# Homeostasis

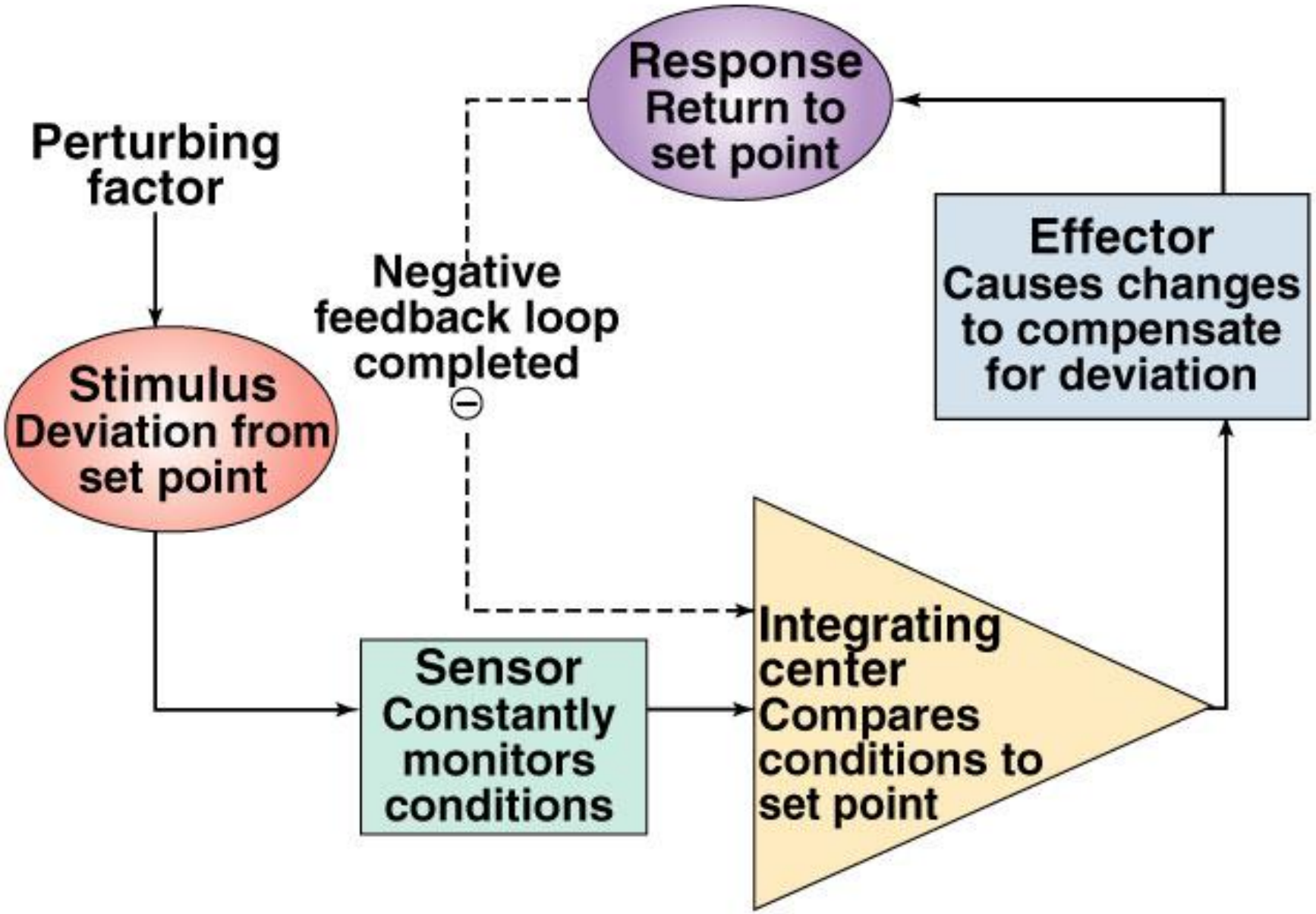
- the steady-state physiological condition of the body
- Ability to regulate the internal environment
- important for proper functioning of cells

# Homeostasis

- **Thermoregulation**
  - how organisms regulate their body temperature
- **Osmoregulation**
  - how organisms regulate solute balance and gain or loss of water
- **Excretion**
  - how organisms get rid of nitrogen-containing waste products of metabolism, such as urea

# Homeostasis

- **Maintenance usually involves negative feedback loops**



# Feedback mechanisms in human thermoregulation

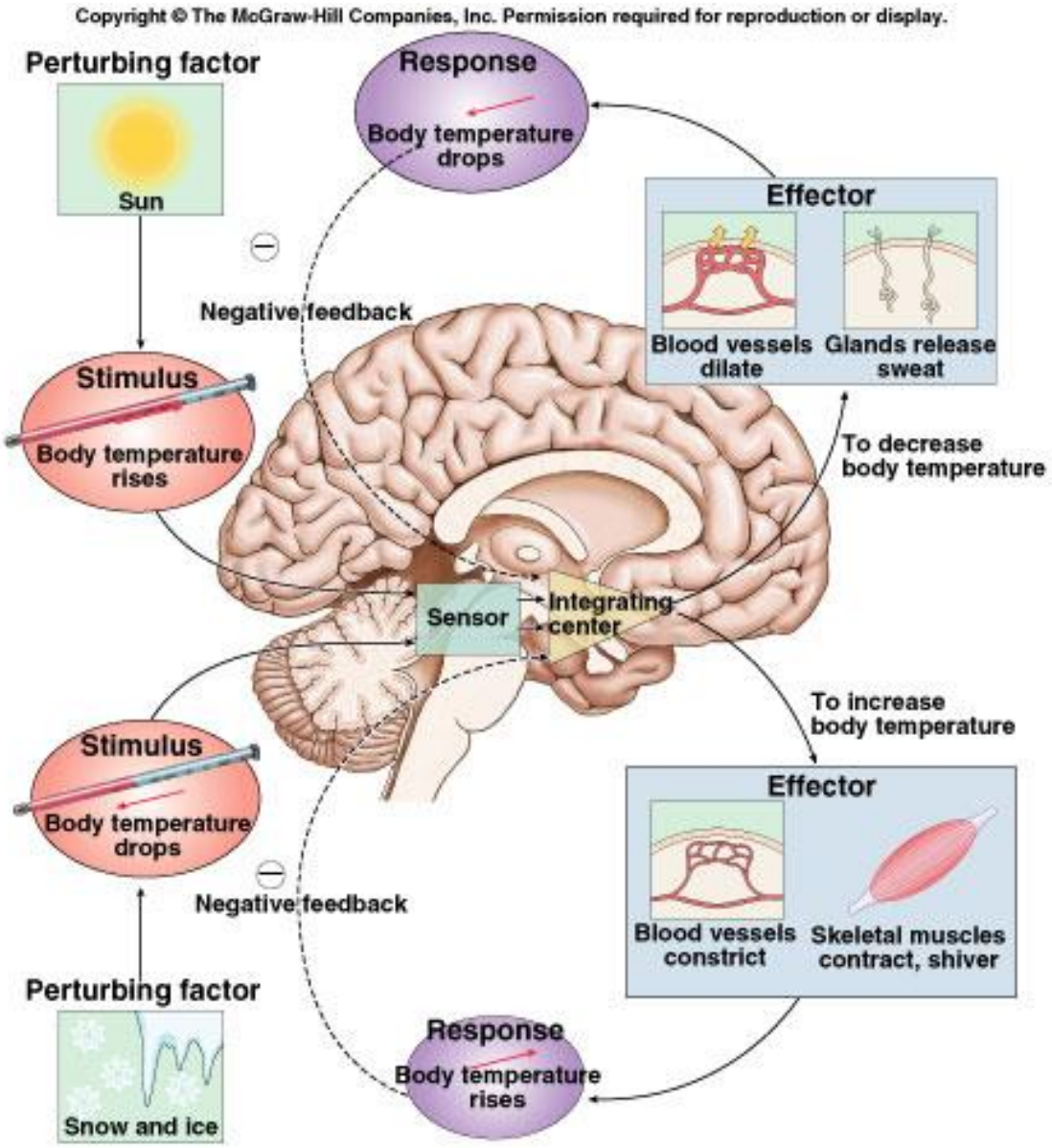
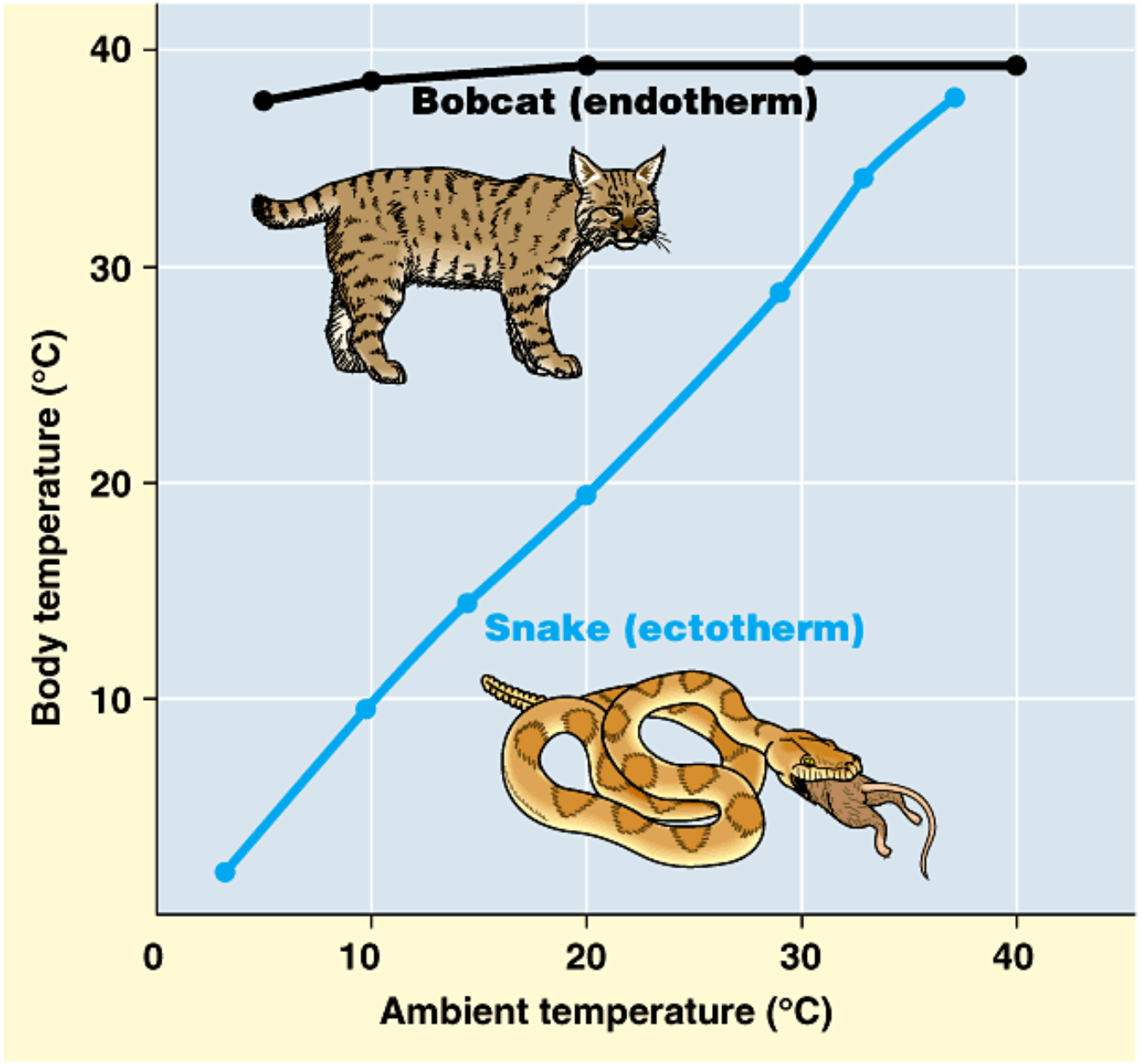
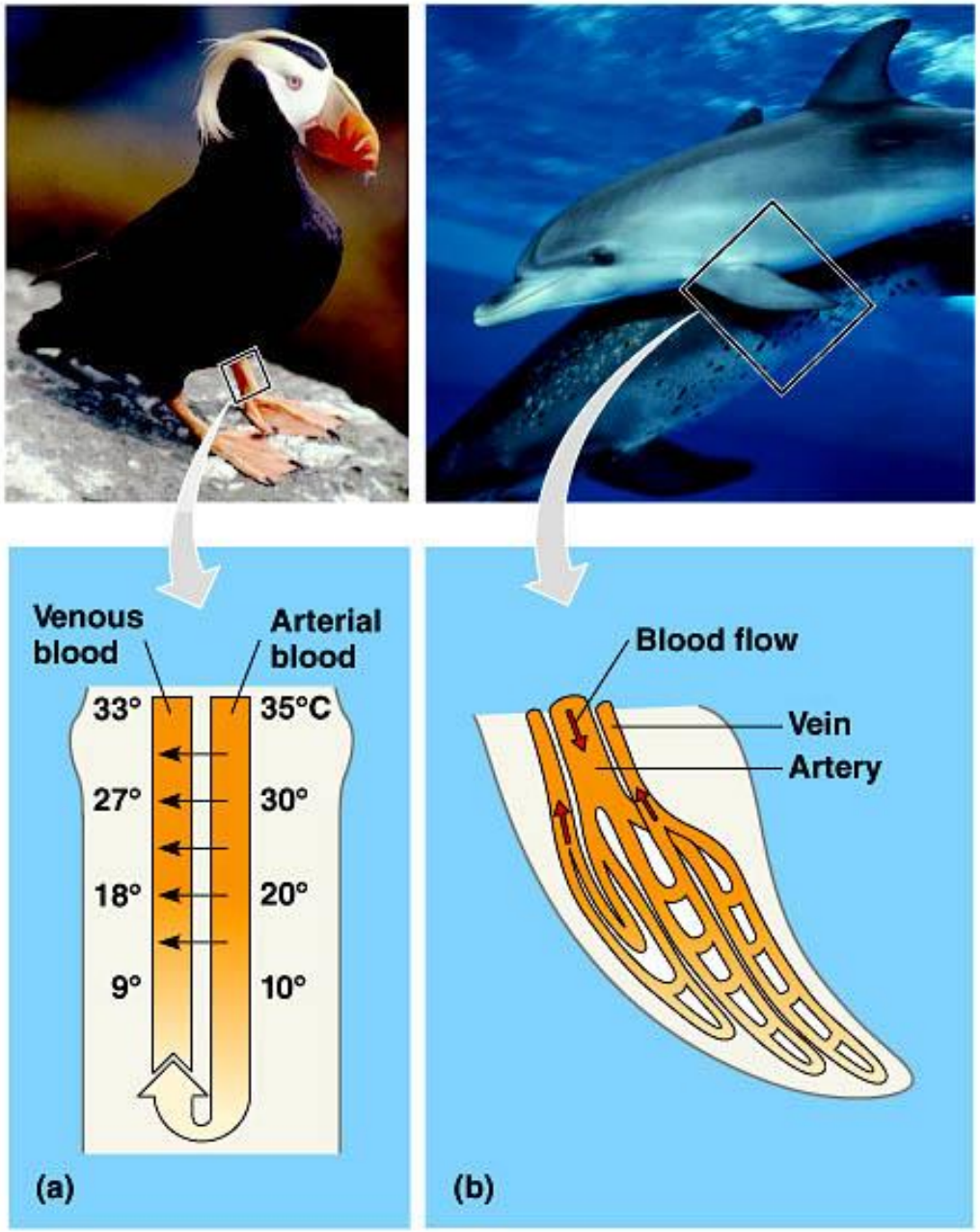


