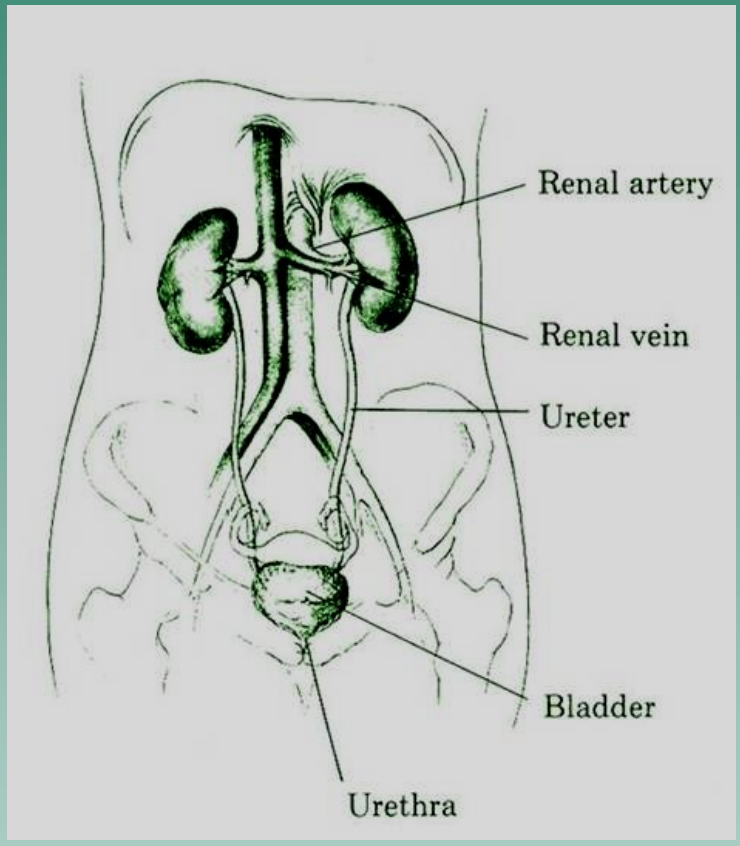
Lecture 3 ESS_3rd semester

MICROSCOPIC STRUCTURE OF THE URINARY SYSTEM

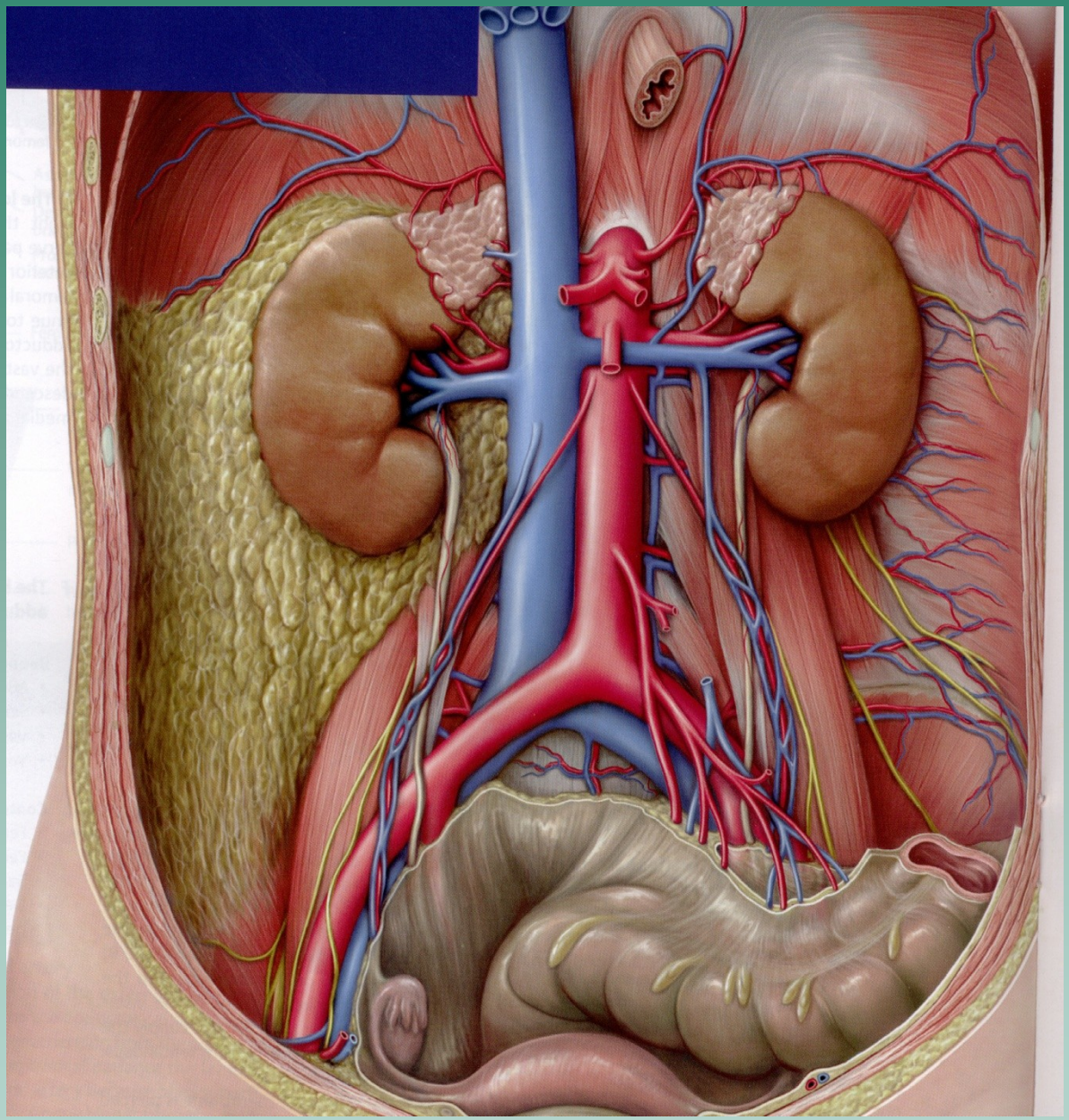
/ STAGES IN DEVELOPMENT OF KIDNEYS (pro-, meso-, and metanephros)/

MICROSCOPIC STRUCTURE OF THE URINARY SYSTEM

- paired kidneys + ureters
- unpaired bladder + urethra



Function:
- formation and elimeination of urine
- regulation of fluid and electrolytic balance of the body´s internal millieu
- production of some hormones - renin, erythropoietin
- conveyance of gamets (the urethra in males)



Kidney

- bean-shaped organ located on dorsal wall of the abdominal cavity (in retroperitoneal position)

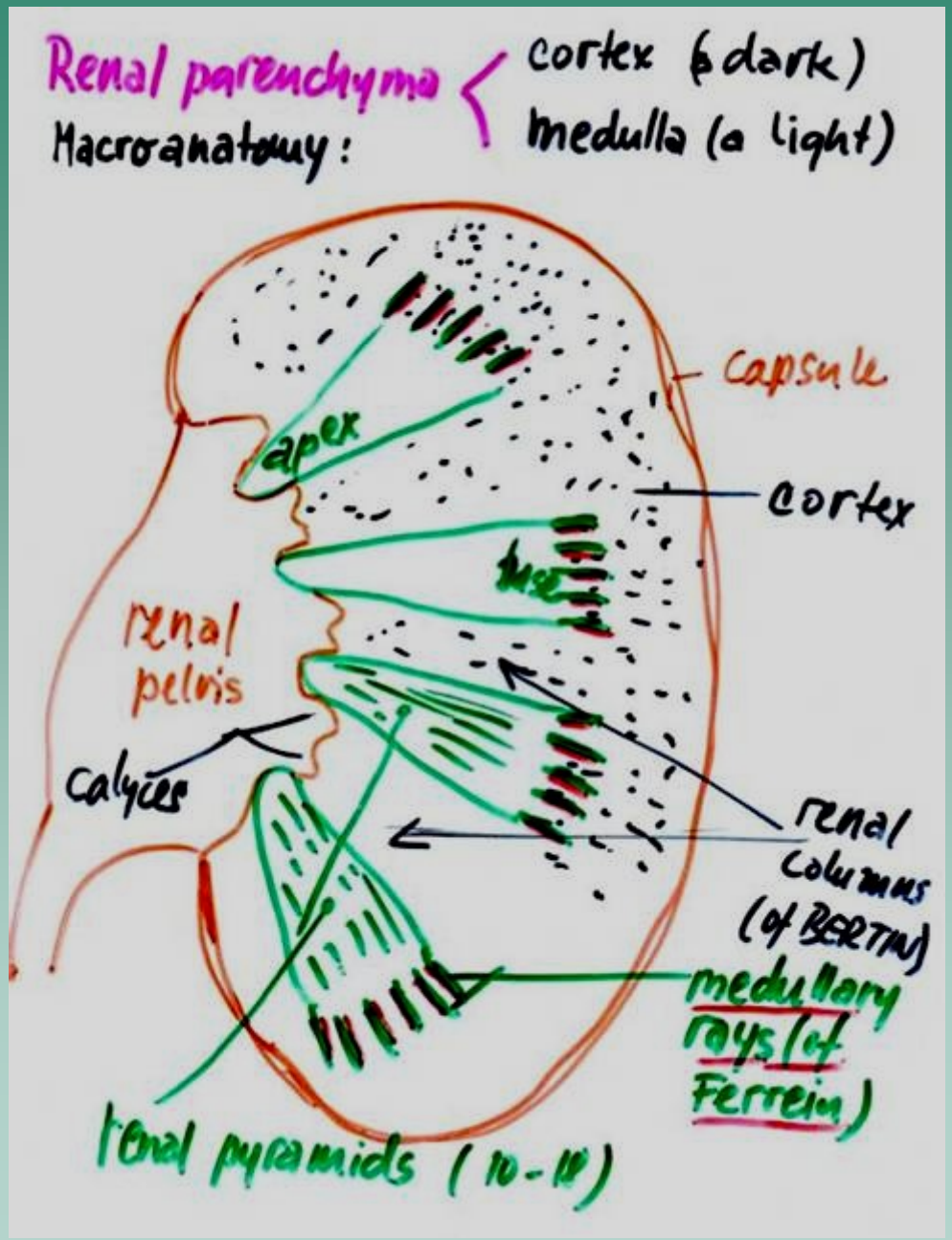
- size - 10-12 cm, 5-6 cm wide and 2-4 cm thick

- hilum + convex aspect

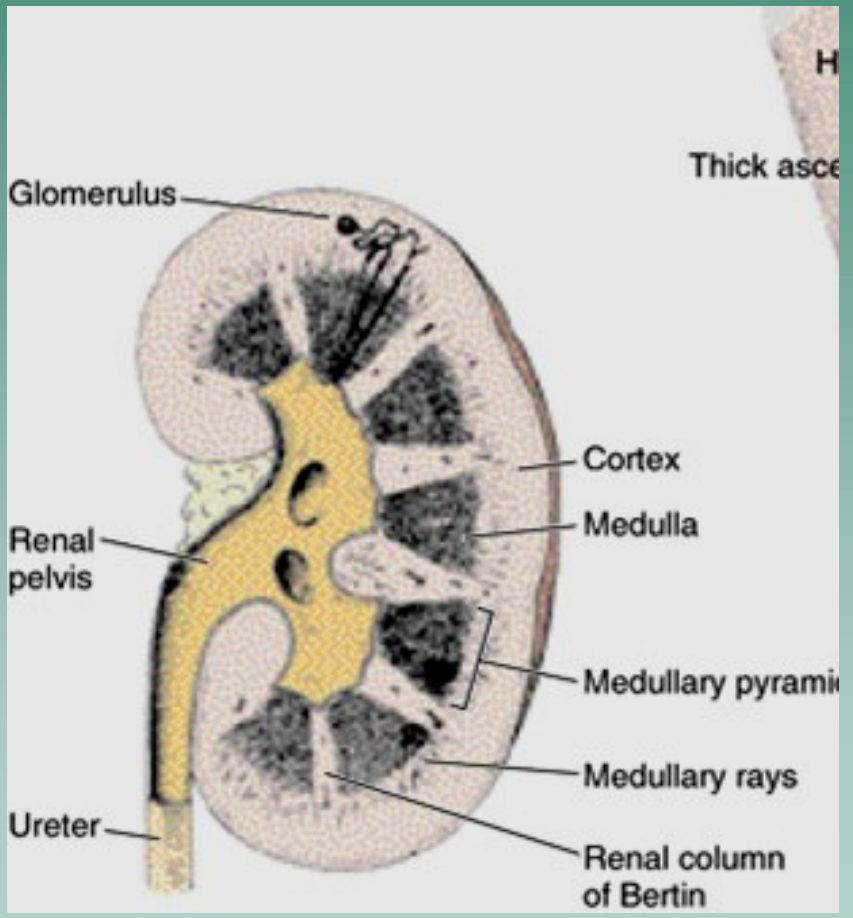
- topography
superior pole - Th_{11}
inferior pole - L_3

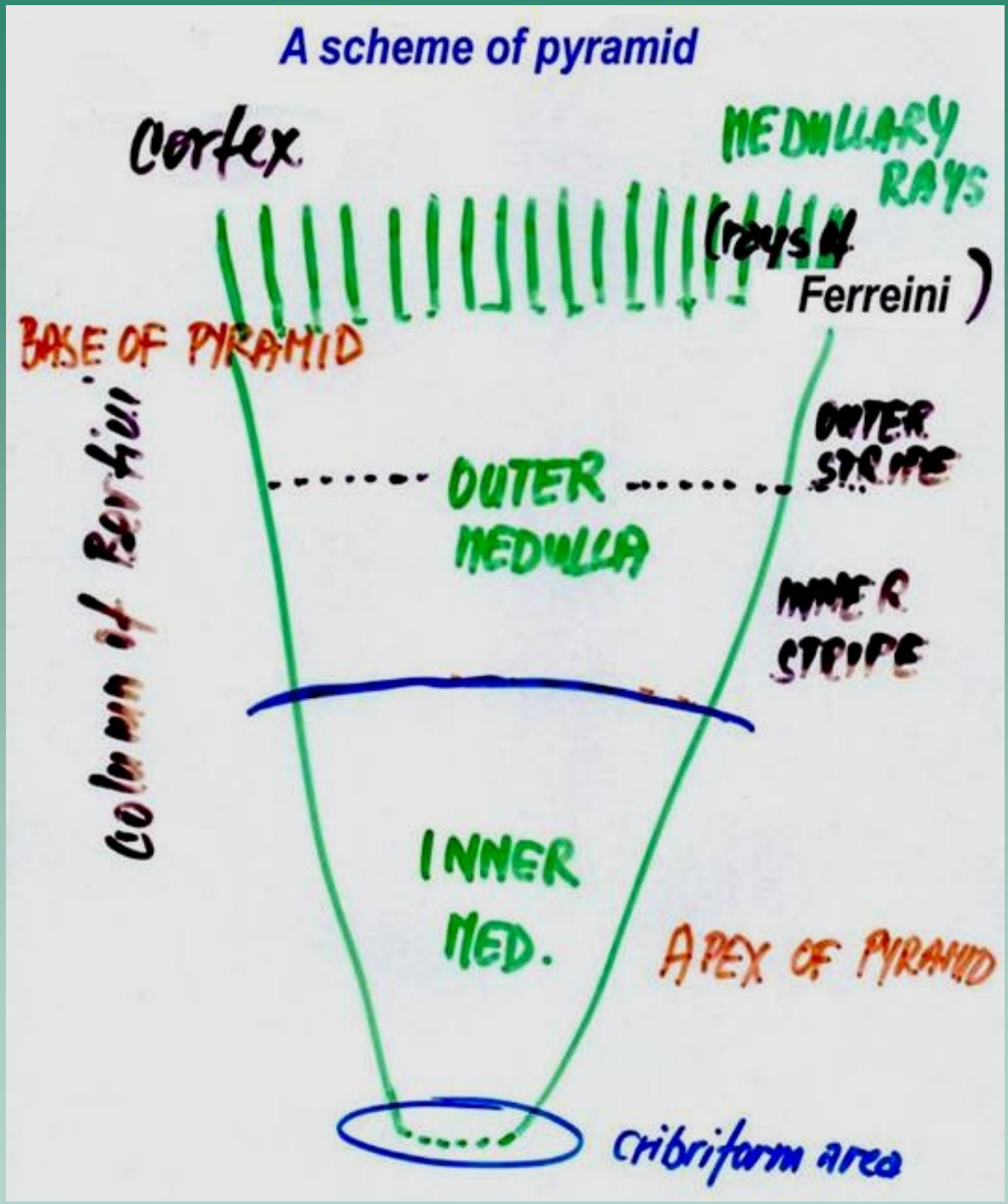
- **fibrous capsule**
- **renal parenchyma**
- **blood vessels**

Fibrous capsule – tunica fibrosa renis – dense collagenous tissue of irregular type



Renal parenchyma: cortex and medulla




A scheme of pyramid
Cortex
MEDULLARY RAYS
(rays of Ferreini)
BASE OF PYRAMID
Column of Bertin
OUTER STRIPE
OUTER MEDULLA
INNER STRIPE
INNER MED.
APEX OF PYRAMID
Cribriform area

