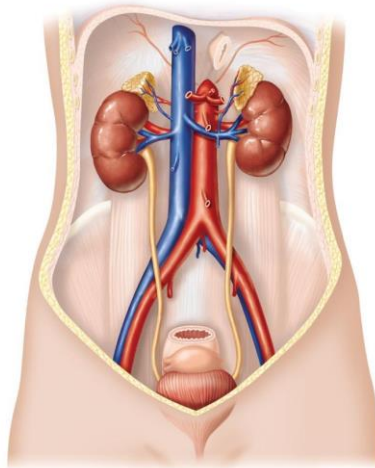
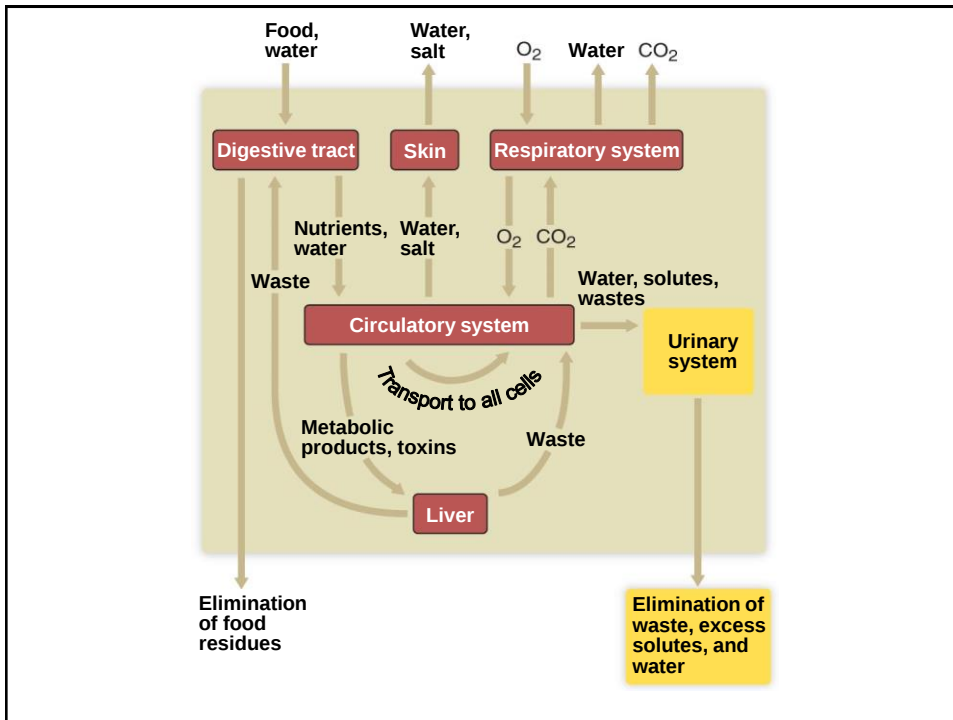


The Urinary System



Urinary System Contributes to Homeostasis

- Excretion: processes that remove wastes and excess materials from the body
 - **Digestive system**: excretes food residues and wastes produced by the liver
 - **Respiratory system (lungs)**: excrete carbon dioxide
 - **Integumentary system (skin)**: excretes water, salt
 - **Urinary system (kidneys)**: excrete nitrogenous wastes, excess solutes, and water



Urinary System Contributes to Homeostasis

- Kidneys regulate body water levels
 - Excess water is excreted
 - Output varies from 2-1/2 liter/day to 1 liter/hour
- Kidneys regulate nitrogenous wastes and other solutes
 - Nitrogen from amino acids is made into urea in liver and transported to kidney as waste
 - Other solutes regulated by kidneys
 - Sodium, chloride, potassium, calcium, hydrogen ions, creatinine

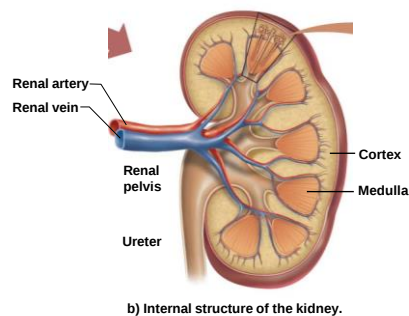
Table 15.1 Sources of water gain and loss per day