Figure 44.4 The relationship between body temperature and ambient (environmental) temperature in an ectotherm and an endotherm



# Figure 44.5 Countercurrent heat exchangers



# Excretion

- Nitrogen-containing wastes from the metabolism of proteins and nucleic acids are particularly bad.
- the nitrogenous waste product is ammonia ($NH_3$)

# Ammonia

- most efficient to excrete directly
- Very toxic, soluble in water
  - must be excreted in dilute solutions
- Excreted by most aquatic organisms
- diffuses across body surface or gills

# Terrestrial animals

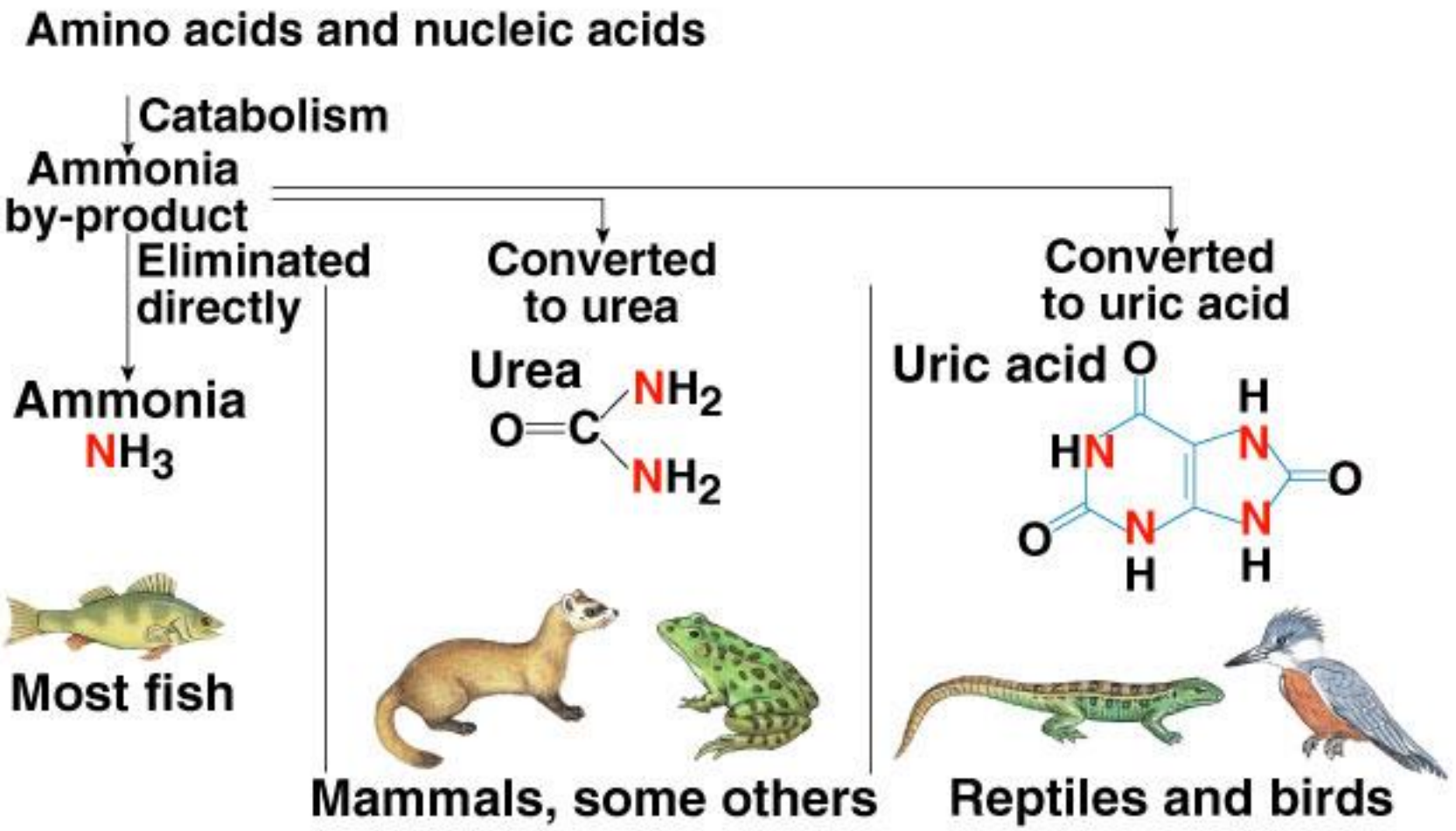
- Can’t afford to lose a lot of water
- excrete substances that can be excreted in more concentrated form
- use energy to convert ammonia to a less toxic molecule
  - urea or uric acid

