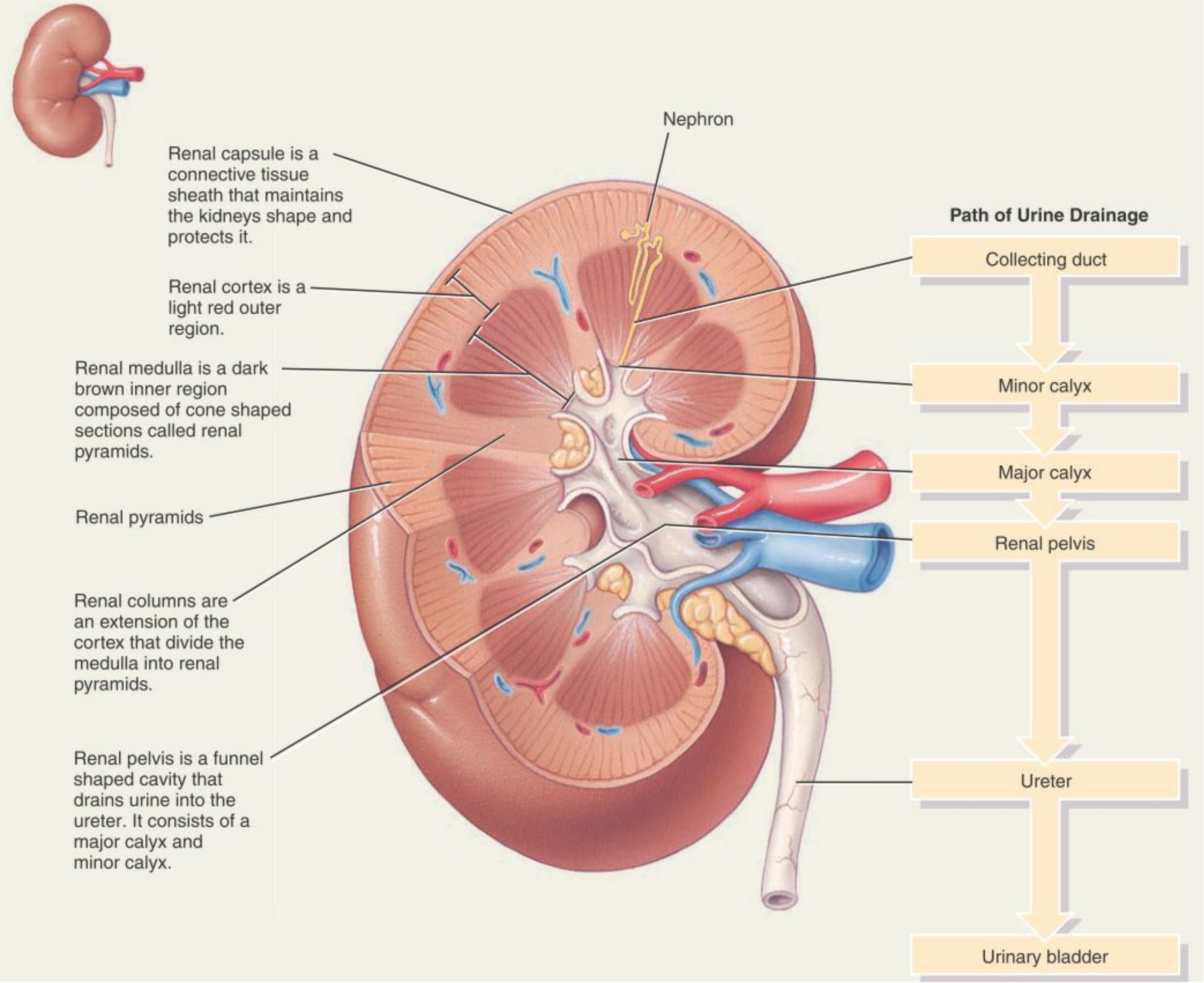
Физиология почек



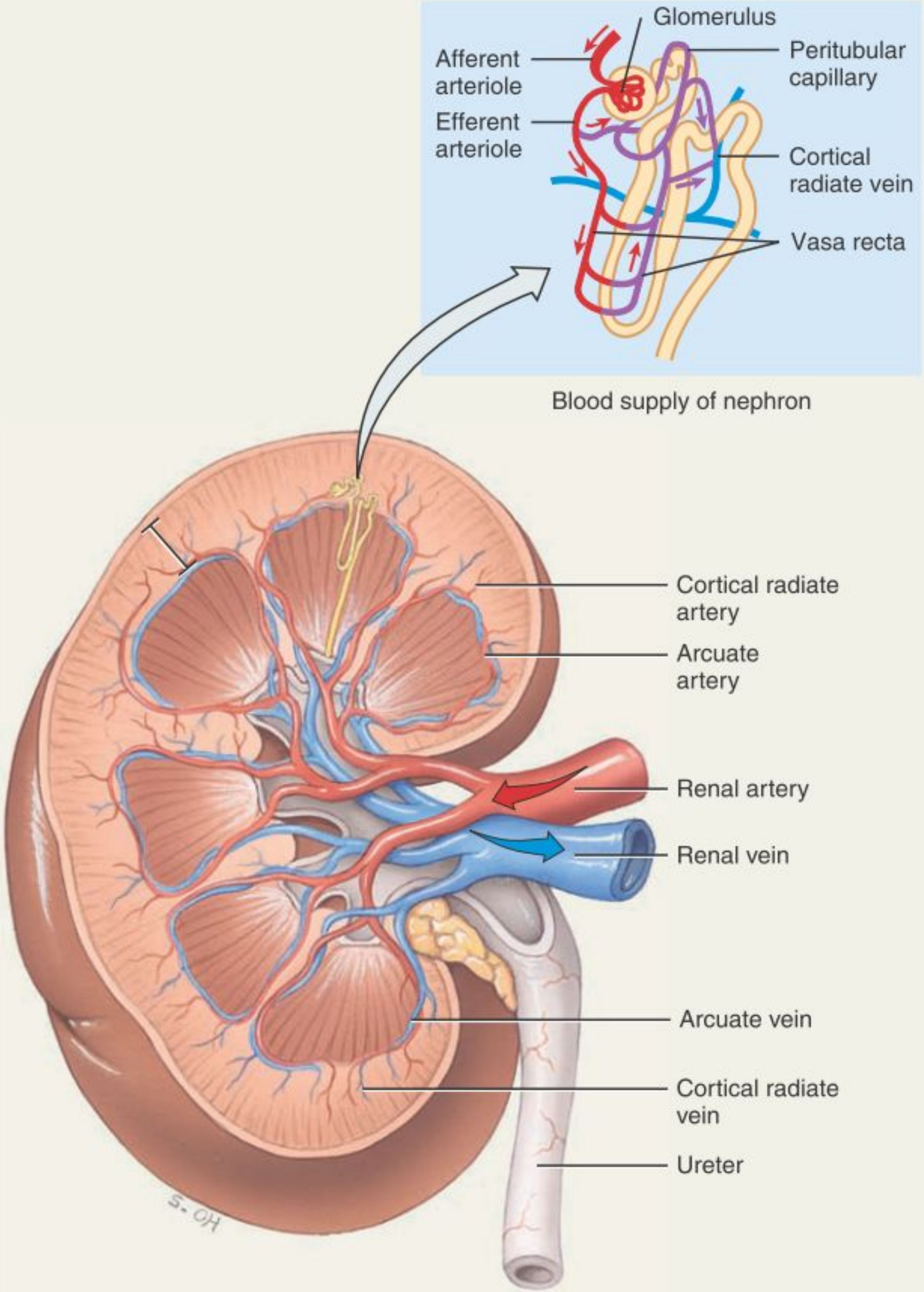
Renal capsule is a connective tissue sheath that maintains the kidneys shape and protects it.

Renal cortex is a light red outer region.

Renal medulla is a dark brown inner region composed of cone shaped sections called renal pyramids.

Renal columns are an extension of the cortex that divide the medulla into renal pyramids.

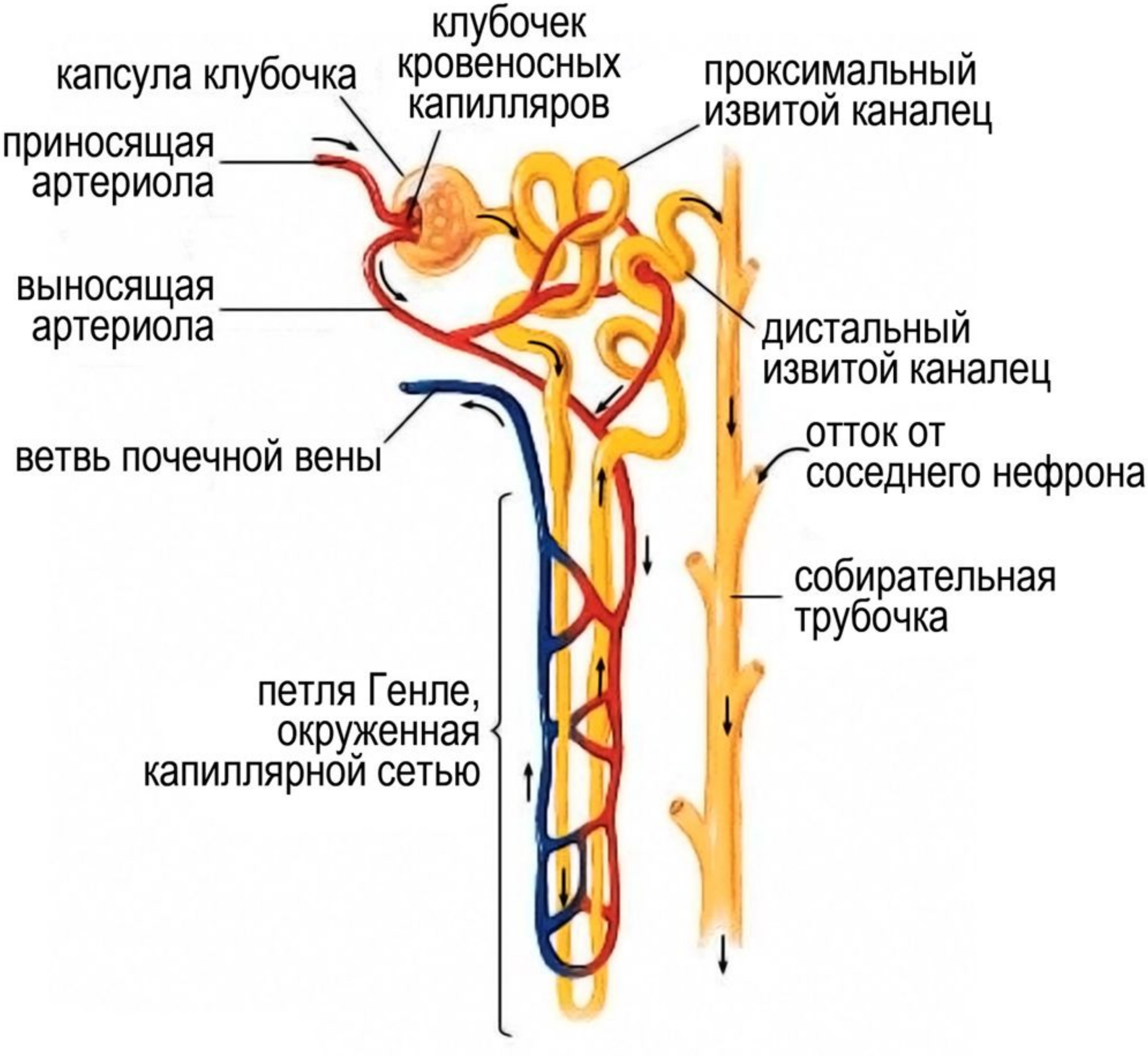
Renal pelvis is a funnel shaped cavity that drains urine into the ureter. It consists of a major calyx and minor calyx.

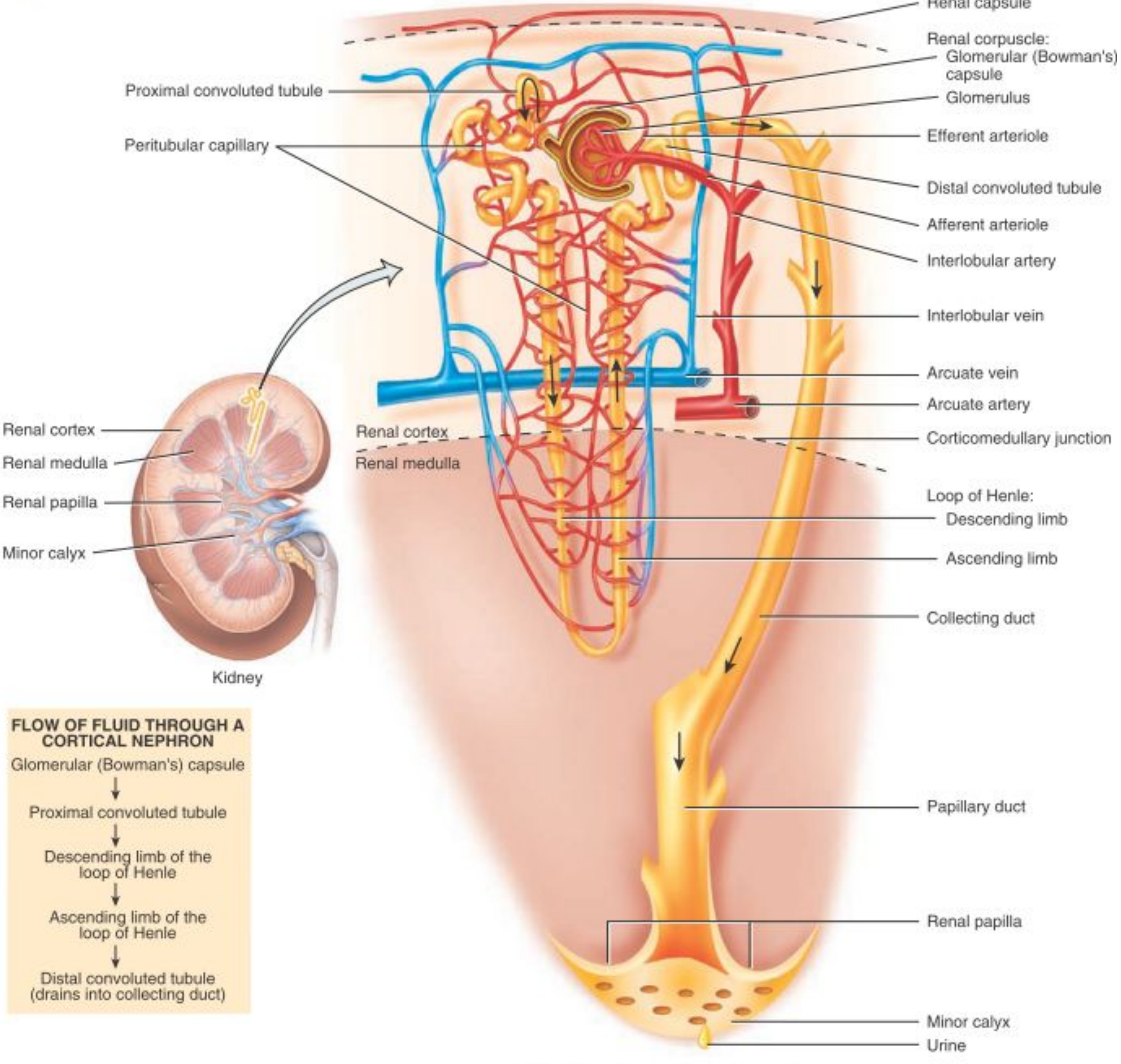


Blood supply of nephron

Path of Blood Flow

Renal artery
↓
Segmental arteries
↓
Cortical radiate arteries
↓
Arcuate arteries
↓
Cortical radiate arteries
↓
Afferent arterioles
↓
Glomerulus
↓
Efferent arterioles
↓
Peritubular capillaries
↓
Cortical radiate veins
↓
Arcuate veins
↓
Interlobar veins
↓
Renal vein

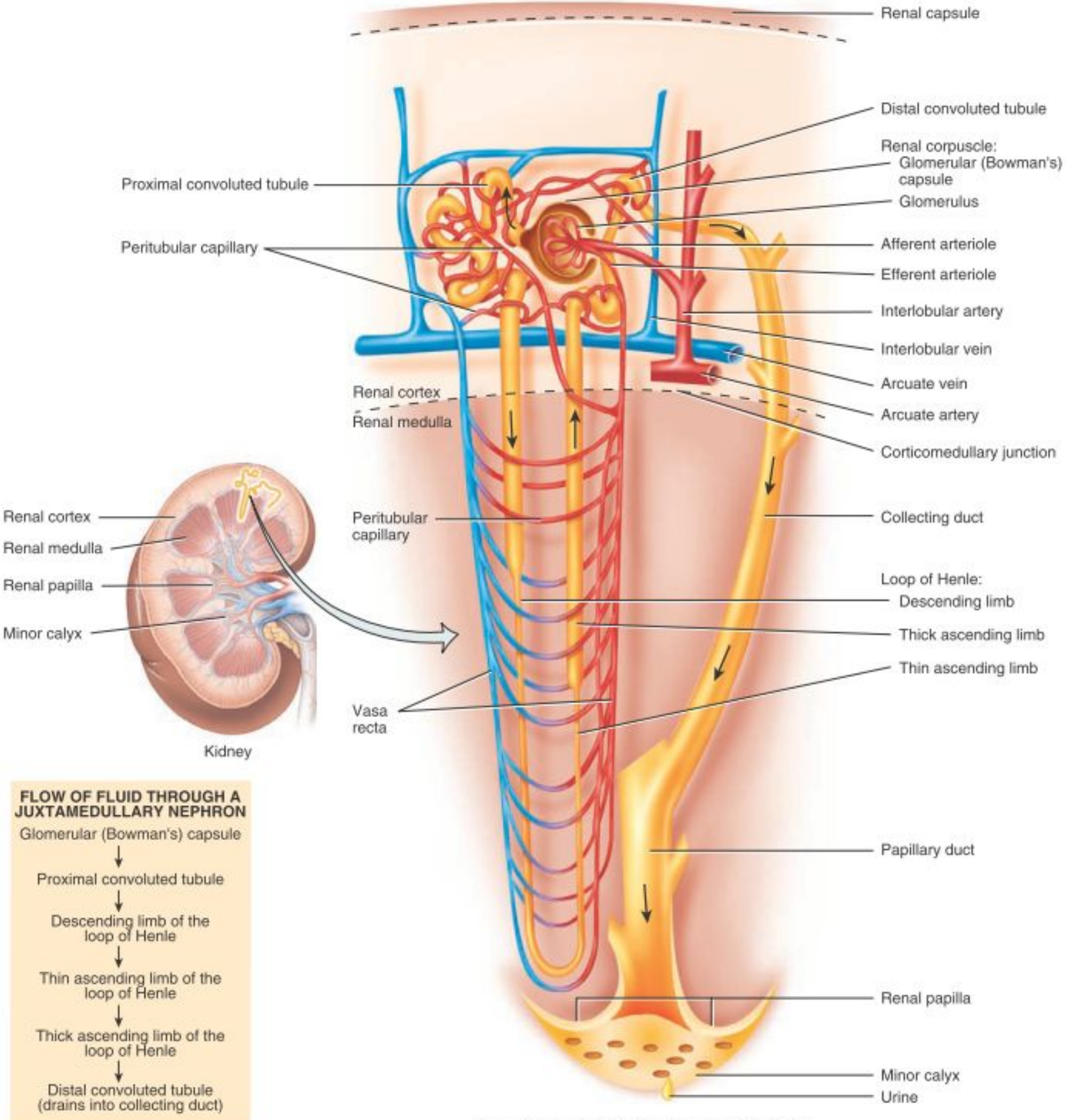

клубочек кровеносных капилляров
капсула клубочка
проксимальный извитой каналец
приносящая артериола
выносящая артериола
дистальный извитой каналец
ветвь почечной вены
отток от соседнего нефрона
собирательная трубочка
петля Генле, окруженная капиллярной сетью



FLOW OF FLUID THROUGH A CORTICAL NEPHRON

Glomerular (Bowman's) capsule
↓
Proximal convoluted tubule
↓
Descending limb of the loop of Henle
↓
Ascending limb of the loop of Henle
↓
Distal convoluted tubule (drains into collecting duct)

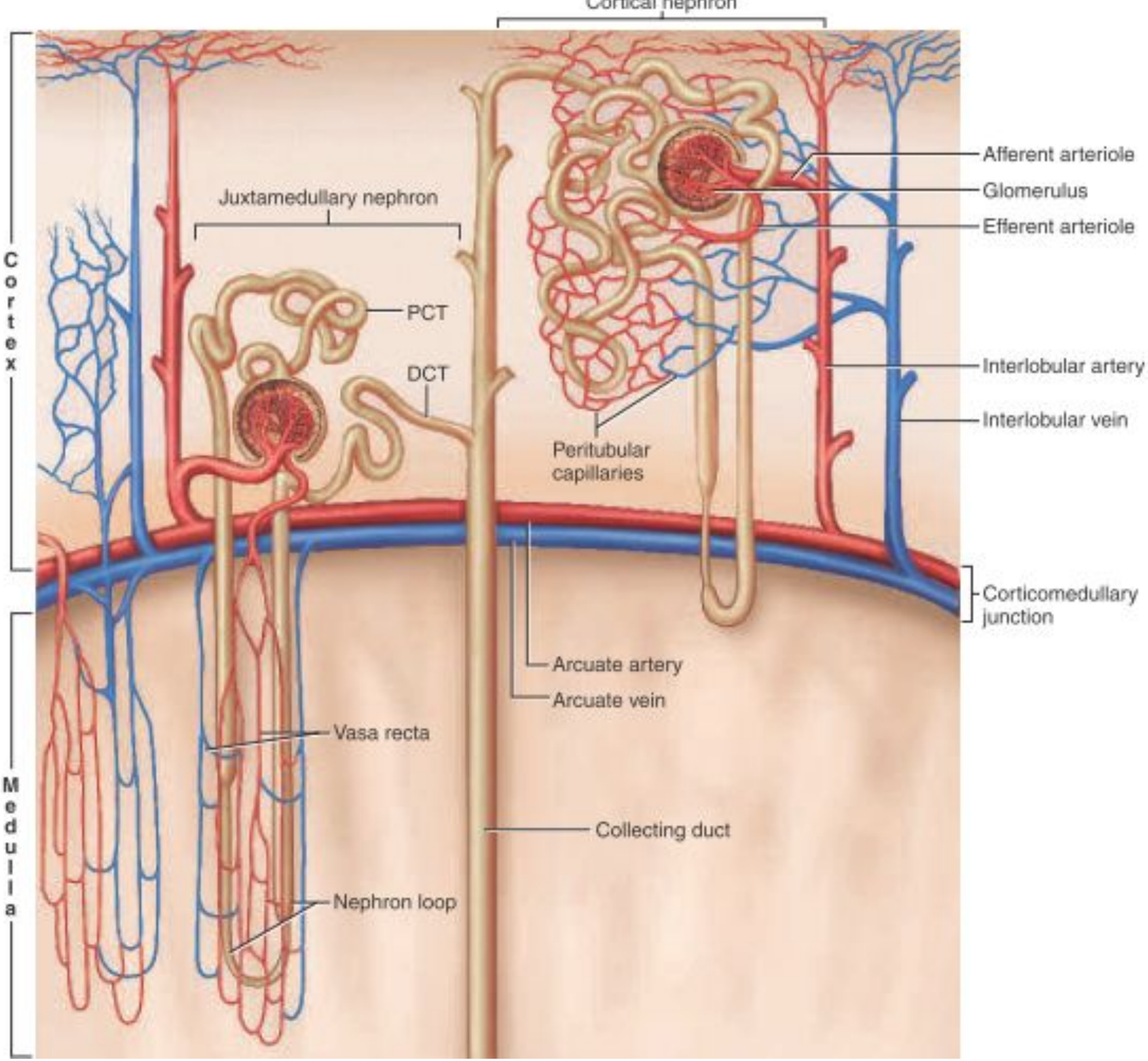
(a) Cortical nephron and vascular supply

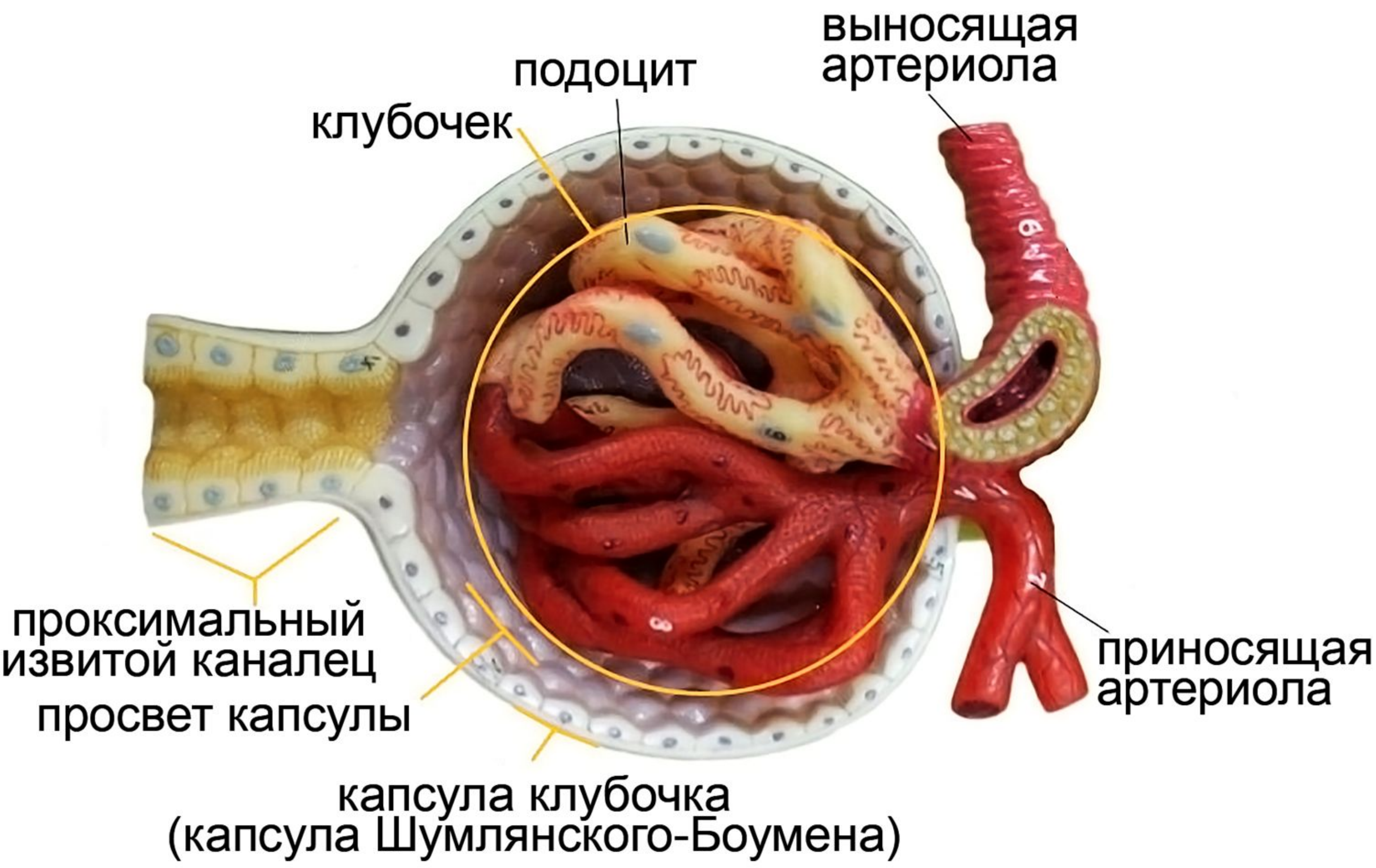


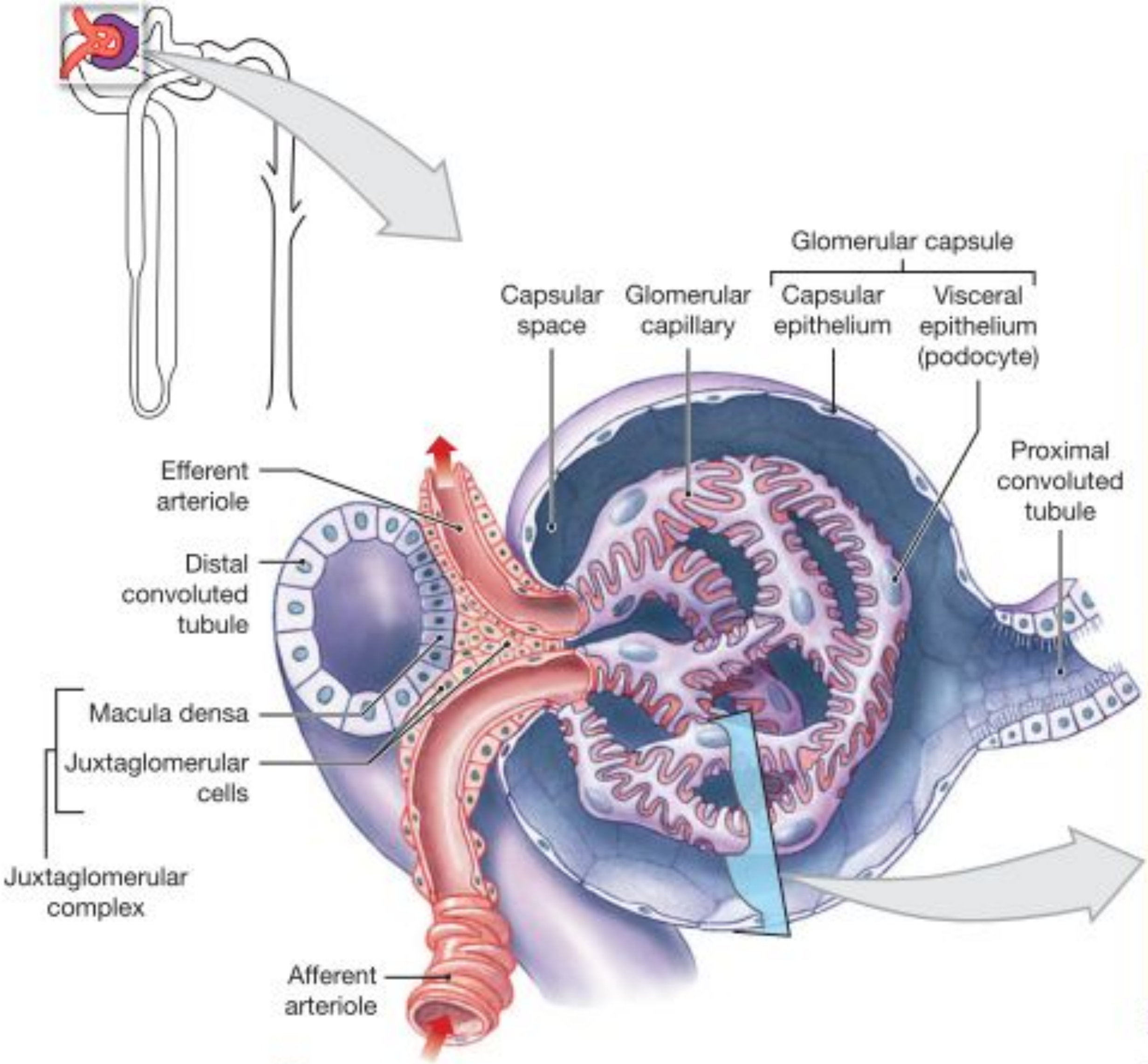
FLOW OF FLUID THROUGH A JUXTAMEDULLARY NEPHRON

Glomerular (Bowman's) capsule
↓
Proximal convoluted tubule
↓
Descending limb of the loop of Henle
↓
Thin ascending limb of the loop of Henle
↓
Thick ascending limb of the loop of Henle
↓
Distal convoluted tubule (drains into collecting duct)

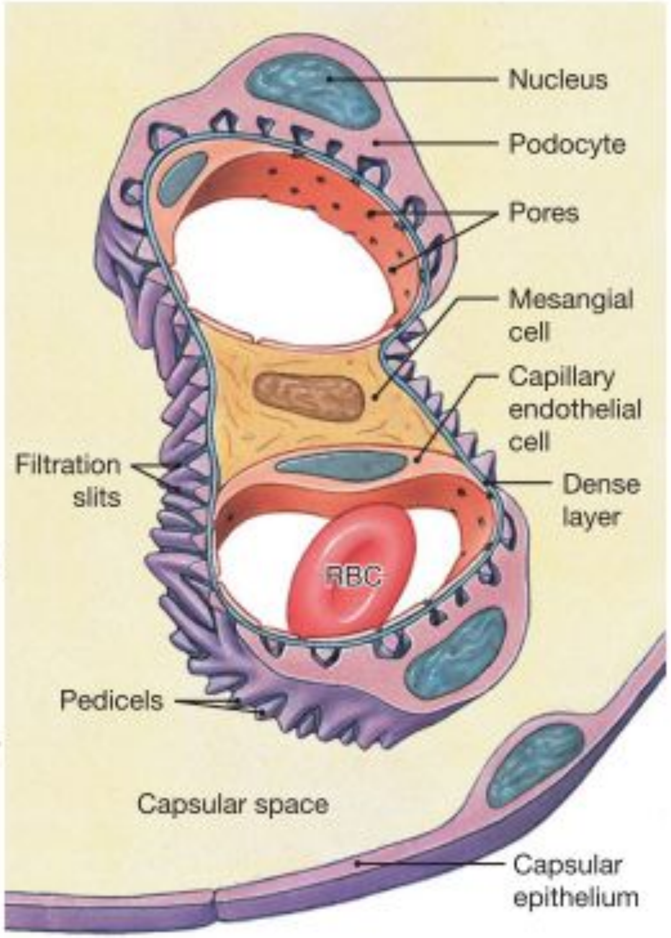
(b) Juxtamedullary nephron and vascular supply


Cortical nephron
Afferent arteriole
Glomerulus
Efferent arteriole
Juxtamedullary nephron
PCT
DCT
Cortex
Interlobular artery
Interlobular vein
Peritubular capillaries
Corticomedullary junction
Arcuate artery
Arcuate vein
Vasa recta
Collecting duct
Nephron loop
Medulla

