Urinary System – 3 Functions

1) Excretion – removes organic waste from fluids
2) Elimination – discharges wastes
3) Homeostatic regulation – helps maintain water and electrolyte balance
   • Regulates pH and volume of body fluids
Structure

- 2 kidneys
- 2 ureters
- 1 urinary bladder
- 1 urethra
Kidney

- **Renal** = pertaining to kidney
- Reddish-brown
- Bean shaped
  - Lateral = convex
  - Medial = concave
- Smooth
  - 10 cm (4”) long x 5.5 cm (2.2”) wide x 3 cm (1.2”) thick
Kidney Location

- On each side of vertebral column
- Abdominal cavity
- BW T12 and L3
- Left kidney 1-2 cm higher than Right
- Retroperitoneal – behind parietal peritoneum and against back muscles
- Held in place by muscle and fat
Kidney Location
Kidney Structure

- **Renal sinus** – hollow chamber
  - Medial side
  - **Hilum** – entrance where blood vessels, nerves, lymphatic vessels, and the ureter pass
Kidney Structure

- Superior end of ureter expands to form Renal pelvis – inside renal sinus
  - Funnel shaped sac
  - Subdivides into major calyces (tubes) and these into minor calyces
  - Contain renal papillae
General Kidney Structure

**Renal capsule**
- Encloses kidney
- Fibrous transparent

**Adipose capsule**
- Fatty mass
- Holds kidney in place
Kidney Regions

1) Medulla – inner
   - Composed of renal pyramids
   - Appears striated
   - Latin for “bark”
Kidney Regions

2) **Renal Cortex** – forms shell around medulla
- Forms renal columns where it dips into medulla bw pyramids
- Granular appearance
- Contains nephrons

*The Excretory System 4 kindoms 12 min*
Kidney Function

1) Help maintain homeostasis
   - Regulates composition and volume of extracellular fluid
   - Removes wastes from blood
     - Combines w/ water and electrolytes to form urine
Kidney Function

2) Secrete erythropoietin – hormone
   - controls RBC production

3) Helps activate Vitamin D
Kidney Function

4) Secrete renin – enzyme that helps maintain blood pressure

5) Maintain volume of extracellular fluid
   - Helps control blood pressure
Renal Blood Vessels

- Renal Arteries – arise from abdominal aorta
  - Large volume of blood
  - 15-30% of total cardiac output goes to kidneys when a person is at rest
  - Enter and leave through hilum
- Leave through renal vein
Renal Blood Vessels

- Aorta to Abdominal Aorta to Renal Arteries enters hilum to interlobal arteries pass between renal pyramids to arcuate arteries to interlobular arteries to **afferent arterioles** which lead to **nephrons**.

- Venous vessels correspond to arterial pathways. Then joins inferior vena cava to R. atrium and so on . . .
Nephron

- ~1.25 million per kidney
- ~85 miles
- Filtering unit
- Form urine

Kidney Dialysis 101 - YouTube [360p].mp4 3 min
Nephron Structure

1) Renal corpuscle consists of:
   - **Glomerulus** – cluster of capillaries that filters fluid
   - **Glomerular capsule** (Bowman’s capsule) – saclike structure that surrounds glomerulus
     - Receives filtered fluid

[Fetal Pig Dissection Part 4- Urinary System - YouTube [360p].mp4 4 min]
Renal Corpuscle
Nephron Structure

2) Renal Tubule

- Leads away from glomerular capsule
- Highly coiled

3 regions:
- Proximal convoluted
- Loop of Henle
- Distal convoluted tubule
  - To collecting duct
Renal tubule
Collecting Duct

- Larger tube-like structure
- Receives urine from nephrons
- Not part of nephron
- Runs downward thru medullary pyramid
- Delivers urine to calyces and renal pelvis
Collecting Ducts
Nephrons and Capillaries

- Unique: Fed and drained by arterioles
  - High pressure in glomerulus
  - **Afferent arterioles**
    - “Feeder vessel”
    - Enters into glomerulus
  
  **Efferent arterioles**
  - Receives blood that has been through the glomerulus
Nephrons and Capillaries

**Peritubular capillary bed**
- Arise from efferent arteriole
  - Low pressure
  - Porous
  - Absorption
  - Around renal tubule
  - Reabsorb substances from tubule cells
Urine Formation

1) **Glomerular filtration** – glomerular capillaries filter plasma

- ~180 L of fluid / 24 hours (~45 gal)
- 125 ml per minute
- 4x more than total water in body
- Hydrostatic pressure forces fluid out
- Occurs as long as blood pressure is normal
- Nonselective, passive process
Glomerular filtration

