The Urinary System
General

• Urinary system
  – Maintains fluid homeostasis including:
    • regulation of volume and composition by eliminating certain wastes while conserving needed materials
    • regulation of blood pH
    • regulation of hydrostatic pressure of blood and, indirectly, of other body fluids

– Contributions to metabolism
  • helps synthesize calcitriol (active form of Vitamin D)
  • secretes erythropoietin
  • performs gluconeogenesis during fasting or starvation
  • deaminates certain amino acids to eliminate ammonia
Kidneys

- Paired reddish organs, just above waist on posterior wall of abdomen
  - partially protected by 11th, 12th ribs
  - right kidney sits lower than the left kidney
  - receive 20-25% of the resting cardiac output
  - Consume 20-25% of the $O_2$ used by the body at rest
Kidneys (cont.)

- Retroperitoneal, as are ureters and urinary bladder
- Renal Pyramids
- Renal Columns
  - Space between pyramids within the medulla
- Renal Papilla
  - Narrow end of pyramid
- Calyx (ces)
  - Collecting tubes
- Renal Pelvis
  - Collecting vessel prior to ureter
Human Kidney

- Minor calyx
- Major calyx
- Renal pelvis
- Medulla
- Cortex
- Renal artery
- Renal vein
- Ureter
Kidney - Internal Gross Anatomy

- Renal column
- Major calyx
- Papilla of pyramid
- Cortex
- Renal pelvis
- Minor calyx
- Renal pyramid of medulla
- Fibrous capsule

- Cortical radiate vein
- Cortical radiate artery
- Arcuate vein
- Arcuate artery
- Interlobar vein
- Interlobar artery
- Segmental arteries
- Renal artery
- Renal vein
- Renal pelvis
- Major calyx
- Ureter
Kidney - Internal Micro Anatomy

• Nephron – the functional unit of kidney
  – Three physiological processes: 1) filtration, 2) reabsorption, and 3) secretion
  – These three processes cooperate to achieve the various functions of the kidney
  – Different sites → different primary functions
• 2 major parts to the nephron

Renal Corpuscle

Renal Tubule
Kidney - Internal Micro Anatomy

• ~1 million nephrons are located in the cortex

• The filtrate is carried by the collecting duct system through the medulla

• The urine is collected at the papillae into the minor and major calyxes
Nephron

- Renal corpuscle
  - Site of plasma filtration
  - 2 components
    - Glomerulus
      - tuft of capillary loops
      - fed by afferent arteriole
      - drained by efferent arteriole

- Glomerular (Bowman's) capsule
  double walled cup lined by simple squamous epithelium
  outer wall (parietal layer) separated from inner wall (visceral layer = podocytes)
  by capsular (Bowman's) space

As blood flows through capillary tuft – filtration occurs
- water and most dissolved molecules pass into capsular space
- large proteins and formed elements in the blood do not cross
Nephron

- Renal tubule - where filtered fluid passes from capsule
  - Proximal convoluted tubule (PCT)
  - Loop of Henle (nephron loop)
  - Distal convoluted tubule (DCT)
  - Short connecting tubules
  - Collecting ducts
  - Papillary duct
    - then to minor calyx
    - 30 pap ducts/papillae
Nephron

• Cortical nephrons
  – 80-85% of nephrons
  – Short loops

• Juxtamedullary nephrons
  – 15-20% of nephrons
  – Longer loops and increased involvement in the reabsorption of water

• Each portion of the nephron has distinctive features
Renal Corpuscle Histology

- The glomerular filtration unit
  - Three components to the filter
  - From inside to out, the layers prevent movement of progressively smaller particles
• PCT - cuboidal cells with apical microvilli

• Descending loop, and beginning of ascending loop
  – simple squamous epithelium
  – water permeable

• Remainder of ascending limb of the loop
  – cuboidal to low columnar epithelial cells
  – impermeable to water
  – permeable to solute (ions)

