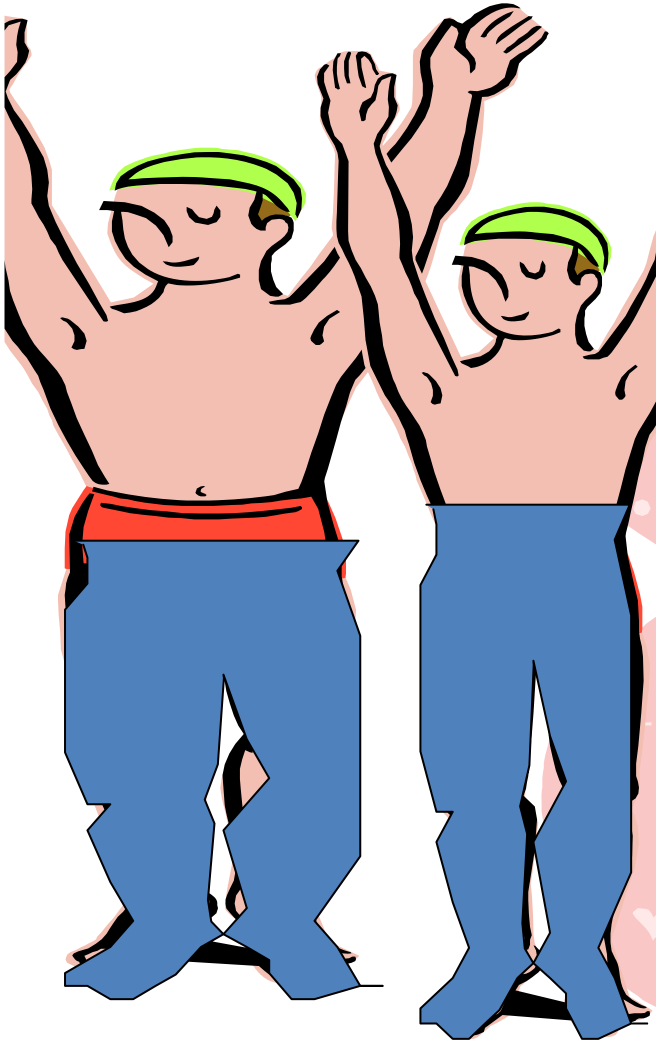
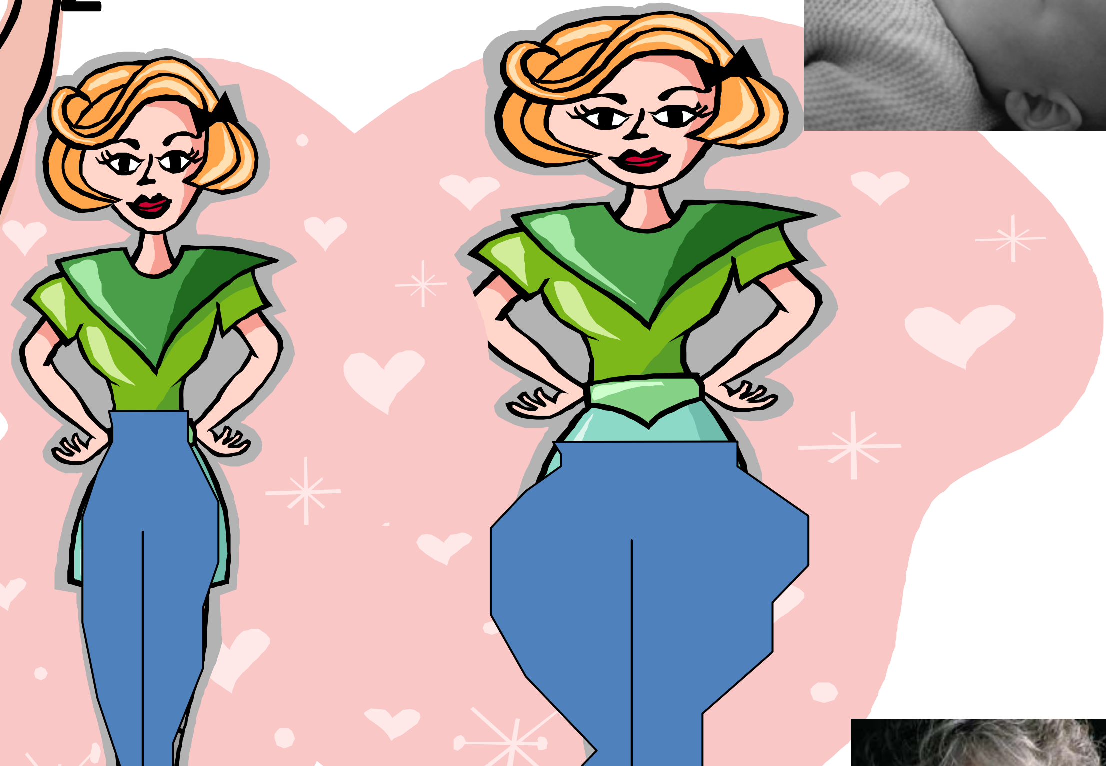
Disturbances of water and mineral balance. Edema

Water Balance

H_2O

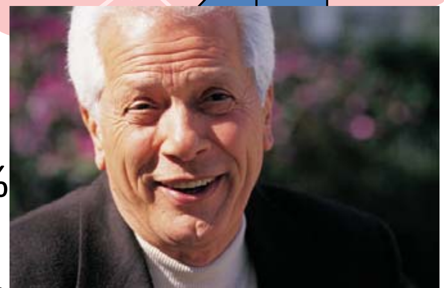




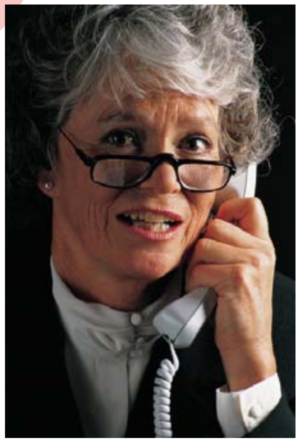
Children under 1 year: 65-75% of body weight

Young men: 60-65% of body weight

Young women: 50-55% of body weight



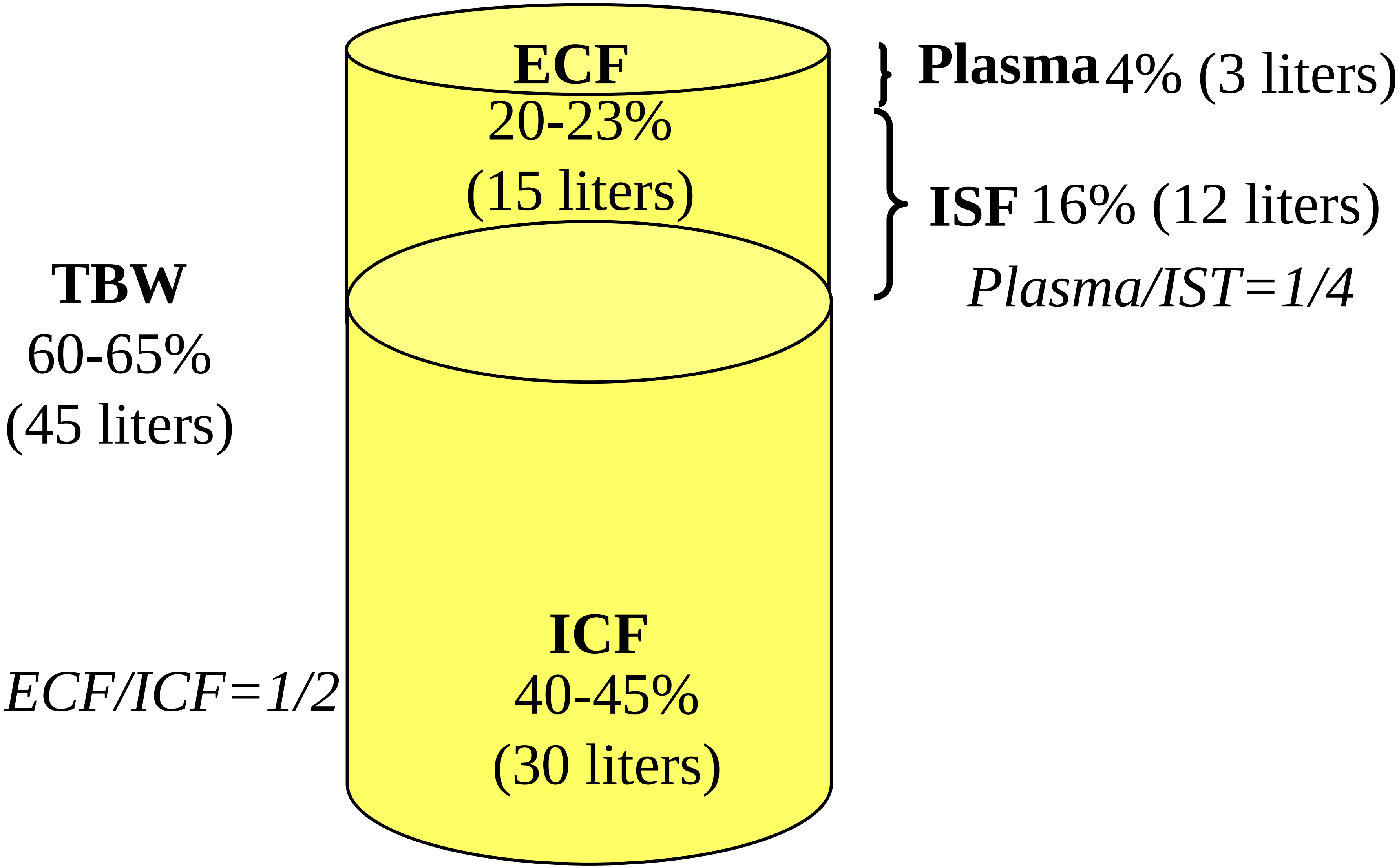
A man over 60 years: 50% of body weight

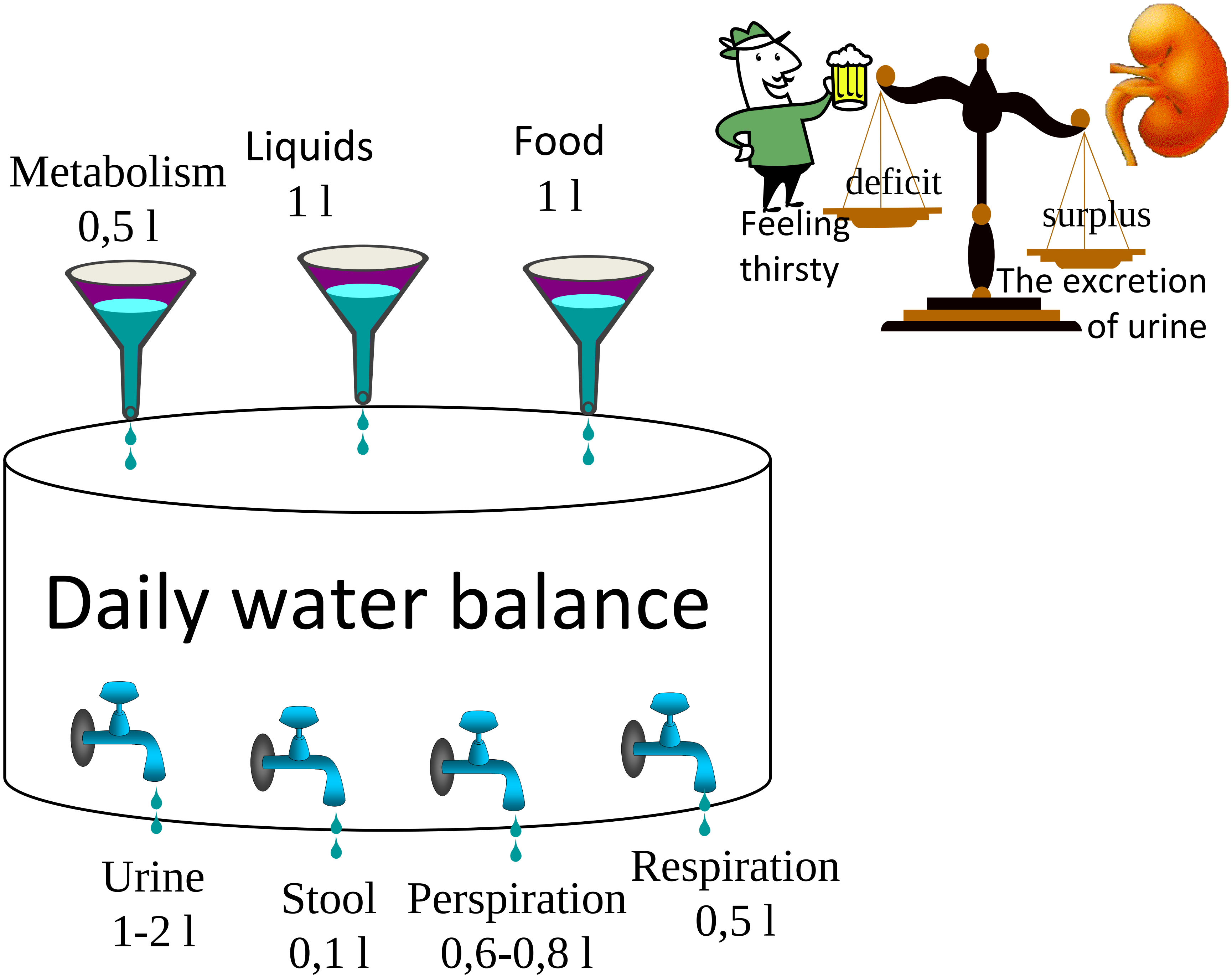


Women over 60 years: 45% of body weight

In obese individuals, the water forms a smaller percentage than in thin

Water content in the body




Metabolism
0,5 l
Liquids
1 l
Food
1 l
Feeling
thirsty
deficit
surplus
The excretion
of urine
Daily water balance
Urine
1-2 l
Stool
0,1 l
Perspiration
0,6-0,8 l
Respiration
0,5 l

Major ions

ECF (extracellular fluid)

4,3 mmol/l K^+

140 mmol/l Na^+

104 mmol/l Cl^-

24-27 mmol/l HCO_3^-

ICF (intracelluar fluid)

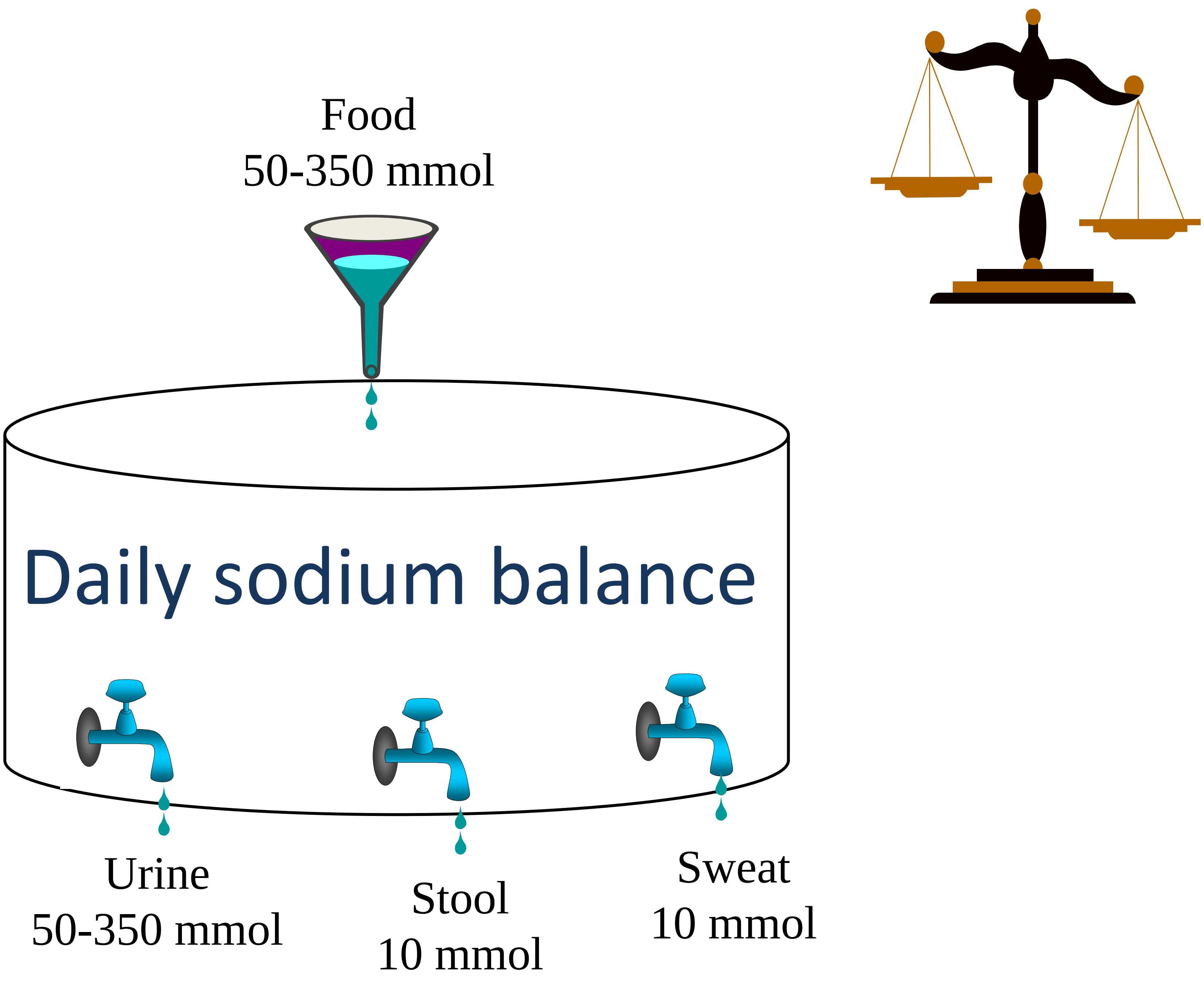
140 mmol/l K^+

12 mmol/l Na^+

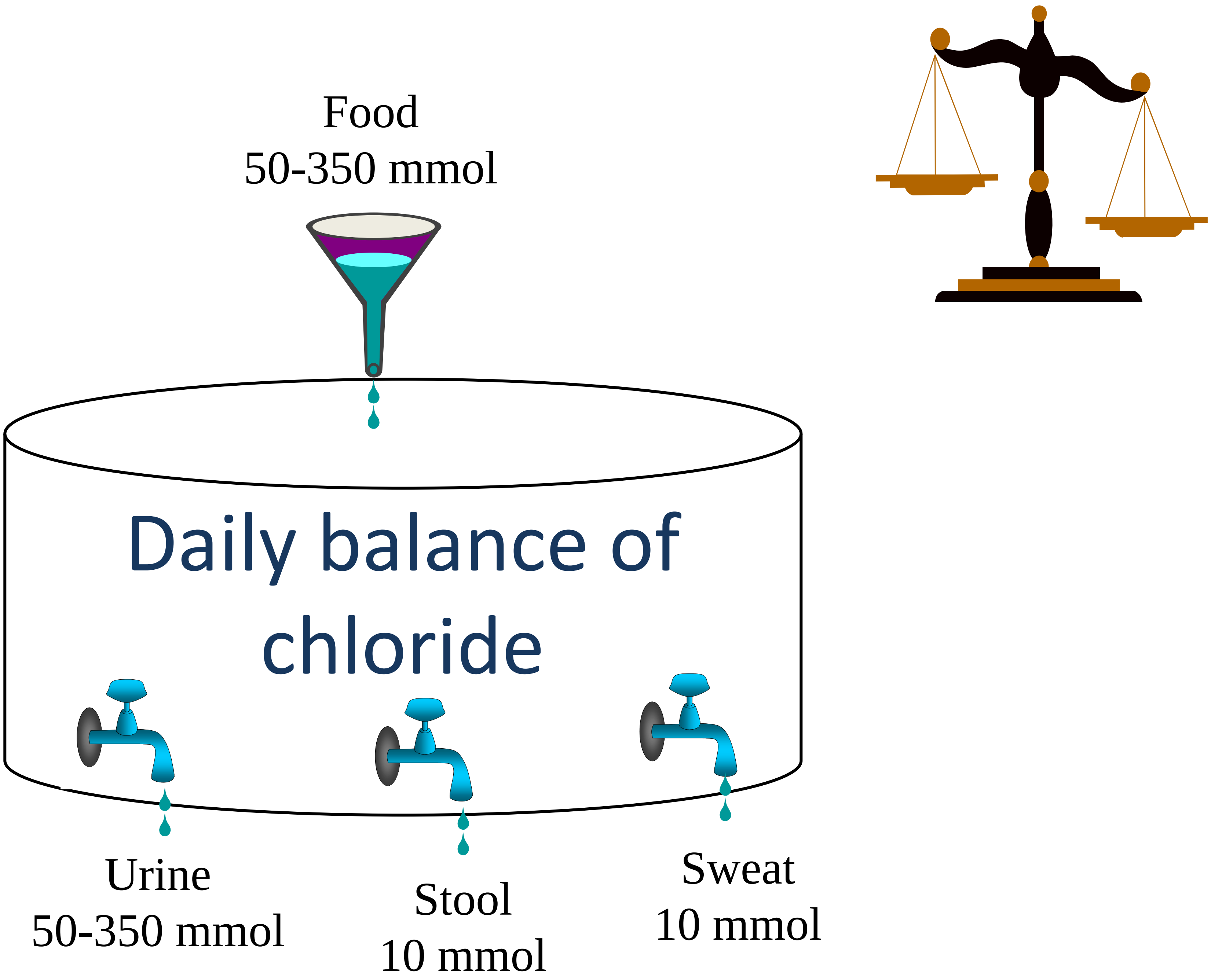
3 mmol/l Cl^-

10 mmol/lHCO3-

The balance of sodium and chloride



Food
50-350 mmol
Daily sodium balance
Urine
50-350 mmol
Stool
10 mmol
Sweat
10 mmol


Food
50-350 mmol
Daily balance of chloride
Urine
50-350 mmol
Stool
10 mmol
Sweat
10 mmol

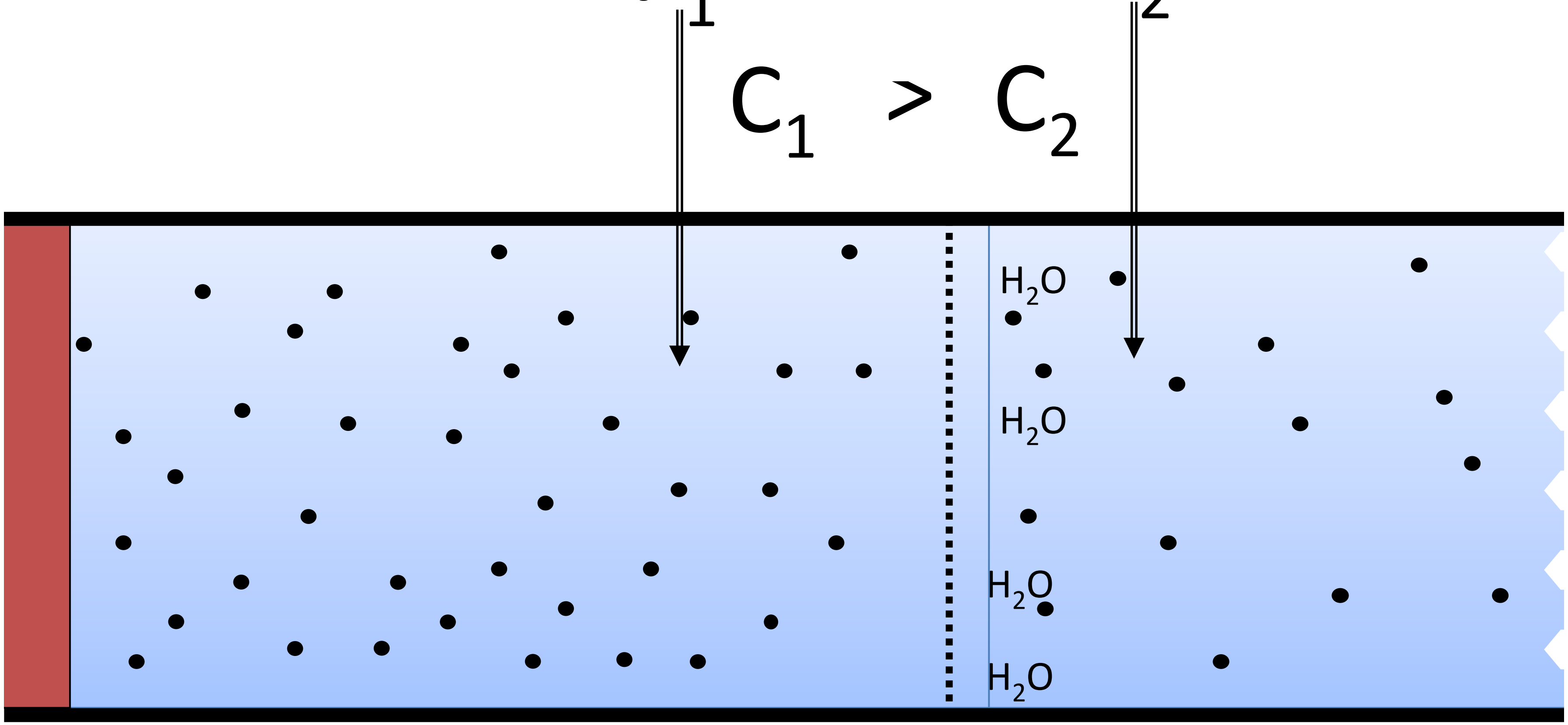
Osmotic balance in body fluids

Osmotic pressure

is related to the concentration of all dissolved particles

$$P_1 = P_2$$

$$C_1 > C_2$$



$$[H_2O]_1 = [H_2O]_2$$

Osmotic pressure

is related to the concentration of dissolved particles

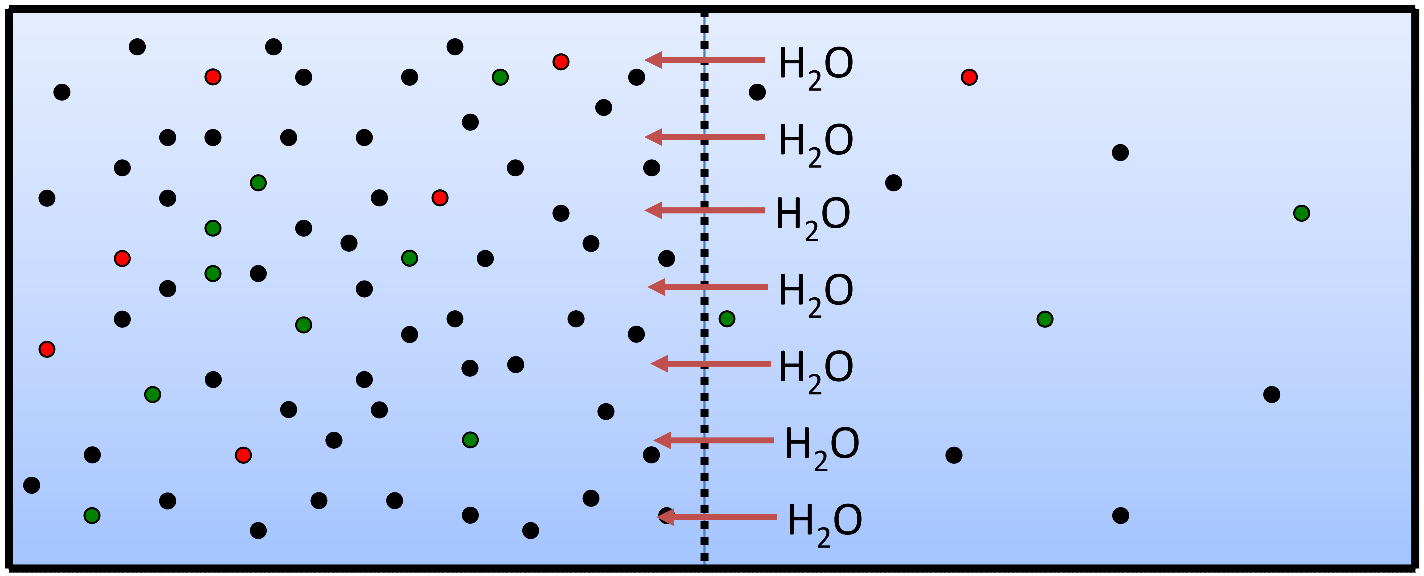
relative to

the weight of the solvent: ***osmolality*** (mmol/kg solvent)

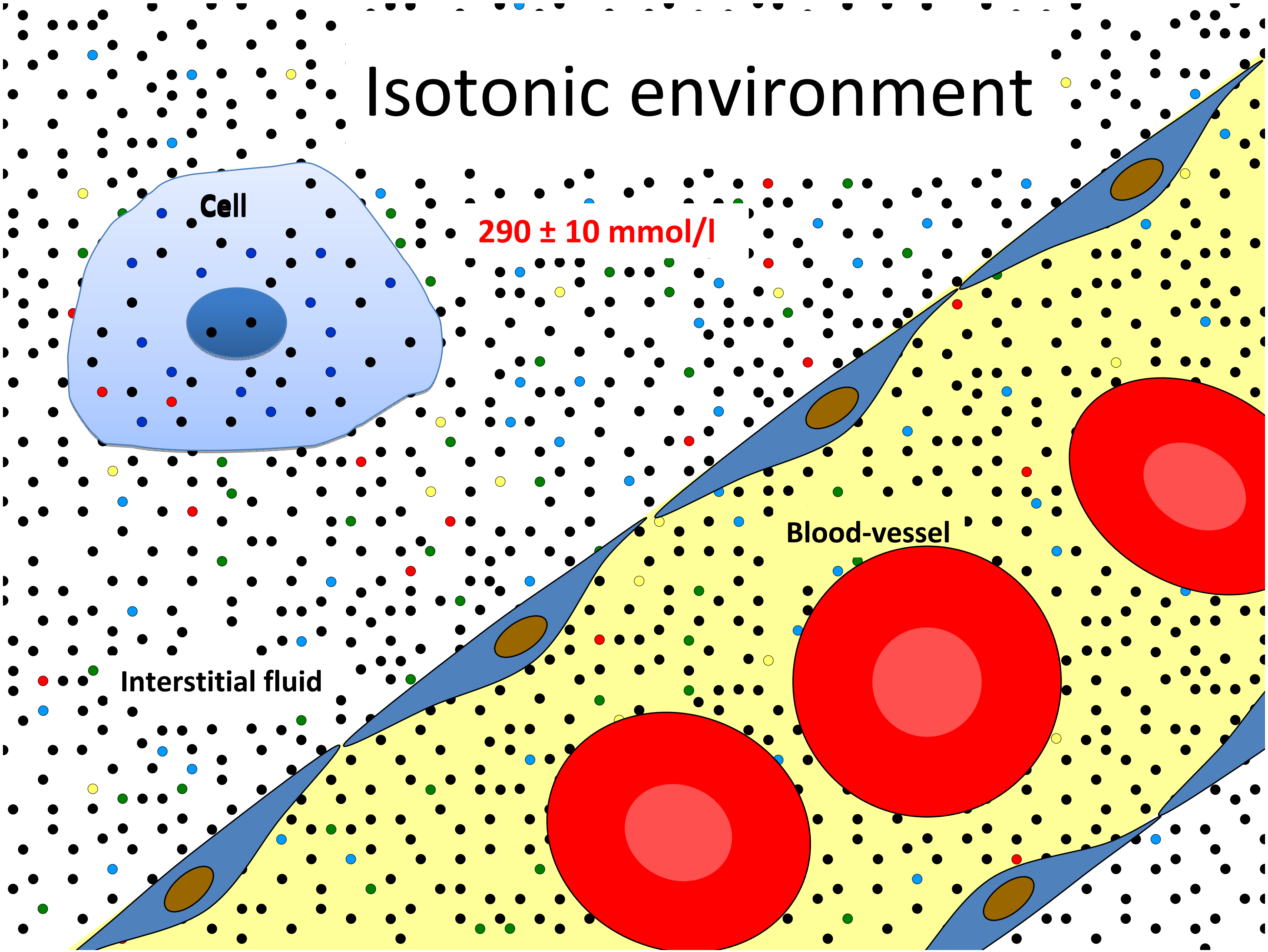
the volume of solution : ***osmolarity*** (mmol/l solution).

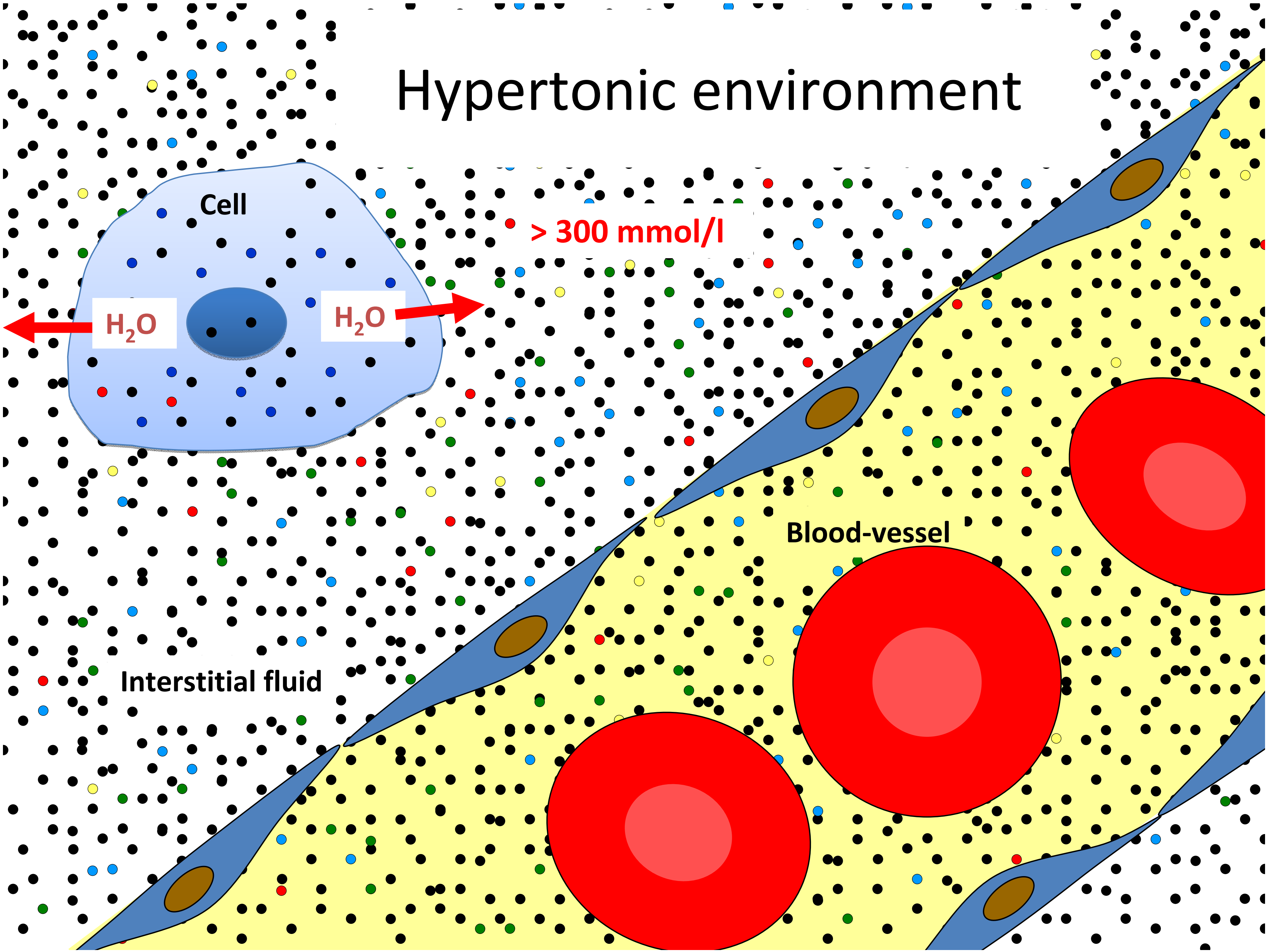
Hyperosmolality
Hyperosmolarity

Hyposmolality
Hyposmolarity



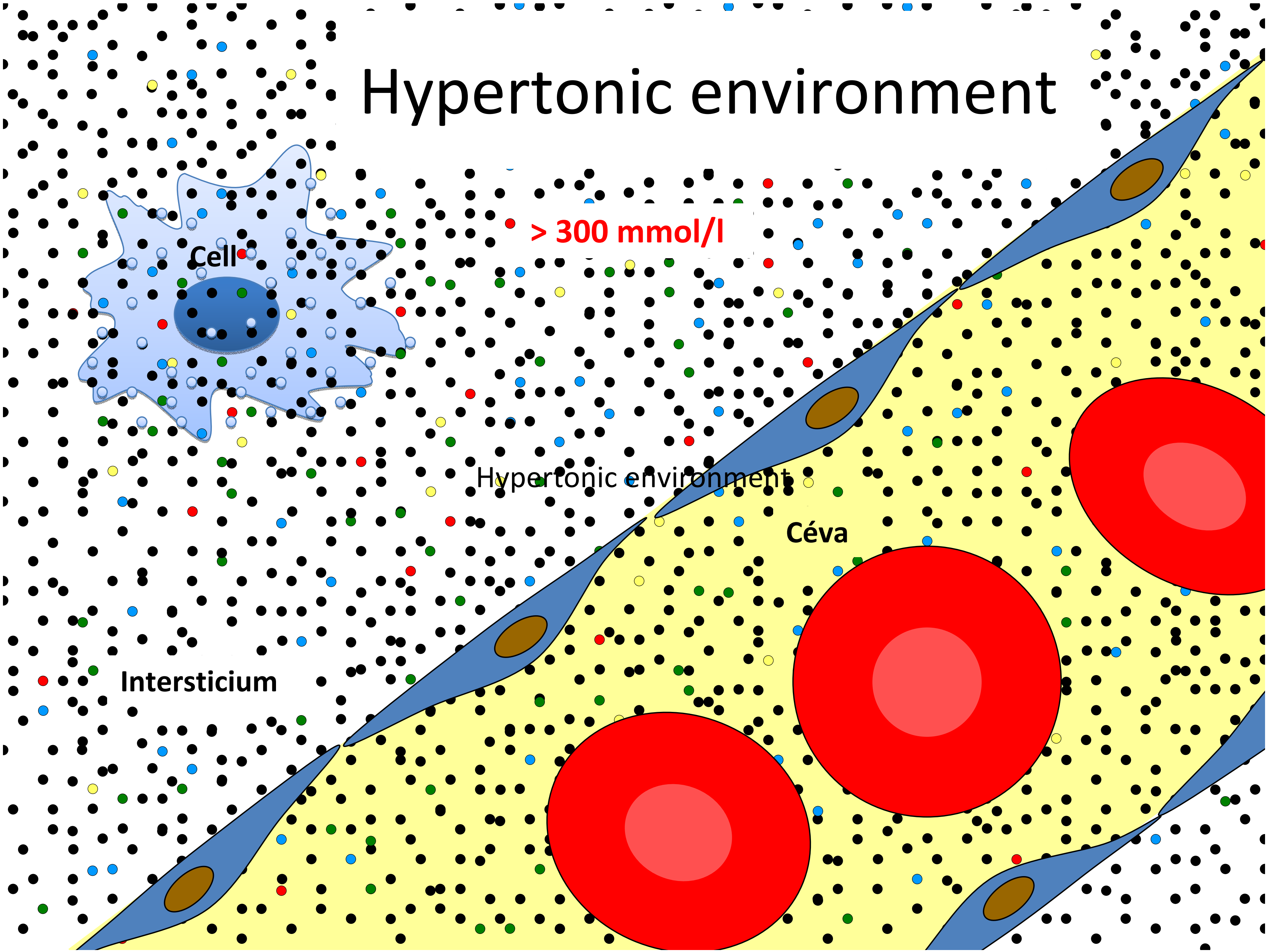
Isotonic environment



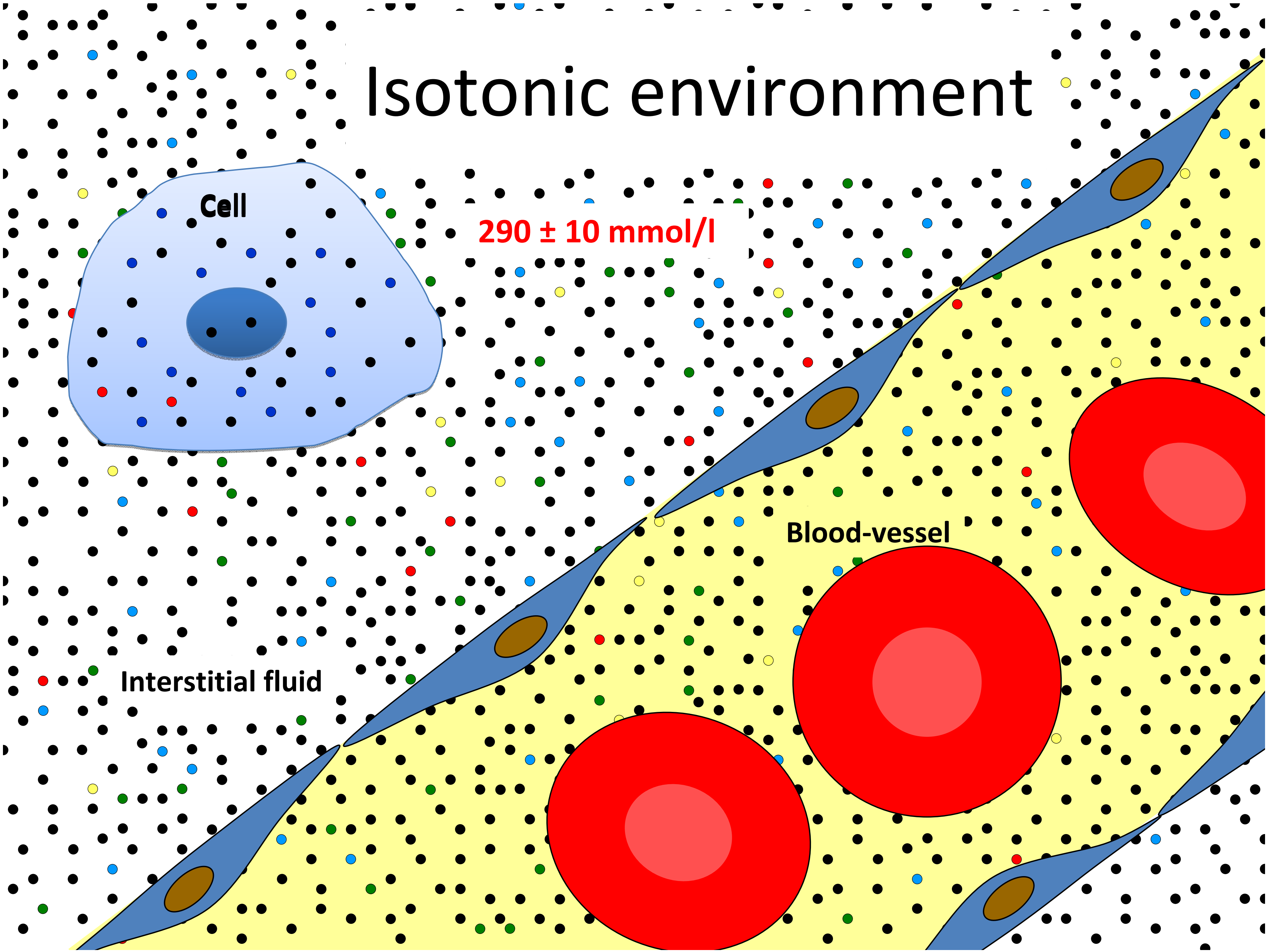


Hypertonic environment
Cell
> 300 mmol/l
H_2O
H_2O
Blood-vessel
Interstitial fluid

