Internal Environment and its possible disturbances

Stanislav Matoušek

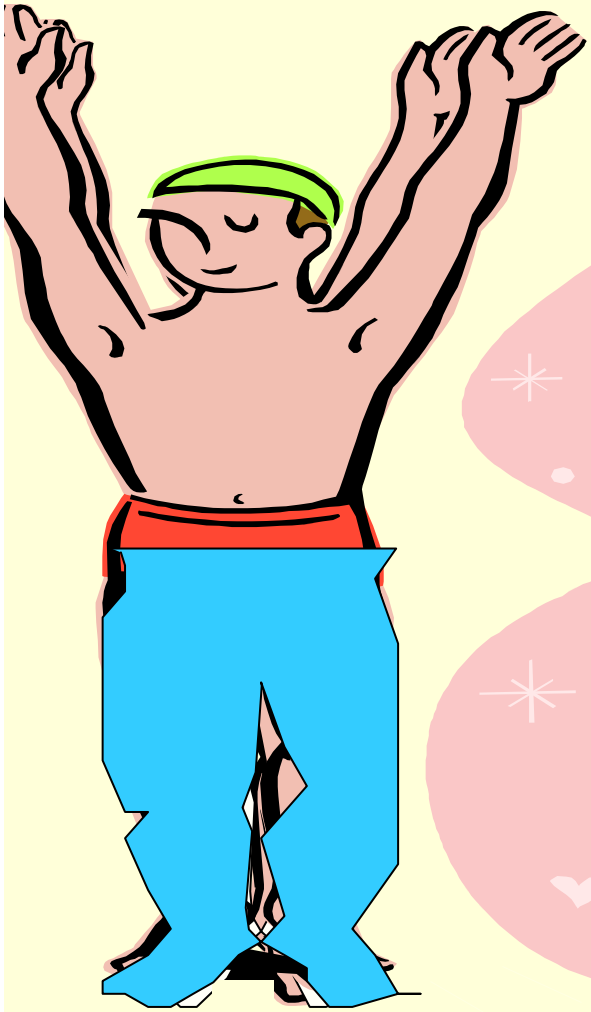
Disturbances of volume and osmolarity

- Dehydration
  - hyperosmotic
  - isoosmotic
  - hypoosmotic
- Hyperhydration
  - hypoosmotic
  - isoosmotic
  - (hyperosmotic)

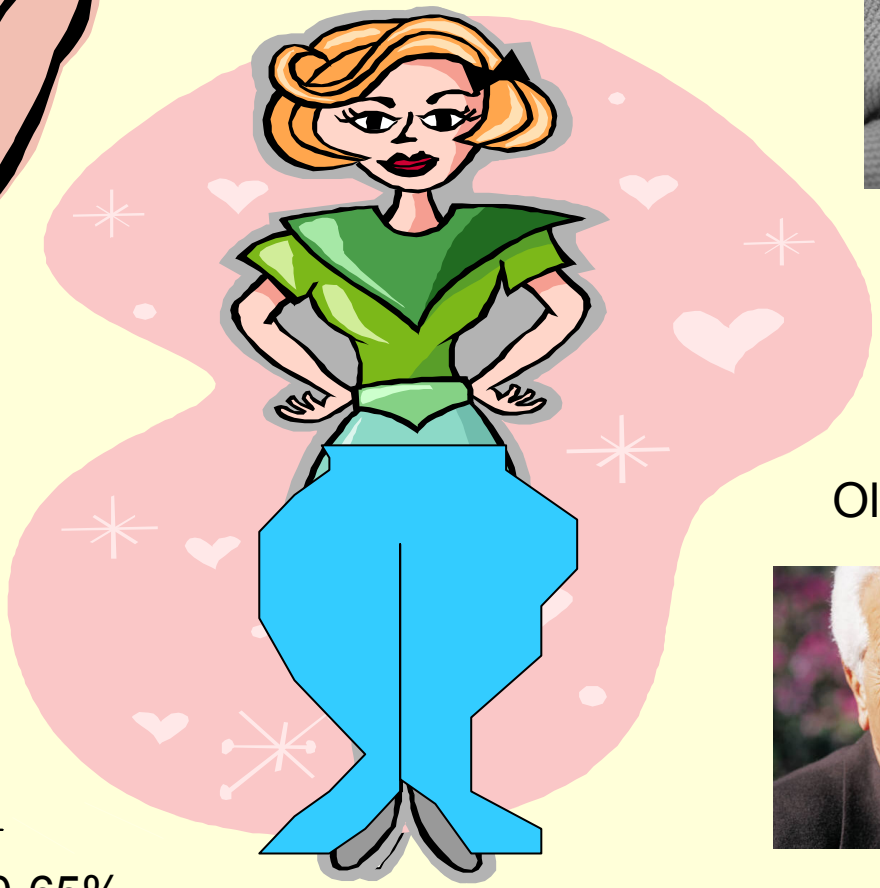
Disturbances of ions

- Hypernatremia and hyponatremia
- Hyperchloremia and hypochloremia
- Hyperkalemia and hypokalemia
- Hypercalcemia and hypocalcemia

WATER



Young men: 60-65%



Young women: 50-55%

Infants : 65-75%

Old men : 50%

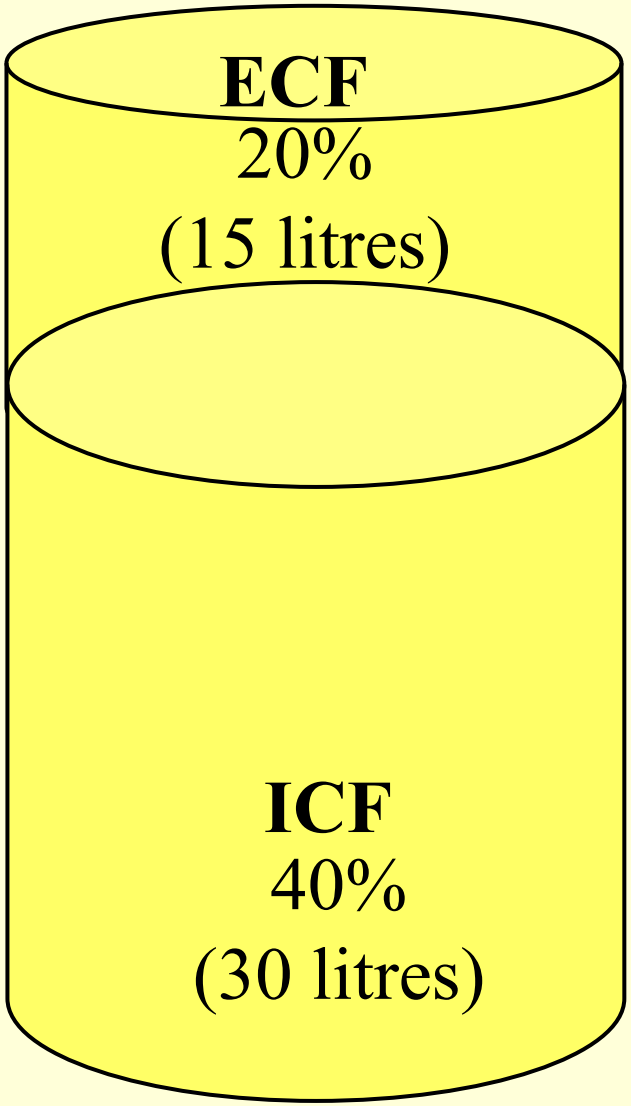
Old women: 45%

60 % of BW

Overweight people have lower % of water then the slim

Water in organism

TBW
60%
(45 litres)



Plasma 4% (3 litres)

ISF 16% (12 litres)

Plasma/IST=1/4

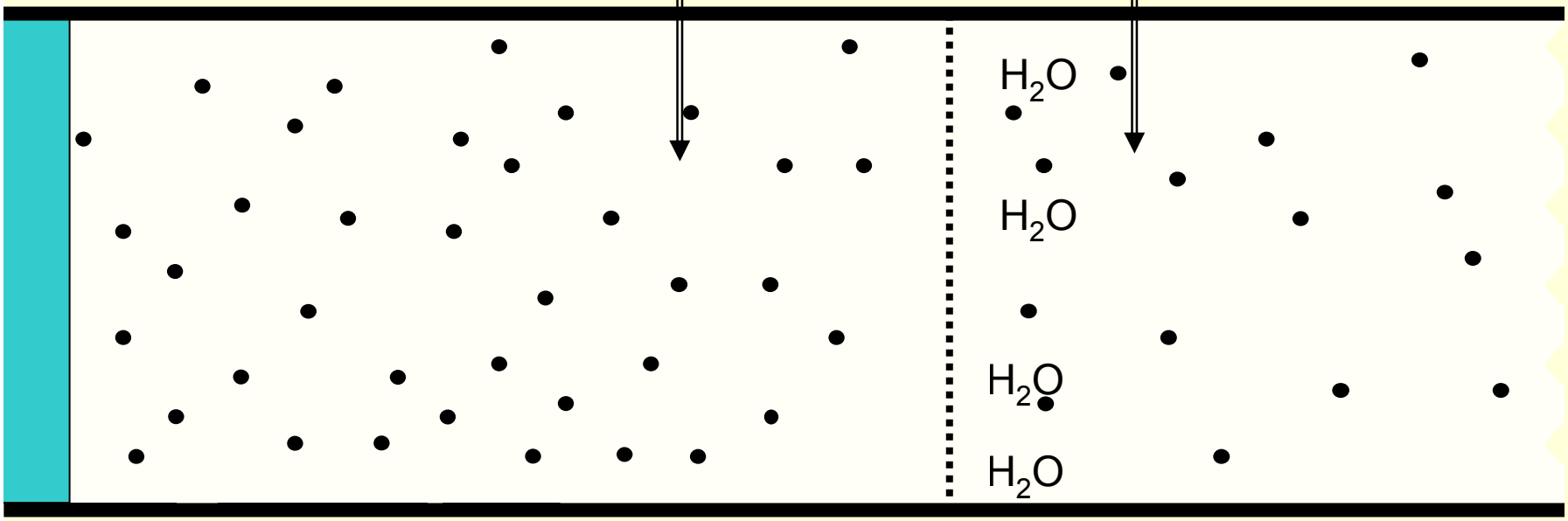
Transcellular water (Third space): Fluid in various body cavities (pleural, peritoneal, intestines)