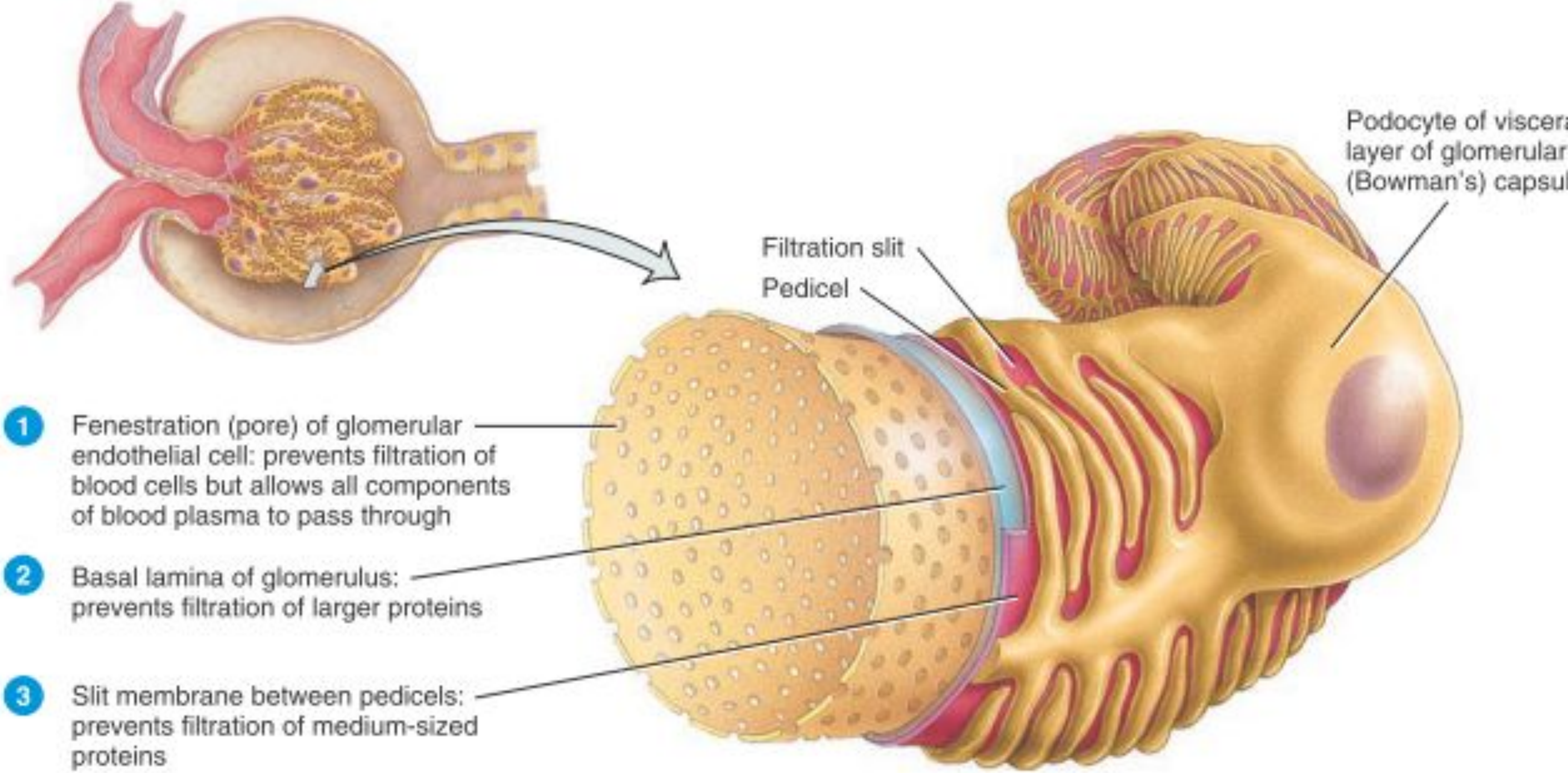

выносящая артериола
подоцит
клубочек
проксимальный извитой каналец
просвет капсулы
капсула клубочка (капсула Шумлянского-Боумена)
приносящая артериола



a Important structural features of a renal corpuscle

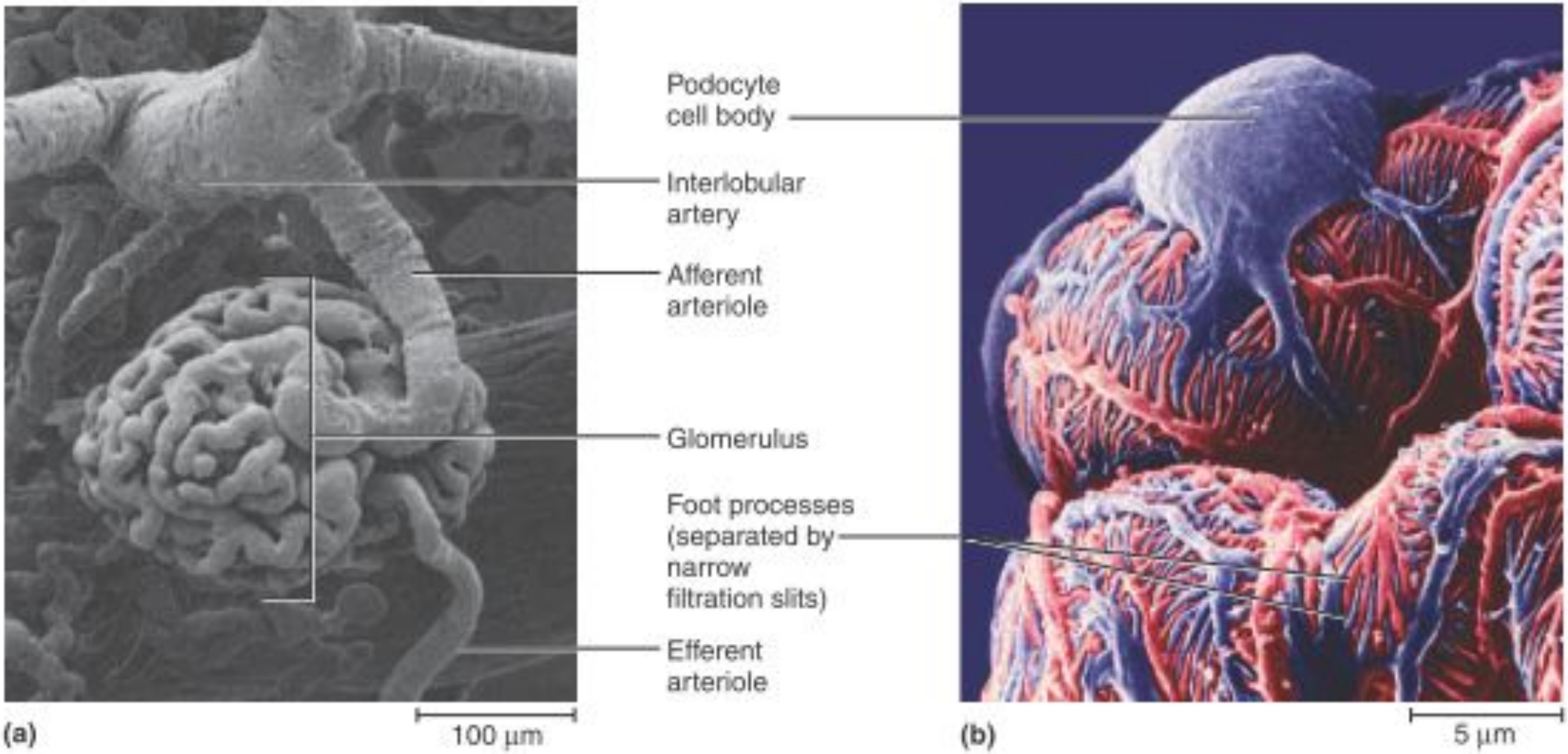


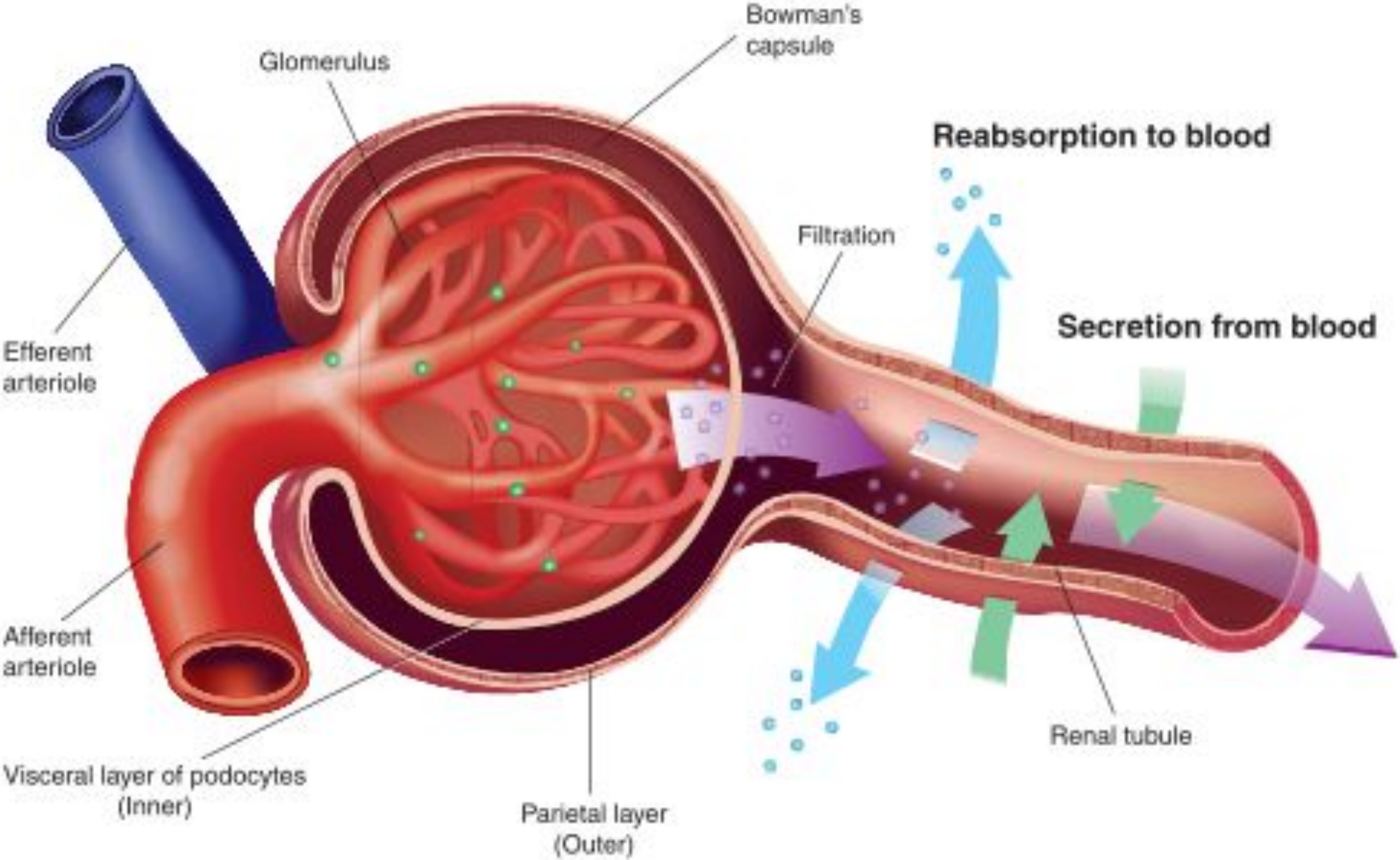
b This cross section through a segment of the glomerulus shows the components of the filtration membrane of the nephron.

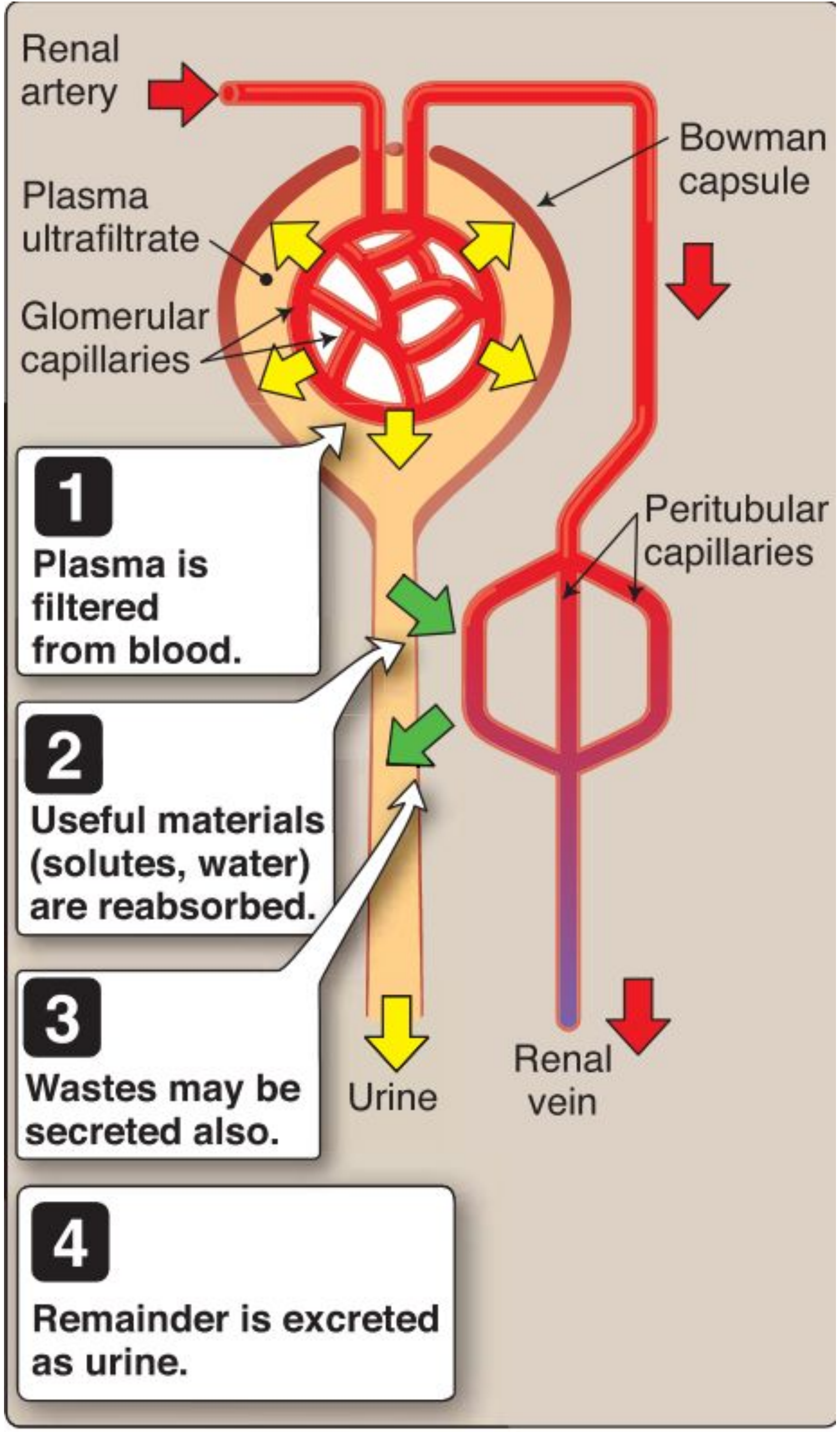


1. Fenestration (pore) of glomerular endothelial cell: prevents filtration of blood cells but allows all components of blood plasma to pass through
2. Basal lamina of glomerulus: prevents filtration of larger proteins
3. Slit membrane between pedicels: prevents filtration of medium-sized proteins

(a) Details of filtration membrane


Podocyte cell body
Interlobular artery
Afferent arteriole
Glomerulus
Foot processes (separated by narrow filtration slits)
Efferent arteriole
(a)
100 µm
(b)
5 µm


Glomerulus
Bowman's capsule
Reabsorption to blood
Filtration
Secretion from blood
Efferent arteriole
Afferent arteriole
Visceral layer of podocytes (Inner)
Parietal layer (Outer)
Renal tubule



1

Plasma is filtered from blood.

2

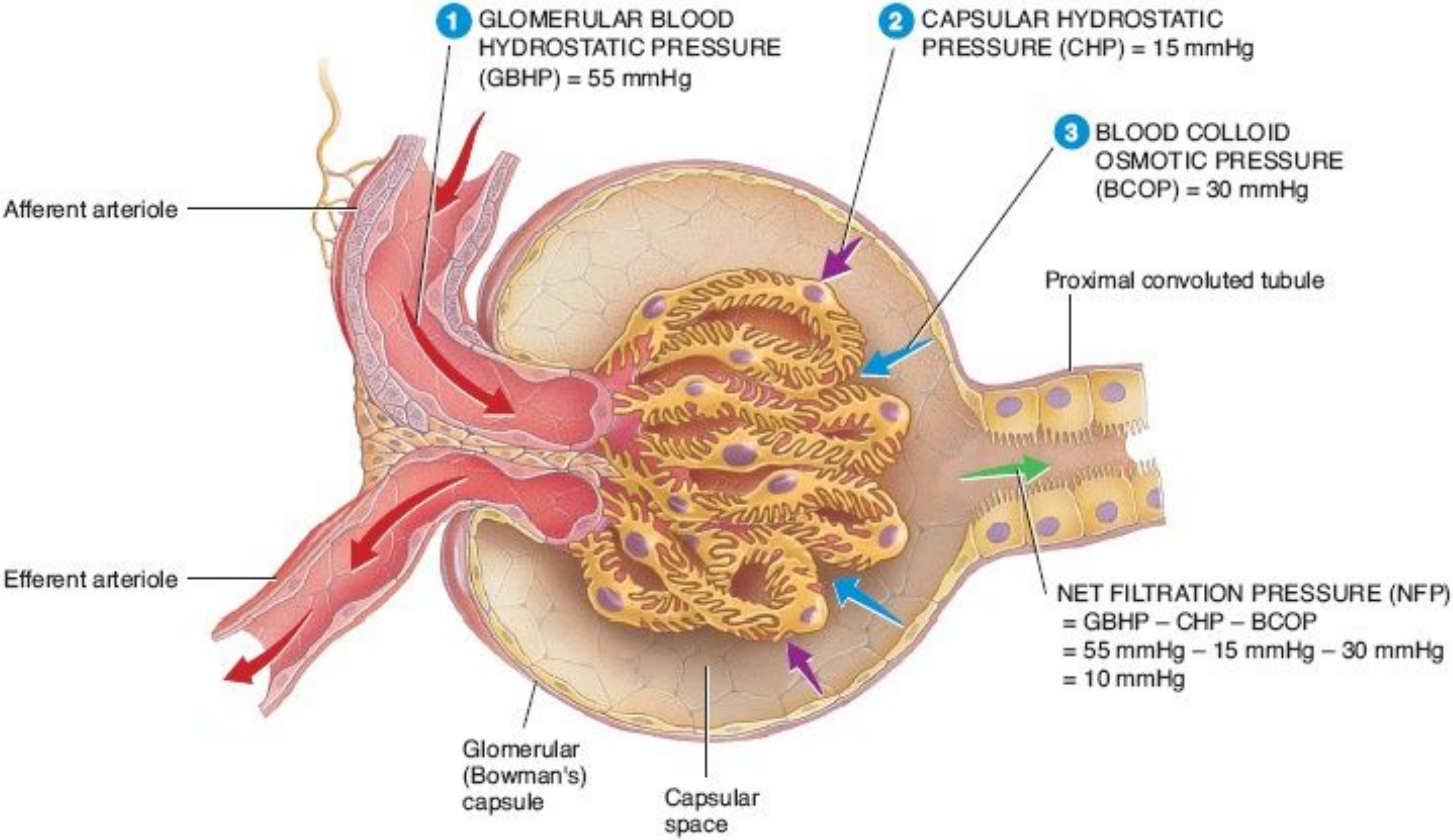
Useful materials (solutes, water) are reabsorbed.

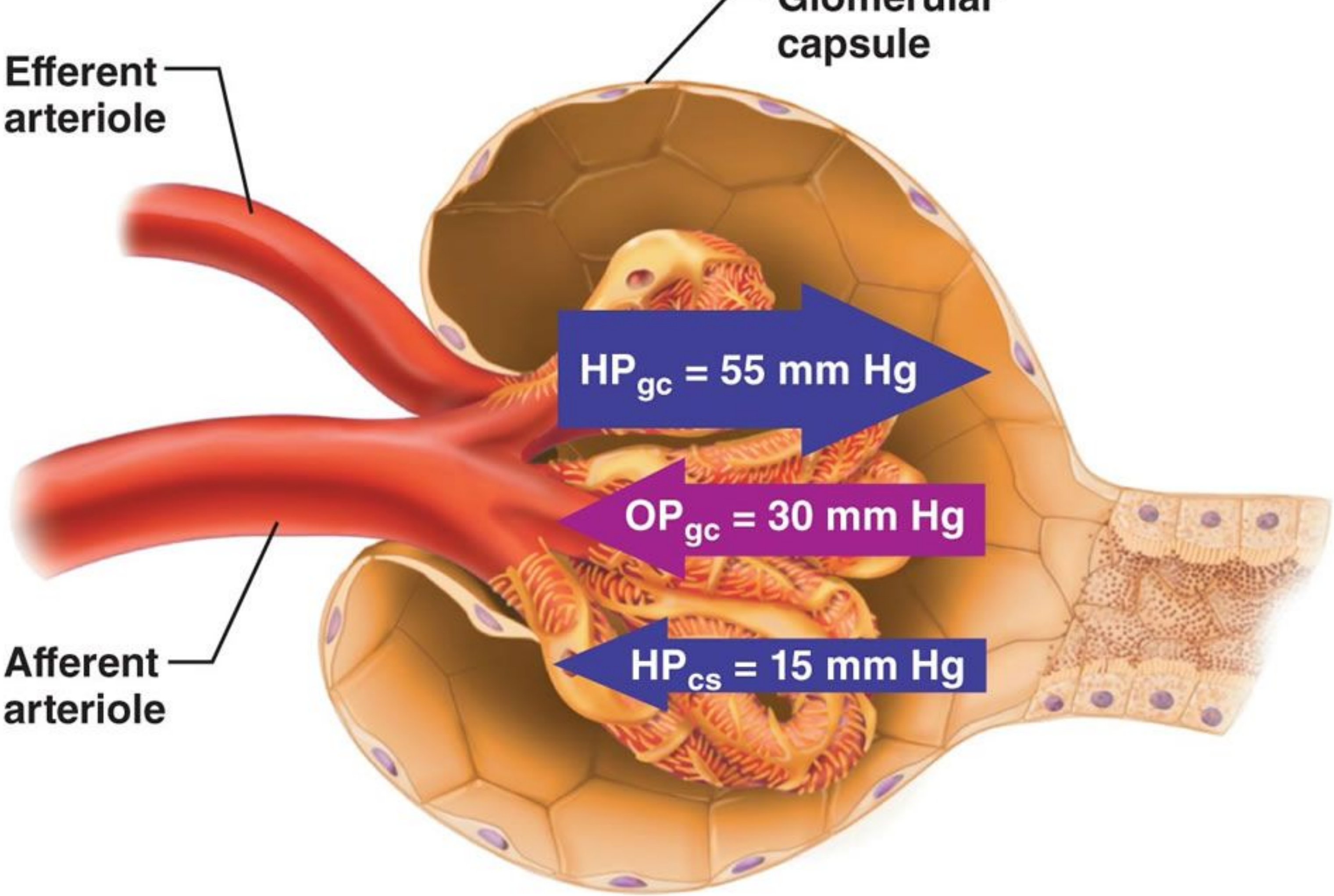
3

Wastes may be secreted also.

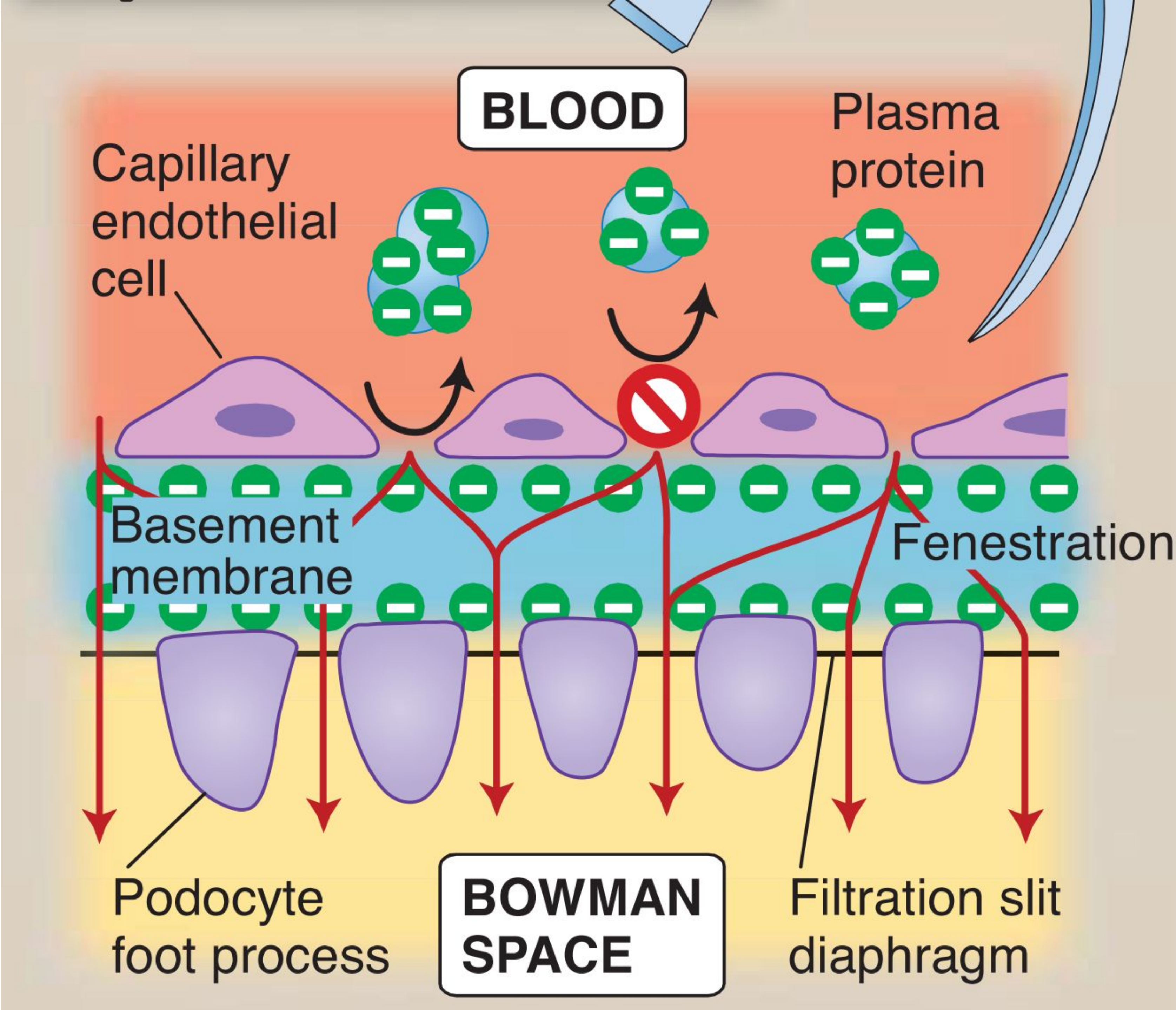
4

Remainder is excreted as urine.

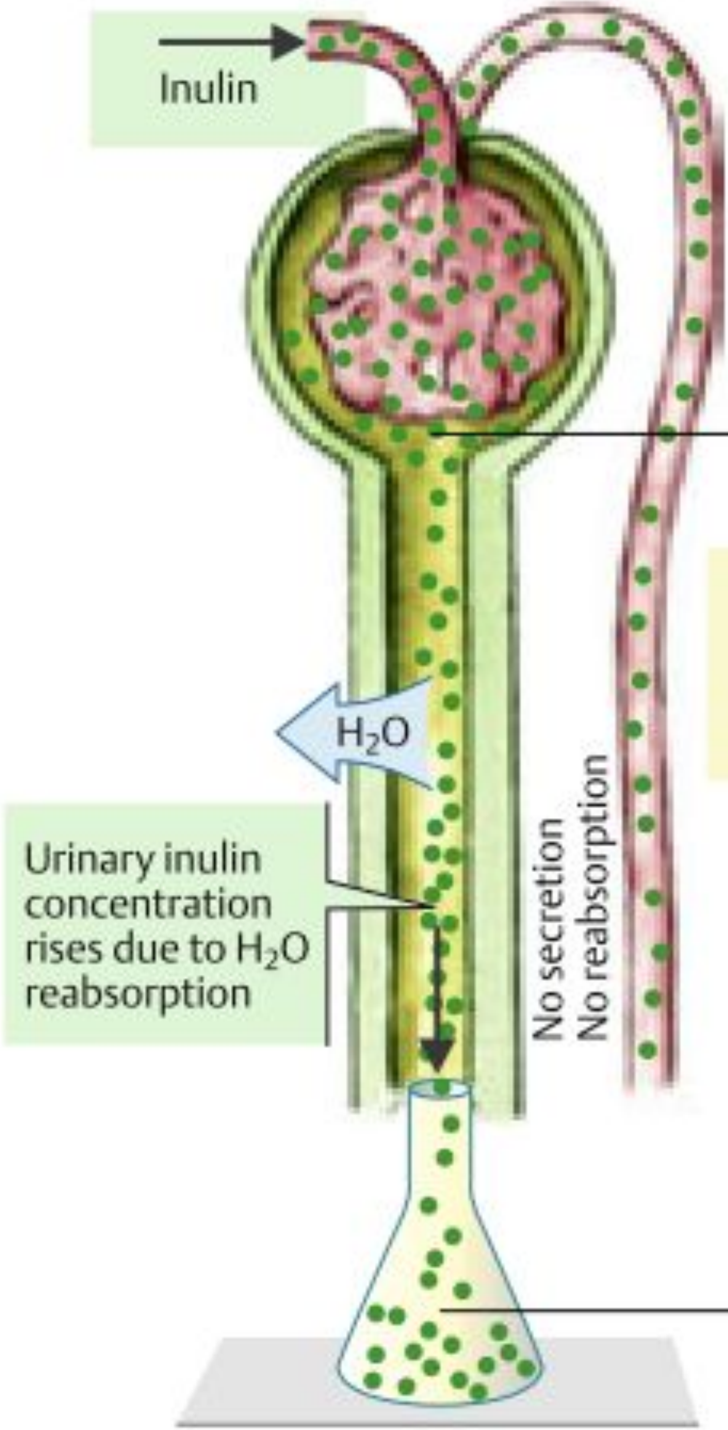

① GLOMERULAR BLOOD HYDROSTATIC PRESSURE (GBHP) = 55 mmHg
② CAPSULAR HYDROSTATIC PRESSURE (CHP) = 15 mmHg
③ BLOOD COLLOID OSMOTIC PRESSURE (BCOP) = 30 mmHg
Afferent arteriole
Proximal convoluted tubule
Efferent arteriole
NET FILTRATION PRESSURE (NFP)
= GBHP – CHP – BCOP
= 55 mmHg – 15 mmHg – 30 mmHg
= 10 mmHg
Glomerular (Bowman's) capsule
Capsular space



$$
\begin{aligned}
\text{NFP} &= \text{Net filtration pressure} \\
&= \text{outward pressures} - \text{inward pressures} \\
&= (HP_{gc}) - (HP_{cs} + OP_{gc}) \\
&= (55) - (15 + 30) \\
&= 10 \text{ mm Hg}
\end{aligned}
$$


BLOOD
Capillary endothelial cell
Plasma protein
Basement membrane
Fenestration
Podocyte foot process
BOWMAN SPACE
Filtration slit diaphragm

Substance	Molecular Weight (Da)	Molecular Radius (nm)	Permeability*
Na^+	23	0.10	1.0
Water	18	0.15	1.0
Glucose	180	0.33	1.0
Inulin	5,000	1.48	0.98
Myoglobin	17,000	1.88	0.75
Hemoglobin	68,000	3.25	0.03
Serum albumin	69,000	3.55	<0.01



Amount excreted/time
=
Urinary inulin concentration
· (urine volume/time)

=
↓
=

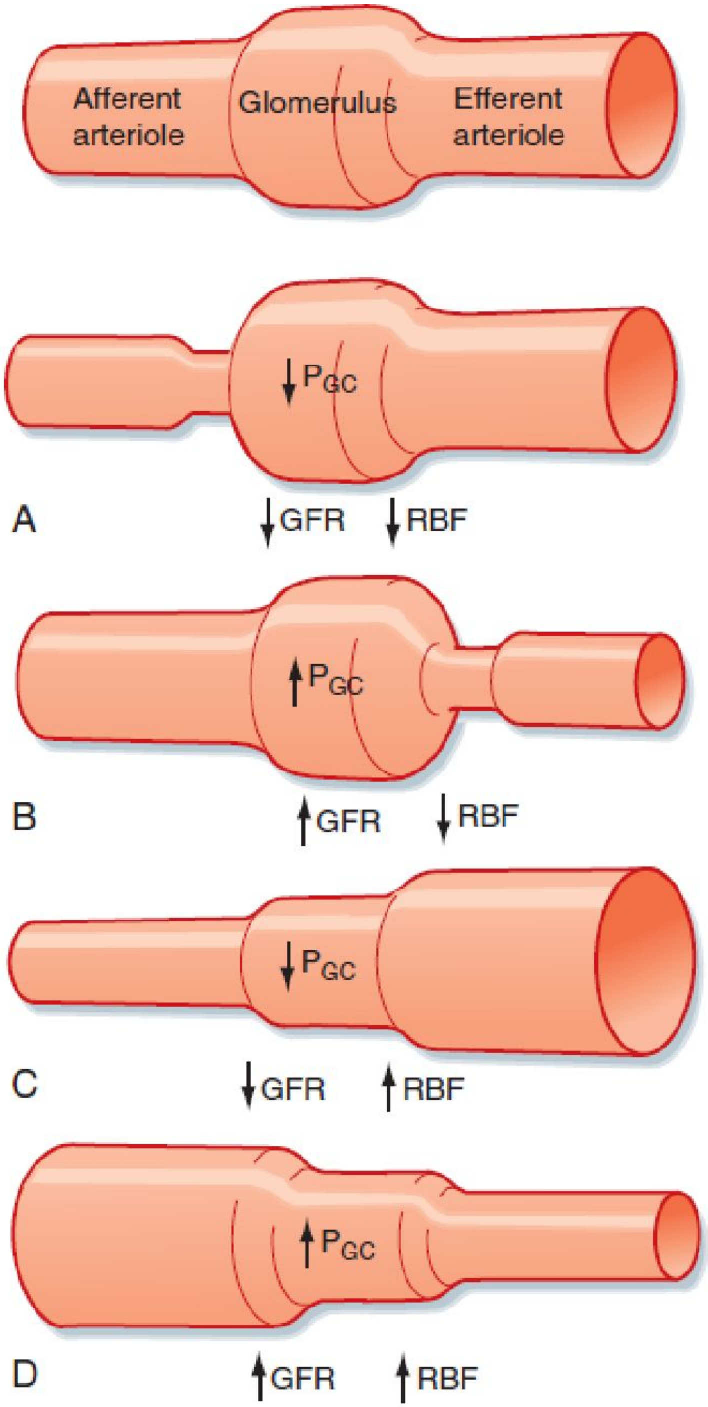
Amount filtered/time
=
Plasma inulin concentration
· (filtered volume/time)

$U_{In}\,(g/L) \cdot \dot{V}_U\,(mL/min) = P_{In}\,(g/L) \cdot GFR\,(mL/min)$

↓

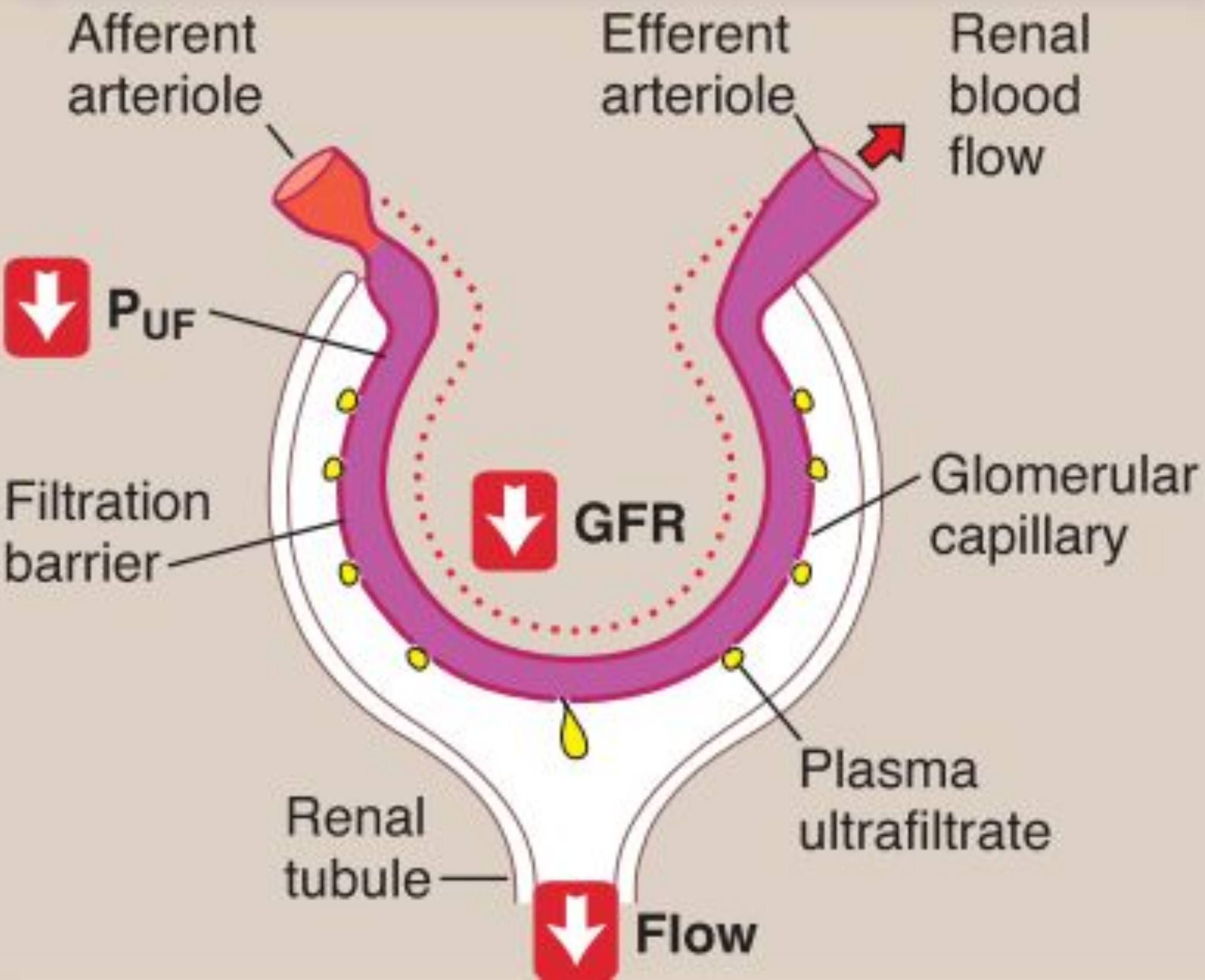
$$GFR = \frac{U_{In}}{P_{In}} \cdot \dot{V}_U \text{ (mL/min)}$$

GFR ≈ ca. 120 mL/min
per $1.73\,m^2$ body surface area

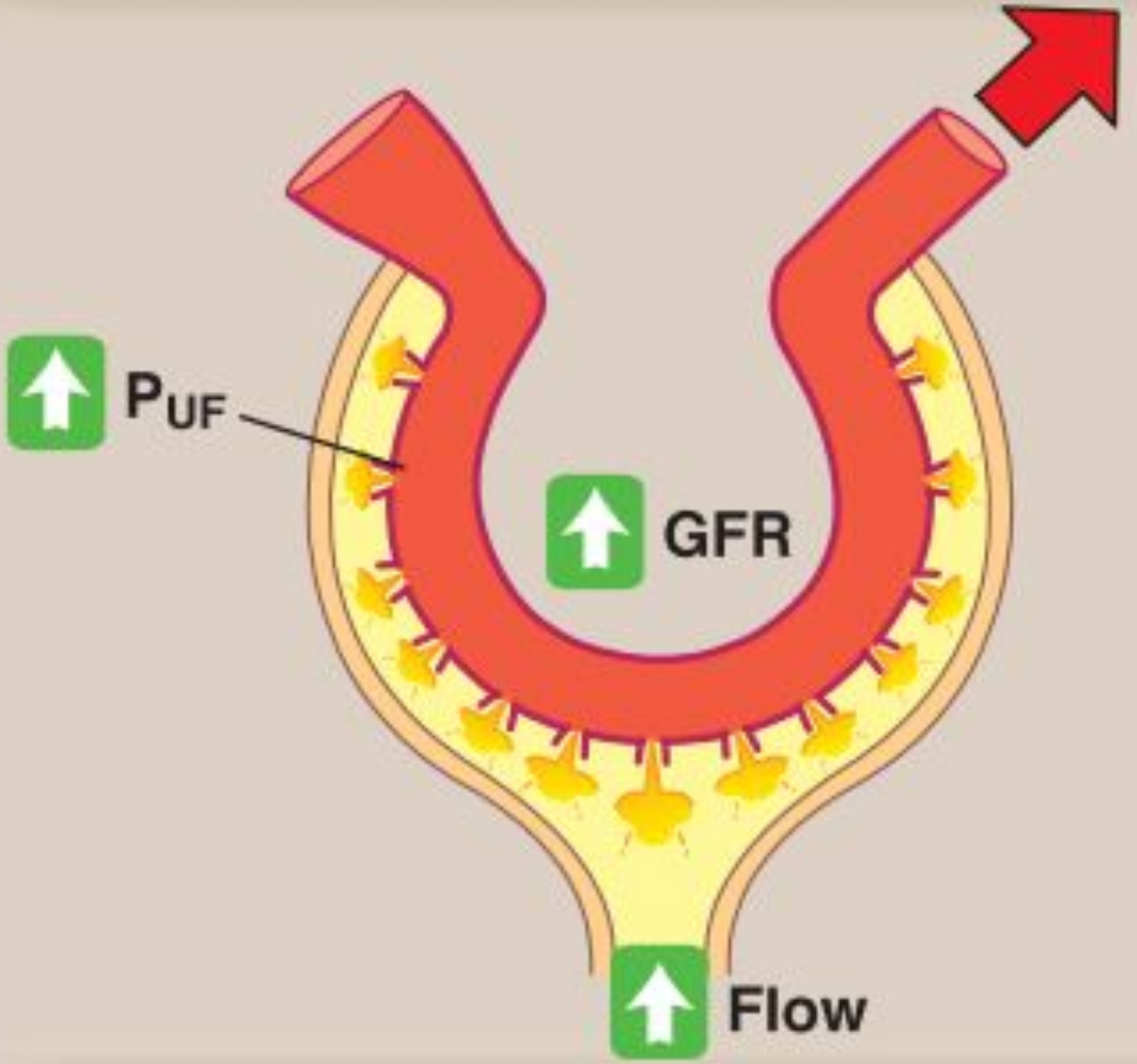

Afferent arteriole
Glomerulus
Efferent arteriole
↓P$_{GC}$
A
↓GFR
↓RBF
↑P$_{GC}$
B
↑GFR
↓RBF
↓P$_{GC}$
C
↓GFR
↑RBF
↑P$_{GC}$
D
↑GFR
↑RBF

AFFERENT ARTERIOLE

Constriction: **Reduces filtration pressure (P_{UF}). GFR falls.**

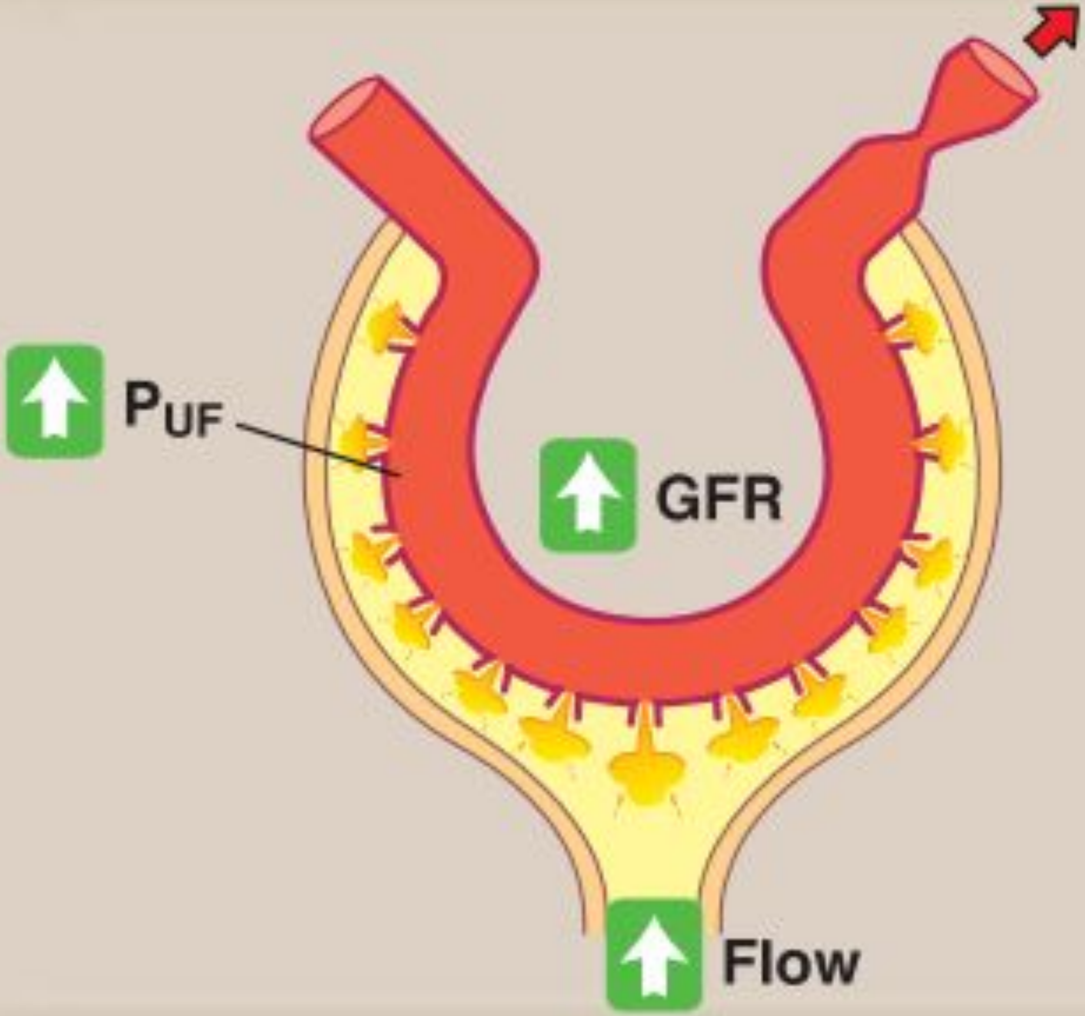


Dilation: Increases the pressure driving ultrafiltration. GFR increases.