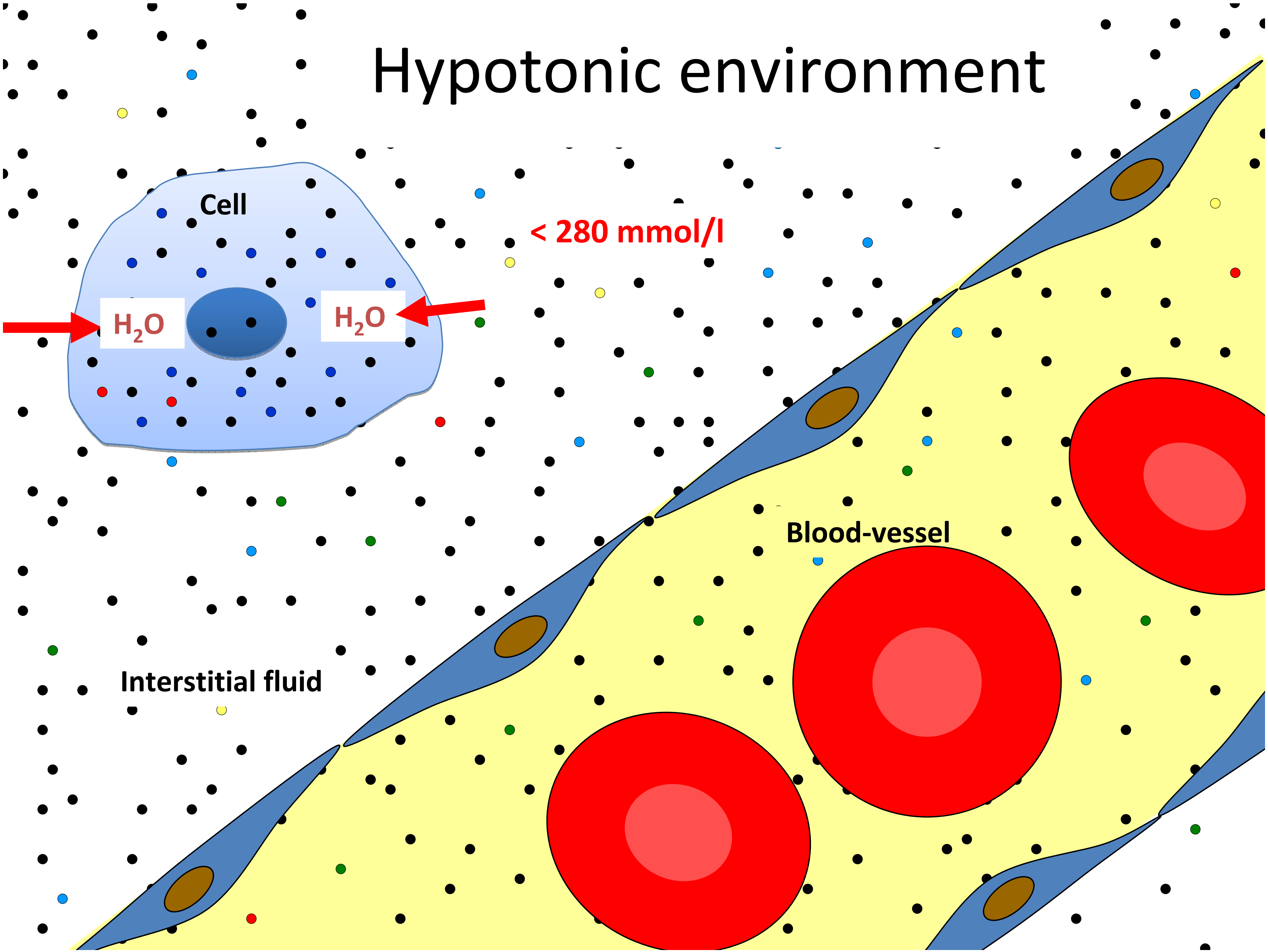
Hypertonic environment



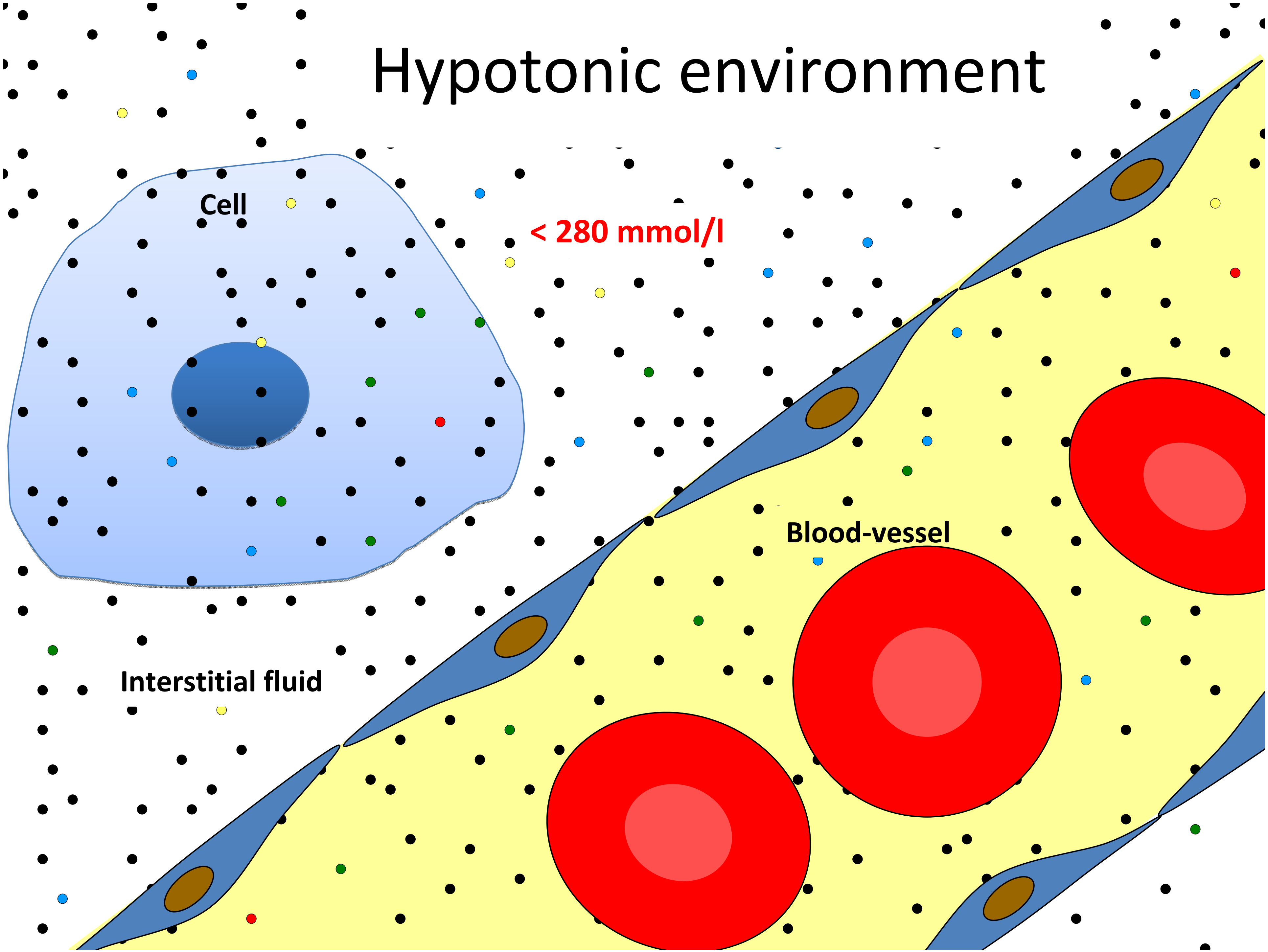
Isotonic environment



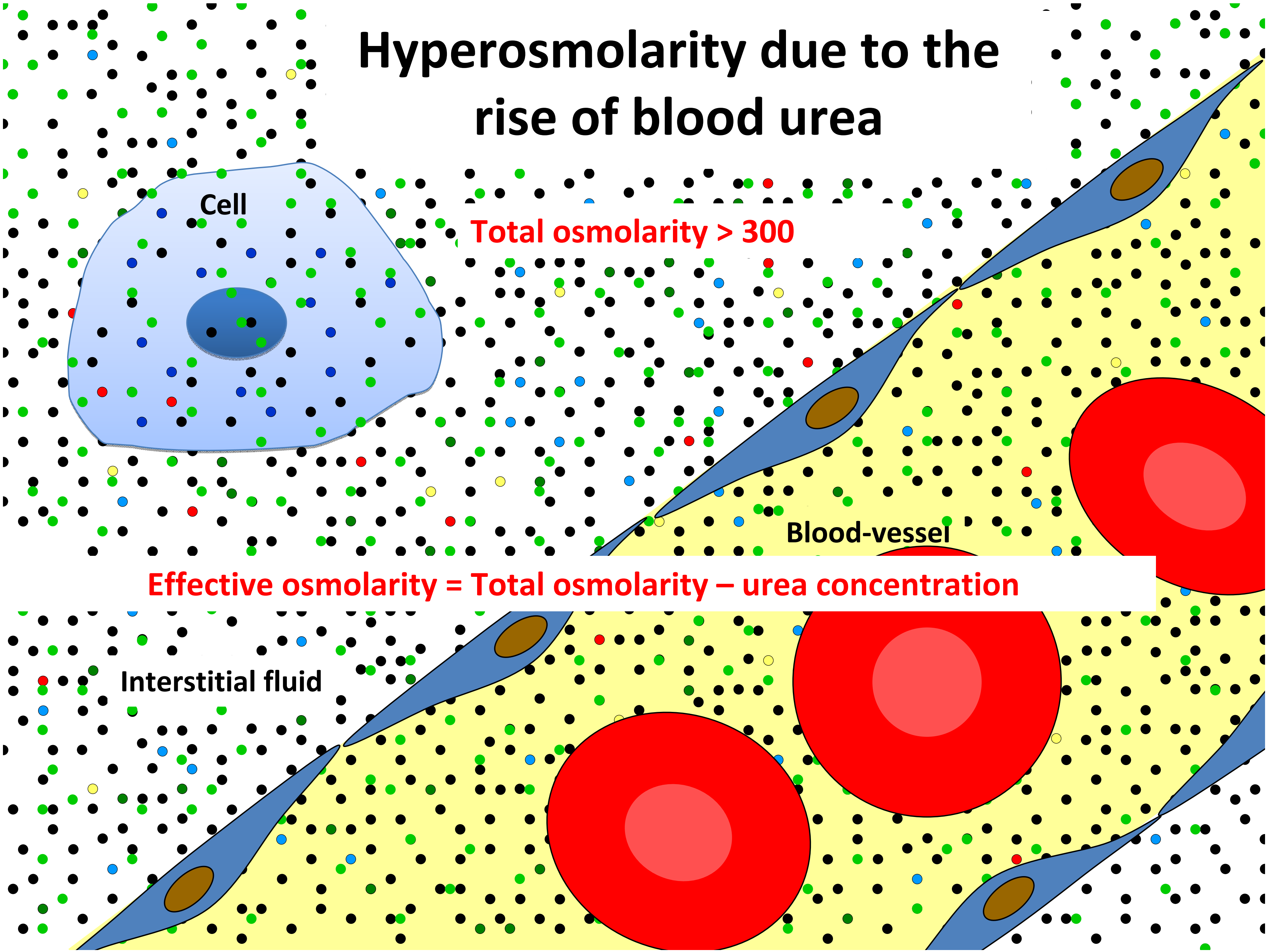
Hypotonic environment



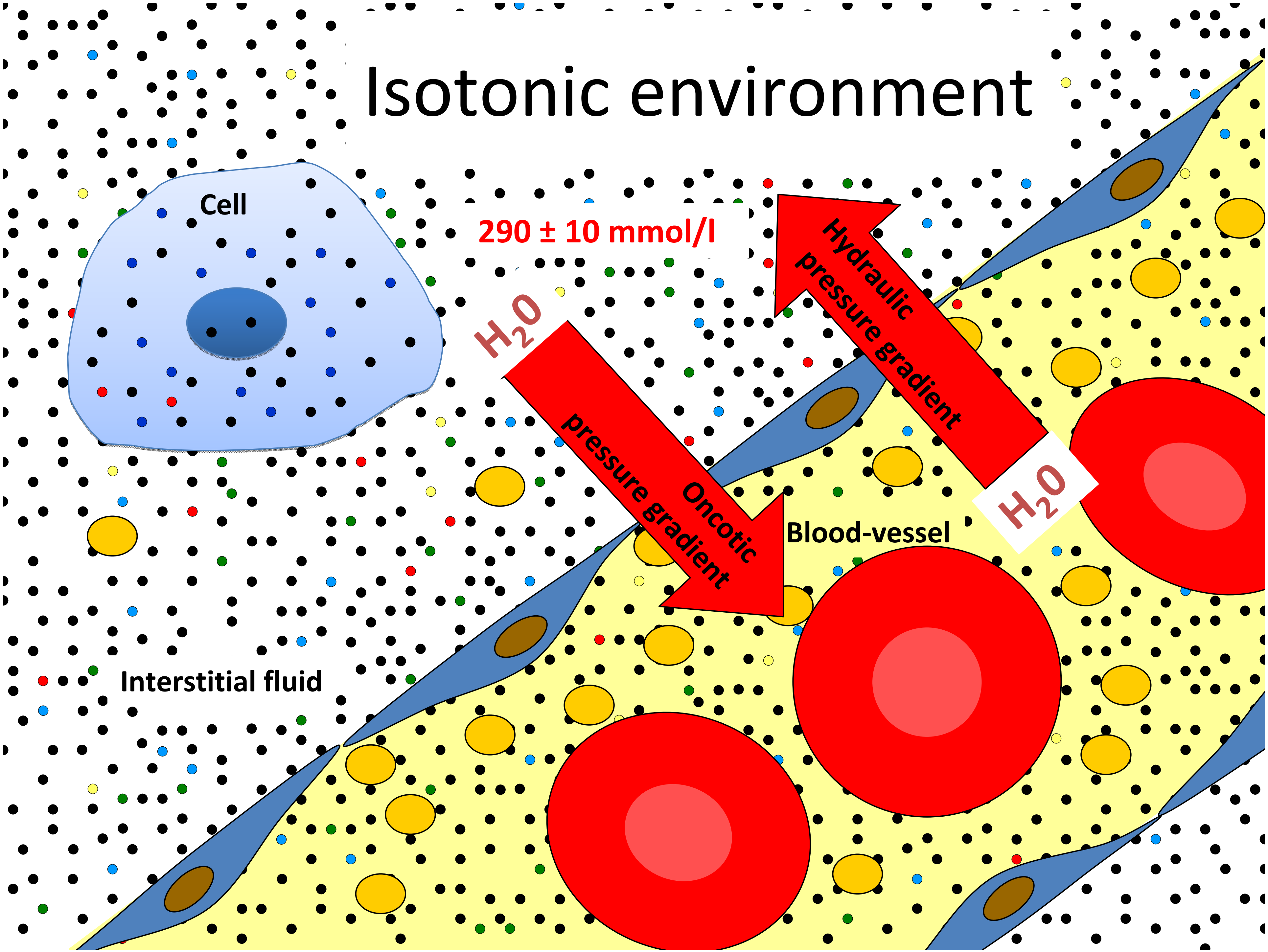
Hypotonic environment



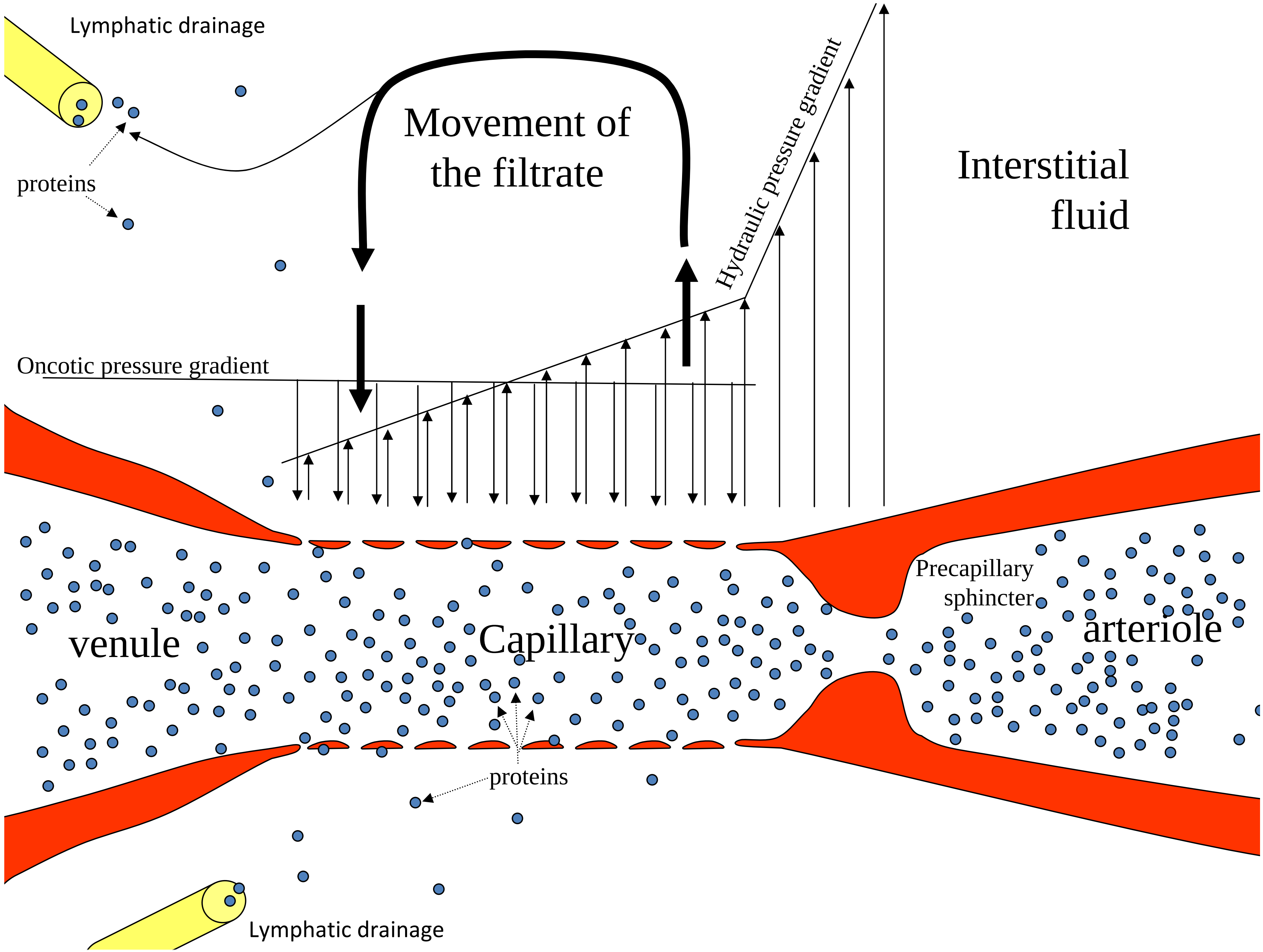
Hyperosmolarity due to the rise of blood urea



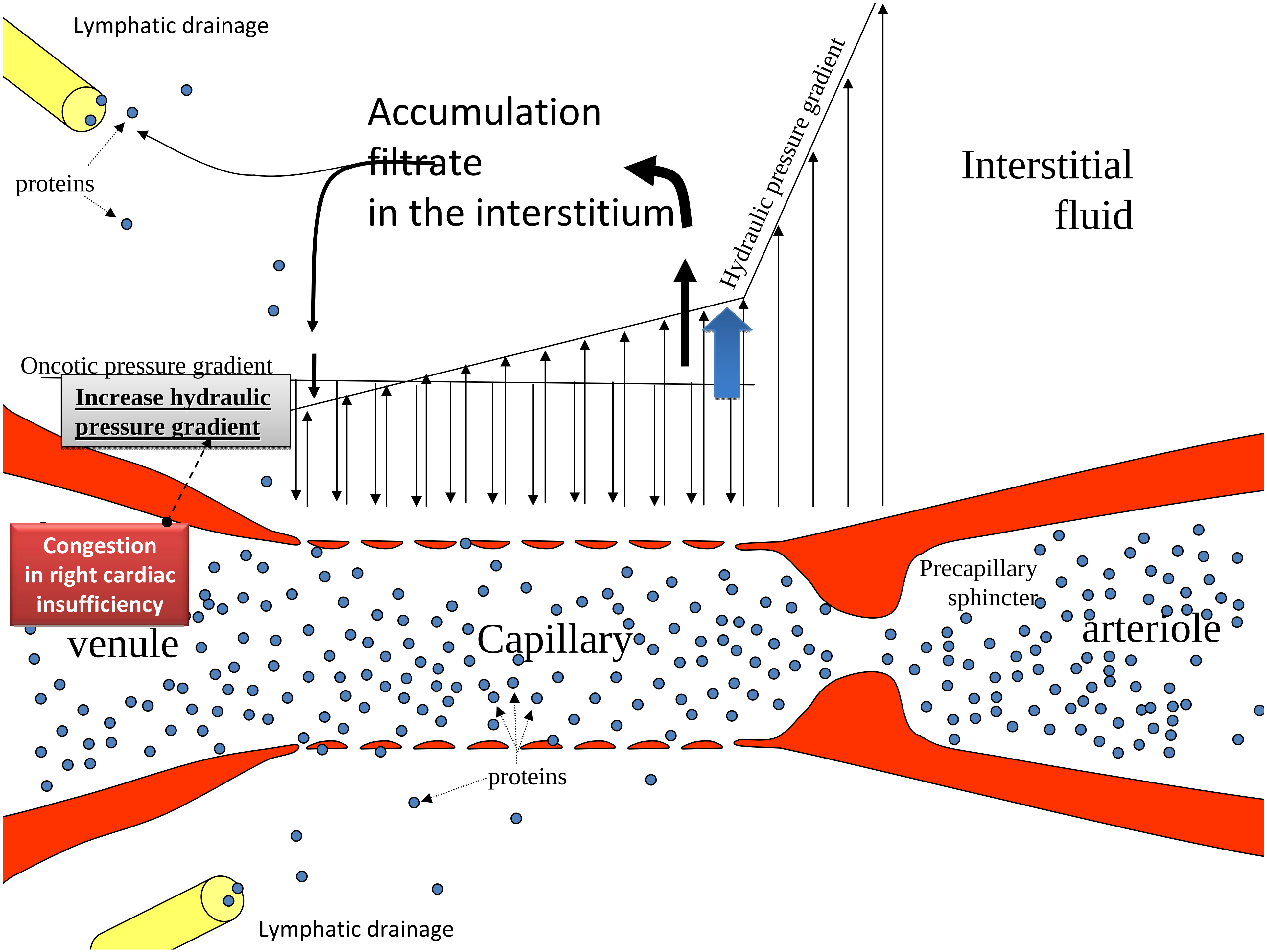
The balance of the capillary and its disorders
(water and soluti movement between plasma and interstitium)



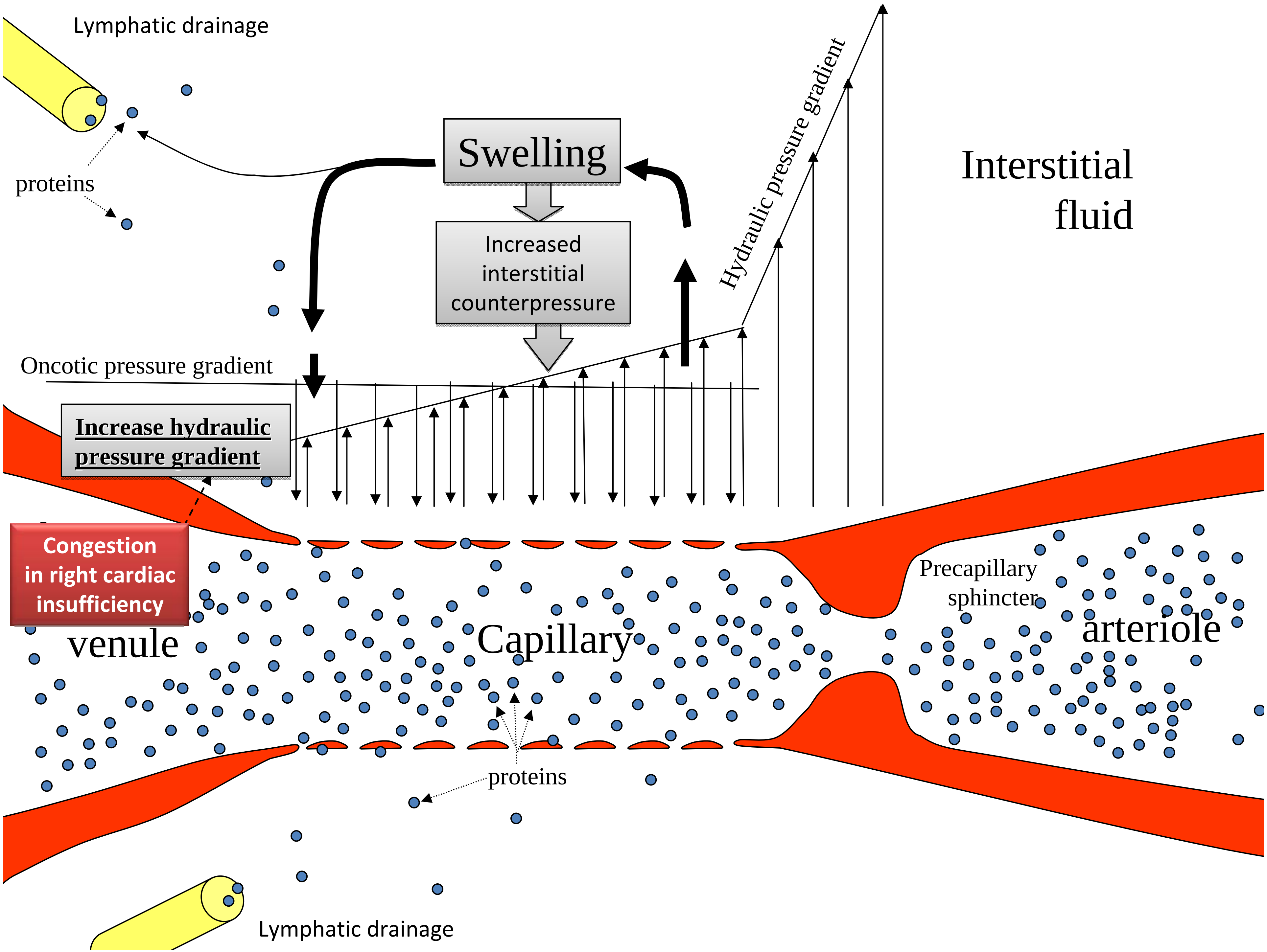
Isotonic environment
Cell
290 ± 10 mmol/l
H_2O
Hydraulic pressure gradient
Oncotic pressure gradient
H_2O
Blood-vessel
Interstitial fluid

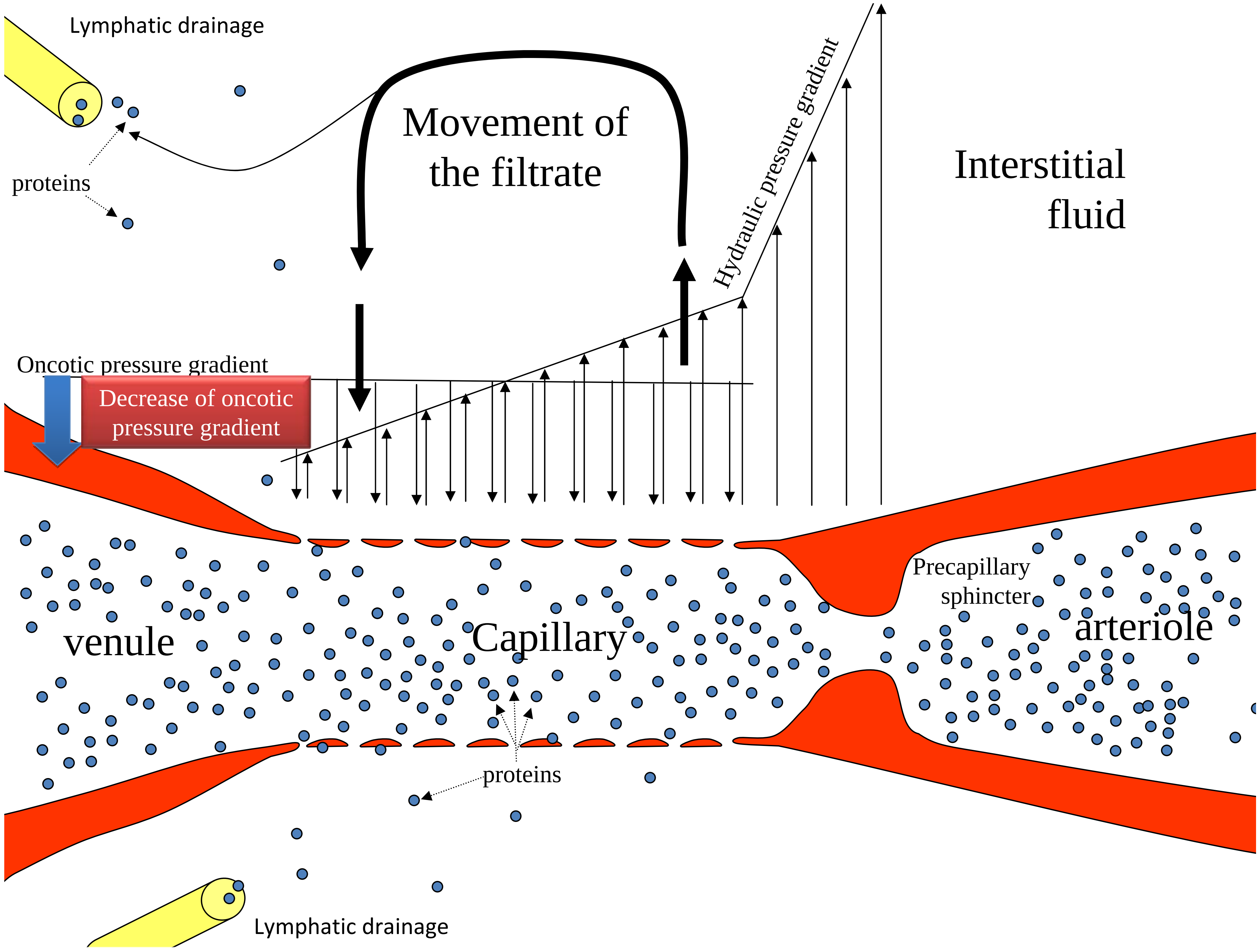


Lymphatic drainage
proteins
Movement of the filtrate
Hydraulic pressure gradient
Interstitial fluid
Oncotic pressure gradient
Precapillary sphincter
venule
Capillary
arteriole
proteins
Lymphatic drainage

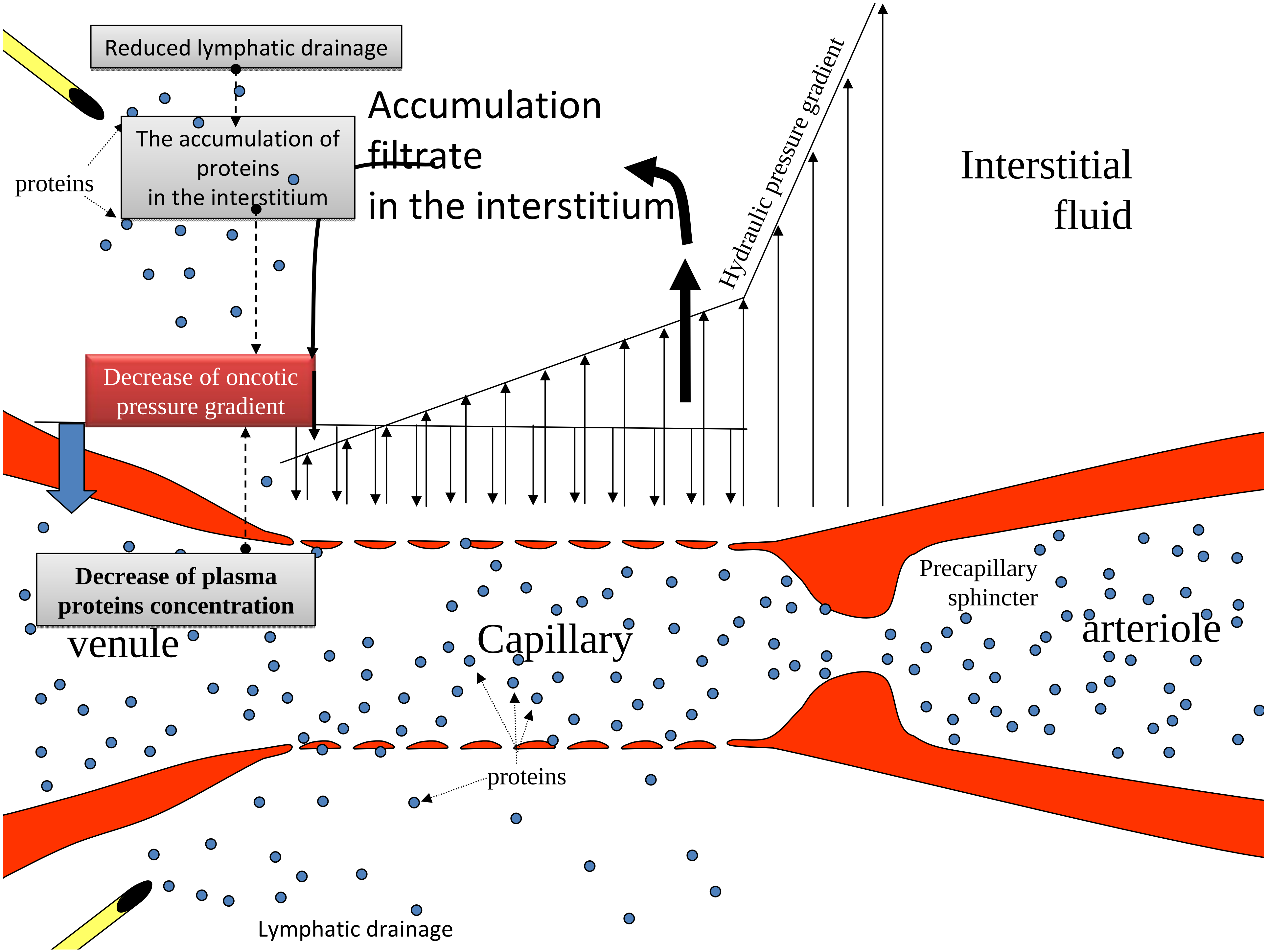


Lymphatic drainage
proteins
Accumulation filtrate in the interstitium
Hydraulic pressure gradient
Interstitial fluid
Oncotic pressure gradient
Increase hydraulic pressure gradient
Congestion in right cardiac insufficiency
venule
Capillary
Precapillary sphincter
arteriole
proteins
Lymphatic drainage

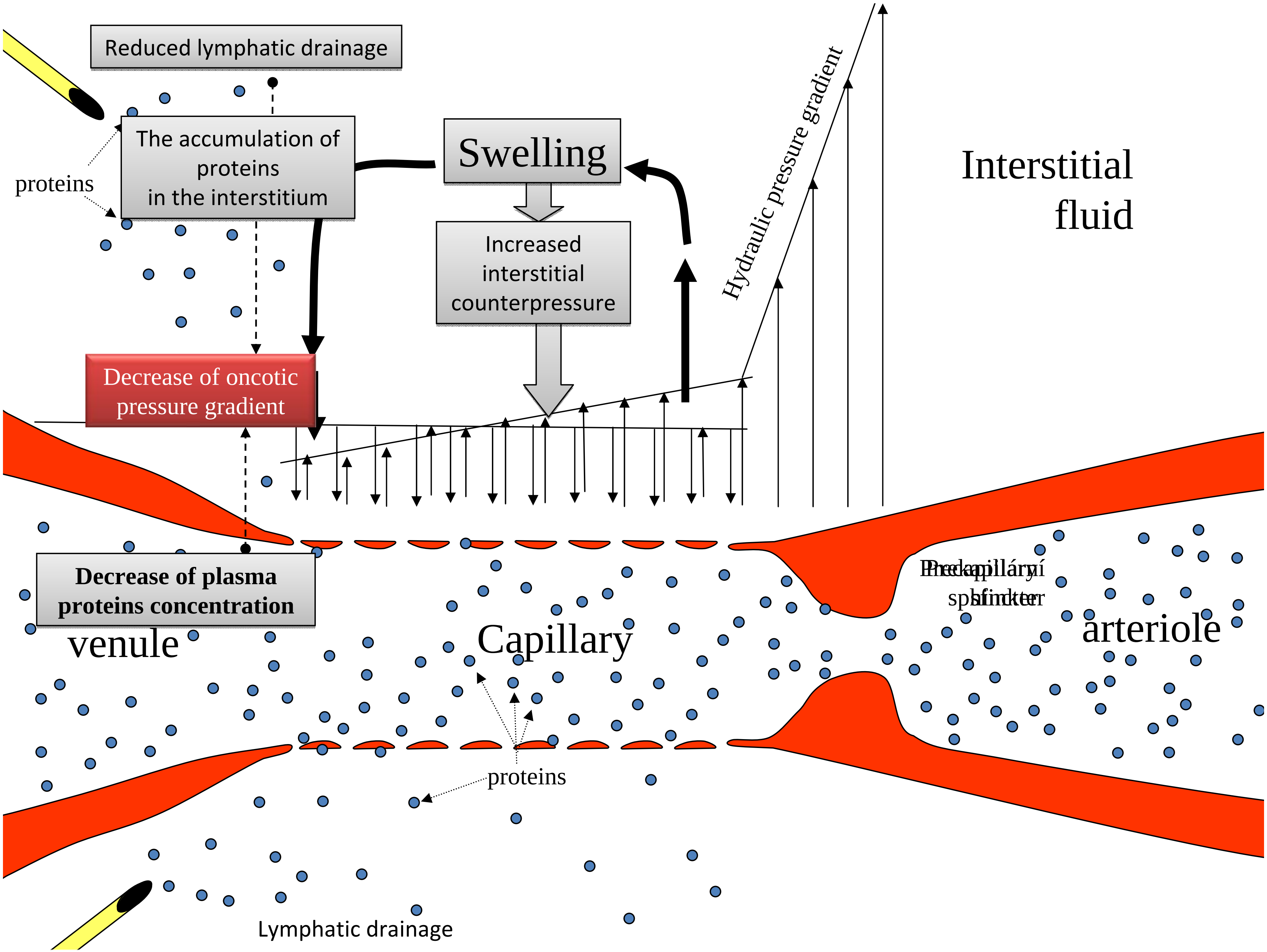

Lymphatic drainage
proteins
Swelling
Increased interstitial counterpressure
Hydraulic pressure gradient
Interstitial fluid
Oncotic pressure gradient
Increase hydraulic pressure gradient
Congestion in right cardiac insufficiency
venule
Capillary
Precapillary sphincter
arteriole
proteins
Lymphatic drainage

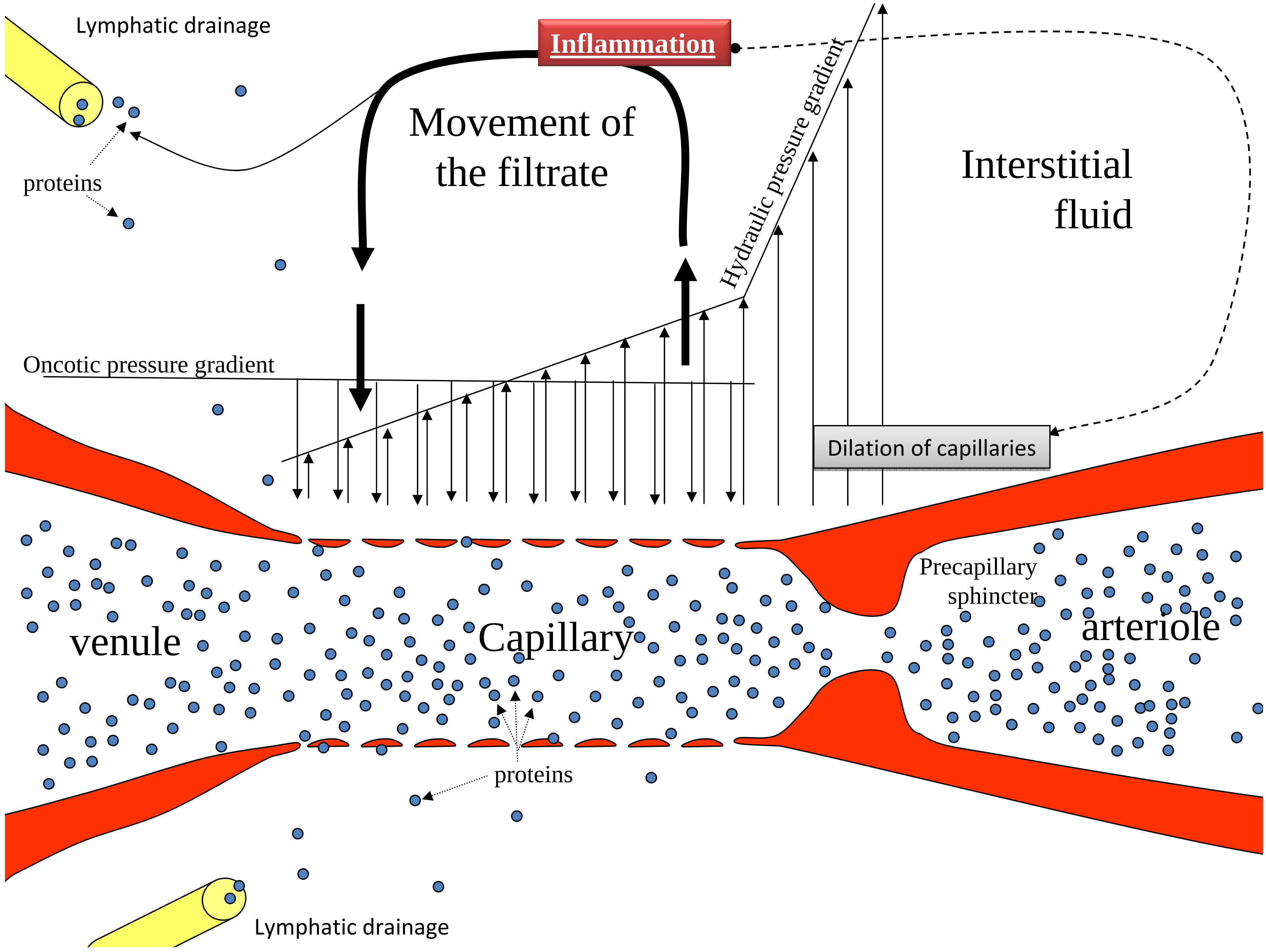


Lymphatic drainage
proteins
Movement of the filtrate
Hydraulic pressure gradient
Interstitial fluid
Oncotic pressure gradient
Decrease of oncotic pressure gradient
venule
Capillary
Precapillary sphincter
arteriole
proteins
Lymphatic drainage

