HUMAN PHYSIOLOGY

Introduction to Physiology

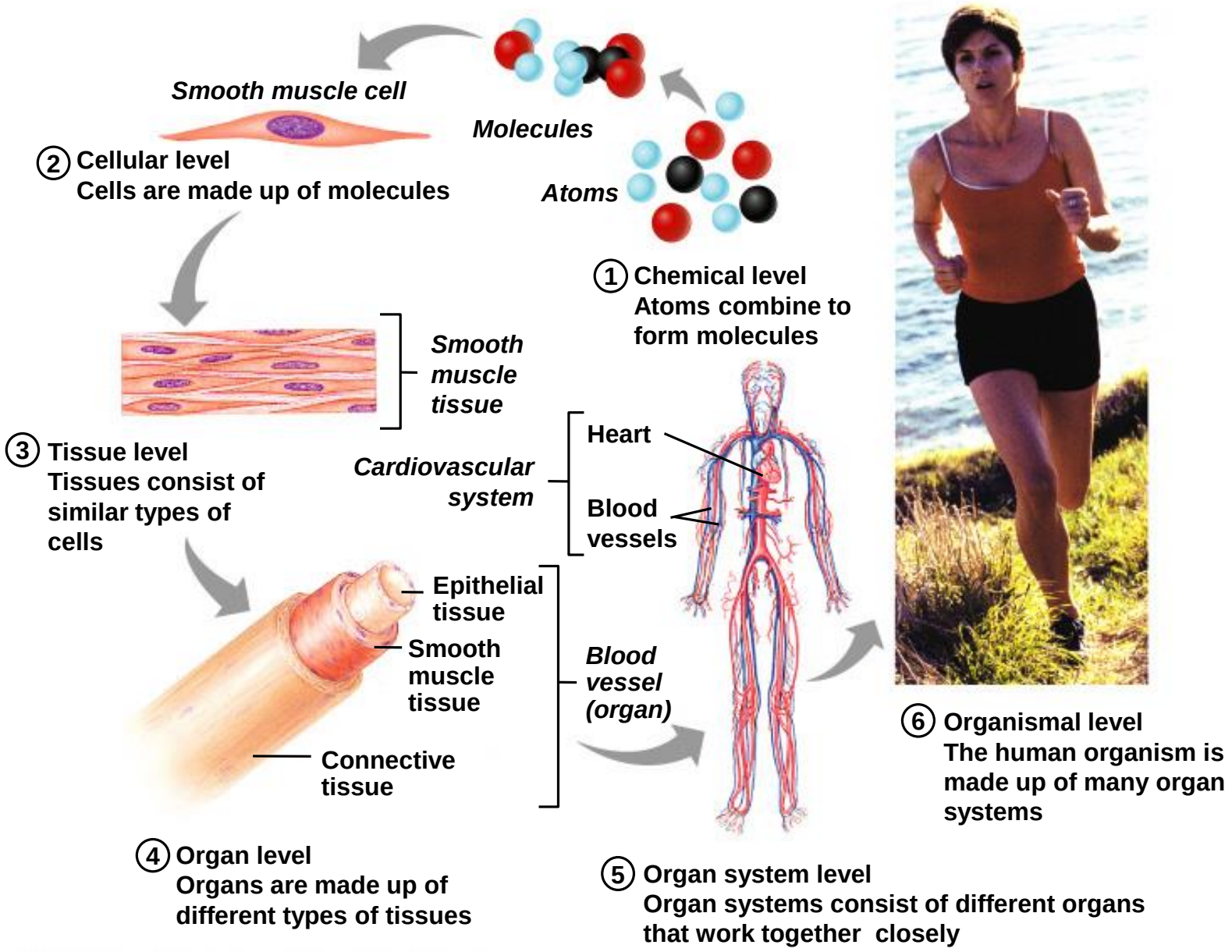
- **Physiology is one of the cornerstones of medicine.**

- **Physiology is the study of how the body works, the ways in which cells, organs and the whole body functions, and how these functions are maintained in a changing environment.**

- **Cellular physiology is the study of the cellular components that primarily determines organ function.**

- **Systems physiology is the study of the coordinated and networked processes that determine whole body function and adaption to change.**

Levels of Structural Organization



Body Fluids

objectives

At the end of this session, the students should be able to:

- **Identify and describe daily intake and output of water and maintenance of water balance.**
- **List and describe of body fluid compartments as intra-cellular fluid (ICF) Extra-cellular fluid A(ECF), interstitial fluid, trans-cellular fluid and total body water.**
- **Describe the composition of each fluid compartment, in terms of volume and ions and represent them in graphic forms.**
- **Identify and describe Physiology factor influencing body fluid: age, sex, adipose tissue, etc. Pathological factors: Dehydration, fluid infusion.**

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DEPARTMENT OF CLINICAL BIOCHEMISTRY

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Location: (MED) Medical Department
Doctor:UNKNOWN *

Sex:F
DOB:22 Sep 86

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Serum

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			Urea and Electrolytes		
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135 - 145	mmol/L	[*]	Sodium	141.0	
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98 - 107	mmol/L	[*]	Chloride	102.0	
22 - 32	mmol/L	[*]	Bicarbonate	26.0	
			Liver Function test profile		
3 - 17	umol/L	[*]	Total Bilirubin	5	
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60 - 80	g/L	[*]	Total Protein	72.2	
30 - 50	g/L	[*]	Albumin	43.0	
50 - 136	U/L	[*]	Alkaline Phosphatase	83.0	
20 - 65	U/L	[*]	Alanine Aminotransferase	23.0	
10 - 31	U/L	[*]	Aspartate Aminotransferase	12.0	
5 - 55	U/L	[*]	Gamma Glutamyl Transferase	17.0	
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2 - 17	umol/L	[*]	Indirect Bilirubin	3	
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0.4 - 1.48	mmol / L	[*]	Triglycerides	0.49	
3.2 - 5.2	mmol / L	[ ]>	Cholesterol	6.40	H
0.93 - 1.94	mmol / L	[*]	HDL-Cholesterol	1.72	
1.63 - 3.63	mmol / L	[ ]>	LDL - Cholesterol	4.46	H

PLS. NOTE THE NEW NORMAL RANGES

RECOMMENDED LEVEL FOR TOTAL SERUM CHOLESTEROL < 5.2 mmol/L

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EDTA Whole Blood

Full Blood Count

[*]	WBC	7.1	4 - 11	x10.e9/L
[*]	RBC	4.78	4.2 - 5.5	x10.e12/L
[*]	HGB	145	120 - 160	g/L
[*]	HCT	42.1	37 - 47	%
[*]	MCV	88.0	80 - 94	fl
[*]	MCH	30.3	27 - 32	pg
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Differential

[*]	%NEUT	60.5	40 - 75	%
[*]	%LYMP	31.3	20 - 45	%
[*]	%MONO	4.6	3 - 9	%
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Morophology

Flag Comments
Flag Comment 1
ANISO .....
MICRO .....
MACRO .....
POIKILO .....
HYPO .....
Polychromasia .....
LSHIFT .....

