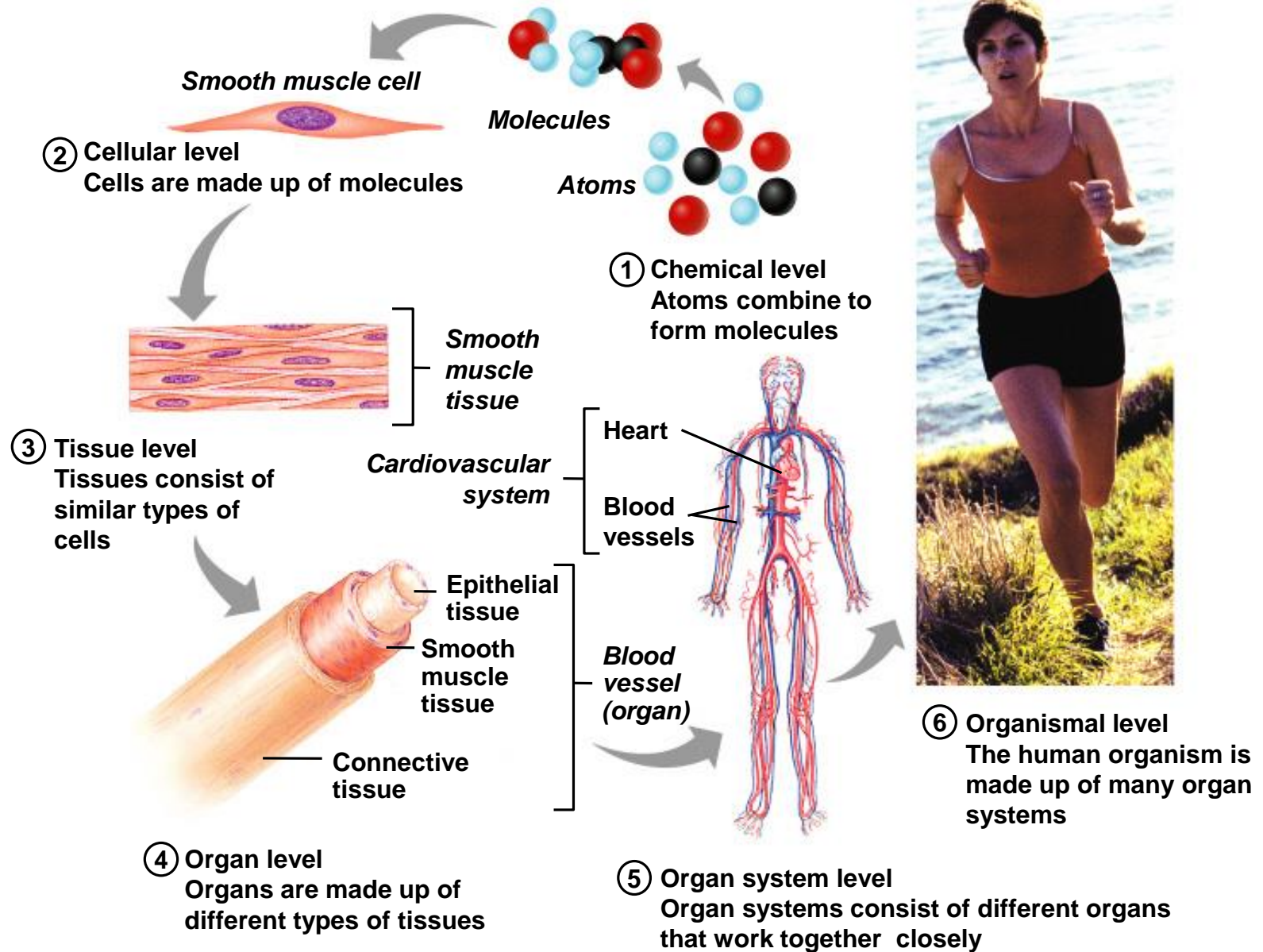


HUMAN PHYSIOLOGY

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 adaptation to change.

Levels of Structural Organization

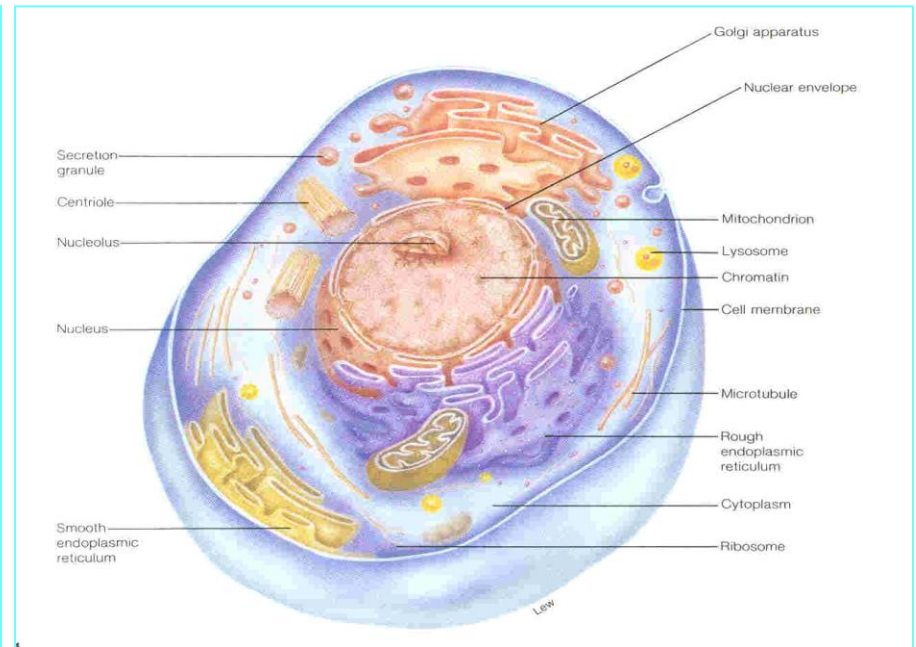
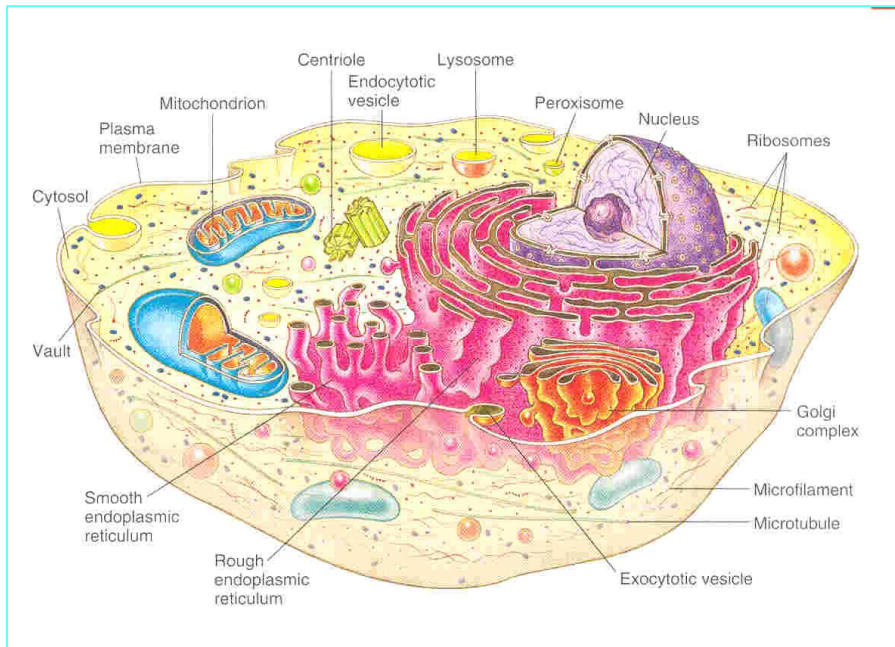