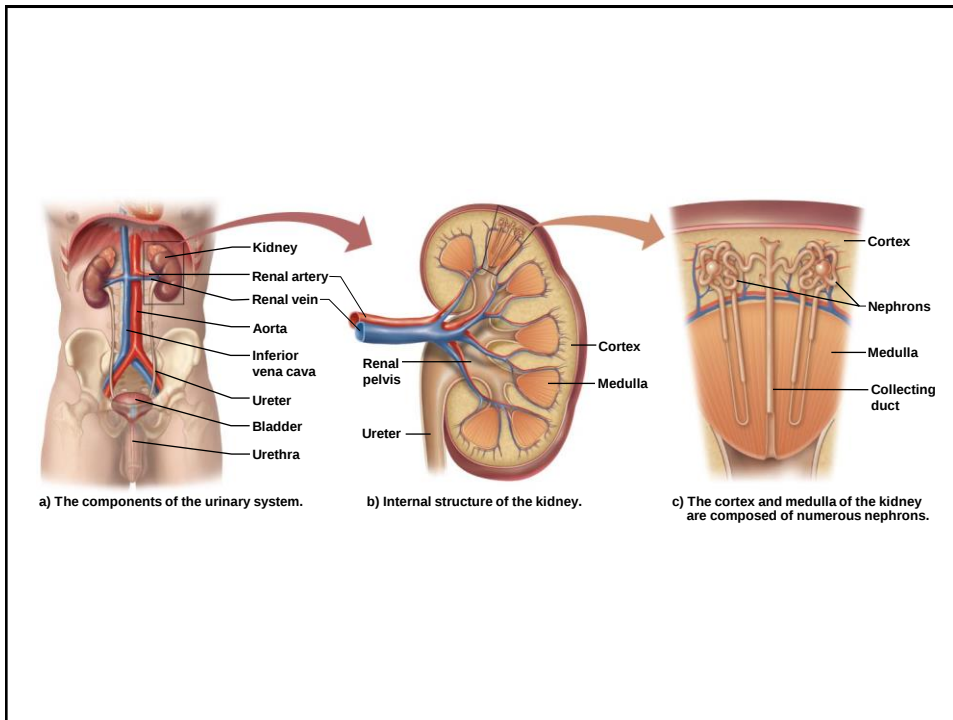
Water gain (ml/day)		Water loss (ml/day)	
Drinking fluids	1,000	Urine	1,500
Water in food	1,200	Evaporative loss (lungs)	500
Metabolic production	300	Evaporative loss (skin)	350
		Feces	150
Total	2,500	Total	2,500

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Organs of the Urinary System

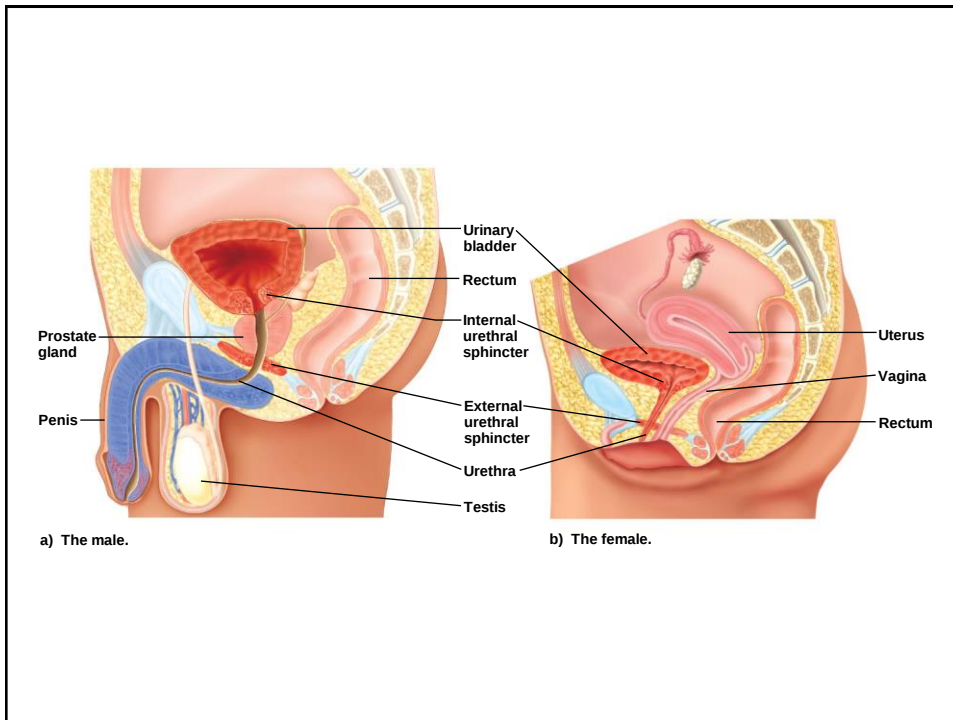
- Kidneys
 - Principal organ of urinary system
 - Cortex
 - outer portion of the kidney
 - Medulla
 - inner region of the kidney





