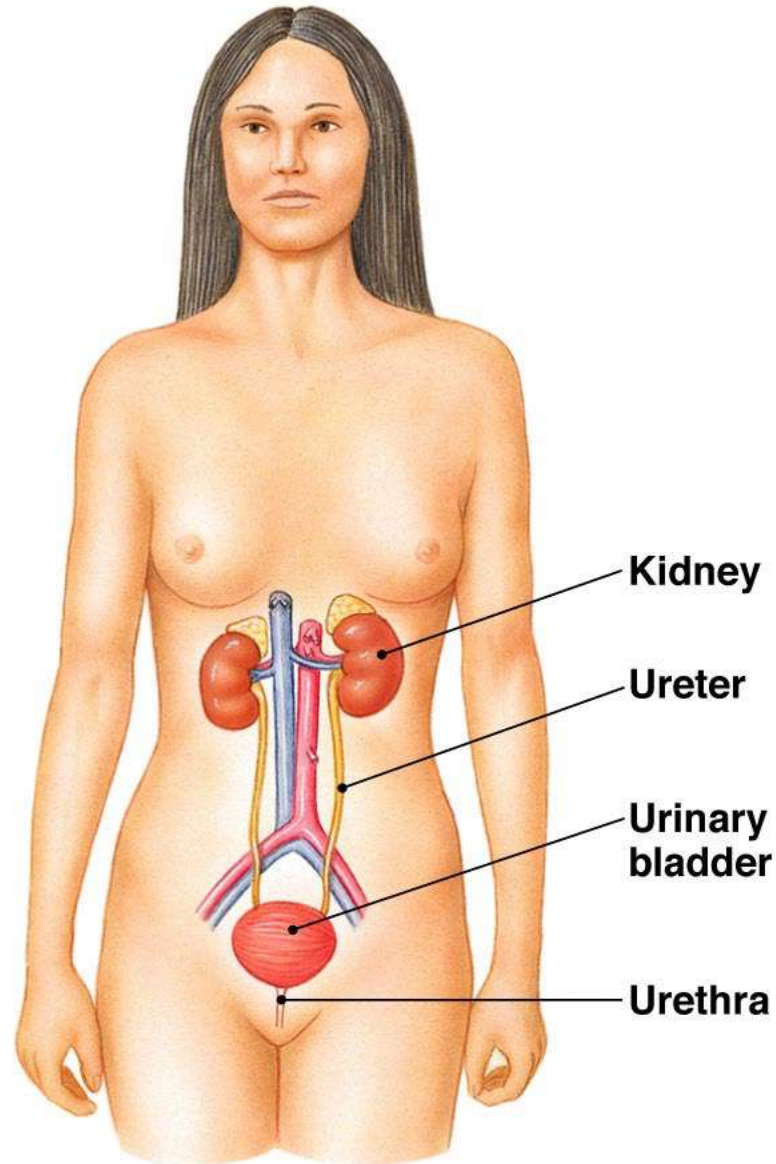


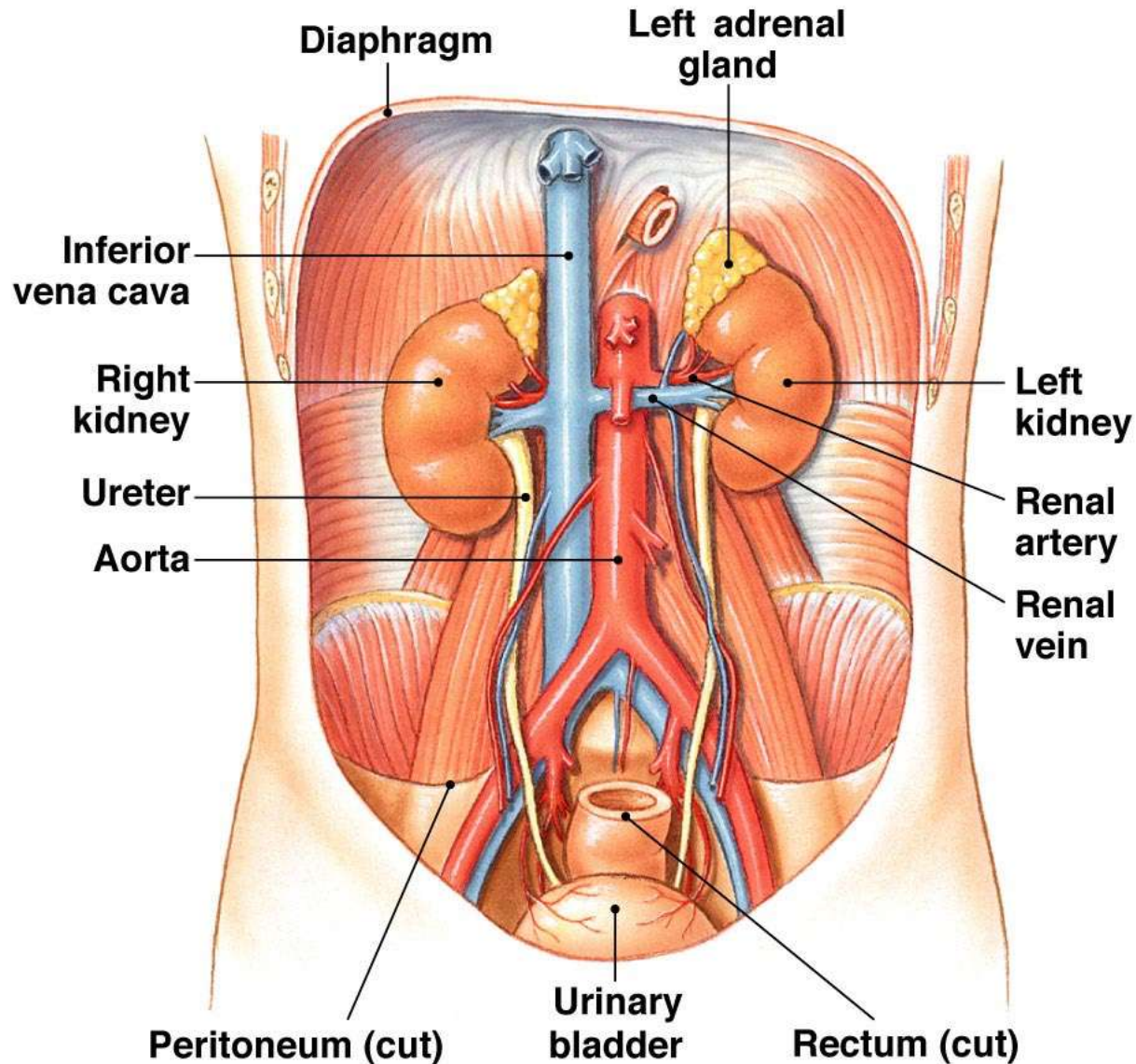
**(a) The urinary system**



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**Figure 19-1a**

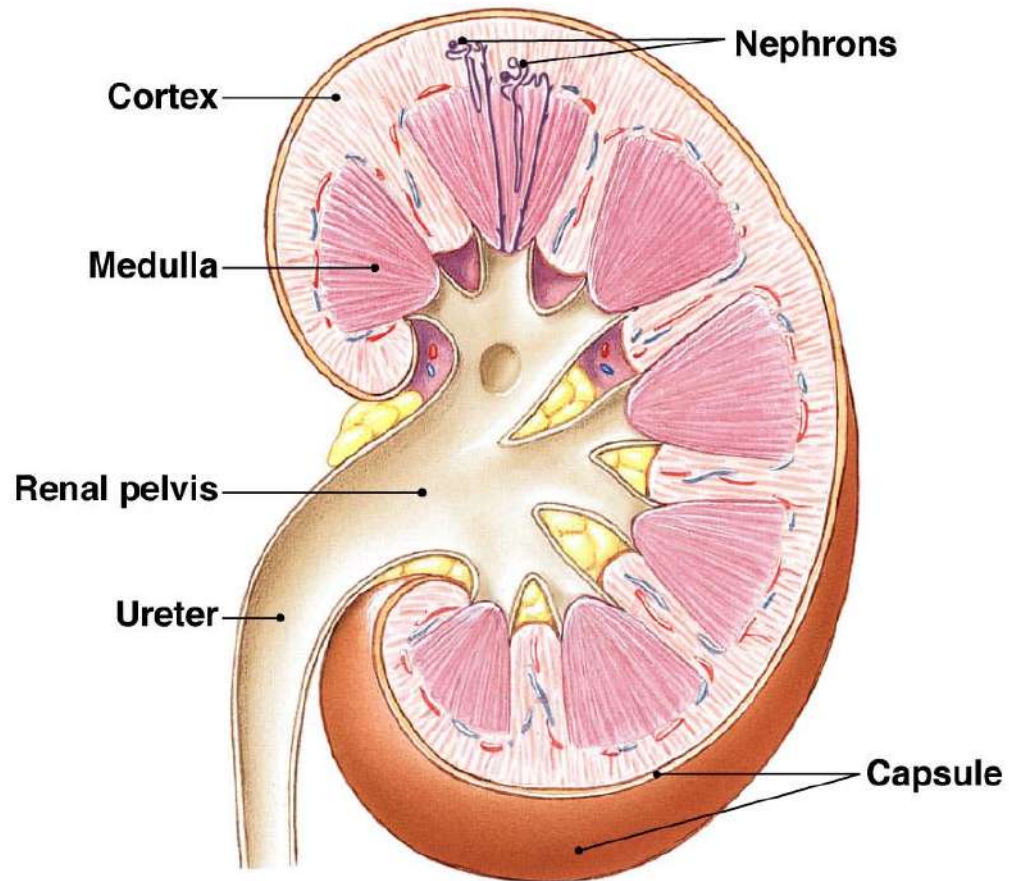
**(b)** The kidneys are located retroperitoneally at the level of the lower ribs.



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Figure 19-1b

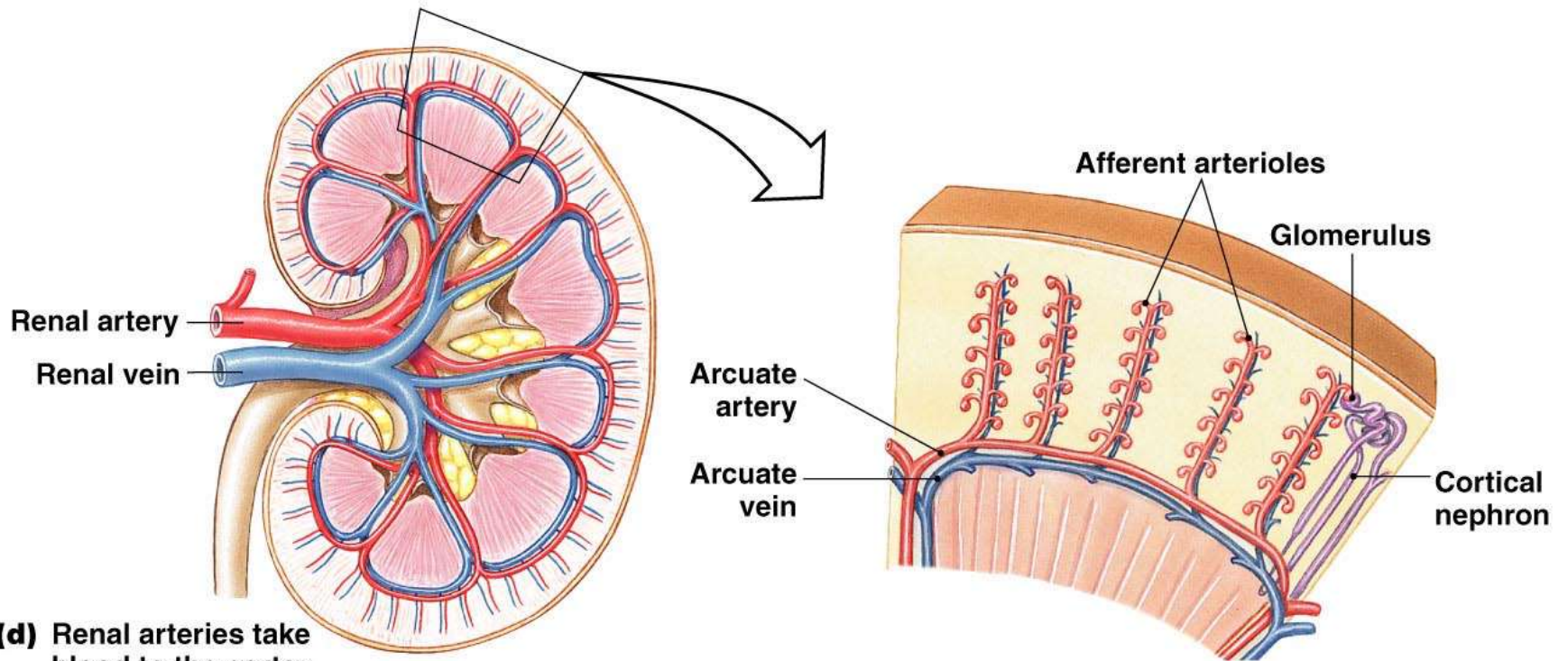
**(c)** In cross section, the kidney is divided into an outer cortex and an inner medulla. Urine leaving the nephrons flows into the renal pelvis prior to passing through the ureter into the bladder.



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Figure 19-1c

## STRUCTURE OF THE KIDNEY

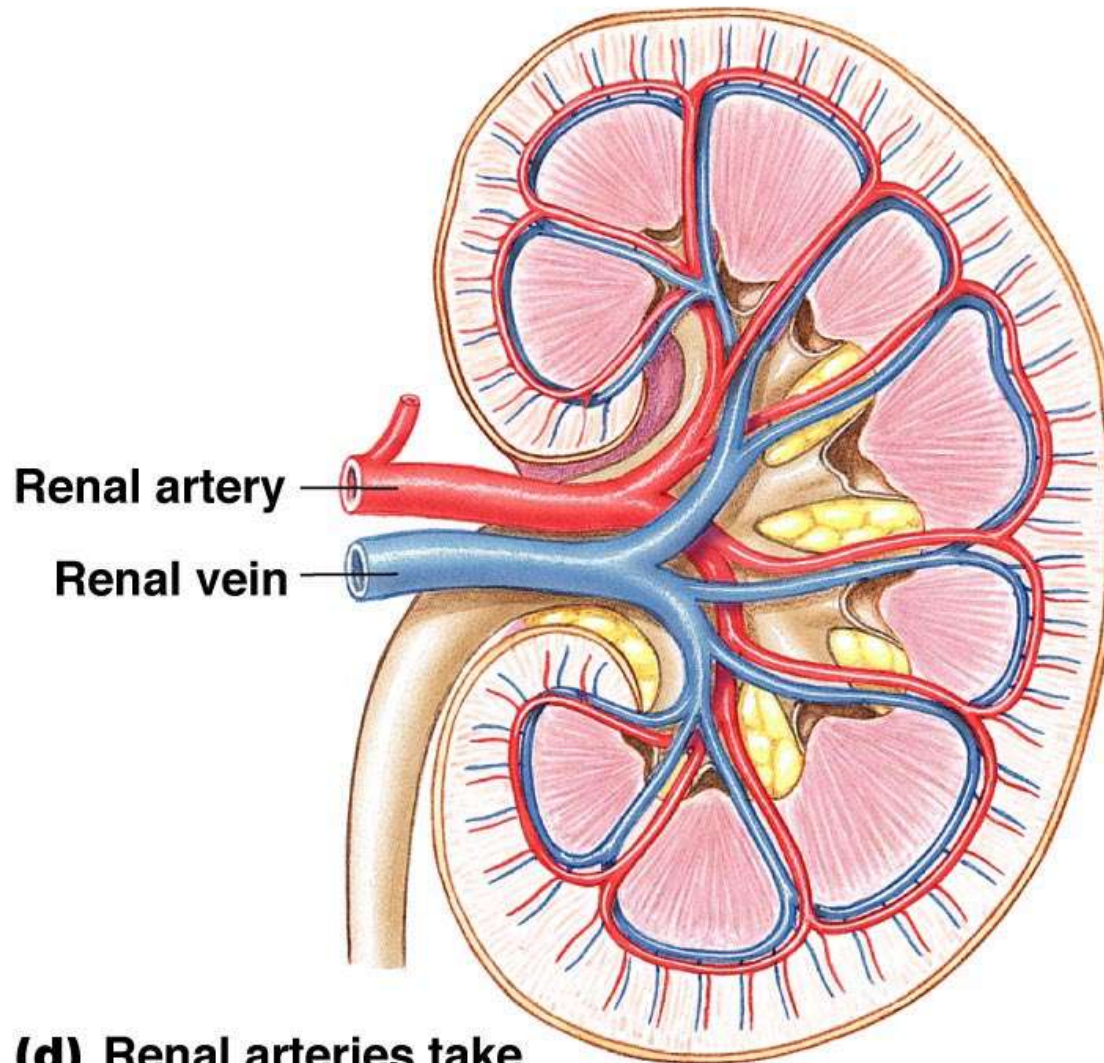


**(d)** Renal arteries take blood to the cortex.

**(e)** Afferent arterioles and glomeruli are all found in the cortex.

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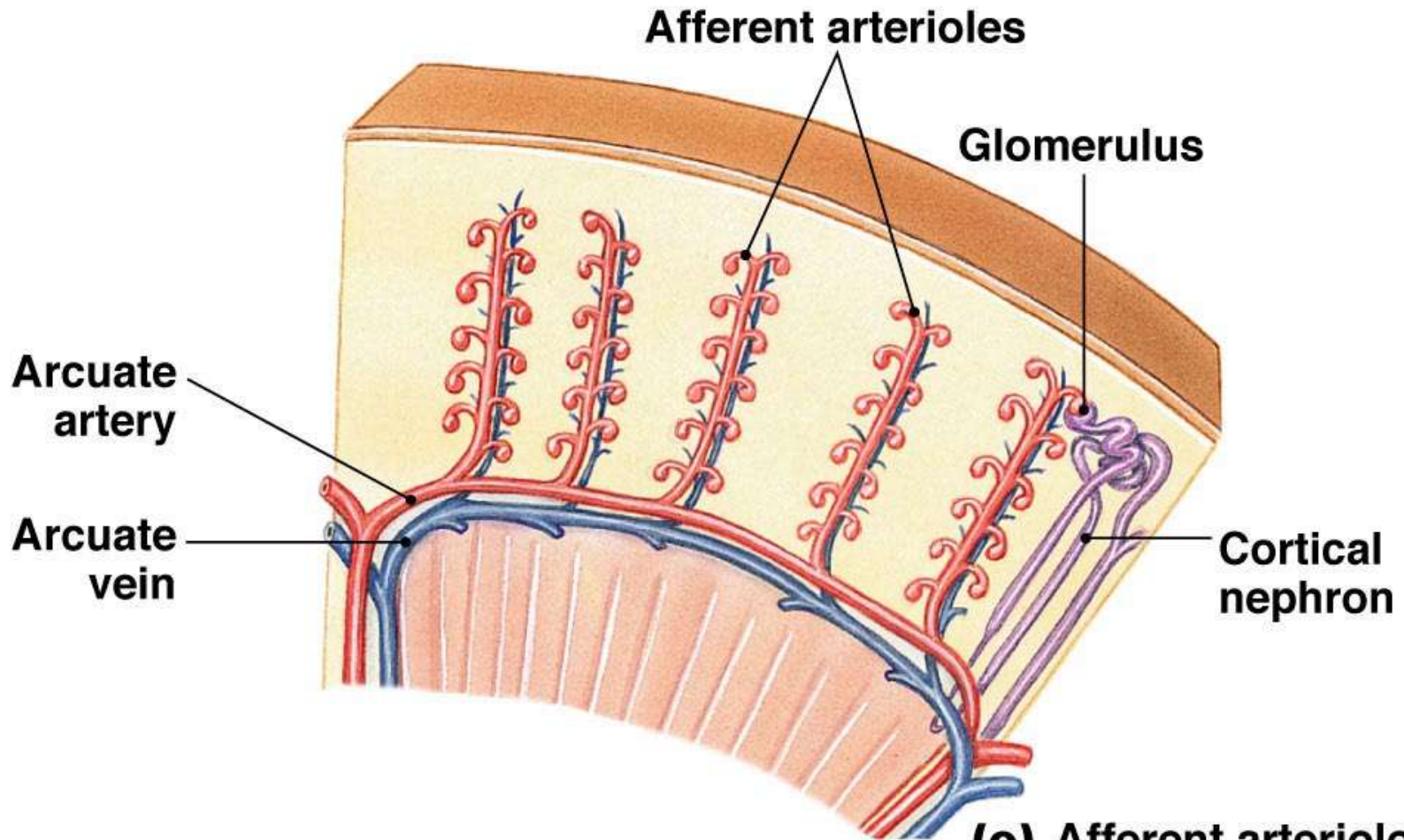
## STRUCTURE OF THE KIDNEY



**(d) Renal arteries take blood to the cortex.**

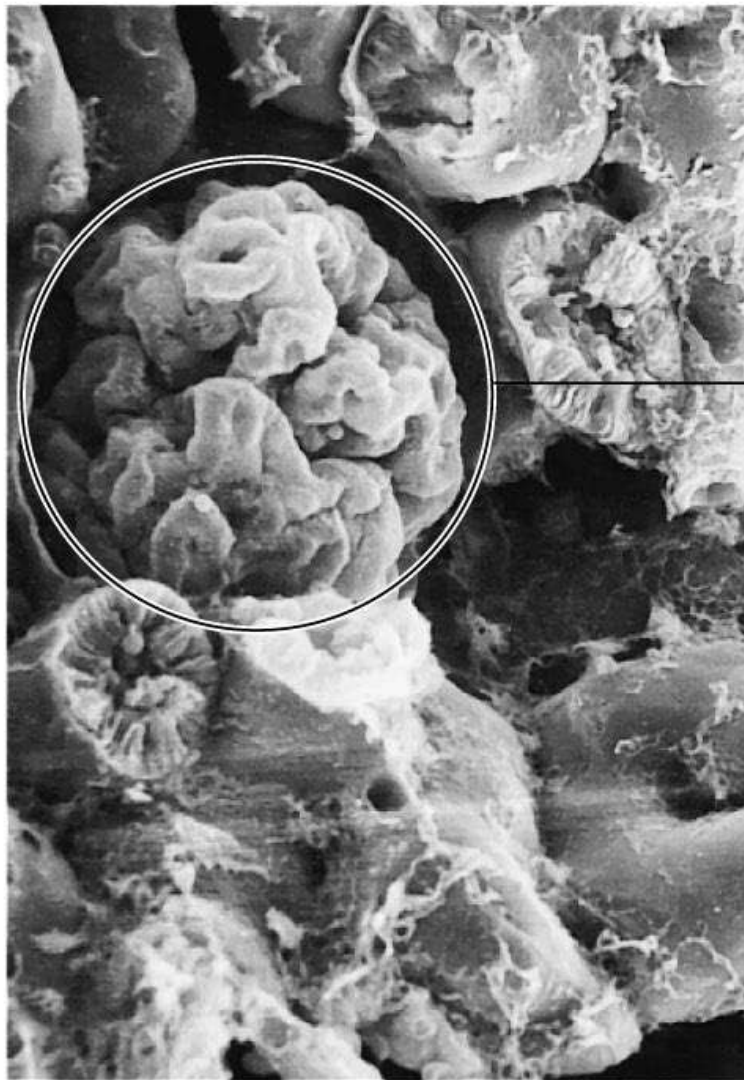
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## STRUCTURE OF THE KIDNEY



**(e) Afferent arterioles and glomeruli are all found in the cortex.**

**(f) The capillaries of the glomerulus form a ball-like mass.**

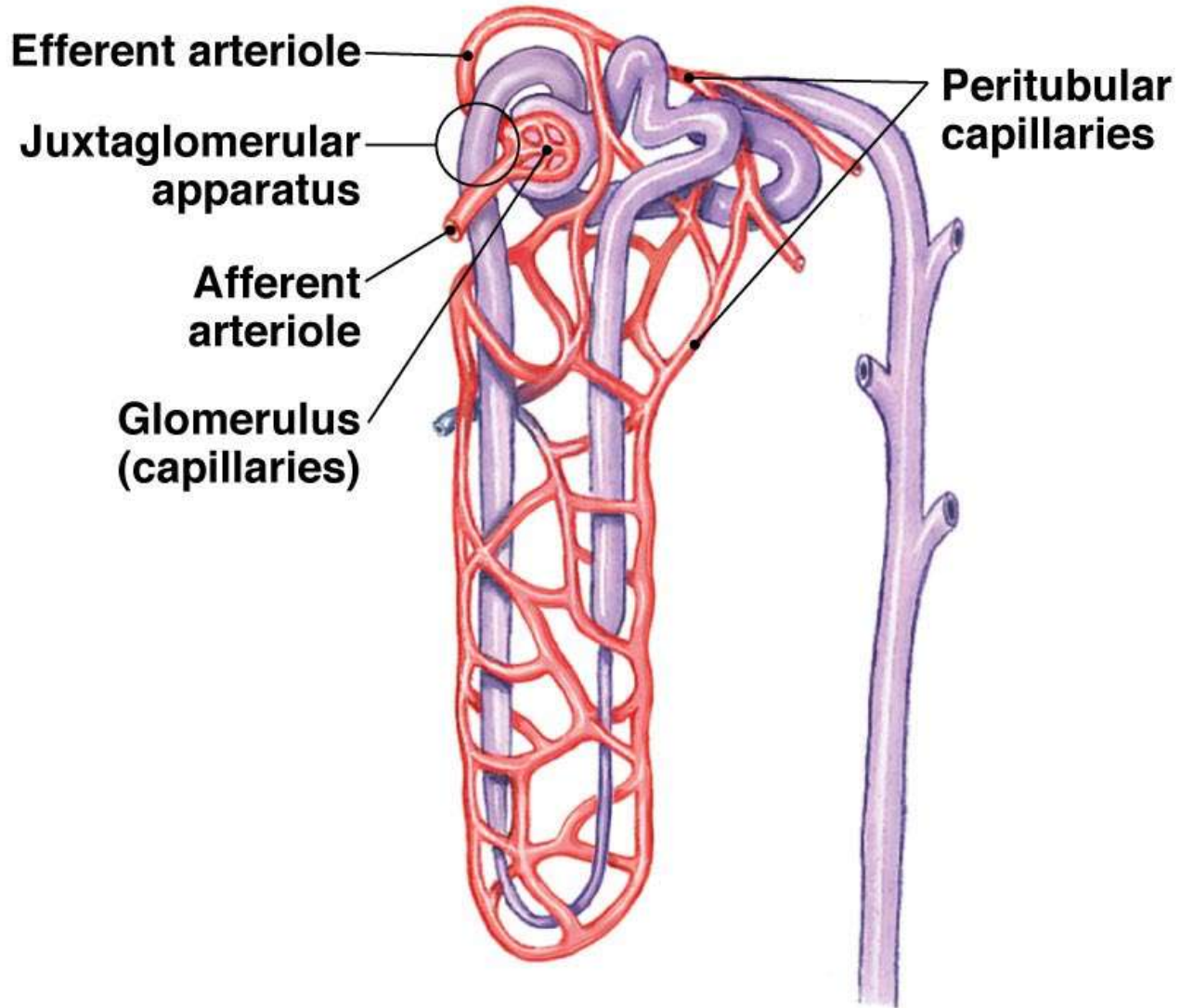


**Glomerulus**

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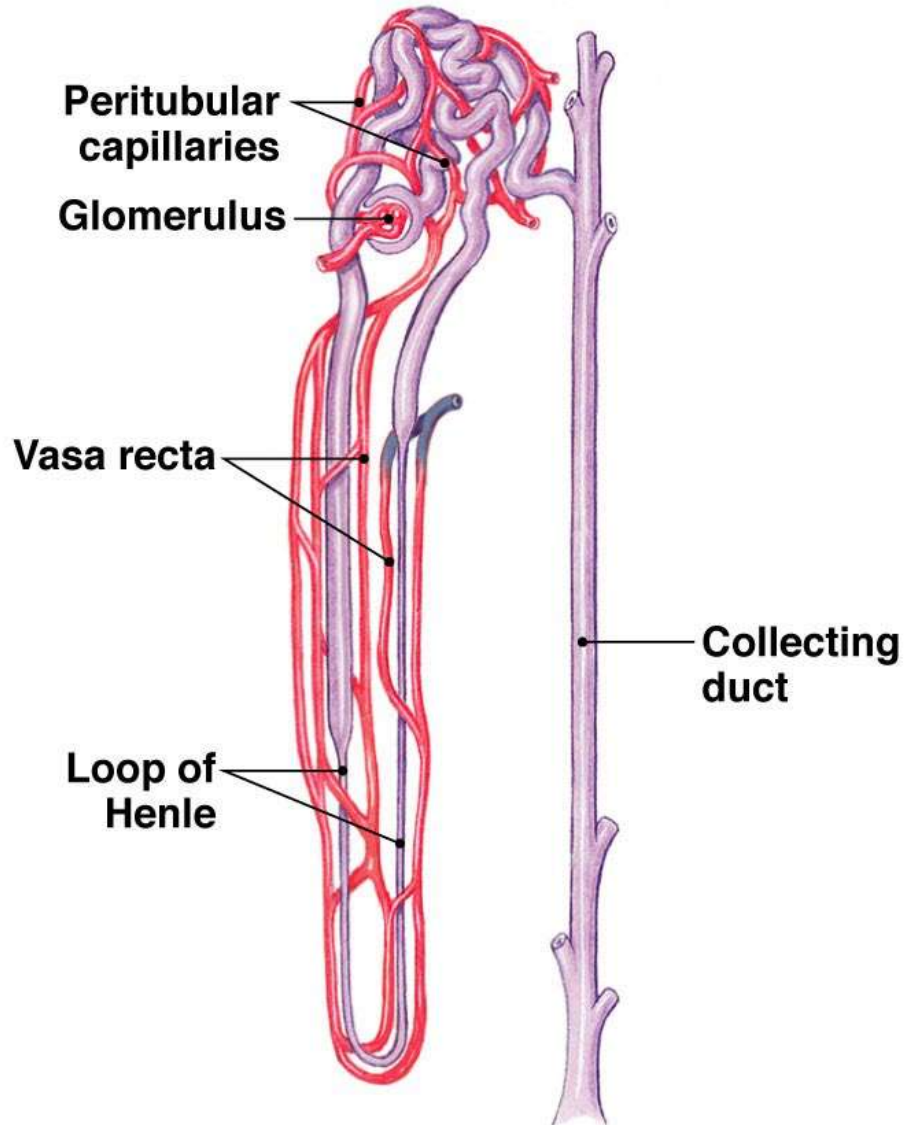
**Figure 19-1f**