LEVELS OF COMPLEXITY

- **Atoms**
- **Molecules**
- **Biomolecules**
- **Organelles**
- **Cells**
- **Tissues**
- **Organs**
- **Systems**

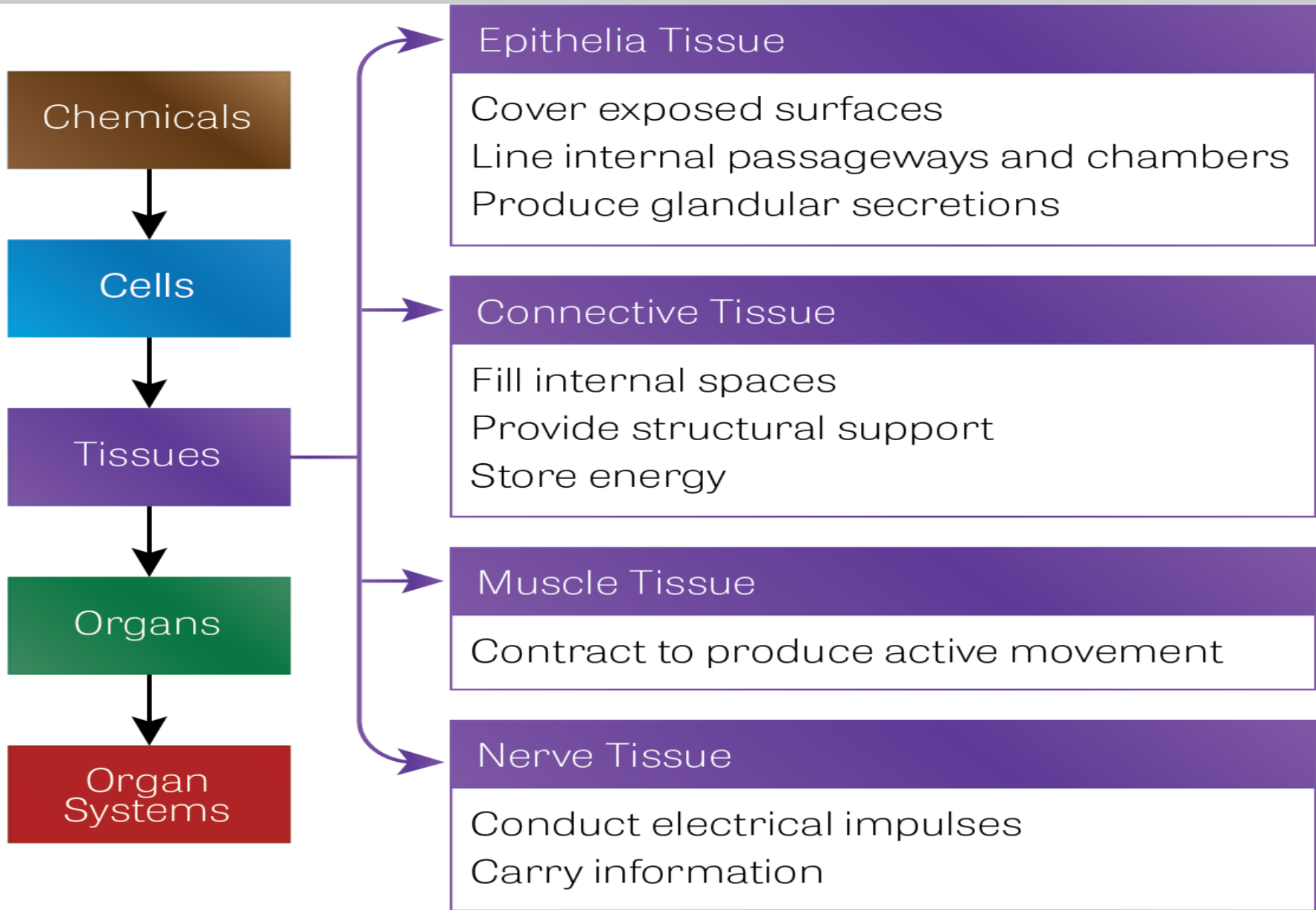
CELL

The Unit of Structure & Function

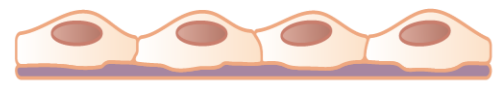


TYPES OF TISSUES

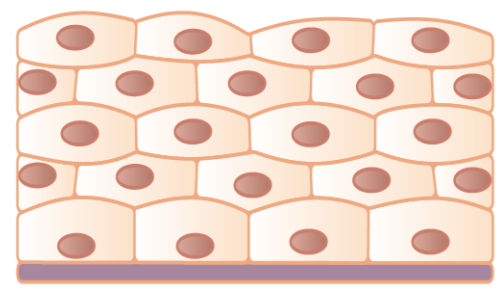
- *Nerve*
- *Muscle*
- *Connective*
- *Epithelial*



Squamous

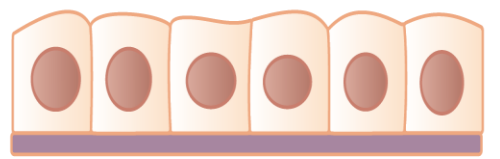


Simple squamous

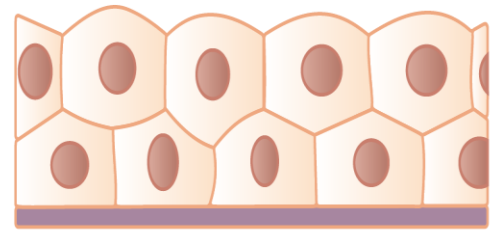


Stratified squamous

Cuboidal

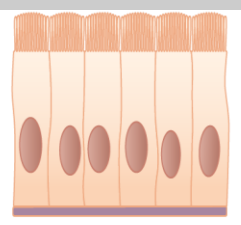


Simple cuboidal

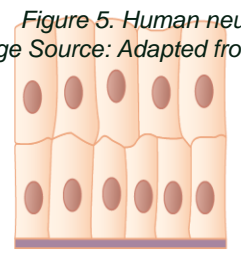


Stratified cuboidal

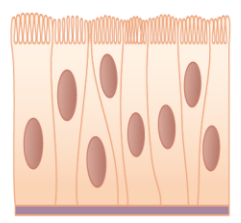
Columnar



Simple columnar



Stratified columnar

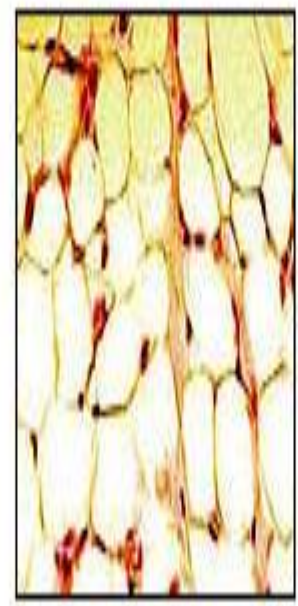


Pseudostratified columnar

Figure 5. Human neuron anatomy
(Image Source: Adapted from iStock Photos, ©)



