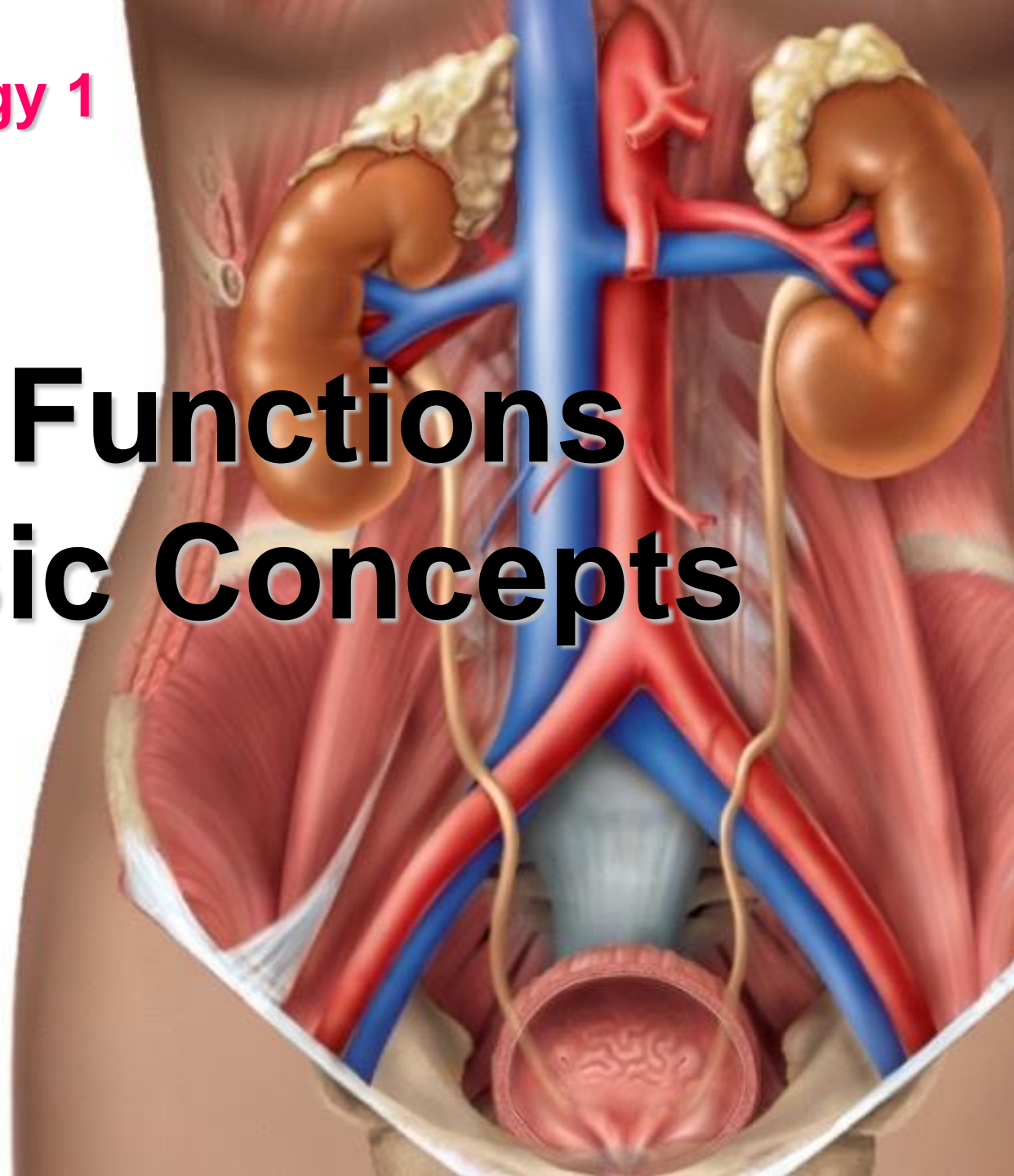


## Renal Physiology 1

# Renal Functions and Basic Concepts



# Learning Objectives:

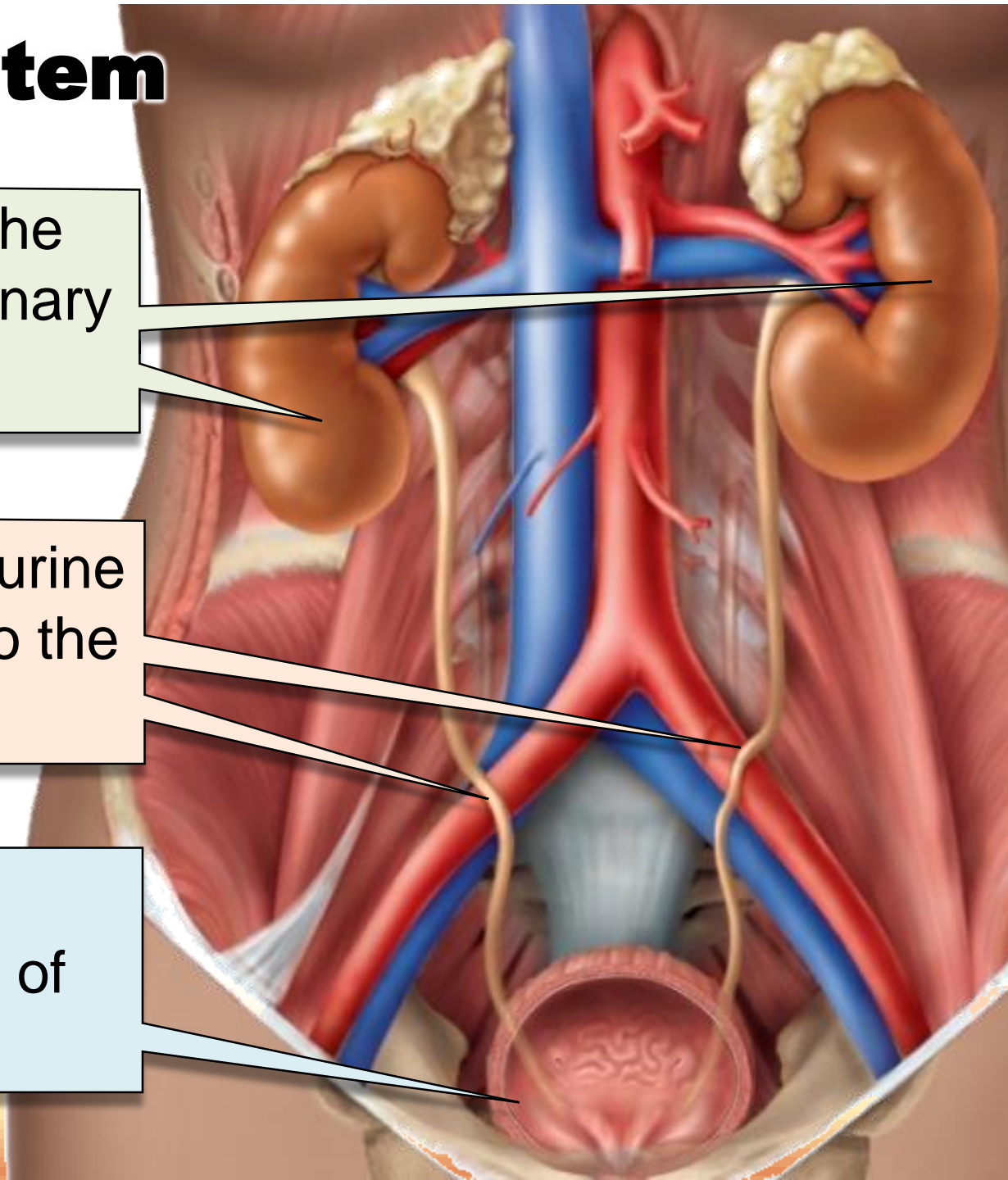
- Enumerate **general functions** of the kidney.
- Identify and describe that the **nephron** is the structural and function unit of the kidney.
- Explain glomerular **filtration membrane** & filtration forces.
- Describe **mechanism of filtration** & composition of the glomerular filtrate.
- Calculate the net filtration pressure using parameters of Starling forces.

# Urinary System

**Kidneys** perform the functions of the urinary system.

**Ureters** transport urine from the kidneys to the bladder

**Urinary bladder**  
temporary storage of urine



# Kidney functions

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## FILTRATION

200 liters of blood daily, allowing toxins, metabolic wastes, and excess ions to leave the body in urine

## BLOOD PRESSURE REGULATION

- By controlling the rate at which water is excreted in the urine → regulate plasma volume → total blood volume → blood pressure.
- By release of renin → vasoactive agents

# REGULATION

of water and electrolyte balance: Maintain the proper balance between water and salts, and acids and bases

- By  $\uparrow$  or  $\downarrow$  the excretion of specific ions in the urine, the kidneys regulate the concentration of the following ions in the plasma:
- $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ ,  $\text{H}^+$  and phosphates.

RBC production by bone marrow by controlling erythropoietin hormone levels.

# Kidney functions

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## EXCRETION

of bioactive substances (hormones and many foreign substances, especially drugs) that affects body function

