RENAL PHYSIOLOGY (INTRODUCTION)

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Lec. 1

Introduction

- The **kidneys** are organs specialized to ***filter*** the **blood**, and as such, contribute importantly to the **removal** of **metabolic waste products** as well as to the **maintenance** of *fluid* and *electrolyte* **balance**.

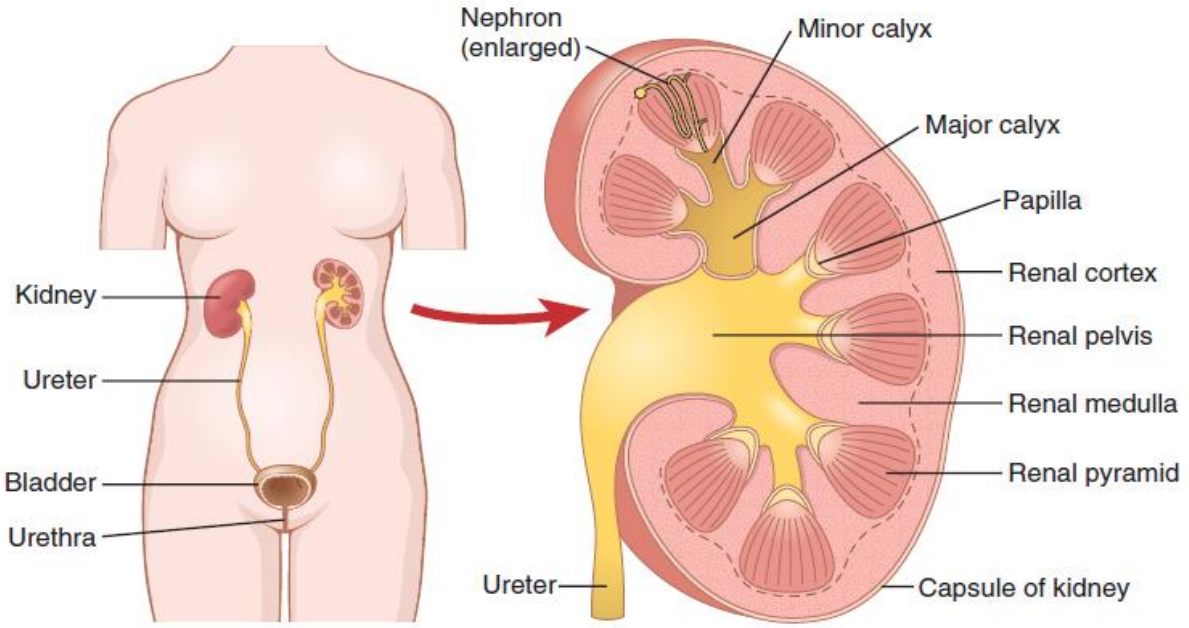


Figure 26-2. General organization of the kidneys and the urinary system.

Specific functions of the kidneys

1. **Regulation** of **extracellular fluid volume**
2. **Regulation** of **inorganic electrolyte concentration** in the extracellular fluid
3. **Regulation** of the osmolarity of the extracellular fluid
4. **Removal** of metabolic waste products
5. **Excretion** of foreign compounds
6. **Maintenance** of acid-base balance
7. **Hormone** and **enzyme** production

Regulation of extracellular fluid volume

- It is more specifically *regulate plasma volume*, is important in the **long-term regulation** of **blood pressure**.(How) ???
- An **increase** in *plasma volume* leads to an **increase** in *blood pressure.*

and

- A **decrease** in *plasma volume* leads to a **decrease** in *blood pressure.*

❖ ***Plasma volume*** *is regulated primarily by* ***altering the excretion*** *of* ***sodium*** *in the* ***urine.***

