EMBRYOLOGY

Urinary Tract

From intermediate mesoderm

Urinary tract

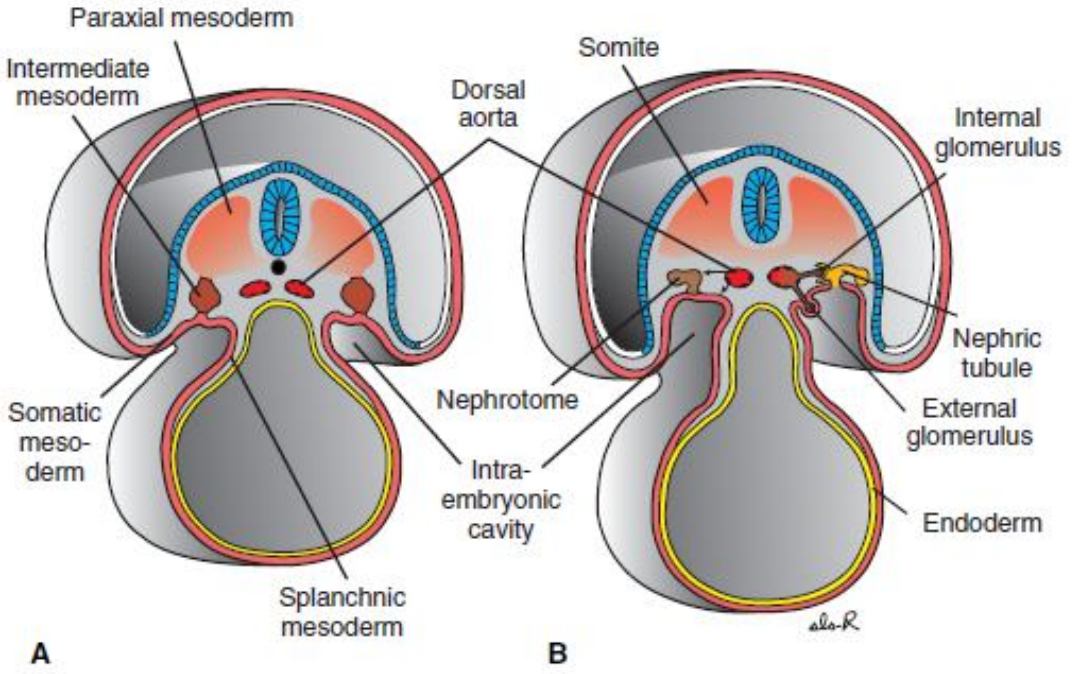


Figure 16.1 Transverse sections through embryos at various stages of development showing formation of nephric tubules. **A.** 21 days. **B.** 25 days. Note formation of external and internal glomeruli and the open connection between the intraembryonic cavity and the nephric tubule.

Kidney

From Cephalic To Caudal :

Pronephros :

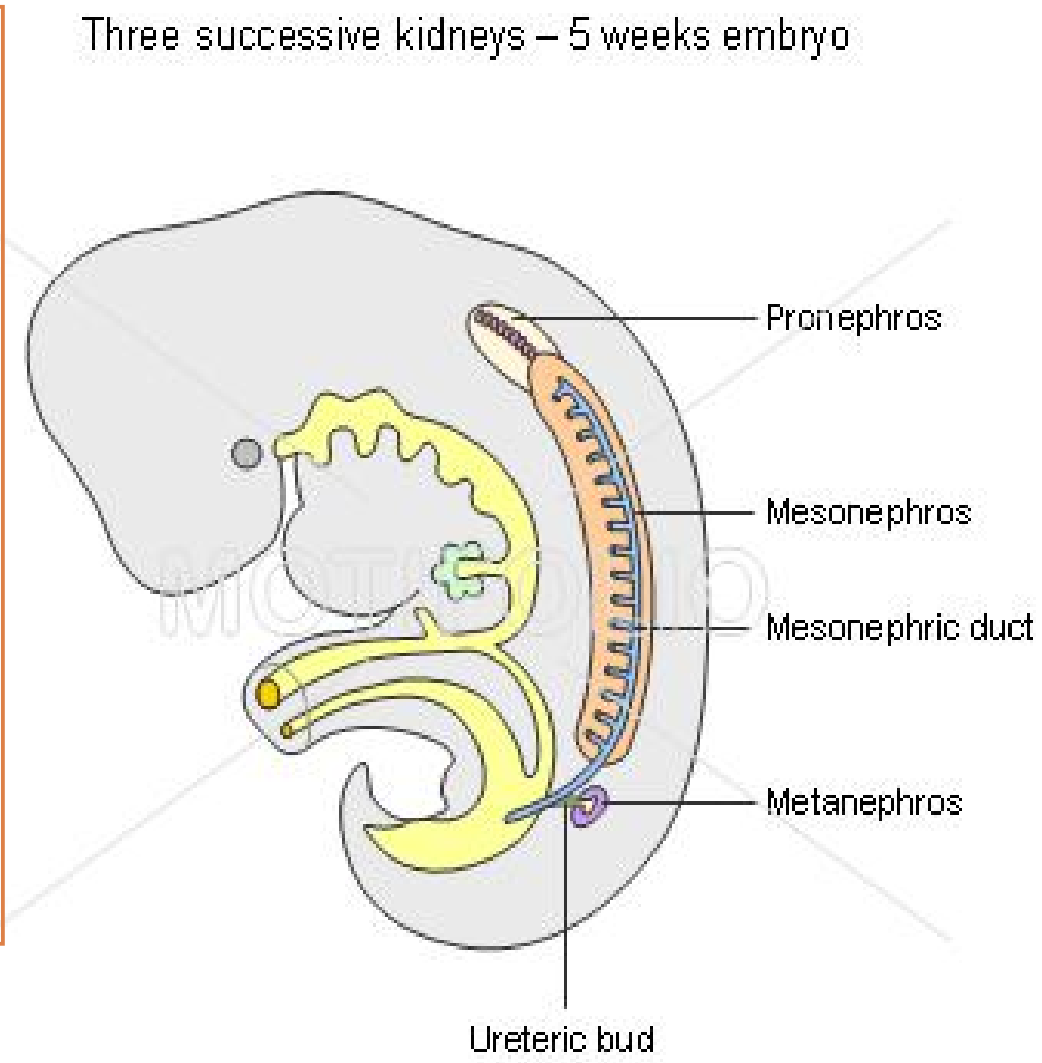
Cervical position / nephrotom / Without Function / 4th week

Mesonephros:

T1-L3 position / Have Function For Few Times / 4th week up 2th month

Metanephros :

Permanent Kidney / 5th week



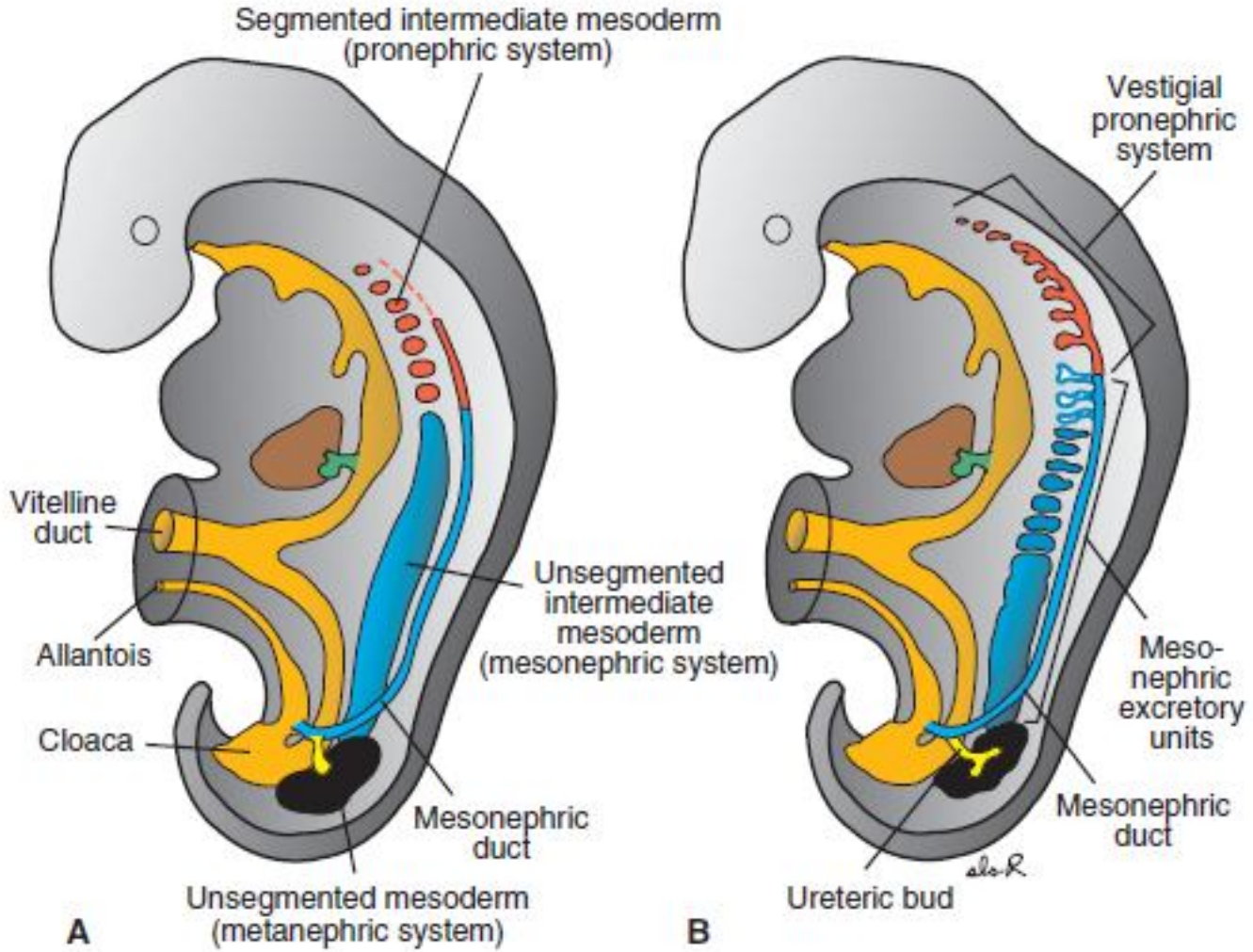


Figure 16.2 A. Relationship of the intermediate mesoderm of the pronephric, mesonephric, and metanephric systems. In cervical and upper thoracic regions, intermediate mesoderm is segmented; in lower thoracic, lumbar, and sacral regions, it forms a solid, unsegmented mass of tissue, the nephrogenic cord. Note the longitudinal collecting duct, formed initially by the pronephros but later by the mesonephros (Mesonephric duct). **B.** Excretory tubules of the pronephric and mesonephric systems in a 5-week embryo.

Mesonephros system:

mesonephric tubules (S like ring)
mesonephric duct

Gonad + mesonephros system Located in Urogenital ridge

Lateral to mesonephric tubules:

Masonephric duct

Medial to mesonephric tubules:

glomerulus/ bowman's capsule /renal corpuscle/gonad

Urogenital mesentery:

attach mesonephros system & gonad to dorsal abdominal wall

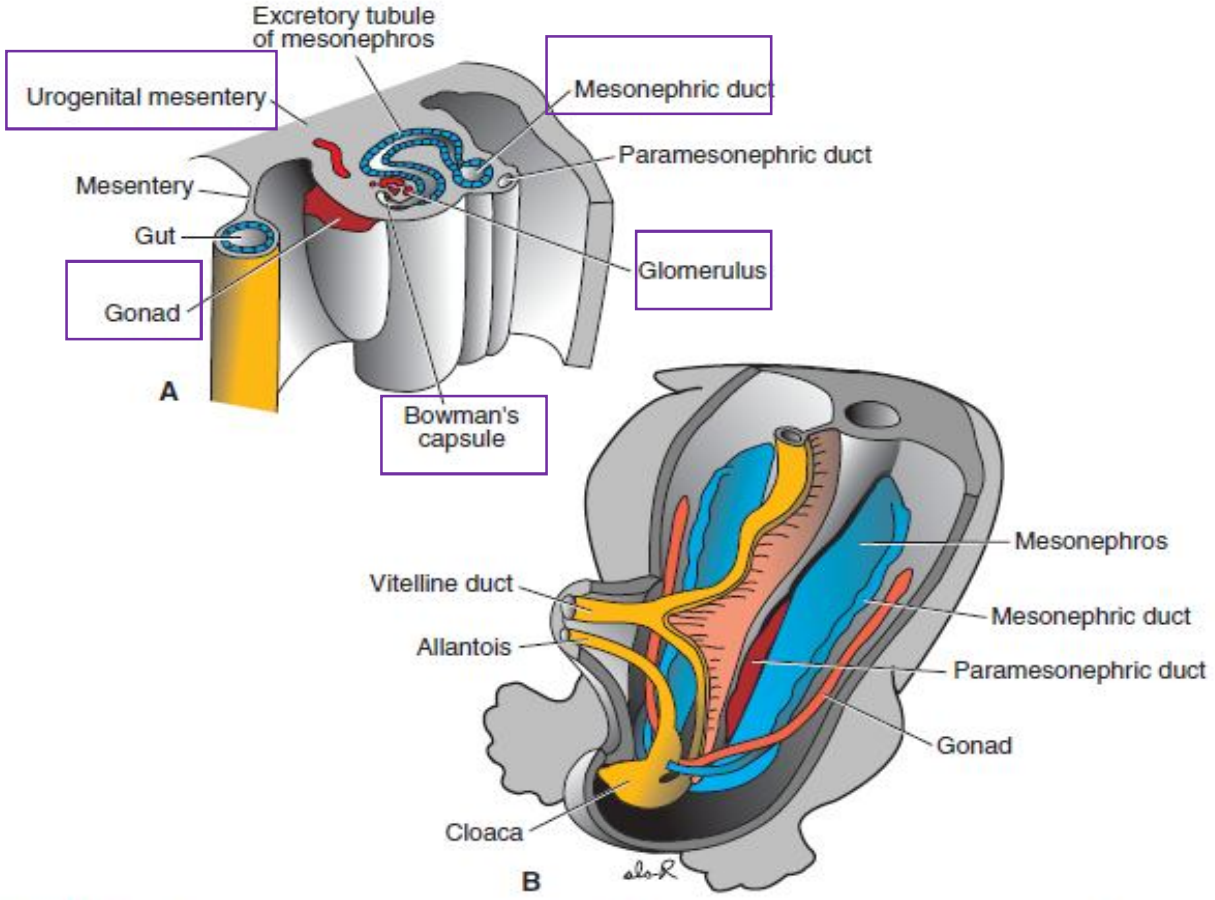


Figure 16.3 **A.** Transverse section through the urogenital ridge in the lower thoracic region of a 5-week embryo showing formation of an excretory tubule of the mesonephric system. Note the appearance of Bowman's capsule and the gonadal ridge. The mesonephros and gonad are attached to the posterior abdominal wall by a broad urogenital mesentery. **B.** Relation of the gonad and the mesonephros. Note the size of the mesonephros. The mesonephric duct (wolffian duct) runs along the lateral side of the mesonephros.

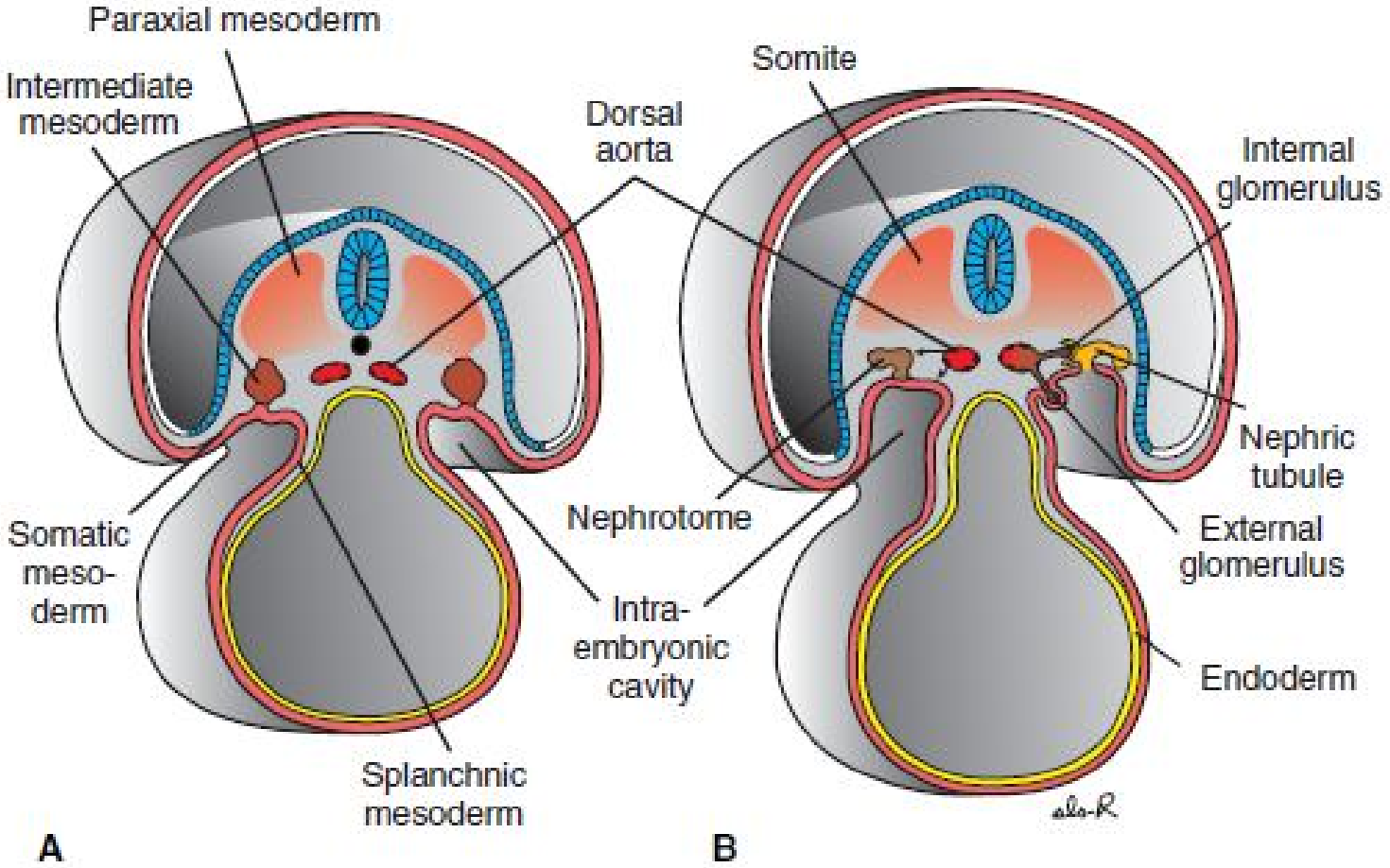


Figure 16.1 Transverse sections through embryos at various stages of development showing formation of nephric tubules. **A.** 21 days. **B.** 25 days. Note formation of external and internal glomeruli and the open connection between the intraembryonic cavity and the nephric tubule.

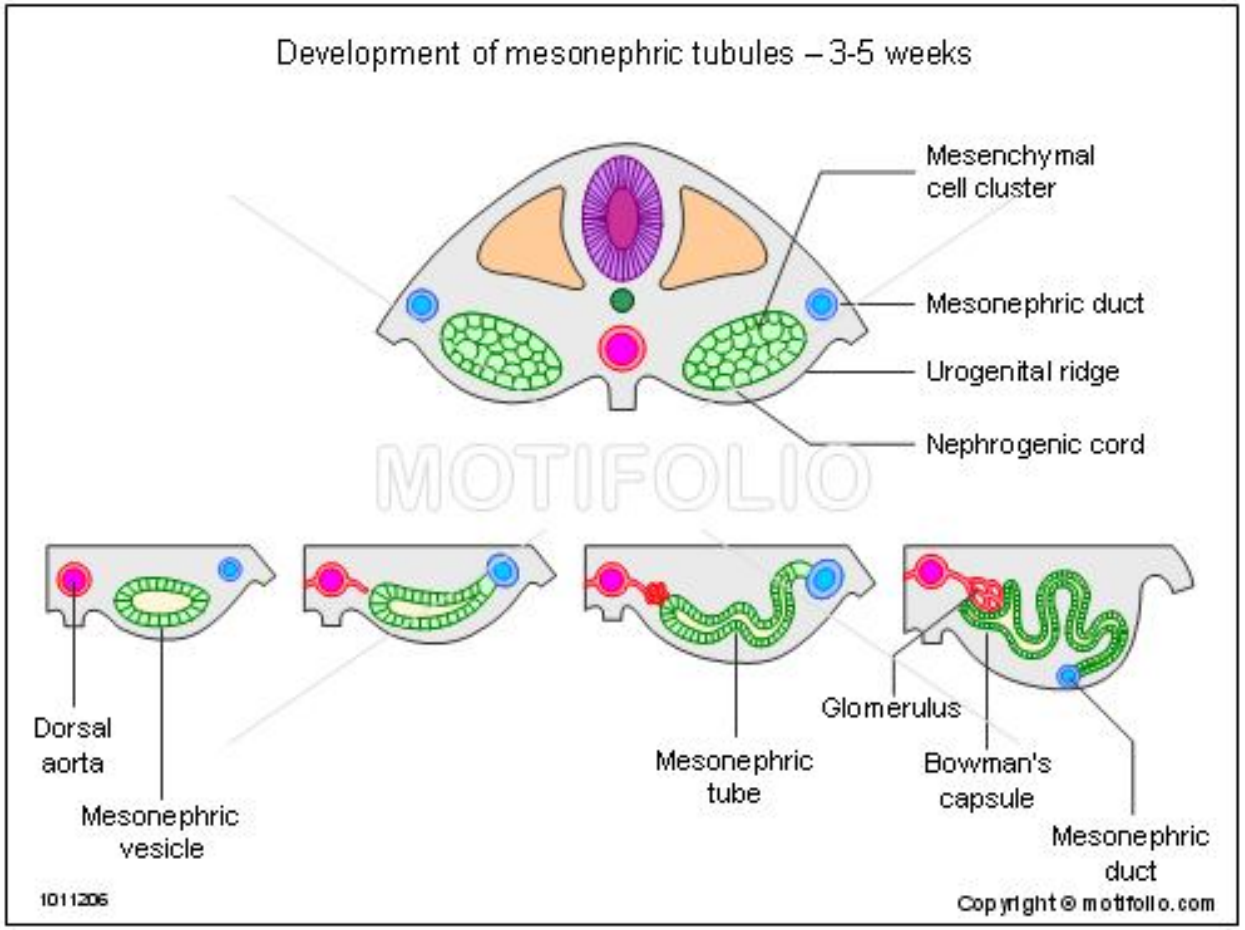
Mesonephros:

T1-L3 position / Have Function For Few Times / 4th week up 2th month

Point:

In male end parts of mesonephros system remain for reproductive system formation

In female all parts of this system degenerated



Metanephros : Collecting Tubules +excretory system

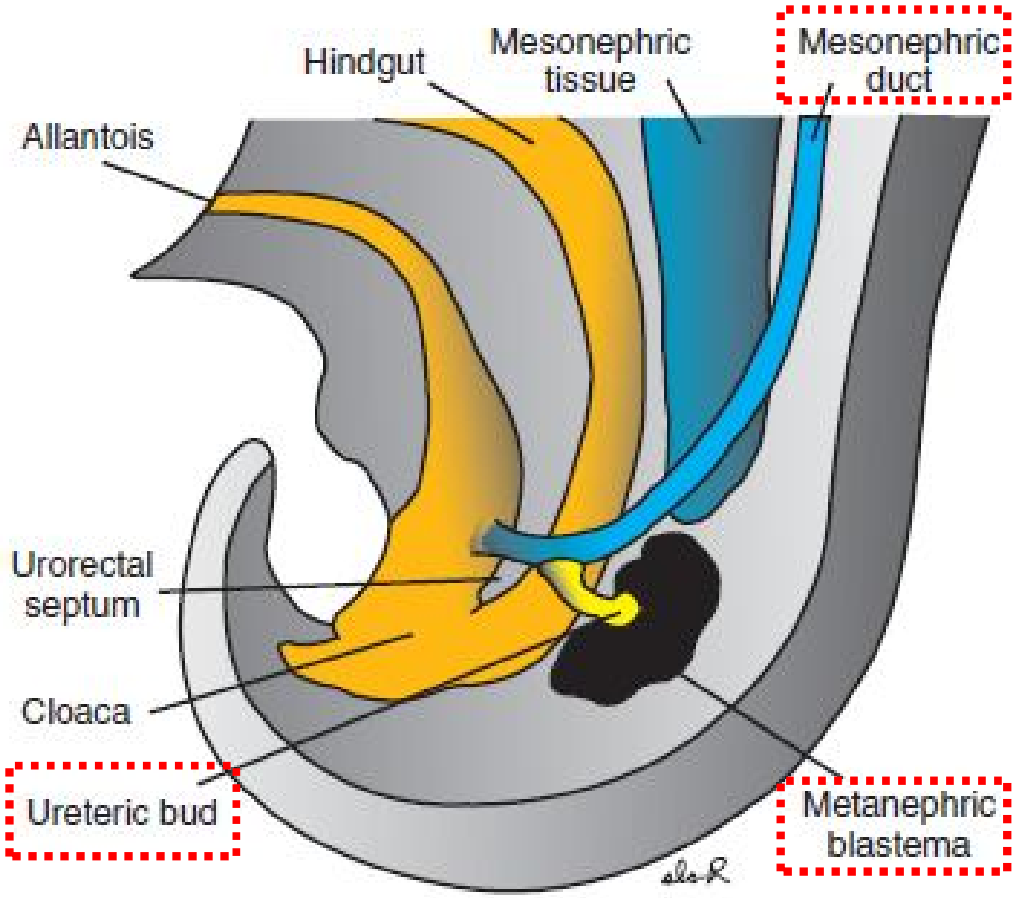


Figure 16.4 Relation of the hindgut and cloaca at the end of the fifth week. The ureteric bud penetrates the metanephric mesoderm (blastema).