Components of the renal parenchyma

Renal parenchyma :- NEPHRONS
- COLLECTING TUBULES + DUCTS
- RENAL INTERSTITIUM

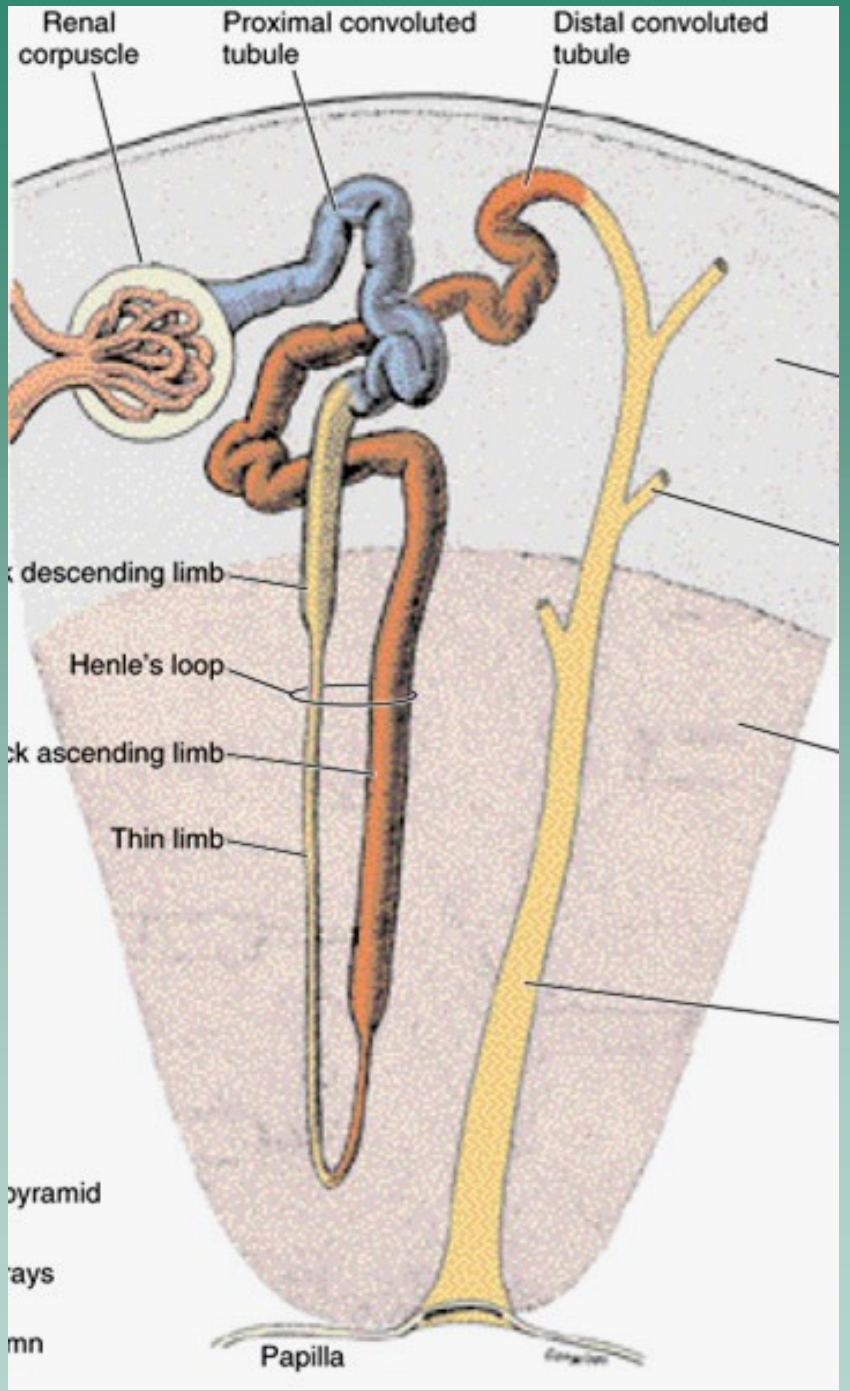
NEPHRON - histological and functional unit of the kidney
more 1 million nephrons / kidney

The nephron consists of:

1) The renal corpuscle
   - the glomerulus
   - the Bowman's capsule

2) the uniniferous tubule
   - the proximal tubule < p. convoluta, p. recta
   - the loop of HENLE < desc. limb, asc. limb
   - the distal tubule < p. recta, p. convoluta
   (- the connecting tubule)

nephron - complex element is situated partly in the cortex, partly in the medulla.



Nephron - its structure, histotopography, and function

Renal corpuscle: in the **cortex**,

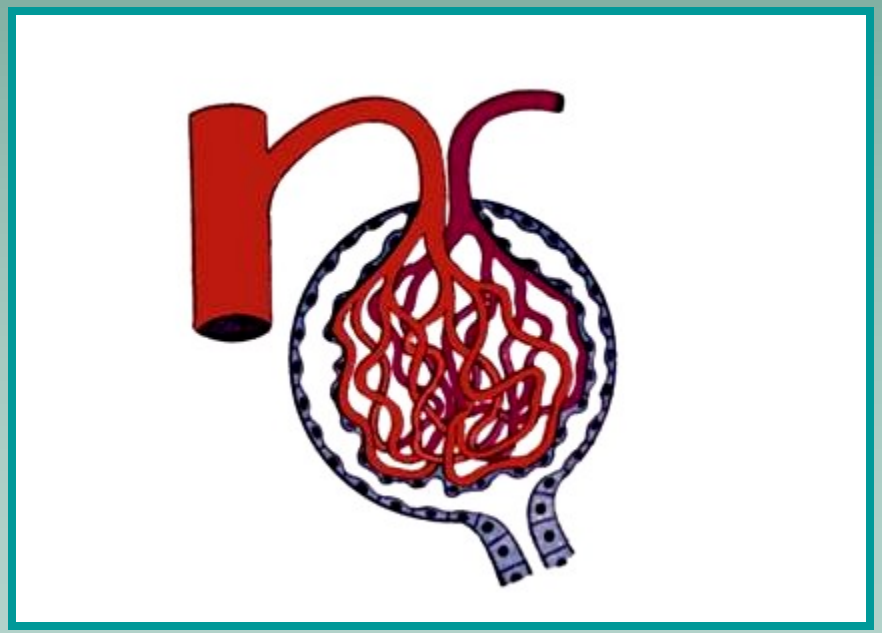
d. 150 μm, functions as filtration apparatus

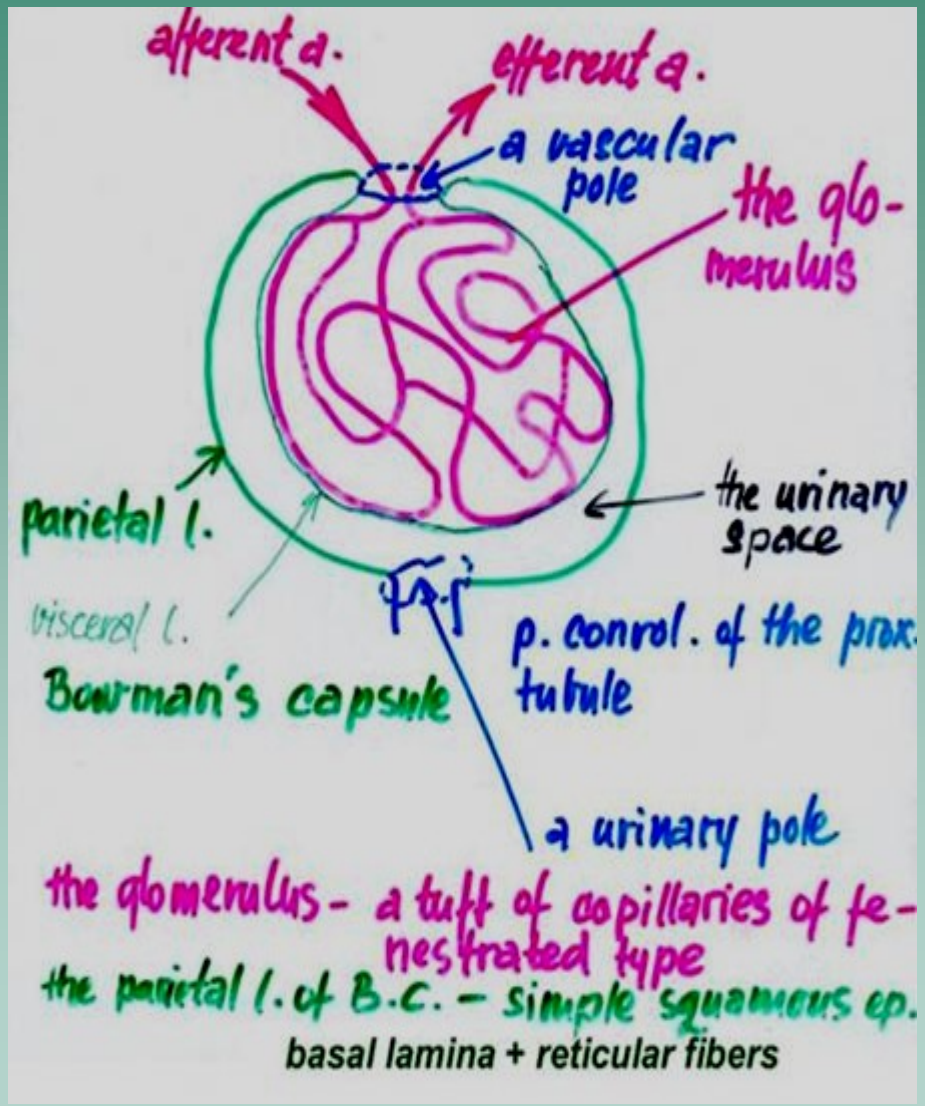
the glomerulus and Bowman´s capsule

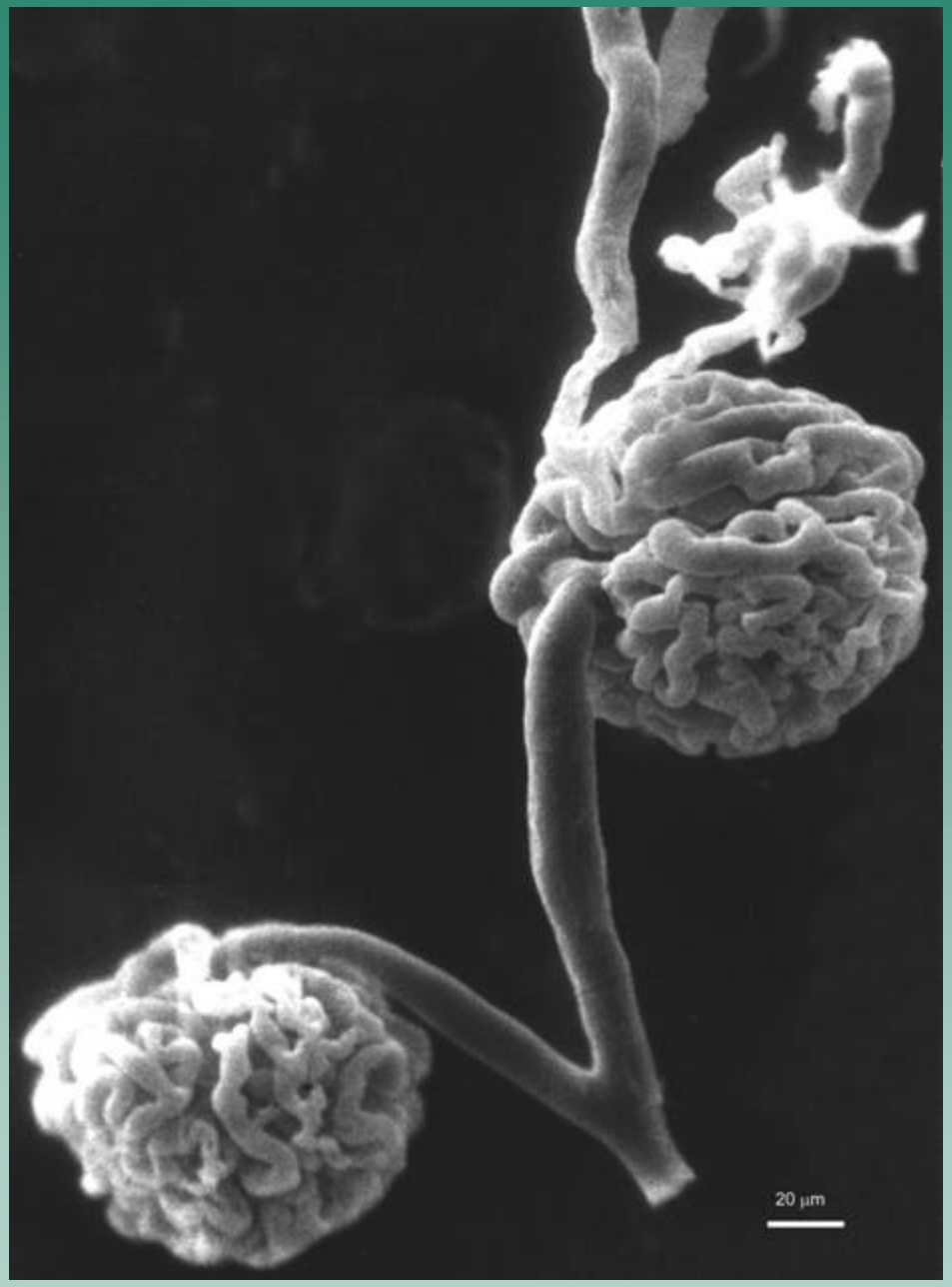
2 poles – a vascular and a urinary

Bowman´s capsule

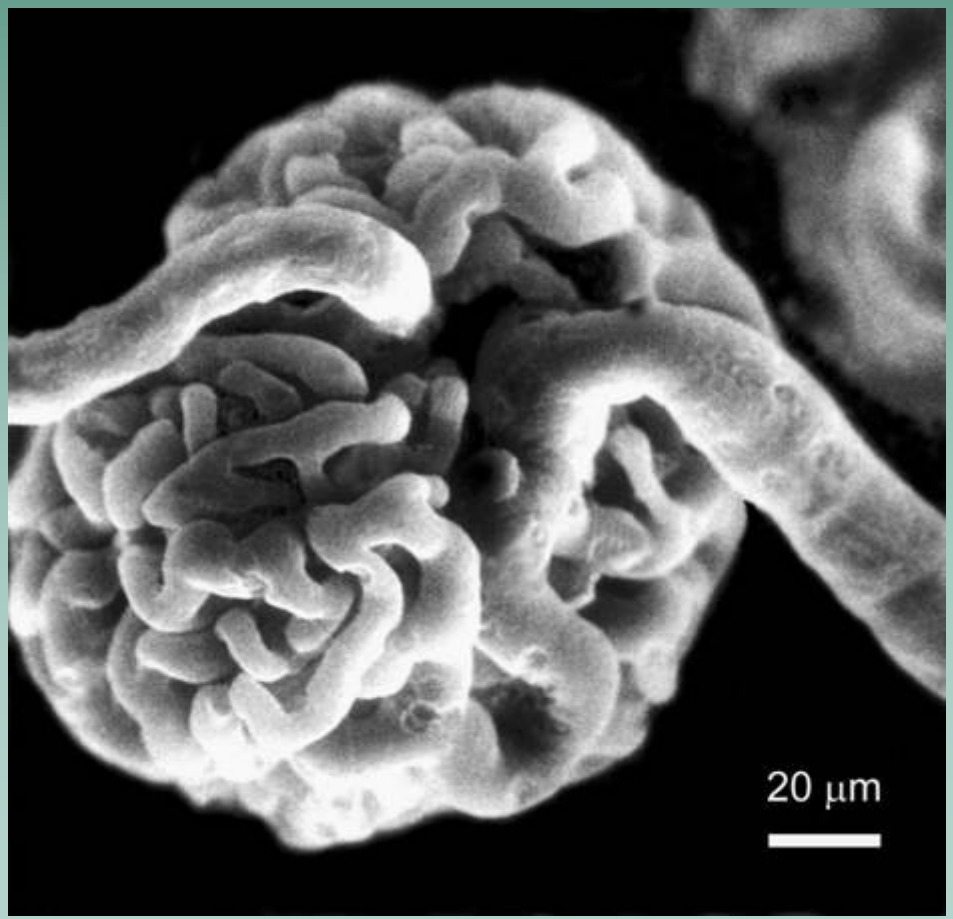
- visceral layer(podocytes)
- parietal layer



