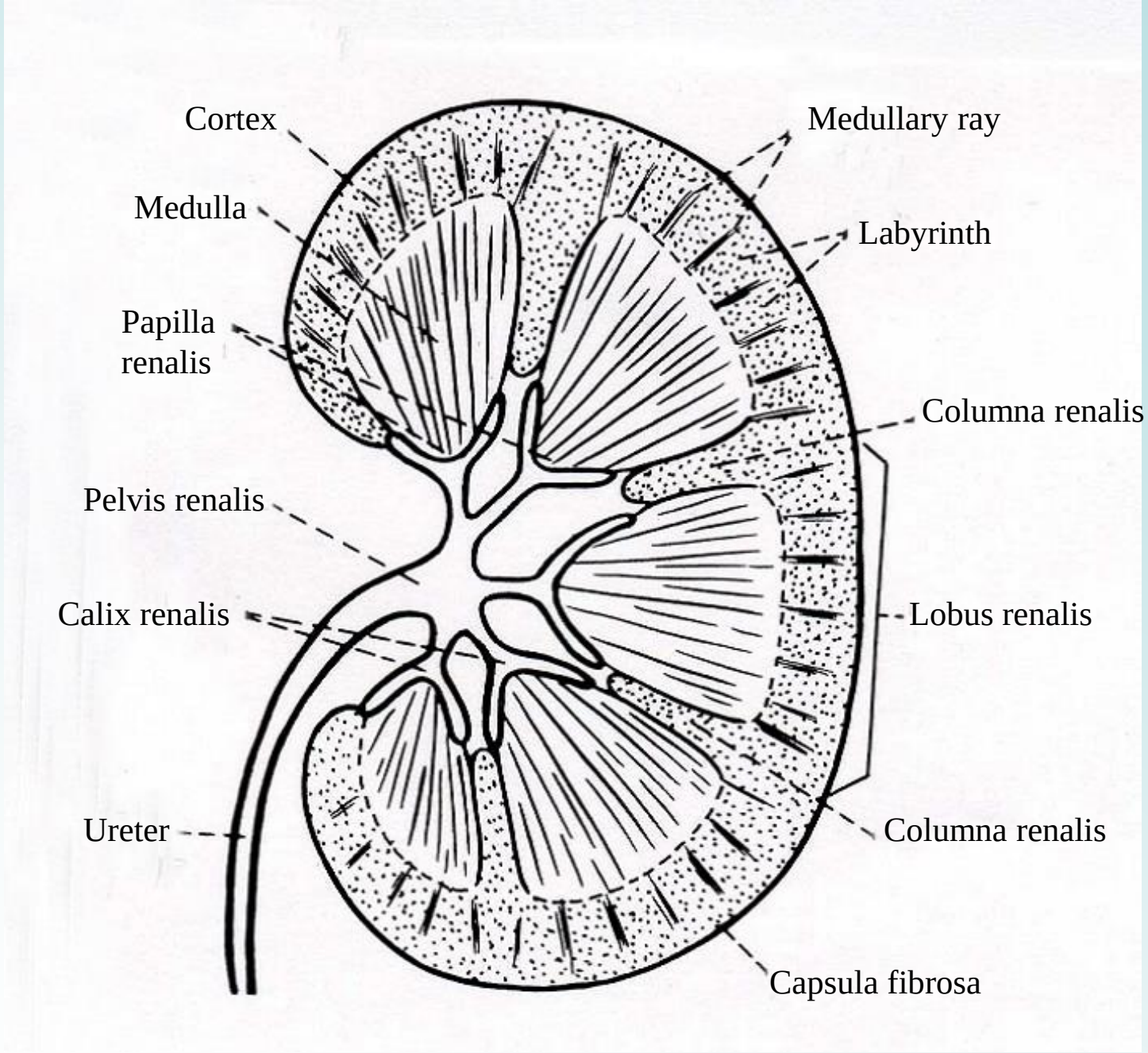
15-00
Urinary System

15 Urinary System
Menu 1/2

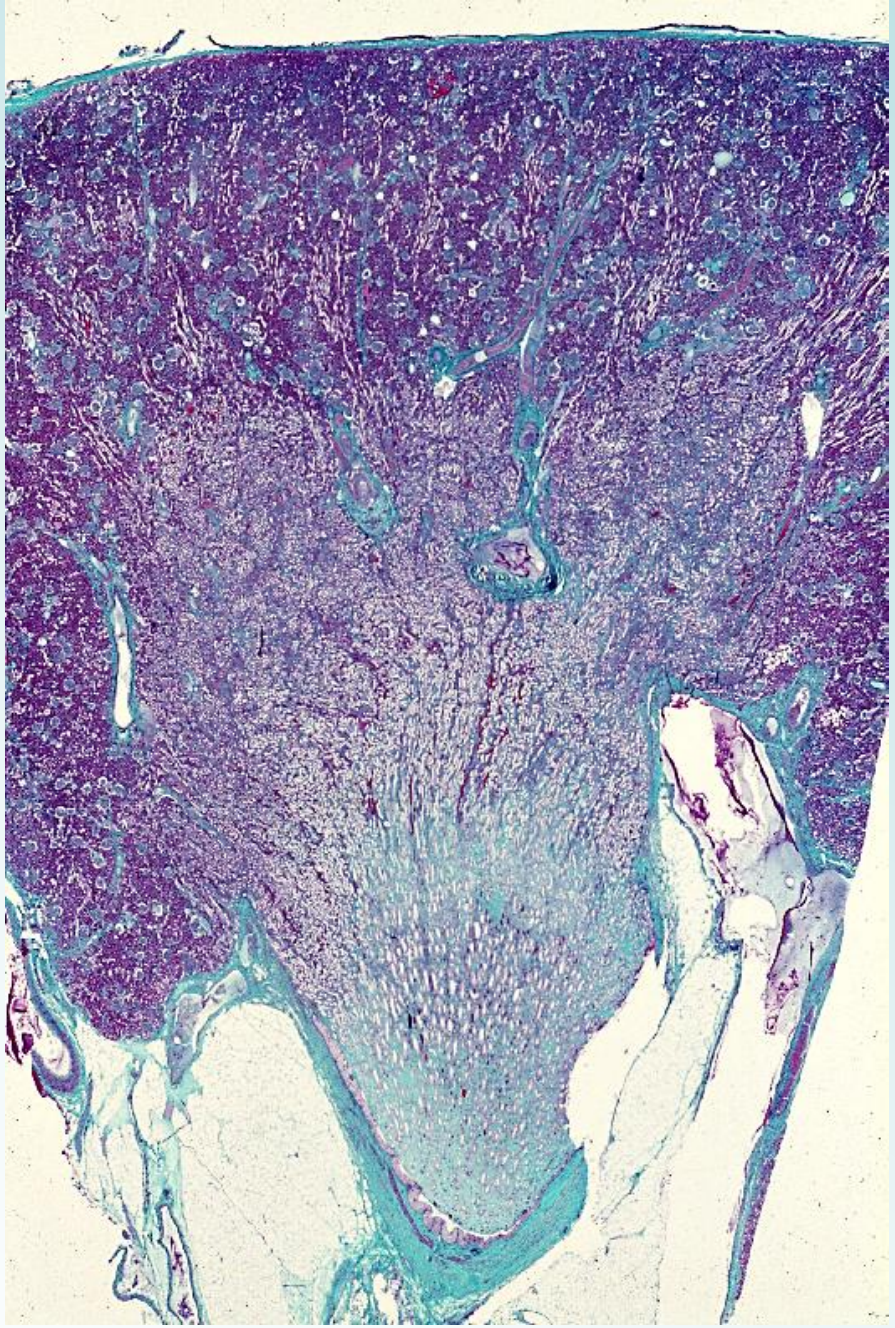
15 Urinary System
Menu 2/2

15-31. Medulla 5. Inner layer of outer zone 2. Human, M-G stain, x 130.
15-32. Medulla 6. Inner zone 1. Human, M-G stain, x 100.
15-33. Medulla 7. Inner zone 2. Human, M-G stain, x 100.
15-34. Medulla 8. Inner zone 3. Human, M-G stain, x 160.
15-35. Apical portion of a renal papilla. Human, M-G stain, x 13.
15-36. Renal papilla 1. Human, M-G stain, x 65.
15-37. Renal papilla 2. Thin limbs of the loop of Henle and collecting ducts. Human, M-G stain, x 130.
15-38. Renal papilla 3. Confluence of collecting tubules. Human, M-G stain, x 40.
15-39. Renal papilla 4. U-turn of a thin limb of loop of Henle. Human, M-G stain, x 64.
15-40. Apex renal papilla. Epithelium covering the apex of papilla and that covers the inner surface of the pelvis. Human, M-G stain, x 64.
15-41. Vascular system of kidney. Scheme.
15-002. Ureter and Urinary Bladder
15-42. Ureter, transverse section. Human, H-E stain, x 10.
15-43. Epithelium of ureter. Human, H-E stain, x 64.
15-44. Wall of the urinary bladder. General view. Human, H-E stain, x 2.7.
15-45. Epithelium of the urinary bladder. Human, H-E stain, x 64.
15-46. Penis, transverse section. Human, H-E stain, x 0.85.
15-47. Male urethra, transverse section. Human, H-E stain, x 4.0.
15-48. Female urethra, transverse section. Human, H-E stain, x 4.0.

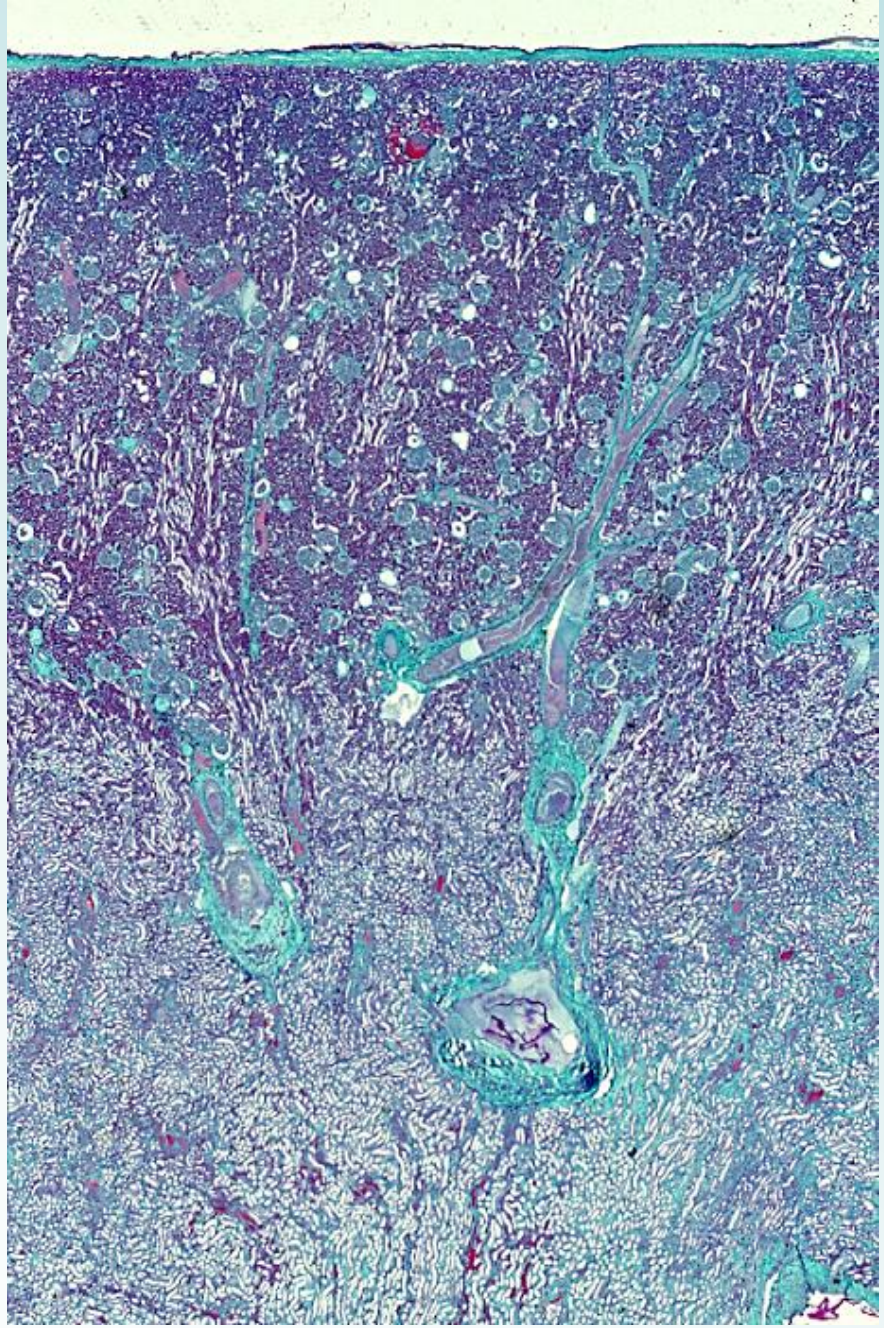
15-001
Kidney



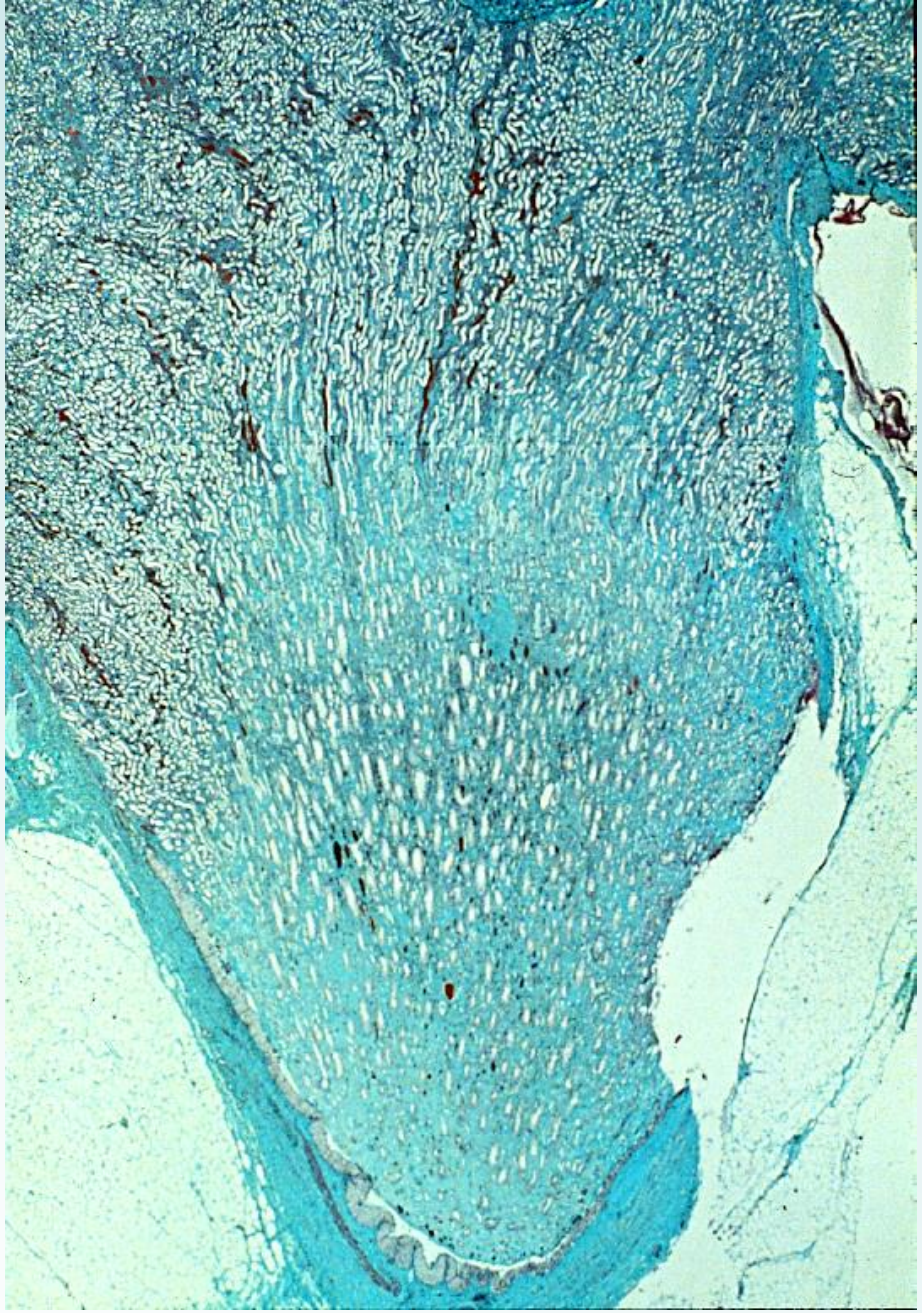
15-01 Frontal section of human kidney (Scheme).



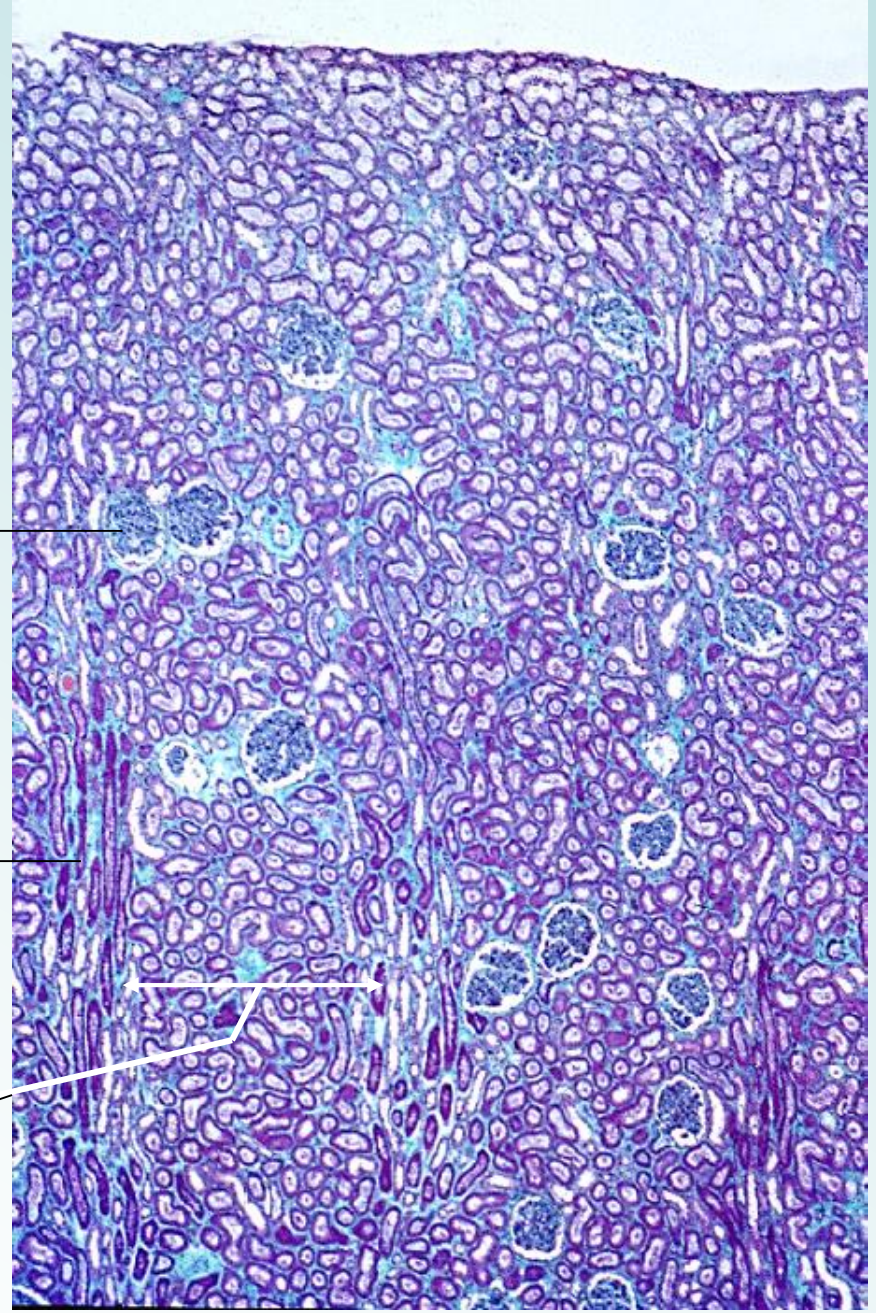
15-02 General view of a renal lobe. Human, M-G stain, x 1.6.



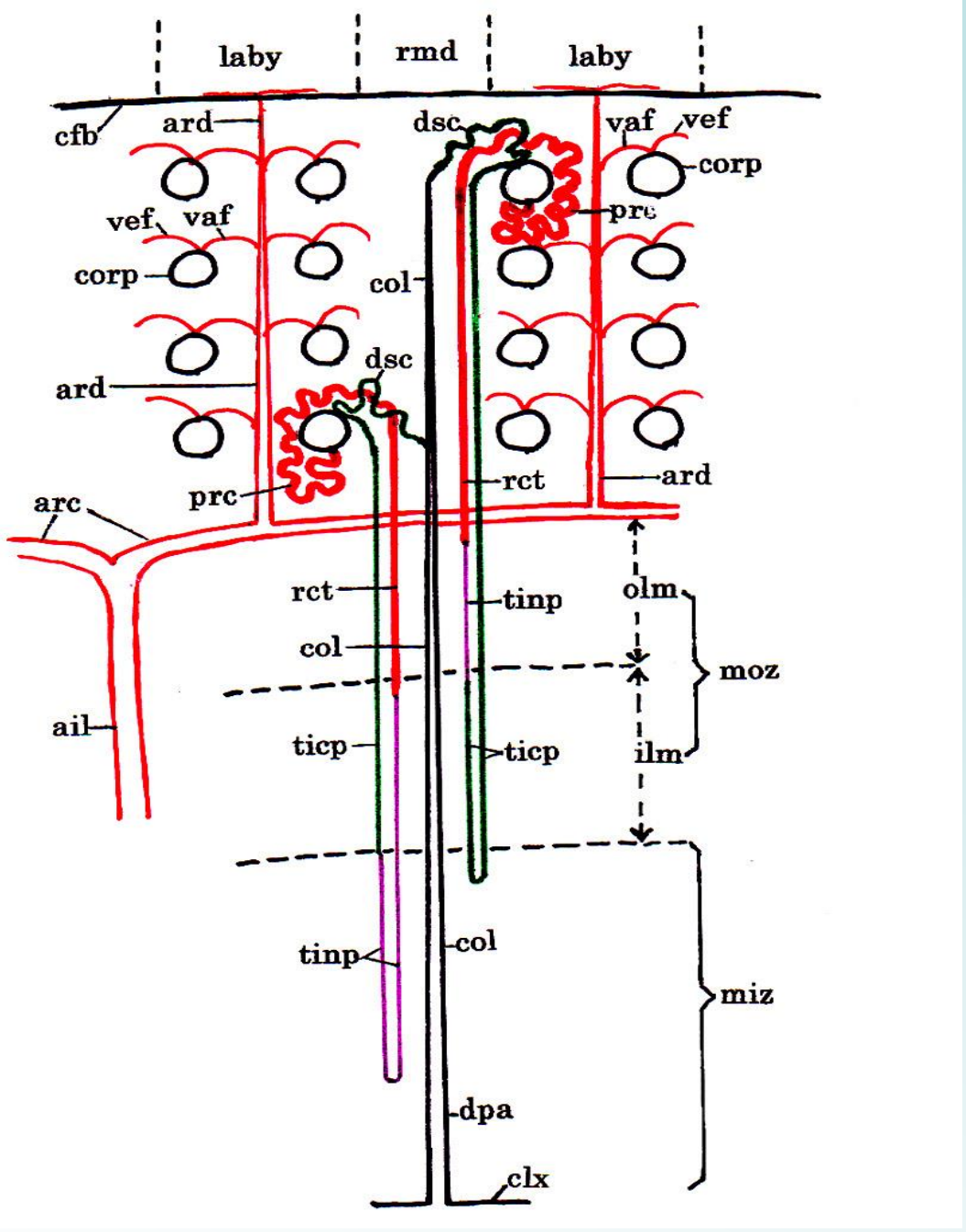
15-03 Cortex and medulla of a renal lobe. General view. Human, M-G stain, x 3.0.



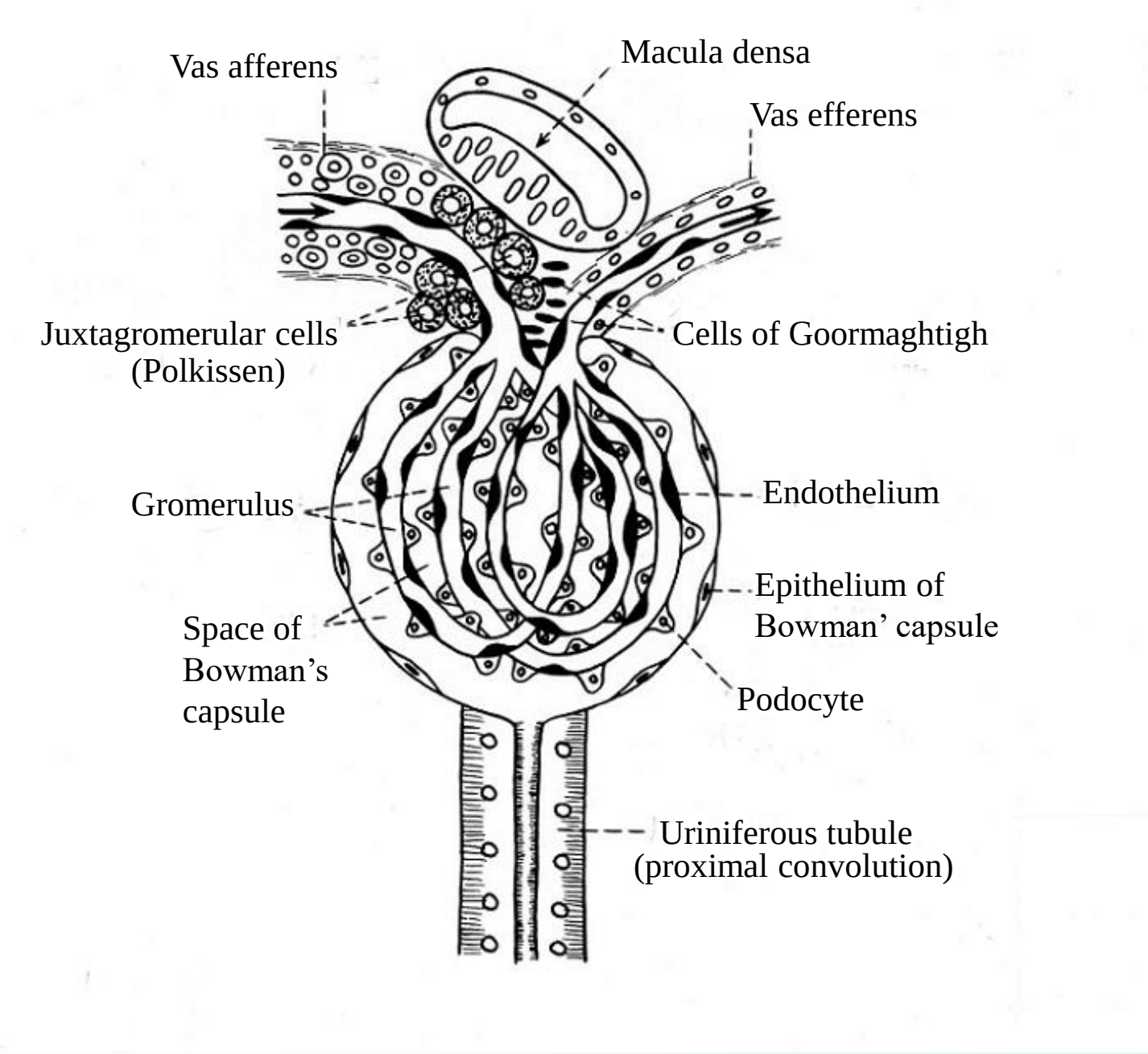
15-04 Medulla, papilla and calyx. Human, M-G stain, x 3.0.