Ureteric Bud – Collecting Tubules

Ureter / Renal pelvis / major calyces / minor calyces / collecting tubules / renal pyramid

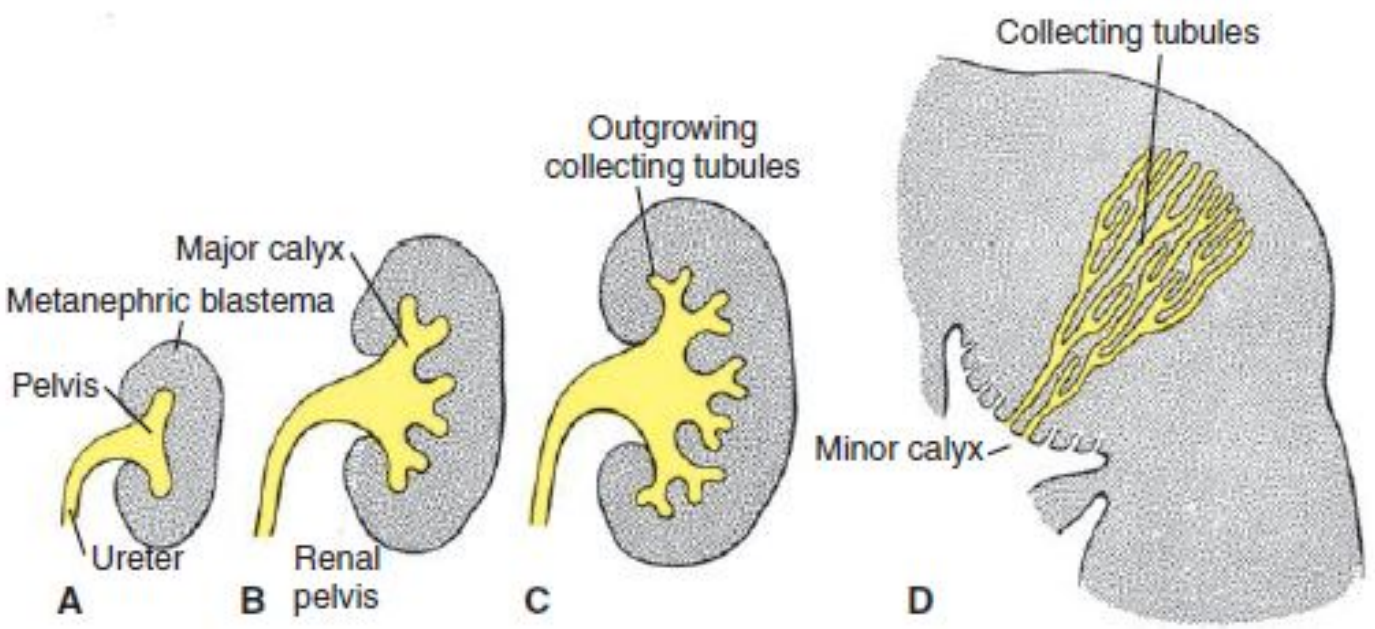
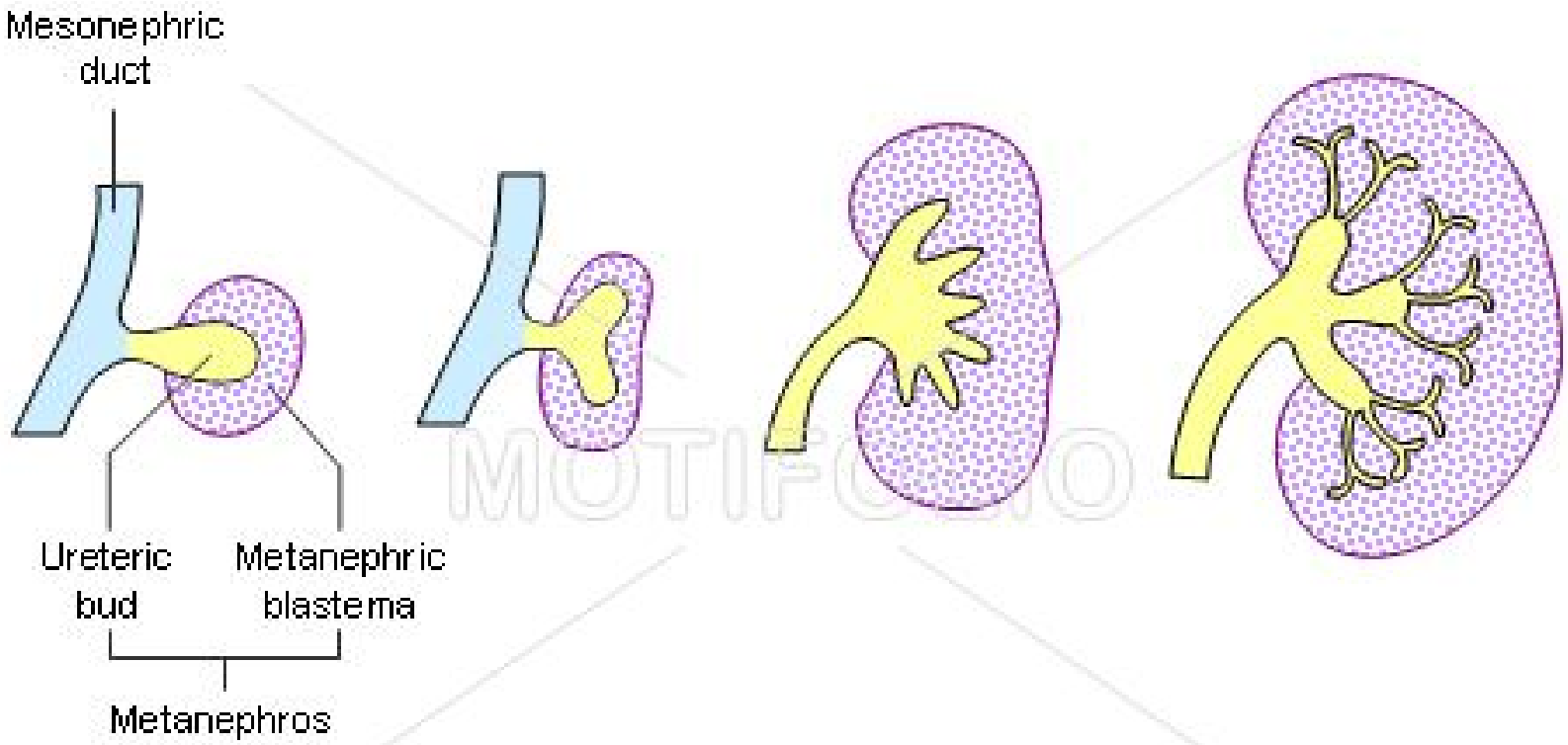


Figure 16.5 Development of the renal pelvis, calyces, and collecting tubules of the metanephros. **A.** 6 weeks. **B.** At the end of the sixth week. **C.** 7 weeks. **D.** Newborn. Note the pyramid form of the collecting tubules entering the minor calyx.

Development of the metanephros and its duct system – 5 – 8 weeks



Renal pelvis → Major calyx → Minor calyx → Collecting duct

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Metenephric Cap – excretory system

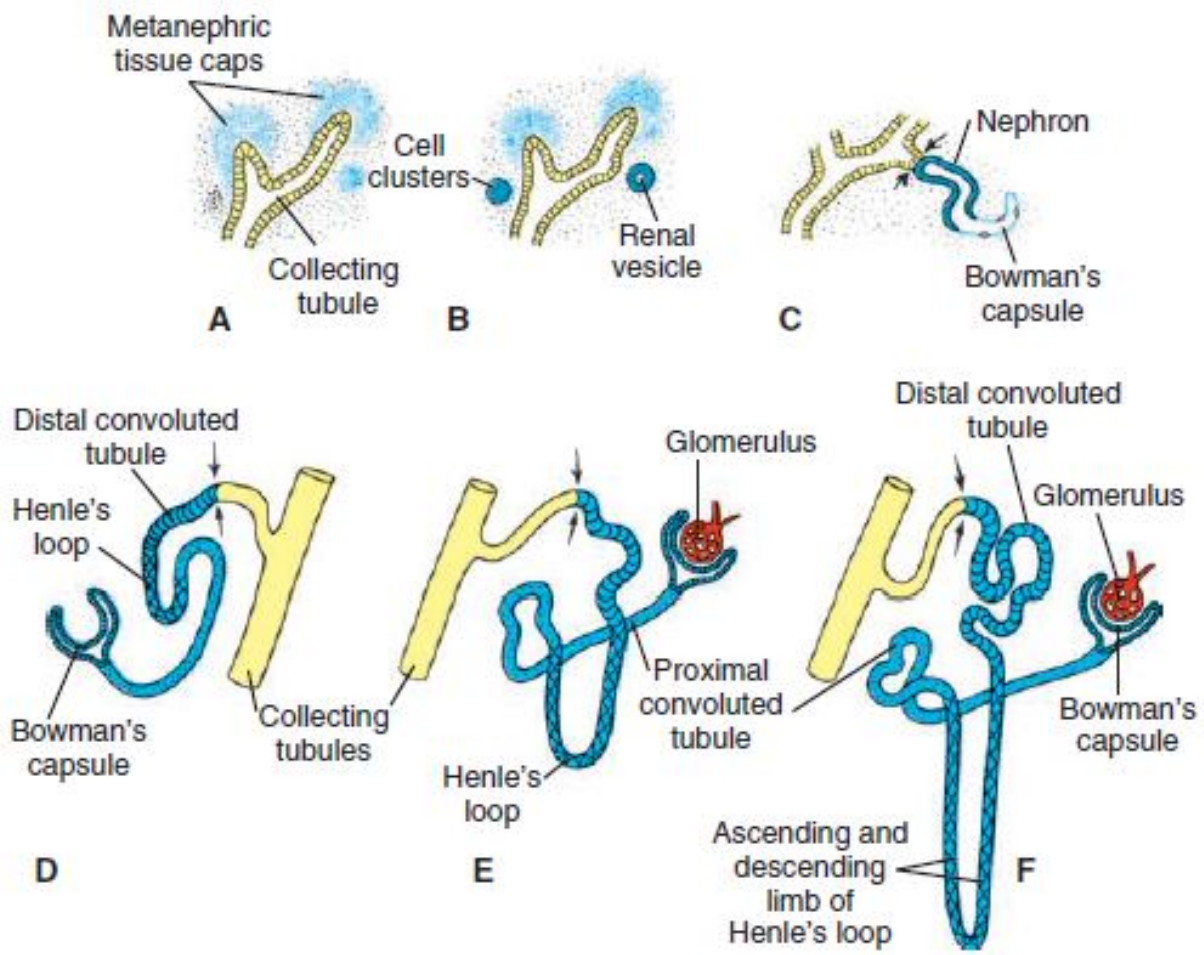
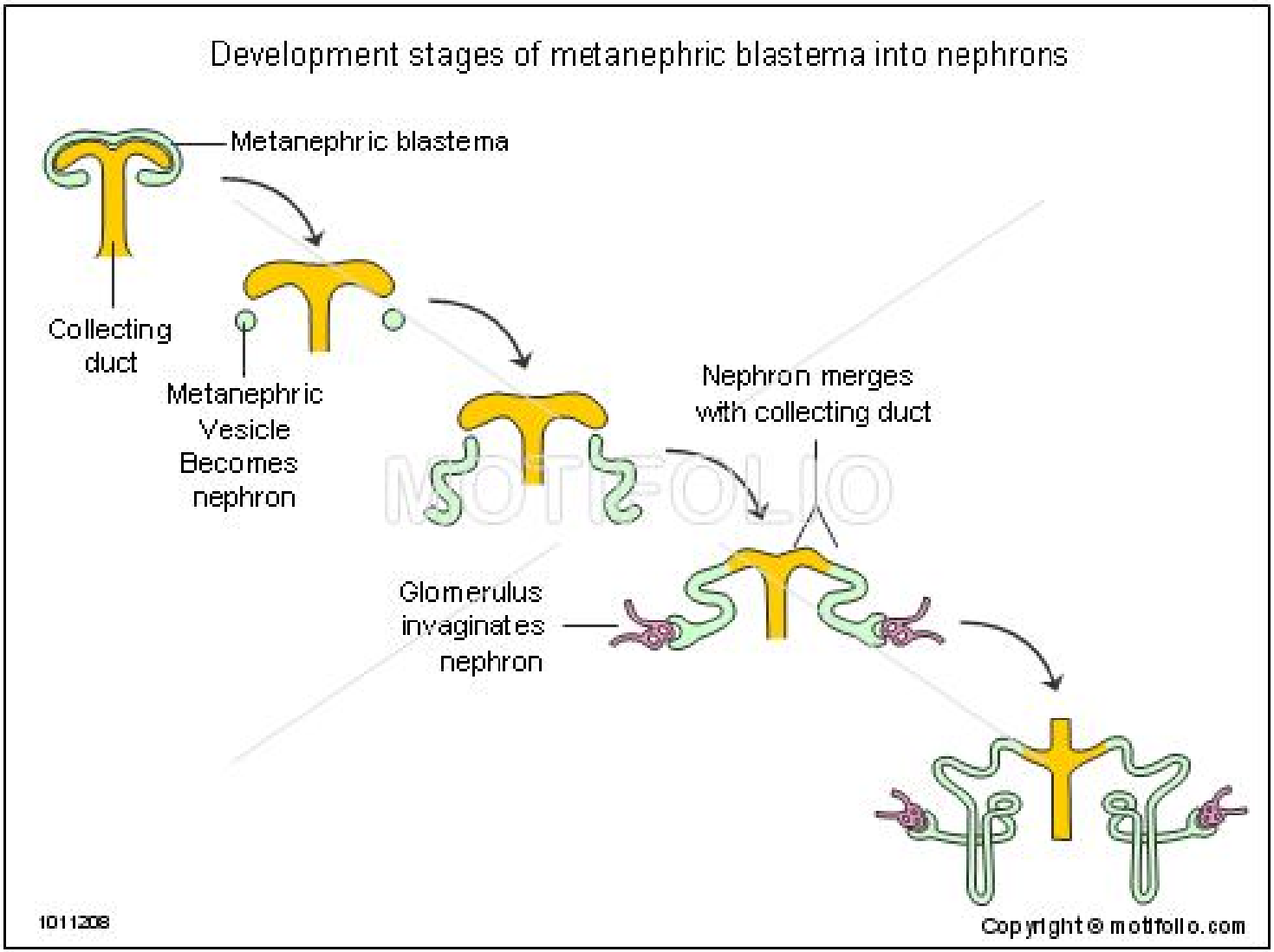


Figure 16.6 Development of a metanephric excretory unit. *Arrows*, the place where the excretory unit (*blue*) establishes an open communication with the collecting system (*yellow*), allowing flow of urine from the glomerulus into the collecting ducts.


Development stages of metanephric blastema into nephrons
Metanephric blastema
Collecting duct
Metanephric Vesicle Becomes nephron
Nephron merges with collecting duct
Glomerulus invaginates nephron
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GDNF & HGF: The bud growth stimulation

BMP7& FGF2 : Proliferation of the mesenchyme and maintain WT1 expression

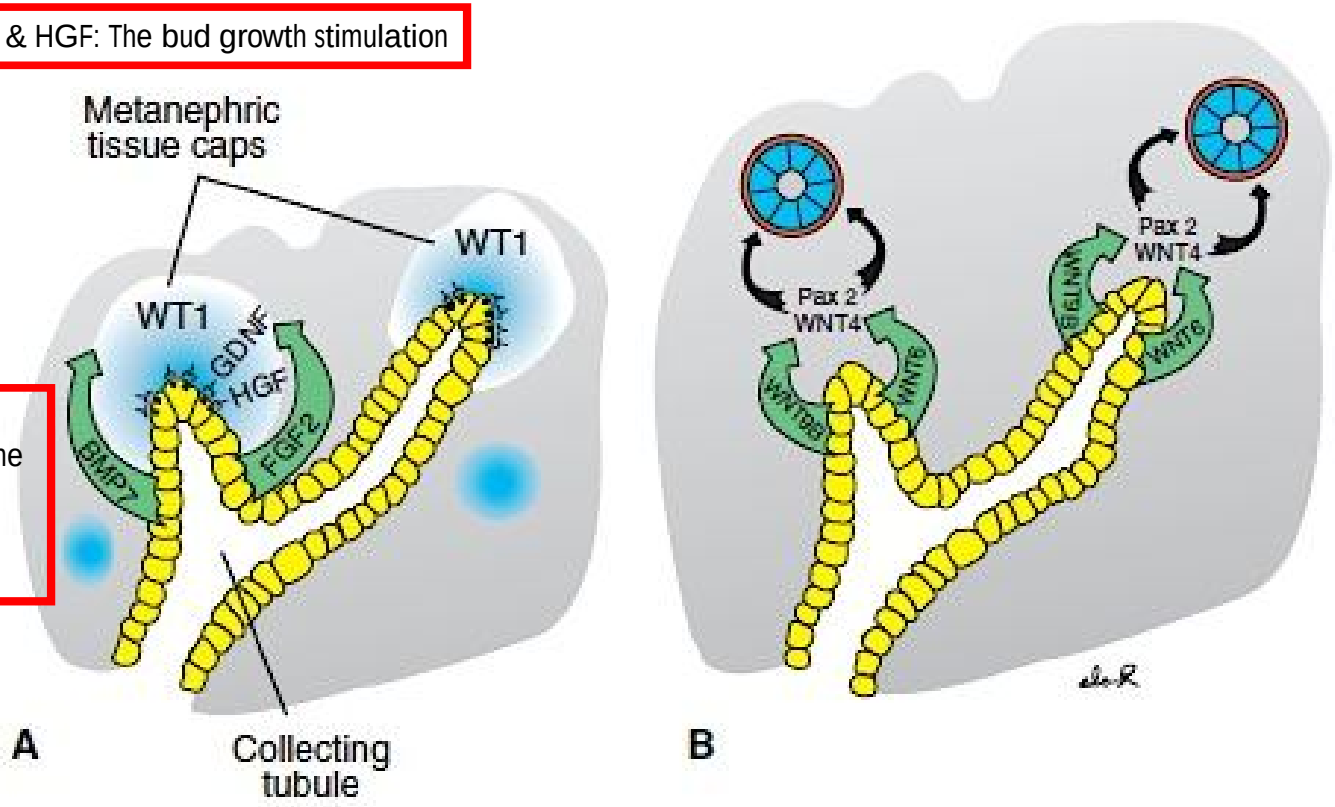
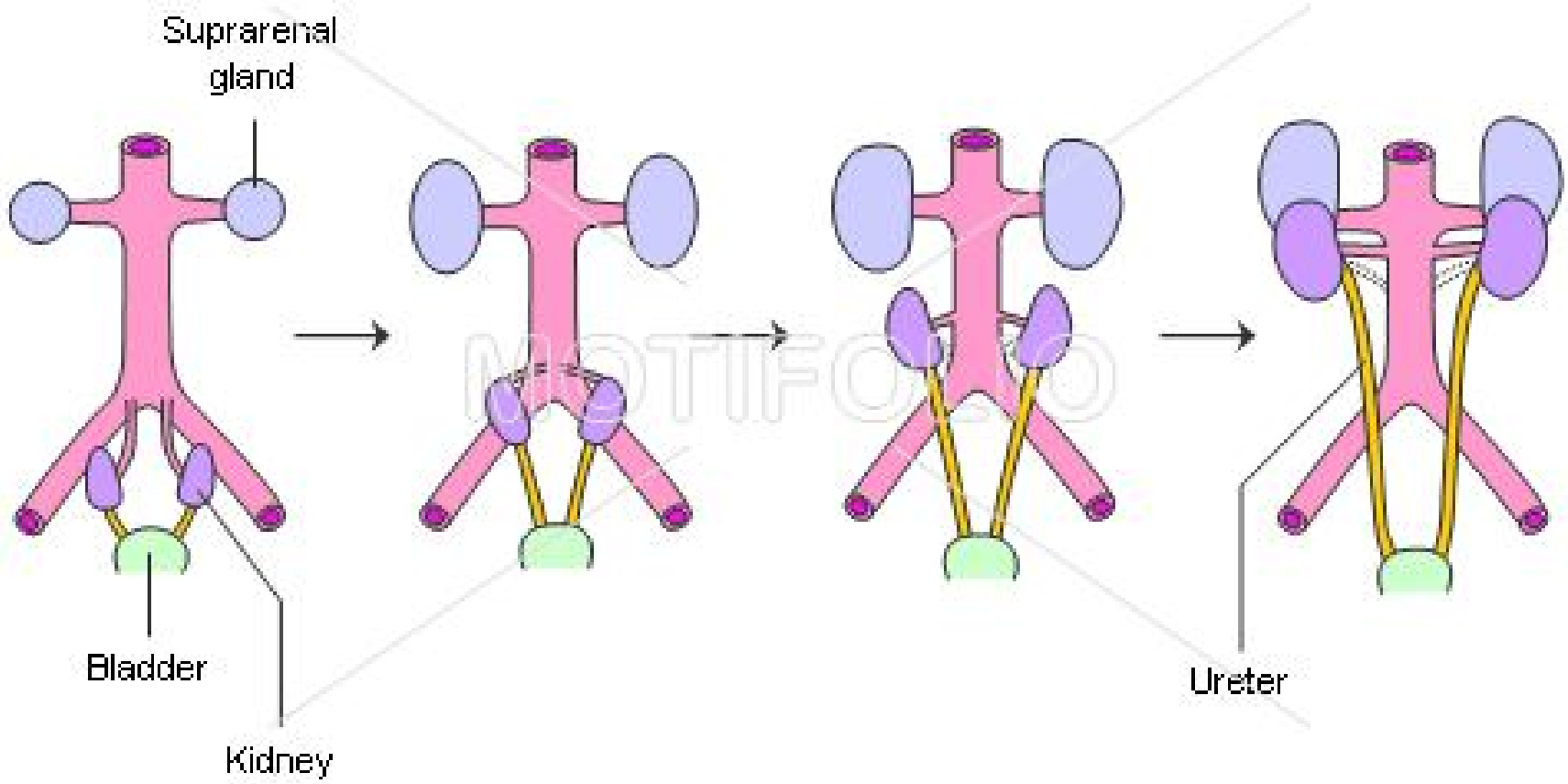


Figure 16.7 Genes involved in differentiation of the kidney. **A.** *WT1*, expressed by the mesenchyme, enables this tissue to respond to induction by the ureteric bud. GDNF and HGF, also produced by the mesenchyme, interact through their receptors, RET and MET, respectively, in the ureteric bud epithelium, to stimulate growth of the bud and maintain the interactions. The growth factors FGF2 and BMP7 stimulate proliferation of the mesenchyme and maintain *WT1* expression. **B.** WNT9B and WNT6 secreted by branches of the ureteric bud epithelium cause upregulation of *PAX2* and *WNT4* in the surrounding mesenchyme. In turn, these genes cause the mesenchyme to epithelialize (*PAX2*) and to then form tubules (*WNT4*). Changes in the extracellular matrix also occur, such that laminin and type IV collagen form a basement membrane (orange) for the epithelial cells.

Kidney Position

The ascent of the kidneys from the sacral to the lumbar position – 6- 9 weeks



Kidney Position

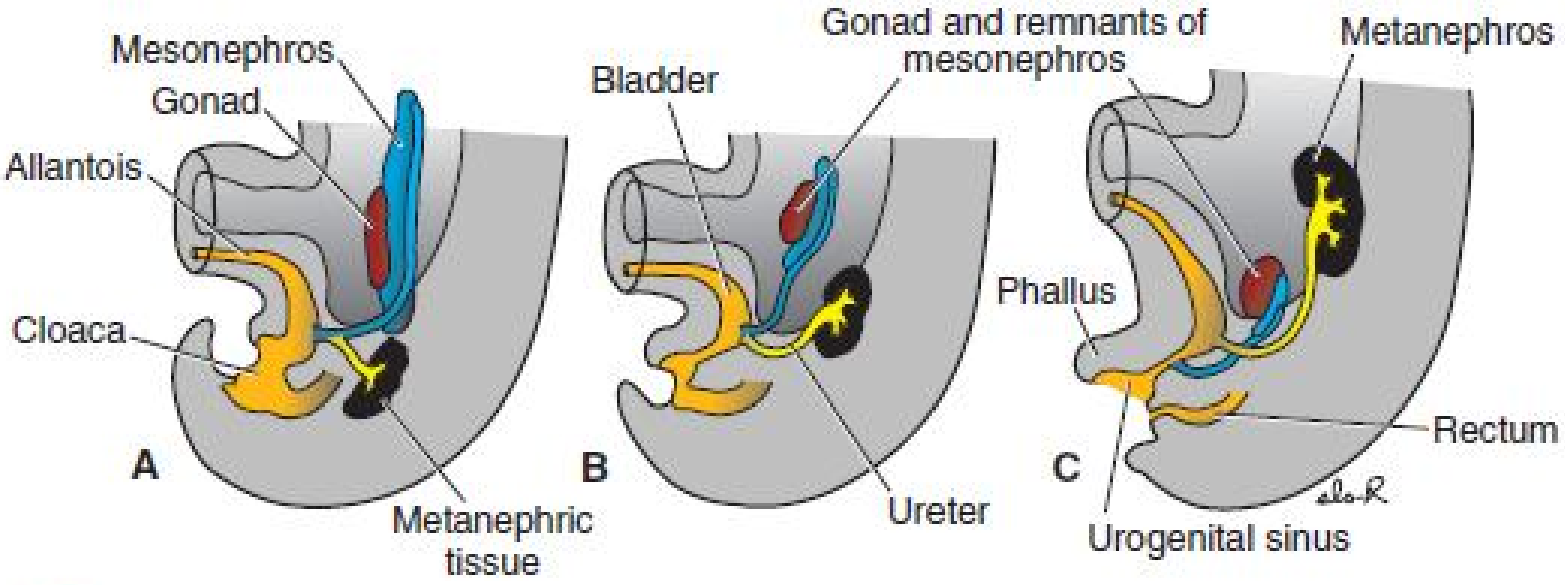
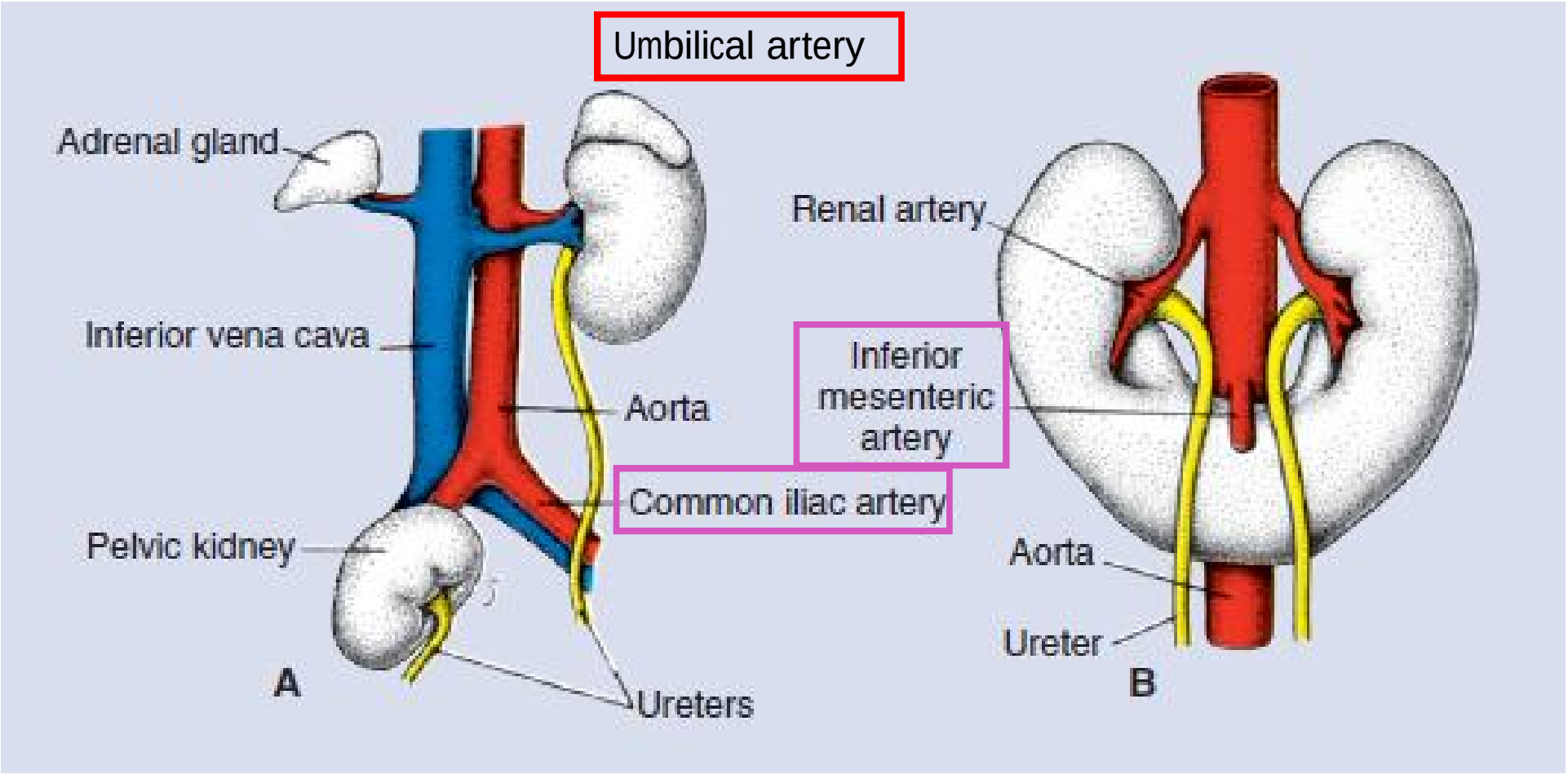


Figure 16.10 A–C. Ascent of the kidneys. Note the change in position between the mesonephric and metanephric systems. The mesonephric system degenerates almost entirely, and only a few remnants persist in close contact with the gonad. In both male and female embryos, the gonads descend from their original level to a much lower position.