**(g) Each nephron has two arterioles and two sets of capillaries associated with it.**

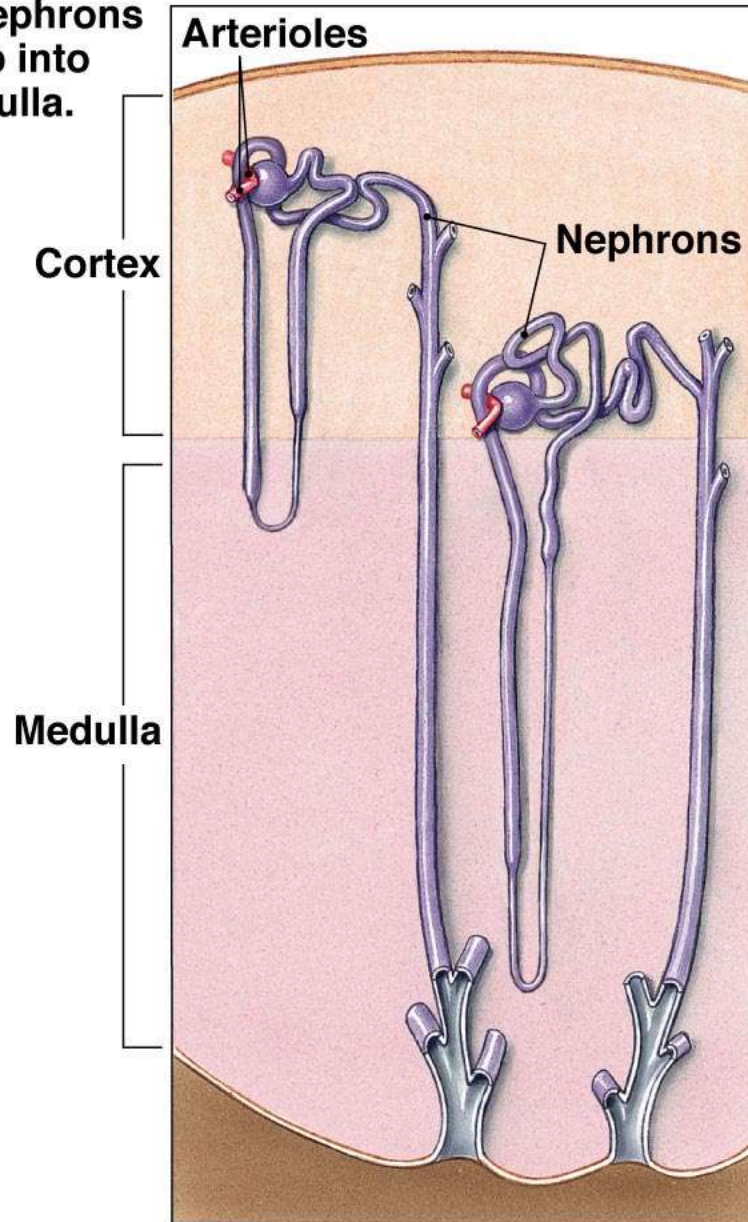


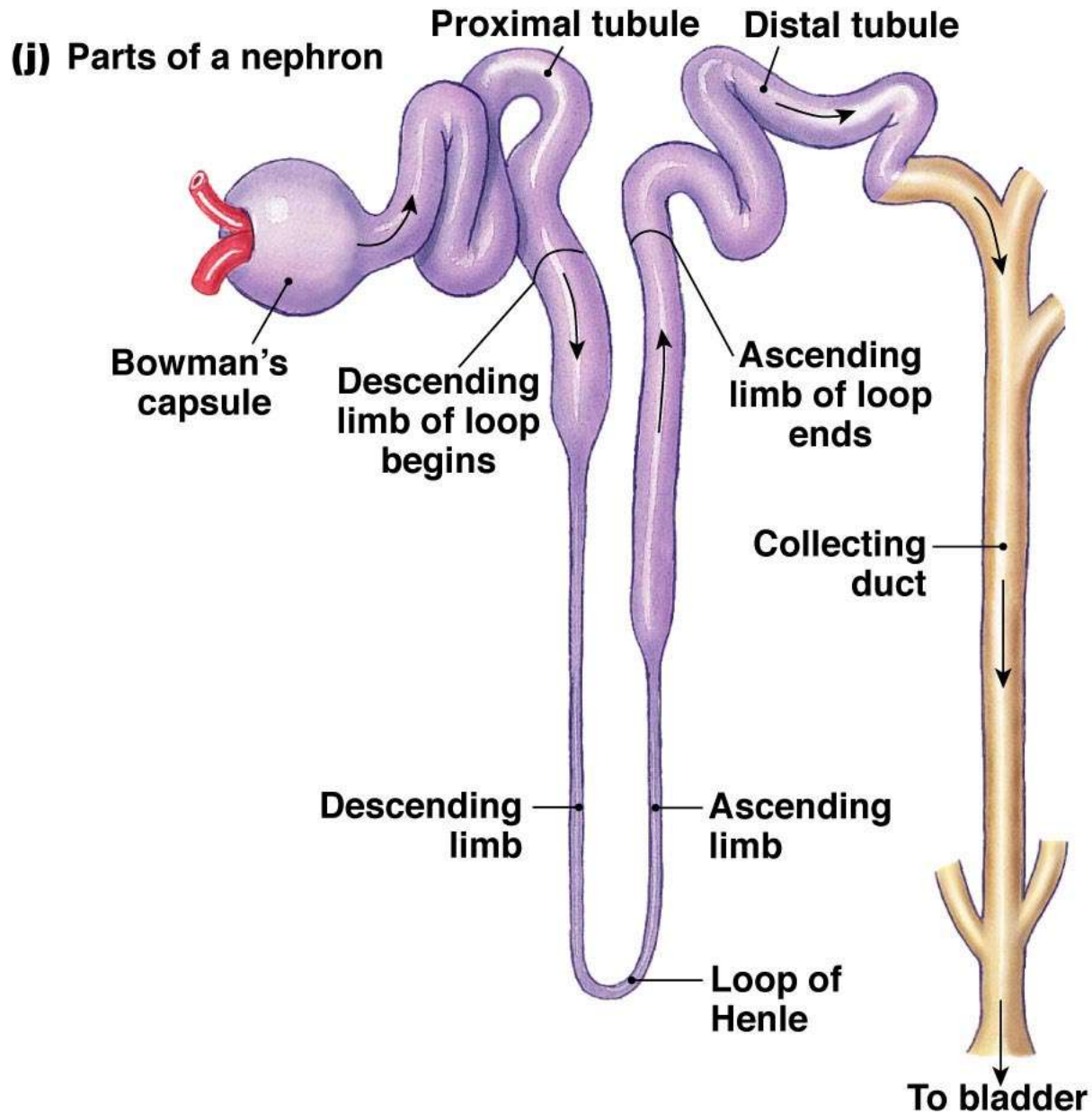


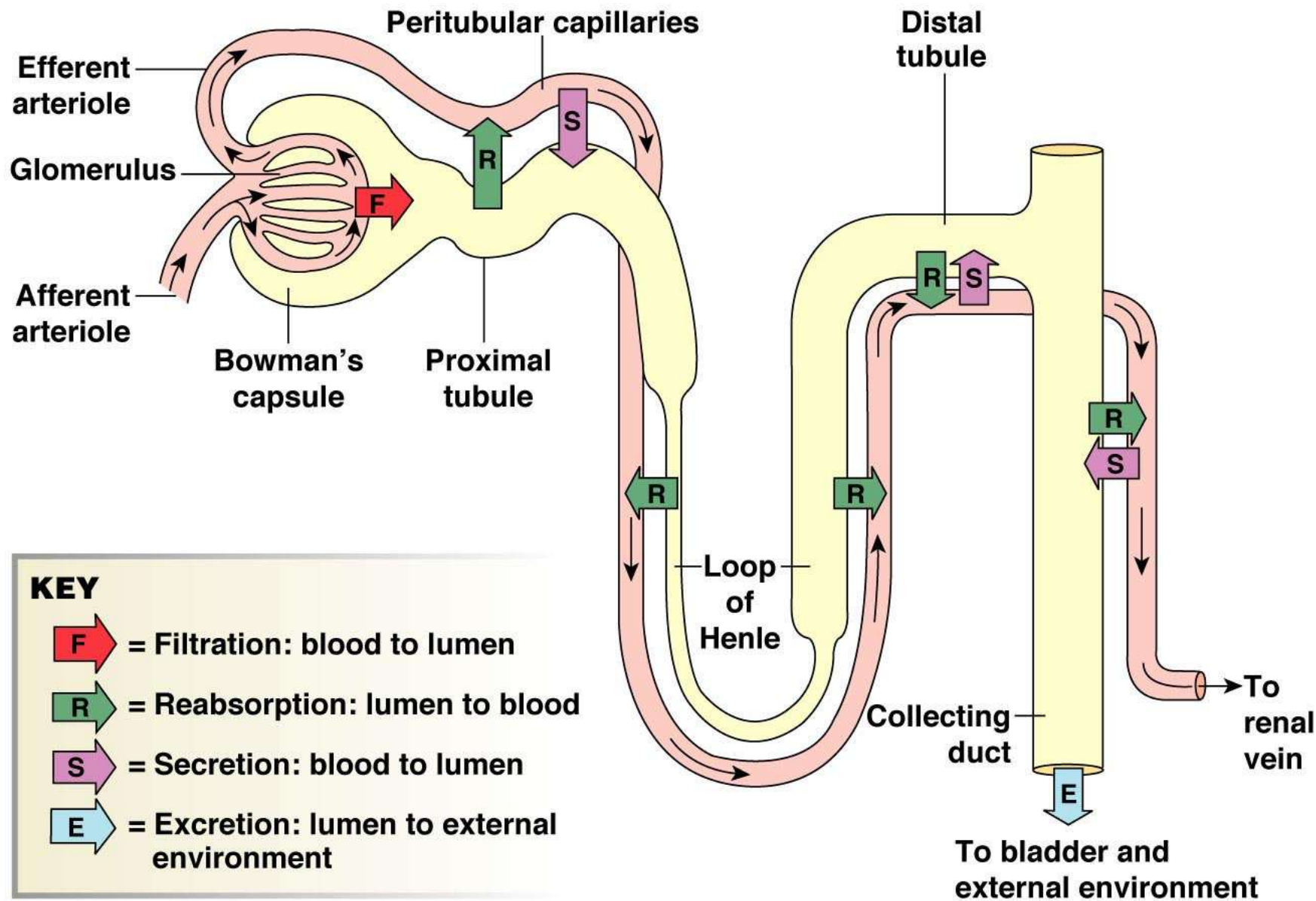
**(h) Juxtamedullary nephron  
with vasa recta**



**(i) Some nephrons dip deep into the medulla.**





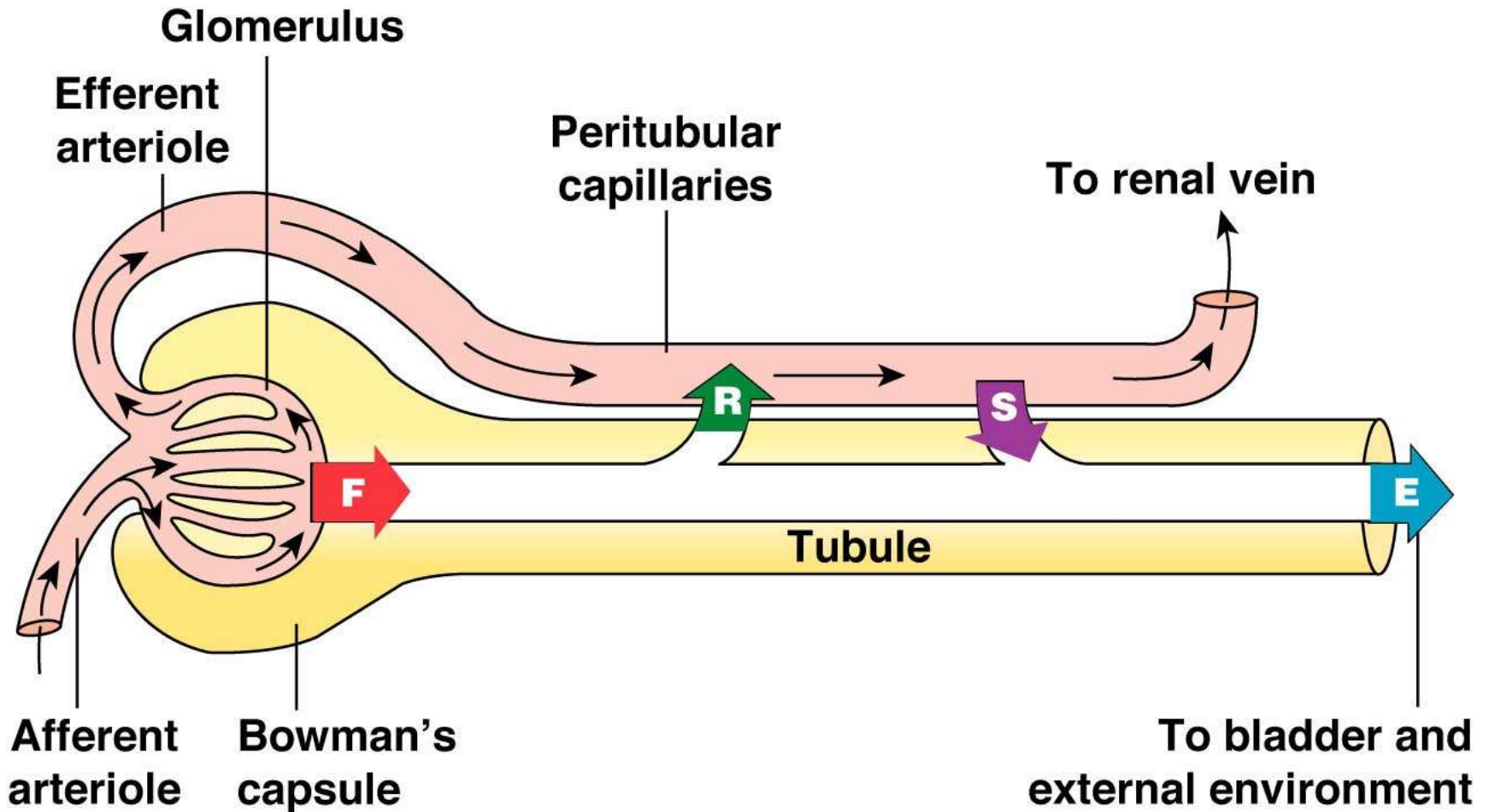


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Figure 19-2

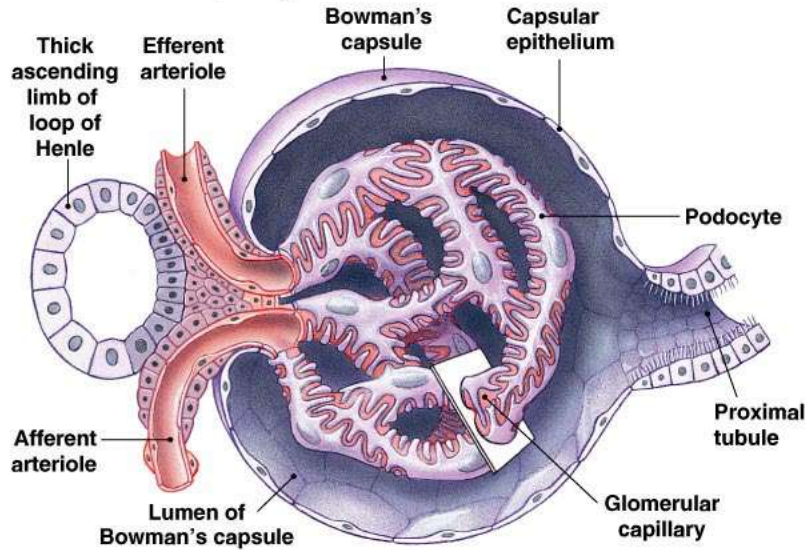
**TABLE 19-1****Changes in Filtrate Volume and Osmolarity Along the Nephron**

<b>LOCATION IN NEPHRON</b>	<b>VOLUME OF FLUID</b>	<b>OSMOLARITY OF FLUID</b>
Bowman's capsule	180 L/day	300 mOsM
End of proximal tubule	54 L/day	300 mOsM
End of loop of Henle	18 L/day	100 mOsM
End of collecting duct (final urine)	1.5 L/day (average)	50–1200 mOsM

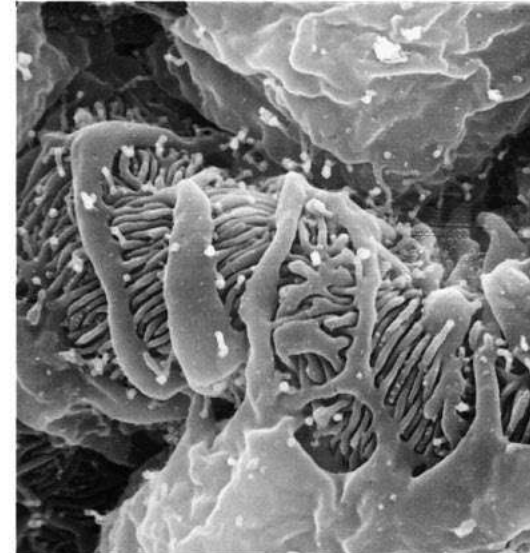


Amount filtered	-	amount reabsorbed	+	amount secreted	=	Amount of solute excreted
<b>F</b>		<b>R</b>		<b>S</b>		<b>E</b>

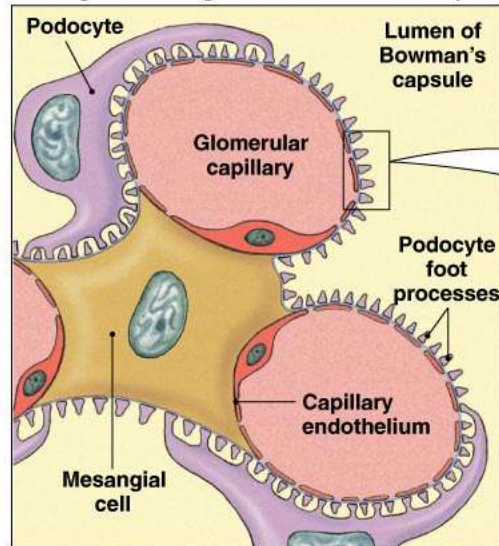
**(a) The epithelium around glomerular capillaries is modified into podocytes.**



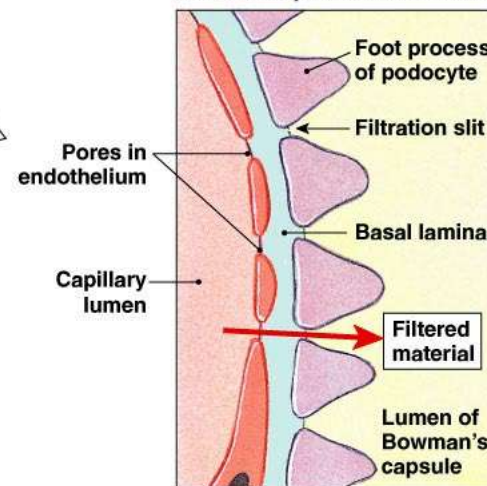
**(b) Micrograph showing podocyte foot processes around glomerular capillary.**



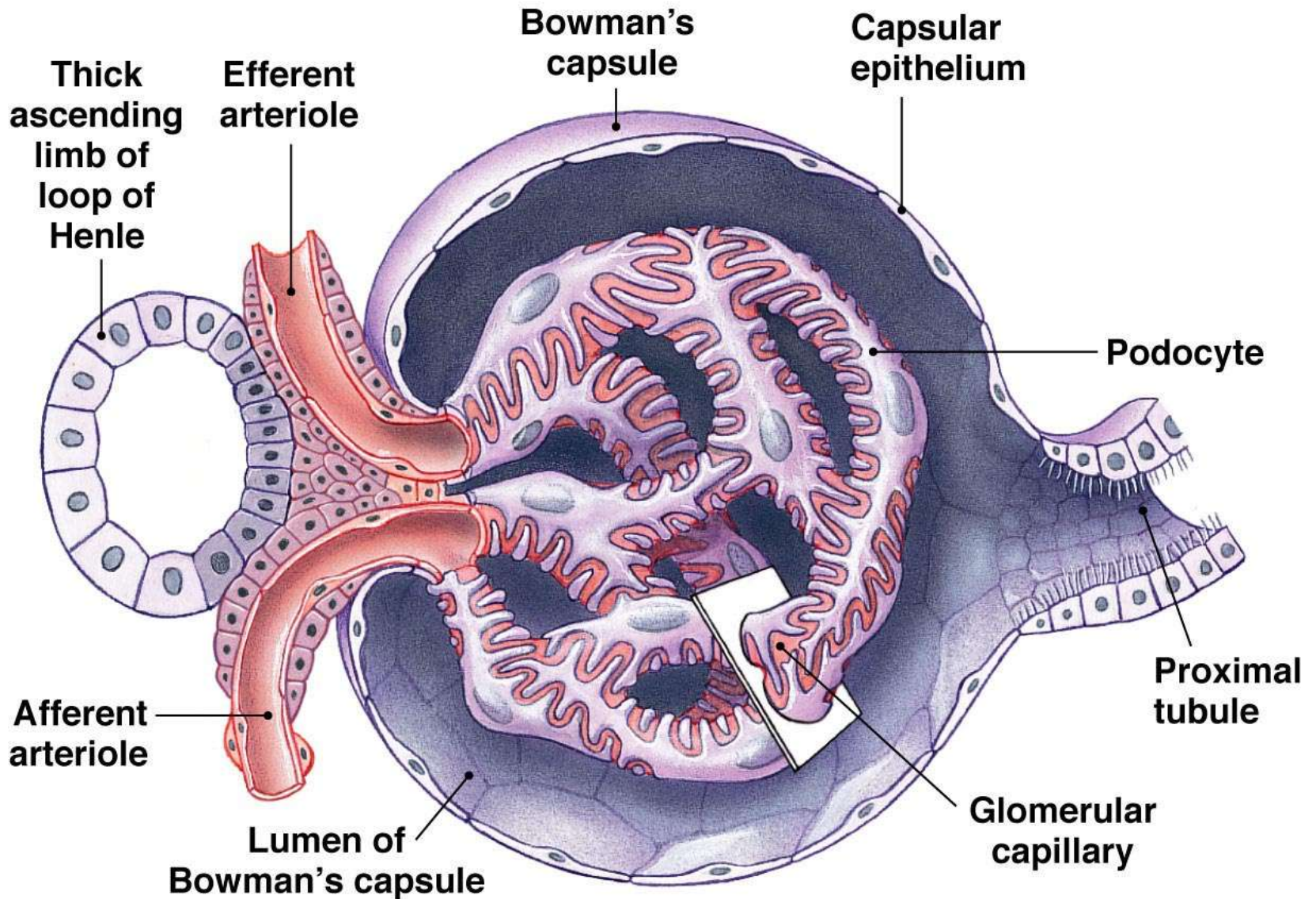
**(c) Podocyte foot processes surround each capillary, leaving slits through which filtration takes place.**



**(d) Filtered substances pass through endothelial pores and filtration slits.**



**(a)** The epithelium around glomerular capillaries is modified into podocytes.

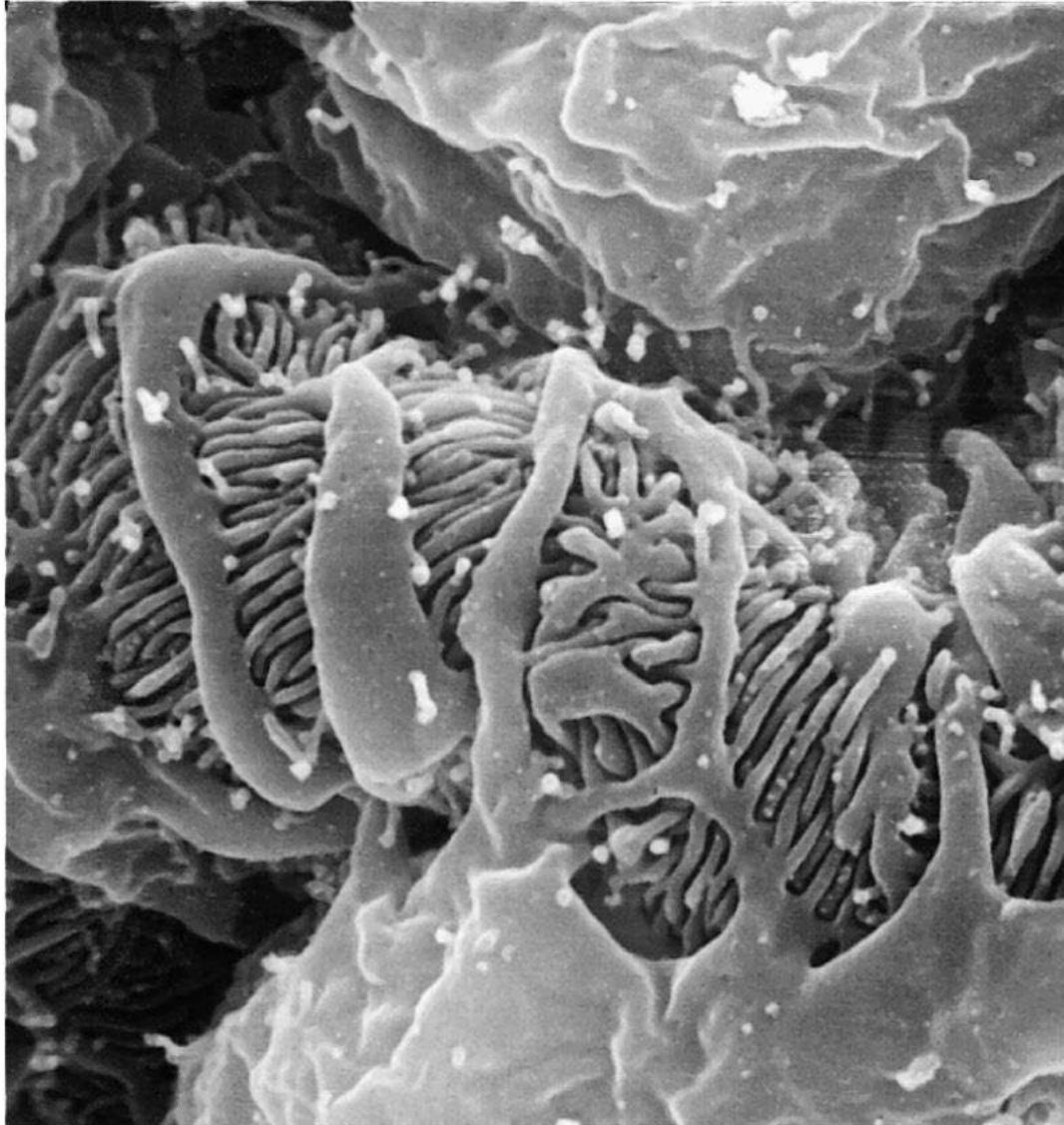


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Figure 19-4a



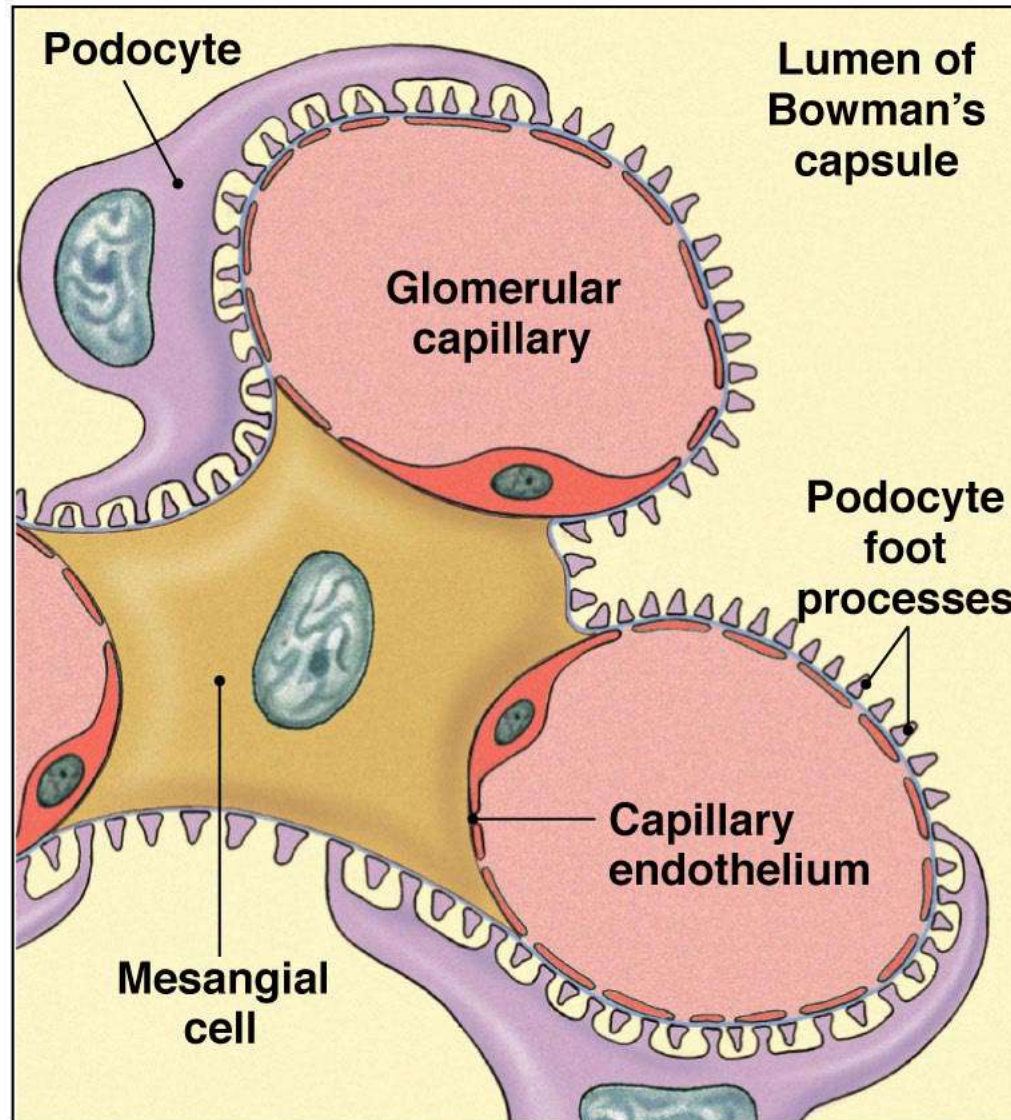
**(b)** Micrograph showing podocyte foot processes around glomerular capillary.