## GLUCONEOGENESIS

during prolonged fasting glucose can be synthesized in the liver and kidneys

Glycerol and certain amino acids are used to synthesize **glucose**

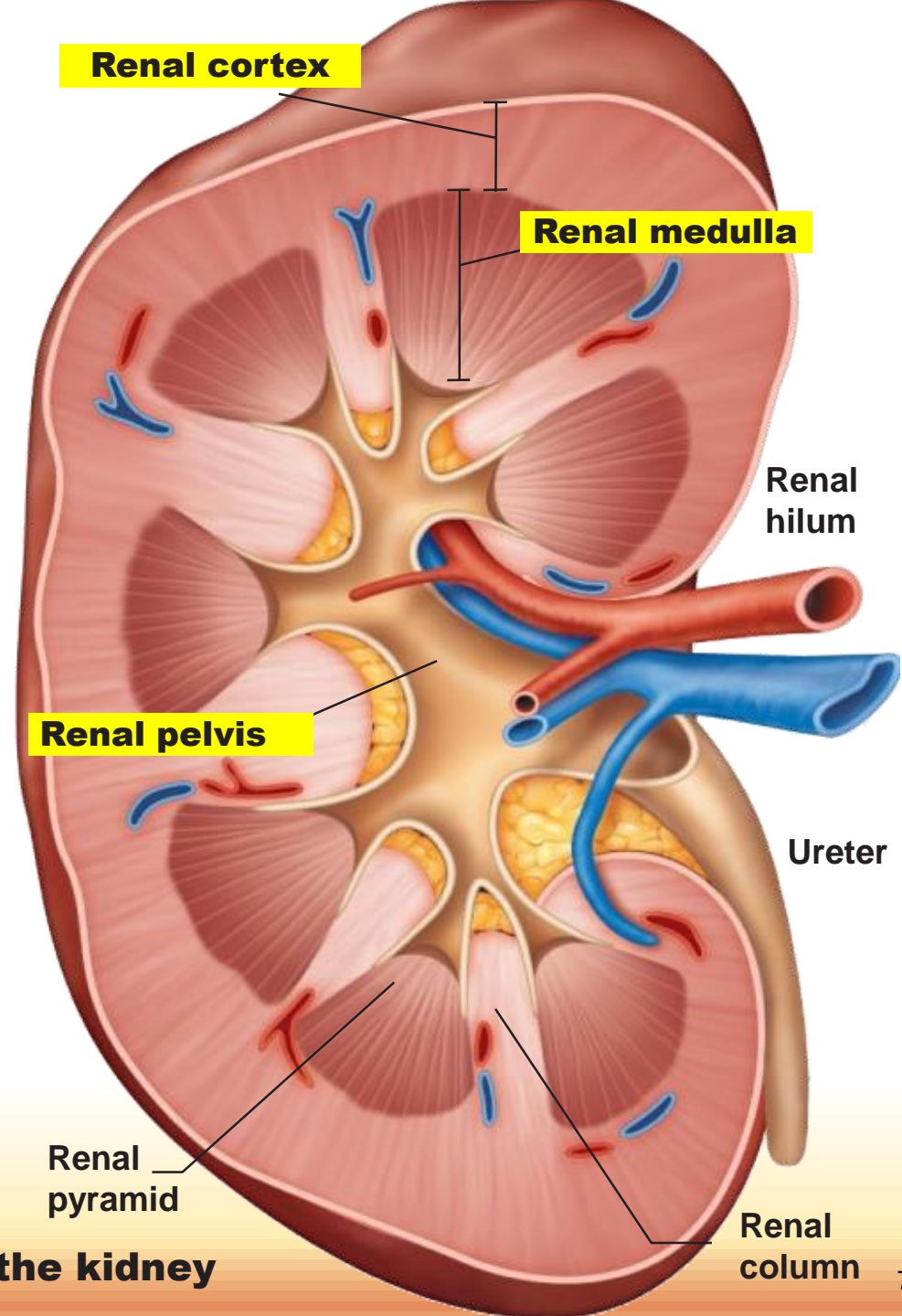
# Three distinct regions

**Cortex** granular superficial region

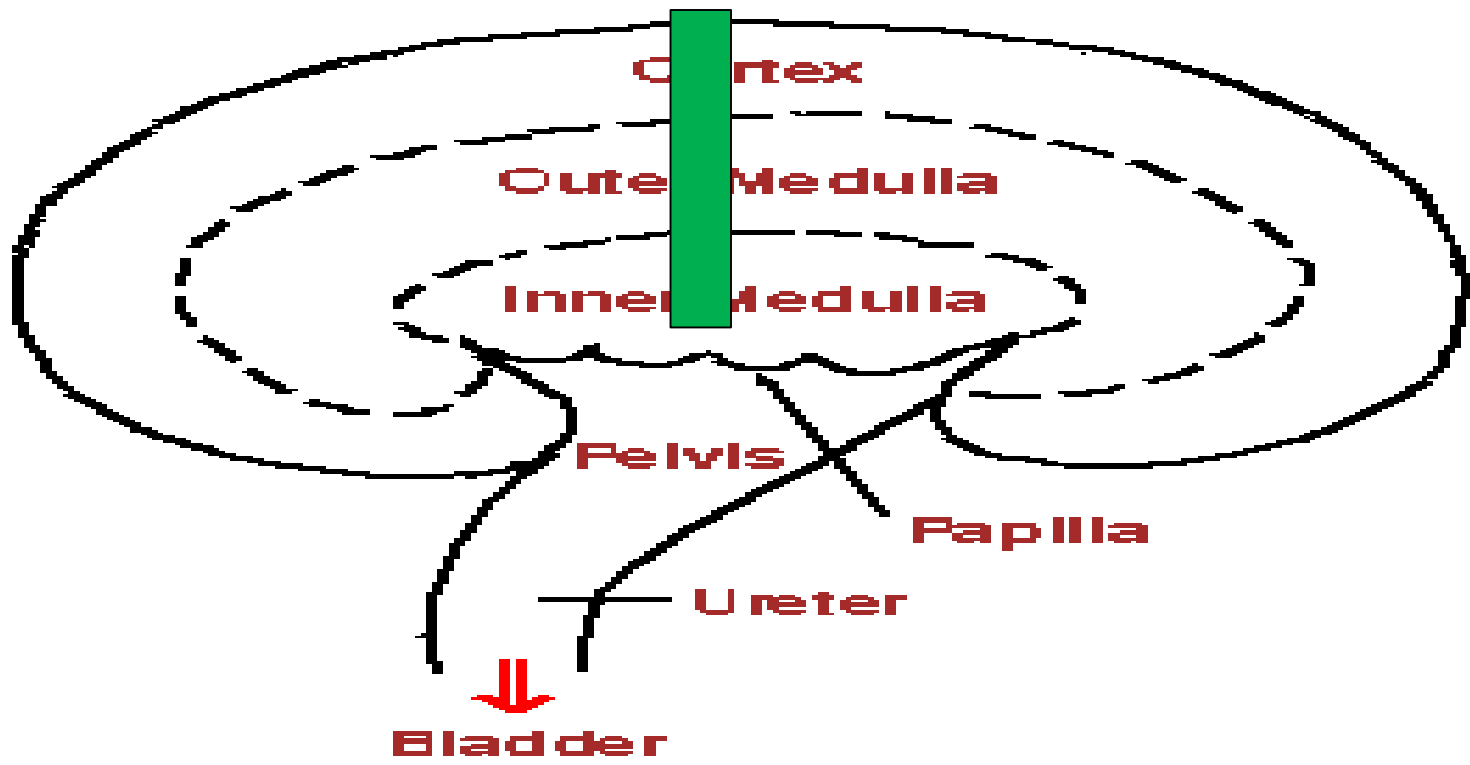
**Medulla** exhibits cone-shaped pyramids

Pyramids are bundles of collecting tubules

**Renal pelvis** flat, funnel-shaped tube

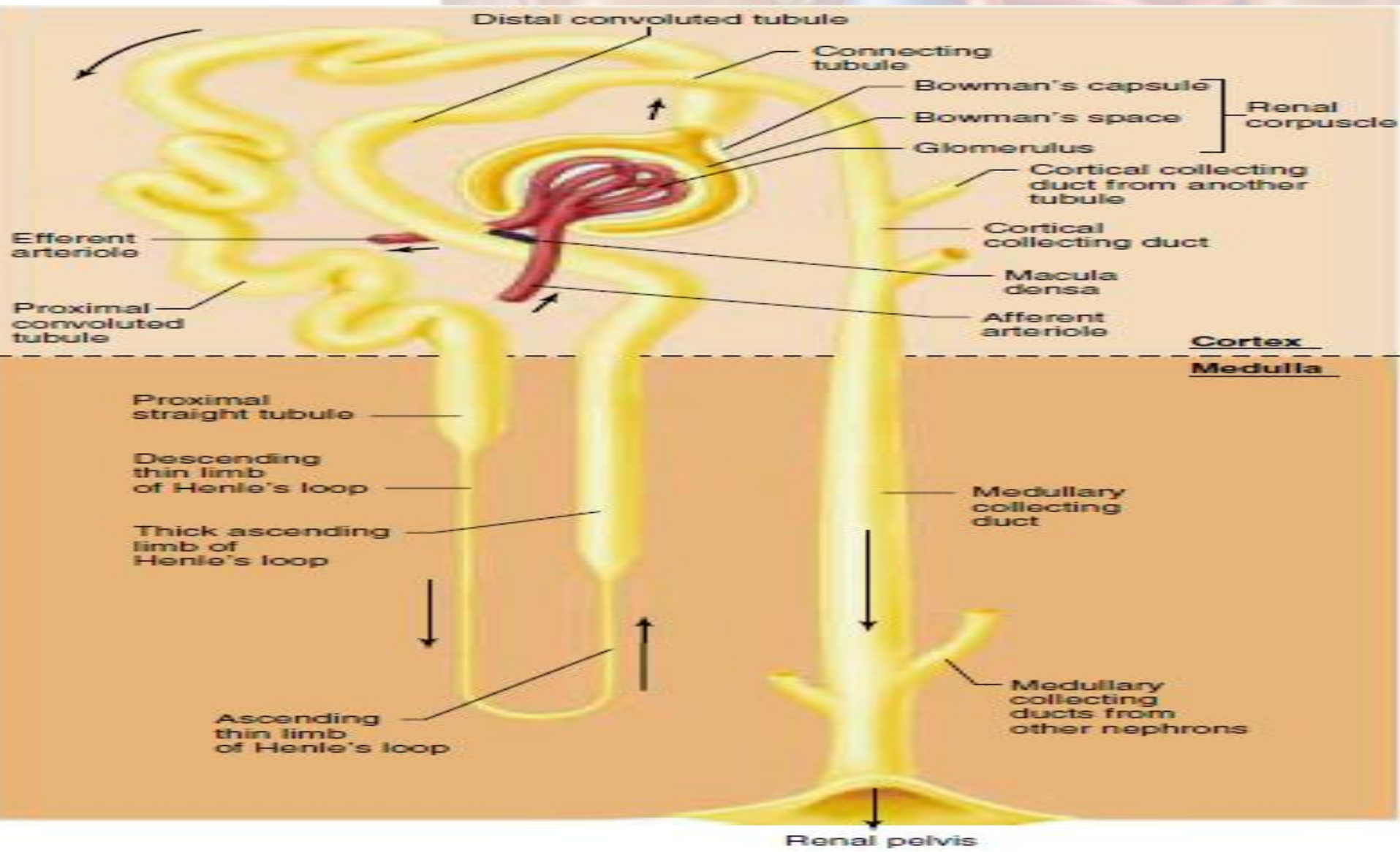


**Diagrammatic view of the kidney**





# Nephron as a functional unit



# Types of nephrons

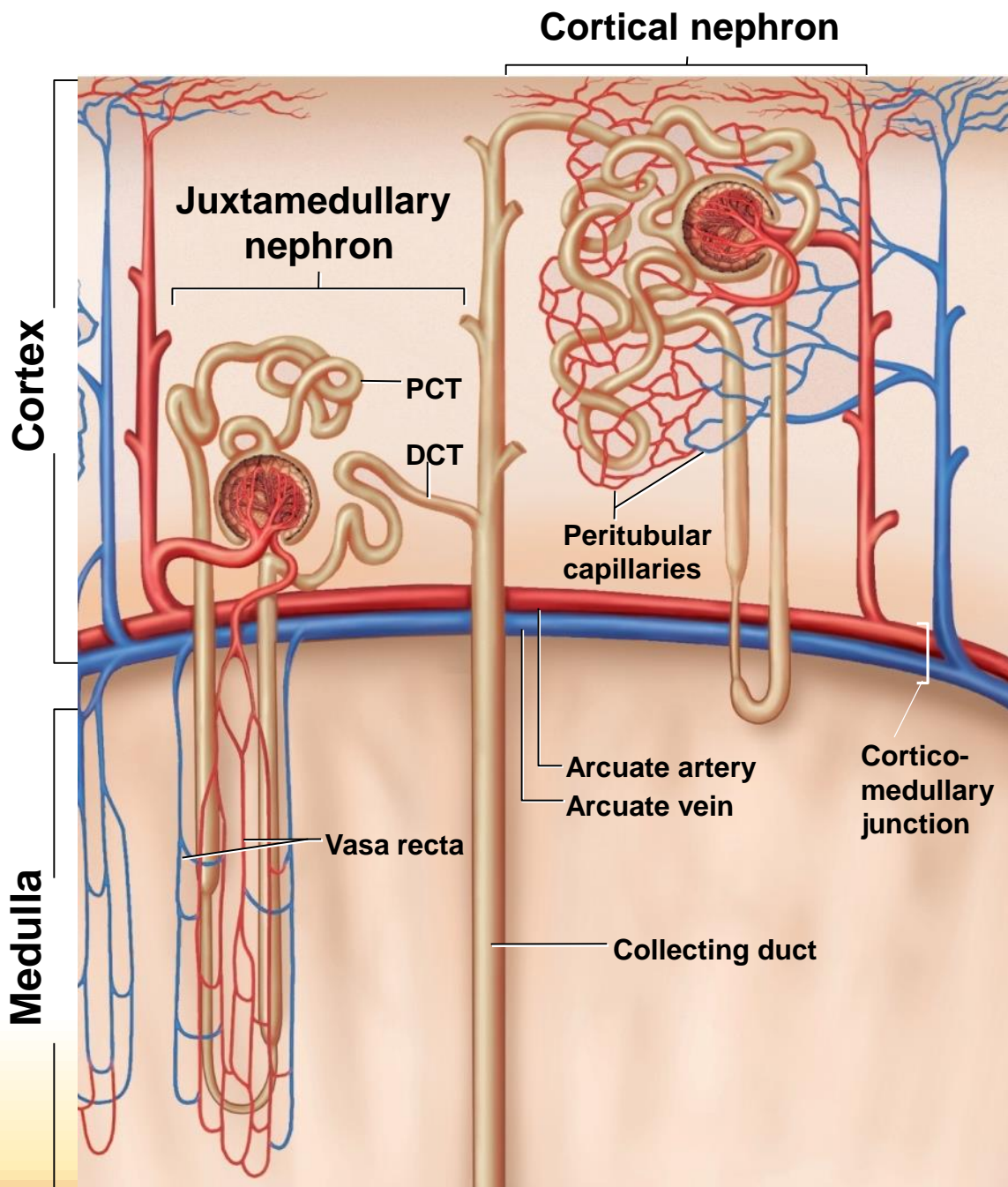
## Cortical nephrons:

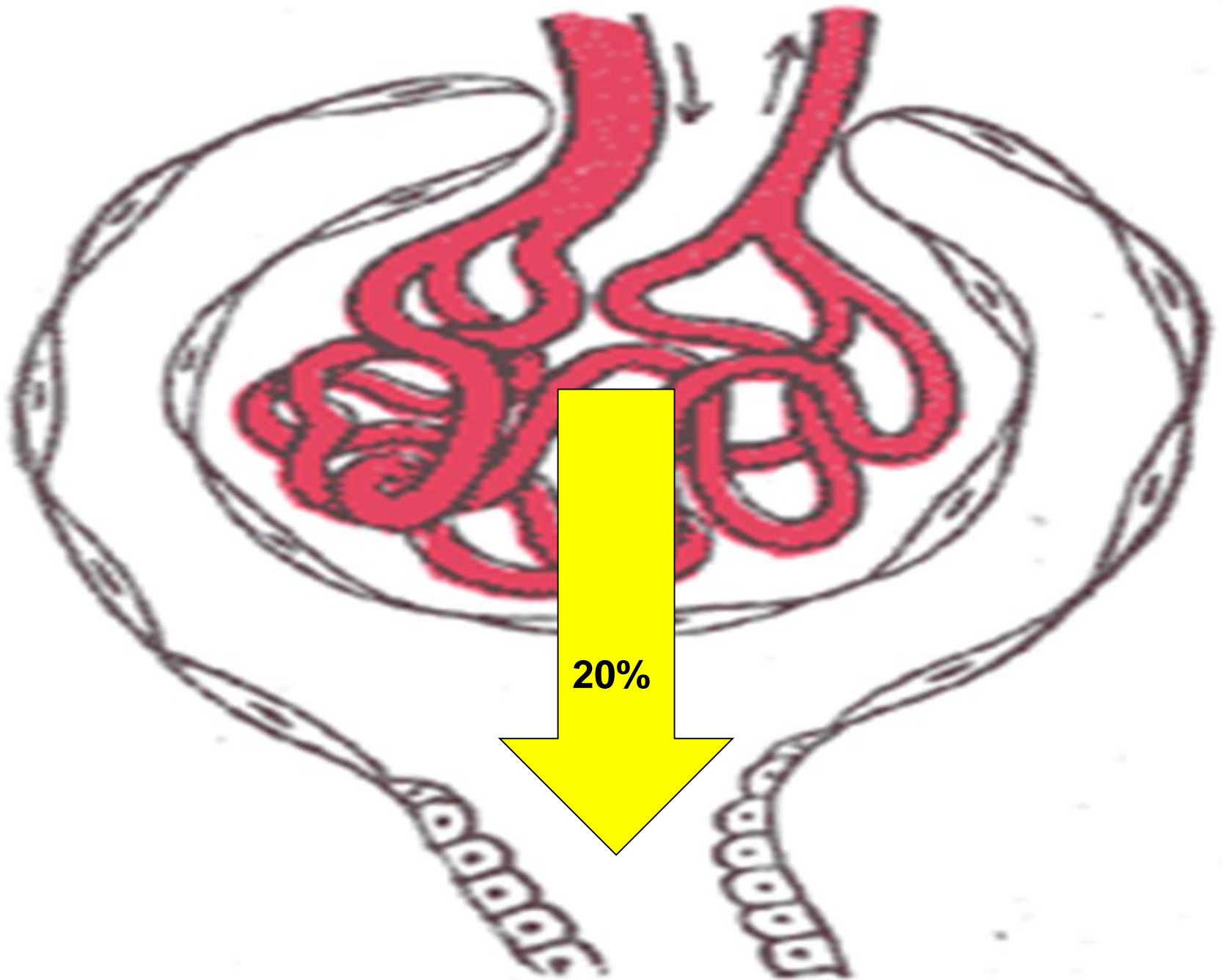
85% of nephrons

## Juxtamedullary nephrons:

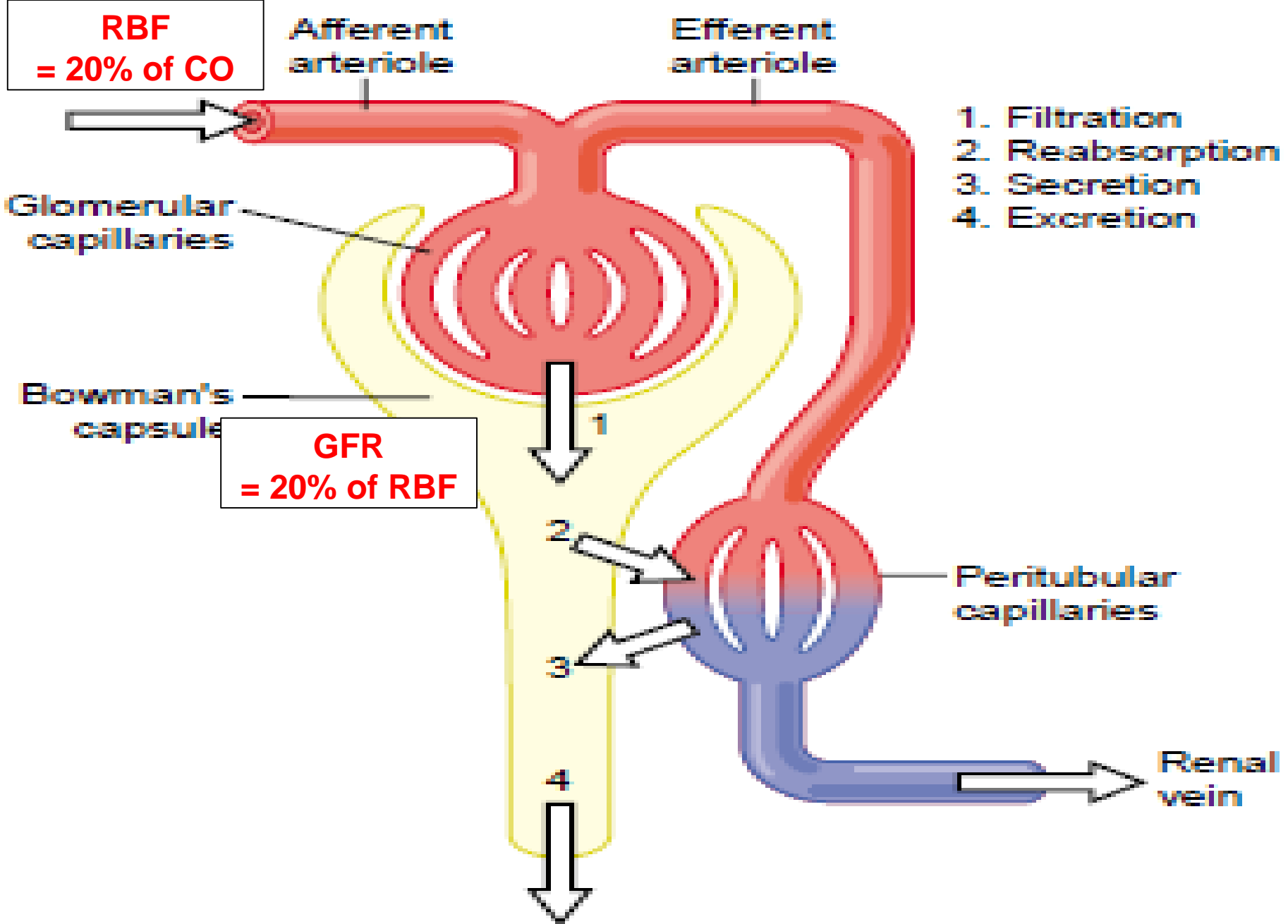
- loops of Henle deeply invade the medulla

- involved in the production of concentrated urine



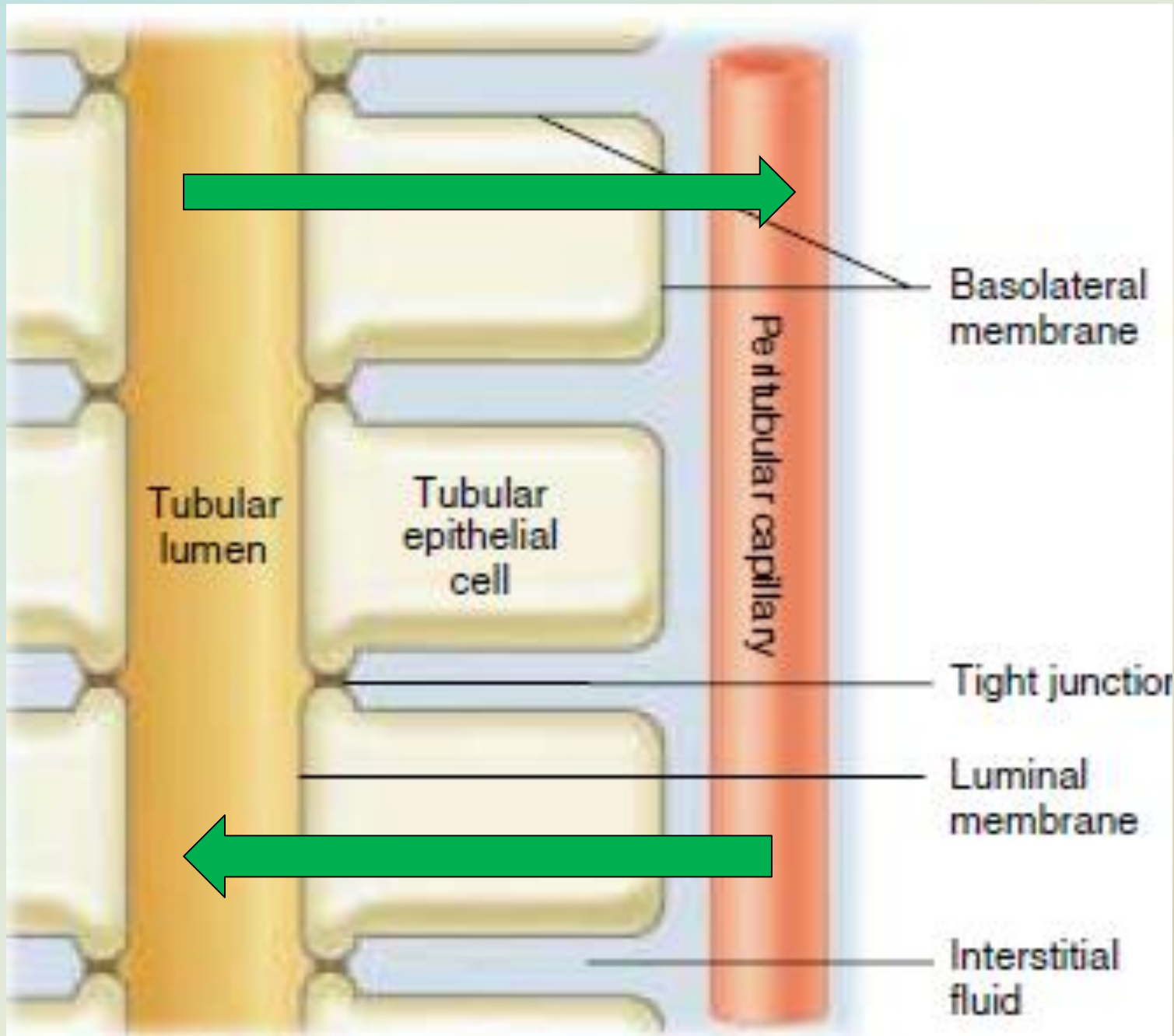


20%

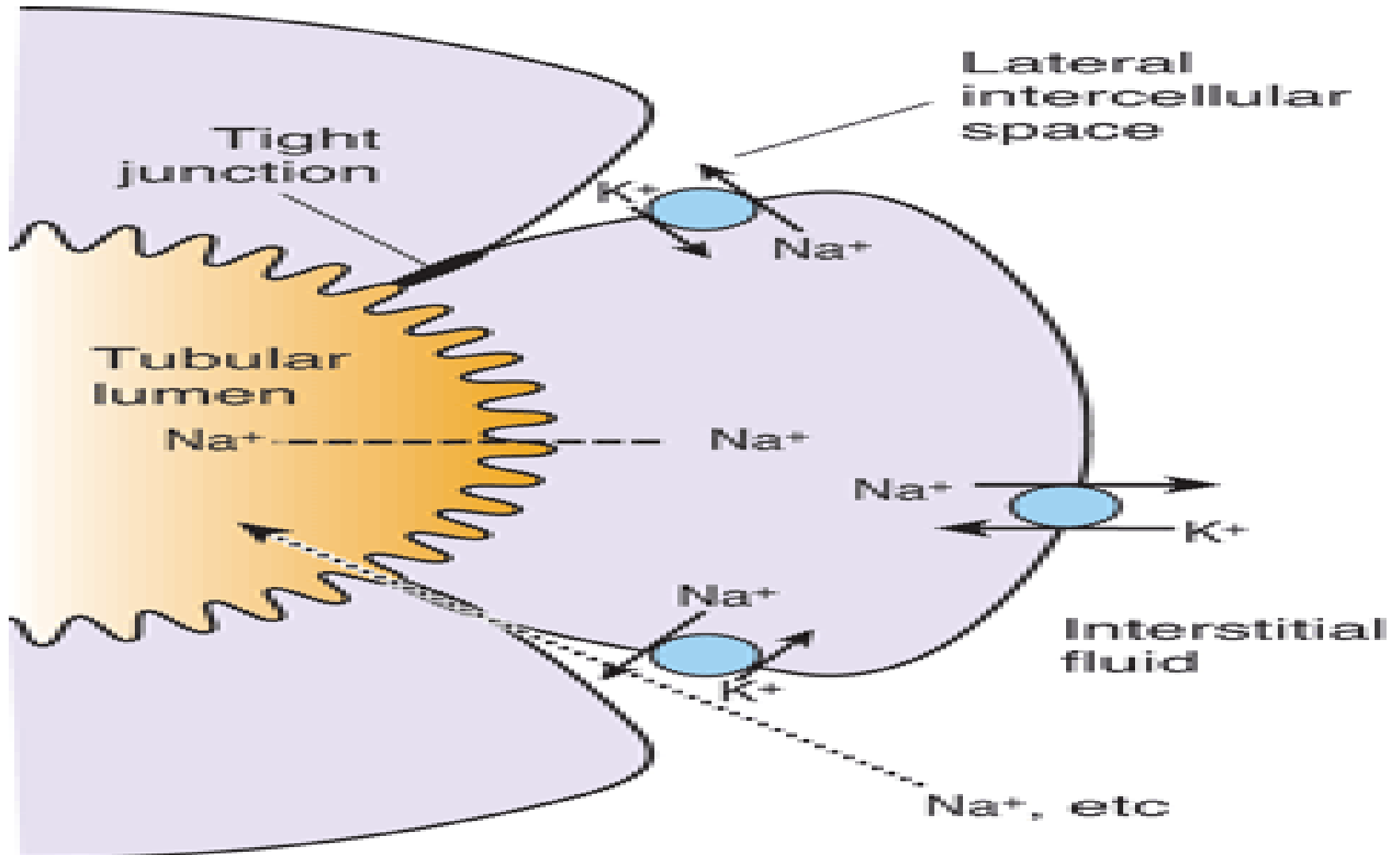


Urinary excretion

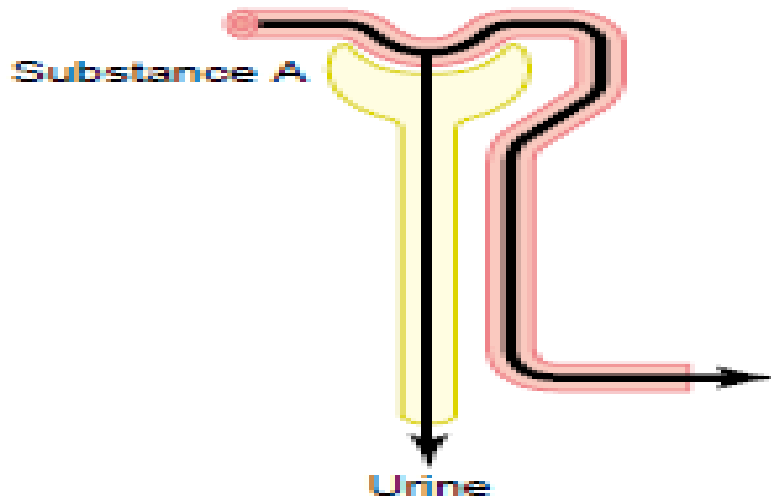
$$\text{Excretion} = \text{Filtration} - \text{Reabsorption} + \text{Secretion}$$