Pelvic kidney / horseshoe kidney



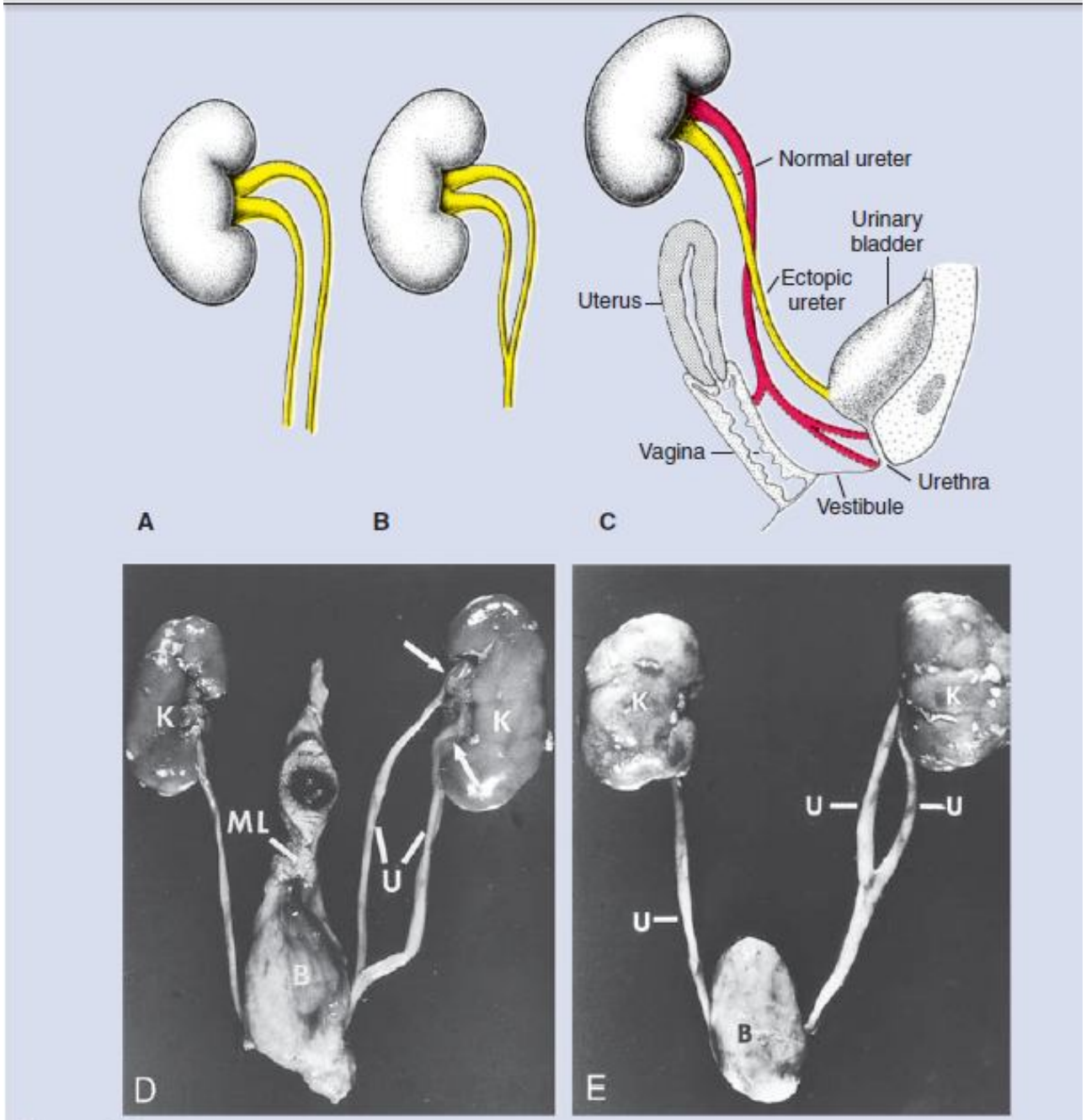


Figure 16.9 **A,B.** A complete and a partial double ureter. **C.** Possible sites of ectopic ureteral openings in the vagina, urethra, and vestibule. **D,E.** Photomicrographs of complete and partial duplications of the ureters (*U*). *Arrows*, duplicated hilum; *B*, bladder; *K*, kidneys; *ML*, median umbilical ligament.

Function of the Kidney

The definitive kidney formed from the metanephros becomes functional near the 12th week. Urine is passed into the amniotic cavity and mixes with the amniotic fluid. The fluid is swallowed by the fetus and recycles through the kidneys. During fetal life, the kidneys are not responsible for excretion of waste products, since the placenta serves this function.

Cloaca Division (4 – 7 weeks)

Perineal body : tip of urorectal septum

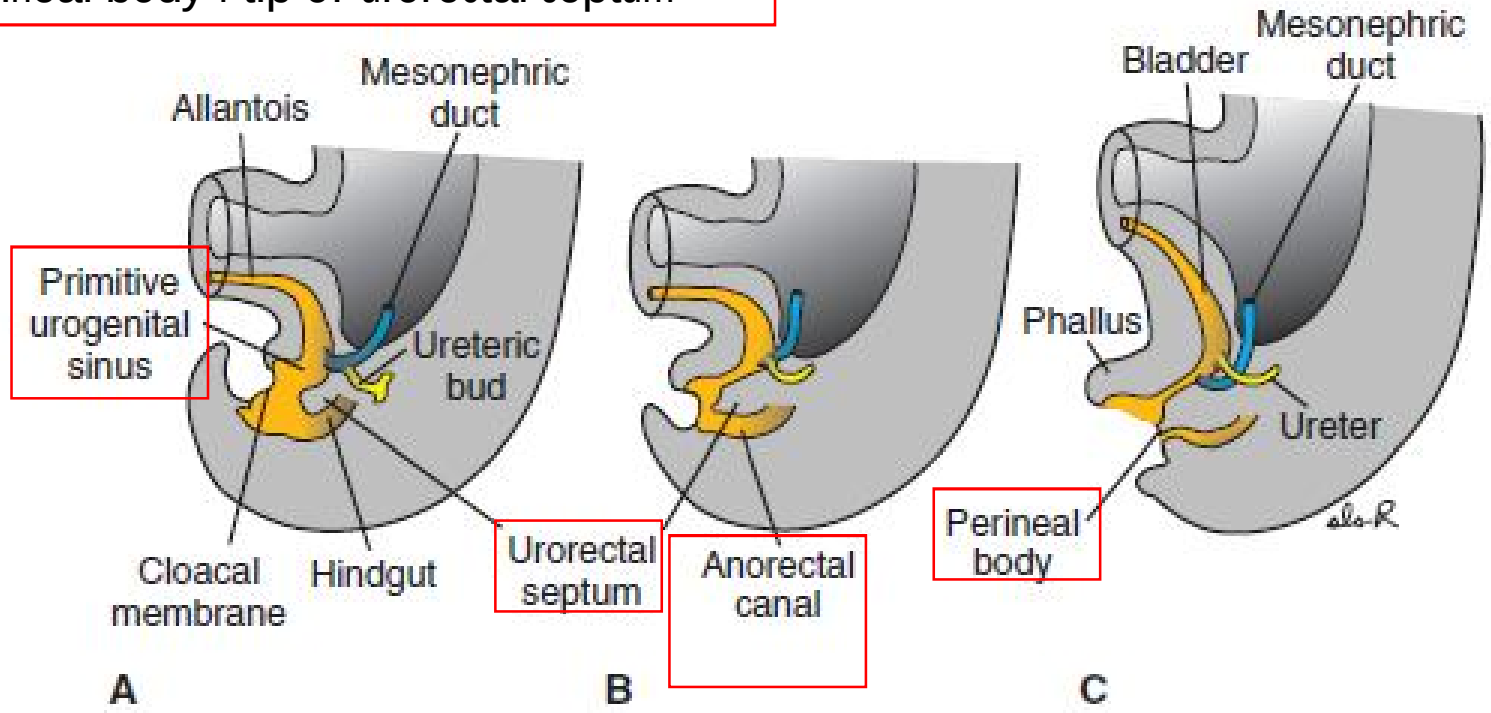
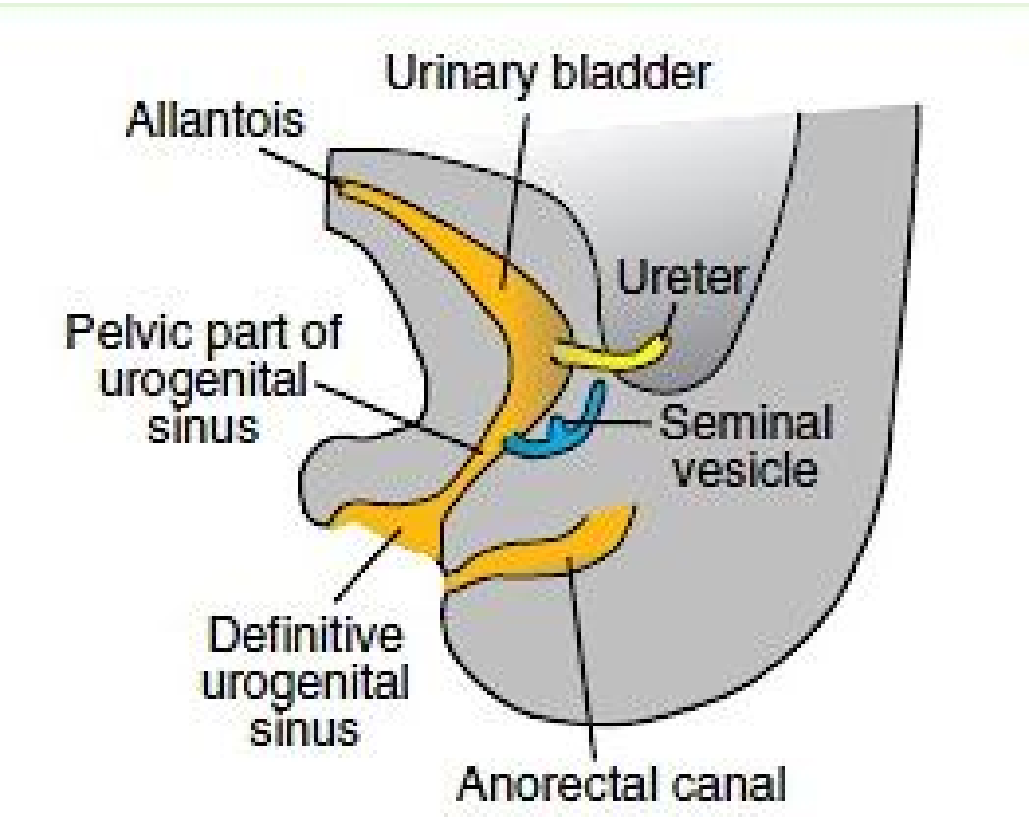


Figure 16.12 Divisions of the cloaca into the urogenital sinus and anorectal canal. The mesonephric duct is gradually absorbed into the wall of the urogenital sinus, and the ureters enter separately. **A.** At the end of the fifth week. **B.** 7 weeks. **C.** 8 weeks.

Urogenital sinus:

Sup. Part : Urinary bladder
Pelvic part: prostatic & membranous part of urethra
Phallic part: different differentiation in male & female



Ureteric bud (ureter) origin: mesoderm
Mesonephric duct origin: mesoderm

Trigone of bladder : mesoderm
But Finally Mesoderm replace by endoderm

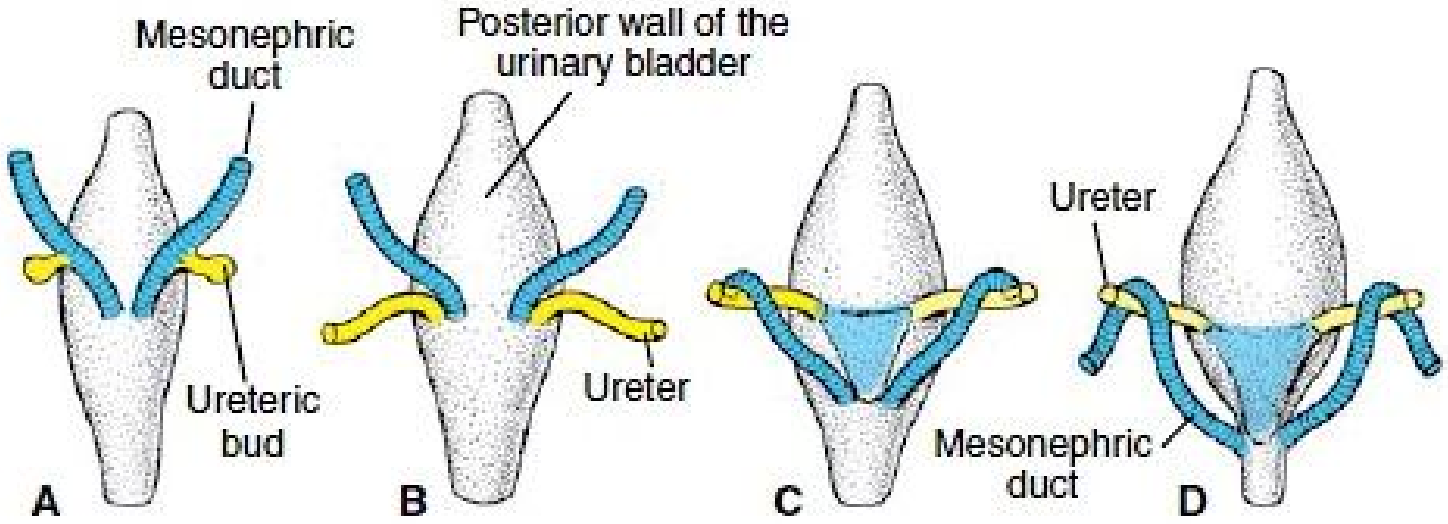


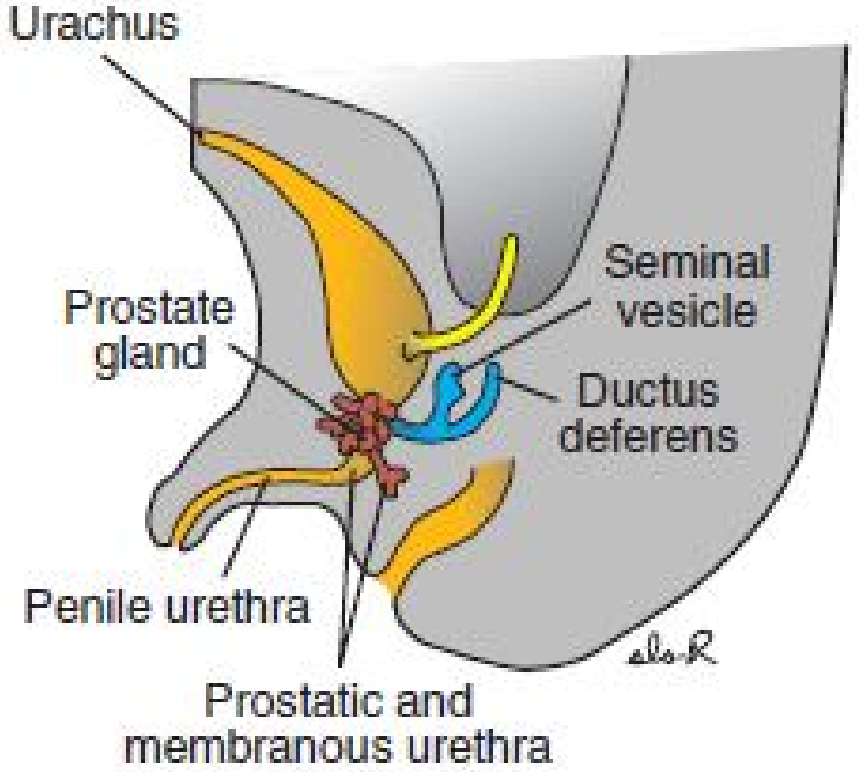
Figure 16.14 Dorsal views of the bladder showing the relation of the ureters and mesonephric ducts during development. Initially, the ureters are formed by an outgrowth of the mesonephric duct **A**, but with time, they assume a separate entrance into the urinary bladder **B–D**. Note the trigone of the bladder formed by incorporation of the mesonephric ducts **C,D**.

At the End of 3th month

Proliferation of prostatic urethra epithelium (endoderm) in :

Men = Prostatic glands
Women = Urethral & Para urethral glands

Connective tissue & smooth muscles around prostatic urethra origin from : mesoderm



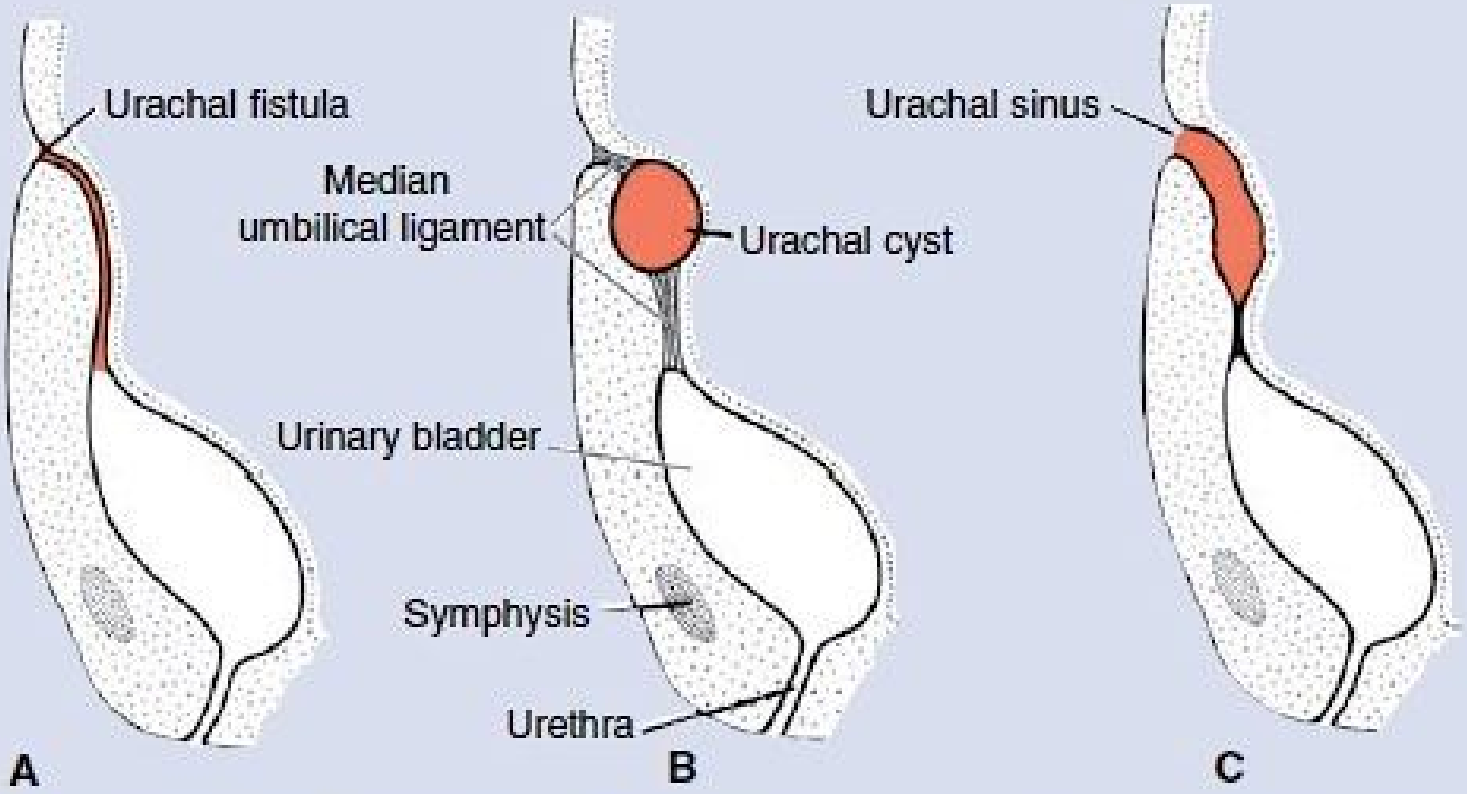
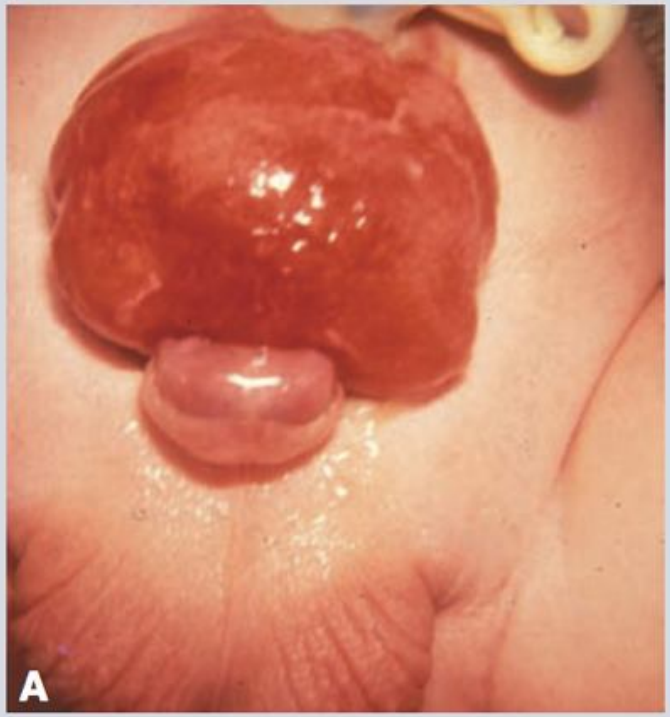
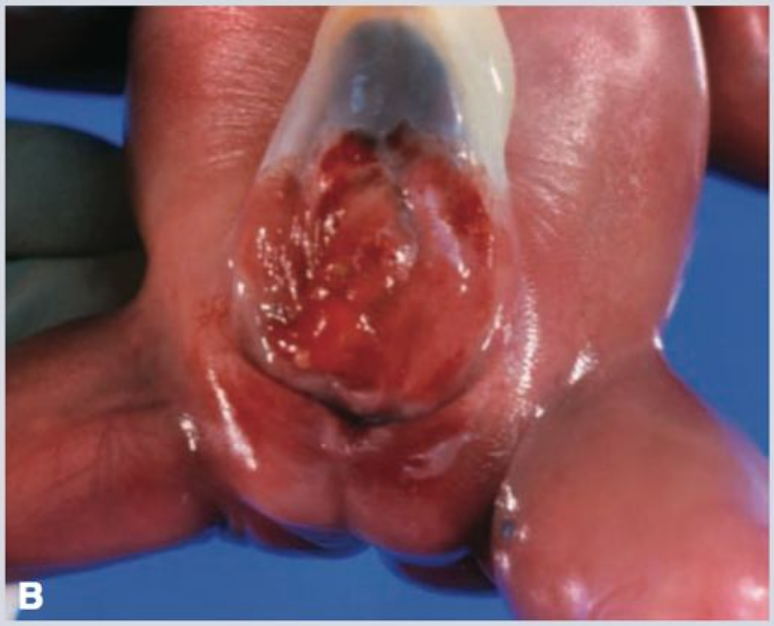


Figure 16.15 **A.** Urachal fistula. **B.** Urachal cyst. **C.** Urachal sinus. The sinus may or may not be in open communication with the urinary bladder.