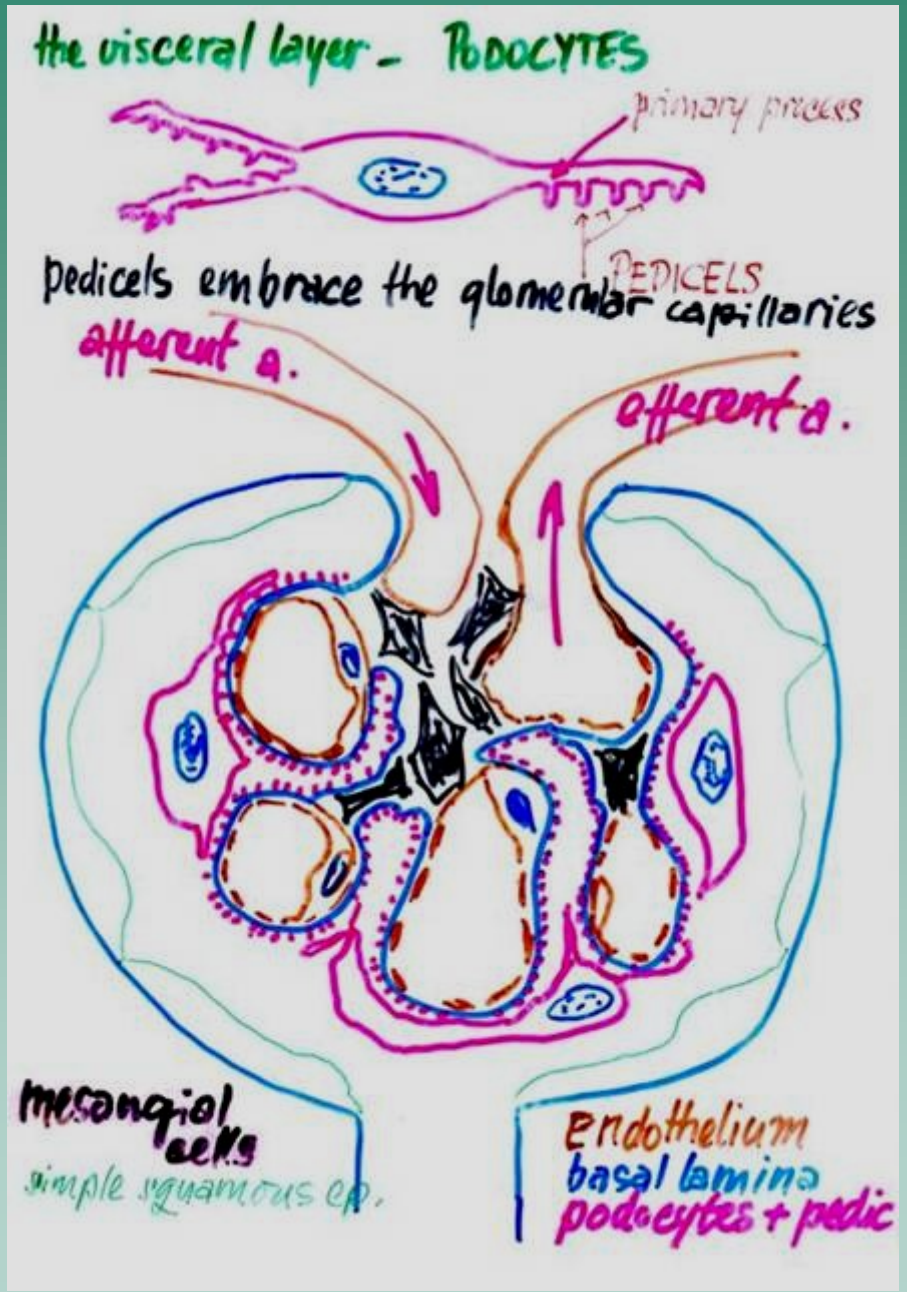


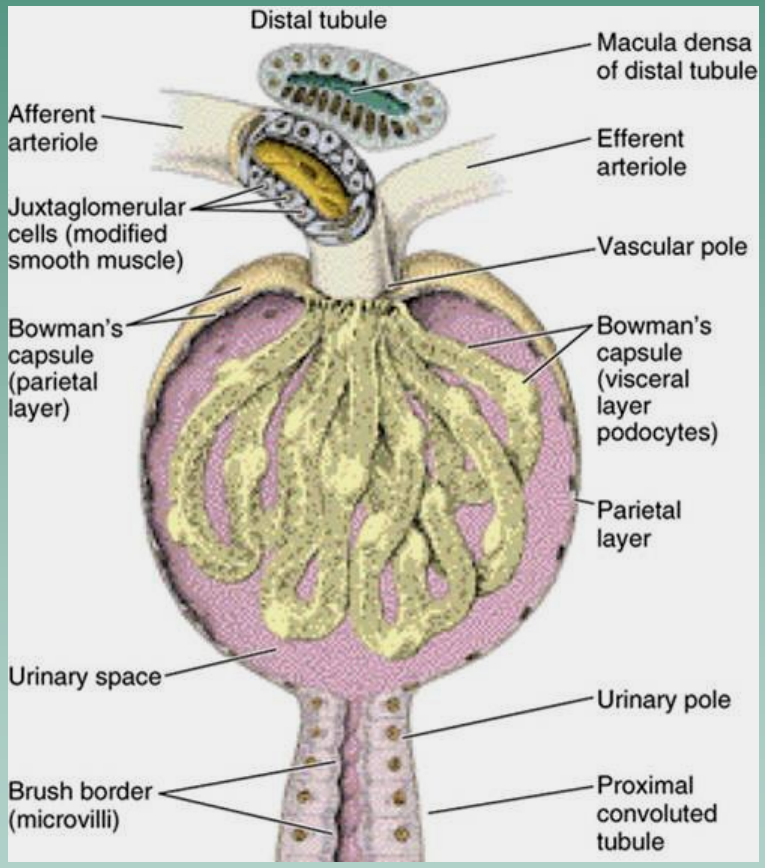


the glomerulus

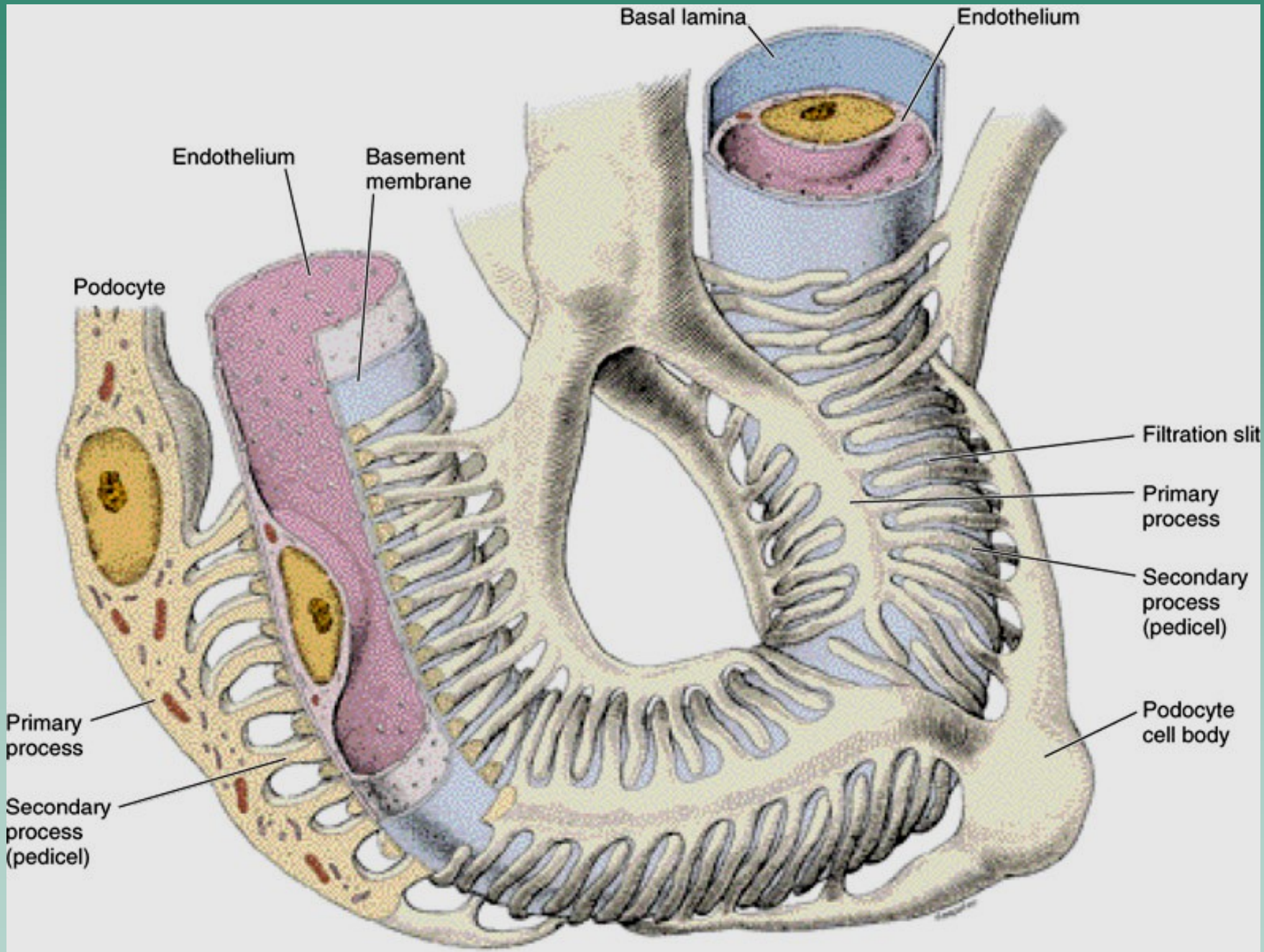


The visceral layer of Bowman´s capsule

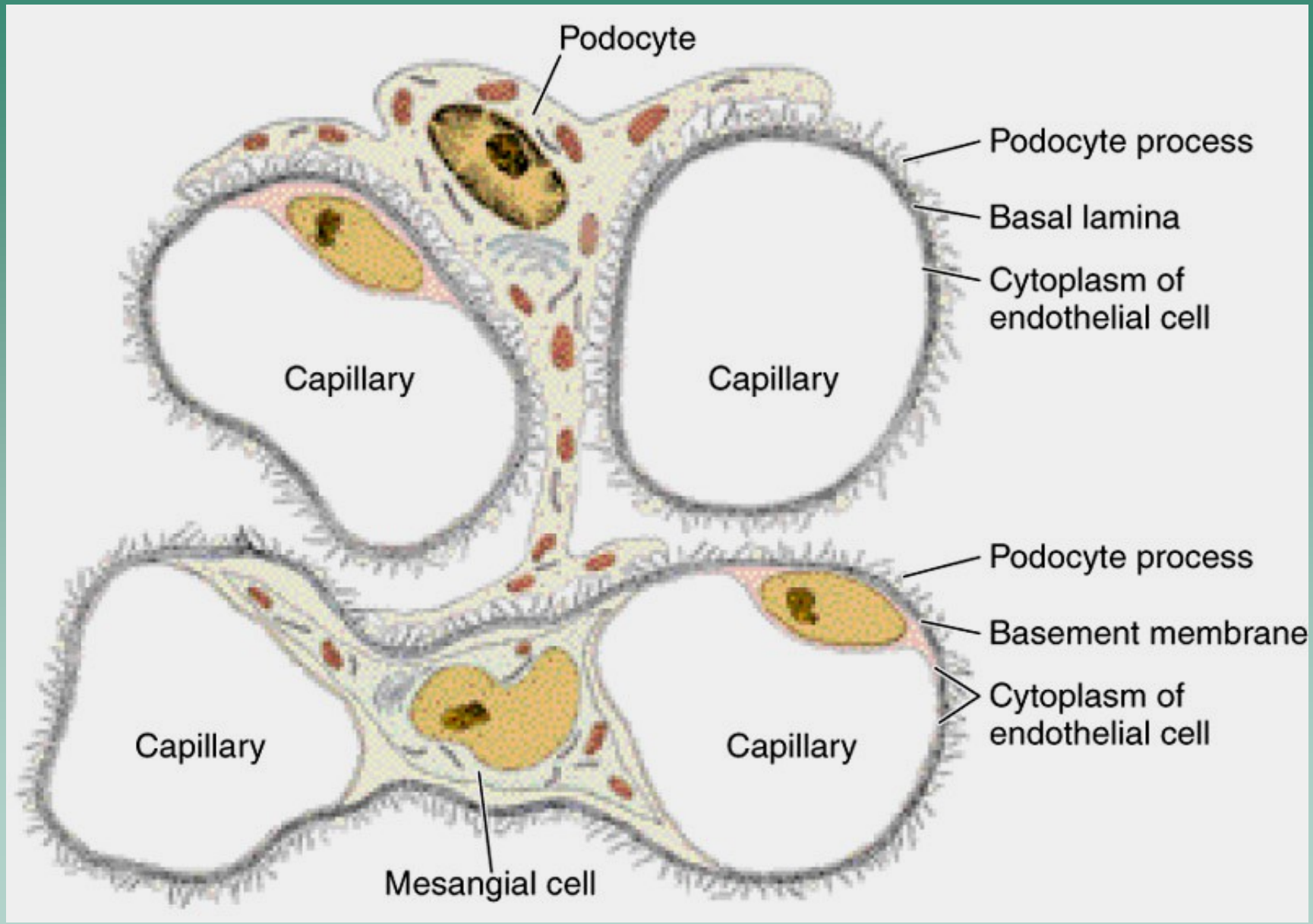


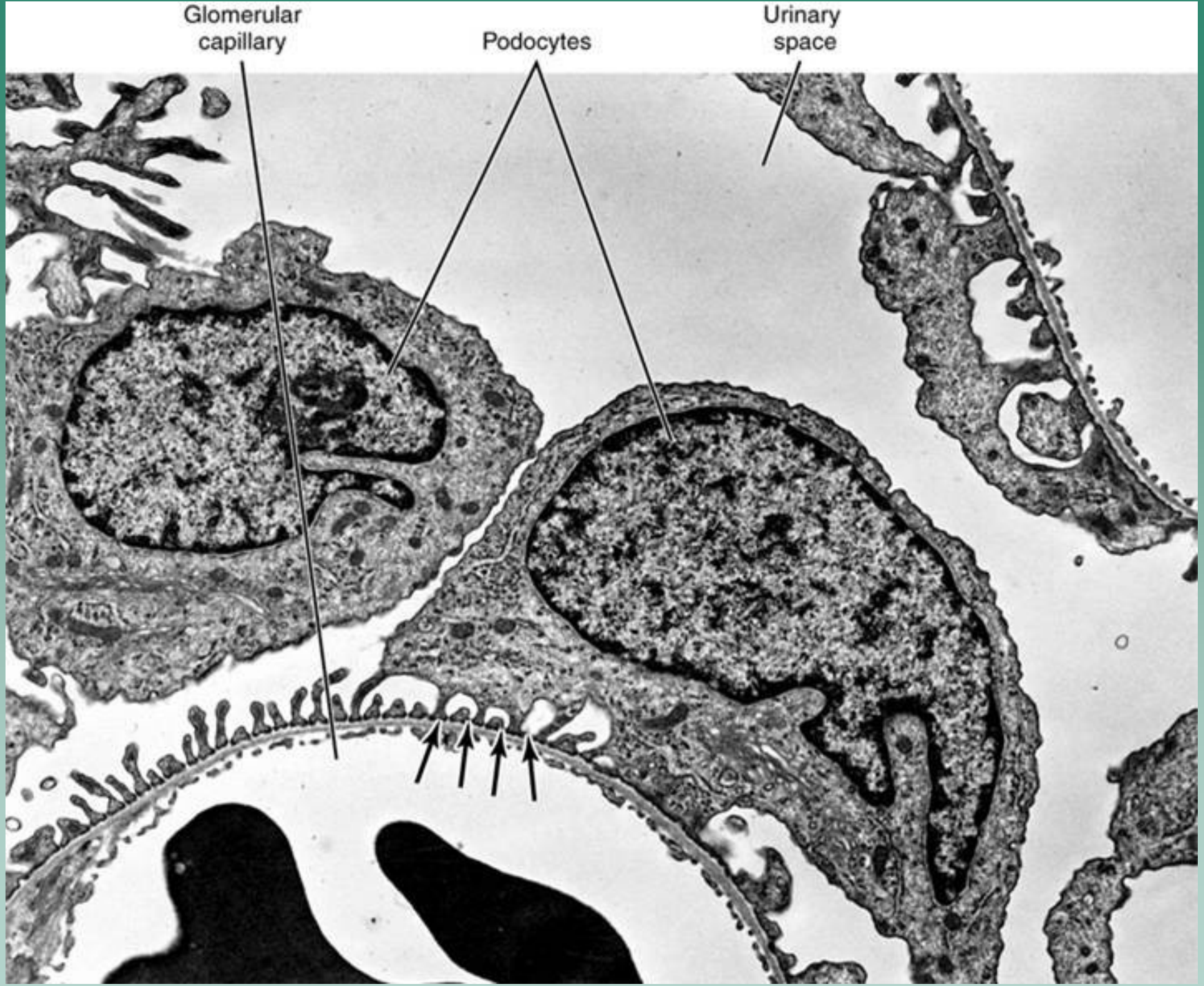


Podocytes and fitration membrane

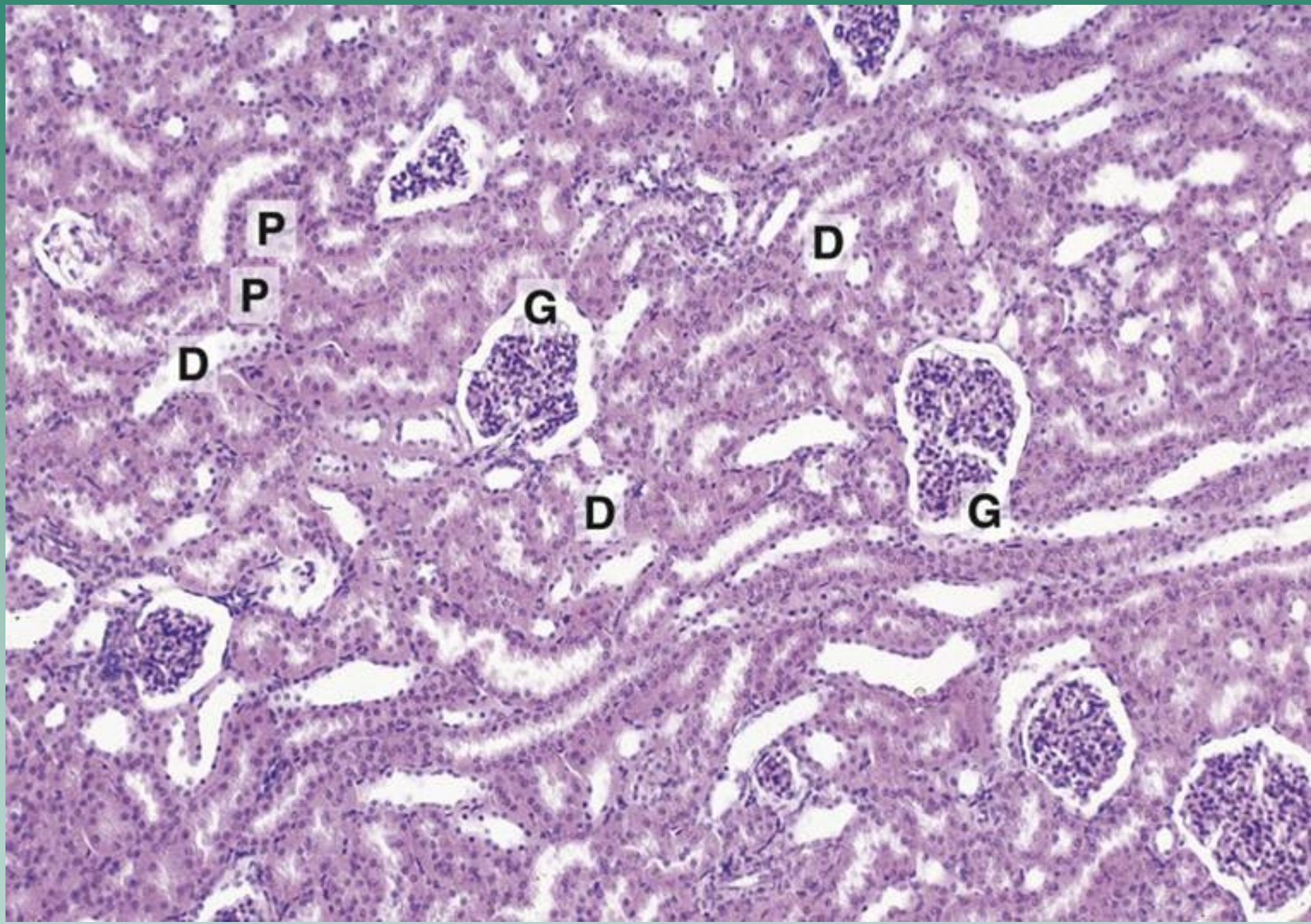


Podocytes and fitration membrane



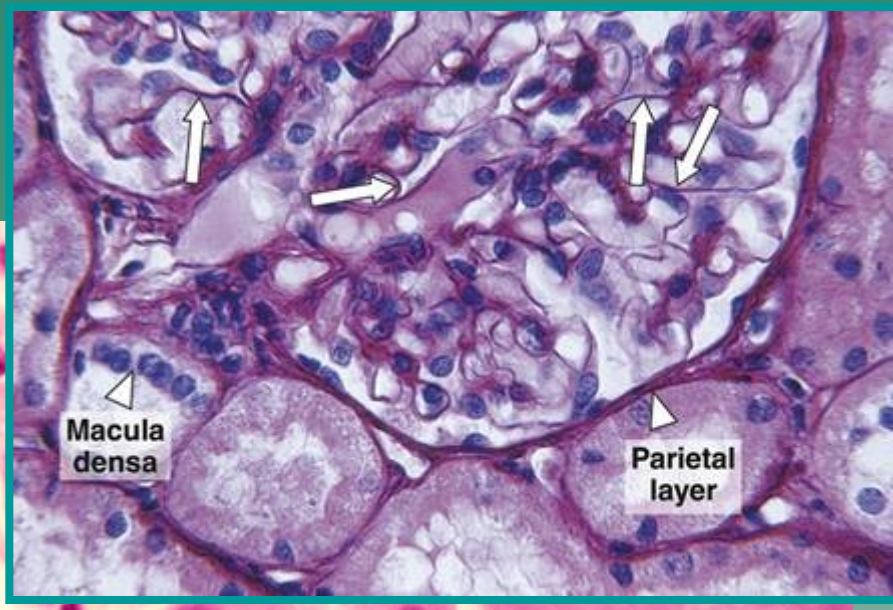

Glomerular capillary
Podocytes
Urinary space

Renal corpuscles - distribution



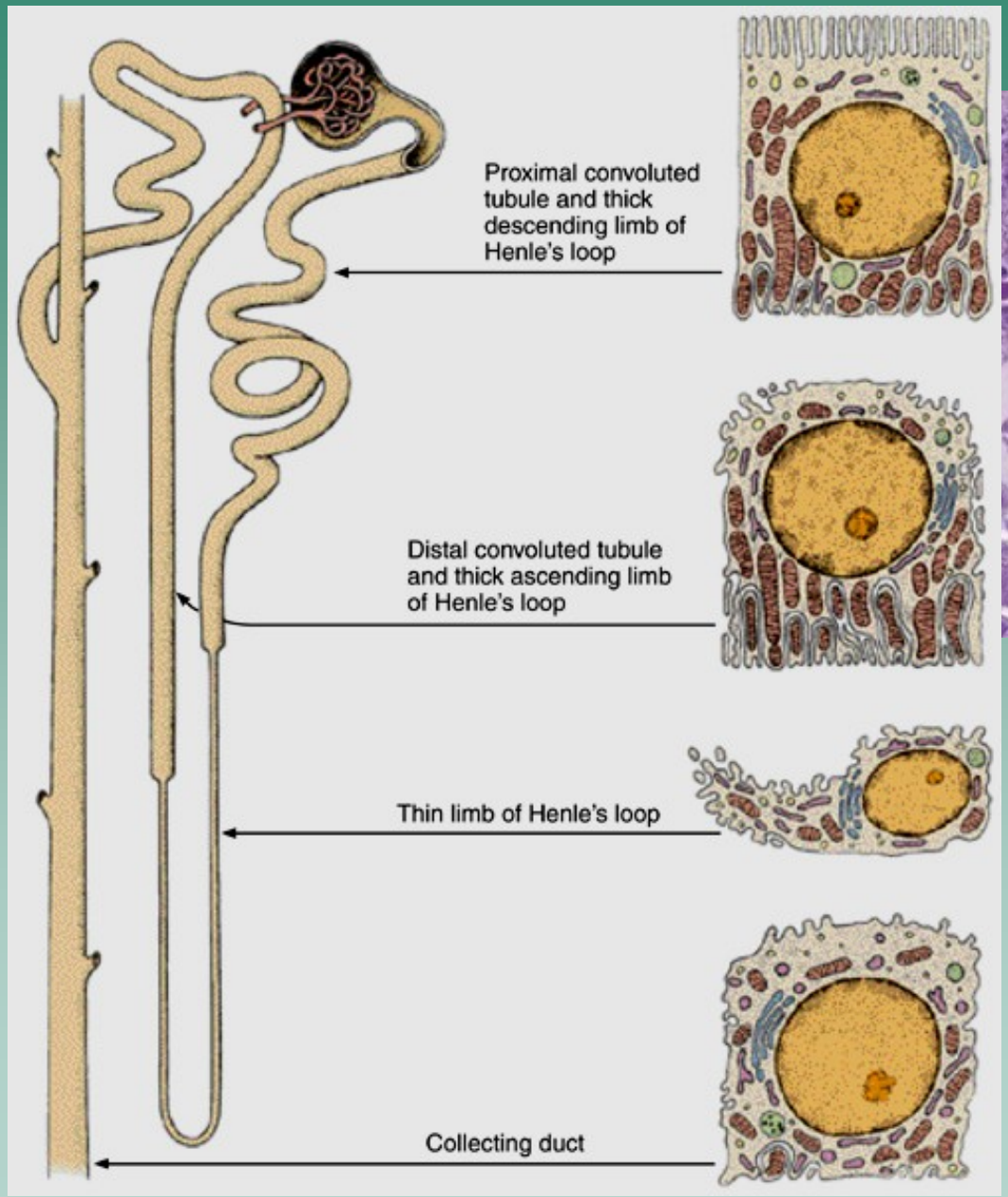
Renal corpuscle – poles:

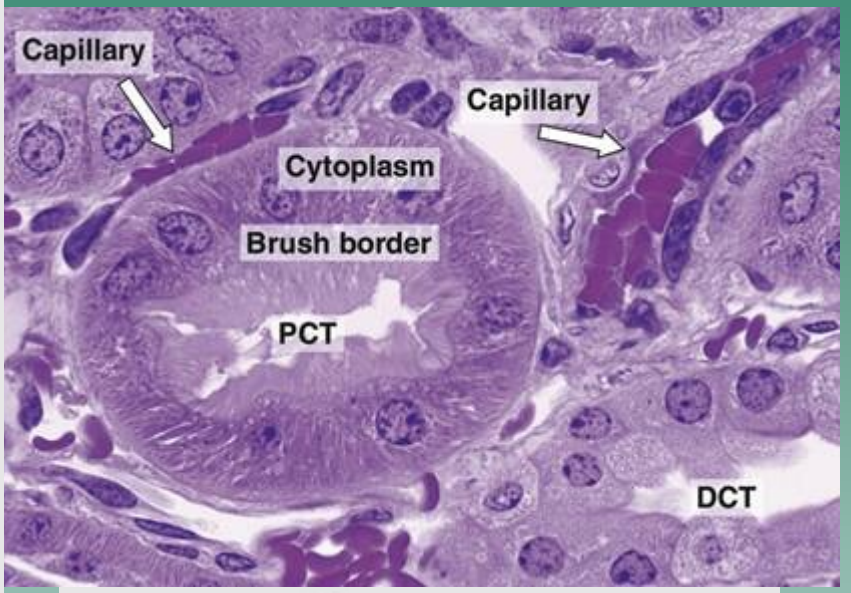
vascular

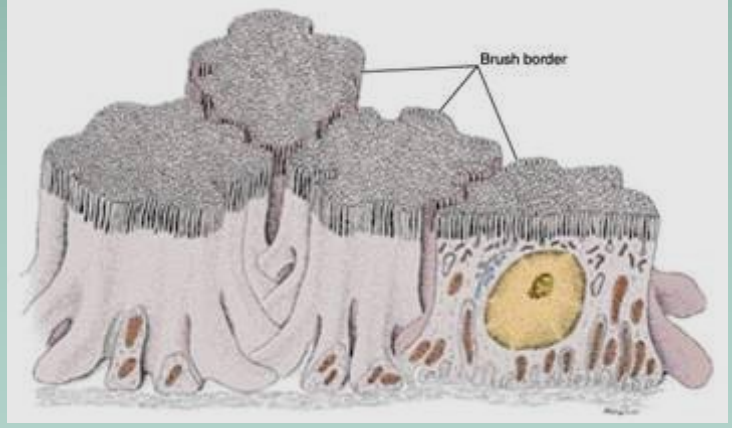


urinary

Uriniferous tubule – tubulus renis





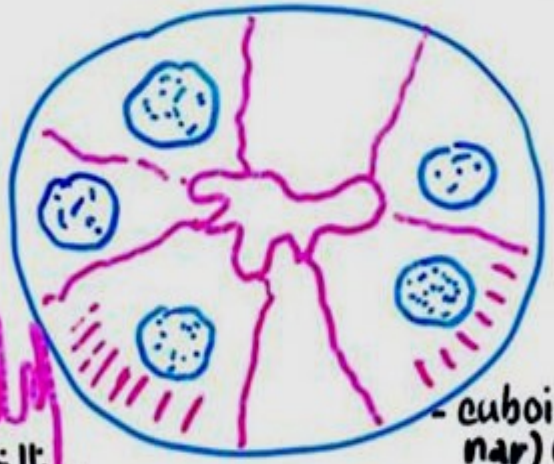


Uniniferous tubule