EQUEST COMMENTS:

- **Human body contains 50-70% water.**
- **E.g.:**
- **70 kg man has 42 L of water.**
- **Kg of water = L of water.**

FACTORS AFFECTING

Infant: 70%

Male adult: 60%

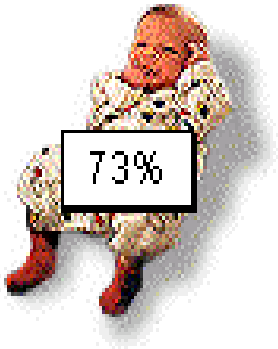
Female adult: 40-50%

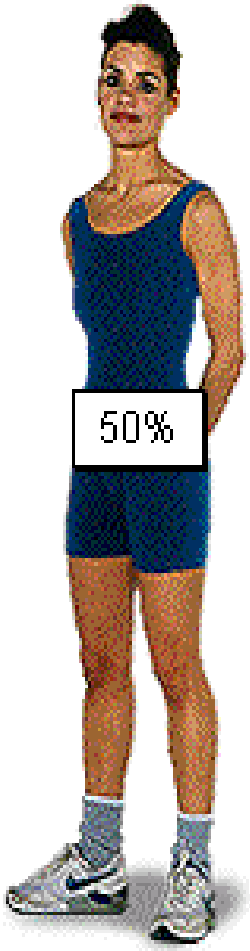
Obesity

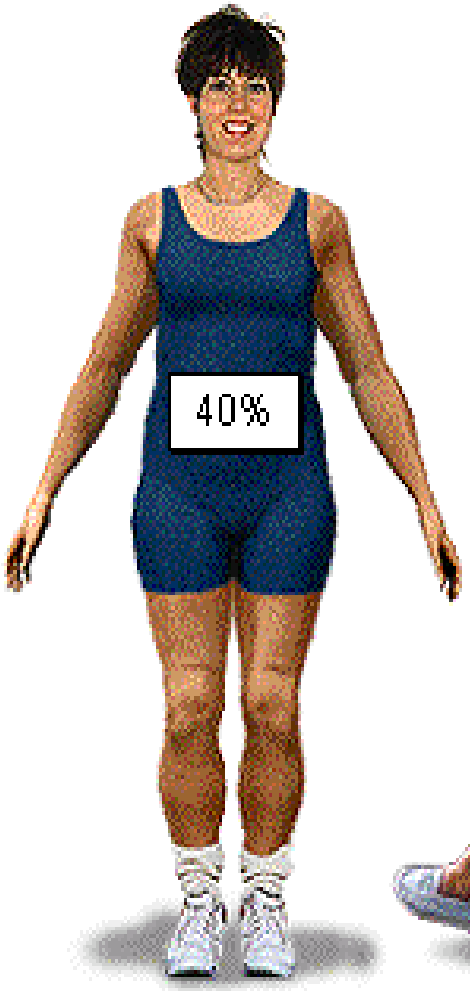
Old age 45%

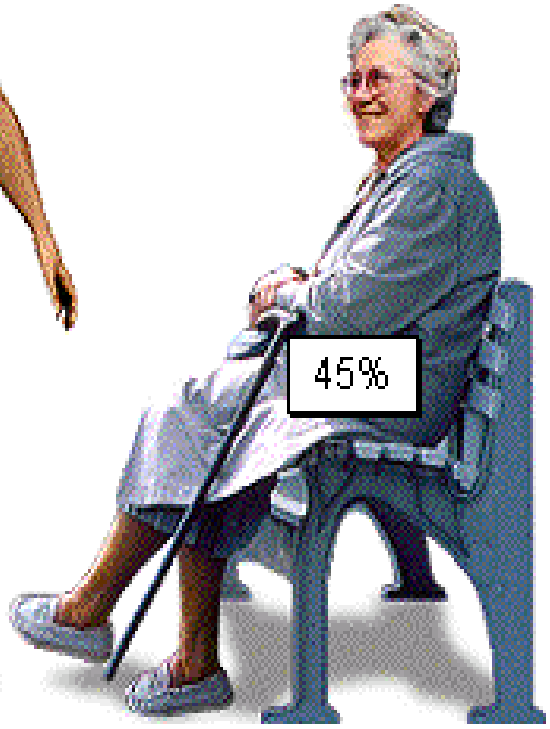
Percentage of Water in the Body

Click each of the people below to determine the approximate percentage of water in their bodies.









Body Water Content

- **Infants** have low body fat, low bone mass, and are 70% or more water

- Healthy **males** are about 60% water; healthy **females** are around 50%
- This difference reflects females':
  - Higher body fat
  - Smaller amount of skeletal muscle

- In **old age**, only about 45% of body weight is water

- Total water content declines throughout life.