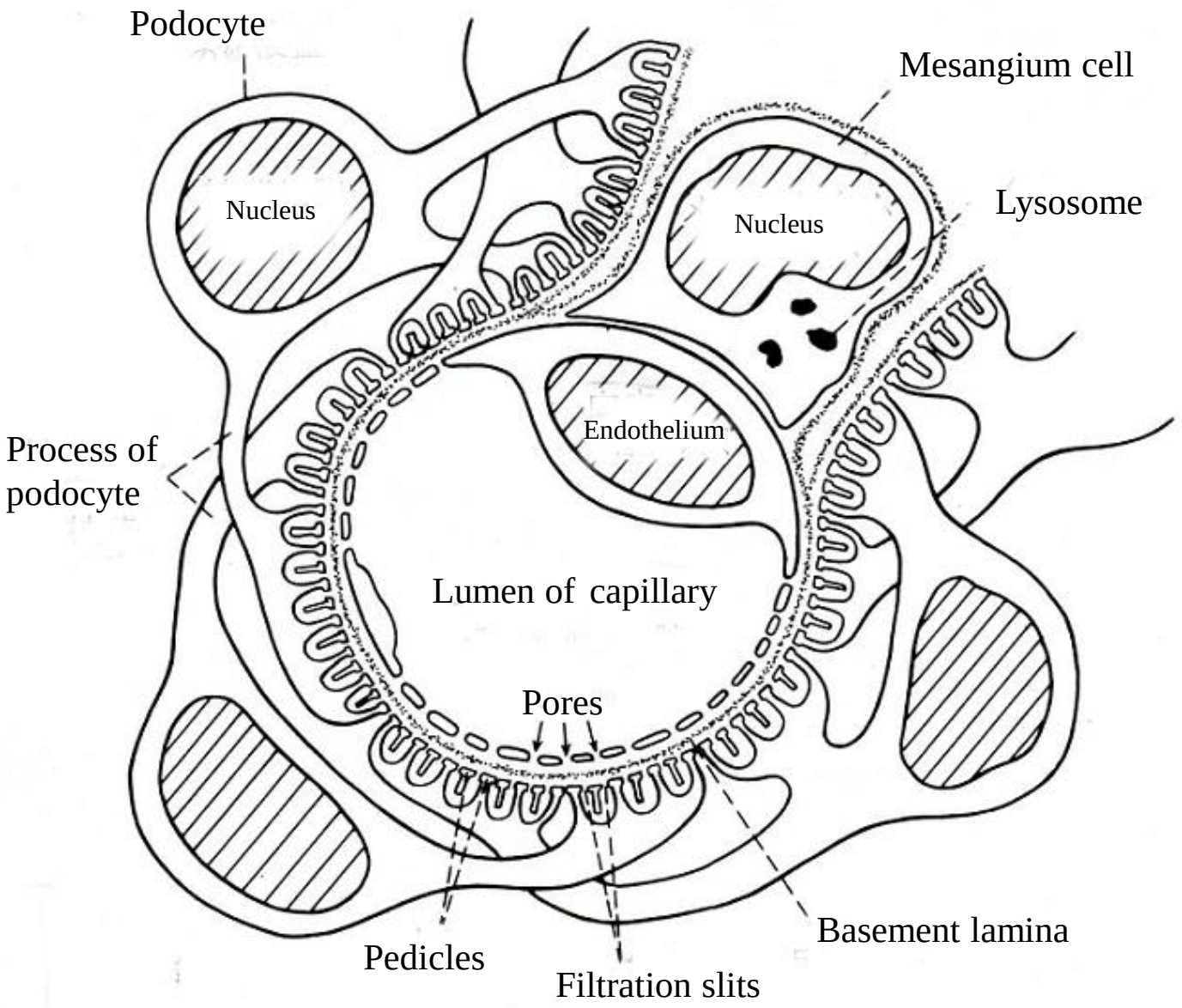
15-05 Renal cortex 1. Low power magnification. Human, M-G stain, x 10.



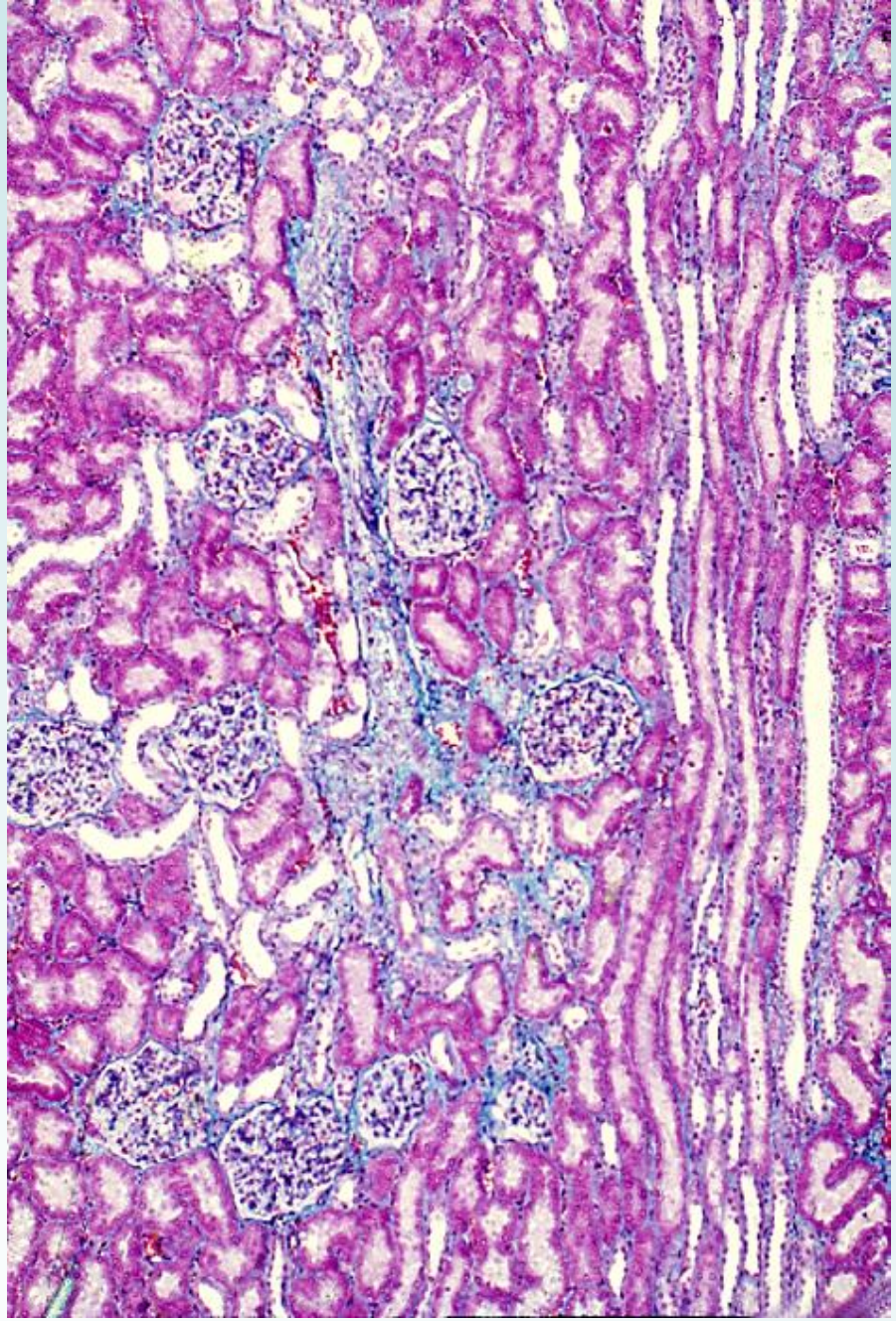
15-06 Scheme showing the structure of nephrons.



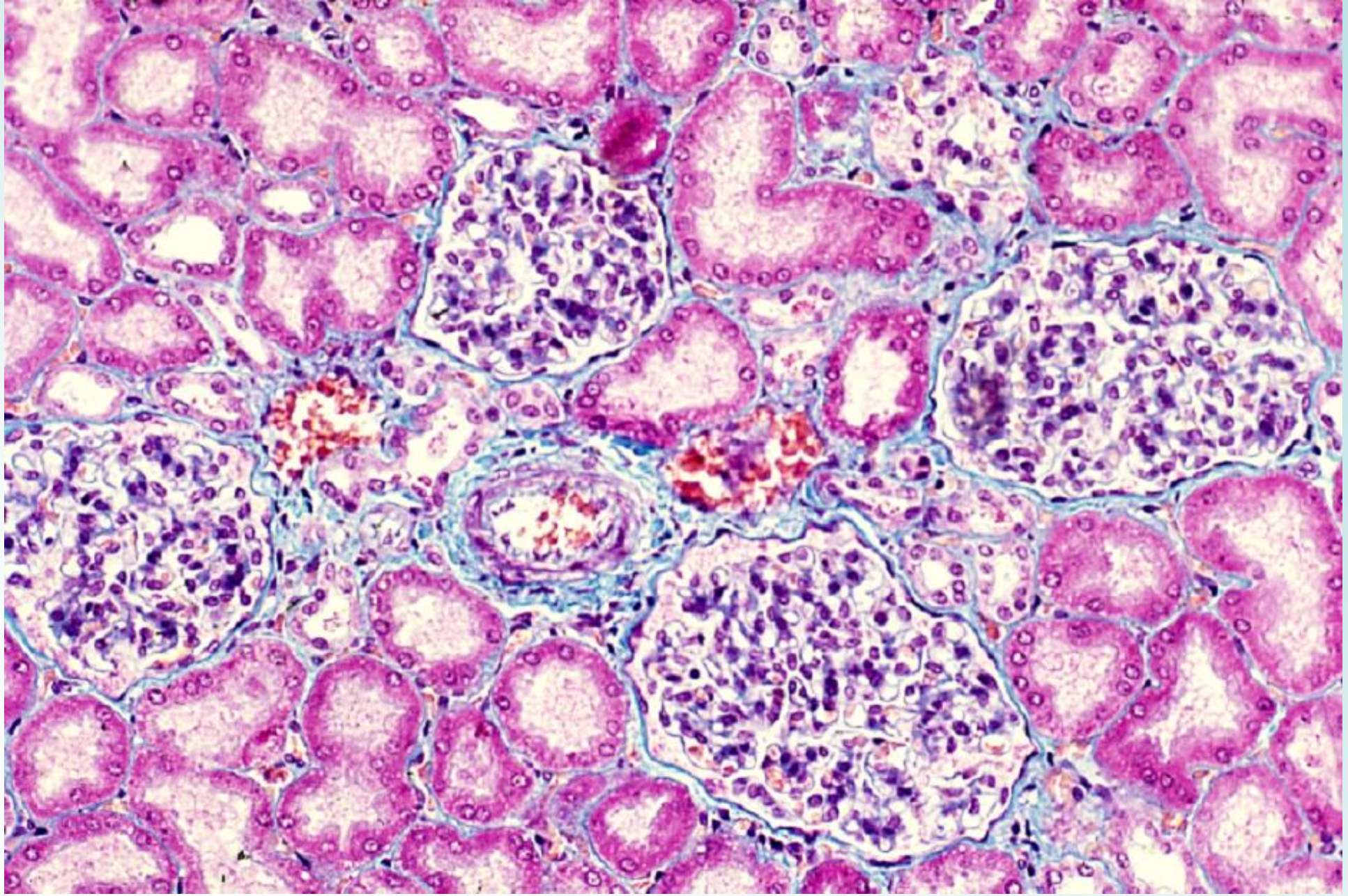
15-07 Scheme showing the structure of a renal corpuscle.



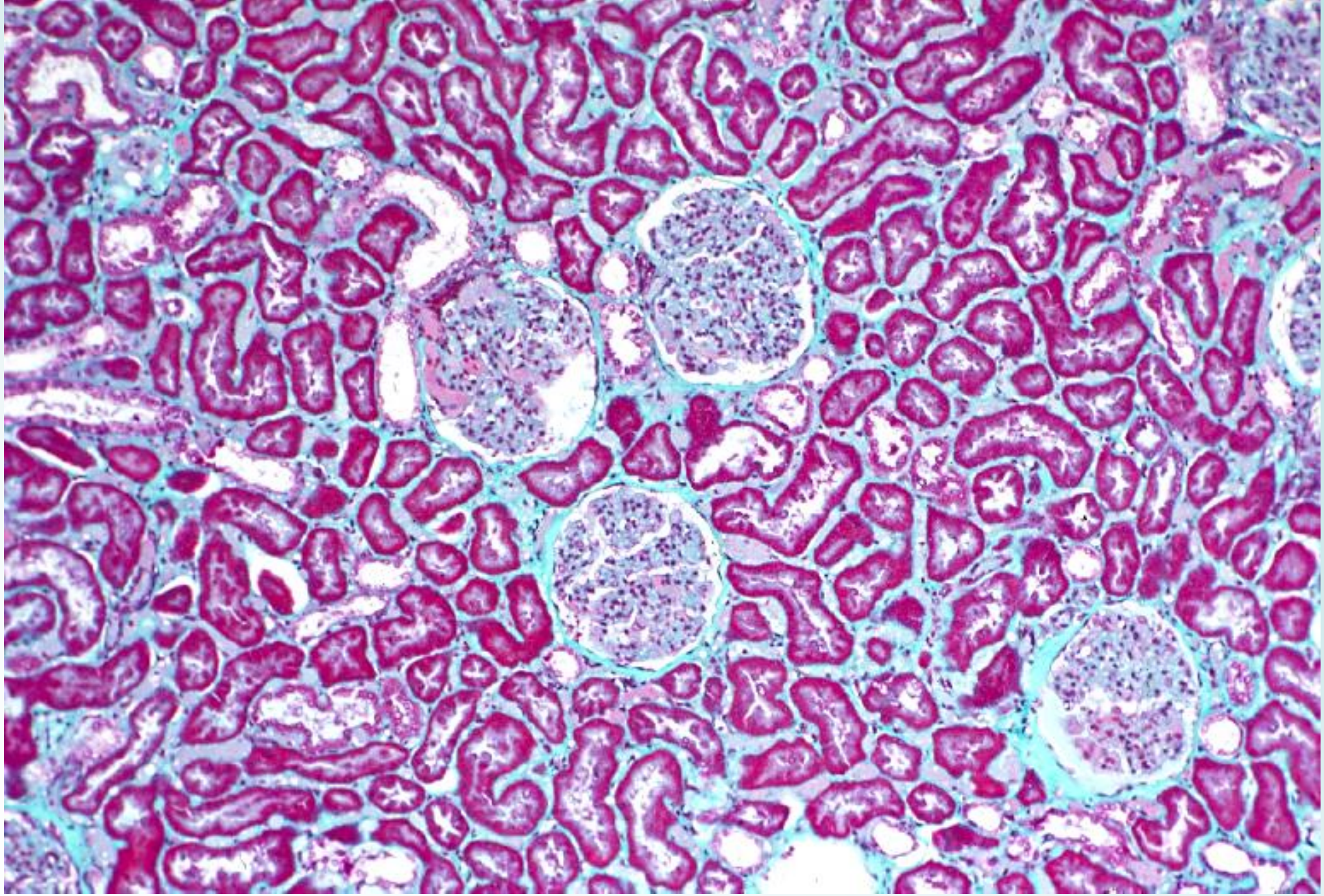
15-08 Scheme showing the interrelationship between the glomerular capillary and the podocytes, based on the electron microscopy.



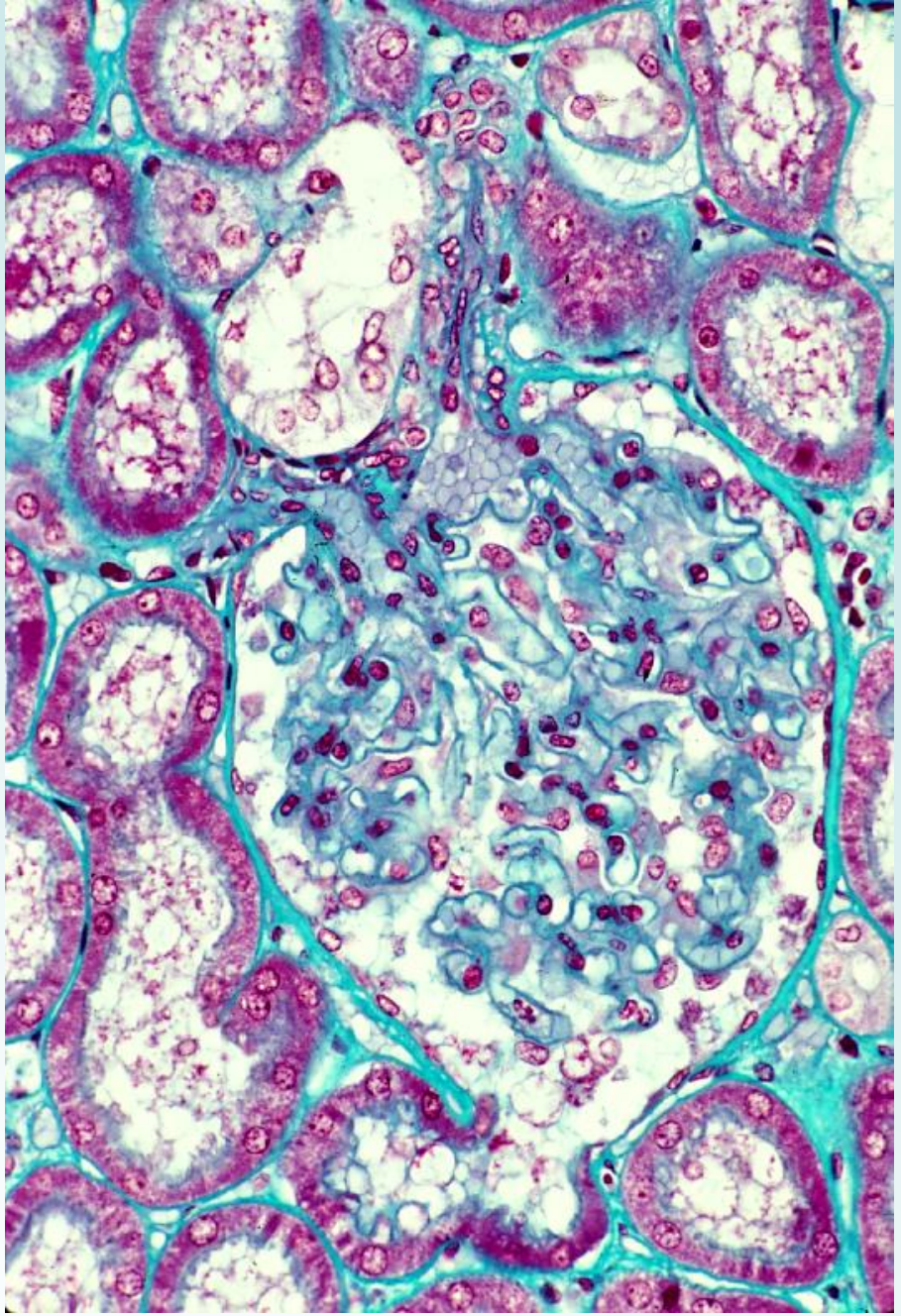
15-09 Cortex 2. Labyrinth and medullary ray. Human, Mallory-Crossmon stain, x 25.



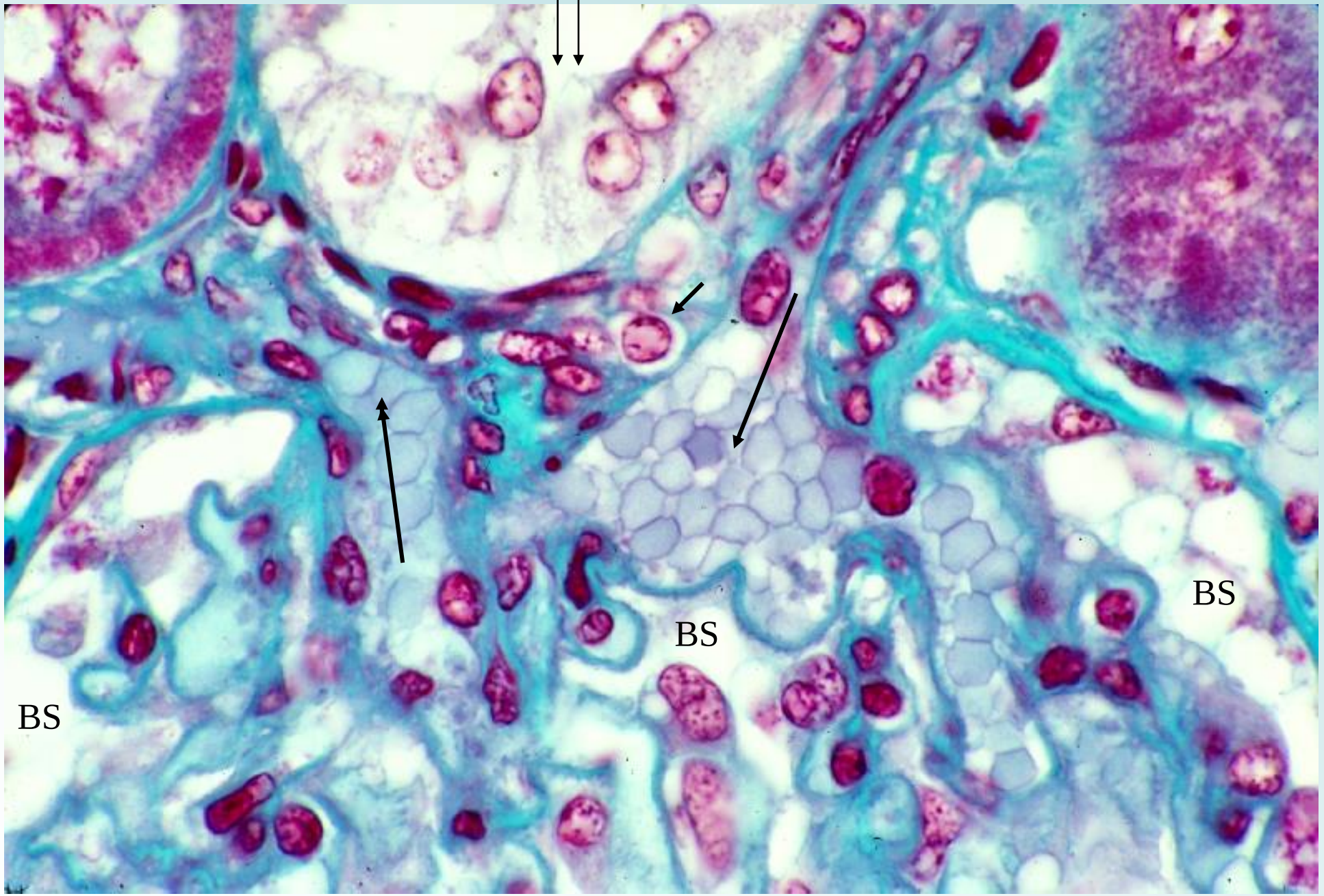
15-10 Cortex 3. Labyrinth 1. Human, Mallory-Crossmon stain, x 64.