Regulation of inorganic electrolyte concentration in the extracellular fluid

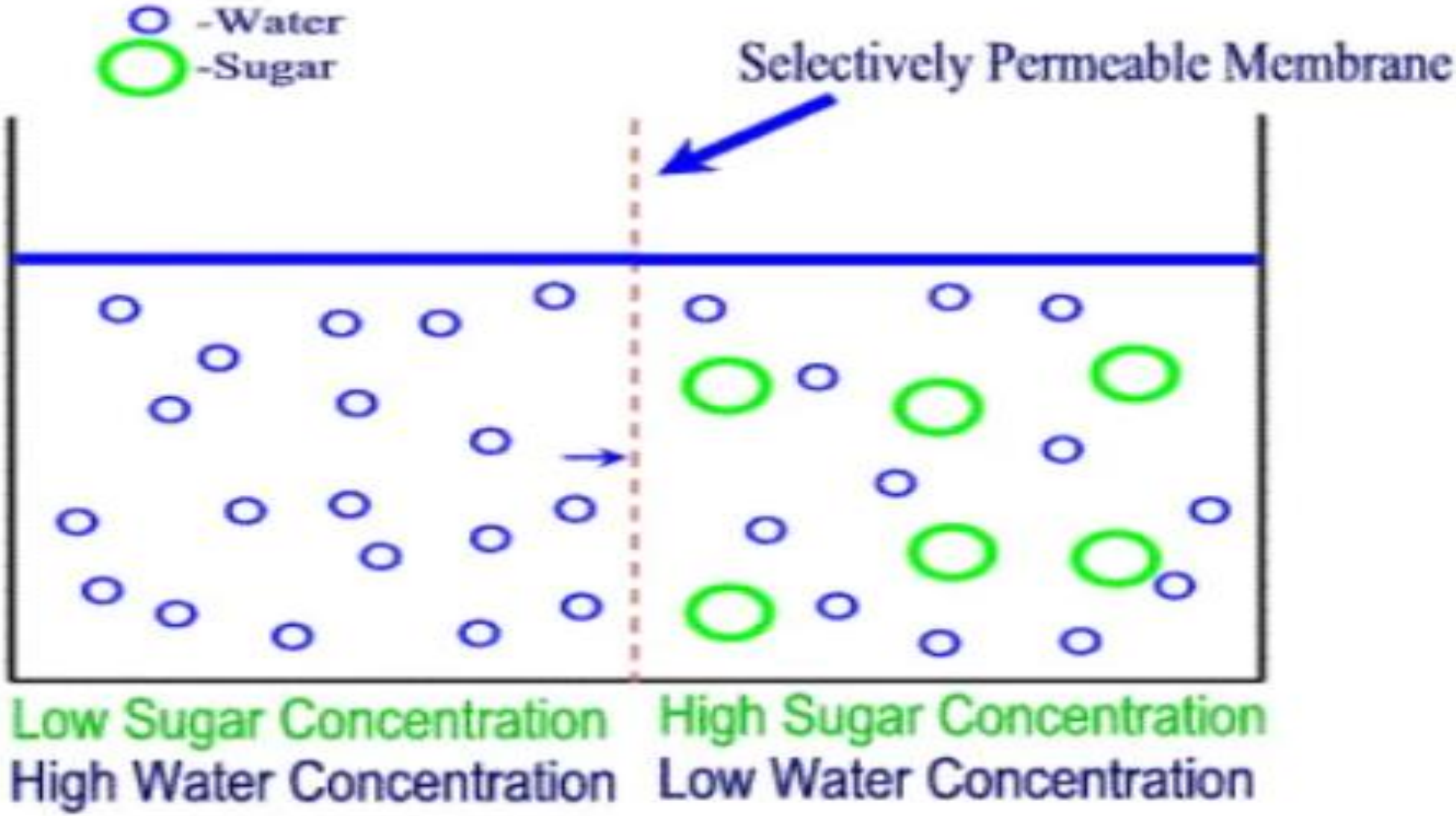
- *Inorganic electrolytes* regulated by the kidneys include:-

  chloride, *potassium*, *calcium*, *magnesium*, *sulfate*, and *phosphate*.

Regulation of the osmolarity of the extracellular fluid

- Diffusion of water *down its concentration* called **osmosis**.
- This regulation is specifically **plasma osmolarity**.
- *The maintenance of plasma osmolarity close to **290 mOsm** **prevents** any **unwanted** movement of fluid **in** or **out** of the **body's cells.***
- An **increase** in plasma osmolarity causes cellular dehydration.
- A **decrease** in plasma osmolarity causes cellular swelling and possibly lysis.

Osmosis


-Water
-Sugar
Selectively Permeable Membrane
Low Sugar Concentration
High Water Concentration
High Sugar Concentration
Low Water Concentration

Removal of metabolic waste products

❖The major excretory organs in the body, the **kidneys** are responsible for the ***removal of many metabolic waste products.***

❖**These include:**

- ***urea*** and ***uric acid***, which are nitrogenous waste products of *amino acid* and *nucleic acid* metabolism, **respectively**
- ***creatinine***, a breakdown product of muscle metabolism; and
- ***urobilinogen***, a *metabolite of hemoglobin* that gives urine its **yellow color**.

Excretion of foreign compounds

- ***Foreign compounds*** **excreted by the kidneys include:**
- ***Drugs*** (e.g., penicillin, nonsteroidal anti-inflammatory drugs)
- ***food additives*** (e.g., saccharin, benzoate)
- ***Pesticides***
- other ***exogenous*** nonnutritive materials that have entered the body. If allowed to accumulate, these substances become quite **toxic.**

Maintenance of acid-base balance

- **Along with the respiratory system, the renal system *maintains acid-base balance* by:**
- Altering the **excretion of hydrogen ions** and **bicarbonate ions** in the urine.
- **When the extracellular fluid becomes acidic and *pH decreases*, then the kidneys act:**

1. excrete H+ ions
2. conserve HCO3 – ions.

- **When the extracellular fluid becomes alkaline and *pH increases*, then the kidneys act:**

1. conserve H+ ions
2. excrete HCO3 – ions.

❖**Normally**, the **pH** of the *arterial blood* is **7.4**.

