

Urinary System and Excretion

Bio105
Chapter 16

Outline – Urinary System

Renal will be on the Final only.

- I. Function
- II. Organs of the urinary system
 - A. Kidneys
 1. Function
 2. Structure
- III. Disorders of the urinary system

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Urinary System

- The digestive system eliminates waste from the digestive tract. But we also need a way to eliminate waste from the rest of the body.
- The function of the urinary system is: To excrete metabolic wastes and to maintain homeostasis of blood.

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Urine

- Urine contains:
 - Water
 - HCO_3^-
 - Inorganic salts
 - H^+
 - Urea
 - Uric acid
 - Creatinine

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Excretion

- **Excretion** - the majority of the metabolic wastes removed from the body is mainly due to the action of the kidneys.

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Organs of the Urinary System

1. **Kidneys** – main organ in the urinary system, produce urine.
2. **Ureters** - conduct urine from the kidneys to the bladder by peristaltic contractions produced from contractions of smooth muscles in ureter wall.

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Organs of the Urinary System

3. **Urinary Bladder** - stores urine until it is expelled from the body.
4. **Urethra** - small tube that extends from the urinary bladder to an external opening. In males the urethra also functions as a reproductive tract organ.

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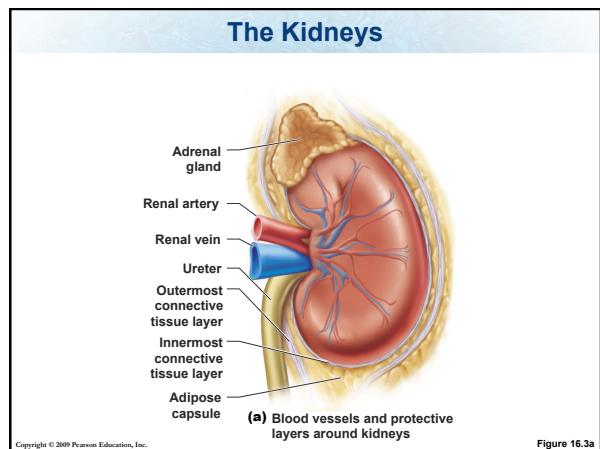
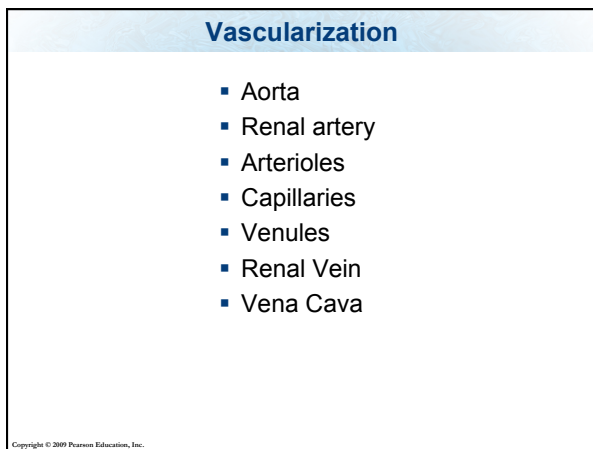
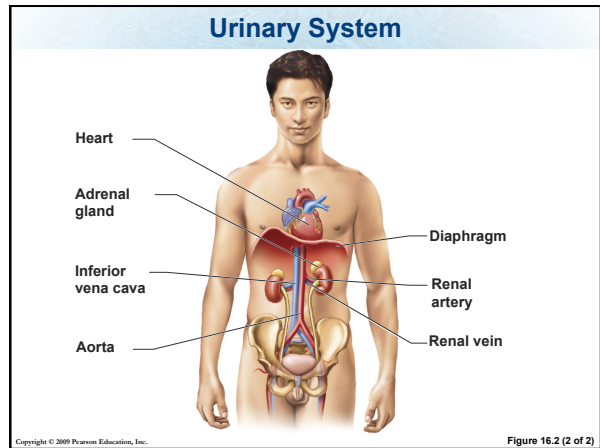
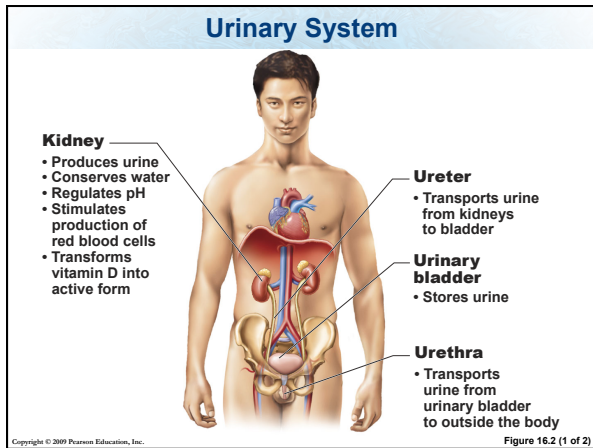
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Functions of the Kidneys