Osmotic pressure

is proportional to the concentration of dissolved substances

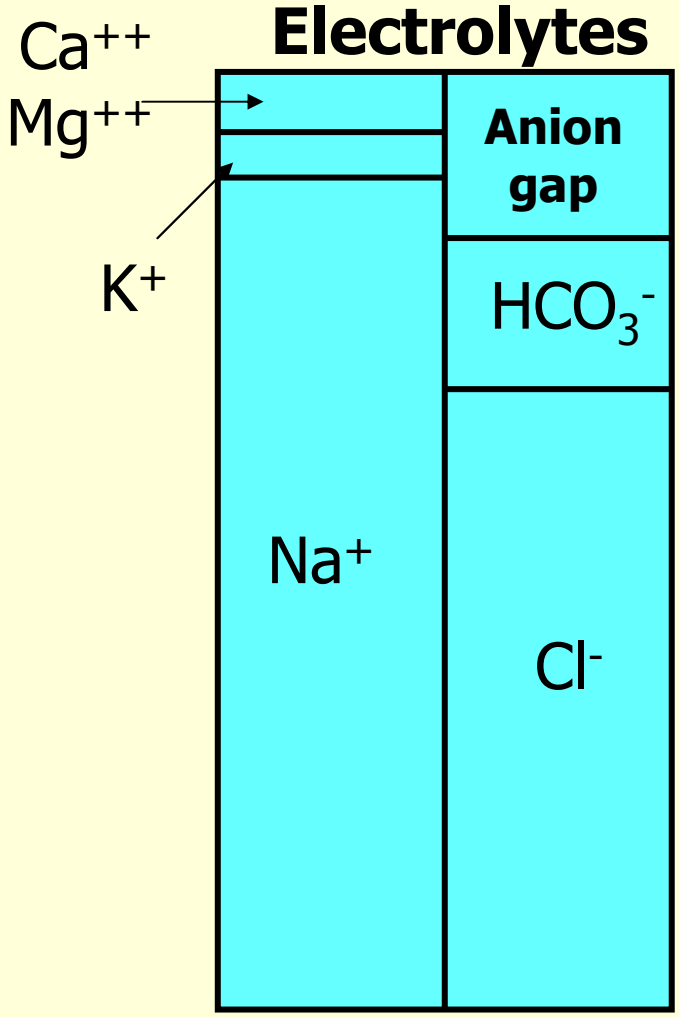
$$P_1 = P_2$$

$$C_1 > C_2$$



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

Osmolarity of the body's fluids



Osm = 2 (Na^+ + K^+) + Glc + Urea

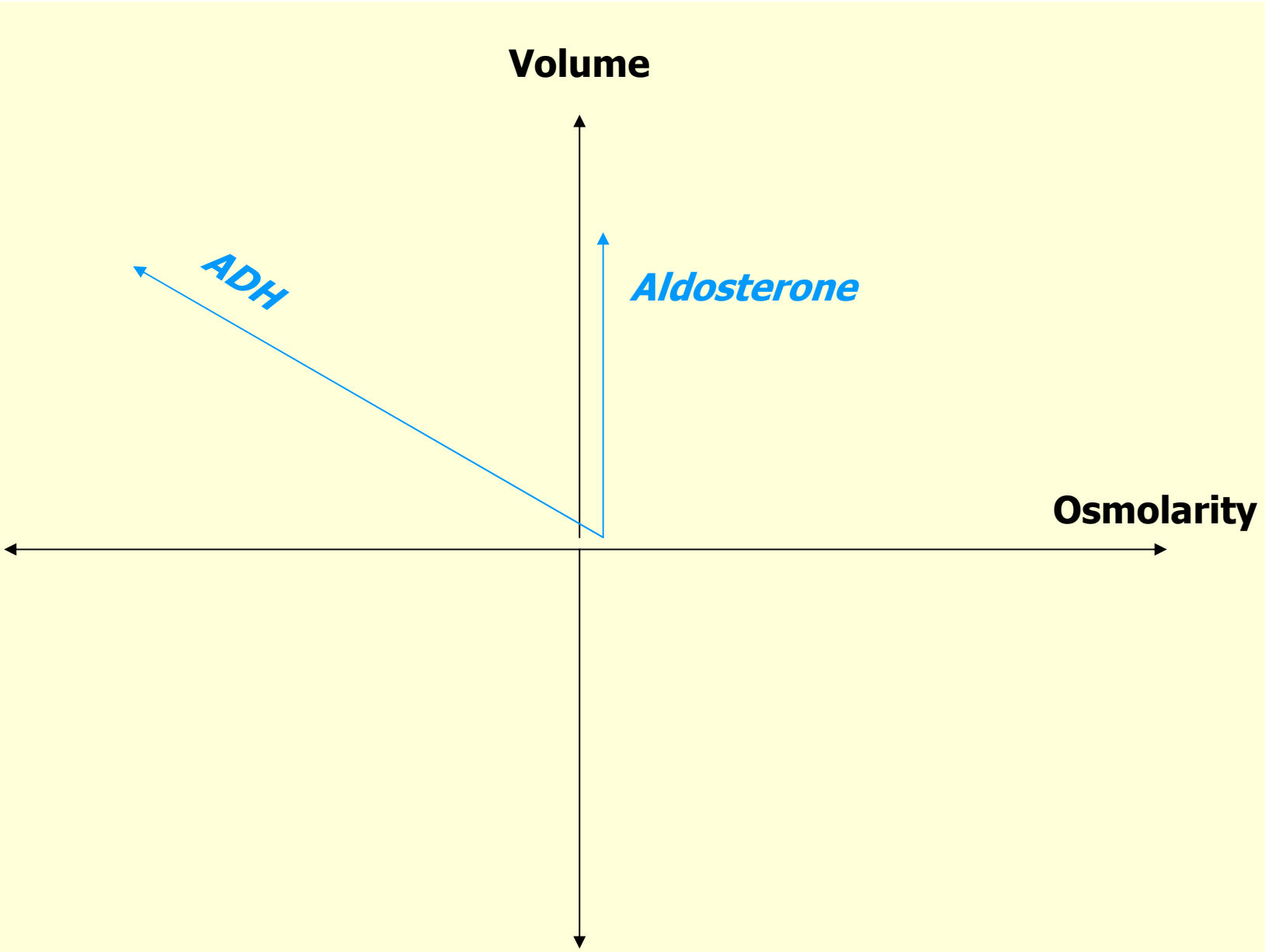
{Glc [mmol/l]} ={Glc [mg/dL] } /18

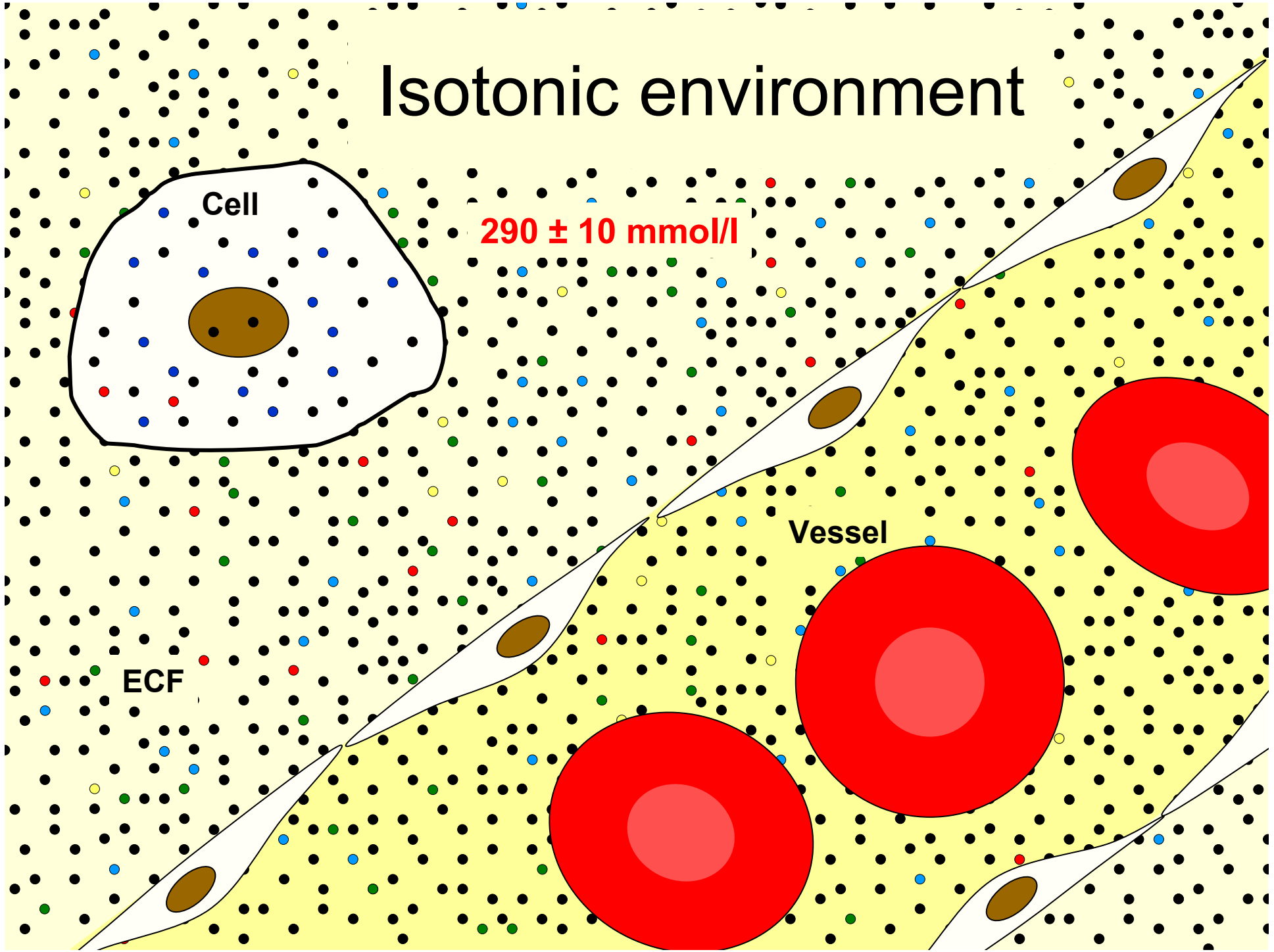
{Urea[mmol/l} ={Urea[mg/dL]} / 6

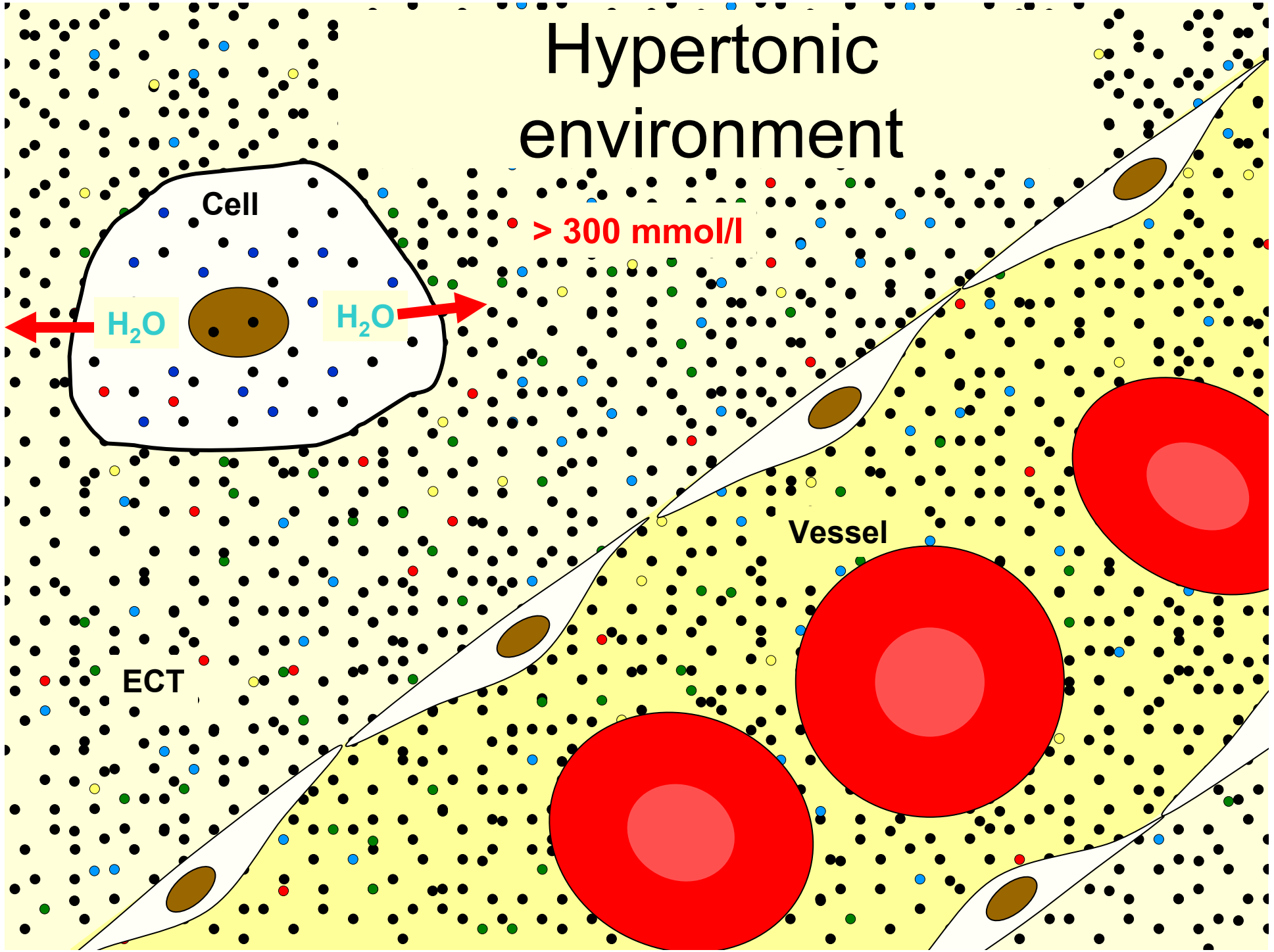
$\{Osm\}_{norm}$ = 280 – 296 mmol/l

