Dilution and Concentration of Urine

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Objectives

At the end of this lecture student should be able to describe:

- **that the loop of Henle is referred to as countercurrent multiplier and vasa recta as countercurrent exchange systems in concentrating and diluting urine**
- **To describe the concentrating and diluting mechanisms of urine**
- **To list the factors affecting concentration and dilution of urine**
- **Differentiate between water diuresis and osmotic diuresis**

Urine concentration

The ability of the kidney to concentrate urine (conserve water) is important function in regulating Extracellular volume (ECV), Extracellular Fluid osmolality

- **When there is excess water in the body and body fluid osmolarity is reduced, the kidney can excrete urine with an osmolarity as low as 50 mOsm/liter.**
- **When there is a deficience of water and extracellular fluids osmolarity is high, the kidney can excrete urine with a concentration of about 1200 to 1400 mOsm/liter.**

Urine volume and concentration

- **When water intake is normal:**
  - **Urine flow is 1 - 2 ml/min**
  - **Urine osmolality is between 500-700 mOsm/kg.**
- **0.5 is obligatory urine volume is the minimum urine volume in which the excreted solute can be dissolved and excreted**

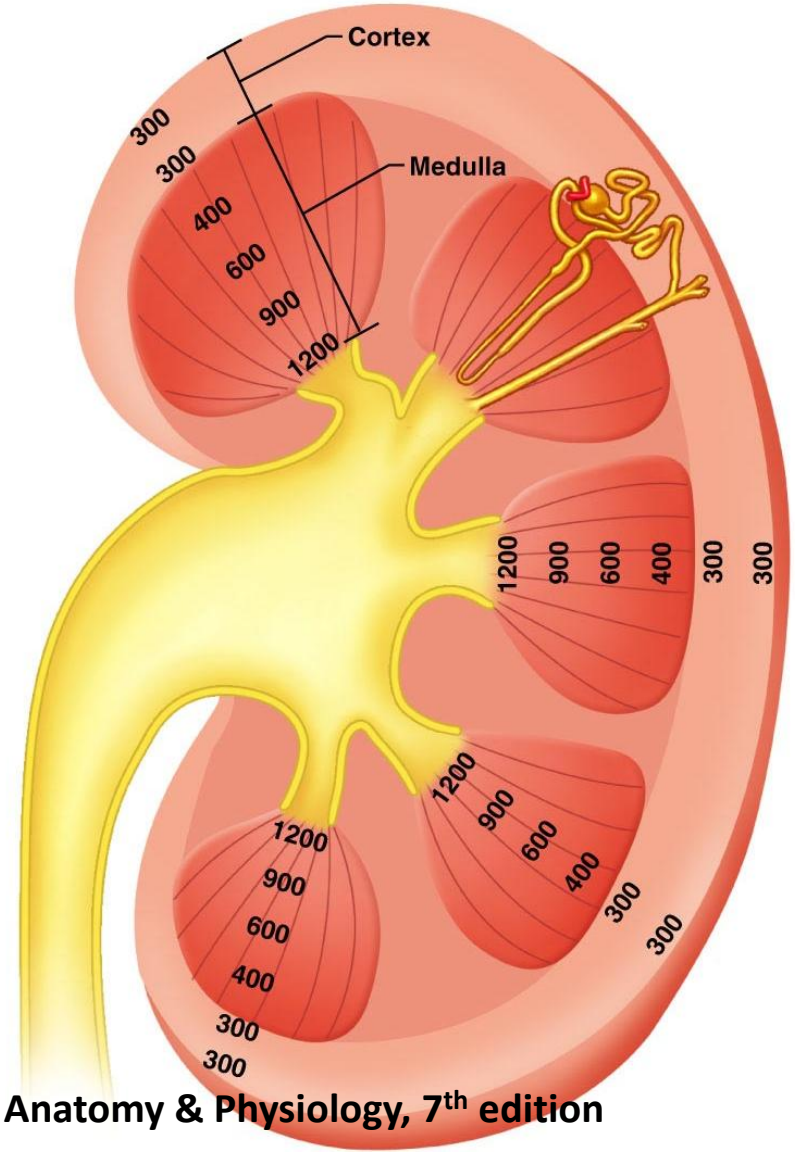
Urine volume and concentration

- **Range of volume and osomolality regulated by the kidney**
  - **Urine Osmolality varies between 30-1200 mosm/kg**
  - **Urine volume varies between 0.5-20ml/minute**