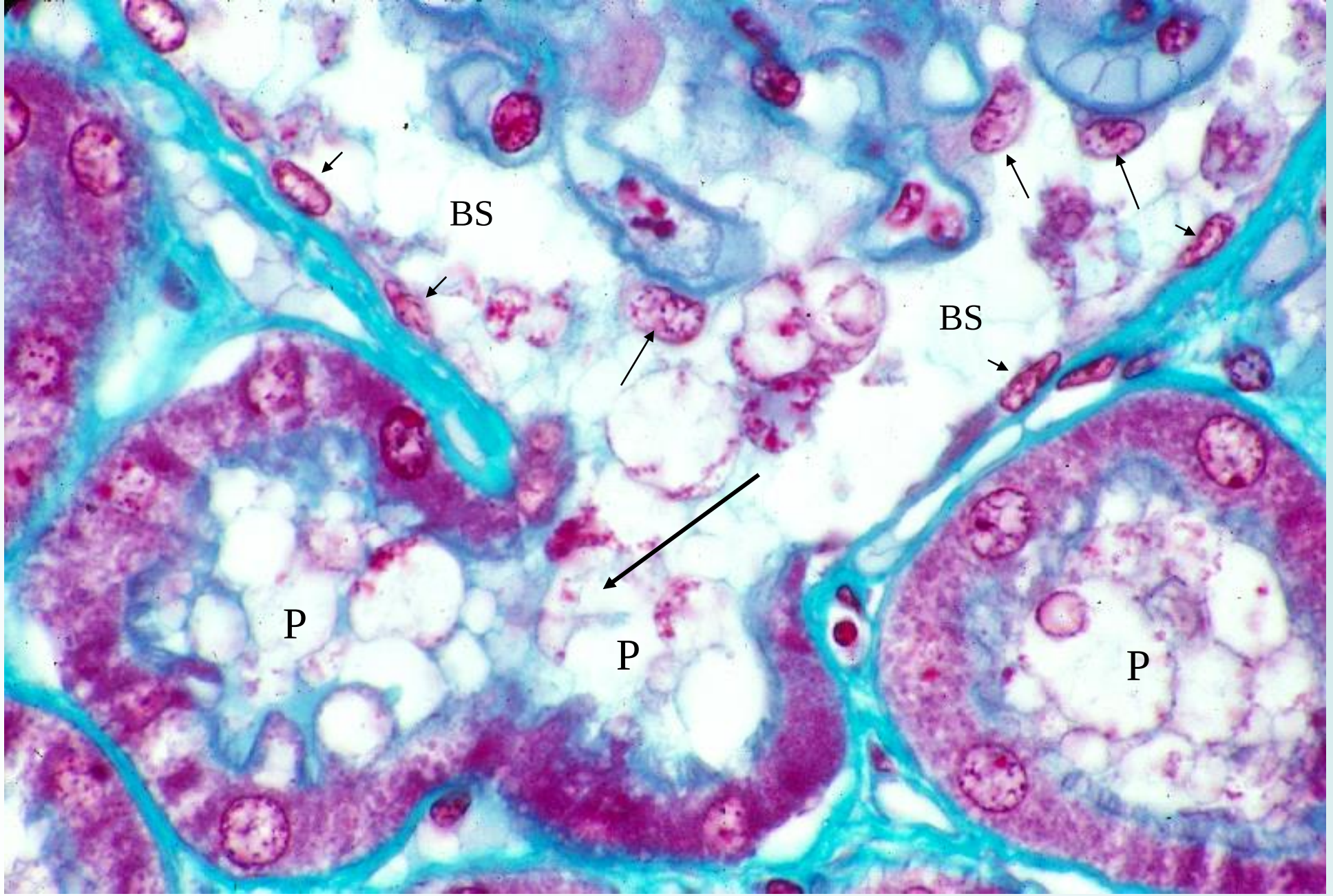
15-11 Cortex 4. Labyrinth 2. Human, M-G stain, x 25.



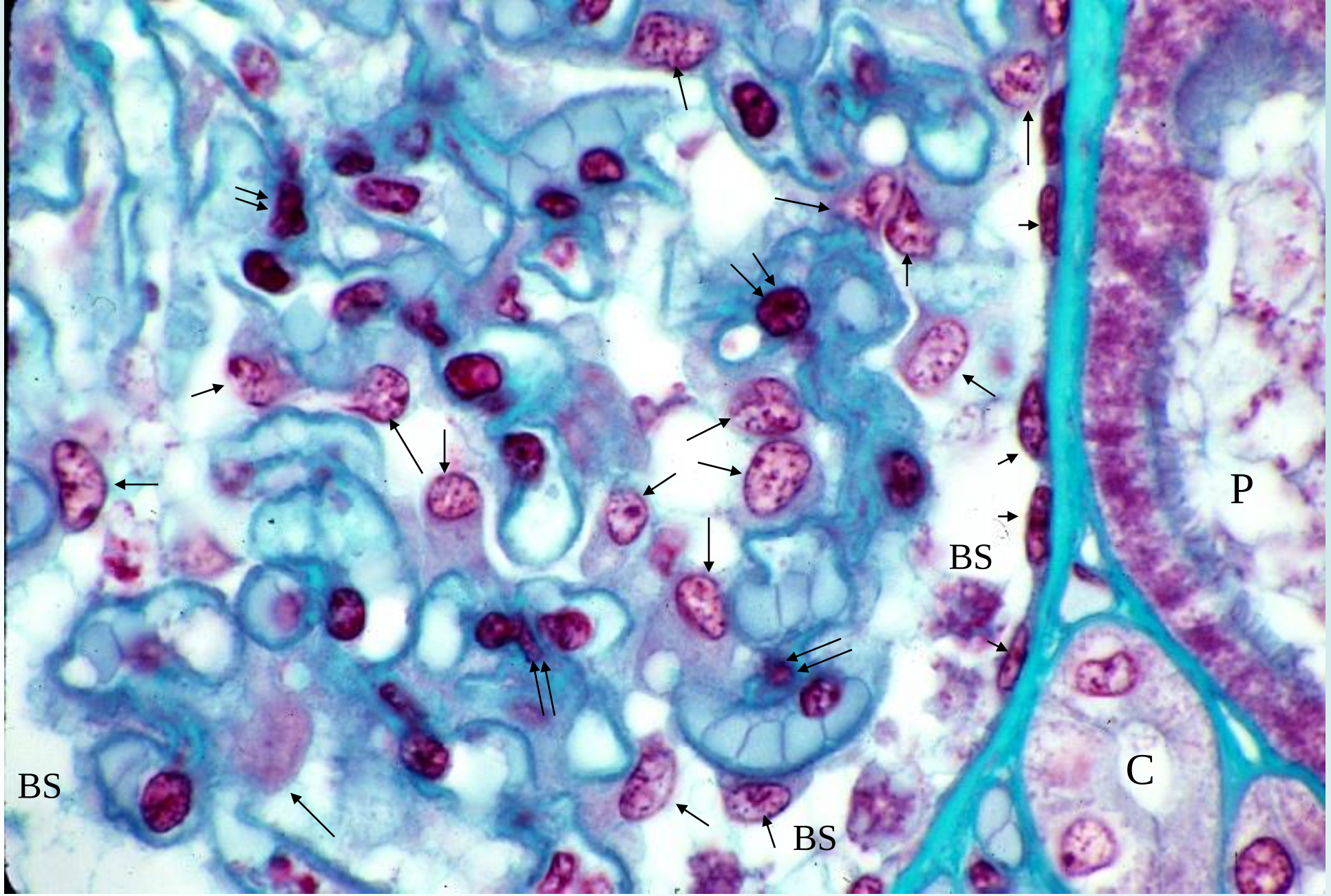
15-12 Renal corpuscle 1. Human, M-G stain, x 100.



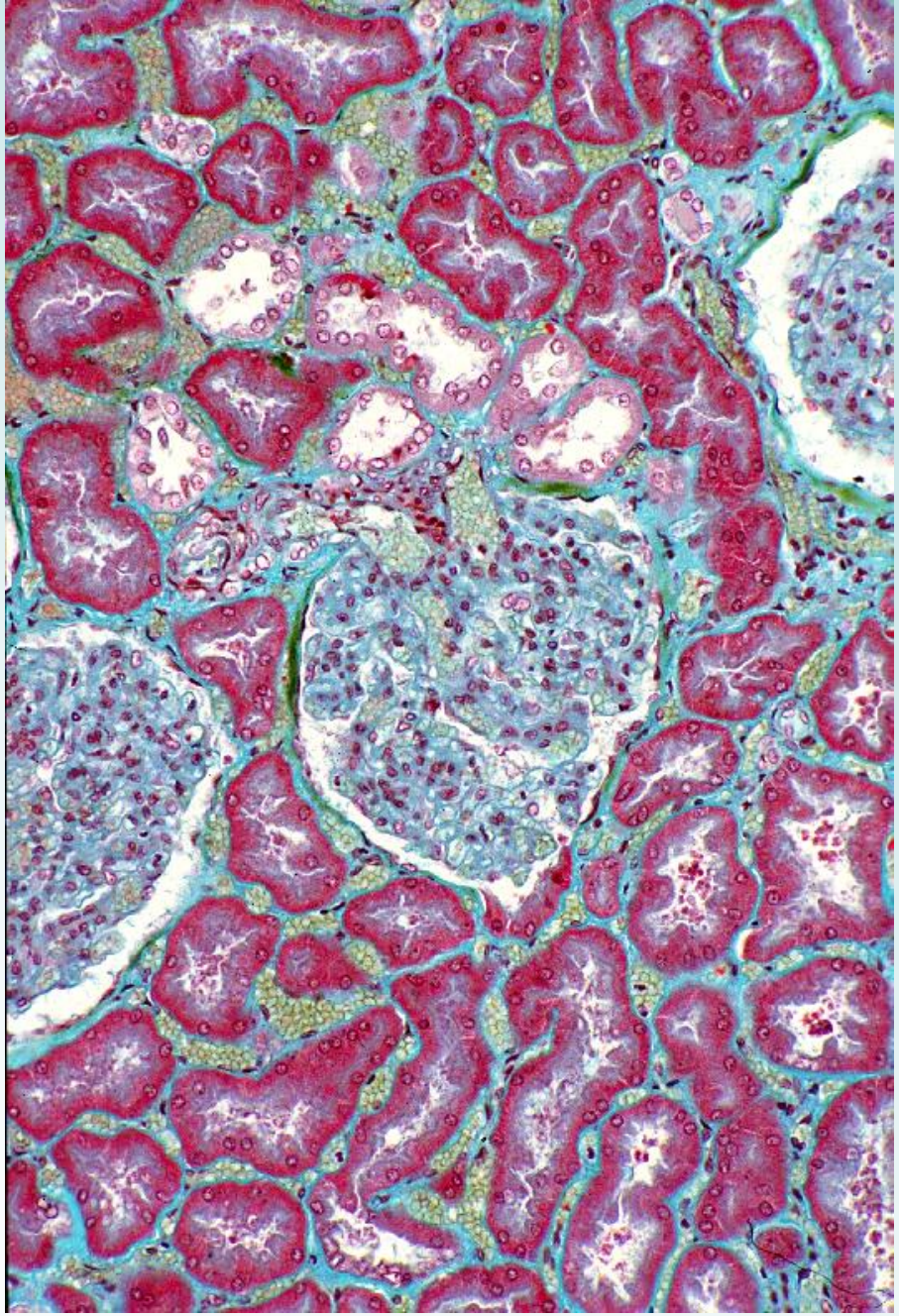
15-13 Renal corpuscle 2. Vascular pole. Human, M-G stain, x 250.



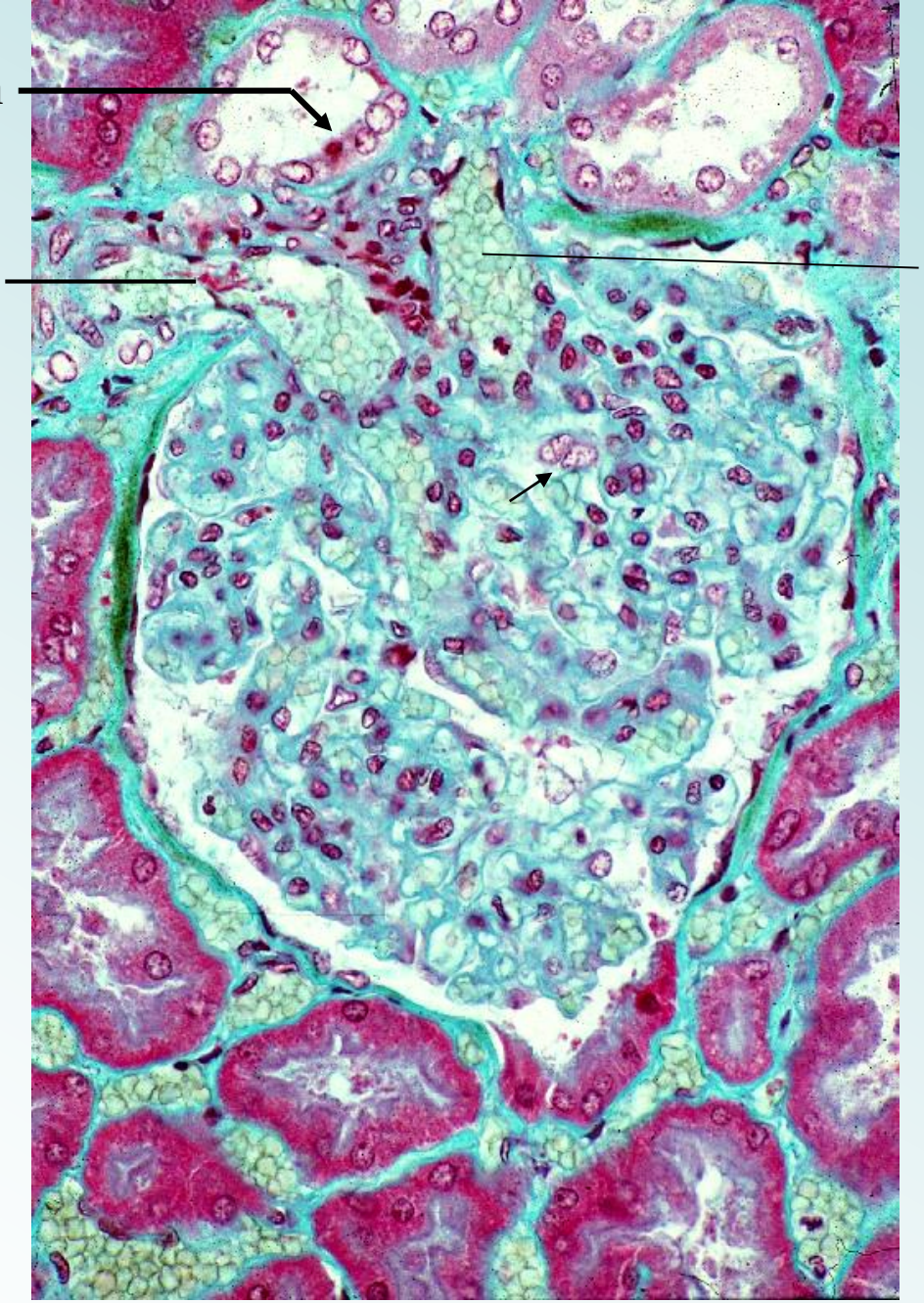
15-14 Renal corpuscle 3. Urinary pole. Human, M-G stain, x 250.



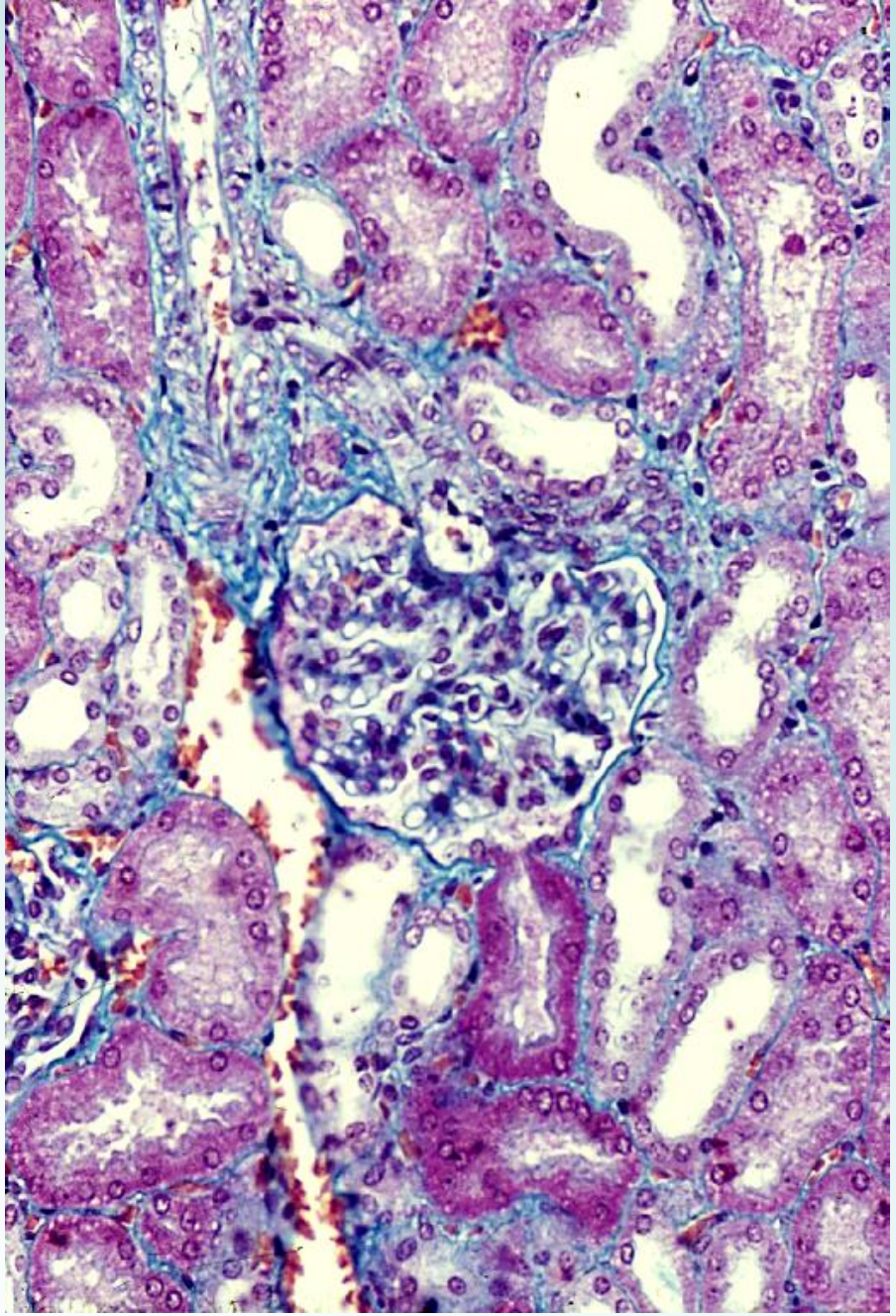
15-15 Renal corpuscle 4. Glomerulus. Human, M-G stain, x 250.



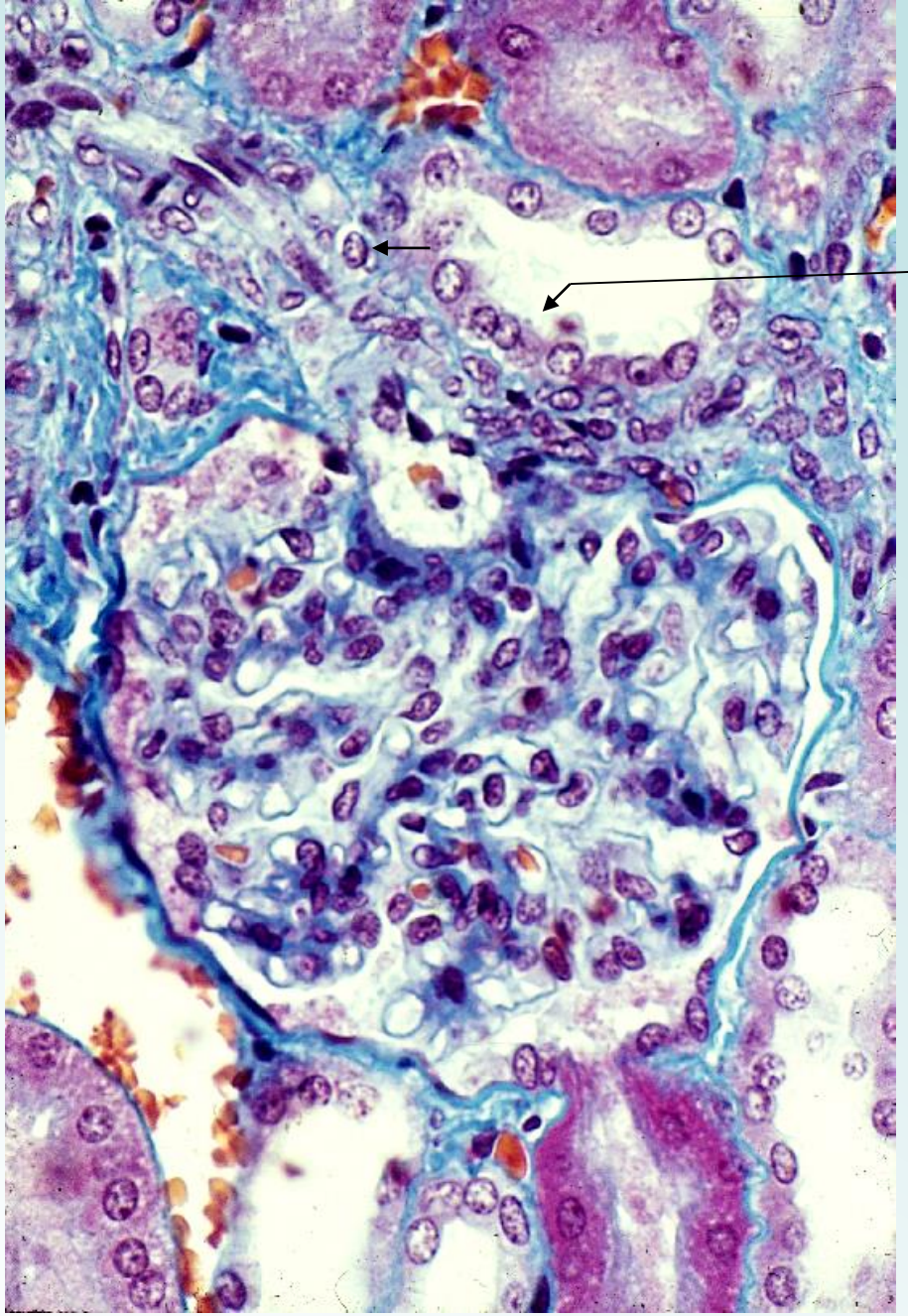
15-16 Cortex 5. Labyrinth 1. Human, M-G stain, x 50.



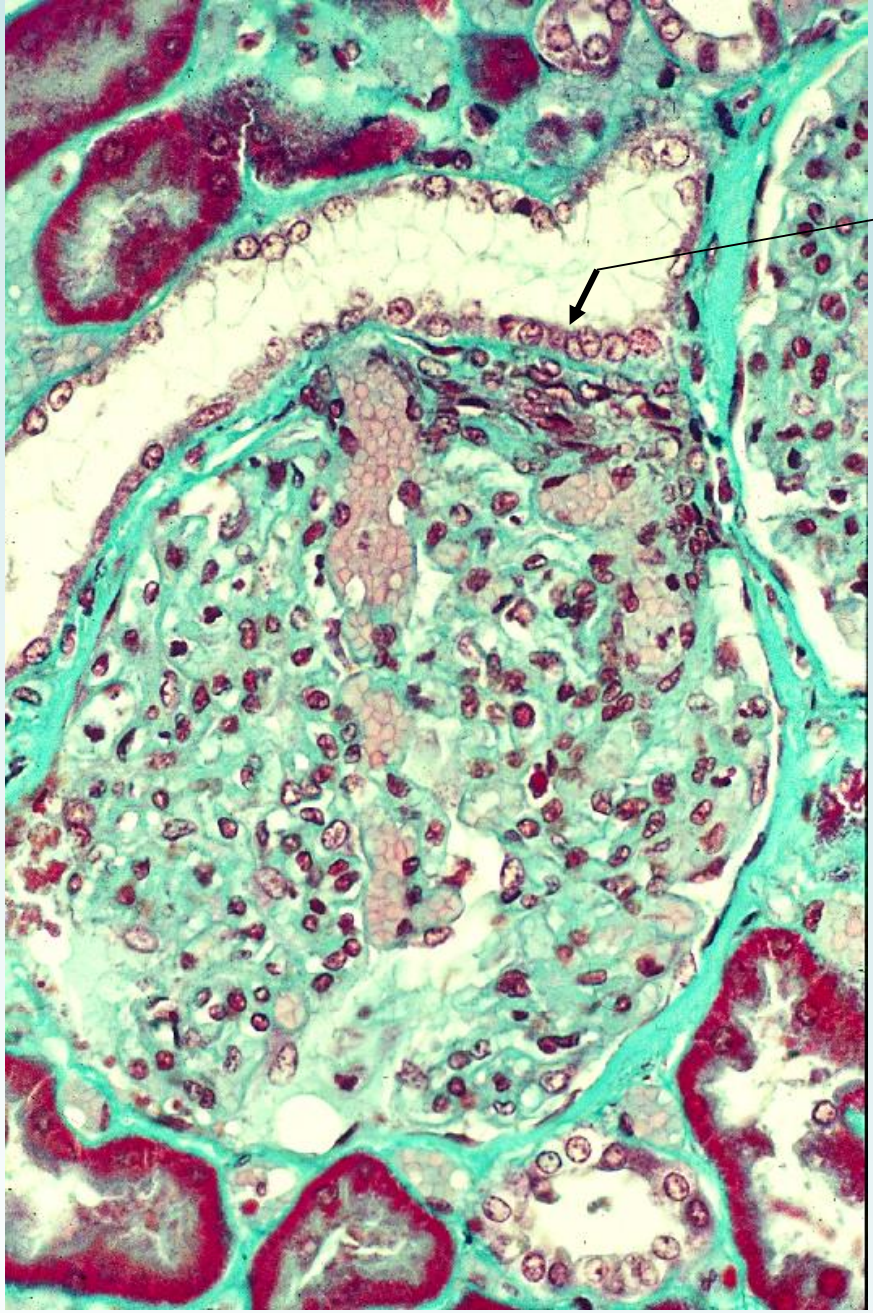
15-17 Renal corpuscle 5. Human, M-G stain, x 100.



