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Fig 19-13, *Junqueira*, 13th ed.
Learning Objectives

1. Understand the organization of the kidney into lobes and lobules and their relationship to cortical and medullary areas.

2. Understand the arterial input and venous drainage through the kidney’s microvasculature.

3. Understand the structure of the renal corpuscle, including podocytes, and the ultrastructure of the glomerular filter.

4. Understand the locations of the various parts of the nephron with respect to cortex and medulla.

5. Identify all parts of the nephron and collecting ducts in histological sections and understand how the structures of the different regions correspond to their functions.

6. Recognize the structure and know the function of the juxtaglomerular apparatus.

7. Identify the key structural features of the ureter, bladder, and urethra.
Keywords

afferent arteriole  macula densa
arcuate arteries  medulla
arcuate veins  mesangial cells
Bowman’s space  nephronephron
calyx  peritubular capillary
collecting duct  podocytes
collecting tubule  proximal convoluted tubule
cortex  renal capsule
distal convoluted tubule  renal corpuscles
afferent arteriole  renal papilla
efferent arteriole  renal pelvis
foot processes  thick ascending limb
glomerular capsule  thin limb
glomerulus  ureter
hilum  urethra
juxtaglomerular apparatus  urinary bladder
juxtaglomerular cells  urinary epithelium
kidney  vasa recta
lacis cells
loop of Henle
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**Slide 14: Kidney, Trichrome**

- Look here for the capsule
- **renal pelvis** lined with transitional epithelium (with surrounding CT & adipose = renal **hilum**)

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Blood flow through kidney:
Renal artery → segmental aa. → interlobar aa. (between pyramids of medulla) → arcuate aa. (between medulla/cortex) → interlobular aa. (in cortex) → afferent arteriole → glomerulus → efferent arteriole → peritubular capillaries / vasa recta → interlobular vv. → ...

arcuate artery and vein (blood in lumen) at border between cortex and medulla
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**Slide 14: Kidney, Trichrome**

- **renal corpuscles**
- **medullary rays**
  "extensions of medulla" into cortex; they consist of collecting tubules and ducts draining nephrons located higher in cortex; distinguished by absence of renal corpuscles
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Slide 14: Kidney, Trichrome

glomeruli (capillary networks) within Bowman's capsule of corpuscles

bulk of parenchyma between corpuscles is filled with tubules; cortex consists mainly of PCTs with a smaller number of DCTs and collecting tubules
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Slide 14: Kidney, Trichrome

- **Bowman's capsule**
  (parietal layer of simple squamous epithelium)
  (visceral layer of podocytes)
- **Glomerulus**
- **Macula densa**
  (specialized DCT)
- **Afferent arteriole**
  (larger lumen)
- **Efferent arteriole**
  (smaller lumen)
- **Vasa recta**
- **Bowman's space**
- **PCT**

[Image of kidney with labeled structures]
Juxtaglomerular Apparatus (JGA): specialization of afferent arteriole and distal convoluted tubule (of same nephron); involved in regulation of systemic blood pressure

Juxtaposed to the pole of the glomerulus is a specialized arteriole, the afferent arteriole, which is modified to form a Juxtaglomerular Apparatus (JGA). The JGA is a complex of cells that plays a crucial role in regulating blood pressure and electrolyte balance. It consists of extraglomerular mesangial (Lacis) cells, which form a conical mass continuous with the mesangium of the glomerulus and bounded by the afferent and efferent arterioles with their bases resting on the macula densa. These cells are flat and elongated, and their function is still unclear.

- **Extraglomerular mesangial (Lacis) cells** form a conical mass continuous with the mesangium of the glomerulus and bounded by the afferent and efferent arterioles with their bases resting on the macula densa. These cells are flat and elongated, and their function is unclear.

- **Juxtaglomerular (JG) cell** modified smooth muscles cells of the wall of the afferent arteriole; cluster around the arteriole before it enters the glomerulus (contains renin granules).

- **Macula densa** specialized epithelial cells of the distal convoluted tubule; situated between arterioles; epithelial cells are taller and their nuclei are situated more apically than in the rest of the DCT; cells are sensitive to [Na+].
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capillary endothelial cell
dark, elongated nuclei around lumen of capillaries

podocytes
large, round, pale nuclei; separate the network of capillaries in the glomerulus from Bowman's space; processes surround the capillaries and form filtration slits

(intraglomerular) mesangial cells
distinguished as nuclei within mesangium (basement membrane-like material); pericyte-like, secrete matrix, and phagocytic
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**Slide 14: Kidney, Trichrome**

**proximal convoluted tubule (PCT)**
emerge from urinary pole of corpuscle; lumen is continuous with Bowman's space and epithelium is continuous with epithelium of parietal layer of Bowman's capsule

simple cuboidal epithelium with tall microvilli (brush border); round nuclei with prominent nucleoli; intensely-staining cytoplasm; prominent basal lamina; lumen often appears closed; surrounded by rich supply of capillaries

*PCT is longer than DCT, so majority of tubules seen in cortex are PCT*
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Slide 14: Kidney, Trichrome

distal convoluted tubule (DCT)

continuation of thick ascending limb of loop of Henle; form macula densa at vascular pole of corpuscle
lack microvilli; generally have larger, clearly defined lumen; more nuclei per cross section (DCT cells are smaller than PCT cells); paler cytoplasm than PCT

