

Urinary System



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Urinary System



- **Urinary System is comprised of:**
 - Two kidneys: form urine from the blood
 - Two ureters: tubes that conduct urine to bladder from kidneys
 - One urinary bladder: reservoir holding urine temporarily
 - One urethra: tube that conducts urine from bladder to outside of body for elimination
- **Kidneys:**
 - Most important excretory organs
 - Eliminate nitrogenous waste, water, electrolytes, toxins & drugs
 - Effectively secretes & maintains water & electrolyte balance

Kidneys

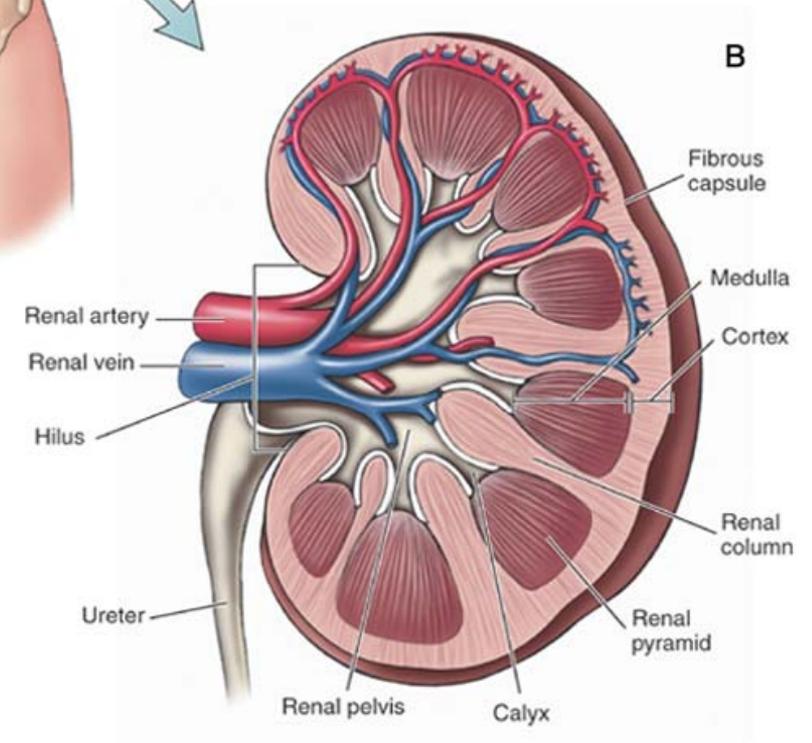
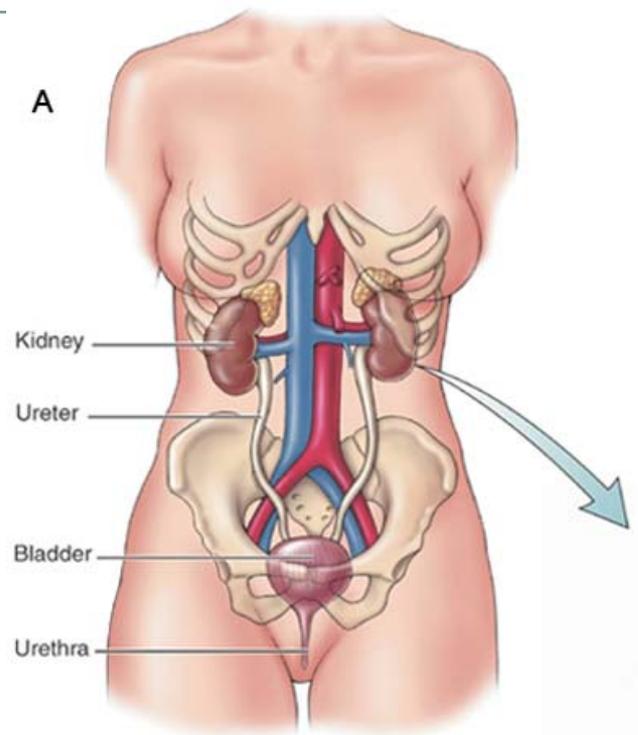


- **Location of kidneys:**
 - Located in the retroperitoneal space; posterior wall of abdominal cavity
 - Renal fascia hold the kidneys in place
 - A cushion of adipose tissue cushions the kidneys
 - The lower rib cage partially encloses & protects them
- **Structure of kidneys:**
 - Reddish-brown bean-like structures enclosed in a tough fibrous capsule
 - 4 inches long, 2 inches wide & 1 inch thick
 - Contains an indentation called hilus which is an area of exit & entrance for blood vessels, the ureter & nerves