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**Figure 19-4b**

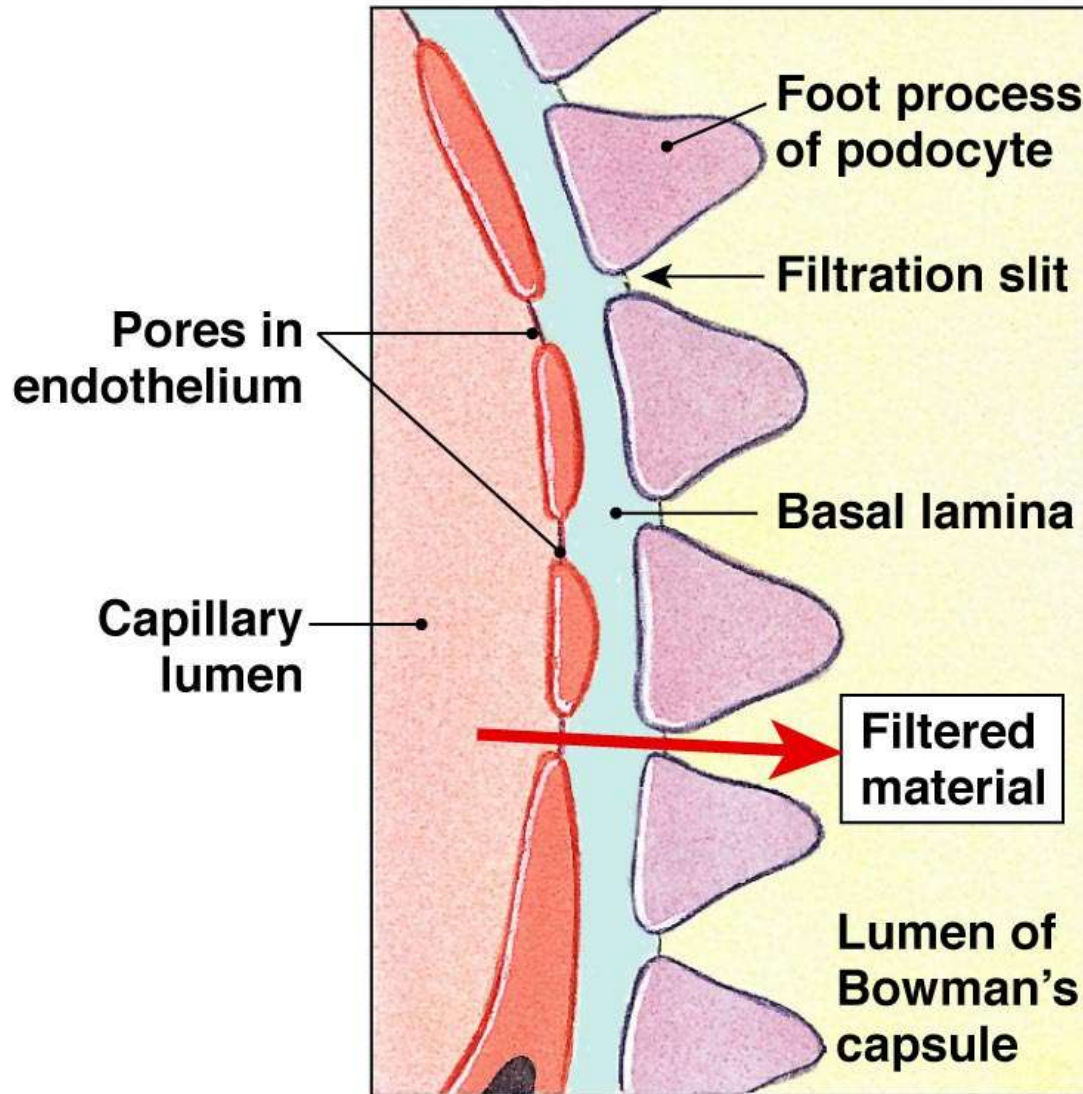
**(c)** Podocyte foot processes surround each capillary, leaving slits through which filtration takes place.

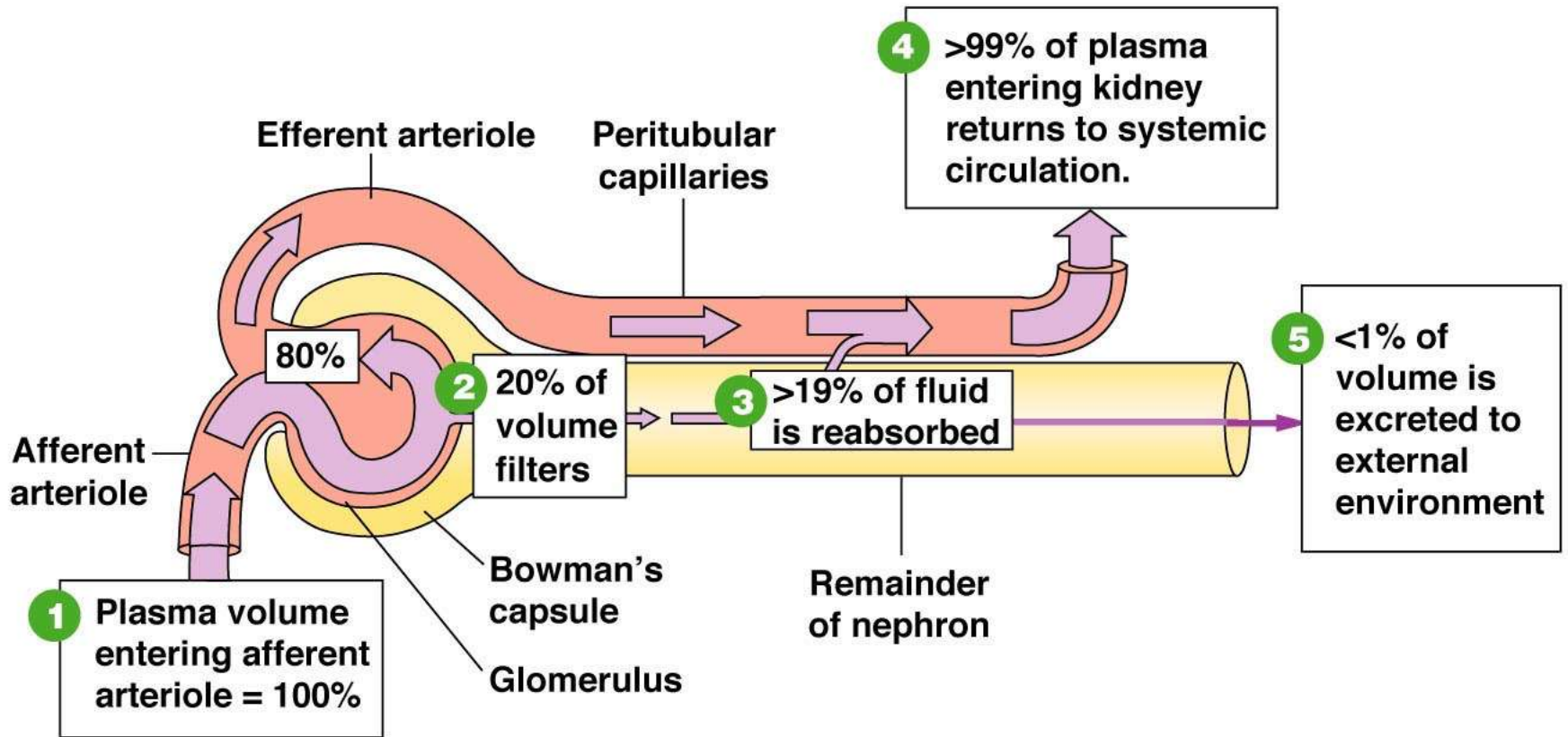


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Figure 19-4c

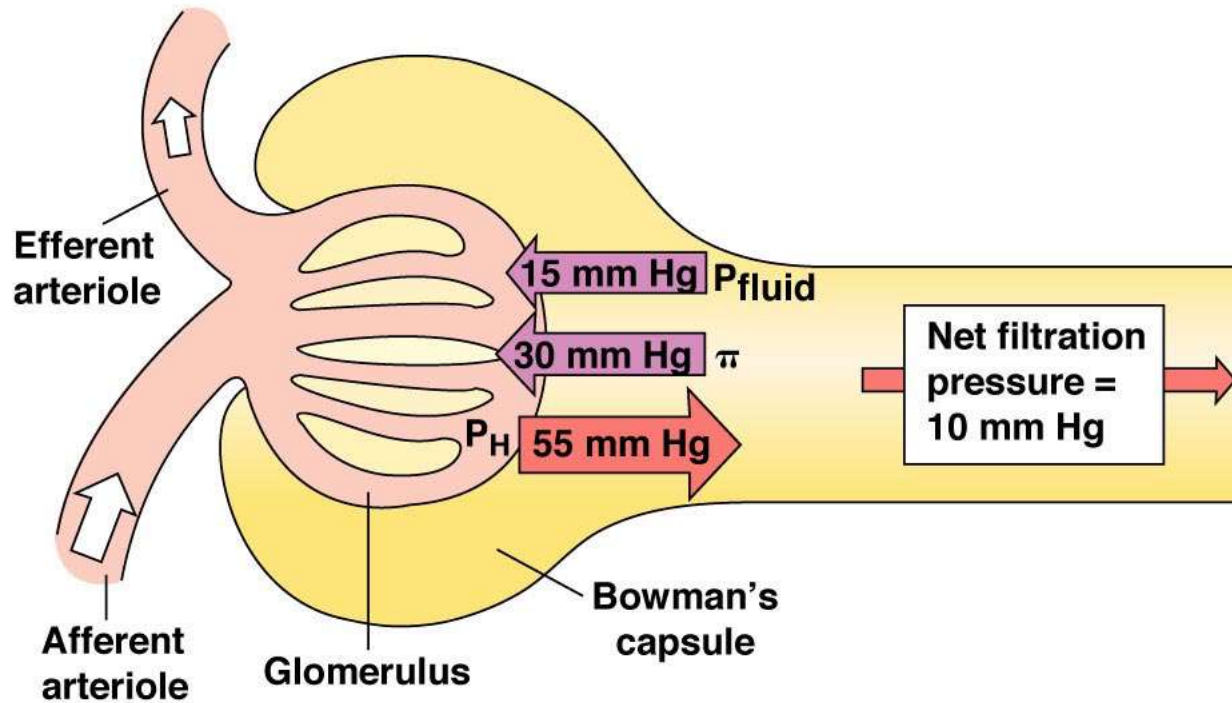
**(d)** Filtered substances pass through endothelial pores and filtration slits.





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Figure 19-5



$$P_H - \pi - P_{\text{fluid}} = \text{net filtration pressure}$$

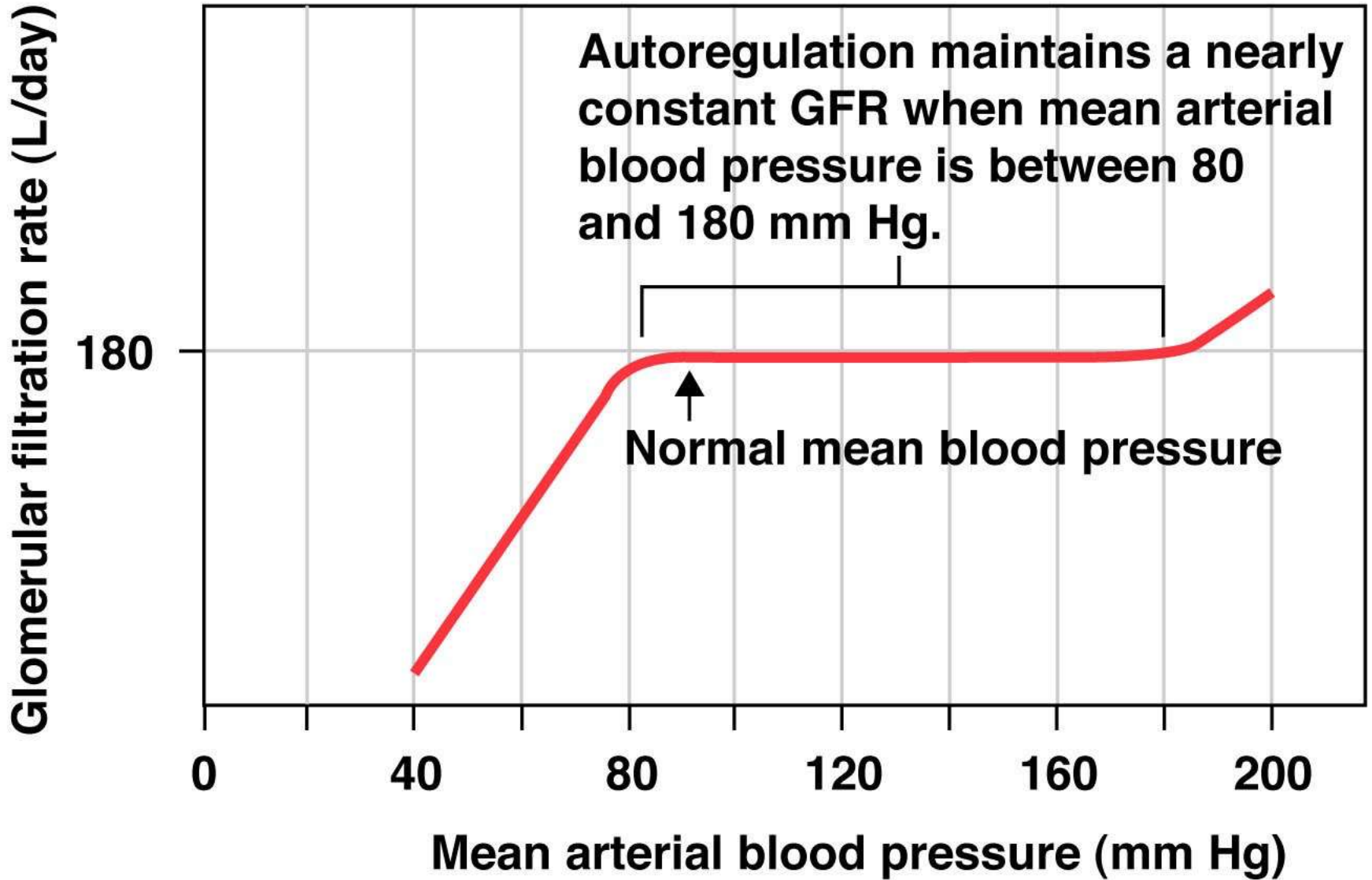
$$55 \text{ mm Hg} - 30 \text{ mm Hg} - 15 \text{ mm Hg} = 10 \text{ mm Hg}$$

### KEY

$P_H$  = Hydrostatic pressure (blood pressure)

$\pi$  = Colloid osmotic pressure gradient due to proteins in plasma but not in Bowman's capsule

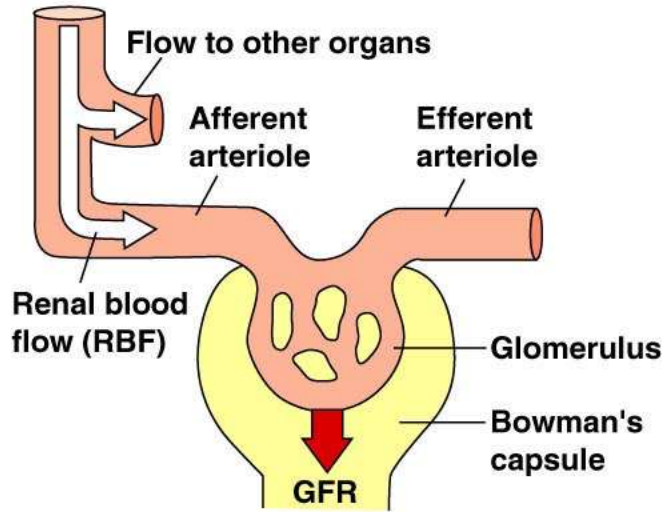
$P_{\text{fluid}}$  = Fluid pressure created by fluid in Bowman's capsule



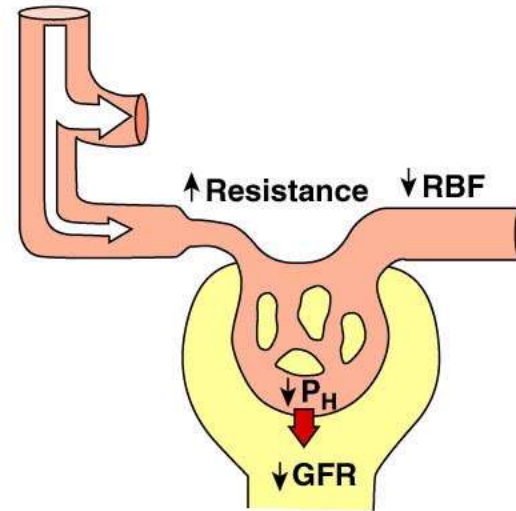
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Figure 19-7

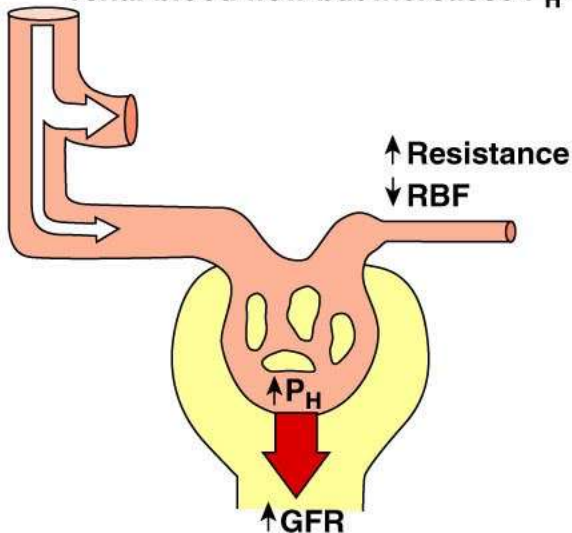
**(a)** Renal blood flow and GFR change if resistance in the arterioles changes.



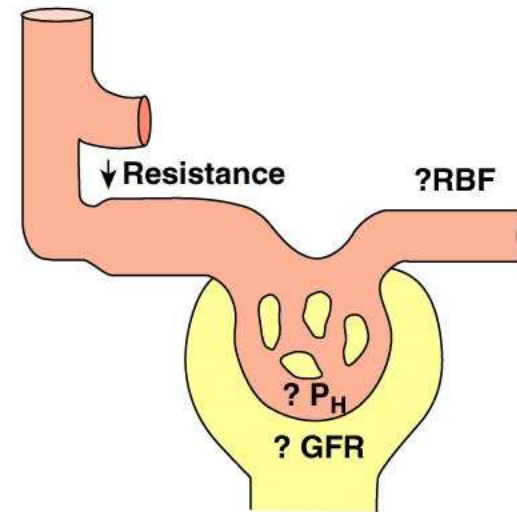
**(b)** Vasoconstriction of the afferent arteriole increases resistance and decreases renal blood flow, capillary blood pressure ( $P_H$ ), and GFR.



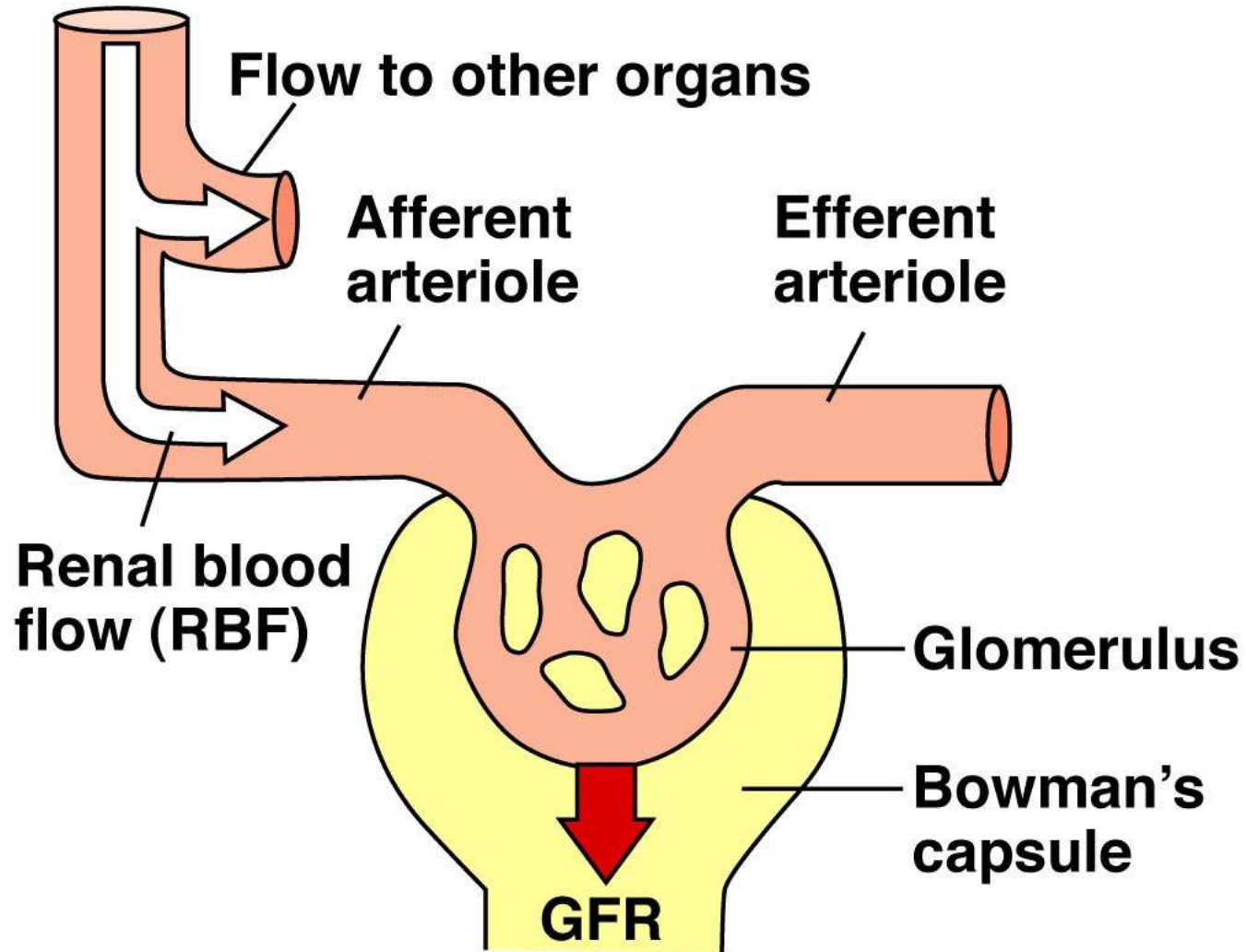
**(c)** Increased resistance of efferent arteriole decreases renal blood flow but increases  $P_H$  and GFR.



**(d)**

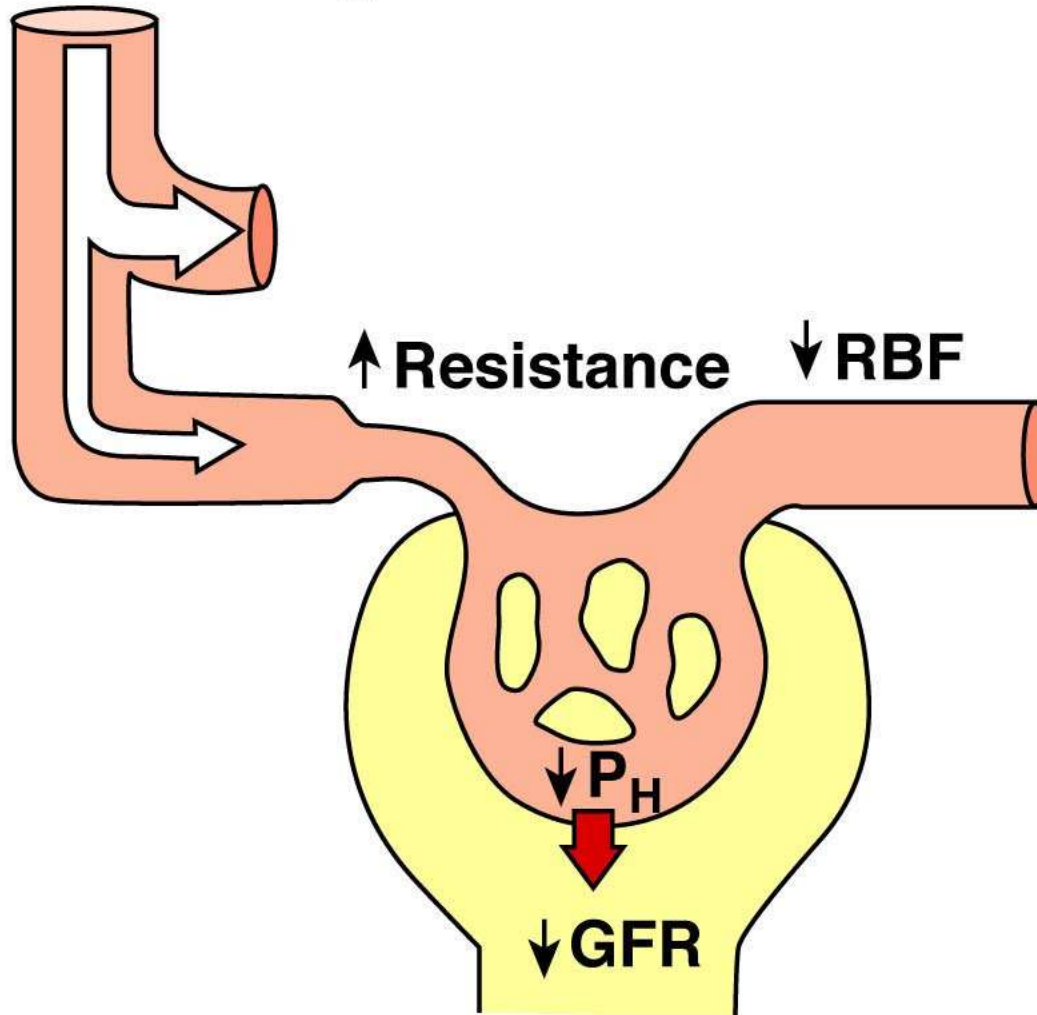


**(a) Renal blood flow and GFR change if resistance in the arterioles changes.**

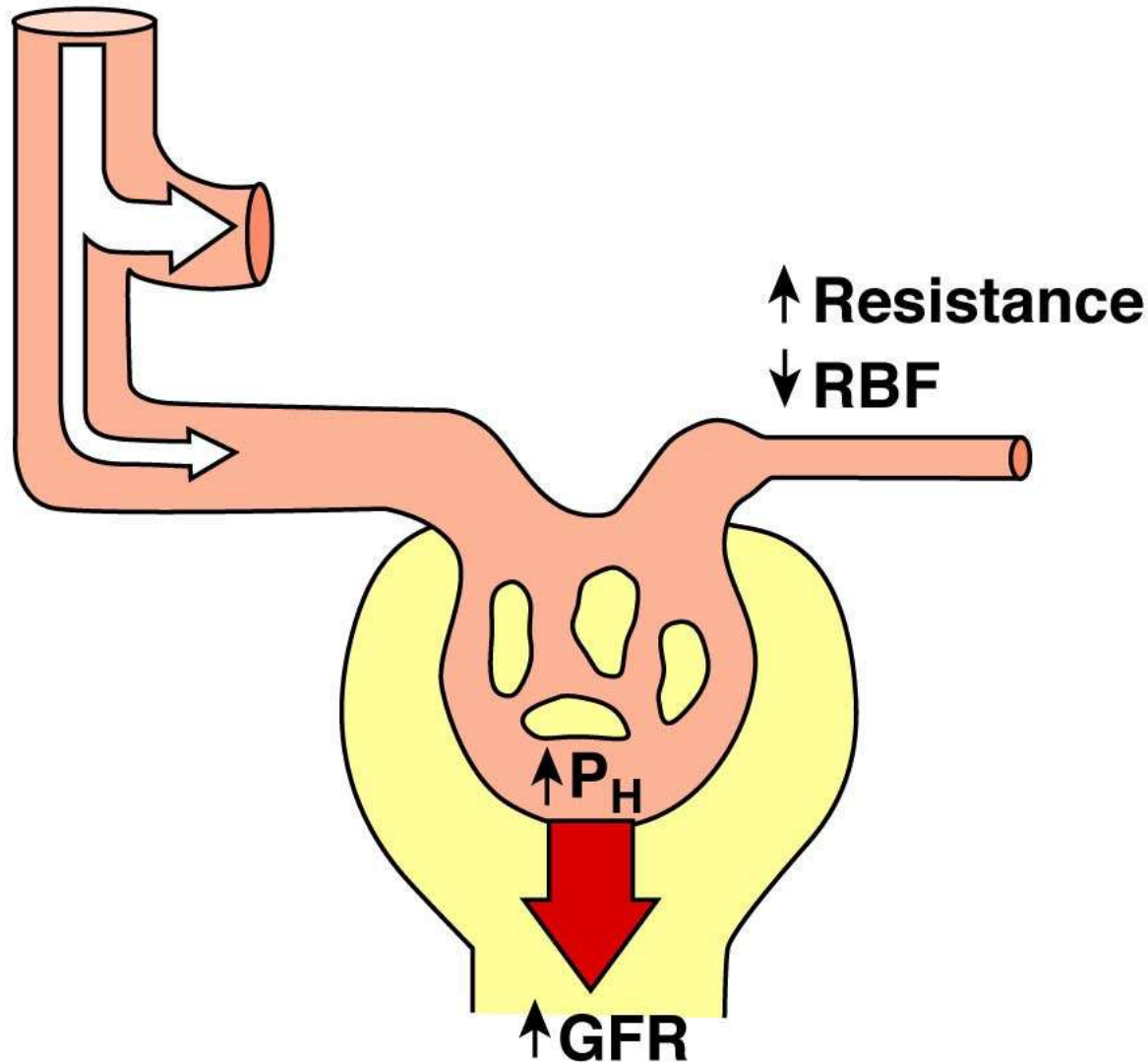




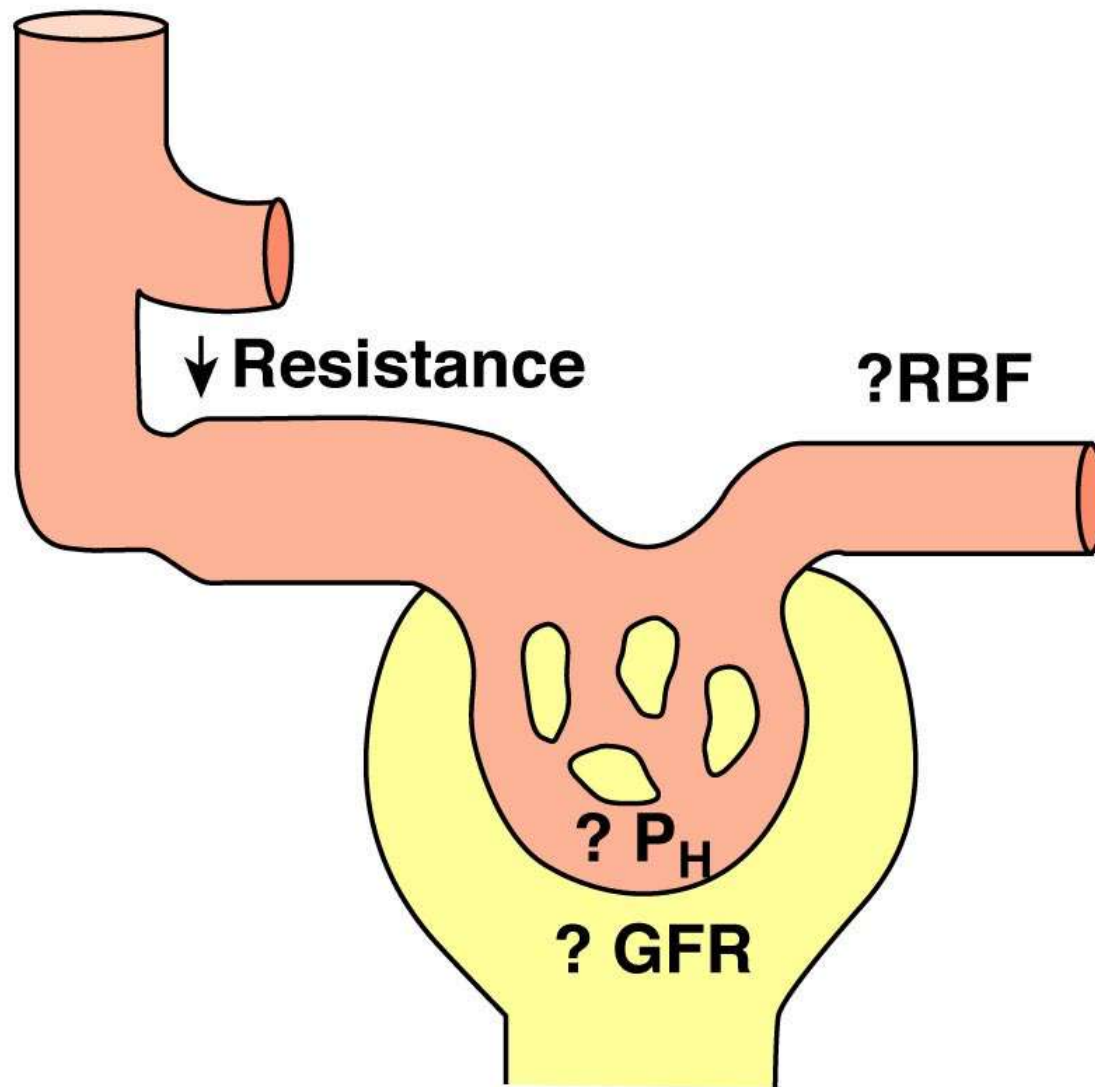
**(b) Vasoconstriction of the afferent arteriole increases resistance and decreases renal blood flow, capillary blood pressure ( $P_H$ ), and GFR.**