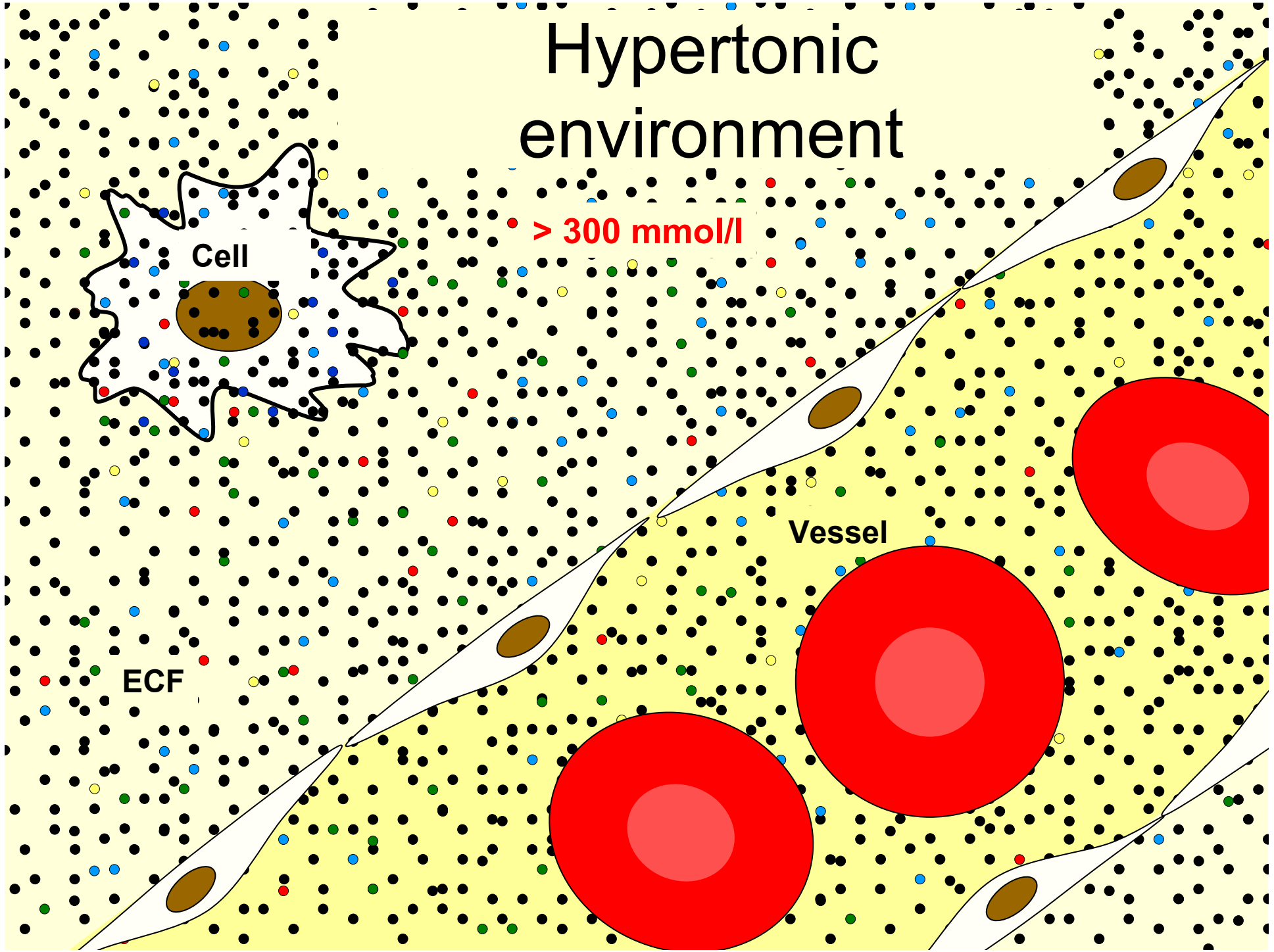
Regulation of Na^+ and H_2O homeostasis

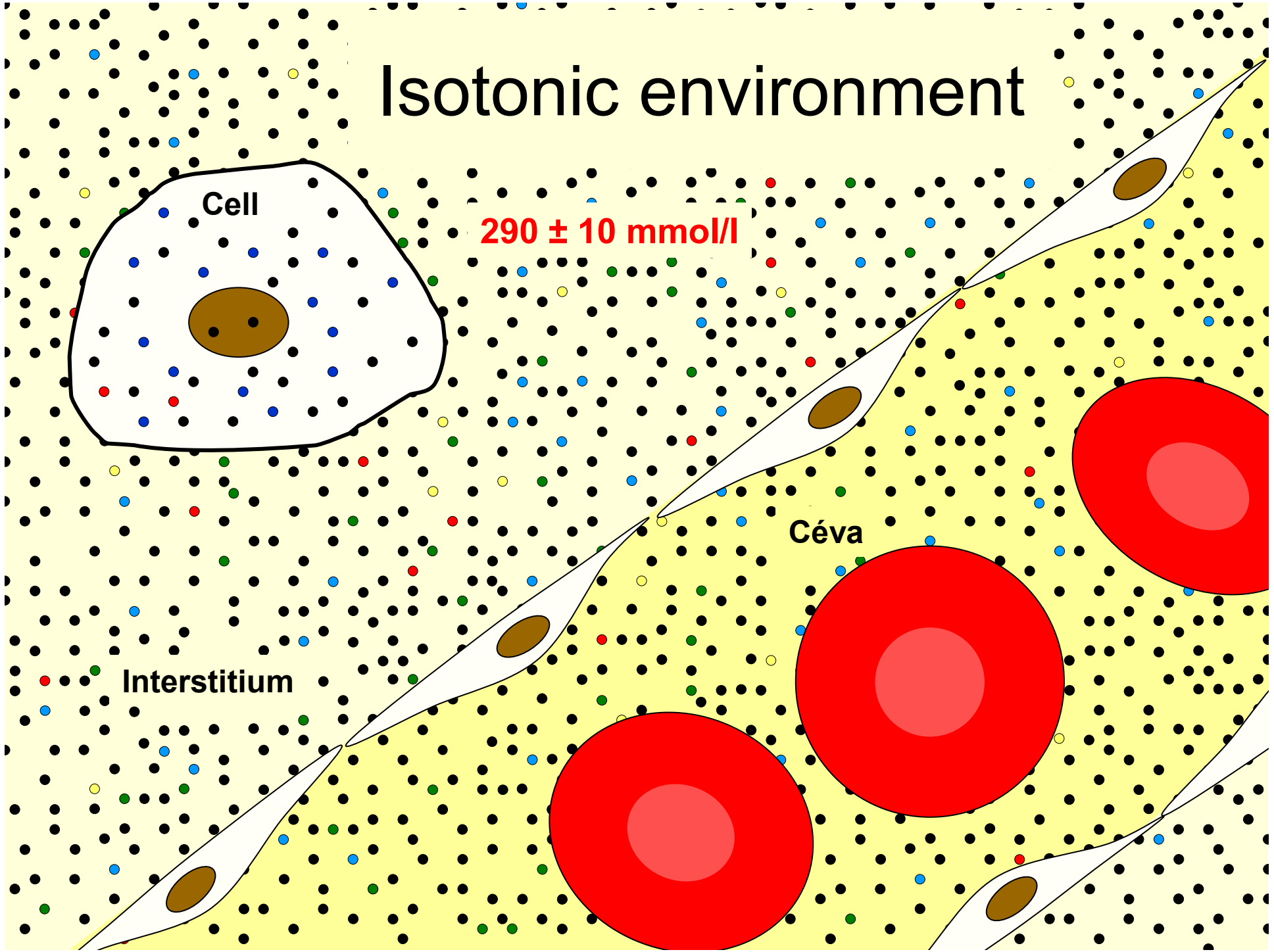
	Circulating volume ↓	*Circulating volume ↑*	*Osmolarity ↑*
Receptors	Baroreceptors (juxtaglomerular apparatus	Volumo-receptors 1(heart)	Osmoreceptors (hypothalamus), baroreceptors (low volume)
Hormones	**Renin – angiotenzin aldosterone**	ANP, BNP	**ADH**
Effects	Retention of Na^+ and H_2O in kidneys	Inhibition of the RAAS	H_2O retention
Feedback loop	Circulating volume ↑	Circulating volume ↓	Osmolarity ↓ *Volume* ↑