The basic requirements for forming a concentrated or diluted urine

1. Controlled secretion of antidiuretic hormone (ADH), which regulates the permeability of the distal tubules and collecting ducts to water;
2. a high osmolarity of the renal medullary interstitial fluid, which provides the osmotic gradient necessary for water reabsorption to occur in the presence of high level of ADH

The graded hyper-osmolar medulla



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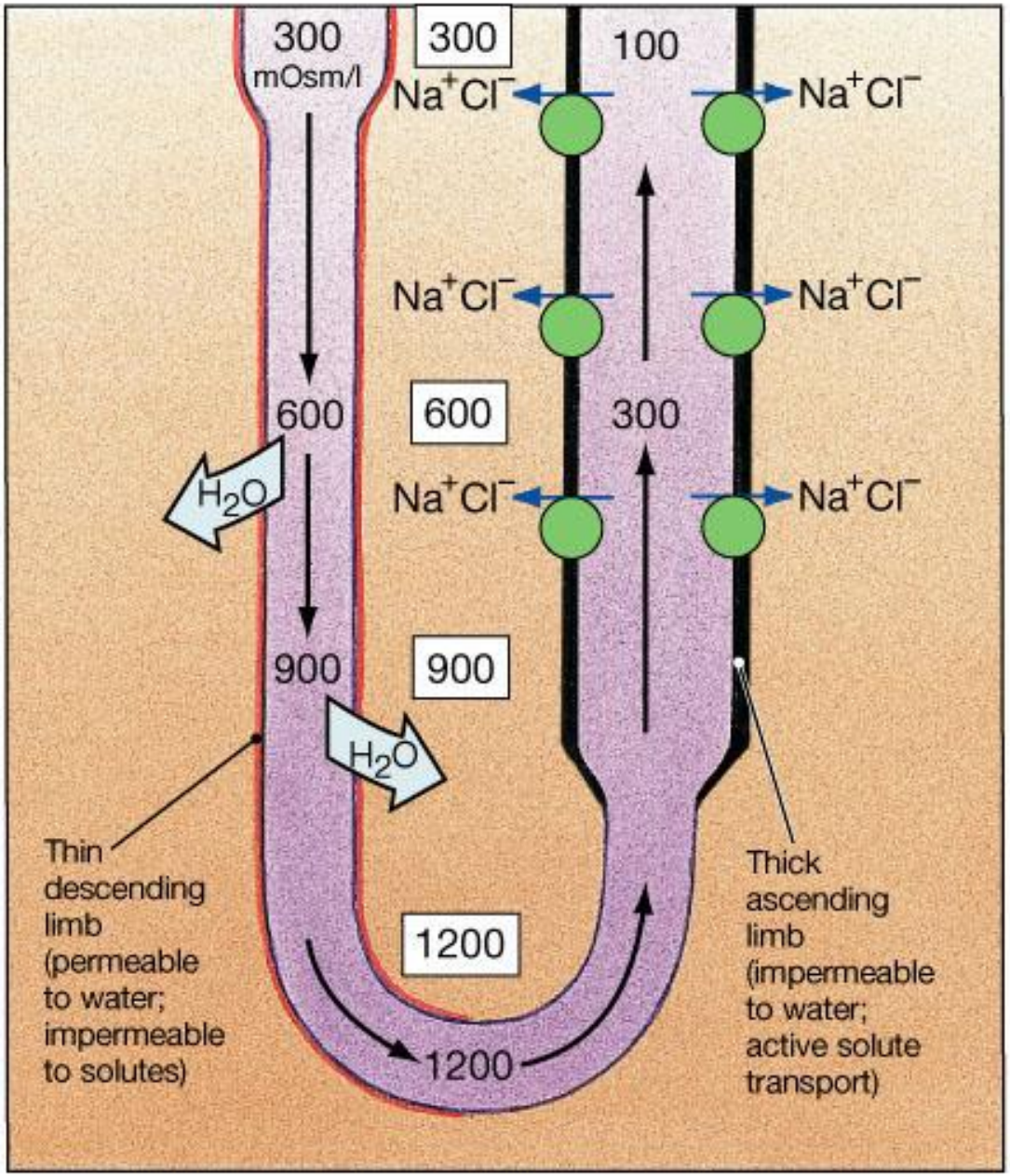
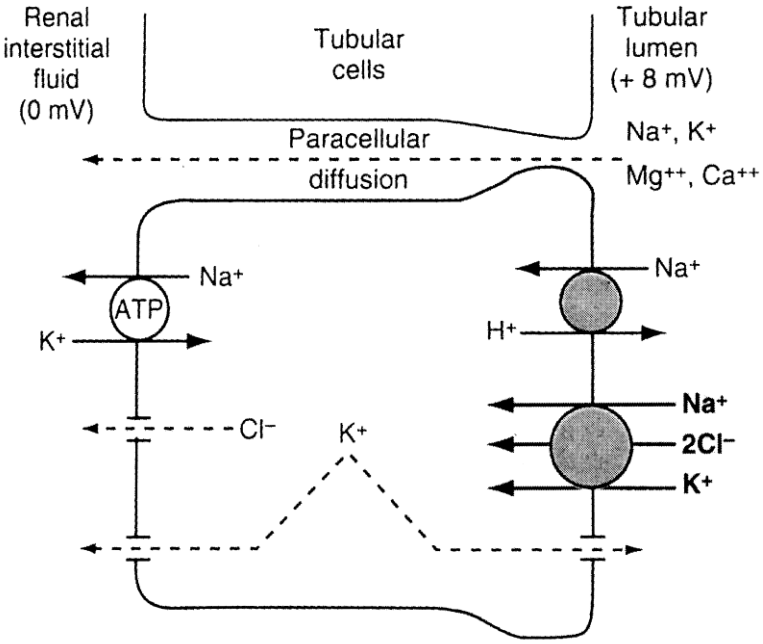
Counter-Current Mechanism