Structure of Kidney



- **Structure of kidney:**
 - **Three distinct regions:**
 - ✦ **Renal cortex:**
 - lighter outer region
 - ✦ **Renal medulla:**
 - darker triangular portion located deeper within
 - Forms striped cone-shaped regions called renal pyramids
 - ✦ **Renal pelvis:**
 - basin that collects urine made by the kidneys
 - helps form the upper end of the ureter
 - Cup-like edges, closest to pyramids are calyces which collect urine formed in the kidneys



Blood supply to Kidney



- **Blood supply to kidney:**
 - Oxygenated blood is supplied by the renal arteries
 - These arteries branch into smaller & smaller arteries ensuring contact with the nephron units (urine making structures of kidney)
 - Blood leaves the kidneys through several veins that finally merge at the renal vein & empties directly into the IVC

Function of Kidneys



- **Function:**
 - Kidneys cleanse the blood of waste products
 - Help regulate volume by determining the amount of water excreted
 - Excrete nitrogenous waste such as urea, ammonia & creatinine
 - Help regulate electrolyte content of blood
 - Regulates the pH of bodily fluids by controlling the excretion of hydrogen ions
 - Regulates BP through the secretion of renin
 - Regulates RBC production through the secretion of erythropoietin

Nephron Unit



- Nephron is the functional unit or the urine making unit of the kidney
- Each kidney contains about 1 million nephron units
- We are born with a certain number of nephrons & they are not replaced if damaged
- Nephrons contains two parts:
 - Renal tubule
 - Blood vessels