DCT is much shorter than PCT, so sections of DCT are much less numerous than PCT
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**Slide 14: Kidney, Trichrome**

*afferent arteriole*

brings blood to glomerulus; generally has larger diameter lumen than efferent arteriole; it is often difficult to distinguish between afferent and efferent arterioles

*efferent arteriole*

brings blood to glomerulus; has smaller diameter lumen than afferent arteriole, so maintains filtration pressure in glomerulus; blood will continue from efferent arteriole to *peritubular capillaries* and *vasa recta*

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![Kidney micrograph with labeled arterioles](image)
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Slide 14: Kidney, Trichrome  

eritubular capillary  
from efferent arterioles of corpuscle  
extensive network around tubules, especially PCT so reabsorbed glomerular filtrate (~65%) is returned to vasculature
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**Slide 14: Kidney, Trichrome**

*medulla:* NO renal corpuscles, lots of tubes
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Slide 14: Kidney, Trichrome

**thick (ascending) limb**
from thin limb and connecting to DCT
cuboidal epithelium which lacks brush border; round lumen; similar appearance to DCT

**thin limb**
simple squamous epithelium
differentiated from vasa recta by regular round shape and lack of RBCs in lumen
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Slide 14: Kidney, Trichrome

**collecting tubule** or **connecting segment**

connect DCT to collecting duct
descend from cortex to medulla in medullary rays
similar to thick limbs but are wider and less regular in shape
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Slide 14: Kidney, Trichrome

**collecting duct** formed from several collecting tubules; drain to papillary ducts which open at tips of renal papillae large diameter; pale-staining columnar epithelium; prominent lateral borders between adjacent epithelial cells can usually be seen
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Slide 111: Kidney, H&E
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Slide 48: Ureter, H&E
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Slide 48: Ureter, H&E

transitional epithelium (urinary epithelium)
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Slide 48: Ureter, H&E

lumen lined by transitional epithelium
Ureter is composed of **mucosa**, **muscularis**, and **adventitia**; the muscularis has two layers: **inner longitudinal** and **outer circular** (a third outer longitudinal layer appears at the distal end as it joins with the urinary bladder) – note the difference in the fiber orientations vs. in the GI tract.
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Slide 16: Aorta, Vena Cava, Ureter, LN

*notice the very thick, prominent lamina propria*
Slide 12: Urinary Bladder, Masson Trichrome

mucosa forms prominent rugae in relaxed state
Slide 12: Urinary Bladder, Masson Trichrome

Three layers of **muscularis** collectively compose **detrusor muscle**: inner longitudinal, outer circular, and outermost longitudinal; however, the layers are often difficult to distinguish.
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Slide 109: Penis, H&E

- urethra
- urinary epithelium (variable)
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Trouble with Tubes
Ureter vs. Urinary Bladder

Slide 16: Aorta, Vena Cava, Ureter, LN

Slide 12: Urinary Bladder, Masson Trichrome

basic organization of ureter (especially distal 1/3) and urinary bladder are the same; the key to differentiating them is to appreciate:

1. **Difference in size**: notice the urinary epithelium lining the lumens, while comparable thickness in both slides, it appears much thinner in the urinary bladder because the image is much more “zoomed out” as the urinary bladder is a larger structure; in the ureter, individual nuclei can be seen in the epithelium, demonstrating a more “zoomed in” magnification level and an overall smaller structure

2. **Mucosa of the urinary bladder often appears more much folded (rugae) when relaxed than in the ureter**
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Trouble with Tubes
Ureter vs. Urethra

Slide 16: Aorta, Vena Cava, Ureter, LN

Slide 109: Penis, H&E

1. Ureter has adventitia and is often surrounded by adipose; urethra is embedded within the CT of the surrounding organ, generally the penis or vagina
2. Urethra contains small mucous glands in the surrounding CT
3. Ureter is lined by transitional epithelium; urethra is generally lined with pseudostratified columnar epithelium (or transitional) that transitions to stratified squamous at the external urethral orifice
4. Ureter has pronounced muscularis layer
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         c. Collecting duct
         d. Renal papilla
         e. Vasculature
            1. Vasa recta
   B. Ureter
   C. Urinary Bladder
   D. Urethra
IV. Summary

EMs to Examine

Fig 19-5: Podocyte
Fig 19-6: Filtration barrier
Fig 19-7: Mesangium
Fig 19-10: Proximal convoluted tubule
Fig 19-11: Thin limb versus vasa recta
<table>
<thead>
<tr>
<th>Segment</th>
<th>Location</th>
<th>Characteristics</th>
<th>Function</th>
<th>Associated Vasculature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal convoluted tubule</td>
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<tr>
<td>Pars recta (descending thick)</td>
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<td>Thin limb (descending/ascending)</td>
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<tr>
<td>Ascending thick limb</td>
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<tr>
<td>Distal convoluted tubule</td>
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<tr>
<td>Collecting tubule</td>
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<tr>
<td>Collecting duct</td>
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<tr>
<td>Papillary duct</td>
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