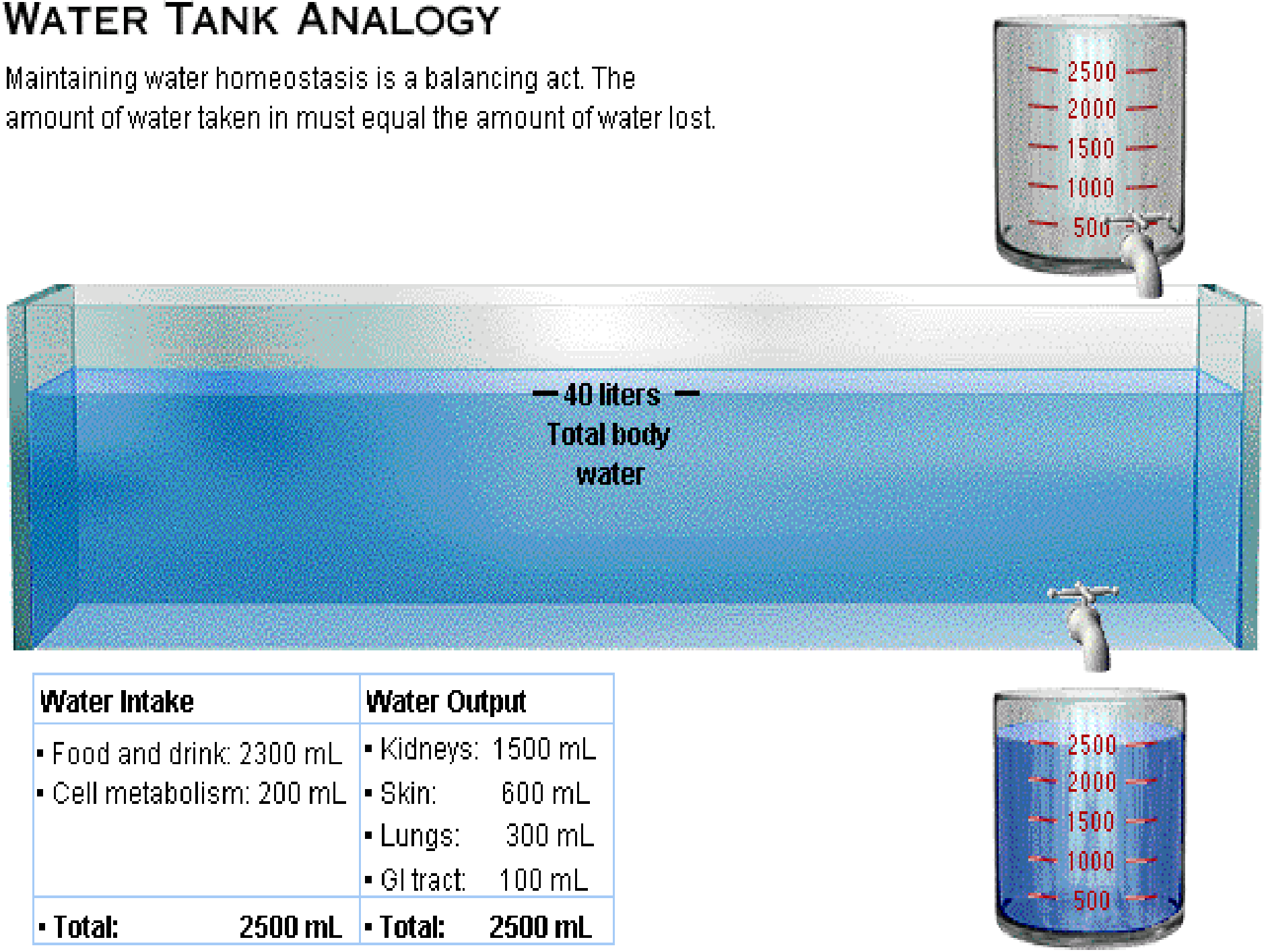
Daily intake of water

TABLE 20–1 DAILY INTAKE AND OUTPUT OF WATER (in ml/day)

	Normal	Prolonged, Heavy Exercise
Intake		
Fluids ingested	2100	?
From metabolism	200	200
Total intake	2300	?
Output		
Insensible—Skin	350	350
Insensible—Lungs	350	650
Sweat	100	5000
Feces	100	100
Urine	1400	500
Total output	2300	6600

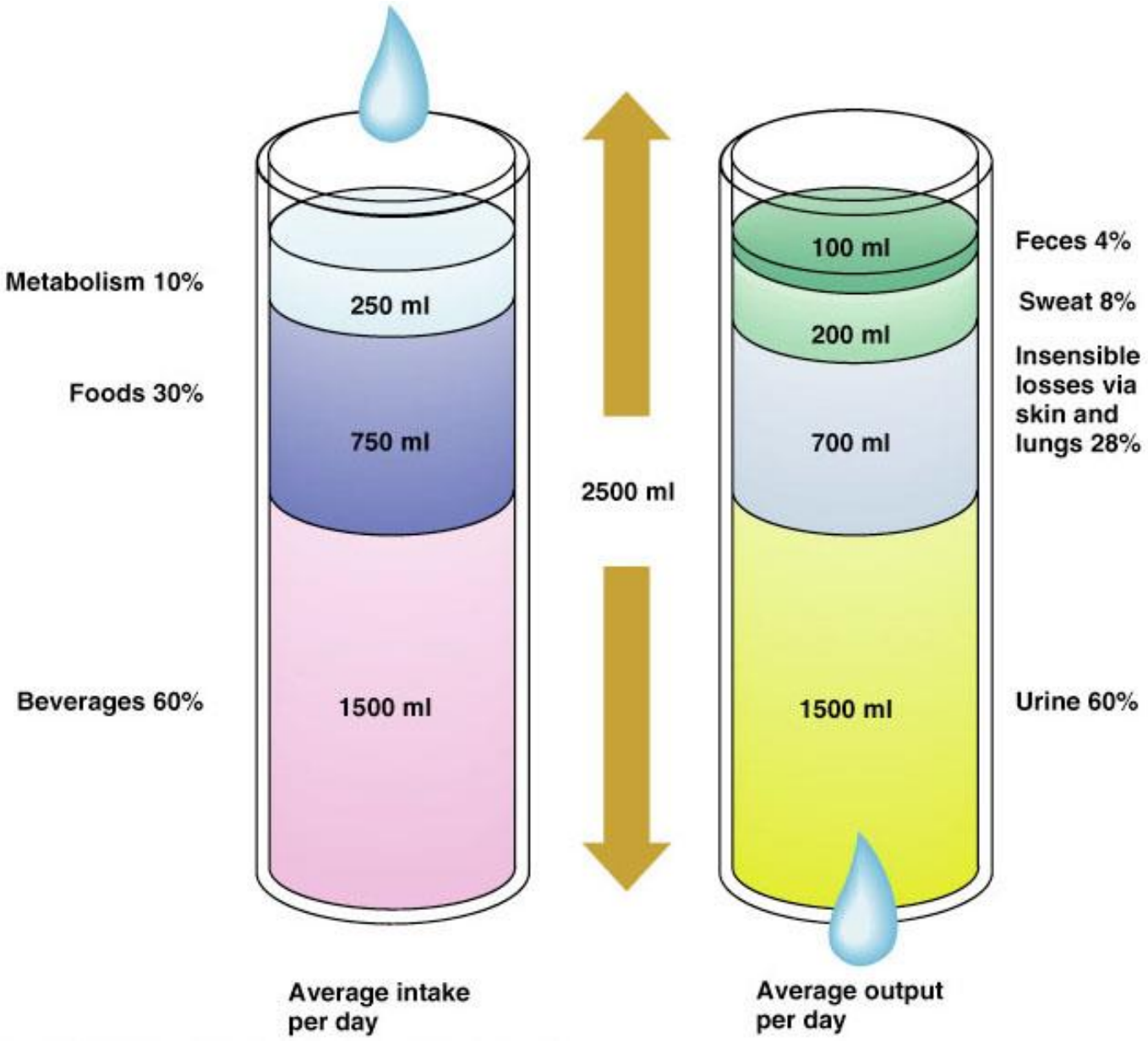
Water Tank Analogy

Maintaining water homeostasis is a balancing act. The amount of water taken in must equal the amount of water lost.



