Controlling the Internal Environment

A urinary system is crucial to balancing the intake and output of water and solutes.

Outline

1. Key concepts
2. Thermoregulation
3. Temperature
4. Water Balance and Waste Disposal
5. Excretory Systems
6. Human Urinary System
7. Key Terms
8. Conclusions

Key Concepts:

* Animals are continuously gaining and losing water and dissolved substances but can maintain a constant internal environment
* A urinary system is crucial to balancing the intake and output of water and solutes
* Kidneys filter the blood in structures called nephrons
Key Concepts:
- Nephrons receive water and solutes from capillaries and return most of the filtrate back to the blood.
- Urine is the filtrate not returned to the capillaries.
- ADH and aldosterone are hormones that adjust urine levels.
- Internal body temperature is maintained within a stable range by metabolism and adaptations.

Controlling the Internal Environment
Thermoregulation: Regulation of body temperature

Ectotherms vs. Endotherms

Temperature
1. Physiological Adjustments:
   a. Insulation
   b. Vasodilation
   c. Vasoconstriction
   d. Countercurrent heat exchange
2. Evaporative heat loss:
   a. Sweating
   b. Alternatives
      Camels

3. Behavioral responses:

4. Thermoregulation by class:
   a. Invertebrates: mostly ectotherms
      i. Exceptions: Bees and large moths
   b. Amphibians and Reptiles: ectotherms
      i. Adaptations
         Bull frogs
         Marine iguana
   c. Fishes: mostly ectotherms
      i. Body temperature close to ambient
      ii. Exceptions: Large active species
         blue fin tuna, swordfish, great white shark
4. Mammals and birds: endotherms
   i. Heat generation:
      shivering
      nonshivering thermogenesis (brown fat)
   ii. Regulation:
      vasodilation/constriction
      insulation (fur, hair, fat)
      evaporative cooling (sweating, panting)
         (enhancements: saliva, urine)
   iii. Behavioral

5. Other temperature adjustments:
   a. Acclimatization
      i. Days to weeks
      ii. Shock proteins
   b. Daily Torpor
   c. Estivation
   d. Hibernation

**Nitrogenous waste disposal**

Breakdown of proteins, nucleic acids or conversion of carbohydrates and fats
i. Ammonia
ii. Urea
iii. Uric acid
Excretory Systems

b. Protonephridia (Planarian flatworm): network of fine tubules and cilia-lined flame cells → elimination of excess water.

c. Metanephridia (Earthworm): most body segments have a pair of nephridia (similar in structure and function to the nephron of the human kidney) → elimination of nitrogen waste, conservation of water.

d. Malpighian tubules (Grasshopper) – nitrogen waste products emptied into the hindgut and eliminated along with digestive wastes. (Insects no liquid urine)
Human Excretory System

A Human Kidney and Blood Vessels

Nephrons: Functional Units

1. Bowman’s capsule
2. Glomerulus
3. Proximal tubule
4. Loop of Henle
5. Distal tubule
6. Collecting Duct
7. Capillaries
Functions of Human Urinary System

1. Function in waste removal
2. Function in maintenance of homeostasis:
   - a. blood water content
   - b. blood pH
   - c. blood pressure and oxygen content
   - d. blood solute concentration
   - e. retention of important nutrients

Review for the Exam2:
Friday
ESB 223 from 4-5 on 11/2

No Discussion Sections Next Week!

Human kidney

1. Kidney structure
   - Cortex, Medulla, and Renal Pelvis (collecting chamber)
2. Function unit = Nephron (more than 1 million)
   - A. force filtration
     - RBC, WBC, large protein cannot move (forced) across the membrane enter the Bowman’s capsule.
     - AAs, glucose, NaCl, vitamins, H₂O, urea... come out
   - B. re-absorption
     - in the proximal tubule region, AAs, NaCl, glucose, vitamins, etc. active transported out of the tubule and back to blood vessels
   - C. Secretion at the proximal tubule region
     - a very selective process. (e.g. controlled secretion of H⁺ ions helps maintain body fluid pH.)
     - NH₃, H⁺, drugs, poisons
Functions of Human kidney

C. Tubule secretion
   In the distal tubule region, some wastes not initially filtered out are actively secreted from blood into the distal tubule for excretion such as K⁺, H⁺, ammonia, and many drugs (penicillin, for example)

D. Water back to circulatory system by osmosis
   The osmotic concentration gradient of salts produced by the loop of Henle → water comes out of the tubule and into the capillary bed

E. Antidiuretic Hormone (ADH) circulates in blood
   Can increase the permeability to water (distal tubule and collecting duct region) → more water reabsorbed

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FUNCTIONS OF HUMAN KIDNEY

FILTRATION: Water, nutrients, and wastes are filtered from glomerular capillaries into Bowman's capsule of the nephron.

TUBULAR SECRETION: In the distal tubule, additional wastes are actively secreted from the tubule into the blood.

TUBULAR REABSORPTION: In the proximal tubule, most water and nutrients are reabsorbed into the blood.

CONCENTRATION: In the collecting duct, additional water may leave the blood, creating urine that is more concentrated than the blood.

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Urine Formation
Reabsorption

Hormone - Induced Adjustments

- ADH: (anti diuretic hormone)
  - Increases water reabsorption
  - Distal tubule and collecting ducts
  - Hypothalamic hormone

- Aldosterone
  - Promotes Sodium reabsorption
  - Distal tubule and collecting ducts

Arterial Pressure
In Conclusion

- Maintenance of internal fluids depends on balances of intake and output of water and solutes.
- Water is gained by absorption from the gut and excretion is via the urinary system, sweating, evaporation, and fecal elimination.
- The vertebrate urinary system consists of 2 kidneys, 2 ureters, a bladder, and urethra.
In Conclusion

- Nephrons are the functional units of the kidney
- Urine forms by 3 processes: filtration, reabsorption, and secretion
- Urine concentration and volume is controlled by ADH and aldosterone

In Conclusion

- Maintaining core temperature depends on balancing metabolically produced heat that is absorbed or lost with the environment
- Animals exchange heat with the environment by radiation, conduction, convection, and evaporation
- Core temperature depends on metabolic rates, and on adaptations