

PowerLecture:

Chapter 42

The Internal Environment

Section 42.0: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online

Impacts, Issues: **Truth in a Test Tube**

- Physicians routinely test:
 - sugar level, pH, protein content
- Urine tests give information about:
 - kidneys
 - hydration
 - pregnancy
 - certain cancers

Impacts, Issues: **Truth in a Test Tube**

- Athletes take urine tests to screen for prohibited drugs
- Urine tells potential employers if you've been taking "street drugs" such as marijuana, cocaine, and Ecstasy

Impacts, Issues: **Truth in a Test Tube**

- 2 fist-sized kidneys filter all blood in your body more than 30 times each day
- Filtration allows body to dispose of excess water, wastes and harmful solutes

Impacts, Issues Video

Section 42.1: Weblinks and InfoTrac

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Animal Fluids

- Interstitial fluid lies between cells and other tissue components
- Blood transports substances by way of the circulatory system
- Interstitial fluid and blood make up the extracellular fluid

Urinary System Interactions

Maintaining Extracellular Fluid

- Urinary system keeps volume and composition of extracellular fluid within tolerable ranges
- It interacts with the digestive, respiratory, and circulatory systems to fulfill this task

Water Gains and Losses

Water Gains

- Absorption from gut

- Metabolism

Solute Gains and Losses

Solute Gains

- Absorption from gut
- Cell secretions
- Respiration
- Metabolism

Controlling Water Gain & Loss

- Urinary excretion provides the most control over water loss
- Concentration of urine can be varied

Controlling Water Gain & Loss

Water and solute balance

Section 42.2: Weblinks and InfoTrac

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Components of

Urinary System

- Pair of kidneys
- Pair of ureters
- Urinary bladder
- Urethra

Components of

Urinary System

Human urinary system

Function of Kidneys

- Filter water, mineral ions, wastes from the blood
- Adjust filtrate concentration and return most to blood
- Remaining water and solutes in filtrate constitute urine

Structure of Kidney

- Renal capsule surrounds kidney
- Two regions
 - Outer renal cortex
 - Inner renal medulla
- Renal pelvis collects urine and funnels it to ureter

Structure of Kidney

Human kidney

Urinary Excretion

- Urine flows from each kidney to a ureter
- Ureters deliver urine to bladder
- Contraction of the smooth muscle of the bladder forces urine out of the body into the urethra
- Skeletal muscle surrounds urethra; allows voluntary control of urination

Nephron

- Functional unit of the kidney
- Each consists of a renal tubule and associated capillaries

Nephron

Urine formation

Section 42.3: Weblinks and InfoTrac

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Urine Formation

Urine Formation

Structure of the glomerulus

Leaky Glomerular Capillaries

- Glomerular capillaries have large pores
- Fluid leaks from glomerular capillaries into kidney tubules

Filtration Rate Varies

- Increased blood pressure increases glomerular filtration
- Flow volume to kidneys changes in response to neural, endocrine, and local changes

Most Filtrate Is Reabsorbed

- Each day, about 180 liters of filtrate flows out of glomerulus into tubules
- 1 to 2 liters excreted
- Most filtrate is reabsorbed into blood

Tubular Reabsorption

- Ions move from the filtrate in tubule lumen into the interstitial fluid
- Sodium ions are actively pumped out of the proximal tubule into the interstitial fluid
- Chloride ions follow; they are passively transported

Tubular Reabsorption

- Ion flow creates an osmotic gradient; it is saltier outside the tubule than inside
- Water flows down the osmotic gradient, from the tubule lumen into the interstitial fluid
- Peritubular capillaries pick up the water and ions from the interstitial fluid

Tubular Reabsorption

Tubular Reabsorption

Tubular reabsorption

Reabsorption

Reabsorption and secretion

Tubular Secretion

- The opposite of reabsorption
- Molecules are transported out of the peritubular capillaries, through tubule cells, and into the filtrate
- Eliminates H⁺ ions, metabolites, and toxins

Section 42.4: Weblinks and InfoTrac

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Hormone Effects

- ADH
 - Acts on collecting ducts; makes walls more permeable to water
 - Urine more concentrated
- Aldosterone
 - Stimulates reabsorption of sodium

Thirst

- Osmoreceptors detect changes
- Activate thirst center in hypothalamus and ADH-secreting cells
- Angiotensin II acts on brain to promote thirst and ADH secretion

Hormone Effects

Hormone-induced adjustments

Section 42.5: Weblinks and InfoTrac

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Acid-Base Balance

- Kidneys work in concert with buffering systems to keep pH in normal range
- Normal range is 7.37 to 7.43
- Normal metabolism produces an excess of H^+

Buffer Systems

- Weak acid and weak base that can reversibly bind and release ions
- Bicarbonate-carbon dioxide buffer system can neutralize excess H^+

Regulating Blood pH (1)

- Involves secretion of H^+ and reabsorption of HCO_3^- (bicarbonate)
- HCO_3^- in filtrate combines with H^+ to form carbonic acid (H_2CO_3)
- H_2CO_3 becomes CO_2 and H_2O , which are reabsorbed into blood from filtrate

Regulating Blood pH (2)

- In blood, HCO_3^- dissociates to form HCO_3^- and H^+
- The H^+ can be secreted into proximal tubule, while the HCO_3^- remains in blood, thus increasing blood pH
- H^+ can also combine with K^+ or ammonia and leave body in urine

Variation in Urinary Systems

- Structure of vertebrate urinary systems varies in details
- Adapted to particular habitats
- Freshwater fish must deal with continuous influx of water by osmosis
- Marine fish must deal with continuous loss of water

Length of Loop of Henle

- Longer loop of Henle allows an organism to produce a very steep osmotic gradient
- Allows reabsorption of more water than a shorter loop

Section 42.6: Weblinks and InfoTrac

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Renal Failure

- Both kidneys are damaged to the point where they are nonfunctional
- Fatal if not treated
- Dialysis is used to restore normal solute balances temporarily
- Transplant is only way to fully restore function

Renal Failure

Kidney dialysis

Kidney Disorders

- Glomerulonephritis
 - Infection of glomeruli leads to chronic inflammation that damages kidney
- Kidney stones
 - Uric acid and calcium salts settle out of urine, form hard deposits that can lodge in ureter or urethra

Section 42.7: Weblinks and InfoTrac

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Core Temperature

- Internal temperature of an animal's body
- Must be maintained within a narrow range for normal enzyme function
- Heat gains and losses must be kept in balance

Heat Gains and Losses

- Metabolic reactions generate heat
- Radiation, conduction, and convection can move heat to or from body to surroundings
- Evaporation causes cooling

Thermal Strategies

- Ectotherms
- Endotherms
- Heterotherms

Thermal Strategies

Endotherms and ectotherms

Section 42.8: Weblinks and InfoTrac

Maintaining Temperature

- Peripheral thermoreceptors in skin
- Thermoreceptors deeper in body
- Feed input to hypothalamus
- Hypothalamus sends messages to effectors by way of nervous system

Response to Heat Stress

- Peripheral vasodilation
- Sweating
- Panting

Mammalian Responses to Core Temperature Shifts

Mammalian Responses to Core Temperature Shifts

Human thermoregulation

Fever

- Part of response to tissue damage
- Hypothalamus resets body thermostat at higher temperature
- Moderate fever can promote healing and need not be suppressed

Response to Cold

- Peripheral vasoconstriction
- Pilomotor response

- Shivering response
- Nonshivering heat response

Mammalian Physiological Responses to Cold Stress