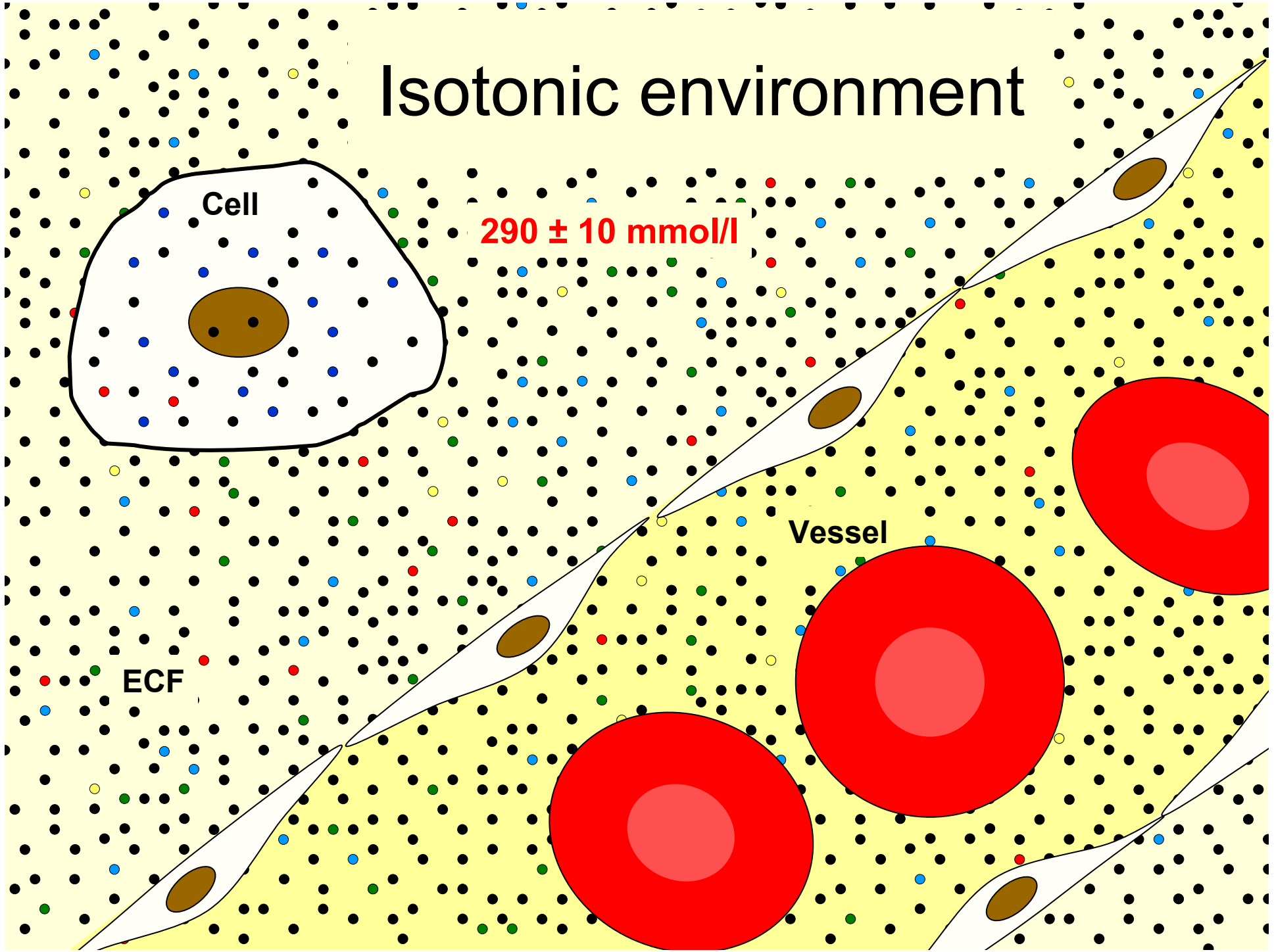

Volume
ADH
Aldosterone
Osmolarity

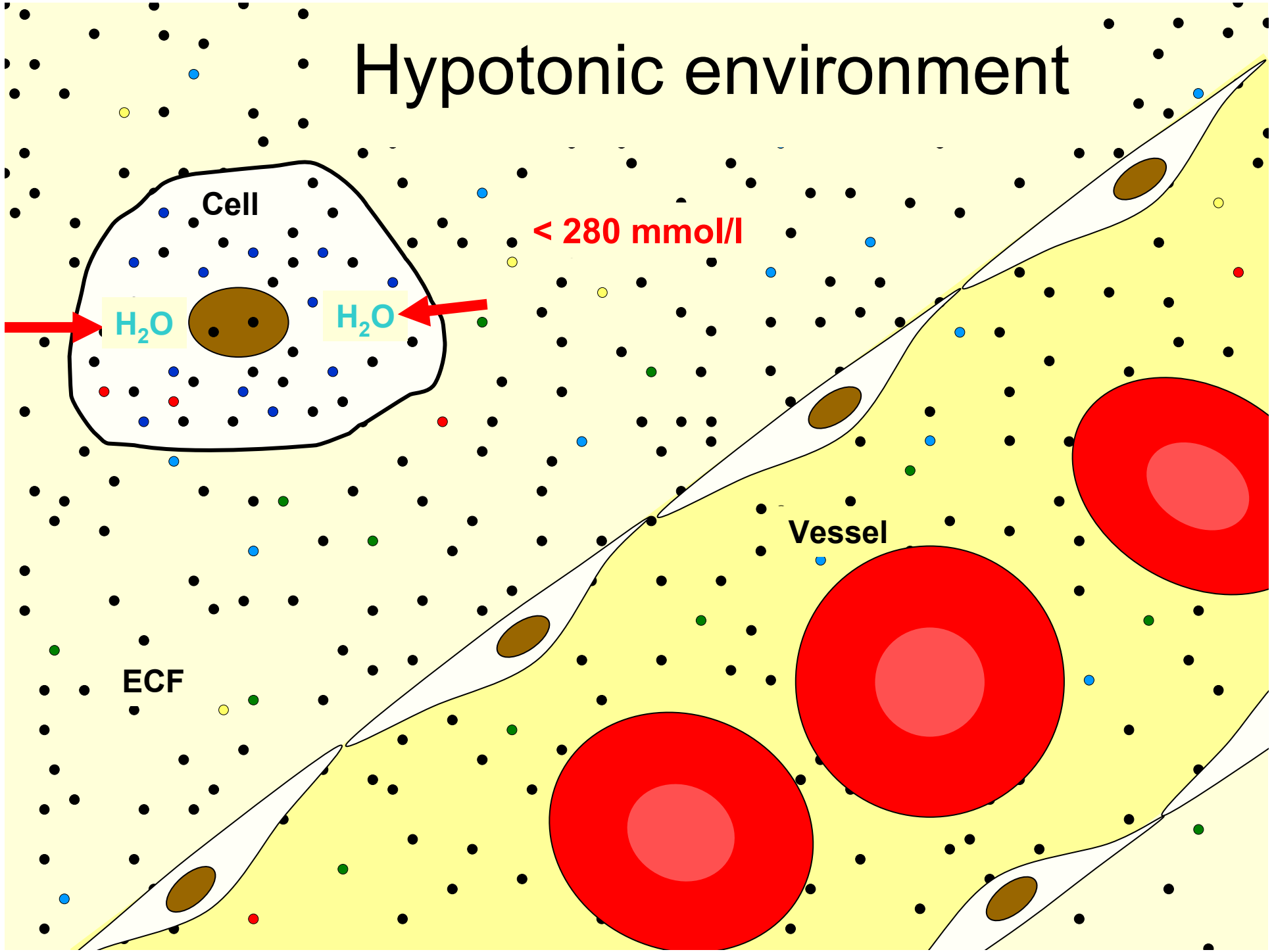

Isotonic environment
Cell
290 ± 10 mmol/l
Vessel
ECF

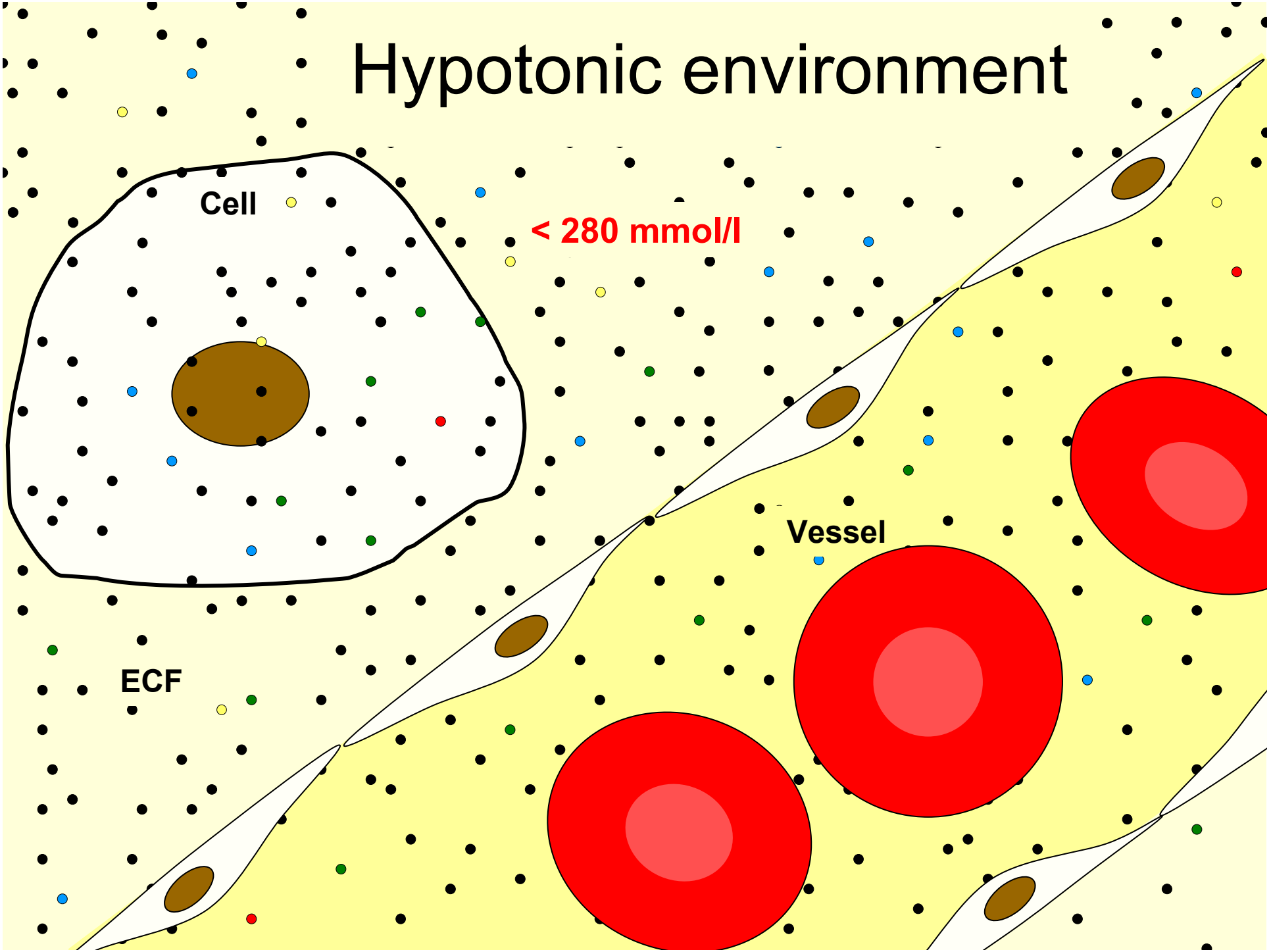

Hypertonic environment
Cell
> 300 mmol/l
H_2O
H_2O
Vessel
ECT

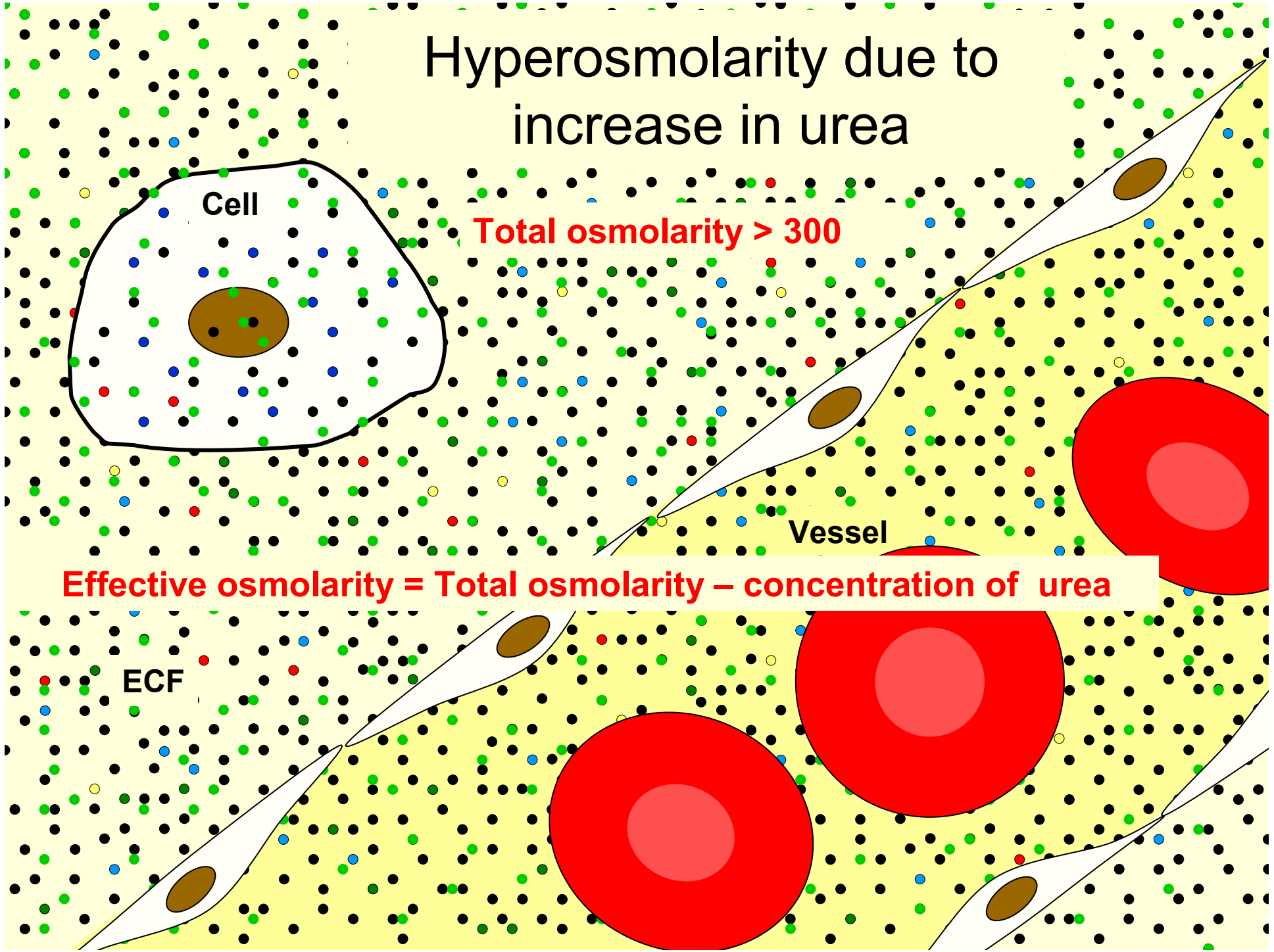

Hypertonic environment
> 300 mmol/l
Cell
Vessel
ECF


Isotonic environment
Cell
290 ± 10 mmol/l
Céva
Interstitium


Isotonic environment
Cell
290 ± 10 mmol/l
Vessel
ECF


Hypotonic environment
Cell
< 280 mmol/l
H_2O
H_2O
Vessel
ECF


