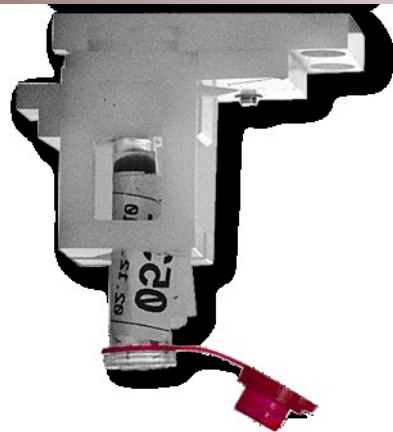


Significance of Na⁺, K⁺, Cl⁻ investigation

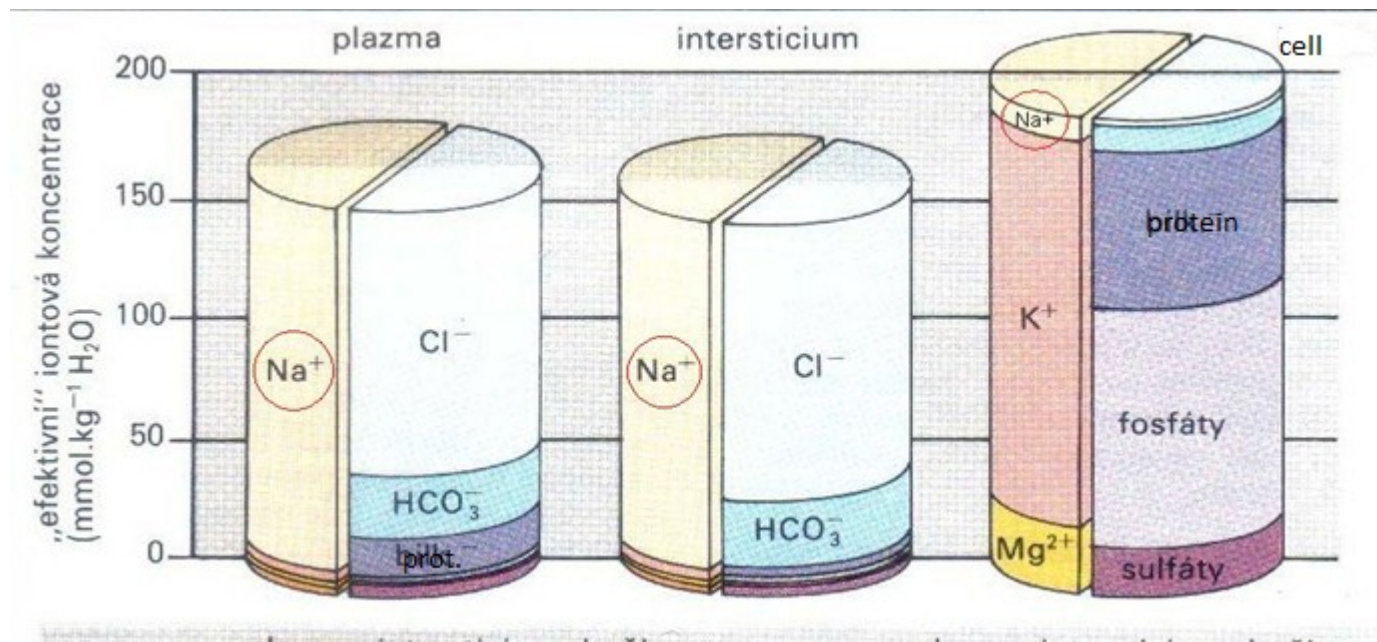


MU Brno a OKB FN Brno



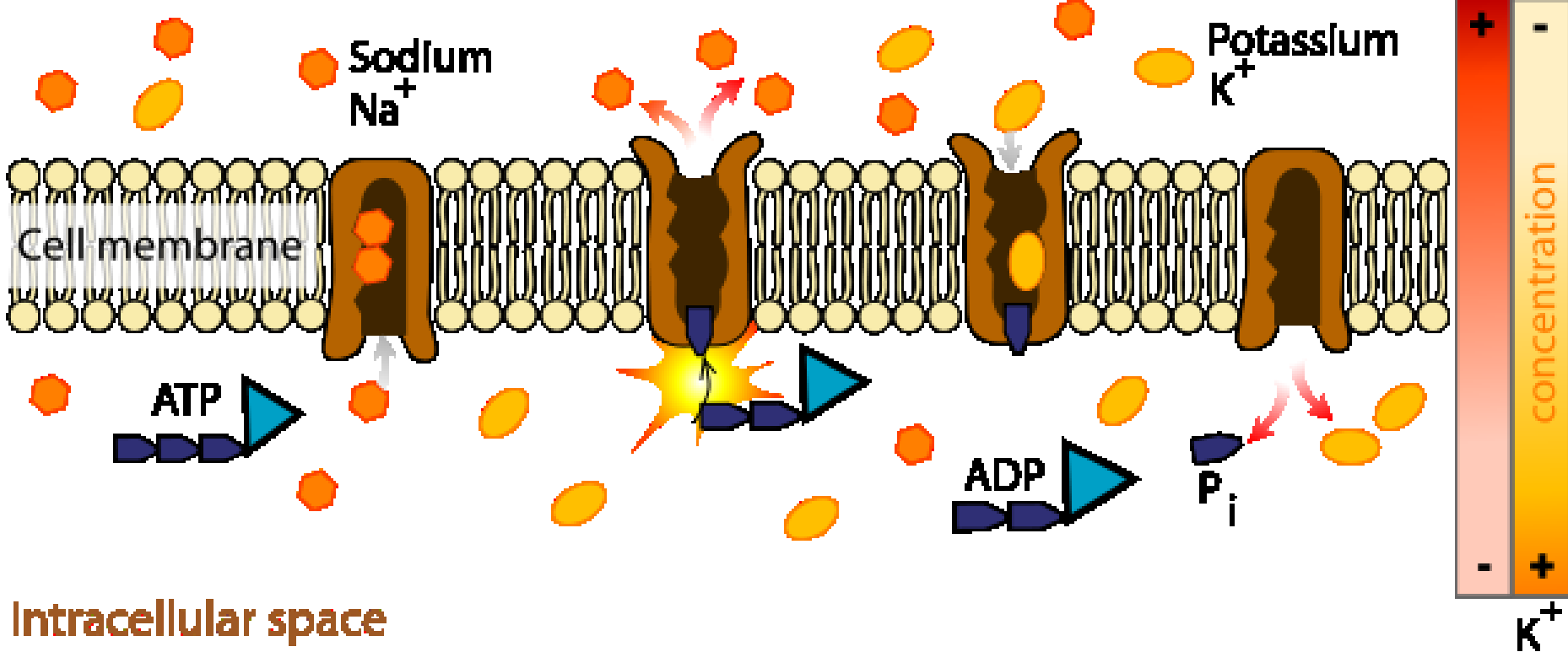
Sodium distribution in the body

- Na^+ is the major extracellular cation – 50 % of Na^+ is in the ECF, 40 % in the bones and 10 % in the ICF



Na⁺/K⁺ ATP-ase

Extracellular space



Intracellular space

The concentration gradient is maintained principally by the Na⁺/K⁺ pump

Total body water
Volume = 40 L
60% of body weight

Intracellular fluid (ICF)
Volume = 25 L
40% of body weight

Interstitial fluid (IF)
Volume = 12 L
80% of ECF

Plasma
Volume = 3 L, 20% of ECF

Extracellular fluid (ECF)
Volume = 15 L
20% of body weight

Assessment of natremia

➤ S-osmolality: $(2\text{Na}^+ + \text{glucose} + \text{urea})$ 285 mmol/kg

➤ Tonicity : $(2\text{Na}^+ + \text{glucose} + ?)$