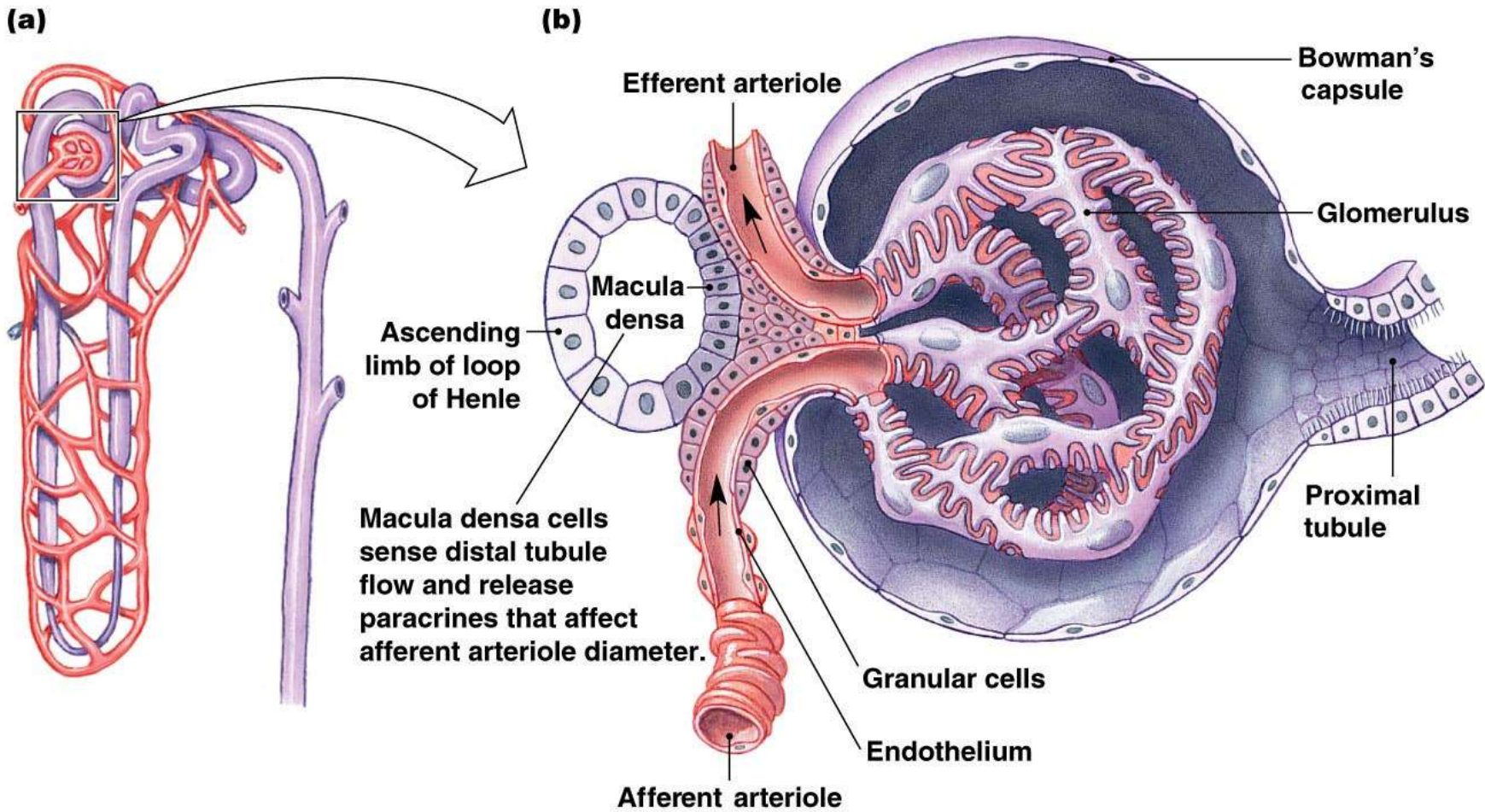


**(c) Increased resistance of efferent arteriole decreases renal blood flow but increases  $P_H$  and GFR.**



**(d)**

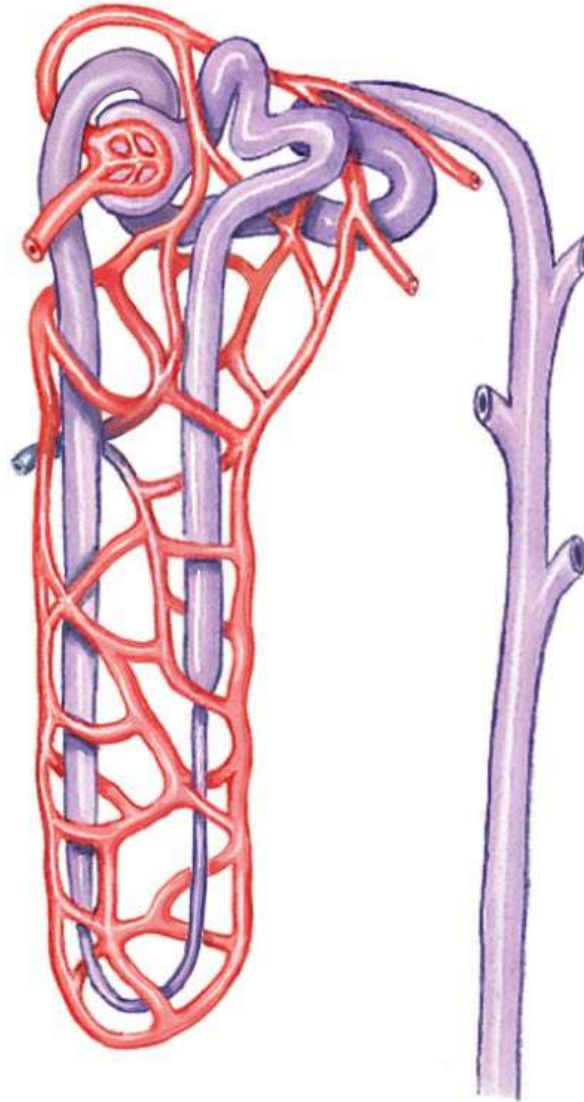




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Figure 19-9 - Overview

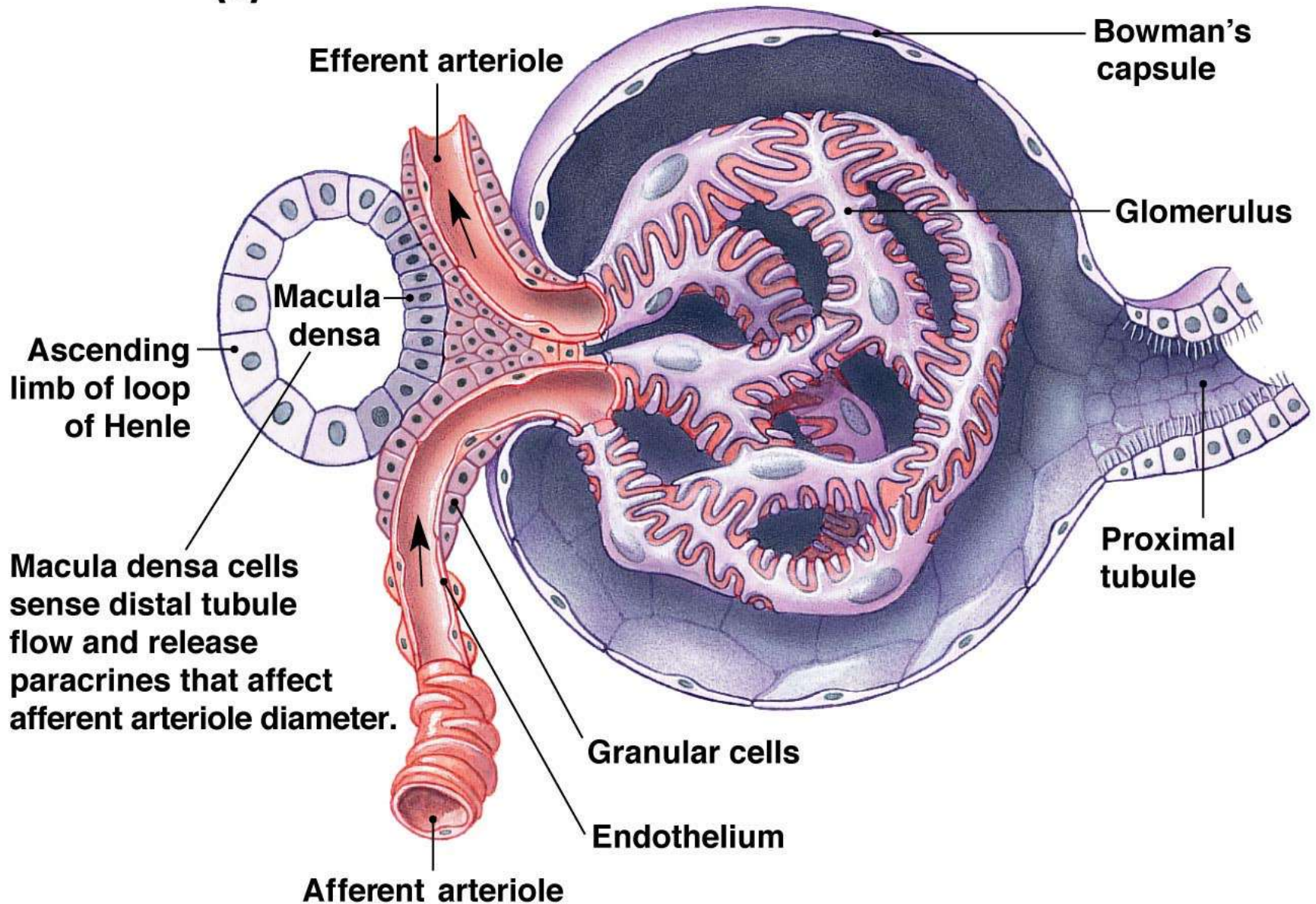
**(a)**



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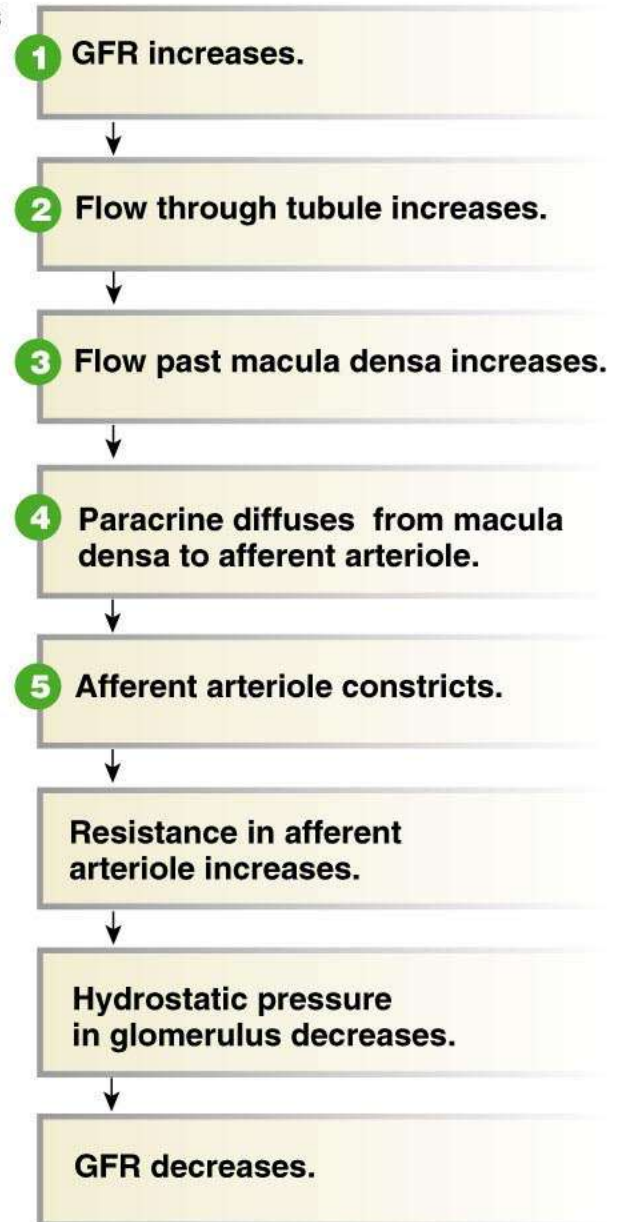
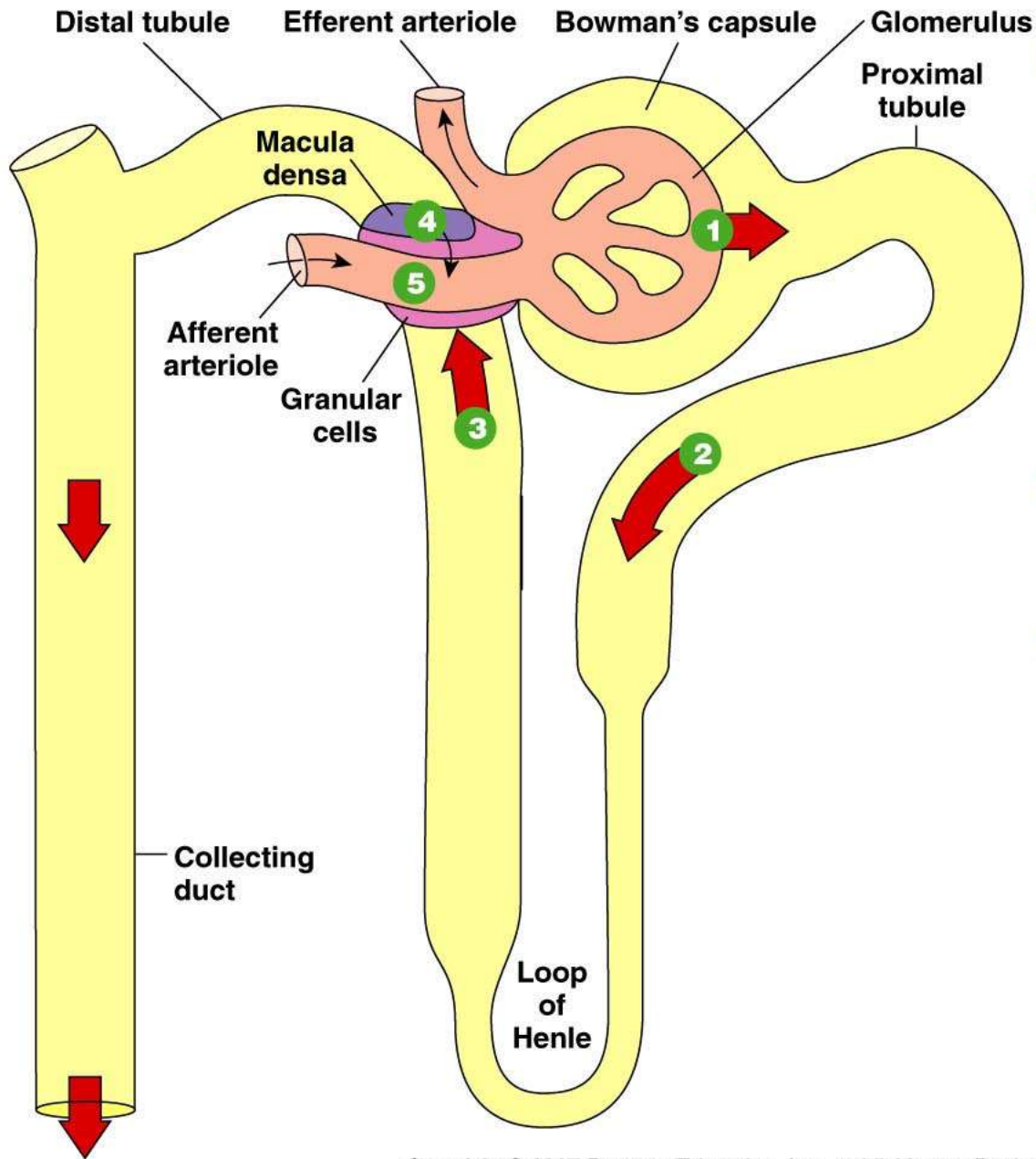
**Figure 19-9a**

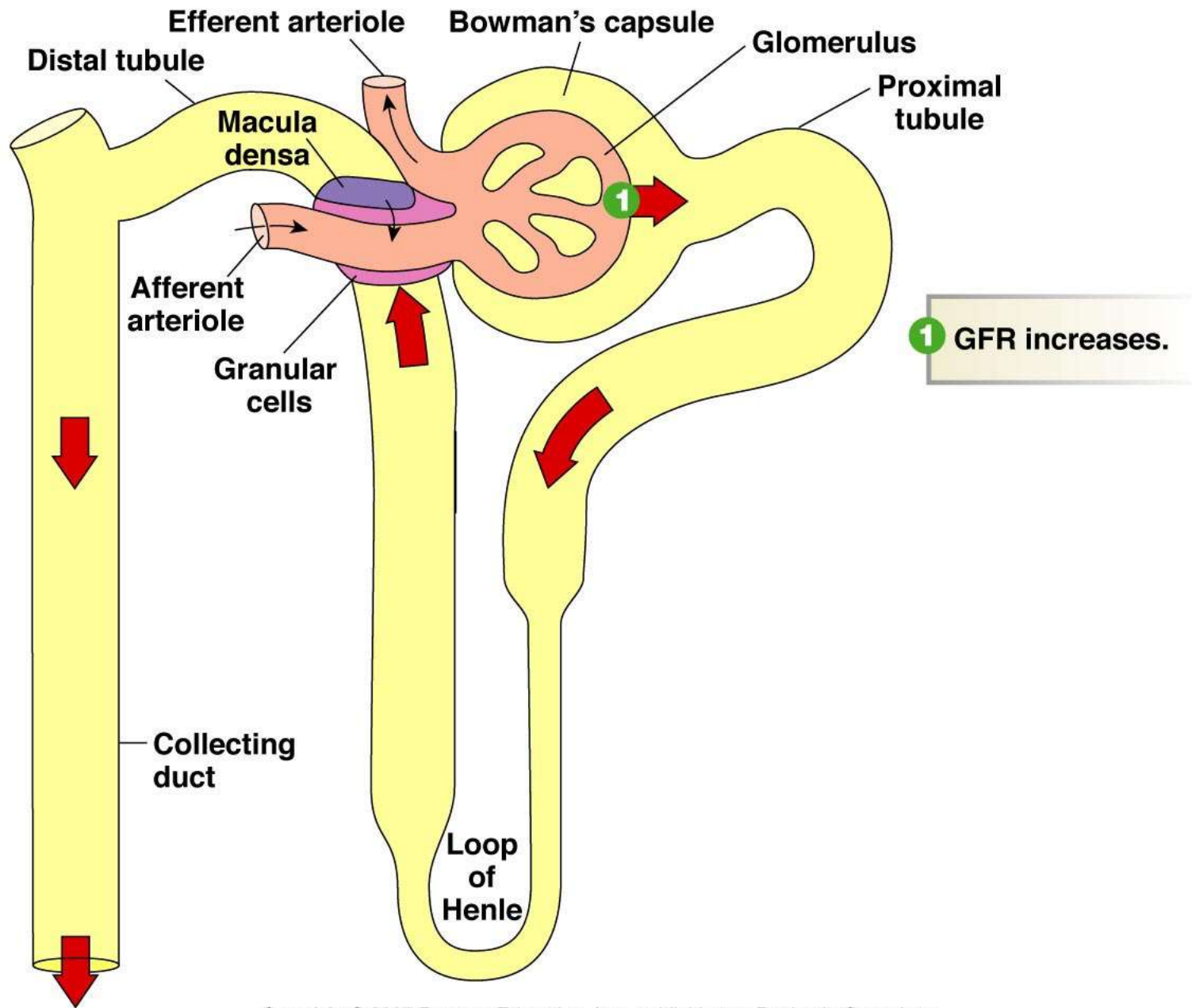
**(b)**



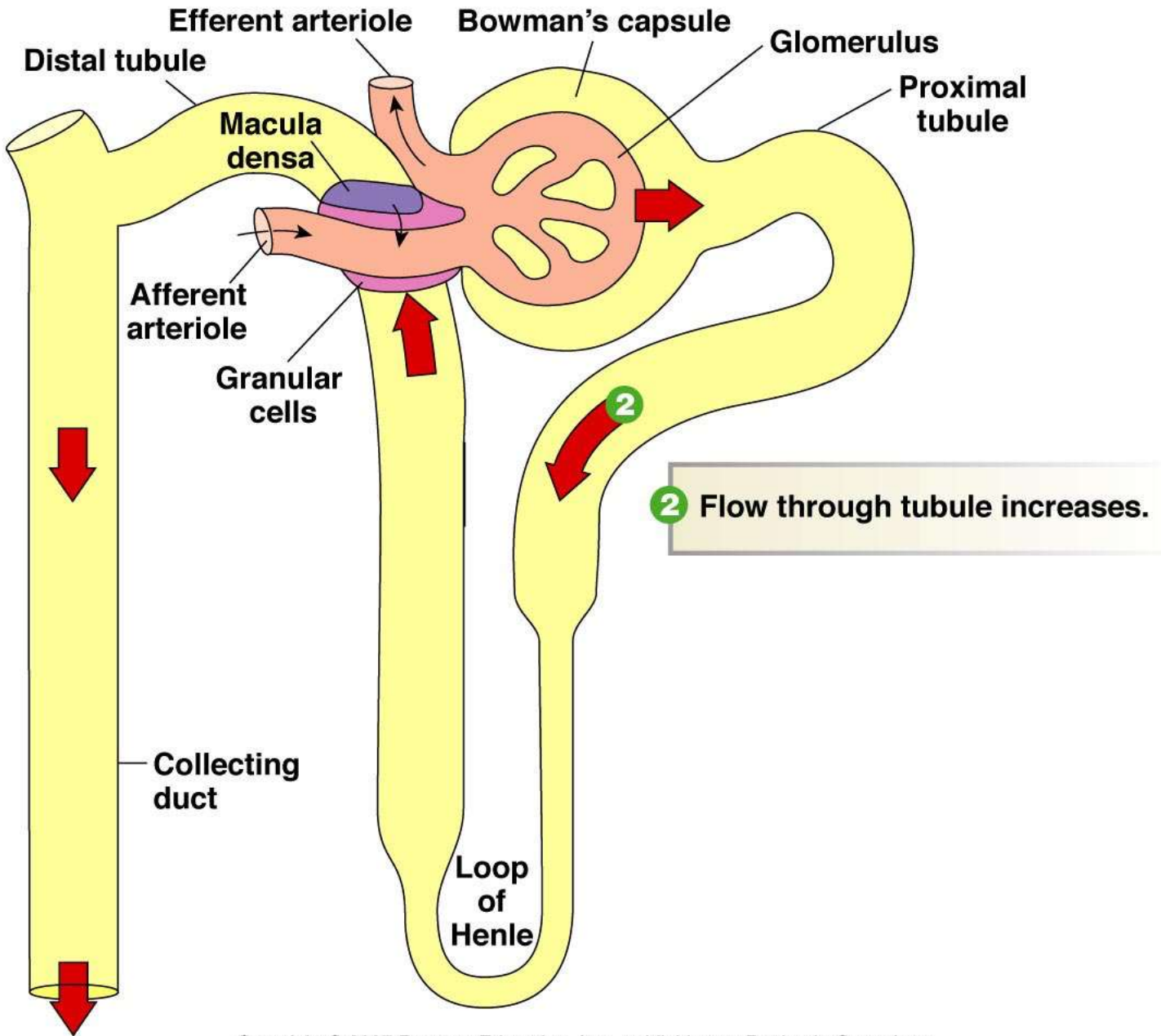
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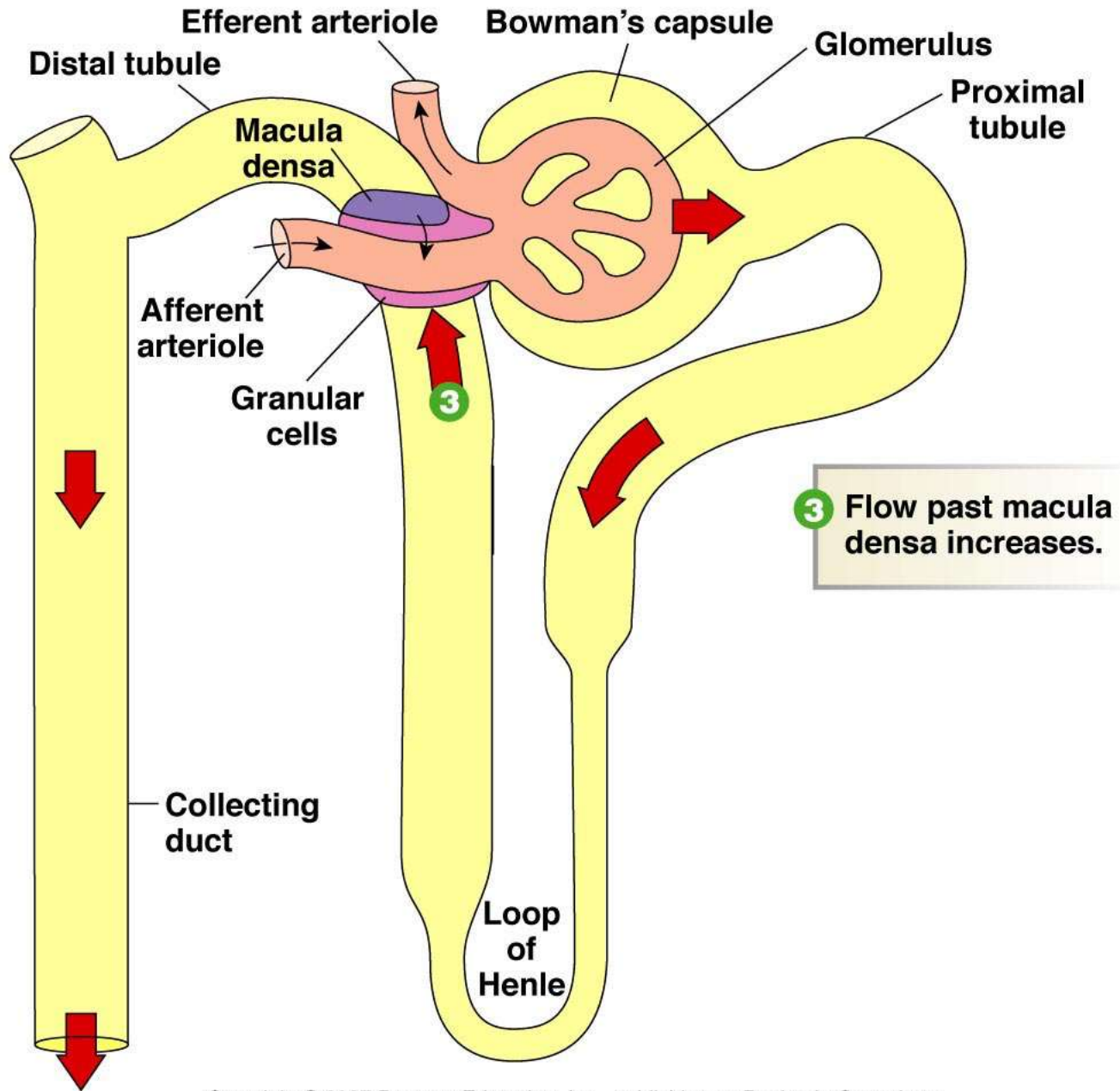
Figure 19-9b