Water Intake	Water Output
• Food and drink: 2300 mL • Cell metabolism: 200 mL	• Kidneys: 1500 mL • Skin: 600 mL • Lungs: 300 mL • GI tract: 100 mL
• **Total: 2500 mL**	• **Total: 2500 mL**

Water Intake and Output



Regulation of Water Intake

Climate

Habits

Level of physical activity.

- The **hypothalamic thirst center** is stimulated:
  - By a decline in plasma volume of 10%–15%
  - By increases in plasma osmolality of 1–2%

  - **In steady state water intake= water loss**

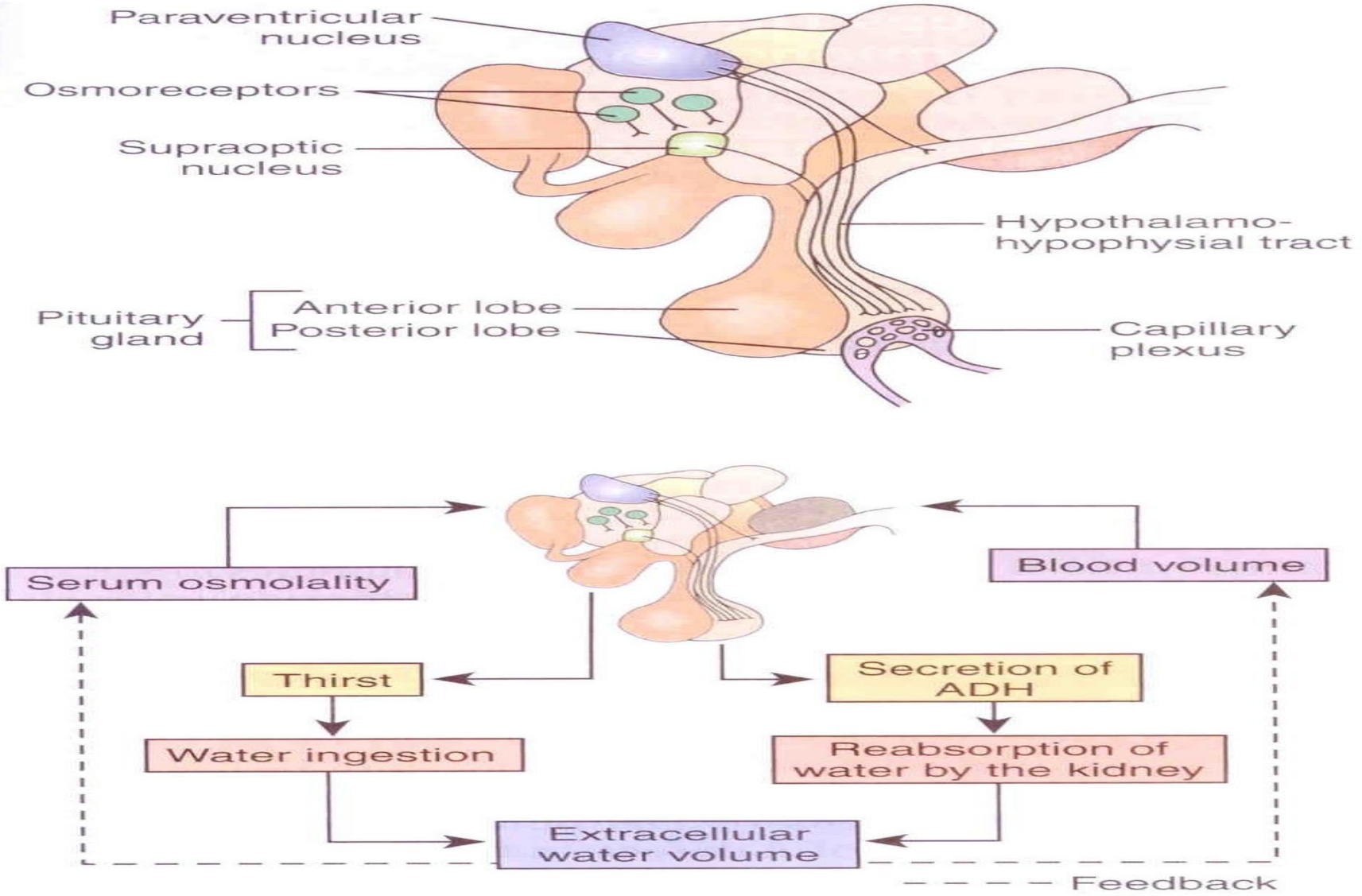


FIGURE 31-7 • (**Top**) Sagittal section through the pituitary and anterior hypothalamus. Antidiuretic hormone (ADH) is formed primarily in the supraoptic nucleus and to a lesser extent in the paraventricular nucleus of the hypothalamus. It is then transported down the hypothalamohypophysial tract and stored in secretory granules in the posterior pituitary, where it can be released into the blood. (**Bottom**) Pathways for regulation of extracellular water volume by thirst and ADH.

Factors that affect the TBW

Physiological factors

- Age
- Sex
- Body fat
- Climate
- Physical activity

Pathological factors

Vomiting

Diarrhea

Diseases with excessive loss of water (DM, excessive sweating,....