1. Filter waste from blood.
2. Maintain water-salt balance of the blood.
3. Regulate blood pressure.
4. Maintain acid-base balance of the blood.
5. Secrete hormones = **renin** and **erythropoietin**.

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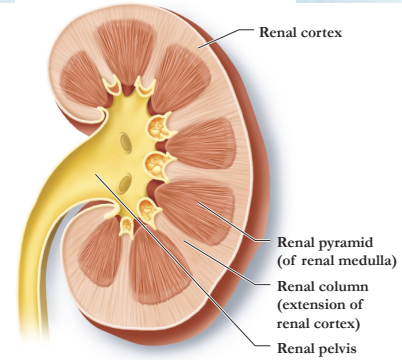


The Regions of the Kidneys

- Each kidney has three regions:
 1. **Renal cortex**
 2. **Renal medulla**
 3. **Renal pelvis**

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Figure 16.3b Structure of the kidney



(b) Internal kidney structure

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Regions of the Kidney

1. Renal Cortex - The outer granulated layer.
2. Renal Medulla - Consists of cone-shaped tissue masses called renal pyramids.
3. Renal Pelvis - A central cavity that is continuous with the ureter.

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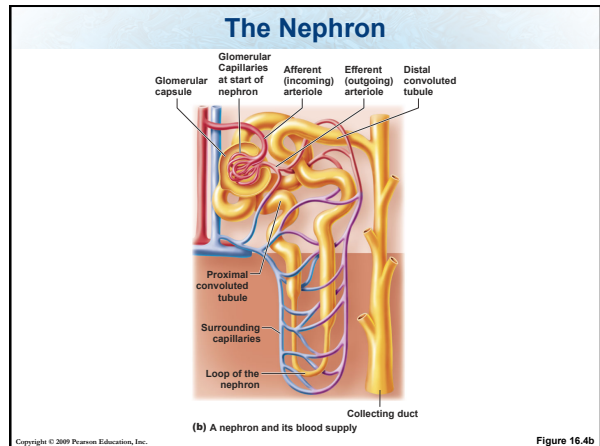
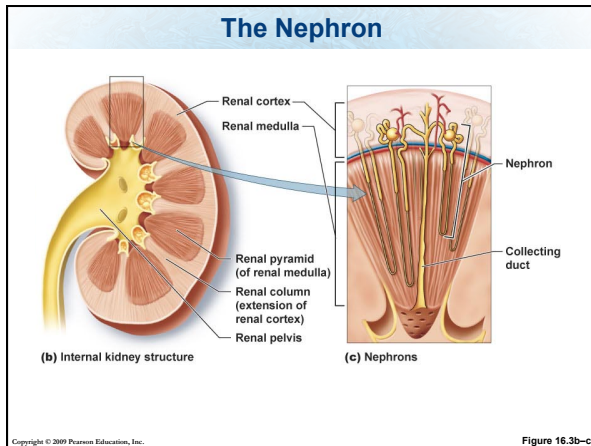
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Nephrons

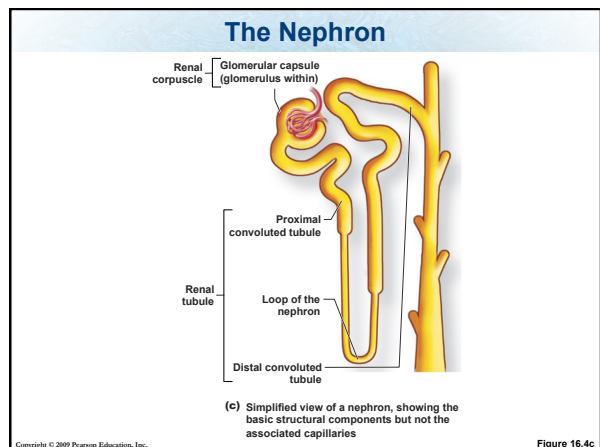
- Nephrons are the functional units of the kidneys.
- Over 1 million nephrons per kidney.
- Nephrons extend from the Renal cortex, into the Renal medulla.