➤ ADH: water reabsorption (convoluted tubulus)

➤ Aldosteron: adrena cortex – distal conv. tub.

reabsortion Na^+ (+ H_2O)

excretion K^+ , H^+

Sodium balance and distribution

Na⁺ concentration in plasma	135-145 mmol/l
Na⁺ concentration in cell	3-10 mmol/l
Na⁺ intake	140-260 mmol/24 hod (8-15 g NaCl)
Na⁺ renally excretion	120-240 mmol/24 hod
Na⁺ excretion via intestines	10 mmol/24 hod
Na⁺ excretion via sweat	10-80 mmol/24 hod
Na⁺ total excretion	140-260 mmol/24 hod

Hyponatremia

- The Na⁺ concentration in the serum is lower than **135 mmol/l**
- **Symptoms:** nausea and vomiting, headache, confusion, lethargy, muscle weakness, spasms, or cramps, seizures, and decreased consciousness or coma

01/11/2013	31/10/2013	30/10/2013	30/10/2013	29/10/2013
Na = 131-	Na = 122-	Na = 117-	Na = 111-	Na = 107-
K = 3.1-	K = 3.4-	K = 3.6	K = 4.2	K = 3.3-
Cl = 90-	Cl = 83-	Cl = 82-	Cl = 74-	Cl = 67-