- **The hyperosmotic Renal Medullary Interstitium is produced by Counter-Current multiplier.**
- **The hyper-osmolar medullary interstitum provides the osmotic gradient necessary for water reabsorption**
- **The hyper-osmolar medulla is formed by the thick Ascending limb of loop of Henle and Collecting Ducts**
- **Is formed mainly by Juxta-medullary nephrons**

Counter current multiplayer

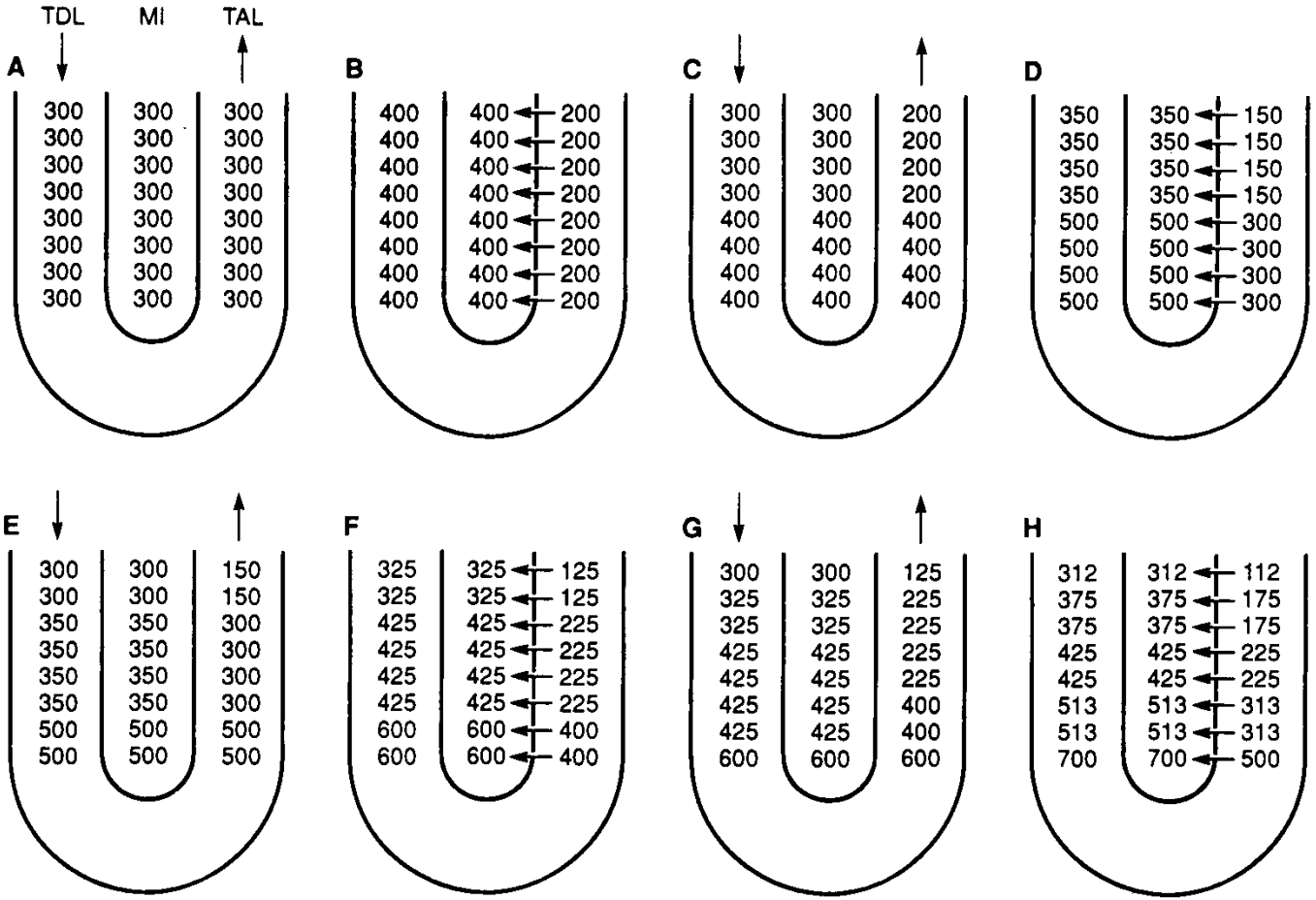
- **Medullary hyper osmolality is due to solute deposition on medullary interstitium**
  - **Nacl reabsorbed from the thick ascending limb of loop is deposited on medullay interstitum**
  - **Urea reabsorbed from collecting duct (ADH) to medullary interstitum also contribute to medullary hyperosmolality**
- **Water will be absorbed from the collecting duct to peritubular capillaries in the presence of ADH due to osmotic gradient**





(b) Active transport of NaCl along the ascending thick limb results in the movement of water from the descending limb.

Counter current multiplayer



Counter current multiplayer

- **Thiazide (antidiuretics) block Nacl reabsorption on thick ascending loop → causes Diuresis**
  - **Mechanism:**
    - **Salt remains in filtrate drag water → Osmotic diuresis**
    - **Decreases medullary osmolality therefore water cannot be reabsorbed from collecting duct (No osmotic gradient) → diuresis**