Hypotonic environment
Cell
< 280 mmol/l
Vessel
ECF


Hyperosmolarity due to increase in urea
Cell
Total osmolarity > 300
Vessel
Effective osmolarity = Total osmolarity – concentration of urea
ECF

Disturbances of volume and osmolarity

Intravascular Fluid

- hypovolemia

  shock

- hypervolemia

  kidney failure
  with water intake

Extracellular Fluid

- Dehydration
  - hypertonic
  - isotonic
  - hypotonic
- Hyperhydration
  - hypotonic
  - isotonic
  - (hypertonic)

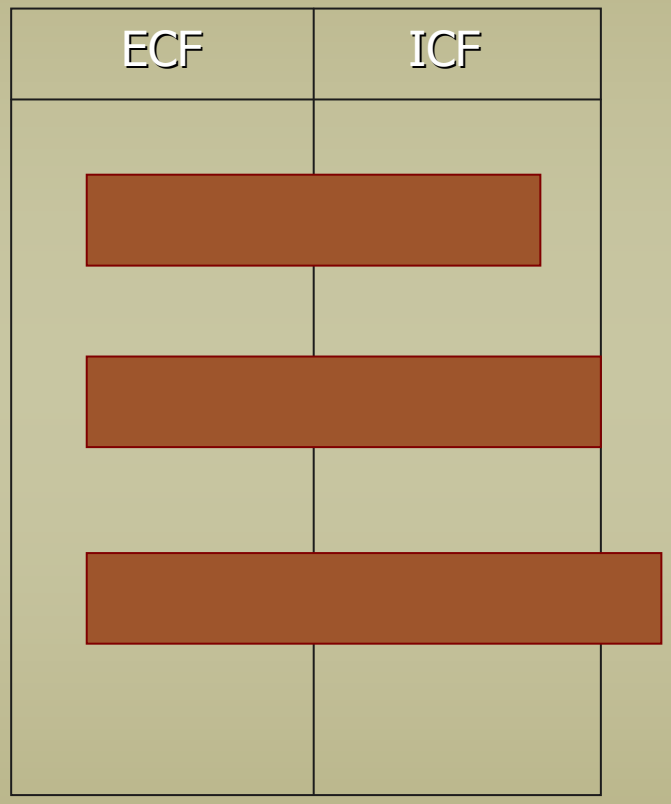
Clinical markers of electrolyte disturbances