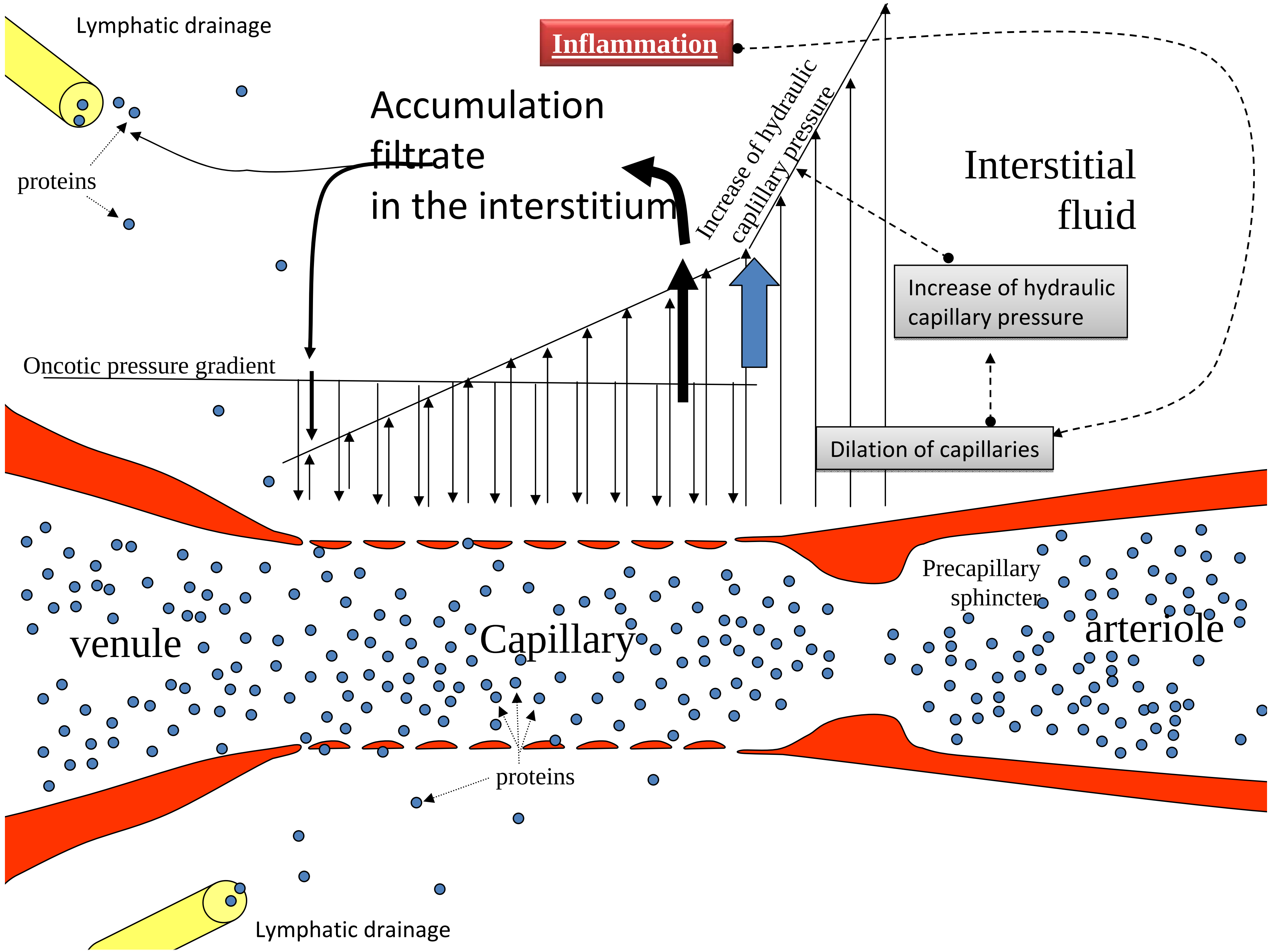


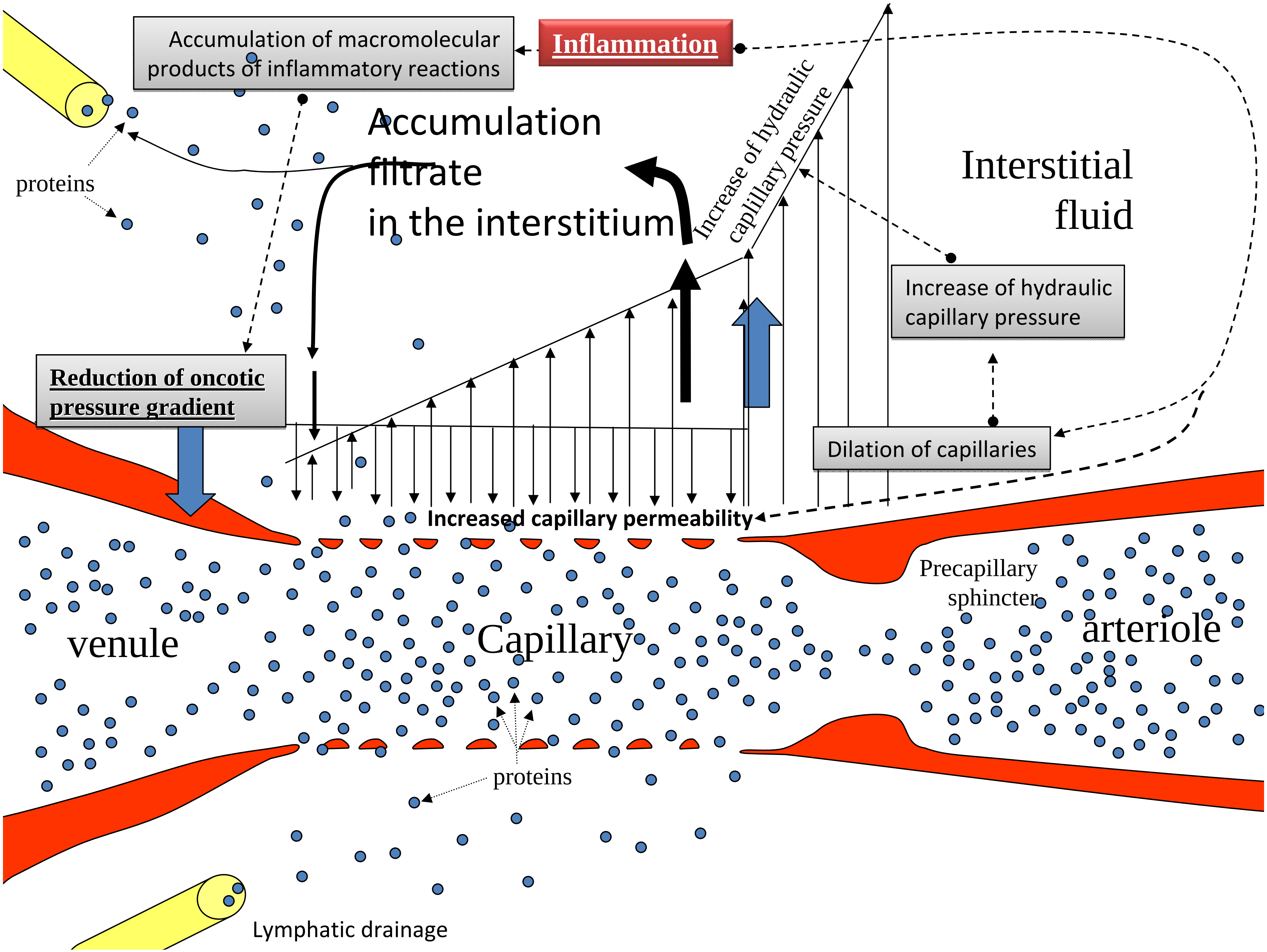
Reduced lymphatic drainage
The accumulation of proteins in the interstitium
proteins
Accumulation filtrate in the interstitium
Hydraulic pressure gradient
Interstitial fluid
Decrease of oncotic pressure gradient
Decrease of plasma proteins concentration
venule
Capillary
Precapillary sphincter
arteriole
proteins
Lymphatic drainage

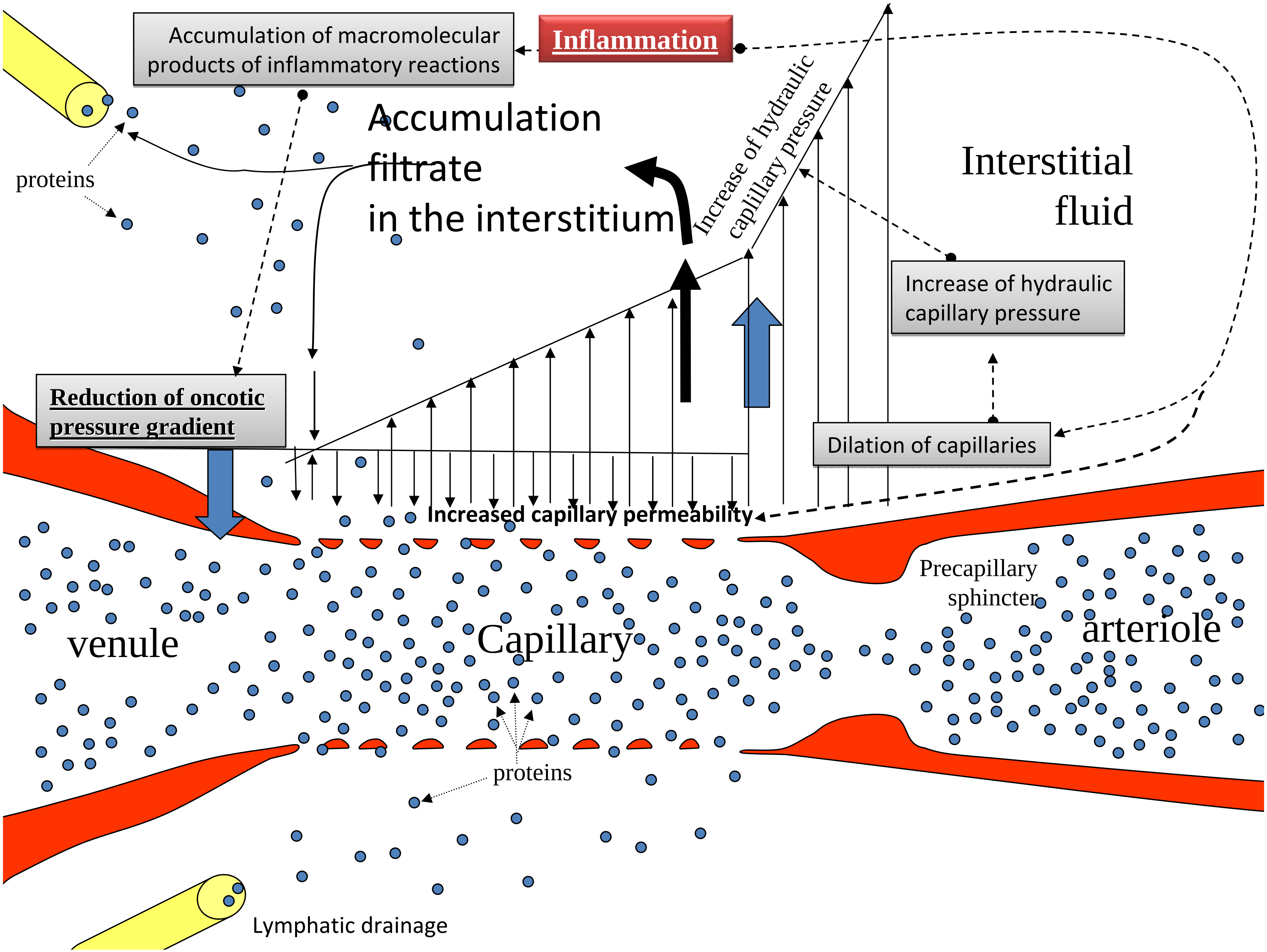

Reduced lymphatic drainage
The accumulation of proteins in the interstitium
proteins
Swelling
Increased interstitial counterpressure
Hydraulic pressure gradient
Interstitial fluid
Decrease of oncotic pressure gradient
Decrease of plasma proteins concentration
venule
Capillary
Precapillary sphincter
Prekapilární sfinkter
arteriole
proteins
Lymphatic drainage



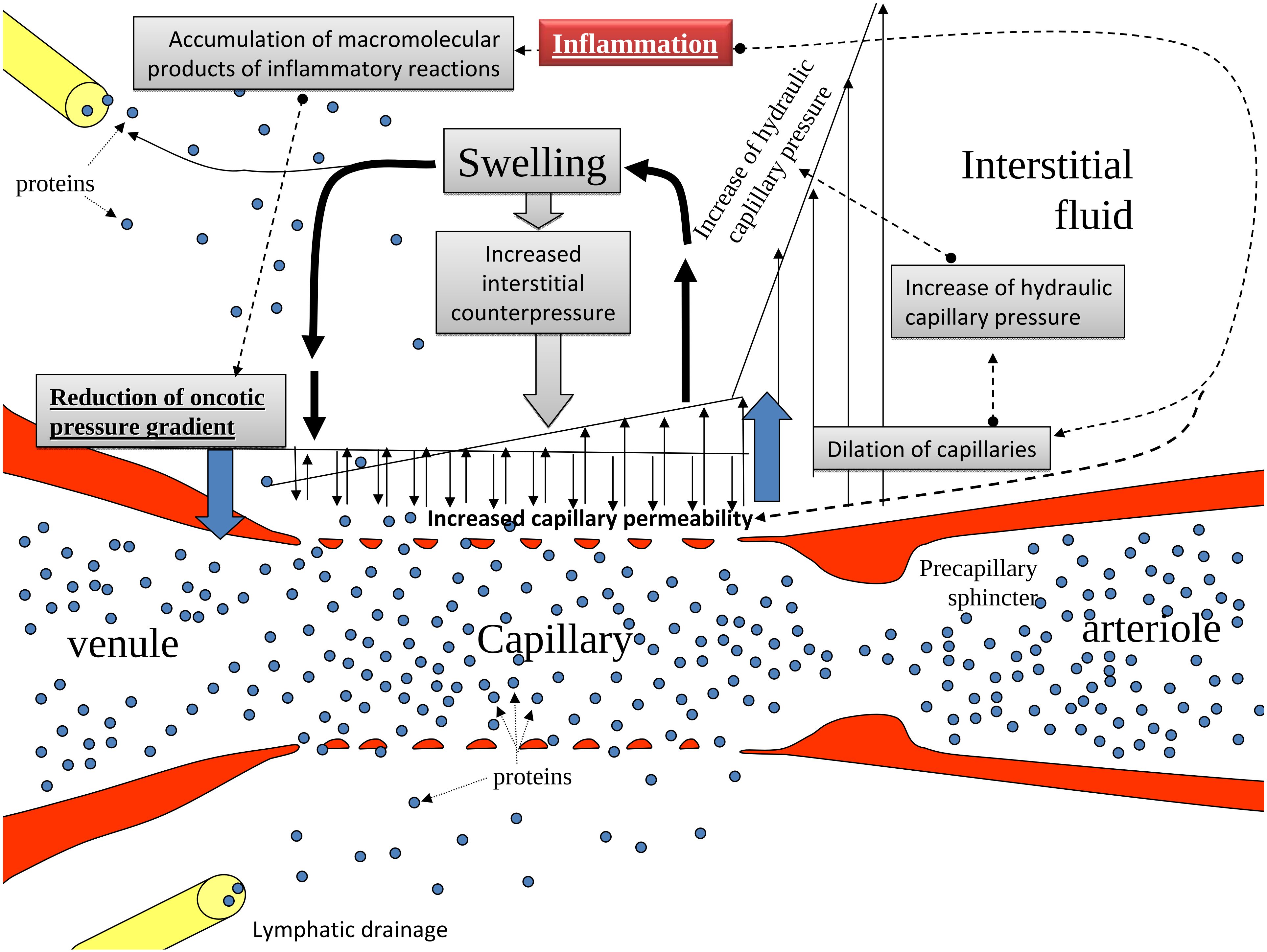
Lymphatic drainage
Inflammation
Movement of the filtrate
proteins
Hydraulic pressure gradient
Interstitial fluid
Oncotic pressure gradient
Dilation of capillaries
Precapillary sphincter
venule
Capillary
arteriole
proteins
Lymphatic drainage


Lymphatic drainage
Inflammation
Accumulation filtrate in the interstitium
Increase of hydraulic capillary pressure
proteins
Interstitial fluid
Increase of hydraulic capillary pressure
Oncotic pressure gradient
Dilation of capillaries
Precapillary sphincter
venule
Capillary
arteriole
proteins
Lymphatic drainage

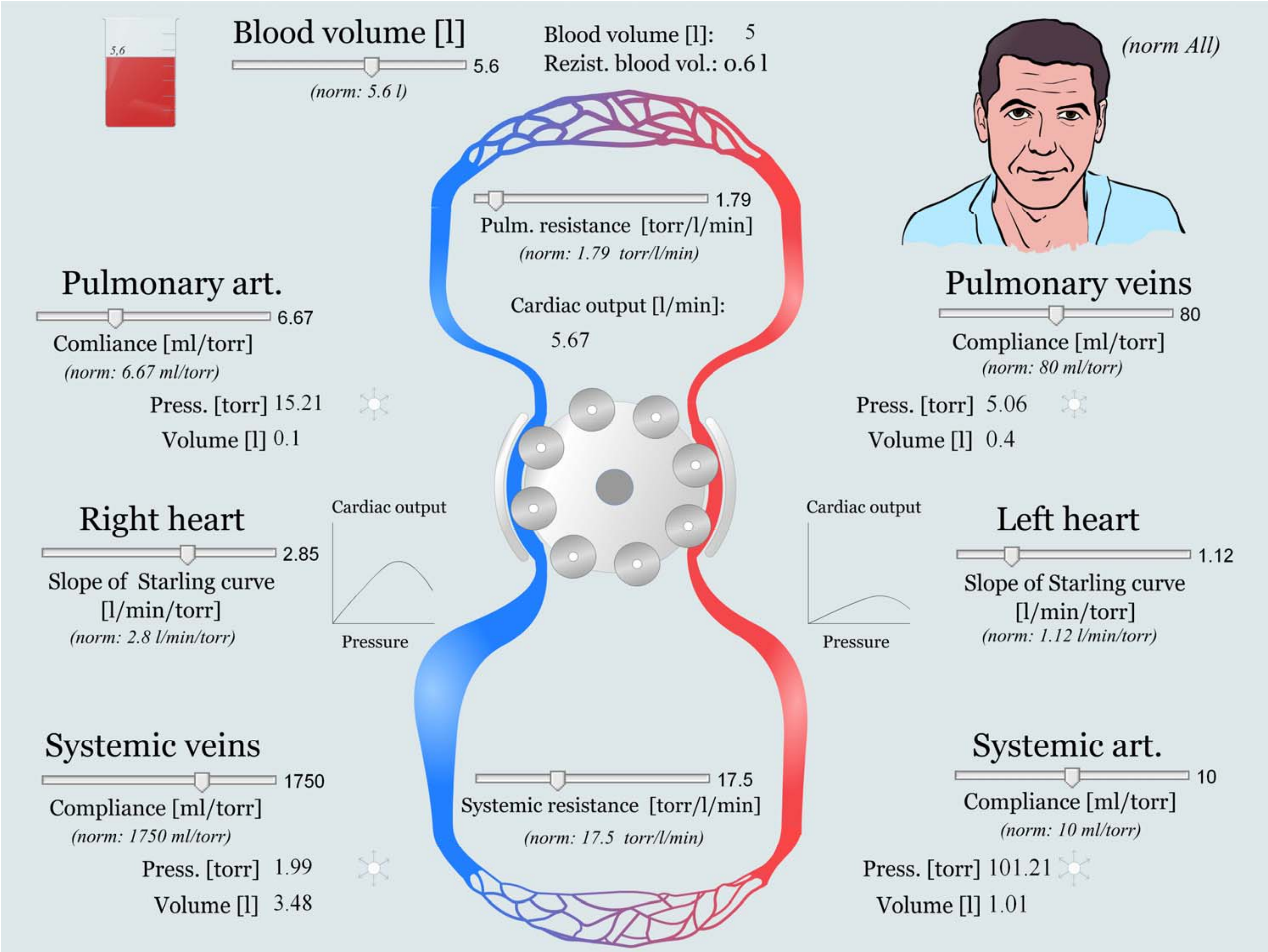

Accumulation of macromolecular products of inflammatory reactions
Inflammation
Accumulation filtrate in the interstitium
Increase of hydraulic caplillary pressure
Interstitial fluid
proteins
Increase of hydraulic capillary pressure
Reduction of oncotic pressure gradient
Dilation of capillaries
Increased capillary permeability
Precapillary sphincter
venule
Capillary
arteriole
proteins
Lymphatic drainage



Accumulation of macromolecular products of inflammatory reactions
Inflammation
Accumulation filtrate in the interstitium
Increase of hydraulic caplillary pressure
Interstitial fluid
proteins
Increase of hydraulic capillary pressure
Reduction of oncotic pressure gradient
Dilation of capillaries
Increased capillary permeability
Precapillary sphincter
venule
Capillary
arteriole
proteins
Lymphatic drainage



Accumulation of macromolecular products of inflammatory reactions
Inflammation
Swelling
proteins
Increased interstitial counterpressure
Increase of hydraulic capillary pressure
Interstitial fluid
Increase of hydraulic capillary pressure
Reduction of oncotic pressure gradient
Dilation of capillaries
Increased capillary permeability
Precapillary sphincter
venule
Capillary
arteriole
proteins
Lymphatic drainage



5,6
Blood volume [l]
5.6
(norm: 5.6 l)
Blood volume [l]: 5
Rezist. blood vol.: 0.6 l
(norm All)
1.79
Pulm. resistance [torr/l/min]
(norm: 1.79 torr/l/min)
Cardiac output [l/min]:
5.67
Pulmonary art.
6.67
Comliance [ml/torr]
(norm: 6.67 ml/torr)
Press. [torr] 15.21
Volume [l] 0.1
Pulmonary veins
80
Compliance [ml/torr]
(norm: 80 ml/torr)
Press. [torr] 5.06
Volume [l] 0.4
Right heart
2.85
Slope of Starling curve
[l/min/torr]
(norm: 2.8 l/min/torr)
Cardiac output
Pressure
Cardiac output
Pressure
Left heart
1.12
Slope of Starling curve
[l/min/torr]
(norm: 1.12 l/min/torr)
Systemic veins
1750
Compliance [ml/torr]
(norm: 1750 ml/torr)
Press. [torr] 1.99
Volume [l] 3.48
17.5
Systemic resistance [torr/l/min]
(norm: 17.5 torr/l/min)
Systemic art.
10
Compliance [ml/torr]
(norm: 10 ml/torr)
Press. [torr] 101.21
Volume [l] 1.01

Control volume and osmolarity

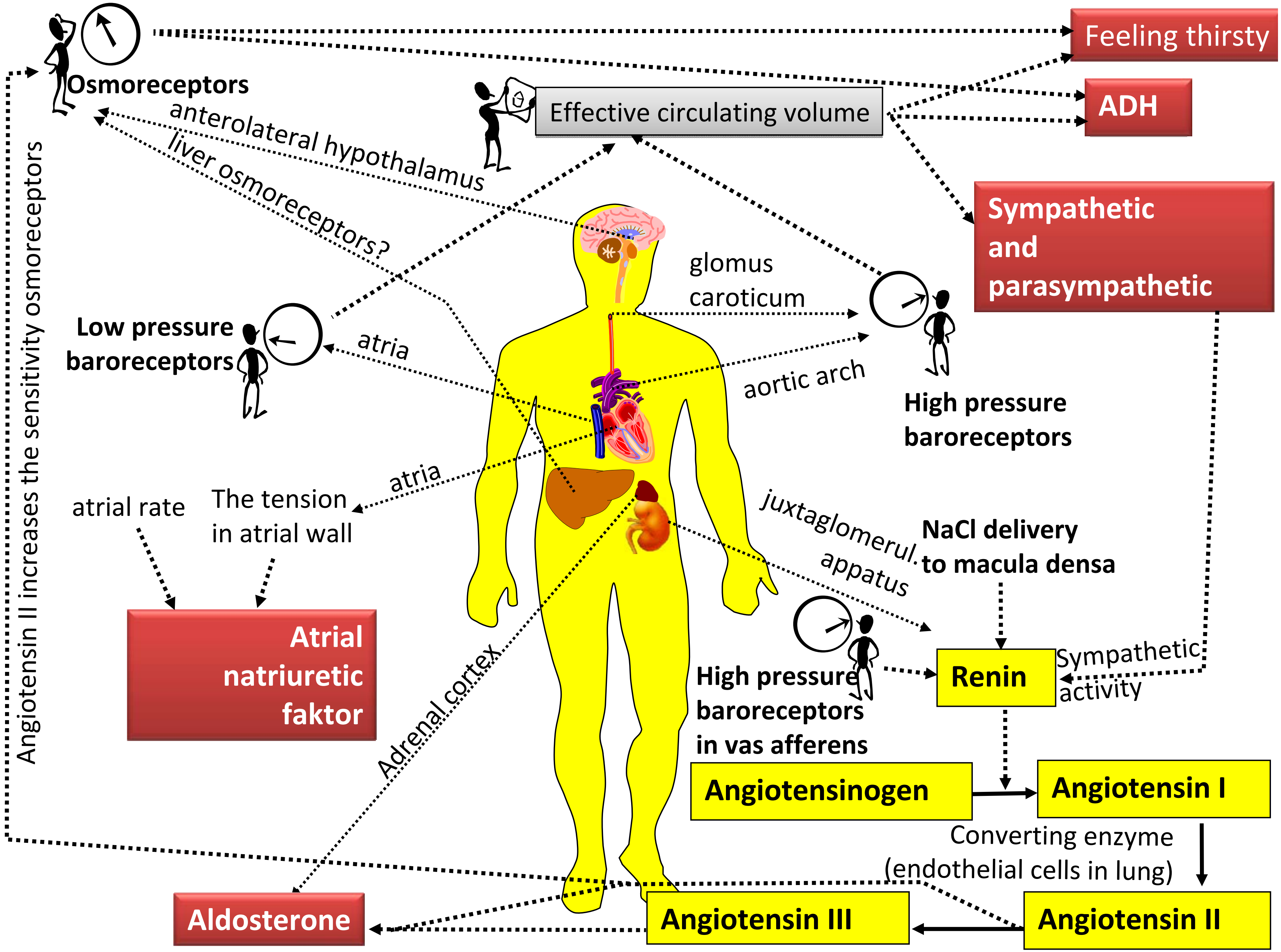
Control volume related to regulation of **circulating blood volume** and thus with hemodynamics (particularly with the regulation of arterial pressure)

Therefore, we are talking about so-called **"effective circulating volume"**

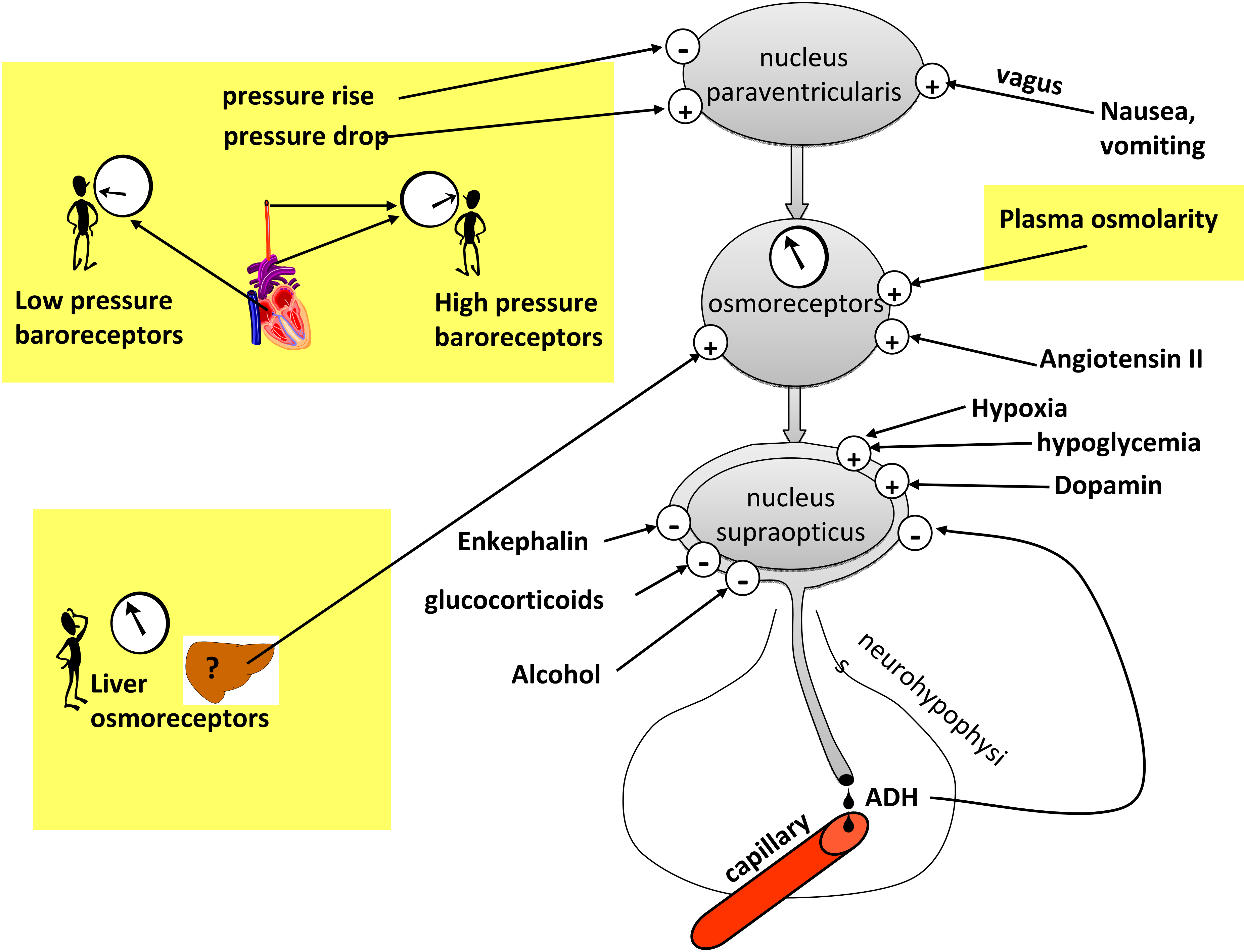
Volume - is detected by atrial tension in the wall (low-pressure baroreceptors), by tension in the artery wall and in the glomus caroticus the aortic arch (high-receptors)

Osmolarity – is detected by osmoreceptors in the hypothalamus and possibly also liver

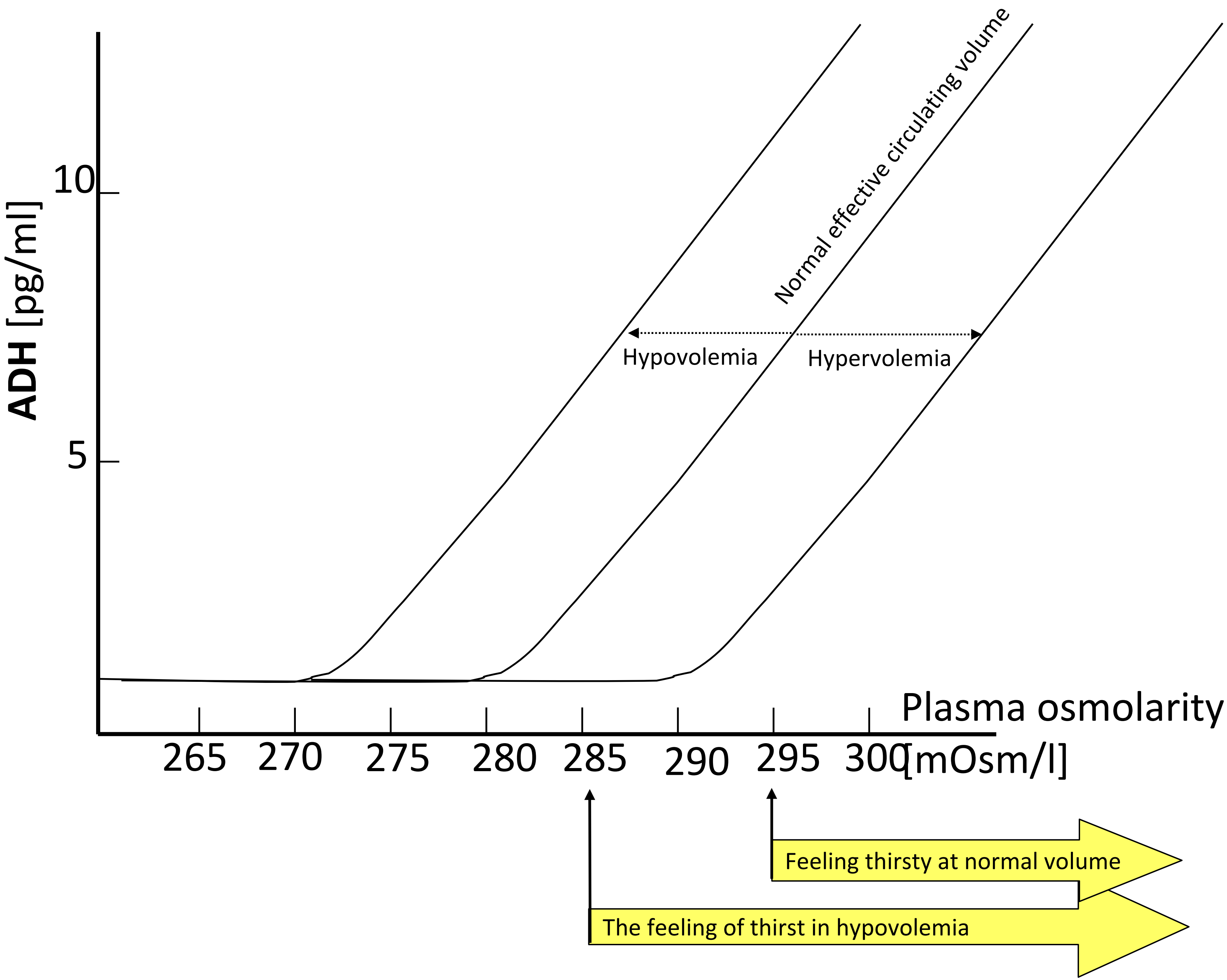
Control volume and osmolarity closely related **to regulation of sodium excretion** (sympaticus, aldosterone, ANF) and **control urine osmolarity** (ADH)

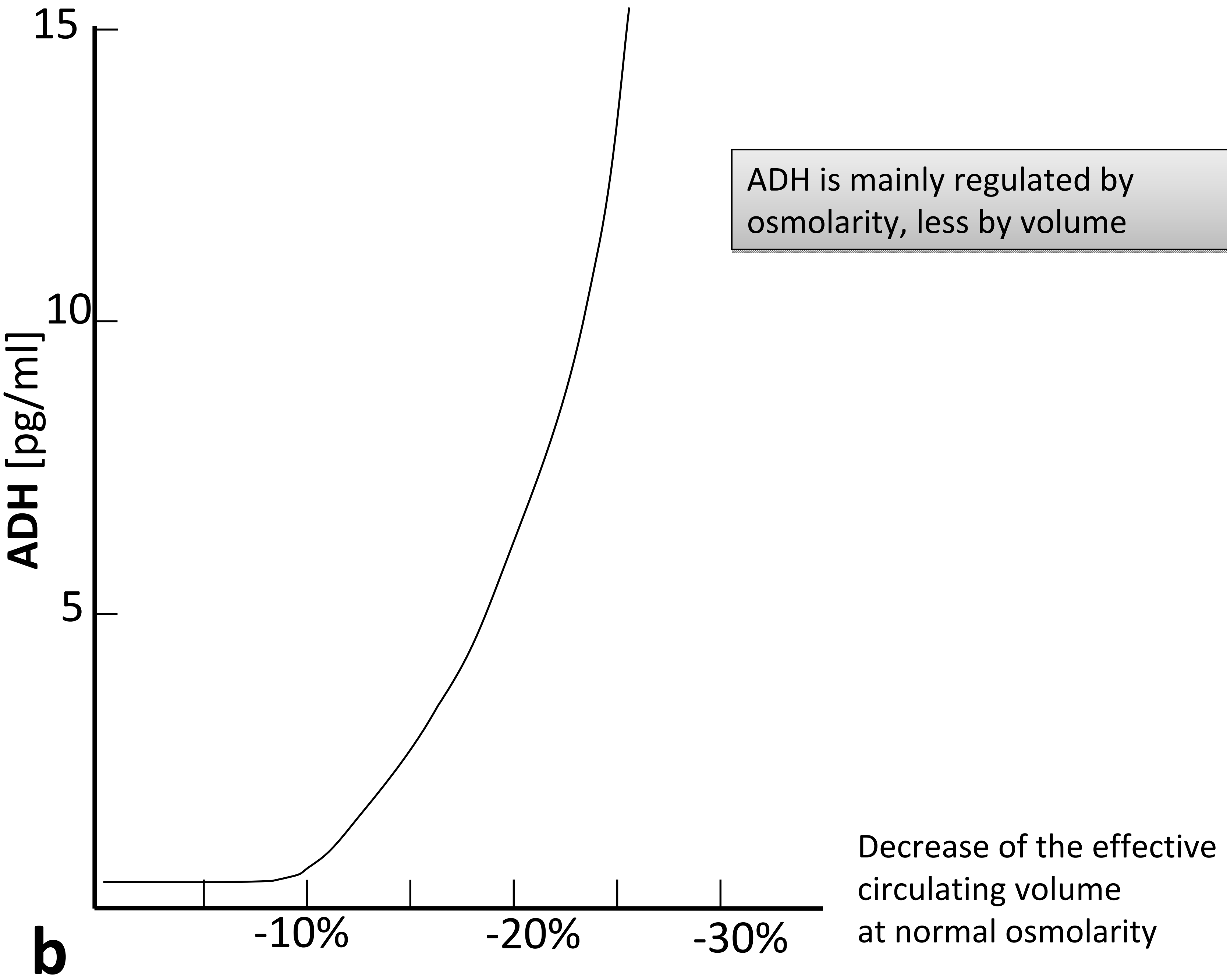


Osmoreceptors
Feeling thirsty
ADH
Effective circulating volume
anterolateral hypothalamus
liver osmoreceptors?
Sympathetic and parasympathetic
glomus caroticum
Low pressure baroreceptors
atria
aortic arch
High pressure baroreceptors
atria
atrial rate
The tension in atrial wall
juxtaglomerul. appatus
NaCl delivery to macula densa
Atrial natriuretic faktor
Angiotensin II increases the sensitivity osmoreceptors
Adrenal cortex
Renin
Sympathetic activity
High pressure baroreceptors in vas afferens
Angiotensinogen
Angiotensin I
Converting enzyme (endothelial cells in lung)
Aldosterone
Angiotensin III
Angiotensin II

