THE EXCRETORY SYSTEM

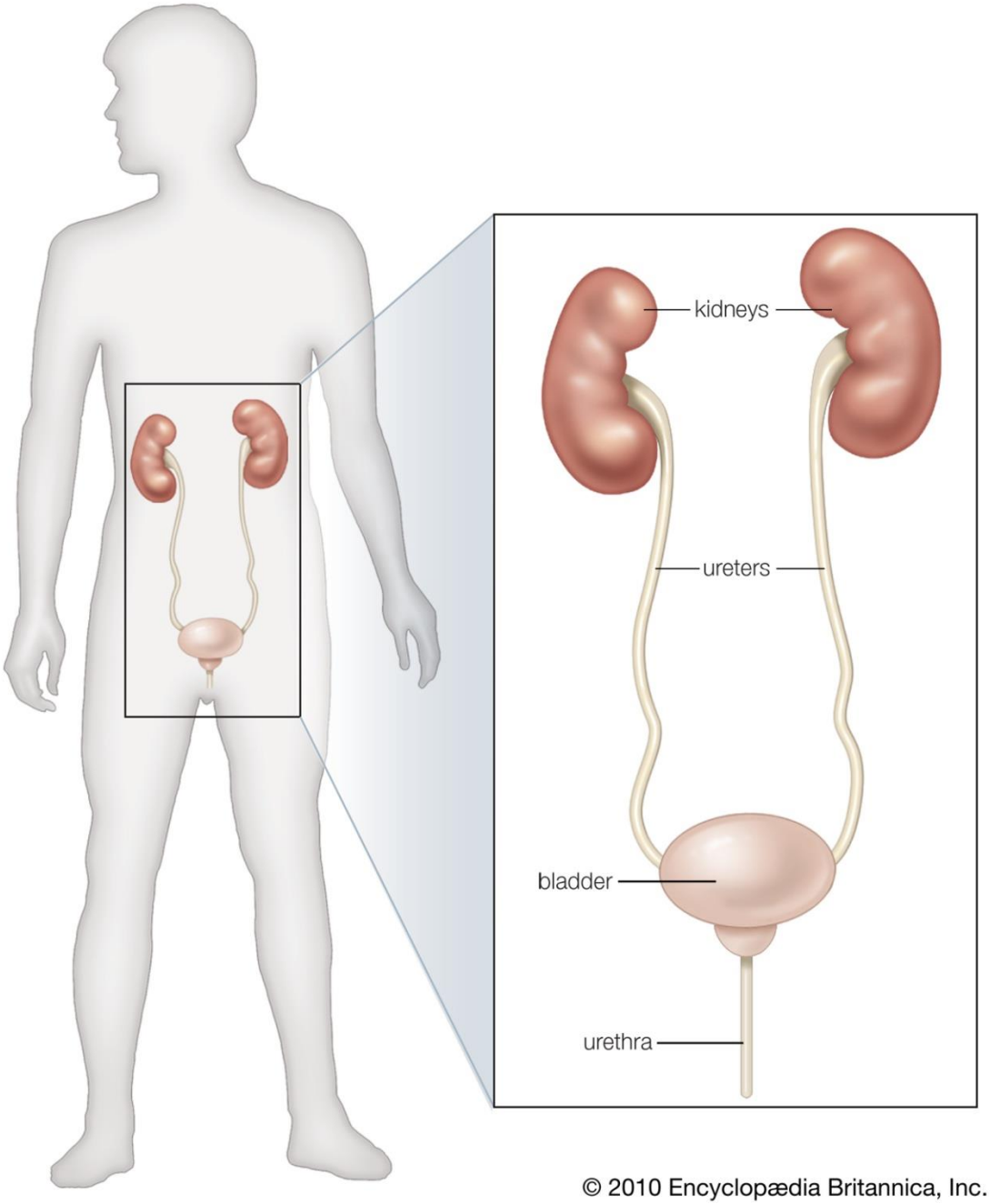
Premedical Biology

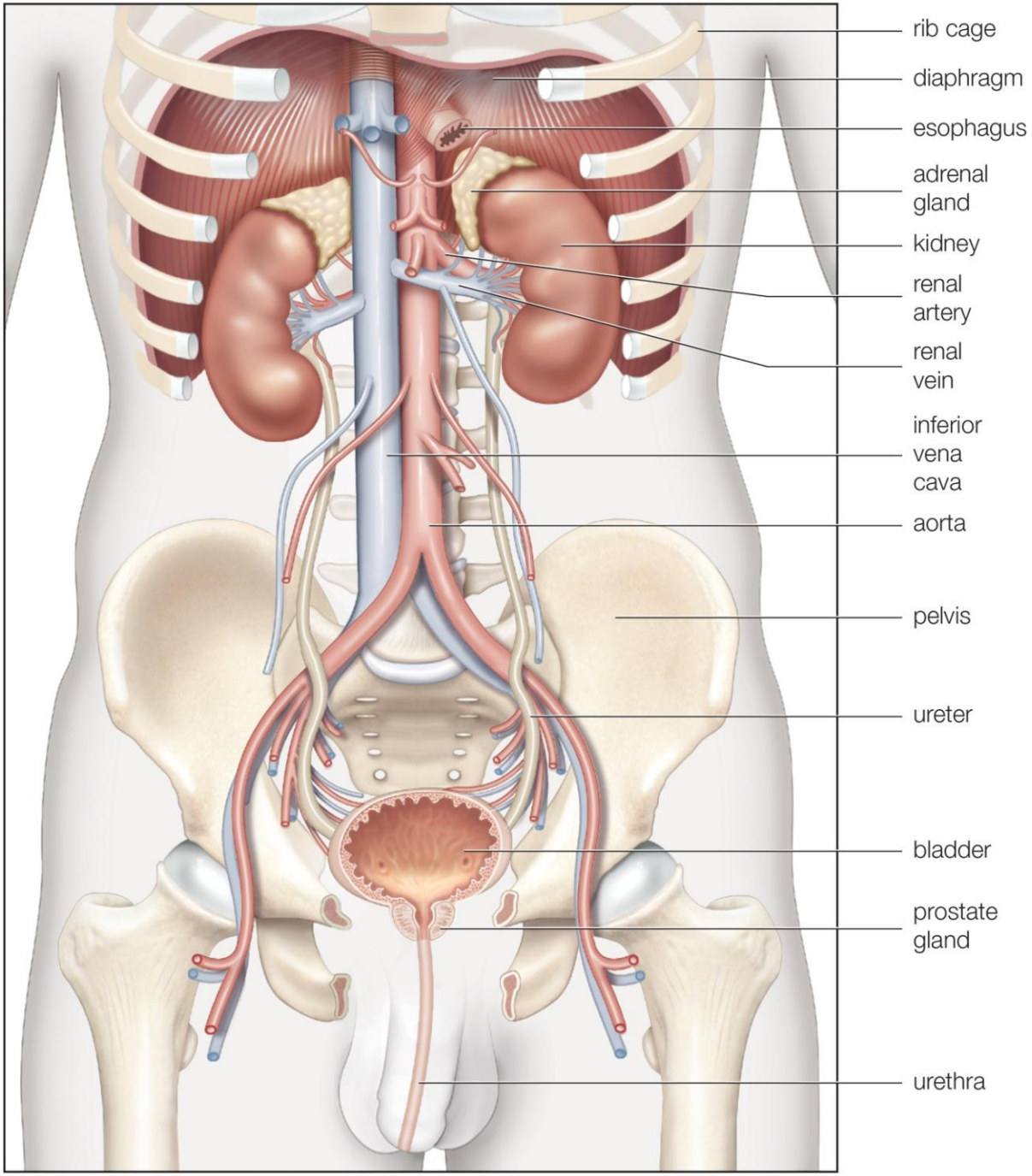
Pair of kidneys

Pair of urethers

Urinary bladder

Urethra





The excretory system

The ***urethers*** are tubes that carry urine from the pelvis of the kidneys to the urinary bladder.

The ***urinary bladder*** temporarily stores urine until it is released from the body.