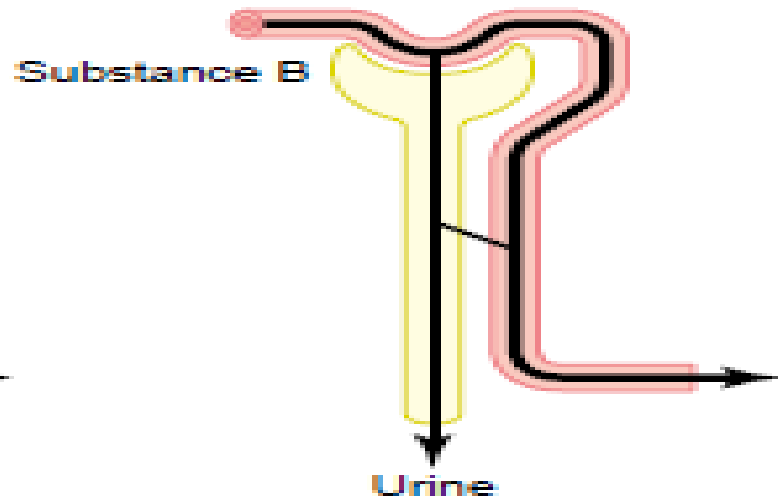
# Tubular cell



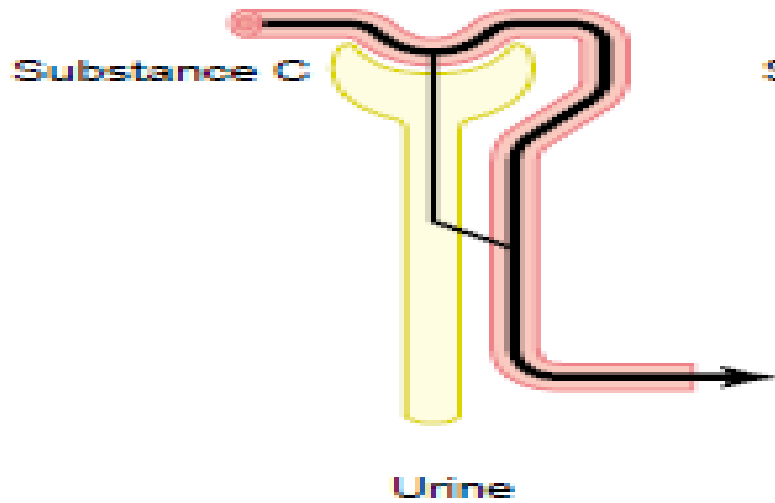
**A. Filtration only**



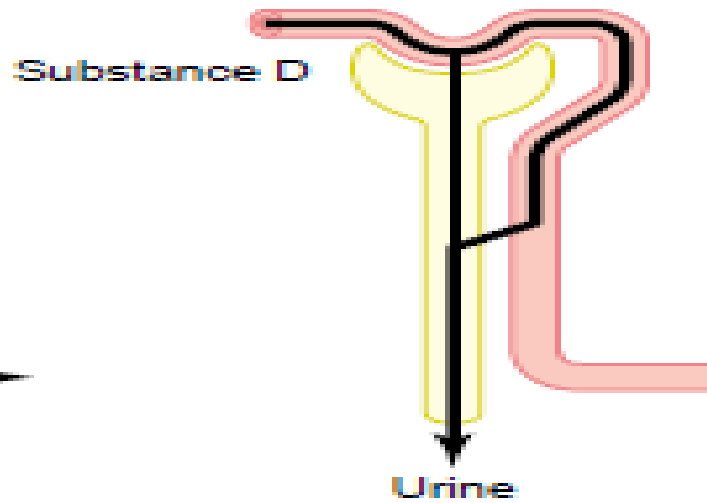
**B. Filtration, partial reabsorption**

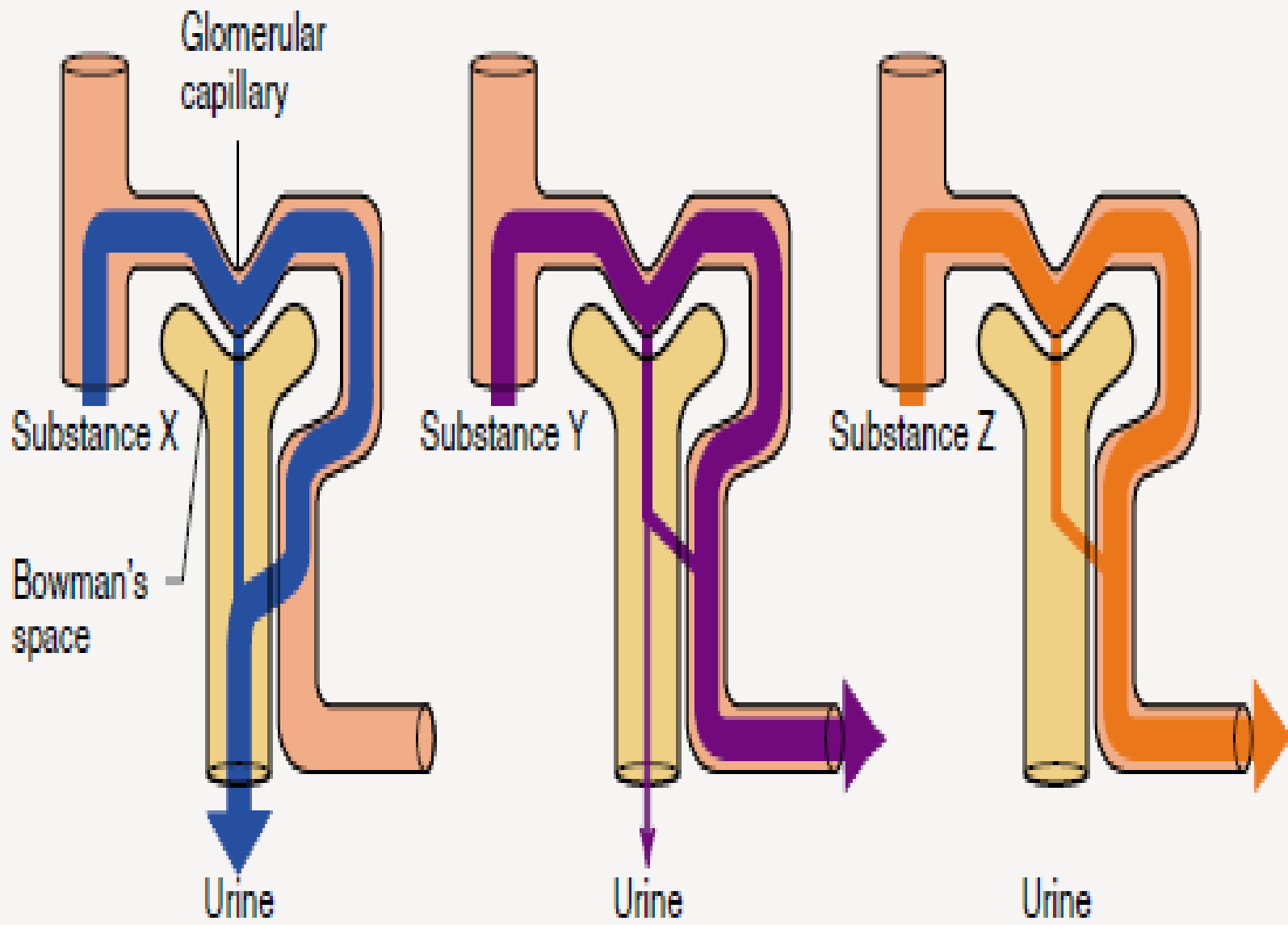


**C. Filtration, complete reabsorption**



**D. Filtration, secretion**



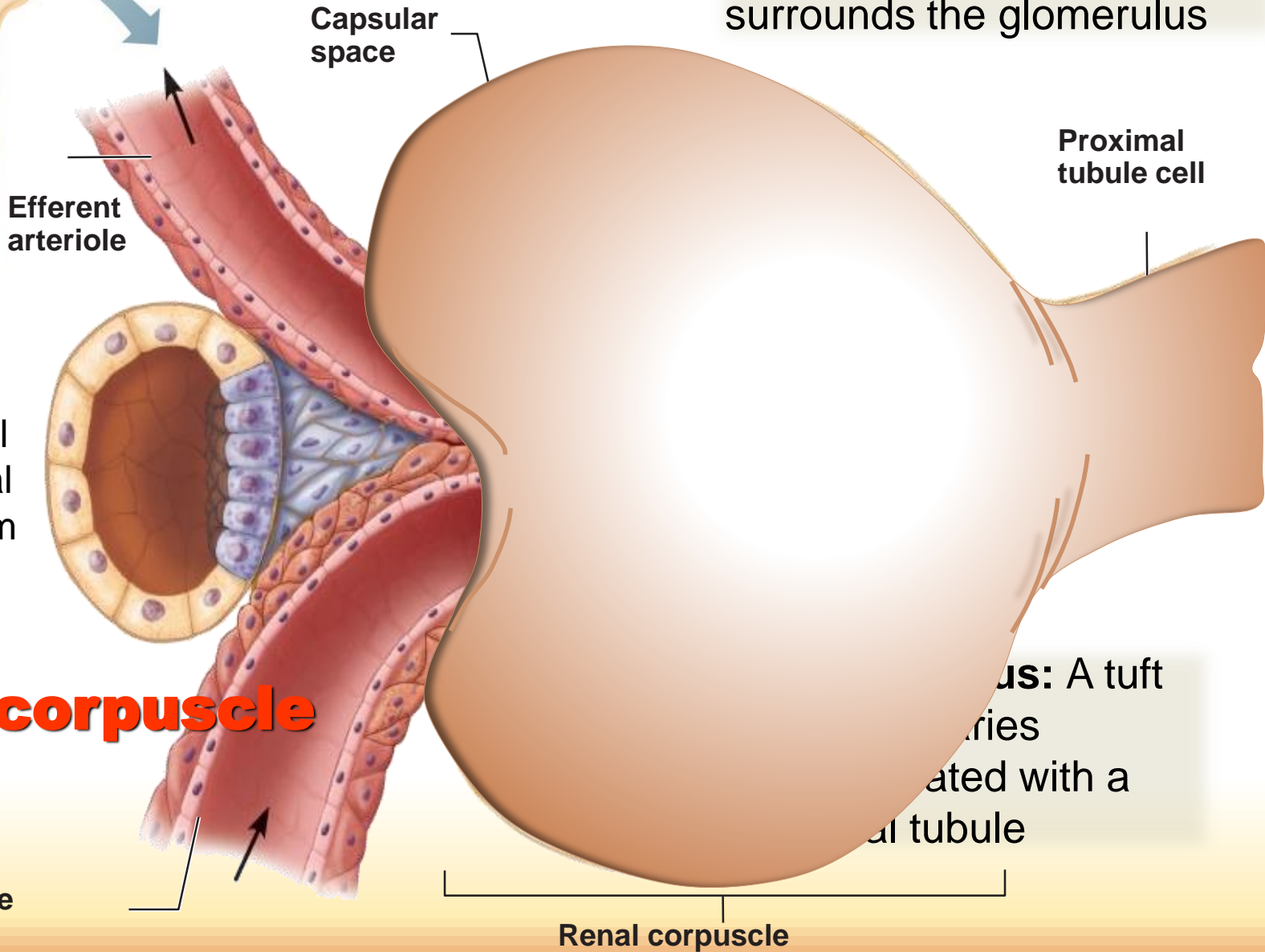




# The nephron



**Bowman's capsule:** Blind end of the tubule completely surrounds the glomerulus



The structural and functional units that form urine.