proximal t. (p. convoluta – cortex
p. recta – medullary ray
outer stripe of the outer med.

14 mm in length
60 µm in d.

proximal straight tubule



- microvilli = brush border

- cuboidal (columnar) epithel.
- acidophilic cyt.
- irregular lum.
- striation of the basal p.

Loop of HENLE

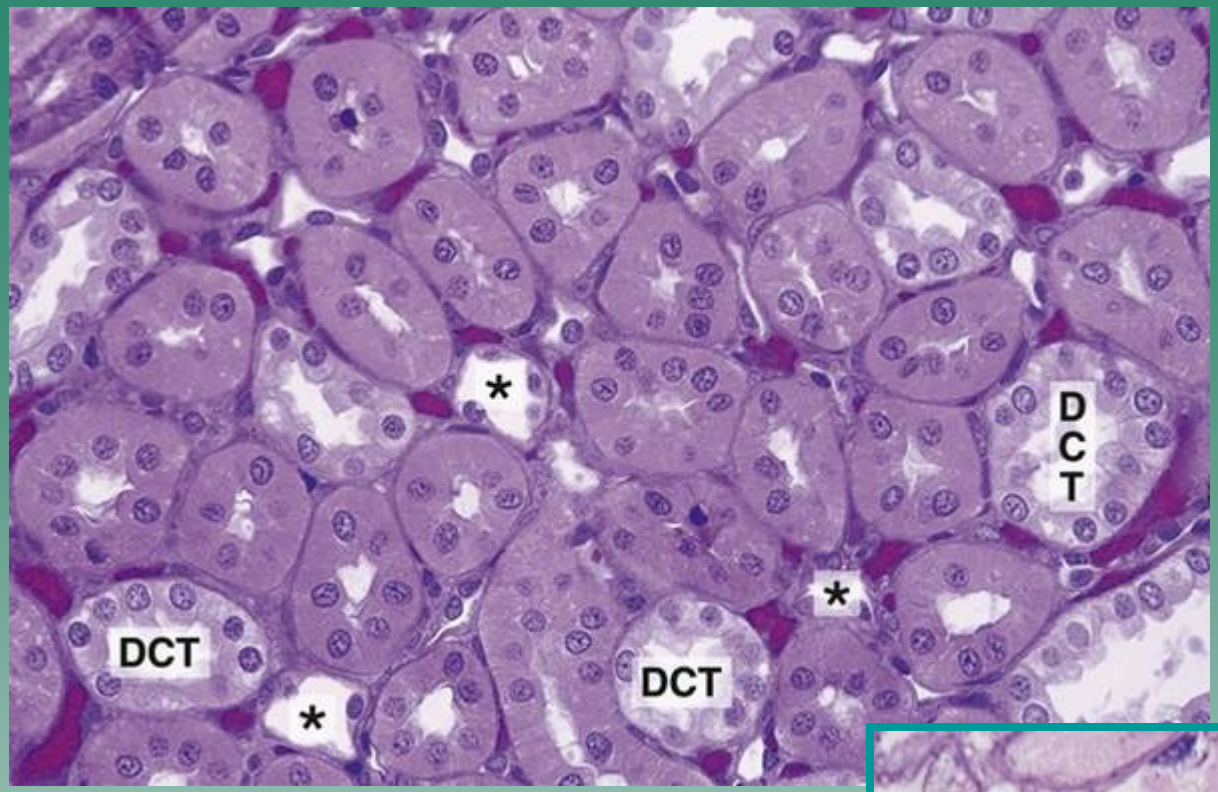
- descending limb – medulla (outer + inner)
(thin)
9 mm long
10-15 µm in d.

simple squamous ep.
lumina are collapsed

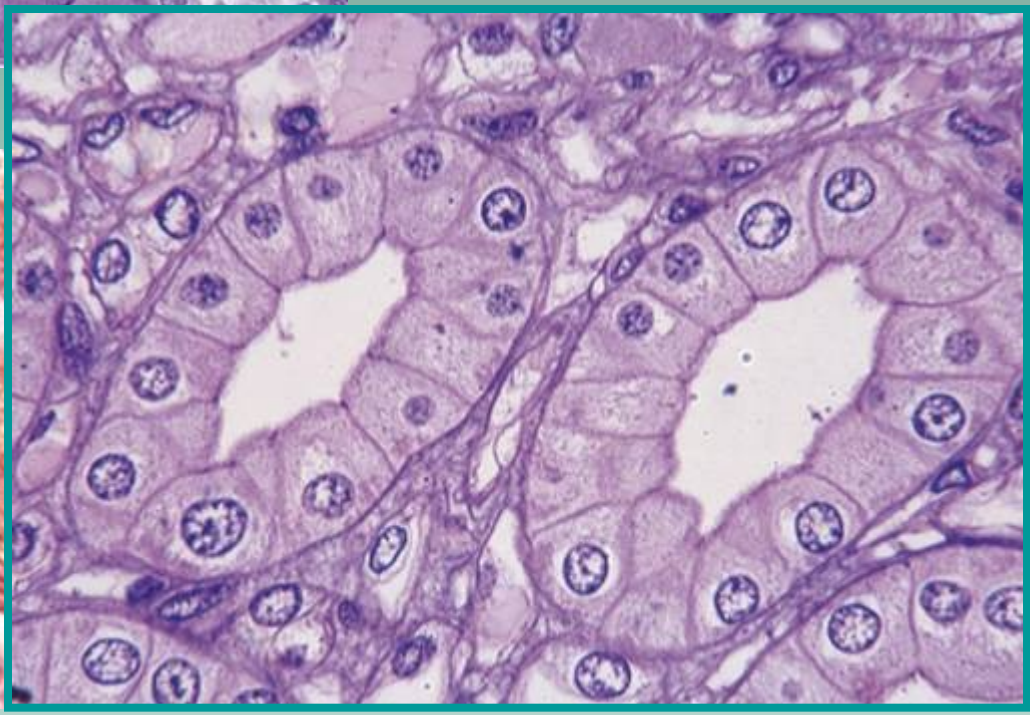
- ascending limb – medulla (inner)
(thick)
40-50 µm in d.

Distal tubule – 5 mm long

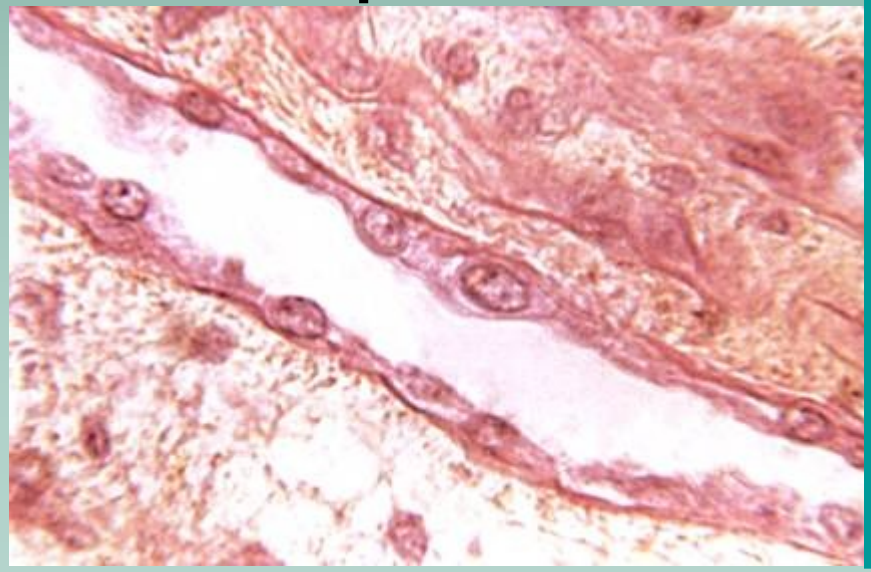
- pars recta (distal straight tub) – outer m. medullary rays
- pars convoluta – CORTEX
simple cubical epithelium
cells are pale
lumen of regular appear.



