

Inquiry into Life

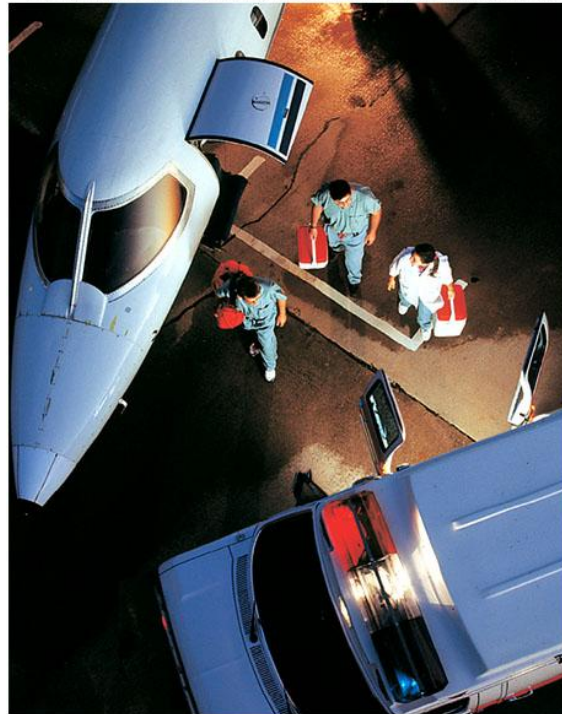
Eleventh Edition

Sylvia S. Mader

Chapter 16 Lecture Outline

Prepared by: Wendy Vermillion
Columbus State Community College

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16.1 The urinary system

- Functions

- Excretion of metabolic wastes

- Nitrogenous wastes

- Urea

- » By-product of amino acid metabolism

- » Ammonia from liver combines with carbon dioxide to form urea

- » Less toxic than ammonia

- Creatinine

- » By-product of creatine phosphate breakdown

- Uric acid

- » By-product off breakdown of nucleotides

- » Build up causes gout

The urinary system cont'd.

- Functions cont'd.

- Maintenance of water-salt balance

- Blood volume is associated with salt balance
 - Salts cause osmosis into the blood
 - The more water the higher the blood pressure
 - Kidneys play role in blood pressure regulation through water and salt regulation
 - Regulates potassium, bicarbonate, and calcium ions also

- Maintenance of acid-base balance

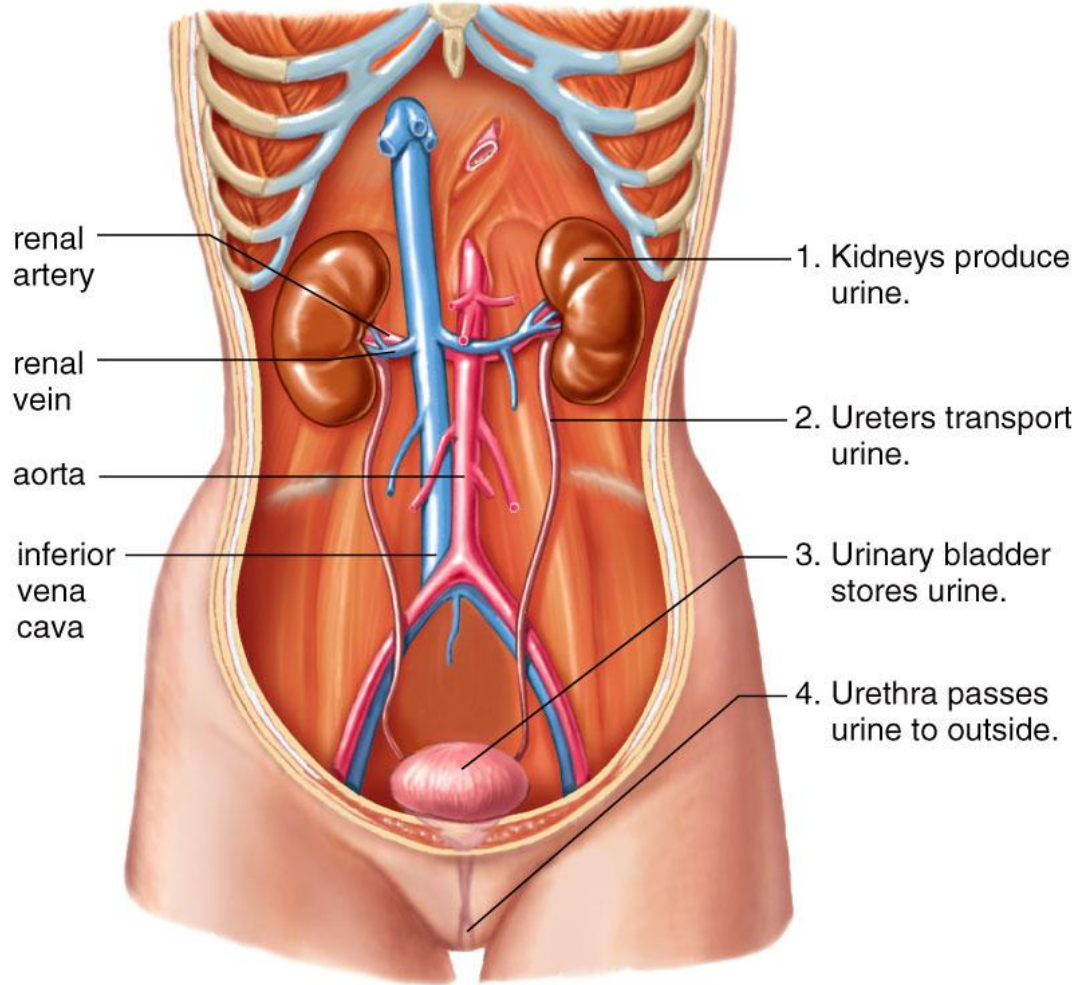
- Excretion of hydrogen ions and reabsorption of bicarbonate
 - Urine pH is normally around 6 due to high acid diet

