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
- Cortex
- Minor calyx
- Major calyx
- Renal medulla or pyramid
- Renal pelvis
- 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

Diagram showing the nephron structure with labels for Bowman's capsule, glomerulus, proximal tubule, distal tubule, loop of Henle, and collecting duct.
Nephron

- **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
- **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
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  - Vasa Recta capillaries around the loops of Henle
Each nephron has two arterioles and two sets of capillaries associated with it.

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

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.
- Filtered water and aqueous wastes are passed 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
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

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
Nephrons

- Notice how the distal convoluted tubule folds around and is next to the afferent arteriole.
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**
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 $\text{Na}^+$ 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.
Nephron Vasculature

- Consists of 2 capillary beds separated by the intervening efferent arteriole.
- The 1st capillary bed (the glomerulus) produces the filtrate.
- The second capillary bed (peritubular capillaries) reclaims most of that filtrate.
- **Vasa recta** - bundles of long straight vessels that run beside the loops of Henle deep into the medulla.
Nephron Vasculature

- Efferent arteriole of cortical nephron
- Interlobular vein
- Interlobular artery
- Afferent arteriole
- Collecting duct
- Distal convoluted tubule
- Efferent arteriole of juxtamedullary nephron
- Peritubular capillaries
- Ascending or thick limb of the loop of Henle
- Arcuate vein
- Arcuate artery
- Loop of Henle
- Vasa recta
Kidney Histology
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

- Intercalated cell
- Principal cell
Cortex Histology

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

- Proximal tubules
- Macula densa
- Capsular space
Kidney Cortex Histology

- DCT (Distal Convoluted Tubule)
- PCT (Proximal Convoluted Tubule)
- Collecting duct
- Glomerulus
Kidney Medulla Histology

- Collecting Duct
- Thick segment: Loop of Henle
- Thin segment: Loop of Henle
- Vasa Recta
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
Bladder Histology

- Transitional Epithelium
- Lamina Propria
- SMOOTH MUSCLE
- Outermost Longitudinal
- Inner Circular
- Outer Circular
Bladder Histology

Transitional Epithelium (binucleate)

Lymphocytes

Lamina Propria
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
Ureter

Ureter Openings

Internal Urethral Sphincter

Trigone

External Urethral Sphincter

Male Bladder
Male Urethra

- 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
The End