Areolar connective tissue



Adipose tissue



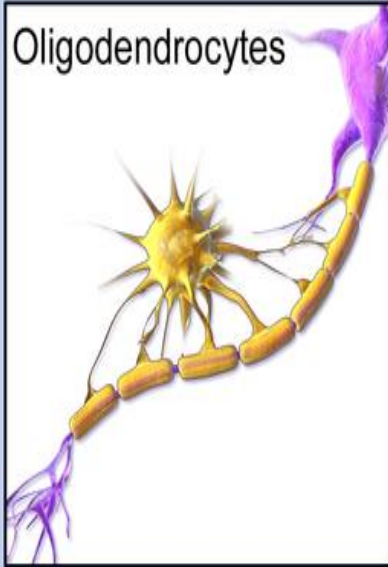
Fibrous connective tissue

Central Nervous System

Ependymal cells



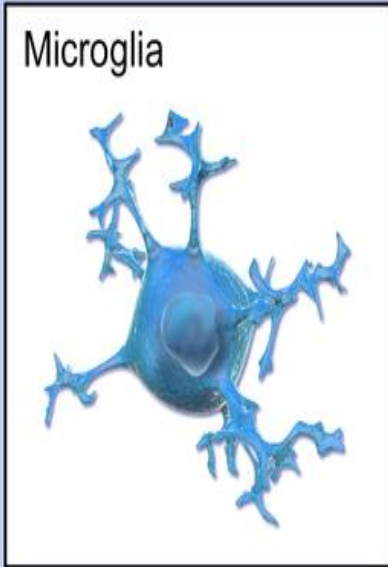
Oligodendrocytes



Astrocytes

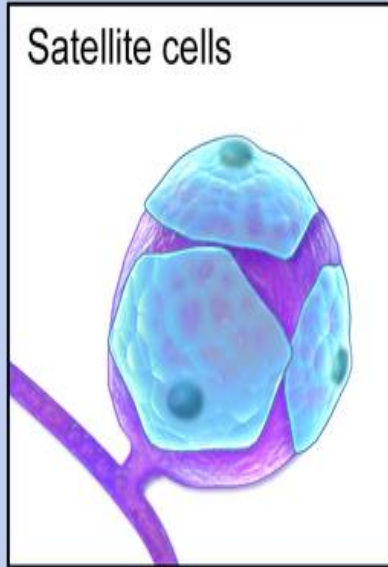


Microglia

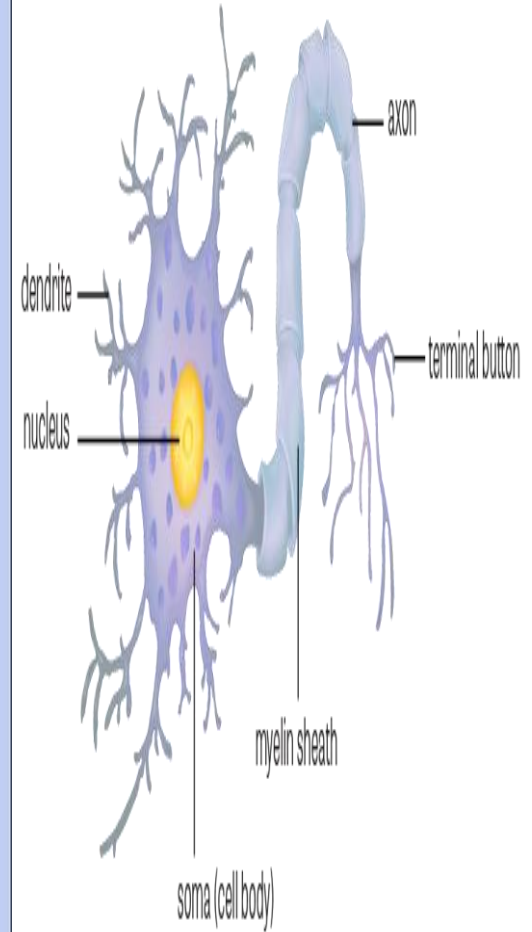
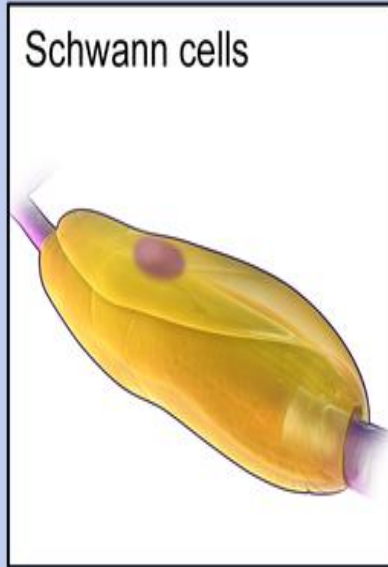


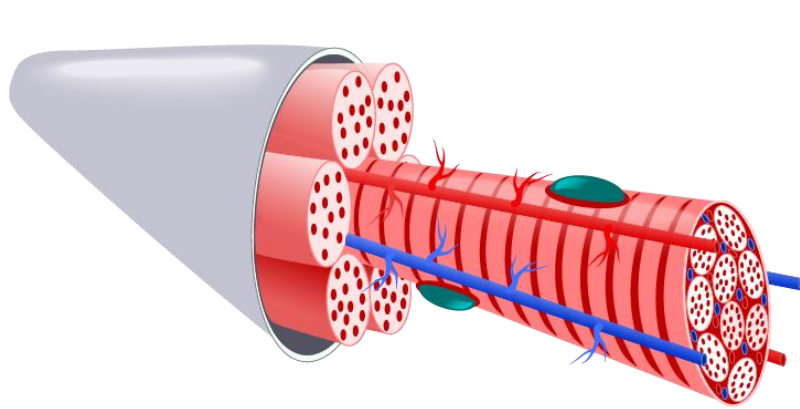
Peripheral Nervous System

Satellite cells

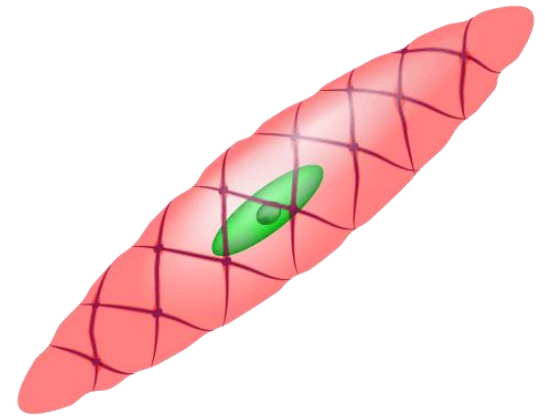


Schwann cells





Skeletal muscle



Smooth muscle



Cardiac muscle

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.**



KING KHALID HOSP.
PO BOX 7805 RIYADH

DEPARTMENT OF CLINICAL BIOCHEMISTRY

| Pat.N
| Name: Page No.:1
| Hospital:KING KHALID UNIVERSITY HOSPITA Sex:F
| Location: (MED) Medical Department DOB:22 Sep 86
Doctor:UNKNOWN *

Xref:

Req No.:R11133779 Date Coll.:15/06/32(18/05/11) Date Recd.:15/06/32(18/05/11)
Printed:19/06/1432(22/05/11)09:03 Time Recd.:11:53

Serum							
3.9 - 5.8	mmol / L	[*]	Fasting Blood Sugar		4.5		
			Urea and Electrolytes				
2.5 - 6.4	mmol / L	[*]	Urea		3.1		
53 - 106	umol/L	[*]	Creatinine		62		
135 - 145	mmol/L	[*]	Sodium		141.0		
3.5 - 5.1	mmol/L	[*]	Potassium		4.4		
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		
0 - 5	umol/L	[*]	Direct Bilirubin		2		
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		
20 - 40	g/L	[*]	Globulins		29.2		
2 - 17	umol/L	[*]	Indirect Bilirubin		3		
			Lipid profile				
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

CONSULTANT ON DUTY

KING KHALID HOSP.
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HEMATOLOGY UNIT

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| Name: Page No.:1
| Hospital:KING KHALID UNIVERSITY HOSPITA Sex:F
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Printed:19/06/1432(22/05/11)09:04 Time Recd.:12:41

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
[*]	MCHC	345	320 - 360	g/L
[*]	RDW	13.3	11.5 - 14.5	%
[*]	PLT	222	140 - 450	x10.e9/L
[*]	MPV	8.8	7.2 - 11.1	fl

Differential

[*]	%NEUT	60.5	40 - 75	%
[*]	%LYMP	31.3	20 - 45	%
[*]	%MONO	4.6	3 - 9	%
[*]	%EOS	3.1	0 - 6	%
[*]	%BASO	0.5	0 - 1	%
[*]	#NEUT	4.3	2 - 7.5	x10.e9/L
[*]	#LYMP	2.2	1 - 5	x10.e9/L
[*]	#MONO	0.3	0.2 - 0.8	x10.e9/L
[*]	#EOS	0.2	0.0 - 0.8	x10.e9/L

Morphology

Flag Comments

Flag Comment 1

ANISO
MICRO
MACRO
POIKILO
HYPO
Polychromasia
LSHIFT

REQUEST COMMENTS:

1

-
- **Human body contains 40-70% 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%

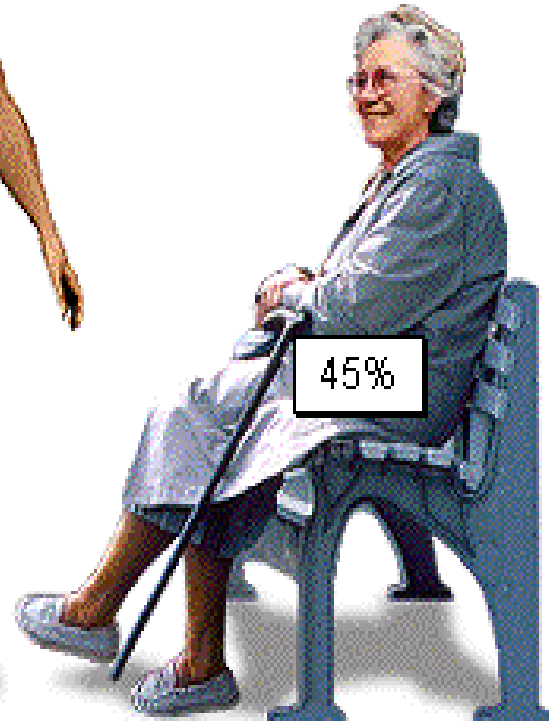
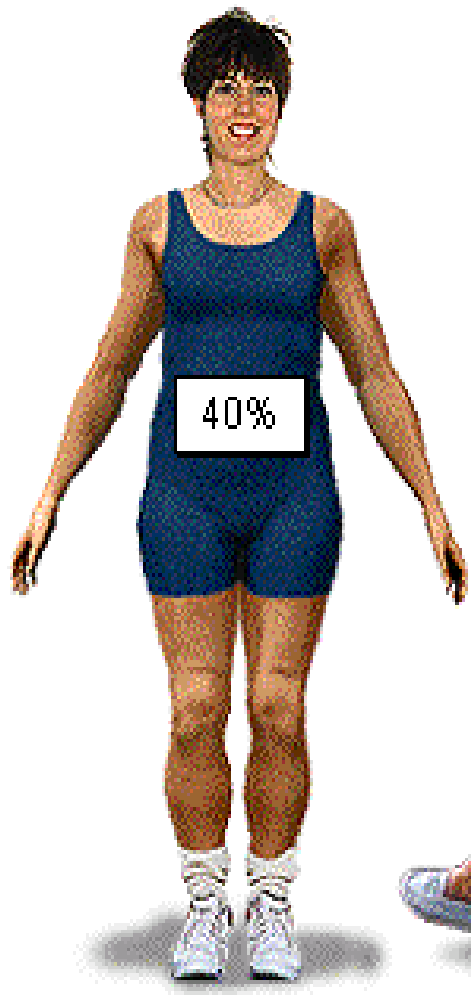
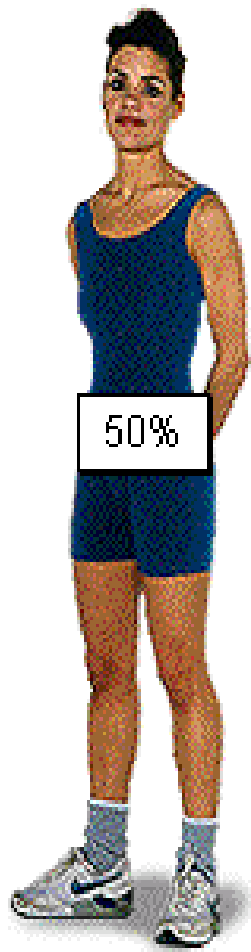
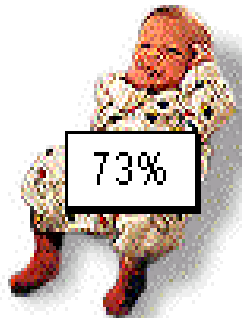
Obesity



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.