The urinary system

- Functions cont'd.
 - Secretion of hormones
 - Renin
 - Leads to aldosterone release from adrenals
 - » Reabsorption of sodium ions
 - Erythropoetin
 - Stimulates red blood cell production
 - Activates vitamin D for calcium absorption

The urinary system

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• Fig. 16.1

The urinary system cont'd.

- Urinary organs

- Kidneys

- Located in lumbar region
 - Behind peritoneum
 - Covered by tough capsule
 - Concave side-hilus
 - Location of renal artery and vein

- Ureters

- Conduct urine from kidney to bladder
 - 3 layered wall
 - Mucosa, smooth muscle, outer connective tissue
 - Conveys urine by peristalsis

The urinary system cont'd.

- Urinary organs cont'd.
 - Urinary bladder
 - Stores urine
 - Expandable
 - Middle layer of circular muscle
 - 2 layers of longitudinal muscle
 - Lined with transitional epithelium
 - 2 sphinctors in bladder neck
 - Internal sphinctor-smooth muscle
 - » Involuntary control
 - External sphinctor- skeletal muscle
 - » Voluntary control

The urinary system cont'd.

- Urinary organs cont'd.
 - Urethra
 - Conducts urine out of body
 - Very short in females
 - Increases likelihood of urinary tract infection
 - Males
 - Prostate associated with urethra
 - Common pathway for reproductive and urinary tracts