Organs of the Urinary System

- Ureters
 - Transport urine from kidneys to bladder
- Urinary bladder
 - Stores urine (600–1,000 ml)
- Urethra
 - Carries urine from body
 - Two sphincters control urination



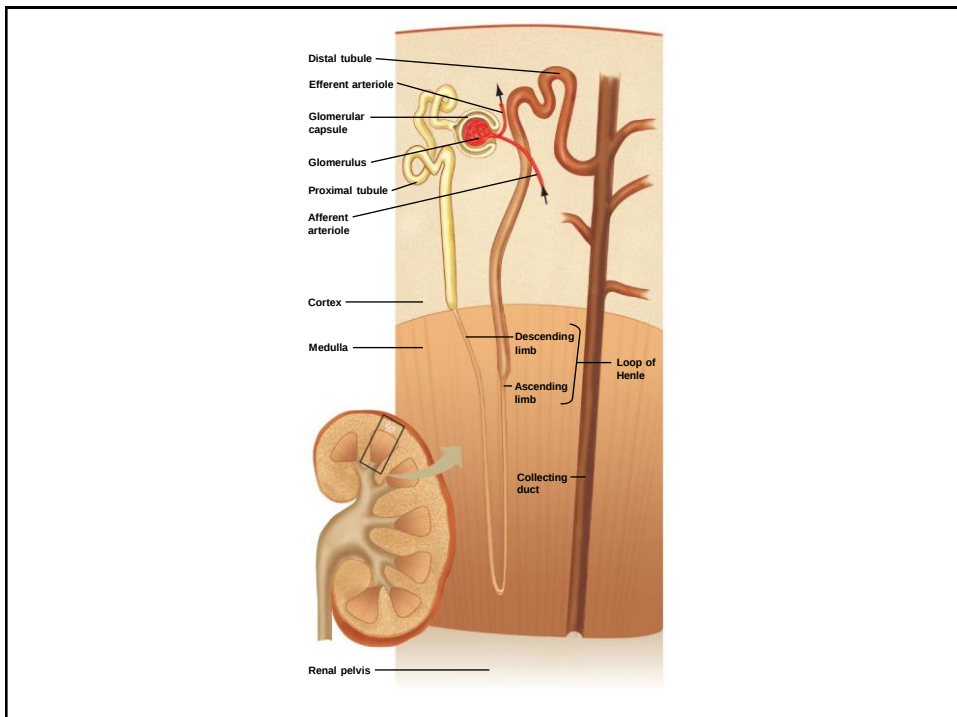
Nephrons Produce Urine

- Nephron: functional unit of the kidney
- ~1 million nephrons per kidney
- Each nephron consists of a long thin hollow tube (tubule) plus associated blood supply
- Role of nephrons
 - remove approximately 180 liters of fluid from the blood daily
 - return most of the fluid, minus the wastes that are excreted