Collecting tubules



Thin limb of loop of Henle



- microvilli lack

COLLECTING TUBULES AND DUCTS

medulla

collecting t. - 40-60 µm in d.
— " — d. - 200 µm — " —

s. cuboidal ep

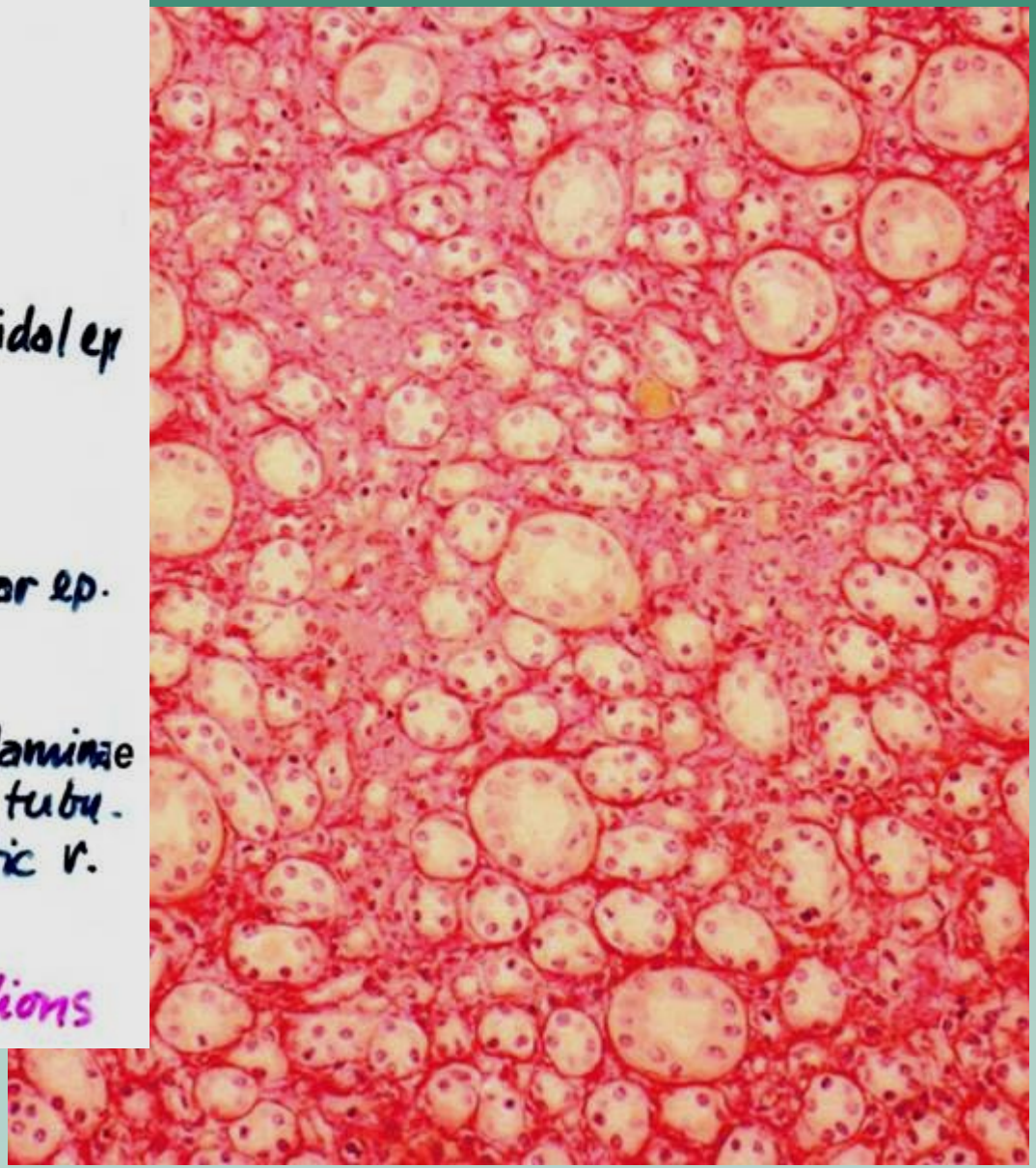
l. columnar ep.

RENAL INTERSTITIUM

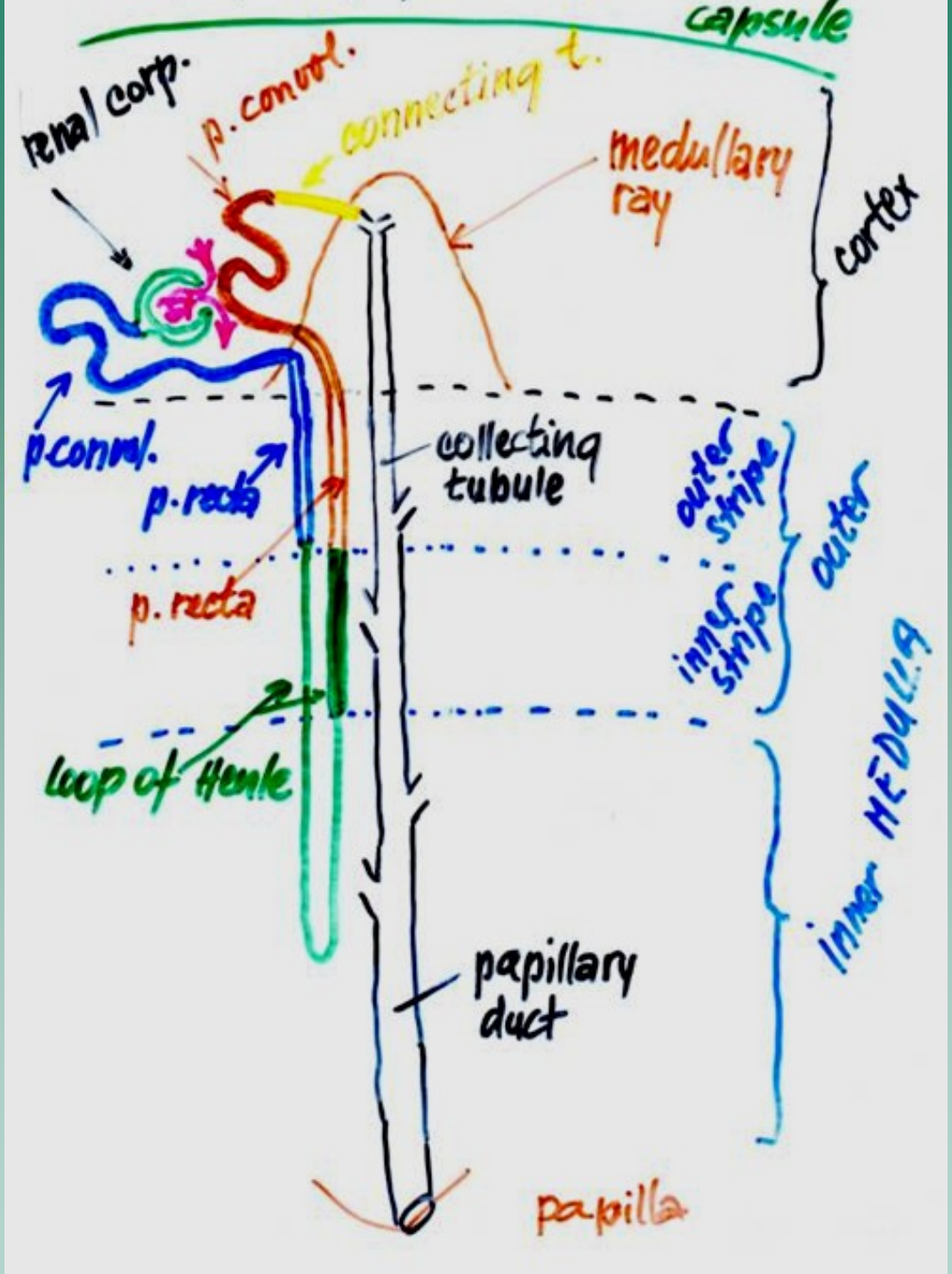
is found in spaces outside basal lamina and components of nephrons, coll. tubules and ducts, blood and lymphatic v. and nerves