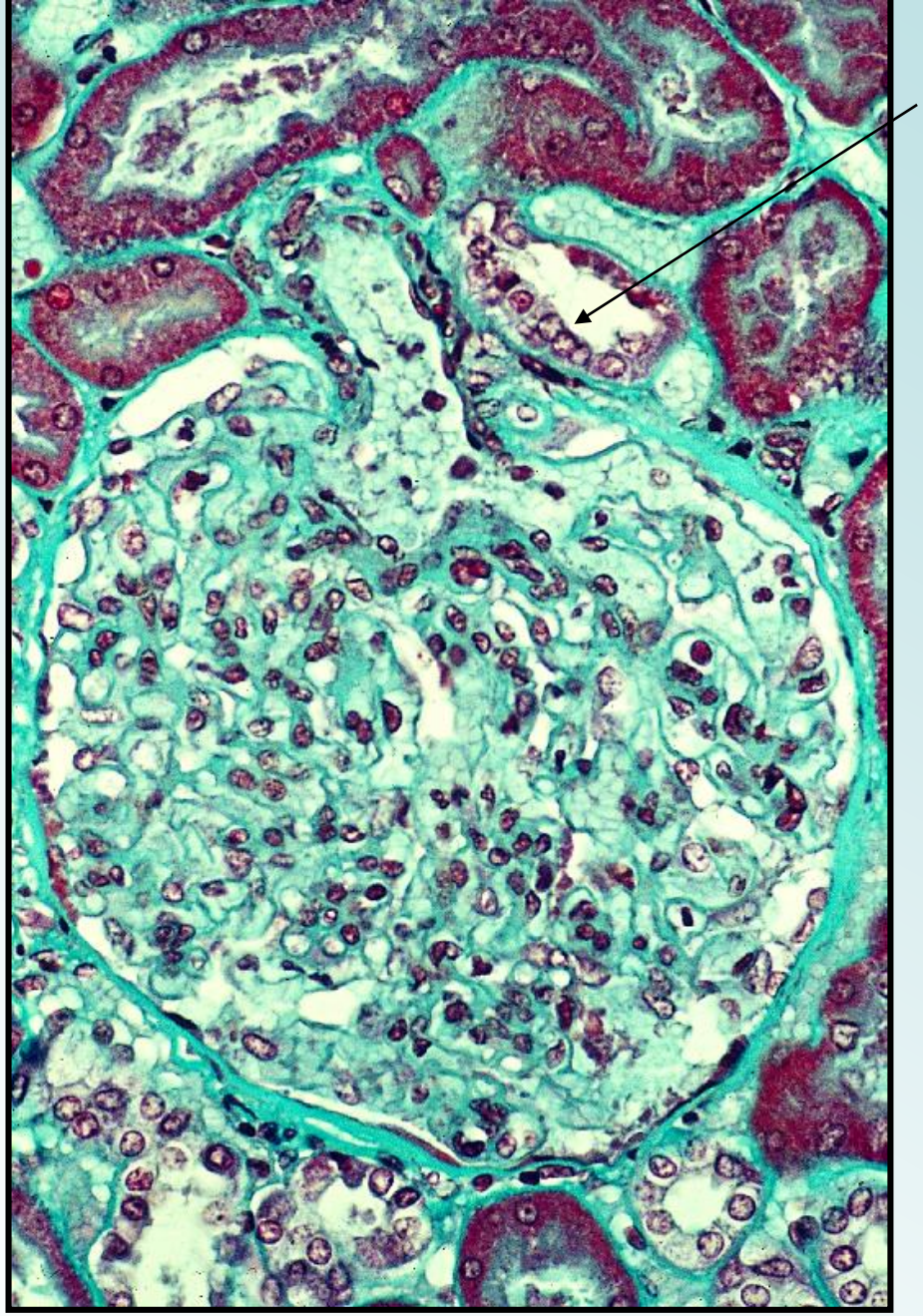
15-18 Renal corpuscle 6. Human, Mallory-Crossmon stain, x 80.



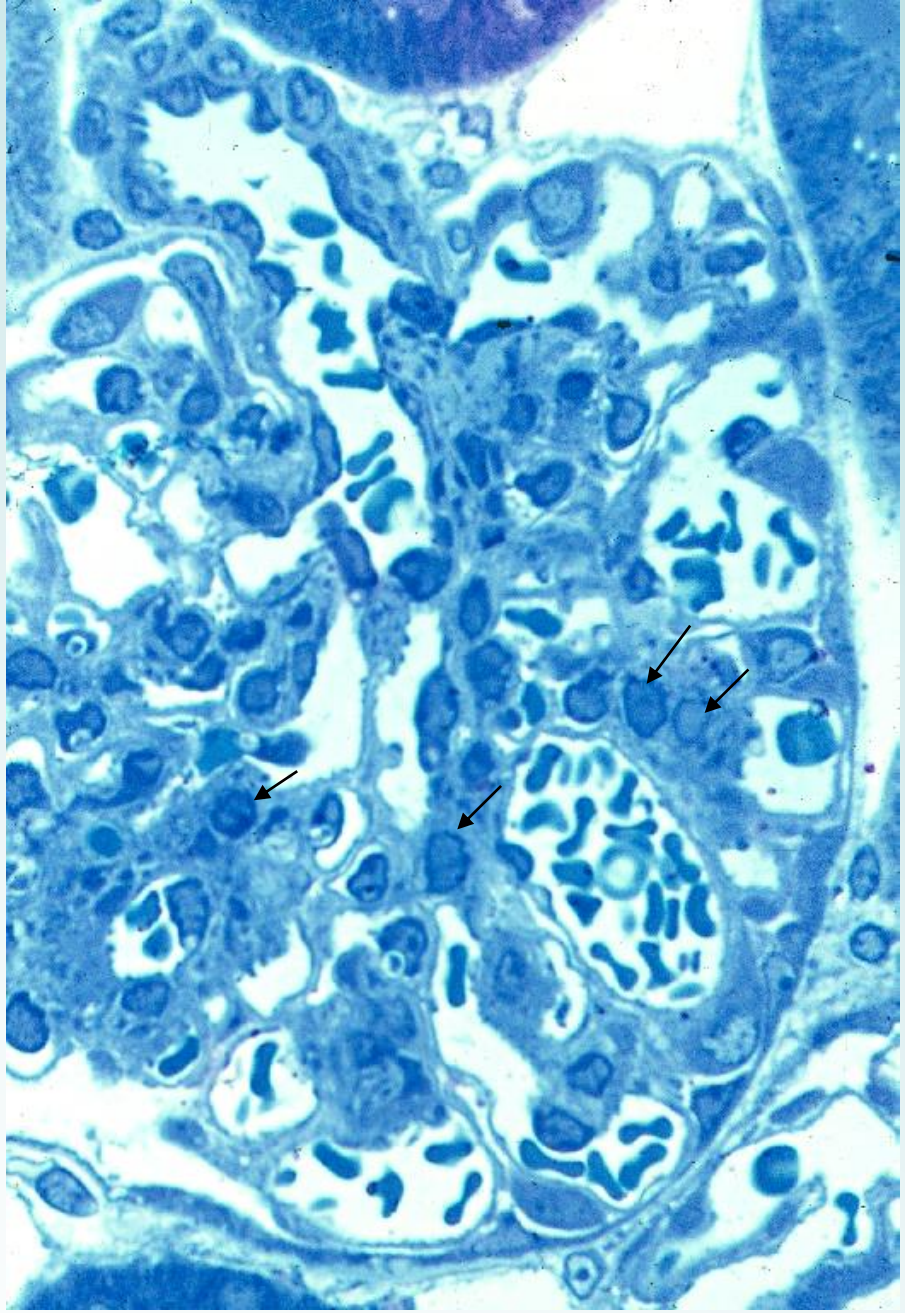
15-19 Renal corpuscle 7. Human, Mallory-Crossmon stain, x 160.



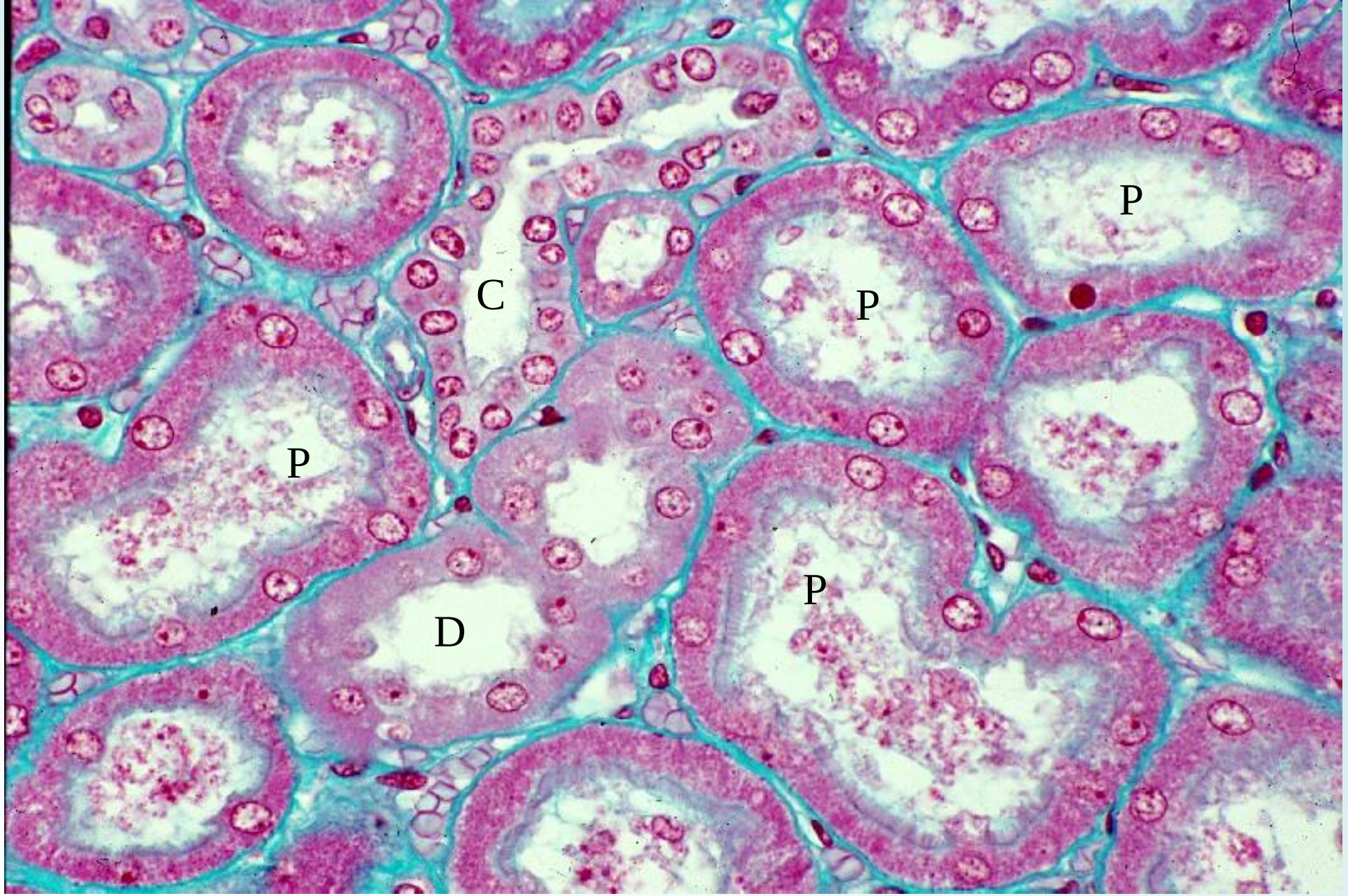
15-20 Renal corpuscle 8. Macula densa 1. Human, M-G stain, x 100.



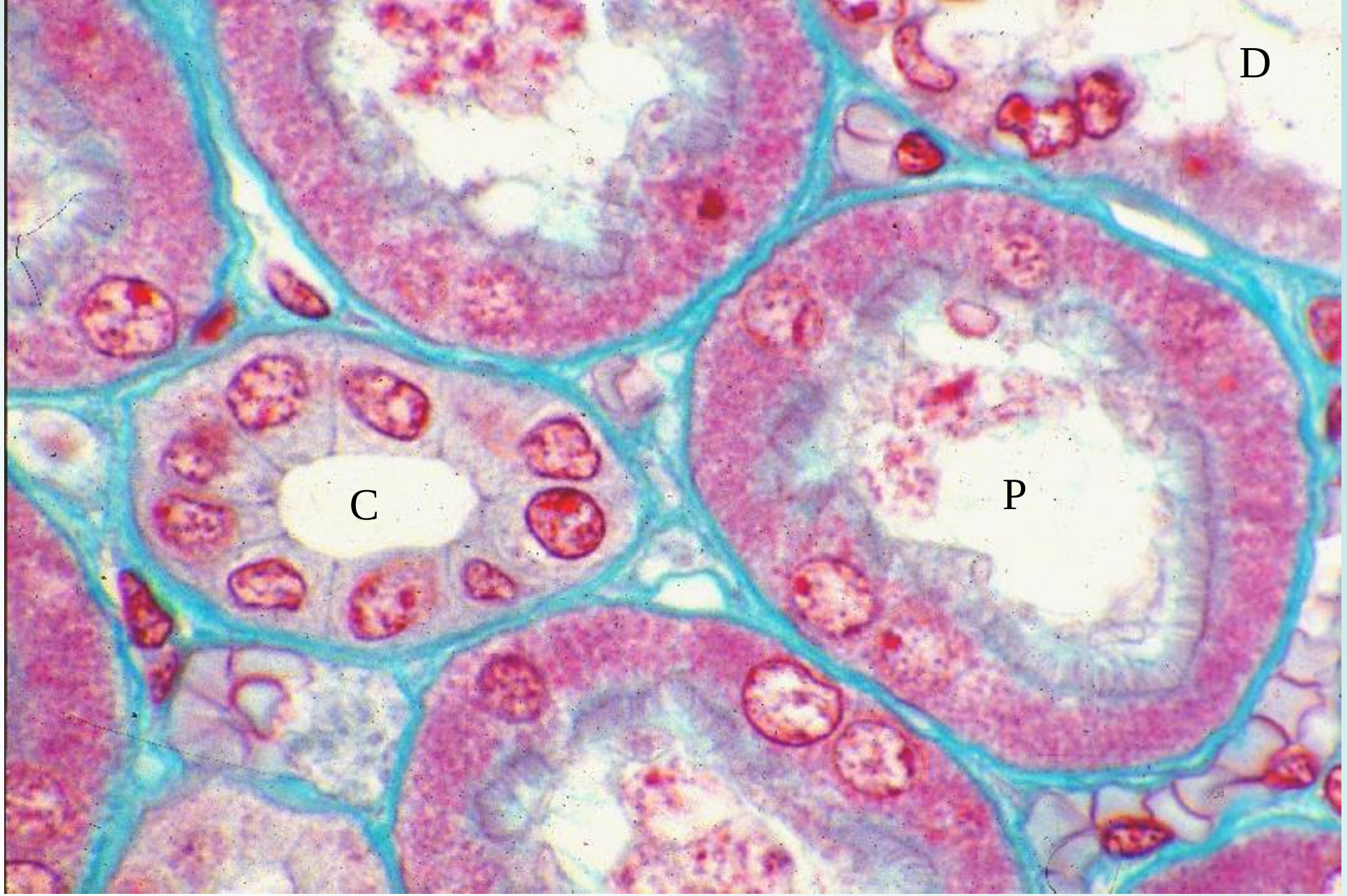
15-21 Renal corpuscle 9. Macula densa 2. Human, M-G stain, x 100.



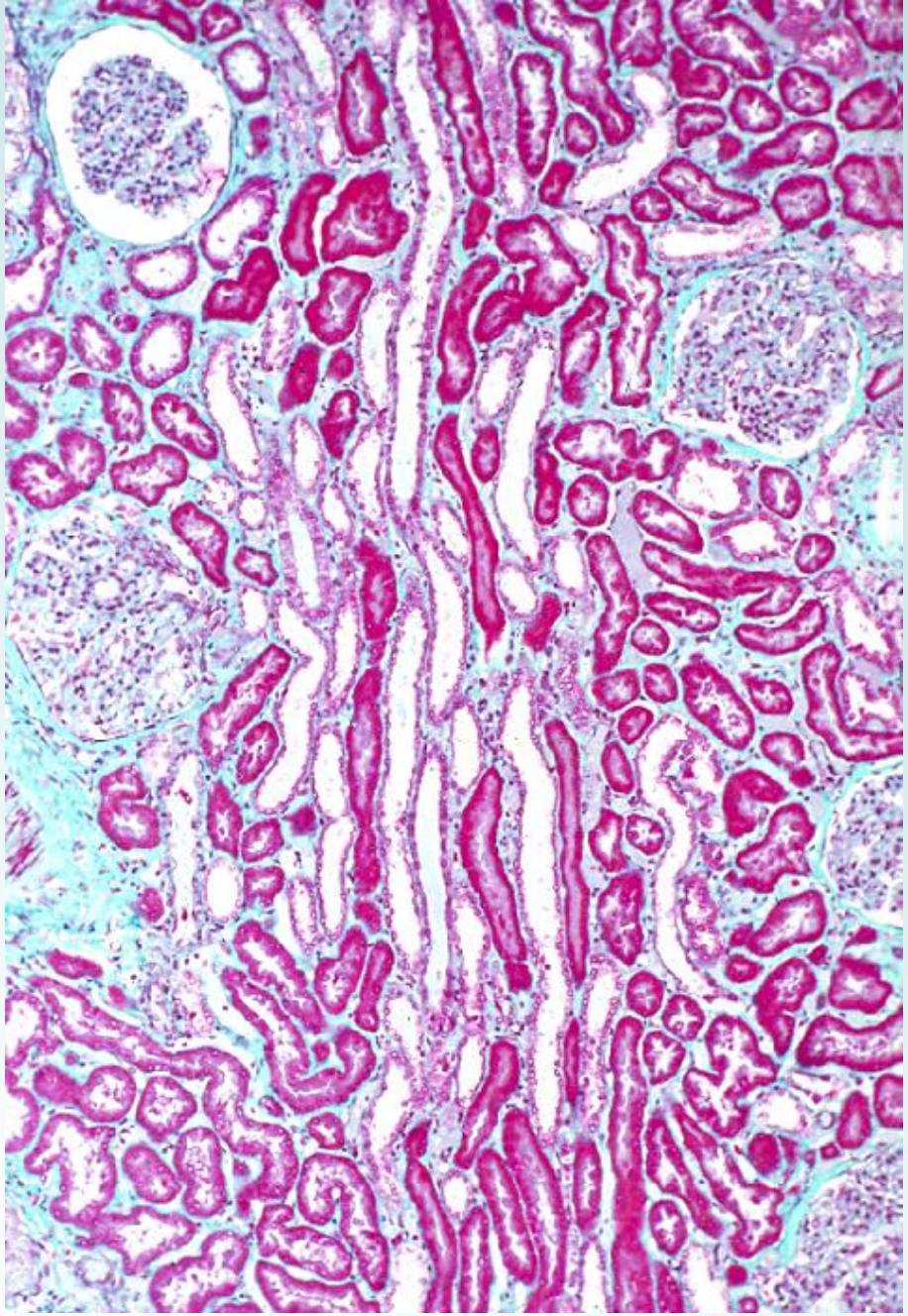
15-22 Renal corpuscle 10. Rat, epon section, toluidine blue stain, x 250.



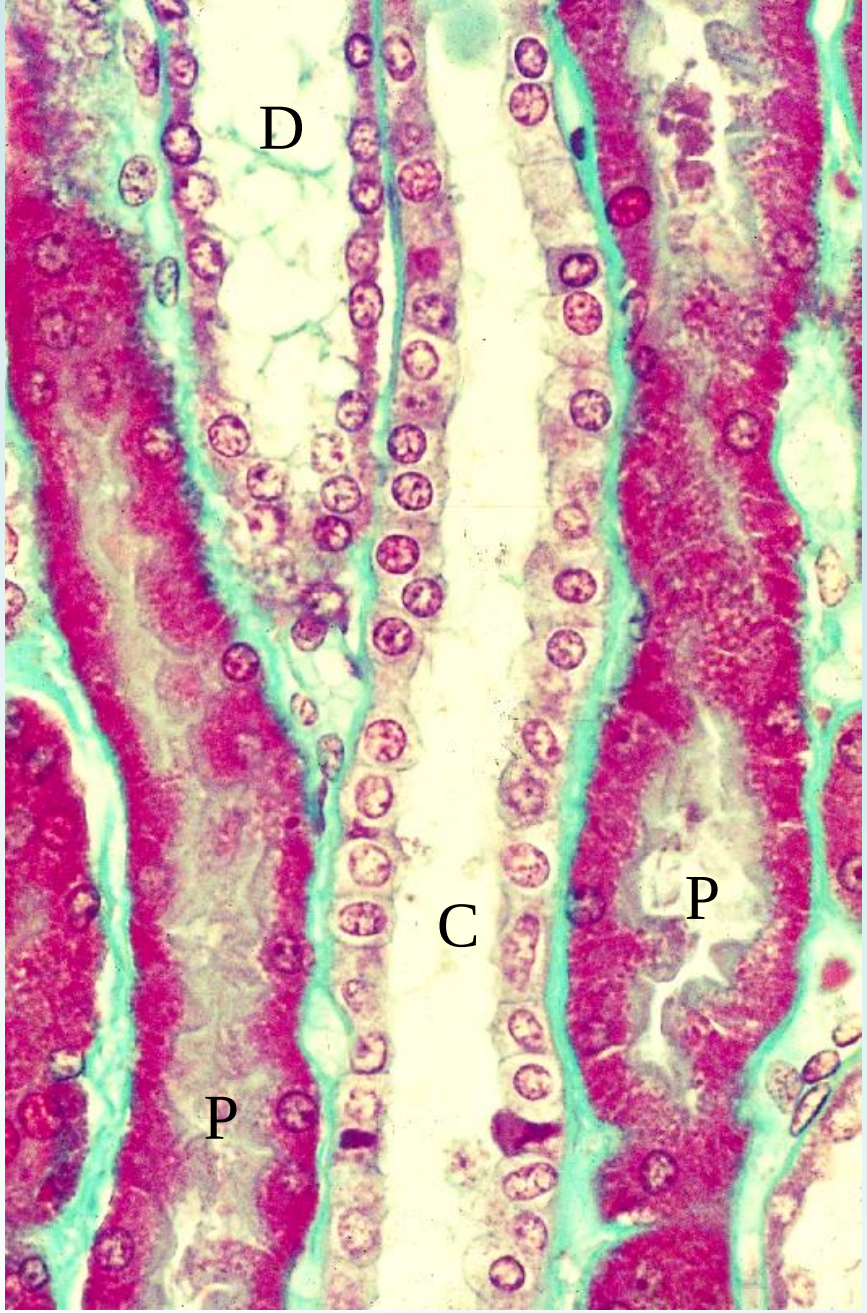
15-23 Urinary tubules 1. Renal labyrinth 1. Human, M-G stain, x 130.



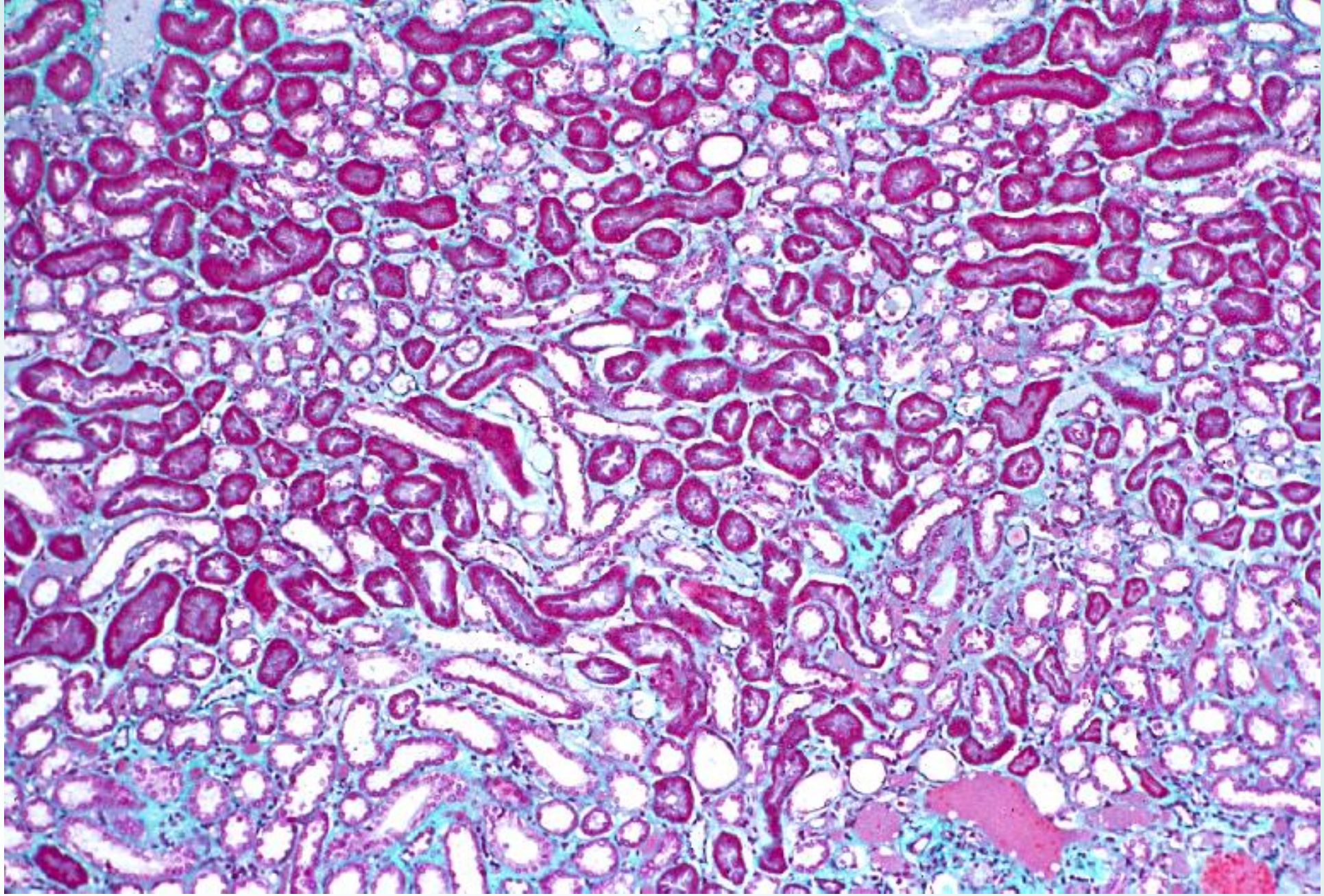
15-24 Urinary tubules 2. Renal labyrinth 2. Human, M-G stain, x 330.