Tubule Filters Fluid and Reabsorbs Substances

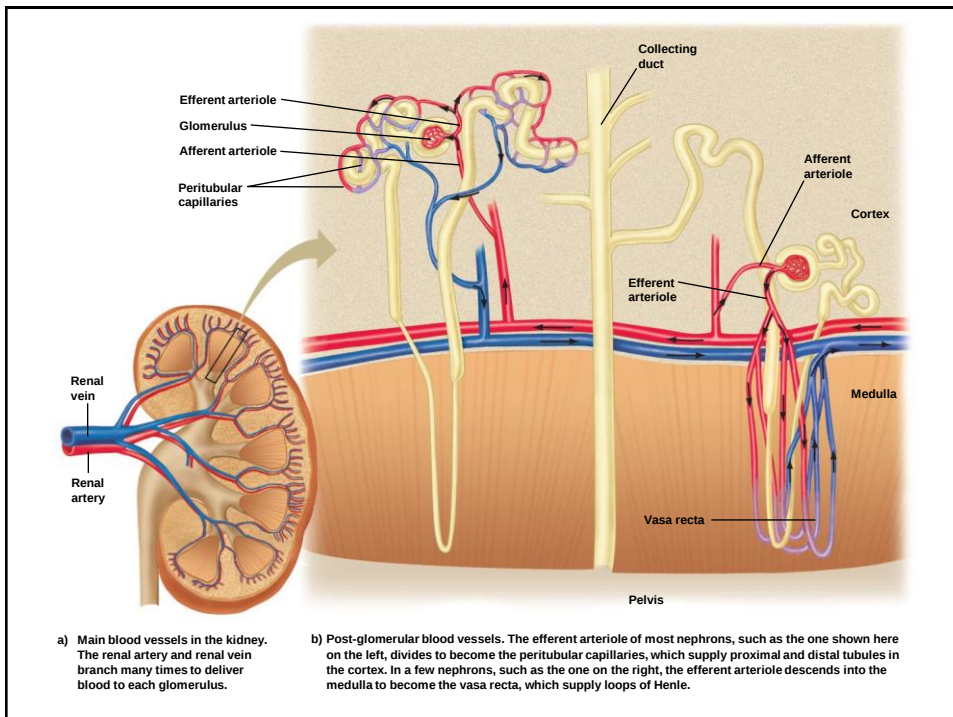
Nephron structure

- **Glomerular capsule**
 - cuplike end of nephron tubule surrounding glomerulus (network of capillaries)
 - This is where filtration occurs
- **Proximal tubule**
 - extends from glomerular capsule to renal medulla
- **Loop of Henle**
- **Distal tubule**
- **Collecting duct**
 - shared by several nephrons, empties into renal pelvis



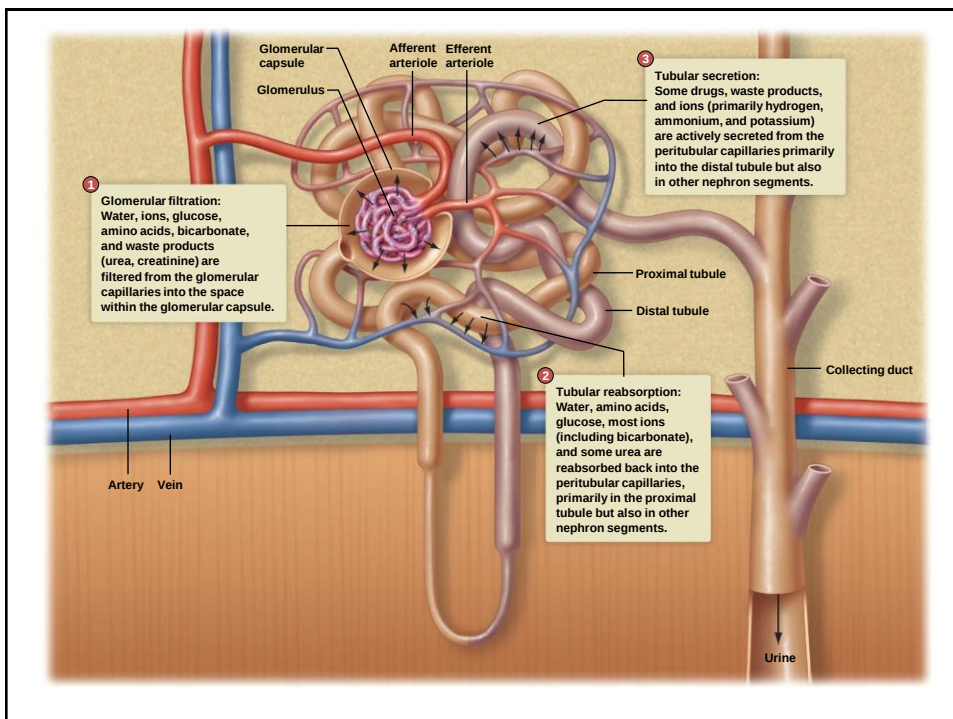
Special Blood Vessels Supply the Tubule

- Renal artery supplies the kidney
 - Arterioles
 - **Afferent**: enters the glomerular capsule
 - **Efferent**: leaves the glomerular capsule
 - Capillaries
 - **Glomerular**: network within the glomerular capsule
 - **Peritubular**: surround proximal and distal tubule
 - **Vasa recta**: parallels the loop of Henle