EFFERENT ARTERIOLE

Constriction: Causes pressure to back up within the capillary. GFR increases.



Dilation: **Allows blood to easily escape the capillary and pressure falls. GFR decreases.**

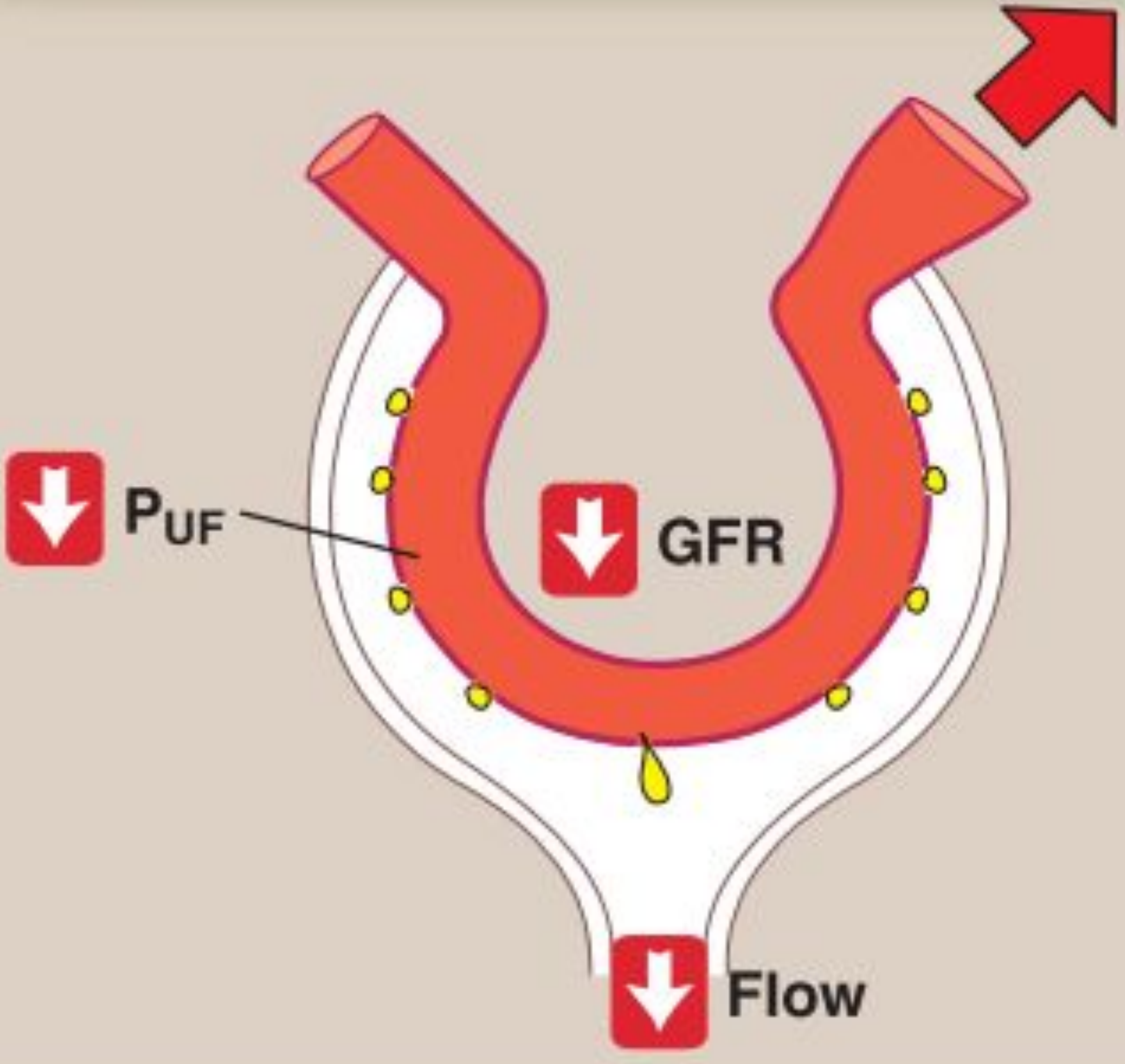
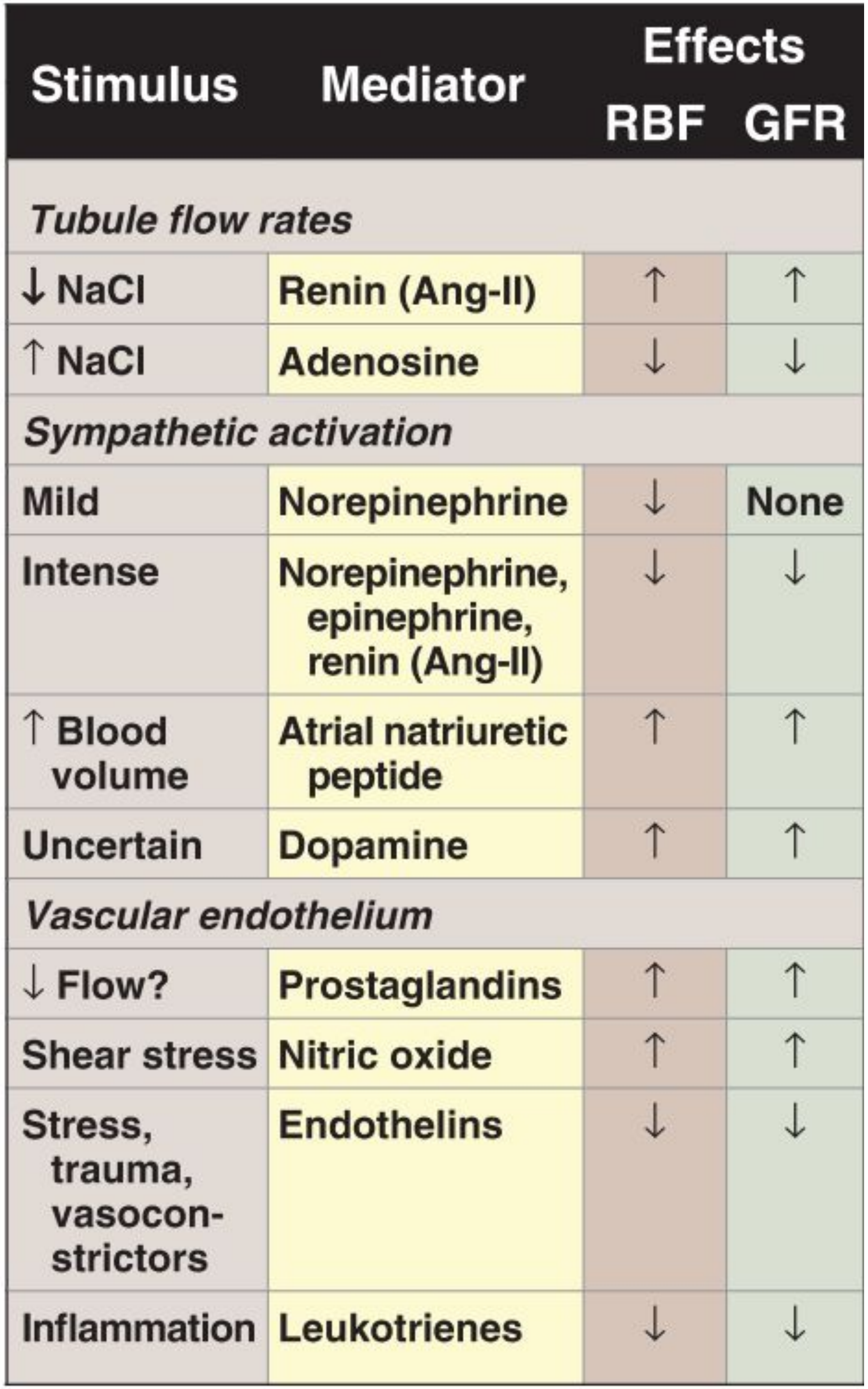


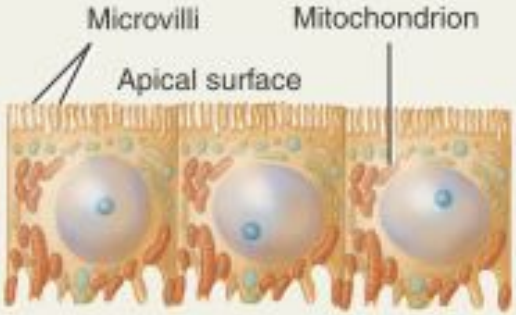
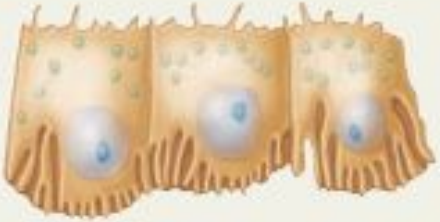
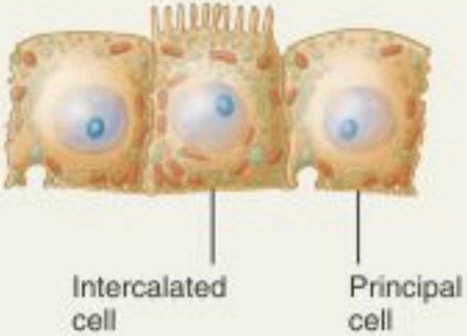
TABLE 38–3 **Agents causing contraction or relaxation of mesangial cells.**

Contraction	Relaxation
Endothelins	ANP
Angiotensin II	Dopamine
Vasopressin	PGE_2
Norepinephrine	cAMP
Platelet-activating factor	
Platelet-derived growth factor	
Thromboxane A_2	
PGF_2	
Leukotrienes C_4 and D_4	
Histamine	



Stimulus	Mediator	Effects	
		RBF	GFR
Tubule flow rates			
↓ NaCl	Renin (Ang-II)	↑	↑
↑ NaCl	Adenosine	↓	↓
Sympathetic activation			
Mild	Norepinephrine	↓	None
Intense	Norepinephrine, epinephrine, renin (Ang-II)	↓	↓
↑ Blood volume	Atrial natriuretic peptide	↑	↑
Uncertain	Dopamine	↑	↑
Vascular endothelium			
↓ Flow?	Prostaglandins	↑	↑
Shear stress	Nitric oxide	↑	↑
Stress, trauma, vasoconstrictors	Endothelins	↓	↓
Inflammation	Leukotrienes	↓	↓

Histological Features of the Renal Tubule and Collecting Duct

REGION AND HISTOLOGY		DESCRIPTION
Proximal convoluted tubule (PCT)		Simple cuboidal epithelial cells with prominent brush borders of microvilli.
Loop of Henle: descending limb and thin ascending limb		Simple squamous epithelial cells.
Loop of Henle: thick ascending limb		Simple cuboidal to low columnar epithelial cells.
Most of distal convoluted tubule (DCT)		Simple cuboidal epithelial cells.
Last part of DCT and all of collecting duct (CD)		Simple cuboidal epithelium consisting of principal cells and intercalated cells.

Объем канальцевой жидкости, % СКФ
100
75
50
25
0
КЖ/П
1
2
3
5
10
20
100
Проксимальный нефрон
Дистальный нефрон
Проксимальный извитой каналец
Прямая часть
Тонкий
Толстый сегмент
Дистальный извитой каналец
Собирательная трубочка
Петля Генле
Максимальный водный диурез
Максимальный антидиурез
0
25
50
75
100
Относительная длина участка нефрона, %

	Per 24 Hours				
Substance	**Filtered**	**Reabsorbed**	**Secreted**	**Excreted**	**Percentage Reabsorbed**
Na^+ (mEq)	26,000	25,850		150	99.4
K^+ (mEq)	600	560[a]	502	90	93.3
Cl^- (mEq)	18,000	17,850		150	99.2
HCO_3^- (mEq)	4,900	4,900		0	100
Urea (mmol)	870	460[b]		410	53
Creatinine (mmol)	12	1[c]	1[c]	12	
Uric acid (mmol)	50	49	4	5	98
Glucose (mmol)	800	800		0	100
Total solute (mOsm)	54,000	53,400	100	700	98.9
Water (mL)	180,000	179,000		1000	99.4

TABLE 34.4

NaCl Transport Along the Nephron

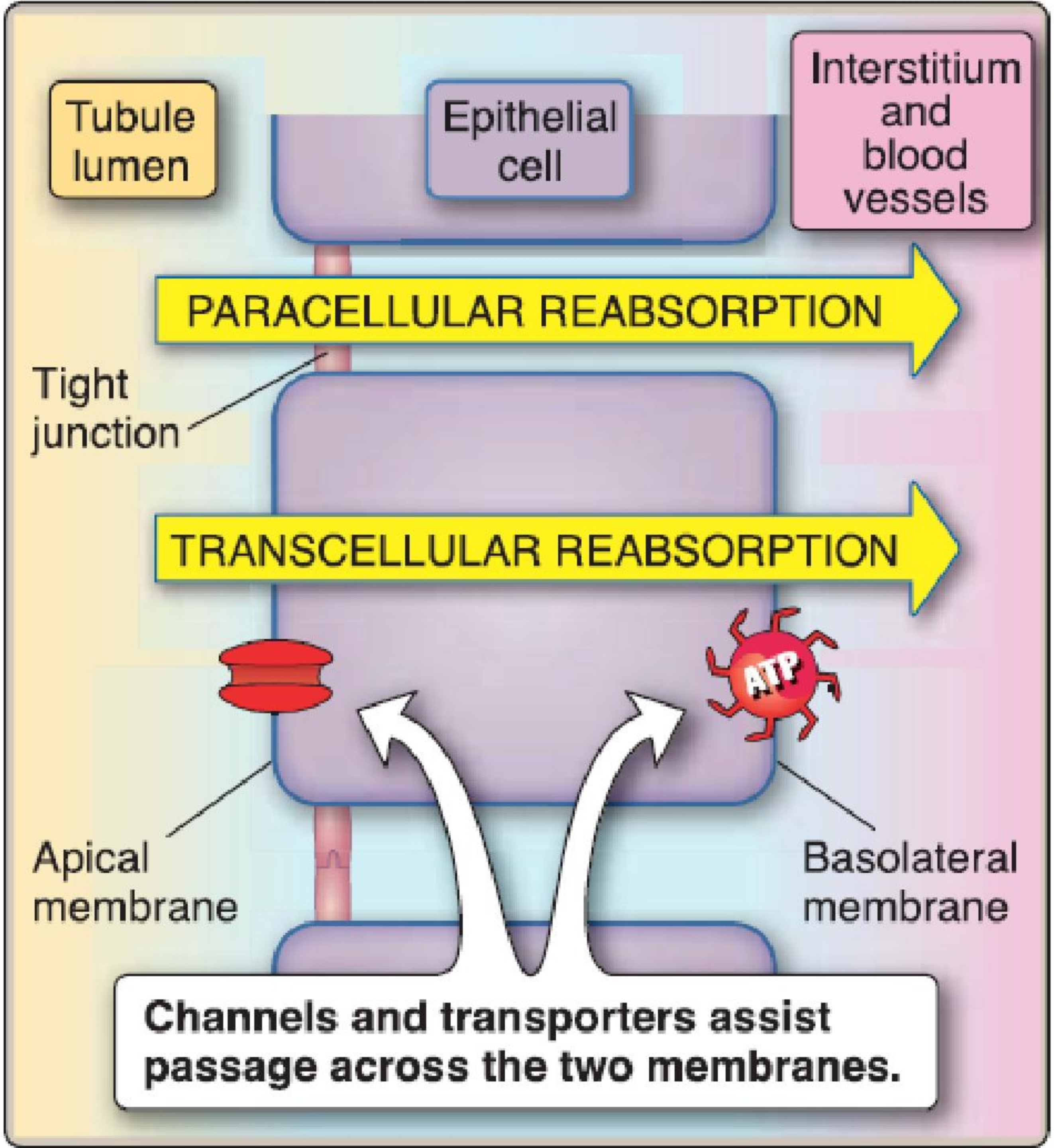
Segment	% Filtered NaCl Reabsorbed	Mechanism of Na$^+$ Entry Across Apical Membrane	Major Regulatory Hormones
Proximal tubule	67	Na$^+$/H$^+$ antiporter (NHE$_3$), Na$^+$ symporter with amino acids and organic solutes, paracellular	Angiotensin II Norepinephrine Epinephrine Dopamine
Loop of Henle	25	1 Na$^+$/1K$^+$/2Cl$^-$ symporter	Aldosterone Angiotensin II
Distal tubule	≈5	NaCl symporter	Aldosterone Angiotensin II
Late distal tubule and collecting duct	≈3	ENaC Na$^+$ channels	Aldosterone, ANP, BNP, urodilatin, uroguanylin, guanylin, angiotensin II

TABLE 34.5

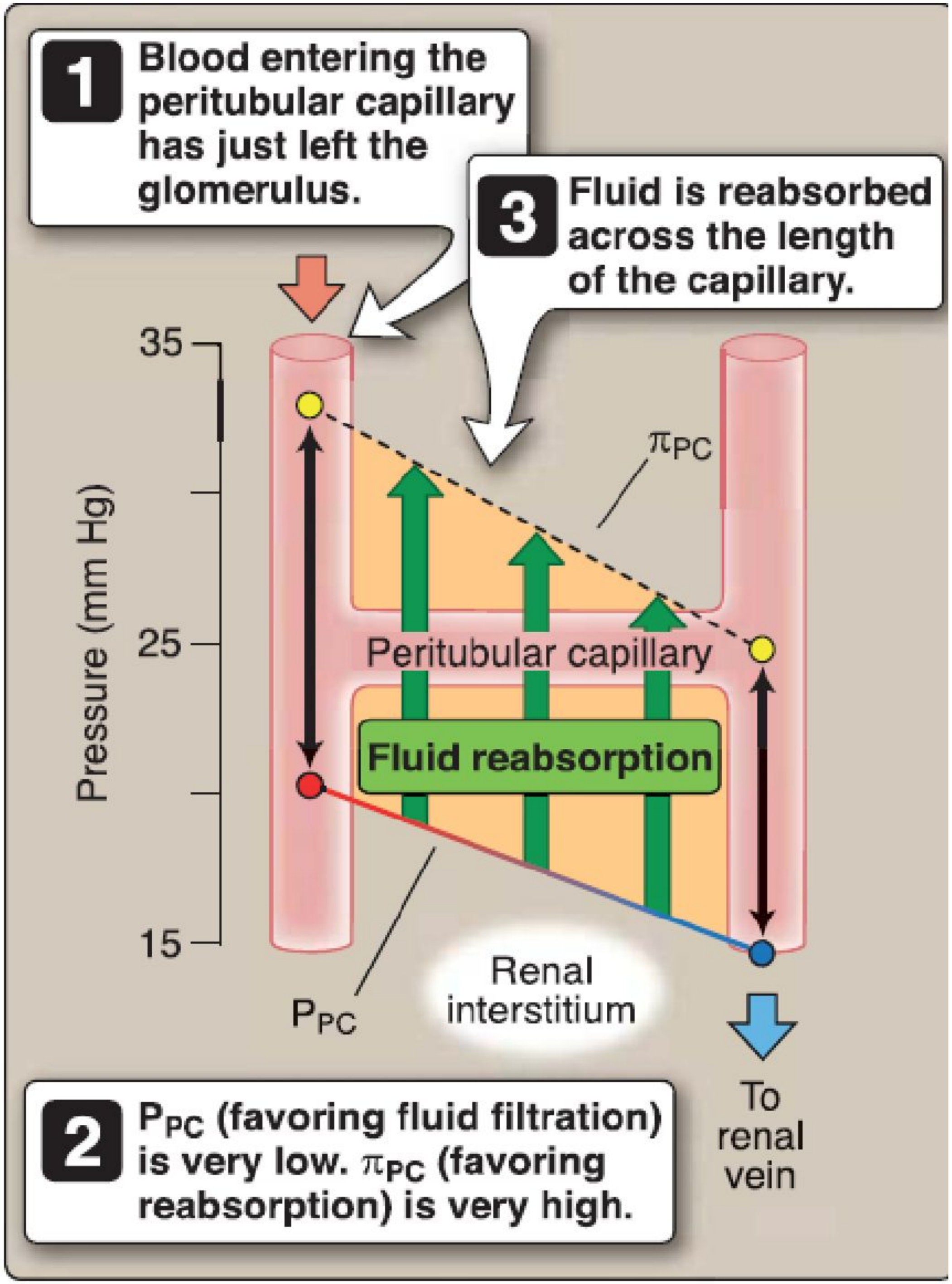
Water Transport Along the Nephron

Segment	% Filtrate Reabsorbed	Mechanism of Water Reabsorption	Hormones That Regulate Water Permeability
Proximal tubule	67	Passive	None
Loop of Henle	15	Descending thin limb only; passive	None
Distal tubule	0	No water reabsorption	None
Late distal tubule and collecting duct	≈8–17	Passive	AVP, ANP[a], BNP[a]

[a] Atrial natriuretic peptide (ANP) and brain natriuretic peptide (BNP) inhibit vasopressin (AVP)-stimulated water permeability.



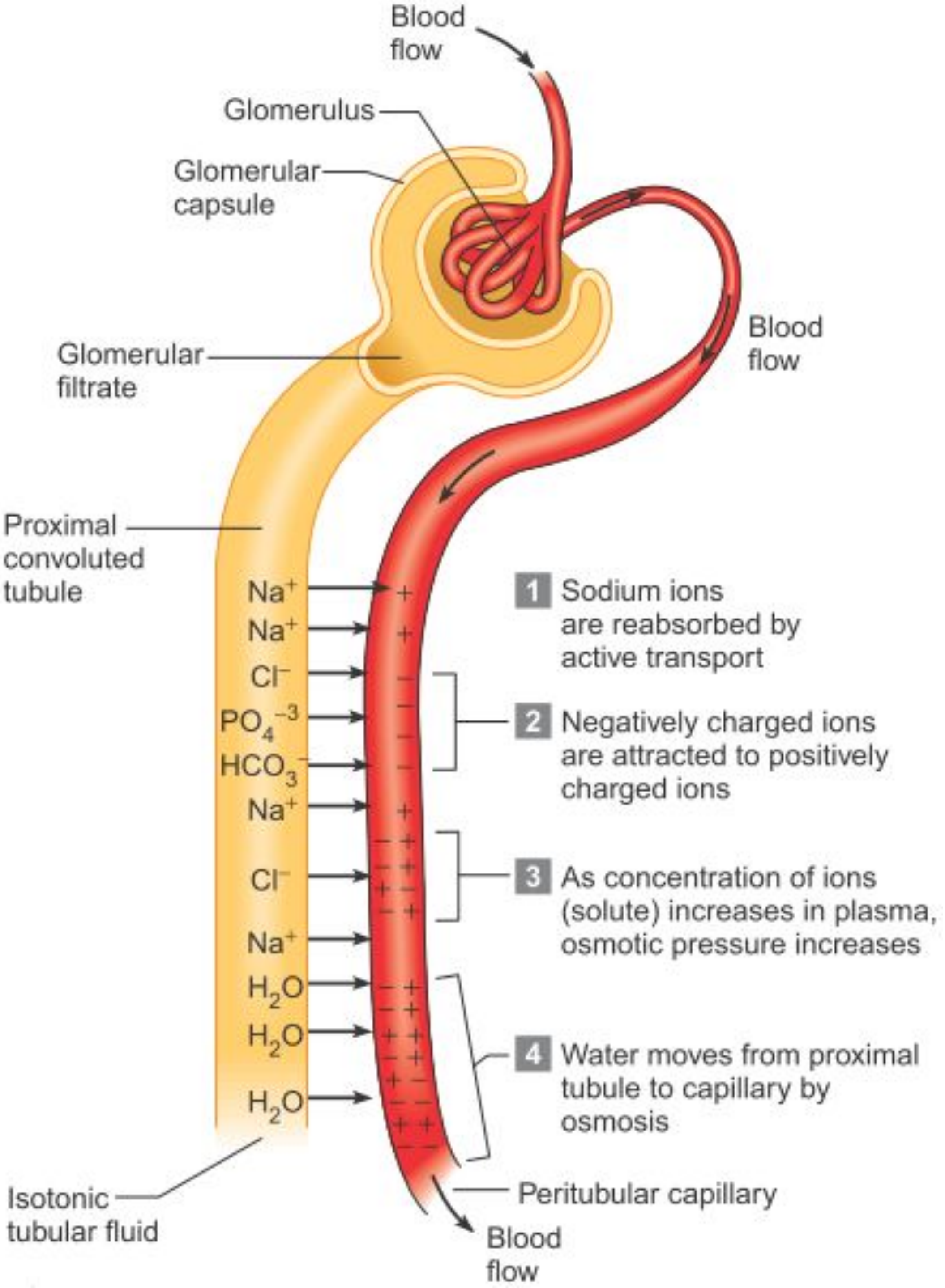
Channels and transporters assist passage across the two membranes.



1 Blood entering the peritubular capillary has just left the glomerulus.

2 P_{PC} (favoring fluid filtration) is very low. π_{PC} (favoring reabsorption) is very high.

3 Fluid is reabsorbed across the length of the capillary.

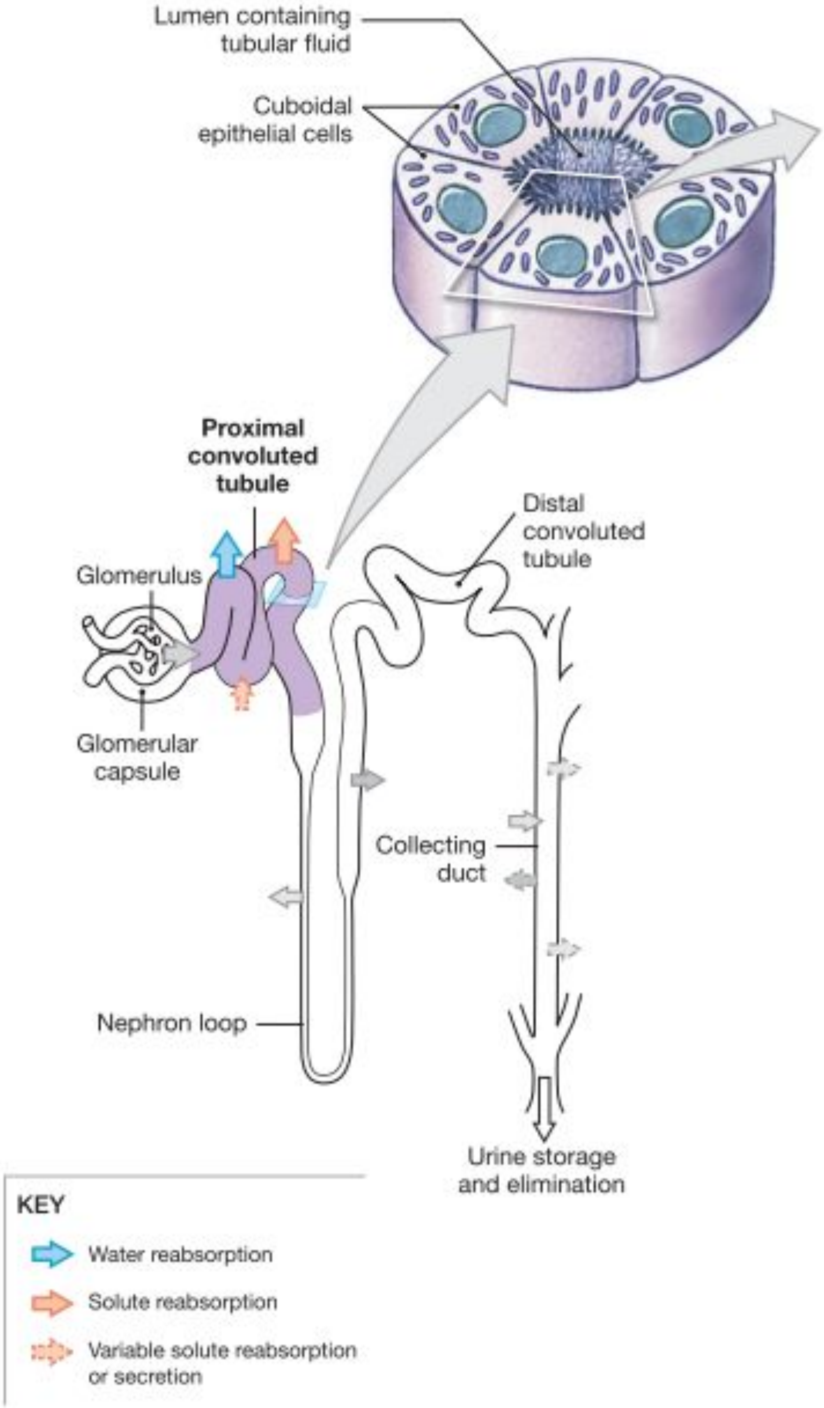


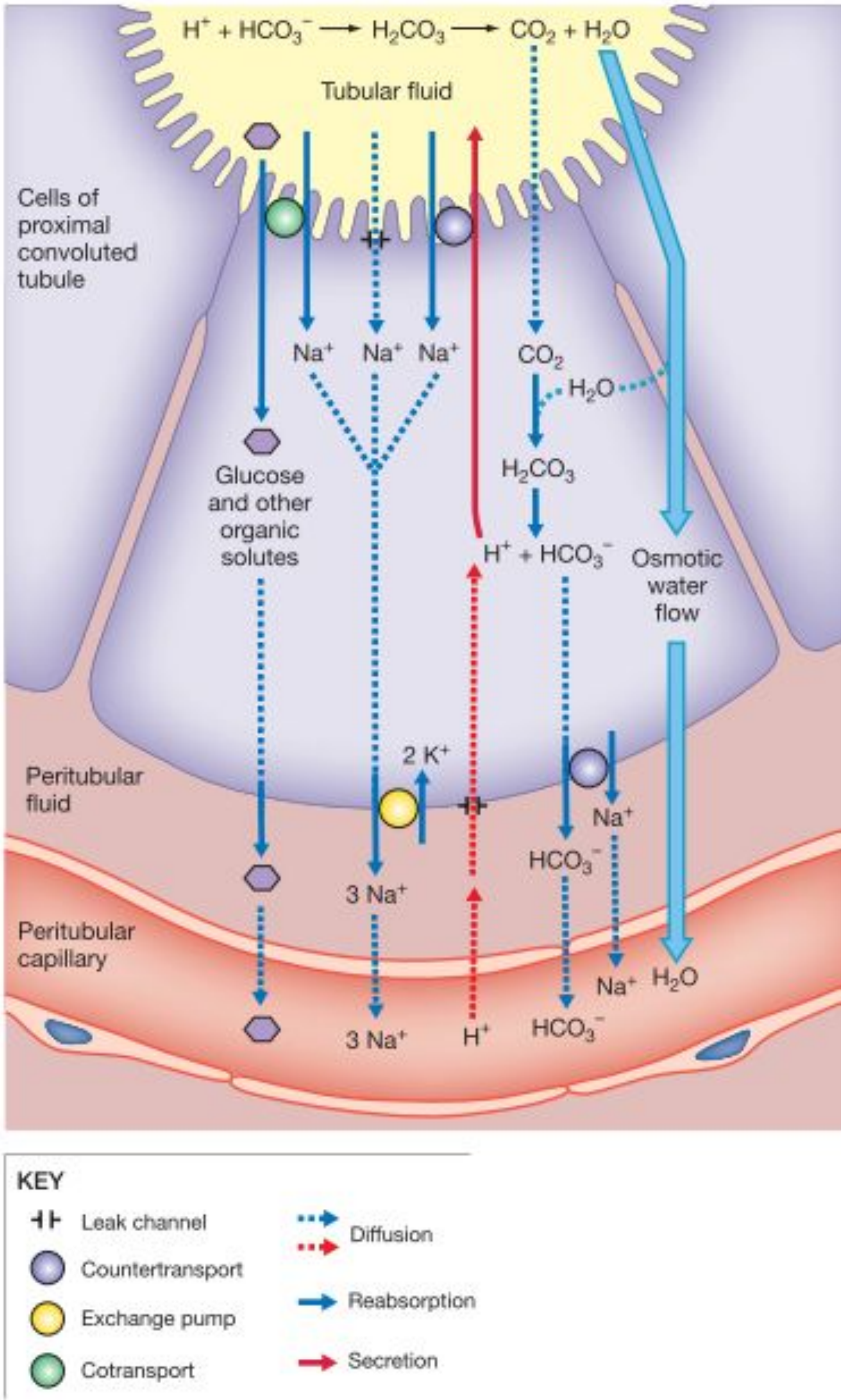
1 Sodium ions are reabsorbed by active transport

2 Negatively charged ions are attracted to positively charged ions

3 As concentration of ions (solute) increases in plasma, osmotic pressure increases

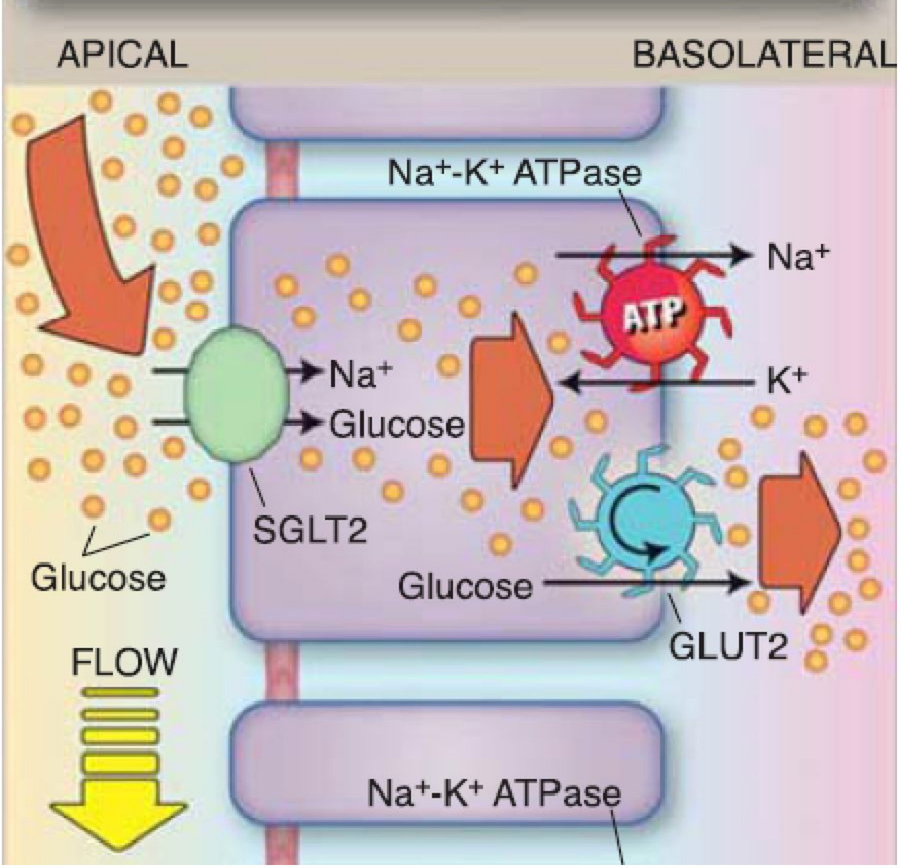
4 Water moves from proximal tubule to capillary by osmosis