The ***urethra*** is the tube that carries urine from the urinary bladder to the outside of the body.

The outer end of the urethra is controlled by a **circular muscle called a sphincter.**

Kidney

Each kidney is composed of three sections:

(renal) cortex,

(renal) medulla (middle part) and

(renal) pelvis.

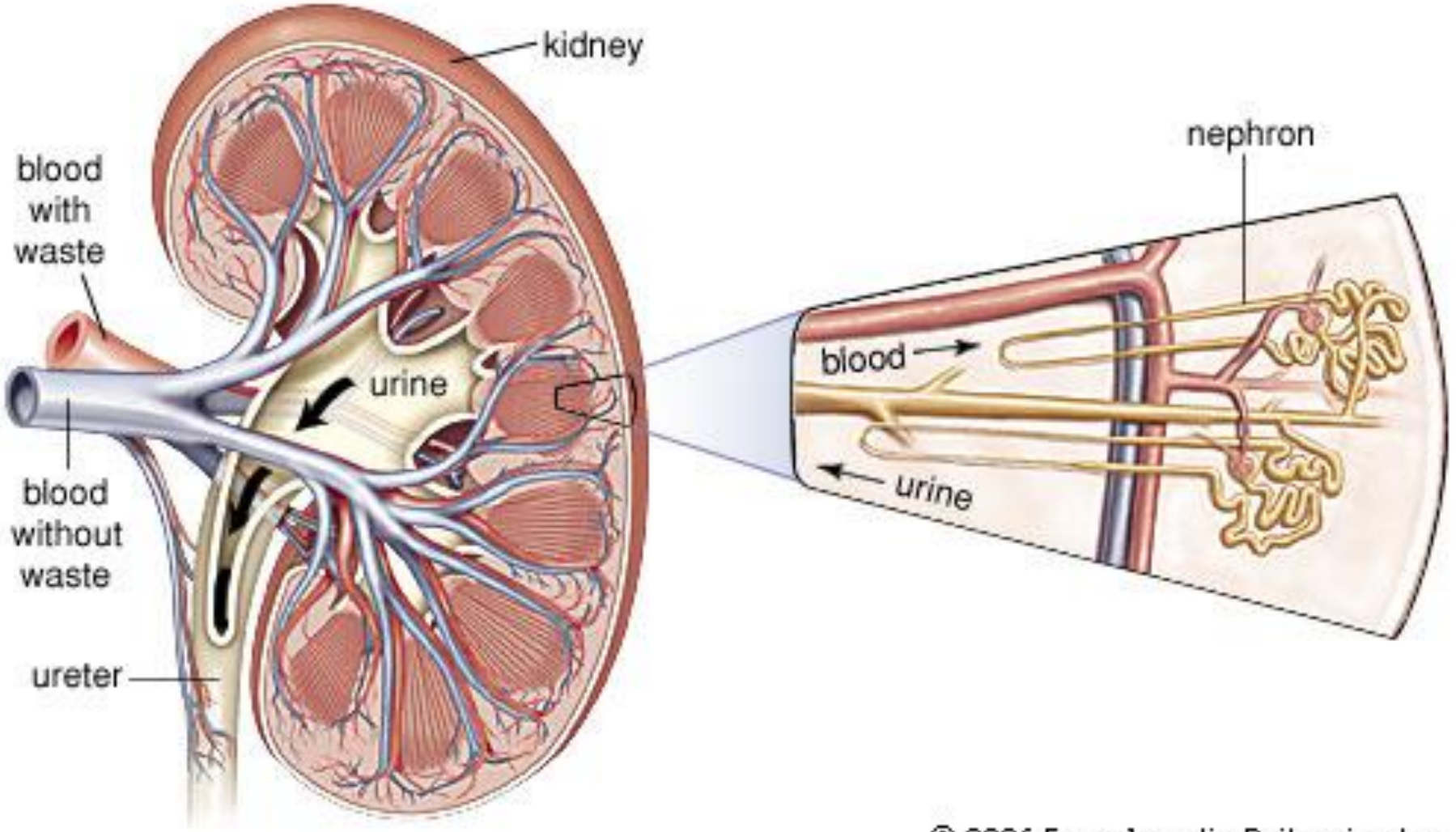
Kidneys are surrounded by adipose tissue – **capsula adiposa**.