• DCT, collecting ducts
  – cuboidal with specialized cells
  – principal cells - sensitive to ADH (antidiuretic hormone)
  – intercalated cells - secrete H⁺
KIDNEY: CORTEX AND ONE PYRAMID
DEEP CORTICAL AREA AND OUTER MEDULLA
KIDNEY CORTEX: THE JUXTAGLOMERULAR APPARATUS

1. Distal convoluted tubule
2. Glomerular capillaries
3. Glomerular arteriole
4. Juxtaglomerular cells
5. Macula densa
6. Proximal convoluted tubule
7. Interlobular vessels:
   a. Veneule
   b. Arteriole
8. Collecting tubule
9. Basement membrane
10. Glomerular (Bowman's) capsule:
    a. Parietal layer
    b. Visceral layer
11. Urinary pole
12. Afferent glomerular arteriole
13. Capsular space
14. Proximal convoluted tubule
15. Distal convoluted tubule
PAPILLA (TS)

1. Straight (descending) segment of proximal tubule
2. Venules
3. Papillary ducts
4. Capillaries
5. Thin segments of the loop of Henle
6. Straight (descending) segment of proximal tubule
7. Straight (ascending) segment of distal tubule
8. Thin segments of the loop of Henle
9. Capillaries
10. Straight (ascending) segment of distal tubule
11. Straight (descending) segment of proximal tubule
12. Connective tissue
• Ureters
  – extensions of the renal pelvis
  – enter the bladder medially from the posterior
  – transport urine to the bladder
  – peristalsis primarily, but hydrostatic pressure of gravity helps in humans
Ureter

- Stellate lumen
- 3 layers of smooth muscle
  - Inner = longitudinal
  - middle = circular
  - Outer = longitudinal
- Peristalsis contribute to urine flow
URETER (TS)

1. Adipose tissue
2. Circular smooth muscle layer
3. Longitudinal smooth muscle layer
4. Lumen
5. Lamina propria
6. Adventitia
7. Nerves
8. Artery
9. Transitional epithelium (superficial layer)
10. Transitional epithelium (basal layer)
11. Venules
12. Adipose tissue and fibroelastic connective tissue (subserous fascia)
Transitional Epithelium

• Lines the ureter and bladder
• Allows for changes in volume
• Impermeable to salt and water
• Look for:
  – Dome-shaped, bulging
  – Eosinophilic
  – Flatten as bladder distends
Ureter

- Transitional Epithelium
- Muscularis
  - 2 or more layers
- Adventitia
  - Contain fat, vessels, nerves
A SECTOR OF THE WALL

1 Arteriole and venule
2 Circular smooth muscle layer
3 Adipose cells
4 Adventitia
5 Surface membrane
6 Mucosal fold
7 Transitional epithelium
8 Longitudinal smooth muscle layer
9 Lamina propria
• Urinary bladder
  – hollow muscular organ
  – generally smaller in females due to presence of a uterus
  – retroperitoneal in the pelvic cavity, posterior to the pelvic symphysis
  – freely movable
• Structure - trigone
• **Bladder histology**
  – inner mucosa lined with transitional epithelium
  – muscularis – smooth muscle in three layers
  – Sphincters control entry from ureters and exit at the urethra
    • circular smooth muscle fibers form internal urethral sphincter
    • lower is the external urethral sphincter with skeletal muscle for voluntary control
  – retroperitoneal (serosa or adventitia)
Bladder

- Transitional epithelium

- Smooth muscle in various planes
  - Allow for contraction in all directions
Bladder

- Transitional Epithelium (Relaxed State)
- Darkly eosinophilic due to invaginated plaques
URINARY BLADDER (WALL : TS)

1 Smooth muscle bundles (sectioned in various planes) (muscularis)
2 Interstitial connective tissue
3 Capillaries
4 Superficial connective tissue
5 Peritoneal mesothelium
6 Mucosal folds
7 Transitional epithelium
8 Lamina propria
9 Smooth muscle bundles (muscularis)
URINARY BLADDER (MUCOSA : TS)

1. Smooth muscle bundles
2. Venule and arteriole
3. Lamina propria
4. Transitional epithelium
5. Outer plasma membrane
6. Binucleate cell