Counter current exchanger

- **Maintains hyper osmolar medulla**
- **Blood supply to medulla is by Vasa recta**
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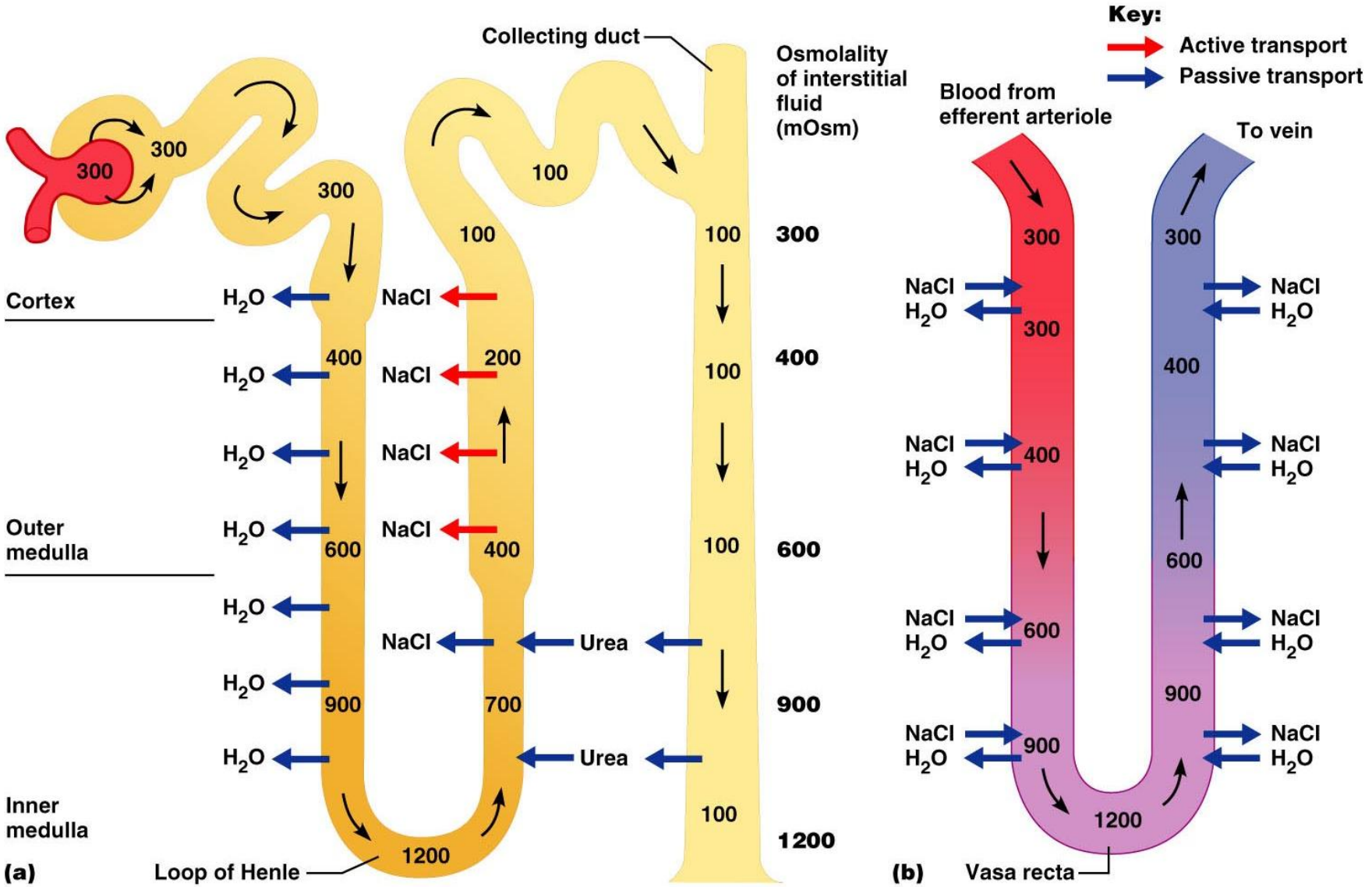
Counter current exchanger

- **Descending limb: water pass out into hyper osmolar medulla carrying O2 & nutrient, Na Cl will enter the blood increasing its osmolalty**
- **Ascending limb:**
  - **water will be absorbed back to the hyper osmolar blood carrying CO2, waste product & Nacl will leave the blood deposited as its in the medulla**
- **Therefore blood leave the hyperosmolar medulla undisturbed**