	Hct, Hb, Tot.pl.prot.	Plasma Na^+ PlasmOsm.	MCV
Dehydration			
hyperosmotic		↑	↓
isoosmotic		normal	normal
normoosmotic		↓	↑
Hyperhydration			
hypoosmotic		↓	↑
isoosmotic		normal	normal
(hyperosmotic		↑	↓

Dehydration

Dehydration

- hypertonic
- isotonic
- hypotonic



Hypertonic dehydration

- Loss of free water
- Eti:
  - Insufficient water intake (**thirsting**)
  - Loss of water through excessive **sweating**, breathing (hyperventilation), kidneys (**diabetic coma, diabetes insipidus**)
  - Iatrogenic
- Signs: Great thirst, fever, confusion, obnubilation, (oliguria)

Isotonic dehydration

- Loss of both Na^+ and water
- Eti.:
  - Through kidneys: **Polyuric phase of kidney insufficiency, diuretics, Addison disease**
  - Through GIT: **Vomiting, diarrhea, fistulas**
  - To the third space: **Pancreatitis, ileus**
  - Through skin: **Burns**
- Thirst, tachycardia, collapses, (polyuria)

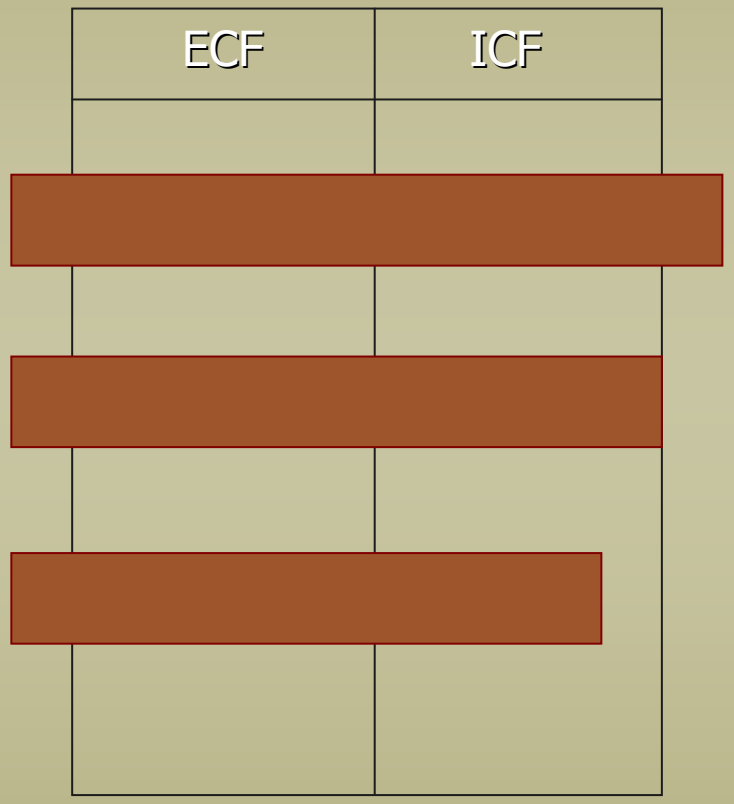
Hypotonic dehydration

- Isotonic dehydration treated by substitution of pure water
- Causes of isotonic dehydration
- Signs of hypovolemia: Collapses, tachycardia, thirst

  Signs of cerebral swelling: Obnubilation, delirium, convulsions
- *Correction must not be too fast (shrinking of the brain!)–even in heavy symptomatic hyponatremia no more then 20 mmol/l per day increase in sodium*

Hyperhydration

- hypotonic
- isotonic
- (hypertonic)



Hyperhydration – causes

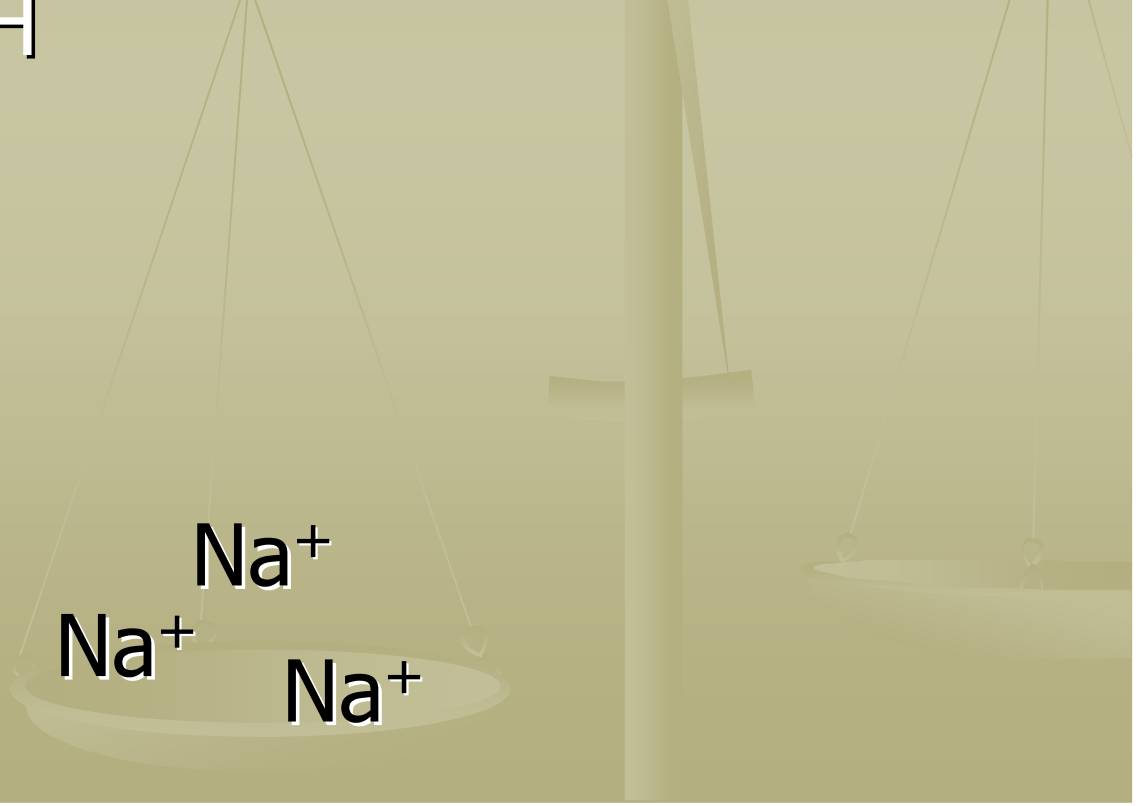
- Renal insufficiency
- Cardiac insufficiency
- Hypoproteinemia – malnutrition, liver cirhosis, nefrotic syndrome
- Regulatory disorders
  - hyperaldosteronism
  - treatment with corticoids
  - SIADH /eg. paraneoplastic/

Hyperhydration - signs

- Increase in weight
- Pulmonary edemas (dyspnoea) or peripheral edemas
- In hypotonic hyperhydratation – cerebral signs – headaches, convulsions, coma
- In (hypertonic) - hypertension

Na^+

- Na^+ norm 135-145 mmol/l
- usually corresponds with osmolarity, regulated by ADH