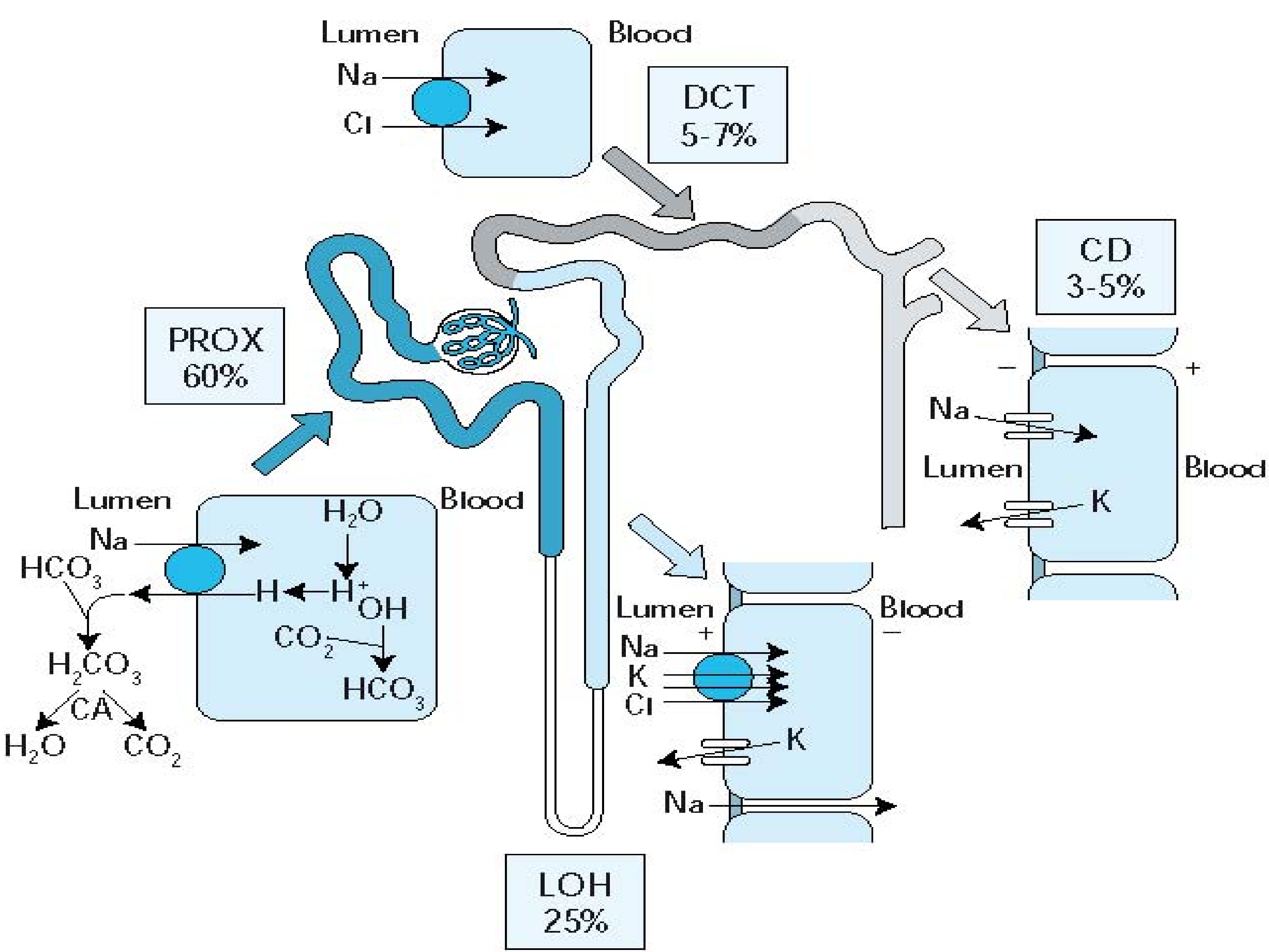


nucleus paraventricularis
pressure rise
pressure drop
vagus
Nausea, vomiting
Low pressure baroreceptors
High pressure baroreceptors
Plasma osmolarity
osmoreceptors
Angiotensin II
Hypoxia
hypoglycemia
Dopamin
nucleus supraopticus
Enkephalin
glucocorticoids
Alcohol
Liver osmoreceptors
?
neurohypophysis
ADH
capillary


ADH [pg/ml]
10
5
Normal effective circulating volume
Hypovolemia
Hypervolemia
Plasma osmolarity
265
270
275
280
285
290
295
300
[mOsm/l]
Feeling thirsty at normal volume
The feeling of thirst in hypovolemia

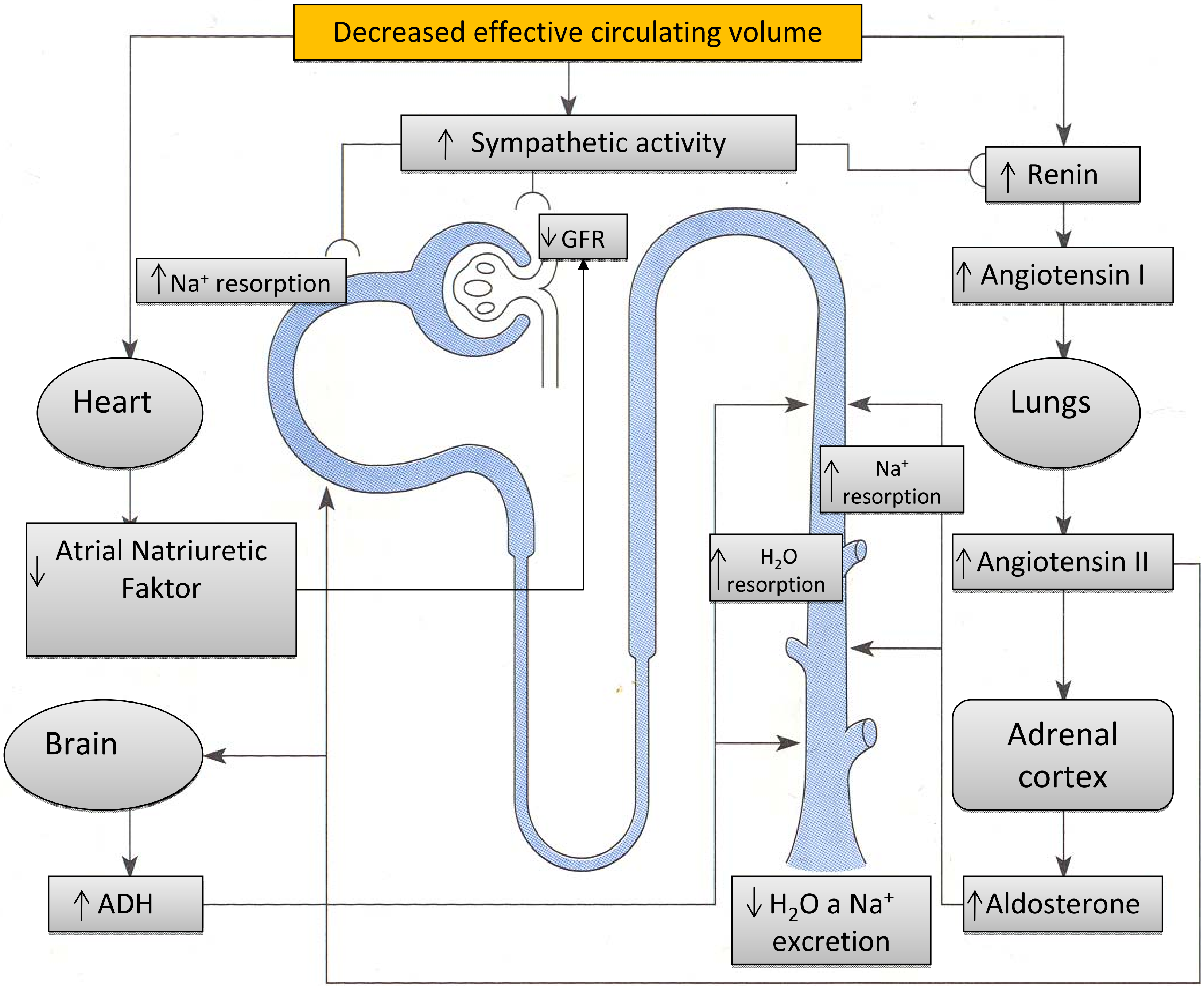

ADH [pg/ml]
15
10
5
-10%
-20%
-30%
ADH is mainly regulated by osmolarity, less by volume
Decrease of the effective circulating volume at normal osmolarity
b

Na^+ excretion in the kidney



Lumen
Blood
Na
Cl
DCT
5-7%
CD
3-5%
PROX
60%
−
+
Na
Lumen
Blood
K
Lumen
Blood
Na
HCO_3
H
H^+
H_2O
OH
CO_2
HCO_3
H_2CO_3
CA
H_2O
CO_2
Lumen
Blood
+
−
Na
K
Cl
K
Na
LOH
25%

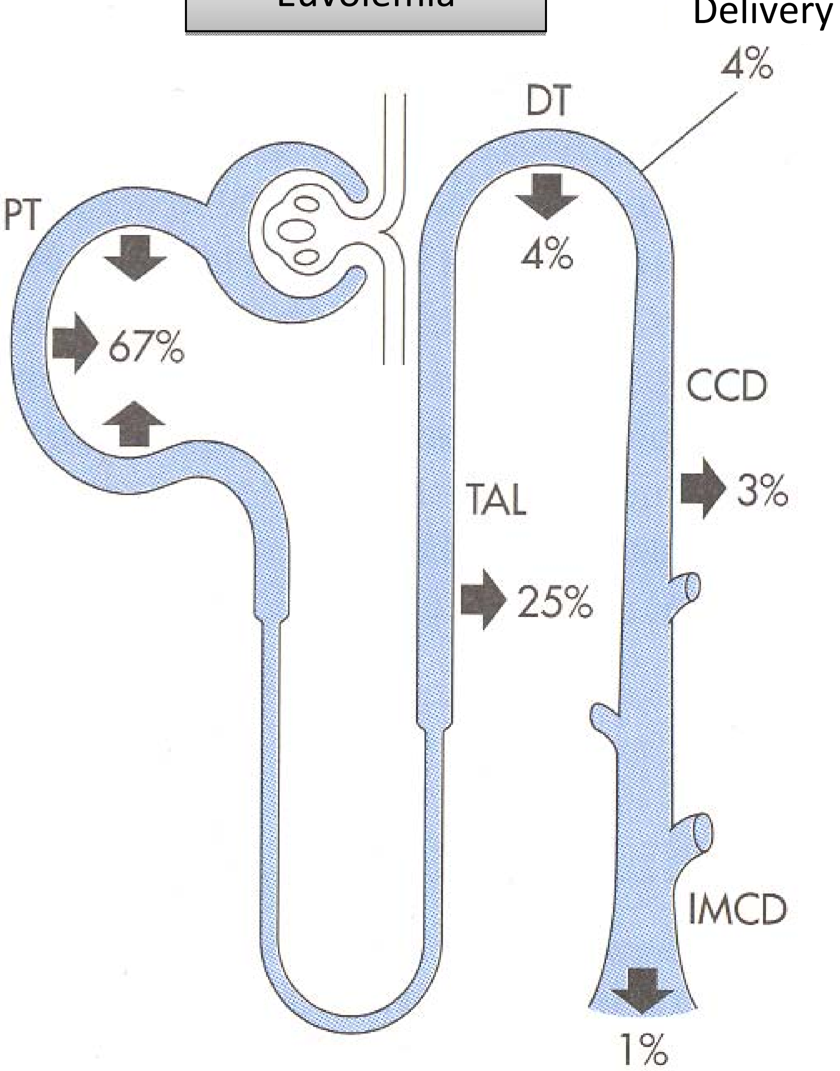
Na$^+$



Decreased effective circulating volume
↑ Sympathetic activity
↑ Renin
↑ Angiotensin I
Lungs
↑ Angiotensin II
Adrenal cortex
↑Aldosterone
↓GFR
↑Na+ resorption
Heart
↓ Atrial Natriuretic Faktor
Brain
↑ ADH
↑ Na+ resorption
↑ H2O resorption
↓ H2O a Na+ excretion

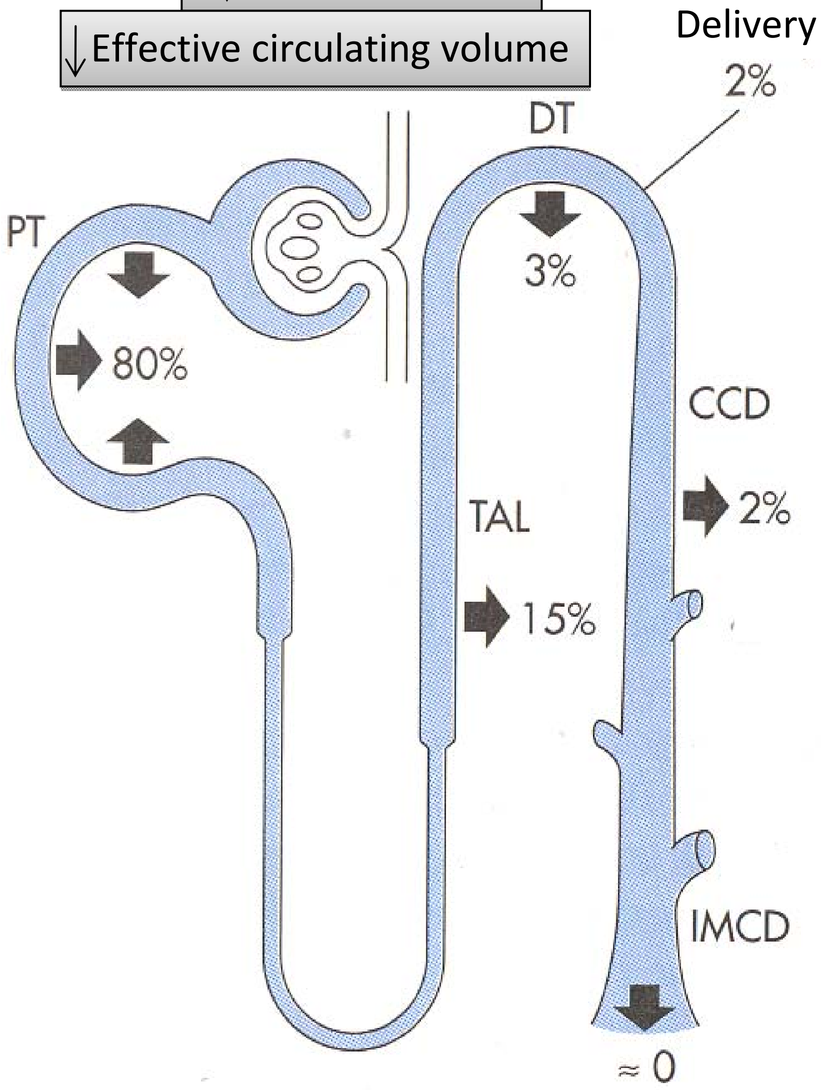
Na$^+$

Euvolemia

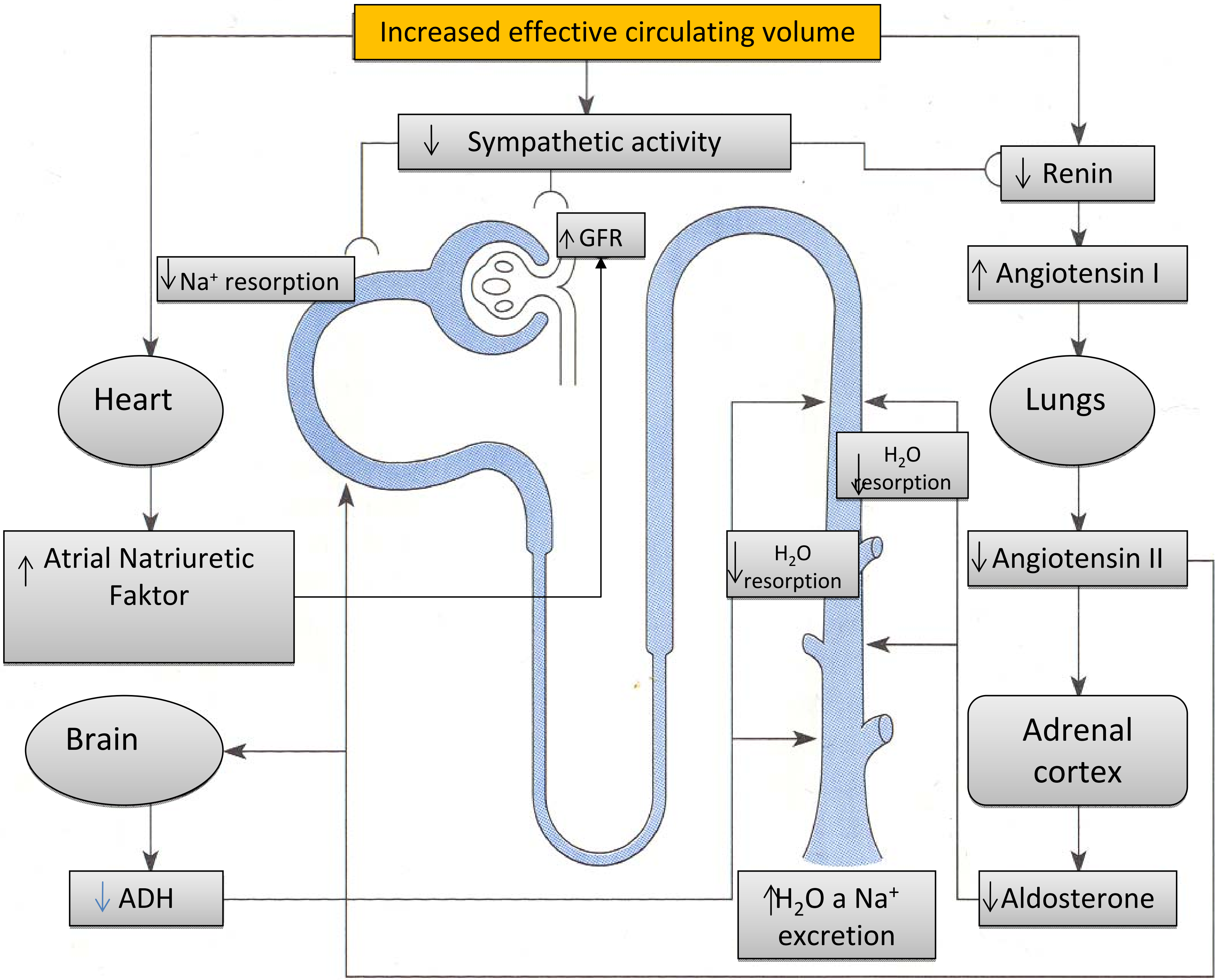


↓ ECF Volume

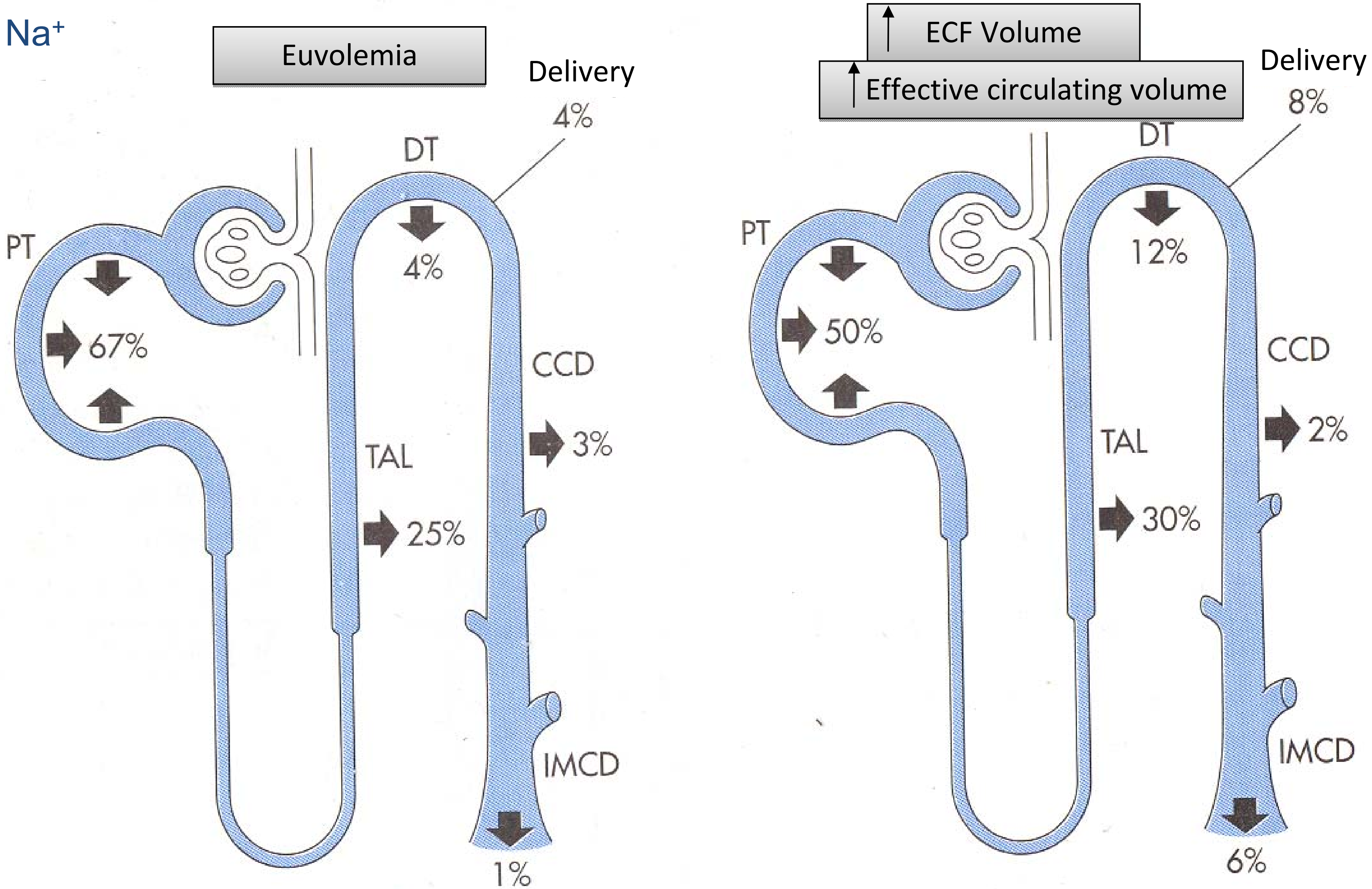
↓ Effective circulating volume



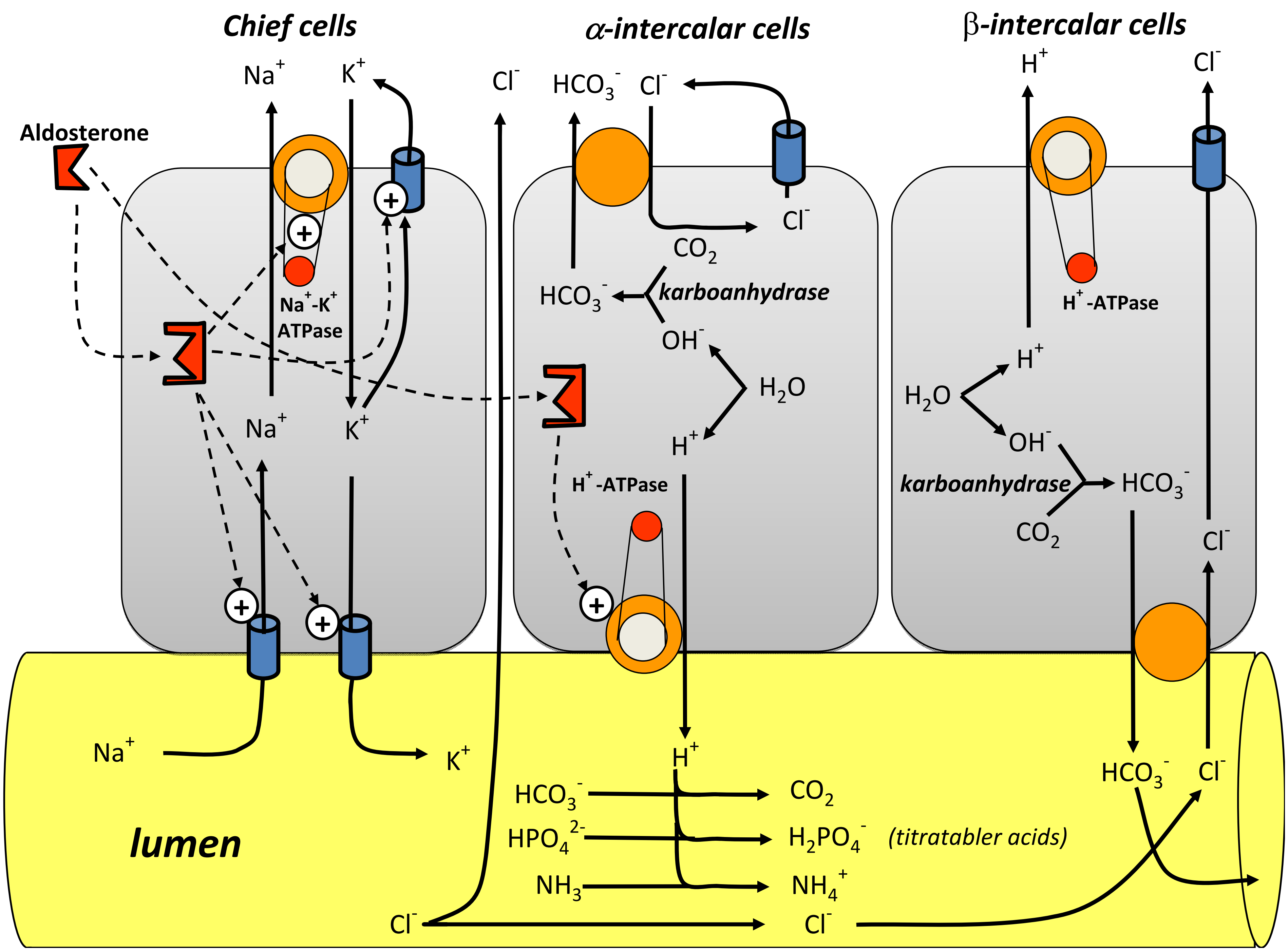
Na^+


Increased effective circulating volume
↓ Sympathetic activity
↓ Renin
↑ Angiotensin I
Lungs
↓ Angiotensin II
Adrenal cortex
↓ Aldosterone
↓ Na+ resorption
↑ GFR
Heart
↑ Atrial Natriuretic Faktor
Brain
↓ ADH
↓ H2O resorption
↓ H2O resorption
↑ H2O a Na+ excretion

Na+



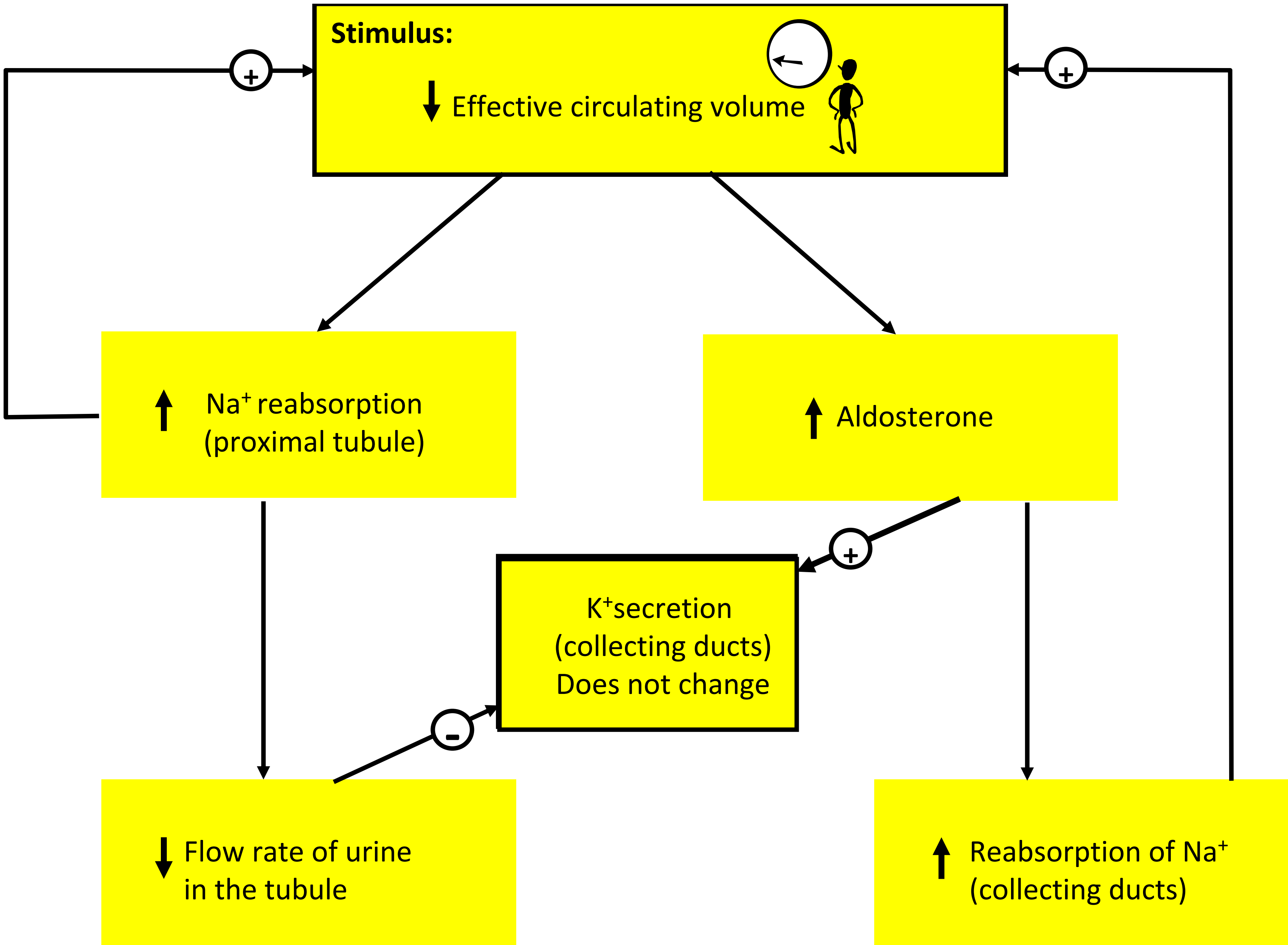
Euvolemia
Delivery
4%
DT
PT
4%
67%
CCD
3%
TAL
25%
IMCD
1%
ECF Volume
Effective circulating volume
Delivery
8%
DT
PT
12%
50%
CCD
2%
TAL
30%
IMCD
6%



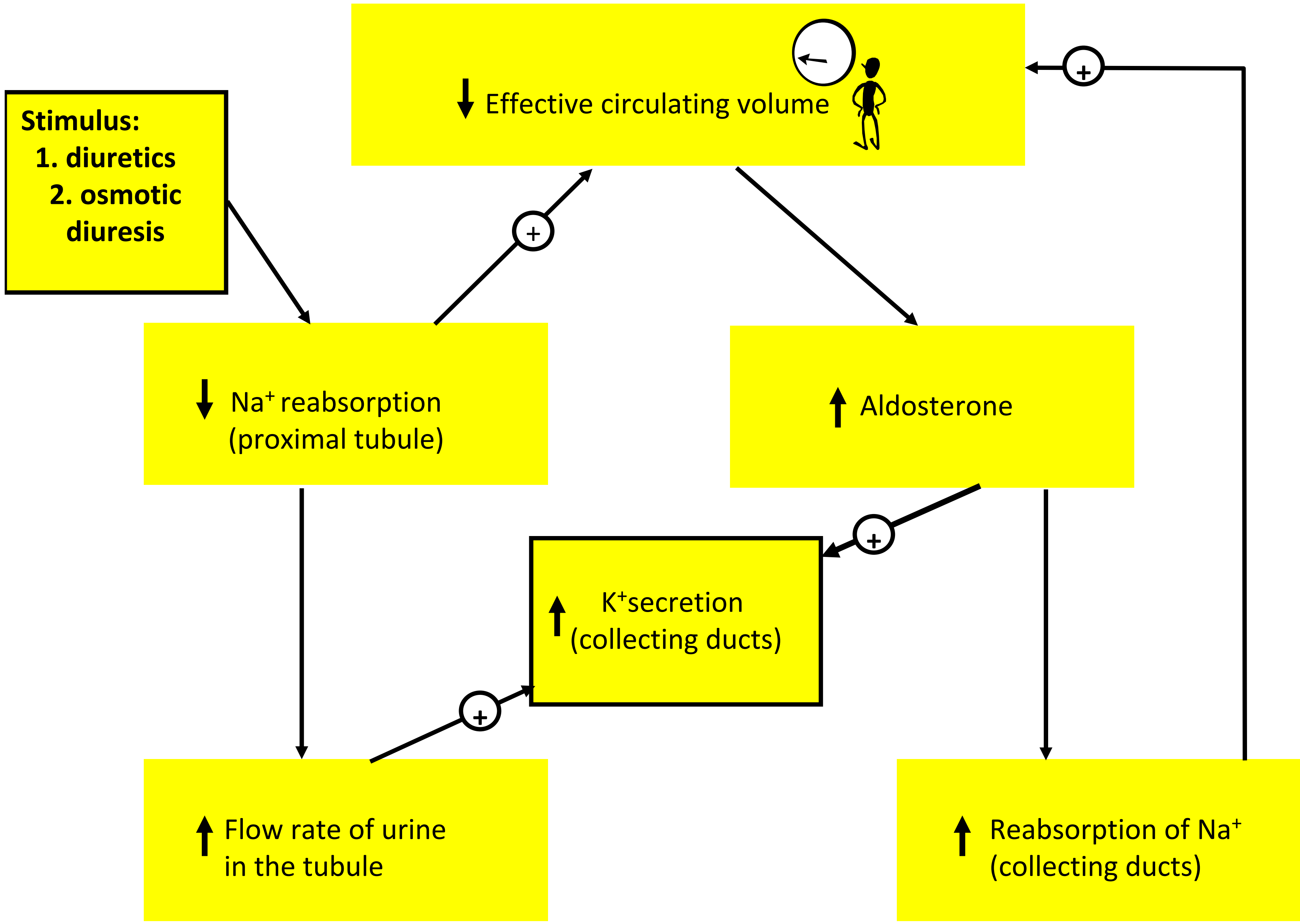
Chief cells
α-intercalar cells
β-intercalar cells
Aldosterone
Na+
K+
Cl-
HCO3-
Cl-
H+
Cl-
Cl-
CO2
HCO3-
karboanhydrase
OH-
H2O
H+
Na+-K+
ATPase
Na+
K+
H+-ATPase
H+-ATPase
H+
H2O
OH-
karboanhydrase
HCO3-
CO2
Cl-
Na+
K+
H+
HCO3-
CO2
HPO4 2-
H2PO4-
(titratabler acids)
NH3
NH4+
Cl-
Cl-
HCO3-
Cl-
lumen

Question

Why in healthy people with reducing the volume of extracellular fluid and subsequent activation of renin-angiotensin-aldosterone system are not lost potassium?



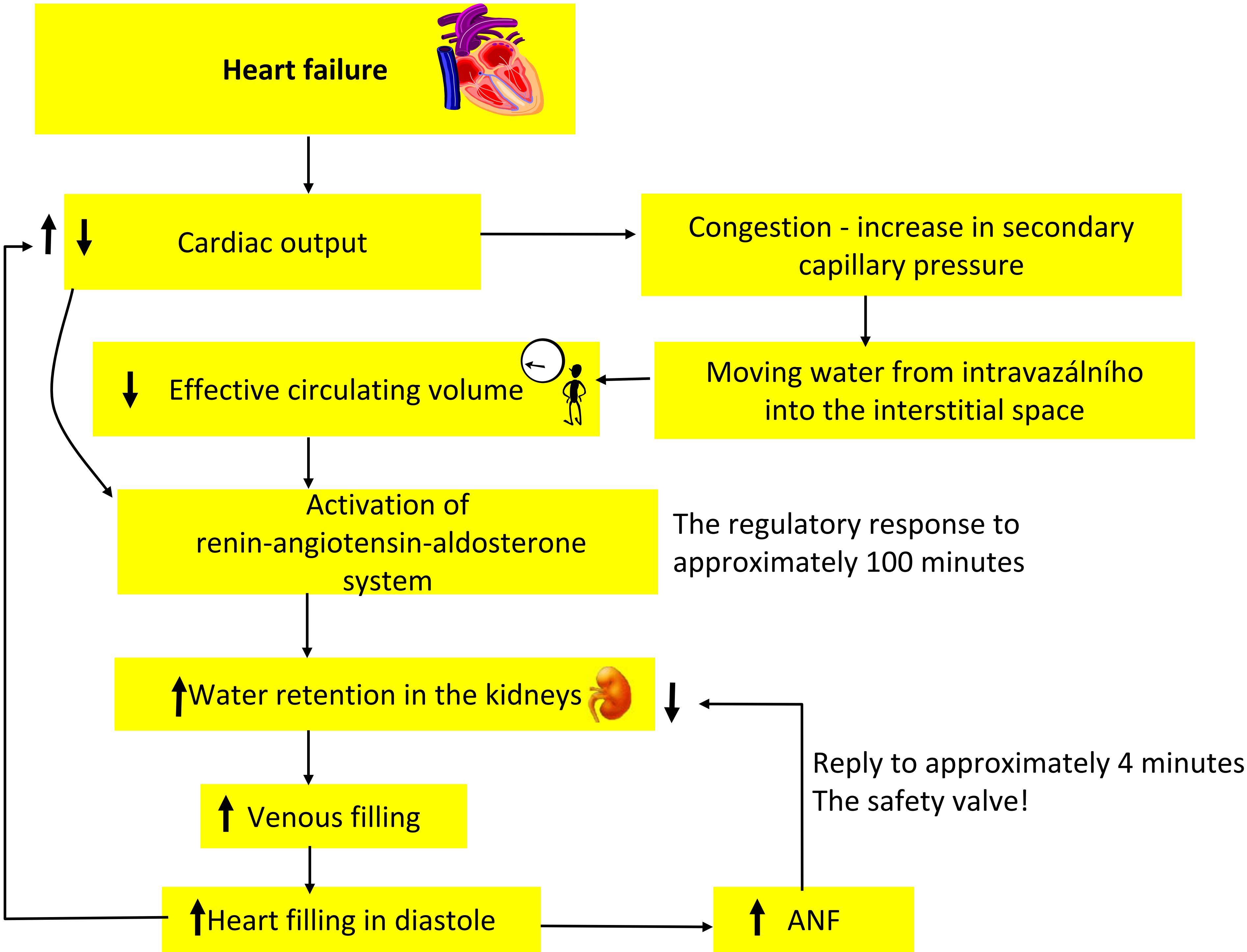
Stimulus:
Effective circulating volume
+
+
Na+ reabsorption
(proximal tubule)
Aldosterone
+
K+secretion
(collecting ducts)
Does not change
-
Flow rate of urine
in the tubule
Reabsorption of Na+
(collecting ducts)


Stimulus:
1. diuretics
2. osmotic diuresis
↓ Effective circulating volume
↓ Na+ reabsorption (proximal tubule)
↑ Aldosterone
↑ K+secretion (collecting ducts)
↑ Flow rate of urine in the tubule
↑ Reabsorption of Na+ (collecting ducts)
+
+
+
+

Question

What is the regulatory importance of atrial natriuretic factor?