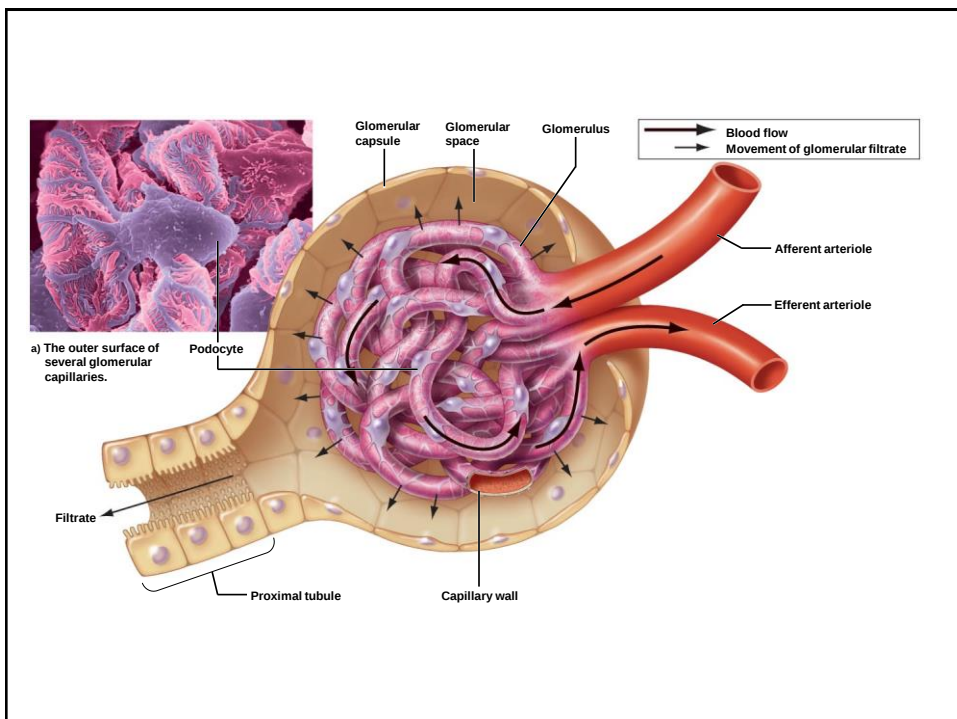
Formation of Urine: Three Basic Processes

- **Glomerular filtration**
 - movement of protein-free solution of fluid and solutes from blood into the glomerular capsule
- **Tubular reabsorption**
 - return of most of the fluid and solutes into the blood
- **Tubular secretion**
 - addition of certain solutes from the blood into the tubule



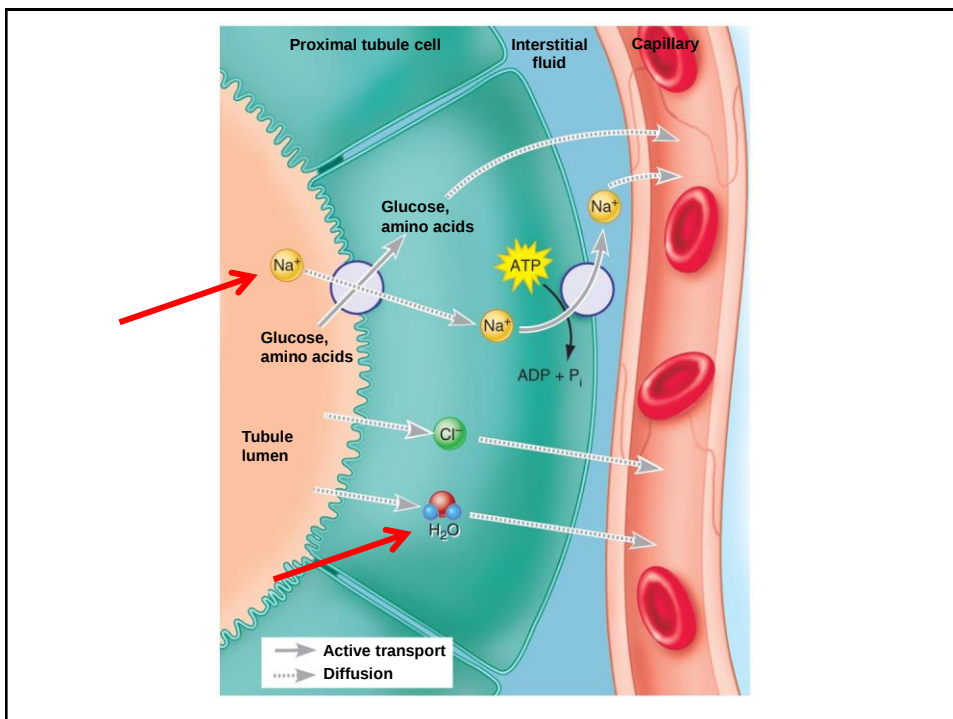
Glomerular Filtration Filters Fluid from Capillaries