# Urea

- Much less toxic
- excreted by many terrestrial animals
- produced in liver
  - metabolic cycle combines ammonia & carbon dioxide

# Figure 44.13 Nitrogenous wastes





# Uric Acid

- Excreted by some land snails, insects, birds & reptiles
- Not soluble in water
- excreted as a precipitate after water has been reabsorbed

# Urea vs Uric Acid

- Both adaptations to conserve water
- depends on mode of reproduction…
- animals with shelled eggs excrete uric acid

# Osmoregulation

- Cells cannot survive a net gain or loss of water
  - common problem to all animals
  - solutions differ

# Osmoregulation

Two basic solutions:

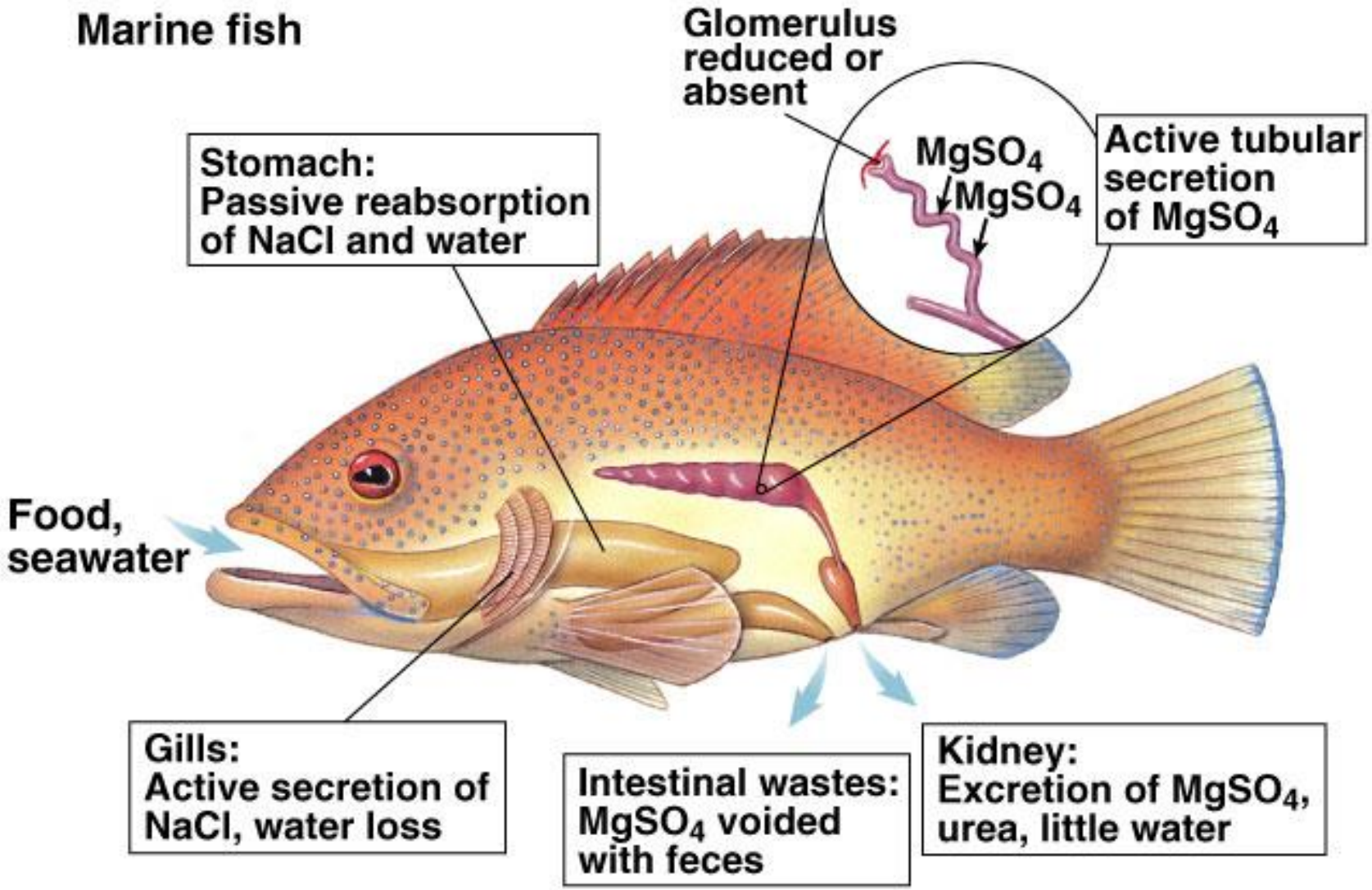
- Be isotonic to the environment
  - **osmoconformers**
- Actively discharge (in hypotonic environments) or take in ( in hypertonic environments) water
  - **osmoregulators**

# Marine Environments

- Most marine invertebrates are osmoconformers
  - may still regulate specific ion concentrations
- Most marine vertebrates osmoregulate
  - Chondrichthyes
    - isotonic but lower salt conc. & high urea conc.
  - Osteichthyes
    - hypotonic to environment