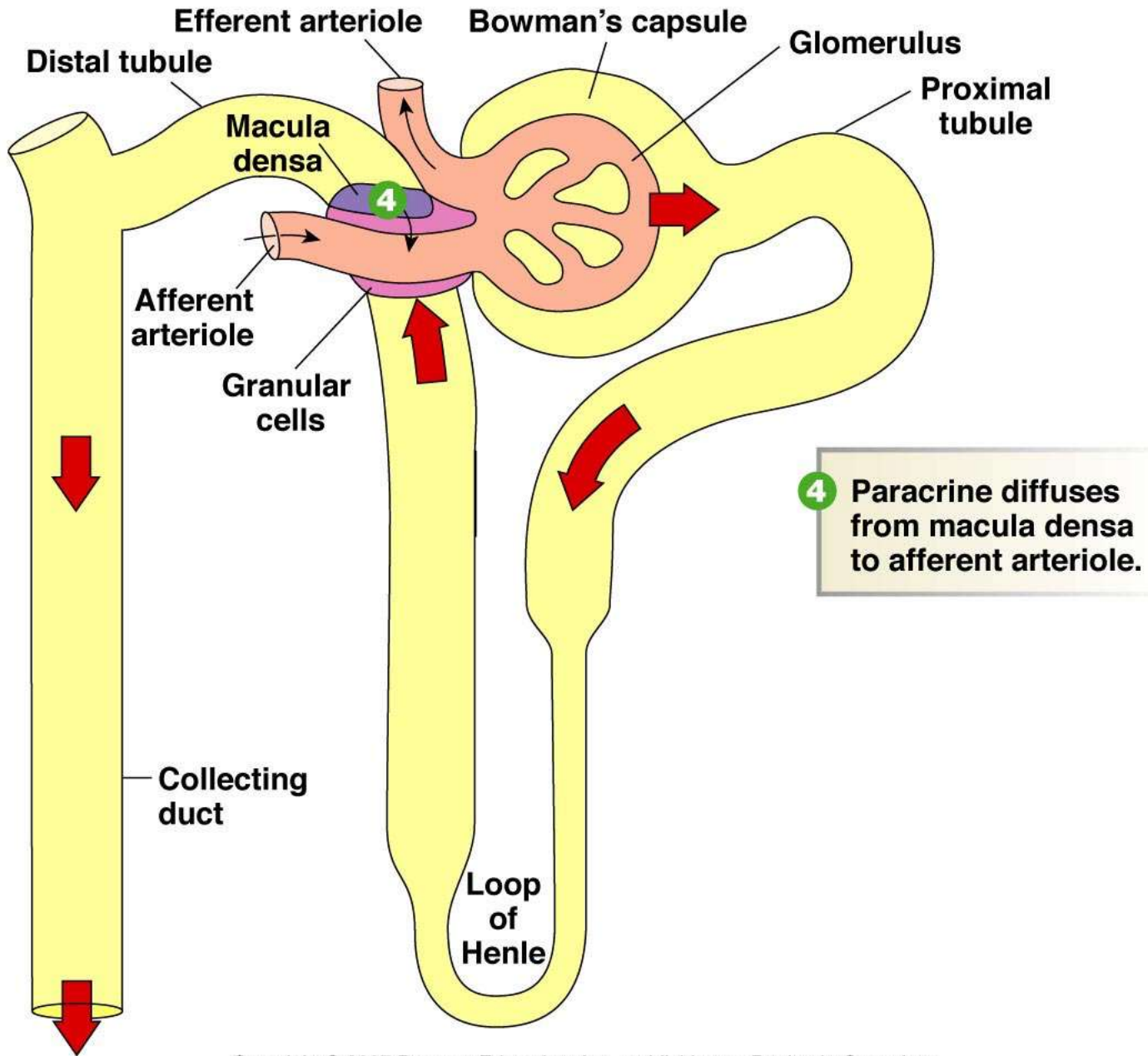


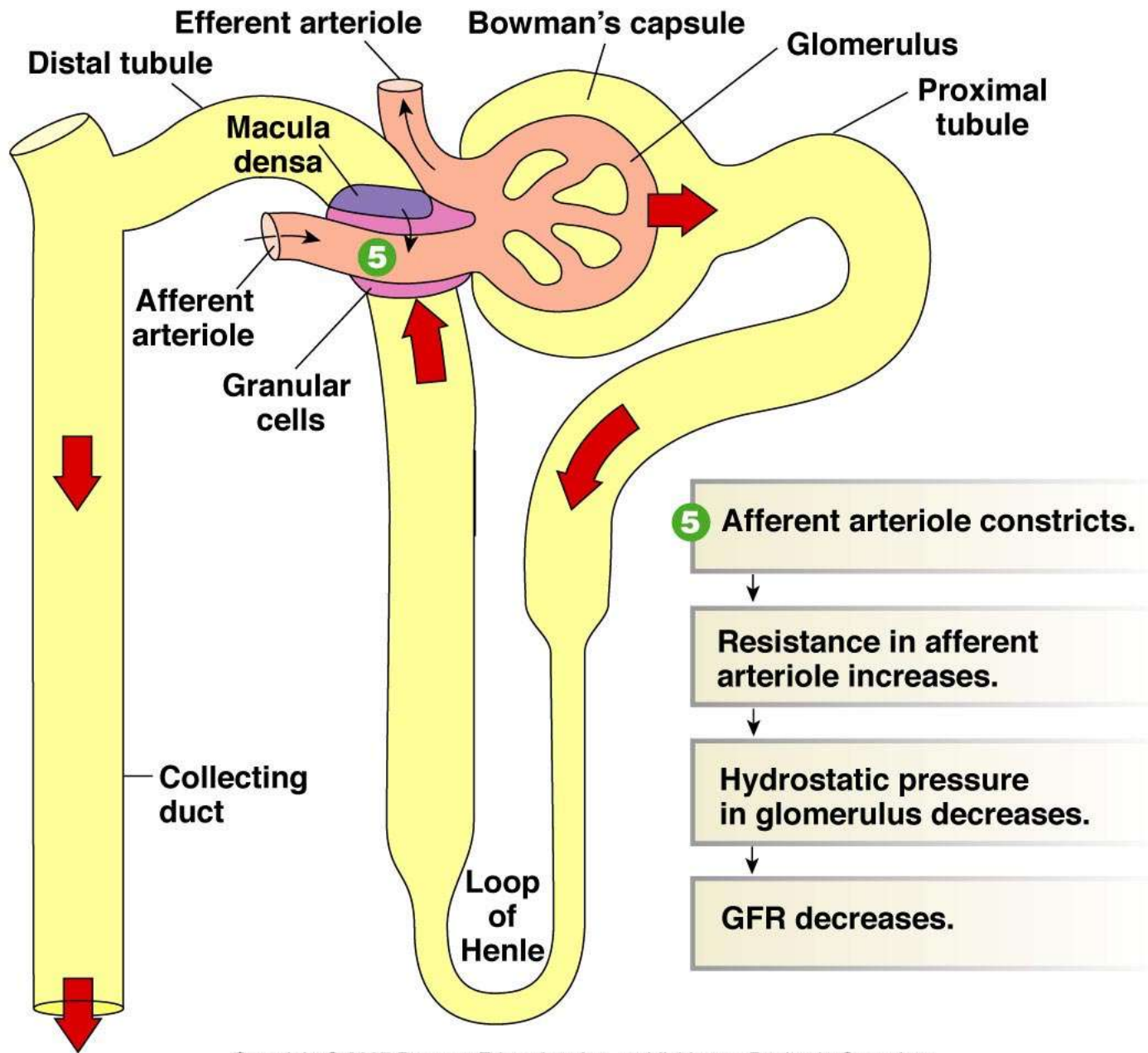


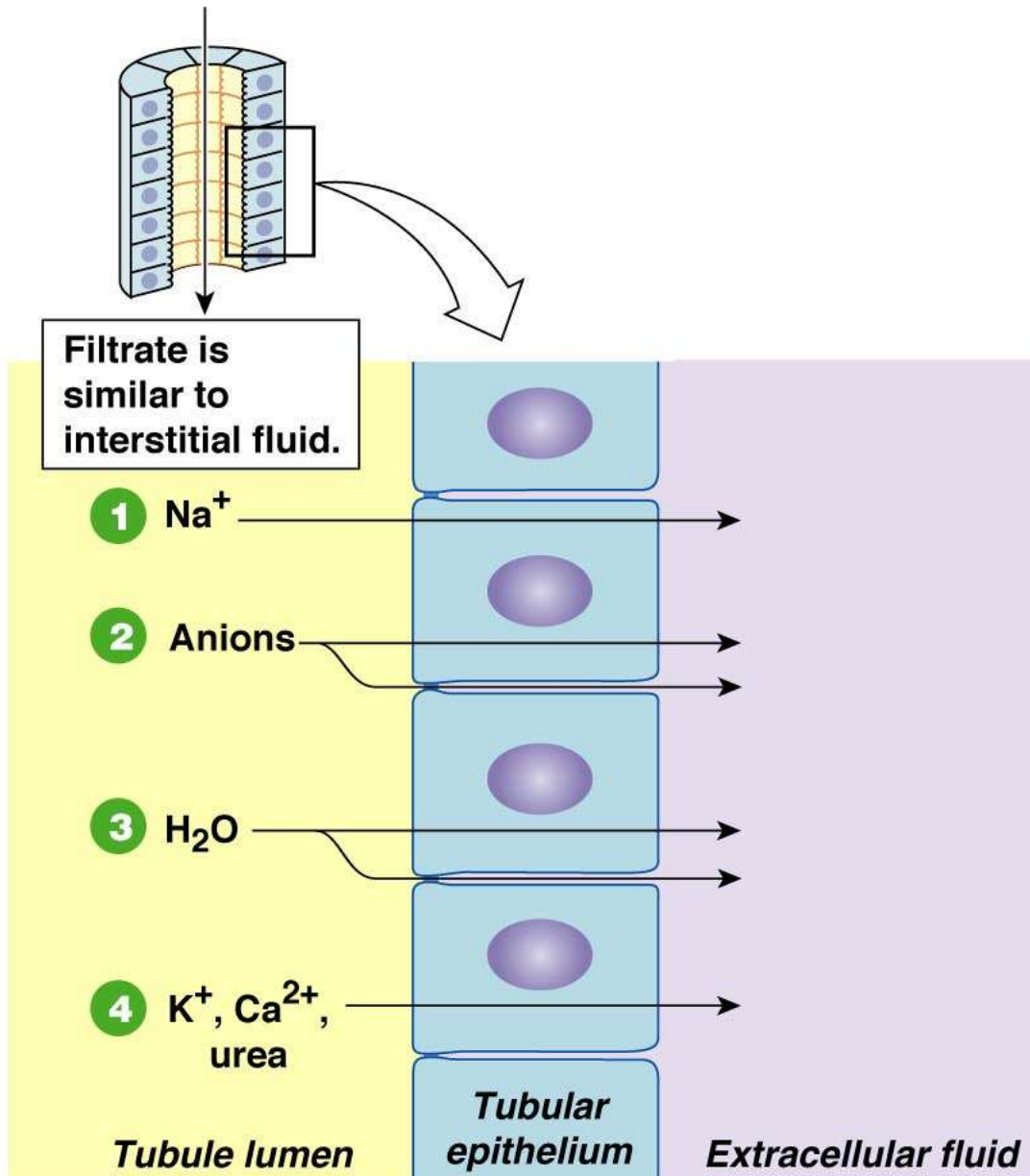










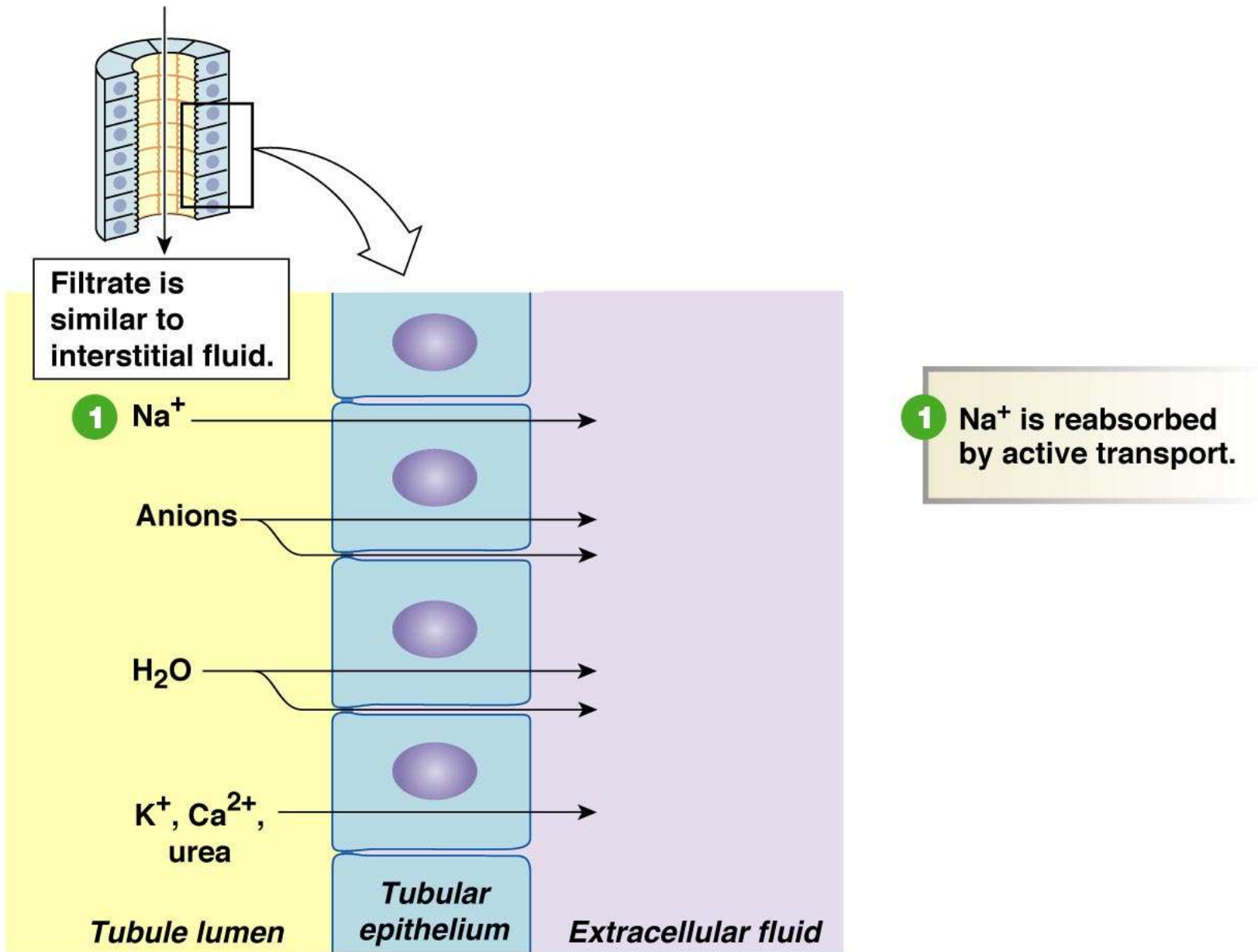


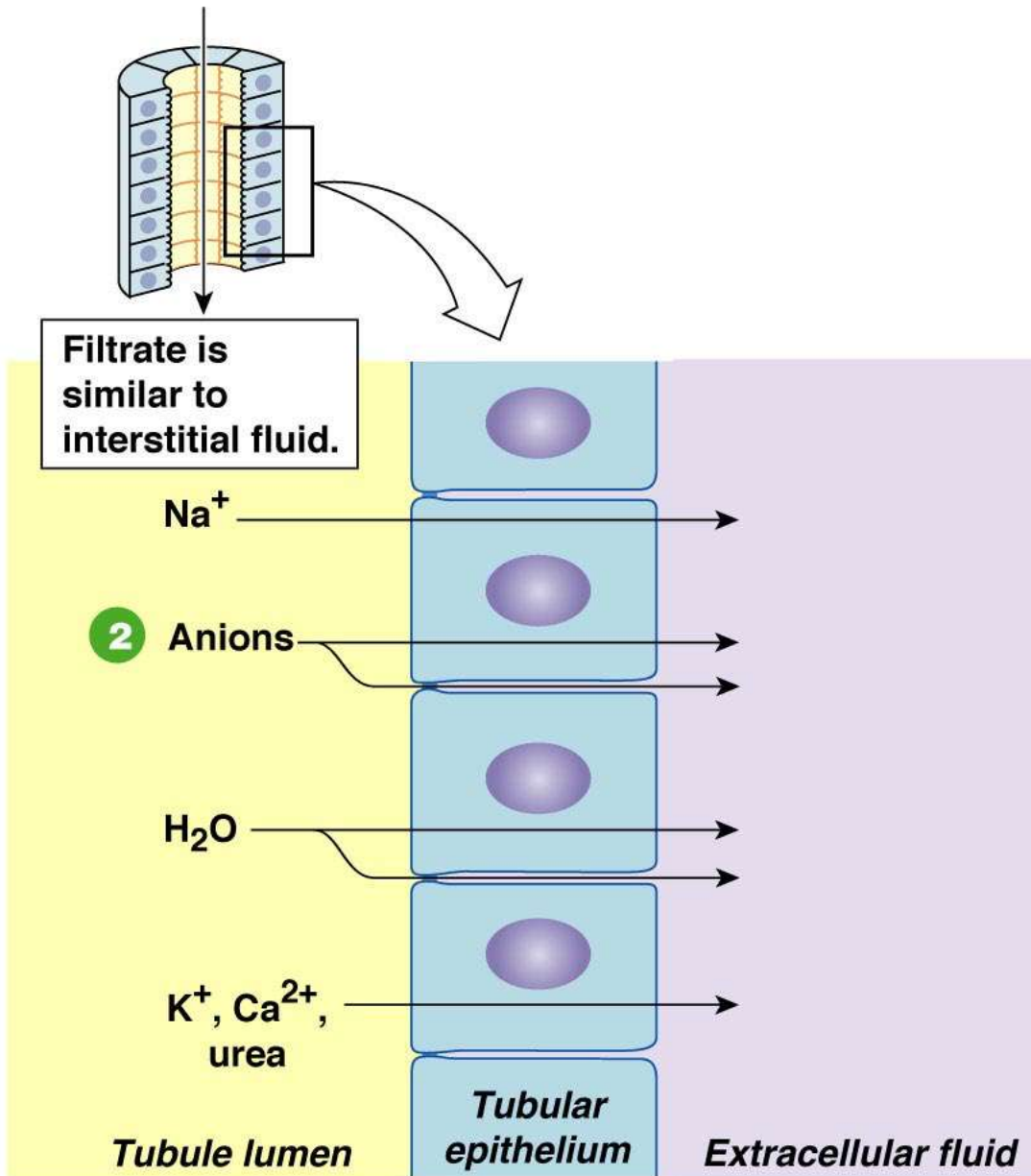
**1**  $\text{Na}^+$  is reabsorbed by active transport.

**2** Electrochemical gradient drives anion reabsorption.

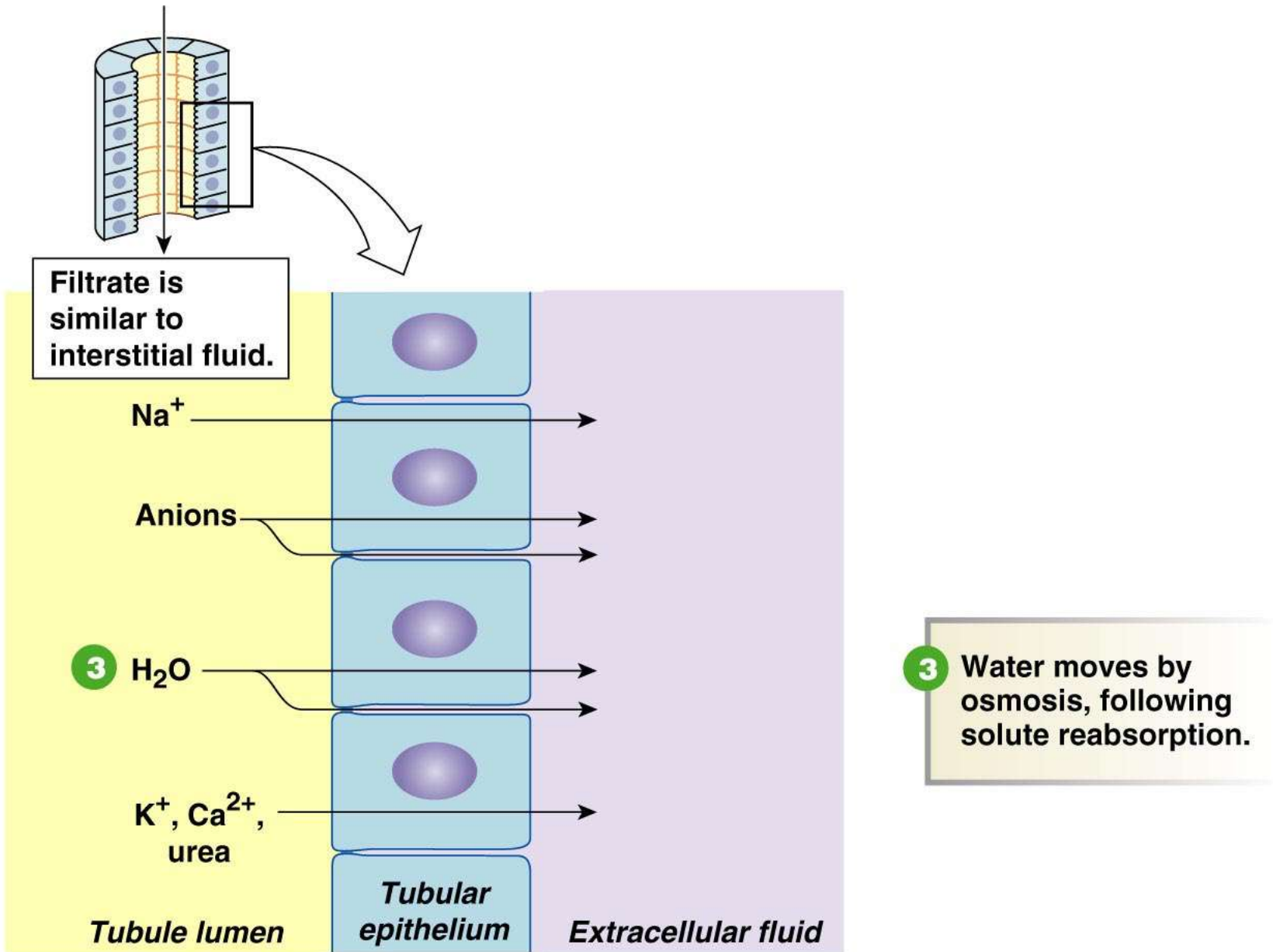
**3** Water moves by osmosis, following solute reabsorption.

**4** Concentrations of other solutes increase as fluid volume in lumen decreases. Permeable solutes are reabsorbed by diffusion.