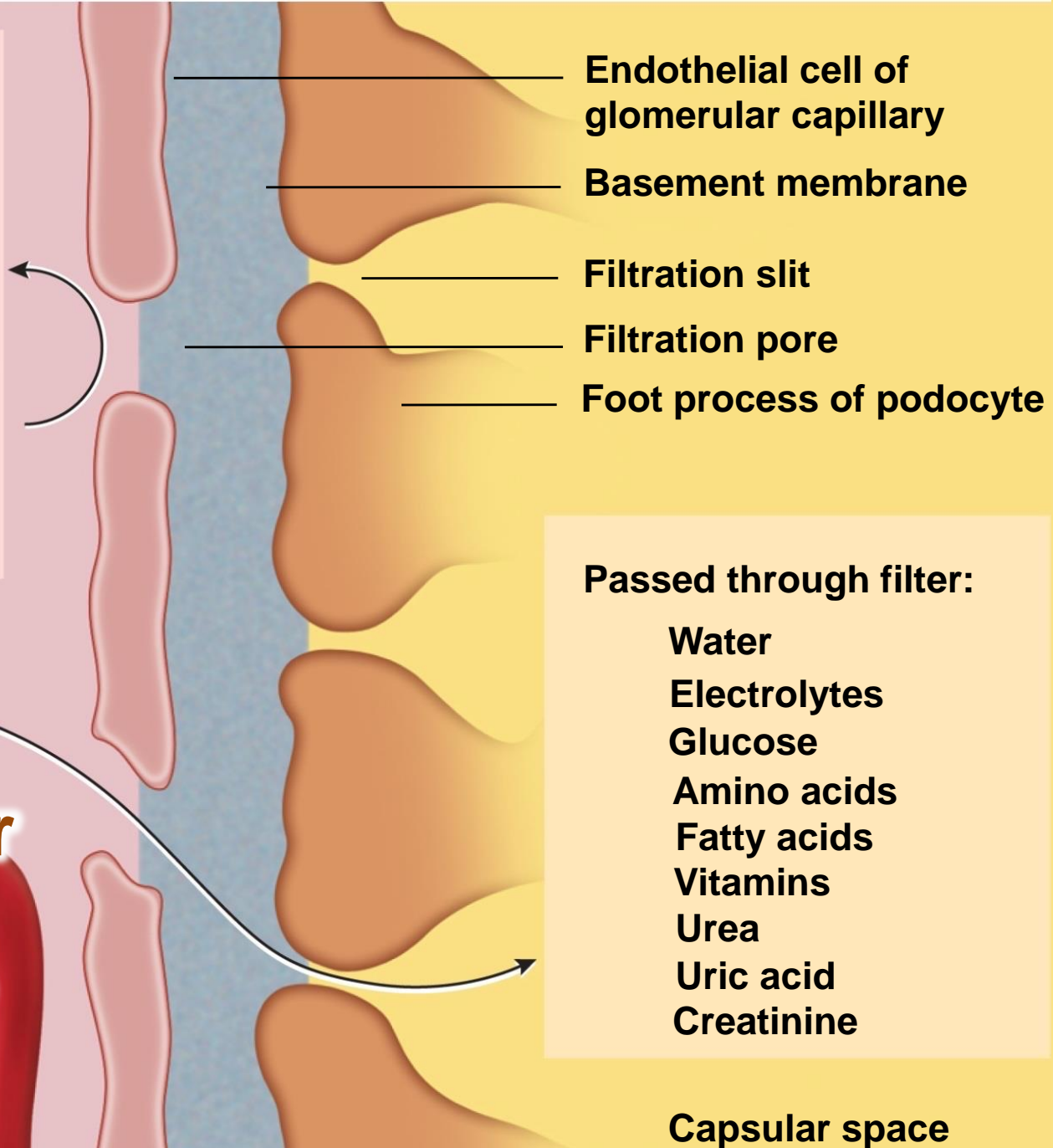
## Renal corpuscle

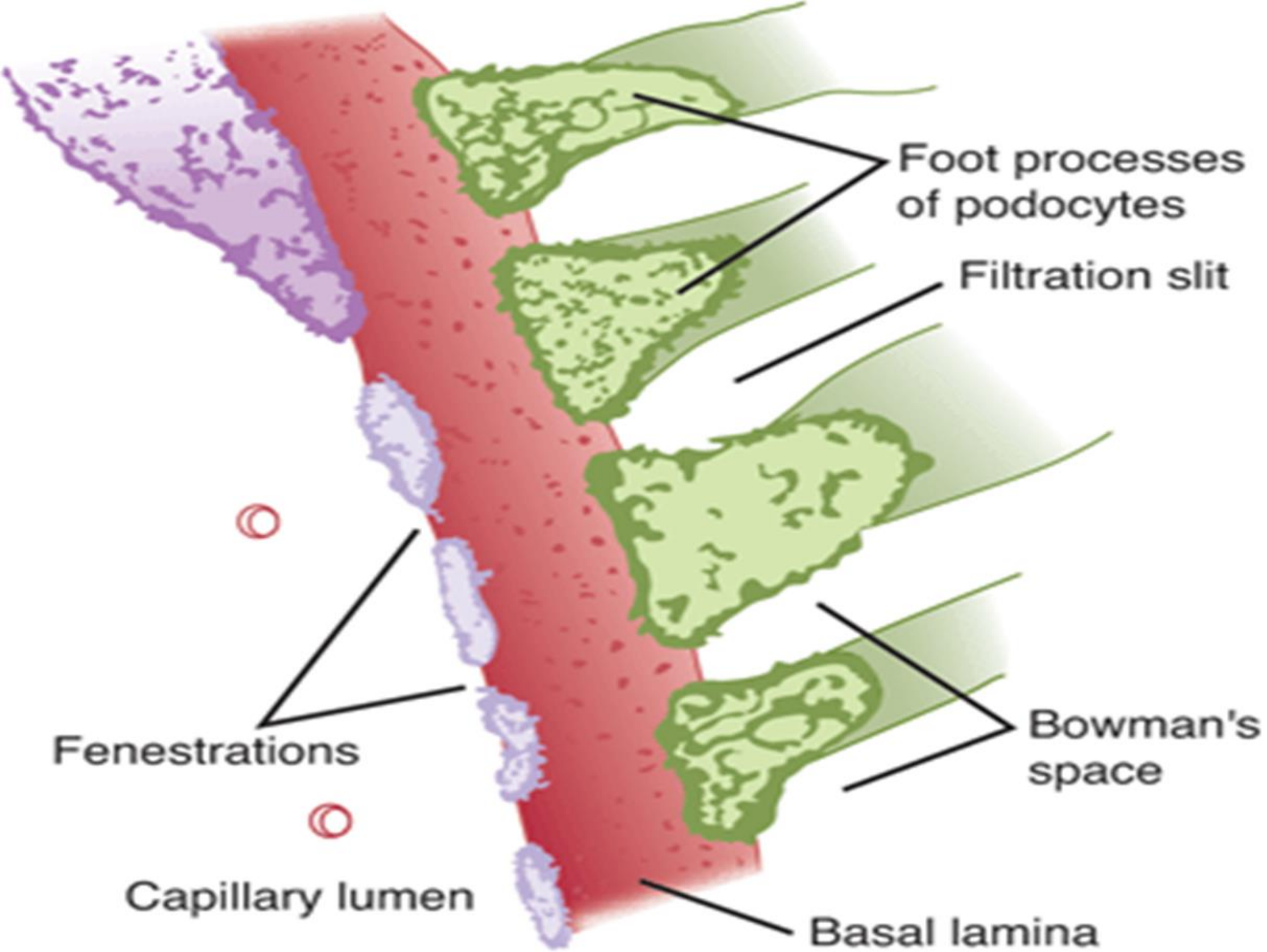
**Glomerulus:** A tuft of capillaries associated with a proximal tubule

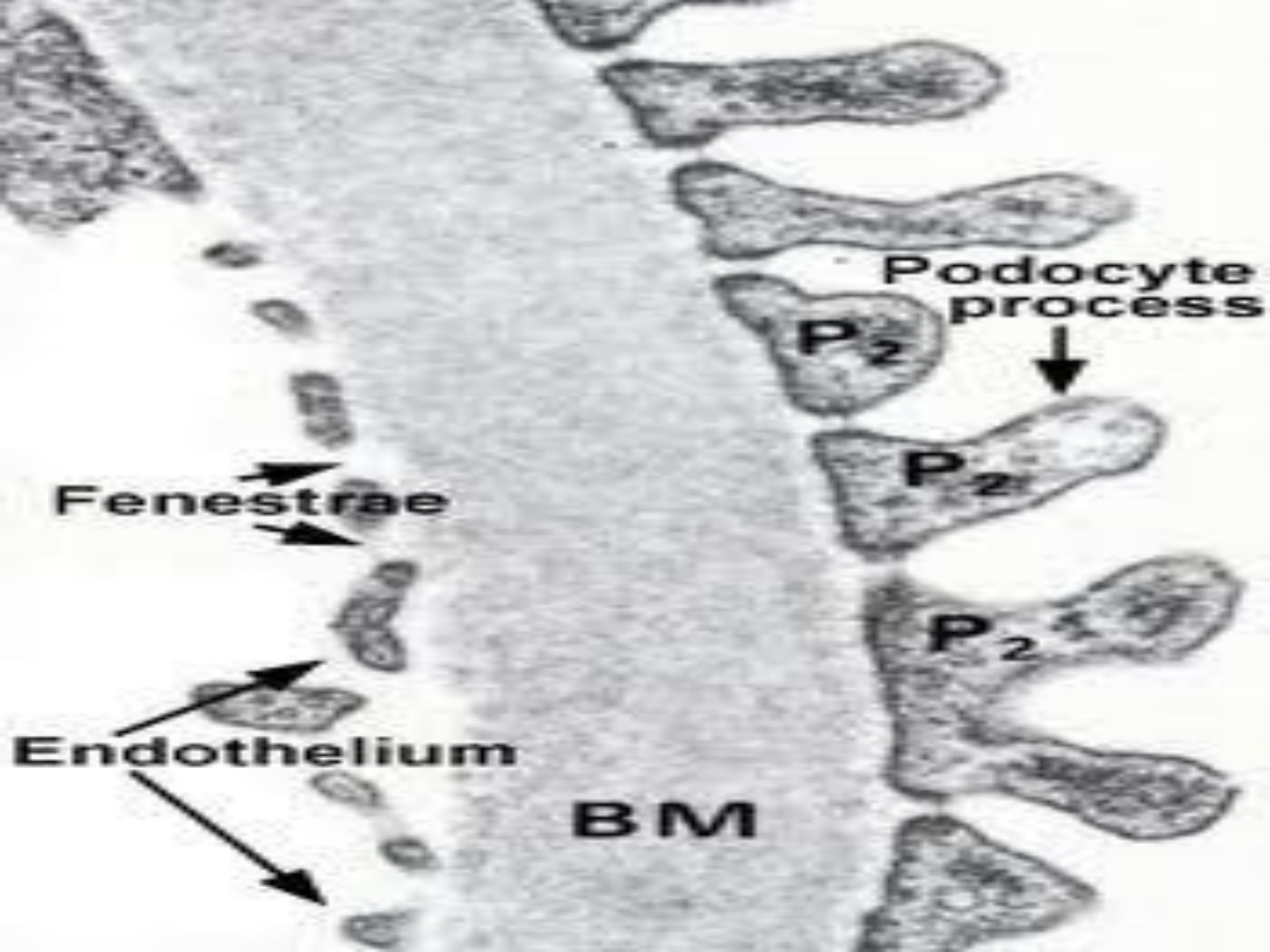
**Turned back:**  
Blood cells  
Plasma proteins  
Large anions  
Protein-bound  
minerals and  
hormones  
Most molecules  
> 8 nm in  
diameter