- Filters protein-free plasma fluid from capillaries into glomerular capsule
- Large volume filtration, yet highly selective
 - Impermeable to large proteins and cells
- Filtration is driven by high blood pressure in glomerular capillaries
- Rate of filtration
 - Resting rate under local chemical control



Tubular Reabsorption Returns Filtered Water and Solutes to Blood

- 100% of filtered glucose, amino acids, and bicarbonate and 50% of urea are reabsorbed
- Most tubular reabsorption occurs in proximal tubule
- Reabsorption of sodium begins the process
 - Sodium moved by active transport from tubule cells to interstitial fluid and diffuses to capillaries
 - Movement of sodium provides energy to transport glucose and amino acids into renal tubule
 - Water reabsorbed with salts

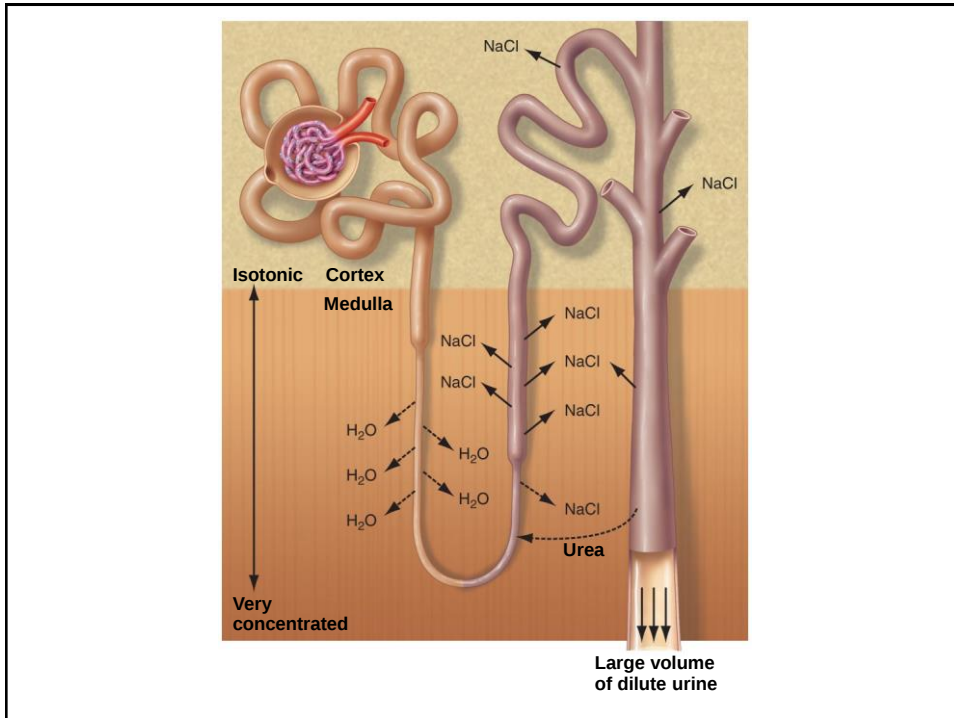


Tubular Secretion Removes Other Substances from Blood

- Involves the movement of materials from the peritubular capillaries or vasa recta to the tubule
- Purpose
 - Regulation of chemical levels in body
 - Excretion of harmful chemicals
- Substances secreted
 - Penicillin, cocaine, marijuana, pesticides, preservatives, hydrogen ions, ammonium, potassium