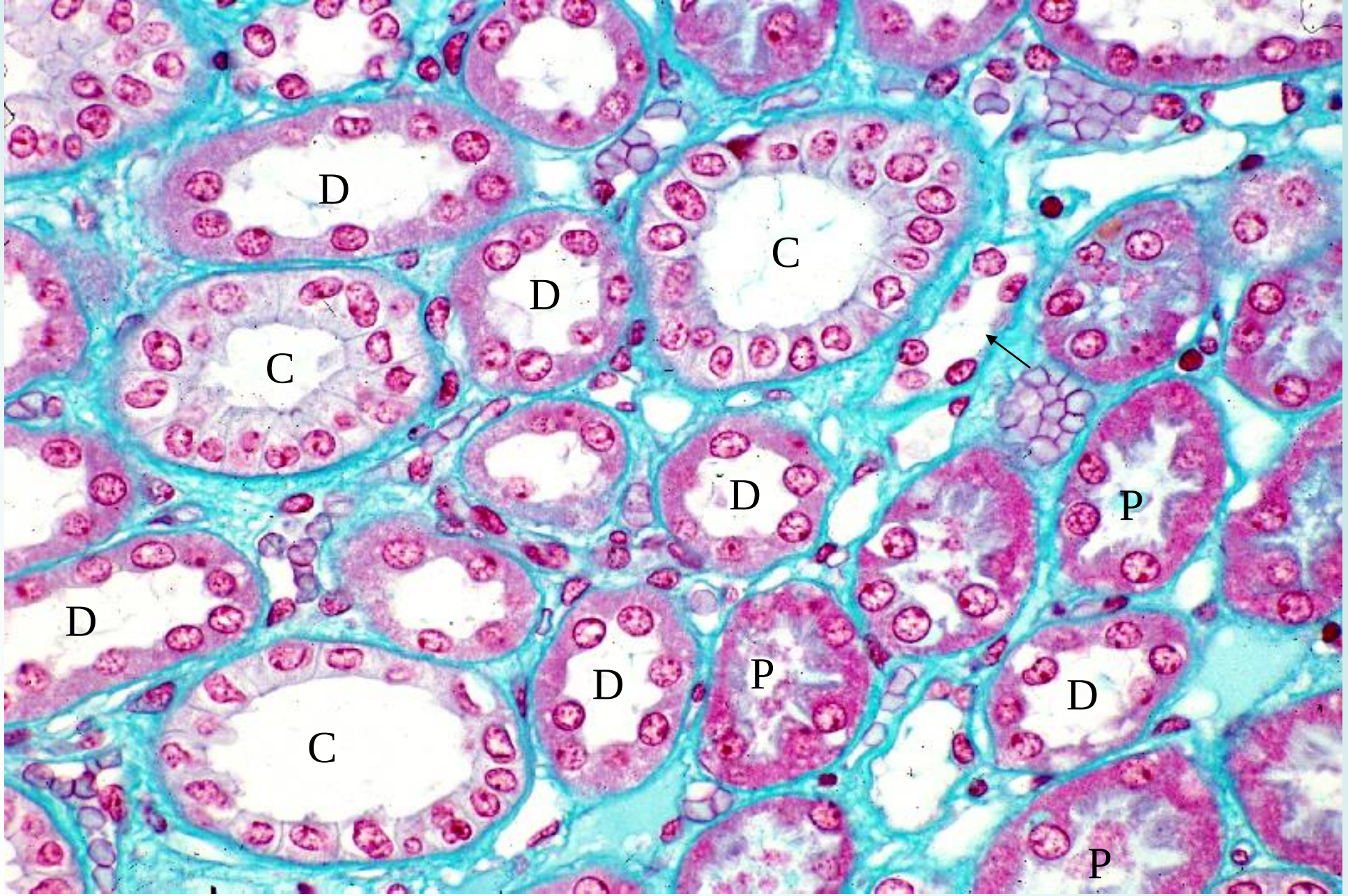
15-25 Medullary ray 1. Human, M-G stain, x 25.



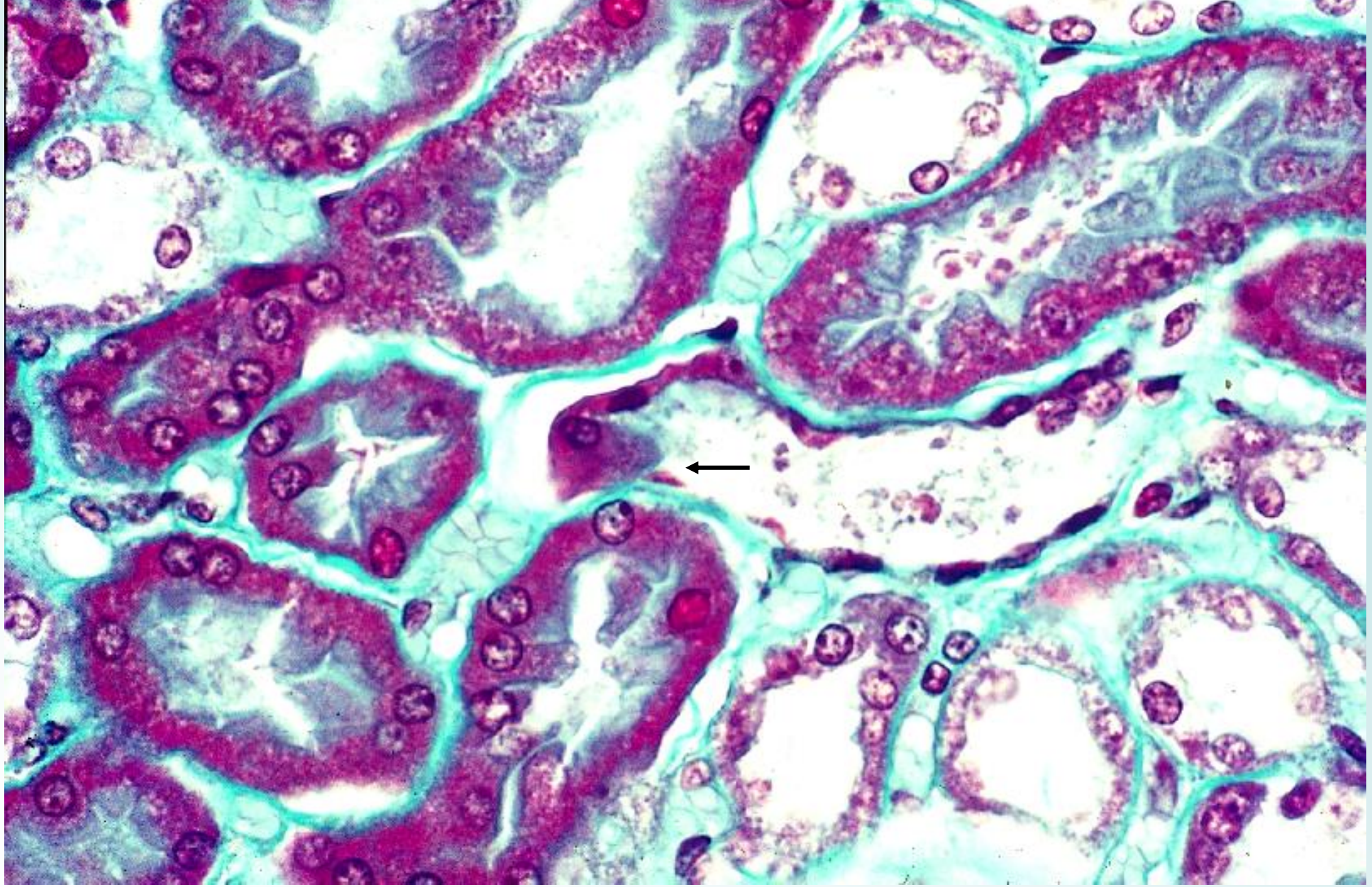
15-26 Medullary ray 2. Human, M-G stain, x 160.



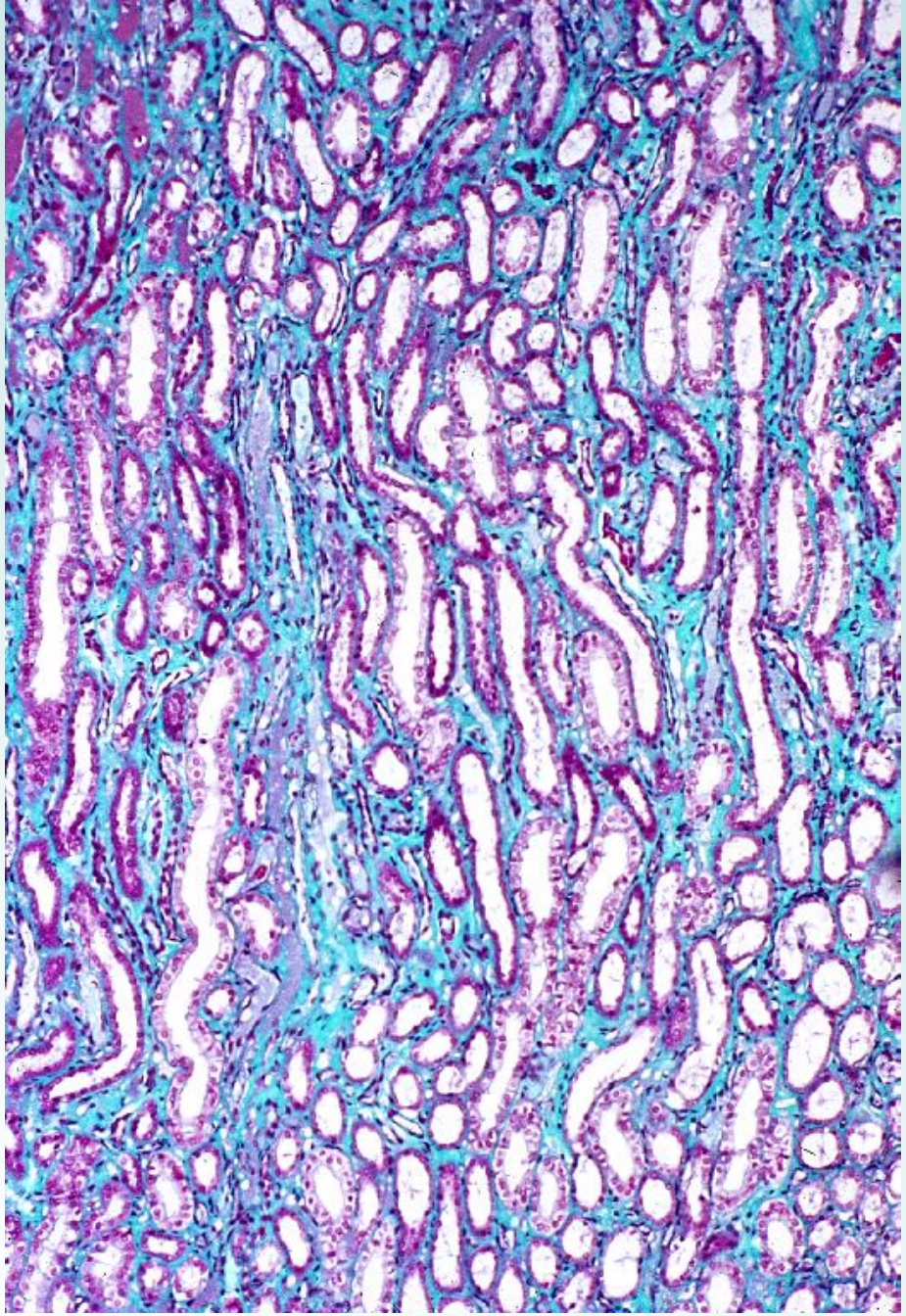
15-27 Medulla 1. Outer layer of outer zone 1. Human, M-G stain, x 25.



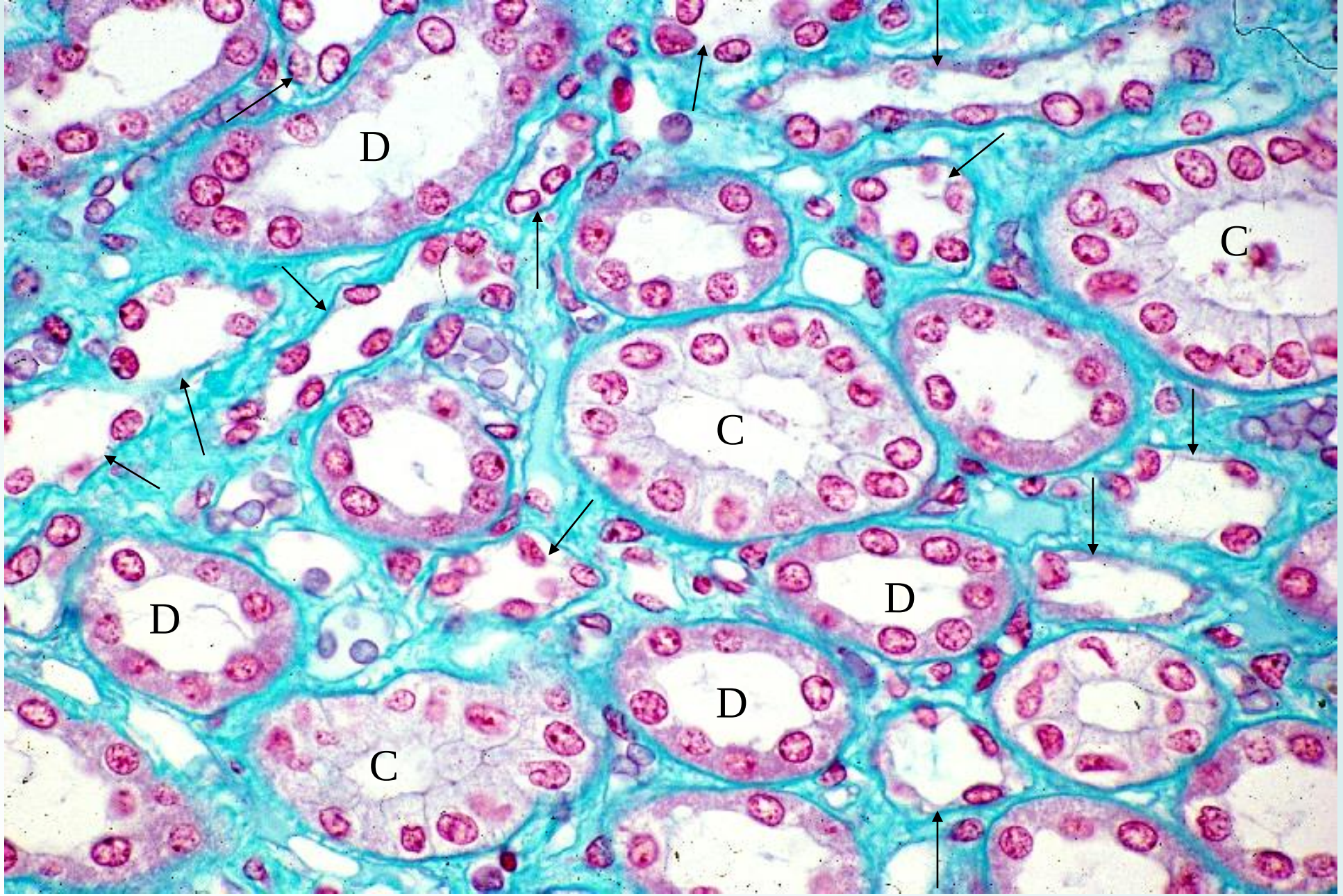
15-28 Medulla 2. Outer layer of outer zone 2. Human, M-G stain, x 130.



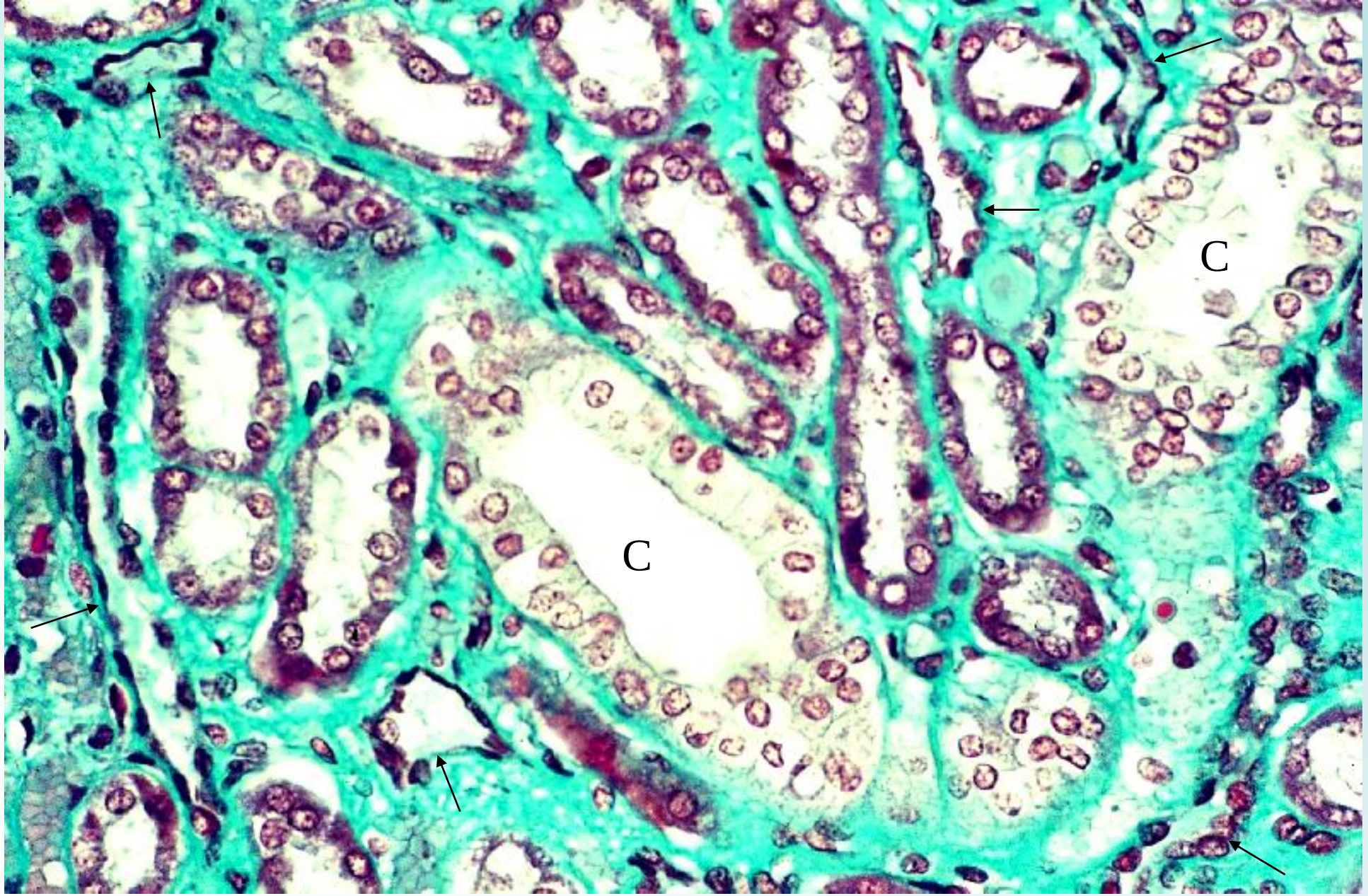
15-29 Medulla 3. Outer layer of outer zone 3. Human, M-G stain, x 160.



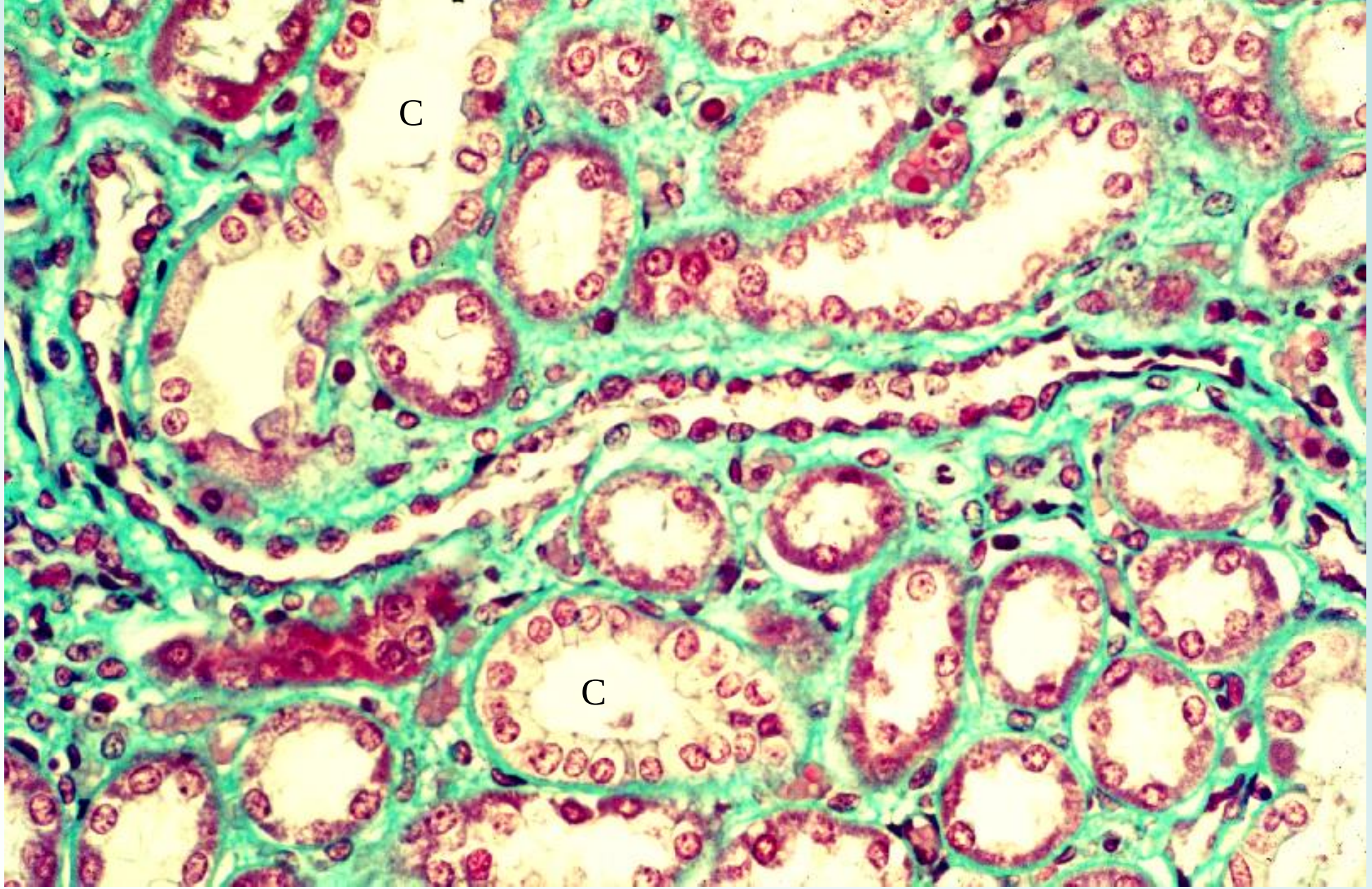
15-30 Medulla 4. Inner layer of outer zone 1. Human, M-G stain, x 25.



15-31 Medulla 5. Inner layer of outer zone 2. Human, M-G stain, x 130.

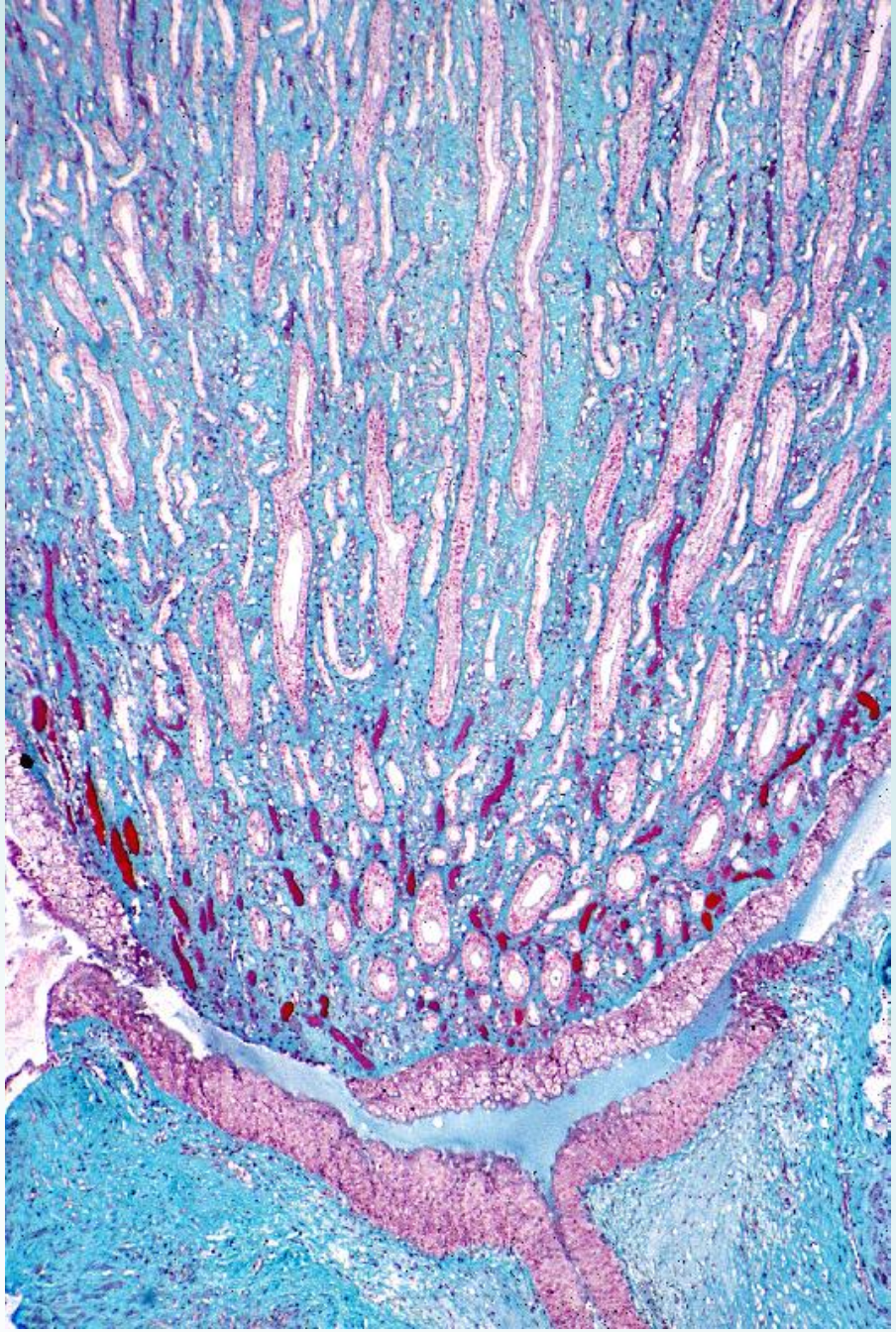


15-32 Medulla 6. Inner zone 1. Human, M-G stain, x 100.