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- ### Parts of the Nephron
1. The Renal Corpuscle.
 - A. The glomerulus
 - B. The glomerular capsule
 2. The Renal Tubule.
 - A. Proximal convoluted tubule
 - B. Loop of the nephron
 - C. Distal convoluted tubule
 3. The Collecting Duct.
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The Renal Corpuscle

- The renal corpuscle is where fluid is filtered from blood.
- Consists of:
 - The **glomerulus** - The network of capillaries.
 - The **glomerular capsule** (Bowman's capsule) - Surrounds the glomerulus.

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The Nephron

- The nephron performs three functions
 1. Glomerular filtration
 2. Tubular reabsorption
 3. Tubular secretion

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The Nephron - Glomerular filtration

- **Glomerular filtration** occurs as blood pressure forces water, ions, and other small molecules in the blood through the pores in the glomerulus and into the glomerular capsule.
- The **filtrate** passes into the renal tubule.

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The renal corpuscle, where blood is filtered

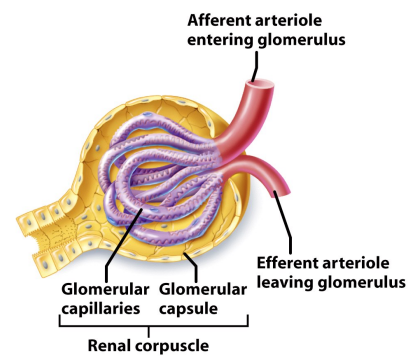
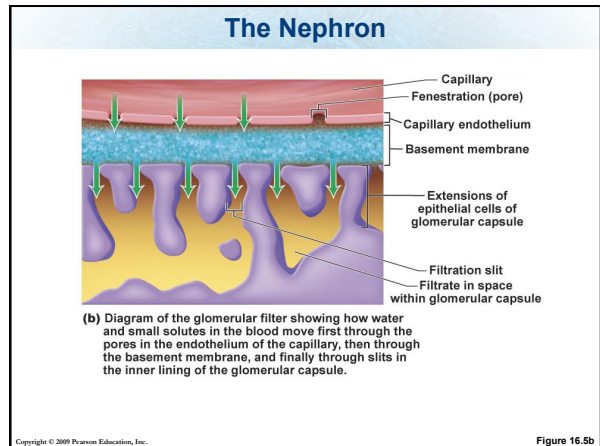
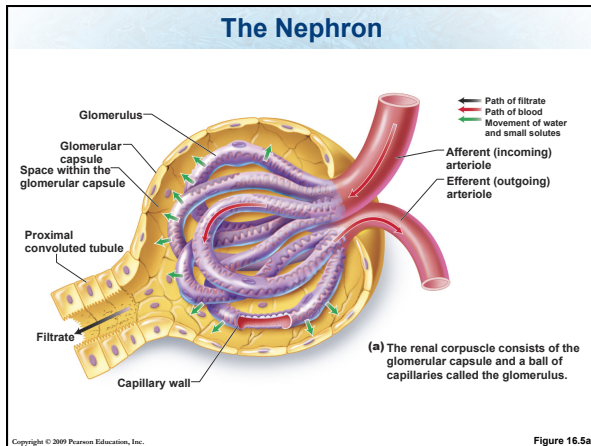


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Urine Formation

- **Tubular Reabsorption** - many molecules are reabsorbed – transported from the lumen into the tissues then into capillaries. Occurs mainly in the PCT (H_2O , nutrients, salts).
- **Tubular Secretion** - substances are removed from the blood and added to the tubular fluid, mainly in the DCT. (H^+ , creatinine, and drugs like penicillin).

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The Renal Tubule

1. **Proximal Convoluted Tubule (PCT)** - where reabsorption of filtrate components occurs, tubular secretion can also occur here.
2. **Loop of the Nephron (Loop of Henle)** - consists of a descending limb and an ascending limb that regulates osmotic balance (creates an osmotic gradient)
3. **Distal Convoluted Tubule (DCT)** – Further reabsorption of water and salts; leads to the renal pelvis.

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Collecting Ducts

- Collecting ducts - carry urine to the renal pelvis.