Hyponatremia

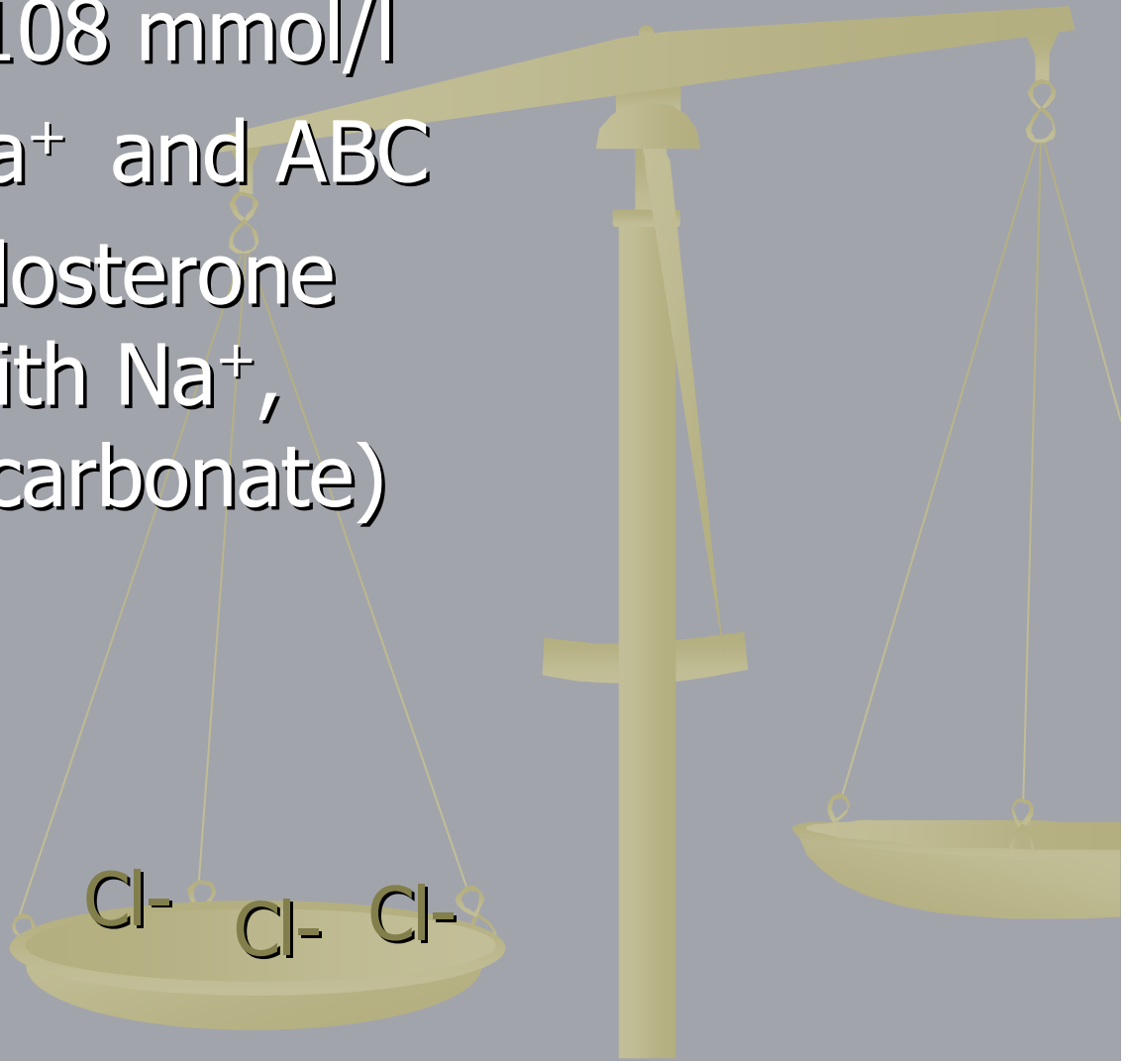
- hyponatremia < 135 mmol/l
- with excess of water and Na^+ : **dilution hyponatremia = hypotonic hyperhydration** (kidney insufficiency, heart insufficiency, low plasma proteins, SIADH)
- with deficit of water and Na^+ : **depletion hyponatremia = hypotonic dehydratation** (diarrhea, pancreatitis, diuretics, Addison disease)
- rarely hypertonic and isotonic form (when other osmotic substances present in plasma – high proteins, manitol)

Hypernatremia

- Na^+ > 145 mmol/l
- with water depletion **hypovolemic hypernatremia = hypertonic dehydration** (thirsting, sweating, diabetes insipidus)

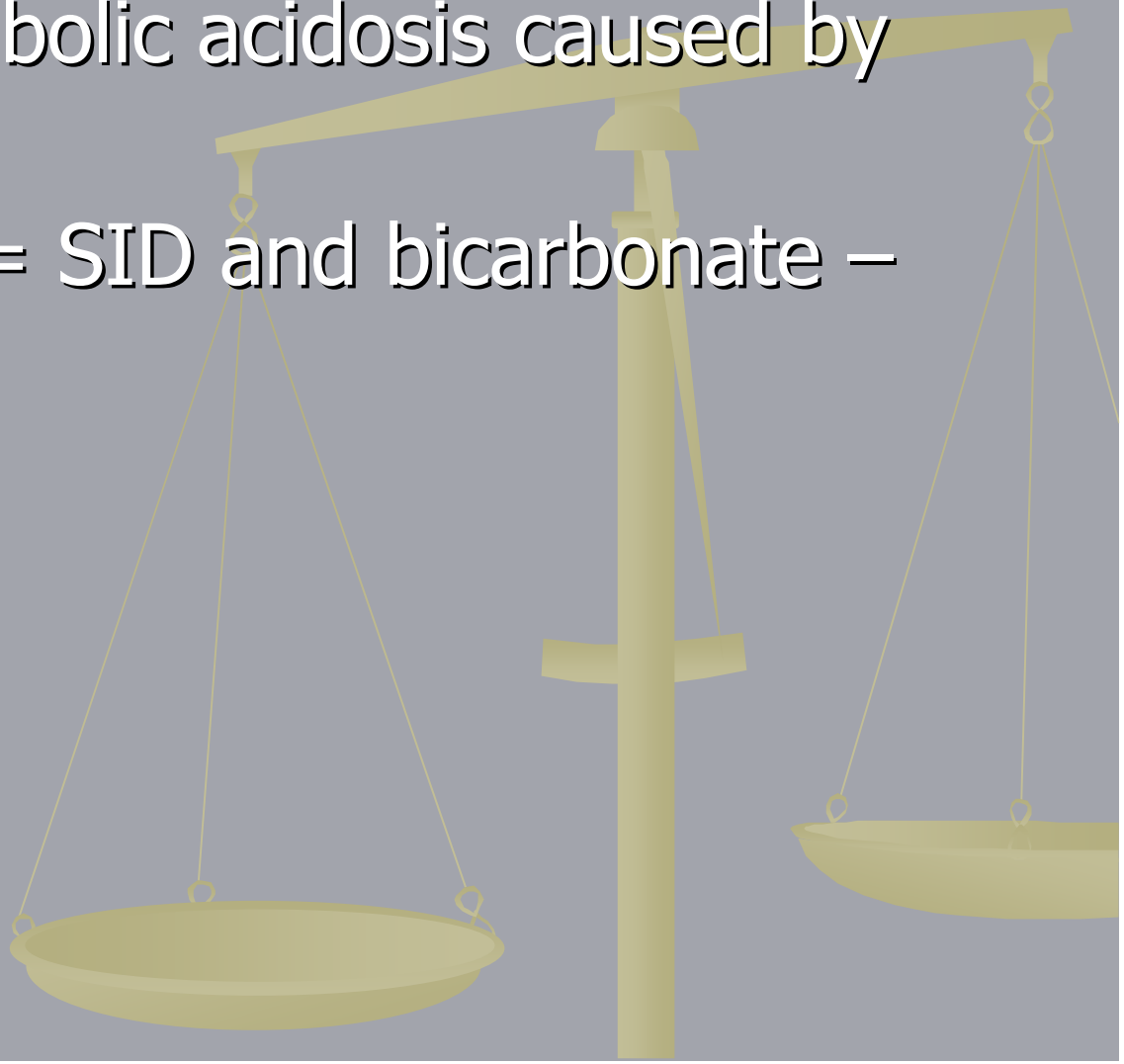
Cl^-

- Cl^- norm = 97- 108 mmol/l
- Connected to Na^+ and ABC
- regulated by aldosterone (reabsorption with Na^+, exchange for bicarbonate)



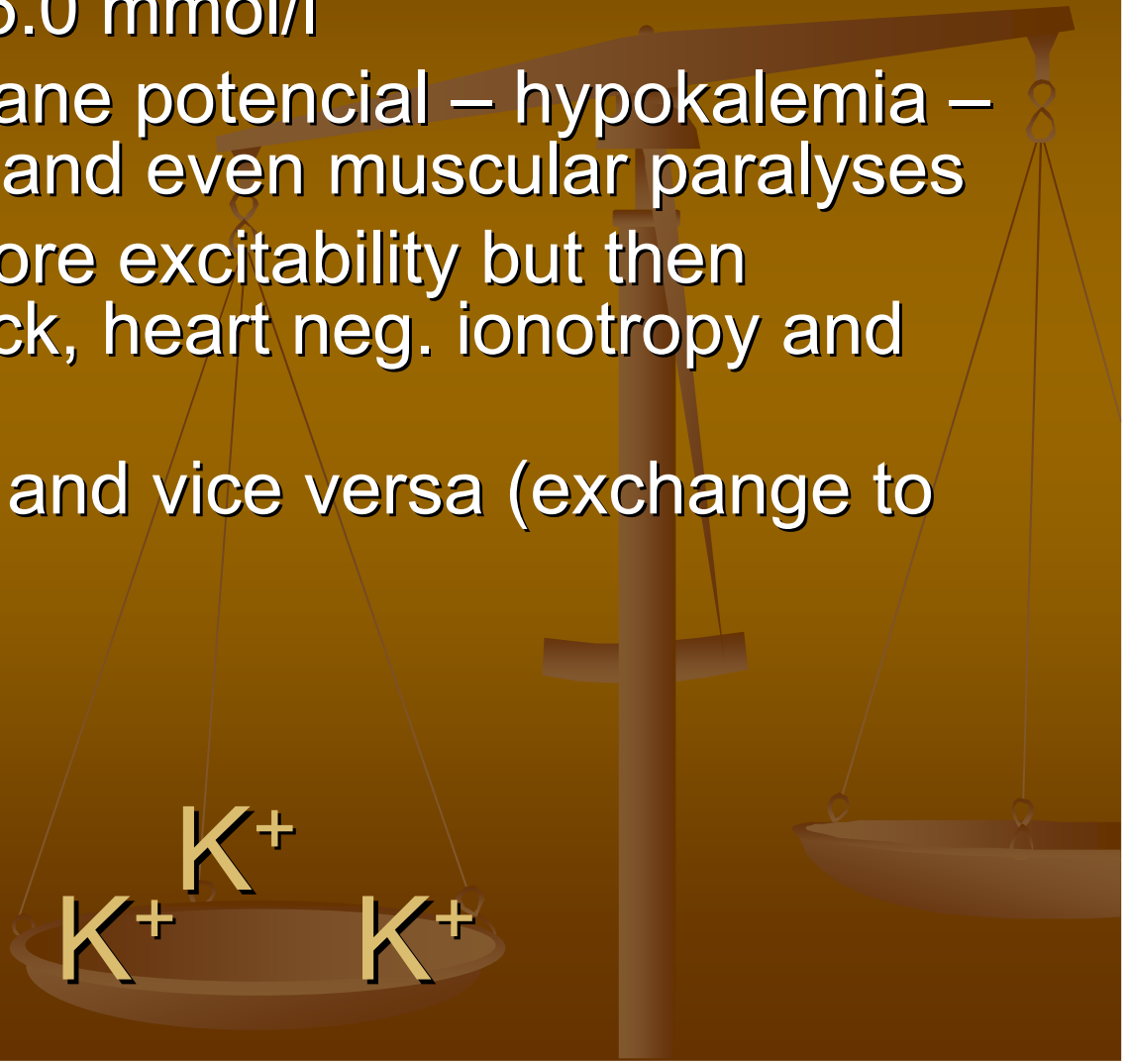
Hypochloremia

- We find in metabolic acidosis caused by vomiting
- Increase in BB = SID and bicarbonate – decrease in Cl^-