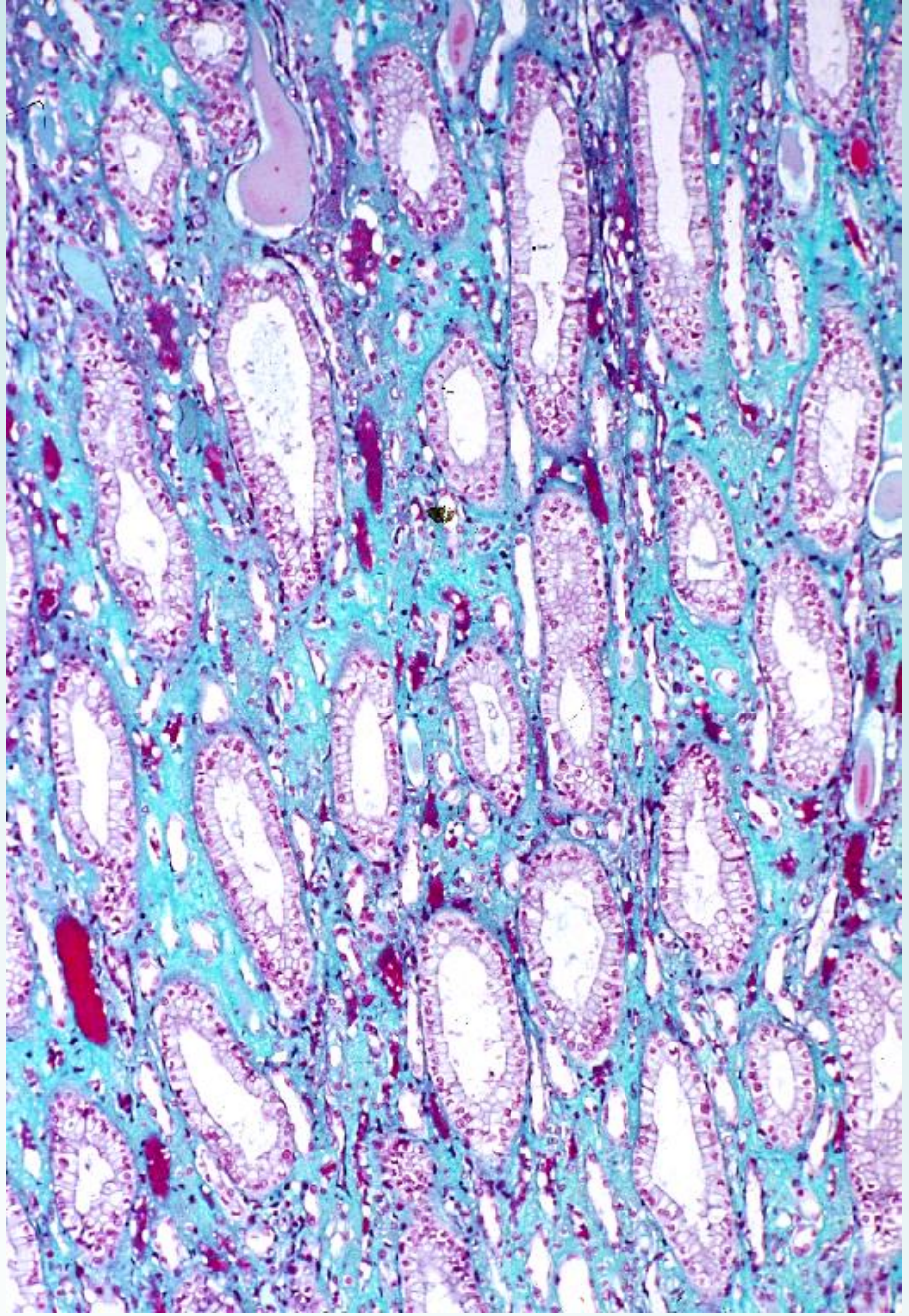


15-33 Medulla 7. Inner zone 2. Human, M-G stain, x 100.

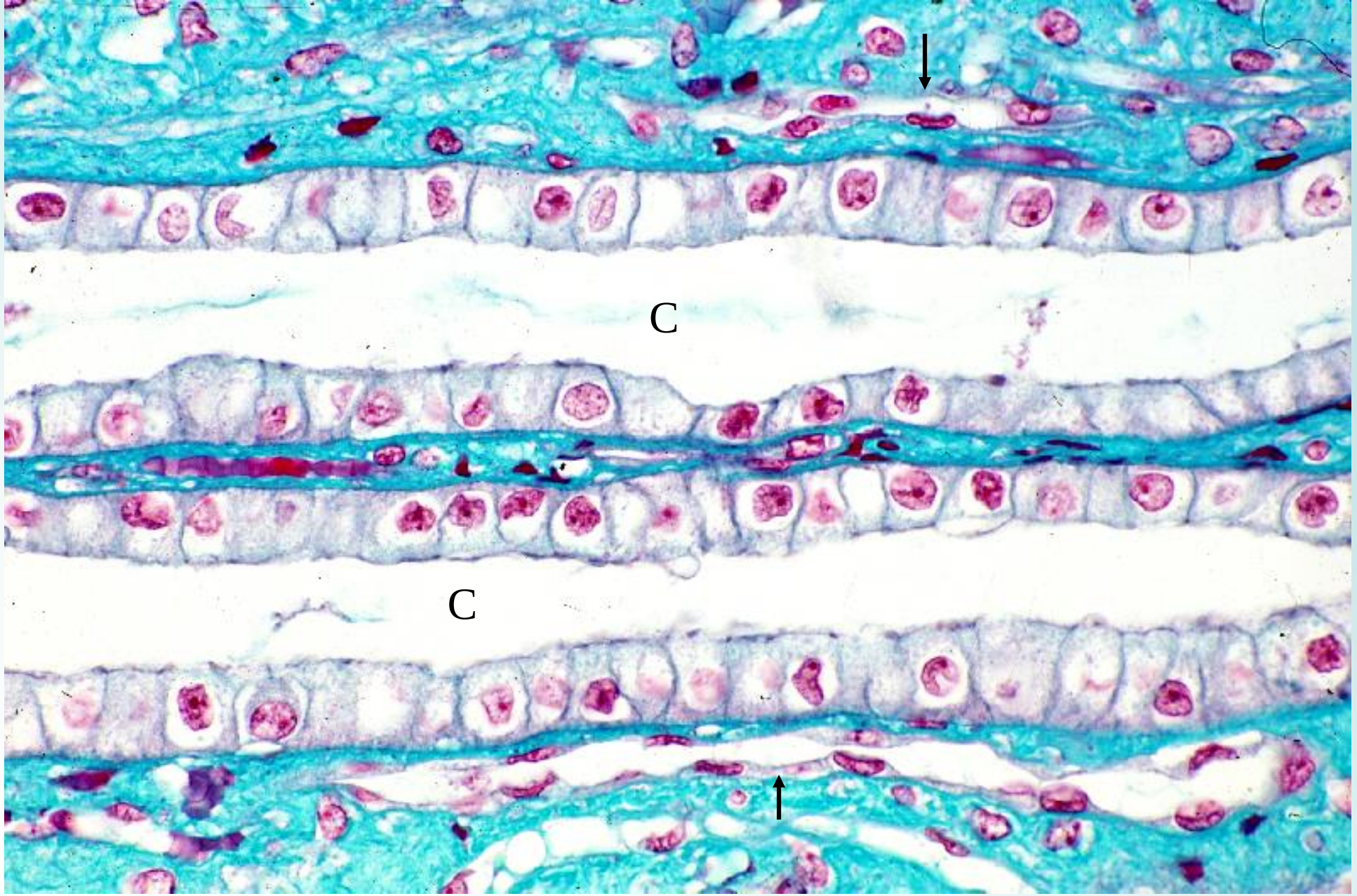
15-34 Medulla 8. Inner zone 3. Human, M-G stain, x 160.



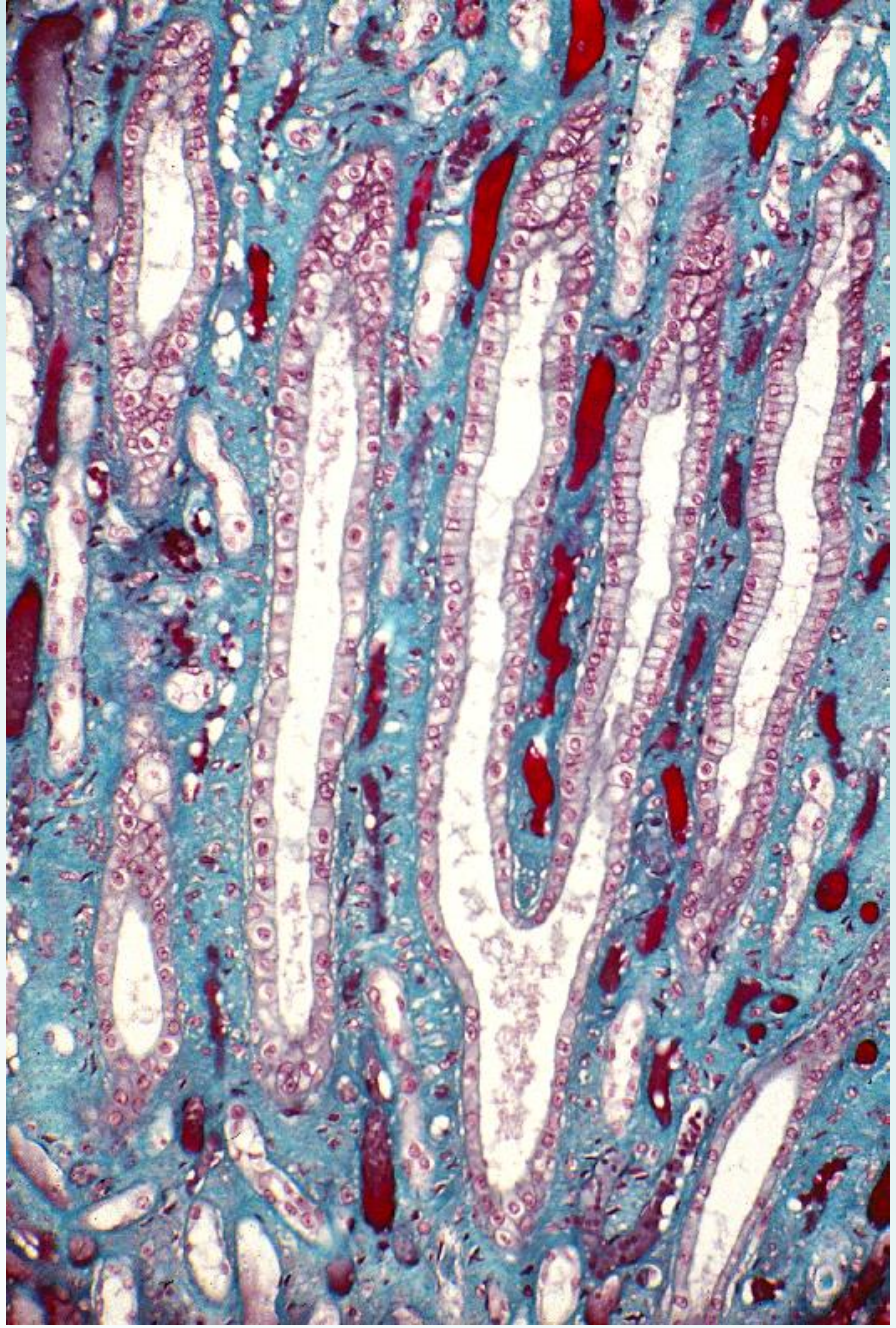
15-35 Apical portion of a renal papilla. Human, M-G stain, x 13.



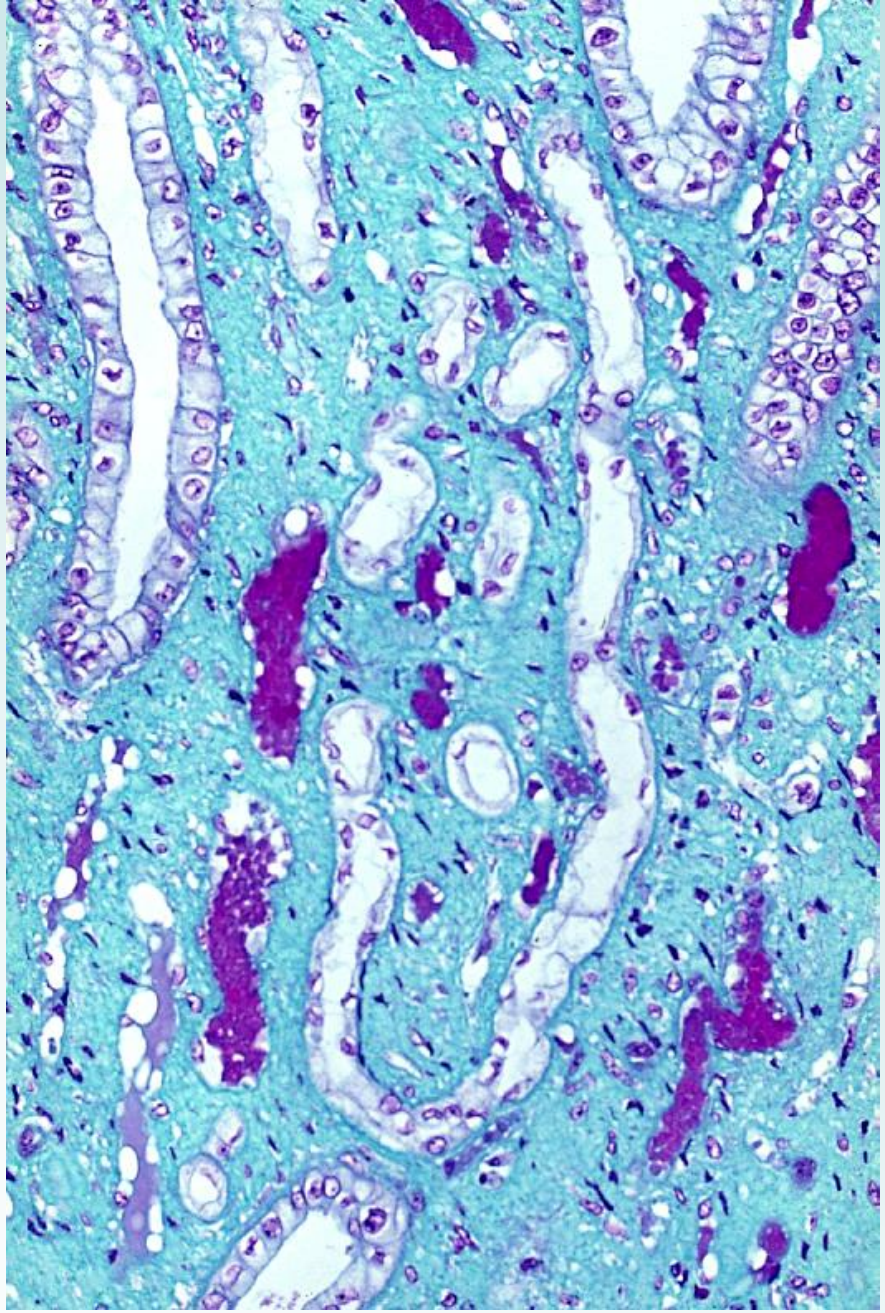
15-36 Renal papilla 1. Human, M-G stain, x 65.



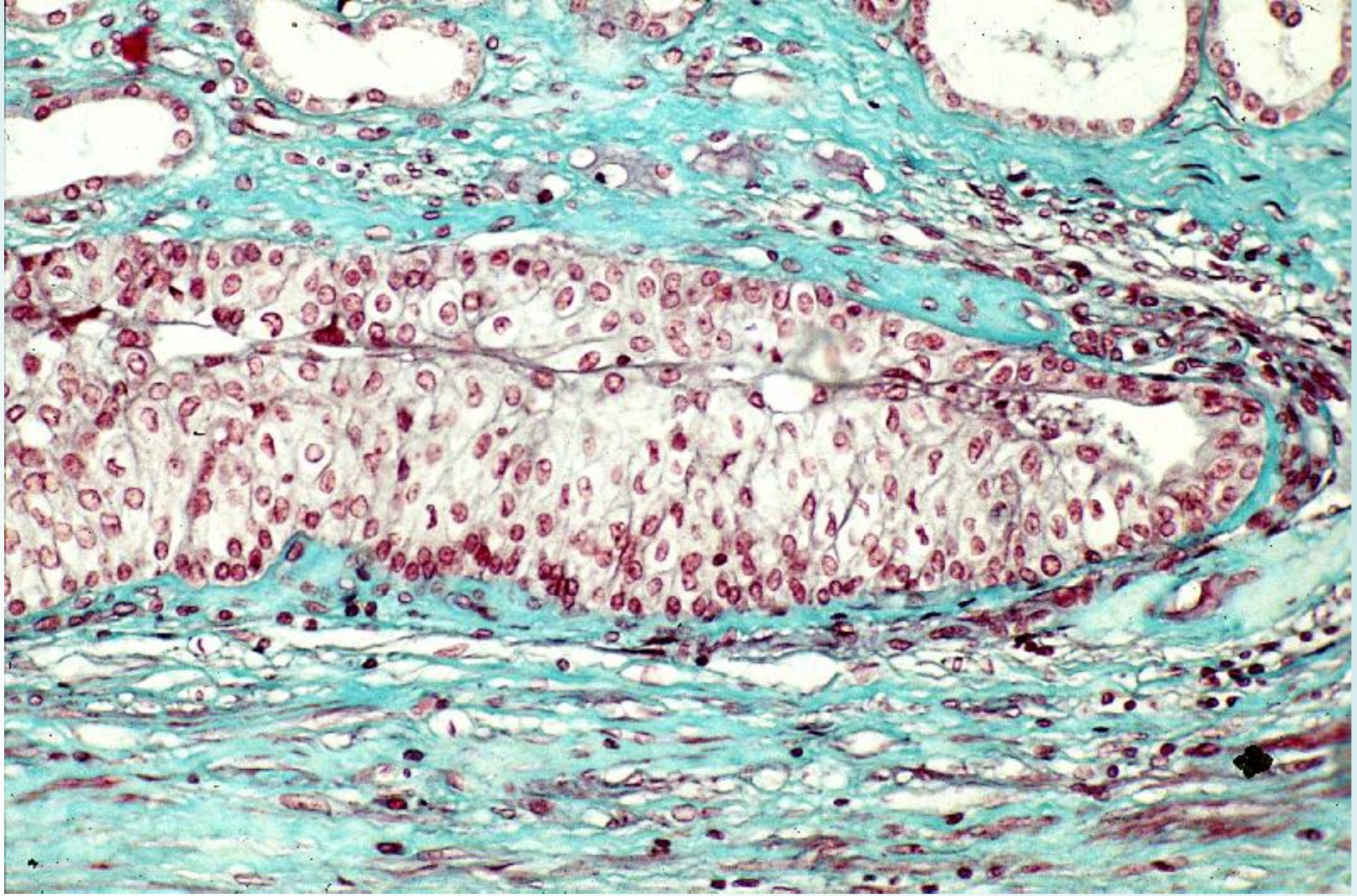
15-37 Renal papilla 2. Thin limbs of the loop of Henle and collecting ducts. Human, M-G stain, x 130.



15-38 Renal papilla 3. Confluence of collecting tubules. Human, M-G stain, x 40.



15-39 Renal papilla 4. U-turn of a thin limb of loop of Henle. Human, M-G stain, x 64.

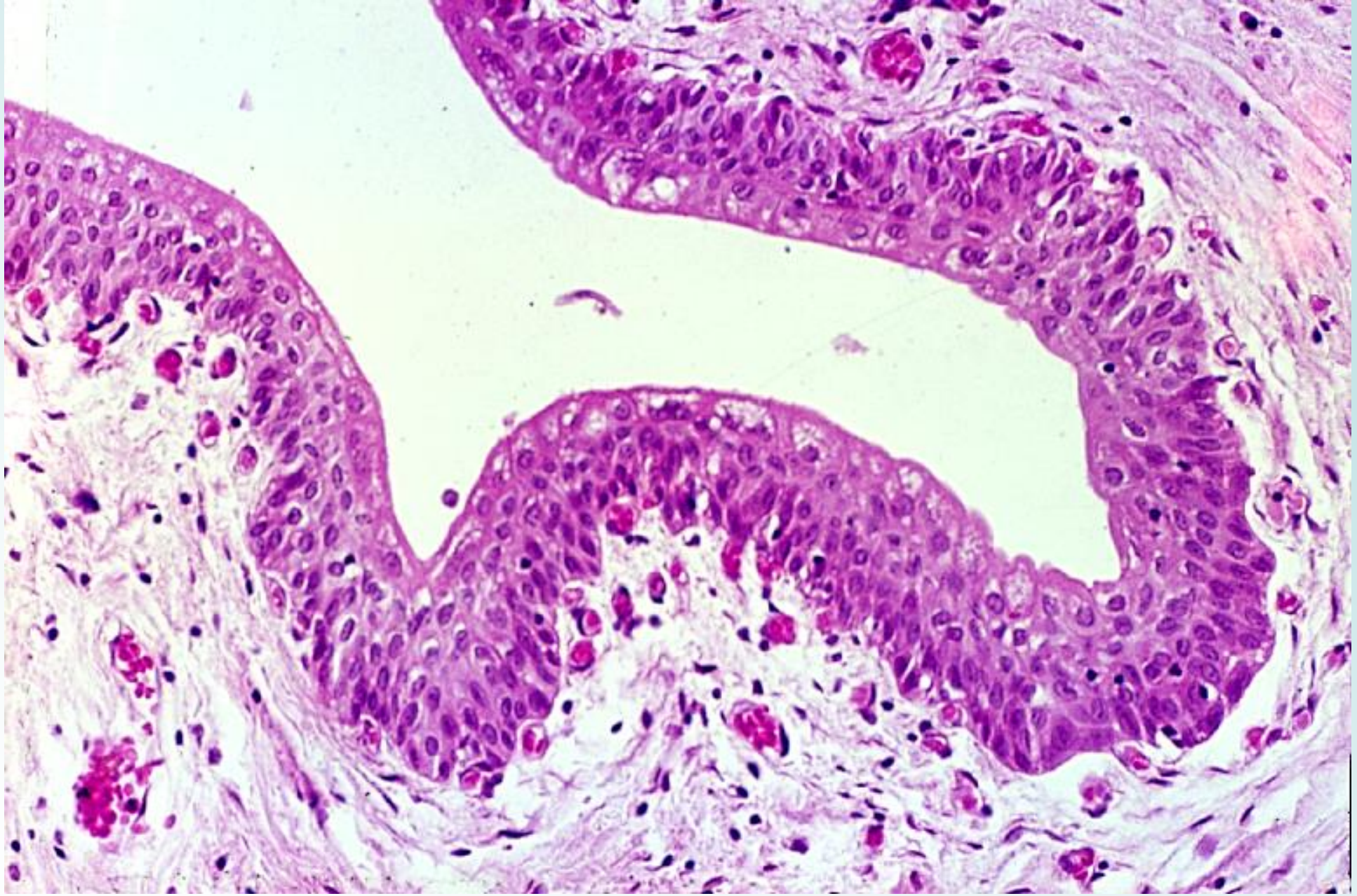


15-40 Apex renal papilla. Epithelium covering the apex of papilla and that covers the inner surface of the pelvis. Human, M-G stain, x 64.

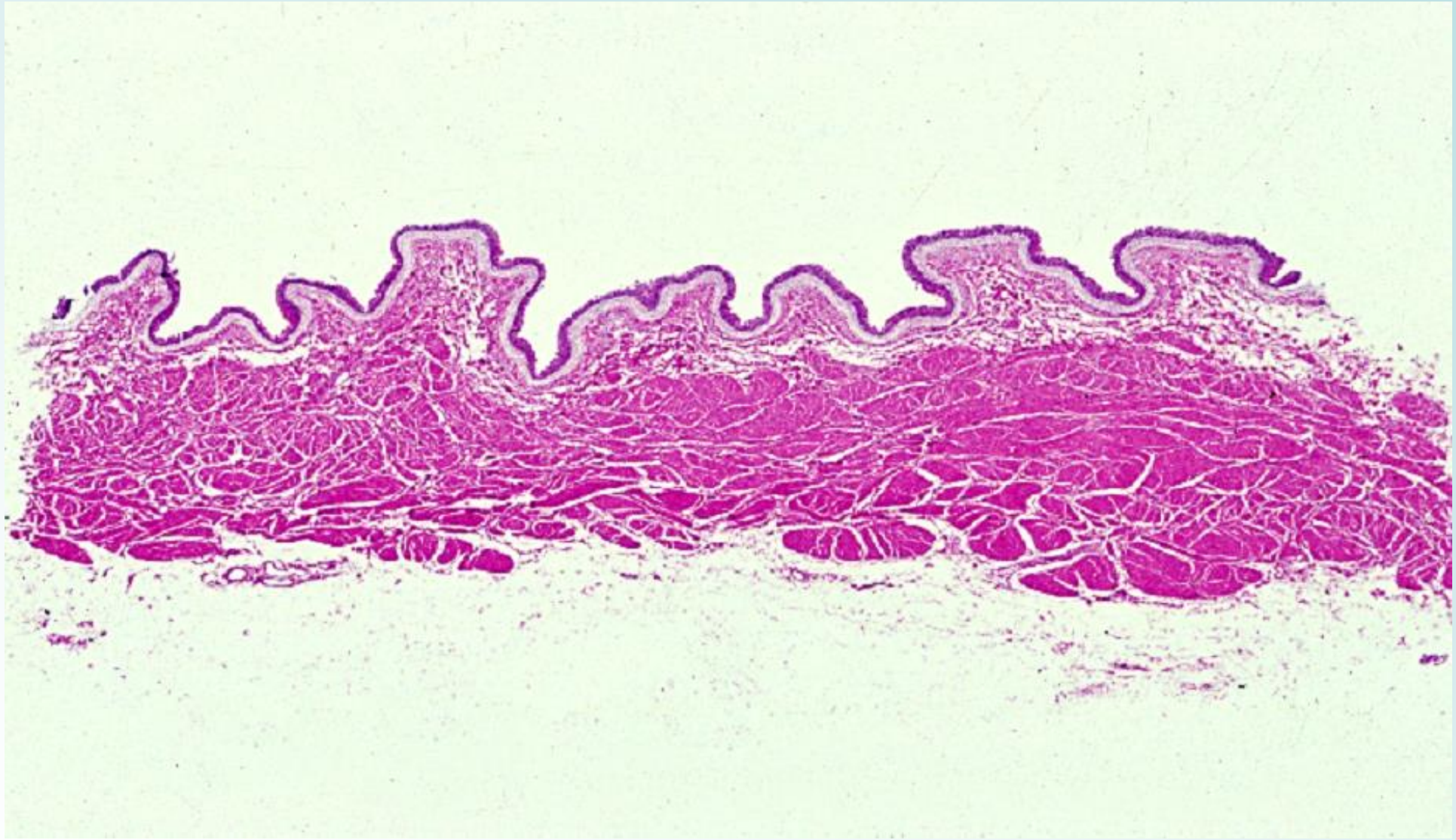
15-41
Vascular system of kidney. Scheme.