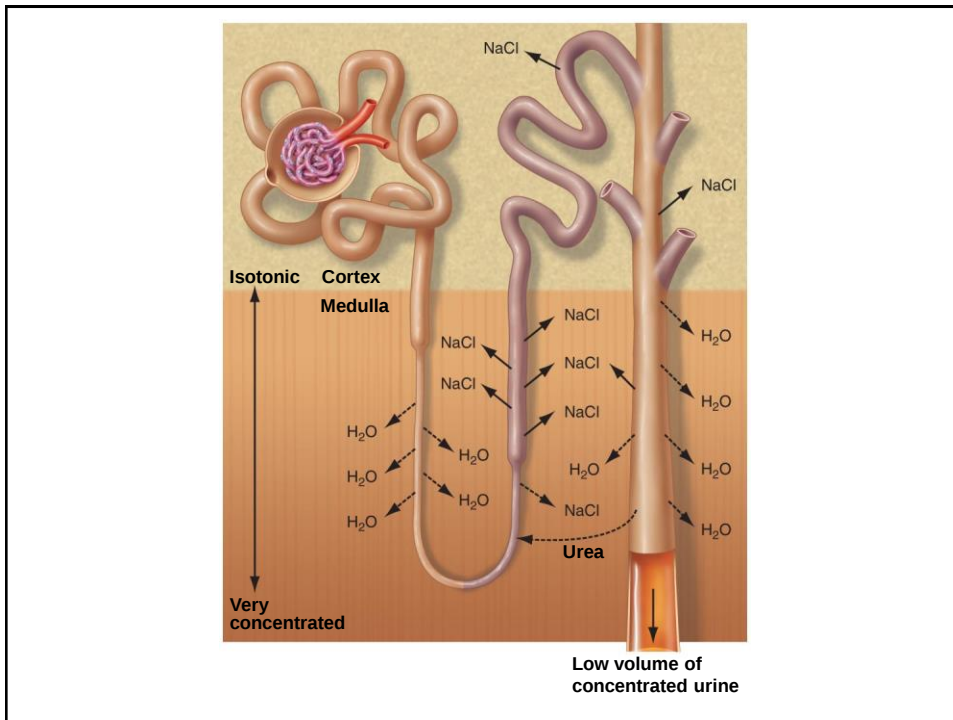
Producing Dilute Urine: Excreting Excess Water

- Kidneys respond to excess water by excreting it
- Mechanism
 - Distal tubule is impermeable to water
 - NaCl is reabsorbed without the concurrent reabsorption of water



Producing Concentrated Urine: Conserving Water

- Too little water can lead to lower blood volume, declining blood pressure, risk of dehydration of body cells
- Kidneys respond by conserving water and producing a more concentrated urine
- Mechanism
 - Mediated by ADH (antidiuretic hormone) from the posterior pituitary gland
 - ADH increases permeability of the collecting ducts to water and increases conservation of water



Urination Depends on a Reflex

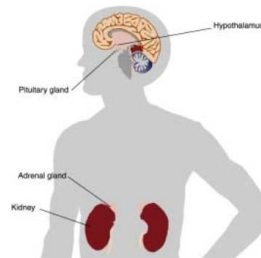
- Micturition reflex
 - Responds to stretch receptors in bladder wall
 - Internal urethral sphincter
 - Smooth muscle
 - External urethral sphincter
 - Skeletal muscle, under voluntary control
- Brain can override the micturition reflex and control the timing of urination
- Voluntary control becomes increasingly difficult as the bladder gets very full

Kidneys Maintain Homeostasis in Many Ways

- Maintain water balance
 - Adjust blood volume and blood pressure
- Aldosterone and renin help maintain salt balance in order to control blood volume
- Maintain acid-base balance and blood pH
- Regulate red blood cell production via erythropoietin (hormone)
- Activate an inactive form of vitamin D