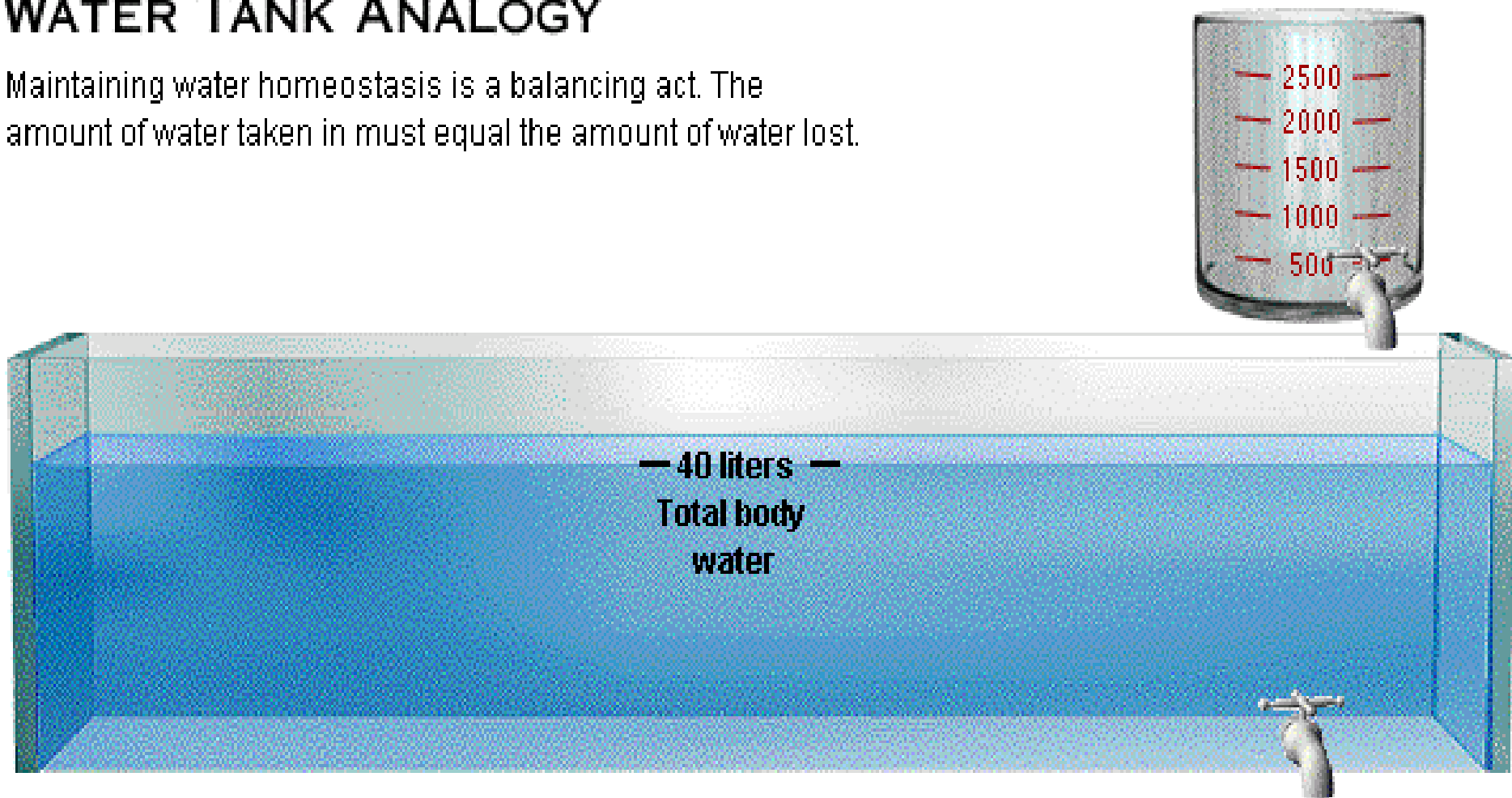
Daily intake of water

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

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

- Food and drink: 2300 mL
- Cell metabolism: 200 mL

▪ **Total:** 2500 mL

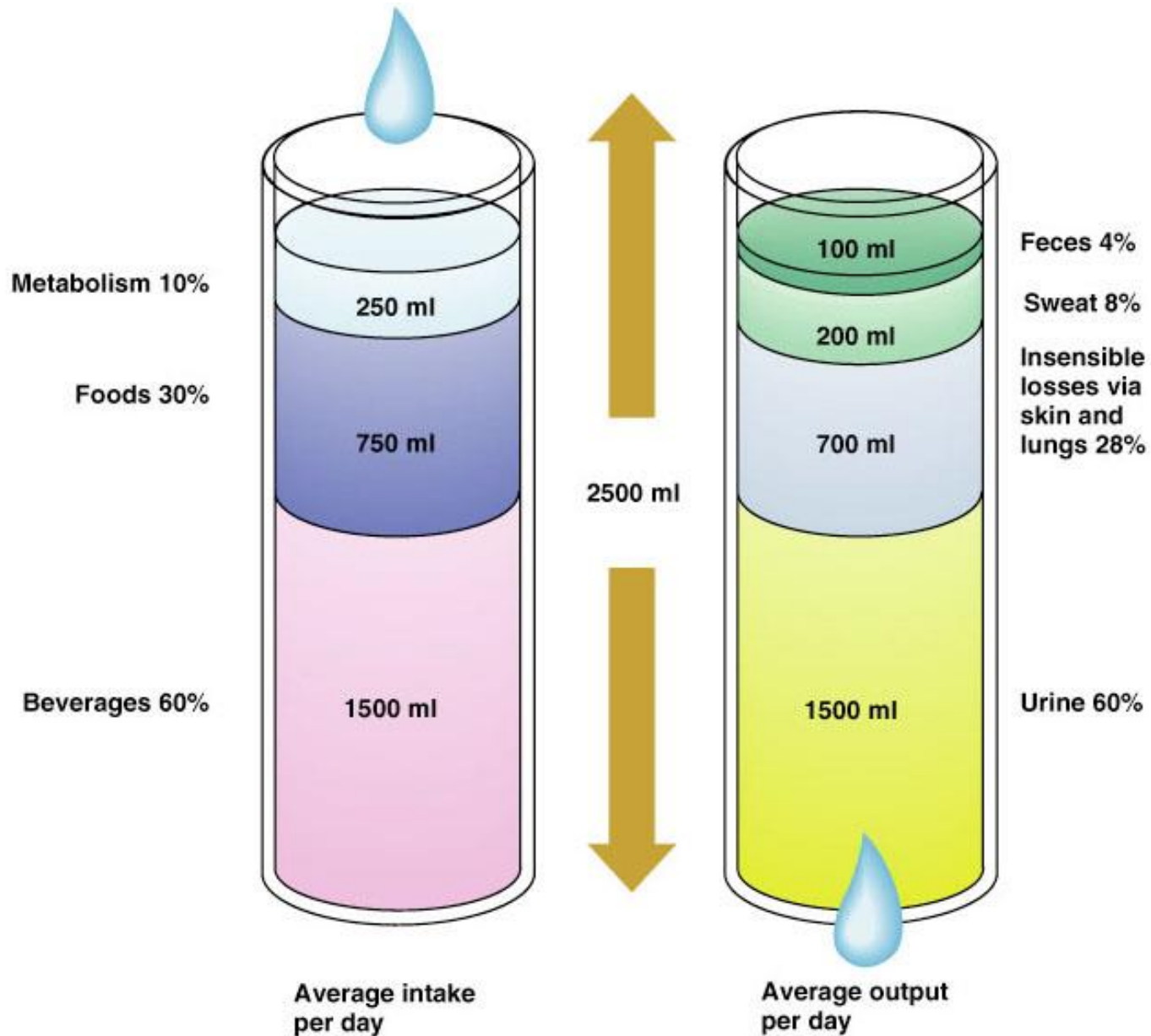
Water Output

- Kidneys: 1500 mL
- Skin: 600 mL
- Lungs: 300 mL
- GI tract: 100 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**