Renal Tubules

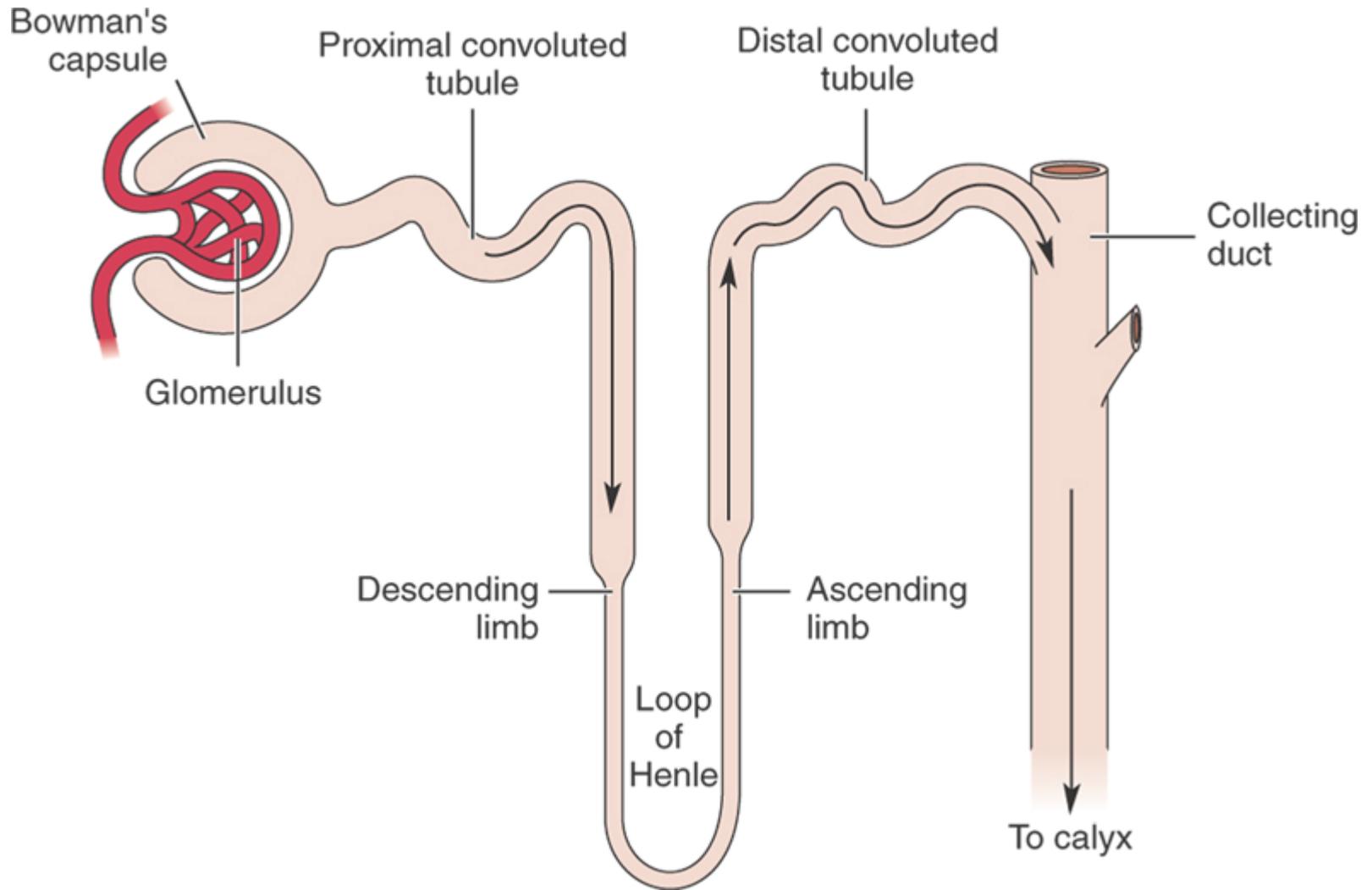


- **Renal tubules:**
 - Consists of a number of tubular structures
 - Bowman's capsule is a C-shaped structure that partially surrounds a cluster of capillaries called glomerulus
 - Bowman's capsule extends from the glomerulus as a highly coiled tubule called proximal convoluted tubule
 - The proximal convoluted tubule dips toward the renal pelvis to form a hairpin structure called the loop of Henle
 - The loop of Henle contains a descending & ascending limb
 - The ascending limb becomes the distal convoluted tubule
 - Many distal convoluted tubules of several nephrons merge to form the collecting duct
 - The collecting ducts run through the renal medulla to the calyx of the renal pelvis
 - Urine is formed within these tubules

Renal Tubules



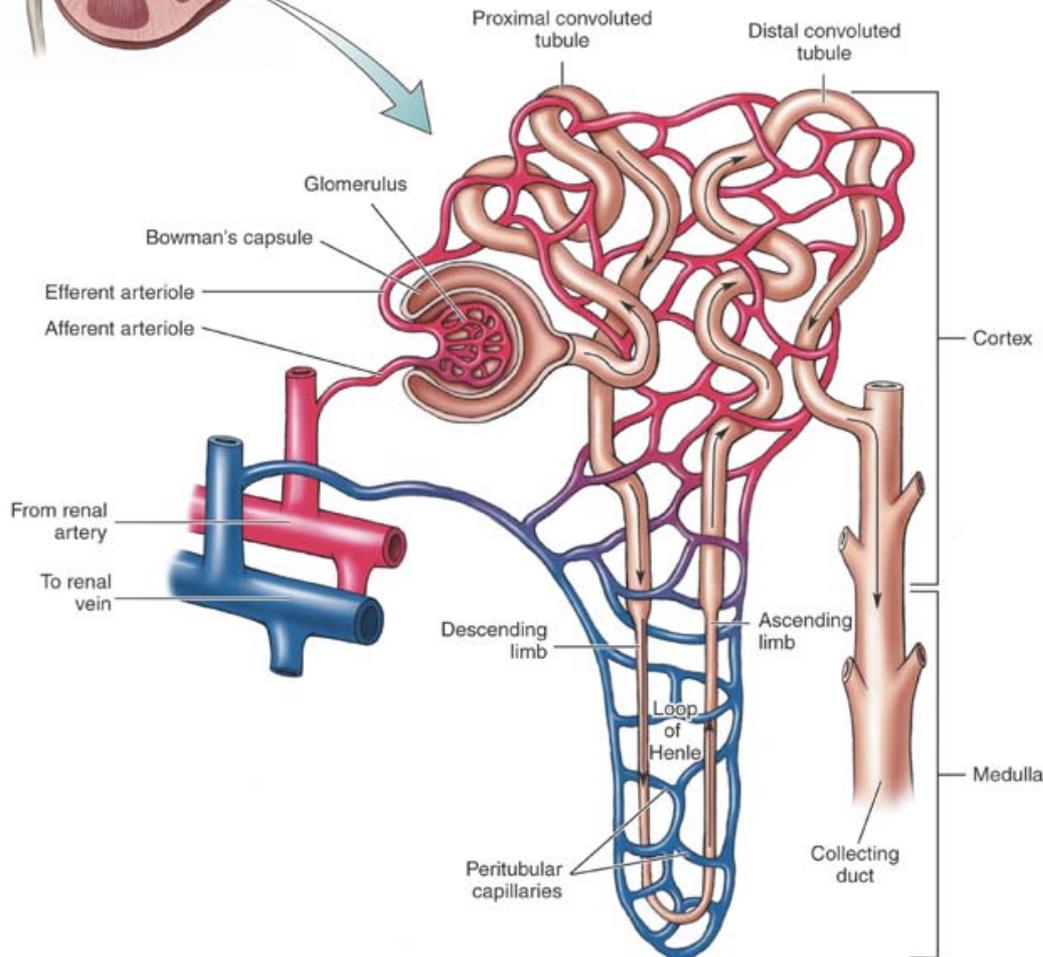
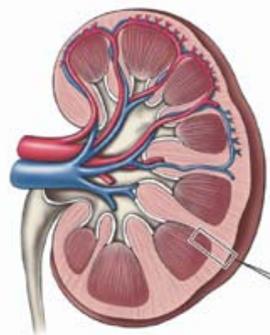
- **Urine formation sequence:**
 - Bowman's capsule
 - Proximal convoluted tubule
 - Descending limb
 - Loop of Henle
 - Ascending limb
 - Distal convoluted tubule
 - Collecting ducts
 - Calyx
 - Renal pelvis