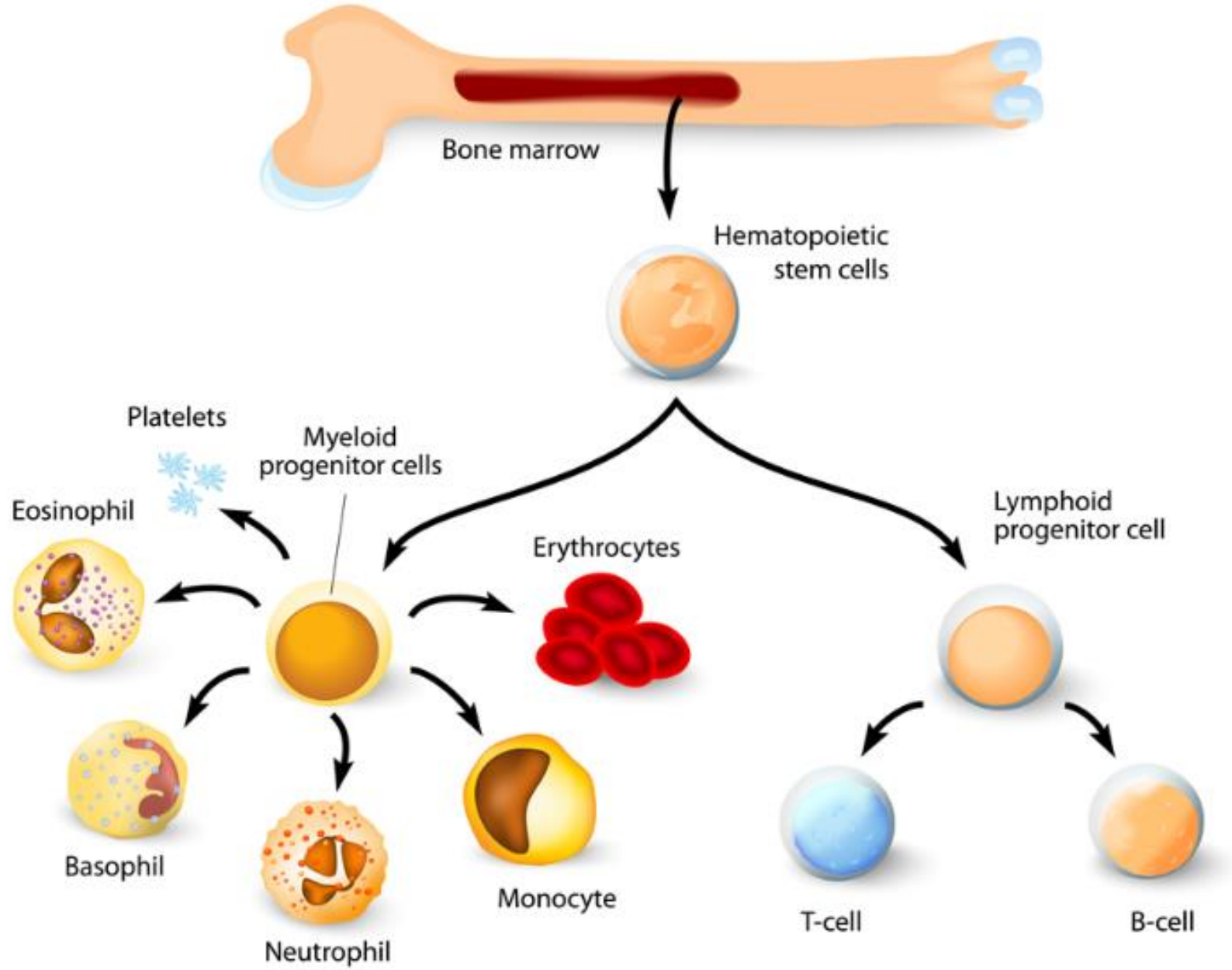
Hormone and enzyme production

❖Although the kidneys are not ***considered endocrine glands***, they are involved in *hormone and enzyme production*.

- **Erythropoietin hormone**
- Renin
- ***25-OH Vit.D-1 alpha-hydroxylase***

Erythropoietin hormone

- The kidneys secrete ***erythropoietin***, *which stimulates the production of* **red blood** *cells by* ***hematopoietic stem*** cells in the **bone marrow**.
- One important **stimulus** for **erythropoietin** secretion by the kidneys is ***hypoxia***.
- In people with severe **kidney disease** or who have had their kidneys removed and have been placed on hemodialysis, **severe anemia develops** as a result of decreased erythropoietin production.


Bone marrow
Hematopoietic stem cells
Platelets
Myeloid progenitor cells
Eosinophil
Erythrocytes
Lymphoid progenitor cell
Basophil
Neutrophil
Monocyte
T-cell
B-cell

Renin

❖The kidneys also contribute to **short-term arterial.**

pressure regulation by secreting hormones and vasoactive factors or substances (***renin***) that lead to the *formation* of *vasoactive products* **(angiotensin II).**