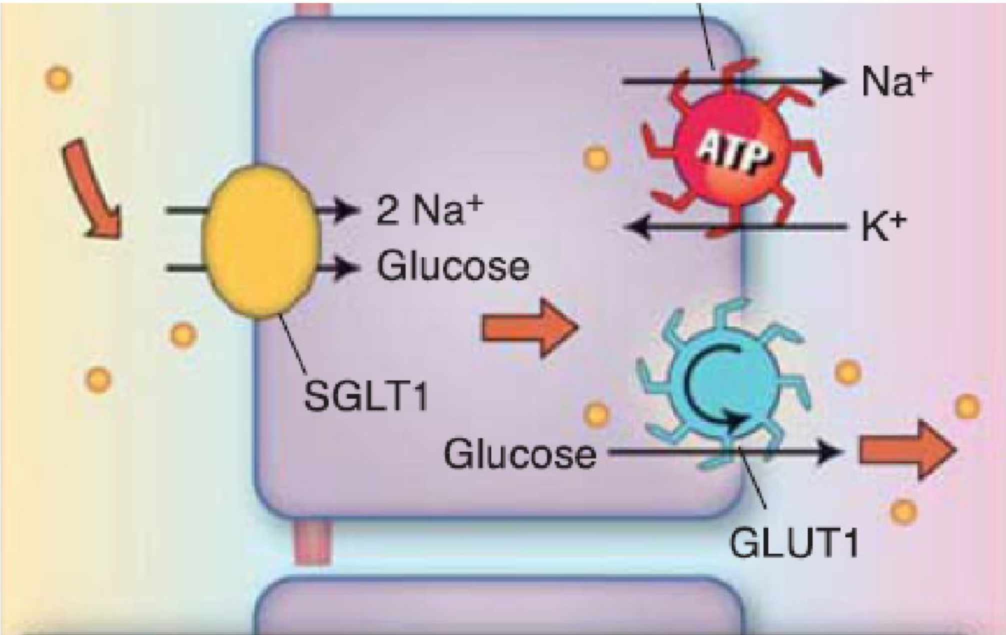

Lumen containing tubular fluid
Cuboidal epithelial cells
Proximal convoluted tubule
Glomerulus
Glomerular capsule
Distal convoluted tubule
Collecting duct
Nephron loop
Urine storage and elimination
KEY
Water reablsorption
Solute reabsorption
Variable solute reabsorption or secretion


$H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow CO_2 + H_2O$
Tubular fluid
Cells of proximal convoluted tubule
Na^+
Na^+
Na^+
CO_2
H_2O
H_2CO_3
Glucose and other organic solutes
$H^+ + HCO_3^-$
Osmotic water flow
Peritubular fluid
2 K^+
Na^+
HCO_3^-
3 Na^+
Peritubular capillary
Na^+
H_2O
3 Na^+
H^+
HCO_3^-
KEY
Leak channel
Countertransport
Exchange pump
Cotransport
Diffusion
Reabsorption
Secretion

EARLY SEGMENTS:

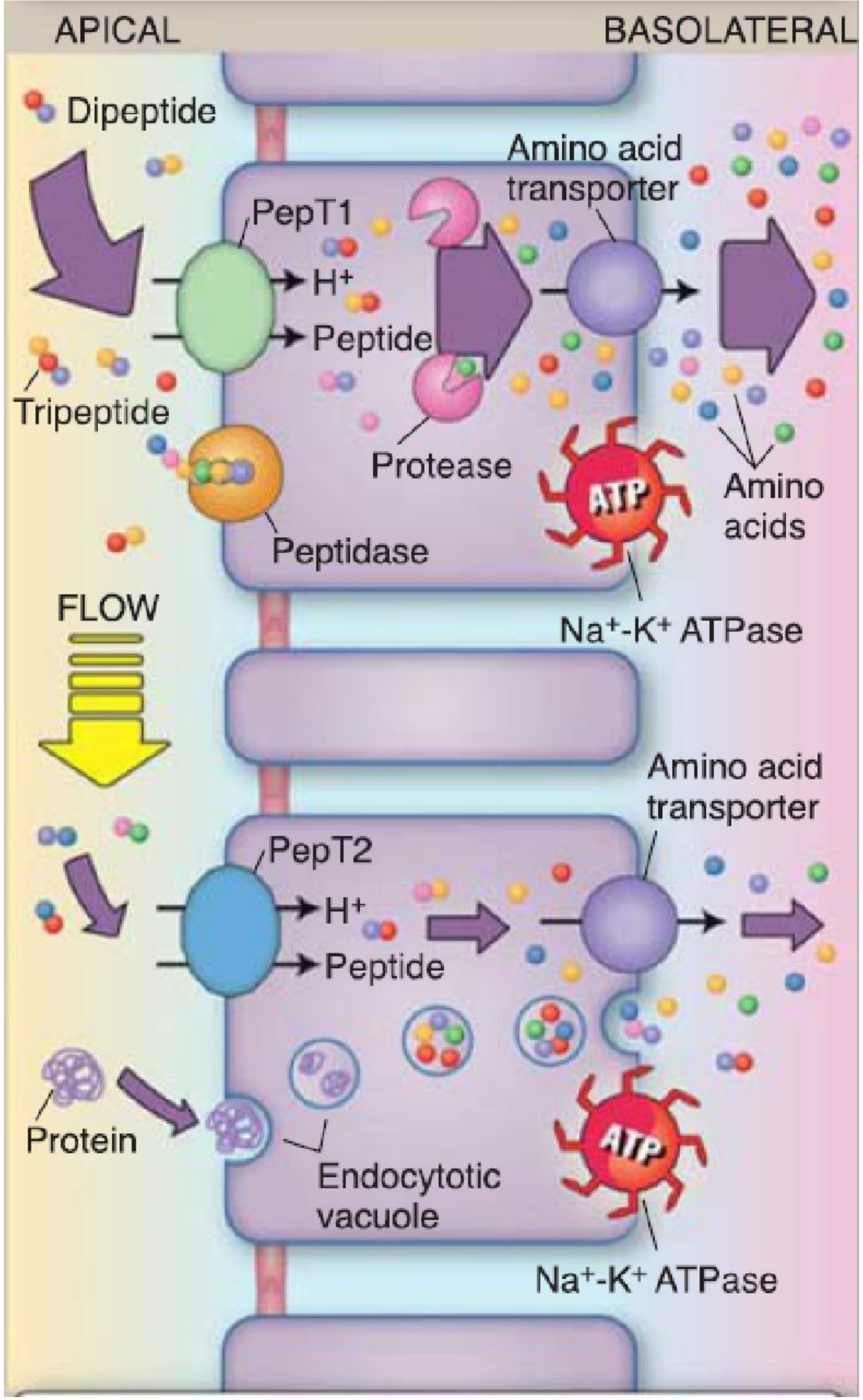
Glucose molecules are recovered *en masse* using a high-capacity, low-affinity glucose transporter (SGLT2).

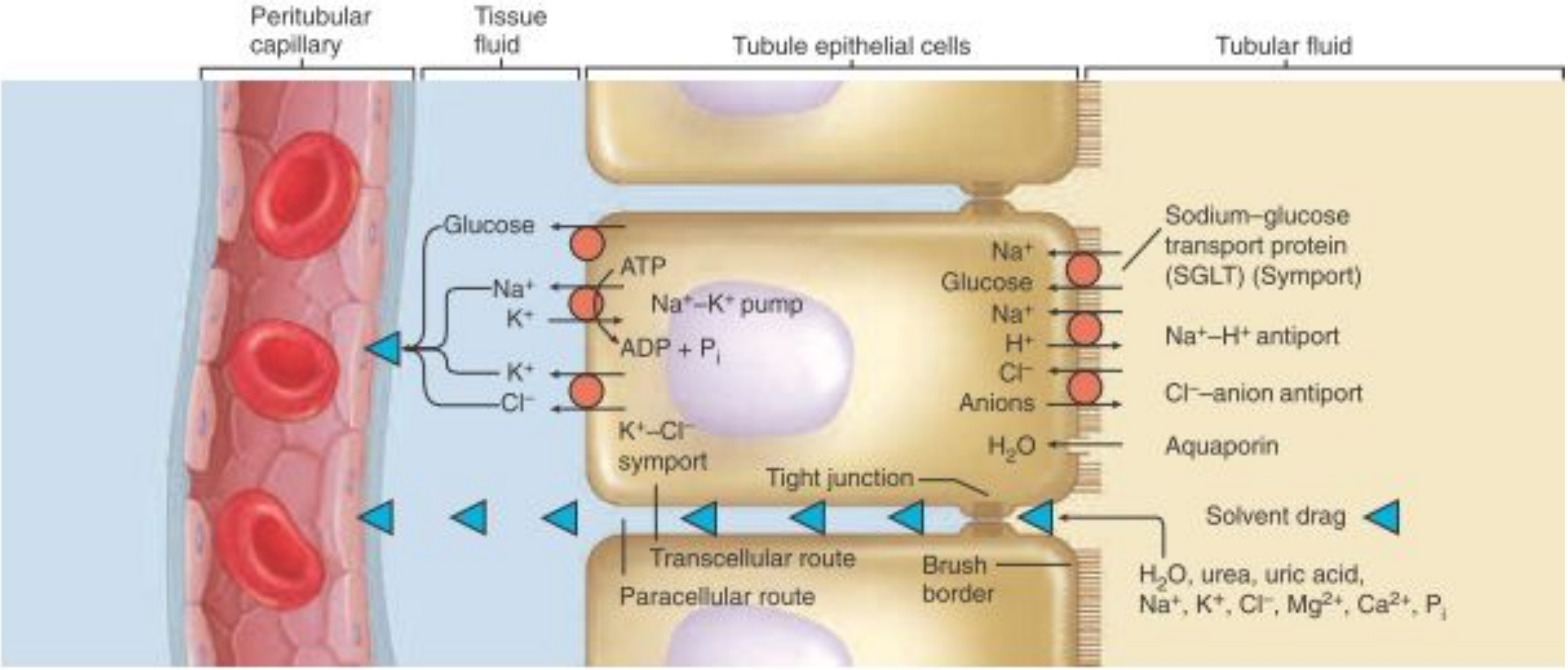


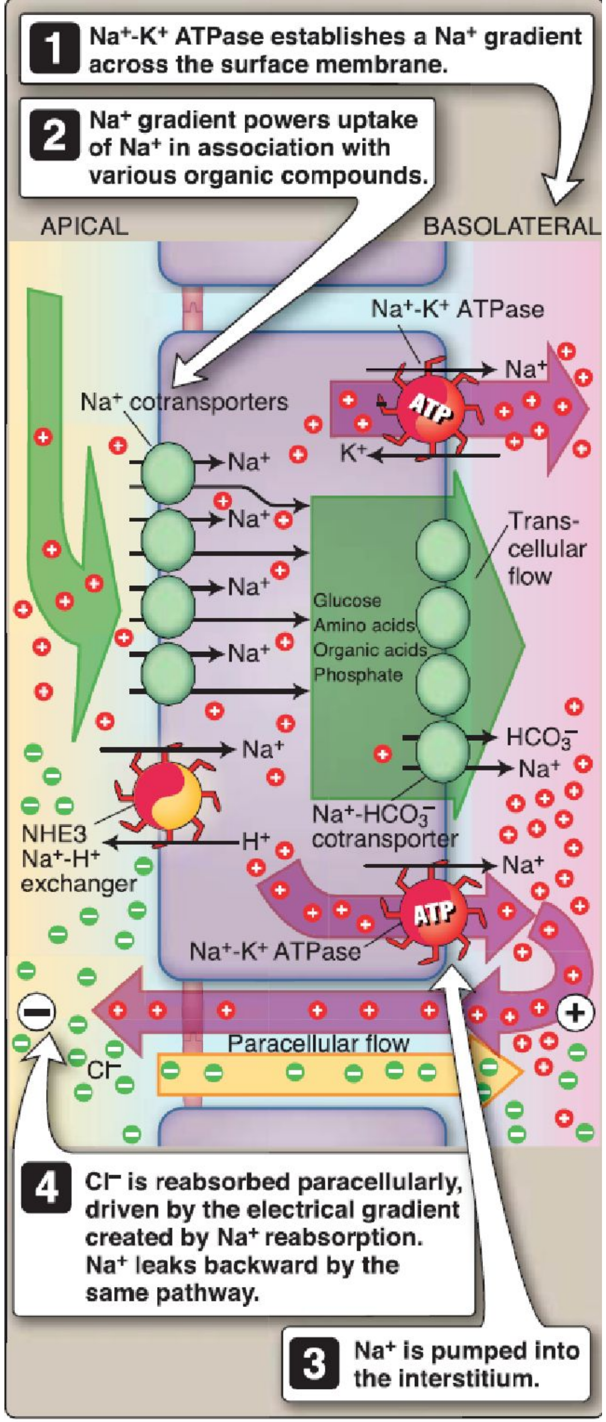


LATE SEGMENTS:

Scavenge for remaining glucose molecules using a low-capacity, high-affinity glucose transporter (SGLT1).


APICAL
BASOLATERAL
Dipeptide
PepT1
H+
Peptide
Amino acid transporter
Tripeptide
Protease
Peptidase
ATP
Amino acids
FLOW
Na+-K+ ATPase
Amino acid transporter
PepT2
H+
Peptide
Protein
Endocytotic vacuole
ATP
Na+-K+ ATPase


Peritubular capillary
Tissue fluid
Tubule epithelial cells
Tubular fluid
Glucose
ATP
Na+
Na+–K+ pump
K+
ADP + Pi
K+
Cl−
K+–Cl− symport
Na+
Glucose
Na+
H+
Cl−
Anions
H2O
Sodium–glucose transport protein (SGLT) (Symport)
Na+–H+ antiport
Cl−–anion antiport
Aquaporin
Tight junction
Solvent drag
Transcellular route
Paracellular route
Brush border
H2O, urea, uric acid,
Na+, K+, Cl−, Mg2+, Ca2+, Pi

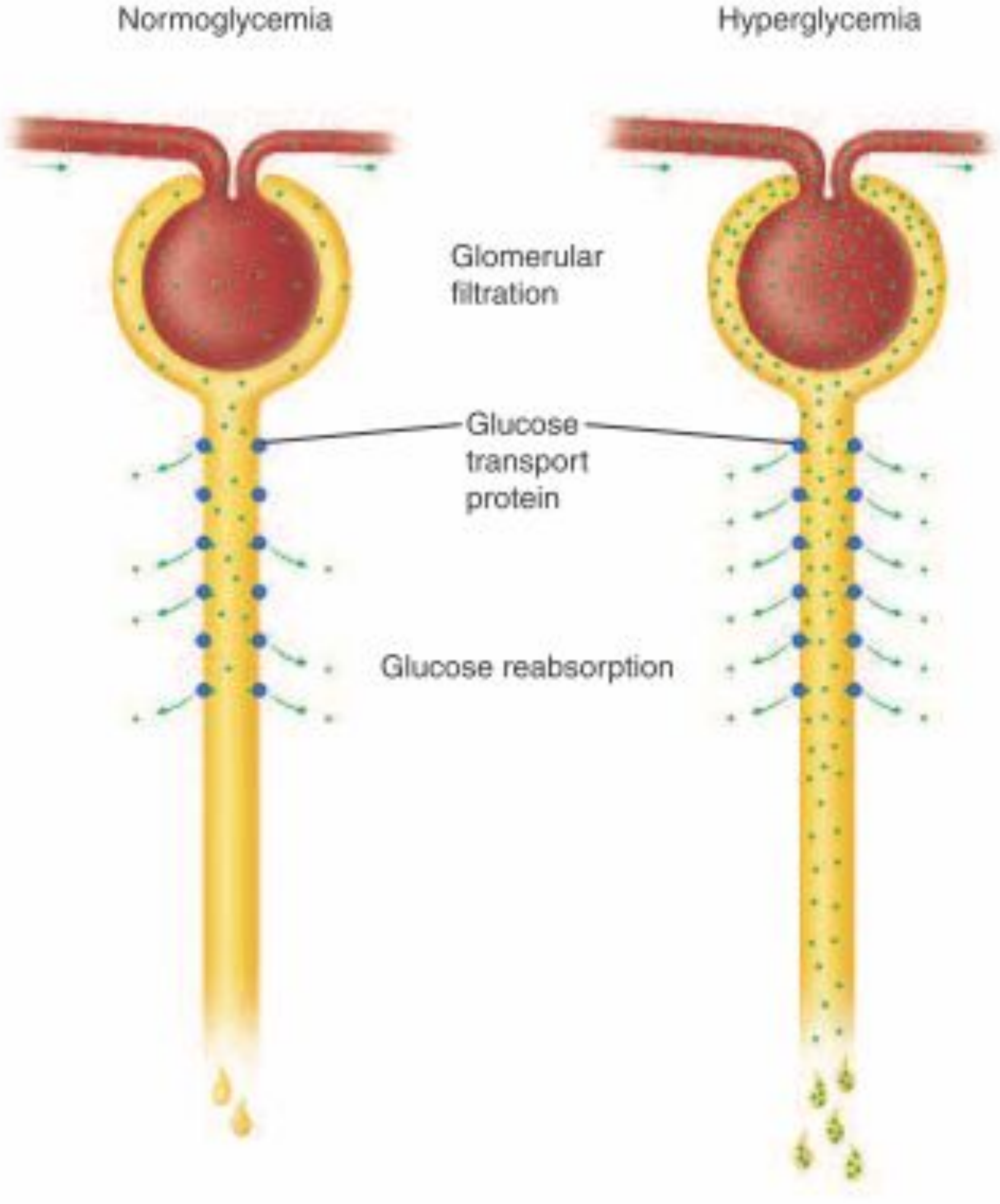


1 Na⁺-K⁺ ATPase establishes a Na⁺ gradient across the surface membrane.

2 Na⁺ gradient powers uptake of Na⁺ in association with various organic compounds.

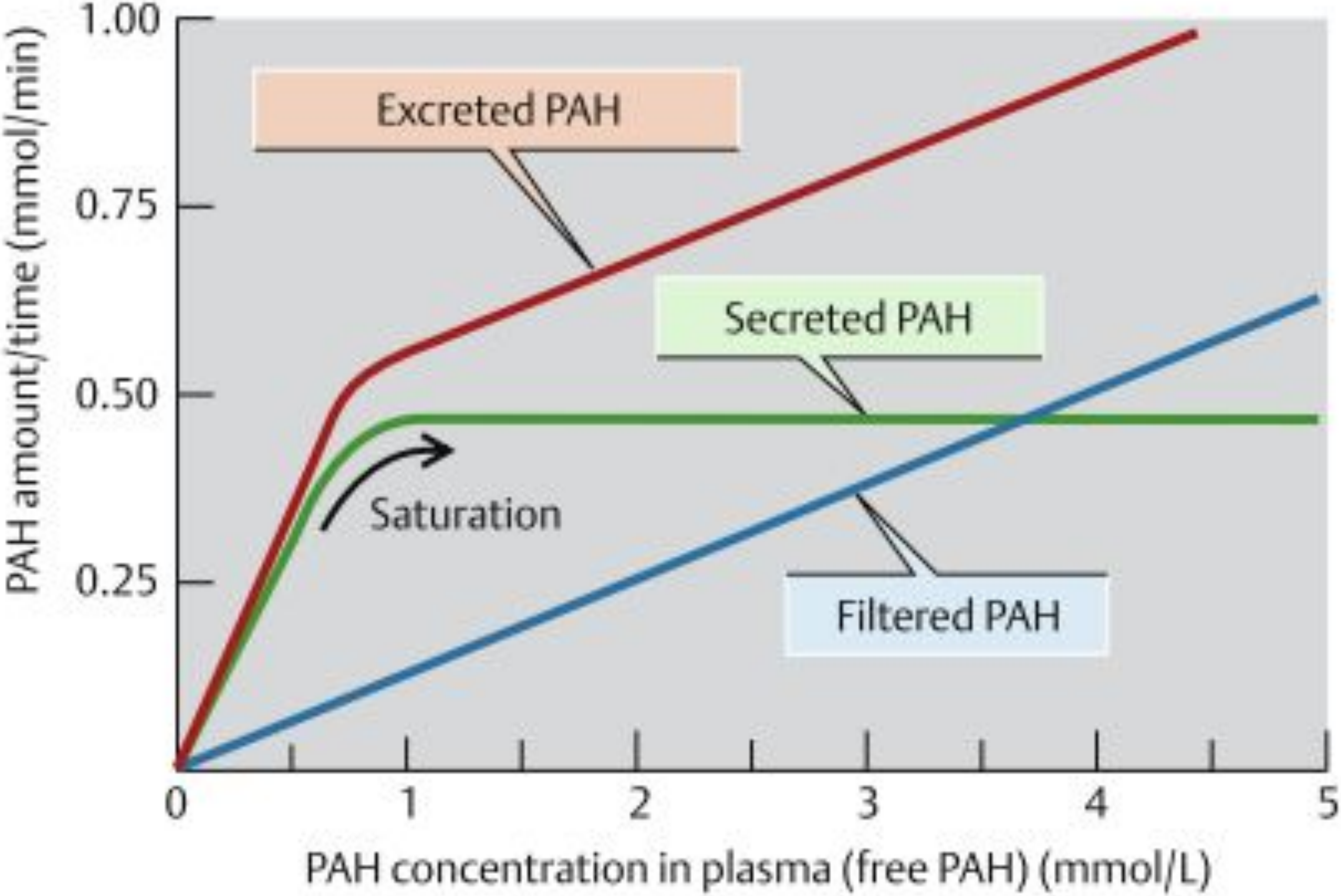
3 Na⁺ is pumped into the interstitium.

4 Cl⁻ is reabsorbed paracellularly, driven by the electrical gradient created by Na⁺ reabsorption. Na⁺ leaks backward by the same pathway.

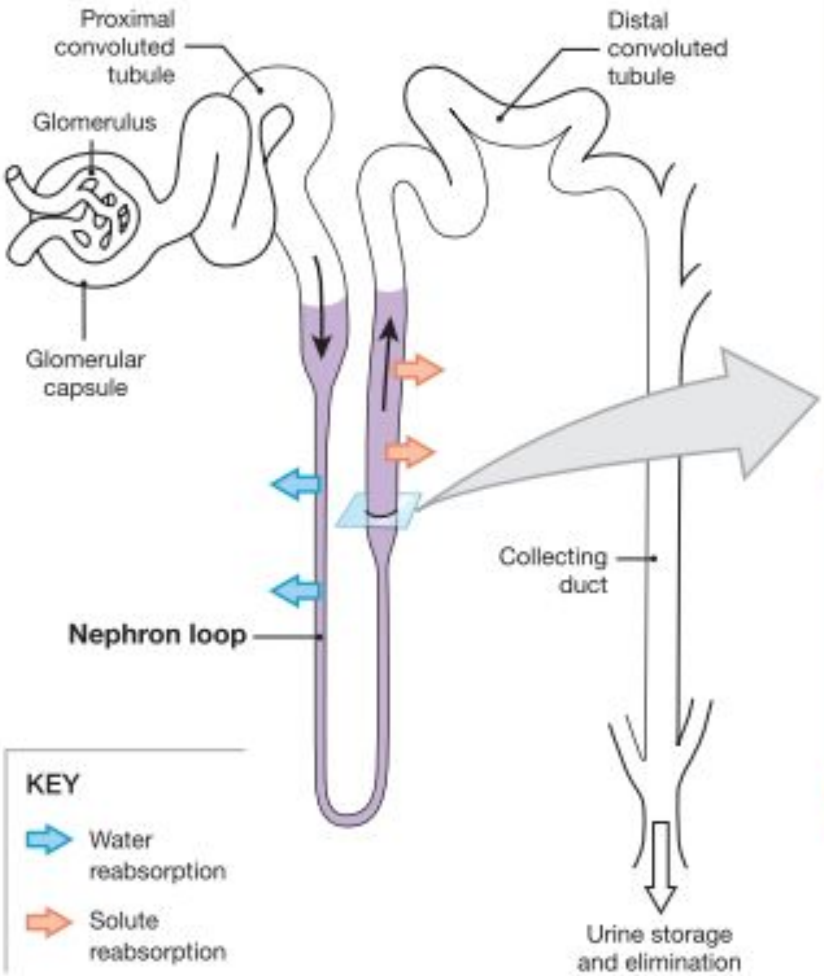


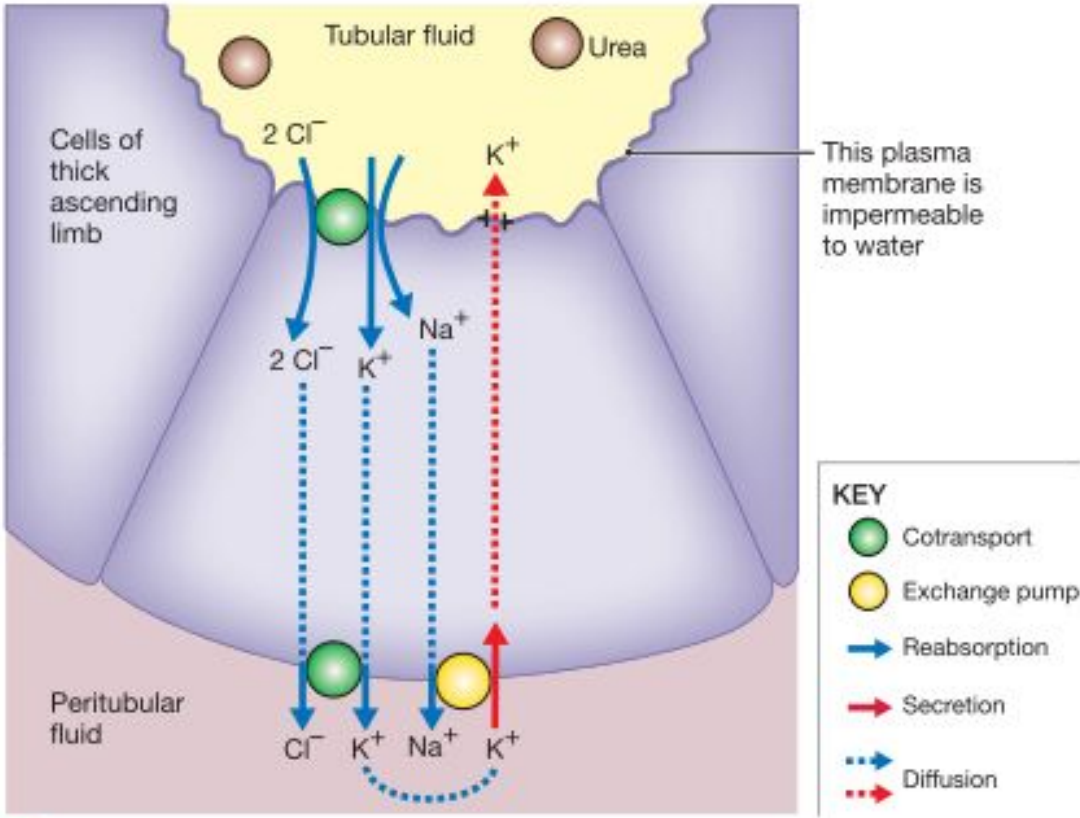
(a) **Normal urine volume, glucose-free**

(b) **Increased urine volume, with glycosuria**

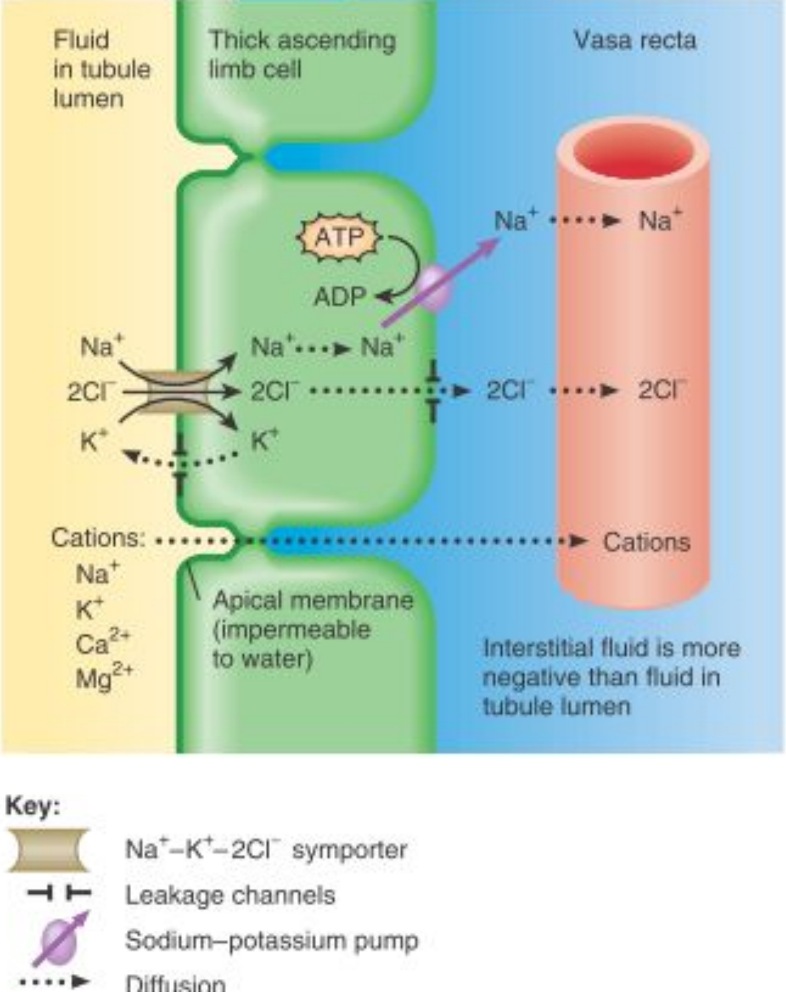


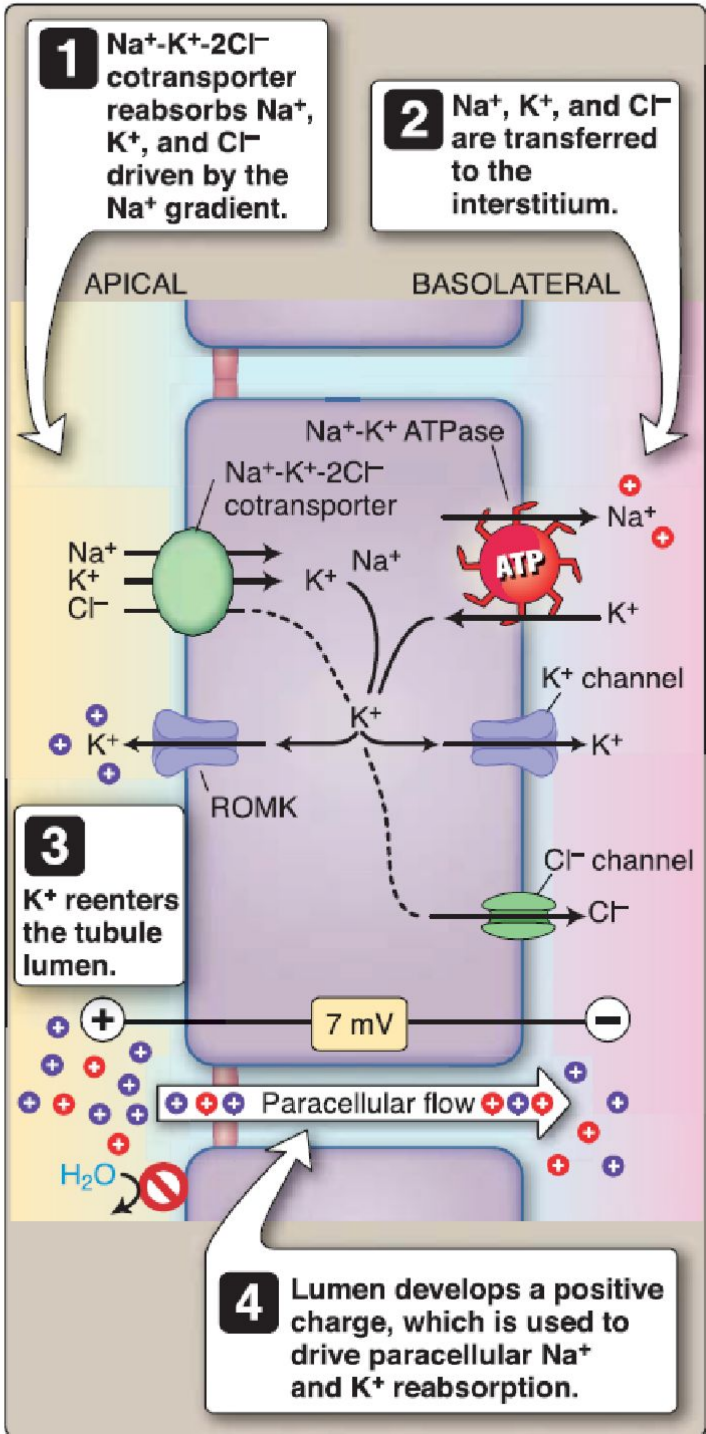
1.00
0.75
0.50
0.25
PAH amount/time (mmol/min)
Excreted PAH
Secreted PAH
Filtered PAH
Saturation
0
1
2
3
4
5
PAH concentration in plasma (free PAH) (mmol/L)

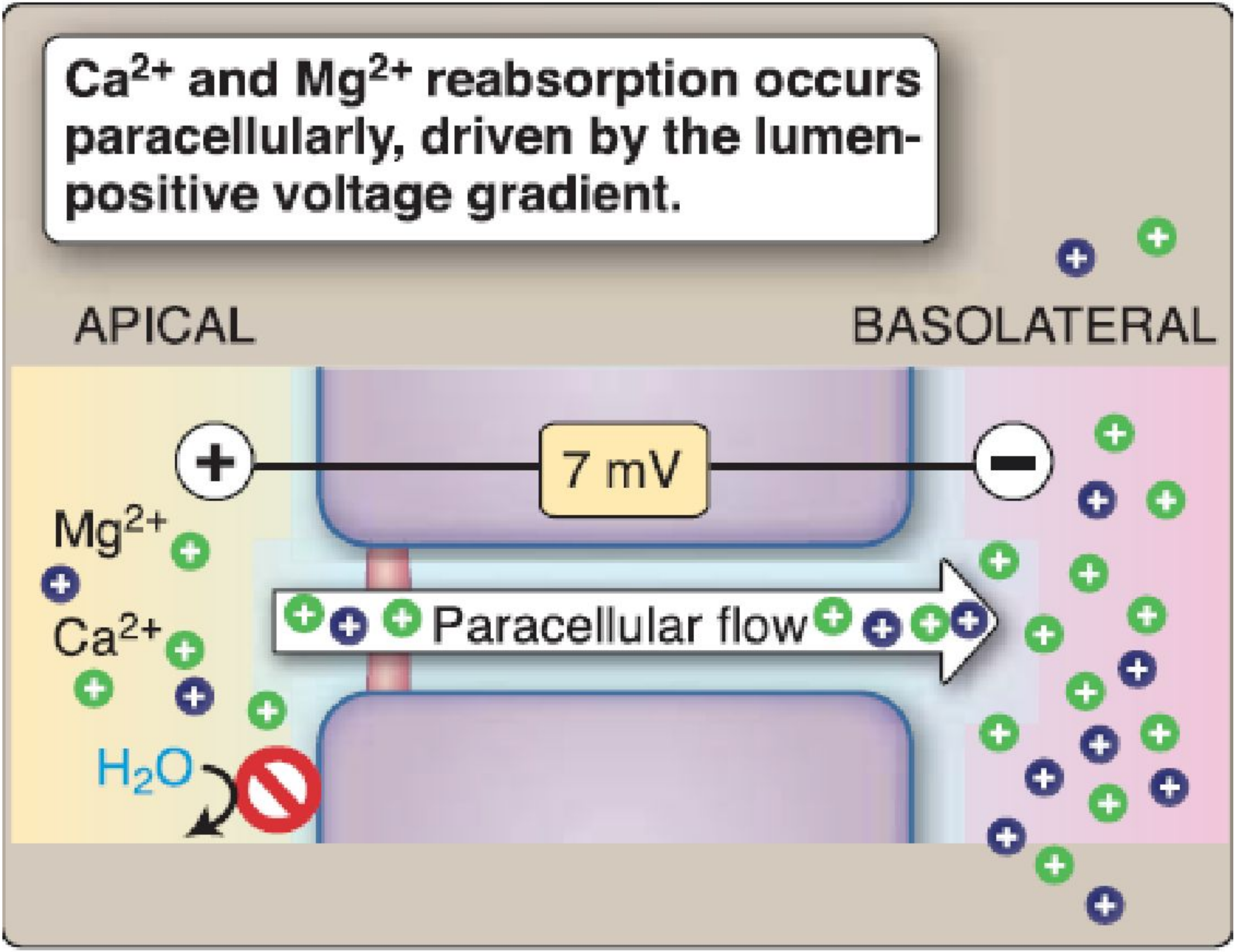




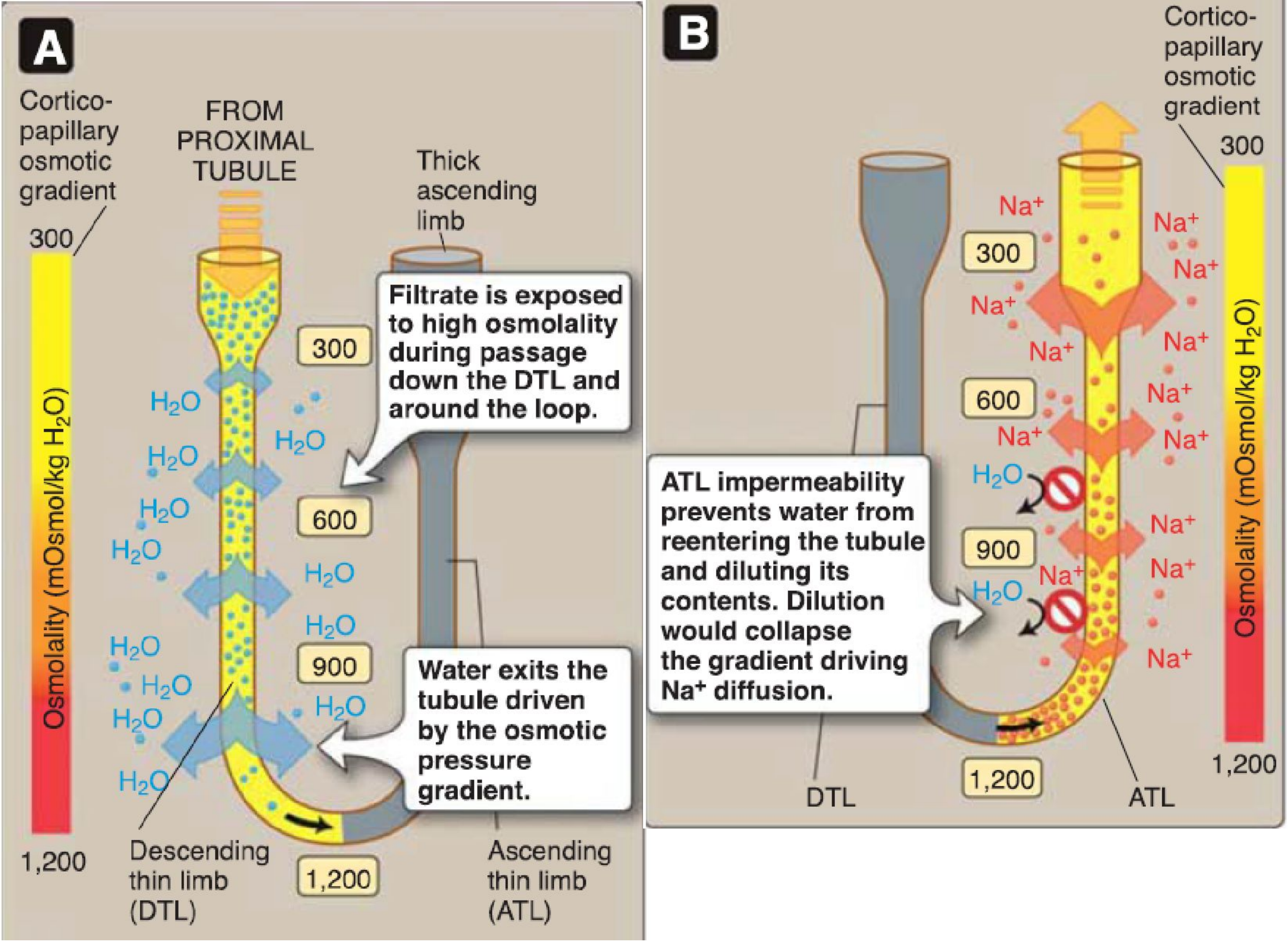
a The mechanism of sodium and chloride ion transport involves the Na^+–K^+/2 Cl^- carrier at the apical surface and two carriers at the basal surface of the tubular cell: a potassium–chloride cotransport pump and a sodium-potassium exchange pump. The net result is the transport of sodium and chloride ions into the peritubular fluid.