Kidney

The ***cortex*** is where the blood is filtered.

The ***medulla*** contains the collecting ducts which carry filtrate (filtered substances) to the pelvis.

The ***pelvis*** is a hollow cavity where urine accumulates and drains into the urether.



Kidney

- essential part of the **urinary system**
- **nephrons** are structural and functional (filtration) units of the kidney

Normal kidney contains **800,000 to one million nephrons.**

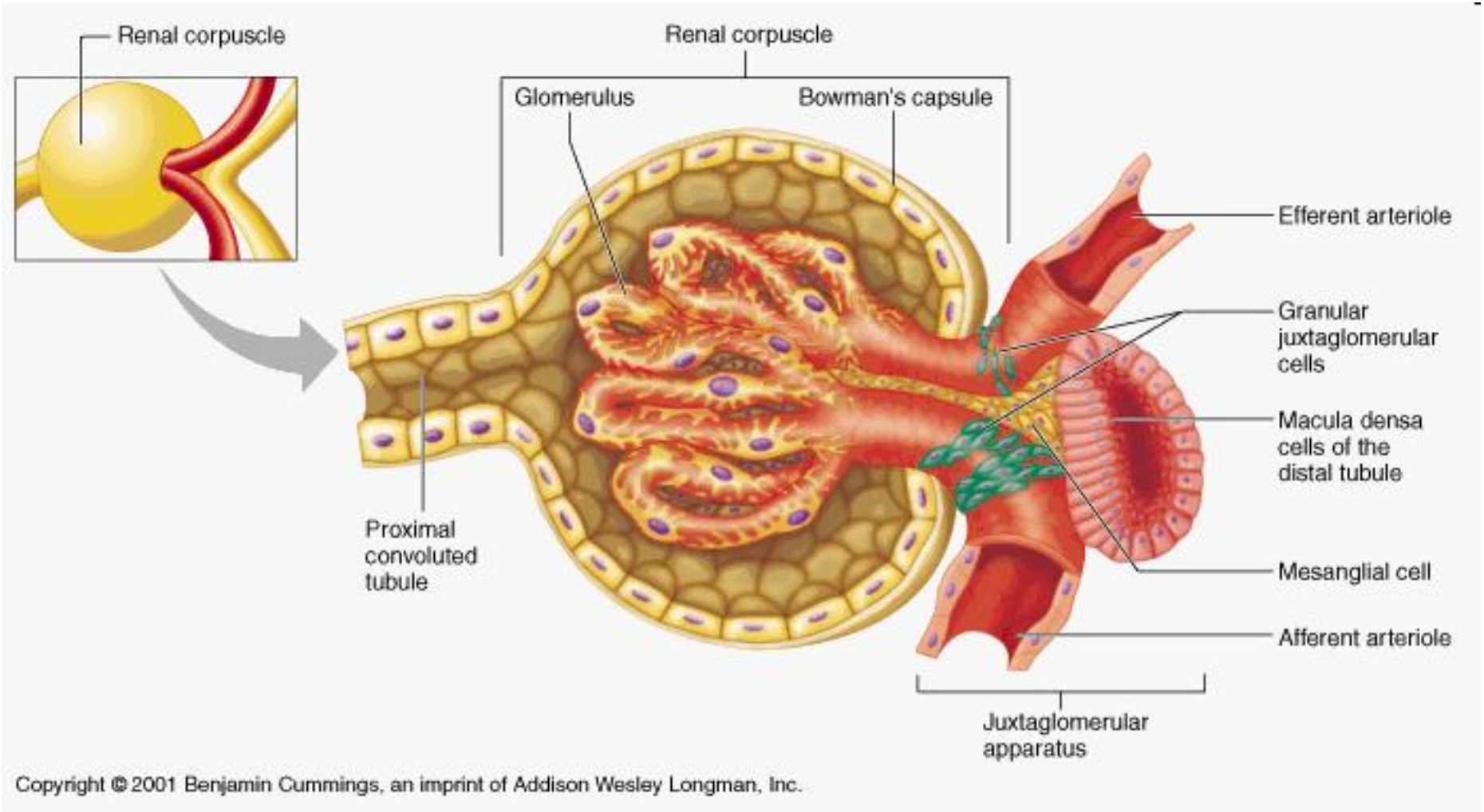
Nephron

- **renal corpuscle is** filtering component ad consists of glomerulus and Bowman‘s capsule
- **renal tubule is** specialized for reabsorption and secretion and consists of proximal tubule, loop of Henle, distal tubule and collecting tubules

Renal corpuscle

- **Renal corpuscle** is composed of **a glomerulus** and **Bowman's capsule.** An **afferent arteriole** enters the glomerulus and an **efferent arteriole** leaves it.
- The glomerulus is composed of a **capillary tuft,** that receives blood from **an afferent arteriole**. The tuft is surrounded by Bowman‘s Capsule consisting of **visceral (inner) and parietal (outer) layer**.
- Between two layer is space where **primary urine** is produced. The parietal outer layer is composed of simple squamous epithelium
- The visceral layer is composed of **podocytes.** There is an ultrafitration of blood plasma. The filtration bariier is **endothelium, podocytes and their basement membranes.**
- The glomerular blood pressure provides the **driving force for blood plasma** to be filtered out into the space made by **Bowman's capsule**.
- Acid-base balance, blood osmolarity, plasma composition and fluid volume: 125ml of primary urine/min **and 1,5-2l/day** by an adult human

Renal Corpuscle



Juxtaglomerular apparatus

The juxtaglomerular apparatus consists **of macula densa** and attachs the afferent arteriole.

