The Urinary System: Outline

1. Adaptation to Arid Environments
2. Urinary System Components and Functional Overview
3. Kidney Lobes and Lobules
4. The Nephron and Tubular Nomenclature
5. The Renal Corpuscle
6. The Glomerulus, Podocytes and the Filtration Barrier
7. The Proximal Tubule
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9. The Distal Tubule
10. Renal Circulation
11. The Juxtaglomerular Apparatus

The Urinary System: Adaptations to Arid Environments

The Cloudless Sulfur: *Phoebis sennae* Linnaeus

Microcell in wing scale is the site of uric acid crystal deposition.

The Kangaroo Rat: *Dipodomys speciabilis*

The Urinary System: Components

1. Paired Kidneys:
   a. Left slightly higher than right
2. Paired Ureters:
   a. Exit Hilum
   b. Insert into Trigone
3. Single Urinary Bladder
4. Single Urethra

The Urinary System: Functions

1. Waste Excretion/Water Conservation
2. Acid/Base Regulation
3. Endocrine functions:
   a. Erythropoietin (90% interstitial fibroblast in cortex)
   b. Renin (juxtaglomerular cells)
4. Hydroxylation of Vitamin D
The Urinary System: The Kidney

Structure: Fetal and Adult Kidney Lobes

Figure 20.6

The Urinary System: The Kidney

Structure: Lobule – Centered on Medullary Rays

Figure 20.6

The Urinary System: The Kidney

Structure: Lobule – Cortex

Figure 20.6

The Urinary System: The Kidney

Structure: Lobule – Cortex

Figure 20.6

The Urinary System: The Kidney

Structure: Lobule – Medulla

Figure 20.6
The Urinary System: Nephron - 2 Types

1. Juxtamedullary Nephron: long loops of Henle
2. Mid-Cortical Nephron: short loops of Henle
3. Inner Stripe: thick and thin tubular segments; outer medullary collecting ducts
4. Outer stripe: only thick tubular segments, outer medullary collecting ducts

3a. Inner Medulla: divided into outer and inner stripes
     a. Outer Medulla: divided into outer and inner stripes
     b. Outer stripe: only thick tubular segments, outer medullary collecting ducts
     c. Inner Stripe: thick and thin tubular segments; outer medullary collecting ducts
4. Inner Medulla: thin segments; inner medullary collecting ducts

3. Medulla: divided into outer and inner medulla
   a. Outer Medulla: divided into outer and inner stripes
   b. Outer stripe: only thick tubular segments, outer medullary collecting ducts
   c. Inner Stripe: thick and thin tubular segments; outer medullary collecting ducts
4. Inner Medulla: thin segments; inner medullary collecting ducts

The Urinary System: Renal Corpuscle

Structure: Renal Corpuscle – Development

Note: Glomerular Arterial "tuft" is surrounded by the renal tubule.

Note: Visceral layer of Bowman’s capsule thins.

Note: Pale purple region represents Bowman’s space, or the urinary space.
The Urinary System: Renal Corpuscle

**Structure:** Podocytes – Visceral Layer Bowman’s Capsule

- **Podocyte Body**
- **Bowman’s Space**

Note:
1° and 2° Podocyte processes

Pedicels branch from 2° processes

The Urinary System: Renal Corpuscle

**Structure:** Podocytes – Visceral Layer Bowman’s Capsule

- **Primary process**
- **Secondary process (pedicel)**
- **Glomerular Basement Membrane (GBM):**
  - **Filtration slits** (with diaphragms)
  - **Fenestrations**

The Urinary System: Renal Corpuscle

**Structure:** Electron Microscopy of Renal Corpuscle

- **Electron Microscopy**
- **Urinary Space**

The Urinary System: Renal Corpuscle

**Structure:** Glomerular Filtration Barrier – Components (3)

1. Podocyte Pedicels
2. Glomerular Basement Membrane (GBM):
   - **Lamina rara externa**
   - **Lamina densa**
   - **Lamina rara interna**
3. **Capillary Lumen**
4. **Fenestrations**