mild	130-135 mmol/l
moderate	120-130 mmol/l
severe	< 120 mmol/l

Hyponatremia

$$\text{Osmolality} = 2\text{Na}^+ + \text{glucose} + \text{urea}$$

90%

Isotonic

pseudohyponatremia

Hypertonic

Manitol
Hyperglycemia
Ethylenglycol

Hypotonic

hypovolemic

hypervolemic

isovolemic

Hyponatremia

Isotonic

pseudohyponatremia

Plasma

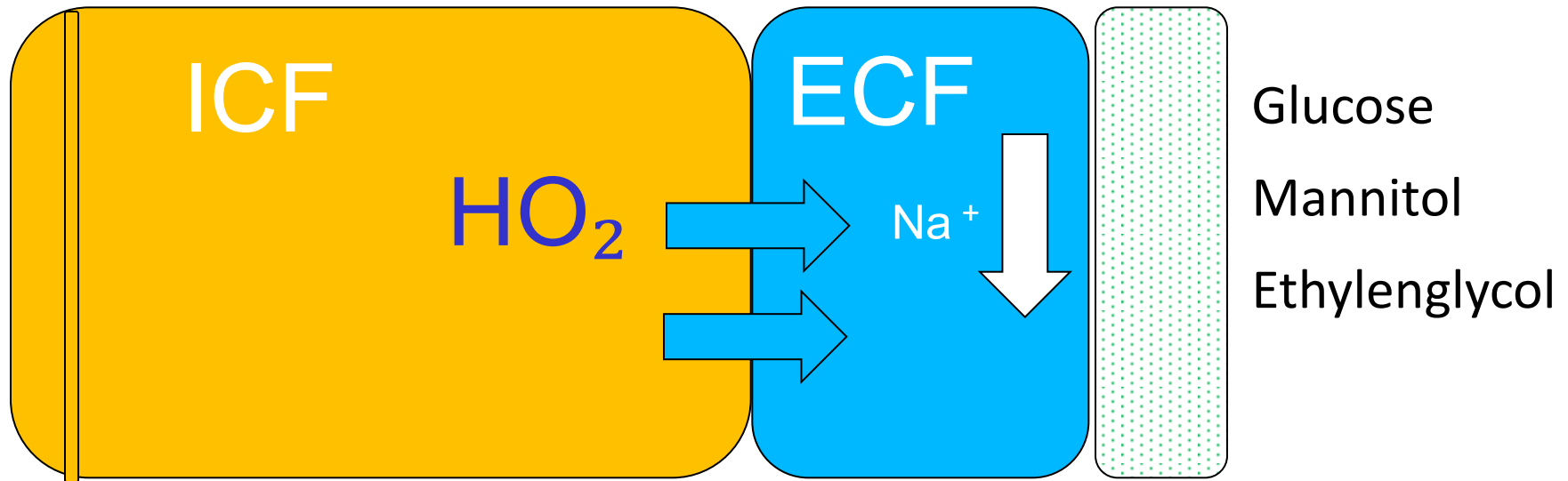
Water 93%

7%

Hyponatremia

Hypertonic

$$\text{Osmolality} = 2\text{Na}^+ + \text{glucose} + \text{urea}$$



NFOLAB - Kumulativní nález KOSÍKOVÁ HANA

855714/4222

06/08/2014 06/08/2014 06/08/2014 06/08/2014 06/08/2014 06/08/2014

Gluk= 50.3+

CRP = 2.8

Na = 120-

K = 5.8+

Cl = 66-

cPGl= 54.2+

cPGl= 54.0+

cPGl=> 33 mm

Udus=negativ

U-pH= 5.0

U-CB= 1

UGlu= 4+

UKet= 2+

UUro=normáln

UBil= 0

UKrv= 1

Leuk= 0

Uhus= 1.014-

esi

sociální fond v ČR EVROPSKÁ UNIE

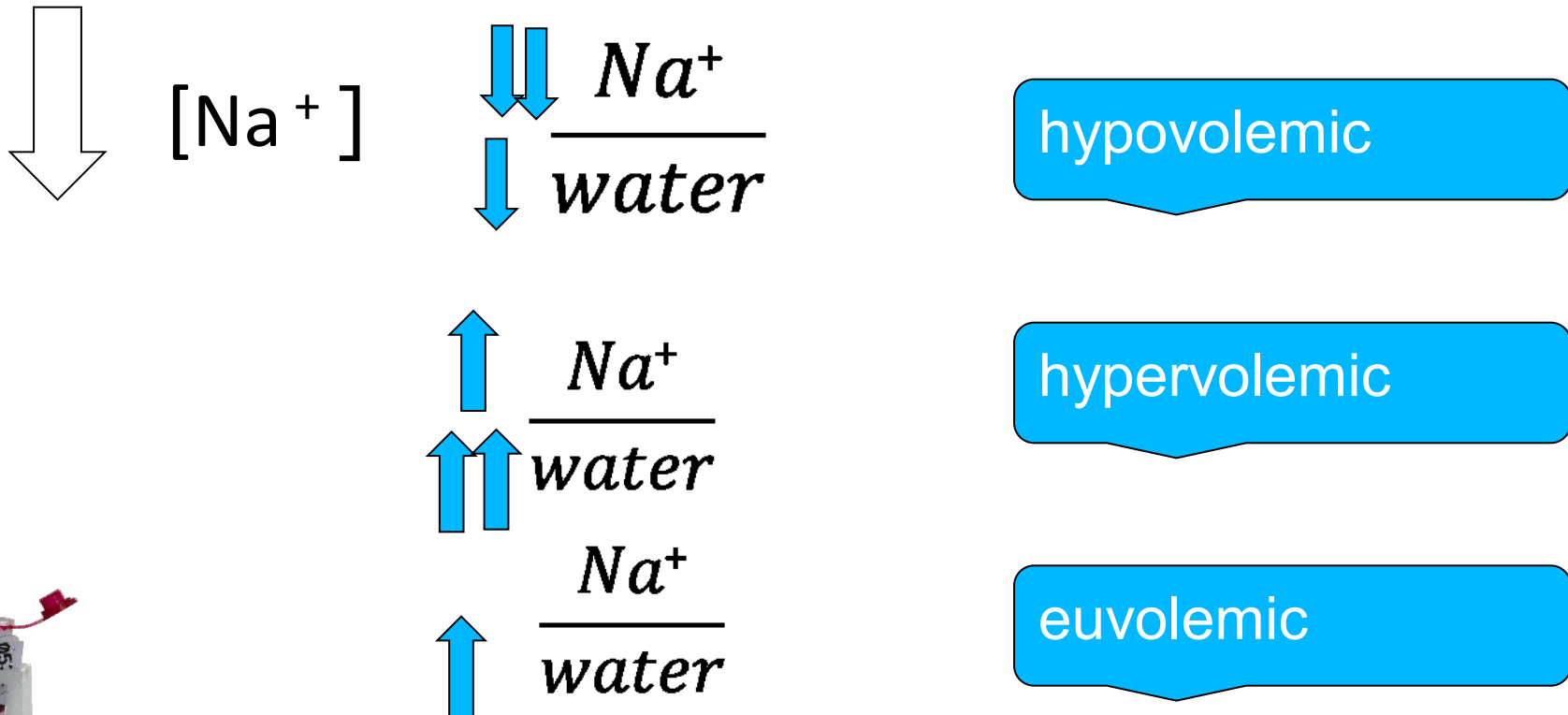
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