fibroblasts or their modifications

Medulla renis

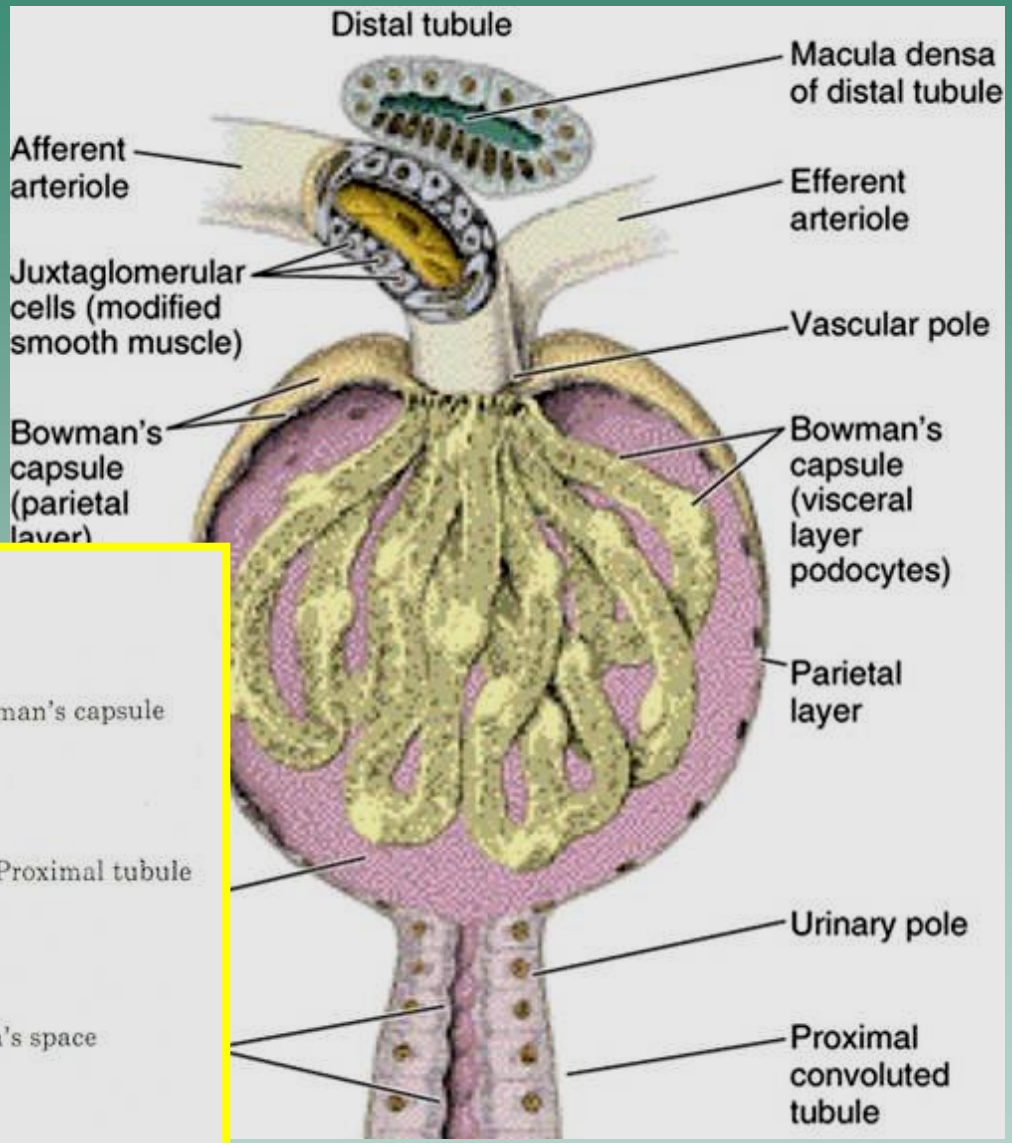


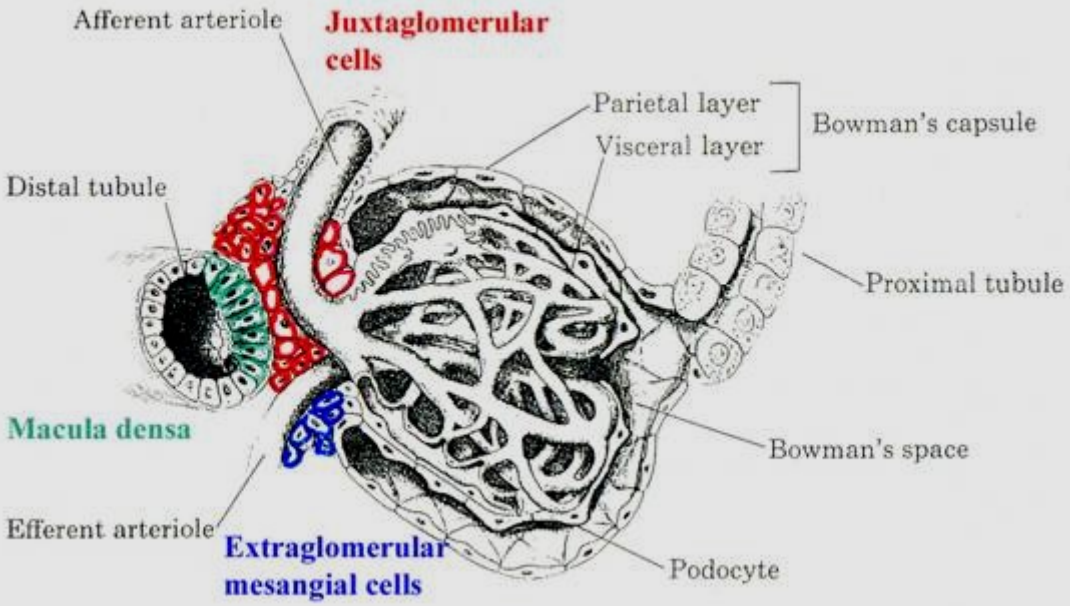
Histotopography of the nephron

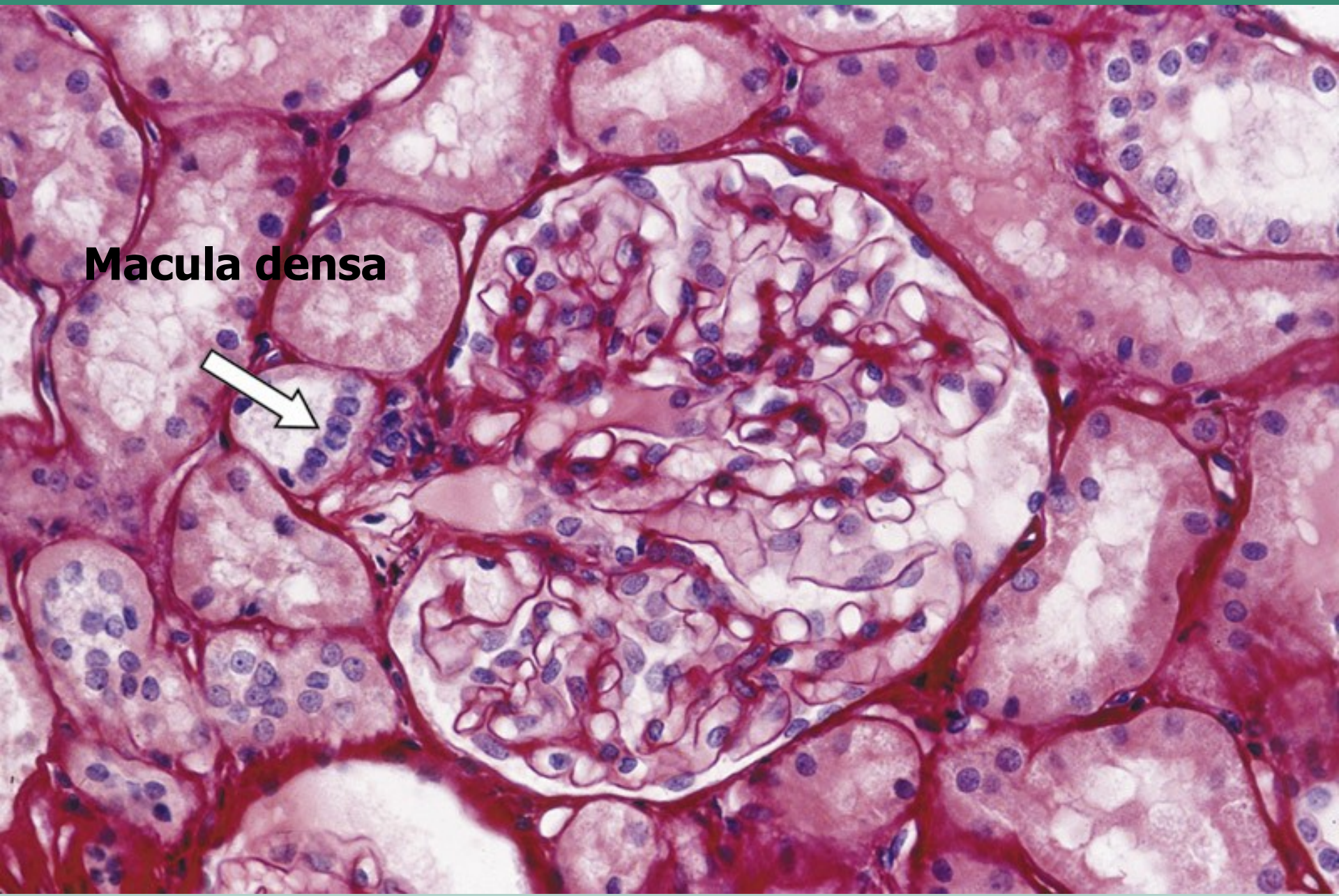


Juxtaglomerular apparatus

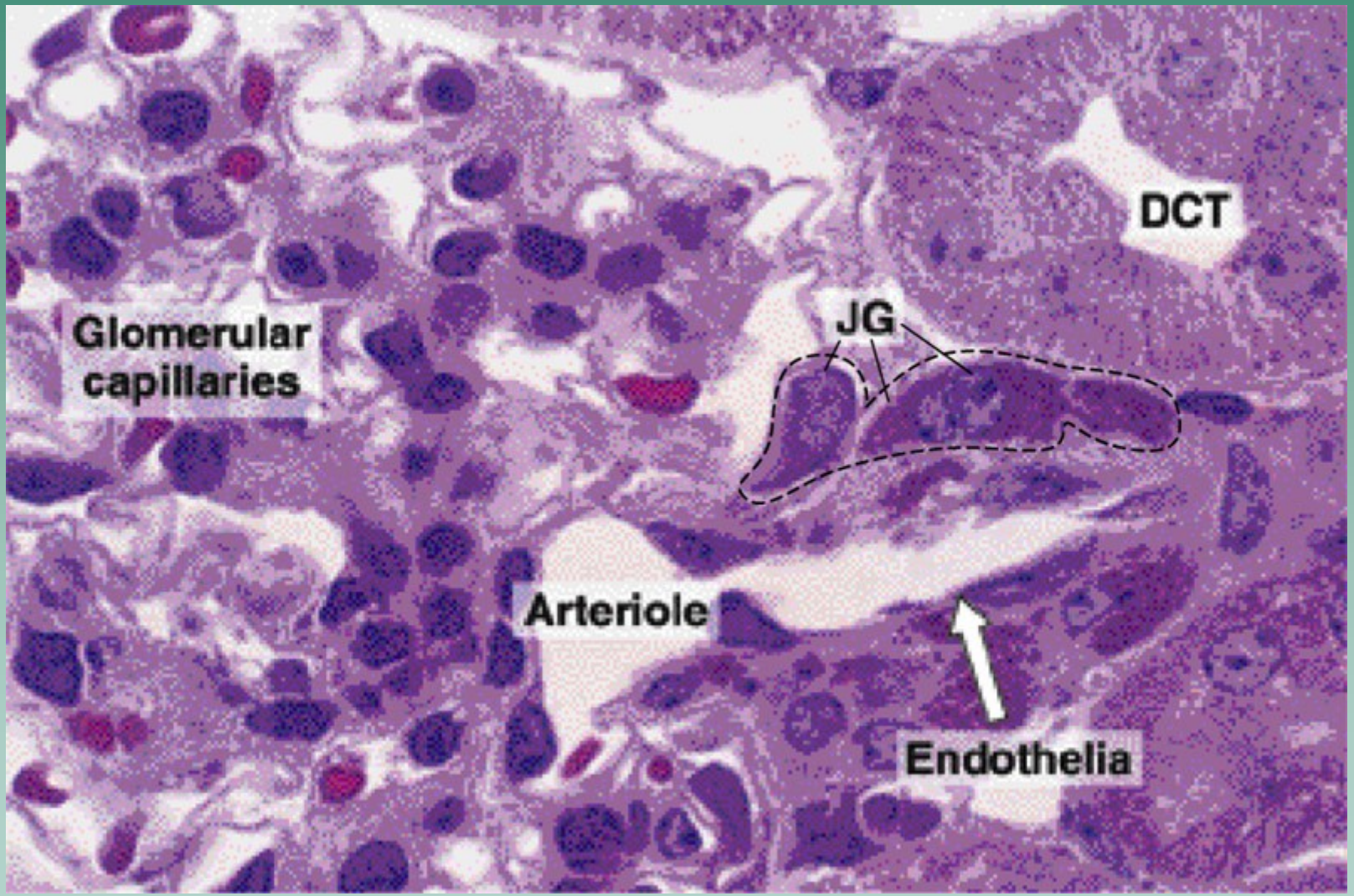
- macula densa - a part of the distal t. located near the vascular pole of the renal corpuscle
  columnar cells
- juxtaglomerular cells - modified muscle cells of the afferent arteriole adjacent to the renal corpuscle, secreting function - renin
- mesangial cells (LACIS CELLS) - within glomerular capillaries



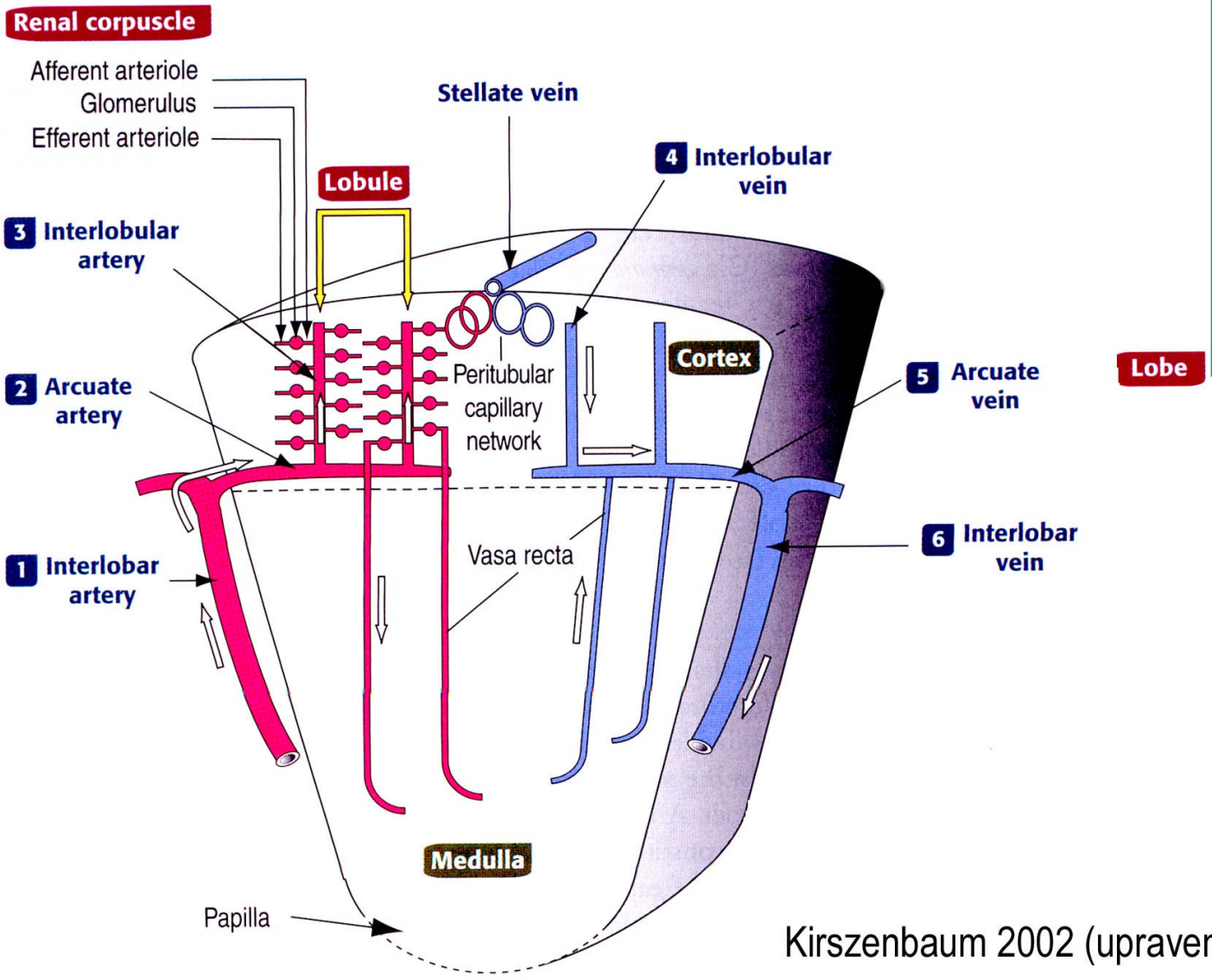



Macula densa

Juxtaglomerular cells

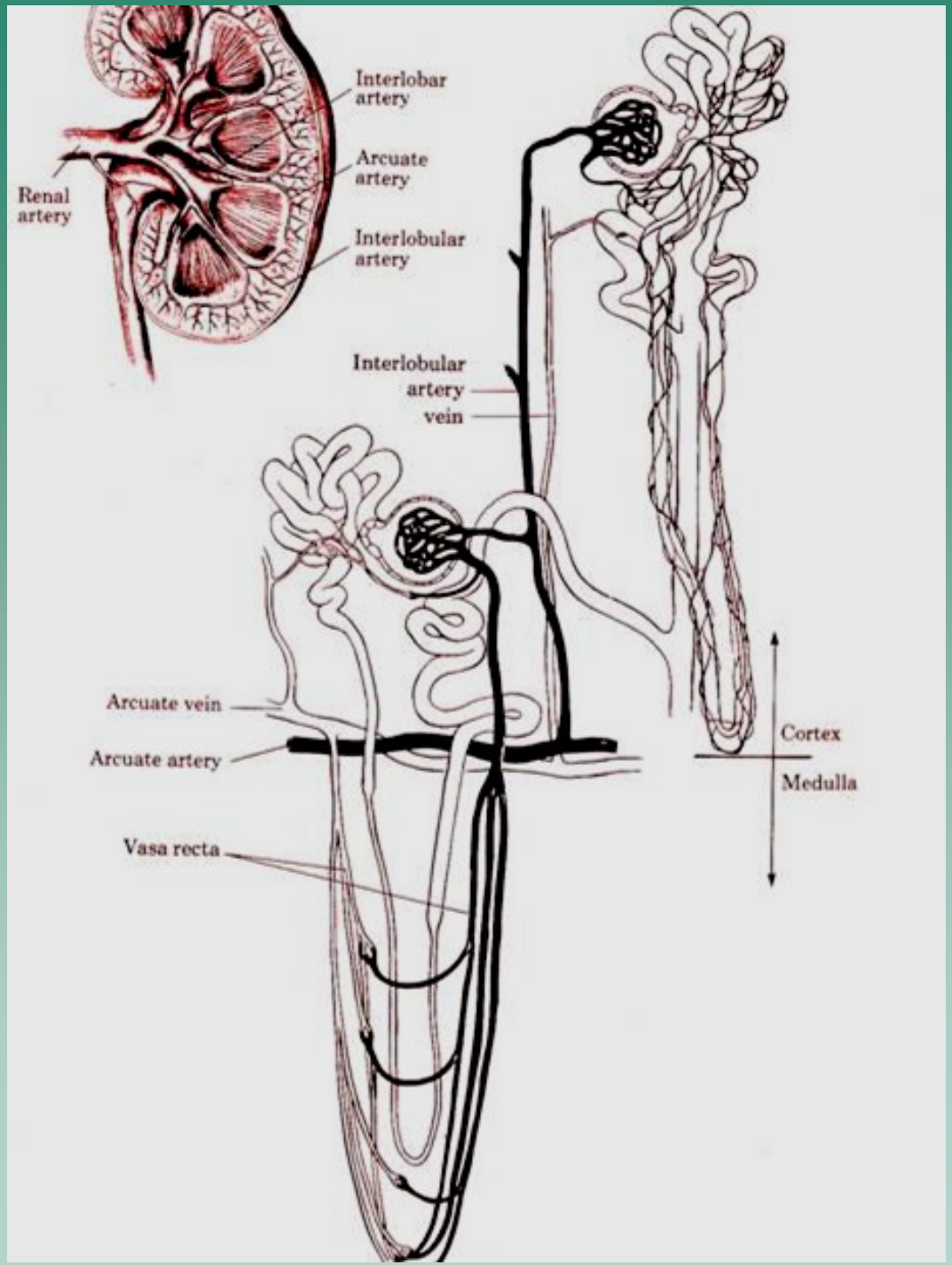


Blood circulation of the kidney

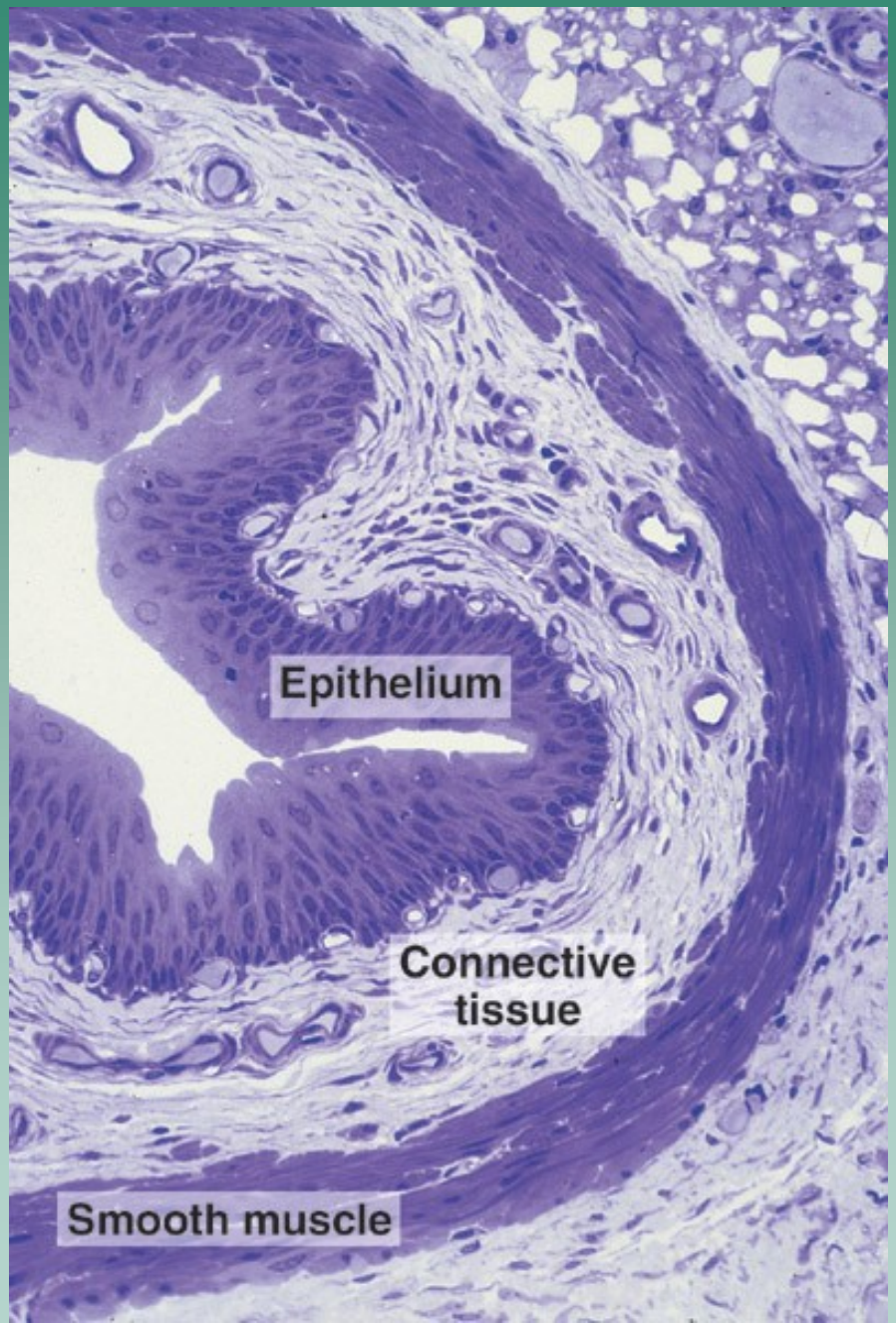


Kirszenbaum 2002 (upraveno)