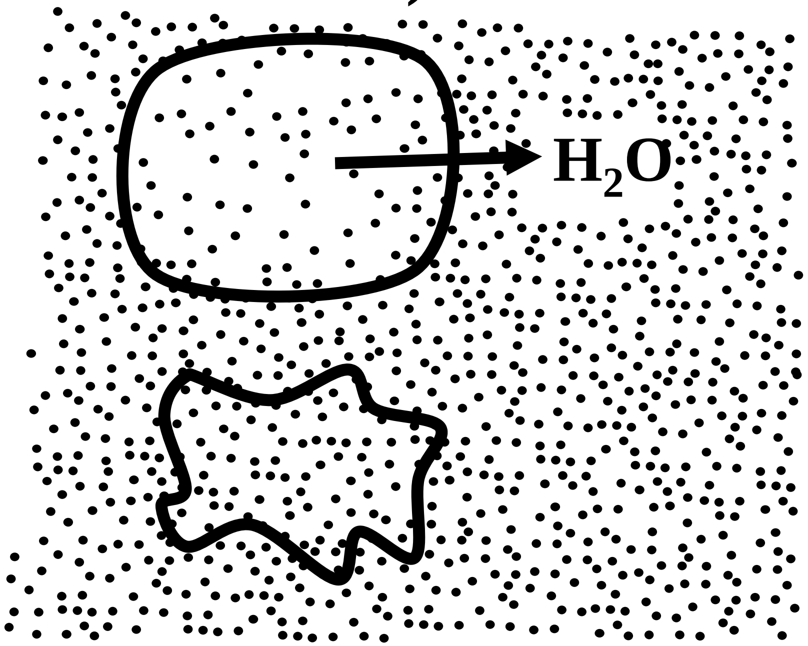
ANF acts as a **safety valve** when the compensatory increase in circulating blood volume



Heart failure
Cardiac output
Congestion - increase in secondary capillary pressure
Moving water from intravazálního into the interstitial space
Effective circulating volume
Activation of renin-angiotensin-aldosterone system
The regulatory response to approximately 100 minutes
Water retention in the kidneys
Reply to approximately 4 minutes
The safety valve!
Venous filling
Heart filling in diastole
ANF

Transfers of water between the ICF and ECF

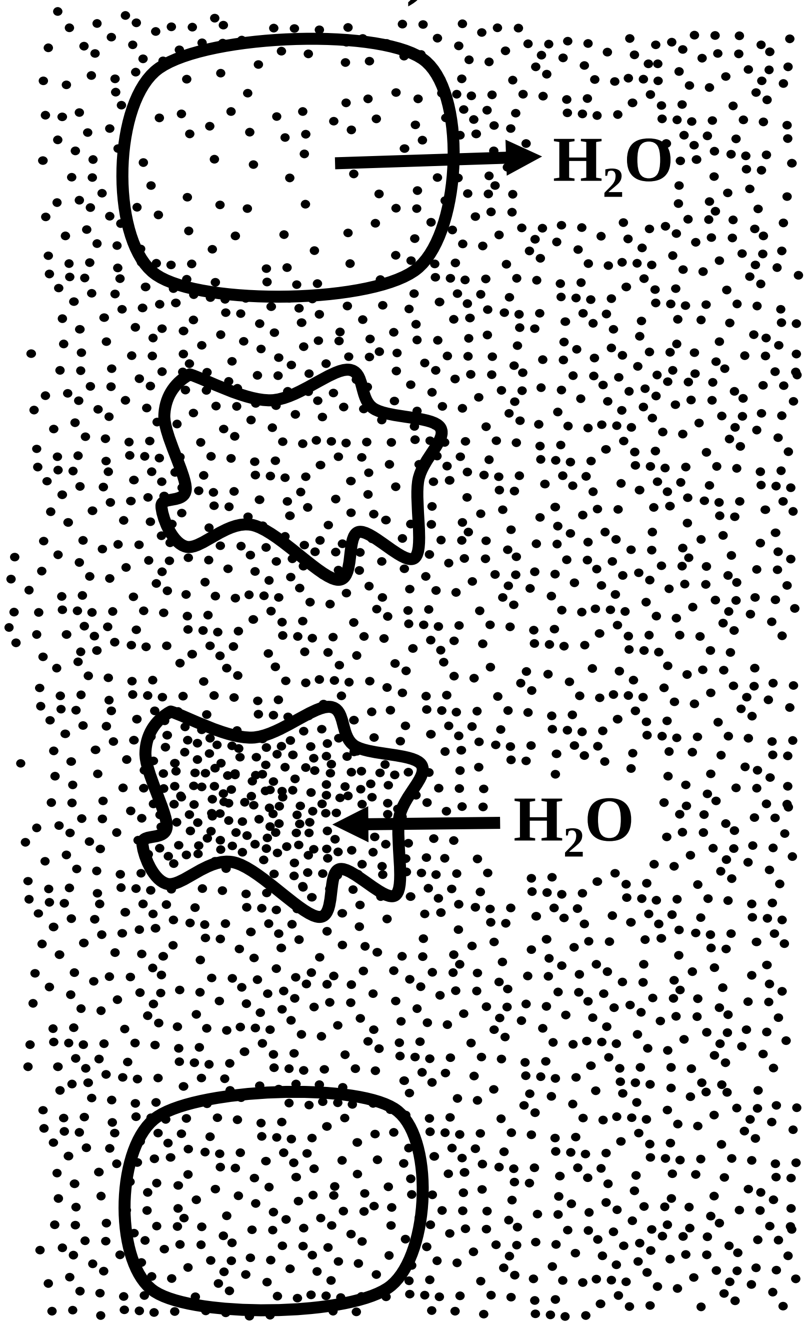
a) Cells in the hypertonic environment



Osmotic shift of water from cells

Reducing the volume of cells

a) Cells in the hypertonic environment

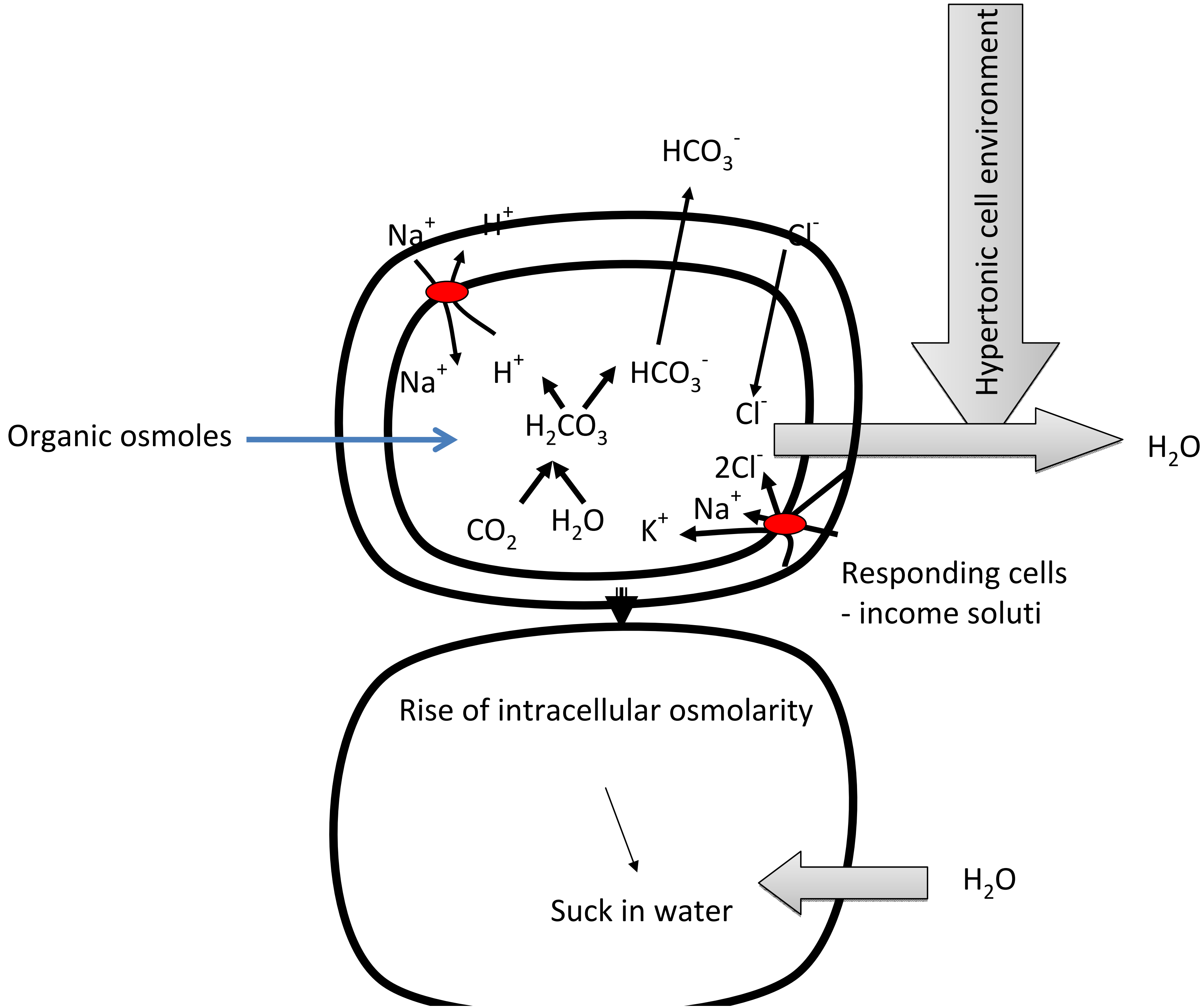


Osmotic shift of water from cells

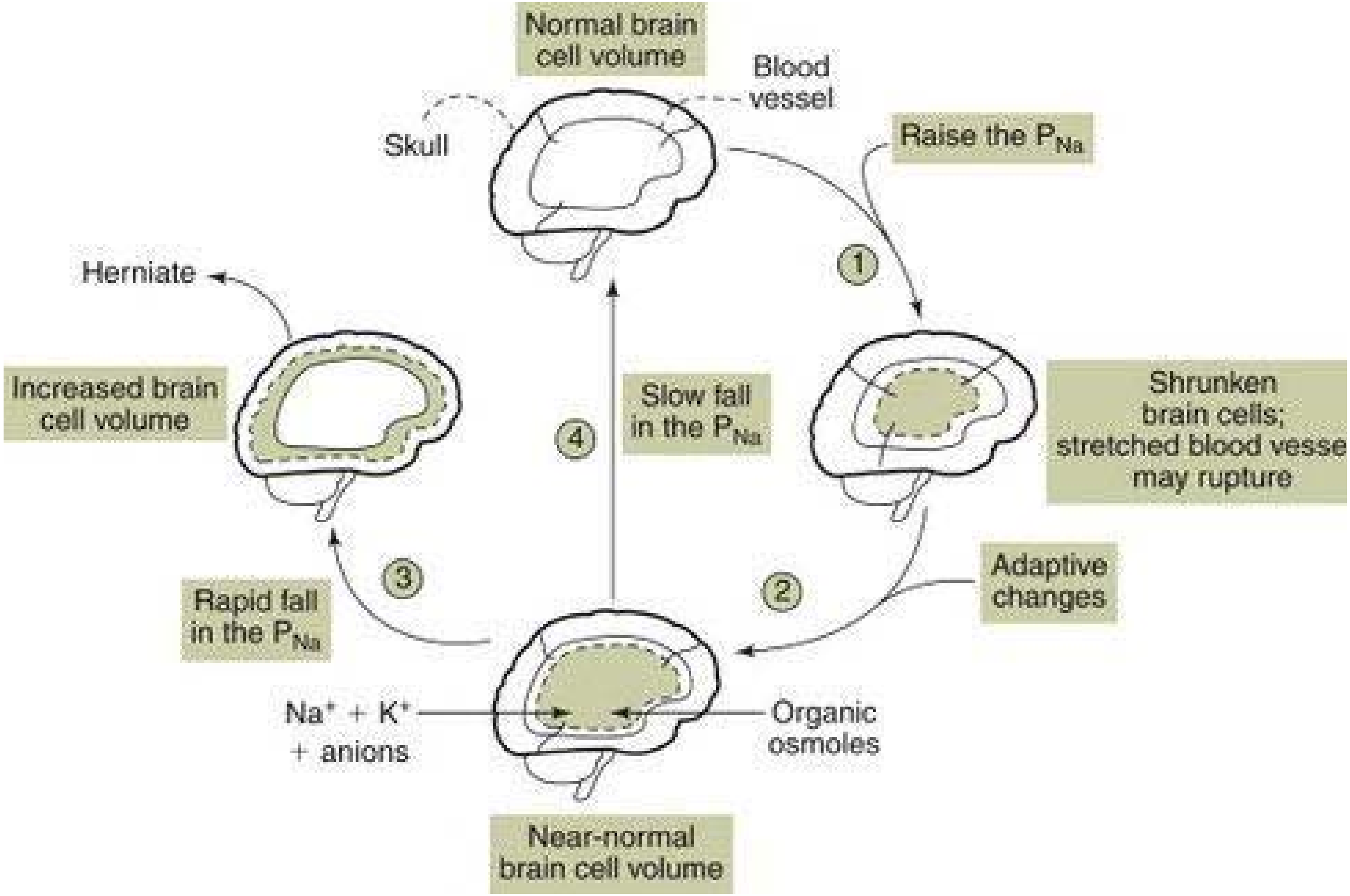
Reducing the volume of cells

Active increase in osmotic pressure in the cell and subsequent transfer of water

Cell volume increases slightly

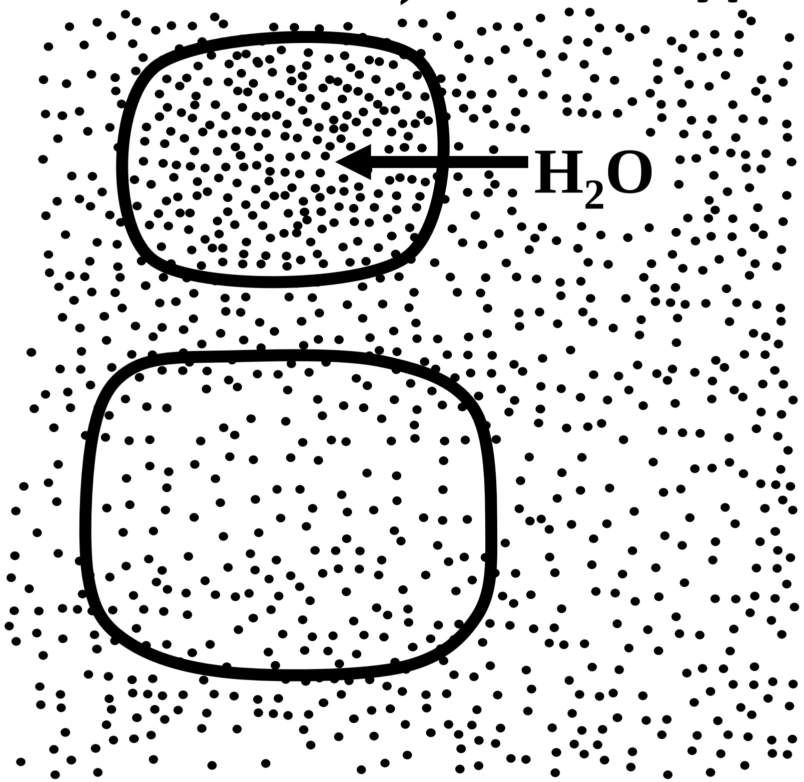


Hypertonic cell environment
HCO_3^-
Na^+
H^+
Cl^-
Na^+
H^+
HCO_3^-
Cl^-
Organic osmoles
H_2CO_3
H_2O
$2Cl^-$
Na^+
K^+
CO_2
H_2O
Responding cells
- income soluti
Rise of intracellular osmolarity
Suck in water
H_2O



Normal brain cell volume
Blood vessel
Skull
Raise the P_{Na}
1
Shrunken brain cells; stretched blood vesse may rupture
Herniate
Increased brain cell volume
4
Slow fall in the P_{Na}
3
Rapid fall in the P_{Na}
2
Adaptive changes
$Na^+ + K^+$ + anions
Organic osmoles
Near-normal brain cell volume

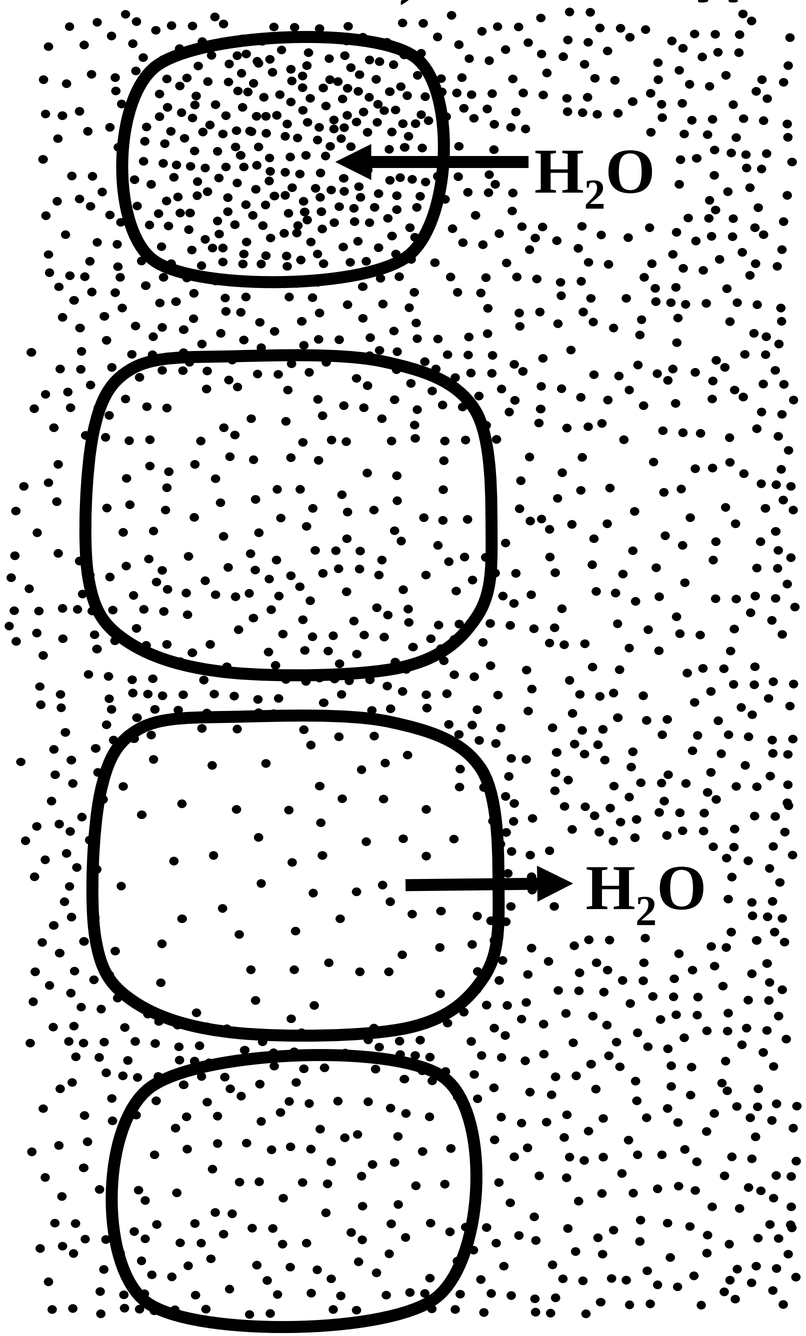
b) Cell in hypotonic environment



Osmotic movement of water into the cell

Increasing the volume of cells

b) Cell in hypotonic environment

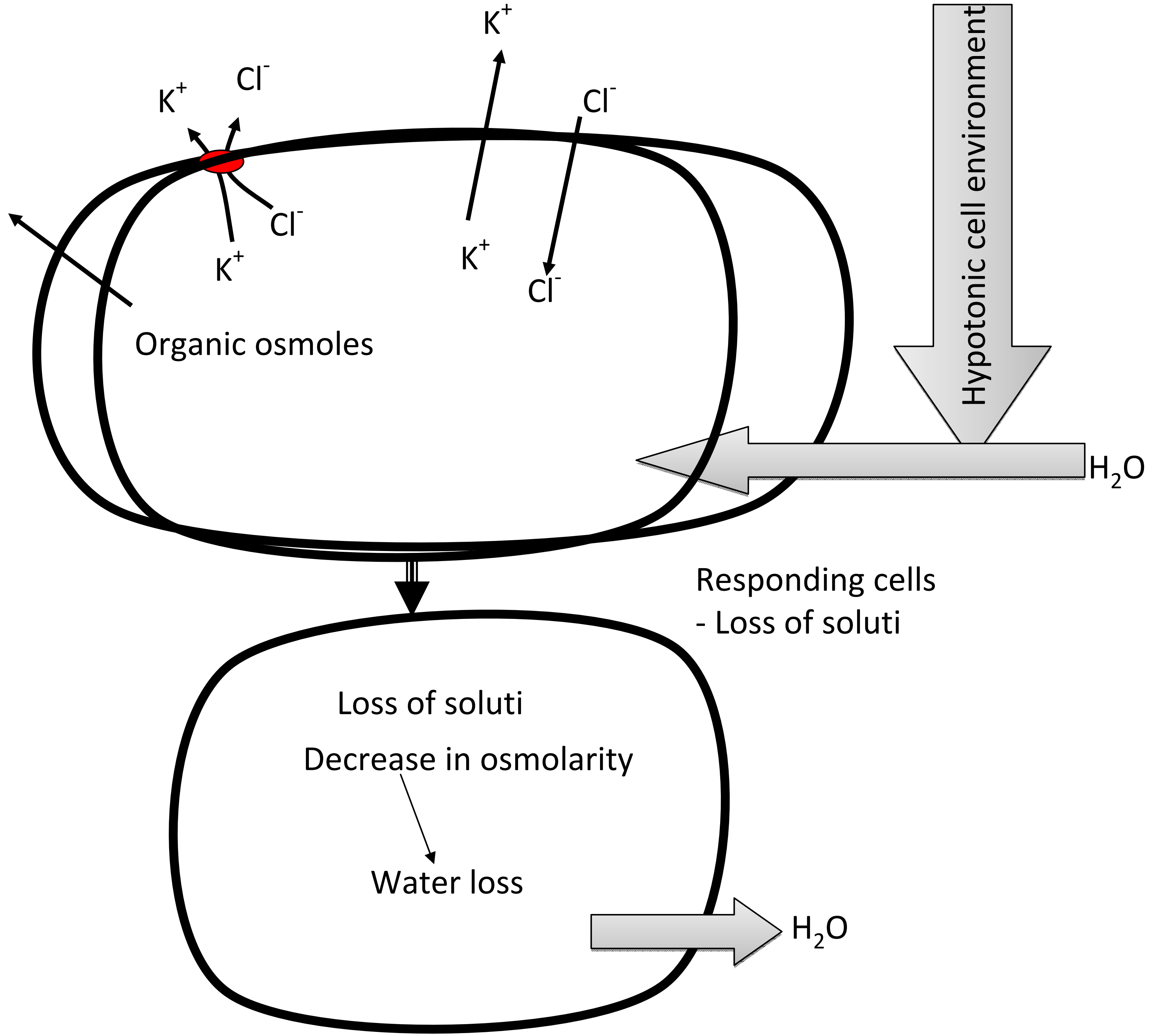


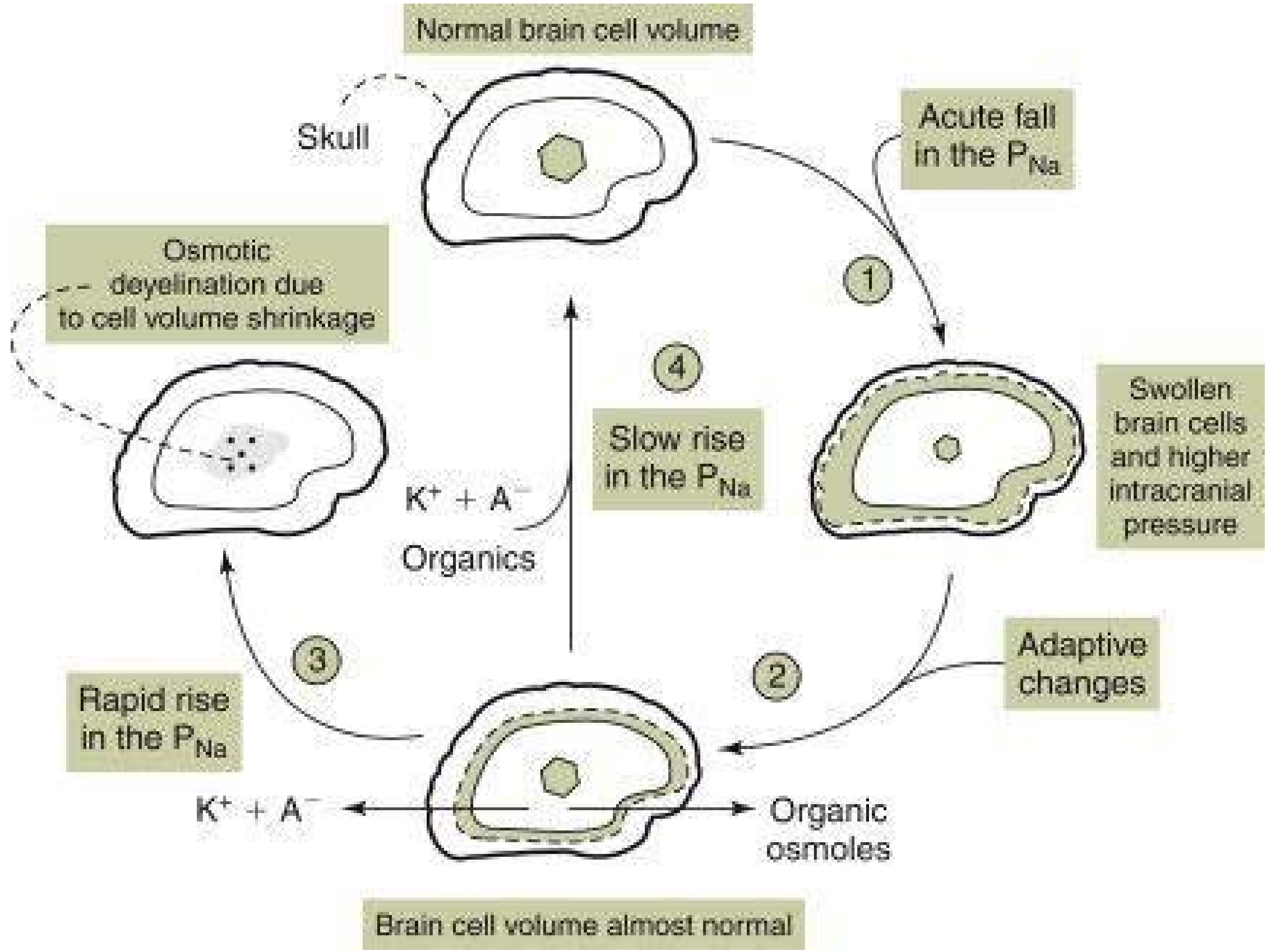
Osmotic movement of water into the cell

Increasing the volume of cells

Active reduction of osmotic pressure
in the cell and subsequent transfer of water

Cell volume is somewhat reduced


K+
Cl-
K+
Cl-
Cl-
K+
K+
Cl-
Organic osmoles
Hypotonic cell environment
H_2O
Responding cells
- Loss of soluti
Loss of soluti
Decrease in osmolarity
Water loss
H_2O


Normal brain cell volume
Skull
Acute fall in the P_{Na}
1
Swollen brain cells and higher intracranial pressure
2
Adaptive changes
Brain cell volume almost normal
$K^+ + A^-$
Organic osmoles
3
Rapid rise in the P_{Na}
Osmotic deyelination due to cell volume shrinkage
4
Slow rise in the P_{Na}
$K^+ + A^-$
Organics

Disorders of the volume and osmolarity

Itravascular fluid

- hypovolemia

  shock

- hypervolemia

  Renal failure and water intake

Extravascular fluid

- Dehydratation
  - hypertonic
  - isotonic
  - hypotonic
- Hyperhydratation
  - hypotonic
  - isotonic
  - (hypertonic)

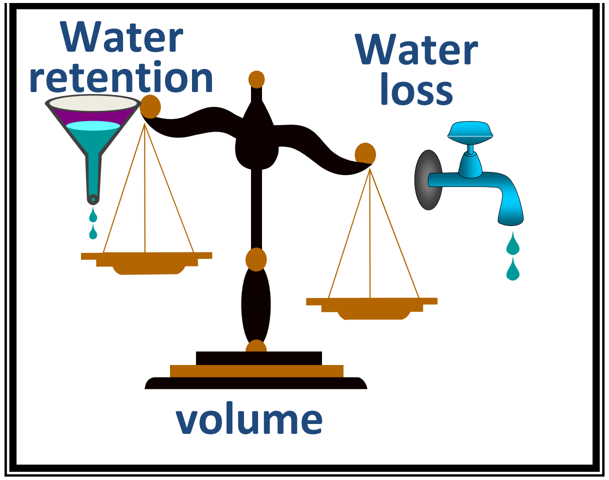
Clinical signs

	Hct, Hb, Tot.pl.prot.	Plasma Na^+ PlasmOsm.	MCV
Dehydratation hyperosmotic isoosmotic normoosmotic	↑	↑ normal ↓	↓ normal ↑
Hyperhydratation hypoosmotic isoosmotic hyperosmotic	↓	↓ normäl ↑	↑ normal ↓

Dehydratation

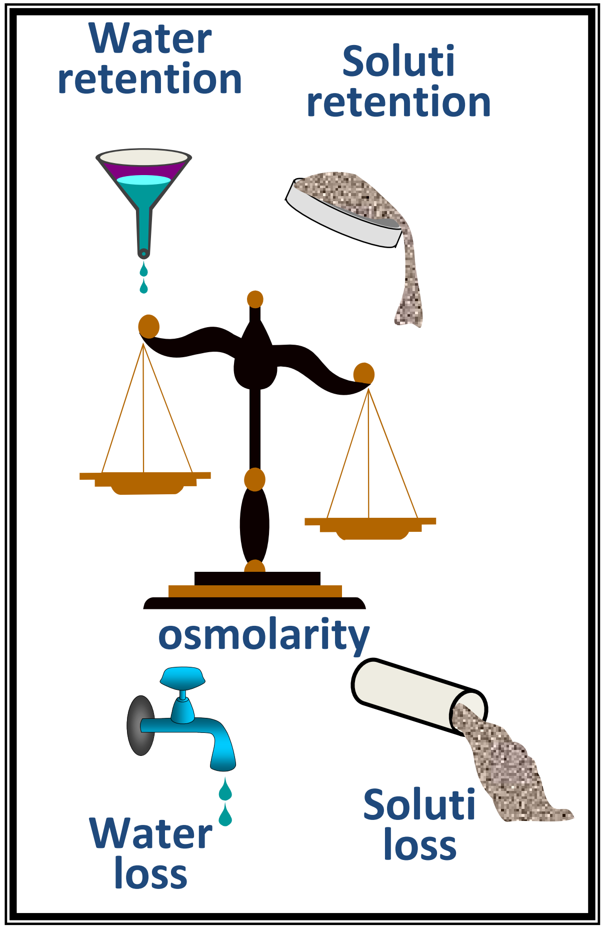
Euvolemia

- *Hypotonic (hypoosmolar)*
- *Isotonic – normal fysiology state*
- *Hypertonic (hyperoosmolar)*



Dehydratation

- *Hypotonic (hypoosmolar)*
- *Isotonic (isoosmolar)*
- *Hypertonic (hyperosmolar)*

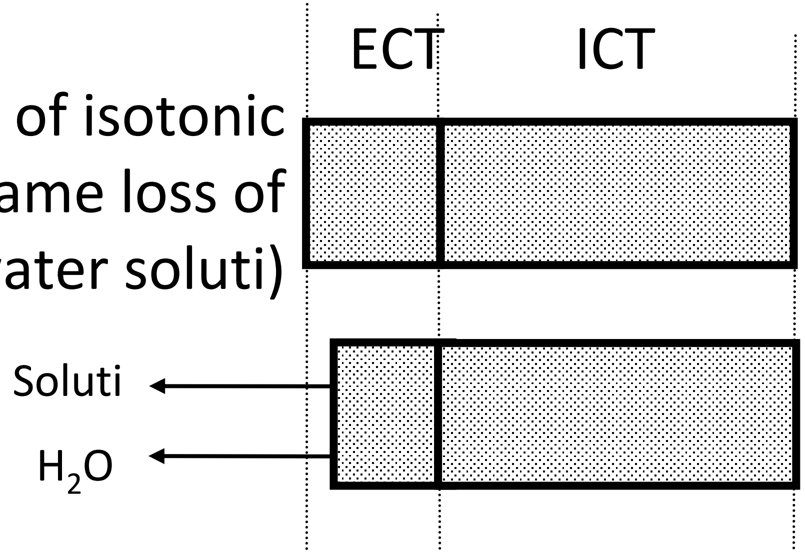


Hyperhydratation

- *Hypotonic (hypoosmolar)*
- *Isotonic (isoosmolar)*
- *Hypertonic (hyperosmolar)*

Isotonic dehydratation

Cause: loss of isotonic fluid (the same loss of water soluti)

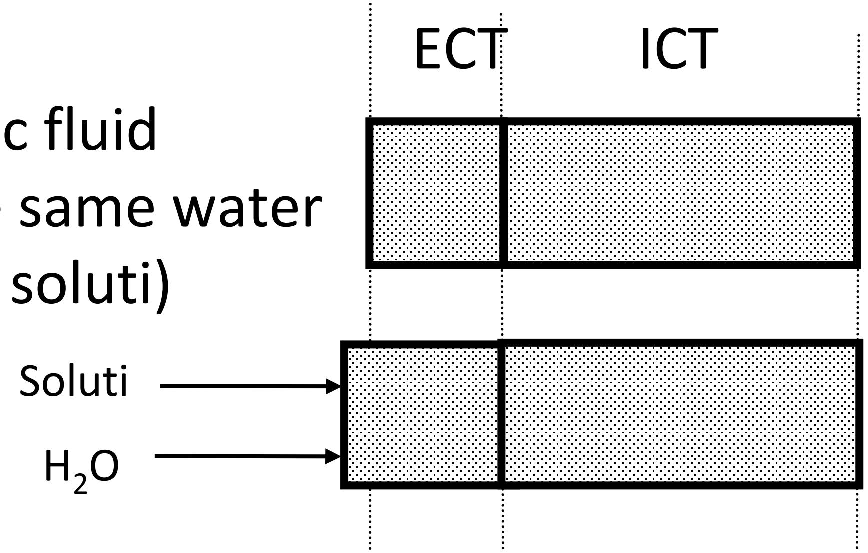


Initial state

Loss of isotonic fluid from the ECF does not displace the water between the ICF and ECF

Isotonic hyperhydratation

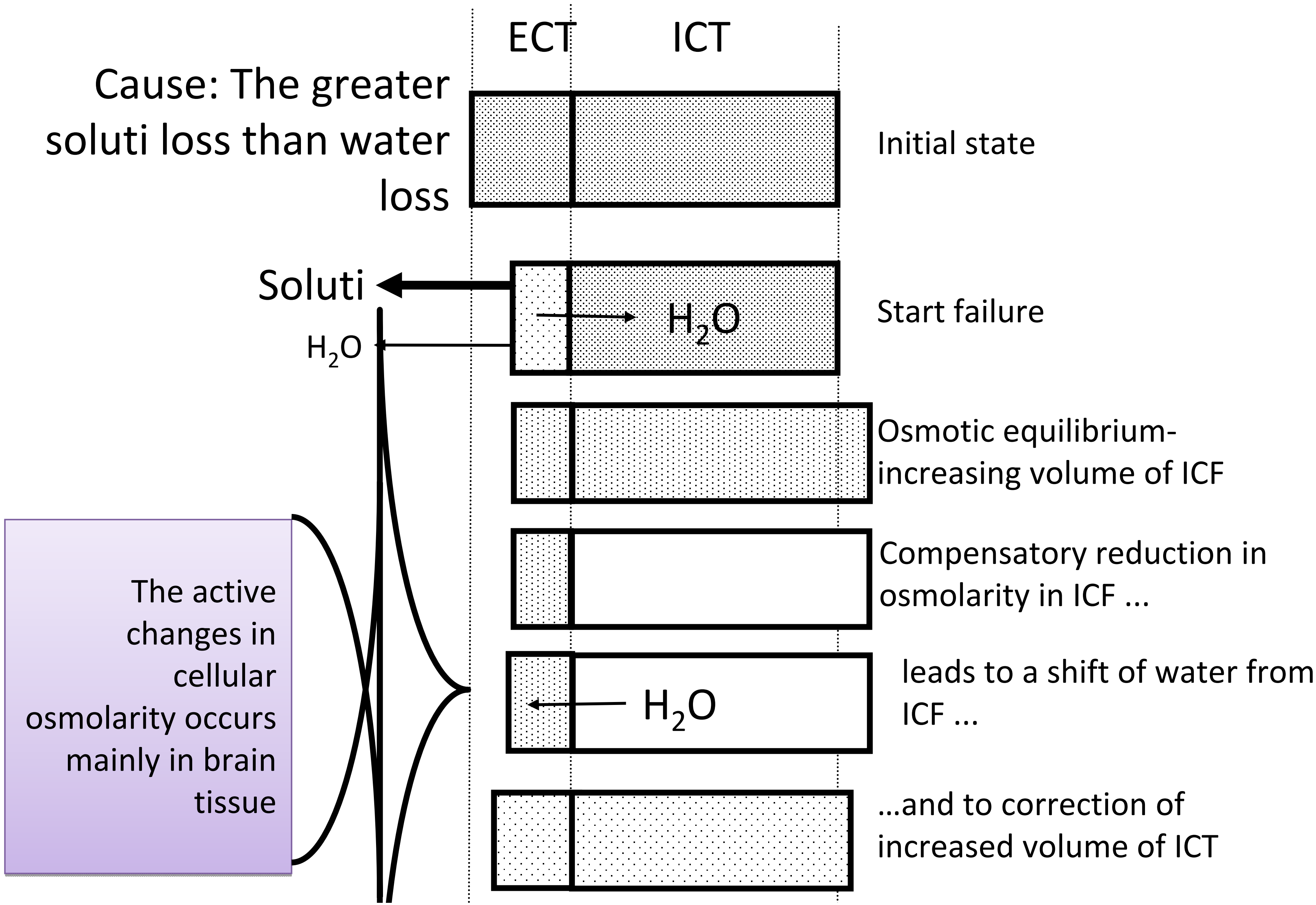
Cause: isotonic fluid retention (the same water retention and soluti)



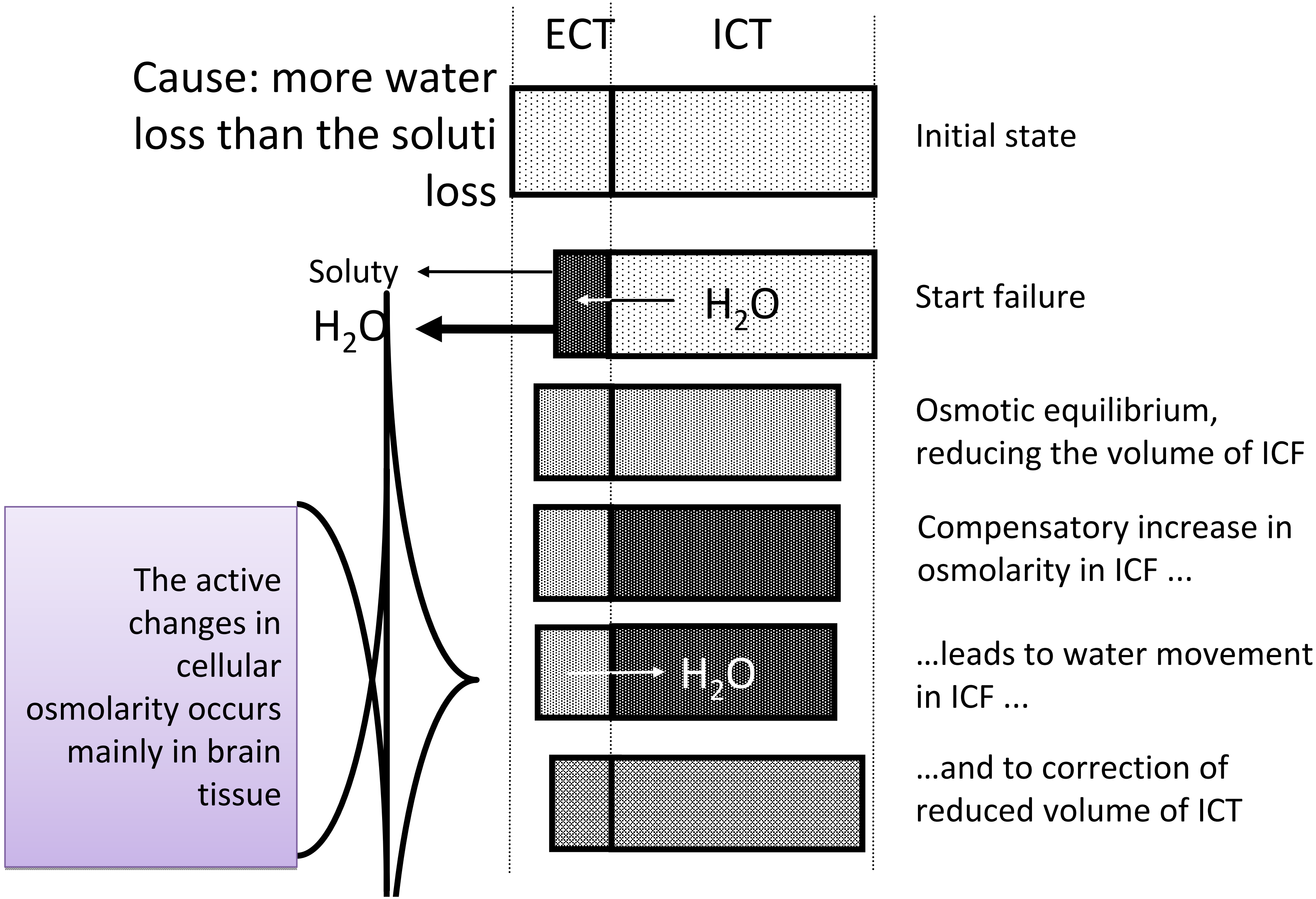
Initial state

Retention of isotonic fluid from the ECF does not displace the water between the ICF and ECF