15-002
Ureter and
Urinary Bladder

15-42 Ureter, transverse section. Human, H-E stain, x 10.



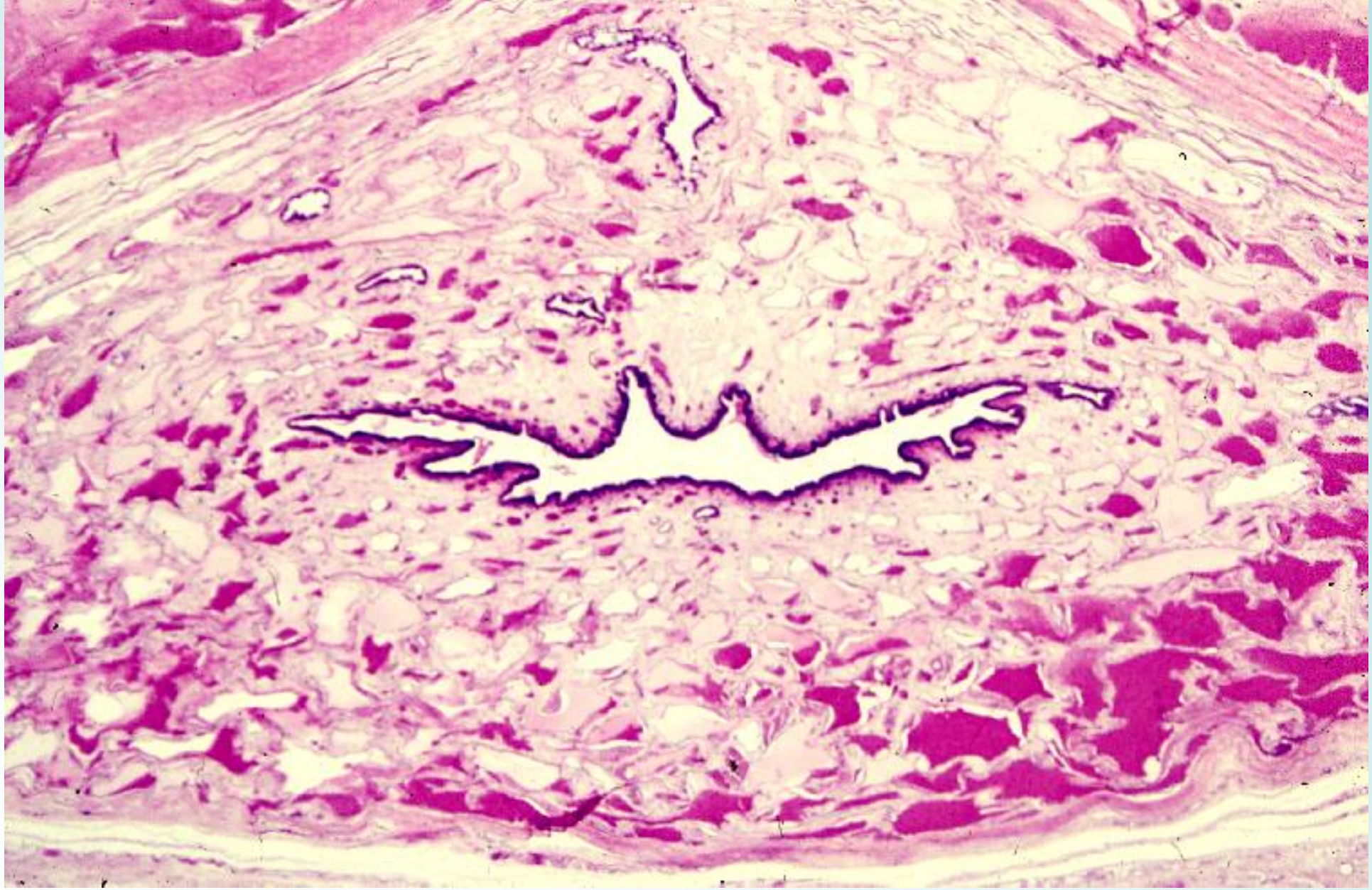
15-43 Epithelium of ureter. Human, H-E stain, x 64.



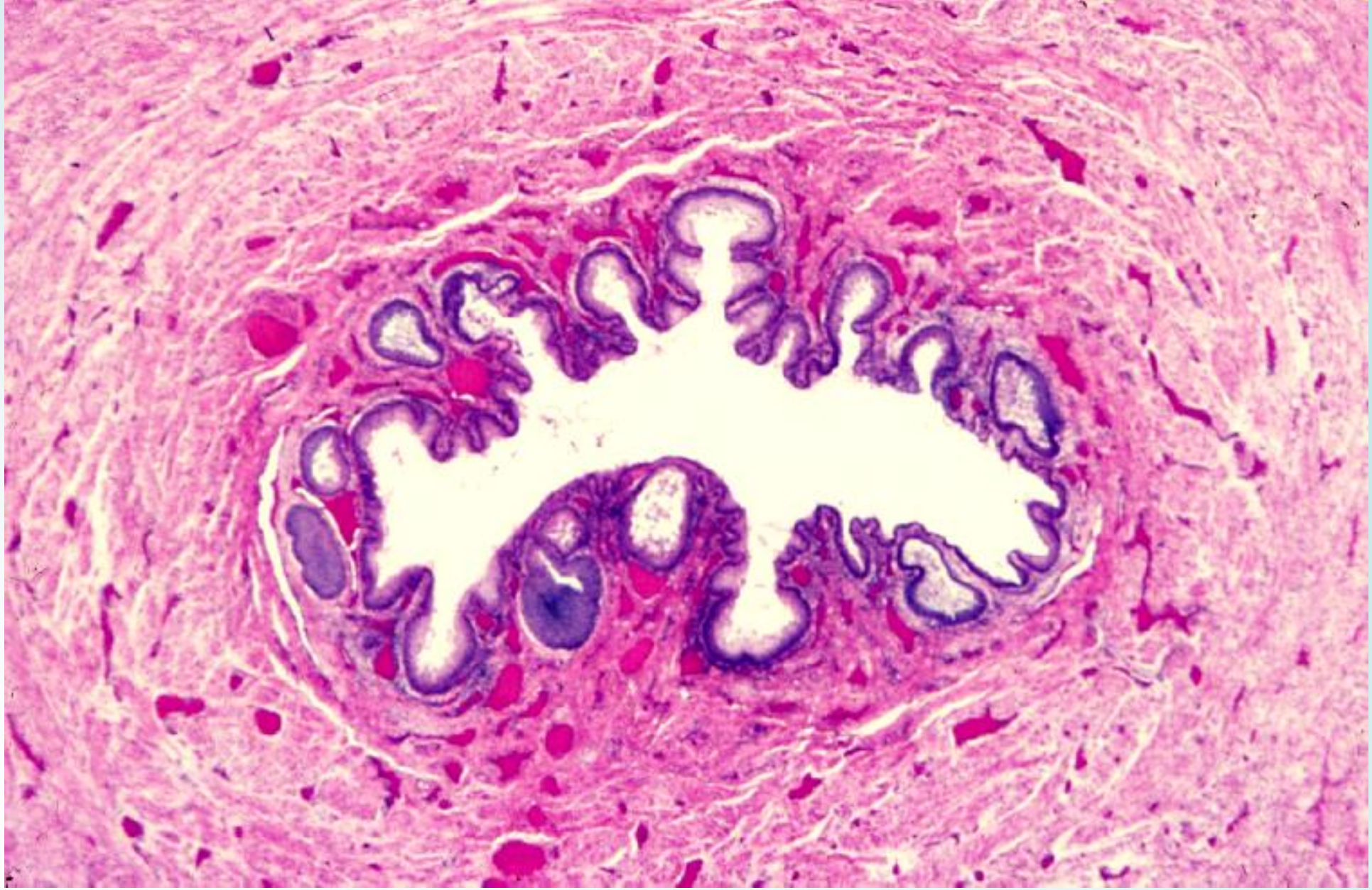
15-44 Wall of the urinary bladder. General view. Human, H-E stain, x 2.7.

15-45 Epithelium of the urinary bladder. Human, H-E stain, x 64.

15-46 Penis, transverse section. Human, H-E stain, x 0.85.



15-47 Male urethra, transverse section. Human, H-E stain, x 4.0.



15-48 Female urethra, transverse section. Human, H-E stain, x 4.0.

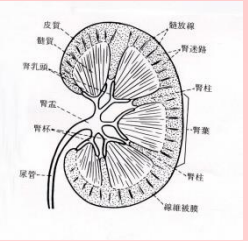
15-00 Urinary System

- The urinary system functions to remove the waste products of metabolism from the blood and to regulate the concentration of many constituents of the body fluids. This system consists of the kidney, which produces the urine, and the ureters, urinary bladder, and urethra, that convey the urine to outside of the body.

15-001 Kidney

- The human kidneys are paired organs situated on the posterior wall of the abdominal cavity on either side of the vertebral column. They are roughly broad bean-shaped with the concavity on the medial side. From this concavity, hilus, emerges a large excretory duct, ureter, and courses downward to the urinary bladder. The kidney is tightly enclosed by a thin but strong capsule of dense collagen fibers and further together with the adrenal gland by an adipose tissue capsule.
- Interior to the hilus there is a large cavity surrounded by the kidney substance, the renal sinus, containing the renal pelvis which divides into 8 to12 renal calyces, accepting each the renal papilla. The remainder of the sinus around these structures is occupied by loose connective tissue and adipose tissue, through which the blood vessels and nerves pass into the renal tissue.

15-01 Frontal section of human kidney（Scheme）.

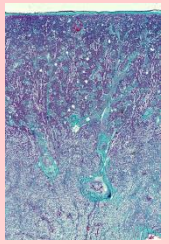


- This is to show the macroscopic organization of the kidney. On the left side, in the middle, is the hilus and its inward extension , the renal sinus, containing the renal pelvis and calyces. On the section surface, viewed with the naked eye, an outer darker reddish brown cortex is distinguishable from an inner lighter gray medulla, which is made up of 8 to 12 conical structures called renal pyramids, having their base toward the cortex and their apex or papilla projecting each into the lumen of a renal calyx. The lateral boundaries of each pyramid are defined by inward extensions of the darker cortical tissue forming the renal columns. A renal pyramid together with the cortical tissue overlying its base and covering its sides constitutes a renal lobe.
- The parenchyma of the kidney is made up of countless minute **uriniferous tubules** that are its functional units. Along the length of these tubules, successive segments are specialized for different roles in the formation of the urine. Corresponding segments of the many parallel tubules are in register at the same level of the renal medulla, resulting in transverse zones that differ slightly in color or pattern. There is an inner and outer zone of the medulla and the outer zone is further subdivided into a darker and thicker inner layer or band and a lighter and thinner outer band.
- From the bases of the medullary pyramids thin radially directed striations extend into the cortical substance, but they do not extend through the entire thickness of the cortex. They are called the **medullary ray** and represent continuation of bundles of tubules from the pyramid into the cortex. Between the medullary rays, the substance of the cortex shows granular appearance; this portion is called the **renal labyrinth**.
- At the tip of each papilla, about 25 pores are seen, that are openings of the terminal segments of the uriniferous tubules into the calyx. This area is called area cribrosa.

15-02 General view of a renal lobe. Human, M-G stain, x 1.6.

- This figure shows a human renal lobe as a whole. The cortex and medulla, and renal column covering the lateral sides of renal pyramid are clearly recognized. The renal calyx covering the tip of the papilla is also evident.

15-03 Cortex and medulla of a renal lobe. General view. Human, M-G stain, x 3.0.

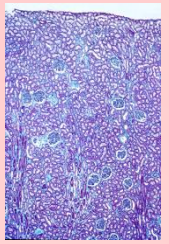


- This figure consists of the upper half, the cortex, and the lower half, the medulla. The surface of the cortex is covered by a thin but strong capsule of dense collagen fibers. In the cortex, stained dark reddish violet, four striations, medullary rays, continuing with the medulla are recognized; between the medullary rays tissue appears granular, that is the labyrinth.
- The medulla, appearing light greenish violet, consists exclusively of the tubules.

15-04 Medulla, papilla and calyx. Human, M-G stain, x 3.0.

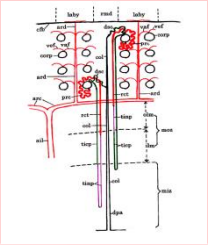
- This figure is downward continuation of 15-03. The medulla consists mainly of longitudinally sectioned tubules. The tip of the renal papilla is covered by a double walled renal calyx.

15-05 Renal cortex 1. Low power magnification. Human, M-G stain, x 10.



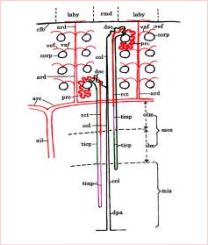
- In this figure three medullary rays and labyrinth between them are recognized. In the labyrinth large round structures are numerously seen; they are renal corpuscles. Otherwise the labyrinth consists of innumerable sections of the uriniferous tubules, stained dark red.

15-06 Scheme showing the structure of nephrons. (1/3)



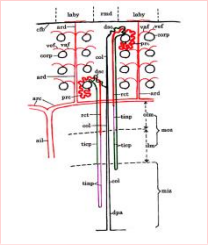
- The **uriniferous tubule** consists of two functionally distinct portions. The first, called the **nephron**, collects a filtrate of the blood created in a spherical mass of tortuous capillaries, at its proximal end, and modifies the composition of this fluid by adding nitrogenous water to it and by reabsorbing from it certain components that need to be conserved. This portion is the so-called glandular portion, derived from the meta- nephrogenic tissue. The second portion, the **collecting tubule**, absorbs water from the filtrate to concentrate its solutes resulting in a hypertonic urine which is conveyed to the renal pelvis. This portion is the excretory duct system in usual glands, derived from the ureteric bud, a diverticulum from the Wolfian duct.
- There are approximately 1.5 million uriniferous tubules in a human kidney. Along the length of the nephron in each of these, traditionally there are six morphologically distinguishable segments, each occurring at a particular level in the cortex or medulla. The epithelium lining of each segment has a characteristic microscopic structure related to its specialization for specific function in the formation of urine.
- The terminology of these segments has been long time very complicated and the origin of confusions of beginners for understanding of the renal functions. Following descriptions are adopted the terminology of Renal Commission of the International Union of Physiological Sciences.
- Four major subdivisions of the uriniferous tubule are now recognized: the **proximal tubule**, **intermediate tubule**, **distal tubule**, and the **collecting system**. Each of these is further subdivided into two or more segments.

15-06 Scheme showing the structure of nephrons. (2/3)



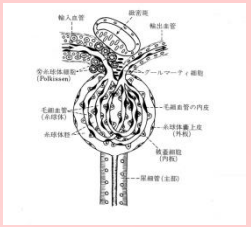
- At the proximal end of each nephron, there is a closed, thin-walled expansion of the tubule that is deeply invaginated to form a cup-shaped follow structure called **Bowman's capsule**. The concavity of this blind end of the nepphron is occupied by a globular tuft of highly convoluted capillaries, **glonerulus**. This mass of capillaries and its surrounding chalice-shaped epithelial capsule, together, constitute the **renal corpuscle**. It has a vascular pole where the afferent and efferent vessels enter and leave the glomerulus , and a urinary pole where the slit-like cavity between the layers of the invaginated Bowman's capsule (urinary space or Bowman's space) is continuous with the lumen of the **proximal tubule**.
- Two segments of the proximal tubule are distinguished: the **proximal convoluted tubule** (**PCT**, pars convolute), situated in the cortex, and the **proximal straight tubule** (**PST**, pars recta), extending from the cortex into the outer stripe of the medulla. This is followed by the **intermediate tubule** which forms a long loop which is subdivided into the **descending thin limb** (**DTL**, pars decendens), traversing the inner stripe of the outer medulla and extending deep into the inner medulla, and recurrent portion, the **ascending thin limb** (**ATL**, pars ascendens). At the junction of the inner and outer medulla, the ascending thin limb is continuous with the **distal straight tubule** (**DST**, thick ascending limb) which traverses the outer medulla and continues into the cortex, where it becomes the **distal convoluted tubule** (**DCT**). In the cortex, the distal convoluted tubule is joined by a **collecting tubule** (**CT**), to a **collecting duct** (**CD**), which passes downward through the cortex and medulla to the area cribrosa of the renal papilla, where it opens into a calyx.

15-06 Scheme showing the structure of nephrons. (3/3)



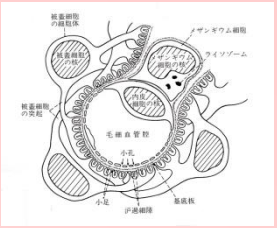
- The portion of the nephron, traditionally called the loop of Henle, includes the segments now called the thick descending limb of the proximal tubule, the thin descending and ascending limbs of the intermediate tubule, and the thick ascending limb of the distal tubule.These several segments are represented in the same sequence in all nephrons, but the length of the loop of Henle varies. In addition to long-looped nephrons described above, there are short-looped nephrons, in which the loop turns back in the outer medulla, and cortical nephrons, which have very short loop that does not extend into the medulla but turns back in the inner cortex. The renal corpuscles also vary in their location. Some may be near the renal capsule, others midcortical, and still others are juxtamedullary.
- The intermingling of the serpentine convoluted tubules within the cortex makes it impossible, in histological sections, to relate their cross sections to a particular renal corpuscle.
- Abbreviations. ail: arteria interlobaris, arc: arteria arcuata, ard: arteria radiate, clx: renal calyx, col: collecting tubule, corp: renal corpuscle, dpa: ductus papillaris, dsc: distal convoluted tubule, mis: inner zone of medulla, moz: outer zone of medulla, ilm: inner layer of outer zone of medulla, olm: outer layer of outer zone of medulla, prc: proximal convoluted tubule, rct: pars recta of proximal tubule, ticp: thick portion of intermediate tubule, tinp: thin portion of intermediate tubule, vaf: afferent arteriole, vef: efferent arteriole, lab: renal labyrinth, rmd: medullary ray.

15-07 Scheme showing the structure of a renal corpuscle.



- Bowman’ capsule around a glomerulus is a double-walled cup composed of squamous epithelial cells. The glomerulus is pushed into and deeply indents a blind terminal expansion of the uriniferous tubule. Therefore, a visceral layer of epithelium, glomerular epithelium, closely applied to the capillaries, and a parietal layer, capsular epithelium, enclose a narrow cavity, capusular space or Bowman’s space. At the vascular pole of the renal corpuscle, the visceral layer is reflected off of the afferent and efferent arterioles and is continuous with the parietal layer of epithelium. At the urinary pole the squamous epithelium of the parietal layer is continuous with the cuboidal epithelium lining the neck of the proximal convoluted tubule.

15-08 Scheme showing the interrelationship between the glomerular capillary and the podocytes, based on the electron microscopy.

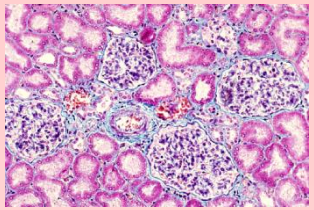


- In the development of the renal corpuscle, the cells of visceral layer become so extensively modified that they are no longer imagined as epithelial cells. The individual cells are called podocytes, and are stellate in form with several radiating primary processes that embrace the underlying capillaries and give rise to very numerous secondary branches called foot-processes or pedicels. These interdigitate with corresponding processes of neighboring podocytes but are not closely adherent to them. An extraordinarily elaborate system of intercellular clefts is thus formed, through which a filtrate of the blood plasma can enter the capsular space. Thus formed filtration slits are 25～35 nm wide.
- The endothelium of the glomerular capillaries is thin and perforated by pores 70～90 nm in diameter. The basal lamina between the glomerular epithelium and endothelium of the capillaries is 0.1～0.15 μm in thickness.
- The continuous filtration of the blood plasma in the renal glomeruli is a process that is essential for the elimination of nitrogenous wastes and control of the extracellular fluid composition and of blood volume. The structural components of the filter are ① the fenestrated endothelium, ② the basal lamina, and ③ the filtration slits between the foot-processes of the podocytes.
- The spaces between the glomerular capillaries are occupied by mesangium, a connec- tive tissue consisting of **mesangial cells** in an extracellular matrix that is relatively free of fibrous elements. The mesangial cells are considered to be a specialized type of pericyte providing structural support for the capillary loops. They show the phgocytic activity and may participate in the continuous turnover of the basal lamina

15-09 Cortex 2. Labyrinth and medullary ray. Human, Mallory-Crossmon stain, x 25.

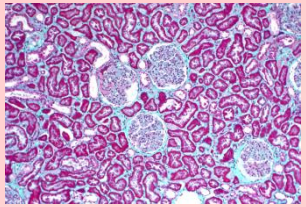
- This is a longitudinal section of human renal cortex, showing the renal labyrinth and medullary ray. The left two thirds of this figure is the renal labyrinth and through its axial portion runs an arteria radiata, which gives rise afferent arterioles at intervals for about eight renal corpuscles. Around them the field is densely filled by the sections of the renal tubules. The right one third is the medullary ray consisting of longiludinally sectioned renal tubules. In this specimen collagen fibers stain deep blue.

15-10 Cortex 3. Labyrinth 1. Human, Mallory-Crossmon stain, x 64.



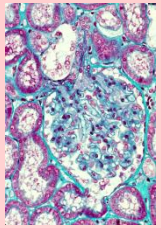
- This is a transverse section of the renal labyrinth, showing a radiate artery, two radiate veins and four renal corpuscles, which may accept the afferent arteriole from this radiate artery. Around these the field is occupied, almost exclusively, by the sections of proximal convoluted tubules, stained deep red. Only a few sections of distal convoluted tubules and collecting tubules are intermingled.
- This specimen of 15-09 and 15-10 was made by Prof. Dr. I. Asami.

15-11 Cortex 4. Labyrinth 2. Human, M-G stain, x 25.



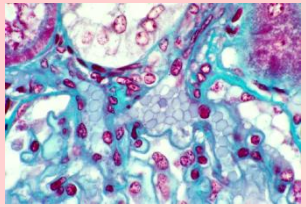
- This is also a transverse section of the human renal labyrinth, showing four renal corpuscles and innumerable sections of renal tubules, which are mainly of the proximal convoluted tubules intermingled by several sections of distal convoluted tubules and connecting tubules. In this specimen collagen fibers stain green.

15-12 Renal corpuscle 1. Human, M-G stain, x 100.



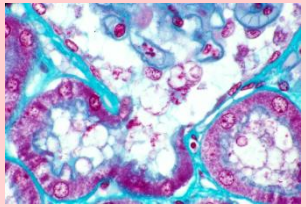
- This is a human renal corpuscle surrounded by sections of the proximal convoluted tubules. In this renal corpuscle the afferent and efferent arterioles, glomerulus, and urinary pole opening into the proximal convoluted tubule are all recognized , and further the macula densa (arrow) at the vascular pole is also seen. This section is 3 μm thick.
- Higher magnifications of this renal corpuscle are shown in 15-13～15-15.

15-13 Renal corpuscle 2. Vascular pole. Human, M-G stain, x 250.



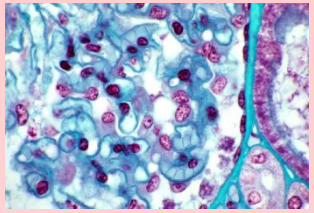
- At upper middle is the section of the macula densa (double arrows). Adjacent to its lower right side enters the afferent arteriole left-downward (long arrow) into the glomerulus and to its lower left side leaves the efferent arteriole upward (long arrow with double arrow heads) from the glomerulus. The afferent arteriole has circular smooth muscle fibers in its wall but the efferent arteriole does not. A round cell with lucent cytoplasm (small arrow) is recognized between the afferent arteriole and the macula densa; this is the juxtaglomerular cell. Small elongated nuclei seen between the macula densa and the afferent and efferent arterioles are called the cells of Goormaghtigh. The afferent arteriole divides into the glomerular capillaries and they put together in the efferent arteriole. SB indicates the space of Bowman.

15-14 Renal corpuscle 3. Urinary pole. Human, M-G stain, x 250.



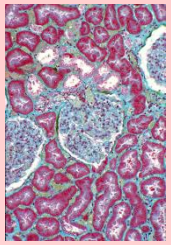
- This figure shows the urinary pole of the glomerulus. The space of Bowman (SB) is here continues with that of the proximal convoluted tubule (long arrow). The simple squamous epithelial cells of the Bowman's capsule (parietal layer, arrow heads) continue here with the simple cuboidal epithelial cells of the proximal convoluted tubule. This change of epithelial cells is quite abrupt. The epithelial cells lining the proximal convoluted tubule (P) are simple cuboidal and provided with very distinct brush border on the free surface. Their cytoplasm stains dark red and basal striation is evident but the cell border between the adjacent cells is not perceived. The podocytes embracing the capillaries (visceral layer) are indicated by arrows. Collagen fibers stain deep green.

15-15 Renal corpuscle 4. Glomerulus. Human, M-G stain, x 250.