Glomerular filtrate = water, large protein molecules, ions

- basically blood plasma w/out proteins or cells
Urine Formation

2) Tubular reabsorption – water, electrolytes, and glucose reclaimed from filtrate and returned to blood

Wastes and excess ions leave filtrate

Mostly occurs in proximal convoluted tubule (where it begins)

- Some by osmosis
- Most by active transport; selective
  - Amino acids, glucose
Tubular Reabsorption
Nitrogenous Wastes

A) Urea – end product of protein breakdown (catabolism)
   - Formed by liver
   - 50% excreted, rest reabsorbed

B) Uric Acid – end product of nucleic acid breakdown
   - Most reabsorbed, little excreted in urine
3) **Tubular Secretion** – opposite of reabsorption

- Faster
- Move H and K ions, ammonia, penicillin
- Moves from peritubular capillary to distal convoluted tubule
Tubular Secretion
Urine Characteristics

- Varies w/ diet and activity
- 95% water
- Urea, uric acid, trace electrolytes and aa
- .6 - 2.5 liters per day
- 50-60 ml per hour
  - < 30 ml may = kidney failure
  - Yellow color b/c of urochrome – very large molecule formed from hemoglobin that in old, used up RBCs
Normal urine solutes
- Na⁺
- K⁺
- Urea
- Uric acid
- Creatinine
- Ammonia
- Bicarbonate ions
- Composition varies with diseases
- Urinalysis
  - Good diagnostic tool

Abnormal urine solutes
- Glucose
- Blood proteins
- Red blood cells
- Hemoglobin
- White blood cells
- Bile
Ureter

- From kidney to bladder
- About 25 cm long
- Narrow; about 6mm in diameter
- Retroperitoneal
- Valve at bladder end to prevent backflow
- 3 layers in wall

UPJ Obstruction and Kidney Stone Removal. All Rights Reserved by the Urology Group 2013. - YouTube [360p].mp4 3 min
3 Layers of Ureter Wall

1) **Mucous coat** – inner layer
   - Continuous w/ renal tubules and bladder lining

2) **Muscular coat** – middle layer
   - Smooth muscle
   - Peristalsis action propels urine

3) **Fibrous coat** – outer layer
   - Connective tissue
Ureter
Kidney Stone

- Form in collecting ducts and pass into ureters
- Causes: concentrated urine
  - frequent infections
  - Urine retention
  - Alkaline urine
- Severe pain, nausea, vomiting
- 60% leave on own, others need removal
  - [Kidney Stones - YouTube](https://www.youtube.com/watch?v=360p.mp4) 3 min
Urinary Bladder

- Hollow, distensible, muscular organ
- Retroperitoneal
- Stores urine
- In pelvic cavity
- Walls smooth as bladder fills
- Trigone – on floor
  - 2 openings to ureters
  - 1 opening to urethra
Urinary Bladder Wall

1) **Mucous coat**
   - Inner
   - Thickness changes
   - Transitional epithelium

2) **Submucous coat**
   - 2\textsuperscript{nd} layer
   - Connective tissue and elastic fibers
Urinary Bladder Wall

3) **Muscular coat** – 3\(^{rd}\) layer
   - Smooth muscle laced together form the **detrusor muscle**
   - **Internal urethral sphincter** – portion of detrusor muscle that surrounds neck of bladder
     - Controls emptying of bladder

4) **Serous Coat** – parietal peritoneum
   - Only on upper surface
Urinary Bladder

Male or Female?
Infections are Common

- **Ureteritis** – inflammation of ureter

- **Cystitis** – inflammation of urinary bladder
  - More common in women
  - Shorter urethral pathway
Urination (Micturition)

- Expelling urine from bladder
- Detrusor, abdominal wall, and pelvic floor muscles contract
- Thoracic wall and diaphragm muscles do NOT contract
- Requires **External urethral sphincter** to relax
  - Surrounds urethra ~ 3 cm from bladder
  - Voluntary skeletal muscle
Urination (Micturition)

- Bladder holds up to 600 ml
- 150 ml usually feel urgency – the need to go
- 300 ml = very intense urgency
Urethra

- Tube that takes urine from bladder to outside of body
- Walls – lined with mucous membrane
  - Thick layer of smooth muscle
  - Urethral glands secrete mucus into canal
- Male - reproductive and urinary function
  - ~ 20 cm -
- Female - ~3-4 cm, urination only
Bladder and Urethra
Urine Production