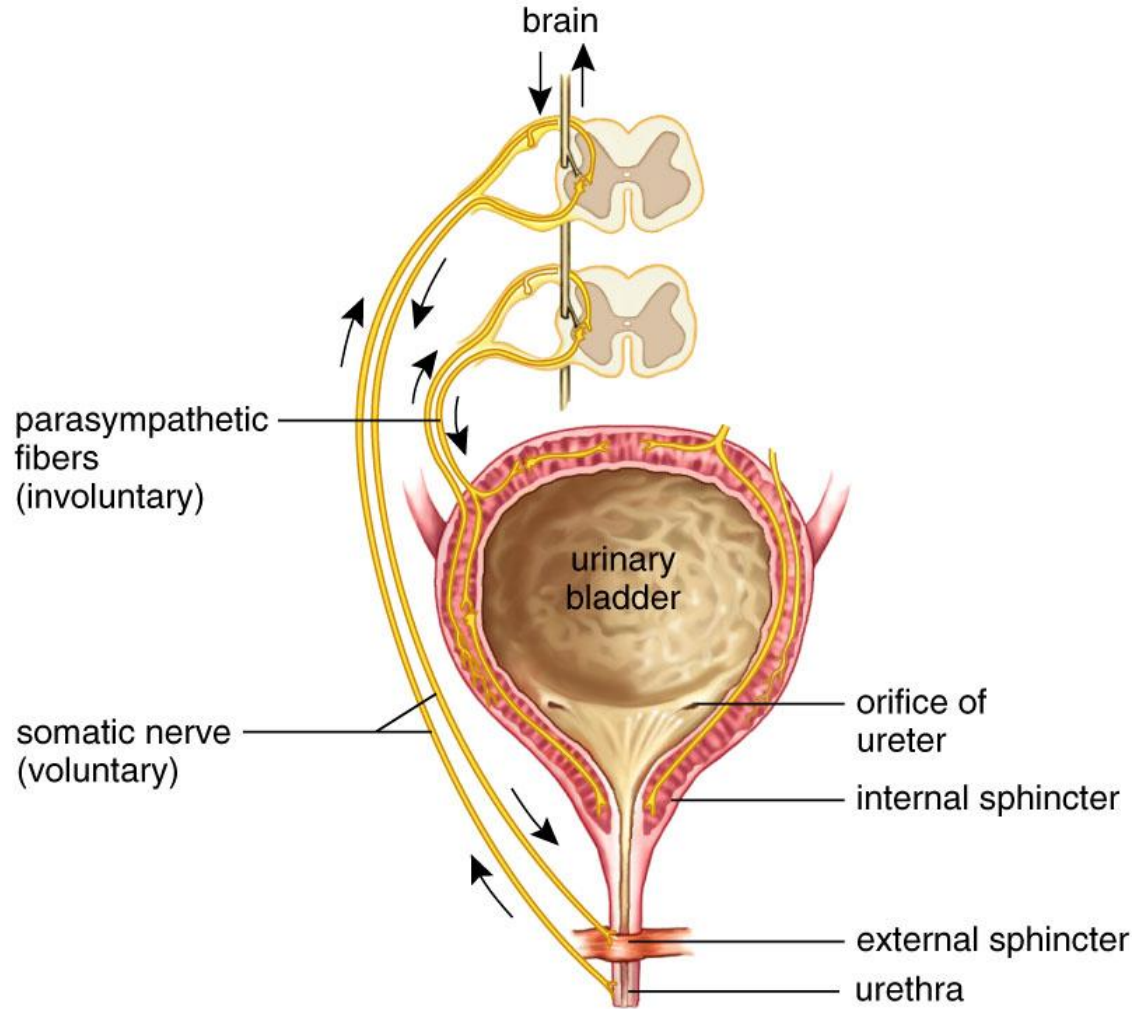
The urinary system cont'd.

- **Urination**

- Stretch receptors in wall of bladder
 - Send impulses when bladder fills to 250 ml
 - Motor impulses from spinal cord
 - Bladder contraction
 - Micturition occurs
- Micturition reflex can be over-ridden by brain in adults and older children
 - Can delay urination til appropriate

Urination

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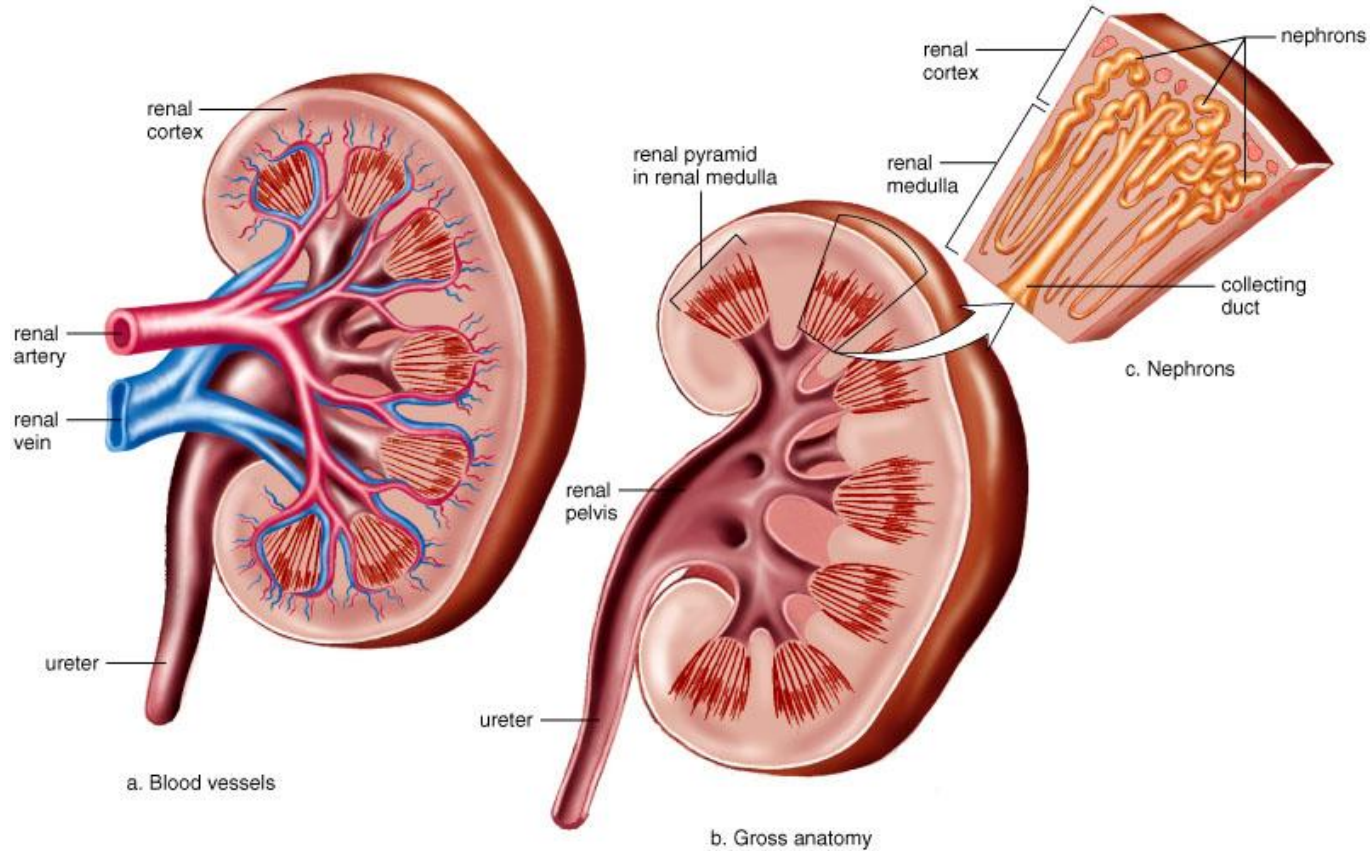
• Fig. 16.2