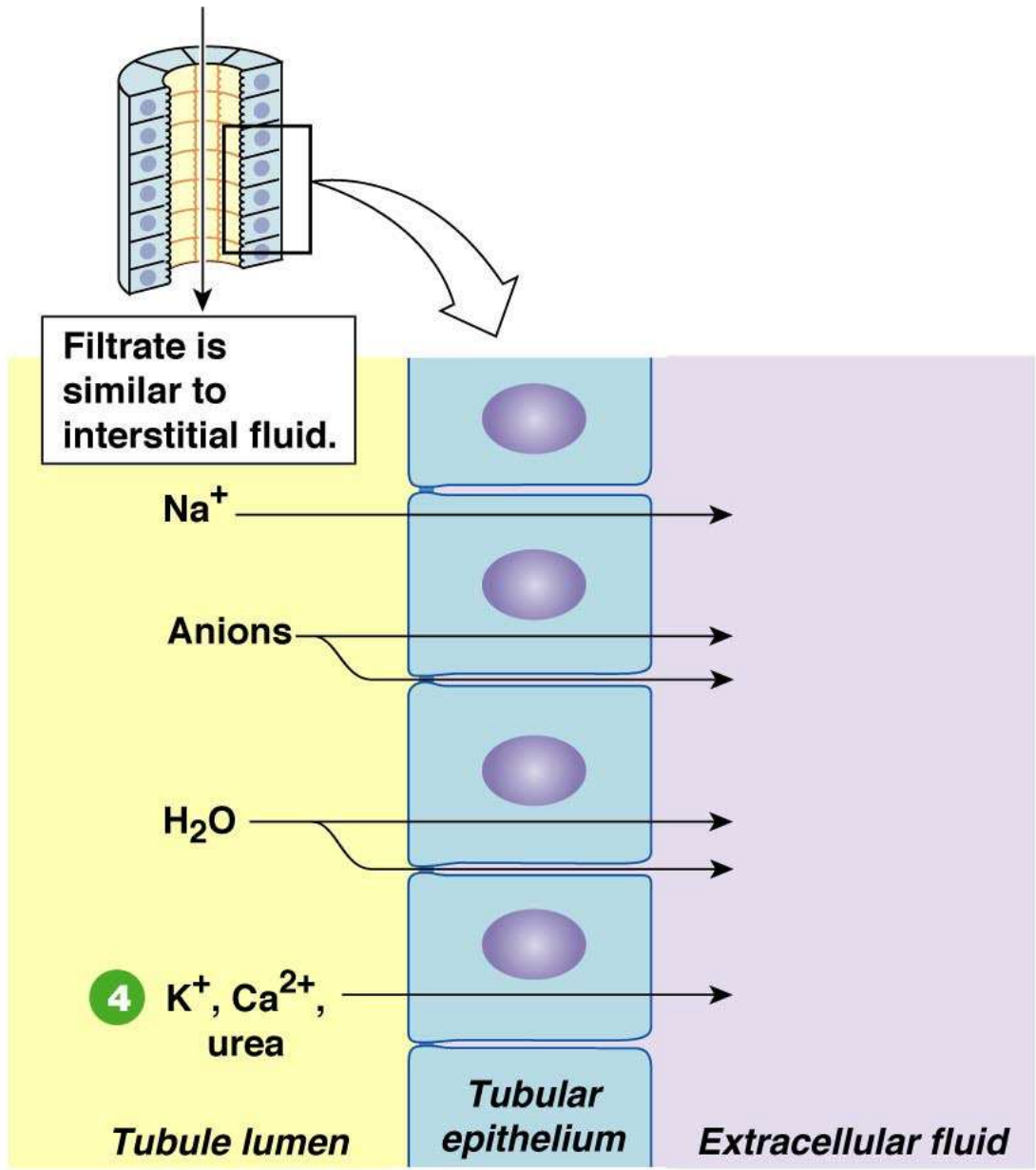




**2** Electrochemical gradient drives anion reabsorption.

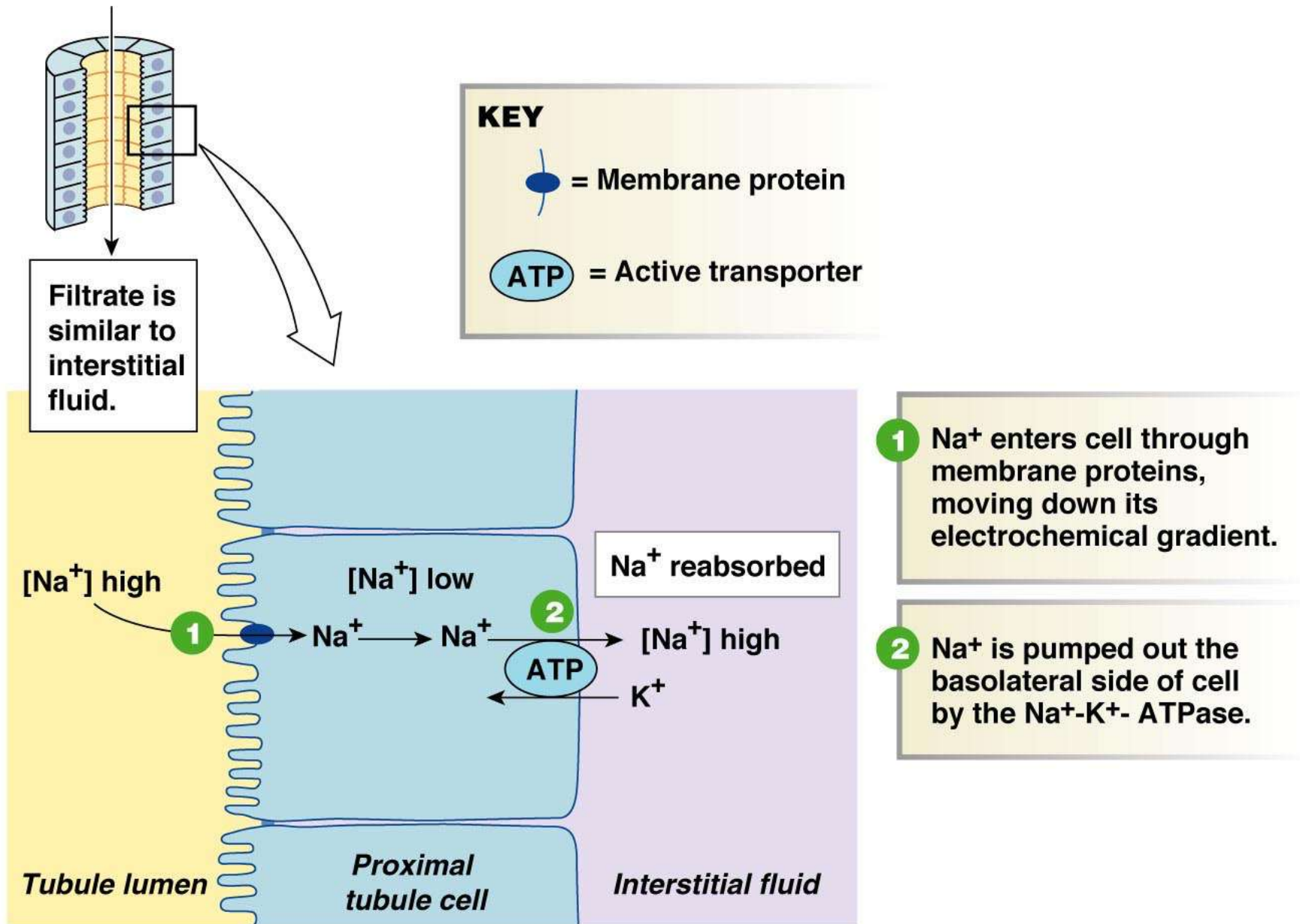


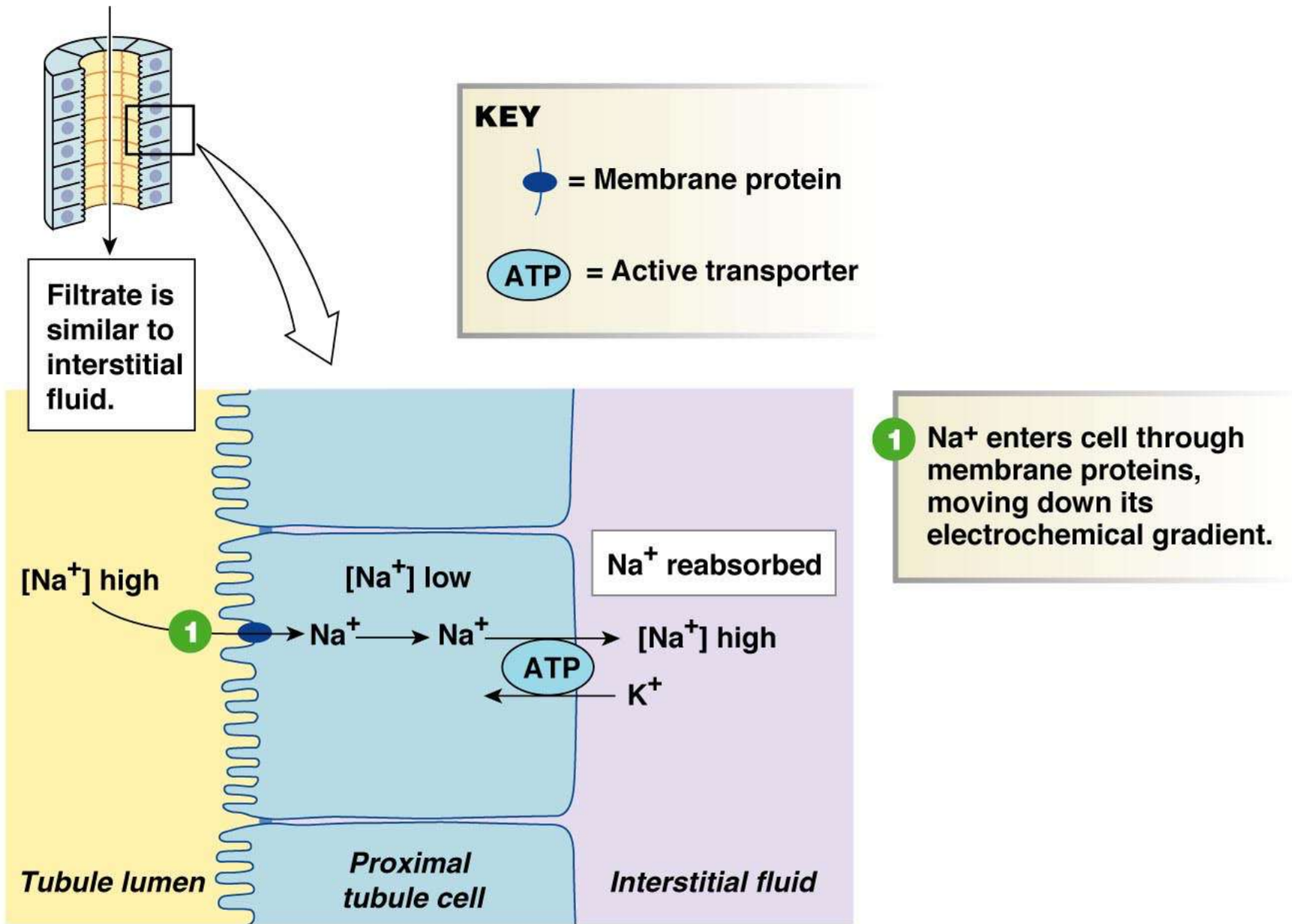


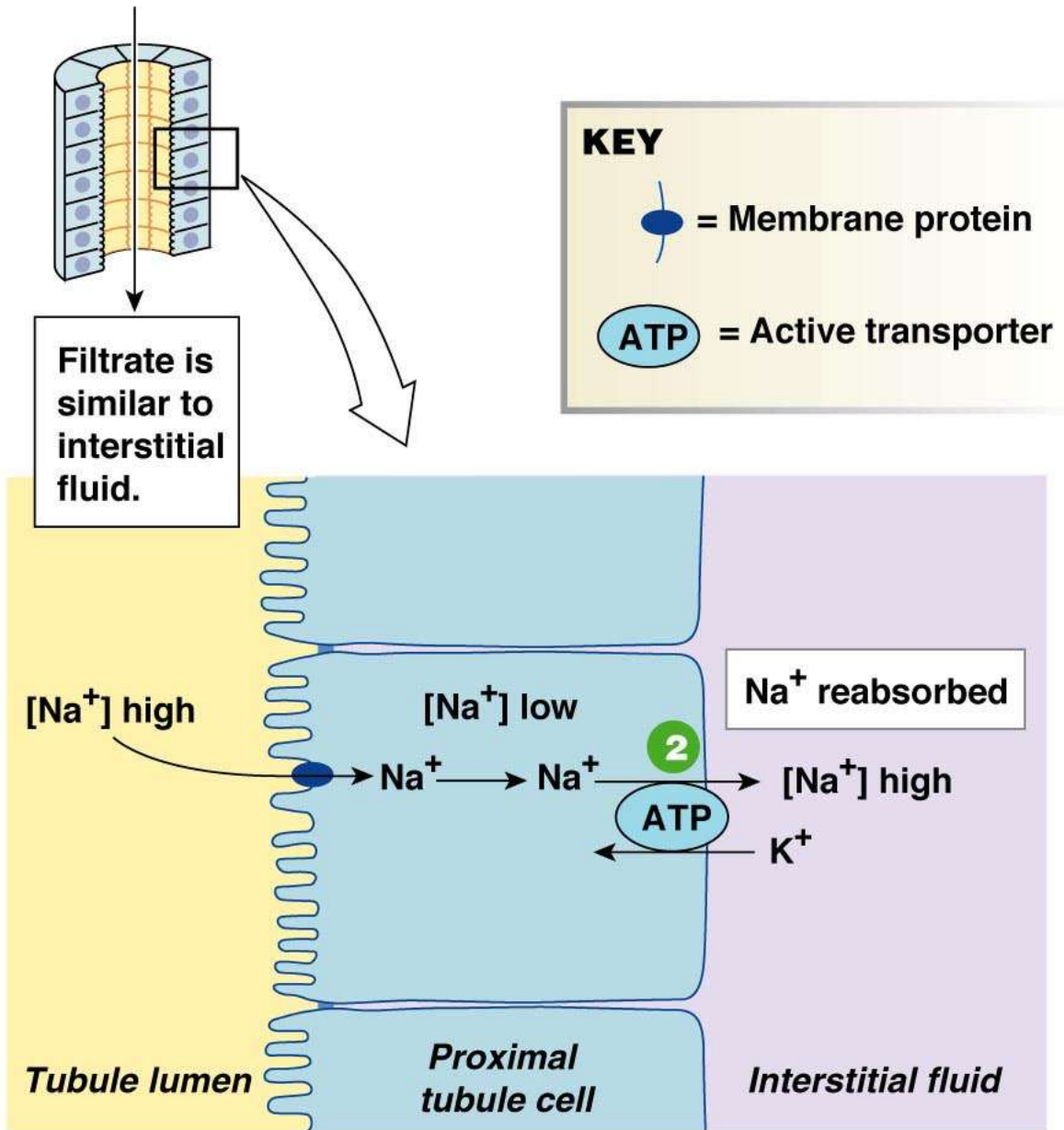


**4** Concentrations of other solutes increase as fluid volume in lumen decreases. Permeable solutes are reabsorbed by diffusion.

Figure 19-11, step 4







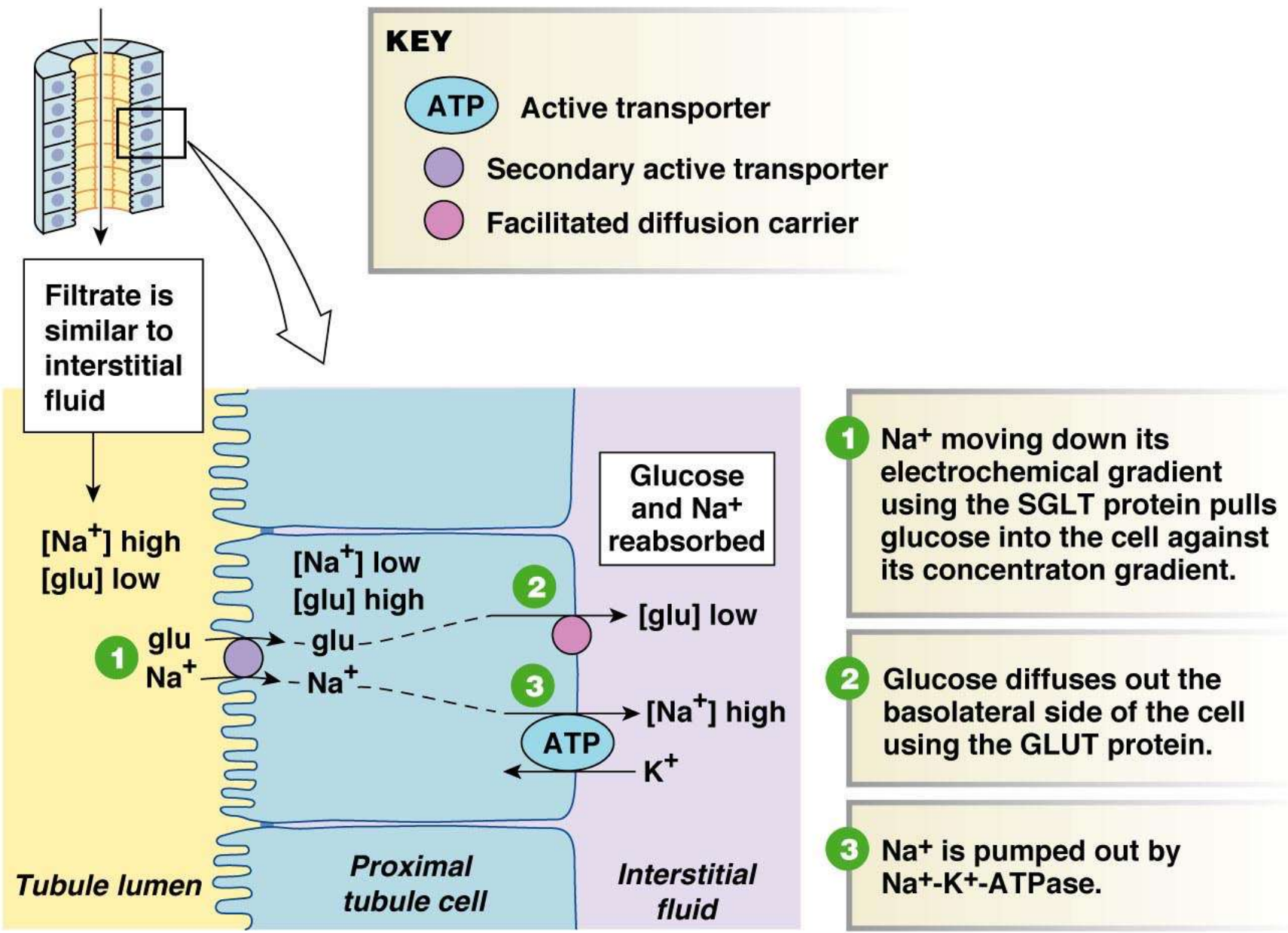
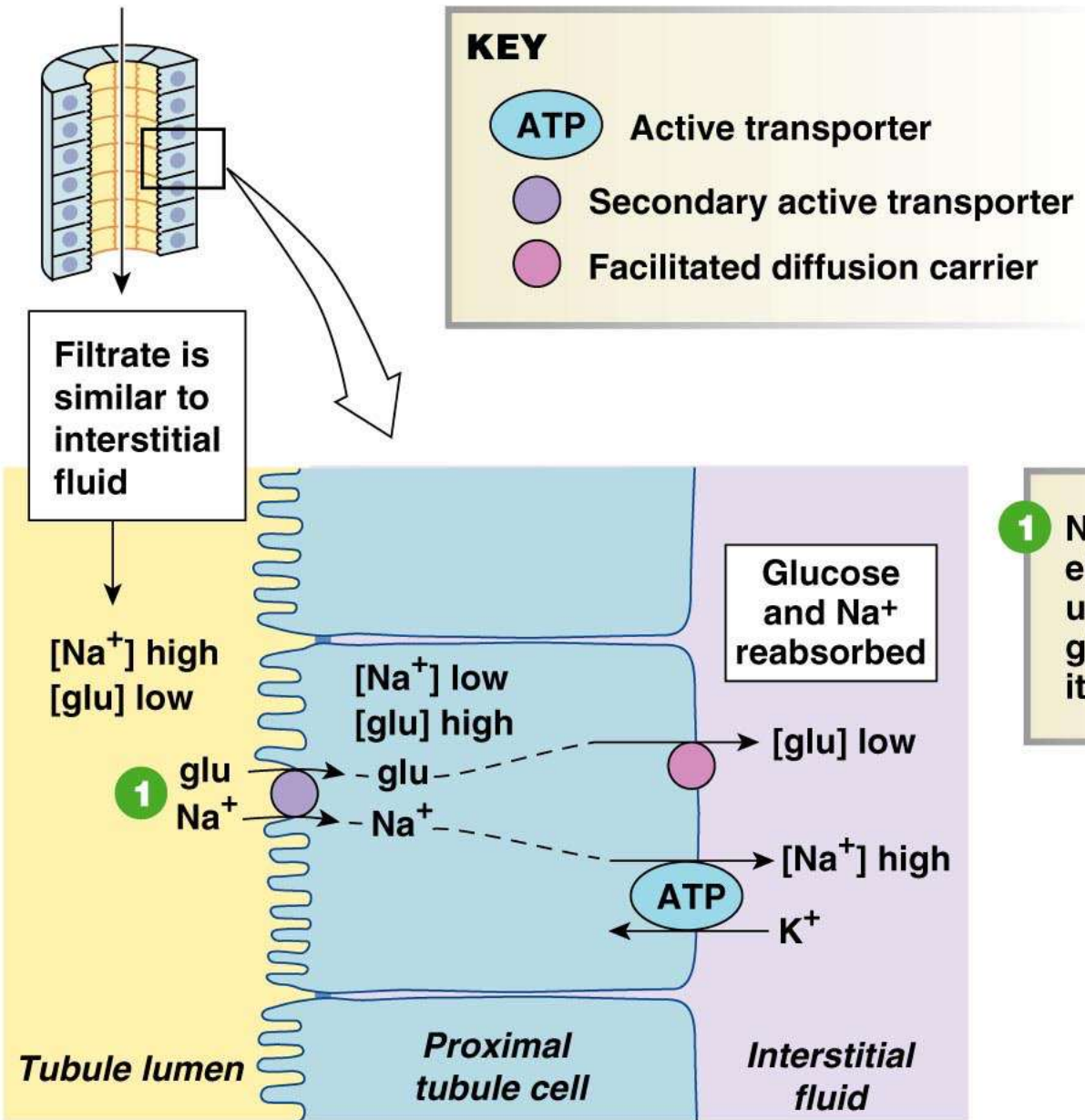
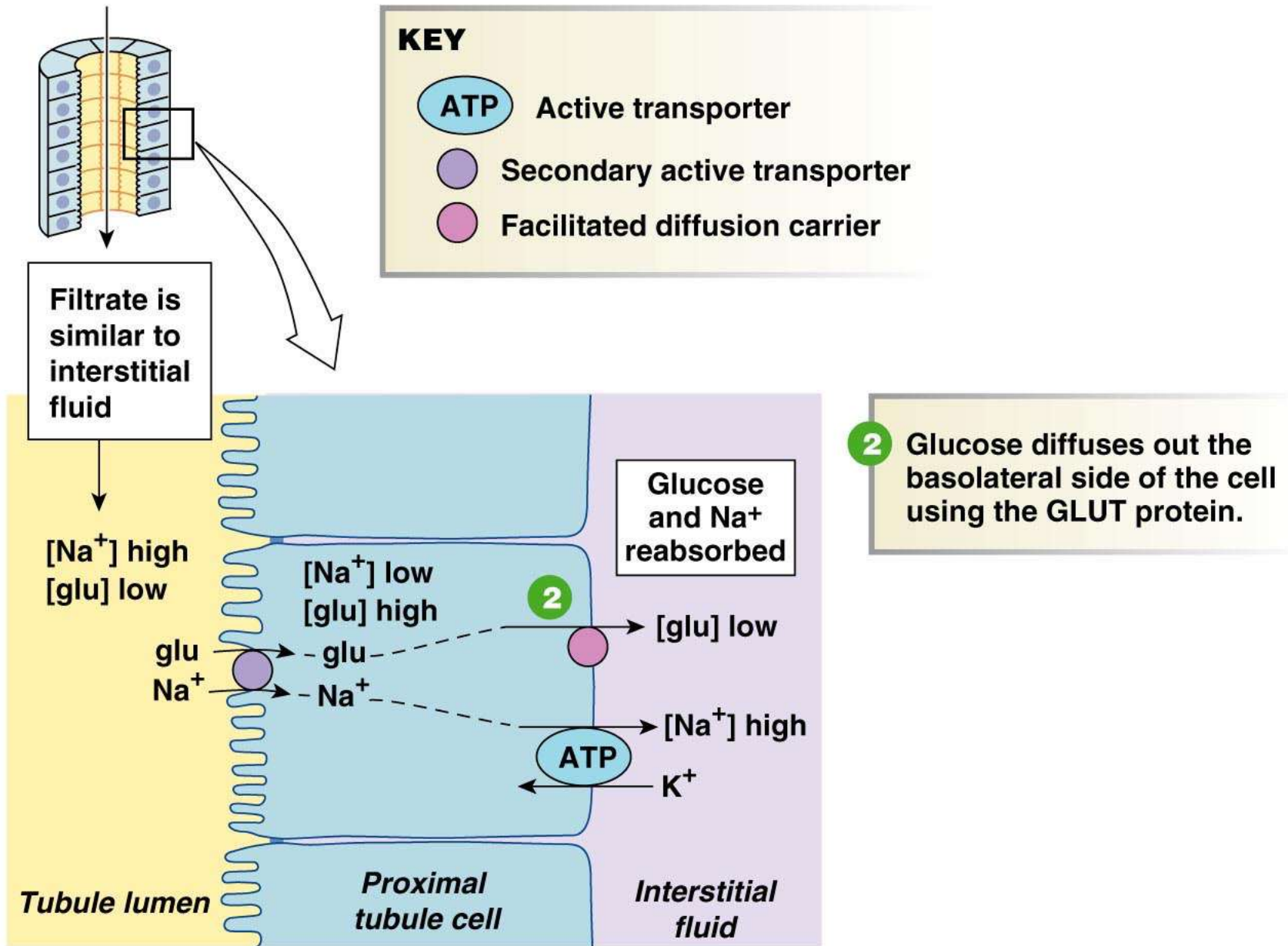
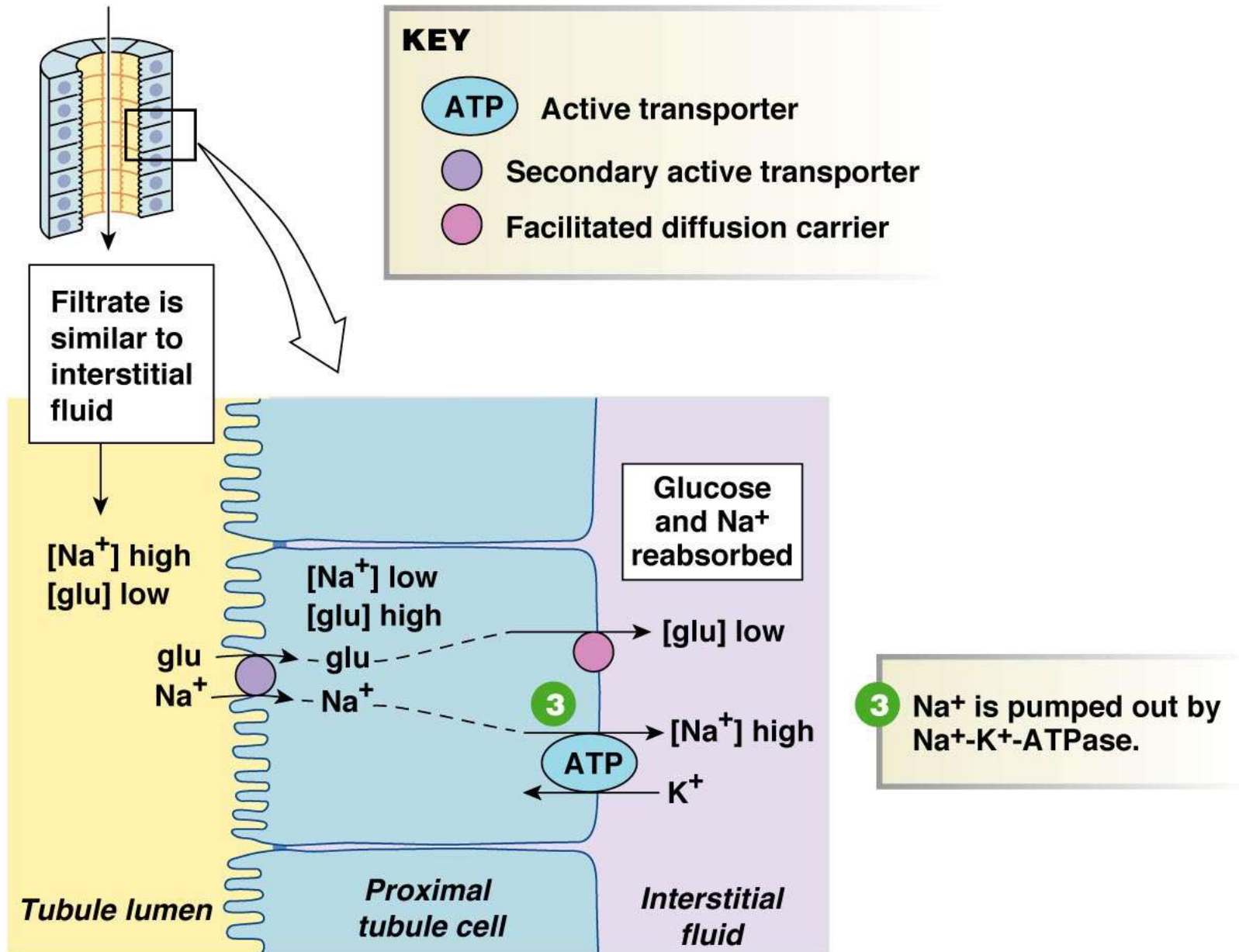


Figure 19-13 - Overview

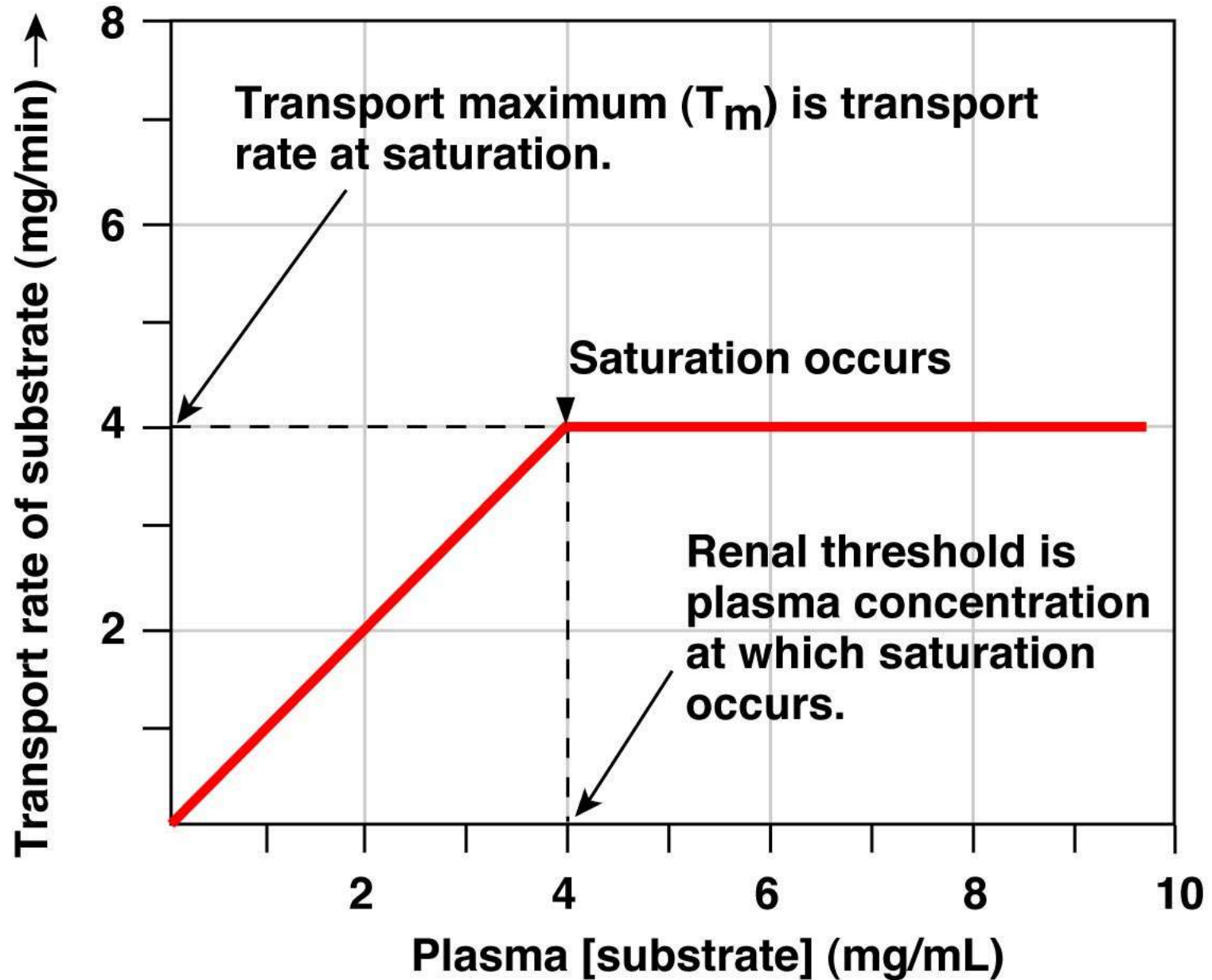


**1** Na<sup>+</sup> moving down its electrochemical gradient using the SGLT protein pulls glucose into the cell against its concentration gradient.









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Figure 19-14

Cortex

65% of filtrate volume reabsorbed

- $H_2O$
- $Na^+$ ,  $HCO_3^-$ , and many other ions
- Glucose, amino acids, and other nutrients

Regulated reabsorption

- $Na^+$  (by aldosterone;  $Cl^-$  follows)
- $Ca^{2+}$  (by parathyroid hormone)

•  $H^+$  and  $NH_4^+$

• Some drugs

Regulated secretion

- $K^+$  (by aldosterone)

•  $H_2O$

•  $Na^+$ ,  $K^+$ ,  $Cl^-$

Outer medulla

Regulated reabsorption

- $H_2O$  (by ADH)
- $Na^+$  (by aldosterone;  $Cl^-$  follows)
- Urea (increased by ADH)

• Urea

Inner medulla

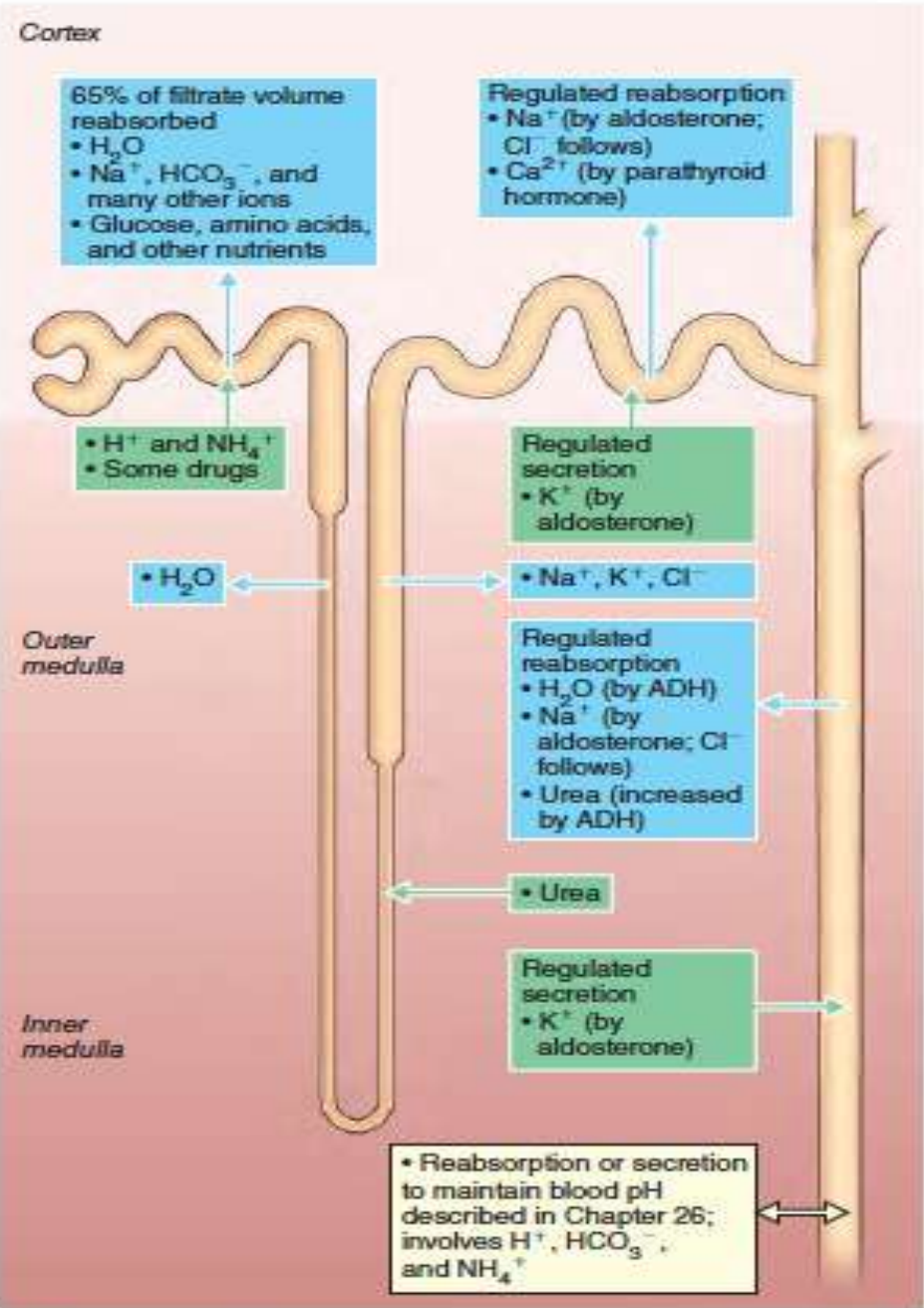
Regulated secretion

- $K^+$  (by aldosterone)

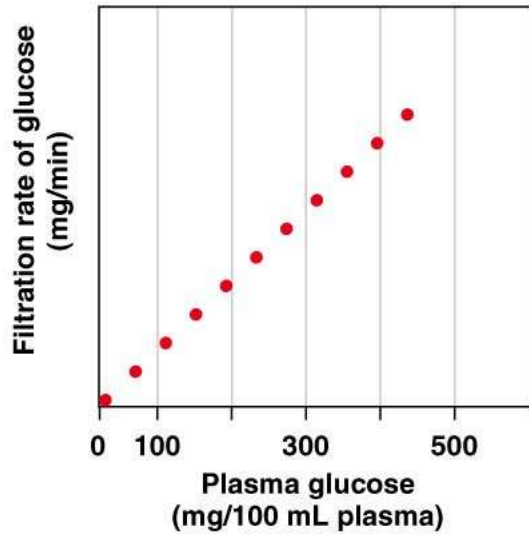
• Reabsorption or secretion to maintain blood pH described in Chapter 26; involves  $H^+$ ,  $HCO_3^-$ , and  $NH_4^+$

→ Reabsorption

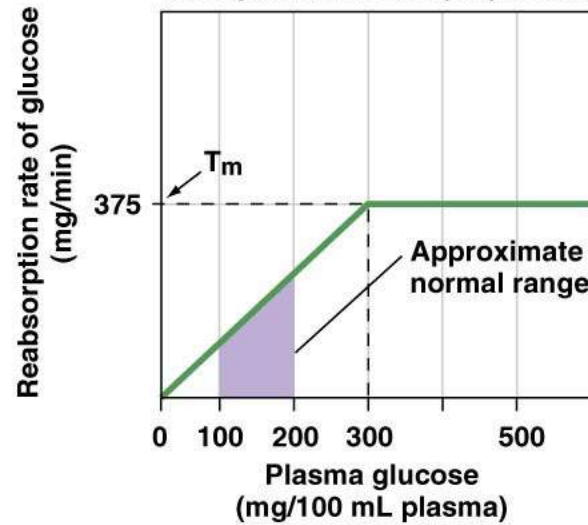
→ Secretion



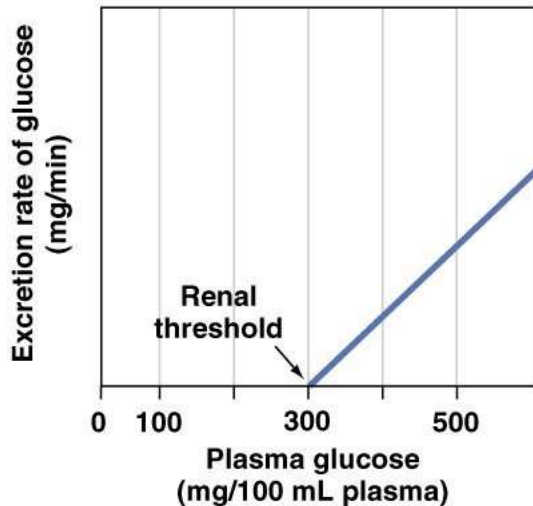
**(a)** Filtration of glucose is proportional to the plasma concentration.