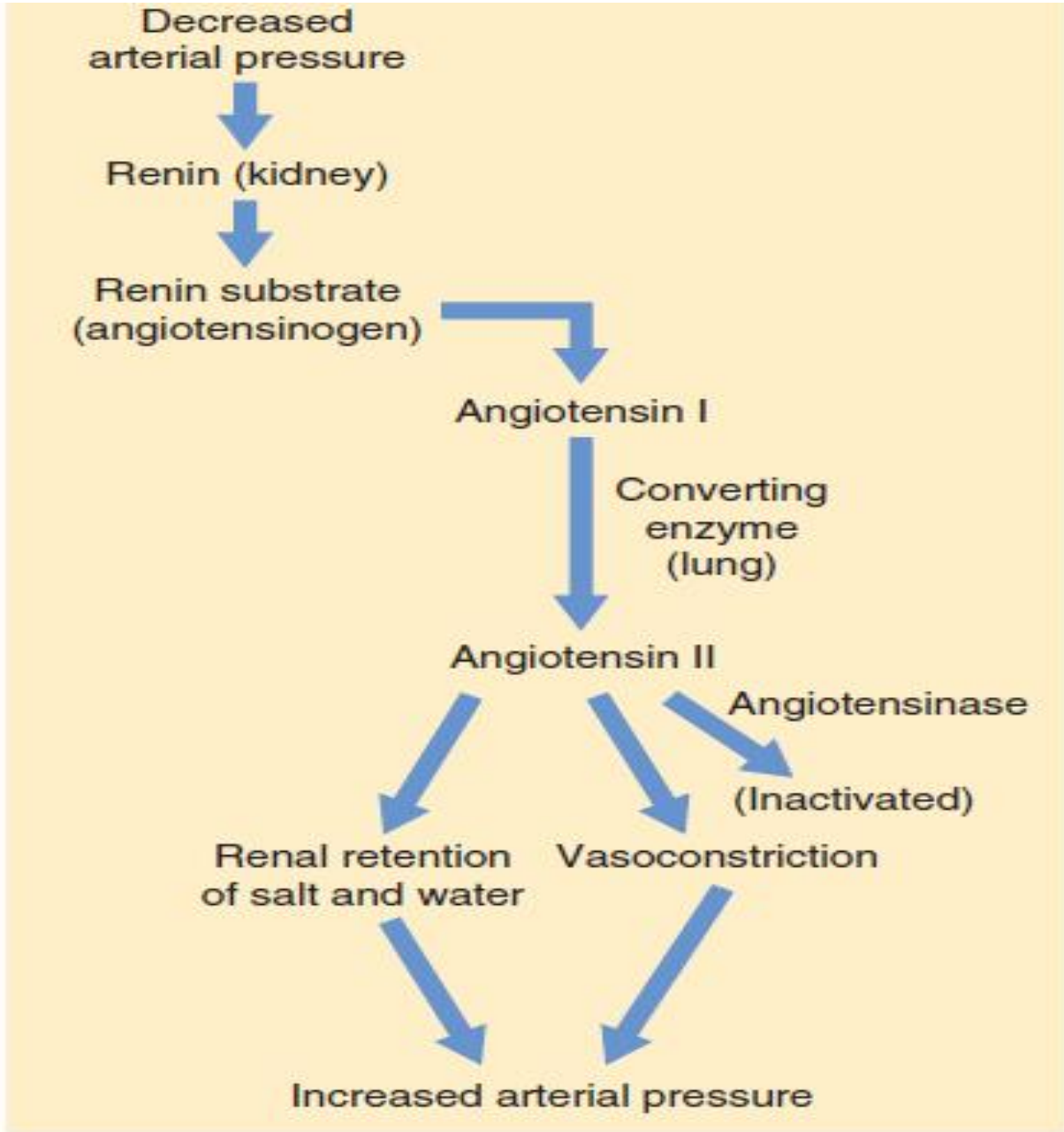


Figure 19-10. The renin-angiotensin vasoconstrictor mechanism for arterial pressure control.

25-OH Vit.D-1 alpha-hydroxylase

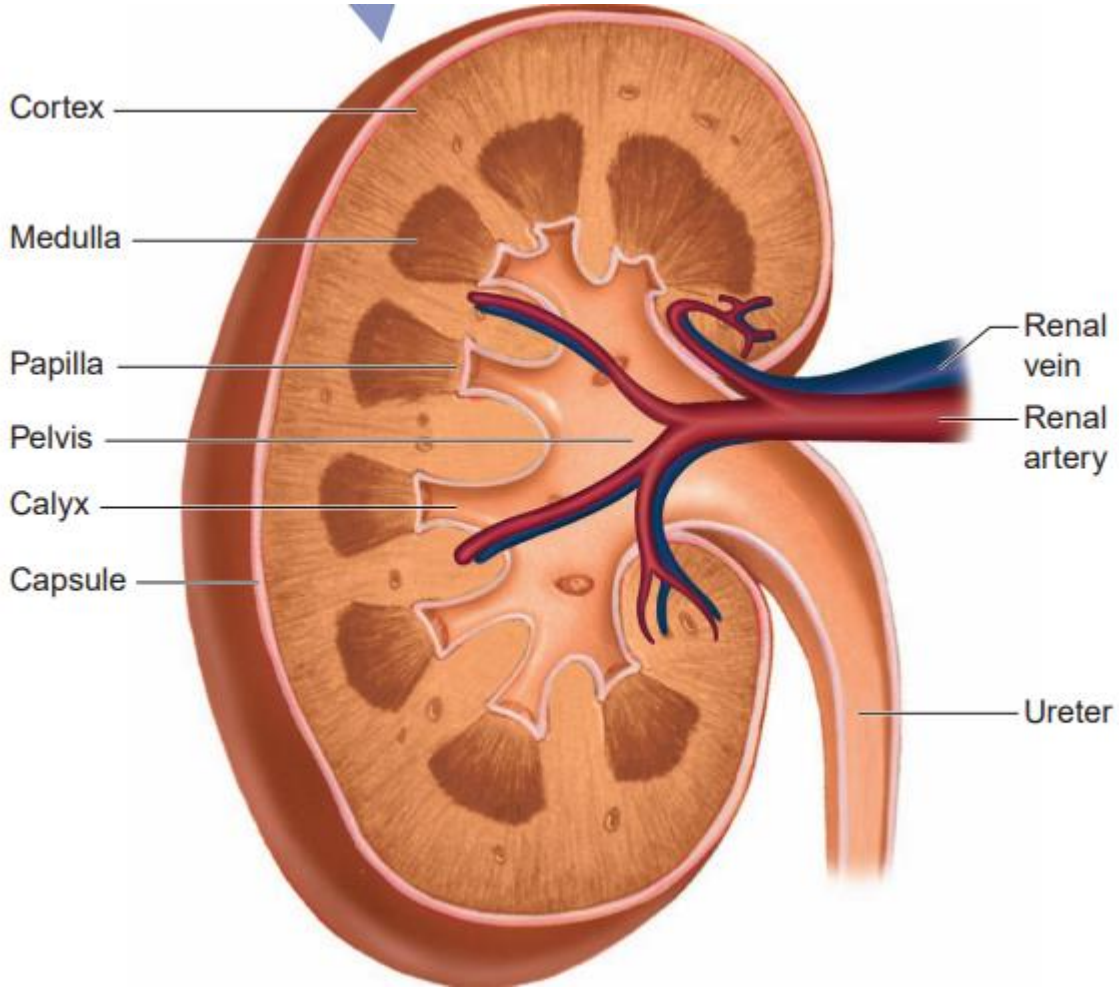
- **The kidneys produce** the *active form* of vitamin D, 1,25-dihydroxyvitamin D^3 (***calcitriol***), **by** *hydroxylating this vitamin at the "number 1" position*.
- **Calcitriol** is essential for *normal calcium deposition* in bone and calcium *reabsorption* by the **gastrointestinal tract**.
- **calcitriol** plays an important role in *calcium* and *phosphate* regulation.