16.2 Anatomy of the kidney

- **Anatomy of a nephron**
 - Functional unit of kidney
 - Approximately one million nephrons
 - each composed of a system of tubules
 - Each has its own blood supply
 - From renal artery, afferent arteriole leads into glomerulus
 - » Glomerulus-specialized capillaries
 - » Blood leaves glomerulus by efferent arteriole
 - Efferent arteriole takes blood to peritubular capillaries
 - » Surround rest of the nephron
 - » Blood then goes to renal vein

Gross anatomy of the kidney

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- Fig. 16.3

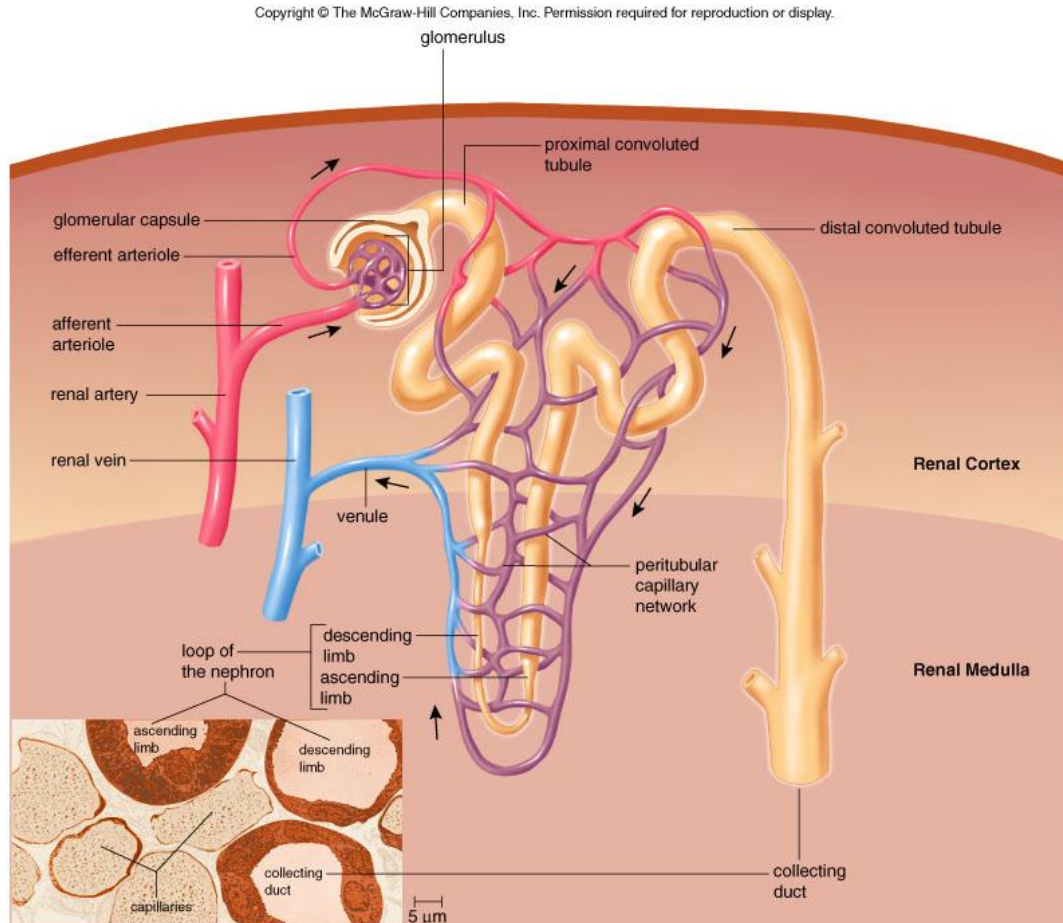
The urinary system cont'd.

