**Homeostasis: Osmotic Regulation, Excretion, and Temperature Regulation - Chapter 30**

**Updated from New 2009 Book Updated 2 April 2009**

**OSMOTIC REGULATION & EXCRETION:**

**Read these pages thoroughly: 249-267**

Know page 257 -- Fig. 30.9 shows diagrams of the different kinds of kidneys (different developmental stages):

1. **archinephros** - found in embryo hagfish; this is the inferred ancestral condition of the vertebrate kidney

2. **pronephros** - functional kidney in adult hagfish, a few bony fishes, and embryonic fishes and amphibians; fleeting existence in reptiles, birds, and mammals

3. **mesonephros** – transient function in embryonic reptiles, birds, and mammals

4. **metanephros** - functional kidney of adult reptiles, birds, and mammals

5. **opisthonephros** - the mesonephros and metanephros, together called the opisthonephros, form the adult kidney of most fishes and amphibians

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Kidney function in vertebrates:

- functional unit is the **nephron** which consists of **Bowman's capsule**, an enclosed **glomerulus**, and the attached **nephric tubule**

- all urine is formed by 3 well-defined physiological processes:

1. **filtration** - the process where the **fluid** from the blood (i.e., plasma filtrate; it consists of water and most substances that are in the blood except the blood cells, proteins, and platelets) **crosses from the glomerulus into the Bowman's capsule**

2. **tubular reabsorption** - most of the substances (e.g., ions, amino acids, glucose) in the fluid (i.e., plasma filtrate) are reabsorbed at various places along the nephric tubule

- note that the **peritubular capillaries** surround the nephric tubules; the substances that pass out of the nephric tubules are picked up by these capillaries and returned to the bloodstream

3. **tubular secretion** - this is the **reverse of tubular reabsorption**; this enables the kidney to build up concentrations of materials to be excreted, e.g., H+ and K+ ions, drugs, various organic foreign materials; the distal tubule is the site for most tubular secretion

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Know the diagrams on page 258 very well and how the different parts of the kidney and the nephron function (Fig. 30.10):

- on kidney diagram, know every structure and its function

- on nephron diagram, know every structure and its function

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How a kidney works (about the same process for most vertebrates, but we will talk here specifically about the mammalian kidney):

- a protein-free filtrate (resembling lymph) is driven by the blood pressure from inside the **glomerulus** across the membranes into **Bowman's capsule**; the fluid then travels through the **proximal convoluted tubule**, down the **descending limb** of the **loop of Henle**, up the **ascending** **limb** of the **loop of Henle**, through the **distal convoluted tubule**, into the **collecting duct** which then sends the urine into the **pelvis** of the kidney, through the **ureter** to the **bladder**, and eventually through the **urethra** to exit the body.

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- along this pathway, certain ions and substances are reabsorbed while waste products pass out in the urine; the following explains how this process works:

- in the **ascending limb**, Cl- ions are actively transported out of the filtrate into the interstitial fluid (Na+ ions follow passively); the end result is that NaCl go out of the ascending limb into the interstitial fluid.

- in the **descending limb**, NaCl goes back into the limb (from the interstitial fluid); also, in the descending limb, water goes out of the limb

- the streams flowing through the ascending and descending limbs are flowing in opposite directions; they call this a **countercurrent system**; notice that there is an opposite concentration gradient going from this**; the overall result of this countercurrent system is that the concentration of NaCl is increased in the interstitial fluid** (as you go deeper into the medulla of the kidney - therefore, this system is called **the countercurrent multiplier system**

**(note: descending limb is permeable to water but impermeable to solute; the ascending limb is nearly impermeable to water**

-diagram (Fig. 30.14) on page 261 sums up most nephron function

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Kidney/Urine:

- **aldosterone** - is a steroid hormone; secreted **by adrenal cortex**; causes Na+ ion (and water) resorption in distal convoluted tubules

- **ADH = antidiuretic hormone = vasopressin**; produced by posterior pituitary gland; causes water resorption (by permeability of the distal convoluted tubule and collecting duct)

- secretion of **aldosterone** is regulated mainly by enzyme called **renin** which is produced by **juxtaglomerular apparatus** in afferent arteriole at its junction with the **glomerulus**

- when Na+ is low or blood pressure is low, renin is released; the renin triggers a series of events which ends in **angiotensin** being secreted; this stimulates aldosterone release and increases secretion of ADH, both of which increase both pressure and stimulate thirst (to replace the low fluid level in blood)

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Fun facts: - humans can concentrate urine 4.2X that of blood; other animals: camels 8X, gerbil 14X, Australian jumping mouse 22X

Compare human and kangaroos rat water balance: see Fig. 30.1

Go back to fish notes and review how freshwater fish and saltwater fish handle osmotic regulation (also see Fig. 30.3)

**TEMPERATURE REGULATION:**

**Know the meaning of these terms:**

* **Poikilothermic** – fluctuating body temperature
* **Homeothermic** – constant body temperature
* **Ectothermic** – body temperature is determined by the environment
* **Endothermic** – internal heat source

**How Ectotherms Achieve Temperature Independence**:

* **Behavioral adjustments**
* **Temperature Compensation** – ectotherms can adjust their metabolic rates to prevailing temperatures (result is metabolic rate remains mostly unchanged regardless of environmental temperature)

**Temperature Regulation in Endotherms:**

* Most mammals have body temperatures between 36 and 38 degress C, somewhat lower that those of birds, which range between 40 and42 degrees C
* Constant temperature is maintained by a balance between heat production and heat loss
* Heat is produced by animal’s metabolism: oxidation of foods, basal cellular metabolism, and muscular contraction
* Heat is lost by: radiation, conducgion, and convection (air movement) to a cooler environment and by evaporation of water

**Adaptations for Hot Environments:**

* Fossorial –live mainly underground
* Nocturnal – active mainly at night
* Evaporative cooling: sweating and/or panting
* Fur color, distribution
* Fat distribution
* see Fig. 30.17 – shows ways an eland loses body heat in a warm environment

**Adaptations for Cold Environments:**

* **decreased conductance** (reduction of heat loss by increasing the effectiveness of the insulation) (some animals use countercurrent heat exchange in extremities or exposed parts to prevent heat loss – see Fig. 30.19)
* **increased heat production**

**- augmented muscular activity** through exercise or shivering

**- nonshivering thermogenesis – from oxidation of foods, especially brown fat**

* Animals (especially small mammals) often use **subnivean** environments (i.e., under the snow)

**Adaptive Hypothermia in Birds and Mammals: daily torpor, hibernation, estivation (read pp.266-267)**