The cells of juxtaglomerular apparatus affect **blood pressure by renin production** (stimulation of Renin-Angiotensin-Aldosterone axis).

Renal blood circulation

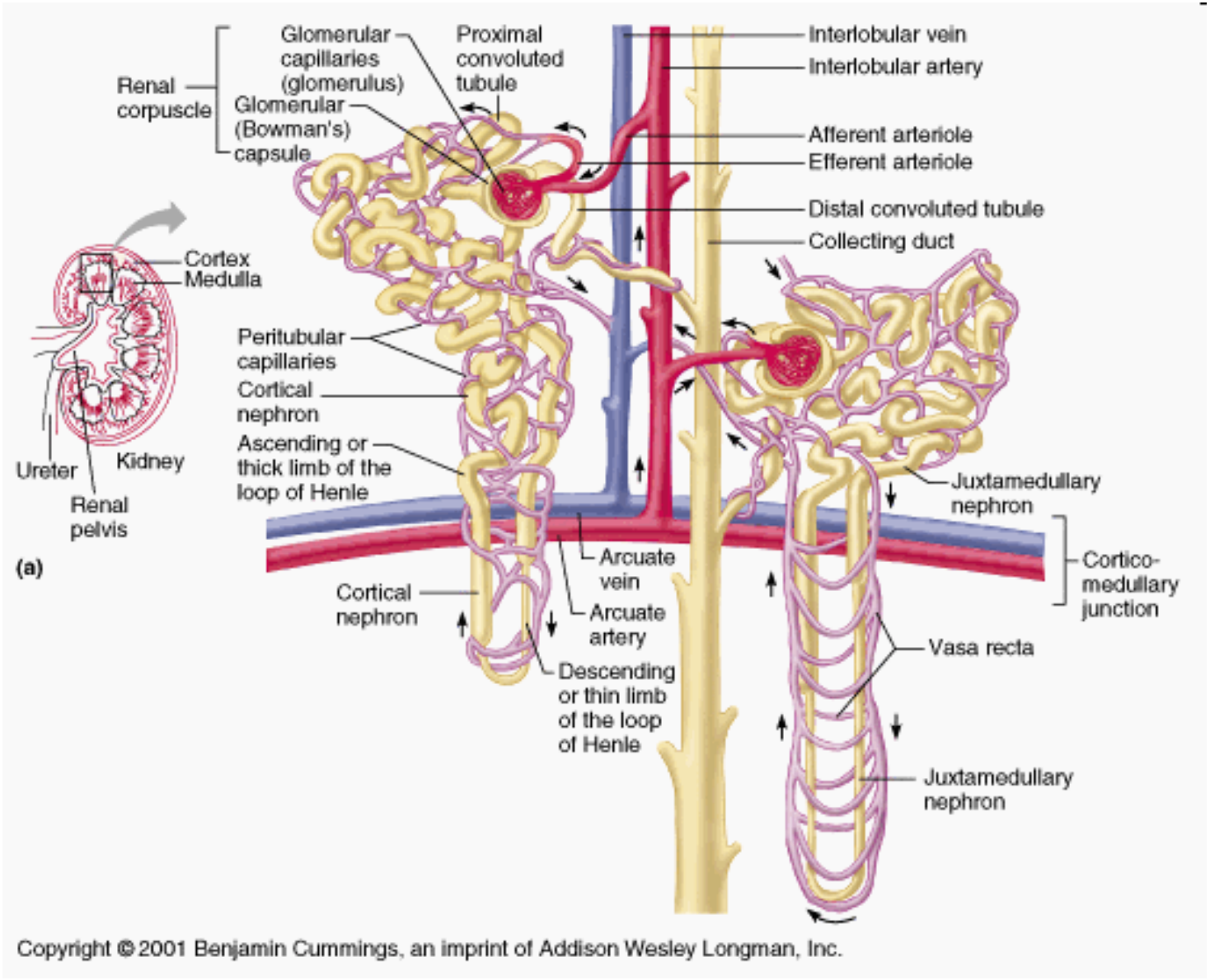
Each kidney is supplied by **a renal artery**. This artery arises from the aorta. It divides into 2-3 branches before entering the renal cortex.

One branch supplies the upper portion of a kidney, another the middle portion and the last one the lower portion.

