells form vesicles which lengthen into tubules.
- These tubules together with capillaries (glomeruli) form nephrons.
- Proximal end of tubule forms Bowman's capsule, distal end forms connection with collecting tubule.
- Continuous lengthening of tubule results in formation of proximal tubule, loop of Henle and distal tubule.



At birth – the kidney is lobulated, lobules disappear during infancy.

Kidney is initially located in the pelvis region, later it shifts to more cranial position



# Development of urinary bladder and urethra

- Cloaca is divided by urorectal septum into anorectal canal and primitive urogenital sinus during 4th and 7th weeks.
- 3 portions of primitive urogenital sinus:
  - upper - urinary bladder (continuous with allantois → obliteration, urachus)
  - middle – pelvic part (in male: prostatic and membranous part of urethra)
  - lower: phallic part (in male: penile part of urethra)
- Caudal portions of mesonephric duct are absorbed into wall of urinary bladder → ureters (initially outbuddings of mesonephric ducts) enter the bladder separately.