Renal Blood Vessels



- Kidney receives blood from the renal arteries which branch off smaller & smaller creating afferent arterioles
- The afferent arterioles branch into a cluster of capillaries called glomerulus
- The glomerulus sit in Bowman's capsule & exits from Bowman's capsule as the efferent arteriole
- The efferent arteriole then form a second capillary network called peritubular capillaries
- Peritubular capillaries empty into venules then larger veins until finally the renal vein



Blood Flow



- **Blood flows:**
 - Renal artery →
 - Smaller & smaller arteries →
 - Afferent arteriole →
 - Glomerulus →
 - Efferent arteriole →
 - Peritubular capillary →
 - Renal venules →
 - Larger & larger veins →
 - Renal vein →
 - Inferior vena cava →

Urine Formation



- **Urine is formed by three processes:**
 - Glomerular filtration: causes water & dissolved substances to move from capillaries (glomerulus) into tubules
 - Tubular reabsorption: causes water & select substances to move from the tubules into the peritubular capillaries
 - Tubular secretion: causes the small amounts of specific substances to move from the peritubular capillaries into the tubules

Urine Formation



- Urine formation begins in the glomerulus & Bowman's capsule
- Glomerular filtration causes water & dissolved substances to move from the glomerulus into the Bowman's capsule
- This occurs because the blood pressure in the glomerulus is higher than the pressure in the Bowman's capsule
- The walls of the glomerulus contain pores & act like a strainer
- The size of the pore determines what moves across the wall from the glomerulus into Bowman's capsule
- Water, sodium, potassium, chloride, glucose, uric acid & creatinine move through the pores easily
- The amount of these substances that moves through is dependent upon the levels in the plasma
- RBC's & proteins do not fit so they do not move through
- The water & dissolved substances are called glomerular filtrate

Urine Formation



- **Glomerular filtration rate (GFR) refers to the rate at which the glomerular filtration occurs**
- **The amount of filtrate formed in 24 hours is 45 gallons**
- **However, We only excrete 1.5 liters/day**
- **This is because the body reabsorbs the filtrate**

Urine Formation



- Tubular reabsorption is the reabsorption of filtrate by the kidneys which is returned to circulation
- It is the process by which water & dissolved substances move from the tubules into the blood of the peritubular capillaries
- Most reabsorption occurs in the proximal convoluted tubule
- The kidney determines what is excreted & what is reabsorbed:
 - ✦ Creatine is not reabsorbed
 - ✦ 50% of urea is absorbed
 - ✦ All of glucose is reabsorbed
 - ✦ 99% of water & sodium are reabsorbed
- Reabsorption occurs either passively or actively
 - ✦ Sodium is actively transported
 - ✦ Water & chloride passively follow sodium
- Diuretics affect sodium tubular reabsorption which causes water & sodium causing diuresis

Urine Formation



- **Tubular Secretion:**
 - Involves the active secretion of substances such as potassium, hydrogen ions, uric acid, ammonium ion & drugs from the peritubular capillaries into the tubules

Hormone Control of Water & Electrolytes



- Several hormones act on the kidneys to regulate water & electrolyte excretion
- Play important role in regulation of BP, blood volume & electrolyte composition of body fluids
- Include are:
 - ✦ Aldosterone
 - ✦ Antidiuretic Hormone (ADH)
 - ✦ Atrial Natriuretic Factor (ANF)
 - ✦ Parathyroid Hormone (PTH)