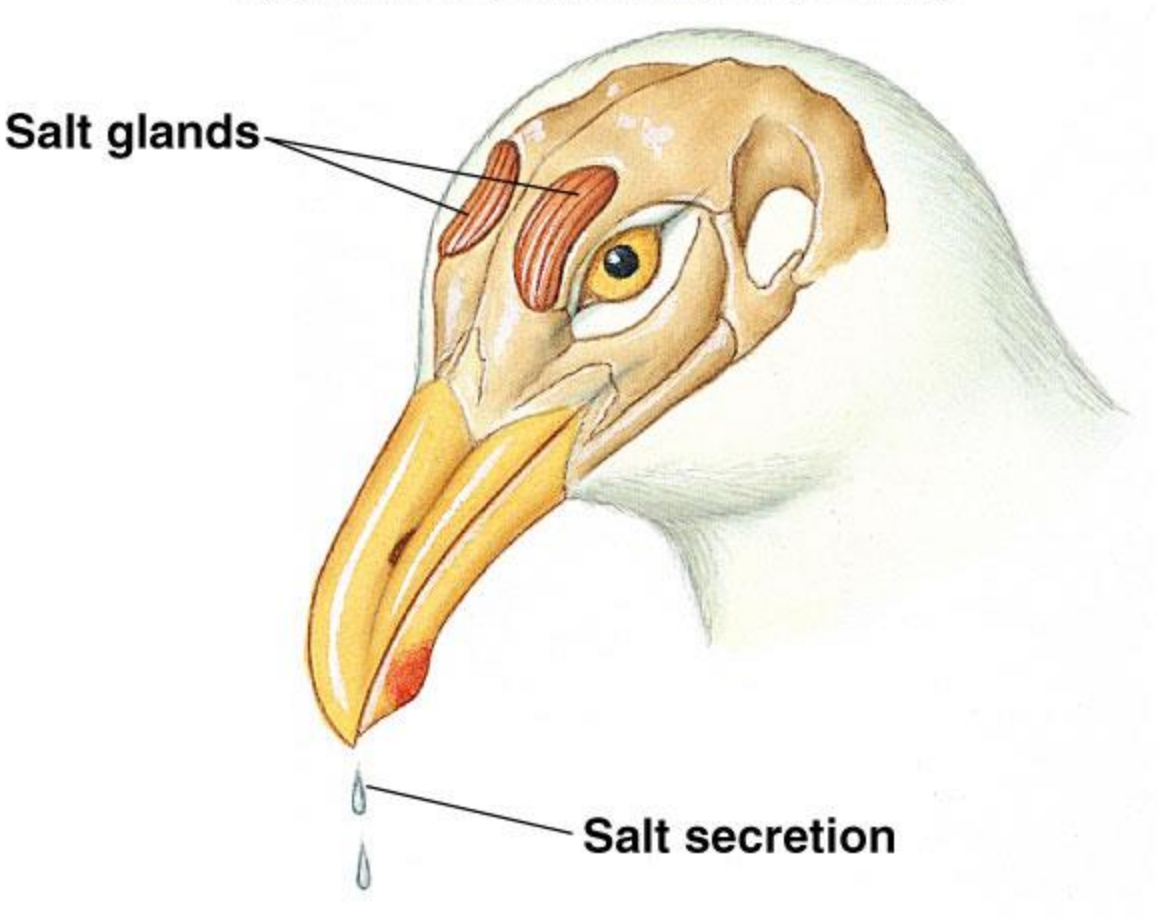
# Osmoregulation in a saltwater fish





# Figure 44.12 Salt-excreting glands in birds

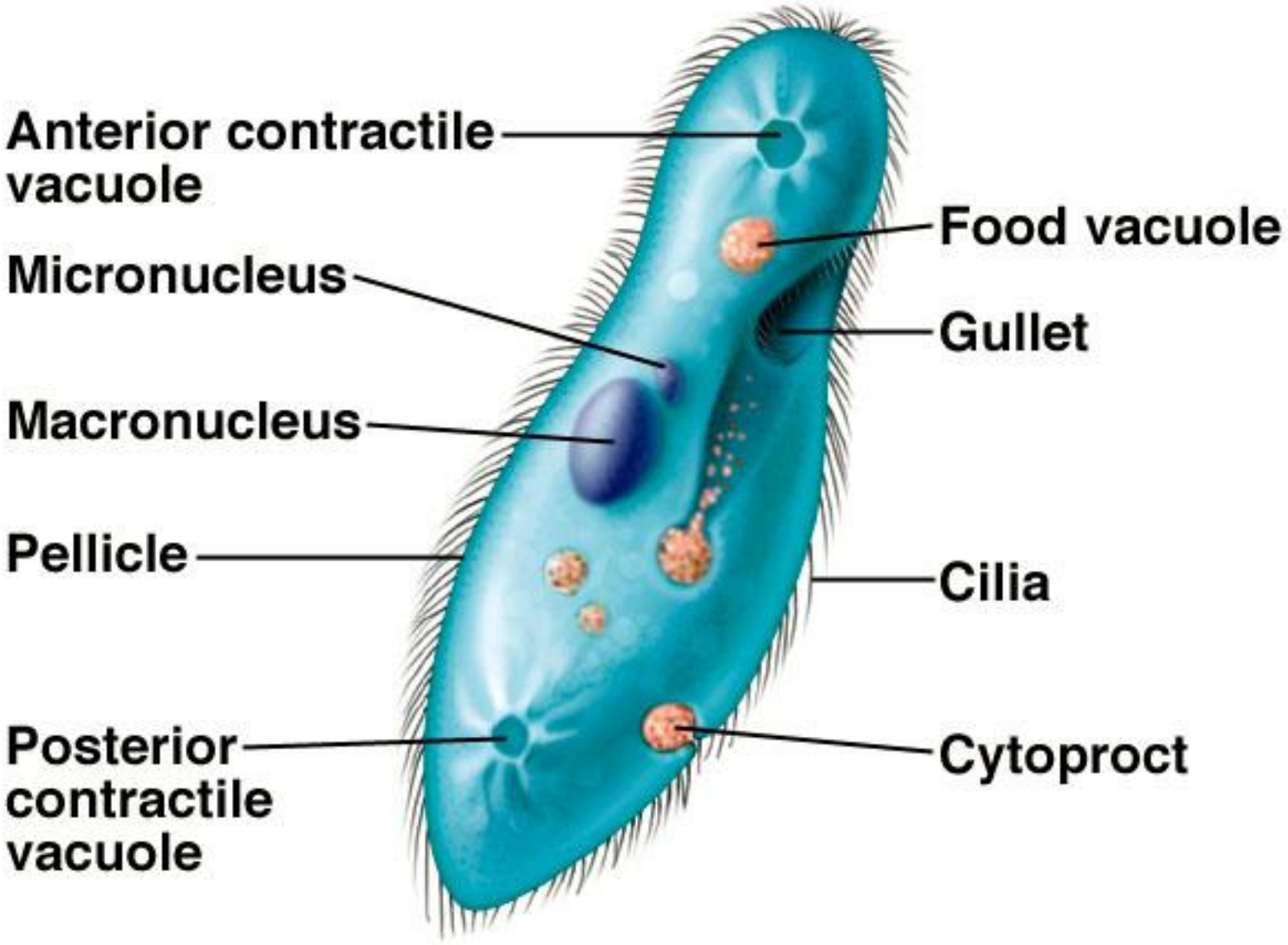




# Freshwater Environments

- Problem of water entering body via osmosis
- Protozoa (amoeba & paramecium)
  - use contractile vacuoles

# *Paramecium*

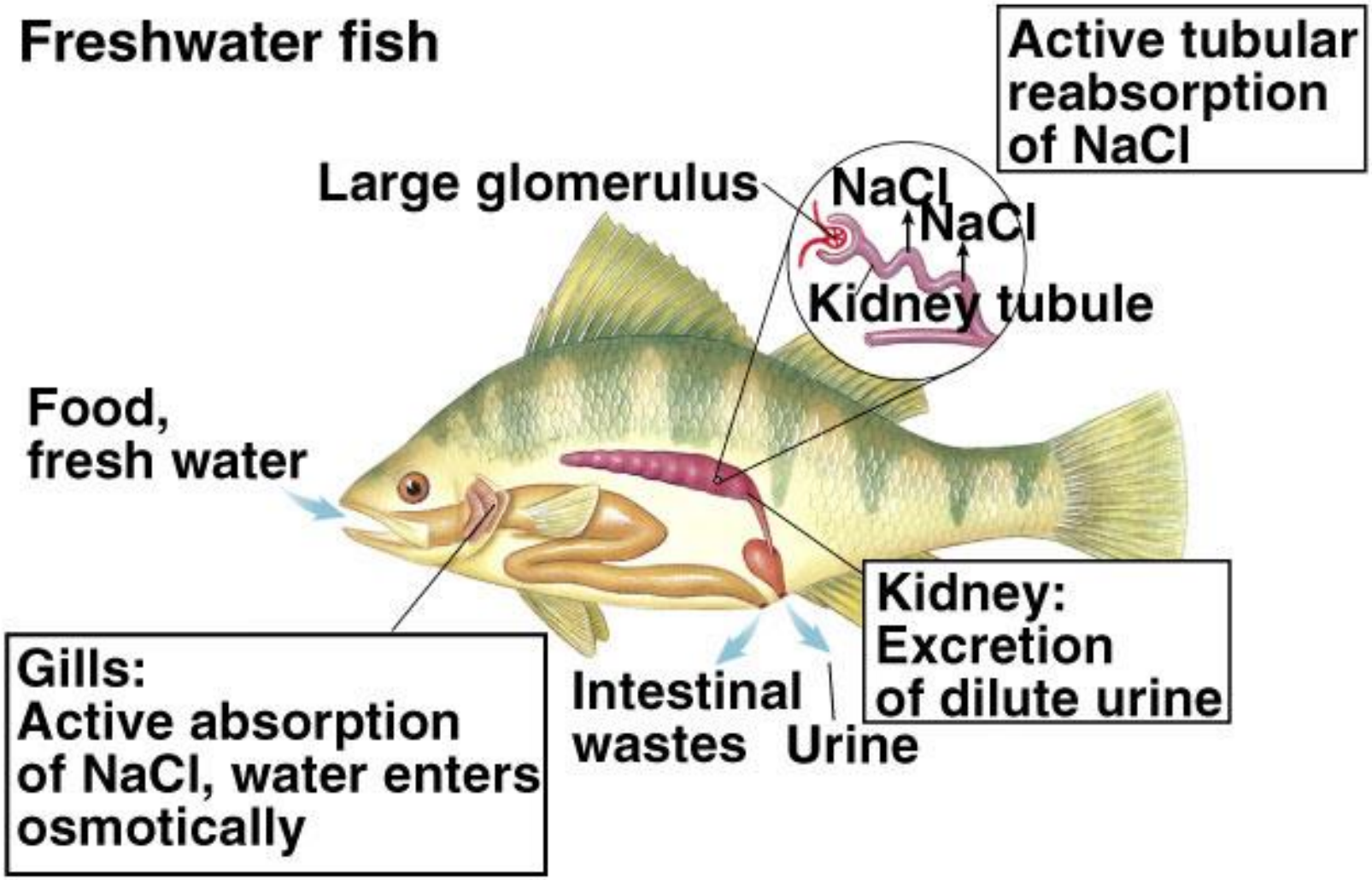


# Freshwater Environments

- Freshwater Bony Fish

# Osmoregulation in a freshwater fish

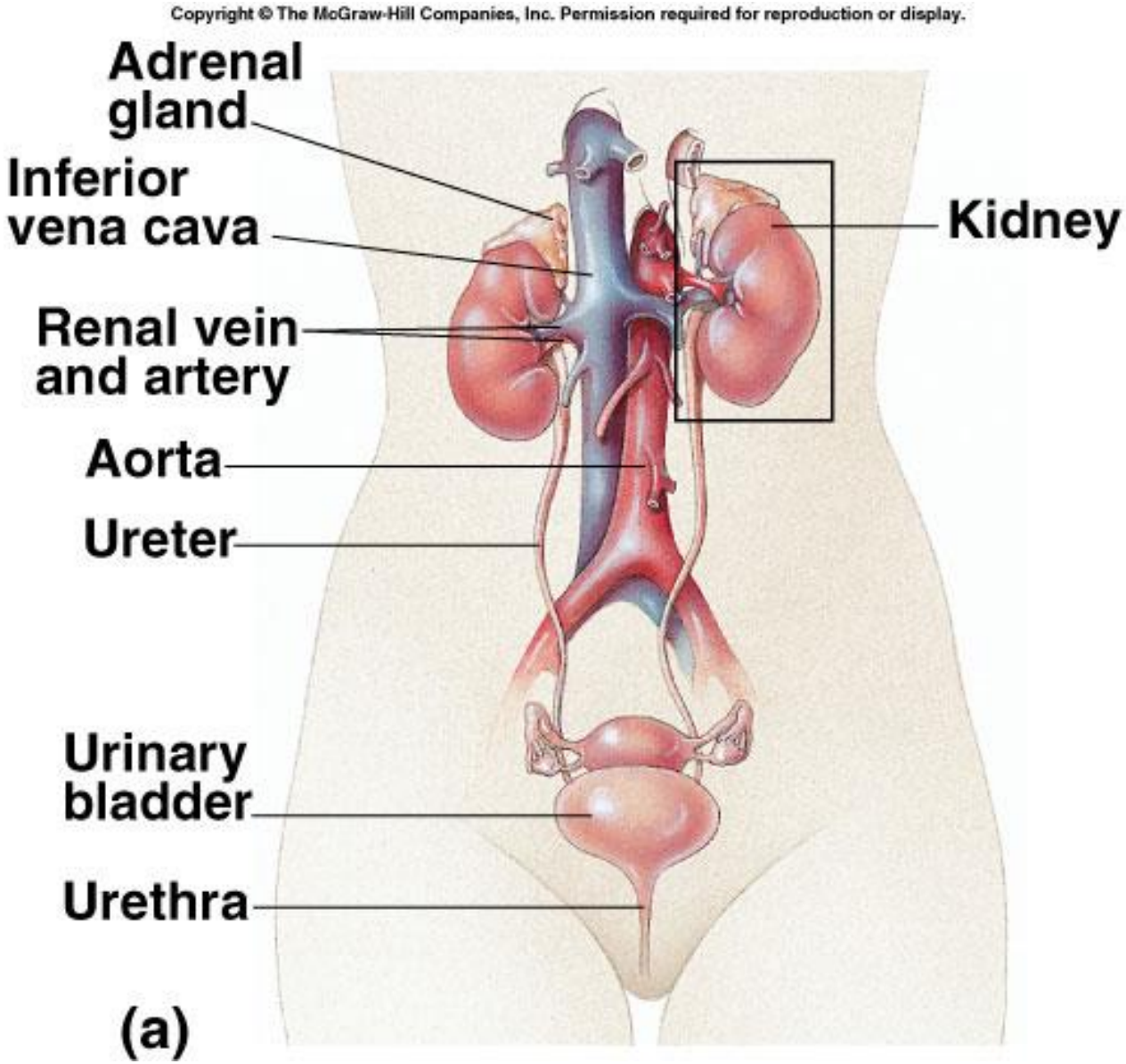




# Terrestrial Environments

- Many adaptations to prevent water loss
  - shells, layers of dead skin, waxy cuticle, exoskeletons, scales, etc.
- Drink water & eat moist foods
- Specialized organs to conserve water
  - ex: kidneys