Blood loss

Fluid Compartments

- **Water occupies two main fluid compartments:**
- **Intracellular fluid (ICF)**
- **Extracellular fluid (ECF)**
  - **Plasma**
  - **Interstitial fluid (IF)**

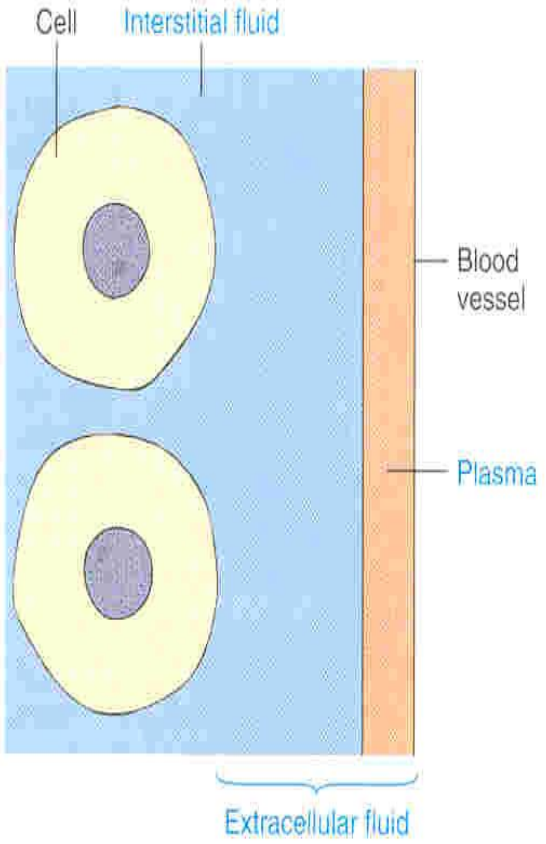


FIGURE 1-2

Fluid Compartments

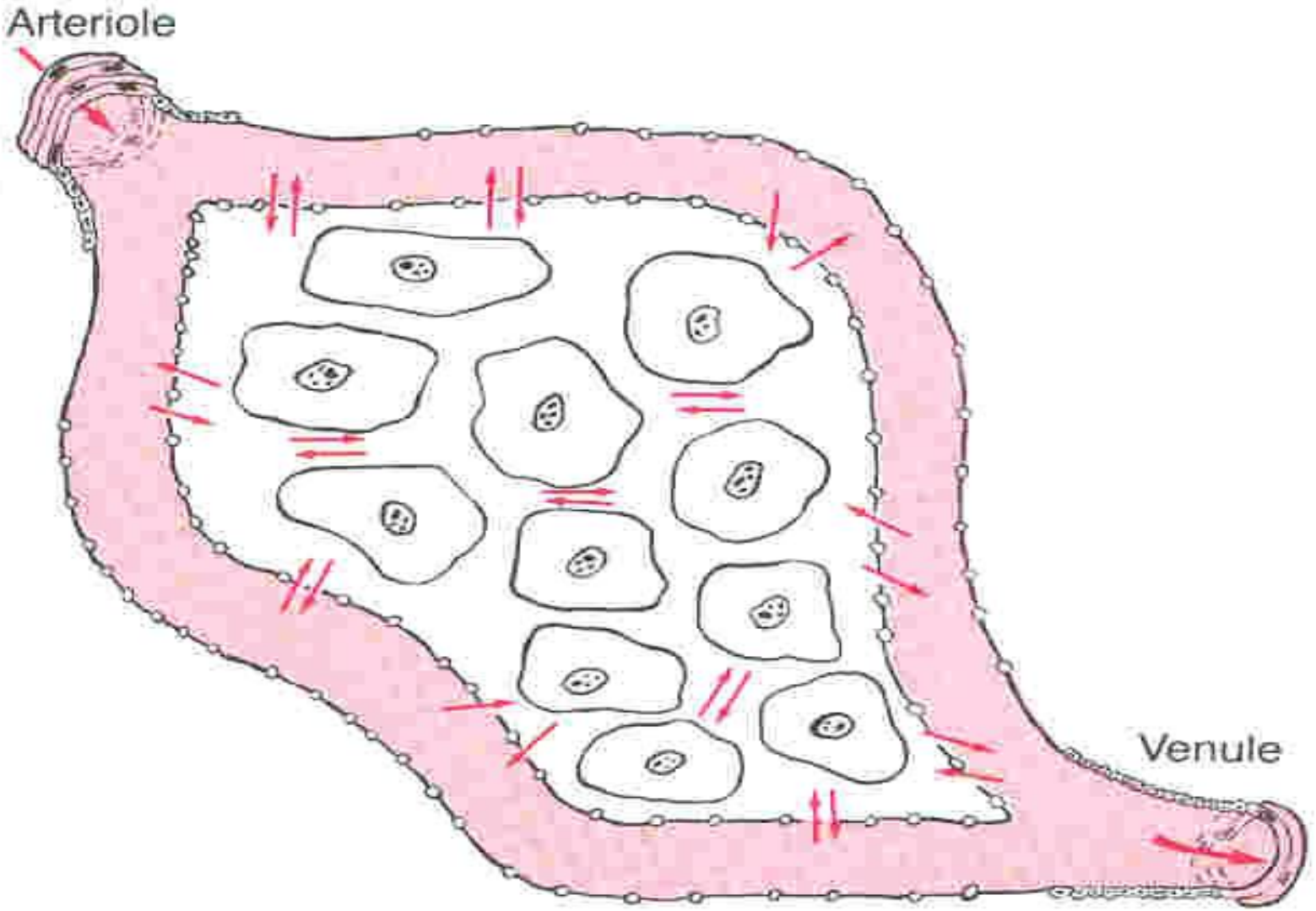
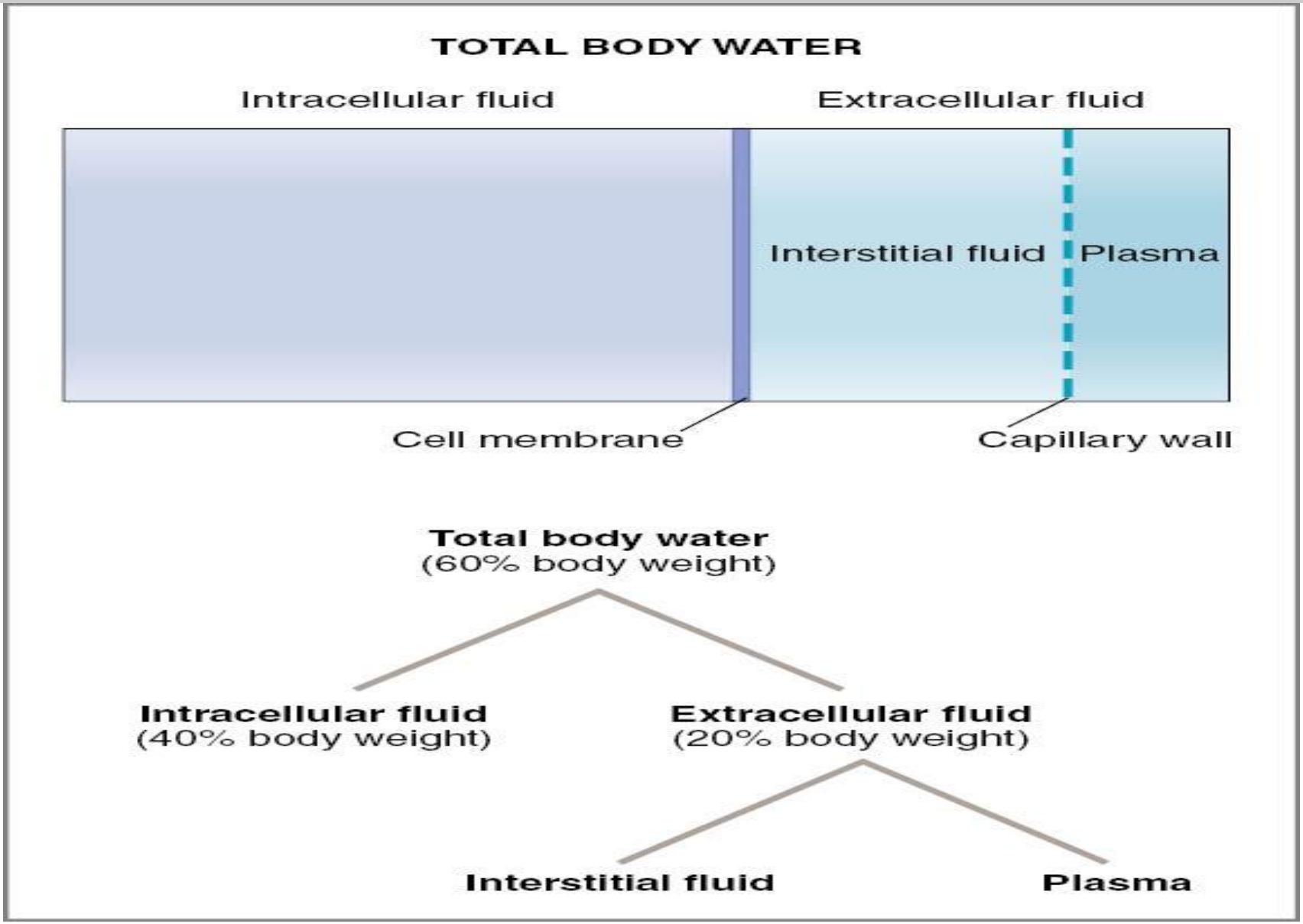
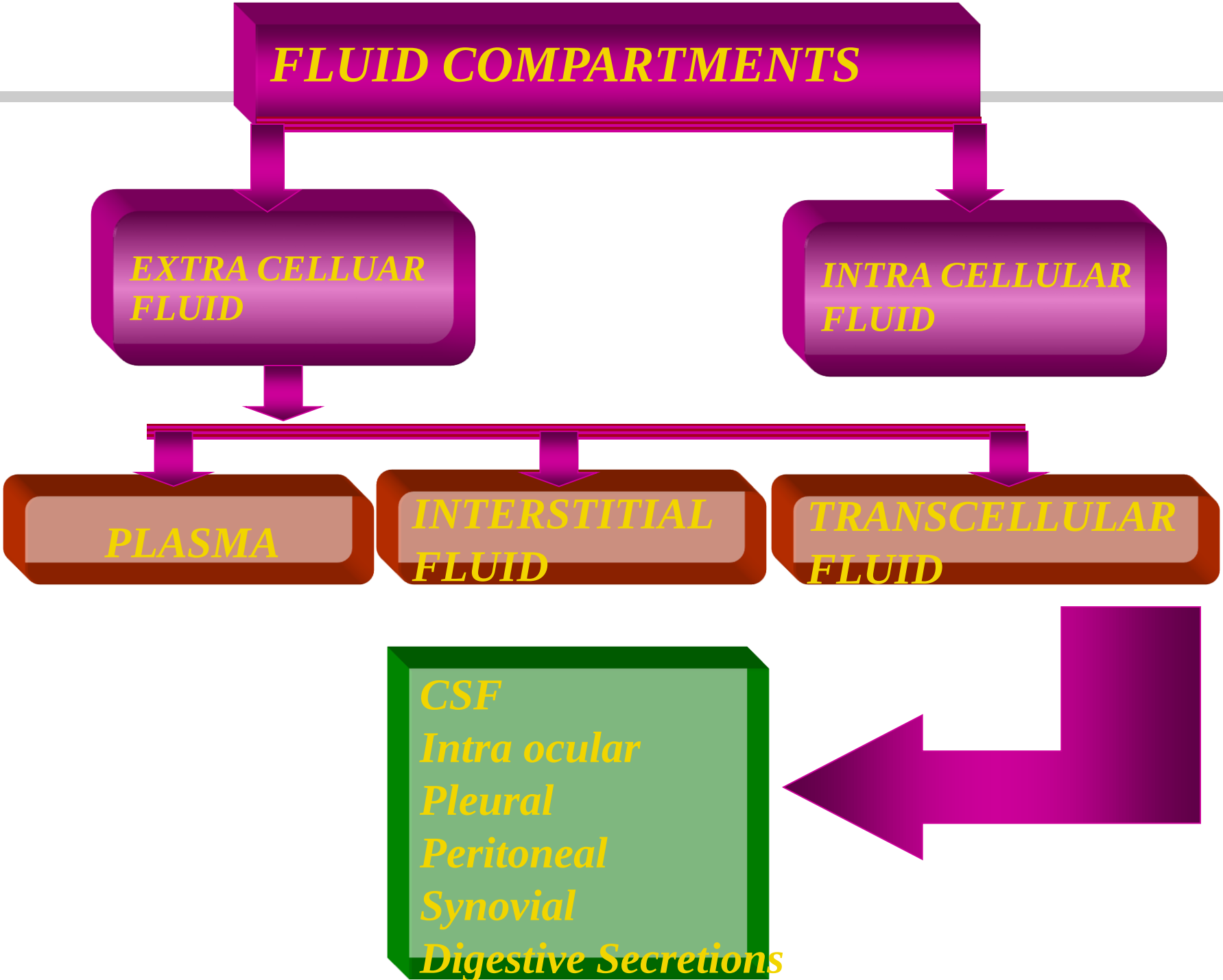


Figure 1–2 Diffusion of fluids through the capillary walls and




FLUID COMPARTMENTS
EXTRA CELLUAR FLUID
INTRA CELLULAR FLUID
PLASMA
INTERSTITIAL FLUID
TRANSCELLULAR FLUID
CSF
Intra ocular
Pleural
Peritoneal
Synovial
Digestive Secretions

Intracellular fluid (ICF)

- **Inside the cell.**
- **2/3 of TBW.**
- **High concentration of protein.**

Extracellular fluid (ECF)

Out side the cell.

