Osmoregulation

Regulating fluids and wastes

Lecture outline

- Osmoregulation overview
  - Marine vs. freshwater vs. land
  - Nitrogenous wastes
- Excretory systems

Osmoregulation

- Managing the water content and solute composition in the body
- Must balance gains and losses (homeostasis?)
- Some terms:
  - Hyperosmotic
  - Hypoosmotic
  - Isoosmotic
- No regulation?
  - Osmoconformers
  - Best environmental conditions?

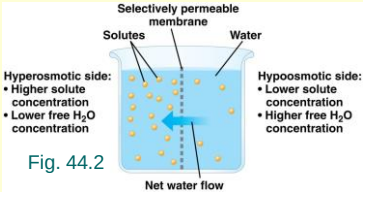

Fig. 44.2

Osmoregulation in bony fishes

- Rely on specialized organs (**kidneys**) and tissues (**transport epithelium**)

Cod: **hypoosmotic** to habitat Perch: **hyperosmotic** to habitat

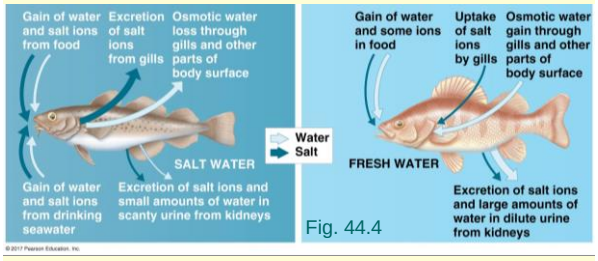

Fig. 44.4

Life in temporary waters

- **Anhydrobiosis** in water bears (Tardigrada)
- Probably use a sugar (trehalose) to replace water and protect cell membranes

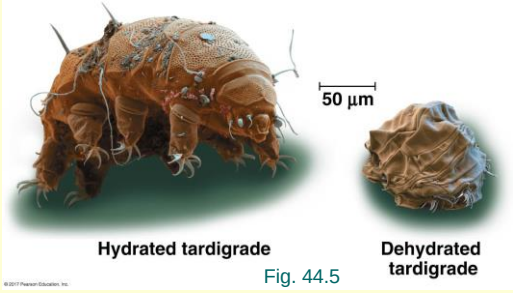

Fig. 44.5

Nitrogenous wastes, osmoregulation, and habitat

- Metabolic wastes are dissolved in water in order to remove them from the body
- Thus, waste removal greatly impacts water regulation
- Focus on nitrogenous wastes
  - Ammonia vs. urea vs. uric acid

Nitrogenous wastes

- **NH_3**—lots of water for dilution
- **Urea**—less water; more energy
- **Uric acid**—insoluble; most energy
  - Eggs with hard shells retain insoluble uric acid

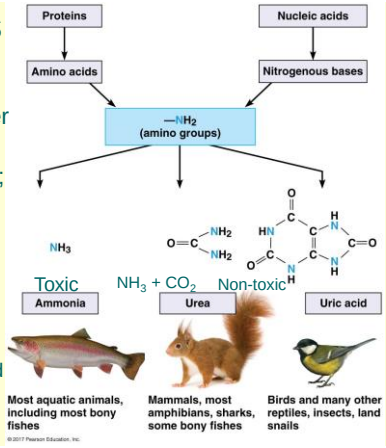

Fig. 44.7

Excretory system overview

- Urine production usually requires a few steps:
  - **Collection** and **filtration**
    - Powered by blood pressure
  - **Selective reabsorption** and **secretion**
    - Powered by active transport

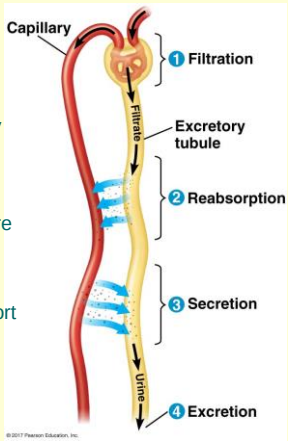

Fig. 44.8

Excretory system diversity

- **Protonephridia**: flame-bulb systems
  - Flatworms (Platyhelminthes); osmoreg. mostly
- **Metanephridia**
  - Earthworms (Annelida); osmoreg. and excretory
- **Malpighian tubules**
  - Insects (Arthropoda); osmoreg. and excretory
- **Kidneys**
  - Vertebrates; osmoreg. and excretory

Protonephridia

- Network of dead-end tubules <u>without</u> internal openings
- Beating cilia inside the **flame bulb** moves fluid through the bulb, which filters the fluid