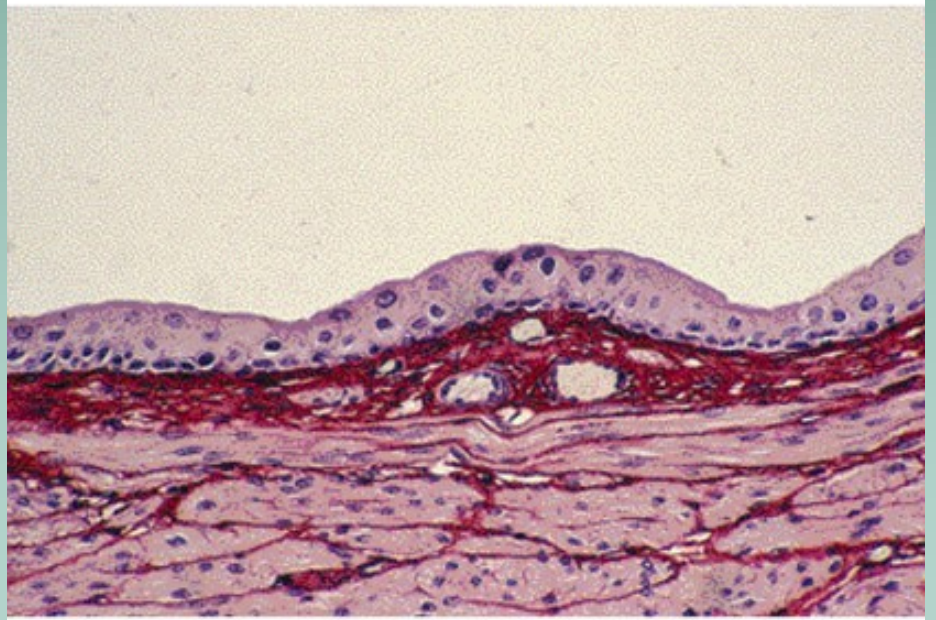
Blood circulation



Urinary passages



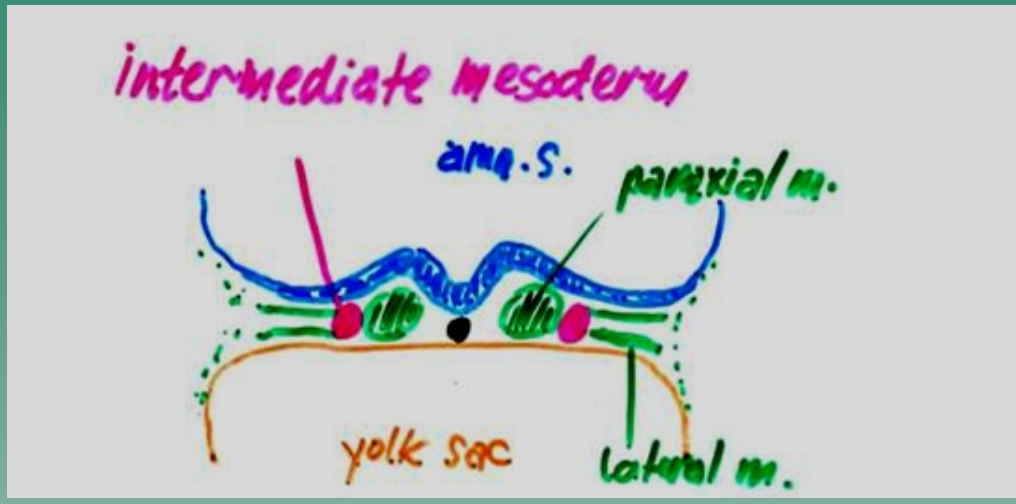
A



B

Introduction

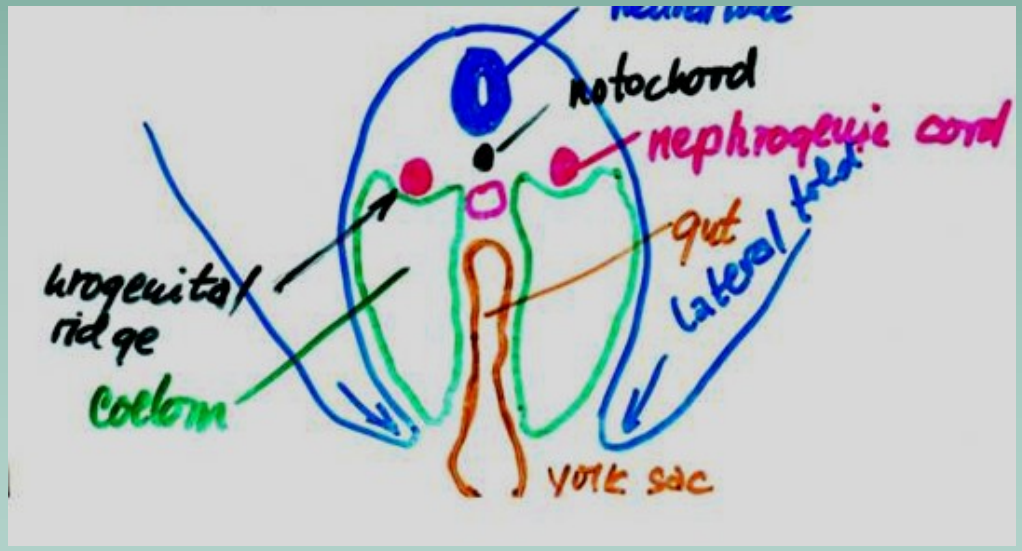
the urinary system and internal sexual organs develop from **the intermediate mesoderm** - a part of the third germ layer interposed between the axial mesoderm or somites and lateral mesoderm
the intermediate mesoderm extends along the entire length of the dorsal body wall of the embryo



it soon loses connection with somites and fuses to form the **nephrogenic cords** on each side of the primitive aorta

the cords rapidly grow, become larger and produce bilateral longitudinal bulges called the **urogenital ridges**

a medial side of each ridge is then separated from the surrounding and is called as the **gonadal ridge** (see the next chapter)



DEVELOPMENT OF KIDNEYS, URETERS, BLADDER, AND URETHRA

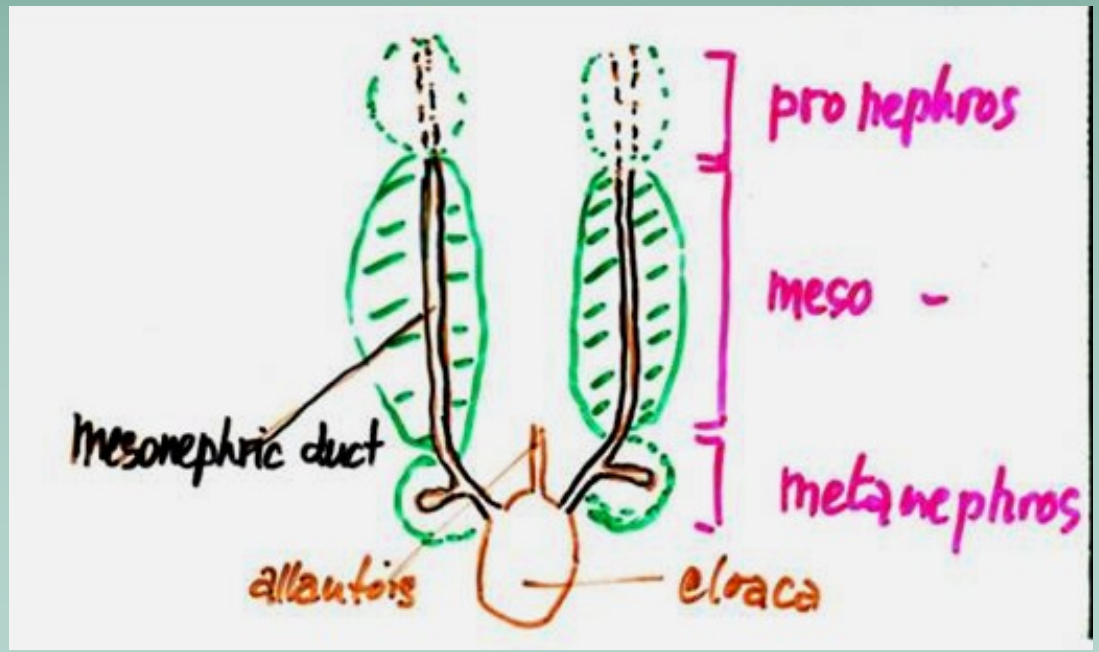
in the human, three sets of excretory organs develop:

the **pronephros** (-oi) - "forkidney" - is **rudimentary** and nonfunctional; forkidney is analogous to the kidney of some primitive fishes,

the **mesonephros** (-oi) -" midkidney" - is analogous to kidney of fishes and amphibians

in human embryos, midkidney is **probably functional for a short time** and then undergoes involution

the **metanephros** (-oi) - "hindkidney" or **permanent kidney**, it begins to produce urine in fetuses aged 11 to 13 weeks

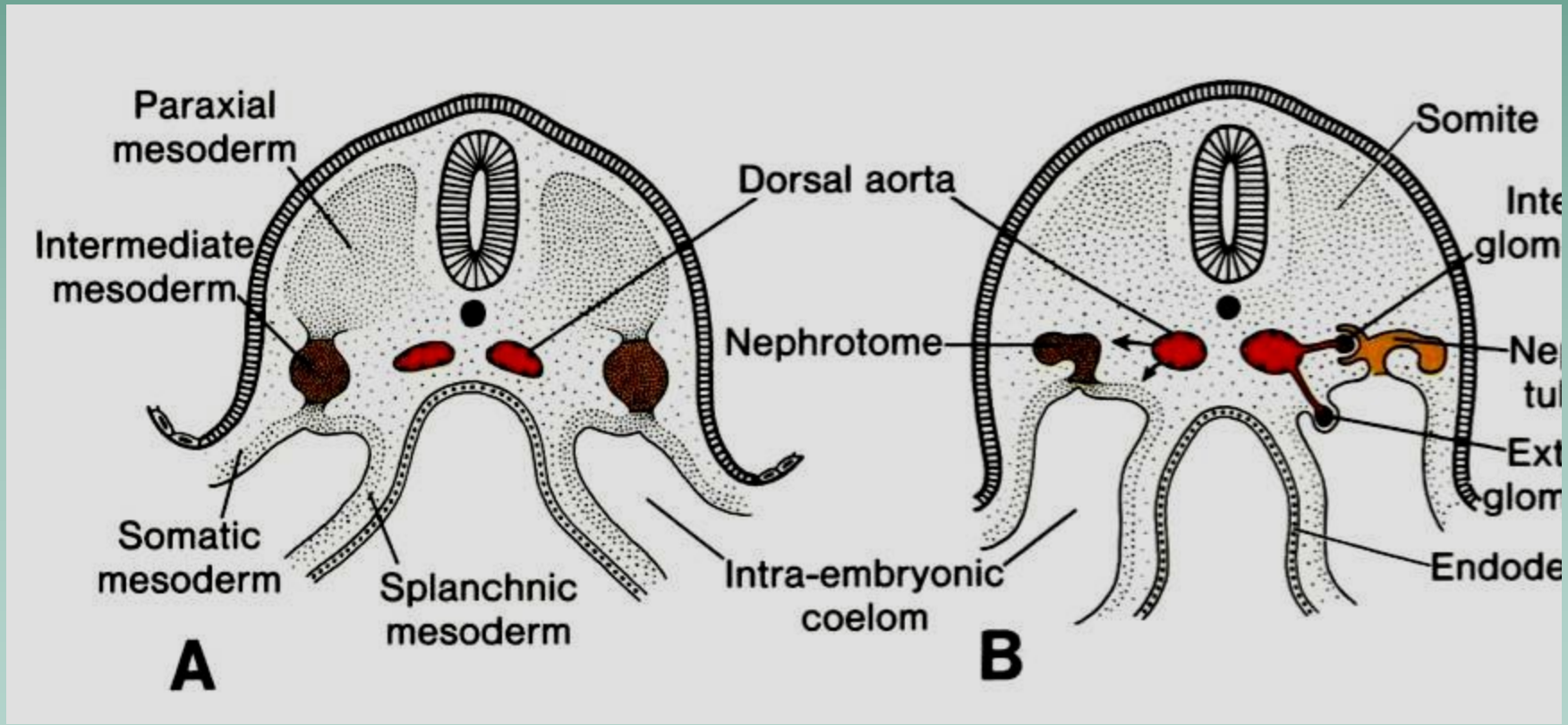


Pronephros (oi)

occurs early in the fourth week in the cervical region on each side

it consists of a few solid cell clusters, rarely short **pronephric tubules** and the **pronephric duct**, which runs caudally and opens into **the cloaca**

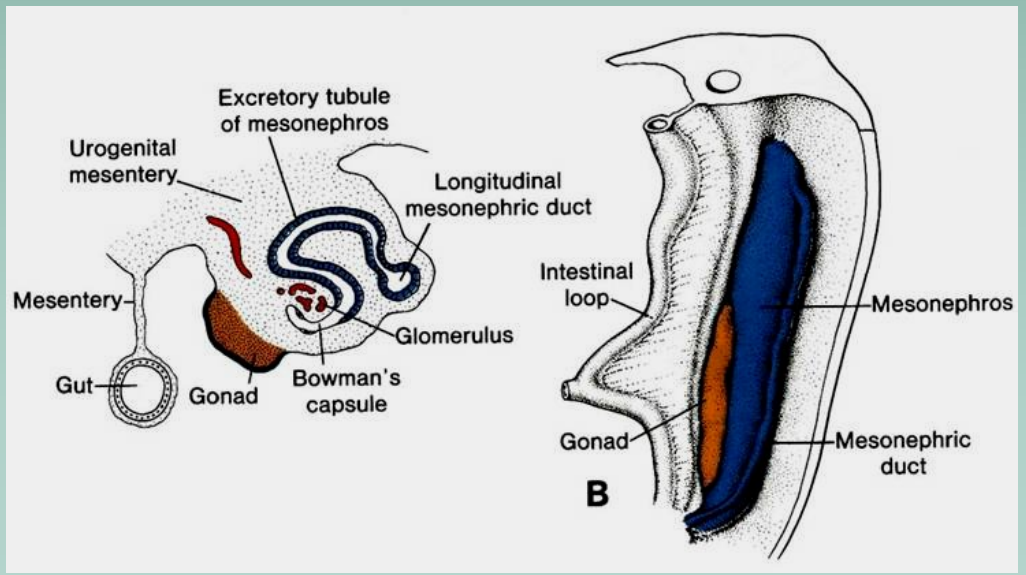
the pronephros soon degenerates, but most of both pronephric ducts are utilized by the midkidney **as mesonephric or Wolffian duct**

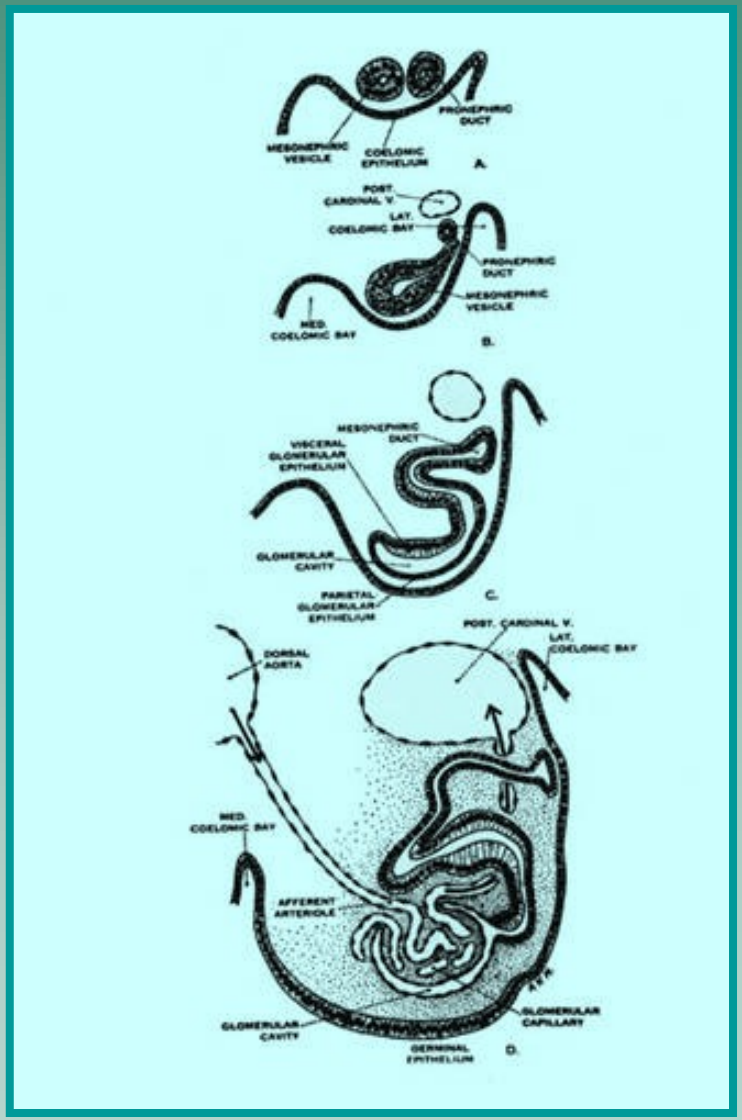


Mesonephros (oi)

develops later in the 4th week caudal to the pronephros in **C_6 to L_3 region**
initially, solid nephrogenic cord (blastema) divides into 40 - 50 mesodermal cell clusters within them lumina develop - **mesonephric vesicles** arise
mesonephric vesicles grow into S-shaped **mesonephric tubules** whose laterally ends become continuous with the **mesonephric duct** or **Wolffian duct**
the medial end of each tubule expands and transforms into the **Bowman´s capsule** (capilary loops of the glomerulus are deriving from the mesonephric artery)
the capsule with glomerulus form a **mesonephric corpuscle** together

cervical and thoracical parts of mesonephroi rapidly degenerate
the lumbar part consisting of a few mesonephric tubules and mesonephric duct persists and is involved in development of genital ducts in males (ductuli efferentes, ductus deferens and ductus ejaculatorius) or vestigial remnants in females (epoophoron and paroophoron)



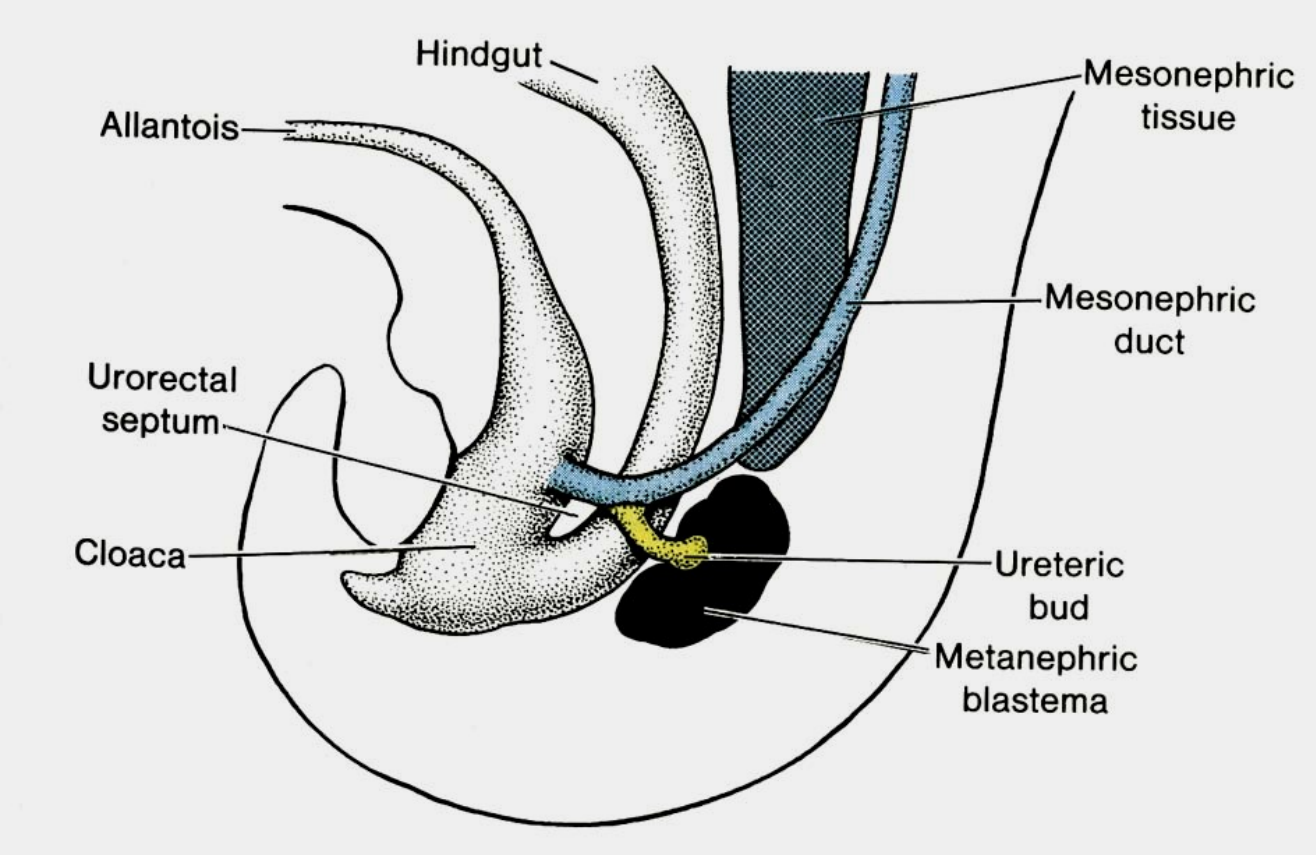


Metanephros (oi)

