Lab Activity 31

Anatomy of the Urinary System

Portland Community College
BI 233
Urinary System Organs

- **Kidneys**
- **Urinary bladder**: provides a temporary storage reservoir for urine
- **Paired ureters**: transport urine from the kidneys to the bladder
- **Urethra**: transports urine from the bladder out of the body
Kidney Location and External Anatomy

- **Retroperitoneal** position behind the peritoneum
  - Superior lumbar region
  - From the twelfth thoracic to the third lumbar vertebrae
  - The right kidney is lower than the left
- **Hilus**: Medial border where ureters, blood vessels, lymphatics, and nerves enter and exit

Adrenal Gland
Kidney: Internal Anatomy

- Renal Capsule
- Renal Papilla
- Minor calyx
- Major calyx
- Renal pelvis
- Cortex
- Renal medulla or pyramid
- Columns
- Ureter
Nephron

- Nephrons are the structural and functional units that form urine, consisting of:
  1. **Renal Corpuscle**: The collective term for the glomerulus and the surrounding capsule
     - **Glomerulus**: Tuft of capillaries
     - **Bowman’s capsule**: Enlarged end of the renal tubule that surrounds the glomerulus
  2. **Renal Tubule**: Tube into which fluid passes
     - Proximal convoluted tubule
     - Loop of Henle
     - Distal convoluted tubule
Nephron

Afferent arteriole

Efferent arteriole

Descending limb of the loop of Henle

Ascending limb of the loop of Henle
Nephrons

- Notice how the distal convoluted tubule folds around and is next to the afferent arteriole.
Cortical Nephrons

- **Cortical Nephrons**: 80-85% of all nephrons
  - Their renal corpuscles lie in the outer portion of the renal cortex
  - Have short loops of Henle
    - Lie mainly in the cortex
    - Penetrate only into outer region of the renal medulla
Cortical Nephron Vasculature

- Interlobular Artery
- Interlobular Vein
- Afferent Arteriole
- Glomerulus
- Efferent Arteriole
- Peritubular capillaries
- Arcuate Artery
- Loop of Henle
- Proximal tubule
- Distal tubule
- Collecting tubule
Juxtamedullary Nephrons

- **Juxtamedullary nephrons**: 15-20% of nephrons
  - Renal corpuscle lies deep in cortex near medulla
  - Have long loops of Henle
    - Responsible for creating medullary concentration gradient that allows the kidney to change dilution of urine
- Vasa Recta capillaries around the loops of Henle
Juxtamedullary Nephron Vasculature

Each nephron has two arterioles and two sets of capillaries associated with it.

- Efferent arteriole
- Glomerulus (capillaries)
- Peritubular capillaries
- Juxtaglomerular apparatus
- Afferent arteriole

Vasa Recta
Glomerulus

- The primary filtering device of the nephron
- Blood is transported into the Bowman's capsule from the afferent arteriole
- Within the capsule, the blood is filtered through the glomerulus and then passes out via the efferent arteriole.
- Filtrate moves out of the Bowman's capsule into the proximal convoluted tubule.
Glomerulus + Bowman’s Capsule = Renal Corpuscle

- The first part of the nephron
- The afferent arteriole leads to the glomerulus, which is a specialized capillary bed.

**Filtration:** The hydrostatic force of the blood pressure pushes the fluid from the blood out into Bowman’s capsule.

**Filtrate:** The fluid pushed out consists of everything except blood cells and large proteins.
Renal Corpuscle

The capsular space contains the filtrate

Podocyte (visceral layer of Bowman's capsule)
1. Fenestrations: Holes in the capillary endothelium

2. Podocytes

3. Fused basement membranes

• #1 Stops all cells and platelets
• #2 Stops medium-sized proteins, not small ones
• #3 Stops large plasma proteins
Filtration

Key:

- Glomerular (blood) hydrostatic pressure (55 mm Hg)
- Blood colloid osmotic pressure (30 mm Hg)
- Capsular hydrostatic pressure (15 mm Hg)

Net outward pressure

Glomerular capsule

10 mm Hg
Reabsorption is the process of moving substances from the filtrate back into the blood.

- Reabsorbed substances must pass through 3 membranes in order to reach the blood:
  1. Apical (lumen) side of the tubule cells
  2. Basal (capillary) side of the tubule cells
  3. Capillary endothelium
Secretion is moving substances from the blood and putting them into the filtrate.