# The human excretory system

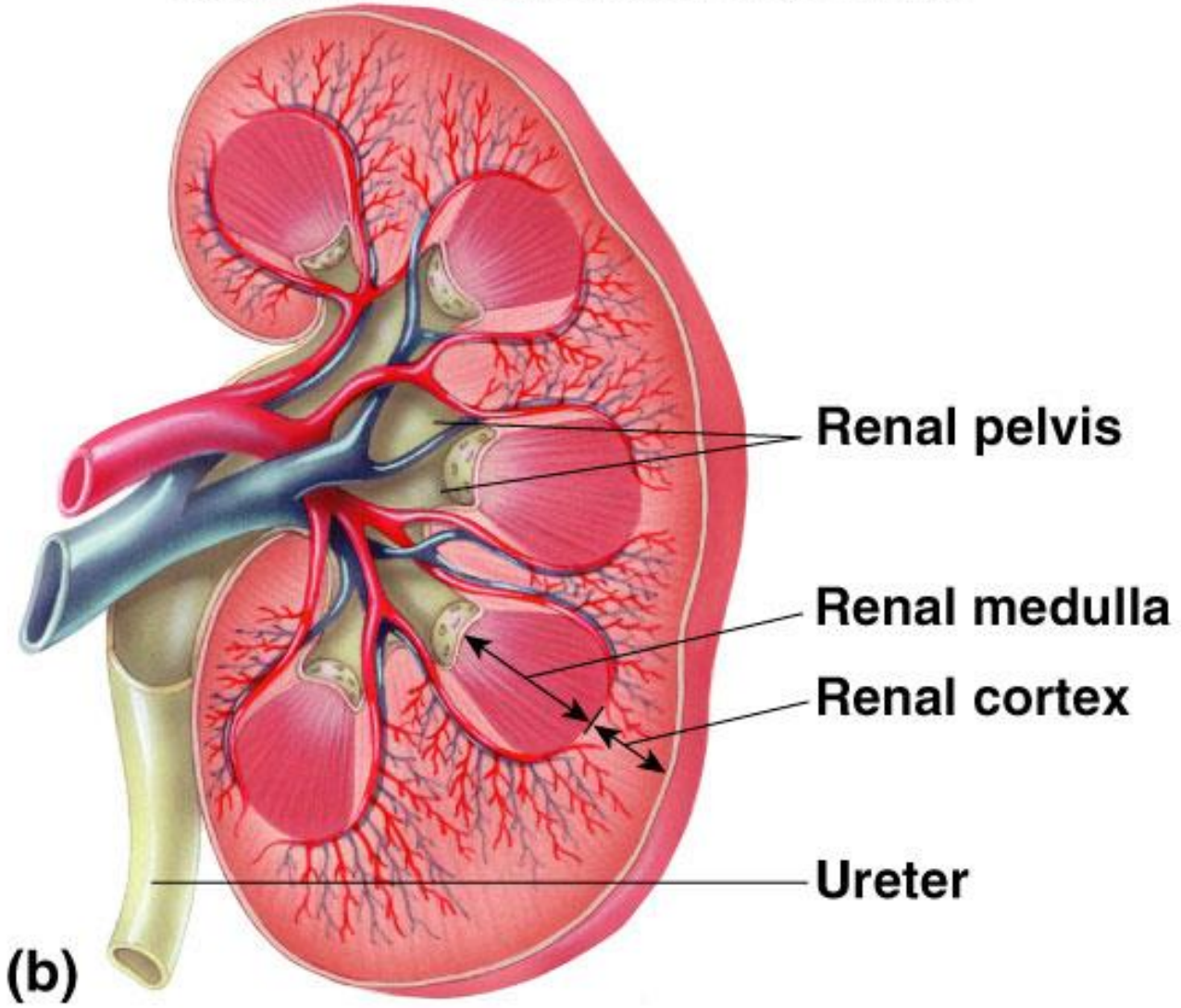


# Mammalian Excretory System

- renal artery and renal vein
- Urine exits the kidneys through the ureter
- The ureters of both kidneys enter the urinary bladder
- Urine leaves the body via the urethra
  - Sphincter muscles between the bladder and urethra control urination

# The human kidney



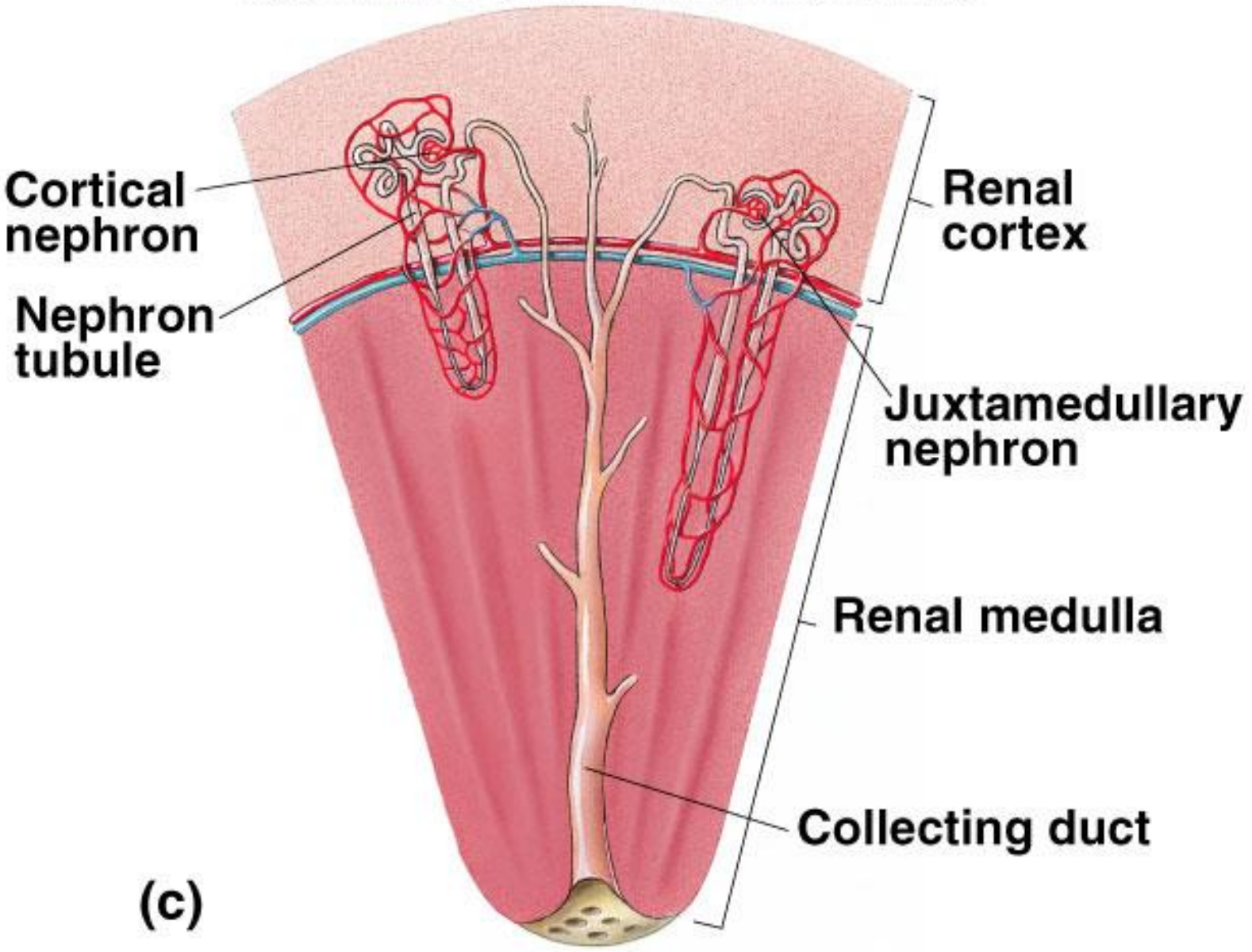


# Kidney

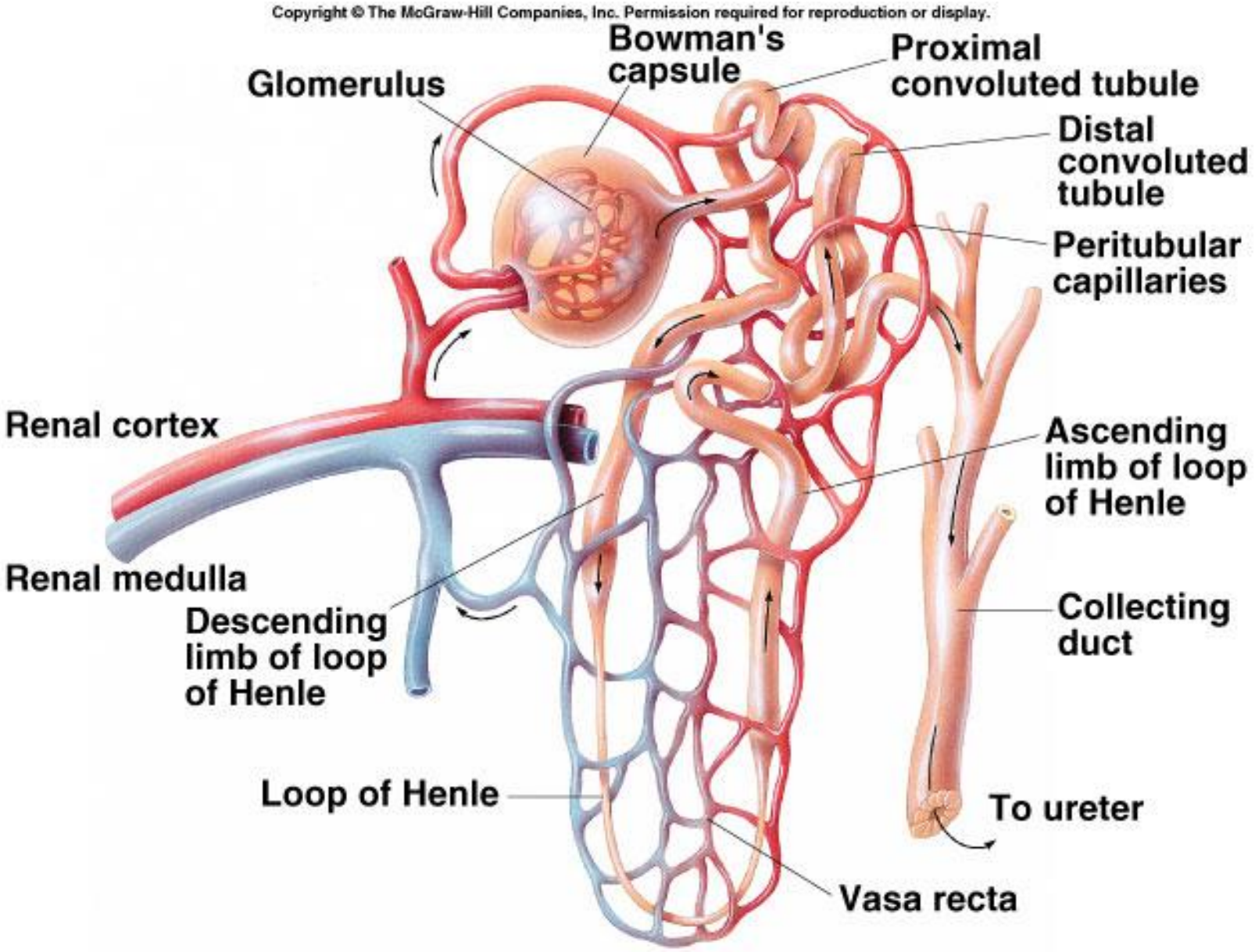
- **outer renal cortex & inner renal medulla**
- within each region are microscopic excretory tubules called nephrons, collecting ducts and capillaries
- the **nephron** is the functional unit of the kidney
- renal pelvis

