Chapter 23

Urine Formation III
Water Conservation
Urine Formation III: Water Conservation

- the kidney eliminates metabolic wastes from the body, but also prevents excessive water loss as well

- as the kidney returns water from the tubules back into the tissue fluid and bloodstream

- the fluid remaining in the renal tubules passes as urine
  - this fluid becomes more concentrated!
Collecting Duct Concentrates Urine

- Collecting duct (CD) begins in the cortex where it receives tubular fluid from several nephrons.
- As CD passes through the medulla, it reabsorbs water and concentrates urine up to four times.
- Medullary portion of CD is more permeable to water than to NaCl.
- As urine passes through the increasingly salty medulla, water leaves by osmosis concentrating urine.
Control of Water Loss

- How concentrated the urine becomes depends on body’s state of hydration:
  - **water diuresis** – drinking large volumes of water will produce a large volume of **hypotonic urine**
    - cortical portion of CD reabsorbs NaCl, but it is impermeable to water
    - salt removed from the urine stays in the CD
    - urine concentration may be as low as 50 mOsm/L
  - producing **hypertonic urine**
    - dehydration causes the urine to become scanty and more concentrated
    - high blood osmolarity stimulates posterior pituitary to release ADH and then an increase in synthesis of aquaporin channels by renal tubule cells
    - more water is reabsorbed by collecting duct
    - urine is more concentrated
  - If BP is low in a dehydrated person, GFR will be low.
    - filtrate moves more slowly and more time for reabsorption
    - more salt removed, more water reabsorbed and less urine produced
Countercurrent Multiplier

• the ability of kidney to concentrate urine depends on salinity gradient in renal medulla
  – four times as salty in the renal medulla than the cortex

• nephron loop acts as countercurrent multiplier
  – multiplier - continually recaptures salt and returns it to extracellular fluid of medulla which multiplies the salinity in adrenal medulla
  – countercurrent - because of fluid flowing in opposite directions in adjacent tubules of nephron loop

• fluid flowing downward in descending limb
  – passes through environment of increasing osmolarity
  – most of descending limb very permeable to water but not to NaCl
  – water passes from tubule into the ECF leaving salt behind
  – concentrates tubular fluid to 1,200 mOsm/L at lower end of loop

• fluid flowing upward in ascending limb
  – impermeable to water
  – reabsorbs Na⁺, K⁺, and Cl⁻ by active transport pumps into ECF
  – maintains high osmolarity of renal medulla
  – tubular fluid becomes hypotonic – 100 mOsm/L at top of loop

• recycling of urea: lower end of CD permeable to urea
  – urea contributes to the osmolarity of deep medullary tissue
  – continually cycled from collecting duct to the nephron loop and back
  – urea remains concentrated in the collecting duct and some of it always diffuses out into the medulla adding to osmolarity
The more salt that is pumped out of the ascending limb, the saltier the ECF is in the renal medulla.

The saltier the fluid in the ascending limb, the more salt the tubule pumps into the ECF.

The more water that leaves the descending limb, the saltier the fluid is that remains in the tubule.

The higher the osmolarity of the ECF, the more water leaves the descending limb by osmosis.

More salt is continually added by the PCT.
Countercurrent Exchange System

- **vasa recta** – capillary branching off efferent arteriole in medulla
  - provides blood supply to medulla and does not remove NaCl and urea from medullary ECF

- **countercurrent system** - formed by blood flowing in opposite directions in adjacent parallel capillaries

- **descending capillaries**
  - exchanges water for salt
  - water diffuses out of capillaries and salt diffuses in

- **as blood flows back up to the cortex the opposite occurs**

- **ascending capillaries**
  - exchanges salt for water
  - water diffuses into and NaCl diffuses out of blood
  - the vasa recta gives the salt back and does not subtract from the osmolarity of the medulla

- absorb more water on way out than the way in, and thus they carry away water reabsorbed from the urine by collecting duct and nephron loop
Maintenance of Osmolarity in Renal Medulla

Countercurrent Multiplier
Loop of Henle

Countercurrent Exchange
Vasa Recta

Osmolarity of ECF (mOsm/L)

Cortex
Medulla

Key

Active transport
Diffusion through a membrane channel
Summary of Tubular Reabsorption and Secretion

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

See C23-6 for more details