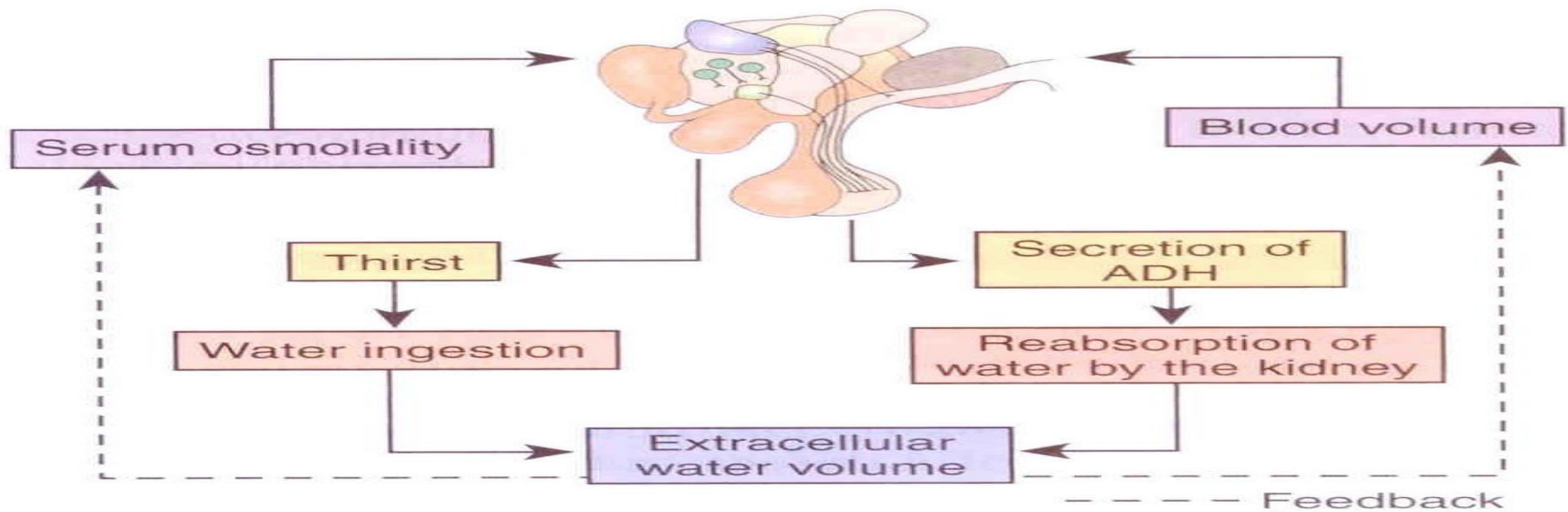
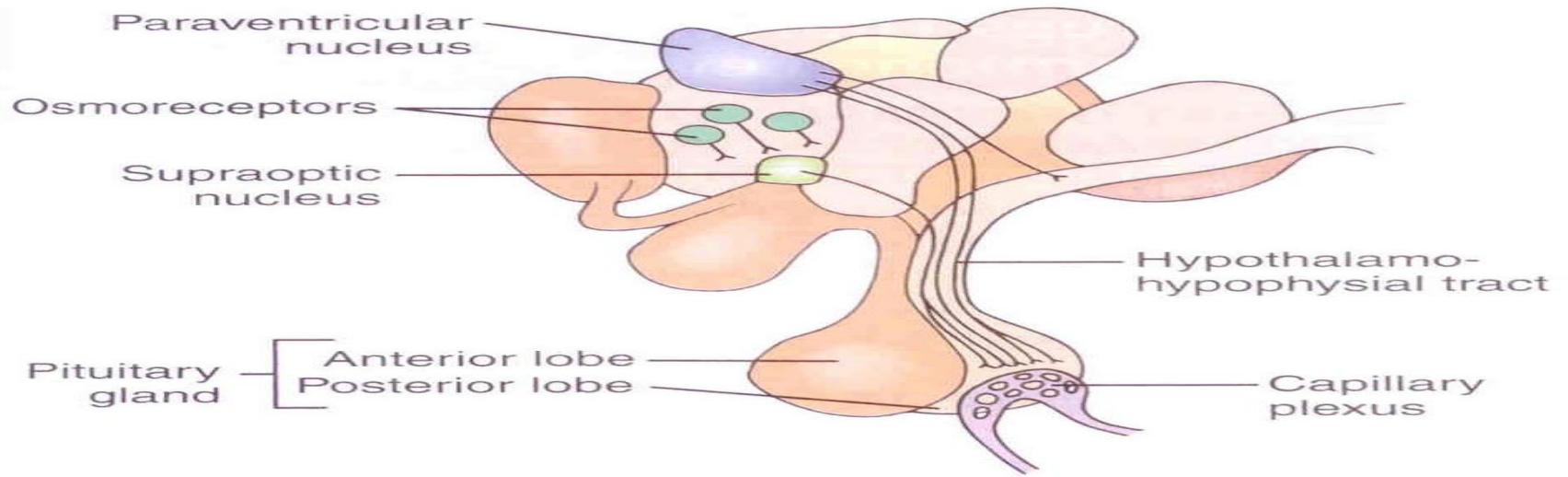


FIGURE 31-7 • (Top) Sagittal section through the pituitary and anterior hypothalamus. Antidiuretic hormone (ADH) is formed primarily in the supraoptic nucleus and to a lesser extent in the paraventricular nucleus of the hypothalamus. It is then transported down the hypothalamohypophysial tract and stored 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)