Fluid in tubule lumen
Thick ascending limb cell
Vasa recta
ATP
ADP
Na+
Na+
Na+
2Cl−
K+
Na+
Na+
2Cl−
2Cl−
2Cl−
K+
K+
Cations:
Na+
K+
Ca2+
Mg2+
Cations
Apical membrane (impermeable to water)
Interstitial fluid is more negative than fluid in tubule lumen
Key:
Na+–K+–2Cl− symporter
Leakage channels
Sodium–potassium pump
Diffusion


1 Na+-K+-2Cl− cotransporter reabsorbs Na+, K+, and Cl− driven by the Na+ gradient.
2 Na+, K+, and Cl− are transferred to the interstitium.
APICAL
BASOLATERAL
Na+-K+ ATPase
Na+-K+-2Cl− cotransporter
Na+
K+
Cl−
K+
Na+
Na+
ATP
K+
K+ channel
K+
K+
K+
ROMK
3 K+ reenters the tubule lumen.
Cl− channel
Cl−
7 mV
Paracellular flow
H2O
4 Lumen develops a positive charge, which is used to drive paracellular Na+ and K+ reabsorption.



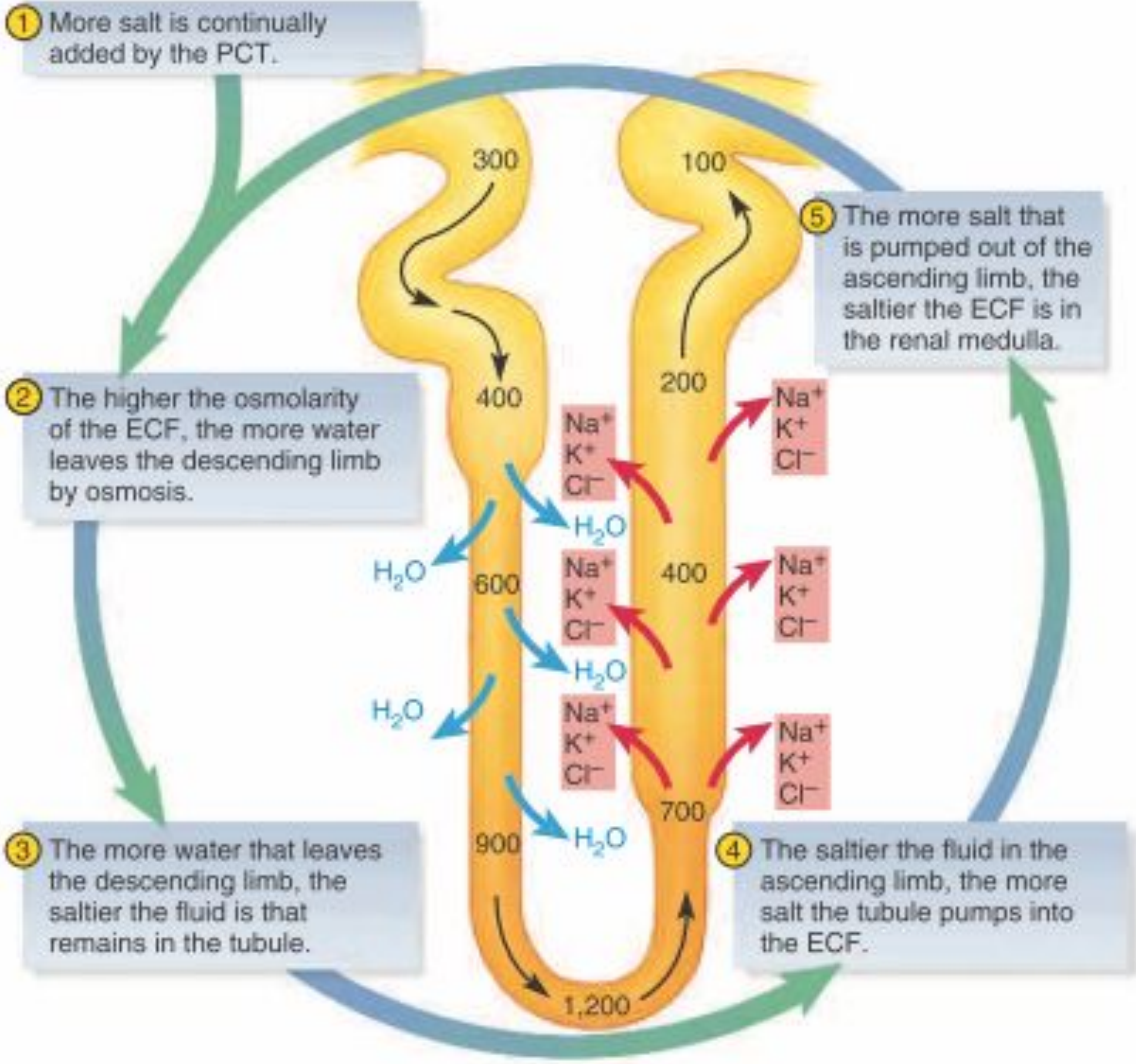
Ca^{2+} and Mg^{2+} reabsorption occurs paracellularly, driven by the lumen-positive voltage gradient.



Filtrate is exposed to high osmolality during passage down the DTL and around the loop.

Water exits the tubule driven by the osmotic pressure gradient.

ATL impermeability prevents water from reentering the tubule and diluting its contents. Dilution would collapse the gradient driving Na^+ diffusion.



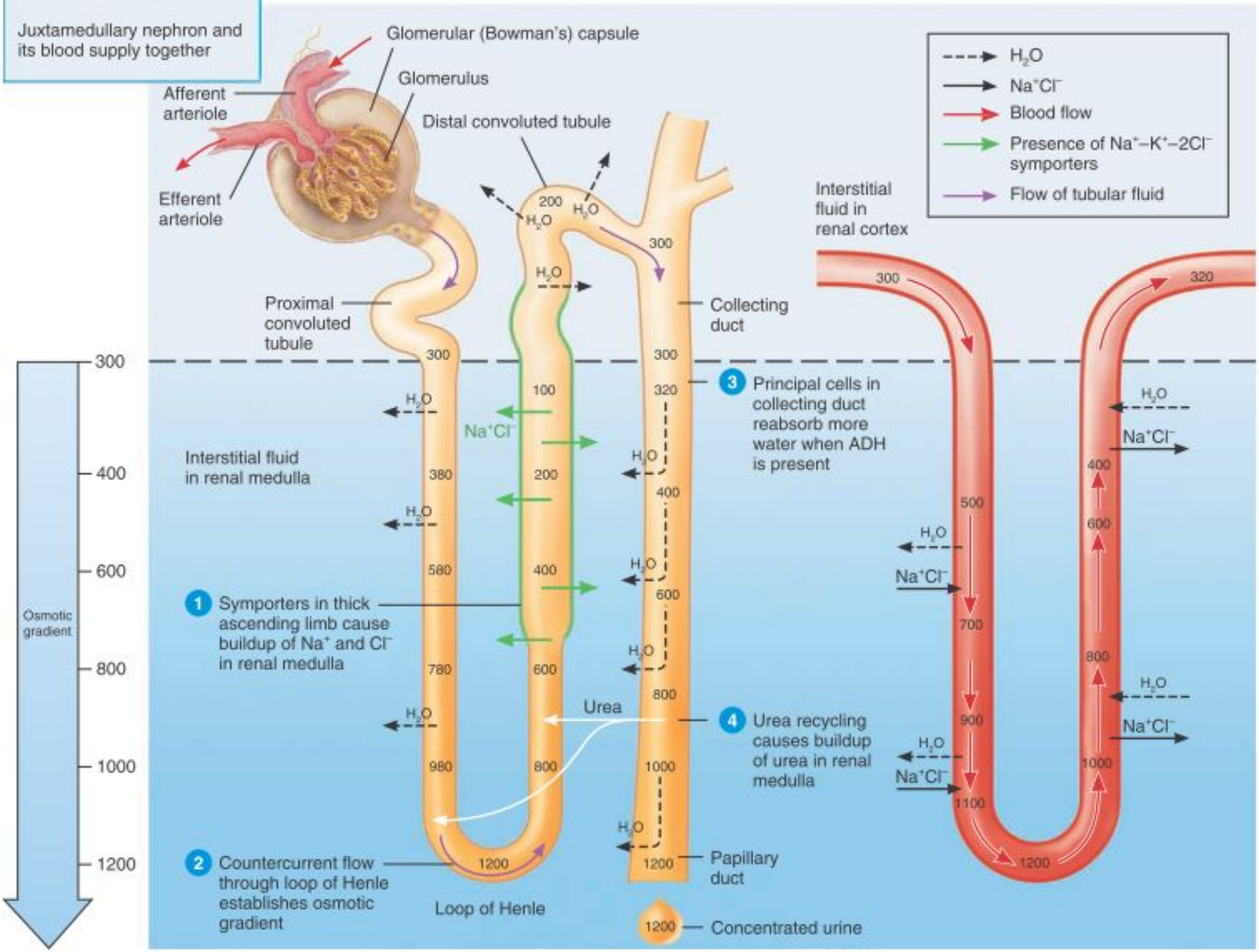
① More salt is continually added by the PCT.

② The higher the osmolarity of the ECF, the more water leaves the descending limb by osmosis.

③ The more water that leaves the descending limb, the saltier the fluid is that remains in the tubule.

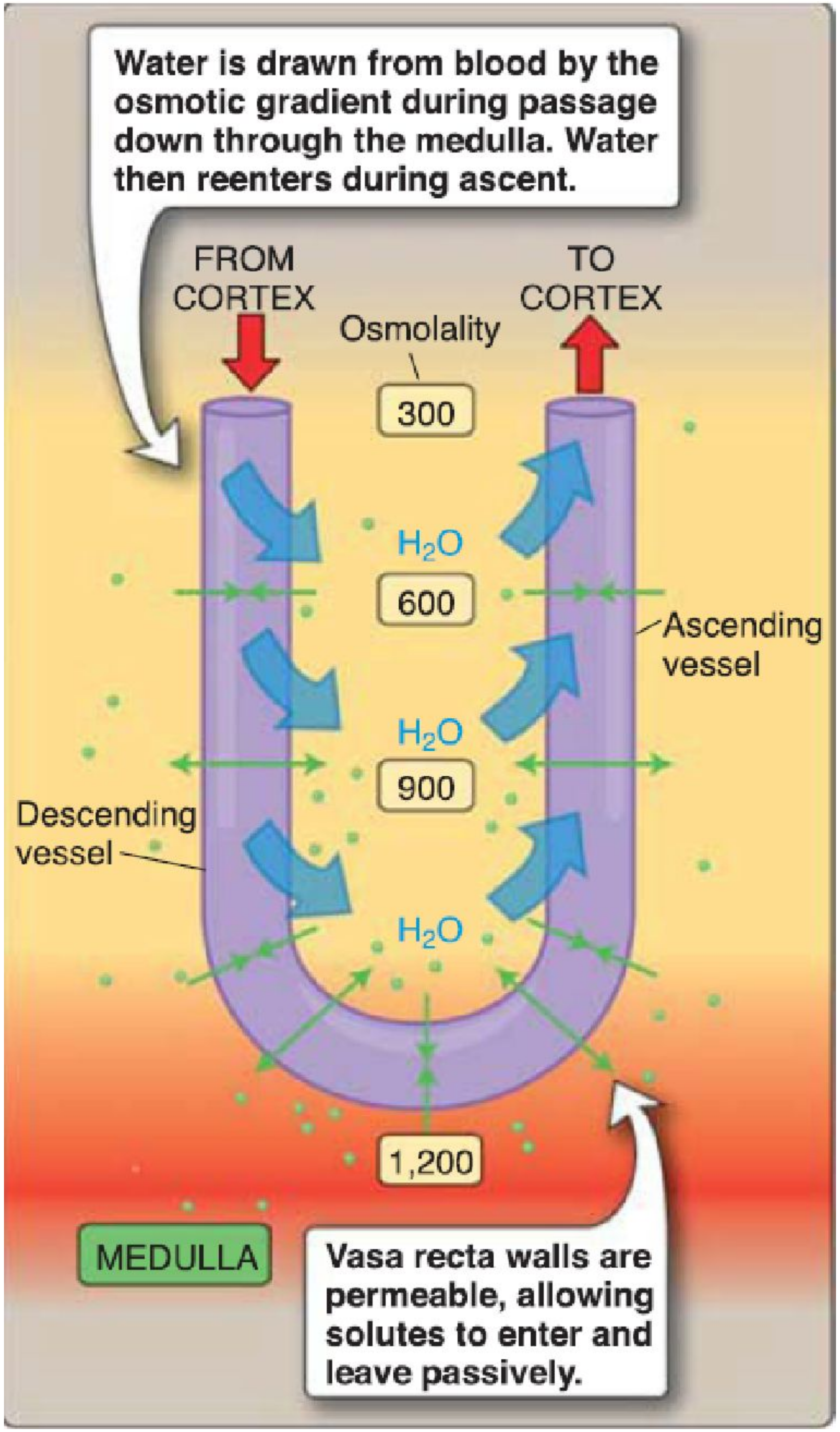
④ The saltier the fluid in the ascending limb, the more salt the tubule pumps into the ECF.

⑤ The more salt that is pumped out of the ascending limb, the saltier the ECF is in the renal medulla.



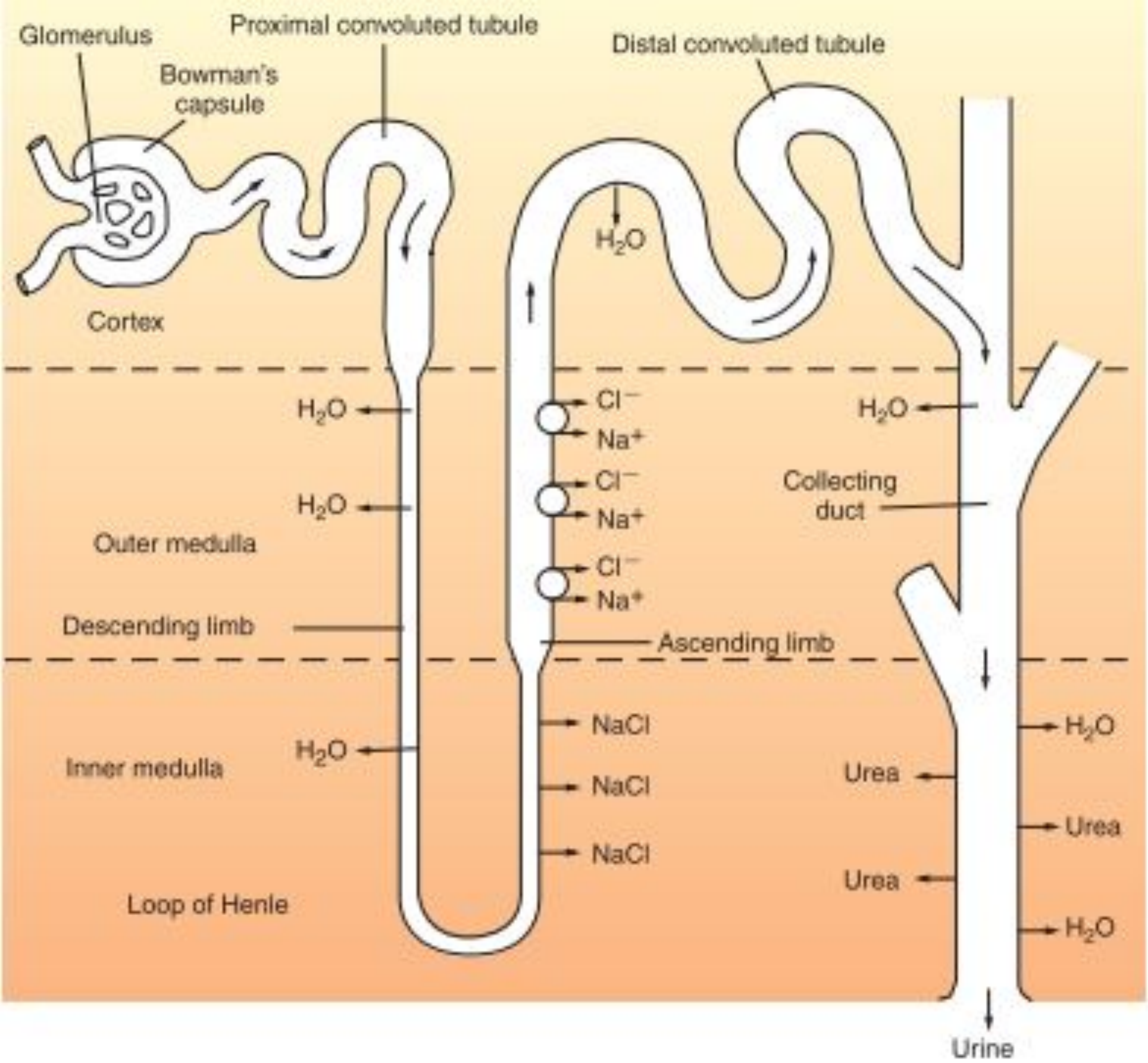
(a) Reabsorption of Na⁺, Cl⁻, and water in long-loop juxtamedullary nephron

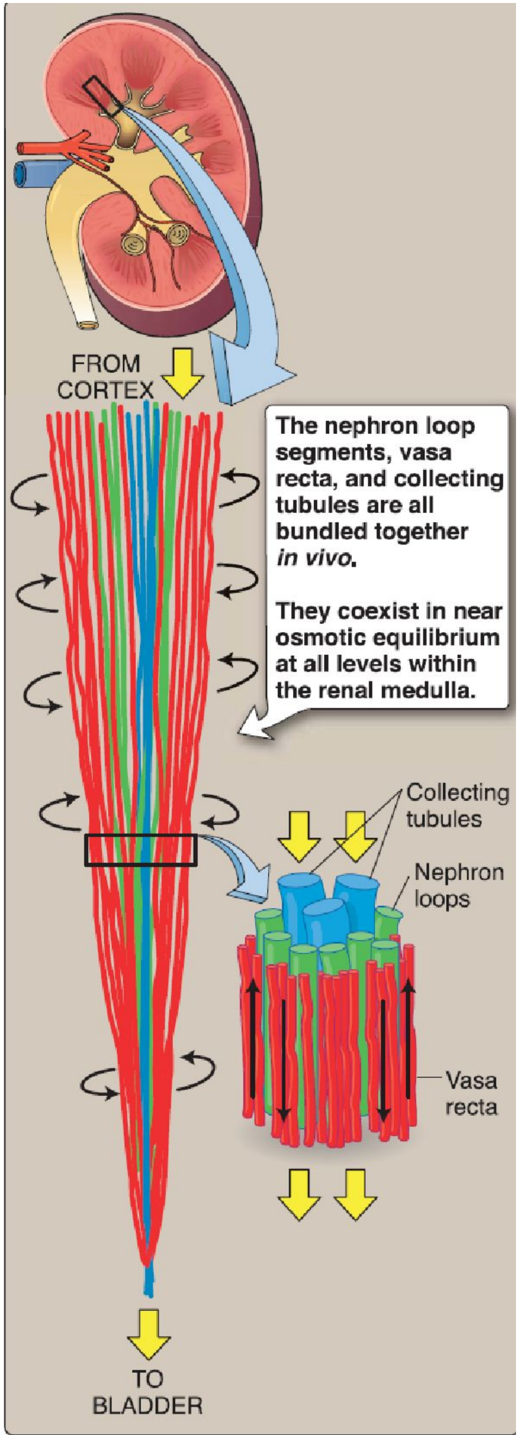
(b) Recycling of salts and urea in vasa recta



Water is drawn from blood by the osmotic gradient during passage down through the medulla. Water then reenters during ascent.

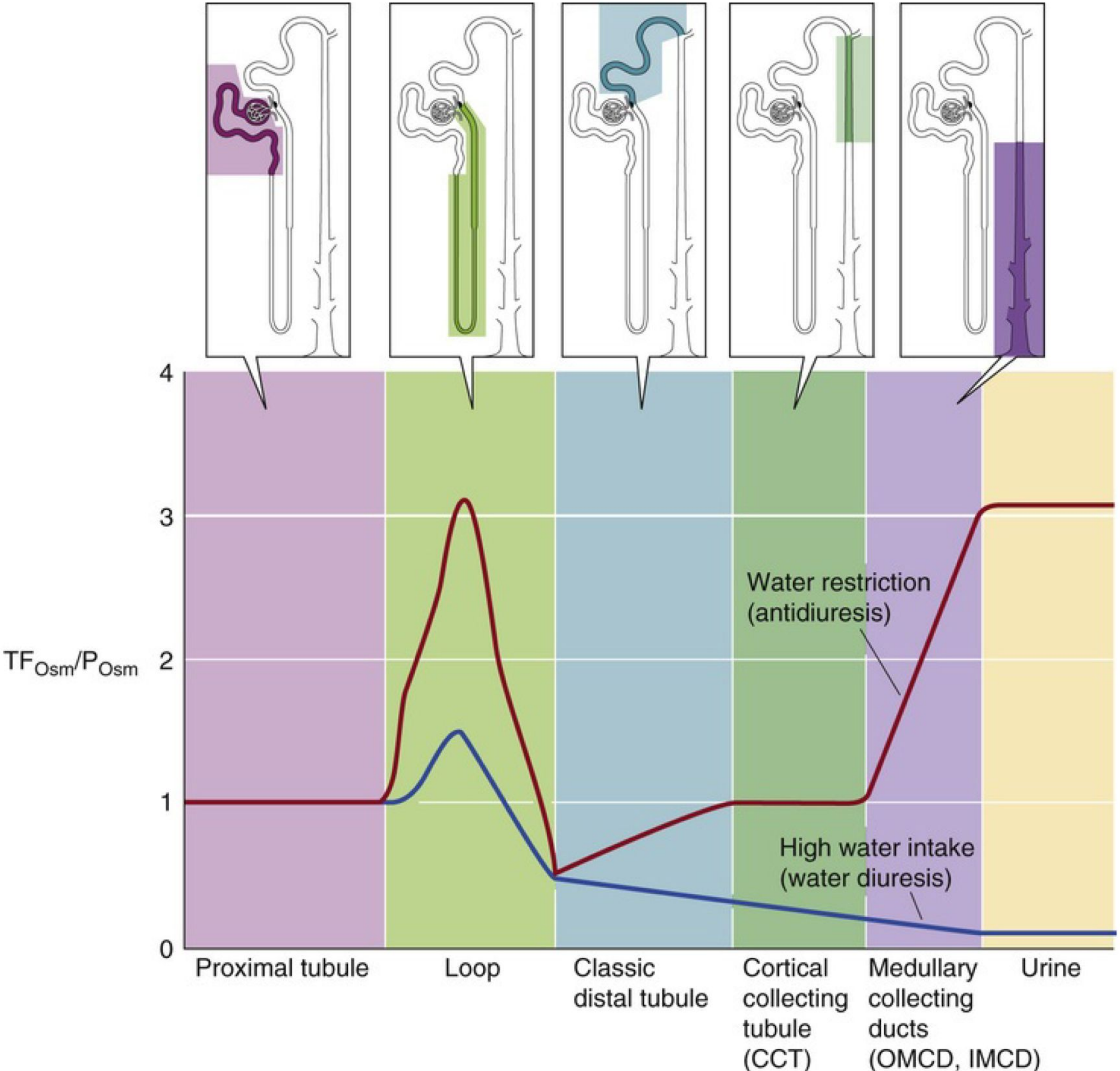
Vasa recta walls are permeable, allowing solutes to enter and leave passively.

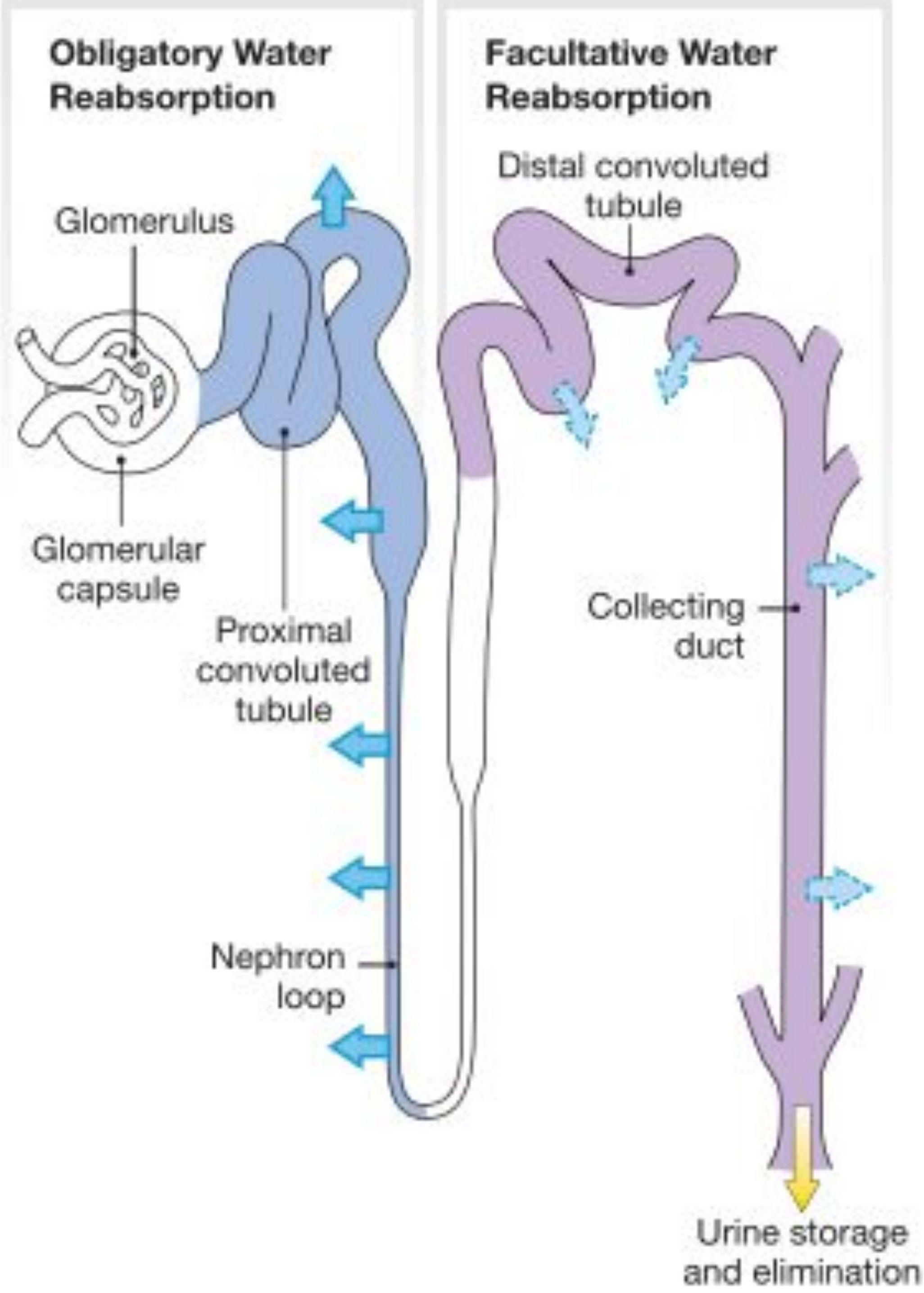

Glomerulus
Proximal convoluted tubule
Distal convoluted tubule
Bowman's capsule
Cortex
H_2O
H_2O
Cl^-
Na^+
H_2O
Cl^-
Na^+
Collecting duct
H_2O
Outer medulla
Cl^-
Na^+
Descending limb
Ascending limb
NaCl
H_2O
Inner medulla
H_2O
NaCl
Urea
Urea
NaCl
Urea
Loop of Henle
H_2O
H_2O
Urine

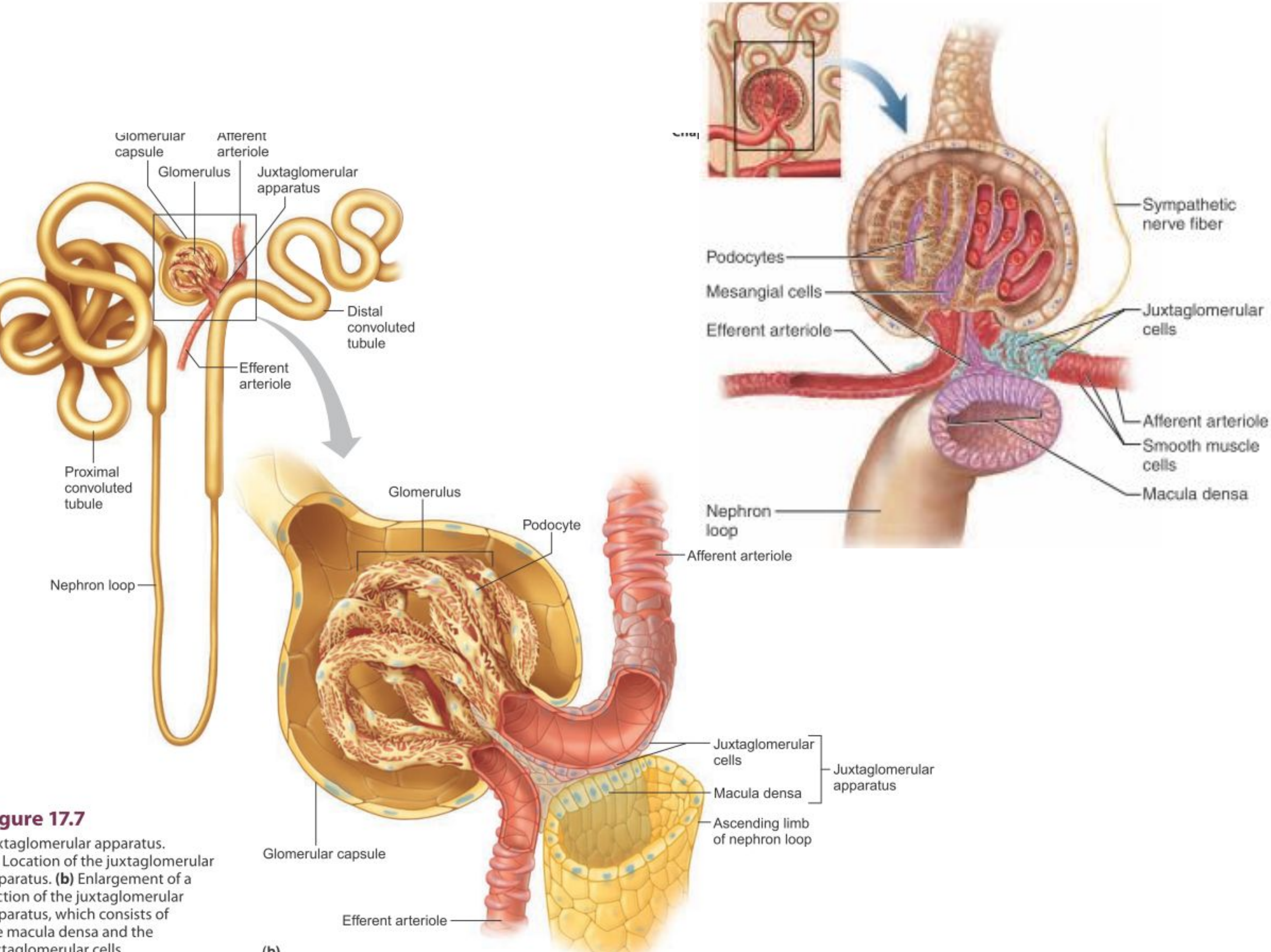


The nephron loop segments, vasa recta, and collecting tubules are all bundled together *in vivo*.

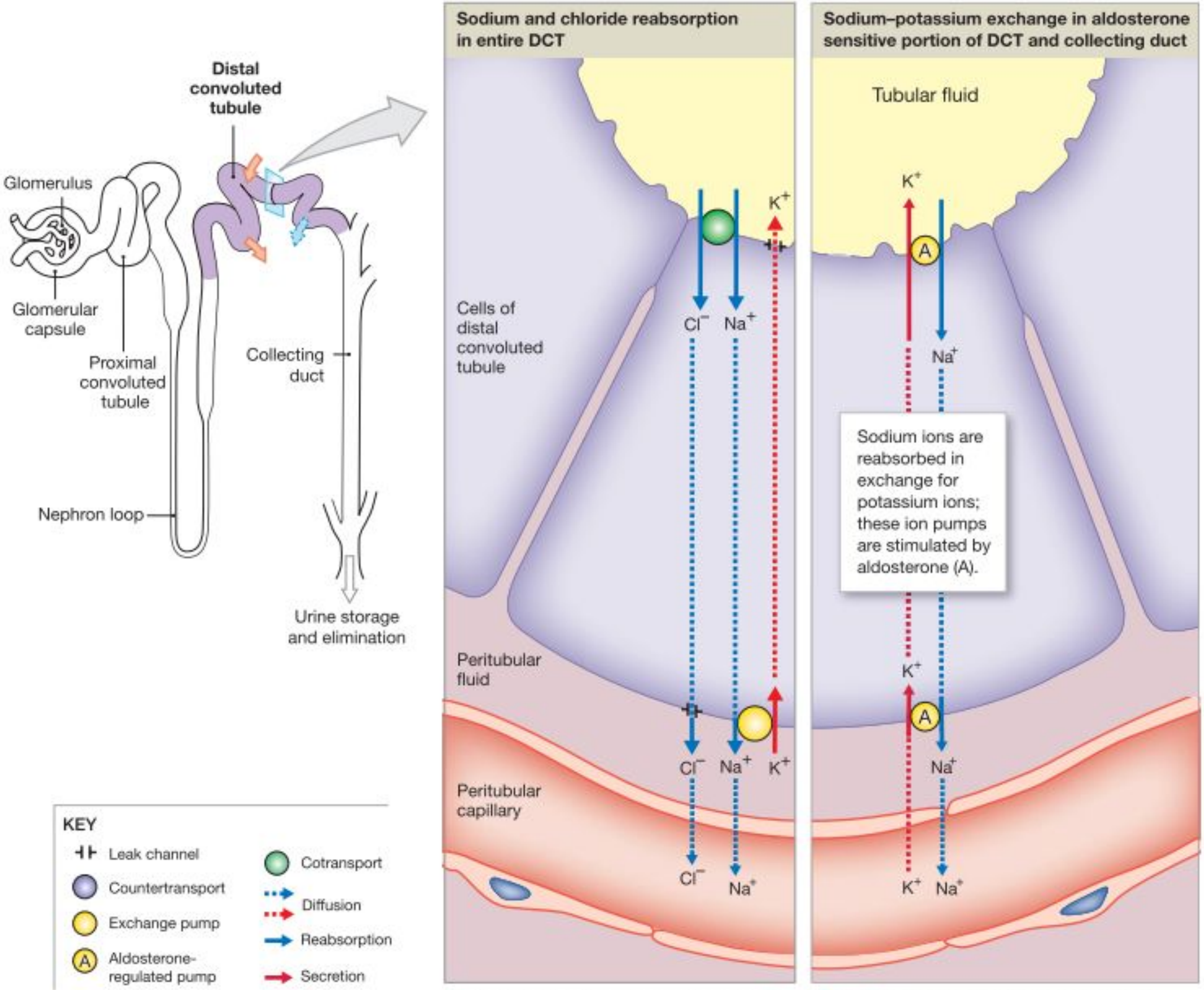
They coexist in near osmotic equilibrium at all levels within the renal medulla.