- Anatomy of a nephron cont'd.
 - Nephron parts
 - Glomerular capsule (Bowman's)
 - Cuplike structure
 - Inner layer has podocytes
 - » Specialized cells
 - Proximal convoluted tubule-PCT
 - cells with microvilli
 - » Increased surface area for absorption

The urinary system cont'd.

- **Anatomy of a nephron cont'd.**
 - **Loop of Henle**
 - U-shaped tube
 - Simple squamous epithelium
 - 80% of nephrons have short loops
 - 20% have long loops of Henle
 - **Distal convoluted tubule-DCT**
 - Cuboidal epithelial cells
 - No microvili
 - DCT's of several nephrons enter one collecting duct
 - **Collecting ducts empty into renal pelvis**
 - Glomerular capillaries and convoluted tubules lie within cortex of kidney
 - Long loops of Henle extend into medulla

Nephron anatomy



- Fig. 16.4

The urinary system cont'd.

- Urine formation

- Glomerular filtration

- Blood enters glomerulus from afferent arteriole
 - Has a high hydrostatic (blood) pressure
 - Water and small molecules filtered into glomerular capsule

Filtered	not filtered
Water	blood cells
Nitrogenous wastes	plasma proteins
Salts (ions)	

Reabsorption from nephrons

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TABLE 16.1 REABSORPTION FROM NEPHRONS

Substance	Amount Filtered (per day)	Amount Excreted (per day)	Reabsorption (%)
Water, L	180	1.8	99.0
Sodium, g	630	3.2	99.5
Glucose, g	180	0.0	100.0
Urea, g	54	30.0	44.0

L = liters, g = grams

- Table 16.1

The urinary system cont'd.

- Urine formation

- Glomerular filtration cont'd.

- Glomerular filtrate

- Composed of same substances as blood plasma minus the cells and large plasma proteins

- Remaining processes must reabsorb desirable substances and allow wastes to pass

- Tubular reabsorption

- 80% of filtrate reabsorbed in PCT

- Both active and passive

- Sodium reabsorbed by active transport

- Chloride follows passively

- Water absorbed by osmosis

The urinary system cont'd.

- Tubular reabsorption cont'd.

