BENG 189
University of California San Diego

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Chapter 1

Lecture 1: Renal System

1.1 Renal System Part 1:

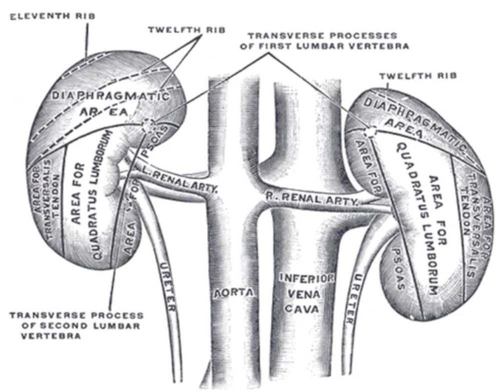

Figure 1.1: Anatomy of Kidneys, showing efferent and afferent blood vessesl

The kidneys sit below. They have two artery branches that feed oxygenated blood to the kidneys. Deoxygenated blood returns back to the <u>Inferior Vena Cava</u>. The kidneys filter nutrition which passes through the <u>ureter</u> which leads to the bladder. The kidneys sit below the ribs

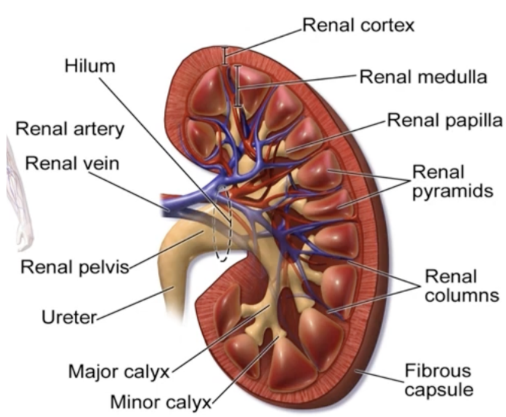

Figure 1.2: Specific anatomy of the kidney. This lecture focused primarily on the Medulla and Bowman's Capsule, discussed later this lecture

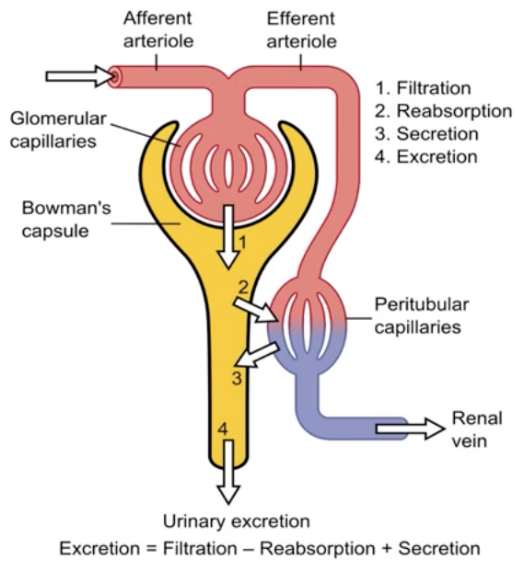

Figure 1.3: Blood Flow of Urinary Tract

1.2 Steps of Blood Flow

- Initial: Blood arrives via the areriole
- 1. Kidneys dump solutes and water in to the urinary tract
- 2. A delicate dance occurs between reabsorbing things and letting things being released to the urine
  - Ex: Retain items such as glucose and amino acids
- 3. Excrete some things
  - Ex: Drugs, urea, etc
- 4. Items go towards the Bladder

Definition 1.2.1: Urinary Excretion

Excretion = Filtration - Reabsorption + Secretion

1.3 How Different Solutes are Treated Differently

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Glucose and Amino Acids are reabsorbed right away at 100% performance.
Optimal Balance $\rightarrow$ excreting "bad" substances effeciently may \underline{require, a
little loss of water.}
Dump blood flow into the Bowman's capsule
The textbook starts at the Glomerulus (G), travels to the Afferent arteriole (AA).
Leaky capillaries lose some water and small molecules.
Proteins are too large to leave and thus they stay. This creates an osmotic pressure against
filtering out water.
blood pressure, can lead to multi-organ failure
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Proximal Tubulue

this is your plasma without proteins

Na reabsorption $\longrightarrow$ water goes too

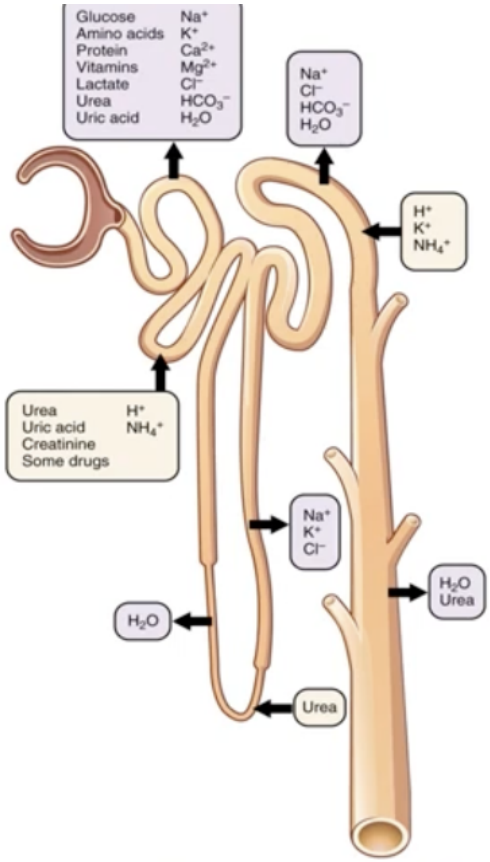

Figure 1.4: Flow of Solutes through the urinary system. The loopy of Henley is key to allowing the concentration of solutes