"hindkidney" or permanent kidney begins to develop early in the 5th week

two different sources:

- the **ureteric bud** or **metanephric diverticulum,** which gives rise to the ureter, pelvis, major and minor calyces and system of papillary ducts and collecting tubules
- the **metanephrogenic blastema** or **metanephric mesoderm** = a caudal part of the nephrogenic cord extending between **L_4 to S_1** - it gives rise to the nephrons



the ureteric bud begins as a dorsal outgrowth from the mesonephric duct near its entry into the cloaca

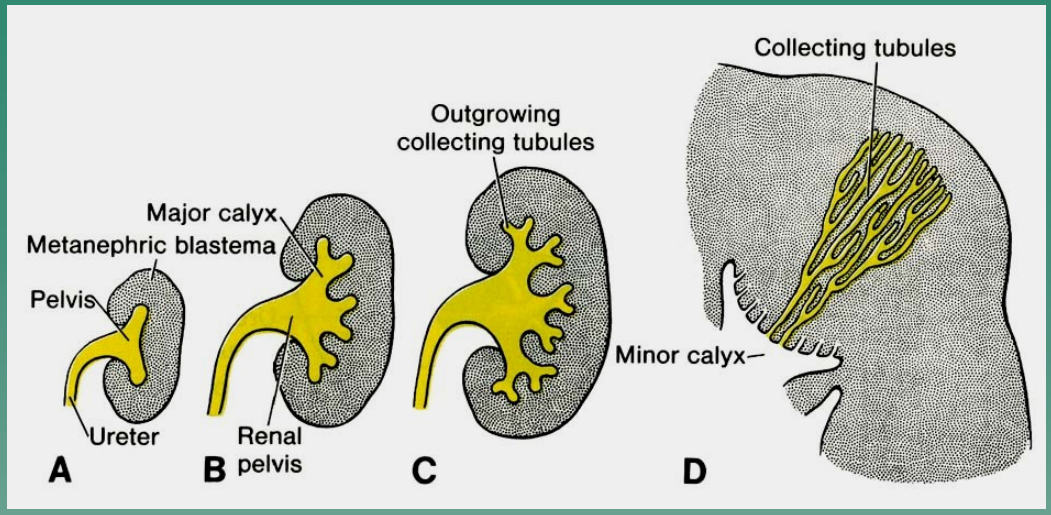
the bud then extends dorsocranially, penetrates the metanephric mesoderm and divides it into cell clusters, located near blind ends of the collecting tubules

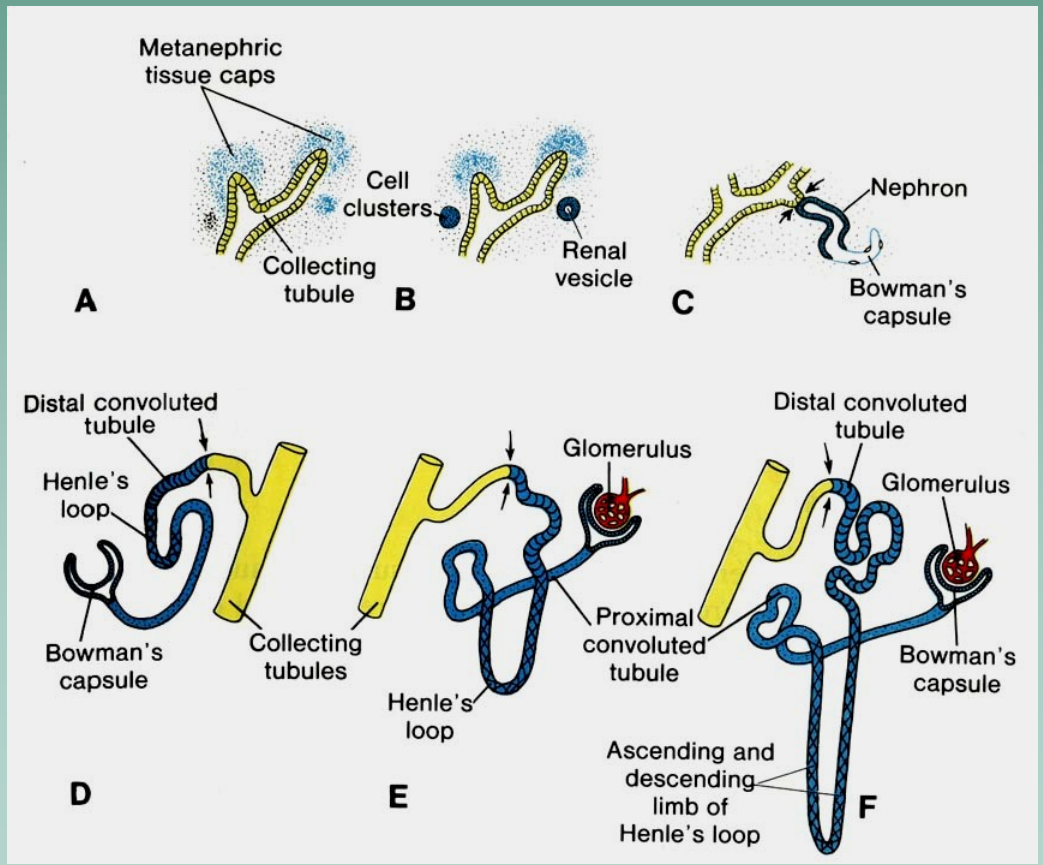
clusters of mesodermal cells become **metanephric vesicles** that are later transformed into **metanephric tubules**

the proximal part of each tubule becomes dilated
and forms the **Bowman´s capsule** of a renal corpuscle, while
the distal end contacts the respective collecting tubule and both tubules become soon confluent

the remaining part of the metanephric tubule undergoes continual lengthening and gradually differentiates into definitive segments of the uriniferous tubule

the proximal tubule, the loop of Henle, and the distal tubule





Positional changes of the kidneys

kidneys develop in the pelvis

from the 2nd trimester, they gradually come to lie in the abdomen

the migration of kidneys is mainly resulted from growth of the embryo´s body caudal to the kidneys

Development of renal pelvis and ureter

both derive from the **distal part of the ureteric bud**

Development of bladder and urethra

both organs develop from the **ventral part of the cloaca**

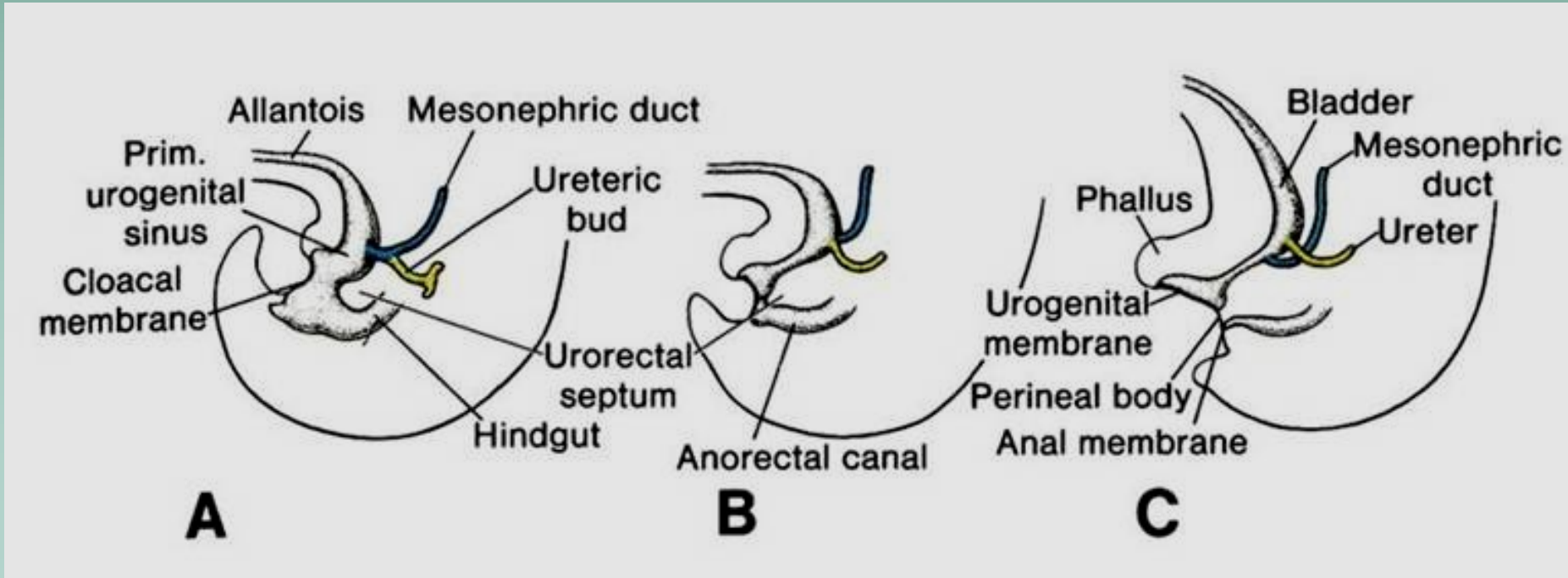
the **cloaca** is the most caudal part of the gut which is ventrally sealed off by a membrane composed of the ectoderm and endoderm - known as the **cloacal membrane**

cranially, the cloaca continues as the allantois that enters the connecting stalk

in higher vertebrates inclusively the human, the cloaca soon divides with the **urorectal septum** (runs frontally) into 2 portions :

- the **anorectal canal** situated dorsally - rectum,
- the **primitive urogenital sinus** situated ventrally - bladder + urethra.

the caudal part of the urorectal septum then fuses with the cloacal membrane: a part covering anorectal canal is the **anal membrane**, a part covering the primitive urogenital sinus is the **urogenital membrane**



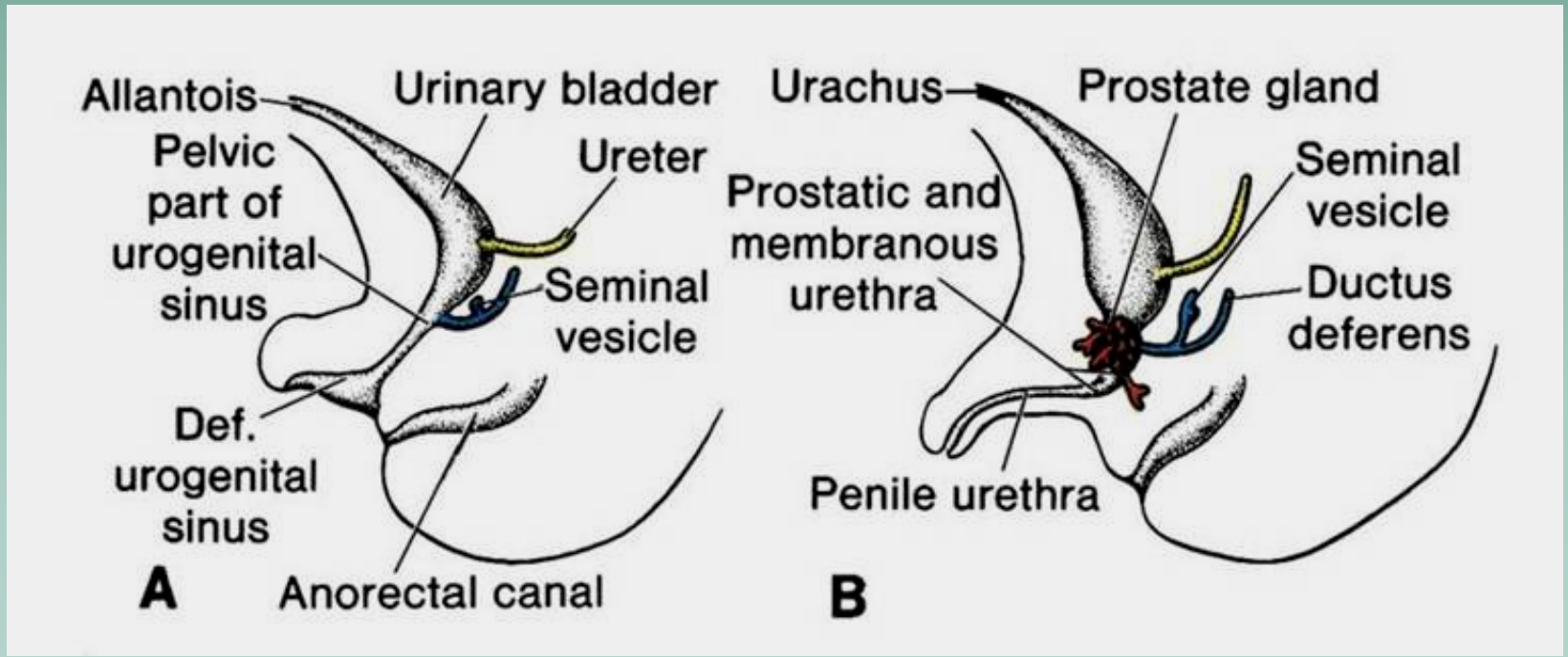
the urogenital sinus includes three parts:

- **vesical segment** (presumptive bladder - there is a wide cranial part
- **pelvic segment** - middle narrow
- **phallic segment** - it appears wide

the **vesical segment develops into the definitive bladder** - in both sexes

the pelvic segment becomes
the definitive urethra in females but **the prostatic urethra in males**

the phallic segment of the urogenital sinus becomes
the vestibule of the vagina in females but **the penile urethra in males**

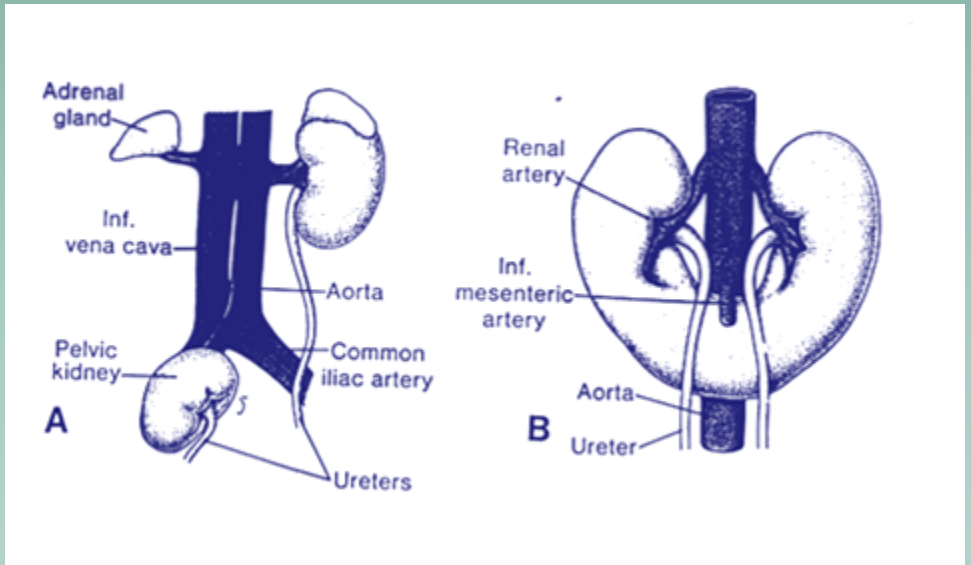


CONGENITAL MALFORMATIONS OF KIDNEYS AND URETERS

Renal agenesis = absence of a kidney
it results from failure of the ureteric bud to growout and is accompanied with an absence of the ureter
it may be uni- or bilateral
(unilateral agenesis is characterised by compensatory hypertrophy of the kidney that is present; bilateral agenesis is incompatible with survival after birth)
incidence is about 2 (3) per 10 000; is more frequent in males than females (3:1)
clinically, it is always accompanied by **oligohydramnios** which results from failure of urine production

Pelvic kidney = a kidney (s) is located in pelvis,
this malformation results from failure of the kidney to ascend

Horshoe kidney - both kidneys are fused at their inferior poles and located in pelvis (failure of kidneys ascend)
horshoe kidney is often symptomless and occurs 1 per 600 live birth.



Polycystic kidney disease = hereditary disease characterised by that one or both kidneys contain numerous small, medium - sized or large urine-filled cysts inhibiting its normal function
polycystic kidney disease may be uni- or bi-lateral
bilateral p. k. d. has almost bad prognosis because it is incompatible with survival after birth

P. k. d. is believed to result from failure of collecting tubules and uriniferous tubules to join up.
Polycystic kidney disease includes two hereditary forms. One is autosomal recessive or **infantile**, the other is autosomal dominant, or **adult**.

Duplication of the ureter -
ureter duplex
and **bifid ureter** (ureter fissus)