- Nutrients reabsorbed

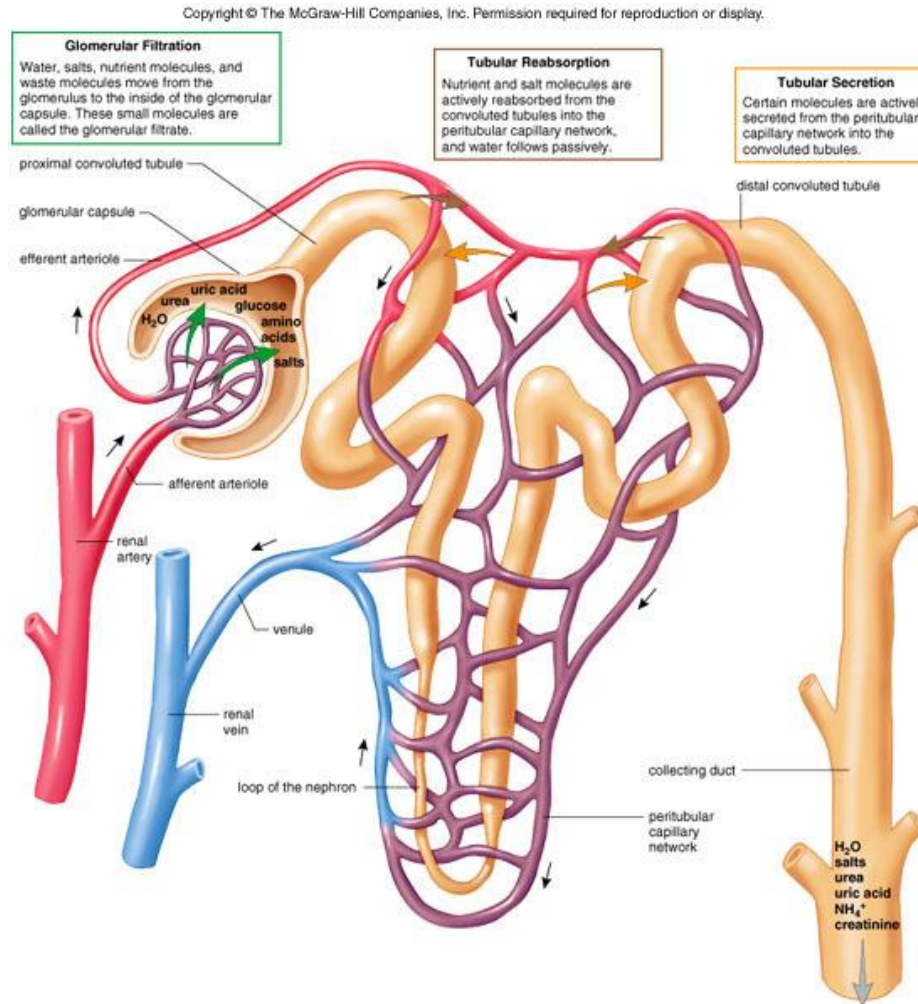
- Glucose- 100% up to maximum allowed by carriers
 - As reabsorbed levels reach 2 mg/ml plasma, excess lost in urine
 - Not enough carriers available to pick it up
- Amino acids

Reabsorbed	Not reabsorbed
Most water	Some water
Nutrients	Nitrogenous wastes
Required salts	Excess salts

The urinary system cont'd.

- Tubular secretion
 - Hydrogen ions, potassium, creatinine, many drugs
 - Active transport from blood of peritubular capillaries
- Urine contains
 - Filtered substances that have not been reabsorbed
 - Substances that have been actively secreted

Processes in urine formation



- Fig. 16.5

16.3 Regulatory functions of the kidneys

- Reabsorption of water

- Excretion of hypertonic depends on reabsorption of water from collecting ducts
 - Reabsorption of water requires
 - #1. Reabsorption of salt
 - #2. Establishment of solute gradient
 - #3. Water reabsorbed by osmosis down gradient
- #1. **Reabsorption of salt**
 - Usually 99% of sodium filtered is reabsorbed
 - 67% by PCT
 - 25% by ascending limb of loop of Henle
 - The rest by DCT and collecting duct

Regulatory functions of the kidneys cont'd.

- Reabsorption of water
 - #1. Reabsorption of salt cont'd.
 - Hormonal regulation of salt reabsorption
 - Aldosterone
 - » From adrenal glands
 - » Promotes excretion of potassium and reabsorption of sodium

Regulatory functions of the kidneys cont'd.

- Reabsorption of water
 - #1. Reabsorption of salt cont'd.
 - Renin-angiotensin mechanism
 - » Angiotensin causes vasoconstriction and aldosterone release
 - » Aldosterone increases sodium reabsorption
 - » This increases water reabsorption by osmosis
 - » Blood pressure and volume increase

Regulatory functions of the kidneys cont'd.

- Reabsorption of water cont'd.
 - #2. Establishment of a solute gradient
 - Long loop of Henle has 2 parts
 - Descending limb and ascending limb
 - Salt diffuses out of lower part of ascending limb
 - Upper part of ascending limb actively transports more salt out
 - Creates high osmotic pressure (high solute concentration) in medullary tissue
 - Urea contributes to high solute concentration in medulla
 - Leaks from lower collecting duct
 - End result- concentration gradient favoring reabsorption of water

Regulatory functions of the kidneys cont'd.