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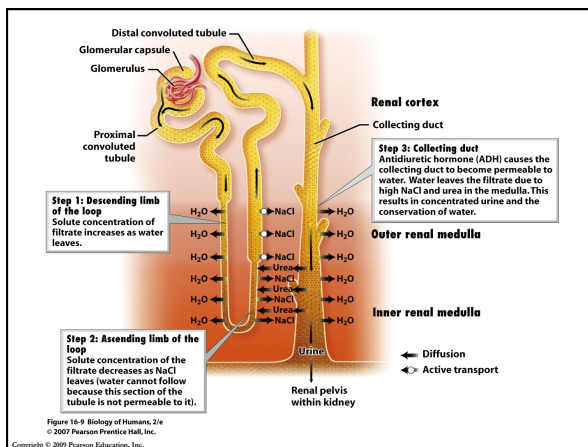
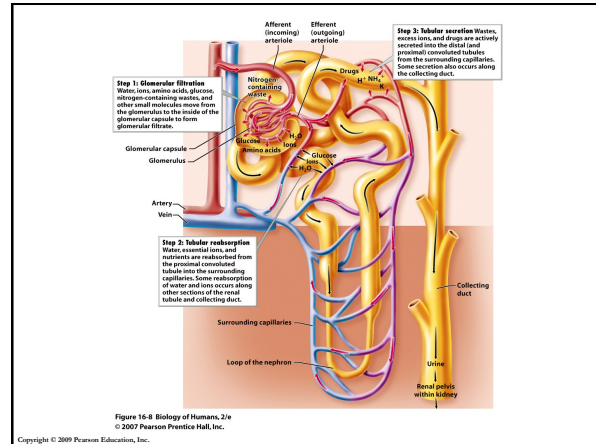
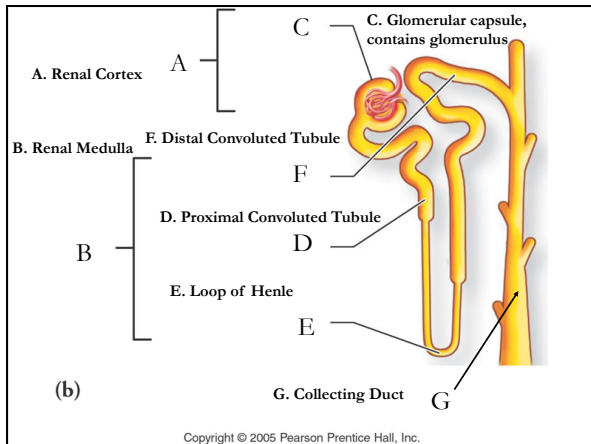


TABLE 16.2 Review of Nephron Regions and their Roles

Region of Nephron	Roles*
Renal corpuscle (glomerular capsule and glomerulus)	Filters the blood, removing water, glucose, amino acids, ions, nitrogen-containing wastes, and other small molecules
Proximal convoluted tubule	Reabsorbs water, glucose, amino acids, some urea, Na^+ , Cl^- , and HCO_3^- Secretes drugs, H^+ , NH_4^+
Loop of the nephron	Reabsorbs water, Na^+ , Cl^- , and K^+
Distal convoluted tubule	Reabsorbs water, Na^+ , Cl^- , and HCO_3^- Secretes drugs, H^+ , K^+ , and NH_4^+

NOTE: *Major reabsorbed or secreted substances are listed here.

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Regulation of Urine

- **Diuretics** increase urinary output, making a large volume, very dilute urine.
- **Examples:**
 - Caffeine
 - Lasix
 - Alcohol

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Hormonal Regulation of Urine

1. **Antidiuretic hormone (ADH)**
 - Makes a low volume, concentrated urine.
 - Increases blood volume and pressure.
2. **Aldosterone**
 - Makes a low volume, concentrated urine.
 - Increases blood volume and pressure
3. **Atrial Natriuretic Peptide (ANP)**
 - Makes a large volume, dilute urine.
 - Decrease blood volume and pressure

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Table 16.3 Review of Hormones

TABLE 16.3 Review of Some Hormones that Influence Kidney Function			
Hormone	Effect on Water and Solute Reabsorption in Nephron	Effect on Blood Volume and Pressure	Urine Produced
Antidiuretic hormone (ADH)	Increases permeability to water of collecting ducts, resulting in more water moving from filtrate to blood	Increases	Concentrated
Aldosterone	Increases reabsorption of Na ⁺ by distal convoluted tubules and collecting ducts, resulting in more water following Na ⁺ as it moves from filtrate to blood	Increases	Concentrated
Atrial natriuretic peptide (ANP)	Decreases reabsorption of Na ⁺ by distal convoluted tubules and collecting ducts, resulting in more Na ⁺ and water remaining in filtrate	Decreases	Dilute

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Hormonal Regulation of Urine - ADH

- **Antidiuretic Hormone (ADH)**
 - Makes the collecting duct more permeable to water therefore, increases the water reabsorption in the collecting duct, making more concentrated urine.
 - Produced by the hypothalamus, released from the posterior pituitary gland.
 - Site of action: Collecting Ducts.