Exstrophy of the bladder (Fig. 16.16*A*) is a ventral body wall defect in which the bladder mucosa is exposed. Epispadias is a constant feature (Fig. 16.35), and the open urinary tract extends along the dorsal aspect of the penis through the bladder to the umbilicus. Exstrophy of the bladder is probably due to failure of the lateral body wall folds to close in the midline in the pelvic region (see Chapter 7, p. 87). This anomaly is rare, occurring in 2/100,000 live births.



Exstrophy of the cloaca (Fig. 16.16*B*) is a more severe ventral body wall defect in which progression and closure of the lateral body wall folds are disrupted to a greater degree than is observed in bladder exstrophy (see Chapter 7, p. 87). In addition to the closure defect, normal development of the urorectal septum is altered, such that anal canal malformations and imperforate anus occur (see Chapter 15, p. 228). Furthermore, since the body folds do not fuse, the genital swellings are widely spaced resulting in defects in the external genitalia (Fig. 16.16B). Occurrence of the defect is rare (1/30,000).

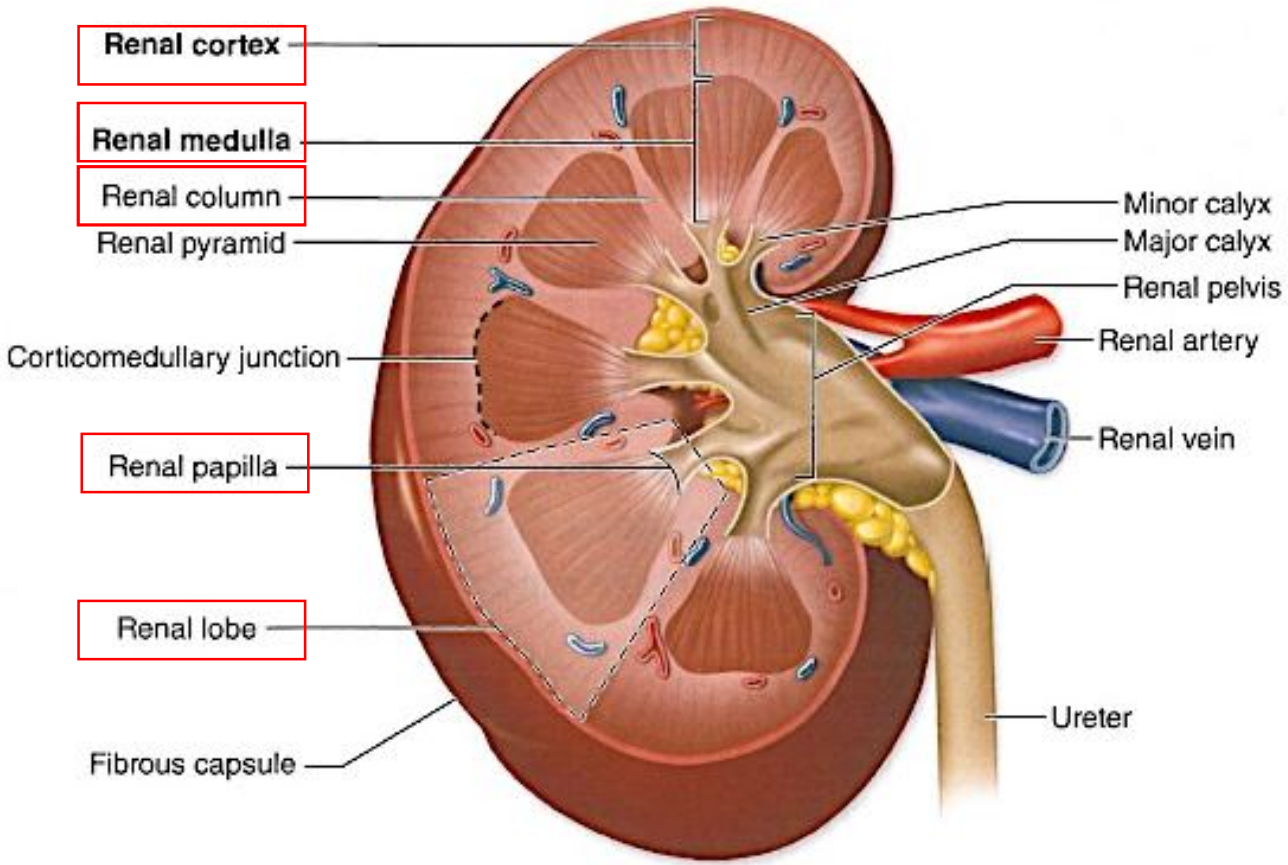


HISTOLOGY

Urinary tract

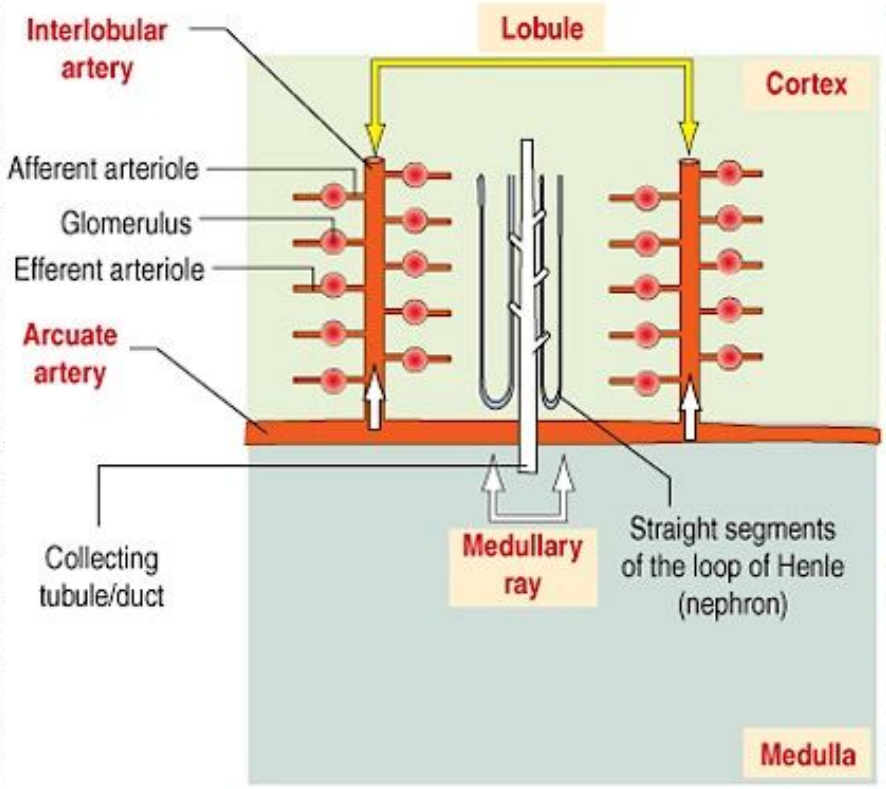
Renal papilla / Area cribrosa
Renal column (column of bertin)
Medullary ray
Renal lobe
Renal lobule

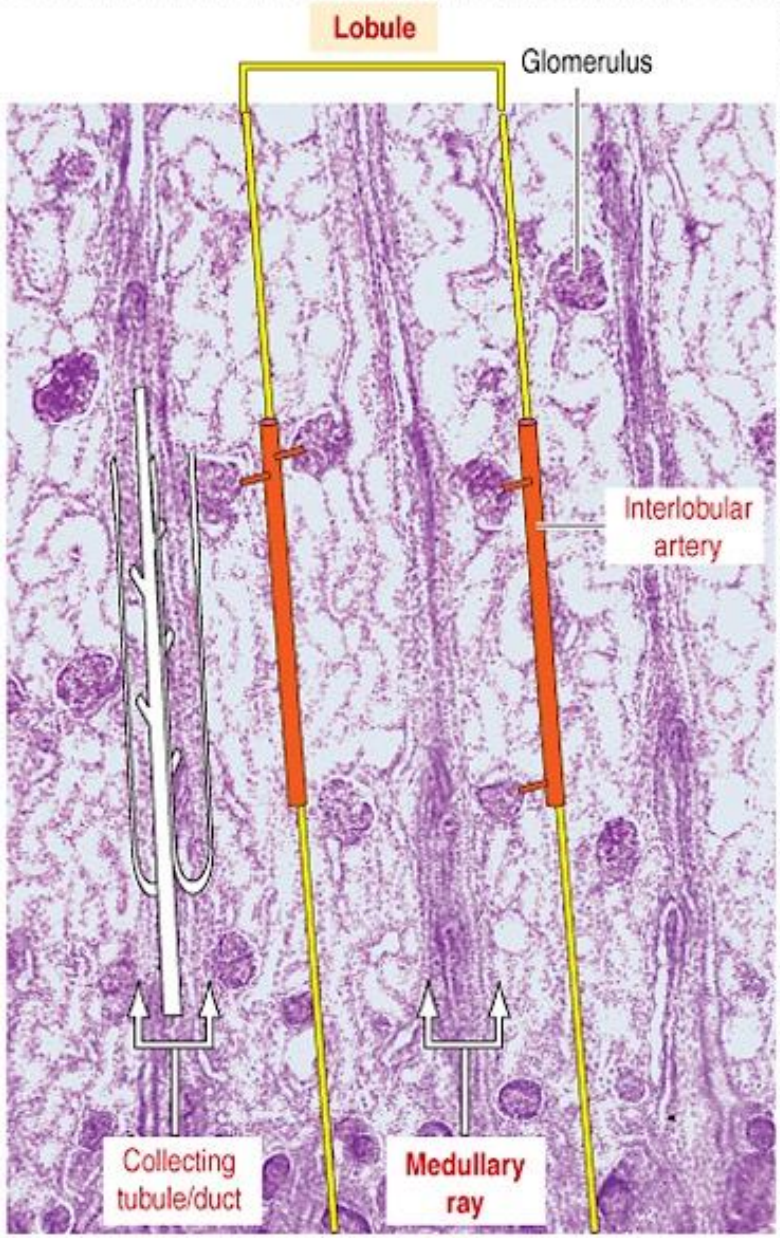
FIGURE **19–1** **Kidney.**



Each kidney is bean-shaped, with a concave **hilum** where the ureter and the renal artery and veins enter. The ureter divides and subdivides into several **major and minor calyces**, around which is located the renal sinus containing adipose tissue. Attached to each minor calyx is a medullary **pyramid**, a conical region of medulla delimited by extensions of **cortex**. The cortex and hilum are covered with a fibrous capsule.

Medullary ray





A medullary ray forms the axis of a renal lobule

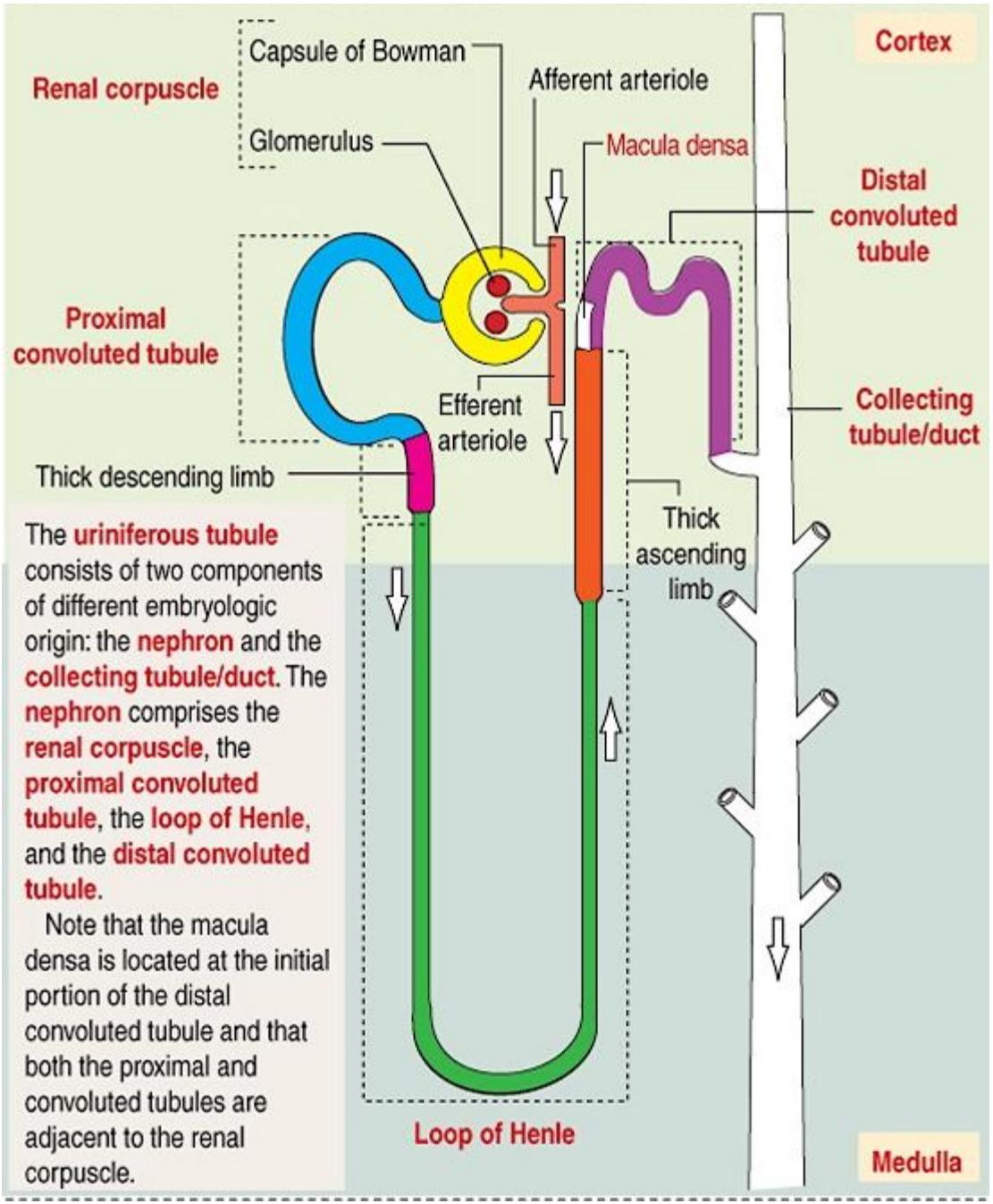
The descending and ascending limbs of nephrons and a collecting tubule/duct are closely aggregated at the middle of the renal lobule. This group of straight tubules forms a **medullary ray** within the cortex.

A medullary ray is the axis of the lobule, a cortical structure. Nephrons of the same lobule drain into the collecting duct.

Functional units of kidney:

Uriniferous tubule =
- ❖secretory part (nephron)
- ❖conductory part (collecting tubules)

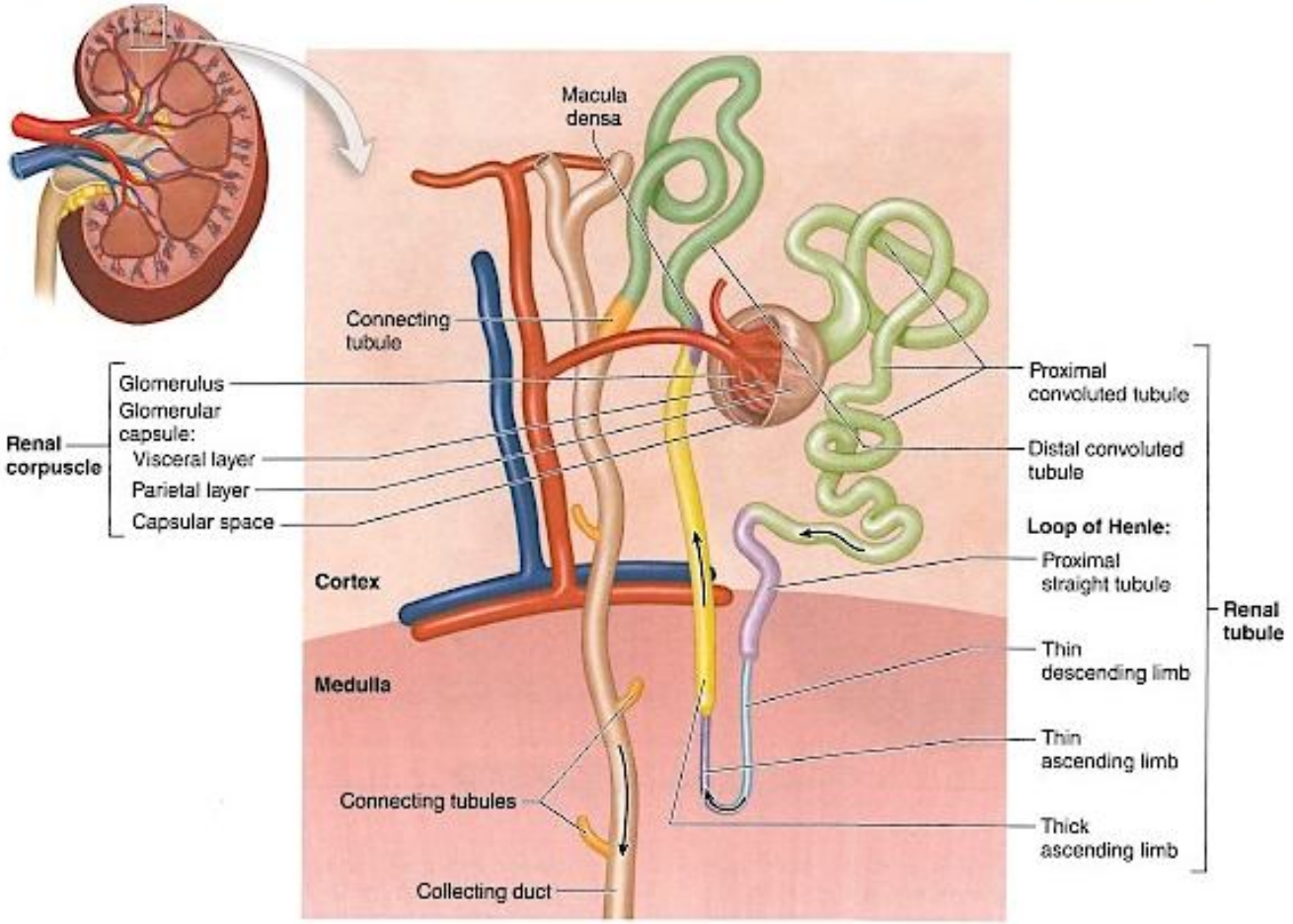
Uriniferous tubule



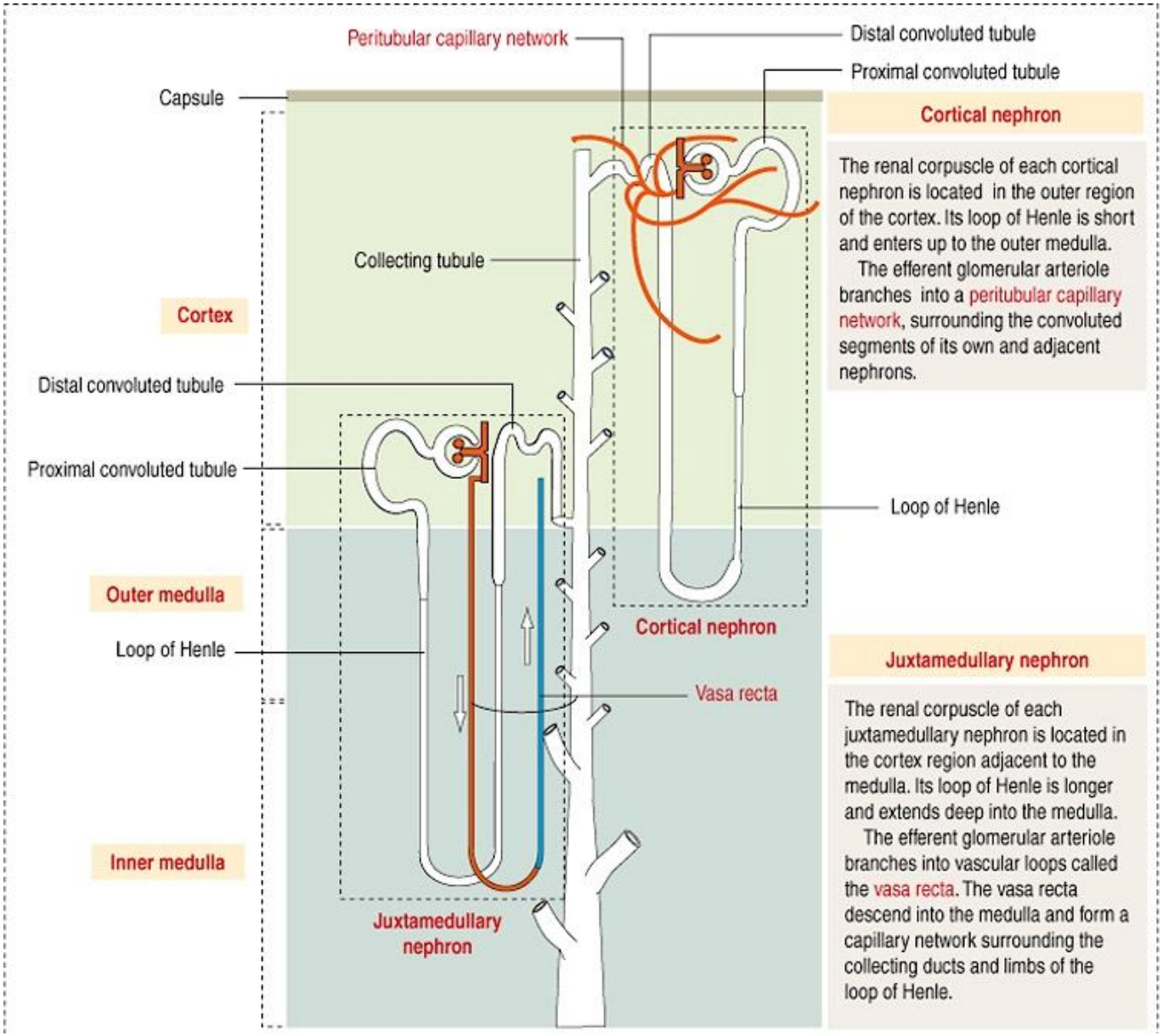
Nephron:

Renal corpuscle : bowman's capsule + glomerulus
Proximal convoluted tubules
Loop of Henle
Distal convoluted tubules

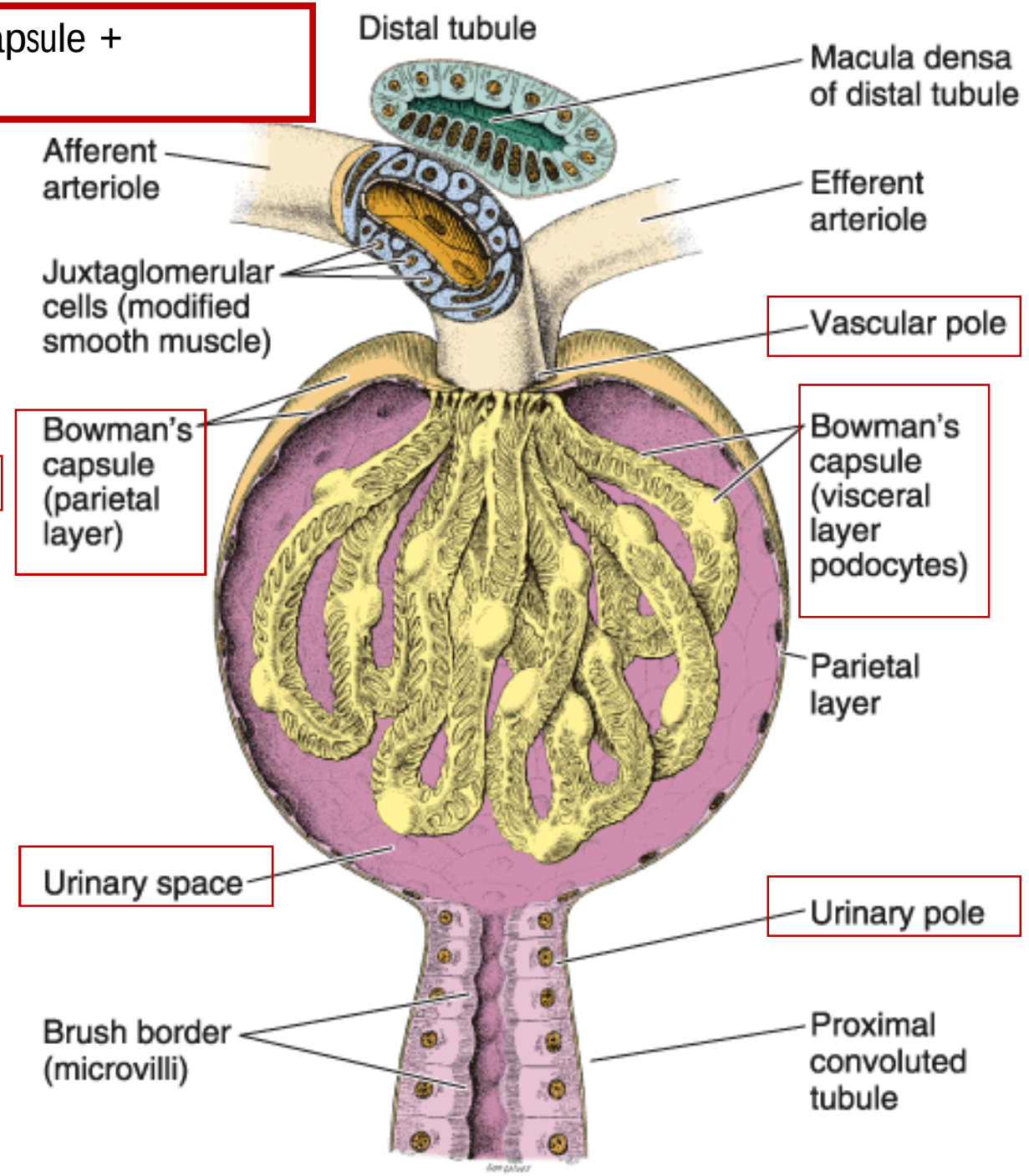
FIGURE **19–2** Nephrons.