# The Glomerular Filtration Membrane

**Blood stream**







Fenestrae

Podocyte process

P<sub>2</sub>

P<sub>2</sub>

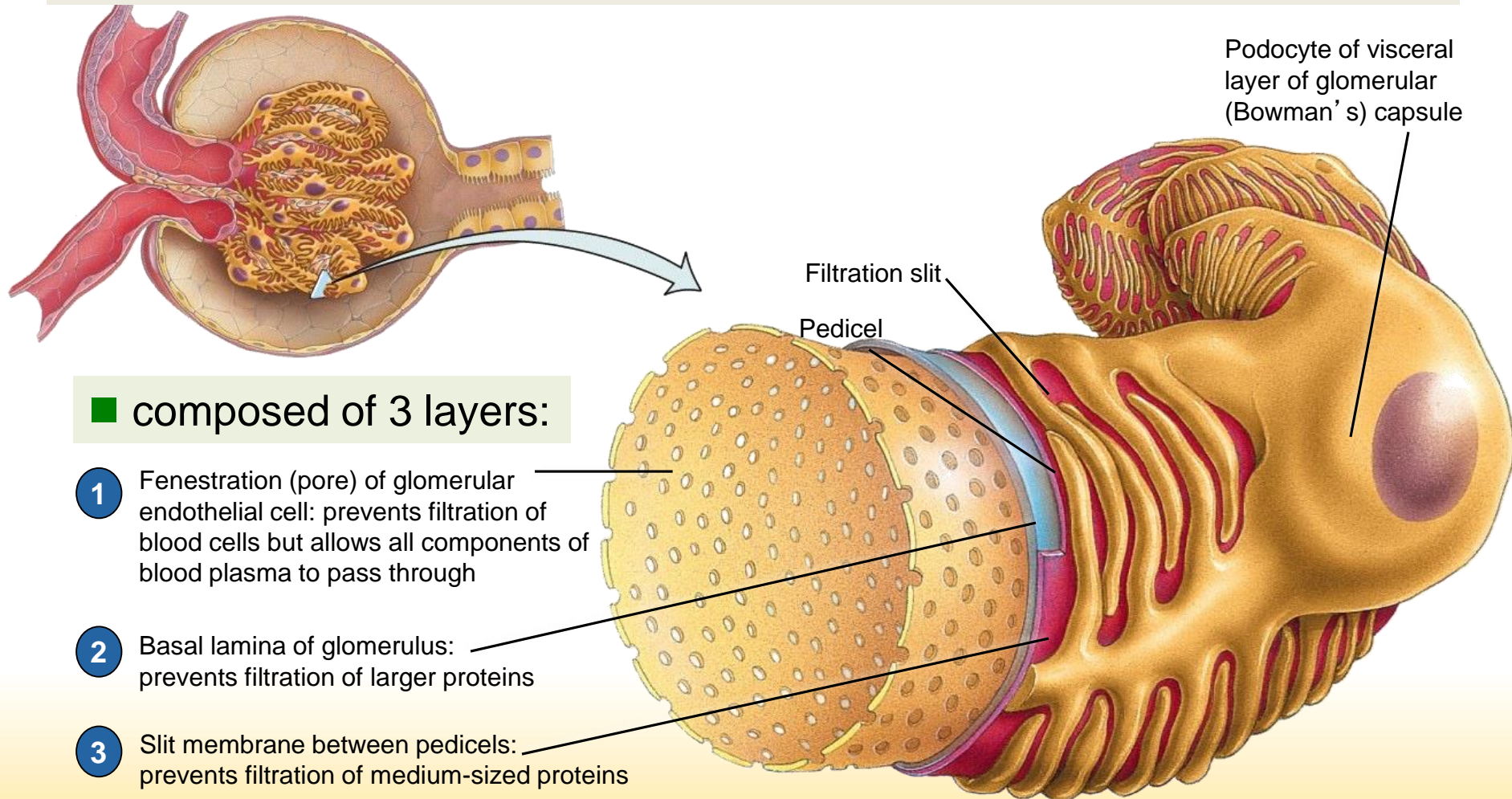
P<sub>2</sub>

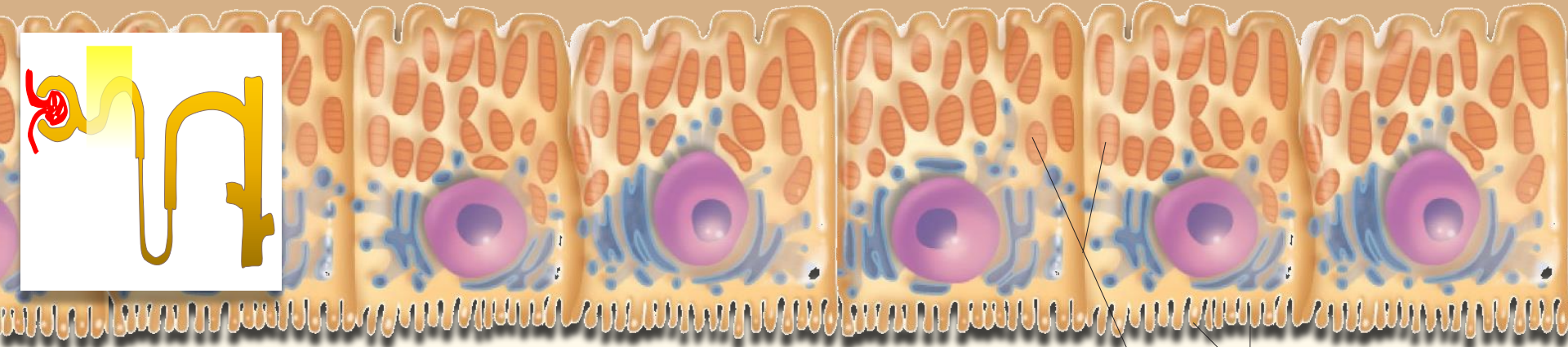
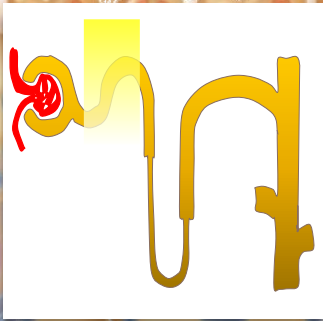
Endothelium

BM

# Filtration Membrane

Filter that lies between the blood and the interior of the glomerular capsule





Microvilli

Mitochondria

# Proximal convoluted tubule

Cuboidal cells

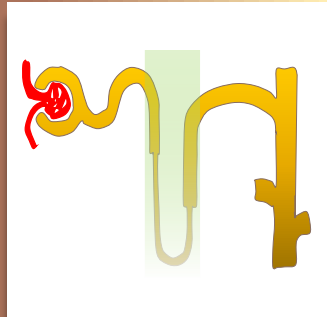
numerous microvilli and mitochondria

Urea, uric acid, creatinine,  $H^+$ ,  $NH_4^+$

$H_2O$

Glucose, Amino acids,  $Na^+$ ,  $Cl^-$ ,  $K^+$ ,  $HCO_3^-$

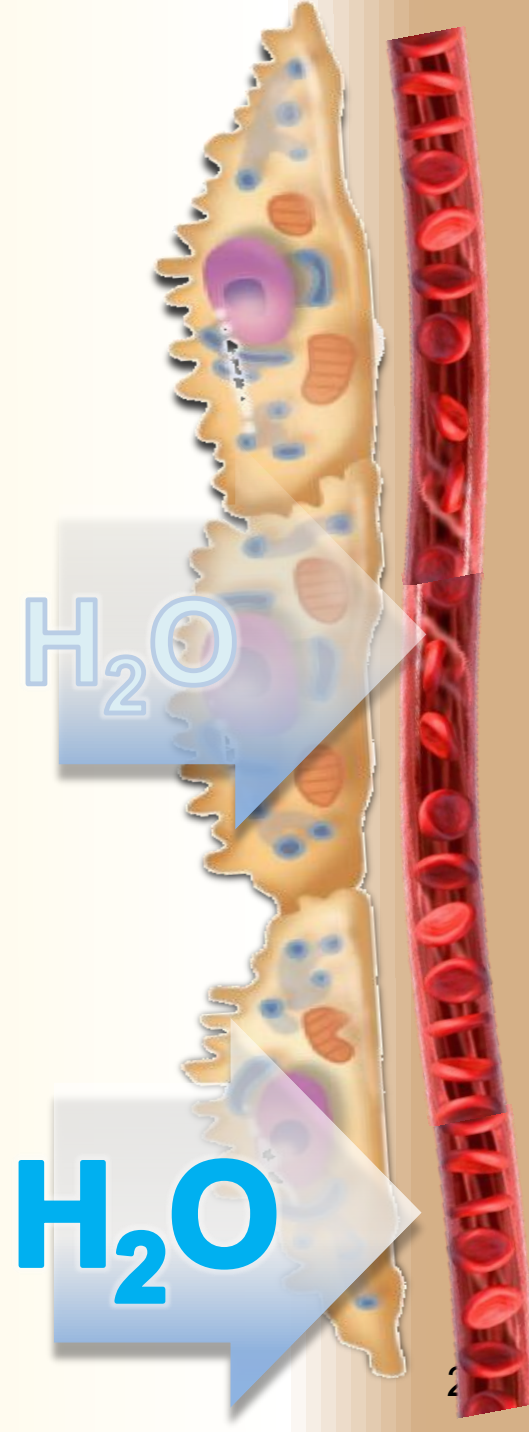


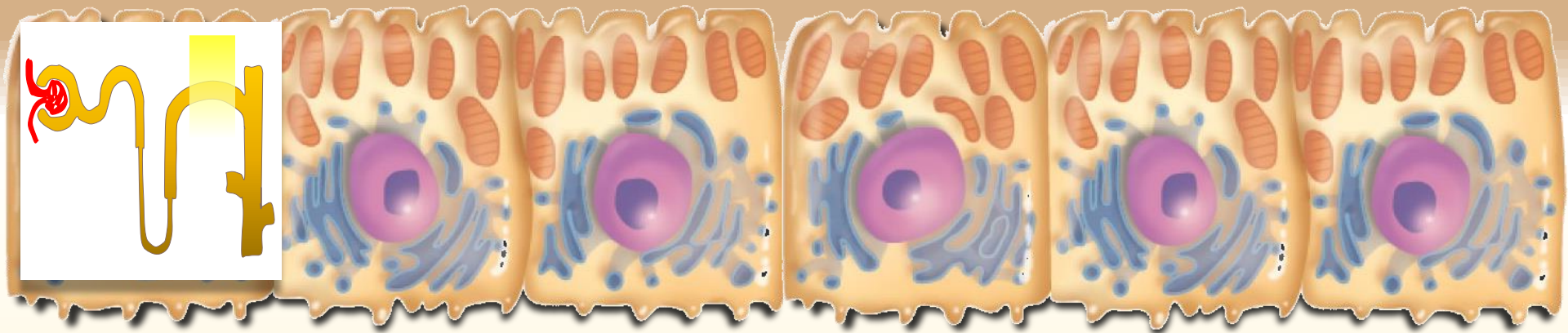


# Loop of Henle

Proximal part is similar to PCT

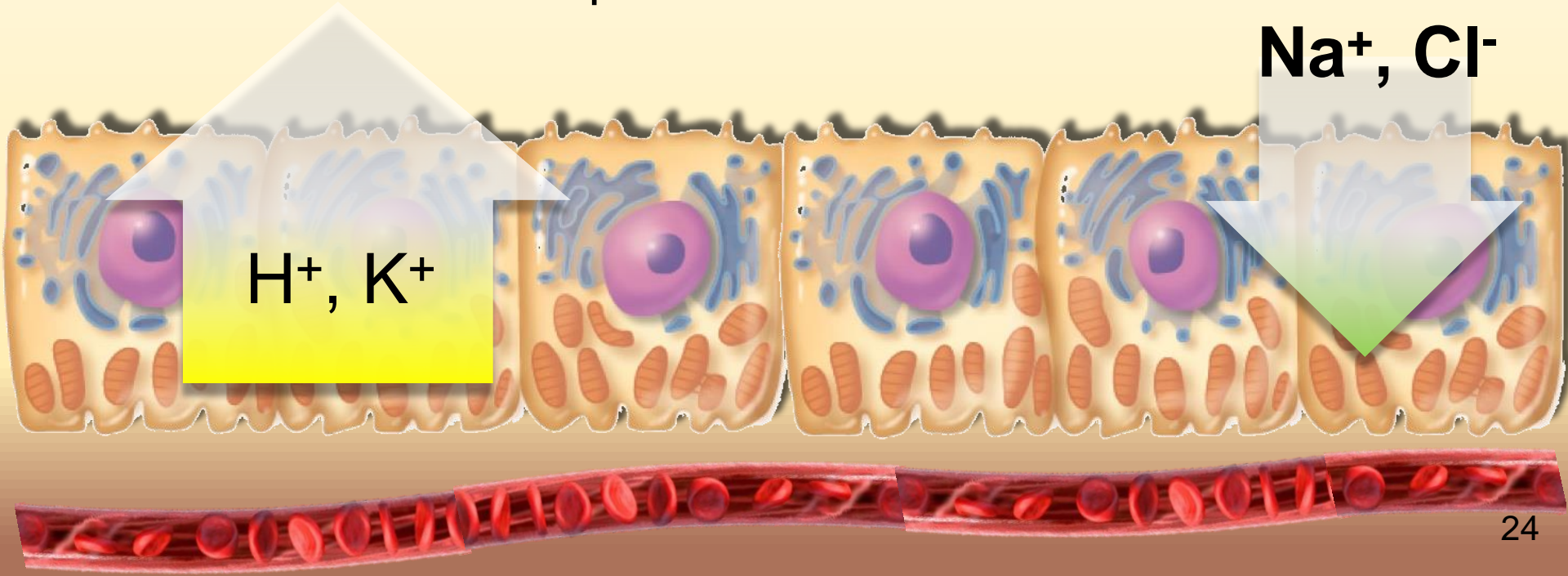
Thin segment (simple squamous cells) followed by thick segment (cuboidal to columnar cells)



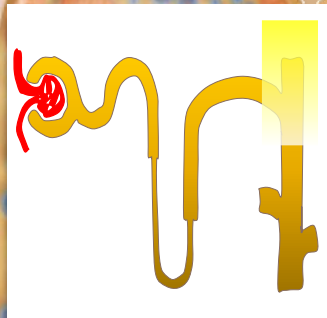


## Distal convoluted tubule

Cuboidal cells without microvilli that function more in secretion than reabsorption







**Collecting duct cells**

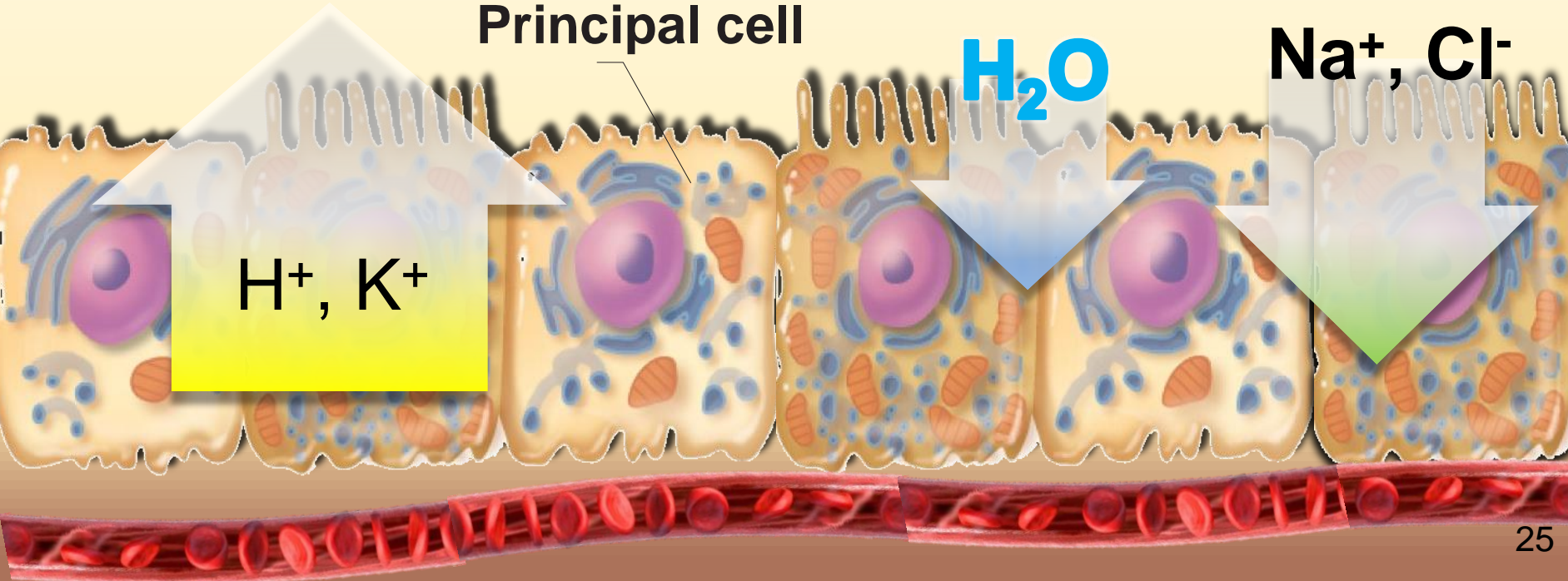
**Intercalated cell**  
Acid-base balance