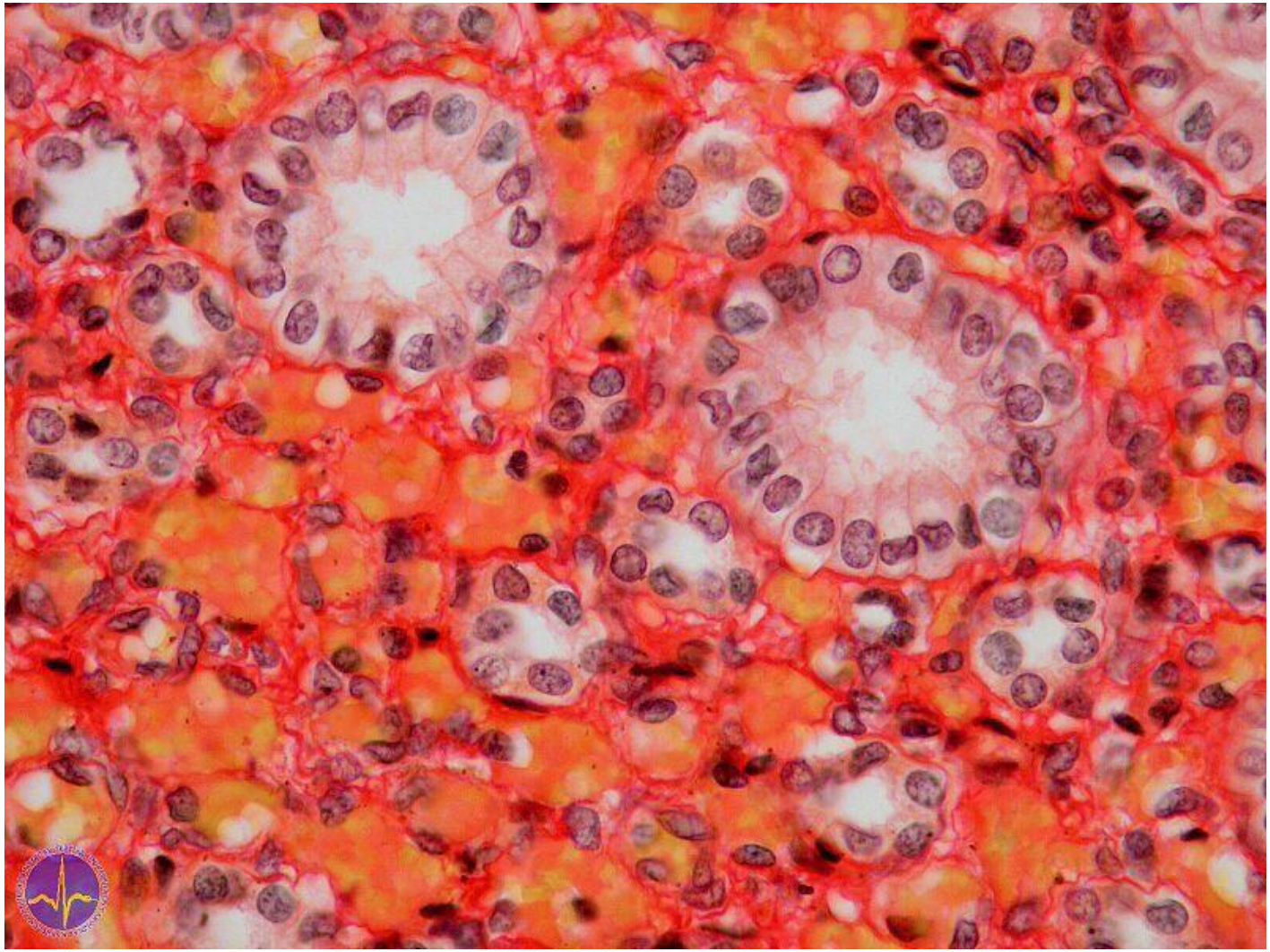
Furthermore, these branches divides into the **interlobular arteries**, which give rise to an **afferent arterioles**. **Blood flows to glomerulus through the afferent arterioles**.

Blood is collected by interlobular veins, then passes to the arcuate veins, from those continue to **the interlobar veins**, which finally merge **into the renal vein**.

Renal blood circulation



Renal tubules



Renal tubule

The ***proximal tubule*** leads from the Bowman's capsule to the Loop of Henle. It is lined by **simple cuboidal epithelium**.

- absorption of amino acids, proteins, glucosa, lactate, urea
- ion transport, bicarbonate, sodium, phosphate + water

The ***loop of Henle*** is a long loop which extends into the medulla.

Descending limb of loop of Henle – squamous

- permeable to water

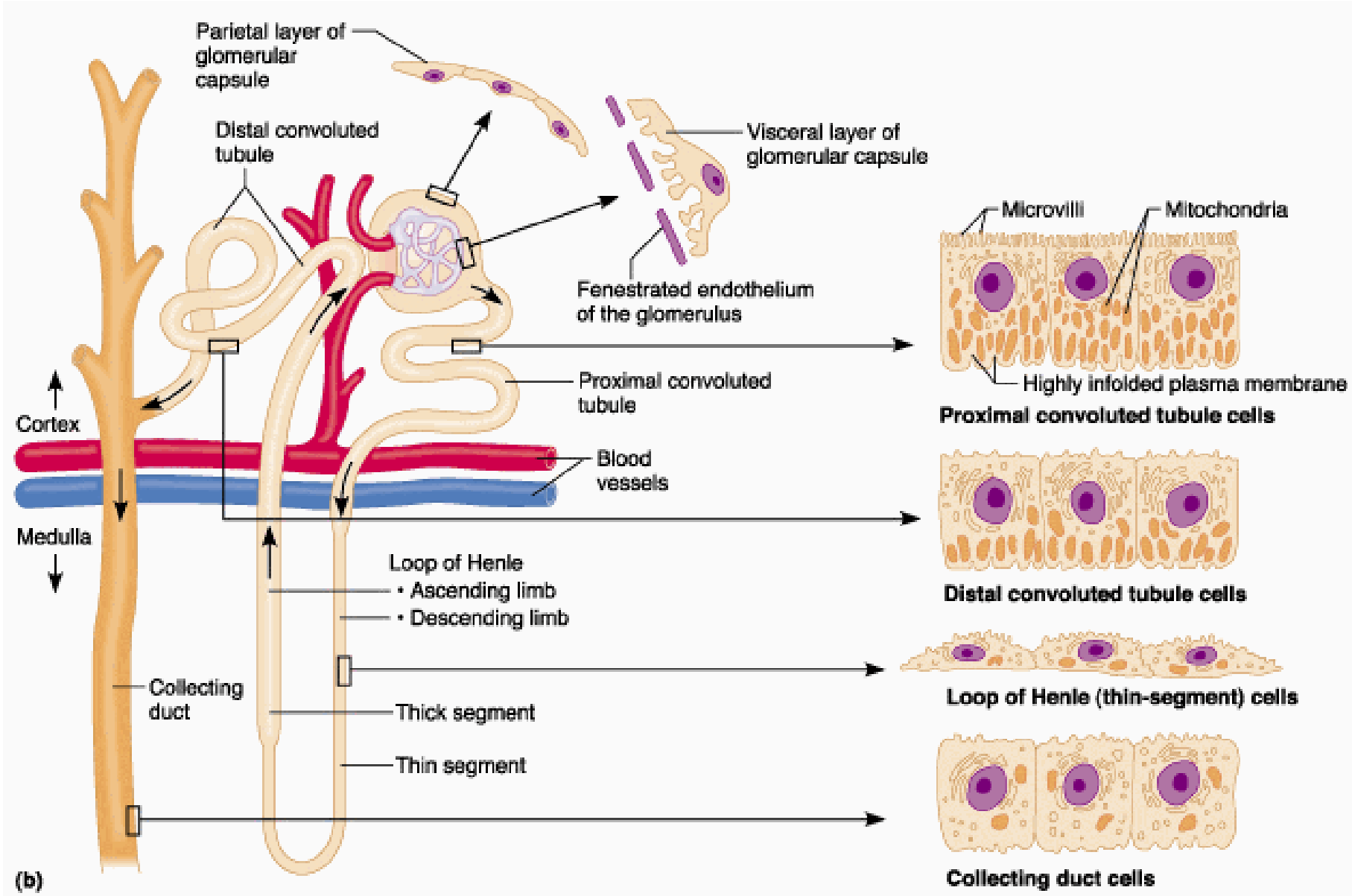
Ascending limb of loop of Henle – cuboidal