2 type of nephron:
Cortical and juxtamedullary nephrons

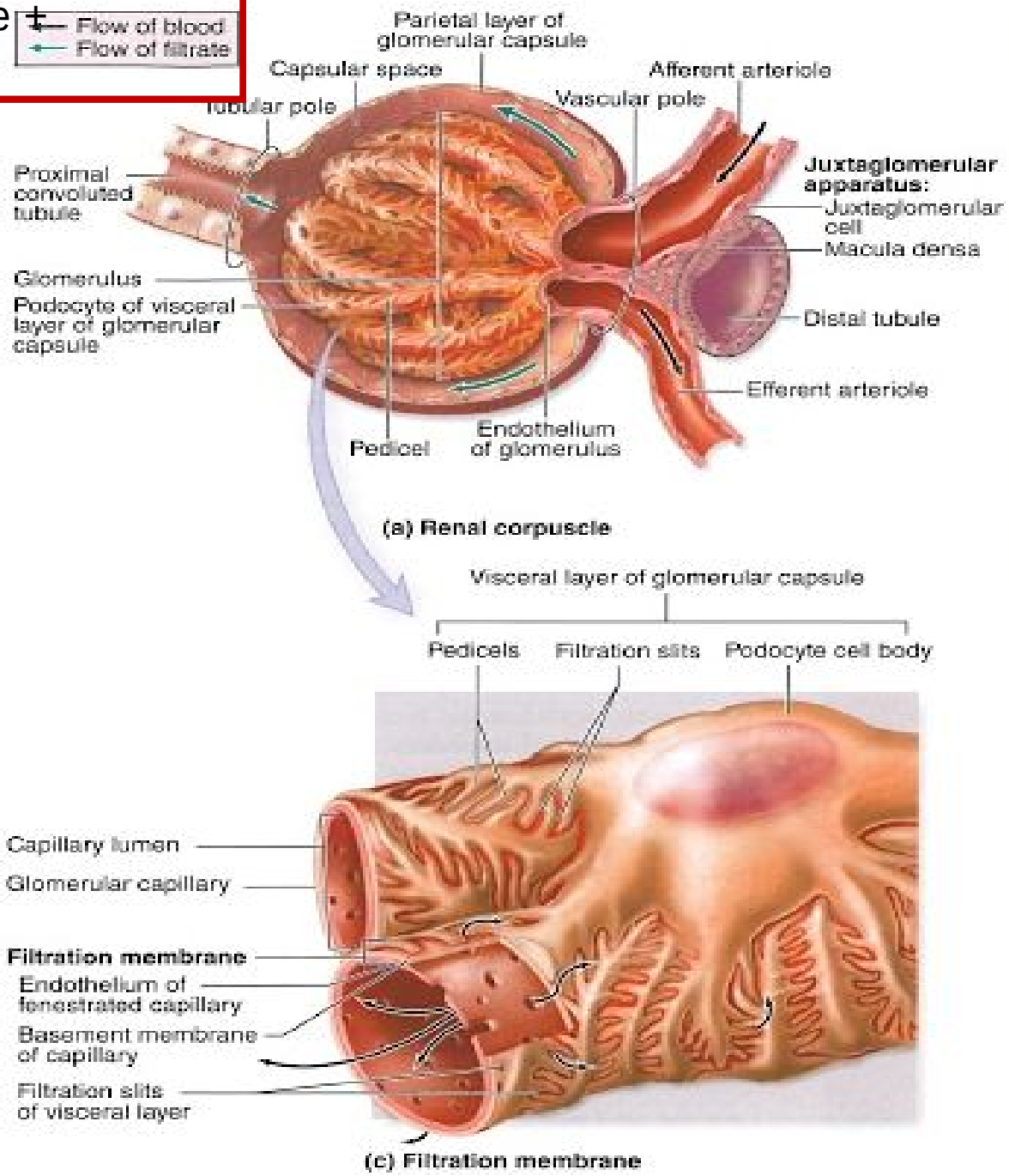


Renal corpuscle : bowman's capsule + glomerulus

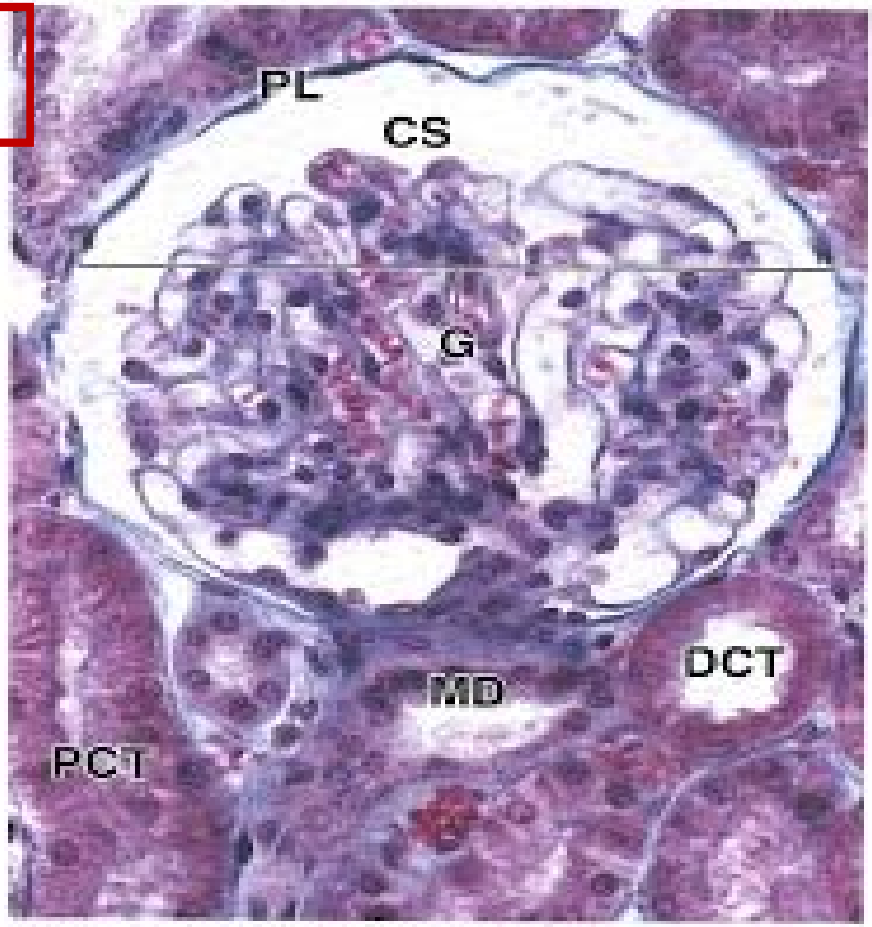


Simple squamous epithelium

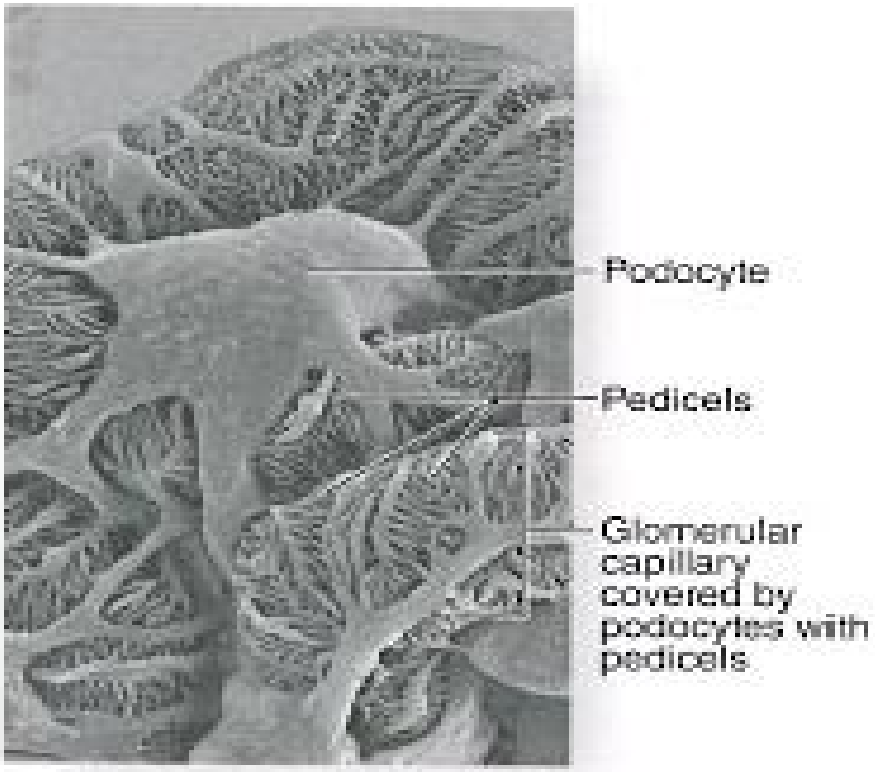
Renal corpuscle : bowman's capsule + glomerulus



Renal corpuscle : bowman's capsule + glomerulus



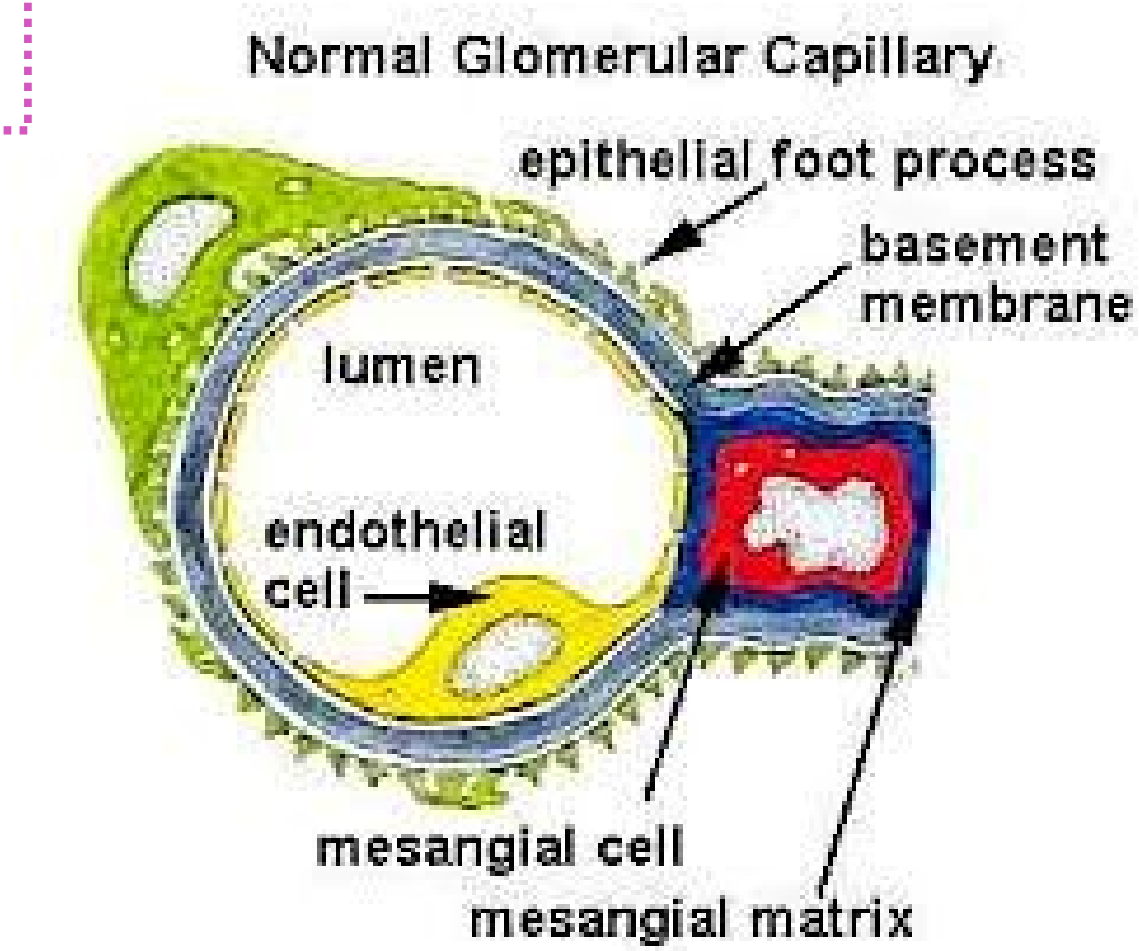
(b) Histology of renal corpuscle



(d) Podocytes

Glomerulus:

Afferent arteriole
Efferent arteriole
Fenestrated endothelium
Basal lamina



BP is high in glomerulus:

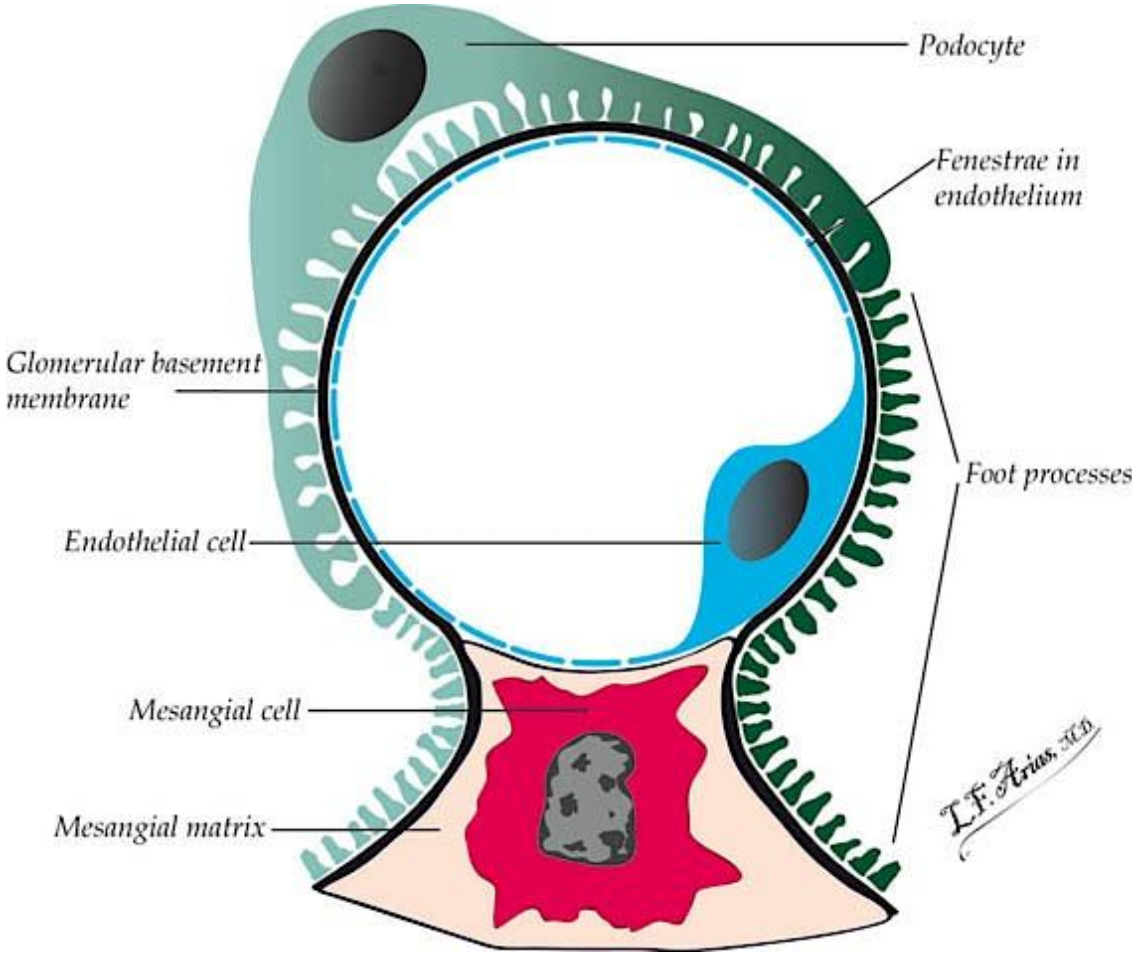
Because:

✓Afferent arteriole diameter is more than efferent arteriole diameter
✓Resistance in efferent arteriole is higher

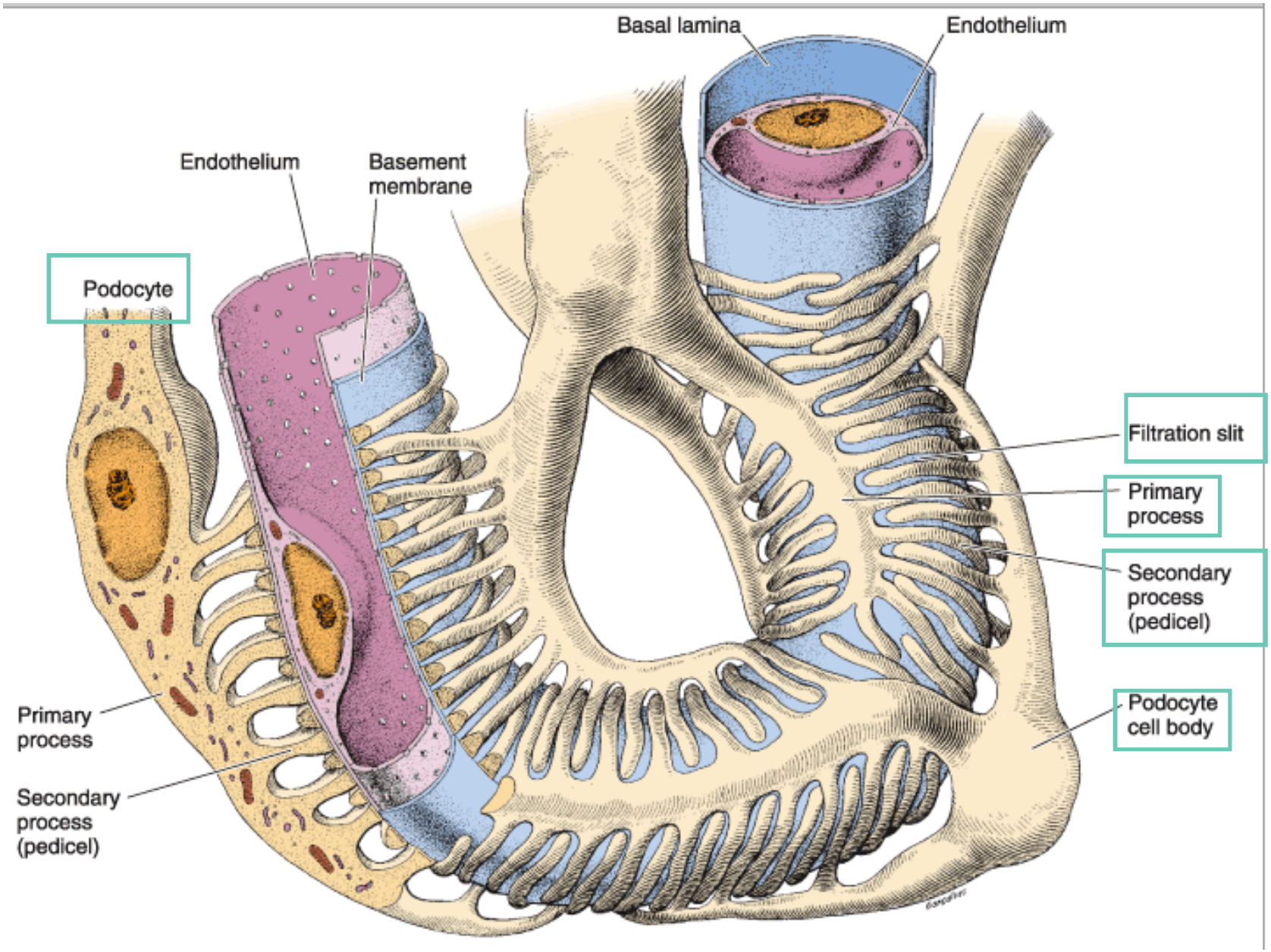
Filtration in glomerulus:

Because:

↑ BP in glomerulus
Fenestrated endothelium



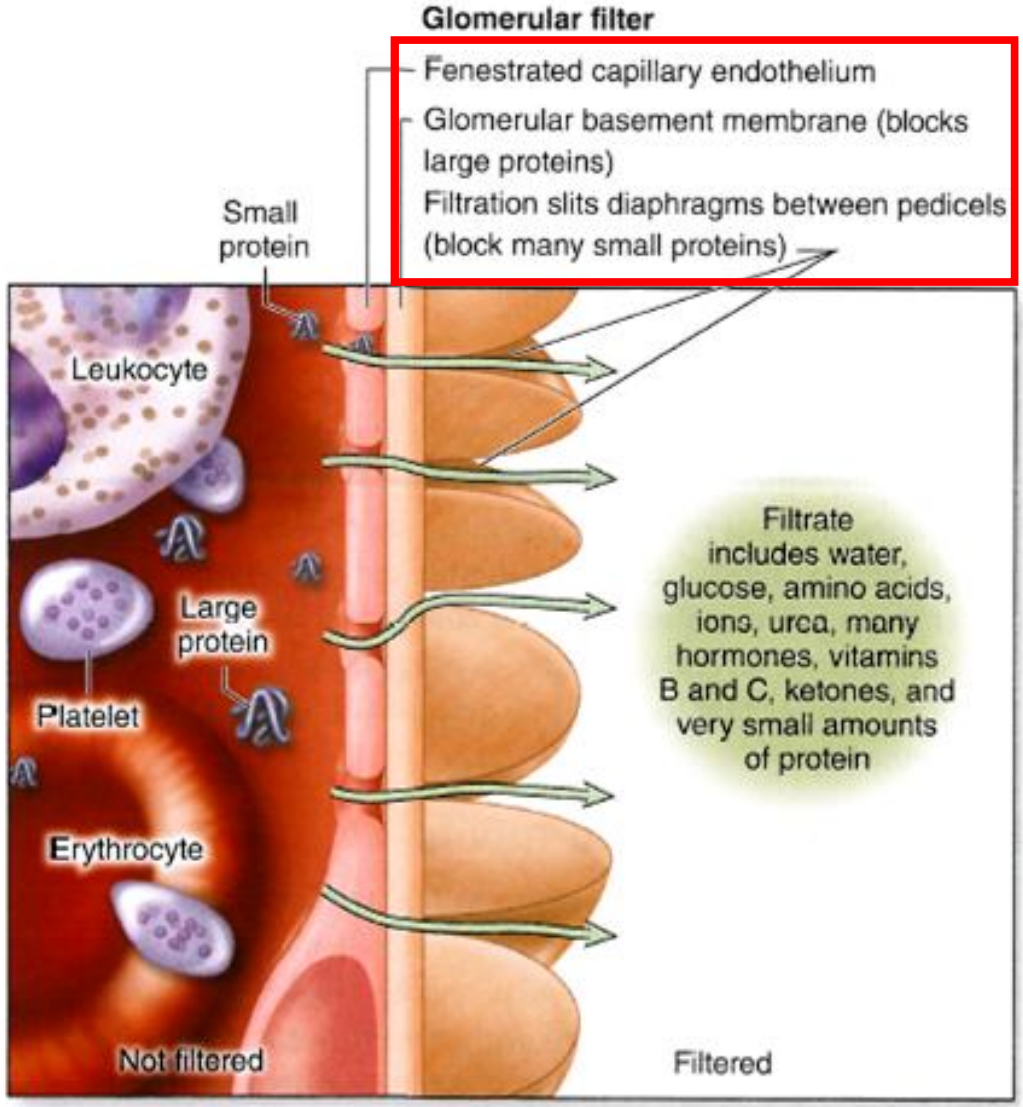
podocyte


Basal lamina
Endothelium
Endothelium
Basement membrane
Podocyte
Filtration slit
Primary process
Secondary process (pedicel)
Podocyte cell body
Primary process
Secondary process (pedicel)

The glomerular filtration barrier consists of three layered components: the fenestrated **capillary endothelium**, the **glomerular basement membrane (GBM)**, and **filtration slit** diaphragms between pedicels. The major component of the filter is formed by fusion of the basal laminae of a podocyte and a capillary endothelial cell. **(a)** TEM shows cell bodies of two podocytes (**PC**) and the series of pedicels on the capillary (**C**) basement membrane separated by the filtration slit diaphragms. Around the capillaries and podocytes is the capsular space (**CS**) into which the filtrate enters. The enclosed area is shown in part **b**. X10,000.

(b) At higher magnification, both the fenestrations (**F**) in the endothelium (**E**) of the capillary (**C**) and the filtration slits (**FS**) separating the pedicels (**P**) are clearly seen on the two sides of the thick, fused basement membrane (**BM**). Thin slit diaphragms (**SD**) bridge the slits between pedicels. X45,750.

(c) Diagram shows the three parts of the glomerular filter and their major functions.