Water and salt balance  
**Principal cell**

$H^+, K^+$

$H_2O$

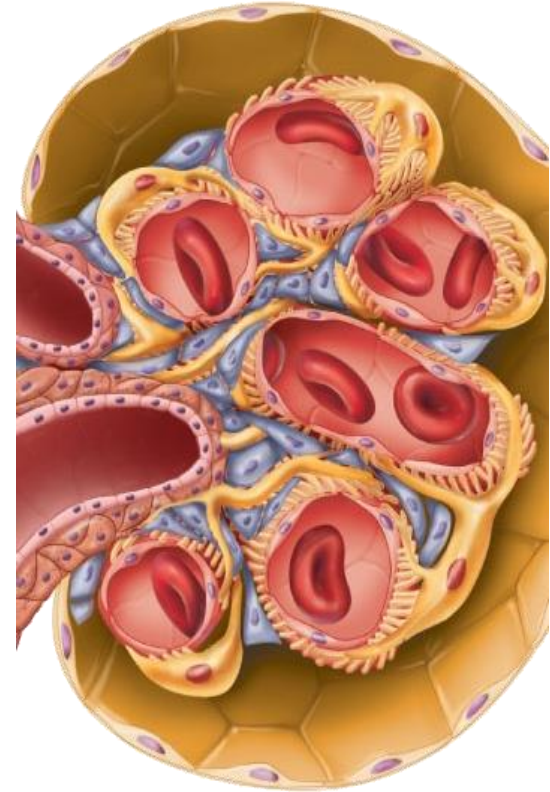
$Na^+, Cl^-$



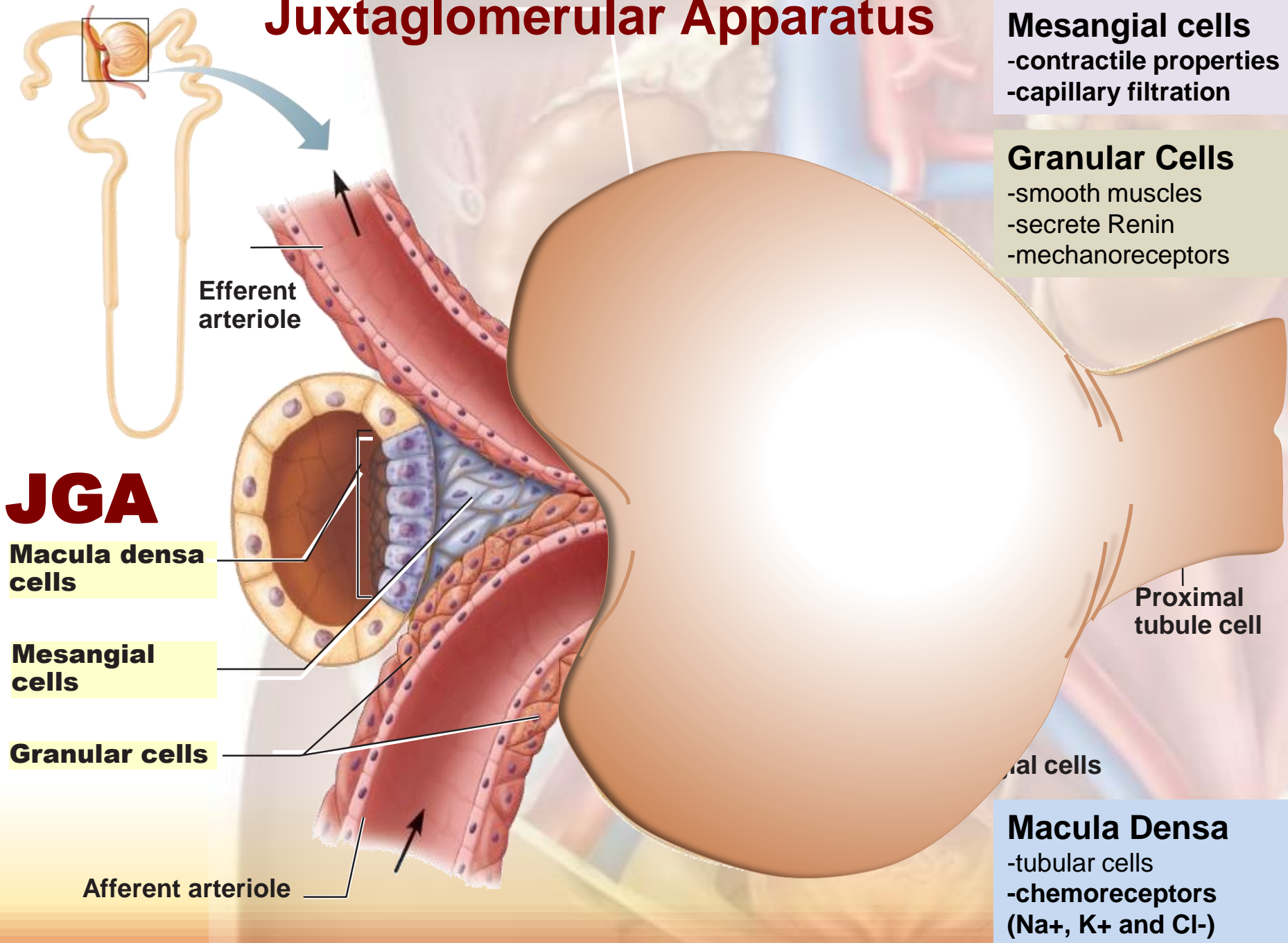
# Mesangial cells

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- Irregularly shaped cells in the central part of the glomerular tuft.
- Phagocytic function → prevent the accumulation of macromolecules in the basement membrane which have escaped from the capillaries.
- Hold the delicate glomerular structure in position.
- Contraction → modifies the surface area of the glomerular capillaries available for filtration.