- transport of ions

The ***distal tubule*** connects the loop of Henle to the collecting duct. Simple cuboidal cells line the distal tubule.

- transport of ions
- absorption and secretion is under hormonal control

Renal tubule



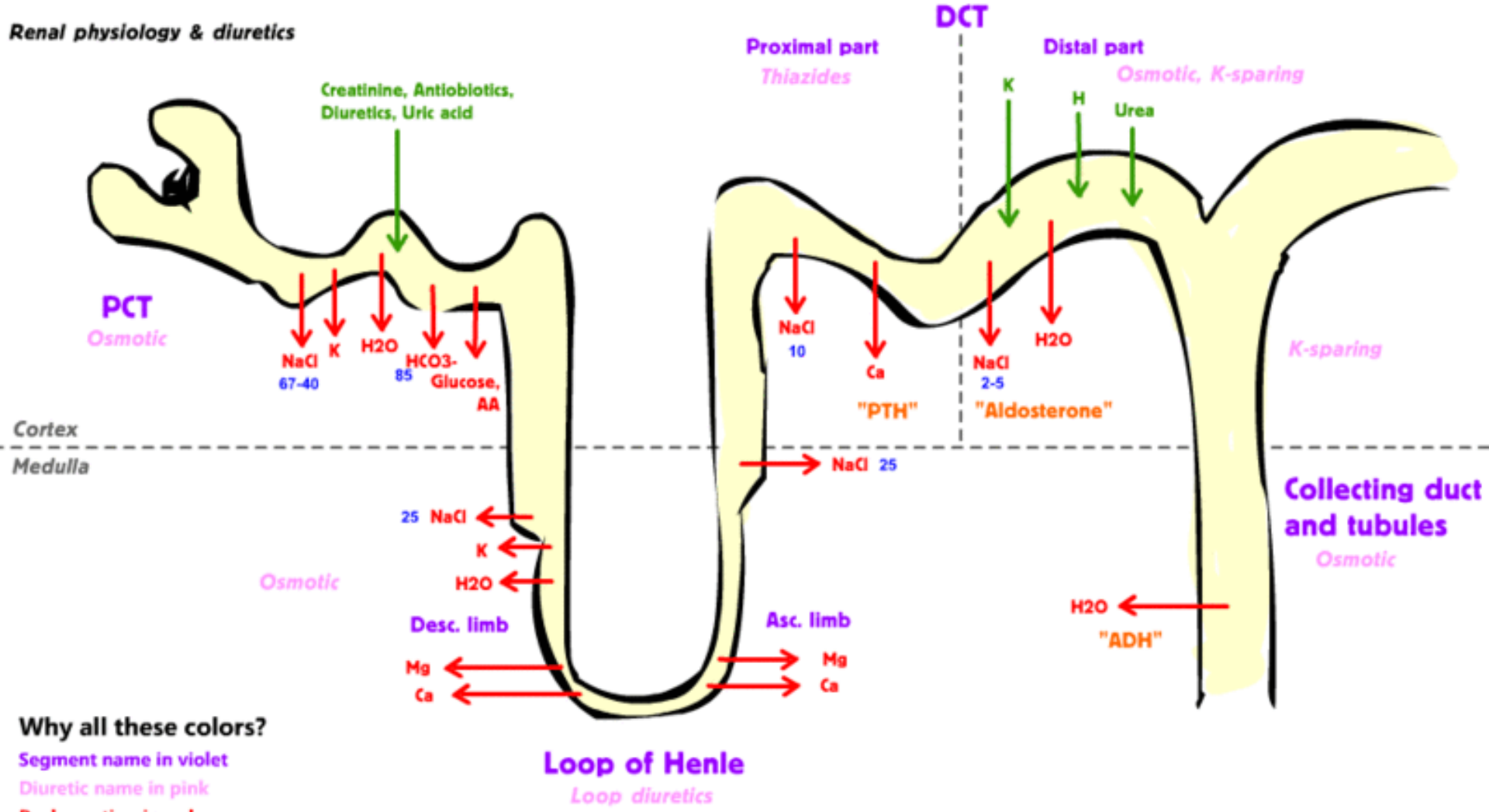
Function of Tubules

Most of these functions concern **the reabsorption and secretion** of various solutes such as ions (**sodium**), **carbohydrates** (glucose), and **amino acids** (glutamate). Each segment of the nephron has highly specialized functions.