(c) Substances filtered by filtration membrane

Glomerular filtration barrier

Glomerular capillary (lumen)

Components of the filtration barrier

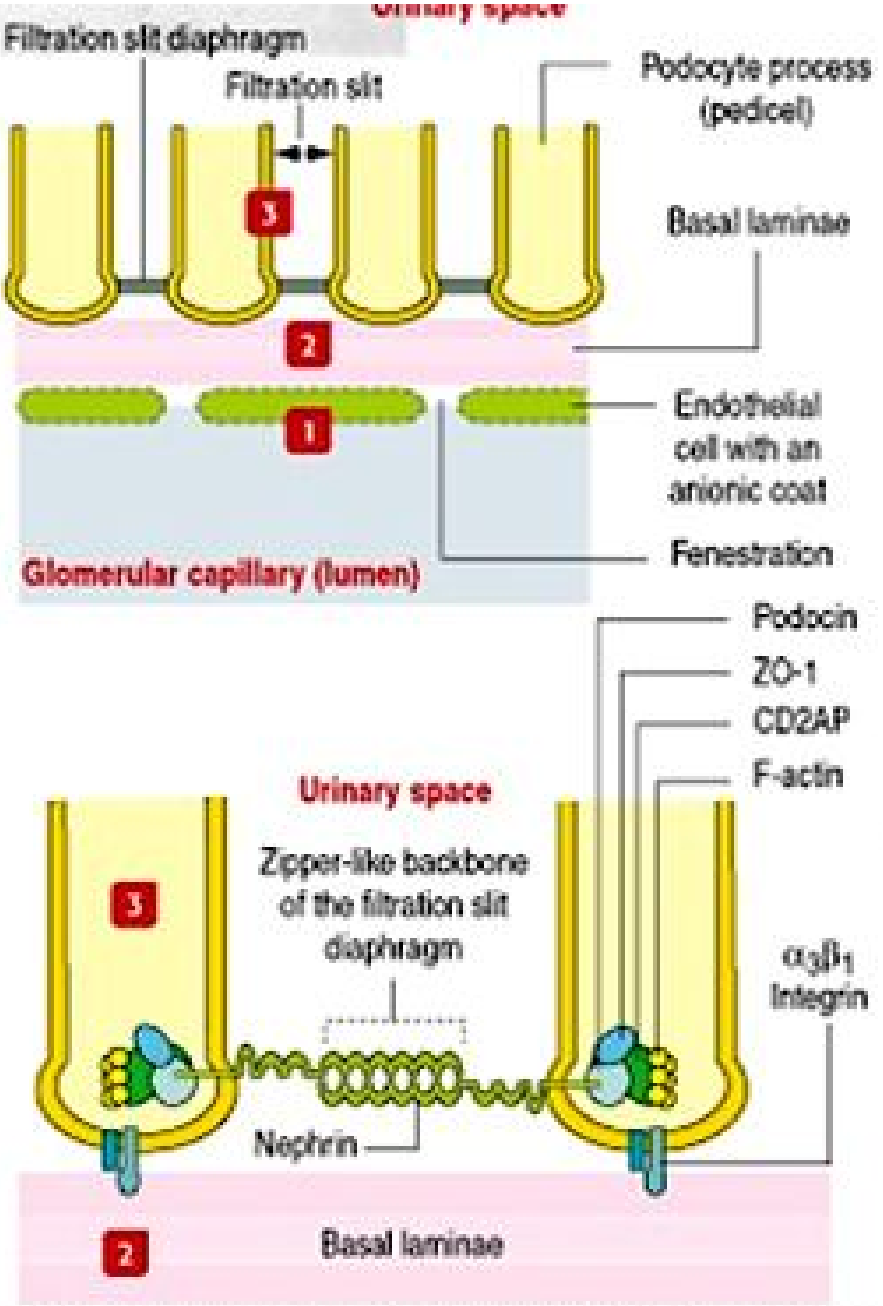
1 The **endothelium** of the glomerular capillaries is **fenestrated** and permeable to water, sodium, urea, glucose, and small proteins. Endothelial cells are coated by **negatively charged glycoproteins** (heparan sulfate), which slow down the filtration of large anionic proteins.

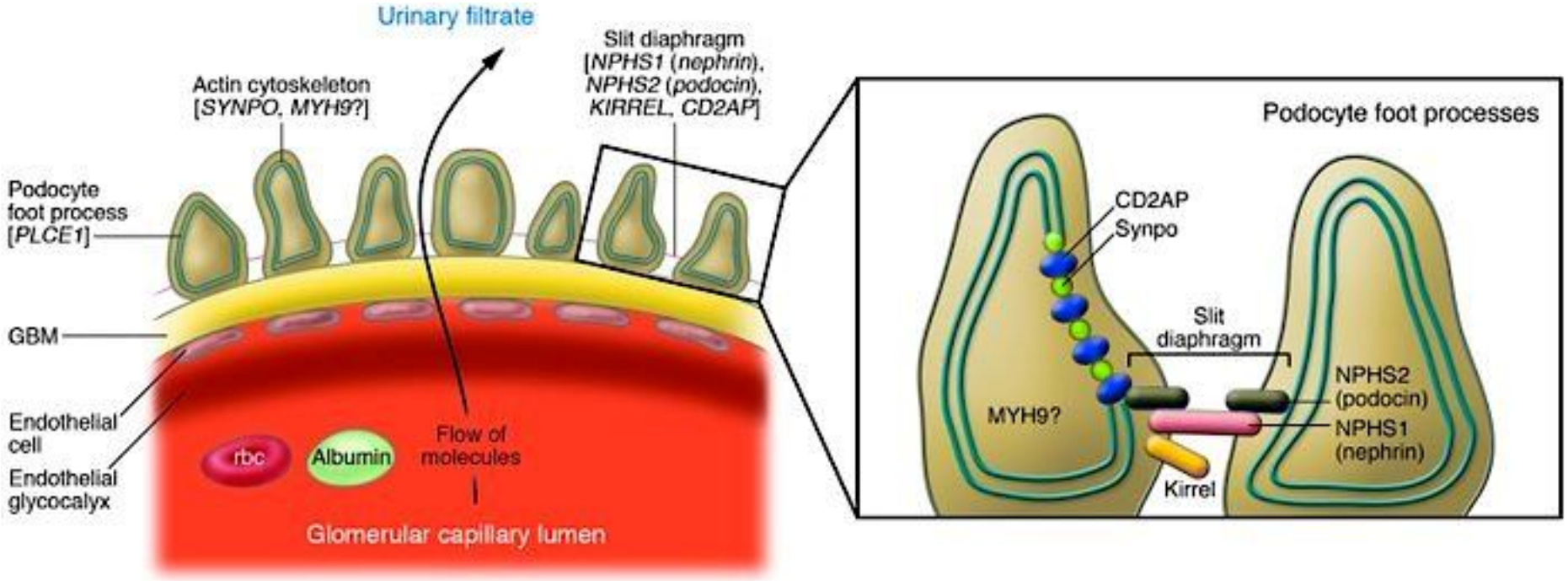
2 The **basal lamina**, a product of endothelial cells and podocytes, contains type IV collagen, laminin, fibronectin, and proteoglycans rich in the glycosaminoglycan heparan sulfate—which also slows down the filtration of anionic proteins.

3 The pedicels are interdigitating cell processes of podocytes covering the basal lamina and coated by a negatively charged glycoprotein coat. The space between adjacent pedicels is called the **filtration slit**. A **filtration slit diaphragm** links adjacent pedicels.

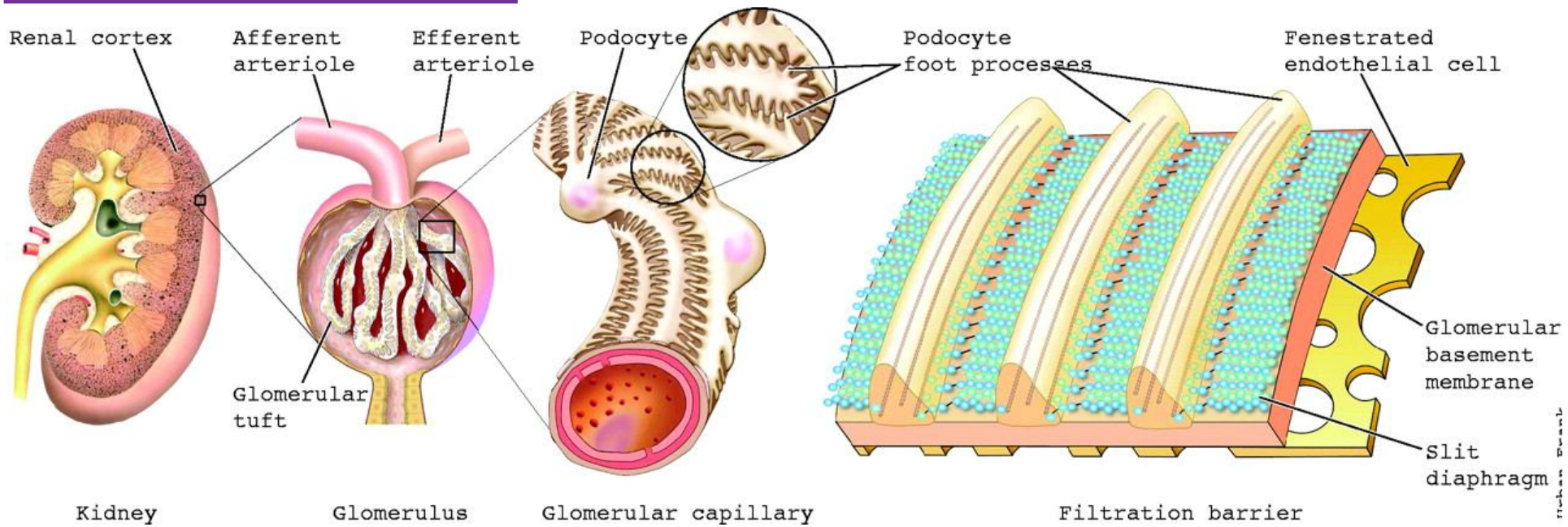
The diaphragm consists of **nephrin**, a cell adhesion molecule of the immunoglobulin superfamily, anchored to actin filaments within the pedicel by the proteins CD2AP, zonula occludens (ZO)-1, and podocin.

A mutation of the gene encoding nephrin causes **congenital nephrotic syndrome**, characterized by massive proteinuria (leakage of albumin in urine) and edema.



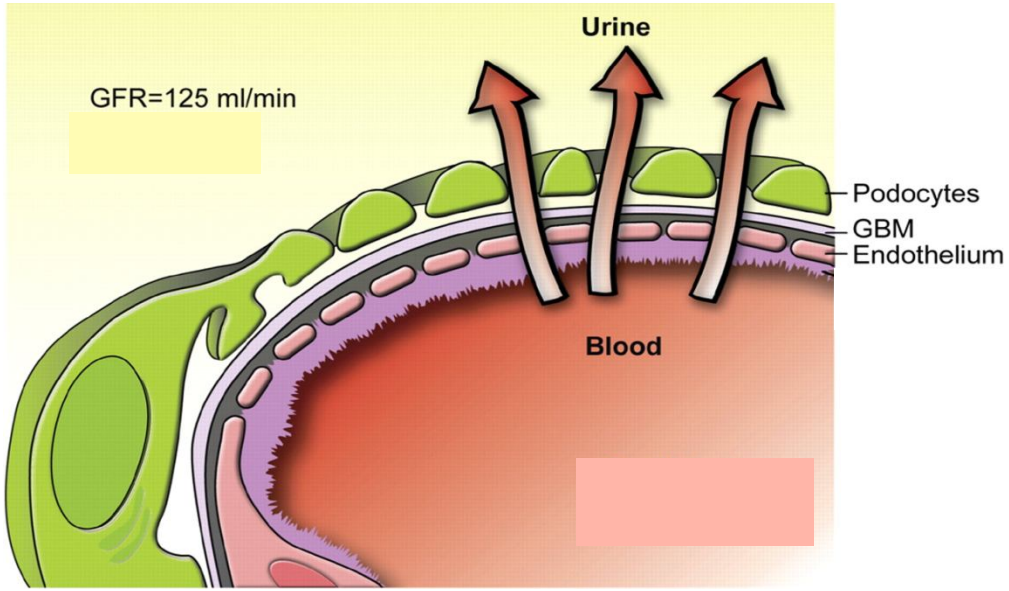


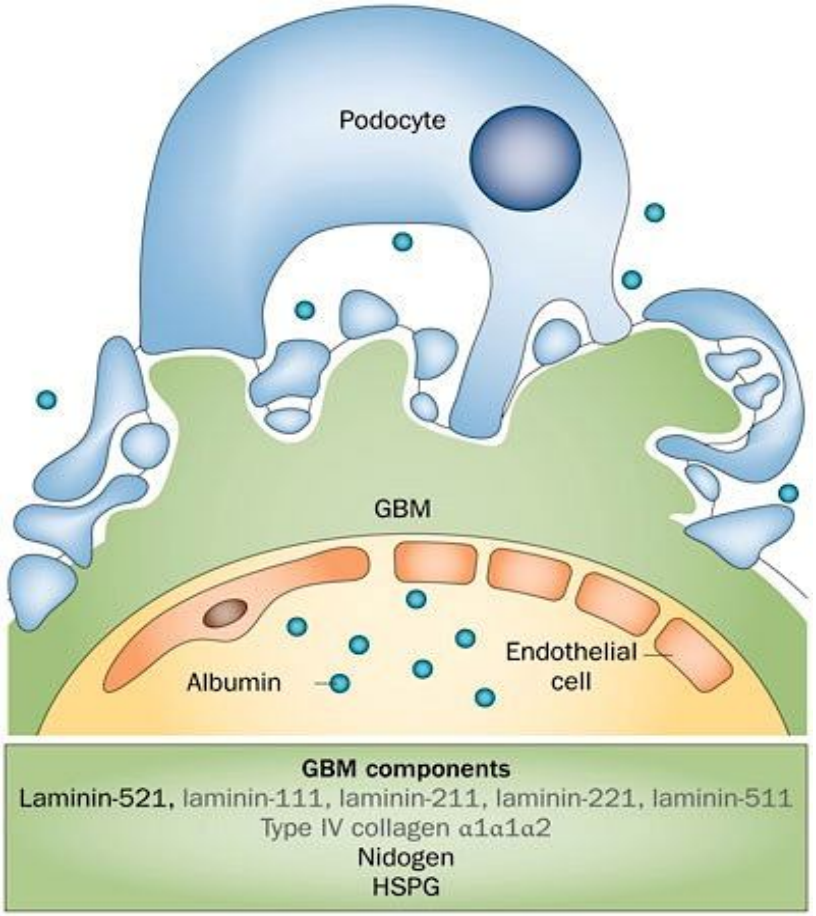
Glomerular filtration barrier



Basal lamina:

A product of endothelial cells and podocyte
Contains:
Collagen IV / laminin / fibronectin / heparan sulfate (negative ions = anionic)





Functions and organization of the (internal) mesangium

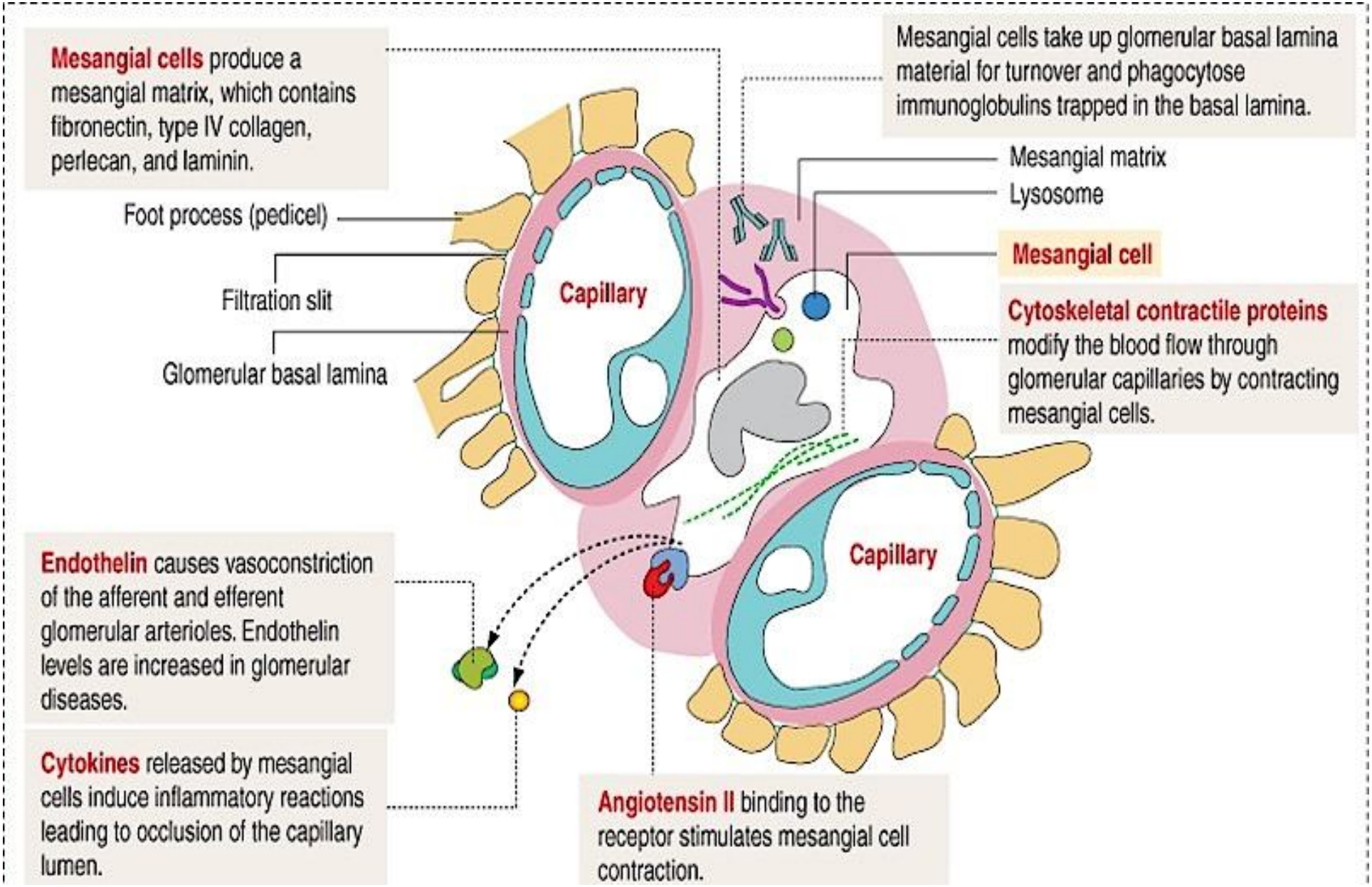
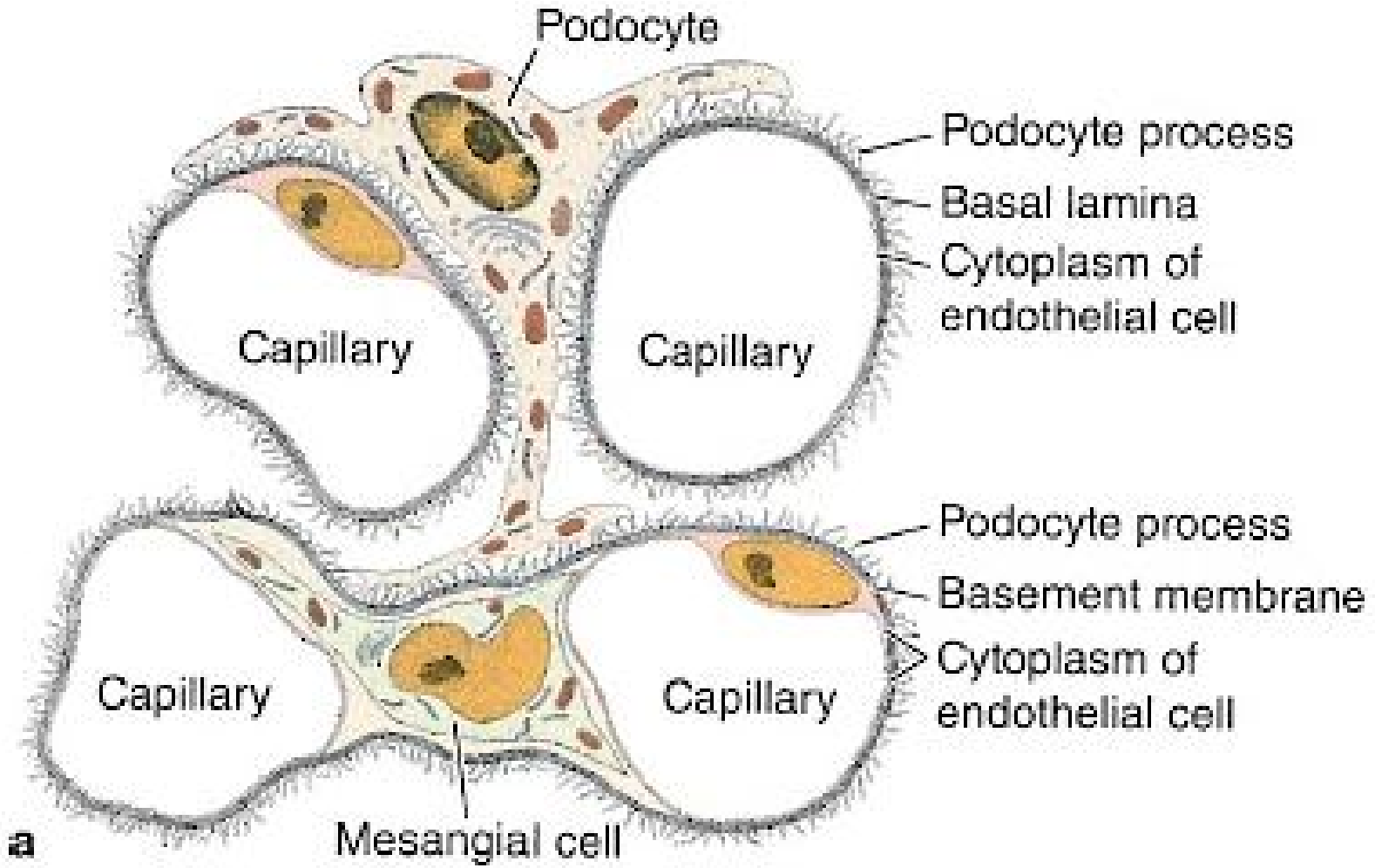
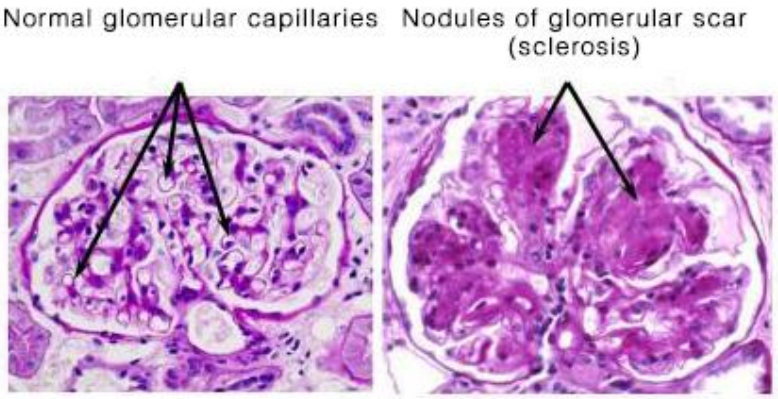


FIGURE 19–7 Mesangium.



diabetic glomerulosclerosis

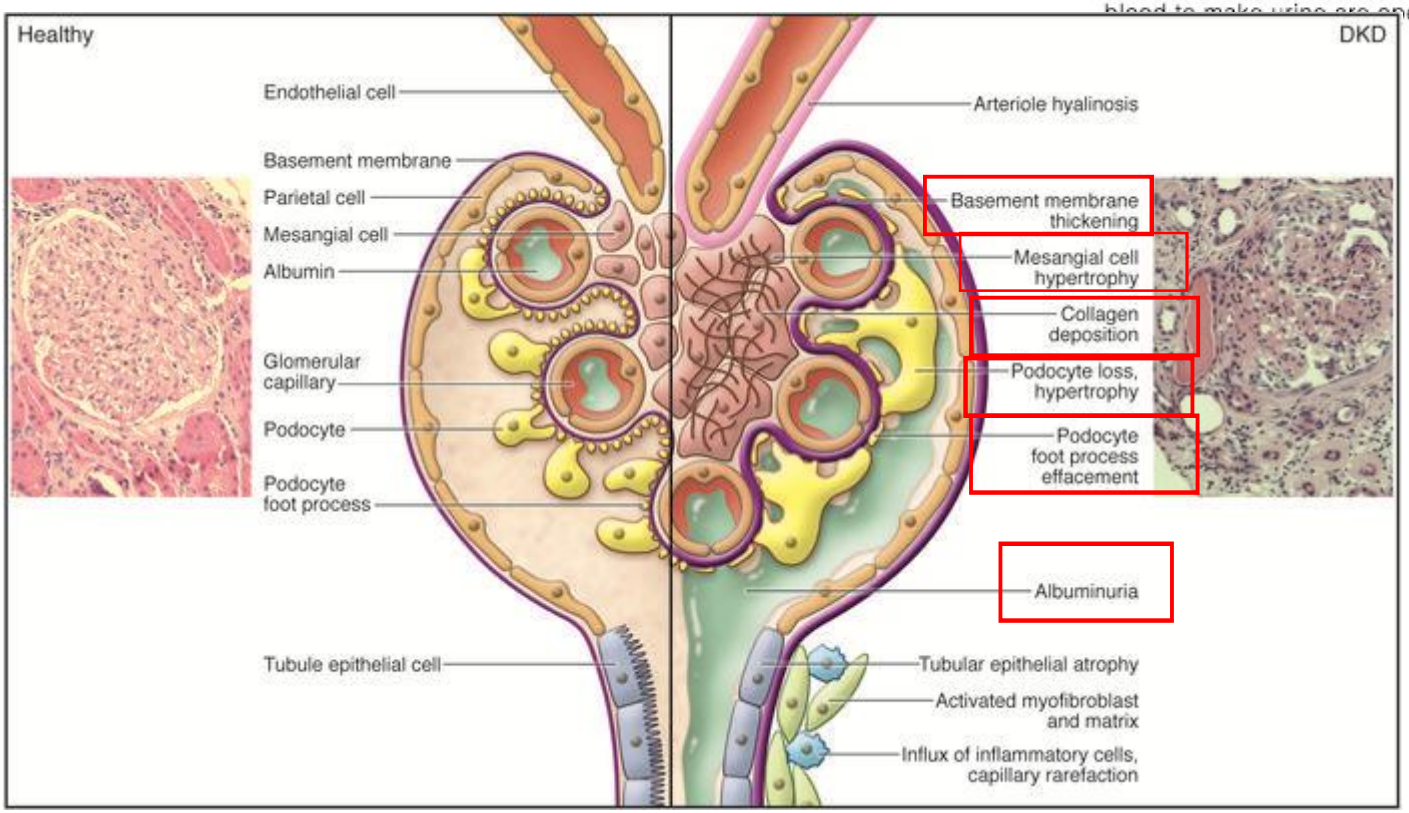


Microscopic photograph of a cross section of a **normal glomerulus** in a kidney biopsy specimen.