1/3 of TBW.

1- Plasma:

Fluid circulating in the blood vessels.

1/4 of ECF

2- Interstitial fluid:

Fluid bathing the cell.

Ultra filtration of plasma.

3/4 of ECF

- **Plasma and interstitial fluid are almost having the same composition except for high protein concentration in plasma**

Trancecellular fluid compartment:

- **Small amount.**

CSF, GIT fluid, biliary fluid, synovial fluid, intrapelural fluid, intraperitoneal fluid, pericardial fluid and intraoccular fluid.

e.g.

- **TBW = 42L.**
- **ECF = 14L.**
- **ICF = 28L.**
- **Plasma = 3,5 L.**
- **Interstitial = 10,5 L.**

Composition of Body Fluids

- **Water** is the universal solvent

- **Solutes** are broadly classified into:
  - **Electrolytes** – inorganic salts, all acids and bases, and some proteins
  - **Nonelectrolytes** – examples include glucose, lipids, creatinine, and urea

  - Amount = in **moles, osmoles.**

concentration

1- Molarity = moles/liter M/L.

2- Osmolarity = osmoles/liter osm/L.

3- Osmolality = osmoles/kg Osm/kg.

In biological solutions:

- **Millimoles per liter (mM/L)**
- **Milliosmoles per (mOsm/L)**
- **1mM=1/1000 M**
- **1mOsm=1/1000 Osm**

Constituents of ECF and ICF

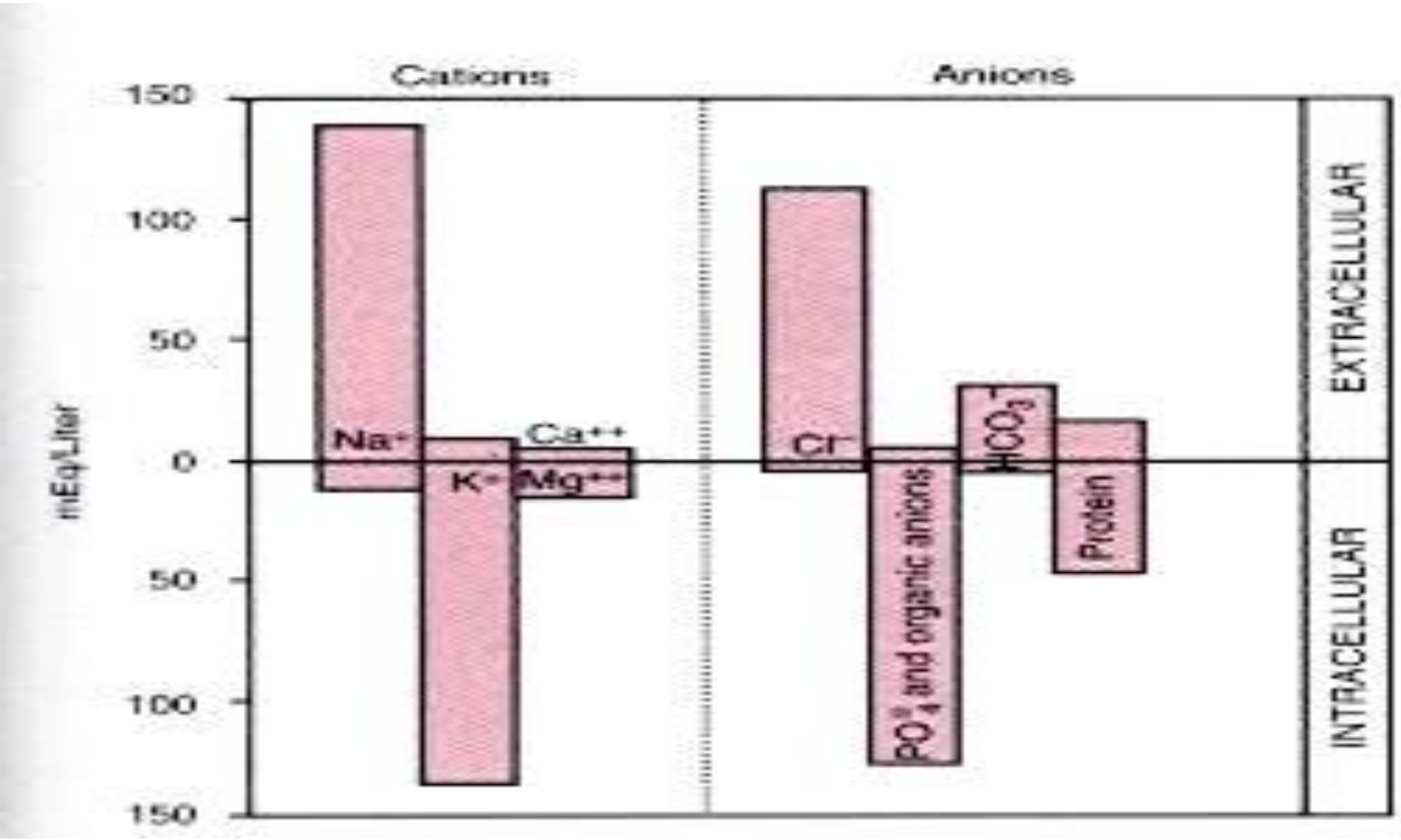


TABLE 20–2 OSMOLAR SUBSTANCES IN EXTRACELLULAR AND INTRACELLULAR FLUIDS

	Plasma (mOsm/liter of H_2O)	Interstitial	Intracellular
Na^+	142	139	14
K^+	4.2	4.0	140
Ca^{++}	1.3	1.2	0
Mg^{++}	0.8	0.7	20
Cl^-	108	108	4
HCO_3^-	24	28.3	10
HPO_4^{--}, $H_2PO_4^-$	2	2	11
SO_4^{--}	0.5	0.5	1
Phosphocreatine			45
Carnosine			14
Amino acids	2	2	8
Creatine	0.2	0.2	9
Lactate	1.2	1.2	1.5
Adenosine triphosphate			5
Hexose monophosphate			3.7
Glucose	5.6	5.6	
Protein	1.2	0.2	4
Urea	4	4	4
Others	4.8	3.9	10
Total mOsm/liter	301.8	300.8	301.2
Corrected osmolar activity (mOsm/liter)	282.0	281.0	281.0
Total osmotic pressure at 37° C (mm Hg)	5443	5423	5423

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Morophology

Flag Comments
Flag Comment 1
ANISO .....
MICRO .....
MACRO .....
POIKILO .....
HYPO .....
Polychromasia .....
LSHIFT .....