OP Vzdělávání pro konkurenceschopnost

Hyponatremia

Hypotonic

$$\text{Osmolality} = 2\text{Na}^+ + \text{glucose} + \text{urea}$$



Hypovolemic hypotonic hyponatremia

- Na^+ loss are bigger than loss of free water
- **Extrarenal loss**
 - diarrhea ,vomiting,burns
 - losses in the "third space" (ileus,peritonitis, fistulas, burns, etc.)
 - $\text{U-Na} < 10 \text{ mmol/l}$
- **Renal loss**
 - Diuretics
 - Aldosteron deficiency
 - $\text{U-Na} > 20 \text{ mmol/l}$
- **Signs**
 - Hemoconcentration,risk of kidney failure and blood circulation



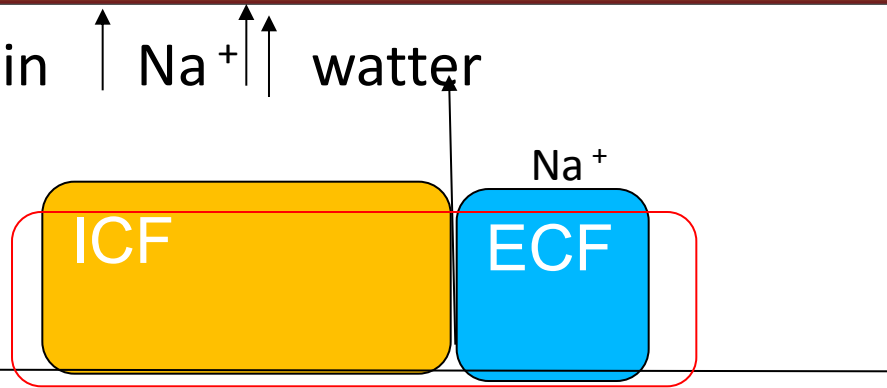
Therapy: isotonic NaCl

Hypervolemic hypotonic hyponatremia

➤ Weight gain ↑ Na⁺ ↑ water

➤ JVP ↑

➤ volume



➤ **Non renal:** U-Na <10 mmol/l

- Intravascular volume depletion

- Trigger – aldosteron, ADH

- Cirrhosis, heart failure, nephrotic syndrome with the development of edema (hypoalbuminemia)

Renal: U-Na >20 mmol/l

Acute renal failure

Therapy: fluid restriction, water restriction, diuretics

Isovolemic hypotonic hyponatremia

- No volume change
- 
- The diagram illustrates the relationship between Intracellular Fluid (ICF) and Extracellular Fluid (ECF) volumes. A yellow rounded rectangle labeled 'ICF' is on the left, and a blue rounded rectangle labeled 'ECF' is on the right. A horizontal line below them is labeled 'volume'. A vertical double-headed arrow between the two boxes is labeled 'Na+' on the left and 'watter' on the right, indicating the exchange of these substances between the compartments.