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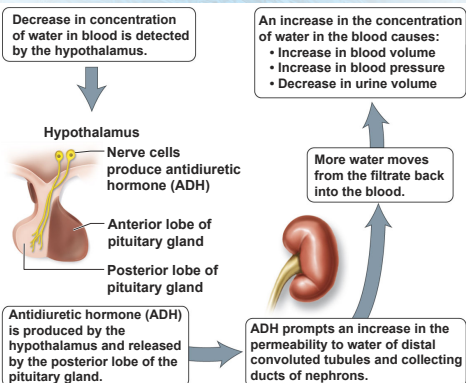
Diabetes insipidus

- Diabetes insipidus is caused by low ADH production.
- Symptoms: Excrete large amounts of dilute urine. Frequent urination and constant thirst.

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Kidney Function and ADH



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Figure 16.9

Hormonal Regulation of Urine - Aldosterone

- **Aldosterone (Mineralocorticoid)**
 - Hormone produced and released by the adrenal cortex.
 - Increases sodium reabsorption in the distal convoluted tubule and the collecting duct.
 - Water follows solutes.
 - Making more concentrated urine.

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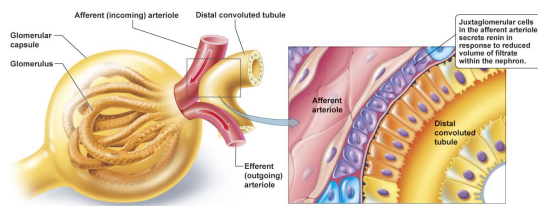
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Juxtaglomerular Apparatus and Aldosterone

- Filtrate volume and blood pressure are monitored by the juxtaglomerular apparatus.
- The cells in the juxtaglomerular apparatus release the hormone renin in response to decreased BP.
- Renin converts Angiotensinogen (from liver) to Angiotensin-1 then to Angiotensin-2 (in the lungs).
- Angiotensin-2 constricts vessels, stimulates Aldosterone release, stimulates the sympathetic NS, stimulates ADH release.

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Kidney Function and Hormones



(a) The juxtaglomerular apparatus (within the square) is a section of the nephron where the distal convoluted tubule contacts the afferent arteriole. The nearby renal corpuscle is shown in ghosted view to reveal its components, the glomerular capsule and the glomerulus.

(b) Close-up view of the juxtaglomerular apparatus

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Figure 16.10

Hormonal Regulation of Urine - ANP

- Atrial Natriuretic Peptide (ANP)
 - Hormone produced by the heart in response to increased blood volume and pressure.
 - Decreases sodium reabsorption in the distal convoluted tubule and the collecting duct, water follows solute and stays in the filtrate.
 - Inhibits production of renin and aldosterone.
 - Making more dilute urine. Lowers blood pressure and blood volume.

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TABLE 16.2 REVIEW OF SOME HORMONES THAT INFLUENCE KIDNEY FUNCTION

HORMONE	EFFECT ON WATER AND SOLUTE REABSORPTION IN NEPHRON	EFFECT ON BLOOD VOLUME AND PRESSURE	URINE PRODUCED
Antidiuretic hormone (ADH)	Increases permeability to water of collecting ducts, resulting in more water moving from filtrate to blood	Increases	Concentrated
Aldosterone	Increases reabsorption of Na^+ by distal convoluted tubules and collecting ducts, resulting in more water following Na^+ as it moves from filtrate to blood	Increases	Concentrated
Atrial natriuretic peptide (ANP)	Decreases reabsorption of Na^+ by distal convoluted tubules and collecting ducts, resulting in more Na^+ and water remaining in filtrate	Decreases	Dilute

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Hormones Produced by the kidneys

1. **Renin** – Increases blood pressure by triggering the release of aldosterone by the adrenal cortex.
2. **Erythropoietin** – speeds up the maturation process of RBCs, target = stem cells in bone marrow.