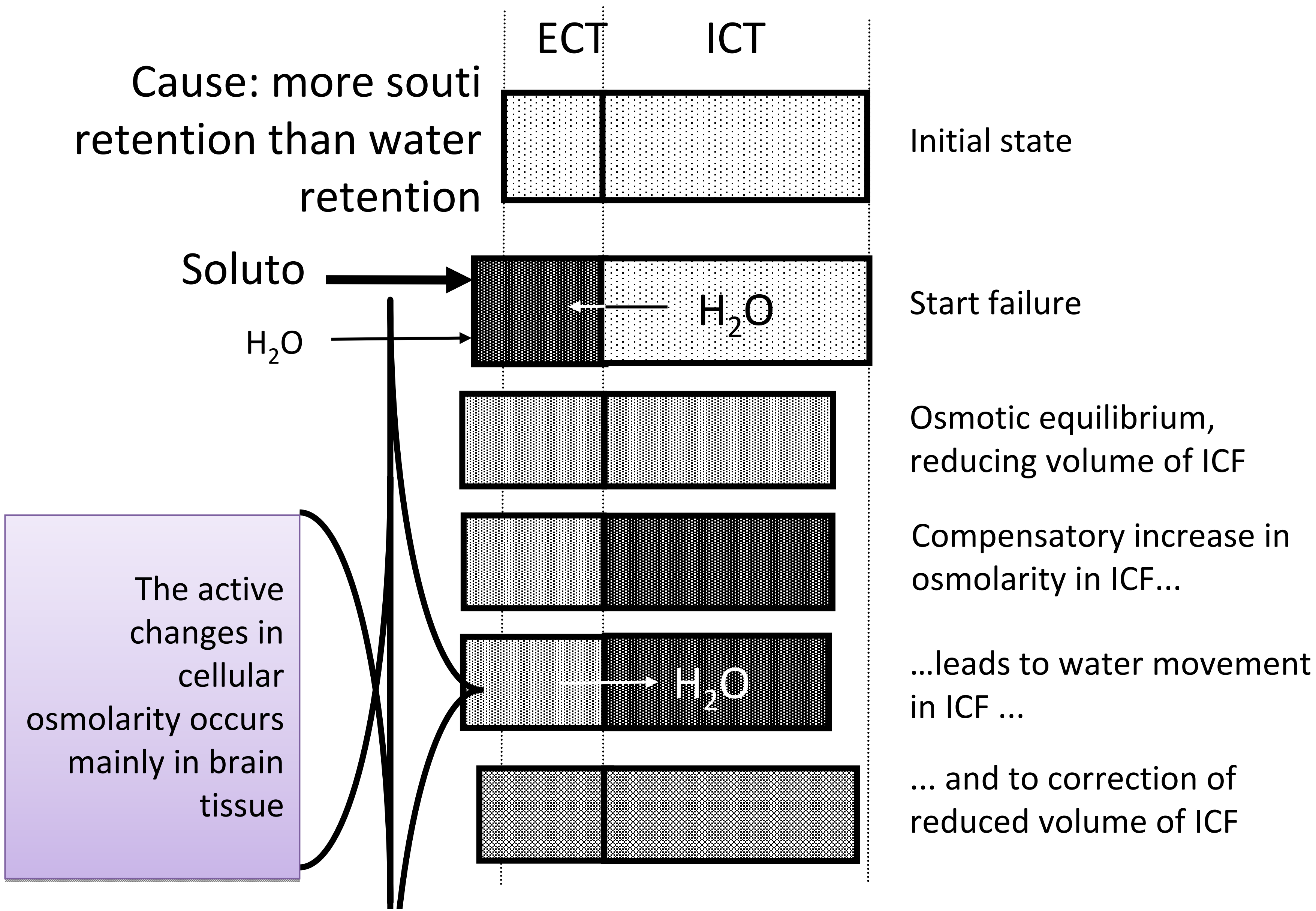
Hypotonic dehydratation



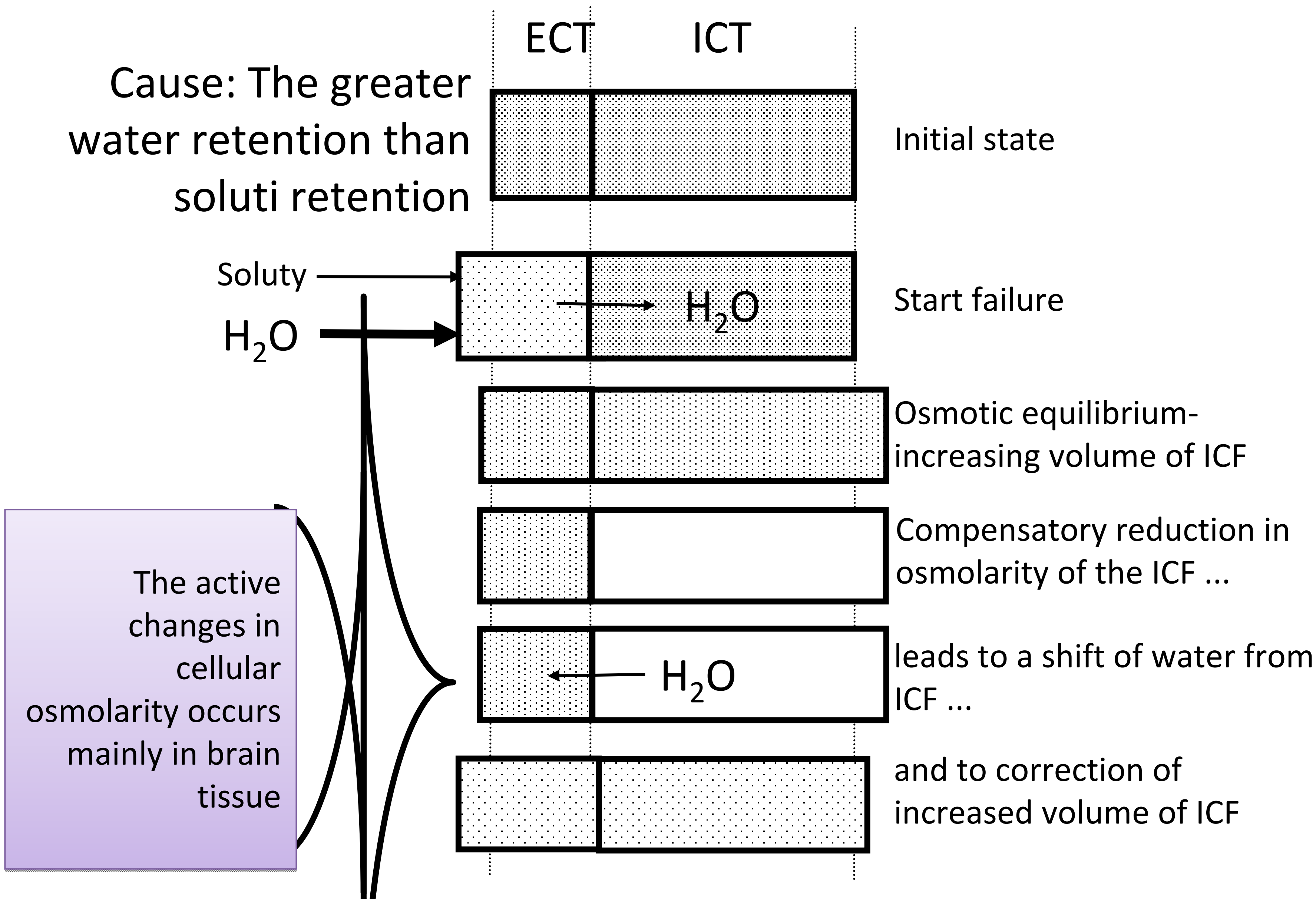
Hypertonic dehydratation

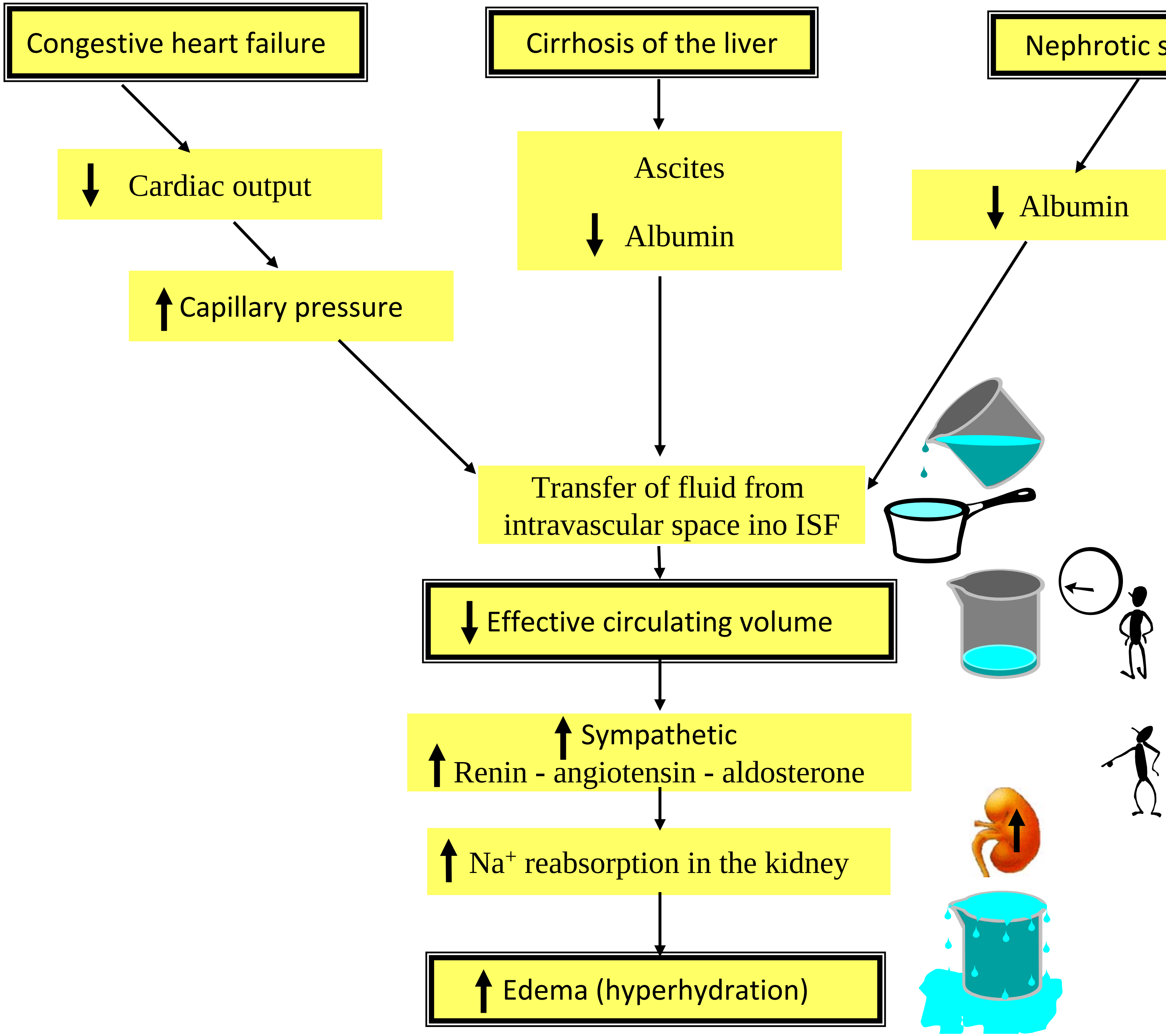


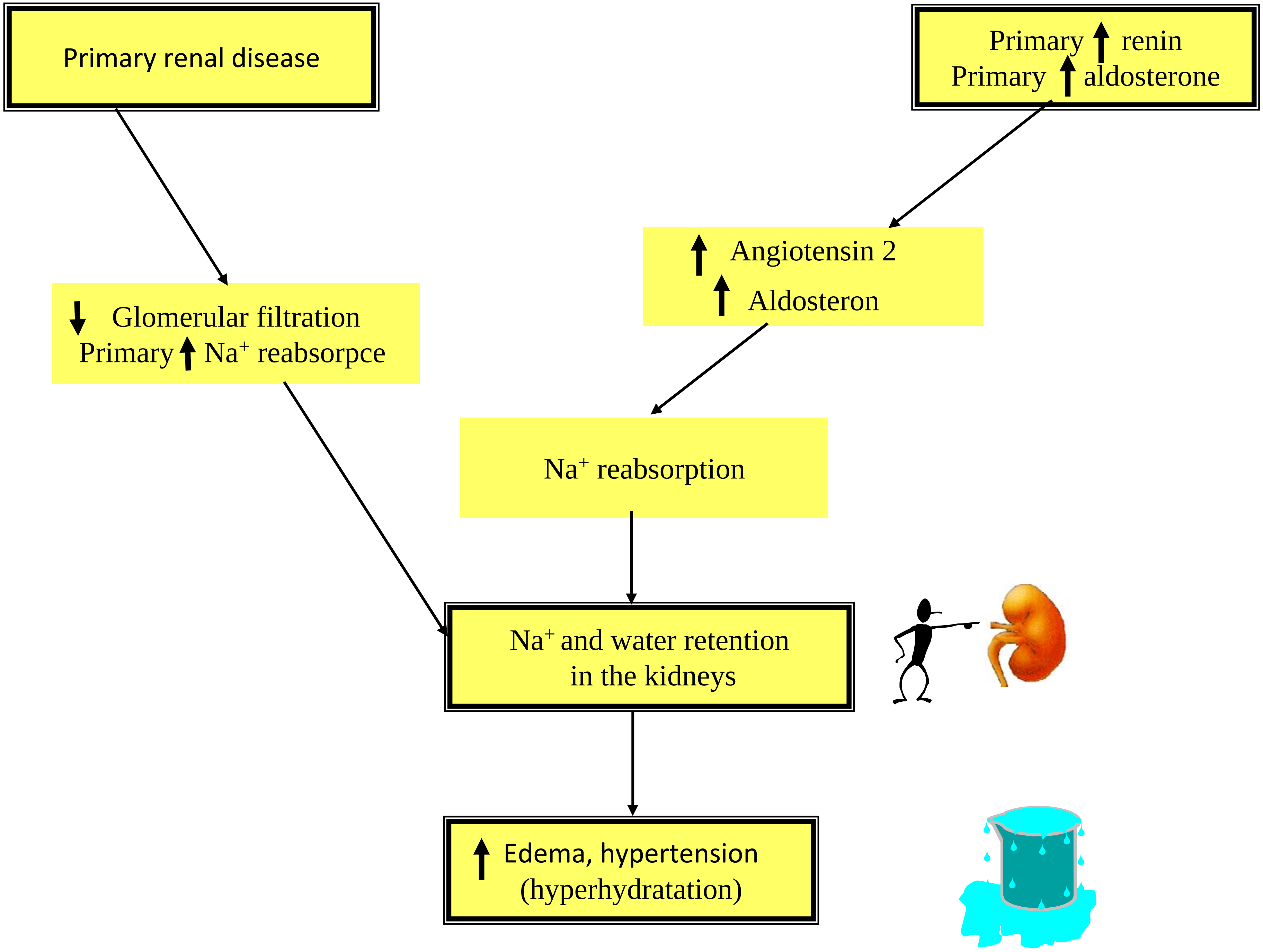
Hypertonic hyperhydratation



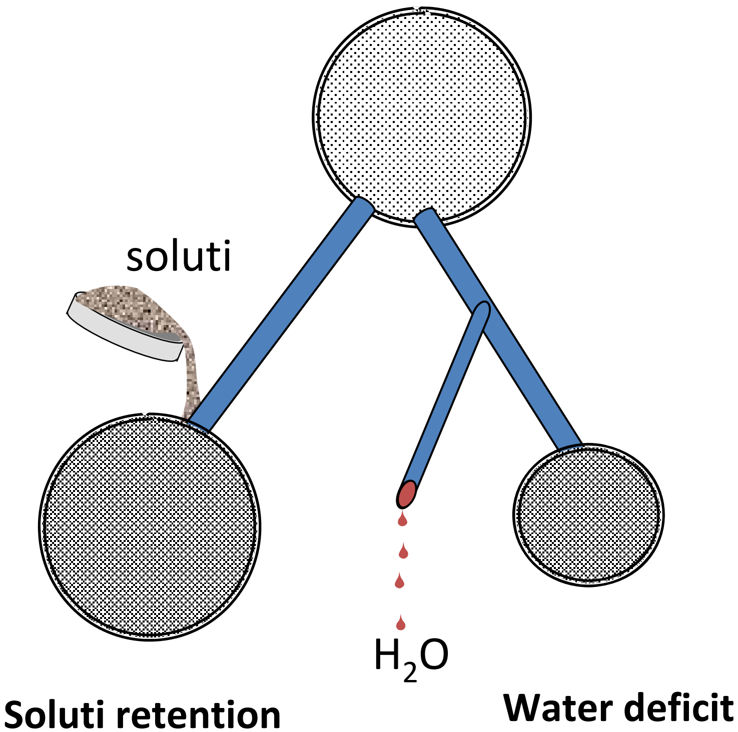
Hypotonic hyperhydratation




Congestive heart failure
Cirrhosis of the liver
Nephrotic syndrome
↓ Cardiac output
Ascites
↓ Albumin
↓ Albumin
↑ Capillary pressure
Transfer of fluid from intravascular space ino ISF
↓ Effective circulating volume
↑ Sympathetic
↑ Renin - angiotensin - aldosterone
↑ Na^+ reabsorption in the kidney
↑ Edema (hyperhydration)

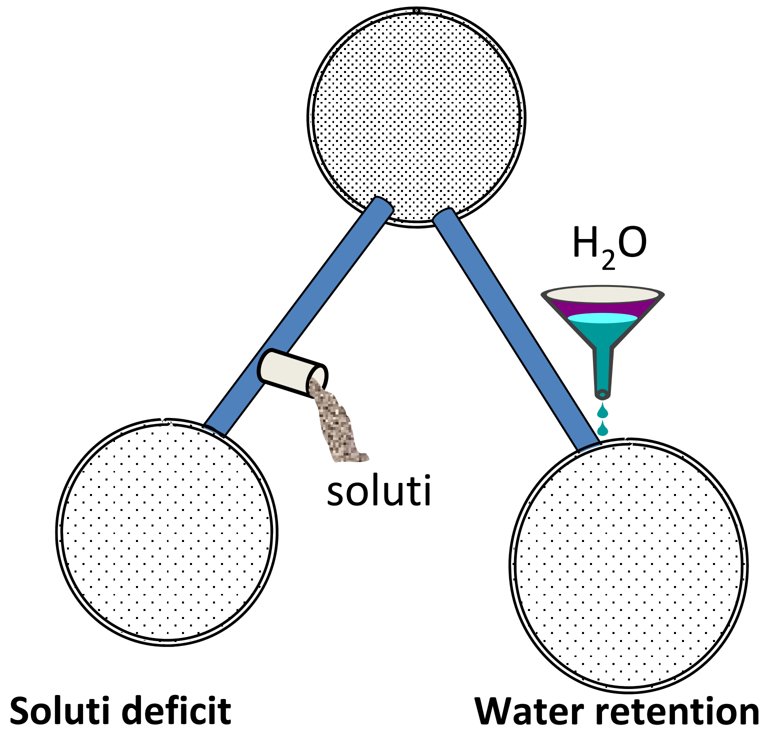

Primary renal disease
Primary ↑ renin
Primary ↑ aldosterone
↑ Angiotensin 2
↑ Aldosteron
↓ Glomerular filtration
Primary ↑ Na^+ reabsorpce
Na^+ reabsorption
Na^+ and water retention in the kidneys
↑ Edema, hypertension (hyperhydratation)

Causes of hyperosmolarity

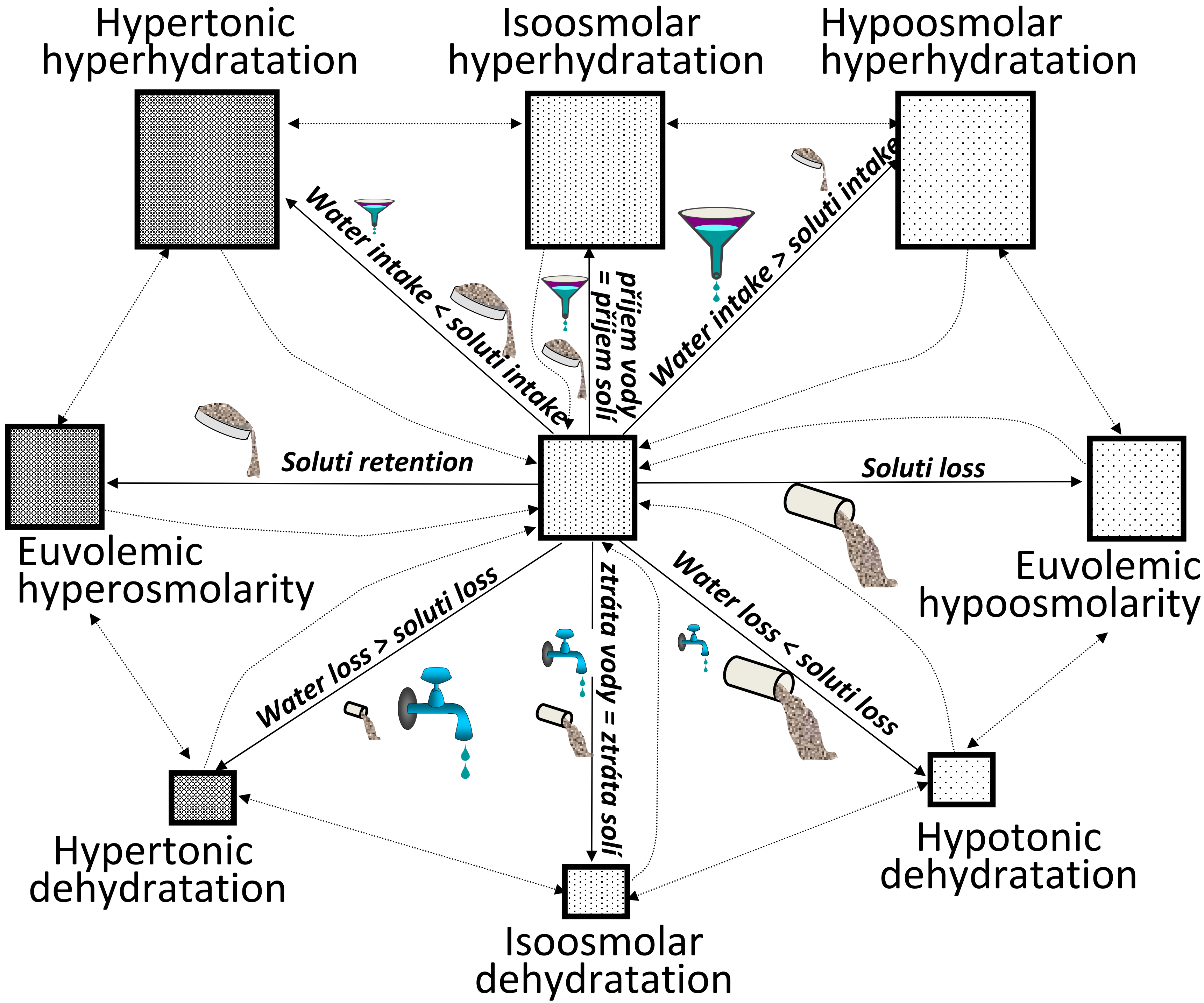


(relative or absolute)

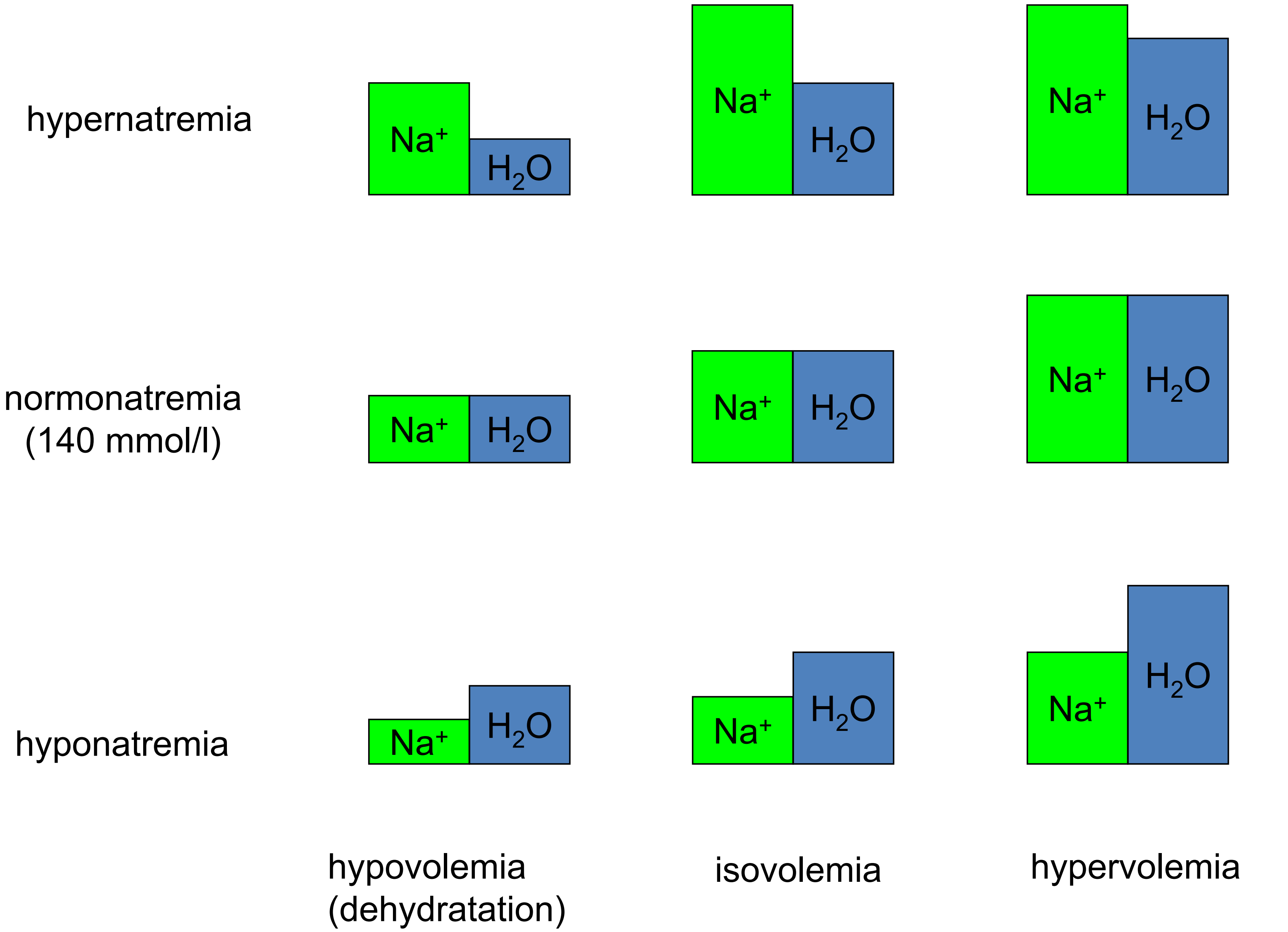
Causes hyposmolarity

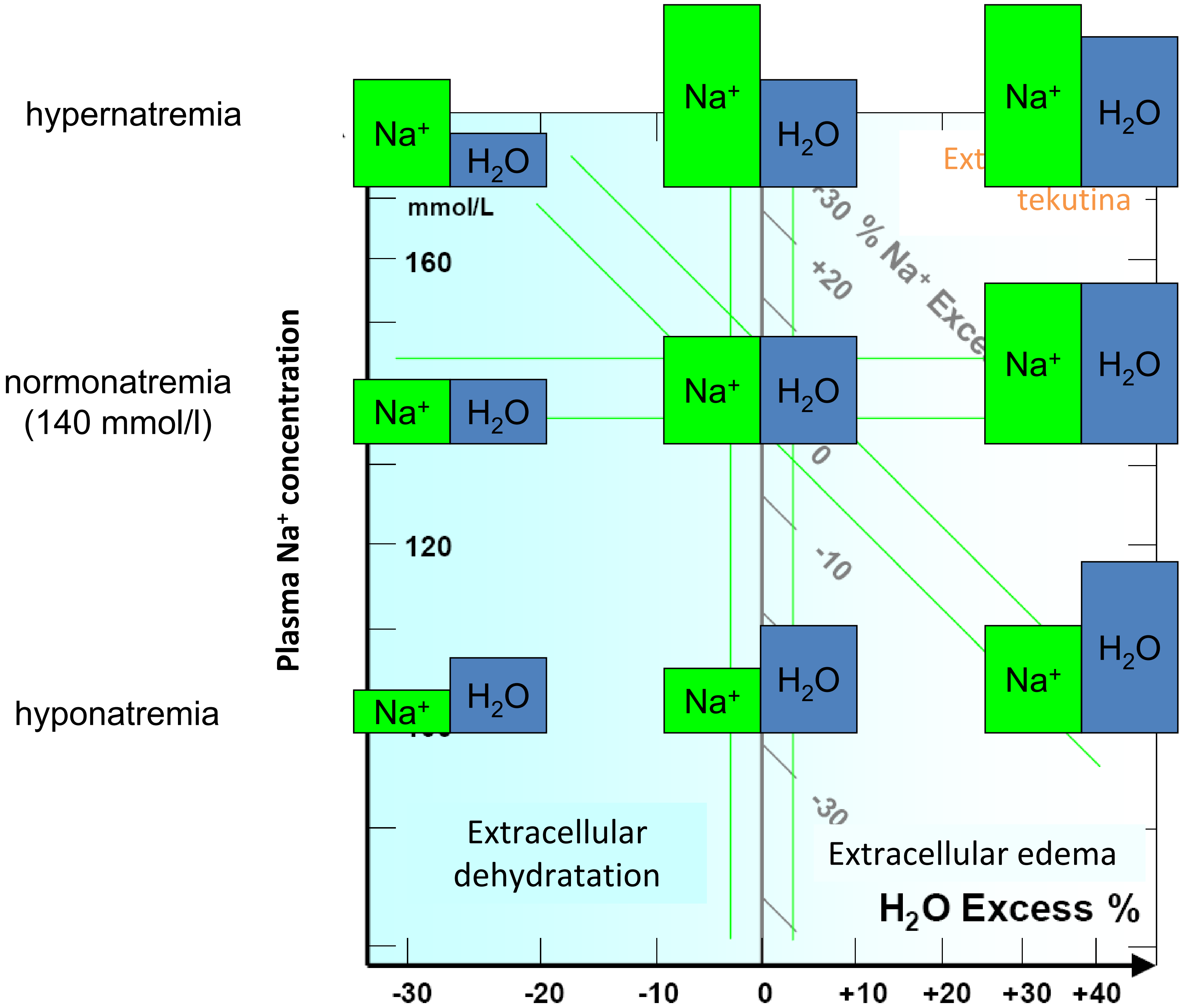


(relative or absolute)



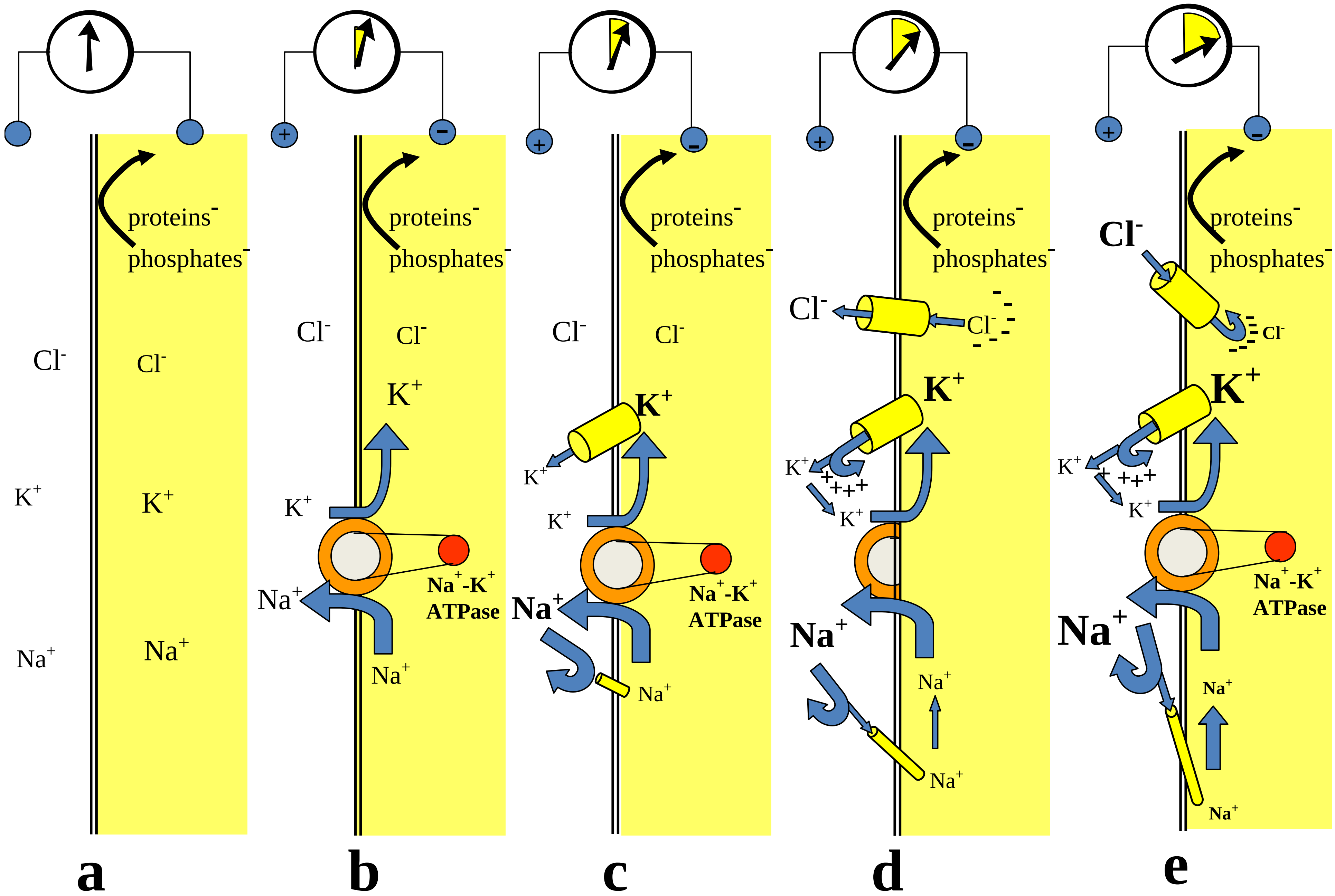
Hypertonic hyperhydratation
Isoosmolar hyperhydratation
Hypoosmolar hyperhydratation
Water intake < soluti intake
příjem vody = příjem solí
Water intake > soluti intake
Soluti retention
Soluti loss
Euvolemic hyperosmolarity
Euvolemic hypoosmolarity
Water loss > soluti loss
ztráta vody = ztráta solí
Water loss < soluti loss
Hypertonic dehydratation
Isoosmolar dehydratation
Hypotonic dehydratation


hypernatremia
Na+
H2O
Na+
H2O
Na+
H2O
normonatremia
(140 mmol/l)
Na+
H2O
Na+
H2O
Na+
H2O
hyponatremia
Na+
H2O
Na+
H2O
Na+
H2O
hypovolemia
(dehydratation)
isovolemia
hypervolemia



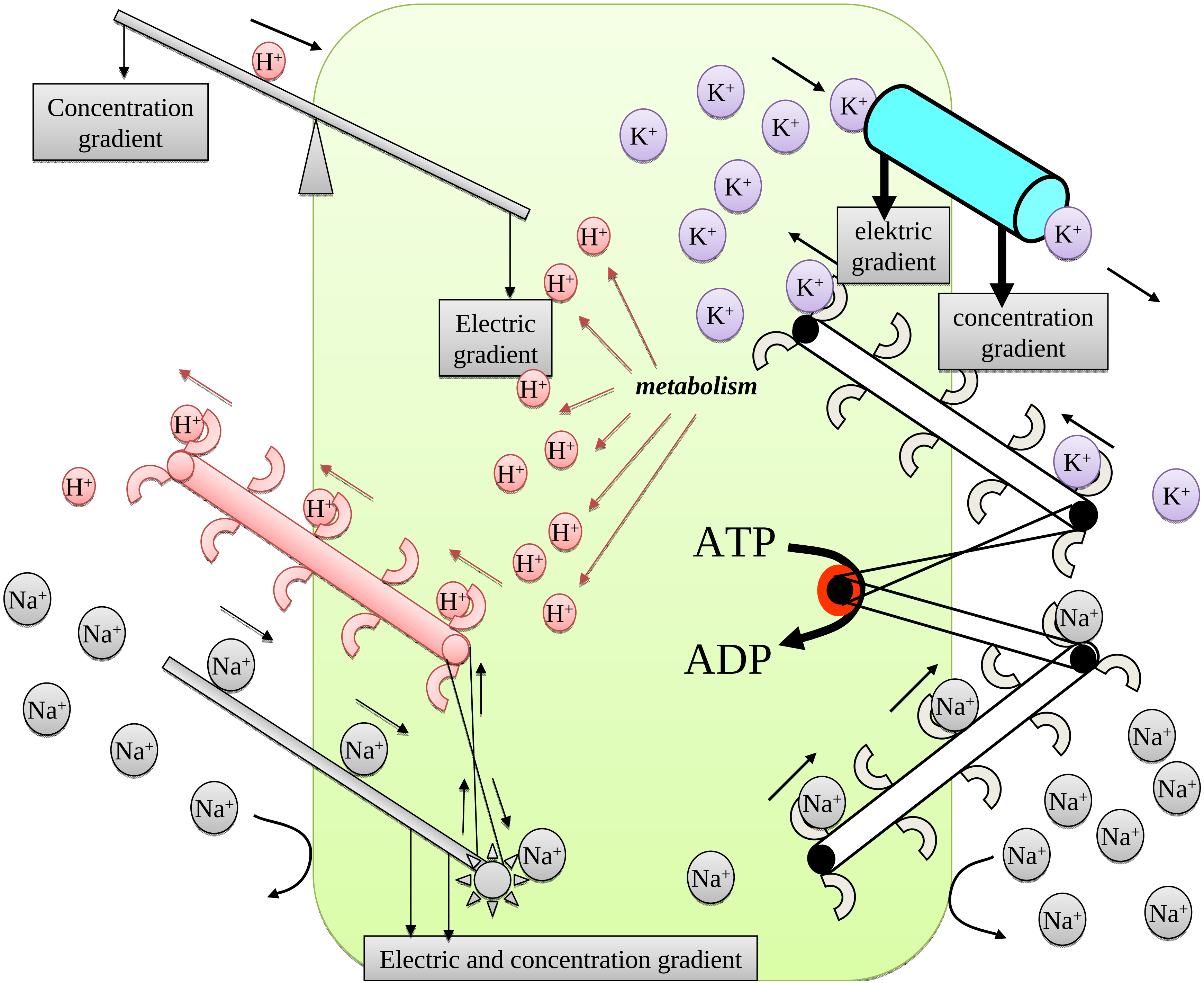
hypernatremia
normonatremia
(140 mmol/l)
hyponatremia
Plasma Na+ concentration
mmol/L
160
120
Na+
H2O
Ext
tekutina
+30 % Na+ Exce
+20
0
-10
-30
Extracellular dehydratation
Extracellular edema
H2O Excess %
-30
-20
-10
0
+10
+20
+30
+40

K^+ - main itracellular cationt

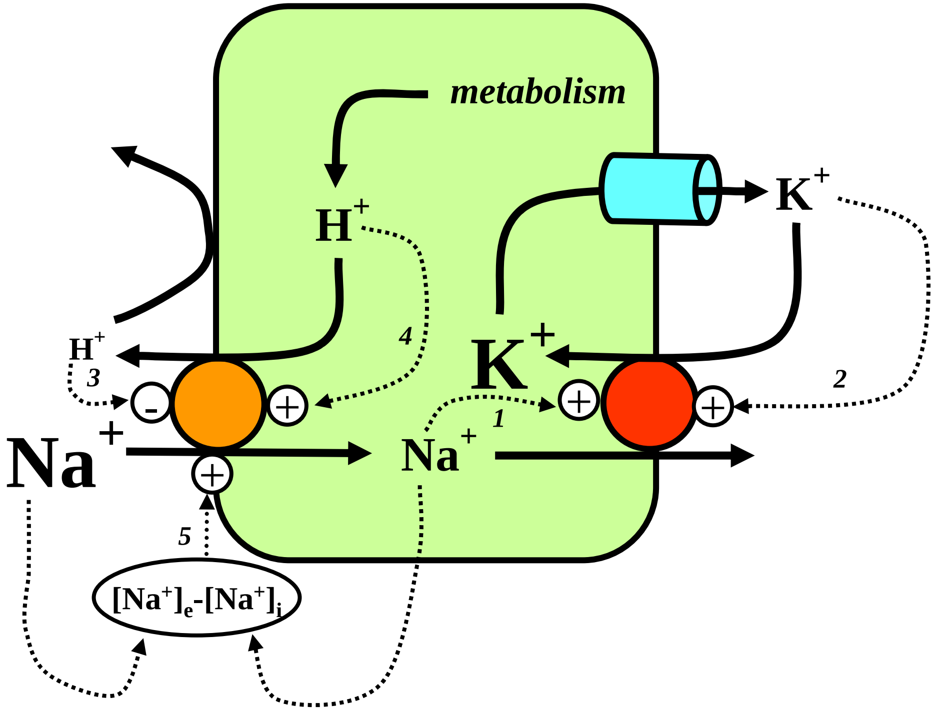


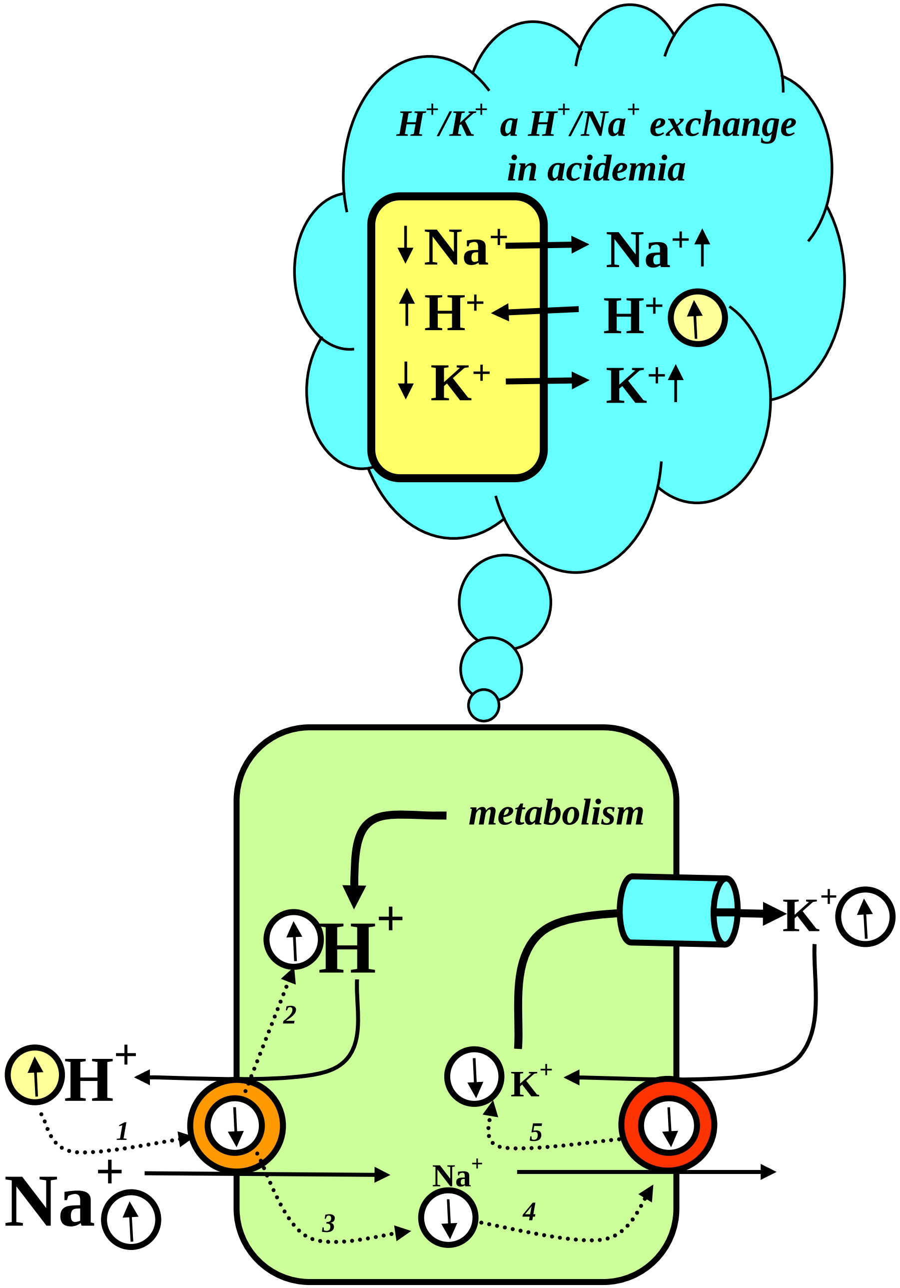
proteins-
phosphates-
Cl-
K+
Na+
Na+-K+
ATPase
a
b
c
d
e