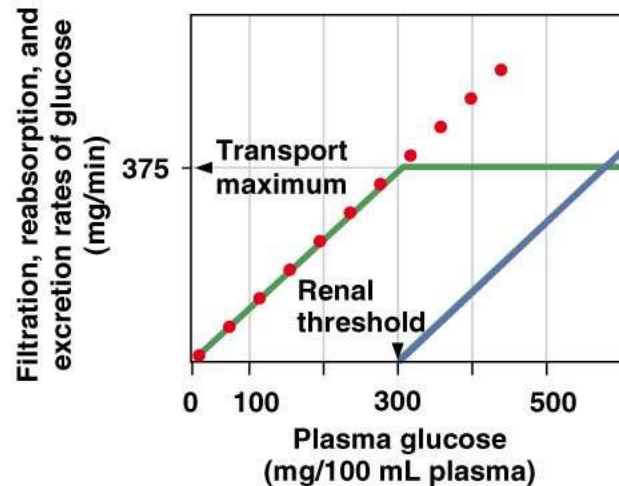
**(b)** Reabsorption of glucose is proportional to plasma concentration until the transport maximum ( $T_m$ ) is reached.



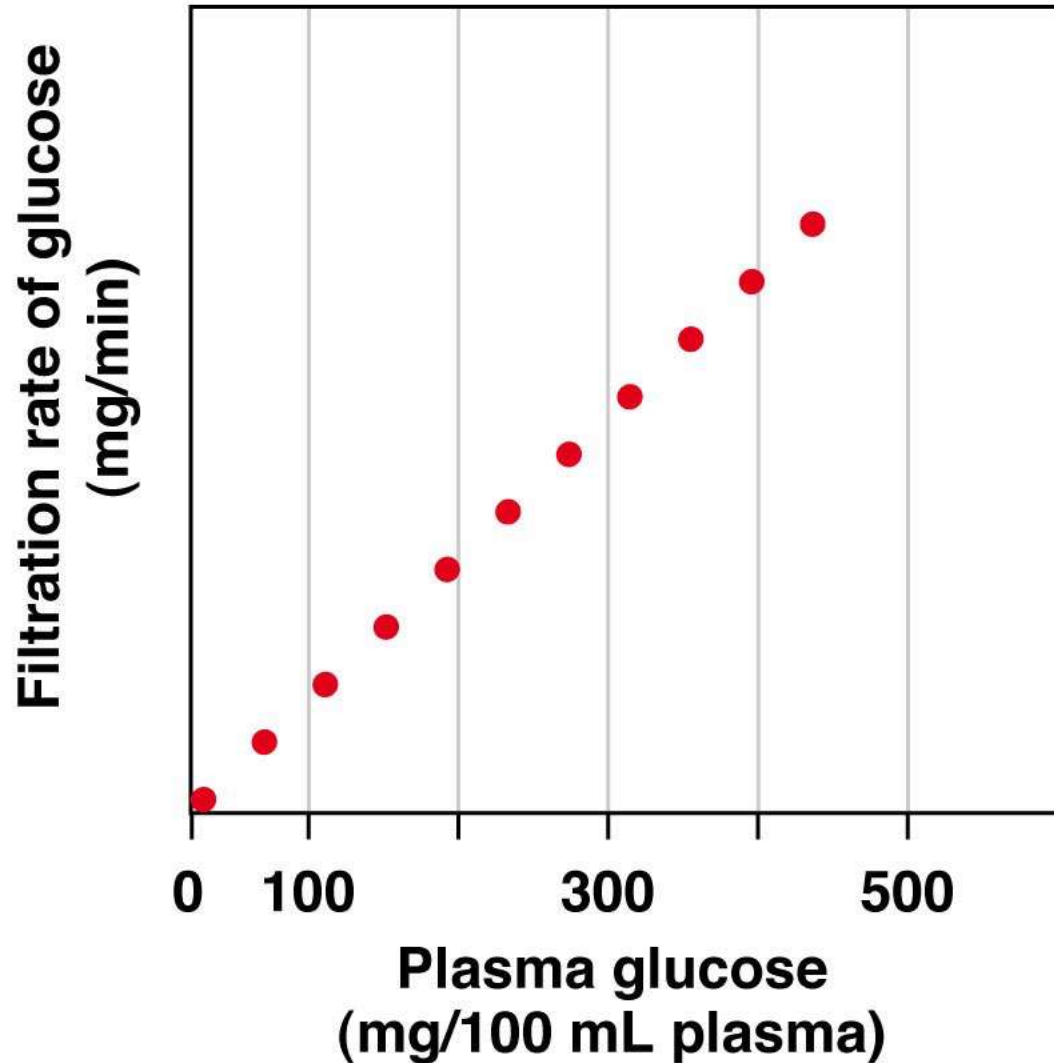
**(c)** Glucose excretion is zero until the renal threshold is reached.



**(d)** Composite graph shows the relationship between filtration, reabsorption, and excretion of glucose.



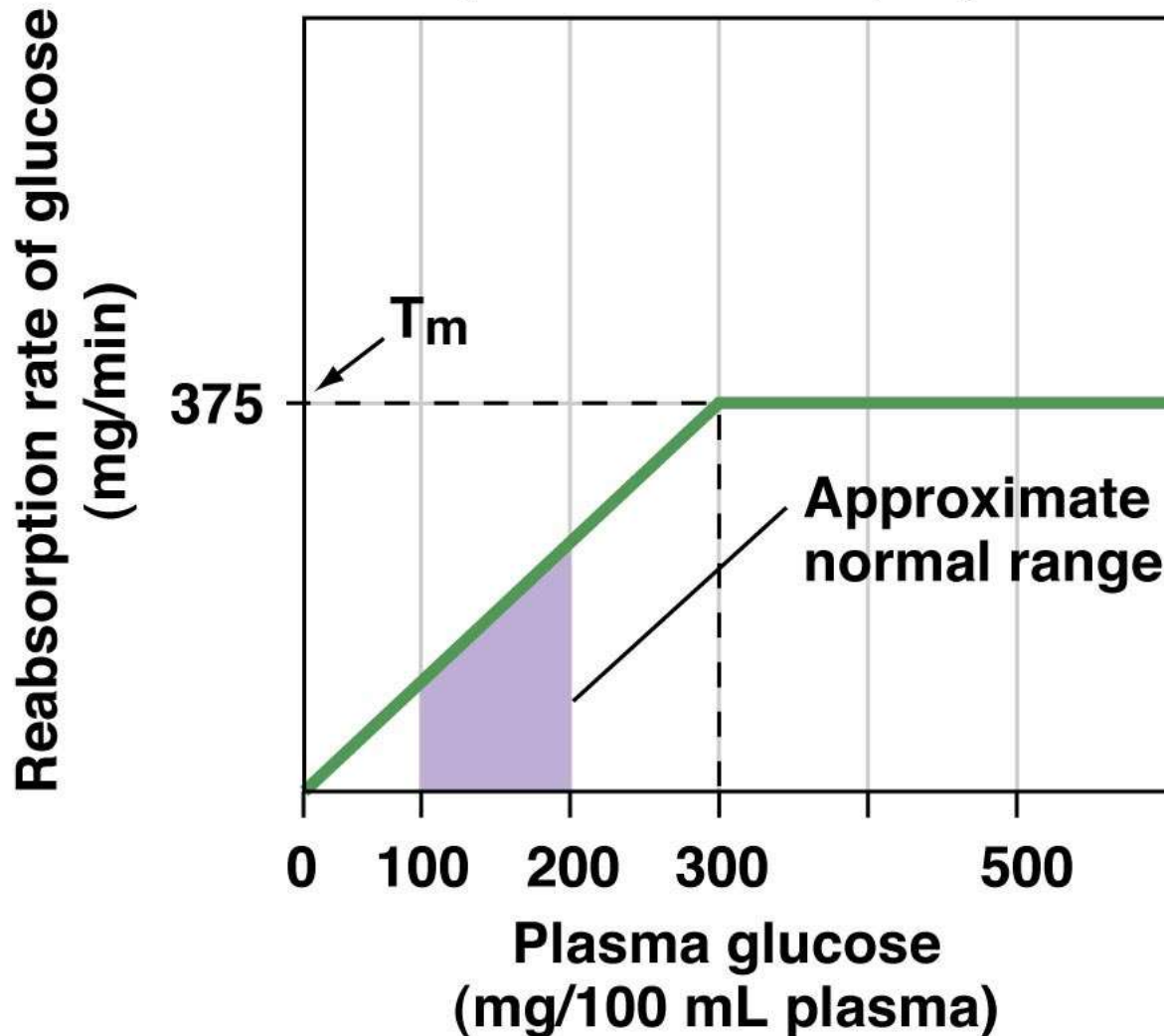
**(a) Filtration of glucose is proportional to the plasma concentration.**



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Figure 19-15a

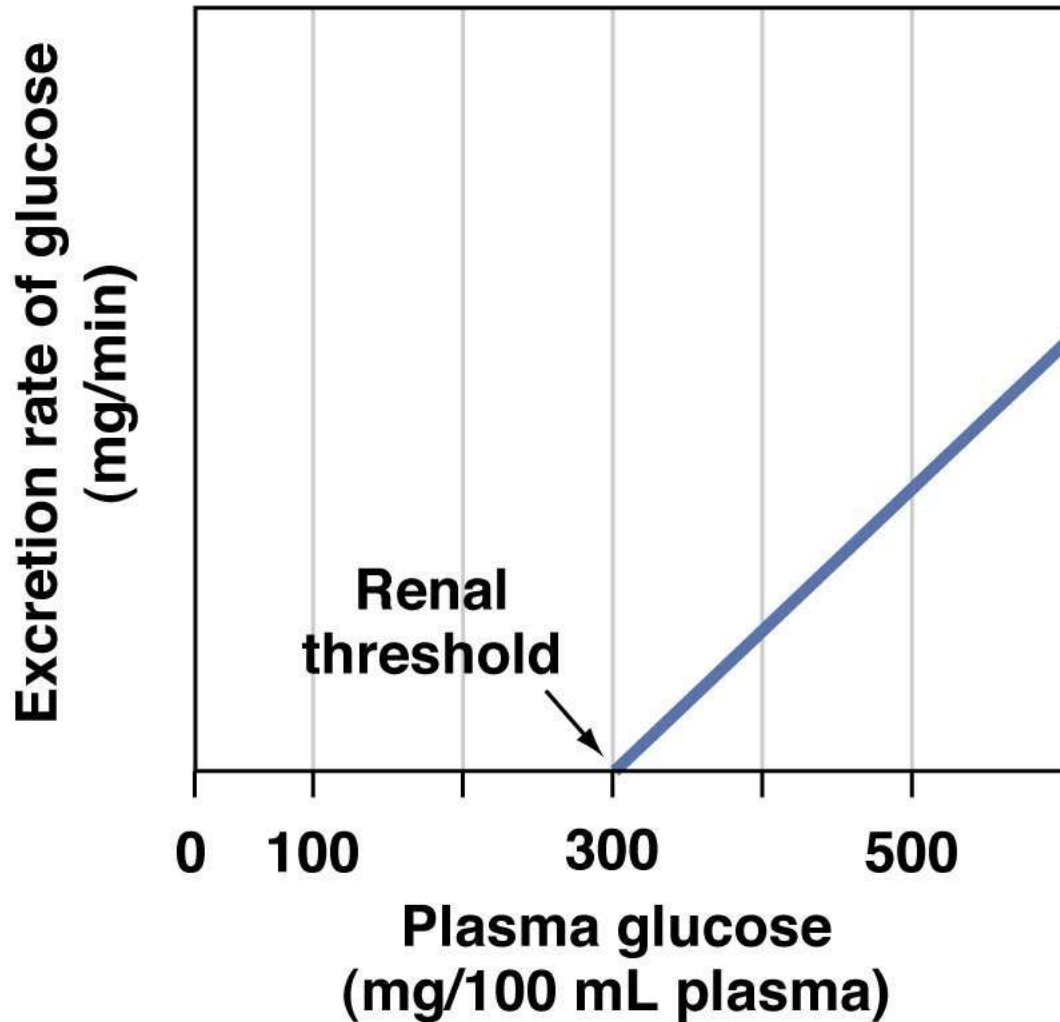
**(b) Reabsorption of glucose is proportional to plasma concentration until the transport maximum ( $T_m$ ) is reached.**



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Figure 19-15b

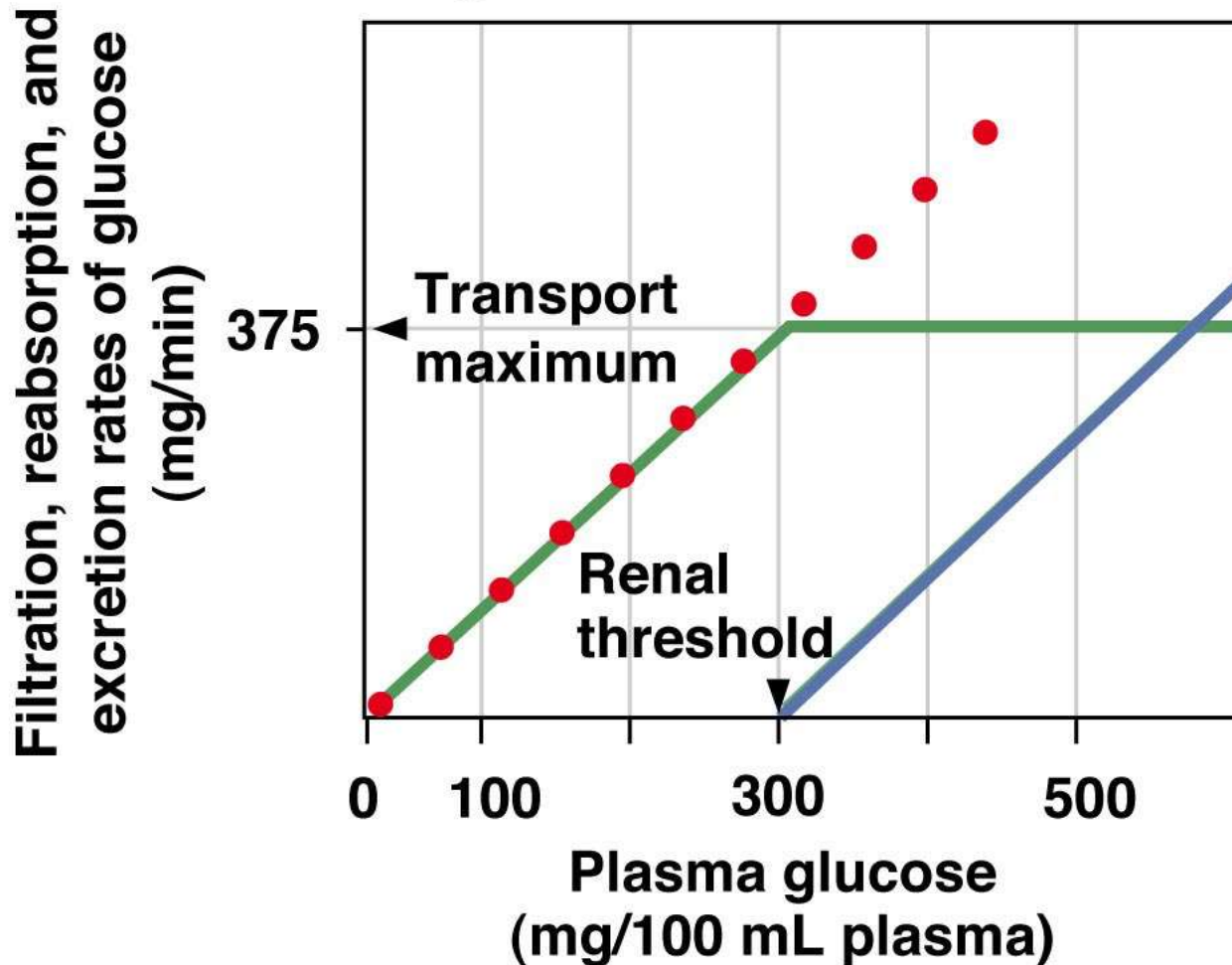
**(c) Glucose excretion is zero until the renal threshold is reached.**



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Figure 19-15c

**(d)** Composite graph shows the relationship between filtration, reabsorption, and excretion of glucose.



Cortex

65% of filtrate volume reabsorbed

- $H_2O$
- $Na^+$ ,  $HCO_3^-$ , and many other ions
- Glucose, amino acids, and other nutrients

Regulated reabsorption

- $Na^+$  (by aldosterone;  $Cl^-$  follows)
- $Ca^{2+}$  (by parathyroid hormone)

•  $H^+$  and  $NH_4^+$

• Some drugs

Regulated secretion

- $K^+$  (by aldosterone)

•  $H_2O$

•  $Na^+$ ,  $K^+$ ,  $Cl^-$

Outer medulla

Regulated reabsorption

- $H_2O$  (by ADH)
- $Na^+$  (by aldosterone;  $Cl^-$  follows)
- Urea (increased by ADH)

• Urea

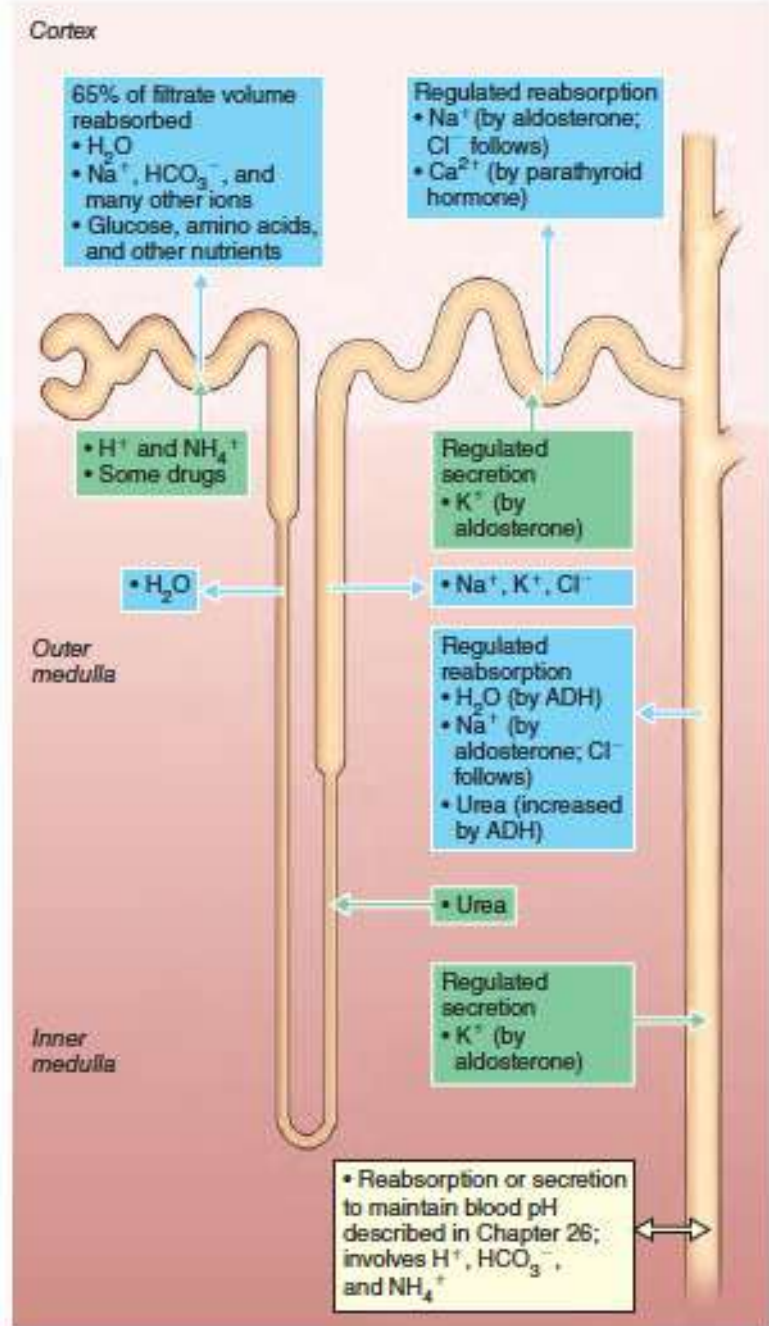
Inner medulla

Regulated secretion

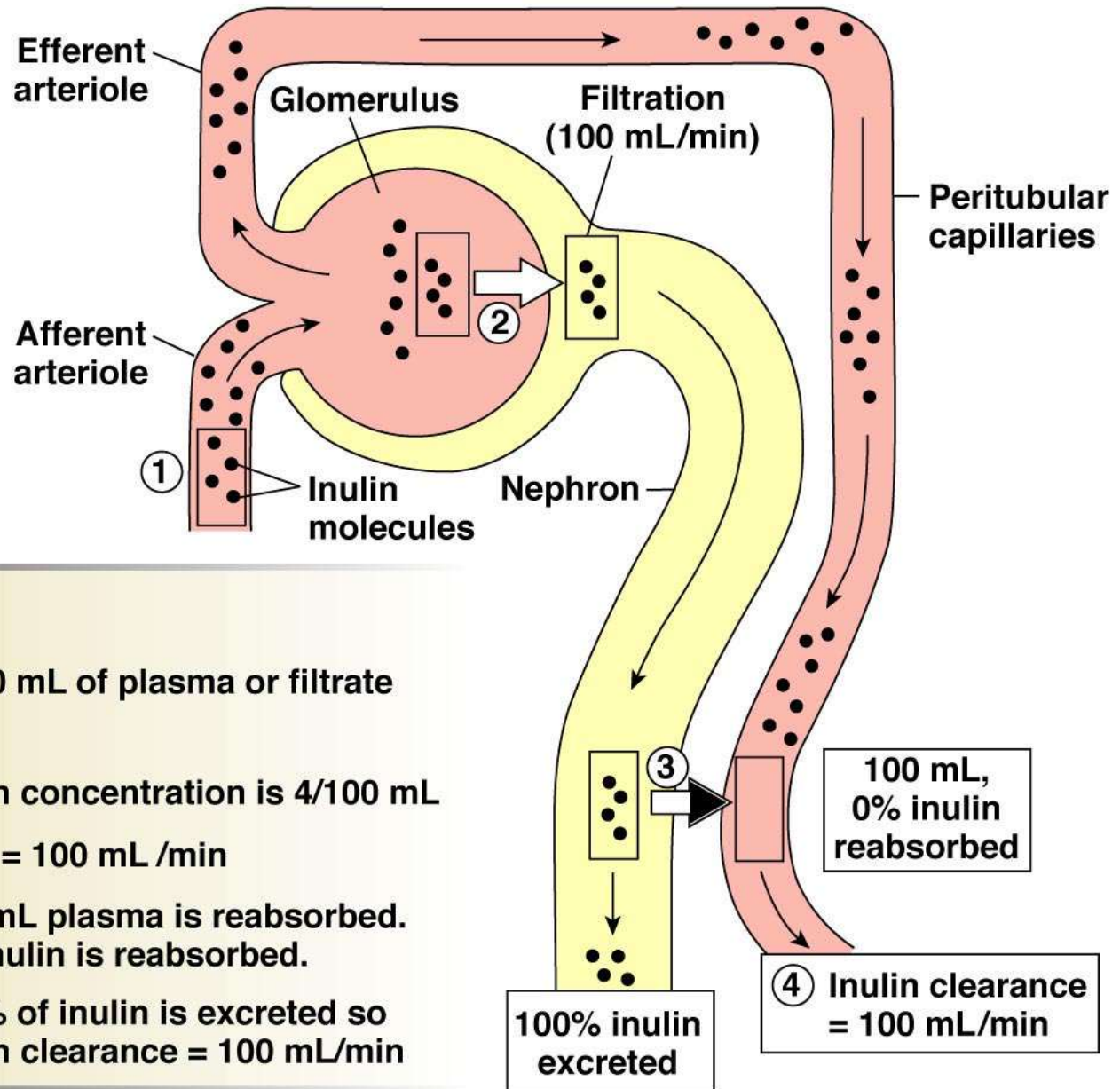
- $K^+$  (by aldosterone)

• Reabsorption or secretion to maintain blood pH described in Chapter 26; involves  $H^+$ ,  $HCO_3^-$ , and  $NH_4^+$

→ Reabsorption  
→ Secretion







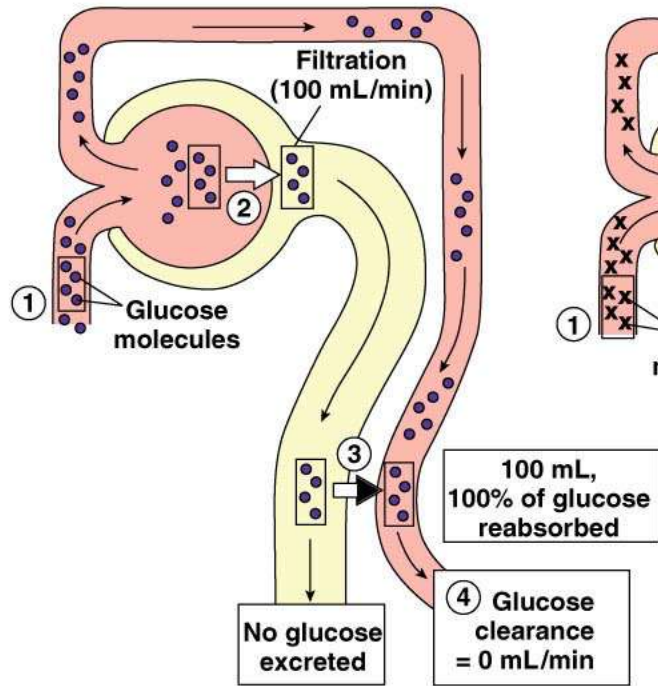
**TABLE 19-2** Renal Handling of Solutes

**For any molecule X that is freely filtered at the glomerulus:**

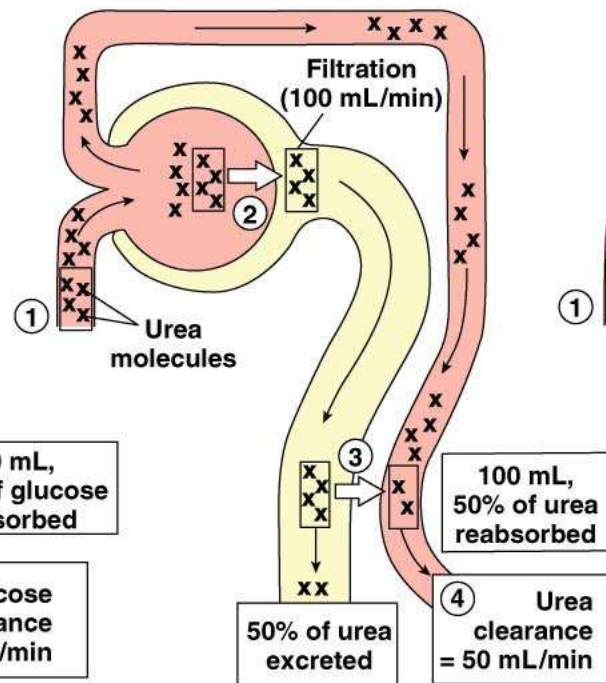
If filtration rate is greater than excretion rate,	there is net reabsorption of X.
If excretion rate is greater than filtration rate,	there is net secretion of X.
If filtration and excretion rate are the same,	X passes through the nephron without net reabsorption or secretion.
If the clearance of X is less than inulin clearance,	there is net reabsorption of X.
If the clearance of X is equal to inulin clearance,	X is neither reabsorbed nor secreted.
If the clearance of X is greater than inulin clearance,	there is net secretion of X.