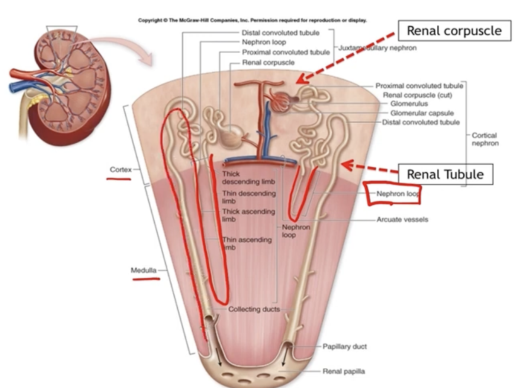

Figure 1.5: There exists 10^6 nephrons, connected in parallel

This functions to decrease the volume of urine

Loop of Henle $\rightarrow$ Na concentration changes

Ascending Limb $\rightarrow$ Metabolically Active, Impermeable to H_2O, Permeable to Na^+

Na^+ is pumped from tubule $\rightarrow$ intersititium $\rightarrow$ leads to concentration gradient $\rightarrow$ Descending Loop of Henle

Descending Loop of Henle $\rightarrow$ proggressively increasing $[Na^+]$

Peritubule capillaries $\rightarrow$ pick up/ return fluid to interstitial vein Distil tube collect duct are imperm to H_2O Distil

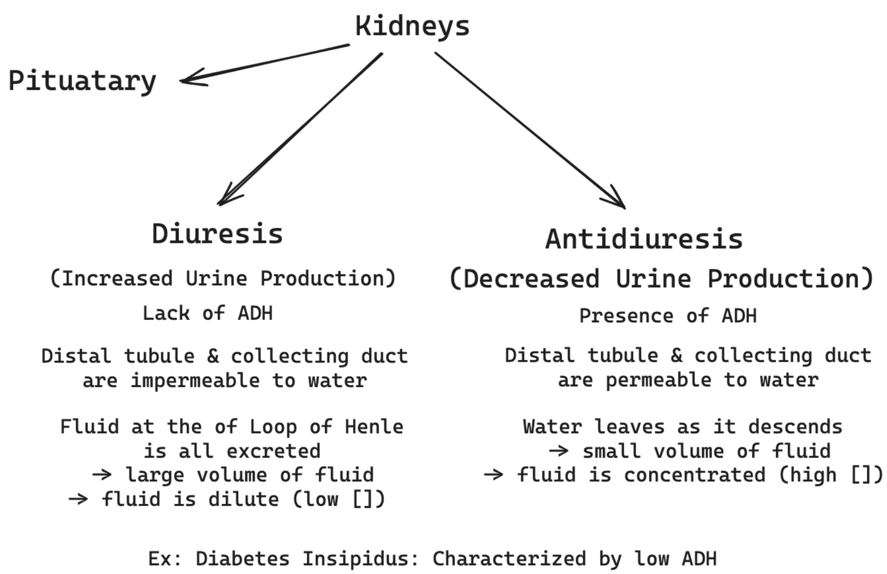

Figure 1.6: Concentration of Urine

tube collect duct are perm to H_2O fluid at the of LH of it is excreted large vlume dilute -¿ low concentration water leave as it descends smaller concentretated volume

Example 1.3.1 (Diseases)

1.4 Dynamics of Na^+ and H_2O Transport

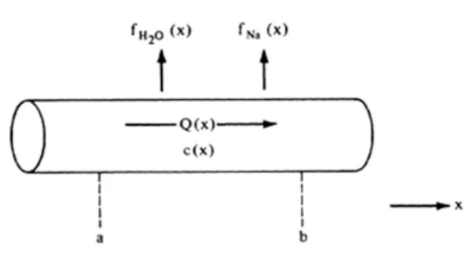

Figure 1.7:

Definition 1.4.1: Flow Rate

let Q(x) be the flower rate past x Assume in steady state let f(x) = the flow through the walls per unit length at x

$$\therefore Q(a) = Q(b) + \int_a^b f\mathrm{H}_2O(\mathrm{x})\,\mathrm{dx}$$
$$\therefore 0 = \frac{\partial Q(b)}{\partial x} + \mathrm{f}_{H_2O}(b)$$
$$\therefore 0 = \frac{\partial Q}{\partial x} + \mathrm{f}_{H_2O}(x)$$

Now consider the concentration of Na^+ and its concentration, c(x)
The amount of Na^+ transport along the tubule by flow as Q(x) (x)
While the flow through the walls, f_{Na^+}

$$Q(a)c(a) = Q(b)c(b) + \int_a^b f_{Na^+}\,dx$$

$$\therefore 0 = \frac{\partial}{\partial x}(Q(b)c(b)) + f_{Na^+}(b)$$
$$\therefore 0 = \frac{\partial}{\partial x}(Q(c)) + f_{Na^+}(x)$$
$$\mathrm{Q(a)c(a)} = \mathrm{Q(b)c(b)} + \int_a^b f_{Na^+}\,dx$$

Model of Loop of Henle Describe a salty meal versus drinking water

Definition 1.4.2: Shannon's Definition of Information (h)

Let an ensemble, X, have input (x, A_x, P_x) where x is a random variable, A_x is a set of possible outcomes $(a_1, a_2, a_3, ...a_1)$ and where P_x is the set of possibilities $P_x = (P_1, P_2, ...P_i)$ such that P(x=a_i) = P_i, we define Shannon's information content as the following:

$$x = a_i h(x = a_i) = log_2$$

$$\therefore h(x = a_i) = log_2 \frac{1}{P(x = a_i)}$$