- volume

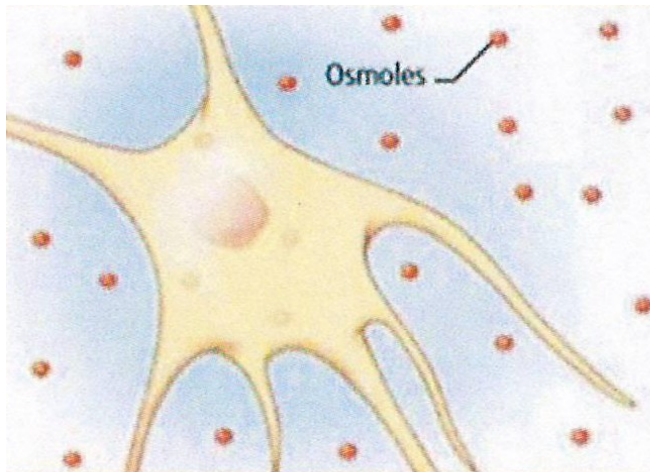
- **Syndrome of inappropriate antidiuretic hormone secretion (SIADH)**

- secretion of substances with effect ADH –brain trauma, lung cancer

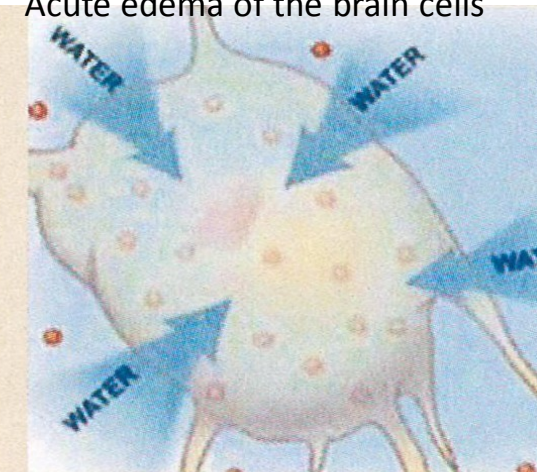
Therapy: water restriction

Normal status

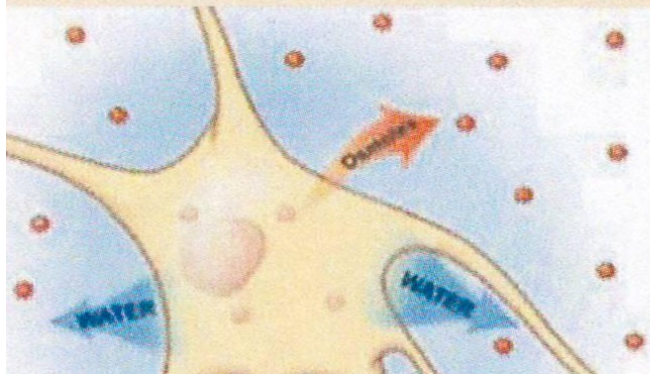
Acute hyponatremia



Acute edema of the brain cells



Adaptace



Osmotická demyelinizace při rychlé korekci hyponatremie

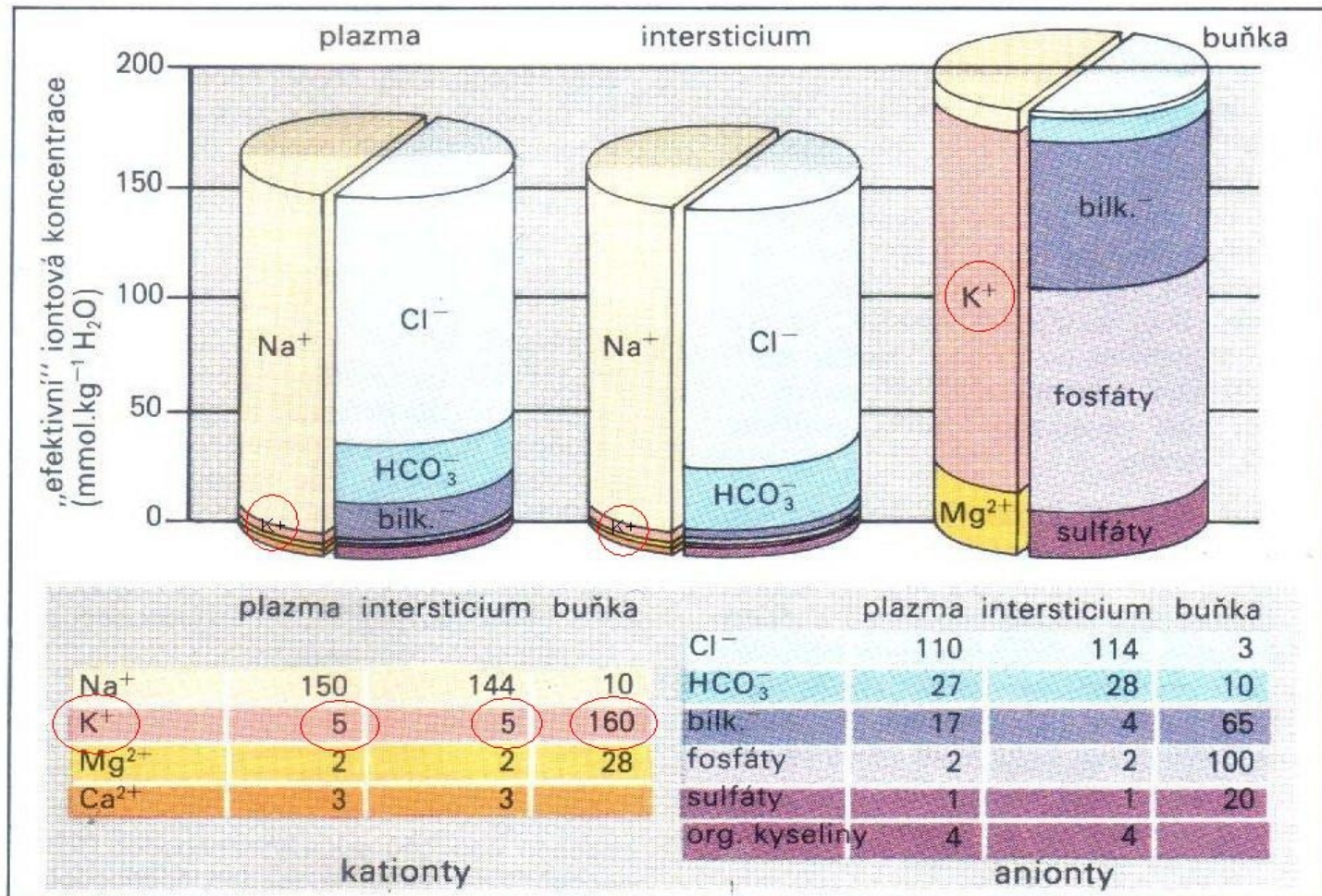


01/11/2013	31/10/2013	30/10/2013	30/10/2013	29/10/2013
Na = 131-	Na = 122-	Na = 117-	Na = 111-	Na = 107-
K = 3.1-	K = 3.4-	K = 3.6	K = 4.2	K = 3.3-
Cl = 90-	Cl = 83-	Cl = 82-	Cl = 74-	Cl = 67-



Distribution of the body's potassium

- K^+ is the main intracellular cation – at least 95% of the body's potassium is found inside the cells



Potassium physiology

- daily intake about 100 mmol (3-4g)
- 90 % urine excretion, 10 % excretion by stool
- cell concentration 100-160 mmol/l
- in plasma 3,8-5,2 mmol/l – **K⁺ is pH dependent!**

pH	K ⁺ in plasma (mmol/l)
6,8	6,5-7,5
7,1	5,5-6,5
7,3	5,2
7,4	4,5
7,5	3,8
7,7	3,5

[/ D / M / R = H . M]