Potassium and Acid-Base

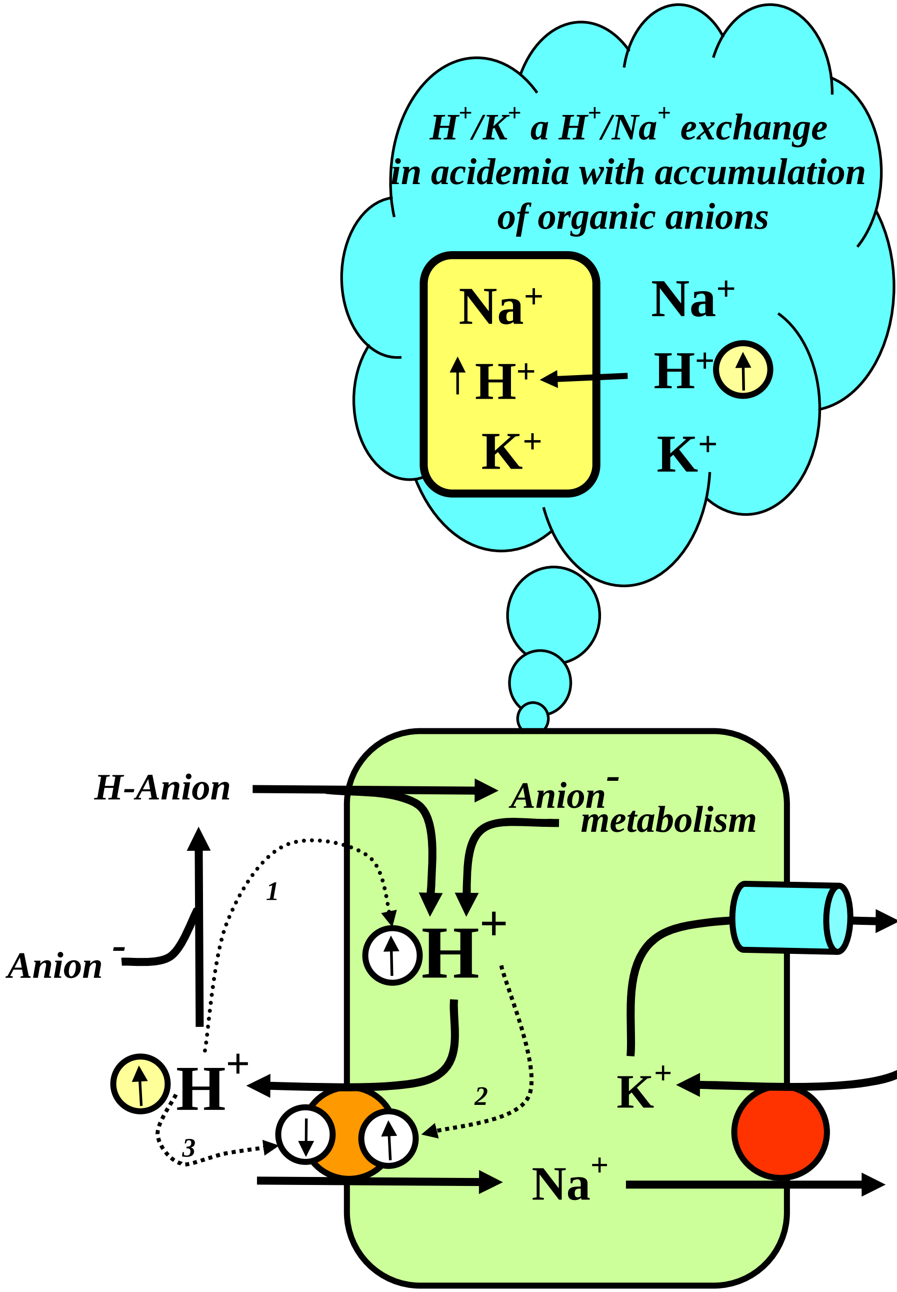


Concentration gradient
H+
Electric gradient
metabolism
K+
elektric gradient
concentration gradient
ATP
ADP
Na+
Electric and concentration gradient

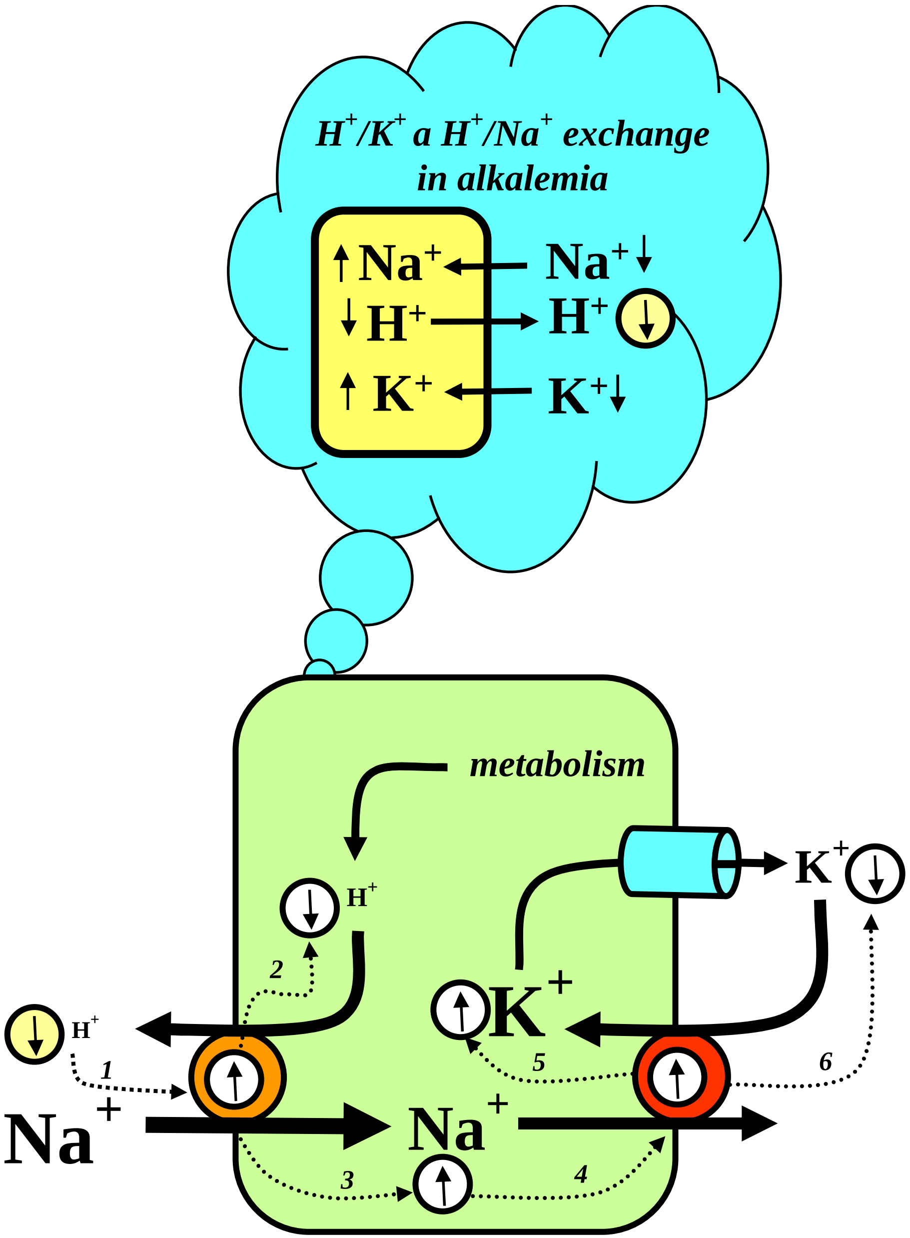

metabolism
H+
K+
H+
4
K+
3
2
1
Na+
Na+
5
[Na+]e-[Na+]i



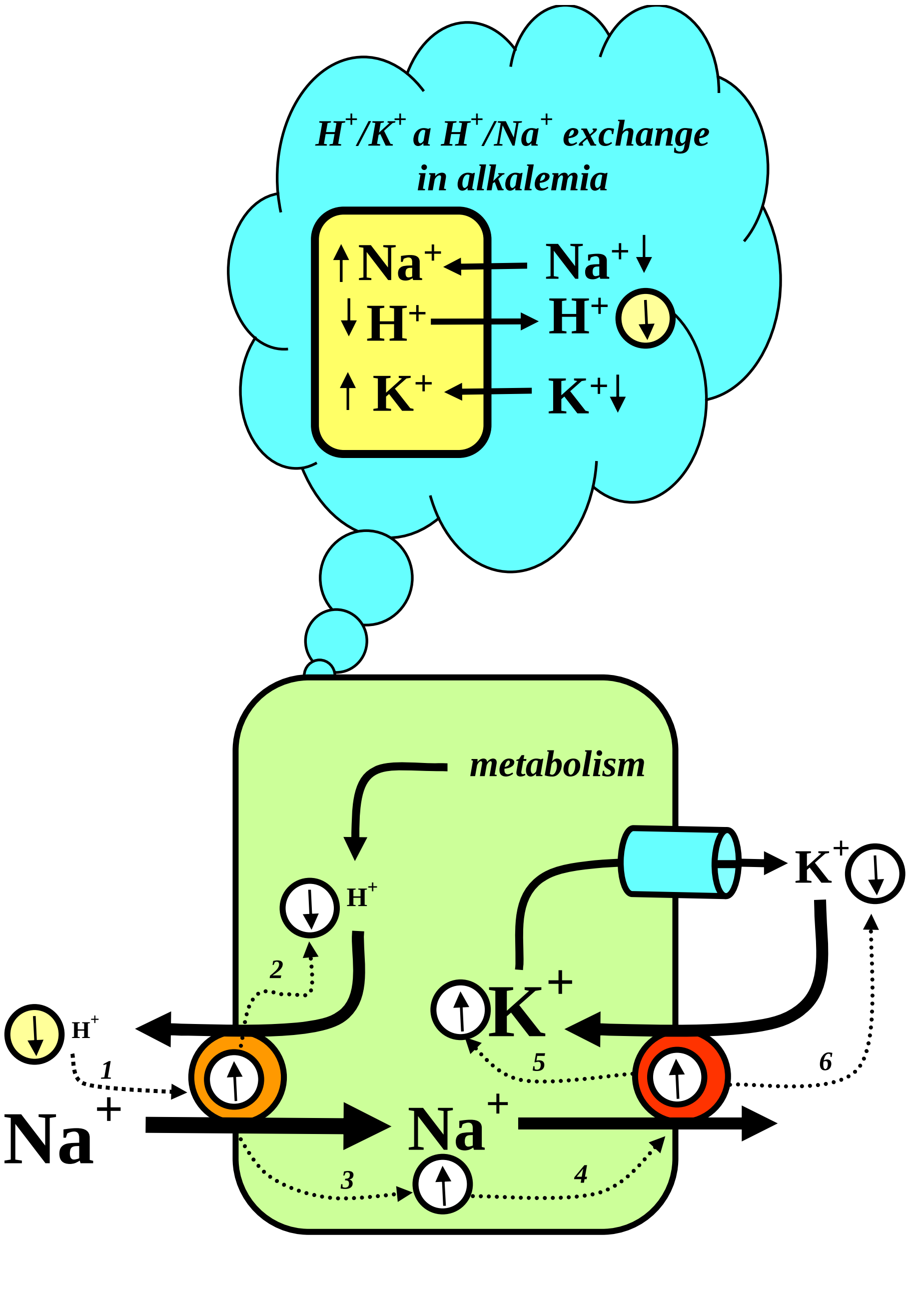
a) acidemia, no accumulation of organic anions



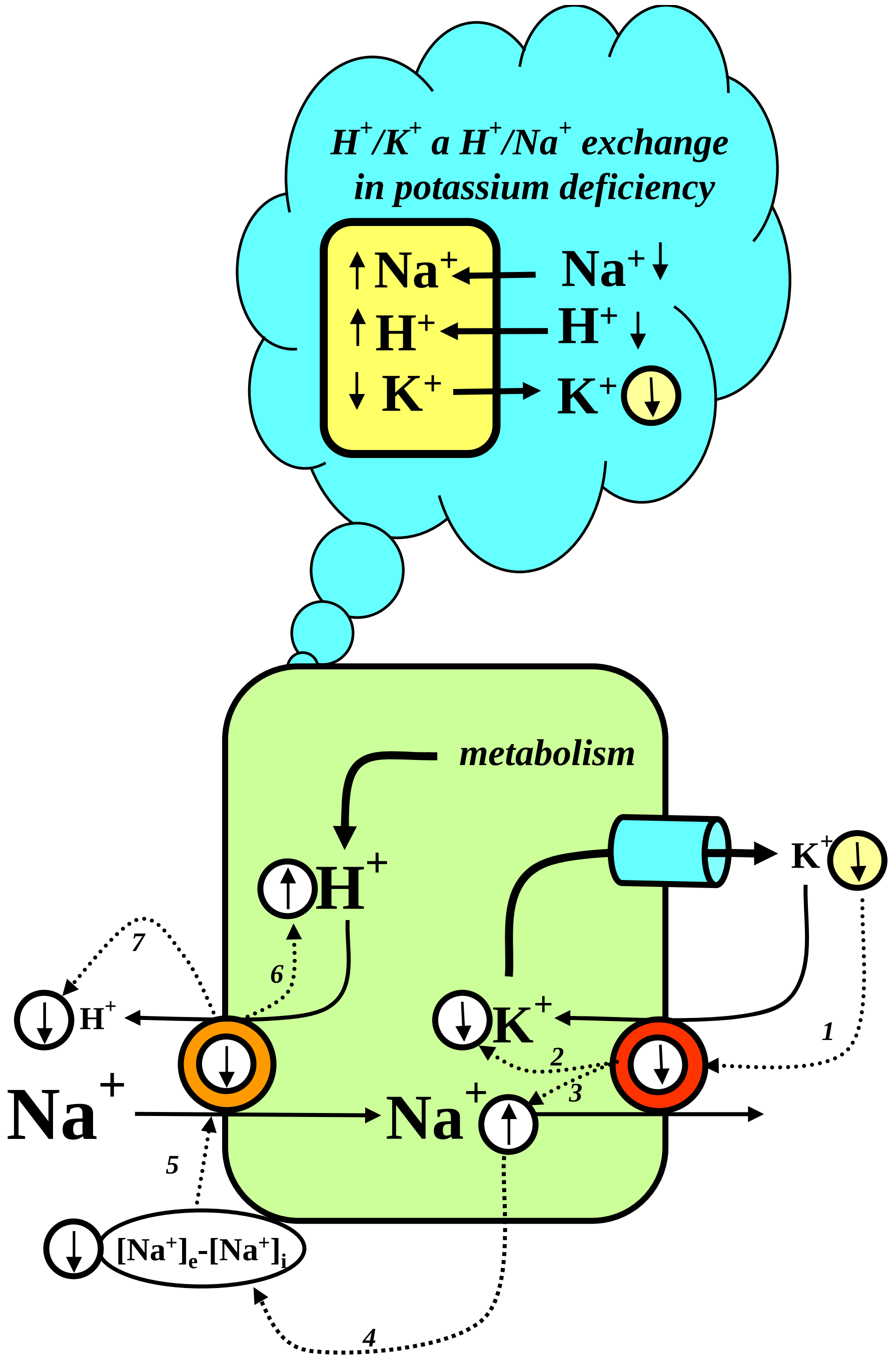
a) acidemia with the accumulation of organic anions



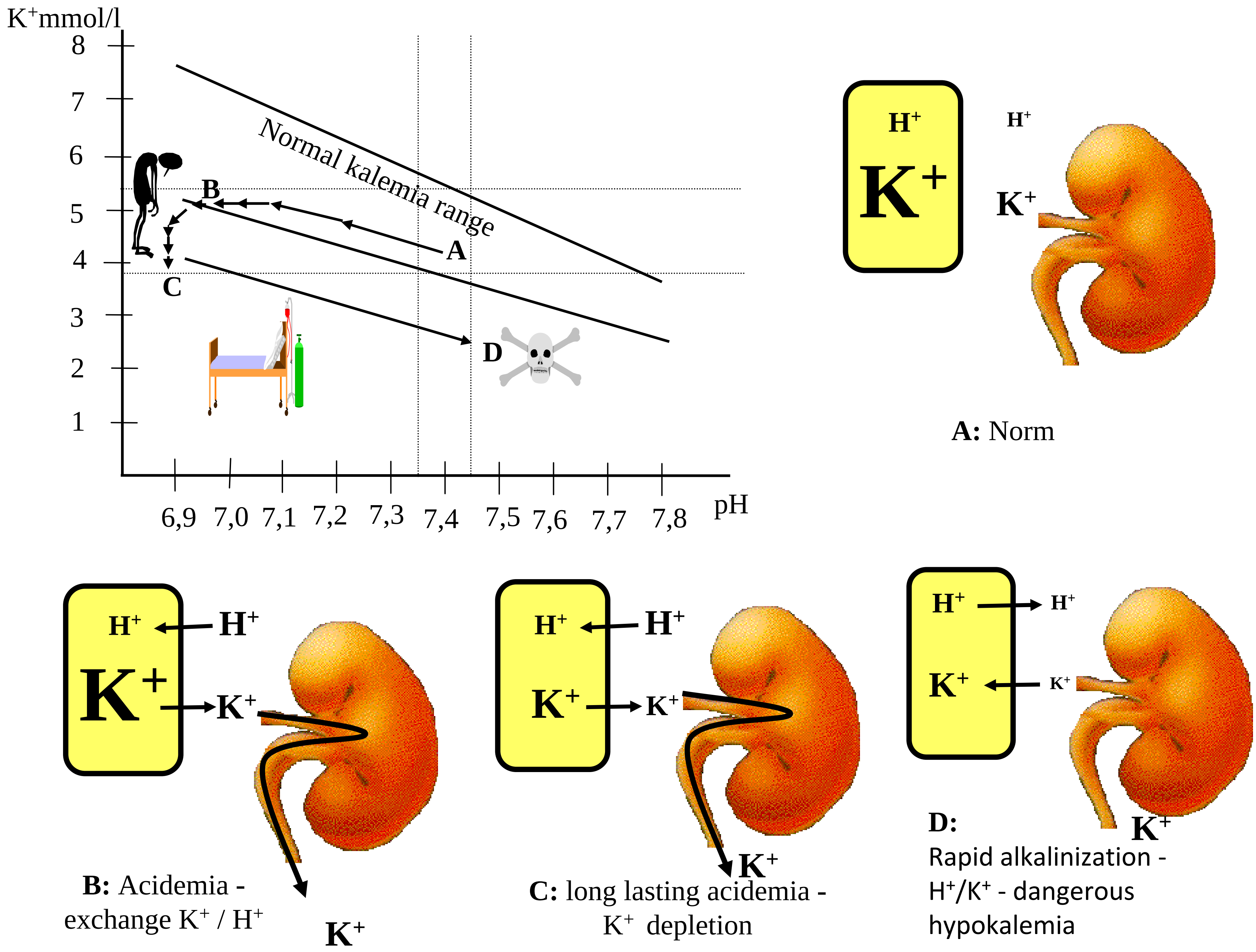
a) Alkalemia without potassium deficiency



a) Alkalemia without potassium deficiency



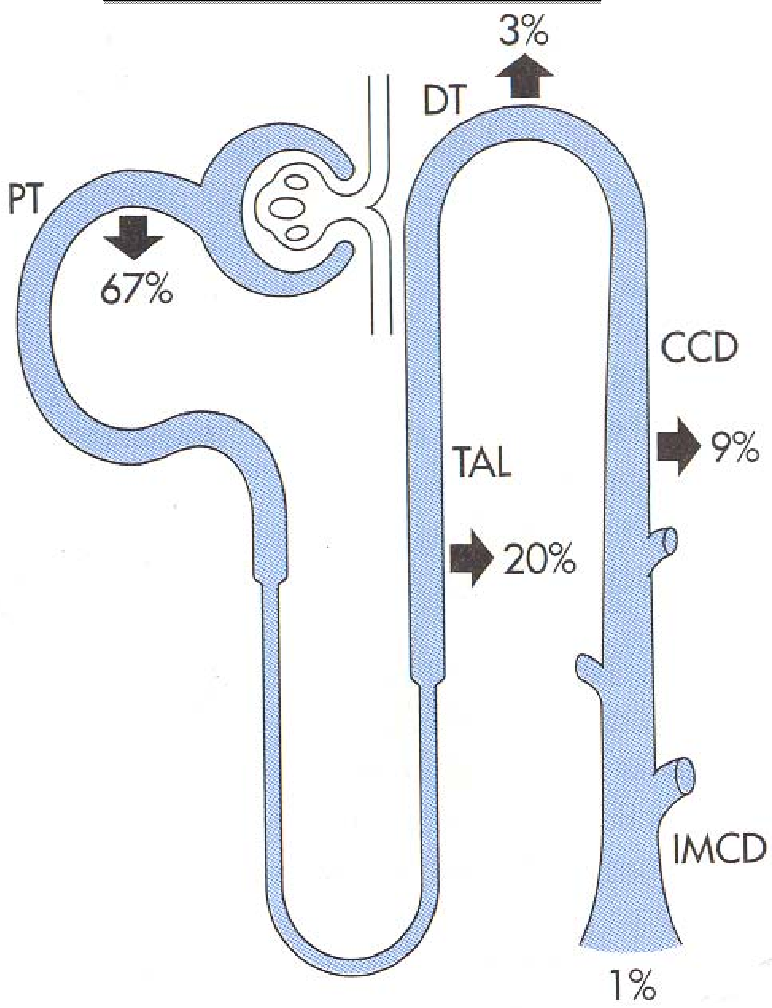
a) Alkalemia with potassium deficiency



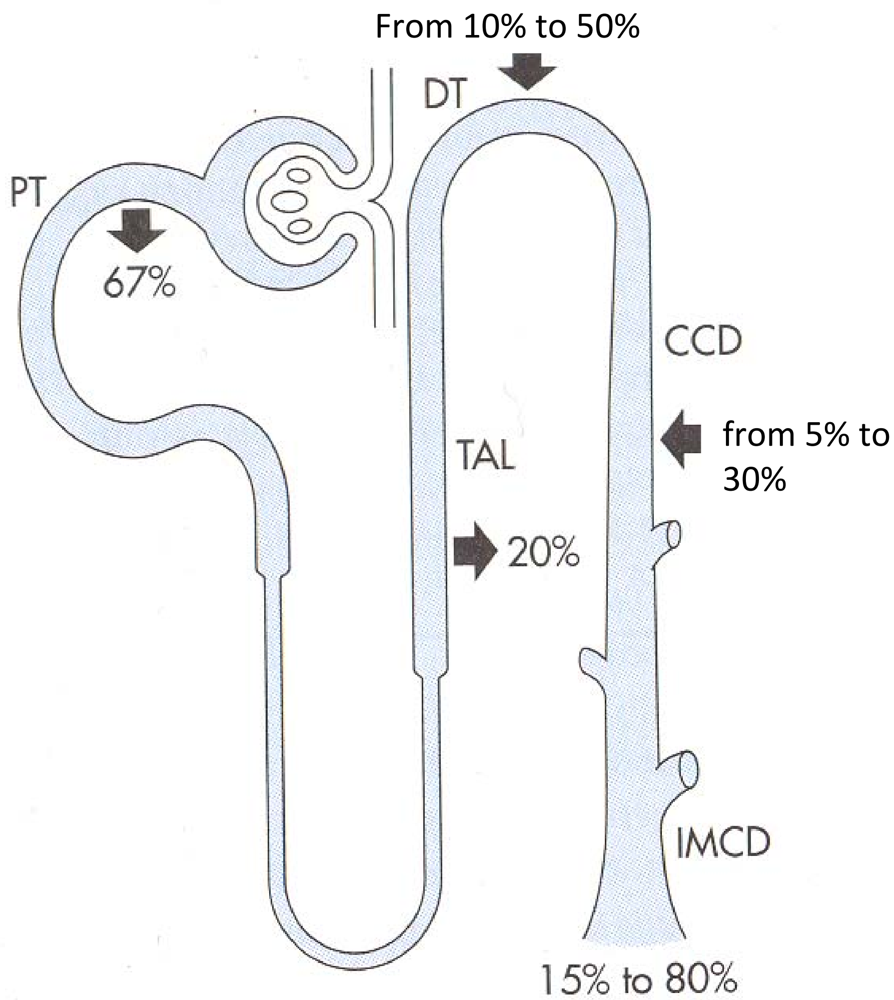
K+mmol/l
8
7
6
5
4
3
2
1
Normal kalemia range
A
B
C
D
6,9
7,0
7,1
7,2
7,3
7,4
7,5
7,6
7,7
7,8
pH
H+
K+
H+
K+
A: Norm
H+
K+
H+
K+
K+
B: Acidemia - exchange K+ / H+
H+
K+
H+
K+
K+
C: long lasting acidemia - K+ depletion
H+
K+
H+
K+
K+
D:
Rapid alkalinization - H+/K+ - dangerous hypokalemia