- Reabsorption of glucose, reabsorption of water, reabsorption of salts, reabsorption of urea

Transports:

- **Passive diffusion** (in the direction of the concentration or electrical gradient),
- **primary active transport against gradient** (needs energy – ATP) or
- **secondary active transport** (transport protein uses the concentration gradient created by a primary active transport realized by other transport protein).



Counter current multiplier system of loop of Henle = formation of a high osmotic pressure (hyperosmolarity)

Collecting duct system

- There are **intercalated cells** with mitochondria and involved in acid-base balance and **principal cells**, which interact **with antidiuretic hormone (ADH)**.
- It participates in **electrolyte and fluid balance** through **reabsorption and excretion**
- The collecting duct system participates in the regulation of other electrolytes, including **chloride, potassium, hydrogen ions, and bicarbonate**.

Functions of renal system

- Serve **homeostatic functions -** the regulation of **electrolytes** and the reabsorption of **water, ptoteins, glucose, and amino acids**

Normal diuresis is 1.5-2 l/day. Polyuria is diuresis higher than 2 l/day, oliguria lower than 0.5 l/day and anuria lower than 0.1 l/day.

- **Excretion of wastes** - include the nitrogenous wastes **urea** (amonium) **from protein catabolism**, and **uric acid from nucleic acid metabolism**

- **Hormone secretion -** produce hormones including **calcitriol, renin, and erythropoietin**

- Functions are regulated by **antidiuretic hormone, aldosterone, and parathyroid hormone, epinephrine, natriuretic peptides (ANP and BNP)**

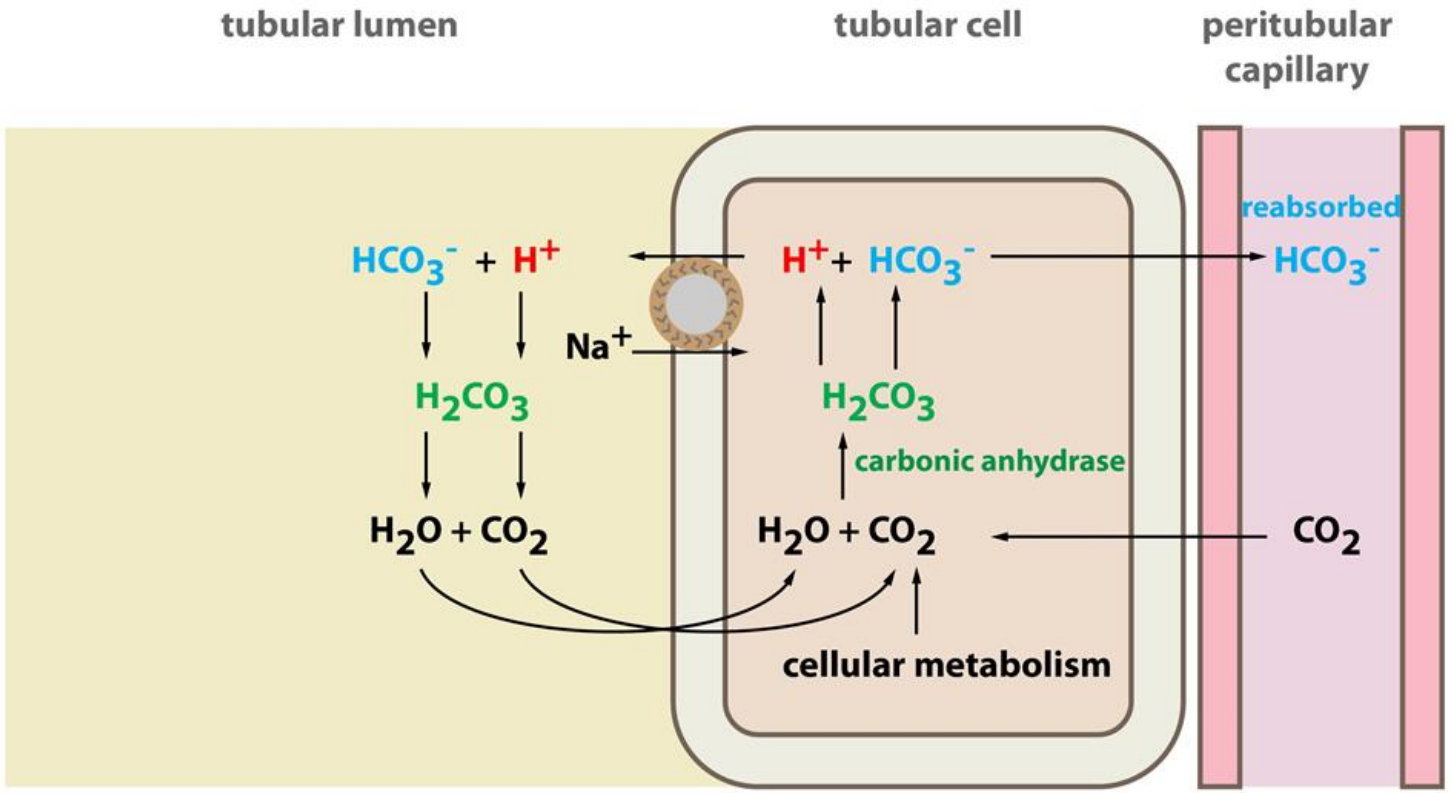
Aldosterone is a hormone that increases the reabsorption of sodium and water and the release (secretion) of potassium in the kidneys

Antidiuretic hormone=Vasopressin controls the reabsorption of water in the tubules by affecting the tissue's permeability. It plays a key role in homeostasis, and the regulation of water, glucose, and salts in the blood.