Číslo, datum.. 5375/10/12/2013-23.16
 Oddělení..... 3124 F10 Zo..E
 Rodné číslo..905209/4183
 Jméno.....DIVIŠOVÁ BARBORA
 Diagnóza.....R55
 Pojišťovna...207
 Lékař.....72100516
 Komentář...>.k7 :HEMOLÝZA!
 —Dat.nar.——— 9/ 2/1990-Ž-(M/Ž)——
 F9 VYŠETŘENÍ.....

Na = 133-	ALT = 0.47	AKR =* Metod
K = 6.0+	AST = 0.66+	PSM =318.00
Cl = 95-	GGT = 0.74+	
Ca = 2.43	ALP = 2.16+	
P = 2.29+	CRP = 7.3+	
Mg = 0.99	SIH = 81.00+	
Urea= 8.0	SIL = 20.00	
Krea= 74	SII = 11.00	
BilT= 5.8	PrVz= 1.00	
Gluk= 30.5+	TAT = 39	

[/ D / M / R = H . M]

Číslo, datum.. 5855/10/12/2013-23.40
 Oddělení..... 1231 F10 Zo..E
 Rodné číslo..905209/4183
 Jméno.....DIVIŠOVÁ BARBORA
 Diagnóza.....E130
 Pojišťovna...207
 Lékař.....72100170
 Komentář...>.

—Dat.nar.——— 9/ 2/1990-Ž-(M/Ž)——
 F9 VYŠETŘENÍ.....

BD -= 28.7+
 ABRv=:
 pHv = 6.89-
 pCO2= 2.4-
 pO2 = 17.3+
 HCO3= 3.4-
 sO2v= 0.931+

Potassium balance and distribution

K⁺ concentration in plasma	3,8-5,2 mmol/l
K⁺ concentration in cell	100-160 mmol/l
K⁺ concentration in urine	30-80 mmol/l
intracellular reserve	3200 mmol
extracelullular reserve	60 mmol
K⁺ intake	50-100 mmol/24 h.
K⁺ excretion	50-100 mmol/24 h.