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The Kidney's Role in Vit D

- Vitamin D is produced in the skin in response to sunlight, and provided by certain foods in diet.
- The kidneys and liver transform Vitamin D into the active form, **calcitrol**.
- Calcitrol promotes the absorption of calcium into the small intestine and re-absorption of calcium in the kidneys.

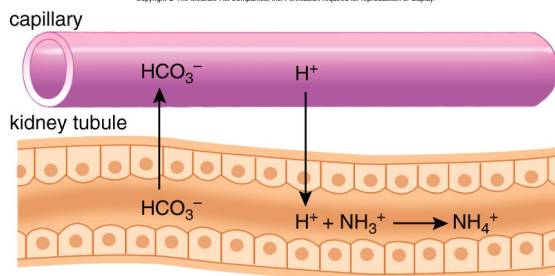
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Kidney's Role in Acid-Base Balance

- H^+ is secreted into the tubules and bicarbonate is reabsorbed out of the tubules

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Kidney's Role in Salt-Water Balance

- The kidneys reabsorb salt and water, maintaining osmotic balance in the blood, this also affects blood pressure.

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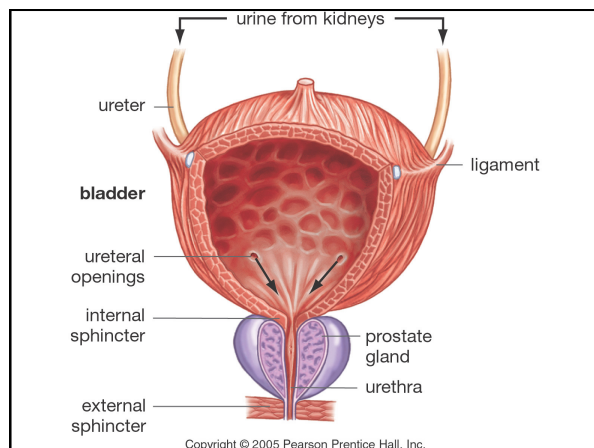
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Bladder

- The urine goes from the kidneys into the ureters then to the bladder where it is stored until it can be released through the urethra.

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Urination

- Urination is controlled by both voluntary and involuntary actions.
- When the bladder fills to about 250ml of urine then the motor nerve impulses cause the bladder to contract and the sphincters to relax so that urination is possible.

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Urinary Function Disorders

- Acute renal failure
- Urinary tract infections (UTIs)

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Urinary Function Disorders

- Acute renal failure – abrupt and nearly complete failure of kidney to function
 - Caused by severe inflammation, drugs, or poisons.
 - Treatment – dialysis and organ transplant.

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Urinary Function Disorders

- Urinary tract infections (UTIs) – Bacterial infection of the urinary tract:
 - Urethritis - infection confined to the urethra.
 - Cystitis - infection of the urethra and bladder.
 - Pyelonephritis - infection reaches the kidneys.
- Treatment: antibiotics.

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Important Concepts

- Read Chapter 17 for next lecture
- What are the functions of the urinary system?
- What compounds are contained in urine, what compounds are not contained normally in urine?
- What are the organs of the urinary system and their functions, including all the functions of the kidney?
- What are the blood vessels that lead to and from the heart and the kidney and the vessels within the kidney?

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Important Points

- What are the three regions of the kidney?
- What is the function of a nephron, what are the parts of the nephron and the functions of these parts?
- What is glomerular filtration, reabsorption and secretion in the nephron, what is contained in the filtrate leaving the renal corpuscle, **what compounds are reabsorbed and what are secreted and where in the nephron are the compounds reabsorbed or secreted?**

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Important Points

- How is urinary output regulated, what are examples of diuretics? What hormones decrease or increase urinary output? What effect on blood pressure do these hormones have? Where are these hormones produced, stored and released from. What is their effect on the nephron?
- What is the cause of diabetes insipidus
- What is the function of renin, where it is produced, what is the target and what is the effect of renin on urine production and blood pressure?

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Important Points

- What is the function of erythropoietin, what is the target, where is it produced?
- What is the role of the kidney in Vit D production and calcium absorption? What is the active form of Vit D?
- How does the kidney regulate blood pH and maintain osmotic balance? How does the regulation of salt/water balance effect blood pressure?
- Be able to discuss the disorders of the urinary system, including the causes, effects and treatments?

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Definitions

- Excretion, renal pyramids, renal corpuscle, tubular reabsorption, tubular secretion, filtration, filtrate, diuretic, calcitrol

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