Planarian

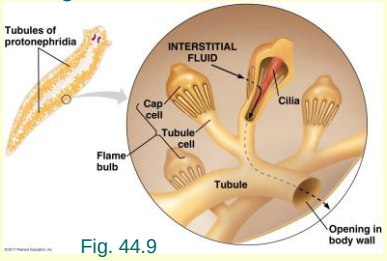

Fig. 44.9

Metanephridia

- Tubule network <u>with</u> <u>internal openings</u> that collect fluids

Annelida

2 metanephridia per segment

Ciliated funnel

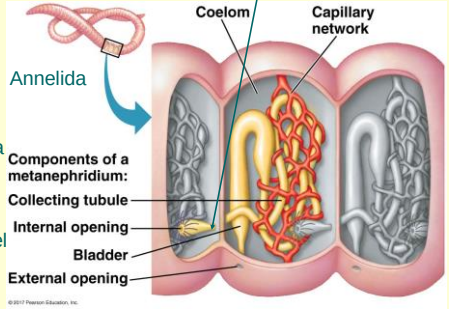

Fig. 44.10

Malpighian tubules

- Outfoldings of the midgut
- Good at reabsorption of water for life on land

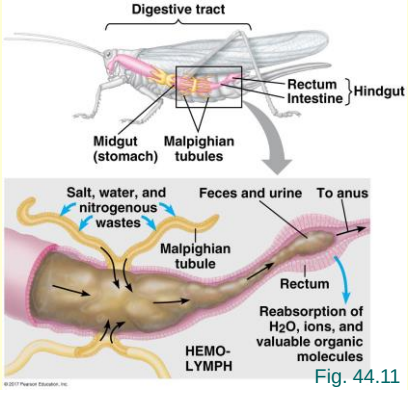

Fig. 44.11

Kidneys

- Urine exits kidney through the **ureter**, collects in the **urinary bladder**, and exits body through the **urethra**
- The '**renals**': inner **medulla**, outer **cortex**, **pelvis**

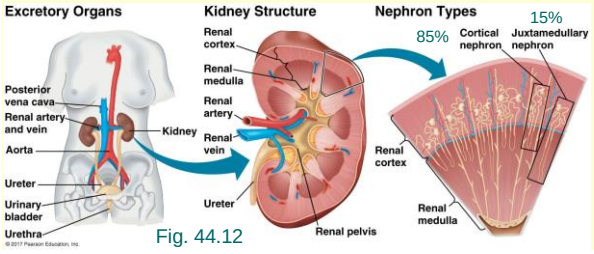

Fig. 44.12

Nephrons of the kidney

- The workhorse of the kidney; each human kidney contains about 1 million nephrons
- A long **tubule** + the **glomerulus**

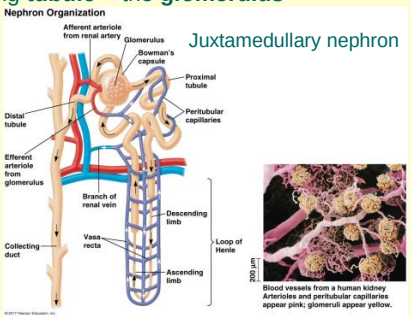

Fig. 44.12

The nephron in action (1)

- Nephron and collecting duct lined by transport epithelium
- Changes in permeability…
- **Proximal tubule** alters the volume and composition of the filtrate
- **Descending limb of loop of Henle**: passive reabsorption of water

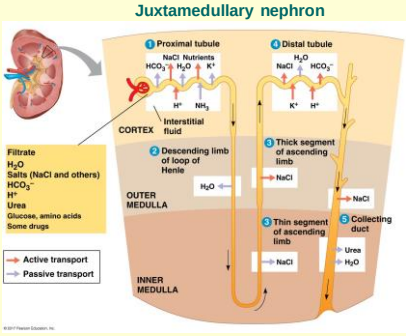

Fig. 44.13

The nephron in action (2)

- **Ascending limb of loop of Henle**: passive & active reabsorption of salt. Why?
- **Distal tubule**: altering the composition again
- **Collecting duct**: more reabsorption

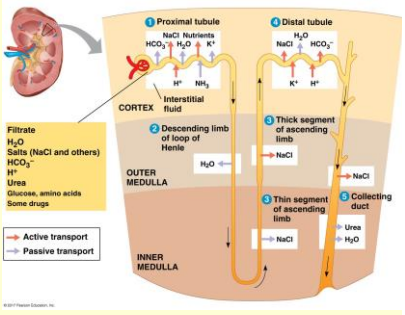

Fig. 44.13

Concentrating urine

- Is this type of a system familiar?
- Maintenance of a steep osmotic gradient
- Result: hyperosmotic urine

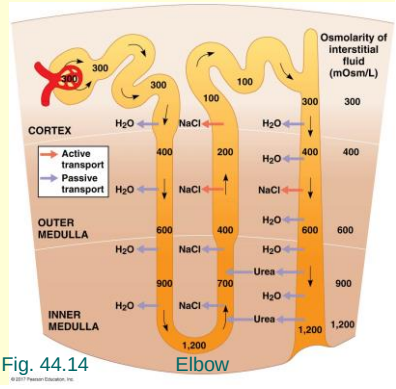

Fig. 44.14

Nephrons of the kidney (again)

- Recycling of water and solutes by the vasa recta

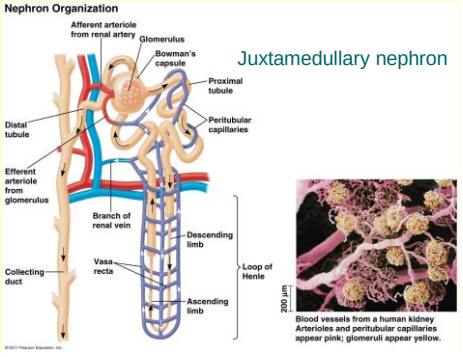

Fig. 44.12

Life with no water

	Kangaroo Rat	Human
Water Gain (mL)		
Ingested in food	0.2	750
Ingested in liquid	0	1,500
Derived from metabolism	1.8	250
Water Loss (mL)		
Urine	0.45	1,500
Feces	0.09	100
Evaporation	1.46	900