Hormone Control



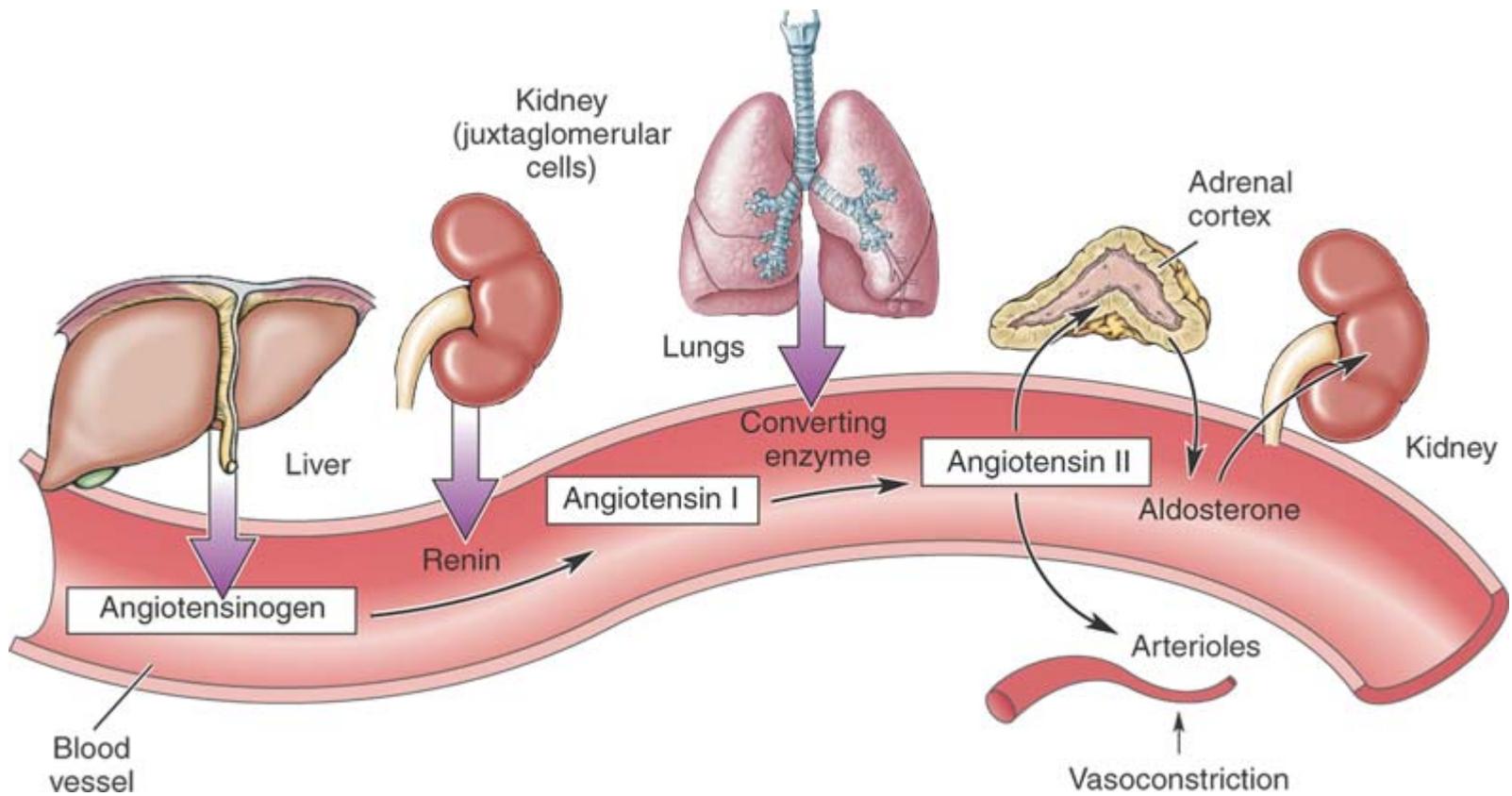
- **Aldosterone:**
 - Hormone secreted by the adrenal cortex
 - Acts on distal tubule
 - Stimulate the reabsorption of sodium & water & the excretion of potassium
 - It increases blood volume
 - Stimulus for aldosterone release is renin
 - Renin is an enzyme that initiates the renin-angiotensin-aldosterone system
 - Renin is secreted by juxtaglomerular apparatus in the afferent arterioles
 - Renin-secreting cells are stimulated by decrease in BP or blood volume