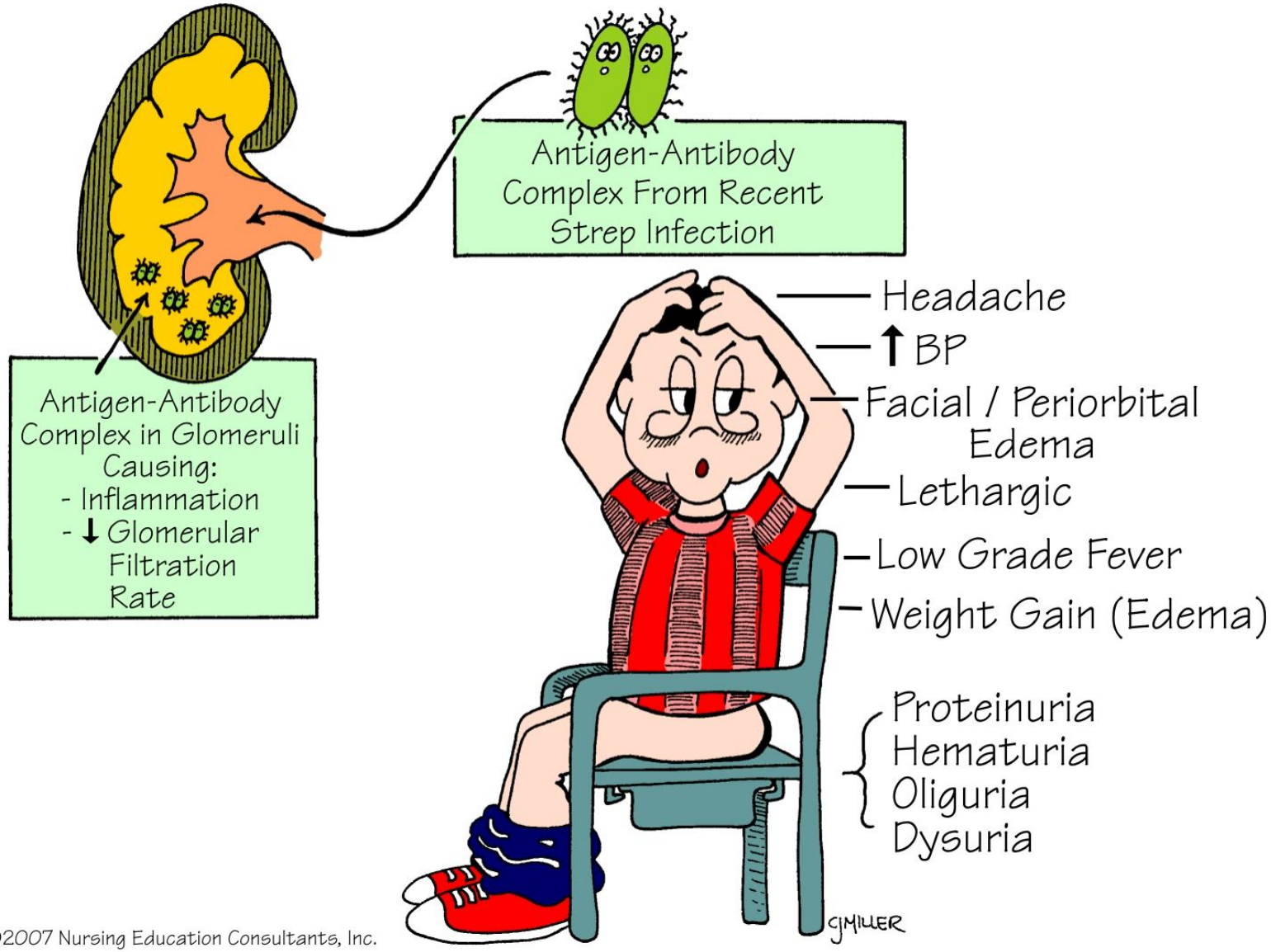
The small capillaries that filter blood to make urine are open.

Microscopic photograph of a cross section of a glomerulus with **nodular diabetic glomerulosclerosis**.

The small capillaries that filter blood are distorted or compressed by the nodular scarring (sclerosis).



GLOMERULONEPHRITIS



Rapidly Progressive Glomerulonephritis

Specific Symptoms

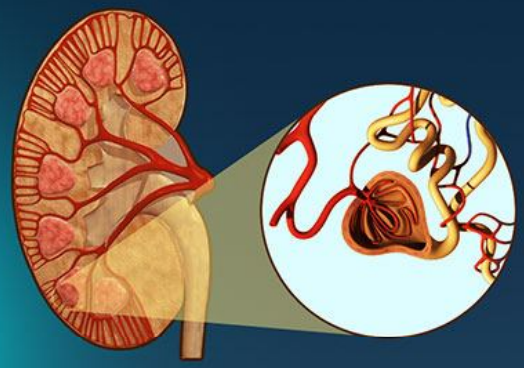
Hypertension
- High blood pressure

Eyes
- Conjunctivitis

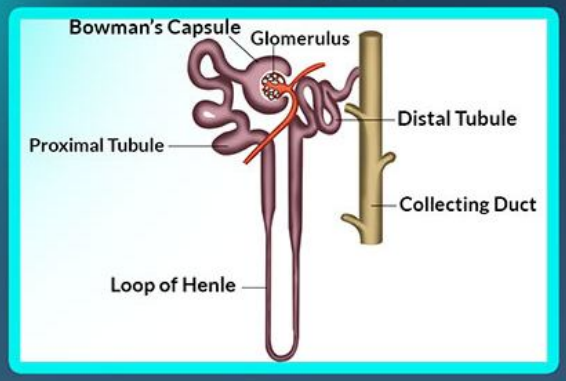
Kidney Disease
- Oliguria
- Proteinuria

Central Nervous System
- Mononeuritis multiplex

Nail
- Discoloration of nail

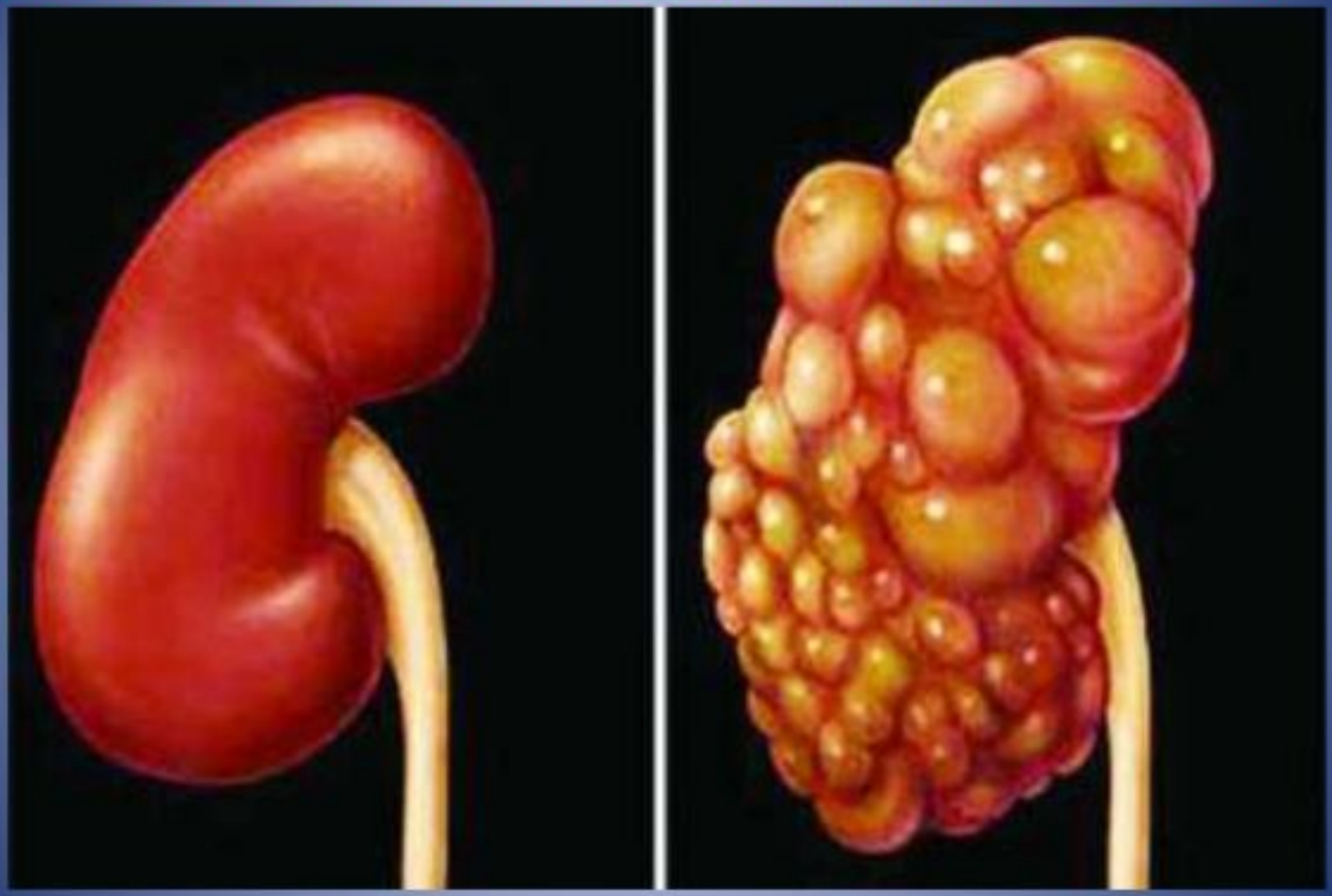


Glomerulonephritis

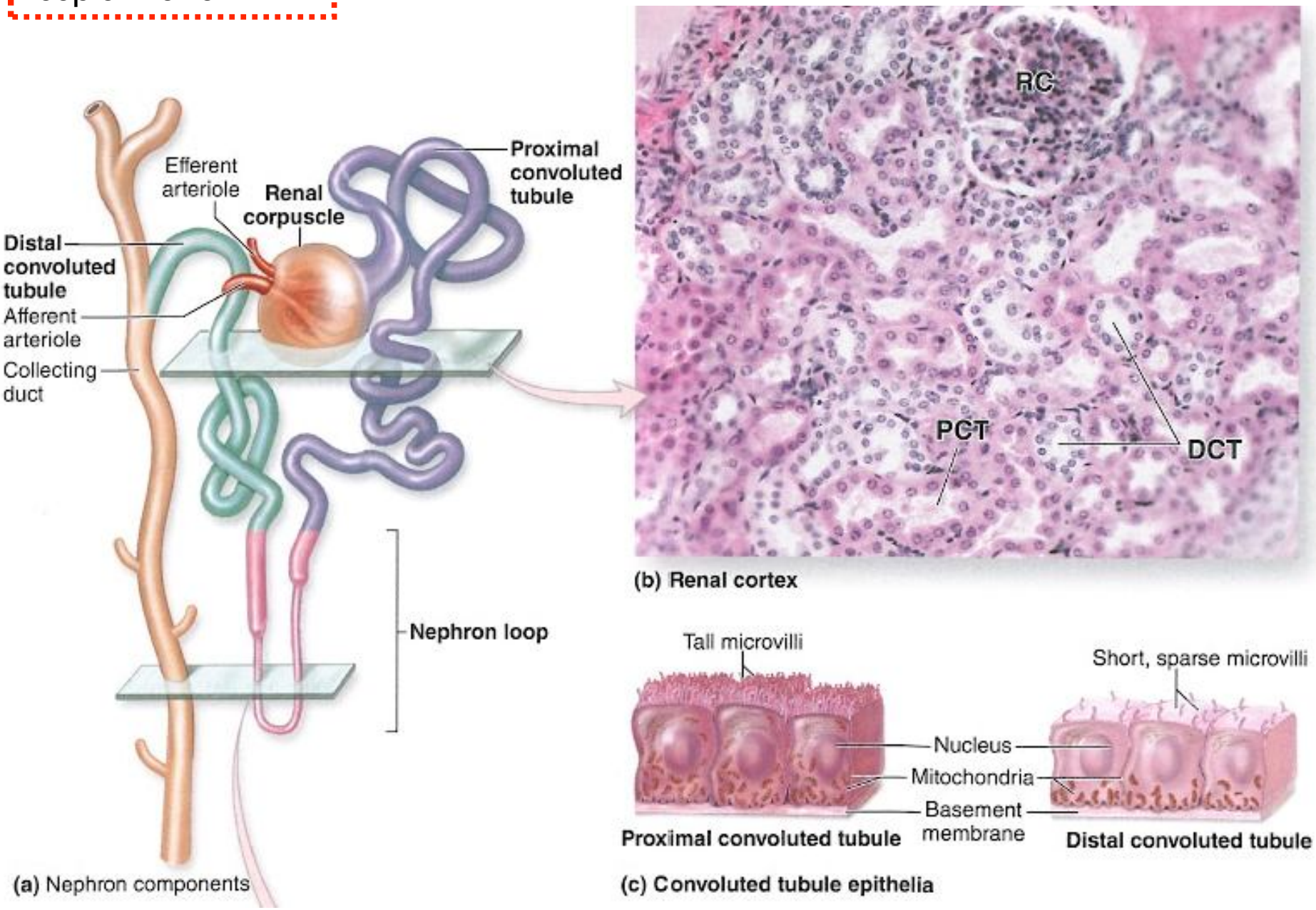


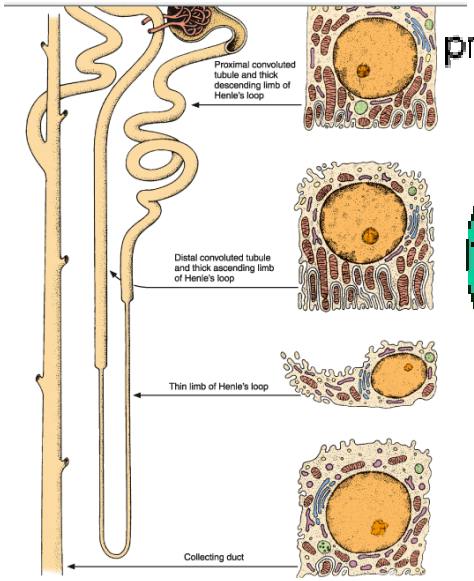
For More Information Visit:www.ePainAssist.com

Autosomal dominant polycystic kidney

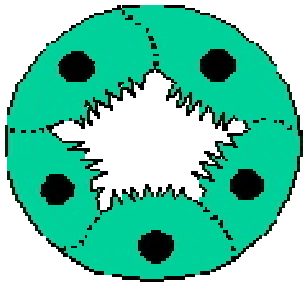


Convoluted tubules
Loop of Henle

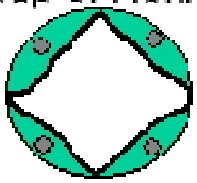




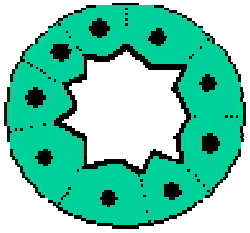
proximal convoluted tubule



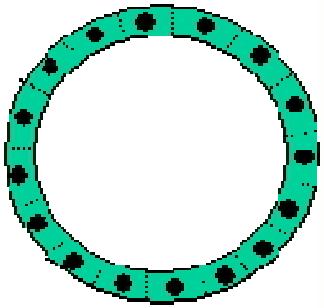
loop of Henle

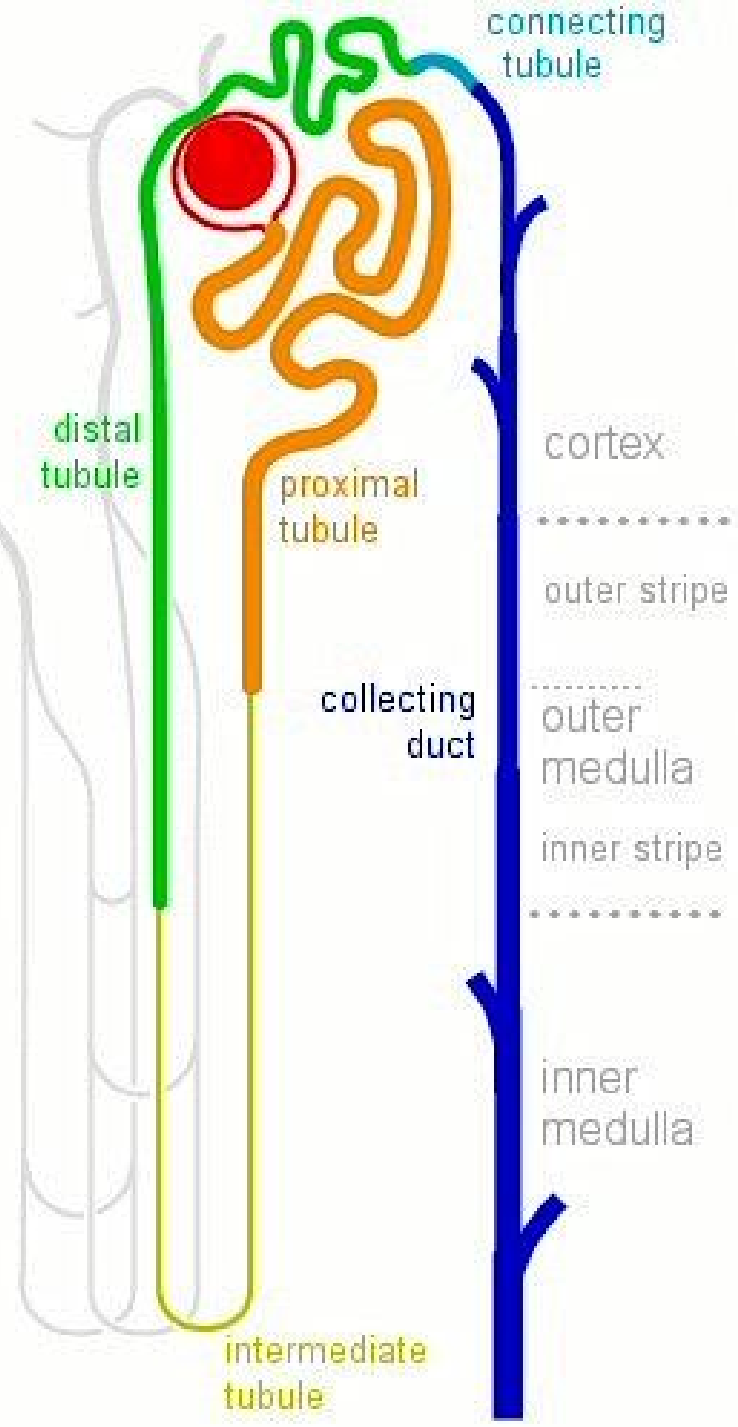


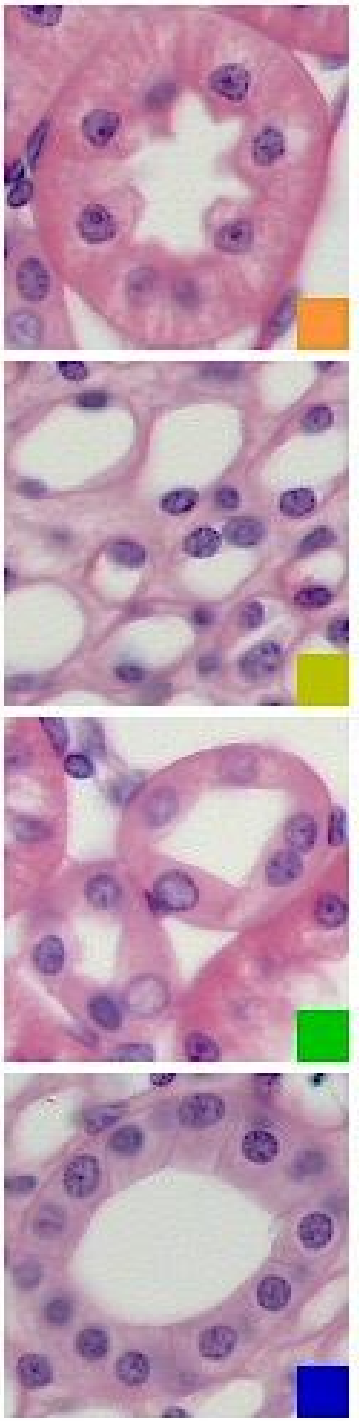
distal convoluted tubule



Collecting tubule



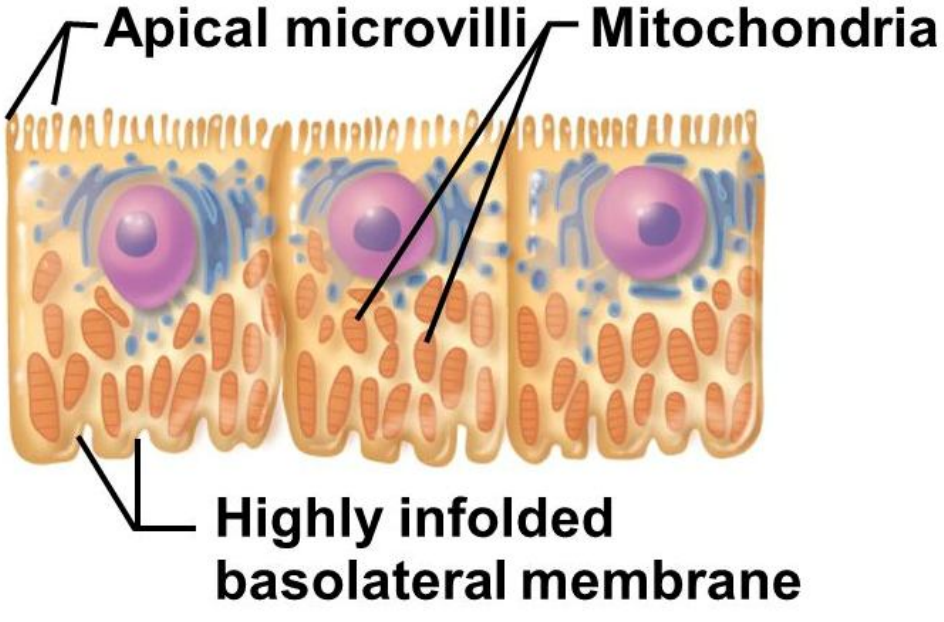




Proximal convoluted tubule (PCT) :

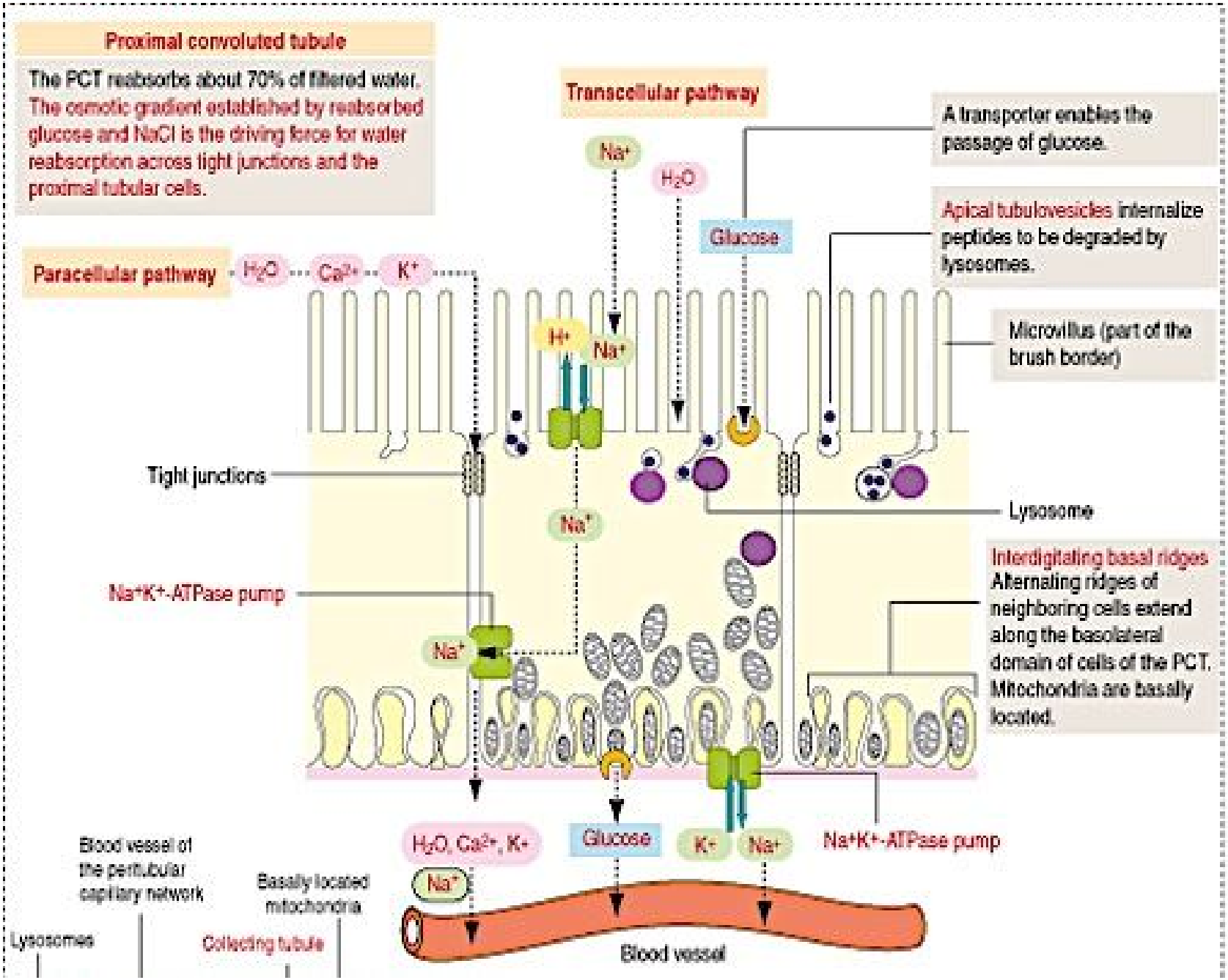
Pars convoluted (in cortex)
Pars recta (medullary ray + outer medulla)

simple cuboid epithelium
Basal lamina
Apex: junctional complex + brush border
Base: basal ridge + mitochondria
Acidophilic + small lumen



Proximal convoluted tubule cells

Proximal convoluted tubule (PCT)



Proximal convoluted tubule (PCT) functions:

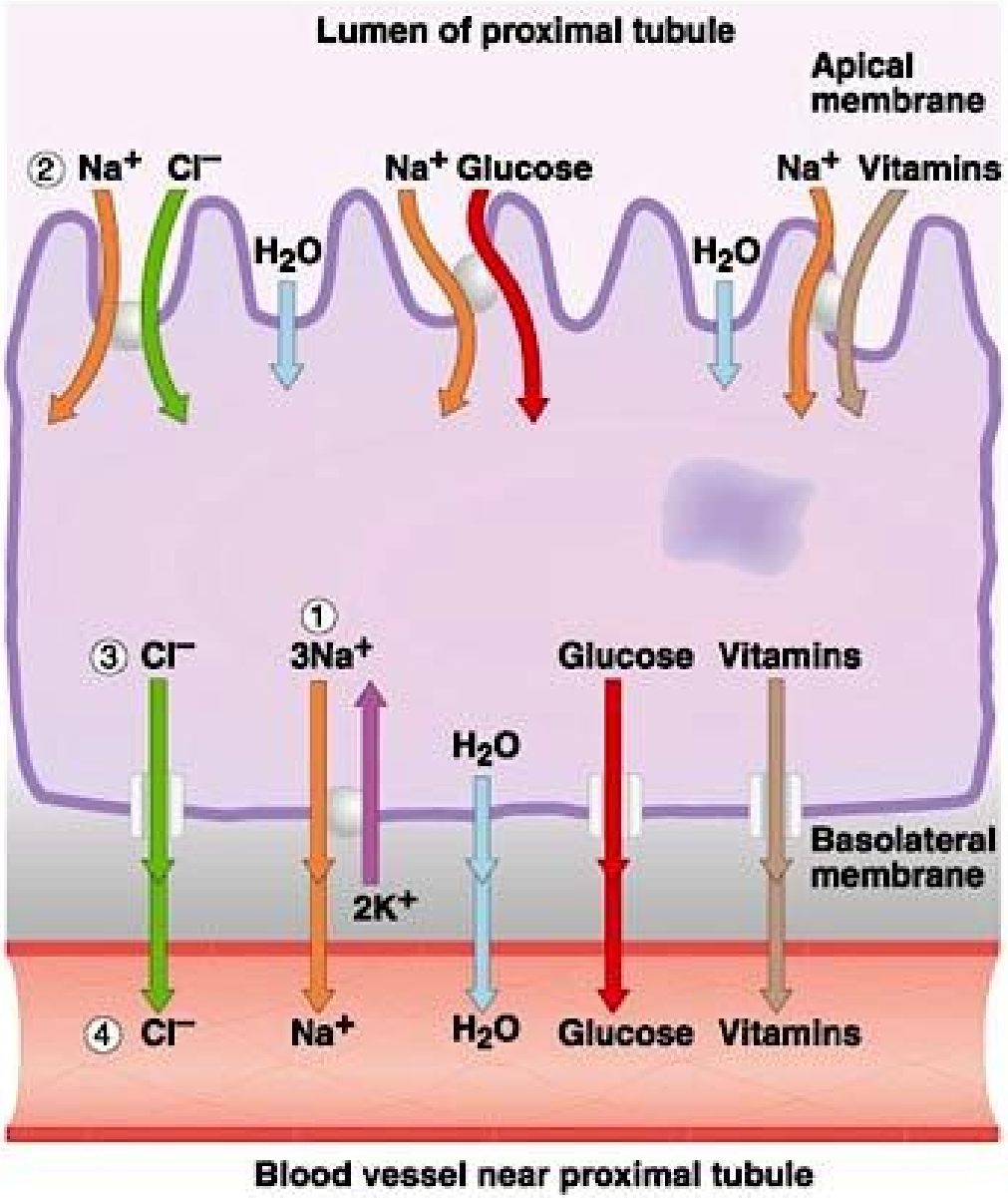
1. Reabsorption of Na / amino acid / glucose by Na – k ATP ase pump in baso lateral cell membrane

2. Reabsorption of water by osmose

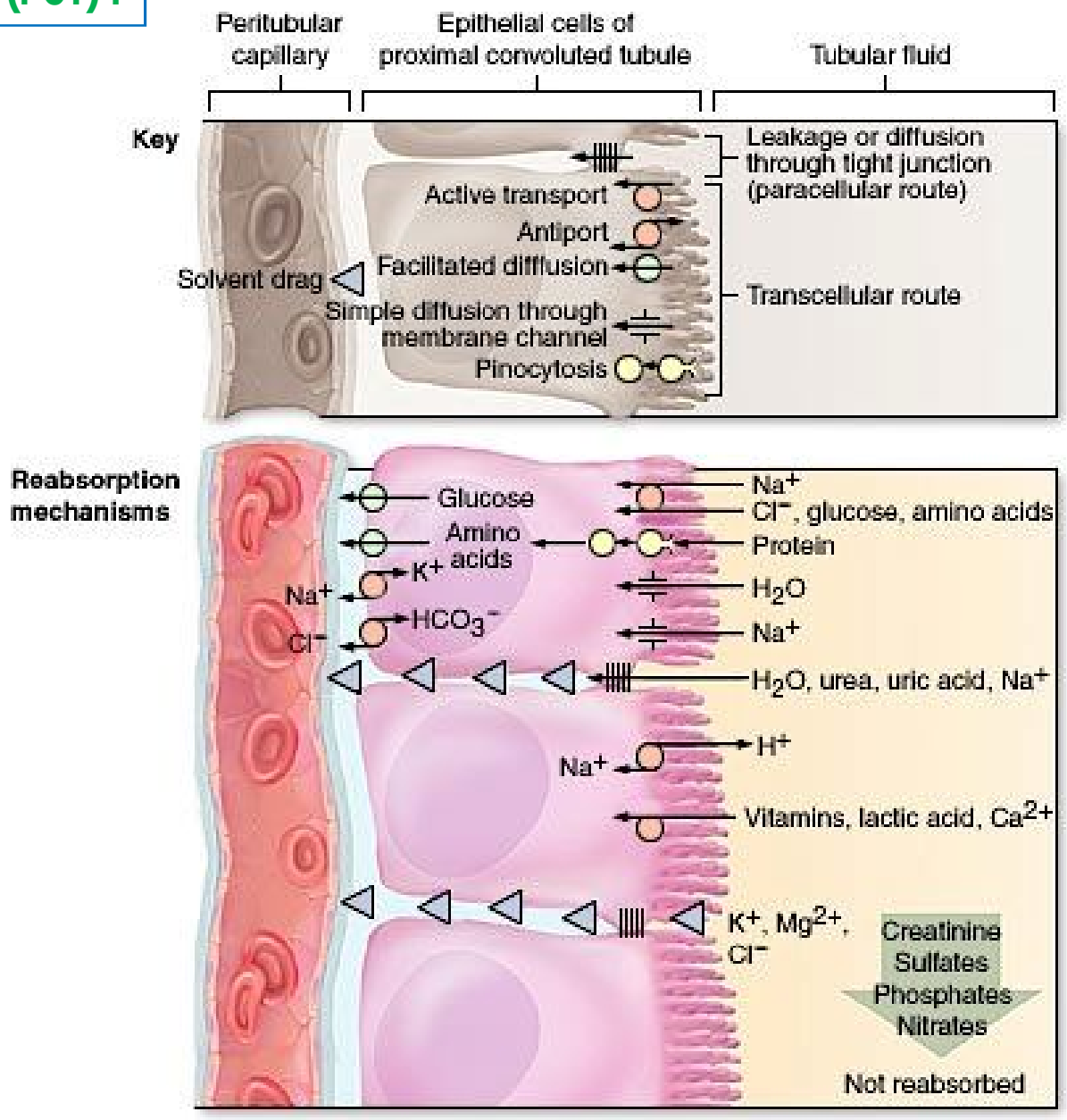
3. Reabsorption of Large molecules (large carbohydrate + protein + polypeptide) by endocytosis / degradation by lysosome

4. Secretion : creatinine + hydrogen

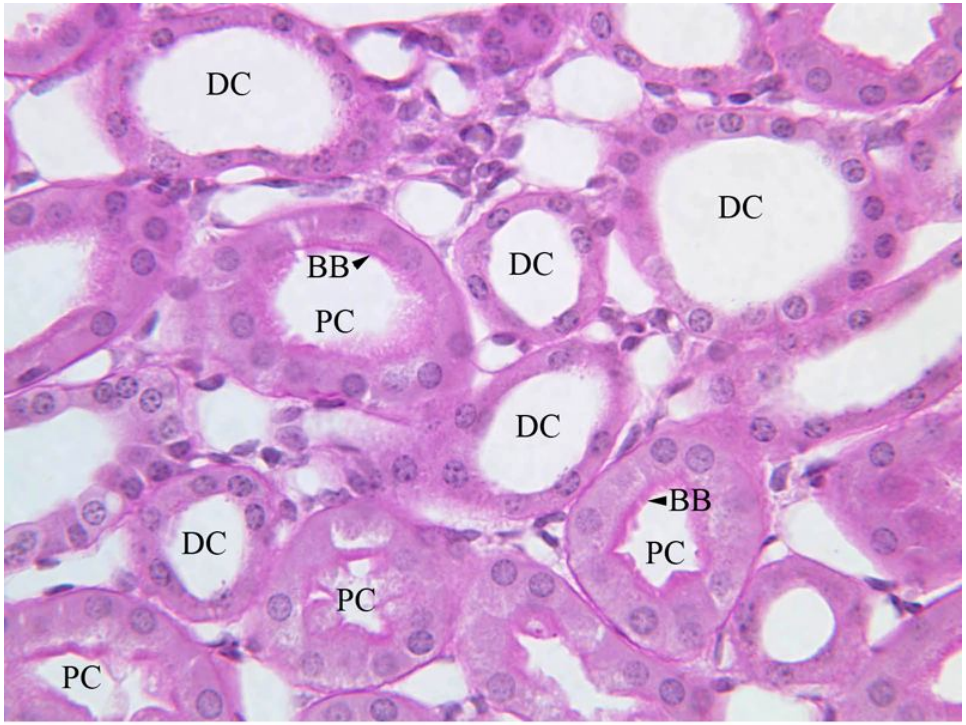
Model of water and solute reabsorption



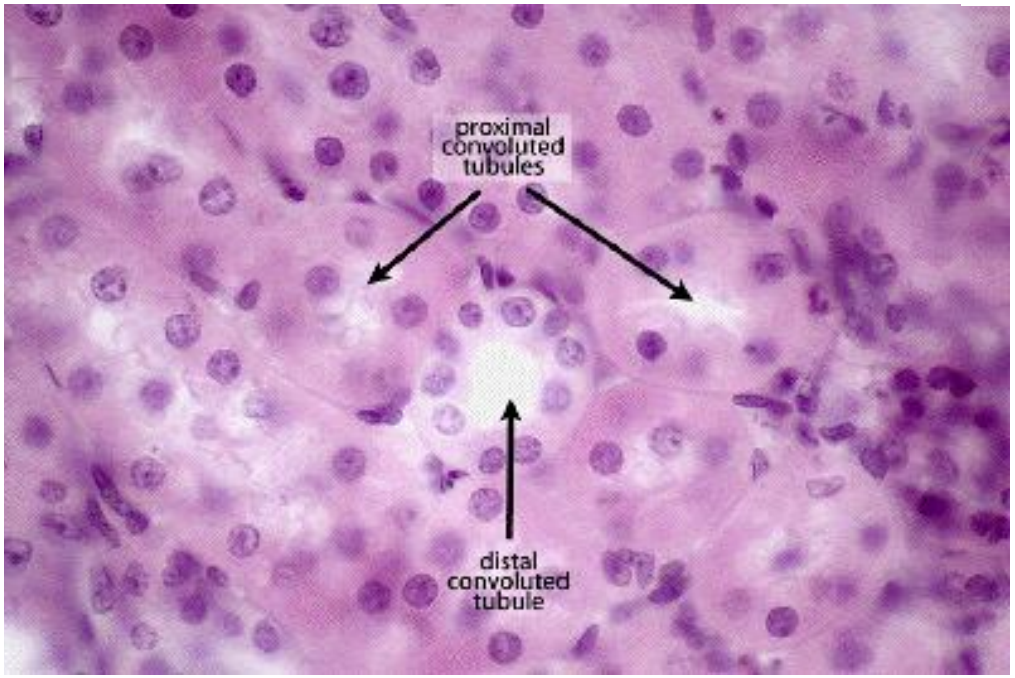
Proximal convoluted tubule (PCT) :



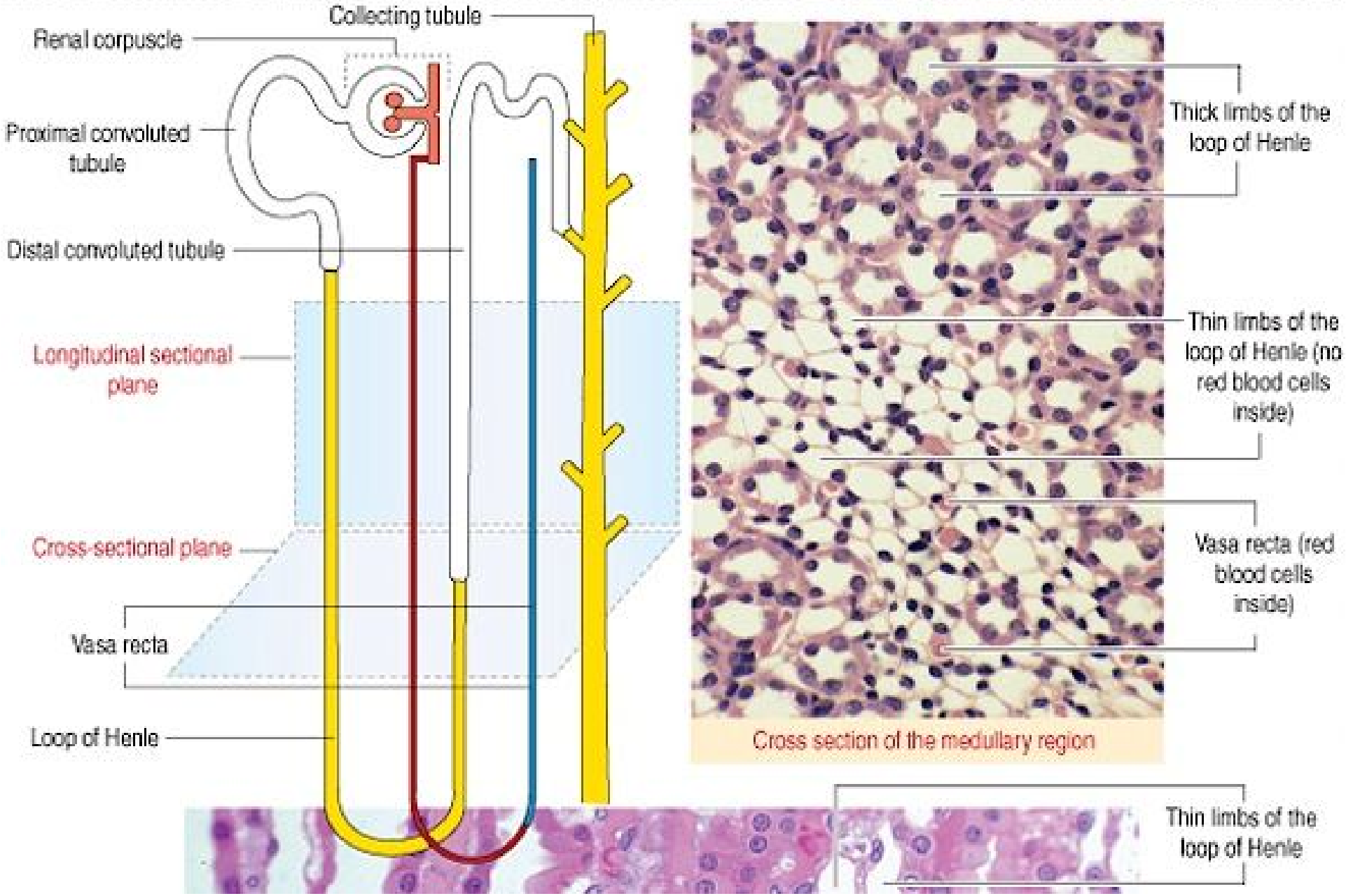
PCT & DCT



DC - distal convoluted tubule PC - proximal convoluted tubule BB - brush border

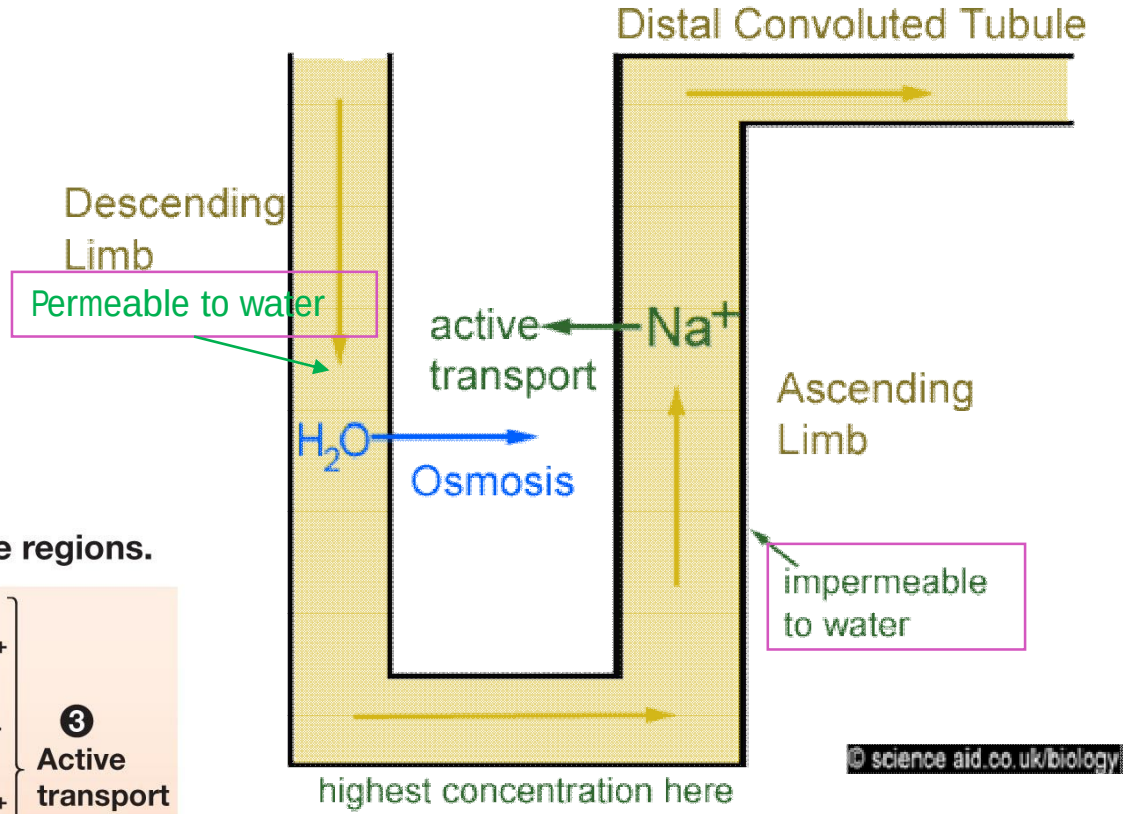


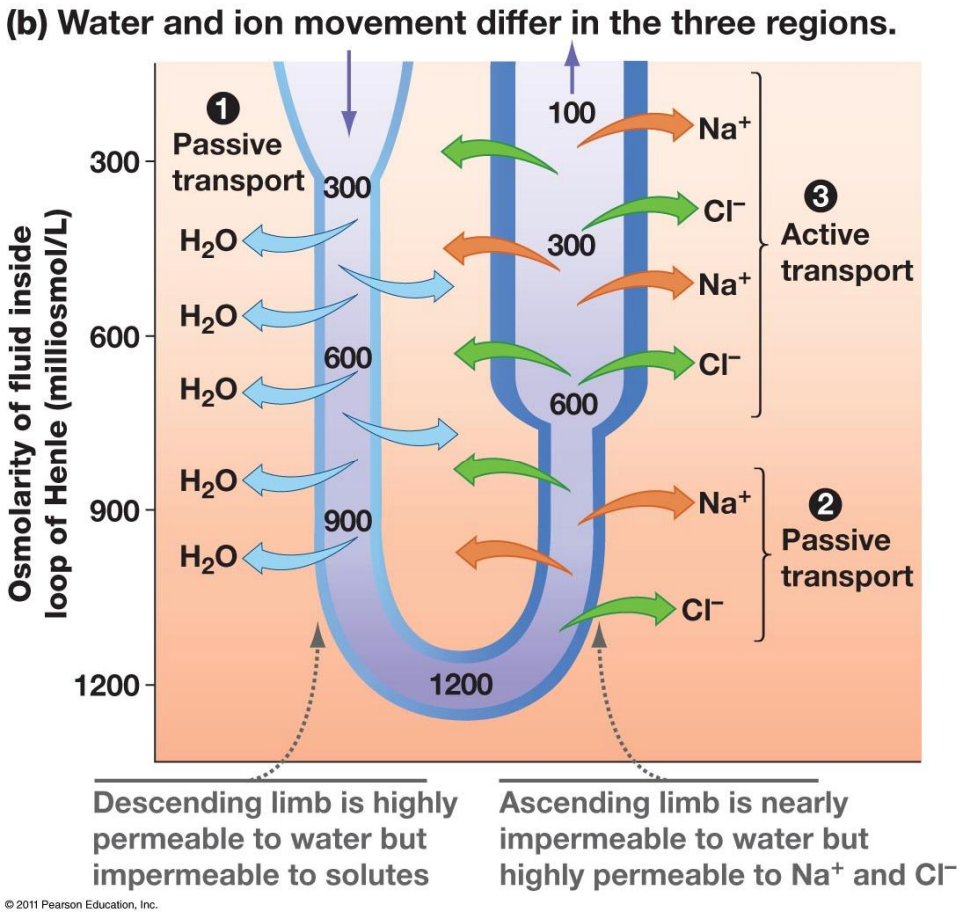
Loop of Henle



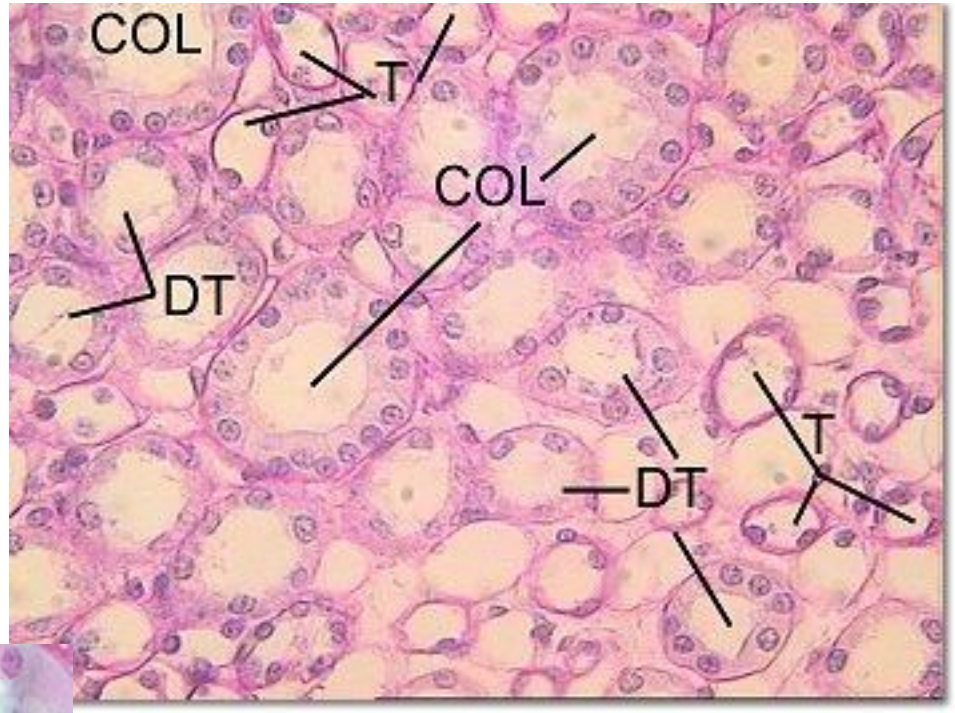
Loop of Henle:

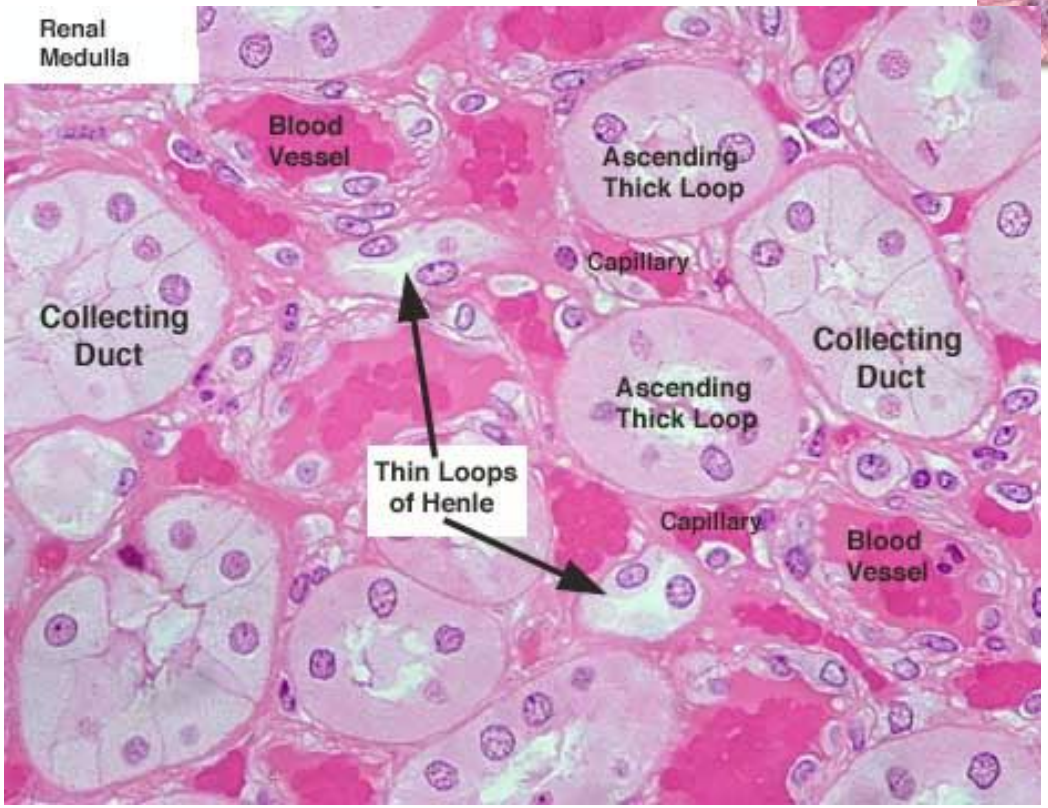
Simple squamous epithelium
Bulge nucleus in lumen
Short microvilli





Loop of Henle





Countercurrent multiplier and exchanger