Functional anatomy of the kidneys

➢ ***Kidney is divided into two regions:***

1. inner *renal medulla*

2. outer *renal cortex*.



Functional anatomy of the kidneys

➢ **The functional unit of the kidney is the *nephron.***

❖There are well *over 1 million nephrons* in each kidney.

❖ ***The nephron has two components:***

1. Vascular component

2. Tubular component

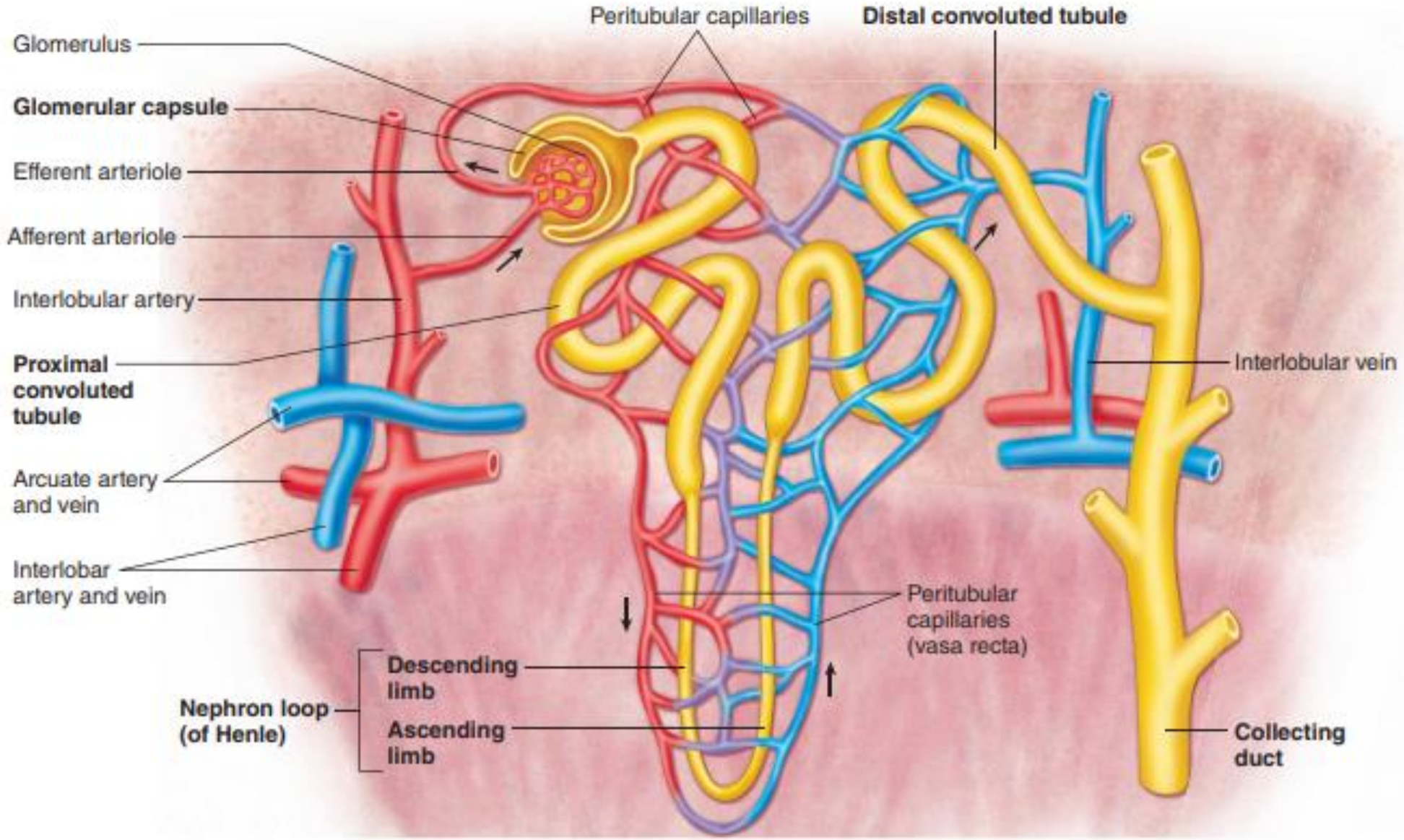
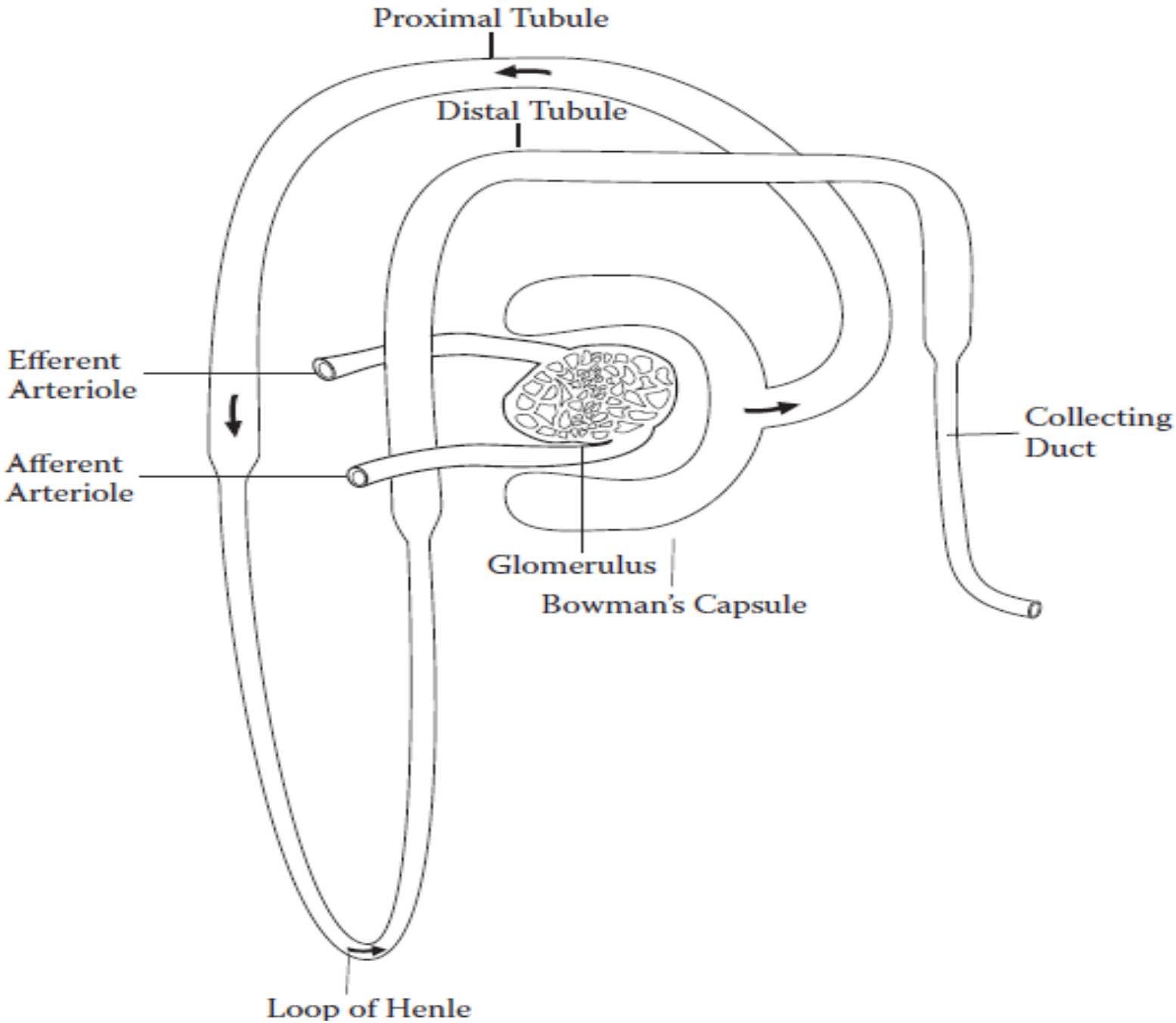
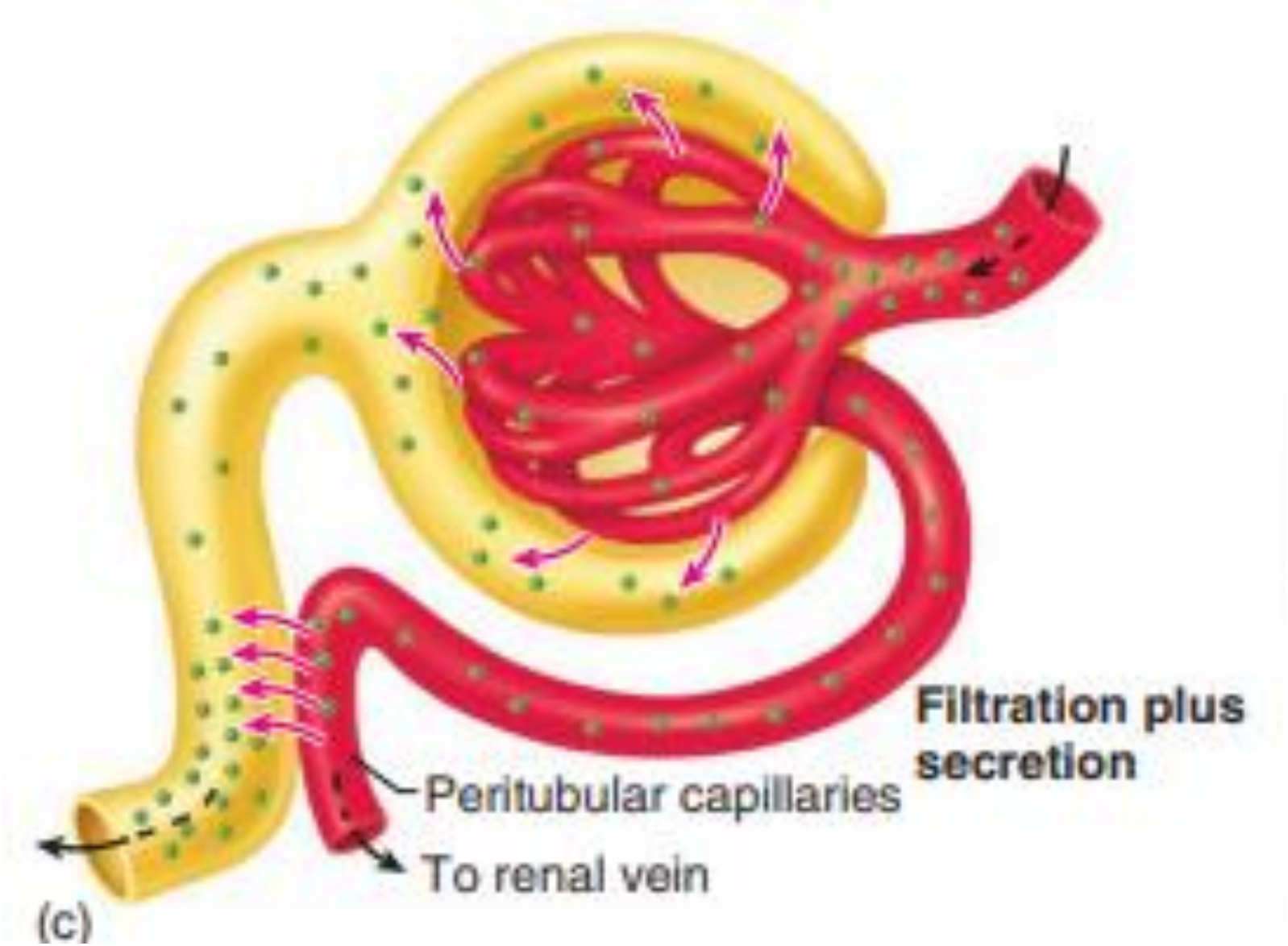