Countercurrent mechanism



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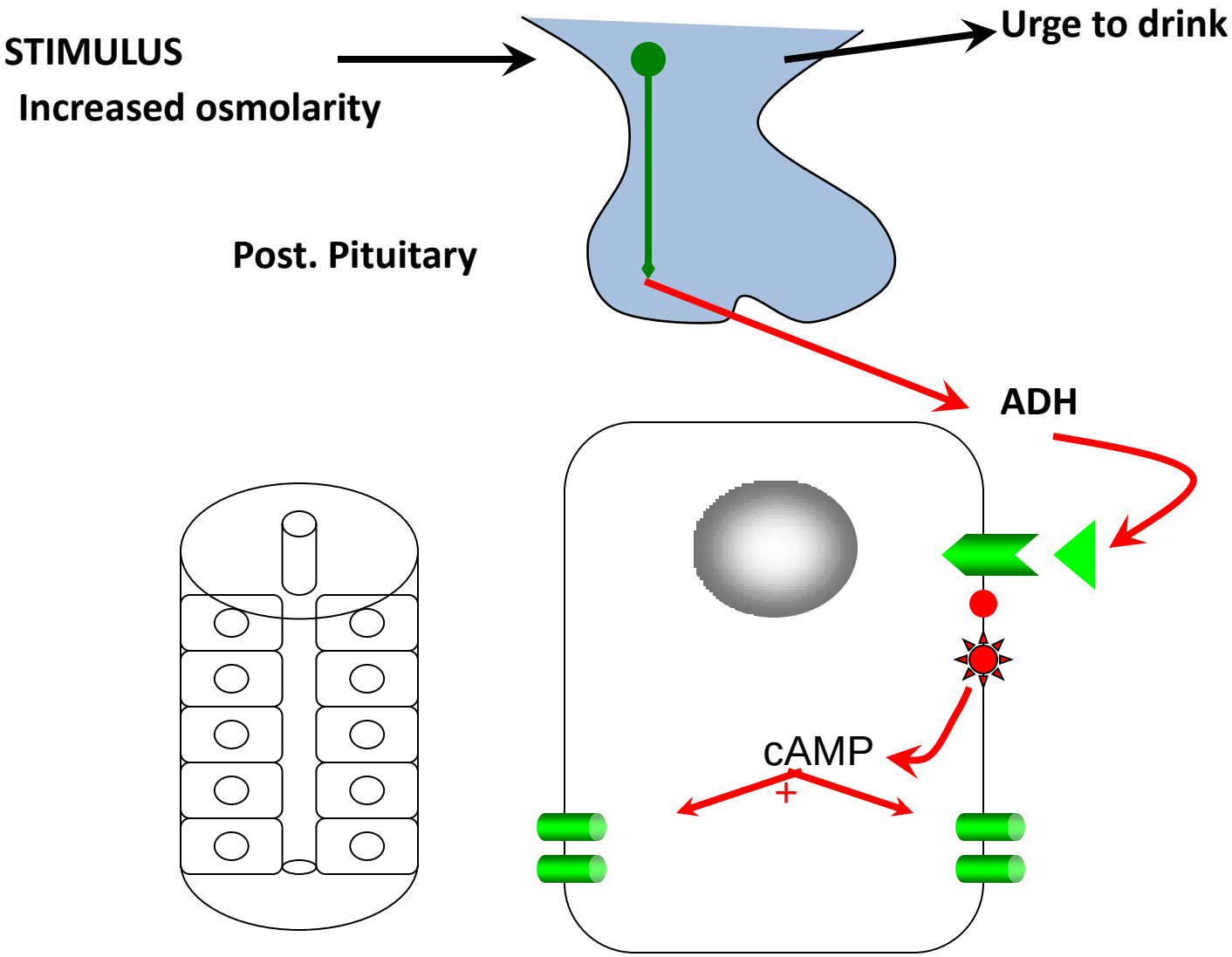
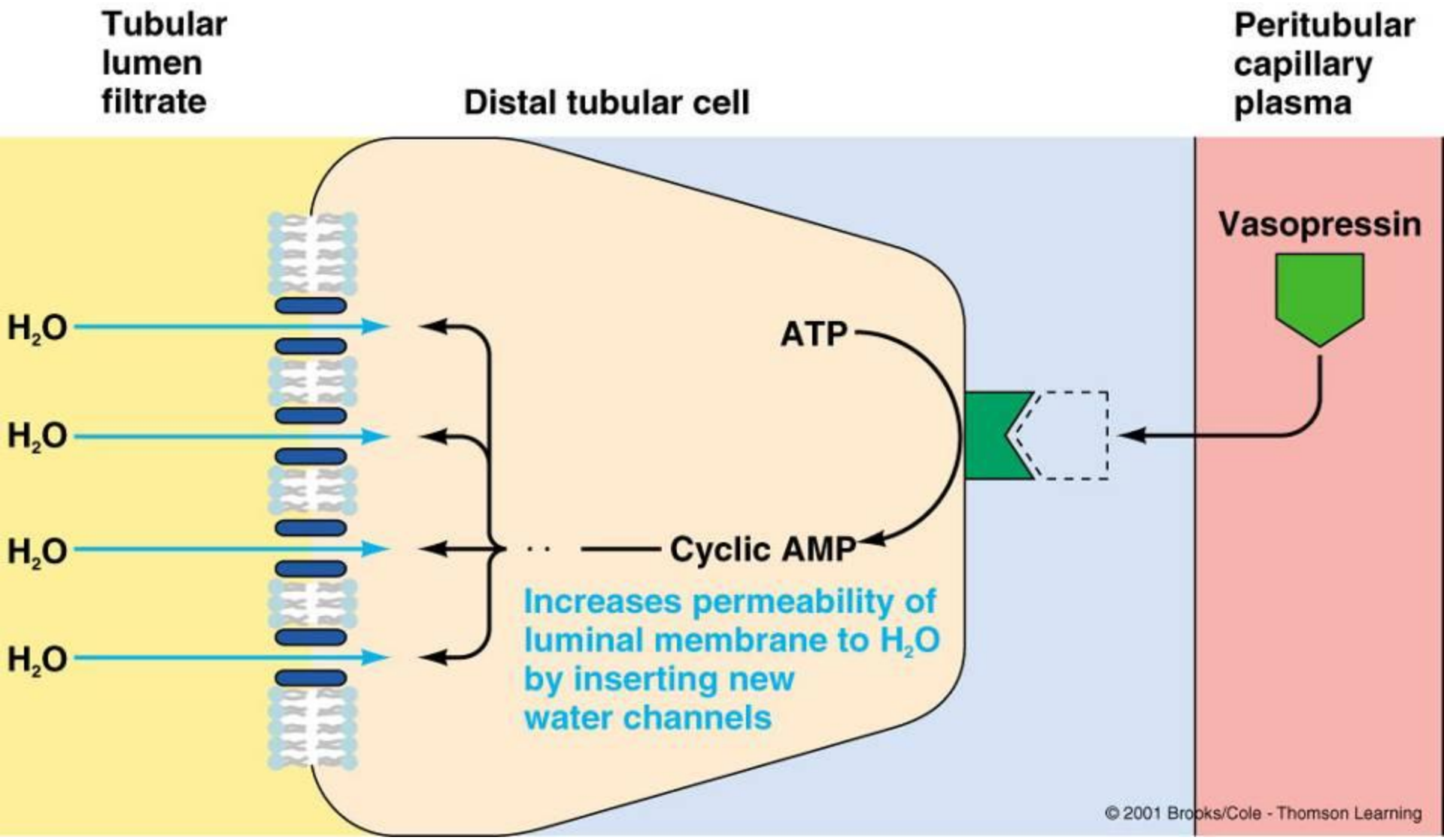
The Role of ADH