Hormone Control



- **Aldosterone**

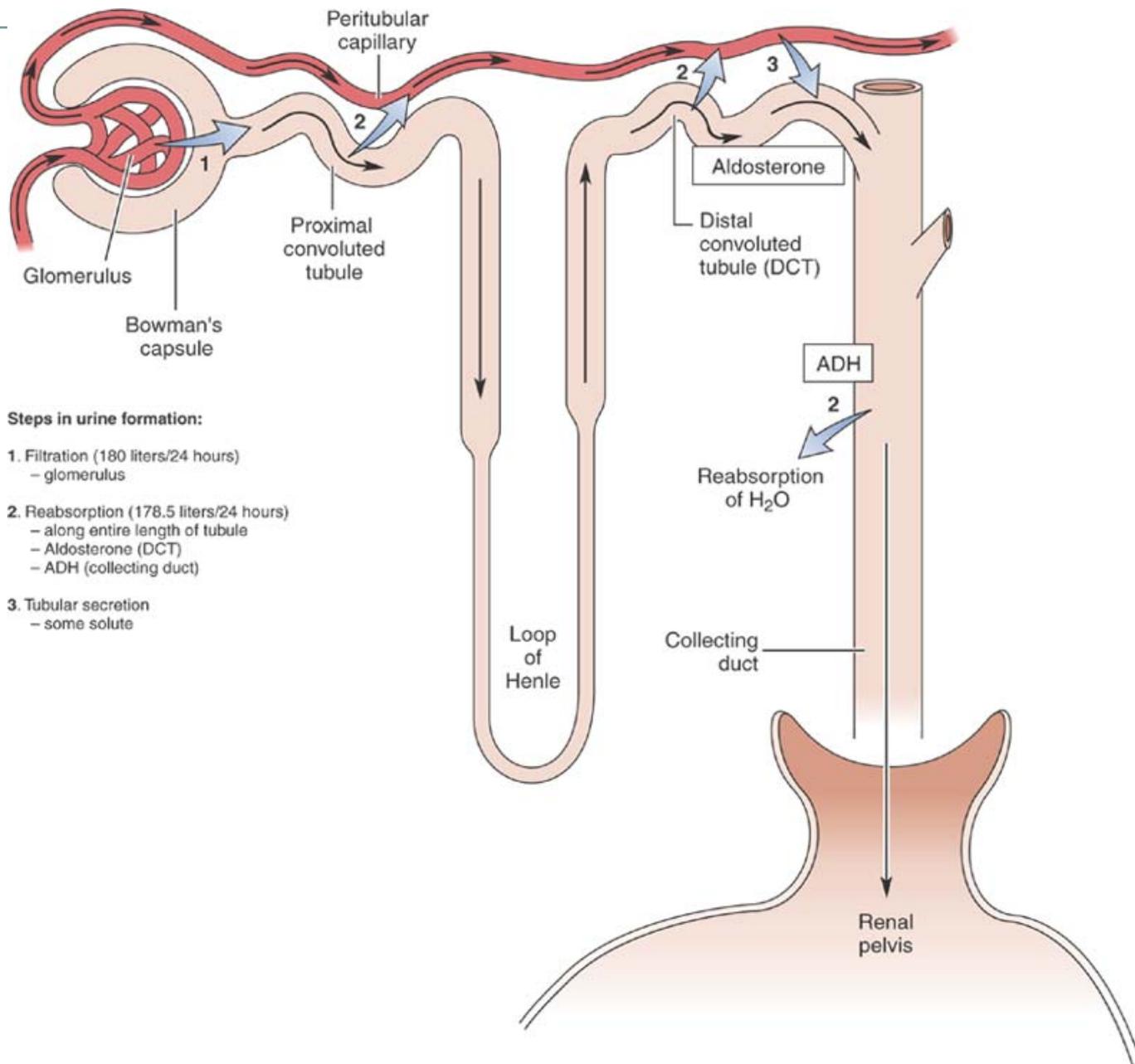
- Renin activates angiotensinogen (which is secreted by liver & circulates in the blood in its inactive form) to form angiotensin I
- A converting enzyme acts on the pulmonary capillaries to change angiotensin I to angiotensin II
- Angiotensin II stimulates the adrenal cortex to release aldosterone
- Aldosterone stimulates the distal tubule to reabsorb sodium & water & to excrete potassium
- Angiotensin II is also a potent vasopressor which causes vasoconstriction & increased BP
- Thus, this system regulates blood volume & blood pressure



Hormone Control



- **Antidiuretic Hormone:**
 - Affects water reabsorption
 - Action allows kidneys to concentrate urine
 - Secreted by the posterior pituitary gland
 - Works on the collecting ducts by determining permeability to water
 - In presence of ADH, the collecting ducts become permeable to water so water is reabsorb from the collecting duct into the peritubular capillaries which decreases the excretion of water causing highly concentrated urine excretion
 - In the absence of ADH, the water cannot be reabsorbed resulting in dilute urine
 - Stimulation of ADH comes from decrease in blood volume & increase in the concentration of solutes in plasma
 - So an decrease in blood volume & increase blood concentration causes release of ADH
 - Increase in blood volume
 - Affects blood volume & BP



Steps in urine formation:

- 1. Filtration (180 liters/24 hours)**
 - glomerulus
- 2. Reabsorption (178.5 liters/24 hours)**
 - along entire length of tubule
 - Aldosterone (DCT)
 - ADH (collecting duct)
- 3. Tubular secretion**
 - some solute

Hormone Control



- **Atrial Natriuretic Factor**
 - Causes the excretion of sodium
 - Called natriuresis
 - ANF is secreted by the walls of the atria in response to an increase in the volume of blood
 - ANF decreases the secretion of aldosterone by the adrenal cortex which decreases sodium & water reabsorption
 - ANF has the opposite effects of aldosterone & ADH

Hormone Control



- **Parathyroid Hormone:**
 - Secreted by the parathyroid glands
 - Plays important role in the regulation of 2 electrolytes, calcium & phosphate
 - PTH stimulates the renal tubules to reabsorb calcium & to excrete phosphate
 - The excretion of phosphate is called phosphaturic effect
 - Stimulus for the release of PTH is low plasma levels of calcium

