Renal Secretion & pH Control

Topics for today:

- Renal secretion of potassium
- Examples of solute clearance rates
- Hormones affecting kidney function
- Counter current concentration mechanism
- Renal mechanisms of pH control
- Buffer mechanisms

Active secretion

Various substances are actively transported across the basal surface. Some organic substances are transported via ‘organic anion transporter’ proteins and secreted into the lumen of the tubule.

<u>organic anions secreted</u> (examples):

- penicillin
- creatinine
- diodrast
- phenol red

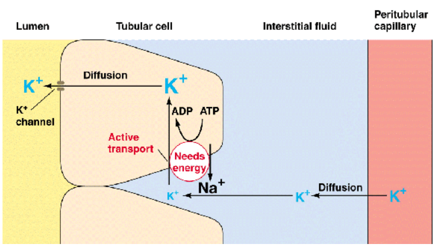
Active secretion

Other organic substances are transported via 'organic cation transporter' proteins and secreted at the apical surface into the lumen of the tubule.

organic cations secreted (examples):
- histamine
- norepinephrine
- quinine

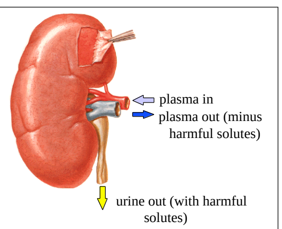
Secretion of potassium ions*

- coupled with active reabsorption of Na
- occurs mainly in distal convoluted tubule



*Prevents disruption of heart EKG rhythm

Renal clearance: some examples



Plasma clearance rates, **ml/min**

- glucose 0 ml/min
- amino acids 1-4 "
- Na^+ 0.5 "
- K^+ 15 "
- PO_4^{-3} 21 "
- urea 60 "
- uric acid 6 "
- creatinine 150 "

$$C_x = \frac{U_x V}{P_x}$$

$$C_x = \frac{(\text{mg/ml})(\text{ml/min})}{\text{mg/ml}}$$

$$C_x = \text{ml/min}$$

Hormones affecting kidneys

- Bradykinin
- Endothelin
- Renin/angiotensin
- Aldosterone
- Antidiuretic hormone (ADH)
- Atrial naturetic factor

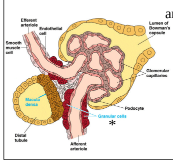
Renin/Aldosterone system

↓blood pressure → kidney ∗granular cells → **renin** → angiotensin I

liver → angiotensinogen → angiotensin I

lungs → angiotenisin converting enzyme → (angiotensin I → angiotensin II)

angiotensin II → adrenal cortex → **aldosterone** → kidney → ↑Na reabsorption → **↑blood pressure**



Water balance and ADH

Input		Output	
water in beverages	1000 ml	skin & lungs	900 ml
water in food	1200 ml	via GI tract	100 ml
water of oxidation	300 ml	via kidneys	1500 ml
total	2500 ml	total	2500 ml

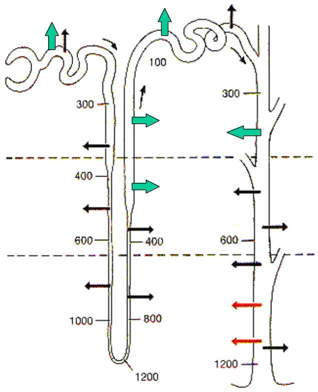
When ouput exceeds input, plasma osmotic concentration increases

- triggers release of antidiuretic hormone (**ADH)**
- reabsorption of water increases —> urine becomes more concentrated

When input exceeds ouput, plasma osmotic concentration decreases

- less ADH released
- reabsorption of water decreases —> high volume dilute urine (diuresis)

Counter current tubule flow



Counter current flow

important mechanism for concentrating some solutes

active transport of NaCl

passive diffusion of H_2O

passive diffusion of urea

Renal mechanisms of pH control

- **secretion** of H^+ ions into kidney tubule
  (H^+ ions excreted in urine)
- **reabsorption** of HCO_3^- ions
  (this raise plasma pH)
- **excretion** of ammonium ions to remove H^+
  $H^+ + NH_3 \longrightarrow NH_4^-$ (excreted in urine)

Buffers and maintenance of pH

Buffers function to minimize the extent of changes in pH of body fluids.
One particularly important buffer system is the **bicarbonate buffer system**:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \underset{K_2}{\overset{K_1}{\rightleftharpoons}} H^+ \quad HCO_3^-$$

acid HA — conjugate base A^-

$$K_a = K_1/K_2$$

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

Henderson-Hasselbach equation

pK is the pH at which $[A^-] = [HA]$

More on bicarbonate system

$$pH = pK_a + \log \frac{[A^-]}{[HA]} = pK_a + \log \frac{[HCO_3^-]}{[H_2CO_3]}$$

CO_2 is equivalent to H_2CO_3

$$pH = pK_a + \log \frac{[HCO_3^-]}{[CO_2]}$$

$[HCO_3^-]$ controlled by kidneys

$[CO_2]$ controlled by lungs

$pK_a = 6.1$

$$pH = 6.1 + \log \frac{[20]}{[1]}$$

The HCO_3^- / CO_2 ratio in ECF is about 20:1

$\therefore$ pH = 6.1 + 1.3 = 7.4

Topic for Friday:

Kidney and Lung Control of pH

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$