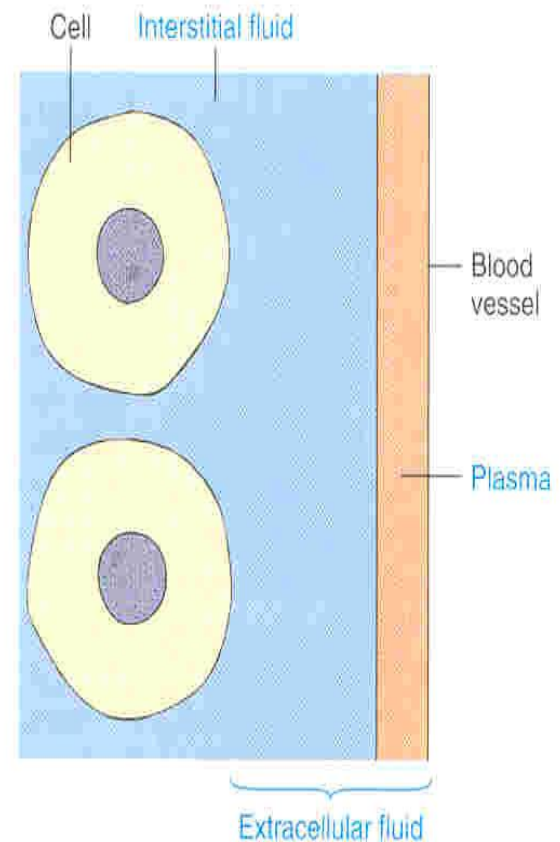


FIGURE 1-2

Fluid Compartments

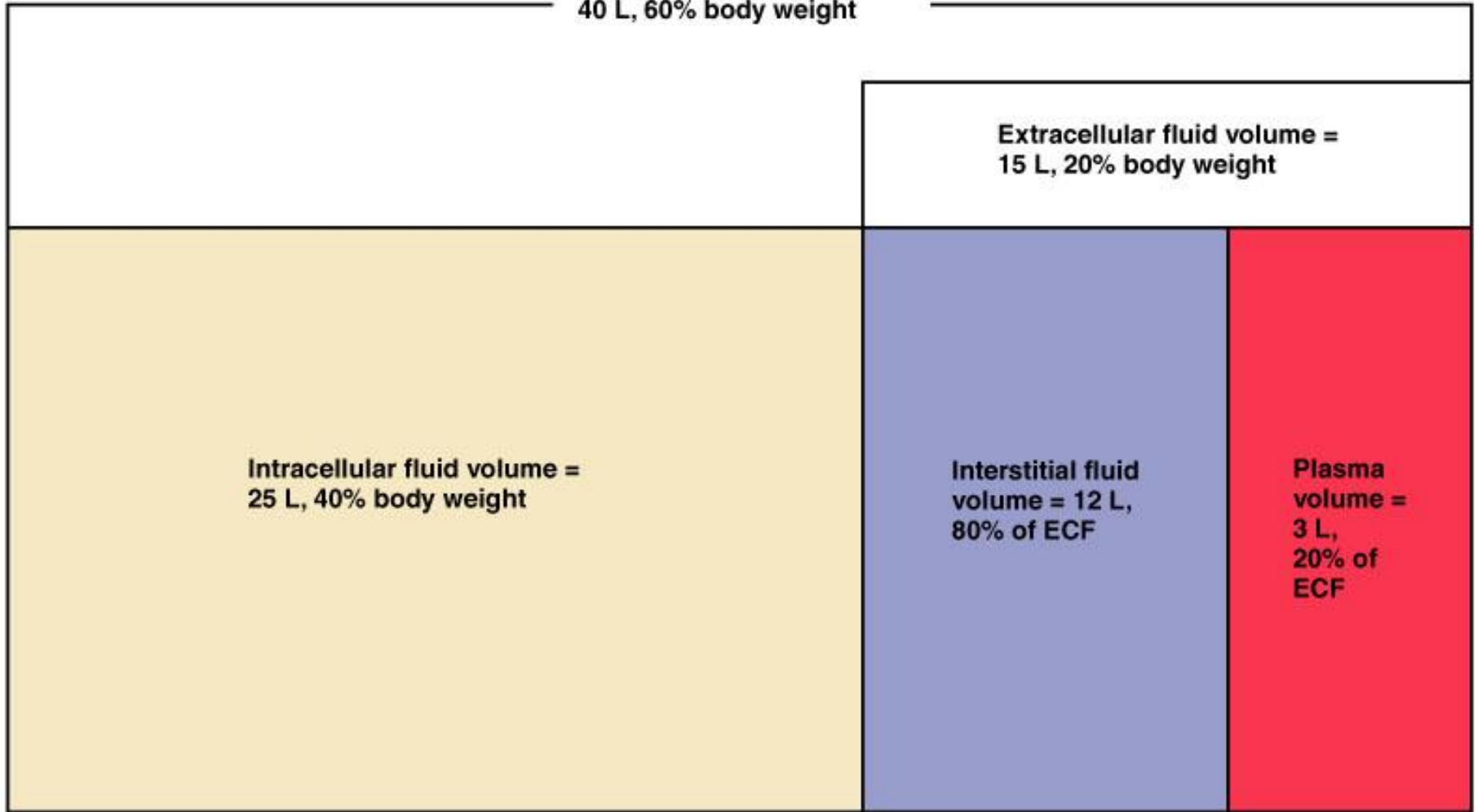
Total body water volume =
40 L, 60% body weight

Extracellular fluid volume =
15 L, 20% body weight

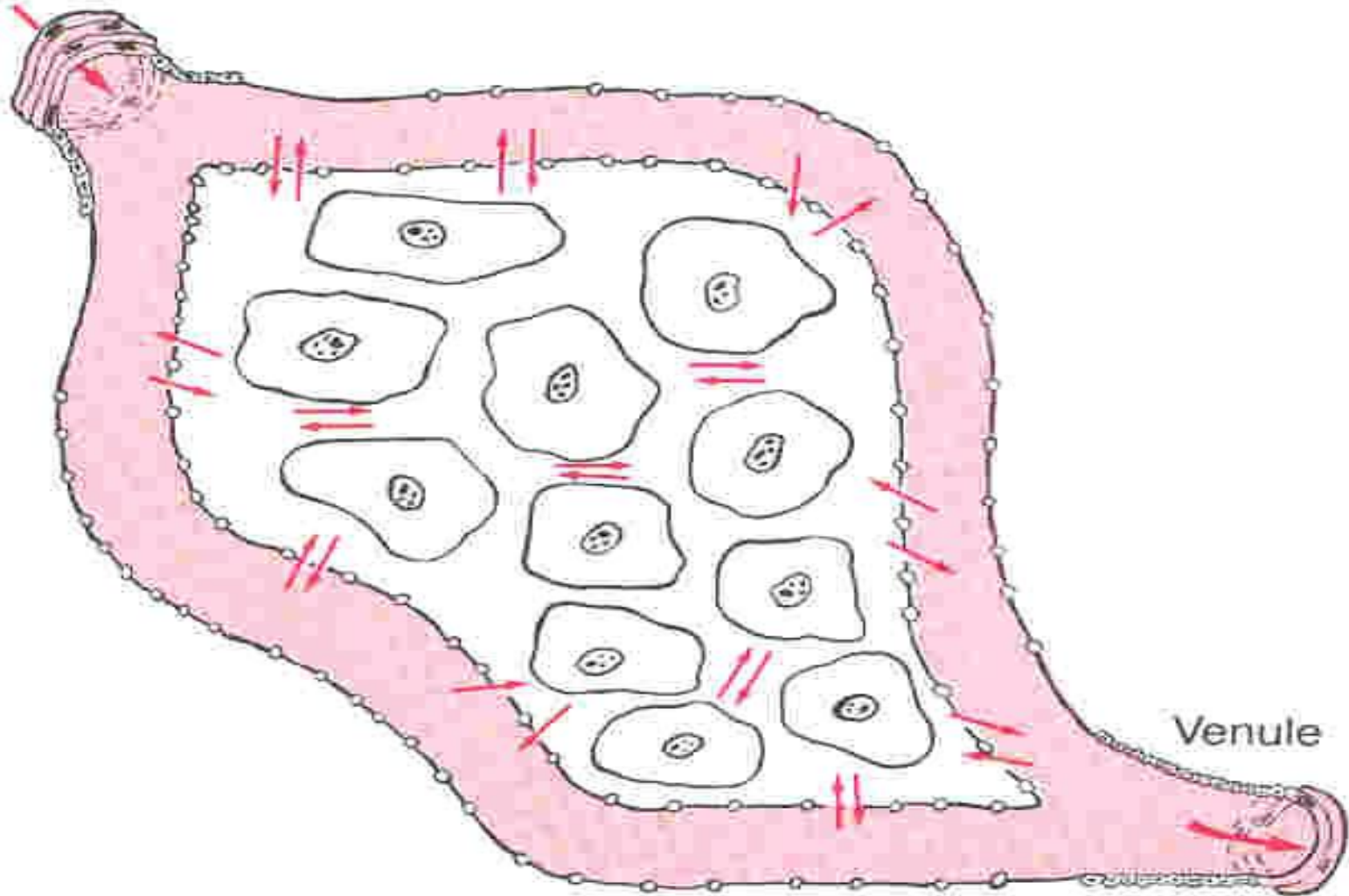
Intracellular fluid volume =
25 L, 40% body weight

Interstitial fluid
volume = 12 L,
80% of ECF

Plasma
volume =
3 L,
20% of
ECF



Arteriole



Venule

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

TOTAL BODY WATER

Intracellular fluid

Extracellular fluid



Cell membrane

Capillary wall

Total body water
(60% body weight)

Intracellular fluid
(40% body weight)