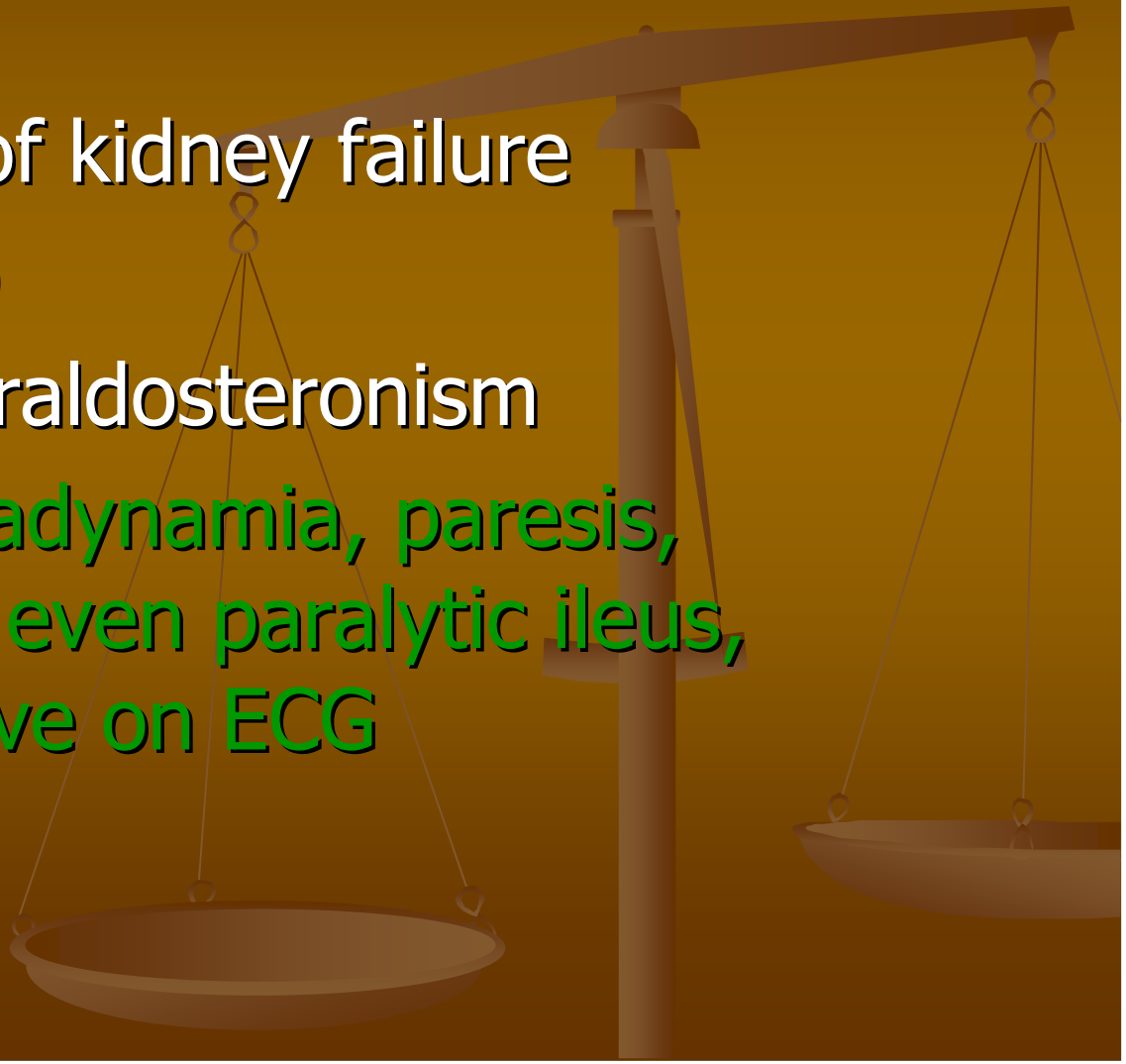
K^+

- K^+ norm. = 3.6 – 5.0 mmol/l
- influences membrane potencial – hypokalemia – loss of excitability,and even muscular paralyses
- hyperkalemia – more excitability but then depolarization block, heart neg. ionotropy and dromotropy
- more H^+ , more K^+ and vice versa (exchange to cells)



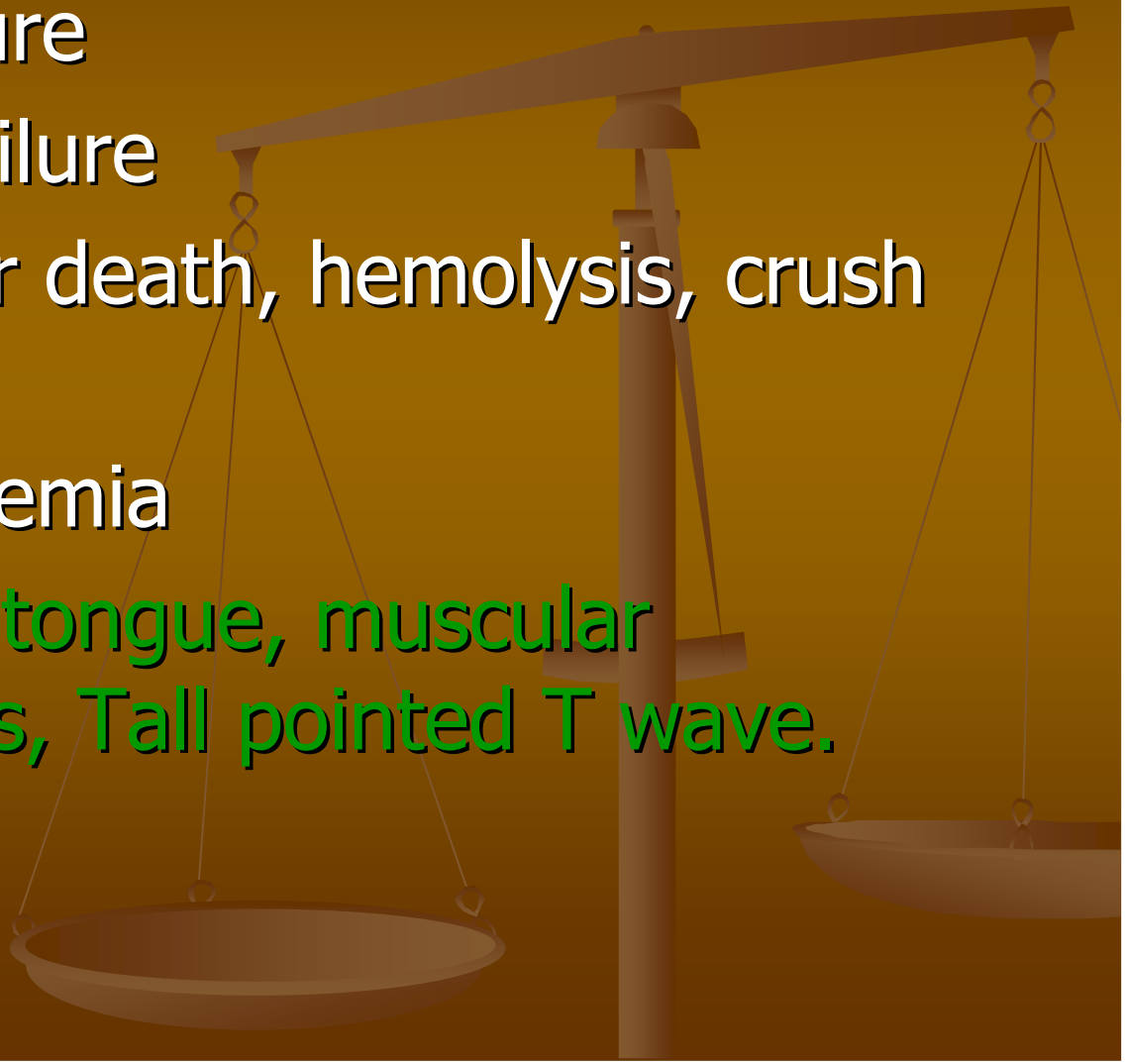
Hypokalemia

- diarreas
- polyuric phase of kidney failure
- diuretics (often)
- corticoids, hyperaldosteronism
- Asymptomatic, adynamia, paresis, obstipation and even paralytic ileus, areflexia , U wave on ECG



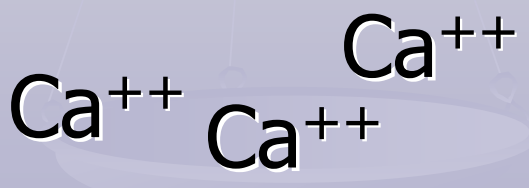
Hyperkalemia

- Acute renal failure
- Chronic renal failure
- Acidosis, cellular death, hemolysis, crush syndrom
- pseudohyperkalemia
- parestesia, stiff tongue, muscular twitches, paresis, Tall pointed T wave.



Ca^{++}

- Ca^{++} norm =2.2 – 2.7 mmol/l
- Ca^{++} free = 1.1 – 1.3 mmol/l
- regulated by PTH, vit. D3, and calcitonin



Hypocalcemia

- hypoparathyreosis (PTH ↓ HPO_4^{2-} high↑)
- vit. D3 defficiency (PTH ↑, HPO_4^{2-} low↓) pankreatitis
- chronic kidney failure (PTH ↑ HPO_4^{2-} high↑)
- alcoholism, malnutrition (low together with Mg^{++})
- Cramps, tetany, parestesia, longer QT

Hypercalcemia

- Malignities (breast cancer, bronchogenic ca)
- Primary hyperparathyreosis, vit. D3 intoxication, insufficiency of adrenal cortex
- Immobilization, sarcoidosis
- polyuria, polydipsia, nausea, vomiting, obstipation, muscular weakness, psychosis, somnolence, coma – hypercalcemic crisis