The Urinary System: Renal Corpuscle

**Structure:** Mesangial Cells – Functions

- **Mesangial cells:**
  - provide mechanical support
  - control GBM material turnover
  - regulate blood flow
  - secrete vasoactive substances
  - respond to angiotensin II

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The Urinary System: **Renal Corpuscle**

**Structure:** Urinary Pole – Proximal Tubule, pars convoluta

- Proximal Tubule
- Distal Tubule

The Urinary System: **Proximal Tubule**

**Structure:** Proximal Convoluted Tubules – Cytology

- Extensive lateral interdigitations
- Primary Cilia
- Cell Border
- Microvilli: Brush Border
- Plicae: lateral infolding
- Basal lamina

The Urinary System: **Loop of Henle**

**Structure:** The Kangaroo Rat and the Loop of Henle

- Concentrated Urine: Counter-Current Multiplier
  - conserves water
  - depends on length of the Loop of Henle

- Kangaroo Rats: live in arid conditions and need to conserve water
  - therefore, have the longest Loop of Henle of all the mammals

The Urinary System: **Distal Tubule**

**Structure:** Distal Tubules: reabsorption of ~7% filtrate

- DTs: sensitive to Aldosterone and Antiduretic Hormone
- Histology: low cuboidal cells; lateral and basal infoldings

The Urinary System: **Collecting Tubule**

**Structure:** Cortical Collecting Tubules/ Medullary Ray

- Histology: Collecting Tubules – low cuboidal cells

The Urinary System: **Collecting Tubule**

**Structure:** Outer Medullary Collecting Tubules/Ducts

- Histology: low cuboidal epithelium, central nuclei, lateral cell borders,
  Interclated (Dark) & Principal cells (sensitive to Aldosterone)
- Vasa recta: Thin Loop of Henle

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The Urinary System: Collecting Ducts

**Structure:** Inner Medullary Collecting Ducts of Bellini

Papillary Collecting Ducts:
- columnar cells
- clear cytoplasm
- lateral cell boundaries

Note: Vascula recta with blood elements in the lumen.

Note: Thin loops of Henle with prominent nuclei in the lumen.

The Urinary System: Blood Supply

**Structure:** The Cortical and Medullary Vasculature

G1 and G2 glomeruli:
- efferent arterioles give rise to peritubular capillaries (pc)

G3 glomeruli:
- efferent arterioles give rise to vasa recta capillaries
  (ARS, MP—medullary plexus)

Arcuate aa. and vv.:
- boundary between cortex and medulla

Interlobular (IL) aa/vv.:
- give rise to stellate aa/vv (sv) afferent arterioles

The Urinary System: The JG Apparatus

**Structure:** The Juxtaglomerular apparatus

The Juxtaglomerular Apparatus

Components of the JGA:
1. Juxtaglomerular cells of the afferent arteriole
2. Macula Densa cells of the Distal Tubule
3. Extraglomerular Mesangial Cells (Lacis cells)

**Function:** The Juxtaglomerular apparatus

Function of the JGA:
1. Juxtaglomerular secrete renin cells react to stretch
2. Extraglomerular Mesangial Cells modify activity of JG cells
3. Macula Densa cells sense changes in Na and regulate JG cells

The Urinary System: Summary

1. The Function of the Urinary System is Carefully Tied to Its Structural Components.
2. The Kidney is divided into a Cortex, containing the filtering structures (Glomeruli) and a Medulla containing a collection system composed of tubular units (Collecting Ducts and Loops of Henle).
3. Loops of Henle within the Medulla are responsible for establishing an interstitial concentration gradient which is part of a Counter-current Multiplier.
4. The Kidney contains a unique circulation responsible for returning materials reabsorbed from the ultrafiltrate to general circulation and helping to maintain a hypertonic interstitial medulla necessary for developing a Concentrated Urine (Countercurrent Exchange System).
5. The Juxtaglomerular Apparatus is important in regulating both renal and systemic blood pressure.