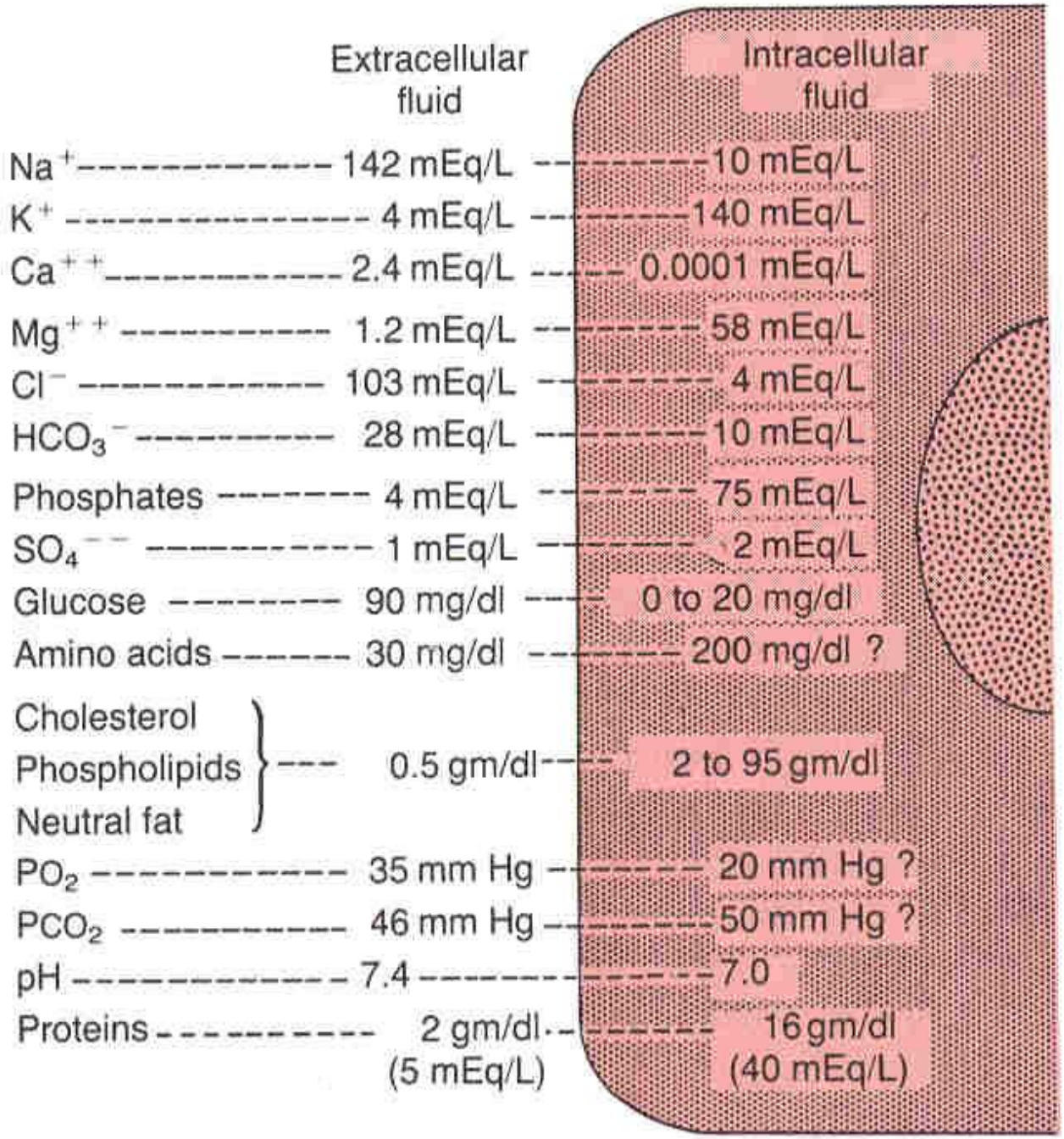
EQUEST COMMENTS:

Extracellular and Intracellular Fluids

- Each fluid compartment of the body has a distinctive pattern of electrolytes
- Extracellular fluids are similar (except for the high protein content of plasma)
  - Sodium is the chief cations
  - Chloride is the major anions

- **Intracellular fluids have low sodium and chloride**
  - **Potassium is the chief cation**
  - **Phosphate is the chief anion**
  - **Each compartment must have almost the same concentration of positive charge (cations) as of negative charge (anion).**

(Electroneutrality)


Extracellular fluid
Intracellular fluid
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10 mEq/L
K^+ 4 mEq/L
140 mEq/L
Ca^{++} 2.4 mEq/L
0.0001 mEq/L
Mg^{++} 1.2 mEq/L
58 mEq/L
Cl^- 103 mEq/L
4 mEq/L
HCO_3^- 28 mEq/L
10 mEq/L
Phosphates 4 mEq/L
75 mEq/L
SO_4^{--} 1 mEq/L
2 mEq/L
Glucose 90 mg/dl
0 to 20 mg/dl
Amino acids 30 mg/dl
200 mg/dl ?
Cholesterol
Phospholipids
Neutral fat
0.5 gm/dl
2 to 95 gm/dl
PO_2 35 mm Hg
20 mm Hg ?
PCO_2 46 mm Hg
50 mm Hg ?
pH 7.4
7.0
Proteins 2 gm/dl (5 mEq/L)
16 gm/dl (40 mEq/L)

- **Hypokalemia: decrease in K concentration in the ECF.**

Hyperkalemia: increase a above normal.

Hypernatremia: **increase in Na concentration in ECF.**

Hyponatremia: **decrease in Na concentration in the ECF.**

Regulation Of Fluid Exchange:

- **Intracellular**

  cell member

- **Extracellular**

  - highly permeable to water

  - relatively impermeable to small ions.

i.e. only water is moving.

- **(osmotic effect of electrolytes Na,K,cl)**

Thank you