# The nephron within the human kidney





# The nephron and collecting duct



# Function of Nephron

- **1. Filtration of blood**
  - blood pressure forces any small molecules from the blood into the lumen in the bowman's capsule
  - a nonselective process with regard to small molecules
  - filtrate initially consists of water, urea, salts, glucose, vitamins, etc.

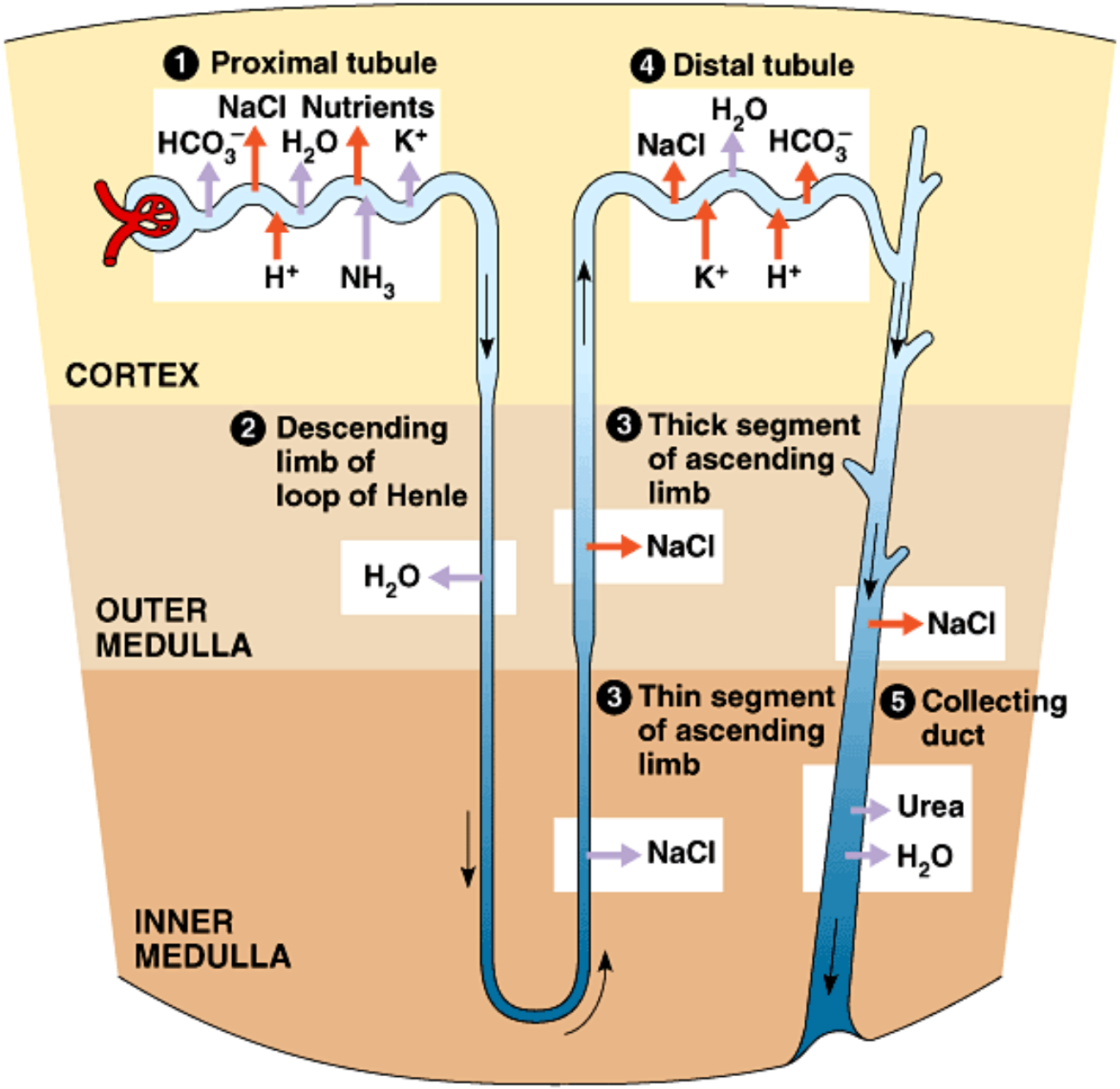
# Function of Nephron

- **2. Secretion**
  - substances are transported into the filtrate
  - most commonly occurs in the proximal and distal tubules
  - a very selective process – involving both passive and active transport

# Function of Nephron

- **3. Reabsorption**
  - the selective transport from the filtrate to the interstitial fluid or blood plasma
  - Sugars, vitamins, organic nutrients and water are all reabsorbed

Figure 44.22 The nephron and collecting duct: regional functions of the transport epithelium



# Function of Nephron

- **4. Excretion**
  - Get rid of the wastes

# Key functions of the nephron



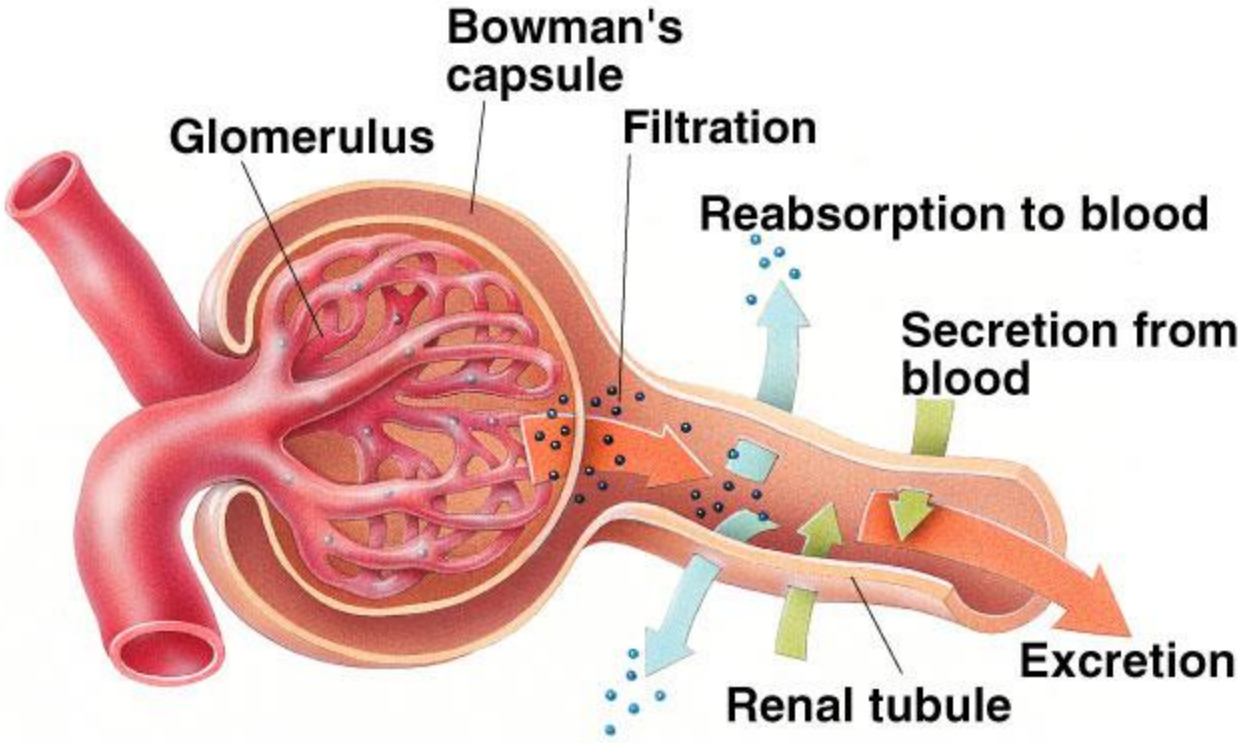


Figure 44.23 How the human kidney concentrates urine: the two-solute model (Layer