Extracellular fluid
(20% body weight)

Interstitial fluid

Plasma

FLUID COMPARTMENTS

```
graph TD; A[FLUID COMPARTMENTS] --> B[EXTRA CELLULAR FLUID]; A --> C[INTRA CELLULAR FLUID]; B --> D[PLASMA]; B --> E[INTERSTITIAL FLUID]; B --> F[TRANSCELLULAR FLUID]; F --> G["CSF<br/>Intra ocular<br/>Pleural<br/>Peritoneal<br/>Synovial<br/>Digestive Secretions"]; style B fill:#800080,stroke:#000,stroke-width:2px; style C fill:#800080,stroke:#000,stroke-width:2px; style D fill:#800000,stroke:#000,stroke-width:2px; style E fill:#800000,stroke:#000,stroke-width:2px; style F fill:#800000,stroke:#000,stroke-width:2px; style G fill:#008000,stroke:#000,stroke-width:2px;
```

The diagram is a hierarchical flowchart. At the top is a purple box labeled 'FLUID COMPARTMENTS'. Two arrows point down from this box to two more purple boxes: 'EXTRA CELLULAR FLUID' on the left and 'INTRA CELLULAR FLUID' on the right. From 'EXTRA CELLULAR FLUID', three arrows point down to three brown boxes: 'PLASMA', 'INTERSTITIAL FLUID', and 'TRANSCELLULAR FLUID'. From 'TRANSCELLULAR FLUID', a large purple arrow points down and then left to a green box containing a list of fluid types: 'CSF', 'Intra ocular', 'Pleural', 'Peritoneal', 'Synovial', and 'Digestive Secretions'.

*EXTRA CELLULAR
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 intraocular 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)**
- **$1\text{mM} = 1/1000 \text{ M}$**
- **$1\text{mOsm} = 1/1000 \text{ Osm}$**

Constituents of ECF and ICF

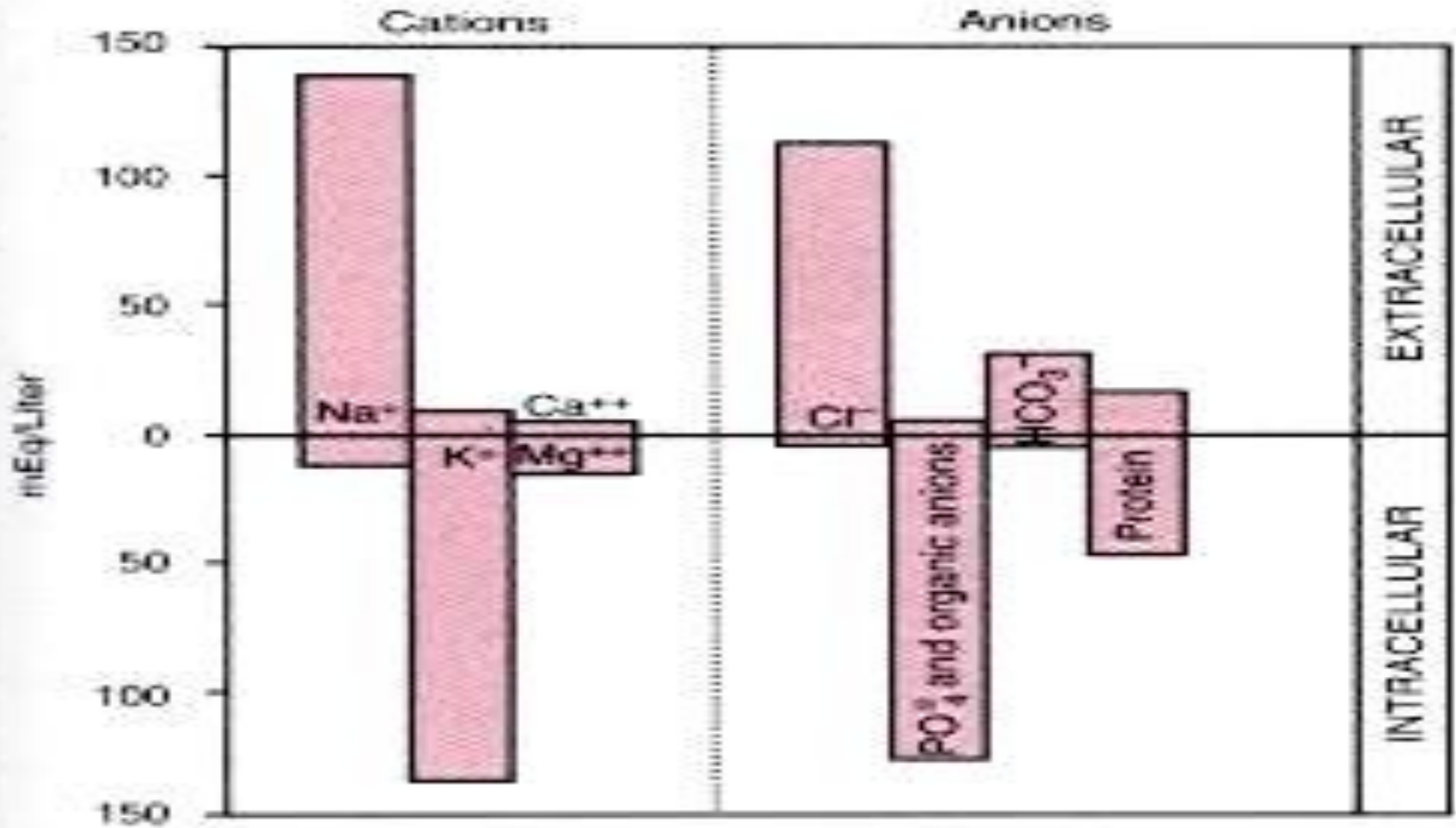


TABLE 20-2 OSMOLAR SUBSTANCES IN EXTRACELLULAR AND INTRACELLULAR FLUIDS

	Plasma (mOsm/liter of H ₂ O)	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 ₂ PO 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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Serum

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			Urea and Electrolytes		
2.5 - 6.4	mmol / L	[*]	Urea	3.1	
53 - 106	umol/L	[*]	Creatinine	62	
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	
0 - 5	umol/L	[*]	Direct Bilirubin	2	
60 - 80	g/L	[*]	Total Protein	72.2	
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5 - 55	U/L	[*]	Gamma Glutamyl Transferase	17.0	
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2 - 17	umol/L	[*]	Indirect Bilirubin	3	
			Lipid profile		
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

CONSULTANT ON DUTY

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Full Blood Count

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[*]	HGB	145	120 - 160	g/L
[*]	HCT	42.1	37 - 47	%
[*]	MCV	88.0	80 - 94	fl
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[*]	%EOS	3.1	0 - 6	%
[*]	%BASO	0.5	0 - 1	%
[*]	#NEUT	4.3	2 - 7.5	x10.e9/L
[*]	#LYMP	2.2	1 - 5	x10.e9/L
[*]	#MONO	0.3	0.2 - 0.8	x10.e9/L
[*]	#EOS	0.2	0.0 - 0.8	x10.e9/L

Morphology

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ANISO
MICRO
MACRO
POIKILO
HYPO
Polychromasia
LSHIFT

REQUEST COMMENTS:

1

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
Na ⁺	142 mEq/L	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	0.5 gm/dl	2 to 95 gm/dl
Phospholipids		
Neutral fat		
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