4
3
2
1
0
TF_{Osm}/P_{Osm}
Water restriction
(antidiuresis)
High water intake
(water diuresis)
Proximal tubule
Loop
Classic
distal tubule
Cortical
collecting
tubule
(CCT)
Medullary
collecting
ducts
(OMCD, IMCD)
Urine


Obligatory Water Reabsorption
Facultative Water Reabsorption
Glomerulus
Glomerular capsule
Proximal convoluted tubule
Nephron loop
Distal convoluted tubule
Collecting duct
Urine storage and elimination



gure 17.7
xtaglomerular apparatus.
Location of the juxtaglomerular
paratus. **(b)** Enlargement of a
ction of the juxtaglomerular
paratus, which consists of
e macula densa and the
xtaglomerular cells.



Sodium and chloride reabsorption in entire DCT

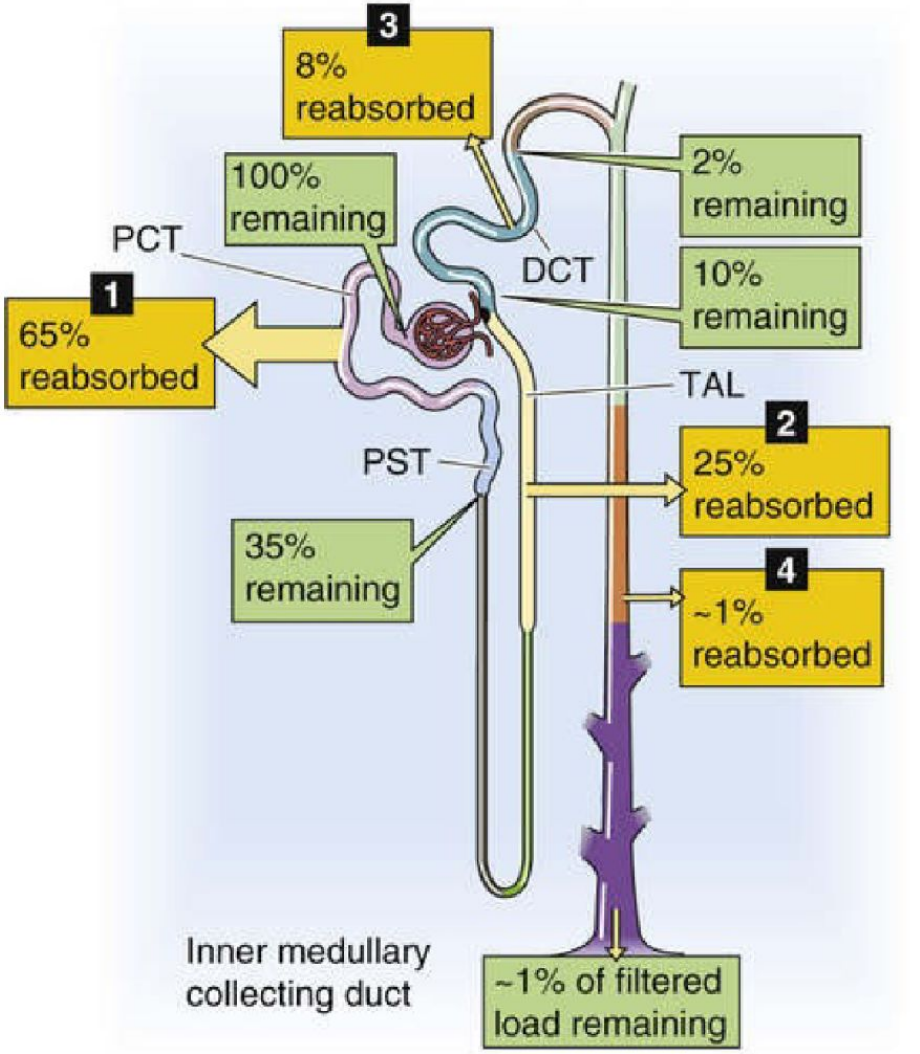
Sodium–potassium exchange in aldosterone sensitive portion of DCT and collecting duct

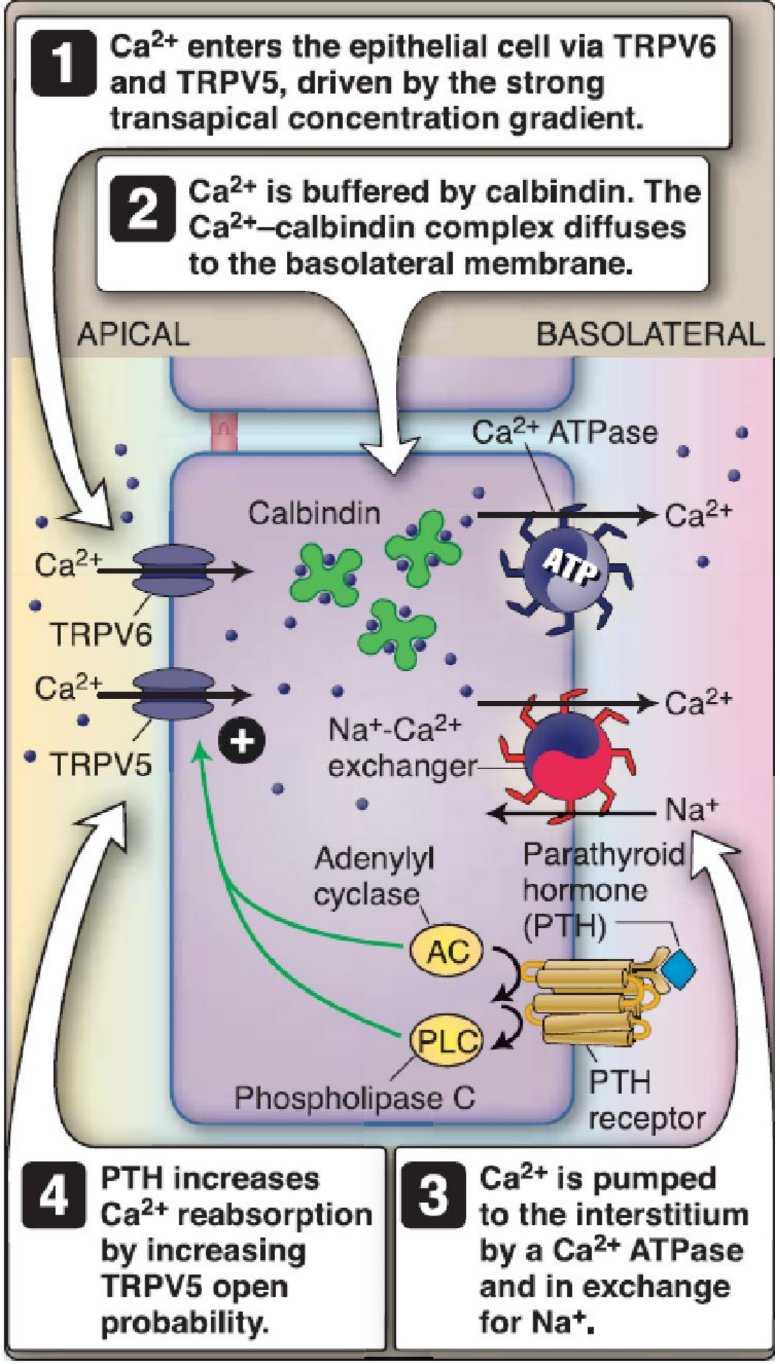
Sodium ions are reabsorbed in exchange for potassium ions; these ion pumps are stimulated by aldosterone (A).

a The basic pattern of the reabsorption of sodium and chloride ions and the secretion of potassium ions

b Aldosterone-regulated reabsorption of sodium ions, linked to the passive loss of potassium ions

A HANDLING OF Ca^{2+} ALONG NEPHRON



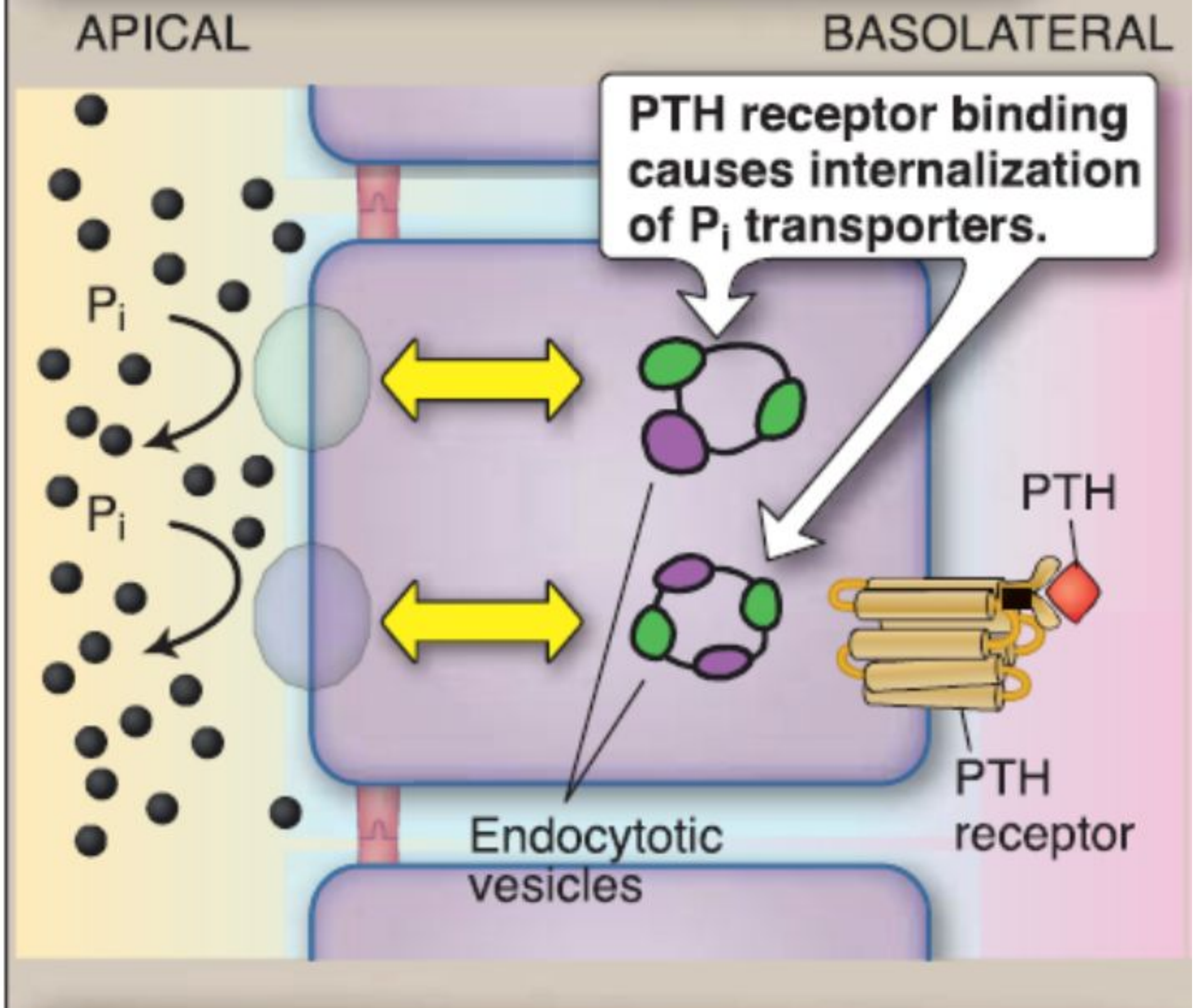

1 Ca^{2+} enters the epithelial cell via TRPV6 and TRPV5, driven by the strong transapical concentration gradient.

2 Ca^{2+} is buffered by calbindin. The Ca^{2+}–calbindin complex diffuses to the basolateral membrane.

4 PTH increases Ca^{2+} reabsorption by increasing TRPV5 open probability.

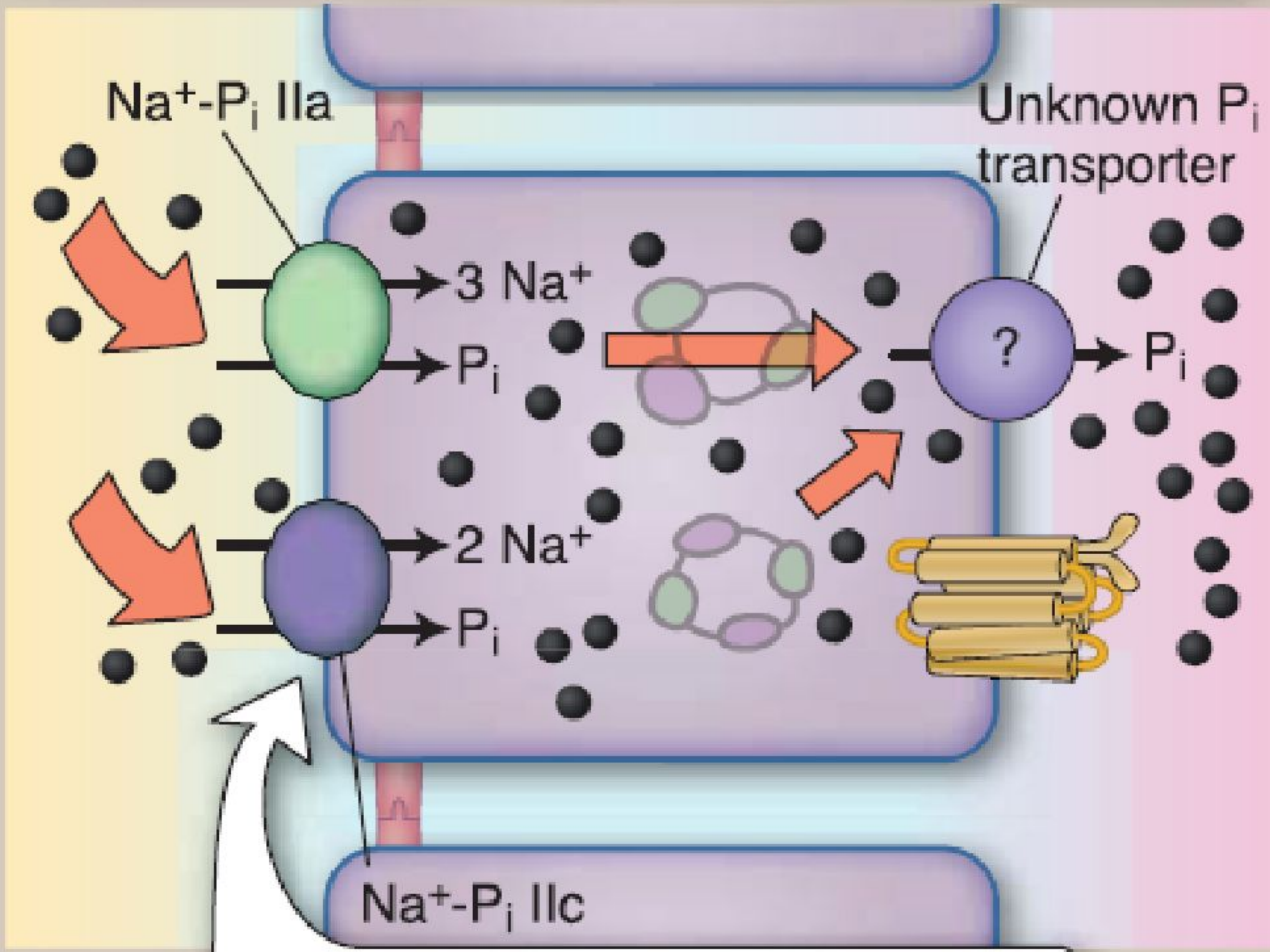
3 Ca^{2+} is pumped to the interstitium by a Ca^{2+} ATPase and in exchange for Na^+.

A Parathyroid hormone (PTH) inhibits phosphate (P_i) reabsorption.



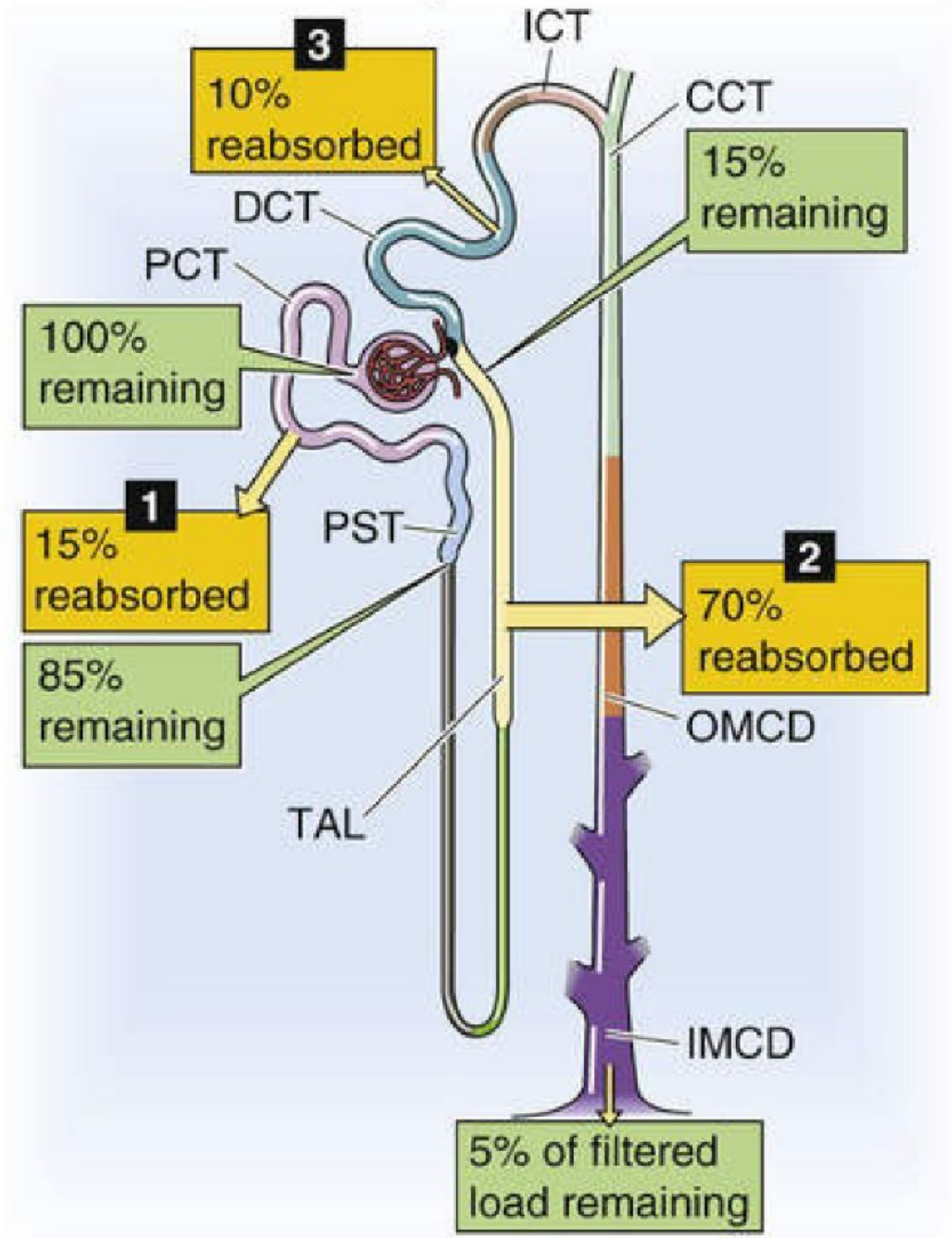
B P_i transporters are inserted into the apical membrane when plasma P_i levels are low.

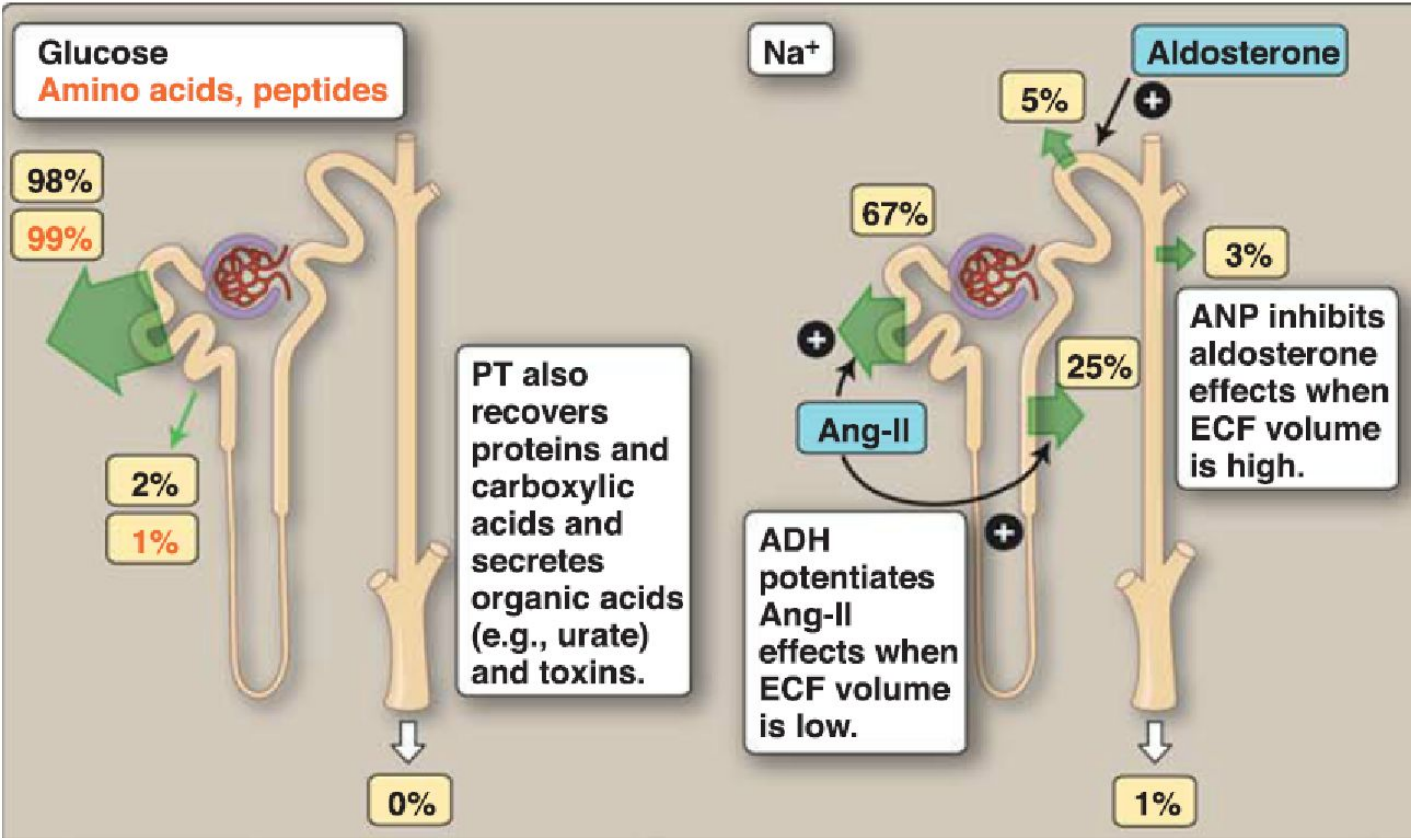
B P_i transporters are inserted into the apical membrane when plasma P_i levels are low.



Transporters provide a pathway for transepithelial P_i recovery.

A HANDLING OF Mg^{2+} ALONG NEPHRON

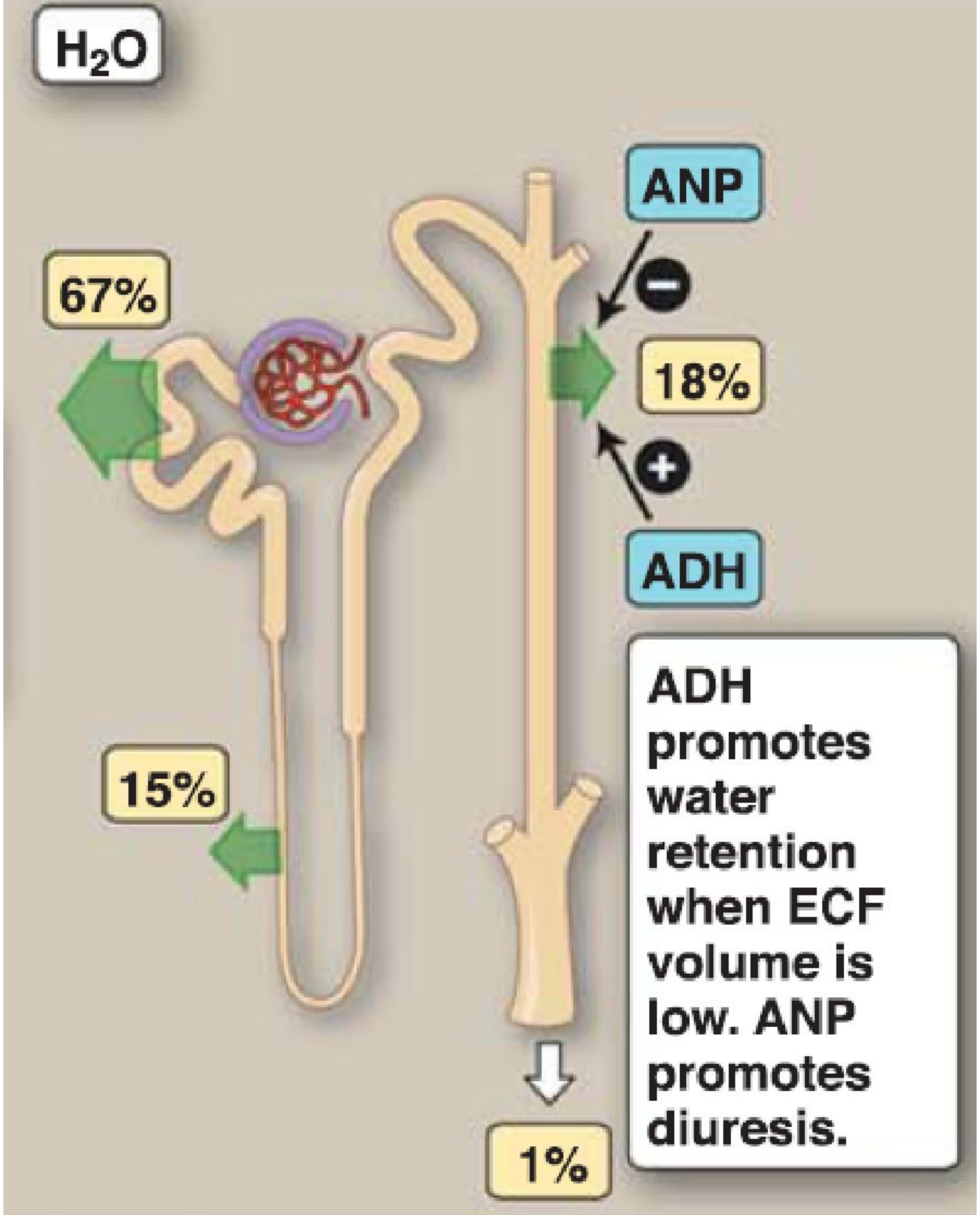




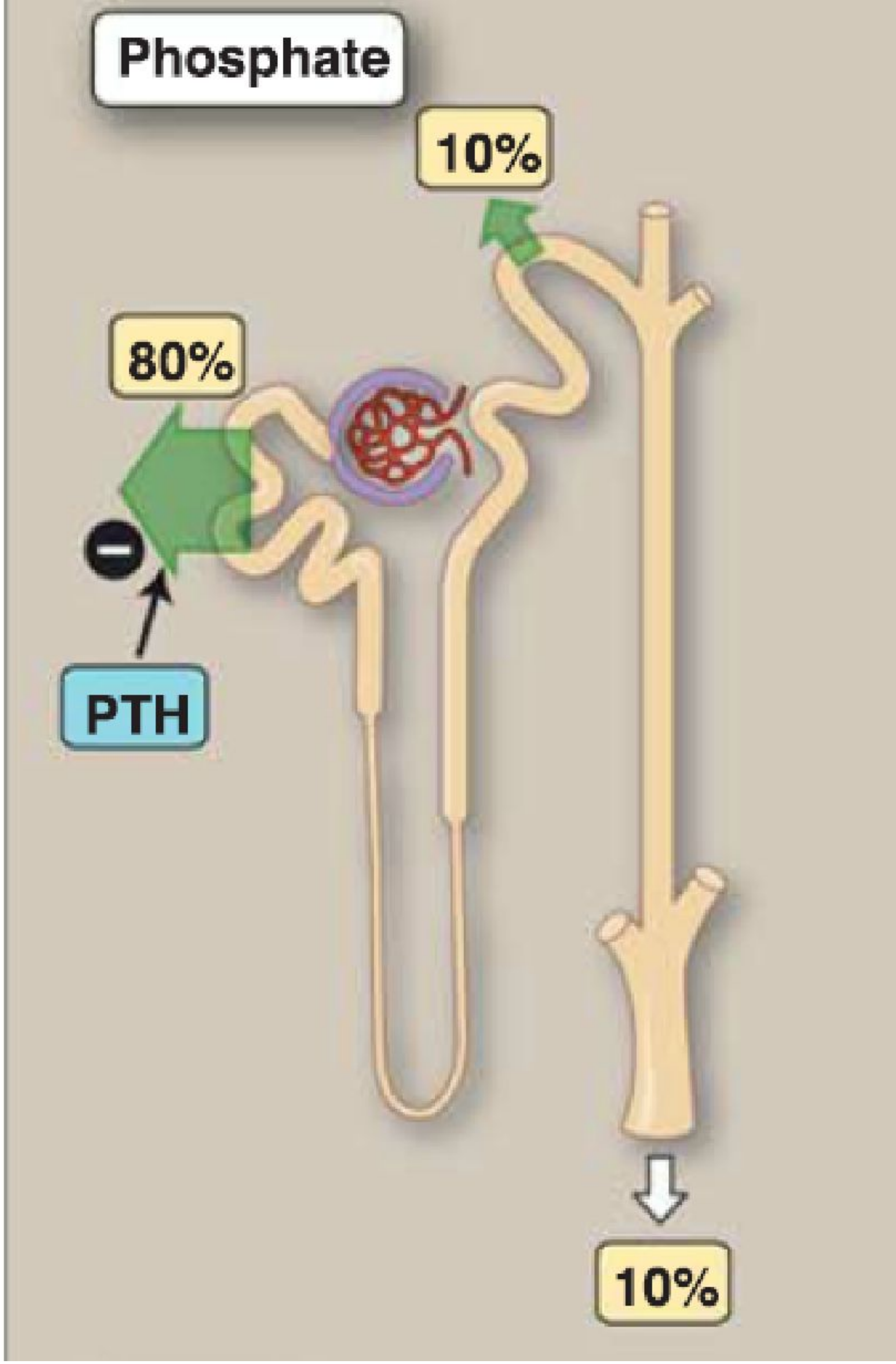
PT also recovers proteins and carboxylic acids and secretes organic acids (e.g., urate) and toxins.

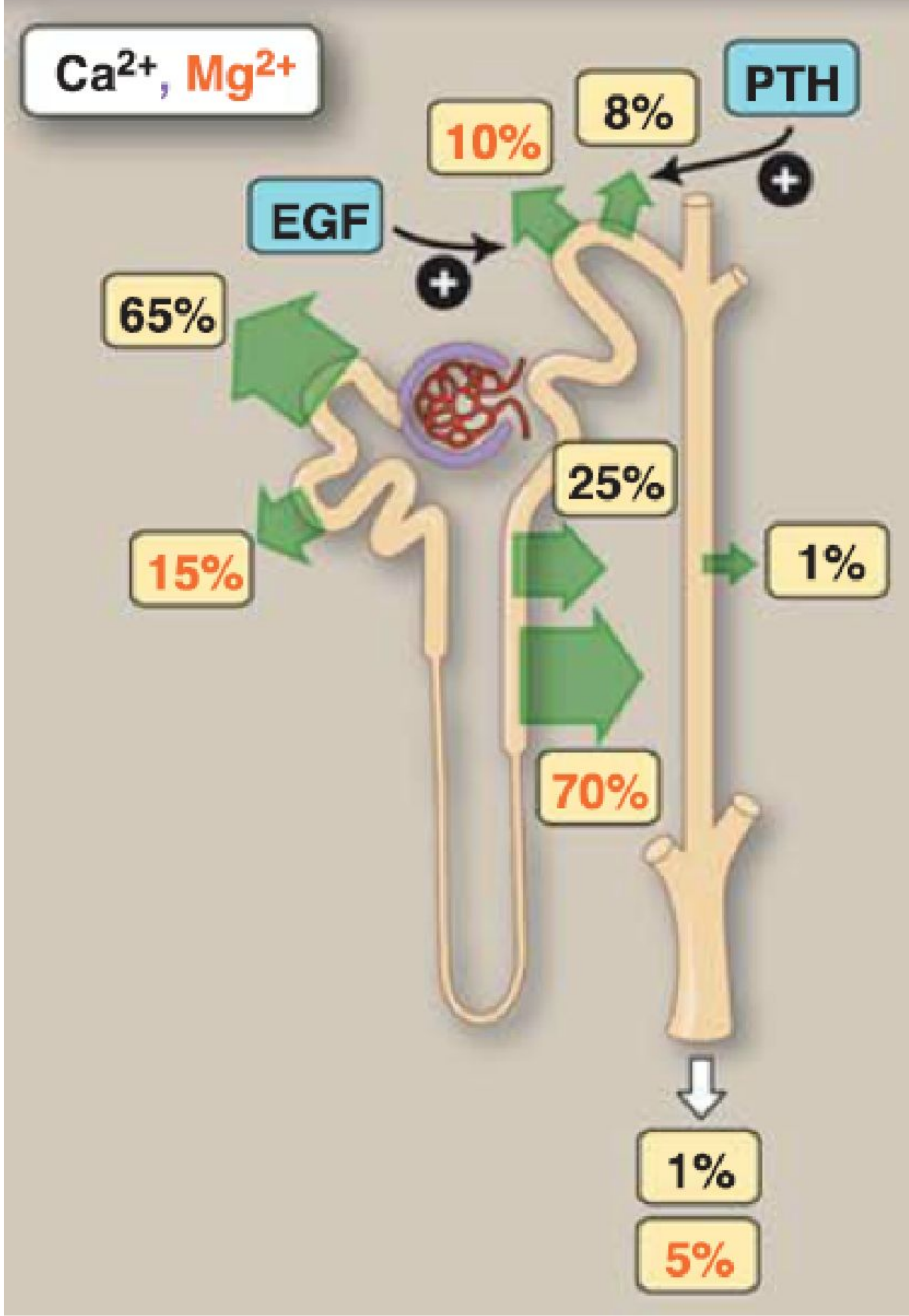
ADH potentiates Ang-II effects when ECF volume is low.

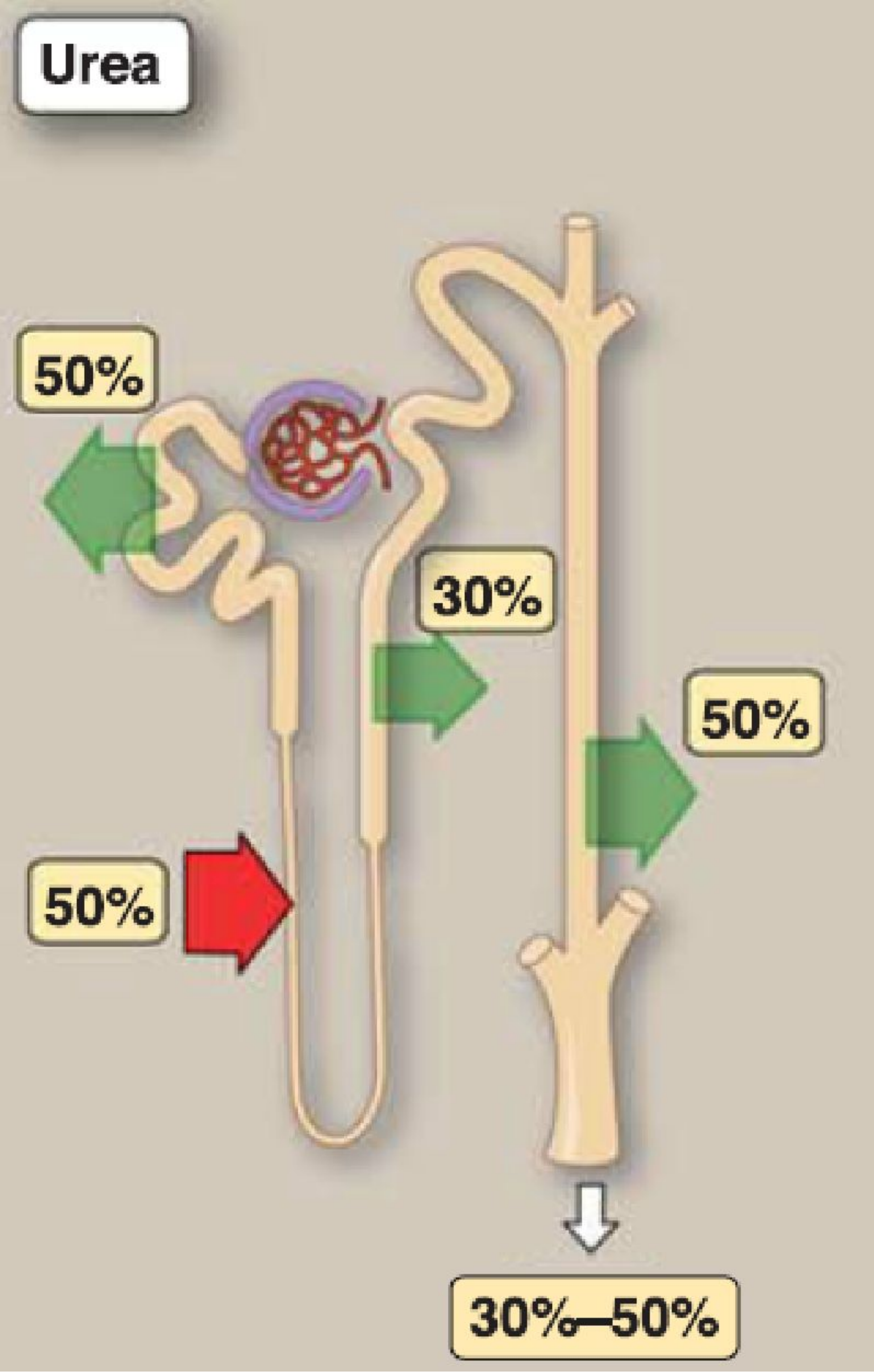
ANP inhibits aldosterone effects when ECF volume is high.