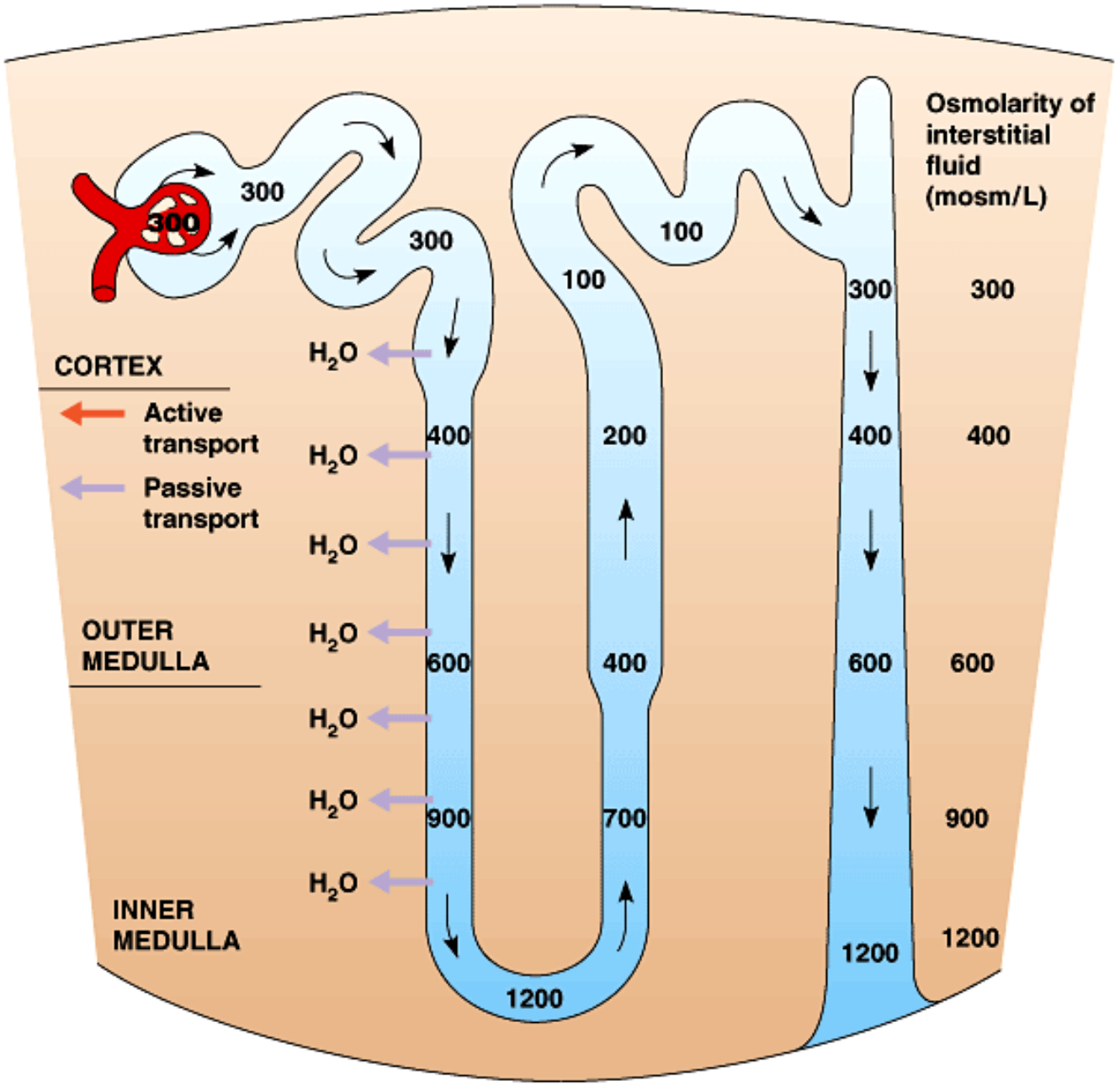


Figure 44.23 How the human kidney concentrates urine: the two-solute model (Layer

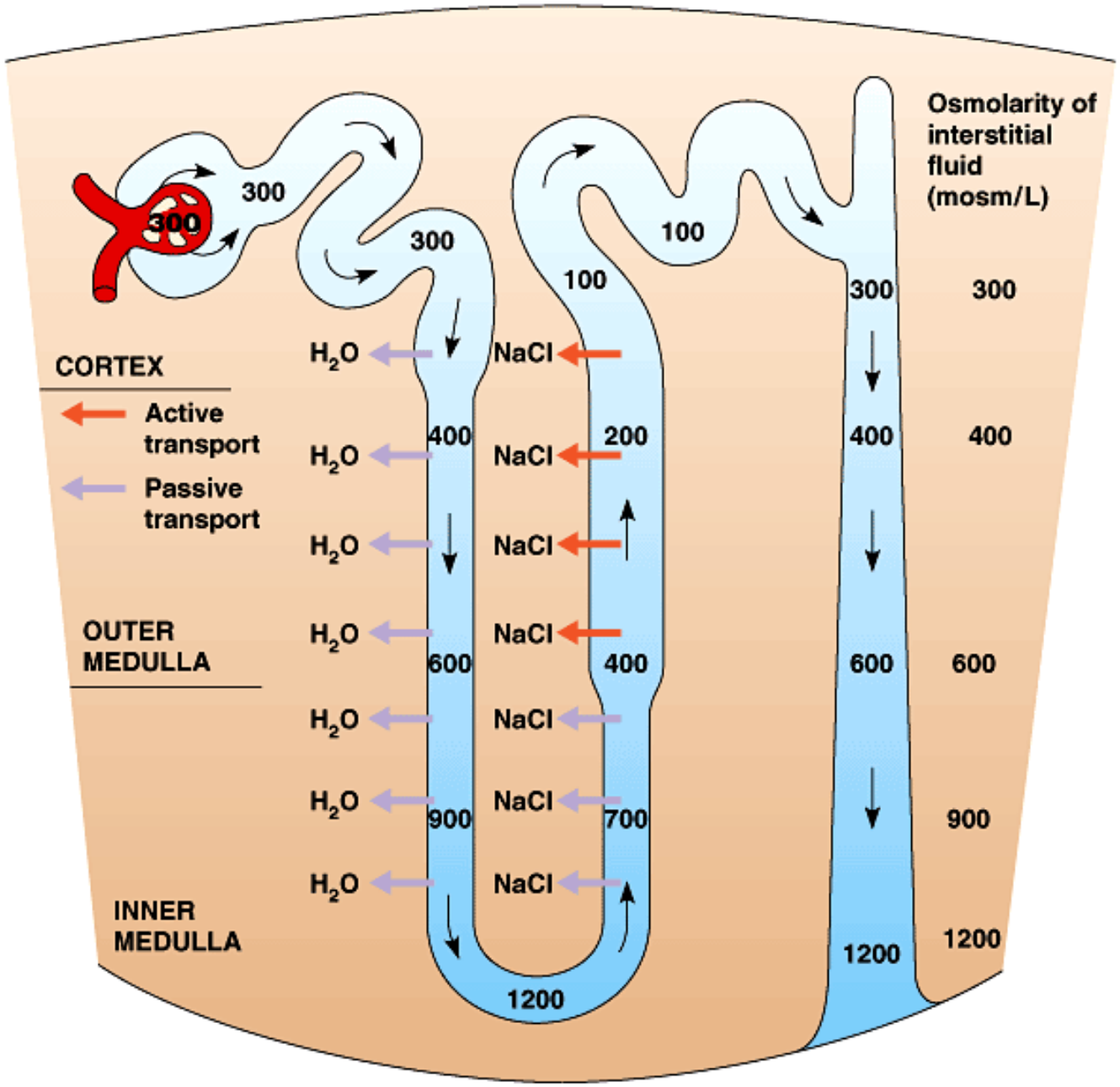
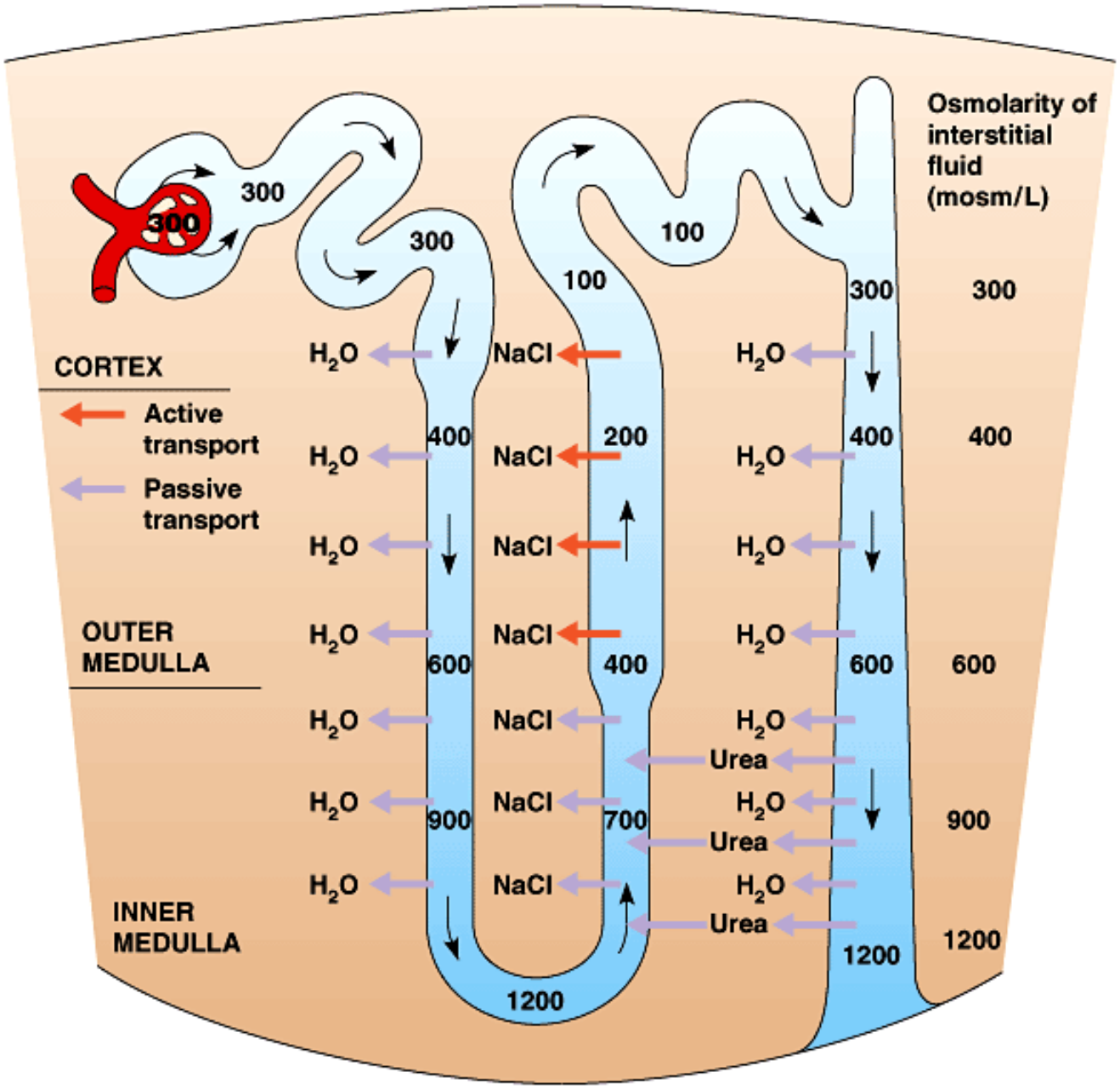
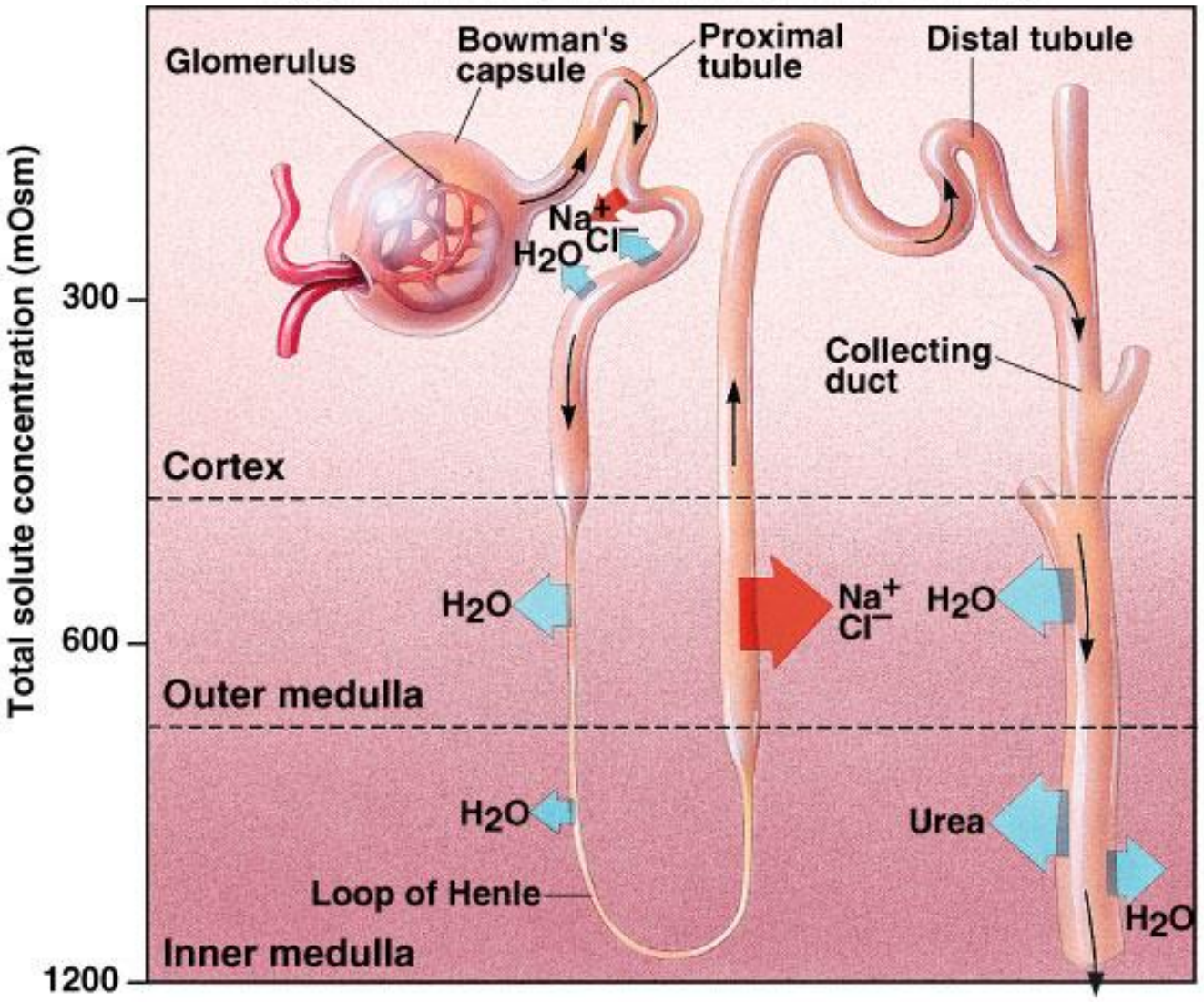