# Juxtaglomerular Apparatus



**Mesangial cells**  
-contractile properties  
-capillary filtration

**Granular Cells**  
-smooth muscles  
-secrete Renin  
-mechanoreceptors

Efferent arteriole

## JGA

**Macula densa cells**

**Mesangial cells**

**Granular cells**

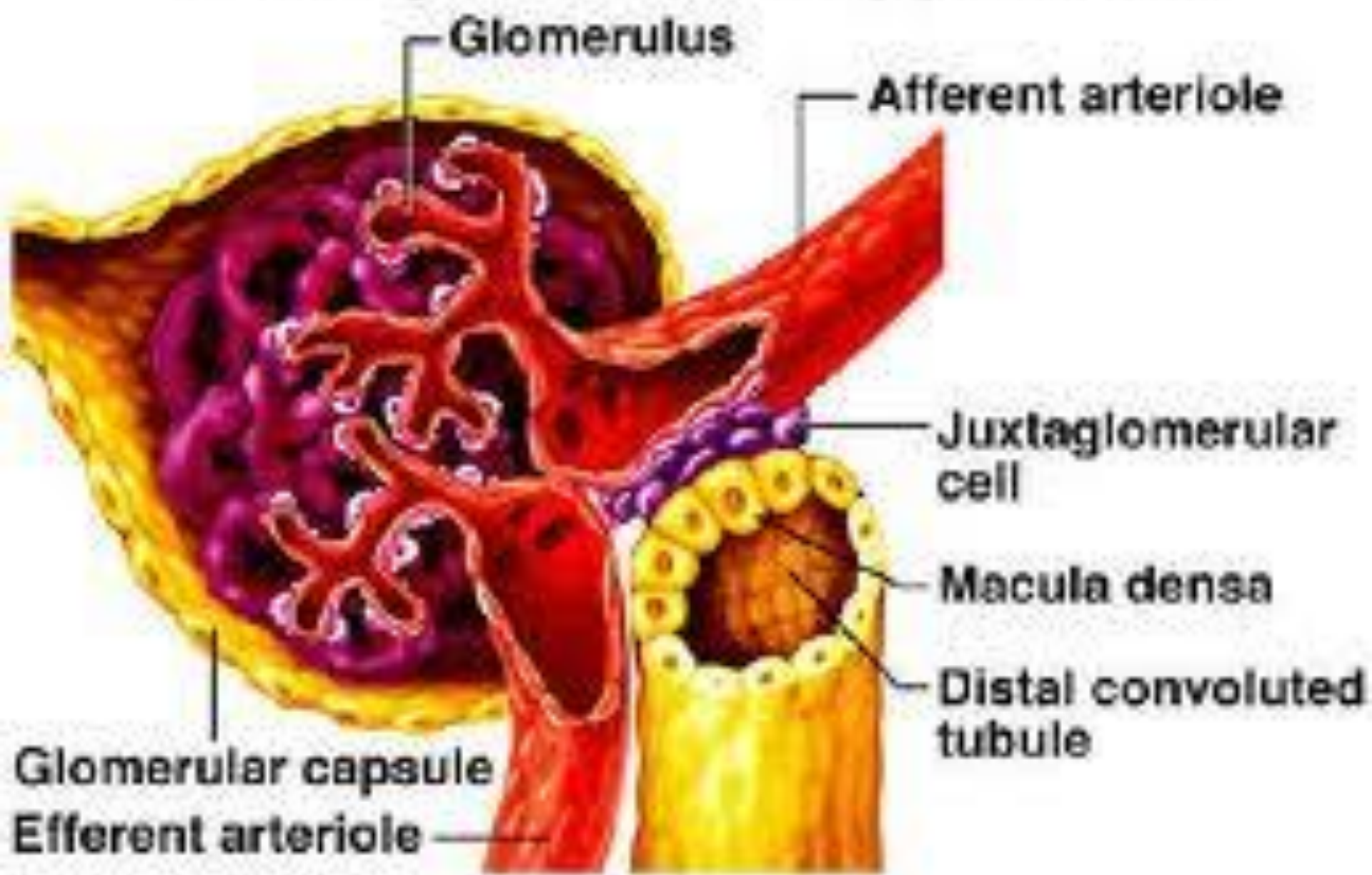
Afferent arteriole

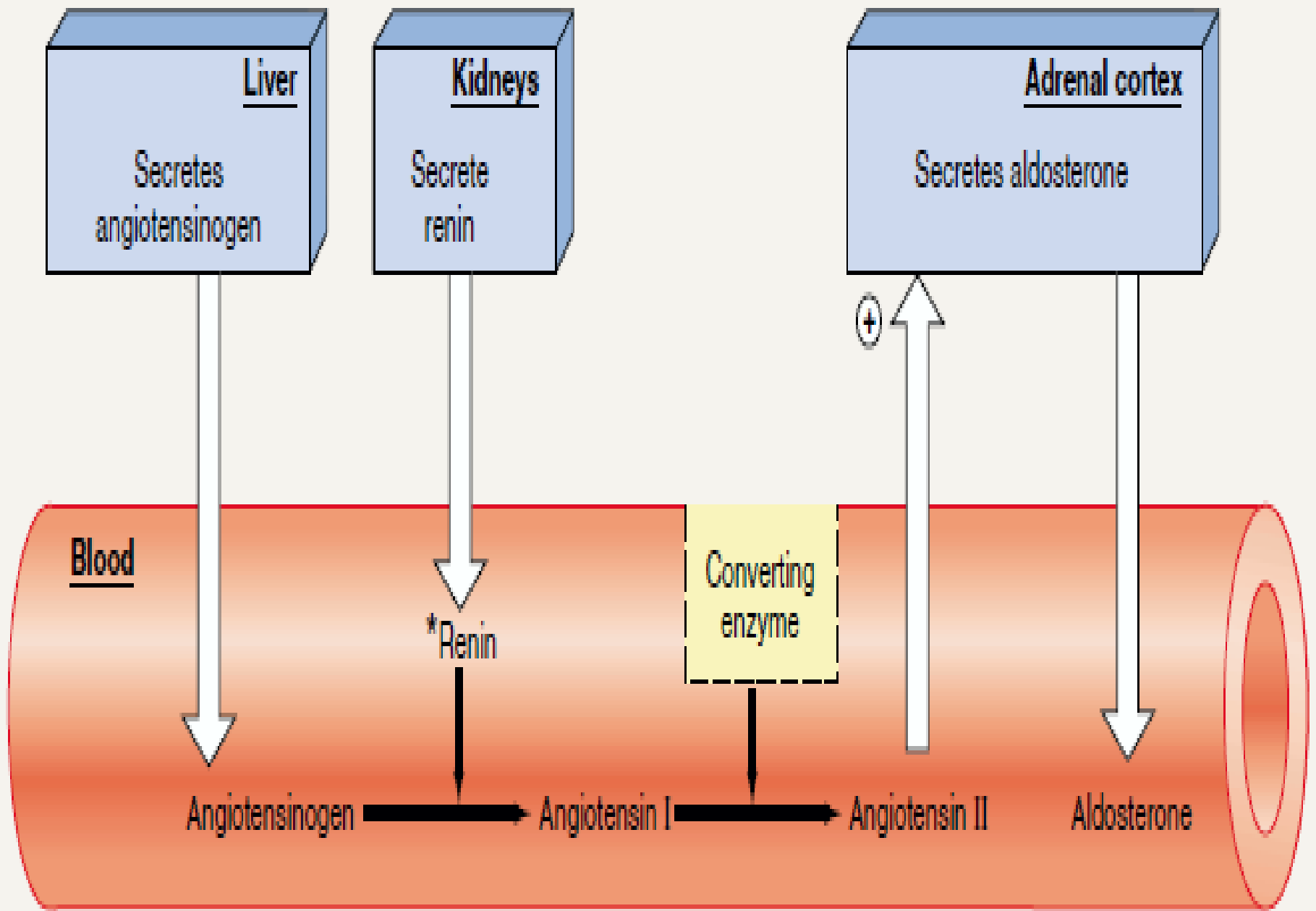
Proximal tubule cell

al cells

**Macula Densa**  
-tubular cells  
-chemoreceptors (Na<sup>+</sup>, K<sup>+</sup> and Cl<sup>-</sup>)

# Juxtaglomerular Apparatus

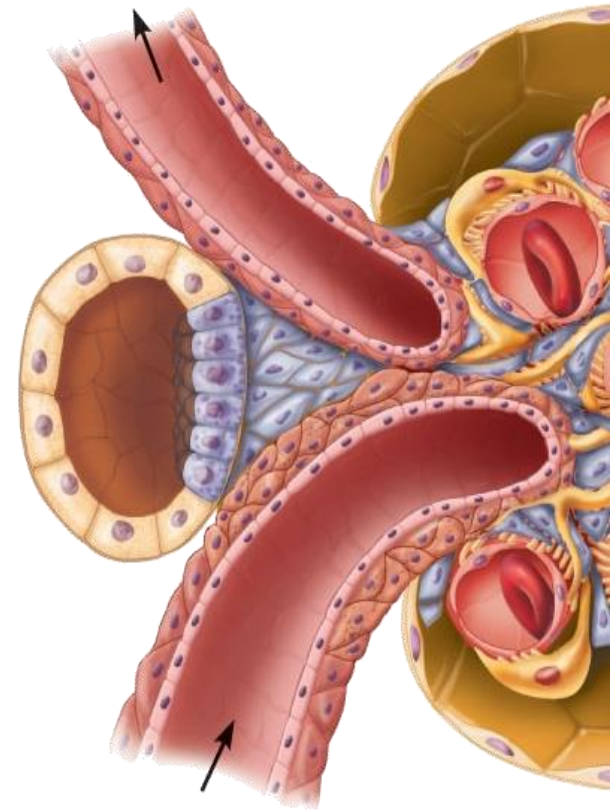




# Macula densa

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- Tall, closely packed distal tubule cells
- Lie adjacent to JG cells
- Function as chemoreceptors or osmoreceptors
- The cells of the macula densa are sensitive to the ionic content and water volume of the fluid in the tubule.
- produce molecular signals that promote renin secretion by the juxtaglomerular cells



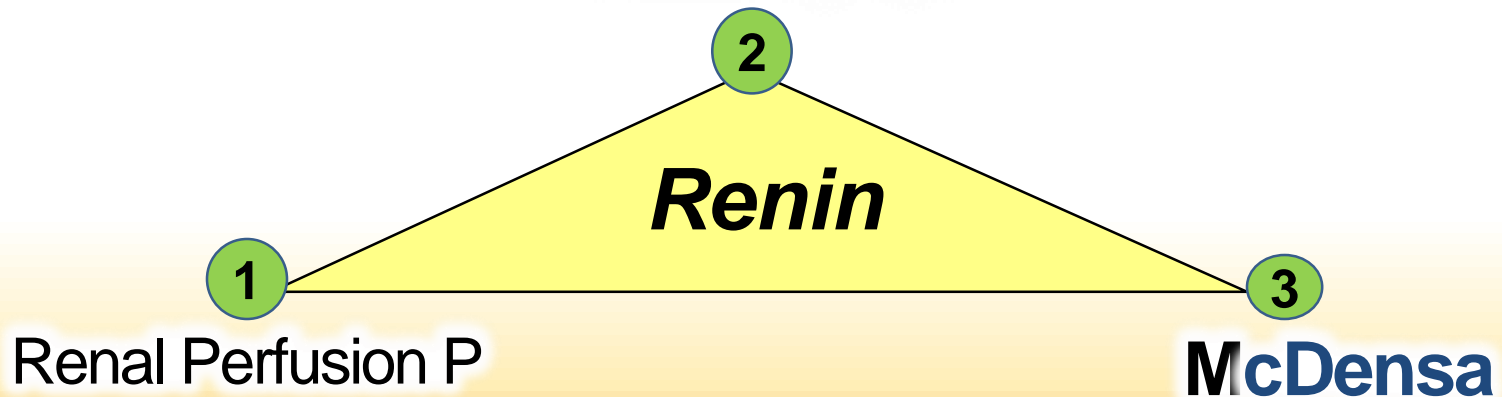
# What is **RAS**?

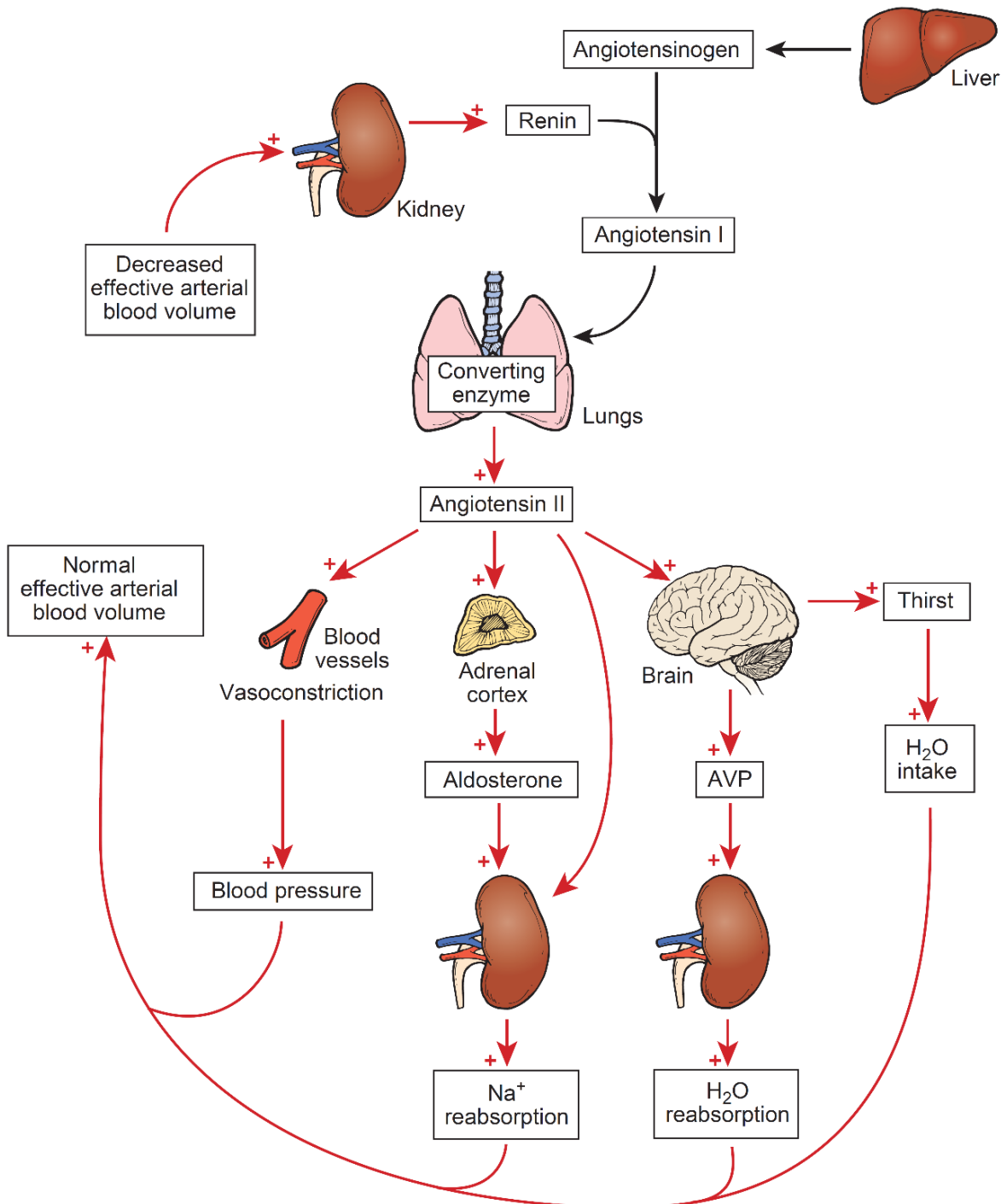
A hormone system that regulates BP and water balance.

Day-to-day control of  $\text{Na}^+$  excretion.

Three main stimuli for renin release

Renal Symp.





# RAS





# Innervation of the kidney

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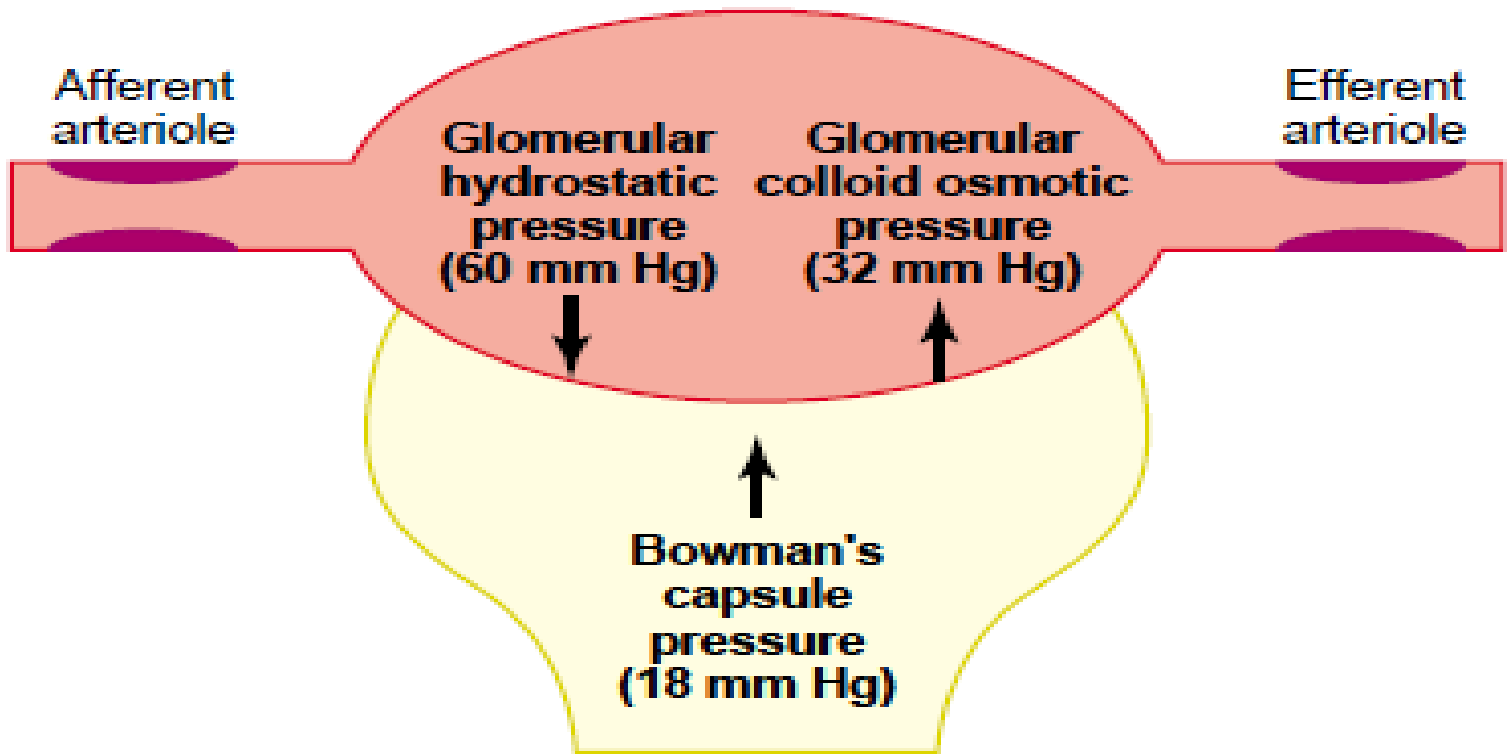
- Only sympathetic nerves supply renal blood vessels

- regulate blood flow, filtration, water reabsorption, renin secretion.

↑ sympathetic = constriction, ↓ blood flow

- There is no parasympathetic innervation

# Control of GFR



$$\text{Net filtration pressure (10 mm Hg)} = \text{Glomerular hydrostatic pressure (60 mm Hg)} - \text{Bowman's capsule pressure (18 mm Hg)} - \text{Glomerular oncotic pressure (32 mm Hg)}$$

Thanks