K^+

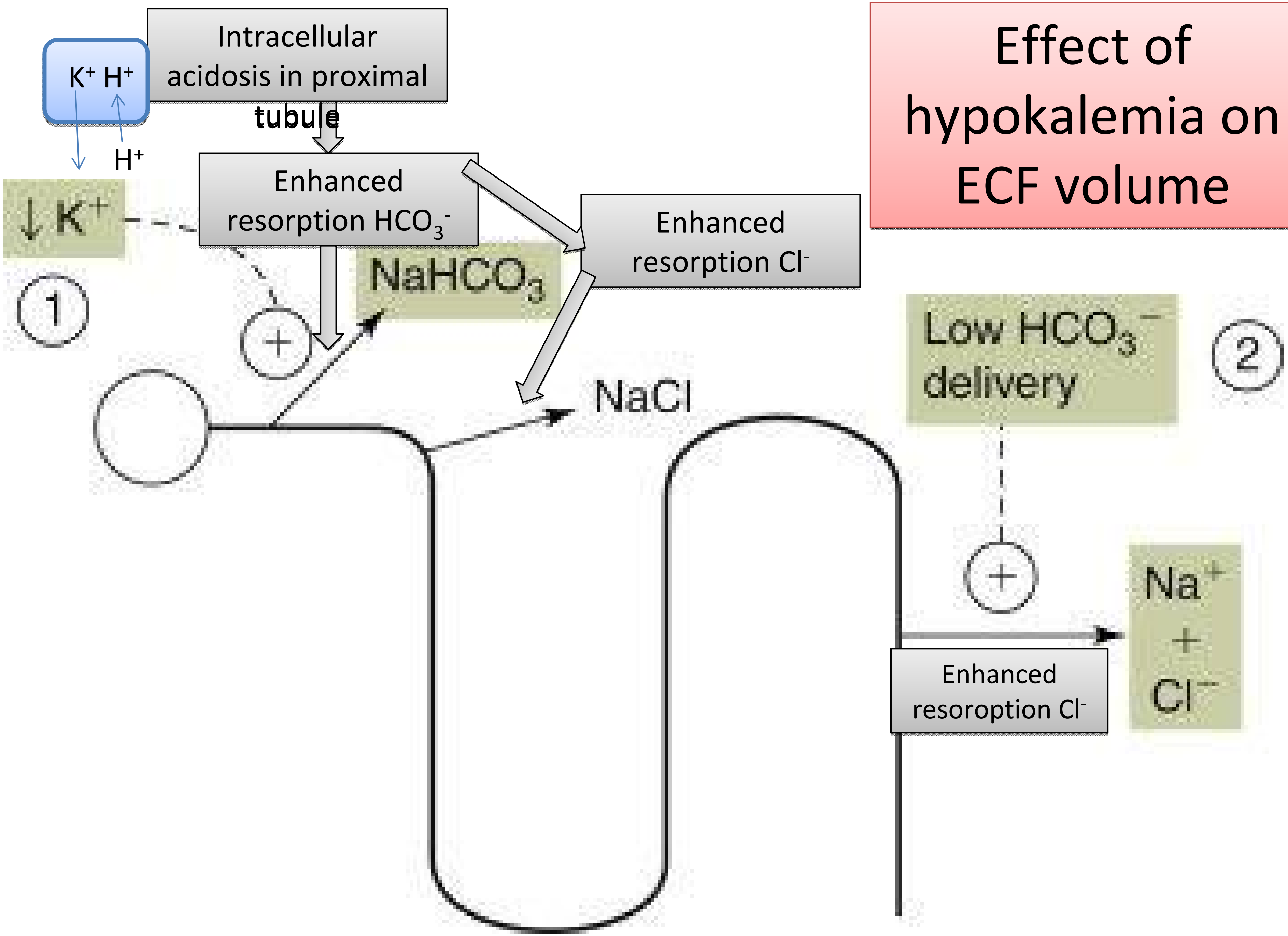
Potassium depletion



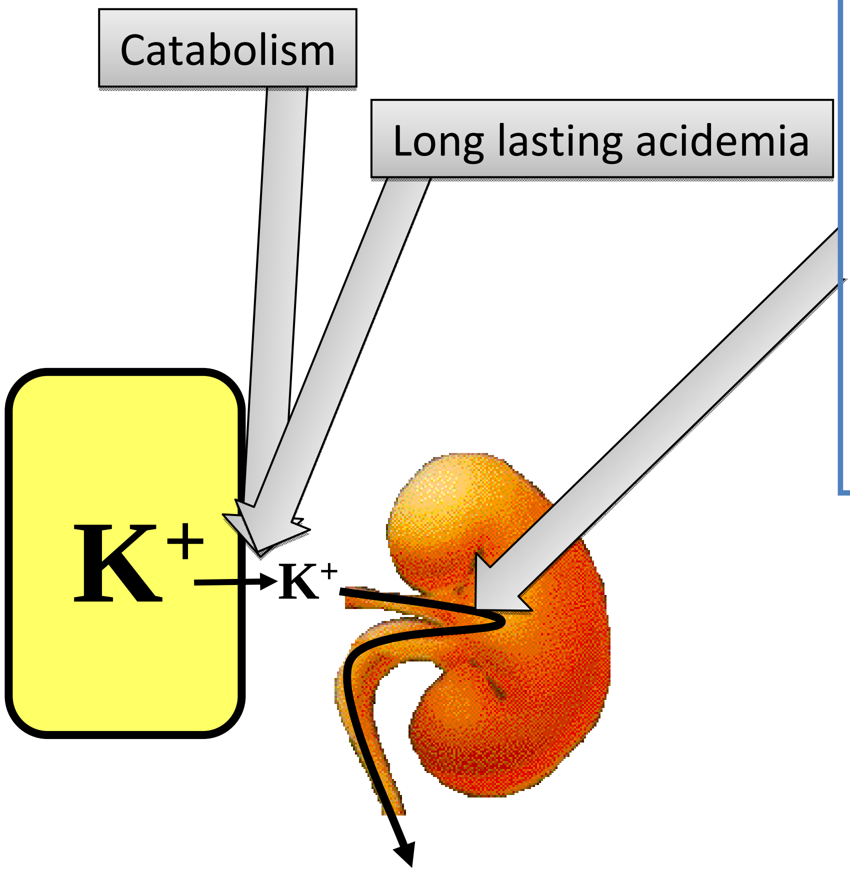
Normal or increased intake of potassium

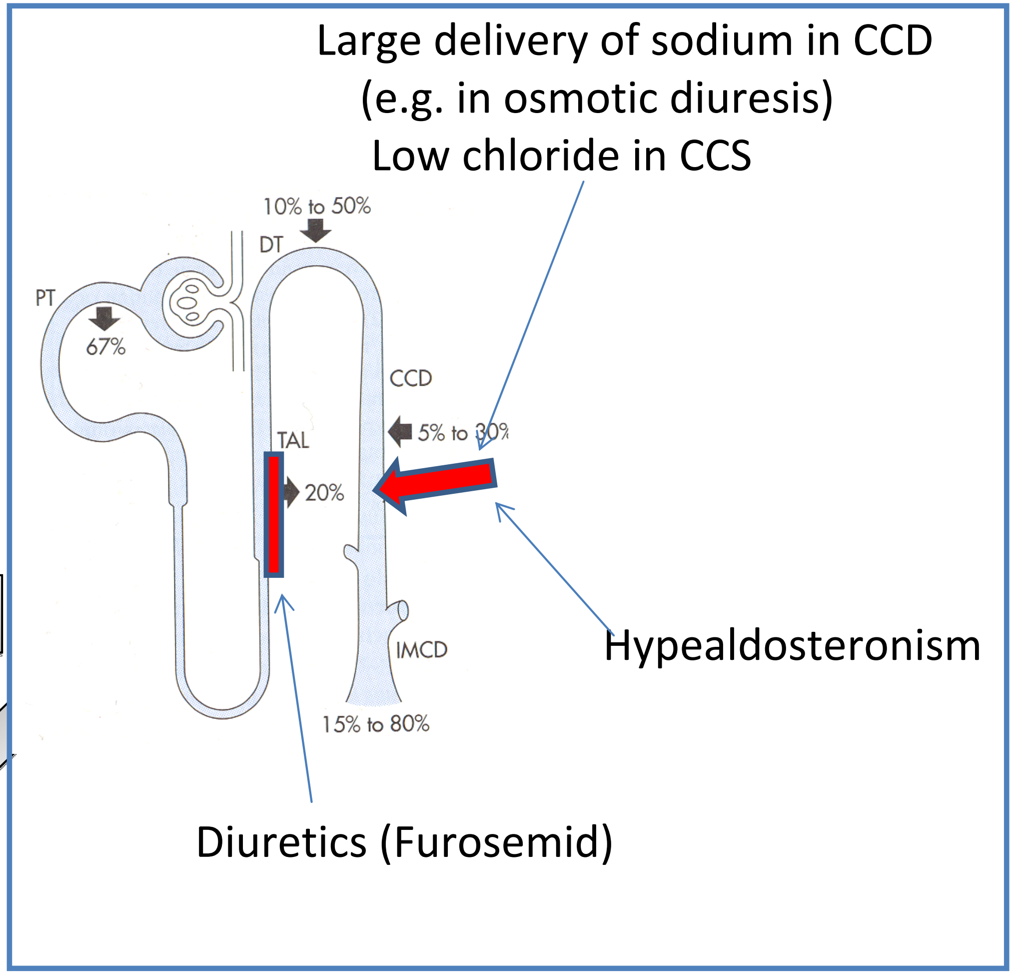


Effect of hypokalemia on ECF volume

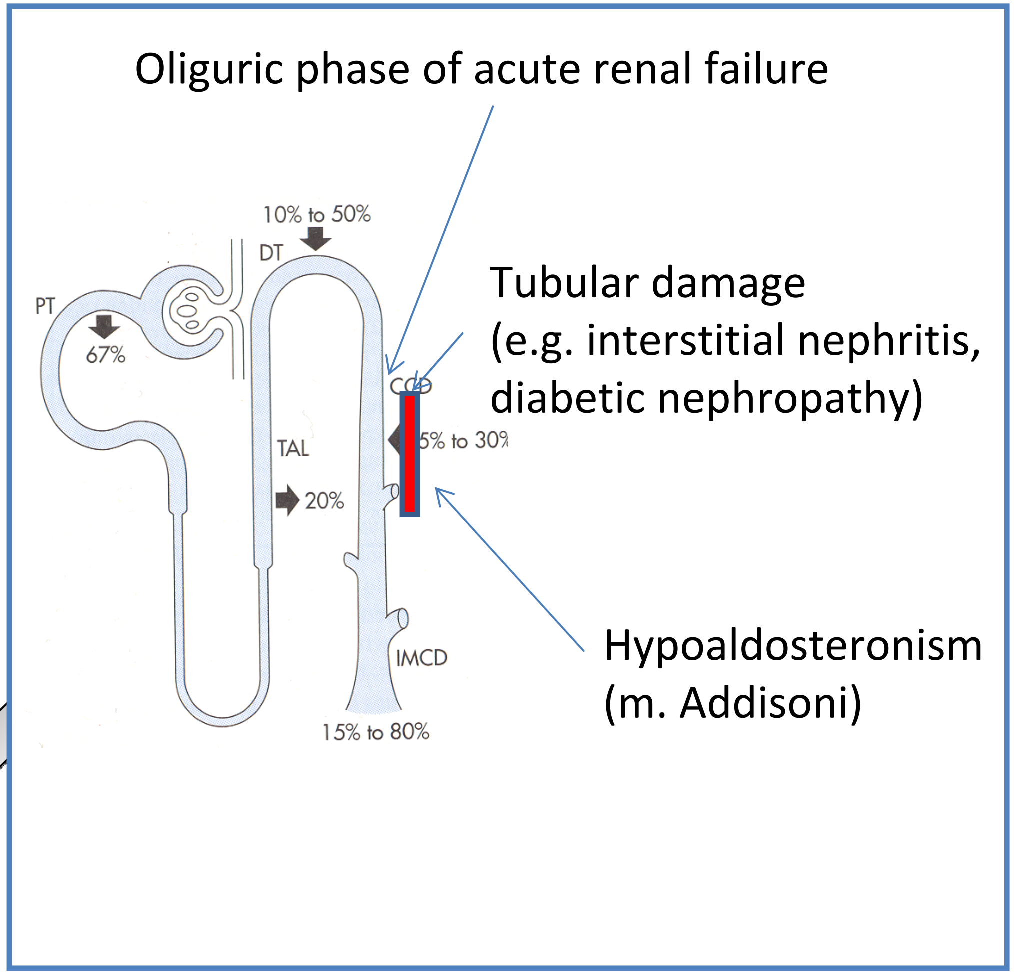


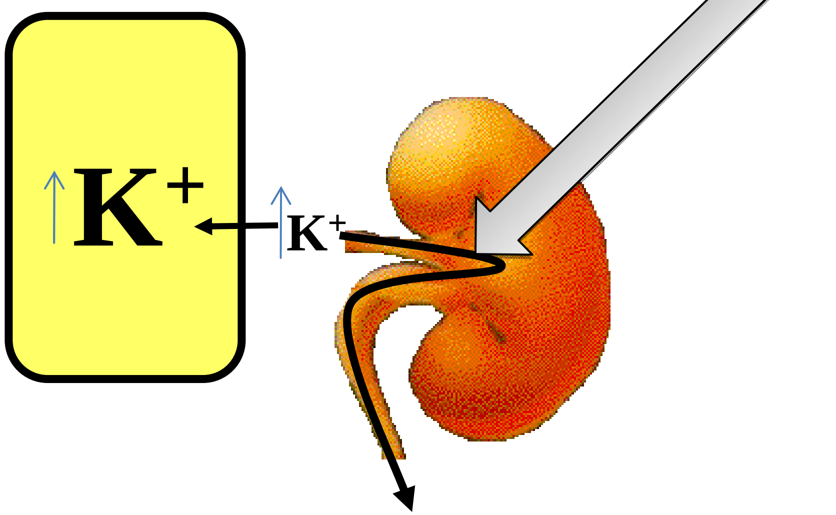
Potassium depletion



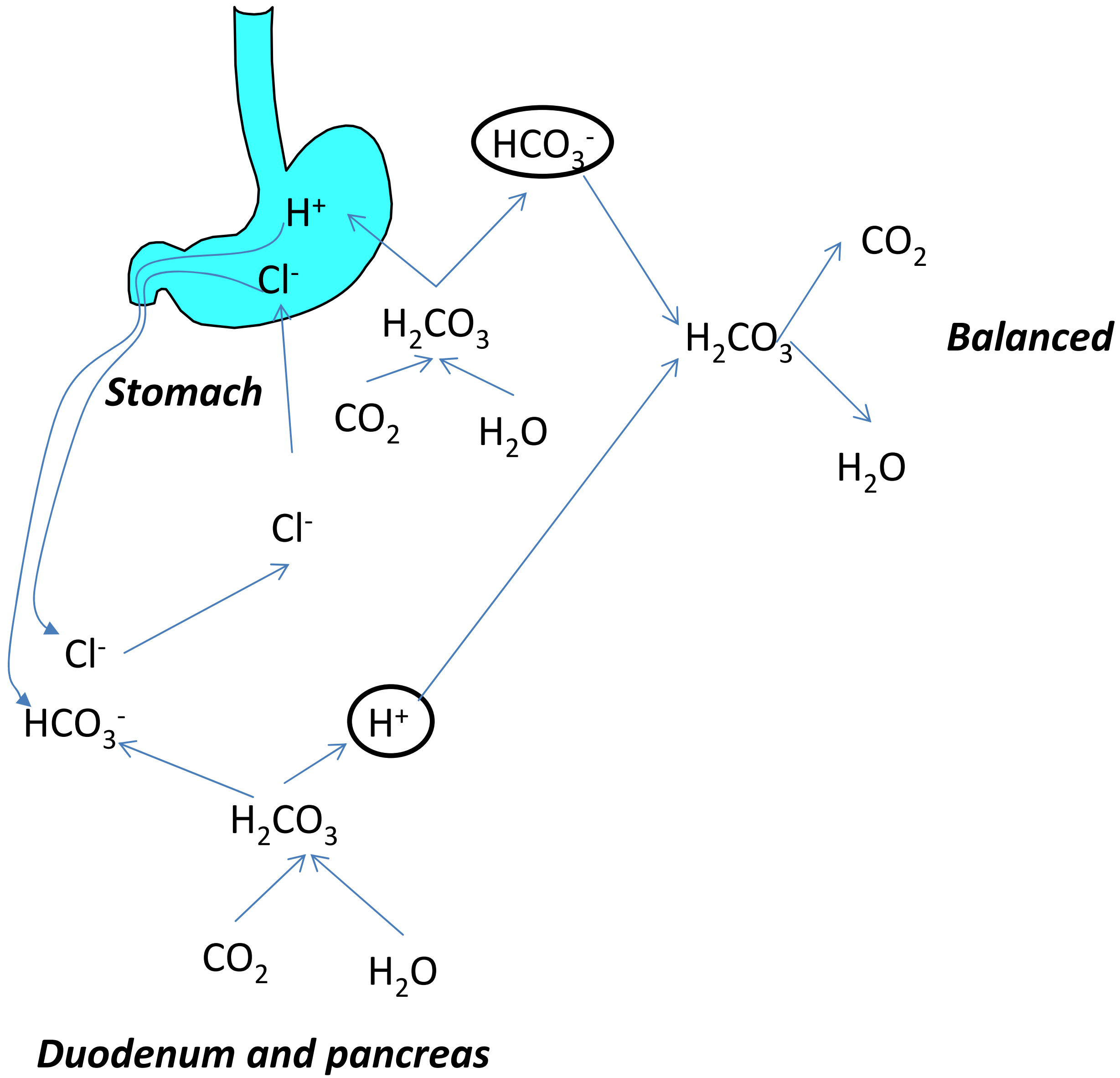


Potassium retention

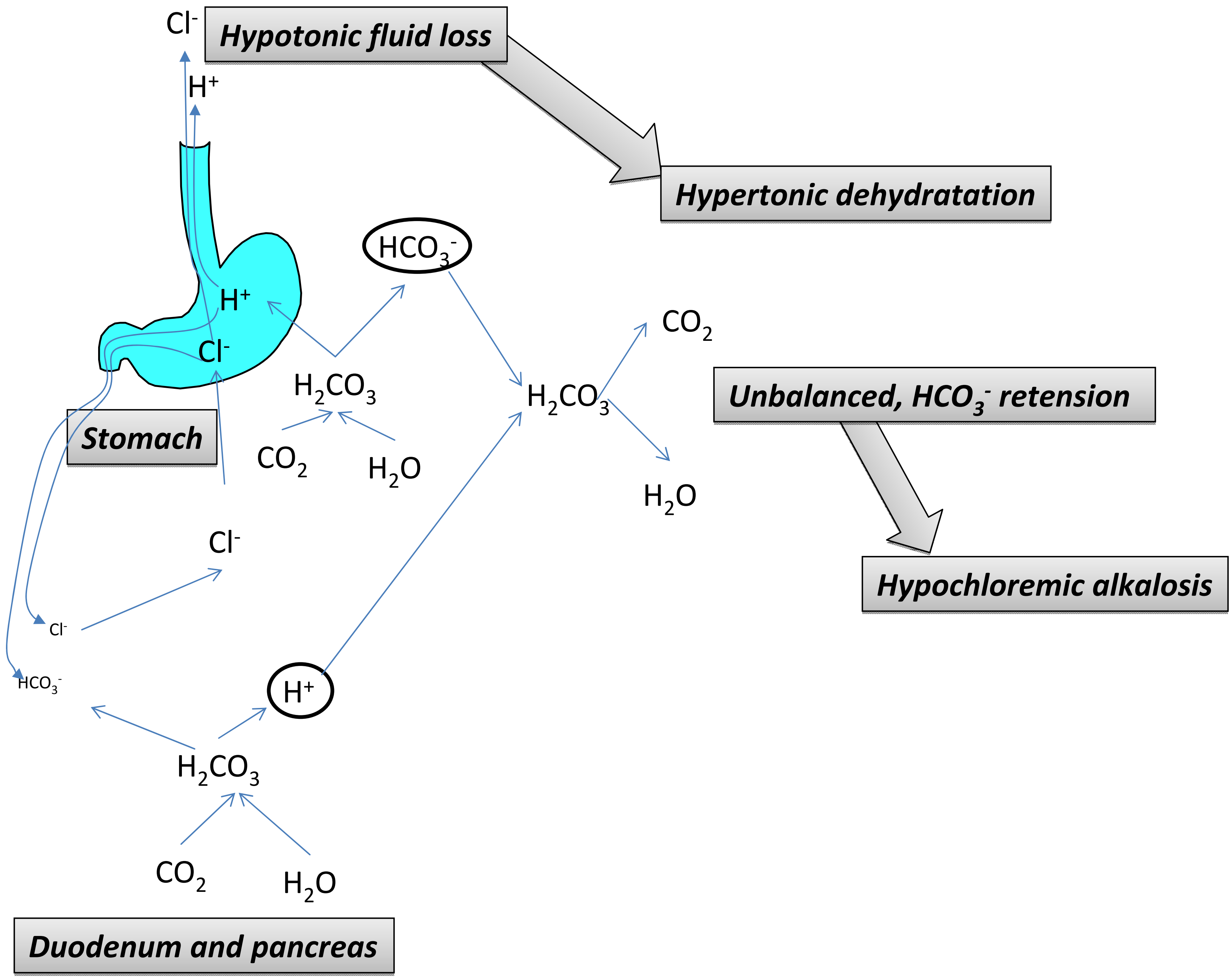




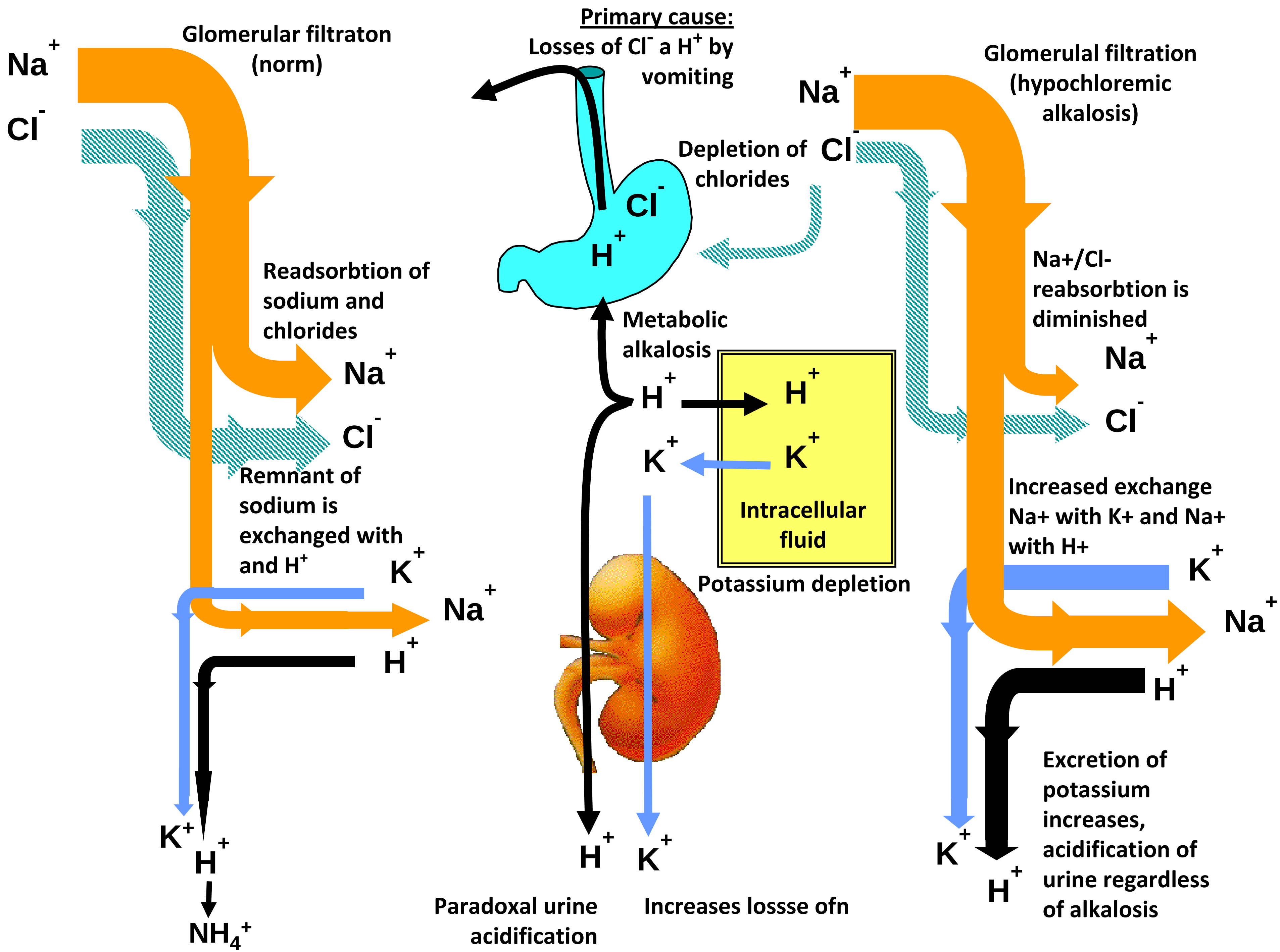
Vomiting



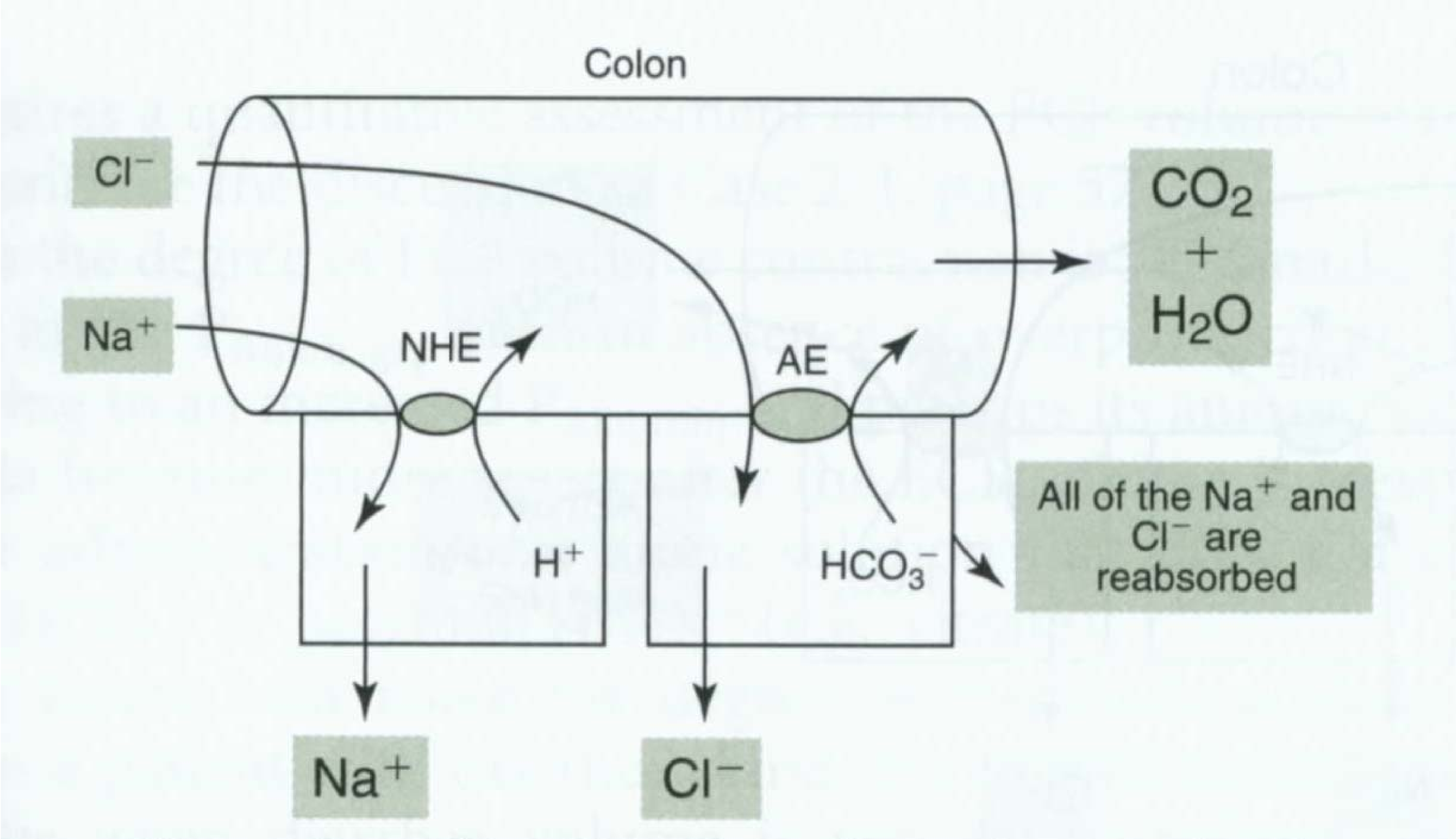
HCO3-
H+
Cl-
H2CO3
CO2
H2O
H2CO3
CO2
H2O
Balanced
Stomach
Cl-
Cl-
HCO3-
H+
H2CO3
CO2
H2O
Duodenum and pancreas



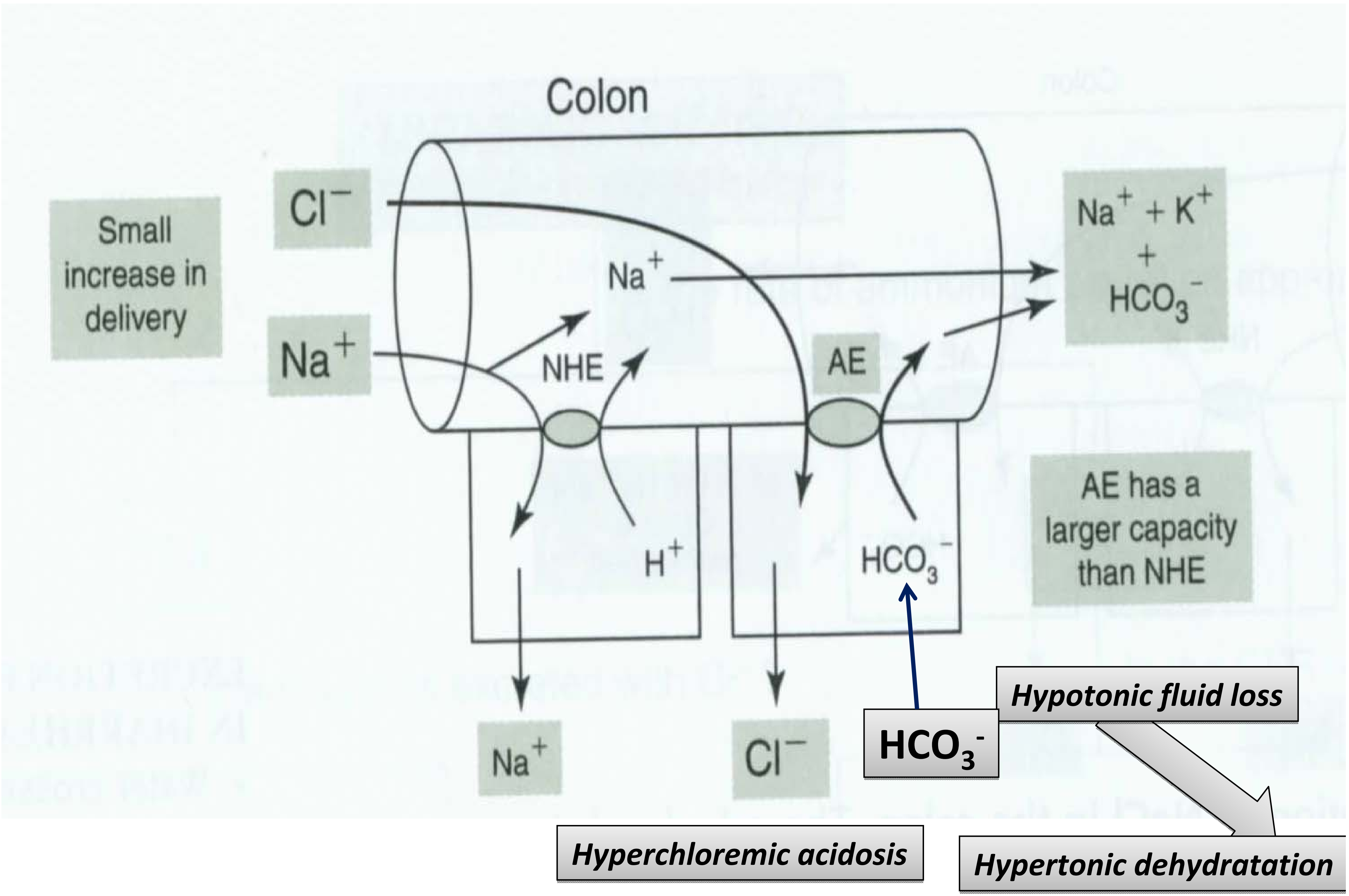
Cl-
Hypotonic fluid loss
H+
Hypertonic dehydratation
HCO3-
H+
Cl-
H2CO3
CO2
H2O
H2CO3
CO2
H2O
Stomach
Unbalanced, HCO3- retension
Hypochloremic alkalosis
Cl-
Cl-
HCO3-
H+
H2CO3
CO2
H2O
Duodenum and pancreas


Primary cause:
Losses of Cl- a H+ by vomiting
Glomerular filtraton (norm)
Na+
Cl-
Readsorbtion of sodium and chlorides
Na+
Cl-
Remnant of sodium is exchanged with and H+
K+
Na+
H+
K+
H+
NH4+
Depletion of chlorides
Cl-
H+
Metabolic alkalosis
H+
H+
K+
K+
Intracellular fluid
Potassium depletion
H+
K+
Paradoxal urine acidification
Increases lossse ofn
Glomerul filtration (hypochloremic alkalosis)
Na+
Cl-
Na+/Cl- reabsorbtion is diminished
Na+
Cl-
Increased exchange Na+ with K+ and Na+ with H+
K+
Na+
H+
K+
H+
Excretion of potassium increases, acidification of urine regardless of alkalosis

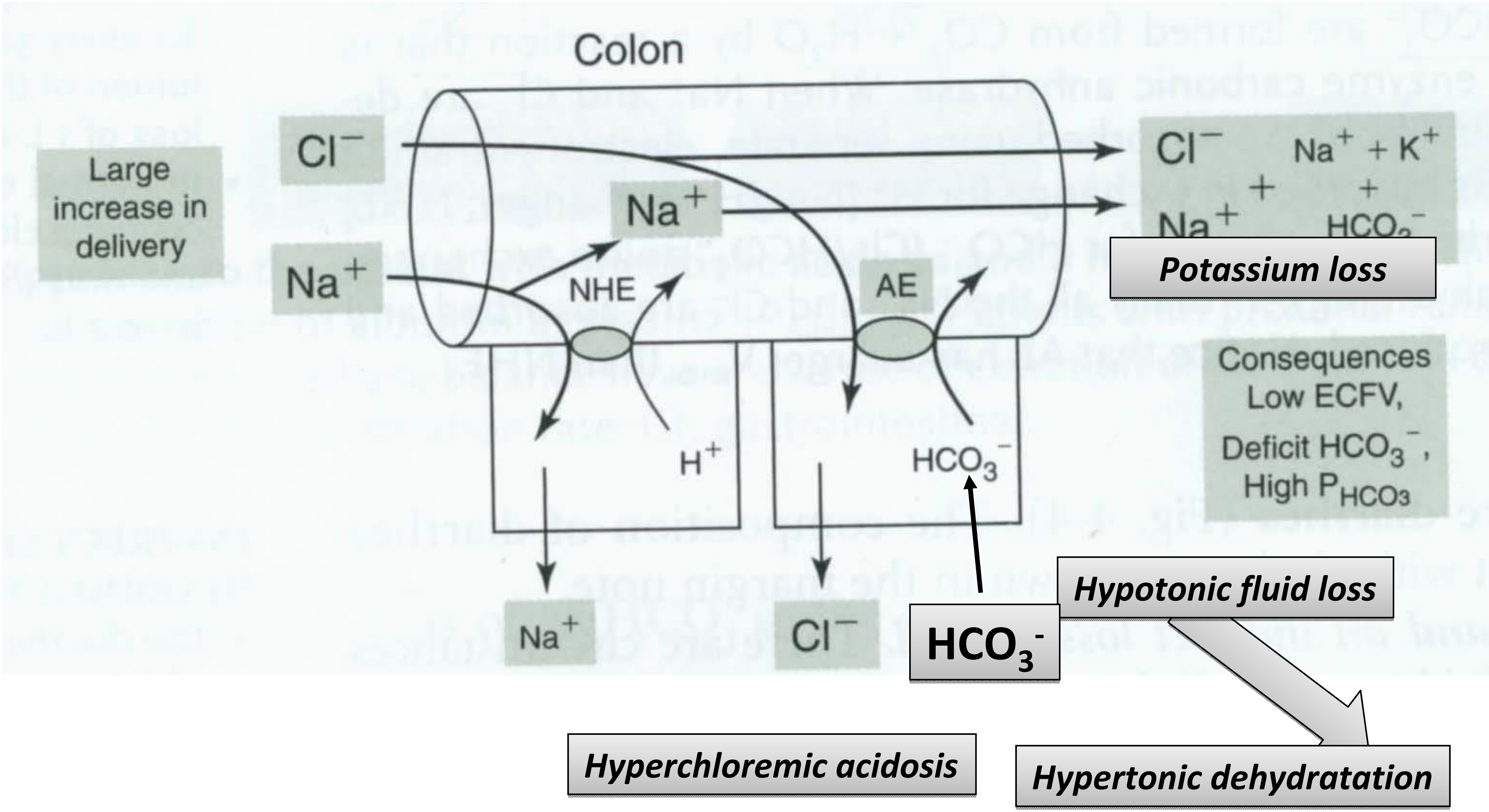
Diarrhoea



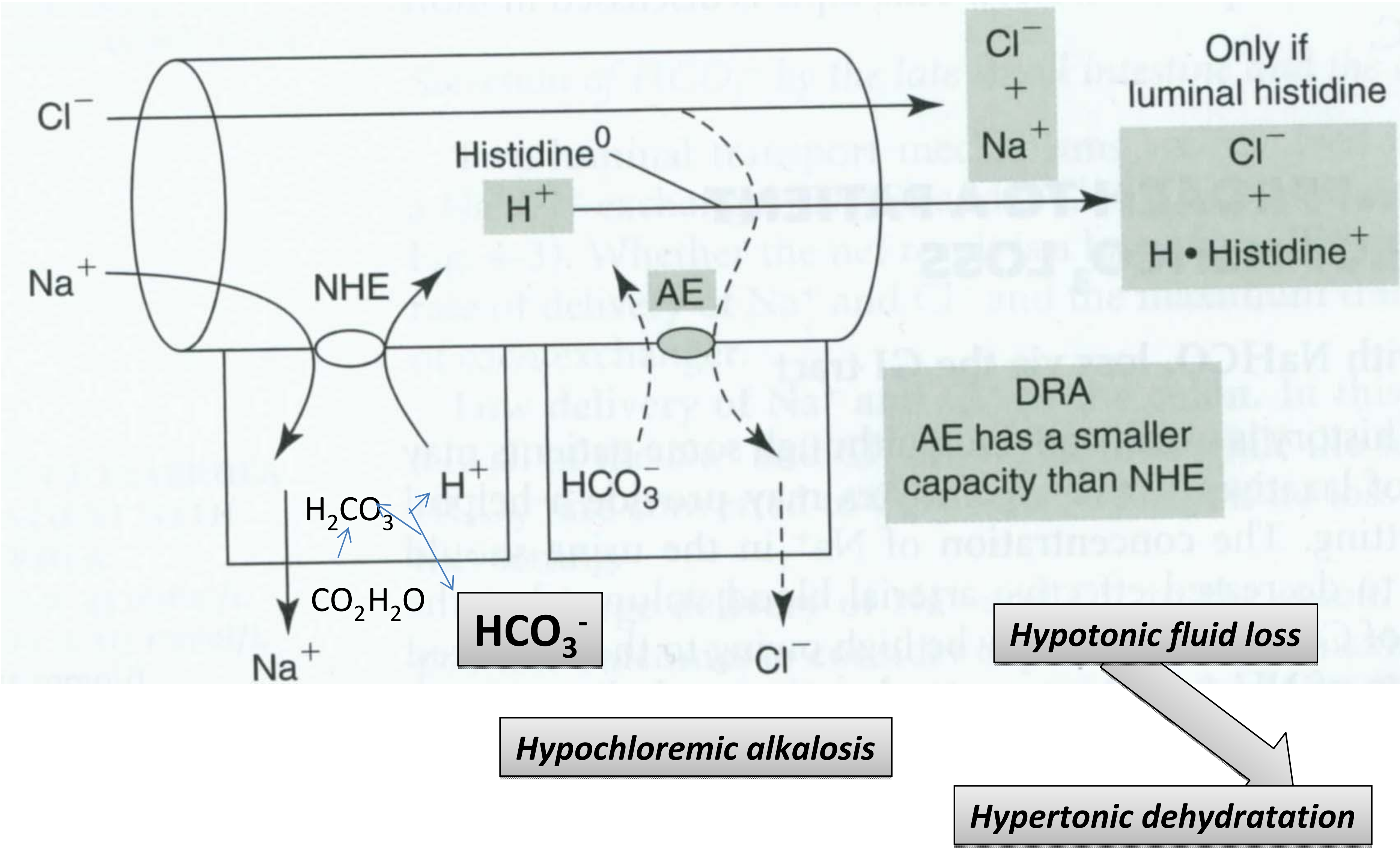
Colon
Cl⁻
Na⁺
NHE
AE
CO_2 + H_2O
H⁺
HCO_3^-
All of the Na⁺ and Cl⁻ are reabsorbed
Na⁺
Cl⁻



Alkalic diarrhoea

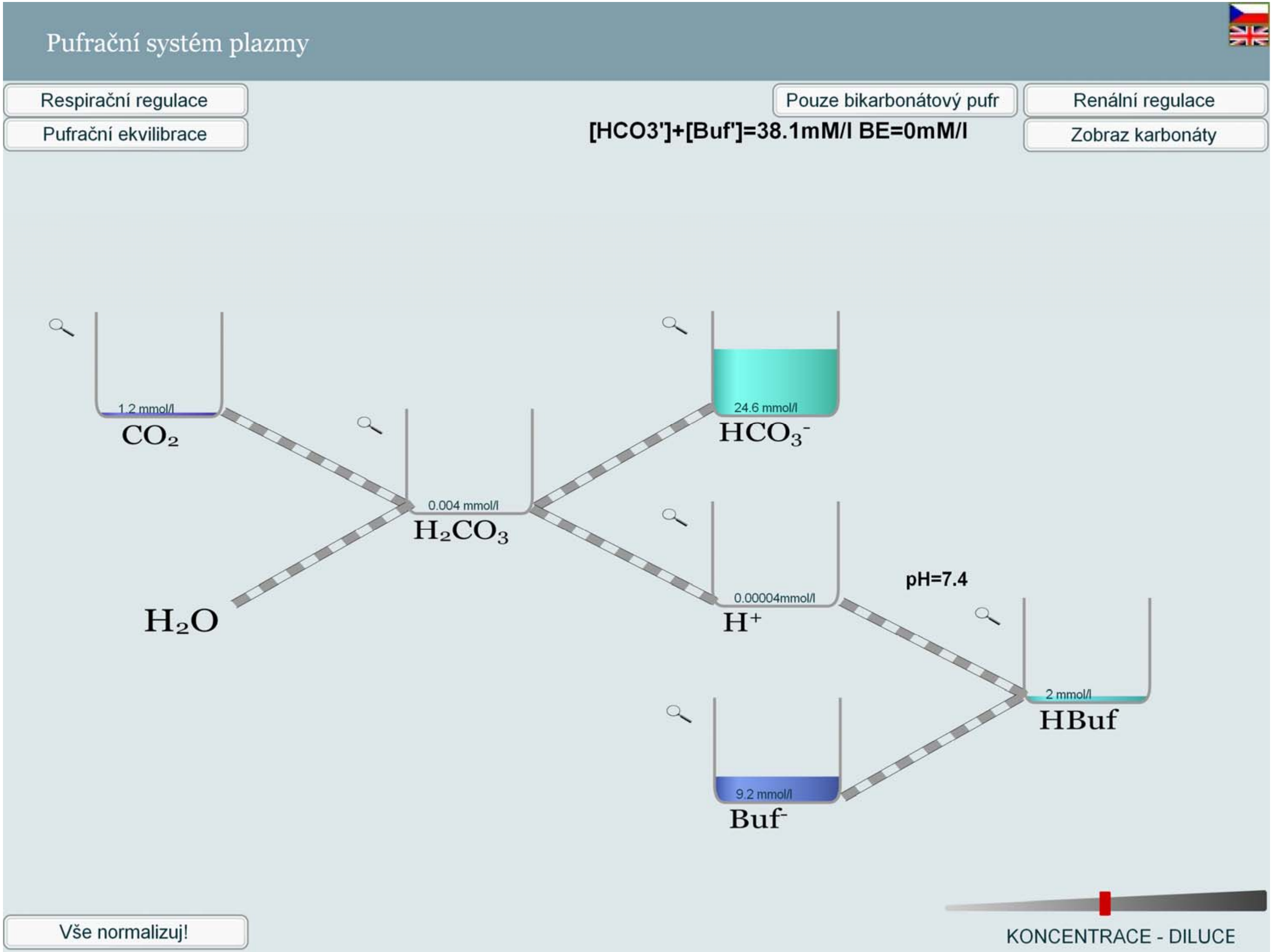


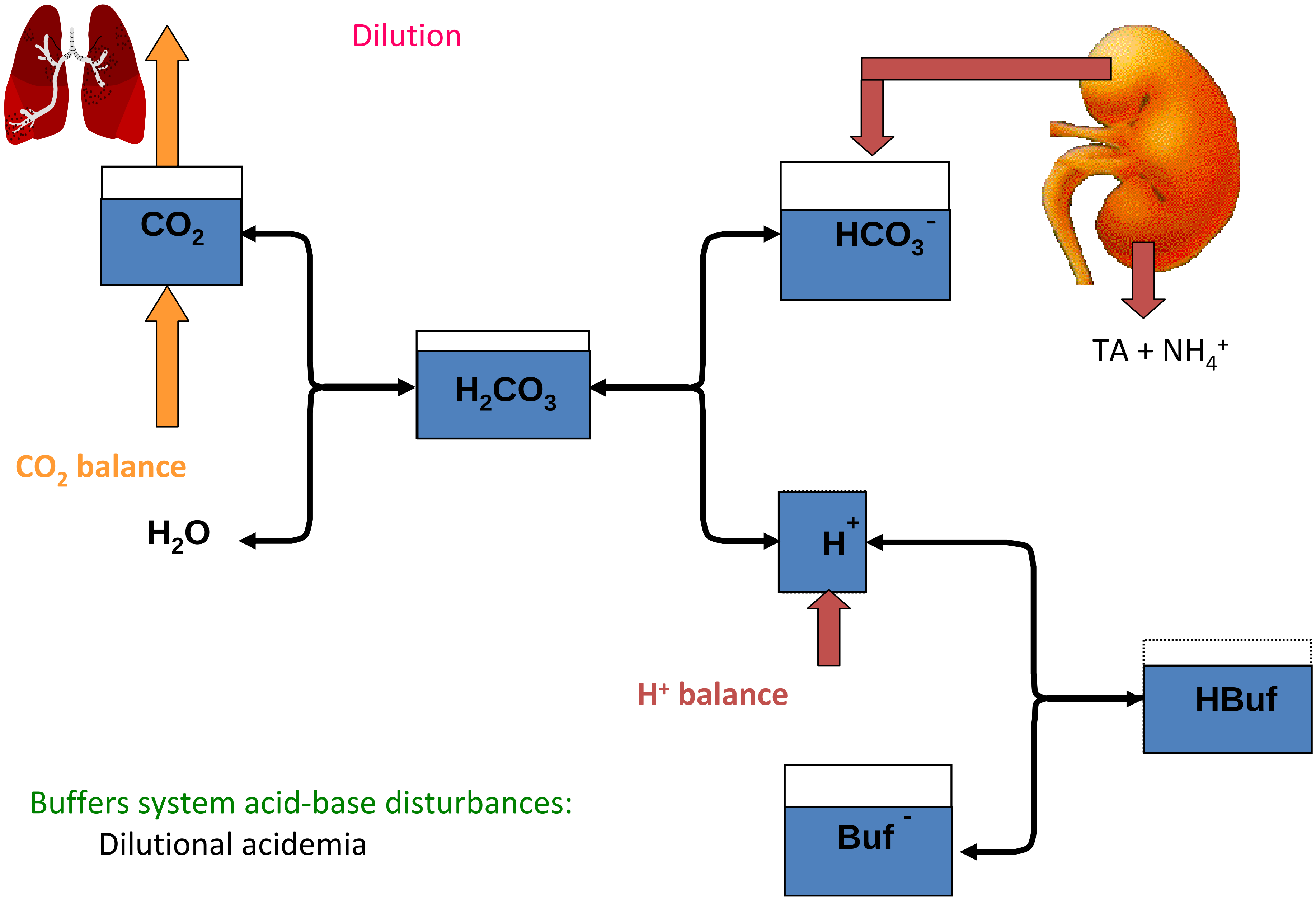
Severe alkalic diarrhoea

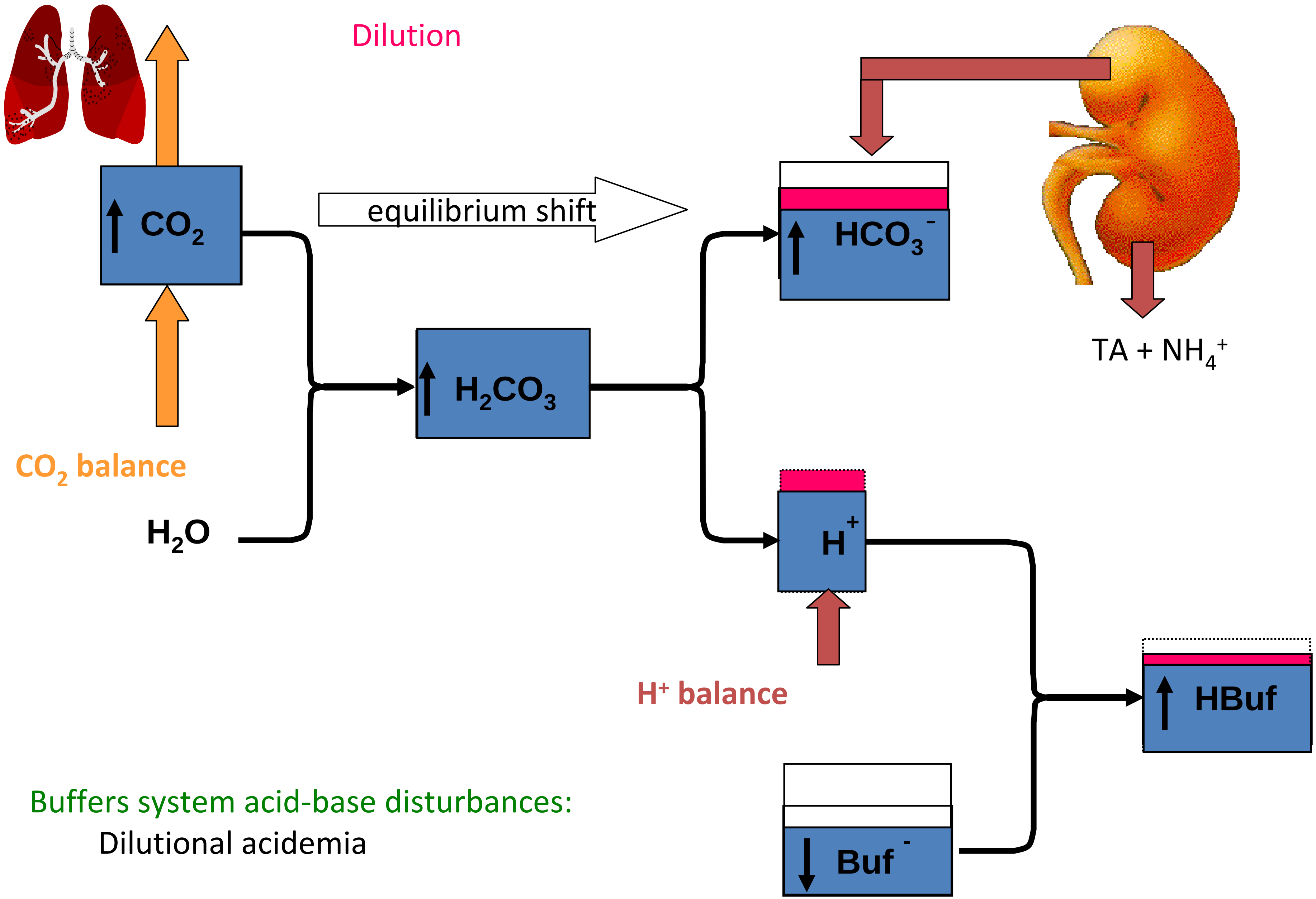


Acidic diarrhoea in DRA, down-regulated adenoma

Acute volume changes and acid-base disturbances


Pufrační systém plazmy
Respirační regulace
Pufrační ekvilibrace
Pouze bikarbonátový pufr
Renální regulace
[HCO3']+[Buf']=38.1mM/l BE=0mM/l
Zobraz karbonáty
1.2 mmol/l
CO₂
0.004 mmol/l
H₂CO₃
24.6 mmol/l
HCO₃⁻
H₂O
0.00004mmol/l
H⁺
pH=7.4
2 mmol/l
HBuf
9.2 mmol/l
Buf⁻
Vše normalizuj!
KONCENTRACE - DILUCE

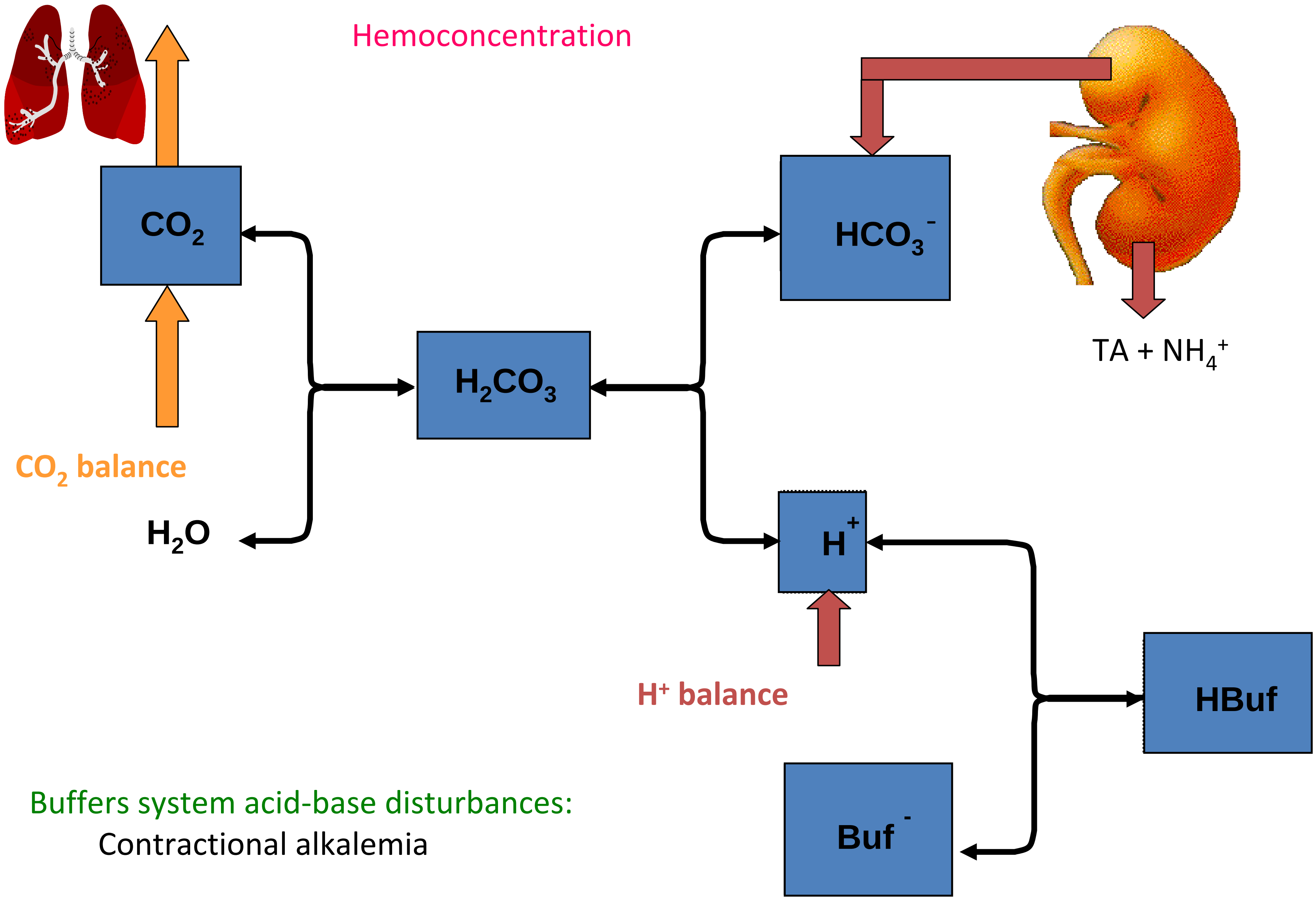

Dilution
CO_2
H_2CO_3
HCO_3^-
TA + NH_4^+
CO_2 balance
H_2O
H^+
H^+ balance
HBuf
Buf^-
Buffers system acid-base disturbances:
Dilutional acidemia



Buffers system acid-base disturbances:

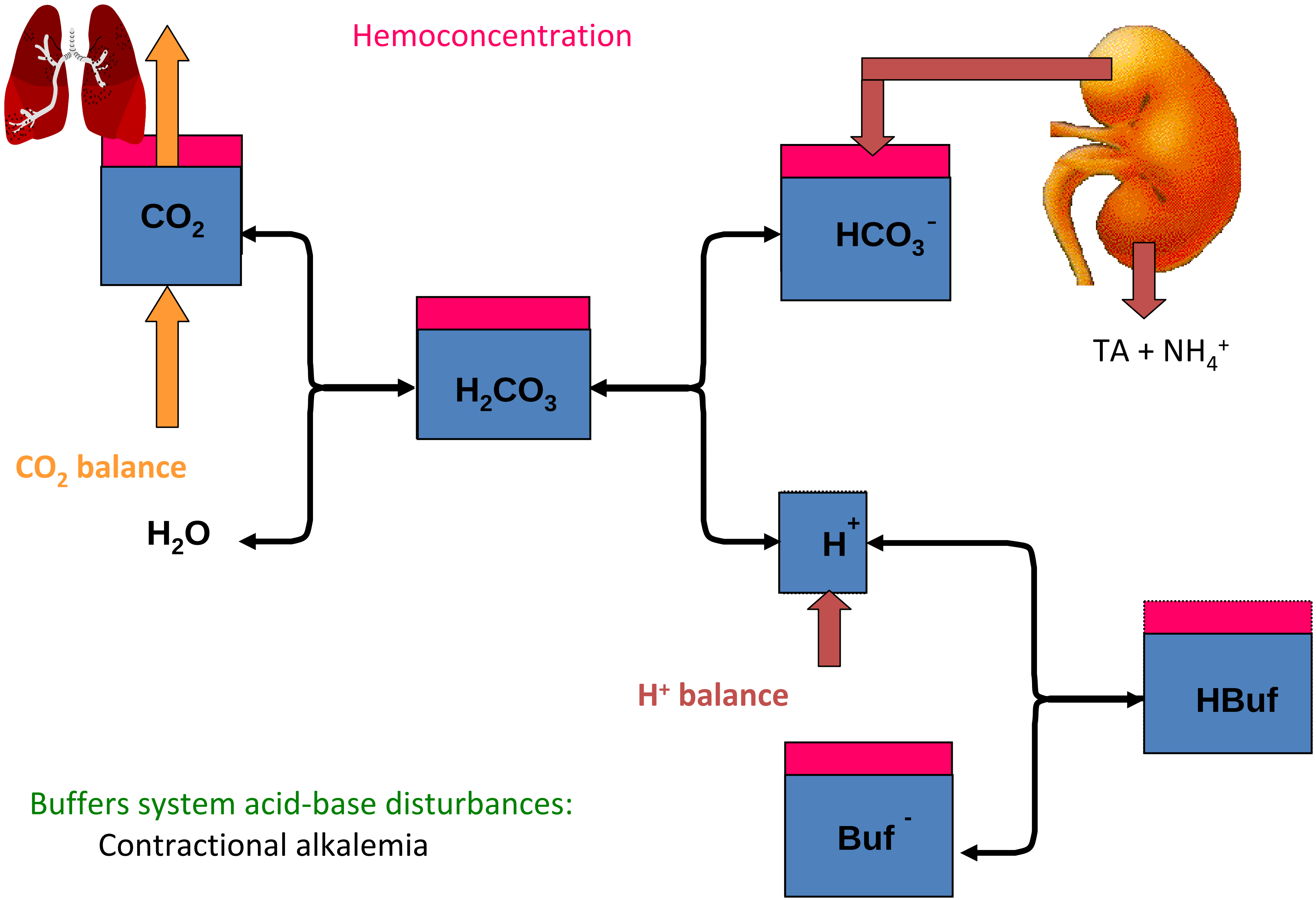
Dilutional acidemia

Hemoconcentration



Buffers system acid-base disturbances:

Contractional alkalemia


Hemoconcentration
CO_2
H_2CO_3
HCO_3^-
TA + NH_4^+
CO_2 balance
H_2O
H^+
H^+ balance
HBuf
Buf^-
Buffers system acid-base disturbances:
Contractional alkalemia