Figure 44.23 How the human kidney concentrates urine: the two-solute model (Layer





# Characteristics of Urine

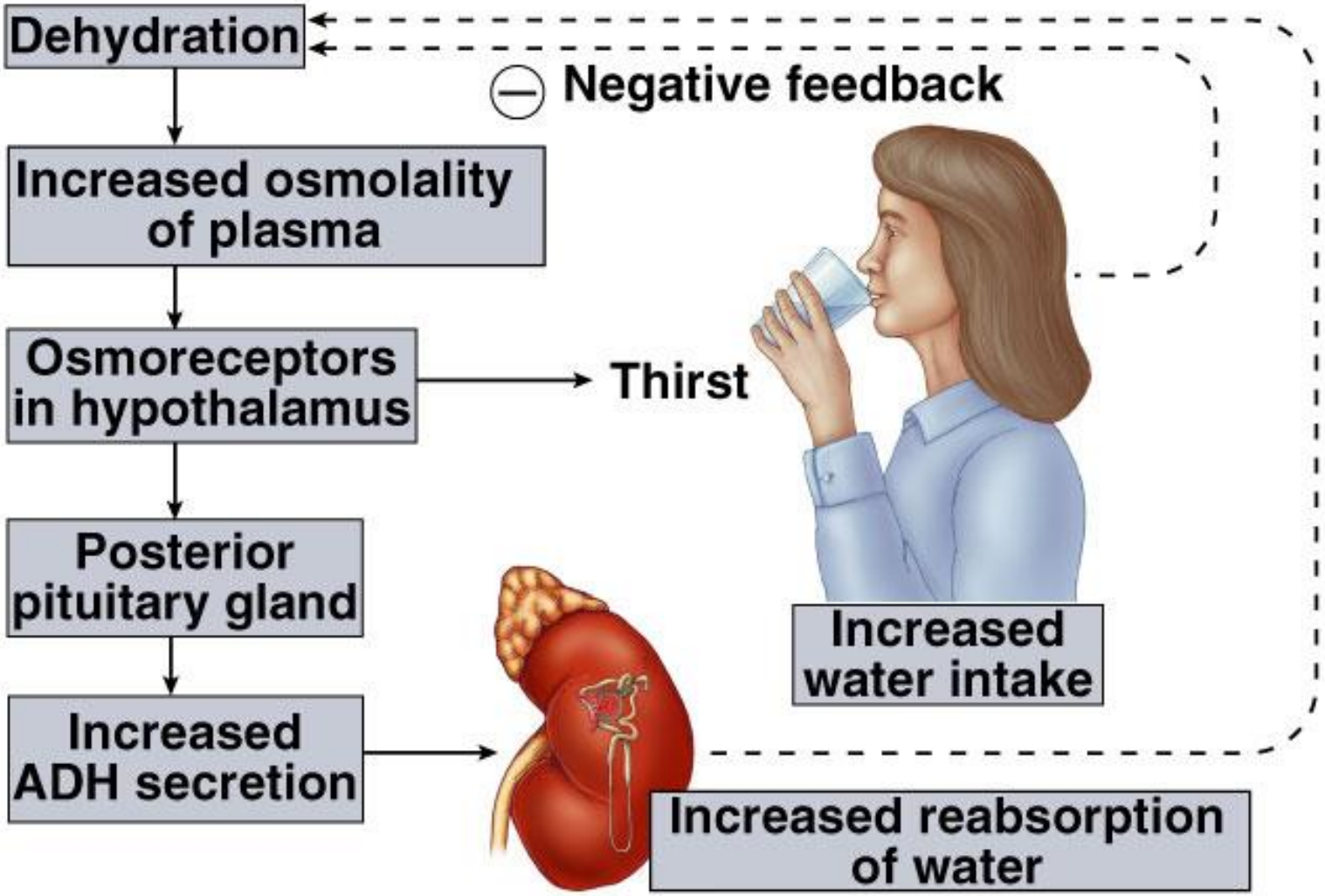
- The kidneys can produce a hypertonic urine when it is necessary
- can excrete a hypotonic urine
- Water and salt reabsorption are subject to nervous and hormonal control

# ADH (Antidiuretic Hormone)

- released when the solute concentration of the blood rises
- makes the transport epithelium of the distal tubules and the collecting ducts more permeable to water
- alcohol inhibits production of ADH

# Hormonal control of the kidney by negative feedback circuits





# Evolution of the Vertebrate Kidney

- 1st – in freshwater fish
- Fish, amphibian & reptile kidneys can only produce urine that is isotonic or hypotonic to their body fluids
- Terrestrial reptiles – can reabsorb water in cloaca

# Evolution of the Vertebrate Kidney

- Only birds and mammals have loops of Henle in their nephrons
  - Hypertonic urine
  - Mammals have more juxtamedullary nephrons than birds

# Osmoregulation by Vertebrates

| Vertebrate | Urine concentration relative to blood | |
|---|---|---|
| Amphibian | Strongly hypotonic |  Skin absorbs $Na^+$ from water |
| Marine reptile | Isotonic |  Drinks seawater<br>Salt gland secretes excess salts |
| Marine bird | Weakly hypertonic |  Drinks seawater<br>Salt gland secretes excess salts<br>Excretes weakly hypertonic urine |
| Marine mammal | Strongly hypertonic |  Does not drink seawater |
| Terrestrial bird | Weakly hypertonic |  Drinks fresh water |
| Desert mammal | Strongly hypertonic |  Drinks no water<br>Obtains water from food and metabolic processes |