Hypokalemia

- serum K^+ concentration is less than **3,5 mmol/l**
- **Causes:**
 - increased potassium loss (vomiting, diarrhea, diuretics),
 - shift of potassium into cells (insulin, alkalosis)
 - insufficient intake

mild	3,0-3,5 mmol/l
moderate	2,5-3,0 mmol/l
severe	< 2,5 mmol/l

Hypokalemia

➤ Barter syndrom

18/07/2006	19/12/2005	01/04/2005	10/02/2005	07/01/2005	20/12/2004
Na = 139	Na = 141	Na = 142	Na = 140	Na = 140	Na = 135
K = 3.3-	K = 3.4-	K = 3.4-	K = 2.6-	K = 2.5-	K = 2.7-
Cl = 96-	Cl = 99	Cl = 103	Cl = 100	Cl = 94	Cl = 93-

Chronic malnutrition, vomiting, ethylism

21/10/2013	21/10/2013	21/10/2013	20/10/2013	20/10/2013	10/10/2013
Na = 128-	Na = 128-	Na = 133-	Na = 127-	Na = 126-	Na = 125-
K = 3.5	K = 2.0-	K = 7.7+	K = 1.8-	K = 1.7-	K = 5.0
Cl = 92-	Cl = 90-	Cl = 105	Cl = 86-	Cl = 83-	Cl = 95-

Hyperkalemia

- value K⁺ in serum is greater than **5,5 mmol/l**

mild	5,5-6,5 mmol/l
moderate	6,5-7,5 mmol/l
severe	> 7,5 mmol/l



Causes of hyperkalemia

- Renal insufficiency
- Endocrine disorders (↓ aldosterone – M.Addison)
- Massive cellular lysis - burns, trauma, chemotherapy, bleeding in the intestines
- Movement from the cells into the blood plasma during acidosis
- Excessive dietary intake (in patients with oliguria or anuria)

Na = 143	ALT = 0.32
K = 6.6+	AST = 0.20
Cl = 103	GGT = 0.11
Ca = 2.35	ALP = 0.84
P = 2.14+	LD = 2.98
Urea= 31.8+	CK = 2.78+
Krea= 1013+	AMS = 1.62
KM = 401+	CB = 72.0
BilT= 3.5	Alb = 40.2
Gluk= 3.9	CRP = < 1.0

Pseudohyperkalemia

- is a rise in the amount of potassium that occurs due to excessive leakage of K^+ from cells during or after blood is drawn

- **Causes:**
 - Excessive tourniquet time
 - late centrifugation of blood
 - rough handling of the sample (e.g. shaking)
 - leukocytosis ($> 50 \cdot 10^9/l$)
 - trombocytosis ($> 750-1000 \cdot 10^9/l$)



Polycytemia vera- pseudohyperkalemia

14.11. 3,5 mmol/l – **plasma** Li-heparin, transport by hand

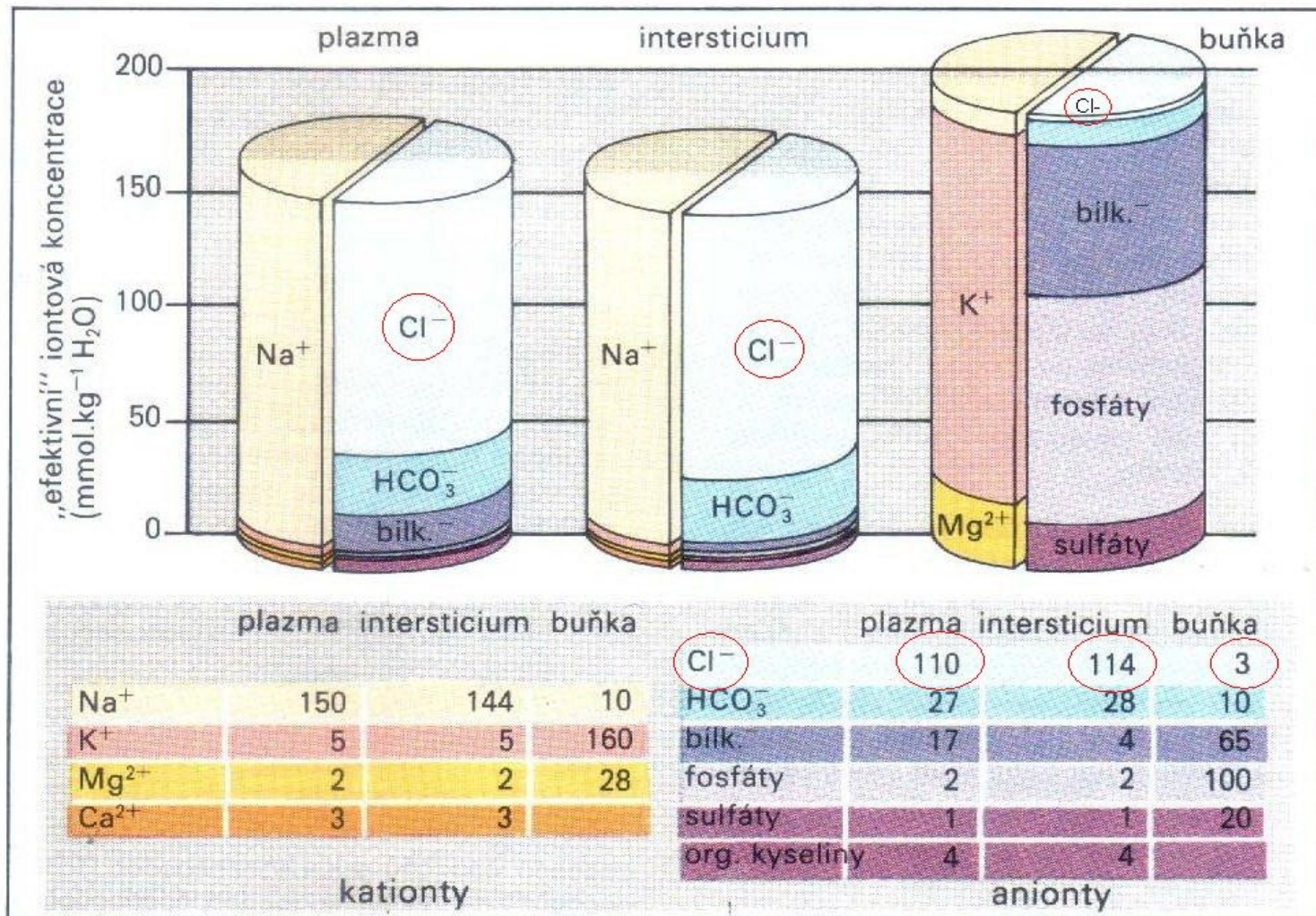
14.11. 8,9 mmol/l – **serum**, transport by hand