- **Water reabsorbed from collecting duct (by osmosis) is determined by the hormone ADH (anti-diuretic hormone)**
- **Osmoreceptors in the hypothalamus detect the low levels of water (high osmolarity), so the hypothalamus sends an impulse to the pituitary gland which releases ADH into the bloodstream.**
- **ADH makes the wall of the collecting duct more permeable to water.**
- **In the present of ADH more water is reabsorbed and less is excreted.**

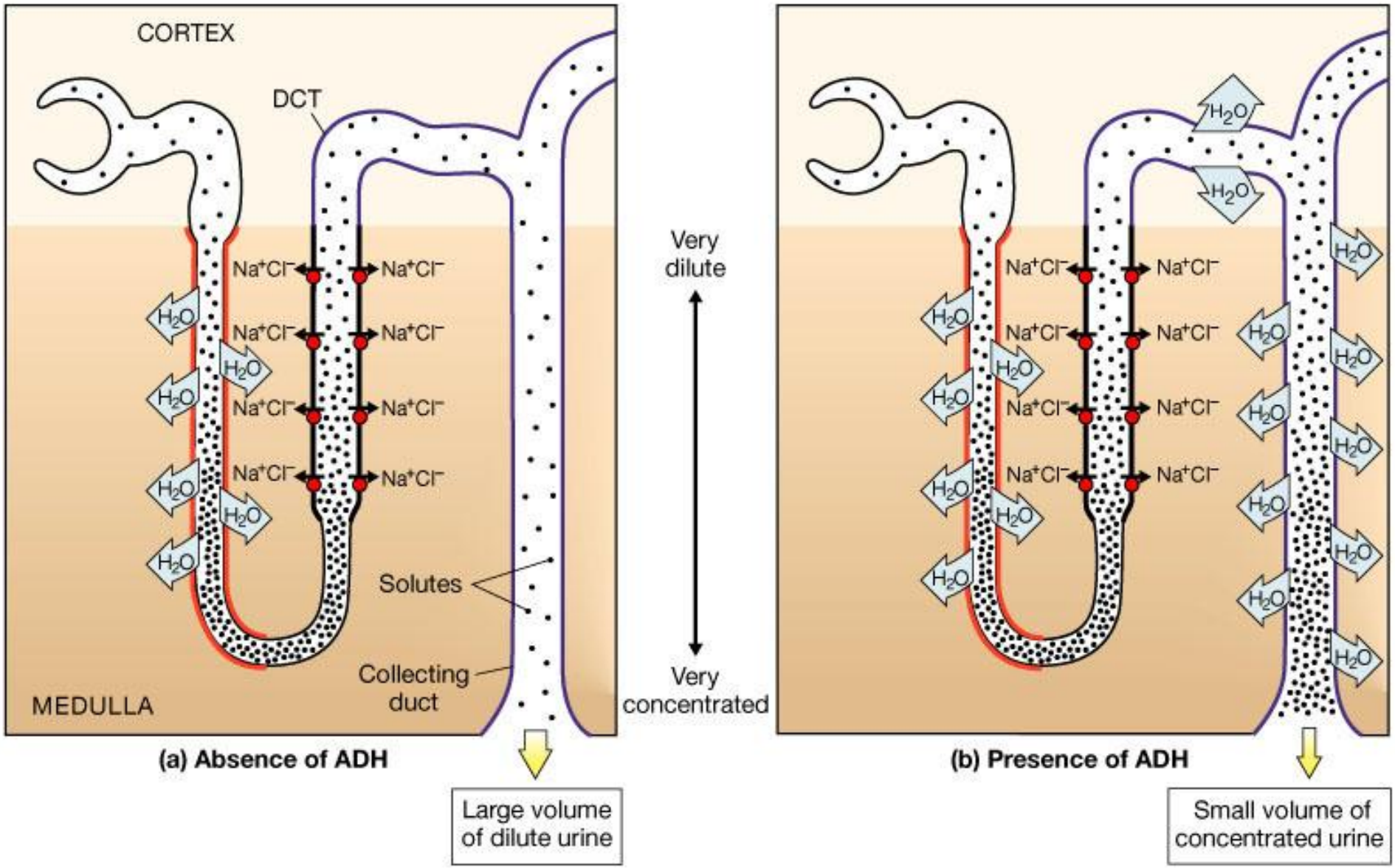
Secretion of ADH



Facultative water reabsorption



The Effects of ADH on the distal collecting duct and Collecting Ducts



Diuresis

- **is increase of urine output.**
- **Water diuresis:**
  - **Drinking large quantity of water →**
  - **→ dilute ECF**
  - **→ ↓ ADH**
  - **→ no water reabsorption in collecting duct**
  - **→ large volume of dilute urine**

Diuresis *cont.*

- **Osmotic diuresis**
  - **Diabetes**
  - **Filtration of excessive osmotic active substances (glucose, mannitol)**
  - **Drag water with it**
  - **Large volume of hyperosmolar urine**
- **Polyurea: Diabetes inspidus**