- **Osmolality regulation -** Any significant rise or drop in plasma osmolality is detected by the hypothalamus, it is secreted **antidiuretic hormone** (ADH), resulting in water reabsorption by the kidney.

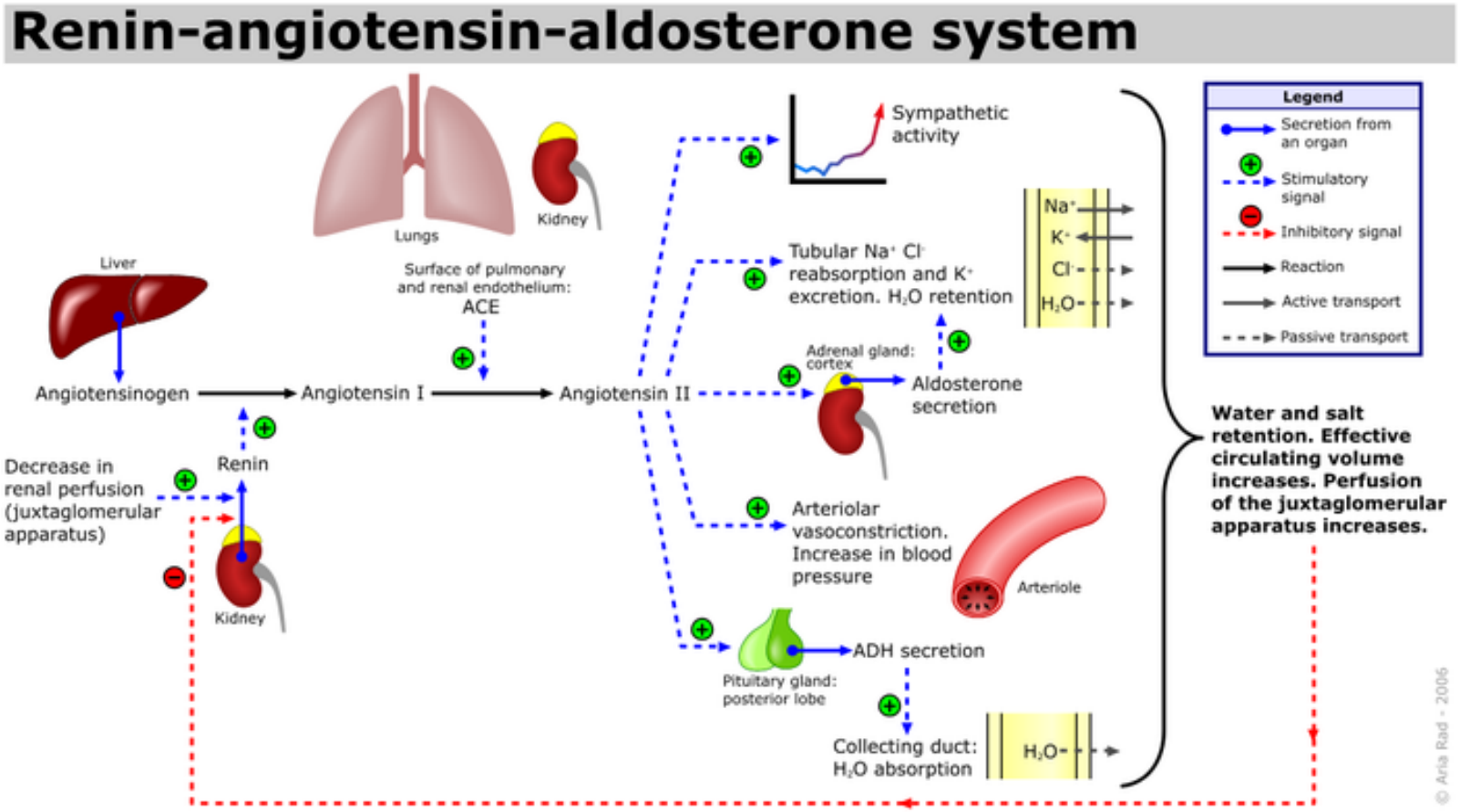
- **Acido-base homeostasis-** the kidneys and lungs maintain **pH** around a relatively stable value. The kidneys contribute to acid-base homeostasis by regulating **bicarbonate (HCO_3^-) concentration –** bicarbonate reabsorption (increased pH)
  - bicarbonate production (excretion of H^+)
  - bicarbonate secretion (decreased pH)

Bicarbonate reabsorption



❑Blood pressure regulation - juxtaglomerular apparatus

Changes in the delivery of sodium and chloride to the distal part of the nephron alter the kidney's secretion of the enzyme **renin**. **renin - angiotensin – aldosteron system**



Renin-angiotensin-aldosterone system (RAAS)

When blood volume is low, the **juxtaglomerular cells** of kidney, modified smooth cells, secrete **renin**. Renin converts **angiotensinogen** (synthesized in the liver) to angiotensin I. **Angiotensin-converting enzyme** (ACE) converts angiotensin I to **angiotensin II** which acts on AT1 receptors in the adrenal cortex, blood vessels and brain. **Angiotensin II** causes blood vessels to **constrict** resulting in **increased blood pressure**. Angiotensin also stimulates the secretion of the hormone **aldosterone** from the adrenal cortex. Aldosterone causes the tubules of the kidneys to increase the **reabsorption of sodium and water**. This increases the volume of fluid in the body, which also **increases blood pressure**.

Thank you for your attention

Campbell, Neil A., Reece, Jane B., Cain Michael L., Jackson, Robert B., Minorsky, Peter V.**,** **Biology**, Benjamin-Cummings Publishing Company, 1996 – 2010.