INFOLAB - Kumulativní nálezn RŮŽIČKOVÁ MARIE 536003/167 SLABÁ HEMOLÝZA!

14/11/2013	14/11/2013	14/11/2013	14/11/2013	14/11/2013	14/11/2013
Na = 129-	Na = 124-		Na = 125-		Urea= 14.8+
K = 3.5	K = 8.9+		K = 8.1+		Krea= 110+
Cl = 96-	Cl = 95-		Cl = 97-		Na = 129-
					K = 7.2+
					Cl = 97-

Distribution of the body's chloride

- Chloride is the main extracellular anion



Chloride balance and distribution

Cl⁻ concentration in plasma	98-107 mmol/l
Cl⁻ concentration in cell	3 mmol/l
Cl⁻ intake	140-260 mmol 24/hod (8-15 g NaCl)
Cl⁻ renally excretion	120-240 mmol/24 hod
Cl⁻ excretion via intestines	10 mmol/24 hod
Cl⁻ excretion via sweat	10-80 mmol/24hod
Cl⁻ total excretion	140-260 mmol/24 hod

Hypochloremia

- is an electrolyte disturbance in which there is an abnormally low level of the chloride ion in the blood ($< 98 \text{ mmol/l}$)
- accompanied hypochloremic alkalosis, hypokalemia, and usually hyponatremia

Causes:

➤ Non renal:

- intestinal secretions loss – vomiting, fistula in proximal part of GIT

➤ Renal:

- increased renal excretion of Cl - polyuric-stage renal failure, a massive treatment saluretics

- **Treatment:** correcting the underlying cause



Hyperchloremia

- is an electrolyte disturbance in which there is an abnormally elevated level of the chloride ion in the blood (> 107 mmol/l)
- also develops metabolic acidosis and hypernatremia
- **Causes:** infusion therapy, diarrhea, certain kidney diseases (e.g. renal tubular acidosis), over activity of the parathyroid glands etc.
- **Treatment:** correcting the underlying cause (hydratation, discontinued infusion therapy atc.)



Specimen contaminated by i.v. medication (F1/1 + Novalgin)

INFO LAB - Kumulativní nález NAVRÁTIL JIŘÍ		541223/3684 SLABE		
11/07/2014	11/07/2014	08/07/2014	07/07/2014	07/07/2014
Urea= 27.7+	Urea= 18.2+	Urea= 24.0+		Urea= 23.4+
Krea= 293+	Krea= 15-	Krea= 263+		Krea= 74
			Chol= 1.3-	
			CB = 48.5-	
		Gluk= 6.0+		
			Alb = 20.7-	
CRP = 221.0+	CRP = 119.4+	CRP = 242.2+		CRP = 238.8+
		Ca = 2.00-		
Na = 134-	Na = 150+	Na = 140		Na = 144
K = 3.3-	K = 2.1-	K = 2.9-		K = 3.4-
Cl = 104	Cl = 122+	Cl = 114+		Cl = 115+
		Mg = 0.59-		
PrVz= 1.00	PrVz= 1.00	PrVz= 1.00	PrVz= 1.00	PrVz= 1.00
SIH = 1.00	SIH = 0.00-	SIH = 0.00-	SIH = 0.00-	SIH = 9.00
SIL = 64.00+	SIL = 47.00+	SIL = 42.00+	SIL = 4.00	SIL = 74.00+
SII = 3.00	SII = 0.00-	SII = 5.00	SII = 5.00	SII = 2.00