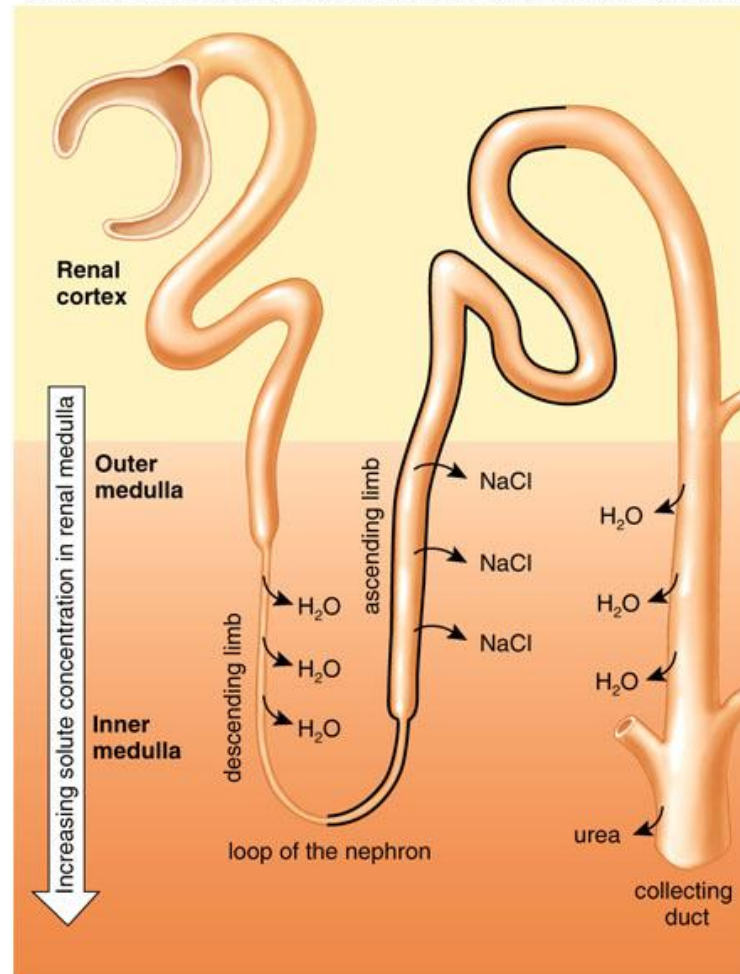
- Reabsorption of water
 - #3. Reabsorption of water
 - Water leaves DCT because of gradient
 - Water also leaves descending limb of loop of Henle
 - Countercurrent multiplier
 - As filtrate enters collecting duct it is isotonic to cells of renal cortex
 - Same tonicity as plasma
 - As filtrate passes down collecting duct it again encounters high osmotic gradient
 - Permeability of collecting duct under hormonal control

Regulatory functions of the kidneys cont'd.

- #3 Reabsorption of water cont'd.
 - Hormonal control of collecting duct permeability
 - Hemoconcentration-blood too concentrated in solutes
 - Posterior pituitary releases ADH (antidiuretic hormone)
 - » Increases permeability of collecting duct to water
 - » More water is reabsorbed from filtrate (urine)
 - » Small volume of hypertonic urine produced
 - Hemodilution-blood too diluted
 - ADH shut off
 - Collecting duct decreases permeability to water
 - More water lost in urine
 - High volume of dilute urine produced

Reabsorption of water at the loop of Henle and collecting duct

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- Fig. 16.7

Regulatory functions of the kidneys cont'd.

- **Diuretics**
 - Increase flow of urine
 - **Alcohol**
 - Shuts off ADH
 - Dehydration causes hangover
 - **Caffeine**
 - Increases glomerular filtration rate
 - Decreases tubular reabsorption of sodium
 - **Diuretic drugs**
 - Many inhibit active transport of sodium at loop of Henle or DCT

Regulatory functions of the kidneys cont'd.

- Acid-base balance
 - Acid-base buffer systems
 - Chemical or combination of chemicals
 - Can take up excess H^+ or OH^-
 - Prevents big changes in pH

Regulatory functions of the kidneys cont'd.

- **Kidneys in pH regulation**
 - Only kidneys can remove many acids and bases
 - Slower acting than respiratory system but more powerful
 - Reabsorbs bicarbonate ions
 - Excretes hydrogen ions
 - In urine ammonia can absorb hydrogen ions
 - Phosphate can also do so