Figure 17.5 **The nephron tubules and associated blood vessels.** In this simplified illustration, the blood flow from a glomerulus to an efferent arteriole, to the peritubular capillaries, and to the venous drainage of the kidneys is indicated with arrows. The names for the different regions of the nephron tubules are indicated with boldface type. AP|R


Proximal Tubule
Distal Tubule
Efferent Arteriole
Afferent Arteriole
Collecting Duct
Glomerulus
Bowman's Capsule
Loop of Henle

Vascular component

- Filtration of the plasma **takes place** at the ***glomerulus*** located in the cortical region of the kidney.
- **Water** and **solutes** **exit** the *vascular compartment* **through** these capillaries to be processed by the **tubular component** of the nephron.
- Blood is delivered to the glomerulus by the *afferent arterioles*. The glomerular capillaries then join to form a second arteriole referred to as the *efferent arteriole*.
- All cellular elements of the blood (red blood cells, white blood cells and platelets) as well as the unfiltered plasma continue through this vessel.
- The efferent arterioles then **lead to** a second set of capillaries, the ***peritubular capillaries.***
- These capillaries provide **nourishment** to the renal tissue and **return** the substances reabsorbed from the tubule to the vascular compartment.


Filtration plus secretion
Peritubular capillaries
To renal vein
(c)

Tubular component

- Approximately **180 L** of filtrate is processed by the kidneys **each day**.
- about **99%** of this filtrate must be **reabsorbed** from the renal tubule back into the vascular compartment.
- Upon leaving the glomerular capillaries, the filtrate enters the tubule that consist of:

1. *Bowman's capsule*
2. *Proximal tubule*
3. *Loop of Henle* → Descending limb and Ascending limb.
4. *distal tubule*
5. *collecting duct*