Composition of Urine



- Urine is a sterile fluid composed of water (95%), urea, uric acid, ammonia, creatinine & electrolytes
- The color is the result of urochrome which is a pigment formed from the breakdown of hemoglobin in the liver
- Specific gravity is the ratio of solute to volume
- Normal specific gravity is 1.001 to 1.035
- The more solute the higher the specific gravity
- Dehydration will increase specific gravity
- Dilute urine results in decrease in specific gravity

Renal Failure

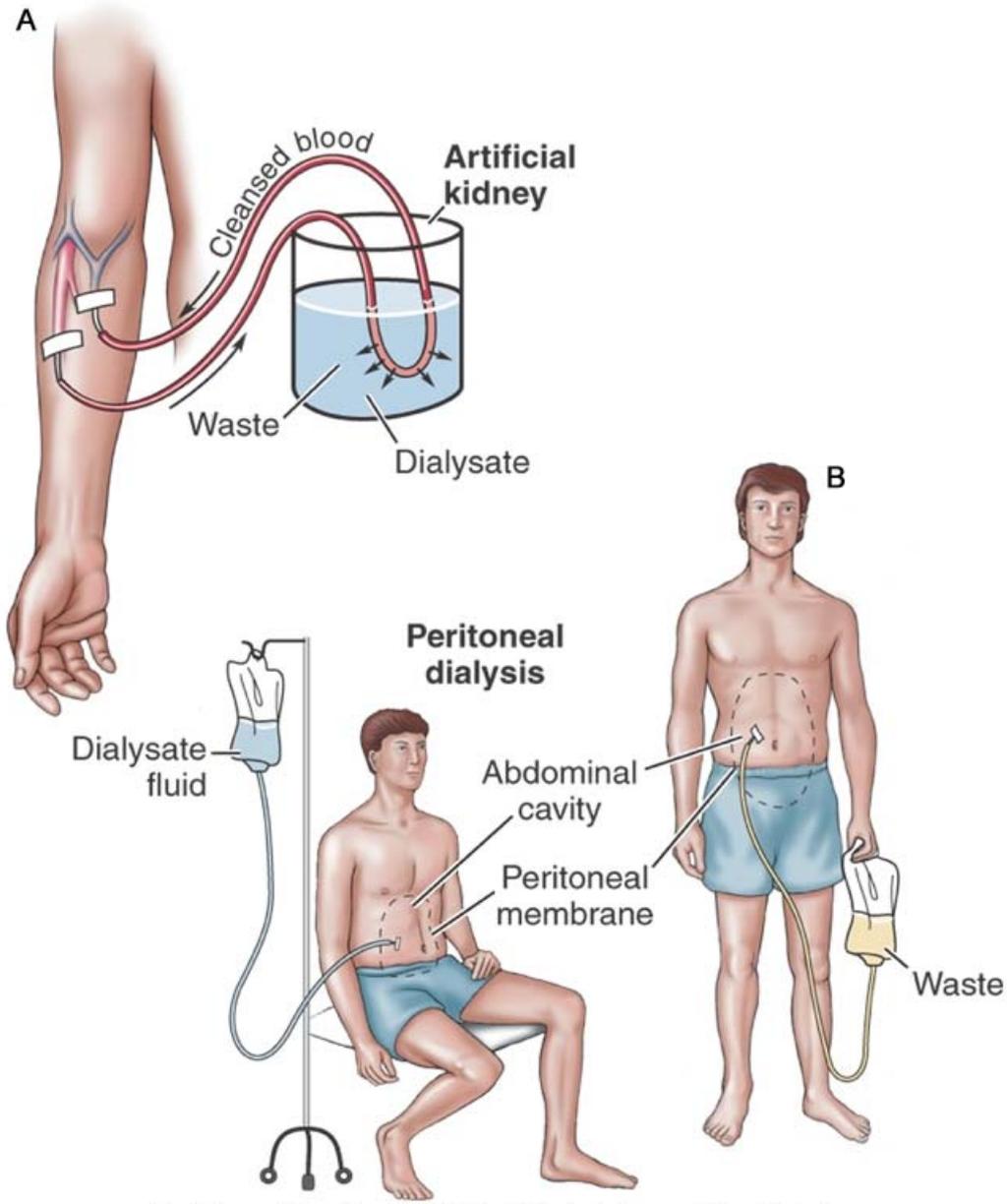


- Renal failure occurs when the kidneys no longer make urine
- The result is the blood is not cleansed of its waste so they remain in the blood causing uremia
- Uremia requires an artificial kidney in the form of dialysis
- The patients blood is passed through a cylinder containing tiny tubes immersed in dialysate
- The dialysate cleanses the blood of waste products & the blood is then returned to the patient