Water Balance Determines Blood Volume and Blood Pressure

- Involves the kidneys, hypothalamus, and posterior pituitary gland



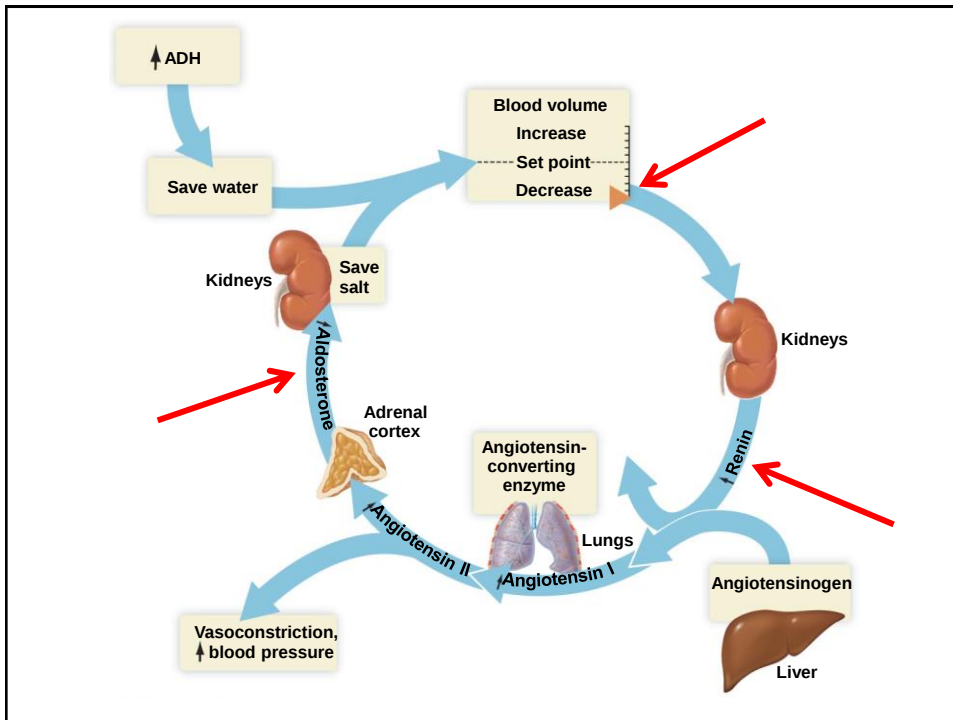
- Negative feedback loop regulates solute concentration of the blood
 - Involves increasing or reducing ADH secretion, which will modify water reabsorption of kidneys
 - Involves increasing or decreasing thirst

Water Balance Determines Blood Volume and Blood Pressure

- **Diuretic:** increases the formation and excretion of urine
 - Lasix (furosemide)
 - medication that reduces blood volume and blood pressure
 - Caffeine
 - inhibits sodium reabsorption
 - Alcohol
 - inhibits ADH release

Aldosterone & Renin Control Blood Volume

- Aldosterone release is stimulated indirectly by decreased blood volume or blood pressure
 - Decreased blood volume/blood pressure cause release of renin
 - Renin is eventually converted to angiotensin II
 - Angiotensin II stimulates adrenal cortex to release aldosterone
 - Aldosterone increases sodium reabsorption by distal tubules and collection ducts



Kidneys Help Maintain Acid-Base Balance and Blood pH

- Blood pH must stay between 7.35 and 7.45
- pH regulated by kidneys, buffers, lungs
- Role of kidneys in pH maintenance
 - Reabsorption of filtered bicarbonate
 - Excretion of acid

Erythropoietin Stimulates Production of Red Blood Cells

- Decrease in amount of oxygen is detected by certain cells throughout the kidney
- Erythropoietin is secreted in response to decrease in oxygen
- Erythropoietin triggers increase in red blood cell production in the bone marrow

Kidneys Activate Vitamin D

- Exposure of skin to sunlight causes production of an inactive form of vitamin D
 - But only about 30 minutes of exposure
- Inactive form of vitamin D is transported to liver, where it is modified
- Inactive form of vitamin D is then converted to active form by kidneys

Disorders of the Urinary System

- Kidney stones
 - Crystallized minerals
 - Block urine flow
- Urinary tract infections (UTI)
 - Usually caused by bacteria
 - More common in women than men because of shorter urethra
 - If untreated, bladder infections may ascend to involve kidneys

Disorders of the Urinary System

- Acute renal failure
 - Short-term impairment, may be reversible
 - Potential causes: sustained very low blood pressure, large kidney stones within renal pelvis, infections, transfusion reactions, severe injury, toxin exposure, drug reactions
- Chronic renal failure
 - Also known as end stage renal disease (ESRD)
 - >60% reduction in functioning nephrons
 - See causes of acute renal failure above
 - 40% of people with Type I diabetes will develop renal failure

Treatment of Irreversible Kidney Failure

- Dialysis



- Kidney transplant

Dialysis Cleanses Blood Artificially

- CAPD: continuous ambulatory peritoneal dialysis
 - Can be done at home
 - Uses peritoneal cavity for waste, ion removal
 - Risk of infection
- Hemodialysis
 - Requires several visits/week to a dialysis center
 - Blood is circulated through a kidney machine

Dialysis Cleanses Blood Artificially

- Problems with dialysis
 - Dialysis cannot achieve complete homeostasis of ions and wastes
 - Dialysis does not replace renal hormones

Kidney Transplants Are a Permanent Solution to Renal Failure

- Best hope for many chronic renal failure patients
- >65,000 people on waiting list for kidneys
- Improvements in transplant protocols/processes have improved outcomes
 - Better tissue-matching techniques
 - Improved anti-rejection medications
 - National data banks