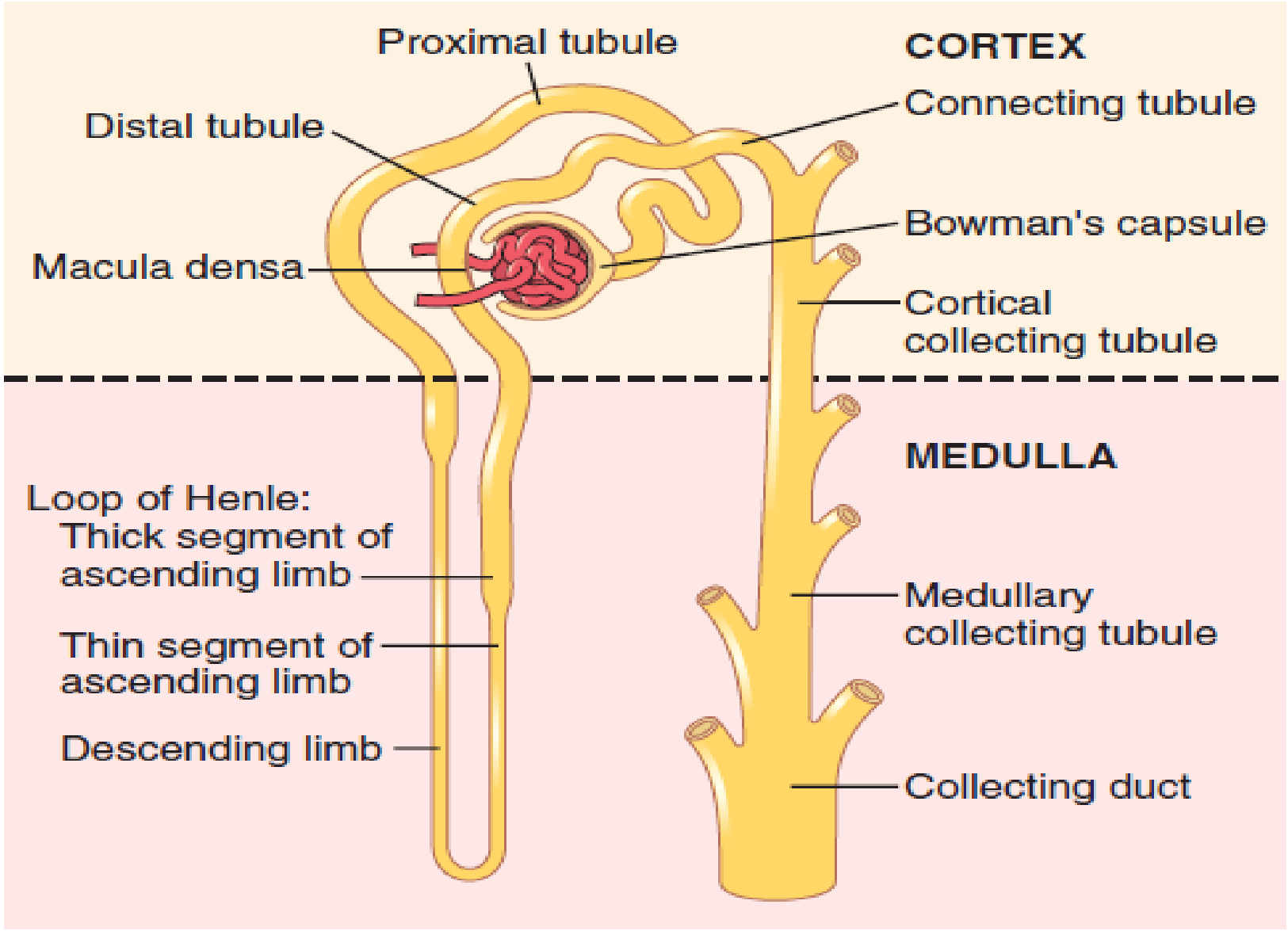


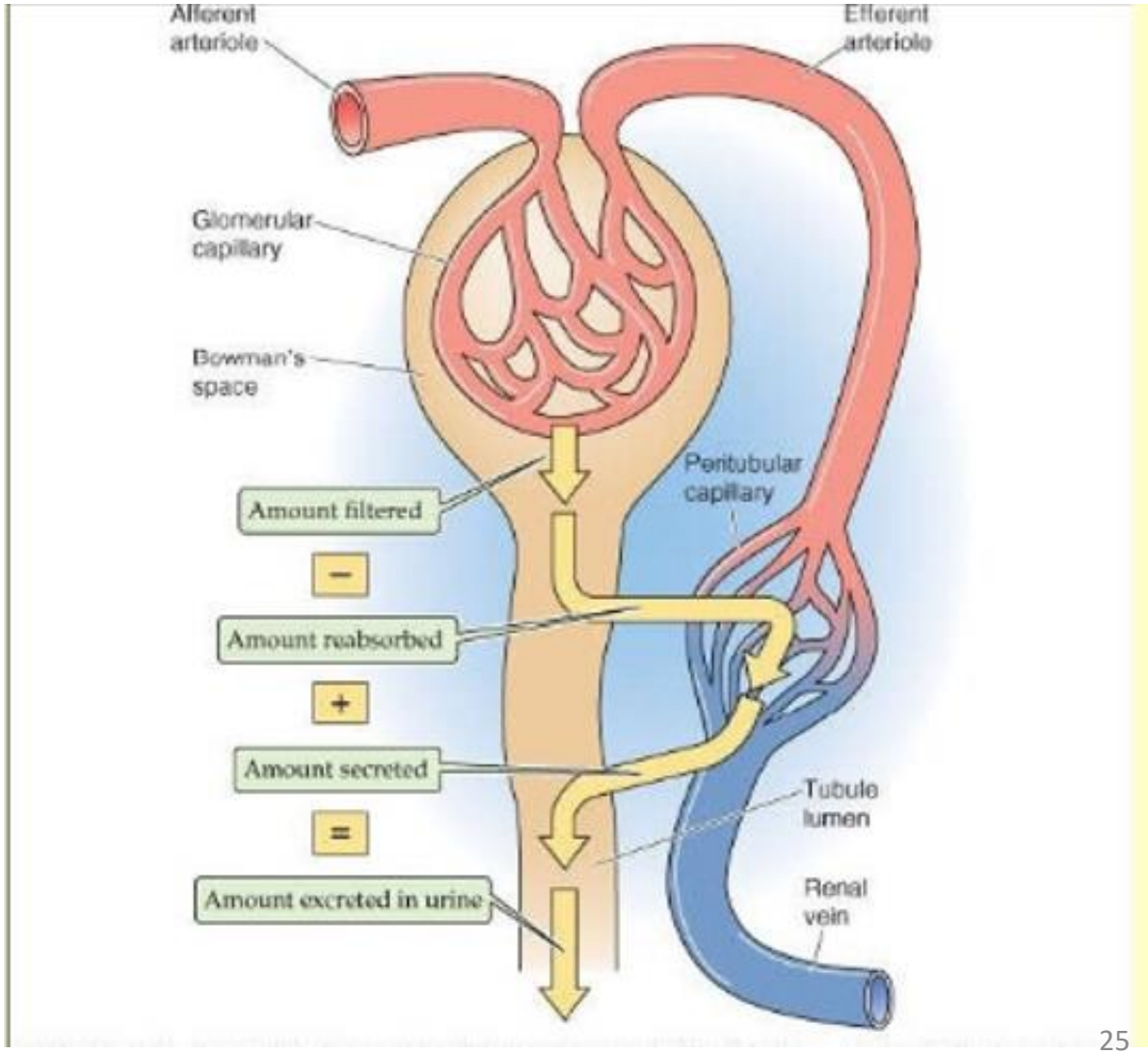
Figure 26-4. Basic tubular segments of the nephron. The relative lengths of the different tubular segments are not drawn to scale.

Basic renal processes performed by the nephron is :-

1.Filtration

2.Reabsorption

3.Secretion



Filtration

➢***Filtration*** is the movement of **fluid** and **solutes** from the *glomerular capillaries* into **Bowman's capsule**.

➢Filtration is a ***nonselective*** process, such that everything in the plasma **except** for the **plasma proteins** is filtered.

❖*glomerular filtration rate* (*GFR*) of **125 mL/min** or 180 L of filtrate per day.

Reabsorption

- ***Reabsorption*** is the movement of **filtered substances** from the **renal tubule** into the **peritubular capillaries** for return to the **vascular** **compartment**.
- This process **takes place** throughout the **tubule.**
- Approximately **178.5 L** of filtrate are **reabsorbed**, resulting in an average urine output of **1.5** L per day.

Secretion

- ***Secretion*** is the movement of **selected unfiltered substances** from the **peritubular capillaries** into the **renal tubule** for **excretion**.
- Any substance that is filtered or secreted, but not **reabsorbed**, is *excreted* in the urine.


Thank
you!