Renal Failure



- Another procedure used in renal failure is peritoneal dialysis
- The peritoneal cavity is infused with dialysate
- The waste diffuse from the blood into the dialysate & then the dialysate is drained & discarded



Urinary Tract



- Urinary system is composed of structures that compose the urinary tract
- These structures simply store or conduct urine from the kidney to outside the body
- The urinary tract is comprised of:
 - Inner layer is a mucous membrane
 - Middle layer is smooth muscle
 - Outer layer is connective tissue
- Structures include:
 - Ureters
 - Urinary bladder
 - Urethra

Urinary Tract

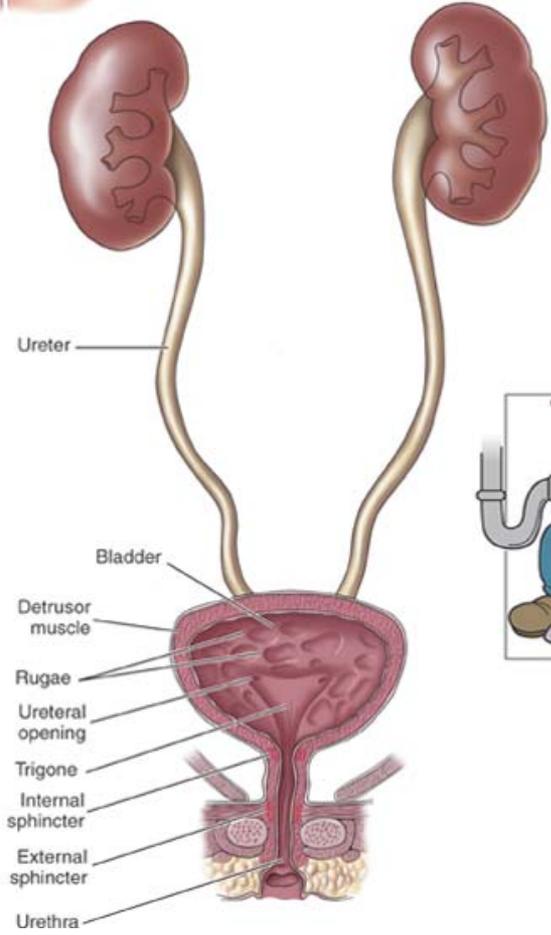
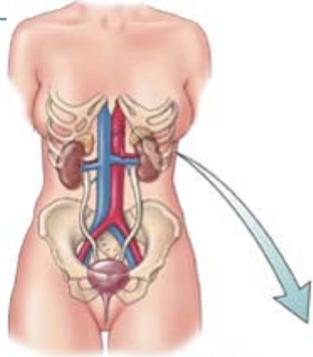


- **Ureters:**
 - Two ureters connect the kidneys to the bladder
 - The ureters originate in the pelvis of the kidneys & terminate in the bladder
 - 10-13 inches in length
 - They are slender muscular tubes that propel urine by peristalsis & gravity

Urinary Tract



- **Urinary Bladder**
 - Temporary reservoir to store urine
 - When empty it is located behind symphysis pubis
 - When full it extends into the abdominal cavity
 - Made up of 4 layers:
 - ✦ Innermost is mucous membrane with transitional epithelium
 - ✦ Second layer is submucosa is made of connective tissue & elastic fibers
 - ✦ Third layer is smooth muscle called detrusor muscle
 - ✦ Outermost layer of upper is serosa & lower portion is covered by connective tissue
 - Bladder wall is made up of rugae which are folds that allow the bladder to expand & stretch
 - The urge to urinate usually occurs when 200ml have accumulated
 - Trigone is a triangular area of the bladder which forms as the entrance point for two ureters & the exit point for the urethra
 - The exit of the bladder contains the internal sphincter which is composed of smooth muscle that contracts involuntarily to prevent emptying
 - The external sphincter surrounds the upper region of the urethra, is composed of voluntary skeletal muscle & contraction allows us to resist urination



Urination



- **Urination:**
- **AKA micturition or voiding**
- **Process of expelling urine from the bladder**
- **As the bladder fills, stretch receptors are stimulated sending a nerve impulse through sensory nerves to the spinal cord; the spinal cord sends reflex motor nerve impulse back to the bladder causing the bladder wall to contract rhythmically & the internal sphincter relaxes**
- **Called micturition reflex**
- **The reflex gives rise to a sense of urgency & the external sphincter prevents involuntary urination**
- **Inability to empty bladder is urinary retention**

Urinary Tract



- **Urethra:**

- Tube that carries urine from the bladder to the outside
- Lined with mucous membrane that contains numerous mucus-secreting glands
- The muscular layer of the urethra contracts & helps to express urine during urination
- Males urethra is about 8 inches & is part of the reproductive system as well
- Female urethra is about 1.5 inches
- The opening of the urethra to the outside is called the urethral meatus