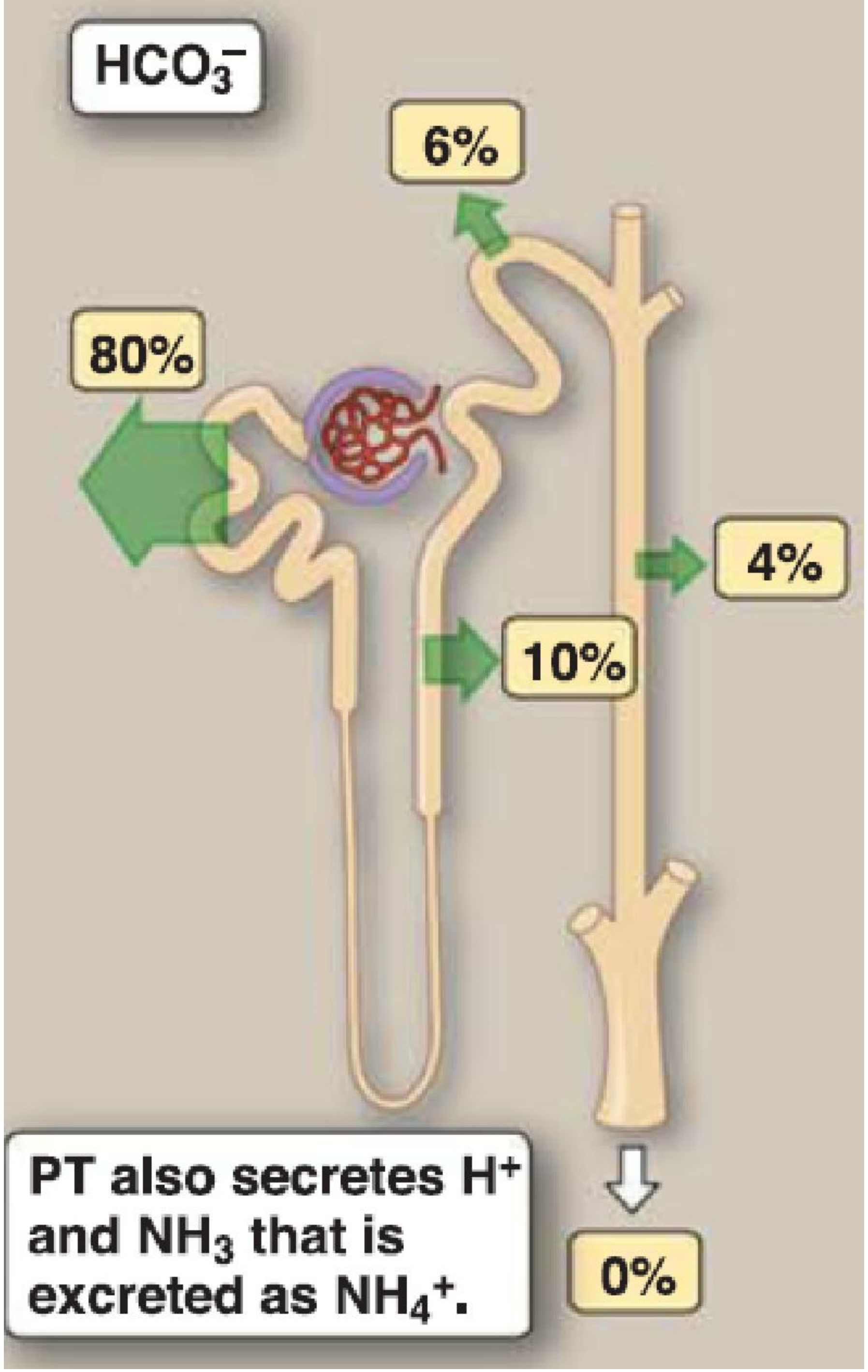


ADH promotes water retention when ECF volume is low. ANP promotes diuresis.

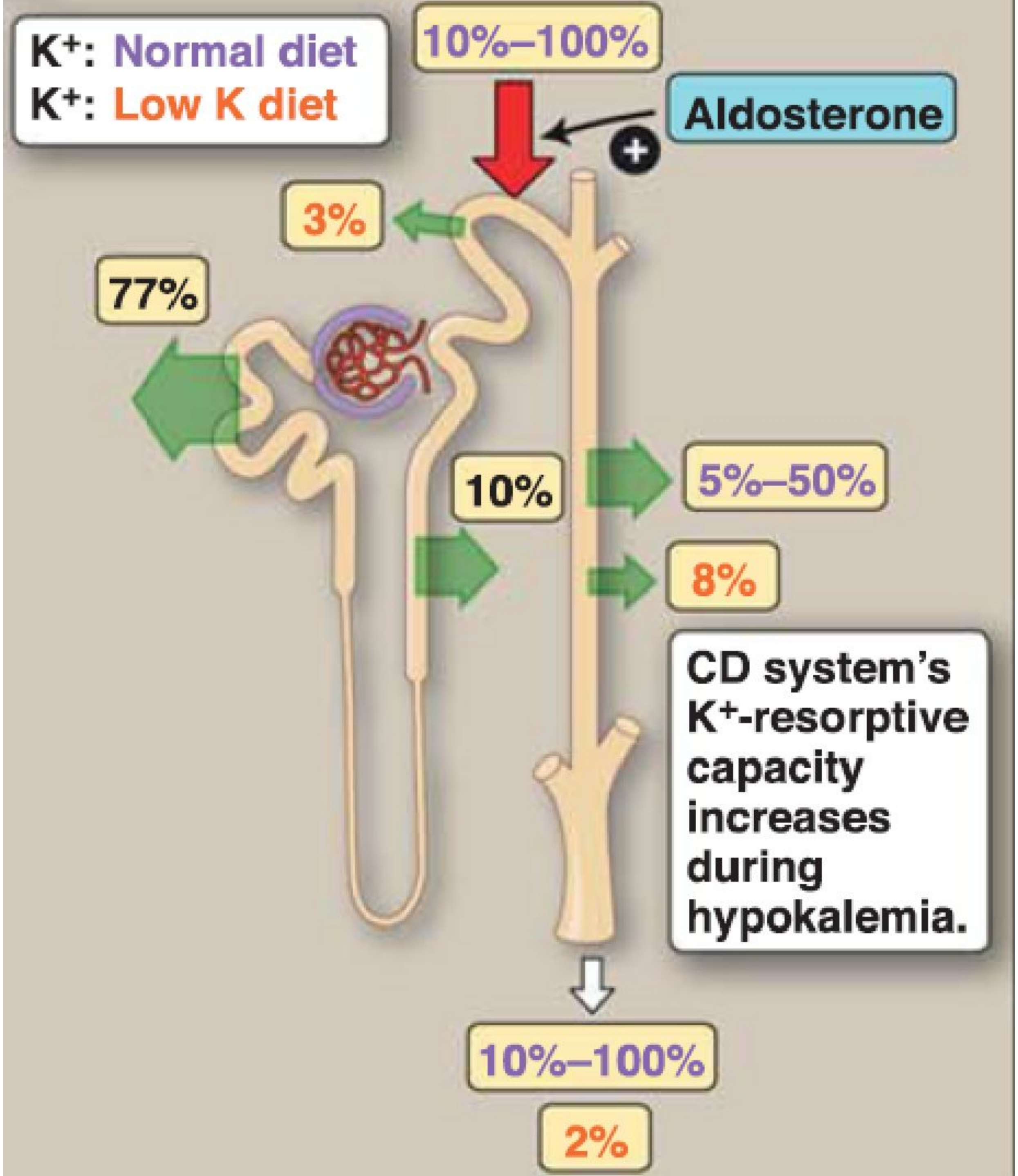

Phosphate
10%
80%
PTH
10%


Ca^{2+}, Mg^{2+}
10%
8%
PTH
EGF
65%
25%
15%
1%
70%
1%
5%

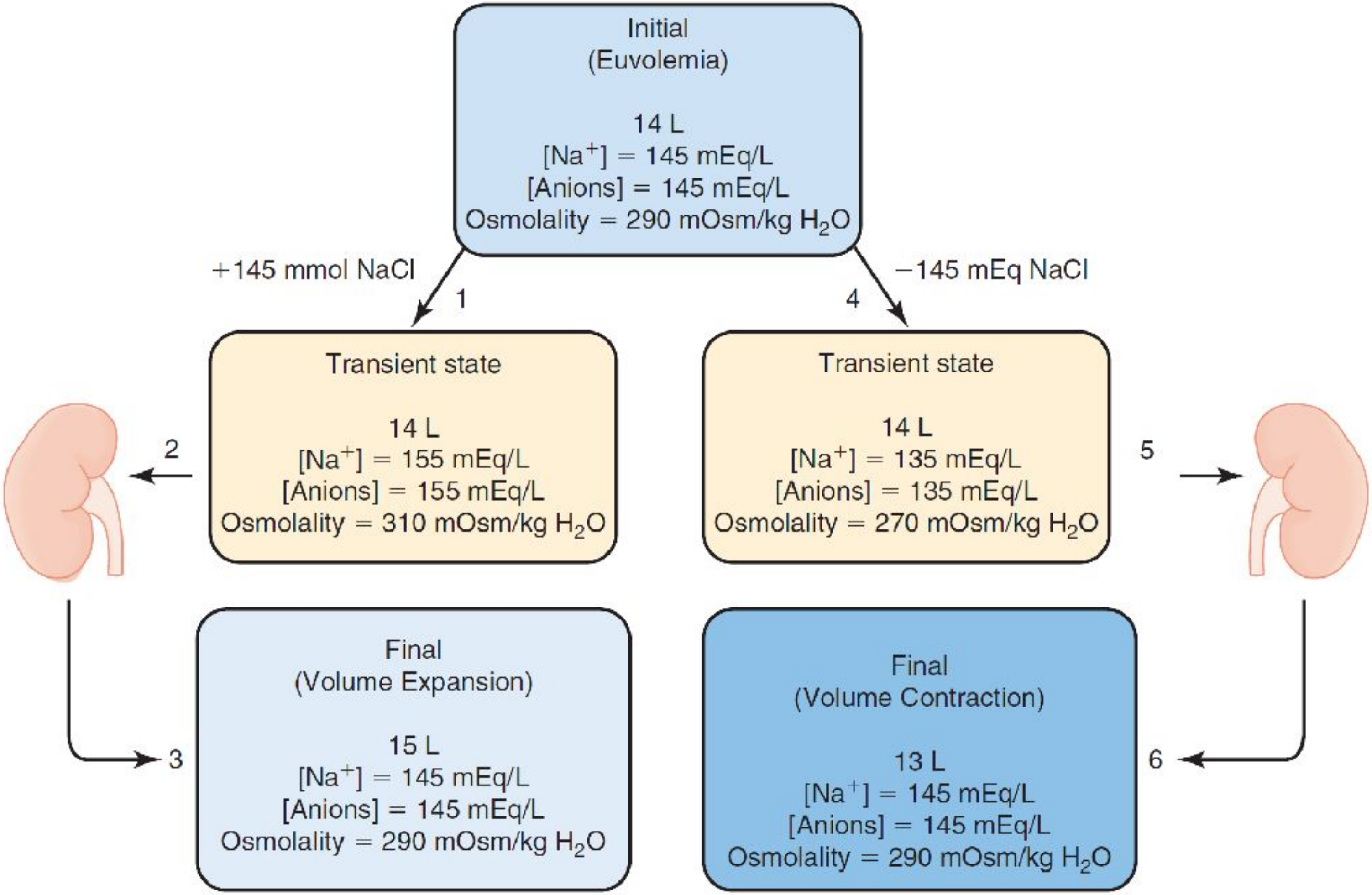




PT also secretes H^+ and NH_3 that is excreted as NH_4^+.



CD system's K$^+$-resorptive capacity increases during hypokalemia.



Initial
(Euvolemia)

14 L
$[Na^+] = 145$ mEq/L
[Anions] = 145 mEq/L
Osmolality = 290 mOsm/kg H_2O

+145 mmol NaCl

1

Transient state

14 L
$[Na^+] = 155$ mEq/L
[Anions] = 155 mEq/L
Osmolality = 310 mOsm/kg H_2O

2

3

Final
(Volume Expansion)

15 L
$[Na^+] = 145$ mEq/L
[Anions] = 145 mEq/L
Osmolality = 290 mOsm/kg H_2O

−145 mEq NaCl

4

Transient state

14 L
$[Na^+] = 135$ mEq/L
[Anions] = 135 mEq/L
Osmolality = 270 mOsm/kg H_2O

5

6

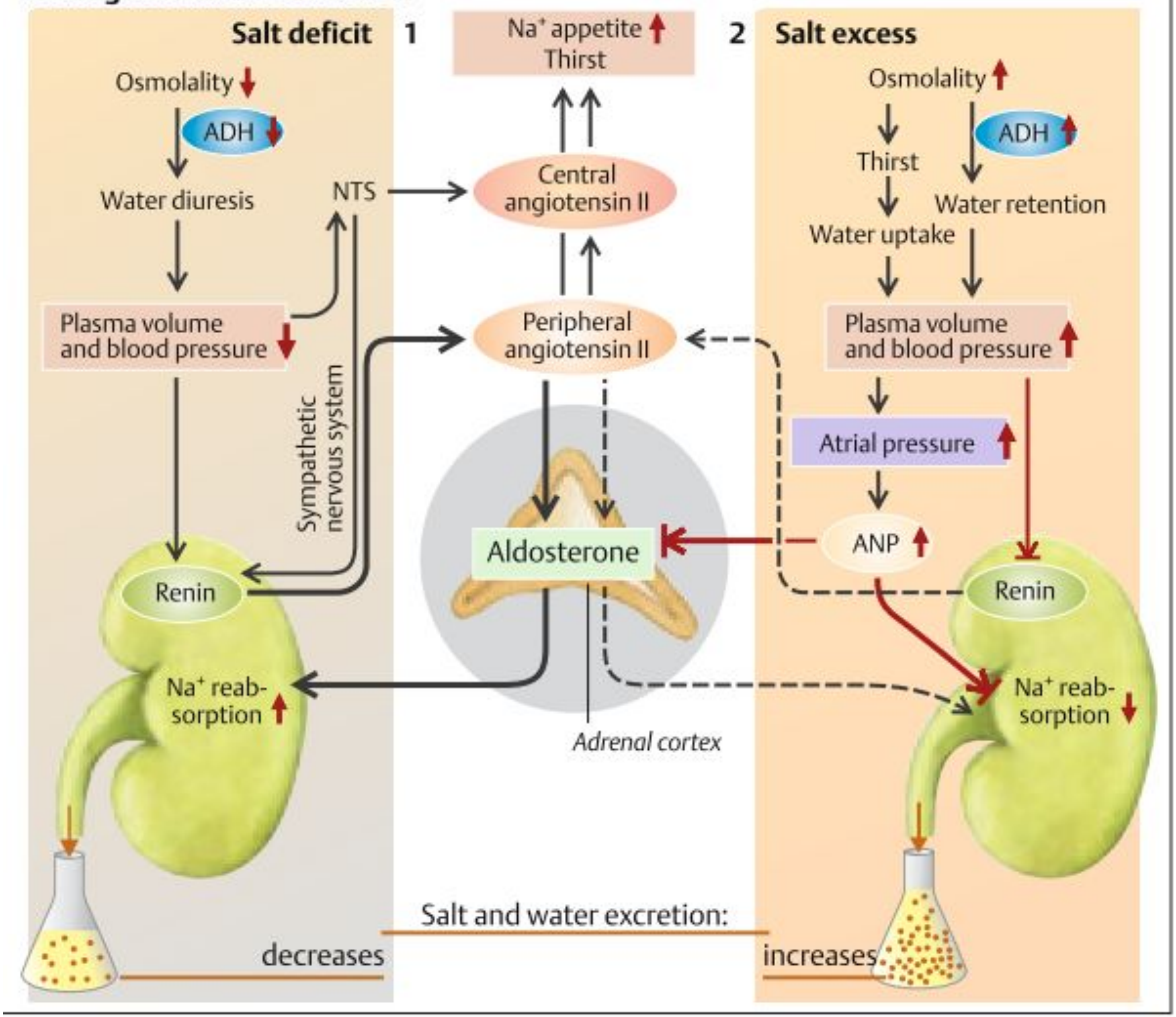
Final
(Volume Contraction)

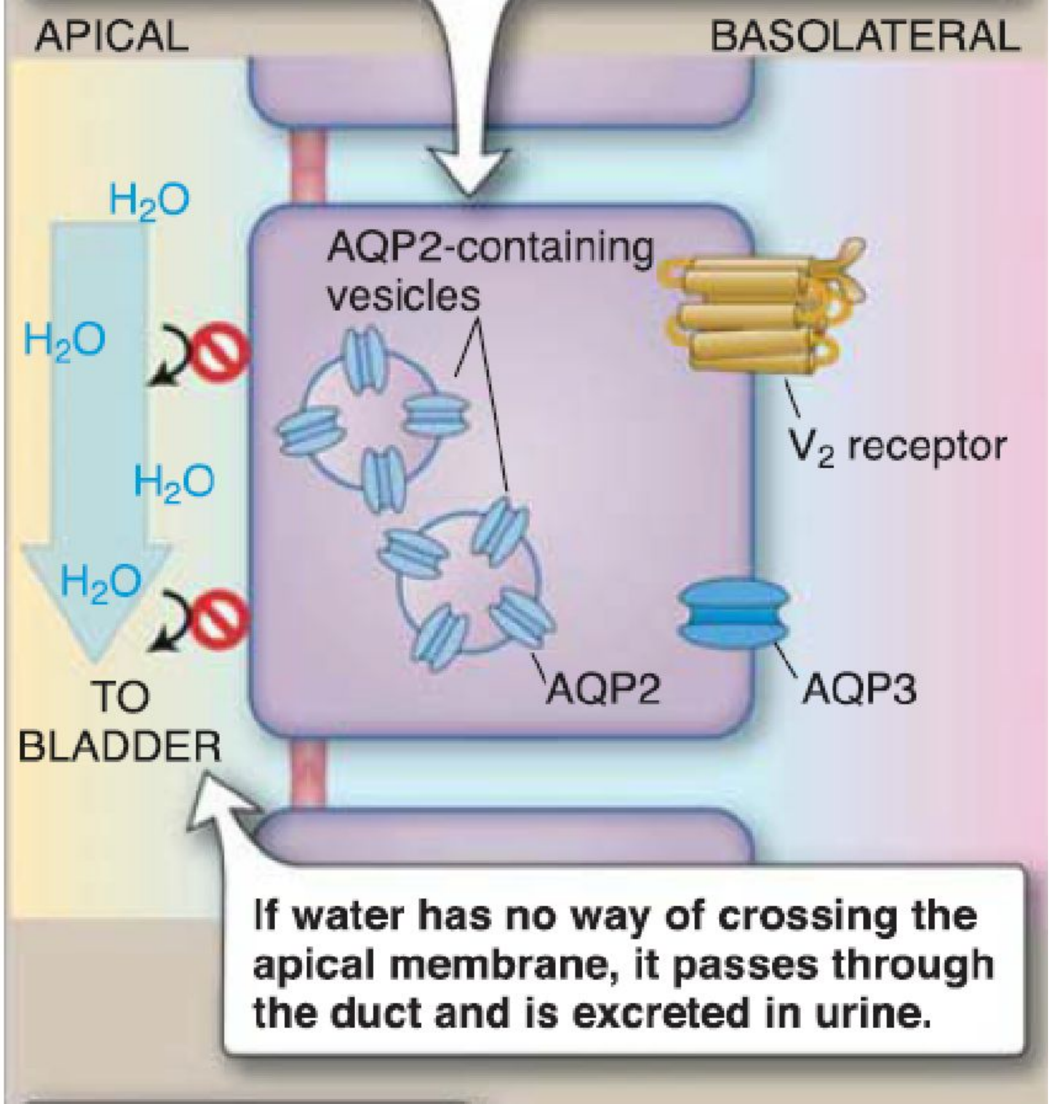
13 L
$[Na^+] = 145$ mEq/L
[Anions] = 145 mEq/L
Osmolality = 290 mOsm/kg H_2O

In response to elevated AVP levels the kidneys retain 1 L of water returning osmolality and $[Na^+]$ to normal, but increasing ECF volume.

In response to decreased AVP levels the kidneys excrete 1 L of water returning osmolality and $[Na^+]$ to normal, but reducing ECF volume.

D. Regulation of salt balance

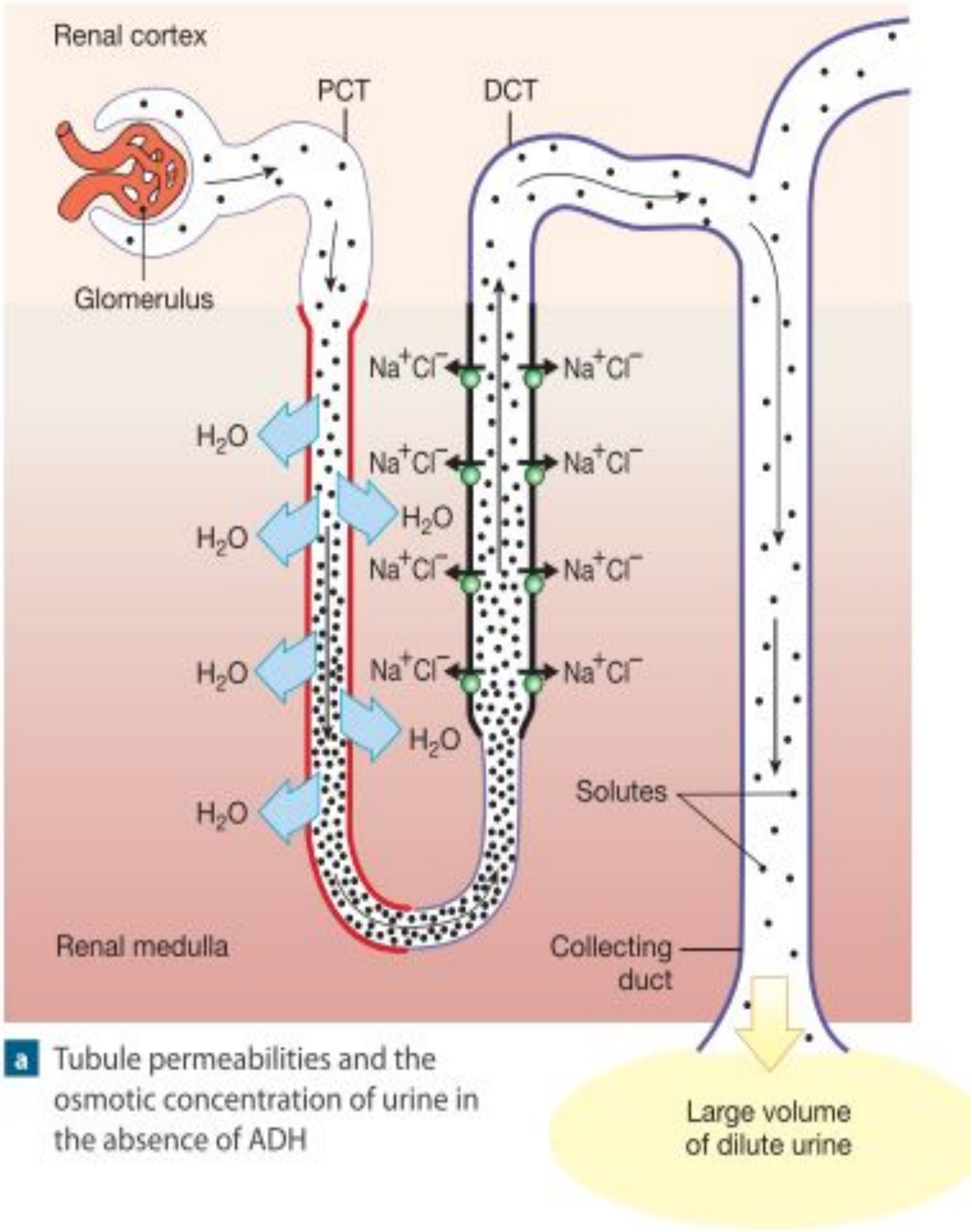




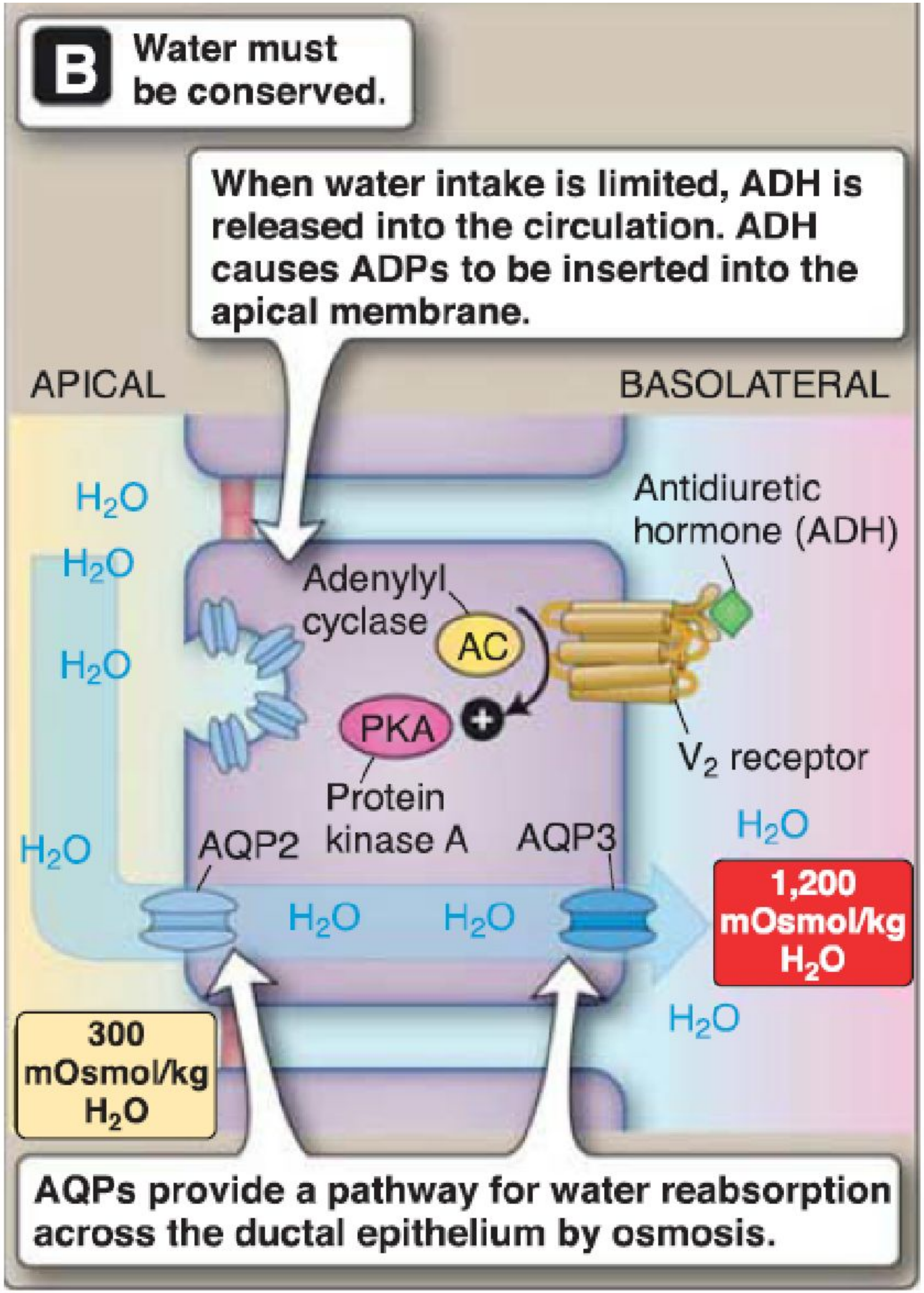
A Water intake exceeds body needs.

When water intake is surplus to body needs, AQP2 channels are internalized in vesicles.

If water has no way of crossing the apical membrane, it passes through the duct and is excreted in urine.



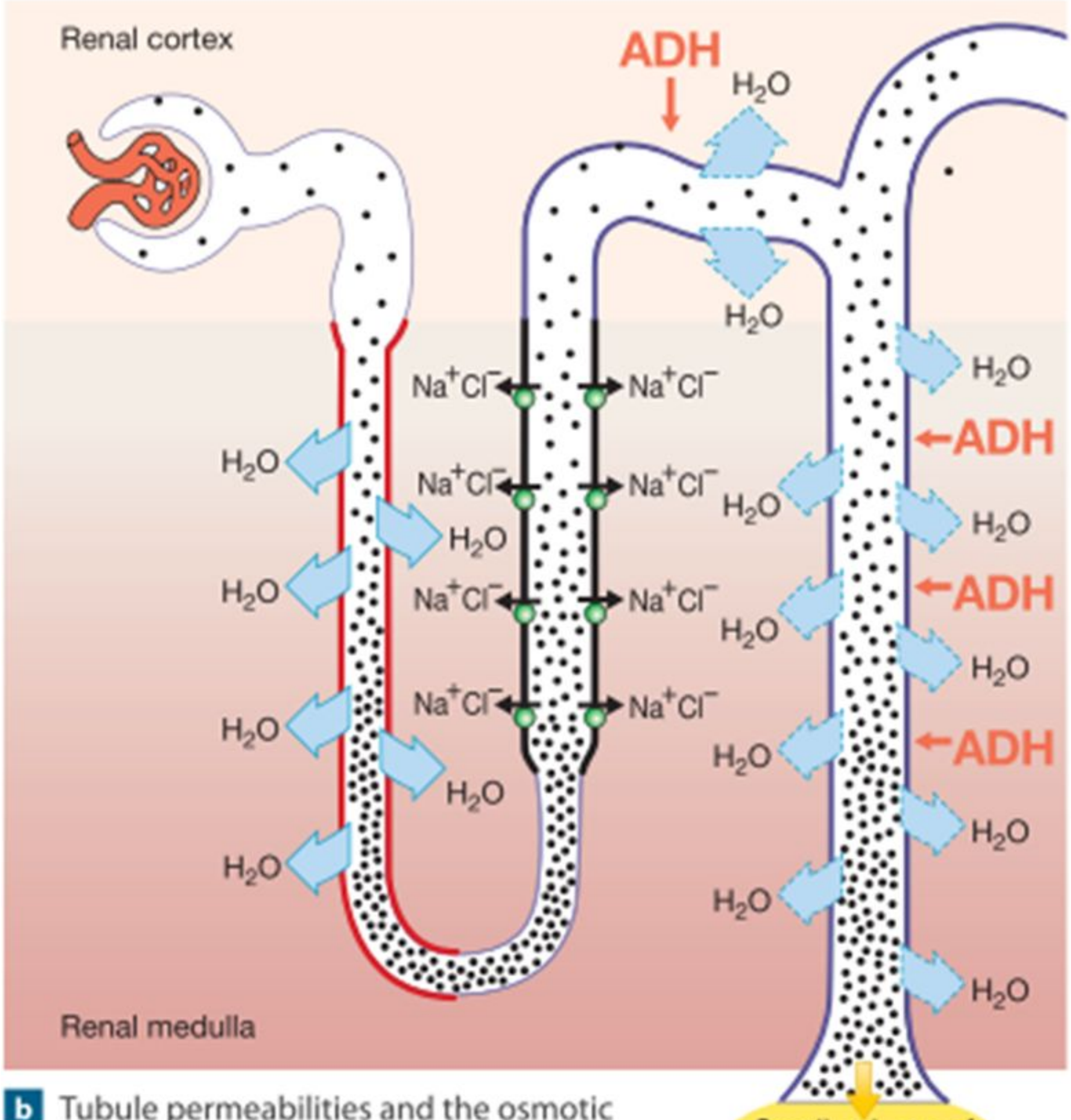
a Tubule permeabilities and the osmotic concentration of urine in the absence of ADH



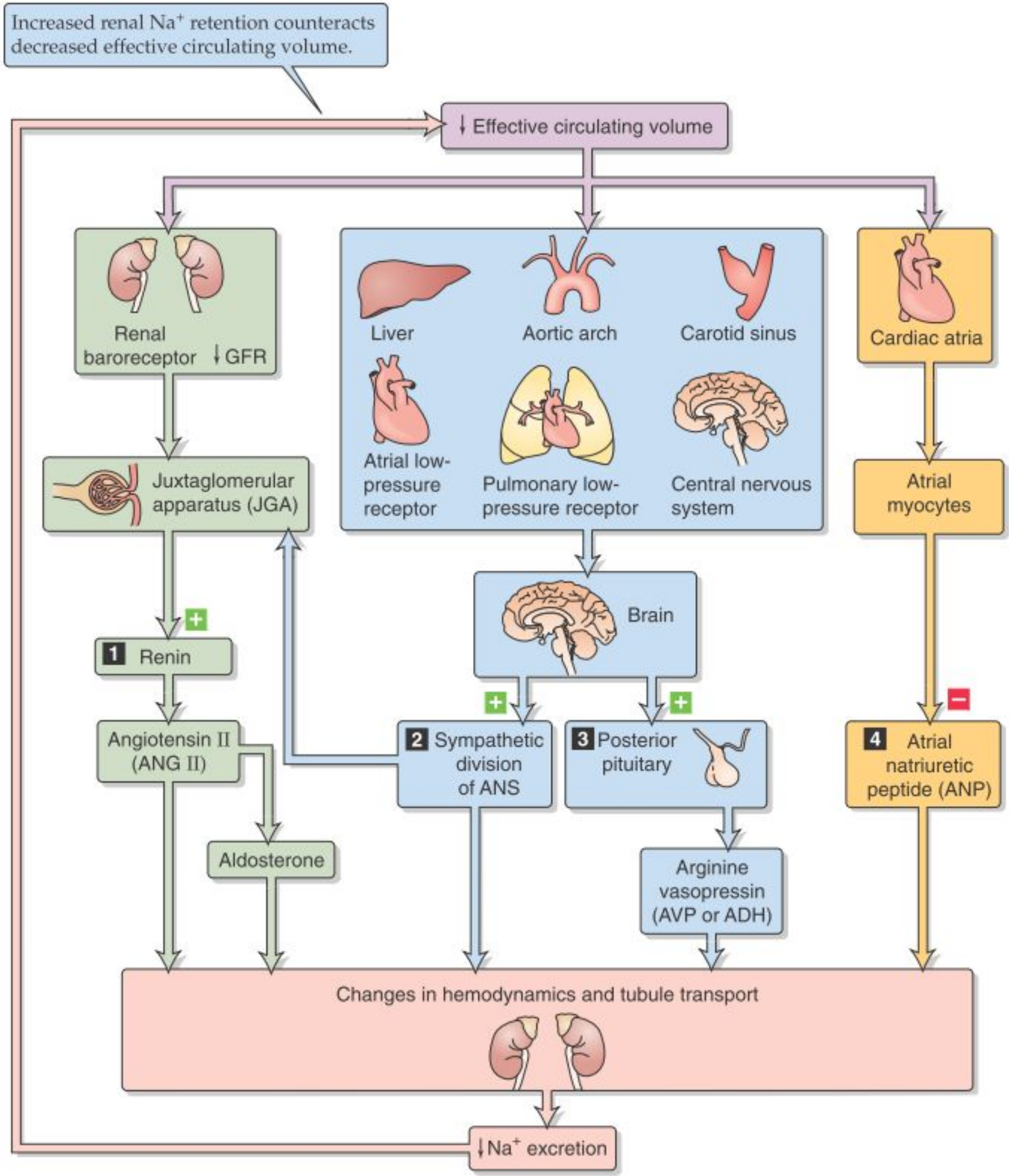
B Water must be conserved.

When water intake is limited, ADH is released into the circulation. ADH causes ADPs to be inserted into the apical membrane.

AQPs provide a pathway for water reabsorption across the ductal epithelium by osmosis.



b Tubule permeabilities and the osmotic concentration of urine in the presence of ADH



Increased renal Na^+ retention counteracts decreased effective circulating volume.