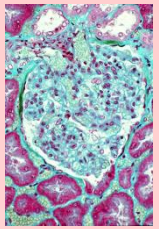
- This figure shows the glomerulus, in detail. At about one fourth of the right side runs vertically the collagen fibers of the Bowman's capsule, staining deep green and on its left side cover the simple squamous epithelial cells (parietal layer, arrow heads). Left side to it is the cavity of the Bowman's capsule which is occupied by the highly convoluted capillaries, glomrulus, embraced by the podocytes (visceral layer, arrows). As this specimen was freshly fixed, thin sectioned, and adequately stained, the podocytes, having large round nucleus and light violet stained cytoplasm, are evidently distinguishable. The space between the podocytes and the capsular epithelium is the space of Bowman (SB). Double arrows indicate the mesangial cells. P:proximal convoluted tubule, C: collecting tubule.

15-16 Cortex 5. Labyrinth 1. Human, M-G stain, x 50.



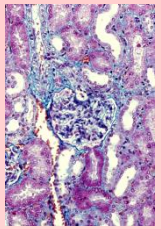
- In this field there are three renal corpuscles and around them numerous sections of the proximal convoluted tubules, stained deep red. In the centrally located corpuscle both the vascular pole and urinary pole are recognized. Above the vascular pole the macula densa and three sections of the distal convoluted tubule are seen. In this specimen capillaries are filled by blood corpuscles.

15-17 Renal corpuscle 5. Human, M-G stain, x 100.



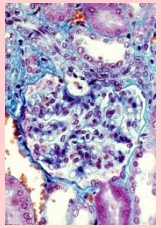
- Higher magnification of 15-16. From the top left enters the afferent arteriole into the corpuscle and from the right side adjacent to this leaves the efferent arteriole. Upper to them locates the macula densa (arrow) and in the triangular space limited by these three is filled by small elongated nuclei of Goormaghtigh cells. At right adjacent to the efferent arteriole is a section of the distal convoluted tubule. As this specimen is not enough thin (about 7 μ m), identification of podocytes (arrow) in the glomerulus is not easy. The epithelial cells of the proximal convoluted tubules stains deep red and are provided with the conspicuous brush border on their free surface. The spaces between the proximal convoluted tubules and the renal corpuscle are filled by capillaries containing blood corpuscles.

15-18 Renal corpuscle 6. Human, Mallory-Crossmon stain, x 80.



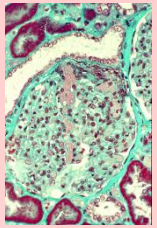
- This figure shows a portion of the renal labyrinth. At center is a renal corpuscle providing with afferent arteriole and urinary pole. Left side adjacent to this run vertically the radiate artery and vein. Around these, space is filled up by sections of the proximal and distal convoluted tubules. In this specimen collagen fibers stain blue.

15-19 Renal corpuscle 7. Human, Mallory-Crossmon stain, x 160.



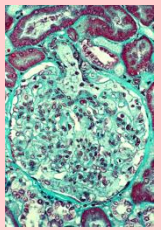
- Higher magnification of 15-18. From the upper left corner runs the afferent arteriole right downward and enters into the renal corpuscle; from the opposite pole begins the proximal convoluted tubule, staining deep red, with a narrow beginning. Right side adjacent to the afferent arteriole is the macula densa. At lower left runs the radiate vein, containing some erythlocytes. In the glomerulus the podocytes are distinguishable.
- Specimen of 15-18 and 15-19 was prepared by Prof. Dr. I. Asami.

15-20 Renal corpuscle 8. Macula densa 1. Human, M-G stain, x 100.



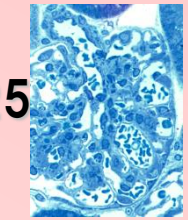
- In the middle is a renal corpuscle with the vascular pole at its top. A thick ascending limb of the intermediate urinary tubule runs along the left edge of this corpuscle arriving at its top where the conspicuous macula densa (arrow) is recognized on the lower wall. Along the lower edge of this field three sections of proximal convoluted tubule (P) and one of the collecting tubule (C) are seen.

15-21 Renal corpuscle 9. Macula densa 2. Human, M-G stain, x 100.



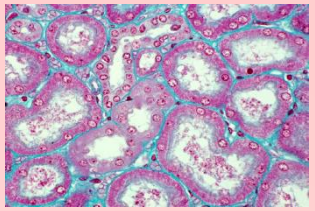
- From the top of this renal corpuscle the afferent arteriole enters into the corpuscle and divides into the glomerular capillaries. Right side to the afferent arteriole is a section of the distal convoluted tubule with macula densa on its lower wall.

15-22 Renal corpuscle 10. Rat, epon section, toluidine blue stain, x 25



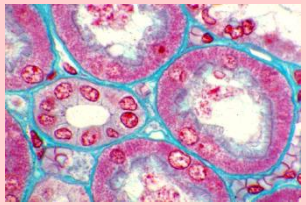
- The afferent arteriole enters into this corpuscle at its top and then divides into the glomerular capillaries. As the section is very thin, about 0.1 μ m, nuclei of the endothelial cells and the erythlocytes in the capillary lumen are evidently distinguished. Arrows indicate the mesangial cell. The space of Bowman (SB) is very narrow in this specimen.

15-23 Urinary tubules 1. Renal labyrinth 1. Human, M-G stain, x 130.



- At lower middle are two transverse sections of distal convoluted duct and upper to it is a longitudinal section of connecting tubule. At upper left corner is a transverse section of collecting tubule. All others are sections of the proximal convoluted tubules, stained deep red and provided with a prominent brush border on their free surface. All of the tubules are encircled by a distinct basement membrane stained green. Spaces between these tubules are filled by blood capillaries.
- The proximal tubule starts as a tubule lined by the cuboidal epithelial cells at the urinary pole, where it continues with the squamous epithelium of the Bowman's capsule. After a few short convolutions near the renal corpuscle, this tubule forms a longer loop directed toward the surface of kidney. The recurrent limb of this loop returns to the vicinity of the renal corpuscle and after making some convolutions enters the nearest medullary ray, where it straightens out to become the pars recta of the proximal tubule, coursing inward toward the medulla.
- The proximal tubules are the longest segment of the nephron, and together they make up the greatest part of the renal cortex.
- The epithelium of the proximal tubule has a prominent brush border which is covered by a glycocalix staining faint green. The cells have a single spherical nucleus, and numerous long mitochondria in the basal half of cells, oriented parallel to the cell axis. This orientation of mitochondria results in a faint vertical striation of the cytoplasm in the histological sections. The cytoplasm stains intensely with acid dyes, as eosin or azocarmine. The lateral boundaries of the cells are usually not resolved with the light microscope, due to, in part, their intensive interdigitation.
- The proximal tubule reabsorbs nearly all of the glucose and amino acids in the glomerular filtrate, while allows other substances of no nutritional value to be excreted in the urine.

15-24 Urinary tubules 2. Renal labyrinth 2. Human, M-G stain, x 330.

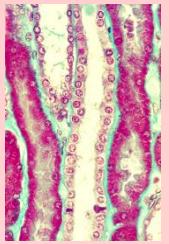


- Higher magnification of 15-24. At center left is a transverse section of connecting tubule, consisting of nine epithelial cells. Their cytoplasm stains less red and the lateral boundary of each cell is distinct. Around this here are five sections of the proximal convoluted tubule, 50～60 μm in diameter, consisting of tall epithelial cells. They contain a spherical nucleus and are provided with a distinct brush border on the free surface. Their cytoplasm stains intensely red with azocarmine and shows granular appearance. The number of nuclei in one section is less numerous. The lateral boundary of each cell is not perceived. At upper right corner is a section of the distal convoluted tubule. All of these sections are encircled by a distinct basement membrane, stained deep green. Spaces between the tubules are occupied by the capillaries containing blood corpuscles.

15-25 Medullary ray 1. Human, M-G stain, x 25.

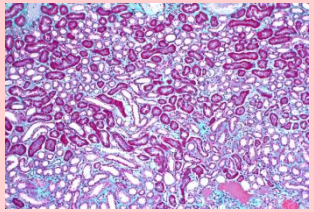
- In the middle runs vertically the medullary ray limited on both side by the renal labyrinth. The medullary ray in this figure consists of the longitudinal sections of pars recta of proximal tubule, thick ascending limbs of intermediate tubule, and collecting tubule.

15-26 Medullary ray 2. Human, M-G stain, x 160.



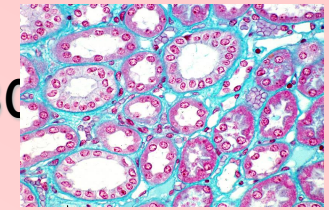
- In the middle runs vertically a collecting tubule, consisting of simple cuboidal epithelial cells with distinct cell boundary. The cytoplasm of them appears almost colorless. Upper left to this is a thick ascending limb if intermediate tubule consisting of simple low cuboidal epithelial cells. They have a spherical nucleus protruding half into the lumen and the cytoplasm stains moderately red. On the right and left sides to them runs each a pars recta of proximal tubule consisting of simple cuboidal epithelial cells, staining deep red and providing with distinct brush border covered by faintly green stained glycocalix on the free surface. The lateral boundary of each cell is not perceived.

15-27 Medulla 1. Outer layer of outer zone 1. Human, M-G stain, x 25.



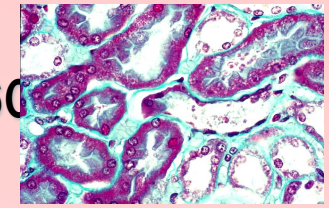
- This figure shows the transverse section of the outer layer of the outer zone, consisting of the descending straight portions of the proximal tubule(PST), the descending thin limbs of the intermediate tubule (DTL), the thick ascending limbs of the intermediate tubule (DST), and the collecting tubules (CT). The descending straight portion (pars recta, PST) of the proximal tubule, about 60 μ m in diameter, abruptly narrows in the outer layer of the outer medulla and continues as descending thin limb (DTL) of the loop of Henle, with a diameter of 15 μ m. Therefore further downward, in the inner layer of the outer medulla, no proximal straight tubule is encountered. In the lower one third of this figure, there are only a few PST are observed.

15-28 Medulla 2. Outer layer of outer zone 2. Human, M-G stain, x 13C



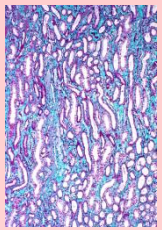
- Higher magnification of 15-27. Here the descending straight portions of the proximal tubule (P), the thick ascending limbs of the intermediate tubule (D), and the collecting tubules (C) are recognized. A descending thin limb is indicated by arrow, which is very alike with a capillary or venule in size as well as in form. Spaces among the tubules are filled by abundant connective tissues.

15-29 Medulla 3. Outer layer of outer zone 3. Human, M-G stain, x 160



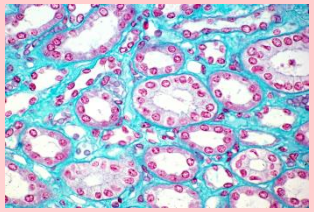
- At the center a descending straight portions of the proximal tubule continues with a descending thin limbs of the intermediate tubule (DTL). At this transition, indicated by arrow, the prominent brush border ends and deeply red stained cuboidal epithelium turns abruptly into the simple squamous epithelium.
- P: descending straight portions of the proximal tubule (PST), C: collecting tubule, D: thick ascending limbs of the intermediate tubule (DST)

15-30 Medulla 4. Inner layer of outer zone 1. Human, M-G stain, x 25.



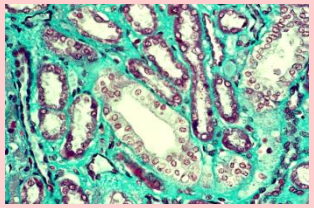
- This is the longitudinal section of the inner layer of the outer zone of medulla. No proximal tubule is seen. There are descending thin limbs, ascending thin limbs, and ascending thick limbs of the intermediate tubule, and collecting tubules. The connective tissue, stained green, among these tubules is abundant.

15-31 Medulla 5. Inner layer of outer zone 2. Human, M-G stain, x 130.



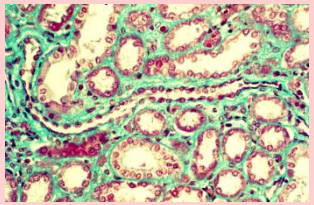
- In the green stained connective tissue, the descending and ascending thin limbs (arrows), ascending thick limbs (D), and the collecting tubules (C) are recognized. The descending and ascending thin limbs are 10～20 μm in diameter and the epithelium is only 0.5～2.0 μm thick, and the central portion of the cells containing the nucleus bulges into the lumen. The shape of the cells and the small caliber of the tubule result in a very alike appearance with that of capillary or venule in the histological sections.
- The descending thin limb is continuous at the bend of the loop with the straight ascending limb of the tubule.
- The distal tubule begins in the inner layer of the outer zone of the medulla at an abrupt transition from the thin limb of the loop of Henle to its thick ascending limb. Its initial portion is called the medullary thick ascending limb and its continuation becomes the cortical thick ascending limb. Where the latter contacts the vascular pole of the renal corpuscle of the same nephron, its epithelium contains a plaque of specialized cells called macula densa. Distal to this point, the tubule pursues a tortu- ous course and called the distal convoluted tubule.
- The epithelium of the thick ascending limb consists of simple low cuboidal cells containing a spherical nucleus. As they lack the brush border on the free surface, the contour of the lumen is smooth. The cytoplasm stains red but much lighter than that of the proximal tubule.

15-32 Medulla 6. Inner zone 1. Human, M-G stain, x 100.



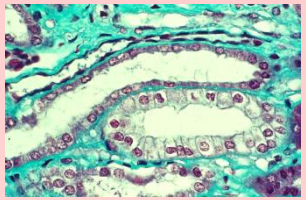
- In the abundant connective tissue, stained green, the thin limbs (arrows) of the intermediate tubule, ascending thick limbs and collecting tubules (C) are seen.

15-33 Medulla 7. Inner zone 2. Human, M-G stain, x 100.



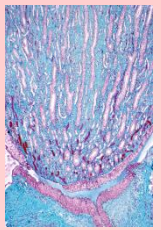
- A long thin limb traverses in the middle of figure. Except for three collecting tubules (C), remaining tubules are the ascending thick limbs of intermediate tubules.

15-34 Medulla 8. Inner zone 3. Human, M-G stain, x 160.



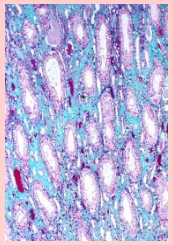
- From lower left to upper right one large tubule, ascending thick limb (D), traverses the figure. Parallel to this runs a thin limb of the intermediate tubule (TL). In the uppermost region traverses a capillary (cap). At middle right is a collecting tubule(C), consisting of the simple columnar epithelial cells, with distinct cell boundary.

15-35 Apical portion of a renal papilla. Human, M-G stain, x 13.



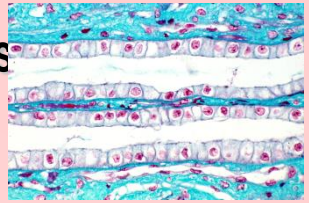
- This shows the apical portion of a renal papilla and renal calyx covering the tip of it. The papilla consists of longitudinally sectioned collecting ducts and descending as well as ascending thin limbs of the loop of Henle. The surface of the papilla is covered by the double walled calyx, the epithelium of which is the transitional epithelium.

15-36 Renal papilla 1. Human, M-G stain, x 65.



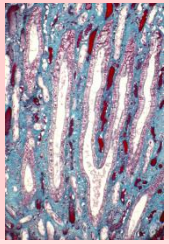
- Higher magnification of 15-35. In the abundant connective tissue, stained deep green, longitudinally or obliquely sectioned collecting ducts and descending as well as ascending thin limbs of the loop of Henle are seen.

15-37 Renal papilla 2. Thin limbs of the loop of Henle and collecting ducts Human, M-G stain, x 130.



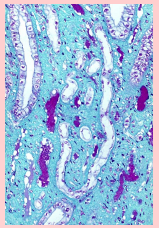
- In the middle traverse two large collecting ducts (C) and parallel to them two very thin tubules (arrows), thin limbs of loop of Henle, one above, the other down to them, are seen.
- The collecting duct system, consisting of connecting tubule, collecting tubule and collecting duct, is the same as the excretory duct system of the usual excretory glands.
- The connecting tubule is a short transitional segment joining the distal convoluted tubule to the collecting tubule, which enters into the nearest medullary ray and courses inward through the cortex and medulla. When the collecting tubules reach the inner zone of the medulla, pairs of them approach at an acute angle and become confluent. About seven such convergences, in the inner zone of the medulla, results in the formation of larger straight ducts 100～200 μ m in diameter, called papillary ducts, that open into a calyx of the renal pelvis on the area cribrosa.
- The morphological features of the epithelial cells of this system are roughly common in the histological specimen. The epithelium consists of simple cuboidal or simple columnar cells with distinct cell boundary. Each of them contains a spherical nucleus in the middle of the cell body. The cytoplasm appears colorless or faintly pink in H-E preparations.

15-38 Renal papilla 3. Confluence of collecting tubules. Human, M-G stain, x 40.



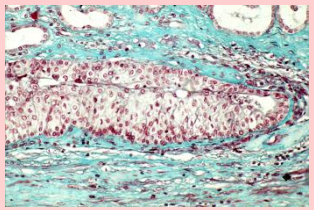
- This is a longitudinal section of a renal papilla. In the middle two collecting tubules or collecting ducts are confluent and become a larger duct. Among the longitudinally sectioned collecting tubules the connective tissue is abundant.

15-39 Renal papilla 4. U-turn of a thin limb of loop of Henle. Human, M-G stain, x 64.



- This figure shows the U-turn of a thin limb of loop of Henle in the renal papilla. In this field three collecting ducts are seen. Others are thin limbs of loop of Henle and capillaries filled by red stained plasm.

15-40 Apex renal papilla. Epithelium covering the apex of papilla and that covers the inner surface of the pelvis. Human, M-G stain, x 64.



- The upper half is the apex of papilla. A thin transitional epithelium covers its surface and turns over at the right end of the figure on to the inner surface of the renal pelvis becoming a thick transitional epithelium. In the upper half of the field there are several sections of distended urinary tubules.

15-41 Vascular system of kidney. Scheme. (1/2)

- The kidney have a very large blood flow, averaging about 1200 ml/min. The know- ledge of the complex vascular architecture is essential for understanding the renal function.
- The **renal artery** enters the hilus and divides in the adipose tissue of the renal sinus into anterior and posterior divisions which give rise to **segmental arteries**. These, in turn, provide **lobar arteries** to each renal pyramid. Just before entering the substance of the kidney, these divide into two **interlobular arteries** that course toward the cortex in the renal columns on either side of the pyramid. These divide dichotomously at the level of the corticomedullary boundary, forming **arcuate arteries** running parallel to the surface of the kidney. Small **cortical radial arteries**, arising at regular intervals from the arcuate arteries, course radially in the cortex. These provide the afferent arterioles to juxtamedullary, mid-cortical, and superficial glomeruli.
- Blood leaves the glomeruli via **efferent arterioles**. Efferent arterioles of superficial glomeruli are of small caliber and ramify to form the cortical **intertubular capillary network**. In the renal cortex, the endothelium of the peritubular capillaries is fenestrated. The larger efferent arteriloes of juxtamedullary glomeruli course into the medulla, branching into many vessels somewhat larger than capillaries, called the **vasa recta**. The efferent vessels of juxtamedullary glomeruli and the vasa recta both contribute to the intertubular capillary network of the medulla.

15-41 Vascular system of kidney. Scheme. (2/2)

- Continuing deeper into the medulla, the vasa recta form hairpin loops at various levels in the medulla, turning back and coursing parallel and close to the descending limb of the loop of Henle. The descending and ascending limbs of these numerous loops form a countercurrent system of vessels referred to as a **vascular bundle** or **rete**. The descending arterial limbs and the ascending venous limbs differ in diameter and in the character of their wall. The descending limbs are smaller and have a continuous endothelium, whereas the larger ascending limbs of the loop have thin walls and a fenestrated endothelium. The proximity of the vessels in the vascular bundles and the large surface area they present to one another facilitate diffusion of ions and small molecules between blood in the ascending and descending limbs. The vascular bundles, thus, serve as efficient countercurrent exchangers for diffusable substances.
- The capillaries of the outermost zones of the cortex are drained toward the surface by radially arranged branches, the **superficial cortical veins**, which join vessels on the surface of the kidney, **stellate veins**, that have a characteristic radial pattern. This outer mantle of venous channels is drained by a relatively small number of **interlobular veins** that are confluent at their inner end with **arcuate veins** that accompany arteries of the same name. Capillaries in the deeper portion of the cortex empty into radially oriented **deep cortical veins**, of which there are 400 per square centimeter, running parallel to a corresponding number of interlobar arteries. The blood in these veins flows inward to the arcuate veins and then into **interlobar veins** that join to form the **renal vein**.
- This Scheme and descriptions are borrowed from “A textbook of Histology”, 12th Ed. by D. W. Fawcett, 1994.

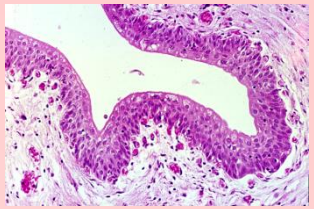
15-002 Ureter and Urinary Bladder

- The excretory passages of the urinary tract are lined by transitional epithelium throughout, but there are regional differences in its thickness. The connective tissue of the lamina propria is abundant and rich in networks of elastic fibers.
  The walls of the renal calyces, pelvis, and ureter are all provided with a well-devel- oped layer of smooth muscle, which is made up of anastomosing bundles of muscle fibers of varying orientation.

15-42 Ureter, transverse section. Human, H-E stain, x 10.

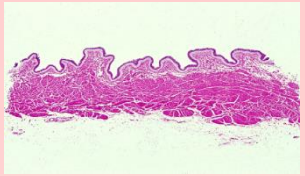
- This is a transverse section of a human ureter. The lumen is lined by the transitional epithelium, underlaid by the connective tissues of lamina propria and tela submucosa. Further outside there are layers of smooth muscle fiber bundles, inner longitudinal and outer circular. Because of the post mortem contraction of the muscle fiber bundles the mucous membrane is thrown up into the lumen, resulting in several longitudinal folds.

15-43 Epithelium of ureter. Human, H-E stain, x 64.



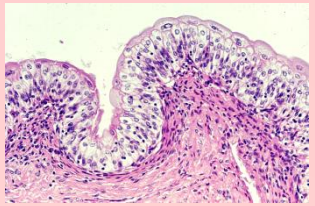
- This is the transitional epithelium of a human ureter, underlaid by loose connective tissue of pamina propria which contains numerous capillaries.

15-44 Wall of the urinary bladder. General view. Human, H-E stain, x 2.7.



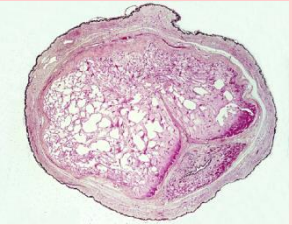
- This is a general view of the wall of a human urinary bladder. The epithelium appear relatively thick, underlaid by thick connective tissue of lamina propria and tela submucosa. The muscle layer is very thick consisting of sizable strands of smooth muscle cells and is roughly divided into three layers. These intermingle at their interface so that the layers cannot be clearly separated from one another. These muscles act as a whole to minimize the lumen of the bladder to discharge the urine.

15-45 Epithelium of the urinary bladder. Human, H-E stain, x 64.



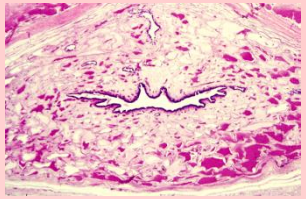
- This is the transitional epithelium of a human urinary bladder, moderately distended. The epithelium is five to seven cells thick and cells at lumenal surface are rounded and lightly elevated into the lumen. Some of these have two nuclei.
- (The three conditions of the transitional epithelium are shown in 02-22, 02-23, and 02-24.)

15-46 Penis, transverse section. Human, H-E stain, x 0.85.



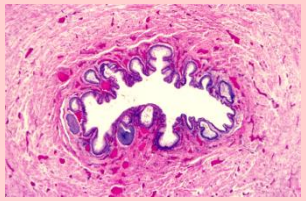
- This is the whole view of a transverse section of a human penis.
- The penis is the male copulatory organ and with skin covered cylindrical body, 15～20 cm long and 3～4 cm in diameter. The core of the penis consists of three cavernous erectile bodies, namely two dorsally located paired corpora cavernosa penis and ventrally located unpaired corpus spongiosum penis (corpus cavernosum urethrae), which is penetrated by the urethra throughout the length.
- The corpora cavernosa penis are enclosed by a common thick collagenous tissue, tunica albuginea, and the corpus cavernosum urethrae is also enclosed by a much thinner tunica albuginea. At the distal end the corpus cavernosum urethrae makes an expansion, the glans penis, which caps the distal ends of the corpora cavernosa. The three corpora cavernosa, are enveloped in the lump by very loose connective tissue and further on the surface by the thin skin.
- The erectile tissue of the corpora cavernosa is a sponge-like system of irregularly shaped vascular spaces fed by afferent arteries and drained by efferent veins. In the flaccid penis these cavernous spaces contain very little blood and appear as irregular narrow clefts. During erection, they expand as they become engorged with blood under pressure. The increased inflow of blood and relative restriction of outflow results in enlargement and rigidity of the erect penis.
- The male urethra serves as the terminal portion of both the urinary tract and the reproductive tract. The lining of the penile urethra, 12～14 cm in length, is stratified columnar epithelium. At its most distal portion the lining becomes into stratified squamous epithelium, which is alike to that covering the glans penis.

15-47 Male urethra, transverse section. Human, H-E stain, x 4.0.



- Higher magnification of 15-46. At center is the male urethra penetrating the axial portion of the corpus cavernosum urethrae. The blood spaces composing the cavernous body are mach narrower the that of the corpora cavernosa penis. Several very small glands are scattered in the upper region.

15-48 Female urethra, transverse section. Human, H-E stain, x 4.0.



- The female urethra is short, 25～40 mm long. It is lined by the stratified squamous epithelium, which is plicated to form longitudinal folds. There are numerous invaginations of the epithelium, that look like the mucous glands. Around the urethra numerous venous blood vessels are scattered. This condition faintly suggests the corpus cavernosun of the male.