- Secreted substances must pass through 3 membranes in order to reach the filtrate:
  1. Capillary endothelium
  2. Basal (capillary) side of the tubule cells
  3. Apical (lumen) side of the tubule cells
Macula Densa

- There is a portion of the DCT that abuts the afferent arteriole.
- At that region of the DCT, there are tall, closely-packed DCT cells that collectively are known as the macula densa.
- **Macula densa** cells are osmoreceptors that are responsible for measuring filtrate Na+
  - If Na+ is low in the filtrate, the macula densa send a chemical signal to the juxtaglomerular cells to release renin.
Juxtaglomerular Cells

• In the afferent arteriole where the DCT is touching, there are specialized smooth muscle cells known as juxtaglomerular cells.

• Act as baroreceptors

• These JG cells contain large amounts of secretory granules containing renin

• When blood pressure low, the JC cells release their renin
Foot processes of podocytes
Parietal layer of glomerular capsule
Capsular space
Afferent arteriole
Juxtaglomerular cells
Macula densa cells of the distal tubule
Mesangial cells between capillaries
Renal corpuscle
Juxtaglomerular apparatus
Renin-Angiotensin System

- **Renin** is an enzyme that cleaves the plasma protein angiotensinogen into angiotensin I.
  - Angiotensinogen is made in the liver
- **Angiotensin I** will be converted into angiotensin II by **Angiotensin Converting Enzyme (ACE)** in the lung
- **Angiotensin II** is a potent vasoconstrictor and thus increases BP.
- The increase in BP will increase glomerular filtration.
Angiotensin II

• **Angiotensin II** causes:
  • Systemic vasoconstriction (increases blood pressure)
  • The adrenal cortex to release aldosterone
  • The posterior pituitary to release antidiuretic hormone.
• **Aldosterone** will cause certain DCT cells and collecting duct cells (principle cells) to reabsorb more Na\(^+\) and thus more water.
• **ADH** will cause the collecting duct and DCT to increase its reabsorption of water.
  • This water will be reabsorbed into the peritubular capillaries causing both blood volume and blood pressure to increase.
Bladder

- It lies retroperitoneally on the pelvic floor posterior to the pubic symphysis
  - Males: Prostate gland surrounds the neck inferiorly
  - Females: Anterior to the vagina and uterus
- The bladder wall has three layers
  - Transitional epithelial mucosa
  - A thick muscular layer
  - A fibrous adventitia
Female Bladder

- Ureter
- Ureter Openings
- Trigone
- Internal Urethral Sphincter
- External Urethral Sphincter
- Urogenital Diaphragm
Ureter

Ureter Openings

Internal Urethral Sphincter

External Urethral Sphincter

Trigone

Male Bladder
Female Urethra

- The female urethra is tightly bound to the anterior vaginal wall
- Its external opening lies anterior to the vaginal opening and posterior to the clitoris
- Length 3-4 cm
  - Shorter length can lead to more frequent bladder infections
The male urethra has three named regions:

- **Prostatic urethra**: runs within the prostate gland
- **Membranous urethra**: runs through the urogenital diaphragm
- **Spongy (penile) urethra**: passes through the penis and opens via the external urethral orifice

Length: 20 cm
Histology of Renal Tubule & Collecting Duct

- **Proximal convoluted tubule**
  - Simple cuboidal with brush border of microvilli that increase surface area
- **Thin segment descending limb of loop of Henle**
  - Simple squamous
- **Thick segment descending limb of loop of Henle**
  - Simple cuboidal
- **Thick Ascending limb of loop of Henle**
  - Simple cuboidal to low columnar
- **Thin segment of ascending limb**
  - Simple squamous
- **Distal convoluted & collecting ducts**
  - Simple cuboidal composed of principal & intercalated cells which have microvilli
(a) Proximal convoluted tubule cells

(b) Loop of Henle cells: descending limb and thin ascending limb

(c) Loop of Henle cells: thick ascending limb

(d) Distal convoluted tubule cells

(e) Collecting duct cells
Cortex Histology

- DCT
- PCT
- Macula Densa
- Collecting Duct
- Bowman’s Capsule (parietal layer)
Kidney Cortex Histology
Kidney Cortex Histology

- DCT
- Collecting duct
- PCT
- Glomerulus
Kidney Medulla Histology

Collecting Duct

Thick segment: Loop of Henle

Thin segment: Loop of Henle

Vasa Recta
Kidney
Medulla Histology

- Vasa recta
- Collecting Duct
- Thick segment LOH
Bladder Histology
Bladder Histology

- Transitional Epithelium (binucleate)
- Lymphocytes
- Lamina Propria
The End