↓ Effective circulating volume

Renal baroreceptor ↓GFR

Liver

Aortic arch

Carotid sinus

Atrial low-pressure receptor

Pulmonary low-pressure receptor

Central nervous system

Cardiac atria

Juxtaglomerular apparatus (JGA)

Atrial myocytes

Brain

\+

1 Renin

Angiotensin II (ANG II)

Aldosterone

\+

2 Sympathetic division of ANS

\+

3 Posterior pituitary

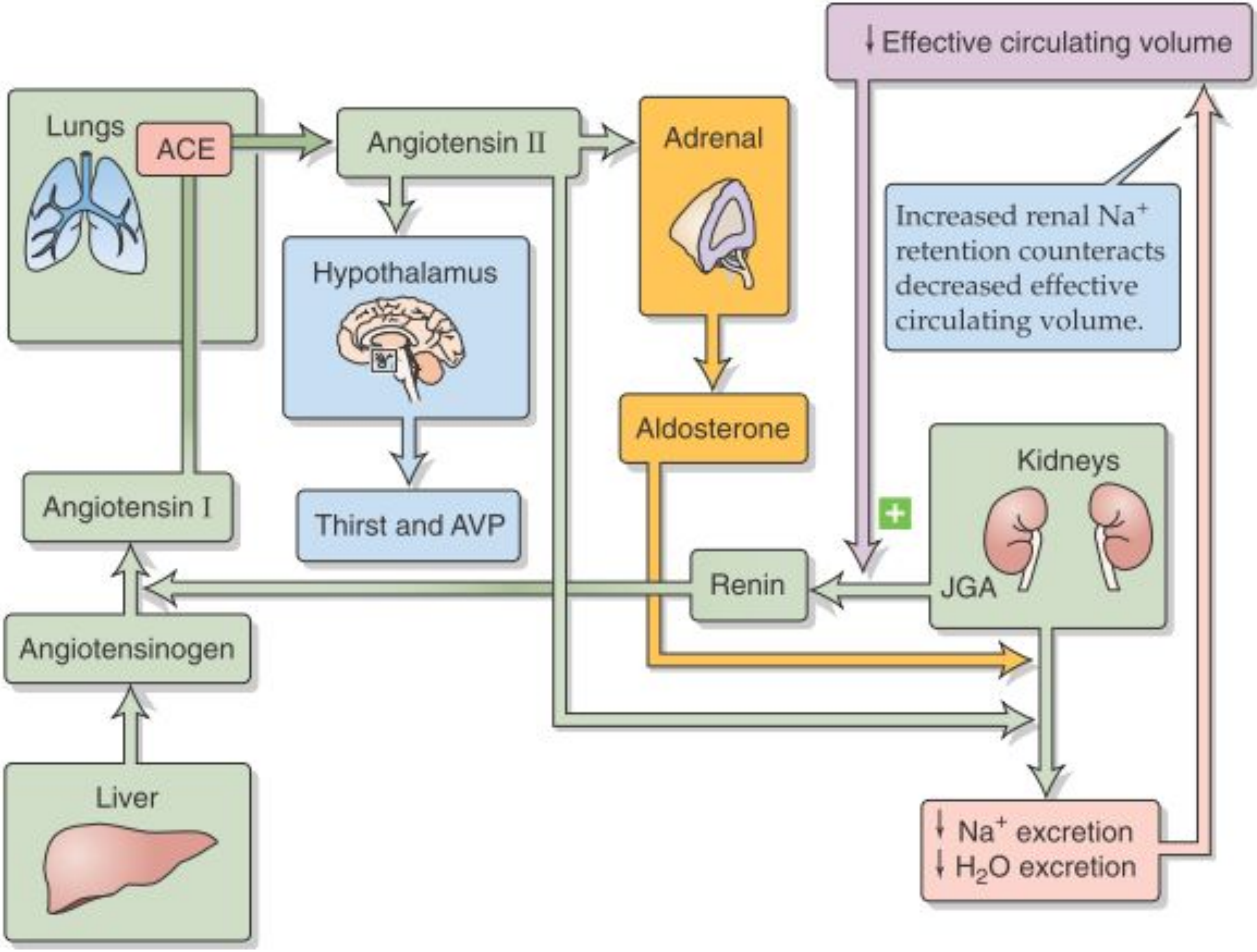
Arginine vasopressin (AVP or ADH)

−

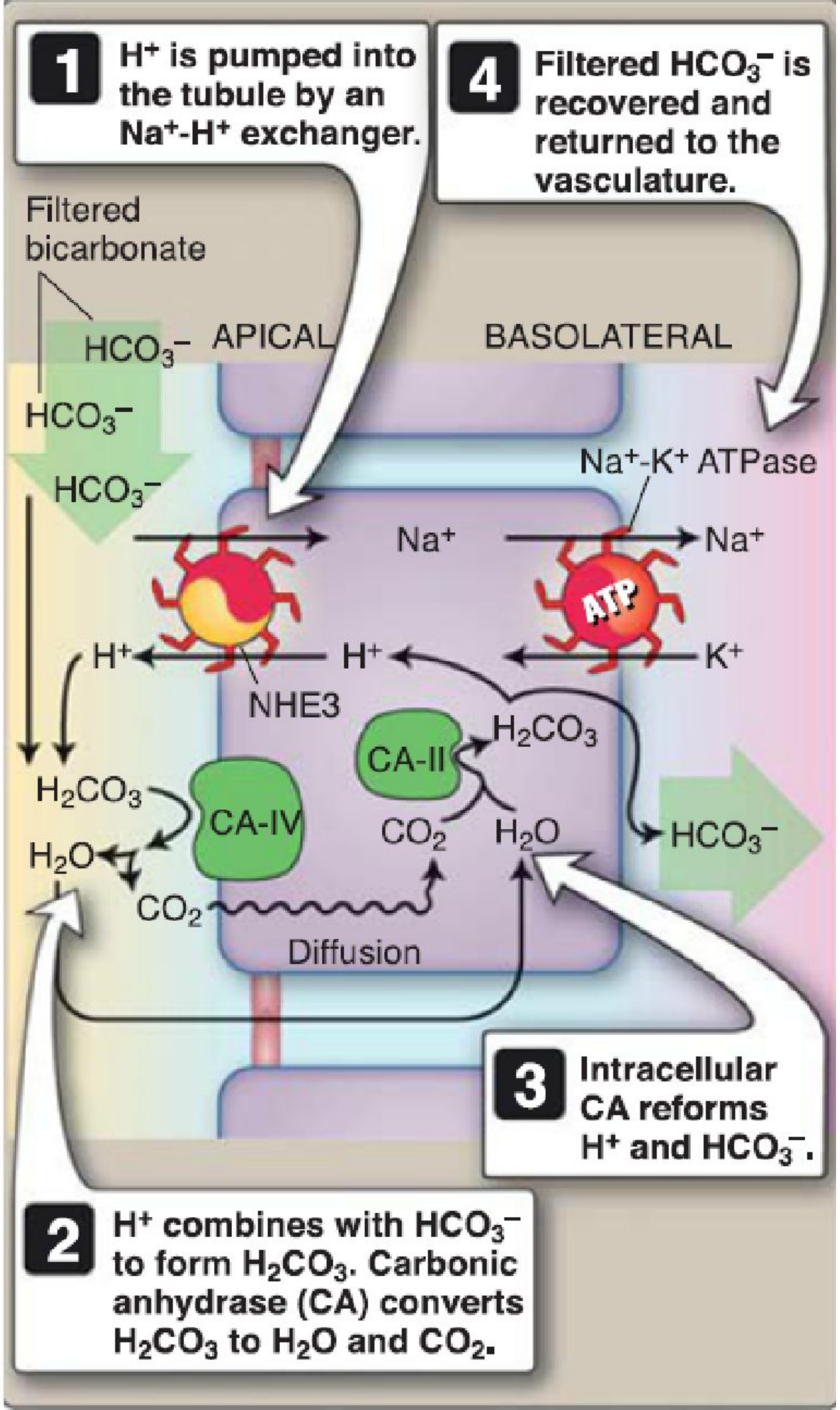
4 Atrial natriuretic peptide (ANP)

Changes in hemodynamics and tubule transport

↓Na^+ excretion



Increased renal Na^+ retention counteracts decreased effective circulating volume.

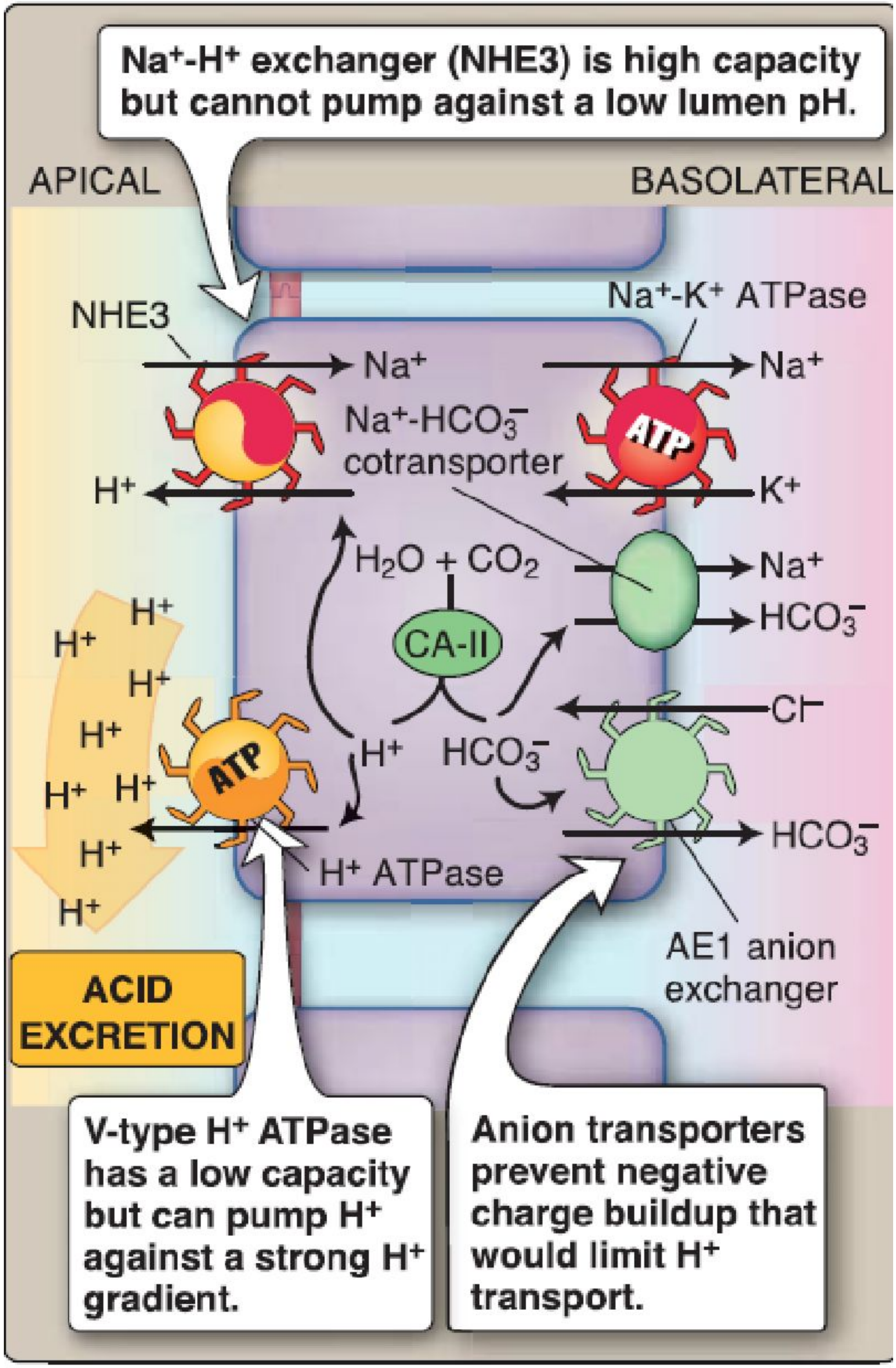


1 H⁺ is pumped into the tubule by an Na⁺-H⁺ exchanger.

2 H⁺ combines with HCO_3^- to form H_2CO_3. Carbonic anhydrase (CA) converts H_2CO_3 to H_2O and CO_2.

3 Intracellular CA reforms H⁺ and HCO_3^-.

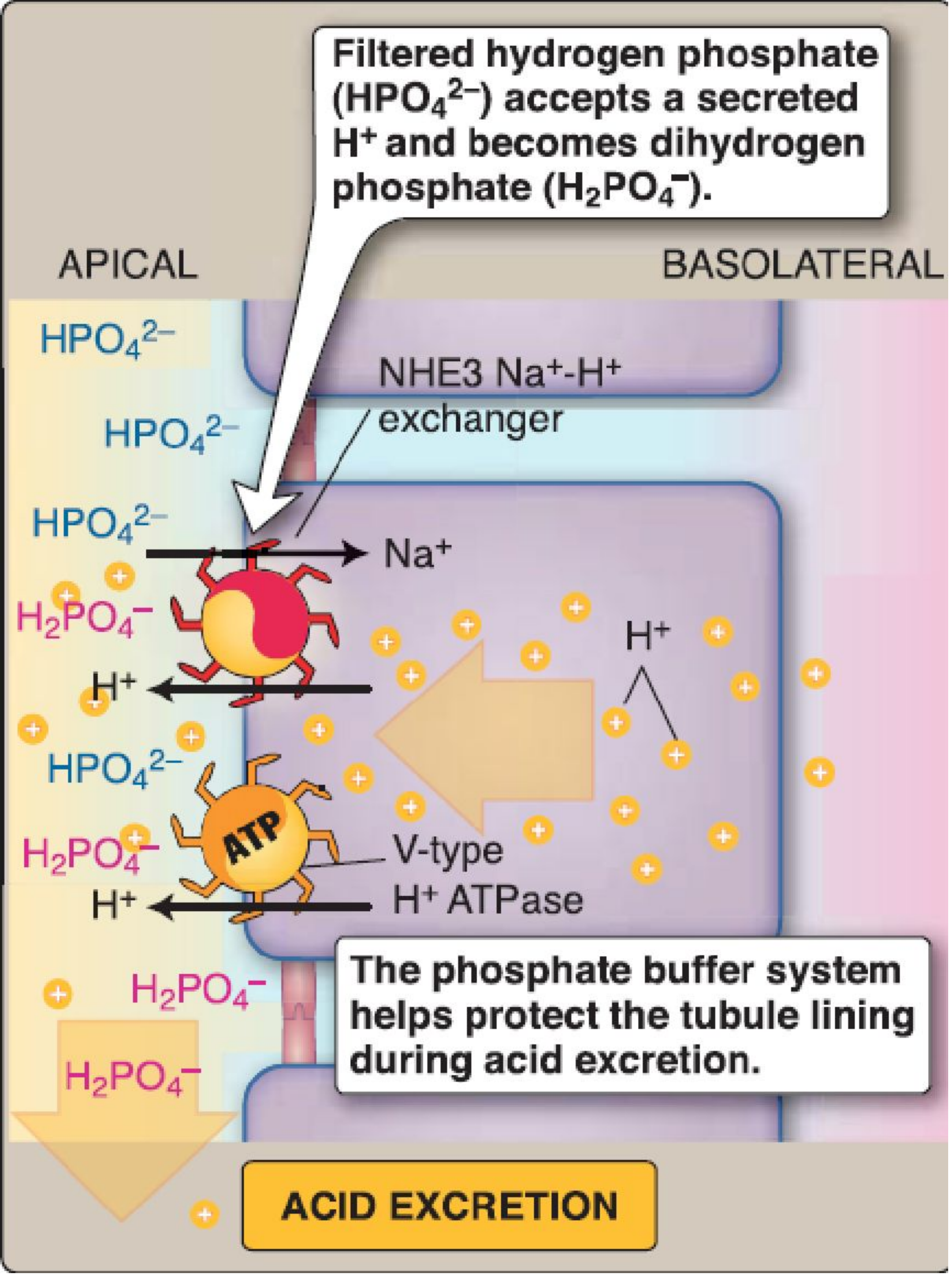
4 Filtered HCO_3^- is recovered and returned to the vasculature.



Na⁺-H⁺ exchanger (NHE3) is high capacity but cannot pump against a low lumen pH.

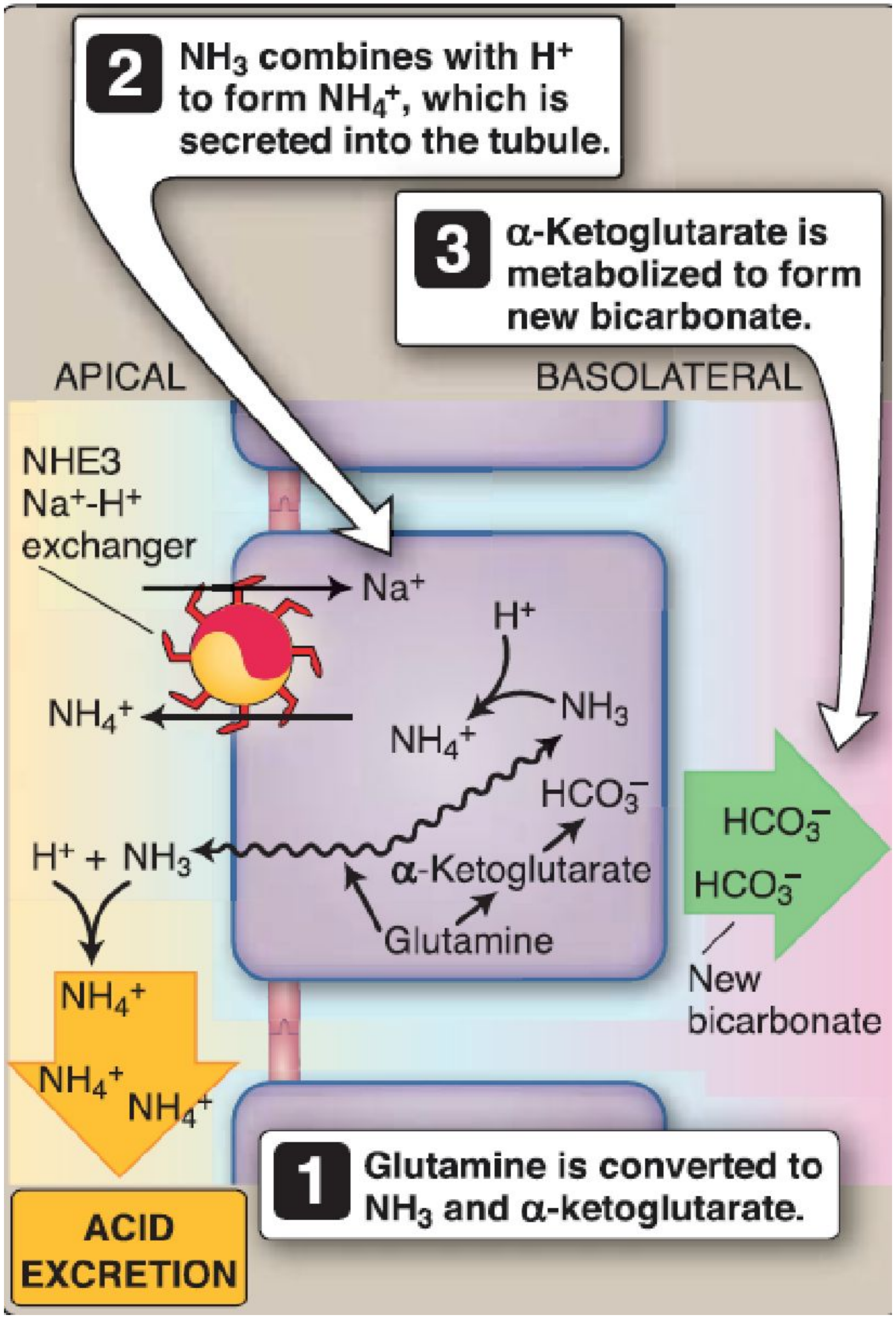
V-type H⁺ ATPase has a low capacity but can pump H⁺ against a strong H⁺ gradient.

Anion transporters prevent negative charge buildup that would limit H⁺ transport.



Filtered hydrogen phosphate (HPO_4^{2-}) accepts a secreted H^+ and becomes dihydrogen phosphate ($H_2PO_4^-$).

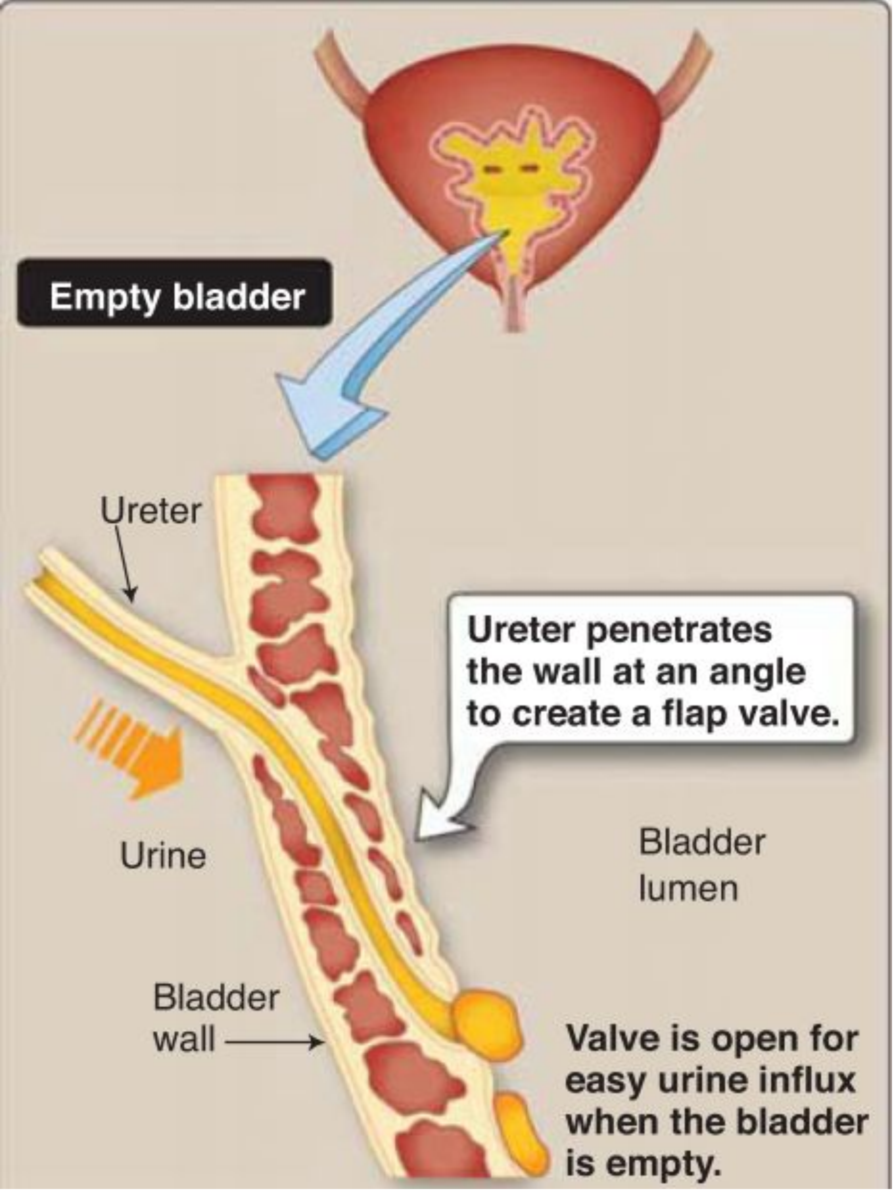
The phosphate buffer system helps protect the tubule lining during acid excretion.



2 NH_3 combines with H^+ to form NH_4^+, which is secreted into the tubule.

3 α-Ketoglutarate is metabolized to form new bicarbonate.

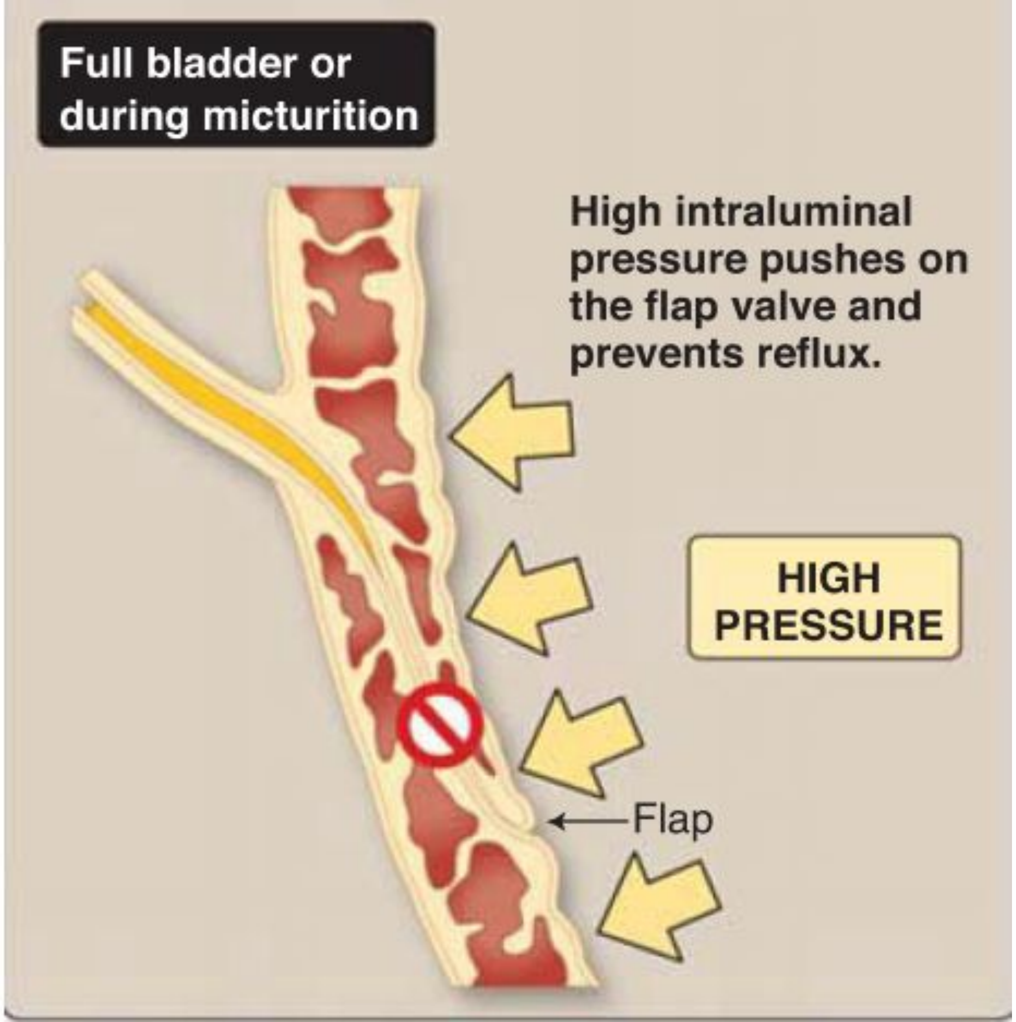
1 Glutamine is converted to NH_3 and α-ketoglutarate.



Empty bladder

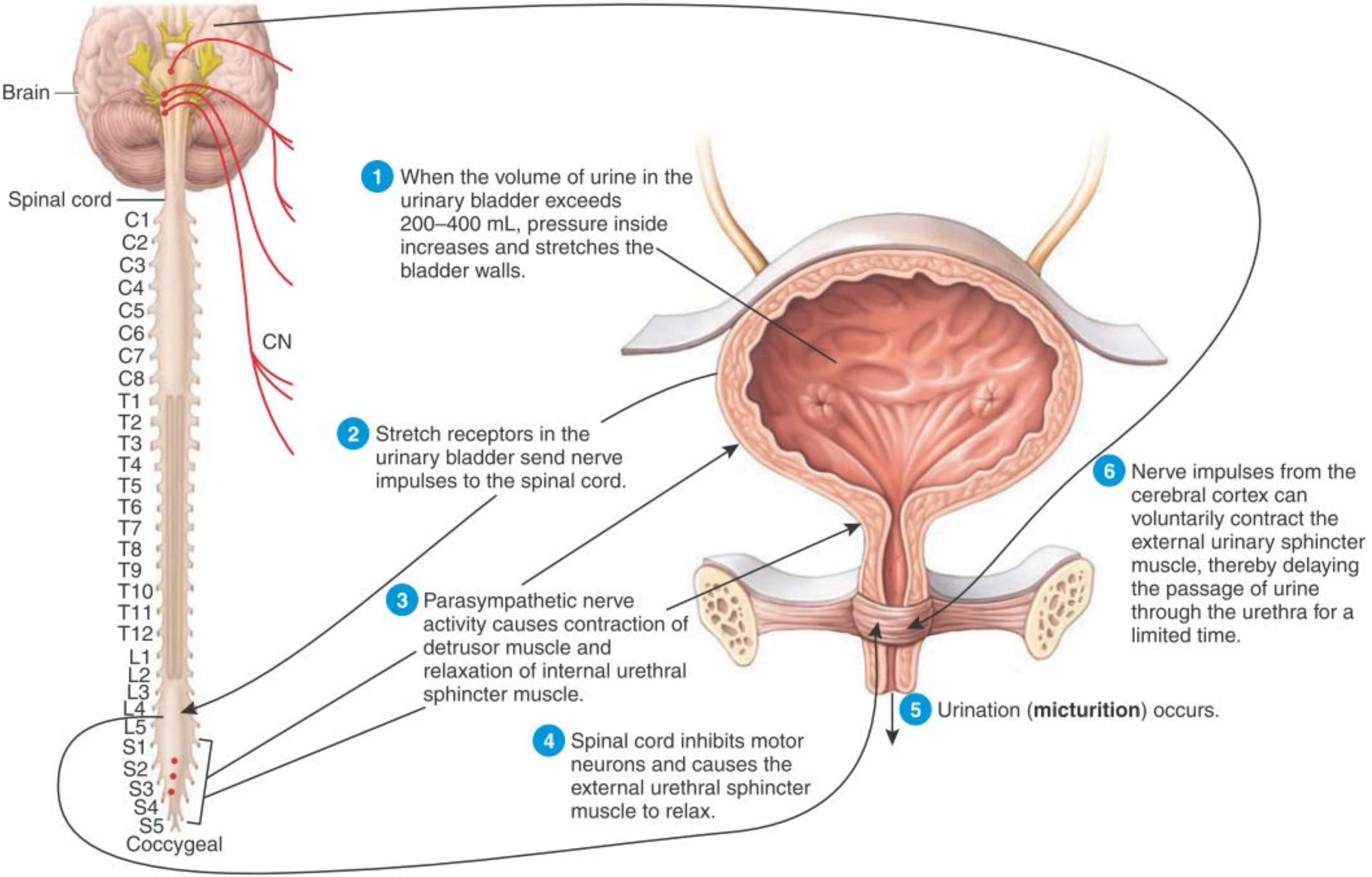
Ureter penetrates the wall at an angle to create a flap valve.

Valve is open for easy urine influx when the bladder is empty.

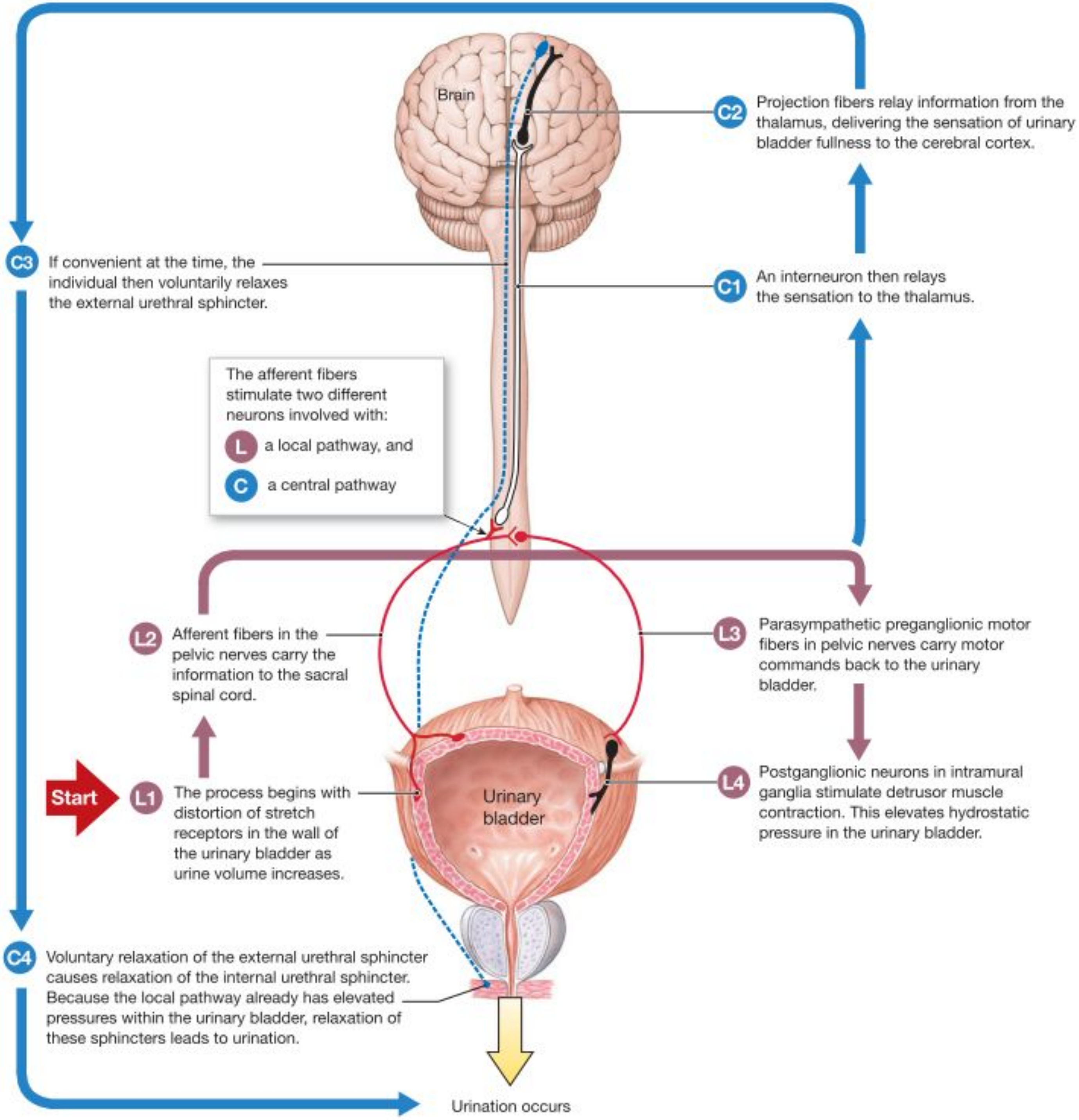


Full bladder or during micturition

High intraluminal pressure pushes on the flap valve and prevents reflux.



1. When the volume of urine in the urinary bladder exceeds 200–400 mL, pressure inside increases and stretches the bladder walls.
2. Stretch receptors in the urinary bladder send nerve impulses to the spinal cord.
3. Parasympathetic nerve activity causes contraction of detrusor muscle and relaxation of internal urethral sphincter muscle.
4. Spinal cord inhibits motor neurons and causes the external urethral sphincter muscle to relax.
5. Urination (**micturition**) occurs.
6. Nerve impulses from the cerebral cortex can voluntarily contract the external urinary sphincter muscle, thereby delaying the passage of urine through the urethra for a limited time.



The afferent fibers stimulate two different neurons involved with:

- **L** a local pathway, and
- **C** a central pathway

L1 The process begins with distortion of stretch receptors in the wall of the urinary bladder as urine volume increases.

L2 Afferent fibers in the pelvic nerves carry the information to the sacral spinal cord.

L3 Parasympathetic preganglionic motor fibers in pelvic nerves carry motor commands back to the urinary bladder.

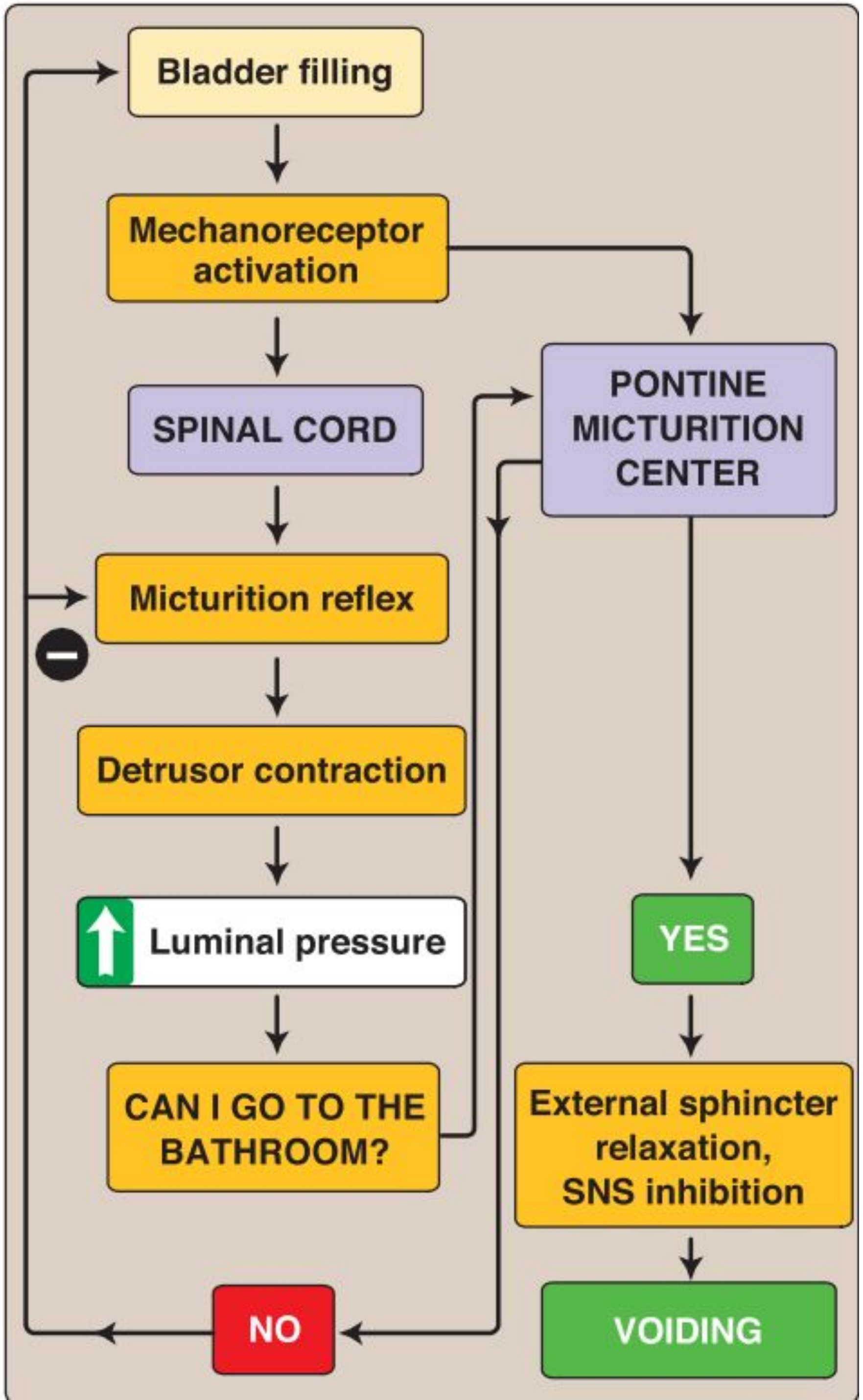
L4 Postganglionic neurons in intramural ganglia stimulate detrusor muscle contraction. This elevates hydrostatic pressure in the urinary bladder.

C1 An interneuron then relays the sensation to the thalamus.

C2 Projection fibers relay information from the thalamus, delivering the sensation of urinary bladder fullness to the cerebral cortex.

C3 If convenient at the time, the individual then voluntarily relaxes the external urethral sphincter.

C4 Voluntary relaxation of the external urethral sphincter causes relaxation of the internal urethral sphincter. Because the local pathway already has elevated pressures within the urinary bladder, relaxation of these sphincters leads to urination.


Bladder filling
Mechanoreceptor activation
SPINAL CORD
PONTINE MICTURITION CENTER
Micturition reflex
−
Detrusor contraction
↑ Luminal pressure
CAN I GO TO THE BATHROOM?
YES
External sphincter relaxation, SNS inhibition
NO
VOIDING