16.4 Problems with kidney function

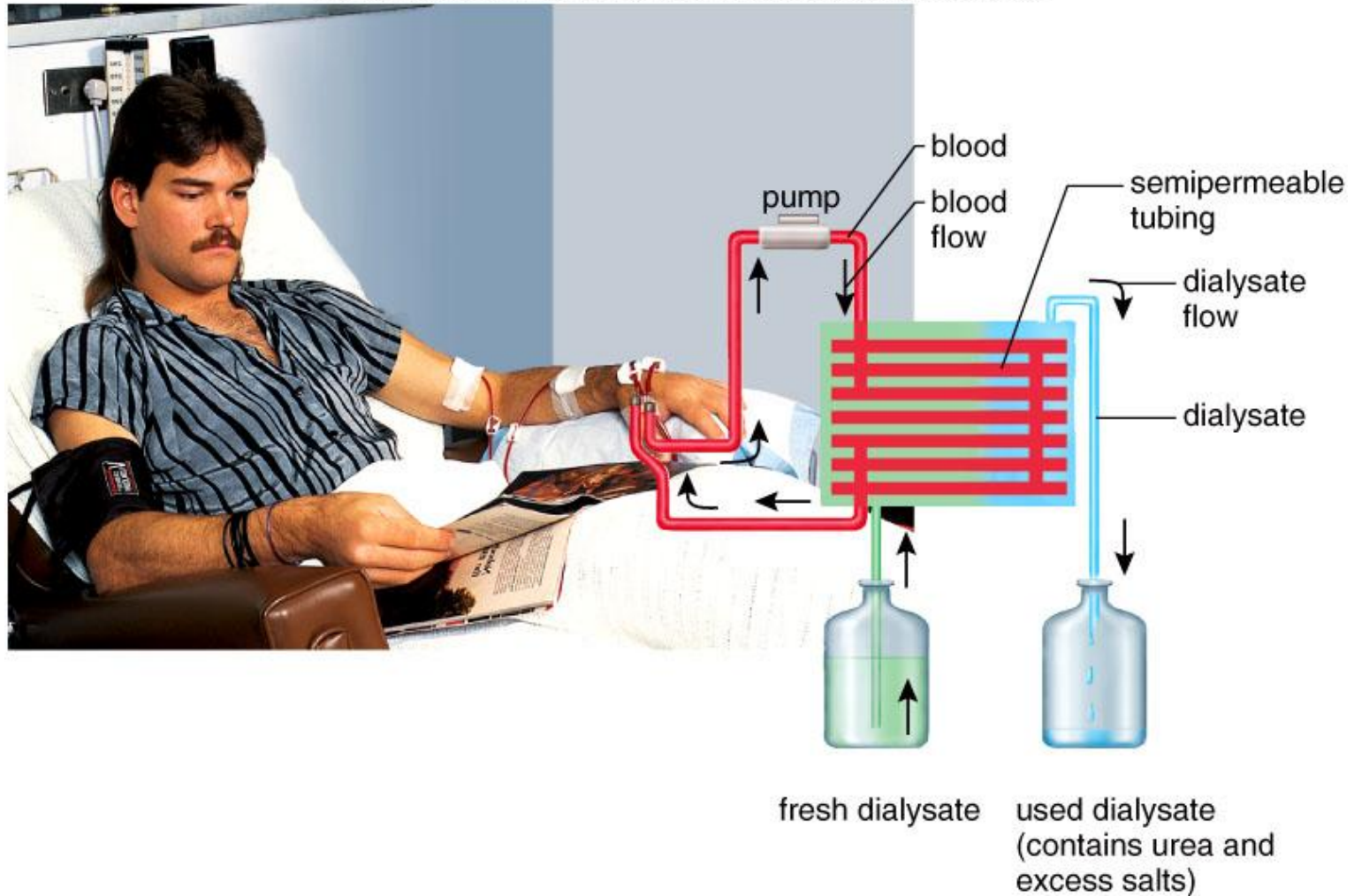
- **Illnesses**
 - **Diabetes, hypertension, inherited conditions**
 - All cause progressive renal disease
 - **Urethritis**-inflammation of urethra
 - **Cystitis**-inflammation of bladder
 - **Pyelonephritis**- infection of kidneys
 - **Kidney stones**
 - UTI, enlarged prostate, pH imbalance, ingestion of too much calcium
 - All can predispose to kidney stones
 - **Signs of kidney disease**
 - Albumin in urine
 - uremia

Problems with kidney function cont'd.

- **Hemodialysis**
 - Artificial kidney machine or continuous ambulatory peritoneal dialysis
 - Dialysis
 - Diffusion of dissolved molecules through a membrane
 - Selective permeability
 - Blood is cleansed
 - pH is adjusted
 - Water and salt balance maintained
 - In CAPD the peritoneum is the dialysis membrane
- **Replacing a kidney**
 - 97% success if from a relative

An artificial kidney

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- Fig. 16.9