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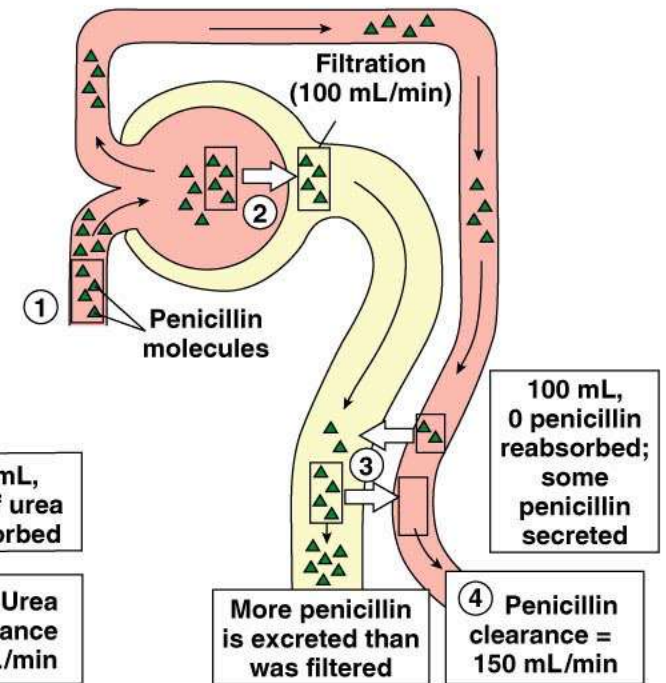
**(a) Glucose clearance**



**(b) Urea clearance**



**(c) Penicillin clearance**



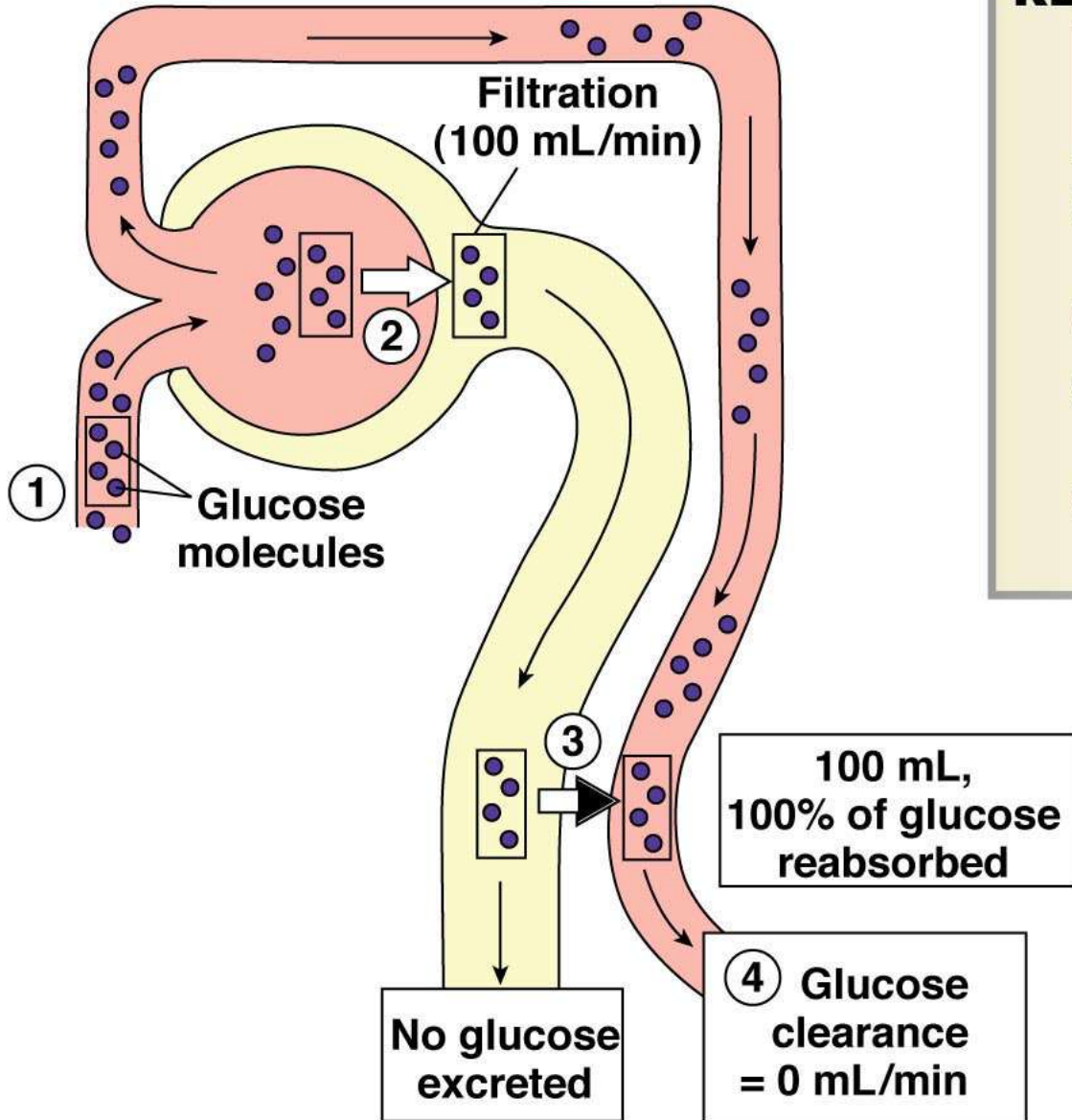
**KEY**

-  = 100 mL of plasma or filtrate
- ① Plasma concentration is 4/100 mL
- ② GFR = 100 mL/min
- ③ 100 mL plasma is reabsorbed.
- ④ Clearance depends on renal handling of solute

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Figure 19-17 - Overview

# (a) Glucose clearance



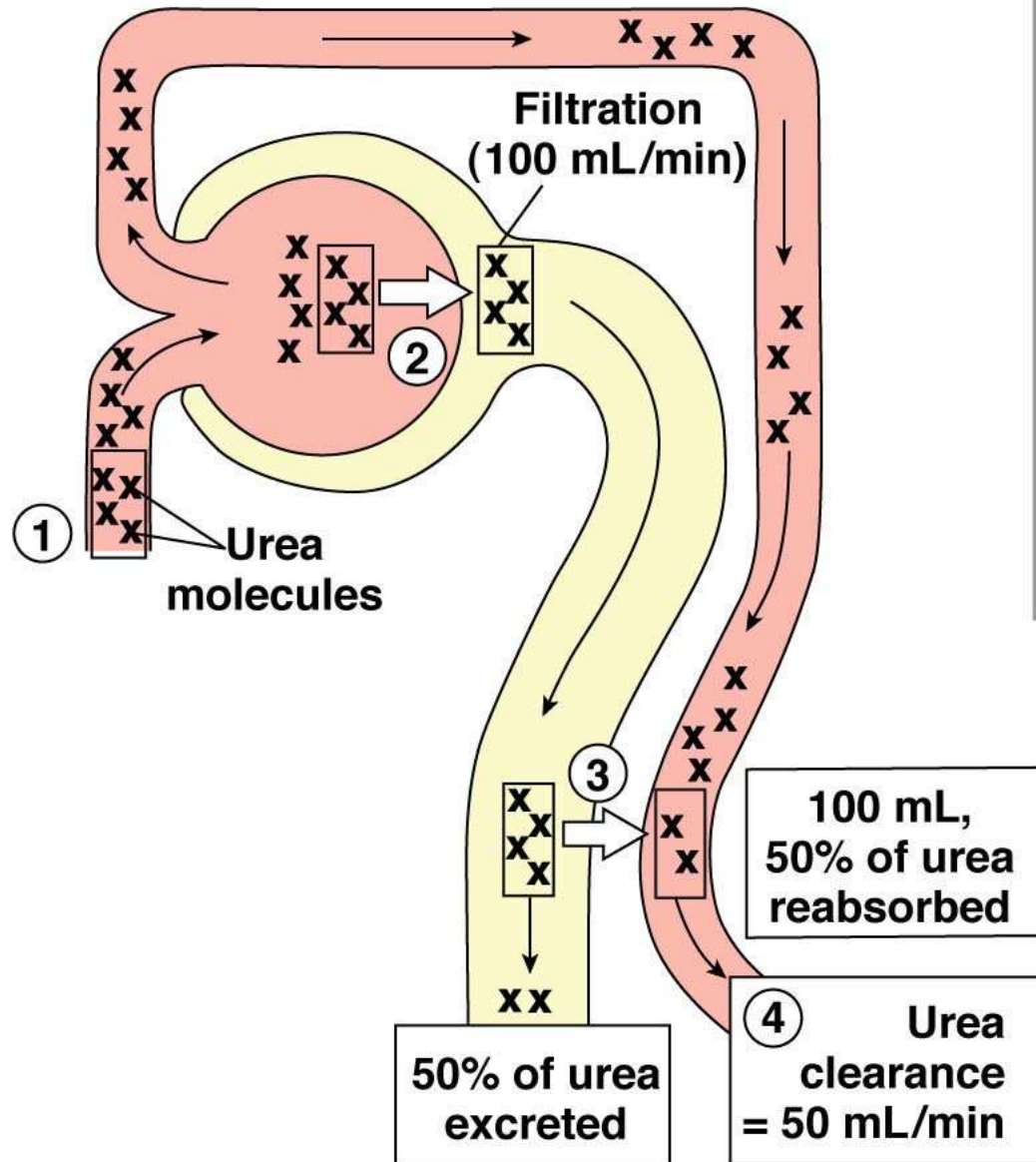
## KEY



= 100 mL of plasma or filtrate

- ① Plasma concentration is 4/100 mL
- ② GFR = 100 mL /min
- ③ 100 mL plasma is reabsorbed.
- ④ Clearance depends on renal handling of solute

## (b) Urea clearance



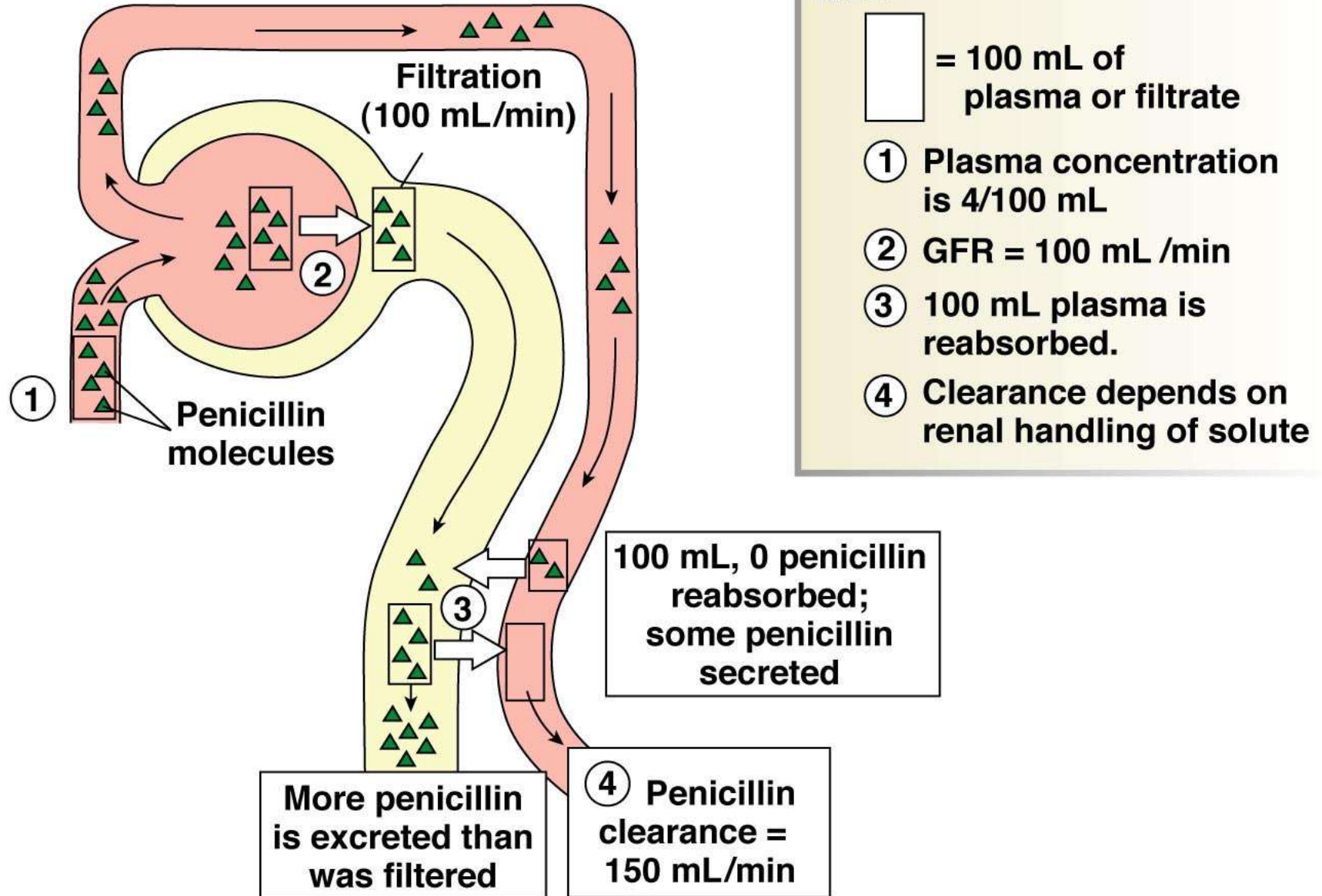
### KEY



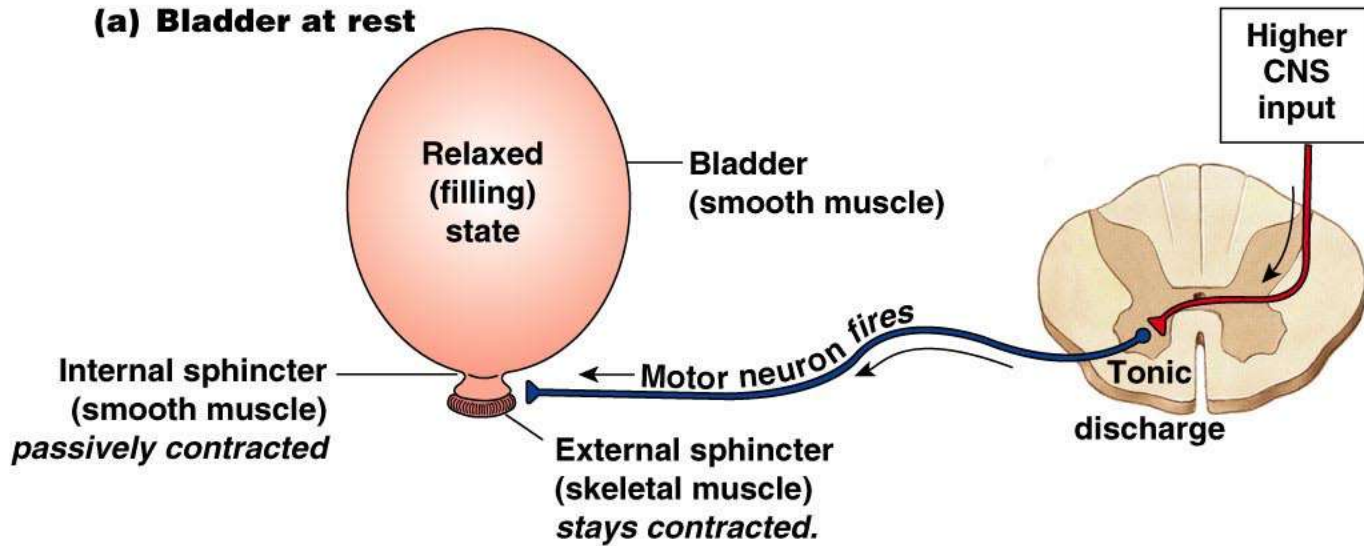
= 100 mL of  
plasma or filtrate

- ① Plasma concentration is 4/100 mL
- ② GFR = 100 mL/min
- ③ 100 mL plasma is reabsorbed.
- ④ Clearance depends on renal handling of solute

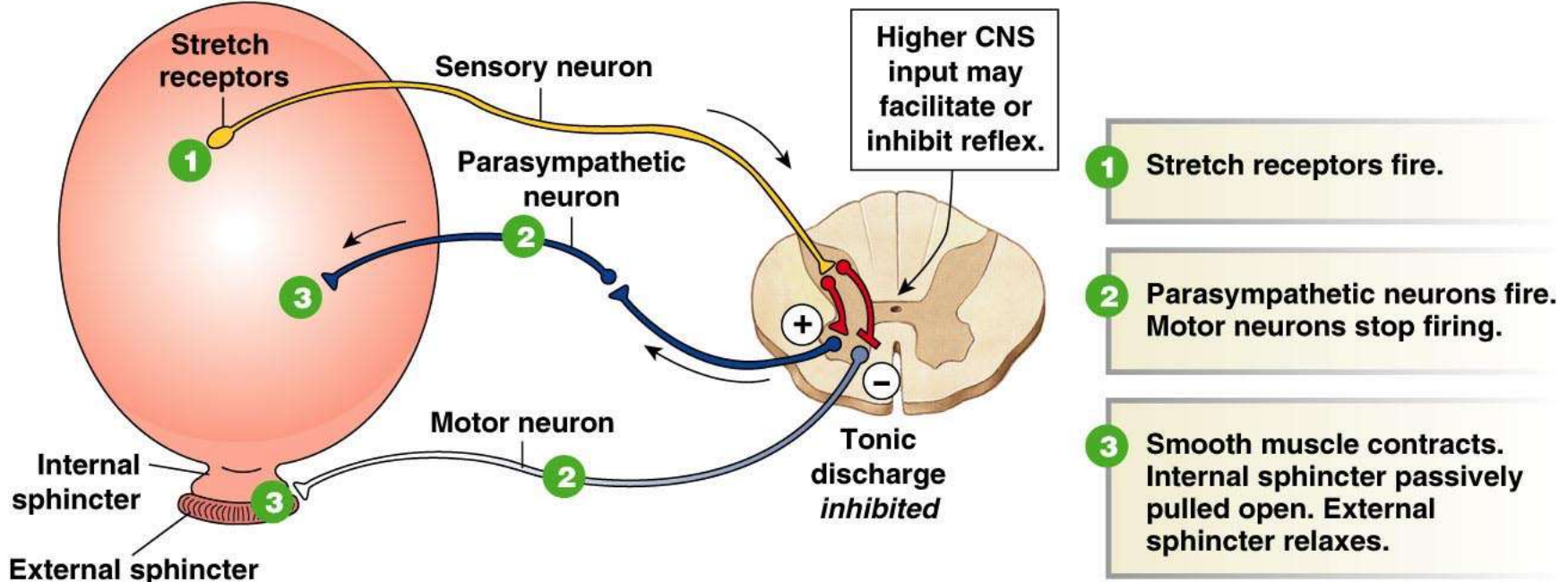
### (c) Penicillin clearance



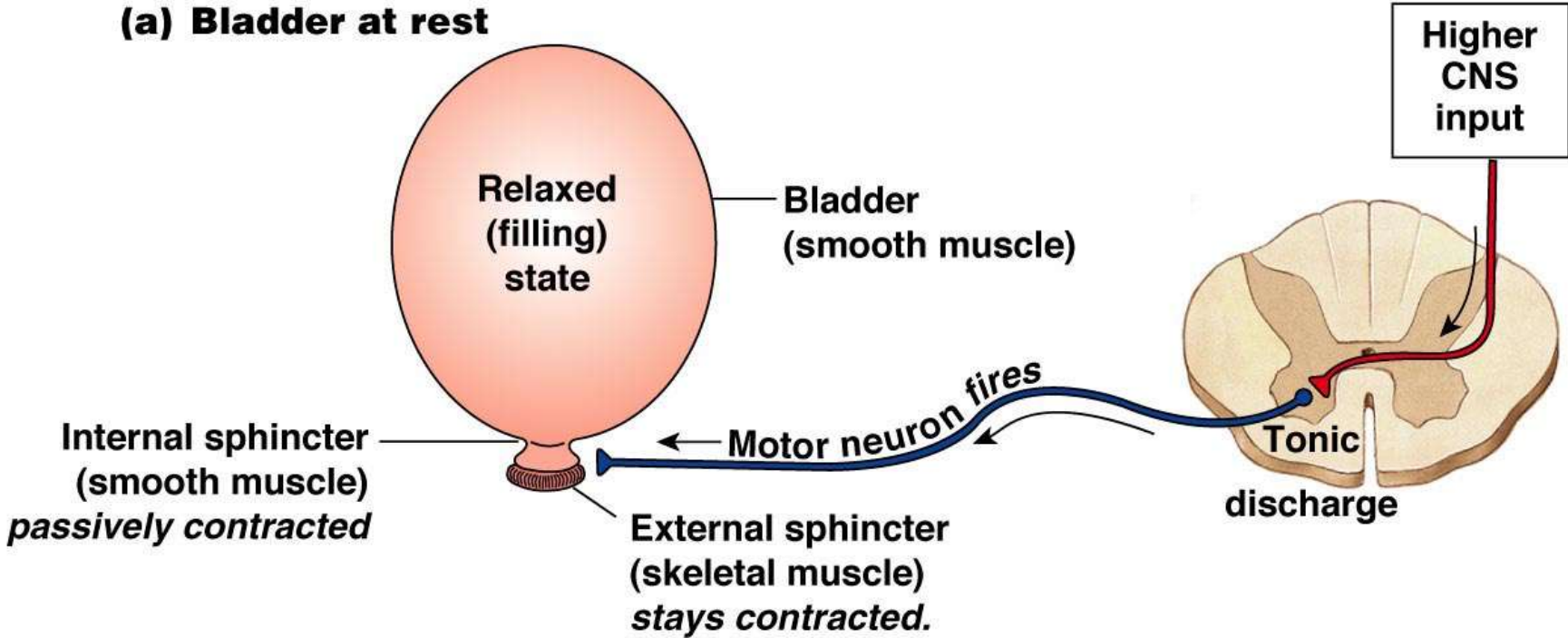
**(a) Bladder at rest**



**(b) Micturition**



**(a) Bladder at rest**



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Figure 19-18a

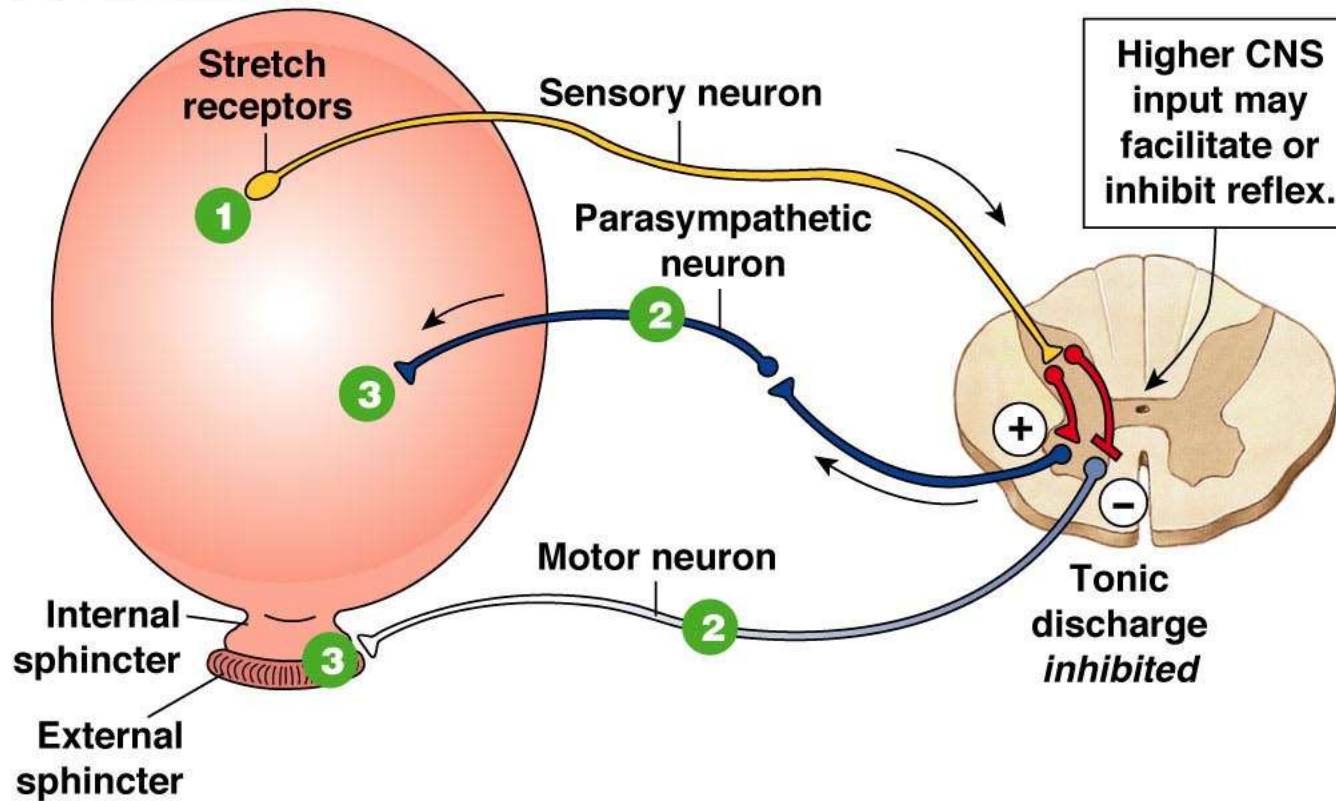


1 Stretch receptors fire.

2 Parasympathetic neurons fire. Motor neurons stop firing.

3 Smooth muscle contracts. Internal sphincter passively pulled open. External sphincter relaxes.

### (b) Micturition

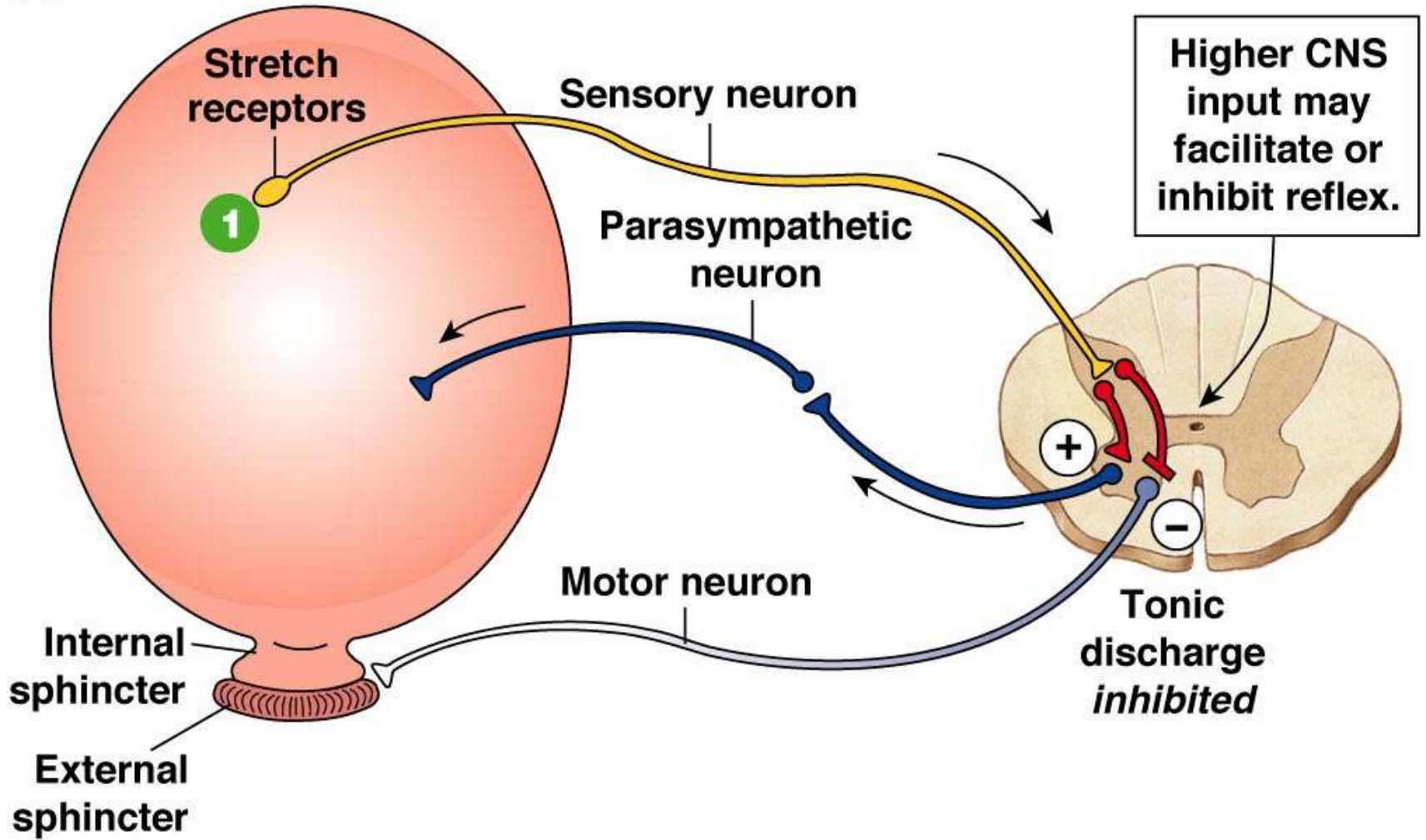


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Figure 19-18b - Overview

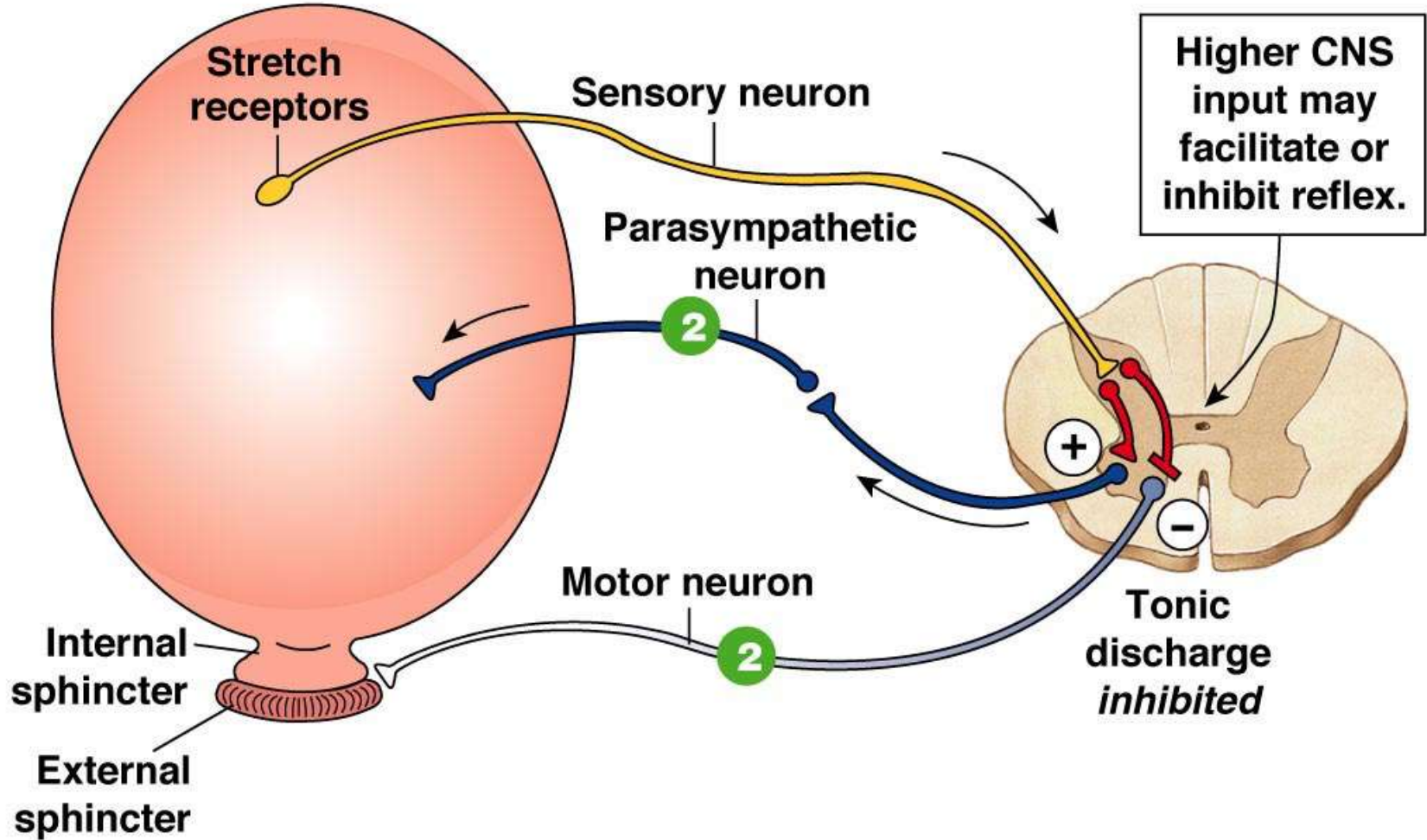
**(b) Micturition**

**1** Stretch receptors fire.



**2** Parasympathetic neurons fire.  
Motor neurons stop firing.

**(b) Micturition**



**3** Smooth muscle contracts. Internal sphincter passively pulled open. External sphincter relaxes.

**(b) Micturition**

